Going the Extra Miles
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I congratulate the Drainage Services Department (DSD) on the 25th anniversary of its establishment.

Hong Kong is renowned for its superior infrastructure. In particular, wastewater and stormwater management facilities play an essential and indispensable role in our urban development. Since its inception in 1989, the DSD has committed itself to providing quality services in flood prevention and sewage treatment for the community. The success it has achieved is for all to see.

The complicated terrain and dense population of the city bring challenges to the DSD. Yet colleagues of the DSD are undaunted. They embrace the challenges and have turned many into opportunities throughout the years. They are the unsung heroes who have helped make Hong Kong a great place to live and work in.

Rainstorms in Hong Kong have become more frequent and intense in recent years as a result of global climate change. Thanks to the DSD’s various flood prevention projects and innovative stormwater interception measures, flooding in various districts has been alleviated and the number of flooding blackspots has been gradually reduced. While the growing population produces more sewage, the water quality of our harbour has not deteriorated but improved significantly since the commissioning of several sewage treatment facilities. A number of beaches in Tsuen Wan closed for years because of concern over water quality are now reopened, and the cross-harbour swimming race was revived in 2011 after a hiatus of more than 30 years. None of these would have been possible without the foresight and hard work of our DSD colleagues. My appreciation and gratitude go to all of them.

Looking ahead, I am sure that the DSD and its team will continue to excel and move with the times, living up to their motto of “Do it from the Heart”. We shall see more of their devotion and innovation in the provision of first-class flood and sewage management facilities and their further contribution to the sustainable development of Hong Kong.

(Mrs Carrie Lam)
Chief Secretary for Administration
The Drainage Services Department (DSD) published this monograph in celebration of its 25th anniversary. The monograph looks back on the drainage developments in Hong Kong and outlines the endeavours, achievements and prospect of DSD in the provision of stormwater drainage and sewage treatment services. Flood prevention strategies are developed to cater for local circumstances as well as future climate change. DSD constructs effective sewerage networks, expands sewage treatment facilities, upgrades technologies and promotes greening, for achieving the objectives of environmental protection and sustainable development. In taking forward new projects, DSD endeavours to engage the public in order to strike a balance among the environmental, developmental and social needs. Besides, DSD boosts team spirit through initiatives on partnership and staff care. This monograph also features interviews with members of the public, staff, stakeholders and professionals who shared with readers their reminiscences and expectations, which help learn from the past and build for the future.

This monograph consists of seven chapters. Chapter 1 introduces the background on drainage development in Hong Kong and outlines the embryonic framework for drainage planning (e.g. pioneering the separation of drainage and sewerage systems and studies on sewage treatment and drainage strategies), and the establishment and mission of DSD. Chapter 2 elaborates the services on sewage treatment, in particular the planning, commissioning, and management of sewage collection, treatment and disposal, as well as on the implementation and effectiveness of the Harbour Area Treatment Scheme. Chapter 3 explains the mapping out of flood prevention plans and provision of flood prevention facilities in Hong Kong by adapting the strategies of stormwater interception, storage and conveyance. These facilities help eliminate flooding blackspots and better equip us for the challenges arising from climate change. Chapter 4 focuses on DSD’s commitment in environmental protection and sustainable development, depicting enhanced ecological conservation of watercourses, full implementation of low-carbon and energy-efficient measures, greening, and cavern development, etc. Chapter 5 highlights how public engagement activities can enable us to gather views of the public and how various platforms can foster our exchanges and deliberations with industries and stakeholders. All these facilitated the promotion of our services to the community. Chapter 6 lists DSD’s award-winning projects with innovative designs, construction methods and green technologies. Chapter 7 concludes that we are able to provide quality public drainage services due to team spirit and collaboration. We believe that staff care, cooperation with our partners and close communication are the keys to strong cohesion and continuous improvement of the Department.
Chapter One  Drainage Development over the Last Century
In the mid to late 19th century, the drainage development in Hong Kong was still in a primitive stage where a combined drainage and sewerage system was in use. The subsequent population growth and outbreak of infectious diseases prompted the Government to separate the drainage and sewerage systems in drainage planning in the early 20th century, shaping the preliminary form of the drainage infrastructure today. In the mid 20th century, Hong Kong’s industrial take-off and flourishing livestock industry led to the discharge of large amounts of sewage from factories and livestock farms without proper treatment, affecting the ecology of the coastal environment. In addition, during the process of urbanisation, concrete paving on farmlands disrupted the natural land drainage, exacerbating the flooding problems. In response to these rising problems, the Government launched a series of territory-wide studies on sewage treatment and stormwater drainage such as Marine Investigation into Sewage Discharges: Brief Report and “Territorial Land Drainage and Flood Control Strategy Study – Phase I”, to formulate long-term improvement measures. In 1989, the Drainage Services Department (DSD) was established as recommended in the White Paper: Pollution in Hong Kong — A Time to Act. Since then, DSD has been taking up the important role of providing sewage collection and treatment as well as stormwater drainage services in Hong Kong.
Overview of early drainage development

Prior to the British colonization, there were many villages on Hong Kong Island, in Kowloon and the New Territories. For example, various clans settled in areas such as Yuen Long, Tuen Mun and Sheung Shui in the New Territories to farm and raise livestock for a living. Meanwhile, there were many communities of boat-dwelling fishermen in the fishing villages of Aberdeen, Shau Kei Wan, Tai O, Cheung Chau, Sha Tau Kok, Sai Kung, etc. For these early inhabitants, human and animal waste was used as fertilizer and fish feed. Given the then sparse population, the domestic sewage produced by villagers had minimal impact on the nearby rivers and coastal ecology.

Compared with sewage, heavy rains posed a greater threat to these early inhabitants. According to records, Hong Kong, being located in the Xinan County had all along suffered from rainstorms, most of which lasted for a whole day or a few days. For example, in the 33rd year of the Qianlong reign (1768) of the Qing dynasty, there were seven consecutive days of rain, resulting in severe flooding, house damage, casualties and loss of property. In the 23rd year of the Jiaqing reign (1818) of the Qing dynasty, it was recorded that “On the Chung Yeung Festival, a rainstorm caused the Liao river to burst its banks at Zhensha bridge. Slopes and fields around Shahe Dong and other places were flooded and collapsed.”
Chapter One  Drainage Development over the Last Century

Early drains

Hong Kong became a British colony in 1842. The Colonial Government made use of the wide and deep Victoria Harbour as a place for administration, management, garrison and berths. Also, the Government carried out the city planning for the northwestern Hong Kong Island and built the City of Victoria.

However, the concept of provision of drains was not featured in the initial city planning. The first Surveyor General, Mr Alexander Thomas Gordon, suggested in his report in 1843 to construct a canal with tributaries in Wong Nei Chung Valley to serve as a source of freshwater supply as well as a trading and transport route. The design of widening rivers into a canal indirectly served the purpose of flood prevention. This canal project was a pioneer river training project in Hong Kong.

As the first drainage works in Hong Kong history, the project was commenced by the Public Works Department (PWD) in Wong Nei Chung Valley in 1845. In the next two years, about 2 440 yards of drains were constructed for the City under the supervision of the Surveyor General's Office.

![Bowrington Canal](image1)

Bowrington Canal was constructed in Wong Nei Chung Valley in 1864. It is now Canal Road in Causeway Bay.

(Leftfig1: Happy Valley Racecourse, 1865; rightfig2: Bowrington Canal, 1910)
In the earlier years, a combined drainage and sewerage system was adopted to wash away the sewage with rainwater to satisfy the sewage treatment need of the City. However, after the 1850s, a large number of Mainlanders moved to the City, nearly doubling the Chinese population from 85,280$^5$ in 1859 to 150,690$^6$ in 1881. Mostly residing in the vicinity of Sheung Wan and Sai Wan, these new migrants contributed to increasingly dense building clusters and upsurge of domestic sewage in those areas. The potential health risks of a combined system started to surface.

Overcrowded living environment in Sheung Wan, with back-to-back tenements, 1870$^{56}$

Shops operated by Chinese lining in Queen’s Road West, 1885$^{56}$
Health problems of the combined drainage and sewerage systems

Owing the past practice of most families in Chinese communities to keep livestock at home with overcrowded living conditions, the sewage and health problems gradually surfaced. The situation was particularly serious in Tai Ping Shan District where the filthy environment had been criticized by the Colonial Surgeon. In 1854, Dr. J. Carroll Dempster stated in his report that Tai Ping Shan District was abounded with cowsheds, pigsties and stinking pools with the filth all around remaining unattended, and that odour was generated from the filth accumulated in the two nullahs in the District. Dr Dempster’s report in 1855 further pointed out that the City of Victoria was in imminent need of drainage and sewerage facilities. He emphasised that the overcrowded, dirty and unventilated living environment in humid weather was conducive to the outbreak of contagious diseases in the City.

1st. I am therefore of opinion that Victoria is in need of Drainage and Sewerage, of better Paving and Scavengering

2d. That the Dwellings of the Natives are faulty in construction, being erected apparently with the view of having the greatest number in the smallest possible space, and without any regard to Ventilation and Drainage.

3d. That Disease prevails most where the Dwellings are overcrowded, and where little if any attention is paid to cleanliness, ventilation, and drainage.

4th. That the Inhabitants of Lanes and other crowded Localities, be compelled to whitewash their Dwellings at least twice a year, and to make free use of water upon the pavements and channels every morning.

5th. That the absence of Sanitary measures in Hongkong leads to the development and dissemination of disease.

It is well known that damp and dirt, that nuisances of all kinds and particularly animal and vegetable matter in a state of decomposition, are circumstances that favor the propagation of disease. Whatever renders the atmosphere impure, impairs the health, and predisposes the body to disease, and where numbers of sick are crowded together in close, dirty, and unventilated rooms, disease spreads with virulence and malignity. I shall conclude these few remarks by a statement of Dr. Arnott: “Aerial moments are to man what the constant gliding past of a clear river steam is to fishes which inhabit it, and as certainly as we should destroy the trout of a stream by confining them in a small porting of the watery element until it become a dirty puddle, so should we destroy or injure human beings when we too closely confine around them a portion of the Aerial element.”

J. CARROLL DEMPSTER, M.D.
Colonial Surgeon.

Extract of Dr Dempster’s report published in 1855

Tai Ping Shan District in 1869. The compact buildings in the foreground were inhabited by Chinese.
In 1870, another Colonial Surgeon, Dr J. I. Murray, pointed out that the surge of fever cases was attributable to the drainage system design and the rainfall in that year. He explained that the design of the drainage system was to rely on rainwater for the cleansing of wastes inside the drains. However, during dry seasons with little rainfall, the wastes accumulated inside the drains and facilitated the spread of contagious diseases.

While revealing the potential risk of public health in their reports, these colonial surgeons had not proposed any concrete solutions to the problem. In 1881, the British Royal Engineer, Sir Osbert Chadwick, was commissioned to come to Hong Kong to conduct a study on public health. He conducted a detailed analysis of the geographical, housing and drainage conditions in Tai Ping Shan District and observed that the living condition of the grassroot Chinese in the District was even more crowded than that in the neighbouring Guangdong area.

Unlike the previous reports by the Colonial Surgeons, Chadwick proposed to the Government a series of improvement measures from the perspective of an engineer, which included planning for hygiene facilities and domestic sewerage systems, and establishing a department to manage the cleansing and health services of the City of Victoria.
Chapter One  Drainage Development over the Last Century

Following Sir Chadwick’s report, the Government embarked on enhancing health policies in Hong Kong, including the establishment of the Hong Kong Sanitary Board in 1883 as well as the enactment of the Public Health Ordinance in 1887 to specify the hygiene requirements for housing, drainage, public toilets and funeral services etc. However, concrete improvement measures regarding the overcrowded living environment of the Chinese and the issues arising from it were yet to be formulated. In 1890, Chadwick was again commissioned to come to Hong Kong to conduct a second public health study. In his second report published in 1891, Chadwick indicated that the hygienic conditions in Tai Ping Shan District was actually worsening rather than improving, and the situation was worrying.

In the same year, the Government established under Public Works Department the Water and Drainage Sub-department designated for waterworks and drainage projects to tackle the hygienic problems caused by the combined system. However, given the drainage improvement works as proposed by Chadwick had not yet been implemented, any outbreak of acute contagious diseases in this densely populated community would have had terrible consequences.

The separate drainage and sewerage system and prevention of plague

Since the establishment of the City of Victoria, the problem of contagious diseases had been prevalent. For example, in 1843, 24% of the British garrison in Hong Kong and 10% of European residents died of fever. This prompted the Government to set up the Committee of Public Health and Cleanliness to monitor the hygienic conditions of the City.

The bubonic plague raging in Guangdong province for more than 40 years hit Hong Kong in 1894 and swept through the unsanitary and overcrowded Tai Ping Shan District. In only four months, the plague took some 2400 lives, making Hong Kong one of the most severely affected areas of this third worldwide plague pandemic. Although the number of infected cases dropped afterwards, it took 30 years for the plague to totally disappear in Hong Kong.
Chapter One  Drainage Development over the Last Century

After the plague, the Government realised that it must expedite the improvement on the hygiene and sewage problems. It therefore invited Chadwick to visit Hong Kong for the third time to plan and enhance the city's drainage system. Chadwick believed that to cope with the growing population, overcrowded living condition and prevalent contagious diseases, coupled with the fact that the combined system was likely to help spread germs and hence not in compliance with the plague prevention requirements, Hong Kong's sewerage and drainage system must be separated. Chadwick recommended the Government not only to provide separate drainage and sewerage system, but also to consider the following improvement measures and works for the public drains and sewers. Many of his opinions and recommendations are still worthy of reference today.

<table>
<thead>
<tr>
<th>Recommendations on sewerage</th>
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<tbody>
<tr>
<td>Sewers should have a sufficient gradient to prevent deposition of solid waste.</td>
</tr>
<tr>
<td>Sewers without a sufficient gradient should be cleared of solid waste every year.</td>
</tr>
<tr>
<td>Test the effectiveness of flushing channels with sea or well water to substitute for the traditional method of using only rainwater.</td>
</tr>
<tr>
<td>Construct intercepting sewers to carry the sewage to more distant outlets.</td>
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<tr>
<td>Determine the locations for sewage outlets with due consideration to tidal direction and strength.</td>
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<tr>
<td>Sewers should be ventilated to prevent accumulation of foul gas.</td>
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<tr>
<td>Prior to opening the manhole vents, connect the house sewers to additional ventilation pipes lest the odour enter the houses.</td>
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<tr>
<td>Remove any tree roots obstructing the pipes or use iron pipes instead.</td>
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<tr>
<th>Recommendations on drainage</th>
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<tbody>
<tr>
<td>Cover drains and nullahs as soon as possible.</td>
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<tr>
<td>Situate the drainage inlets above sea level or higher as far as practicable.</td>
</tr>
<tr>
<td>Cover the drains in coastal low-lying areas and align them along the shortest route to the sea for rainwater discharge, but do not connect them to the drains or nullahs near tidal zones.</td>
</tr>
<tr>
<td>Minimise the length and size of underground drains in planning the newly developed districts or designing the street levels.</td>
</tr>
<tr>
<td>It is very important to carry away the sewage from drains. The steep landscape of Hong Kong Island allows rainwater to flow down and flush out the filth.</td>
</tr>
<tr>
<td>Keep a complete drainage record for future drainage development plans.</td>
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In the early 20th century, the Government adopted Chadwick's proposal of separating the formerly combined system, i.e. building two separate systems: the drainage system and the sewerage system. Since then, the Government has since progressively laid drains and sewers on Hong Kong Island and in Kowloon. Independent planning of the drainage and sewerage systems started to take place, laying the foundation for Hong Kong's drainage development.
Chapter One  Drainage Development over the Last Century

Implementation of the separate drainage and sewerage system

To improve overcrowding in urban areas, the Government created more land through reclamation. The reclamations in Central District and Wan Chai were completed in 1904\(^{13}\) and 1929\(^{14}\) respectively, while the reclamations in Yau Ma Tei, Mong Kok Tsui\(^{15}\) (renamed as Mong Kok in 1930) and other areas commenced in 1909\(^{16}\). The separate system was built during these reclamation works.

Between 1903 and 1940, under the recommendations of Chadwick made in 1902, the Government progressively built the separate system on Hong Kong Island and in Kowloon.

The Government first improved the hygienic conditions of road sewers and implemented improvement works for sewers in residential districts. Afterwards, stormwater storage tanks were provided at Blake Garden and Arbuthnot Road to store water for channel flushing. At a later stage, the Government gradually replaced the traditional sewers with iron ones, extended the sewers to the residential areas, and developed a large-scale and more comprehensive sewerage system for the newly-built structures on Hong Kong Island and in Kowloon. By 1935, most urban areas were covered by the underground sewer system network.

Early drainage works for Hong Kong Island mainly included: reconstructing road drains, providing additional drains between Bonham Road and Hill Road, training several streams on Hong Kong Island with drain laying works of different scales to raise the overall flood prevention capacity of the area.

Note: For details of the early separate system, please refer to Sewerage and Flood Protection – Drainage Services 1841-2008 published in 2008.
Sewage problems

Urban development and water pollution

A large number of Mainlanders migrated to Hong Kong after the Second World War, resulting in a drastic growth in Hong Kong’s population. In just two years between 1949 and 1950, the population of Hong Kong soared from 1.85 million to 2.23 million. During the unstable political period in the Mainland from the early 1960s to the late 1970s, a myriad of Mainlanders flooded into Hong Kong which turned Hong Kong into one of the most densely populated cities in the world. This influx helped enlarging the labour force in Hong Kong, promoting the industrial take-off, agricultural transformation and rapid urbanisation. On the other hand, the upsurge in factories and livestock farms led to huge amounts of industrial effluent and livestock waste being discharged directly into rivers and the sea, bringing about water pollution, red tides and other impacts on coastal ecology. These problems posed a new challenge for Hong Kong.

Domestic sewage

With the increase in urban population, the living environment became more crowded. It was not uncommon to see ordinary people living in three-to-four-storey tenement houses or hillside squatters. All their domestic sewage, no matter used water from vegetable washing, laundry, and baths or urine, was discharged through the same sewer. Night-soil was stored in buckets, collected door to door by night-soil collectors, transported by boat to the New Territories or the Mainland and sold as fertiliser.

A hillside squatter area, 1969

Tenement houses at Reclamation Street in Yau Ma Tei, 1968
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Manual night-soil collection could help reduce the amount of waste to be discharged into the sea, yet it was not considered an effective way to solve the sewage problem. Spill from the night-soil buckets would pollute roads and drains, give off horrible stenches, attract flies and affect the sanitary conditions. In addition, unsold night-soil would still have to be directly disposed of into the sea and likewise cause pollution.

Night-soil from urban households was collected by workers, transported by boat to the New Territories or the Mainland and sold as fertilizer.
Ms Wong Shau-ping, a Wan Chai resident, was born and grew up in Wan Chai. She recalled the living conditions in the 1960s when her nine-member family with parents and siblings lived together in a tenement building at Stone Nullah Lane. At that time, all 32 residents of the building had to share a room for cooking, bathing and placing night-soil buckets. They poured different types of domestic sewage into the only drain within the building. Water pollution and environmental hygiene were not their concerns.

Speaking of the hygienic conditions at that time, Ms Wong commented that the situation was fairly acceptable as the night-soil buckets were covered with wooden lids. However, at night when some residents used spittoons to hold the excrement, the bad odour would spread to the air. And the worst thing was probably the daily collection of night-soil in the small hours, during which the whole street would stink.

The Government actively explored for a more effective and hygienic sewage treatment method in the late 1950s. The first properly built sewage screening plant in Hong Kong came into operation at Anchor Street in Kowloon in 1956. Back then, the sewage treatment strategy comprised three steps: collection, treatment and disposal. The sewage was first collected through a sewerage system for screening to remove solids before being discharged through submarine outfalls into the deep Victoria Harbour, where the current could disperse the pollutants to reduce the coastal water pollution. Since then, the Government had built more sewage screening plants at both sides of Victoria Harbour and Hong Kong’s sewage treatment services entered into a new milestone.
Pollution from factories and livestock farms

After Hong Kong’s industrial take-off in the 1960s, the number of factories in urban districts increased tremendously, especially in San Po Kong, Cheung Sha Wan, and Kwun Tong, etc. At that time, the community was unaware of the pollution problem and had no concept of environmental protection. The then public’s knowledge of the consequences of directly discharging large amounts of industrial effluents into nearby drains or waters was superficial. In fact, the effluents containing toxic substances would have adverse impacts on human health and marine environment.

On the other hand, due to the agricultural transformation in the New Territories and population growth, many people were prompted to build squatters on farmlands and raise livestock for higher and steadier income. However, more often than not, they indiscriminately dumped or discharged the massive amounts of animal excrement and carcasses into neighbouring rivers, bringing about serious water pollution.
Challenges arising from flooding

As early as in the 19th century, Hong Kong had been suffering from flooding. Situated in the subtropical zone, Hong Kong always witnesses heavy rains with the daily rainfall level reaching as high as 500 mm. Rainstorms coming at high tides or during typhoons very often caused flooding which would bring about serious economic loss and casualties. Since the 1940s, the midstream and downstream areas near both sides of Victoria Harbour underwent urban development. The water storage and drainage capacity of the land became weakened after they were concrete-paved. On rainy days, the runoff from hills made those areas more prone to flooding. In addition, some coastal areas became inner streets after reclamation, implying that rainwater had to flow through the flat reclaimed land before they were discharged into the sea. The flooding problem became even worse under inclement weather, causing traffic paralysis and property loss. Rainstorms might also trigger landslides and incur casualties.

The daily rainfall on 12 June 1966 was 382.6 mm, the fourth highest among the records of the Hong Kong Observatory (HKO). Flooding at King’s Road (left) and the Hong Kong City Hall (right). Flooding in Happy Valley, 1926. The traffic was disrupted and pedestrians had to wade through flooded water.
Chapter One  Drainage Development over the Last Century

The 1966 Wan Chai Flooding

In 1966, serious flooding occurred at Stone Nullah Lane. Ms Wong Shau-ting recalled that during that time, she was at home with her mother and watching the downpour at the balcony. Suddenly, they heard a bang and were stunned to see the floodwater rushing down from the hill. In a split second, the retaining wall of the hill slope collapsed and a number of large manhole covers and cars were washed away at Stone Nullah Lane. The Wongs and their neighbours were worried that the wooden building they were staying in would collapse any time, and even worse they were deterred from escaping to downstairs by the fast-flowing floodwater. They had no choice but to use bed boards to climb to the opposite new building at King Sing Street for shelter. The reminiscence of the danger at that time still makes Ms Wong scared.

Rainstorms also caused flooding problem in the New Territories. The population of Hong Kong grew continuously in the 1950s and 1960s. Because of the limited land supply in urban districts on Hong Kong Island and in Kowloon, the Government planned to build new towns such as Kwun Tong, Tsuen Wan and other satellite towns, as well as to start developing the New Territories.

To provide housing and roads for the new towns, it was necessary to level the farmlands and fill the fish ponds. After concrete paving of the land, rainwater could no longer infiltrate into the soil. The significant increase in surface runoff aggravated the flooding problem. Flooding affected not only the daily lives of members of the public, but also the traditional ritual activities, such as the Jiao Festival, Ching Ming Festivals, and Chung Yeung Festival, etc.
The natural river courses in the northern New Territories tended to be narrow and meandering and therefore were susceptible to overflow. In the past, as farming and irrigation required broad and flat land with abundant water resources, most farming villagers in the New Territories settled along the river courses. As the areas concerned were easily flooded by overflow of the rivers, they were known as “floodplains”.

Extensive flooding in the vicinity of Shenzhen River and Ma Tso Lung, Sheung Shui in 1993 during Typhoon Dot's attack on Hong Kong

The Shenzhen River after the completion of stages I to III of the regulation works

Flooding in Kam Tin Village, the New Territories, 1982

Fig 29

Fig 30
Flooding in Ma Tin Tsuen at Shap Pat Heung of Yuen Long

Located next to Yuen Long Town, Ma Tin Tsuen has a history of more than 300 years. Mr Wong Tung-keung, a village representative, described that when he was a youngster, the village was a place with abundant water resources from the surrounding rivers. Water from the hill slowly flowed to Deep Bay through the drainage channel. This explained why many people were attracted to reside and farm there. Traditional ritual activities such as lantern-lighting, dragon dances and celebration of the birthday of Tin Hau ("Goddess of the Sea") are still held today in the village.

Between the 1950s and 1960s when the Government developed new towns, the ground level around Ma Tin Tsuen was raised and the latter became low-lying. Since then, flooding became frequent in Ma Tin Tsuen and the floodwater level was always at ankle-to-knee depth. Furniture was ruined by the rainwater and the environmental hygiene was affected by the overflow of septic tanks. In particular, coincided with a high tide, chest-high flooding was experienced during a heavy rainfall in 2000. The door-high flood floated up the cars in the car park.
Mr Liu Hing-hung, the representative of the indigenous inhabitants of Sheung Shui Heung, noted that in the past, flooding would not pose serious impacts on villagers’ lives, as the village office would send people to alert villagers of flooding by beating gongs and all celebrations would be suspended. Villagers would relocate their household wares to higher positions to reduce loss. For children growing up in the village, however, flooding could be fun. Mr Liu recalled that when he was small, kids used to play around during flooding, such as swimming in the floodwater or catching fishes washed away alive from fish ponds.

He also pointed out that besides persistent rainfall, the backflow of the Shenzhen River at high tide also caused flooding in Sheung Shui Heung. On one occasion, the flooding inundated the village office and damaged the documents and records stored therein, and seriously hampered the preparations for the Jiao Festival. Also, there was another occasion when the route of the autumn ancestral worship had to be changed due to flooding.
Chapter One  Drainage Development over the Last Century

**Territory-wide review on drainage facilities**

After decades of development, the Government realised that the sewerage and drainage systems constructed in the early years had become outdated and that long-term plans were required to solve the problems of water pollution and flooding. Between the 1970s and 1980s, the Government conducted a series of territory-wide studies on sewerage and drainage systems such as the report “Marine Investigation into Sewage Discharges” (by J.D. and D.M. Watson) and “Territorial Land Drainage and Flood Control Strategy Study – Phase I”. These studies facilitated the Government to better understand the operation of the sewerage and drainage systems at that time, and to plan new territory-wide flood prevention facilities and formulate a holistic sewage treatment strategy in future.

**Watson's report “Marine Investigation into Sewage Discharges”**

The report “Marine Investigation into Sewage Discharges” issued in 1971 was the blueprint for Hong Kong’s sewage treatment and disposal strategy. It evaluated the water quality of various water bodies such as Victoria Harbour and Tolo Harbour and recommended improvement works. The recommendations included upgrading of the sewage screening plants at both sides of Victoria Harbour, construction of more submarine outfalls, and building of higher level sewage treatment works at inner harbours (e.g. Tolo Harbour, Sham Wan, etc.) to meet the demand brought by population growth in new towns. The report also proposed the adoption of a set of water quality objectives to monitor water quality.

From the 1970s to 1980s, based on these recommendations, the Government provided additional screening facilities in sewage screening plants at both sides of Victoria Harbour to enhance the effluent quality. In addition, the Government was dedicated to studying new sewage treatment technologies, with the aim of establishing higher level sewage treatment works. In 1974, the first pilot secondary sewage treatment works came into operation in Shek Wu Hui, Sheung Shui. Drawing reference to this successful experience, the Government built another secondary sewage treatment works in Tai Po in 1979, marking a milestone in the development of sewage treatment technology in Hong Kong.

**Territorial Land Drainage and Flood Control Strategy Study — Phase I**

A comprehensive flood prevention strategy is essential for systematic handling of the flooding problem. In November 1988, the Government commenced Territorial Land Drainage and Flood Control Strategy Study – Phase I. The study findings recommended that new drains must reach the standard to withstand certain rainstorm peak flow. To prevent extensive flooding in urban areas, the flood protection standard for trunk drains should be of 200-year return period, whereas for the branch network with a relatively smaller catchment, the standard for branch drains should be of 50-year return period.

