



International
Water Association



World Health
Organization

Water Safety
Conference 2010

Woo Chee Hoe

**Integrated Water Quality Management Plan –
PUB's Strategy in Ensuring Safe Drinking Water**

Our Demographics



Land Area	~700 km ²
Population	5 million
Average Annual Rainfall	2,400 mm
Average Water Demand	1.6 mil m ³ /day

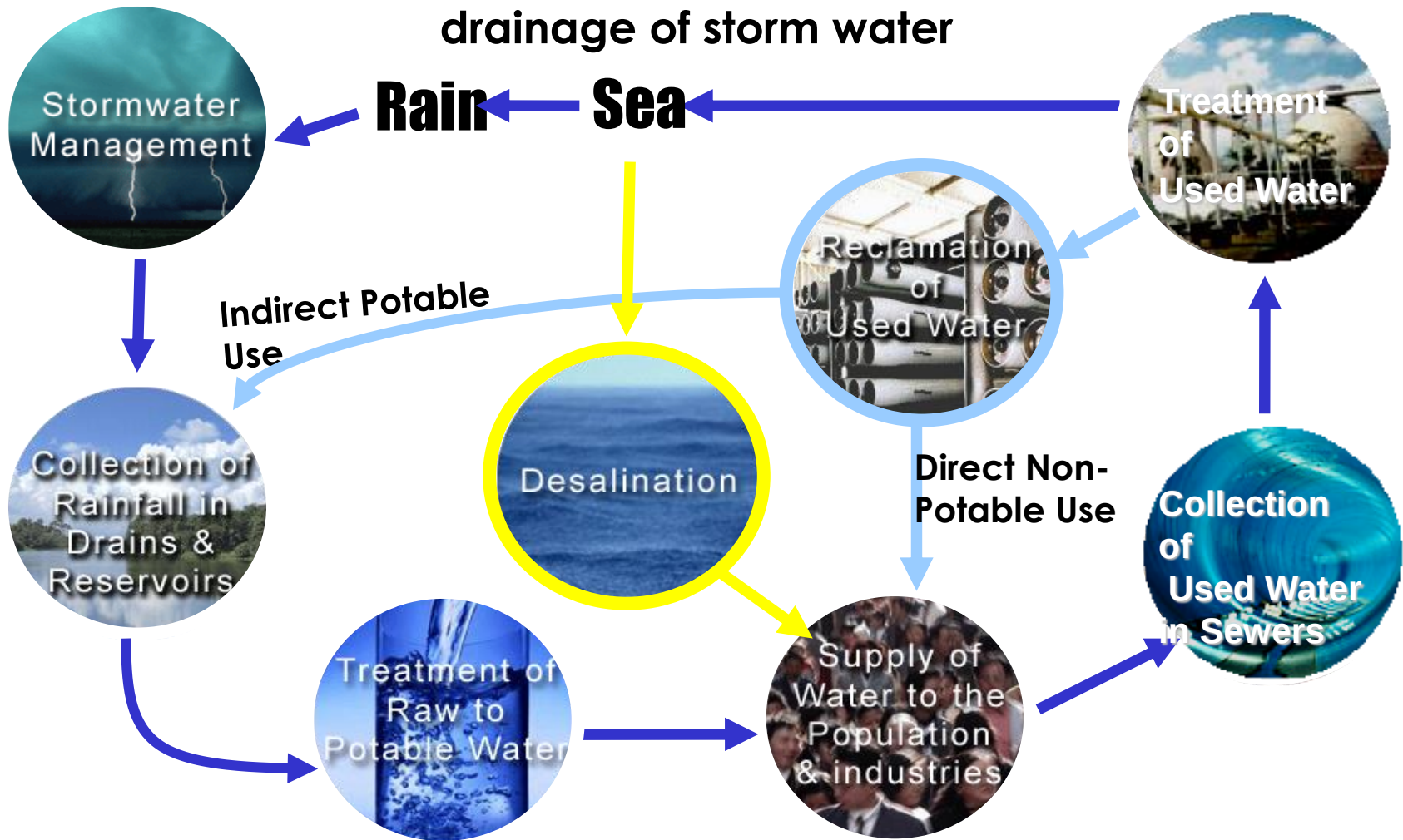
Augmenting Singapore's Water Supply

Our 4 National Taps



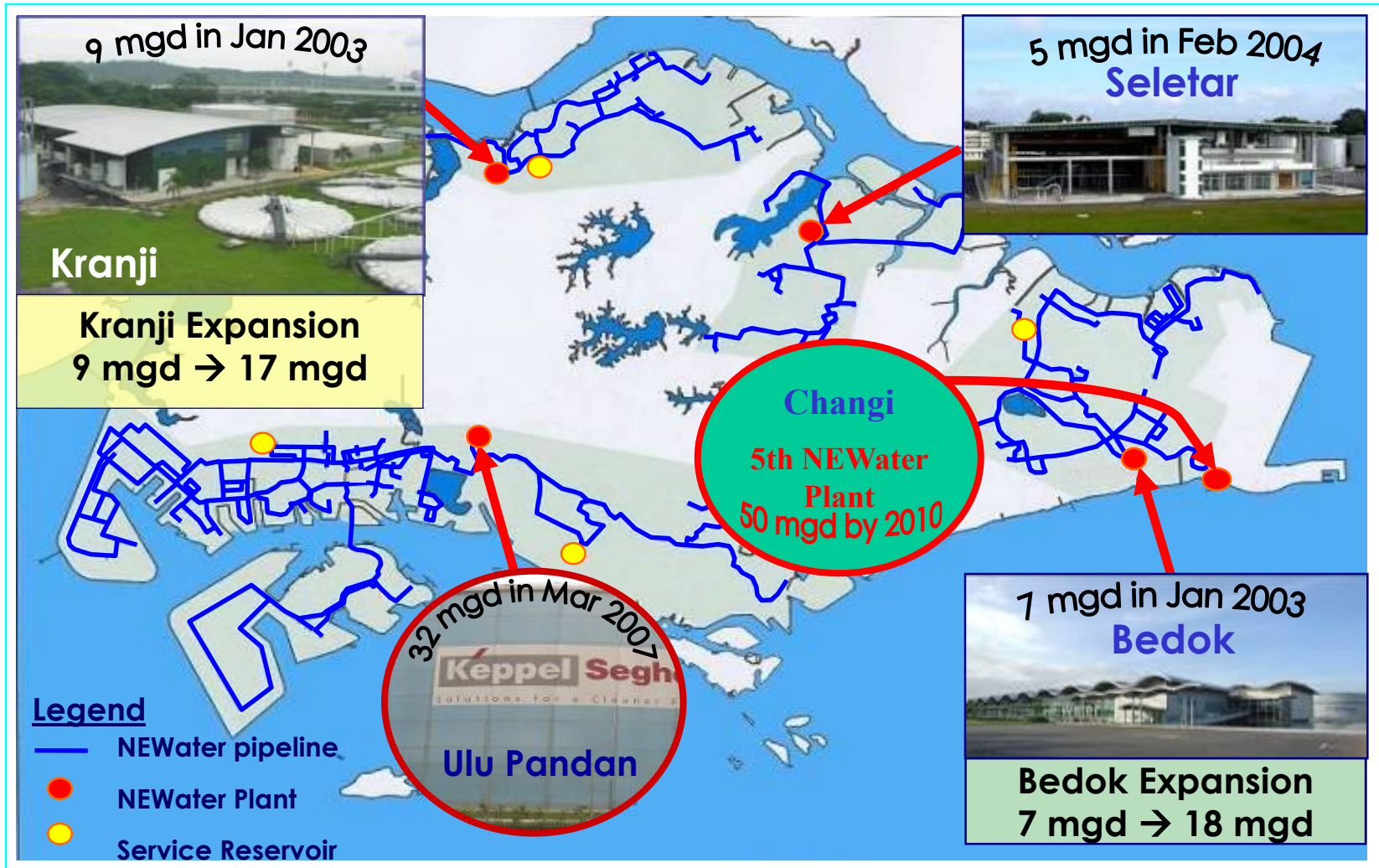
PUB Manages The Complete Water Cycle

From sourcing, collection, purification and supply of drinking water, to treatment of used water and turning it into NEWater, drainage of storm water

