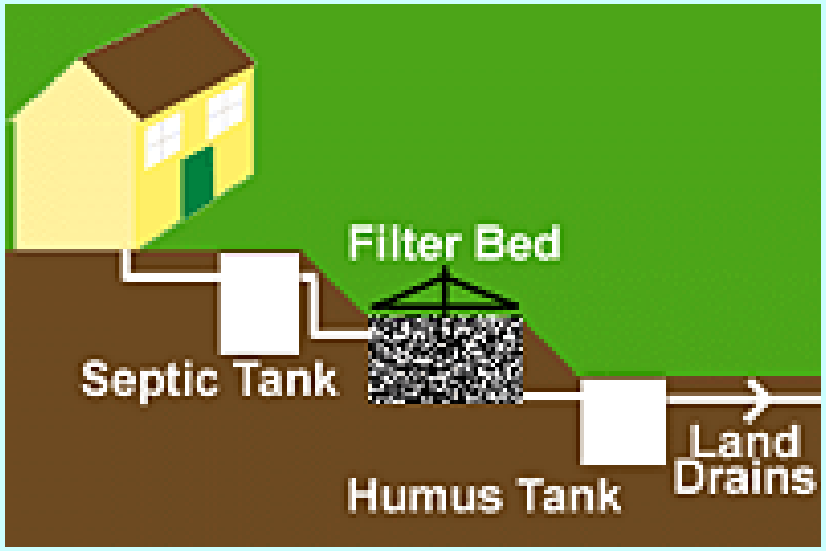
MEBS6000 Utility Services

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



Sewage Disposal

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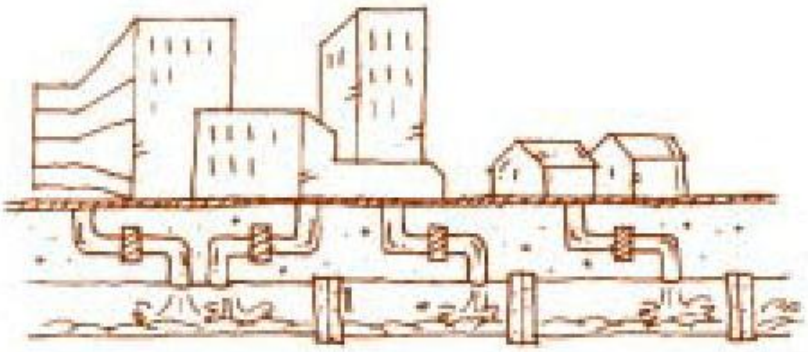
Oct 2010

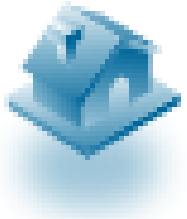
Contents

- Drainage below ground



- Sewage pumping
- Methods of sewage disposal
- Sewage treatment process

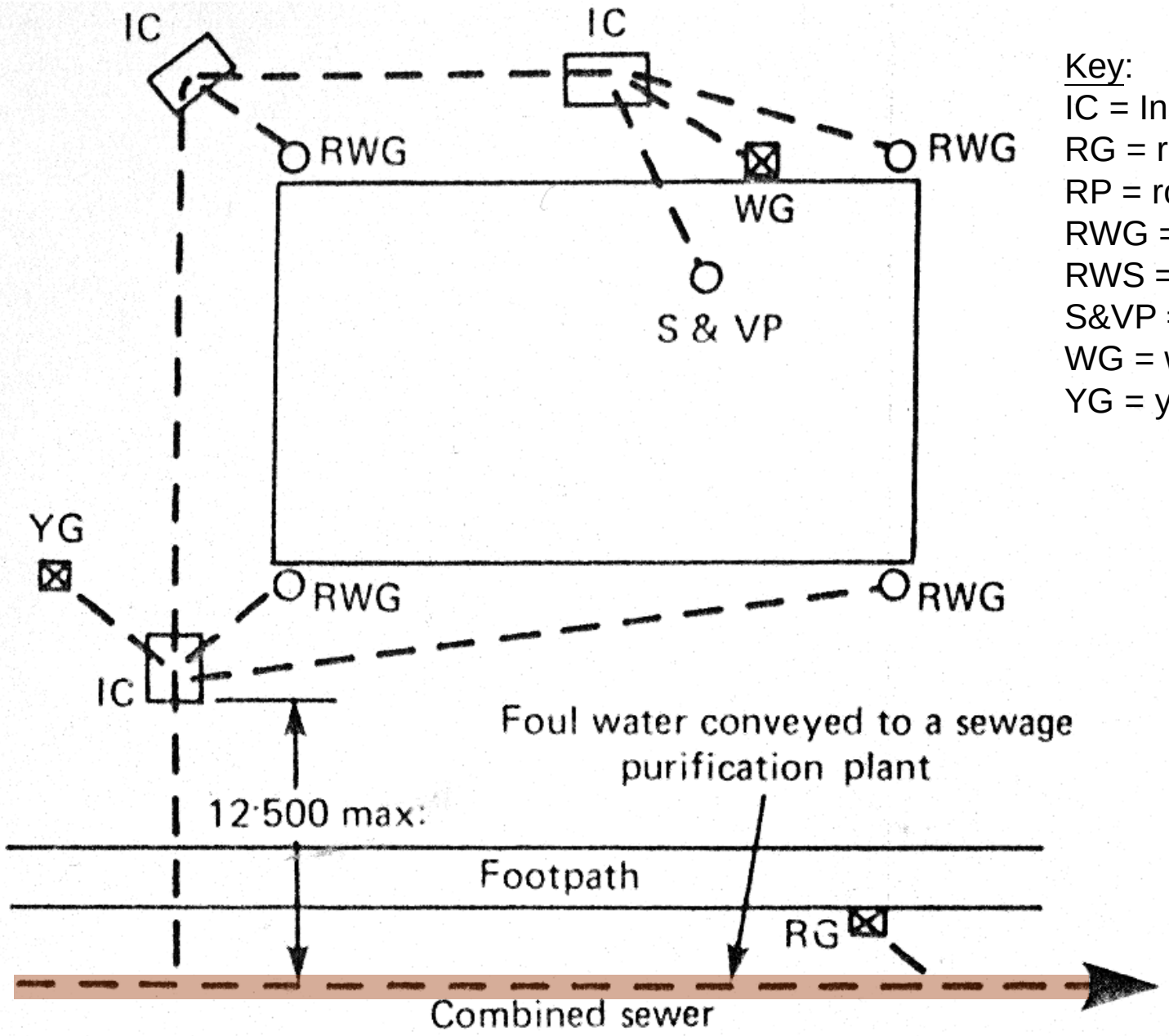
Drainage below ground



- Basic design objectives
  - Operate under natural flow of sewerage
  - Reliable and require little maintenance
  - Drains are not subject to undue stress
  - Fully accessible for occasional clearance
- Design calculations: based on flow rates, discharge units, gradients, pipe material & pipe diameter
  - Hydraulic calculation may be required

Drainage below ground

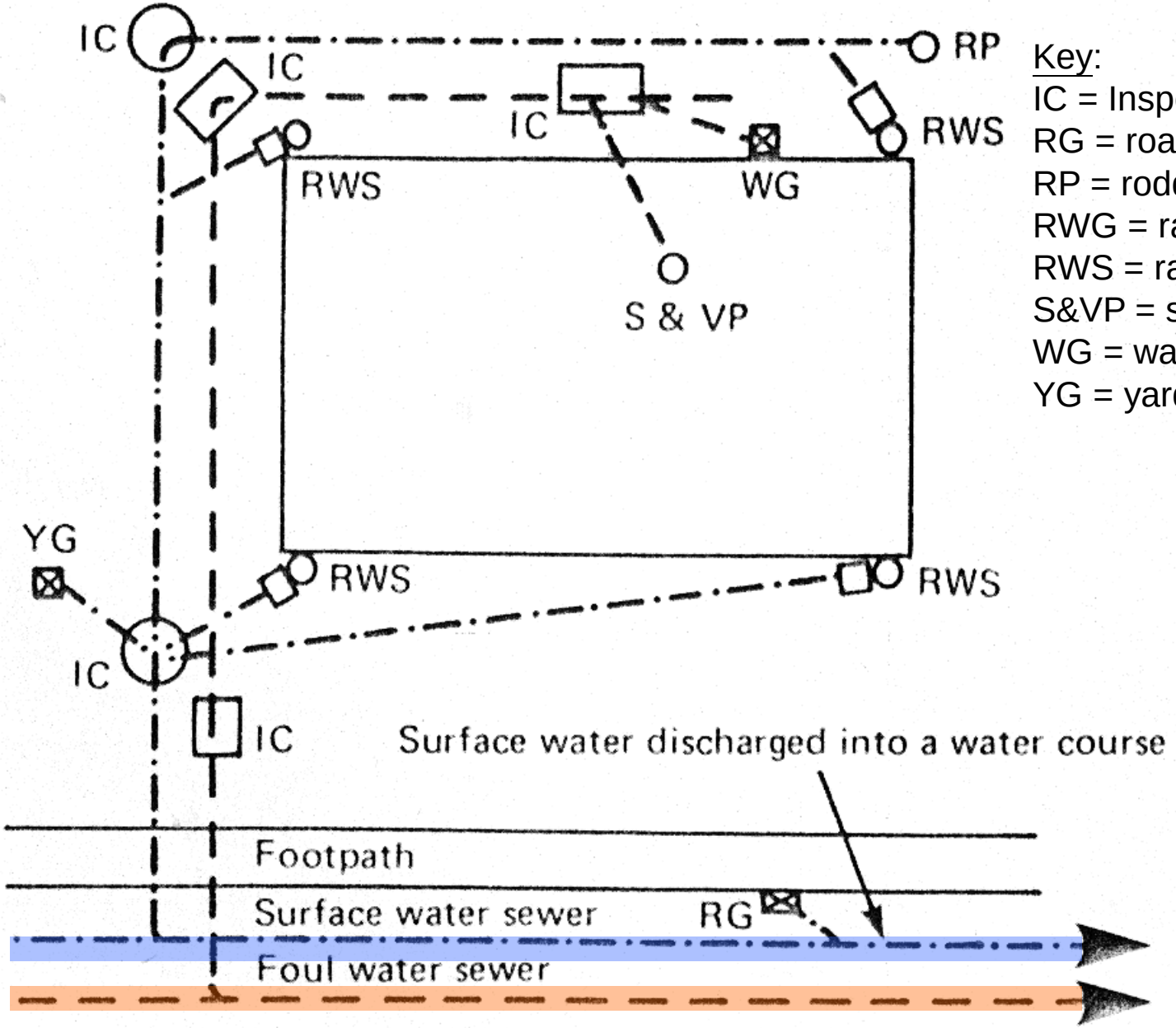
- System types
  - 1. Combined system (foul water + rainwater)
  - 2. Separate system
  - 3. Partially separate system
- Design considerations: costs, load on sewers
- Common fittings
  - Rainwater gully (RWG), yard gully (YG)
  - Inspection chamber (IC), rodding pod (RP)
  - Shoe and rest band (smooth connection)



Key:
IC = Inspection chamber
RG = road gully
RP = rodding pod
RWG = rainwater gully
RWS = rainwater shoe
S&VP = soil & vent pipe
WG = waste gully
YG = yard gully

Combined system

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)