The study also proposed the adoption of a well-rounded flood prevention strategy in the New Territories. In designing the main rivers, rural drainage channels and village flood protection schemes, factors such as local needs as well as social and economic impacts of flooding should be taken into account to provide flood prevention facilities which fulfilled the specified flood protection standards.

The above mentioned strategy has been a general guideline listing the highest flood protection standards for new drainage facilities. The Government would definitely consider the unique features of different catchments and make appropriate adjustments to balance relevant factors such as urban development and feasibility of the works.
Establishment of DSD

In the late 1980s, the Government found it necessary to establish an independent department to review, plan and construct the territory-wide drainage and sewerage systems. Published by the Environmental Protection Department (EPD) in 1989, the White Paper: Pollution in Hong Kong – A Time to Act formally recommended the establishment of DSD designated for sewage treatment and stormwater drainage services.

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

The White Paper: Pollution in Hong Kong – A Time to Act was a vital environmental policy document which stressed the importance of environmental planning and proposed a series of environmental measures tailor-made for Hong Kong in the 1990s. It pointed out that the acute water pollution in Hong Kong was mainly caused by a lack of proper mechanism for sewage collection, treatment and disposal. In addition, many factories, restaurants and residences improperly discharged the sewage into drains, causing it to flow to the sea, typhoon shelters or catchments with the rainwater and hence the serious pollution.

The White Paper also pointed out that, although there were eight biological sewage treatment works (in Sha Tin, Tai Po, Yuen Long, Shek Wu Hui, Sai Kung, Sha Tau Kok, Hei Ling Chau and Mui Wo respectively), only 10% of the sewage in Hong Kong had undergone biological treatment and 40% undergone preliminary screening before being discharged through submarine outfalls, while the remaining 50% was directly discharged into inshore waters or inland rivers without any treatment, deteriorating water quality and leading to the closure of some beaches. Furthermore, sewage was rich in nutrients which could easily induce red tides and suffocation of numerous aquatic species, gravely affecting the marine ecology and aquaculture industry.  

In view of such pollution, the White Paper put forward the following policy objectives:

- To maintain the quality of inshore waters for legitimate purposes such as water sports activities, habitats for marine life, food sources, commercial fishing and navigation;
- To provide adequate public sewerage system to manage the current and foreseeable sewage discharges;
- To treat and dispose of the sewage collected from public sewerage system to ensure that the water quality standard was met; and
- To promote and implement relevant measures to safeguard the health and welfare of the community from the adverse environmental effects associated with the discharge of toxic chemicals and bacteria.
For effective implementation of the above mentioned policy objectives, the Government established DSD on 1 September 1989 to work together with EPD to tackle water pollution in Hong Kong. EPD was mainly responsible for planning sewage collection, treatment and disposal facilities for the territory, monitoring water quality and taking legal actions against polluters, whereas DSD was in charge of building, operating and managing sewerage systems and treatment facilities.

DSD was formed by combining the Drainage Works Division of the Civil Engineering Services Department (CESD) and several divisions of the Electrical and Mechanical Services Department (EMSD). Apart from providing sewage treatment services, DSD undertook the planning, building, operation and maintenance of drainage systems and facilities with a view to reducing the flood risk in Hong Kong and safeguarding the life and property of the public.

### Evolution of the drainage services

<table>
<thead>
<tr>
<th>Year</th>
<th>Development</th>
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<tbody>
<tr>
<td>1843</td>
<td>Surveyor General’s Office overseeing the drainage works</td>
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<tr>
<td>1891</td>
<td>Establishment of Water and Drainage Sub-Department, Public Works Department</td>
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<tr>
<td>1924</td>
<td>Establishment of Drainage Office, Public Works Department</td>
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<tr>
<td>1964</td>
<td>Establishment of Roads and Drainage Offices (Hong Kong, Kowloon and New Territories), Public Works Department</td>
</tr>
<tr>
<td>1969</td>
<td>Establishment of Drainage Works Division, Civil Engineering Office, Public Works Department</td>
</tr>
<tr>
<td>1973</td>
<td>Establishment of Environmental Branch, Colonial Secretariat</td>
</tr>
<tr>
<td>1986</td>
<td>Establishment of the Drainage (Design) Division, Drainage (Construction) Division, Urban Drainage Division and New Territories Drainage Division, Civil Engineering Office, Civil Engineering Services Department</td>
</tr>
<tr>
<td>1989</td>
<td>Establishment of the Drainage Services Department</td>
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Chapter One Drainage Development over the Last Century

Interview with the first Director of Drainage Services

In his 1988 Policy Address, the then Governor of Hong Kong, Lord David Wilson, proposed the establishment of DSD to share the tasks concerning sewerage and drainage systems with CESD and EMSD. Upon its establishment in September 1989, DSD introduced a 10-year environmental improvement programme consisting of 45 projects, and a flood protection scheme specifically for old areas in the northwestern New Territories. The first Director of Drainage Services, Ir C. R. Saunders, opined that the lack of holistic drainage and sewerage systems in Hong Kong caused the water quality of the watercourses, inshore waters and beaches to decline. The increasing load on the sewerage system also led to flooding. Hence, the Government earmarked HK$13 billion for flood prevention and water pollution control. In the first place, it combated the flooding problems in the northwestern part of the New Territories, e.g. Sheung Shui, Fanling, etc. At a later stage, it improved the similar problems in Kowloon and other parts of the New Territories, particularly the drainage systems of Kwun Tong and Kwai Chung.

Ir Saunders added that sewers and drains would be extended through engineering works to prevent the sewage from entering reservoirs and threatening public health, and that the public and industry would be educated to use the sewage treatment system. As these measures would take some time to achieve results, Ir Saunders hoped that the community at large would collaborate with DSD to protect the environment.
Vision, Mission and Values of DSD

Vision
- To provide world-class wastewater and stormwater drainage services enabling the sustainable development of Hong Kong

Mission
- Improving drainage services in a cost-effective and environmentally responsible manner
- Enhancing a caring, harmonious, safe and healthy work environment that fosters staff development and a mindset for change
- Strengthening relationships with community, industry and worldwide counterparts

Values
- Customer Satisfaction
- Quality
- Commitment
- Teamwork
Conclusion

The drainage system of Hong Kong, evolving from a combined drainage and sewerage system to the existing separate system, has been developing in the last 30 years to meet the social development needs and provide better living environment for the public. There have been numerous sewerage and drainage projects, and DSD has been closely cooperating with various departments including the Highways Department (HyD), the Civil Engineering and Development Department (CEDD), the Water Supplies Department (WSD), EPD, EMSD, HKO, the Lands Department (LandsD), the Planning Department (PlanD), the Home Affairs Department (HAD), the Food and Environmental Hygiene Department (FEHD) and the Agriculture, Fisheries and Conservation Department (AFCD). To cope with the climate change, DSD has also collaborated with several universities to study and enhance new schemes for stormwater drainage and sewage treatment, with a view to bracing Hong Kong for the challenges ahead.

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2. Same as Footnote 1.
6. “Population, according to Census of 3rd April, 1881,” Hong Kong Blue Book, 1881.
9. Mr. Chadwick’s Reports on the Sanitary Condition of Hong Kong with Appendices and Plans, 1882.
11. Same as Footnote 4.
15. 油尖旺區議會：〈油尖旺區風物志〉，香港：1999年，頁18。「芒角咀」又名「望角咀」，後改稱「旺角」。
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18. 《衛生局將討論改善清糞辦法》載《大公報》，1940年9月16日。
21. Environmental Protection Department, White Paper: Pollution in Hong Kong – A Time To Act, Hong Kong: Environmental Protection Department, 1989.
22. 《渠務署成立展所長》載《華僑日報》，1989年7月8日。

Fig. 1, 4–6, 11–12, 15–16, 19, 31 were provided by courtesy of the Hong Kong Museum of History.
Fig. 2, 8–10, 13, 17, 20 were provided by courtesy of the Public Records Office under the Government Records Service.
Fig. 3, 7, 14, 18, 21–28, 30, 33 were provided by courtesy of the Information Services Department.
Fig. 29 was provided by courtesy of the Lands Department (G8/2014).
Fig. 32 was provided by courtesy of the South China Research Center, the Hong Kong University of Science and Technology.
Chapter Two  Sewage Services and Harbour Area Treatment
Hong Kong is in possession of a long coastline. The ocean has the natural self-purification capability to dilute and decompose pollutants in waters. However, to treat large amounts of sewage generated due to rapid population growth and industrial development, we need appropriate water quality control measures. The Government completed the Report on Marine Investigation into Sewage Discharges in the late 1960s and implemented the Water Pollution Control Ordinance and the Waste Disposal Ordinance. The Sewage Strategy Study was also conducted between 1988 and 1989 to establish a long term strategy for collection, treatment and disposal of wastewater for the territory. They included, inter alia, the formulation of the Strategic Sewage Disposal Scheme, construction of regional sewage collection facilities (such as the Village Sewerage Programme), setting of different sewage treatment levels, extension of sewage disposal systems (such as the Tolo Harbour Effluent Export Scheme) and the enforcement of odour management measures. Successive implementation of these projects helped continuously improve the water quality of our rivers and beaches. Moreover, with the commissioning of Stage 1 of the Strategic Sewage Disposal Scheme (now renamed as the Harbour Area Treatment Scheme) in late 2001, the water quality of Victoria Harbour improved substantially.
Chapter Two  Sewage Services and Harbour Area Treatment

Water quality and functions of water bodies in Hong Kong

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

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

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

The Water Pollution Control Ordinance

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

The Waste Disposal Ordinance

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

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

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

**Functions of water bodies**

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

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

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

Sewage collection

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

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

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

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

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

Village Sewerage Programme

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

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

Septic tank system

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

Operating principle of septic tanks

When sewage enters the septic tank, solid waste sinks to the bottom while grease and other lighter material float to the top and form a layer of scum. The remaining liquid further flows to the soakaway pit, and disperses into surrounding sand and soil which filter and decompose the pollutants.
In response to the need of village sewerage, DSD launched the Village Sewerage Programme to extend the public sewerage network to the vicinity of private land with village houses in order to facilitate connection between private and public sewers. The works resulted in remarkable improvement of the water quality of surrounding watercourses and betterment of the living environment for the villagers.
Mr Wong Tung-keung, village representative of Ma Tin Tsuen in Shap Pat Heung Yuen Long, New Territories, stated that underground septic tanks were usually installed in the front together with the construction of the houses. At times, however, the sewage seeped out and caused odour. Mr Wong believed that sewer connection to the public sewerage system would be the solution to the problem. Yet, since sewer laying works have to be carried out at the narrow and busy alleys in Ma Tin Tsuen which caused inconvenience to the villagers and affected their normal living. Coupled with the situation that not all households were willing to pay for connecting the private sewers to the public sewerage, the progress of sewer connection was slow.

Mr Wong also pointed out that with excessive sewage remaining in the soil, saturation would eventually occur and give rise to hygienic problems. In his view, the Village Sewerage Programme must be carried out for the long-term interests of Ma Tin Tsuen. Despite the controversy aroused during the programme promotion, Mr Wong still encouraged the villagers to support the programme with a view to enhancing the living environment of the village.
The demand for sewage treatment services grows correspondingly with continuous new town developments. Expansion of the public sewerage network is the future direction for sustainable development. As of March 2014, DSD has completed village sewerage projects for approximately 160 villages to connect private sewers with the public sewerage. At present, the sewerage works in about 90 villages are ongoing, while those for some 240 villages are under planning and design.

Experience sharing on constructing village sewers

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

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

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

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

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

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

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

Dry weather flow interceptors

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

Interception facilities at the Kowloon Bay stormwater box culvert

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

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

The Cherry Street stormwater box culvert collects rainwater primarily from Western Kowloon and upper reaches amounting to a catchment area of about 5.3 km² for discharge into New Yau Ma Tei Typhoon Shelter. The box culvert has always been conveying polluted water which has been either illegally or improperly connected to the box culvert. This has affected the water quality in New Yau Ma Tei Typhoon Shelter and created odour nuisance as well as hygiene problems.

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

Maintenance of sewage collection facilities

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

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

Sewage treatment is one of the major services of DSD. With the use of different sewage treatment procedures and advanced technologies, most pollutants, toxic substances and bacteria in the sewage are removed to ensure that the effluent quality meets the environmental protection standards. Currently, DSD has 293 sewage treatment facilities (including 68 sewage treatment works and 225 sewage pumping stations) to treat the sewage (with an average daily volume of about 2.8 million m³) collected through the sewerage network.

Sewage treatment facilities and levels

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

The collected sewage is conveyed to sewage treatment works for treatment. In 2013–2014, DSD handled in total about 1 billion m³ of sewage, of which 29.7% underwent preliminary treatment, 53.4% primary or chemically enhanced primary treatment, 16.8% secondary treatment and the remaining 0.1% tertiary treatment.

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

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

Principles of UV disinfection

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

Sludge treatment

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

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

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

The process of sludge dewatering

Dewatering centrifuge  Screw conveyor of the dewatering centrifuge  Dewatered sludge cake
Improvement works for sewage treatment facilities

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

Expansion of Shek Wu Hui Sewage Treatment Works

The existing Shek Wu Hui Sewage Treatment Works (SWHSTW) has been put into operation since 1984 to provide secondary sewage treatment services for Sheung Shui, Fanling and nearby areas. In the coming years, the volume of sewage to be treated by SWHSTW will exceed its design capacity of 93,000 m³ per day. To provide quality sewage treatment services for Sheung Shui, Fanling and new development areas, DSD is planning to progressively raise the sewage treatment capacity of SWHSTW in phases and upgrade its treatment level from secondary to tertiary. In December 2012, DSD commenced an investigation study for the further expansion of SWHSTW, which included the sewage and sludge treatment process design, various impact assessments, site investigations, preliminary project design, landscape and greening plans, implementation strategies and programme, as well as public engagement activities for public consultation.
New sewage treatment facilities on Lamma Island

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

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

Submerged Membrane biological reactor

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

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

Maintenance of sewage treatment facilities

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

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

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

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

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

Sewage Services Charging Scheme

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

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

The Sewage Services Charging Scheme comprises two charges, namely:

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

Discharge of treated effluent

Discharge plan

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

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

3D Environmental Impact Assessment System of the Project WATERMAN

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

Effluent assessment system

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

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

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

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

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

Professional laboratory services: sewage and effluent testing

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

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

Professional laboratory services

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

<table>
<thead>
<tr>
<th>20 kinds of accredited tests</th>
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<tbody>
<tr>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand</td>
</tr>
<tr>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>Ammonia Nitrogen</td>
</tr>
<tr>
<td>Nitrite Nitrogen</td>
</tr>
<tr>
<td>Nitrate and Nitrite Nitrogen</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen</td>
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<tr>
<td>Non-ionic Surfactants</td>
</tr>
<tr>
<td>Chloride</td>
</tr>
<tr>
<td>Sulphate</td>
</tr>
</tbody>
</table>
Odour management

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

Seawater flushing and sewage odour

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

Today, over 80% of local population is supplied with seawater for flushing. In 2013, the average daily volume of seawater used for flushing was over 760 000 m³, equivalent to the total capacity of 300 standard swimming pools.

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

- Adequate dosing of chemicals (such as calcium nitrate, ferric chloride and other deodorants) and oxygenation of sewage to reduce the odour generated under septic conditions;
- Covering potential odourous facilities (such as drains and sewage tanks) to prevent the spread of odour; and
- Installing deodorisation systems such as activated carbon systems, chemical scrubbers and biofilters at appropriate locations for odour reduction to an acceptable level before discharge. At present, our practice is to install one or a combination of different odour removal devices at pumping stations and sewage treatment works according to the odour level and type.
To properly implement odour mitigation measures, staff must be trained to master the technology for odour test. Currently, Hong Kong, like many other countries, uses analysers to measure hydrogen sulphide levels as a proxy for overall odour levels. In abnormal situations, staff are swiftly assigned to adjust the operation mode, such as by adding chemicals, increasing or changing deodorising materials in the odour removal unit, and if needed, implementing other necessary improvement.

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

Effectiveness of sewage purification

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

Improving water quality of watercourses

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

Improving beach water quality

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

World’s ten best city beaches: Stanley Main Beach

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

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

A novel system for water quality monitoring

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

Water quality improvement of beaches in Tsuen Wan

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

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

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

Harbour Area Treatment Scheme (HATS)

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

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

HATS Stage 1 was completed in December 2001, comprising a 23.6 km-long system of deep underground tunnels, for conveyance of sewage from Kowloon, Tsing Yi, Kwai Chung, Tseung Kwan O and the Northeastern part of Hong Kong Island to Stonecutters Island Sewage Treatment Works. Since their commissioning in December 2001, the Stage 1 facilities have been collecting 75% of the sewage generated from both sides of Victoria Harbour, with current daily volume reaching 1 400 000 m³. The sewage is then conveyed to Stonecutters Island Sewage Treatment Works for chemically enhanced primary treatment. This has effectively intercepted about 600 tonnes of sludge from entering the Harbour each day and thus greatly improved the water quality of the central and eastern Harbour.
To effectively maintain the water quality of Victoria Harbour to a high level, the Government consulted the public on HATS Stage 2 in 2004. The findings suggested that the majority of the public valued the cleaning up of Victoria Harbour and supported the implementation of HATS Stage 2A and 2B in phases. DSD is carrying out the construction works for HATS Stage 2A and reviewing Stage 2B.

**Double-decked design to optimise the space**

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

**Alignment of the sewage conveyance system of HATS Stage 2A**
Chapter Two  Sewage Services and Harbour Area Treatment

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

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

Construction of deep sewage conveyance tunnels

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

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

Expansion works in Stonecutters Island Sewage Treatment Works
(The figure shows the new main pumping station under construction)
Not just a man’s job: the first female Blasting Competent Supervisor working inside the deepest sewage tunnel in Hong Kong

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

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

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

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

Improving the water quality of Victoria Harbour

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

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

Changes in cross harbour swimming race

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

Sharing from a race participant in the early days

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

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

The revival of the cross harbour swimming race

The Honorary Secretary of the Hong Kong Amateur Swimming Association, Mr. Wong Man-chiu, J.P., explained that the Association had hoped for years for the revival of the cross harbour swimming race for the public. Yet, their request was turned down by EPD as the harbour water quality was not up to standard. It was only after the implementation of HATS by DSD, the water quality has improved. In 2009, experts engaged by the Association confirmed that the water quality in certain sections of the Harbour was suitable for swimming. Following this confirmation, the Association recommended to the Government the revival of the race. With the support from a number of departments, including the Home Affairs Bureau, LCSD, and Marine Department, as well as the approval from EPD, the cross harbour swimming race was revived on 16 October 2011 after a suspension of 33 years. In fact, a trial race was held in 2010, attracting over 1 000 participants. The route started at Tsim Sha Tsui Promenade and ended at the Yacht Club in Causeway Bay. In 2013, more than 3 500 swimmers took part in the race. The increase in the number of participants suggests that public confidence in the water quality of Victoria Harbour has been growing.
The third New World Harbour Race since its revival took place on 6 October 2013. The route crossed the eastern Victoria Harbour, which was different from the route in the 1970s (from Tsim Sha Tsui to the already demolished Queen’s Statue Wharf in Central). We envisage a cleaner Harbour upon completion of HATS Stage 2A. By then, swimming along the previous route will be just round the corner.

Sharing from participants of the cross harbour swimming race in 2013

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

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

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

2 Environmental Protection Department. A Guide to the Water Pollution Control Ordinance. Website: http://www.epd.gov.hk/epd/english/environmentinhk/water/guide_ref/guide_wpc_wpc0_1.html Accessed date: 12 September 2013
6 The University of Hong Kong. Project WATERMAN. Website: http://www.waterman.hku.hk/about.aspx Accessed date: 5 November 2013.
11 〈閩別31年海水含菌量劇減99%，維港已淨化渡海泳復辦〉載《蘋果日報》, 2010年9月4日。
Chapter Three Flood Prevention – Stormwater Interception, Storage and Conveyance
Attributable to its geographical location, climate change, urban development and other factors, Hong Kong has experienced occasional river overflow, seawater backflow and flooding. To protect public safety and minimise economic loss, DSD, by adopting three main concepts, namely stormwater interception, stormwater storage and improvement to stormwater conveyance, conducts flood prevention planning, designs drainage works for different districts and regularly reviews the effectiveness of these works to reduce flooding hazard. In addition, DSD has implemented contingency measures against flooding, including the setting up of a 24-hour Drainage Hotline and Emergency Control Centre, in order to minimise the impacts of flooding. With sustained efforts, DSD has largely reduced both the flooding menace to the public and the number of flooding blackspots.
Environmental factors and flooding

Hong Kong’s geographical location, climate change and urban development all lead, directly or indirectly, to flooding. One of the main tasks of DSD is to identify the causes of flooding for planning and carrying out flood prevention works to reduce the flood risk and prevent casualties and property loss brought by flooding.

With Shenzhen to its north and the South China Sea to its south, Hong Kong is situated in a subtropical maritime monsoon region. Its average annual rainfall is one of the highest among the cities in the Pacific Rim.

Unlike the Northwestern New Territories which is mostly flatland, other areas in Hong Kong are mountainous. Affected by the monsoon and maritime climate, Hong Kong is subject to intense and localised rainfall in summer. In the past, abruptly-increased stormwater runoff rushing down from hills caused not only flooding in low-lying areas but also river overflow. Flood plains in the Northern New Territories were in particular often flooded. Owing to the exacerbated global climate change, storm surges and rainstorms have become more frequent in Hong Kong. Furthermore, rapid urbanisation has further reduced the land drainage capacity following slopes and farmlands being cement-paved to erect high rises. This has resulted in occasional river overflow, seawater backflow and flooding. Thus, one of the prime tasks of DSD is to mitigate the flooding hazard to Hong Kong.
Chapter Three Flood Prevention – Stormwater Interception, Storage and Conveyance

Flood control planning

Territorial Land Drainage and Flood Control Strategy Study

In the late 1980s, the Government became aware of the need to develop a comprehensive flood control strategy for the territory. The Territorial Land Drainage and Flood Control Strategy Study — Phase I, commenced in November 1988, recommended the implementation of a comprehensive flood control strategy for the New Territories and formulation of feasible proposals on flood prevention infrastructure to tie in with new town developments. In 1990, the Government completed the Study and, based on its findings, devised a set of flood protection standards for planning and designing drainage systems, and stipulated that all future designs of flood prevention facilities should comply with these standards.

Flood protection standards

The flood protection standards are crucial indicators in flood control strategy and serve as the benchmark for the planning and design of public stormwater drainage systems. These standards were established with consideration of factors like past annual rainfall records, land use, economic growth, socio-economic needs, consequences of flooding and cost-effectiveness of flood mitigation measures. Hence, different drainage systems would have their own standards. The standards currently adopted in Hong Kong, which are comparable with those in developed countries overseas, are shown in the following table:

<table>
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<tr>
<th>Drainage system type</th>
<th>Return period of flooding that the systems can cater for (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban drainage trunk systems</td>
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</tr>
<tr>
<td>Urban drainage branch systems</td>
<td>50</td>
</tr>
<tr>
<td>Main rural catchment drainage channels</td>
<td>50</td>
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<tr>
<td>Village drainage</td>
<td>10</td>
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<tr>
<td>Intensively used agricultural land</td>
<td>2-5</td>
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</tbody>
</table>

Note: A flooding incident is defined mainly based on the extreme rainfall intensity with a certain rise in sea level (tidal backwater). Return period is the average time (expressed in years) expected to elapse between occurrences of the same incident.

To monitor and manage the flood-prone areas (including five catchments in the Northern New Territories, namely San Tin, Indus (Ng Tung River), Ganges (Ping Yuen River), Tin Shui Wai, and Yuen Long/Kam Tin/ Ngau Tam Mei), DSD commenced in 1991 the Territorial Land Drainage and Flood Control Strategy Study — Phase II. Also, between 1991 and 1995, the Government enacted the Town Planning Ordinance and the Land Drainage Ordinance for the New Territories and conducted drainage impact assessments. DSD was authorised to carry out drainage repair works on private land in the New Territories and advise on relevant drainage projects to lower the risk of river overflow.

In 1995, DSD implemented the Territorial Land Drainage and Flood Control Strategy Study — Phase III, reviewing the cost-effectiveness and environmental impacts of the drainage projects and their maintenance. The purpose of the review was to carry out effective flood prevention works with due regard to the sedimentation and ecological balance of natural rivers at the same time.
Drainage Master Plans and Review Studies

Between 1994 and 2010, DSD implemented the Drainage Master Plans (DMPs) for the territory. Dividing Hong Kong Island, Kowloon, the New Territories and Outlying Islands into eight regions, short-term and long-term drainage improvement measures were recommended for respective regional drainage systems. In implementing these DMPs, various computer simulation techniques were used to help select the most cost-effective flood prevention proposals and enhance the accuracy of drainage project designs.

DMPs served to:
- Check and identify deficiencies of the existing drainage system and associated facilities within the study area;
- Recommend and formulate short-term and long-term improvement measures to meet the current standards and future demand, and evaluate their feasibility and impacts on traffic and the surrounding environment;
- Confirm the proposed locations of flow-meter and rain-gauge stations to collect data for assessing the effectiveness of flood mitigation measures, and;
- Establish an additional computerised database of drainage systems for full scale monitoring.
DSD has successively embarked on various DMP Review Studies since 2008. The Studies aimed to review the DMPs and assess the capacity of existing drainage systems, with a view to formulating improvement measures to cope with the latest land development plans, and improving hydraulic models to accommodate climate change. The Review Studies for Yuen Long and North District of the New Territories and Happy Valley were completed in 2011, while those for Eastern Kowloon and Western Kowloon commenced in January 2012, those for Shatin, Sai Kung and Tai Po commenced in February 2013 and those for Northern Hong Kong Island commenced in May 2014. The Review Studies for other areas will also be conducted successively in the coming years.

### Progress of DMP Review Studies

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<th>Study Areas</th>
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<th>COMPT. DATE</th>
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<td>4/08</td>
<td>12/11</td>
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<td>3. Happy Valley</td>
<td>7/10</td>
<td>10/11</td>
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<td>4. West Kowloon</td>
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<td>6/15</td>
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<tr>
<td>7. Shatin &amp; Sai Kung</td>
<td>2/13</td>
<td>6/15</td>
<td></td>
</tr>
<tr>
<td>8. Northern Hong Kong Island</td>
<td>5/14</td>
<td>12/16</td>
<td></td>
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<tr>
<td>9. Lantau Island &amp; Islands</td>
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<td></td>
<td>Proposed</td>
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<td>10. Tsuen Wan, Tuen Mun &amp; Tsing Yi</td>
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<tr>
<td>11. Tseung Kwan O</td>
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<td>12. Southern Hong Kong Island</td>
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</tbody>
</table>
The concept of comprehensive flood prevention

DSD has adopted a comprehensive and multi-pronged approach in considering, planning and designing flood prevention projects to cater for both imminent and long-term technical needs. A set of procedures for implementation of flood prevention projects and regulatory measures on land drainage have been formulated.

