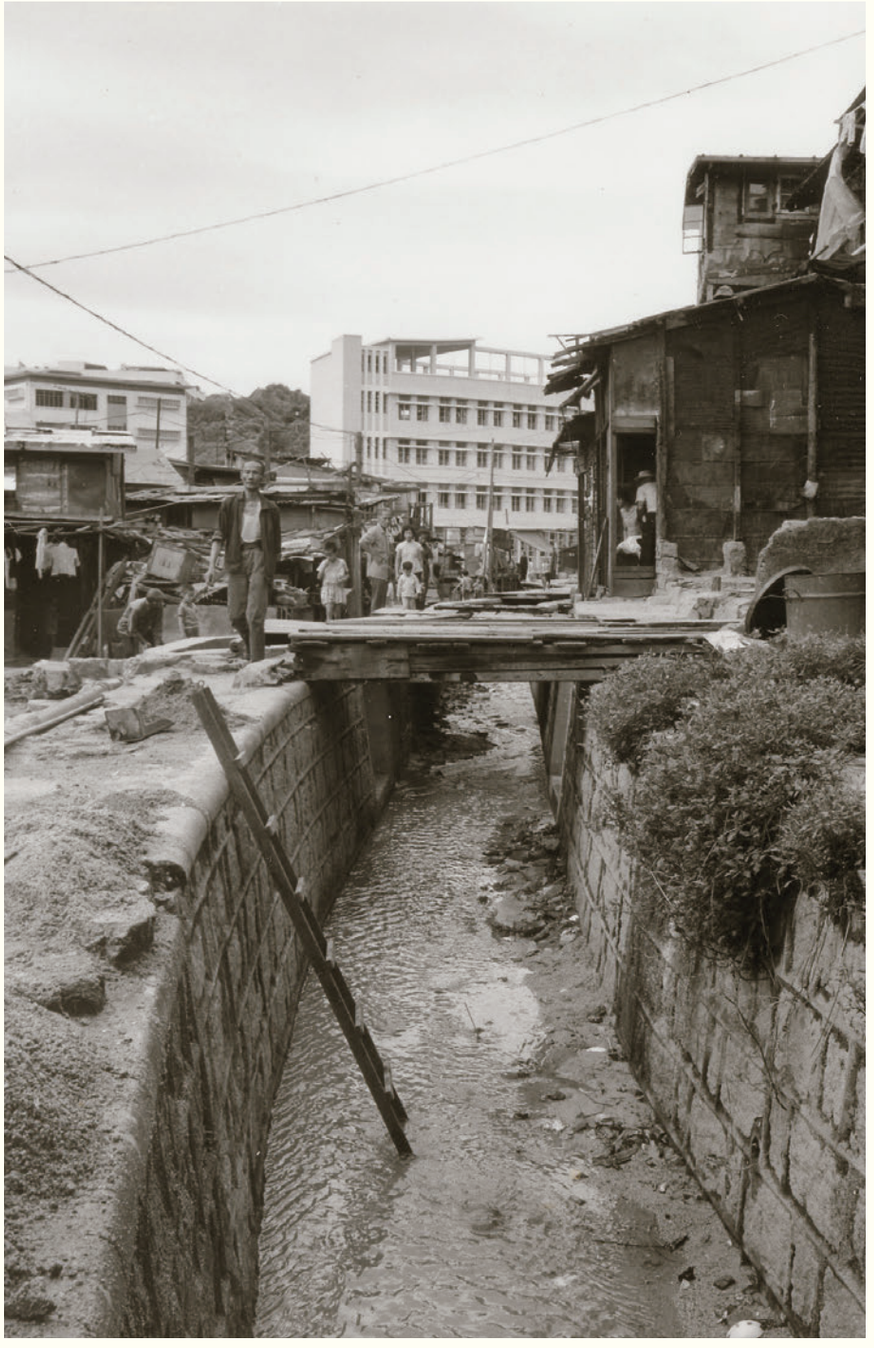

Brave
the
Challenges
1971~1988

Part II : Transition to a New Era 1971–1988

Chapter 4: Transition to New Frontier of Environmental Protection 1971–1988

It can be clearly seen, from the previous three chapters, that drainage services were often associated with sanitation whenever problems occurred, as was the case in Hong Kong for over a hundred years. Drainage services played a very important role in containing the sanitary catastrophes of the territory hence protecting the health of the people. Towards the end of the 1960s, keeping abreast with developments in other parts of the world, the role of drainage services in Hong Kong began to shift from sanitary containment and health protection to environmental protection in a much wider context.



Open channels at Kwai Chung Licensed Area (left) and stormwater drains at Kowloon Tsai squatter area (right) during late 1960s. At that time, environment issues of any drainage services were seldomly accounted for.

Bowrington Road Nullah in Wanchai (Canal Road of to-date). Stormwater drains carried away untreated wastewater, rubbish, oil spill and other pollutants, together with sand and silt into the nullah. Man-entry into open nullahs for manual removal of sand and silt has become uncommon nowadays.

Watson's Report

In July 1971, J. D. & D. M. Watson presented a report to the Hong Kong Government entitled Marine Investigation into Sewage Discharges: Report and Technical Appendices.

The Report, citing opinions from renowned engineers, while commended on the existing developments at the same time reminded that the population of Hong Kong would reach 6.14 million by 1991. The engineers made several recommendations to tackle the problems of sewerage, outfalls, night soil and refuse tipping. It was further pointed out that drainage services in the urban areas were operated on a nominally 'separate' system. The storm water drainage system had been affected by sewage discharge through illegal connection.

The Report also pointed out that the sewage was not given any pre-treatment before discharging into the sea or rivers. It had thus polluted areas such as Castle Peak, Brewery Bay, Tsuen Wan, Aberdeen, and Chai Wan. This, the Report pointed out, had led to water pollution and wider implications of environmental protection.