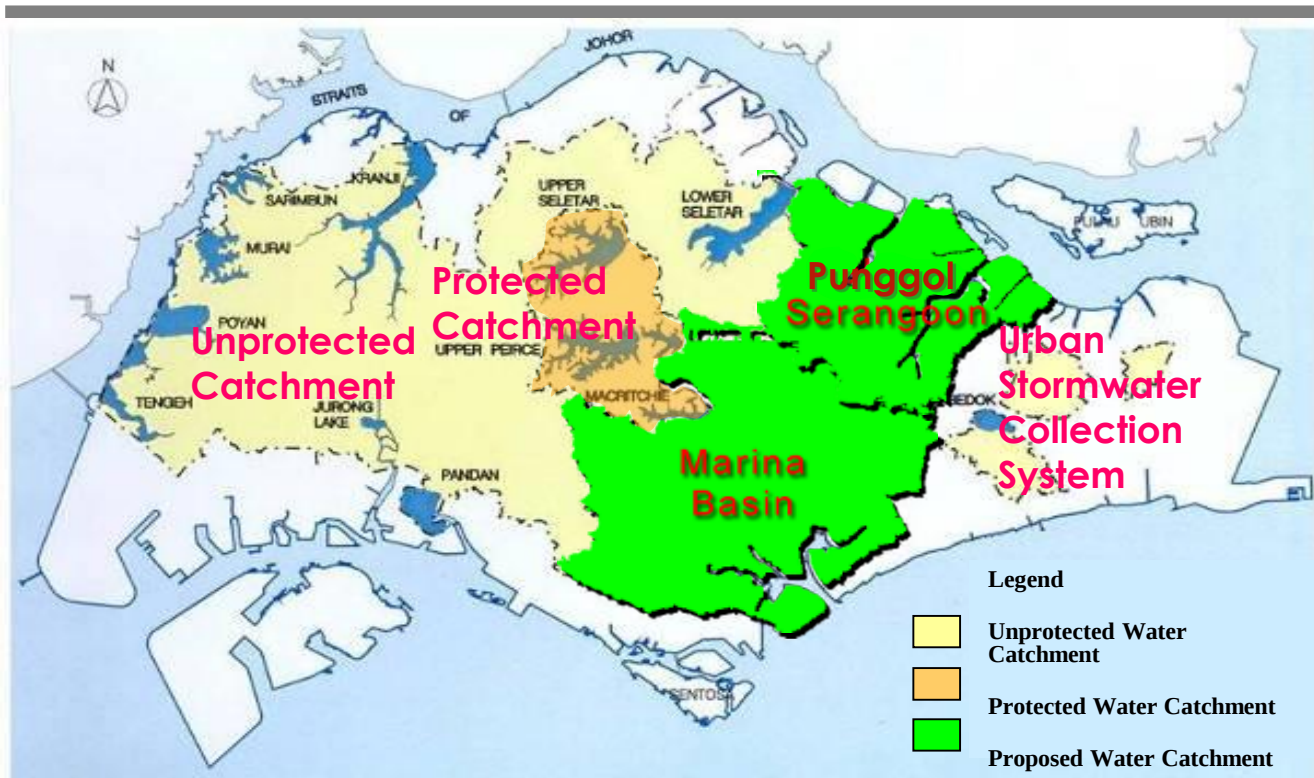


Closing the Water Loop

NEWater independent of the vagaries of weather



Harvesting Every Drop



- Half of Singapore is already water catchment
- Catchment area will be increased from half to two-thirds by 2011

Desalinated Water

- To diversify our water resources and ride out the vagaries of weather
- SingSpring Pte. Ltd., under a 20 year DBOO arrangement with PUB
- Supply of 30 mgd for 20 years
- Opened in Sep 05



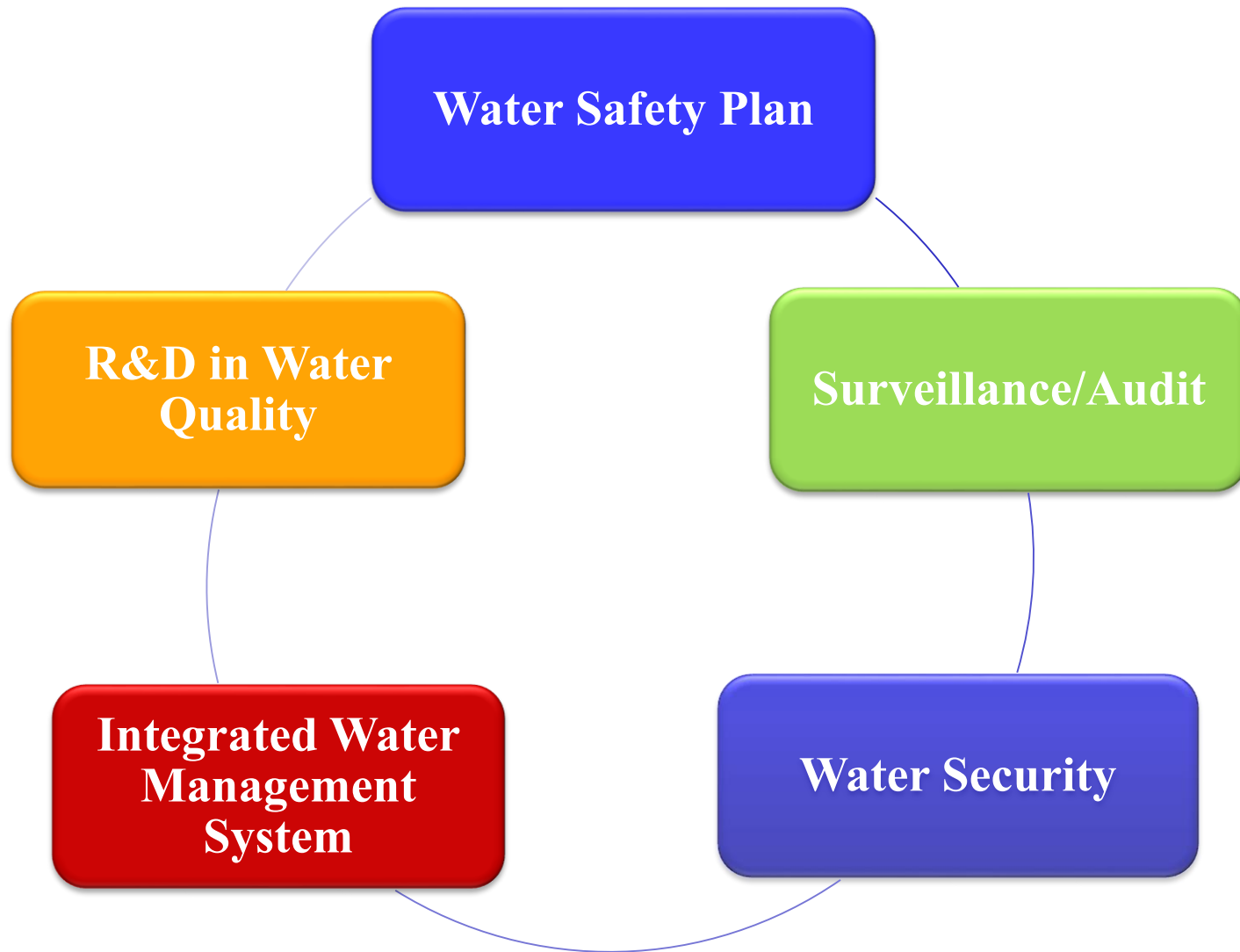
Integrated Water Quality Management

- *A holistic approach to managing water quality of Singapore's water bodies*

Objectives

- *Ensure all water collected can be treated for drinking which is always safe for consumption*
- *Maintain high level public confidence in drinking water especially when more drinking water will be from unconventional sources*
- *Achieve Key Performance Index (KPI)*