<table>
<thead>
<tr>
<th>Project implementation procedures</th>
<th>Regulatory measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set the flood protection standards commensurate with the actual circumstance of Hong Kong with reference to major overseas cities</td>
<td>Enforce the Land Drainage Ordinance to protect major watercourses</td>
</tr>
<tr>
<td>Conduct comprehensive studies to ensure the feasibility of new drainage works and improvements works</td>
<td></td>
</tr>
<tr>
<td>Implement the approved new drainage works and improvement works to enhance the drainage capacity to meet the flood protection standards wherever practicable</td>
<td>Invoke the Town Planning Ordinance, Buildings Ordinance and the terms of land leases to carry out drainage impact assessments of new development projects</td>
</tr>
<tr>
<td>Carry out comprehensive preventive maintenance to ensure proper functioning of the stormwater drainage system</td>
<td></td>
</tr>
</tbody>
</table>

The findings of DMP Studies indicated that flooding in urban areas and the New Territories were of similar causes. The normal causes are overloading of existing aging drainage systems by a sharp increase in surface runoff due to urbanisation, inefficient stormwater drainage due to blockages of drainage inlets by rubbish, some areas being situated in flood plains or low-lying areas. According to the established practice, the concepts adopted in flood prevention works can broadly be classified into three types, namely stormwater interception, stormwater storage and drainage channel or pipe improvement. Specific projects for implementation include construction of drainage tunnels at mid-hill levels to intercept the runoff from the upstream and midstream, building of stormwater storage tanks in low-lying areas to temporarily retain part of the stormwater, and river training works for existing watercourses or construction of drainage conduits to enhance the drainage and flood prevention capacity. When putting these concepts into practice, we would take into consideration the specific circumstances of individual areas, and coupled with appropriate minor drainage improvement works and interim measures, devise appropriate measures to enhance their overall flood prevention performance. In recent years, DSD has more often adopted the two approaches of stormwater interception and stormwater storage to alleviate flood risk in urban areas. The advantages are that they help minimize disturbance to the environment, traffic and the public, as well as optimise land use. The completed projects included the construction of four drainage tunnels in Kai Tak, Western Hong Kong Island, Lai Chi Kok and Tsuen Wan, and two underground stormwater storage tanks in Sheung Wan and Tai Hang Tung. In addition, the underground stormwater storage tank in Happy Valley is being constructed for completion and commissioning in phases between 2015 and 2018.
Interview with hydraulics expert: Professor Lee Hun-wei, Joseph — Vice President of the Hong Kong University of Science and Technology

Professor Lee Hun-wei, Joseph, Vice President of the Hong Kong University of Science and Technology, is an internationally-renowned hydraulics expert specialising in environmental hydraulics, hydrodynamics and water quality modelling. The theory of buoyant jets developed by him and his team (formed with elite researchers from all over the world) has been applied to numerous urban environmental projects and preventive measures against virus transmission.

Since the 1980s, Hong Kong’s mariculture has been plagued by red tides (or algal blooms) caused by water pollution that led to massive reproduction of algae. In 1998, huge quantities of fish in mariculture areas within Hong Kong’s waters died because of red tide. To find out the causes, Professor Lee worked on a mariculture raft, for 24 consecutive hours on some occasions, to observe and examine the dynamic changes in water quality. He realised in the process that besides relying on theory, engineers should also pay attention to the factor of natural environment. Only through fieldwork, data collection and repeated research and experiments that we could prove the feasibility of a theory and then figure out the most effective solution.

Professor Lee believes that Hong Kong’s unique geographical environment is like a complex natural laboratory which provides ample research materials for engineering scholars. He stresses that engineering is a subject that involves application and experiments. For large-scale flood prevention projects in Hong Kong, each requires meticulous calculation and consideration, including feasibility study, design and construction, which normally will take years to complete. Factors such as actual site conditions, construction time and project costs, etc. have to be taken into account in the process. For engineers, design and construction are only part of this lengthy process. After completion of the projects, their effectiveness upon commissioning still need to be monitored with a view to planning and designing improvement works. For example, after the commissioning of the stormwater storage tank in Tai Hang Tung, to eradicate the flooding problems in Mong Kok area, Professor Lee and his team adjusted the height of the weir (i.e. the tank inlet) after sustained monitoring of the rainfall data during wet seasons and with the aid of relevant theories and computer simulation.
Drainage works

In recent years, adopting the three concepts of stormwater interception, stormwater storage and improvement to stormwater conveyance, DSD has implemented a number of drainage works of varying scales to tackle the flooding problems in Hong Kong.

Stormwater interception

In urban areas, highly compact buildings do not allow us enough space for large-scale excavations for drainage improvement works. In view of this, stormwater interception is a key flood prevention strategy to mitigate flooding problems. It is necessary to intercept and divert part of the stormwater from upstream urban areas for discharge into the sea or transfer to other catchments. By reducing the stormwater flow into the urban drainage system, the flood protection level of the area will be raised.

To date, under the concept of stormwater interception, DSD has built four drainage tunnels in urban areas, namely the Hong Kong West Drainage Tunnel, the Lai Chi Kok Drainage Tunnel, the Tsuen Wan Drainage Tunnel and the Kai Tak Transfer Scheme. In view of the rapid urbanisation in Yuen Long over recent years, DSD constructed a bypass floodway under the same concept to intercept part of the stormwater at the upstream which would otherwise flow to the Yuen Long town centre, thereby lessening the flooding hazard to the area.
Drainage tunnels

Save for the Kai Tak transfer tunnel, the other three drainage tunnels are all built at mid-hill levels to intercept the stormwater from uplands and reduce the impacts of stormwater on downstream urban areas. As the stormwater will bypass urban areas via the catchwater system for discharge into the sea by gravity, energy consumption for pumping or transferring the stormwater is not required during the whole process. Also, the construction of drainage tunnels took place deep underground, obviating large-scale excavation works in busy areas and greatly alleviating their impacts on the traffic, residents and business activities.

Diagram of stormwater interception at mid-hill levels

The design concept of the three drainage tunnels was to minimise disturbance to private property. Because of this, government land, roads, the land under flyovers and the like were the most preferred sites for tunnel alignments and water intakes. As the construction environments of different drainage tunnel sections varied, the challenges of the respective works were diverse, and so were the solutions. At present, urban drainage tunnels can withstand rainstorms with a return period of 200 years.
Hong Kong West Drainage Tunnel

The Hong Kong West Drainage Tunnel is the longest drainage tunnel in Hong Kong, running from Tai Hang to Cyberport, its main tunnel is 10.5 km in total length. A section of the main tunnel is 7.25 m in diameter, making it Hong Kong’s largest drainage tunnel. The tunnelling works were carried out with the largest hard rock tunnel boring machine ever used in Hong Kong at that time.

A formidable challenge was that the main tunnel had to go through several loosely structured fault zones. Given that these fault zones were subject to groundwater infiltration which might cause tunnel collapse, affecting as a result the tunnel’s structural integrity or even leading to ground subsidence, it was necessary for the project team to closely monitor the geological and groundwater conditions during construction. To stabilise the fault zones and prevent damage by groundwater, grouting works were carried out in advance to fill the cracks between rocks when necessary.

Also, densely developed domestic premises at Mid-levels rendered the sites for the drainage tunnel and intakes inevitably close to residential areas. To collect the upland stormwater effectively, 34 intakes, the highest number for any drainage tunnel in Hong Kong, were built at Mid-levels, scattered in Causeway Bay, Wan Chai, Admiralty, Sai Ying Pun and Pok Fu Lam. In implementing the works while alleviating disturbance to residents along the tunnel alignment, DSD used the raise boring method, i.e. “bottom-up” construction in lieu of the conventional top-down excavation approach. Excavated gravel was carried away through the tunnel. This method succeeded in not only avoiding disruption to traffic near the shafts, but also reducing noise and dust during the construction.
Raise boring method

The raise boring machine first drills down to the connection adit. After its drill is replaced with a larger reamer, it bores upwards back to the ground surface. All excavated gravel will fall to the bottom of the shaft for subsequent removal through the main tunnel.

To complete the project as early as possible, DSD specially designed a set of detailed logistic and construction procedures to allow the excavation works for the main tunnel and blasting operations for the connection adit to be performed simultaneously. Such arrangement significantly shortened the construction period.
Lai Chi Kok Drainage Tunnel

The main tunnel of the Lai Chi Kok Drainage Tunnel had to bypass four operating railways, the proposed Guangzhou-Shenzhen-Hong Kong Express Rail Link, and the piles of above-ground structures. The minimum clearance between the main tunnel and the Express Rail Link tunnels is only 1.8 m. Given the scale of this project, both the design and construction of the drainage tunnel required very meticulous planning.

The coastal area of Lai Chi Kok is reclaimed land. Upon detailed investigation and study, the project team decided to construct the main tunnel at the soil layer 45 m below ground, the minimum depth for the tunnel to bypass existing piles and railways. This led to another challenge to the tunnelling works, in that 2.5 km long uphill branch tunnel and the 1.2 km long main tunnel within the reclaimed land would then have to pass through two entirely different geological layers respectively, i.e. hard granite layer and loose soil layer.
Normally, two different tunnel boring machines are required for excavation works at soil and rock layers. However, the project team used a special “mixshield slurry type” tunnel boring machine, the first of its kind in Hong Kong, to bore through hard rock and soil layer (under high pressure). This proposal of “one machine two usages” saved not only the cost of an extra tunnel boring machine, but also 650 tonnes of steel materials as well as the energy required for manufacturing a tunnel boring machine. It was indeed a green construction design.

The Lai Chi Kok Drainage Tunnel is the only drainage tunnel in Hong Kong built using the hyperbaric technology. During construction of the main tunnel, we need to prevent the loss of groundwater and soil so as to reduce the impacts on surrounding foundations and underground facilities. To achieve this, the works were designed to pressurise the front face of the tunnel boring machine, with some location under 4.2 times atmospheric pressure. Since tunnel workers were required to work under hyperbaric environment for, inter alia, replacement and maintenance of cutter heads of the tunnel boring machine, safety measures had to be seamless.

**Experience sharing on pressure regulation**

Improper decompression after working under hyperbaric environment may cause decompression sickness. During construction of the Lai Chi Kok Drainage Tunnel, for construction safety, the project team specially engaged experienced medical experts from overseas to help establish comprehensive working procedures to closely monitor the works and staff health. In the end, the project team overcame the challenges of the hyperbaric working environment and attained the highest safety standard of “zero decompression sickness”.

![The “mixshield slurry type” tunnel boring machine](image)

![Decompression procedures](image)
As the main tunnel was built 45 m underground, the “inverted siphon” design was adopted to allow stormwater to flow into the sea through the U-shaped channel. In addition, to prevent blockage by sedimentation of soil and grit in the U-shaped main tunnel, a stilling basin was provided between the main and branch tunnels to slow down the stormwater flow for sedimentation of soil and grit in water. This design also facilitates future maintenance.

Occupying an area of about 7 000 m², the stilling basin was built under the viaduct of Tsing Sha Highway which had originally been designated for tunnel maintenance. To fully utilise land resources, DSD took the initiative to recommend the Leisure and Cultural Services Department to open the site for public use. Subsequent consultation indicated that local residents in Sham Shui Po had longed for a sizable pet garden. Therefore, DSD turned the deck of the stilling basin into a large pet garden, enabling it to serve the multiple purposes of flood prevention, transportation, recreation, etc. Moreover, making the best use of water resources, DSD introduced the rainwater harvesting system to filter part of the stormwater collected by the stilling basin for toilet flushing, irrigation for the pet garden and street cleansing by the Food and Environmental Hygiene Department.
Tsuen Wan Drainage Tunnel

The Tsuen Wan Drainage Tunnel, 5.1 km in total length and 6.5 m in diameter, intercepts, conveys and discharges stormwater from the upstream catchment areas at mid-hill levels of Tsuen Wan and Kwai Chung into the sea near Yau Kom Tau, thereby relieving the loading of the existing drainage systems in downstream urban areas.

The design discharge capacity of the Tsuen Wan Drainage Tunnel is the highest among the drainage tunnels in Hong Kong. This tunnel has a maximum flow rate of 223 m$^3$/s, equivalent to filling up a standard swimming pool in 11 seconds, and collects stormwater from natural rivers only. To ensure that the downstream flow is adequate to maintain the ecological balance, all intakes will be activated to intercept stormwater only when the rainstorm warning signal is in force. In designing the tunnel, the project team also conducted physical model tests for every water intake of the tunnel in order to grasp the actual situation of stormwater collection.
Kai Tak Transfer Scheme

The Kai Tak Transfer Scheme is a flood prevention measure to alleviate the flooding problem in Western Kowloon. The design of this scheme adopted the concept of bypass flow to divert the stormwater from the Waterloo Road culvert to the Kai Tak Nullah in San Po Kong through the underground channels in Kowloon Tong and Kowloon City for discharge into the sea. Since its operation, the transfer tunnel, together with the Tai Hang Tung Underground Stormwater Storage Scheme, has been effective in draining away the surface runoff in Mong Kok and Prince Edward, greatly reducing the flood menace in the area. In addition, the tunnel transfers the intercepted surface runoff to the Kai Tak Nullah, which helps flush the nullah and relieve its odour problem.
Yuen Long Bypass Floodway

To lower the flood risk in Yuen Long town centre and the nearby low lands, a 3.8-km long bypass floodway was constructed at the south of Yuen Long town to intercept and divert 40% of the flow from the Yuen Long catchment to the downstream of Kam Tin River for subsequent discharge into Deep Bay. One of the merits of the project was that it could obviate large-scale construction activities in Yuen Long town centre, alleviating the impacts on the residents and traffic in the district.

With green elements being incorporated, the design of the Yuen Long Bypass Floodway placed emphasis on greening and no disturbance to the surrounding ecology. The river bends, shallow ponds, engineered wetland and watercourses along the Floodway help enrich biodiversity. A low flow pumping station and an inflatable dam provided at the downstream end facilitate the control of water level in the Floodway so as to relieve the tidal impact of Deep Bay.
Stormwater storage

Stormwater storage refers to the temporary retention of excess stormwater during heavy rain to attenuate the peak flow rate for flood prevention. Stormwater storage facilities in both urban areas and the New Territories are built on flatlands or in low-lying areas. Those in urban areas are located underground, freeing up above-ground space for other land uses and making the works less disturbing to the busy urban areas.

Urban and rural stormwater storage facilities vary in design. There are three storage tanks in urban areas, including the operating Tai Hang Tung Underground Stormwater Storage Tank and Sheung Wan Stormwater Storage Tank, as well as the Happy Valley Underground Stormwater Storage Tank under construction. Urban storage tanks are usually housed at midstream or downstream areas to hold part of the stormwater upstream and hence ease the burden on downstream drainage facilities for effective flood prevention. After the rainstorm, the stormwater in the storage tank will be discharged. For storage ponds with embankments built in low-lying villages in the New Territories, the stormwater stored will be removed out of the villages through pumping stations to spare the villagers from flooding.
Tai Hang Tung Underground Stormwater Storage Scheme

The Tai Hang Tung Underground Stormwater Storage Scheme is the first and largest scheme of its kind in Hong Kong. The storage tank has a capacity of 100,000 m$^3$, collecting the surface runoff from Beacon Hill, Sham Shui Po and Tai Hang Tung to reduce the flood risk in Yau Tsim Mong District.

Though simple to operate, this storage tank was designed with meticulous planning with the aid of physical models to simulate actual operation of the storage tank. The overflow weir atop the tank controls the stormwater storage and no manual or mechanical operation is required. In short, the overflow weir is a fixed structure mainly for flow diversion. Normally, when the water level in the drainage system is below the overflow weir, the flow will be discharged into the sea via the downstream drainage system. During rainstorms, when the water level in the drainage system rises above the overflow weir, the stormwater will naturally overflow into the tank to keep the downstream flow within the design capacity. After rainstorms, the stored stormwater will be pumped through the pumping station to the downstream drainage system for discharge. In this way, downstream areas can be protected from flooding.
Sheung Wan Stormwater Storage Scheme

The Sheung Wan Stormwater Storage Scheme was implemented to tackle the flooding problem in the vicinity of Wing Lok Street in Sheung Wan. It prevents not only flooding but also tidal backflow. As Wing Lok Street is in the low-lying coastal area, flooding occurs due to rainstorms or seawater backflow. Hence, the Sheung Wan Stormwater Storage Tank, besides holding surface runoff temporarily, is equipped with a special sluice gate against seawater backflow during high tides. Together with the use of stormwater pumps, it has improved the long-existing flooding problem in the area. In addition, the Scheme comprised the “Intercepting Drains at Queen’s Road Central” which involved the laying of intercepting drains of 650 m in length along Queen’s Road Central (upstream of Wing Lok Street) and Gilman’s Bazaar. These drains intercept 30% of the stormwater which will otherwise flow into the Wing Lok Street area, and further reduce the flooding hazard.
Chapter Three  Flood Prevention – Stormwater Interception, Storage and Conveyance

Happy Valley Underground Stormwater Storage Scheme

The Happy Valley Underground Stormwater Storage Tank is under construction. The experience on the Tai Hang Tung Stormwater Storage Tank has enabled relevant works to adopt a number of innovative technologies, such as a movable crest weir together with the Supervisory Control and Data Acquisition System for real-time monitoring of the water level in downstream drains and proper adjustment of the overflow weir height to precisely control the stormwater storage period and volume.

The computer model of Happy Valley Underground Stormwater Storage Scheme

**Operation of the movable crest weir**

During rainstorms, when the stormwater in downstream drains fails to flow away timely, the rising water will trigger the water level sensors, and the movable crest weir will be lowered to let the stormwater flow into the storage tank. This can attenuate the peak flow rate and alleviate the flooding hazard to downstream areas. After rainstorms, when the water level in downstream drains falls to a normal level, the water level sensors will be activated and the movable crest weir will be further lowered so that stormwater in the storage tank (with water level higher than that in drains) can flow back to downstream drains for discharge into Victoria Harbour.

Given the flexibility of this new system in controlling stormwater storage and discharge, the size of the stormwater storage tank could be reduced by one-third, saving space and much costs for the construction. Phase I of the underground stormwater storage tank came into operation by the wet season of 2015 and the whole project is scheduled for completion by the wet season of 2018.
Village flood protection schemes

Village flood protection schemes are flood prevention measures for low-lying villages. The principles involved are similar to those of stormwater storage tanks. Embankments are built around the villages to exclude outside runoff, while flood storage ponds are provided in the villages to collect surface runoff inside the villages. Stormwater pumping stations are constructed beside the flood storage ponds to pump the stormwater within the embankments to drainage channels outside the villages for flooding hazard mitigation. Depending on villagers’ preference, the flood storage ponds can be designed as dry or wet ponds (i.e. permanently retaining water or not).

Stormwater pumping stations constructed under village flood protection schemes are unmanned as they operate with a fully automatic system. There are 30 such stations in the New Territories. Data from these stations are transmitted directly to the flood control centre or the department’s Land Drainage Division for monitoring. The flood control centre for the New Territories is located at the Yuen Long Sewage Treatment Works, and is manned under inclement weather to monitor the operation of all the stormwater pumping stations.

DSD has completed a total of 27 village flood protection schemes involving more than 240 hectares of low-lying areas to reduce the flooding hazard to residents of 35 villages.
Chapter Three  Flood Prevention – Stormwater Interception, Storage and Conveyance

Improvement to Stormwater Conveyance

Improvement works to stormwater conveyance have been carried out to address flooding problems from ancient to modern times. Drainage conduit improvement refers to the straightening, widening and deepening of existing watercourses, or enhancement of constructed drainage channels or pipes to increase their drainage capacities.

River training works

Conveyance capacity improvement is the major approach in river training works. For example, as at late 2013, there were 707 km of underground drains and 273 km of engineered channels constructed in the Northern New Territories, greatly improving the flooding problem in the area. In recent years, DSD has incorporated ecological conservation elements into river training works, elevating the flood control capacity and maintaining the biodiversity of rivers. In addition, DSD has carried out works to improve and revitalise Kai Tak River in the urban area to transform it into an urban green river with flood prevention function.

Shenzhen River Regulation Project

The Shenzhen River, with a total length of 37 km and a catchment area of 312 km², is the estuary of various rivers, including Ng Tung River, Ping Yuen River and the San Tin streams in Hong Kong, as well as Shawan River, Buji River and Futian River in Shenzhen. Frequent flooding in these river catchments has caused severe casualties and property loss. Thus, the Shenzhen and Hong Kong governments have jointly implemented the Shenzhen River Regulation Project in a comprehensive and systematic manner to alleviate the flooding problem.
The Shenzhen River Regulation Project commenced in 1995 mainly comprised the straightening, widening and deepening of an 18 km long river section downstream. Earlier works were carried out in three stages. Stage 1 involved the straightening of the Lok Ma Chau bend and the Liu Pok bend while Stage 2 involved the widening and deepening of the remaining section from the Liu Pok bend to the estuary. These two stages of works, being the most critical flood prevention projects in the Northern New Territories, were completed in April 1997 and June 2000 respectively. They have significantly enhanced the flood prevention capacity of the river section from Lo Wu to the Deep Bay estuary. The Project, in tandem with other river training works upstream in the Northern New Territories, has largely eliminated the flooding hazard to the area.

Stage 3 of the Project, i.e. the widening and deepening of the river section from the upstream of the Liu Pok bend to the confluence with Ping Yuen River, was implemented in two phases. Phase 1 covered the advance works including the relocation and reconstruction of boundary patrol roads and fences, while Phase 2 were river modification works. Stage 3 was completed in mid-2006 and the Shenzhen River has become wide and straight, with uniform embankments and smooth revetments.

Commenced in 2012, Stage 4 of the Project enables the section of Shenzhen River from the Ping Yuen River estuary to Pak Fu Shan (about 4.5 km long) to withstand flooding of 50-year return period. It is expected to be completed in 2017 to complement the Liantang/Heung Yuen Wai Boundary Control Point under construction. The works primarily involve widening and deepening the River without changing the alignment, paving the riverbed with natural soil, and turning the largest river bend to a water storage basin to achieve the two objectives of flood prevention and conservation. Advance works including the reprovisioning of boundary patrol roads and associated security facilities are near completion.
Chapter Three  Flood Prevention – Stormwater Interception, Storage and Conveyance

River training works at Ping Yuen River, Ng Tung River and Sheung Yue River

The completion of the first three stages of the Shenzhen River Regulation Project was conducive to the improvement works for tributaries like Ping Yuen River, Ng Tung River, Sheung Yue River, etc. Upon completion of relevant works, flooding incidents in Lo Wu, Tin Ping Shan, Ho Sheung Heung, Yin Kong and Ta Kwu Ling have been largely reduced.

River training works for Kam Tin River and Shan Pui River

DSD implemented improvement works for Kam Tin River and Shan Pui River in Yuen Long in the early 1990s. Works for the main drainage channels downstream at Yuen Long, Kam Tin and Ngau Tam Mei were completed in the late 1990s, while those for the tributaries upstream have also been completed successively. The flooding problem in Kam Tin, Yuen Long town and Tin Shui Wai has since been largely alleviated.
Kai Tak River Improvement Works

The Government developed a residential area called Kai Tak Bund in the 1920s. The Kai Tak Nullah was then formed with the then existing streams in the vicinity of Wong Tai Sin District to discharge stormwater into Victoria Harbour. Later, the alignment of the Nullah was changed several times following urban development and the Nullah has now been renamed as Kai Tak River. After a series of public engagement activities and consultations, DSD is working in stages to reconstruct and improve a section of Kai Tak River from Po Kong Village Road to Prince Edward Road East, including the upstream section from Wong Tai Sin Police Station to Tung Tau (II) Estate and the midstream section from Tung Kwong Road to Prince Edward Road East. The project will tie in with the improvement works carried out by CEDD for the downstream section of Kai Tak River within the Kai Tak Development Area. It will not only enhance the drainage capacity of Kai Tak River, mitigating the flood risk in the surrounding areas, but also provide in the urban area a green river corridor with aesthetic, greening, landscaping and ecological elements along the river banks and river bed. DSD will collaborate with other departments to better integrate Kai Tak River with adjacent development sites and open space. Works for the upstream section commenced in October 2011, while those for the midstream section commenced in December 2013. The whole project is expected to be completed in late 2017.
Emergency measures for flooding

24-hour Drainage Hotline

DSD has set up a 24-hour Drainage Hotline (tel: 2300 1110) to answer public enquiries regarding drain blockage, sewage leakage, flooding and the like. In 2013, DSD handled a total of 30,124 cases, mainly about drain blockage and flooding. On average, the Hotline receives 80 to 100 enquiries daily. The ratio of sewerage to drainage cases is about 5:2. During wet seasons, most cases are related to stormwater drain blockage. Under inclement weather, the Hotline may receive more than 400 enquiries in one day.

Emergency Control Centre

Under inclement weather (e.g. when HKO issues the Tropical Cyclone Warning Signal No. 8 or above, or the Red or Black Rainstorm Warning Signal), DSD will provide contingency manning and activate the Emergency Control Centre (ECC). Led by a senior engineer, ECC serves to monitor the situation and where necessary, deploy DSD’s Direct Labour Force (DLF) or contractor teams to the scenes for assistance in preventing or dealing with any possible scenario under adverse weather. Besides, in case of emergency, DSD will work with the Government Secretariat’s Emergency Monitoring and Support Centre to coordinate the emergency responses concerning drainage issues. If this happens, DSD’s ECC will also be activated.
### Numbers of cases handled in 2013

<table>
<thead>
<tr>
<th>Operation frequency of DLF</th>
<th>Number of emergency cases</th>
<th>Numbers of general public enquiries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Drainage incidents</td>
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<tr>
<td></td>
<td></td>
<td>Non-drainage incidents*</td>
<td></td>
</tr>
<tr>
<td>Total annual number of cases</td>
<td>159</td>
<td>25,527</td>
<td>30,124</td>
</tr>
<tr>
<td>Highest daily number of cases handled*</td>
<td>49</td>
<td>438</td>
<td>439</td>
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</table>

* The Drainage Hotline also answers public enquiries redirected from the 1823 hotline. Non-drainage cases will be preliminarily processed for subsequent referral to relevant departments for follow-up.

* Date of record: 22 May 2013

### Numbers of emergencies in 2013

<table>
<thead>
<tr>
<th>Emergency types</th>
<th>Total annual number</th>
<th>Percentage to total annual number of cases</th>
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</thead>
<tbody>
<tr>
<td>Flooding</td>
<td>146</td>
<td>0.48%</td>
</tr>
<tr>
<td>Gas leakage</td>
<td>13</td>
<td>0.04%</td>
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<tr>
<td>Red Rainstorm Warning Signal</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Black Rainstorm Warning Signal</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Tropical Cyclone Warning Signal (No. 8 or above)</td>
<td>2</td>
<td>—</td>
</tr>
</tbody>
</table>

The mission of ECC is to relieve the hardship of the public. The nature of duties of ECC may seem narrow, but it involves frequent collaboration with other government departments (including the Highways Department, Food and Environmental Hygiene Department and Hong Kong Police Force) to tackle problems. ECC staff take up a liaison role with other departments to follow up enquiries, and arrange DLF or contractor teams to carry out field operations and provide assistance to the public.
Chapter Three  Flood Prevention – Stormwater Interception, Storage and Conveyance

Direct Labour Force

According to the number of cases in 2013 as mentioned above, DLF is required to handle on average at least 82 cases daily, including emergencies. Therefore, it is paramountly important to assess precisely the seriousness of each case and prioritise them properly. DLF members work shifts round-the-clock and stand fast to their duties in order to promptly deal with drainage problems for the public. DLF consists of:

- **Customer Services Team**: Responsible for answering public enquiries, systematically recording the details and passing them to relevant colleagues for follow-up.

- **Operation Management Team**: Responsible for categorising the jobs, assigning field operations to the Sewer Gang, passing the jobs completed but requiring follow-up action to the colleagues working in the district concerned or other relevant government departments for further action, and preparing case reports and work reports.

- **Sewer Gang**: Each team comprises a drain chargeman (as the leader) and six staff (including a driver, two leading sewermen and three workmen) for scene investigation and case handling. Upon completion of relevant work, the team will report to the caller on the work progress.

For blocked drains or manholes, the Sewer Gang will first use portable tools for drain clearance. If the blockage still exists, a high pressure water jetting unit will be deployed to the scene to help. The high-pressure hose and other drain clearance equipment on the water jetting unit can normally flush away the blockage and restore the effectiveness of the drains.

**High pressure water jetting unit**

**Drain clearance tools**
A flowchart for handling cases of common drain blockage

1. When common portable tools for drain clearance prove ineffective, a high pressure water jetting unit will be deployed to the scene to help clear the blockage with a high-pressure hose (which is pressure adjustable).

2. Generally, a high-pressure water jet can break up the blockage inside a drain and flush away the blockage material, restoring the drain’s effectiveness in a flash.

