RP11/99-00

Water Quality Control Measures In Overseas Places

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C O N T E N T S

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EXECUTIVE SUMMARY

1. Hong Kong, Sydney, New York City and Singapore need to convey water from external sources outside the city. Measures are introduced to control water quality, mainly categorized as (1) protection of water sources in catchment areas, (2) treatment of water, and (3) exploration of alternative water sources. Catchment protection programmes are found to be most effective, as in the case of New York City and Sydney, which includes legislative, educational and financial measures.

2. Despite the respective water supply agreements, Hong Kong and Singapore encounter problems in ensuring raw water quality. In Hong Kong, problems arise as the raw water supply institution belongs to another administrative authority and open aqueduct is used for water transportation, which increases the risk for contamination.

3. Penalty clauses for non-compliance and mechanism for dispute resolution are clearly stipulated in the water supply agreement in Sydney, which cannot be found in that between Hong Kong and Guangdong authority.

4. The actual quality of drinking water is acceptable in all four places, which basically complies with the WHO 1993 Guidelines for Drinking Water Quality. However, the increases in filtration cost reveal the fact that the quality of raw water deteriorates in Hong Kong. Places like Hong Kong and Singapore which rely mostly on water treatment may bear a possibly higher health risk for the concentration of residual chlorine and Trihalomethanes is relatively high.

5. Hong Kong purchases water at a higher price than Singapore while the treatment cost of imported water is similar. Total cost is higher in Hong Kong than in Sydney. The New York City experience illustrates that savings in water treatment can be achieved through catchment management.

6. The Guangdong authority steps up catchment protection in recent years. Hong Kong Works Bureau officials stress that time is needed for environmental rehabilitation and raw water quality at present is well within the treatment capacity of waterworks in Hong Kong. The HKSAR Government said that the cost implication for developing alternative water sources needs further study.

SUMMARY TABLE

Water Sources and Water Quality Protection Measures in Hong Kong and Overseas Places

	Hong Kong	New York City	Singapore	Sydney
Population in 1998 (million)	6.7	8.0	3.8	3.7
Annual Water Consumption in 1998-99 (million cubic metres)	916	1798.4	467.2	584
Water Consumption per Capita in 1998 (cubic metres per capita)	136.7	224.8	122.9	157.8
Major Source of Water Supply (% of total)	Dongjiang (83)	Catskill-Delaware Catchment (90)	Rivers in Johor (70)	Warragamba Dam (80)
Water Purchased from another Political Entity (% of total)	Yes (83% from another administrative region)	No	Yes (70% from another country)	No
Distance from Water Intake (km)	78	200	35[1]	82
Types of Water Transfer Channel	Open aqueduct	Pipelines and tunnels	Pipelines	Pipelines and open canal
Has Raw Water Standard	No (but China has standards)	No	No (but Malaysia has standards)	Yes with penalty for non-compliance
Standard for Treated water	WHO 1993 Guidelines for Drinking Water Quality	National Primary and Secondary Drinking Water Standards	WHO 1993 Guidelines for Drinking Water Quality	Australian Drinking Water Guidelines
Compliance with Standard for Treated Water	No For residual chlorine	No for colour	No for residual chlorine	Yes
Major Measures to Ensure Water Quality	Treatment	Catchment management	Treatment	Catchment management

[1] The Johor River Waterworks near Kota Tingii Town is the furthest waterworks from Singapore, which is 35 km away. The nearest waterworks in Johor is the Tebrau Waterworks which is 13 km away.

WATER QUALITY CONTROL MEASURES IN OVERSEAS PLACES

PART 1 - INTRODUCTION

1. Background

1.1 The Legislative Council Panel on Environmental Affairs requested at its meeting on 2 July 1999 the Research and Library Services Division (RLS) to conduct a study on the measures adopted in some overseas places to control the quality of water. Places that need to transport water from outside its boundary would be of relevance. The findings of the research would provide reference gained from overseas experience on protection of water sources and enforcement of relevant environmental legislation.

2. Objective and Scope

2.1 The objective of this research is to provide information and an analysis on the measures adopted in overseas places in controlling the quality of raw and drinking water.

The scope of the research is as follows:

- To describe and analyze the standard and quality of raw and treated water at intake point, during transportation and at distribution point in overseas places; and

- To describe and analyze the measures to control the quality of raw and treated water at intake point, during transportation and at distribution point in overseas countries.

3. Methodology

3.1 Three places are selected, namely Sydney, New York City and Singapore because they all need to transport water from outside for internal consumption. There is reference value from each of them for Hong Kong. (Please refer to appendix I for location maps of the four places under study.) Letters were sent to relevant organizations in these three places to obtain information.

3.2 In addition, information is collected over the Internet and from reference books.

3.3 A list of questions was sent to the Works Bureau of the Hong Kong Government to obtain detailed information on Dongjiang water and water in local reservoirs. Interviews were held with local academics and officials of the Works Bureau.

3.4 This research compares seven health-related parameters, four aesthetic parameters and four microbial parameters of the three sets of drinking water standard. This selection is based on the Audit Report which chose similar parameters in analyzing the quality of drinking water in Hong Kong. Such parameters include those which are carcinogenic, cause kidney and central nervous system problems or cause problems to reproductive systems.

PART 2 - SCHEMA OF WATER SUPPLY SYSTEM

4.1 It might be useful to make a brief description of a water supply system in general and to introduce some special terms which will be used in the rest of this research report.

5. Raw Water

5.1 Fresh water comes from rainfall and is collected into river courses. The river basin that collects water into a reservoir for water supply is called *catchment area* and the fresh water collected is called *raw water*.

5.2 For a city, raw water from external sources (such as Dongjiang water) is conveyed by aqueducts or pipelines to local reservoirs. Raw water receives no treatment at this stage in most cases and the *quality of raw water* is seldom controlled by legally enforceable standards. However, as raw water usually forms a part of the natural ecosystem, some conventional pollutants indicators are employed by catchment authorities for monitoring. These include biochemical oxygen demand, dissolved oxygen, pH value and turbidity, which are important for aquatic life.

6. Drinking Water

6.1 The *quality of drinking water* is ensured by *treatment* for health reason. *Drinking water standards* are the standards which measure the physical, biological, chemical and aesthetic characteristics of water.

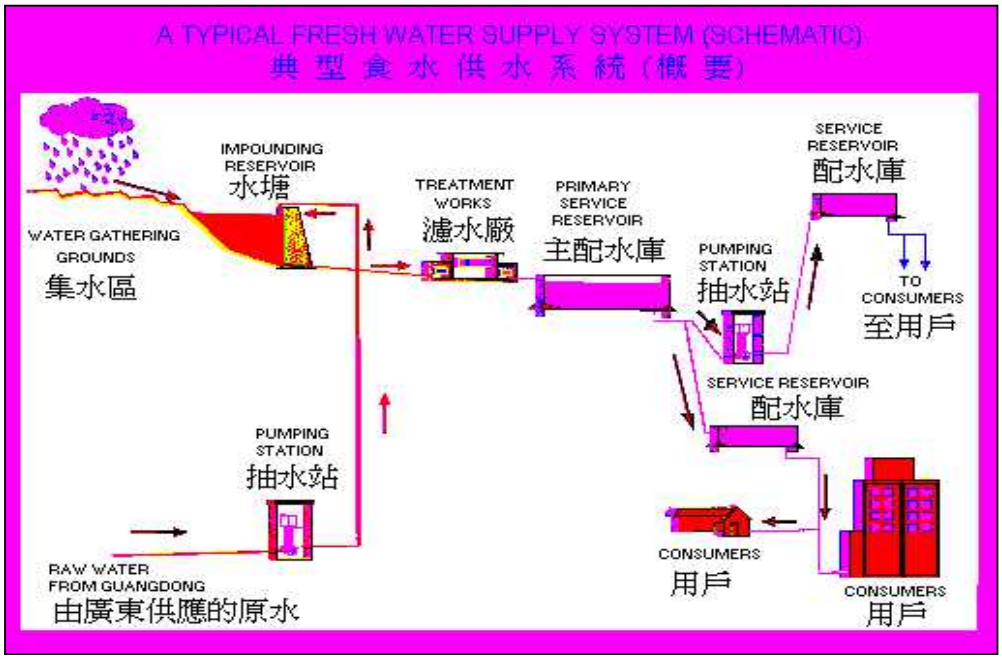
6.2 To minimize the risk of diseases transmission, virus, bacteria and parasites[2] are to be removed. Toxic chemicals like aresenic, chromium, mercury, manganese, aluminium and Polychlorinated biphenyls (PCBs) are to be kept at low concentration. In addition, radionuclides are tested to ensure water is free from radiative contamination.

[2] Examples of virus include Adenviruses which may cause eye infections, Hepatitus A virus which may cause infectious hepatitus; examples of bacteria include Salmonella typhi which may cause typhoid fever, Vibrio cholerae which may cause cholera; examples of parasites include Cryptosporidium and Giardia. For details of these two parasites, please refer to paragraphs 10.6 and 10.7 below.

6.3 The treatment process consists of chemical *coagulation*, *filtration* and *disinfection*. In the chemical coagulation process, coagulants and coagulant-aids are dissolved in raw water to combine the colloidal and suspended matters which settle and are removed in the sedimentation tank. Water then passes through rapid gravity filters[3] which remove the finer particles. Hydrated lime is added for pH value correction. The filtered water is disinfected with disinfectants like chlorine, fluoride, sodium hydroxide and sometimes ozone, which get rid of all harmful bacteria. Chlorination in turn will produce Trihalomethanes (THMs) and a high concentration may present cancer risk. Thus, residual chlorine and THMs are supplementary standards tested in the distribution network.

6.4 The treated water is conveyed by pipelines to primary service reservoirs for storage. It then goes through a *delivery* system, from pumping stations to service reservoirs and finally at water taps. A schema of the water supply system in Hong Kong is provided below.

Schema 1 - A Typical Fresh Water Supply System in Hong Kong



Source: Water Supplies Department

[3] Rapid gravity filtering is a method to filter suspended particles out from water with a filter bed. Water passes through a layer of filter materials with natural gravity force and the suspended particles are screened out on the filter bed.

PART 3 - HONG KONG

7. Water Sources

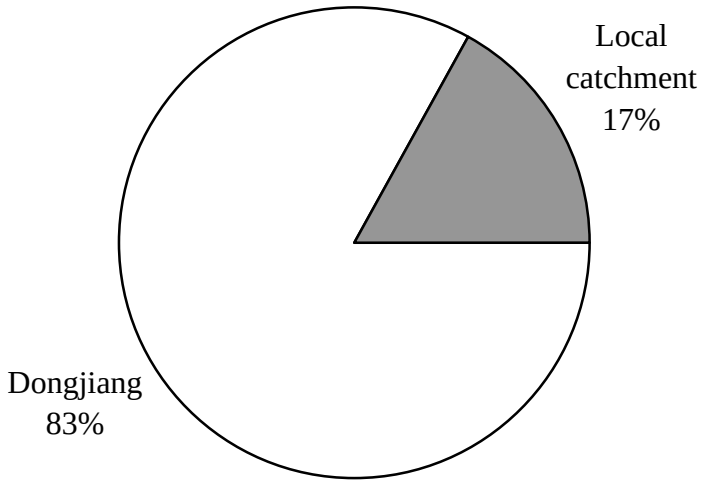
7.1 Hong Kong does not have adequate water resources within its boundary to meet the demand of its population. It has been purchasing Dongjiang (East River) water from Guangdong Province since 1960. In 1998, 83% or 760 million cubic metres of water came from Dongjiang. This compared to about 22% or 41 million cubic metres in 1965 (Table 1).

Table 1 - Annual Water Supply from Dongjiang (million cubic metres)

Year	Population (million)	Annual consumption of fresh water (million cubic metres)	Actual amount delivered by Guangdong (million cubic metres)	% of water from Guangdong
1965	3.7	185.4	41.1	22.1
1975	4.4	360.7	92.7	25.7
1985	5.5	637.0	319.3	50.1
1994	6.0	923.0	683.1	74.0
1995	6.1	919.0	690.0	75.1
1996	6.3	928.0	720.0	77.6
1997	6.5	913.0	698.0	76.5
1998	6.7	916.0	760.0	83.0

Sources: Dongshen-Hong Kong Water Supply Scheme: A Summary of the Exchange of Experience and Cooperation between Guangdong Province and Hong Kong, The Water Resources Board of Guangdong Province and Hong Kong Water Supplies Department, 1998 Water Supplies Department Annual Report 1997-98

Chart 1 - Hong Kong's Water Supply in 1998



Dongjiang Water

7.2 Raw water is extracted from downstream of Dongjiang at a point 78.47 kilometres north of Hong Kong[4]. Dongjiang water is then transferred to Hong Kong through the Dongshen (Dongjiang-Shenzhen) Water Supply System - an open aqueduct comprised of natural river courses and artificial canals.

7.3 The water intake point used to be at Qiaotou pumping station in Qiaotou Town of Dongguan City. But it was moved to Tai Yuen pumping station in 1998 owing to deteriorating water quality at Qiatou. Both pumping stations are in the same town and are 350 metres apart.

7.4 Dongjiang water pumped into Dongshen Water Supply System flows through Dongguan City and Shenzhen City into the Shenzhen Reservoir. It then flows across the border into large reception tanks at the Muk Wu Pumping Station, near Lo Wu, in Hong Kong.

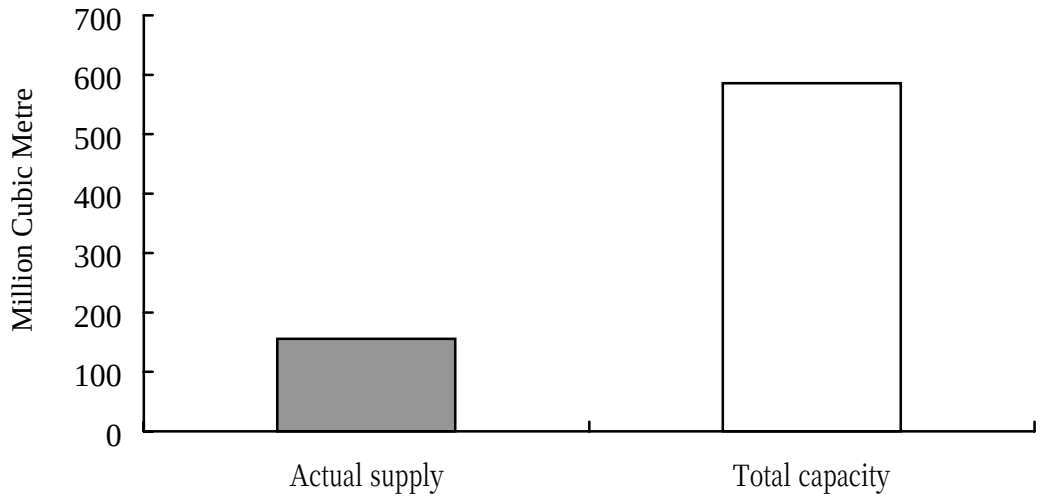
Local Supply

7.5 Rain water collected from local catchments and stored in reservoirs meets about 17% of Hong Kong's water demand. There are 17 reservoirs in Hong Kong and their aggregate storage capacity is 586 million cubic metres.

