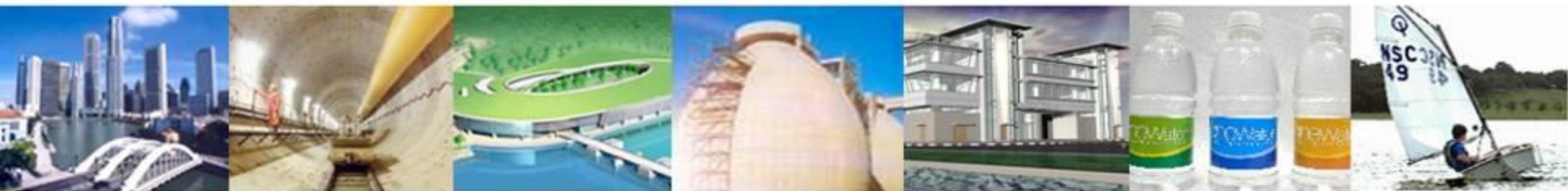


Water for All
Conserve, Value, Enjoy

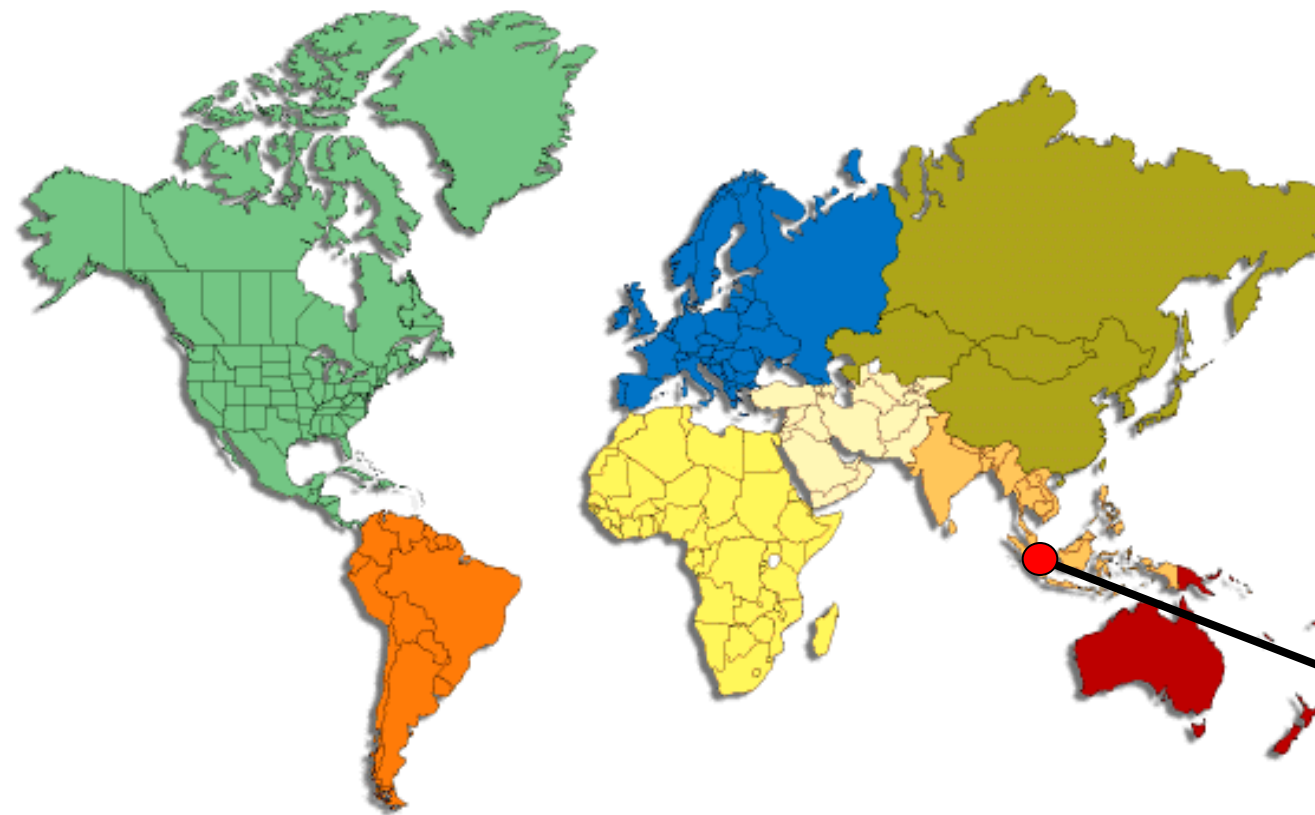


NEWater : Singapore's Experience in Wastewater Reuse

Koh Siong Teck
Assistant Director, Policy & Planning Department
PUB Singapore

Outline of Presentation

- Introduction
- The NEWater Study
- Public Education of NEWater
- Implementation of NEWater
- Uses of NEWater
- MBR-RO



Country Information



About Singapore

Land Area	710 km ²
Population	5.08 mil
Average Annual Rainfall	2,400 mm
Average Water Demand	1.7 mil m ³ /day

Introduction

- **PUB : Part of Singapore's MEWR Family**



Ministry of the Environment
and Water Resources

To deliver and sustain a clean and healthy environment and water resources for all in Singapore.



