Urban Water Management Programme

Singapore's Approach to Water Sustainability

Workshop Organised by
Ministry Of Housing & Urban Affairs-MOHUA
in coordination with
Singapore Corporation Enterprise-SCE

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Workshop #1 Understanding of Urban Water Cycle including Treatment and Network Management, and Stakeholder Engagement through sharing Singapore Experience

About Singapore

734 km^2
Land Area

5.92 million
Population

2,200 mm
Annual Rainfall

Singapore in Early days

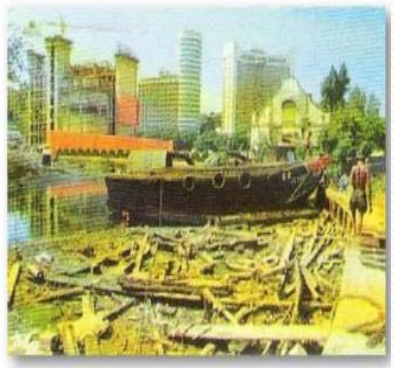
"Singapore … at the 170th position among a list of 190 countries in terms of freshwater availability." - United Nations World Water Development Report, 2002

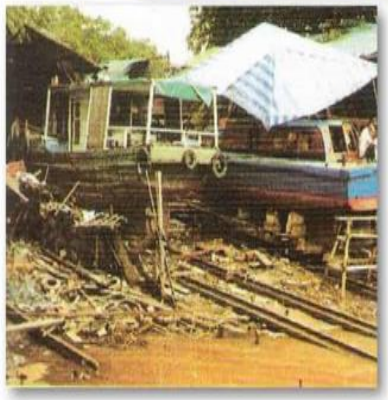
1960's

Water resources were scarce…

Last water rationing in 1963

And rivers were polluted.





Water is a National Priority for Singapore

4 National Taps

Over the past 50 years, Singapore has built a robust and diversified supply of water to meet **rising water demand** through our **4 National Taps:**

WATER FROM LOCAL CATCHMENT

Singapore's 15th Reservoir, Marina Reservoir, has 3-in-1 benefits and was officially opened in 2008

IMPORTED WATER

Singapore imports water from Johor, Malaysia

NEWATER

Singapore's 5th NEWater Factory, Changi NEWater Factory 2, commenced operations in 2017.

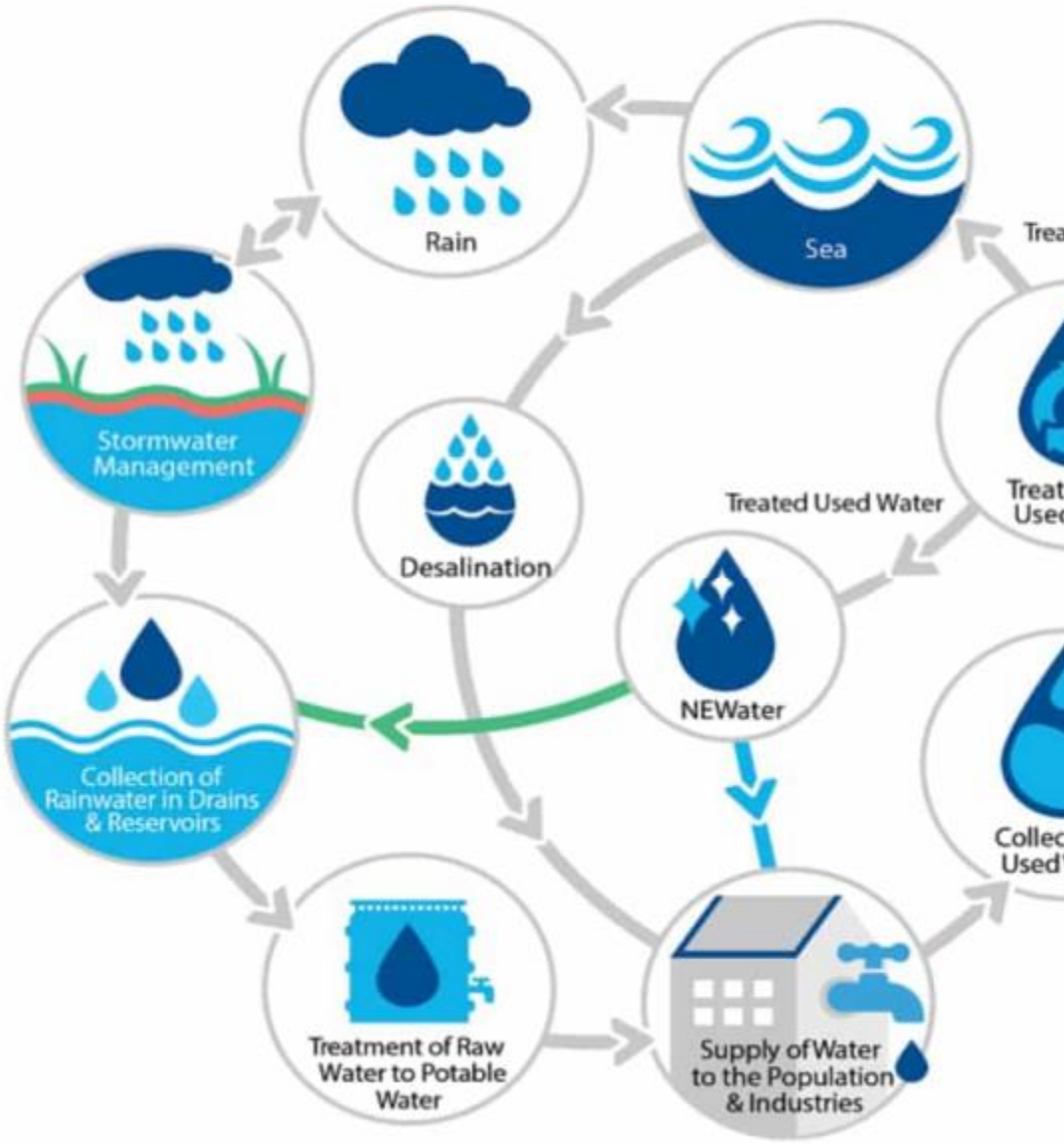
DESALINATED WATER

Singapore's 5th desalination plant, Jurong Island Desalination Plant, commenced operations in April 2022.

