淨港揚清　給維港的信

Fragrant Again　Letters to Victoria Harbour

渠務署
Drainage Services Department

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書話

Victoria Harbour is a precious natural asset and an integral part of Hong Kong's identity. Yet once, not long ago, our treasured harbour was polluted. Our beaches were closed, the Cross Harbour Race suspended and marine life impaired. This book tells the story of how the Harbour Area Treatment Scheme cleaned up our harbour and restored its beauty, fragrance and vitality.

This series of letters from the Drainage Services Department sheds light on the vision, challenges and successes of the Scheme spanning over two decades. We dedicate this book to the people of Hong Kong, our engineers and our dear Victoria Harbour, for making this city a great metropolis and our beloved home.

維多利亞港是香港的寶貴天然資源，也是香港身份的重要象徵。然而，不久之前，我們的珍貴海港卻嚴重污染，多個泳灘關閉、維港渡海泳停辦、海洋生態受損。這書闡述了「淨化海港計劃」怎樣為維港除污，重現美麗、芬芳與活力。

「淨化海港計劃」橫跨廿多年，渠務署希望透過這系列給維港的信，展現計劃背後的願景、挑戰與成就。香港既是卓越的大都會，也是我們深愛的家。我們謹將此書，獻給為香港努力的全體市民、我們的工程團隊和摯愛的維港。

淨港揚清

FRAGRANT AGAIN

LETTERS TO VICTORIA HARBOUR

給維港的信

MESSAGE FROM THE SECRETARY FOR THE ENVIRONMENT
環境局局長序

The quality of the harbour environment in Hong Kong is closely associated with our economy, society and environmental protection effort. Hence, the Harbour Area Treatment Scheme (HATS) had established at its early conception a clear target to support sustainable development in Hong Kong.

Established in 1989 and tasked with the implementation of HATS, an important project, the Drainage Services Department (DSD) has worked tirelessly to realise the HATS vision to improve the water quality of Victoria Harbour. A challenging project on a mega scale, HATS incorporates elements of environmental-friendly design and has become a model of sustainability in many respects. Take for example, its deep sewage tunnel system is based on energy-saving design principles; the Stonecutters Island Sewage Treatment Works and its associated preliminary treatment facilities attach great importance to energy efficiency and other environmental performance. Most notable and well recognised is its highly environmentally responsible sludge disposal arrangement, including the design and building of two marine vessels, namely *Clean Harbour 1* and *Clean Harbour 2*, dedicated to transporting sludge to T▪PARK in Tuen Mun to achieve energy saving and emissions reduction. Indeed, T▪PARK is an innovative waste-to-energy facility which transforms sludge into energy, generating not only a self-sufficient amount of energy for its own consumption, but also surplus electricity to feed into the city grid. This is one of the sources of renewable energy in Hong Kong.

I heartily thank our DSD colleagues for their professionalism and pragmatism as well as their innovation and quest for progress over the years in making HATS a reality, and all stakeholders for their contribution. The classic Cross Harbour Race has returned in recent years to the central part of Victoria Harbour, a testimony to the many benefits brought by HATS to the community, including fostering a water-friendly culture. This is beneficial to people's livelihood and our economic development too. Looking ahead, we must continue to monitor and upgrade the water quality in Victoria Harbour to ensure that both sides of the Harbour and the Harbour itself continue to thrive, so that our people will happily embrace the water-friendly culture while society enjoys bliss and harmony.

香港的海港環境質素，與經濟、社會及環保三方面環環相扣。故此，「淨化海港計劃」早在構思階段已確立清晰目標，支持本港的可持續發展。

渠務署於1989年成立，肩負「淨化海港計劃」的重要任務，多年來致力落實改善維港水質的願景。此計劃工程浩大而艱巨，更結合環境設計，多方面成就範例，例如其深層污水隧道系統以節能設計為本；昂船洲污水處理廠及基本污水處理設施亦十分著重能源效益及其他環保表現。尤為津津樂道的為其高度環保的污泥處理方法，當中包括設計及建造環保專船「淨港一號」及「淨港二號」，以水路運送污泥往屯門T▪PARK [源▪區]，節能減排；而T▪PARK [源▪區]更是創新轉廢為能設施，將污泥轉化為能源，令設施所需能耗達致自供自給外，還有餘電上網，為香港可再生能源之一。

渠務署同事歷年來專業務實，而又創新求進，落實「淨化海港計劃」，相關持份者亦貢獻良多，我深表謝意。近年，經典維港渡海泳復辦並回歸維港中央，正好見證「淨化海港計劃」造福香港社會，裨益親水文化，有利民生以至經濟發展。承先啟後，我們必須持續監察及進一步淨化維港水質，讓維港及港九兩岸更生機勃勃，令大眾更樂於親水，社會樂也融融。

Secretary for the Environment
環境局局長
WONG Kam-sing
黃錦星

MESSAGE FROM THE DIRECTOR OF DRAINAGE SERVICES
渠務署署長序

Our harbour has shaped Hong Kong and its people for centuries. Over the past 25 years, the phased implementation of the Harbour Area Treatment Scheme (HATS) has restored the beauty and fragrance of Victoria Harbour, which had been lost to serious pollution by the 1980s. The story of HATS is a stellar example of how the Drainage Services Department (DSD) provides world-class sewerage services to protect public health and enable the sustainable development of Hong Kong.

Renowned worldwide for its engineering feats, HATS has won major international awards and helped put Hong Kong at the forefront of global infrastructure excellence. Indeed, Hong Kong has been ranked first in the world in infrastructure by the World Economic Forum for eight consecutive years, an achievement to be proud of and a legacy for us all to continue.

HATS is also unique for its compactness and efficiency. Comprising a labyrinth of deep sewage tunnels embedded in the bedrock stratum and a centralised sewage treatment works on a 10-hectare site on Stonecutters Island, which is just about half the size of Victoria Park, HATS now serves the sewage treatment needs of around 4.5 million people on both sides of the harbour. With a capacity to serve up to 5.7 million people, HATS is probably the most efficient sewage treatment system of its kind in the world.

Interestingly, despite the importance of sewage treatment in daily life, the community is seldom aware of HATS. This is a testimony to another HATS achievement: by putting its sewage tunnels deep in the bedrock, disruption to the community during construction was kept to a minimum. While it was business as usual for Hong Kong, a pioneering environmental infrastructure was being built deep beneath the city to give a new lease of life to our harbour.

Having worked on both Stages 1 and 2A of the project, I look back at my long association with HATS with a sense of honour and privilege. The numerous technical hurdles, twists and turns, setbacks and eventual successes that the DSD team experienced have not only been dramatic and very challenging, but always inspiring and fascinating. This book is a record of this extraordinary journey. We dedicate the book to our dear Victoria Harbour and the people of Hong Kong, for whom HATS exists to serve.

數百年來，海港塑造了香港和港人的發展方向。過去廿五年，「淨化海港計劃」分階段落實，令於上世紀八十年代曾遭嚴重污染的維多利亞港，重現美麗芬芳。渠務署多年來提供世界級的污水系統及處理服務，以保障公共衛生及推動香港的可持續發展，而「淨化海港計劃」的故事，正是印證我們工作成效的最佳例子。

「淨化海港計劃」創下多項工程佳績，屢獲國際大獎，有助香港躋身世界最佳基建城市的前列。香港的基建成就，更獲世界經濟論壇連續八年選為全球排名第一，這是香港的驕人成就，也是我們應努力延續的優勢。

「淨化海港計劃」也以設計密集和高效率見稱。計劃涵蓋一個建於基岩深處的污水隧道網絡，及位於昂船洲的中央污水處理廠。昂船洲污水處理廠佔地10公頃，面積只有半個維多利亞公園左右，但已為維港兩岸約450萬人口提供污水處理服務，最高更可處理570萬人口產生的污水，是全球同類最高效率的污水處理系統之一。

有趣的是，污水處理對日常生活雖然重要，但市民普遍並不察覺「淨化海港計劃」的存在。這正突顯了該計劃的另一成就：工程團隊將污水輸送隧道興建在深層基岩內，以盡量減低對社區做成的滋擾。正當香港的各項社會活動運作如常，一個將為維港展新顏的環保基建先驅項目，則在城市之下默默成形。

多年來我有幸參與「淨化海港計劃」第一期和第二期甲的工程，實與有榮焉。渠務署團隊在項目施工期間，經歷無數技術困難、重重波折和嚴峻考驗後，終於成功完成項目，過程不但曲折和極富挑戰性，更帶給我們無窮啟迪，十分精采，本書記錄了這段非凡的旅程。「淨化海港計劃」既為摯愛的維港又為全港市民而建，我們謹以此書向維港及香港市民致意。

Director of Drainage Services
渠務署署長
Edwin TONG Ka-hung
唐嘉鴻

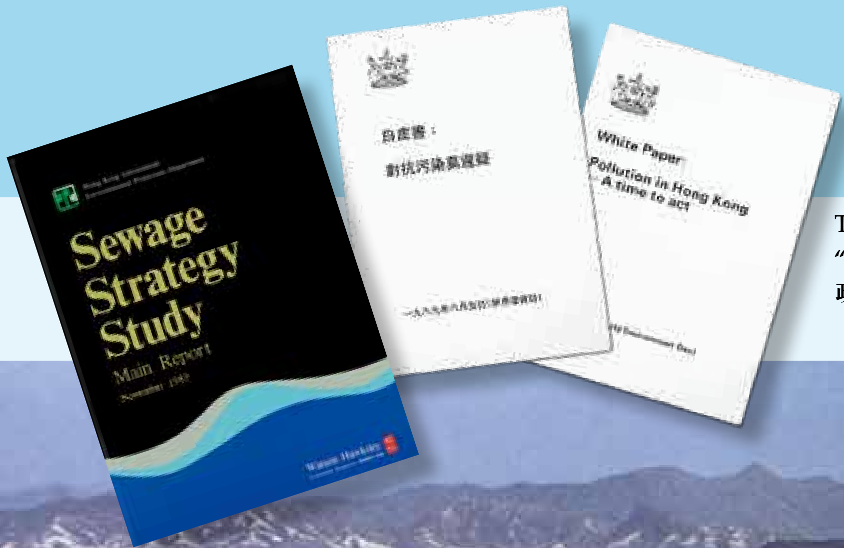
THE BIRTH OF HARBOUR AREA TREATMEMT SCHEME
淨化海港計劃緣起

LETTER 1 信件一

THE BIRTH OF HARBOUR AREA TREATMEMT SCHEME

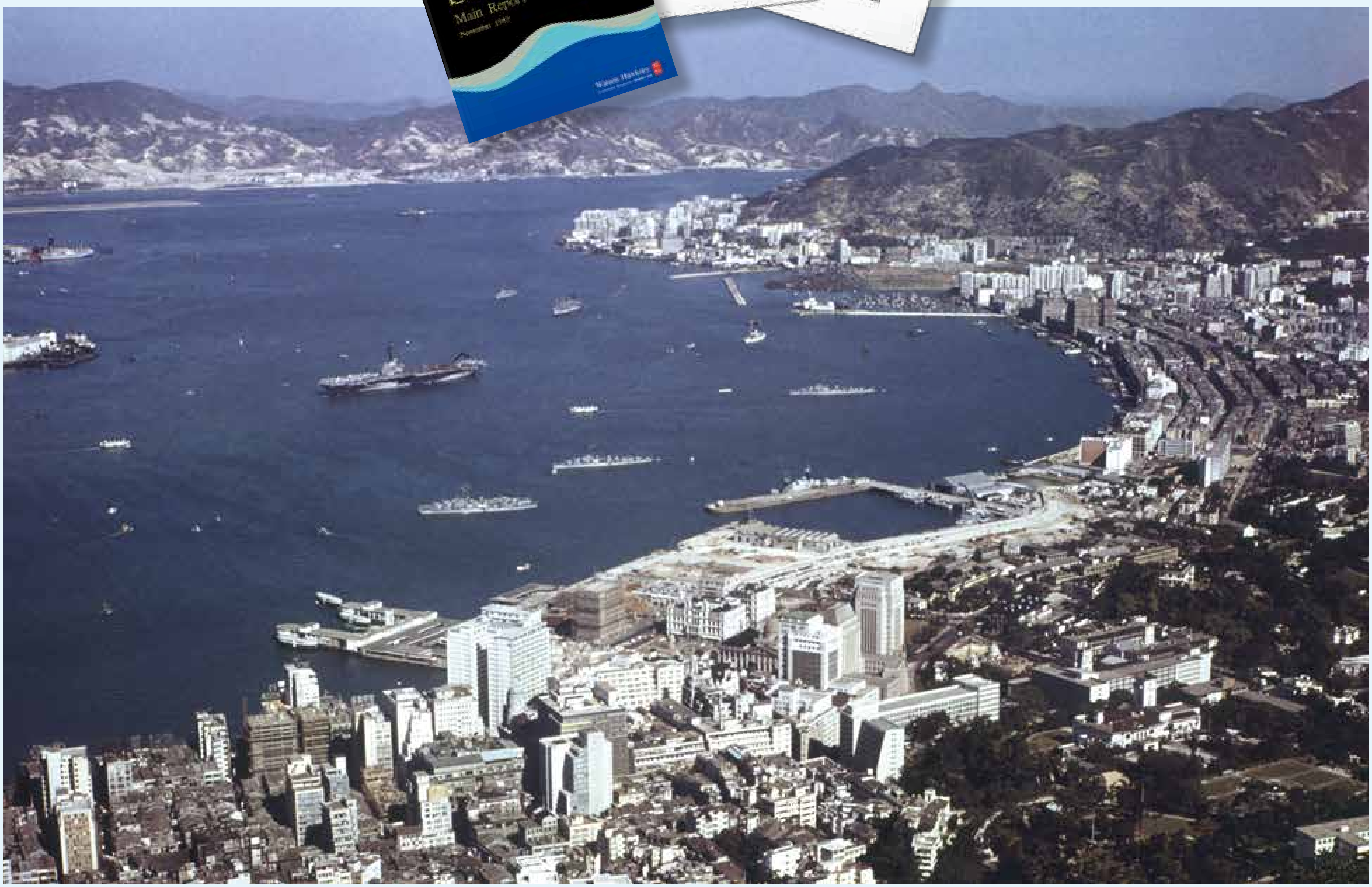
淨化海港計劃緣起

The Birth of Harbour Area Treatment Scheme
淨化海港計劃緣起



The Government embarked on
the Sewage Strategy Study in 1987
政府1987年開始進行「污水策略研究」

The Government published
"White Paper: Pollution in Hong Kong" in 1989
政府1989年發表《白皮書：對抗污染莫遲疑》



Victoria Harbour in the 1960s
1960年代維多利亞港

Dear Harbour,

This is the first of a series of letters from us at Drainage Services Department to our dear, fragrant Victoria Harbour. A symbol of Hong Kong and renowned for your deep waters and strategic location, you have made our city a leading port and a major financial centre. From a traditional shelter for seafaring merchants to a thriving world city, Hong Kong owes its prosperity and international reputation to our Harbour. You have witnessed centuries of history and changes in a place that has become our city today. But our city has changed You too.

For hundreds of years, your fast moving currents had very good self-cleansing capacities to dilute pollutants from human activities. But with the rapid growth of population and industries, harbour pollution came to the fore in the 1970s when you lost much of your beauty and fragrance to water pollution.

These letters have been written for You, dear Harbour, to tell the story of a mega environmental infrastructure project called the Harbour Area Treatment Scheme, or HATS, on which our team has worked tirelessly for over 20 years to restore the beauty, fragrance and vitality of Victoria Harbour.

Background

Up to the 1980s, untreated or preliminarily treated sewage was directly discharged into the Harbour which had certain self-cleansing capacities, but only up to a point. Once its self-cleansing capacities were exceeded, our aquatic environment became unhealthy for marine lives, ending up with polluted beaches, red tides, contaminated sea food and visual impacts.

Another problem was the widespread connection of wastewater discharges from industry, restaurants and residential accommodation directly to stormwater drains instead of to foul sewers, giving rise to black water and stink in waterfront areas. Victoria Harbour was in crisis.

In response to the situation, the Government embarked on the Sewage Strategy Study (SSS) in 1987, mapping out an overall sewage treatment strategy for Hong Kong, including the Strategic Sewage Disposal Scheme (SSDS), later renamed the Harbour Area Treatment Scheme (or HATS) in 2001 to abate Harbour water pollution.

As a policy initiative of the “White Paper: Pollution in Hong Kong — a Time to Act”, the Drainage Services Department (DSD) was also established in 1989, responsible for the provision and management of wastewater treatment and stormwater drainage infrastructures in Hong Kong, including the implementation of HATS. The HATS project was born.

The Birth of Harbour Area Treatment Scheme
淨化海港計劃緣起

Initial Plan

The initial SSDS plan in the early 1990s had four stages. Three of them were duly implemented under HATS, while the ocean outfall system under the original Stage II was replaced by an alternative arrangement, detailed in our next letters.

HATS Today

These days, Victoria Harbour is clean again, its vitality revived. Once heavily polluted beaches have re-opened. Coral has been found again in the harbour. The Cross Harbour Race, a signature annual event in Hong Kong dating back to 1906 but suspended in 1978 because of harbour pollution, resumed in 2011 in the harbour east and finally returned to the central part of the harbour in 2017 — a testament to the harbour's now revived good water quality.

So, what exactly has HATS done? Put simply, HATS has put in place an infrastructure that has successfully reduced and contained the polluting effects of many decades of urban development on both sides of our Harbour. To date, two stages of HATS, namely Stages 1 and 2A, have been commissioned.

Stage 1 comprised the construction of the Stonecutters Island Sewage Treatment Works (SCISTW) as a hub of centralised sewage treatment facilities, along with 23.6 kilometres of deep tunnels for collecting sewage from Kowloon, Kwai Tsing, Tseung Kwan O, and north-eastern Hong Kong Island and upgrade of seven existing preliminary treatment works (PTWs). Stage 1 began works in 1994 and was commissioned in December 2001, providing treatment to 75% of sewage from both sides of the harbour.

1980 Enactment of the Water Pollution Control Ordinance

制定《水污染管制條例》

1987 Commencement of the Sewerage Master Plan programme

開展「污水收集整體計劃」

1989 Formulation of the Strategic Sewage Disposal Scheme

制訂「策略性污水排放計劃」

Stage 2A provides treatment to the remaining 25% of sewage from the northern and south-western parts of Hong Kong Island. Works included the construction of 21 kilometres of deep sewage tunnels to the SCISTW, along with the upgrade and expansion of the original SCISTW facilities and eight existing PTWs. Stage 2A commenced its major works in 2009 and was commissioned in December 2015.

Stages 1 and 2A together can treat a total of 2.45 million cubic metres of sewage per day, serving ultimately up to 5.7 million people in 10 districts on both sides of Victoria Harbour. Since the commissioning of Stage 2A, all sewage collected from both sides of the harbour is treated and disinfected at the centralised SCISTW treatment facilities before discharged through an outfall.

Soon after Stage 2A commissioning in December 2015, the Environmental Protection Department confirmed in its 2016 Marine Water Quality Report substantial improvement in harbour water quality compared to 2011-2015, and most notably a 10-fold reduction in overall *E. coli* count compared to the late 1990s.

So, dear Harbour, this is the gist of the HATS story. More to follow in the next letter.

1994

Enactment of the Water Pollution Control (Sewerage) Regulation

實施《水污染管制(排污設備)規例》

Commencement of works on Harbour Area Treatment Scheme Stage 1

展開「淨化海港計劃」第一期建造工程

The Birth of Harbour Area Treatment Scheme
淨化海港計劃緣起

親愛的維港：

這是我們渠務署給您一系列信件的第一封信。

摯愛的維港，您素以水深港闊和優越地理位置見稱，使香港發展成為世界主要港口和國際金融中心，您更成為香港的象徵。從舊日為飄洋渡海的商旅提供停泊之所，漸次變為充滿活力的國際都會，香港今天的繁榮、成就和美譽，實有賴您這獨一無二的海港。您見證了這城市百多年來的歷史蛻變，如何成就今日的香港，但這城市也改變了您。

數百年來，您憑藉足以自淨的急速水流，有效稀釋了市民生活產生的污染物。但隨著香港人口和工業的高速增長，自上世紀七十年代開始，海水污染日益嚴重，維港亦開始失去昔日的光彩芬芳。

過去20多年，我們渠務署的團隊一直為這個名為「淨化海港計劃」的大型環保基建項目努力不懈，務使維多利亞港重現美麗、芬芳與活力。親愛的維港，這些信就是為您而寫，細說「淨化海港計劃」的故事。

1995 Declaration of the Victoria Harbour (Phase II) Water Control Zone

公布維多利亞港（第二期）水質管制區

1996 Declaration of Victoria Harbour (Phase III) Water Control Zone

公布維多利亞港（第三期）水質管制區

背景

直至八十年代，未經處理或只經基本處理的污水，一般都直接排放進維港。雖然維港的自淨流速足以稀釋污染物，但畢竟有上限。污染物一旦超過海港自淨能力上限，海水污染便日趨嚴重，水質變差，海洋生態大受影響，導致泳灘嚴重污染、紅潮、海產污染、觀感惡劣等情況。

此外，由於當時很多工廠、食肆和住宅將污水管道擅自接駁到雨水渠而非污水渠，造成沿岸地區出現黑水和發出惡臭，維港水質陷入危機。

有見情況嚴峻，政府於1987年開始進行「污水策略研究」，為香港制訂整體污水處理策略，包括「策略性污水排放計劃」，以解決維港海水污染問題。該計劃於2001年正式易名為「淨化海港計劃」。

隨着政府於1989年發表《白皮書：對抗污染莫遲疑》政策倡議，渠務署亦於同年成立，肩負提供及管理香港的污水處理和雨水排放的基礎建設工作，包括落實「淨化海港計劃」。「淨化海港計劃」項目正式誕生。

1997 Commissioning of chemically enhanced primary treatment works at Stonecutters Island

昂船洲化學強化一級污水處理廠投入服務

2001 Full commissioning of Harbour Area Treatment Scheme Stage 1

「淨化海港計劃」第一期全面投入服務

The Birth of Harbour Area Treatment Scheme
淨化海港計劃緣起

計劃雛形

上世紀九十年代初的「策略性污水排放計劃」，原先項目共分四階段，其中三階段已納入在「淨化海港計劃」之內，並已經順利完成。原屬「策略性污水排放計劃」第二階段的海洋排放管道系統，則由後來的替補方案取代，我們會於稍後信件談及。

今天的「淨化海港計劃」

今天，維多利亞港活力重現，回復昔日的潔淨和光彩。一度嚴重污染的泳灘已重新開放，珊瑚在海港重生，維港渡海泳得以復辦。這一年一度的盛事始於1906年，但因海港污染於1978年停辦；直至近年維港水質改善，渡海泳亦於2011年復辦。初時賽道設於維港東部，至2017年更重返維港中部作賽，足證今天的維港水質已復元。

那麼，「淨化海港計劃」究竟做了什麼？簡而言之，該計劃是一項大型環保基建工程，成功減低及控制了維港兩岸數十年來，因城市急速發展而造成的污染。「淨化海港計劃」至今已完成兩期工程，即第一期和第二期甲，並已全面啟用。

第一期工程包括興建昂船洲污水處理廠，作為集中污水處理設施的樞紐，以及建造全長23.6公里的深層污水輸送隧道網絡，以收集九龍、葵青、將軍澳及港島東北部的污水，並為現有七個基本污水處理廠進行全面改善工程。第一期工程於1994年展開，並於2001年12月投入服務，肩負起維港兩岸約75%的污水處理工作。

第二期甲工程則負責其餘25%的污水處理工作，覆蓋範圍包括港島北及西南地區。工程包括興建全長21公里的深層污水隧道，連接昂船洲污水處理廠，以及提升與擴充昂船洲污水處理廠和八個現有污水處理廠的設施。第二期甲主要工程於2009年開展，並於2015年12月投入服務。

第一期和第二期甲合共每日可以處理245萬立方米污水，足以為維港兩岸10個地區最多570萬人口提供污水處理服務。自從第二期甲落成啟用後，來自維港兩岸的所有污水，都集中輸送到昂船洲污水處理廠進行處理及消毒，才經過排放管道排出海港。

2015年12月第二期甲工程落成啟用後不久，環境保護署在其《2016年香港海水水質》報告中指出，與2011至2015年比較，維港海水水質錄得明顯改善；其中整體大腸桿菌水平與上世紀九十年代末相比，更大幅減少了約十倍。

親愛的海港，這就是「淨化海港計劃」的故事重點。細節會在往後信件中詳談。

POSTSCRIPT

"The most difficult days of HATS were encountered during Stage 1. Soon after the tunnelling works commenced, the contractor unreasonably withdrew from the sites and works came to a halt. The government team came under enormous public pressure and faced the dilemma of abandoning the project or pressing on. However, we believed that persevering with HATS would benefit millions of people in Hong Kong and decided to press ahead against all odds to complete the project."

"If Victoria Harbour was once polluted and sick, it can now be described as having almost fully recovered."

附箋

「這項目最艱難、最難忘的日子，是第一期隧道工程開展不久，承建商即無理離場停工，政府團隊面對很大公眾壓力。當時的抉擇是放棄項目抑或堅持下去。但我們深信項目對全港幾百萬人有莫大利益，決定排除萬難，堅持完成項目。」

「如果說維港曾經污染病重的話，現在已接近百份百康復了。」

HON Chi-keung
韓志強

Former Permanent Secretary for Development (Works), Development Bureau
發展局前常任秘書長(工務)

From the Archives
舊報剪影

160 SWIMMERS TO TAKE WATER IN TO-DAY'S HARBOUR RACE

A RECORD ENTRY

CAMPBELL AN ALMOST WINNER.

Keen Regimental Competition.

CHOPPY WATER WILL SLOW RACE.

One of the outstanding sporting events of the Colony will take place this afternoon when 160 swimmers will dive in for the annual Services' Harbour Race. The entry is a record one and a great race is expected.

Pte. Campbell, the sensational Borderers' distance swimmer, is an almost certain winner, even though he is just recovered from an illness.

The race will start at 5 p.m. from Police Pier, Kowloon, and will end at the Praya wall between Queen's Pier and the V.R.C.

Conditions are fair, although the choppy water will no doubt reduce the times considerably, and it is hardly likely that time of 21 minutes 6 seconds set by Gunner Forrester last year will be beaten.

The loss of Coleman, who succumbed to an injury while playing water-polo at the Y.M.C.A. last night, will be a great loss to the South Wales Borderers hopes, and from a glance at the field it seems highly probable that the Royal Artillery will lift the team prize.

The Argyll and Sutherland Highlanders are likely to make a strong bid for team honours, this being their last swimming season in the Colony, but it is hardly likely that they will gain first place.

Last year the event drew 74 competitors, and out of that number only two failed to finish the course. It will be surprising if this year's field can return the same high percentage of finishers.

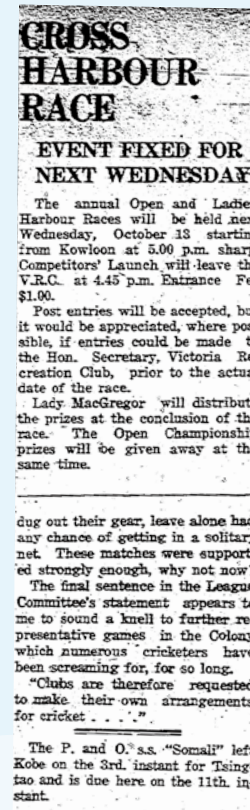
FRESH AND FAIR.

To-day's weather report from the Royal Observatory ...

China Mail 1932
1932年《中國郵報》

一聲槍響六百餘健兒齊撲水
渡海泳今晨舉行
加利基頓奪男子組冠軍
女將祖安嘉娜蟬聯后座

Kung Sheung Evening News 1978
1978年《工商晚報》



CROSS HARBOUR RACE

EVENT FIXED FOR NEXT WEDNESDAY

The annual Open and Ladies' Harbour Races will be held next Wednesday, October 13 starting from Kowloon at 5.00 p.m. sharp. Competitors' Launch will leave the V.R.C. at 4.45 p.m. Entrance Fee $1.00.

Post entries will be accepted, but it would be appreciated, where possible, if entries could be made to the Hon. Secretary, Victoria Recreation Club, prior to the actual date of the race.

Lady MacGregor will distribute the prizes at the conclusion of the race. The Open Championship prizes will be given away at the same time.

dug out their gear, leave alone had any chance of getting in a solitary net. These matches were supported strongly enough, why not now?

The final sentence in the League Committee's statement appears to me to sound a knell to further representative games in the Colony which numerous cricketers have been screaming for, for so long.

"Clubs are therefore requested to make their own arrangements for cricket . . . ."

The P. and O. s.s. "Somali" left Kobe on the 3rd. instant for Tsingtao and is due here on the 11th. instant.

China Mail 1937
1937年《中國郵報》

CHEONG KIN-MAN, CYNTHIA EAGER WIN CROSS-HARBOUR RACE

Cheong Kin-man, Fortuna's and Hong Kong's sensational swimmer, successfully defended his title in the Annual Cross-Harbour Swim yesterday, finishing the course in 23 minutes 24.6 seconds.

In the Women's Section, Cynthia Eager, who captured four titles in the recent Championships held at the Victoria Recreation Club, easily stroked her way to first place in 28 minutes 12.8 seconds.

WITHOUT FEAR OR FAVOUR

By the Sports Editor

Led the way

Three groups

Results

IRISH LEAGUE CITY CUP RESULTS

Winners of cross-harbour swim

Photo shows the winners of yesterday's Annual Cross-Harbour Swim after the distribution of prizes. From left to right: Jean Eager, Cynthia Eager, Cheong Kin-man, Ng Tung-choi and Kwok Ngan-hung.—"China Mail" photo.

China Mail 1950
1950年《中國郵報》

中大進行調查顯示
海水污染嚴重
促建污水處理廠

Kung Sheung Evening News 1980
1980年《工商晚報》

Harbour Race Winners

Chan Chun-nam Wins Cross-Harbour Race

The Hong Kong Sunday Herald 1948

渡海泳
男子冠軍：王敏超
女子冠軍：曾旺卿

渡海泳花絮

Kung Sheung Evening News 1968
1968年《工商晚報》

體育

本屆渡海泳停辦

Ta Kung Pao 1979
1979年《大公報》

第一頁　農曆壬子年九月十六日

史提堡 葉佩英 渡海泳中奪標

一年一度渡海泳賽

Kung Sheung Evening News 1972
1972年《工商晚報》

卅年來首次 港九渡海泳 今年將停辦

Kung Sheung Evening News 1979
1979年《工商晚報》

海水污染日益嚴重

將軍澳列為污染區

魚類大量死亡海灘已不能游泳

Ta Kung Pao 1982
1982年《大公報》

浸會學院研究海水污染中心

盧惠森主持揭幕

Kung Sheung Daily News 1975
1975年《工商日報》

本港海水染污程度日見嚴重

中大研究員郭王曉瑚促當局注視

Kung Sheung Evening News 1973
1973年《工商晚報》

渡海泳龍虎榜

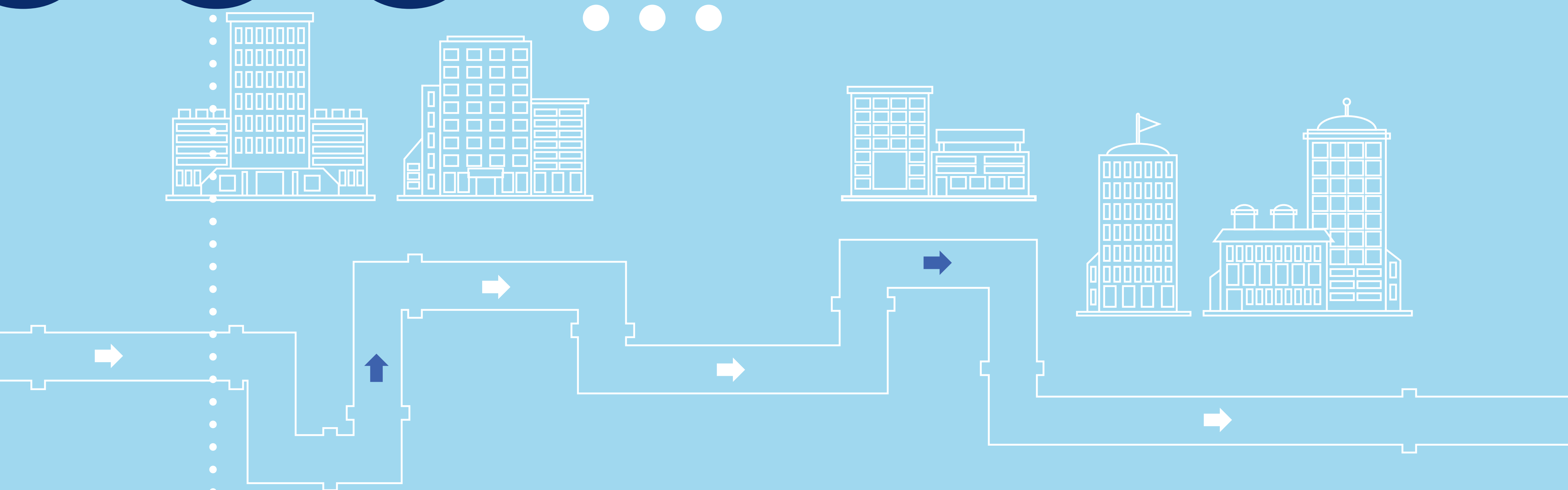
男子蔡永健 女將梁沼蓮

Kung Sheung Evening News 1974
1974年《工商晚報》

政府派出專船 測量海水染污

Kung Sheung Evening News 1973
1973年《工商晚報》

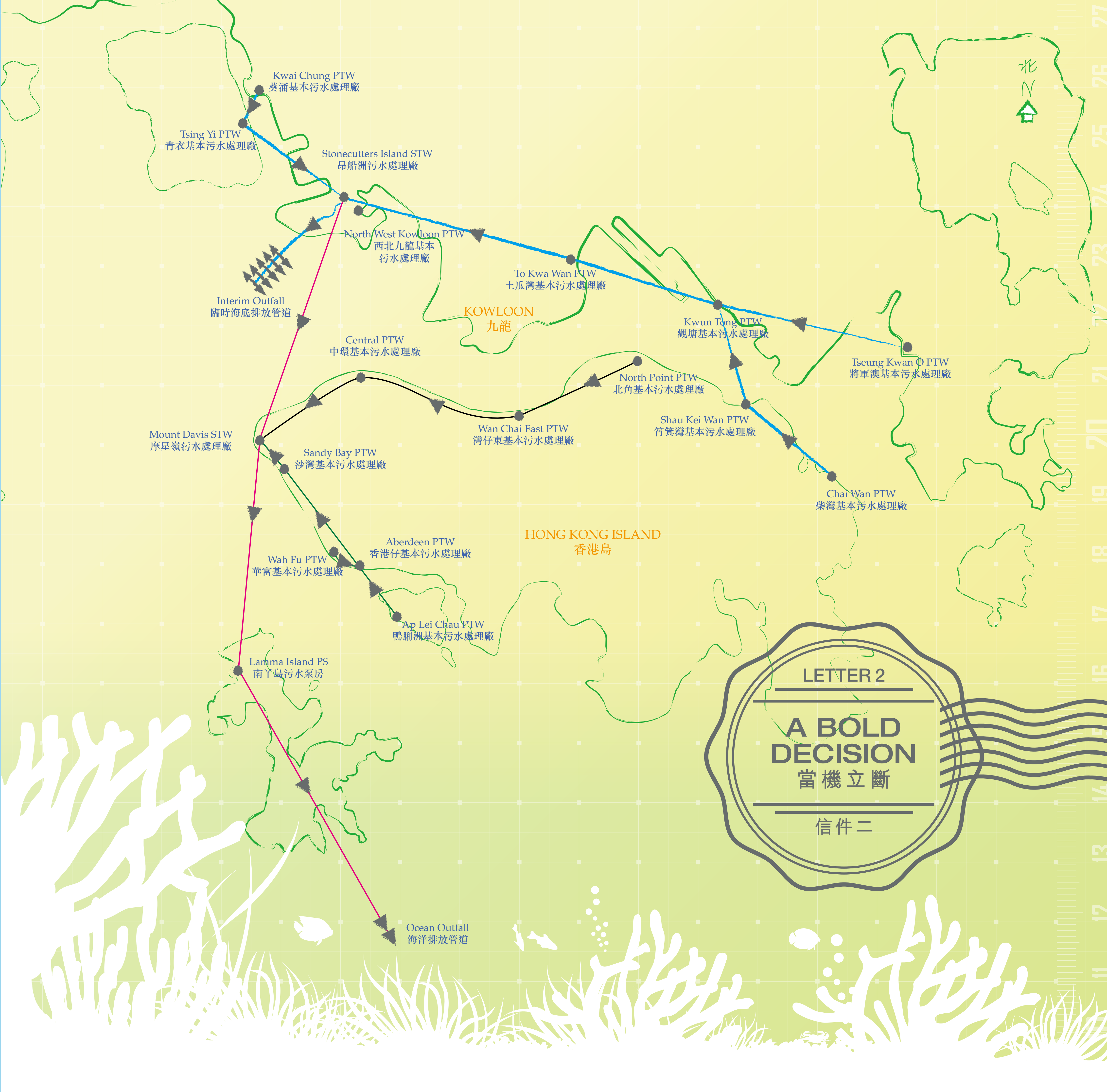
A BOLD DECISION
當機立斷



LETTER 2

A BOLD DECISION 當機立斷

信件二



A Bold Decision
當機立斷

Dear Harbour,

Let us share with You the story of the early years of HATS and how it evolved to become the successful environmental infrastructure it is today. Thanks to the Government's decision to go ahead with HATS despite great uncertainties, the pollution problem in our dear Harbour was tackled before too late.

A mega-sized project such as HATS naturally attracts attention and controversy. During the HATS planning stage, a key bone of contention was whether to adopt a centralised or decentralised approach to sewage collection and treatment. The centralised option would require the construction of deep tunnels to convey sewage from various districts on both sides of the Harbour to a centralised plant for further treatment before discharge into the sea. The decentralised option, on the other hand, would require constructing advanced sewage treatment works in individual districts, from which treated sewage could be directly discharged into the sea.

There was also controversy on the location of the proposed ocean outfall of the treated sewage.

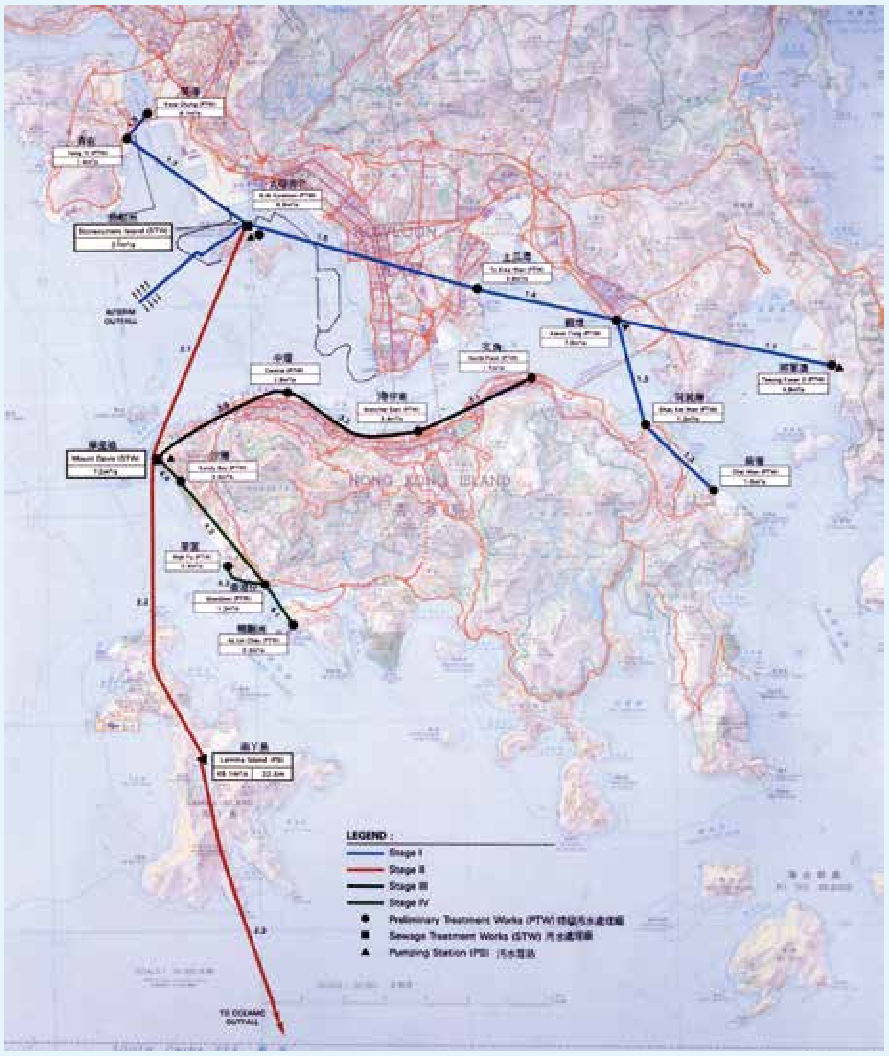
Centralised vs Decentralised Options

Both computer and physical models were used to test the environmental impact of different levels of treatment and different outfall locations. A decision support system was adopted to help shortlist strategies and evaluate options.

These analyses found that the most cost-effective solution for HATS was the centralised option — an integrated deep sewage tunnel system to collect and treat all sewage from both sides of the Harbour at a centralised sewage treatment plant on Stonecutters Island. A long ocean outfall was planned to discharge treated sewage into the South China Sea to make use of the vast self-cleansing capacity of the ocean, which would do away with the need for a higher level of sewage treatment. The decentralised option was ruled out as it would be greatly constrained by scarcity of land in urban areas.

Accordingly, the Government formulated a four-stage conceptual implementation plan for HATS, still called Strategic Sewage Disposal Scheme (SSDS) then. Further studies were necessary to confirm the technical feasibility of the deep sewage tunnel system and the centralised treatment plant, and pave the way for detailed design and construction. We promptly moved to engage a consortium of consultants to conduct comprehensive site investigation and engineering studies beginning in June 1990 for completion in 1992.

Investigation was conducted to look into the performance of diffusers of the ocean outfall with the aid of a physical model. Vertical and inclined boreholes as well as geophysical method were used to identify the most suitable founding stratum for the ocean outfall.



Original proposal of the Strategic Sewage Disposal Scheme
「策略性污水排放計劃」的原本擬案

As later developments would show, the ocean outfall originally planned under SSDS was overtaken by events and not implemented, whereas the other stages in SSDS were duly carried out and became Stage 1 and Stage 2A of HATS today.

