

Additional Treatment and Water Transfer Facilities for the Metropolitan Area and North-eastern New Territories - Stage I

1. Introduction

The project forms an essential part of the additional land supply programme for construction of additional housing units announced by the Government in 1994. It is anticipated that there will not be adequate water treatment and transfer facilities for the supply of treated water to the metropolitan area and the north-eastern New Territories to meet the water demand arising from these additional housing and other developments. Construction work for the Stage I project with a throughput of 250 million litre per day (MLD) is underway for commissioning by early 2002 to meet the anticipated treated water deficit.

The project is characterized by special features, new and innovative designs, congested site, limited access and a very tight project programme. The project includes four major components - a treatment works at Tai Po, a primary service reservoir at Butterfly Valley, a raw water aqueduct from the existing Tai Po Tau 'D' pumping station to the new treatment works and a treated water aqueducts linking the new treatment works and the primary service reservoir. The total project cost is \$3.335 billion.

2. Tai Po Treatment Works

The Tai Po treatment works is being constructed on a natural hillside at Pun Chun Yuen, Tai Po. The site selected occupies a strategic location of the water supply network such that the treatment works can integrate effectively with the existing network as well as enhancing operational flexibility. In view of the difficulties in identifying suitable site for new treatment works, one of the design objectives for Tai Po treatment works is to maximize the utilisation of the available site area. With the adoption of versatile water treatment technology and other space saving measures such as common wall and multi-level design, it has been able to fit a 3-stage treatment works of ultimate capacity at 1,200 MLD within a hilly site with a total formed flat area of 9 hectares. Upon its full commissioning, the Tai Po treatment works will be the second largest in Hong Kong after Shatin treatment works which has a capacity of 1,227 MLD. The Stage I treatment works has a capacity of 250 MLD, further uprating of the treatment works is under constant review in the light of territory water demand trends.

The treatment works process starts in a powered activated carbon contactor, then passes through the dissolved air floatation (DAF) units to the primary aerated biological filters (PABF), then to a manganese reaction tank prior to secondary gravity filters. The water is disinfected by chlorine and stored in treated water reservoir for pumping into the Butterfly Valley Primary Service Reservoir via the treated water aqueduct.

The DAF unit is a robust and efficient process unit employing a mixture of air and water to be injected into raw water to lift coagulated solid loadings to the water surface for subsequent removal by scraper. The rapid start-up capability of the unit can react to sudden changes in raw water quality effectively. In more conventional treatment works, ammonia and manganese in raw water is removed by chlorination. The introduction of PABF, a process using bacteria to 'eat up' ammonia and manganese under a controlled environment, will significantly reduce the use of chlorine as well as the risk of the associated potential hazards.

The contract was let as a single contract for civil and M&E work to minimize possible delays due to interface problems.



Tai Po Treatment Works Under Construction

3. Raw Water and Treated Water Aqueducts

The raw water aqueduct comprises 220 m of twin 2.0 m diameter steel pipeline and 1,200 m of 3.8 m diameter water tunnel. The treated water aqueduct is a 12 km steel-lined tunnel of 2.7 m diameter which will be used to transfer the treated water from the Tai Po treatment works to the Butterfly Valley Primary Service Reservoir. Under the Stage I project, the aqueducts will be constructed to their ultimate capacities of 1,200 MLD.

While the raw water tunnel was constructed by the more conventional drill and blast method, the long length of treated water aqueduct, close proximity with waterworks and highways installations, tight construction programme and lack of access have ruled out the use of this method for the treated water tunnel. Two hard rock tunnel boring machines (TBMs) have been employed to ensure timely completion of the tunnel through probably the hardest rock in Hong

Kong at depth up to 600 m underneath the Tai Mo Shan range. Special considerations were also given in determining the tunnel route as it passes the Shing Mun Reservoir and Shing Mun vehicular tunnel. When completed, the tunnel will be the longest and deepest treated water tunnel of its kind in Hong Kong. The selection of proper tunnel lining to ensure a watertight, maintenance free and durable aqueduct to resist the high internal and external pressure was another challenge. A number of options were investigated thoroughly including pipes in tunnel, insitu concrete with steel lining, steel lining, precast concrete segment, etc. Finally it was concluded that steel lining of thickness ranging from 18 mm to 42 mm with 25 mm internal cement mortar lining for corrosion protection was the best solution.

