Water Management Issues in Singapore

by

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Introduction and Background

Singapore is an island and urban city state with no rural hinterland. The main island and a number of islets scattered off its north-east and southern parts occupy a land area of around 699 km^2. Singapore is not short of fresh water as it receives an average of around 2,400 mm of rainfall annually, well above the global average of 1,050 mm.[1] The only constraint faced by the country is capturing and storing as much of this rainfall as possible, on limited amounts of land areas.

In spite of being the country with the highest GDP per capita in Southeast Asia, Singapore is disadvantaged and categorised as a "water-stressed" country, as less than 1,000 m^3 per person of water is available from within the country (column 2 of Table 1). Nevertheless, as Kog points out,[2] this figure does not imply a future shortage of available water, since supplies are affected by actual water usage and the efficiency with which water is used and reused.

The ratio of annual per capita of internal renewable water resources in Malaysia, its closest neighbour, and presently supplying around 40 percent of Singapore's water needs, is one hundred and sixty eight times that of Singapore's (column 2 of Table 1). From the same table, the potential for Indonesia, Singapore's other closest neighbour, to meet Singapore's water needs is favourable as its per capita annual renewable water resources is around ninety one times that of Singapore's.[3]

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[1] Joey S.R. Long, "On the Threshold of Self-Sufficiency: Toward the Desecuritisation of the Water Issue in Singapore-Malaysia Relations" in C.G. Kwa, editor, *Beyond Vulnerability? Water in Singapore-Malaysia Relations*. Singapore: Institute of Defence and Strategic Studies, 2002, p. 109.

[2] Y.C. Kog, "Natural Resource Management and Environmental Security in Southeast Asia: Case Study of Clean Water Supplies in Singapore", IDSS Working Paper No. 15, May 2001, p. 11 and Y.C. Kog, "Natural Resource Management & Environmental Security in Southeast Asia: A Case Study to Clean Water Supplies to Singapore" in C.G. Kwa, editor, *Beyond Vulnerability? Water in Singapore-Malaysia Relations*. Singapore: Institute of Defence and Strategic Studies, 2002, pp. 34-35.

[3] In October 1989, Singapore announced a decision to study the feasibility of buying water from Batam in Indonesia. In August 1990, Singapore and Indonesia signed the Agreement on Joint Development of Riau Province to cooperate on the development of water as well as tourism and industries in Riau. In June 1991, Singapore and Indonesia signed a long term water agreement which would ensure the supply of Indonesian water from Riau well into the 21st Century. Indonesia, in this context, presents a not-too-distant and a potential source of water for Singapore. Looking even further ahead, Table 1 also suggests that a framework for sharing water resources among ASEAN countries could also be worked out in the future, as water resources in the region become scarcer in some of the countries while less so in others.

Table 1: Water Resources of ASEAN Countries, GNP Per Capita, and Population: 2000

Country	Annual Renewable Water Resources: Total[4] (km^3)	Annual Renewable Water Resources: Per Capita (m^3)	Annual Water Withdrawals: Total (km^3)	Annual Water Withdrawals: Per Capita (m^3)	2000 GDP Per Capita (US$)	Population 2000 (millions)
Cambodia	**476**	**32,876**	**4.1**	**311**	**274**	**12.2**
Indonesia	**2,830**	**12,749**	**82.8**	**391**	**750**	**203.5**
Laos PDR	**334**	**57,638**	**3.0**	**567**	**328**	**5.2**
Malaysia	**580**	**23,316**	**9.0**	**392**	**3,870**	**23.2**
Myanmar	**1,046**	**20,870**	**33.2**	**699**	**142**	**49.0**
Philippines	**479**	**5,884**	**28.5**	**377**	**981**	**76.3**
Singapore	**1**	**139**	**--**	**--**	**23,071**	**4.0**
Thailand	**410**	**6,459**	**87.1**	**1,429**	**1,963**	**62.4**
Vietnam	**891**	**10,805**	**71.4**	**914**	**403**	**77.7**

Source: *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty*. Washington, DC: World Resources Institute in Collaboration with United Nations Development Programme, United Nations Environment Programme, and World Bank, 2005; ASEAN Statistics <http://www.aseansec.org/13100.htm>; ASEAN Statistical Yearbook 2001 <http://www.aseansec.org/macroeconomic/yearbook.htm>.

As such, besides its own raw water reservoirs which presently covers around 50 percent of the land area, Singapore sources for water from the neighbouring state of Johore in Malaysia. Singapore has also been moving into recycling used water for non-potable uses (NEWater),[5] and has embarked on desalination in September 2005. Nevertheless, water from its domestic reservoirs and imported Malaysian water continue to be the main sources of water supply for the Republic. In the years ahead, it is anticipated that NEWater and desalinated water will be produced in more significant quantities to supplement these traditional sources.

Singapore's water management strategy has always had to incorporate this external dynamic where a significant portion of its water is imported from neighbouring Malaysia. This has played a role in influencing Singapore's water management stance by moving it towards the direction of conserving existing supplies, enhancing the storage capacities of present water catchments and reservoirs, and adopting new technologies to produce water.

