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Legislative Council

of the

Hong Kong Special Administrative Region

Delegation of the Panel on Development

Report on the duty visit to Singapore to study its experience in developing water resources and safeguarding the quality of drinking water

20 to 23 March 2016

TABLE OF CONTENTS

TABLE OF CONTENTS

CHAPTER 1 — INTRODUCTION

1.1 Purpose of the report

1.1.1 A delegation of the Panel on Development ("the Panel") of the Legislative Council visited Singapore from 20 to 23 March 2016 to study the country's experience in developing water resources and safeguarding the quality of drinking water. This report presents the main findings and observations of the delegation.

1.2 Background of the visit

1.2.1 At present, the fresh water resources in Hong Kong come from local catchment and Dongjiang ("DJ") water imported from the Guangdong ("GD") Province. In view of the challenges arising from climate change and the keen competition among the cities in GD Province for DJ water, the Administration has been developing new water resources which are insensitive to climate change, such as seawater desalination and water reclamation, to safeguard the security of the water supply in Hong Kong.

1.2.2 With the support of the Panel and the endorsement of the Public Works Subcommittee, the Administration obtained the approval of the Finance Committee ("FC") on 26 June 2015 for a funding of $154.5 million in money-of-the-day prices for carrying out an investigation study review, design and associated site investigation works for developing the first stage of a proposed seawater desalination plant in Tseung Kwan O. The review and the design work for the plant, started in late-2015 for completion in end-2017, will be followed by site formation works and construction works. The first stage of the plant is targeted for commissioning in 2020.

1.2.3 Having regard to the aforementioned development, the Panel considered it an opportune time to study the policy matters and technology related to seawater desalination in overseas places. Given the similarity between the water supply situations in Singapore and Hong Kong, as well as the rich experience of Singapore in diversifying its water supply sources,

including the development of seawater desalination and water reclamation, in November 2015, the Panel agreed to conduct a duty visit to Singapore.

1.2.4 Moreover, in the light of the occurrence of the incident in the second half of 2015 in which the drinking water at consumers' taps in some public rental housing ("PRH") estates, residential buildings, hospitals and schools was found to have a lead content exceeding the standards set out in the World Health Organization Guidelines for Drinking-water Quality ("WHO Guidelines"), the delegation also agreed that the opportunity should be taken to learn about the measures taken by the Singapore government to safeguard the quality of drinking water.

1.2.5 On 11 December 2015, the Panel obtained the House Committee's permission to undertake the duty visit to Singapore.

1.3 Objectives of the visit

1.3.1 The objectives of the duty visit were to:

(a) study Singapore's experience, policies and strategies on water supply management;

(b) obtain first-hand information on the development, operation and cost-effectiveness of seawater desalination and water reclamation in Singapore;

(c) exchange views with the relevant parties involved in the formulation, implementation and monitoring of strategies on water supply management; and

(d) learn about the measures taken by the Singapore government to safeguard the quality of piped drinking water.

1.4 Membership of the delegation

1.4.1 The delegation comprised the following 12 members:

Panel members

Hon Tony TSE Wai-chuen, BBS (Delegation Leader and Chairman of the Panel)
Hon LEUNG Che-cheung, BBS, MH, JP (Deputy Delegation Leader and Deputy Chairman of the Panel)
Hon Cyd HO Sau-lan, JP
Hon IP Kwok-him, GBS, JP
Hon Alan LEONG Kah-kit, SC
Hon LEUNG Kwok-hung
Hon Albert CHAN Wai-yip
Hon James TIEN Pei-chun, GBS, JP
Hon CHAN Chi-chuen
Hon CHAN Yuen-han, SBS, JP
Dr Hon Helena WONG Pik-wan

Non-Panel member

Hon Kenneth LEUNG

1.4.2 At the invitation of the Panel, Mr WONG Chung-leung, Deputy Director of Water Supplies, joined the visit at the Government's expense to offer technical advice on water supply management and drinking water quality. Ms Sharon CHUNG, Clerk to the Panel, Mr Raymond CHOW, Senior Council Secretary, and Ms Maggie LAU, Council Secretary, also accompanied the delegation during the visit.

1.5 Visit programme

1.5.1 The delegation arrived in Singapore on 20 March 2016 and returned to Hong Kong on 23 March 2016. During the visit, the delegation met with senior government officials, members of the Parliament of Singapore ("MPs") and representatives of the water management authorities, as well as paying visits to various water facilities. The detailed visit programme and a list of the organizations and persons met by the delegation are in **Appendices I and II** respectively.

CHAPTER 2 — WATER RESOURCES MANAGEMENT AND REGULATION OF QUALITY OF DRINKING WATER IN HONG KONG

2.1 Overview

2.1.1 In Hong Kong, the Water Supplies Department ("WSD") is responsible for monitoring and managing all facets of securing and maintaining fresh and sea water supplies, including the monitoring of the water quality. It also administers the Waterworks Ordinance (Cap. 102) ("Waterworks Ordinance") and the Waterworks Regulations (Cap. 102A) ("Waterworks Regulations").

2.1.2 With a view to ensuring a sustainable use of the water resources and better preparing for future uncertainties resulting from climate change, WSD promulgated the Total Water Management Strategy ("TWMS") in 2008 covering two limbs viz water supply management and water demand management. Since then, various demand and supply management measures have been rolled out to take forward the strategy. In late-2014, WSD appointed consultants to conduct a review of TWMS. The review results will help WSD formulate the best possible long-term water management strategy for addressing future challenges and uncertainties.

2.2 Sources of water supply

2.2.1 At present, the water supply of Hong Kong comes from three sources: (a) local yield; (b) raw water imported from DJ; and (c) seawater used for toilet flushing. In 2015, Hong Kong consumed a total of 1 245 million cubic metres ("mcm") of water, of which around 16% was from local yield, 62% from DJ and the remaining 22% from seawater.

Local yield

2.2.2 With a lack of natural lakes, rivers or substantial underground water sources, the Administration has constructed 17 impounding reservoirs and designated about one-third of the territory as water gathering grounds ("WGGs") to collect rainwater. Yet, the locally collected rainwater,

fluctuating from the lowest yield of 103 mcm in 2011 to the highest yield of 336 mcm in 2013 over the past 20 years, is far from sufficient for meeting the demand in Hong Kong.

2.2.3 Hong Kong adopts a multiple-barrier approach to safeguarding the quality of drinking water from source to distribution. For controlling and preventing the risks of contamination at source, development within WGGs is subject to control. In view of the land shortage problem in Hong Kong, the Administration considers that further expanding WGGs should require careful consideration.

2.2.4 In regard to the use of urban areas as WGGs, the Administration holds the view that it is not in line with the multiple-barrier approach that protection of water quality should start from source. According to the Administration, urban stormwater commonly gets contaminated by emissions and wastes from motor vehicles, industrial and municipal wastes, and other urban-specific pollutants. Such pollutants may be present in varying quantities at different times in the urban runoff and could exceed the treatment capability of water treatment works, possibly making the quality of treated water not meeting the required standard for drinking water.

Importation of Dongjiang water

2.2.5 To make up the shortfall of the local yield, DJ water has been imported from GD Province since 1965. Under the "package deal lump sum" approach adopted since 2006, Hong Kong imports DJ water as needed up to an annual ceiling quantity of 820 mcm to ensure a 99% reliability[1] of water supply in Hong Kong. The actual quantity of DJ water to be imported each year is dependent on the amount of local yield, reservoir storage level and water demand.

[1] "99%" reliability means that water supply is maintained round-the-clock even under extreme drought condition with a return period of 1 in 100 years. "Return period" is the average number of years during which an event will occur once statistically. A longer return period means a rarer chance of occurrence.

2.2.6 Under the latest 2015-2017 DJ water supply agreement, the annual lump sum water prices are $4,222.79 million in 2015, $4,491.52 million in 2016 and $4,778.29 million in 2017.

Seawater for toilet flushing

2.2.7 To save fresh water resources, seawater toilet flushing system was implemented in the 1950s. Since then, all new buildings were required to be installed with dual plumbing systems for potable and flushing water. The seawater supply networks in Hong Kong currently cover about 80%[2] of the population, rendering Hong Kong unique in the world to use seawater for toilet flushing on such a scale. WSD has been expanding the seawater supply network. Infrastructure for extending seawater supply to Pokfulam and Northwest New Territories has already been constructed to increase the population coverage to 85%. In these areas, the flushing water systems are changing from fresh water systems to seawater systems.

Development of new water supply sources

2.2.8 In view of the challenges arising from climate change and continued population growth, WSD has been developing the following new water supply sources that are insensitive to climate change as part of TWMS.

Seawater desalination

2.2.9 A consultancy study on a pilot desalination plant commissioned by WSD, completed in 2007, concluded that seawater desalination using reverse osmosis was technically feasible in Hong Kong. In December 2012, WSD engaged consultants to carry out a planning and investigation study for a proposed seawater desalination plant in Tseung Kwan O. The study was completed in 2015 and confirmed the technical feasibility, including the environmental viability, of the project. Subsequent to the approval of FC on 26 June 2015 for the Administration's funding proposal for carrying out an investigation study review, design and associated site investigation works

[2] The areas currently using fresh water for toilet flushing include Sheung Shui, Fanling, the Peak and the Southern District.

for developing the first stage of the proposed seawater desalination plant, WSD engaged consultants in November 2015 to embark on the design of the proposed plant.

2.2.10 The output capacity of the proposed plant will amount to 135 million litres per day or 30 million gallons per day ("mgd") at its first stage with provisions for future expansion to an ultimate capacity of 270 million litres per day, accounting for 5% (10% if expanded) of the total fresh water consumption in Hong Kong. The first stage of the proposed plant is targeted for commissioning in 2020.

Reclaimed water

2.2.11 Reclaimed water is primarily for non-potable uses. As Hong Kong has been extensively using seawater for toilet flushing, and the industrial water demand is small, the scope of the use of reclaimed water in Hong Kong has been limited. Nevertheless, since it is not cost-effective to construct and operate a seawater flushing supply system in some inland areas (e.g. Sheung Shui and Fanling) due to their long distance from the seashore, opportunities have arisen in these areas for the use of reclaimed water.

2.2.12 To cater for the new developments in the northeastern part of the New Territories, the Drainage Services Department ("DSD") is going to expand the Shek Wu Hui Sewage Treatment Works ("SWHSTW") in phases and upgrade its treatment level from secondary to tertiary. WSD took the opportunities to carry out a study, in collaboration with relevant departments including DSD, on the technical feasibility and financial viability of converting the tertiary treated sewage effluent from SWHSTW into reclaimed water for toilet flushing and other non-potable uses in Sheung Shui, Fanling and other areas in the northeastern part of the New Territories. According to WSD, the study confirmed the viability of the option.

2.2.13 WSD has commenced the design of the necessary infrastructure to effect the supply of reclaimed water to Sheung Shui and Fanling for flushing and non-potable uses. The supply of reclaimed water is scheduled to be commissioned in phases starting from 2022. Upon full commissioning of the supply of reclaimed water to the northeastern part of the New Territories, the seawater and reclaimed water flushing supply networks will cover approximately 90% of the population in Hong Kong. Meanwhile, the relevant legislations are under review to cater for the supply of reclaimed water.

2.2.14 According to WSD, the unit costs of various water supply sources were as follows:

	Seawater for flushing	Reclaimed water for non-potable uses	Local yield	DJ water	Desalinated water
Unit cost ($/cubic metre ("$m^3$"))	3.7 Note 1	3.8 Note 2 (estimated)	4.2 Note 1	9.1 Note 1	12.6 Note 3 (estimated)

Note 1: Unit costs in the 2014-2015 financial year

Note 2: Based on an assessment in 2012, the unit production costs of reclaimed water and seawater for Sheung Shui and Fanling were $3.8 and $10.4 respectively.

Note 3: At 2013-2014 price level

Source: WSD

Compared with other water supply sources, the cost of seawater desalination is most expensive due to the high energy expenses incurred during the energy-consuming desalination process.

Grey water reuse and rainwater harvesting

2.2.15 WSD has also been exploring the wider use of grey water[3] recycling and rainwater harvesting systems by installation of such systems in suitable new government projects. WSD has established corresponding technical and water quality standards and provided detailed guidelines on the use of recycled grey water and rainwater in government premises. So far, grey water recycling systems or rainwater harvesting systems have been included in over 50 government projects including schools and various government facilities. According to the Administration, when planning large-scale new development projects such as the Anderson Road Quarry site development, the Administration will reserve space and ancillary facilities for introducing grey water recycling and rainwater harvesting in future as appropriate.

Stormwater management and harvesting

2.2.16 DSD is operating three drainage tunnels in Tsuen Wan, Lai Chi Kok, and Hong Kong Island West respectively. In the course of the engineering studies, various options were examined for reusing the stormwater collected in the drainage tunnels in terms of economic viability and technical feasibility. According to the Administration, as all options required huge capital investments on the additional tunnels and/or pipe works and pumping facilities and these facilities would only be used several times a year during rainstorms, it was concluded that harvesting the stormwater collected from the drainage tunnels would not be cost-effective.