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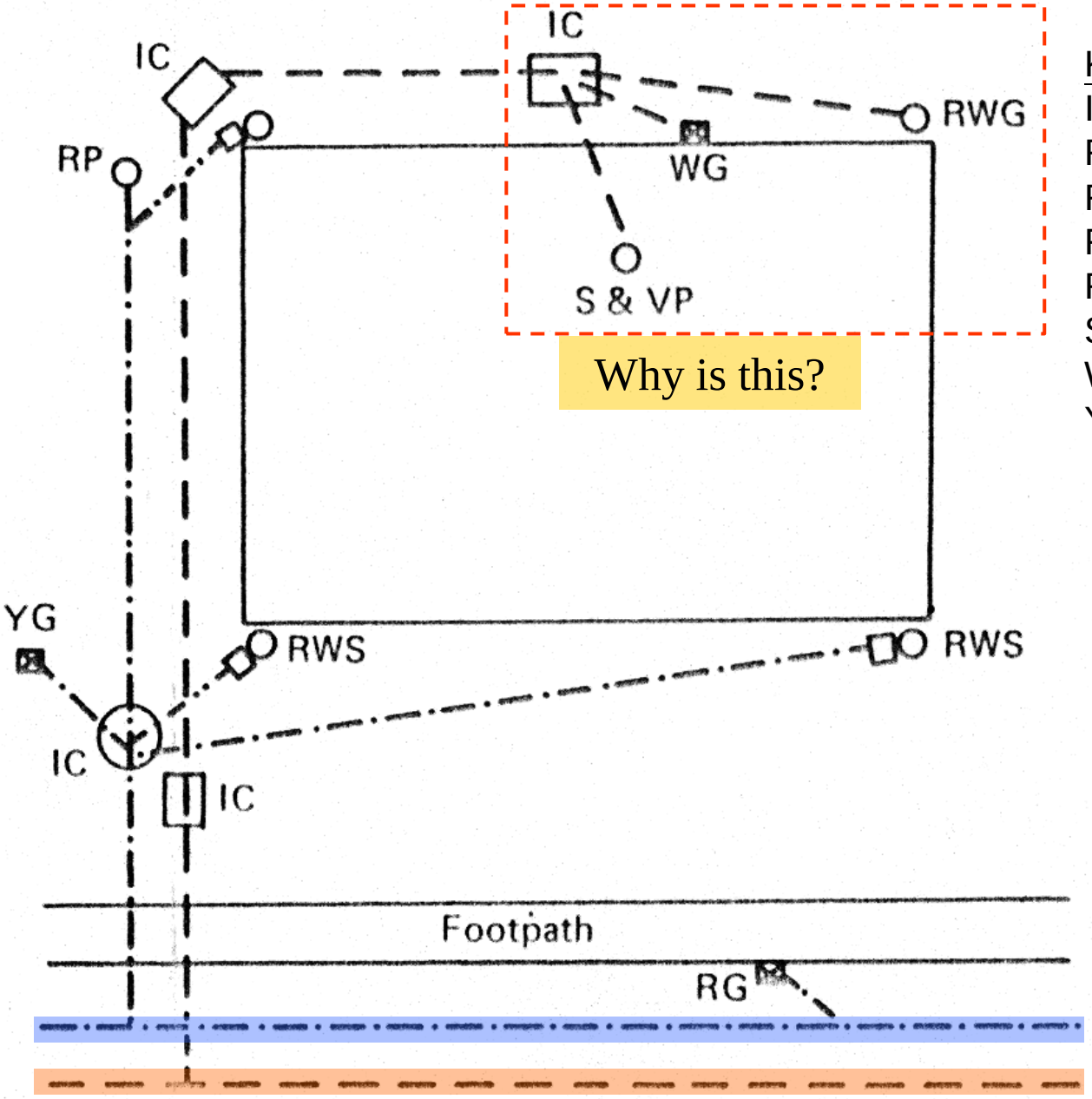
YG = yard gully

Separate system

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)



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IC = Inspection chamber
RG = road gully
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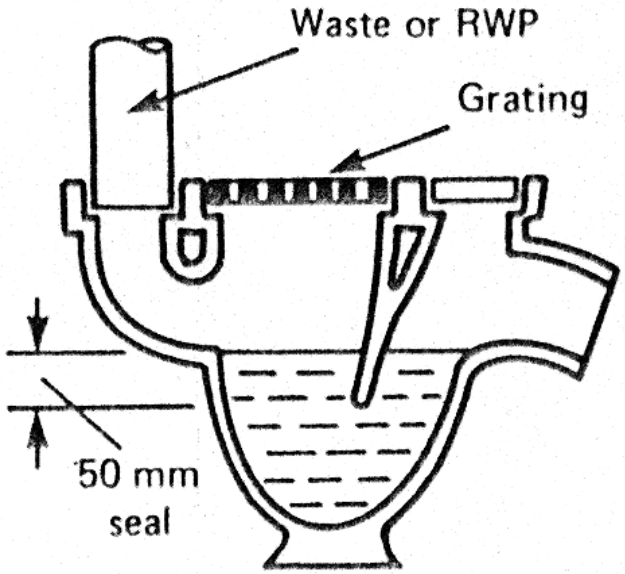
RWG = rainwater gully
RWS = rainwater shoe
S&VP = soil & vent pipe
WG = waste gully
YG = yard gully

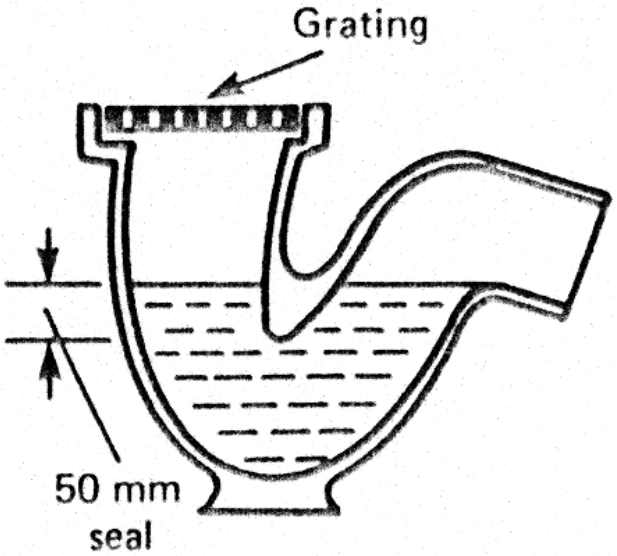
- Most of the surface water conveyed by a surface water drain to a surface water sewer or soakaway
- Some rainwater is discharged to the foul water drain. The rainwater can be conveniently connected to the foul water drain, usually at the rear of the building

Partially separate system

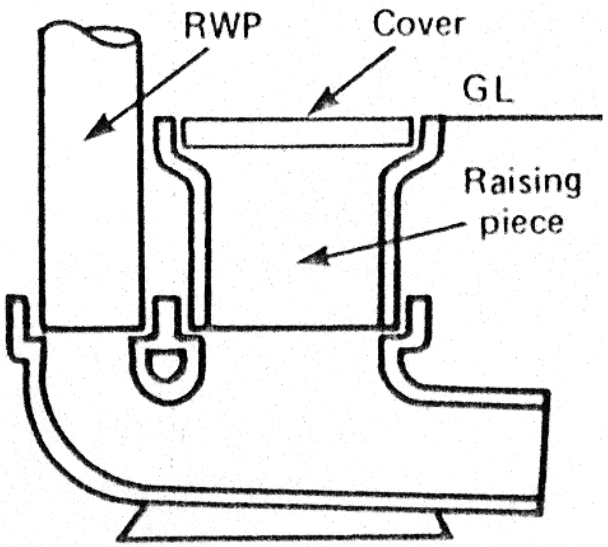
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)



