

MANAGEMENT OF FLUSHING WATER SUPPLY

Executive Summary

1. Hong Kong is the world's first city to systematically utilise seawater for flushing and, up till now, is one of the few places in the world extensively applying seawater for flushing. The use of seawater, a sustainable water resource, plays an important role in Hong Kong's water resources management. In the late 1950s, seawater flushing was introduced in Hong Kong in view of the then acute shortage of fresh water for potable use and to conserve fresh water. Seawater supply systems were then added one after another, extending the seawater supply network for flushing in Hong Kong.

2. Since 1965, all new buildings have been required to be installed with dual plumbing systems for potable and flushing water. According to the Waterworks Regulations (Cap. 102A), the Water Authority, who is the Director of Water Supplies (for simplicity, the Water Authority is referred to as the Water Supplies Department (WSD) in this Audit Report), may require the use of salt water for flushing. For areas without seawater supply at the moment, as an interim measure, WSD would approve the use of temporary mains fresh water for flushing (TMF). Seawater for flushing is supplied free of charge while the use of fresh water for flushing may be subject to charge depending on usage.

3. WSD is responsible for operation and maintenance of the seawater supply systems (consisting of 42 pumping stations, 54 salt water service reservoirs (SWSRs) and 1,660 kilometres of salt water mains as of March 2021). In 2020-21, the total operating and administration expenses (including depreciation but excluding staff cost) related to flushing water supply was about \$976 million. The seawater supply network for flushing currently covers about 85% of the population in Hong Kong. WSD targets at expanding the network coverage of using lower grade water (i.e. seawater and recycled water) for flushing from 85% of the total population to 90% in the long run in order to further reduce the fresh water demand for flushing.

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The Audit Commission (Audit) has recently conducted a review to examine WSD's work in managing flushing water supply.

Management of projects for extension of seawater supply network

4. The latest extension of seawater supply network involved two areas, namely Pok Fu Lam and Northwest New Territories. The works for these two areas commenced in August 1996 and February 2008 and were substantially completed in July 2013 and March 2015 respectively. As of June 2021, the total project expenditure was \$1,380.9 million. Between 1996 and April 2012, WSD awarded 4 contracts (Contracts A to D) and 9 contracts (Contracts E to M) under the projects for extension of seawater supply network in Pok Fu Lam (Projects A to C) and Northwest New Territories (Projects D and E) respectively. The works under the 13 works contracts were supervised by in-house staff of WSD except Contract D for which a consultant (Consultant X) was engaged to supervise the works (paras. 1.11, 2.2 and 2.3).

5. ***Disputes under Contract D.*** Contract D was a lump sum contract covering the construction of 2 SWSRs and 2 salt water pumping stations (SWPSs), and laying of associated salt water mains in Pok Fu Lam. WSD awarded Contract D to Contractor D in September 2009 at \$190.7 million. The works commenced in October 2009 and were substantially completed in July 2013. Consultant X was the Engineer responsible for supervising the contract works. There were disputes under Contract D and counterclaims against Consultant X. In June 2015, Contractor D served a Notice of Arbitration in respect of disputes relating to various claims under Contract D. Before the completion of arbitration hearing, WSD and Contractor D agreed to settle various claims (mainly low-value claims) at a total sum of \$3.2 million (paid in October 2015 and December 2019). The disputes then proceeded to arbitration hearing in June 2019 and the Arbitrator issued a Partial Award which covered all the claims except interest and legal costs in December 2019. In October 2020, the Arbitrator issued a Final Award on the terms agreed between WSD and Contractor D. In the event, WSD paid a total of \$47.5 million to Contractor D in January and October 2020 to settle all the claims under Contract D. After the Partial Award was issued by the Arbitrator in December 2019, WSD decided to claim against Consultant X. In the event, Consultant X paid to the Government a sum of \$13.6 million to settle all the claims under Consultancy X on a “without any

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admission of liability or wrongdoing” basis. According to WSD, the disputes under Contract D mainly involved (paras. 2.4 to 2.7, 2.11 and 2.13):

