Chapter Four Innovative Thinking of Blue-Green Infrastructure

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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


Tai Po River before (left) and after (right) river training works

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[1]. 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".

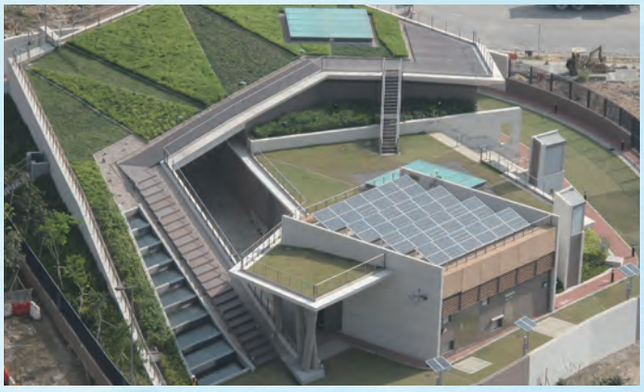
Since its inception 25 years ago, DSD has all along been committed to providing world-class sewage treatment and stormwater drainage services, and taking the sustainable development of Hong Kong as its vision. To this end, DSD has been trying to integrate ecological conservation elements into project 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.

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.

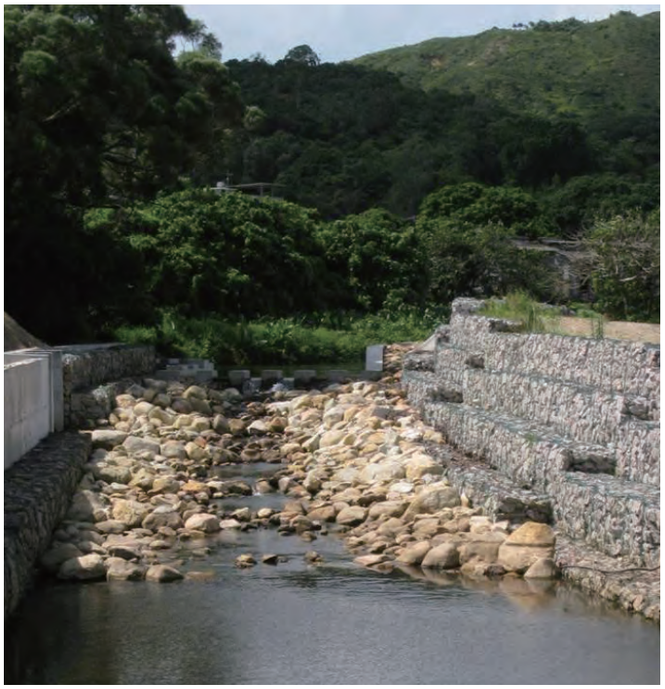
Eco-channels – Revitalisation of water bodies

Ho Chung River after greening works

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[2]. 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.



The fish ladder at Pak Ngan Heung River, Mui Wo

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.

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.

The downstream natural riverbeds of Kam Tin River and Shan Pui River

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.

Gabions provided along the embankments of Lam Tsuen River

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.

The upstream geotextile riverbank and riverbed of Sheung Yue River

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.

Procedures for laying grasscrete along Ngau Tam Mei Main Drainage Channel

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

The grass clippings are decomposed into humus

Soil conditioner is formed

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.



Being the only tailed amphibian species found in Hong Kong, Hong Kong Newt is statutorily protected

Ir. Chan Hak-keung

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.

The upstream meanders of Ng Tung River were preserved

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 hectares[3].

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 ponds[4]. 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.

The engineered wetland at Yuen Long Bypass Floodway

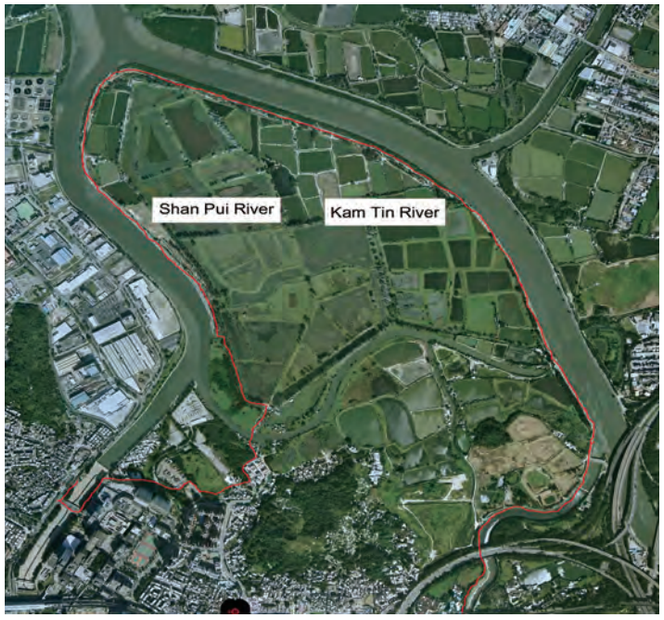
The shallow pond at Yuen Long Bypass Floodway