PUB- Singapore's National Water Agency

anages the Entire Water Cycle

rcing, collection, purification
pply of drinking water, to
treatment of
water and turning it into
er, drainage of storm water



Singapore's Approach to Water Sustainability

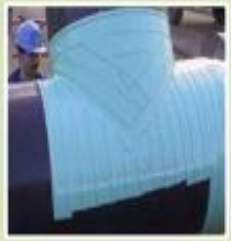
1. Robust and diversified supply of water to meet rising water demands.
2. Advanced Planning, design and construction of water supply systems
   - Pipe jacking & micro tunneling
3. PPP framework for water infrastructure projects.
4. Network loss management
   - Accurate metering
   - Proactive leak detection
   - Network management
5. legislations/Rules with regard to water supply
6. water demand management strategy
   - Pricing
   - Mandatory minimal wastage
7. Asset Management
8. SCADA System for efficient supervision.

Network Management

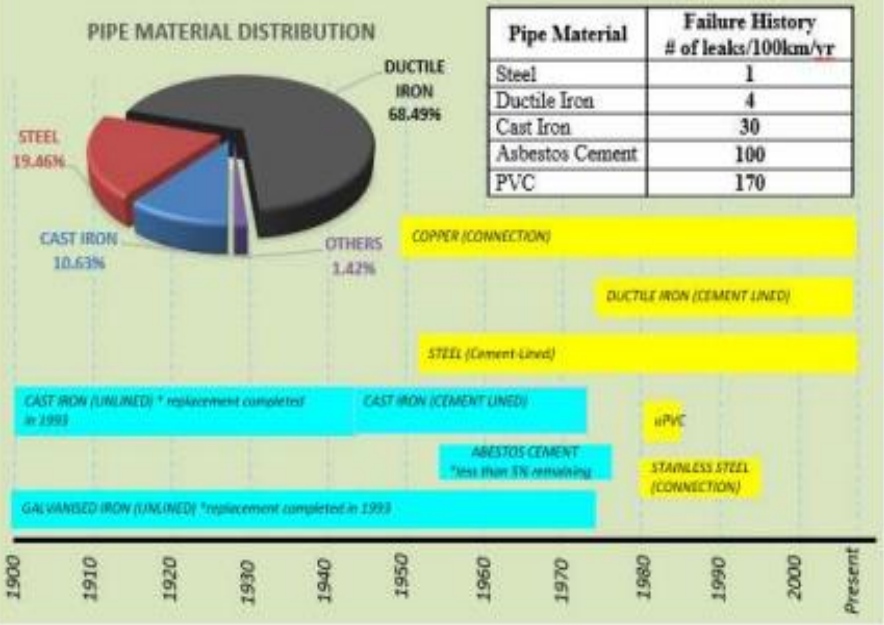
Planning, Design and Construction

- **Good planning & design** – sizing of pipes, location of valves, alternate supplies, etc
- **Strict supervision & control on workmanship**
- **Usage of Reliable Pipe Material and Coating**
  - Use PU-coating DI or ST pipe for all replacement projects

- **Application of Wrapping Material for Corrosion Prevention**
  - Prevent contact with water and oxygen



- **Use good quality / corrosion-resistant material**
  - Connections: Copper
  - Mains (100 – 300 mm): cement-lined DI
  - Mains (≥ 700 mm): cement-lined steel



Pipe Material	Failure History # of leaks/100km/yr
Steel	1
Ductile Iron	4
Cast Iron	30
Asbestos Cement	100
PVC	170

Proactive Leak Detection

Preventive and Proactive Leak Management Framework

Distribution Mains (<500mm)

Noise Loggers

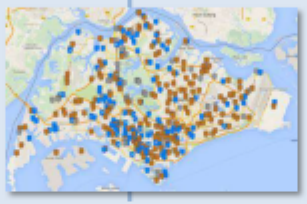
Correlators

Mobile Phone Sensors

Permanent Leak Detection Sensors

500 sensors

Real Time Digital Twin (WaterWise)



~480 sensors

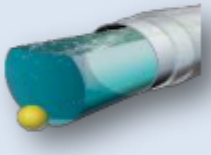
Transmission Mains (>=500mm)

Permanent Leak Detection Sensors

Daily Monitoring

1200 sensors

Invasive Leak Detection Tools



Inline Pipe Inspection

100km/yr

Key Benefits of Early Leak Detection:

- Less unplanned disruption to stakeholders
- Reduce water loss
- Small leaks, less costly repair

Leak Detection Technologies

Smartphone Sensor

Sensitive smartphone listening device that provides results accurately and faster than conventional methods