- (a) ***Measurement and valuation of formwork.*** Under Contract D, Contractor D was required to carry out certain formwork at two SWPSs in accordance with the formwork requirements stipulated in the contract specification. The Bills of Quantities (BQ) under Contract D specified the firm quantities of classes of formwork finish required. During the tender assessment for Contract D, Consultant X noted that under Contractor D’s tender, there were substantially over-priced/under-priced and un-priced BQ items. These items included class F2 formwork finish (substantially over-priced) and class F4 formwork finish (substantially under-priced). Contractor D commenced the formwork in March 2011. The actual quantities of classes F2 and F4 formwork finish provided by Contractor D during the construction stage were found to have substantially deviated from the corresponding firm quantities in BQ. Contractor D and Consultant X had different views on the valuation of formwork (para. 2.8); and
- (b) ***Omitted items in BQ.*** The disputes involved whether certain works were omitted items in BQ and their valuation, and the valuation of a number of omitted items agreed between Contractor D and Consultant X (para. 2.10).

6. ***Need to draw lessons from disputes under Contract D.*** Audit noted that: (a) according to the Arbitrator, the disputes under Contract D on measurement and valuation of formwork arose from different interpretations on the application of class of formwork finish and BQ of Contract D did not correctly represent the works shown on the drawings and described in the contract specification. Other major disputes were related to omitted items in BQ (see para. 5(b)). In the event, \$13.6 million and \$5.9 million were paid to Contractor D to settle these claims respectively (see also para. 5 for WSD’s claim against Consultant X); and (b) according to Consultant X, during the course of construction, it certified the interim payments to Contractor D based on the formwork of class F2 standard with the intention to assist Contractor D with its cash flow. According to WSD, interim payments had to be based on the BQ rate for class F2 formwork finish so long as they were applicable according to the terms of contract. Consultant X subsequently adjusted the interim payments to Contractor D to recover the overpaid amount of \$8.9 million. In Audit’s view, there is scope for WSD to draw lessons from the disputes under Contract D (paras. 2.8, 2.13 and 2.15).

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7. ***Scope for enhancing pre-tender site investigations and tree surveys.***

Under Contract J, Contractor J was required to construct a SWPS and carry out associated works. The contract works were substantially completed in late December 2014, about 23 months later than the original completion date of February 2013. According to WSD, extensions of time had been granted except 21 days (subject to liquidated damages). The reasons for granting the extensions of time mainly included: (a) additional works arising from the adverse ground conditions (i.e. marine mud and large boulders found below the original foundation level of the proposed intake culvert) identified during the construction stage, which was at variance with the contract drawings; (b) need for transplantation of 3 trees, which were not shown in the contract drawings, before the construction of SWPS commenced; and (c) substantial increase in the volume of rocks excavated, which significantly raised the construction difficulty. In the event, extensions of time totalling 595.5 days were granted for the above reasons, leading to prolongation costs of \$8.7 million as assessed according to the terms of the contract. In October 2021, WSD informed Audit that its manual was recently updated in September 2021 with a view to strengthening the requirements on pre-tender site investigations and a review of the requirements on tree surveys was in progress. In Audit's view, WSD needs to remind its staff to comply with the requirements on pre-tender site investigations in implementing works projects in future. WSD also needs to early complete the review of the requirements on tree surveys with a view to enhancing planning and design work (paras. 2.18, 2.20 and 2.21).

8. ***Need to timely conduct post-completion review.*** According to the Project Administration Handbook for Civil Engineering Works, a post-completion review is a useful project management tool and should be carried out within a reasonable period, say six months, after the substantial completion of a consultancy agreement or a works contract. As a broad guideline, post-completion reviews are generally not warranted for consultancy agreements and works contracts of a project which has a total cost less than \$500 million. The total project expenditure of Project E (one of the projects for the extension of seawater supply network in Northwest New Territories) exceeded \$500 million (i.e. \$798.2 million as of June 2021) and all works were substantially completed in March 2015. However, as of June 2021 (6 years later), WSD had not conducted a post-completion review for the project (paras. 2.26 and 2.27).