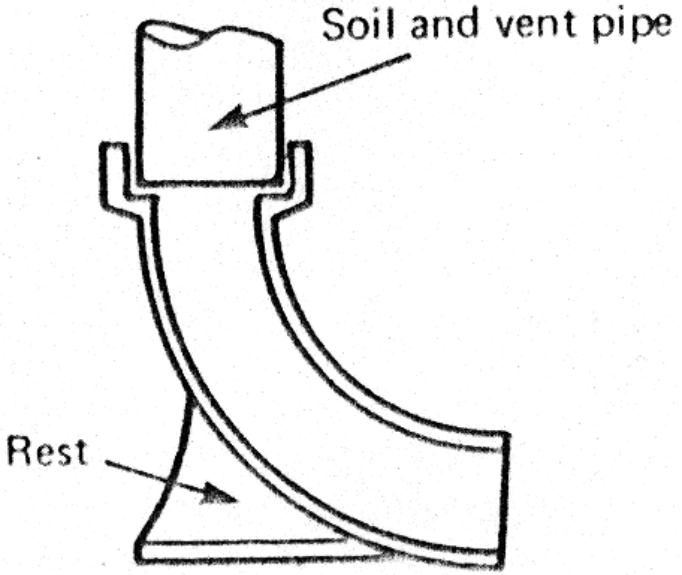
Waste or rainwater gully



Yard gully

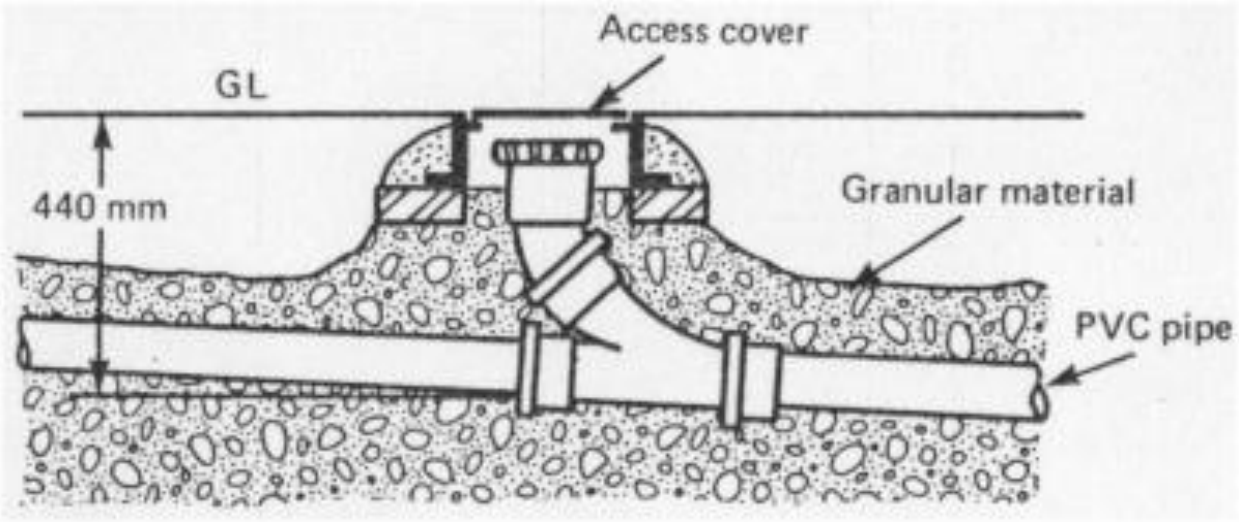


Rainwater shoe

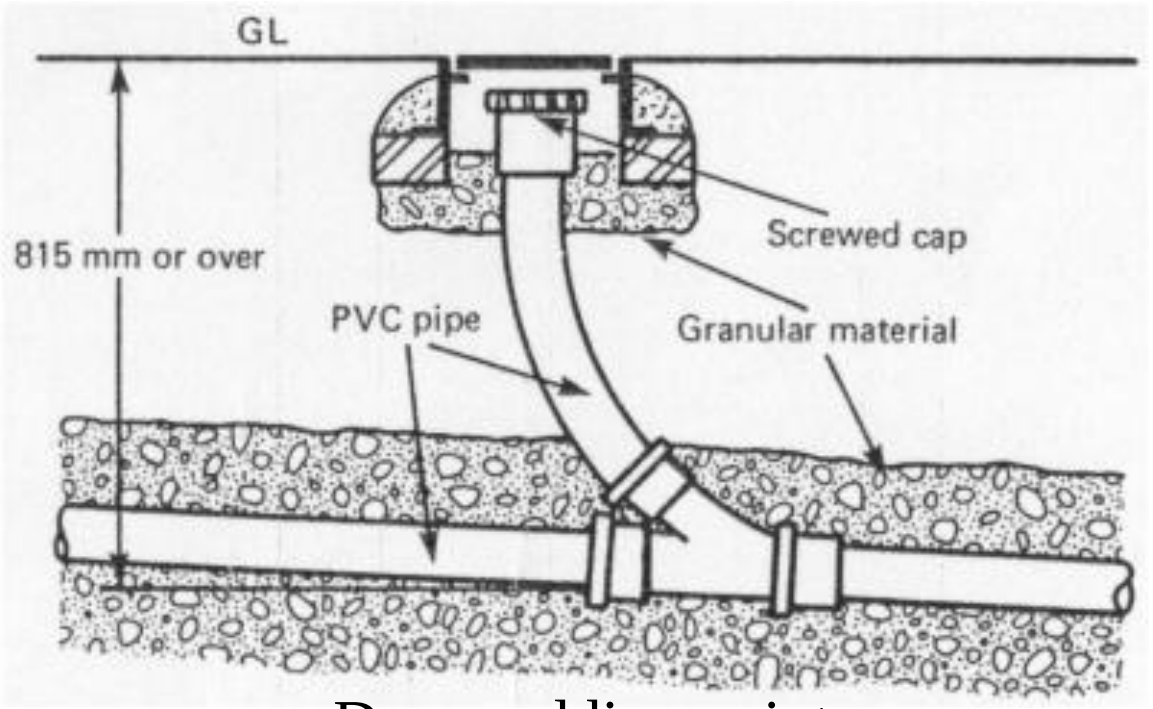


Rest bend

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)



Shallow rodding point



Deep rodding point

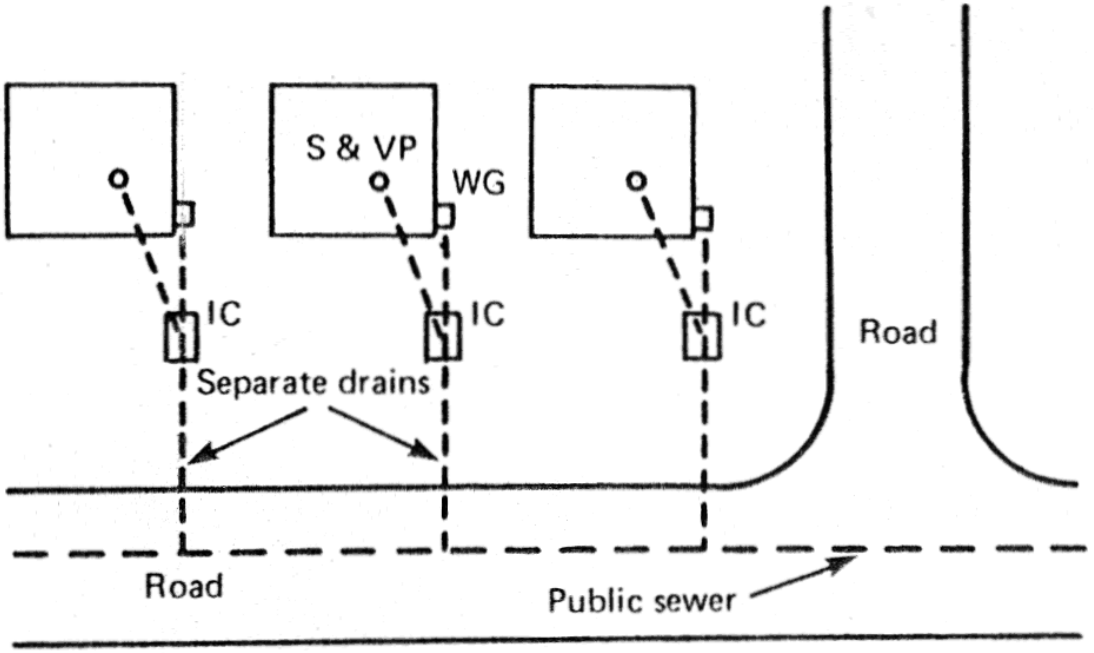
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Drainage below ground

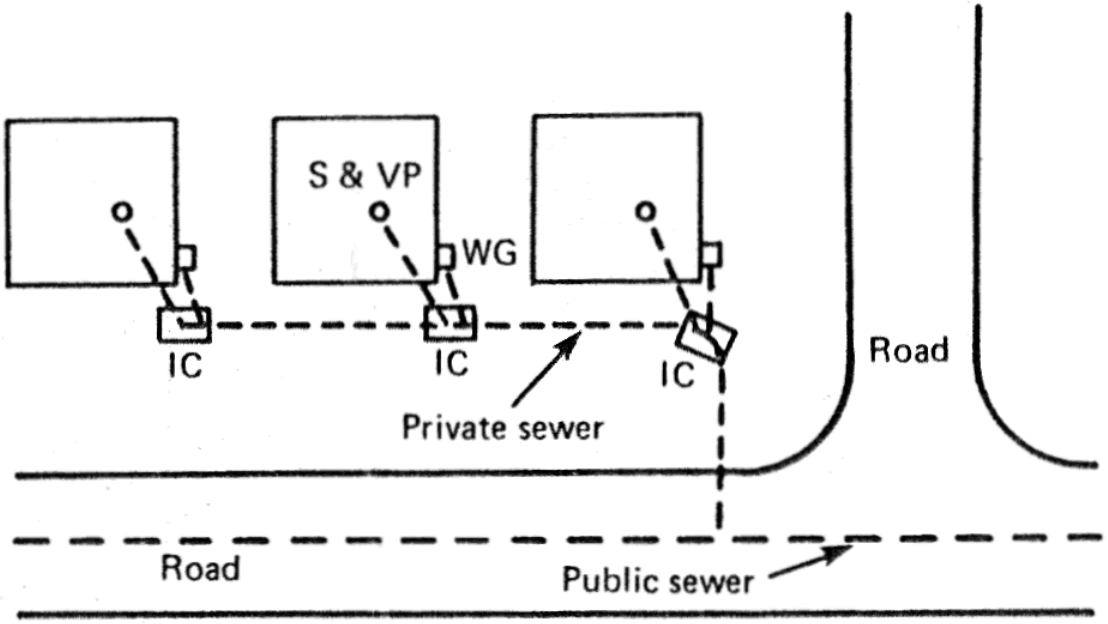
- Combined drainage system
  - Pros:
    - One drain for both foul & surface water reduces cost of drainage
    - No risk of making a wrong connection
    - Foul water flushed through the drain by the surface water
  - Cons:
    - The loss of a trap seal in a rainwater gully allows the foul gas from the drain to pass into the open air around the building
    - The size of the sewage disposal plant is greater
    - Greater cost of the sewage disposal
    - Possibly greater pumping costs (surface water and foul water to reach sewage disposal works)

Drainage below ground

- Separate drainage system
  - Pros:
    - Sewage disposal plant is much smaller
    - The cost of sewage purification is less
    - Less sewage is pumped → reduction in pumping cost
    - Surface water flow can be by gravity to a nearby river
  - Cons:
    - Two sets of drains increase the cost of building drainage
    - Risk of a wrong connection (a foul water branch drain to a surface water drain)
    - The foul water drain not thoroughly flushed by rainwater
    - Foul air passing through an unsealed rainwater gully trap



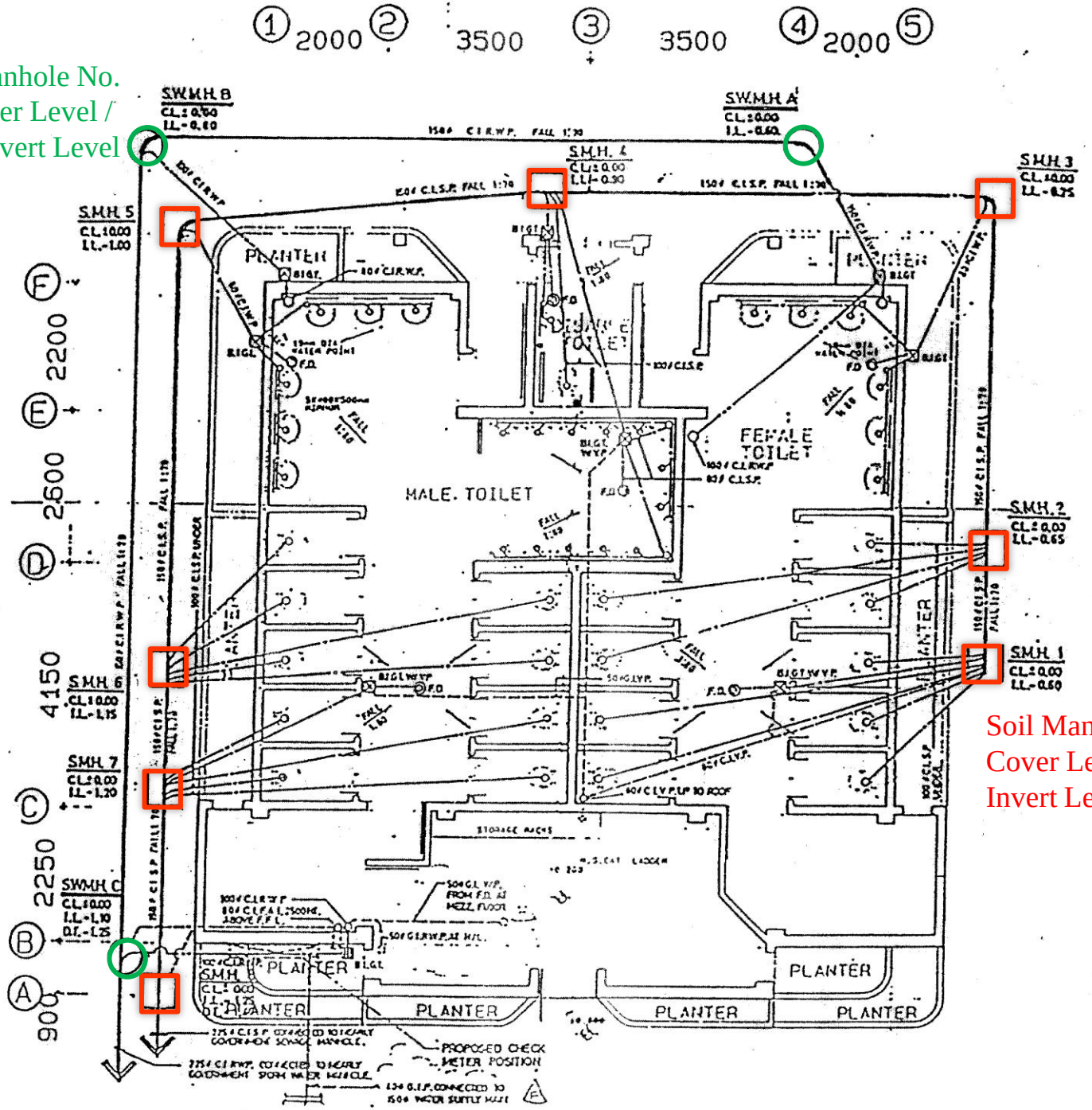
Use of separate drains
(more favorable)



