

# MEBS6000 Utility Services

<http://www.hku.hk/mech/msc-courses/MEBS6000/index.html>



## Course Overview

Sept. 2010

# Course Arrangements



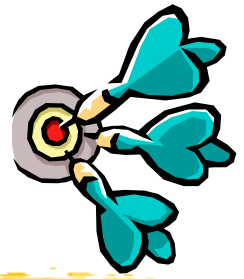
- First Semester 2010-11
- Every Tuesday 19:00 – 21:30
- Venue: Chong Yuet Ming Physics Building P4
- Lecturers:  
Dr. Benjamin P.L. Ho (benjamin.ho@hku.hk)  
Ir. K.F. Chan (kfchan@southa.com)

# Enrolment Statistics



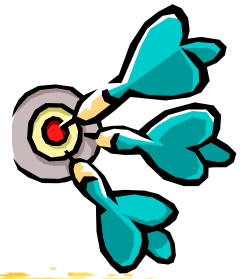
- MSc(Eng) in BSE – 83  
MSc(Eng) in EEE – 2  
MSc(Eng) in EnvE – 2  
MSc(Eng) in IELM – 1  
MSc(Eng) in ME – 11
- Year 1 – 42  
Year 2 – 52  
Year 3 & 4 – 5
- Full-time / Part-time – 2 / 97

# Course Overview

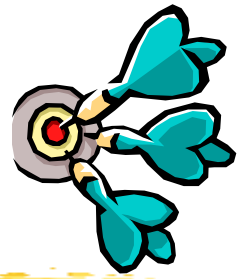


- Utility Services (公共設備)
  - “Utility” = a service used by the public
  - Utility companies like electric company, telephone companies, etc.
  - Utility Services in Buildings = public services that are necessary for the occupants to live and carry out activities inside buildings, e.g. electric supply, water and sanitation, gas supply, telecommunication, vertical transportation

# Course Overview



- Educational Objectives:
  - To introduce students to various utility services installations in modern buildings
  - To enable students to design appropriate utility services systems aiming at achieving integration and co-ordination between disciplines



# Course Overview

- Study Topics:

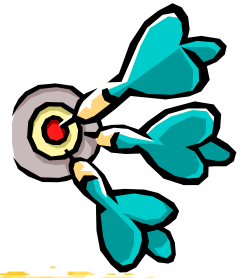
- 1) Cold and hot water systems
- 2) Steam systems
- 3) Sanitary & stormwater drainage
- 4) Sewage disposal

**Dr. P.L. Ho**

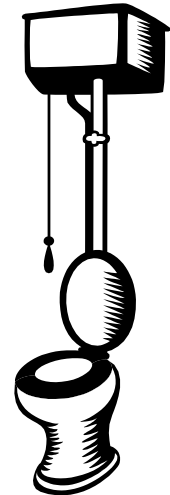
- 
- 1) Lifts & escalators
  - 2) L.V. electrical installation
  - 3) Communication systems
  - 4) Security and alarm systems

**Ir. K.F. Chan**

# Course Overview



- Teaching content (by Dr. P.L. Ho)
  - Cold & flush water supply
  - Hot water supply
  - Design of water supply systems
  - Steam systems
  - Storm water & sanitary drainage
  - Sewage disposal



給水排水

# MEBS6000 Utility Services

<http://www.hku.hk/mech/msc-courses/MEBS6000/index.html>



## Cold & Salt Water Supply



Sept. 2010





# Contents for this session

- Water supply in Hong Kong
- Water treatment processes
- Water supply distribution
- Water tanks & pumps
- Water quality & management
- Water conservation





# **Water Supply In Hong Kong**

# History of water supply in HK



- A comprehensive history of water supply in Hong Kong can be referred to the website of the Water Supplies Department ([www.wsd.gov.hk](http://www.wsd.gov.hk))
  - 1851: sinking of 5 wells in the “City of Victoria”
  - 1863: Pok Fu Lam reservoir with a capacity of 9,000 cubic metres and aqueduct completed
  - .....
  - 1960: Work started on Plover Cove reservoir, the first fresh water reservoir in the world to be carved out of the sea.
  - 1960: First Agreement reached with Guangdong authorities for supplies from Guangdong.

# History of water supply in HK



- A comprehensive history of water supply in Hong Kong can be referred to the website of the Water Supplies Department ([www.wsd.gov.hk](http://www.wsd.gov.hk))
  - 1968: Plover Cove reservoir with a capacity of 170 million cubic metres completed.
  - 1975: Lok On Pai Desalter came into operation
  - 1978: High Island reservoir, with a storage capacity of 281 million cubic metres, completed
  - 1982: Shut down of Lok On Pai Desalting Plant

# History of water supply in Hong Kong (1946-2007)

1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974



**1957**  
Use of seawater for toilet flushing in Shek Kip Mei and Lei Cheng Uk Estate



**1960**  
Water Supply Agreement with Guangdong  
Supply from Shenzhen Reservoir



**1963**  
Completion of Shek Pik Reservoir  
24.5 mcm capacity



**1968**  
Completion of Plover Cove Scheme and Extension in 1973  
230 mcm capacity



**1959**  
Completion of Tai Lam Chung Reservoir  
20.5 mcm capacity



**June 1963 - May 1964**  
Severe Water Rationing  
4 hours of supply every 4 days



**1965**  
Completion of Lower Shing Mun Reservoir  
4.3 mcm capacity

**1965**  
Water Supply Agreement with Guangdong  
68.2 mcm/year of Dongjiang water supply

# History of water supply in Hong Kong (1946-2007) (cont'd)



**1978**  
Completion of High Island Scheme  
281 mcm capacity



**1989**  
Water Supply Agreement  
with Guangdong  
Maximum 1,100 mcm/year  
of Dongjiang water supply



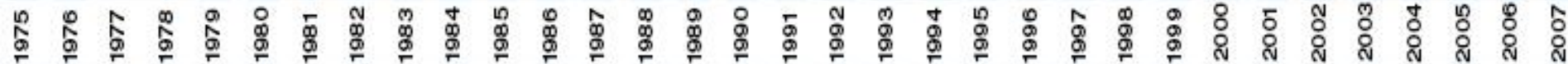
**2006**  
Water Supply Agreement  
with Guangdong  
Flexible supply of Dongjiang water



**1981-1982**  
Last water rationing  
in Hong Kong



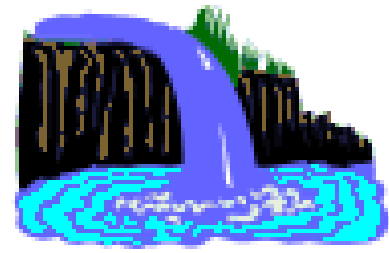
**2003**  
Commissioning of 83km dedicated  
aqueduct for delivery of Dongjiang water





Reservoirs & water gathering grounds in Hong Kong

(Source: Water Supplies Department, [www.wsd.gov.hk](http://www.wsd.gov.hk))



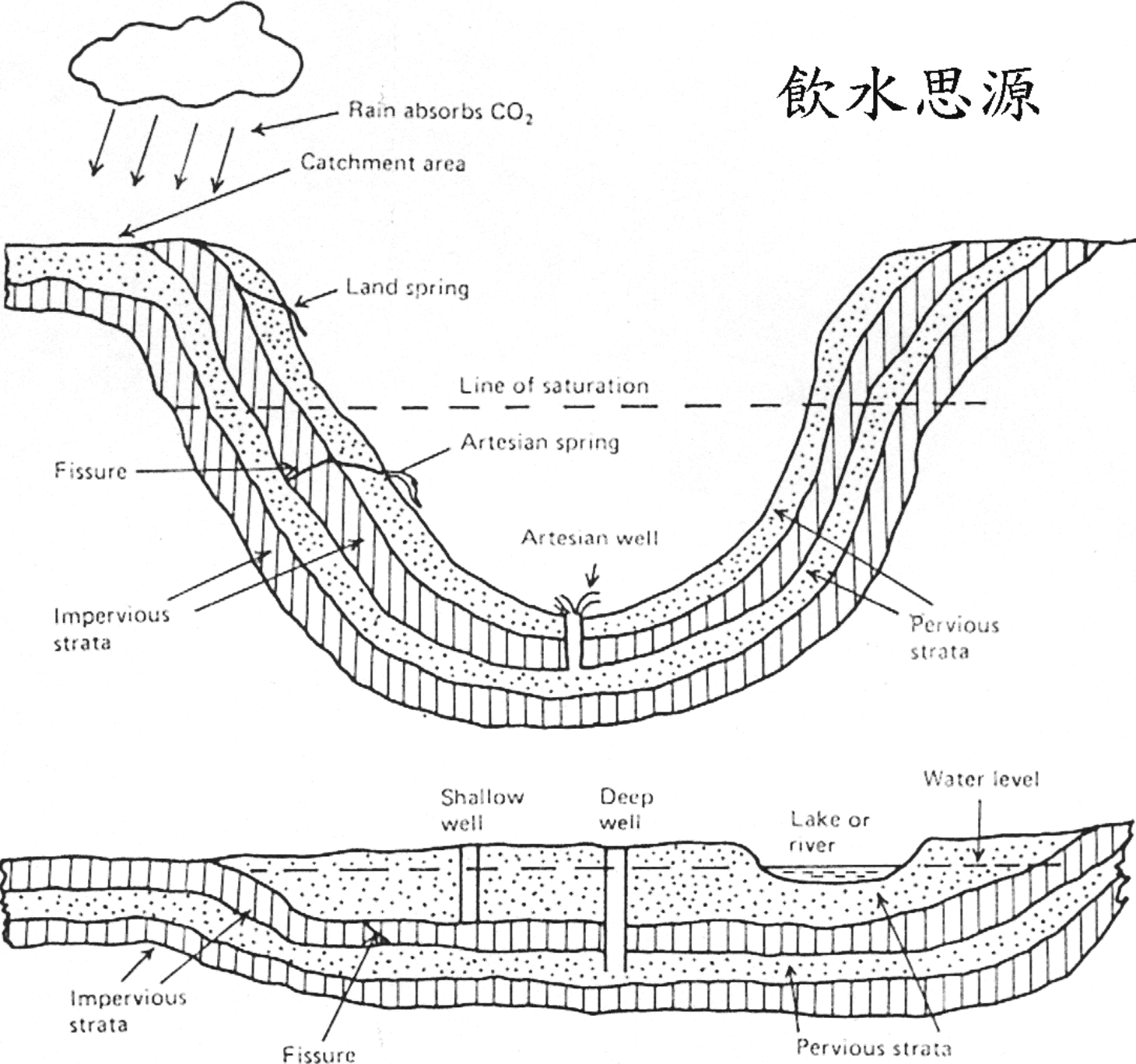
# Water sources

- Surface & underground water sources:
  - Shallow wells
    - Sinkings in top water-bearing strata
  - Intermittent or land springs
    - From top water-bearing strata
  - Deep wells
    - Sinkings below the first impervious strata
  - Artesian wells and springs
    - The same source as deep wells
  - Lakes & rivers
    - Catchment of surface and subsoil water

飲  
水  
思  
源



# 飲水思源



(Source: Hall, F. and Greeno, R., 2007. *Building Services Handbook*)