Watson's Report formed the blue print for the strategy for wastewater treatment and disposal in Hong Kong in the 1970s. Counting on the natural assimilative capacity and beneficial use of the receiving water bodies, the study recommended the construction of 1) screening plants with submarine outfalls for areas around Victoria Harbour; and 2) wastewater treatment plants for areas discharging into inland and enclosed coastal waters such as Tolo Harbour and Deep Bay.

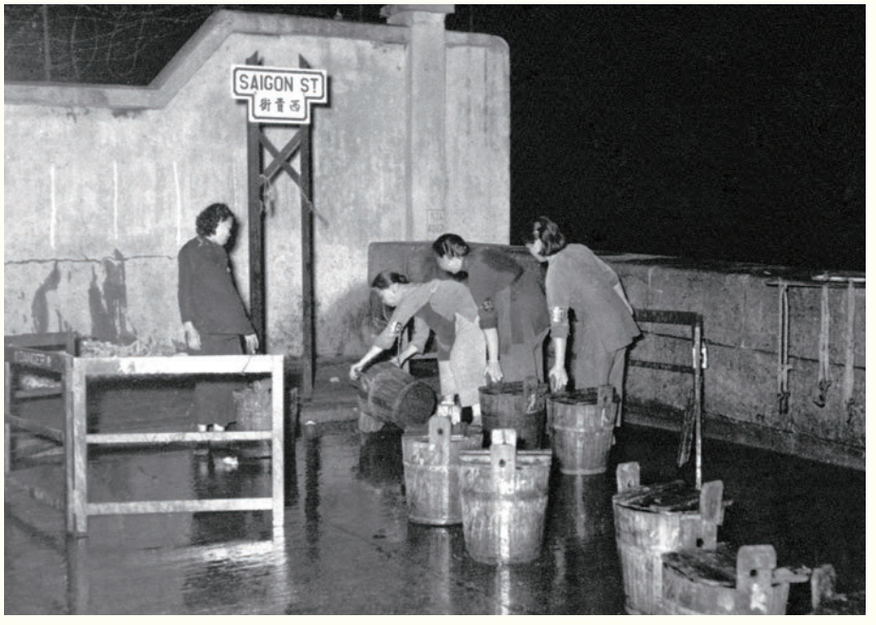
Environmental protection and water pollution

In those decades it was common for people to try and find solutions to environmental issues that preferably would not force them to take stands on questions of value which could become personal, difficult and subjective. In particular, while looking for neutral and impersonal methods, it would leave all questions of value, for instance the concept of "sustainability", to the personal realm.

Today, however, 'sustainability' is a universal concept. People all over the world agree that human systems should be sustainable, and if they are not sustainable it is usually because of three essential reasons:

1) *The systems are producing levels of pollution which exceed the local, regional, and even global capacity to absorb and render them harmless;*
2) *The systems will exhaust finite nonrenewable resources;*
3) *The systems are using renewable resources such as forests faster than such resources can be naturally regenerated.*

If human systems exceed the capacity of our planet to supply resources for dealing with our wastes, they will erode our planet's ability to support life. To create a sustainable future, mankind must revamp the systems that support our lives. The challenge is twofold: we must adjust our existing systems to make them as sustainable as possible, and we must build new systems using the principles of sustainable design.



In the 1950s, the wastewater from cleaning the manure buckets was drained directly into the surface drains and discharged into the harbour, resulting in pollution.

Drainage services basically deal with one very important aspect of environmental protection, i.e. the control of water pollution. To approach this problem, we must first of all define what water pollution is and understand what its sources are.

Water pollution is any physical or chemical change in water that adversely affects organisms. The problem is global in scope, but the types of pollution vary according to a country's level of development. In under-developed non-industrial countries, water pollution is mainly caused by human and animal wastes, pathogenic organisms from such wastes, pesticides, and sediment from unsound farming and timbering practices.

Developed industrial nations, on the other hand, create an additional assortment of potentially hazardous pollutants such as heat, toxic metals, acids, pesticides and organic chemicals. In between these two extremes are numerous countries which have achieved various degrees of industrialisation. Often, these countries do not have laws, or only have inadequate laws, to combat water pollution. Even when there are such laws, the lack of funding may prevent them from being effectively enforced.

Shan Pui River in Yuen Long originates from hilltop in Tai Tong and flows through the Yuen Long town centre, Mai Po and Wang Chau, and converges with Kam Tin River into Deep Bay. Because of untreated livestock waste, water in the main nullah in the town centre of Yuen Long was used to be contaminated and malodorous.

Sources of water pollution

Numerous sources, both natural and anthropogenic, contribute to water pollution. As a rule, anthropogenic sources are the most important because they tend to be localised and thus contribute significantly to the deterioration of local waterways or groundwater. In short, water pollution arises from identifiable point sources such as factories, and from diffuse non-point sources such as farm fields and streets. Point sources are much easier to control.

Villagers washing in a stream near Wu Kau Tang in north-eastern New Territories, 1950s. As the waste generated was within the local capacity to absorb, the practice produced only insignificant damage to the environment.

Heavily polluted water in Lei Yue Mun, 1987.

Vessel repair facilities in the vicinity of Cheung Sha Wan waterfront, circa 1960s; onshore pollution then was serious due to industrial development.

Sha Tin Hoi, circa 1970s; it used to be a popular resort area until the early 1970s when the marine environment started to deteriorate.

Signs and warnings of water pollution in Hong Kong

The combined effects of industrial development and population increase during the 1950s and 1960s in Hong Kong were signified by obvious signs of water pollution in the territory. The situation worsened as the pace of development accelerated in the 1970s and 1980s. The marine environment deteriorated rapidly as most of Hong Kong's sewage and wastewater ended up in the sea with the bulk of it receiving little or no treatment before discharge. This in turn led to increases in organic and inorganic pollutants, reductions in the oxygen content of the water, and increases in the bacteria level. The Cross-Harbour Swimming Race, a major sport event in Hong Kong, was held in Victoria Harbour in 1973 for the last time, to the regret of many people.