Use of private sewer
(only if connection to public from individual buildings is difficult)

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Stormwater Manhole No.
Cover Level /
Invert Level

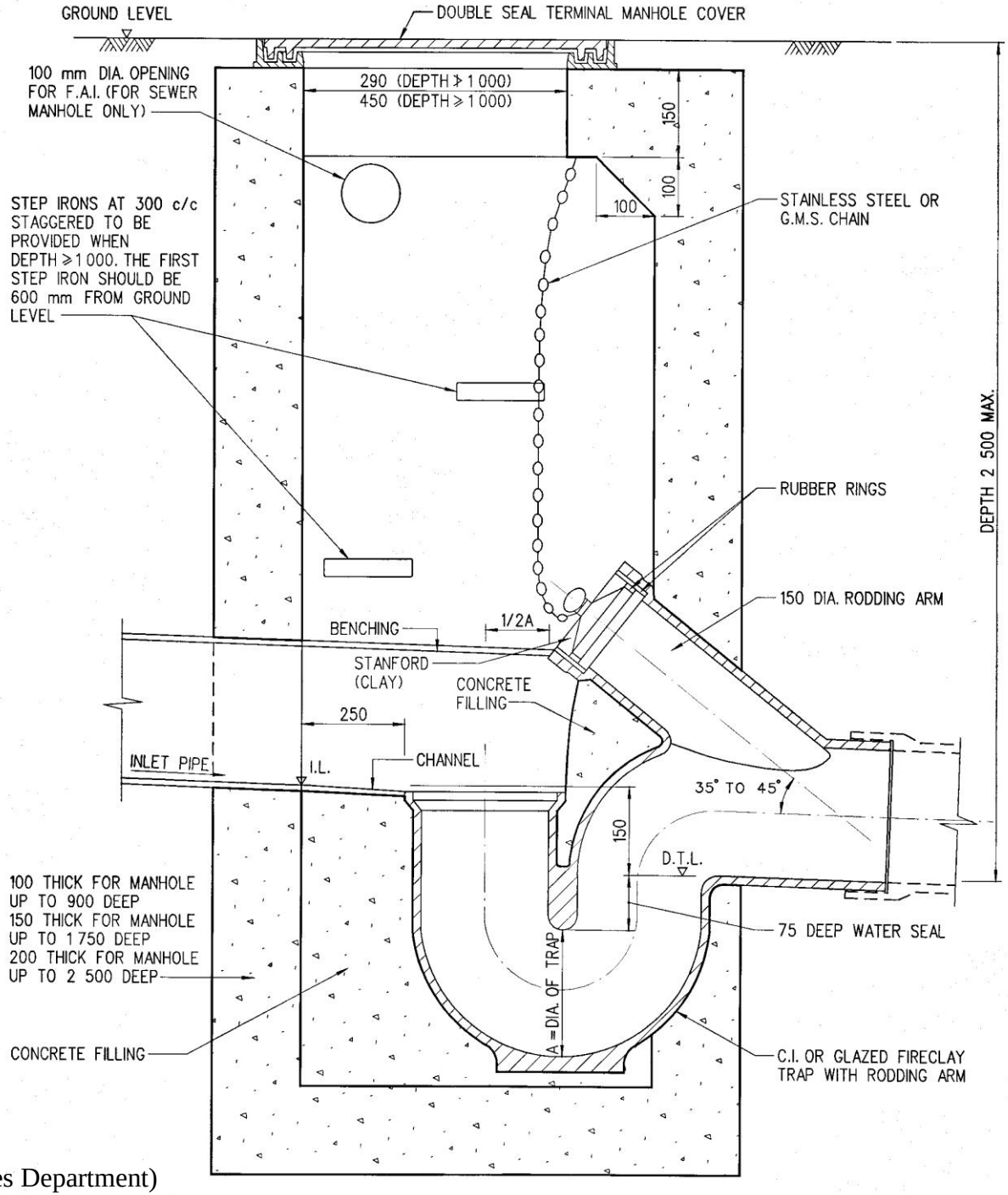


Soil Manhole No.
Cover Level /
Invert Level

Drainage below ground

- Connection of drainage to sewer
  - Must be made obliquely in the direction of flow
    - Drain to another drain
    - Drain to a private sewer (私家污水渠)
    - Drain to a public sewer (公共污水渠)
  - Cost and maintenance issues
    - Private sewer/drain up to & include **terminal manhole**: paid by building owner
    - Public sewer & sewer connecting from the terminal manhole: paid by government/authority

Terminal Manhole



(Source: Drainage Services Department)

Drainage below ground

- Stormwater or foul sewers?
  - Swimming pool main drain, footbath main drain and swimming pool make-up tank drain → stormwater drains
  - The filtration plant backwash → foul sewers
  - Drainage serving open transport interchanges and cargo handling areas → to stormwater drains (via petrol interceptor)
    - But allow stormwater bypass during peak flow periods

Drainage below ground

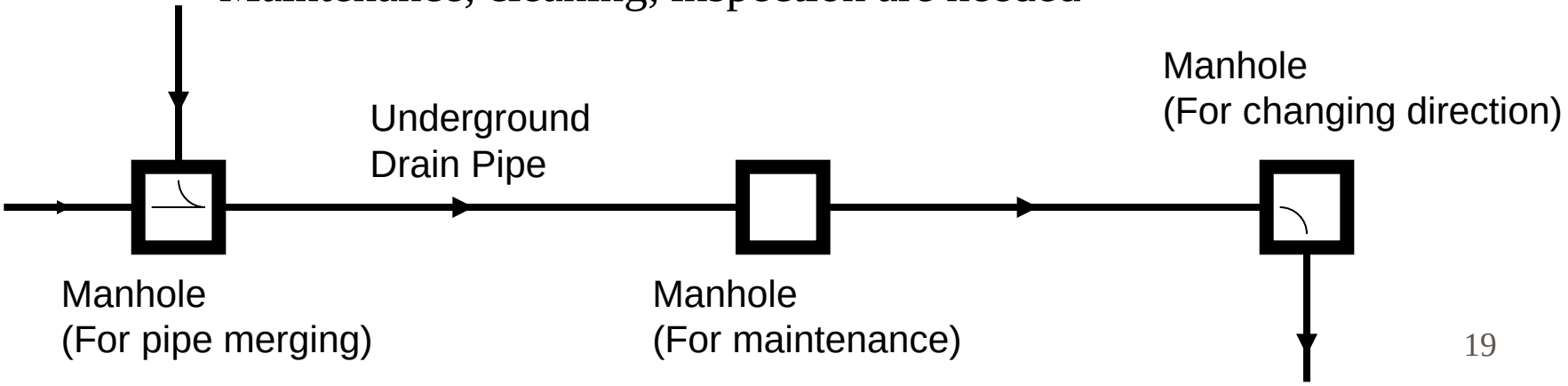
- Pipe materials and depth
  - A minimum diameter of 150 mm and be of the following materials or other approved materials:-
    - Foul sewer - vitrified clay, ductile iron, uPVC
    - Storm water drain - concrete, ductile iron, uPVC
  - Larger sewer: concrete
  - Smaller drains: clayware/uPVC
  - Drains should be laid at a depth of 900mm (minimum) under roads and at least 600mm below fields and gardens

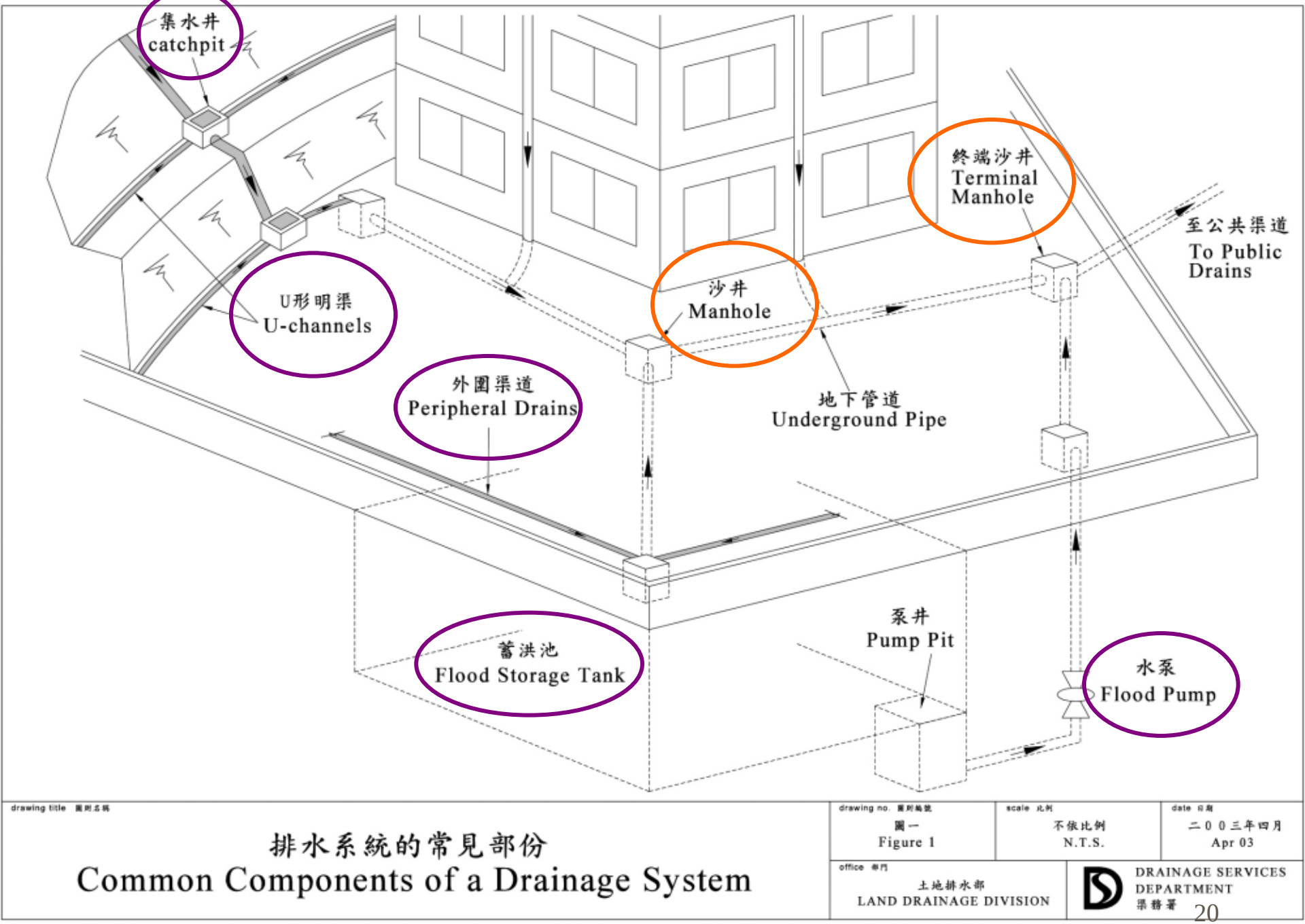
Drainage below ground

- Underground drainage pipe
  - Foul sewers should be designed so that the velocity of the flow will exceed the self-cleansing velocity on a regular basis
  - According to Buildings Regulation CAP123, the minimum fall of foul sewers is:
    - Pipe diameter 100 mm:- Fall 1:40
    - Pipe diameter 150 mm:- Fall 1:70
    - Pipe diameter 225 mm:- Fall 1:100
    - Pipe diameter 300 mm:- Fall 1:150

