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REACHING THE UNREACHED: CHALLENGES FOR THE 21ST CENTURY

Strategic sewage disposal in Hong Kong

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IN MY PREVIOUS paper presented in the 21st WEDC Conference (Tang, 1995), the overall strategy used to tackle wastewater produced in the whole territory of Hong Kong was described. Also briefly mentioned in that paper was a mega scale project named "Strategic Sewage Disposal Scheme" which is being undertaken in Hong Kong. The scheme is not a solution to the water pollution problems in the whole territory but is only for solving the problems at the most densely populated urban areas, viz, Kowloon Peninsula, northern part of Hong Kong Island, and the harbour (named Victoria Harbour) separating Kowloon Peninsula and Hong Kong Island (see the rectangular frame in Figure 1). The current paper is to give a detail discussion on the strategic sewage disposal scheme (SSDS).

4 Stages in the SSDS

There are four stages in the SSDS. The 1st stage involves the construction of a deep tunnel system (at least 100m below ground level) collecting all sewage from the whole Kowloon Peninsula and the northeast part of the Hong Kong Island. The sewage collected will be treated primarily with chemical enhancement (called CEPT, chemically enhanced primary treatment) at a place named Stonecutter's Island (Figure 2) (Hong Kong EPD, April 1995). The effluent will be discharged to the west side of Victoria Harbour as an interim measure. The construction of the 1st stage will be completed by June 1997, immediately before the taking over of the territory by China. The implementation of this stage of the scheme has been agreed on 20 December 1995 by both the Chinese Government and the Hong Kong / British Government (SCMP, 21 December 1995). Agreements for the remaining 2nd, 3rd and 4th stages, however, have not yet been reached. Tentatively, the 2nd stage will involve the construction of a long deep tunnel submarine outfall starting at the Stonecutter's Island which will supersede the interim outfall of the 1st stage to dispose the effluent to deep ocean waters 13km from Lamma Island in the South China Sea. The 3rd and 4th stages will be the construction of deep tunnel systems collecting sewage from the Hong Kong Island (except the northeast part of it which has already been completed in the 1st stage) to the same CEPT plant at the Stonecutter's Island.

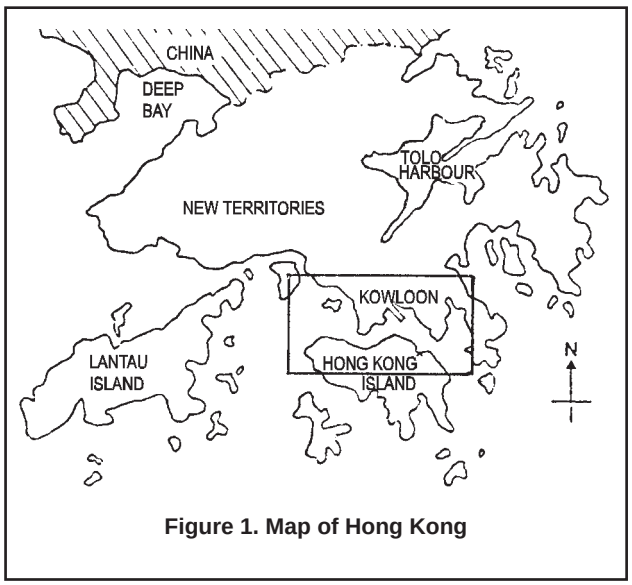

Figure 1. Map of Hong Kong

Stage 1 of the SSDS

In the past, wastewaters collected from the Kowloon Peninsula and the northern part of Hong Kong Island were discharged, with or without passing through preliminary treatment plants, directly to the Victoria Harbour (Tang, 1984, 1995). As the harbour is badly polluted by these untreated or preliminarily treated wastewaters,