2.2.17 Nevertheless, in the Lai Chi Kok drainage tunnel project, DSD, in collaboration with WSD, has proposed an inter-reservoir transfer scheme to convey the overflow from the Kowloon Group of Reservoirs to Lower Shing Mun Reservoir during heavy rainfalls. Planning of the transfer scheme is in progress.

[3] Grey water refers to the water from a bath, shower, lavatory basin, sink, etc. but excludes water from a slop sink, toilets or urinals.

2.3 Water conservation and reduction of water loss

2.3.1 In Hong Kong, the daily per capita domestic fresh water consumption is about 130 litres, which is higher than the world average of 110 litres. As one of the steps for a progressive reduction of water consumption, WSD launched the "Let's Save 10L Water" campaign in 2014 to promote the saving of 10 litres of fresh water consumption each day by each member of the public. Under the campaign, complimentary flow controllers have been distributed to participating households to assist them in saving water.

2.3.2 Apart from the "Let's Save 10L Water" campaign, WSD has also organized a series of educational programmes, roving exhibitions and mobile showrooms to promote water conservation at schools and within the community.

2.3.3 To further promote public education on water resources and water conservation, the Administration proposed the establishment of a permanent Water Resources Education Centre ("WREC") in the proposed new WSD building in Tin Shui Wai.[4] FC approved the funding proposal of the project on 26 June 2015 and the permanent WREC is expected to be commissioned in 2018. In addition, WSD plans to mandate the use of water saving devices registered under the Water Efficiency Labelling Scheme [5] in new developments and major renovation of buildings.

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[4] At present, WSD has a temporary WREC in Mong Kok, which was opened in late 2012. It will be decommissioned after the commissioning of the new WREC in Tin Shui Wai.

[5] WSD introduced the voluntary Water Efficiency Labelling Scheme in 2009 to advise consumers about the efficiency of common types of plumbing fixtures and water-consuming appliances in order to help consumers make the best product choices for water conservation. Products participating in the Scheme will incorporate a water efficiency label that will tell consumers the level of water consumption and water efficiency.

2.3.4 As regards the measures to reduce water loss, the 15-year programme to replace and rehabilitate 3 000 kilometres ("km") of aged water mains was substantially completed in 2015. The water main leakage rate has also been reduced from exceeding 25% in 2000 to 15% in 2015.

2.3.5 WSD now plans to progressively implement the Water Intelligent Network by installing sensors in the water supply networks to continuously monitor their conditions and implement cost-effective network management measures including (a) active leakage detection and control through the usage of the monitoring and sensing equipment installed in the networks; (b) pressure management to reduce the pressure in the networks, where appropriate; (c) quality and speedy repairs to water main leaks and bursts; and (d) asset management by reprovisioning of aged water mains which are beyond economic repair.

2.4 Regulation of the quality of drinking water

2.4.1 In Hong Kong, neither the Waterworks Ordinance nor the Waterworks Regulations specifies any standards on water quality. Yet, WSD has pledged to supply drinking water to consumers in full compliance with the WHO Guidelines up to the connection points, i.e. the points between government water mains and the inside service.[6] WSD has undertaken the following measures to control the quality of drinking water in Hong Kong:

(a) Control of water quality at source — Section 30 of the Waterworks Ordinance prohibits pollution of the local raw water source at the gathering grounds, while the GD side maintains the quality of DJ water supplied to Hong Kong in compliance with Type II waters in the Environmental Quality

[6] For a residential development, the registered consumers or their agents are responsible for the maintenance and repairs of the systems within the development (inside service). The inside service includes pipes and fittings in premises, and those between premises and those connecting to the public mains.

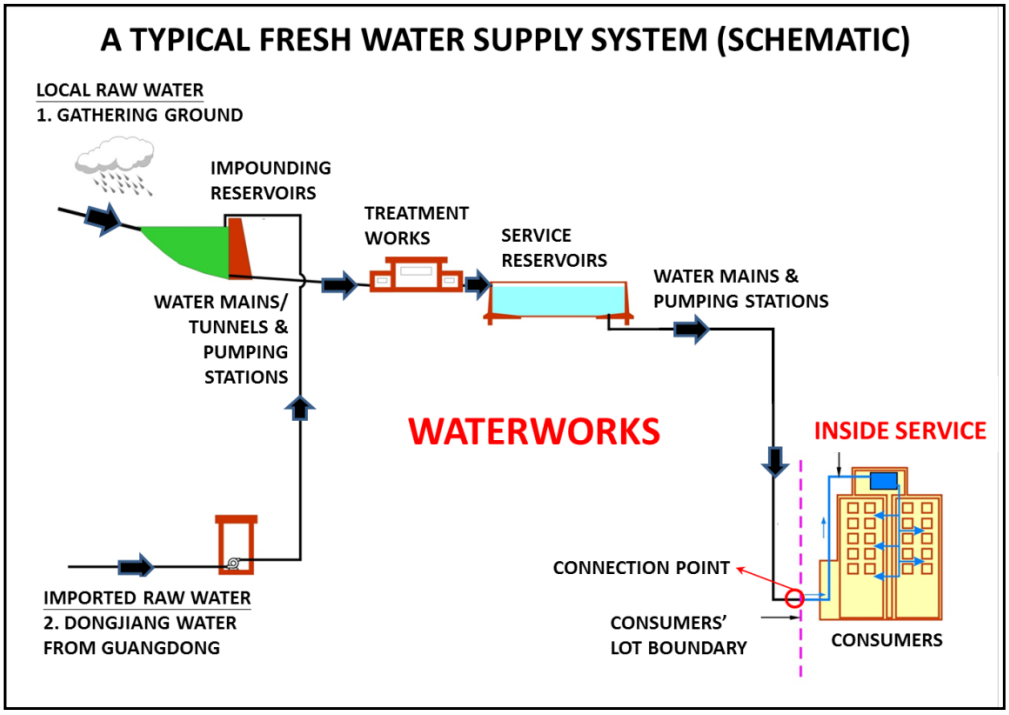
Standards for Surface Water (GB 3838-2002), the highest national standard for surface water applicable for the abstraction for human consumption. WSD has also implemented round-the-clock on-line water quality monitoring system to monitor the quality of DJ water.

(b) Control of water quality at waterworks — At WSD's water treatment works, raw water is treated to a standard in compliance with the WHO Guidelines. According to WSD, more stringent standards for some of the parameters (e.g. fluoride) and inclusion of additional parameters (total coliform, heterotrophic plate count, iron, manganese, etc.) have also been adopted in the internal control of the water treatment process. Treated water is then delivered to the connection points to consumers through an enclosed distribution network.

(c) Control of water quality at inside service — Under the Waterworks Ordinance, construction of inside service has to be undertaken by licensed plumbers, whereas the Waterworks Regulations provide that the pipes and fittings used in inside service are of the British Standard.

Moreover, licensed plumbers are required to certify that the materials used in the plumbing works are those as prescribed in the Waterworks Regulations and to submit an inventory of pipes and fittings as required by the Water Authority ("WA"), i.e. Director of Water Supplies, for seeking permission to commence plumbing works. The Authorized Person of the construction project is also required to certify that the materials used in the plumbing works are in full compliance with the Waterworks Regulations before commencement and upon completion of the plumbing works. Upon completion of the plumbing works, WA will carry out inspection of the works and examine test results of the water samples taken from the inside service.

A schematic illustration of
a typical fresh water supply system in Hong Kong



Source: WSD

(d) Monitoring of water quality through water sample testing — Water samples are taken by WSD at various points of the entire water supply system (including WGGs, DJ water delivered to Hong Kong, impounding reservoirs, water treatment works, distribution network and consumers' taps) for testing. The water sample testing comprises a series of physical, chemical, bacteriological, biological and radiological examinations covering both WHO and non-WHO parameters.

(e) Since 2007, WSD has implemented the Water Safety Plan ("WSP") based on the preventive risk management and the multiple-barrier approach according to WHO's requirements to further enhance the safety of drinking water supply in

Hong Kong. WSP covers the protection of water resources, operation and water quality control at individual water treatment works as well as contingency plans under emergency situations.

(f) The quality of drinking water is under the surveillance of a joint task group of Department of Health ("DH") and WSD, which hold regular meetings to review and discuss health-related issues of drinking water supply. In addition, WSD provides drinking water quality monitoring results to DH at regular intervals.

The "lead in drinking water" incident

2.4.2 Between July and December 2015, drinking water at consumers' taps in some PRH estates, residential buildings, hospitals and schools was found to have a lead content exceeding the standards set out in the WHO Guidelines.[7] The incident not only seriously affected the daily lives of the affected households, but also shattered the public's confidence in the safety of drinking water.

2.4.3 Members of the Legislative Council have expressed grave concerns on the incident. The House Committee, the Panel on Health Services and the Panel on Housing held a number of meetings to discuss the issues related to and arising from the incident. Moreover, a motion on "Legislating for Safety of Drinking Water", moved by Dr Hon KWOK Ka-ki and amended by Hon CHAN Han-pan, was passed at the Council meeting of 28 October 2015.

2.4.4 To ease the public's worries and address Members' concerns, the Administration has implemented a number of corresponding measures immediately after the incident. These measures include:

[7] The provisional guideline value of the WHO Guidelines (2011) is 10 micrograms per litre for lead in drinking water.

(a) carrying out water sampling tests for all PRH estates, public sector and Direct Subsidy Scheme schools built with public funding and completed in and after 2005, all the kindergartens, social welfare units serving children aged under six years old who have to stay for long hours and consume drinking water in these units, and paediatric wards of the Hospital Authority with in-patients aged under six years old;

(b) rendering assistance to the affected persons, such as providing bottled water and standpipes, and requiring the contractors concerned to install temporary water supply points on each floor of the building blocks, and to install water filters and replace filter cores for free for the households in the affected PRH estates;

(c) arranging the groups of people that are more vulnerable to the effects of lead (i.e. children aged below eight, lactating women and pregnant women) to receive blood lead testing, and taking necessary follow-up actions for the persons with borderline raised blood lead levels;

(d) strengthening the inspection and approval mechanism for inside services, including adding parameters for lead and three other types of heavy metals in the tests for water samples taken from newly installed inside services; and

(e) enhancing the control of pipe materials and fittings of inside services. For example, if soldering is used in the connection between copper pipes in the plumbing works, the licensed plumber concerned has to provide a supporting document for lead-free soldering materials to WA before commencing the works.

2.4.5 Apart from taking the aforementioned contingency and follow-up actions, three committees have been set up to investigate and review the

incident. The work progress and conclusions/recommendations of these three committees are as follows:

(a) The Task Force on Investigation of Excessive Lead Content in Drinking Water led by WSD submitted its final report to the Secretary for Development on 31 October 2015.

The report concluded that the use of leaded solder materials in the solder joints was the cause of excess lead in drinking water in Kai Ching Estate and Kwai Luen Estate Phase 2. While copper alloy fittings would also leach lead, they did not result in excess lead in drinking water. The Task Force considered that the conclusion should be applicable to the other 9 PRH developments with excess lead in water samples. The Task Force has also made a number of recommendations [8] on preventing recurrence of similar incidents.

(b) The Review Committee on Quality Assurance Issues Relating to Fresh Water Supply of Public Housing Estates set up by the Hong Kong Housing Authority ("HA") submitted its final report to the HA Chairman on 8 January 2016.

The Review Committee is of the view that, among others, the past quality control mechanism of HA/Housing Department ("HD") had certain inadequacies, i.e. while HD has the expertise and experience and has put in place a stringent quality control mechanism in aspects where high risks have been identified, it had not been conscious of the risks of

[8] The Task Force recommends: (a) measures to prevent the use of leaded solder material and non-conforming pipes and fittings; (b) WA to explore the use of pipe materials free from the risk of misuse of leaded solder joints in plumbing works; (c) the Hong Kong Housing Authority to consider requiring the adoption of central procurement for solder materials (and other essential components of the plumbing works as appropriate); and (d) WA to consider reviewing relevant legislation to effect the above recommendations and see if improvement is necessary to further strengthen its regulatory regime on the construction of inside services.

presence of lead in solder joints and of such presence leading to excess lead in water. Therefore, it had not targeted soldering materials as a high risk item for contractors' checking and monitoring upon delivery to site and during construction, and had not checked the lead content in soldering materials when pipe joints were inspected in the past.

Noting the inadequacies in HA/HD's past quality control system, the Review Committee has put forward recommendations[9] and expected HA/HD to keep in view the developments on the understanding of risks, including the findings and recommendations of the Commission of Inquiry into Excess Lead Found in Drinking Water, and the latest statutory and administrative requirements, in respect of all aspects of water quality.

(c) The Commission of Inquiry into Excess Lead Found in Drinking Water was appointed by the Chief Executive in Council on 13 August 2015 to ascertain the causes of excess lead found in drinking water in PRH developments, review and evaluate the adequacy of the present regulatory and monitoring system in respect of drinking water supply in Hong Kong, and make recommendations with regard to the safety of drinking water in Hong Kong.