Drainage below ground

- Manholes (沙井)
  - They are required when
    - Pipes merge together
    - Change in direction >45 degree
    - Change in gradient
    - On long straight runs (e.g. 600mm pipe for 40m)
    - Maintenance, cleaning, inspection are needed





drawing title 圖則名稱

排水系統的常見部份
Common Components of a Drainage System

drawing no. 圖則編號	scale 比例	date 日期
圖一 Figure 1	不依比例 N.T.S.	二 0 0 三年四月 Apr 03

office 部門
土地排水部
LAND DRAINAGE DIVISION

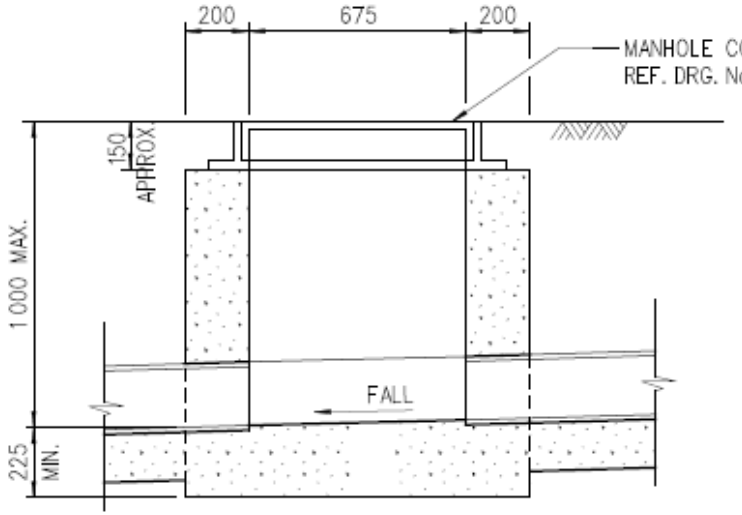
DRAINAGE SERVICES DEPARTMENT
渠務署

(Source: Drainage Services Department, www.dsd.gov.hk)

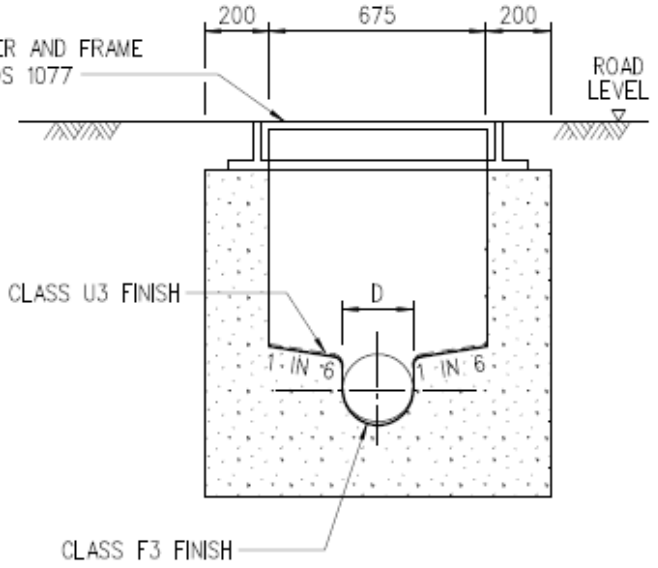
Drainage below ground

- Manholes (沙井) (cont'd)
  - Construction
    - 215 mm thick brickwork in cement mortar or 125 mm thick 1:2:4 reinforced concrete or other approved
    - Inside surface cement rendered
    - Cast iron cover (double-sealed airtight cover if inside or under a building)
    - See the standard drawings by DSD
  - Every building or project should have only one "terminal or last manhole" to public sewer

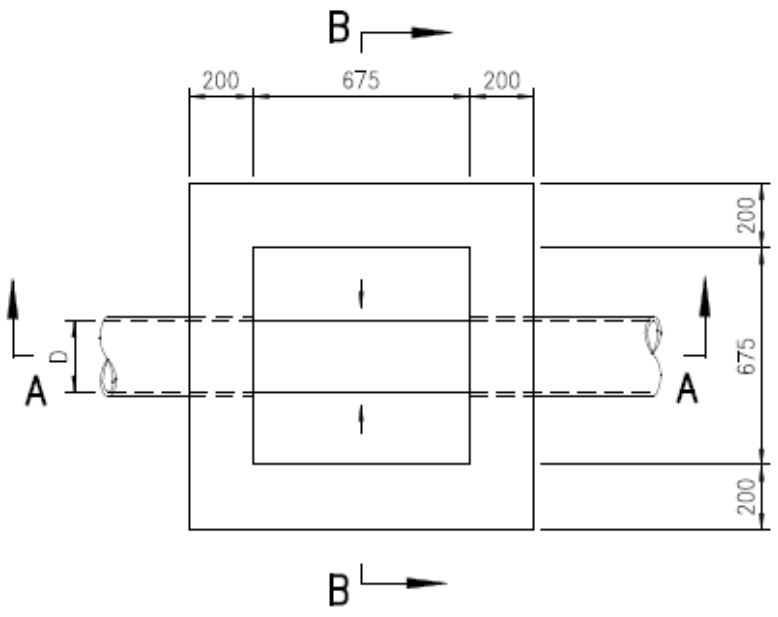
Standard manhole design



SECTION A-A



SECTION B-B

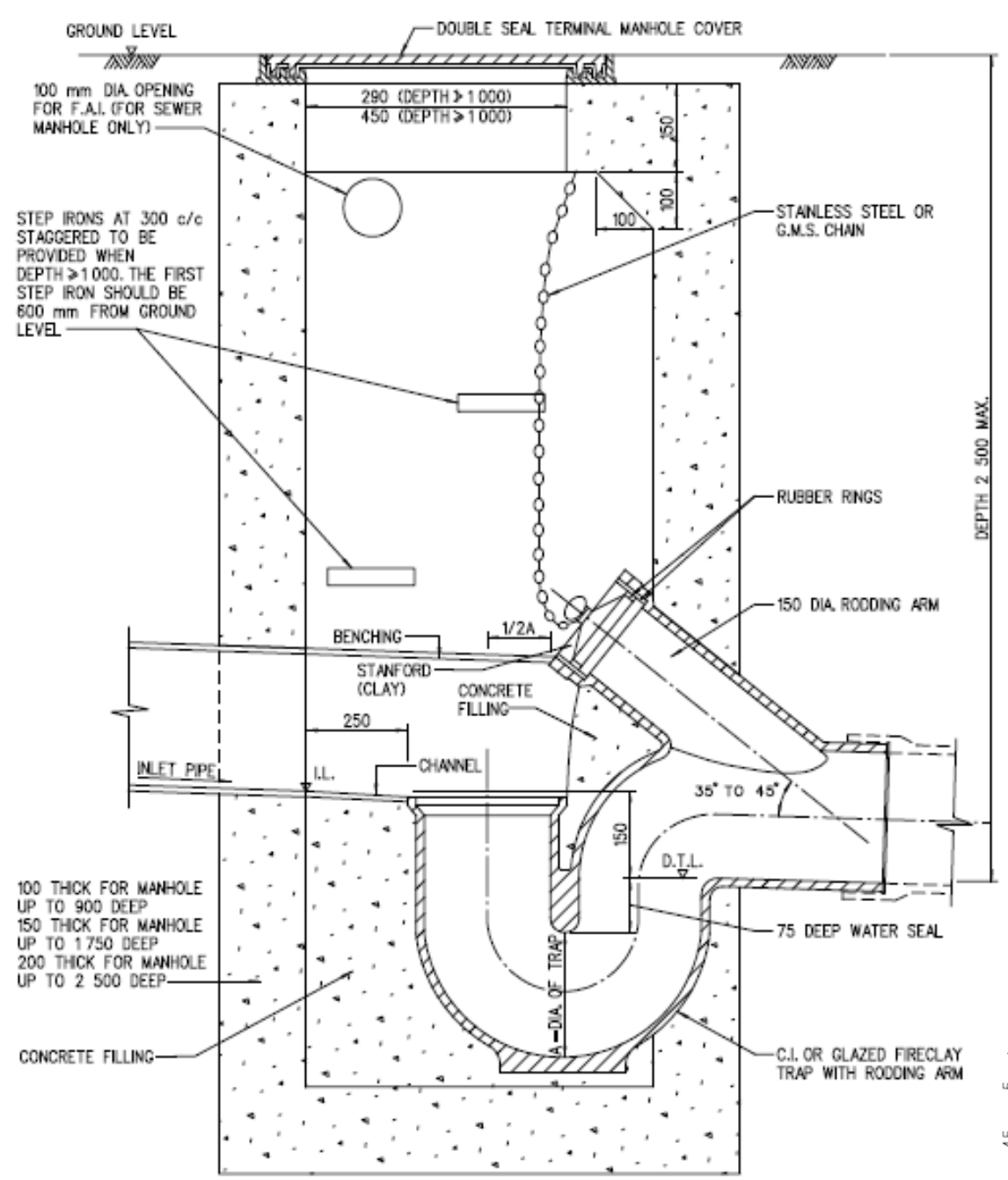


PLAN

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. PIPE DIAMETER : 150 TO 300 mm
3. NORMAL RANGE OF DEPTH : MAX. 1 000 mm (MEASURED FROM ROAD LEVEL TO LOWEST INVERT)
4. USED IN : STORMWATER DRAIN AND SEWER
5. JUNCTION : POSITION OF JUNCTION TO BE DETERMINED IN INDIVIDUAL CASE.
6. TOP TREATMENT : SEE DRG. No. DS 1032
7. FOUNDATION : FOUNDATION OF MANHOLE VARIES WITH SITE CONDITION. THEREFORE, IT SHOULD BE DETERMINED ON SITE BY THE ENGINEER.
8. CONCRETE : GRADE 30/20
9. COVER AND FRAME NOT SHOWN ON PLAN FOR CLARITY

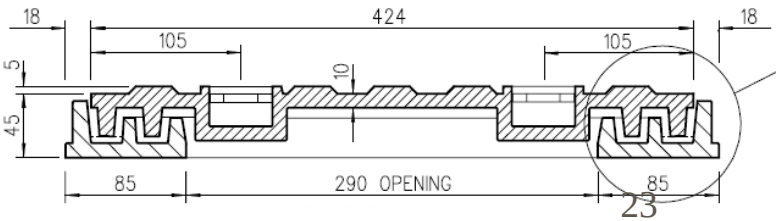
(Source: Drainage Services Department, www.dsd.gov.hk)



<u>Terminal manhole</u>, typical characteristics:

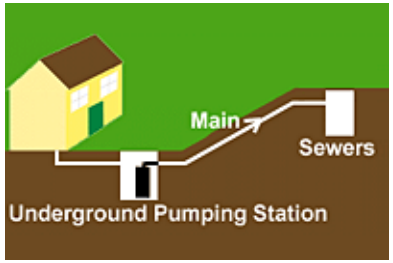
- Trapped
- Rodding arm for cleaning
- Opening for fresh air intake (FAI)
- Steps for maintenance

Double-sealed manhole cover

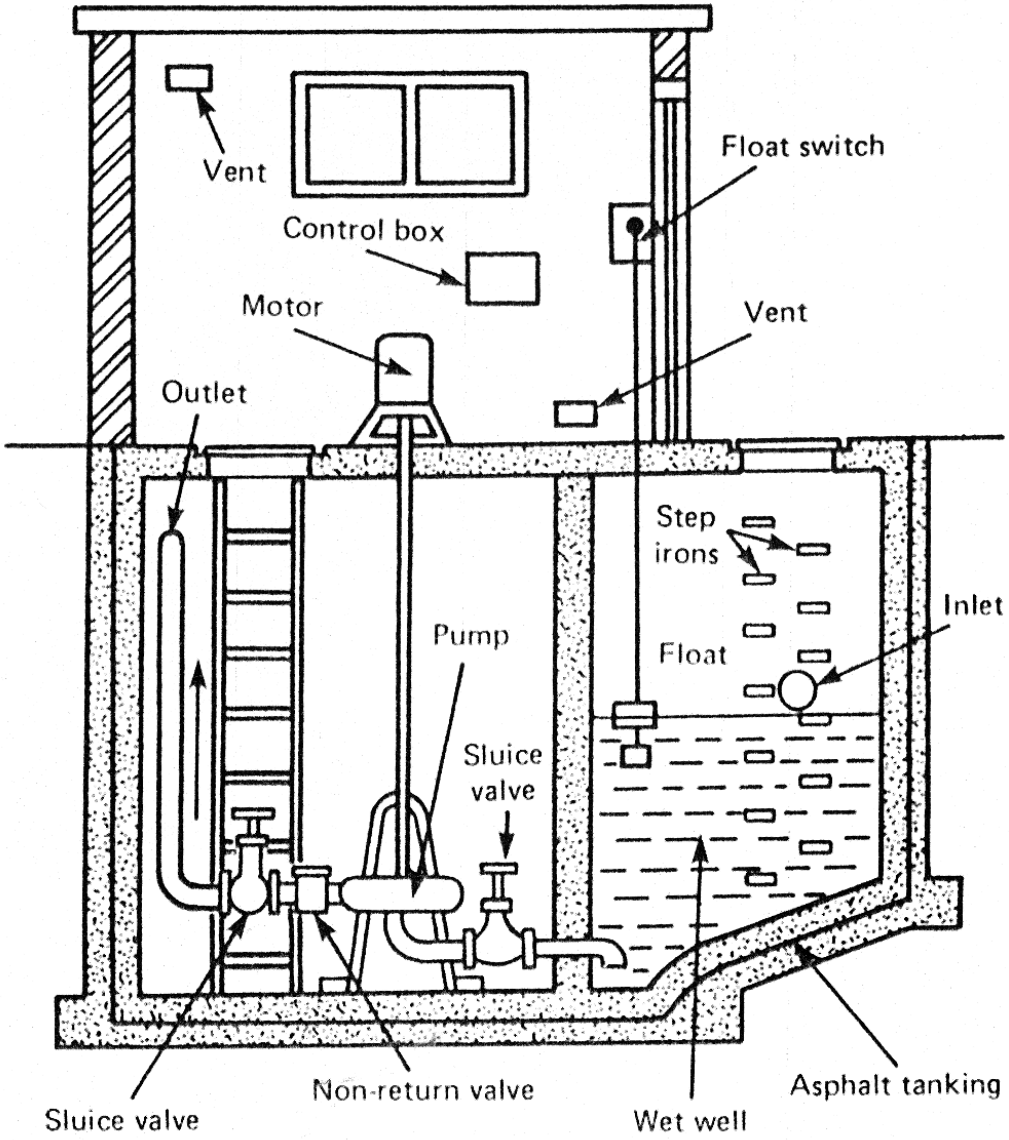


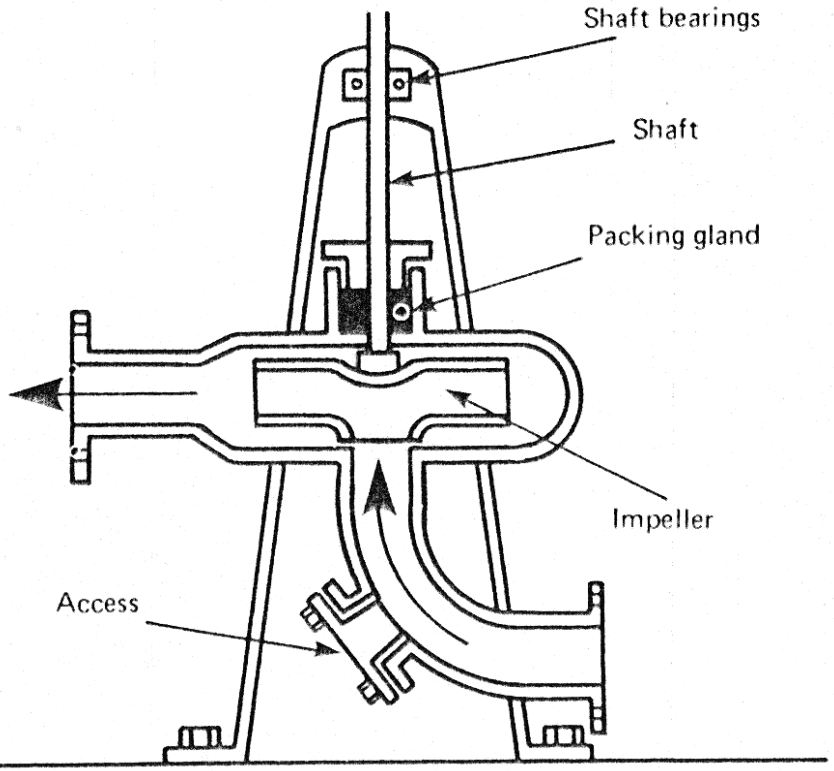
(Source: Drainage Services Department, www.dsd.gov.hk)

Sewage pumping



- Whenever possible, gravity flow should be used for drainage & sewage
- If site levels do not permit, sewage pumping stations can be used, such as those with centrifugal pumps
  - Installed below the fluid (self-priming)
  - Impeller curved on plan to reduce risk of blockage
  - Discharge pipe pass into a manhole before connected to public sewer

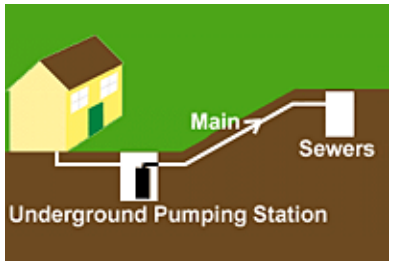




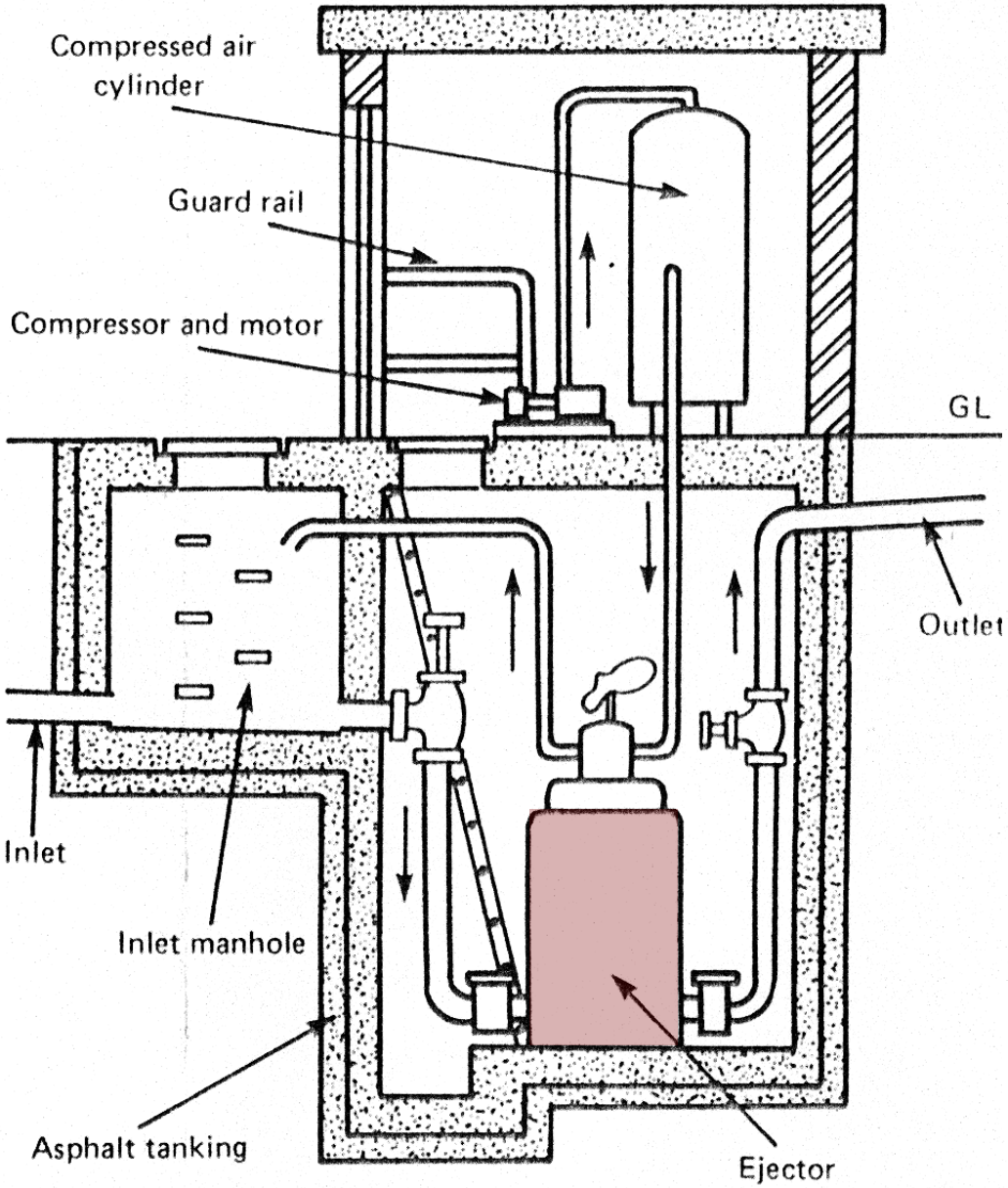
Sewage pumping station using a centrifugal pump