9. ***Need to continue to expedite the conversion to seawater flushing.*** The projects for extension of seawater supply network in Pok Fu Lam and Northwest New Territories were completed in July 2013 and March 2015 respectively. However,

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Audit noted that, as of June 2021 (i.e. about 8 and 6 years after the completion of the extension projects), WSD had not completed the conversion to seawater flushing in the two areas. Over 80% of TMF accounts in the two areas had not been converted to seawater for flushing. In 2020, a total of 8.2 million cubic metres (Mm³) of fresh water was still used for flushing in the two areas (or 40% (1.6 Mm³) and 17% (6.6 Mm³) of the total volume of flushing water in each respective area). Apart from the two areas, Audit noted that some consumers in other seawater supply zones (i.e. with salt water supply systems available) were still using fresh water for flushing (there were 4,134 such TMF accounts as of June 2021 and 18.8 Mm³ of fresh water was used for flushing in 2020) (paras. 2.34 and 2.37).

Operation and maintenance of seawater supply systems

10. *Scope for improving the sampling of flushing water quality at customer ends.* WSD has laid down standards (i.e. Water Quality Objectives) for flushing water to ensure that the quality of seawater for flushing is acceptable, and set out a key performance measure to ensure that flushing water supplied to customers complies with WSD's Water Quality Objectives. Under the programme for monitoring flushing water quality, samples are taken from monitoring points at SWPSs, SWSRs and customer ends (such as publicly accessible toilets at estate management offices, shopping centres, government buildings and community facilities). According to WSD, for sampling of flushing water quality at customer ends, the selection criteria are based on accessibility and the representativeness of the sampling point with inputs from the regional offices. However, Audit noted that, as of October 2021, WSD had no specific guidelines in this regard. According to WSD, it issued such guidelines in November 2021. Audit also noted that the number of monitoring points at customer ends decreased from 63 in 2018-19 to 55 in 2019-20, and further to 30 in 2020-21. A total of 70 different monitoring points were covered in the three-year period, of which the same 25 (36%) monitoring points had been selected in all three years. While the changes of relevant sampling programmes for flushing water were reported in regular WSD's meetings, the details were not documented (paras. 3.3, 3.4, 3.6 and 3.8).

11. *Scope for improving handling complaints on seawater supply systems.* According to WSD, it will provide a substantive reply to a complainant within 30 calendar days as far as practicable. From January 2018 to March 2021, WSD received 2,544 complaints on seawater supply systems. Audit noted that, as of March 2021: (a) the follow-up actions for 2,497 complaints had been completed. There were

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68 complaints with data entry problems (e.g. follow-up actions and completion dates for handling the complaints not recorded) in the complaint management system. For 607 (25%) of the remaining 2,429 complaints, WSD took more than 1 month and up to 12 months (averaging 2 months) to complete the follow-up actions after receipt of the complaints; and (b) the follow-up actions for 47 complaints had not been completed, of which 27 (57%) complaints had been received for more than 1 month and up to 9 months (averaging 4 months) (paras. 3.11 and 3.12).

12. ***Improvement works for salt water mains.*** Audit noted the following issues:

- (a) ***Scope for improving the selection of salt water mains for improvement works.*** According to WSD, it will assess the risk of water main bursts or leaks taking into account various factors and accord priorities to those water mains assessed with high risk for improvement works so as to reduce the risk of water main bursts and leaks. A scoring system is developed to prioritise all water mains into five ranks (from Rank 1 (the highest risk) to Rank 5 (the lowest risk)). WSD conducted a prioritisation exercise of water mains based on the scoring system in 2016. Audit noted that, as of March 2021 (about five years after the 2016 prioritisation exercise), 2 (67%) of the 3 salt water mains of the highest risk (i.e. Rank 1) and 23 (38%) of the 61 salt water mains of high risk (i.e. Rank 2) had not been selected for improvement works (paras. 3.16 and 3.20); and
- (b) ***Improvement works for some salt water main burst hot spots not completed after a long time.*** WSD has outsourced the risk-based improvement works of water mains to contractors. According to WSD, it accords the highest priority to arrange improvement works at hot spots (i.e. locations with repeated water main bursts) to eliminate the risk of water main bursts. WSD identified 44 hot spots of salt water main bursts for which improvement works were required. Audit noted that, as of April 2021, the improvement works for 14 (32%) of the 44 hot spots were still in progress. The works for 13 (93%) of the 14 hot spots had not been completed for more than 2 years and up to 6.5 years (averaging about 4.5 years) after the last burst at the hot spot (para. 3.21).