- MINIMAL TRAINING REQUIRED
- QUICK AND ACCURATE READINGS
- SENSITIVE AND PRECISE DETECTION TOOLS

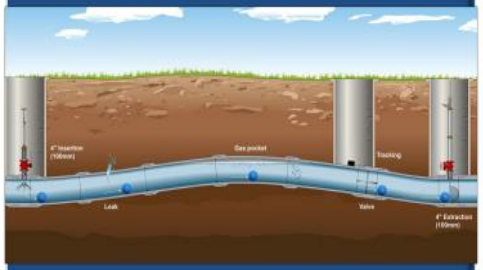
Permanent Sensors

Sensors are deployed along critical and sensitive stretches of mains for regular leak monitoring

- 750M RANGE
- DAILY MONITORING
- LOCALISING WITHIN +/-3M

Invasive Tools

Sensitive and precise leak detection tool that can be deployed under live condition, targeted for water loss reduction



- 15KM RANGE
- DETAILED ANALYSIS
- MOST SENSITIVE AND PRECISE, LOCALISING WITHIN ±2D

Water from Malaysia – The Johore river waterworks (JRWW)

The Singapore drinking water distribution network and reservoirs

- Treated water form JRWW is pumped to Singapore through major pipelines;
- After crossing the causeway, these inject into the complex Singapore water distribution system, comprising pipework and service reservoirs;
- Drinking water from all Singapore waterworks and JRWW is mixed and distributed to homes and industry throughout the island by gravity