The introduction of NEWater and desalination has placed Singapore on a less dependent position on Malaysia for water, but the Singapore Government has nevertheless expressed the view that it would like to continue to purchase water, under fair terms, from Malaysia or, for that matter, from any other country which is

[4] Data from Table 9 "Water Resources and Fisheries" in *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty*. Washington, DC: World Resources Institute in Collaboration with United Nations Development Programme, United Nations Environment Programme, and World Bank, 2005, p. 208. The data produced in Table 9 was in turn obtained from the FAO in 2004 and represent long term averages originating from multiple sources and years. See <http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastat/water_res/index.htm>.

[5] NEWater has been scientifically been proven to be cleaner than drinking water.

willing to be its long-term supplier.[6] The then Prime Minister of Singapore, Goh Chok Tong, alluded to water from Malaysia as being a symbol of the interlocking relationship between both countries, and a sign of their interdependence and co-existence.[7]

Water imported from Malaysia is governed historically by two existing water agreements dating back to the 1960s, prior to Singapore's separation from Malaysia. The issue of supplying water to Singapore has, at times, been brought to the forefront of the Malaysian and Singapore political arena; this dating back to 1965, the year when Singapore was separated from Malaysia. Being countries in close proximity to one another, with interdependent economies, and also sharing a common historical past, there has been the occasional political sparring and exchanges between Singapore and segments of the Malaysian polity (ruling and opposition members) and some of its constituents, especially when Singapore pursued specific diplomatic, economic or political stances which ran contrary to Malaysia's interests.[8] The threat of cutting or stopping water supplies would sometimes accompany such disagreements, although the Malaysian Government has never gone to the extent of actually cutting off water supplies to Singapore. Water has therefore been seen at times as a trump card for Malaysian politicians, "a leverage to induce Singapore to defer to Malaysia."[9]

There has nevertheless been repeated assurances from the Malaysian authorities that Malaysia will observe the 1961 and 1962 water agreements made with Singapore.[10] Since late 2003, the tiffs occurring over the bilateral negotiations on various issues between the two countries now look set to settle into a more amiable stance with Datuk Abdullah Badawi succeeding Dr Mahathir at the helm as Malaysia's Prime Minister.[11] In January 2004, Datuk Badawi expressed the view that both Malaysia and Singapore should engage in bilateral talks instead of arbitration to resolve the deadlock in the present water negotiations.

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[6] "S'pore Wants Water Price Pegged to NEWater's", *The Business Times*, 24 July 2002. <http://business-times.asia1.com.sg> Retrieved on 24 July 2002.

[7] J. Long, "Desecuritizing the Water Issue in Singapore-Malaysia Relations", *Contemporary Southeast Asia* 23, No. 3 (December 2001), p. 522.

[8] See, for example, A. Tan, "Malaysia-Singapore Relations: Troubled Past and Uncertain Future?", *Monographs on South-East Asian Studies and Institute of Pacific Studies, The University of Hull*, 2001 T. Huxley, *Defending the Lion City: The Armed Forces of Singapore*. Australia: Allen and Unwin, 2000, for a discussion of some of the bilateral issues existing in Singapore-Malaysia relations. These have included the visit of the Israeli President Chaim Herzog to Singapore, the relocation of Malaysia's Customs, Immigration and Quaratine checkpoint, violations into Malaysian airspace, the disputed ownership over Pedra Banca, over-the-counter trades of Malaysian shares on CLOB International after Malaysian shares have been officially delisted, land reclamation, and construction of a new causeway bridge.

[9] Ibid., p. 506.

[10] See "Malaysia Raises Water Pressure", *BBC News*, 6 August 2002. <http://news.bbc.co.uk> Retrieved on 14 November 2002, "Time to Refer Water Issue for Arbitration", *The Star Online*, 21 October 2002. <http://thestar.com.my/ > Retrieved on 26 October 2002, and "KL Won't Cut Supply Despite Troubled Water Talks", *The Straits Times*, 22 October 2002. <http://straitstimes.asia1.com.sg/> Retrieved on 24 October 2002.

[11] Nevertheless, as recently as November 2005, Dr Mahathir was again cited in the press as saying that Singapore was becoming bolder in its relationship with Malaysia, when making statements on Kuala Lumpur's proposal for a bridge to replace the present causeway. See "Mahathir Cites Bridge Issue in Criticising 'Bold' Singapore", *The Straits Times*, 8 November 2005. <http://straitstimes.asia1.com.sg> Retrieved on 8 November 2005.

Subsequently, both prime ministers (Prime Minister Badawi and then Prime Minster Goh Chok Tong) have agreed to resolve issues through negotiations, where such matters have not been already sent for arbitration, as in the case of Pedra Branca. Both countries also brought up the possibility that the package of issues might have to be "unscrambled".[12] Talks have now resumed with both sides agreeing not to discuss details of their negotiations with the media (quiet diplomacy). The air is now very positive between both countries, entering into a new phase where there is a new will to resolve bilateral differences.[13]

Water is a national security issue, with security to a large extent dependent on self sufficiency. Singapore has always been dependent on Malaysia for its water supplies. This has in turn created a sense of "vulnerability", as reservoirs within the country can presently only meet up to 60 percent of the country's daily requirements. Singapore policy makers have been moving in the direction of reducing its reliance on outside sources and strengthening its own internal capacities. In line with this stance, Singapore has been looking for means to augment domestic supplies by enlarging the size of its present catchment areas, pursuing conservation measures to reduce wastage, looking for more efficient means to collect and store rainwater, and significantly in the past decade has been developing and refining new technologies to harness water from non-traditional sources (recycling and desalination).