3. The Sewer Gang opens another manhole downstream to check whether the cleared sewer is functioning properly.

4. Clean the street in the scene to eliminate sewage and bad smell. Lastly, notify the caller by phone that the case has been dealt with properly.

Causes of drain blockage

DLF is usually responsible for handling drain blockage issues, with more cases involving sewers. The causes of drain blockage are grouped into two main types. The first type is the aging and small-diameter drains of old buildings, which are susceptible to blockages. The second one is the improper disposal of waste or solid objects into sewers, where the common blockages are clothing, plastic bags, cardboard, etc. For drains near slopes, blockages are mostly caused by grit and leaves washed down by rainwater. In winter, grease coagulating on the inner wall of sewers outside restaurants causes blockage. Such blockage is more difficult to handle.
Sharing by DLF members

DLF is DSD’s frontline team which has frequent contact with the public and attaches great importance to communication with the public. Priority must be given to cases involving personal, property or road safety. Apart from deploying DLF staff to the scene promptly, our staff will at the same time liaise with relevant departments for assistance.

We once received a call from a school, reporting a sewer blockage outside the school gate and that the sewage kept overflowing onto the ground. As it was near the end of school hours, DLF staff immediately rushed to the scene for drain clearance so that the blockage would not cause inconvenience to the students. Even for enquiries not directly related to DSD, DLF members will still, with the motto “serving the public”, conduct inspection at the scene and, where appropriate, offer assistance as far as practicable.

The job of DLF is obnoxious, as it often involves follow-up work about excrement and odour problems in handling sewer blockages. In spite of this, solving problems for the public indeed brings job satisfaction. It is true that many passers-by will cover their noses due to the odour and filth when they see DLF staff working on the street. Nevertheless, when the drain clearance is done, the public will express their gratitude and some may even call or write letters to compliment DLF's enthusiastic service. Hereunder are some memorable experiences shared by our DLF colleagues.

Assistance in identifying the transmission path for SARS

Mr Ng Ka-ho, a DLF member, recalled his experience in assisting the Department of Health in investigating the Severe Acute Respiratory Syndrome (SARS) cases in 2003. During that period, DLF staff worked every day at Amoy Gardens. In the end, the investigation team found a clue as to how the virus was transmitted in Amoy Gardens. This was a key step to help contain the epidemic, and aroused deep feelings in Mr Ng. This worldwide infectious disease, which raised global concern, was gradually under control in mid-2003. Research findings revealed that the virus was spread through building sewers.
Handling a suspected case of gas explosion

Mr Luk Koon-keung, a DLF member, once witnessed a manhole explosion which was deeply engraved in his memory. Actually, whenever the Fire Services Department suspects that there is an accumulation of flammable gas in a manhole, it will inform DLF to provide on-site assistance. DLF also has to help clear relevant drains or sewers after any manhole explosion.

On 13 July 2012, there was a suspected case of manhole gas explosion at the junction of On Ning Road and Pau Cheung Square in Yuen Long. After being informed by firemen at the scene, DSD immediately deployed DLF to assist in opening the manhole cover and conducting gas tests. DLF stayed at the scene until it was confirmed that there was no explosion risk.

Helping the police collect exhibits in drains

Mr Ng Ka-ho, a DLF member, recalled a dismemberment case in Shek Kip Mei Street in early 2008. It was suspected that a teenage girl was murdered and dismembered with her limbs dumped into the drains. DSD, at the police’s request, provided assistance in collecting exhibits by sending DLF staff for salvage work in the drains.

On 8 May 2008, DSD was informed by the Kowloon West Regional Crime Unit of the Hong Kong Police Force to search in the sewers and manhole for relevant exhibits of the dismemberment case.
Chapter Three Flood Prevention – Stormwater Interception, Storage and Conveyance

Flood warning system

To reduce the flooding hazard to villagers’ lives and property, DSD will, as an interim measure, install flood warning systems in flood-prone villages where relevant improvement works have yet to complete. When the floodwater reaches the predetermined alert level, the water-level sensor will trigger the siren through telemetry to warn the villagers so that they can evacuate or take precautions in time.

Effectiveness of flood prevention works

Removal of flooding blackspots

To combat the flooding problem in Hong Kong, DSD identified the flooding blackspots and implemented suitable improvement solutions as appropriate. In 1995, there were over 130 identified flooding blackspots in Hong Kong. As at March 2014, the number of blackspots has dropped to 11. For four of these blackspots, DSD has completed the improvement works which will be subject to review on their effectiveness. Improvement works for the other two are underway, while the second stage of works for the remaining five are under planning and design.

Flooding blackspots

The list of flooding blackspots kept by DSD is compiled based on previous flooding records and complaints. It is used to monitor the progress of relevant drainage maintenance works and flood prevention measures. DSD pays special attention to these blackspots, carries out precautionary maintenance and takes immediate mitigation measures during flooding.

With the successive completion of drainage improvement works, those blackspots where flooding no longer occurs will be removed from the list.
Chapter Three  Flood Prevention – Stormwater Interception, Storage and Conveyance

Substantial alleviation of flooding problems — recognition by the public

Nam Pak Hong Street and Dried Seafood Street in Sheung Wan

Wing Lok Street, Bonham Strand East, Bonham Strand West and Des Voeux Road West in Sheung Wan are low-lying areas of Northwestern Hong Kong Island. Among these, Wing Lok Street is the most low-lying area in the district, which is only about 2.64 metres above the principal datum. In the 1950s, businesses thrived in the area. However, whenever a rainstorm came along with a spring tide, particularly when it was a high tide or storm surge, seawater tended to flow back to the street via the drains. Should the surface runoff fail to drain away, severe flooding and serious business loss for shop operators would ensue. Such case still occurred at times in the 2000s.

Flooding incidents on Wing Lok Street in Sheung Wan on 24 June 2005 (left) and 7 June 2008 (right) respectively

Mr Lam Hon-wah, Director of Nam Pak Hong Association, had a deep impression of the flooding on Nam Pak Hong Street. When he entered the industry in 1959, the buildings on both sides of the Street were only of two to three storeys. Later, with the gradual development of Wing Lok Street, the drains were overloaded and the neighbouring streets were often flooded. He recalled that when flooding occurred, sewage from the Chinese barbeque shop upstream would flow down with the floodwater and dirty the wading pedestrians, and this was really an ordeal for the latter. The shopkeepers were afraid that their goods might be wetted by the floodwater, and erected shut boards at the shop entrances and sealed the gaps between the wooden boards with incense adhesive to prevent the influx of floodwater into the shops. Mr Lam recalled that the most serious flooding incident occurred in June 2008, when the heavy rain made the shut boards useless, and floodwater of more than three feet deep kept surging into his store. The floodwater damaged many of his goods and costed him a loss of over $400,000.

Mr Lam Hon-wah, Director of Nam Pak Hong Association, showing the floodwater level during the flooding in 2008
Mr Mak Ching-po, Chairman of the Hong Kong Dried Seafood and Grocery Merchants Association, has been running his dried seafood business at Des Voeux Road West for half a century. He witnessed the evolution of the area from the former “Salted Fish Market” to “Dried Seafood Street” which is famous for selling of high-value dried seafood such as abalone, shark’s fin, fish maw, etc. Mr Mak told us that since around 40 years ago, there had been occasional flooding and even seawater backflow on this street. In the past, to protect their shops against inundation, the shop operators erected wooden boards at the front and back doors as sluice gates and raised the shop platforms. He explained that although the flooding in 2008 lasted only a few hours, a large amount of dried seafood were sodden and went to waste, which caused a tremendous loss to the shop owners.

Records show that from 2001 to 2008, the flooding occurred in low-lying areas of Sheung Wan was of 0.5 to 1.2 m deep. Since the commissioning of the Sheung Wan Stormwater Pumping Station and stormwater storage tank in 2009, there has been no flooding in Sheung Wan district as at May 2014, despite that HKO issued Red Rainstorm Signal and Black Rainstorm Signal on 12 and 5 occasions respectively over the same period. This is the best proof that the flood prevention works are highly effective.

Mr Lam Hon-wah said that DSD carries out regular drain inspection or clearance and, in emergency situations, promptly sends staff for follow-up.
Sheung Shui Heung

The Liu clan settled at Sheung Shui Heung in the New Territories more than 600 years ago. To facilitate farming, their ancestors chose to live by the river, constructed river bunds (known as “Shek Po Tau”) with stones, and installed sluice gates to store water for irrigation. No doubt, water resources are crucial to agriculture, but river overflow during high tides or inclement weather cause much inconveniences to the villagers. For instance, as recorded in a stele (with inscription regarding the reconstruction of “Shek Po Tau”) erected by the Liu clan by Ng Tung River, “Shek Po Tau” was burst by a heavy flood on 21 June 1954, showing that Sheung Shui and its vicinity had long been plagued by floods.

Farmlands have water storage capacity to help drain away stormwater, as they allow rainwater to infiltrate into the soil. However, with the development of Sheung Shui, the villagers no longer work in farming, and former farmlands have been gradually cement-paved, which made stormwater infiltration impossible. As pointed out by Mr Liu Hing-hung, an indigenous inhabitant representative of Sheung Shui Heung, the most severe flooding, which was up to waist deep, occurred around 30 years ago.
Mr Liu added that flooding affected not only daily life, but also the important rituals of the clan. For example, the route for the Liu’s autumn ancestral worship was altered once because of flooding, and the ancestral register of the “Tai Ping Qing Jiao” (also known as “Da Jiao”), i.e. Jiao Record, was destroyed in another flooding. Da Jiao is a big event in the community to offer sacrifices to wandering spirits and to gratify the deities for the protection and blessings given, and to cleanse the community with rituals for a fresh start. The frequency of the event varies among communities. It is normally held annually, every five, seven or ten years. The Da Jiao Festival in Sheung Shui is held every 60 years and the previous one took place in 1946. Since the Jiao Record had been damaged and those previous participants might have passed away or have vague memories of the event, villagers had to search high and low for the lost information to make the Festival in 2006 a success.

DSD took forward the village flood protection scheme for Sheung Shui Heung, which made use of a stormwater pumping station and bunds to relieve the flooding menace to the village. Since then, there has been no flooding even during rainstorms.
Ma Tin Tsuen, Shap Pat Heung, Yuen Long

Mr Wong Dong-keung, a resident representative of Ma Tin Tsuen at Shap Pat Heung in Yuen Long, mentioned that Ma Tin Tsuen has a history of more than 300 years. In the past, villagers worked as farmers for a living. Mr Wong believed that his ancestors had avoided flood-prone areas for settlement, so the flooding problem in the village is undoubtedly be caused by urbanisation. At present, Ma Tin Tsuen is low-lying, as the roads surrounding the village were raised unceasingly for new town development, gradually turning Ma Tin Tsuen into a sunken area. In the most serious flooding, the chest-deep floodwater even surged into the age-old Entrance Gate and Shrine. But following DSD’s construction of a stormwater pumping station in the village, no more flooding has occurred.

Tai O

Tai O was a well known fishing village in Hong Kong. Early fishermen in Tai O built alongside a watercourse stilt houses as replenishing points for their fishing operations. The stilt house areas in Tai O are low-lying as they were developed along the watercourse running between an island and coastal lowlands. Therefore, the areas are vulnerable to seawater backflow during typhoons or high tides. Ms Leung, a resident at Wing On Street, recalled that the silty seawater flowing into her house and the toilet sewage backflow made the house stink all over.

On 7 June 2008, HKO issued the Black Rainstorm Warning Signal and torrential rain fell generally over Hong Kong. On 23 September of the same year, Hong Kong was struck by the Severe Typhoon Hagupit. These two inclement weather events triggered flooding in several parts of Tai O and the situation was more acute at certain locations.

Mr Chan Kam, a 70-year-old resident at Tai Ping Street in Tai O, still remembers the flooding in 2008. At first, the floodwater inside his house was over one metre deep, by the time firemen used rubber boats for rescue and advised the residents to evacuate, the floodwater depth was equivalent to a man’s height, creating a breath-taking scene.
Nowadays, stilt house areas in Tai O have become a popular tourist attraction in Hong Kong. During the Dragon Boat Festival each year, Tai O residents hold the dragon boat water parade along the watercourse. This ritual has been inscribed onto the National List of Intangible Cultural Heritage.

The Chairman and two Vice-chairmen of the Joint Association of Traditional Dragon Boats in Tai O, Hong Kong, the organiser of this ritual, recalled that the dragon boat water parade was once affected by the severe flooding in June 2008 as the downpour swept away a large traditional dragon boat from the dragon boat factory. Without the boat, a highlight of the parade, the activity could not proceed. Fortunately, they managed to recover the boat later in an undamaged condition. Yet, rainstorms brought by Typhoon Hagupit accelerated the river flow, making dragon boating impossible. Thus, small boats were used instead to “receive the deities”. Moreover, because of traffic paralysis, many residents and their friends and relatives could not join the event that year.

In view of this, DSD implemented a series of flood prevention works and built a stormwater pumping station in Tai O. However, as Tai O is a low-lying coastal area, seawater backflow may still recur during high tides. Therefore, DSD and other government departments formed the Emergency and Storm Damage Organisation to formulate contingency plans for Tai O to deal with emergencies and flooding problems.
Conclusion

Given Hong Kong’s unique geographical setting, urbanisation and climate change, rainstorms can easily result in flooding and hence casualties and property loss. Over the years, DSD has put in place a number of overall flood prevention strategies to keep mitigating flooding problems in different areas across the territory. This has proven remarkably effective as the number of flooding blackspots has dropped from over 130 to ten or so. Notwithstanding this achievement, in response to the intensification of the greenhouse effect and observation of extreme weather worldwide, Hong Kong, as a coastal city, must stay alert and brace itself for the challenges arising from climate change.

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4. Incense adhesive is the adhesive used in making incense sticks.

Fig. 1–2, 4–6 were provided by courtesy of the South China Research Centre, the Hong Kong University of Science and Technology. Fig. 3 was provided by courtesy of *Sing Tao Daily*. 

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Chapter Four  Innovative Thinking of Blue-Green Infrastructure
To keep Hong Kong a liveable city, DSD takes sustainable development as a vital consideration in taking forward our projects. As such, DSD has been endeavouring to introduce “Blue-Green Infrastructure” in recent years. “Blue” broadly refers to water bodies while “Green” represents plants. “Blue-Green Infrastructure” means an urban drainage system incorporating natural elements, community features and modern functions. Apart from using environmental practices in construction works, DSD particularly cares about the ecological conservation of rivers to maintain biodiversity. In these years, DSD has adopted highly efficient sewage treatment technologies with notable achievements in carbon reduction and energy saving. Besides, DSD has carried out greening works at its facilities, contributing to the forming of a green city. DSD will continue to conduct relevant studies, step up efforts in building green infrastructure and cavern development, and actively develop plans on “Blue-Green Infrastructure”, including flood retention lakes, porous pavements, river revitalisation, green roofs, stormwater storage and purification facilities in urban areas, sustainable drainage systems, etc. In doing so, we strive for achieving the objectives of water revitalisation, promotion of water-friendly culture, greening, beautification and better use of water resources.
Promoting sustainable development

Beyond the skyscraper-dominated urban areas is the green and serene countryside. Hong Kong’s unique terrain and subtropical climate offer varied habitats for the biodiverse flora and fauna, including species of global conservation importance.

“Biodiversity” refers to different life forms (with three key elements, namely ecosystems, species and genes) and the relationships among these forms. An environment conducive to biodiversity not only contributes to nature conservation, but also brings human beings countless benefits, such as oxygen and food supply, as well as river purification. To achieve biodiversity, it is necessary to maintain ecological balance, take care of the nearby environment and safeguard natural resources. Such determination to protect the nature coincides with the concept of “sustainable development”.

Since its inception 25 years ago, DSD has all along been committed to providing world-class sewage treatment and stormwater drainage services, and taking the sustainable development of Hong Kong as its vision. To this end, DSD has been trying to integrate ecological conservation elements into project designs and adopt the best environmental practices for low-carbon efficiency. DSD’s vision is to implant the concept of “sustainable development” and “liveable city” into society and join hands with other parties to make Hong Kong a clean, scenic and comfortable city to face up to global warming and climate change. In addition, DSD has been taking proactive measures to reduce energy consumption, avoid damage to the natural environment, and retain and revitalise water bodies in order to lessen greenhouse gas emissions and heat island effect.

To make Hong Kong a “liveable city”, DSD has been actively providing “Blue-Green Infrastructure” in community development projects. “Blue” refers to water bodies while “Green” refers to plants. Such infrastructure and relevant measures blend flourishing greenery and attractive waterscapes into our community. Through different water-friendly activities, the public can learn to treasure the natural resources more. In this connection, DSD plans to construct flood retention lakes and rainwater harvesting systems to reduce surface runoff at source. In short, “Blue-Green Infrastructure” means an urban drainage system with natural elements, community features and modern functions being integrated.
Chapter Four   Innovative Thinking of Blue-Green Infrastructure

Blue-Green Infrastructure

The green river of Yuen Long Bypass Floodway

The stormwater storage pond in Kiu Tau Wai, Ping Shan

Rainwater harvesting facilities at Kowloon City Sewage Pumping Station No. 1
To provide more green belts and space integrated with the natural environment for leisure, learning and sightseeing, DSD will critically study the conversion of urban watercourses into tree-shaded and water-friendly environments, for the public to stroll along the riverside and get closer to the nature. DSD is now planning to conduct a feasibility study on “Revitalisation of Water Bodies”, covering study items such as eco-channels, water retention basins, sustainable drainage systems, as well as stormwater storage and purification facilities in urban areas.

“Sustainable development” is a vital consideration in DSD’s daily operation. In respect of flood prevention, river works are carried out with ecological measures for adequate flood attenuation capacity and river biodiversity. Regarding sewage treatment, in recent years, DSD has initiated collaboration with local universities on large-scale pilot schemes to develop more efficient sewage treatment processes. Meanwhile, carbon reduction and energy saving have been taken into account in both the design and operation of sewage treatment works to strengthen energy management and emission control. Examples are the use of biogas (a renewable energy source) to generate electricity and undertaking of carbon audits to evaluate energy saving performance.

On the other hand, DSD has been working on the proper storage and better use of precious water resources, e.g. using reclaimed water for toilet flushing and irrigation and carrying out pilot schemes on rainwater harvesting. Apart from these, DSD is studying the feasibility of relocating large-scale sewage treatment facilities to caverns so as to release more land for other community needs and provide more options for land use and development.

**Eco-channels – Revitalisation of water bodies**

Like many other international cities, Hong Kong’s drainage facilities built in the early years were primarily flood prevention-oriented. Drains were designed with reference to international practice at that time. However, the flood prevention strategies have been changed with time following a growing global concern about the importance of conserving the river ecology. Since many years ago, DSD has started conducting trials on different ecological conservation measures, e.g. integrating green and conservation elements into the existing and new flood prevention facilities, and minimising the use of concrete in the construction of drainage channels. Up to now, DSD has completed the improvement works for a number of nullahs and watercourses like Kai Tak Nullah (now called Kai Tak River), Ho Chung River, etc. Those works comprised the provision of vegetation covers, river beautification and ecological revitalisation.
Conserving the river ecology

Natural watercourses are not only channels for flood drainage but also habitats for a wide range of flora and fauna. To enhance river training works, DSD will, as far as practicable, include suitable conservation measures and maintain the natural river characteristics during project planning to mitigate environmental impacts of the works. Nowadays, many watercourses in the New Territories have adequate flood prevention capacity, lush green embankments and favourable ecological environment. Some natural streams in the vicinity have also been retained and greened, contributing to a more ideal river environment for Hong Kong.

For ecological conservation, DSD seizes every opportunity to incorporate ecological features into river improvement works. For example, the improvement works for Ho Chung River, Pak Ngan Heung River and Lam Tsuen River used fish ladders made of natural materials to enable the fish to swim upstream and downstream; the Yuen Long Bypass Floodway project included the provision of grasscrete along the embankments and riverbed to support plant growth; the Luk Tei Tong Bypass Channel in Mui Wo retained the original top soil and seeds of native plants on its riverbed. These ecological measures were put in place to imitate as much as possible the natural river setting and minimise the ecological impacts brought by the works.

The fish ladder at Pak Ngan Heung River, Mui Wo

Ecological facilities at Ho Chung River, Sai Kung

A polder was constructed at the confluence of Luk Tei Tong Bypass Channel and Luk Tei Tong River in Mui Wo for aquatic species to inhabit and birds to forage and rest
DSD has also tried to use various materials (particularly the more natural ones) to replace concrete in constructing riverbeds and embankments. For instance, geotextile and grasscrete have been provided along the embankments for vegetation covers and hence the rivers could blend in with the adjoining ecological environment. The following are some ecological measures implemented at watercourses:

**Natural riverbed**

Retaining or reusing the original soil on the riverbed can effectively maintain the natural ecological environment along a river. However, the soil is subject to erosion by water current and therefore only suitable for use at downstream or river sections with slow flow. At present, the natural riverbed design is adopted at the downstream sections of Kam Tin River, Shan Pui River, Shenzhen River, etc.

**Rip-rap riverbed**

Gravel is more resistant to erosion by water current than soil and the cracks in the gravel provide habitats for aquatic species, which helps raise the ecological value of rivers. For training works at river sections of more rapid flow, gabions and geo-fabric reinforced grass lining were used to stabilise embankment slopes and hence prevent the stones from being washed downstream. The works at Lam Tsuen River, Ho Chung River and Pak Ngan Heung River adopted the rip-rap riverbed design.
Chapter Four  Innovative Thinking of Blue-Green Infrastructure

Geotextile riverbank and riverbed

Geotextile is woven with water-permeable synthetic fabric in the form of cloth for preventing soil loss from the riverbed. The apertures in the geotextile allow plant growth. Yet, geotextile riverbeds, like those at the upstream sections of Ng Tung River and Sheung Yue River, can only withstand gentle wash and are therefore not applicable to rapid or meandering watercourses.

Grasscrete embankment

Grasscrete can provide space for plant growth on embankments, but it is inferior to other materials in maintaining biodiversity. Grasscrete can withstand current and is easier to repair, making it suitable for midstream and downstream sections which require higher drainage capacity. Grasscrete embankments can be found along Kam Tin River, Ng Tung River, Lam Tsuen River, Yuen Long Bypass Floodway, etc.
Trials on composting grass clippings

The grass planted along riverbanks requires regular trimming, from which a monthly average of over 100 tonnes of grass clippings are generated. In the past, they were simply transported to landfills for disposal. To reduce wastage, DSD is conducting trials on “Open Composting” with the use of micro-organisms to decompose green waste into humus within eight weeks or so. This not only can reduce the volume of grass waste by one-third, but also produce soil conditioner for gardening. DSD plans to fully promote such simple, safe and cost-effective means for zero green waste.

Pilot trial on reuse of green waste

Trim the grass by the river

Pile the grass clippings in an open enclosure for decomposition by micro-organisms

Soil conditioner is formed

The grass clippings are decomposed into humus
Chapter Four  Innovative Thinking of Blue-Green Infrastructure

Experience sharing on conserving endangered species

Since joining DSD as an engineer in the Drainage Projects Division in 2011, Ir Chan Hak-keung has been aware that DSD values environmental protection and ecological conservation. He pointed out that DSD applied green concepts and closely liaised with green groups during the project design and construction stages. DSD would adopt specific measures to preserve the environment when necessary.

The project team for the recent river works in Tai Po observed that Lam Tsuen River and the streams at Kau Lung Hang were the habitats for two rare species, namely Hong Kong Newt (formerly known as Hong Kong Warty Newt) and Acrossocheilus parallens. In the end, the project team caught them by hands for translocation to ensure that these rare species would not be affected by the works, of which Ir Chan was deeply impressed.

To further enhance staff awareness of environmental and ecological conservation, DSD particularly invited a number of green groups to co-organise training courses concerning ecology of urban stream. During the courses, Ir Chan shared his experience in river training works and ecological conservation. He planned to incorporate more ecological conservation elements into river training works in the future, so that the drainage facilities would not only be for flood prevention, but also for ecology and environmental protection.

Acrossocheilus parallens (left) is a rare freshwater fish species in Hong Kong. To protect this precious species, DSD staff, prior to the river improvement works at Kau Lung Hang, translocated them to a tailor-made temporary fish tank, and upon completion of the works, released them back to the streams.
Preserving the meanders

Meandering watercourses favour the breeding of many aquatic species and attract various birds to forage and roost. Therefore, for the river training works in recent years at Shenzhen River, Ng Tung River, Sheung Yue River and Kam Tin River, etc., meanders were deliberately preserved and modified for better use, resulting in reliable water supply and thus protecting river ecology.

Creating wetland

While constructing the Yuen Long Bypass Floodway in 2003, DSD combined a few abandoned fishponds in the vicinity to form an engineered wetland as compensation for the ecological impacts of the works. The wetland, seven hectares in area (as large as ten standard football pitches), has nurtured many plant species. The purposely built ponds of varying depths attract various species to stay. There have been records of 118 bird species, 21 dragonfly species, 30 butterfly species (with 7 of which being rarely found in Hong Kong), 7 amphibian species and 4 reptile species in the wetland since its completion.
What is wetland?

In general, wetland is where land and water meets. According to the Ramsar Convention signed in the Iranian city of Ramsar by a number of countries on 2 February 1971, wetland means marsh, fen, peatland or inundated land, whether natural or artificial, permanent or temporary, with water that is flowing or static, fresh, brackish or salty. Wetland even includes coastal areas with water depth less than six metres at low tides.

The Ramsar Convention (also known as the “Convention on Wetlands”) is the first international treaty on wetland protection. Its official name is “The Convention on Wetlands of International Importance especially as Waterfowl Habitat“. The Convention, with its scope already covering all aspects of wetland conservation, aims to promote national and international work on conservation and wise use of wetlands. It came into effect in 1975 and it had a total of 168 contracting parties as at April 2014. China effected the Convention on 31 July 1992, and at present has a total of 41 Ramsar sites with an area of 3.7 million hectares³.

Most wetlands in Hong Kong are in the Northwestern New Territories. They include rivers and streams, natural marshes, mangrove forests, intertidal mudflats, man-made fishponds, “gei wai” (traditional shrimp ponds) and ponds⁴. Among them, a wetland of 1,540 hectares in Mai Po, Inner Deep Bay in the Northwestern New Territories was listed as a Ramsar site on 4 September 1995.

Wetlands not only provide habitats and feeding grounds for different species, but also offer values for water retention, flood prevention, ecology, economy and recreation. For example, they provide sites for fishponds and hydroponics; and they can be open for bird watching, wildlife photography, fishing and other public activities.

DSD applied the concept of sustainable water use in the engineered wetland design to provide a sedimentation pond, crushed brick field and oyster shell field for water purification. Specifically, water from Yuen Long Bypass Floodway first passes through the sedimentation pond, allowing solid particles such as sand and grit to settle. The supernatant then enters the crushed brick field and oyster shell field for natural filtration and purification before being diverted into four separate reedbeds, where the reeds further absorb the nutrients in the water to inhibit red tide. These natural purification facilities have no doubt greatly improved the water quality of the engineered wetland.
Chapter Four  Innovative Thinking of Blue-Green Infrastructure

Nam Sang Wai River Education Trail

Various bird species roosting in Nam Sang Wai

Route maps of Nam Sang Wai River Education Trail

DSD believes that the environmental features of many completed river projects can help raise the public awareness of environmental protection. The launched scheme, Nam Sang Wai River Education Trail, is a case in point. It comprised the erection of information boards along Shan Pui River, Kam Tin River and Yuen Long Bypass Floodway to explain the background and purposes of the river improvement works. This has on one hand enabled the public to take self-guided tour along the trail, and on the other hand served as an education platform for the public to learn about DSD’s work on flood prevention, environmental protection and conservation. The setting up of facilities for the guided tour was completed in autumn 2014 to provide the public with a trail suitable for excursion and environmental education.
An interview with Dr Cheng Luk-ki, Division Head of Scientific Research and Conservation of Green Power

Dr Cheng Luk-ki, Division Head of Scientific Research and Conservation of Green Power, advised that Green Power had been promoting environmental education, as it believed that education was the most fundamental way to change human perception and behaviour. River conservation has been a major task for Green Power over the past six years. By means of organising workshops for teachers and publishing teaching kits, Green Power has raised the education sector’s awareness of river conservation in Hong Kong. In recent years, realising that the public have only limited understanding of the rivers across the territory, Green Power has particularly stepped up efforts to introduce to the public the wholistic concept of local rivers.