NEWater Production Process

Treated Used Water

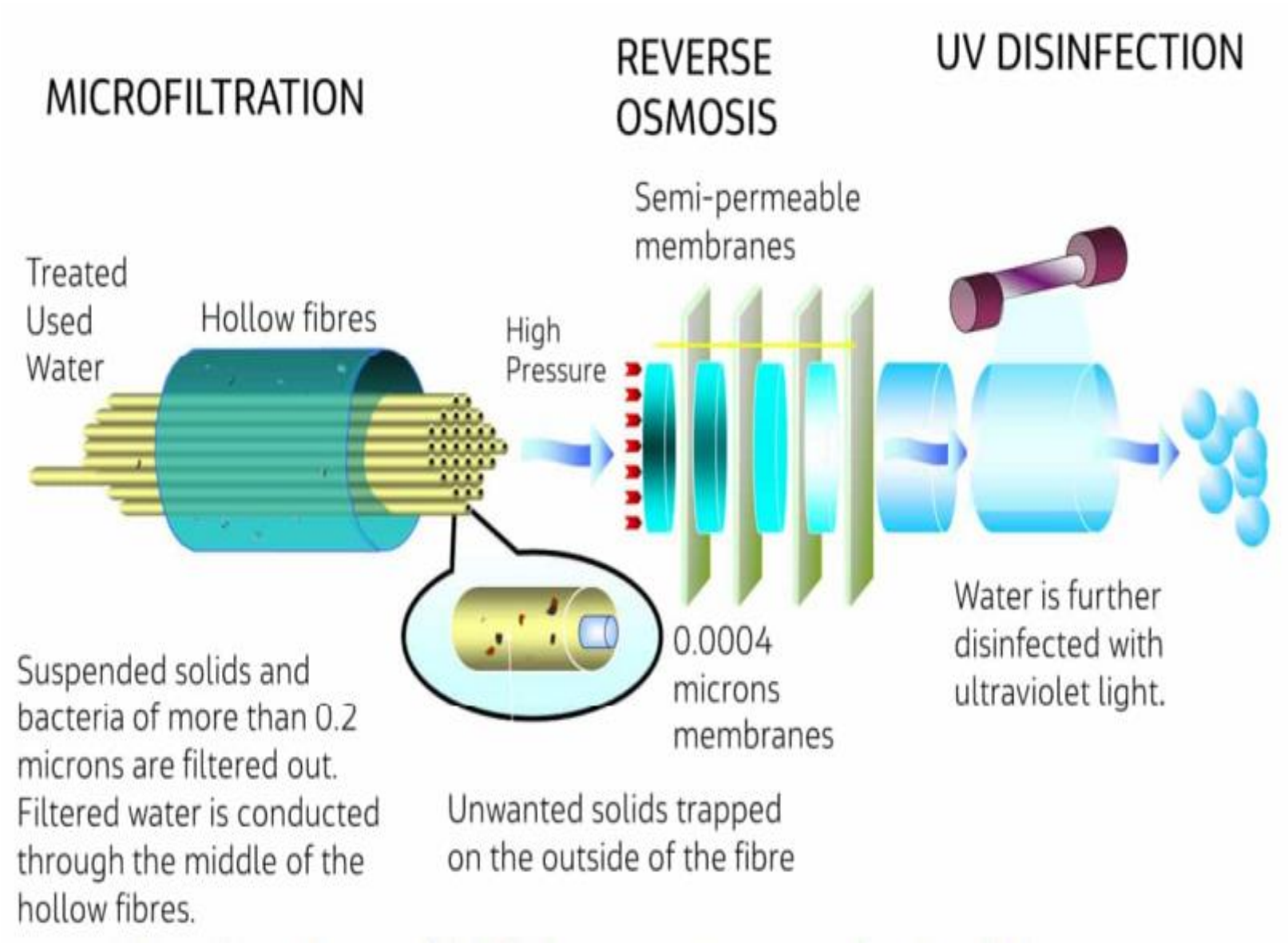
NEWater

Microfiltration / Ultrafiltration

Reverse Osmosis

Ultraviolet Disinfection

NEWater (Recycle and Reuse of treated used water) – Tech

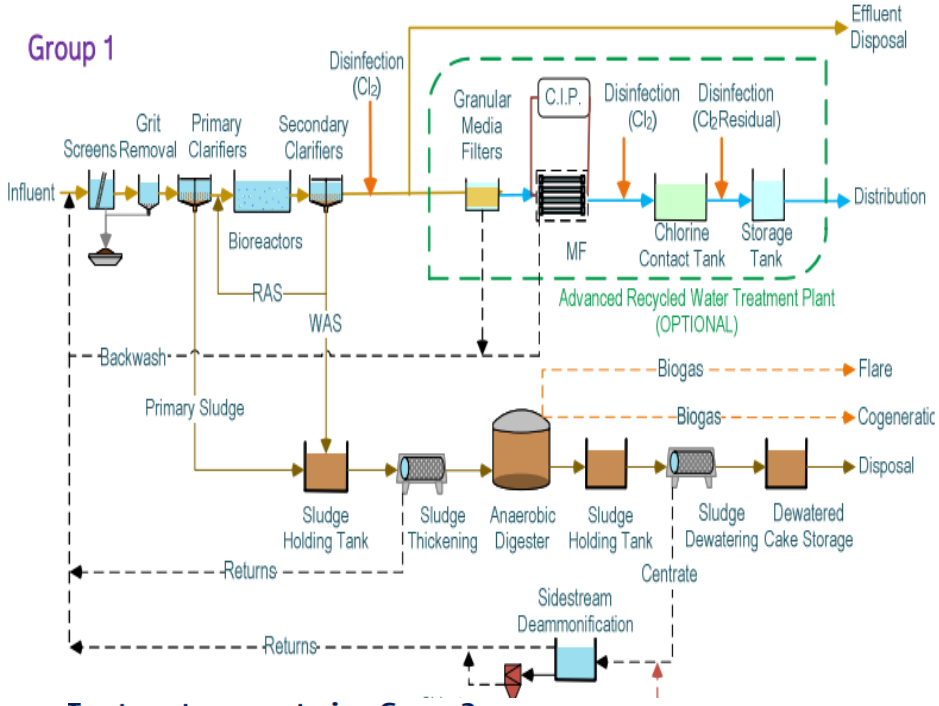

MICROFILTRATION
REVERSE OSMOSIS
UV DISINFECTION
Semi-permeable membranes
Treated Used Water
Hollow fibres
High Pressure
Suspended solids and bacteria of more than 0.2 microns are filtered out. Filtered water is conducted through the middle of the hollow fibres.
0.0004 microns membranes
Unwanted solids trapped on the outside of the fibre
Water is further disinfected with ultraviolet light.

Selected WRP Technologies

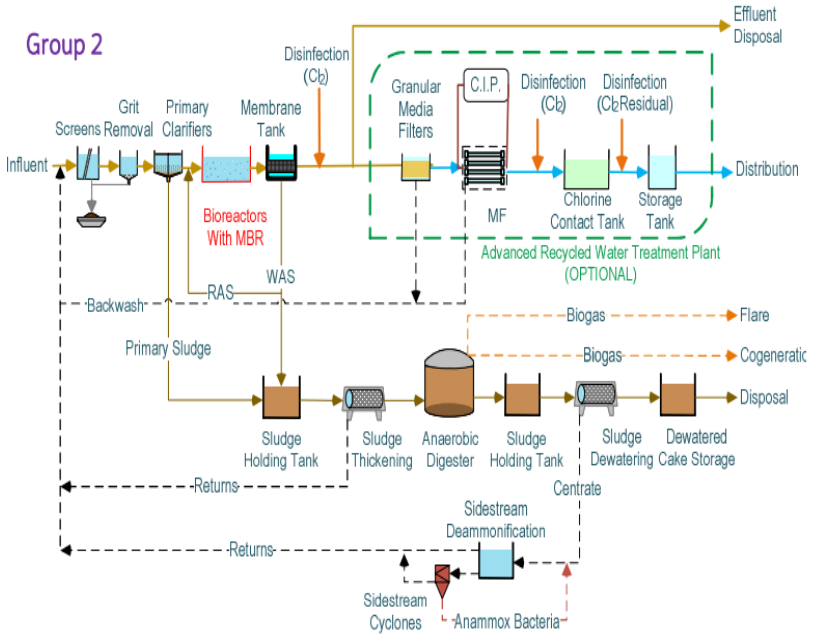
Group	Process	Technology	Objectives Achieved
1	Primary	Primary clarification	• Treated used water target • Energy saving • Energy producing • Biosolids volume reduction • Biosolids recovery for beneficial reuse
	Secondary	Conventional BNR	
	Biosolids Treatment	Anaerobic digestion	
	Other	Sidestream deammonification as return stream treatment	
2	Primary	Chemically enhanced primary treatment	• Treated used water target • Minimal land footprint • Energy saving • Energy producing • Biosolids volume reduction • Biosolids recovery for beneficial reuse
	Secondary	MBR if additional land purchase is required / IFAS	
	Biosolids Treatment	Advanced anaerobic digestion	
	Other	Sidestream deammonification as return stream treatment	
3	Primary	No primary treatment	• Treated used water target
	Secondary	Conventional BNR	
	Biosolids Treatment	Aerobic digestion	
	Other	-	
4	Primary	No primary treatment	• Treated used water target
	Secondary	MBR if additional land purchase is required / IFAS	
	Biosolids Treatment	Aerobic digestion	
	Other	-	

- The economic and environmental analysis of full-scale projects indicate that the RO-based treatment trains are more costly and more energy intensive than the Ozone-BAC-UV Disinfection based treatment train, especially at inland locations where reverse osmosis concentrate disposal is difficult and can be very expensive.

