

EXPANSION OF TAI PO WATER TREATMENT WORKS

Executive Summary

1. The Tai Po Water Treatment Works (TPWTW) and the Sha Tin Water Treatment Works (STWTW) are major water treatment works in Hong Kong. TPWTW was commissioned in 2003 and supplied treated water to Tai Po and Central Kowloon. In order to maintain a continuous supply of treated water to the supply zones during the planned in-situ reprovisioning of STWTW (after more than 40 years of services as of 2009) in stages, it was necessary to increase the output capacity of TPWTW from 250 to 800 million litres per day (Mld) in phases for taking up part of the loading of STWTW. Upon completion of the expansion works, the increased output capacity of TPWTW could take up the loading of STWTW for supplying fresh water to Central and West Kowloon, and Central and Western District of Hong Kong Island. The Development Bureau (DEVB) is responsible for the formulation of water supply policies and coordinating their implementation. The Water Supplies Department (WSD) was the works agent responsible for implementing a project for the expansion of TPWTW (the Project).

2. The Project was implemented under Project Votes I to III. A total funding of \$6,480 million was approved by the Finance Committee of the Legislative Council between May 2009 and January 2013. In June 2008 and June 2009, WSD awarded two consultancies (Consultancies X and Y) to a consultant (Consultant M) for the Project. Between February 2010 and September 2013, WSD awarded three works contracts (Contracts A to C) to three contractors (Contractors A to C) for the implementation of the Project. The Project commenced in February 2010 and was substantially completed in December 2019. As of March 2023, \$4,986.4 million (77%) of the approved project estimate (APE) totalling \$6,480 million for the Project had been incurred. WSD, which is committed to providing a safe, clean and reliable water supply to customers in Hong Kong, is responsible for the operation and maintenance of TPWTW. The Audit Commission (Audit) has recently conducted a review of WSD's work in implementing the Project and operation and maintenance of TPWTW.

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3. Contracts A to C were substantially completed between January 2013 and December 2019, which were 2.7 to 19.1 months later than the respective original contract completion dates. Full extensions of time (EOTs) had been granted to the three contracts according to the contractual provisions. Consultant M was the Engineer or Supervising Officer responsible for supervising the contract works. The total final contract sum of the three contracts was \$4,309.3 million (para. 2.3).

4. *Scope for improvement in setting out the Employer's Requirements.* Under Contract B, Contractor B was required to design and construct two washwater storage tanks at the base of the two new process buildings for storing washwater required for filter washing. According to the Employer's Requirements of Contract B, the washwater storage tanks should be designed to provide adequate volume for storage for backwashing at least two filters. According to Consultant M, the size of washwater storage tanks proposed by Contractor B in Contractor's Proposals deviated from the Employer's Requirements as given on the Employer's Drawings. According to the Legal Advisory Division (Works) of DEVB, the Employer's Drawings were merely an outline or reference design, which was not binding on the contractor, and the request to amend the Contractor's Proposal for larger tanks would likely constitute a variation. In the event, in September 2018, Consultant M issued a variation order (VO) (later valued at a cost of \$78.7 million) under Contract B to instruct Contractor B to increase the volume of the washwater storage tanks in the two new process buildings from 2,800 to 3,600 cubic metres (m³) and 3,000 to 6,066 m³ respectively. EOTs of 124 days were also granted to Contractor B. In Audit's view, there is scope for improvement in setting out the Employer's Requirements (paras. 2.4, 2.6 and 2.8 to 2.10).

5. *Need to better ascertain the conditions of the existing structures.* According to Consultancy Y, during the review and design phase of Contracts A to C, Consultant M shall conduct a condition survey to assess and baseline the conditions of the existing structures that may potentially affect or be affected by the project. Audit noted that: (a) the condition survey report submitted by Consultant M for Contract C in March 2010 did not include the results of the conditions of existing waterstops installed at the existing compartment of the Butterfly Valley Fresh Water Primary Service Reservoir. After commencement of works under Contract C, additional physical tests on six samples of existing waterstops found that all six samples failed to meet the specified requirements of Contract C and the test results

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inferred that all waterstops were likely to be defective; and (b) in the event, Consultant M issued a VO (later valued at a cost of \$2.7 million) under Contract C to instruct Contractor C to remove and replace the defective waterstops. In Audit's view, in implementing works projects, WSD needs to take measures to conduct condition surveys as comprehensively as practicable with a view to better ascertaining the conditions of the existing structures (paras. 2.11 and 2.12).