[4] This is the physical distance between the intake point at Dongjiang and the point of delivery to Hong Kong. The length of the open aqueduct which transports Dongjiang water to Hong Kong is about 83 kilometres.

7.6 Apart from Dongjiang water and rain water, Hong Kong does not have other sources of water. There are no appreciable underground water or sizeable lakes in Hong Kong. While Hong Kong once had a desalination plant - Lok On Pai desalter - built in 1975, it was decommissioned, dismantled and sold in 1992.

Chart 2 - Local Supply of Water in Hong Kong in 1998



8. Water Supply Agreements

8.1 Hong Kong signed the first water supply agreement with Guangdong in 1960 to receive 22.7 million cubic metres of water a year. Over the years, there have been five water supply agreements (Table 2). The latest water supply agreement was signed between Guangdong and Hong Kong in 1989. The agreement provides for incremental water supplies from Guangdong up to a maximum quantity of 1,100 million cubic metres per annum in 2008. The next agreement negotiation is scheduled to start in 2004.

8.2 According to the 1989 agreement, all water supplied to Hong Kong will not be inferior to Class II standard stipulated in the Environmental Quality Standard for Surface Water[5], GB 3838-83, promulgated by the People's Republic of China (PRC) in 1983 ("the 1983 standard"). We note that the PRC published a more stringent national standard for surface water in 1988 ("the 1988 standard"), which was not adopted in the 1989 agreement. According to the Water Supplies Department, the 1983 standard was used by the Hong Kong authorities during the negotiation because the Guangdong authorities had not yet adopted the 1988 standard; hence, reference was made to the 1983 standard in the 1989 agreement. The Guangdong authorities adopted the 1988 standard in 1991.

[5] Surface water refers to raw water here.

8.3 The People's Republic of China published the Environmental Quality Standard for Surface Water GB 3838-88 in April 1988. Type II water quality of 1988 refers to "water in Class I protection areas, which are centralized for potable water supplies…". While the 1988 standard has been in force in China for more than 10 years, it is not a standard applicable to Dongjiang water supplied to Hong Kong. The major differences between the two standards are as follows:

- The 1988 standard stipulates 30 parameters of water quality while the 1983 standard only set 19 parameters;
- Two in the 11 additional parameters are operationally significant, un-ionised ammonia and total manganese, and they have been included in the 1988 standard but not in the 1983 standard; and
- Limiting values[6] set in the 1988 standard are more stringent than those of the 1983 standard.

8.4 In 1998, Hong Kong and Guangdong signed a loan agreement. This provides for Hong Kong to make an interest-free loan to Guangdong for the construction of a closed aqueduct in the Dongshen Water Supply System. In return, Guangdong would reduce the quantity of annual water supply to Hong Kong. The Guangdong authority promised in the agreement to strive to achieve the Type II standard stipulated in the PRC Environmental Quality Standard for Surface Water, GB 3838-88 published in 1988 mentioned in paragraph 8.3 above.

[6] Limiting values refer to the maximum values for standards compliance.

Table 2 - Water Supply Agreements between Hong Kong and Guangdong

Year	Agreement	Details of agreement
1960	1st Water Supply Agreement	Annual purchase of 22.7million cubic metres a year from Shenzhen Reservoir
1964	2nd Water Supply Agreement	Annual water supply would increase from 68.2 million cubic metres in 1965 to 84 million cubic metres in 1972 and 109 million cubic metres in 1976.
1980	3rd Water Supply Agreement	Annual water supply would increase from 145 million cubic metres in 1979 to 182 million cubic metres in 1982. This agreement was amended in October 1981 and again in 1982. It was agreed that annual water supply to Hong Kong would increase to 220 million cubic metres in 1982 with an annual increment of 30-50 million cubic metres until it reached 620 million cubic metres in 1994/95.
1987	4th Water Supply Agreement	Effective from 1989/90, annual water supply would rise annually to 660 million cubic metres in 1994/95.
1989	5th Water Supply Agreement	Annual water supply would increase by 30 million cubic metres from 690 million cubic metres in 1995 to 840 million cubic metres in 2000, and up to 1,100 million cubic metres by 2008.
1998	Loan Agreement	Hong Kong would provide an interest-free loan of $2,364 million to the Guangdong Provincial People's Government to help finance the construction of a new closed aqueduct for conveying water from Dongjiang to Hong Kong. Guangdong authority promised to strive to achieve the Type II standard stipulated in the PRC Environmental Quality Standard for Surface Water, GB 3838-88 published in 1988. Guangdong Province agreed to reduce the annual committed increase in supply quantity from 1998 to 2004, and thereafter take into account Hong Kong's demand growth and reservoir storage situation in considering the supply quantities.

Sources: p. 187-188, Dongshen-Hong Kong Water Supply Scheme
FCR(98-99)12 on 3 April 1998

8.5 The unit price for Dongjiang water has always been subject to reviews and has undergone signifiant increases, from JMP[7]$0.1 per 1000 gallons in 1960 to HK$3.085 per cubic metre in 1999.

8.6 The pricing mechanism has changed too. Before 1987, the agreed price in each negotiation was to remain effective until the next revision. But in the 1987 4th Agreement, the unit prices for the three years to come were agreed. As summarized in 1989 5th Agreement, the basis of water price adjustments relates to increases in operation costs and will take into account changes in relevant price indices in Guangdong and Hong Kong and the exchange rates between the Hong Kong Dollars and the Renminbi. For details, please refer to Appendix II.

9. Administrative Arrangements

Management of Dongshen Water Supply System

9.1 The Guangdong Provincial Bureau of Water Conservancy and Hydro-Power in January 1965 set up "Dongjiang-Shenzhen Water Supply Project Administration Board", which began operation with 330 staffs. The number of staff grew to 1,350 in 1994. The Board is responsible for the overall management and maintenance of water supply courses, collecting water charges from Hong Kong and Shenzhen, and protecting and monitoring the water quality.

Liaison between Hong Kong and Guangdong

9.2 The water supply agreement signed in 1989 provided for a mechanism for liaison between Hong Kong and Guangdong. An Annual Business Meeting between Hong Kong and Guangdong would be held once every year to conduct negotiations on water supply for the year. According to the Water Supplies Department, the agenda of the meeting mainly covered issues on the quantity, quality and pricing of water supply. In addition, an Operation and Management Technical Sub-group meets at least twice yearly in Shenzhen and Hong Kong alternatively to discuss matters relating to the management and operation of the Dongshen Water Supply System, such as water quality.

[7] Water Supplies Department explained that JMP was the Chinese dollar unit (RMB). Different abbreviations were adopted in English translation of the agreements for the Chinese dollar during different periods of time.

10. Standards and Actual Quality of Raw Water

Standards of Raw Water

10.1 Hong Kong does not have a standard for raw water but the government makes reference to the PRC 1983 Class II standard stipulated in the Environmental Quality Standard for Surface Water GB 3838-83 in monitoring the quality of raw water. The PRC Class II standard is used as the reference for monitoring Dongjiang water at Muk Wu.

10.2 Guangdong Authority has the contractual duty under the 1989 Water Supply Agreement to ensure that all water supplied to Hong Kong meets the PRC Class II standard of GB 3838-83.

10.3 In the 1998 Loan Agreement, the Guangdong authority promised to strive to achieve the Type II standard stipulated in the PRC Environmental Quality Standard for Surface Water, GB 3838-88 published in 1988. The actual quality of the water supplied by the Guangdong Authority is detailed in paragraphs 10.4 to 10.15 below. Table 3 shows the standards applicable to raw and treated water in Hong Kong.

Table 3 - Standards Applicable to Raw and Treated Water in Hong Kong

Type of water	Standard/guidelines	Remarks
Raw water from Dongjiang	Class II, Environmental Quality Standard for Surface Water GB 3838-83 published by the People's Republic of China in September 1983	A more stringent standard, Type II, Environmental Quality Standard for Surface Water GB 3838-88 published by the People's Republic of China in April 1988 is currently used in the Mainland.
Raw water in local reservoirs	No	GB 3838-83 is used as the reference.
Treated water	WHO 1993 Guidelines for Drinking Water Quality Final Treated Water Quality Targets	Internal day-to-day operational instructions based on the WHO guidelines

Source: Audit Report No. 33, Audit Commission, 11 October 1999

Actual Quality of Raw Water

10.4 Direct comparison between the quality of Dongjiang water and local raw water is not possible because the parameters employed in water quality testing are different. In addition, there is no significant variation in the quality of local raw water among different catchment areas.

Non-compliance with Raw Water Standards

10.5 The Hong Kong government has been monitoring the water quality of the Guangdong supply since 1960. A wide range of physical, chemical and microbiological parameters in raw water is examined routinely. These include: turbidity, conductivity, the contents of manganese, dissolved oxygen, ammoniacal nitrogen, nitrate nitrogen, total phosphate and the microbiological count of total Coliform organisms.

10.6 Water quality in the Dongshen Water Supply System started to deteriorate since late 1980's owing to increasing industrial activities along the route. Increasing population and the use of pesticides in farming also contribute to the pollution of the Dongjaing water.

10.7 A comprehensive picture of Dongjiang water quality emerged when Audit Report No.33 was published in October 1999. The Audit Commission analyzed the water quality test data collected by the WSD at the Muk Wu pumping station from 1989 to 1998 and found that raw water from Dongjiang failed to comply with some of the key parameters of the 1983 standard. For dissolved oxygen, total phosphorus, total nitrogen and pH, some of the test results showed that the water quality did not comply with the 1983 standard during the above-mentioned period.

10.8 In addition to analyzing the key parameters laid down in the 1983 standard, the Audit Commission also analyzed the amount of ammoniacal nitrogen that Dongjiang water contained. Ammoniacal nitrogen is an indicator of possible contamination by bacteria, sewage and animal waste. It has to be removed before the water is treated. The Audit Commission compared the test data with the standard for Guangdong Provincial water quality control index values[8] and found that half of the test data showed that ammoniacal nitrogen in the water exceeded the standard.

[8] The 1983 standard does not cover Ammoniacal nitrogen and the Guangdong Provincial water quality control index is used for comparison.

Table 4 - Percentage of Water Samples Failed to Meet the 1983 Standard

Parameters	% of test data not complying with the 1983 standard	Remarks
Dissolved oxygen	62	Low concentration indicates an active growth of micro-organisms causing taste and odour problems. The 1997 and 1998 test data showed that Dongjiang water was almost depleted of dissolved oxygen.
Total nitrogen	83	This is an indicator of sewage and industrial contamination. Nitrogen concentration in Dongjiang water exceeded the 1983 standard by as much as five times in 1998.
Total phosphorus	12	The source of phosphorus is phosphate. Water supply containing phosphate is usually contaminated by minerals, fertilizers, detergents, sewage or industrial waste.
pH	2	pH control is necessary in all stages of water treatment to ensure satisfactory water clarification and disinfection.
Ammoniacal nitrogen*	49% exceeded the standard for Guangdong Provincial water quality control index values.	In March 1998, the ammoniacal nitrogen level exceeded the index value by as much as seven times.

Source: Audit Report No. 33, October 1999, Audit Commission

Remark: * Ammoniacal nitrogen is not a parameter of the 1983 standard

Carcinogenic Materials

10.9 Raw water from Dongjiang was also found to contain carcinogenic substances though the concentration levels of these substances were low, compared to the guideline values for drinking water recommended in WHO 1993 Guidelines for Drinking Water Quality.

10.10 The guideline value for carcinogenic substance represents one additional incidence of cancer per 100 000 of the population ingesting drinking water containing the substance for 70 years. A government information paper to the LegCo Panel on Environmental Affairs[9] revealed that Dongjiang water at Muk Wu contained three types of carcinogenic substances and four types of substances which are probably carcinogenic to humans (Table 5).

[9] Source: CB(1)199/99-00 Annex B

Table 5 - Types of Chemicals Found in Dongshen Water at Muk Wu Pumping Station and their Respective Carcinogenic Risk

WHO's classification of chemical substances according to their potential carcinogenic risk	Number of each type of chemicals in Dongjiang water at Muk Wu	Type of chemicals
Group 1 The substance is carcinogenic to humans	3	Vinyl chloride Benzene Arsenic
Group 2A The substance is probably carcinogenic to humans	4	Epichlorohydrin Benzo(a)pyrene Formaldehyde Cadmium

Source: CB(1)199/99-00 Annex B

10.11 Dr Ho Kin-chung of the Environmental Studies Programme of the Open University of Hong Kong has conducted water quality surveys at various points of the Dongshen Water supply System since 1996. In these surveys, he found that sediments collected at the lower stream of Dongjiang contained low levels of carcinogenic compounds - PCBs and benzo(a)pyrene (PAHs). The presence of these compounds indicated possible pollution from industrial and domestic effluents at Wei Zhou, which was at the downstream of Dongjiang.

10.12 According to the water samples taken six times a year at Muk Wu pumping station by the Water Supplies Department, no PAH has been detected over the period of 1994/95 to 1998/99 in Dongjiang water. Furthermore, a survey in 1999 showed no detectable quantity of PCB in the water.

Bacteria

10.13 Dr Ho Kin-chung found that Coliform levels had been on the rise from 1996 to 1998, which indicated contamination by faecal material.

10.14 Water samples analyzed by the Water Supplies Department showed that total Coliform levels were stable in the period from 1994/95 to 1998/99, with 96.7% to 83% of compliance.

Cryptosporidium and Giardia

10.15 The government told the LegCo in December 1998 that Dongjiang water contained two water-borne parasites, Cryptosporidium and Giardia. These parasites have caused several large outbreaks of gastro-intestinal illness such as diarrhoea in other parts of the world.

11. Standards and Actual Quality of Treated Water

Standards of Treated Water

11.1 In monitoring treated water, Hong Kong uses WHO 1993 Guidelines for Drinking Water Quality as the standard. WHO set guidelines for 94 health-related parameters in respect of certain impurities in treated water which had a direct impact on pubic health. WHO also set the levels for 25 aesthetic parameters in treated water.