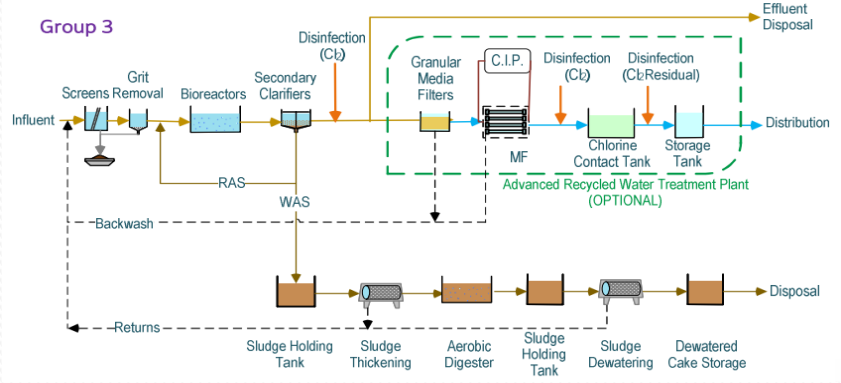
Treatment process train – Group 1 (> 50 MLD, land available)



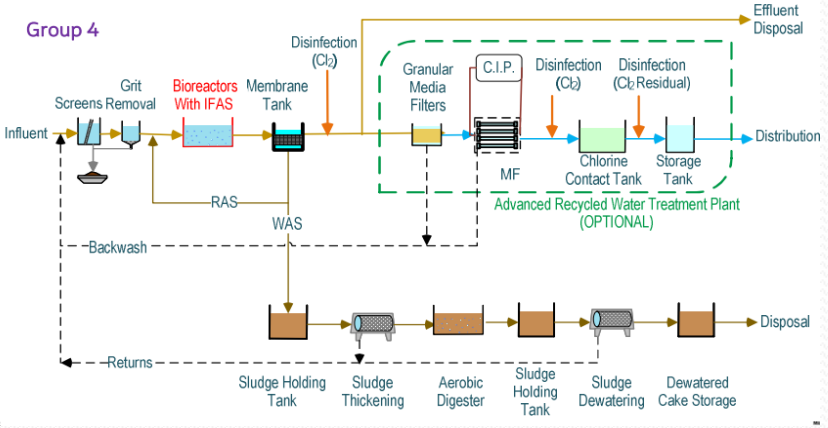
Treatment process train – Group 2 (> 50 MLD, land constraints)



Treatment process train – Group 3 (< 50 MLD, land available)



Treatment process train – Group 4 (< 50 MLD, land constraints)



Construction Of Conveyance Systems

Trenchless vs Open-Cut Excavations

Trenchless (Pipejacking & Micro-tunneling)

Open-Cut Excavation

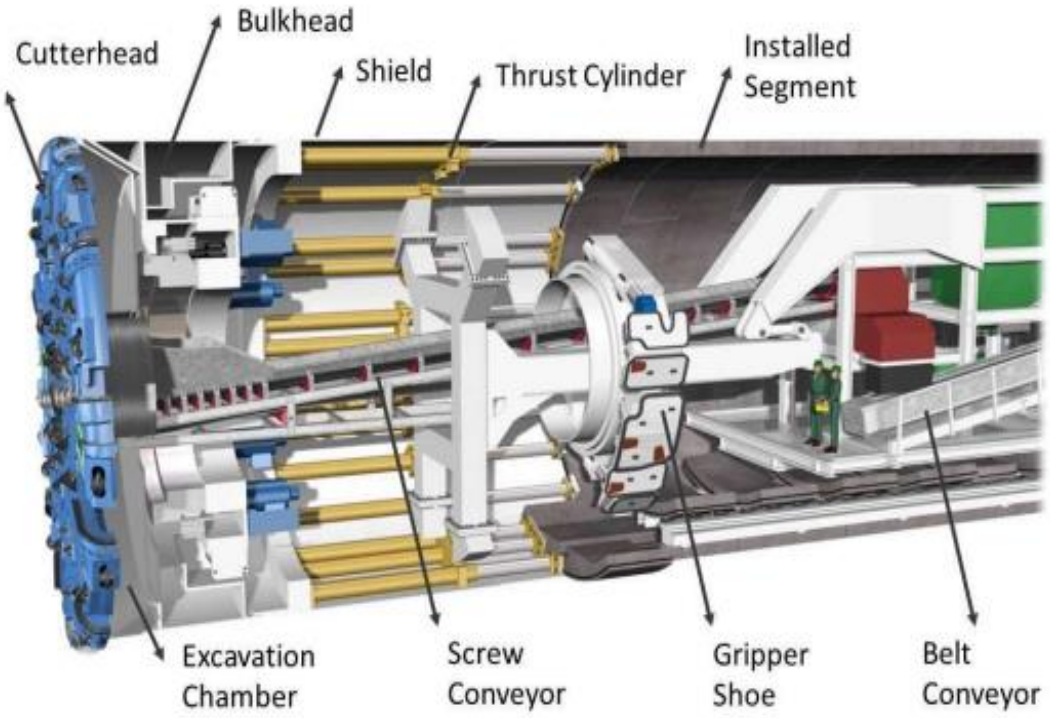
Source: https://www.clicksafety.com/trenching-excavation-awareness-for-construction