Cross-harbour swimming race in 1967

As the Sha Tin New Town development scheme commenced in 1970s, water quality in Sha Tin Hoi started to deteriorate.

To house the growing population, the Government began building new towns in the 1980s. This certainly did not benefit the surrounding environment. For example, two of the new towns, Sha Tin and Tai Po, were built in the catchment area for Tolo Harbour which, owing to its enclosed nature, could easily become polluted by pollutants from these two new towns.

Another major problem of marine water pollution in the past few decades was the untreated waste generated by the livestock industry. In the early 1980s, many parts of the New Territories and some urban areas were home to thousands of pig farms and chicken farms. Large volumes of effluent from these farms were discharged directly into Hong Kong's rivers, carrying the pollutants out to sea.

The farms near Tsang Tai Uk in Sha Tin, circa 1975. Wastewater discharged into Shing Mun River from these farms further aggravated the pollution of Tolo Harbour.

In the 1980s, Hong Kong was home to many industrial enterprises. Thousands of factories, particularly those in the Kwun Tong and Tsuen Wan areas, discharged their untreated waste directly into sewers that led to the sea. The waste was particularly high in chemical and metal content as they were, among other sources, originated from factories belonging to the prominent textile, electroplating, bleaching and dyeing industries.

Tsuen Wan in 1978. Industrial wastewater was discharged directly into the sea. This was commonplace in 1980s.

Pollution of streams

In as early as 1974, the attention of the Government was drawn to the problem of stream pollution in Hong Kong. A consultant firm commissioned by the Government carried out a survey and study of the subject in that year. It was reported that, of the 250 miles of stream covered by the survey, about 150 miles (60%) could be classified as clean (with water showing little or no sign of pollution). Of the remainder, 60 miles (24%) could be classified as polluted (but not offensive) and 40 miles (16%) as grossly polluted (offensive in appearance and/or smell).

The unpolluted streams were generally in uplands above the 200 feet contour. The polluted or grossly polluted streams were situated in the lowlands where the rural population of the New Territories resided.

Sewage and night-soil contributed to 10% of the total polluting load discharged or dumped into the streams. This could be explained by the fact that only 16% of the population in the New Territories was served by public sewers and a further 3% with WC's draining to septic tank systems.

Sai Kung Town before development in 1970s. As a result of industrial wastewater pollution stemmed from Ho Chung Bleaching and Dyeing Factory, streams and beaches in the vicinity of Sai Kung were at one time seriously polluted.

The Tai Po New Town in development in 1980s

Rubbish and siltation in a river channel in the New Territories, 1970s.

Industrial effluents, virtually all of which were discharged untreated, accounted for about 22% of the total polluting load entering the streams. About 90% of the total flow of industrial effluent originated from three groups of dyeing and bleaching factories in Tsuen Wan, Fo Tan and Ho Chung. The rest was discharged from more than 200 factories of various industries like slaughter-houses, tanneries, chemical works that were scattered throughout the New Territories.

There were more than 13 000 pig farms with a total of about 370 000 pigs. At least 80% of the excreta were discharged into the streams without any form of treatment. The number of poultry in the New Territories was about 6 million, of which 90% were chickens. 350 tonnes of droppings were produced daily in the New Territories, and more than 50% of it was dumped into the streams.

Aerial view over Sheung Shui, 1985. Numerous small farms can be seen.

Pig farms in the New Territories. Faeces were generally hosed down into nearby drains or water courses causing severe pollution.

Pollution of coastal waters

Apart from stream pollution, the water quality of the coastal waters and Victoria Harbour also came under scrutiny. A report produced in 1982 made the following assessment on the coastal waters:

1) *Western Hong Kong: In general the water quality was fair, with relatively high turbidity and low dissolved oxygen. The major areas of significant pollution were Deep Bay and the beaches along Castle Peak Road. This was likely due to the dense population and industrial development in the Tsuen Wan and Tuen Mun areas. The water quality of Deep Bay was deteriorating, as shown by (i) reduction in the total number of species captured in the shrimp ponds; (ii) high nutrient nitrate and phosphate level; (iii) longer period of time taken by oysters to grow to market size.*

2) *Eastern Hong Kong: As this area was open to the currents and waves from the South China Sea with high waste receiving capacity, the coastal waters were of high quality in general. There were, however, certain exceptions, e.g. in Tolo Harbour, where it was found that (i) the water quality was poor, with high coliform content; (ii) there was an increasing occurrence of red tide; (iii) the clams collected from the inner harbour were unfit for human consumption; (iv) there were mass mortalities of the benthos in 1972, 1979 and 1980; (v) the dissolved oxygen in the water was low, especially at the bottom of the harbour. In short, the inner harbour was grossly polluted.*

Western edge of Tolo Harbour in Yuen Chau Tsai, 1975. Insufficient tidal flush and limited dilutive capacity in the semi-closed harbour added to the extent of environmental degradation.

Tuen Mun in development in 1979. Both population and industrial development would increase.

The same report also commented on the water quality of Victoria Harbour. Before 1960, most of the sewage that ended up in the Harbour was untreated except where there was limited treatment by septic and Imhoff tanks. From 1960 onwards, though screening plants and submarine outfalls were constructed, the Harbour remained grossly polluted particularly in the following areas:

1) *The northern coast of west Kowloon, where the water had high coliform content;*

2) *The typhoon shelter area between Kwun Tong and the Kai Tak Airport runway, where the water was black with bad smell and the coliform content was high;*

3) *The northwest coast of Hong Kong Island near Sheung Wan and Yau Ma Tei and Causeway Bay Typhoon Shelter, where the water had high coliform content.*

Typhoon Shelter in Causeway Bay by the end of 1960s

Sham Shui Po, circus 1975; untreated wastewater, garbage, oil spills and other pollutants were discharged into drainage system, which eventually flew into the Victoria Harbour.