As such, water management policies in Singapore has been increasingly moving towards an adoption of a policy mix of the espousal of newer technologies which are less cost effective but nevertheless necessary if Singapore were to achieve a higher degree of self sufficiency, while maintaining existing cost-effective measures (enlarging storage capacity of its reservoirs plus continuing to import water from Malaysia).[14] Singapore has allocated 50 percent of its land area for reservoirs, a considerably disproportionate amount considering its land scarcity, with this increasing to two-thirds when the Marina Barrage is completed.

Has the decision been politically and economically rational? Yes. In such an instance, it has been essential for the government to consider the trade-off between a strategic need to be self-sufficient against the economics of importing supplies albeit at a lower cost but having to factor in a greater element of vulnerability. The premium to be paid for self sufficiency (and national sovereignty) may therefore be justifiable for Singapore from a strategic and national interest perspective, as well as provide

[12] In the past, several issues have been tied together with water. These are the use of Malaysian airspace by Singapore's air force, the withdrawal of Central Provident Funds (CPF) by West Malaysians, the location of Malaysia's customs, immigration and quarantine facilities, land reclamation, the development of Malayan Railway land in Singapore, and the construction of a bridge to replace the present causeway. For the land reclamation issue, Singapore and Malaysia signed an agreement in April 2005 which has effectively ended the three year dispute. See "S'pore-M'sia Relations Have Improved – S'pore FM", *Bernama.com*, October 12, 2005. <http://www.bernama.com.my>. Retrieved on 31 October 2005.

[13] "S'pore-M'sia Relations Have Improved – S'pore FM", *Bernama.com*, October 12, 2005. <http://www.bernama.com.my>. Retrieved on 31 October 2005.

[14] In the future, water suply from Malaysia after 2061 is dependent on the signing of a new agreement, currently still in the process of being negotiated. Should an agreement take place then, Singapore would still be importing water from Malaysia. However, an eventuality may arise where Singapore will be producing all its water requirements from its reservoirs and from NEWater and desalination, should external sourcs not be available.

Singapore with greater leeway in its future negotiations with Malaysia on many bilateral issues, to put both countries on a more equal footing.[15]

Sources of Water Supply in Singapore

- *The Four Taps Strategy*

Singapore has adopted a "Four Taps Strategy", where it sources water from its own reservoirs, from Johore in Malaysia, recycling (NEWater), and desalination. Each of these sources will now be discussed in some detail.

Table 2: Domestic Water Statistics

	2002	**2003**	**2004**
Number of raw water reservoirs in Singapore	14	14	14
Number of NEWater Plants (For Recycling Water)		2	3
Volume of Used Water Treated Per Day (1,000m^3/day)[16]	1,315	1,360	1,369
Water Tariffs			
Domestic (consumption ≤ 40 m^3 per month) (cents/m^3)	117	117	117
Domestic (consumption > 40m^3 per month) (cents/m^3)	140	140	140
Shipping (cents/m^3)	192	192	192
Sale of Water in Singapore	1,259	1,224	1,203
Domestic (1000 m^3/day)	687	690	686
Non-domestic (1000 m^3/day)	572	534	517
Domestic water consumption per person (litres/day)	165	165	162

Source: Key Environmental Statistics 2005, Ministry of the Environment and Water Resources, Singapore. http://www.pub.gov.sg/downloads/pdf/stats_booklet_v5.pdf

Table 3: Water Consumption in Singapore: 1960-2000 (Thousand m^3)

Year	Domestic	Shipping	Commerce/ Industry	Government and Statutory Boards	Total Annual Consumption
1960	**40,786.9**	**NA**	**21,697.6**	**36,997.2**	**99,481.7**
1970	**71,024.0**	**2,276.9**	**35,718.3**	**43,923.6**	**152,942.8**
1980	**113,478.0**	**3,347.0**	**75,991.3**	**23,750.0**	**216,566.3**
1990	**177,343.3**	**2,914.4**	**113,148.6**	**29,391.8**	**322,798.1**
2000	**241,388.0**	**1,841.0**	**181,477.0**	**30,742.5**	**455,488.5**

Source: Kog (2000) and Department of Statistics (Singapore)

[15] The crucial question would be the "price" or value that the Singapore Government and its citizenry attach to self sufficiency, national sovereignty, and being placed on a more "equal footing" in its future bilateral dealings. If the premium on self-sufficiency is "x" dollars, then the price that Singapore is willing to pay for self-sufficiency would be the current price of water (say "y") plus this premium "x". As such, the price for self-sufficiency in water is S$ (y + x).

[16] The treated water in this row refers to a lower grade of non-potable water for industrial use in Singapore.

Presently, the major consumers of water in Singapore are the "domestic" and "commerce/industry sectors" (Table 3 above). Fifty three percent of total water supply was used up by the domestic sector, and forty three percent by the commerce and industrial sector. The per capita domestic consumption has been falling gradually in recent years. Between 2002 and 2004, consumption per head fell from 165 litres/day to 162 litres/day. Water shortages and price hikes are likely to have greater impacts on the economy and the well being of Singapore's population, thus having both economic and political implications on the state machinery.

- *Reservoirs*

Presently, around 680,000 m^3 (or 149.58 million gallons) of Singapore's water consumption is sourced from catchment areas around the city state.[17]
In 2005, there are now fourteen raw water reservoirs in Singapore that cover around fifty percent of its land area (see Table 2 above).