Integrated Water Quality Management



Water Safety Plan

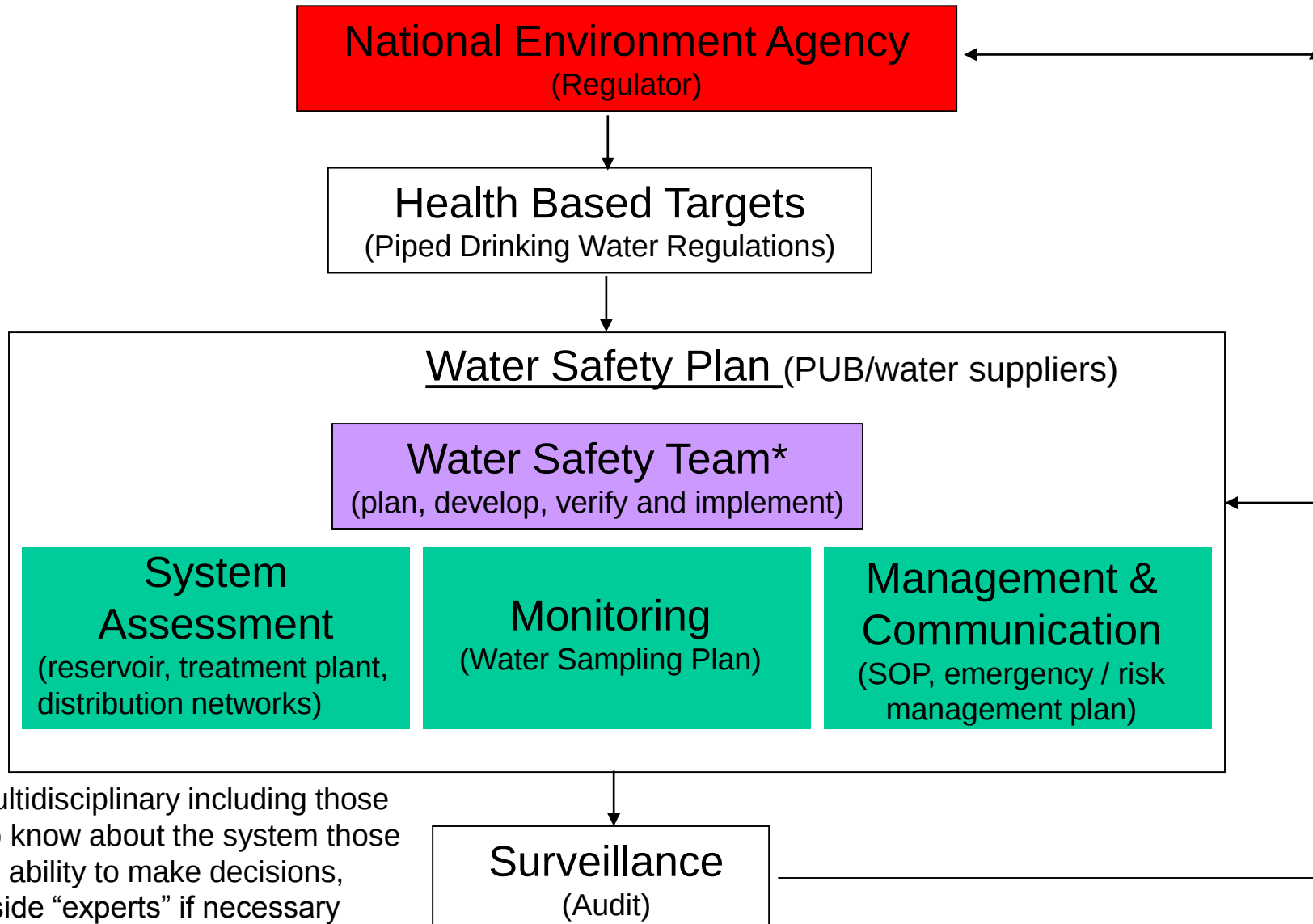
What ?

A plan describing the risk assessment and risk management measures that are or are to be used in order to minimize the likelihood of any piped drinking water failing to comply with the water quality standards

Why ?