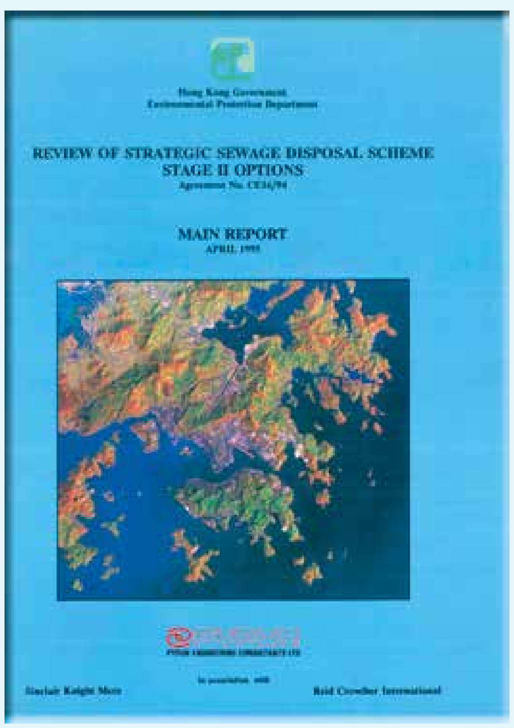
Funding was secured too. Stage 1 of HATS required around HK$6 billion for capital cost, while its operation and maintenance would call for a recurrent expenditure of HK$300 million per annum. Government decided to fund the capital cost from its Capital Works Reserve Fund, with the annual recurrent cost being met by a new Sewage Services Charging Scheme based on the "polluter pays" principle new to Hong Kong. The charging scheme was made possible by the Sewage Services Ordinance (Cap. 463) enacted in 1994, which enabled DSD to start collecting sewage charges from 1995 onwards.

DSD proceeded in July 1993 to engage consultants to carry out the detailed design and construction of HATS Stage 1, so as to tackle harbour pollution as soon as possible.

Mainland Concerns about Ocean Outfall

While engineers were working on the preliminary design of Stage 1 works, the project caught the attention of the Mainland authorities who were concerned that the water quality of Lema Channel in China waters would be affected by the discharges of HATS. At about the same time, the Government commissioned a study named "Review of Strategic Sewage Disposal Scheme Stage II Options" in July 1994. An International Review Panel (IRP) was set up, also in 1994, to advise the Government on the Stage II options review study. The IRP comprised three renowned environmental experts including one from the Mainland.

After much deliberation, the IRP concluded that chemically enhanced primary treatment (CEPT) ought to be the minimum level of treatment at the Stonecutters Island centralised plant. Three outfall locations were proposed — East Lamma, West Lamma, and Lema Channel — subject to the findings of a joint Environmental Impact Assessment (EIA) study commissioned by Hong Kong and Mainland authorities in May 1996.



The Government commissioned the Review of Strategic Sewage Disposal Scheme Stage II Options in 1994
政府1994年開始進行「策略性污水排放計劃第二階段選項檢討研究」

The IRP review marked the beginning of a prolonged period of communication between the Hong Kong Government and Mainland authorities on various outfall and treatment level options of HATS.

Decision to Press Ahead

Despite these longer-term uncertainties, the Government decided to abate the serious harbour pollution problem as soon as possible and press ahead with the design and construction of Stage 1 of HATS, previously known as SSDS Stage 1.

The scope of work of HATS Stage 1 included: A deep tunnel system at a total length of 23.6 km to collect sewage from Kowloon and Hong Kong Island North East, covering Preliminary Treatment Works (PTWs) in Kwai Chung, Tsing Yi, Kwun Tong, To Kwa Wan, Tseung Kwan O, Chai Wan, and Shau Kei Wan; upgrading works at those seven PTWs; a centralised chemically enhanced primary treatment works on Stonecutters Island; and an interim outfall at 1.7 km off Stonecutters Island to discharge treated sewage.

In July 1993, DSD engaged consultants to carry out detailed design and construction of HATS Stage 1. The target was to complete the works before July 1997 when Hong Kong would become a Special Administrative Region of the People's Republic of China. As things turned out, Stage 1 was successfully commissioned in 2001, after quite a few twists and turns.

親愛的維港：

讓我們細說「淨化海港計劃」早期發展的故事，以及該計劃如何演變成為今天成功的環保基建項目。儘管當時項目前景並不明朗，但政府依然勇於承擔，當機立斷，令維港水質污染問題能及時得到解決。

誠然，一項如此龐大的基建項目自然備受關注，並引起不少爭議。計劃初期，在決定污水收集及處理方案上，應該採用中央系統集中處理，抑或分散式處理，曾引起分歧。集中式中央處理方案需要建造深層污水隧道，從維港兩岸各區輸送污水到中央處理廠進行污水處理，再排放出大海。而分散式處理方案，則必須在各區分別興建先進的污水處理設施，再把經處理的污水，由各分區的污水處理廠直接排放出大海。

此外，排放經處理的污水出大海之海洋排放管道位置，也引起爭議。

集中處理和分散式處理的選項比較

我們利用電腦模擬和實物模型，分析比較不同級別的污水處理及不同排放管道位置對環境造成的影響，衡量方案優劣之處，從而篩選其中較佳的策略和選項。

分析結果顯示，中央處理是最具成本效益的淨化海港方案，即是以一個綜合深層污水隧道系統收集維港兩岸所有的污水，並在昂船洲設立污水處理廠進行集中污水處理。當時的計劃是建造一條長的海洋排放管道，直達南中國海，利用海洋巨大的自淨流速，稀釋經處理的污水，更無需高級別的污水處理設施。至於分散式污水處理方案，則由於市區土地稀缺珍貴，不合乎成本效益，因此不被接納。

循這思路，政府為「淨化海港計劃」制定一個包含四個階段的概念實施計劃，當時仍稱為「策略性污水排放計劃」。政府隨後亦開展有關深層污水隧道系統及中央污水處理廠的可行性研究，以確定技術可行性、詳細工程設計和建造細節。我們隨即聘請顧問團隊，於1990年6月開始進行深入全面的實地勘察和工程研究，並於1992年完成有關研究。

我們借助實體模型，研究海洋排放管道擴散器的性能表現，利用垂直和傾斜的鑽孔以及地質物理勘測方法，以訂定最合適海洋排放管道的地層。

然而後來事態發展出現變化，令「策略性污水排放計劃」原先的海洋排放管道未能落實，但其他階段的工程則如期進行，成為今日「淨化海港計劃」的第一期和第二期甲工程。

至於項目撥款亦順利獲批。第一期工程造價約為60億港元，其營運及維修等經常性開支則為每年3億港元。政府決定從基本工程儲備基金撥款支付項目造價，並推出「污水處理服務收費計劃」，引入嶄新的「污染者自付」原則，讓用者和市民分擔項目的每年經常性開支。1994年通過的《污水處理服務條例》(香港法例第463章)，為收費計劃提供了法律依據，渠務署根據這條例由1995年起開始徵收排污費。

渠務署於1993年7月聘請顧問，進行「淨化海港計劃」第一期的詳細設計和建造工程，希望能盡早處理維港水質污染問題。

內地關注海洋排放位置

正當工程師團隊着手進行「淨化海港計劃」第一期工程的初步設計時，項目卻引起內地當局關注，他們擔心位於中國海域的擔杆海峽水質，會受到項目排放的污水影響。與此同時，政府於1994年7月委託進行一項名為「策略性污水排放計劃第二階段選項檢討研究」，並於同年成立國際專家小組，為第二階段的選項檢討研究提供意見。小組由三位國際知名環保專家組成，包括一位內地專家。

國際專家小組經過詳細深入的研究討論後，認為昂船洲中央處理廠的污水處理級別，不可低於化學強化一級處理。小組亦提出三個排放管道的位置選擇，包括東南丫島、西南丫島和擔杆海峽，最終選址會根據香港和內地當局於1996年5月共同委託進行的一個聯合環境影響評估的報告結果而定。

這次國際專家小組的檢討研究，標誌着香港政府與內地有關部門，日後就「淨化海港計劃」污水處理級別和排放管道位置的選項議題上，展開了長時間的對話和討論。

果斷推進

儘管項目存在長遠不明朗因素，但維港污染問題逼在眉睫，政府決定果斷推進，落實「淨化海港計劃」第一期（即「策略性污水排放計劃」第一階段）的設計和建造工程，以盡快解決海港污染問題。

第一期項目工程包括：興建一個全長23.6公里的深層隧道系統，收集來自九龍和港島東北部的污水，包括位於葵涌、青衣、觀塘、土瓜灣、將軍澳、柴灣及筲箕灣的基本污水處理廠，以及全面改善這七所處理廠的設施；於昂船洲興建中央化學強化一級污水處理廠；以及一條離昂船洲1.7公里的臨時海底排放管道，排放經處理的污水。

1993年7月，渠務署着手聘請顧問為「淨化海港計劃」第一期進行詳細設計和建造工程，目標是希望在1997年7月香港回歸成為中華人民共和國特別行政區之前完成。但項目後來幾經波折，第一期最終於2001年成功落成啟用。

POSTSCRIPT

"We shall work continuously with our colleagues to maintain the water quality in Victoria Harbour, progress with the times to make Hong Kong's water quality even better, and enhance our culture of water excellence."

"Sludge from HATS used to take up considerable landfill space which was an issue. Ever since T▪PARK began working with HATS to turn its sludge into energy, it not only generates sufficient electricity for the park facilities but also surplus electricity to feed into the city grid. The 'waste-to-energy' loop has made Hong Kong more environmental too."

附箋

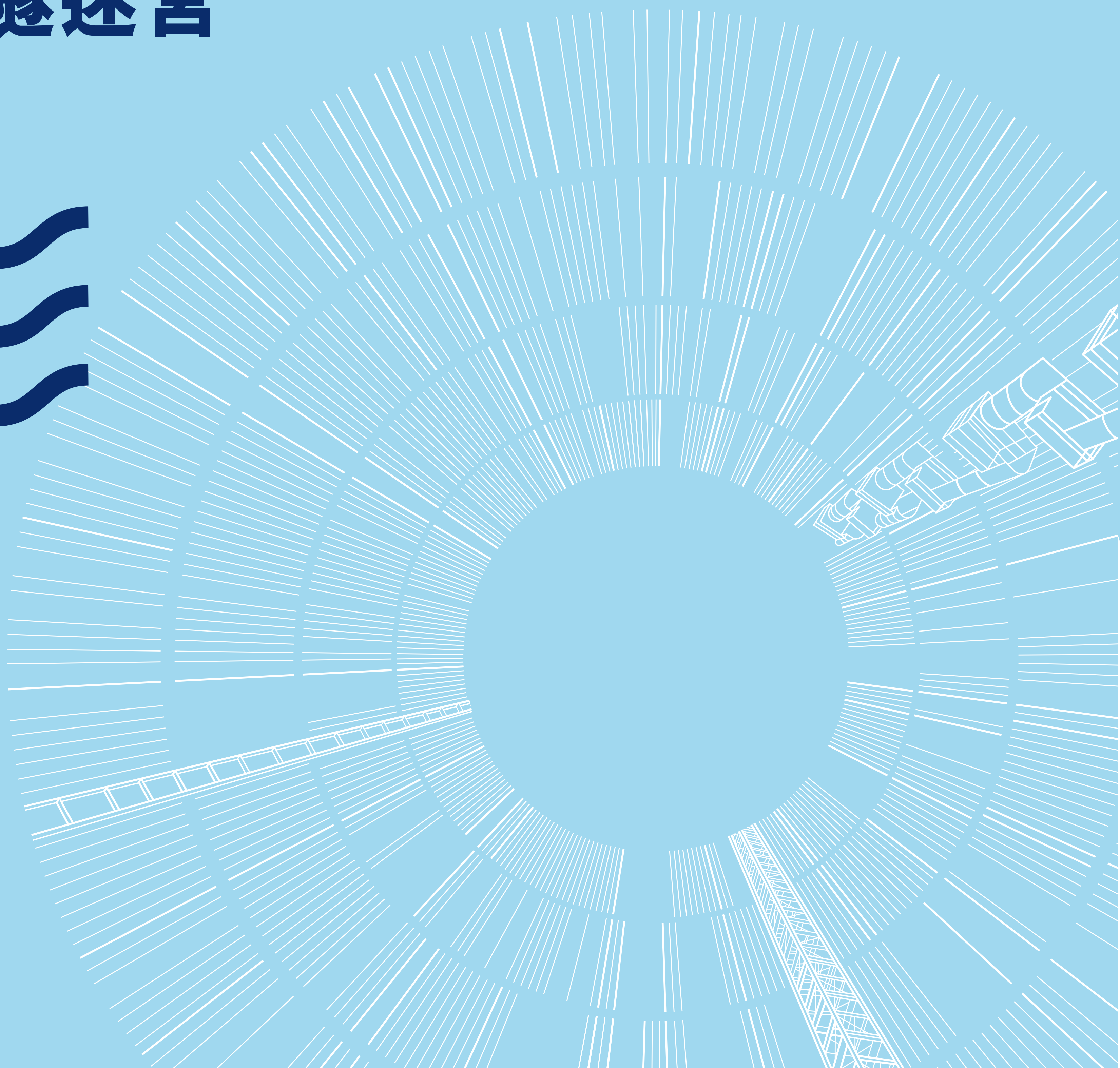
「維港要保持水質，甚至與時並進，繼續與同事一齊努力，令香港水質更好，有更好的優水文化。」

「『淨化海港計劃』產生的污泥由於佔用大量堆填區空間，一度是個問題。不過自從T▪PARK [源▪區]與『淨化海港計劃』開始合作，將後者的污泥轉為電力之後，不但為T▪PARK [源▪區]的設施提供足夠電力，更有額外電力供給市電網。這『轉廢為能』的循環也令香港更環保。」

WONG Kam-sing
黃錦星

Secretary for the Environment,
Environment Bureau
環境局局長

A HIDDEN LABYRINTH
深隧迷宮




LETTER 3 信件三
A HIDDEN LABYRINTH
深隧迷宮

A Hidden Labyrinth
深隧迷宮

Dear Harbour,

To reduce pollution in Your waters, our first crucial task in the 1990s was to construct a deep tunnel system for Stage 1 of HATS.

Comprising 23.6 kilometres of deep hard-rock tunnels at depths of up to 150 metres, this labyrinth of tunnels is truly one of Hong Kong's engineering wonders. The tunnels were designed to collect preliminarily treated sewage from the whole urban area of Kowloon, from Tseung Kwan O in the east to Tsuen Wan in the west, as well as from Chai Wan and Shau Kei Wan on Hong Kong Island, and convey it to the Stonecutters Island Sewage Treatment Works (SCISTW) for centralised chemically enhanced primary treatment. The effluent would then be discharged via a 1.7-kilometre outfall off SCISTW to the western approach of Victoria Harbour.

Stage 1 also included upgrading works at the seven existing Preliminary Treatment Works (PTWs) at Kwai Chung, Tsing Yi, Kwun Tong, To Kwa Wan, Tseung Kwan O, Chai Wan, and Shau Kei Wan, all located at connecting points of the deep tunnel system.

Upgrading Seven PTWs

Seven existing PTWs of Stage 1 served to protect the deep tunnel system against the risk of sediment accumulation and blockage of tunnel. Works included the installation of 6-millimetre fine screens to trap small objects and degritting facilities to remove 95% of grit greater than 0.2 millimetres.

Air extraction system complete with modular activated carbon type deodourisation units were added to minimise odour nuisance to the neighbourhood. The operational control system was also upgraded.

Choice and Design of Deep Tunnel System

Sewerage networks are typically constructed by the open trench method, following the alignment of the road system. However, given Hong Kong's unique urban environment, the open trench method would cause major traffic disruptions, clashes with existing utilities, environmental nuisance, loss of business to shops and other social disruption.

An innovative approach using a deep tunnel system was therefore selected to eliminate these issues and disruptions to the public.

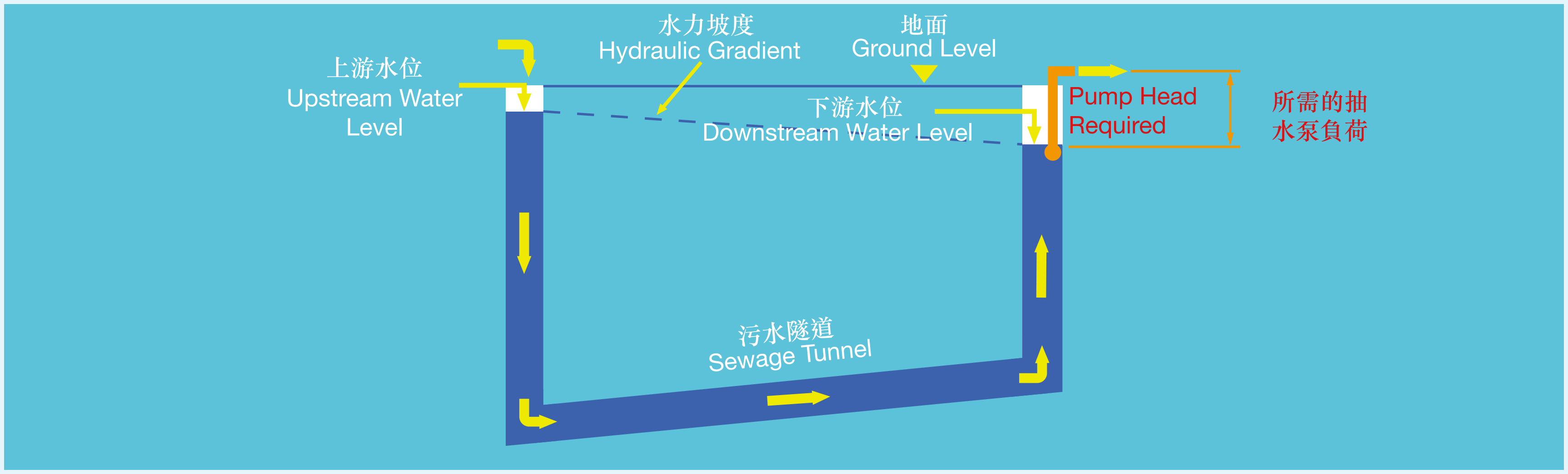
During the early stage of development in Hong Kong, all sewage flows generated in urban areas were essentially conveyed to PTWs for simple screening and grit removal before discharge to the Harbour. It was therefore feasible to design a tunnel system linking the seven existing PTWs under Stage 1 to convey the sewage collected to the SCISTW. Straight alignments were adopted between the PTWs to minimize the length of the tunnels. After studying the geological information, the project team decided to locate the tunnels in the bedrock stratum at depths of about 80 metres to 150 metres below sea level in order to maintain a minimum rock cover of 30 metres.

Placing the tunnels in rocks at these great depths would minimise any interference with the use and development of the land above. In order to do away with the need for resumption of private lots located along the tunnel alignment, the Sewage Tunnels (Statutory Easements) Ordinance (Cap. 438) was enacted in 1993 to empower the Government to create legal rights to construct, maintain, and operate the tunnels by following appropriate statutory procedures. It also provided a mechanism for the relevant land owners to raise objections and seek compensation if their private rights were affected.

The tunnel system was designed to operate as an inverted siphon, which would save substantial pumping energy compared to a gravity feed system. As future maintenance of the tunnels would be difficult, the designed flow would achieve self-cleansing velocity during the peak flow periods daily, so as to scour any solids or silts settled during other periods.

The great depth of the tunnel system means that any pockets of gas in the system might form air locks at the drop shafts thus obstructing the inflow of sewage. To minimise air entrainment, a specially designed vortex inlet was adopted with deaeration chambers at the bottom of every shaft. The tunnels are also designed to slope upwards at a minimum gradient of 1 in 500 to prevent the accumulation of residual air.

How Inverted Siphon Works
倒虹吸管的運作



Geology and Tunnel Excavation

Geological conditions in Hong Kong made the construction of the HATS deep tunnel system especially challenging. Overall, the Stage 1 tunnel excavation works took place mainly in unweathered hard rock which inherently contained interconnected fissures in the form of rock joints and fractures. At such great depths below sea level, significant amount of salty ground water under high pressure would flow into the tunnels through the rock fissures.


Tunnel dispute ends as firms agree to pay

Hong Kong iMail of 2 October 2001
香港郵報2001年10月2日報導

Such inflow, if not properly controlled, would draw down the ground water table and cause ground settlement. Depending on the quantity of inflow, water ingress would also cause practical difficulties to tunnel excavation such as rusting of construction equipment and flooding. Isolated sections of weak ground in highly weathered rock dykes and faults would also create great difficulties for tunnelling, particularly in the presence of high water ingress under great pressure.

Difficulties in Tunnelling

The Stage 1 tunnels, with lengths ranging from 3.6 to 5.5 kilometres, were excavated using five Tunnel Boring Machines (TBMs). The only exception was the shortest tunnel, at 0.78 kilometre in length, between Kwai Chung and Tsing Yi where the conventional drill and blast method was used.

At the time of their construction, the HATS Stage 1 tunnels were the deepest tunnels ever constructed in the world and there was hardly any experience from similar works for reference. This posed a major challenge to the tunnelling works which had to be carried out under the difficult geological conditions mentioned above.

The contractor for Stage 1 tunnels commenced works in early 1995. Water ingress under high pressure and the presence of weak ground at isolated locations soon created difficulties in tunnelling works. The project team tried its very best to work out feasible solutions together with the contractor to allow the works to proceed. However, the contractor eventually considered that it was “physically impossible” to complete the tunnelling works and gave up any further attempt to continue with the works.

Tasked with the mission to restore Your health, dear Harbour, we did not give up despite the serious difficulties encountered. We promptly took over all works from the contractor in December 1996 and relentlessly arranged for recommencement of the tunnelling works. As You will see later in this letter, it was subsequently demonstrated that the tunnelling works, though difficult, were viable. The contentions raised by the contractor were untenable and it turned out that it had to pay significant financial compensation to the Government for its unilateral decision to relinquish the tunnelling works.

Tunnelling Continued

Starting from July 1997, three new contractors were appointed to recommence the tunnelling works. Despite the serious technical difficulties, we continued the tunnelling works with unyielding and persistent efforts and actively worked out solutions to tackle the complications. We believed that grouting the ground ahead of tunnel excavation to seal rock fissures by pre-excavation grouting was the most appropriate way forward in reducing ground water ingress under high ground water pressure.

What followed was the difficult but successful task to modify all the existing five TBMs used for Stage 1 tunnelling works to provide them with mechanical equipment for drilling grout holes around the tunnel perimeter in front of the excavation face. In addition to pre-excavation grouting, installation of ground supports in the forms of timber laggings, reinforcement, steel support frames and concrete lining were also adopted for maintaining stability during excavation through weak ground.

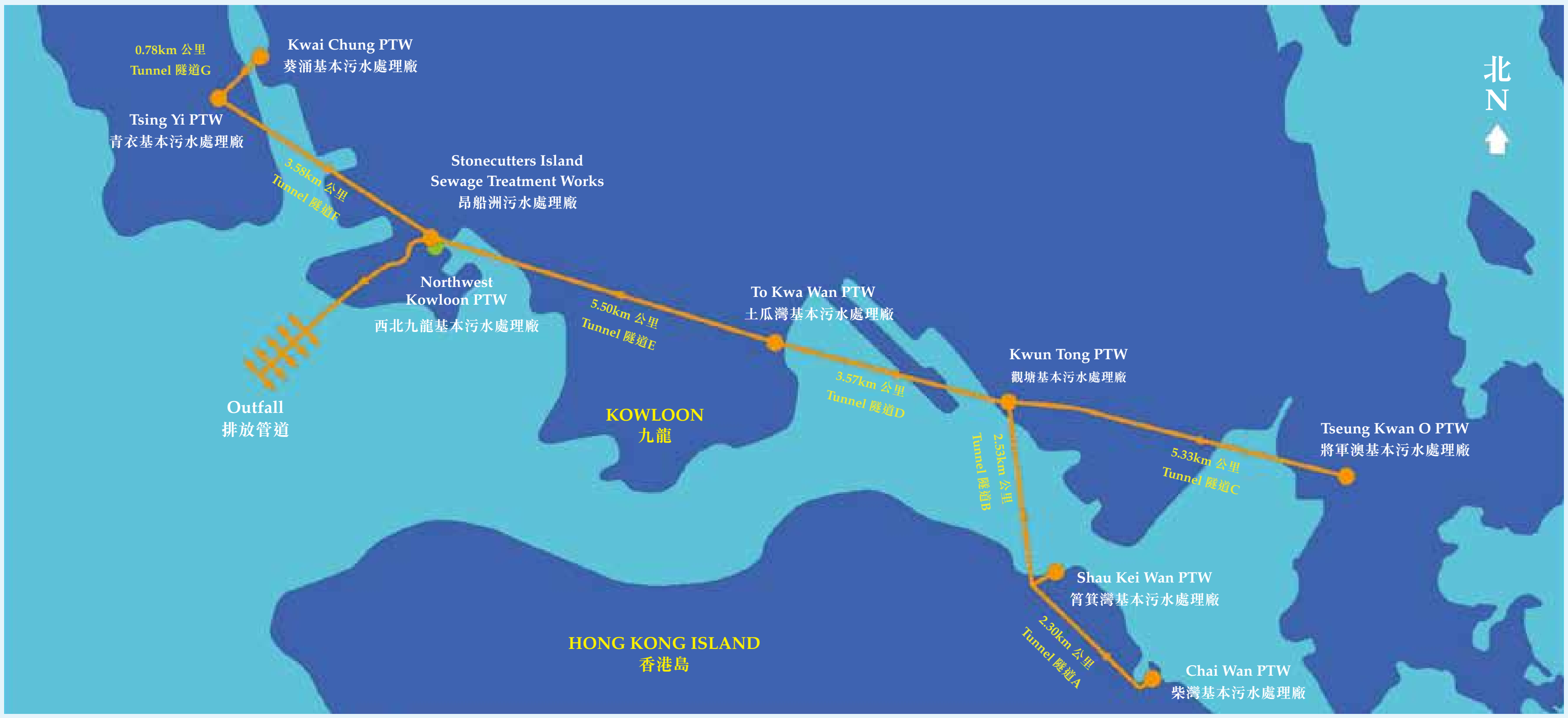
The project team also decided that it was necessary to set a limiting figure on the amount of ground water to be allowed to enter the tunnel during excavation, but this posed another major challenge. On the one hand, allowing too much water to enter the tunnel would increase construction difficulties and cause ground water table drawdown that might lead to ground settlement. On the other hand, it would be very difficult to achieve an overly stringent allowable water ingress limit even with the use of pre-excavation grouting.

To tackle this, different allowable water ingress limits were worked out for different areas and a balance was carefully maintained through an observational approach to allow tunnel excavation to proceed in a carefully controlled and orderly manner. With determination and perseverance, the project team achieved a major milestone in November 2000 with the break-through of the last tunnel section from To Kwa Wan to Stonecutters Island. While settlement had occurred in some locations which required patching up to restore serviceability of the settled ground, there was no impact to public safety in any material way.

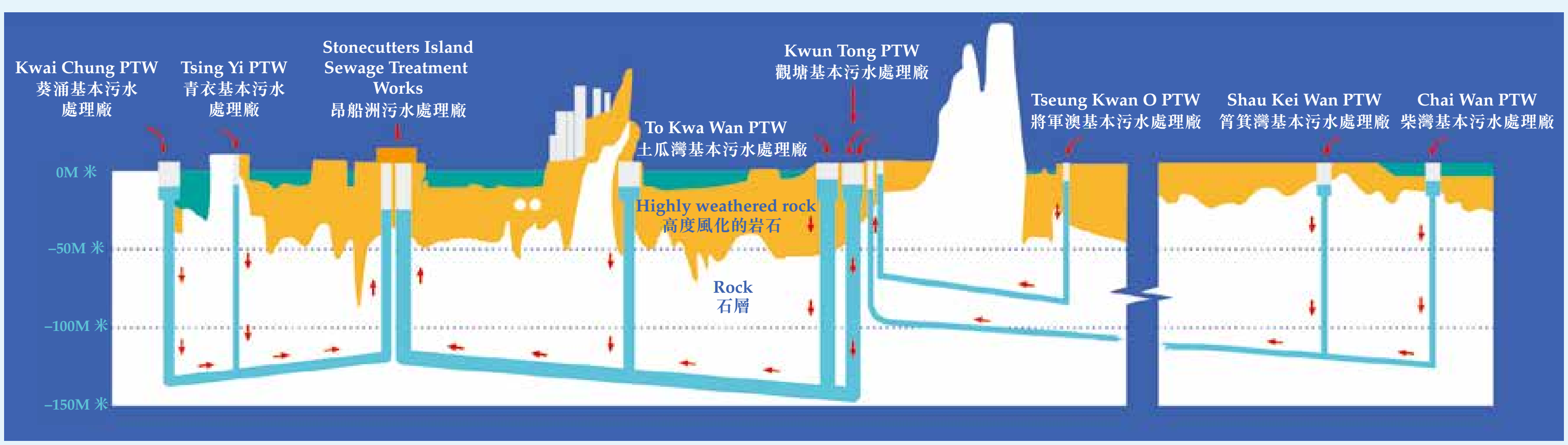
The many setbacks during the tunnelling process marked the most challenging aspect of Stage 1 works, not to mention community concerns and queries about HATS triggered by these issues. By 2001, all Stage 1 works including the deep tunnel system were completed. Once operational, the deep tunnel system began collecting over 1.3 million cubic metres of preliminarily treated sewage every day from the seven PTWs in Kowloon and north-eastern Hong Kong Island for chemically enhanced primary treatment at SCISTW and discharged through the outfall off Stonecutters Island. The deep tunnel system laid a solid foundation for the successful commissioning of the entire HATS Stage 1 in December 2001.

A Hidden Labyrinth
深隧迷宮

HATS Stage 1 Tunnels Alignment
「淨化海港計劃」第一期隧道走線



HATS Stage 1 Tunnels Longitudinal Profile
「淨化海港計劃」第一期隧道縱斷面圖



Information of HATS Stage 1 Tunnels
「淨化海港計劃」第一期隧道資料

Tunnel Drive 隧道段落	From 由	To 至	Length (km) 長度（公里）	Finished Diameter (m) 完成後直徑（米）	Level (mPD) 深度（主水平基準，米）	Lining Type 襯層類型
A[1] (TBM)	Chai Wan 柴灣	Shau Kei Wan 筲箕灣	2.30	1.20	–121 to 至 –126	Cast-in-situ 現澆
B[1] (TBM)	Shau Kei Wan 筲箕灣	Kwun Tong 觀塘	2.53	1.35	–76 to 至 –121	Cast-in-situ 現澆
C (TBM)	Tseung Kwan O 將軍澳	Kwun Tong 觀塘	5.33	1.35 Twin circular 雙管圓形	–76 to 至 –87	Cast-in-situ 現澆
D (TBM)	Kwun Tong 觀塘	To Kwa Wan 土瓜灣	3.57	2.82	–136 to 至 –143	PC Segment[3] 預製組件[3]
E (TBM)	To Kwa Wan 土瓜灣	Stonecutters Island 昂船洲	5.50	3.54	–125 to 至 –136	PC Segment[3] 預製組件[3]
F (TBM)	Tsing Yi 青衣	Stonecutters Island 昂船洲	3.58	2.36	–125 to 至 –132	Cast-in-situ 現澆
G (D&B)[2]	Kwai Chung 葵涌	Tsing Yi 青衣	0.78	2.21	–132 to 至 –134	Cast-in-situ 現澆

Notes:
註：

1. Tunnel A and Tunnel B were excavated using the same tunnel boring machine (TBM).
隧道A及B使用同一部隧道鑽挖機挖掘。
2. “D&B” means drill and blast method.
「D&B」即鑽爆方法。
3. “PC Segment” means precast concrete segment.
「PC Segment」即預製組件。

A Hidden Labyrinth
深隧迷宮

親愛的維港：

為了減少您的水質污染，我們在上世紀九十年代的首要任務，就是為「淨化海港計劃」第一期工程，建造一個深層隧道系統。

這個深埋堅石有如迷宮般的深層隧道網絡，長23.6公里，最深達150米，堪稱香港工程界的奇蹟。隧道系統的目的，是收集整個九龍市區的污水，從東面的將軍澳至西面的荃灣，以及港島的柴灣及筲箕灣，將已經基本處理的污水，通過隧道輸送到昂船洲的中央污水處理廠進行集中化學強化一級處理。經過處理後的污水，將通過一條從昂船洲延伸1.7公里的排放管道，於維多利亞港西部水域排放。

第一期工程也包括全面改善位於深層隧道系統連接點上的基本污水處理廠設施，即位於葵涌、青衣、觀塘、土瓜灣、將軍澳、柴灣及筲箕灣的七所原有基本污水處理廠，提升它們的操作控制系統及隔篩和除砂等污水處理能力。

全面改善七所基本污水處理廠

第一期工程的七所現有污水處理廠，能使深層污水隧道系統避免因沉澱物積聚而出現堵塞。改善工程包括安裝6毫米的隔篩以隔除細小物體，及安裝除砂設施去除95%大於0.2毫米的砂礫。

此外，也加裝了配有組裝活性碳類型除味裝置的抽氣系統，以盡量減低氣味對鄰近社區的影響，而操作控制系統也進行了升級優化。

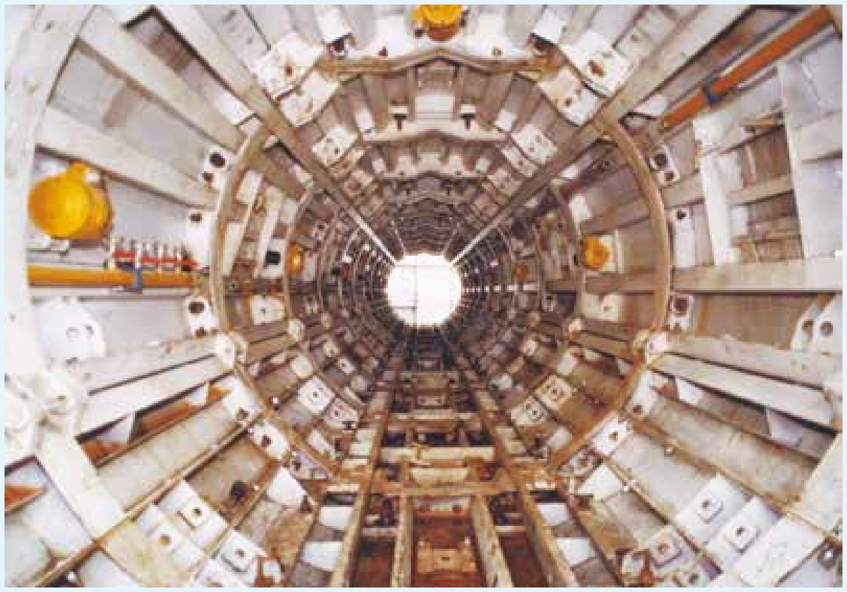
Air extraction system complete with modular activated carbon type deodourisation units on the roof top of Chai Wan PTW
柴灣基本污水處理廠的屋頂裝了配有組裝活性碳類型除味裝置的抽氣系統

選擇深層隧道系統與系統設計

一般情況下，污水渠網絡會跟隨道路網絡走線，利用明坑挖掘法鋪設污水渠。然而，鑑於香港獨特的市區環境，這方法會嚴重影響路面交通及原有的地底公共設施，對環境及民生造成滋擾，沿線商舖及社區運作也會大受影響。

因此，採用創新的深層隧道系統，可以避免這些對公眾造成的滋擾及影響。

在香港發展早期，市區產生的所有污水都會輸送到基本污水處理廠，進行簡單的隔篩和除砂後排放出維港。因此，為第一期工程設計一個連接七所原有基本污水處理廠的隧道系統，將污水收集及輸送到昂船洲的中央污水處理廠是可行的。基本污水處理廠之間的隧道路線則採用直線設計，以盡量縮短隧道的長度。經過地質勘察後，工程團隊決定隧道定位在基岩層，深度約為海平面以下80米至150米，以確保隧道上面有至少30米的石層覆蓋。



Tunnel formwork in Tunnel F from Tsing Yi to Stonecutters Island
由青衣至昂船洲隧道F的隧道模板

將隧道建在如此深的岩石層，有助減少對隧道上面土地的使用和開發造成影響。1993年頒布的《污水隧道(法定地役權)條例》(香港法例第438章)，賦予政府法律權力，循適當的法定程序建造、維修及使用污水隧道，無需收回隧道沿線的私人地段。法例同時為土地業權人提供機制，他們的私人權益如受影響，可以提出反對及索償。

隧道系統採用倒虹吸管設計，與重力供給系統相比，可以節省大量泵送能源。由於維修保養隧道將會非常困難，設計的流速要每天在高流量時段達到自淨流速，才可以將任何在其他時段已沉積在隧道內的固體或沙泥沖刷掉。

隧道系統由於極深，系統內任何氣體或會在傾卸豎井形成氣鎖，阻礙污水流入。為了減少空氣夾帶，每個豎井都裝有一個特殊設計的渦流入口，並於底部設有脫氣室。隧道也設計成向上傾斜，斜度為1/500或以上，防止殘餘空氣積聚。

地質與挖掘隧道

基於香港的地質環境，興建「淨化海港計劃」的深層隧道系統別具挑戰。總的來說，第一期隧道的挖掘工程主要是在堅硬、未風化的岩石層進行。由於岩石層本身有接縫和裂縫相互連接，加上隧道位於海平面以下極深處，大量地下鹹水會在高壓下從這些石縫湧入隧道。

地下水湧入如沒有適當控制，會造成地下水位下降並導致地面沉降。地下水的湧入量，也會給隧道挖掘帶來大大小小的實際問題，例如引致施工設備鏽蝕和水浸等。此外，高度風化的岩脈和岩石斷層形成部份地質脆弱段，再加上要在大量地下水於高壓湧入的情況下施工，亦令隧道挖掘困難重重。

隧道鑽挖困難重重

第一期隧道的長度由3.6至5.5公里不等，主要採用五部隧道鑽挖機進行挖掘工作，只有葵涌至青衣之間一段長度僅780米最短的隧道採用了傳統的鑽爆方式進行挖掘。

「淨化海港計劃」第一期隧道工程進行時，為全球歷來最深的隧道，世界各地都沒有類似的工程項目經驗可供參考。既無先例可援，加上要在上述惡劣的地質環境下進行隧道挖掘工作，挑戰更形艱巨。

第一期隧道的承建商於1995年年初展開工程。但地下水在高壓下湧入，加上部份位置地基脆弱，隧道挖掘工程很快已出現重重困難。工程團隊努力嘗試與承建商一起商討及制定可行的解決方案，以便工程得以繼續進行。然而，承建商最終認為「按照自然規律不可能」完成隧道工程，並放棄進一步嘗試繼續工程。

親愛的維港，儘管面對重重困難，我們並沒有放棄肩負的使命，就是要恢復您的健康。我們隨即於1996年12月接管承建商的所有工程，並下定決心重新啟動隧道工程。您將稍後在這封信裏看到，隧道工程雖然艱巨，但並非不可行。事實證明，承建商提出的論點站不住腳，最後並要為單方面決定放棄隧道工程，向政府支付大筆賠償金。

繼續鑽挖

由1997年7月起，我們委任了三個新承建商，重新開展隧道工程。儘管面對嚴重技術問題，我們仍一直堅持，努力不懈繼續隧道工程，為每個難題積極尋求解決方案。我們認為在隧道開挖前，進行預先灌漿以密封石縫，是有效減少地下水在高壓下湧入的最佳方法。

接下來是要將第一期隧道工程所有五部現有隧道鑽挖機進行改動，加裝機械設備，讓鑽挖機可以於挖掘面前方的隧道周邊鑽灌漿孔。改裝工作雖然艱巨，但最終也順利完成。除了進行預先灌漿工作外，我們還採用木材擋土板、鋼筋加固、鋼支架、混凝土襯砌等支撐裝置，以確保在脆弱地質位置進行挖掘時，有安全穩定的施工環境。

工程團隊也決定，有必要對挖掘過程中進入隧道的地下水水量設定容許限值，但這又帶來另一個挑戰。一方面，假如限值定得太過寬鬆，容許過多地下水湧入隧道，會令施工困難，也會引致地下水位下降，並可能導致地面沉降。另一方面，假如設限太過嚴謹，即使進行預先灌漿工作，亦難以達到過於嚴格的進水容許限值要求。

為了解決這問題，我們針對不同的區域制定了不同的進水容許限值，並透過細心觀察和監察，讓隧道挖掘過程可以調控有序地進行，並與進水容許限值取得平衡。工程團隊憑藉決心和毅力，最後一段從土瓜灣到昂船洲的隧道，終於2000年11月正式貫通，為項目達到一個重要里程碑。雖然部份位置曾經出現沉降，但已進行修補工程並回復適用狀態，沒有對公眾安全造成任何實質影響。

隧道鑽挖過程中遇上的種種挫折，正是第一期工程面對的最大挑戰，上述問題更一度引起社會大眾對「淨化海港計劃」的關注和疑慮。到2001年，包括深層隧道系統在內的所有第一期工程終於完成。深層隧道系統正式投入服務後，每天從九龍及港島東北部的基本污水處理廠，收集超過130萬立方米已經基本處理的污水，輸送往昂船洲污水處理廠進行化學強化一級處理，並經排放管道排放出昂船洲對開水域。2001年12月「淨化海港計劃」第一期得以成功啟用，深層隧道系統無疑為整個項目奠定了堅實基礎。

Breakthrough ceremony of Tunnel C Tseung Kwan O to Kwun Tong was held on 9 November 1999

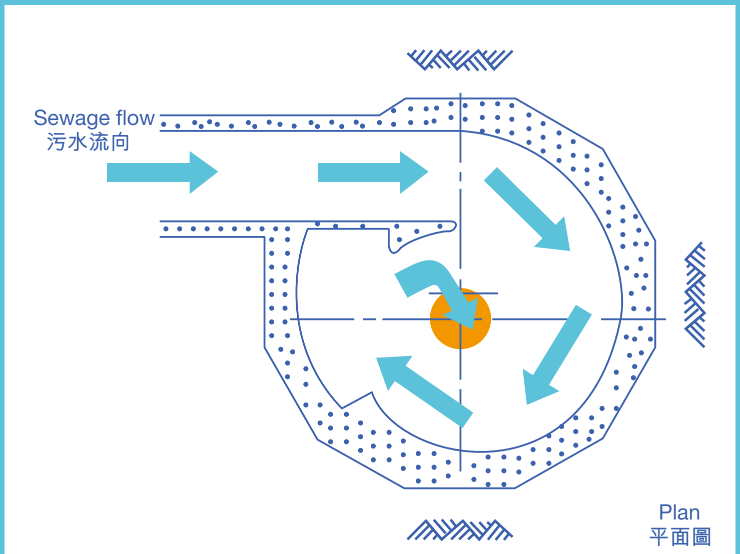
由將軍澳至觀塘的隧道C於1999年11月9日舉行貫通典禮

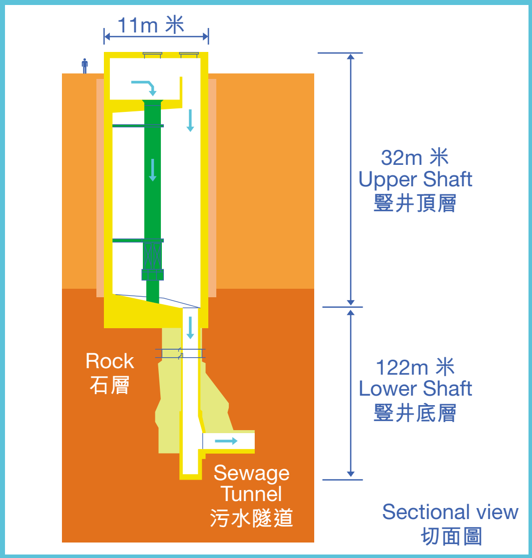
Celebrating the tunnel breakthrough on site

在現場慶祝隧道貫通

A Hidden Labyrinth
深隧迷宮

Vortex Inlet of Typical Drop Shaft
典型豎井的渦流入口





Vortex chamber
渦流入水井

Interior of upper drop shaft
豎井頂層內部

Chai Wan drop shaft under construction
興建中的柴灣豎井

POSTSCRIPT

“I was involved in HATS from 1993 to 2009 and went through the most challenging days in Stage 1 works — such as our re-entering the work sites, conducting arbitration with the contractor who abandoned the works, resolving the problem of serious underground water ingress into the deep tunnels as well as settlement issues in certain areas along the tunnel alignment. However, it is also because of these precious lessons learnt from Stage 1 that we were able to grasp the techniques of deep tunnel construction for Stage 2A and became a world-class pioneer in this respect.”