Where history recalls, the 150 or so inhabitants in Singapore were initially self-sufficient in water when Sir Stamford Raffles arrived in 1819.[18]

A small reservoir was subsequently constructed at Fort Canning to supply water to ships which called at its port. By 1850, the population had increased to more than 50,000 without any provisions made to supply these residents with water. It was only in 1857 that philanthropist Tan Kim Seng made a donation of $13,000 for the construction of Singapore's first waterworks and piped water supply. Municipal water supplies began in 1867, with the completion of Singapore's first reservoir, MacRitchie Reservoir (then know as the Thomson Road Reservoir). The MacRitchie dam was subsequently enlarged between 1890 and 1894, and again at the turn of the century.[19]

Through a series of studies by the PUB from 1950s, the government realised that it was not possible for Singapore to be competitively self-sufficient in water supply. As such, Johore water was increasing seen as playing a major source for meeting Singapore's water requirements. Two water agreements were subsequently signed with the Johore Government in 1961 and 1962 respectively, following the 1927 Water Agreement.

Since 1965, the Water Department of the Public Utilities Board (PUB) has been enlarging Singapore's capacity to provide its population with water. In Singapore, three storage reservoirs (MacRitchie, Peirce, and Seletar), have been in operation since the 1960s, when Singapore separated from Malaysia. The PUB also expanded the capacity of the Seletar Reservoir in 1969. The Seletar Reservoir (renamed Upper Seletar Reservoir in 1992) was enlarged by more than 35 times in 1969. By 1986, fourteen storage reservoirs were in operation, up from the then existing three, with the total storage capacity increasing from 31.1 to 140.00 million m^3.[20] Reservoirs were

[17] See, for example, Long, 2002, op. cit., p. 512, and "Greater Self-reliance in Water is the Way to Go", *The Straits Times*, 10 April 2002. <http://straitstimes.asia1.com.sg> Retrieved on 10 April 2002.
[18] An excellent account of the history of Singapore's water supply and demand is available from Kog (2002) and this section draws heavily from that account. See Kog, 2002, op. cit., pp.26-30.
[19] Ibid., p. 26.
[20] Long, 2001, op. cit., p. 510.

either built by damming river estuaries, or built from ground up. It was also in 1986 that the Sungei Seletar/Bedok Reservoir Scheme was completed. This involved the simultaneous building of two reservoirs, a water catchment plant, and a network of storm collection depots.[21]

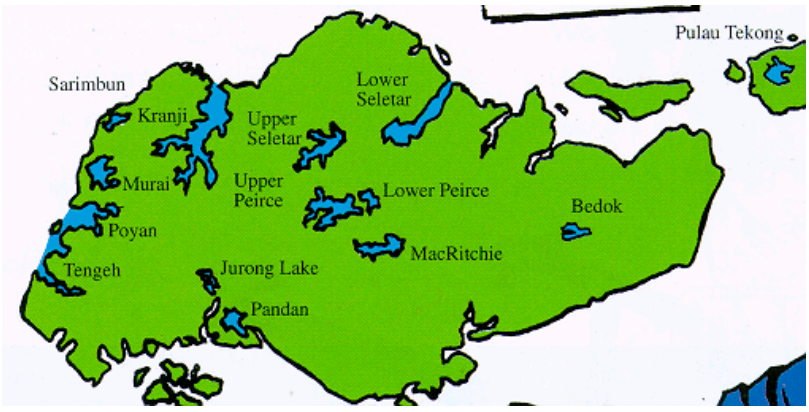
At the Lower Seletar Reservoir, there are plans to create new reservoirs downstream. The development of such reservoirs downstream of the existing Lower Seletar Reservoir to tap water from the north-eastern coast of Singapore operates under the Seletar Serangoon Reservoir Scheme under the PUB. The first stage is scheduled for completion by 2006 while the second stage is scheduled to be completed by 2008. Singapore also plans to continue with the construction of stormwater collection depots, as these serve to collect water in urban areas, a proven case in point is the Sungei Seletar/Bedok Reservoir Scheme.

Table 4: Singapore's Reservoirs and Storage Capacity

Name of Reservoir	Year Completed	Storage Capacity (million m^3)
MacRitchie	1867 (enlarged in 1894)	4.2
Lower Pierce	1912	2.8
Seletar	1935 (enlarged in 1969)	24.1
Upper Pierce	1974	27.8
Kranji/Pandan	1975	22.5
Western Catchment	1981	31.4
Bedok/Sungei Seletar	1986	23.2
Total		142.0

Source: Adapted from Table 6 cited in Segal (2004) with date amendments.[22]

Figure 1: Map of Singapore's Reservoirs



Source: Map from Public Utilities Board cited in http://homepage.mac.com/voyager/NoPlace/ctlb.html

Singapore is working on increasing its domestic reservoir catchment areas to around two-thirds of the island state from the present half. This will occur when the Marina

[21] Ibid..
[22] D. Segal, *Singapore's Water Trade with Malaysia and Alternatives*. Masters Thesis submitted to John F. Kennedy, School of Government, Harvard University, March 30, 2004.