11.2 In addition to the WHO guidelines, the Water Supplies Department has an internal operational standard for treated water, the Final Treated Water Quality Targets. The internal standard, which is based on the WHO guidelines but is more stringent, is adopted as a reference in the monitoring of treated water quality to ensure its compliance with WHO guideline values and is used in the design of new treatment works.

Cryptosporidium and Giardia

11.3 The World Health Organization 1993 Guidelines for Drinking Water do not include any specific regulations relating to Cryptosporidium and Giardia, which are protozoa parasites that reproduce inside animals only. Cryptosporidium may cause intractable diarrhoea in people with damaged immune systems, such as cancer, transplantation and AIDS patients. Giardia may also cause diarrhoea and prolonged infection (lasting months) can have serious health consequences. These parasites have caused several large outbreaks of gastro-intestinal illness such as diarrhoea in other parts of the world.

11.4 The Water Supplies Department introduced the technique of testing the two parasites in 1997. In 1998, the Water Supplies Department formulated an action plan to monitor the situation closely. The frequency of sampling was once every three months and the sampling frequency would increase if water sample was found to have contained the two parasites. (A copy of the Contingency Plan for tackling the two parasites are attached in Appendix III.)

Contamination by Storage Tanks

11.5 The government has imposed a legal responsibility on the management office of individual buildings to keep water storage tanks within the buildings clean. According to Section 7 of the Waterworks Ordinance, the agent (usually the management office, incorporated owners etc.) has the responsibility to maintain communal service including the water storage tanks within a building. Under Reg. 7 of the Waterworks Regulation, the agent has to keep communal service clean. In case the water storage tank is found to be the cause of a water quality problem, the Water Authority may, by means of a repair notice or advisory letter, require the agent to carry out the necessary repair. Should the agent fail to do so, the Water Authority can disconnect the water supply to the building under the provision of the Waterworks Ordinance.

11.6 In 1998, 168 advisory letters and two repair notices were issued and the numbers in 1999 were 173 and seven respectively. No prosecution action had been necessary.

11.7 In addition, the first public education campaign on cleanliness of storage tanks has been launched in February 1999 and the department is planning new programmes.

Actual Quality of Treated Water

11.8 The Audit Commission found that the quality of treated water complied with the selected 1993 WHO health-related guidelines but did not fully comply with the aesthetic level of residual chlorine. It also observed that the quality of treated water did not fully comply with the Water Supplies Department's internal operational standard for turbidity, aluminum and residual chlorine.

11.9 An increasing amount of residual chlorine has resulted in an increase in the formation of Trihalomethanes (THMs) in treated water. THMs occur in drinking water as the by-product of chlorine and they cause liver, kidney and central nervous system problems and increase the risk of cancer. Two types of THMs, chloroform and bromodichloromethane, are classified as substances which are possibly carcinogenic to human.

11.10 The Water Supplies Department said the level of THMs in treated water is much lower than the WHO standard: "the health risks caused to human beings by a level lower than 50μg of THMs per litre of treated water is minimal." But the Audit Commission considered that the government should be alert to the increasing level of THMs in treated water leaving the Sha Tin Water Treatment Works (which treats Dongjiang water).

12. Measures to Ensure Water Quality

Legislative Measures in China

12.1 China introduced environmental protection legislation more than 20 years ago. The Chinese Environmental Protection Law, promulgated in 1979, outlined the principles of environmental protection on a national basis.

12.2 In addition, it is a crime to pollute the environment under the Criminal Law promulgated in 1979. The Criminal Law, amended in 1997, contained seven clauses on the crimes of destroying environmental resources.

12.3 The Law on Water Pollution Control was enacted in 1984 and was amended lately in May 1996. The amended Law on Water Pollution Control puts the responsibility for enforcing environmental regulations and measures to local governments. The law also prohibits the discharging of waste water into surface water in Class 1 protection area, which is for drinking.

12.4 In addition to national legislation, the Guangdong Province has also introduced its own legislative measures for preventing water pollution. The main legislative measures are listed in Table 6. The latest provincial legislation was the Guangdong Province Zhu Jiang Delta Water Quality Protection Ordinance enacted at the end of 1998. The legislation establishes the water quality objectives and requires these objectives to be used to manage the water environment. It also puts emphasis on the protection of water sources. It sets out clear guidelines on the responsibilities of local governments for managing rivers which flow through different counties and cities. It also provides the authorities with more power to monitor and manage large industrial pollution sources.

Table 6 - Guangdong Provincial Rules and Legislation for Protecting Water Sources

Date of enactment	Rules/Legislation
10 January 1991	Water Quality Protection Rules for Dongjiang System in Guangdong
24 June 1991	Stipulations of Water Quality Protection of Drinking Water Sources in Dongshen Water Supply Scheme
15 March 1993	Finance Use Administration Rule for Water Quality Protection in Dongjiang System in Guangdong
22 June 1993	Trial Procedure of Water Quality Objective Management of the Cross-City River Boundary in the Guangdong Province
27 November 1998	The Guangdong Province Zhu Jiang Delta Water Quality Protection Ordinance

Sources: Dongshen-Hong Kong Water Supply Scheme: A Summary on the Exchange of Experience and Cooperation between Guangdong Province and Hong Kong
CB(1) 199/99-00

Enforcement

12.5 The Guangdong government enforces through the Dongshen Water Quality Protection Office the regulations and orders factories and enterprises to reduce pollution within a definite time. The Hong Kong government listed the recent enforcement actions taken by the Guangdong Authority in two information papers to the LegCo Panel on Environmental Affairs[10].

Table 7 - Enforcement Action Against Water Pollution along the Dongshen Water Supply System

Type of pollution	Enforcement action
Control of fluorine contamination	Six factories were told to tackle the problem by October 1998. Two factories were reported to have been closed. The fluoride level dropped significantly since end 1998 but was on the rise again in May 1999.
Control of oil contamination	97 oil storing units which lacked leak-proof facilities were ordered to install the necessary facilities by the end of 1998.
Control of medical effluent	Nine hospitals along the converging route did not have proper effluent treatment facilities. They were required to construct new treatment facilities or improve the existing treatment facilities.
Control of effluent from the livestock	All farms located on conservation zone classes 1 and 2 along the Dongshen Water Supply System were ordered to be demolished by October 1998. Eight large piggeries along the river banks route were ordered to bring the level of effluent discharge within the standard limit. The treatment plants were completed and acceptance tests started in June 1999.
Construction of sewage treatment works	Six sewage treatment plants or sewage pumping facilities have been constructed along the Dongshen Water Supply Route. The new sewage treatment works in Pinghu was put into operation in June 1999.
Control of land use	The Guanlan Golf Course Phase II construction was ordered to stop.

Sources: CB(1)199/99-00, and CB(1)1603/98-99(02)

[10] CB(1)199/99-00, and CB(1)1603/98-99(02)

12.6 But despite the enforcement effort, the Guangdong government recognizes the limitations - economic interest very often overrides environmental concerns.

> "Considering the prevention and remedy of water pollution may have some influence on the development of economy, some of the region in virtue of local benefit might take the passive attitude. Therefore, water quality cannot be improved in a short time." (p.182, Dongshen-Hong Kong Water Supply Scheme)

Legislative Measures in Hong Kong

12.7 The Waterworks Ordinance, the Water Pollution Control Ordinance, and the Waste Disposal Ordinance are the primary legal instruments protecting local water resources. Penalties can be imposed on contravention of the above Ordinances. According to section 30 of the Waterworks Ordinance on pollution, any person guilty of an offence shall be liable on summary conviction to a fine of $20,000 and to imprisonment for two years.

12.8 The number of non-compliance cases in Hong Kong regarding contamination of water supply from 1994 to October 1999 are given in Table 8. The non-compliance cases involved: swimming and playing paddle boat in the reservoir, entering reservoir to catch fish and dumping building materials or waste from farm into catchment area.

Table 8 - Number of non-compliance of the Waterworks Ordinance

Year	1994	1995	1996	1997	1998	1999 (up to October 1999)
Number of non-compliance	5	1	1	2	2	2

Source: Reply from Works Bureau

12.9 According to the reply of the Works Bureau, the difficulty of enforcement is the vast catchment areas which can hardly be covered adequately by limited staff resources. They considered the long-term solution is to increase staff resources.

12.10 The Environmental Impact Assessment (EIA) Ordinance stipulates that a person shall not construct or operate inter alia designated projects enlisted in the Ordinance without a permit. EIA reports of the proposed projects are required to be circulated among government departments concerned for comments. Should the project likely have adverse effect on any water resources of Hong Kong, Water Supplies Department will raise objection or provide comment, which may form a part of the conditions in the environmental permit to the proponent.

Charging Policy to Promote Water Conservation

12.11 One of the purposes of charging for water consumption is to promote water conservation, with free supply for the low consumption users. The proportion of those accounts whose consumption is within the free allowance accounts for about 15% of the total two million domestic accounts.

Administrative Measures

Relocation of Intake Point

12.12 To avoid contamination from one of Dongjiang's tributaries, the water intake point for Dongshen Water Supply System was relocated 350 metres upstream of Dongjiang from Qiaotou to Tai Yuen in September 1998.

Catchment Management

12.13 The provincial government has set up the Dongjiang-Shenzhen Water Quality Protection Leading Group to implement the related legislation. The concerned authority of the upstream section has to ensure that the water quality is satisfactory before water flows downstream.

12.14 Five major aspects are identified for protection of water quality:

- Control on the source of major industrial pollution;
- Control of effluent from livestock;
- Treatment of domestic sewage;
- Disposal of rubbish in the twelve towns *en route*; and
- Prevention of oil contamination in accordance with the relevant requirements.

12.15 The Dongguan Municipal Government will establish a responsibility system for water quality protection, so that it can achieve its targeted domestic sewage treatment rate of over 50% by late 2002. Besides, tourist activities were stopped at the river source in 1998.

Covering the Open Aqueduct

12.16 In August 1997, the Guangdong Authorities proposed an estimated $5 billion project to construct a closed aqueduct. They said that covering the existing open aqueduct would significantly reduce the pollution of raw water during its transport to Hong Kong. The $5 billion project started in late 1998 and is scheduled to complete by end 2002. (For detailed map, please refer to Appendix IV)

Refusal of Water Supply

12.17 Both sides have agreed in the 8th Annual Business Meeting held in May 1997 that if water quality dropped below acceptable standards, the representatives of both sides would decide on the arrangements to reduce the daily supply rate upon mutual consultation.

12.18 The Water Supplies Department "requested the Guangdong side to reduce the quantity of Dongjiang water supply on two occasions owing to deteriorating and unstable water quality. The two occasions occurred in early 1998 and were caused by work involved in quality improvement project of the Guangdong side."[11] The first occasion was during 20 January 1998 and 5 February 1998 and the daily supply was reduced from 2.3 million cubic metres per day to 1.1 million cubic metres. The second occasion was between 18 March 1998 and 31 March 1998; the daily supply was reduced to 1.5 million cubic metres. The quantity of Dongjiang water not supplied during these two periods was recouped later in the year.

Water Treatment

Pre-treatment in Shenzhen

12.19 Since January 1999, a Bio-nitrification plant pre-treats the Dongjiang water at Shenzhen Reservoir to lower the ammonia content and to increase the dissolved oxygen content in water. The plant costs 200 million Renminbi.

12.20 A number of sewage treatment plants serving development areas along the Dongjiang-Shenzhen supply route are being constructed.

Pre-treatment in Hong Kong

12.21 In the light of the deteriorating quality of Dongjiang water, Hong Kong has to treat Dongjiang water before the water goes through normal treatment process. Additional pre-treatment processes include the following:

- to pump oxygen into the raw water in an aeration plant at the Muk Wu Pumping station;
- to pre-chlorinate raw water; and
- to blend some raw water with water in reservoirs before pumping it to the water treatment works.

[11] Replies from Works Bureau and Water Supplies Department

12.22 To implement the above measures, the WSD incurred additional costs, such as the cost of chemicals and electricity, and capital costs. Additional recurrent cost was put at a total of $104 million for the period from 1996-97 to 1998-99. Capital cost at $35 million was also incurred for the provision of an aeration plant at the Muk Wu pumping stations and for upgrading the pre-chlorination equipment in various water treatment works.

Regular Treatment

12.23 Table 9 illustrates the cost of water consumption in Hong Kong in the past five years. According to the Water Supplies Department, the filtration cost was on the rise mainly due to the poor quality of Dongjiang water which entailed the need for more chemicals for water treatment. However, there seemed to be signs of stability in 1999. The Water Supplies Department further advised that, apart from the deteriorating quality of water which necessitated enhanced treatment, an increase in electricity consumption in the delivery of water and fluctuations in electricity charges also contributed to the rise in electricity costs.

Treatment Cost

12.24 Table 9 explains in details the total unit cost of water consumption. The total cost of treated water in Hong Kong is composed of four parts:

- Expenditure on purchasing Dongjiang water;
- Departmental expenses, including filtration cost, expenses on purchase of chemicals for other treatment process, electricity for water pumping and other maintenance cost;
- Staff cost; and
- Depreciation.

Table 9 - Total Cost of Metered Consumption Per M^3

	1998/99 HK$ per m^3			1997/98 HK$ per m^3			1996/97 HK$ per m^3			1995/96 HK$ per m^3			1994/95 HK$ per m^3		
Cost of metered consumption															
Purchase of Dongjiang Water		3.90	38.9%		3.51	37.8%		3.10	36.9%		2.61	34.0%		2.11	33.7%
WSD Departmental expenses															
Chemicals	0.12			0.12			0.10			0.08			0.07		
Electricity	0.90			0.84			0.76			0.69			0.58		
Others[12]	1.48	2.50	24.9%	1.44	2.40	25.9%	1.33	2.19	26.1%	1.45	2.22	28.9%	1.16	1.18	28.9%
Staff costs		2.81	28.0%		2.58	27.8%		2.39	28.5%		2.16	28.2%		1.81	28.9%
Depreciation		0.82	8.2%		0.79	8.5%		0.72	8.6%		0.68	8.9%		0.54	8.6%
Total cost		10.03	100.0%		9.28	100.0%		8.40	100.0%		7.67	100.0%		6.27	100.0%

Source: Reply from Water Supplies Department, January 2000

[12] Others means maintenance and repair expenses.