# Water sources

- Water Supplies Department (WSD)
  - To plan & manage water resources & water supply systems
  - To design & construct waterworks projects
  - To operate & maintain water supply & distribution systems
  - To control the quality of water supply to customers
  - To enforce the Waterworks Ordinance & Regulations
    - Include vetting plumbing proposals for buildings (from ‘Licensed Plumbers’)
- Water resources in HK
  - Rainfall from natural catchment + supply from Guangdong
    - **70-80% of water demand is supplied by water from Guangdong**
  - Sea water for flushing toilets (for over 80% population)



Xinfengjiang Reservoir  
新豐江水庫

Dongjiang 東江

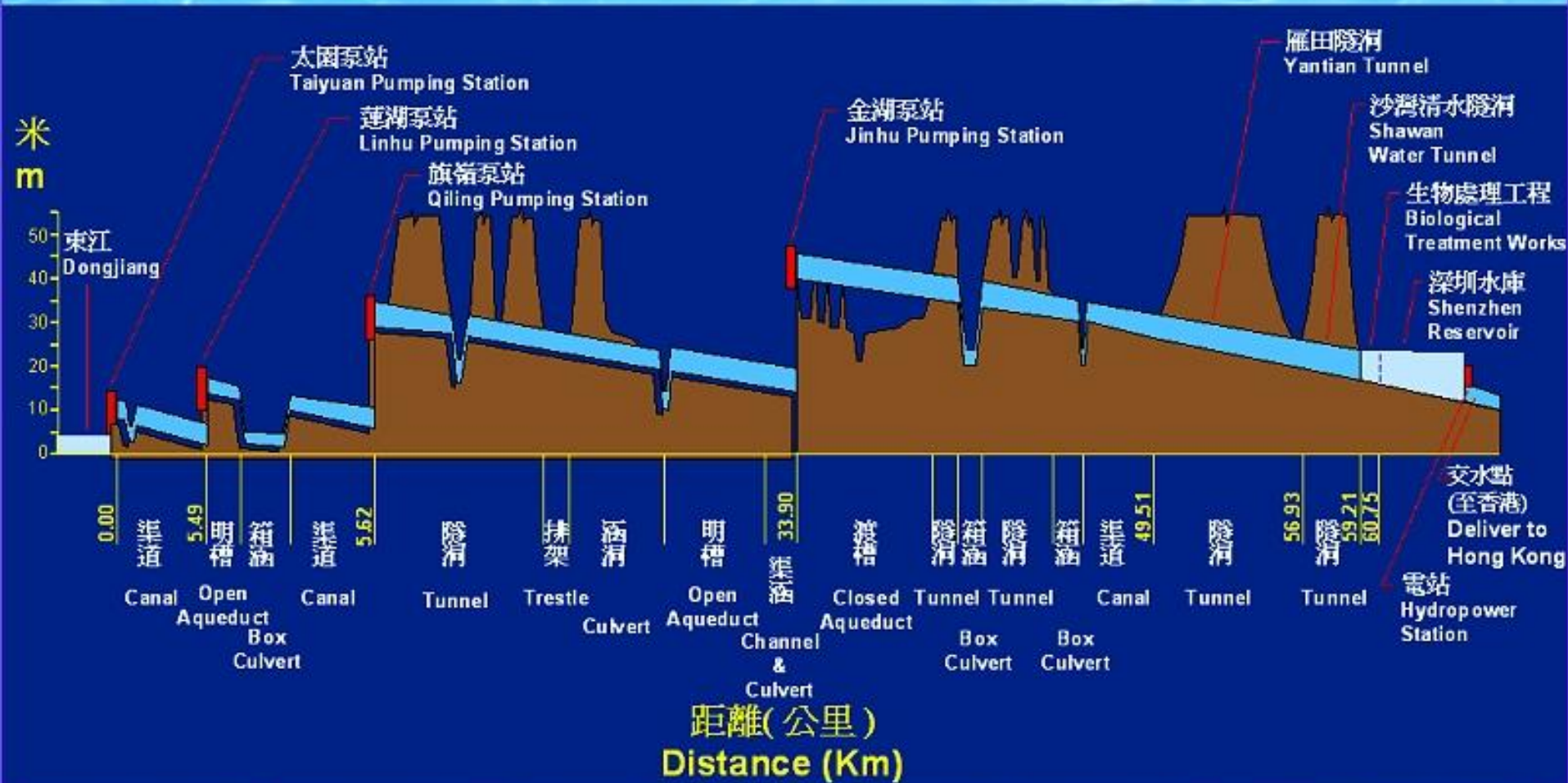
Shenzhen Reservoir  
深圳水庫

Muk Wu Pump Station (HK)  
木湖泵站(香港)

Water pipes along the  
railway line

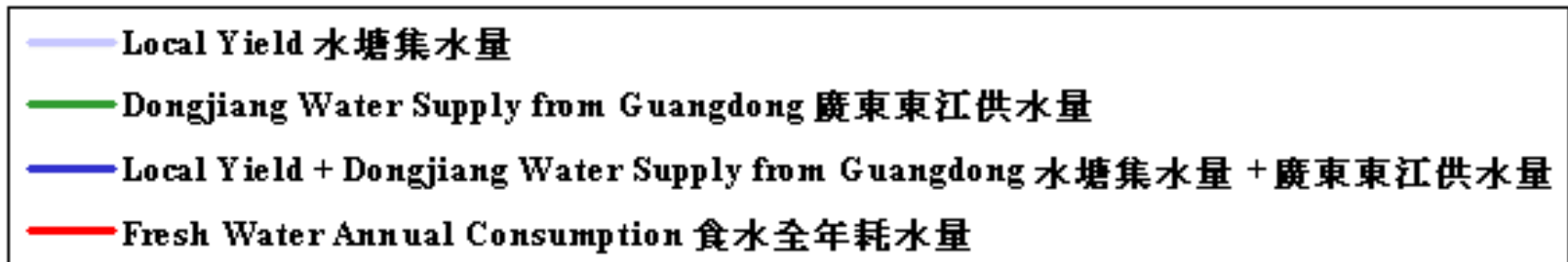
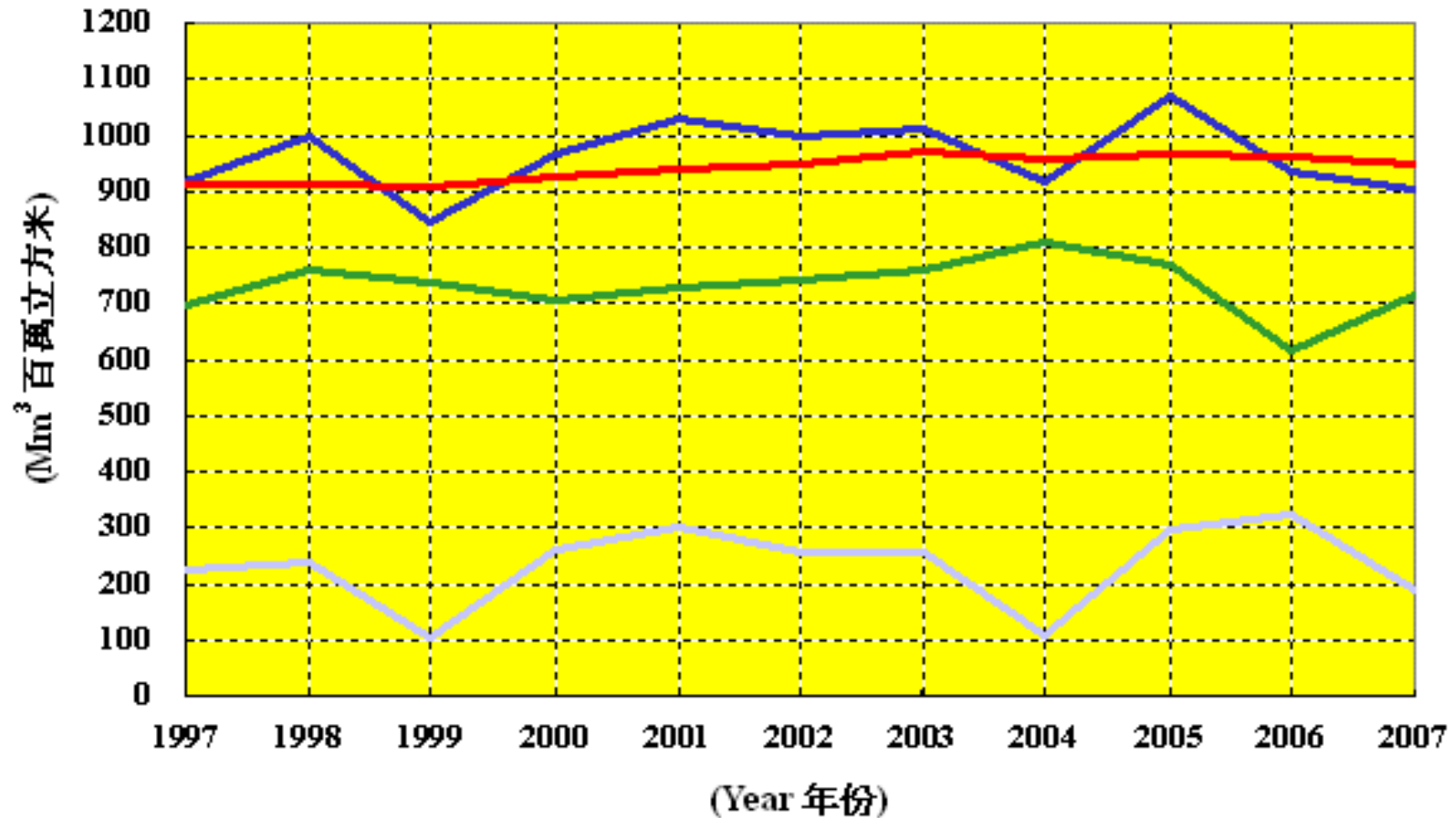
# 東深供水系統 - 密封式輸水管道(縱切面)