Reservoir is completed in 2007/2008 and also upon the completion of the first stage of the Seletar-Serangoon Reservoir in 2006. Singapore has embarked on the Reservoir Integration Scheme to connect the various reservoirs through a system of pumps and pipelines when the system is complete. Excess water collected from one reservoir will be pumped into another for storage, therefore reducing the wastage of such water. This scheme is scheduled for completion in 2006.

In June 2004, tenders have been called to convert the Marina Basin into Singapore's fifteenth reservoir. It will be the first reservoir to be created within the city. [23] On the drawing board are plans to convert Marina Basin into a freshwater reservoir, estimated to cost between S$250 million to S$300 million. In addition, the dam at Marina Basin will be used to prevent flooding and to encourage water sports, prompting the PUB to call it the 3-in-1 Marina Barrage.

The Marina Reservoir, formed behind the Marina Barrage across the 350 metres-wide Marina Channel, will have inflatable dams and steel gates built across to act as a tidal barrier and also to keep the water level at the Marina Basin constant. As such, there will be three functions performed by the 3-in-1 Marina Barrage project. The first will be to create a water reservoir. The second would be to act as a tidal barrier to prevent flooding. The third would be to provide an avenue for water sports and recreation to be undertaken in the area.

The PUB has said that it will take around one to two years to flush all the seawater out after the barrier has been built. In addition, the technology used to process recycled water (NEWater) will be used in this reservoir to ensure that the water that flows into it from the Singapore River and Rochor Canal is as pristine as that of protected reservoirs. The project director, Mr Yap Kheng Guan, also said that the technology used in this basin is unlikely to result in an increase in the price of water. The Marina Reservoir Scheme is scheduled to be completed by 2007.

- *Water from Malaysia*

An important source of water supply from Singapore comes from the state of Johore in neighbouring Malaysia. Malaysia began supplying water to Singapore in 1932, five years after the first water agreement was signed in 1927, and three years after the Gunong Pulai Scheme was only completed. Between 1937 and 1941, Gunung Pulai's treatment capacity doubled. A subsidiary reservoir feeding the Pontian Reservoir in Johore was also completed.

- *The Water Agreements*

The 1927 Agreement, in full, is known as "The Agreement as to Certain Water Rights in Johore between the Sultan of Johore and the Municipal Commissioners of the Town of Singapore signed on 5 December 1927" (extracted from the Administration Report of the Singapore Municipality for the year 1927). Both Malaysia (Johore) and Singapore were then colonies of Britain and British protectorates.

[23] K.Y. Wong, "Singapore's Experience in Water Resource Management", *Forum on Water Issues in Southeast Asia: Present Trends and Future Directions*, 16-17 August 2005, Singapore: Institute of Southeast Asian Studies, p. 5.

The 1927 Agreement was signed three years after the completion of the causeway between Singapore and Malaysia in 1924. In the 1927 Agreement, Singapore did not have to pay for raw water, although rent was paid for the land surrounding where Singapore was to exercise the full and exclusive rights to impound, treat, and store water. In addition, Singapore was responsible for building, paying, and maintaining the infrastructure that was used to impound, process and transport water. The 1927 Agreement was succeeded by the 1961 Water Agreement. This Agreement was subsequently replaced by the 1961 Gunong Pulai/Pontian Tebrau River and Scudai River Water Agreement.

Presently, water supplies are guaranteed by the 1961 and 1962 Water Agreements. These agreements are in force up to 2011 and 2061 respectively.[24] The 1961 Water Agreement is known as the "Tebrau and Scudai Water Agreement", while the 1962 Agreement is referred to as the "Johor River Water Agreement". Both Agreements have been confirmed and guaranteed by the governments of Singapore and Malaysia as part of the 1965 Separation Agreement, and lodged with the United Nations.

The 1961 agreement allows Singapore to draw up to 86 million gallons of water per day (mgd) from the Pontian and Gunung Pulai Reservoirs, as well as the Tebrau and Skudai Rivers, while the 1962 agreement allows up to 250 mgd of water to be drawn from the Johor River. In total, these agreements allow Singapore to draw up to 336 mgd (1.53 million m^3 per day).

In these Agreements, Singapore pays Malaysia (the Johor Government) 3 cents (RM 0.03) for every 1000 gallons (4,546 m^3) drawn from the rivers.[25] In turn, the Johor Government pays Singapore 50 cents (RM 0.50) for every 1000 gallons of treated water.[26] Both also contain a provision that allows for a review of water prices in 25 years time,[27] and arbitration in the event of a disagreement.[28] Prices can be revised in line with the purchasing power of money, labour costs, and cost of power and materials used to supply water.[29] Malaysia (Johore) did not revise water rates in 1986 and 1987 because it had to purchase treated water from Singapore. If the Johore government raised the price of raw water, it would concurrently have to pay dearer prices for the treated water it buys from Singapore.[30]

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[24] Collectively known the Johore Water Agreements. The first was the "Agreement made on 1st September 1961 between the Government of the State of Johore and the City Council of the State of Singapore relating to the use of water from the Tebrau River and the Scudai (Skudai) River. The second was the "Agreement made on 29th September 1962 between the Government of the State of Johore and the City Council of the State of Singapore relating to the use of water from the Johore River. Singapore was then a state in then Malaya (now Malaysia).

[25] Section 16 (i) of the 1961 and Section 13 (1) of the 1962 Agreement.

[26] Section 16 (ii) of the 1961 and Section 13 (2) of the 1962 Agreement.