Trenchless vs Open-Cut Excavations

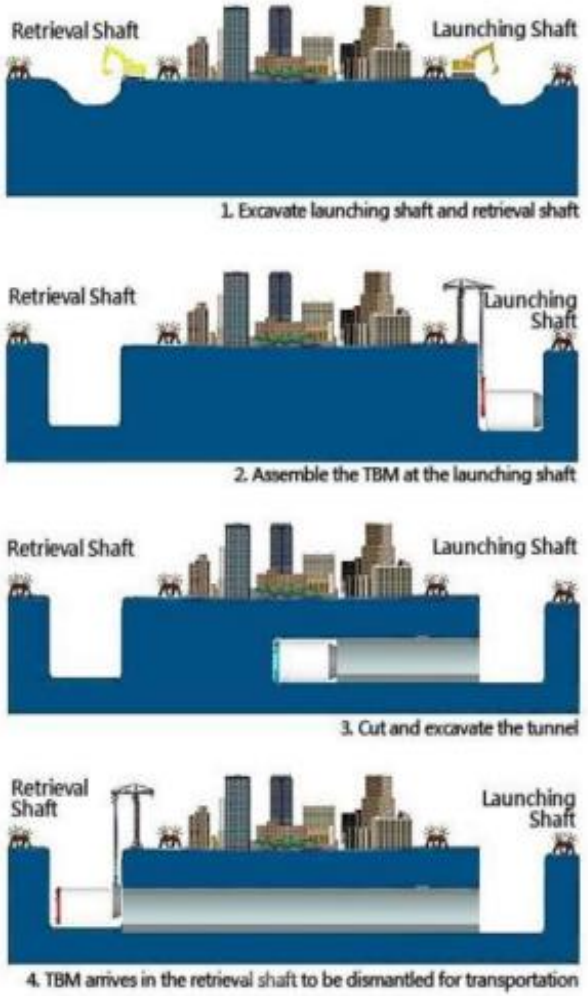
	Trenchless (Pipejacking & Micro-tunneling)	Open-Cut Excavation
Time	Typically faster	Typically requires more time
Cost	Higher in cost	Lower in cost
Social	Typically less disturbance	Typically more disturbances as it usually requires diversion of existing infrastructure
Environment	Typically lesser gate-to-gate carbon footprint as it requires lesser machinery	Typically higher gate-to-gate carbon footprint
Space	Less space requirement	More space requirement
Ground Condition	Require stronger ground condition; if not, ground improvement may be required	Ground condition requirement is less stringent
Technical challenges	Technically more challenging to do and higher risk	More straightforward to execute and lesser risk