As the design is closely related to the construction method, a design and build type of contract was adopted so that the contractor can optimize the design by making best use of his resources and construction methods.

4. Butterfly Valley Primary Service Reservoir

The service reservoir is located at a knoll on the southeast side of Butterfly Valley at Lai Chi Kok. The site for the service reservoir has been formed by cutting down the knoll by about 55 m. To suit the site geometry, the service reservoir is polygonal on plan comprising four compartments with an ultimate capacity of 200,000 m³. One compartment of capacity 40,000 m³ will be constructed under the Stage I project.

With a conventional pipework arrangement, five large diameter inlet and outlet pipelines would have to be laid on steep slopes near Ching Cheung Road. To reduce the risk of slope instability and visual impact, an innovative design of housing the inlet and outlet mains and associated valves in a central shaft and tunnel system built underneath the service reservoir was adopted. This design has allowed maximum use of the site area and would provide better access and easier maintenance in the future.



Butterfly Valley Primary Service Reservoir Stage I Project – Compartment Under Construction

5. Construction

Construction began in mid 1997. Details of the contracts are given below:

Contract No.	Title of Contract	Commencement date	Contract sum
5/WSD/96	Aqueducts between Tai Po and Butterfly Valley	23 June 1997	\$1,096M
7/WSD/96	Butterfly Valley Primary Service Reservoir	15 May 1997	\$298M
15/WSD/96	Tai Po Treatment Works and Pumping Station	18 February 1998	\$1,941M
		Total cost	\$3,335M

The project is anticipated to be commissioned in early 2002. Upon completion, the facilities will not only meet the anticipated supply deficit in the metropolitan area and the north-eastern New Territories but will also improve system flexibility and reliability thereby fulfilling Water Supplies Department's mandate to provide an adequate and reliable supply of potable water in support of Hong Kong's continuing growth and prosperity.

都會區及新界東北部增添濾水及輸水設施 - 第 I 階段

1. 引言

一九九四年，政府宣布增加土地供應以增建房屋單位的計劃，上述工程計劃是當中重要的一環。預計現有的濾水及輸水設施將不足以應付在都會區及新界東北部的房屋及其他發展項目而增加的食水需求。因此，現已展開第 I 階段計劃的建造工程(日產量達 25 萬立方米)，以期於二〇〇二年年初竣工，解決食水短缺的問題。

設施獨特、設計時尚新穎、工地狹窄、通路不足及施工時間異常緊迫，均是這項工程計劃的特點。工程範圍包括四個主要部分：大埔濾水廠、蝴蝶谷主配水庫、由現有大埔頭‘D’抽水站至新濾水廠之間的原水輸水管，以及連接新濾水廠與主配水庫的食水輸水管，造價合共 33.35 億元。

2. 大埔濾水廠

大埔濾水廠於大埔半春園依山而建，選址為供水網絡的策略位置，使之能與現有的網絡妥為整合，增強運作靈活性。鑒於為新濾水廠尋覓合宜地點實在不易，大埔濾水廠的設計目標之一，是盡量利用可用的地方。經採用多功能濾水技術，並配合共用隔牆和多層式設計等節省空間的措施，在陡坡上平整的 9 公頃土地，足可容納分 3 期興建、最終日產量達 120 萬立方米的濾水廠。大埔濾水廠全面啓用後，將成為全港第二大濾水廠，僅次於日產量為 122.7 萬立方米的沙田濾水廠。大埔濾水廠第 I 階段設施日產量為 25 萬立方米，至於日後的擴建事宜，將會因應本港的用水需求趨勢定期予以檢討。

大埔濾水廠的濾水過程始於粉狀活性炭接觸池，繼而經氣泡浮聚淨化系統進入初段曝氣生化過濾池，接著輸往錳反應池和其後的重力濾池。最後，經過濾的水會加入氯消毒，並貯存於食水庫，以便經食水輸水管泵送至蝴蝶谷主配水庫。