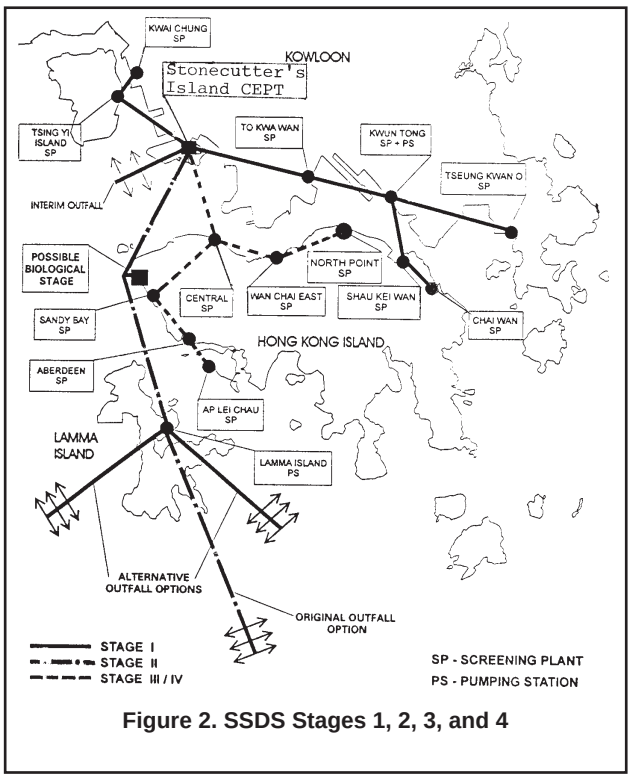

Figure 2. SSDS Stages 1, 2, 3, and 4

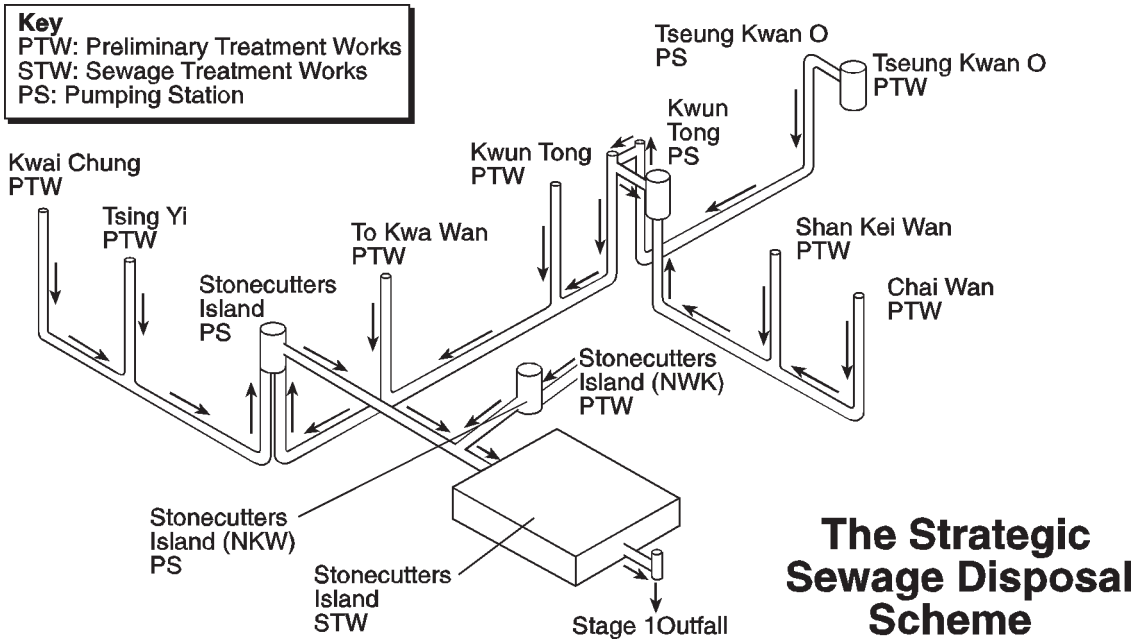

Figure 3. Stage 1 of the SSDS

the SSDS has the purpose of rerouting these wastewaters to a deep tunnel system which ends at the CEPT plant located at the Stonecutter's Island. The CEPT plant will remove 85 per cent suspended solids and 50 per cent BOD (CIWEM Hong Kong Branch, 1996). The use of chemicals allows higher overflow rates in the sizing of the works, thus fewer tanks each with a greater throughput to handle the design flow can be used. The selected chemical will be either ferric chloride or ferric sulphate, and pilot trials are currently being carried out to determine the most appropriate chemical. After treatment, the effluent will be discharged to the Western Harbour through a 1.6km long and 5m diameter submarine outfall. This outfall is only an interim one as it will be replaced by the Stage 2 outfall of the SSDS.