Boat squatters within typhoon shelter in Yau Ma Tei in 1979

Jordan Road Ferry Pier, and Man Wah Sun Chuen in Yau Ma Tei under construction. Most wastewater at that time only undergone simple treatment or no treatment before conveyed into the Victoria Harbour, causing deterioration in water quality in the Harbour.

Preparatory measures taken by the Government to combat water pollution

The above surveys and studies revealed that the quality of Hong Kong's waters in the late 1970s was severely threatened by a mixture of pollution sources, while its controls were mostly inadequate. In response to such challenges, the Government began to draw up a blueprint to contain the deterioration of Hong Kong's marine environment under the new Water Pollution Control Ordinance (1980).

The ordinance divided the Hong Kong's marine waters into ten Water Control Zones (WCZs). A set of Water Quality Objectives (WQOs) and discharge standards was established for each WCZ.

These WQOs outlined the qualitative and quantitative standards of water that needed to be met as conservation goals, and they were also used to support the various beneficial uses of different water bodies. In other words, they were designed as long term environmental goals to safeguard Hong Kong's marine environment.

In the same year, the Waste Disposal Ordinance was enacted. Among other things, it provided for the preparation of a statutory Waste Disposal Plan (WDP), the notification of certain classes of toxic and difficult wastes, and measures to control the storage of agricultural wastes. Wastes from agriculture, especially pig wastes, had caused widespread pollution in the New Territories for some decades, and much of the problem was caused by the then practice of discharging the wastes into water courses. The legislation aimed at putting a stop to this practice.

Also in 1986, the Environmental Protection Department was established and entrusted with the task of monitoring Hong Kong's marine waters. It devised a comprehensive marine water monitoring programme which was first implemented in 1986 and later given regular revisions and expansions. The monitoring programme was crucial for measuring whether individual Water Control Zones complied with the WQOs. Based on the information, the Government was able to assess the effectiveness of its pollution control measures for further strategies.

The programme was designed with the following aims and objectives:

1) *to indicate the state of health of coastal waters;*
2) *to assess compliance with the statutory WQOs;*
3) *to reveal long term changes in water quality;*
4) *to provide a basis for the planning of water pollution control strategies.*

In retrospect, the efforts showed positive signs of improvement in the marine environment; particularly in areas where Hong Kong's marine waters are relatively enclosed or near urban areas and receive large volumes of waste water, e.g. in Tolo Harbour and Victoria Harbour. By 1988, only a year before the establishment of the Drainage Services Department, Hong Kong had reached the threshold of a new frontier of environmental protection in combating water pollution. Much work had to be done before anything meaningful could be accomplished.

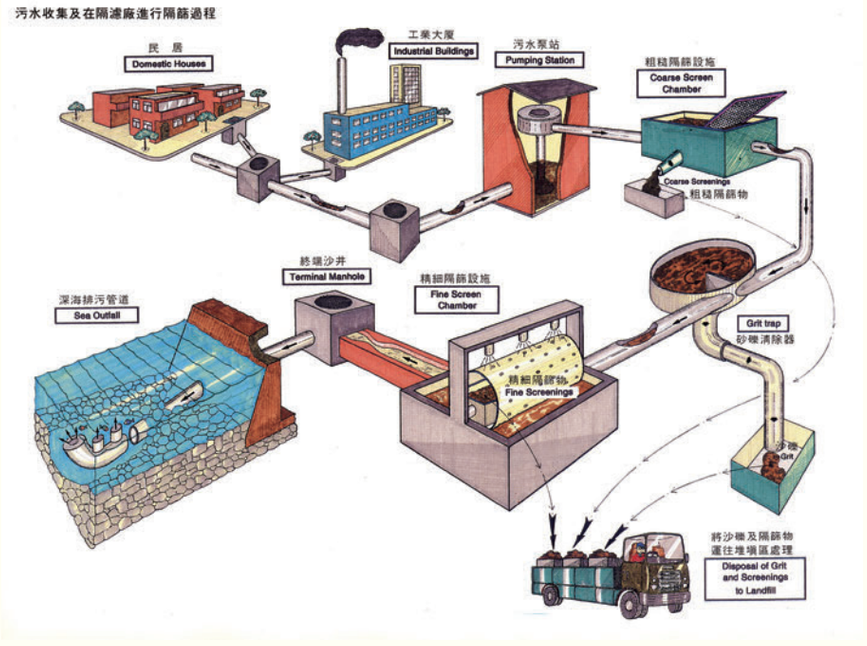
The Yau Ma Tei typhoon shelter in 1979. Surrounded by sea walls and breakwaters, the water quality of typhoon shelters is particularly vulnerable to pollution from coastal and moored boats.

Post-1971 construction of sewerage infrastructures

Sewage treatment plants for Victoria Harbour

Following the successful commissioning of the first sewage screening plant at Anchor Street in 1956, similar plants along both sides of Victoria Harbour were built in the 1950s and 1960s. Simple preliminary treatment involving only removal of large particles was adopted then as the appropriate technology for treating sewage in Hong Kong. Bar screens and rotating drum screens were typical equipment for coarse and fine screening of sewage. Grit channels were also used to allow heavier grit particles to settle.

The Watson's Report (1971) had recommended the continuous adoption of preliminary treatment plants with submarine outfalls for areas around Victoria Harbour to best utilise the flushing effects of the strong tidal currents in the Harbour. Many more advanced screening plants were built in the 1970s and 1980s, installed with fine screens to improve the quality of the discharge.



Typical operation flow within a preliminary treatment plant

The Anchor Street Sewage Screening Plant. It was decommissioned in 1992 after commissioning of the North West Kowloon Sewage Treatment System.