12.25 The total unit cost of water in 1998/99 was HK$10.03 per cubic metre, of which the largest item of expenditure was the cost of purchasing Dongjiang water. In money terms, it increased 85% from HK$2.11 per cubic metre in 1994/95 to HK$3.90 per cubic metre in 1998/99. In terms of proportion of the total cost of metered consumption, purchase of Dongjiang water increased from 33.7% in 1994/95 to 38.9% in 1998/99. This means that 80% of the water supplied in Hong Kong in 1998/99 cost the average consumer an extra $3.90 per unit consumed.

12.26 Treatment cost is presented as the cost of chemicals in WSD departmental expenses. It has increased by 7% from 1994/95 to 1998/99. This is presented as filtration cost[13] in Works Bureau documents, such as the source of Table 10.

12.27 Table 10 shows a breakdown of filtration costs[14] and the volume of water treated. It can be seen that although the volume of water treated has fluctuated in the period 1994/95 to 1998/99 , the unit filtration costs have increased by 56% from HK$0.078 per cubic metre to HK$0.122 per cubic metre. As filtration removes suspended particles in raw water, increased filtration costs is an indication of the deteriorating quality of raw water which requires increased treatment before consumption in Hong Kong.

Table 10 - Filtration Costs and the Volume of Water Treated

Year	Filtration costs (HK$ million)	Water treated (million cubic metres)	Unit Filtration Costs (HK$ cubic metres)
1994/95	72.0	933.9	0.078
1995/96	78.0	915.5	0.085
1996/97	83.0	933.0	0.089
1997/98	101.0	916.4	0.110
1998/99	113.0	923.0	0.122
4-11/99*	64.0	622.9	0.103

Source: Reply from Works Bureau

Remark: * Data only available for eight months in the financial year 1999/2000.

[13] The cost of chemicals presented in materials from Water Supplies Department forms the bulk of, but is not equal to the "filtration cost". According to Water Supplies Department, the cost of chemicals includes also other relatively smaller elements such as cost of related equipment and maintenance. Another factor which may account for the differences between Water Supplies Department and Works Bureau figures is the different accounting systems adopted in the two departments.

[14] The filtration cost cannot be further subdivided into constituent costs for coagulation, filtration and disinfection as there is no means of ascribing costs to each of the above-named process.

Upgrade of Water Treatment

12.28 To improve the deteriorating quality of Dongjiang water, Hong Kong, in addition to regular treatment, will introduce a 3-stage water treatment process in two new treatment works, Ngau Tam Mei Water Treatment Works and Tai Po Water Treatment Works. The 3-stage water treatment process involves: (i) clarification; (ii) rapid gravity filtration and biological filtration; and (iii) disinfection with ozone and chlorine. The two treatment works are scheduled to be commissioned by mid-2000 and late 2001 respectively.

Quality of Dongjiang Water after Implementation of Measures

12.29 For the first six months of 1999, the average level of ammoniacal nitrogen in Dongjaing water from Guangdong decreased but still exceeded the relevant Guangdong provincial water quality control index values. During the same period, the levels of manganese and dissolved oxygen in Dongjiang water also decreased. However, the level of dissolved oxygen in Dongjiang water in this period still failed to comply with the 1983 standard.

PART 4 - SYDNEY

13. Water Sources

13.1 Sydney's population at about four million people consumes 1600 million litres of water every day. There are four catchment systems outside the metropolitan area, among which the biggest is the Warragamba system with a hydrological catchment of 905 000 ha. In 1960 Warragamba Dam was built four kilometres upstream of the junction of the Warragamba River and the Nepean River and now supplies up to 85% of Sydney's water. It impounds 2 057 000 megalitres, almost four times the capacity of Sydney Harbour. The Dam is about 82 kilometres west of Sydney.

13.2 Water from Warragamba Dam is delivered by pipelines to Prospect Water Filtration Plant. Water is then distributed to inner city and suburbs by tunnels and mains. The aqueduct that carries water from Nepean Cataract and Cordeaux is not enclosed.

13.3 In extended periods of low rainfall, these supplies are augmented by water from the Shoalhaven River.

14. Administrative Arrangements

Historical Background

14.1 In 1994, a private company 'Sydney Water' was established to be responsible for water supply, including the management of water catchments and the distribution of treated water to consumers. After the discovery of two parasites in drinking water in 1998, two authorities were established.

Water Contamination in 1998

14.2 In July, August and September 1998, the parasites Cryptosporidium and Giardia were detected in Sydney's drinking water. Residents were advised by the New South Wales Health Department to boil their water before consumption to avoid the possibility of contracting the diseases caused by these parasites.

14.3 The NSW Government set up an independent inquiry to identify the problems leading to the contamination and to determine whether existing water management and supply systems were adequate.

14.4 After a six-month investigation, the inquiry concluded that the catchments were seriously compromised by many possible sources of contamination. One possible cause was that the Upper Canal section of the water transfer was open and dead animals were found from time to time by staff patrolling the catchment.

14.5 The report also pointed out fragmented responsibilities, potential overlaps and gaps among a large number of government and non-government agencies. No one body was responsible for ensuring that the catchment was managed to minimize contamination of the raw water.

14.6 In addition, Sydney Water staff lacked the means to enforce effectively protection measures in the catchment areas such as illegal access, dumping of refuse and sewage.

14.7 It was recommended in the inquiry report that there was a need to develop directions, catchment-wide strategies and water quality objectives to guide management activities and development decisions in the catchment.

Ministerial Control Over Sydney Water

14.8 The inquiry also found that the relevant Minister did not have sufficient power to obtain information from Sydney Water.

14.9 Responding to the inquiry's recommendation, the government introduced the Sydney Water Legislation Amendment (Drinking Water and Corporate Structure) Act 1998 to change Sydney Water from a private company to a state owned corporation under the State Owned Corporations (SOC) Act. This provides the Minister with the power to obtain information and to give directions to the Boards of Sydney Water Corporation in matters of public interest, particularly on the grounds of urgency, public health or safety.

Bulk Water Supply Agreement

14.10 As a result of the inquiry, the Sydney Catchment Authority was established on 2 July 1999 as a statutory body under the Sydney Water Catchment Management Act. The Authority took over Sydney Water Corporation's responsibilities for managing the catchment, including ownership of land.

14.11 The Bulk Water Supply Agreement was signed between Sydney Catchment Authority and Sydney Water Corporation on 5 September 1999, which defined their complementary relations and mutual obligations. Sydney Catchment Authority conserves water resources in the catchment and provides the Sydney Water Corporation with raw water on an agreed charging scheme. The Corporation then treats and distributes drinking water to consumers in Sydney.

14.12 In the agreement, raw water supplied to Sydney Water Corporation has to achieve a set of specified standards. In case of non-compliance, the Sydney Catchment Authority must reduce the charges at a 'Reduction Amount' as set out in the supplementary schedules. (Please refer to Appendix V for details.)

14.13 In case of dispute, a negotiator is to be appointed for resolution. If differences cannot be settled within 10 days, an independent panel is to be set up for a binding decision. If the panel cannot reach a unanimous decision within 30 days, either party may pursue any remedy available at law.

Customer Contract

14.14 Sydney Water Corporation is required by law to draw up a customer contract which spells out the rights and responsibilities of both customers and the corporation. According to the contract, a customer who experiences discontinuity of water/sewerage service is entitled to an automatic 10% rebate on the water/sewerage charge if the discontinuity lasts more than one hour without notice or six hours if notice is given.

15. Standards and Actual Quality of Raw Water

Standards of Raw Water

15.1 In the Bulk Water Supply Agreement, Sydney Catchment Authority has to supply water of an agreed quality, with reference being made to the Australian Water Quality Guidelines for Fresh and Marine Waters.

15.2 Raw water is tested for their microbiological content such as faecal Coliforms and physical characteristics such as turbidity, dissolved oxygen and true colour. These water quality standards are set having regarded the water treatment capacity of the Sydney Water Corporation. (Please refer to Appendix VI for details.)

Cryptosporidium and Giardia

15.3 A draft Interim Drinking Water Quality Incident Management Plan is produced, which includes a list of contaminants and their concentrations which would trigger a routine, significant or major incident. In raw water, more than one and less than 100 oocysts of Cryptosporidium and Giardia per 100 litres triggers a routine incident; more than this triggers a significant or major incident.

Actual Quality of Raw Water

15.4 Sydney Catchment Authority is responsible for monitoring the quality of raw water in both the dams and catchments. Sampling and analysis are provided at various points, at rivers and storages. The quality has deteriorated in two of the Southern Area dams. Fitzroy Falls and Willgecarribee Dams are affected by Blue Green algae. This may result in depletion of dissolved oxygen in water and give out bad smell.

16. Standards and Actual Quality of Treated Water

Standards of Treated Water

16.1 Sydney Water Corporation's Operating Licence requires the corporation to comply with the latest edition of the Australian Drinking Water Guidelines as the standard for treated water.

16.2 The Australian Drinking Water Guidelines were drawn up by the National Health and Medical Research Council and Agriculture and Resource Management Council of Australia and New Zealand. The first edition was published in 1980 and the latest edition in 1996. The 1996 Guidelines are largely similar to the WHO 1993 Drinking Water Guidelines.

16.3 In addition, Sydney Water Corporation has to notify the health authority immediately of any water system event or monitoring results which indicate the potential existence of a public health hazard.

Cryptosporidium and Giardia

16.4 The Australian Drinking Water Guidelines has not set guideline values for Cryptosporidium or Giardia but Sydney Water Corporation conducts tests for these as a precautionary measure. Sydney Water Corporation and New South Wales Health Department have a protocol which covers testing, monitoring and providing information to the public about these micro-organisms. Water entering the filtration plants is tested for Cryptosporidium and Giardia. If either of these micro-organisms is found, further tests are undertaken on the filtered water in accordance with the protocol.

16.5 The draft Interim Drinking Water Quality Incident Management Plan is also applicable to treated water. In filtered water, one oocyst per 100 litres triggers a significant incident and more than this triggers a major incident.

Actual Quality of Treated Water

16.6 Results of tests are reviewed by New South Wales Health Department. The 1998 review showed that water supplied by the Sydney Water Corporation was in high compliance with the 1996 Australian Drinking Water Guidelines. Samples of water tested during the period between 14 December 1997 to 12 December 1998 met most health-related requirements. Table 11 lists the parameters which some of the water samples failed to achieve targets. It should be noted that only a small percentage of the samples had failed.

Table 11 - Parameters with Samples Failed to Comply with 1996 Australian Drinking Water Guidelines Level

Characteristic	1996 Australian Drinking Water Level	Annual Performance from 14/12/1997 to 12/12/1998 (% of compliance)
Microbiological CFU/100ml		
Thermotolerant Coliforms	>98% of samples contain no Thermotolerant Coliforms	99.9%
Total Coliforms	>95% of samples contain no Total Coliforms	98%
Inorganic	**Units in mg/L**	
Aluminium	0.2	99.8%
Lead	0.01	98.5%
Nickel	0.02	99.5%

Source: http://www.sydneywater.com.au/annual/table1.html

16.7 Sydney Water Corporation published its first annual report on drinking water quality in 1999 which reported that the water supplied satisfied the 1996 Australian Drinking Water Guidelines in the year of review (1998).

17. Measures to Ensure Water Quality

Legislative Measures

17.1 There are some 50 major statutes dealing with or affecting water in New South Wales. Some of the latest ones are the Protection of the Environment Operations Act 1997, the Contaminated Land Management Act 1997 and the Water Legislation Amendment Act 1997.

17.2 In addition, the Local Government (Approvals) Amendment (Sewage Management) Regulation 1998 was introduced to require local council approval to operate septic tanks and small sewage management systems and to require local council supervision of the operation of these systems

Catchment Management

Inner Catchments

17.3 The Sydney Catchment Authority defines the areas surrounding Sydney's catchment as "Special Areas", measuring approximately 1 570 000 ha. The Authority issued a strategic plan of protection for the areas with the objective to maintain good quality water resources.

17.4 The measures under the plan promote the identification and application of water quality objectives which recognize the importance of the catchments and rivers as sources of drinking water.

17.5 The Authority seeks progressive cessation of mining operation in the areas and rehabilitation of the sites as they close. Other controls like fire management, weed control and soil conservation are launched for protecting ecological values.

17.6 The Authority works jointly with other departments for further conservation purposes, such as the National Parks and Wildlife Service. Restrictions are imposed on recreational activities and access to these areas so as to minimize the risk of water contamination.

Outer Catchments

17.7 The Sydney Catchment Authority is also charged with protecting the outer catchments. The outer catchments include large areas of farming land and many towns, villages and cities, including the City of Blue Mountains and the City of Goulburn.

17.8 Under the Sydney Water Catchment Management Act of 1998, the Catchment Authority is empowered to review and determine certain prescribed development proposals in the outer catchments that would normally be determined by local councils. The objective is to ensure that approvals are only given to developments that will not have a detrimental affect on water quality.

Water Conservation

17.9 A staged and on-going education programme on water quality and catchment management issues is introduced in secondary classes jointly by Sydney Catchment Authority and the Department of School Education. Public education and awareness campaigns are also launched.

17.10 The water charging system is so designed as to provide financial incentive to household and business users to save water. An Independent Pricing and Regulatory Tribunal is set up to monitor the user-pay pricing policy of Sydney Water Corporation.

Problem of Open Aqueduct

17.11 It was proposed in the final report of the inquiry conducted in 1998 that consideration should be given to covering the Upper Canal in those parts where it was most exposed to contamination risks.

17.12 However, the Sydney Catchment Authority has no major water quality issues that would suggest that the Upper Canal needs to be enclosed.

Treatment

17.13 Since late 1996, all of Sydney's water supply has been filtered. Eleven water treatment plants are installed to filter drinking water supplied to Sydney, Illawarra and the Blue Mountains. In addition, water is disinfected using chlorine and sometimes ammonia. Fluoride is also added for dental health.

17.14 Water treatment plants in Sydney generally use alternatives to "conventional" treatment because the water quality is deemed to contain low levels of pathogens and to be of consistently high quality. Conventional water treatment includes a series of steps including coagulation, flocculation, sedimentation, filtration and disinfection.

Publication of Water Quality Results

17.15 Introducing greater public transparency on water quality data is also a way to encourage Sydney Water Corporation to ensure good water quality.

17.16 After the Sydney Water parasite crisis in 1998, the government introduced the Sydney Water Legislation Amendment (Drinking Water and Corporate Structure) Act 1998 to require Sydney Water Corporation to produce and publish three-monthly consumer confidence reports on the quality of drinking water. Summaries of the reports and details of their availability are to be provided to each customer with their water bill.