氣泡浮聚淨化系統是一套強而有效的食水處理設備，其作用是將空氣和水的混合物注入原水，使絮凝後的固化物浮上水面，然後用刮泥板將之清除。該系統具備快速起動能力，可以對原水質素的突變作出有效反應。較為傳統的濾水廠是以加氯方法清除原水中的氨和錳，而曝氣生化過濾程序是在一個受控制的環境下，利用細菌「吃掉」水中所含的氨和錳。採用這種過濾方法可大大減低使用氯氣的機會及其可能帶來的危險。

這份建造工程是以單一的土木及機電工程合約形式批出，務求盡量減少工序銜接問題所造成的延誤。



興建中的大埔濾水廠

3. 原水及食水輸水管道

原水輸水管道，包括一段長 220 米、直徑 2 米的雙線鋼管及一條長 1 200 米、直徑 3.8 米的輸水隧道；而食水輸水管道為一條長 12 公里、直徑 2.7 米的鋼板襯砌隧道，日後會將大埔濾水廠的食水輸送至蝴蝶谷主配水庫。第 I 階段工程計劃項目下所建造的管道，最終輸水量每日可達 120 萬立方米。

原水輸水隧道採用傳統的鑽挖及爆破方法開挖，而食水輸水隧道則基於多種原因，不能使用上述方法，例如食水輸水管道較長、非常接近水務及公路設施、施工時間緊迫及沒有通路等。由於挖掘至大帽山段地底 600 米時可能會遇到本港最堅硬的岩石，因此用了兩台硬岩隧道鑽挖機施工，務求隧道工程可準時完工。此外，由於隧道會經過城門水塘及城門行車隧道，於是在釐定隧道路線時，曾作出特別考慮。工

程完成後，該隧道的長、深度將成為全港同類型輸水隧道之冠。其他所面對的挑戰，還包括如何為隧道內層選擇適當的襯砌，以確保管道防滲、耐用及不須作維修，足可承受來自內外的高壓。經過詳細研究多個方案，包括在隧道內敷設喉管、現場澆築混凝土配以鋼板襯砌、安裝鋼板襯砌及預澆混凝土管段等，最後選擇以 18 至 42 毫米厚的鋼板作襯砌，並配以 25 毫米厚水泥沙漿作防蝕保護內層。

由於設計與建造方法息息相關，這項工程採用了設計連施工的合約類別，使承建商能透過善用資源及建造方法，定出最佳的設計。

4. 蝴蝶谷主配水庫

配水庫位於荔枝角蝴蝶谷東南面的山丘，施工的地盤是透過削去約 55 米山丘而成。為配合工地地形，計劃中的配水庫是一個包括四個間隔的多邊形，最終容量達 20 萬立方米。第 I 階段工程計劃將建造其中一個容量達 4 萬立方米的間隔。

如果以傳統的水管排列方式，有需要於呈祥道附近陡坡敷設五條大口徑的入水及出水管道。因此為減低斜坡不穩定的風險及避免有礙觀瞻，工程採用了嶄新的設計，在配水庫底建造中央豎井及隧洞系統，把入水及出水管和關連閘掣置於其中。這個設計盡量利用了工地的面積，提供更完善的通路，令到日後的維修保養將更為容易。



蝴蝶谷主配水庫第 I 階段工程計劃 – 興建中的間隔

5. 建造工程

建造工程於一九九七年年中展開，合約詳情如下：

合約編號	合約名稱	動工日期	合約造價
5/WSD/96	由大埔至蝴蝶谷輸水管道建築工程	一九九七年六月二十三日	10.96 億元
7/WSD/96	蝴蝶谷主配水庫	一九九七年五月十五日	2.98 億元
15/WSD/96	大埔濾水廠及抽水站	一九九八年二月十八日	19.41 億元
		工程總額	33.35 億元

工程預計將會於二〇〇二年年初完竣。完工後，有關設施不單可應付都會區及新界東北部預計欠缺的食水供應，亦可提高食水供應系統的靈活性和可靠程度，使水務署得以履行承諾，為市民提供充足可靠的食水供應，協助香港繼續發展，欣欣向榮。