Kwun Tong Preliminary Treatment Works

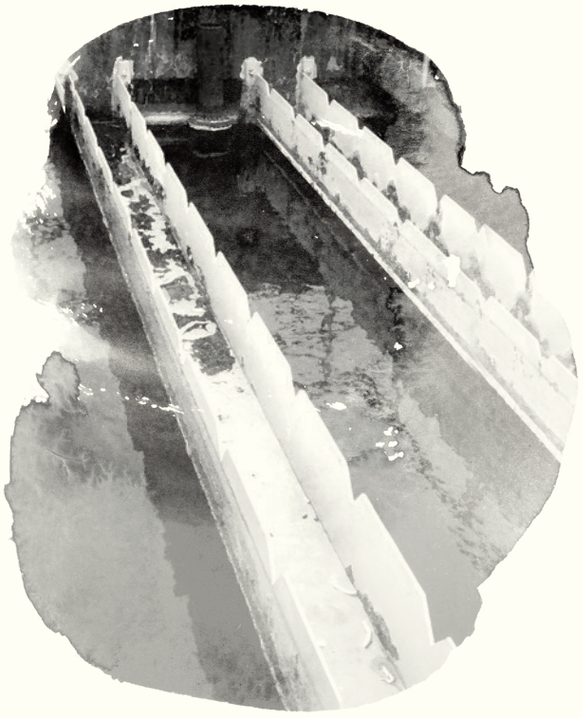
Sewage treatment plants for inland waters

Beginning from the 1970s, more and more people have been moving into the new towns in the New Territories. Unlike Hong Kong Island and the Kowloon Peninsula, these new towns are not close to a water body like Victoria Harbour, and sewage discharge with preliminary treatment were inadequate. The Watson's Report therefore recommended that sewage treatment with standard higher than preliminary should be adopted.

In order to select the most appropriate technology for Hong Kong and to gain first hand operational experience, the Government set up a pilot secondary treatment plant in 1974 at Shek Wu Hui where different technologies for secondary treatment, namely the oxidation pond, the trickling filter and the activated sludge process, were tested and evaluated. These technologies were further developed after the United States passed the Federal Water Pollution Control Act Amendments of 1972. The conclusion of the trial was that the activated sludge process was the most suitable technology for secondary sewage treatment in Hong Kong, and this decision set direction for the subsequent full-scale development of secondary treatment plants.

Tseung Kwan O Preliminary Treatment Works

Trickling Filter of the Shek Wu Hui Pilot Sewage Treatment Plant



The Tai Po Sewage Treatment Works (TPSTW) within the Tai Po Industrial Estate, occupying 12 hectares of land

Anaerobic Sludge Digester of the Shek Wu Hui Pilot Secondary Sewage Treatment Plant

The first large-scale secondary sewage treatment plant was commissioned in 1979 in Tai Po to serve the industrial estate and the new town. Being a semi-landlocked water body, Tolo Harbour has much less capacity to assimilate the sewage arising from the Sha Tin and Tai Po new towns. To cope with the new towns' development, secondary treatment plants were urgently required.

The Stage I works of TPSTW were completed in October 1979 with a treatment capacity of 9 500 cubic metres/day, serving the Tai Po Tai Yuen Estate and the industrial demands in the area. The Stage II works were completed in July 1983 with treatment capacity increased to 33 600 cubic metres/day to cope with the development of the new town.

Sha Tin New Town

The Sha Tin development plan was first considered in 1963 and was revised in 1965. The revised plan incorporated more high-density housing to satisfy pressing needs. The plan was to be implemented in four phases over a period of 15 years. It could support a population of 1.09 million and yield new land amounting to 2 135 acres, of which 232 acres could be used to build 540 000 low-income housing units.

The first phase of the project involved areas around the Shing Mun River and the feng shui hill in Yuen Chau Kok. The major areas of work were drainage, reclamation and water supply. In 1973–1974, before the launching of the 10-year housing programme, the Sha Tin development was making very slow progress. In 1973, not even the first stage of construction was completed. The development plan was further refined in 1976 and a blueprint that largely resembled the layout of present-day Sha Tin was finalised in 1977.

As a stop-gap measure to control water pollution in the Sha Tin area, a temporary and interim sewage treatment plant was commissioned in phase since 1975 in a site near the downstream section of the Fo Tan Nullah (at present Jockey Club Ti-I College), adopting respectively extended aeration process and contact stabilisation process.

Settling Tank of the Shatin Sewage Treatment Plant

Shatin temporary secondary sewage treatment plant started operation since October 1978 and testing completed by then as well

Shatin temporary secondary sewage treatment plant. In the background is the Fo Tan Road under construction.

In 1982, Stage I of the Sha Tin Sewage Treatment Works, capable of treating 102 870 cubic metres of sewage per day, was commissioned to take over the duty of the interim secondary sewage treatment plant. Stage II of the sewage treatment works was commissioned in 1986, increasing the treatment capacity to 205 000 cubic metres/day.

In early 1980s, the district of Sha Tin was developed into several industrial areas: Fo Tan, Tai Wai, Siu Lek Yuen and Shek Mun. Since then, Sha Tin has been transformed into a modern town, bustling with business enterprises and industrial activities.

Shatin Sewage Treatment Works in 1982

Sha Tin New Town, 1977.

Other secondary sewage treatment works

Following the Tai Po and Sha Tin STWs, additional secondary treatment plants were built in the 1980s at Shek Wu Hui, Yuen Long and Sai Kung from which effluent was discharged into inland waters or coastal waters with limited self-purification capacity.

In 1984, Stage I of Shek Wu Hui STW was constructed and commissioned to handle a dry weather flow of 60 000 cubic metres/day, serving an equivalent population of 220 000 from the new town developments in the Sheung Shui and Fanling areas.

The Yuen Long STW was designed to treat both domestic wastewater from Yuen Long town and industrial wastewater from Yuen Long Industrial Estate. Stage I was commissioned in 1984 to provide a treatment capacity of 53 000 cubic metres/day.

The Sai Kung Sewage Treatment Works, occupying an area of about two hectares on reclaimed land at Tui Min Hoi, Sai Kung, was commissioned in November 1988. It was designed to treat sewage generated from a population of 42 000 in Sai Kung District with a dry weather flow of 15 200 cubic metres/day.