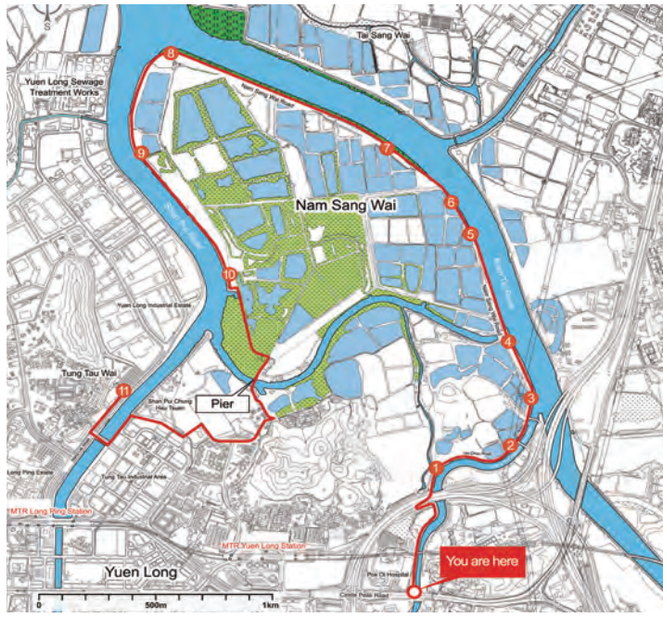
The sedimentation pond, crushed brick field and oyster shell field in the wetland

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.

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[5], 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.

Dr Cheng Luk-ki (second from left) conducting a field trip with DSD staff

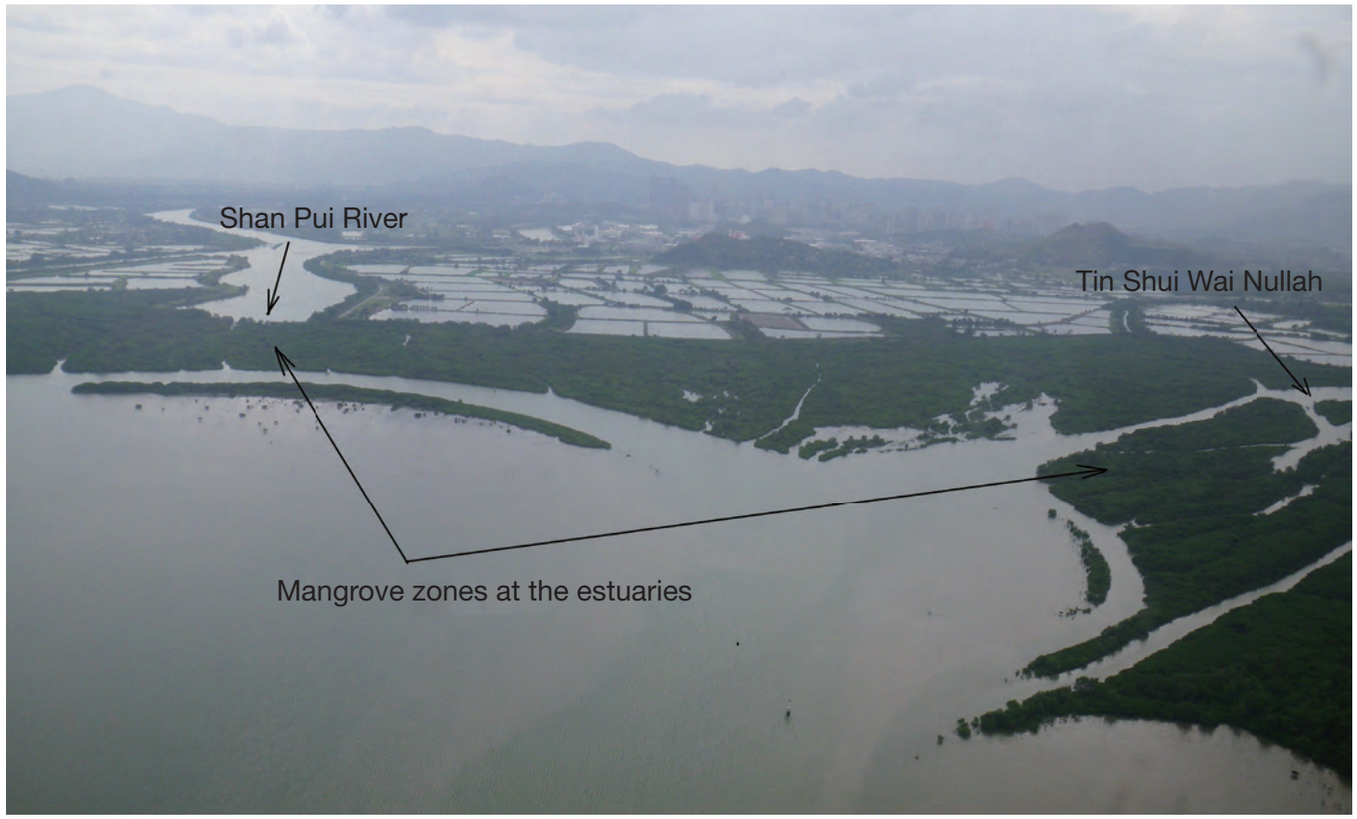
Mangrove management

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.