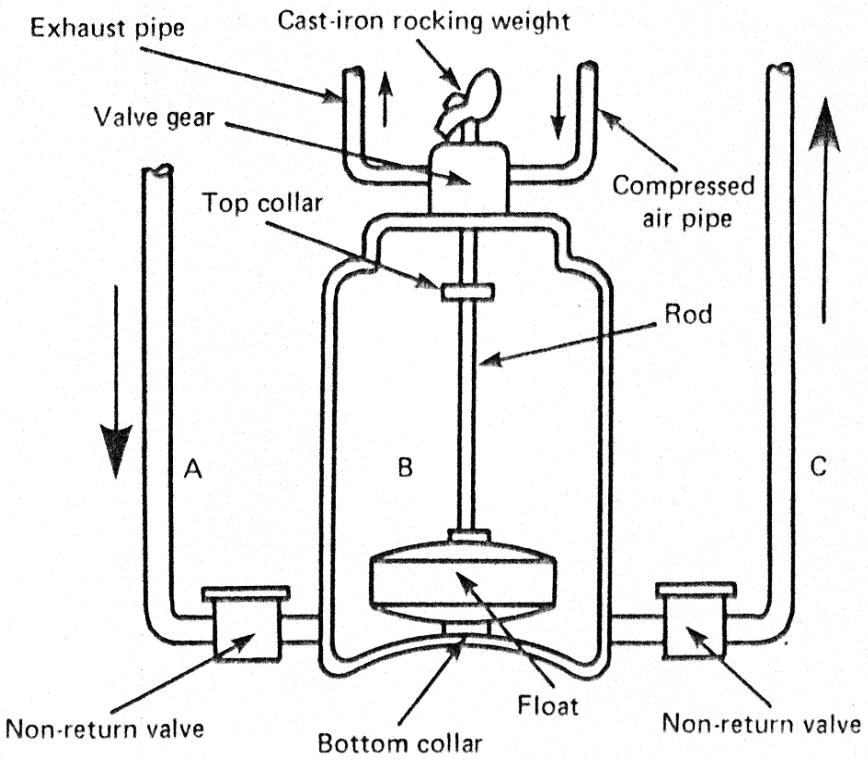
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Sewage pumping



- Sewage ejector may replace centrifugal pump in the sewage pumping station
  - Less risk of blockage
  - Fewer moving parts and less maintenance
  - A wet well is not required
  - One compressor unit can supply compressed air to several ejectors
- Not common in Hong Kong

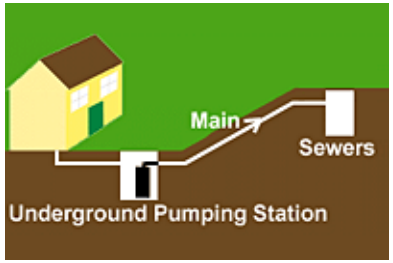




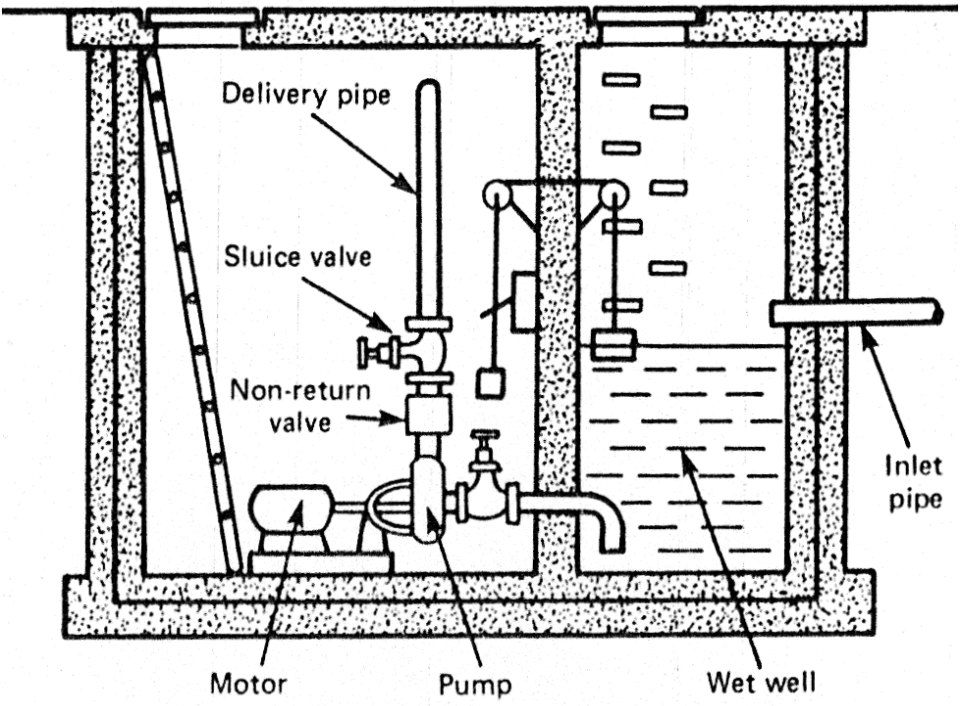
Sewage pumping station using an ejector

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

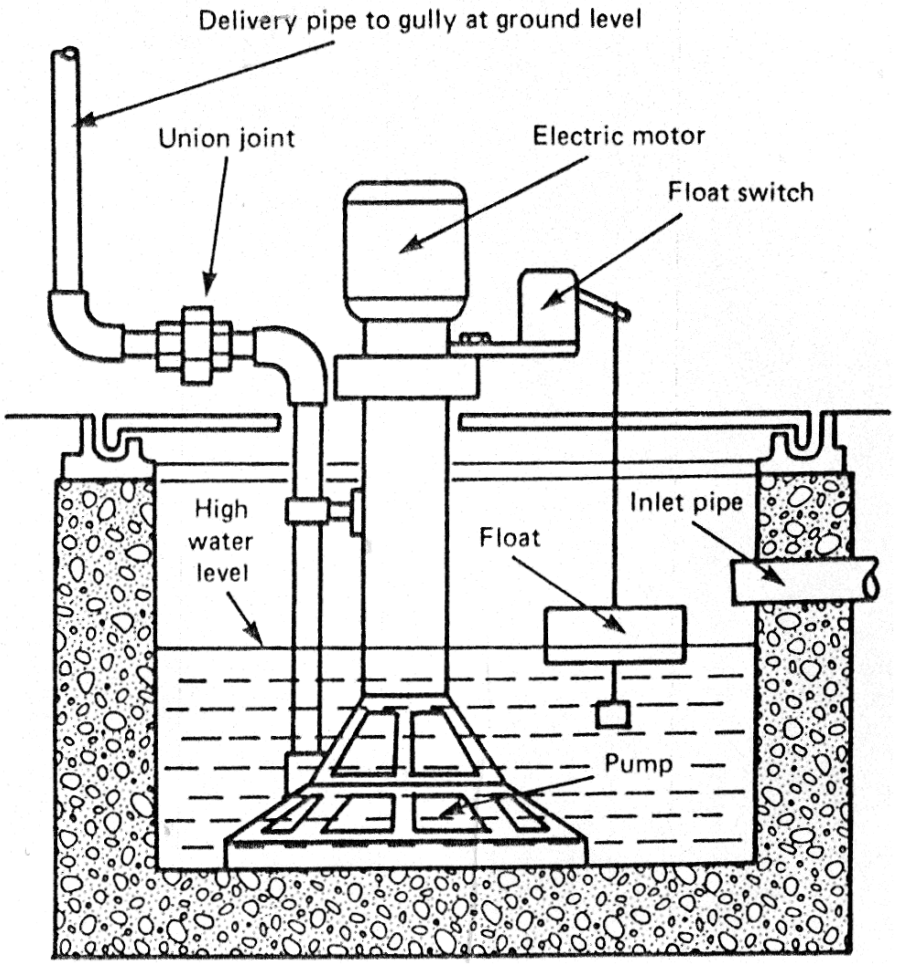
Sewage pumping



- Design considerations
  - Information required
    - Type of the drainage flow (S&W / Stormwater)
    - Maximum quantity of flow per hour
    - Height to which the fluid has to be lifted
    - Length of delivery pipe
    - Type of electric supply (a.c. or d.c.)
    - Availability of essential power supply
  - Motor room below ground level
    - Much neater and the noise can be isolated
    - Sump pump needed to remove water seepage/leakage



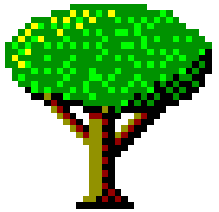
Underground pump room



Sump pump

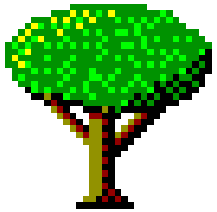
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Methods of sewage disposal

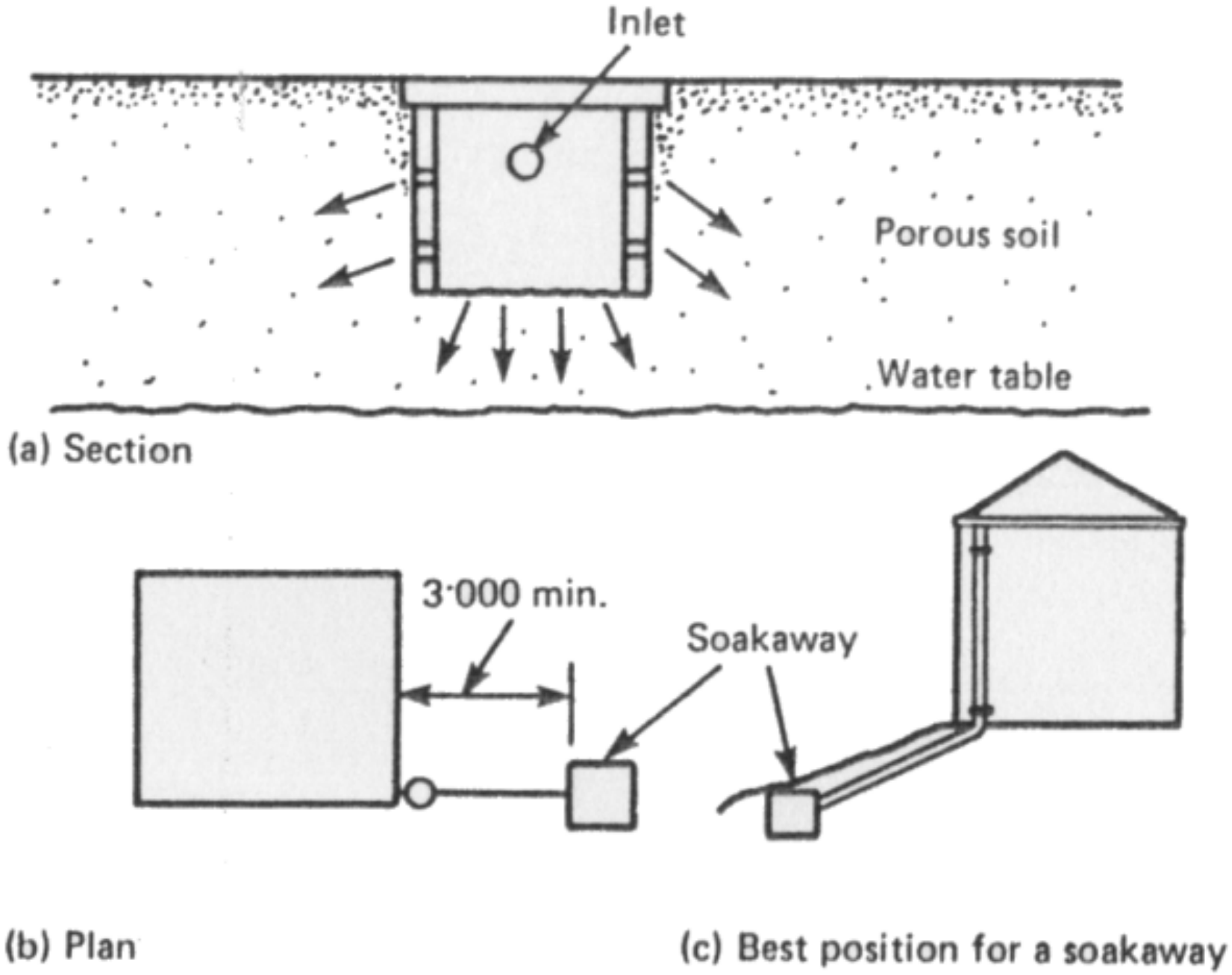


- Sewage
  - Pollute the environment & harm human health
  - Should be ‘treated’ before discharged
- Public sewers
  - If they are within 30 m of the site boundary, connection should be made
  - If they are further away, additional pipework will be required (the authority may bear the cost)
    - In Hong Kong, either the Government bears this cost or a local sewage treatment is required