The Shek Wu Hui Sewage Treatment Works

The Yuen Long Sewage Treatment Works located adjacent to the Industry Estate similar to the Tai Po Sewage Treatment Works

The Sai Kung Sewage Treatment Works in 1988

Sewage treatment plants for small communities

Apart from large-scale secondary treatment plants designed to combat pollution, small or package sewage treatment plants were built for small communities, including institutions such as military camps, prisons and quarters, in remote areas in the New Territories and Outlying Islands.

Various technologies were adopted in these plants, depending on the assimilation power and the water quality objectives of the receiving water bodies. The first primary treatment plant in Hong Kong was built in 1983 at Tai O where an Imhoff Tank was built for processing of the sewage. The Imhoff Tank consists of a top compartment which serves as a sedimentation tank and a lower compartment in which the settled solids are collected and anaerobically stabilised. Another primary treatment plant was built in 1985 in Cheung Chau to serve the community on the island.

The Tai O Imboff Tank, built in 1983, is the first primary treatment plant in Hong Kong.

Other secondary treatment processes such as trickling filters, oxidation ditches, and rotating biological contactors were chosen for other locations.

The trickling filter consists of a bed of highly permeable media on whose surface a mixed population of microorganisms is developed as a slime layer. The passage of wastewater through the filter causes the bacteria, protozoa and other organisms in the slime layer to consume the organic matters in the wastewater.

The oldest trickling filter plant was the Tam Mei Barracks sewage treatment plant in Ngau Tam Mei. It began functioning in 1953, and had a treatment capacity of 288 cubic metres/day serving a domestic military population of approximately 1 200 people.

The first Rotating Biological Contactor (RBC) plant for government institutions was commissioned at Shek Pik Prison in 1984. It consists of a series of discs attached to a common shaft. The discs are partially submerged in a trough of continuously flowing wastewater and a film of microorganisms grows on the discs. As the discs rotate, the microorganisms consume oxygen from the air and organic matters from the wastewater. In this way, organic matters are removed from the wastewater.

Trickling Filter

Shek Pik Rotating Biological Contactor Plant

Rotating Biological Contactor

The advantage of RBCs over trickling filters is that RBCs are more reliable and can withstand sudden change in hydraulic and organic load.

The first oxidation ditch plant at Hei Ling Chau Correctional Institute, with a treatment capacity of 900 cubic metres/day, was put into service in 1984. It is a small wastewater treatment device operated on extended aeration. It consists of a long channel of an elliptical or circular shape, and a rotor for generating water flow and aerating the water in the channel by stirring. With its simple structure, it is easy to operate and can remove nitrogen efficiently.

Hei Ling Chau Oxidation Ditch Plant

Primary and secondary treatment processes

Primary Treatment — In addition to screening and degritting, it includes the reduction of settleable solids in sewage by plain sedimentation. This process can remove 50% to 70% of suspended solids and 25% to 40% of biochemical oxygen demand — an indicator of sewage strength.

Chemically Enhanced Primary Treatment — Chemicals are added in the primary sedimentation process to enhance removal of solids to achieve removal of around 80% suspended solids and 70% of biochemical oxygen demand.

Secondary Treatment — Generally refers to using micro-organisms in biological treatment process to stabilise organic matters including dissolved solids left in the sewage after primary treatment. This process can remove over 90% of both the suspended solids and biochemical oxygen demand.

Overview

From 1950s, population in Hong Kong has rapidly increased, but most of the wastewater were discharged direct to the nearby drains, causing severe water pollution in the rivers and the harbour. In the beginning of the 1970s, the government based on the recommendations in the Watson's Report on Marine Investigation into Sewage Discharges and proceeded to formulate overall strategy for the territory-wide sewage treatment, followed by upgrading the screening facilities for the sewage screening plants to improve the quality of the discharge, along with building sewage treatment plants with treatment standard higher than preliminary for the New Towns. However, water pollution problem remained serious.

In 1980, to tackle the water pollution problems, the government legislated the Hong Kong's marine waters into several Water Control Zones to control wastewater discharge. In the same year, the Waste Disposal Ordinance was enacted. Legislations for pollution control and implementation of the recommendations in the Watson's Report had led Hong Kong to the threshold of a new frontier of environmental protection.

Chapter 5 : Threats and Damage of Rainstorms before 1989

Hong Kong is constantly under the threats and damage of flooding which can be attributed to a number of factors, namely topography, geology, rainfall, land use and population.

The topography of Hong Kong Island is rugged with steep natural slopes of residual soil mantles. Apart from coastal reclaimed land, natural slopes exceeding 30 degrees with heights rising to 450 meters are common. On the other hand, a large part of Kowloon Peninsula is leveled, while major roads in fairly newly-developed housing estates have been built with deep cuttings, large-scale platforming and substantial embankments.

The rainfall of Hong Kong is seasonal, averaging about 2 214 millimetres each year. During the wet season from April to October, rains mostly come in heavy downpours, lasting a number of days. On average, about 25 per cent of the annual rainfall is due to tropical cyclones. The rest is largely caused by the active southwest monsoon and its associated troughs which bring continuous rain, each time for a number of days. Tropical cyclones are often associated with strong to gale force winds and can also produce intense rainfall, but each

Sau Mau Ping during development, 1968. Housing estates were built on large flat platform created from leveling off the hillside.

High-rise in a steep slope, a rare view in other major cities of the world.