Pipejacking/Micro-tunneling Machines

Tunnel Boring Machine (TBM) is typically used for pipejacking/micro-tunneling



Stages of TBM Construction

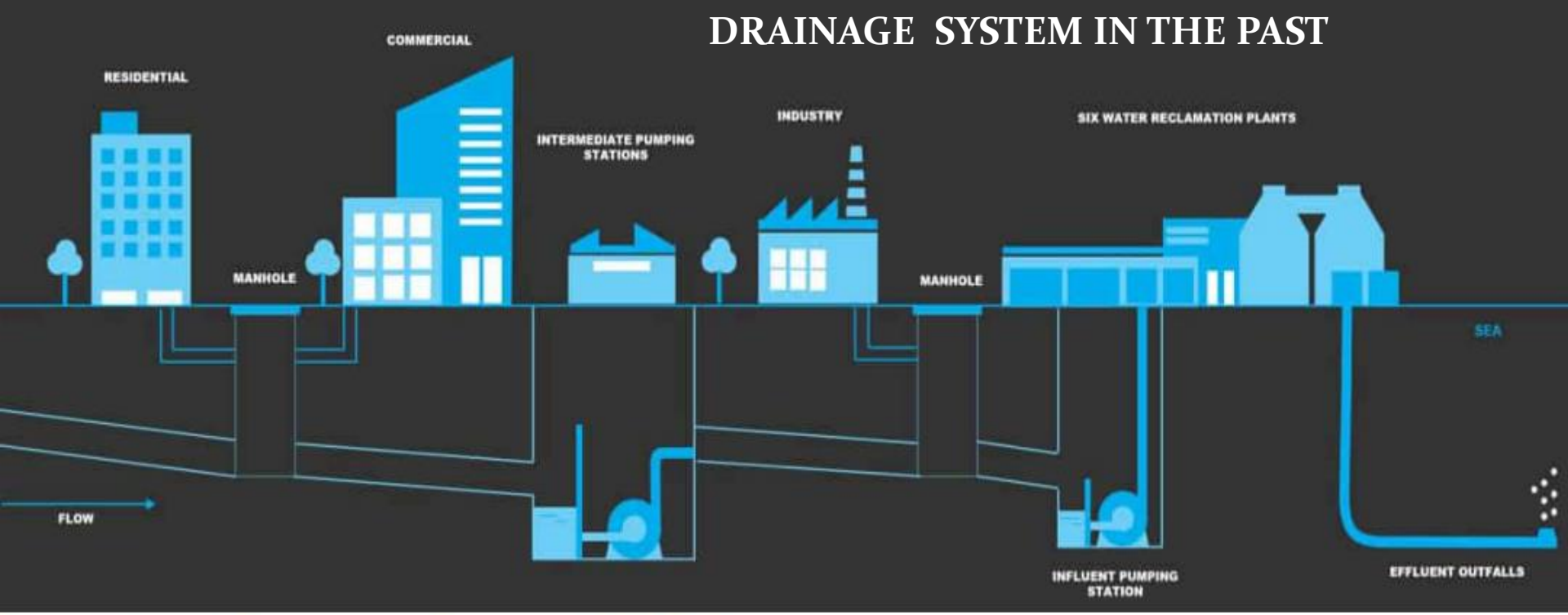


Drainage

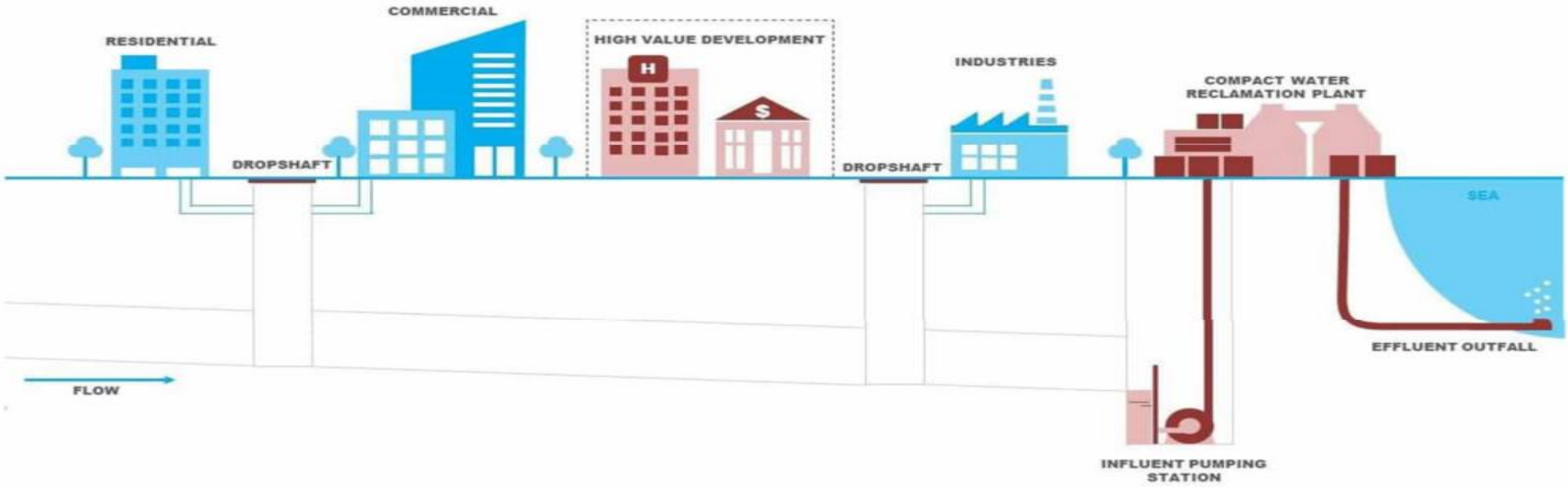
- Singapore operates separate systems for drainage and sewers
- Rain is conveyed to the sea to prevent flooding;
- Rainfall in Singapore is much higher than many other countries
- PUB launched the Active, Beautiful, Clean Waters (ABC Waters) Programme in 2006 Strategic initiative to transform Singapore into a City of Gardens and Water

Major Storm Drains

DRAINAGE SYSTEM IN THE PAST



Deep Tunnel Sewerage System (DTSS) Concept



International Standards For Recycled Potable Water

Recycled Standards Singapore

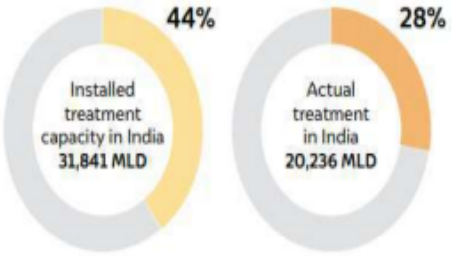
PUB NEWater Quality (Typical Values)			
Parameters	**Unit**	**WHO Guideline Value***	**Typical Value**
Microbiological Parameters			
Escherichia coli (*E. coli*)	cfu/100mL	<1	<1
Heterotrophic Plate Count (HPC)	cfu/mL	-	<1
Physical Parameters			
Colour	Hazen	-	<5
Conductivity	µS/cm	-	<250
Chlorine	mg/L	5	<2
pH Value	Units	-	7.0-8.5
Total Dissolved Solids (TDS)	mg/L	-	<150
Turbidity	NTU	5	<5
Chemical Parameters			
Ammonia (as N)	mg/L	-	<1.0
Aluminium	mg/L	-	<0.1
Barium	mg/L	1.3	<0.1
Boron	mg/L	2.4	<0.5
Calcium	mg/L	-	<20
Chloride	mg/L	-	<20
Copper	mg/L	2	<0.05
Fluoride	mg/L	1.5	<0.5
Iron	mg/L	-	<0.04
Manganese	mg/L	-	<0.05
Nitrate (as N)	mg/L	11	<5
Sodium	mg/L	-	<20
Sulphate	mg/L	-	<5
Silica (as SiO_2)	mg/L	-	<3
Strontium	mg/L	-	<0.1
Total Trihalomethanes Ratio	-	<1	<0.04
Total Organic Carbon (TOC)	mg/L	-	<0.5
Total Hardness (as $CaCO_3$)	mg/L	-	<50
Zinc	mg/L	-	<0.1

* WHO Guideline Values listed in this report are obtained from WHO Guidelines for Drinking-water Quality 2017, 4th edition incorporating 1st addendum