DSD launched the Nam Sang Wai River Education Trail. Its purpose is to educate the public about river training and conservation works mentioned through the information boards provided at the popular outing spot at Nam Sang Wai. Green Power pointed out that the purpose of the Trail is in line with its mission and is thus very worth supporting.

Dr Cheng added that the rivers in the vicinity of Nam Sang Wai are the ideal locations for field trips on local river conservation works. At this place, the public can learn about the river training measures adopted at different stages of development, e.g. river sections with concrete lining constructed in the early years, river sections with grasscrete, gabions and the like as conservation measures, and river sections with restoration of the original riverbeds. Dr Cheng believes that the Trail helps the public understand the concept of river basin and perceive that river conservation not only covers the flowing water, but also the nearby lands. Due to the development of neighbouring lands along the watercourses with more concrete pavements, the natural land drainage capacity has been greatly reduced, resulting in greater surface runoff and flood risk. In addition, sewage improperly discharged into stormwater drains or watercourses will pollute rivers and coastal waters, endangering the ecology and human health.

Dr Cheng hopes that the Nam Sang Wai River Education Trail promotes environmental education and encourages the public to be conscious of their lifestyle and environmental conservation.
Mangrove management

Mai Po, adjacent to Inner Deep Bay in the Northwestern New Territories, has been designated under the Ramsar Convention as a Wetland of International Importance. It is the largest natural wetland in Hong Kong and the sixth largest mangrove forest in China. Every winter, the dense mangroves attract tens of thousands of migratory birds, including black-faced spoonbills, to stop over or stay. However, some mangroves at the Shan Pui River estuary and the Tin Shui Wai Nullah outlet hinder the normal flows, posing a higher flood risk to Yuen Long and Tin Shui Wai. In view of this, DSD has implemented the Mangrove Management Plan to strike a balance between flood prevention and ecological protection.

As early as 2002, DSD pruned the mangroves at the mouth of Shan Pui River. To ensure that passage bird migrants would remain unaffected, the pruning was scheduled outside the migration period (i.e. from November till March next year). Also, to keep the mangroves intact, DSD from time to time reviews the pruning operation. Normally, it only involves the common mangrove species and is limited to the trunk above the mud, leaving the roots intact. Normally, the affected mangroves will fully recover in five years.

DSD plans to commence another round of mangrove pruning in summer 2015. To ensure that the Mangrove Management Plan will not bring significant ecological impacts to the environment, it is necessary to conduct the environmental and ecological baseline studies in advance to record, inter alia, the species, growth and distribution of mangroves found near the Shan Pui River estuary and the Tin Shui Wai Nullah outlet, as well as the species, population and active season of inhabitants in the vicinity. The studies are near completion and the findings will facilitate the planning of the next round of mangrove pruning and formulation of environmental and ecological mitigation measures.
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Ecological importance of mangroves

Dense mangroves provide habitats, breeding grounds and shelters for various species (including the common fiddler crabs and mudskippers), attracting birds to forage. Fallen leaf fragments are the food for aquatic species such as fish, prawns, shellfish, crabs and the like, or necessary plant nutrients upon decomposition by microorganisms. Furthermore, mangrove roots can absorb the inorganic substances in the water to improve water quality, hold the soil in place and slow down the water flow to expedite silt sedimentation. This on one hand favours the formation of new land at the estuary and on the other hand spares the embankments or coastline from wave erosion. Mangroves serve as natural barriers to winds and waves, preventing flood in coastal areas. The biodiverse ecological environment of mangroves not only helps maintain the yield of coastal and inshore fishery, but also acts as a scenic outdoor classroom and forms an eco-tour route for the public.
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Constructing an ecological water storage basin

To address the flooding problem on both sides of the Shenzhen River, the Hong Kong Special Administrative Region Government and the Shenzhen Municipal Government have set up the "Joint Working Group on Regulation of the Shenzhen River" designated for implementing the Shenzhen River Regulation Project. DSD has closely collaborated with the Shenzhen Municipal Government for the planning, design and construction of relevant works to alleviate the flood risk, improve the river environment and enhance the navigation. Stages 1 to 3 of the Project were completed. Originally stretching about 18 km in length, the Shenzhen River, after straightening, widening and deepening, was shortened to 13.5 km with a new look.

The Project places much emphasis on heritage conservation. Carried out in 2003, Stage 3 of the Project entailed reconstruction of the Lo Wu Railway Bridge built in 1945. Given its exceptional historical value, the two governments decided to preserve the Bridge as a relic. To ensure no damage to the Bridge, the project team used a system of pulley and trolley to relocate the Bridge from the former site to the vacant land adjacent to the Lo Wu Railway Station by the Shenzhen River.

The conservation work for Stage 4 of the Project will be more comprehensive. While the primary objective is to enhance the flood protection standard of the Shenzhen River, the ecological value of the River will be upgraded by the adoption of eco-channel design. Instead of the conventional straightening approach, the proposed river alignment will follow the original topography and natural flow direction as much as possible. Various ecological and environmental elements will be blended into the works. They include ecological revetments, green embankments, natural riverbed, water and soil stabilisation, etc. These measures will reduce silting downstream and, in tandem with relevant sewage interception projects, reduce the pollution loads to the River.

Besides, the existing meanders along the River will be retained as far as practicable to provide a natural habitat suitable for flora and fauna. The largest meander will be converted into an ecological water storage basin occupying an area of 22 000 m² with a capacity of 80 000 m³ for stormwater diversion and downstream flow control during rainstorms.
Mudflat and wetland will be constructed at the water storage basin. For the landscape design of the water storage basin, the project team, taking into account the unique features of the site as well as the planned land uses of nearby areas, decided to use aquatic plants for preventing riverbank erosion, purifying the water and protecting water resources. Also, landscaping will be implemented at the riparian zone to provide habitats for flora and fauna, and establish a natural riparian ecosystem fostering the natural development of the environment.
Proposed urban stream

Without compromising the drainage performance, DSD plans to apply the novel concept of “urban streams” by integrating more ecological and water features into future river works in Hong Kong. By doing so, the new or existing drainage facilities will enhance the aesthetic of the nearby environment and mitigate the heat island effect. DSD is working on the designs for the revitalisation of Tsui Ping Nullah in Kwun Tong and the Rehabilitation of Yuen Long Town Nullahs to further improve the existing drainage systems and provide a better living environment for the public.
Revitalisation of Kai Tak River

The existing Kai Tak Nullah was formed with several streams in the vicinity of Wong Tai Sin after continual development and evolution of the community.

The name “Kai Tak” was originated from “Kai Tak Bund” in Kowloon City District in the 20th century. In 1920, Kai Tak was developed into a residential area called Kai Tak Bund under the first stage of Kai Tak Reclamation, in which the then existing streams nearby were also merged into Kai Tak Nullah and extended to the waterfront. Kai Tak Bund was redeveloped into Kai Tak Airport in 1930. During World War II, buildings in the vicinity of Kai Tak Airport were demolished for airport expansion and the alignment of Kai Tak Nullah was therefore changed. In the late 1950s, the Nullah was still under extension in line with the urban development.

After the relocation of the Hong Kong International Airport to Chek Lap Kok in 1998, the Government determined to take forward the Kai Tak Development at the ex-Kai Tak Airport site, including Kai Tak Nullah, to make the area an ideal leisure place and park for public enjoyment. DSD proposed to put the concept of sustainable development into practice by incorporating ecological elements into the works for Kai Tak Nullah in order to transform it into an urban green river corridor – Kai Tak River.

Although Kai Tak Nullah is not a natural watercourse, its improvement works have adopted the design with fish shelters and natural boulders with reference to the views of the World Wide Fund for Nature and the successful experience of the Ho Chung River Improvement Project in Sai Kung. Various landscape, greening and ecological features have also been included in the design. Kai Tak River will be revitalised into an attractive urban green river corridor for public leisure.⁶
An artist’s impression of the cross-section and elevation of the Kai Tak River after revitalisation. Taking up the suggestions put forward in the public engagement exercise on Building our Kai Tak River, DSD will not only enhance the flood prevention capacity of the River, but also make it a pleasant urban green river corridor.
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Green infrastructure

In Hong Kong, the dense urban high-rises, the lack of green space, together with emission of hot air from the skyscrapers' air-conditioning systems and the solar heat absorbed by concrete road surfaces, tend to give rise to an urban temperature higher than the surroundings and result in the heat island effect. Greening at DSD's premises has not only improved the cityscape, but also helped cool the building roofs during hot summers, save energy, relieve the urban heat island effect and improve air quality.

Between 2013 and 2014, DSD planted more than 2,100 trees and 320,000 shrubs at its facilities and provided additional green roofs with a total area of 4,900 m² for its existing premises.
In recent years, DSD has further enhanced its greening works by collaborating with various local universities to study and explore new greening modes, gradually extending the ground level planting area vertically. There are two main types of skyrise greening, namely roof top greening and vertical greening. They require small footprint and are hence particularly suitable for implementation in the densely populated urban areas of Hong Kong.

An interview with Professor Jim Chi-yung from the University of Hong Kong

Professor Jim Chi-yung, Chair Professor of the Department of Geography of the University of Hong Kong, reckoned that greening can improve the city environment and help develop a liveable city. Plants give a scenic view, as well as mitigate the heat island effect, filter out dust and some pollutants, and improve air quality.

Professor Jim proposed to modify Hong Kong’s green space planning by adoption of an innovative skyrise greening approach, namely green building. As he pointed out, plants can provide buildings with a protective layer to block the sunlight and rain, reduce the damage due to temperature difference, help extend the building life cycle and indirectly cut down the maintenance cost and waste generated from maintenance works. Professor Jim believes that green building is particularly suitable for implementation in Hong Kong as the horizontal platforms of buildings can be converted into green roofs or podiums, while the vertical sides can accommodate climbing plants for developing into green walls.

Professor Jim has been working with DSD to carry out a vertical greening study since 2009, using the exterior walls of four large circular sludge storage tanks at the Sha Tin Sewage Treatment Works to trial plant various climber species to identify those fit for vertical greening in Hong Kong. Given the different effects under varying exposure to the sunlight, the exterior walls of these tanks facilitated the testing on suitable plant species and the cooling effect of green walls. Before commencing the study, Professor Jim and his team selected from literature some climber species (mainly evergreen and perennial plants) that survive better under local soil conditions and climate, and then considered their features like growth height, flower colour, etc.

Having collaborated with DSD for more than three years, Professor Jim is convinced that DSD highly values greening and actively promotes it. He hopes that DSD will take the lead to share with different sectors in Hong Kong its successful experience in greening works and promote green buildings in the territory. Professor Jim’s vision is to gradually transform the bustling downtown into green belts, making Hong Kong a liveable city conducive to biodiversity.
Trial greening with “3+1 Approach”

DSD is carrying out a trial greening project with “3+1 Approach” at Sha Tin Sewage Treatment Works. The Approach is a combination of three greening modes, namely at-grade planting, green roof and vertical greening using reclaimed water for irrigation. The irrigation system is equipped with rainwater and soil humidity sensors to help reduce water consumption and practise environmental protection. This is an important one step forward to make Hong Kong a green city.

At-grade planting

DSD considers that greening should not be limited to green plants and has therefore hand-picked various plant species, enabling the sewage treatment works to provide seasonal garden views and blend with the surrounding nature for landscape improvement. For instance, DSD planted 2300 trees and 520 000 shrubs at Sha Tin Sewage Treatment Works to-date.
Green roof

Green roof refers to the provision of vegetation cover atop a building to revitalise the area into a scenic green belt with colourful plants and create a pleasing environment for residents in the vicinity. By now, the green roof area at Sha Tin Sewage Treatment Works has reached 4000 m² with a total of nearly 120000 ground cover plants of 11 species with varying colours, including Lily Turf, Hairy-leaved Sword-fern, Perennial Peanut, Dwarf Oyster Plant, Smooth Joyweed and Jaburan Lily-turf.

Workflow of roof greening

- Original roof composite layer
- Install root barrier
- Install drainage
- Install water reservoir panel
- Place planting soil
- Plant vegetation cover

DSD is working with the Hong Kong Polytechnic University to study the effectiveness of green roofs in reducing surface runoff and the impacts of gales on green roofs. The findings of the study are expected to provide reference for the design, development and maintenance of greening systems in other Asia-Pacific regions.
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Vertical greening

Vertical greening refers to either planting at-grade or on elevated planters to create greenery on the vertical surfaces of a structure. Since June 2009, DSD has been collaborating with the University of Hong Kong to carry out a vertical greening study on the exterior walls of four sludge storage tanks at Sha Tin Sewage Treatment Works. The study was completed in March 2013, recording the growing nature and cooling effect of a total of 20 climber species in 30 months. The findings are as follows:

Impacts of environmental factors on climbers

- Climbers growing in the south and west quarters perform better.
- Plants growing in improved soil are taller.
- Bauhinia corymbosa and Pyrostegia venusta relying on mesh system perform better.

Growth and performance of 16 climber species

- Among the species relying on mesh system, Quisqualis indica and Wisteria sinensis perform the best.
- Among the self-climbing species, only Parthenocissus dalzielii performs satisfactorily.

Cooling effect

- The temperature can drop by 7°C in summers for buildings with exterior green walls.

The area with vertical greening at Sha Tin Sewage Treatment Works has reached 3000 m² so far. Findings of this study will be highly conducive to future greening projects. As vertical greening facilities are easy to install and maintain with sound greening effect, DSD will add vertical greening elements to new projects and existing facilities.
New spot for greening trial: Pilot vertical greening in caverns

Indoor vertical greening can beautify the interior environment and improve air quality. In recent years, DSD has been studying the feasibility of indoor vertical greening. A trial scheme was launched at the Stanley Sewage Treatment Works in caverns in January 2013. At present, an indoor vertical green wall of more than 60 m in length with five different vertical greening systems can be found inside the caverns. The performance and cost-effectiveness of relevant plants are currently under review, and the feasibility study is expected to complete in mid-2015.

Building Environmental Assessment Method Plus

Apart from greening its existing facilities, DSD is dedicated to developing green buildings. Assessments under the Building Environmental Assessment Method (BEAM) Plus have been carried out for certain construction works. The stormwater pumping station and the fan room with green building design under the Happy Valley Underground Stormwater Storage Scheme, the Kowloon Bay Sewage Interception Pumping Station, and the Kowloon City Sewage Pumping Stations were awarded the Provisional Platinum rating under BEAM Plus by the Hong Kong Green Building Council on 8 January, 28 January and 24 March 2014 respectively. Besides, the Stonecutters Island Sewage Treatment Works is at present under assessment.
Building Environmental Assessment Method Plus certification

BEAM Plus certification is a comprehensive assessment scheme tailor-made for Hong Kong to rate the environmental performance of a building. It stipulates various assessment criteria mainly in respect of the environmental sustainability of buildings in five areas, namely (1) site aspects; (2) materials aspects; (3) energy use; (4) water use; and (5) indoor environmental quality.

For the purpose of accrediting its green buildings, DSD will adjust and improve their performance at the construction stage. Take the two sewage pumping stations in Kowloon City as an example, porous grass paver with infiltration function was used to pave the carriageways and rainwater harvesting systems were installed to increase the green coverage and save irrigation water.
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Carbon reduction and energy saving

To protect the environment, alleviate the greenhouse effect and promote sustainable development, DSD has been endeavouring to strengthen its energy management and emission control in recent years. Since the establishment of the Energy and Emission Management Team in 2007, DSD has adopted numerous energy-saving and emission-reduction measures, e.g. the use of renewable energy and biogas (produced in sewage treatment process) to generate electricity, and the introduction of high efficiency sewage treatment technologies to reduce the need for fossil fuels. Since 2008, DSD saved in total over 11 million kilowatt hours (kWh) of electricity and reduced about 7700 tonnes of carbon emission.

![Statistics on electricity saving by DSD in recent years](image)

Carbon emission and local climate change

Over the past five decades, carbon emission has been on a rising trend, affecting the global climate change. The rise in global average temperature has been about 0.13°C every decade. Relevant data from the Hong Kong Observatory showed that the temperature in Hong Kong for the last 50 years was persistently high and exhibited an upward trend. The rising temperature has brought unstable weather with more typhoons and tropical cyclones, resulting in potential adverse effect on Hong Kong.

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High efficiency sewage treatment technologies

The sewage treatment process is highly energy-consuming, hence its optimisation is one of our priority research focuses. In these years, DSD has been seeking out and developing more energy-saving sewage treatment technologies including, inter alia, co-settling technology and SANI Process to boost the sewage treatment efficiency for electricity reduction and prevent the emission of greenhouse gases such as carbon dioxide during electricity generation to ease the global warming problem.

Co-settling technology

Co-settling technology is an environmentally friendly sludge treatment process developed by DSD. The principles involved are to return a portion of the surplus activated sludge after secondary biological treatment back to the primary sedimentation tanks. This technology saves time and energy for sludge processing, as well as produces more biogas for electricity generation.

Since implementing the environmentally friendly sludge treatment process of co-settling, Sha Tin Sewage Treatment Works is managed to save 6.6 million kWh of energy each year. Regarding environmental protection, this process has reduced about 4,600 tonnes of carbon emission, amounting to the total annual carbon absorption by about 200,000 trees. It has also reduced 700 tonnes of solid waste which would have otherwise been transported to landfills for disposal. It is noteworthy that this process, with a payback period of only two weeks, is highly cost-effective.
SANI Process

SANI (stands for Sulphate reduction, Autotrophic denitrification and Nitrification Integrated) Process is a novel energy-saving sewage treatment method. Traditional secondary sewage treatment process uses micro-organisms to decompose organic substances in the sewage, requiring high oxygen consumption to remove the nutrients in the sewage for purification. Yet, the drawback is that micro-organisms have a short life cycle and therefore a large amount of sludge has to be transported to landfills for disposal.

As for SANI Process, it uses sulphate in seawater as the medium for the sulphate reducing bacteria to oxidise and eliminate pollutants. Owing to the slow bacterial growth, it can largely reduce sludge production, save the cost and space for sludge treatment process and help reduce greenhouse gas emissions.

The widespread use of seawater for toilet flushing in Hong Kong creates exactly the environmental conditions required for SANI Process. Since 2007, DSD has been working with the Hong Kong University of Science and Technology to carry out trial tests on SANI Process at the Tung Chung Sewage Pumping Station. Test results indicated a reduction by 90% in sludge production, by 35% in greenhouse gas emissions, and by 50% in the cost. DSD plans to conduct a large-scale test on SANI Process at Sha Tin Sewage Treatment Works which is hoped to be widely used in Hong Kong within five years.
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Renewable energy

To reduce both the greenhouse gas emissions and fossil fuel demand, DSD has been trying out different energy-saving measures, including the use of renewable energy. Renewable energy refers to non-fossil fuels which could be regenerated naturally. Currently, DSD harnesses solar power, biogas and wind power as renewable energy sources, which generate electricity without greenhouse gas or air pollutant emissions and are therefore cleaner. This has the dual advantages of requiring less fossil fuels and saving electricity on one hand, and preventing the exacerbation of global warming on the other.

Biogas

Biogas (commonly known as “marsh gas”) is produced in the sewage treatment process at secondary sewage treatment works. It is a combustible gas mixture which will intensify the greenhouse effect if directly emitted into the air. In view of this, DSD installed a dual-fuel generator with an output capacity of one megawatt at Sha Tin Sewage Treatment Works as early as 1989 to recycle biogas as an energy.

DSD introduced in 2006 the first combined heat and power (CHP) generator at the Shek Wu Hui Sewage Treatment Works to further enhance the performance of electricity generation from biogas. The CHP generator, which only requires the combustion of a single fuel (like biogas) to generate electricity and heat simultaneously, helps raise the overall energy efficiency. Fuelled solely by biogas, the CHP generator emits less carbon dioxide and is hence more environmentally friendly than the dual-fuel generator in the early stage.

In 2013, considering the relatively small amount of sewage flow and biogas production at the Yuen Long Sewage Treatment Works, DSD installed at the plant a micro-turbine generator, the first of its kind in Hong Kong, for electricity generation from biogas. Since its operation, the system generates 108 000 kWh of electricity annually. As regards greenhouse gas emissions, there has been a reduction by some 76 tonnes in carbon dioxide emission, which is equivalent to the carbon absorption by about 3 300 trees in a year.
To date, DSD has installed biogas-fuelled generators, including biogas hot water boilers, dual-fuel generators, CHP generators and micro-turbine generators, at major secondary sewage treatment works. These facilities collectively generate electricity of 29 million kWh per year and reduce carbon dioxide emission by some 20,000 tonnes, amounting to the carbon absorption by about 870,000 trees in a year.
Solar and wind power

To further save energy, some DSD facilities have been equipped with renewable energy installations such as solar water heaters, solar photovoltaic systems, solar-wind power lamp poles, etc. For extensive use of renewable energy, DSD is planning to install a large-scale solar photovoltaic system with an electricity output capacity of 850 kW at the Siu Ho Wan Sewage Treatment Works. This system will be the largest of its kind owned by the Government and provide about 20% of the electricity required for the plant’s operation.

Hydroelectric power

Hydropower is another form of renewable energy. The principle is to drive the turbine and generator by the water level difference to produce electricity. In recent years, DSD has been working on hydroelectric studies. To prepare for the future implementation of suitable hydroelectric proposals, small hydro-turbines have been installed at the Stonecutters Island Sewage Treatment Works as a pilot scheme on hydropower application.
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Water management and sustainable drainage system

Use of reclaimed water

Global water resources are running short. For long-term protection of Hong Kong’s water resources, DSD proactively studies and develops sustainable water resources – reclaimed water, which is rigorously treated and disinfected effluent meeting the quality standard for reusable water. Currently, DSD applies two sewage purification technologies, namely membrane bioreactor and reverse osmosis, to further purify the secondary effluent to produce reclaimed water for non-potable uses.

With its micropores, the membrane bioreactor filters out most impurities such as suspended solids, sludge, bacteria and the like. Filtered water can serve non-potable purposes such as toilet flushing and irrigation. Reverse osmosis is a purification technology by which only water molecules can pass through the osmosis membrane under pressure. The quality of water purified by reverse osmosis fulfils the drinking water requirements of the World Health Organisation and the United States Environmental Protection Agency, and is close to the standard of distilled water on the market.
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Reclaimed water is clean and odourless. With trace nutrients (like phosphorus and nitrogen), reclaimed water for irrigation can facilitate plant growth and reduce the use of chemical fertilisers. At present, reclaimed water is used for non-potable purposes, e.g. facility cleaning, garden irrigation, toilet flushing, chemical dilution, make-up water for deodorisation systems, fire fighting, landscaping, etc.
Rainwater harvesting

Rainwater is a precious natural freshwater resource and yet a load to the drains. DSD is conducting rainwater harvesting trials to make the best use of water resources and reduce the drainage need at source. Rainwater collection equipment has been added to some drainage and sewerage facilities of DSD as an important reference for future exploitation of rainwater resources. The rainwater harvesting initiative is a pilot scheme, and the objective is to study how to reuse the rainwater collected from drainage tunnels and stormwater storage tanks. At present, projects under this pilot scheme include the Lai Chi Kok Drainage Tunnel and the Happy Valley Underground Stormwater Storage Scheme.

The stilling basin of the Lai Chi Kok Drainage Tunnel allows sedimentation of sand and grit in the rainwater to prevent blockage of the main tunnel. As the uphill rainwater intercepted by the drainage tunnel is cleaner, it can be reused simply after filtration and disinfection. The rainwater harvesting system can purify some 120 m$^3$ of rainwater in the stilling basin daily for toilet flushing, irrigation, cleansing, as well as street cleaning by the Food and Environmental Hygiene Department, ensuring the proper use of precious water resources.

DSD’s plan is to construct a groundwater and rainwater harvesting system under the Happy Valley Underground Stormwater Storage Scheme. With a capacity of 600 m$^3$ per day, the system will collect groundwater as well as irrigation water and rainwater from sports venues, then convey these waters to the untreated water storage chamber for purification and subsequent flow into the treated water storage chamber for future toilet flushing and irrigation.
Besides, the roofs of some sewage facilities can be utilised to collect rainwater, which is another way to exploit rainwater resources. To test the feasibility of rainwater harvesting, DSD has provided relevant systems at two sewage pumping stations in Kowloon City to reuse the rainwater for irrigation and water features. This on one hand saves drinking water and on the other hand reduces loads to the drainage system.

To implement rainwater harvesting, it is necessary to install a rainwater collection system on the roof for the rainwater to be diverted to the storage tank, then pumped to the sand filter where solid particles will be filtered out, disinfected with UV, and finally mixed with drinking water in the mixing tank. The main function of the mixing tank is to ensure supply to irrigation water in dry seasons with less rainfall.
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Reducing drainage loads at source

Alongside the above mentioned rainwater harvesting methods, DSD actively studies other sustainable drainage system options, including porous pavement to allow rainwater to permeate into the soil, ecological drainage system to provide green belts to collect, filter and purify rainwater by natural means, rain garden to create a green landscape, slow down the water flow and filter the rainwater, and water storage facilities to temporarily retain the floodwater and attenuate the flow rate and hence drainage loads at source. DSD endeavours to adopt sustainable drainage system designs to help Hong Kong effectively withstand the flooding menace amid the challenges of climate change.

Green management

For green management, DSD has specially established the Green Management Committee to formulate and review departmental policy on green management, set environmental objectives and targets, and monitor the effectiveness of relevant policy. Routine green work is monitored through seven integrated management systems. DSD also set up in early 2007 the Energy and Emission Management Team designated for improving the departmental energy and emission management. Specifically, it is responsible for identifying emission sources; implementing energy/emission reduction measures with benchmarking; conducting carbon audits and preparing reports; and sharing experience. During 2012–13, DSD made much effort in environmental protection for facility operation and construction works. For example, in late 2012, DSD conducted two extra carbon audits for the Stonecutters Island Sewage Treatment Works and the Tai Po Sewage Treatment Works to identify major emission sources of greenhouse gases and formulate measures to reduce greenhouse gas emissions. Regarding energy saving, DSD has saved 1.3 million kWh of electricity. DSD also used renewable energy to generate electricity such that the utilisation rates of biogas were 79%, 90% and 80% in 2011, 2012 and 2013 respectively. By doing so, fossil fuel consumption and carbon emission could be reduced.

DSD is committed to taking care of the environment, protecting the ecology and safeguarding public health for sustainable development while delivering its projects and services. For better quality services and minimum environmental impacts of its facilities and systems, DSD is dedicated to:

- Adopting state-of-the-art clean technologies and pollution prevention measures;
- Incorporating sustainability considerations into the design, construction and operation of its facilities;
- Minimising and mitigating adverse environmental impacts of its construction works and facilities;
- Meeting all statutory and regulatory requirements on environmental performance that are applicable to its activities; and
- Planning and conducting internal operations in a consistent, environmentally responsible manner.
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Meanwhile, DSD will ensure that its staff, consultants and contractors are clearly aware of its environmental policy, which is also open to public scrutiny. Staff at different levels are committed to upholding this policy. Relevant training will be provided and necessary resources allocated for its full implementation. In addition, staff with interest in green promotion are invited to form the Green Champions to convey green messages to colleagues in daily work, share successful experience and encourage and support co-workers to develop a more environmentally friendly working style. These contribute to higher energy efficiency and less carbon footprint, putting the concept of sustainable development into practice in the workplace.