The Commission took forward the inquiry through collecting relevant information and documents from government departments and conducting hearings. On 11 May 2016, the

[9] The recommendations of the Review Committee include: (a) requiring the main contractors to test water samples for lead and other heavy metals for newly established inside services; (b) requiring the main contractors to submit and comply with a stringent plumbing subcontractor management plan covering supervision and on-site monitoring; (c) using quick test methods to check for the presence of lead in soldering joints; (d) including soldering/brazing alloys, and copper pipes and fittings in the list of on-site delivery verification items; and (e) training site inspection staff to inspect whether the main contractors have duly conducted their supervisory checks.

Chief Executive received the report of the Commission. As at 30 May 2016, the Administration is studying the report, and is consulting the Department of Justice on the manner of the publication of the report and other relevant matters (including whether any redaction is necessary).

CHAPTER 3 — WATER RESOURCES MANAGEMENT AND REGULATION OF QUALITY OF DRINKING WATER IN SINGAPORE

3.1 Overview

3.1.1 Singapore is one of the most densely populated countries in the world, with a total land area of 719 square kilometres ("km^2") and a population of about 5.5 million. With limited natural water resources such as lakes and groundwater resources, Singapore was primarily dependent on water imported from Malaysia and rainwater as the major sources of water supply in the past.

3.1.2 In an effort to ensure an adequate and sustainable supply of fresh water for the country, the Singapore government has diversified its sources of water supply through the "Four National Taps" over the past two decades. The "Four National Taps" are (a) rainwater collected from local catchment areas; (b) imported water from Malaysia; (c) NEWater (high-purity reclaimed water); and (d) desalinated water.

Responsible authorities

3.1.3 Water resources management in Singapore is under the purview of the Ministry of the Environment and Water Resources ("MEWR") tasked to ensure a clean, sustainable environment and water supply for Singapore. Specifically, the Water Policy Division of MEWR is responsible for formulating policies to provide a reliable and high quality water supply, manage flood risk and drainage planning, and manage water demand in Singapore.

3.1.4 Under MEWR, there are two statutory boards, namely the Public Utilities Board ("PUB") and the National Environment Agency ("NEA"). PUB serves as Singapore's national water agency responsible for managing the water resources in the country, while the main duties of NEA are to improve and sustain a clean and green environment in Singapore, which include regulating the quality of piped drinking water.

3.1.5 The delegation met with representatives of MEWR, PUB and NEA on 21 March 2016 and was briefed on their work and water policies of Singapore. Delegation members also attended a lunch reception hosted by Mr NG Joo Hee, Chief Executive of PUB, on the same day.

Delegation members exchanged views with representatives of MEWR, PUB and NEA.

Hon Tony TSE (left), delegation leader, presented a souvenir to Mr NG Joo Hee (right), Chief Executive of PUB, after a lunch reception hosted by Mr NG.

3.1.6 Under the Parliament of Singapore, there are 12 Government Parliamentary Committees ("GPCs") to scrutinize the legislation and programmes of various ministries, and to serve as an additional channel of feedback on government policies. GPCs are made up of MPs from the ruling People's Action Party and each GPC is backed by a resource panel of subject experts and lay persons.

3.1.7 GPC for Environment and Water Resources deals with policy matters relating to environment and water resources. Chaired by Er Dr LEE Bee Wah, GPC for Environment and Water Resources consists of six other MPs. The delegation met with members of GPC for Environment and Water Resources on 22 March 2016 and exchanged views with them on water issues of mutual concern.

CHAPTER 3 — WATER RESOURCES MANAGEMENT AND REGULATION OF QUALITY OF DRINKING WATER IN SINGAPORE

The delegation met with Er Dr LEE Bee Wah (second from right), Chairperson of the GPC for Environment and Water Resources, and Mr LIANG Eng Hwa (far right), member of the Committee.

Singapore's water policies

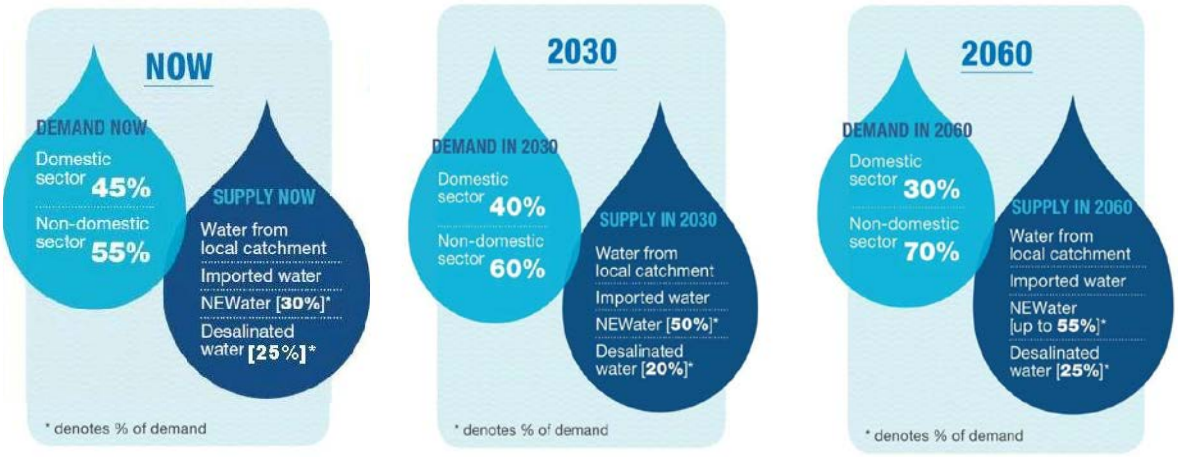
3.1.8 The delegation has learnt from representatives of the receiving organizations that the water policies of Singapore are characterized by the following:

Development of a long-term water plan

3.1.9 Anticipating that the water demand will almost double by 2060 compared with the present demand, the Singapore government has formulated a water master plan to outline the country's long-term water supply strategy towards water self-sufficiency and guide the development of water supply infrastructure.

3.1.10 According to the long-term water plan, the Singapore government will ramp up the production capacity of NEWater and desalinated water, so that NEWater can meet up to 55% of the total water demand and desalinated water can meet up to 25% by 2060.

The plan for sources of water demand and supply in Singapore up to 2060



Source: PUB

3.1.11 The delegation notes that, since seawater desalination and NEWater are made possible by technological breakthroughs following decades of research efforts, the research and development on water technologies has been playing an important role on sustaining the water supply in Singapore. PUB has actively engaged the academic and private sectors on exploring new water technologies. The areas under study include lowering energy consumed during the desalination process, recovering energy from brine streams, and increasing energy and water recovery from used water. Delegation members had the opportunity to learn about the latest water technologies adopted in Singapore during their visit to a seawater desalination plant and a NEWater factory.

Members were briefed on the technologies used in seawater desalination and production of NEWater in Singapore.

Integrated water management

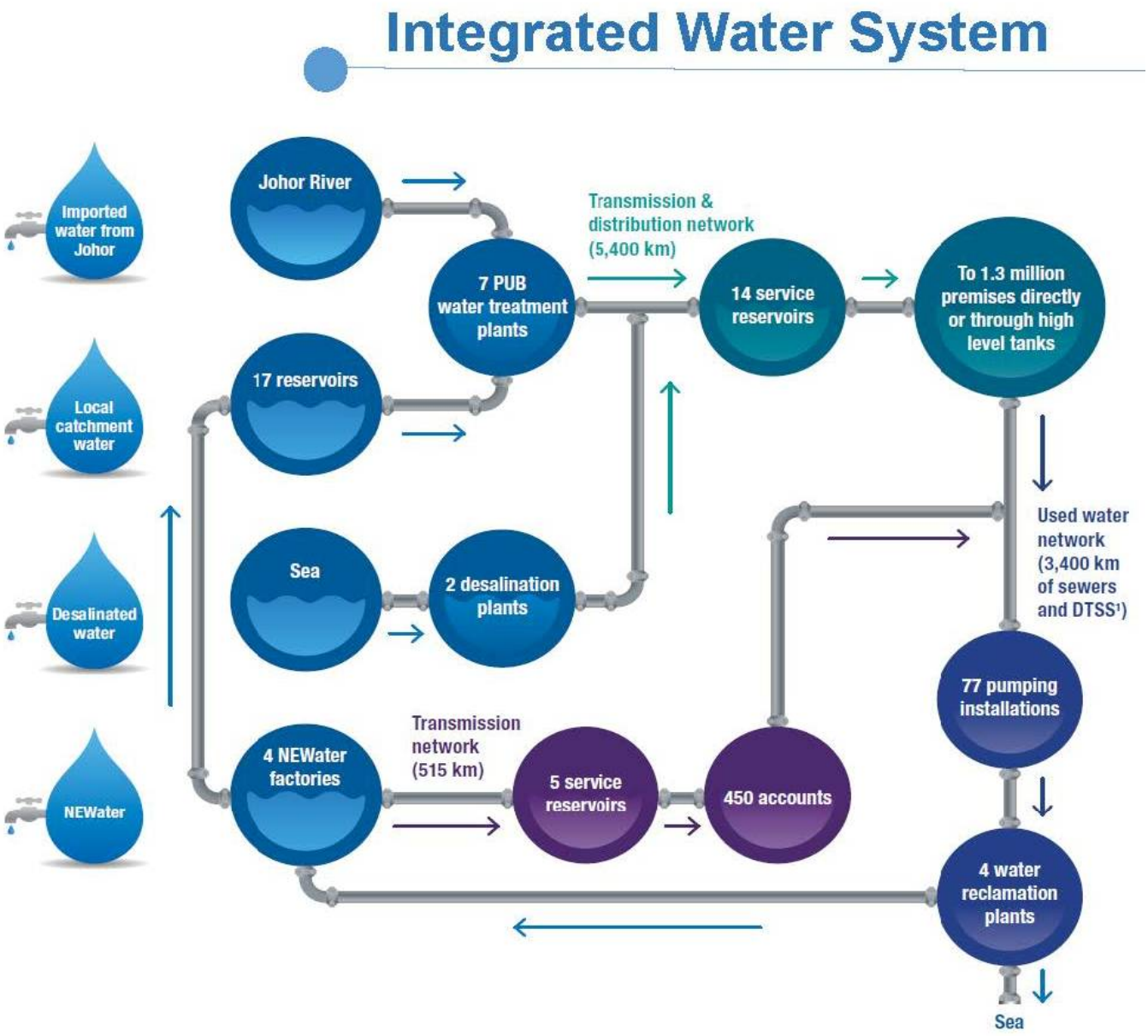
3.1.12 According to PUB, an integrated approach has been adopted in managing the entire water loop, from the collection of rainwater to the purification and supply of drinking water, to the treatment of used water and its reclamation into NEWater. The principles underlying the above water supply management approach are to:

(a) capture every drop of rain that falls on Singapore;

(b) collect every drop of used water; and

(c) recycle every drop of water more than once.

The integrated water system in Singapore



Source: PUB

Engagement of the community in conserving, valuing and enjoying water resources

3.1.13 The delegation notes that, apart from management of water supply, the Singapore government has taken steps to manage water demand by engaging the community to maintain water consumption at a sustainable level amid the population and economic growth.

3.1.14 Under the 3P (i.e. people sector (e.g. non-governmental organizations and grassroots organizations), private sector and public sector) engagement approach, the Singapore government calls on all Singaporeans to conserve water, keep the waters clean and build a relationship with water so that they can enjoy the water resources.

Adoption of a holistic approach in regulating the quality of drinking water

3.1.15 During the discussion with representatives of PUB on water safety measures, delegation members were advised that the Singapore government had adopted an holistic approach with the following key features to regulating the quality of drinking water from source to taps:

(a) sound watershed and reservoir management to safeguard the quality of source water;

(b) multi-barrier treatment at water treatment plants to treat source water to potable water standards;

(c) effective water distribution network to deliver safe drinking water to consumers; and

(d) comprehensive water monitoring mechanism to check the water quality.

3.1.16 Moreover, Singapore has put in place the following legislation to regulate the quality of drinking water and drinking water service installations, namely

(a) NEA to regulate the quality of piped drinking water in accordance with the Environmental Public Health (Quality of Piped Drinking Water) Regulations 2008; and

(b) PUB to oversee the standards of water fittings and drinking water service installations within buildings pursuant to the Public Utilities (Water Supply) Regulations.

3.2 The first National Tap — local catchment

3.2.1 Imported water from Johor of Malaysia and rainwater collected had been a major source of fresh water supply in Singapore before the 2000s. The heavy reliance on imported water has prompted the Singapore government to plan for achieving self-sufficiency of water supply in the long run. Over the past decade or so, the Singapore government has strived to boost rainwater collection from local catchment.