“HATS is a mega project involving many profound issues and must be handled with great care. We had to control the cost and programme and strike a balance in every respect. We have weathered the most stormy days and gathered valuable experiences, which will make the team more confident in dealing with future challenges.”

附箋

「我由1993至2009年參與『淨化海港計劃』的工作，經歷了第一期工程最嚴峻的日子，包括收回地盤、與放棄工程的承建商進行仲裁、解決深層隧道地下水大量湧入、和隧道沿線部份地區出現沉降等問題。但也幸好汲取了第一期工程的教訓，讓我們在第二期甲工程得以掌握建造深層隧道的技術，成為這方面的世界先驅。」

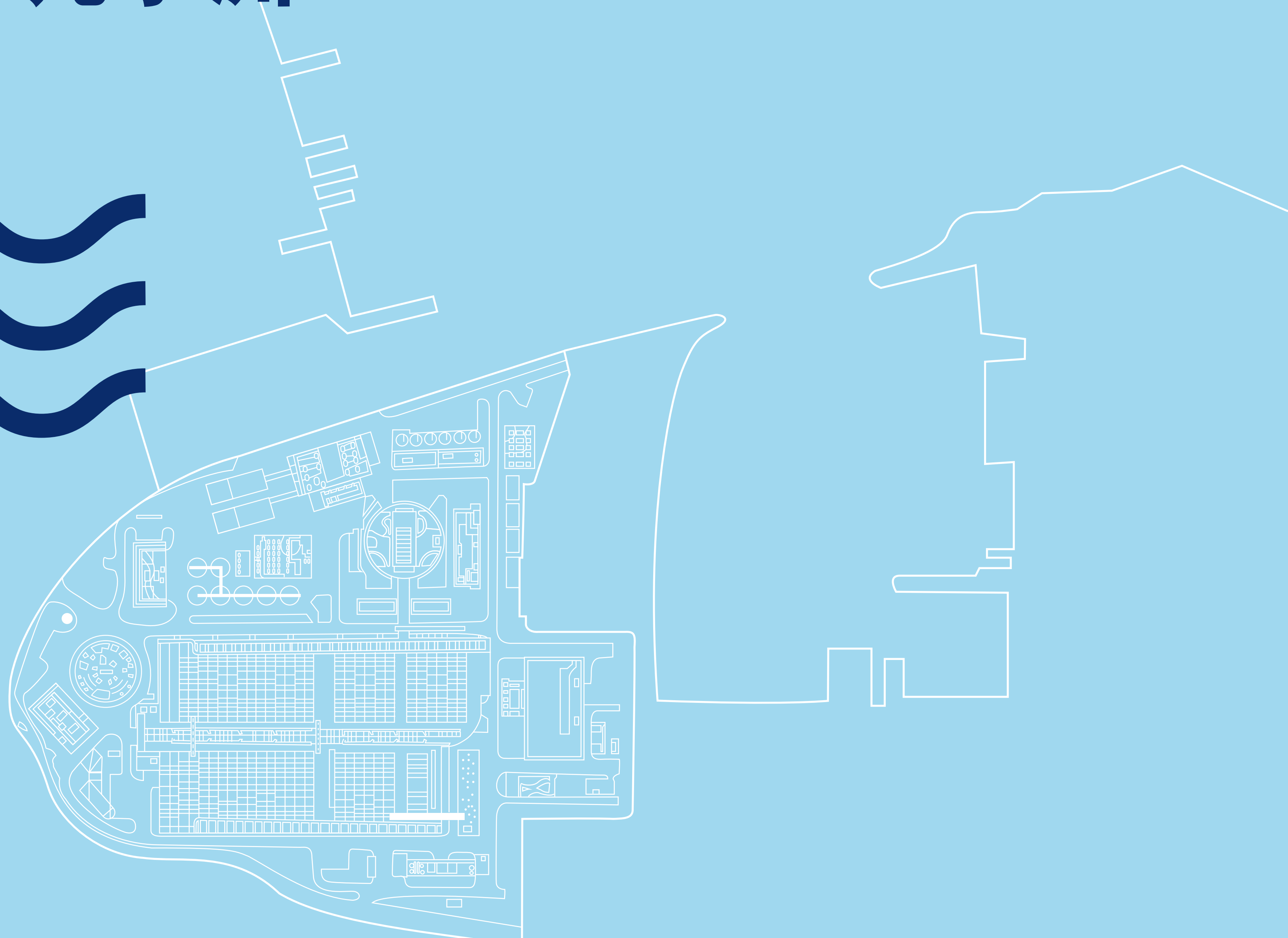
「『淨化海港計劃』是龐大工程，涉及很深入的問題，必須小心處理，既要控制成本和進度，也要做到各方面平衡。我們最艱難的日子都渡過了，取得寶貴的經驗，讓團隊對未來的挑戰更有信心。」

Raymond TAI Wai-man

戴懷民

Former Chief Engineer/Project Management, DSD
渠務署前總工程師／工程管理

AN UNUSUAL ISLAND
非凡小洲



LETTER 4 信件四

AN UNUSUAL ISLAND
非凡小洲

An Unusual Island
非凡小洲

Dear Harbour,

In our earlier letters, we shared with you how the HATS project began, why the centralised option was chosen, and how a labyrinth of deep sewage tunnels was successfully constructed despite enormous engineering difficulties. This crucial work took place from the early 1990s onwards as part of HATS Stage 1 to tackle increasingly serious pollution in your Harbour waters.

The centralised sewage treatment works on Stonecutters Island is the beating heart of HATS: fed by the deep tunnels that are its arteries, it treats the city's sewage and discharges the treated sewage into the western approach of the Harbour.

Stonecutters Island

Since 1997, when Hong Kong became a Special Administrative Region of the People's Republic of China, Stonecutters Island has housed naval facilities as well as a number of civil facilities, including the newly commissioned Stonecutters Island Sewage Treatment Works (SCISTW). Also on the island is the pre-existing North West Kowloon Preliminary Treatment Works (NWKPTW), which serves Sham Shui Po, Yau Ma Tei and Cheung Sha Wan.

Stonecutters Island was chosen to house the centralised sewage treatment works for an obvious reason: its central location in relation to all the Preliminary Treatment Works (PTWs) on both sides of the Victoria Harbour covered by the HATS plan keeps the length of the deep tunnels to a minimum. Although SCISTW was designed to ultimately serve the needs of 5.7 million people, the area designated for the entire treatment works was only 10.6 hectares, just about half the size of Victoria Park. The result is a world-class, compact and highly efficient sewage treatment works.

Stonecutters Island Sewage Treatment Works

The SCISTW is a key component of HATS Stage 1 and provides centralised chemically enhanced primary treatment (CEPT) to preliminarily treated sewage collected from the deep tunnel system. SCISTW is designed to handle average dry weather flow of 1.7 million cubic metres per day. HATS Stage 1 is intended to serve about 3.5 million people, with further HATS stages taking that number up to 5.7 million.

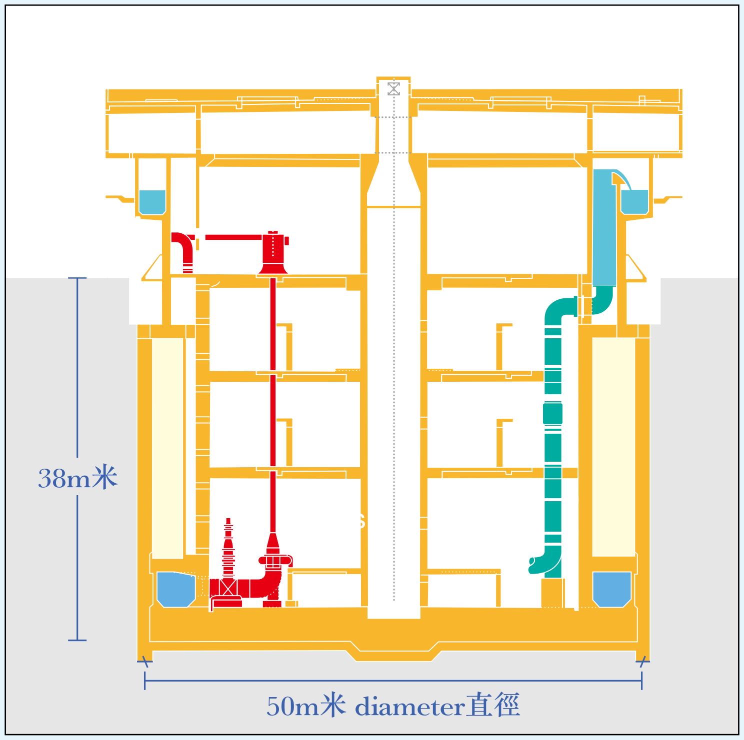
The SCISTW consists of six main facilities, all constructed during HATS Stage 1, including: Main Pumping Station No. 1, Sedimentation Tanks Facility, Chemical Dosing Facility, Sludge Dewatering Facility, Power Supply and Control System, and Stage 1 Outfall System.

Overview of Main Pumping Station No.1
一號主泵房外觀

Main Pumping Station No. 1

The large Main Pumping Station No. 1 (MPS1) is designed to lift the sewage from the deep tunnel system and deliver it to downstream treatment facilities above ground. For compactness, the MPS1 is circular, with a diameter of 50 metres and a depth of over 38 metres. The wet well is located at the periphery, while the central space houses the pumps, motors and control room. The pumping system comprises eight gigantic centrifugal pumps, together with four variable speed drives for energy efficient operation.

Sectional View of Main Pumping Station No.1
一號主泵房切面圖



Sedimentation Tanks Facility

The Sedimentation Tanks Facility is designed with double-decked tanks so as to halve its footprint. The incoming sewage first goes through a rapid mixing process where ferric chloride is introduced. It then enters a flocculation zone where small particles are allowed to clump together with the aid of polymer to form floc for easier removal.

Following flocculation, pollutants in the sewage can be removed as sludge, while floatable solids can be removed as scum, leaving the effluent ready for discharge. The CEPT process at SCISTW is capable of removing about 80% of suspended solids and 70% of biochemical oxygen demand from the sewage, thus reducing bacteria growth.

Chemical Dosing Facility

The Chemical Dosing Facility provides storage and dosing facilities for adding ferric chloride and polymer to sewage for the subsequent sedimentation process. Highly automated, and capable of dosing ferric chloride from 10 milligrams per litre (mg/l) to 20 mg/l, the facility ensures round-the-clock supply of these essential chemicals for the CEPT process.

Sludge Dewatering Facility

Sludge and scum collected during sedimentation are conveyed to the Sludge Dewatering Facility (SDF). When the sludge and scum, collectively called sludge, leave the sedimentation tanks, it has a dry solids content ranging from 2% to 4% by weight. Five sludge storage tanks are used to temporarily store the pre-dewatered sludge.

At the core of the SDF are ten centrifuges which dewater the wet sludge to a minimum of 32% dry solids by weight to meet the disposal requirement. Polymer is added as a coagulant to enhance the process. After dewatering, sludge cakes from the centrifuges are transported to one of the four sludge cake silos by conveyors before container loading. The sludge cakes were disposed at the South East New Territories Landfill and the West New Territories Landfill. The liquid removed during the dewatering process, which is known as centrate, is returned to the MPS1.

Power Supply and Control System

To ensure the smooth, round-the-clock operation of SCISTW, stable and uninterrupted power supply is vital. Power supply to SCISTW is a dual-feed system comprising two 11-kilovolt cables from different primary substations at Container Port Road and Ha Kwai Chung, an arrangement which ensures reliable electricity supply and minimises the risk of an outage due to cable damage.

The highly automated Distributed Control and Data Acquisition System controls the various process systems under HATS Stage 1 at SCISTW. Each independent facility control systems are linked by the System Information Network. Operator Work Stations at each facility allow operators to monitor the system operation and performance.

Overall, SCISTW is highly efficient considering its large treatment capacity versus the small number of staff required.

Outfall System

Effluent gravitates to the outfall and is discharged to the tidal stream southwest of Stonecutters Island for dilution and dispersion. The outfall tunnel is 1.7 kilometres long with a 1,200-metre long diffuser pipeline.

For optimal diffusion effect, two sections of steel diffuser pipeline are extended from the central risers. The pipeline has a total of 24 diffusers, each with eight discharge ports, to maximise dispersion. It is also protected from possible ship anchor damage by a rock layer and by resilient polyethylene domes over the ports.

North West Kowloon Pumping Station

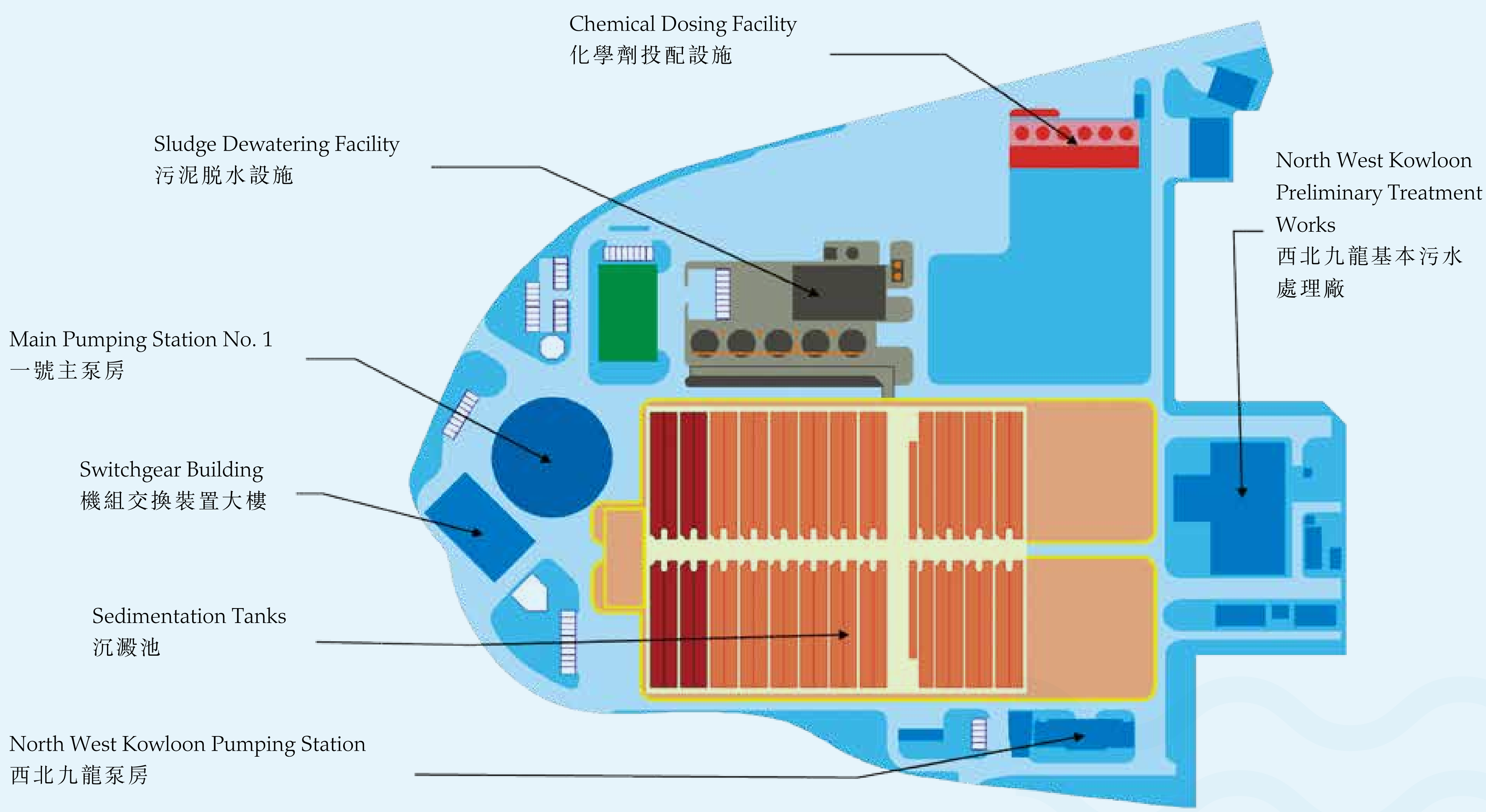
Adjacent to the SCISTW is the pre-existing NWKPTW which serves Sham Shui Po, Yau Ma Tei and Cheung Sha Wan. As the NWKPTW is right next to the SCISTW, we built and commissioned in 1997 the North West Kowloon Pumping Station (NWKPS) under Stage 1 to convey the effluent from NWKPTW directly to the sedimentation tanks, without going through the deep tunnel system.

All Set on the Island

Thus, by late 2001 when all the key SCISTW facilities were completed and ready to roll, Stonecutters Island had been completely transformed. The island had become the “heart” of a powerful sewage treatment system that would prove highly effective in cleaning up our Harbour and improving the quality of life for millions.

Completed SCISTW in HATS Stage 1
於「淨化海港計劃」第一期落成的昂船洲污水處理廠

Stonecutters Island Sewage Treatment Works HATS Stage 1 Layout Plan
「淨化海港計劃」第一期昂船洲污水處理廠規劃圖



An Unusual Island
非凡小洲

親愛的維港：

在之前的信中，我們與您分享了「淨化海港計劃」的緣起，選擇中央污水處理方案的原因，以及我們如何克服萬難，成功興建一個迷宮般的深層污水隧道網絡。這工作始於上世紀九十年代初，是「淨化海港計劃」第一期工程的重要部份，目的是要解決您水域內日益嚴重的污染問題。

昂船洲的中央污水處理廠可說是「淨化海港計劃」的心臟，而深層隧道就像動脈，源源不絕向中央污水處理廠輸送維港兩岸的污水，經它處理後再排放出維港西面。

昂船洲

香港自1997年成為中華人民共和國特別行政區後，軍方隨即於昂船洲設置海事設施，島上亦有一些民用設施，包括剛落成啟用的昂船洲污水處理廠。此外，當時島上還有已存在的西北九龍基本污水處理廠，服務深水埗、油麻地及長沙灣。

「淨化海港計劃」選址昂船洲設置中央污水處理廠，原因很簡單：昂船洲位處維港兩岸所有基本污水處理廠的中心，地理位置優越，可以將所需的深層隧道長度減到最低。雖然昂船洲污水處理廠最高能為多達570萬人口提供污水處理服務，但廠房設施佔地僅10.6公頃，只約半個維多利亞公園的大小，是一個密集而效率極高的世界級污水處理設施。

昂船洲污水處理廠

昂船洲污水處理廠是「淨化海港計劃」第一期的核心部分。維港兩岸的污水經基本處理後，再經深層隧道系統輸送到昂船洲污水處理廠作集中化學強化一級處理。「淨化海港計劃」第一期的昂船洲污水處理廠每天可處理170萬立方米的平均旱天污水流量，為350萬人口提供服務。至於整個「淨化海港計劃」，最終更可為多達570萬人口提供服務。

昂船洲污水處理廠包含六個主要設施，全部皆於「淨化海港計劃」第一期建成，包括一號主泵房、沉澱池設施、化學劑投配設施、污泥脫水設施、電力供應和控制系統以及排放系統。

一號主泵房

大型的一號主泵房的作用是從深層隧道系統將污水抽往地面，輸送到下游的處理設施。為了節省佔地面積，一號主泵房以圓形設計，直徑50米，深入地底逾38米。濕井位於周邊，中央部份設置抽水泵、發動機和控制室。抽水系統包括八台巨型離心泵，配以四個變速驅動器，以符合操作能源效益。

沉澱池設施

沉澱池設施採用雙層設計，令佔地面積減半。進入沉澱池的污水首先經過快速混合，過程中加入三氯化鐵。污水然後進入絮凝區，水中的小顆粒會借助聚合物凝聚在一起，並形成絮狀物，以方便移除。

污水經絮凝後，水中污染物會結成污泥，而漂浮的固體會結成浮渣。在去除污泥及浮渣後，剩餘的就是已處理的污水，可以排放。昂船洲污水處理廠採用化學強化一級污水處理，能夠除去污水中八成的懸浮固體和七成的生化需氧量，從而減少細菌滋生。

化學劑投配設施

化學劑投配設施包括儲存和注入化學劑的設施，將三氯化鐵和聚合物注入污水中，讓污水可進行沉澱。投配設施高度自動化，能夠為污水注入每公升10毫克至20毫克的適量三氯化鐵，並全日二十四小時無間斷運作，確保整個化學強化一級污水處理過程運作暢順。

污泥脫水設施

沉澱過程中收集的污泥和浮渣，會運送到污泥脫水設施。當污泥和浮渣—統稱為污泥—離開沉澱池時，其固體濃度是重量的2%至4%，並會臨時儲存在五個污泥儲存缸內，準備進行脫水過程。

污泥脫水設施的核心設施是10台離心機，將濡濕的污泥脫水至固體重量達32%或以上，以符合污泥棄置標準。脫水過程會加入聚合物作為凝結劑，以加強脫水效果。脫水後的污泥塊，會經運輸帶輸送往污泥塊儲存倉暫存，然後送往新界東南堆填區及新界西堆填區棄置。而在脫水過程中除去的離心機廢液，則會送返一號主泵房。

Sludge dewatering facility
污泥脫水設施

Centrifuges in sludge dewatering facility
污泥脫水設施內的離心機

Control room in Main Pumping Station No. 1
一號主泵房內的控制室

電力供應和控制系統

為確保昂船洲污水處理廠全天候運行順暢，無間斷的穩定電力供應尤其重要。污水處理廠採用一個雙重供電系統，電源分別來自貨櫃碼頭路和下葵涌的主變電站兩條11千伏電纜。雙重供電系統能確保可靠的電力供應，並可將因電纜損壞而導致停電的風險減到最低。

「淨化海港計劃」第一期在昂船洲污水處理廠的所有工序系統，均由高度自動化的分佈式操控和數據採集系統控制，而每個獨立的設施控制系統，都經系統信息網絡互相連接。每個設施均設有操作員工作站，讓操作員監控系統操作和表現。

總體而言，昂船洲污水處理廠的污水處理量雖然龐大，但只需要少量員工操作，效率極高。

排放管道系統

經處理的污水經由排放管道，排放出昂船洲西南水域，隨潮汐流擴散和稀釋。排放管道長1.7公里，配有1,200米長的擴散器管道。

排放管道的尾端連接着兩條擴散器管道，提升擴散效果。整個擴散器管道共有24個擴散器，每個擴散器有8個排放端口，以達到最佳擴散效果。擴散器管道上有石層保護，擴散器頂部的排放端口也加裝了韌性聚乙烯保護圓罩，以免受到船錨損壞。

西北九龍泵房

毗鄰昂船洲污水處理廠的西北九龍基本污水處理廠，早於「淨化海港計劃」之前已存在，為深水埗、油麻地及長沙灣提供基本污水處理服務。由於二者位置相鄰，我們興建並於1997年落成西北九龍泵房，作為「淨化海港計劃」第一期工程之一，讓西北九龍基本污水處理廠處理的污水，可以毋須經深層隧道而直接輸送到昂船洲污水處理廠的沉澱池，作化學強化一級處理。

島上一切就緒

2001年底，昂船洲污水處理廠的所有主要設施均已落成，一切準備就緒。這時的昂船洲已搖身一變，成為一個強大污水處理系統的「心臟」，自此不但成功淨化維港，更改善了數百萬人的生活質素。

An Unusual Island
非凡小洲

Main Pumping Station No.1
under construction
興建中的一號主泵房

Main Pumping Station No. 1 inlet chamber
一號主泵房進水室

Main Pumping Station No. 1 motor hall
一號主泵房摩打房

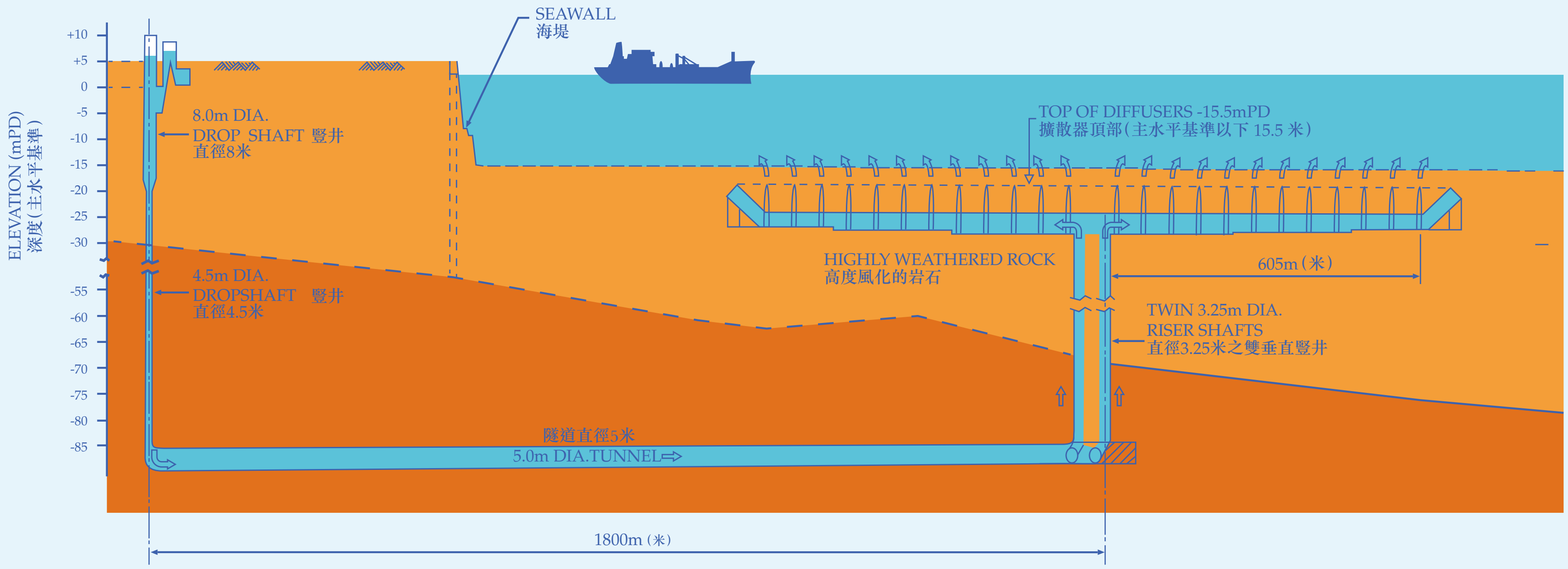
Double-decked sedimentation tanks
雙層沉澱池

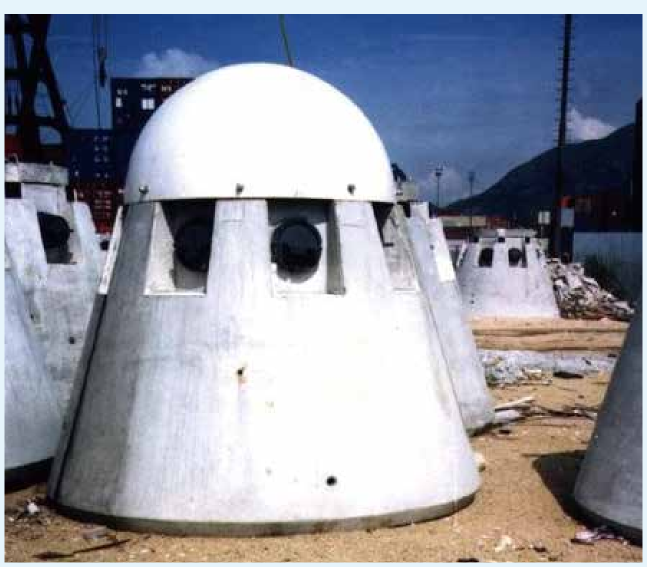
Chemical dosing facility
化學劑投配設施

Ferric chloride storage tanks
三氯化鐵儲存缸

An Unusual Island
非凡小洲

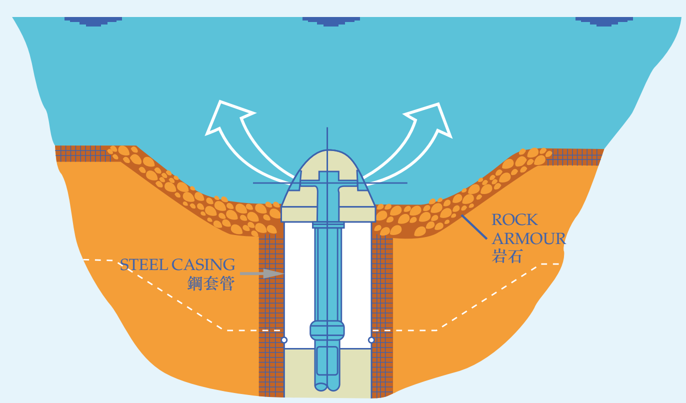
Longitudinal Profile of Outfall
排放管道縱斷面圖





Diffuser head with protective dome
擴散器頂部加裝了保護圓罩

Diffuser Details
擴散器細節



POSTSCRIPT

"The E&M facilities of HATS have many characteristics. Its Main Pumping Station No. 1 (MPS1) for example, is the first pumping system in Hong Kong that lifts water from very deep tunnels. For the double-tray sedimentation tanks, a special engineering solution is required to pump away the sewage in the upper tray before maintenance of the lower tray can proceed. As to the sludge dewatering facilities, as Hong Kong's sewage contains grit, the blades of the early centrifuges were seriously worn out. After discussions with the manufacturers, we re-designed the blades and replaced the centrifuges, thus solving the problem."

"During Stage 2A design stage, we decided to construct the Main Pumping Station No. 2 (MPS2) to handle the newly increased sewage volume, and build an underground tunnel to connect MPS1 with MPS2. The tunnel will facilitate future maintenance when sewage from one pumping station can be diverted to the other to ensure continuous operation of the sewage treatment plant. In fact, we just completed a three-month major maintenance of the MPS1 at the end of 2018, the largest-scale maintenance exercise in 20 years. Both pumping stations and the interconnection tunnel performed exactly as planned in the exercise."

附箋

「『淨化海港計劃』的機電設施有不少特色，例如一號主泵房是香港第一個從極深層隧道抽水上地面的泵水系統。至於雙層沉澱池的下層維修保養，則要有特別方案先抽去上層的污水才可進行。而污泥脫水設施方面，早期的離心機葉輪由於本港污水帶砂粒而引致磨損嚴重，經與廠方商討後從新設計葉輪和更換離心機，順利解決問題。」

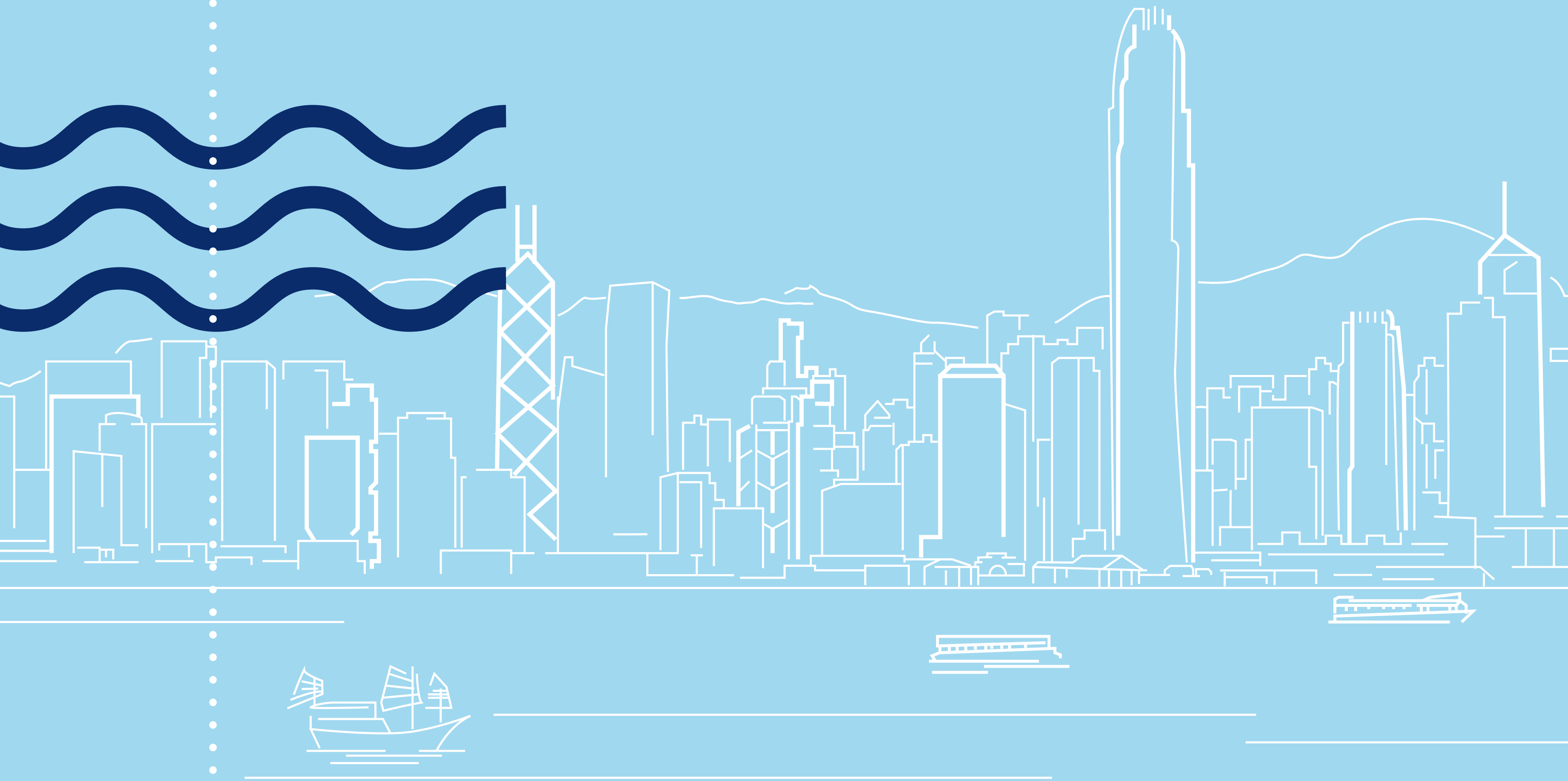
「我們在設計第二期甲時，已決定要興建二號主泵房以應付新增的污水處理量，並興建一條地下隧道與一號主泵房連接起來，以便將來維修保養時，污水可抽到另一個泵房，使污水處理廠能持續運作。我們在2018年年底便為一號主泵房進行了歷時三個月的大型維修，是廿年內規模最大的泵房維修保養工程，兩座主泵房和連接隧道完全發揮了原先設計的作用。」

Norman SIU Ka-kam
蕭嘉錦

Former Assistant Director/
E&M, DSD
渠務署前助理署長／機電工程

NEW CENTURY, NEW HARBOUR

維港新世紀



Kwai Chung PTW
葵涌基本污水處理廠
Tsing Yi PTW
青衣基本污水處理廠
SCISTW (CEPT)
昂船洲化學強化
一級污水處理廠
STONECUTTERS
ISLAND
昂船洲
Existing SCI Outfall
現有的昂船洲排放口
To Kwa Wan PTW
土瓜灣基本污水處理廠
KOWLOON
九龍
Kwun Tong PTW
觀塘基本污水處理廠
Tseung Kwan O PTW
將軍澳基本污水處理廠
Central PTW
中環基本污水處理廠
North Point PTW
北角基本污水處理廠
Wan Chai East PTW
灣仔東基本污水處理廠
Shau Kei Wan PTW
筲箕灣基本污水處理廠
Sandy Bay PTW
沙灣基本污水處理廠
Cyberport PTW
數碼港基本污水處理廠
Chai Wan PTW
柴灣基本污水處理廠
HONG KONG ISLAND
香港島
Aberdeen PTW
香港仔基本污水處理廠
Wah Fu PTW
華富基本污水處理廠
Ap Lei Chau PTW
鴨脷洲基本污水處理廠
北
N
LETTER 5 信件五
NEW CENTURY,
NEW HARBOUR
維港新世紀

Dear Harbour,

When HATS Stage 1 was commissioned in December 2001, the city's vision to clean up our precious Victoria Harbour was finally realised. The timing could not have been more auspicious: bringing a new lease of life to our marine waters for the new millennium.

Once operational, HATS Stage 1 began treating an initial flow of about 1.3 million cubic metres of sewage each day, removing some 600 tonnes of sludge that had previously been directly discharged from the most densely populated urban areas into our dear Harbour. The positive environmental impact on our Harbour water quality was dramatic.

All this was made possible thanks to the successful completion of the HATS Stage 1 major works.

Stage 1 Benefits: Obvious Water Quality Improvement

HATS Stage 1 commissioning brought obvious improvement to the water quality in Victoria Harbour. An average increase of about 10% in dissolved oxygen in our Harbour waters supported marine life to flourish. Corals were found thriving again in Harbour waters.

At the heart of it all is the SCISTW which removes from the sewage 70% of organic pollutants in terms of biochemical oxygen demand, 80% of suspended solids, and 50% of sewage pathogens in terms of *E. coli*.

Yet HATS Stage 1 also had its problems. After the full commissioning of Stage 1, although remarkable water quality improvements were seen at the middle and eastern areas of the harbour, the western harbour, notably in the area of the Tsuen Wan beaches, was still subject to the impacts of the large volume of treated but not yet disinfected effluent discharged from SCISTW. Coupled with the relatively short outfall off SCISTW, the seven Tsuen Wan beaches had to be closed due to the high *E. coli* level. Also, odour from the SCISTW became an issue for the neighbouring community in West Kowloon where new residential and commercial developments unforeseen during Stage 1 planning had mushroomed.

This pointed to the need for a longer outfall or the provision of disinfection facilities. The odour problem had to be resolved too.

After Stage 1, What's Next?

There were quite a few twists and turns before the Government eventually decided to embark on what we now know as Stage 2A to enhance the HATS project.

In 1999, the Government decided to halt the implementation of further stages of HATS until consensus had been reached on the way forward. This acknowledged public concerns triggered by delays in the Stage 1 deep tunnel system construction, and differing views in the community on issues such as the level of sewage treatment and the discharge outfall location.

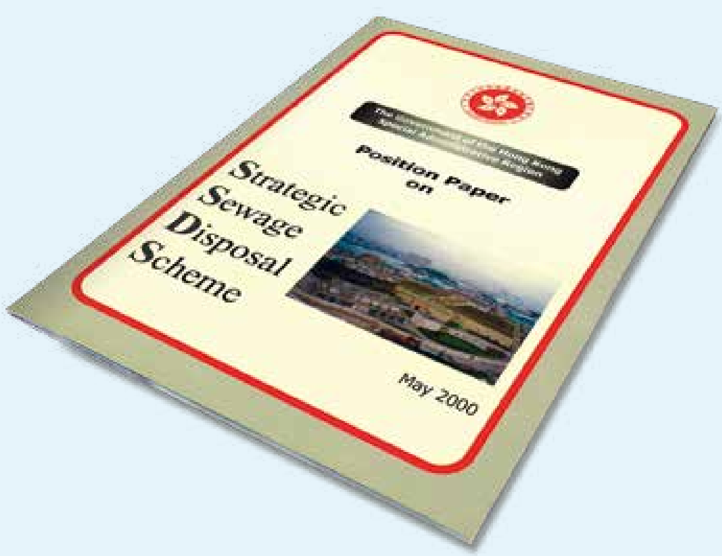
At the same time, the Stage 1 works were still not adequate to protect the Harbour. Sewage from the northern and south western sides of Hong Kong Island was still discharged virtually untreated into the Harbour.

It was against this backdrop that the Government commissioned an International Review Panel (IRP) in April 2000. The second IRP on HATS, it was asked to re-examine the entire HATS scheme. The IRP comprised six members including two professors from the Mainland and USA, both of whom served on the first IRP back in 1994, and four other expert professors from various disciplines.

International Review Panel Recommendations

In its final report, released in November 2000, the IRP proposed four treatment and discharge options, recommending Biological Aerated Filters (BAF) as the preferred treatment technology, with deep tunnels for sewage transfer and short outfall for disposal. The SCISTW was commended as the most efficient chemically enhanced primary treatment (CEPT) plant in the world, providing a common base for further development.

However, as Hong Kong uses seawater for toilet flushing, the effectiveness of BAF technology for our saline sewage was uncertain. Public acceptance of the high recurrent cost of tertiary treatment had yet to be ascertained, too. Another constraint was the unavailability of land at Stonecutters Island, North Point and Sandy Bay to house the proposed treatment facilities.



The Government issued a position paper on the Strategic Sewage Disposal Scheme
政府於2000年發表「策略性污水排放計劃」立場書

Going for Tertiary Treatment?