National
Environment
Agency

To ensure a sustainable quality environment in Singapore

- ❖ Clean Land
- ❖ Clean Air
- ❖ Public Health



Water for All: Conserve, Value, Enjoy

To ensure an efficient, adequate and sustainable supply of water

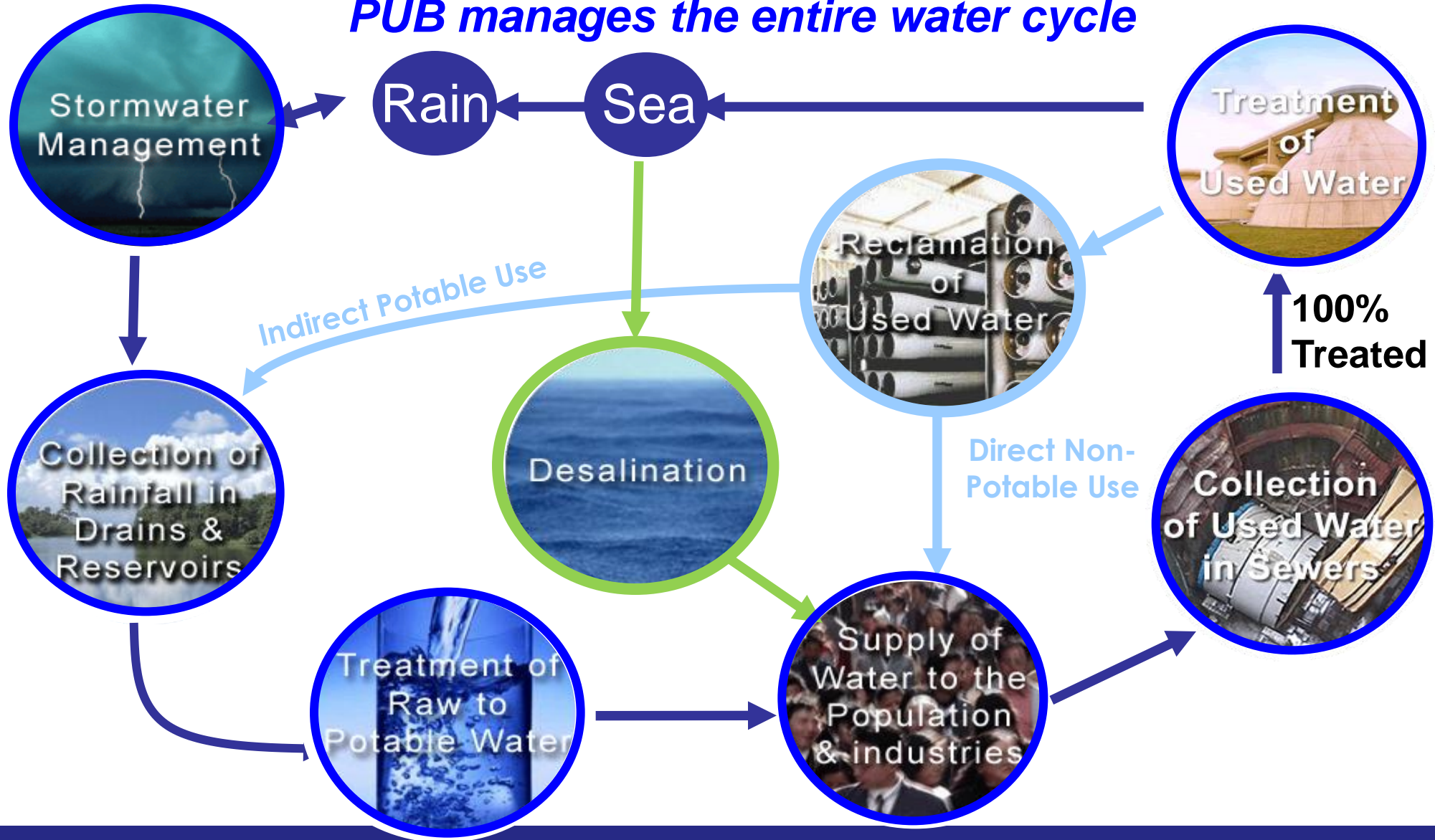
- ❖ Water Supply
- ❖ Used Water
- ❖ Drainage