ISO 14001 Environmental Management System

For better environmental management, DSD has launched the internationally recognised ISO 14001 Environmental Management System to manage the internal operation, set targets and indicators, implement plans to enhance the environmental performance and thereby bring long-term economic benefits to DSD. The three basic environmental policy requirements of ISO 14001 are (1) pollution prevention; (2) compliance with laws and ordinances; and (3) continuous improvement of the environmental management system.
Daily energy saving measures

DSD has introduced numerous energy saving measures in its daily operation, in order to manifest the green concept in the workplace. These measures include holding “paperless meetings” to save paper, installing LED lighting systems to save electricity, de-lamping unnecessary lighting, setting the office temperature at 25.5°C and promoting waste recycling and green transport. DSD is now trial using 11 electric vehicles (EVs) to reduce greenhouse gas (like carbon dioxide) emissions. As at March 2013, these 11 EVs travelled a total of about 600 km daily. The trial will facilitate future feasibility study on the extensive use of EVs.
Assessment on energy saving performance

To effectively assess the energy-saving performance, DSD follows the international practice to conduct carbon audits (also known as carbon footprints) to identify greenhouse gases and calculate their emissions for tracing major emission sources and formulating corresponding measures.\(^\text{10}\)

**Carbon audit**

Carbon audit is a systematic approach to identify and quantify the greenhouse gases emitted within a specific area. Various operating activities such as construction works, plant facility operation and the like, all consume electricity and fuels, generating carbon dioxide which will exacerbate the greenhouse effect and raise the global temperature. DSD’s specific procedures for carbon audits are as follows:

1. **Formulate a low carbon construction plan**
   - Include materials, energy, logistics, waste/water/greening

2. **Collect, verify and analyse data with site visit**

3. **Review the effectiveness of the planned measures**

4. **Conduct the audit**

5. **Prepare the report**

Throughout the carbon audit, DSD regularly collects data on greenhouse gas emissions and removals (scopes 1, 2 and 3 below) relating to the construction activities at construction sites:

<table>
<thead>
<tr>
<th>Scope</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope 1</td>
<td>Direct emissions and removals (i.e. emission sources directly related to construction activities such as combustion)</td>
</tr>
<tr>
<td>Scope 2</td>
<td>Energy indirect emissions (purchase of electricity or coal gas for construction activities)</td>
</tr>
<tr>
<td>Scope 3</td>
<td>Other indirect emissions (sewage treatment, water consumption, paper waste, as well as the transportation and production of materials bought from third parties)</td>
</tr>
</tbody>
</table>

* Scope 3 is incorporated into carbon audits for construction sites in all countries (including the United Kingdom, France and Sweden) except the United States.
Between 2008 and 2009, DSD conducted a feasibility study on carbon audit for its sewage treatment facilities and carried out the first annual carbon audit (also the first for sewage treatment works in Hong Kong) for Sha Tin Sewage Treatment Works. Lately, DSD has planned to extend the application of carbon audit to other sewage treatment works and construction works for stormwater drainage systems and sewage treatment facilities. DSD has identified two on-going projects, namely the Drainage Improvement Works in Pok Fu Lam Road, Mount Butler and Happy Valley, and the Upgrading of Pillar Point Sewage Treatment Works for trial assessment.

Since the implementation of carbon audits, environmental impacts of construction works and facility operation have been mitigated. To date, DSD has reduced in total 7700 tonnes of carbon dioxide emission, equivalent to the annual carbon absorption by about 330000 trees (which can fill up about 840 Hong Kong Stadiums). In addition, a number of sewage treatment works have been using biogas to generate electricity. DSD will continue to reduce carbon emission, improve and review the energy management policy for its sewage treatment works, promote full-scale energy saving, and put sustainable green initiatives into practice.
Cavern development

Hong Kong is densely populated and is lack of land. To optimise land supply, the Government has been taking every opportunity to explore different plans including cavern development. For instance, the relocation of Sha Tin Sewage Treatment Works to caverns is being considered in order to release the existing site for other beneficial uses and improve the community and environment.

What are the suitable development uses of caverns in Hong Kong?

Findings of the study on the Enhanced Use of Underground Space in Hong Kong completed by CEDD in 2011 suggest that, in terms of geology, caverns in Hong Kong are particularly suitable for various development uses. There are also many successful examples worldwide.

Hong Kong's first secondary sewage treatment works constructed in caverns: Stanley Sewage Treatment Works

Stanley Sewage Treatment Works came into operation as early as February 1995 to provide sewage treatment services for more than 27,000 residents of Stanley Peninsula, Tai Tam, Chung Hom Kok and Red Hill Peninsula. With a current daily capacity of 8,800 m$^3$, it has set a successful precedent for cavern sewage treatment works.

In designing the Stanley Sewage Treatment Works, DSD took account of factors such as carbon emission reduction, odour management and construction costs. Since the plant is built in a cavern, it requires particular attention to fire prevention, gas monitoring, ventilation and emergency evacuation facilities, etc. The Stanley Sewage Treatment Works integrates well with the surroundings, making it inconspicuous with no adverse visual impacts on the beautiful scenery of Stanley.
Sha Tin Sewage Treatment Works

DSD commenced the feasibility study on the relocation of Sha Tin Sewage Treatment Works to caverns in May 2012. In the study, besides making reference to the experience of the Stanley Sewage Treatment Works, DSD staff and its consultants conducted overseas visits to cavern sewage treatment works in Nordic countries such as Finland, Norway and Sweden, as well as underground sewage treatment works in Asian countries like Japan and South Korea.

Occupying about 28 hectares of land, Sha Tin Treatment Works is the largest secondary sewage treatment works in Hong Kong. It was put into operation in 1982 and has been equipped with UV disinfection system to improve the effluent quality with a current daily capacity of about 230,000 m$^3$.

The consultant undertaking this feasibility study confirmed that Nui Po Shan of A Kung Kok on the opposite shore to the existing Sha Tin Sewage Treatment Works is the best relocation site for the plant. In reviewing the proposed relocation site, the consultant has considered key factors including, inter alia, geology, impacts on the existing sewage collection and disposal system, land ownership, impacts on neighbouring environment and traffic network, etc.

To complement Tolo Harbour Effluent Export Scheme, Sha Tin Sewage Treatment Works discharges the treated sewage collected from Sha Tin and Tai Po into Victoria Harbour through the effluent tunnel and Kai Tak River.
Views of Mui Tsz Lam Village residents

According to Mr Ng Shui-ching, indigenous inhabitant representative of Mui Tsz Lam Village, the Village has gone through 15 generations and most villagers farmed for a living in the past. At first, Mr Ng and other villagers opposed the relocation of Sha Tin Sewage Treatment Works to Nui Po Shan because the Government did not consult them nor explain the project details and they were therefore very concerned about the subsequent odour and hygiene problems. Also, as the Village has only one carriageway, the villagers worried that construction vehicles would cause serious traffic disruption.
Later, DSD organised a number of public engagement activities for residents of nearby housing estates and villages to learn about the project details and progress, as well as successful overseas examples. Project consultants, engineers and other staff also held meetings with nearby residents to address their concerns. DSD also held public forum to gather public opinions and explain the proposed mitigation measures to be adopted during construction, e.g. interim traffic arrangements, construction vehicle routing, etc. Since commencement of the feasibility study, DSD has been carrying out consultation for two years.

Mr Ng attended a series of public engagement activities arranged by DSD and visited the Stanley Sewage Treatment Works accommodated in caverns. Although the plant has neither covers for the treatment tanks nor deodorisation units, the sewage flowing into the final sedimentation tank after secondary biological treatment is basically odourless, and there is no odour problem outside the plant. Given that there will be odour control measures at the relocated Sha Tin Sewage Treatment Works, Mr Ng expects no odour outside the plant and he no longer worries about the air quality issue too. Regarding the noise during construction, he believes that with advanced modern technologies, DSD should be able to implement proper mitigation measures outside the caverns and for outdoor works to prevent nuisance. Better understanding the relocation project now, Mr Ng has ceased opposing the relocation plan, and agrees that the existing plant site should be used for housing development to solve the land shortage problem.

Apart from Sha Tin Sewage Treatment Works, DSD also plans to start feasibility studies on relocating the Sai Kung Sewage Treatment Works and the Sham Tseng Sewage Treatment Works to caverns in August and December 2014 respectively, with a view to alleviating Hong Kong’s long-term land supply problem and improving the neighbouring community environment.
Chapter Four  Innovative Thinking of Blue-Green Infrastructure

Conclusion

Looking ahead, DSD will continue to conduct relevant studies and innovatively adopt “Blue-Green Infrastructure” design for drainage systems, with a view to promoting an urban drainage system with natural elements, community features and modernised functions being incorporated in a co-used setting. Proposals of “Blue-Green Infrastructure” take the form of flood retention lakes, porous pavements, river revitalisation, green roofs, sustainable drainage systems, etc. DSD will on one hand further explore the application of these proposals, and on the other hand work closely with relevant departments to make every effort to integrate the land use with the drainage master layout at the early planning stage, as well as to reserve land for more “Blue-Green Infrastructure” where practicable.

In designing river improvement works, DSD will take the opportunity to not only improve the rivers’ flood-carrying capacity, but also revitalise them with water features, landscaping and ecological concepts. The idea is to provide a green river corridor in the community for public enjoyment, with a view to achieving the objectives of revitalisation of water bodies, promotion of water-friendly culture, greening, beautification and better use of water resources.

Regarding sewage treatment and disposal, DSD has been devoted to reducing the water pollution problem with remarkable results. In recent years, DSD has also implemented a series of environmental management measures in response to global warming and environmental conservation issues. As for energy management, DSD is working to explore the use of reclaimed water and renewable energy, introduce energy-efficient sewage treatment technologies, conduct carbon audits and reduce greenhouse gas emissions at its sewage treatment works. In respect of land resources, DSD proposes to relocate some of its large-scale sewage treatment works to caverns to free up land for other community development purposes. These initiatives are all planned to promote the sustainable development of Hong Kong.
Chapter Four  Innovative Thinking of Blue-Green Infrastructure

2 Early drains around the world (such as Singapore, Korea and Los Angeles) were made of concrete.
8 Hong Kong Observatory. *Observed Climate Change in Hong Kong—Temperature*. Website: http://www.hko.gov.hk/climate_change/obs_hk_temp_e.htm Accessed date: 11 October 2013.

Fig. 1 was provided by courtesy of the Information Services Department.
Chapter Five  Community Sharing and Open-mindedness
To optimise plans for drainage and sewerage works, it is essential to consult different sectors of society. To this end, DSD endeavours to explain its project details through various channels to the public, District Council members, construction industry, green groups, etc., and hear their views to foster exchanges. Taking the Relocation of Sha Tin Sewage Treatment Works to Caverns project as an example, a variety of public engagement activities were organised for the community to learn about the project details and help enhance the works proposal. In addition, DSD arranges from time to time promotional events such as visits to its facilities, open days and eco-tours, allowing the community to have a deeper understanding of DSD’s work. DSD staff are also active in voluntary services to contribute to the community.
Public engagement

Boosting social development and harmony is the current global trend. To keep abreast of times, the Government has in recent years been promoting public engagement as a consultation approach and proactively establishing communication channels with the public. Also, government departments take initiative to contact community groups, gauge public views and formulate improvement plans through consultations to enhance local development.

Public engagement is a two-way communication that encourages the public to express their views. Through holding of various consultation activities, the Government on the one hand explains to the public its policy objectives, implementation process, implications, etc., while on the other hand responds to concerns of different sectors and considers public opinions. The objective is to reach consensus between the public and Government on the proposed plans and enhance the relevant measures.

DSD is committed to providing quality stormwater drainage and sewage treatment services for the public. As public comments are the key to enhancing its services, DSD spares no effort in hosting public engagement activities, local and international exchanges with the engineering industry, media briefings, visits to its facilities, and educational and promotional programmes to gauge opinions from all walks of life for achieving excellence in its projects. In addition, DSD staff are encouraged to participate in charitable and voluntary services of different kinds to contribute to the community.

DSD staff introducing the environmentally friendly sludge treatment process to the media
Receptive to suggestions

All drainage and sewerage works are closely related to our daily life. Therefore, DSD values the views of experts, industry practitioners and the public on its projects, so as to know about the concerns of the stakeholders and their expectations for drainage development. DSD liaises with the media to keep the public and construction industry abreast of its latest activities. It also holds inter-departmental seminars to study issues of common concern and identify solutions. Besides, seminars, sharing sessions and forums are also organised each year to bring together experts of the industry for exchanging ideas about the latest developments and future trend of drainage services. Furthermore, DSD endeavours to keep in contact with local communities, District Council members and green groups to collect their opinions on drainage and sewerage projects as well as development strategies through established communication channels.

DSD appreciates that its large-scale projects attract public concerns. Hence, it will, throughout the planning, construction and post-completion stages of a large-scale project, conduct various kinds of public engagement activities such as consultation meetings, focus group meetings, seminars, progress briefings and the like, to keep in contact with relevant stakeholders, explain the project details and hear their opinions for formulating effective mitigation measures and more suitable works proposals. To maintain good interaction with the stakeholders for better exchanges and communication, DSD will invite them to visit its facilities and learn more about the facility operation.

Release of departmental information

To update the public about its work, DSD often arranges media briefings, interviews and visits to increase operational transparency and address public concerns.

DSD and the media

Ir Daniel Chung Kum-wah, the then Director of Drainage Services, outlined the latest progress and shared views on flood prevention works at the Annual Media Briefing 2014. DSD also organised a media visit to Lai Chi Kok Drainage Tunnel and Butterfly Valley Road Pet Garden built atop the stilling basin of the Tunnel.
Chapter Five  Community Sharing and Open-mindedness

Exchanges with local communities

Attaching great importance to local views, DSD, very often, sends its staff to attend District Council meetings to hear district representatives’ views on strategy planning. Between 2012 and 2014, the Director of Drainage Services attended meetings of the District Councils of Sai Kung, Kwai Tsing, Sha Tin, Tuen Mun, Tai Po, Yuen Long, Kwun Tong, Central and Western District, Wan Chai, Islands, and Southern District, to outline DSD’s work and report the latest progress of its projects in the respective districts. This did not only facilitate public understanding of DSD’s work, but also gave its staff more opportunities to solicit feedback.
Public engagement activities

Prior to planning of a large-scale project, DSD will seek public views to decide on the most suitable works option. Taking the nullah improvement works in Tai Hang as an example, DSD adopted the suggestion put forward by local communities to deck the nullah and widen and green the original pedestrian link. This design option eradicated the odour problem of the nullah, as well as created a comfortable promenade for the public. The new pedestrian link is named Fire Dragon Path, which refers to the Tai Hang Fire Dragon Dance, a local cultural activity that has been listed under the national intangible cultural heritage.
Revitalisation of Kai Tak River

In recent years, the water quality and ecological environment of Kai Tak Nullah have been greatly improved to the extent that it is even called by many as Kai Tak River. There are views that it should be revitalised into a green watercourse and unique attraction in the district. Thus, while implementing the improvement works for Kai Tak Nullah, DSD took the opportunity to invite the public to render their views, and to engage them in planning and design of the project.

Public engagement exercise on Building our Kai Tak River

Public engagement exercise on Building our Kai Tak River was carried out in two stages in the forms of focus group meetings, workshops, press releases, newspaper advertisements, pamphlets, posters and websites.

The stage 1 exercise took place in late 2010 with two Community Envisioning workshops for local communities so as to collect public views and suggestions on the design concept of Kai Tak River. For the stage 2 exercise launched in mid-2011, a Consensus Building workshop was held to solicit feedback from local communities on the river design theme and the riverside facilities, facilitating DSD to formulate a suitable design plan.

We learned from the two-stage exercise that the public had diverse views. Some argued that Kai Tak Nullah should remain undecked, while others considered that the Nullah should be turned into an attractive green river corridor integrated with the surroundings with additional pedestrian linkages across the river for convenient access.

With reference to the results of this public engagement exercise and the remarks made in subsequent District Council and local community meetings, DSD resorted to incorporate greening, landscape and ecological elements into the improvement works for Kai Tak River, thus enabling the River to prevent flooding while providing open space for leisure, education, community art and the like for the local community. Also, to match with the adjoining land development, the River has been planned as the cityscape axis to link and integrate the neighbouring old districts with the Kai Tak New Development Area.
Chapter Five  Community Sharing and Open-mindedness

Feasibility Study on Relocation of Sha Tin Sewage Treatment Works to Caverns

In the Feasibility Study on Relocation of Sha Tin Sewage Treatment Works to Caverns, DSD convened focus group meetings to exchange ideas with green groups and professional bodies, as well as public forums for participants to raise questions and express views on the project. The stage 1 public engagement exercise included a roving exhibition at 16 venues and 12 community centres or community halls in Sha Tin and Ma On Shan to explain details of the feasibility study and gather public opinions and concerns about the project by questionnaires. As regards the stage 2 public engagement exercise, DSD staged a roving exhibition and arranged visits for the public to the Stanley Sewage Treatment Works located in caverns (a successful precedent of its kind).

Interview with Ir Lai Cheuk-ho, the then Chief Engineer of Sewerage Projects Division

Ir Lai Cheuk-ho, the then Chief Engineer of Sewerage Projects Division at DSD, said that the public consultation on Relocation of Sha Tin Sewage Treatment Works to Caverns offered him a new insight about his work, viz. it is necessary for the project team to explain to the public the project details as part of the project planning. Since the commencement of the feasibility study in 2012, various impact assessments on odour, blasting vibration, traffic, etc. were conducted. Ir Lai added that before explaining the assessments to the nearby affected residents, community groups and organisations, it was necessary to collate the information and work out the presentation approach to address their concerns. The project team also fine-tuned the technical details of the works based on the opinions collected to better meet public expectations.
Happy Valley Underground Stormwater Storage Scheme

The construction site of the Happy Valley Underground Stormwater Storage Scheme is adjacent to both residential areas and recreation and sports venue (surrounded by the racecourse of the Hong Kong Jockey Club) frequently used by local residents, sports sector and schools. The site is only just one street away from neighbouring school. For this reason, listening to the views of stakeholders from all sectors is particularly crucial to the works. Prior to construction, the project team specially convened a consultation meeting on project impact and mitigation measures and invited representatives from relevant bodies such as the Hong Kong Jockey Club, the Hong Kong Football Club, nearby schools and residents, as well as the Leisure and Cultural Services Department (LCSD) to attend for discussion on traffic, noise and environmental impacts and formulation of the most appropriate mitigation measures.

Experience sharing on mitigation measures

According to the project team, a uniqueness of this project is that it involves a large number of stakeholders. Based on their views, DSD developed a range of mitigation measures, including strict regulation of working hours, use of low-noise construction technologies, provision of a material transport tunnel underneath the racecourse to minimise the impacts on horse racing and recreation ground users, erection of fences to protect the City of Victoria Boundary Stone, structural survey for St. Paul’s Primary Catholic School (a grade 2 historic building), tree protection with barriers, provision of green hoardings, etc. Since the commencement of construction, the project team has rarely received public complaints, and this reflects that the public engagement activities are highly effective in enhancing public confidence in the project.
Stakeholder involvement

In addition to arranging consultation activities for relevant stakeholders and the public, DSD also actively liaises and fosters exchanges with other public bodies and organisations.

Research & Development Forum

DSD values greatly the advice from the construction industry, experts and academics. To encourage collaboration amongst the Government, academia and industry in research and new technologies regarding stormwater drainage and sewage treatment services, DSD Research & Development Forum 2013 was held, focusing on four areas, namely Sustainable Drainage, New Engineering Contract (NEC), Greening and Wastewater Treatment. The Forum, attended by a great number of experts, was a four-day sharing of knowledge and experience. It contributed to further studies on the feasibility of applying novel technologies to drainage and sewerage works and facilities. The year 2014 marked DSD’s 25th anniversary. In celebration of this, the DSD International Conference 2014 was organised and academics from all over the world were invited to exchange views on various research topics.

Exchanges on environmental protection

Sustainable development is a new approach of environmental protection in the 21st century. To further raise the ecological awareness among engineering staff and explore feasible conservation plans for river training works, DSD regularly invites green groups such as the Green Power, the Conservancy Association, the Kadoorie Farm and Botanic Garden, and the World Wild Fund for Nature to its seminars, workshops and training courses for exchanges and discussion on common ecological issues and environmental impacts of DSD works. These communication platforms allow DSD staff to be more acquainted with relevant precautions during construction and ways to enhance conservation measures and further allowing their wider use in future projects.
Chapter Five  Community Sharing and Open-mindedness

Workshop on Ecological Consideration of Urban Stream

In 2012, DSD organised the Workshop on Ecological Consideration of Urban Stream to share with green groups its eco-channel design for drainage improvement works in Ho Chung, Lam Tsuen and Mui Wo, and to study the emerging concept of urban stream ecology in Hong Kong. Representatives from various green groups attended the Workshop by invitation to put forward their views and recommendations on protecting and enriching the river ecology.

Training course on urban stream ecology

In 2013, DSD invited several green groups to co-organise a training course on urban stream ecology to heighten its staff’s awareness of environmental conservation of streams. Representatives of green groups lucidly outlined to course participants the local river ecology and elaborated on common ecological issues and environmental impacts of local river training works. A field visit was also arranged to better illustrate to participants about relevant precautions for works carried out at natural watercourses and ways to enhance ecological measures.
Education and publicity

In 2013, DSD organised guided tours to the Tai Hang Tung Stormwater Storage Tank and several sewage treatment works for more than 3,300 visitors. To facilitate public understanding of DSD's work through interesting means and cultivate public awareness of environmental protection by cherishing resources, DSD, from time to time, holds seminars, open days and exhibitions, as well as establishes websites, publishes newsletters and produces publicity videos for projects.

Exhibitions

DSD launches public exhibitions at some of its facilities to present its sewage treatment methods, green measures, the Total Water Management programme and the like in an easy-to-understand approach. Besides, an exhibition is located at the San Tin Stormwater Pumping Station for showcasing the flood prevention strategy for the New Territories. Also, the Equipment Enclosure at the Lai Chi Kok Drainage Tunnel is open to schools and organisations for visits by appointment.
With thematic panels, 3D models, computer games, audio-visual materials, sample displays, etc., DSD presents the drainage information in detail. It also arranges guided tours for schools and community groups (by appointment) in which DSD ambassadors will explain the information and introduce plant facilities.
Open days
DSD stages open days for the public to learn about its work in stormwater drainage and sewage treatment, including green measures at its premises, various community involvement activities and a number of major infrastructure projects. DSD Open Day 2014 held at Sha Tin Sewage Treatment Works featured thematic guided tours, exhibitions, model displays, field visits, etc. This two-day event, attracting about 12 000 visitors in total, was well received.

Public seminars
DSD is keen on co-organising public seminars to explain its work to the public. For instance, as one of a series of activities under the Science in the Public Service Campaign 2013, a talk entitled Modern-day Dayu Tames the Water - Flood Prevention Strategy in Hong Kong was delivered to introduce DSD’s three flood prevention approaches, namely drainage conduits improvement, stormwater storage and stormwater interception, together with the flood control strategy adopted in Hong Kong and its effectiveness.
Participation in exhibitions

DSD often participates in different exhibitions in a bid to enhance public understanding of its projects. In 2012, DSD took part in the InnoCarnival held at the Hong Kong Science Park to brief the public about its Vertical Greening Study at Sha Tin Sewage Treatment Works and the Happy Valley Underground Stormwater Storage Scheme. Besides, at the Hong Kong Flower Show 2013 organised by LCSD, DSD displayed a floral exhibit entitled Kaleidoscopic Cavern to promote cavern development, which won the Gold Award for Design Excellence under Landscape Display category.

Outreach education

Every year, DSD launches the outreach education programme under which its staff will visit schools to publicise DSD’s work in flood prevention and sewage treatment. In 2013-14, DSD hosted talks for 26 secondary and primary schools, and were well received by students. In addition, DSD arranges various educational activities like slogan contests and drawing competitions for participating students to know more about DSD’s work.
Interview with Ms Kong Mei-fong, Community Relations Officer

Ms Kong Mei-fong joined DSD in 2010 as Community Relations Officer. Her main duties are to plan and coordinate public relations activities, handle media or public enquiries and complaints, collect and compile media coverage, as well as assist in producing DSD publications and publicity materials.

As a Community Relations Officer, Ms Kong is required to handle public and media enquiries. In general, upon receiving an enquiry, she will assess the priority and give a reply in compliance with the requirements of the Code on Access to Information within a reasonable time. For Ms Kong, the greatest challenge is to obtain the information and answer the public in a short time. Speaking of her unforgettable experience, Ms Kong mentioned that a person once came to DSD Headquarters to argue with DSD about a compensation for works. Ms Kong listened carefully to his requests and took appropriate follow-up actions, and was pleased to see the case being settled at the end. This made her realise the importance of DSD’s culture of “Do it from the Heart”, i.e. feeling for the others and be people-oriented.

Ms Kong recalled that before joining DSD, she was just like any other ordinary citizens with no knowledge of DSD’s work in flood prevention and sewage treatment, which is in fact closely linked with our daily life. She hopes that DSD will hold more diverse public relations activities in the future to let more people understand its work.
Eco-tours

To publicise the flood prevention projects for watercourses in the New Territories, DSD organised many eco-tours, allowing public access to the river areas to learn about the major flood control facilities and ecological conservation measures. Recently, DSD arranged the Yuen Long Bypass Floodway eco-tour for schools, in which DSD staff guided teachers and students around the San Tin Stormwater Pumping Station, the low-flow pumping station and inflatable dam of the Yuen Long Bypass Floodway, the engineered wetland, Nam Sang Wai and Kam Tim River to observe the river and wetland habitats at the field and learn about the design concepts of green channels and eco-channels.

Apart from eco-tours for schools, DSD is planning to launch the Nam Sang Wai River Education Trail. We believe that, upon launching, the Trail will become another public attraction with high ecological value and ample information about flood prevention.

Caring for the community

Adhering to its motto “Do it from the Heart”, DSD has been encouraging its staff to care for the community and contribute to society. A group of its staff formed the DSD Volunteer Team which proactively participates in various community services and charity events. For example, the Team co-organised the annual Blood Donation Day with the Hong Kong Red Cross to invite DSD staff to donate blood; held interest classes for the elderly; participated in other charitable fundraising activities; and responded to the Social Welfare Department’s "Hong Kong Citizen, Hong Kong Heart" Campaign by preparing handmade gifts for the elderly in residential care homes.
Conclusion

DSD has been all along providing the public with people-oriented quality services, be it the management of the daily operation of its stormwater drainage and sewage treatment facilities, or implementation of projects. Making every effort to perform better in flood prevention and sewage treatment services, DSD adopts a multi-pronged communication approach to consult stakeholders and take advice from different sectors for formulating the most suitable and cost-effective plan with various mitigation measures in place.

Fig. 1 was provided by courtesy of the South China Research Center, the Hong Kong University of Science and Technology.
Chapter Six  Recognition of Remarkable Performance
Drainage works aim to improve environmental quality and protect the public from flooding. To achieve this, DSD endeavours to adopt new concepts and approaches to improve the design in our works projects, bearing in mind the needs of all parties concerned. Several DSD projects win local and international awards in recent years for their innovative design and application of advanced technology. These award-winning projects include Happy Valley Underground Stormwater Storage Scheme which integrated new technology and environmental consideration, Lai Chi Kok Drainage Tunnel which achieved a number of technological breakthroughs, Relocation of Sha Tin Sewage Treatment Works to Caverns which saw wide public engagement, Harbour Area Treatment Scheme (HATS) which was designed to improve the water quality in Hong Kong, as well as Environmentally Friendly Sludge Treatment Scheme and Research Studies on Vertical Greening which both helped foster sustainable development.
Outstanding Drainage Projects

Since our establishment, DSD has been serving Hong Kong people with dedication for 25 years and striving for betterment of our services in flood prevention, sewage treatment, environmental protection and greening. The year 2013 saw fruitful achievements of DSD, with our works and research projects winning awards in several local and international competitions. Entering into 2014, DSD also won prestigious awards in the internationally renowned 2014 International Water Association (IWA) Global Project Innovation Awards Competition, including Winner in the Marketing and Communications Category and Honour Award in the Design Category.