Urban stormwater harvesting

3.2.2 As a small island that does not have natural aquifers and lakes and has little land to collect rainwater, Singapore has to maximize urban stormwater harvesting. At present, Singapore uses two separate systems to collect rainwater and used water. Rainwater is collected through a comprehensive collection network before it is channelled to 17 reservoirs in Singapore for storage. The catchment areas now cover two-thirds of Singapore's land area and PUB has planned to further expand the catchment areas to cover 90% of Singapore's land area by 2060.

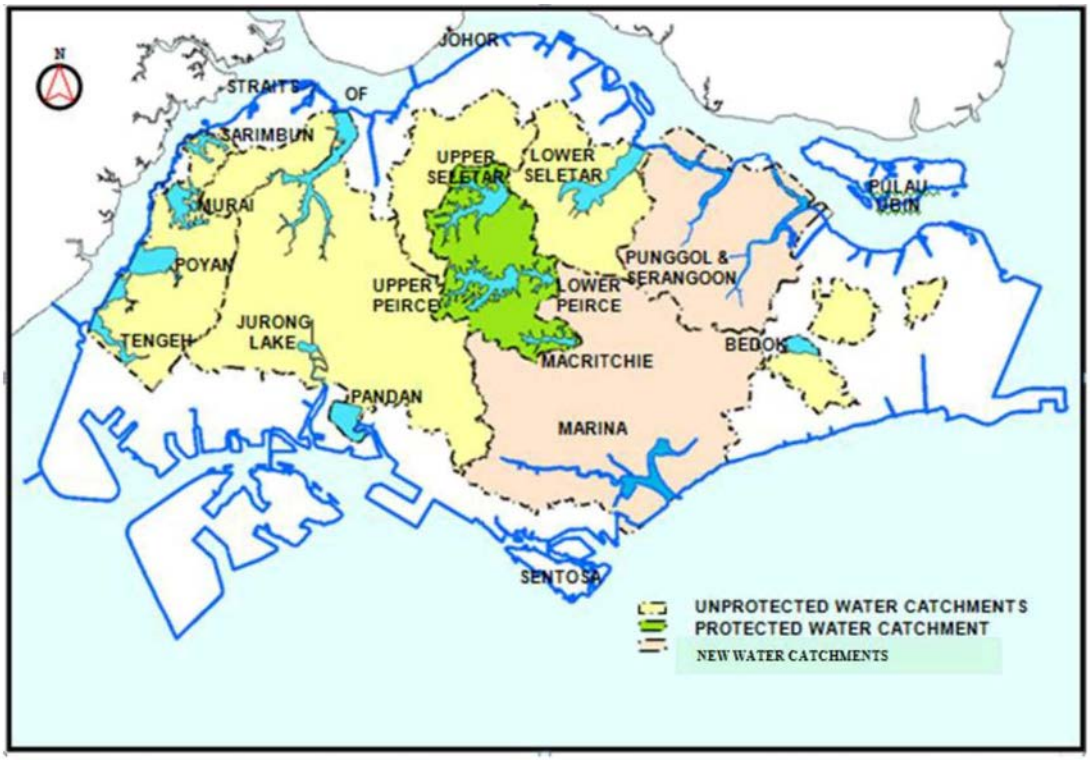
3.2.3 Coupling with the separation of the rainwater and the used water infrastructures, Singapore has adopted the following strategies to safeguard the quality of the rainwater collected:

(a) Integration of land use planning and water resources management

The delegation notes that the strategy aims to mitigate the adverse impact of developments on the environment, especially on water resources, and is carried out through coordination with all relevant government agencies, including PUB, the Urban Redevelopment Authority, the Housing and Development Board, and JTC Corporation.[10] Under such a coordinated planning approach, only non-pollutive activities are allowed in protected water catchment area whereas housing developments and non-pollutive industries are allowed in unprotected water catchment areas but under stringent pollution control.

[10] JTC Corporation is a statutory board in Singapore to plan, promote and develop industrial facilities for the country.

Distribution of protected water catchment areas, unprotected water catchment areas and NEWater catchment areas in Singapore



Source: PUB

(b) Implementation of stringent pollution control measures

The delegation has also learnt that Singapore has established a comprehensive regulatory regime to control the pollution at catchment areas. NEA has been collaborating with PUB to enforce the provisions of the relevant legislation. For example, NEA is responsible for administering the Environment Protection and Management Act and PUB is the law enforcement body of the Public Utilities (Reservoirs, Catchment Areas and Waterway) Regulations 2006.

The Marina Reservoir

3.2.4 The Marina Reservoir is an initiative of the Singapore government to boost water collection from local catchment by developing a fresh water reservoir in Marina Bay, downtown of Singapore. The reservoir was formed in 2008 with the completion of a dam, known as the Marina Barrage, across the mouth of Marina Channel to separate the water in Marina Basin from seawater. With a catchment area of 10 000 hectares or about one-sixth the size of Singapore, Marina Reservoir is Singapore's largest and most urbanized catchment, which can meet about 10% of Singapore's water needs.

The Marina Reservoir

3.2.5 For treating the urban runoff to meet water quality standard for potable uses, Singapore has adopted membrane filtration technology in addition to the conventional water treatment process. Singapore has also undergone a series of major improvement works to mitigate the risks of pollution to the urban runoff. They included a large-scale clean-up started in the 1970s involving a massive relocation of squatters, re-zoning of developments and dredging of foul-smelling mud from the river banks, and a comprehensive sewers rehabilitation programme started in 1996 to rehabilitate more than 1 100 km of sewers to avoid pollution to waterways.

3.2.6 The Marina Barrage is characterized as a three-in-one project meaning that the project can serve three objectives: (a) creating a new source of fresh water supply for Singapore; (b) being part of a flood control scheme to alleviate flooding in the low-lying areas (e.g. Chinatown); and (c) turning the Marina Reservoir an ideal place for organizing water recreational activities, such as windsurfing, canoeing and dragon boating.

3.3 The second National Tap — imported water

3.3.1 Owing to the insufficient local water source to satisfy the daily water demand, Singapore has been importing water from Johor of Malaysia. The first bilateral agreement between the two countries was signed in 1961 and expired in August 2011. The second agreement was signed in 1962 and supplemented by another agreement signed in 1990. These two agreements will expire in 2061.

The 1962 Agreement

3.3.2 Under the 1962 Agreement, Singapore is allowed to draw up to 250 mgd of water from the Johor River of Malaysia. Singapore is required to pay 0.03 Malaysian ringgit[11] to the Johor government for every 1 000 gallons of raw water. In turn, the Johor government can buy treated water from Singapore at 0.5 Malaysian ringgit per 1 000 gallons. Singapore is also required to pay an annual rent for the land it uses in Malaysia for importing the water. The 1962 agreement also contains a provision that allowed for a review of water prices after 25 years (i.e. in 1987) and arbitration if there was a disagreement. The Johor government did not adjust the prices in 1987.[12]

[11] Exchange rate as at late May2016: 1 Malaysian ringgit = HK$1.93

[12] See Chew, V. (2009)

The 1990 Agreement

3.3.3 The 1990 Agreement allows Singapore to construct the Linggiu Reservoir in Johor to facilitate the extraction of water from the Johor River, with Johor setting aside about 216 km^2 of land for the project.

3.3.4 In accordance with the 1990 Agreement, Singapore has to pay 320 million Malaysian ringgits to Johor as compensation for the permanent loss of use of the land and its associated revenue, a premium of 18,000 Malaysian ringgits per 10 000 m^2 and an annual rent of 30 Malaysian ringgits for every 92.9 m^2 (i.e. 1 000 square feet) of the land it uses. The cost of constructing and operating the Linggiu Reservoir is also borne by Singapore.

3.3.5 In return, Singapore can buy treated water generated from the Linggiu Reservoir, meaning that it can draw additional water from the Johor River in excess of the 250 mgd under the 1962 Agreement.

3.3.6 The water purchase price under the 1990 Agreement is calculated on the basis of the following fixed formula: (a) the weighted average of Johor's water tariffs plus 50% of the surplus from the sale of this water source by PUB to its consumers after deducting Johor's price and PUB's cost of distribution; or (b) 115% of the weighted average of Johor's water tariffs, whichever is higher.[13]

[13] See Chew, V. (2009)

3.4 The third National Tap — NEWater

3.4.1 PUB started as early as in the 1970s exploring the feasibility of producing drinking water from treated used water to supplement Singapore's water supply. However, PUB only decided to adopt NEWater as an alternative water source in the early 2000s, when the necessary water treatment technologies had matured and the production cost of producing reclaimed water came down significantly.

3.4.2 The production capacity of NEWater can now meet up to 30% of the total water demand in Singapore. In order to attain self-sufficiency in water supply in the long run, the Singapore government has planned to further expand the production capacity of NEWater so that NEWater can meet up to 55% of Singapore's future water demand by 2060.

Usage of NEWater

3.4.3 The delegation notes that, as part of the "replacement strategy", NEWater has been mainly used for industrial purposes by the wafer fabrication, electronics and power generation industries, as well as for toilet flushing and air conditioning cooling purposes by commercial buildings. The practice can free up large amount of potable water for other vital potable purposes. The delegation observes that, unlike Hong Kong where the manufacturing sector is small, Singapore retains a robust manufacturing industry, hence a strong demand for NEWater.

3.4.4 During dry months, a small amount of NEWater (up to about 2.5% of total daily water consumption) is pumped into reservoirs for indirect potable use by blending it with the raw water in the reservoir. The raw water from the reservoirs will then go through regular treatment at the waterworks before it is supplied to consumers as tap water.

Strategies to gain public acceptance of NEWater

3.4.5 As regards public perception on whether NEWater is safe to drink, the delegation was informed by PUB that to build up the public's confidence in and acceptance of NEWater, PUB had implemented a comprehensive sampling and monitoring programme to monitor the quality of NEWater and embarked on an extensive public communication programme to convey the message that NEWater was safe for human consumption.

3.4.6 According to PUB, the sampling and monitoring programme for NEWater, which covers 293 water quality parameters, is comprehensive when compared with the standards specified by the United States Environmental Protection Agency (100 parameters) and WHO (92 parameters). The monitoring results so far have proved that the quality of NEWater consistently meets the prescribed standards. Moreover, PUB has conducted toxicological studies on NEWater and the studies conclude that NEWater has no adverse health impact on animal species.

3.4.7 The public communication programme to enhance public confidence in NEWater as a source of drinking water features:

(a) top government officials becoming NEWater ambassadors drinking NEWater publicly to show their endorsement;

(b) briefings and exhibitions;

(c) NEWater bottled in attractive packaging for public sampling; and

(d) setting up the NEWater Visitor Centre for continuous public education on NEWater.

3.4.8 The delegation visited the NEWater Visitor Centre, which is adjacent to the Bedok NEWater Factory, on 22 March 2016 to learn about the implementation of the public education programme and take a taste of NEWater.

The delegation at the NEWater Visitor Centre with bottled NEWater in their hands.

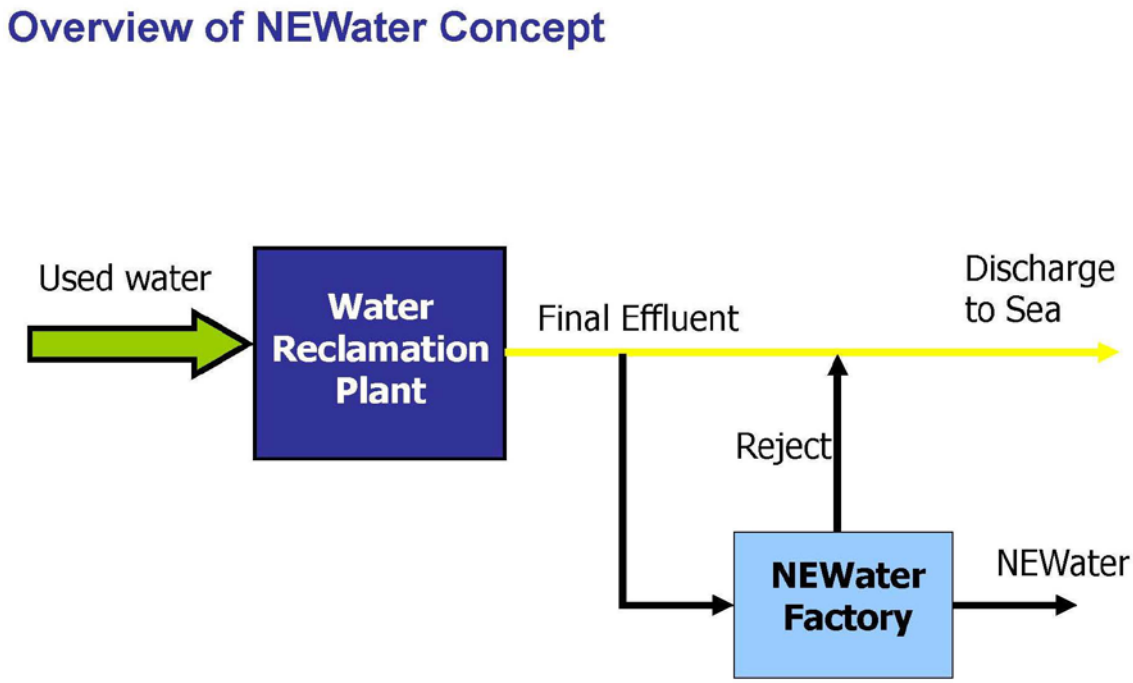
Deep Tunnel Sewerage System

3.4.9 Under the guiding principle of collecting every drop of used water to ensure an adequate water supply in Singapore, the Deep Tunnel Sewerage System ("DTSS") has been developed to cater for the country's long-term needs for used water collection, treatment, reclamation and disposal.