- End-point testing is “too-little” and “too-late” to give effective response
-and microbial indicators don't reflect risk

Water Safety Plan



* Multidisciplinary including those who know about the system those with ability to make decisions, outside “experts” if necessary

Source Water Protection

- Protected Water Catchment
 - only non-pollutive activities are allowed
- Unprotected Water Catchment
 - housing developments and non-pollutive industries with stringent pollution control measures implemented
- Catchment Surveillance
- Algae Control
- Water Quality Monitoring



Aeration

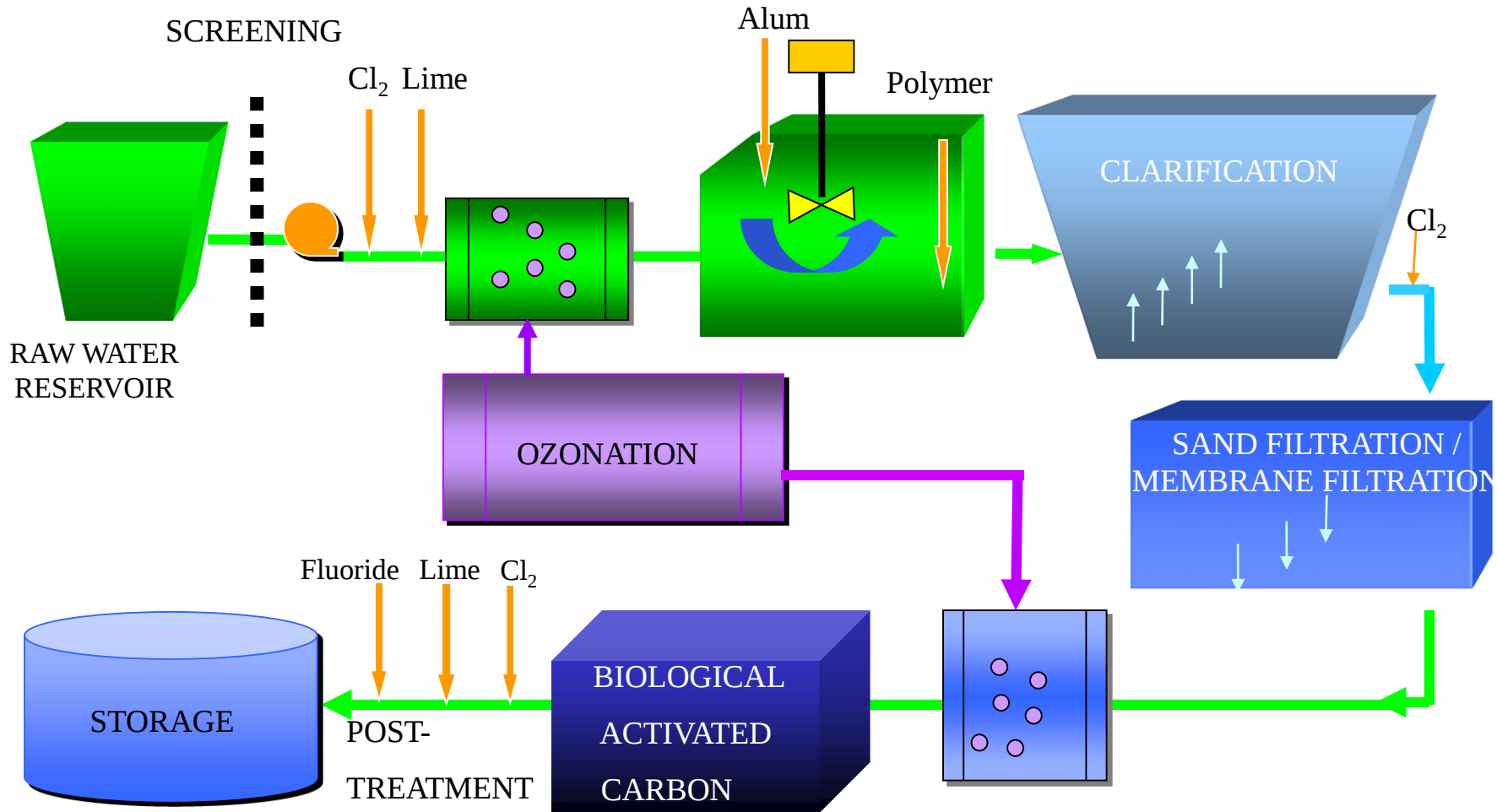


Fish culture



Aquatic plant removal

Protected Central Water Catchment Urbanised Catchment



Water Quality Management in Water Supply System

1. Management System adopting HACCP

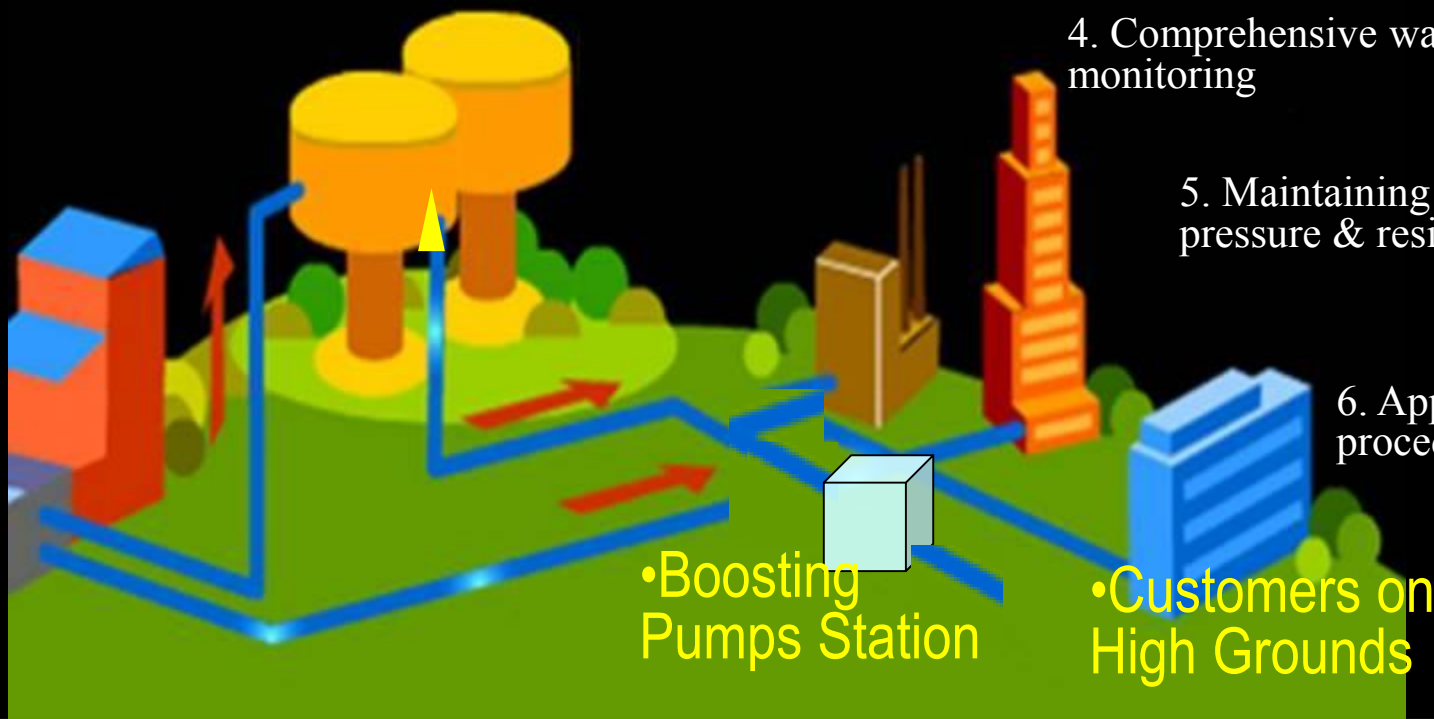
2. Fully enclosed distribution system and storages

3. Ensure compliance of COP by suppliers/retailers of water fittings

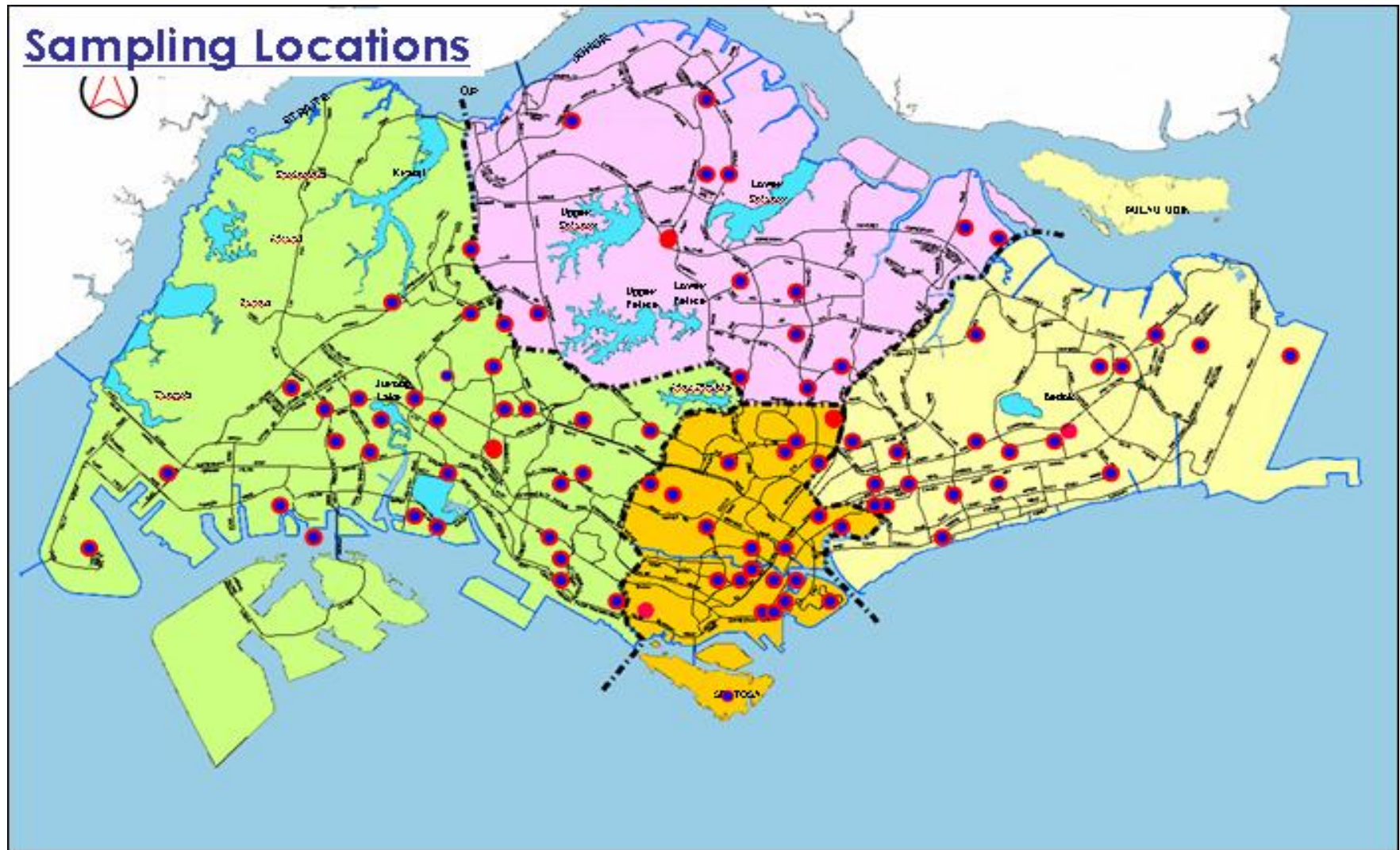
4. Comprehensive water quality monitoring