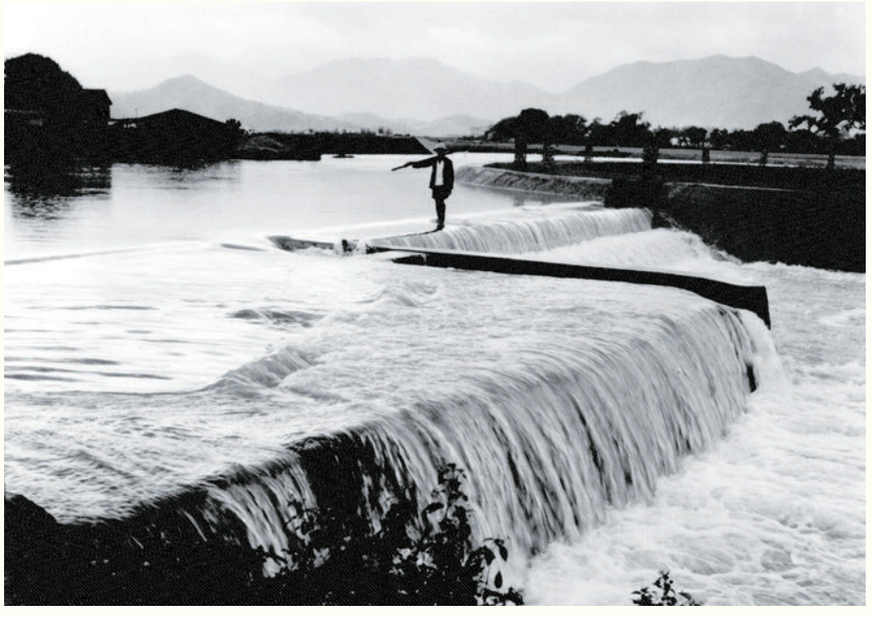
On 17th June 1983, rainfall of 346.7 millimetres was recorded, which was the fifth highest daily rainfall recorded in Hong Kong (1884–2017).

cyclone visit seldom lasts for more than a few days. As the troughs also produce very heavy rainfall, they tend to have more destructive effects than the tropical cyclones with regard to slope failures that often lead to catastrophic disasters.

Another important factor closely related to flooding is land use and population. The 1960s saw a massive population increase in Hong Kong, putting pressure on housing requirements. Demands for social services, water supply and linking roads were high. To keep abreast with this development, it was natural for a large number of residential blocks and schools to be built higher and higher up slopes and embankments.

The flatter land in the rural areas in the New Territories faced a different problem. Fish ponds and farmland used to serve as flood storage areas but they were gradually converted to built-up areas thereby significantly increased the demand of artificial stormwater drainage infrastructures in the New Territories.

The combined effects of the above-mentioned factors are closely related to flooding which has brought unfathomable threats and massive damage to Hong Kong. This can be seen in the following significant events that took place in the period before 1989.



In 1960s, farms and fish ponds at Sheung Shui were submerged in floodwater.

Ferries blown ashore in Kowloon Bay when Typhoon Rose struck Hong Kong

Typhoon Rose on 10–17 August 1971

Typhoon Rose was one of the most severe and destructive typhoons that have wreaked havoc on Hong Kong. Like other tropical cyclones, it approached Hong Kong from the south, bringing very heavy rainfall.

A daily rainfall of 288.1 millimetres was recorded by the Hong Kong Royal Observatory on 17 August 1971. The casualty was 100 dead and 5 644 people from 1 032 families were made homeless. 653 huts were destroyed and about 24 buildings were devastated on 12 locations, of which 6 were beyond repair. Affected cables rendered some 30 000 telephones out of order. There were numerous landslides resulting in 110 cases of road blockage, and flooding occurred in 35 locations across the territory.

Monsoon trough on 16–18 June 1972

On 16–18 June 1972, a total of 652.3 millimetres of rainfall was recorded, causing two most tragic disasters in Hong Kong. First, on Kowloon Peninsula, on 18 June 1972, a filled slope approximately 130 feet in height was washed on to the Sau Mau Ping Class II Licensed Area where nearly 400 people lived in licensed and unlicensed huts, killing 71.

On Hong Kong Island, at 8 pm on the same night, a major landslip measuring 900 feet from top to bottom and 200 feet across 3 roads crushed en bloc onto a two-storey building on Po Shan Road and other huts in the vicinity. Almost at the same time, a 12-storey building on Kotewall Road was also devastated, killing 67 people.

The total casualty of these two incidents killed 138 people. In other parts of the territory, there were also 56 injured, flooding at 53 locations and 7 800 people rendered homeless. On 18 June 1972 alone, 232.6 millimetres of rainfall with a peak hourly rate of 98.7 millimetres from 11 am to noon was recorded.

On 18th June 1972, Tsui Ping Road in Kowloon East was buried under mudslide.

Remains of two buildings at Kotewall Road, following the devastating landslip that occurred on 18th June 1972. 40 000 cubic meters of rocky debris unearthed in this slip.

Severe tropical storm Ellen on 24–25 August 1976

Unfortunately, Sau Mau Ping received a second strike from Severe Tropical Storm Ellen on 24–25 August 1976. The embankment adjoining an estate block collapsed and the landslip buried much of the ground floor of the estate, killing 18 people.

Away from Sau Mau Ping, landslips also took place in many other locations, causing 2 424 people to be evacuated from their homes. 511.6 millimetres of rainfall was recorded in the two days with a daily rainfall of 416.2 millimetres on 24 August 1976 alone.

Rainfall from 28 May 1982 to 2 June 1982

Between 28 May 1982 and 2 June 1982, 676 mm of rainfall was recorded by the Royal Observatory. In northwestern New Territories, in the same period, rainfall was in the range of 524 millimetres to 697 millimetres. The highest daily total rainfall occurred on 29 May 1982, with over 400 mm being recorded in the upper catchment area of the Kam Tin River on the slopes of Tai Mo Shan. Coinciding with the peaks in rainfall and tide level, the peak flood level in Kam Tin occurred between 2 am and 6 am on 29 May 1982, and persisted for a few hours before receding.

Following the event, the New Territories Development Department conducted field surveys to determine the extent of flooding and flood levels. Generally, areas with ground levels lower than 5 m PD in the tidal floodplain area were inundated. The then Agriculture & Fisheries Department's records indicated that in the New Territories as a whole 1 000 hectares of farmland and 400 hectares of fish ponds were inundated. Livestock losses amounted to 10 000 pigs and 700 000 heads of poultry. The total agricultural losses were reported at HK$ 23 million.