The pruned mangroves

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.



The dense mangroves at the Shan Pui River estuary and the Tin Shui Wai Nullah outlet obstructing the normal flows

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 micro-organisms. 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.

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 old Lo Wu Railway Bridge by the Shenzhen River

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 m^2 with a capacity of 80 000 m^3 for stormwater diversion and downstream flow control during rainstorms.

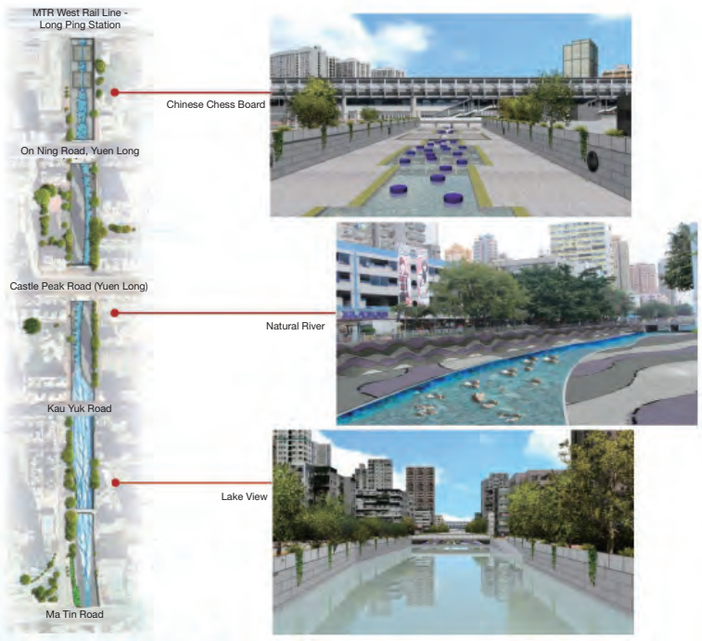
Mudflat and wetland will be constructed at the water storage basin. For the landscape design of the water storage basin, the project team, taking into account the unique features of the site as well as the planned land uses of nearby areas, decided to use aquatic plants for preventing riverbank erosion, 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.

A sketch of the water storage basin for Stage 4 of the Shenzhen River Regulation Project

Proposed urban stream

The existing Tsui Ping River and its environs

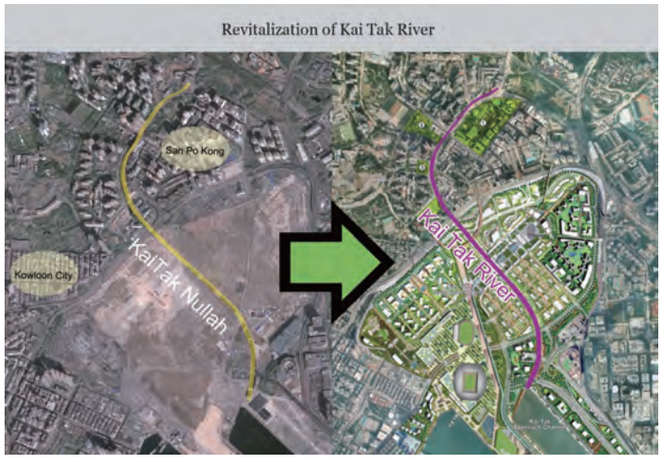
Without compromising the drainage performance, DSD plans to apply the novel concept of "urban streams" by integrating more ecological and water features into future river works in Hong Kong. By doing so, the new or existing drainage facilities will enhance the aesthetic of the nearby environment and 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.



Proposed themes for the Rehabilitation of Yuen Long Town Nullahs (artist's impression)

Revitalisation of Kai Tak River

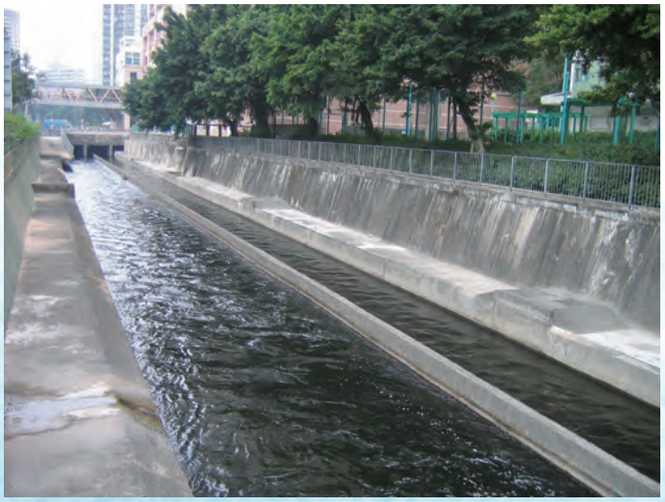
The existing Kai Tak Nullah was formed with several streams in the vicinity of Wong Tai Sin after continual development and evolution of the community.