The Government commissioned two further studies, namely the "Environmental and Engineering Feasibility Studies" (EEFS) and "Compact Sewage Treatment Technologies Trials" (CSTTT). The former was to assess the water quality impacts and engineering feasibility of the IRP options while the latter was to test the effectiveness of compact treatment technology in treating Hong Kong's saline sewage.

When the two studies were completed in June 2004, all four IRP options were found to be environmentally acceptable and technically feasible, but the tertiary treatment option would pose substantial operational and cost issues. The BAF technology was found not suitable for Hong Kong's saline sewage, and the water quality modelling results did not warrant the adoption of tertiary treatment to protect our Harbour waters.

It followed then that among the options, upgrading the existing centralised treatment facilities at SCISTW was preferred in terms of cost, environmental and engineering considerations. The preferred option for HATS going into Stage 2 comprises Stages 2A and 2B.

Stage 2A will cover the provision of additional facilities, including the upgrading of existing PTWs in the harbour area catchments on the northern and south western sides of Hong Kong Island, the construction of about 21 kilometres of deep tunnels to convey sewage from the above PTWs to Stonecutters Island, and the upgrading of the existing SCISTW to provide CEPT, disinfection and deodourisation functions.

Stage 2B will cover the provision of biological treatment facilities to raise the level of treatment to meet higher effluent standards, located adjacent to the existing SCISTW.

The Strategic Sewage Disposal Scheme International Review Panel visited the Stonecutters Island Sewage Treatment Works in May 2000.
「策略性污水排放計劃」國際專家小組於2000年5月參觀昂船洲污水處理廠

The Preferred Stage 2 and Public Consultation

The Government then moved on to conduct a five-month public consultation in 2004 to ascertain the community's views on the way forward for HATS.

The consultation process solicited feedback from a broad spectrum of the community, including political parties, Government's advisory bodies, District Councils, professional bodies, academia, community groups, and various business and trade organisations. The majority supported the timely implementation of the Stage 2 option as outlined above, and in phases. There was also public support for the recurrent cost in future HATS phases to be recovered through sewage charges.

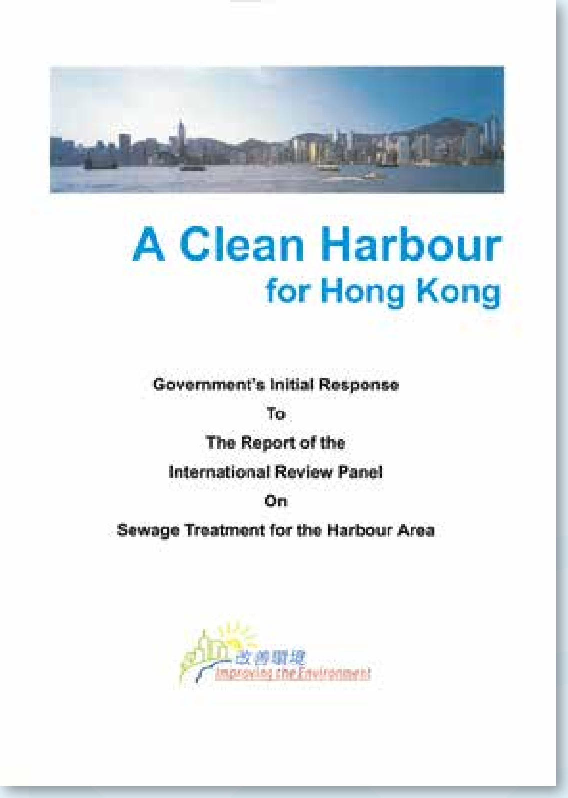
HATS Stage 2 to Proceed in Phases

The Government decided to proceed with Stage 2, with Stage 2A scheduled for completion in 2014. It also decided that the implementation programme of Stage 2B would be reviewed, taking into account the population increase and water quality trends after the commissioning of Stage 2A.

Finally, a note about costs. Under the "polluter pays" principle, the Sewage Services Ordinance was already enacted back in 1994, enabling DSD to collect sewage charges to meet recurrent expenditure. A new arrangement was made whereby the annual sewage charge to the community would increase incrementally at 9.3% every year from 2008 onwards for 10 years to meet anticipated recurrent expenditure for Stages 1 and 2A combined. A capital cost of HK$17.5 billion for Stage 2A was also earmarked from the Capital Works Reserve Fund.

With funding secured, the Government decided to advance the disinfection facilities for completion in 2009 ahead of other Stage 2A works in order to bring early improvement to the water quality of the western part of our Harbour.

HATS had opened a new chapter.



The Government responded to the Report of the International Review Panel in 2001
政府於2001年發表對國際專家小組報告的回應

親愛的維港：

「淨化海港計劃」第一期於2001年12月落成啟用，我們淨化維多利亞港的願景終於實現。第一期落成啟用的時間，更適逢千禧新紀元之始，為維港您帶來新生與活力。

「淨化海港計劃」第一期正式投入服務初期，每天處理的污水約130萬立方米，每天移除的污泥約達600噸。這些污泥來自全港人口最稠密的市區，以往都是未經處理，便直接排放出海港。「淨化海港計劃」第一期落成啟用之後，維港海域的水質隨即有大幅改善。這一切，都要歸功第一期工程的順利完成。

第一期工程效益：水質明顯改善

「淨化海港計劃」第一期投入服務後，維多利亞港水質有明顯改善。維港水域的海水溶解氧平均增加約10%，有利海洋生物生長，珊瑚也再現，生意盎然。此中的關鍵是昂船洲污水處理廠，它能消除污水中70%的生化需氧量及有機污染物、80%的懸浮固體和50%的大腸桿菌等污水病原體。

然而，「淨化海港計劃」第一期也存在問題。第一期落成啟用後，雖然維港中部及東部的水質明顯好轉，但維港西部水域，尤其是荃灣一帶泳灘的水質，仍然受到來自昂船洲污水處理廠經處理但未經消毒的大量排放水所影響。加上昂船洲污水處理廠的排放管道較短，離岸不遠，造成大腸桿菌數量飆升，令荃灣區七個泳灘需要關閉。此外，由於西九龍出現了大量全新商業及住宅項目，這些都是第一期規劃期間無法預計的，故來自昂船洲污水處理廠的氣味也成為西九龍社區的問題。

基於上述情況，昂船洲污水處理廠急需增設消毒設施，或興建一條較長的排放管道；而氣味問題也必須解決。

一期之後　何去何從？

政府最終決定為「淨化海港計劃」開展新工程，亦即今天的第二期甲。然而作出決定之前，過程也幾經曲折。

由於興建第一期深層隧道系統時出現延誤，加上公眾對污水處理級別及排放管道位置等議題亦意見紛紜，為了釋除公眾對計劃的疑慮，政府於1999年決定暫停進行「淨化海港計劃」其他階段的工程項目，直至社會就計劃的未來方向達成共識。

同時，來自港島北部和西南部的污水，依然幾乎未經處理便直接排入維港。第一期工程仍不足以保護整個維港的水質。

在這情況下，政府於2000年4月委託了一個國際專家小組，也是「淨化海港計劃」的第二個國際專家小組，負責重新檢視整個「淨化海港計劃」。專家小組由六位成員組成，其中兩位分別來自內地及美國的教授，亦曾為上次於1994年成立的國際專家小組成員，其餘四位則是來自不同學科領域的專家教授。

國際專家小組和建議

國際專家小組在2000年11月公布最後報告，提出四個污水處理和排放方案，推薦使用生物曝氣濾池技術為處理技術方案的首選，並配置深層隧道輸送污水及採用較短的排放管道。報告更讚譽昂船洲污水處理廠為全球效率最高的化學強化一級污水處理設施，足以作為日後進一步發展的共同基礎。

然而，香港使用海水作沖廁用途，但生物曝氣濾池技術在處理帶鹹的污水方面的成效，卻尚待釐清。此外，進行三級污水處理涉及高昂的營運開支，公眾是否接受仍是未知之數。再者，昂船洲、北角和沙灣，也缺乏土地去設置擬議的污水處理設施。

應否採用三級污水處理？

政府繼而推行兩項進一步研究，即「環境及工程可行性研究」和「密集型污水處理技術試驗」。前者旨在評估國際專家小組四個方案的工程技術可行性及對水質的影響，而後者則是測試密集型污水處理技術對香港帶鹹的污水的成效。

兩項研究均於2004年6月完成，結果顯示，國際專家小組建議的四個方案都是技術上可行，對環境的影響也可以接受，但三級污水處理方案，卻牽涉相當大的操作及成本問題。研究發現，生物曝氣濾池技術並不適合處理香港帶鹹的污水，而水質模擬結果也顯示，要保護維港水質，並不需要採用三級污水處理方案。

政府於考慮成本、對環境的影響和工程技術因素後，從四個方案之中，最終挑選了提升昂船洲現有的中央污水處理設施為首選方案，並以此作為「淨化海港計劃」第二期工程方案，其中又分為第二期甲及第二期乙。

第二期甲工程將增建一系列額外設施，包括全面改善港島北面及西南面集水區的現有基本污水處理廠，建造長約21公里的深層隧道，以便將污水從上述基本污水處理廠輸送至昂船洲，並會提升昂船洲污水處理廠的現有設施，以提供化學強化一級處理、消毒和除味功能。

至於第二期乙，則會在昂船洲污水處理廠的相鄰地段興建生物處理設施，以符合更高的排放標準。

The then Secretary for the Environment, Transport and Works, Dr Sarah Liao (middle), announced that the Government would commence public consultations for the Harbour Area Treatment Scheme Stage 2 on 21 June 2004.
前環境運輸及工務局局長廖秀冬博士(中)宣布，政府將於2004年6月21日展開「淨化海港計劃」第二期的公眾諮詢

第二期工程首選方案與公眾諮詢

政府隨即於2004年進行為期五個月的公眾諮詢，收集社會人士對「淨化海港計劃」未來方向的意見。

公眾諮詢徵集了公眾及社會不同界別人士的意見，包括政黨、政府諮詢機構、區議會、專業團體、學術界、社區團體以及工商業界組織。大部份意見都支持上述第二期工程的首選方案，並支持盡快分階段落實有關項目。此外，公眾也支持透過增收排污費，應付「淨化海港計劃」未來各階段項目的經常性開支。

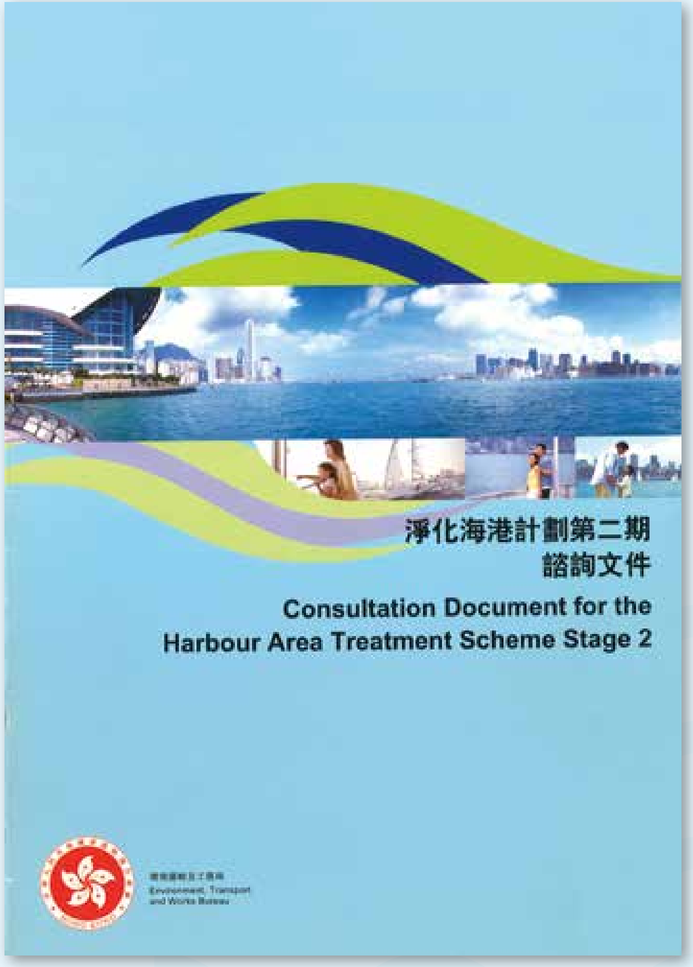
第二期工程分階段進行

政府決定落實第二期工程，目標是於2014年完成第二期甲工程。至於第二期乙的推展時間表，則會先檢討屆時人口增長的情況，及第二期甲工程落成啟用後的水質趨勢等因素，再作決定。

最後是有關項目造價及營運開支的安排。根據1994年通過的《污水處理服務條例》及「污染者自付」原則，渠務署向使用者和市民徵收排污費，分擔項目的每年經常性開支。此外，政府更作出新安排，排污費會由2008年起的十年內以每年9.3%的幅度逐步遞增，以應付第一期及第二期甲預算的經常性開支。政府也從基本工程儲備基金，為第二期甲175億港元的項目造價作出撥備。

款項來源既已就緒，政府隨即以興建消毒設施作為前期工程，優先在第二期甲的主要工程推展前展開，目標是於2009年完成消毒設施，務求盡早改善維港西面的水質。

「淨化海港計劃」揭開了新的篇章。



The Government conducted a public consultation in 2004 on the way forward of Harbour Area Treatment Scheme
政府於2004年為「淨化海港計劃」的未來路向作公眾諮詢

Kick-off ceremony of environmental education programmes on the HATS on 21 July 2004
「淨化海港計劃」環保教育活動於2004年7月21日舉行開幕禮

Roving exhibition of Harbour Area Treatment Scheme at Cityplaza in September 2004
太古城中心於2004年9月舉辦「淨化海港計劃」巡迴展覽

Roving exhibition of Harbour Area Treatment Scheme at Tsuen Wan Plaza in September 2004
荃灣廣場於2004年9月舉辦「淨化海港計劃」巡迴展覽

POSTSCRIPT

"I first came to Hong Kong in the 1980s to work on the HATS project and to start our water business in East Asia. I came back again in 2007 when the Stonecutters Island Sewage Treatment Works was to be upgraded under Stage 2A. When Stage 2A was finally commissioned in 2015, it was a moment of great joy and a big relief to us all."

"What makes the HATS project stand out is its huge scale and compactness compared to other sewage projects. For a similar scale project in the UK, the site required for the treatment plant would be ten times bigger!"

附箋

「我在八十年代第一次來香港，就是為了參與『淨化海港計劃』，和開展公司在東亞的水業務。到二零零七年我再回來香港，當時昂船州污水處理廠已即將進行第二期甲之下的優化工程。當第二期甲工程於2015年全面落成啟用時，對團隊來說是極歡欣的一刻，大家也如釋重負。」

「『淨化海港計劃』突出之處，在於項目的鉅大規模和高度密集，這是其他污水處理項目少有的。同樣規模的項目，如果在英國，污水處理廠所需的用地就要多十倍！」

David PICKLES

Director, ARUP
奧雅納工程顧問公司董事

THE QUEST CONTINUES
再下一城


LETTER 6 信件六
THE QUEST CONTINUES
再下一城

Dear Harbour,

After the successful commissioning of HATS Stage 1 in December 2001, the Government decided to go ahead with HATS Stage 2 in 2004 after thorough expert reviews, numerous technical studies and extensive public consultation.

Let's turn the clock back to the early 2000s to get a sense of things at that juncture.

Stage 2A: Treating the Remaining 25% Sewage

Remarkable water quality improvements were seen in the middle and eastern areas of the Harbour upon completion of HATS Stage 1, which provided treatment to 75% of sewage from urban districts on both sides of the Harbour. However, the remaining 25% of sewage, originating from the northern and south-western parts of Hong Kong Island, was yet to be intercepted. Some 450,000 cubic metres of virtually untreated sewage was still being directly discharged into the Harbour each day.

Another complication was that the western harbour was still being affected by the large volume of effluent from the Stonecutters Island Sewage Treatment Works (SCISTW) without disinfection. Further investment in HATS was needed to resolve these issues and make our entire Harbour healthy again.

Stage 2A Works Scope

HATS Stage 2A included these major works:

- Upgrading of eight existing Preliminary Treatment Works (PTWs) at North Point, Wan Chai East, Central, Sandy Bay, Cyberport, Aberdeen, Wah Fu and Ap Lei Chau to enhance their screening and degritting facilities
- Construction of around 21 kilometres of long, deep sewage tunnels to collect and transfer sewage from these eight PTWs to SCISTW for treatment
- Upgrading the existing chemically enhanced primary treatment (CEPT) capacity of SCISTW from the existing design level of 1.7 million cubic metres per day to about 2.45 million cubic metres per day
- Disinfection facilities at SCISTW, given priority ahead of other works, to tackle water pollution at beaches in Tsuen Wan
- A new Distributed Control and Data Acquisition System (DCDAS)

Stage 2A works began in 2009. Works for part of the disinfection facilities were advanced, with early commissioning in 2009 to facilitate the re-opening of seven closed Tsuen Wan beaches in the western harbour.

Advance Disinfection Facility

The provision of disinfection facilities at Stonecutters Island to prevent pollution in the western part of the Harbour, where effluent was discharged from SCISTW, was urgent and had to be tackled as early as possible.

Accordingly, the Government conducted in 2005 an environmental impact assessment (EIA) study for the Advance Disinfection Facilities (ADF) to be built at SCISTW. The EIA study concluded that chlorination using sodium hypochlorite was the preferred option.

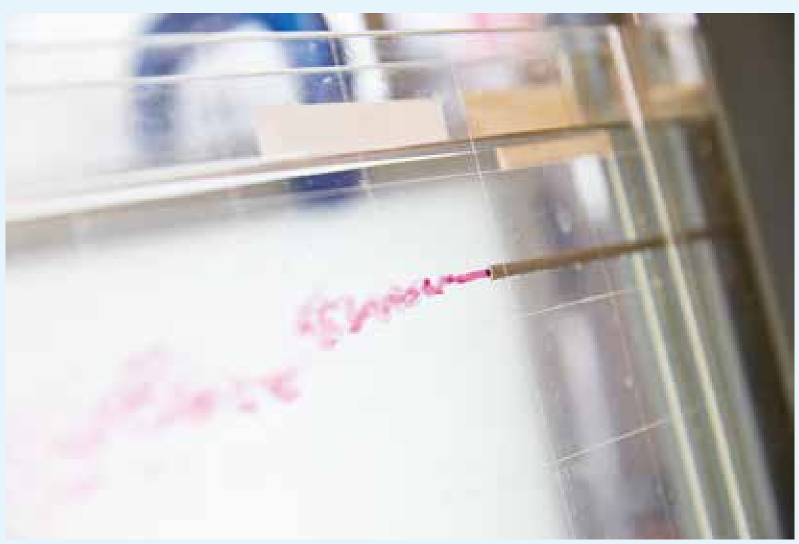
Construction of the ADF commenced in April 2008. By December 2009, the facilities began providing disinfection to Stage 1 effluent from SCISTW prior to its discharge into the Harbour, with immediate positive impacts. When the ADF was put into full operation in March 2010, it significantly improved the water quality of Victoria Harbour, in particular in its western part.

Seven Tsuen Wan beaches were re-opened progressively, with the last one re-opened in 2014. Indeed, the Cross Harbour Race had already resumed in 2011 in the east of the Harbour after years of suspension, thanks to greatly improved water quality.

Upgrading Eight PTWs

Eight existing PTWs in the northern and south-western parts of Hong Kong Island had to be upgraded to cater for the technical requirements of HATS Stage 2A. Works included the installation of 4-millimetre fine screens to trap small objects and degritting facilities to remove 95% of grit greater than 0.2 millimetres, all to avoid clogging of the deep sewage tunnels, as well as the replacement of pumps.

Aesthetics of the PTWs was improved, adding greenery and rooftop photovoltaic panels for renewable energy. Deodourisation units were built too, bringing lasting environmental benefits to nearby residents.



Hydraulic model for optimisation of disinfection facilities in SCISTW
用以優化昂船洲污水處理廠消毒設施的水力模型

Deep Tunnel System

With geology and design similar to the Stage 1 tunnels, Stage 2A comprises a network of interconnected deep tunnels at a total length of 21 kilometres located at depths varying from 70 metres to 160 metres below sea level.

With experience gained from Stage 1 works, detailed considerations were made at an early stage in the investigation and design of the Stage 2A tunnel system. An innovative and state-of-the-art technology called Horizontal Directional Coring was adopted to investigate the geology, which cored continuously for as far as 1,247 metres from the coring point in one tunnel section to obtain continuous rock cores directly along the tunnel route.

Stage 1 works had proved that pre-excavation grouting was the most practicable and effective means in controlling ground water ingress under great pressure. One of the key difficulties of Stage 1 tunnel works was the modification of the Tunnel Boring Machines (TBMs) to provide them with mechanical equipment for drilling grout holes around the tunnel perimeter in front of the excavation face, because of limited working space.

With this in mind, and making reference to hard rock tunnelling experience elsewhere in the world, particularly in Scandinavian countries, the project team decided that the use of drill and blast method would allow pre-excavation grouting to be carried out in the most effective manner. The contractor was therefore required to procure a tailor-made drilling jumbo with state-of-the-art drilling equipment mountings to facilitate pre-excavation grouting operation and the drilling of blast holes.

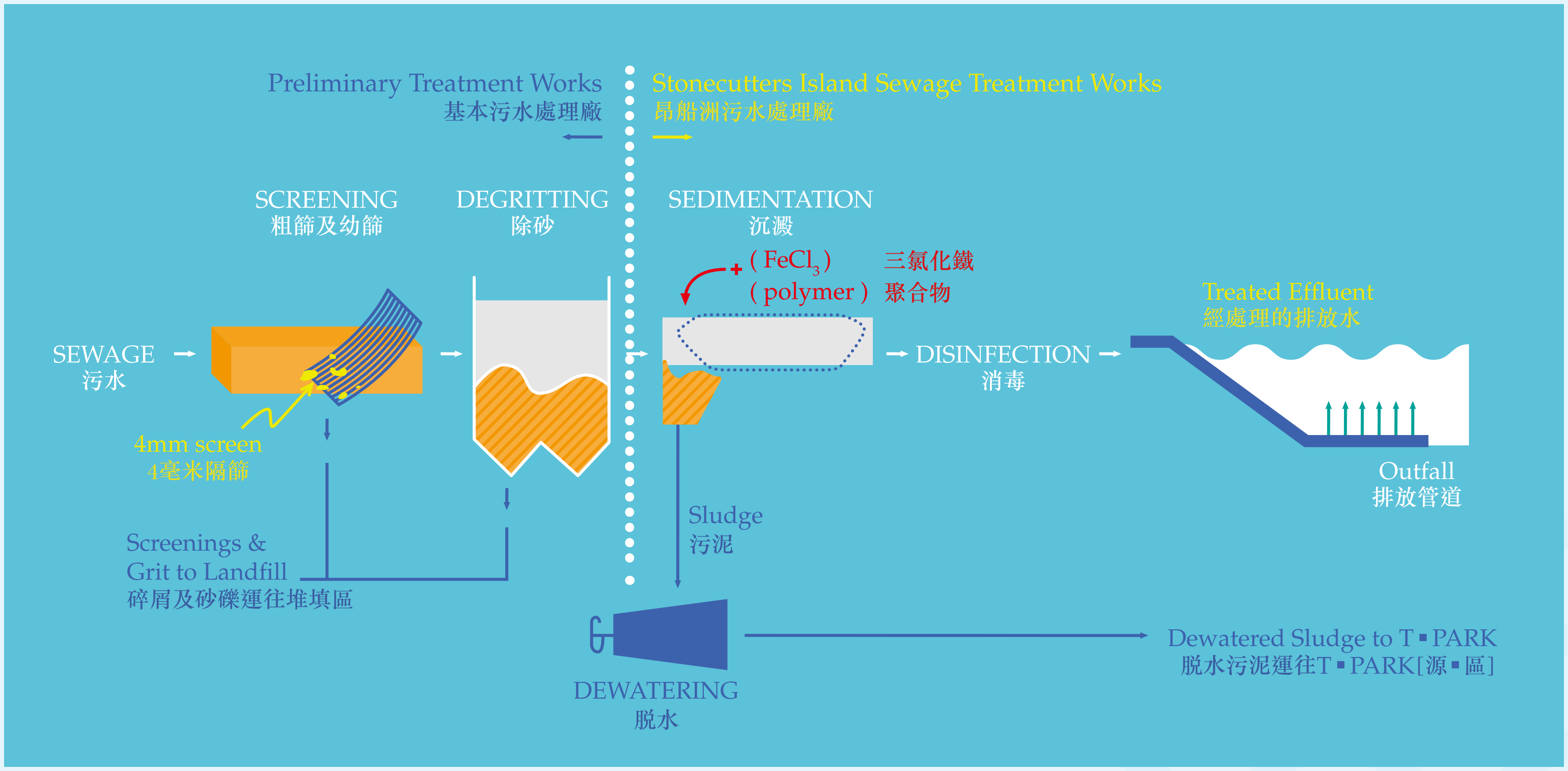
Technical requirements for the blasting operation were carefully assessed and determined at an early stage to allow the operation to be carried out in a safe manner. Detailed arrangements and procedures were discussed and agreed in advance with the relevant authority, the Commissioner of Mines, on the delivery and use of explosives for the blasting works. Adopting the drill and blast method also made it possible for the project team to design a curved tunnel alignment to minimise encroachment into private lots. At the same time, the lower set-up cost of blasting, as compared with the use of TBMs, would allow excavation to be carried out concurrently from both ends of a tunnel section to speed up progress. As it transpired, after commencement in July 2009, all the Stage 2A tunnelling works were completed in June 2015 in a systematic and well controlled manner.

The tunnel from Ap Lei Chau to Aberdeen stood out as one with construction difficulties foreseen at an early stage. The presence of a major geological fault zone, the Aberdeen Fault, would pose serious challenges for tunnelling even if pre-excavation grouting coupled with various kinds of ground supports were used. In order to minimise the risks in tunnelling through this weak ground zone, it was decided to construct this tunnel section with state-of-the-art Horizontal Directional Drilling technology. More on this in the next letter.

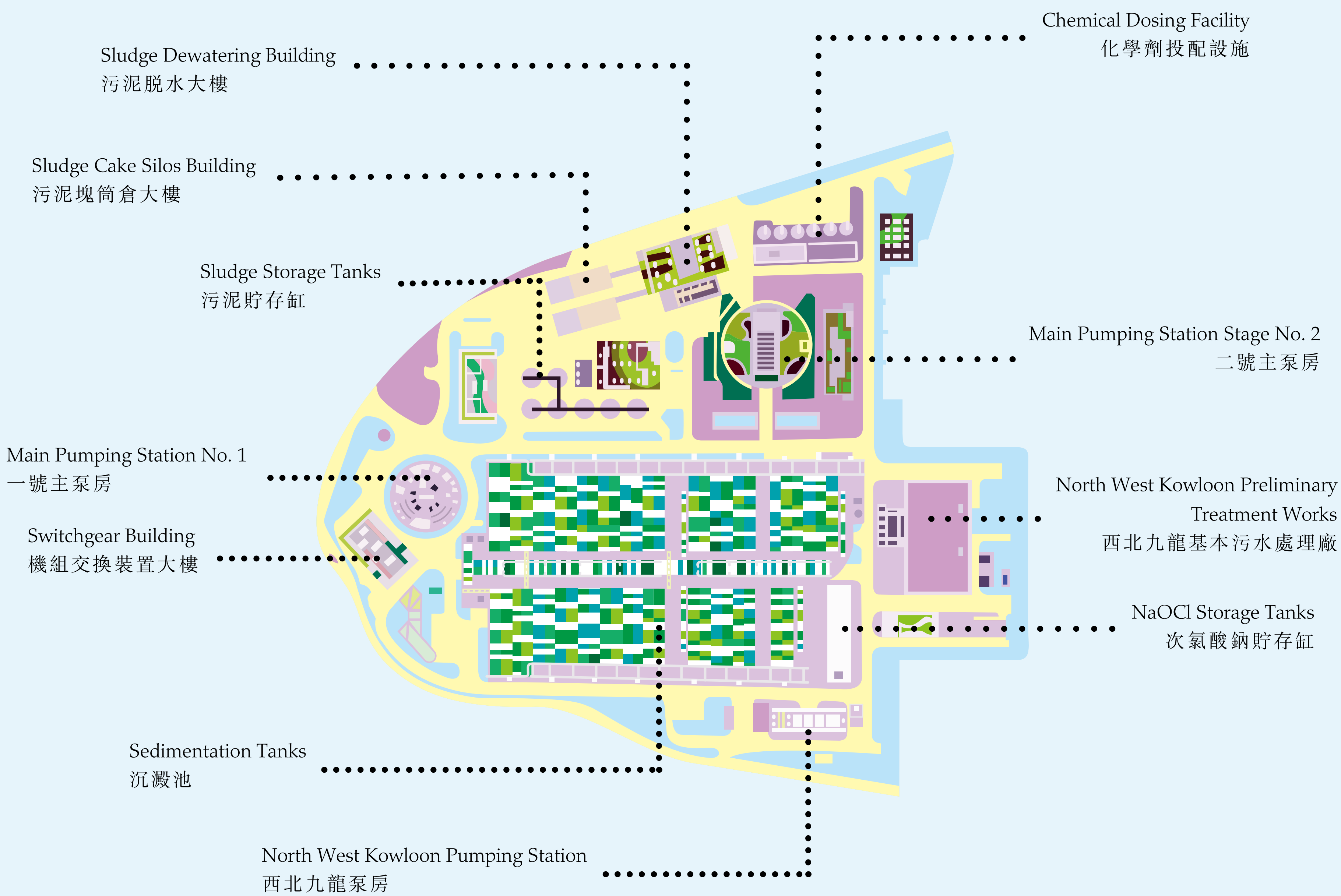
Upgrading Works on Stonecutters Island

Key upgrading works at SCISTW included constructing a second main pumping station and additional CEPT tanks, expanding the sludge dewatering facilities, adding new disinfection facilities and deodourisation units, and implementing a new control system for all these additional facilities. Let's begin with the new pumping station.

HATS Sewage Treatment Process
「淨化海港計劃」污水處理流程



Stonecutters Island Sewage Treatment Works HATS Stage 2A Layout Plan
「淨化海港計劃」第二期甲昂船洲污水處理規劃圖



Main Pumping Station No. 2

The Main Pumping Station No. 2 (MPS2), comprising eight pumps, is designed to cater not only to lift additional sewage flows from Stage 2A deep tunnels to the surface for treatment, but also to provide flexibility for sewage flow that may be diverted from MPS1, the Stage 1 pumping station, in case of machinery breakdown or major overhauls.

The maximum pumping capacity of MPS2 is 32 cubic metres per second, augmenting the MSP1 maximum pumping capacity of 31.2 cubic metres per second. MPS2 comes with two wet wells to allow flexibility in operation and ease of future maintenance. An underground interconnection tunnel of 250 metres long was built between MPS2 and MPS1, again for operational flexibility and future maintenance.

Sedimentation Tanks

Also at the core of the SCISTW upgrading works was the construction of eight additional double-deck sedimentation tanks, bringing the total number of sedimentation tanks to 46.

An advance contract was let to provide deodourisation facilities and to supply fibre-glass covers in three vivid colours for all the existing Stage 1 CEPT tanks, for completion in 2012. These measures have alleviated to a large extent the odour nuisance to nearby residents in Sham Shiu Po, Cheung Sha Wan and West Kowloon.

Disinfection Facility

One of the main reasons for implementing HATS Stage 2A was to address the need to disinfect CEPT-treated sewage to avoid polluting the Harbour.

After the CEPT process, sodium hypochlorite, or bleach, is added to the effluent for disinfection. Effluent from both Stages 1 and 2A undergoes disinfection in a new effluent tunnel which also functions as the chlorine contact chamber. The bleach kills more than 99% of *E. coli*, a step vital to restoring water quality in our Harbour. Prior to discharge, the effluent then also undergoes a de-chlorination process to neutralise the residual chlorine for protection of the marine ecosystem.

Computational Fluid Dynamic (CFD) modelling in conjunction with physical models were used to enhance the disinfection process, such as testing the effectiveness of different concentrations of sodium hypochlorite and dosing locations. As a result, a second dosing unit was added just before the overflow weir to the drop shaft to optimise mixing of chemicals with sewage.

Meanwhile, another valuable tool called Waterman was developed by Professor Joseph LEE, a renowned expert in environmental hydraulics. An advanced modelling tool, Waterman helps predict the far field effect of effluent discharged from outfall diffusers, and shows how the effluent impacts the water quality at nearby beaches under different weather and tidal conditions.

These modelling tools proved very useful in understanding the impacts and minimising the consumption of chemicals for optimal disinfection.

Double-decked sedimentation tanks with fibre-glass covers
雙層沉澱池以玻璃纖維罩覆蓋

Motor hall of Main Pumping Station No. 2
二號主泵房摩打房

Sewage pump of Main Pumping Station No. 2
二號主泵房主泵

Overview of Main Pumping Station No. 2
二號主泵房外觀

The Quest Continues
再下一城

Deodourisation units
除味裝置

Sludge dewatering building
污泥脫水大樓

Sludge cake silos buildings
污泥塊筒倉

Centrifuges inside the sludge dewatering building
污泥脫水大樓內的離心機

Sludge Dewatering Facility

A new sludge dewatering building housing 14 gigantic centrifuges was built to cater for sludge generated from HATS Stages 1 and 2A. The sludge dewatering capacity was increased from 600 tonnes per day to 1,200 tonnes per day.

A solid pumping system is used to convey dewatered sludge to a total of 16 sludge cake silos, designed to provide ample storage in case of adverse weather conditions delaying the transportation of dewatered sludge. Indeed, two ocean-going vessels for transporting sludge to T▪PARK in Tuen Mun for incineration were built, too. More on that sustainability story later.

Deodourisation Units

Deodourisation units (DOUs) were added to various potentially odorous facilities at SCISTW, including pumping stations, sludge dewatering buildings, sludge cake silos and sedimentation tanks, all of which are enclosed to ensure the odour stays inside. Odorous gas is ducted to DOUs using bio-trickling filters, wet chemical scrubbers or activated carbon units for treatment before discharge.

New Control System

A new Distributed Control and Data Acquisition System (DCDAS) was added to allow for the integrated control of the whole HATS system. An expert system was developed to assist in training SCISTW operators, using different operational simulations and providing an advanced decision support system.

Stage 2A Commissioned in 2015

After six years of hard work, HATS Stage 2A was commissioned in December 2015. From then onwards, all sewage from urban Kowloon and Hong Kong on both sides of the Harbour would be fully treated at one of the world's best CEPT sewage treatment works. We would have no more beach closures nor coral decay because of harbour pollution.

Swimming Again!

The commissioning of Stage 2A brought further improvements to our marine water quality, so much so that the Cross Harbour Race, the annual swimming gala first held in 1906 but suspended from 1978 to 2010 due to rising pollution in the Harbour, was moved back to the central part of the Harbour in 2017. This was further to the resumption of the Race in 2011 in the eastern part of the Harbour when the water quality was already suitable for swimming.

So, dear Harbour, this is the story of HATS, so far as major construction work goes. The HATS vision has come true, and Victoria Harbour is fragrant and healthy again.

The Quest Continues
再下一城

Tunnel boring machine used for interconnection tunnel construction
建造連接隧道的隧道鑽掘機

Interior structure of interconnection tunnel
連接隧道內部結構

Underground interconnectional tunnel connecting between MPS1 and MPS2
連接一號主泵房和二號主泵房的連接隧道

親愛的維港：

「淨化海港計劃」第一期在2001年12月落成啟用，政府經過全面的專家檢討、大量技術研究和廣泛公眾諮詢後，於2004年決定展開「淨化海港計劃」第二期。

讓我們把時光倒流至2001年左右，重溫當時的情況。

第二期甲：處理其餘25%污水

自從「淨化海港計劃」第一期工程落成啟用後，即肩負起處理維港兩岸區域約75%污水的工作，維港中部及東部地區的水質因而得到明顯改善。然而，其餘25%來自港島北部及西南部的污水尚待處理，當時每天仍有約45萬立方米近乎未經處理的污水，直接排進維港。

另一問題，就是昂船洲污水處理廠排放的污水雖已經處理，但由於仍未經消毒，維港西面受到這些污水影響。政府仍需要進一步投資擴建「淨化海港計劃」，方能令整個維港回復健康。

第二期甲工程範圍

第二期甲包括以下主要工程：

- 全面改善八所位於北角、灣仔東、中環、沙灣、數碼港、香港仔、華富及鴨脷洲的現有基本污水處理廠，以加強隔篩和除砂等污水處理設施
- 建造全長約21公里的深層污水隧道，將上述八所基本污水處理廠的污水收集並輸送到昂船洲污水處理廠進行化學強化一級處理
- 提升昂船洲污水處理廠的化學強化一級污水處理量，從原先設計的每天處理170萬立方米的污水，提升至每天處理約245萬立方米污水
- 在昂船洲污水處理廠優先興建消毒設施，定為前期項目，以解決荃灣一帶泳灘的水質污染問題
- 設立新的分佈式監控和數據採集系統

第二期甲主要工程於2009年動工，而其中的消毒設施系統工程則已提早進行，並於2009年率先提前落成啟用，讓維港西面荃灣區七個關閉的泳灘，得以早日重新開放。

前期消毒設施

昂船洲污水處理廠排放的污水雖已經處理，但由於未經消毒，維港西面受到這些污水影響。為保護維港西面的水質，在昂船洲興建消毒設施實在刻不容緩，以盡早解決問題。

因此，政府於2005年對昂船洲污水處理廠興建前期消毒設施工程，進行環境影響評估研究。研究結果顯示，使用次氯酸鈉進行氯化消毒，乃首選方案。

前期消毒設施工程於2008年4月動工，2009年12月開始啟用，為昂船洲污水處理廠排出的經處理污水進行消毒，然後才排放出維港，效果顯著。2010年3月，前期消毒設施全面投入服務，維港的水質馬上有明顯改善，而以維港西部水域的水質改善情況尤其明顯。

荃灣區七個原先關閉的泳灘陸續重開，最後一個泳灘也於2014重新開放。事實上，由於水質大幅改善，停辦多年的維港渡海泳，已早於2011年在維港東部水域復辦。

全面改善八所基本污水處理廠

位於港島北部和西南部的八所現有基本污水處理廠必須進行改善工程，以配合「淨化海港計劃」第二期甲的技術要求。工程包括安裝4毫米的隔篩以隔除細小物體，及安裝除砂設施去除95%大於0.2毫米的砂礫，避免深層污水輸送隧道堵塞。此外，工程也包括更換污水泵。

基本污水處理廠的建築外觀也進行了優化工程，增加綠化植物和在屋頂安裝可再生能源的光伏板，還加設了除味裝置。種種設施，都能長遠改善附近居民的生活環境。

深層隧道系統

第二期甲是由相連的深層隧道網絡組成，全長21公里，深度介乎海平面以下70米至160米之間，在地質和設計方面都與第一期的隧道系統類似。

借鏡第一期工程的經驗，工程團隊在第二期甲隧道系統地質勘測和設計的早期，已經進行各種詳細考慮。我們採用一種名為「水平定向取芯」的先進創新技術進行地質勘測，更在其中一個隧道路段的取芯點，直接沿隧道路線連續取芯1,247米，取得連續完整的岩心樣本。

第一期工程證明，挖掘前進行預先灌漿，是控制地下水在高壓下滲入的最可行及最有效的方法。第一期隧道工程的主要困難，是要在有限的工作空間內，為隧道鑽挖機進行改動，為其加裝機械設備，使鑽挖機能在挖掘面前方的隧道周邊鑽灌漿孔。

基於上述考慮，並參考世界其他地方，特別是北歐國家的硬岩隧道鑽挖經驗，工程團隊認為，使用鑽爆方法，能讓挖掘前的預灌漿工作在最高效的情況下進行。因此，工程團隊要求承建商度身定造流動巨型鑽孔機，上面裝有最先進的鑽挖設備，用以進行挖掘前預灌漿工作及鑽炮孔。

我們在工程初段已經就爆破工程的技術要求作出詳細評估及決定，確保工程在安全情況下進行。至於爆炸品的運送及使用，我們亦預先與有關當局，即礦務處處長，商討及落實安排細節及程序。採用鑽爆方法，也讓工程團隊可以設計彎曲的隧道路線，以盡量減少侵佔私人地段。此外，與隧道鑽挖機相比，爆破的設置成本較低，可以在隧道的兩端同時進行挖掘，加快工程進度。事實上，自從2009年7月工程展開後，調控有序，所有第二期甲的隧道工程均於2015年6月順利完成。

在工程早期，我們已經預知鴨脷洲至香港仔的隧道段，乃建造工程的一大難題。由於該隧道段途經一個主要地質斷層帶—「香港仔斷層」，即使採用預灌漿及安裝不同的地基支撐，在脆弱的地質裏進行隧道工程仍然充滿嚴峻挑戰。為了減少進行隧道工程時的風險，我們決定採用最先進的「水平定向鑽挖」技術來建造這隧道段。有關技術，我們會在下一封信詳談。

Drilling jumbo
巨型鑽孔機

Drilled blast holes on a blast face
爆破面的炮孔

Government explosives delivery truck
政府爆炸品運送車

Detonators for explosives
爆炸品用的雷管

Deep sewage tunnel under construction
深層污水隧道在建造中

Shaft connecting deep sewage tunnel under construction
連接深層污水隧道的豎井在建造中

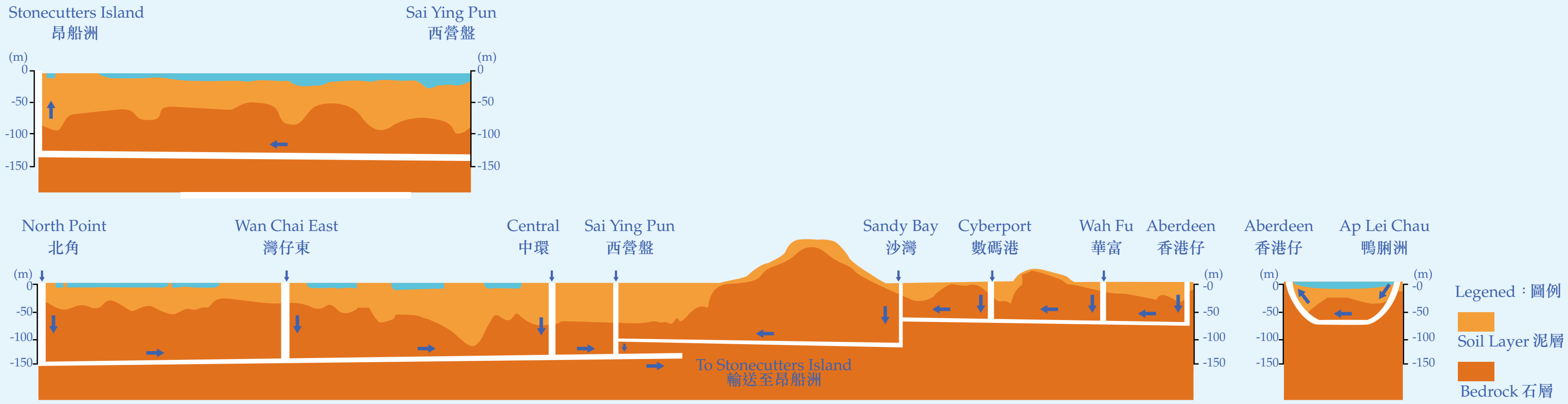
6,990 blasts were completed in HATS Stage 2A project
「淨化海港計劃」第二期甲工程共完成了6,990次爆破