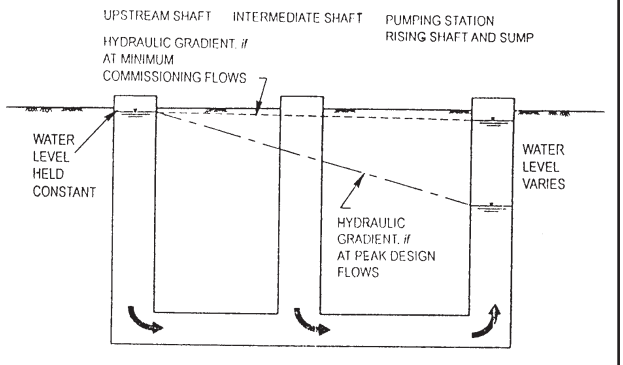

Figure 4. Schematic hydraulic profile

Deep tunnel conveyance of Stage 1

In the SSDS, the existing preliminary treatment (or screening) plants, after modifying or upgrading, will act as connection nodes to the deep tunnel conveyance system (Figure 3) (SCMP, 1995). The most important aspect at the preliminary treatment plants is to achieve high standard of grit removal in order to avoid the deposition and accumulation of solids in the tunnel conveyors. After passing through screening plants, the flow will then be led to a vortex drop shaft through which it will enter into the SSDS deep tunnels. Before it is led to the drop shaft, the flow will be measured using a magnetic flowmeter, as the control of the SSDS pumps will be dependent upon measurement of flows and levels at each connection node. The main tunnel system will be operated as a series of inverted syphons, with pumping stations to compensate the head losses within the system. In Stage 1, for example, it will be operated in a surcharged condition as a series of "U-tubes" with flow discharging into a vertical vortex drop shaft at each preliminary treatment plant (i.e. connection node) and raised from the tunnels by pumping stations through rising shafts at the downstream ends such as Kwun Tong and Stonecutter's Island (Figure 3 and Figure 4) (AB_2H Consultants, 1993). Pumps will be operated automatically based on flow rates within the conveyance system. The upstream control method will be used, which means that the water level in the upstream shafts will be maintained rather constantly at a high level using variable speed drives of the pumps.

Design criteria

The design criteria of the SSDS are as follows:

- Ensure that untreated sewage is not discharged to the conveyors.
- Ensure adequate preliminary treatment to avoid sediment deposition in the conveyance system.
- Design conveyors (by selecting suitable diameters and gradients) to transport sediment so as to avoid sediment build-up.
- Ensure a minimum of bed rock cover of 30m over the top of the tunnels (this means that all tunnels are 100m to 150m below ground level).
- Design conveyors to be capable of operating efficiently over a long period of time with minimum maintenance.
- Ensure sufficient hydraulic capacity under maximum flow conditions.
- Ensure sufficient hydraulic capacity at the design horizon of year 2021.

The average dry weather flows from 1997 to 2021 are estimated as follows (Pypun, 1995):

	Estimated sewage flow (m^3/sec)			
	1997	2001	2011	2021
Stage 1	12.82	16.36	17.46	19.97
Stages 3 and 4	-	4.00	4.18	4.27
Total	12.82	20.36	21.64	24.24

Contract packages and costs for Stage 1

The total estimated costs at 1995 price for Stage 1 is HK$5.2 billions (ie. US$0.67 billion). There are 4 advance works contracts, 6 main civil works contracts and 5 E&M works contracts for Stage 1 (CIWEM Hong Kong Branch, 1996). A summary of these contracts and their costs break down are shown below.