## Dongshen Water Supply System – Closed Aqueduct (Longitudinal Section)



# RESOURCES AND FRESH WATER ANNUAL CONSUMPTION

## 各水源供水量及食水全年耗水量



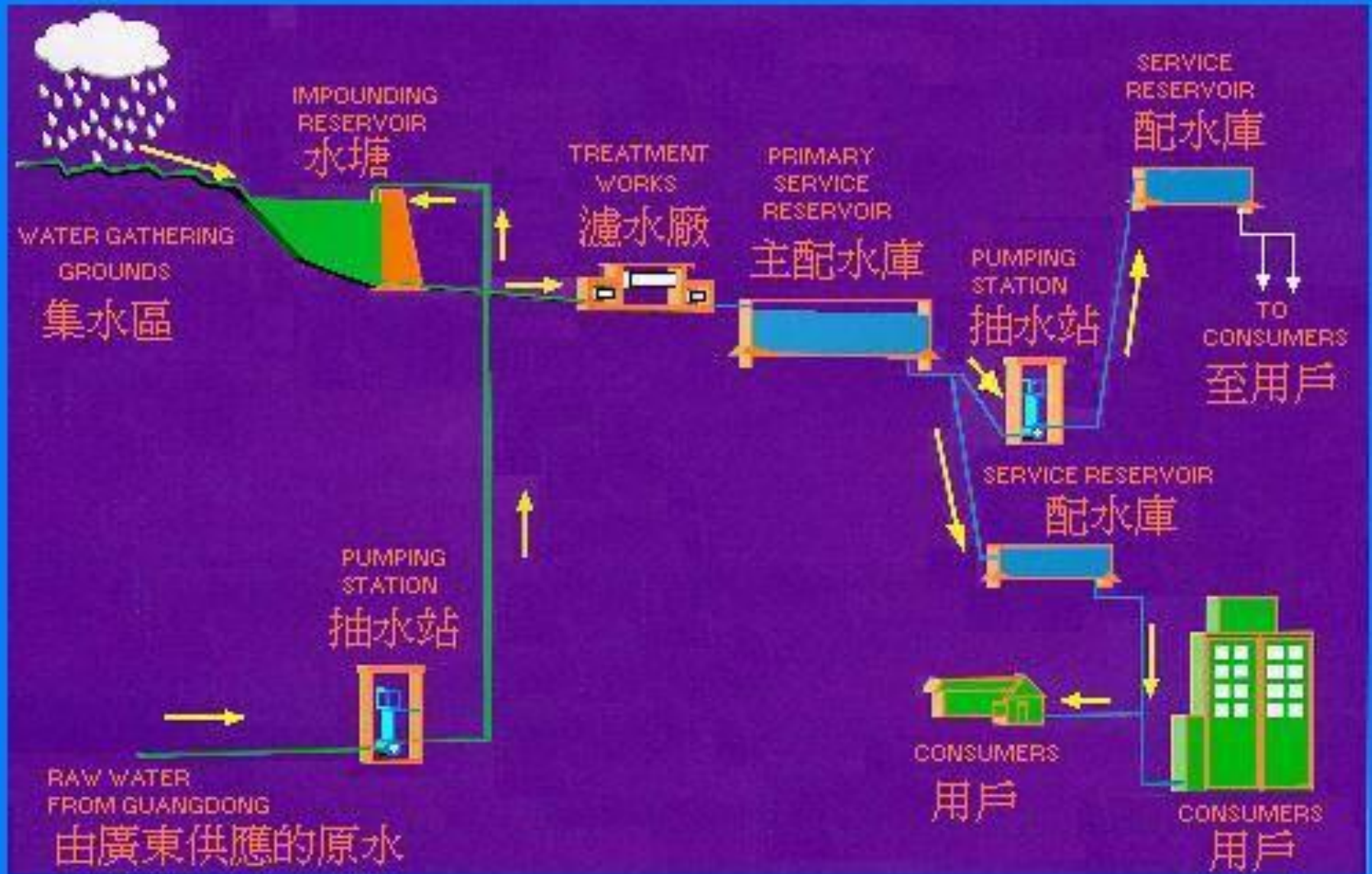
# Some statistics on water consumption



- Annual fresh water consumption in 2008 = **956M m<sup>3</sup>**  
Distribution:
  - Domestic – 519M
  - Industrial – 59M
  - Service Trades – 241M
  - Free Supply – 45M
  - Construction and Shipping – 11M
  - Flushing – 81M
- Annual seawater consumption = **275M m<sup>3</sup>**

# A TYPICAL FRESH WATER SUPPLY SYSTEM (SCHEMATIC)

## 典型食水供水系統(概要)



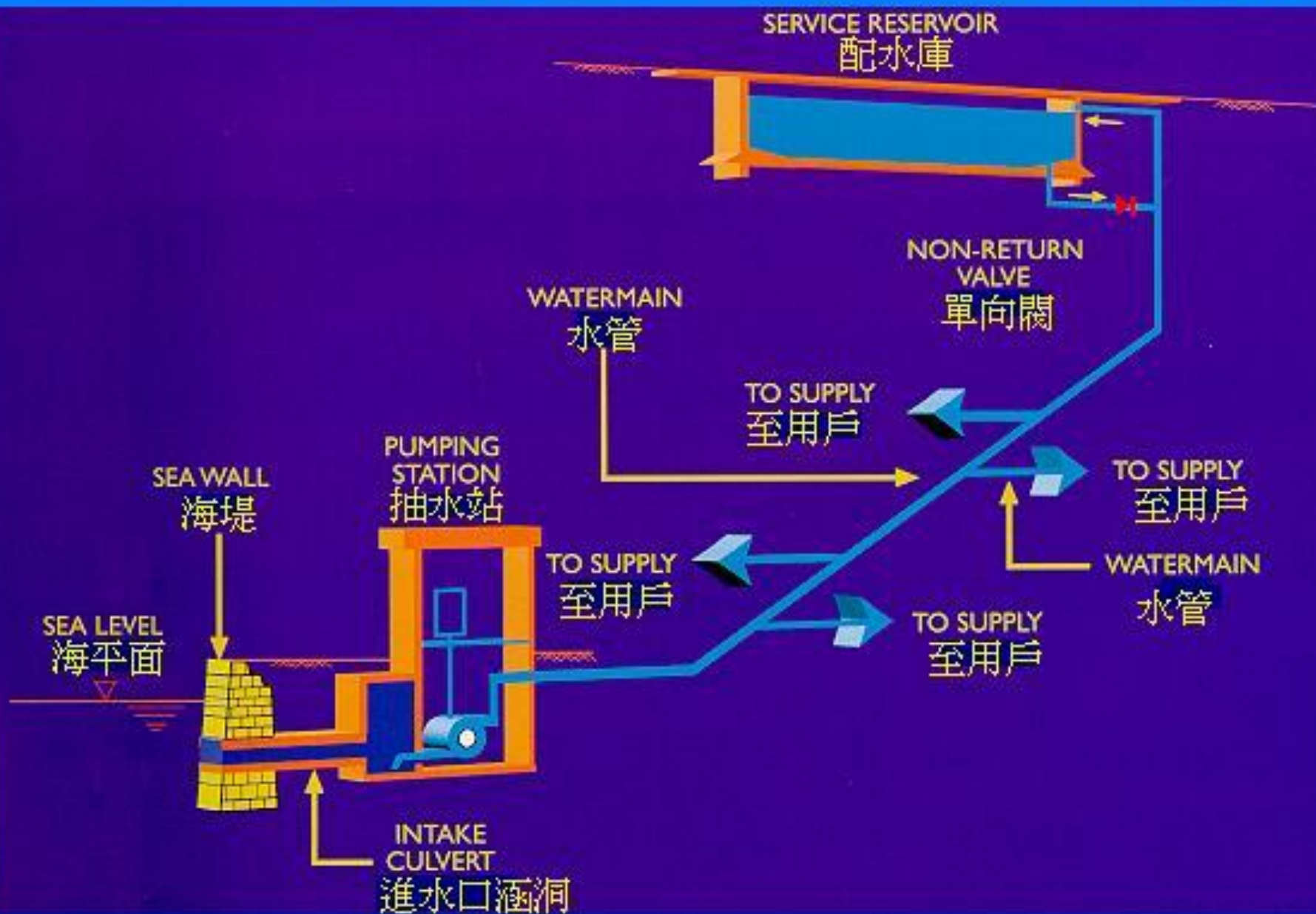


Existing seawater  
flushing situation &  
proposed extensions<sup>24</sup>

(Source: Water Supplies Department, [www.wsd.gov.hk](http://www.wsd.gov.hk))



A TYPICAL SEA WATER SUPPLY SYSTEM (SCHEMATIC) 典型海水供水系統 (概要)