17.17 The Chief Health Officer publishes an annual report on drinking water quality to inform the public on the state of the drinking water supply from a health perspective.

17.18 Sydney Water Corporation publishes on the Internet all treated water test results for parasites. A revised Memorandum of Understanding between Sydney Water Corporation and New South Wales Health Department requires the Corporation to commit to develop a system to provide regulatory agencies on-line access to test results.

18. Water Cost

18.1 According to the Annual Report 1999 of Sydney Water Corporation, the operation expenditure for the year ended by 30 June 1999 was A$713.7 million and the average unit operation expenditure is about A$1.22 (HK$6.3) for a cubic metre.

PART 5 - NEW YORK CITY

19. Water Sources

19.1 The New York City surface (reservoir) water supply system provides approximately 1.3 billion gallons of drinking water daily for nearly 8 million people in New York City. About 90% of the water comes from the Catskill/Delaware system, and the remaining 10 percent from the Croton system.

19.2 The Croton, Catskill, and Delaware catchments are in upstate New York. Parts of the catchments extend as far as 200 kilometres from the City. New York City owns and operates the catchment areas. The City purchased the watershed land in the 19th and 20th century and created reservoirs by damming streams and rivers.

19.3 The water flows to New York City through enclosed aqueducts - pipelines or tunnels - and travels most of its journey (97%) by gravity. Water only needs pumping for three percent of the journey.

20. Administrative Arrangements

20.1 The City's Department of Environmental Protection has overall responsibility for the water supply system. The Department's Bureau of Water Supply, Quality, and Protection oversees the operation, maintenance, and protection of the upstate reservoir systems. The Bureau of Water and Sewer Operations manages the city distribution systems.

20.2 The primary agency with environmental protection responsibilities in New York State is the Department of Environmental Conservation, which administers the pollution control regulations of the state for surface water and also handles groundwater policy.

20.3 The New York State Department of Health also makes groundwater policy, sets state drinking water standards, and enforces both state and national standards in this field.

21. Standards and Actual Quality of Raw and Treated Water

Water Quality Standards

21.1 The US does not have a standard for raw water. In order to ensure that tap water is safe to drink, the New York State Department of Health and the United States Environmental Protection Agency prescribe regulations which limit the amount of contaminants in water provided by water supply systems.

21.2 The Federal Safe Drinking Water Act was passed in 1974 to ensure the safety of public drinking water supplies. In 1986, amendments to the Act were passed to further strengthen the drinking water programme by establishing a timetable for the United States Environmental Protection Agency to develop additional drinking water regulations.

21.3 The Surface Water Treatment Rules which were passed in 1989 introduced standards on water. The standards are administered by the Environmental Protection Agency. There are two sets of standards under the Safe Drinking Water Act: the primary standards and the secondary standards.

21.4 The primary standards, given in the National Primary Drinking Water Regulations, set legally enforceable standards that apply to public water systems. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in public water systems.

21.5 The secondary standards, given in the National Secondary Drinking Water Regulations, set non-enforceable guidelines regulating contaminants that may cause cosmetic or aesthetic effects in drinking water. The United States Environmental Protection Agency recommends secondary standards to water systems but does not require water systems to comply with such standards. However, states may choose to adopt them as enforceable standards.

21.6 For each contaminant, the United States Environmental Protection Agency sets a health goal, or Maximum Contaminant Level Goal (MCLG). This goal is not a legal limit with which water systems must comply; it is based solely on human health. This is the level at which a person could drink two litres of water containing the contaminant every day for 70 years without suffering any ill effects. For known cancer-causing agents, the United States Environmental Protection Agency sets the health goal at zero, under the assumption that any exposure to chemicals could present a cancer risk.

21.7 In addition to the health goal, the United States Environmental Protection Agency also sets a legal limit, or Maximum Contaminant Level (MCL), for each contaminant. The legal limits reflect both the level that protects human health and the level that water systems can achieve using the best available technology.

Cryptosporidium and Giardia

21.8 New York City began monitoring for the protozoa Cryptosporidium and Giardia as part of its comprehensive watershed monitoring programme in 1992. The law requires all water suppliers to notify their customers about the potential risks of Cryptosporidium and Giardia.

21.9 The Surface Water Treatment Rules impose a requirement that drinking water be treated to achieve 99.9% removal or inactivation of Giardia. In 1994, the United States Environmental Protection Agency proposed to extend the regulations to include Cryptosporidium. A final Enhanced Surface Water Treatment Rule has not yet been released as of the date of publication of this report.

Contamination by Pipelines

21.10 The New York State Department of Health also sets an action level for lead concentration at 0.015 mg/L. At-the-tap lead monitoring is conducted at various households around the City twice a year to ensure the lead concentration does not exceed limit. While New York City's water is lead-free when it is delivered from the City's upstate reservoir system, water can absorb lead from solder, fixtures, and pipes found in the plumbing of some buildings or homes. Water with high lead concentration is harmful to human beings. Infants and children who drink water containing lead in excess of the action level could experience delays in their physical or mental development. Adults who drink water with such high lead content over many years could develop kidney problems or high blood pressure.

Actual Water Quality

21.11 The City's drinking water is of good quality. It only requires chlorination to ensure its purity at the tap and is not filtered. The monitoring programme of the Department of Environmental Protection demonstrates that the quality of New York City's drinking water remains high, meeting all health-related State and Federal drinking water standards. The 1998 quality statement shows that New York City's drinking water meets all the parameters set by New York State's Department of Health except for colour. There were two colour violations in the Croton system but water from the Catskill-Delaware system meets all the requirements.

21.12 The Surface Water Treatment Rule requires that all surface water supplies be filtered unless the supplier can demonstrate that its water meets a number of stringent standards. If a supplier demonstrates that it meets these avoidance criteria, a filtration avoidance determination can be issued.

21.13 New York City has applied for and received filtration avoidance status for its Catskill and Delaware supplies three times since the Surface Water Treatment Rule was promulgated in 1989, and a fourth determination for avoidance is expected soon. With each application the City provided documentation about its water quality and watershed protection efforts. These include source water quality standards for faecal Coliform and turbidity, disinfection requirements for raw water, entry point and distribution system chlorine residual requirements, auto shutoff requirements, and distribution system water standards for THMs. The resulting determinations required compliance with a number of conditions concerning staffing, programme implementation, monitoring, and reporting.

21.14 Water in the Croton System will be filtered when the filtration plant becomes operational by 2007. Water from this system currently meets all federal and state standards. The United States Environmental Protection Agency, however, has determined that water from the Croton System should be filtered in order to preserve its high quality since the water system is located in a fairly developed area.

22. Measures to Ensure Water Quality

Legislative Measures

22.1 The principal law governing pollution of the US surface waters is the Federal Water Pollution Control Act, or Clean Water Act. The Clean Water Act consists of two major parts, one being the provisions which authorize federal financial assistance for municipal sewage treatment plant construction. The other is the regulatory requirement that applies to industrial and municipal discharges.

22.2 The regulatory emphasis of the Clean Water Act was, until 1987, focused completely on point-source threats to surface waters. The policy instrument is a permit system designating site-specific criteria for any point-source pollution. Under current legislation, states are required to establish strategies to co-ordinate and execute 'best practices' for reducing nonpoint pollution and set up efforts to control nonpoint sources.

Catchment Protection

22.3 New York City's catchment areas straddle many counties - Putnam, Westchester, Delaware, Greene, Schoharie, Sullivan and Ulster - and are very far away from the City. Effective protection of the catchment areas cannot depend on legislation only. Instead the City relies very much on collaboration between parties with vested interest to protect the water from being polluted. The voluntary programme among farmers was a success. It led to a more extensive watershed agreement which involves the various watershed communities, the city and state authorities, the United States Environmental Protection Agency and environmentalists.

Watershed Agricultural Programme

22.4 In 1990, New York City released the draft watershed regulations which included provisions on tackling agricultural pollution. Dairy and livestock farmers in the watershed areas were concerned that the regulations would force the agricultural industry out of business. They sought assistance from the Farm Bureau, the New York State Department of Agriculture and Markets, the New York State Water Resources Institute, and other local, state, and federal agencies. As a result, an Ad Hoc Task Force on Agriculture and New York City Watershed Regulations was formed. The Task Force explored non-regulatory alternatives for protecting and maintaining the quality of the city's water supply while helping to sustain the economic viability of farming in the watershed.

22.5 Farmers and the City drew up the Watershed Agricultural Programme, based on the task force's recommendations. Under the programme, the City provided funding to demonstrate an environmentally sound approach to farm management - whole farm planning. Whole farm plans use site-specific "best management practices" to address agricultural contaminants such as nutrients, pathogens, sediment, and toxic and organic matter. Best management practices also address soil erosion control and the management of animal waste, plant nutrients, domestic animal pathogens, and chemicals and pesticides.

22.6 In addition, the farmer-led Watershed Agricultural Council undertook to have at least 85% of the farmers participated in the programme. The Council, which has assumed administrative and operational responsibility for the programme, facilitates the implementation of the programme. There are also incentives for the farmers to join the programme: financial support from federal, state, local and city governments and professional support in implementing the whole farm plans.

22.7 The programme has proved to be a success which demonstrates the fact that environmental and economic needs can be balanced, and - in some circumstances - voluntary partnerships can protect water quality as effectively as regulatory restrictions.

Watershed Memorandum of Agreement

22.8 As noted in the above section, New York City needs to build a filtration plant at Croton to ensure the quality of drinking water there. To ensure a long-term waiver of the federal requirement to filter water from the Catskill/Delaware system, the City developed a comprehensive watershed protection programme.

22.9 An agreement - the Watershed Memorandum of Agreement - was signed on 21 January 1997 among various stakeholders: the watershed communities, New York City, New York State, the EPA and environmentalists. The agreement is a comprehensive catchment protection plan on cooperative effort to protect water quality. It also aims to preserve the autonomy and economic viability of watershed communities.

22.10 Under the agreement, New York City would invest $1.2 billion to purchase land - undeveloped land near reservoirs, wetlands and watercourses, or land possessing certain other natural features that are water-quality sensitive. In 1998, 13 098 acres of land were either acquired or under purchase contracts of the City.

22.11 The City has also committed millions of dollars on partnership programmes on water quality planning, economic development and infrastructural projects in the watershed areas. The partnerships programmes include:

- septic system inspection and rehabilitation,
- construction of new, centralized sewage systems to correct existing water quality problems,
- stormwater management measures,
- environmental education,
- improved storage of sand, salt and de-icing materials, and
- stream corridor protection projects.

22.12 Such partnership makes the watershed residents much more conscious of the importance of water quality and thus become the day-to-day stewards of water quality. The agreement also creates a Watershed Protection and Partnership Council, which serves as a regional forum for the discussion and review of water quality concerns and related watershed issues.

22.13 In addition to the partnership programmes and land acquisition, the City also amended watershed rules and regulations in May 1997. The new regulations establish design and operation standards for wastewater treatment plants, septic systems and stormwater control measures. The regulations also provide for the City's right to review and approve of certain activities having a potentially adverse impact on water quality.

22.14 In enforcing the new regulations, the City's Department of Environmental Protection works closely with the City 's Law Department and local, State and federal law enforcement agencies to prosecute offenders. In 1998, the Department of Environmental Protection staff reviewed over 769 applications for new or remediated septic systems, 21 stormwater pollution prevention plans and over 75 other projects that proposed one or more regulated activities. In addition, the Department issued 19 Notices of Violation and over 810 Notices of Failure.

Water Disinfection

22.15 The City's drinking water is not filtered but still requires disinfection. All surface water and groundwater entering New York City's distribution system is treated with chlorine, fluoride, orthophosphate, and, in some cases, sodium hydroxide. New York City uses chlorine to meet the New York State Sanitary Code and Federal Safe Drinking Water Act disinfection requirements. A small amount of fluoride (one part per million) to help prevent tooth decay has been added to the City's water supply since the mid-1960's in accordance with the New York City Health Code. Orthophosphate is added to create a protective film on pipes which reduces the release of metals such as lead from household plumbing. Sodium hydroxide is added to the water to raise the pH and reduce corrosivity.

23. Water Cost

23.1 As a filtration system is not required for 90% of the water from Catskill and Delaware Watershed of New York City, a proposed filtration plant is avoided. This plant is estimated about US$6 billion (HK$46.7 billion) and would have an annual operation and maintenance cost of millions of dollars a year. The co-operation of all parties involved has led to a savings of US$6 billion in capital cost and millions of US dollars in recurrent expenditure.

23.2 The Watershed Agricultural Programme costs about US$35 million (HK$272 million) a year and the average unit cost is HK$0.15 per cubic metre.

PART 6 - SINGAPORE

24. Water Sources

24.1 Singapore, with a total population of some 3.7 million, uses an average of 1.28 million cubic metres of water per day. About 70% of the water comes from the Johor State of Malaysia. The water sources in Johor are: Gunong Pulai dam, Tebrau Waterworks, Scudai River, Johor River and Linggiu Reservoir. Singapore receives water from Malaysia under two 50-year agreements and is discussing a new 100-year water deal with Malaysia.

24.2 Water from Gunong Pulai and Scudai River and Johor River is treated in Singaporean treatment plants built in Malaysia before it is transferred to Singapore via pipelines. Water from other sources in Johor is raw water and has to be treated after it is transferred to Singapore via pipelines. Under present deals, Singapore sells back some of the treated water to Malaysia.

24.3 Singapore has set aside about 40% of its land for water catchment purposes, which provides about 30% of water supply. However, Singapore is planning for a water self-sufficiency target of 50% from local source.

Alternative Sources of Water

24.4 Singapore is eager to secure alternative water sources due to the uncertainty of continued water supply from Malaysia. The concern was expressed, in an article to urge the public to conserve water, by the National Education Branch: "The stability of our water supply from Malaysia depends very much on the state of relationship between Singapore and Malaysia, with or without the water agreements. Malaysian politicians have always brandished the threat of cutting off whenever there is a spat between the two countries." [15]

Desalination

24.5 Desalination of seawater would be the next new source of water for Singapore. The engineering and site feasibility study by the consultants for a desalination plant to be built on reclaimed land at Tuas has been completed. The plant, with a daily capacity of 136 000 cubic metres, is scheduled for completion by 2005. Researches are being carried out for two more plants which will add up the total capacity to 400 million cubic metres a day.

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[15] This article under the title of 'The Beginning of the Longest Water Rationing' was prepared by the National Education Branch and was put on the home page of the Public Utilities Board.

Water from Indonesia

24.6 Singapore plans for future water supply projects which may include construction of a pipeline to bring water from Indonesia. In 1997, Singapore jointly explored with the Indonesia for water resources in Riau Province in Indonesia.