Water for All: Conserve, Value, Enjoy



Introduction

PUB manages the entire water cycle



Water for All: Conserve, Value, Enjoy

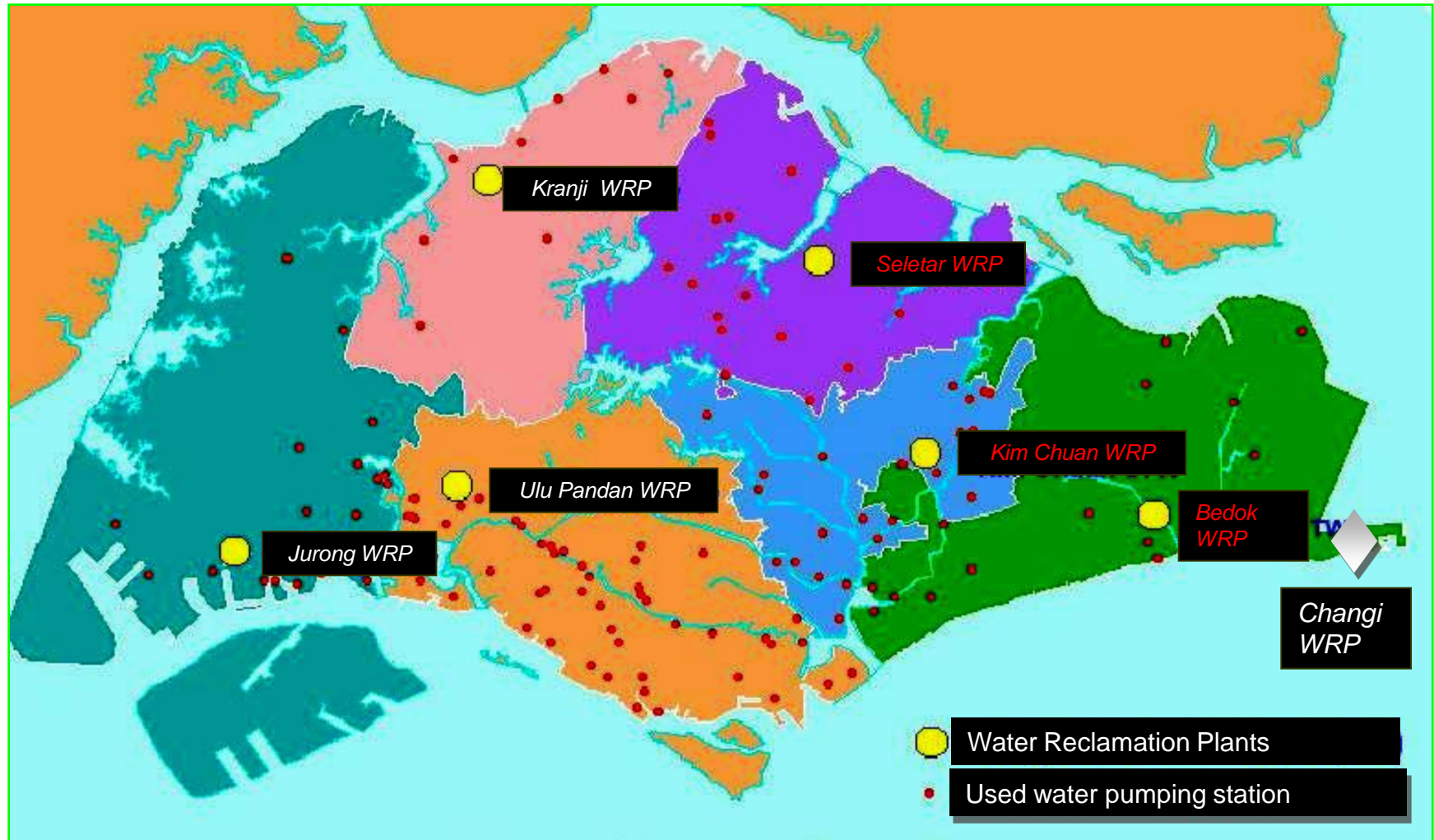
FOUR NATIONAL TAPS



Water for All: Conserve, Value, Enjoy

Recycle every drop

Collection of used water (100% sewerage)



Water for All: Conserve, Value, Enjoy

Deep Tunnel Sewerage System (DTSS)

Deep tunnel and outfall completed



Water for All: Conserve, Value, Enjoy

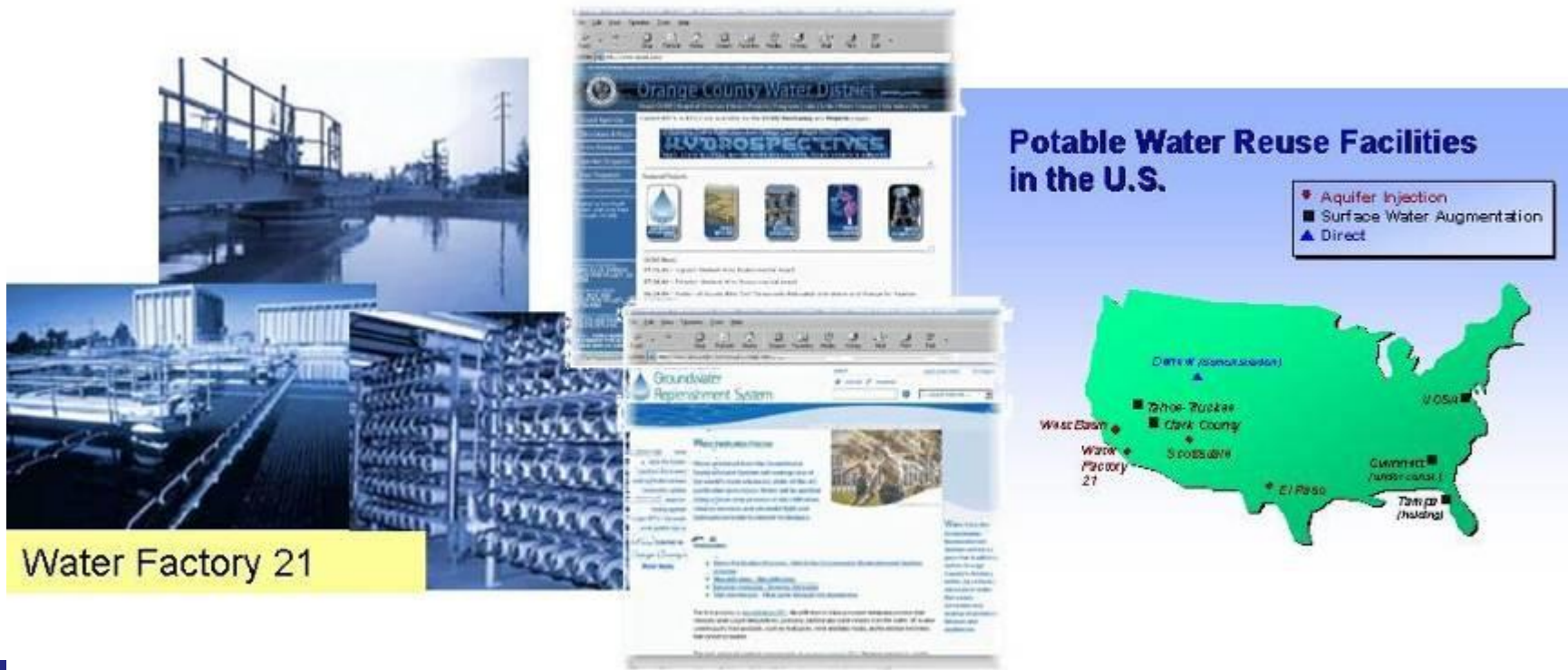
The NEWater Study

Background

- Since the 1970s, Singapore has been testing new water technologies to produce water of drinking standards from secondary treated wastewater effluent
- The NEWater Study was initiated in 1998
- Primary objective of the study was the suitability of using NEWater as a source of raw water to supplement Singapore's water supply.

Background

- Planned Indirect Potable Use (IPU) as a source of water supply is not new. It has been practised in several parts of the United States for more than 20 years.
- Study Trip was conducted to learn from overseas experience