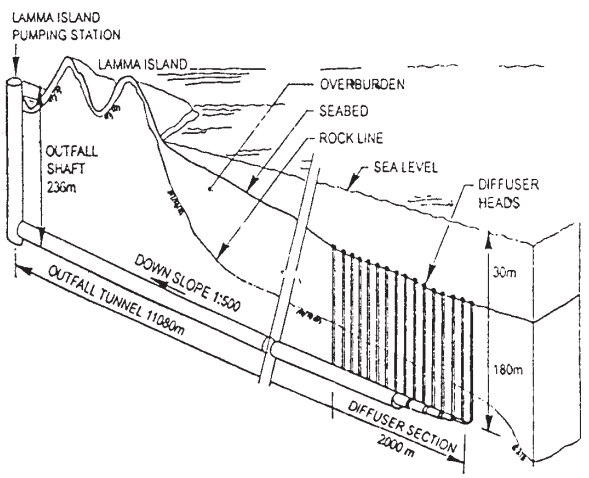

Figure 5. Stage 2 oceanic outfall

Contracts	**Per cent of stage 1 costs**
Advance works	
• Piling for the foundation for the sedimentation tanks.	2.0 per cent
• Production shafts to gain access to tunnels.	4.4 per cent
• Diaphragm walls for Stonecutter's Island main pumping station.	2.2 per cent
• Site offices and facilities.	1.4 per cent
Civil works	
• Tunnelling (Chai Wan and Tseung Kwan O to Kwun Tong).	9.5 per cent
• Tunnelling (Kwun Tong and Kwai Chung to Stonecutter's Island).	13.3 per cent
• Sedimentation tanks structure.	7.7 per cent
• Stonecutter's Island pumping station building and other infrastructure.	6.0 per cent
• Sludge handling and loading facilities.	1.1 per cent
• Interim outfall.	10.4 per cent
E&M works	
• Upgrading existing preliminary treatment plants.	17.7 per cent
• Sludge dewatering facilities.	5.9 per cent
• Chemical dosing facilities.	2.7 per cent
• Pumping equipment for all pumping stations.	8.1 per cent
• E&M equipment for sedimentation tanks.	7.6 per cent

The estimated recurrent cost for stage 1 scheme will be approximately HK$300 millions per year (ie. US$38.5 millions per year). The recurrent cost will be recovered by "sewage charge" collected from citizens / residents of Hong Kong. The capital cost will not be recovered but will be borne entirely by the Hong Kong Government.

Stages 2, 3 and 4 of the SSDS

These stages were proposed to be completed at the same time (about 2003). Combined implementation of Stages 3 and 4 was recommended and Stage 2 would remain separate. The works included in Stages 3 and 4 are similar and combining them would result in earlier environmental benefits and a more efficient implementation programme. Stage 2 ocean outfall was estimated to be of a capital cost of HK$3.6 billions (ie. US$0.46 billion) at 1992 prices. This estimated cost for the ocean outfall (Figure 5) was based only on a likely location, since an agreement

between the Chinese and the Hong Kong / British governments has not yet been reached and the Stage 2 design has not yet been endorsed. The capital costs for Stages 3 and 4 were estimated to be HK$2.2 billions (ie. US$0.28 billion) at 1992 prices. The recurrent costs for Stage 2 and Stages 3 and 4 were estimated to be HK$39 million per year and HK$59 millions per year respectively.

The decisions ahead

The effects on the water quality of the Victoria Harbour as a result of implementing Stage 1 of the SSDS were assessed using the Hong Kong Environmental Protection Department's WAHMO computer model. It showed that a significant improvement in water quality within the harbour can be achieved. Considerable improvement in terms of dissolved oxygen, E. coli, ammonia and inorganic matters was predicted. For Stage 2 of the SSDS, the environmental assessment of the impact of discharges from the oceanic outfall has not been carried out. Following the agreement between the Chinese and the Hong Kong / British governments made on 20 December 1995 (SCMP, 21 December 1995), environmental assessment was proposed to be carried out at several oceanic outfall locations to assess the potential and adverse impacts on the receiving water quality attributable to the chemically enhanced primarily treated (CEPT) effluent discharged. A joint-venture engineering consultant company, consisting of both Hong Kong and Chinese experts, will be awarded the contract of carrying out an overall environmental assessment at the oceanic outfall locations. The job will last for a period of 30 months, starting in 1996. The study includes the determination of influences on the ecology, water quality of the surrounding environment, potential risks, capital cost and engineering feasibility.

The author of this paper is of the opinion that the proposed CEPT with an oceanic disposal offers the best value for money for the said pollutant removal efficiency if the proposed environmental assessment does not find the water quality around the outfall to be too unacceptable. The scheme offers an early water quality improvement in the worst polluted areas as well as a long term strategy of oceanic disposal to improve the water quality in Hong Kong harbours as a whole. As a precaution, however, a site at Mount Davis (west tip of Hong Kong Island) is reserved to accommodate a secondary treatment plant (Figure 2) if the future monitoring of water quality at the outfall reveals that such a plant is necessary. The additional cost of a secondary treatment plant will be in the order of HK$4 billions (ie. US$0.52 billion) at 1995 prices (Hong Kong EPD, April 1995). This is also something that the experts of the joint-venture engineering consultant company will look into.

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