Twin oval tunnels
雙管橢圓形隧道

The Quest Continues
再下一城

HATS Stage 2A Tunnels Alignment
「淨化海港計劃」第二期甲隧道走線

HATS Stage 2A Tunnels Longitudinal Profile
「淨化海港計劃」第二期甲隧道縱斷面圖



Information of HATS Stage 2A Tunnels
「淨化海港計劃」第二期甲隧道資料

Tunnel Drive 隧道段落	From 由	To 至	Length (km) 長度（公里）	Finished Diameter (m) 完成後直徑（米）	Level (mPD) 深度（主水平基準，米）	Lining Type 襯層類型
J (D&B)[1]	North Point 北角	Wan Chai East 灣仔東	3.2	1.2*2.4 and 1.1*2.0 Twin oval 雙管橢圓形	-157 to 至 -163	Cast in-situ 現澆
K (D&B)	Wan Chai East 灣仔東	Central 中環	4.3	1.2*2.4 and 1.6*3.1 Twin oval 雙管橢圓形	-150 to 至 -157	Cast in-situ 現澆
	Central 中環	Sai Ying Pun 西營盤		1.2*2.4 and 2.0*3.6 Twin oval 雙管橢圓形	-149 to 至 -150	Cast in-situ 現澆
L (D&B)	Sai Ying Pun 西營盤	Stonecutters Island 昂船洲	4.5	3.05 Circular 圓形	-139 to 至 -149	Cast in-situ 現澆
M (D&B)	Sandy Bay 沙灣	Sai Ying Pun 西營盤	3.7	1.26*2.16 and 1.0*1.9 Twin oval 雙管橢圓形	-116 to 至 -123	Cast in-situ 現澆
N (D&B)	Cyberport 數碼港	Sandy Bay 沙灣	1.2	1.26*2.16 and 1.0*1.9 Twin oval 雙管橢圓形	-73 to 至 -75	Cast in-situ 現澆
P (D&B)	Wah Fu 華富	Cyberport 數碼港	2.6	1.26*2.16 and 1.0*1.9 Twin oval 雙管橢圓形	-75 to 至 -78	Cast in-situ 現澆
	Aberdeen 香港仔	Wah Fu 華富		1.11*2.04 and 1.0*1.9 Twin oval 雙管橢圓形	-78 to 至 -80	Cast in-situ 現澆
Q (HDD)[2]	Ap Lai Chau 鴨脷洲	Aberdeen 香港仔	1.3	0.6 Twin circular 雙管圓形	+2 to 至 -99	HDPE pipe[3]

Notes:
附註

1. "D&B" means drill and blast method.
「D&B」即鑽爆方法。
2. "HDD" means horizontal directional drilling method.
「HDD」即水平定向鑽挖。
3. "HDPE" means high density polyethylene.
「HDPE」即高密度聚乙烯。

污水處理廠改善工程

至於昂船洲污水處理廠的主要改善工程，則包括興建第二個主泵房及增建化學強化一級處理的沉澱池，並擴建污泥脫水設施、增加新的消毒設施和除味裝置、和設置新的控制系統以管理上述設施。讓我們逐一介紹有關設施，首先由新主泵房開始。

新主泵房

新主泵房設有8台巨型污水泵，把污水從深層污水隧道抽到地面作處理。新主泵房不單負責處理第二期甲深層隧道帶來的新增污水，而當第一期的主泵房發生機械故障或進行大型維修時，新主泵房更可提供分流作用，提升操作的靈活性。

新主泵房的最高抽水量為每秒32立方米，第一期主泵房的最高抽水量為每秒31.2立方米。新主泵房配有兩個濕井，操作靈活，方便日後進行維修。新主泵房和第一期主泵房之間，由一條250米長的地下隧道連接起來，也是為了方便日後維修及提升設施操作的靈活性。

化學強化一級處理沉澱池

昂船洲污水處理廠改善工程另一核心項目，就是增建8個雙層沉澱池，使沉澱池的總數達到46個。

我們也提前批出合約，為現有第一期的全部沉澱池安裝除味裝置，以三種悅目色調的玻璃纖維罩覆蓋沉澱池，工程於2012年完成。這措施有效減少沉澱池對鄰近深水埗、長沙灣及西九龍區居民造成的氣味滋擾。

消毒設施

進行「淨化海港計劃」第二期甲工程的主要原因之一，就是要為經過化學強化一級處理的污水進行消毒，避免對維港造成污染。

污水經過化學強化一級處理過程後，會加入漂水，即次氯酸鈉，以進行消毒。來自第一期和第二期甲處理過的污水，會進入新建的排放水隧道進行消毒，該隧道也用作加氯設施，漂水可以消滅污水中99%以上的大腸桿菌，乃改善維港水質的重要一步。為了保護海洋生態系統，經處理和消毒後的污水也會隨之進行除氯程序，中和污水中的餘氯，才排放出海港。

我們也同時應用了計算流體力學電腦模型和實體模型，以加強消毒程序，例如模擬測試不同的次氯酸鈉濃度、和在不同位置投配次氯酸鈉的果效。基於測試結果，我們在溢流堰通往傾卸豎井之前的位置，增添了第二個投配化學劑的裝置，務求化學劑與經過處理消毒後的污水，能混合得最好。

與此同時，著名的環境水力學專家李行偉教授也開發出一套名為Waterman的先進電腦模型，有助預測由排放管道擴散器排放出去的排放水，在不同天氣及潮汐情況下，對鄰近海灘水質的遠場影響。

事實證明，這些模型工具，讓工程團隊更深入了解化學劑的消毒成效，並能以最少量的化學劑發揮最大的消毒果效，非常有用。

污泥脫水設施

新的污泥脫水大樓設有14台巨型離心機，負責處理「淨化海港計劃」第一期和第二期甲產生的污泥。新的污泥脫水設施，將污泥處理量從每日600噸增加至每日1,200噸。

脫水後的污泥由一個固體泵輸送系統運送到污泥塊儲存倉。由於共設有16個污泥塊儲存倉，即使遇上惡劣天氣令脫水污泥運輸延誤，仍可提供足夠的儲存空間。我們更建造了兩艘輪船，專責將污泥運往屯門的T▪PARK[源▪區]進行焚化。稍後我們會再談有關這個可持續發展的故事。

除味裝置

昂船洲污水處理廠的所有可能產生氣味的設施都加設了除味裝置，包括泵房、污泥脫水大樓、污泥塊儲存倉及沉澱池，而所有這些設施都已加上覆蓋，以確保氣味不會外溢。至於有味的氣體，則會經過管道被抽到除味裝置，再以生物滴濾池、濕化學洗滌器或活性炭裝置進行除味程序，然後排出。

新控制系統

我們引進了一個新的分佈式控制和數據採集系統，以便對整個「淨化海港計劃」系統進行綜合控制。我們也開發了一個專家系統，能提供各種模擬操作及先進的決策支援系統，有助培訓昂船洲污水處理廠的操作員。

第二期甲於2015年落成啟用

經過六年努力，「淨化海港計劃」第二期甲於2015年12月正式落成啟用。從此，維港兩岸包括港島及九龍市區的所有污水，都會經昂船洲污水處理廠這全球首屈一指的化學強化一級處理廠進行全面處理。我們不會再因海港污染而關閉泳灘，珊瑚也不會在維港凋萎。

復辦渡海泳！

第二期甲工程投入服務後，維港水質進一步改善，足以讓停辦多年的維港渡海泳得以復辦。維港渡海泳始於1906年，曾是香港一年一度的盛事，惜後來因維港水質污染嚴重而於1978至2010年停辦，直至近年維港水質因「淨化海港計劃」獲得改善，再適合游泳後，才於2011年在維港東部復辦。2017年，渡海泳更重返維港中部水域舉行。

親愛的維港，這就是「淨化海港計劃」主要工程的故事。「淨化海港計劃」的願景經已實現，維多利亞港回復健康，芬芳再現。

POSTSCRIPT

"For the past 20 years I have focused on buoyant jet diffusion study, which aims to make effluent dilute within a short period of time and a small area so as to protect the environment. I also developed a mobile application called Waterman which utilises big data to make real-time analysis of water quality in all of Hong Kong's beaches. This is particularly useful to protecting the beaches in Tsuen Wan, and can help us give alerts and take contingency measures when emergencies arise."

"Universities conduct basic research, but practical problems are highly complex. Our long-term cooperation with the Drainage Services Department is complementary. It helps us give back to the community and is valuable to our teaching and grooming of talent. HATS is among the world's top engineering projects. I am honoured to be part of it."

附箋

「過去二十年我主要從事浮射流擴散研究計劃，讓排放的污水在很短時間和很小範圍內稀釋，保護環境。我也研發了一個名為Waterman的流動程式，運用大數據實時分析全港海灘每日水質，對保護荃灣一帶海灘特別有用，也有助出現突發事故時作出預警和進行危急應變。」

「大學做的是基礎研究，但實際問題卻很複雜。我們和渠務署長期合作，是相輔相成，對回饋社會、教學和培養人才都很有意義。『淨化海港計劃』是全球數一數二的工程，我很榮幸能參與其中。」

Professor Joseph LEE Hun-wei

李行偉教授

Professor Emeritus and Visiting Professor of Department of Civil & Environmental Engineering, Senior Advisor to the President and Chair Professor of Guangzhou Fok Ying Tung Research Institute at the Hong Kong University of Science and Technology

香港科技大學
土木與環境工程學系客座教授、
校長高級顧問及
廣州霍英東研究院講座教授

1989

Formulation of the Strategic Sewage Disposal Scheme

制訂「策略性污水排放計劃」

1994

Commencement of works on Harbour Area Treatment Scheme (HATS) Stage 1

展開「淨化海港計劃」第一期的建造工程

1997

Commissioning of chemically enhanced primary treatment works at Stonecutters Island, as part of HATS

昂船洲化學強化一級污水處理廠投入服務，是「淨化海港計劃」工程的一部份

2001

Full commissioning of HATS Stage 1

「淨化海港計劃」第一期全面投入服務

2004

Public consultation on the way forward for HATS conducted

為「淨化海港計劃」第二期進行公眾諮詢

2009

Commencement of works on HATS Stage 2A

展開「淨化海港計劃」第二期甲的建造工程

2011

Cross Harbour Race returned in Victoria Harbour

維港渡海泳復辦

2012–14

Seven Tsuen Wan beaches reopened

重開荃灣七個泳灘

2014

Breakthrough of deep tunnel system

深層隧道全面貫通

2015

Full commissioning of HATS Stage 2A

「淨化海港計劃」第二期甲全面投入服務

Maiden Voyage for *Clean Harbour 1* and *Clean Harbour 2*

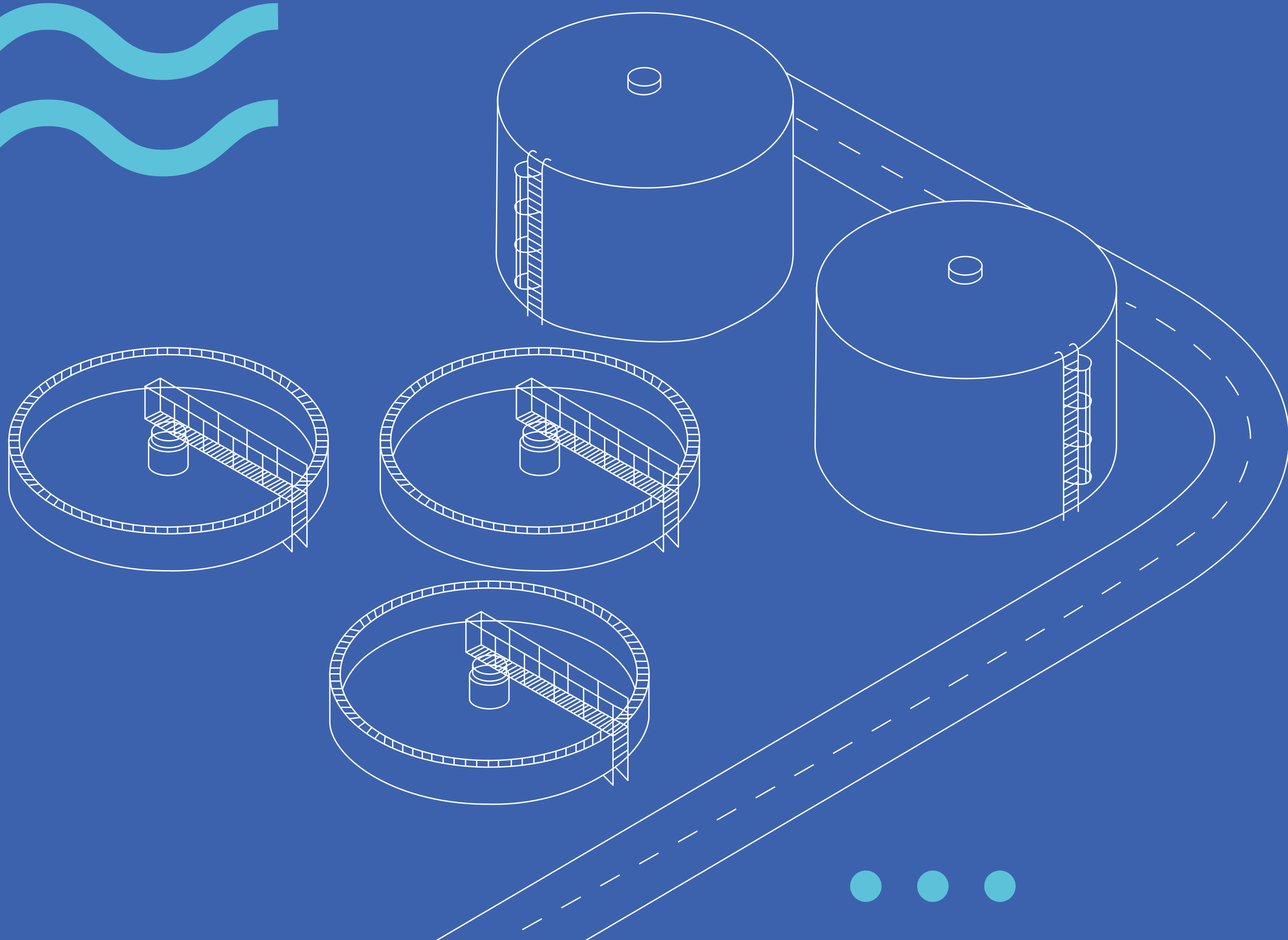
「淨港一號」和「淨港二號」處女航

2016–18

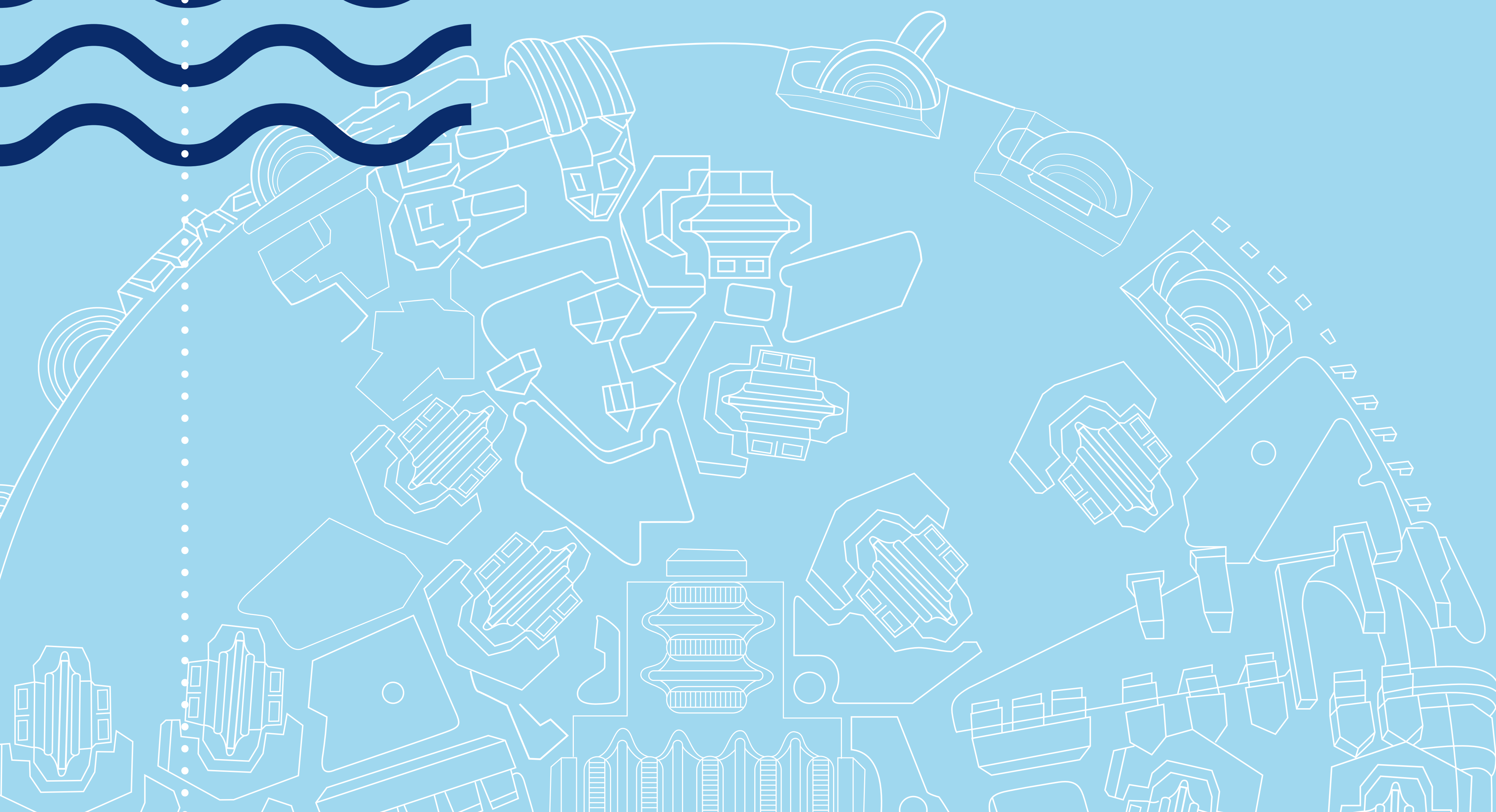
Numerous national and international awards won for the HATS project

「淨化海港計劃」贏得多個國家及國際獎項

MILESTONES **TIMELINE**
里程碑**時序**



INSPIRING CHALLENGES
挑戰與啟迪



LETTER 7 信件七

INSPIRING CHALLENGES
挑戰與啟迪

Inspiring Challenges
挑戰與啟迪

Dear Harbour,

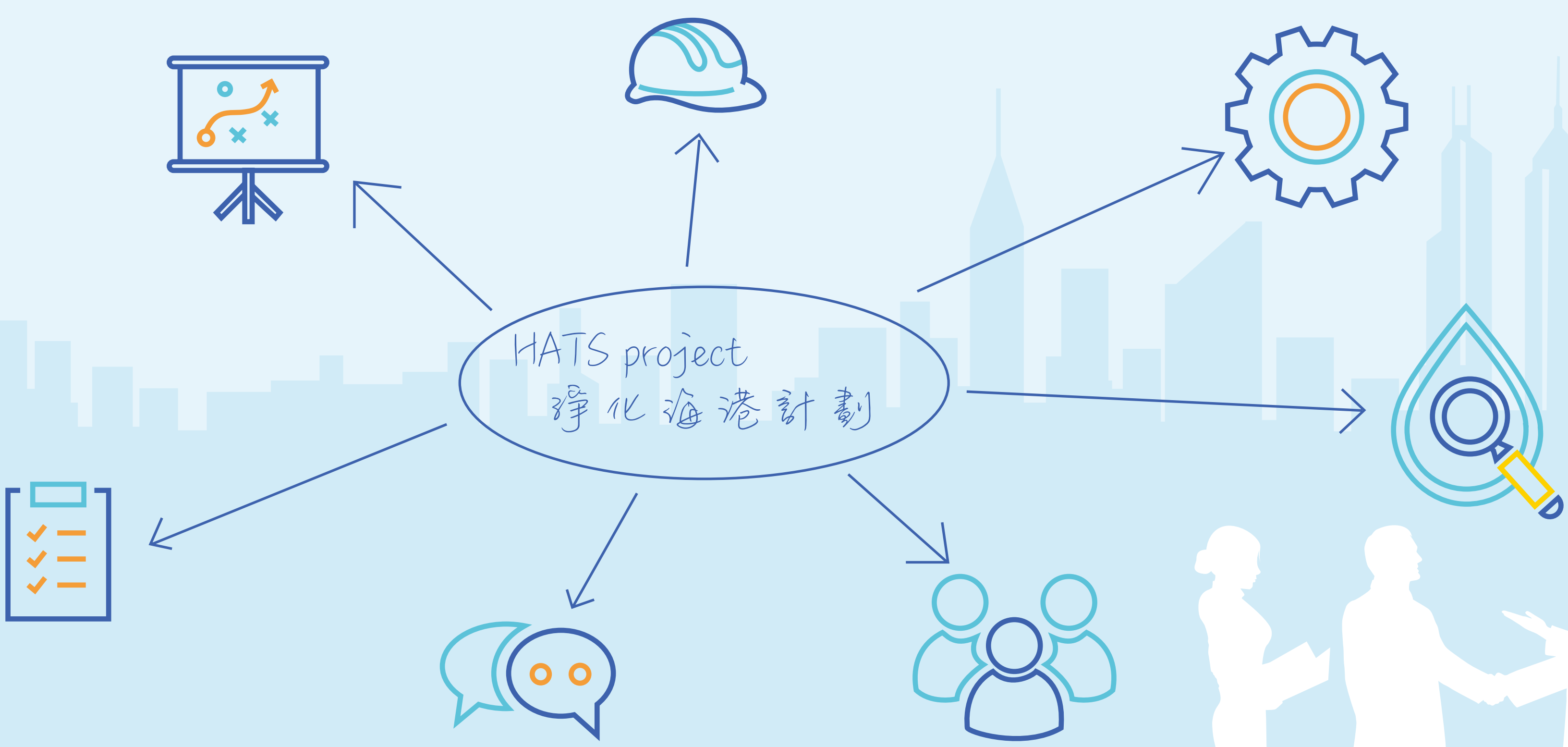
If You could speak and ask us to name the greatest difficulty of the entire HATS project, our answer would have to be "the tunnels". Most of the engineering challenges that arose during HATS came from the tunnelling process. This was perhaps inevitable, as we were constructing one of the longest and deepest tunnel systems in the world, and doing so under complex geological conditions.

Our friends in Hong Kong and elsewhere may want to know what those engineering challenges were and how we resolved them. And so, our story continues.

親愛的維港：

如果您能說話，問我們整個「淨化海港計劃」工程最大的挑戰是什麼，我們的答案定必是「隧道」。「淨化海港計劃」進行期間出現的挑戰大多來自隧道工程。這也無可厚非，因為我們當時正在相當複雜的地質裏，建造世界上最長和最深的隧道系統之一。

香港與世界各地的朋友也許都想了解這些工程挑戰，我們又如何一一解決。且聽我們繼續娓娓道來。



Challenge 1: Water Ingress under High Pressure

Solution: Pre-excavation Grouting System

To understand the tunnelling challenges of the HATS project, it is important to note that Tunnel Boring Machines (TBMs) were used for Stage 1 tunnelling, whereas the drill and blast method was used for Stage 2A tunnelling except a short interconnection tunnel on Stonecutters Island where a TBM was deployed.

In fact, ground water ingress into the tunnels under high pressure had caused significant difficulties from early on during Stage 1 tunnelling works. Water ingress, if not properly controlled, would increase construction difficulties and cause ground water table drawdown leading to ground settlement. We soon learned from Stage 1 experience that pre-excavation grouting was the most effective solution to control water ingress. This method means drilling grout holes around the tunnel perimeter ahead of excavation and injecting grouting material into the holes to seal up rock fissures to reduce the inflow of ground water into the tunnel.

However, it was easier said than done. As the TBMs used in Stage 1 tunnelling works were not equipped with the mechanical drilling equipment required for pre-excavation grouting operation, it was necessary to retrofit them first with such equipment. But the retrofitting works under congested conditions inside the tunnels turned out to be a very challenging task. Stage 1 tunnelling works, though eventually completed safely, gave us hard earned insights to critically examine whether TBMs would be the best choice for HATS Stage 2A tunnel construction.

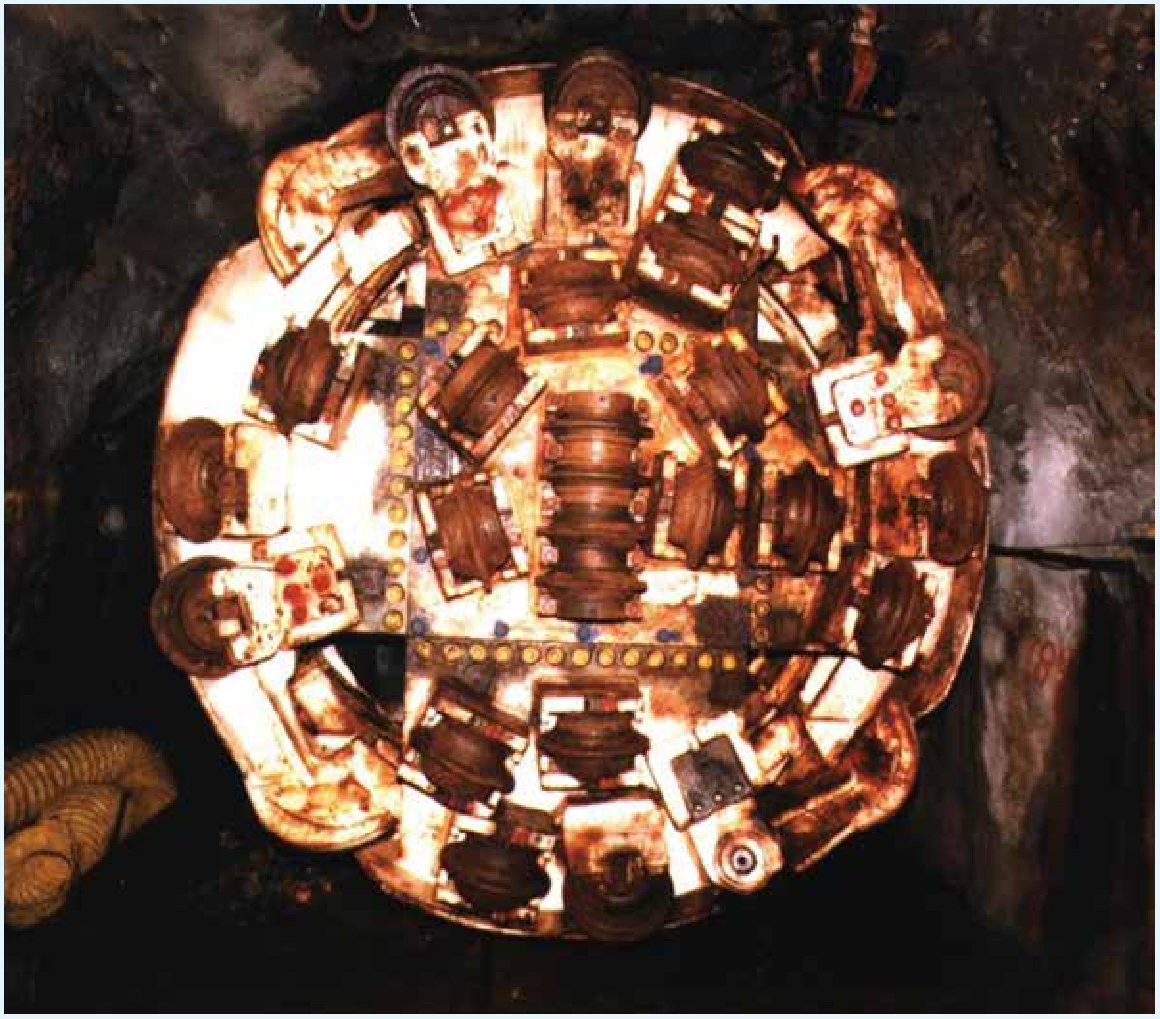
To find the answer, we consulted leading TBM manufacturers and specialist designers in Europe, but found that the inherent difficulties associated with equipping and operating a TBM with drilling equipment required for pre-excavation grouting still remained unresolved. Concurrently, we studied the drill and blast method in detail, in particular its suitability to tunnelling at great depths, and decided to construct Stage 2A tunnels using the drill and blast method.

The drill and blast method had several major benefits. First, it provided sufficient working space for the pre-excavation grouting system to operate efficiently, which hinged on the use of mechanical drills mounted on a computerised mobile vehicle called a drilling jumbo. Also, with careful application of cutting-edge drill and blast technology, the effects of blasting were well limited, with minimum disturbance to neighbouring communities during Stage 2A tunnelling works. Key logistical issues and statutory constraints, including the delivery of explosives across the Harbour, were well resolved through meticulous planning before Stage 2A works commenced.

Inspiring Challenges
挑戰與啟迪

Stage 2A tunnelling works also put us at the leading edge of pre-excavation grouting technique making use of micro fine cement and/or a then newly available grouting material called colloidal silica. We were able to achieve for Stage 2A tunnelling a water ingress limit several times more stringent than that of Stage 1 works. This success was well recognised by the industry as a "quantum leap" in pre-excavation grouting technology.

Our efforts in developing and applying the pre-excavation grouting technique also successfully limited settlement in all areas to a negligible level during Stage 2A tunnelling works.



Cutter head of tunnel boring machine
隧道鑽挖機的鑽頭

Serious water inflow in Tunnel F from Kwai Chung to Tsing Yi
由葵涌至青衣的隧道F地下水湧入情況嚴重

挑戰一：地下水在高壓下湧入

解決方案：預先灌漿系統

如要了解「淨化海港計劃」在隧道工程方面的種種挑戰，大前提是必須知道，我們為第一期的隧道工程採用了隧道鑽挖機進行挖掘工作，而第二期甲隧道工程則主要採用鑽爆方法，除了昂船洲一段較短小的連接隧道仍採用隧道鑽挖機。

事實上，在第一期隧道工程的早期，我們已遇上地下水在高壓下湧入隧道的嚴峻情況。如無法適當控制地下水湧入，施工會困難，更會造成地下水位下降並導致地面沉降。第一期隧道工程的經驗，讓我們很快知道進行預先灌漿是控制地下水湧入的最有效方法。預灌漿的工序，是在開挖前預先在隧道周邊鑽灌漿孔，並將灌漿注入孔中以密封石縫，從而減少地下水流入隧道。

然而，說易行難。由於第一期隧道工程使用的隧道鑽挖機並未配備進行預灌漿所需的機械鑽孔設備，因此必須首先為這批隧道鑽挖機進行改裝，但要在擠迫的隧道環境進行改裝工程，難度極高。第一期的隧道工程雖然最終能安全完成，但這些歷盡艱辛而取得的寶貴經驗，令我們重新檢視及研究，隧道鑽挖機是否建造第二期甲隧道工程的最佳方案。

為找出答案，我們向歐洲各主要隧道鑽挖機製造商和專業設計師徵詢意見，發現為隧道鑽挖機裝配及操作預灌漿所需的鑽孔設備，其中牽涉的技術問題尚未解決。同時，我們也仔細研究了鑽爆方法，特別是深入探討這方法是否適合建造極深層隧道。我們最後決定使用鑽爆方法建造第二期甲的隧道。

鑽爆方法有幾個最大優點。首先，它提供了足夠的工作空間，讓預灌漿系統能有效操作，其中的關鍵，是利用一台配備多支機械鑽在電腦操控流動車輛的巨型鑽孔機。此外，我們使用最先進的鑽爆技術，仔細控制爆破的力度和影響，務求把第二期甲隧道工程對鄰近社區造成的滋擾減到最低。第二期甲工程施工前，我們更事先作出詳細規劃，解決了主要的物流問題和確保符合法定限制，包括怎樣在維港渡海運送爆炸品等。

第二期甲隧道工程也促使我們引入最先進的預灌漿技術，採用微細水泥和／或當時新推出的灌漿材料「膠體二氧化矽」進行灌漿。我們在第二期甲隧道工程達到的進水容許限值要求，比第一期工程的進水限值要求高達數倍，非常嚴謹。我們在預灌漿技術取得成功「大飛躍」，贏得業界一致稱許。

在第二期甲隧道工程中，我們在開發和應用預灌漿技術方面的努力，也成功把所有區域的沉降，控制在不構成任何影響的極微幅度。

Challenge 2: Stability Problem in Weak Ground

Solution: Pre-excavation Grouting and Robust Ground Support System

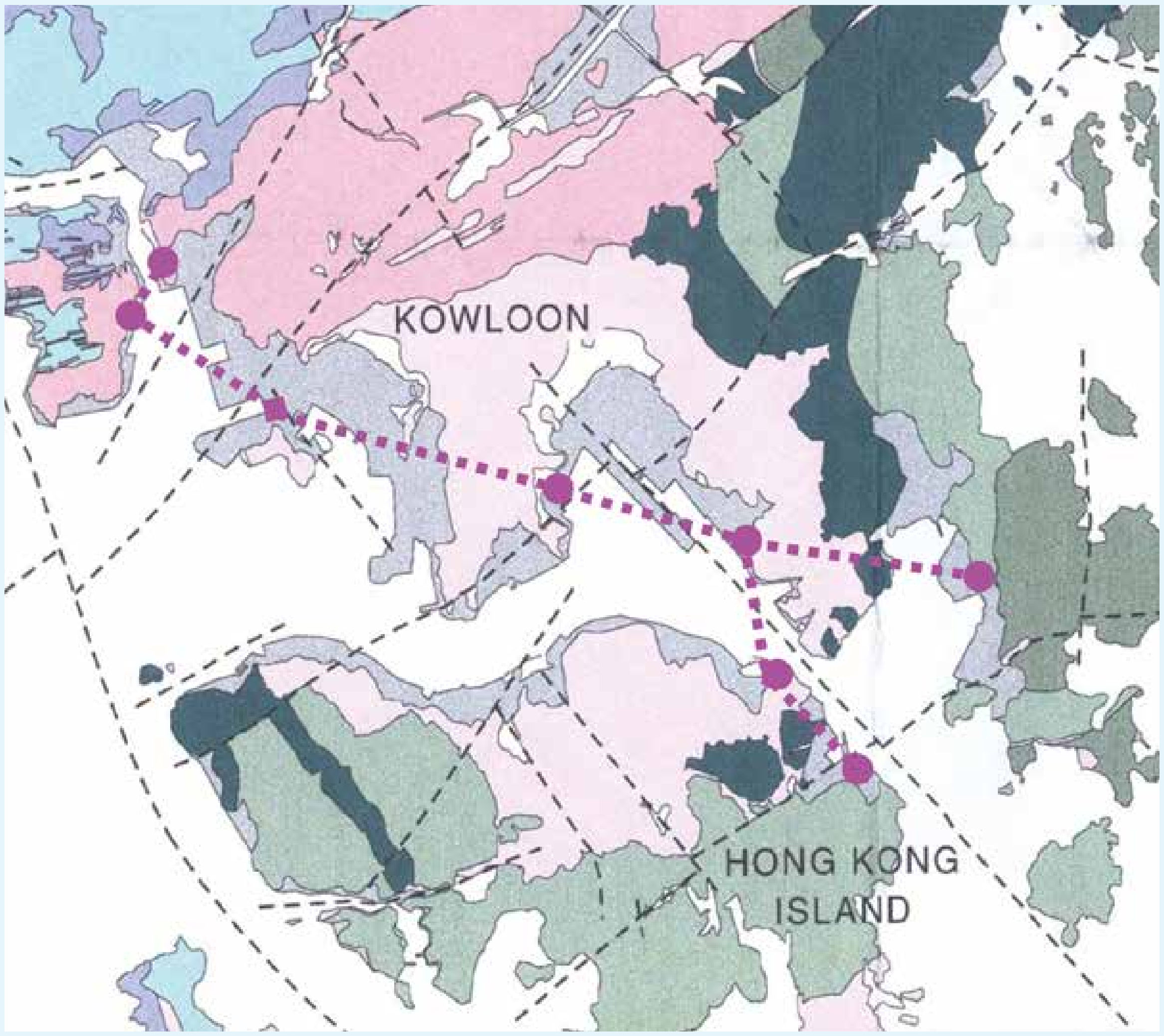
This was related to the water ingress challenge, and again our Stage 1 experience proved valuable in helping us find the solution.

Coupled with ground water ingress under high pressure, the presence of weak ground in isolated locations posed another major challenge to constructing the HATS tunnels. During Stage 1, for example, the most unforgettable difficulties were encountered in the tunnel from Tsing Yi to Stonecutters Island, which traversed the 278-metre long Tolo Channel Fault and another 120-metre long rhyolite dyke zone of fractured rocks. Extensive pre-excavation grouting had to be carried out to control water ingress in these two parcels of weak ground without disrupting the operation of Kwai Chung container terminals nearby. In addition, very substantial ground support systems had to be installed to maintain ground stability. It took us 191 days and 309 days respectively to excavate through these two zones.

Further complicating the matter was the 20-metre long Lead Mine Pass Fault which we encountered in the same tunnel, comprising soft clayey material. After seeking expert advice, we decided to retract the TBM and resorted to manual excavation to slowly creep through this zone. Extensive grouting and ground support systems were applied in progressive, small steps for safety reasons. Coupled with other machinery breakdown problems, it took us 12 months to excavate through this zone.

Stage 1 taught us the precious lesson that TBMs were susceptible to jamming by loose boulders or roof stability problems in weak ground, but extensive pre-excavation grouting coupled with the installation of a robust system of ground supports proved indispensable to tackling stability problems associated with tunnelling through weak ground. The solution enabled us to excavate through all weak ground zones encountered in Stage 1. This also inspired us to explore and eventually adopt the drill and blast method for Stage 2A tunnelling works, which allowed pre-excavation grouting and ground support installation to be carried out in the most efficient manner.

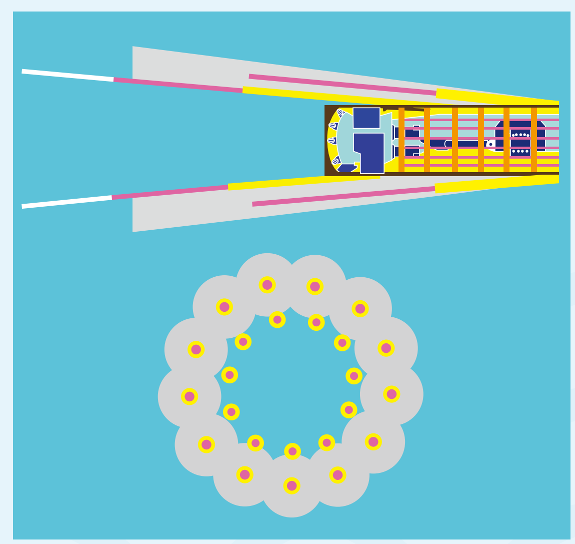
The HATS tunnels were designed at unprecedented depths in order to avoid disturbing the city during construction, but their depths as well as the geological conditions encountered brought unforeseen challenges of water ingress and ground stability issues. In successfully completing both Stages 1 and 2A tunnelling works, we have become pioneers in tunnelling technology too.



Geological map for HATS Stage 1 works
「淨化海港計劃」第一期的地質圖

Major fault
主要斷層帶

Manual excavation through Lead Mine Pass Fault in Tunnel F from Chainage 744 to Chainage 760
隧道F經過鉛礦坳斷層由744至760段的人手挖掘情況



Pre-excavation grouting
挖掘前灌漿

挑戰二：脆弱地質引發的穩定性問題

解決方案：預灌漿和穩固的土層支撐系統

這牽涉地下水湧入的問題。第一期工程的寶貴經驗，再一次幫我們找到解決方案。

地下水在高壓下湧入，加上部份路段的地質脆弱，為「淨化海港計劃」的隧道建造工程帶來另一重大挑戰。最難忘的例子，發生在第一期工程：從青衣到昂船洲的隧道，須穿越278米長的赤門海峽斷層和另一段120米長的流紋岩岩脈碎石帶。我們在挖掘隧道前，必須先進行大幅度的預灌漿工作，以控制這兩塊脆弱地質的地下水湧入，同時避免影響鄰近葵涌貨櫃碼頭的運作。此外，我們必須安裝大規模的土層支撐系統，以確保土層穩固。我們分別花了191天和309天，才成功挖掘穿越這兩個地帶。

這條隧道更遇上20米長包含黏質砂土的鉛礦坳斷層，令挖掘工作更形複雜。經徵詢專家意見後，我們決定收回隧道鑽挖機，採用人手挖掘，緩慢地挖掘穿越這地帶。基於安全理由，我們只可以小步的漸進方式，在斷層內進行大幅度灌漿工作和建造土層支撐系統。再加上其他機械故障問題，我們共花了12個月時間來挖掘穿越這地帶。

第一期隧道工程給我們的寶貴經驗是，在脆弱的地質採用隧道挖掘機進行挖掘，容易受到鬆散的大石堵塞及隧道頂部不穩的問題影響，但如能進行大幅度的預灌漿，再加上安裝穩固的土層支撐系統，則證明能解決在脆弱地質地帶挖掘隧道涉及的穩定性問題。這方案讓我們成功挖掘穿越第一期工程遇到的所有脆弱地質帶，並啟迪我們深入探索鑽爆方法，最終更決定以鑽爆方法進行第二期甲隧道挖掘工程，讓預灌漿及土層支撐安裝工作能以最高效率方式進行。

「淨化海港計劃」的隧道設計位處於前所未有的深度，原意是為了避免工程施工時影響城市民生，但隧道的深度及沿線遇上的複雜地質問題，卻帶來地下水湧入及土層不穩定等種種無法預見的挑戰。我們最終都能成功完成第一期及第二期甲隧道工程，也因而成為隧道工程技術的先驅。

Challenge 3: Ground Investigation to Reduce Tunnelling Risks

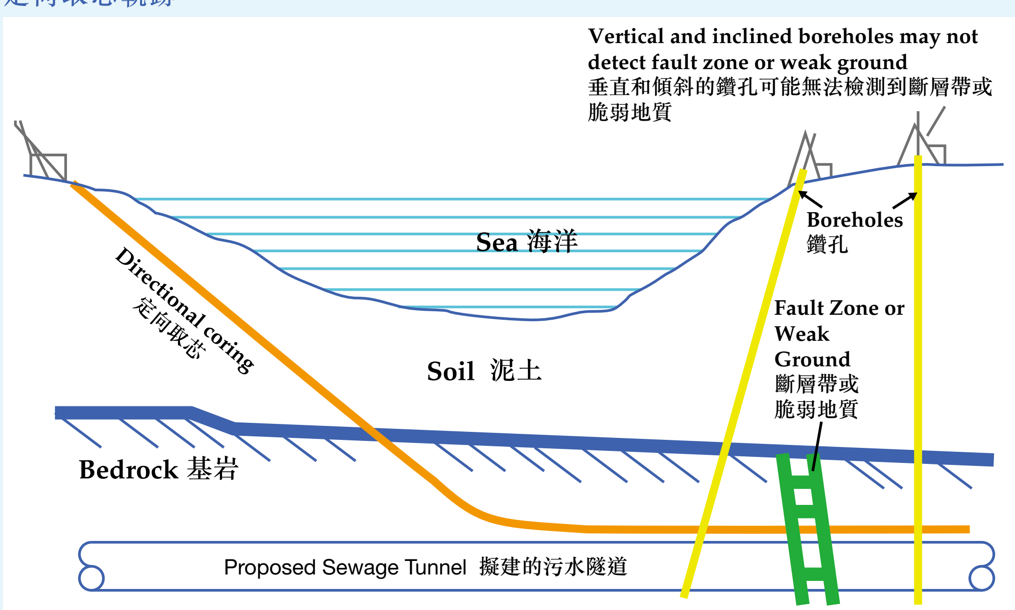
Solution: Comprehensive Ground Investigation Programme with State-of-the-art Technology

The importance of investigating the ground conditions beforehand to facilitate proper planning and design for the tunnelling works cannot be over-emphasised. The traditional ground investigation method involves drilling vertical and inclined boreholes. For Stage 1 tunnels, a total of 144 boreholes were drilled during the planning and design stage to investigate the ground conditions. This provided a general picture of the geology along the tunnel alignment, but not any direct information on the intermediate tunnel sections between the boreholes.