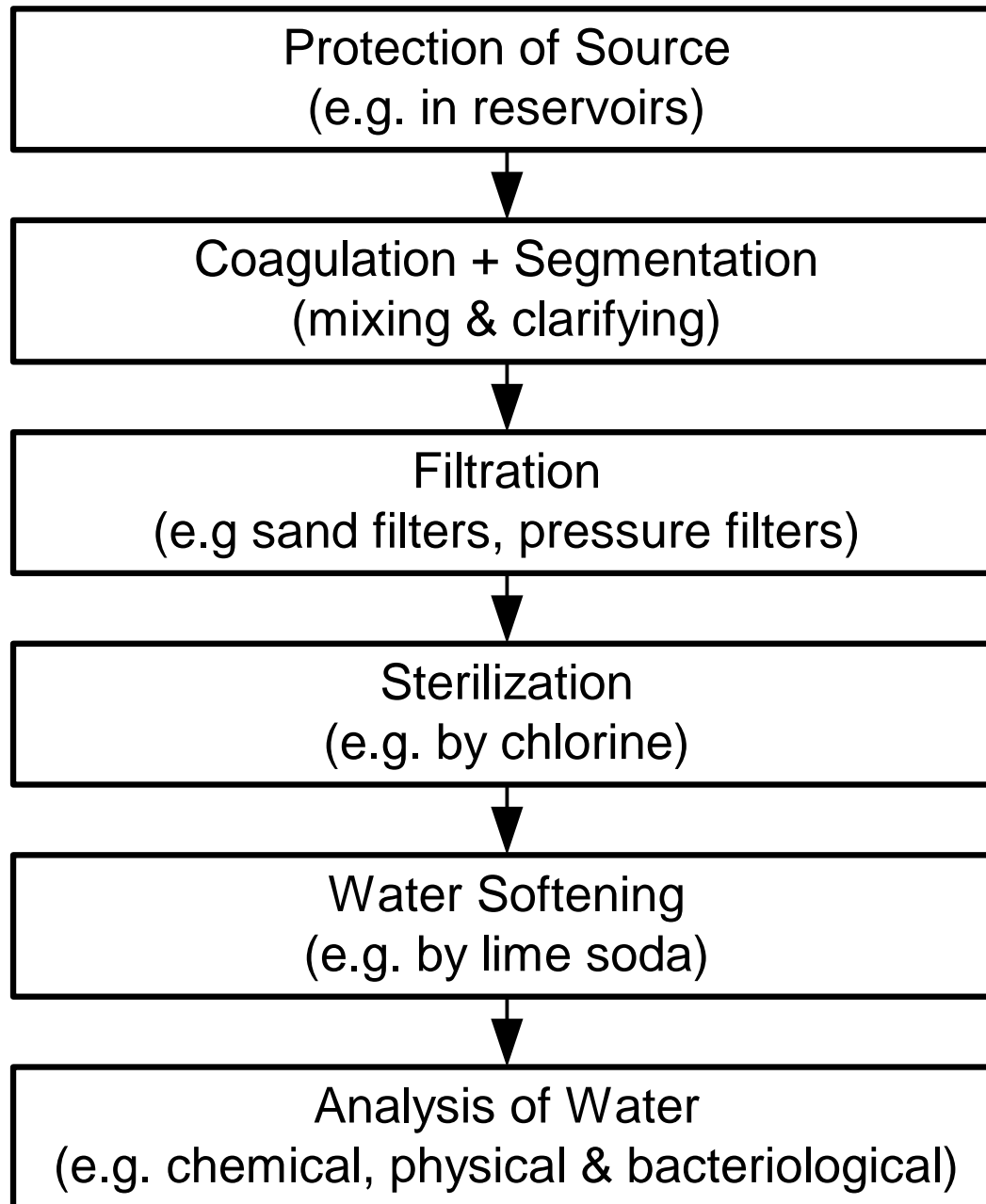


# **Water Treatment Processes**



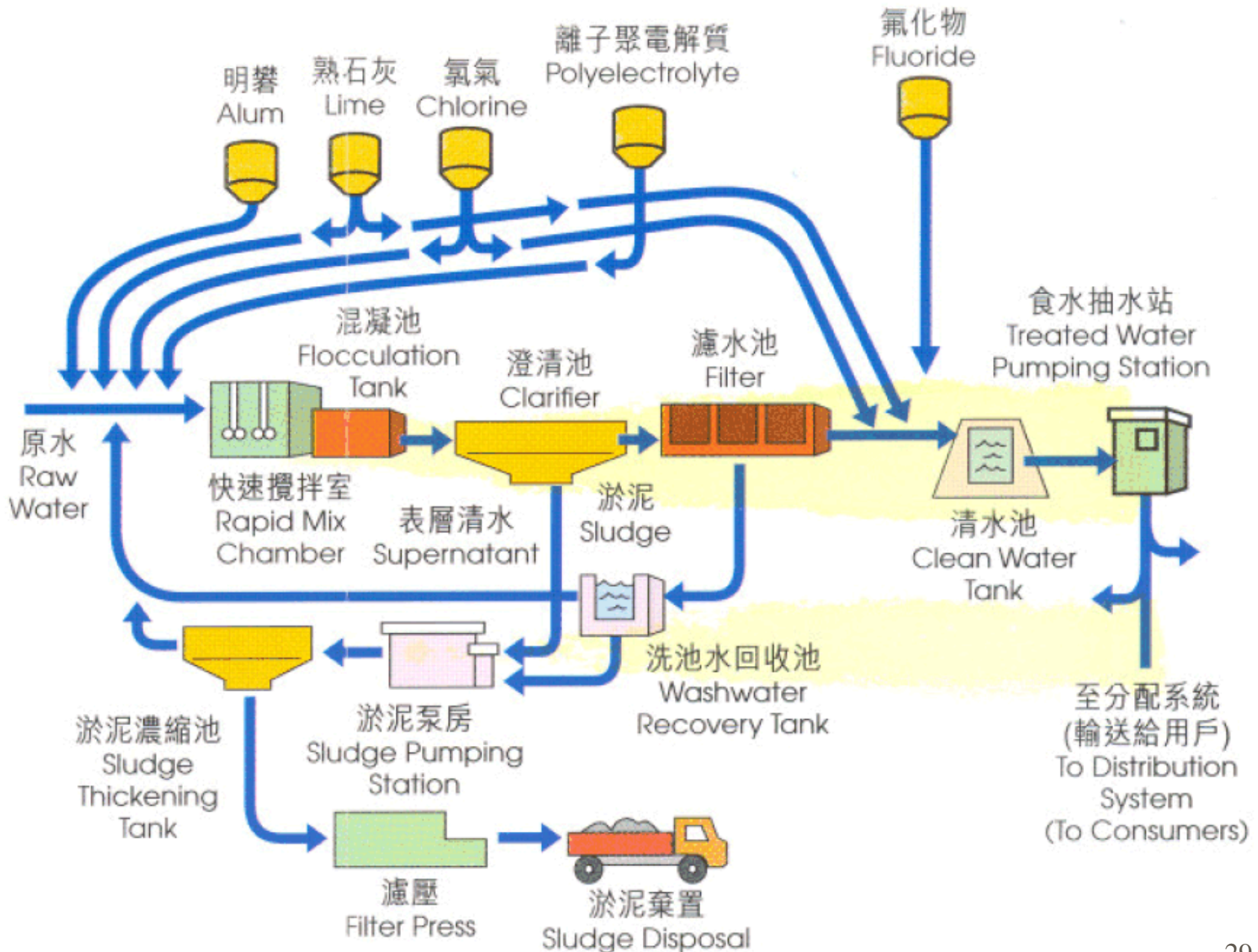
# Water treatment

- Water for human consumption must be:
  - Free from harmful bacteria & suspended matter
  - Colourless
  - Pleasant to taste
  - For health reasons, moderately ‘hard’ ( $\text{CaCO}_3$ )
- Water storage & treatment process to ensure good water quality
  - Complies with World Health Organization (WHO) guidelines for drinking water



Typical water treatment process

# The water treatment process

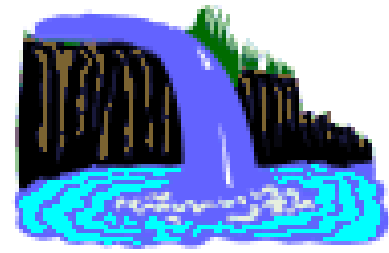




# Water treatment processes

- Typical water treatment process in HK
  - 1. Raw water
    - Comes from different sources, including reservoir(s) and Dongjiang water of Guangdong
  - 2. Mixing
    - Raw water is dosed at the mixing chamber with
      - Hydrated lime to precondition the raw water
      - Chlorine to control algae
      - Alum to coagulate impurities
      - Polyelectrolyte to improve the coagulation and flocculation of impurities

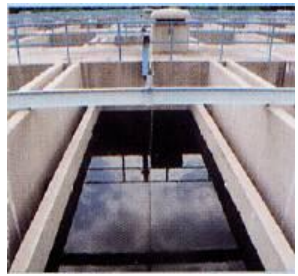
# Water treatment processes



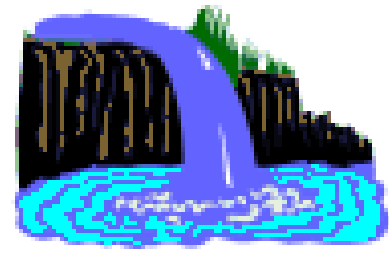
- Typical water treatment process in HK (cont'd)

- 3. Flocculation and Sedimentation

- After mixing, water is passed to the clarifiers where coagulation and flocculation of the impurities in the water will occur
- The dissolved alum coagulate impurities in the water into large particles where settle as sludge
- The sludge is collected and conveyed to sludge thickening tanks for further treatment before disposal



# Water treatment processes



- Typical water treatment process in HK (cont'd)

- 4. Rapid Gravity Filtration

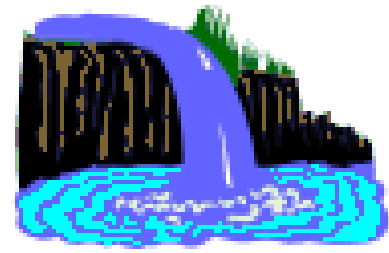


- Settled water from the clarifiers flows to the constant rate sand filters for removal of more finely divided suspensions
    - Periodically the filter beds are cleaned by backwashing with air and then water

- 5. Clear Water Tanks

- Chlorine, fluoride and lime are dosed into the filtered water in the contact tanks and disinfect, fluoridate and control the alkalinity of the final treated water
    - The treated water is stored in the clear water tank before conveying to service reservoirs for distribution to people





# Water treatment processes

- Typical water treatment process in HK (cont'd)

- 6. Pumping Facilities

- Pumping station in the treatment to pump the water to the distribution

- 7. Environmental Friendly Facilities

- The washwater is collected in the recovery tanks for repumping to the inlet for recycling
- Sludge produced is thickened by three circular sludge thickening tank using electrolyte as coagulant
- Thickened sludge is compressed by membrane type filter presses into cakes for disposal at landfill sites



# Water treatment processes



- Typical water treatment process in HK (cont'd)
  - 8. Water Quality Control
    - The quality of water is closely monitored by means of chemical, bacteriological and biological examinations of water samples taken
    - To comply with the Guidelines for Drinking Water Quality recommended by WHO, to ensure a safe and wholesome potable supply



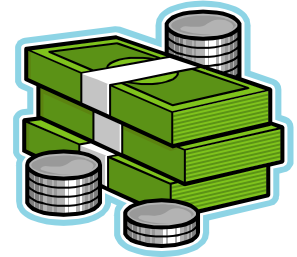
# Water Charges



- Water charges in Hong Kong

- Domestic consumers

- Billed at 4-monthly intervals (121.64 days)
    - 4 tiers with progressively increasing prices
    - To discourage excessive and unnecessary use of water
    - First tier: 12 cubic metres: free of charge
    - Second tier: 31 cubic metres: \$4.16 per cubic metre
    - Third tier: 19 cubic metres: \$6.45 per cubic metre
    - Fourth tier: > 62 cubic metres: \$9.05 per cubic metre





# Water Charges

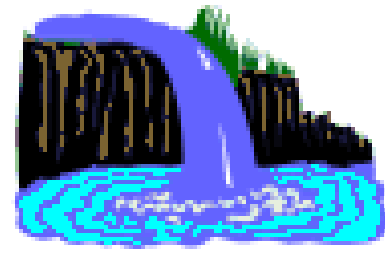
- Water charges in Hong Kong (cont'd)

- Non-domestic consumers

- Billed at 4-monthly intervals (for large consumption consumers, billed at monthly intervals)
- At a flat rate dependent on the purpose of the supply
- For trade: \$4.58 per cubic metre
- For construction: \$7.11 per cubic metre
- For non ocean-going shipping: \$4.58 per cubic metre
- For ocean-going shipping: \$10.93 per cubic metre

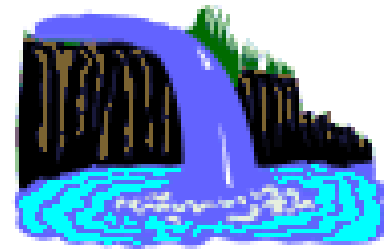


# Water Charges



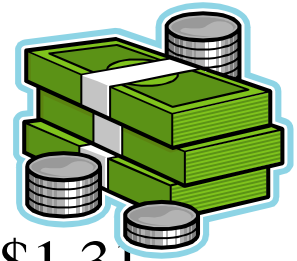
- Water charges in Hong Kong (cont'd)
  - [Water for Flushing purposes](#)
    - Sea water supply for flushing is free of charge
    - Fresh water supply for flushing is usually billed at 4-monthly intervals
      - First tier: 30 cubic metres per flat: free of charge
      - Second tier: > 30 cubic metres per flat: \$4.58 per cubic metre
    - Only one meter installed in each building to record the total consumption of all flats in the same building
      - Billed separately to the management office, agent, incorporated owner or development company





# Water Charges

- Water charges in Hong Kong (cont'd)
  - Sewage charges
    - For domestic consumers: at a 4-month interval: \$1.31 per cubic metre, with an exemption for the first 12 cubic metres
    - For trade, business and manufacture consumers: \$1.31 per cubic metre. Some trades are eligible for 30% discount (e.g. bleaching & dyeing, restaurants, softdrinks & ice-making industries)
    - For 30 types of trade/business/manufacture which discharge trade effluent, the consumer shall also pay a Trade Effluent Surcharge



# Licensing of Plumbers

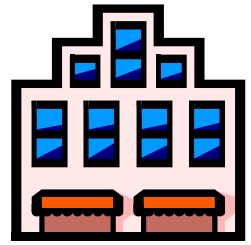


- Licensed Plumbers (持牌水喉匠)
  - A person licensed under the Waterworks Ordinance to construct, install, maintain, alter, repair or remove water supply plumbing
    - Grade I – for construction, installation, maintenance, alteration, repair or removal of a fire service or inside service of any type
    - Grade II – for maintenance and repair of a fire service or inside service; and for installation, maintenance, repair or removal of water appliances