3.4.10 PUB has explained to the delegation that the concept of DTSS is to make use of deep tunnel sewers to deliver used water by gravity to centralized water reclamation plants ("WRPs") located at the coastal areas for treatment. The treated used water is then further purified into high-purity

reclaimed water (i.e. NEWater) in NEWater factories,[14] or discharged to the sea through the outfalls.

An overview of the NEWater concept

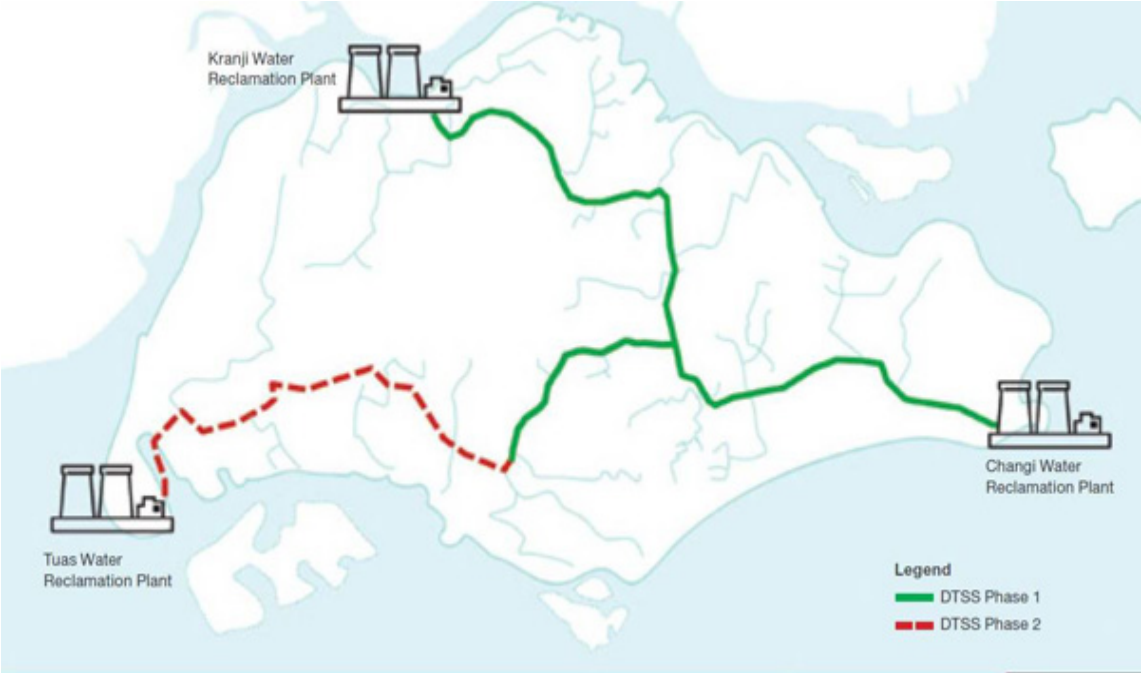


Source: PUB

3.4.11 DTSS is carried out in two phases. Upon the completion of Phase 2, there will be three centralized WRPs across Singapore: the Changi WRP in the east, the Kranji WRP in the north and the Tuas WRP in the west.

[14] The NEWater factories in Singapore are located close to WRPs from which treated used water is obtained for further purification.

Locations of the three centralized water reclamation plants in Singapore



Source: PUB

3.4.12 According to PUB, the development of the DTSS project has brought about the following benefits:

(a) ensuring the sustainability of NEWater through the efficient and large-scale water recycling system, thereby helping Singapore to meet the ambitious goal of boosting the NEWater production capacity from the present 30% of the total water demand to up to 55% by 2060;

(b) optimizing land use, as the phasing out of the existing conventional WRPs and intermediate pumping stations frees up the previously occupied lands for other higher-value developments ; and

(c) enhancing the reliability of the used water system, so that the risk of cross-contamination between the water catchments and the used water system can be minimized.

NEWater factories in Singapore

3.4.13 Four NEWater factories are currently in operation in Singapore to recycle used water. Opened in 2003, the Bedok and the Kranji NEWater Factories were the first two factories coming on stream. The 18 mgd-Bedok NEWater Factory and the 17 mgd-Kranji NEWater Factory are both operated by PUB.

The Bedok NEWater Factory

3.4.14 To learn from Singapore's experience in the development of NEWater facilities, the delegation visited the Bedok NEWater Factory on 22 March 2016.

The delegation visited the Bedok NEWater Factory.

The delegation was briefed on the production process of NEWater.

3.4.15 Unlike the two earlier NEWater factories, the Ulu Pandan NEWater Factory (opened in 2007) and the Changi NEWater Factory (opened in 2010) are public-private partnership projects developed under the design-build-own-operate arrangement.

3.4.16 The delegation notes that, as part of the integrated water management, all NEWater factories across Singapore has been linked together by a network of transmission pipelines under the NEWater Infrastructure Plan. The transmission pipelines enable PUB to integrate individual NEWater supply clusters so that NEWater could be supplied efficiently to users across the country.

Development of NEWater production

3.4.17 To meet the long-term goal of increasing NEWater production up to 55% of the total water demand, the Singapore government has plans to develop two more NEWater factories before 2024. One of these is expected to commence operation in late-2016 and will have a production capacity of 50 mgd.

Production process of NEWater

3.4.18 According to PUB, the production of NEWater involves the following processes:

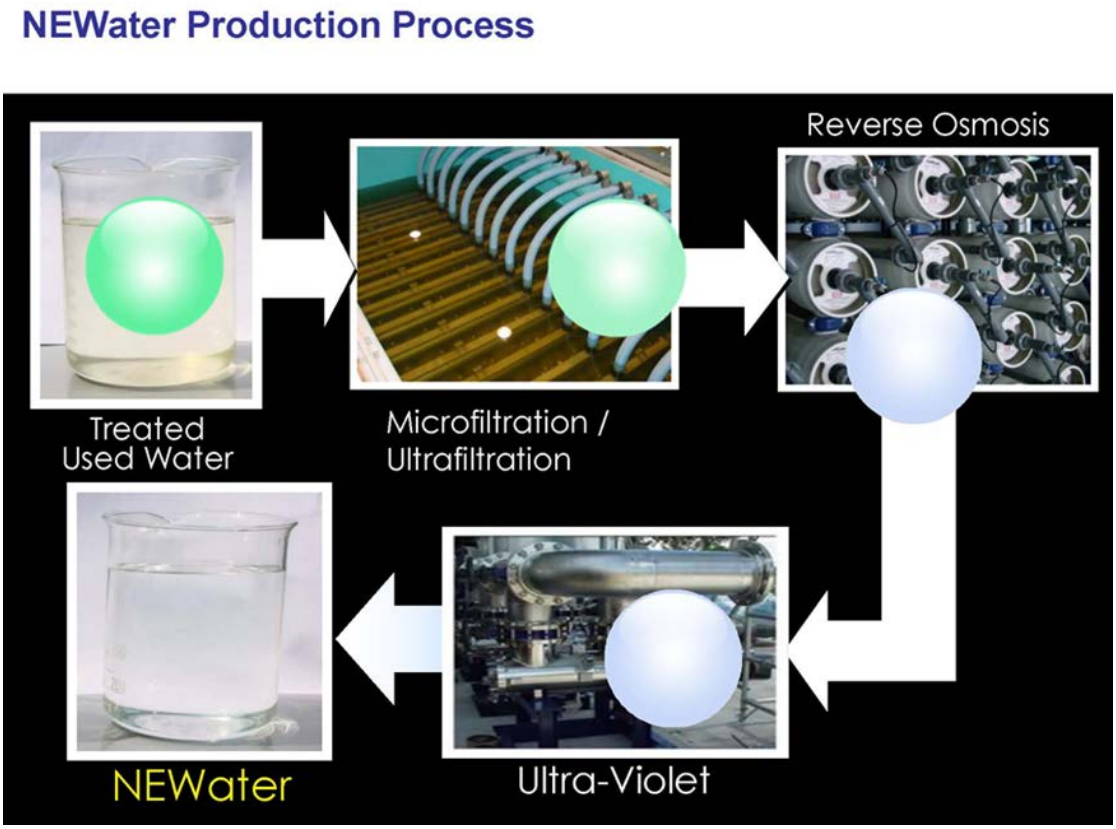
(a) microfiltration — filtering out fine solids and particles from treated used water;

(b) reverse osmosis treatment process[15] — using semi-permeable membranes to filter out other undesirable contaminants such as bacteria, viruses and heavy metals, and most dissolved salts; and

[15] The reverse osmosis technology used in the production process of NEWater is the same as that adopted for producing desalinated water in Singapore.

(c) ultraviolet disinfection — ensuring the safety and purity of NEWater by inactivating all organisms.

NEWater production process



Source: PUB

3.5 The fourth National Tap — seawater desalination

3.5.1 PUB began as early as in the 1970s the feasibility study of using desalination technology to provide an alternative source of fresh water supply. However, the study did not come to fruition at that time due to the high production cost involved. Subsequent improvement to seawater desalination technologies, particularly the growing global popularity of the reserve osmosis technology, has helped lower the production cost. This in

turn set the stage for the introduction of seawater desalination in Singapore in the 2000s to diversify its sources of water supply.

3.5.2 Desalinated seawater can now meet up to 25% of the total water demand in Singapore. As the water demand will almost double by 2060, the Singapore government plans to expand the current desalination capacity to the extent that up to 25% of water demand will be sourced from desalinated water by 2060.

Seawater desalination plants in Singapore

3.5.3 At present, there are two seawater desalination plants in Singapore, namely the SingSpring Desalination Plant and the Tuaspring Desalination Plant. These two plants are public-private partnership projects developed under the design-build-own-operate arrangement, whereby a private company, Hyflux Ltd, has been appointed by PUB to design, build, own and operate the plants, and to deliver desalinated water to PUB for distribution. Both plants are located in Tuas, an industrial zone in the western part of Singapore, and adopt the reserve osmosis technology.

3.5.4 The SingSpring Desalination Plant is the first seawater desalination plant in Singapore. It was constructed in 2004, and commenced operation in 2005 with a production capacity of 30 mgd. Under the water purchase agreement, SingSpring is obliged to deliver desalinated water to PUB over a 20-year period from 2005 to 2025.

3.5.5 The second seawater desalination plant in Singapore is the Tuaspring Desalination Plant. Commissioned in 2013, Tuaspring is the largest seawater desalination plant in Singapore with a production capacity of 70 mgd. Under the water purchase agreement, Tuaspring is required to deliver desalinated water to PUB over a 25-year period from 2013 to 2038, with the price set at a low of S$0.45/$m^3$ (about HK$2.79/$m^3$) in the first year of delivery. Annual price adjustments for the subsequent years are subject to factors such as fuel price and inflation rate.[16]

[16] Little information is available on how the first-year delivery price was set, the cost components of the price and the prices in the subsequent years.

3.5.6 The delegation visited the Tuaspring Desalination Plant on 21 March 2016 and received a briefing by the plant management on the seawater desalination process and technologies.

The delegation received a briefing on the seawater desalination process and technologies during a visit to the Tuaspring Desalination Plant.

3.5.7 The delegation is particularly interested in understanding the design of a combined desalination and power supply system in the Tuaspring Desalination Plant. The Tuaspring plant is equipped with an on-site power plant to provide it with a secure source of electricity supply for seawater desalination. Heat from the power generation process warms the water which is fed into the desalination plant. With warmer feed water, lower osmosis pressure is required during the reverse osmosis process, thereby lowering the energy consumption and desalination cost. Moreover, excess power generated by the power plant is sold to the national power grid.

The delegation and representatives of Hyflux Ltd at the Tuaspring Desalination Plant

Development of seawater desalination plants

3.5.8 To meet the growing water demand, the Singapore government plans to construct two more seawater desalination plants in the near future. The third plant, with a production capacity of 30 mgd, will also be located at Tuas. Scheduled for completion in 2017, the plant will be owned and operated by PUB. As for the fourth plant, it will be located at Marina East and developed under the design-build-own-operate arrangement.