NEWater Demonstration Plant

Demonstration Plant Studies

↑

Pilot Plant Studies

↑

Upstream fundamental research

Demonstration Plant

**Learning from
Overseas
experiences**



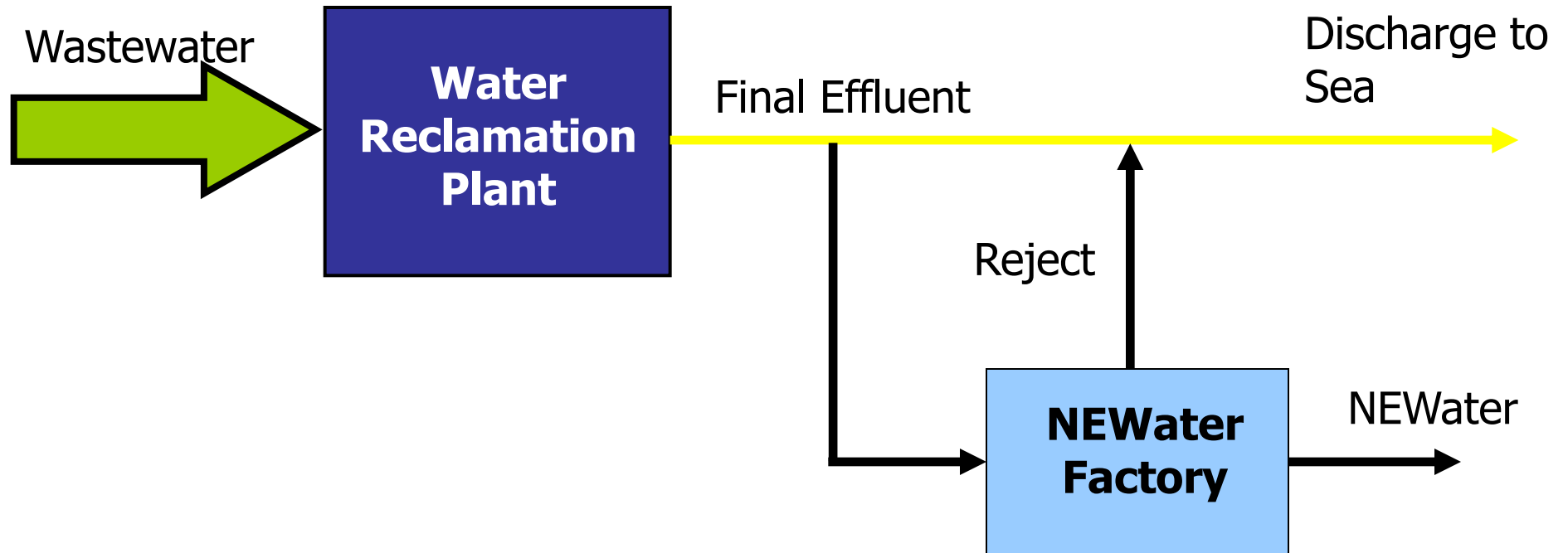
Water Factory
21

NEWater Demonstration Plant



- To design, construct and operate a 10,000 m³/day advanced water reclamation demonstration plant, operational since May 2000
- Objective of demo plant is to test the technology for its reliability and robustness
- Operational problems experienced at demo plant level can be incorporated into the design of full scale plant
- Some problems and concern: low flow at night, use of hypochlorite will damage membrane

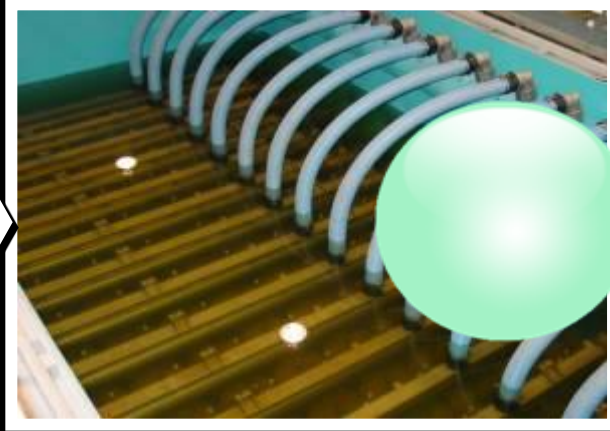
Overview of NEWater Concept



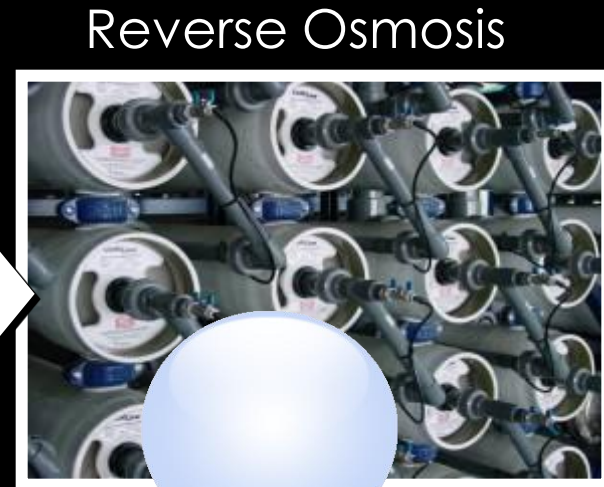
NEWater Treatment Process



Treated
Used Water



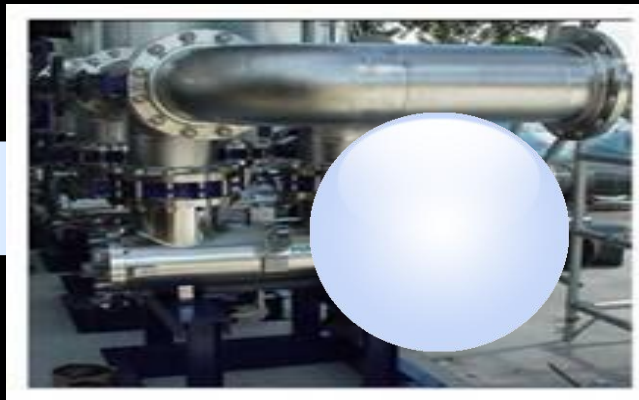
Microfiltration /
Ultrafiltration



Reverse Osmosis



NEWater



Ultra-Violet

Sampling and Monitoring Programme

- 293 water quality parameters; more than the 100 specified by *USEPA* and 122 specified by *WHO*
- Most comprehensive water quality study of reclaimed water to date
- Categories of parameters
 - Physical, inorganic, organic, radio-nuclides, pesticides / herbicides, wastewater signature compounds, synthetic / natural hormones
- Microbiological water quality parameter study

Sampling and Monitoring Programme (SAMP)

- To date, more than 100,000 tests have been conducted on samples from treated used water and NEWater
- The quality of NEWater consistently meets the latest requirements of the U.S. Environmental Protection Agency's (USEPA) National Primary and Secondary Drinking Water Standards and World Health Organisation's (WHO) Drinking Water Quality Guidelines

Health Effects Study

- Complements SAMP in determining the safety of NEWater
- Toxicological assessment of NEWater against reservoir water
- Short and long term health effects on two animal species
 - **Mice** Long term toxicity and carcinogenicity assessment
 - **Fish** Long term toxicity and carcinogenicity assessment, and estrogenic assessment (reproductive and development)

Health Effects Study



*Mice testing facility at the
Animal Handling Unit, NUS*

(Mice; B6C3F1 strain)

*Modified and improved fish testing
facility at the NEWater
Demonstration Plant*

(Fish; Japanese Medaka)



Histopathological analyses of animal tissues and organs at Experimental Pathology Laboratories Inc. (EPL) in the U.S.