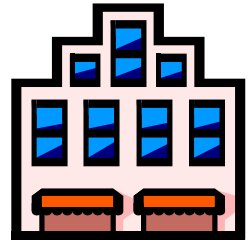
# **Water Supply Distribution**





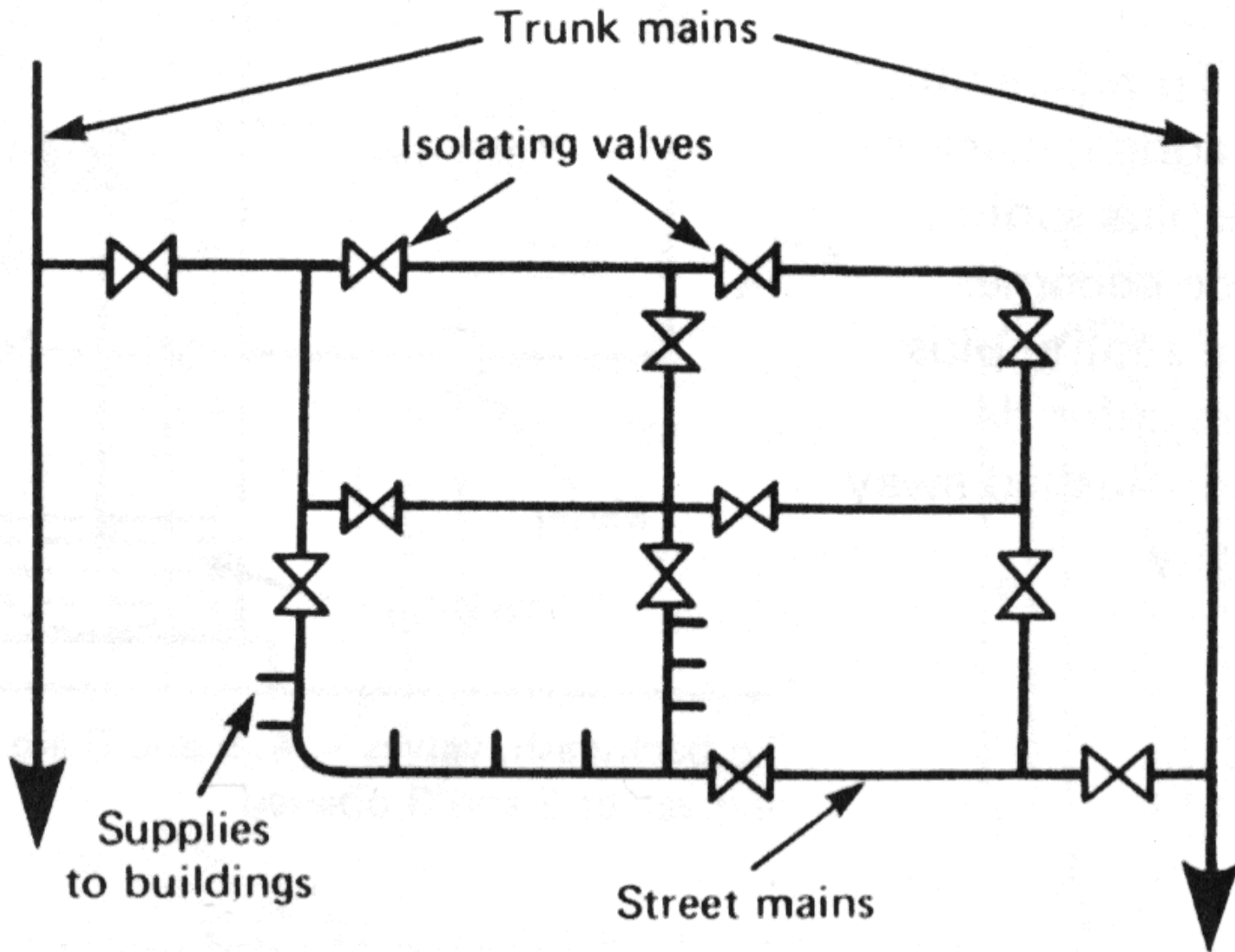
# Water supply distribution

- Water Mains distribution network
  - Main reservoir
  - Pumping stations
  - Water treatment plants
  - Pumping substations
  - Service reservoirs
  - Trunk mains or service trunks
  - Street mains or water mains (into buildings)

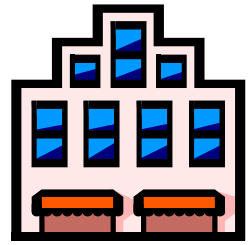


# Water supply distribution

- Mains water supply
  - Size of the water mains
  - Pressure (or head) of water (20 or 30m head)
  - Such as a 75 mm diameter pipe fed from both ends or a 100 mm diameter pipe fed from one end
  - Min. head of 30 m for firefighting purposes
  - Max. head of 70 m to limit wastage and pipe noise
- A ring circuit & a grid of pipes
  - To increase reliability & facilitate maintenance



Ring main distribution

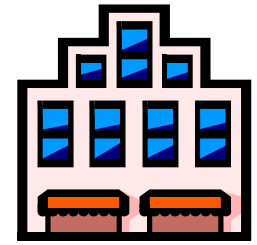


# Water supply distribution

- Pressure of water supplies in HK
  - Fresh water supply: 15-30 mH (metres head)
  - Salt water supply: 15 mH (metres head)
- They are maintained in the distribution systems except at their extremities
- Reduction of the minimum residual pressure (since 2007): lower from 30- to 20-metre head

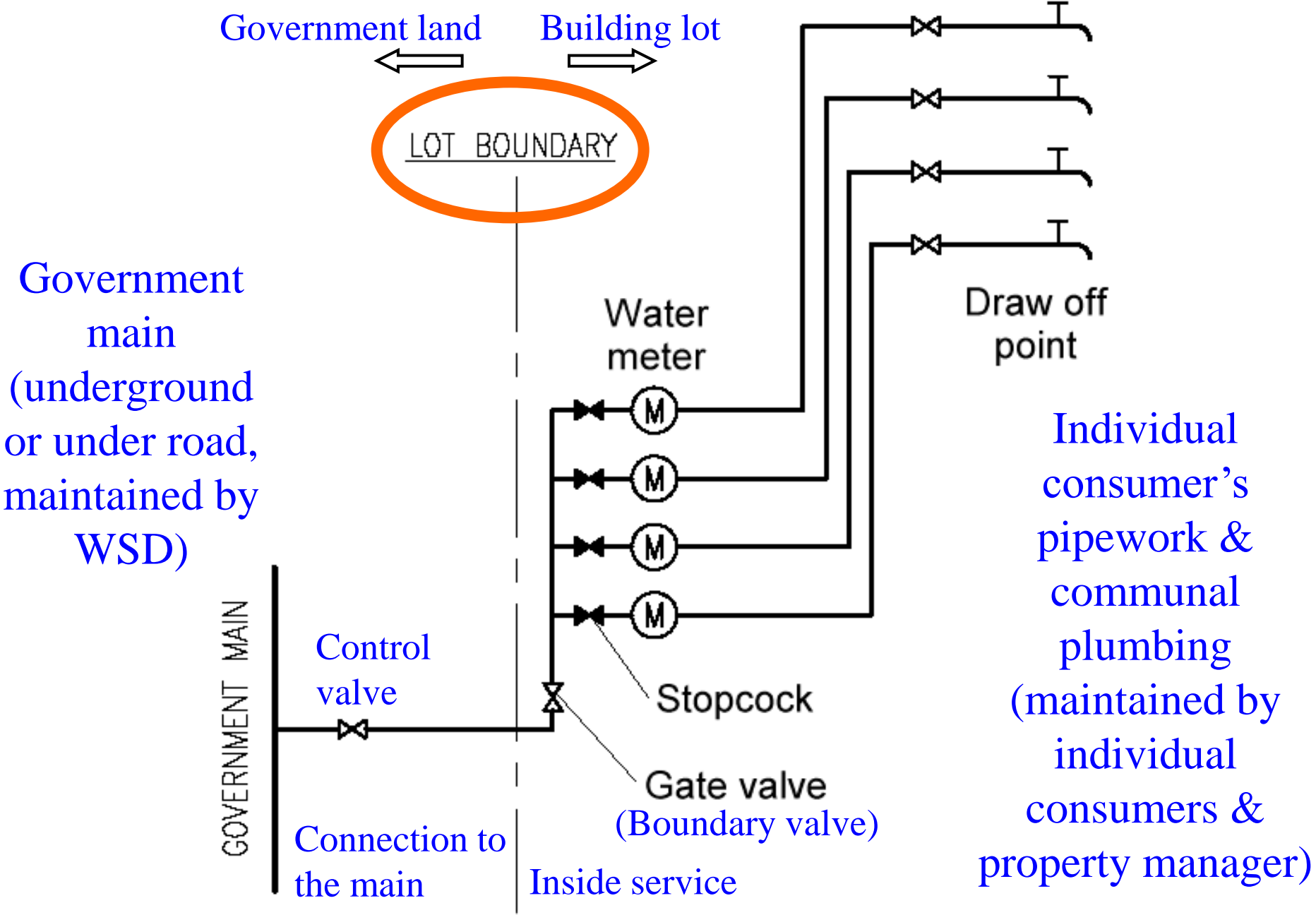
1mH = 1m of water column = 9,810Pa

1 atm pressure = 101,325Pa = 10mH (approx)



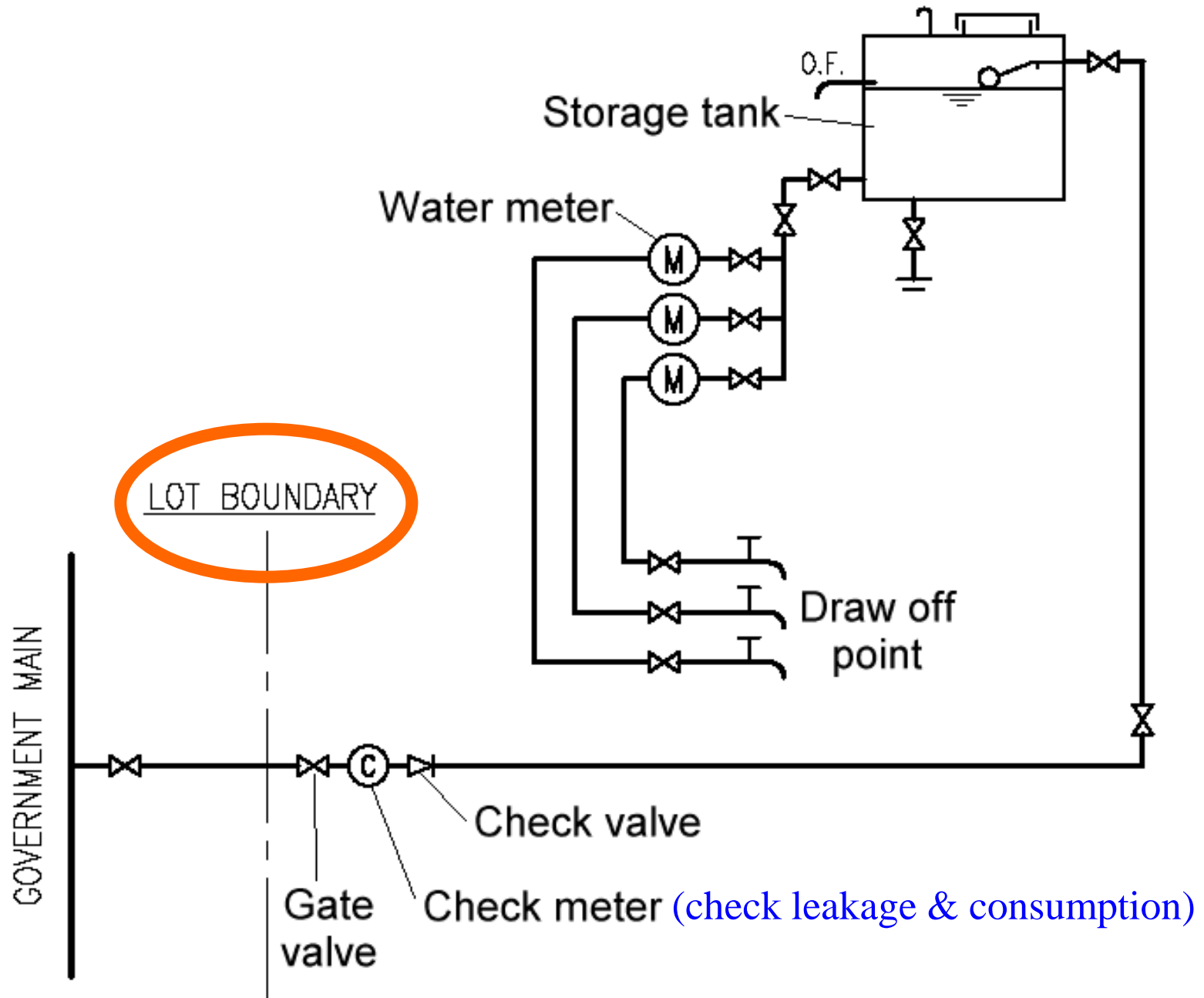
# Water supply distribution

- Water supply systems in buildings
  - Direct supply system: conveys water directly from water mains to the point of usage without any transit water storage tanks (**only for fresh water**)
  - Indirect supply system: conveys water from water mains to the point of usage through a transit water storage tank (usually a sump water tank and a roof water tank)
- Potable/fresh water, flushing/salt water and water for fire services (e.g. FH/HR, sprinkler)