6. *Need to critically assess the method for mainlaying works.* In April 2009 and December 2012, the Public Works Subcommittee of the Finance Committee of the Legislative Council was informed that the trenchless method would be adopted where practicable and WSD anticipated that such method would be used for laying water mains at the junction of Cornwall Street and Chak On Road South. Audit noted that: (a) Consultant M did not identify any parts of the water mains that must be constructed by trenchless techniques to avoid unacceptable traffic conditions in the final traffic impact assessment report; and (b) after the unsuccessful implementation of the original temporary traffic arrangements (TTAs) (using open-trench excavation method) for three road sections (including the Cornwall Street and Chak On Road South section), Consultant M took about 2.3 to 7.9 months to submit and obtain approval of the revised TTAs (changing to trenchless method) before issuing 3 VOs (later valued at a total cost of \$3.9 million) to instruct Contractor C to carry out the mainlaying works. According to WSD, in June 2021, a Design Review Committee was established to, amongst others, conduct design review. In particular, the feasibility of using trenchless method for water mains works would be considered in the preliminary design review. In Audit's view, in implementing mainlaying works, WSD needs to remind its staff and consultants to follow the latest requirements in assessing the methods for mainlaying works (particularly at busy roads) (paras. 2.22 to 2.25).

7. *Need to early consult the relevant authorities about the statutory requirements.* According to WSD, chlorine is used for disinfection of drinking water produced in water treatment works in Hong Kong. In 2016 (i.e. after commencement of the expansion works of TPWTW), WSD decided, as a departmental policy, to adopt the on-site chlorine generation (OSCG) technology for all water treatment works and pre-chlorination station in Hong Kong starting from December 2018. After obtaining WSD's approval, in February 2017, Consultant M issued a VO (VO A) at an estimated cost of \$180 million (later valued at \$310.5 million) under Contract B to supply and install four sets of OSCG plant at TPWTW. Based on the site conditions of TPWTW, OSCG plant would be installed in the existing chlorine store of TPWTW (i.e. on the lower level) while liquid chlorine was being stored and used on the upper

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level of the same building. The then-existing liquid chlorine system would be demolished after the commissioning of OSCG plant. There are four types of chemicals involved in the OSCG plant which are dangerous goods (DG) under the Dangerous Goods Ordinance (Cap. 295). Relevant approvals for storage and manufacturing of DG should be obtained from the Fire Services Department (FSD). Audit noted that: (a) in March 2017, Consultant M submitted the application for approval for storage of DG for the OSCG plant at TPWTW to FSD. FSD advised WSD in April 2017 that the siting of DG store immediately above or below another DG store was not acceptable; (b) according to WSD, it took about 7 months to implement the alternative measures (through revising VO A in April 2017 at an estimated cost of \$40 million (later valued at \$62.7 million)) to address the problems arising from the decommissioning of the then-existing liquid chlorine system and supply of chlorine before the commissioning of OSCG plant at TPWTW; and (c) after the decommissioning of the then-existing liquid chlorine system at TPWTW in November 2019, approvals for manufacturing and storage of DG for the OSCG plant at TPWTW were obtained from FSD in the same month. In Audit's view, in implementing works projects, WSD needs to take measures to early consult the relevant authorities about the statutory requirements relating to the storage and manufacturing of DG and chemicals (paras. 2.28 to 2.34).

8. ***Need to finalise the design of works before issuing the related VO.*** Audit noted that VO A's cost (see para. 7) had increased significantly from the original total estimated cost of \$220 million by \$153.2 million (70%) to the final value of \$373.2 million. According to Consultant M, the estimated cost of VO A was provided by Contractor B and vetted by Consultant M in the absence of a detailed design of works. According to WSD, there was urgency to request Contractor B to purchase and install OSCG plant and the cost estimate of VO A was prepared based on the available information at the time of preparation of VO A and preliminary consultation with the stakeholders. In Audit's view, in implementing works projects, WSD needs to finalise the design of works before issuing the related VO as far as practicable (paras. 2.35 to 2.38).