Production process of desalinated water

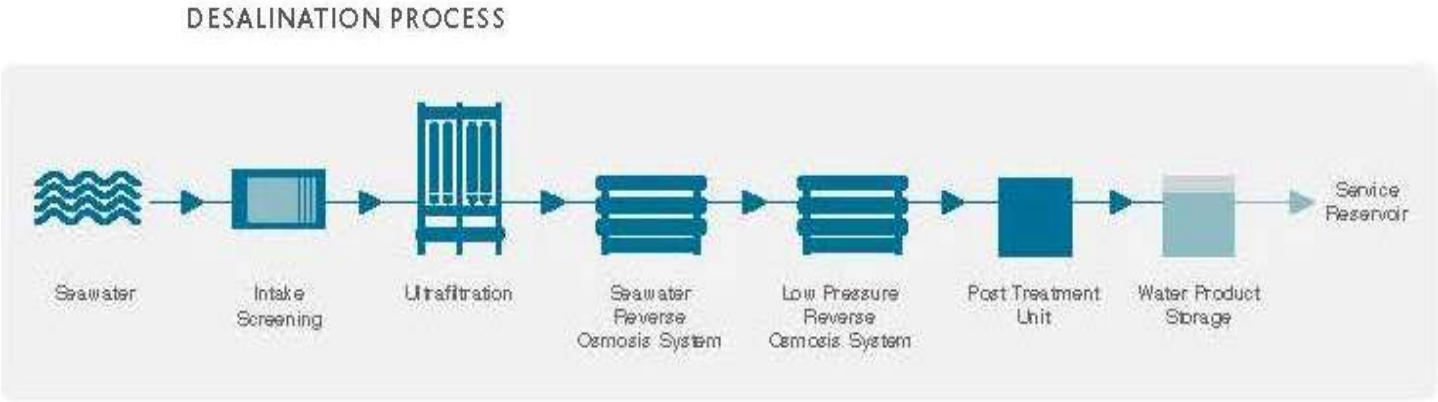
3.5.9 According to Hyflux Ltd, seawater desalination in Tuaspring involves the following steps:

(a) intake screening and ultrafiltration — filtering suspended solids from seawater and removing micro-organisms and bacteria that can foul the downstream reverse osmosis system;

(b) double pass reverse osmosis treatment process — removing dissolved salt and minerals from seawater by double passage of seawater through the semi-permeable reverse osmosis membranes; and

(c) post-treatment process — re-mineralizing and adjusting pH of the treated water. As water after the double pass reverse osmosis treatment process is low in minerals and pH, which has corrosive effects on water mains, re-mineralization and adjustment of pH is required.

The desalination process



Source: Hyflux Ltd

3.6 Water demand management

3.6.1 Well understanding that management of water resources is not only about developing water resources to diversify supplies, the delegation took the opportunity of the visit to obtain information about the water demand management initiatives taken in Singapore.

Water conservation strategies

3.6.2 Representatives of PUB explained to the delegation that to encourage the public to conserve water, PUB had put in place the following strategies:

(a) Pricing — Water tariff in Singapore is set at a rate to recover the full production and supply costs. The water conservation tax[17] was also introduced in 1991 to reinforce the message that every drop of water is precious.

(b) Mandatory water conservation requirements — A number of mandatory measures have been carried out in Singapore to cut down the excessive flow and wastage of water. These measures include the requirement of the maximum flow rates allowed for taps and showers, and the implementation of the Mandatory Water Efficiency Labelling Scheme ("MWELS") in accordance with the Public Utilities (Water Supply) Regulations. Introduced in 2009, MWELS requires suppliers to introduce more efficient water fittings and appliances into the market. To complement MWELS, PUB further requires all new premises and existing premises undergoing

[17] The tax rate is set at 30% of the tariff for all units of water consumed by non-domestic customers and the first 40m^3 consumed by domestic customers in each month. A higher tax rate of 45% will apply to domestic customers when they consume more than 40 m^3 of water.

renovation to install water fittings that are labelled with at least one tick under the scheme.[18]

(c) Facilitation measures — Various public education and publicity programmes have been launched to raise public awareness on water conservation and enhance the ability of water users to improve their water efficiency. These programmes include the Water Efficient Homes Programme where water saving kits with thimbles are distributed, and the 10-Litre Challenge. The delegation notes that PUB has made use of its mascot, Water Wally, to help spread the water conservation message in a lively and interactive way.

The delegation with Water Wally outside the Environment Building, where delegation members received a briefing by representatives of MEWR, PUB and NEA

[18] Under MWELS, water fittings are rated to have zero to three ticks on the label to reflect their water efficiency level. The more ticks a product has, the more efficient it is.

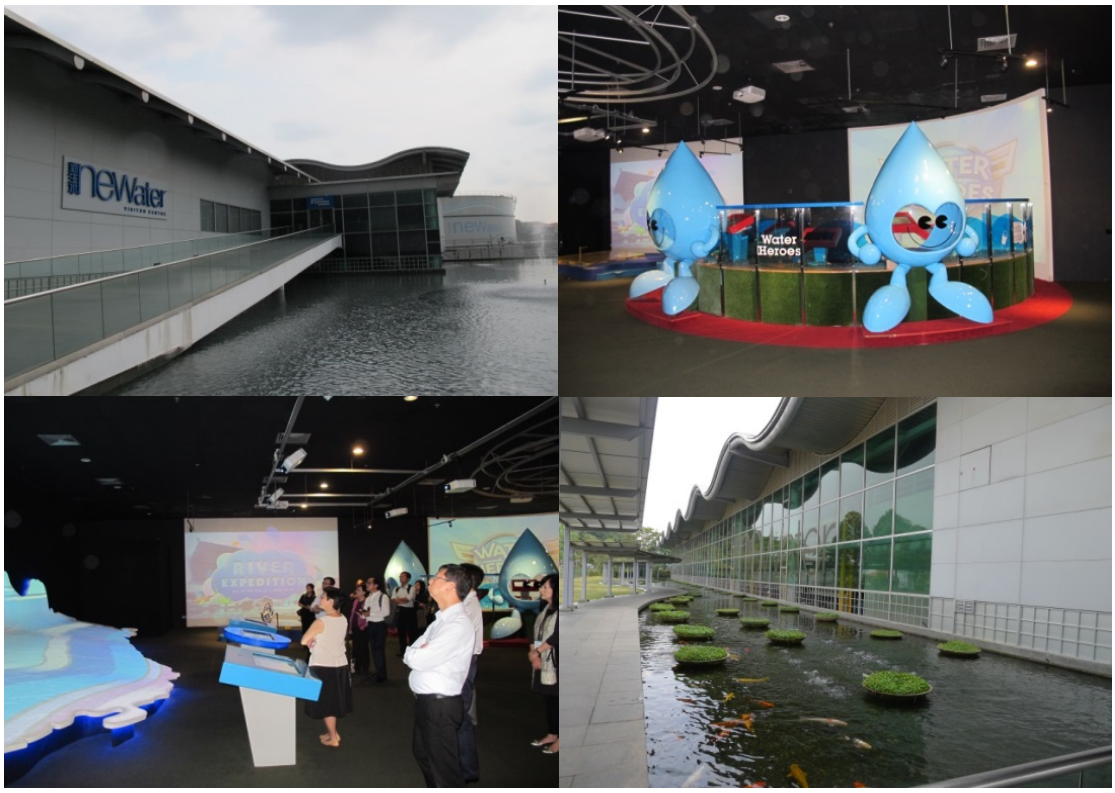
3.6.3 The delegation was advised that the water conservation strategies adopted helped lower the daily per capita domestic water consumption in Singapore from 165 litres in 2003 to 150 litres in 2014. PUB has targeted to further lower the daily per capita domestic water consumption to 140 litres by 2030.

Community engagement programmes

3.6.4 The delegation was further informed that in an effort to nurture ownership of the precious water resources, PUB had partnered with the people, private and public ("3P") sectors to educate the community to conserve, value and enjoy water responsibly. Key community engagement programmes include:

(a) the United Nations World Water Day (22 March) bringing 3P partners and the community together for the celebration of water; and

(b) the NEWater Visitor Centre targeting on the young generation of Singapore. Visitors can enjoy not only interactive games and multimedia exhibits on a range of water-related topics, but also witness the production of NEWater.



The NEWater Visitor Centre

3.7 "Active, Beautiful and Clean" Waters Programme

3.7.1 Launched in 2006, the "Active, Beautiful and Clean" Waters Programme ("ABC Waters Programme") is an initiative of PUB to transform the waterways and reservoirs in Singapore beyond their traditional functions of drainage, flood control and water storage into beautiful streams, rivers and lakes.

3.7.2 Through enhancement and opening up of water bodies, the ABC Waters Programme brings Singaporeans closer to water so that they can enjoy and bond with water, and better appreciate this precious resource. The three key concepts underpinning the programme are:

(a) Active — providing new community and recreational spaces;

(b) Beautiful — improving the aesthetics of the urban environment; and

(c) Clean — Improving water quality and cultivating environmental responsibility among the public.

3.7.3 Since the launch of the ABC Waters Programme, PUB has completed 32 projects and is planning to implement another 20 projects in the next 5 years. Among the projects completed by PUB is the flagship project at the Bishan-Ang Mo Kio Park. The delegation toured the Bishan-Ang Mo Kio Park on 22 March 2016 (coincidentally the United Nations World Water Day) and received a briefing by PUB representatives at the Park on the ABC Waters Programme.

The delegation received a briefing on the ABC Waters Programme at the Bishan-Ang Mo Kio Park.

3.7.4 The delegation was advised that to implement the ABC Waters Programme, PUB had adopted the following three-pronged approach:

(a) developing the ABC Waters Master Plan to guide the overall project implementation;

(b) encouraging the community to take ownership of the water assets in Singapore under the 3P engagement approach (for example, schools are encouraged to develop ABC Waters learning trails so that students can better appreciate the waters); and

(c) promoting the adoption of the ABC Waters concept by the public and private sectors. The ABC Waters Design Guidelines have been published to provide reference to developers and industry professionals on how to implement environmentally sustainable green features or ABC Waters design features in their developments. Development projects of public agencies and private developers which have incorporated the ABC Waters design features will be recognized as "ABC Waters certified" projects. So far, 54 ABC Waters certified projects have been completed.

The Bishan-Ang Mo Kio Park

3.7.5 The 62-hectare Bishan-Ang Mo Kio Park is one the largest urban parks in central Singapore. Under a joint collaboration between PUB and the National Parks Board, the ABC Waters project at the park was completed in 2012, which deconcretizes and naturalizes a straight concrete drainage canal into a 3-km meandering river.

The Bishan-Ang Mo Kio Park

The delegation toured the Bishan-Ang Mo Kio Park.

3.7.6 The delegation was very impressed by the results of the ABC Waters project at the park. The project demonstrates how to improve the country's water quality at source and control flood, while at the same time beautifying the urban landscape and creating new community spaces for the public. Delegation members note that key design features of the project include:

(a) Soil bioengineering techniques, combining traditional civil engineering and natural materials such as vegetation and rocks, have been applied to soften the edges of the waterway, give it a natural appearance and prevent soil erosion. The techniques help create natural habitats and enrich the biodiversity of the park.

Natural river at the Bishan-Ang Mo Kio Park with bioengineering riverbanks

(b) A cleansing biotope is built at the upstream of the park which serves as a natural cleansing system to filter pollutants in the water without the use of chemicals. Under such a design, water is pumped from the river and the downstream ponds within the park into the cells of the biotope, where it is filtered by the plants in the biotope before being returned to the ponds and eventually to the river.

(c) The design of the river channel of the park is based on a flood plain concept and is linked to a network of drains. During dry weather, the flow of water is confined to a narrow stream in the middle of the river. In the event of a storm, the adjacent park area will also be used to carry the rainwater downstream to Marina Reservoir.

(d) With the naturalized river, playgrounds, riverside gallery and open lawns, ample spaces have been created in the park for community and recreational uses.

Delegation members played shuttlecock with local residents at a playground at the Bishan-Ang Mo Kio Park.

(e) Comprehensive safety features have been put in place to warn the public of heavy rains or rising water levels.

Safety features inside the Bishan-Ang Mo Kio Park (from left to right): red marker (to advise the public to move beyond it during rain), warning sign and lifebuoy.

3.8 Regulation of the quality of drinking water

3.8.1 In view of the widespread public concern over the quality of drinking water in Hong Kong after the occurrence of the "lead in drinking water" incident in the second half of 2015, the delegation took the opportunity of the visit to obtain information from representatives of MEWR, PUB and NEA on the regulation of quality of drinking water in Singapore.

The delegation with representatives of MEWR, PUB and NEA

<u>The Environmental Public Health (Quality of Piped Drinking Water) Regulations 2008</u>

3.8.2 As informed by representatives of NEA, Singapore has enacted the Environmental Public Health (Quality of Piped Drinking Water) Regulations 2008 ("EPH Regulations"), which provide that piped drinking water must comply with the standards prescribed under the Regulations covering 101 parameters grouped under the following four categories:

(a) microbial parameters such as Escherichia coli;

(b) physico-chemical parameters such as colour, turbidity and pH;

(c) radiological parameters; and

(d) chemical parameters such as contaminants from pipes and fittings (such as lead), disinfectant, contaminants from treatment chemicals, inorganic chemicals (including heavy metals), pesticides used for public health purposes, and pesticides used for agricultural purpose.[19]

3.8.3 The delegation learnt that these standards were developed based on the WHO Guidelines and the recommendations of the Technical Committee on National Drinking Water Quality Standards. The Technical Committee, comprising Singaporean and overseas experts from various fields such as water treatment, human health, toxicology and microbiology, is formed by NEA to review and provide advice on water quality standards.