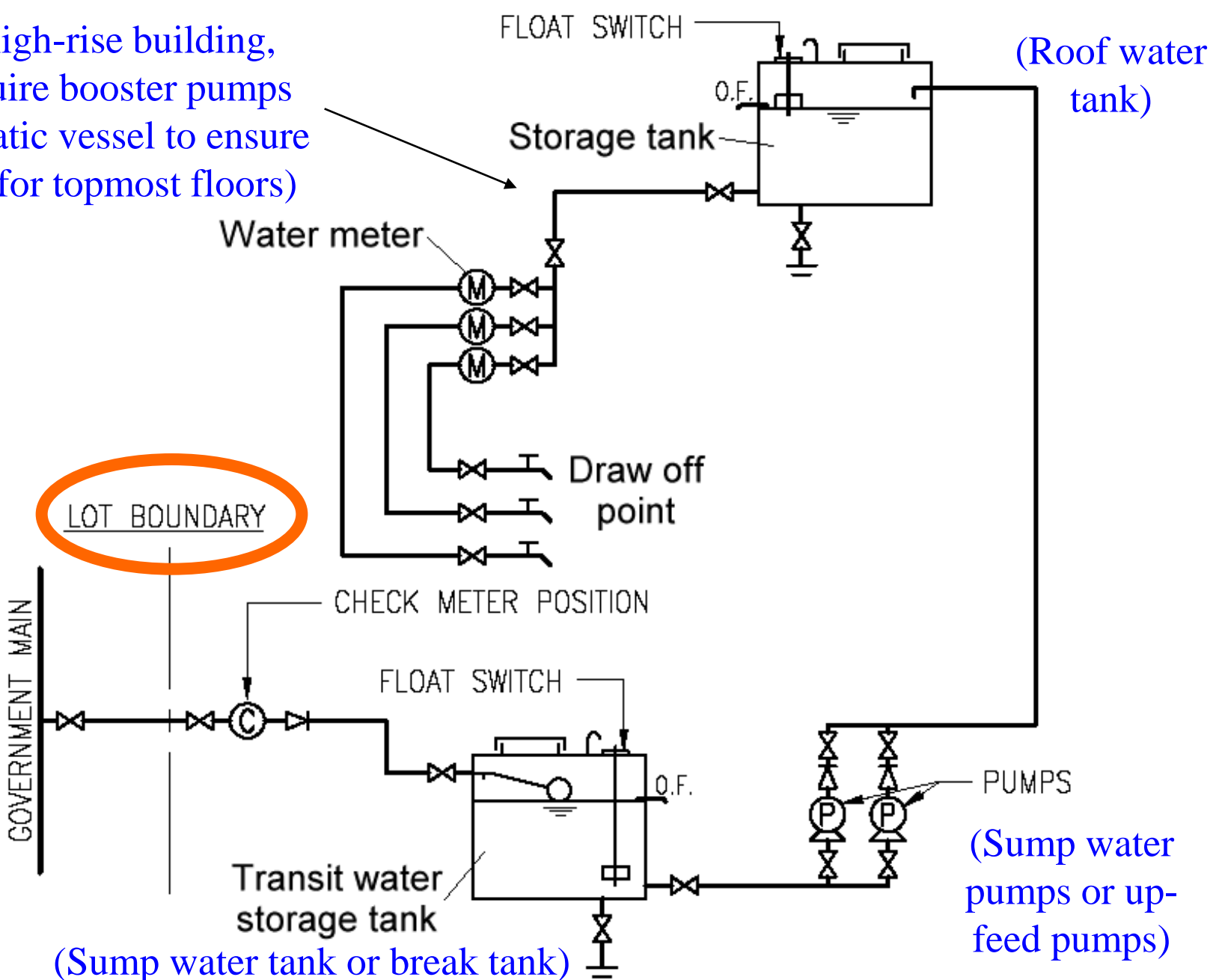
Direct supply system (without storage tank)

(Source: Water Supplies Department, [www.wsd.gov.hk](http://www.wsd.gov.hk))



Direct supply system (with storage tank)

(For a high-rise building, may require booster pumps & pneumatic vessel to ensure pressure for topmost floors)

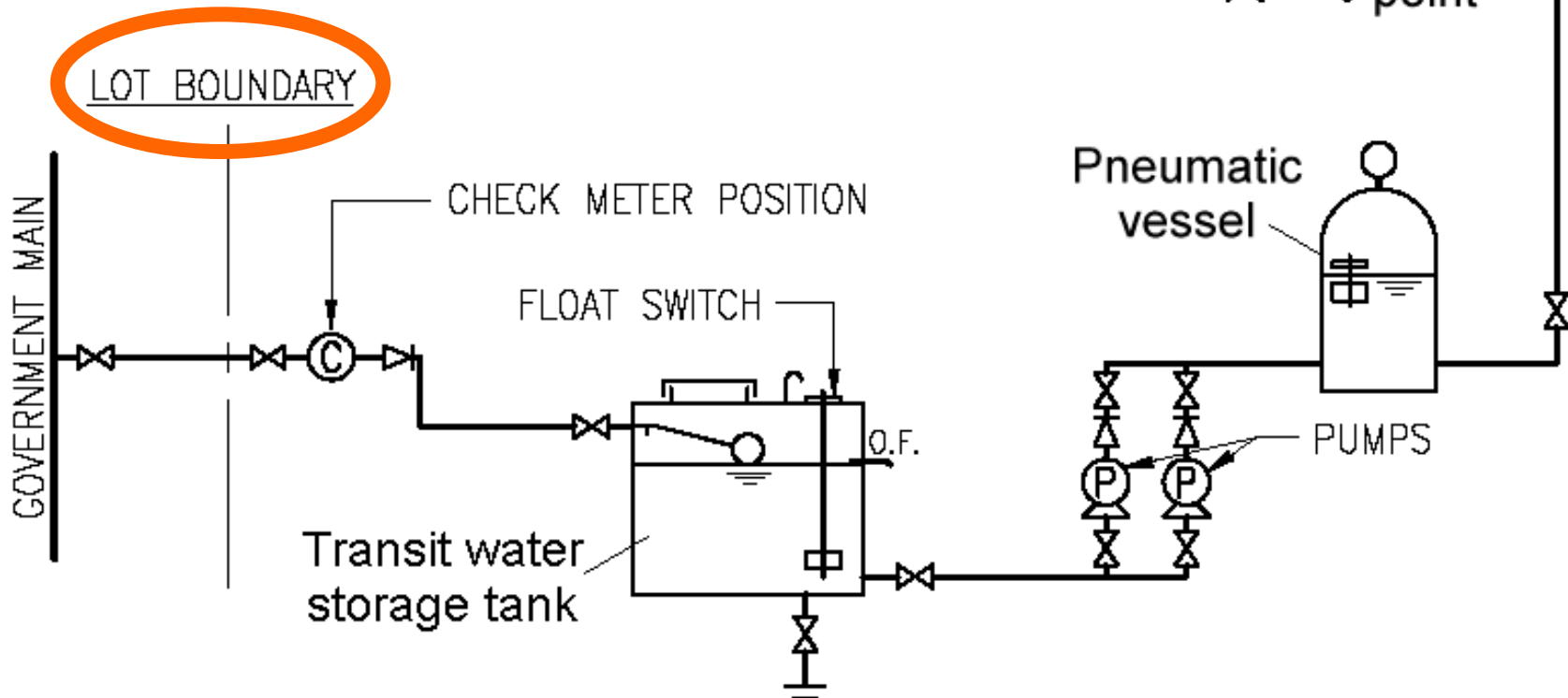


Indirect supply system (with sump and pump)

(Source: Water Supplies Department, www.wsd.gov.hk)



(\* Pressure vessel is used to adjust the supply pressure, if it is not practicable to control the pumps by level switches.)



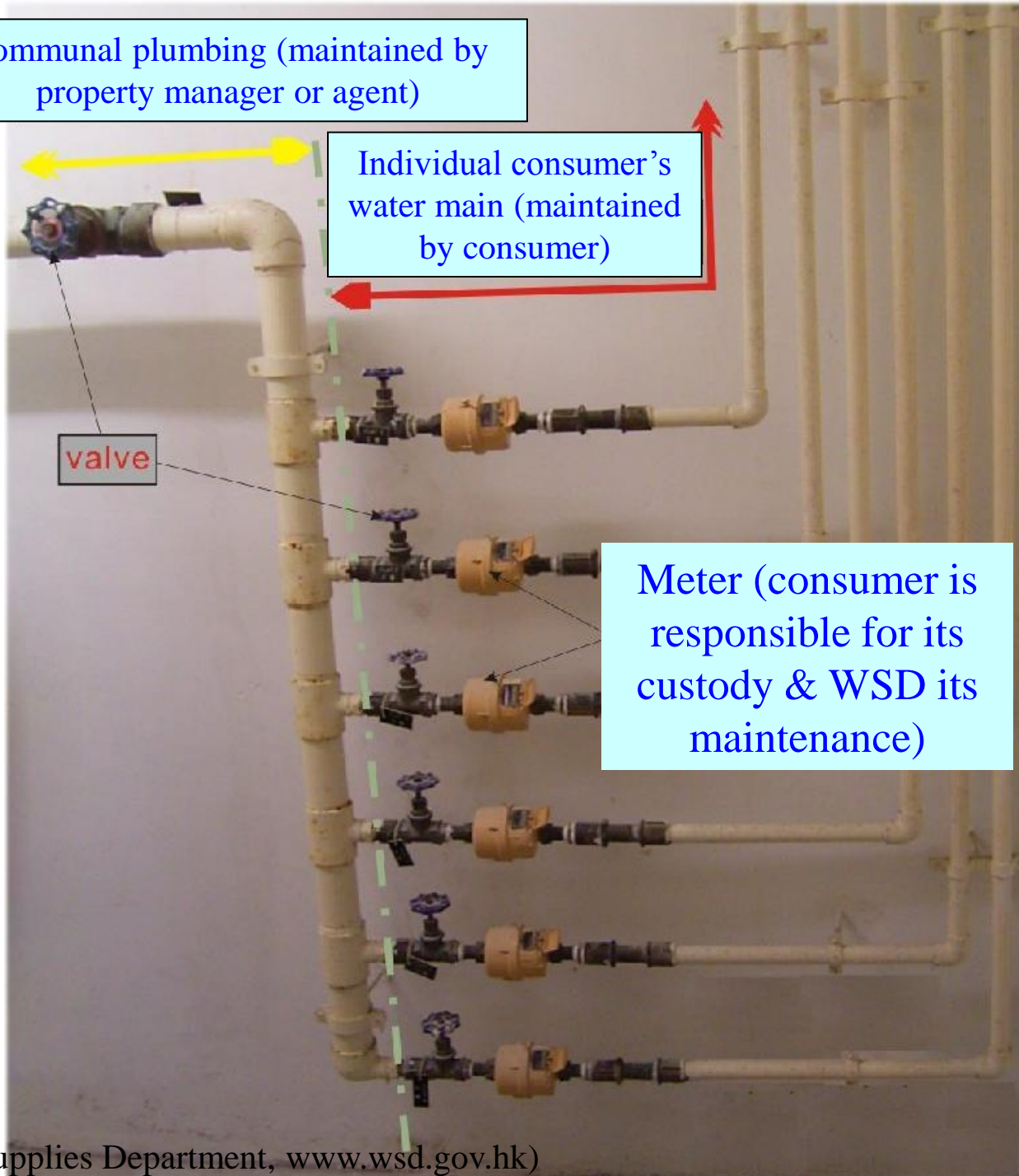
Indirect supply system (with pneumatic vessel)