Updated as of April 2020

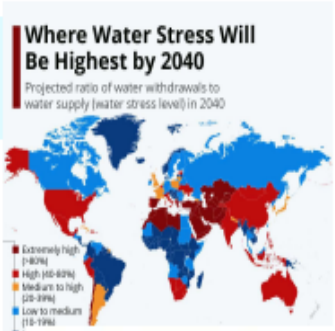
India- Water Recycle Status

- In 2021, the total volume of used water generated by households in urban India was 72,368 MLD.
  - Of this amount, the estimated infrastructure capacity for treating used water to secondary level is 44% (31,841 MLD)
- As per the inventory of UWTPs (STP) published by CPCB,
  - only a small proportion is reused
  - <1000 MLD, i.e ~3% of treated used water is being reused for some valuable purposes
- Treated used water in almost entirety, is either discharged to
  - watercourses or
  - used for irrigating parks, lawns or public places.
- Its reuse for non-potable purposes, such as crop irrigation, industrial processes, and groundwater recharge, is still relatively uncommon



Water Stress

- Globally India is ranked as the 13th most water stressed country
- Water scarcity necessitates diversification to alternative water supplies
- It is estimated that if 80% of urban used water could be collected and treated by 2030, there would be a total volume of around 17 billion m3 (BCM) per year**
- 17 BCM of treated used water resource, if captured, treated safely and recycled,
  - ~almost 75% of the projected industrial demand in 2025 (MoWR 2006) and
  - almost a quarter of the total projected drinking water requirements in the country**
- This can help in reducing the demand for freshwater



EXTREMELY HIGH WATER STRESS

Rank	Country	Score
1	Qatar	4.97
2	Israel	4.82
3	Lebanon	4.82
4	Iran	4.57
5	Jordan	4.56
6	Libya	4.55
7	Kuwait	4.43
8	Saudi Arabia	4.35
9	Eritrea	4.33
10	UAE	4.26
11	San Marino	4.14
12	Bahrain	4.13
13	India	4.12
14	Pakistan	4.05
15	Turkmenistan	4.04
16	Oman	4.04
17	Botswana	4.02

Source: Aqueduct/WRI

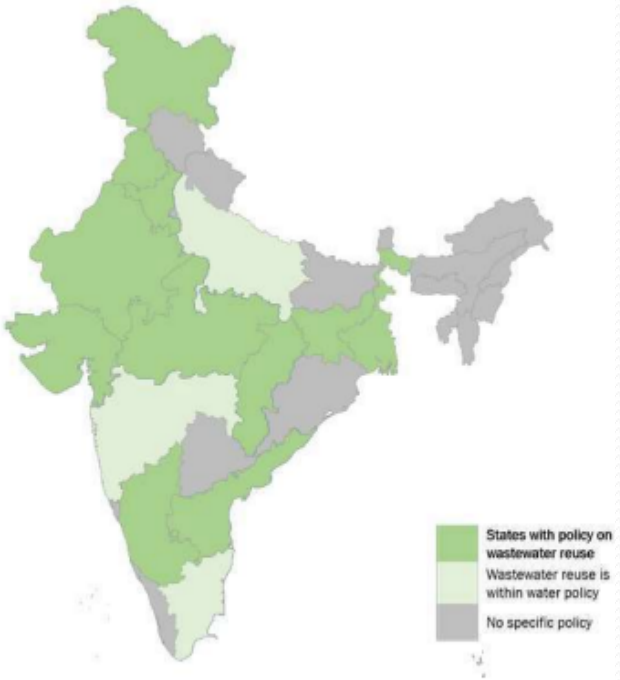
Central Laws and Policies in India

According to the Constitution of India, **water, sanitation and used water are State subjects**

- **The Water (Prevention and Control of Pollution) Act, 1974** emphasizes to maintain and restore the '**wholesomeness**' of aquatic resources.
  - Used water (Sewage) or pollutants cannot be discharged into water bodies, including lakes, and the state pollution control board must intervene and stop such activity
- **The Ganga Action Plan, 1986** was launched to protect river Ganga from further pollution, improve the quality of water by treatment of the used water, and to prevent the mixing of industrial wastes.
- **The Environment Protection Act, 1986** which is an **umbrella legislation** designed to provide a framework for central government coordination of the activities of various central and state authorities established under previous laws, such as the Water Act and the Air Act.
  - This Act applies in principle to every establishment, agency, or individual discharging any pollutant into the environment.

State Policies in TUW

- 12 States have Safe Reuse of Treated Water (SRTW) polices, either approved or at an advanced stage of drafting (e.g. Karnataka, Chhattisgarh, Tamil Nādu, J&K, UP, Maharashtra, West Bengal, etc.)
- Majority of State policies prescribe mandatory usage of TUW for industrial estate/zones within a certain distance from an UWTP provided the off-take is shown to be viable.
- ULBs have set targets ranging from 20% to 25% of TUW, replacing freshwater usage in the initial years.
- For some States, the target varies by city size. States like **Gujarat and Haryana** prescribe higher targets in subsequent years, **to achieve 100% reuse by 2030 and 2033** respectively, while Karnataka prescribes **50% reuse by 2030.**
- Quality standards in the state policies are limited to CPCB/SPCB discharge standards



States having policy on reuse of treated water

Reuse of Treated Wastewater in Urban/Peri-Urban Agriculture in India
Source NITI Aayog, June 2023

Ministry of Housing and Urban Affairs
Government of India

SCE
SINGAPORE COOPERATION ENTERPRISE

Remember Every Drop Counts