Sewage Treatment

To tie in with the Government’s development strategy of better utilising land resources, DSD initiated the Relocation of Sha Tin Sewage Treatment Works to Caverns project. After a year of public engagement activities, we finally gained the support of the general public to this relocation project. The public engagement strategy adopted in the project brought DSD success in and was bestowed the Winner in the Marketing and Communications Category of both the 2014 IWA Global Project Innovation Awards and the 2014 IWA East Asia Regional Project Innovation Awards. In addition, DSD has implemented Sewerage Master Plans for different areas in the territory and the Harbour Area Treatment Scheme (HATS). The HATS was voted by Hong Kong people as the first runner-up in the poll of The Hong Kong People Engineering Wonders in the 21st Century organised by the Hong Kong Institution of Engineers, which was a remarkable achievement.

Relocation of Sha Tin Sewage Treatment Works to Caverns

Relocation of Sha Tin Sewage Treatment Works to Caverns is Hong Kong’s first project to relocate sewage treatment facilities to caverns. The objective is to release the existing site for other beneficial uses. To facilitate the residents living in the vicinity of the proposed relocation site to have a better understanding of the project, we invited them to visit the existing Stanley Sewage Treatment Works which was also located inside caverns, where the visitors could have first-hand experience of the effectiveness of the deodourisation facilities therein. In addition, DSD arranged a thematic website, newsletters, posters and mascots, and organised roving exhibitions, focus group and community group meetings as well as public forum to enhance public understanding of the relocation project and exchange views with the participants. The project gained international recognition and was named as the Winner in the Marketing and Communications Category of both the 2014 IWA Global Project Innovation Awards and the 2014 IWA East Asia Regional Project Innovation Awards. The Judge Panel of the latter considered that the “Experiential, Multi-platform and Iconic” approach adopted by this project had gone beyond traditional communication framework of engineering projects and acted as a good reference for planning of other similar “Not In My Back Yard” facilities in urbanised cities in the next decades.
Harbour Area Treatment Scheme

The HATS, which began in 1994, is the largest sewerage infrastructure project in Hong Kong, aimed at improving the water quality of Victoria Harbour. Under this scheme, sewerage infrastructures are constructed in stages to tackle the problem of water pollution brought along by urbanisation. Since the commissioning of Stage 1, over 600 tonnes of sewage sludge and associated pollutants have been prevented from entering Victoria Harbour every day, substantially improving the water quality of the eastern and central parts of the Harbour. With these achievements, the project was voted as the first runner-up in the poll of The Hong Kong People Engineering Wonders in the 21st Century. While Stage 2A is currently in progress, advance disinfection facilities of Stage 2A have now been put into operation which further improved the water quality and enabled the reopening of beaches in the Tsuen Wan region. Other construction works under Stage 2A are now in full swing and, upon future commissioning, could further enhance the water quality of Victoria Harbour.

Dynamically Adaptive Scum Collection System

In the past, sewage treatment works adopted traditional technologies to collect scum in sedimentation tanks. As the water levels inside the tanks are different in day and night time, sewage might be over-collected when the water level is high and this will in turn affect the volume of scum collection. DSD developed the dynamically adaptive scum collection system in recent years. Being applied at the Stonecutters Island Sewage Treatment Works, this system employs innovative information and communication technology by installing sensors to capture the real-time sewage level of the sedimentation tank, together with a dynamically adaptive data algorithm to optimise scum collection.

Hong Kong ICT Awards 2014: Best Innovation (Innovative Technology) Award Certificate of Merit

The Hong Kong ICT Awards 2014 was organized by the Office of the Government Chief Information Officer, and supported by the Hong Kong Productivity Council and the Hong Kong Trade Development Council, and co-organised by 10 trade associations and professional bodies in Hong Kong. The Awards aim to recognise, promote and commend exemplary innovations in ICT field, and to build a locally as well as internationally acclaimed brand of ICT awards. The Awards also encourage local practitioners to sustain momentum in developing innovative and creative ICT technologies.
Stormwater Drainage

Hong Kong’s complex landscape, uneven rainfall and unexpected heavy rainstorms all pose challenges to our work on flood prevention. With due consideration of the characteristics of Hong Kong, DSD formulates comprehensive flood prevention strategies, through dredging, stormwater storage and interception. Major storage and interception works have been carried out in the urban area. They included drainage tunnels in Hong Kong West, Lai Chi Kok and Tsuen Wan, as well as building of underground stormwater storage tanks at Tai Hang Tung, Sheung Wan and Happy Valley. Working together, these large-scale projects offer long-term and effective flood protection to Hong Kong’s urban area.

Lai Chi Kok Drainage Tunnel

The Lai Chi Kok Drainage Tunnel project adopted a number of innovative design and advanced technologies to successfully achieve “zero impact” to adjacent facilities and attain a commendable safety record of “zero decompression sickness”. These effective and innovative approaches earned DSD the Honour Award in the Design Category of the 2014 International Water Association (IWA) Global Project Innovation Awards, Winner in the Design Category of the 2014 IWA East Asia Regional Project Innovation Awards, and Merit Award of the Construction Category in the Innovation Award for the Engineering Industry 2012/13, presented by the Hong Kong Institution of Engineers. The IWA judging panel commended the project for its contribution to the promotion of sustainable development. For instance, a pet garden was built on top of the stilling basin of the drainage tunnel, utilising the scarce urban land resources. Rainwater collected in the tunnel is partly reused after purification, achieving efficient use of water resources.

2014 IWA East Asia Regional Project Innovation Awards

The Project Innovation Awards were established by the IWA to recognise excellence and innovation in water engineering projects around the world. Awards are presented in six categories: Applied Research, Design, Operations/Management, Planning, Small Projects, Marketing and Communications².
Chapter Six  Recognition of Remarkable Performance

Innovation Award for the Engineering Industry

The Hong Kong Institution of Engineers (HKIE) set up in Engineering Week 2013 the Innovation Award for the Engineering Industry to pay tributes to engineering innovators who dedicate their professionalism to improving the public’s quality of life by introducing original and transformative developments in engineering. Awards were presented in the categories of Construction, Industrial and Technology.

Representatives of DSD receiving the Merit Award in the Construction Category

Hong Kong West Drainage Tunnel

The Hong Kong West Drainage Tunnel project adopted several technical breakthroughs in the engineering sector of Hong Kong and overcame numerous problems during construction. The project won awards locally and internationally, including being named the Tunnelling Project of the Year 2011 at the International Tunnelling Awards. The project also obtained the third-highest vote by the public in the poll of Hong Kong People Engineering Wonders in the 21st Century.

International Tunnelling Awards

The International Tunnelling Awards are jointly organised by two British publications, namely New Civil Engineer and Ground Engineering. The objective of the awards is to recognise outstanding tunnelling projects worldwide. In 2011, the Awards received 74 entries and among them, Hong Kong West Drainage Tunnel was the only Hong Kong works project which was shortlisted and awarded by the judging panel. The project was commended by the judging panel as “a model tunnelling project, delivered under difficult circumstances”.

Representatives of DSD project team, consultants and contractor received the 2011 International Tunnelling Awards together
The Hong Kong People Engineering Wonders in the 21st Century

The Engineering Week 2013 was a major event organised by the HKIE. It included, inter-alia, a voting campaign named Hong Kong People Engineering Wonders in the 21st Century for the Hong Kong people to select their 10 favourite projects from 20 projects shortlisted by the HKIE. The purpose of the voting campaign was to enrich the public’s understanding of Hong Kong’s engineering projects on the one hand, and recognise the contributions of local engineers to sustainable development in Hong Kong on the other.

Experience Sharing in Drainage Tunnel Projects

Ir Tai Wai-man, Chief Engineer of the Project Management Division, opined that the drainage tunnel projects in Hong Kong West, Lai Chi Kok and Tsuen Wan each has its own characteristics. For the Hong Kong West Drainage Tunnel, it is the longest drainage tunnel in Hong Kong, linking up several residential areas. During its construction, raise boring machines were extensively used and tunnel boring machine (TBM) excavation and adit blasting were concurrently employed. In addition, the project team successfully overcame the problem of highly water-permeable fault zones composed of loose soil. Attributable to proper organisation of the workflow by the team, the works were swiftly completed within a short period of time, something that attracted much recognition from the engineering sector.

For the Tsuen Wan Drainage Tunnel, it has the highest discharge capacity. As it intercepts the flow of some natural watercourses, hence the tunnel was designed to ensure adequate flow in these watercourses in order not to affect the natural habitats therein.

Lai Chi Kok Drainage Tunnel was constructed underneath the foundations of many buildings and five railways including the Guangzhou-Shenzhen-Hong Kong Express Rail Link which was less than two metres above. In addition, as the tunnel routed across fresh granite and mixed ground and soil, innovatively we used TBMs which could excavate tunnels through both soil and rock strata. The project team also brought in hyperbaric pressure technologies during the construction. Ir Tai pointed out that DSD paid great importance on construction safety, and engaged overseas experts to come to Hong Kong to provide safety training and supervision, attaining the highest safety standard of zero decompression sickness at the end. This success has introduced a new way forward for the Hong Kong’s tunnelling industry.
Happy Valley Underground Stormwater Storage Scheme

Happy Valley Underground Stormwater Storage Scheme (HVUSSS) is Hong Kong's first application of Movable Crest Weir system with Supervisory Control and Data Acquisition. Owing to its innovative design, the project won in the Planning Category at the 2012 IWA East Asia Regional Project Innovation Awards. Also, it won a Merit Award in the Construction Category of the Innovation Award for the Engineering Industry presented by the HKIE.

The IWA judging panel commended the HVUSSS project for its uniqueness in planning, with adoption of various innovative environmental design. Besides serving the purpose of flood prevention, the project also pioneered in rainwater and underground water harvesting, targeting at reuse of water resources to meet the society's expectation of sustainable development. The HKIE commended the innovative design of the movable crest weir system which, together with the shallow tank design, enables substantial reduction of energy consumption by the water pumps. Such a design serves the dual objectives of flood prevention and environmental protection.

Financial Secretary—My Blog, posted on 6 April 2014 (Summary)

Hong Kong's Financial Secretary, Mr Tsang Chun-wah, John recalled that more than 10 years ago, heavy rainstorms always resulted in widespread flooding in Mong Kok, Sham Shui Po, Sheung Wan, North District and other districts. The flooding severely affected our livelihood and caused economic loss. Attributable to the commitment and years of efforts of DSD in upgrading our flood prevention infrastructure, the situation has improved significantly nowadays. Since its establishment in 1989, DSD has invested a total of $24 billion on 80 major flood prevention projects, reducing the number of flooding blackspots from over 130 to 11. Apart from the traditional methods of river improvement and diversion of stormwater, DSD adopted innovative methods in recent years, such as construction of drainage tunnels and stormwater storage tanks which effectively reduced the flood risk. Mr Tsang viewed the drainage tunnels as shields safeguarding downstream areas, while stormwater storage tanks allowed additional time for the diversion of stormwater. Both methods alleviated flood damage and protect human lives and economic activities in relevant areas. Mr Tsang emphasized the fact that Hong Kong's infrastructure is ranked No.1 among over 140 economies. Drainage infrastructure facilitated resumption of the normal public life after heavy rainstorms.
Research and Development, and Environmental Protection

Developing new technologies is the key to continual improvement of DSD’s services. DSD established a Steering Committee on Research and Development in 2001. The committee is responsible for coordinating the mapping out and implementation of research strategies. The Projects and Development Branch of DSD is responsible for exploring new technologies, and carrying out tests to assess their effectiveness. To strengthen the research and development, DSD also takes initiatives to cooperate with local research experts on different research projects with the objective of introducing new technologies to flood prevention, sewage treatment and green facilities in Hong Kong.

Environmentally Friendly Sludge Treatment Scheme

In recent years, DSD developed an innovative sludge treatment technology called the Environmentally Friendly Sludge Treatment Scheme Developed on Co-settling. The environmental efficiency of this innovative technology is very high. It can reduce the volume of solid sludge and produce additional biogas for electricity generation at the same time. The technology has won several local and international awards. They included an Honour Award in the Small Projects Category of the 2014 IWA East Asia Regional Project Innovation Awards, the Champion of the Technology Category in The Innovation Award for the Engineering Industry 2012/13 and the Certificate of Merit of the Green Innovations Awards, in the 2012 Hong Kong Awards for Environmental Excellence.

The then Director and representatives of DSD received the Honour Award in the Small Projects Category of IWA East Asia Regional Project Innovation Awards.

Representatives of DSD received the Champion of the Technology Category in The Innovation Award for the Engineering Industry 2012/13.

The 2012 Hong Kong Awards for Environmental Excellence- Green Innovations Awards

The Environmental Campaign Committee, together with the Environmental Protection Department and nine other organisations, jointly launched the Hong Kong Awards for Environmental Excellence. The Awards aim to encourage local organisations to promote green management and implement innovative environmental concepts in a sustainable manner. Four schemes are offered: Sectoral Awards, Green Innovations Awards, Environmental Labels and Carbon Reduction Certificates. Among them, the Green Innovations Awards Scheme serves to recognise achievements of green innovations with proven environmental benefits.
Studies on Sustainable Drainage and River Works

In recent years, DSD collaborated with experts to study sustainable drainage and river works. Our research study on revitalisation of urban streams\(^9\) received a Merit Award in the Hong Kong Institute of Planners (HKIP) Awards 2013. The adjudicating panel complimented the research team on their effort in fostering the engagement of local communities and non-governmental organisations in the study\(^{10}\). By researching into international guidelines on river revitalisation and paying visits to successful urban stream revitalisation projects in Seoul, Taipei, Singapore and Shenzhen, the study devised a set of guidelines for future revitalisation of urban rivers in Hong Kong.

**Greening Studies**

In recent years, DSD took the initiative to cooperate with several local universities on various greening studies. In 2012, DSD’s research study on green roofs and vertical greening at the Sha Tin Sewage Treatment Works won several awards:
- The Studies, Green Roofs at Sha Tin Sewage Treatment Works and Vertical Greening at Tai Hang Tung Stormwater Pumping Station won the Silver Award and the Merit Award, respectively, in the Government Projects Category of the Skyrise Greenery Awards 2012,
- Vertical Greening Study at Sha Tin Sewage Treatment Works received the Merit Award in the Planning/Research Projects Category of the Skyrise Greenery Awards 2012 and the Merit Award in the Landscape Planning Project/Research Study Category of The Hong Kong Institute of Landscape Architects Design Awards; and
- Transplanting a Gigantic Tree at Kai Tak Development received the Merit Award in the Environmental Design/Greening Category of the Hong Kong Institute of Landscape Architects Design Awards.

**Skyrise Greenery Awards 2012**

Organised by the Greening, Landscape and Tree Management Section of the Development Bureau, the Skyrise Greenery Awards 2012 aimed to promote the development of quality skyrise greening, and to give recognition to exemplary projects that showcased the integration of skyrise greenery into the building environment of Hong Kong\(^{11}\).
Chapter Six  Recognition of Remarkable Performance

Quality Services

Over the years, the DSD team has dedicated to solving problems arising from sewage and stormwater. Our customer-oriented approach alongside the belief in teamwork is the key to providing quality services. In the past, DSD has received numerous team awards.

Recognition of DSD’s Team Spirit

DSD was awarded the Grand Award of The Ombudsman’s Award 2013 for Public Organisations, and the Silver Prize for Team Award (General Public Service) in the Civil Service Outstanding Service Award Scheme 2013. The Office of the Ombudsman praised DSD for taking a proactive manner in handling complaints referred by them, and for taking prompt improvement measures, particularly in conducting mediation to resolve complaints and taking initiative to liaise with concerned departments on cross-departmental cases. The Ombudsman also commended DSD's exemplary service culture, making DSD a deserving winner of the Grand Award.
Ombudsman’s Awards Scheme

The Ombudsman’s Awards Scheme was launched by the Office of The Ombudsman. The Scheme includes the Awards for Public Organisations and the Awards for Officers of Public Organisations, both of which aim to recognise the positive attitude of government departments and public organisations as well as their staff in handling public complaints. The Scheme encourages the departments and public organisations to improve public administration through handling complaints, and to cultivate a positive complaint culture.

Civil Service Outstanding Service Award Scheme

The Civil Service Outstanding Service Award Scheme, presented by the Civil Service Bureau, aims to recognise the outstanding services provided by the winning departments and teams. It promotes a customer-oriented service culture in the civil service and encourages the pursuit of excellence in the delivery of public services by the departments.

Interview with Ir Sam Kai-pong, Derek, from Sewage Treatment Division 2

Ir Sam Kai-pong, Derek is an Electrical and Mechanical Engineer of DSD responsible for managing the maintenance of the sewage treatment and flood prevention facilities in Lantau Island and Islands district since 2006. His most memorable project was the taking over of the management of the Ma Wan Sewage Treatment Works ahead of schedule in order to expedite the improvement to the odour problem of the plant. Prior to the taking over, he had been working on the regular publication of Ma Wan Sewage Treatment Works Odour Control Periodical, and had been home visiting Ma Wan residents to gain a thorough understanding of the situation. After confirmation of the source of odour, Ir Sam and his team quickly worked out an improvement plan. Eventually, members of the Legislative Council and of the Owner Committees, along with Ma Wan residents, were satisfied with the outcome of the improvement project. Throughout the process, Ir Sam was impressed by the positive and conscientious working attitude of staff from all the divisions in handling the related complaints. In 2013, DSD received the Grand Award of the Ombudsman’s Awards for Public Organisations, an honour which greatly encouraged Ir Sam.
Chapter Six  Recognition of Remarkable Performance

Interview with Mr Chan Hok-fung, Vice Chairman of Central and Western District Council

Mr Chan Hok-fung, Vice Chairman of Central and Western District Council, grew up in Sai Wan and used to live in a three-storey pre-war tenement that used the “empting nightsoil” method. A burst of odour would be generated when “empting nightsoil,” he recalled. At that time, many tenement house occupants poured sullage into the nearby drainage, attracting rats and cockroaches and resulting in poor hygiene conditions. Later, when he moved into a public housing estate, he noted the presence of a flush toilet in the bathroom and soon discovered its merits. He realised that having the sewage directly conveyed to a sewage treatment works through sewers was convenient and conducive to environmental hygiene. These facilities greatly improved residents’ living condition.

Since his appointment as a member of the District Council, Mr Chan has frequently liaised with DSD to follow up issues related to flooding which affect local shops and odour nuisance from the sewerage near Belcher’s Street. He praised DSD staff as the unsung heroes who spare no effort to serve the public.

Conclusion

DSD strives to provide quality wastewater and stormwater drainage services, introduce innovative designs and implement major works projects, as well as upgrade the skill level in order to bring a better living environment to citizens of Hong Kong. Keeping in pace with the international trend, DSD has in recent years collaborated with experts to introduce innovative environmental elements to our projects with regard to the unique environment of Hong Kong. We are glad to see that these continuous efforts have won us many awards in the local and international engineering field.
### List of DSD Awards (from 2009 to mid-2014)

<table>
<thead>
<tr>
<th>Year</th>
<th>Awards</th>
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| **2014**  | Relocation of Sha Tin Sewage Treatment Works to Caverns was named the Winner in the Marketing and Communications Category of the 2014 IWA Global Project Innovation Awards, and Winner in the Marketing and Communications Category of the 2014 IWA East Asia Regional Project Innovation Awards.  
Lai Chi Kok Drainage Tunnel won the Honour Award in the Design Category of the 2014 IWA Global Project Innovation Awards, and winner in the Design Category of the 2014 IWA East Asia Regional Project Innovation Awards.  
Environmental Sludge Treatment Scheme Developed on Co-settling received the Honour Award in the Small Projects Category of the 2014 IWA East Asia Regional Project Innovation Awards.  
Dynamically Adaptive Scum Collection System was awarded a Certificate of Merit for Best Innovation (Innovative Technology) Award in the Hong Kong Information and Communication Technology Awards 2014. |
| **2013**  | DSD received the Grand Award of The Ombudsman’s Awards 2013 for Public Organisations.  
Lai Chi Kok Drainage Tunnel won the Merit Award in the Construction Category in The Innovation Award for the Engineering Industry 2012/13.  
Happy Valley Underground Stormwater Storage Scheme received a Merit Award in the Construction Category in The Innovation Award for the Engineering Industry 2012/13.  
Environmental Sludge Treatment Process Developed on Co-settling Technology was named Champion in the Technology Category in The Innovation Award for the Engineering Industry 2012/13.  
Harbour Area Treatment Scheme received the second -highest vote totals in the poll of The Hong Kong People Engineering Wonders in the 21st Century, organised by the Hong Kong Institution of Engineers (HKIE).  
Hong Kong West Drainage Tunnel received the third-highest vote totals in the poll of The Hong Kong People Engineering Wonders in the 21st Century, organised by the Hong Kong Institution of Engineers (HKIE).  
A DSD study of revitalising urban streams entitled, A Comparative Study of Revitalization of Urban Streams in the Major Cities in Asia, received a Merit Award in the Hong Kong Institute of Planners (HKIP) Awards 2013.  
Lai Chi Kok Drainage Tunnel won a Silver Prize in the Team Award (General Public Service) of the Civil Service Outstanding Service Award Scheme 2013.  
A DSD research study entitled, Image from Sewage, was given a Meritorious Award in the Civil Service Outstanding Service Award Scheme 2013.  
Safety Measures for Working Personnel in Confined Spaces received the Best Public Service Application (Small Scale Project) Gold Award in the Hong Kong Information and Communication Technology Awards 2013.  
Happy Valley Underground Stormwater Storage Scheme was named the Winner in the Planning Category of the 2012 IWA East Asia Regional Project Innovation Awards.  
Co-settlement and Energy Conservation Approach for Sludge Treatment received a Certificate of Merit in the 2012 Hong Kong Awards for Environmental Excellence — Green Innovations Awards.  
Green Roofs at Sha Tin Sewage Treatment Works and Vertical Greening at Tai Hang Tung Stormwater Pumping Station were awarded Silver and Merit Awards respectively in the Government Projects Category of the Skyrise Greenery Awards 2012.  
Vertical Greening Study at Sha Tin Sewage Treatment Works received a Merit Award in the Planning/Research Projects Category of the Skyrise Greenery Awards 2012, and a Merit Award in the Landscape Planning Project/Research Study Category in the Hong Kong Institute of Landscape Architects Design Awards 2012.  
Transplanting a Gigantic Tree at Kai Tak Development received a Merit Award in the Environmental Design/Greening Category in Hong Kong Institute of Landscape Architects Design Awards 2012.  
The DSD paper Bank of Green Roofs in Drainage Services Department received a Merit Award in the 2012 Environmental Paper Award organised by the Environmental Division of The Hong Kong Institution of Engineers (HKIE). |
Chapter Six  Recognition of Remarkable Performance

<table>
<thead>
<tr>
<th>Year</th>
<th>Awards</th>
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<tbody>
<tr>
<td>2011</td>
<td>The Hong Kong West Drainage Tunnel project was named the Winner of Tunnelling Project of the Year (US$100m to US$1bn) in the International Tunnelling Awards 2011, organised by New Civil Engineer and Ground Engineering. The Hong Kong West Drainage Tunnel project team won Silver Prize in the General Public Service Award under the Civil Service Outstanding Service Award Scheme 2011. DSD (Headquarters) was awarded a Certificate of Merit in the 2011 Hong Kong Awards for Environmental Excellence. A DSD paper entitled, 3+1 Approach for Greening Works at Sha Tin Sewage Treatment Works, was awarded the 1st Prize in the Civil Engineering Paper of the Year Award 2011, organised by the Civil Division of The Hong Kong Institution of Engineers.</td>
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<tr>
<td>2010</td>
<td>Shek Wu Hui Sewage Treatment Works was awarded a Certificate of Merit in the 2010 Hong Kong Awards for Environmental Excellence.</td>
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<tr>
<td>2009</td>
<td>Intercepting Drains at Queen’s Road Central won the Champion in the General Public Service Award under the Civil Service Outstanding Service Award Scheme 2009. DSD Sewage Treatment Division 2 was awarded a Certificate of Merit in the 2009 Hong Kong Awards for Environmental Excellence.</td>
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7. In 2013, DSD has finished 7 studies, including (1) Conducting flow monitoring and hydrology analysis in Yuen Long Bypass Floodway, (2) Evaluating the rehabilitation of stormwater tunnels and sewers using trenchless technology, (3) Detecting gaps around underground tunnels, (4) Studying odour control carried out in the polluted Tai Kang Po KT-5 section, (5) Studying the chemical dosing control of disinfection facilities in the Harbour Area Treatment Scheme, (6) Conducting a comparative study of revitalisation of urban streams in the major cities in Asia, (7) Studying the application of vertical greening in different DSD facilities.
DSD works in close collaboration with our colleagues and industry partners in order to better achieving our service goals. DSD cares about the needs and well-being of our staff. For examples, we have established the “Occupational Health and Safety Management System” to optimise the working environment, set up communication platforms namely the “Goodwill Visit” and the Departmental Consultative Committees to strengthen the exchange of views between management and staff, and arranged activities of various natures to promote connection amongst colleagues. In addition, DSD staff participate in different competitions and activities with industry partners with a view to enhancing team spirit and promoting the “New Engineering Contract”.
“Do it from the Heart”

“Do it from the Heart” is our motto in serving Hong Kong citizens. DSD believes that teamwork is prerequisite for achieving this goal. We endeavour to provide a harmonious, safe, and healthy workplace and foster a sense of belonging among our staff and trade partners so that they can deliver their best and work in close and mutual trust relationships. In recent years, DSD has introduced the “New Engineering Contract” model in our projects to promote partnership, so that we can enhance the progress and cost-effectiveness of our works, and ultimately better our services to Hong Kong citizens.

As a Family

DSD provides a wide spectrum of training opportunities to broaden the horizons of our staff and cultivate their innovation mindset change. We believe that effective dialogue amongst management and staff enables us to maintain a workforce with strong sense of belonging and dedication to serve the public. To achieve this, we have established a total of three Departmental Consultative Committees as platforms to gauge the views of staff of different ranks. Our Directorate officers take the initiative to pay goodwill visits to frontline staff at their workplace. In addition, we organise safety talks, workshops and other recreational activities to remind our staff of the importance of occupational safety and work-life balance. Also, DSD staff are enthusiastic in forming the Green Champions and volunteer teams to serve our society.
Staff Training and Development

Staff are our most valuable assets and we accord high emphasis on staff training. We are of the view that if we provide our staff with suitable development opportunities, they no doubt would work devotedly with a sense of belonging. In 2013-2014, DSD organised 86 training courses relating to environmental and sustainable development and offered visits, in-house training, overseas visits/seminars and workshops for staff of different ranks according to their qualification and experience. As a result, we managed to provide each staff member with an average of 30.9 hours of training in the year. This figure is much higher than the average training hours per employee territory-wide.

Team-building courses

DSD has also organised team-building courses, mainly in the form of culinary and outdoor training, to foster both communication skills and team spirit among staff through relaxing classes and group games.
Chapter Seven  As a Team, as a Partner

Occupational Safety and Health

To ascertain a safe and healthy working environment for our staff, we have established the DSD Safety Steering Group under the chairmanship of the Deputy Director. It holds regular meetings with the Division Heads to review in-house work safety policies and procedures as well as issue new safety directives from time to time. The Safety Steering Group has formed four committees (refer to diagram below) to monitor and protect staff health and safety, regularly review the current health and safety management systems. In addition, the Divisional Safety Coordinators disseminate the latest information and alerts on construction site safety to our project consultants and contractors to further enhance site safety.