5. Maintaining adequate system pressure & residual

6. Appropriate repair procedures



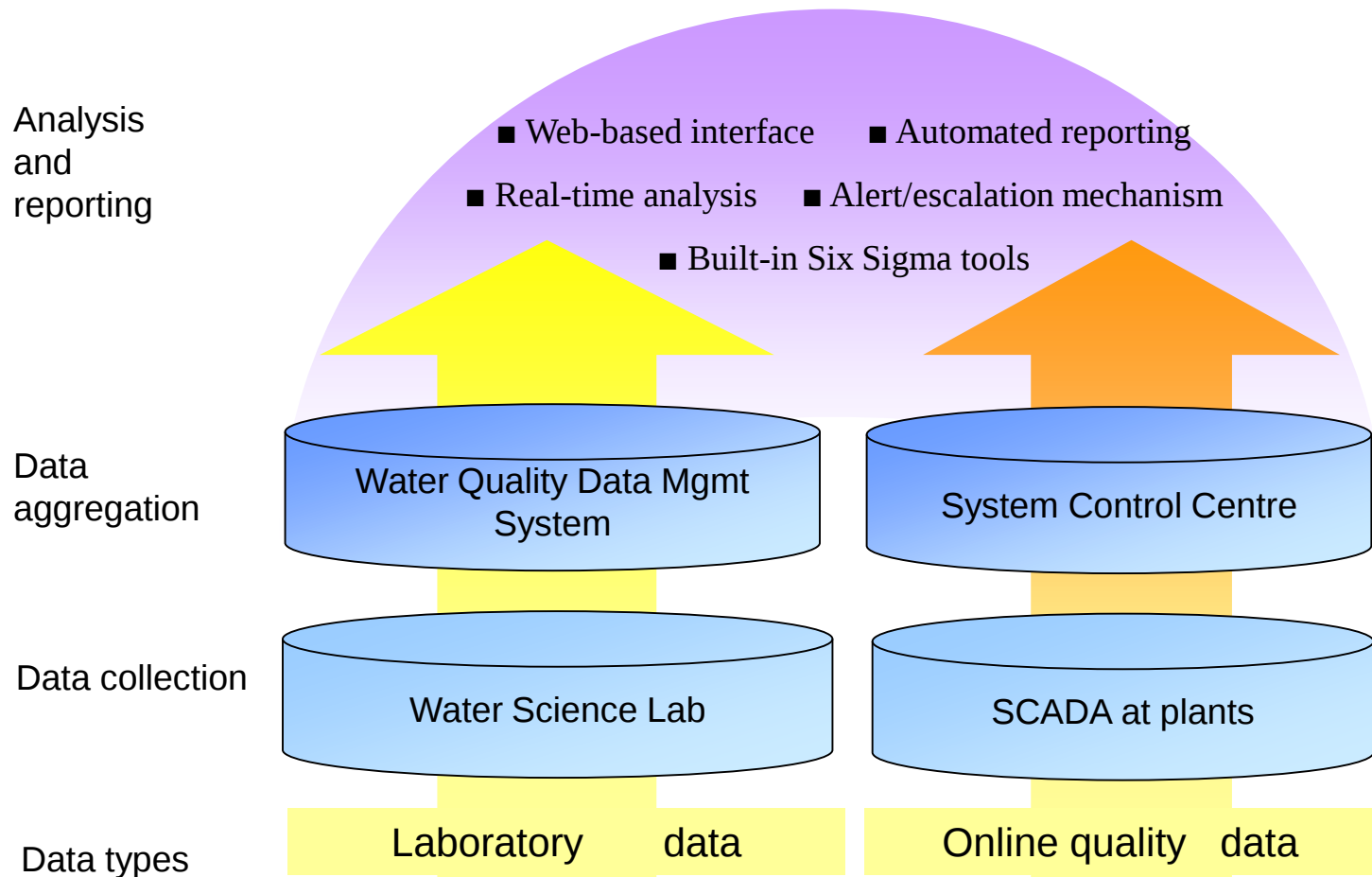
Sampling Points



Water Quality Monitoring Approach

Routine Sampling	• Over 120 sample/week taken from network • 50% direct supply, 50% indirect supply • Also include samples from customers premises
Investigatory Sampling	• Re-sample when routine sample exceed typical value • Change in network operation or supply source (e.g Desal zone, source from new reservoir) • Report from customers on abnormal water supply
Special Sampling	• Sensitive or major events • Step up sampling frequency if necessary