Water Reclamation

24.7 Singapore has embarked on a study on the feasibility of water reclamation using secondary treated sewage effluent. The study is expected to be completed in 2002. The sewage treatment plant will treat the sewage effluent, using advanced membrane technology, to a quality that is well within internationally accepted Drinking Water Standards. It will convert about 12 000 cubic metres of effluent into 10 000 cubic metres of drinking water per day.

24.8 The water produced during the initial stages would be for non-human uses such as watering golf courses. The project will undergo four years of testing before the water treated in this way would be considered for human consumption.

25. Administrative Arrangements

25.1 The Public Utilities Board (PUB) is Singapore's national water authority. The PUB was inaugurated on 1 May 1963 to take over from the former City Council the responsibility for providing electricity, water and piped gas. The Water Department of PUB is responsible for providing an adequate and reliable supply of drinking water at the most economic cost to sustain Singapore's economic growth.

Water Supply Agreement with Malaysia

25.2 There are two Water Agreements with Johor, Malaysia for the supply of water to Singapore - the 1961 Water Agreement, which will expire in 2011 and the 1962 Water Agreement, which will expire in 2061.

25.3 The two agreements provide for a supply of up to 350 million gallons per day of raw water. The charge paid by Singapore is 3 Malaysian cents per 1000 gallons. The agreements do not stipulate the quality for raw water supplied to Singapore.

26. Standards and Actual Quality of Raw Water

Standards of Raw Water

26.1 Singapore does not have a standard for raw water. The water agreements with Johor do not specifically address the quality of raw water. However, Malaysia has a set of standards for raw water quality.

Actual Quality of Raw Water

26.2 Of concern is the quality of raw water from Malaysia. The average water quality index for various rivers in Malaysia was reported in FT Asia Intelligence Wire on 18 May 1998. A quality index below 60 indicates serious pollution. The index for Sungai Pasir Gudang was 34, Sungai Segget 36 and Sungai Skudai - one of the water sources for Singapore - 60.

26.3 Urban development and waste discharges from plantation and factories in Malaysian catchment areas are thought to be the cause of deterioration. There were occasions when the raw water was untreatable leading to shutdown of the plant in Malaysia.[16]

27. Standards and Actual Quality of Treated Water

Standards of Treated Water

27.1 The PUB adopts the WHO 1993 Guidelines for Drinking Water Quality as the standard in monitoring the quality of its treated water. The Guidelines also apply to water treated by PUB waterworks in Johor, Malaysia.

27.2 Samples of water at various stages of treatment at all waterworks, raw water from all sources, treated water from all service reservoirs and selected points in the distribution network are collected for daily or periodic analysis.

[16] Reply from Public Utilities Board

Actual Quality of Treated Water

27.3 The water is moderately soft and treated to a quality well within the World Health Organization's Guidelines for Drinking Water Quality and is fluoridated. Some of the readings for total chlorine in distribution network are found to exceed the standard, ranging from <0.01 to 2.80 mg/l. The standard for the chemical is set at <0.2 mg/l while the average is found to be 0.36 mg/l.

28. Measures to Ensure Water Quality

Legislative Measures

28.1 The Water Pollution Control and Drainage Act (WPCDA) governs the discharge of pollutants into inland waters. The key strategy to keep inland waters clean is to ensure that all effluent is either discharged into the sewage system or treated to an acceptable level before discharge into the watercourses.

Catchment Management

28.2 Singapore takes great care in protecting its catchment areas since they are critical to Singapore's water supply from its own territory. Watershed management is mainly achieved through land use planning.

Protected Water Catchments

28.3 About 5% of the main island of Singapore has been set aside as protected water catchments. These comprise the central water catchments of Seletar, Upper Pierce, Lower Pierce and MacRitchie. In these protected water catchments, development is not allowed. A large portion of the catchment areas has been gazetted as nature reserves for conservation. Land-use planning into the future will ensure that this 5% of Singapore's land area remains allocated to the preservation of nature.

28.4 The Public Utilities Board carries out reservoir management which includes control of aquatic plants and algae. Biological control of water quality and a fish culture project were embarked to control excessive growth of micro-organisms in reservoirs.

Unprotected Water Catchments

28.5 In addition, about 36% of land comprising the catchments of Kranji, Pandan, Sarimbun, Murai, Tengah, Poyan, Sungei Seletar and Jurong Lake is also developed as unprotected water catchment areas. The level and type of urbanization in these unprotected water catchment areas is controlled. Only clean industries are sited within these catchments and all residential and industrial premises are served by public sewers.

Treatment

28.6 There is an increasing trend of more chemicals being used in treatment plants in Johor for treating water from river sources in Malaysia. This is due to the deteriorating quality of the raw water. In Singapore, the chemical usage has been stable due to stable raw water quality.

28.7 At the Choa Chu Kang and Bedok Waterworks, raw water comes from unprotected catchment areas. In addition to chlorine, ozone, a more effective disinfectant, is also used.

Water Conservation

28.8 The Singapore government has launched various programmes to integrate water conservation into the Singaporean lifestyle.

28.9 There are fiscal incentives to promote water conservation in industry and monetary penalties to discourage wasteful use of water. There are four annual increments in the water tariffs for domestic customers and there is a water conservation tax. The long-term objective of these annual increments was to restructure the water tariffs and water conservation tax into uniform flat rates.

Measures with Malaysian Government

28.10 The Public Utilities Board liaises with the Malaysian authorities, Johor Water Regulatory Body and the Malaysian Department of Environment regarding any pollution in the catchment areas which affects the quality of the raw water abstracted.

28.11 The Public Utilities Board operates three waterworks in Johor where raw water is treated to potable standard for supply to Singapore and Johor. They are the Scudai Waterworks, Gunong Pulai Waterworks and Johor River Waterworks. The two water supply agreements between Singapore and Malaysia provide the Public Utilities Board to build, own, operate and maintain, at its own cost, waterworks in Johor for the duration of the agreements. The Johor River Waterworks, which is the largest of the three, consists of construction of river intakes, water treatment plants, sludge de-watering facilities and pumping stations. It is currently being extended at an estimated cost of S$213 million and will increase its capacity to 1 136 000 cubic metres per day in 2000.

28.12 Water conservation programmes are also carried out jointly by the two governments. Singapore authority starts a conservation study on Sungai Skudai in Johor catchment areas while the Malaysian government launched a relocation programme of squatters along the river.

29. Water Cost

29.1 The average treatment cost of water sold in the years 1994-98 was S$0. 5 (HK$2.33) per cubic metre. In 1998, the unit cost of water sold was S$0.52 (HK$2.42) per cubic metre, slightly over the four years' average.

29.2 The Waterborne fees which reflect the per unit cost of maintenance and extension of the public sewage system was HK$0.93 for a cubic metre for domestic users. The fees increase to HK$1.4 this year.

PART 7- ANALYSIS

30. Water Sources

30.1 Water in these four places, Hong Kong, Singapore, New York City and Sydney, travels a long distance to reach the distribution systems. However, Hong Kong is the only place in the study where water is conveyed by open water channels; the remaining three cities use pipelines or tunnels to transfer water from the catchments. Water to Hong Kong is thus vulnerable to pollution throughout its transfer route. A similar problem exists in Sydney as part of the water transportation system is open, which is considered as one of the possible causes of water contamination in 1998.

30.2 Only Hong Kong is restricted to one in-take point (Tai Yuen Pumping Station in Dongjiang) for drawing water. Singapore's water comes from several rivers and reservoirs in Malaysia; Sydney and New York City draw water from vast catchment areas and have the flexibility to choose water from different depths and layers in the dams or lakes to ensure water is of good quality.

30.3 Hong Kong and Singapore have much less flexibility than Sydney and New York City in regulating the amount of water delivered to them since they purchase most of their drinking water from another political entity. The quantity of water supplied to Hong Kong and Singapore is governed by agreements with Guangdong and Malaysia respectively.

Number of Authorities Involved

30.4 Apart from New York City, the water delivery system in each of the other three places involves two separate authorities, each one being responsible for one of the two stages of the process: (1) conservation and transport of raw water and (2) treatment and transport of drinking water to end-users.

30.5 In Sydney, the two authorities, Sydney Catchment Authority and Sydney Water Corporation, belong to the same administrative authority. In Singapore, the two authorities belong to two sovereign states and thus, Singapore faces uncertainty of continued water supply from Malaysia as political tension emerges. In the middle, the two authorities in Hong Kong belong to two administrative authorities, namely those of HKSAR and Guangdong Province, within one country.

31. Standards of Raw Water

31.1 None of the four places studied have laid down raw water standards in legislation. However, raw water in Sydney has to comply with specifications as set out in the agreement between the two water supply authorities. It is the most comprehensive and legally-binding framework for raw water quality assurance among the places studied.

31.2 Hong Kong makes reference to the Environmental Quality Standard for Surface Water published by the People's Republic of China. However, in the US and Singapore, there is not any standard for raw water.

Compliance and Penalty

31.3 In the cases of Hong Kong and Singapore, water supply agreements focus on quantity rather than quality. However, the Guangdong authority promised to achieve the Type II standard stipulated in the Environmental Quality Standard for Surface Water, GB 3838-88 published in 1988. This undertaking was included in the 1998 Loan Agreement, under the term that the project of enclosing the open aqueduct would be completed by 2002. Penalty clause for non-compliance was raised by the Hong Kong side during liaison meetings but was turned down by the Guangdong side.

31.4 The Singapore Water Supply Agreements with Malaysia do not stipulate quality of raw water nor any penalty clause.

31.5 The agreement between Sydney Catchment Authority and Sydney Water Corporation is the only water supply agreement that includes an indemnity clause for failure to achieve these standards. Sydney Catchment Authority must undertake to indemnify the Sydney Water Corporation for any additional expenses in case of providing sub-standard raw water. In return, Sydney Water Corporation must undertake to indemnify the Sydney Catchment Authority for additional expenses in case of failure to provide information and quality supervision. The obligations are mutual in the agreement.

31.6 In New York City, the conservation of raw water and drinking water is included in one protection programme and the Department of Environmental Protection has overall responsibility for the water supply system. Thus, there is no arrangement to penalize non-compliance.

Dispute Resolution

31.7 Unlike the Sydney agreement, there is no dispute resolution mechanism in the Hong Kong-Guangdong and Singapore-Malaysia agreements. The New York Watershed Memorandum of Agreement was worked out among all stakeholders in the watershed community, and it provides for the creation of a Watershed Protection and Partnership Council to discuss and review watershed issues.

31.8 Officials from the Works Bureau have explained that the nature of the agreement with Guangdong authority is a government-to-government political contract, not one of buy-and-sell commercial relations. Thus, political negotiation between the two governments is the proper way to resolve differences, instead of resorting to penalization mechanism or litigation.

31.9 The officials have also said that a joint working group with the Guangdong environment protection department is scheduled to hold meetings in 2000. The government is confident that the pollution problem in Dongjiang river will be under control.

31.10 Similarly, water supply between Singapore and Malaysia is discussed at inter-governmental level and is highly politicized. The controversy is further complicated because the negotiation is mixed with other disputes between the two countries, such as central provident fund issue, loans to Malaysia and railway problems.

31.11 The Singapore Minister for Trade and Industry Lee Yock Suan said in Parliament that firm agreements were in need because 'if there are disputes, we need to be able to go to somewhere to try and resolve the matter'.[17]

32. Standards of Treated Water

32.1 For testing and monitoring the quality of treated water, both Hong Kong and Singapore adopt the WHO 1993 Guidelines for Drinking Water Quality as the standard. Both New York and Sydney use their national standard for treated water. It should be noted that only the US standard - for health-related parameters - is legally enforceable within the US. Other guidelines while adopted as standard do not have legal force. In addition, individual states such as the New York State would refine the national standard to accommodate local water characteristics.

32.2 This research compares 15 parameters of treated water standards, including those which are carcinogenic, cause kidney and central nervous system problems or cause problems to reproductive system (For details, please refer to paragraph 11.3 and 11.4).

[17] The Straits Times Interactive - Welcome to Singapore, 12 October, 1999.

32.3 We have compared the 15 parameters in treated water standards and found that the standard set by the New York State Department of Health is lower than that of the WHO 1993 Guidelines for Drinking Water Quality in most of the selected parameters except for the concentration level of benzo(a)pyrene. The Australian Drinking Water Guidelines (1996) have similar guideline levels except for the concentration of manganese which has a more stringent level. The drinking water standard for both New York City and Sydney have total THMs levels while the WHO 1993 Guidelines only give guideline level for individual THMs. Details are listed in Table 12 below.

Table 12 - Drinking Water Standards in Hong Kong and Overseas Places

	The WHO 1993 Guidelines for Drinking Water Quality	**Maximum Contaminant Level set by the New York State Department of Health based on the National Primary and Secondary Drinking Water Regulations**	**Australian Drinking Water Guidelines (1996)**
Arsenic	<0.01 mg/litre	<0.05 mg/litre	-
Chromium	<0.05 mg/litre	<0.1 mg/litre	-.
Mercury	<0.001 mg/litre	<0.002 mg/litre	-
Manganese	<0.5 mg/litre	0.3 mg/litre	<0.1 mg/litre
Trihalomethanes (THMs)			
Total Trihalomethanes	No set value	0.1mg/litre	<0.25 mg/litre
Chloroform	<0.2 mg/litre	-	-
Bromodichloromethane	<0.06 mg/litre	-	-
Dibromochloromethane	<0.1 mg/litre	-	-
Bromoform	<0.1 mg/litre	-.	-
Residual chlorine	<5 mg/litre	-	<5mg/litre
Benzo(a)pyrene	<0.0007 mg/litre	0.0002 mg/litre	-
Turbidity	<5NTU	-	<5NTU
Colour	<15 TCU	15 TCU	<15HU
Iron	<0.3 mg/litre	0.3 mg/litre	<0.3 mg/litre
Aluminium	<0.2 mg/litre	-	<0.2 mg/litre

Sources: New York City - 1999 Drinking Water Supply and Quality Statement, Department of Environmental Protection
Water quality test results - http://www.sydneywater.com.au
Audit Report N. 33, October 1999, Audit Commission

Remarks: "-" represents no set guideline value

33. Water Quality

33.1 We have made a comparison of the actual water quality in the four places in this study and the compliance with respective drinking water standards. Table 13 shows that Sydney's drinking water from Warragamba meets nearly all the parameters of the Australian Drinking Water Guidelines. Only 0.2% of the samples exceed the standard for aluminium.