Learning from Stage 1, we specifically drilled a total of 150 boreholes for Stage 2A tunnel works to investigate the ground conditions more thoroughly. We also adopted a state-of-the-art technology called Horizontal Directional Coring (HDC) to take continuous core samples at strategic locations along the tunnel alignment.

This was how we applied HDC to Stage 2A. The drilling angle was around 45 degrees at entry. Once the drill had entered the bedrock, directional steering was applied in accordance with the planned trajectory, allowing for continuous coring at about eight metres above the designed crown level of the tunnels. Apart from avoiding disturbance to the actual alignment, this would enable us to obtain information close to the tunnel crown level for assessment of roof stability problems. The beauty of HDC was that it gave comprehensive information for the designer to mitigate the risks identified and the tenderers to price the job.

Directional Coring Trajectory
定向取芯軌跡



The longest continuous directional coring completed was 1,247 metres, a new record for Hong Kong. A total of about 5 kilometres of horizontal directional coring was completed successfully for Stage 2A. This comprehensive ground investigation programme using vertical and inclined boreholes, supplemented with information obtained from HDC, proved highly valuable in the subsequent design of ground support and groundwater ingress control, and in the assessment of settlement within the tunnel influence zone.

挑戰三：進行地質勘測以減低隧道工程風險

解決方案：採用最先進技術的全面地質勘測計劃

事先進行地質勘測工作，對妥善規劃及設計隧道工程極為重要。傳統的地質勘測方法涉及垂直及傾斜鑽孔。在第一期隧道工程的規劃和設計階段，我們共鑽探了144個鑽孔以勘測地質情況，提供了隧道沿線的整體地質概貌，但鑽孔之間的隧道沿線部分，卻沒有任何直接資料。

我們借鑑第一期工程的經驗，為第二期甲隧道工程特地鑽了150個鑽孔，更詳盡全面地勘測地質情況。我們還採用了最先進的水平定向取芯法，在隧道沿線的關鍵路段連續鑽取岩芯樣本。

這是我們把水平定向取芯法應用於第二期甲工程的方式：鑽孔入口角度約為45度，鑽頭進入基岩後，會按照預定的軌跡進行定向轉向，在距離隧道頂部上面約八米的位置，進行連續取芯；這距離可避免對真正的隧道路線造成影響，並可提供接近隧道頂部的地質數據，有助評估隧道頂部的穩定性問題。水平定向取芯法的優點，是可以提供全面的數據資料，供工程設計師參考，從而降低可見的工程風險，也有助投標者為工程造價估算。

第二期甲的隧道工程運用水平定向取芯法，為香港創下了一段連續定向取芯1,247米的新紀錄，而工程過程中以水平定向取芯的總長度則共約5公里。第二期甲隧道工程的地質勘測計劃詳盡全面，既以垂直及傾斜鑽孔取芯，又加上水平定向取芯法，取得的地質資料，對之後的土層支撐及控制地下水滲入的施工設計大有幫助，也有助評估隧道區域的沉降幅度。

Setup for directional coring
定向取芯設置

Directional barrel
定向桿

Challenge 4: Constructing Small-Diameter Tunnels in Adverse Ground Conditions

Solution: Horizontal Directional Drilling

The construction of twin 600-millimetre diameter rising mains between the Ap Lei Chau and Aberdeen Preliminary Treatment Works (PTWs) in Stage 2A was a special case worth mentioning.

While the drill and blast method has many merits as discussed before, it is not ideal for constructing small-diameter tunnels. Typically, a horse-shoe section of about 3.5 meters wide and 4 metres high is required to provide working space for the blasting and pre-excavation grouting operation. After excavation, the section has to be reduced to the required size of the conduit by infilling the overbreak with concrete, which is neither economical nor environmentally friendly.

Furthermore, we were well aware of the presence of the Aberdeen Fault which crossed the alignment of the tunnel between the Ap Lei Chau and Aberdeen PTWs. The ground is highly variable and its effect on excavation could only be known when the weak zone is actually encountered during excavation. Given the uncertainty of ground conditions, and to minimise the safety risks of ground collapse during excavation to frontline workers, we decided to adopt Horizontal Directional Drilling (HDD) for completing this section of twin tunnels. The HDD technique means that a pilot hole of small size is drilled along the designed alignment, after which the pilot hole is progressively reamed by stages to the required larger size.

Even so, the HDD technique encountered additional difficulties. The twin tunnels are on a curved alignment both horizontally and vertically. The length of these tunnels, at about 1.4 kilometres, is also approaching the maximum limit of HDD drilling equipment. Moreover, pilot hole directional control proved difficult. This was because HDD directional control, which is guided by the magnetic field of the Earth, was interfered by the magnetic field produced by high voltage electric cables on the seabed nearby. The problem was finally resolved using a mobile magnetic source on a boat above the tunnel alignment.

Furthermore, the rock turned out to be much harder than expected during the reaming operation, which caused abnormal wear and tear to the drilling bits and breakage of the drilling rods. The team reinforced the drilling bits and closely monitored the drilling force to avoid overstressing the drilling rods during reaming. After much patient drilling, the team finally achieved breakthrough and high-density polyethylene pipes were pulled through the reamed holes. HDD had been successfully deployed to drill a unique section of the Stage 2A tunnel system.

挑戰四：在惡劣地質環境下建造小口徑隧道

解決方案：水平定向鑽挖

我們在鴨脷洲和香港仔這兩所基本污水處理廠之間，興建了兩條只有600毫米直徑的泵喉，是值得一提的特別工程案例。

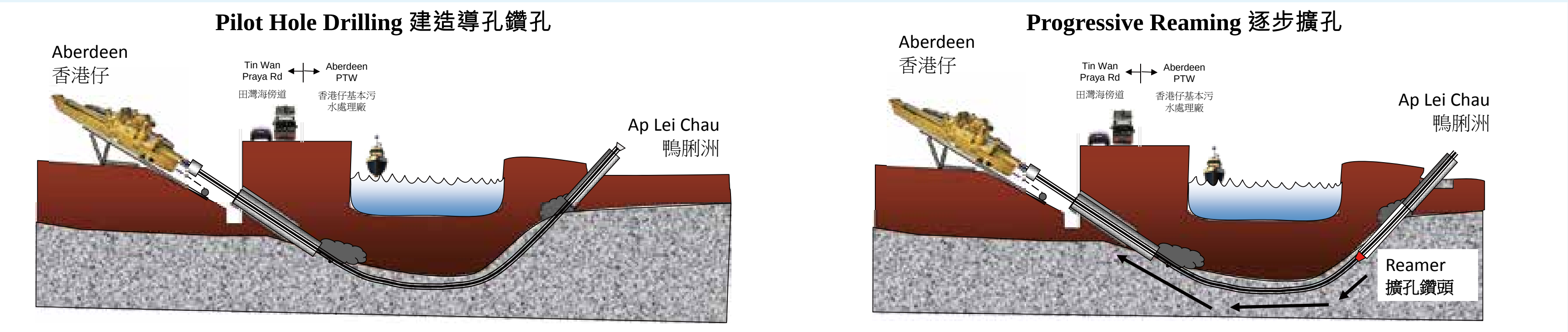
雖然鑽爆方法有上面談到的眾多優點，卻不是挖掘小口徑隧道的理想方法。鑽爆方法通常需要一個約3.5米闊和4米高的馬蹄形工作空間，用作爆破和預灌漿工作。隧道挖掘完成後，往往需要用混凝土填補多出的半圓形部份，將管道縮小至所需的尺寸，這後續工作既不化算也不環保。

此外，我們也清楚知道，鴨脷洲和香港仔這兩所基本污水處理廠之間的隧道路線會橫跨香港仔斷層帶，地質環境充滿變數，而且只能等到在挖掘過程中真正見到脆弱地質的時候，方可了解它對挖掘工作的影響。鑒於地質環境的不明朗因素，並為了確保前線工作人員的安全，和盡量減低進行挖掘時發生土層坍塌的風險，我們決定採用水平定向鑽挖法來建造這雙管隧道段，即是沿隧道設定路線鑽挖細小的定位孔，完成後隨即利用大型擴孔鑽頭，逐步擴大鑽孔至隧道所需的大小。

然而，水平定向鑽挖技術也遇到其他難題。無論是水平或垂直方向，雙管隧道均處於彎曲路線；而且隧道長約1.4公里，已接近水平定向鑽挖設備的最高操作極限。另一方面，定位孔的定位控制也殊不簡單，因為水平定向鑽挖借助地球磁場導向，但當時的工程卻受到附近海床上高壓電纜產生的磁場干擾，工程團隊於是運用船隻，在隧道路線之上為鑽挖設備提供移動磁源導向，順利解決問題。

然而，岩石層比預期堅硬得多，導致鑽頭出現異常磨損和鑽桿破損。工程團隊對鑽頭進行了加固，並密切監察鑽挖力度，避免在鑽挖過程中對鑽桿過度施力。經過耐心鑽挖後，工程團隊終於貫通隧道，並將以高密度聚乙烯製成的管道拉過了擴孔。第二期甲這段獨特的隧道，最後順利以水平定向鑽挖方法建成。

Horizontal Directional Drilling Method
水平定向鑽挖法示意圖



Setup of horizontal directional drilling
水平定向鑽挖設置

Completion of pilot hole drilling
完成鑽挖導孔

Completion of pipe pulling
完成拉喉工序

Challenge 5: Launching TBM in Soft Ground

Solution: Artificial Ground Freezing

TBM was used in one instance in Stage 2A tunnel construction. An earth-pressure-balancing slurry-shield TBM was chosen to construct an interconnection tunnel in soft ground at about 30 metres below ground level between the Main Pumping Station 1 (MPS1) and Main Pumping Station 2 (MPS2) at Stonecutters Island Sewage Treatment Works (SCISTW). The tunnel would be 250 metres long with a diameter of 4 metres. The challenge was how to control the sudden inrush of soil and groundwater during the breakthrough operation of TBM at the launching shaft and the inlet chamber of MPS2, as well as to limit potential settlement of existing facilities in the close vicinity.

The project team decided to adopt Artificial Ground Freezing (AGF) technique as the mitigation measure. AGF quickly forms a frozen soil block, which stops water inflow and also acts as temporary support to facilitate the TBM breakthrough at the launching shaft and the inlet chamber. Two-dimensional thermal analysis was used to help determine the arrangement of the ground freezing pipes and to estimate the time and energy required to form the frozen soil wall at the right temperature.

Brine, or salt water solution, was used as the coolant for AGF. Using an industrial refrigeration system, brine was lowered to a temperature of –28°C to form a 2.5-metre thick frozen block with a temperature of –16°C in front of the TBM breakthrough, which blocked out groundwater and also acted as temporary support. Indeed, this was the first time in Hong Kong that brine was successfully used in AGF as an alternative coolant to liquid nitrogen which is commonly adopted, another innovation of the HATS project.

Refrigeration plant
製冷設備

Insulated delivery and return pipes
輸送和回流的絕緣喉管

Tunnel boring machine fabrication in Shanghai
在上海裝嵌中的隧道鑽挖機

Breakthrough by tunnel boring machine "Victoria" at inlet chamber
隧道鑽挖機「維多利亞」貫通進水室

挑戰五：在軟土使用隧道鑽挖機

解決方案：凍土法

在第二期甲隧道工程中，其中一條隧道段採用了隧道鑽挖機。我們選用了一部土壓平衡並配備泥漿屏擋的隧道鑽挖機，在離地面約30米深的軟土裏，建造一條長250米、直徑四米的連接隧道，接連昂船洲污水處理廠一號主泵房和二號主泵房。當時的挑戰，是在隧道鑽挖機貫穿開挖隧道入口豎井及二號主泵房的進水室的過程中，如何控制泥土及地下水突然湧入，並控制鄰近現有設施可能出現的沉降。

工程團隊決定使用凍土法作為緩解措施。這方法能迅速將泥土冷凍成凍土塊，有效阻止地下水滲入，並可作為臨時支撐，讓隧道鑽挖機貫穿開挖隧道入口豎井及進水室。我們利用二維熱能分析，以確定泥土冷凍管的位置安排，並估計以適當溫度形成凍土牆所需的時間和能量。

今次的凍土法，以鹽水作為冷卻劑。工程人員運用工業製冷系統，將鹽水降至–28°C的溫度，在隧道鑽挖機貫穿混凝土牆前形成一層2.5米厚，溫度為–16°C的冷凍塊，以阻塞地下水，並可作為臨時支撐。這是香港首次應用鹽水於凍土法作為冷卻劑，替代較常用的液態氮，也是「淨化海港計劃」工程的另一項創新措施。

Challenge 6: Deterioration of Concrete Quality During Long-Distance Pumping

Solution: Special Concrete Mix and Telescopic Formwork

The length of the sewage tunnel sections posed problems for concrete pumping, as concrete quality could deteriorate during the long pumping process. Long-distance concrete pumping was necessary to complete concrete lining works for the tunnels, sometimes at lengths of up to 3.5 kilometres. The excessive heat generated by the long pumping operation was highly detrimental to the quality of the concrete, not to mention segregation of the concrete when pumped over such a distance. As the lining works were a critical activity in the construction programme, an innovative solution was called for.

The project team began work on two fronts: find the right concrete and identify a device to place the concrete. Various special concrete mixes and designs were explored in order to develop a self-compacting concrete with sufficiently high workability and early strength development. The concrete temperature had to be carefully controlled too, such that heat generated during pumping would not lead to early setting and hardening of the concrete within the pumping pipes.

The project team also decided on a tailor-made telescopic formwork device, at a length of 120 metres, specially designed to facilitate continuous concrete placing. Both the special concrete mix and the formwork proved effective, which greatly expedited the lining works to meet the very tight construction programme.

Telescopic lining formwork
伸縮式模板裝置

挑戰六：混凝土的質素在長距離泵送過程中受影響

解決方案：特製混凝土配方和伸縮式模板

污水隧道段的長度令混凝土泵送困難重重，因為在長距離的泵送過程中，混凝土的質素會被影響。但為了進行隧道的混凝土襯砌工程，卻必須長距離泵送混凝土，部份路段更長達3.5公里。漫長的泵送過程引致設備操作過熱，令混凝土的質素受到影響，而長距離泵送更會令混凝土出現離析情況。由於襯砌工程是施工時間表的關鍵一環，必須找個創新的解決方案。

工程團隊從兩方面着手：找尋合適的混凝土和澆灌混凝土的設備。為了調配出一種有足夠和易性與早期強度的自壓實式混凝土，我們研究了多種特殊的混凝土配方和設計。此外，混凝土的溫度也必須小心控制，避免泵送期間產生的熱力，導致混凝土在管道內過早凝固和硬化。

工程團隊還決定訂製一個120米長的伸縮式模板裝置，專門用於連續澆灌混凝土的工作。特製的混凝土配方和模板效果十分理想，大大加快了襯砌工程的進度，成功配合非常緊湊的施工計劃。

Concrete mixing equipment
混凝土拌合機

Concrete pumping equipment
混凝土泵送設備

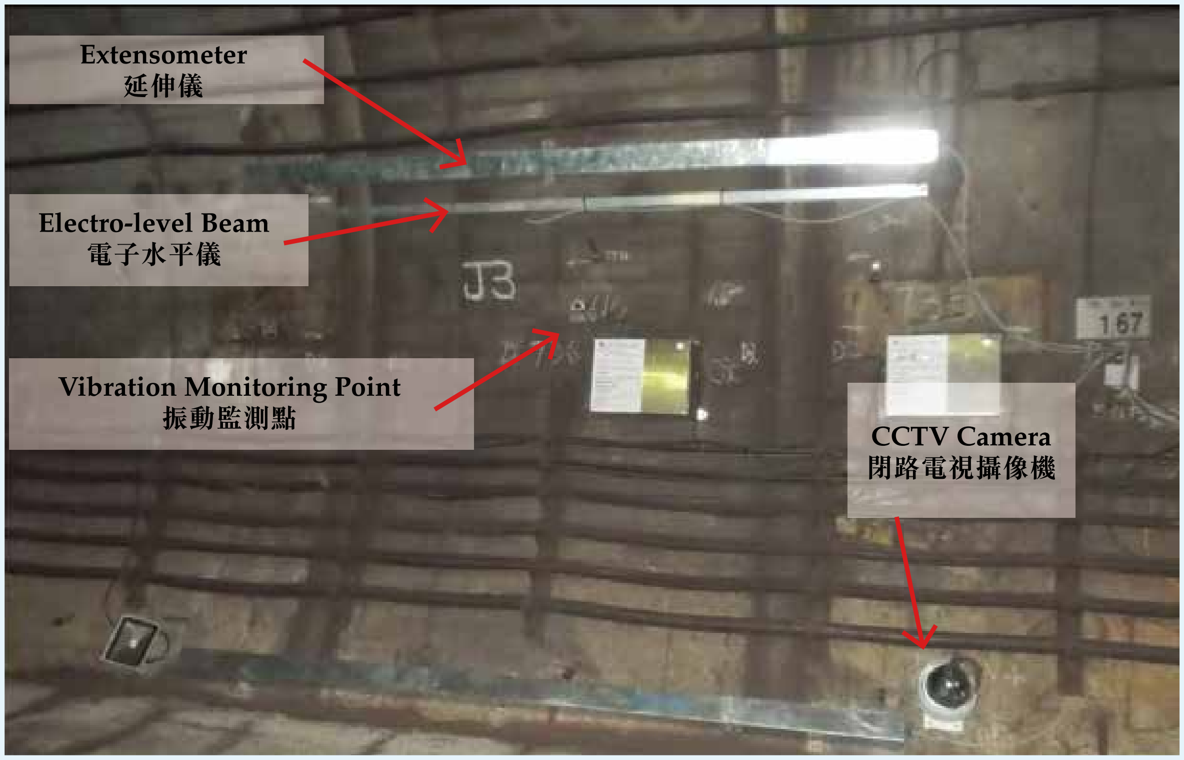
Concrete lining completed
混凝土襯砌完成

Challenge 7: Crossing Major Traffic Routes and Important Infrastructures

Solution: Careful Control and Close Communication with Key Stakeholders

Some tunnel sections in both Stages 1 and 2A are located underneath existing major transport tunnel routes such as the Eastern Harbour Crossing (EHC) and the MTR Tsuen Wan Line and Airport Express. These tunnel sections also run below important infrastructures of the city such as the Kwai Chung container terminals. It was therefore necessary to tunnel underneath these major infrastructures while keeping settlement and vibration to a negligible level to avoid disrupting the normal operation and services of these infrastructures. This posed another major challenge to the HATS project.

Our starting point was careful application of the appropriate construction technique as mentioned earlier, and close monitoring. No less important was close communication with both the operators of these infrastructures and related government departments to alleviate their concerns before and during tunnelling. Comprehensive monitoring devices and instruments were also installed on an extensive scale to closely monitor the effects of the tunnelling works on these infrastructures.



Devices installed in MTR tunnels for monitoring the blasting underneath
於港鐵隧道內安裝儀器以監測隧道下的爆破工程

Through effective communication and close liaison, the project team built trust and good working relationships with all relevant stakeholders including the MTRC as well as operators of EHC and the container terminals. All tunnelling works under HATS Stages 1 and 2A were safely completed without affecting the major infrastructures in any material way. For HATS Stage 2A, we went a step further by realigning, in an early stage, the initially planned route of the cross harbour section of our tunnel to avoid crossing underneath the Western Harbour Crossing, another major infrastructure.

挑戰七：跨越主要交通路線和重要基建設施

解決方案：仔細監控施工並與主要持份者緊密溝通

第一期及第二期甲的部分隧道，均處於現有主要交通管道下，包括東區海底隧道、港鐵荃灣線及機場快線；它們又同時位處葵涌貨櫃碼頭等香港主要基建設施的下，所以隧道施工時必須確保沉降及振動保持在極低水平，避免對這些基建設施的正常運作及服務造成影響，這又是「淨化海港計劃」另一重大挑戰。

首先，我們小心運用上面談到的合適工程方案及技術，並密切監控施工。同樣重要的是在隧道施工前及施工期間，與有關基建設施的營運者及相關政府部門保持緊密溝通，以釋除疑慮。我們亦廣泛安裝了綜合監察裝置及儀器，大規模密切監察隧道工程對這些基建設施的影響。

MTR tunnels monitoring equipment
港鐵隧道監測設備

通過有效溝通和緊密聯繫，工程團隊與所有相關持份者，包括港鐵公司、東區海底隧及貨櫃碼頭的營運者，建立了互信和良好的工作關係。「淨化海港計劃」第一期及第二期甲的所有隧道工程均安全完成，並沒有對主要基建設施造成任何實質影響。我們在第二期甲工程中更多走一步，在計劃早期已將原先的跨海隧道段重新定線，避免在另一主要基建設施—西區海底隧道的下面走過。

POSTSCRIPT

“We must never forget the human dimension in any engineering project. For a few years our team communicated closely with stakeholders along the HATS tunnel alignment, such as elderly homes and schools. We took all necessary steps to make sure that the noise and disturbance caused by tunnelling works to the neighbourhood was kept to a minimum. Through drawing competitions, young people had the opportunity to express and paint their vision of a clean harbour.”

“A memorable experience was using Horizontal Directional Drilling for constructing the Ap Lei Chau to Aberdeen tunnel, a fairly new technique for Hong Kong at that time and very challenging. Looking back, HATS taught us that every innovative idea must come with careful risk management for it to work. Mutual trust and team spirit among the Drainage Services Department, consultants and contractors are also vital for HATS to succeed.”

附箋

「我們不應忘記每個工程項目都有人性化的一面。我們的團隊有好幾年都與『淨化海港計劃』沿線的持份者，像老人院舍和學校等保持緊密溝通，並採取一切必要措施，去確保隧道建造工程對鄰近社區帶來的噪音和滋擾減到最低。透過繪畫比賽，年青人則有機會表達和繪畫出他們對潔淨維港的願景。」

「一個難忘的經驗，是我們採用了水平定向鑽挖法去建造鴨脷洲和香港仔之間的隧道。這技術在當時的香港相對先進，挑戰也很大。現在回望，『淨化海港計劃』讓我們明白，每個創新的意念都要有謹慎的風險管理，才會成功。同樣，渠務署、各個顧問公司和承建商之間的互信和團隊精神，也是『淨化海港計劃』得以成功的要素。」

Keith TSANG
曾建雄

Director, AECOM
艾奕康有限公司董事

SEVEN WONDERS OF HARBOUR AREA TREATMENT SCHEME
淨化海港計劃七大亮點

With the rapid urban development and booming population in Hong Kong during the past few decades, the Hong Kong Government conducted studies on strategic sewage disposal since 1987, with an aim to improving the water quality of the Victoria Harbour area. The Harbour Area Treatment Scheme (HATS), formerly known as Strategic Sewage Disposal Scheme, was committed in 1989 and was implemented in stages. Stage 1 and 2A were fully commissioned in 2001 and 2015 respectively. The water quality of Victoria Harbour has since improved significantly, not only enhancing the image of Hong Kong as an international city, but this is also beneficial to everyone in Hong Kong.

This world-class environmental infrastructure project has also accomplished its Seven Wonders.

隨著近數十年間城市發展及急劇的人口增長，香港政府早於1987已展開了策略性排污研究，以改善維多利亞港一帶水質，並於1989年正式落實推行一項名為「策略性污水排放計劃」的大型基建項目，亦即是現時的「淨化海港計劃」。這項計劃分階段進行，當中第一期及第二期甲分別已於2001年及2015年正式啟用，維港水質得到了明顯改善，不但提升香港的國際城市形象，亦同時惠澤全港市民。

這項世界級環保基建項目創造了七大亮點。

1 HONG KONG'S LARGEST EVER ENVIRONMENTAL INFRASTRUCTURE
香港歷來最龐大的環保基建項目

Total budget at HK$25.8 billion

總工程費用達258億港元

2 WORLD'S DEEPEST SEWAGE TUNNEL
全球最深污水隧道

The deepest tunnel section is at 163m under sea level, equivalent to the height of a commercial building at about 50 storeys (Jardine House)

最深一段隧道位於海平面以下163米，相等於約50層高的商業大廈(怡和大廈)

3 ASIA'S LONGEST VERY DEEP SEWAGE TUNNEL
亞洲最長的極深層污水隧道

Total length of deep sewage tunnel is 44.6km, even longer than a full marathon (42km)

深層污水隧道總長44.6公里，比全馬拉松(42公里)更長

4 ONE OF THE WORLD'S LARGEST CHEMICALLY ENHANCED PRIMARY TREATMENT WORKS
世界其中一個最大的化學強化一級污水處理廠

Treatment capacity of Stonecutters Island Sewage Treatment Works is 900 million m^3 per year, or 2.45 million m^3 per day (the latter equivalent to the volume of about 1,000 standard swimming pools)

昂船洲污水處理廠的處理能力達每年9億立方米，或每日245萬立方米(後者相等於約1,000個標準游泳池的容量)

5 MOST EFFICIENT USE OF LAND FOR PROVIDING CHEMICALLY ENHANCED PRIMARY TREATMENT
最地盡其用的化學強化一級污水處理廠

The footprint of Stonecutters Island Sewage Treatment Works is only 10 ha (about half the size of Victoria Park) but serves up to 5.7 million people

昂船洲污水處理廠只佔地10公頃(約半個維多利亞公園的大小)，卻可以服務570萬人

6 WORLD'S MOST POWERFUL SEWAGE PUMPING SYSTEM IN CHEMICALLY ENHANCED PRIMARY TREATMENT WORKS
全球化學強化一級污水處理廠中最強的泵水系統

Max. capacity of 63.2 m^3/s, i.e. a standard swimming pool of water can be pumped out in 40 seconds

泵力達每秒63.2立方米，只需約40秒便可抽走一個標準游泳池的水

7 THE ENVIRONMENTAL INFRASTRUCTURE PROJECT SPANNING THE GREATEST NUMBER OF DISTRICTS IN HONG KONG
香港橫跨最多區域的環保基建項目

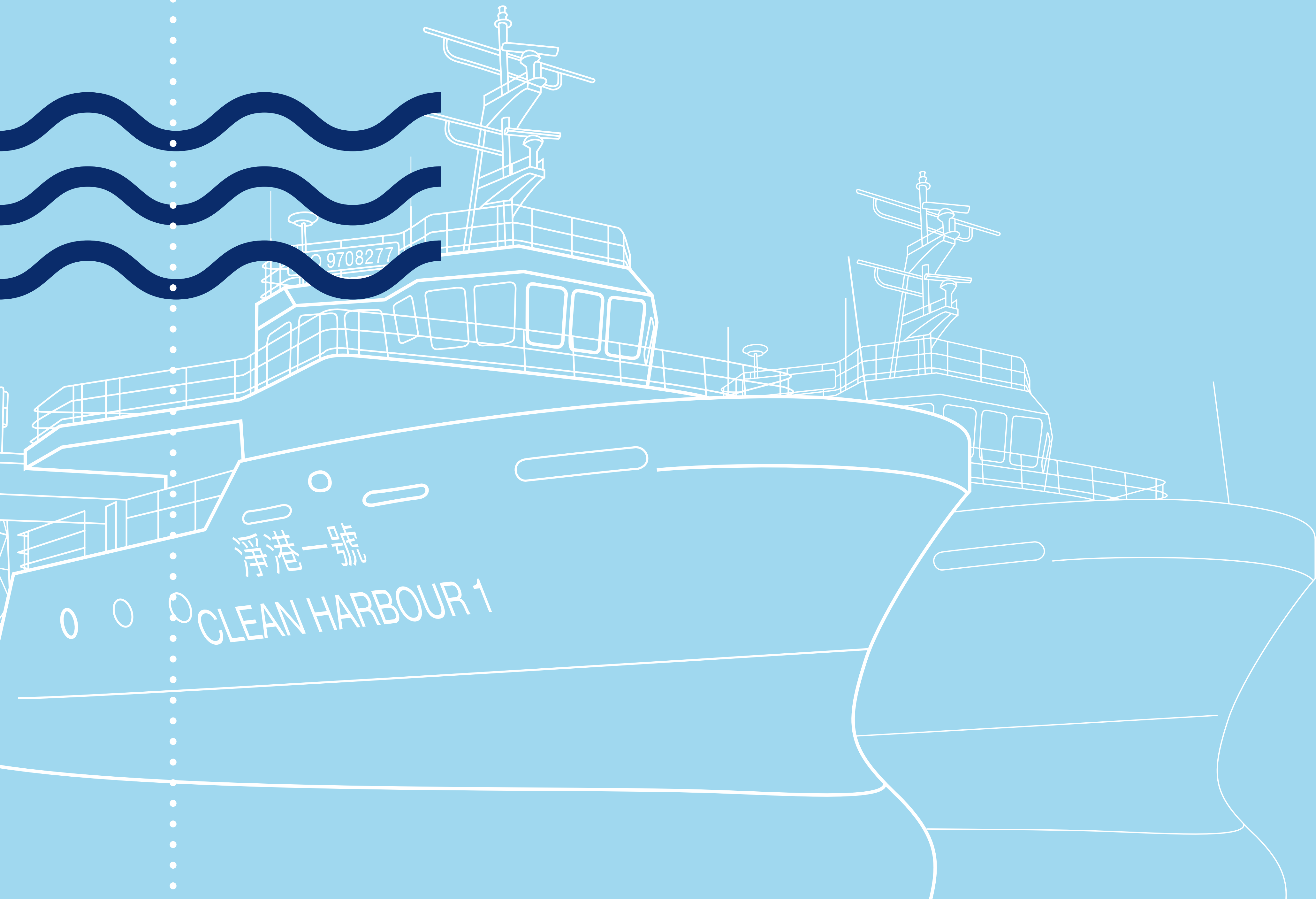
The works spanned 10 districts on both sides of Victoria Harbour, including Sai Kung, Kwun Tong, Kowloon City, Yau Tsim Mong, Sham Shui Po, Kwai Tsing, Eastern, Wan Chai, Central & Western and Southern Districts

工程橫跨維多利亞港兩岸10個區域，包括西貢、觀塘、九龍城、油尖旺、深水埗、葵青、東區、灣仔區、中西區及南區

SEVEN WONDERS OF HARBOUR AREA TREATMENT SCHEME

淨化海港計劃**七大亮點**

A NEW JOURNEY
雙船出海




IMO 9708277
渠務署
Drainage Services Department
淨港一號
CLEAN HARBOUR 1
LETTER 8 信件八
A NEW JOURNEY
雙船出海

A New Journey
雙船出海

Dear Harbour,

One of the delights of working on the HATS project was that it took us on unexpected adventures, such as the building and commissioning of two ocean-going vessels!

This is the story of how the project team built *Clean Harbour 1* and *Clean Harbour 2* — advanced vessels tailor-made for the transportation of sludge from Stonecutters Island Sewage Treatment Works (SCISTW) to T▪PARK at Tuen Mun for incineration to generate electricity, thereby completing the waste-to-energy sustainability loop.

Sludge and T▪PARK: Waste to Energy

When HATS Stage 1 was commissioned in December 2001, landfilling was the only means of sludge disposal in Hong Kong. Sludge was therefore transported on container trucks to the South East New Territories Landfill and the West New Territories Landfill for disposal. However, the amount of sludge increased rapidly from around 600 tonnes daily in the early 2010s to 800 tonnes daily by late 2015 after the commissioning of Stage 2A, and is expected to eventually rise to around 1,200 tonnes daily. The Government soon found that this was not a sustainable waste management solution. The large amount of sludge from HATS Stages 1 and 2A was shortening the lifespan of the landfills.

In contrast, incineration is a much better way to dispose of sludge. Burning sludge at ultra-high temperature of above 850 degrees Celsius, converts it into ash and residue, reducing the original sludge volume by as much as 90%, and dramatically cuts the quantity of waste to be disposed of at the landfills.

After much deliberation, the Government decided to create T▪PARK as Hong Kong's first self-sustaining sludge treatment facility. At T▪PARK, sludge is incinerated to generate heat energy that is harvested and turned into electricity to support the power requirements of various park facilities, including a day spa and a range of recreational and environmental education facilities for the public. Surplus electricity is fed into the power grid, forming an impeccable waste-to-energy cycle.

T▪PARK can handle up to 2,000 tonnes of sludge per day, more than adequate to incinerate the sludge from SCISTW and other sewage treatment works. In March 2015, HATS began transporting dewatered sludge from SCISTW to T▪PARK for incineration, using two purpose-built ocean-going vessels.

Clean Harbour 1 and Clean Harbour 2

To bring the sludge to T▪PARK, sea transportation was preferred as it would eliminate environmental nuisance and traffic impact compared to land transport using container trucks. If container trucks were to be used for transferring sludge to T▪PARK, around 60 truck trips would be expected every day since late 2015, and so impacting on the traffic conditions of the trunk roads from SCISTW to T▪PARK. The project team thus began talking to overseas vessel building experts to identify the best design with environmental features.

Detailed Specifications of Vessels
兩艘輪船技術規格

Overall Length 總長度	69.9m	69.9米
Breadth 闊度	17.5m	17.5米
Hull Depth 船身深度	5.5m	5.5米
Type of Vessel 船舶類型	ocean-going vessels	遠洋輪船
Displacement 排水量	3390 tonnes	3390噸
Capacity 容量	90 twenty-foot equivalent unit (TEU)	90 TEU / 標準貨櫃

A New Journey
雙船出海

A Design-Build-Operate contract was eventually let for the building of two ocean-going vessels and their operation for 10 years, with a five-year extension. This arrangement was chosen to incentivise the contractor to adopt state-of the-art technologies. The vessels were named *Clean Harbour 1* and *Clean Harbour 2*.

Each vessel can handle up to 90 sludge containers per trip, corresponding to about 1,200 tonnes of sludge. Transporting sludge in ocean-going vessel is superior to conventional barge transportation, as a typical barge can only carry about 50 containers of sludge and its operation must be suspended whenever typhoon signal No.3 or above is hoisted. Ocean-going vessels, on the other hand, may continue operating up to typhoon signal No. 8, helping avoid a backlog in the Sludge Dewatering Facility and sludge cake silos on SCISTW during adverse weather conditions.

Environmental Features

The two vessels are the first-ever diesel-electric cargo vessels to be registered in Hong Kong. To reduce their carbon footprint, they are propelled by electric motors using power generated from ultra-low-sulphur diesel or biodiesel. Compared to conventional diesel drives, diesel-electric propulsion systems are technically and operationally superior, with optimal manoeuvring and positioning properties, low vibration and noise levels, and improved fuel efficiency.

When berthed, the vessels are connected to an on-shore power supply, eliminating the use of diesel to further reduce emissions. Compared with ordinary diesel vessels, *Clean Harbour 1* and *Clean Harbour 2* together can cut carbon dioxide emissions by up to 130,000 kg per year, which is equivalent to the annual carbon dioxide absorption capacity of 6,000 trees.

Vessel Design

The new vessels feature a double hull design such that the inner hull will remain watertight in case of damage to the outer hull, allowing the vessel to return safely to the dockyard for repairs. The navigation system includes onboard radar, an electronic chart system, magnetic and gyro compass systems, a depth sounding system, a bridge sound reception system to enable crew to hear fog horns and receive other signals, and other equipment.

The vessels are also equipped with an overhead gantry crane for the direct loading and unloading of sludge containers from lorries. The crane can handle 20 containers in one hour. The gantry crane also minimises the chance of damage to the containers during loading and unloading even in rough sea conditions.

Let the Sailing Begin!

After undergoing thorough stability tests and a number of sea trials, *Clean Harbour 1* and *Clean Harbour 2* set sail on 5 March 2015, loaded with sludge to fuel T ▪ PARK operations. A new journey had literally begun for HATS — a journey of waste-to-energy transformation that has seen our two new vessels move HATS sludge from Stonecutters Island to Tuen Mun day after day ever since.