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13. ***Salt water main bursts and leaks.*** Audit noted the following issues:
- (a) ***Scope for enhancing the monitoring of repair works for salt water main bursts.*** For water main bursts and leaks, WSD has mainly engaged term contractors to carry out repair works of the water mains. According to the contracts, the contractors should provide adequate labour and/or plant to handle all emergency works, including deploying a specified minimum number of workers for attending to an emergency involving water main burst. From January 2018 to March 2021, there were 105 salt water main burst cases. Audit noted that there were 10 cases with shortfall in contractors' workers by 2 to 5 (ranging from 20% to 63%, averaging 33%) (paras. 3.22 and 3.23); and
 - (b) ***Scope for improving attendance to salt water main leaks.*** While the number of salt water main leak cases decreased by 3% from 1,876 cases in 2017 to 1,827 cases in 2018, it increased by 10% from 1,827 cases in 2018 to 2,006 cases in 2020. From January 2018 to March 2021, there were 6,193 salt water main leak cases. Audit noted that, for 1,991 (32%) of the 6,193 cases, more than 2 hours and up to 49 days (averaging 22 hours) were taken to close the valve after receipt of report of salt water main leaks. For 217 (4%) of the 6,193 cases, the duration of supply interruption due to salt water main leak was more than 24 hours and up to 7 days (averaging 39 hours) (paras. 3.25 and 3.26).
14. ***Scope for utilising advanced technologies to monitor seawater supply systems.*** From January 2018 to March 2021, most of the salt water main burst and leak cases were identified by the public and not by WSD. Audit notes that WSD has implemented a Water Intelligent Network (including active leakage detection and control measures), which only covers fresh water distribution systems but not seawater supply systems. In Audit's view, WSD needs to explore the feasibility of utilising advanced technologies (such as the Water Intelligent Network) to monitor the seawater supply systems (paras. 3.30 to 3.32).

Other related issues

15. ***Quality Water Supply Scheme for Buildings — Flushing Water (Quality Flushing Water Scheme).*** Audit noted the following issues:

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- (a) ***Need to keep up efforts to encourage more buildings to participate in Quality Flushing Water Scheme.*** WSD has launched the Quality Flushing Water Scheme since July 2013. The number of buildings participating in the Scheme had been fluctuating since its launch in July 2013 (increasing from 550 buildings in December 2013 to 1,804 buildings in December 2016, decreasing to 1,414 buildings in December 2020, and increasing to 1,949 buildings in September 2021). As of September 2021, only two government buildings participated in the Scheme (paras. 4.2 and 4.5); and
 - (b) ***Need to complete processing of applications as soon as practicable.*** As of March 2021, WSD had not completed the processing of 176 new applications (involving 876 buildings) and 240 renewal applications (involving 784 buildings) for the Quality Flushing Water Scheme. For the 176 new applications, they had been received by WSD for about 7 months on average. For 104 (59%) of the 176 applications, they had been received for more than 6 months and up to 17 months (averaging about 10 months). For the 240 renewal applications, they had been received by WSD for about 5 months on average. For 90 (38%) of the 240 applications, they had been received for more than 6 months and up to 13 months (averaging about 8 months) (para. 4.9).
16. ***Slow progress of mainlaying works under a project for uprating the existing seawater supply system for Wan Chai.*** According to WSD, for some areas with seawater supply systems, the existing systems may not be able to cope with the increasing seawater demand arising from the existing or planned developments in the areas, and enhancement works to uprate the existing seawater supply system will be required. As of September 2021, an uprating project for the salt water supply system for Wan Chai (Wan Chai uprating project) was still in progress. WSD had awarded four contracts for the project, of which three contracts had been completed. For the remaining contract (Contract Q), WSD awarded it in January 2012 to a contractor (Contractor Q) for mainlaying works at \$165.6 million. Audit noted that: (a) as of September 2021 (about 5.7 years after the original contract completion date of January 2016), the works for Contract Q were still not yet completed, mainly due to problems encountered during mainlaying works (e.g. congested and uncharted underground utilities and obstructions affecting trenchless works); and (b) according to WSD, the performance of Contractor Q was unsatisfactory (including persistent slippage of progress, poor planning of works and inadequate resources). In Audit's view, WSD needs to complete the Wan Chai uprating project as soon as practicable and draw on the experience gained in implementing the project (paras. 4.15 to 4.20).