Other contract management issues

9. ***Need to take measures to ensure that project costs are estimated as accurately as possible.*** The APE for Project Vote III was \$6,176.7 million. Audit noted that, as of March 2023, the total expenditure under Project Vote III was \$4,724.5 million (i.e. \$1,452.2 million (24%) less than the APE of \$6,176.7 million).

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In Audit's view, in implementing works projects, WSD needs to take measures to ensure that project costs are estimated as accurately as possible (paras. 3.3 and 3.4).

10. ***Need to ensure timely completion of required works during maintenance period.*** Under Contract B, Contractor B was required to carry out any outstanding works and defects rectification works within the 12-month maintenance period at its own cost. Audit noted that: (a) as of December 2020 (end of the 12-month maintenance period), of the 22,373 defects or outstanding works items identified, 358 (2%) had not yet been rectified or completed by Contractor B; and (b) all the defects and outstanding works were only rectified and completed by end of February 2022 (i.e. more than one year after the end of the maintenance period) (paras. 3.10 and 3.11).

11. ***Scope for improvement in preparing contractors' performance reports.*** According to the Project Administration Handbook for Civil Engineering Works issued by the Civil Engineering and Development Department, the basic objective of the contractors' performance reports is to monitor the contractors' performance and assess their suitability for future work. Audit noted that Contractor B's performance reports of the relevant period had not reflected instances related to its late reporting of 7 (out of 10 — see para. 12) reportable accidents and unauthorised access to the chlorine building by its worker in June 2018 (see para. 13) (paras. 3.13 and 3.14).

12. ***Scope for enhancing construction site safety.*** According to the Construction Site Safety Manual issued by DEVB and WSD guidelines, contractors are required to complete an injury report form within 7 days from the date of an accident. Audit noted that, of the 11 non-fatal reportable accidents (i.e. accident resulting in an injury with incapacity for more than three days) happened at the construction site of Contract B between June 2014 and January 2019 (according to WSD, enhancement measures for site safety had been implemented by Contractor B), late reporting of reportable accidents by Contractor B was found in 10 accidents, ranging from 14 to 263 days (paras. 3.19, 3.21, 3.23 and 3.24).

13. ***Scope for enhancing security of construction sites.*** According to WSD, chlorine building is classified as hazardous/restricted area and any person entering the chlorination plant or store room of the chlorine building should sign the register maintained in the station control room. During a site safety inspection conducted by WSD at TPWTW in June 2018, it was observed that a worker of Contractor B entered

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the first floor of chlorine building through a lock-broken door and used the water from the fire hydrant inside the chlorine building without authorisation. According to Consultant M, in late June 2018, it was subsequently found that the locks of 16 (38%) of the 42 doors at the chlorine building were out-of-order. In Audit's view, there is scope for enhancing security of construction sites (paras. 3.26 to 3.28).

Operation and maintenance of Tai Po Water Treatment Works

14. *Scope for enhancing the administration of works orders for maintenance works.* As of July 2023, 283 works orders for maintenance works of TPWTW (with a target commencement date within the period from January 2020 to March 2023) had been finalised. Audit noted that: (a) of these 283 finalised works orders, the actual expenditures of 36 (13%) works orders were higher than the original estimates by 5% (i.e. \$1,553) to 418% (i.e. \$103,732) (averaging 62%) and the works of 6 (2%) works orders were completed 10 to 263 days (averaging 103 days) after the target completion dates; and (b) according to WSD guidelines, photographic records of the works carried out on site should be taken by WSD and uploaded onto the Maintenance Works Management System (MWMS) as soon as possible. For 15 finalised works orders, photographs relating to the works of 6 (40%) works orders were not available in MWMS (paras. 4.13 and 4.14).