[27] Section 17 of the 1961, and Section 14 of the 1962 Agreement.

[28] Section 17 of the 1961, and Section 17 (iii) of the 1962 Agreement.

[29] Section 17 of the 1961 and Section 14 of the 1962 Agreement.

[30] This view was expressed in 1987 and reiterated by Dr Mahathir in October 2002. Dr Mahathir said that Malaysia did not revise (increase) prices 15 years ago because it was believed that Singapore would respond by increasing the price of treated water sold to Malaysia (The New Straits Times, 12 October 2002). However, there could also be other possible explanations why prices were not revised in 1986 and 1987. Recall that there were domestic issues plaguing the country in the mid 1980s like the short but severe recession, and also *Operasi Lalang* in 1987 which diverted the attention of the Federal Government towards consolidating its rule rather than focussing on an issue like the revision of water prices. See Loh, F.K.W., "Developmentalism and the Limits of Democratic Discourse" in Loh, F.K.W,

- *NEWater and Desalination*

It must also not be forgotten that Singapore has been exploring the possibility of recycling water (NEWater) since 1988 and such plants have already begun supplying water to Singapore's reservoirs since 2003 (see Table 2 above).

Recycled water, also known as NEWater, is similar to distilled water. Not only is it clean enough for drinking, it is mixed with reservoir water so that it will not be "too clean" for drinking. Singapore experimented with recycling water back in the 1970s when it began treating its sewage instead of dumping it out to the sea. This was back in 1974. The first test recycling plant was however closed in 1975 because it was expensive and unreliable.

A new water reclamation study was conceptualised in 1998 as a joint initiative between the PUB and the Ministry of the Environment (ENV). The prototype plant began operations in May 2000; located on a site downstream of the Bedok Water Reclamation Plant (formerly known as Bedok Sewage Treatment Works). The plant produced 10,000 m^3 (2.2 million gallons) of water per day, and had to undergo a sampling and monitoring programme for two years before an expert panel concluded on its robustness and reliability.

Not only did the plant pass the physical and engineering tests but the quality of NEWater was found to be in line with parameters and standards set by the US Environmental Protection Agency and the World Health Organisation. This verdict was arrived after some 20,000 comprehensive chemical and microbiological tests and analyses were conducted (PUB Annual Report 2002). It was found that the quality of the water produced was purer than that of potable water now produced by the PUB.

NEWater involves a three stage process comprising of filtering out elements - bacteria, viruses, and solids, passing the water through a semi-permeable membrane, and then exposing the water to ultraviolet light. The first two stages involve stringent purification and treatment processes using an advanced dual-membrane technology (micro filtration followed by reverse osmosis). Micro filtration is necessary to remove particles and bacteria larger than 0.2 microns in size. This prevents the reverse osmosis membrane from clogging. Reverse osmosis in turn removes and filters out particles as small as 0.001 microns. This includes viruses, salts, and dissolved organics. Alkaline chemicals are then added to restore the pH balance. And the membranes are cleaned with citric acid every sixty days.

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and Khoo, B.T., editors, *Democracy in Malaysia: Discourses and Practices*. Surrey: Curzon Press, 2002, pp. 38-45 for a discussion of such issues.

NEWater Treatment Process

	Stage 1	*Stage 2*	*Stage 3*	
Secondary Effluent→	**Microfiltration →**	**Reverse Osmosis →**	**UV Disinfection→**	**NEWater**
Turbidity, Inorganics, Virus, Bacteria, Protozoa, Organics	Removes Turbidity, Bacteria, and Protozoa	Removes Inorganics, Virus, Organics, any Remaining Turbidity, Bacteria, and Protozoa	Inactivates any remaining Virus, Bacteria, and Protozoa	

Source: *Towards Environmental Sustainability: State of the Environment 2005 Report Singapore*. Singapore: Ministry of the Environment and Water Resources, February 2005.

NEWater will be used primarily for non-potable purposes. Water fabrication plants which require high grade water will be one of the industries using NEWater. NEWater will become the primary source of water for Singapore's industrial and commercial sectors. Semiconductor and water fabrication plants, and some air conditioning cooling towers have begun using NEWater since February 2003. NEWater which is purer than tap water is more cost-effective for these firms as they save money on further treatment needed to produce water of an ultra-pure quality. The present production costs of NEWater is around 50 to 60 percent less than that of treating seawater.[31]

Although NEWater is safe to drink on its own, the Government has decided to allow such water to be treated before being piped to homes. Initially, two million gallons (9,092 m^3) per day will be blended with raw water supplies in reservoirs (less than one percent of the total raw water), but this would gradually be increased to ten million gallons (45,460 m^3) per day by 2011, eventually making up 3.5 percent of Singapore's daily drinking water consumption. In January 2005, the PUB lowered the price of NEWater to S$ 1.15 per m^3.[32]

The Singapore Government has also stated that the Republic will be able to partly replace quantities of water imported under the 1961 Agreement with NEWater. Presently, the three NEWater plants at Bedok, Kranji, and Seletar respectively produce 6mgd, 5mgd, and 9 mgd on a daily basis, totalling 20 mgd. By end-2006, the Ulu Pandan Plant will be producing 25mgd.[33] The fourth NEWater plant is the first plant that is to be offered to the private sector to design, construct, and operate.