✓ No long term carcinogenic effect

Histopathological analyses of fish tissue and organs

- ✓ No long term carcinogenic effect
- ✓ No estrogenic effect

Public Education of NEWater

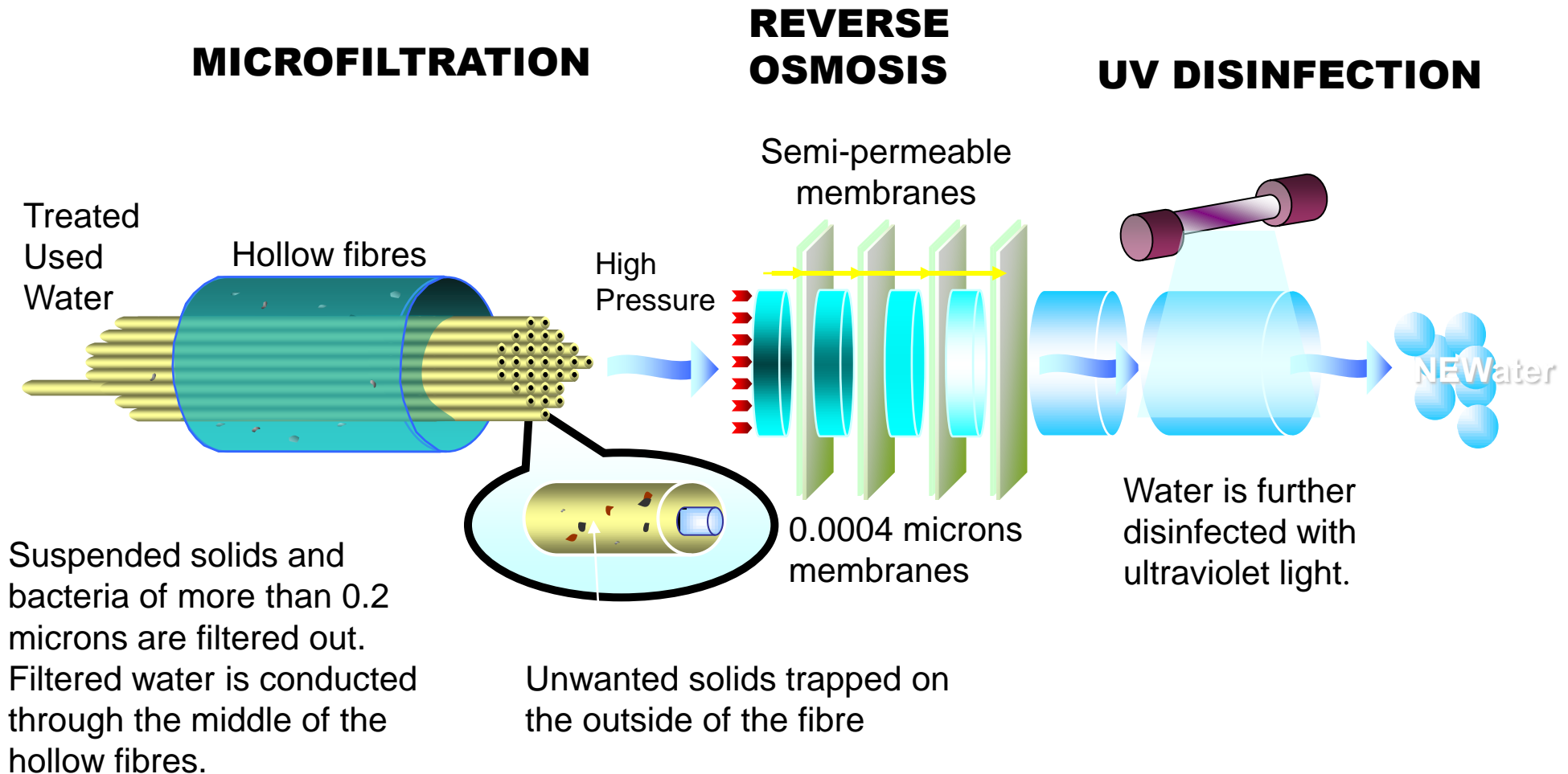
Gaining Public's acceptance



(Briefing to Grassroots, Jul 2002)

- PUB and its parent ministry, ENV, took the lead in public communication with support from the Panel of Experts
- Bottled NEWater for public sampling, bottles distributed on National Day Parade
- Strong political leadership with its ability to rally the entire community to face a national challenge
- Grassroots leaders helped NEWater to reach out to the community in the heartland

Public Communication - Simple Messaging



Production of NEWater – too technical?

Reverse Osmosis
Pore Size

X 100 Million
Times

= Size of Tennis
Balls

RO Membrane

Water
molecules

Estrogen
Water
Endocrine
molecules
Disruptors





- NEWater Visitor Centre is the focal point of our public education on:
 - ✓ Role of NEWater as one of the 4 national taps
 - ✓ The importance of water
 - ✓ The technology behind NEWater
- Targets mainly our younger generation (eg students)
- Opened in Feb 2003



Public Communication

- Good Branding
- Choice of words
 - “Used Water” vs “Wastewater”;
 - “NEWater” vs “Reclaimed Water”
 - “Water Reclamation” vs “Sewage Treatment”
- Emphasis
 - Concept is not new
 - RO technology
 - Indirect Potable Use



Public Communication

- Overwhelming acceptance of NEWater by the public
- 98% of Singaporeans supported indirect potable use – an independent poll by Forbes Research
- Consistent positive response from related surveys, Feedback Unit, and during briefing sessions