33.2 Treated water in Hong Kong, Singapore and New York City met their respective standard for health-related parameters but all failed in one of the selected aesthetic parameters. Hong Kong and Singapore's treated water had too much residual chlorine, which would increase the chance of formation of THMs, which are carcinogenic substances. The rising level of residual chlorine reflects that more chlorine is being used to treat raw water of deteriorating quality.

33.3 Drinking water of the Croton system of the New York City also failed to meet the colour level of the national standard. Some colour-forming organic compounds can react with chlorine to form by-products such as THMs. It is desirable to remove such compounds before chlorine is added.

Table 13 - Actual Water Quality in Hong Kong and Overseas Places (Compliance with Respective Drinking Water Standard)

	Hong Kong	Singapore	New York City	Sydney
Arsenic	√	√	√	-
Chromium	√	√	√	-
Mercury	√	-	√	-
Manganese	√	√	√	√
Trihalomethanes (THMs)				
Total Trihalomethanes	√	-	√	√
Chloroform	√	-	-	-
Bromodichloromethane	√	-	-	-
Dibromochloromethane	√	-	-	-
Bromoform	√	-	-	-
Benzo(a)pyrene	√	-	√	-
Turbidity	√	√	-	√
Colour	√	√	X	√
Iron	√	√	√	√
Aluminium	√	√	-	99.8%
Residual chlorine	X	X	-	-

Sources: New York City - 1999 Drinking Water Supply and Quality Statement, Department of Environmental Protection
Water quality test results - http://www.sydneywater.com.au as of December 1999
Audit Report N. 33, October 1999, Audit Commission

Remarks: √ means compliance and X means non-compliance.
"-" represents no set guideline value

34. Measures to Ensure Water Quality

34.1 Measures to ensure water quality include catchment management, water treatment and exploration of alternative water sources. The four places under study put different degrees of emphasis on these measures depending on their own situations.

Catchment Management

34.2 The case of New York City shows that the participation of watershed communities is important, and in fact more effective, in ensuring good water quality. The Environmental Protection Agency in the US considers the watershed protection programme to be quite successful because it is a voluntary programme and emphasizes an integrated approach for pollution control.

34.3 Sydney demonstrates the importance of having one single organization in charge of catchment management so as to ensure the protection of water quality. Sydney Catchment Authority undertakes to ensure raw water quality and is empowered to review and even veto development projects in the catchment areas.

34.4 In Hong Kong, authorities which are responsible for protecting the catchment areas are fragmented and sometimes overlapping. Under the Waterworks Ordinance, the Water Supplies Department has the power to prosecute those who contaminate the water gathering grounds. A major portion of the water gathering grounds is within country parks and hence is also under the management of the Agriculture, Fisheries and Conservation Department. The control of development is the jurisdiction of the Director of Lands while the Department of Environmental Protection is the authority on Water Pollution Control Ordinance. Regarding the distribution systems and water quality at water taps, the Water Supplies Department is the enforcement agency.

34.5 Fast economic developments and growing farming activities along the Dongshen Water Supply System make it difficult and costly for the government to enforce the law to protect water quality. Information on the number of industrial and farming activities along the water supply route is not available. Even when resources are spent on patrolling and enforcement, the effect may not be satisfactory when the economic incentive for the industry and farms to locate along the water route is strong.

34.6 Guangdong authority has launched a catchment management programme in September 1999. Officials from the HKSAR Works Bureau have admitted that the pace of pollution along the Dongjiang River is much faster than that of environmental restoration.

Water Treatment

34.7 There are basically two approaches to deal with the problem of deteriorating quality of drinking water: (1) catchment management; and (2) water treatment. Because of its limited influence over the management of the catchment areas in Guangdong, Hong Kong has put a high emphasis on water treatment. Raw water supplied to Hong Kong goes through more stages of treatment than that for the other three places concerned in this research. Raw water to Hong Kong receives pre-treatment in Shenzhen, then in Hong Kong. It then receives water treatment by coagulation and rapid gravity filtration. In future when the Ngau Tam Mei Water Treatment Works and Tai Po Water Treatment Works are completed, some raw water will receive further multi-stage treatment.

34.8 By comparison, raw water of New York City and Sydney undergoes much less treatment. Sydney can choose to skip some of the process in the conventional treatment depending on the quality of the water. Raw water of New York City is only disinfected and not filtered.

34.9 Indeed, treatment may produce harmful by-products. In the case of Hong Kong, since more chlorine is added to treat raw water, treated water has a higher concentration level of THMs, which according to the government, is still lower than that prescribed by WHO. It should be noted that the United States set the health goal level at zero for carcinogenic substances, under the assumption that any exposure to the chemical could present a cancer risk.

Alternative Water Sources

34.10 Owing to the inevitable but unsatisfactory dependence upon external water supply, Singapore has devoted much resource to exploring new water supply sources. Apart from a new desalination plant, Singapore has started to study sewage recycling and procuring water supply from Indonesia. At the same time, Singapore puts high emphasis on financial incentives for customers to use less water, such as the introduction of Water Conservation Tax and Waterborne Fees, which are charged according to usage.

34.11 In Hong Kong, a consultant research is being carried out on alternative water sources since September 1999 and is scheduled to finish by June 2000. The objective of the study is to explore all possible alternative water sources in Hong Kong, which may include desalination of seawater, recycling of sewage and purchasing water elsewhere other than Guangdong.

35. Water Cost

35.1 Although the quality of treated water in the four places under study is similar, there are significant differences in the costs of water supply. Water costs can reflect the differences among the four places under study in payment methods for the purchase of raw water from external sources, purchase prices of water and costs of water treatment.

Charging Methods

35.2 The 1987 4th Water Supply Agreement for Dongjiang water introduced a practice of price increase relating to operation costs and financial situation in Hong Kong and Guangdong. Singapore purchases water from Malaysia at a fix rate. Sydney Water Corporation pays Sydney Catchment Authority for the raw water at a rate laid down in the Bulk Water Supply Agreement. In addition, an upper limit is set for price adjustment in the agreement.

Prices of Water

35.3 Hong Kong purchases Dongjiang water at a price of HK$3.09 per cubic metre in 1999 while Singapore pays Malaysia HK$0.33 for the same volume of water. That means Hong Kong purchases external water sources at a price as much as nine times higher than Singapore.

35.4 The actual cost of water from Guangdong is much higher if the cost of treatment is added to the price of water. It should be noted that this cost has not taken into account the capital cost for constructing various treatment plants. The installation of pre-treatment facilities and measures to reduce pollution in Guangdong will also have a bearing on the future price of Dongjiang water.

35.5 Singapore and Hong Kong place much emphasis on water treatment as raw water quality is deteriorating. Taking out the cost for the purchase of imported raw water, staffing and depreciation, treatment and transportation cost in the two places are similar, more than HK$2 per cubic metre.

35.6 Overall water cost is lower in Sydney than in Hong Kong, roughly by 40%. Much saving is attained by filtration avoidance in New York City, such as avoiding building and maintaining a proposed filtration plant estimated to cost more than HK$40 billion in construction and millions of US dollars in annual recurrent expenditure. If we take the New York Watershed Agricultural Programme as an alternative to water treatment, per unit costs of the two measures are similar, HK$0.15 for Agricultural Programme in New York City and HK$0.103 for filtration in Hong Kong.

36. Reference for Hong Kong

36.1 The experience of New York City clearly demonstrates the importance of careful catchment management, with communal participation and environmental protection awareness among the public. This is the only case in this study that raw water needs no filtration for human consumption. Billions of dollars of "savings" (US$6 billion capital cost and millions of US Dollars in annual recurrent expenditure) are achieved, which shows that a holistic approach can serve the dual purposes of environmental conservation and economy.

36.2 In addition, maintaining the high quality of raw water in New York can reduce water treatment that may in turn bring about other health risks. Intense treatment of raw water of low quality may result in a high concentration of carcinogenic substances such as residual chlorine and THMs in drinking water. Unfortunately, Hong Kong is an example of the latter.

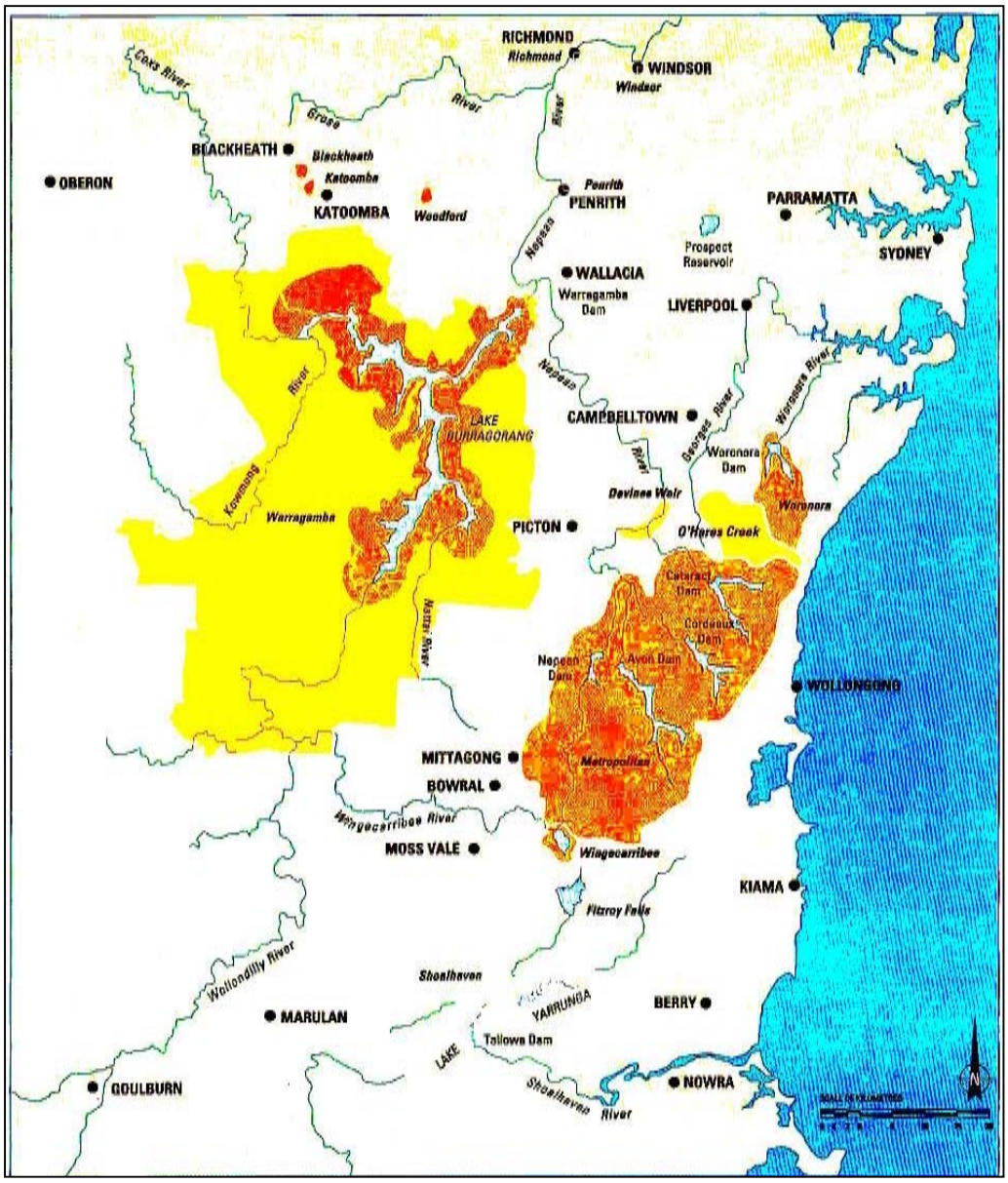
36.3 The institutional arrangement in Sydney is born out of water crisis, characterized by the presence of clear obligations and indemnity clauses for non-compliance. The raw water standard stipulated in the agreement between Sydney Catchment Authority and Sydney Water Corporation is unique among all cases studied. It sets out in clear terms each party's duty and legal remedy in case of failure.

36.4 Singapore is in the same predicament as Hong Kong: natural scarcity of water resources and deterioration in the quality of imported raw water. However, much effort has been made in Singapore to explore alternative water sources, like desalination, effluent recycling and a new provider for purchased water. Singapore targets at a self-sufficiency rate of 50% in the future.

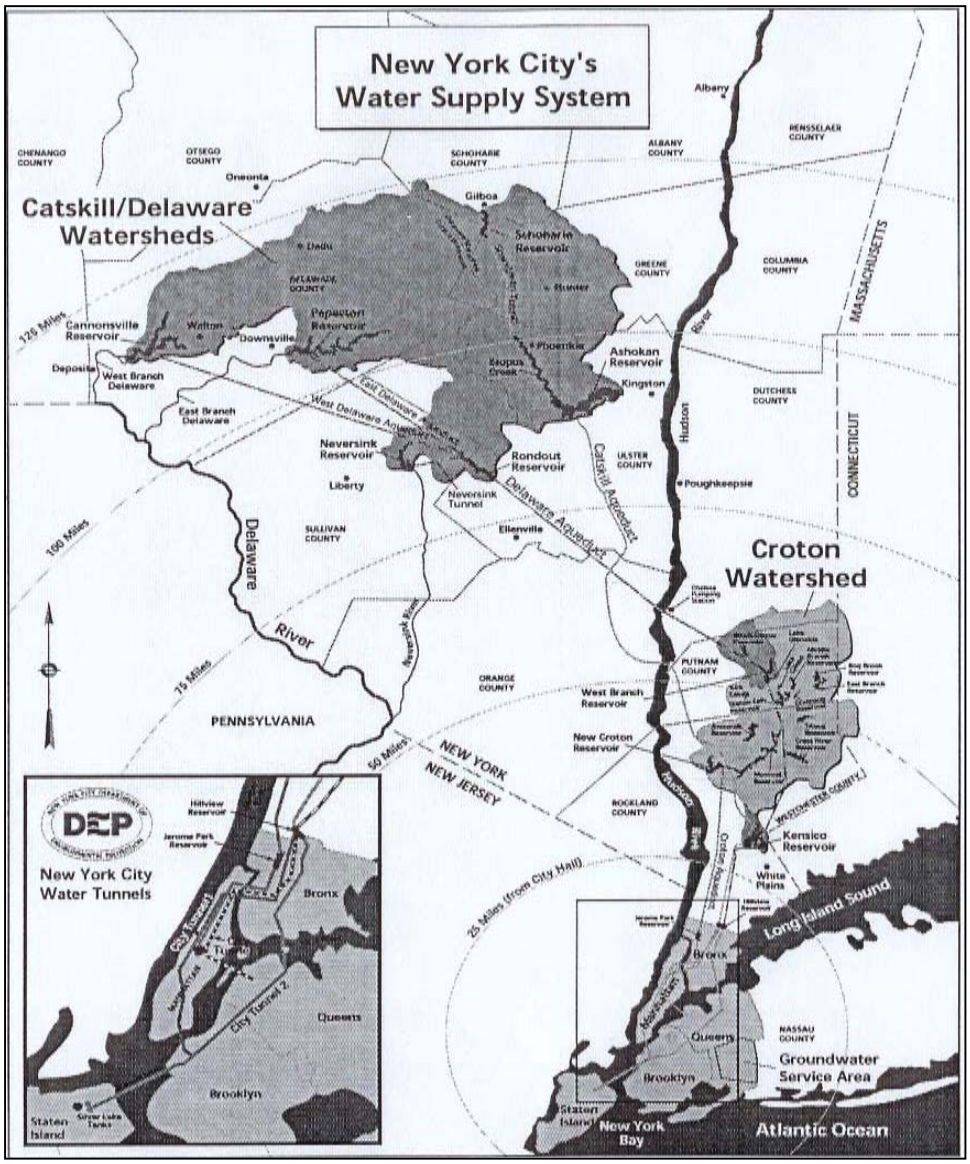
Appendix I

Part A: Location Map of Water Delivery System from outside Hong Kong

Part B: Location Map of Water Delivery System from outside Sydney



Part C: Location Map of Water Delivery System from outside New York City



Part D: Location Map of
Rivers in Malaysia which Supply Water to Singapore

Appendix II

Adjustment of Unit Price of Dongjiang Water

According to a written reply from Water Supplies Department, the unit prices of Dongjiang water has always been subject to periodic reviews and revision was made after agreement was reached through negotiation.