By 2011, Singapore plans to supply 55 mgd of NEWater for non-potable use, and 10 mgd for indirect potable use. Potentially around 20 percent of Singapore's water supply could be met through this means. The first two NEWater plants supply water to the wafer fabrication plants, industries, and commercial buildings at the eastern and northern parts of Singapore. The Seletar Plant, on the other hand, serves Ang Mo Kio and Serangoon at the north-eastern part of Singapore.

Singapore also supplements its water supply through its desalination programme. The PUB has been assessing desalination technologies since the 1970s.[34] The merits of

[31] "Four Big Taps will Keep Water Flowing", *The Straits Times (Print Edition)*, 23 May 2005.
[32] PUB Annual Report, 2005
[33] *Towards Environmental Sustainability: State of the Environment 2005 Report Singapore*. Singapore: Ministry of the Environment and Water Resources, February 2005, p. 19.
[34] "Singapore Scores Milestone with Completion of 1st Desalination Plant", *channelnewasia.Com*, 12 September 2005. <http://www.channelnewsasia.com> Retrieved on 21 September 2005, and "PM Lee

desalination was pursued by the PUB as far back as in 1985. For a decade, high costs have nevertheless prevented this venture from fully bearing fruit. It was only in 1995 that Singapore ascertained that desalination was technically feasible and financially viable, after conducting study trips to plants in Saudi Arabia, the United Arab Emirates, and Malta. Subsequently, in 1996, the PUB started exploring potential sites for building such plants. By 1998, Singapore had also built a test desalination plant, a joint effort between Singapore Power, AquaGen, and Singapore Technologies.

Then, projecting for Singapore's future water needs, it was reported that the PUB was planning to build a S$900 million plant to begin production in 2005. Initially, the construction of the proposed plant by the PUB was to be based on multi-stage flash (MSF) distillation technology. But recent developments suggest that MSF is not likely to be adopted in the construction of the plants as newer technologies like reverse osmosis (RO) and multi-effect distillation (MED) have proven to be the more cost-effective alternatives.[35]

Originally, tenders were called to supply about 20 mgd by 2005, with the PUB supplying 10 mgd. In 1999, the Government decided instead to just involve the private sector participation in the venture. Conditions were then laid down to include building a plant capable of desalting 140,000 m^3 (30.8 million gallons) of water daily by 2005 and for tenders to supply the whole amount.

In June 2002, from the tenders submitted to the PUB in Singapore, estimated costs of processing sea water ranged from US $0.44643 or S $0.78126 per m^3 (RM 7.42/4.546 m^3) to US $0.80286 or S $1.4050 per m^3 (RM 13.34/4.546 m^3).[36] Cost estimates have varied markedly because of the different range of methods chosen to desalinate water. The contract was ultimately won by SingSpring (a consortium consisting of local water specialist Hyflux and foreign French water-treatment company Ondeo (Ondeo Services and Ondeo Degremont). In June 2003, Hyflux took over Ondeo's stake in Singapore's desalination project, making it the sole owner of the desalination plant when it is completed in 2005.

On 13 September 2005, SingSpring, a subsidiary of Hyflux commenced operation of the first desalination plant in Singapore (costing S$ 200 million, with a capacity to produce 30 mgd (or 136,000 m^3 per day), about 10 percent of Singapore's daily water needs.[37] By 2011, it is estimated that the desalination programme will produce around 30 percent of Singapore's water requirements, of around 88 mgd (400,000 m^3).[38]

Opens Asia's Largest Water Desalination Plant in Tuas", *channelnewasia.com*, 13 September 2005. <http://wwwchannelnewsasia.com> Retrieved on 21 September 2005.

[35] Both MSF and MED are based on evaporative desalination techniques, with MSF being the more common and mature technology (albeit more costly method due to its higher energy consumption). MED requires less energy than MSF as it uses a different method of evaporation and heat transfer where evaporation is from a seawater film in direct contact with the heat transfer surface. In MSF, a convective heating of seawater occurs where "flash" evaporation takes place from brine flowing across the bottom of the stage. RO is based on passing seawater through filter membranes which remove suspended particles and salt. RO also uses less energy per m^3 of production compared to general MSF and MED desalination technologies.

[36] "Desalination Plant Gets Four Bids", *The Straits Times (Printed Edition)*, 1 June 2002.

[37] Ibid., and *Towards Environmental Sustainability: State of the Environment 2005 Report Singapore*, p. 19.

[38] Long, op. cit., p. 518.

- *Negotiations for Water*

In July 2002, Singapore stated that it will allow the 1961 agreement to lapse when it expires in 2011. It will be acquiring that amount domestically rather than importing it from Johore.

Since 2004, because of the policy of "quiet diplomacy" not much has been reported to the media on the details of the bilateral negotiations ongoing between Singapore and Malaysia. The Badawi era has nevertheless fostered a more amiable environment with negotiations proceeding with less ostensible fanfare with the resolve to look ahead and not allow old issues to affect bilateral cooperation.

There has also been substantive developments in economic cooperation between the two countries. Petronas has signed a Gas Services Agreement (GSA) with Keppel Engineering in June 2005 worth around $ 3 billion, to supply gas to Singapore through a new pipeline. In September 2005, Health care giant, Parkway Holding in Singapore paid about SGD 139 million for a 31 percent stake in Pantai Holdings, Malaysia's largest private health-care provider. Telekom Malaysia and Khazanah Nasional bought a 12.1 percent stake of Singapore's telecommunication giant, M1 in August 2005. In February 2005, Singapore's investment company, Temasek Holdings and its Malaysian partner purchased a controlling 15.4 percent interest in MPlant which wholly owns Alliance Bank.