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17. ***Need to keep under review the implementation of projects for supply of recycled water.*** According to WSD, it has been actively exploring the use of recycled water (see para. 3 for WSD's related target) by providing a centralised recycled water supply system in those areas where fresh water is being used for flushing and in new development areas (especially in the inland areas) to contain the fresh water demand. It is implementing two projects: (a) constructing a district-based grey water (which is collected from baths, wash-basins, kitchen sinks, etc.) recycling system at the Anderson Road Quarry Development site. The system is anticipated to be completed in 2023; and (b) carrying out works to supply reclaimed water, converted from tertiary treated sewage effluent at the Shek Wu Hui Effluent Polishing Plant, to the Northeast New Territories for non-potable uses (including toilet flushing) in phases. The supply of reclaimed water to Sheung Shui and Fanling will start in 2024. In Audit's view, WSD needs to keep under review the implementation of projects for supply of recycled water (paras. 1.6, 4.27 and 4.29).

Audit recommendations

18. **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:**

Management of projects for extension of seawater supply network

- (a) **in implementing works projects in future:**
 - (i) **remind WSD staff and consultants to critically vet contract documents (e.g. BQ) for ensuring their completeness, accuracy and consistency with one another in accordance with the related guidelines (para. 2.16(a));**
 - (ii) **in certifying interim payments to contractors, require consultants to pay particular attention to payments involving over-priced/under-priced items when there is substantial change in quantities and report to WSD any irregularities including possible overpayments (para. 2.16(b)); and**

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- (iii) remind WSD staff to comply with the requirements on pre-tender site investigations recently updated in September 2021 (para. 2.30(a));
- (b) early complete the review of the requirements on tree surveys with a view to enhancing planning and design work (para. 2.30(b));
- (c) complete the post-completion review for Project E as soon as practicable, and remind WSD staff and consultants to conduct post-completion reviews as needed in a timely manner (para. 2.30(c) and (d));
- (d) continue to expedite the conversion to seawater flushing for consumers in seawater supply zones (including Pok Fu Lam and Northwest New Territories) (para. 2.39(a));

Operation and maintenance of seawater supply systems

- (e) document more details about the changes of sampling programmes for flushing water (para. 3.13(a));
- (f) continue to follow up the complaints on seawater supply systems as early as practicable and take measures to ensure that information about the complaints is accurately and timely updated in the complaint management system (para. 3.13(c) and (d));
- (g) include salt water mains of high risk for implementation of improvement works and continue to take measures to ensure that improvement works of salt water mains are completed as soon as practicable (para. 3.33(a) and (c));
- (h) take measures to ensure that the contractors comply with the contract requirement of deploying adequate labour to handle emergencies involving salt water main bursts, and attend to salt water main leaks as soon as practicable, balancing all relevant factors (para. 3.33(e) and (f));

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- (i) **explore the feasibility of utilising advanced technologies to monitor the seawater supply systems (para. 3.33(h));**

Other related issues

- (j) **keep up efforts to encourage more buildings to participate in the Quality Flushing Water Scheme and complete the processing of applications for the Scheme as soon as practicable (para. 4.13(a) and (b));**
- (k) **strengthen actions to complete the Wan Chai uprating project as soon as practicable and draw on the experience gained in implementing the project (para. 4.24(a) and (b)); and**
- (l) **keep under review the implementation of projects for supply of recycled water (para. 4.32(a)).**

Response from the Government

- 19. The Director of Water Supplies agrees with the audit recommendations.