DSD obtained accreditation of the Occupational Health and Safety (OHSAS 18001) in 2012

Occupational Health & Safety Advisory Services (OHSAS 18001)

To properly put into practice DSD’s vision, mission and values, the “Integrated Management System” has been adopted to assist staff to strive for a balanced development when providing quality drainage services, protecting the environment and promoting occupational health and safety. In 2012, within a short period of 10 months or more, DSD had successfully obtained accreditation of “Occupational Health & Safety Management System” OHSAS 18001, which enabled us to better protect our staff through a systematic and comprehensive management system. More training courses in occupational health and safety were arranged for our staff in the year 2012-2013. Among them, over 1,000 staff participated in the OHSAS training programme.
Participating in Safe Workplace Activity

Besides initiating Safety Forums, the Construction Sites Housekeeping Award Scheme and the Tunnel Safety Campaign, DSD also participated in the Considerate Contractors Site Award Scheme (CCSAS) organised by the Development Bureau, in order to raise staff awareness of safety and health issues when working in work sites like confined spaces, tunnels and sites with power cables nearby. These activities were well-received among our staff as well as work consultants and contractors. Our management joined hands with frontline staff to strive hard for the goal of “Zero Accident”.

The then Director and other guests of honour practiced Baduanjin at the Zero Accident Flag Presentation Ceremony in 2014

DSD attended the Award Ceremony of the Considerate Contractors Site Award Scheme
Goodwill Visits Programme

The “Goodwill Visits” programme was launched to enhance communication with staff. The Director, Deputy Director and Assistant Directors of DSD conduct regular visits to sewage treatment plants, maintenance depots and general offices to better understand working conditions of our staff at different places and exchange views with staff in a relaxing atmosphere.

Departmental Consultative Committees

Staff opinions matter a great deal to us. To facilitate direct communication between staff of different grades and the management, three Departmental Consultative Committees (DCCs), namely DCC for Professional and Technical Grades Staff, DCC for the General and the Common Grades Staff, and DCC for the Junior Grades Staff have been established to boost two-way communication and cooperation. In addition, Labour Relations Officers are employed to handle disputes between project contractors and workers.
Interview with a representative of the DCC for Junior Grades Staff — Mr Hon Yat-keung

Mr Hon Yat-keung is a member of the Direct Labour Force (DLF) which is frequently in direct contact with the public. Each time when the DSD hotline receives a complaint, the DLF will be promptly sent to the scene to deal with the issue, whether it is flooding or a blocked drain. At all times, even in extremely inclement weather, the DLF stands ready to serve the public. Mr Hon feels honoured to be part of DSD, and serves the citizens in accordance with DSD’s motto of “Do it from the Heart.” He pointed out that, with more advanced drainage equipment nowadays, we could respond to drainage problems more efficiently and in a safer manner. This in turn enhances the relationship between the DLF and the citizens.

Mr Hon, nicknamed “Brother Cow”, joined the former Public Works Department in 1978 as a Workman II, and became a Leading Sewerman in 1982. He was promoted to Drain Chargeman in 1996, the main duty of which was to lead his team to clear blocked drainages along the streets and on hillsides. Through years of service, he gradually accumulated expertise in drainage work. His mission is to work wholeheartedly to meet the public’s expectations. Although sometimes the citizens acted impatiently, they would express their appreciation when we worked hard and got the job done. Mr Hon was awarded the Chief Executive’s Commendation for Government/Public Services in 2010 in recognition of his work devotion.

Mr Hon is also actively engaged in protecting the interests of staff, and has served in the DCC for Junior Grades Staff for 15 years. The DCC holds regular meetings, reviews staff’s benefits and enhances understanding and cooperation between the staff and management side. As convener of the staff side, Mr Hon is tasked to bridge the gap between DSD and his fellow colleagues, to make sure that staff views can be heard by the management on the one hand and his fellow grade members be posted of the meeting progress on the other. Mr Hon believes that mutual trust between the management and its staff is of paramount importance for building a strong team spirit.
The Green Champions

The Green Champions was formed by a group of staff who care about the environment. They take the lead as role models to encourage a more sustainable working style and spread eco-responsibility messages in their workplaces. The group believes that subtle changes in our workplaces can help enhance energy efficiency and reduce carbon footprints, thus contributing to a sustainable development in our offices. To cultivate a culture of environmental protection in DSD, the Green Champions are of the view that they need to widely collect and implement staff suggestions.

The DSD Staff Club, together with the Volunteer Team and the Green Champions, responded to the call of the “Working Group on Clean Shorelines”, helped to clean up the shorelines of Peng Chau.

Staff Funfest

DSD team spirit is not limited to work. Team spirit can also be shown through the DSD Staff Club which voluntarily organises various recreational activities for staff members. For instance, DSD Staff Club has organised teams to join the Standard Chartered Hong Kong Marathon and the Dragon Boat Race. In addition, it organises sports competitions including football, basketball, table tennis, squash, snooker, tennis and badminton, etc. Besides, it organises outdoor activities and interest classes to provide more opportunities for DSD staff to maintain a healthy work-life balance, through embracing the nature, acquiring more knowledge and strengthening friendship with their counterparts. The Christmas Party and Annual Dinner are two major events which are well received by DSD staff.
Interview with Chairman of DSD Staff Club

The DSD Staff Club was established in 1994 and has been organising sports, educational, recreational and welfare activities for staff members enthusiastically. Besides the Annual Dinner which is always the signature event of the year, the Staff Club also organises football, basketball and golf competitions, as well as hiking, tai chi and dragon boat racing classes. Among other interest classes, the Staff Club has held green seminars on dendrobium plantation and narcissus cutting and red wine workshops. Ir Tsang Lap-kei, a senior engineer in the Sewerage Projects Division, has been the Chairman of DSD Staff Club since 2011. He has organised a wide range of interesting workshops such as balloon twisting classes, chocolate-making classes and coffee tastings. At present, he is thinking of forming a DSD live band.

In May 2014, the post of DSD Staff Club Chairman was taken up by an engineer - Ir Chan Hei-yuet. Both Ir Chan and Ir Tsang regard the annual Standard Chartered Hong Kong Marathon and Dragon Boat Race as the two most notable activities arranged under the Club’s auspices. For the Marathon, there was one occasion when as many as 200 staff participated, coupled with the energetic cheering from a large supporting team, rendering it a memorable event for all participants. For the Dragon Boat Race, the DSD team practises from March till September every year and raced in five to six open competitions during that period. Ir Chan and Ir Tsang both hope that the Dragon Boat Team will win more awards this year in celebration of the 25th anniversary of DSD.

The two of them greatly appreciate the staff’s contribution and support all these years, which is crucial to the steady development of the Staff Club and contributes to the harmonious relationship among divisions. They hope that all staff members of DSD will continue to actively support the activities of the club.
DSD 25th Anniversary Activities

Since the establishment of DSD 25 years ago, the unremitting effort and devotion by the staff enabled us to obtain so many outstanding achievements. In order to enhance the sense of belonging among DSD staff, the Drainage Services Department 25th Anniversary Activities Suggestion Competition was held to allow all colleagues to voice their suggestions freely. Many of the celebration activities suggested by the staff were subsequently selected and organised, such as Orienteering-On-Bike Fun Day, Join Hands to Green the Roof, Green River Day 2014, and Trail Walk along Rivers in Mainland North District. In particular, we published this monograph to review the past developments and achievements of DSD and publicize the work of DSD through interviews with our staff and members of the public.

DSD held its Open Day at the Sha Tin Sewage Treatment Works on 11 and 12 January 2014 with the theme of “DSD’s Memorable 25 years with Hong Kong”. Besides game booths and model exhibitions set up by the staff and 25 industry partners serving to promote the works of DSD, group performances were also arranged to entertain the participants. The Open Day attracted more than 10,000 visitors and their response was overwhelming.

The DSD International Conference 2014, under the theme of “Sustainable Stormwater and Wastewater Management”, was another mega event for the 25th anniversary held from 12 to 14 November 2014. The conference provided an opportunity for world-renowned scholars, professionals and policymakers to come to Hong Kong to share with us their latest research work and practical experience concerning flood prevention and sewage treatment, which help promote Hong Kong’s sustainable development.
Chapter Seven  As a Team, as a Partner

Interview with the then Director of DSD — Ir Chung Kum-wah, Daniel

Ir Chung Kum-wah, Daniel JP was appointed as the Director of Drainage Services in early 2014. Soon after his appointment, he was impressed by the working attitude of the frontline staff who accorded top priority in serving the public and always went the extra mile to meet the expectations of the public. For example, during the first few months of 2014 when there were many occasions of heavy rainstorms, myriad flooding reports were received by DSD. In response, members of the Direct Labour Force (DLF) worked tirelessly and regardless of the inclement weather, arriving swiftly at spots with reported flooding to clear the drainage so that the flow could resume normal. When encountered cases where the flooding took place in roadside drains which were outside DSD’s jurisdiction, members of the DLF would still arrive at the scene to offer assistance whenever possible. To-date, whenever flooding takes place, the public always seek help from DSD straight away. In the eyes of the public, DSD has become a hallmark department responsible for flooding incidents.

Ir Chung pointed out that we needed to understand the thinking and needs of the staff in order to bring the team spirit into full play. Hence, DSD has established three DCCs catering for members of different grades to enhance communication between staff and the management. Also, periodic visits to DSD facilities like the Sha Tin Sewage Treatment Works, the Lai Chi Kok Drainage Tunnel and the Happy Valley Stormwater Storage Tank have been organised for DCC members, both to enhance their understanding of the facilities and the work of DSD and to reinforce their sense of belonging.

In addition, the “Goodwill Visits” programme was launched in June 2013, under which the Director, Deputy Director and Assistant Directors from different branches take turns to meet frontline staff at different offices and listen to the views of frontline staff. The visits enable the senior management to better understand the daily work of the staff and problems they may have. Not all the staff problems can be readily solved but it is important that they feel the sincerity of the management. In addition, the Director, Deputy Director and Assistant Directors attend staff meetings of different divisions and have lunch with staff afterwards to enhance relationships. Ir Chung believes that all decision-making officers have their own management philosophy. Direct communication with staff can help fine-tuning the decision, provide the foundation for a trust-based relationship between management and staff, and so create a team that functions like a partnership.

DSD has long been advocating a proper work-life balance and cares deeply about the needs of the staff. We encourage staff to join the leisure and sports activities arranged by the Staff Club such as the dragon boat team and the Marathon team. We also responded to the appeal of Food and Health Bureau by setting up a Lactation Room in our offices in the Revenue Tower, the Kowloon Government Offices and Sha Tin Sewage Treatment Works etc, to attend to the particular needs of colleagues.

Ir Chung is convinced that family support and understanding are important if the staff are to dedicate themselves to work. Hence, to coincide with the DSD’s 25th Anniversary, the “Job Shadowing” Scheme was introduced, allowing family members to accompany staff to work, learning more about their daily work within the actual settings. It is hoped that this will cultivate harmony between our staff and their family members.

Ir Chung stresses that only by being “people-oriented” can staff in DSD join together and develop their abilities.
Chapter Seven  As a Team, as a Partner

Staff voices

“Awake all night because of you” — Mr Ip Chun-wing

I have been working in DSD for 19 years and I am now a Senior Electrical Inspector, working as the shift duty-in-charge at the Stonecutters Island Sewage Treatment Works. Working on shift duty reverses my biological clock and sacrifices the time that I spend with my family. Working on duty during holidays in particularly is not a pleasant matter. Despite that, I keep reminding myself that, “This is my mission”. My two sons learned to swim when they were small, and although I do not have much time to accompany them to swim, my present job can help improve the water quality of Victoria Harbour. I guess, making an effort for the living environment of our next generation is the best gift for my children from me.

“Enthusiasm, dedication, and be prepared for challenges” — Mr Yuen Wa-sum

I am a Special Driver working in the Direct Labour Force (DLF) in Mainland South Division since mid-1999. My daily duty is to drive large high-pressure waterwheels and assist other DLF team members to conduct normal drainage cleansing work. Although I am not the one who actually carries out the drainage cleansing, being a DLF team member, I know the enthusiasm and industrious working attitude of my teammates well. They have to work for long hours wherever there is serious flooding. This is a difficult job but being able to solve problems for the public does bring much satisfaction to us. All my team members work according to the principle of “Addressing the needs of the people”. We try our very best to solve every case, no matter whether it is during very hot weather, heavy rain or tropical cyclone. The past 15 years of work makes me believe that any problem can be solved if we all work wholeheartedly together.
Chapter Seven  As a Team, as a Partner

Partnership

DSD believes that a sound partnership helps improve project efficiency and solve works problems quickly. In recent years, DSD advocates the adoption of the "New Engineering Contract" (NEC) concept in our projects in order to strengthen the interaction among contractors, consultants and our project teams. For example, joint participation in community care activities is an extremely effective way in building mutual trust among concerned parties.

The New Engineering Contract

DSD was the first Government department to adopt NEC on a trial basis. As the adoption of this model was unprecedented, DSD was indeed trying a new form of engineering cooperation. To implement this, we sent staff to England to learn their experience in applying NEC in the actual contract management of their projects, and make corresponding modifications to suit the situation in Hong Kong.

A New Engineering Contract

Hong Kong’s works contracts have long followed a standard contract model in which the contractors are required to exclusively handle all project details and be responsible for the results. The shortcoming of this model is that projects tend to be slow in progress and are easily subject to delay. The NEC model, on the other hand, emphasises the spirit of mutual trust and partnership where parties concerned would share responsibilities as well as difficulties. This partnership model contains a distinct risk-management mechanism through which all contractual parties are allowed to issue early risk warnings to their partners with a view to exploring possible solutions in a timely manner. This new contract model also helps raise economic benefits, avoid unnecessary contractual disputes, and ensure smooth works progress.

To implement NEC, DSD has formed a dedicated working group to plan for the implementation details. First, DSD engaged a consultancy company to design and conduct partnering workshops for staff, consultants and contractors to attend and understand the new cooperation model. The workshops enabled relevant parties to establish mutual trust and common goals. NEC also encourages staff of these parties to share a common office to enhance communication and facilitate the operation of the project. In addition, representatives at management level from contractual parties would conduct regular high-level meetings to evaluate performance of the partnership, handle issues arising from the works and improve project efficiency.
Chapter Seven
As a Team, as a Partner

Sharing experience of the New Engineering Contract

Fuk Man Road Nullah Improvement Works in Sai Kung

The pilot Fuk Man Road Nullah improvement works in Sai Kung was the first public project using NEC. By adoption of this new working model, the project was completed six months ahead of schedule and the actual expenditure was 5% less than the project estimate, representing a saving of 2 million dollars.

In addition, the risk management mechanism included in NEC played a crucial role during the construction period. In 2010, the project required road widening works at the busiest road in Sai Kung. Considering the likely adverse impacts of the works on the traffic of that area, the contractor issued a risk warning to DSD. At the risk management meeting, the two sides managed to jointly devise a series of risk mitigation measures which subsequently were proved effective in reducing the adverse impacts on the traffic.

Fuk Man Road Nullah before the improvement works

After the nullah improvement works, Fuk Man Road Nullah has become Fuk Man Garden

The Happy Valley Underground Stormwater Storage Scheme

The Happy Valley Underground Stormwater Storage Scheme has been under construction for almost a year under the NEC model. To-date, DSD and the contractors have set up various communication channels such as morning meetings and smart phone communication groups. The latter enables immediate communication during emergencies to identify solutions.

DSD staff holding morning meeting with the contractors
In early 2013, the project team discovered at the worksite multiple sets of underground facilities which needed to be relocated. One of the discovered facilities was actually an optical data transmission cable connecting to the totalizator for the racecourse. Under the old contract model, the contractors would have been required to approach relevant departments or organisations for assistance, and this usually took a long time. Under NEC, DSD staff assisted the contractors to follow up the issue with the Hong Kong Jockey Club (HKJC). Thanks to the full support of HKJC and the Leisure and Cultural Services Department, relocation of the facilities was completed in August 2013. This proved that NEC, albeit would entail greater workload and responsibility to DSD, could help establish better understanding and mutual trust among the partnering teams and at the end improve works efficiency.

DSD is now planning to apply NEC in six upcoming drainage projects. The purpose is to promote a culture of partnership and encourage a wider use of NEC by the industry.

<table>
<thead>
<tr>
<th>Projects under the New Engineering Contract</th>
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<tbody>
<tr>
<td>Happy Valley Underground Stormwater Storage Scheme</td>
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<tr>
<td>Sewerage at Yuen Long Kau Hui and Shap Pat Heung</td>
</tr>
<tr>
<td>Lam Tsuen Valley Sewerage - Village Sewerage, Stage 2, Phase 1</td>
</tr>
<tr>
<td>Pak Hok Lam Trunk Sewer and Sha Tau Kok Village Sewerage</td>
</tr>
<tr>
<td>Building and Civil Maintenance and Minor Works to DSD Plants and Facilities (2012-2016)</td>
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</table>
Interview with the then Deputy Director of DSD – Ir Tsui Wai

Traditionally, works contracts between the Government and contractors placed emphasis on monitoring and end results. NEC, on the other hand, advocates a trusting and cooperative partnership between the contractual parties in order to achieve better risk management, effective cost control, and thus minimisation of disputes and boosting of morale. The then Deputy Director Ir Tsui Wai, took charge of the implementation of this model in DSD, which was unprecedented for the works departments in Hong Kong. The first pilot project was the Fuk Man Road Nullah improvement works in Sai Kung commenced in August 2009. Ir Tsui recalled that, in the early stages of the project, both DSD and the contractors adopted an approach of trial and error, and it was pleased to note that both parties could adapt to this new cooperation model quickly. As a result, the works were completed in May 2012, six months ahead of the completion date stipulated in the contract, with an achievement of cost savings of around 5%.

Given the success of the pilot scheme and the valuable experience gained by DSD colleagues therein, DSD decided to extend the NEC model to other suitable projects and the results were encouraging. Recognising DSD’s experience, the Development Bureau has earlier required all works departments to broadly adopt the NEC model in new projects starting from 2016 with the objective of enhancing efficiency and saving costs.

Ir Tsui has been invited to attend several forums organised by international professional associations to share with participants and the industry DSD’s successful experience in implementing NEC. For example, Ir Tsui attended the 18th NEC User’s Group Annual Seminar held on 28 April 2014 in the UK to deliver a talk on “NEC in Hong Kong”. The function was held at the Headquarters of the Institution of Civil Engineers in London, and Ir Tsui was the first Hong Kong speaker ever invited by the NEC Users’ Group to speak at their annual seminar held in the UK where the NEC concept was first introduced.

Ir Tsui pointed out that, despite the smooth start, there were obstacles to be overcome if we were to continue promoting NEC. These obstacles include insufficient resources in the early stage, the culture and practices of the industry and the general doubtful attitudes towards this model. In brief, we still have a long way to go to accomplish this important task.
Organise team activities

DSD, together with our consultants and contractors, jointly organised team activities such as dragon boat racing, volunteer visits and clean work sites day to nurture friendly relationships that ultimately raise the efficiency of works management. Particularly worth mentioning is the Hong Kong Marathon in which, for the purpose of boosting team spirit, DSD has invited our working partners in the engineering sector to join the 10-km race together consecutively for 3 years since 2012. Under the team title of “DSD Partners”, around 200 DSD staff and their relatives, together with DSD working partners, a total of 760 team members, took part in the 2014 Hong Kong Marathon. Emboldened by the mutual encouragement and common determination among team members, higher team spirit was developed throughout the training and race periods.
Chapter Seven  As a Team, as a Partner

1 According to the 2012 Training and Development Needs Survey conducted by Hong Kong Institute of Human Resource Management, the average number of training hours per employee per annum was 19.1 hours.


Conclusion

For many years, DSD serves with the commitment of “Do it from the Heart”. We encourage our staff to keep striving for better and providing quality services. DSD believes that establishing understanding and trustful relationships with staff and working partners are of great importance to providing better services. Hence, DSD arranges various recreational, sports and community service activities to enhance communication with our working partners and to develop team spirit. We accord high emphasis on the physical and mental development of DSD staff and are committed to provide them with a safe and healthy working environment. We also offer versatile training opportunities and recreational activities to help staff develop innovative thinking and foster their sense of belonging.

Lastly, we sincerely hope that every member in the family of DSD can join hands together for achieving the common goal of delivering quality services to Hong Kong citizens.

Fig 1-2 was provided by courtesy of Wen Wei Po.
### Appendix: An Overview of Drainage Development in Hong Kong

<table>
<thead>
<tr>
<th>Year</th>
<th>Notable Developments</th>
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<tbody>
<tr>
<td>1854</td>
<td>The Government’s first identification of local drainage and sewerage needs</td>
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<tr>
<td>1860</td>
<td>Completion of Bowrington Canal (600 ft long, 90 ft wide), the first nullah</td>
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<tr>
<td>1882</td>
<td>Hong Kong’s first study report on sanitation by Sir Osbert Chadwick</td>
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<tr>
<td>1891</td>
<td>Establishment of the Water and Drainage Department under the Public Works Department</td>
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<tr>
<td>1902</td>
<td>Chadwick’s third visit to Hong Kong for a sanitation study followed by his recommendation of separate systems for stormwater and sewage</td>
</tr>
<tr>
<td>1906</td>
<td>Construction of the first water storage tank in Blake Garden</td>
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<tr>
<td>1908</td>
<td>The first major sewer rehabilitation works in Connaught Road</td>
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<tr>
<td>1911</td>
<td>The first use of sewers for sewage discharge into Craigmin Road</td>
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<tr>
<td>1924</td>
<td>Completion of the first stormwater drain from Wan Chai Road to the harbour-front</td>
</tr>
<tr>
<td>1951</td>
<td>Successive decking of urban nullahs for road construction and development</td>
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<tr>
<td>1956</td>
<td>Commissioning of the sewage screening plant in Anchor Street as the first large sewage treatment works</td>
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<tr>
<td>1971</td>
<td>Release of a report entitled <em>Marine Investigation into Sewage Discharges: Brief Report</em> setting out the sewage treatment and disposal strategy for Hong Kong</td>
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<tr>
<td>1974</td>
<td>Commissioning of the first pilot secondary sewage treatment works in Shek Wu Hui</td>
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<tr>
<td>1975</td>
<td>Commissioning of the first secondary sewage treatment works (interim) in Sha Tin</td>
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<tr>
<td>1979</td>
<td>Commissioning of the Tai Po Sewage Treatment Works</td>
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<tr>
<td>1980</td>
<td>Enactment of the Water Pollution Control Ordinance</td>
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<tr>
<td>1982</td>
<td>Inclusion of the Shenzhen River Regulation Project in the agenda</td>
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<tr>
<td>1986</td>
<td>Establishment of the Environmental Protection Department tasked with sewerage planning</td>
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<tr>
<td>1987</td>
<td>Declaration of the first water control zone in Tolo Harbour</td>
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<tr>
<td>1988</td>
<td>Commissioning of the first village flood protection scheme in Sik Kong Wai</td>
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<tr>
<td>1989</td>
<td>Establishment of the Drainage Services Department</td>
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<tr>
<td>1990</td>
<td>Completion of the Territorial Land Drainage and Flood Control Strategy Study – Phase I</td>
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<tr>
<td>1993</td>
<td>Completion of the Territorial Land Drainage and Flood Control Strategy Study – Phase II</td>
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<tr>
<td>1994</td>
<td>Introduction of the Sewage Services Charging Scheme to implement the “polluter pays” principle with the charges depending on the sewage volume and pollution level</td>
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<tr>
<td>1995</td>
<td>Commissioning of the Tolo Harbour Effluent Export Scheme</td>
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<tr>
<td>1997</td>
<td>Completion of the Shenzhen River Regulation Project Stage 1</td>
</tr>
<tr>
<td>Year</td>
<td>Notable Developments</td>
</tr>
<tr>
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</tr>
<tr>
<td>1998</td>
<td>Commencement of the West Kowloon Drainage Improvement Scheme</td>
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<tr>
<td>2000</td>
<td>Completion of the Shenzhen River Regulation Project Stage 2</td>
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<tr>
<td>2001</td>
<td>Completion of HATS Stage 1 &lt;br&gt; Commencement of construction works for the Tai Hang Tung Stormwater Storage Tank &lt;br&gt; Commencement of construction works for the Kai Tak Transfer Scheme &lt;br&gt; The pioneer incorporation of an engineered wetland into the flood prevention works in San Tin</td>
</tr>
<tr>
<td>2004</td>
<td>Commissioning of the Tai Hang Tung Stormwater Storage Tank, the first of its kind in urban areas &lt;br&gt; Completion of the Kai Tak Transfer Scheme</td>
</tr>
<tr>
<td>2005</td>
<td>Decking of 16 nullahs for environmental improvement as proposed in the Policy Address &lt;br&gt; Commissioning of the Ngong Ping Sewage Treatment Works, the first tertiary sewage treatment works with water reclamation facilities in Hong Kong</td>
</tr>
<tr>
<td>2006</td>
<td>Commencement of a pilot scheme on reclaimed water at the tertiary sewage treatment works in Ngong Ping &lt;br&gt; Completion of the Shenzhen River Regulation Project Stage 3 &lt;br&gt; Completion of the Yuen Long Bypass Floodway &lt;br&gt; Commencement of construction works for the Sheung Wan Stormwater Pumping Station &lt;br&gt; Completion of the Ping Yuen River Training Works &lt;br&gt; Opening of the first sewage treatment information centre at the Stonecutters Island Sewage Treatment Works</td>
</tr>
<tr>
<td>2007</td>
<td>Commencement of construction works for the Hong Kong West Drainage Tunnel &lt;br&gt; Commencement of construction works for the Tsuen Wan Drainage Tunnel</td>
</tr>
<tr>
<td>2008</td>
<td>Commencement of construction works for the Lai Chi Kok Drainage Tunnel &lt;br&gt; Commencement of Drainage Master Plan Review Studies for various districts in stages</td>
</tr>
<tr>
<td>2009</td>
<td>Commissioning of the Sheung Wan Stormwater Storage Scheme &lt;br&gt; Commissioning of the new Emergency Control Centre</td>
</tr>
<tr>
<td>2010</td>
<td>Commissioning of advance disinfection facilities at the Stonecutters Island Sewage Treatment Works under HATS Stage 2A &lt;br&gt; Elimination of all major flooding blackspots in Hong Kong &lt;br&gt; Commissioning of the water reclamation facilities and information centre at the Sha Tin Sewage Treatment Works &lt;br&gt; Commencement of construction works for the Provision of Interception Facilities at Kowloon Bay stormwater box culvert</td>
</tr>
<tr>
<td>2011</td>
<td>Commencement of construction works for the Happy Valley Underground Stormwater Storage Scheme &lt;br&gt; Completion of the Drainage Master Plan Review Studies for Yuen Long, North District and Happy Valley &lt;br&gt; Commencement of the River Flood Risk Study in stages</td>
</tr>
<tr>
<td>2012</td>
<td>Commissioning of the Hong Kong West Drainage Tunnel &lt;br&gt; Commissioning of the Lai Chi Kok Drainage Tunnel &lt;br&gt; Completion of the Improvement of Fuk Man Road Nullah in Sai Kung, the first project under the new engineering contract (NEC) &lt;br&gt; Commencement of construction works for the Kai Tak River Improvement Works &lt;br&gt; Commencement of the feasibility study on the relocation of the Sha Tin Sewage Treatment Works to caverns &lt;br&gt; Completion of the River Flood Risk Study, Stage 1</td>
</tr>
<tr>
<td>2013</td>
<td>Commissioning of the Tsuen Wan Drainage Tunnel &lt;br&gt; Commissioning of construction works for the Shenzhen River Regulation Project Stage 4 &lt;br&gt; Commissioning of the new information centre at the Sha Tin Sewage Treatment Works</td>
</tr>
<tr>
<td>2014</td>
<td>Commissioning of the Butterfly Valley Road Pet Garden atop the stilling basin of the Lai Chi Kok Drainage Tunnel &lt;br&gt; Launch of DSD Eco-channels Database Management System &lt;br&gt; Completion of the Provision of Interception Facilities at Kowloon Bay stormwater box culvert &lt;br&gt; Completion of the Upgrading of Pillar Point Sewage Treatment Works, the first project of its kind under the design-build-operate (DBO) contract &lt;br&gt; DSD International Conference on “Sustainable Stormwater and Wastewater Management”</td>
</tr>
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**Organisations and Government Departments:**

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Information Services Department
Lands Department
Public Records Office, Government Records Service
Sing Tao Daily
Ta Kung Pao
Wen Wei Po