- *Self Sufficiency*

Singapore is now moving closer and closer towards achieving self-sufficiency in water.

This, however, begs the question: would Singapore's population increase by 2011 create undue pressures on its future production capabilities? Educated guesses have reported that Singapore consumes between 1.2 to 1.4 million m^3 (264.2 to 300 thousand gallons) of water per day.[39] That water consumption will not increase dramatically, can be supported by data from the Public Utilities Board which indicates that water consumption per head has, in fact, fallen in recent years: from 165 m^3 in 2002 to 162 m^3 in 2004 (See Table 1 above). Drastic population increases are also unlikely to occur. Total fertility rates have decreased from 1.7 in 1996 to 1.4 in 2001, with Singapore's population (citizens and permanent residents) projected to hover around 3.3 million in 2010.[40] Total population will not climb above 4.3 million by 2010, assuming that the number of foreigners remain between 800,000 to 1,000,000. Compared to the present population of around 4.1 million in 2001, this projected figure suggests that any additional pressures created on water production should be manageable in 2011.

By 2011, together with water from its reservoirs, desalination, and recycling plant, Singapore should no longer be in the dire straits condition that has plagued the country (see Table 5 below).

[39] See Kog, op. cit., 2002, p. 36; and Long, 2002, p. 131.
[40] S.H. Saw, *The Population of Singapore*. Singapore: Institute of Southeast Asian Studies, 1999, p. 229.

Table 5: Major Sources of Water (Per Day)

Total Water Requirement for Singapore		1.2 to 1.3 million m^3 (264 to 286 million gallons
Domestic Reservoirs and Catchments (a)	**0.68 million m^3 (149.58 million gallons)**	
Desalination (b)	**0.40 million m^3 (88 million gallons)**	
NEWater (c)	**0.55 million m^3 (121 million gallons)**	
Total: a+b+c		**1.63 million m^3 (358.58 million gallons)**

Source: Long (2002); The Straits Times, Various Issues.

Table 6 provides expenditure based on Singapore sourcing its entire water supplies domestically through its own reservoirs, NEWater plants, and desalination.[41] This would compare to around RM 4,000 million if water was sourced from domestic reservoirs and from Malaysia. Self sufficiency may not be that high a price to pay, if such is the cost.

Table 6: Year 2011 Expenditure with Water Sourced Domestically (at 2002 Prices)

Sources of Water	**Volume (million m^3)**	**Cost (RM million)**
Water from Reservoirs and Catchments	0.68	1,632 (0.68*2.4)
Desalination Plants	0.40	2,968 (0.4*7.42)
NEWater Plants	0.55	2,041 (0.55*3.71)
Total	1.63	6,641

Note: Calculations based on data obtained from published newspaper sources. Figures on the cost of desalination (RM 7.42/4.546 m^3) is based on the price of the lowest tender submitted to the PUB. This was obtained from the Straits Times, 1 June 2002. The cost of producing NEWater approximates fifty percent of the cost of desalination (Straits Times, 30 July 2002). Based on the lowest cost of desalination, NEWater would cost RM 3.71/4.546 m^3. Costs may decrease further when cheaper technologies come into play.

- *Conclusion*

A delicate balance is needed for Singapore to manage its water requirements in the coming years ahead. For strategic reasons and its own national interests, Singapore must ensure that it has the capacity to be self-sufficient in meeting its water needs. For economic reasons, however, it also has to consider the least-cost option of meeting such requirements. There is therefore this trade-off between the strategic need to be self-sufficient, and the economic need to acquire (import) water supplies at a lowest cost but with greater vulnerability.

[41] Figures taken from P.O. Lee, "The Water Issue Between Singapore and Malaysia: No Solution in Sight?", Economics and Finance No. 1 (2003), ISEAS Working Papers, Singapore: Institute of Southeast Asian Studies, 2003 and P.O. Lee "The Singapore-Malaysia Water Issue: Trade-Off and Alternatives", *Regional Outlook: Southeast Asia 2003-2004*. Singapore: Institute of Southeast Asian Studies, 2003, pp. 80-81.

History, security, and economic factors have all played a part in influencing Singapore's water management strategy. Previously, when Singapore was part of Malaysia, it had a "hinterland" to supply part of water requirements. Since separation in 1965. this could no longer be taken as a given, although Malaysia is still legally bound by the Water Agreements of 1961 and 1962 to supply over water to Singapore and has been doing so.

Economic costs have in the past been that has prevented Singapore from achieving self-sufficiency. Given the more cost-effective technologies present at the moment, the likelihood of achieving self-sufficiency is very much on the horizon and Singapore has been moving towards that direction. Singapore's water management strategy in the coming years will likely incorporate acquiring water from newer technologies like recycling (NEWater) and desalination, and also from its domestic reservoirs (and imported water should a new agreement come into play after 2061 when the Second Water Agreement with Malaysia expires).

Abbreviations

mgd	million gallons per day
RM	Ringgit Malaysia (Malaysian Currency)
S $	Singapore Dollar

Unit Conversion

1,000 gallons	4.546 m^3
RM 2.09	S$ 1