3.8.4 The EPH Regulations also stipulate that water suppliers (e.g. PUB) are required to prepare and implement a water safety plan and a water sampling plan for the purpose of ensuring that the piped drinking water supplied by them complies with the statutory standards.

3.8.5 Delegation members were told that compared with the traditional water quality monitoring focusing on end-point testing, which was too late to give effective response, the water safety plan for water suppliers adopted a different approach. Under the "prevention through process control approach", water suppliers should conduct hazard assessment to understand how hazards can enter into the water supply system and work out control measures to prevent hazards. As regards the water sampling plan, it is a plan

[19] The acceptable limit for each of the parameters is specified under the water quality standards. For example, the maximum prescribed quantity for lead in water is 0.01 milligram or 10 micrograms per litre, which is the same as the provisional guideline value of the WHO Guidelines (2011).

containing detailed information on the sampling and testing of piped drinking water, including the parameters to be tested, test methods to be used, frequency of the tests, sampling locations and sampling protocol.

3.8.6 NEA has set up a dedicated unit, the Drinking Water Unit, to regulate the quality of piped drinking water, approve the water safety plan and water sampling plans, and conduct site inspections. Moreover, NEA has published the Code of Practice on Piped Drinking Water Sampling and Safety Plans to provide guidance to water suppliers on the preparation and implementation of the water safety and water sampling plans.

Roles of the regulatory authorities

3.8.7 In terms of the roles of NEA and PUB in managing water resources and quality, the delegation was told that there was a clear division of responsibility between the two authorities:

(a) NEA and PUB are jointly responsible for undertaking the pollution control measures to protect the catchment areas;

(b) PUB manages reservoirs, water treatment plants and water distribution network, as well as monitors the water quality of the water supply system;

(c) NEA regulates the quality of drinking water under the EPH Regulations; and

(d) building managements/town councils maintain the water service installations and water storage tanks. Meanwhile, PUB has the responsibility to oversee the standards of water service installations within buildings in accordance with the Public Utilities (Water Supply) Regulations.

Water quality monitoring mechanism

3.8.8 Delegation members visited the Water Quality Office of PUB on 23 March 2016 to obtain first-hand information on the measures put in place by PUB to safeguard the quality of piped drinking water. Dr LIM Mong Hoo, Chief Specialist of the Water Quality Office, briefed the delegation on the water quality monitoring mechanism in Singapore.

The delegation visited the Water Quality Office of PUB.

Dr LIM Mong Hoo (far left), Chief Specialist of the Water Quality Office, briefed the delegation on the water quality monitoring mechanism in Singapore.

3.8.9 Dr LIM advised the delegation that PUB had adopted a holistic approach to maintaining the quality of drinking water from source to taps. The measures adopted include: (a) integration of land use planning and water management to prevent pollution of source water; (b) multi-barrier treatment at water treatment plants to treat source water to potable water standards; and (c) delivery of quality drinking water from treatment plants to consumers via a fully enclosed water distribution network.

3.8.10 Moreover, PUB has put in place a comprehensive sampling and monitoring programme to ensure that the water supplied is safe from source to taps. According to Dr LIM, no lead has been found in drinking water in Singapore so far. The PUB statistics also indicate that all the water quality tests conducted between 2008 and 2014 met the requirements of the EPH Regulations and the WHO Guidelines.

3.8.11 The delegation learnt from Dr LIM that, notwithstanding the above achievements, PUB had taken a step forward by adopting more stringent standards than the regulatory requirements in its internal control of the water treatment process.

3.8.12 Under the sampling and monitoring programme, the Water Quality Office conducts tests on water samples collected from various points in the water loop, including reservoirs, NEWater factories, seawater desalination plants, the water distribution network and waterworks. The Water Quality Office has formed a number of water analytics and research laboratories to conduct water sampling tests and water technologies studies. The delegation had the opportunity to tour the laboratories during the visit to the Water Quality Office.

The laboratories of the Water Quality Office

3.8.13 The delegation was told that, as a check-and-balance measure, the sampling and analysis results of water quality were audited by NEA and reviewed twice a year by an internal audit panel and an external audit panel comprising experts from various disciplines ranging from engineering and water chemistry to toxicology and microbiology.

3.8.14 In addition to the sampling and monitoring programme, PUB has developed other water quality monitoring systems to enhance the effectiveness of its work in monitoring water quality. These monitoring systems are: (a) an online water quality monitoring system to monitor the pH level, turbidity, etc., of water at strategic locations; and (b) a Fish Activity Monitoring System, which is a system using video analytics to monitor and analyze the swimming patterns and activities of fishes round-the-clock to detect irregularities in water quality.

Regulation of drinking water service installations

3.8.15 In Singapore, water fittings for use in drinking water service installations are regulated by PUB in accordance with the Public Utilities (Water Supply) Regulations. The Regulations contain provisions governing, among others, the quality and standards of water fittings, testing of water fittings, installation of hot water apparatus, and maintenance and security of water storage tanks.

3.8.16 According to PUB, water fittings in Singapore should comply with the standards and requirements stipulated by PUB, primarily an appropriate Singapore Standard, or other equivalent standards. The delegation notes the Public Utilities (Water Supply) Regulations provide that no water fittings in Singapore should be made of lead or lead alloy. Soldering joints for copper pipes are forbidden for use as well. Instead, the use of brazing or autogenous welding for copper pipes has been specified, which helps prevent the leaching of lead into the piped drinking water.

3.8.17 Moreover, the installation and use of water fittings in Singapore must conform to the Public Utilities (Water Supply) Regulations and the Singapore Standard CP 48: Code of Practice for Water Services, which

provides authoritative guidance on the design, installation, fixing and testing of drinking water service installations.

3.8.18 Pursuant to the Public Utilities (Water Supply) Regulations, water service works must be carried out by water service plumbers licensed by PUB and supervised by a registered professional engineer.[20] Random sampling check is also carried out on the completed plumbing works. To ensure that the water storage tanks are properly maintained, the Regulations also stipulate that premises owners should engage, at least once a year, a licensed water service plumber to inspect, and, where necessary, to clean and disinfect, and to certify the cleanliness of water storage tanks.

[20] Except for water service installation which is to be installed downstream after the meter position and does not require any pumping equipment or water storage tank.

4.1 Observations

4.1.1 Having received briefings and exchanged views with senior government officials, MPs and representatives of the water management authorities, and visited a number of water facilities in Singapore, the delegation has the following observations.

Long-term water plan

4.1.2 The delegation notes that the Singapore government attaches great importance to water self-sufficiency for the country's sustainable development. Against this background, Singapore has formulated a water master plan, setting out an overarching policy framework of the country's water policies up to 2060, and has endeavoured to roll out initiatives to achieve the goal of water self-sufficiency.

4.1.3 The delegation further observes that a holistic approach has been adopted in Singapore for the formulation and implementation of water policies. For example, land use planning has been integrated with water resources management to mitigate the adverse impact of developments on water resources. PUB, Singapore's national water agency, oversees the operation of the entire water loop, from water catchment, water supply systems, drainage systems, water reclamation plants, to sewerage systems. Concerted efforts are made among all the relevant government agencies to take forward the implementation of national water policies.

4.1.4 The delegation considers that, by comparison, the Government of the Hong Kong Special Administrative Region ("HKSARG") lacks a vision for the development of long-term water policies for Hong Kong and accords a low priority to the formulation of such policies. There is also a lack of long-term strategy to maximize stormwater harvesting and hence the design of flood control infrastructure has not given due regard to collection and storage of stormwater for local consumption.

4.1.5 The delegation considers that, to better prepare for the future development of Hong Kong and to cope with the challenges arising from

climate change, the HKSARG, in the review of TWMS, should formulate a long-term water plan covering not only the development of new water sources, the initiatives to manage water demand, but also the target weighting of each of the water sources in different times, etc.

Design of water projects

4.1.6 The delegation is impressed by the innovative design of the water projects in Singapore. For instance, the ABC Waters project at the Bishan-Ang Mo Kio Park improves water quality at source and controls flood, while at the same time creates new community spaces. Similarly, the three-in-one Marina Barrage project meets Singapore's needs for fresh water supply, while providing flood control and venues for recreational activities.

4.1.7 In Hong Kong, the water facilities tend to serve single purposes. For example, many stormwater drainage schemes (e.g. the Hong Kong West Drainage Tunnel) are designed for the sole purpose of preventing flooding caused by heavy rains. The delegation considers that more thoughts should be given to constructing water catchment facilities to keep the stormwater collected for consumption. The delegation suggests that the HKSARG should make reference to Singapore's experience in adopting innovative ideas in the development of water facilities so that they may serve diversified and meaningful purposes.

Local catchment

4.1.8 Given that the unit cost of collecting water for potable uses from local yield is the lowest among all the available fresh water sources in Hong Kong, the delegation considers Singapore's experience of enhancing local yield is worth learning from. In Singapore, two-thirds of the land area have become catchment areas. The Singapore government has pressed ahead with urban stormwater harvesting development. An example is the construction of the Marina Reservoir in downtown Singapore. Some delegation members have suggested that the HKSARG should develop similar systems in Hong Kong to store urban stormwater. They opine that some of the stormwater drainage schemes (e.g. the Hong Kong West Drainage Tunnel and the Happy Valley Underground Stormwater Storage Scheme), which are used to

collect stormwater during heavy rains for discharging to the sea to prevent flooding, fail to make good use of precious water resources. They urge the HKSARG to expedite a comprehensive study to explore the potential of incorporating water catchment facilities into flood prevention projects.

4.1.9 The delegation understands that in Hong Kong, rainwater intercepted at the hillside WGGs is delivered by gravity to the reservoirs for storage via catchwater channels. The delegation considers that the HKSARG should make use of the hilly nature of Hong Kong to enhance the water yield collected from local catchment. Consideration may be given to expanding the WGGs (currently occupying one-third of the territory) to intercept more hillside rainwater.

4.1.10 Some members suggest that, apart from expanding WGGs, the HKSARG should expand reservoir storage and build new reservoirs, say, in Tung Chung, to store more rainwater. There is also a suggestion that consideration be given to developing water storage facilities underground.

4.1.11 There is a view from delegation members that, to preserve and protect local catchment water, the HKSARG should be cautious on any suggestion of developing the land in the country parks, where there are many water catchment areas.

4.1.12 The delegation believes that by enhancing the local yield, the demand for DJ water will be reduced, which can help save the precious DJ water resources and the public monies used for purchasing DJ water.

Development of new water sources

4.1.13 The delegation observes that, in view of climate change and population growth, the Singapore government has developed an acute sense of awareness over the importance of developing new water sources and has undertaken various measures to boost the production capacity of desalinated water and NEWater.

4.1.14 There is a general consensus among delegation members that Hong Kong should explore new water sources to cope with the challenges arising

from climate change and the keen competition among Hong Kong and other cities in GD Province for DJ water.

Seawater desalination

4.1.15 On the development of seawater desalination in Hong Kong, some delegation members consider that, while Singapore and Hong Kong face the same problem of insufficient local yield and have to rely on imported water, the situations between the two cities are quite different: in Singapore, for the sake of survival, the government has to develop seawater desalination at whatever the cost is to achieve water self-sufficiency. Whereas in Hong Kong, the supply of DJ water is guaranteed and the price is reasonable, rendering it unworthy for Hong Kong to spend huge sums of money to develop seawater desalination. These members consider that DJ water will remain an important water source for Hong Kong and its role will not be substituted by the development of seawater desalination.

4.1.16 Other members are of the view that, to cope with future uncertainties and in consideration of the great demand of other cities in GD Province for DJ water, there is a need for Hong Kong to develop seawater desalination as a water source to complement the existing sources. Noting that the cost of production of desalinated water as estimated by WSD is on the high side, i.e. $12.6/m^3$ (at 2013-2014 price level),[21] members urge WSD to look into ways to reduce the production cost.

4.1.17 The delegation notes that the Tuaspring Desalination Plant is equipped with an on-site power plant to provide electricity supply for seawater desalination, and excess power generated by the power plant is sold to the national power grid. The combination of the desalination plant and the power plant helps create synergies between the two operations and lower the desalination cost.

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[21] As reported in paragraphs 2.2.14 and 3.5.5, the cost of importing DJ water in 2014-2015 was HK$9.1/m^3$, and the price of desalinated water produced in Tuaspring, Singapore, sold by Hyflux Ltd to PUB, was S$0.45/m^3$ (about HK$2.79/m^3$) in 2013. The costs given by WSD (for DJ water and desalinated water) includes water distribution and customer service costs. As for the price of desalinated water in Singapore, little information is available about the components.