Continued Public Education/ Acceptance



Uses of NEWater



- ✓ Direct Non-Potable Use
(primary use)
- ✓ Indirect Potable Use

NEWater for Direct Non-Potable Use

- Encourage substitution with NEWater, High Grade Industrial Water and Seawater
- NEWater :
 - i) frees up potable water for other uses
 - ii) quality suitable for process use (UPW), boilers, laundry, air-con cooling towers, toilet flushing, general washing
 - iii) lower price

	Potable Water	NEWater
Tariff \$/m3	1.17	1.10
WCT *	30%	N.A
Total	1.52	1.10

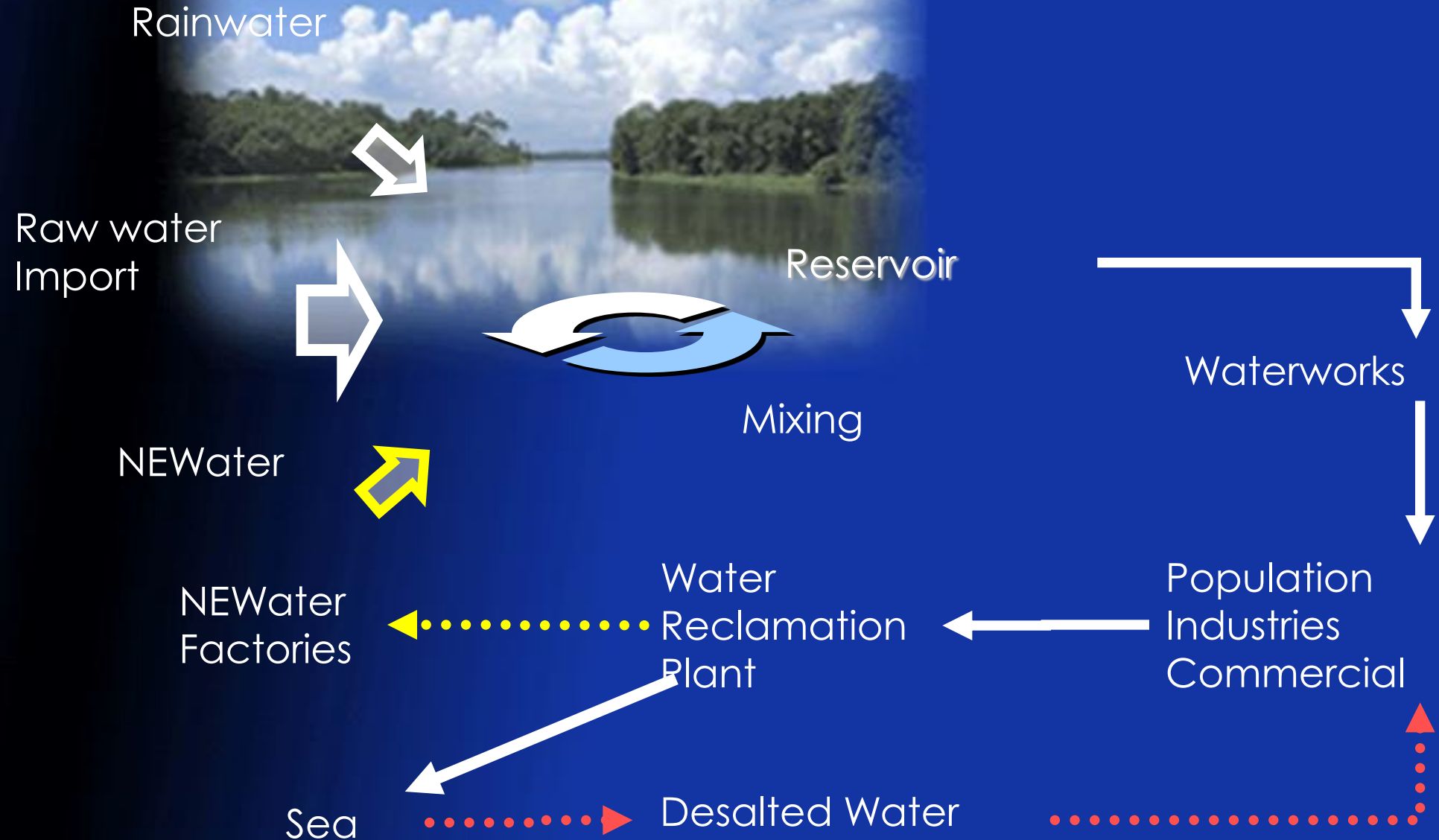
* WCT – Water Conservation Tax



NEWater for Direct Non-Potable Use

- Wafer Fab Industry
 - Supply to electronics and wafer fab industry
 - Supply since Jan 2003
- Air-con cooling in commercial buildings
 - 30% of building water consumption
- Cooling and Boiler Feed

Indirect Potable Use in Singapore



Implementation of NEWater

NEWater Factories

Bedok NEWater Factory



Jan 2003

Bedok NEWater Factory (32,000 m³/d)
→ expanded to 81,800 m³/d

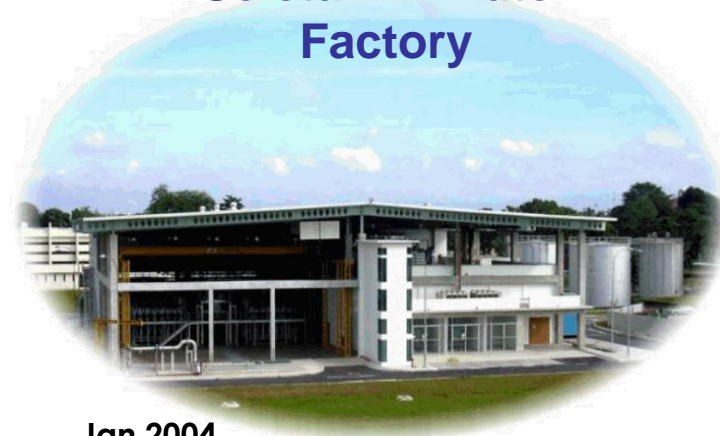
Kranji NEWater Factory



Jan 2003

Kranji NEWater Factory (40,000 m³/d)
→ expanded to 77,300 m³/d

Seletar NEWater Factory



Jan 2004

Seletar NEWater Factory (22,700 m³/d)