Integrated Water Management System



A strategic operation system for water quality management

Water Security

- 1) **Conventional Fish Tanks**
- 2) **Online surrogate parameters sensors**
- 3) **Fish Biosensors**



Conventional Fish Tanks for Water Quality monitoring

Fish Biosensor

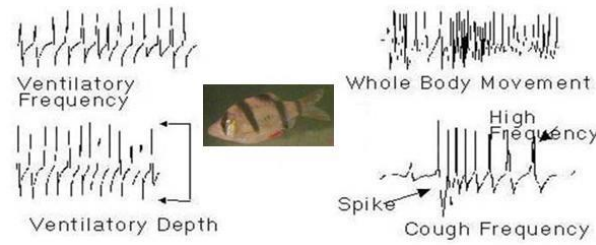
•Physiological Responses

Control Panel

- A proprietary online system that assesses water quality by monitoring physiological responses of fish to water contaminants

De-Chlorination System

- ✓ Round-the-clock surveillance of water resources at sensitive and critical installations.
- ✓ Improve lead time for action during trigger events.



•Normal



•Alert

Fish Activity Monitoring System

•Camera

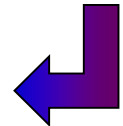
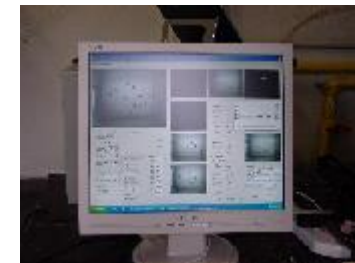
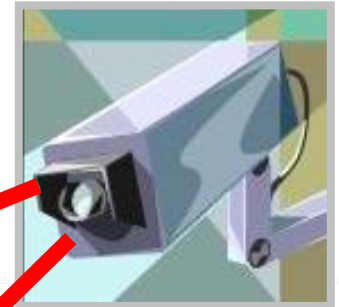
•An on-line system that assesses water quality by monitoring the physical behaviour (e.g. movement) of fish to generate fish silhouette and motion trajectory.



- ✓ Round-the-clock, automated surveillance of water resources.
- ✓ Further improve lead time for action during trigger events.
- ✓ To install the FAMS stations at 55 locations, such as service reservoirs and waterworks.

•Fish Tank

•*Collaborative Project between PUB and I2R*



Three Tier Water Monitoring Plan

- **First tier water monitoring**
 - Rapid screening the likely presence of toxic chemical and biological hazard in water sample within 30 minutes
- **Second tier water monitoring**
 - Identify, quantify and confirm the presence of specific chemical and microbial contaminants within 4 hours
- **Third tier water monitoring**
 - Identify and confirm the presence of specific pathogens and bacteria species in water sample within 24 – 48 hours

Internal and External Audit Panels

- IAP: chaired by local expert in NUS
- EAP: 5 foreign experts and 2 local experts
- Independent audit every 6 months



External Audit Panel	Area of expertise
Prof Joan Rose (Chairperson)	Microbiology
Prof Thomas Grizzard	Environmental Engineering/Water Quality Monitoring
Prof Wolfgang Kühn	Water Chemistry
Prof Laszlo Somlyody	Environmental Engineering/Water Quality Monitoring
Mr Michael Wehner	Water Quality and Water Technology
Prof Ong Choon Nam	Human Health and Toxicology
Prof Lee Hian Kee	Environmental and Analytical Chemistry

Areas of Audit



- Sampling and analysis of water quality including NEWater, reservoir raw water and potable water



- Operation and maintenance of NEWater Factories and Waterworks



CHANGI
WRP & NEWATER

- Major water projects and initiatives undertaken by PUB e.g. Tuas Desalination DBOO, Ulu Pandan NEWater DBOO Plant, Marina Barrage & Punggol-Serangoon Reservoir Scheme

DTSS

MARINA
RESERVOIR



- Staff training and competency



- Emerging Issues & concerns for Drinking Water

R&D in Water Quality

Pumping Mains / Transmission / Distribution



Study Flow Pattern in SR

Study on Nitrification

Microbial Ecology in distribution system

Trace Organics & PPCPs

Improving Water Flow in Pipelines

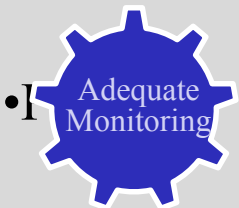


Fish Activity Imaging

Response of Surrogates to Toxic Contaminants

Event Prediction (SANDIA)

• **Consistent**
• **Good**
• **Quality**



Wireless Sensor for Distribution Network (MIT)

Developing WQ Sensors for Deployment in Network

R&D for Real-time Water Quality Monitoring

**Online
Sensors
(critical
locations)**



- ✓ Fish Biosensors
- ✓ FAMS
- ✓ Transgenic Fish

**Mobile
Water
Quality
Stations**

- ✓ Next
Generation
Microbial
Sensors

**Distribution
System**

**Water
Sampling**

**Baseline
Data**

Service Reservoir

- ✓ Piezoelectric
- ✓ N DLC: Pt
- ✓ MZI sensors

- ✓ Wireless Data
Transmission

**Online
Sensors
(pumping
mains)**

- ✓ Online Event Detection
(CANARY)
- ✓ Source Identification
(PONI)
- ✓ Sensor Placement
(SPOT)



Marina Barrage, Singapore