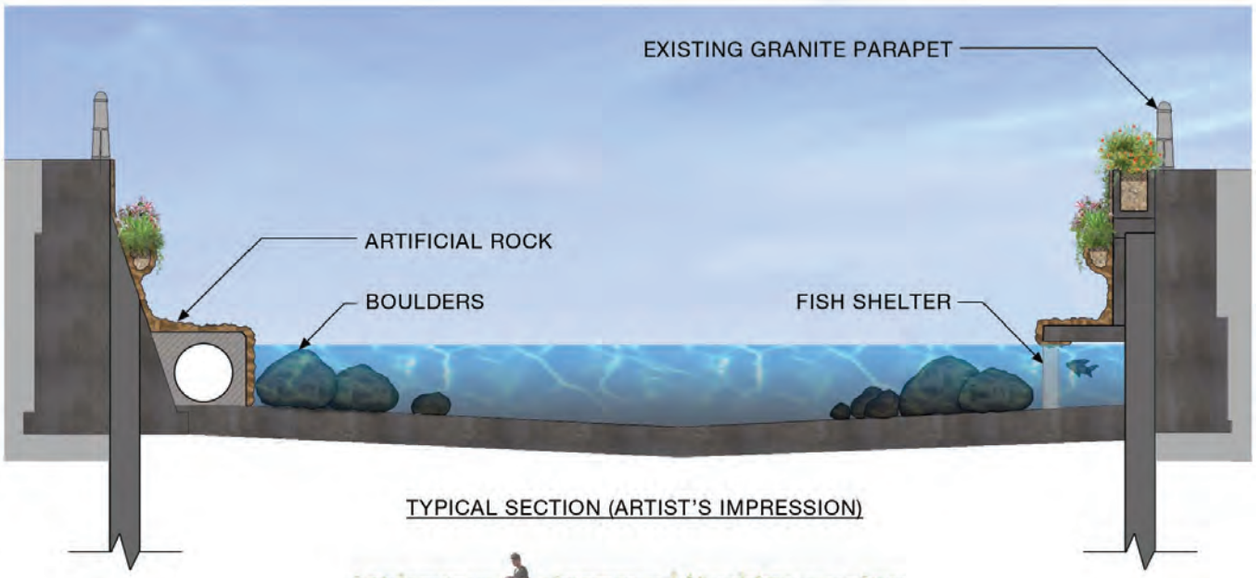
The name "Kai Tak" was originated from "Kai Tak Bund" in Kowloon City District in the 20th century. In 1920, Kai Tak was developed into a residential area called Kai Tak Bund under the first stage of Kai Tak Reclamation, in which the then existing streams nearby were also merged into Kai Tak Nullah and 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.

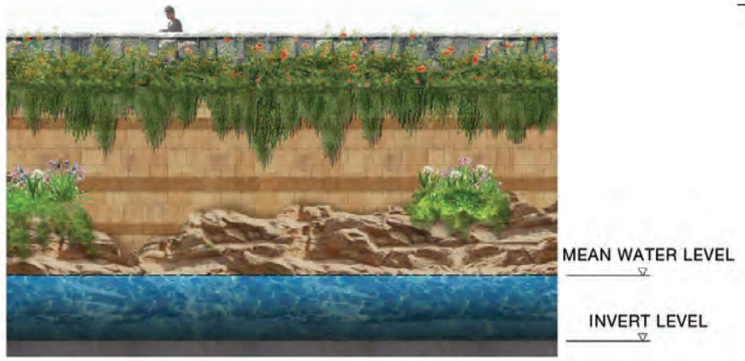
Although Kai Tak Nullah is not a natural watercourse, its improvement works have adopted the design with fish shelters and natural boulders with reference to the views of the World Wide Fund for Nature and the successful experience of the Ho Chung River Improvement Project in Sai Kung. Various landscape, 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].



Kai Tak Nullah before revitalisation



TYPICAL SECTION (ARTIST'S IMPRESSION)



ELEVATION (ARTIST'S IMPRESSION)

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

Green infrastructure

Green roof at Sha Tin Sewage Treatment Works

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 m^2 for its existing premises.

Green roof at Water Boat Dock Sewage Pumping Station

Green roof at Yuen Long Kau Hui Stormwater Pumping Station

Green roof at Ha Tsuen Sewage Pumping Station

Kowloon Bay Sewage Interception Station

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 Chi-yung

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 2 300 trees and 520 000 shrubs at Sha Tin Sewage Treatment Works to-date.

At-grade planting at Sha Tin Sewage Treatment Works

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 4 000 m^2 with a total of nearly 120 000 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

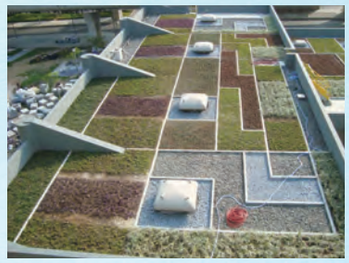
Original roof composite layer

Install root barrier

Install drainage

Install water reservoir panel

Place planting soil



Plant vegetation cover

Green roof at Sha Tin Sewage Treatment Works

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.