15. *Need to keep under review the demand of treated water of TPWTW.* Audit noted that, since the commissioning of TPWTW after expansion in December 2019, the treated water out from TPWTW was approaching the output capacity of 800 Mld for some days. In 2021 and 2022, there were 107 and 179 days with treated water out from TPWTW over 700 million litres respectively. The maximum daily volumes of treated water out from TPWTW were 778 and 766 million litres in 2021 and 2022 respectively, which were quite close to the design capacity of 800 Mld. According to WSD, the site of TPWTW has allowed for further expansion with an ultimate output capacity of 1,200 Mld. In Audit's view, WSD needs to keep under review the demand of treated water of TPWTW with a view to early considering the need for further expansion of TPWTW (paras. 4.18 and 4.19).

16. *Scope for improvement in monitoring the treated water quality of TPWTW.* According to WSD guidelines, TPWTW's water quality is monitored by taking and analysing samples at different stages of the water treatment process.

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According to WSD, from April 2019 to March 2023: (a) the quality of fresh water supplied to customers (including the treated water of TPWTW) were of 100% compliance with the Hong Kong Drinking Water Standards (HKDWS); and (b) there were incidents that the test results of water samples collected at different stages of the water treatment process at TPWTW did not meet the relevant performance indicators, which are, in general, more stringent than HKDWS and provide early indication for monitoring operation of water treatment works. Follow-up actions had been taken on such instances and, as a result, the final water of TPWTW was considered satisfactory. Audit noted that the record sheet for recording the water quality test results of TPWTW and the follow-up actions taken was a manual record. According to WSD, the digitalisation of the manual record sheet was feasible and would be included as one of the requirements in future system upgrade. In Audit's view, WSD needs to keep under review the treated water quality of TPWTW and complete the digitalisation of the manual record sheet as soon as practicable (paras. 4.22 to 4.24).

Audit recommendations

17. **Audit recommendations are made in the respective sections of this Audit Report. Only the key ones are highlighted in this Executive Summary. Audit has *recommended* that the Director of Water Supplies should:**

Construction works of TPWTW

- (a) **in implementing works projects under a design-and-build contract, clearly set out the requirements on essential works in the Employer's Requirements (para. 2.26(a));**
- (b) **in implementing works projects:**
 - (i) **take measures to conduct condition surveys as comprehensively as practicable with a view to better ascertaining the conditions of the existing structures (para. 2.26(b)(i));**
 - (ii) **take measures to early consult the relevant authorities about the statutory requirements relating to the storage and manufacturing of DG and chemicals (para. 2.43(a)); and**

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- (iii) **finalise the design of works before issuing the related VO as far as practicable with a view to better ascertaining the works needed and assessing the estimated VO cost (para. 2.43(b));**
- (c) **in implementing mainlaying works, remind WSD staff and consultants to follow the latest requirements in assessing the methods for mainlaying works (particularly at busy roads) (para. 2.26(c));**

Other contract management issues

- (d) **in implementing works projects:**
 - (i) **take measures to ensure that project costs are estimated as accurately as possible (para. 3.8(a));**
 - (ii) **remind WSD staff and consultants to closely monitor the outstanding works and defects rectification works of contractors and take measures to ensure the timely completion of such works (para. 3.16(a));**
 - (iii) **take measures to ensure that performance issues of contractors are duly reflected in their performance reports (para. 3.16(b));**
 - (iv) **make continued efforts to enhance construction site safety and take measures to ensure that WSD contractors timely report accidents at construction sites in accordance with related requirements (para. 3.29(a) and (b)(i)); and**
 - (v) **take measures to tighten the controls on access to hazardous/restricted areas with a view to preventing unauthorised access to and use of facilities in these areas (para. 3.29(b)(ii));**

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- (e) **take measures to ensure that:**
 - (i) **works orders for maintenance works of TPWTW are timely completed and their costs are estimated as accurately as possible (para. 4.16(d)(i)); and**
 - (ii) **complete and up-to-date information of works orders for maintenance works of TPWTW is recorded in MWMS (para. 4.16(d)(ii));**
- (f) **keep under review the demand of treated water of TPWTW with a view to early considering the need for further expansion of TPWTW (para. 4.25(a)); and**
- (g) **keep under review the treated water quality of TPWTW and complete the digitalisation of the manual record sheet for recording the water quality test results of TPWTW and the follow-up actions taken as soon as practicable (para. 4.25(c)).**

Response from the Government

18. The Director of Water Supplies agrees with the audit recommendations.