Clean Harbour 2 launching ceremony
淨港二號下水儀式

Vessel naming competition
污泥運輸船提名比賽

Control panel
控制面板

Captain in wheelhouse
船長在駕駛室

Overhead gantry crane
高架式龍門起重機

Connected to on-shore power supply when berthed
泊岸時連接岸上的電源

Clean Harbour 1 set sail
「淨港一號」啟航

Loading and unloading of sludge containers
裝卸污泥貨櫃

Biodiesel power generator
生物柴油發電機

親愛的維港：

「淨化海港計劃」工程為我們帶來不少工作樂趣，更引領我們勇闖一些意想不到的天地，例如建造兩艘遠洋輪船！

以下是我們工程團隊如何建造「淨港一號」和「淨港二號」的故事。這兩艘設計先進、特別訂造的輪船，專責將昂船洲污水處理廠的污泥運送至屯門的T▪PARK[源▪區]進行焚燒發電，達致轉廢為能的可持續循環。

污泥與T▪PARK[源▪區]：轉廢為能

「淨化海港計劃」第一期於2001年12月落成啟用時，將污泥直接棄置於堆填區是當時唯一處理污泥的方法，即是將經過處理的污泥，由貨櫃車運往新界東南堆填區及新界西堆填區棄置。可是，污泥量的增長很快。自從第一期啟用後，污泥量在2010年代初約為每天600公噸，到第二期甲於2015年年底啟用後，污泥量已增至每天800公噸，預計未來更將增至每天約1,200公噸。政府很快發現，這並非持續可行的廢物處理方案。第一期和第二期甲產生的大量污泥，勢將縮短堆填區的使用壽命。

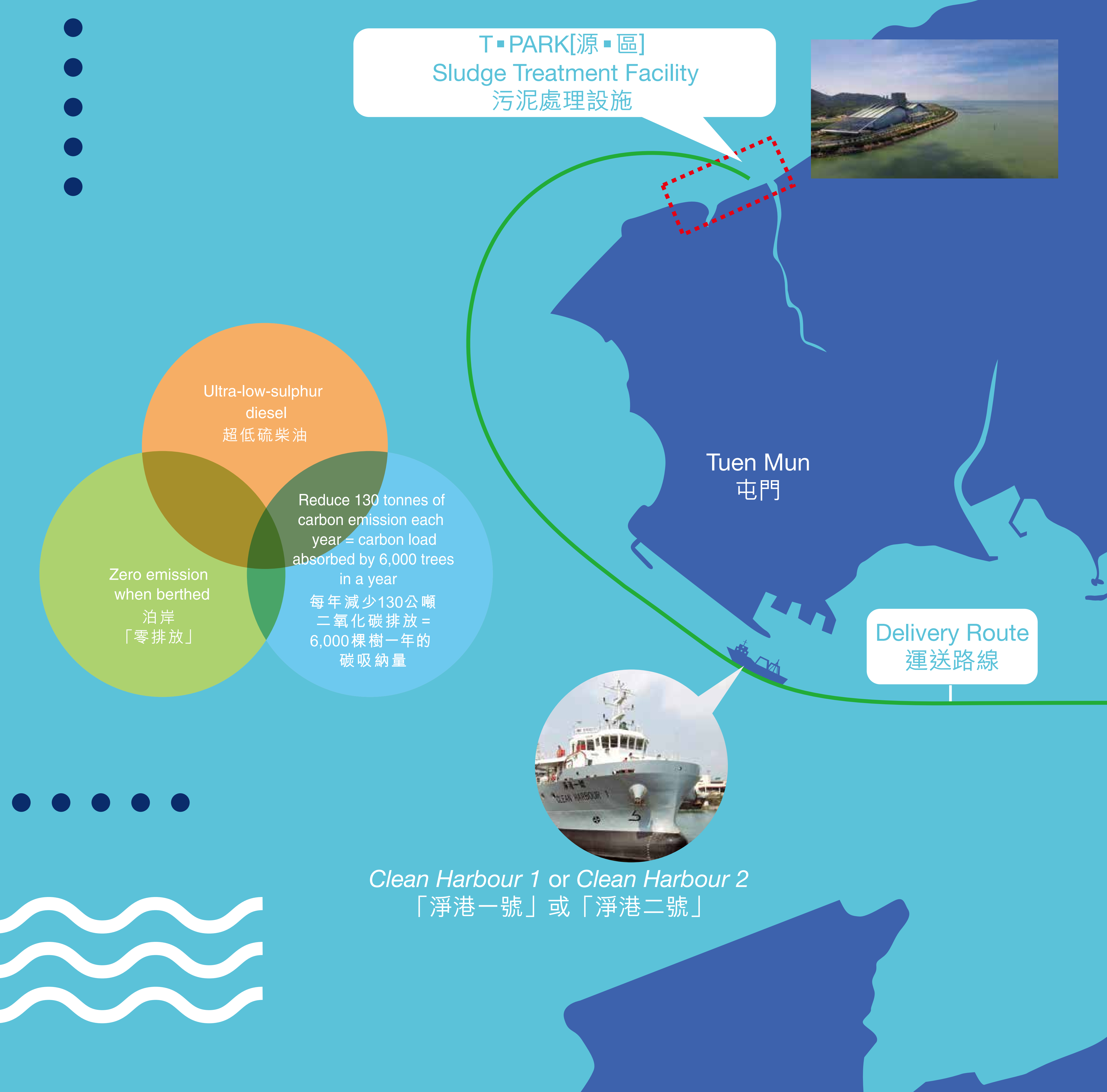
相比之下，焚燒是處理污泥的更佳和更有效方法。污泥經攝氏850度以上超高溫焚燒後會轉化為灰燼和殘渣，體積大減九成，大大減少了要棄置於堆填區的廢物量。

經過深思熟慮，政府決定興建T▪PARK[源▪區]，作為香港首個自給自足的污泥處理設施。T▪PARK[源▪區]將污泥作燃料，焚燒過程產生的熱量會轉化為電力，供應整個園區內所有設施，包括水療池等一系列休閒與環保教育的公共設施。剩餘電力會輸入公共電網，達致轉廢為能的完美循環。

T▪PARK[源▪區]每天可焚燒處理多達2,000公噸污泥，足以應付昂船洲污水處理廠和其他污水處理廠運來的污泥。2015年3月，「淨化海港計劃」開始使用這兩艘特別訂造的遠洋輪船，將經過脫水的污泥從昂船洲污水處理廠運往T▪PARK[源▪區]進行焚燒處理。

「淨港一號」「淨港二號」

與採用貨櫃車的陸路運輸比較，以海路將污泥運往T▪PARK[源▪區]是較佳的方案，可以大大減低運輸過程對陸路交通及環境造成的滋擾和影響。假如採用貨櫃車將污泥運往T▪PARK[源▪區]，估計由2015年年底起，每天需要約60架次，會對由昂船洲污水處理廠至T▪PARK[源▪區]之間主要幹道的交通構成影響。工程團隊於是開始徵詢海外造船專家意見，以確定船隻的最佳設計和應具備的環保特性。


T▪PARK[源▪區]
Sludge Treatment Facility
污泥處理設施
Ultra-low-sulphur diesel
超低硫柴油
Zero emission when berthed
泊岸「零排放」
Reduce 130 tonnes of carbon emission each year = carbon load absorbed by 6,000 trees in a year
每年減少130公噸二氧化碳排放=6,000棵樹一年的碳吸納量
Tuen Mun
屯門
Delivery Route
運送路線
CLEAN HARBOUR 1
Clean Harbour 1 or Clean Harbour 2
「淨港一號」或「淨港二號」


北
N
Stonecutters Island
Sewage Treatment Works
昂船洲污水處理廠

A New Journey
雙船出海

我們最終批出一份設計、建造和營運合約，承建商負責建造兩艘遠洋輪船，營運期為十年，並可延長五年。這種合約安排提供誘因，鼓勵承建商採用最先進的船舶科技及設計。兩艘新船命名為「淨港一號」和「淨港二號」。

每艘船每程可以運載多達90個污泥貨櫃，約等於1,200公噸污泥。以這船運載污泥，較傳統的駁船運輸為佳，因為一般駁船只能運載相當於約50個貨櫃的污泥，而且只要懸掛3號或以上颱風信號，駁船就必須暫停操作。相反，遠洋輪船則可繼續航行至8號颱風信號掛起為止，有助避免昂船洲污水處理廠的污泥脫水設施和污泥塊筒倉在天氣惡劣時，出現污泥積壓的情況。

輪船環保設施

這兩艘船是首批在香港註冊的柴油電動貨輪。船隻由超低硫柴油或生物柴油發電驅動，減少碳排放。與傳統柴油驅動器相比，柴油電動驅動系統在技術和操作上都較優勝，不但提升了燃料功率，更具備最佳操縱和定位功能，振動和噪音水平都極低。

船隻泊岸後，會連接岸上的電源，不用再燒燃柴油，以進一步減少碳排放。與普通柴油船比較，「淨港一號」和「淨港二號」兩艘輪船每年共可減少排放130公噸的二氧化碳，相當於約6,000棵樹木一年的吸碳量。

輪船設計

兩艘新船採用雙殼設計，在船身外殼發生損壞的情況下，仍然有內殼保護，防止船身入水，使船隻能夠安全返回船廠進行維修。船內導航系統設備完善，包括船上航行雷達、電子海圖系統、磁羅盤及陀螺羅盤系統、水深探測系統、及橋樑聲測系統，使機組人員能夠聽到霧角聲和接收其他海上信號。

兩艘船還配備高架式龍門起重機，可以直接從貨車裝卸載有污泥的貨櫃。起重機每小時可處理20個貨櫃，即使海面情況惡劣，仍可減少貨櫃在裝卸過程出現損壞。

揚帆出海！

經過全面的穩定性測試和多次海上試航後，「淨港一號」和「淨港二號」於2015年3月5日正式啟航，載着污泥朝T▪PARK[源▪區]出發，為T▪PARK[源▪區]的運作提供燃料。兩艘新船，自此為「淨化海港計劃」展開了名符其實的新旅程，一天復一天將污泥從昂船洲運送往屯門，也開展了一個轉廢為能的變革之旅。

POSTSCRIPT

"I am privileged to have had the opportunity to participate in the HATS project which spanned over 20 years. Numerous difficulties and setbacks were encountered, particularly during Stage 1. We strived to overcome the engineering challenges and conducted extensive public consultations. All difficulties were eventually resolved satisfactorily."

"HATS often gave us interesting assignments never imagined before, such as designing two ocean going vessels. The vessels were built to transport sludge to T▪PARK for incineration and electricity generation to complete the waste-to-energy loop. The process of designing sea vessels was very satisfying indeed!"

附箋

「很難得有機會參與這橫跨廿多年的項目，經過很多困難和挑戰，第一期更曾出現很多問題。我們除了努力處理工程問題，也做了很多公眾諮詢，最後都能順利解決。」

「『淨化海港計劃』有趣的地方，是讓我們涉獵到意想不到的工作，比如要設計兩艘遠洋輪船，把污泥從昂船洲污水處理廠運往T▪PARK[源▪區]焚化發電，轉廢為能。有機會設計輪船，非常有滿足感！」

Henry CHAU Kwok-ming
周國銘

System Advisor,
Drainage Services Department
渠務署系統顧問

COMMUNICATION AND RAPPORT
溝通共融

LETTER 9 信件九

COMMUNICATION AND RAPPORT

溝通共融

Communication and Rapport
溝通共融

海岸清潔

Dear Harbour,

The Harbour Area Treatment Scheme, or HATS, was designed to serve up to 5.7 million people. As such, extensive consultation and community engagement as well as rapport building were important to get people's buy-in. Listening to different stakeholders' views also helped minimise disruption to community life and normal economic activities during HATS construction and its subsequent operation.

Naturally, a mega infrastructure project straddling more than two decades and on the scale of HATS would not be smooth sailing all the way. Indeed, HATS Stage 1 drew public concerns about the environmental and technical problems associated with its deep tunnels, as well as criticisms of its sewage treatment level and heavy reliance on one centralised treatment works.

The project team learnt very quickly that HATS had to earn the trust of the public and community support if it was to succeed. We thus undertook an extensive communication and public engagement programme for HATS Stage 2.

Public Consultation

Back in the 1990s, it was not common practice to conduct extensive public consultation on government projects, and HATS Stage 1 was no exception. There was formal consultation on HATS Stage 1, including presentations to the Legislative Council and District Councils, called District Boards at that time. The Government also set up the first International Review Panel (IRP) in 1994 to examine the Stage 1 plan. After Stage 1 full commissioning and with the benefit of experience from Stage 1, the project team embarked on a more extensive public consultation and community engagement programme for Stage 2.

On an expert level, the Government set up the second IRP in 2000 to examine its treatment and disposal options for Stage 2 of HATS. It was the second IRP which paved the way for the first public territory-wide consultation on HATS.

In its final report released in November 2000, the second IRP proposed four treatment and discharge options with varying degrees of decentralisation and recommended the Government carry out a series of technical trials and studies to determine the way forward.

Upon completion of those trials and studies in June 2004, the Government moved on to conduct a five-month, territory-wide public consultation from June to November 2004. In-depth briefings on HATS Stage 2 were provided to key stakeholders such as green groups, professional bodies and community representatives. A public hearing was also held to collect views from the public directly.

Overall, the public expressed very positive views about water quality improvements achieved since HATS Stage 1 was commissioned in 2001. The public also supported the implementation of HATS Stage 2 in two phases, as proposed by the Government, to bring further improvement to our Harbour water quality.

There was also strong public support for the "polluter pays" principle in funding sewage treatment services in the territory, a vital element for the new works and ongoing operation of HATS. Results of the public consultation were reported to the Legislative Council, which eventually gave the green light to HATS Stage 2A.

Continuous Public Involvement

Despite overall public support for HATS, there were still specific concerns about the disinfection facilities proposed for the Stonecutters Island Sewage Treatment Works (SCISTW), such as worries about the effectiveness of different disinfection technologies, the toxicity effects of by-products from the disinfectants on marine ecology, and the environmental impacts of Stage 2A on human health and aquatic life.

The Government next commissioned two Environmental Impact Assessment (EIA) studies, one on the Advance Disinfection Facility for the SCISTW and the other on HATS Stage 2A works. The EIAs were an excellent opportunity to address the public concerns, as they provided a framework for comprehensive environmental impact assessments on every aspect of Stage 2A works, including water quality, odour and other risks to human and marine life.

Leveraging the EIAs, the project team decided to adopt a proactive Continuous Public Involvement (CPI) programme to facilitate the public to learn about HATS Stage 2A. Our aim was to help members of the public become reasonably conversant with the issues when giving opinions and suggestions, which would in turn help finetune the project. Intensive and targeted, the CPI programme lasted more than two years from December 2005 to January 2008.

In addition to holding formal briefings for District Councils, the Legislative Council and the Advisory Council on Environment, six more rounds of public consultations were held for specific sectors like green groups, academics and professional institutions to solicit in-depth views. Various concerns expressed were fully considered and responded to through follow-up communications and meetings. This was well documented in the EIA reports, and approval of the EIA studies was subsequently obtained from the authorities with minimal public objections.

Communication and Rapport
溝通共融

Engaging the Community and Media

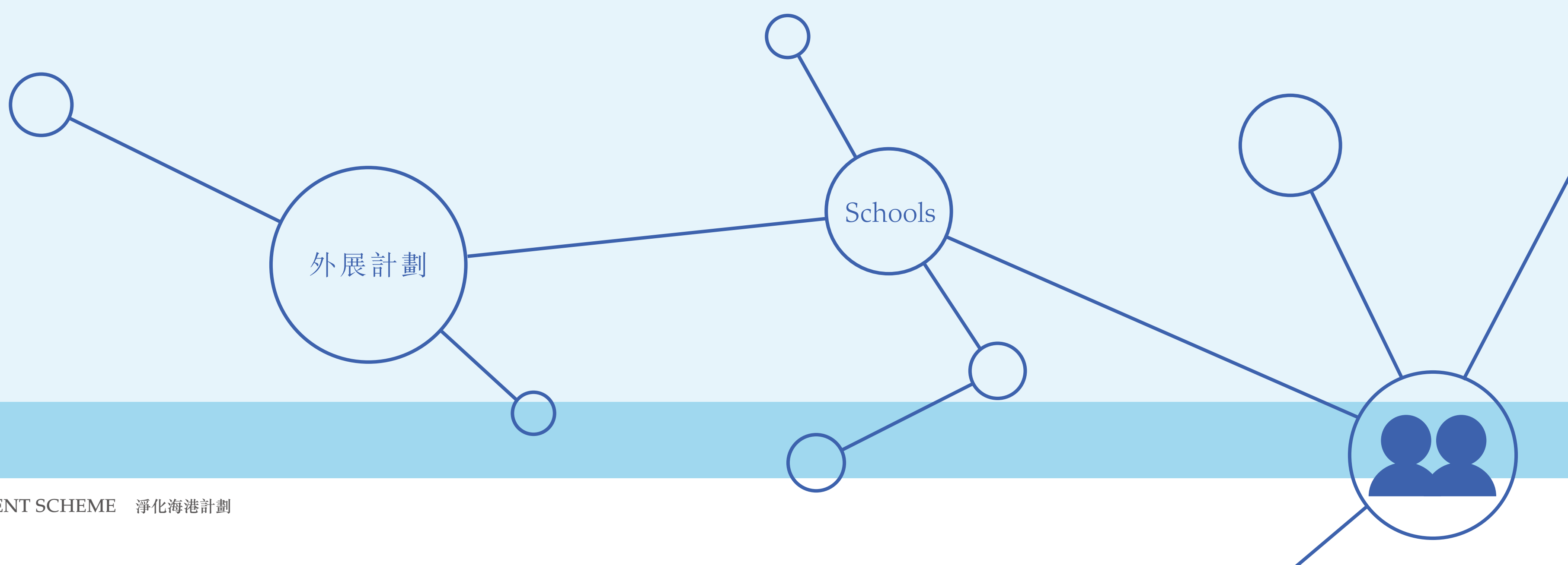
The project team decided early on that a comprehensive community engagement programme for HATS Stage 2A works would be invaluable, in particular in those districts along the alignment of the deep tunnel system. DSD set up a dedicated committee that met regularly to plan and oversee all community relations, public engagement and publicity activities. Key contractors were also obligated to put together a front-line community relations team to help implement the programme.

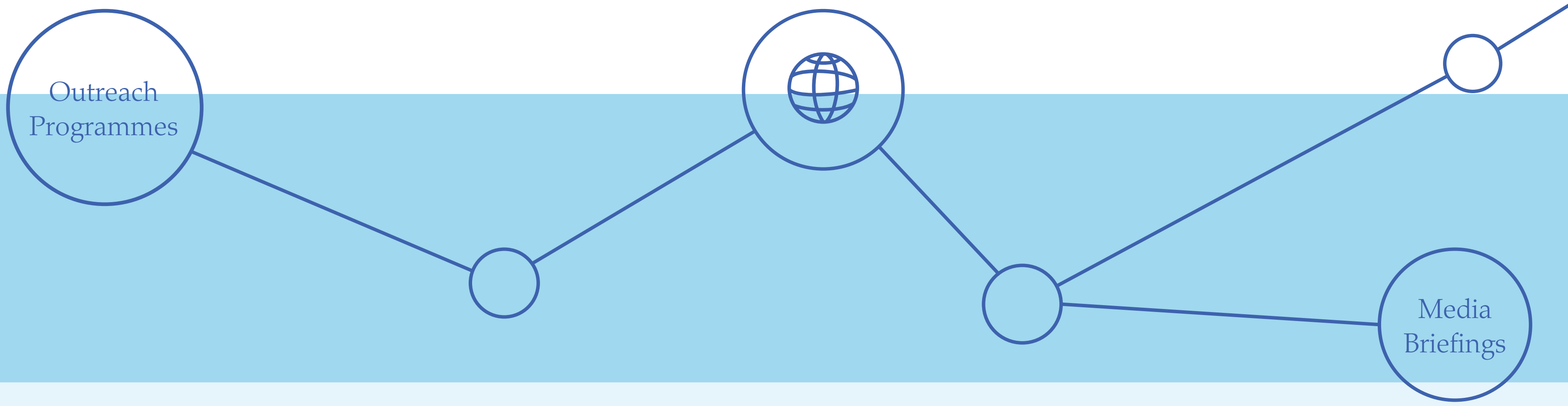
A wide range of communication and rapport building tools were deployed: regular newsletters on engineering works updates, a 24-hour hotline, community outreach programmes for schools, site visits for students and interested groups, drawing competitions for site hoardings, fundraising activities for the Community Chest and other charitable organisations, and blood donation days for the Red Cross — just to name a few.

The project team and its contractors also took extra measures to make sure that the drill and blast method used for Stage 2A tunnelling caused minimal disruption to nearby neighbourhoods. Special visits were made, for example, to schools, hotels and homes for the elderly near the tunnel alignment and even the Society for the Prevention of Cruelty to Animals to allay their concerns about the potential impact of underground blasting. After a few rounds of communication and several test blasts, the actual drill and blast works proceeded smoothly without noticeable disruption to the neighbourhood.

Media relations was another component of our publicity and engagement exercise. Numerous media briefings were held to mark key milestones, such as the breakthrough of major sections of the deep tunnels, the maiden voyage of the two sludge vessels, the activation of the flow turning process at the upgraded Preliminary Treatment Works, and the grand commissioning ceremony for Stage 2A.

Overall, both local and international media coverage was positive and enthusiastic, reflecting the sentiment that HATS was truly a project for the good of the Harbour and everyone in Hong Kong.





Awards and Recognition

HATS has won numerous local, national and international awards for its engineering excellence and technological innovation in recent years, not to mention various occupational safety and health accolades and other excellence awards that our contractors have won for HATS-related work.

Here are just a few of the major awards in the HATS trophy cabinet.

- The Global Water Award by the International Water Association (IWA) recognises significant contributions to the world in which water is wisely managed. The HATS project, together with the T▪PARK project, won the **IWA Global Water Awards — Wastewater Project of the Year (Distinction) in 2016**, the most prestigious international honour.

- The HATS project was awarded the **15th Tien-yow Jeme Civil Engineering Prize — Municipal Engineering Category in 2018** for its outstanding achievements in technological innovation and application. Established by the China Civil Engineering Society and the Beijing Tien-yow Jeme Foundation for Development of Science and Technology in Civil Engineering, this award is widely known as the top civil engineering prize in China.

- Other international awards have also followed, such as the **British Construction Industry Awards — International Project of the Year (Highly Commended) in 2016**. This is a prestigious award in the built environment sector, with winning projects and teams recognised for their achievements within the industry and among the public at large.

- The HATS project also won the **2018 Edmund Hambly Medal of the Institution of Civil Engineers, U.K.** for its outstanding achievements in sustainable development.

- Here in Hong Kong, the HATS project got the **Second Highest Votes in the Hong Kong People Engineering Wonders in the 21st Century in 2013** — a public poll organised by the Hong Kong Institution of Engineers. This award aims to enrich the public's understanding of engineering projects in Hong Kong and to recognise the contribution of local engineers to sustainable development in our city.

- Also in Hong Kong, the HATS project won the **Silver Award in the Public Sector Category of the Construction Industry Council Sustainable Construction Award 2018** for its achievements in sustainable construction.

So, dear Harbour, our mission to make your water pristine and healthy again is accomplished. But we must make sure that your water stays clean and healthy in the long run in a sustainable manner — the topic for another letter.

親愛的維港：

「淨化海港計劃」的設計，最終能為570萬人提供污水處理服務。因此，廣泛的公眾參與和諮詢及與社區建立融洽關係非常重要，這樣方可獲得市民的支持。用心聆聽不同持份者的意見，有助減少項目在工程進行期間及日後營運時，對社區民生及日常經濟活動造成的影響或滋擾。

「淨化海港計劃」乃規模龐大的超級基建項目，歷時二十多年，自然不會一帆風順。事實上，項目第一期的深層隧道工程曾引起公眾關注，擔心項目涉及的環境和技術問題；當時更有批評指項目過份倚賴單一的中央污水處理廠，對污水處理級別的問題也有意見。

工程團隊很快明白到，項目成功關鍵，在於必須得到公眾和社區的支持與信任。因此，我們為「淨化海港計劃」第二期進行了廣泛的公眾溝通和參與計劃。

公眾諮詢

回顧九十年代，政府工程項目的大型公眾諮詢並不多見，「淨化海港計劃」第一期也不例外。我們為「淨化海港計劃」第一期工程進行了正式諮詢，包括向當時的立法局和區議會進行簡報闡釋，並於1994年成立國際專家小組，檢視第一期工程的計劃。第一期工程全面落成啟用之後，工程團隊汲取了第一期工程的經驗，決定為第二期工程推出更全面的公眾諮詢和社區參與計劃。

在專家層面，政府於2000年成立了第二個國際專家小組，負責檢視及研究第二期的排放及處理方案。這國際專家小組的有關研究，更為日後的公眾諮詢工作開路。

第二個國際專家小組在2000年11月公布最終報告，提出四個污水處理和排放方案，包括不同程度的分散式處理方案，並建議政府進行一系列的技術測試和研究，以決定計劃的未來路向。

政府在2004年6月完成這些測試和研究後，於2004年6月至11月進行了為期五個月的公眾諮詢工作，當中包括為環保組織、專業團體及社區代表等主要持份者，就「淨化海港計劃」第二期工程舉辦了深入的技術簡介會。此外還舉行了公聽會，直接收集公眾意見。

整體而言，市民對於「淨化海港計劃」第一期自2001年投入服務後維港水質的明顯改善，有非常正面反應。市民亦支持政府分兩階段落實「淨化海港計劃」第二期工程的建議，以進一步改善維港水質。

此外，以「污染者自付」原則應付本港污水處理服務的開支，也得到市民強烈支持，這徵費安排對「淨化海港計劃」的未來工程及營運至關重要。政府其後將公眾諮詢結果向立法會滙報，立法會隨後亦為第二期甲工程開了綠燈。

持續的公眾參與

儘管市民普遍支持「淨化海港計劃」，但對昂船洲污水處理廠的消毒設施仍有疑慮，例如擔心消毒技術的成效、消毒劑釋出的有毒副產品會否影響海洋生態、及第二期甲工程對人類健康和海洋生物造成的環境影響等。

政府繼而推出兩項環境影響評估(環評)研究，一項是關於在昂船洲污水處理廠興建前期消毒設施的研究，另一項是關於「淨化海港計劃」第二期甲工程的研究。環評研究提供全面的環境影響評估框架，包括水質、氣味以及其他影響人類及海洋生態的風險。進行環評研究是個大好機會，讓公眾在過程中釋除對項目的種種疑慮。

工程團隊決定主動推出一個持續公眾參與計劃，借助環評研究，讓公眾人士了解「淨化海港計劃」第二期甲工程，從而熟悉有關議題及提出意見和建議，好讓團隊對項目作出微調。密集和針對不同持份者的持續公眾參與計劃，由2005年12月起舉辦至2008年1月，持續了兩年多。

除了為區議會、立法會和環境諮詢委員會舉行多場正式簡報會外，我們還為環保組織、學術界和專業機構等不同界別舉辦了六輪公眾諮詢，以徵詢及收集他們的深入意見，並透過跟進通訊和會面，充分考量及回應他們在諮詢過程中表達的關注及疑慮，在環評報告中亦有詳盡記錄。這些報告，其後在極少公眾反對的情況下順利獲得通過。

動員社區參與和傳媒關係

工程團隊很早已知道，為「淨化海港計劃」第二期甲工程制訂全面的社區參與計劃非常重要，特別是受深層隧道系統沿線影響的地區。渠務署就此成立了專責委員會，定期舉行會議，策劃和監督所有社區關係、公眾參與和宣傳活動，並要求主要承建商成立前線社區關係小組，協助實施計劃。

團隊部署了一系列加強溝通及建立融洽社區關係的活動，包括出版定期通訊報導工程進度、24小時查詢熱線、學校外展計劃、安排學生和有興趣的團體實地參觀、工地圍板繪畫比賽、公益金及其他慈善機構的籌款活動、及紅十字會捐血日等。

工程團隊及承建商還採取了額外措施，確保第二期甲隧道挖掘工程進行鑽爆時，能盡量減低對附近社區的滋擾及影響，包括特別拜訪隧道沿線的學校、酒店、老人院以至愛護動物協會，釋除他們對地下爆破或會造成影響的疑慮。經過多次溝通和數次爆破測試後，爆破工程最終都能順利進行，並沒有對附近社區造成影響。

傳媒關係是我們宣傳及公眾參與活動的重要一環。就「淨化海港計劃」的各個重要里程碑，我們舉辦了多場傳媒簡報會，包括深層隧道主要路段貫通、兩艘污泥貨櫃船正式啟航、多所基本污水處理廠改善工程落成後啟動截污轉流、及慶祝第二期甲項目全面落成啟用的盛大儀式等。

Communication and Rapport
溝通共融

Clean Shorelines

總體而言，「淨化海港計劃」廣受傳媒歡迎，本地和國際傳媒的報導都積極正面，反映項目確能為維港及港人帶來裨益。

獎項與表彰

憑藉卓越的工程和創新技術，「淨化海港計劃」近年贏得不少本地、國家及國際級獎項及榮譽，還有林林總總的職業安全及健康獎項，和承辦商透過「淨化海港計劃」各項出色合約工程獲發的獎項。

「淨化海港計劃」獲獎甚多，以下是較重要的例子。

- 「淨化海港計劃」聯同污泥處理設施T▪PARK[源▪區]榮獲**2016年「全球水獎之年度污水處理專案卓越大獎」**。「全球水獎」是備受推崇的國際榮譽，由「國際水協會」創辦，旨在表彰在全球水資源管理方面作出重要貢獻的項目。
- 「淨化海港計劃」於**2018年獲頒第十五屆「中國土木工程詹天佑獎」的「市政工程組別」獎項**，表揚項目在科技創新和應用方面的傑出成就。該獎項由中國土木工程學會和北京詹天佑土木工程科學技術發展基金會共同設立，公認為中國土木工程界的最高榮譽。
- 其他獎項還包括**2016年英國建造業大獎之「年度國際工程項目高度表揚獎」**。這是建築環境業界的重要獎項，獲獎項目及相關團隊的成就，均獲業界及公眾高度認同。
- 「淨化海港計劃」更獲頒**2018年度英國土木工程師學會Edmund Hambly獎章**，表揚計劃在可持續發展方面的傑出成就。
- 在香港，「淨化海港計劃」在**2013年以第二最高票數，獲選為「21世紀香港十大傑出工程項目」**之一。這獎項由香港工程師學會舉辦，透過公開投票方式，讓市民直接選出心目中本港十大傑出工程項目，旨在提高公眾對本港工程項目的認識，及表揚本地工程師對本港可持續發展的貢獻。
- 另一個香港獎項是**2018年「建造業議會可持續建築大獎」公營組別的銀獎**，以表揚「淨化海港計劃」在可持續建造方面的出色表現。

親愛的維港，我們要讓您水質再現澄澈、回復健康的任務，至此已經完成。然而，我們仍必須確保您的水質，可持續地永保清潔健康。這正是下一封信的主題。

POSTSCRIPT

"I am one of the few who have participated in both HATS Stage 1 and Stage 2A works. There are many unforgettable experiences, such as dealing with the Stage 1 contractor which unilaterally abandoned the works, the underground water ingress problem, and alleviating concerns about the project in certain quarters of the community. The most memorable occasions are the first tunnel breakthrough in Stage 1, the flow turning of the Stage 2A works and the full commissioning ceremony. All of them are exciting moments."

"In future we must continue to monitor the water quality in Victoria Harbour to ensure it is no longer affected by pollution. We must also monitor the deep tunnel system to make sure that it operates smoothly, and explore more application of new technology to make HATS operate even better."

附箋

「我是少數在『淨化海港計劃』第一期和第二期甲工程都有參與的人，當中難忘經驗很多，譬如處理第一期隧道工程承建商單方面放棄工程、地下水滲入問題、和釋除社會部份人士對項目的疑慮等。印象最深的，則是第一期工程首次成功貫通隧道，第二期甲工程啟動截污轉流和開幕典禮，都是令人興奮的時刻。」

「未來我們仍須繼續監察維港水質，確保不再受污染影響，也要監察深層隧道系統，確保運作暢順，和探討應用更多新科技去使整個『淨化海港計劃』運作得更好。」

Edwin TONG Ka-hung
唐嘉鴻
Director,
Drainage Services Department
渠務署署長

WORLD-WIDE

AWARDS AND RECOGNITION

全球**獎項與嘉許**

Hong Kong People Engineering Wonders
in the 21st Century (2013)
Second Highest Votes
21世紀香港十大傑出工程項目(2013)
第二最高票數

The Hong Kong Institution of Engineers
香港工程師學會

British Construction Industry Awards (2016)
International Project of the Year
Highly Commended
英國建造業大獎(2016)
年度國際工程項目
高度表揚獎

Institution of Civil Engineers, U.K.
英國土木工程師學會

Edmund Hambly Medal (2018)
Edmund Hambly獎章 (2018)

Institution of Civil Engineers, U.K.
英國土木工程師學會

The 15th Tien-yow Jeme Civil Engineering Prize (2018)
Municipal Engineering Category
第十五屆中國土木工程詹天佑獎(2018)
市政工程組別

China Civil Engineering Society and the Beijing Tien-yow Jeme Foundation for Development of Science and Technology in Civil Engineering
中國土木工程學會和北京詹天佑土木工程科學技術發展基金會

Global Water Awards (2016)
Wastewater Project of the Year
Distinction
全球水獎(2016)
年度污水處理專案
卓越大獎

International Water Association
國際水協會

CIC Sustainable Construction Award (2018)
Public Sector Category
Silver Award
建造業議會可持續建築大獎 (2018)
公營組別
銀獎

Construction Industry Council
建造業議會


技术交流会暨颁奖大会


第十五届中国土木工程詹天佑奖
技术交流会暨颁奖大会


HKIE


Edmund Hambly
Award
Harbour Treatment
Scheme Hong Kong
HATS

THE SUSTAINABILITY DRIVE
永續發展


LETTER 10 信件十
THE
SUSTAINABILITY
DRIVE
永續發展

The Sustainability Drive
永續發展

Dear Harbour,

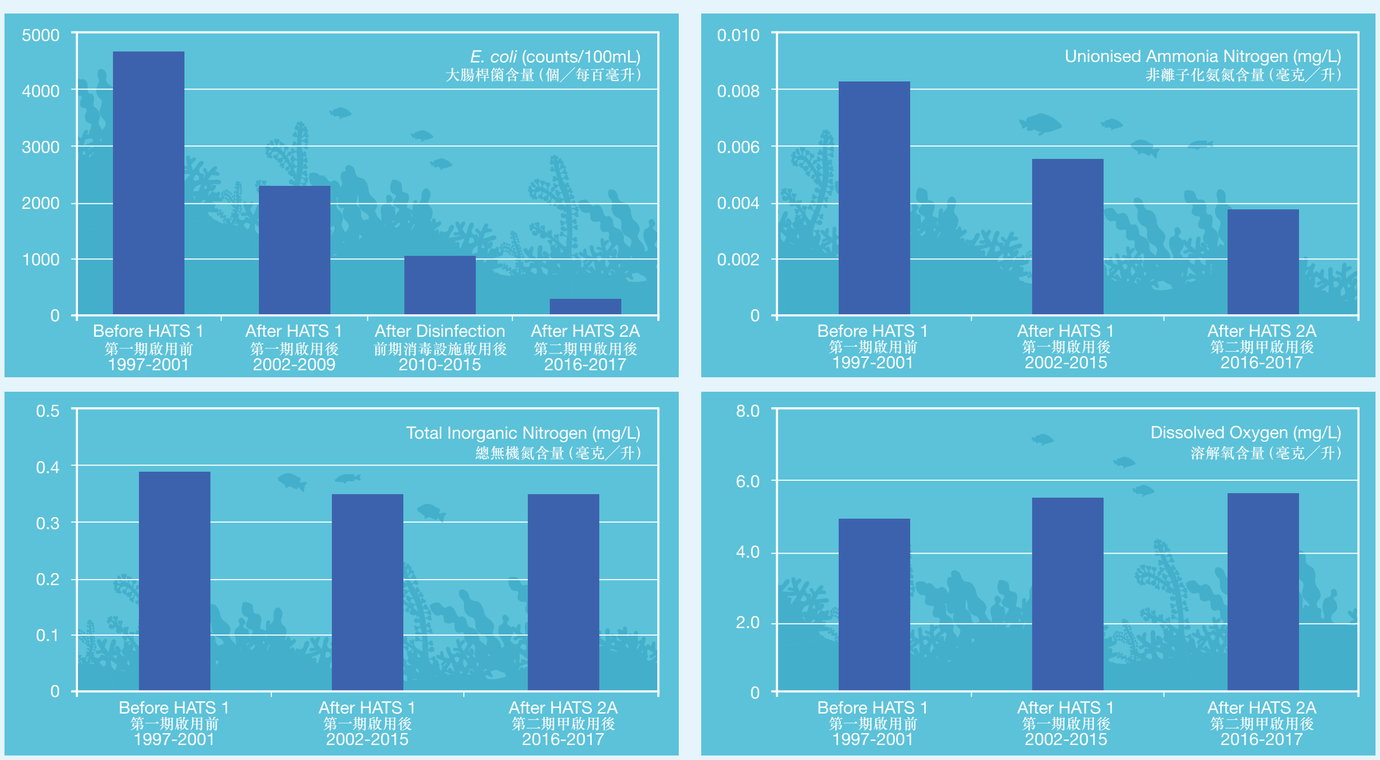
The HATS story would not be complete without a note on its sustainability achievements. The project was designed and constructed in accordance with eco-friendly objectives and principles, and these also guide its ongoing operation. As the largest ever sustainable infrastructure project in Hong Kong, HATS has created a template for future sewage collection, treatment, and disposal infrastructure development in our city.

Water Quality

HATS was initiated primarily to tackle harbour water pollution, and so water quality improvement in Victoria Harbour is our single most important sustainability objective.

In its 2016 Annual Report on Marine Water Quality, the Environmental Protection Department said this of Victoria Harbour: "Water quality has been improving significantly with the progressive implementation of the Harbour Area Treatment Scheme, particularly after the commissioning of HATS Stage 2A in December 2015."

Water Quality Improvement Since Implementation of Harbour Area Treatment Scheme
「淨化海港計劃」實施以來水質改善情況



The report goes on to say that the Water Quality Objectives (WQO) compliance rates for Dissolved Oxygen, Unionised Ammonia Nitrogen and Total Inorganic Nitrogen were 100%, 100% and 80% respectively in 2016, as compared with only 50% to 90% in the 2011–2015 period. The overall annual geometric mean *E. coli* level in the harbour was also down to around 300 counts per 100 millilitres, a tenfold reduction from the late 1990s.

Biodiversity is also on the increase, as exemplified by coral colonies and other aquatic life thriving again in the harbour. "Soft coral found living in Victoria Harbour points to cleaner water," reported the *South China Morning Post* in August 2014, echoing similar articles in other media.

Another environmental milestone was achieved in 2011 with the resumption of the annual Cross Harbour Race in the eastern part of the harbour. The event had been suspended since 1978 due to harbour pollution. In 2017, the race finally returned to its original route in the central part of the harbour after 40 years — a testament to improving water quality. Secondary water contact activities and events such as dragon boat racing are now held in Victoria Harbour throughout the year.

The Cross Harbour Race finally returned to the central part of Victoria Harbour in 2017
渡海泳終於2017年重返維港中部水域舉行

專家歸功淨化海港計畫

維港現珊瑚媲美潛水勝地

北角水質差 珊瑚遭「淹死」

Sing Tao Daily of 10 October 2004
《星島日報》2004年10月10日報導

Sustainable Project Design

The HATS project is sustainable at many levels. From the design and operation of the deep sewage tunnels and the Stonecutters Island Sewage Treatment Works (SCISTW), to the waste-to-energy disposal of the dewatered sludge from SCISTW and the greening and landscaping of the various enhanced Preliminary Treatment Works (PTWs), every facility and process aims to reduce energy consumption, minimise carbon emissions, and conserve natural resources.

The HATS economic model is self-sustaining and its relationship with its neighbourhood is harmonious.

Energy Efficiency and Conservation

The collection and transportation of sewage consume a lot of energy. HATS has adopted the "inverted siphon" principle in the design of its deep sewage tunnel system, achieving significant savings in energy. Furthermore, sewage levels in the drop shafts of upstream PTWs are monitored by sensors that provide real-time data to the pumping control system on SCISTW. This serves to optimise pumping energy without causing overflow upstream.

Hydro-turbine system at SCISTW
昂船洲污水處理廠的水力渦輪發電系統

A key environmental feature of SCISTW is the Sludge Dewatering Facility which converts wet sludge into sludge cakes. These are transported by two sludge vessels to the T▪PARK at Tuen Mun for incineration and electricity generation, a good example of the waste-to-energy principle in action. Other eco-friendly and energy-saving facilities adopted at SCISTW include insulated glass glazing, daylight sensors, energy-efficient variable refrigerant volume air-conditioning, skylights, green roofs, photovoltaic panels, solar water heaters, and energy-efficient lighting — many of which are adopted at PTWs, too.

The DSD is also adding new green features. As part of a pilot scheme, a hydro-turbine system has been introduced to utilise sewage flow hydraulic energy to move turbine impellers that in turn drive a generator to produce electricity for SCISTW. The system can generate up to 120,000 kWh of electricity per year, reducing energy cost and carbon emissions.

Greening, Landscaping and Neighbourhood

The SCISTW and PTWs are designed to be aesthetically pleasing, with lots of greening and landscaping. Additional greening features have also been introduced, such as bioswales and rain gardens that remove pollutants from stormwater runoff. Permeable pavements with grasscrete panels are used in place of hard concrete pavements to allow rainwater to drain more easily into the soil and thus to avoid flooding — an application of the "Sponge City" concept.

We also take proactive measures to reduce noise and odour nuisance to residential developments near the SCISTW and PTWs. Furthermore, green roofs have been incorporated in the design of buildings and structures to improve aesthetics.

We also meet community aspirations by opening up some areas originally designated to operation and maintenance for people's enjoyment. A good example is a direct route through the Cyberport PTW, now opened to the public for easy access to the seaside promenade. Planned fencing works there have also been replaced by beautification and planting works to make the access route more pedestrian friendly.

Another example is the Sai Ying Pun Junction Shaft area, connected to the promenade, which will only be closed during a short period annually for inspection and maintenance.

Access road and pedestrian footpath at Cyberport PTW
於數碼港基本污水處理廠的車輛通道及行人路

Economic Sustainability

The introduction of a sewage charge and trade effluent surcharge based on the "polluter pays" principle has not only secured funding to offset ongoing operations and maintenance cost, but also helped raise public awareness of the importance of sewage treatment. It provides an incentive, too, for the trade and industries to reduce pollution. Under the Chemical Oxygen Demand reassessment mechanism, trades and industries that have good practices or provide treatment to reduce polluting loads can apply for a reduction in trade effluent surcharge.

The DSD is constantly exploring cost-saving measures to ensure the economic sustainability of HATS and other treatment facilities in terms of energy consumption, chemical usage, and asset management. Maintaining your water quality, our dear Harbour, is our long-term commitment. The economic sustainability of HATS is in place to help us keep our promise to you for the future.

Sai Ying Pun junction shaft and adjacent paved area
西營盤匯合豎井及鄰近已鋪設的路面

Greening and landscaping at North Point PTW
北角基本污水處理廠的綠化和園境設計

Permeable pavement with grasscrete panels at North Point PTW
北角基本污水處理廠的透水性鋪面及混凝土草格

Green roof at Wan Chai East PTW
灣仔東基本污水處理廠的綠化天台

Curtain wall at Wan Chai East PTW
灣仔東基本污水處理廠的玻璃幕牆

Green roof at SCISTW sludge dewatering facility
昂船洲污水處理廠污泥脫水設施的綠化天台

Green roof at SCISTW Main Pumping Station No. 2
昂船洲污水處理廠二號主泵房的綠化天台

Bird eye view of Central PTW
中環基本污水處理廠鳥瞰圖

Green roof at Central PTW
中環基本污水處理廠的綠化天台

Close-up of a skylight at Central PTW
中環基本污水處理廠的採光天窗

The Sustainability Drive
永續發展

親愛的維港：

在整個「淨化海港計劃」中，可持續發展方面的成就是不可不提的。由設計、建造至日常營運操作，整個項目都根據環保目標和原則去進行。「淨化海港計劃」乃香港有史以來規模最大的可持續發展基建項目，為我們未來的污水收集、處理和排放的基建發展提供典範。

水質

「淨化海港計劃」的初衷，是為了解決維多利亞港的水質污染問題，所以改善維港水質是我們最重要的可持續發展目標。

有關維港的水質狀況，環境保護署在其2016年海水水質年報中這樣描述：「隨著「淨化海港計劃」的逐步實施，特別是於2015年12月第二期甲工程啟用後，維多利亞港水質顯著改善。」

報告表示，維港水域的溶解氧、非離子化氨氮及總無機氮水質指標在2016年的達標率分別為100%、100%和80%，而2011–2015年期間僅為50–90%。大腸桿菌全年幾何平均水平亦下降到每百毫升約300個，與上世紀九十年代末相比減少了十倍。

生物多樣性也在增加，珊瑚和其他海洋生物在海港重生。《南華早報》在2014年8月報導：「軟珊瑚在維多利亞港出現，證明水質已經改善」，其他傳媒也有類似關於維港水質改善的報導。

渡海泳已於2011年於維港東面復辦，標誌着另一個環保里程碑。這游泳盛事一度因為海港污染由1978年起停辦，直至40年後的2017年，渡海泳終於重返40年前的路線，在維港的中部水域舉行，足證維港水質已經復元。今天，林林總總的間接接觸水上康樂活動，例如龍舟競賽等，均可以一年四季在維多利亞港舉行。

可持續的項目設計

「淨化海港計劃」項目在很多層面都是可持續的。從深層污水隧道及昂船洲污水處理廠的設計及運作，到昂船洲污水處理廠將脱水後的污泥「轉廢為能」，以及基本污水處理廠的各種綠化及園境設計等，每個設施和流程都旨在減少能源消耗、減少碳排放及珍惜保護自然資源。

「淨化海港計劃」的經濟模式是自給自足的，而項目與鄰近社區的關係也相當和諧。

能源效益及保育

污水的收集和運輸過程，會消耗大量能源。「淨化海港計劃」的深層污水隧道系統採用倒虹吸管設計，可節省大量能源。此外，上游基本污水處理廠的豎井備有感應器監測污水水位，能提供實時數據到昂船洲污水處理廠的泵送控制系統，有助優化控制泵送量，避免上游出現溢流。

污泥脫水房是昂船洲污水處理廠一個重要的環保設施，它將濡濕的污泥脫水成污泥塊，然後由兩艘污泥貨櫃船運送到屯門的T▪PARK[源▪區]，進行焚燒發電，乃「轉廢為能」的最佳典範。昂船洲污水處理廠的其他環保及節能設施包括隔熱玻璃窗、日光感應器、備有可變製冷劑量的節能空調系統、天窗、綠化天台、光伏板、太陽能熱水器及節能照明系統。其他基本污水處理廠也採用了許多上述設施。

渠務署還增添了新的環保設施。我們在昂船洲污水處理廠安裝水力渦輪發電系統的先導計劃，利用下瀉的污水的液壓能量推動渦輪機，從而產生電力供廠內設施使用。該系統每年可產生高達12萬度電，有助節省能源及減少碳排放。

綠化、園境設計及鄰近社區

昂船洲污水處理廠及基本污水處理廠的建築力求美觀環保，包含大量綠化和園境設計。我們還引入其他綠化元素，例如生態窪地和雨水花園，可以過濾雨水徑流中的污染物; 並以草磚鋪設透水路面代替混凝土路面，使雨水更容易滲入土壤，發揮「海綿城市」作用，有助防洪。

我們還積極採取措施，減少昂船洲污水處理廠及基本污水處理廠對鄰近的住宅發展項目造成噪音及氣味滋擾。此外，污水處理廠的建築物都採用綠化天台設計，美化外觀。

我們也開放了一些原本用作操作及維修的地方供市民享用，滿足公眾期望。數碼港基本污水處理廠是例子之一，廠房部份路段現已開放給市民直接前往海濱長廊。原計劃的圍欄工程也以一些美化及綠化工程代替，讓行人更樂於使用該通道。

另一例子是與長廊相連的西營盤匯合豎井範圍，該處每年僅關閉一段短時間作檢查及維修之用。

經濟可持續性

我們以「污染者自付」原則引入排污費和工商業污水附加費，不僅可補助項目日常營運及維修的開支，更有助提高公眾對污水處理重要性的意識，同時也提供誘因予工商業用戶減少污染。工商業用戶如具備良好作業或污水處理，並有效減少排污比率，可透過「化學需氧量重新評估機制」，申請下調其帳戶的工商業污水附加費收費率。

渠務署會不斷探索節省成本的措施，以確保「淨化海港計劃」及其他處理設施在能源消耗、化學品用量和資產管理方面的經濟可持續性。親愛的維港，為您的水質把關是我們的長遠承諾。「淨化海港計劃」已具備可持續的經濟模式，有助我們履行對您未來的承諾。

POSTSCRIPT

"I was involved in the maintenance and operation work of HATS in its early days, and began participating in its overall management in 2014. That was the time when the scheduled commissioning of Stage 2A was imminent, and there was enormous pressure on the team. Fortunately, all the difficulties were eventually resolved and the full commissioning went smoothly."