The tropical cyclone that occurred between 24th and 25th August 1976 had brought about unusually heavy rains, leading to landslip in Sau Mau Ping.

Typhoon Ellen on 29 August to 9 September 1983

Typhoon Ellen passed Hong Kong at about 7 nautical miles southwest of Fan Lau, the southwestern tip of Lantau Island. Hurricane Signal No. 10 was hoisted for a period of 8 hours. The highest gust over Hong Kong, 248 kilometres/hour, was recorded at Stanley. At Waglan Island, the maximum gust of 225 kilometres/hour was the highest since 1964.

The most seriously affected areas were Yuen Long and Kam Tin. 120 hectares of fish ponds were flooded, mostly in Tin Shui Wai, Kam Tin and Ngau Tam Mei. Some 80 000 households in Kowloon and the New Territories suffered from power failure. Some places in Kwun Tong, Sha Tin, Fanling, Sai Kung, Yuen Long and Lantau Island were deprived of electric supply for 4 days. Water supply was also interrupted in Ha Kwai Chung and Mei Foo Sun Chuen.

There were a total of 150 reports of flooding and 250 reports of road blockage. The casualty was 10 dead, 12 missing, 333 injured and 1 607 homeless. The daily rainfall recorded on 9 September 1983 was 172.4 millimetres.

The aggregate rainfall in the first four months of 1983 measured more than 300 millimetres

Floods near Admiralty brought by Typhoon Ellen in 1983

Typhoon Warren on 14–20 July 1988

Typhoon Warren affected Hong Kong on 14–20 July 1988. Heavy rains associated with Warren caused severe flooding in several parts of the New Territories. According to press reports, flooding also occurred in Shenzhen. During the one-hour period between 3 am and 4 am on 18 July 1988, 65.5 millimetres of rainfall was recorded by the Royal Observatory.

Damage caused by the flooding was severe. A total of 118 cases of flooding and five minor landslips were reported. Flooding was most severe in Tuen Mun and in north and northwestern New Territories. The low-lying areas were inundated. Many village houses were submerged. In Sheung Shui, more than 20 people were stranded by severe flooding in Tin Ping Shan and had to be rescued from rooftops of squatter huts by helicopters and rubber dinghies. About 100 hectares of fish ponds in San Tin, Kam Tin, Sheung Shui and Lam Tsuen were flooded and 220 tonnes of fish lost. Fish farmer estimated a total loss of HK$760 000. In addition, 270 hectares of agricultural land were also flooded, 60 hectares of which were in Yuen Long, Tuen Mun, San Tin and Pat Heung. The remaining 210 hectares were in Sheung Shui, Fanling, Ta Kwu Ling and Tai Po. Livestock farmers reported that 1 370 pigs and 133 000 heads of poultry were drowned. During the passage of Warren, 12 people were injured and a 5-year old boy was reported missing after falling into the sea at Tsim Bei Tsui.

Typhoon Brenda on 16–21 May 1989

Typhoon Brenda struck Hong Kong on 16–21 May 1989. At Tate's Cairn, the maximum gust speed was 187 km/h. On 20 May 1989, rainbands associated with Brenda brought periods of heavy rain and frequent squally downpours. The stormy weather stopped in the early morning of 21 May 1989, but isolated showers continued into the rest of the day. The amount of rain recorded at Shek Pik on 20 May 1989 was 382.5 millimetres.

Torrential rain associated with Brenda resulted in 100 cases of landslides and 118 floods in Hong Kong. In Tsz Wan Shan, more than 20 tonnes of mud and rocks crashed down a hillside and struck three squatter huts, leaving two people dead. In Yuen Long, a mud slide created a 100 square metre cavern at Lam Kam Road. Flooding was most severe in the northwestern part of the New Territories and 100 villagers had to be evacuated by boat in Au Tau, Yuen Long. Serious flooding also occurred in Nam Bin Wai and Ha Tsuen. About 130 hectares of fish ponds were flooded. The loss of fish was estimated to be 250 tonnes and worth about HK$2.8 million. The affected areas included Sheung Shui, San Tin, Ngau Tam Mei, Kam Tin, Lok Ma Chau, Pak Nai and Yuen Long. In addition, about 190 hectares of farmland were inundated and huge livestock losses were incurred, including some 66 000 chickens, 6 000 ducks, 1 000 pigs and 1 300

Rainstorm occurred between 1960 to 1980 has caused floods near Hennessy Road, Wanchai.

pigeons. Damage to crops and livestock in Pat Heung, San Tin, Kam Tin, Ha Tsuen, Shap Pat Heung, Ping Shan, Tuen Mun, Ta Kwu Ling, Sha Tau Kok, Kwu Tung and Sheung Shui was estimated to worth HK$6 million. There were also reports of fallen trees and collapsed scaffoldings. At the airport, more than 100 flights were diverted, delayed or cancelled. During the passage of Brenda, six people were killed, one was reported missing, 119 were injured and 899 were made homeless.

Overview

Hong Kong has been exposed to the threats of typhoons and rainstorms for years. A number of severe typhoons and rainstorms have caused destructions and casualties, with the memory of all such catastrophes still remain fresh with us to-date. Most new housing estates and major roads involved extensive slope-cutting, forming of large platforms or substantial road embankments, which were prone to slope failures under heavy rains. Over in the rural areas in the New Territories, fish ponds and farmland were levelled off to give way to housing development, thereby diminishing their flood storage function and causing these newly built-up areas vulnerable to flooding.

The government was fully aware of the need for comprehensive stormwater drainage planning and main river training works. Works on a series of flood protection schemes were commenced to overcome the flooding problems.

Nam Pin Wai, Yuen Long was turned into a swamp due to rainstorm.

Typhoon Brenda had brought about serious floods in Kam Tin in 1989