

# Singapore

## Country background

The Republic of Singapore is an island city-state in southeast Asia, situated at the southern tip of the Malay Peninsula, south of the Malaysian state of Johor and north of the Indonesian Riau Islands. It consists of the main island of Singapore, with Jurong Island, Pulau Tekong, Pulau Ubin and Sentosa being the largest of many smaller islands. The country lies just 137 km north of the Equator at latitude 1° North and longitude 104° East. (*See Appendix 1 -- Map of Singapore*). The island is connected to the state of Johor in Malaysia by a rail and road causeway completed in 1923, and a more recent road bridge.

With a population of over 4.35 million people living on a land area of 697.1 km<sup>2</sup> Singapore is one of the most densely populated countries in the world. It is also highly urbanised and in recent decades the government has constructed many new towns, resulting in an almost entirely urban landscape, requiring extensive land reclamation to accommodate the growing population.

Most of the country is less than 15 m above sea level, with the highest point (Bukit Timah) rising to 164 metres. Hills and valleys of sedimentary rock dominate the northwest of the island, while the eastern region consists of flatter, sandy land.

Because of its geographical location close to the equator Singapore has a tropical rainforest climate with no distinct seasons, and is characterised by uniform temperature and humidity and abundant rainfall, averaging 2,345 mm per annum. With the higher ground being on the western portion of the island, this region also experiences greater rainfall, leaving the eastern side both drier and hotter. Rainfall also varies with the passage of the monsoons, firstly the Northeast monsoon from December to early March, and later by the Southwest monsoon, which occurs from June to September. Between the monsoon periods the climate is drier. Despite the adequate rainfall, Singapore has no natural lakes or rivers.

## Water resources and supply

Without these natural lakes and rivers the primary domestic source of water is rainfall collected in reservoirs or catchment areas. Rainfall collected this way accounts for approximately half of Singapore's water needs with the remainder being imported from Malaysia, as well as from alternative sources from NEWater plants, and from desalination plants. NEWater is high grade reclaimed water produced using advanced membrane technologies. The NEWater quality is well within World Health Organisation drinking water guidelines and United States Environmental Protection Agency Drinking water standards. NEWater which is supplied to industries for non-potable use and for indirect potable use has been such a success that the government has commissioned three plants around the island (with the fourth plant to be operationally ready by end 2006) to meet demand. The current demand for potable water is approximately 1.3 million cubic metres per day.

The reservoirs include the central catchment areas which were enlarged during the 60's and 70's and provide protected catchments with good raw water quality, and the estuarine reservoirs that are large impounding reservoirs created in tidal estuaries. Here polluting industry and activities have been either relocated away from the reservoirs, or are subject to additional treatment processes and stringent pollution control measures.

Supplementing the collection of rainfall in catchment areas are stormwater collection systems that capture the high-intensity and short duration storm runoff from the urban areas. There are strict controls on land use in these areas through a coordinated and integrated approach to town planning. In addition only the cleanest stormwater is abstracted and pumped to the reservoirs.

The desalination plant on the western coast of Tuas, commissioned in September 2005, is capable of supplying up to 30 million gallons of drinking water a day for 20 years. This reverse osmosis plant was constructed by the private sector under a design, build, own and operate (DBOO) arrangement.

With water such a precious commodity in Singapore, efforts to conserve water supplies have also been introduced, including water accounting by metering to reduce "unaccounted for" water, improvement in piping systems to reduce leakage, and a programme of replacement and rehabilitation of water mains.

Programs of public education regarding conservation measures, partnering the community in protecting water catchments, promoting the reuse and recycling of water, the installation of water saving devices, and the use of audits and taxation measures have been integrated to reduce further the wastage or overuse of water.

The quality of supplies has also been improved by the adoption of multi-barrier principles in treatment practices, including the protection of catchments, the use of rapid sand filters, disinfection by chlorine and ozone, and the use of activated carbon and membrane filtration systems.