"We tried to apply renewable energy as much as possible in HATS, such as installing rooftop photovoltaic panels at the preliminary treatment works. We also installed hydro-turbines to tap the energy from falling sewage in the double-tray sedimentation tanks to generate electricity for internal use. This boosts cost efficiency and provides a good case for public education."

附箋

「我早期曾參與『淨化海港計劃』的維修和操作工作，到2014年更直接參與整體工程的管理工作。當時離第二期甲工程預計於2015年落成啟用的日子只有很短時間，壓力很大，幸好最後也能解決各種困難，全面啟用順利進行。」

「我們於『淨化海港計劃』盡量運用可再生能源，例如在各個基本污水處理廠天台安裝太陽能板，和在昂船州污水處理廠的雙層沉澱池安裝渦輪，利用下墜的水流發電供內部使用，以增強成本效益，並藉此教育市民。」

MAK Ka-wai
麥嘉為

Deputy Director,
Drainage Services Department
渠務署副署長

HATS ACHIEVEMENTS AND PROSPECTS
淨化海港計劃成就與展望

HATS STAGE 1 第一期

HATS Stage 1 provides treatment to 75% of sewage from both sides of Victoria Harbour. With the full commissioning of Stage 1 in end 2001, about 600 tonnes of sewage sludge are prevented from entering Victoria Harbour every day and the water quality of Victoria Habour has improved significantly.

「淨化海港計劃」第一期處理來自維港兩岸約 75% 的污水。第一期設施於 2001 年年底全面啟用後，每日可阻截約 600 公噸的污泥流入維港，維港的水質大為改善。

HATS STAGE 2A 第二期甲

HATS Stage 2A provides treatment to the remaining 25% of sewage from the northern and southwestern parts of Hong Kong Island. In addition, a disinfection facility is installed to further improve the quality of the harbour waters. The implementation of HATS Stage 2A leads to significant improvement in the harbour water quality. The provision of disinfection under Stage 2A removes over 99% of the *E. coli* from the sewage, making it possible to re-open the Tsuen Wan beaches.

「淨化海港計劃」第二期甲處理餘下 25% 來自港島北及南部的污水，並且加建消毒設施，令維港水質大幅改善。第二期甲工程內的污水消毒設施，能消除污水中逾 99% 的大腸桿菌，使荃灣多個泳灘可以重新開放。

An average increase of

ABOUT 13%

of dissolved oxygen (vital for marine life) in the harbour waters, bringing obvious benefits to marine ecology.

維港海水溶解氧（海洋生物賴以維生的要素）平均增加約13%，對海洋生態帶來明顯的益處。

TREAT ALL THE SEWAGE

DISCHARGING TO THE HARBOUR

處理所有排出維港的污水

MAINTAIN A HEALTHY MARINE ENVIRONMENT

WHILST MEETING FUTURE DEVELOPMENT NEEDS

在應付海港地區發展的同時仍能維持理想的海洋環境

The levels of key pollutants in the harbour waters have generally decreased:

維港主要污染物水平普遍下降：

Ammonia nitrogen (toxic to marine life) has declined by 40%

氨氮（對海洋生物有害）含量下降

40%

Total inorganic nitrogen (nutrients, which in rich supply can increase the likelihood of red tides) has reduced by 16%

總無機氮（營養物，過量可能增加紅潮發生的機會）總量下降了

16%

The overall *E. coli* level (an indicator of disease-causing micro-organisms) has reduced by some 90%

大腸桿菌（致病微生物的指標）整含量下降約

90%

SEE MORE SPECIES OF **MARINE LIFE**

有更多不同品種的海洋生物

REMOVE THE SIGHT OF **SEWAGE PLUMES** FROM THE HARBOUR

消除海港內令人噁心的污水卷流

RESUME **CROSS HARBOUR RACE**

復辦渡海泳

RE-OPEN THE **TSUEN WAN BEACHES**

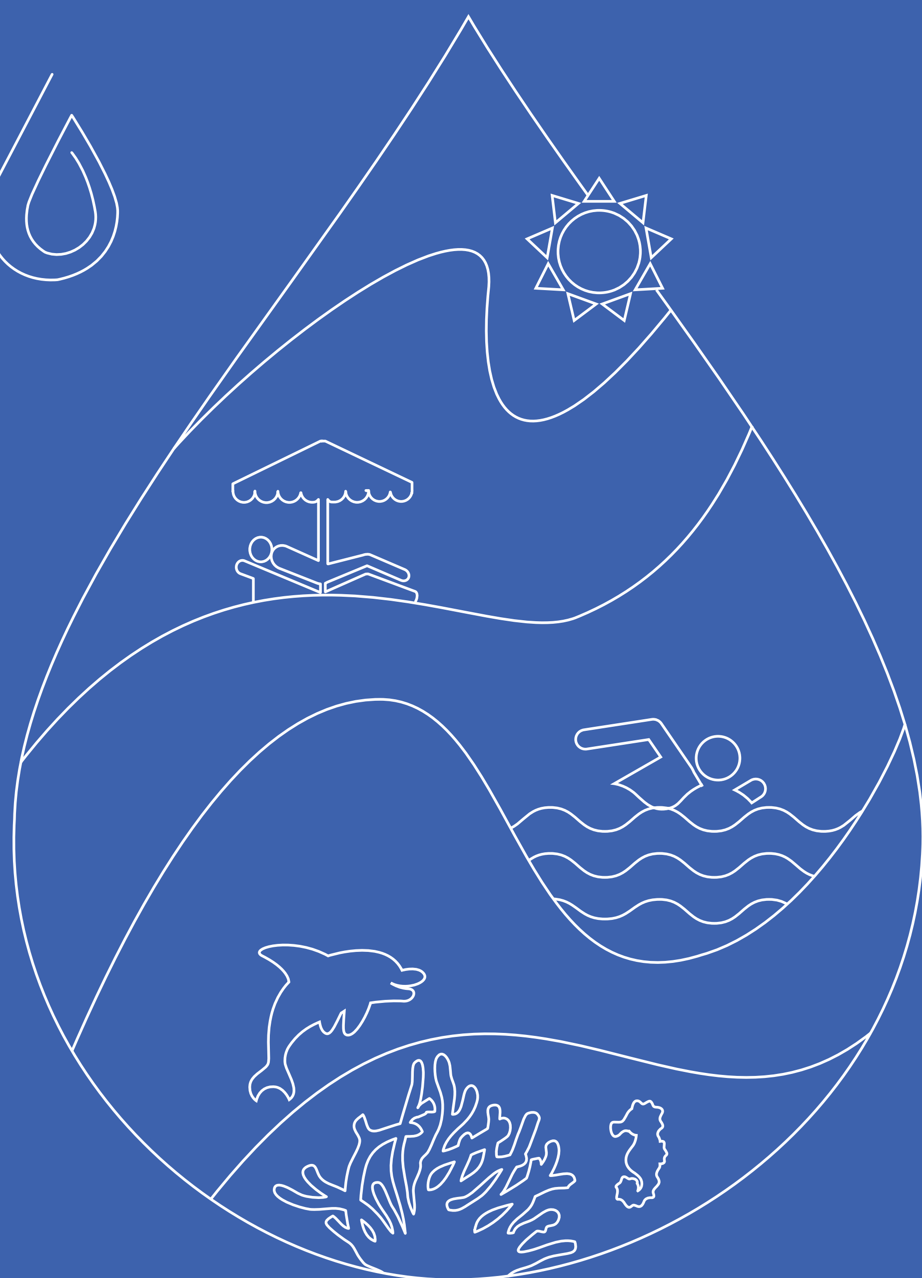
重開荃灣一帶的泳灘

PROSPECTS 展望

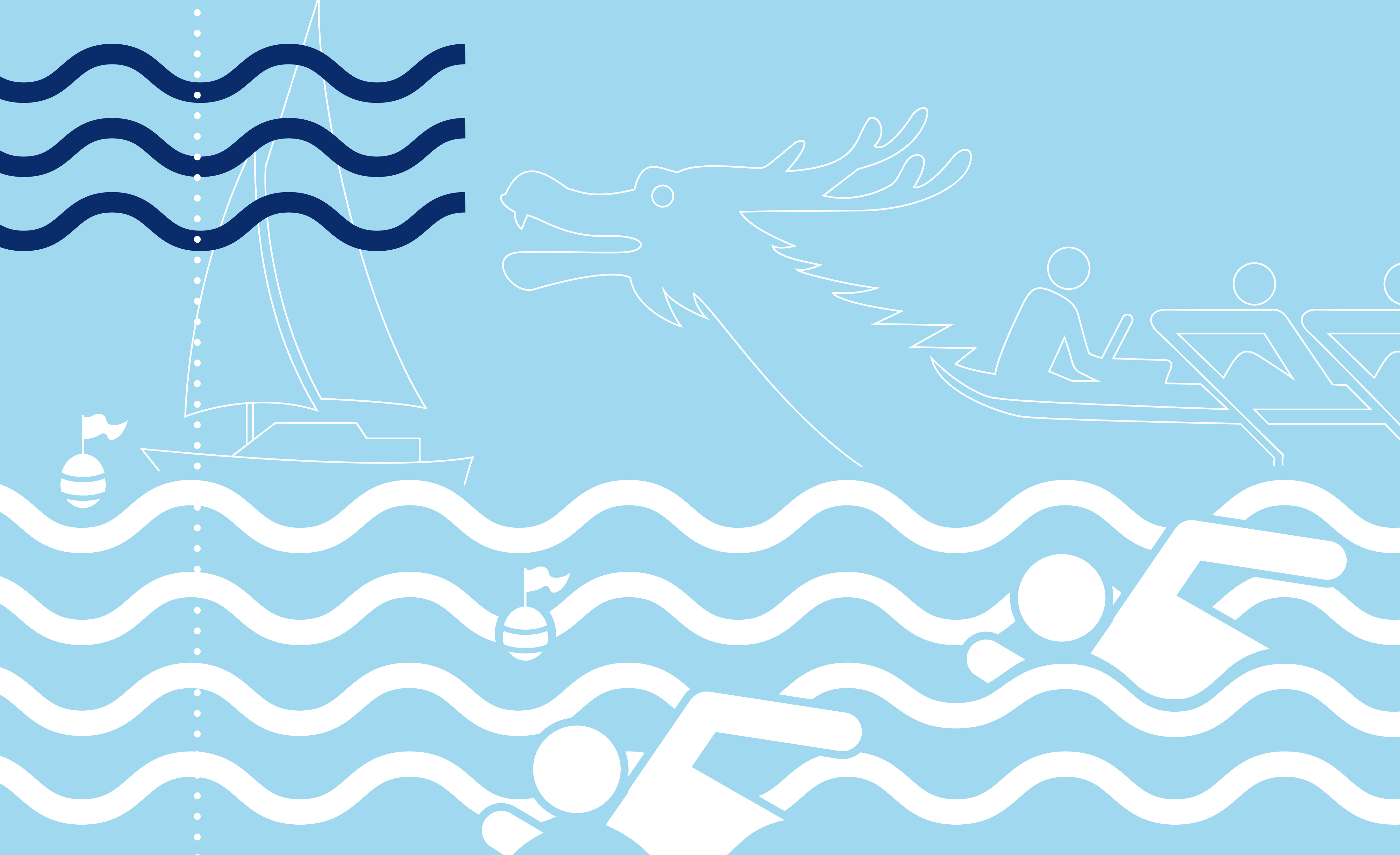
To facilitate the sustainable development of the harbour area in the long term, HATS Stage 2B will be constructed near to SCISTW and will provide biological treatment to all the effluent, thus improving water quality further. The time table for the implementation of HATS Stage 2B will be subjected to review, taking into account the increase in population and water quality trends.

為了促進海港地區長遠的可持續發展，我們會在昂船洲污水處理廠附近興建第二期乙工程，為所有經「淨化海港計劃」收集的污水提供生物處理，以進一步改善維港的水質。第二期乙的實施時間表會因應人口增長和水質趨勢而再作檢討。

HATS ACHIEVEMENTS AND PROSPECTS
淨化海港計劃成就與展望



ORCHESTRATED VIBRANCY
齊譜新活力




SAMSUNG
LETTER 11 信件十一
ORCHESTRATED VIBRANCY
齊譜新活力

Orchestrated Vibrancy
齊譜新活力

Dear Harbour,

This is the last in our series of letters to You, dear Victoria Harbour, on the Harbour Area Treatment Scheme or HATS. Even so, this is only the beginning of our long-term commitment to maintaining your water quality. We vow that Hong Kong will continue to enjoy a clean and fragrant harbour as it evolves as a smart city.

You have come a long way, our dear Harbour, from the 1980s when your water suffered from serious pollution which threatened marine life and our community wellbeing. The successful implementation of the HATS project, which spanned more than two decades from the early 1990s, has revived your vitality and enriched our city.

When HATS Stages 1 and 2A were fully commissioned in 2001 and 2015 respectively, your water quality saw immediate and dramatic improvement. Victoria Harbour is now clean and healthy again, with coral and other marine life thriving once more and closed beaches re-opened for all to enjoy. The city's signature Cross Harbour Race, once suspended due to harbour pollution, resumed in the eastern part of the harbour in 2011, and moved back to its original route in the central part of the harbour in 2017.

Harbour Water Quality Improvement

Harbour water quality improvement is the most important benefit brought by HATS. By collecting sewage from both sides of Victoria Harbour and conveying it via a deep tunnel system to a centralised sewage treatment works on Stonecutters Island for chemically enhanced primary treatment before discharge into the western part of the harbour, HATS has dramatically improved harbour water quality. We have removed 70% of biochemical oxygen demand, 80% of suspended solids, and 99% of *E. coli* from sewage before discharge. We also observed that there has been about 13% increase in dissolved oxygen in our harbour water, a critical factor for marine life to flourish.

In fact, by 2016, just one year after the full commissioning of Stage 2A, the overall annual geometric mean *E. coli* level in the harbour was down to around 300 counts per 100 millilitres, a tenfold reduction from the late 1990s.

HATS now serves the sewage treatment needs of about 4.5 million people, with the capacity to serve up to 5.7 million in the future. As the gatekeeper of our harbour water quality, HATS will continue to maintain a healthy marine environment as our city grows.

The Seven Wonders of HATS

A world-class and award-winning environmental infrastructure project, HATS is a major engineering feat with many innovative achievements. HATS is also known internationally for its "Seven Wonders".

- **Hong Kong's largest environmental infrastructure project** — built over more than two decades with an investment of HK$25.8 billion
- **The world's deepest sewage tunnel** — reaching 163 metres below sea level at its deepest point, equivalent to a commercial building at about 50 storeys, such as Jardine House in Central
- **Asia's longest very-deep tunnel** — running a total length of 44.6 kilometres, the combined sewage tunnels are longer than a full marathon
- **One of the world's largest chemically enhanced primary treatment works** — treating up to 900 million cubic metres of sewage per year, the Stonecutters Island Sewage Treatment Works (SCISTW) has a sewage capacity of 2.45 million cubic metres per day, equivalent to the volume of about 1,000 standard-size swimming pools
- **The most efficient use of land for providing chemically enhanced primary treatment** — occupying a site of about 10 hectares, SCISTW is only half the size of Victoria Park and yet serves up to 5.7 million people
- **The world's most powerful sewage pumping system in a chemically enhanced primary treatment works** — with pumping capacity up to about 63.2 cubic metres per second, the sewage pumping system at SCISTW can pump the water out of a standard-size swimming pool in just 40 seconds
- **The environmental infrastructure project spanning the greatest number of districts in Hong Kong** — covering 10 districts on both sides of Victoria Harbour: Sai Kung, Kwun Tong, Kowloon City, Yau Tsim Mong, Sham Shui Po, Kwai Tsing, Wan Chai, Eastern, Central and Western, and Southern Districts

These "wonders" explain why HATS has become such a popular destination for visitors and delegations of engineers, technical experts and municipal government officials from all over the world. Visitors are particularly impressed with the compact design of SCISTW, which gives it the capacity to serve the sewage treatment needs of up to 5.7 million people while making highly efficient use of our precious land resources.

Innovation

In our earlier letters to You, our dear Harbour, we explained the numerous engineering challenges encountered during HATS Stages 1 and 2A works, in particular the difficulties in site investigation for deep tunnels, tunnelling works, and underground water ingress control. With great patience and perseverance, the project team overcame every challenge. In the process, it also introduced many innovative technologies and methods to Hong Kong, making a positive and lasting impact on the local engineering and construction sectors.

For example, HATS was the first project in Hong Kong to use brine as a coolant in Artificial Ground Freezing to control groundwater inflow for the construction of an interconnection tunnel. Horizontal Directional Coring and Horizontal Directional Drilling, both state-of-the-art technologies at the time, were adopted for tunnel site investigation and drilling small-diameter tunnels respectively. These are just a few examples of the innovative solutions we tailored to overcome the numerous engineering challenges of this ambitious project.

Sustainability

HATS is not only an engineering feat, but also a sustainability success story. As the largest-ever environmental infrastructure project in Hong Kong, HATS strives to save energy and contribute to sustainable development in every aspect of its design and operation.

Examples of sustainability in action at HATS include adopting the “inverted siphon” principle in designing the deep tunnel system to save pumping energy, deploying numerous eco-friendly and greening features at SCISTW and various Preliminary Treatment Works, and building two ocean-going vessels for the daily transportation of sludge cakes to T▪PARK for incineration to generate electricity and thus complete the waste-to-energy sustainability cycle. These and other measures make HATS a template for future sewage collection, treatment and disposal infrastructure development in Hong Kong.

Economically, the ongoing operation and maintenance cost of HATS is offset by a statutory sewage charge and trade effluent surcharge based on the “polluter pays” principle. Indeed, HATS was the project that introduced the “polluter pays” principle to Hong Kong in the 1990s, a concept that has served the city well ever since.

So, our dear Harbour, we have come to the end of these letters. Your beauty and vibrancy, now fully restored, will continue to charm and nourish the people of our beloved city for decades and centuries to come. We at DSD shall continue to protect and enhance your water quality, and where necessary further advance the HATS project in future to make You, Victoria Harbour, ever more pristine and fragrant.

With love,
Drainage Services Department

Yachts of the China Sea Race 2018 set off from Victoria Harbour on 28 March 2018
2018年3月28日「中國海帆船賽2018」參賽帆船於維多利亞港揚帆啟航

Hong Kong Dragon Boat Carnival from 10 to 12 June 2016
香港龍舟嘉年華於2016年6月10日至12日舉行

The 2018 Asian Rowing Coastal Championships held on 24 and 25 November at Victoria Harbour
2018亞洲海岸賽艇錦標賽於11月24日及25日在維多利亞港舉行

親愛的維港：

這是我們給您有關「淨化海港計劃」信件系列的最後一封信。但這並非終結，而是我們致力維持您水質這長遠承諾的開始。我們承諾，香港在蛻變成為智慧城市的過程中，會繼續享有一個潔淨、芬芳的海港。

從上世紀八十年代到今天，親愛的維港，您經歷了很多，也改變了很多。當時您的海水受到嚴重污染，海洋生態大受威脅，並影響市民的福祉。幸得「淨化海港計劃」成功落實，這個由上世紀九十年代初動工，歷時二十多年的項目，令您重現活力，亦使我們的城市更豐富多采。

當「淨化海港計劃」第一期和第二期甲分別在2001年和2015年全面啟用後，您的水質立即得到大幅改善。維多利亞港現已回復潔淨、健康，珊瑚和其他海洋生物重生，關閉了的泳灘重新開放供公眾享用。渡海泳這個標誌性的城市盛事，一度因為海港污染停辦，終於2011年於維港東面復辦，並於2017年重返以前的路線，在維港中部水域舉行。

改善維港水質

「淨化海港計劃」帶給香港最重要的效益，就是改善了維港的水質。「淨化海港計劃」從維多利亞港兩岸收集污水，經過一個深層隧道系統輸送到昂船洲的中央污水處理廠，進行化學強化一級處理，然後排放到維港以西海域，項目令維港水質得以大大改善。在排放前，我們已經移除污水中70%的生化需氧量、80%的懸浮固體和99%的大腸桿菌。我們還觀察到，維港海水的溶解氧增加了約13%，這是海洋生物賴以繁盛滋長的要素，有利海洋生態。

事實上，到2016年，即第二期甲全面啟用僅一年後，維港的大腸桿菌全年幾何平均水平已下降到每百毫升約300個，與上世紀九十年代末相比減少了十倍。

目前，「淨化海港計劃」為約450萬人提供污水處理服務，日後最多能為570萬人服務。隨著我們城市的發展，「淨化海港計劃」會肩負維港水質守護者的重要角色，繼續保持健康的海洋環境。

淨化海港計劃「七大亮點」

「淨化海港計劃」屢獲殊榮，乃世界級的環保基建項目及工程壯舉，樹立許多創新成就，更以「七大亮點」聞名於世。

- **香港歷來最龐大的環保基建項目**—建造工程歷時二十多年，總投資額達258億港元
- **全球最深污水隧道**—最深一段隧道位於海平面以下163米，相等於中環怡和大廈，一棟約50層高商廈的高度
- **亞洲最長的極深層污水隧道**—深層污水隧道總長44.6公里，比全馬拉松長跑的長度更長
- **世界其中一個最大的化學強化一級污水處理廠**—昂船洲污水處理廠的處理能力達每年9億立方米，或每日245萬立方米，即每日處理相等於約1,000個標準游泳池的容量
- **最地盡其用的化學強化一級污水處理廠**—昂船洲污水處理廠佔地約10公頃，只有半個維多利亞公園的大小，卻可以為570萬人提供服務
- **全球化學強化一級污水處理廠中最強的泵水系統**—泵力達每秒約63.2立方米，只需約40秒便可抽走一個標準游泳池的水
- **香港橫跨最多區域的環保基建項目**—工程橫跨維多利亞港兩岸10個區域，包括西貢、觀塘、九龍城、油尖旺、深水埗、葵青、灣仔區、東區、中西區及南區

有這麼多「亮點」，無怪「淨化海港計劃」吸引了許多來自世界各地的訪客，和工程師、技術專家與政府官員等各種代表團來訪。其中又以昂船洲污水處理廠的密集設計給予訪客的印象特別深刻，一方面污水處理廠地盡其用，能高效地使用我們珍貴的土地資源，另一方面則能為多達570萬人提供污水處理服務。

敢於創新

親愛的維港，早前給您的信中，我們已經解釋「淨化海港計劃」第一期和第二期甲工程遇到的種種挑戰，尤其是深層隧道的地質勘測、隧道挖掘工作及控制地下水湧入時面對的困難。工程團隊憑藉極大的耐心和毅力，將挑戰一一解決。過程中，團隊更為香港引進了許多創新的科技和方法，為本地工程及建造業界帶來正面和深遠的影響。

舉個例子，在建造一條連接隧道工程中，「淨化海港計劃」是香港第一個工程項目在凍土法過程中應用鹽水作冷卻劑以控制地下水湧入。另外在隧道地質勘測及鑽挖小口徑隧道工程中，我們分別採用了水平定向取芯和水平定向鑽挖方法，為當時最先進的技術。這雄心萬丈的項目，需要克服的工程挑戰林林總總，上述只是我們為項目度身訂造的各種創新解決方案的部份例子。

可持續發展

「淨化海港計劃」不僅是一項工程壯舉，也是一個可持續發展的成功案例。「淨化海港計劃」乃香港歷來最龐大的環保基建項目，由設計到營運等各方面，均致力節約能源，為可持續發展作出貢獻。

「淨化海港計劃」的可持續發展實例多不勝數，例如深層隧道系統採用倒虹吸管設計，節省大量泵送能源；在昂船洲污水處理廠及基本污水處理廠安裝各種不同的節能及環保設施；以及建造兩艘遠洋輪船，每天將污泥塊運送到T▪PARK [源▪區]進行焚燒發電，達致轉廢為能的可持續循環。「淨化海港計劃」的上述種種及其他設施，為香港未來的污水收集、處理和排放的基建發展提供典範。

在經濟層面，我們以「污染者自付」原則引入排污費和工商業污水附加費，補助項目日常營運及維修的開支。事實上，「污染者自付」這徵費原則是由「淨化海港計劃」在上世紀九十年代率先引入香港的，多年來行之有效。

親愛的維港，這系列信件已進入尾聲。您已完全回復昔日的美麗與活力，在未來的數十甚至數百年間，您將繼續潤澤市民，繼續發揮令人們着迷的魅力。而我們渠務署亦定必繼續守護及提升您的水質，日後有需要時，更會進一步拓展「淨化海港計劃」，務求令維多利亞港您更澄澈、芬芳。

摯愛
渠務署謹啟

VICTORIA HARBOUR **WISHES** 維港祝願

淨維港、齊共享

淨化海港計劃，淨化維港，令廣大市民受惠，工程歷年更榮獲多項國內外重要獎項。能與工程團隊一同克服種種挑戰，令工程能順利完成，實深感榮幸。

曾國良
渠務署助理署長

在淨化海港計劃這個改善維港水質的龐大工程上，能參與其中，並見證著從無到有的設施建設。使我在人生的旅途上，增添上一份滿足及自豪感。

MK TSANG
Project Co-ordination Manager, DSD

The Harbour Area Treatment Scheme project is the most important sewage project in Hong Kong over the century, providing cost-effective sewage collection and treatment system. I am very proud of participating in this challenging project. My whole-hearted thanks to those involved in planning, design, construction, and operation of this project.

WS CHUI
Assistant Director, DSD

有創新的思維，也要有細心的風險管理，加上客户、顧問公司和承建商三者的互信和團隊精神，才能完成一個像「淨化海港計劃」般困難的工程。

Keith TSANG
Director, AECOM

It is my privilege to participate in this important project, where numerous unforeseen technical difficulties were overcome through the hard work and dedication from all parties.

Edmond CHOW
Senior Resident Engineer, Arup

Arup is truly honored to have had the opportunity to play such a major role on this city - enhancing project. The key to the projects' success was the collaborative approach taken by all parties involved despite the significant challenges.

Fergal WHYTE
Partner, Arup

I feel privileged to have been involved in a project that will provide environmental, social and health benefits to Hong Kong for generations to come. This truly is a career defining project and one I am proud to share with my family and friends.

Robert BATES
Senior Resident Engineer, Arup

「凝聚共識齊互勉，克服挑戰全達標」

淨化海港計劃第二期甲工程獲得空前的成功，並得到國際工程界的認可及獎賞。這全賴渠務署、工程顧問及承建商內各專業團隊包括土木、機電、海事、系統控制及化工專業人士上下一心，排除萬難所得的成果。

Ted TANG
Principal Resident Engineer, Arup

It's a great privilege to have participated in the bold and eye-opening HATS project. Will always cherish the teamwork and our harbour so painstakingly revived.

HS KAN
Former Chief Engineer, DSD

我以曾經參與淨化海港計劃，與工程團隊一起克服重重嚴峻的挑戰，成功改善維港水質而自豪。

CHAN Kai-yuen
Chief Resident Engineer, AECOM

I truly marvel at the meticulous planning and seamless implementation of the many complementary facilities by DSD under the Harbour Area Treatment Scheme to improve services to the society at large.

CY FONG
Project Director, ATAL

Upgrading an operating sewage treatment plant is always a challenging job, especially for a mega scale plant currently serving over 3 million people. Its success was very much hinged on the seamless coordination and cooperation between the project team and plant operator.

YK TSE
Chief Engineer, DSD

因能參與而感榮幸，更願其成造福百年。

Nelson HONG
Project Manager, ATAL

要保護維港水質，關鍵詞是慳水。市民和工商各業都應節省用水，減低污水處理廠的負荷。

黃錦星
環境局局長

「淨化海港計劃」讓我們有機會涉獵意想不到的有趣工作，例如要設計兩艘遠洋輪船運送污泥，非常有滿足感！

周國銘
渠務署系統顧問

如果說維港曾經病重，它現在已接近百份百康復。市民也要幫忙維護水質，例如不要把污水倒進雨水渠。

韓志強
發展局前常任秘書長（工務）

經過「淨化海港計劃」，維港已經重生，希望它持續保持光芒。

戴懷民
渠務署前總工程師

Integrating an additional 450,000 m³/d achieved without interruption to treatment, impact to effluent quality, or detriment to local residents marks a significant achievement by all those participating towards the solution. Proud to have been part of the HATS team success, and the enhanced efficiencies achieved.

Paul ZUBER
Technical Manager, Sun Fook Kong

Despite the challenging experience in sailing through the onerous design and construction stages of various E&M systems, the successful commissioning of HATS, a mega-infrastructure project, has paid off impressive dividends in improving Hong Kong's harbour areas for our citizens to enjoy.

Ricky LI
Former Chief Engineer, DSD

好榮幸參與香港淨化海港計劃多個工程項目的總承包施工管理，工程積極應用與創新超深地下連續墻、冷凍法隧道洞口土體加固和超小曲率半徑盾構施工等技術，使公司的科技創新與技術應用能力再上新臺階。

PUN Suk-kit
General Manager, CSHK

We are most excited that we can overcome all challenges and successfully complete this 160m below ground and 12km long sewage tunnel.

SY YU
Project Director, Gammon

In spirit of partnering, every members in construction team worked diligently in their expertise. It was remarkable moments to witness the commissioning of new pumping station which engraved the key success of Hong Kong environmental project.

Patrick LEE
Managing Director, Sun Fook Kong

Well begun is half done. While DSD has wisely introduced the integrated Civil and E&M contracts for upgrading & PTWs in HK Island, we have been offered the most suitable environment to contribute our best parts to overcome any technical and interfacing challenges, with excellent results achieved in the contracts.

Wilfred SO
Project Manager, Leader

The Chief Resident Engineer role on Hong Kong's largest environmental infrastructure project provided me with a career pinnacle. Leading an excellent team, complex, multidisciplinary contracts were implemented with sustainability and environmental issues in mind, an achievement recognized with the Construction Manager Excellent Award of the Construction Industry Council.

Jeremy SPARROW
Chief Resident Engineer, Arup

如果維港可以說話，我想它會說「多謝你們還我本色」。

唐嘉鴻
渠務署署長

"My message for HATS? You can swim again!"

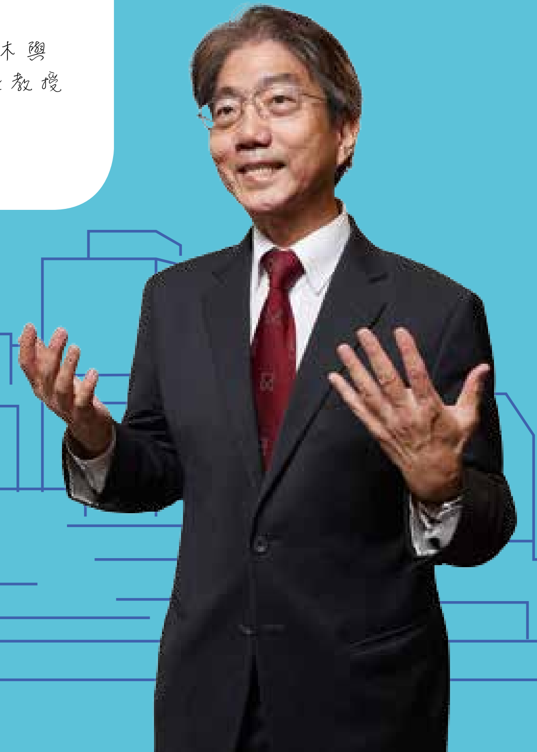
David PICKLES
Director, ARUP

第二期甲落成啟用前半年，時間緊逼，壓力很大。我們在承建商之間做了很多溝通協調工作，終於順利完成工程。

麥嘉為
渠務署副署長

希望「淨化海港計劃」能成為大灣區的典範，幫助解決大灣區水污染的問題，造就世界級的可宜居發展。

李行偉教授
香港科技大學土木與
環境工程學系客座教授



Whilst many advocate the partnering approach, it is under our Contract DC/2009/17 within the existing Stonecutters Treatment Works, that I genuinely felt the client, consultant and contractor are truly working together through the good and bad times to make this such a success and happy time. Definitely "We are family".

Tony WONG
Project Manager, CSHK

能參與「淨化海港計劃」而對維港兩岸的可持續發展作出承擔，實感自豪。

李超臻
渠務署總工程師

Every Hong Kong people can enjoy a clean harbour and peaceful promenade, came from the insight of HATS Project. We were proud to contribute our technical and expertise knowledge to deliver the project successfully.

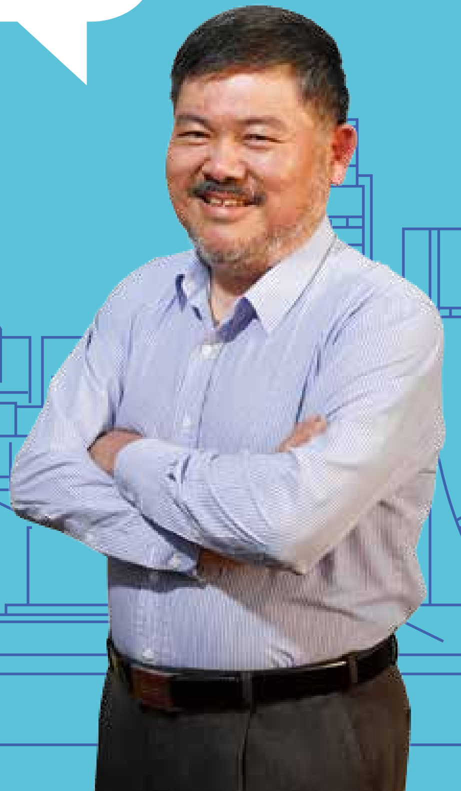
Keith HO
Site Agent, Sun Fook Kong

作為香港淨化海港計劃多個總承包工程項目的主要參與者，團隊克服了大量工程技術與管理挑戰，為實現綠色維港、推動香港可持續發展貢獻了自己一份力量而深感自豪

George CHAN
Deputy General Manager, CSHK

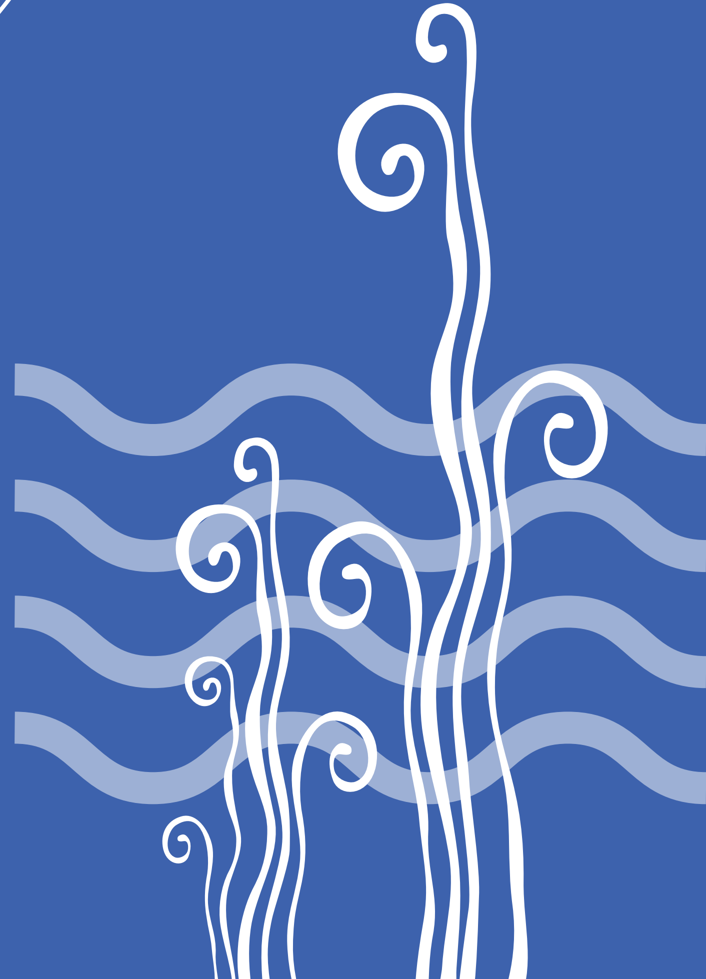
「淨化海港計劃」很偉大，也是成本效益極高的項目。

蕭嘉錦
渠務署前助理署長

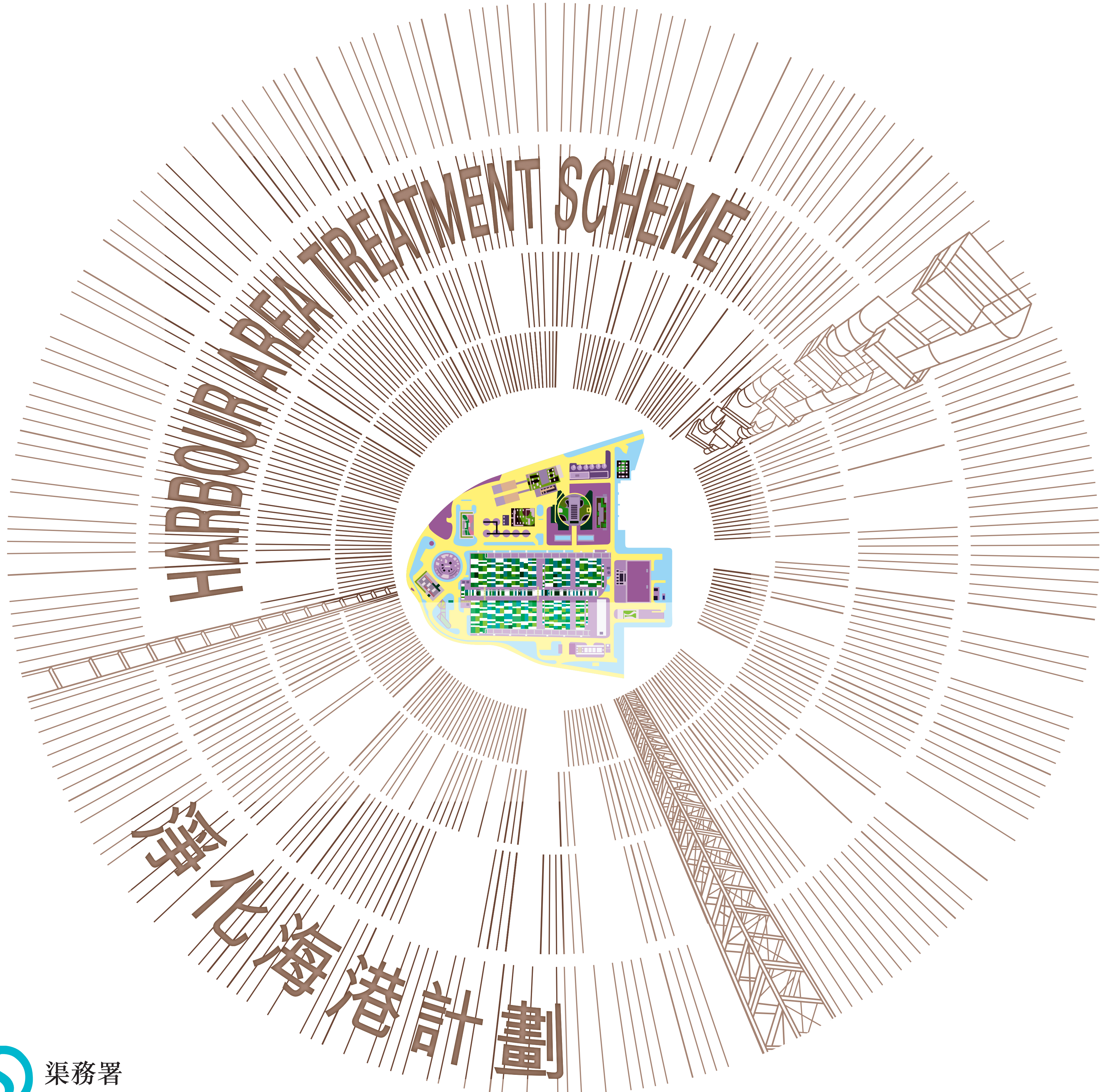


We are proud to have participated in the Stonecutters Island Sewage Treatment Works Project. This project, under the HATS, is a world-class infrastructure and improves the water quality of Victoria Harbour and the living environment for Hong Hong people.

Derrick PANG
Chief Executive Officer, Chun WO



Harbour Area Treatment Scheme Stage 2A grand ceremony on 19 December 2015
2015年12月19日「淨化海港計劃」第二期甲啟用典禮



渠務署
Drainage Services Department
https://www.dsd.gov.hk