Results of negotiations were formally accepted either as one of the terms of the Agreements or through written correspondence. The agreed prices were then to remain effective until the next revision was agreed upon. Up to 1987, the practice was that a single unit price was agreed upon every time a price revision was made in the course of discussions for increased quantities of supply. But in the December 1987 Agreement, the unit prices for the three years to come (viz. the supply periods of 1988/89, 1989/90 and 1990/91) were agreed and reflected in the terms of the Agreement. The same was done in the December 1989 Agreement in which the unit prices for the periods 1991/92, 1992/93 and 1993/94 were agreed and recorded in the Agreement. Subsequent revisions of unit prices were done periodically through meetings and discussions whenever required.

The basis of water price adjustments as summarized and set out in the 1989 Agreement relates to increases in operation costs and will take into account changes in relevant price indices in Guangdong and Hong Kong and the exchange rate between the Hong Kong Dollar and the Renminbe.

The unit prices of previous years are summarized in the following table.

Agreement	Unit Price	
Nov 60 1st Agreement	JMP$0.1/1000 gallons	
Apr 64 2nd Agreement	JMP$0.1/$m^3$	
Nov 78 3rd Agreement	JMP$0.15/ m^3	
May 80 Supp.Agreement	No change	
Nov 81 Correspondence	JMP$0.25/ m^3	
Apr 85 Correspondence	RMB$0.33/ m^3	
Jan 87 Correspondence	HK$1.03/ m^3	
Dec 87 4th Agreement	HK$1.112/ m^3	(for supply period 88/89)
	HK$1.201/ m^3	(for supply period 89/90)
	HK$1.297/ m^3	(for supply period 90/91)
Dec 89 5th Agreement	HK$1.439/ m^3	(for supply period 91/92)
	HK$1.597/ m^3	(for supply period 92/93)
	HK$1.772/ m^3	(for supply period 93/94)
Subsequently - through meetings	HK$1.940/ m^3	(for supply period March - Dec 1994*
	HK$2.160/ m^3	(for 1995)
	HK$2.405/ m^3	(for 1996
	HK$2.613/ m^3	(for 1997)
	HK$2.839/ m^3	(for 1998)
	HK$3.085/ m^3	(for 1999)

Appendix III

Contingency Plan
Cryptosporidium & Giardia in Water Supply

1. Preamble

1.1 This Contingency Plan lays down the procedures, which will operate when Cryptosporidium oocysts and Giardia (C&G) cysts are detected in the treated water supply in Hong Kong.

1.2 The Department of Health has in place an existing contingency plan to cope with waterborne disease outbreaks, which is applicable to dealing with an outbreak of cryptosporidiosis and giardiasis.

2. Cryptosporidium and Giardia

2.1 *Cryptosporidium* and *Giardia* (C&G) are microscopic parasitic protozoa, which can infect the gut of cattle, sheep, wild and domestic animals, and man. They occur in all surface waters and some ground waters. Infection of humans occurs by ingestion of food or water contaminated with C&G. Cryptosporidiosis and giardiasis are **not** common water-borne diseases. However, it is imperative that an effective treatment system is maintained.

2.2 Monitoring of *Cryptosporidium* and *Giardia*

Currently, there is no world-wide consensus on the infectivity of the *Cryptosporidium* oocyst and *Giardia* cyst on humans. There is no **health-related** standard for *Cryptosporidium* and *Giardia* in drinking water at the present moment. There is **no** guideline value for *Cryptosporidium* oocyst or *Giardia* cyst in the Guidelines for Drinking-water Quality, World Health Organization (1993).

The public health significance of finding *Cryptosporidium* oocysts and *Giardia* cysts in treated water is still debatable. Their presence does not necessarily implicate diseases. In the recent event in Sydney, there were no increased activities of diarrhoeal diseases despite the finding of such oocysts/cysts in treated water. Moreover, whether such oocysts/cysts are infective or not is another concern. People with normal immune function usually have asymptomatic or self-limited symptomatic infections. However, the presence of oocysts/cysts does indicate the need to review the water supply system, in particular the filtration process and possibilities of backwash etc.

WSD currently monitors *Cryptosporidium* and *Giardia* levels in the treated water from treatment works in Hong Kong. They are located at Au Tau, Ma On Shan, Pak Kong, Shatin, Silvermine Bay and Siu Ho Wan. Samples are also sent to the Water Research Centre of UK for analysis.

2.3 Monitoring of other water quality parameter

Other water quality parameters such as continuous high turbidity can give early warning of particle breakthrough and alert operators to an increased risk of the presence of protozoan oocysts/cysts in the treated waters.

In addition, the use of intestinal organisms, typically faecal coliforms, as faecal contamination indicators are universally accepted practice for monitoring and assessing the microbial safety of water supplies.

2.4 Strategy for control and removal of *Cryptosporidium* and *Giardia* in water treatment.

Risk minimisations is the principal strategy. It is generally recognized that the following means are effective **minimise** the risk of *Cryptosporidium* and *Giardia*:-

a. Operate each treatment works within its nominal capacity.
b. Check coagulation/flocculation process regularly.
c. Treatment processes should not be bypassed or overloaded.

3. Contingency Plan for C&G

3.1 For the purpose of this plan, 2 levels: a vigilance level and an action level are set for C&G.

3.2 Vigilance level

A vigilance level for C & G is set to prompt risk minimisation review of the water treatment system. Such level once reached will immediately initiate review of treatment processes. The vigilance level is set with reference to that used in U.K. at 1 *Cryptosporidium* oocyst per 10 litres treated water. For *Giardia*, it is set at zero tolerance. This level will be reviewed regularly by a Task Group comprising of representatives from WSD and DH, taking into account of the international practices and local data. Other factors e.g. abnormal operational parameter of plants, high turbidity in treated water or suspected failure of treatment will also trigger investigation and/or step-up monitoring by WSD staff at the treatment works.

3.3 Action level

An action level for C & G is also set to activate further actions (in addition to treatment process reviews) such as issuing of precautionary boil water advice and for very serious case, it may be necessary to suspend the water supply from the suspected water treatment plant(s). The action level will be determined by the Task Group and will make reference to the Information Collection Rule of the USEPA on C&G for the issue of boil water advice, which is set at greater than 5 *Giardia* cysts or greater than 50 *Cryptosporidium* oocysts per litre of treated water.

3.4 Action on reaching vigilance level

The following measures will be carried out in the event that the vigilance level for C&G is reached.

i) Ch/T will inform S Ch(1) or S Ch(4) and C Ch the levels of *Cryptosporidium* oocysts and/or *Giardia* cysts detected in the treated water sample and other relevant details including sampling location, sampling time, operating conditions, plant throughput, washwater recovery etc.

ii) C Ch will notify D of Health, AD/S&D(1) and AD/S&D(2).

iii) Ch/T will arrange for the following:-

a. Examine operational parameters including throughput, filter runs, and chemical doses.
b. Check quality of raw, settled, filtered and final water.
c. Consult Headworks Division for any major maintenance/overhaul/change in operational conditions and identify any problems.
d. Adjust plant throughput, chemical doses and treatment processes as necessary to optimize plant performance for removal of C&G.
e. Recommend any change of raw water sources and stop the recycling of washwater, supernatant and filtrates as necessary.
f. Improve the backwashing process for filters by extending the washing duration, reduce the filter run time and delay start of filtration after backwashing if necessary.
g. Arrange re-sampling for *Cryptosporidium* oocysts and *Giardia* cysts analyses.
h. Submit a report to C Ch on the incident

iv) C Ch will set up an in-house incident management team to review the treatment process and assess the necessary actions required, C Ch will arrange for the Task Group comprising representatives of both DH and WSD to be mobilized.

v) C Ch will take into account the results of the reviews and assessments and take necessary actions to minimize the risk of *Cryptosporidium* and *Giardia* in water supplies including following:-

a. Alert DWS and DDWS of the situation.
b. Mobilize staff to step up monitoring water quality at treatment works and keep AD/S&D(1) and AD/S&D(2) informed of the monitoring results.
c. Mobilize through CE/Region departmental resources for other actions e.g. isolation of suspected units as necessary.
d. Keep WSD management informed of the situation as the incident develops and advise on issue of public statements.

3.5 Action on reaching action level

In addition to the system review as described in 3.4, the Task Group comprising DH and WSD representatives will take into consideration the following in addition to the action level to see if actions to alert the public are required:-

a. source water quality indicators and the vulnerability of the source to contamination;
b. treatment effectiveness and distribution system integrity;
c. finish water quality indicators; and
d. epidemiological evidence i.e. evidence that associates gastrointestinal illness in the population with drinking water.

3.6 In case of an occurrence of an outbreak of cryptosporidiosis and/or giardiasis in the territory, an Outbreak Control Team (OCT) will be set up by the Department of Health. WSD staff will participate in the OCT and act on the team's advice according to DH's Contingency Plan to dealing with disease outbreaks.

3.7 The vigilance level is to initiate system review, whereas the action level is to activate further actions(in addition to system reviews) such as boil water alert or suspension of supply from plant where the problem has occured. However, single results of abnormal high reading and other abnormal operational parameters of plants (e.g. turbidity, abnormal coliforms reading) can trigger the process of alert for system reviews.

Public announcement to advise people to boil water or special groups such as immuno-compromised people to boil water will be determined by the Task Group taking into consideration the factors stated in para 3.5. These same factors will be considered in evaluating whether a boil water advice should be rescinded.

December 1999

Appendix IV

Location Map of
Enclosed Aqueduct of Dongjiang Water to Hong Kong

Appendix V

The Bulk Water Supply Agreement is supplemented with six schedules. Schedule 6 stipulates charges for raw water and part C lays down principles for charges adjustments. If raw water fails to comply a certain quality parameter, charges will be reduced and different plant has different adjustment rate. Plant Prospect is cited below as an example.

PART C
of Schedule 6 -
Adjustments to Charges

1. The relevant charges established under Parts A and B of this Schedule 6 are to be adjusted as set out in Clauses 2 and 3.

2. If the Authority provides water to Sydney Water with a Raw Water Quality as set out in Tables 1 to 10 below, the Authority must reduce the charges for each megalitre of such water supplied by the amount ("Reduction Amount") set out in those Tables, which amount corresponds to any of the Raw Water Quality parameters there indicated into which the water supplied falls, but

   (a) if turbidity and colour are such that more than one Reduction Amount can apply for each megalitre of such water supplied, then the highest applicable Reduction Amount must be applied; and

   (b) if the applicable turbidity and colour Reduction Amounts are of equal value, only one Reduction Amount must be applied.

3. Each Reduction Amount is to be adjusted by the movement in the Consumer Price Index for the twelve (12) months to 31 March immediately preceding each Financial Year in which the Reduction Amount is to apply.

Table 1 - Prospect Water Filtration Plant

Raw Water Quality		Reduction Amount per Megalitre
Turbidity (NTU)	$0 < NTU \leq 2$	Nil
Colour (HU)	$0 < HU \leq 10$	Nil
Turbidity (NTU)	$2 < NTU \leq 7$	$10
Colour (HU)	$10 < HU \leq 30$	$10
Turbidity (NTU)	$7 < NTU \leq 40$	$20
Colour (HU)	$30 < HU \leq 60$	$20
Turbidity (NTU)	> 40	$36
Colour (HU)	> 60	$36

Appendix VI

Schedule 1 part B stipulates raw water standards which are drafted having regarded the capacity of each water treatment facility. Thus, each plant has a different set of criteria and plant Prospect is extracted below as an example.

B. QUALITY

All Bulk Raw Water supplied to each of the water treatment facilities designated hereafter must conform to the water quality standards or criteria indicated for each such facility.

These standards or criteria are based on historical data regarding the capacity of each water treatment facility to meet the applicable treated water quality standards.

I. Prospect

PARAMETER	UNITS	MINIMUM	MAXIMUM
Turbidity	NTU		40
True colour	HU		60
Iron	mg/L		3.50
Manganese	mg/L		1.40
Aluminium	mg/L		2.58
Hardness	mg/L as $CaCo_3$	28.5	53.5
Alkalinity	mg/L as $CaCo_3$	21	45
pH	pH units	6.27	7.87
Temperature	°C	10.0	23.6
Algae (Note 2)	ASU/ml		1000

Note 1: When the Authority makes available to Sydney Water Bulk Raw Water that is capable of being blended so that the Bulk Raw Water at the Prospect Water Filtration Plant inlet can satisfy the above criteria, then the Bulk Raw Water is deemed to satisfy those criteria provided the Authority has given reasonable prior notice to Sydney Water of the need to blend the Bulk Raw Water.

Note 2: If turbidity is greater than 10 NTU or true colour is greater than 30 HU, then the maximum Algae criteria will be 500 ASU/ml.

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