Changi NEWater Factory



May 2010

Changi NEWater Factory (227,200 m³/d) -
DBOO

Ulu Pandan NEWater Factory

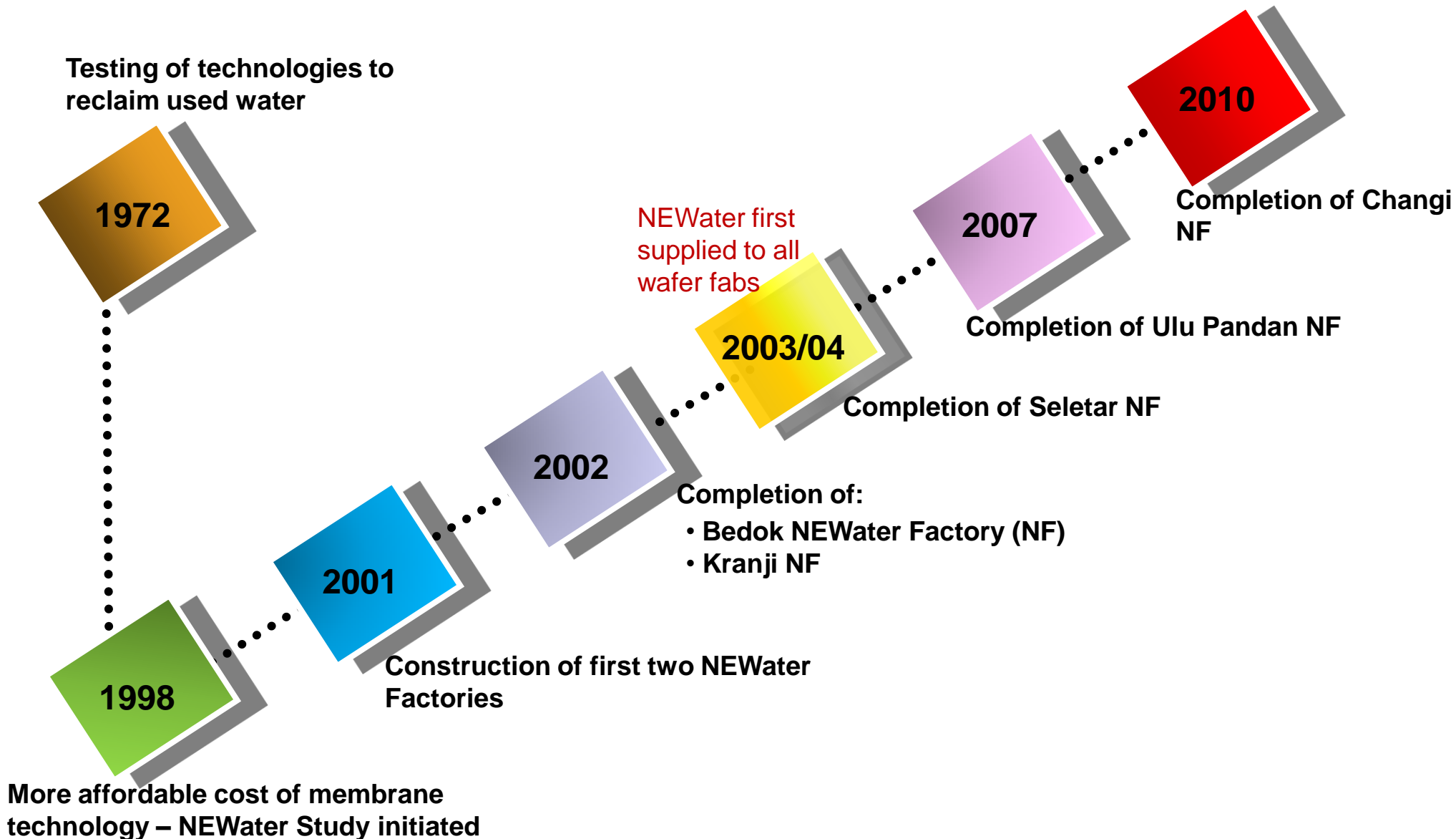


Mar 2007

Ulu Pandan NEWater Factory (145,400 m³/d)
Design, Build, Own & Operate (DBOO)

Water for All: Conserve, Value, Enjoy

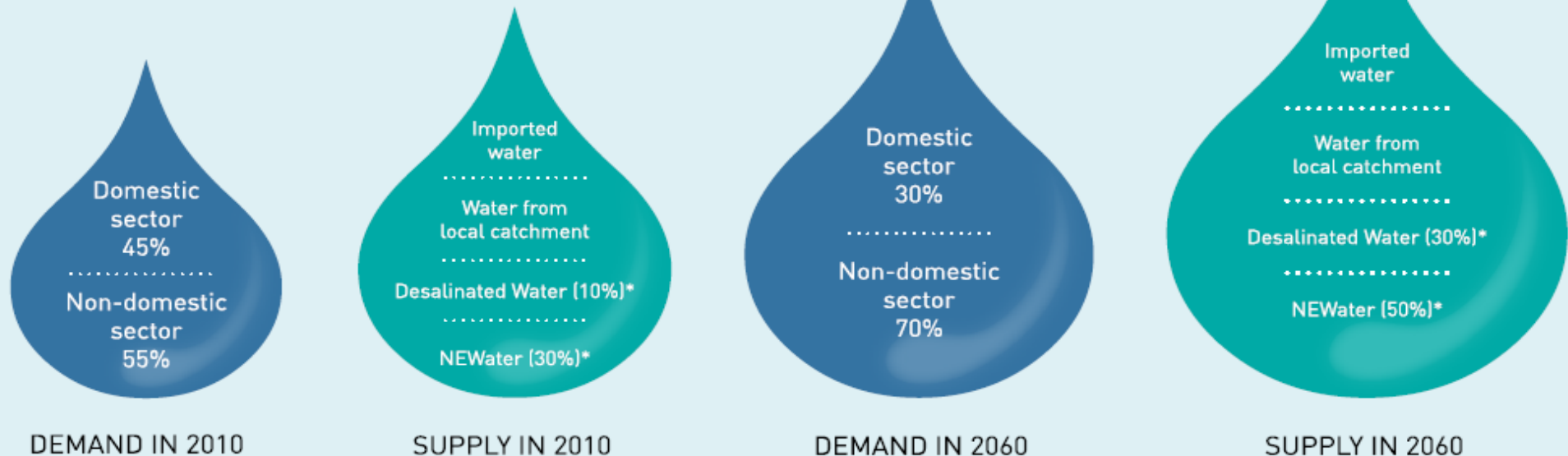
Summary: The NEWater Journey ...