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 m^2 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.

Bauhinia corymbosa

Pyrostegia venusta

Quisqualis indica

Wisteria sinensis

Infrared sensors on the exterior walls for temperature measurement

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.

The indoor vertical green wall at Stanley Sewage Treatment Works

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.


HKGBC
香港綠色建築議會

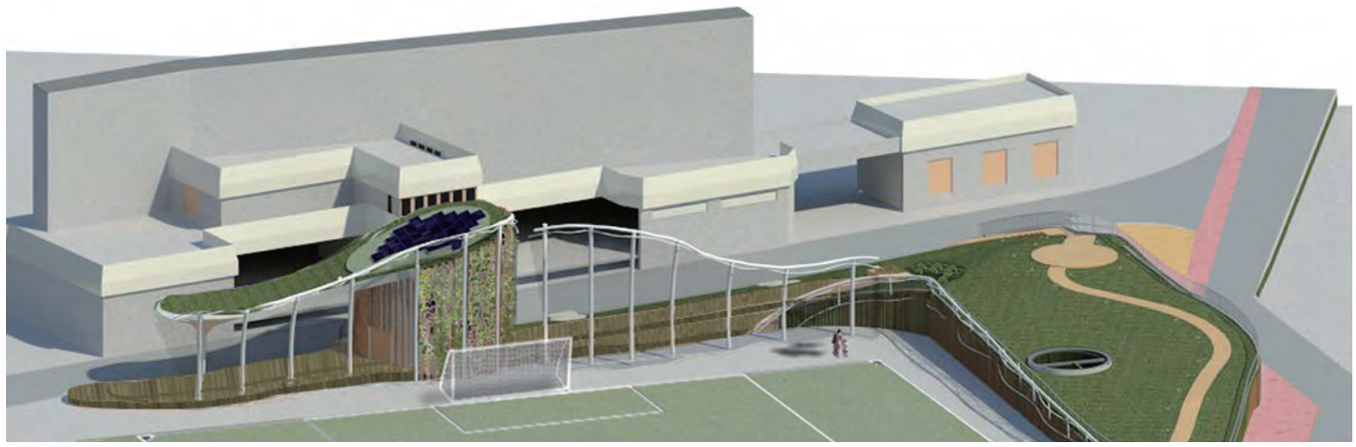
Happy Valley Underground Stormwater Storage Scheme
跑馬地地下蓄洪計劃

Happy Valley Recreation Ground, Sports Road, Happy Valley, Hong Kong
香港跑馬地體育道跑馬地遊樂場

has achieved the

PROVISIONAL
PLATINUM rating

暫定鉑金級



Outlook design of the facilities under Happy Valley Underground Stormwater Storage Scheme

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.

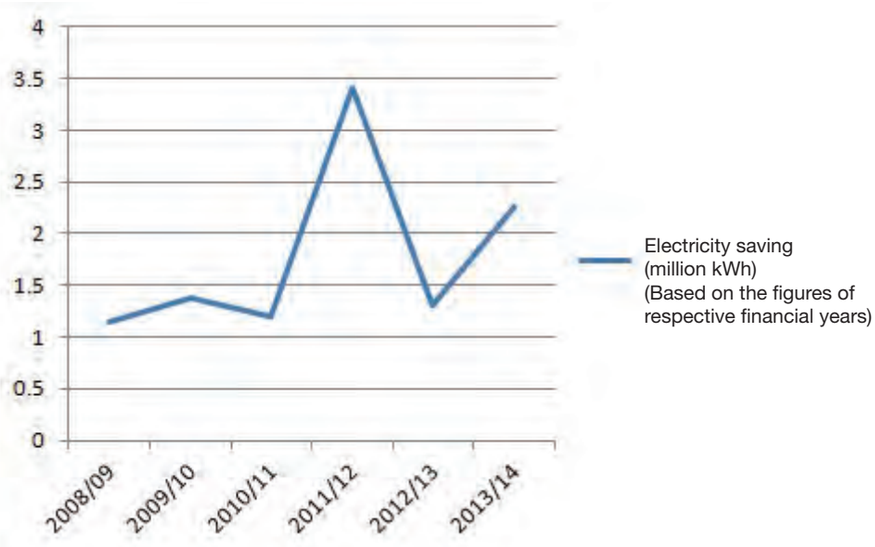
For the purpose of accrediting its green buildings, DSD will adjust and improve their performance at the construction stage. Take the two sewage pumping stations in Kowloon City as an example, porous grass paver with infiltration function was used to pave the carriageways and rainwater harvesting systems were installed to increase the green coverage and save irrigation water[7].

Grass paver was used to pave the emergency vehicular access of Kowloon City Sewage Pumping Station No. 1

Grass paver

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 7 700 tonnes of carbon emission.