Communal plumbing (maintained by property manager or agent)

Individual consumer's water main (maintained by consumer)

valve

Meter (consumer is responsible for its custody & WSD its maintenance)



Communal plumbing system (maintained by property management office or agent)

Government main (maintained by WSD)



## Comparison of direct and indirect water supply systems

<b>Direct supply</b>	<b>Indirect supply</b>
- Less pipework, smaller or no water tank	- More pipework, large water storage tank
- No storage to satisfy peak demand period	- Water storage to meet peak demand
- Risk of contamination and pressure fluctuation of mains	- Less risk of adverse effects by water mains
- Not feasible for high-rise buildings due to insufficient mains pressure	- Can be used in high-rise buildings



# Water tanks & pumps

- Water tanks
  - Materials: reinforced concrete, fibre glass, etc.
    - Reinforced concrete is the most common material used
    - Fibreglass storage cistern for potable water shall be of an approved type or certified, with no toxic materials and suitable for storage of potable water
  - Storage capacities:
    - Assessment of water consumption & demand
    - Proportion:- Sump tank : Roof tank = 1 : 3
    - Recommend to meet one-day (24 hours) demand (uncommon in normal practice)
    - Domestic supply – follows WSD recommendations

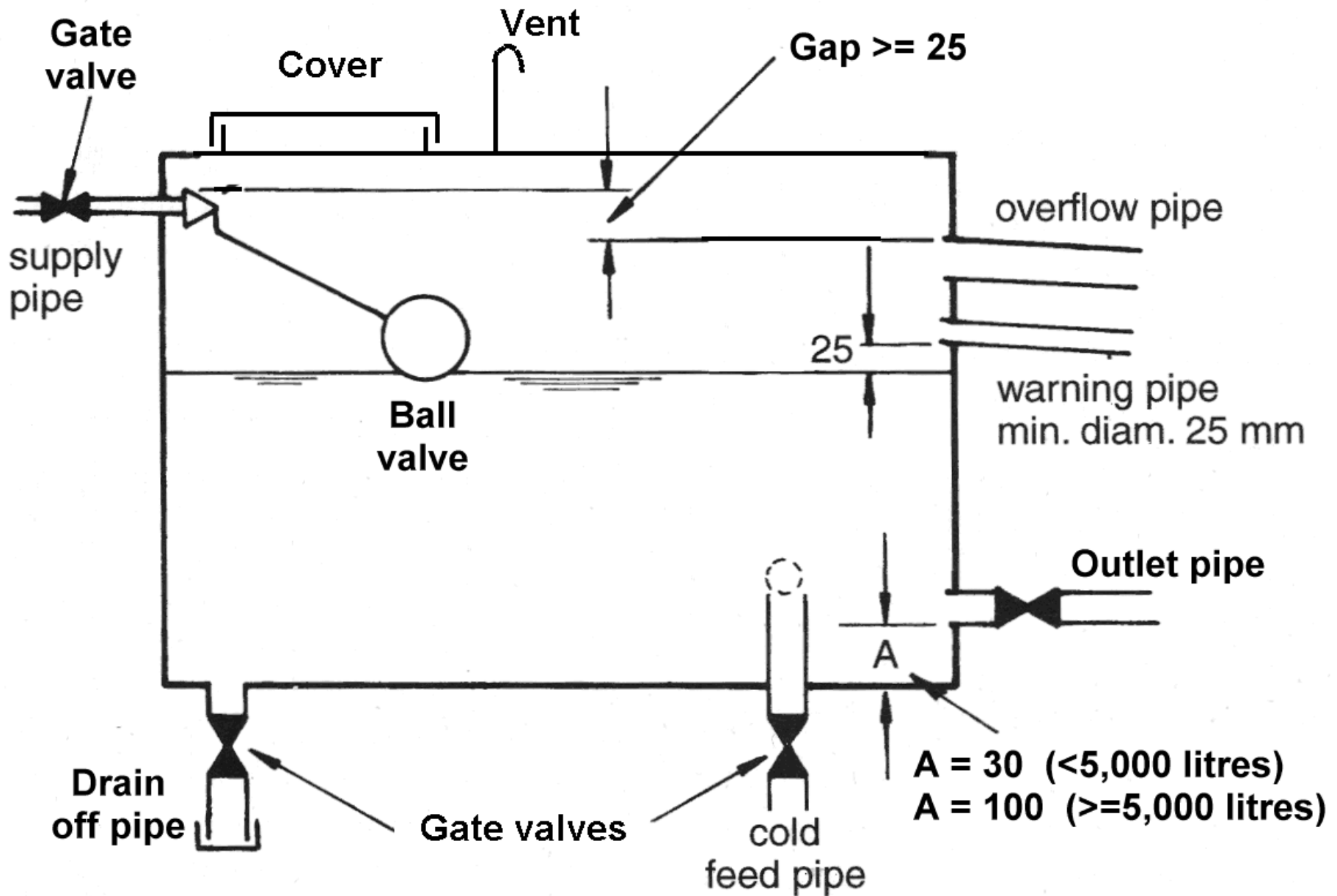
## Recommended storage capacities in water supply systems

<b>Domestic water supply with sump and pump</b>		<b>Flushing supply using salt water</b>	<b>Temporary mains fresh water for flushing (TMF)</b>
Up to 10 flats	> 10 flats		
135 litres/flat (total storage including sump tank)	90 litres for each additional flat	Minimum 1/2 day consumption (usually 45L per point)	45 L per point, minimum 225 litres

# Storage capacities for other industries



- Office, cinemas, theatres - 45L/point (10 gal.)
- Restaurants - 22.5 L/seat (taking 10ft<sup>2</sup> per person)
- Barber shop - 135L/chair
- Hotel – 45L/single room, 67.5L/double room
- Industry - 100% of daily demand
- Etc.



Water tank basic requirements (for a gravity supply)





# Water tanks & pumps

- Cleansing of water storage tanks
  - Such as sump tank and roof tank
  - They should be cleansed once every three months
- Maintenance of internal plumbing
  - WSD maintains the water supply distribution system up to the building lot boundaries
  - Internal & communal plumbing are maintained by the consumers



Double sealed tank cover with lock



Damaged water tank cover



Water tank not cleaned



Rusty water tank cover



Storage tank without proper maintenance & management



# Water tanks & pumps

- Water pumps
  - For pumping water from the sump tank to other higher level tanks (e.g. roof tank)
  - Provide a duplicate set (100% duty + 100% standby)
  - Pumping capacity  $\geq$  designed out-flow of roof tank
  - Minimise vibration and noise problems
    - Adequate pipework support & anchor
    - Solid foundation
- Common pump types
  - Horizontal end suction centrifugal
  - Vertical multistage centrifugal