The WHO/UNICEF Joint Monitoring Programme in its Country, Regional and Global Estimates on Water & Sanitation gave a 2002 estimate for Singapore as shown below:

Population			Improved Drinking Water Coverage						Improved Sanitation Coverage		
			Total		Urban		Rural				
Total (thousands)	Urban %	Rural %	Total %	Household Connection %	Total %	Household Connection %	Total %	Household Connection %	Total %	Urban %	Rural %
4,183	100	0	-	-	100	100	-	-	-	100	-

Singapore reports that its estimated population of 4,351,400 is completely urbanised, with the entire population having access to both improved sanitation, and to improved drinking water through household connections.

### Water and Health

Potable water has been fluoridated since 1958 as part of a programme to fight dental decay and tooth loss in the population. This has helped reduced dental caries by about 30%

### Pressures on resources and supply

Light industry in Singapore tends to be distributed around the island in industrial estates, and heavy industry is located around Jurong and Jurong Island while urban housing is designed to produce little or no pollution.

All domestic and industrial premises are connected through the public sewerage system and kept separate from the drainage system. The wastewater is treated to a high standard before discharge. The Deep Tunnel Sewerage System (DTSS) was conceived as a long term solution to meet the

needs for used water collection, treatment and disposal to serve the development of Singapore through the 21st Century. Phase 1 of the DTSS is expected to be completed in 2008.

Solid wastes are managed by classification into domestic or trade waste, and industrial wastes. The majority (87.5%) is incinerated while the remainder is used for landfill. There are currently four incineration plants and an offshore landfill at Pulau Semakau.

### **Water quality surveillance and monitoring**

There is an Integrated Water Quality Management System, including a comprehensive water quality monitoring programme; source control measures and monitoring; research and development on water quality; and a water quality data management system to ensure safe drinking water is delivered to Singaporeans at all times.

The comprehensive water quality monitoring program consists of regular testing of water samples taken from raw water sources, treatment plants, reservoirs and selected points in the distribution network.

The monitoring of raw water quality is undertaken from streams, ponds and reservoirs in catchment areas and the parameters assessed to determine long-term quality trends to gauge the impact of urbanisation, the effectiveness of measures in place, and whether changes to treatment processes are required. Tests are also conducted to ensure that waste water is not discharged into water courses used for drinking water supplies, and that the water body remains environmentally healthy.

For potable water, the quality is measured at the treatment plant outlets and service reservoirs (water storage tanks), and at sampling points throughout the distribution network. Parameters are measured regularly, and over the course of the year all parameters with values listed in the WHO Drinking Water Quality Guidelines are tested at least once. Samples are also independently tested by the Health Sciences Authority and the Singapore General Hospital. The National Environment Agency also conduct audit checks to ensure that drinking water quality meets the guidelines. The drinking water quality is well within the values set by the WHO Guidelines.

Laboratories conducting the testing are fully equipped with modern equipment capable of analysing more than 250 parameters which far exceeds the 144 parameters listed in the WHO Guidelines and the United States Environmental Protection Agency (USEPA), and they are evaluated under a national scheme to ensure technical competence based on ISO/IEC requirements.

Singapore has adopted an integrated approach to the development and management of its water supply allowing for innovative change and initiatives that enable the provision of safe water to meet the rising demand. To support this it has the infrastructure and legislation in place for environmental controls to protect raw water sources, and a comprehensive approach to water quality monitoring and the management and conservation of water.

### **Water quality standards**

Singapore has adopted the WHO Guidelines for Drinking Water Quality (2004) as the Singapore water quality standards for the interim. Notwithstanding, the Public Utilities Board (PUB), as the municipal supplier of drinking water, has set its own internal product water quality which are above the WHO guidelines. A Technical Committee has recently been formed to look into

developing a set of National Drinking Water Quality Standards for subsequent adoption by the National Environment Agency.

### **Referenced documents**

1. ***Tiew King Nyau, Charlie Tan*** “An integrated approach to provision of a safe water supply in Singapore”
2. ***Delia Teo***, International Cooperation, Ministry of Health (Singapore) (updated information)

Appendix 1 - Map of Singapore