Statistics on electricity saving by DSD in recent years

Carbon emission and local climate change

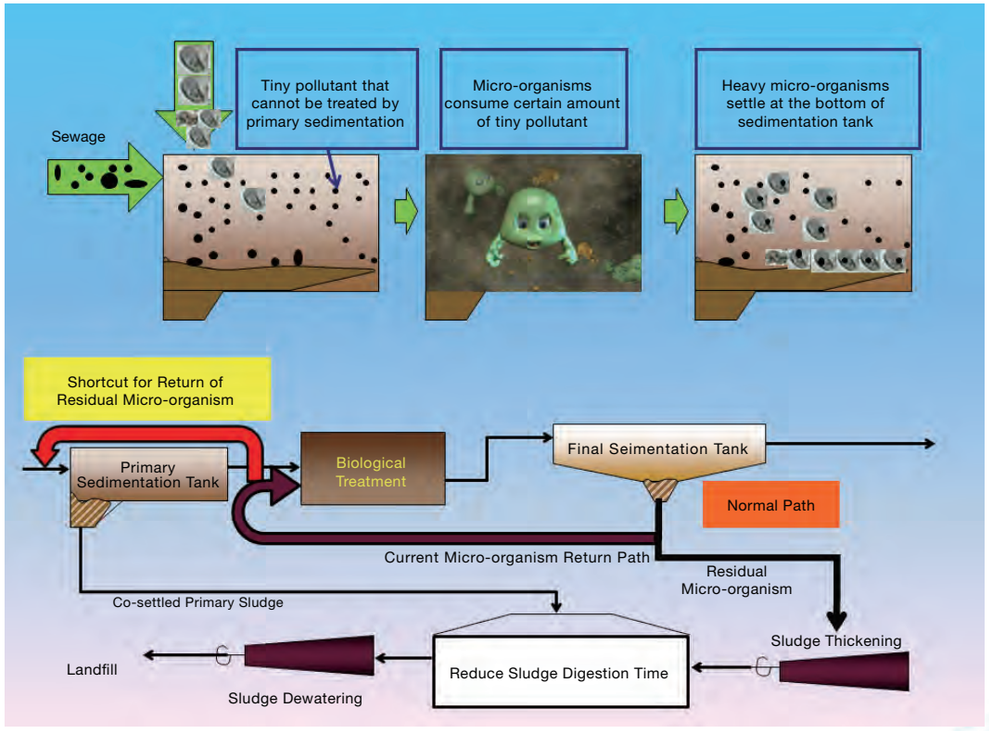
Over the past five decades, carbon emission has been on a rising trend, affecting the global climate change. The rise in global average temperature has been about 0.13°c every decade. Relevant data from the Hong Kong Observatory showed that the temperature in Hong Kong for the last 50 years was persistently 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[8].

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.



Co-settling procedures adopted at Sha Tin Sewage Treatment Works

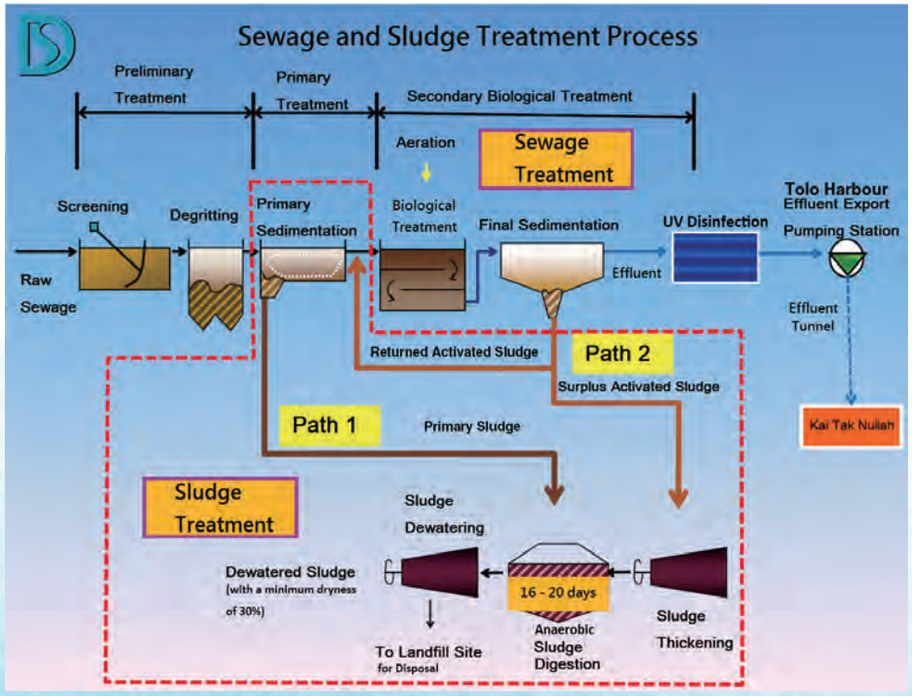
Since implementing the environmentally friendly sludge treatment process of co-settling, Sha Tin Sewage Treatment Works is managed to save 6.6 million kWh of energy each year. Regarding environmental protection, this process has reduced about 4 600 tonnes of carbon emission, amounting to the total annual 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.