Ensuring Water Sustainability for Singapore

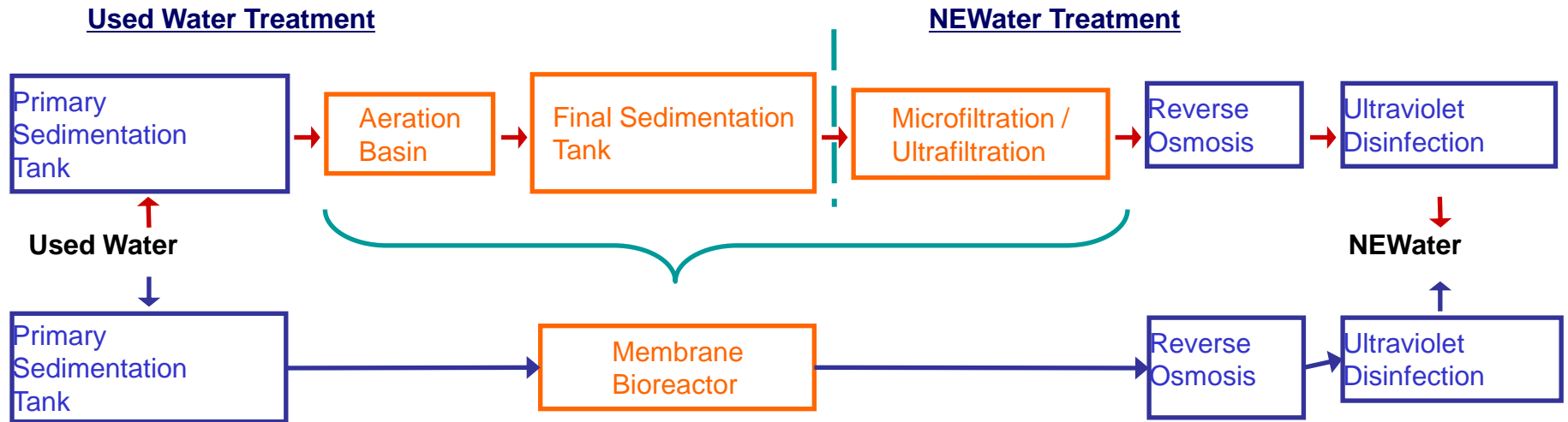
DEMAND AND SUPPLY 2010 & 2060

Singapore's daily water demand from the domestic sector and the non-domestic sector are met by a blend of the Four National Taps. NEWater is supplied mainly to the non-domestic sector.



* % of demand

Membrane Bioreactors + Reverse Osmosis



R&D in Membrane Bioreactors

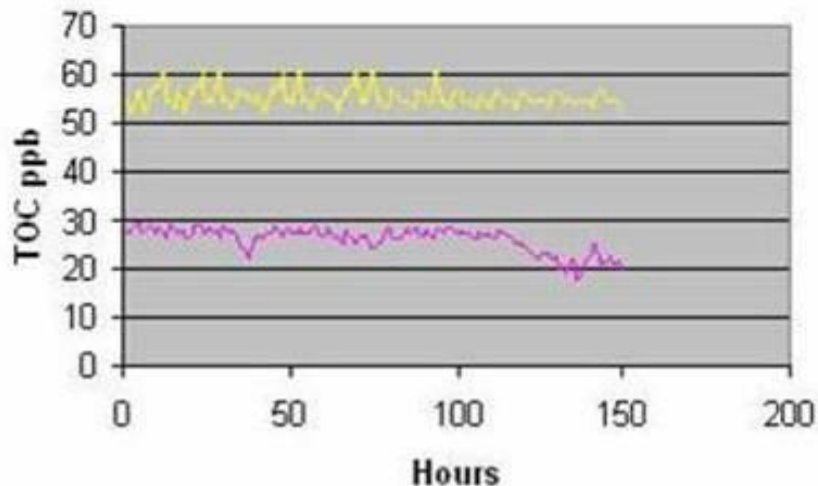
Three different MBR systems (300 m³/d capacity) pilot tested at in 2004:

- Mitsubishi (hollow fiber membrane, horizontal)
- Zenon, (hollow fiber membrane, vertical)
- Kubota (flat sheet membrane)

Membrane Bioreactors + Reverse Osmosis



TOC Values



- Reliability and effectiveness in MBR technology tested for 2 years
- MBR-RO process has produced NEWater of better quality than using current process
 - Example: Lower TOC values in RO permeate produced from MBR-RO
- Moved on building a demonstration plant at Ulu Pandan wastewater reclamation plant (WRP).

Membrane Bioreactor Demonstration Plant

- Demonstration plant in operation since Dec 06
- Achieved stable operations at
 - Flux: 25.3 LMH
 - Energy consumption: 0.5 to 0.6 kWh/m³
- HRT reduced from 6.3 hrs to 3 hrs
→ 40% process air reduction achieved so far.
- **New research project to optimize process aeration and membrane scouring using computational modeling methods, such as artificial neural networks, bioprocess and fouling modeling.**



- The **global platform for water solutions**
 - Brings together policymakers, industry leaders, experts and practitioners
 - Address challenges, showcase technologies, discover opportunities & celebrate achievements
- **Key highlights** include Lee Kuan Yew Water Prize, Water Leaders Summit, Water Convention, Water Expo & Business Forums

Year	No. of attendees	No. of countries participated	Value of deals, tenders & investments announced	No. of co-located events	No. of participating companies in Water Expo
2008	8,500	79	S\$380m	42	350
2009	10,000	82	S\$2.2b	76	420
2010	14,000*	112*	S\$2.8b	120	514
2011	13,500	99	S\$2.9b	131	604

* Jointly with World Cities Summit





Singapore International Water Week

Visit us at
[www. siww.com.sg](http://www.siww.com.sg) to find out more!



Thank you



Water for All: Conserve, Value, Enjoy