4.1.18 As Hong Kong is going to develop a desalination plant in Tseung Kwan O, some delegation members suggest that the HKSARG should draw reference from Tuaspring and consider the installation of power generation facilities inside the proposed desalination plant to reduce the desalination cost. However, having regard to the prevailing electricity supply arrangements in Hong Kong, delegation members consider that Tuaspring's arrangement of selling the excess power generated from the power plant at the desalination plant to the power grid may not be applicable to Hong Kong.

Other new water sources

4.1.19 As regards the development of other new water sources, the delegation notes that Singapore has made tremendous efforts to produce NEWater and to gain the public's acceptance of NEWater. By contrast, Hong Kong is lagging behind Singapore in terms of the use of reclaimed water. The delegation urges the HKSARG to step up its efforts to develop the reclaimed water supply system. In addition to introducing the system in certain new developments in future, the HKSARG should study carefully whether and how reclaimed water can be used in existing developments.

4.1.20 The delegation appreciates the efforts of WSD in developing an extensive seawater flushing system, which helps bring down the demand for fresh water. Meanwhile, no similar system is found in Singapore, where in general fresh water is used for flushing. Yet, seawater mains are susceptible to corrosion due to the high salinity of seawater. In this connection, the delegation suggests that the HKSARG should introduce measures to encourage the recycling of grey water for toilet flushing and other non-potable uses, not only in new government projects, but also in private buildings (e.g. by requiring the inclusion of grey water recycling design in new buildings).

Regulation of quality of drinking water

Regulatory framework

4.1.21 The delegation notes that Singapore has put in place the EPH Regulations to regulate the quality of piped drinking water. Moreover, the delegation observes that there is a clear division of responsibility of the water authorities in Singapore, with PUB focusing on the management of the water supply system and NEA specializing in the regulation of drinking water quality under the EPH Regulations. In playing the role of water quality regulator, NEA places emphasis on issues from the perspectives of public health and environmental protection. It is noteworthy that policies on environmental protection and water resources management are under the purview of one ministry, i.e. MEWR. The Singapore water management system enables a holistic and integrated approach to protecting and planning of water resources, while building in effective checks and balances in the regulatory regime for the quality of drinking water.

4.1.22 In the delegation's view, the water quality regulatory regime in Hong Kong is less developed than that of Singapore. First, neither the Waterworks Ordinance nor the Waterworks Regulations regulates the standards of water quality. Consumers rely on WSD's pledge of supplying drinking water in full compliance with the WHO Guidelines. Second, WSD is the sole authority in Hong Kong responsible for managing the water supply system and regulating water quality. Unlike the situation in Singapore, there is no authority independent of WSD to monitor water quality from the perspectives of public health and environmental protection. The delegation calls on the HKSARG to review the regulatory regime for the quality of drinking water and seriously consider legislating for the safety of drinking water.

Water quality monitoring mechanism

4.1.23 On the water quality monitoring mechanism, the delegation has learnt that Singapore has adopted more stringent standards than the regulatory requirements in its internal control of the water treatment process to ensure the quality of drinking water. A comprehensive sampling and

monitoring programme is in force to ensure that the water supplied to consumers is safe from source to taps. Moreover, as a check-and-balance measure, the water sampling and analysis conducted by the Water Quality Office of PUB is audited by NEA, and reviewed by an internal audit panel and an external audit panel.

4.1.24 The delegation notes that WSD has been taking water samples at various points of the water supply system (including consumers' taps) for testing. Yet, some of WSD's current practices, such as not collecting first-draw water samples from consumers' taps, may not be the best practice, taking in view the occurrence of the "lead in drinking water" incident. The delegation urges WSD to draw on Singapore's experience and re-examine its water quality monitoring mechanism.

Control of water quality at inside service

4.1.25 The delegation was informed that no lead had ever been found in drinking water in Singapore. Under the Public Utilities (Water Supply) Regulations, no water fittings in Singapore shall be made of lead or lead alloy. Soldering joints for copper pipes are also forbidden for use in Singapore. Moreover, water service works must be carried out by water service plumbers licensed by PUB.

4.1.26 The delegation is of the view that the HKSARG has not been alert or paid sufficient attention to the harmful effects of lead on public health before the occurrence of the "lead in drinking water" incident. The delegation concurs with the views expressed in the Counsel's closing submission[22] to the Commission of Inquiry into Excess Lead Found in Drinking Water that, while WSD and HA were aware of the harmful effect of lead, they lacked the alertness about the illegal use of leaded solder at fresh water inside services. The project contractors also failed to follow the checking procedures to ensure that the compliant solder materials were used. Moreover, to avoid inadvertent breach of the law, the HKSAR should clarify,

[22] A transcript of the closing submission of Mr Paul SHIEH Wai-tai, SC (Counsel for the Commission of Inquiry) to the Commission made at the hearing on 17 March 2016 is available at the following hyperlink: http://www.coi-drinkingwater.gov.hk/eng/pdf/transcript20160317.pdf

under section 15 of the Waterworks Ordinance, whether the licensed plumbers should carry out the construction etc. of inside service personally or could delegate the works to other workers under plumbers' supervision.

Water conservation

4.1.27 The delegation observes that the Singapore government has been collaborating closely with schools, public and private sectors to carry out various public education programmes about conservation of water resources. The NEWater Visitor Centre has been set up to educate the young generation on the concept of cherishing water resources. These efforts have helped lower the water consumption rate of the Singaporeans.

4.1.28 As the daily per capita domestic fresh water consumption in Hong Kong is higher than the world average, the delegation urges the HKSARG to make reference to Singapore's experience and vigourously engage the community, schools and non-governmental organizations in raising public awareness of water conservation.

Bringing people closer to the water

4.1.29 A striking feature of the waterways and reservoirs in Singapore is that they have gone beyond the traditional functions of drainage, flood control and water storage. Under the ABC Waters Programme, the waterways and reservoirs have been transformed into beautiful and clean destinations for the public to enjoy. The delegation notes that the Singapore government has made lots of efforts in implementing ABC Waters projects and encouraging new lifestyle activities to flourish in and around the waters.

4.1.30 The delegation urges the HKSARG to draw on the experience of the ABC Waters Programme and launch more nullah revitalization projects in addition to the Tsui Ping River project[23] and the Kai Tak River project,[24] so as to beautify the urban environment, create more community spaces and promote a water-friendly culture. The HKSARG should ensure that the water running in these rivers is clean stormwater and will not be polluted by industrial or household effluents due to misconnection of sewers to the stormwater drainage system. Through the implementation of these projects, the HKSARG should educate the public that they share the responsibility to conserve and protect water resources, while enjoying the waters.

4.2 Conclusions

4.2.1 The delegation considers the visit very useful and enlightening. It has deepened members' understanding of Singapore's experience in water resources management. The briefings by and exchanges of views with government officials, MPs and representatives of relevant authorities have enabled the delegation to obtain first-hand information on the development and operation of seawater desalination and water reclamation in Singapore. Moreover, through meetings and site visits, delegation members have the opportunity to learn about the measures taken by PUB and NEA to regulate the quality of drinking water.

4.2.2 The delegation appreciates that the Singapore government has made a lot of efforts over the years to ensure an adequate and sustainable supply of fresh water for the country. The delegation is particularly impressed by the foresight and vigour of the Singapore government in formulating and implementing a long-term water plan to address the future water needs, adopting an integrated approach in diversifying sources of

[23] The HKSARG has proposed to revitalize the King Yip Street nullah in Kwun Tong into Tsui Ping River with environmental and landscaping upgrading of the vicinity. DSD commissioned a consultancy study in July 2015 for site investigation and preliminary design for the project. The study will last about 20 months.

[24] The project is to revitalize the Kai Tak nullah into Kai Tak River. It is being carried out in stages and is scheduled for completion by 2018.

water supply, managing water demand and maintaining a high standard of quality of drinking water.

4.2.3 While the water management experience of Singapore may not be readily applicable to Hong Kong owing to the differences in situations and city characteristics, delegation members believe that Singapore's experience is valuable and can serve as a useful reference for Hong Kong for the development of new water sources, implementation of water conservation measures and maintenance of water quality.

ACKNOWLEDGEMENTS

The delegation wishes to thank the organizations and persons listed in **Appendix II** for receiving the delegation and the time they have taken to brief the delegation on their work and exchange views with delegation members.

The delegation is grateful to the Ministry of the Environment and Water Resources of Singapore, the Consulate-General of Singapore in the Hong Kong Special Administrative Region and the Hong Kong Economic and Trade Office in Singapore for their assistance in drawing up the visit programme and advice on the logistics arrangements for the visit. The delegation also expresses sincere gratitude to the staff of the Legislative Council Secretariat for their unfailing support and hard work.

ACRONYMS AND ABBREVIATIONS

3P	People, private and public
ABC Waters Programme	Active, Beautiful and Clean Waters Programme
DH	Department of Health
DJ	Dongjiang
DSD	Drainage Services Department
DTSS	Deep Tunnel Sewerage System
EPH Regulations	Environmental Public Health (Quality of Piped Drinking Water) Regulations 2008
FC	Finance Committee
GD	Guangdong
GPCs	Government Parliamentary Committees
HA	Hong Kong Housing Authority
HD	Housing Department
HKSARG	Government of the Hong Kong Special Administrative Region
km	kilometre
km^2	square kilometres
m^3	cubic metre
mcm	million cubic metres

MEWR	Ministry of the Environment and Water Resources
mgd	million gallons per day
MPs	members of the Parliament of Singapore
MWELS	Mandatory Water Efficiency Labelling Scheme
NEA	National Environment Agency
PRH	Public rental housing
PUB	Public Utilities Board
S$	Singapore dollar
SWHSTW	Shek Wu Hui Sewage Treatment Works
The Panel	The Panel on Development
TWMS	Total Water Management Strategy
WA	Water Authority
Waterworks Ordinance	Waterworks Ordinance (Cap. 102)
Waterworks Regulations	Waterworks Regulations (Cap. 102A)
WGGs	Water gathering grounds
WHO Guidelines	World Health Organization Guidelines for Drinking-water Quality
WREC	Water Resources Education Centre

WRPs	Water reclamation plants
WSD	Water Supplies Department
WSP	Water Safety Plan

Appendix I: Visit programme

20 March 2016 (Sunday)	Arrival in Singapore
21 March 2016 (Monday)	Meeting with representatives of the Ministry of the Environment and Water Resources, the Public Utilities Board and the National Environment Agency
	Visit to the Tuaspring Desalination Plant
22 March 2016 (Tuesday)	Visit to the Bishan-Ang Mo Kio Park
	Meeting with members of the Government Parliamentary Committee for Environment and Water Resources of the Parliament of Singapore
	Visit to the Bedok NEWater Factory
23 March 2016 (Wednesday)	Meeting with representatives of Water Quality Office and Water Supply (Network) Department of the Public Utilities Board
	Departure for Hong Kong

Appendix II: List of organizations and persons met by the delegation

21 March 2016 (Monday)
Ministry of the Environment and Water Resources Ms NG Mie Ling, Director, Water Policy Mr LIM Kim Shin, Deputy Director, Water Policy Ms Rhoda TONG, Assistant Director, Water Policy
Public Utilities Board Mr NG Joo Hee, Chief Executive Mr CHUA Soon Guan, Deputy Chief Executive, Policy & Development Mr William YEO, Director, Policy & Planning Mr Michael TOH, Director, Water Supply Network Dr LIM Mong Hoo, Chief Specialist, Water Quality Office Mr KOK Tze Weng, Deputy Director, Policy & Planning Mr MOH Tiing Liang, Senior Assistant Director, Industry Development Ms Kelly SER, Senior Planner, Policy & Planning
National Environment Agency Ms Siti Suriani ABDUL MAJID, Deputy Director, Food & Environmental Hygiene Dr Pranav JOSHI, Senior Assistant Director, Food & Environmental Hygiene
Hyflux Ltd Ms CHIONG Woan Shin, Managing Director, Business Development, Southeast Asia Mr Michael SIEW, Senior General Manager, Global Operations & Maintenance

22 March 2016 (Tuesday)
Public Utilities Board Ms CHENG Geok Ling, Deputy Director, Sustainability Office Ms LAU Ying Shan, Senior Manager, Sustainability Office Ms Nikki YE, Engineer, Catchment & Waterways Mr ONG Key Wee, Senior Principal Engineer, Water Supply Plants Mr YAP Wai Kit, Assistant Director, 3P Network
Government Parliamentary Committee for Environment and Water Resources, the Parliament of Singapore Er Dr LEE Bee Wah, Chairperson of the Government Parliamentary Committee for Environment and Water Resources Mr LIANG Eng Hwa, Member of the Government Parliamentary Committee for Environment and Water Resources
23 March 2016 (Wednesday)
Public Utilities Board Dr LIM Mong Hoo, Chief Specialist, Water Quality Office Mr LAI Kah Cheong, Chief Engineer, Water Supply Network Mr LEE Cai Jie, Senior Engineer, Water Supply Network Mr Matthew LOH, Chemist, Water Quality Office

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