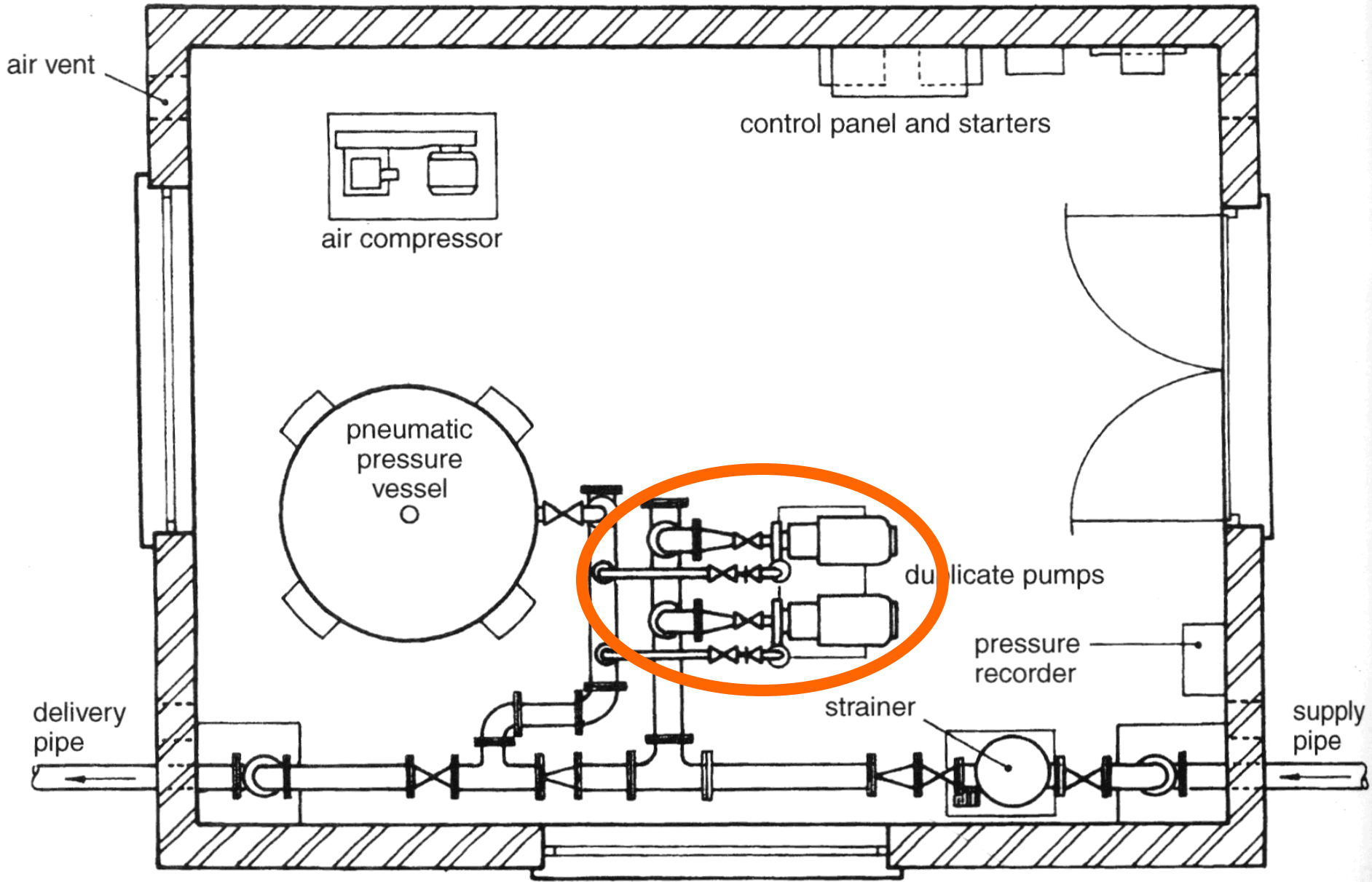


THE WATER  
FOR THE  
FEATHER  
AND OTHERS



# Water tanks & pumps

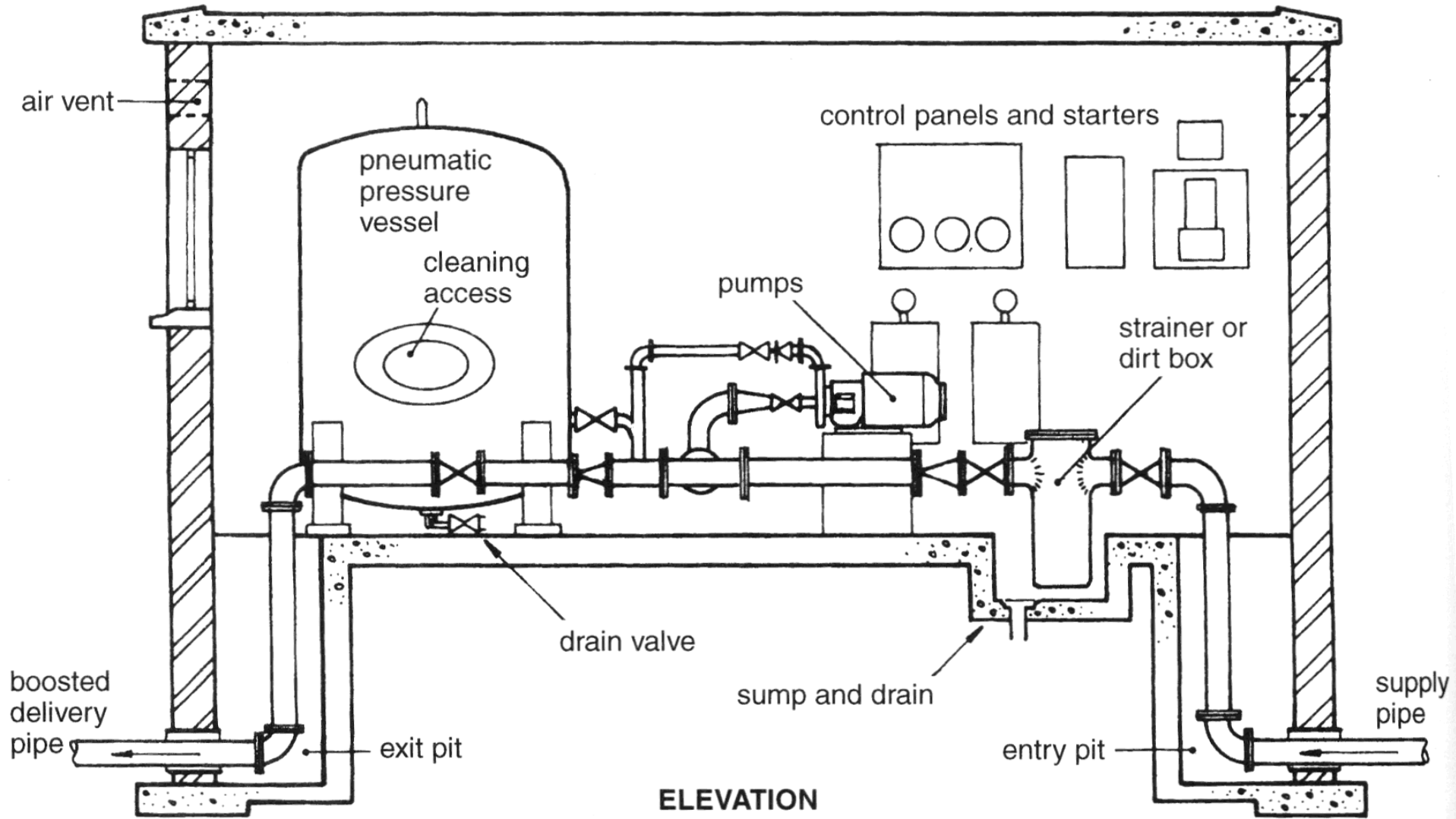
- Pump control
  - Automatic control using pressure switches, level switches, high-level & low-level electrodes
  - Pump selector switch & ON/OFF/AUTO
  - Low-speed preferred (longer life & quiet)
  - Newer design adopts the use 'Frequency Inverter' (Variable Frequency Drive, VFD)
    - Slower starting current, minimize sudden hammering effect during starting and stopping
    - Maintain constant pressure in pipework
- Pump motor
  - Such as squirrel cage induction type
  - Overload protection (electrical)



PLAN

# Typical pump room

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)



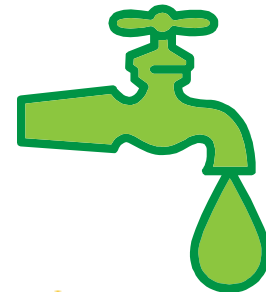
Typical pump room

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)



# **Water Quality Management**





# Water quality & management

- Treated water supplied by WSD at the connection points fully complies with the WHO guidelines for drinking water
- Quality Water Recognition Scheme for Buildings (launched in 2002 by WSD)
  - To encourage building owners to maintain their plumbing systems properly
  - There are 3 grades of certificates:
    - Blue Certificates: New participation or continuous participation with less than 3 years
    - Silver Certificates: Continuous participation 3-5 years
    - Gold Certificates: Continuous participation  $\geq$  5 years

# Recommended practices for water quality



- Regular maintenance – water tank cleaned every 3 months, proper and well maintained water tank covers
- Prevent contamination, proper cleaning of filters / purifiers
- Use of suitable materials for pipework
  - no more unlined GI pipes,
  - use only approved copper, ductile iron, stainless steel, GI with lining or PVC pipes



# **Water Conservation**

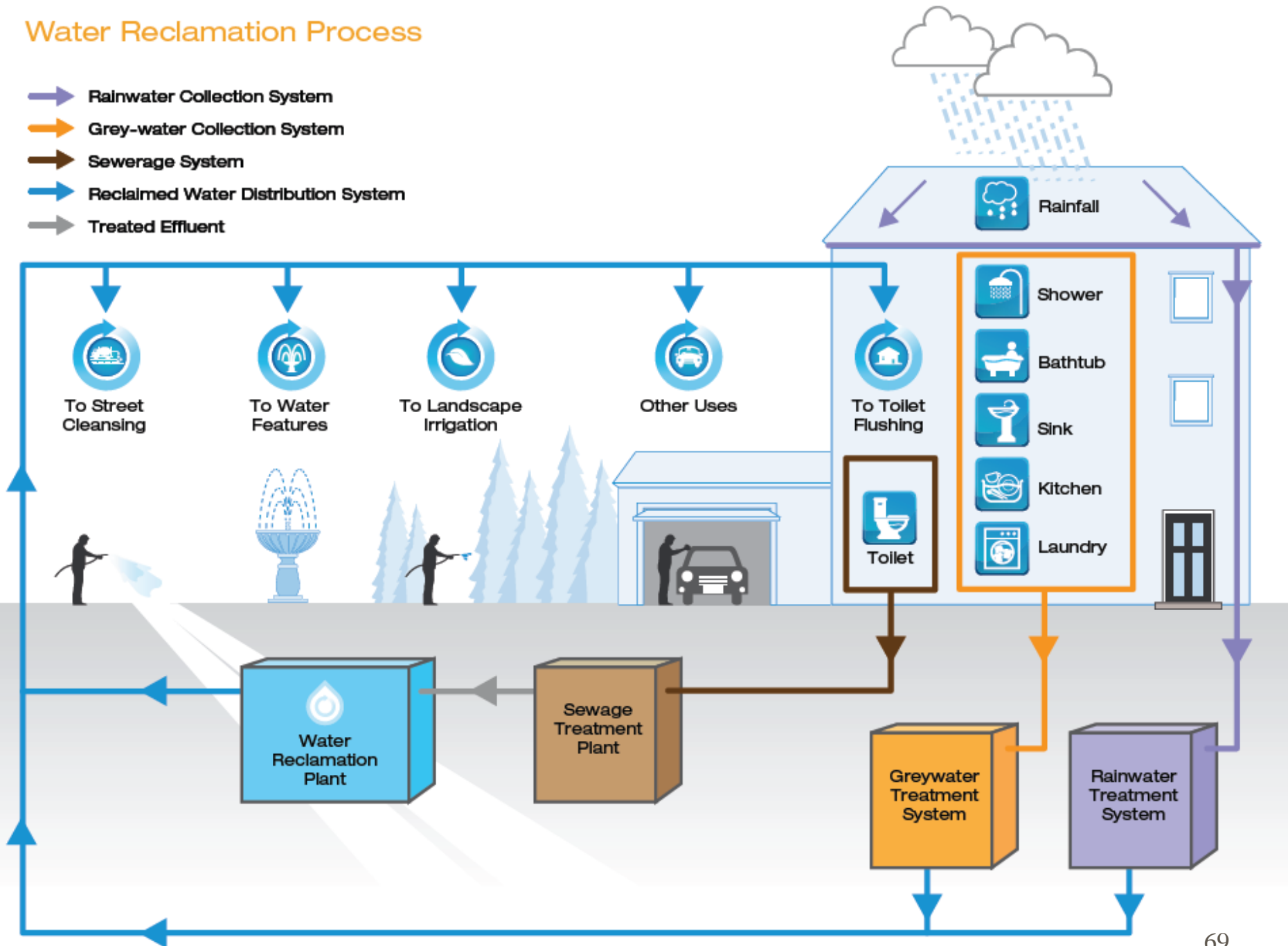
# Water Conservation



- Water is a very scarce resource, but in need by every living creature on this planet
- Every day water consumption is huge
- Water are not used effectively
- So, how can we save water?
  - Some ideas from WSD...  
([http://www.wsd.gov.hk/en/education/water\\_conservation/water\\_saving\\_tips/index.html](http://www.wsd.gov.hk/en/education/water_conservation/water_saving_tips/index.html))

# Water Reclamation Process

- ➔ Rainwater Collection System
- ➔ Grey-water Collection System
- ➔ Sewerage System
- ➔ Reclaimed Water Distribution System
- ➔ Treated Effluent



# Voluntary Water Efficiency Labeling Scheme



- Present schemes: showers for bathing, water taps, based on nominal flowrate (from 50kPa to 500kPa)
- Showers:
  - $\leq 9.0$  L/min – Grade 1 ...  $> 16$  L/min – Grade 4
- Water Taps:
  - Non-mixing type
    - $\leq 2.0$  L/min – Grade 1 ...  $> 6.0$  L/min – Grade 4
  - Mixing type
    - $\leq 5.0$  L/min – Grade 1 ...  $> 9.0$  L/min – Grade 4
- Testing conditioning: upstream dynamic flow pressure at 50kPa, 150kPa, 250kPa, 350kPa & 500kPa, then take average