Flow chart of SANI Process at Sha Tin Sewage Treatment Works

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.

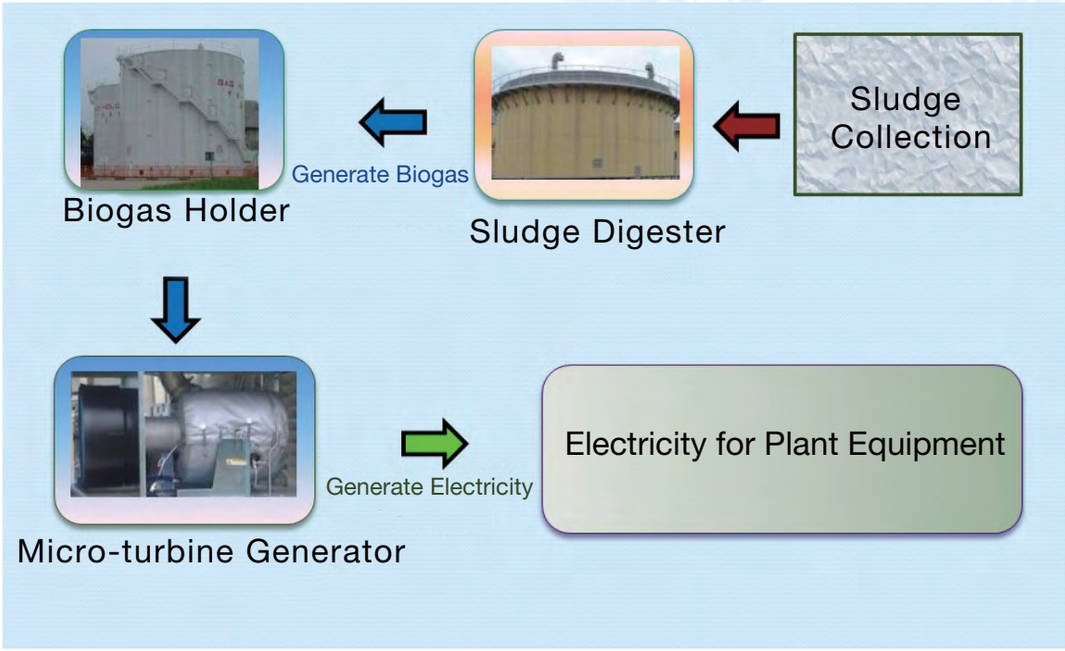
Biogas

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.

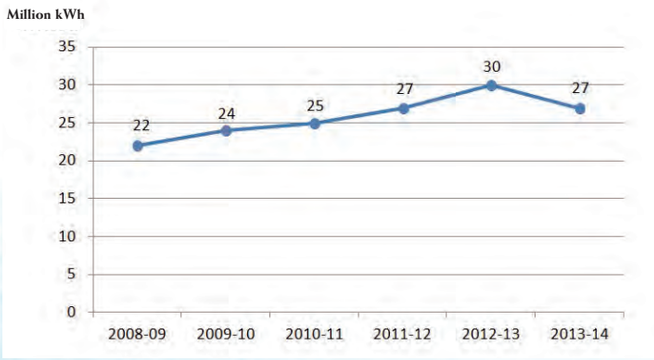
CHP generator at Shek Wu Hui Sewage Treatment Works

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.



Operational procedures for the micro-turbine generator to generate electricity from biogas

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.



Total electricity generated from biogas by DSD over the past six years

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.

The solar water heater at Shek Wu Hui Sewage Treatment Works supplies hot water for daily use

Solar-wind power lamp poles at Ngong Ping Sewage Treatment Works for lighting

The solar photovoltaic system at the roof top of Yuen Long Sewage Treatment Works provides partial electricity supply for the plant by grid-connection

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.

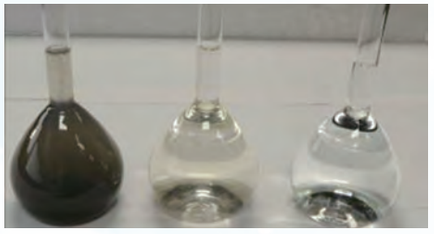
Water management and sustainable drainage system

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.

Membrane components for reverse osmosis



(From left) Sewage, effluent, reclaimed water

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.

Garden irrigation

Facility cleaning

Ornamental fish rearing

Toilet flushing

Dilution of chemicals
(e.g. polymers)

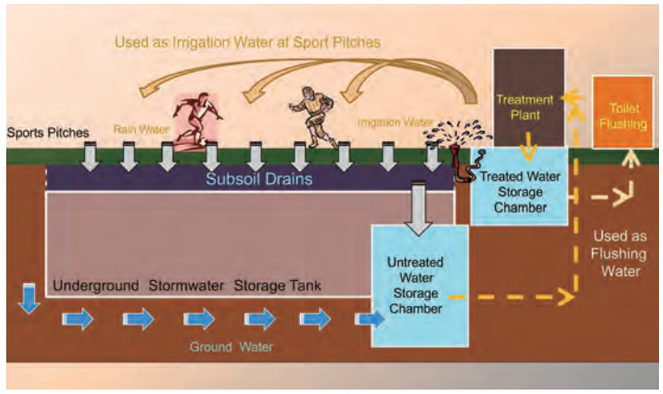
Make-up water for deodorisation systems

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.

Intake of the main tunnel for Lai Chi Kok Drainage Tunnel

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.



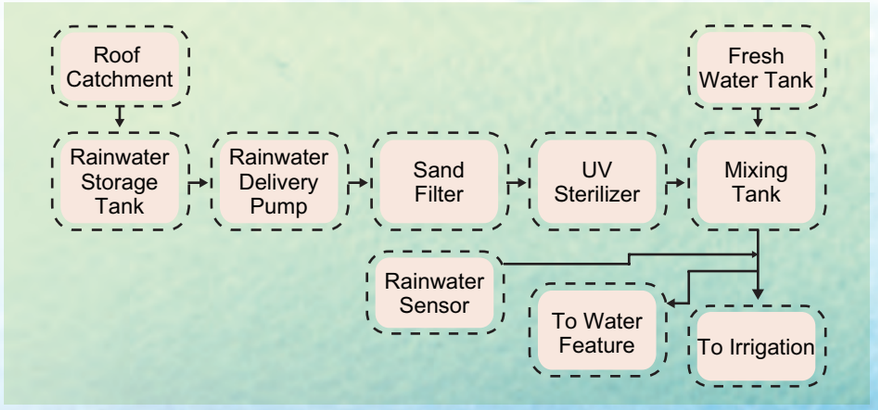
The groundwater and rainwater harvesting system under Happy Valley Underground Stormwater Storage Scheme

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.

The rainwater harvesting system at Kowloon City Sewage Pumping Station supplies water to the water feature



Operation flow chart of the rainwater harvesting system

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.

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[9].

渠務署
香港特別行政區政府

總部

ISO 9001、ISO 14001及OHSAS 18001 綜合管理系統政策

渠務署總部承諾本著對安全、健康和環境負責任的態度，提供優質的專業、技術和行政服務，支援本署提供世界級的污水和雨水處理排放服務，以促進香港的可持續發展。

我們承諾

- 遵守適用的法例、法規和其他規定；
- 推行預防污染的措施以減少對環境造成的影響；
- 為員工提供足夠的資源和所需的培訓；
- 持續改進服務表現、環保和安全成效；
- 為員工提供和維持安全與健康的工作環境、並適當地保護受我們工作影響的人士；
- 以殷勤的態度理解和回應客戶不斷提升的期望；
- 向全體員工、供應商、顧問、承建商和市民大眾傳達這項政策；和
- 發展、推行和維持一套符合ISO 9001、ISO 14001及OHSAS 18001要求的綜合管理系統。

陳建光

陳建光
管理者代表
二〇一二年五月

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.

"Paperless meeting" to save paper

Travelling between construction sites by EV to reduce greenhouse gas (e.g. carbon dioxide) emissions

Energy-saving LED lighting system

De-lamping unnecessary lighting

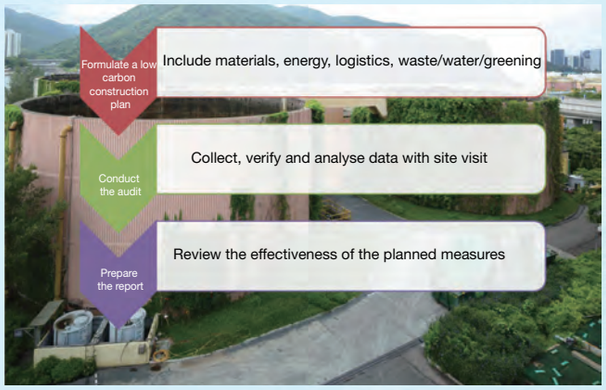
Office temperature set at 25.5°C (left) and recycling bins placed in the office (right)

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[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:



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:

Scope 1 — Direct emissions and removals
(i.e. emission sources directly related to construction activities such as combustion)

Scope 2 — Energy indirect emissions
(purchase of electricity or coal gas for construction activities)

Scope 3 * — Other indirect emissions
(sewage treatment, water consumption, paper waste, as well as the transportation and production of materials bought from third parties)

* 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[11].

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.

Sha Tin Sewage Treatment Works under construction, 1975[Fig 1]

Recent view of Sha Tin Treatment Works

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

Mui Tsz Lam Village, next to Tai Shui Hang, is on Nui Po Shan (centre), Ma On Shan, Sha Tin

Mr Ng Shui-ching, Indigenous Inhabitant Representative of Mui Tsz Lam Village

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.

Roving exhibition

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.

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.

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Fig. 1 was provided by courtesy of the Information Services Department.