Methods of sewage disposal

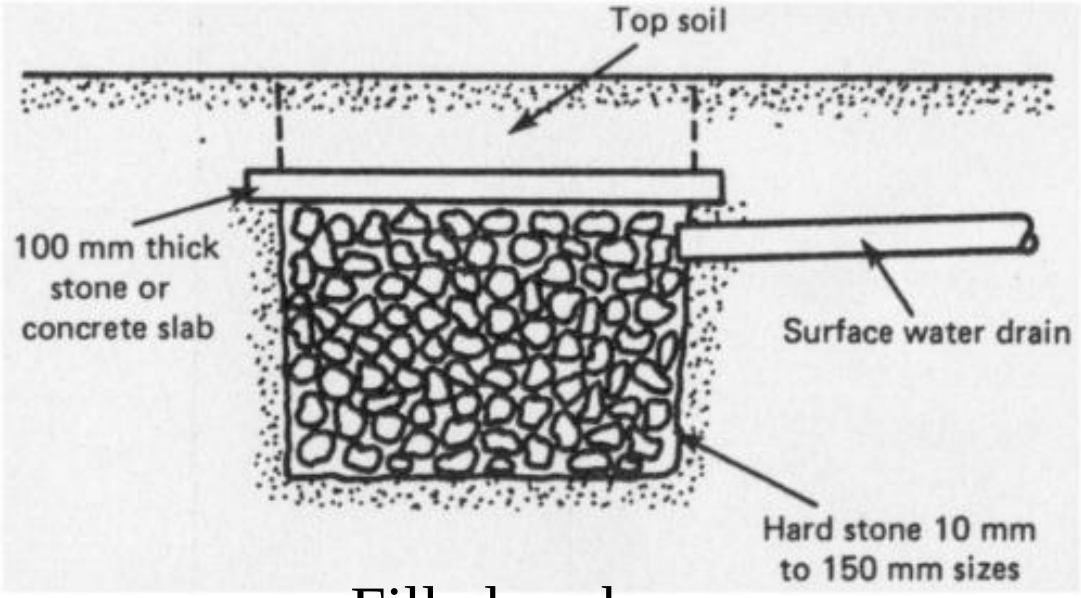


- Disposal of stormwater or rainwater
  - Government Sewer: combined or a separate surface-water
    - Interceptors required for car parks and kitchens
  - Soakaway: ground permeability
    - Using perforated precast concrete, dry stone or brick pit
  - Storage
    - Artificial pond or lake, or underground storage tank
  - Watercourse
    - Expected flow rates at normal and flood levels

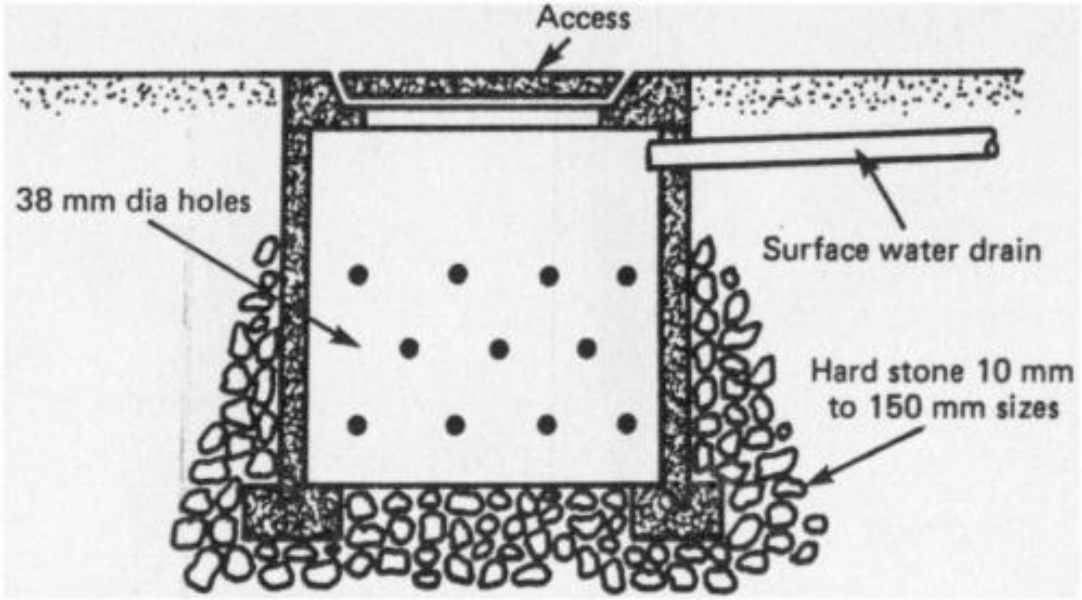


Siting of a soakaway

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)



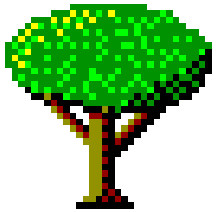
Filled soakaway



Precast concrete soakaway

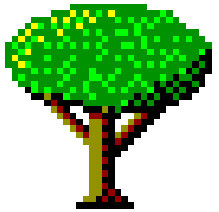
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Methods of sewage disposal



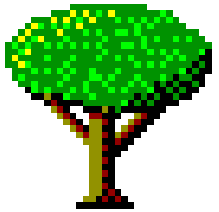
- Disposal of foul water: If no public sewers, three disposal methods:
  - Dilution
  - Conservancy
  - Treatment
- See also the guidelines from Environmental Protection Department (EPD)
  - Guidance notes on discharges from village houses
  - Guidelines for the design of small sewage treatment plants (up to 2,000 population)

Methods of sewage disposal

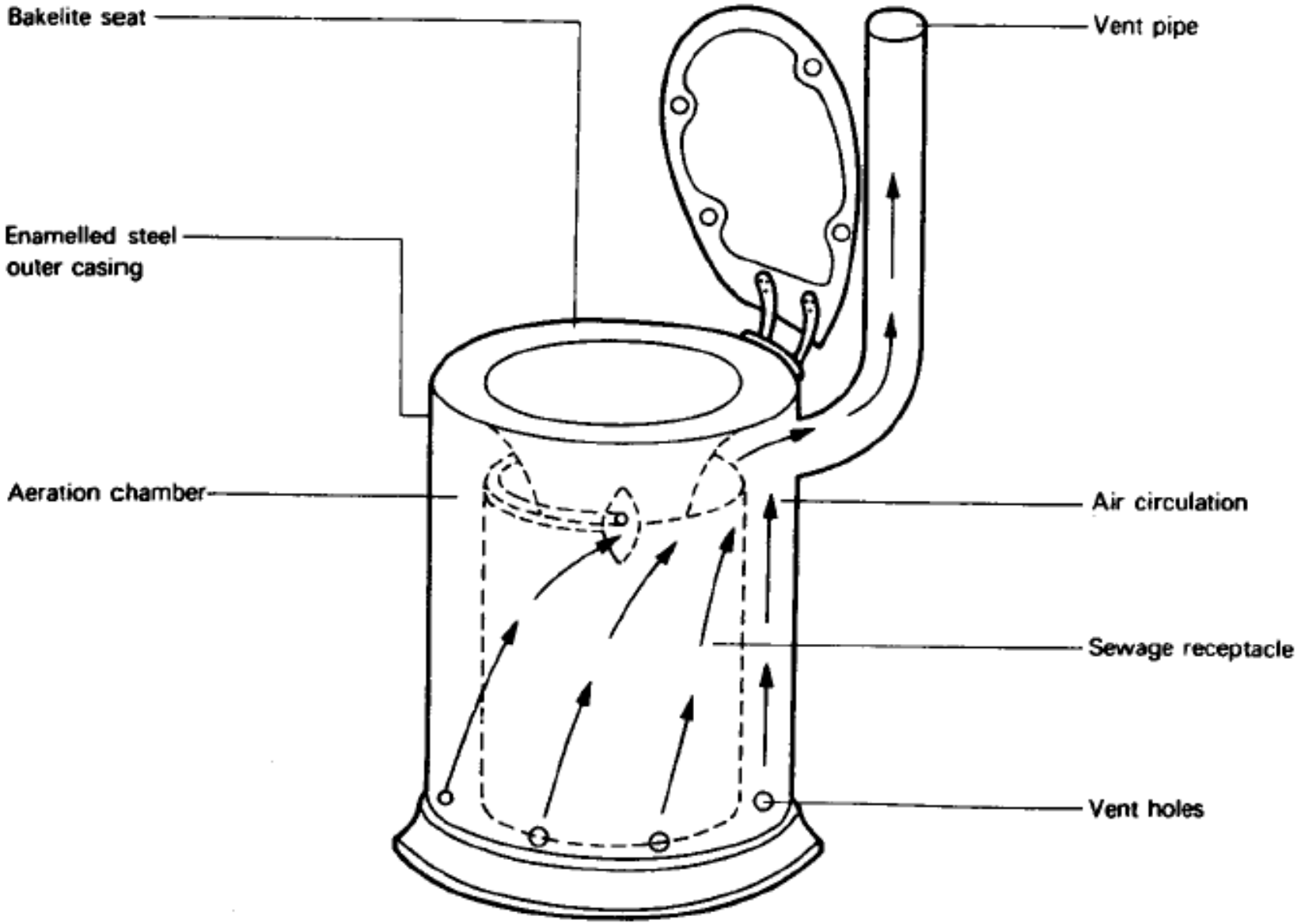


- Basic design parameters
  - Flow rate (Litre/head/day)
  - Load: Biochemical oxygen demand (BOD in mgO_2/L) and total suspended solids (SS) (mg/L)
- Dilution
  - With large amount of water
  - Oxidation of the organic matter by the oxygen dissolved in the water
  - Not appropriate for large demand
  - Civil work can be very expensive

Methods of sewage disposal

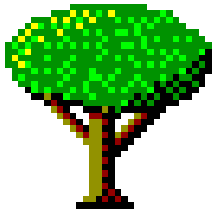


- Conservancy
  - Retained on the site & periodically removed
  - In temporary buildings, use chemical closets
    - Portable types, used in camping sites and aircraft
    - As fixed types incorporating an underground storage tank in schools, factories and dwellings in rural areas
    - The sterilising fluid breaks down the solids of sewage
    - Smells control - a deodorising agent with the chemical, or by an oil film which seals off the surface

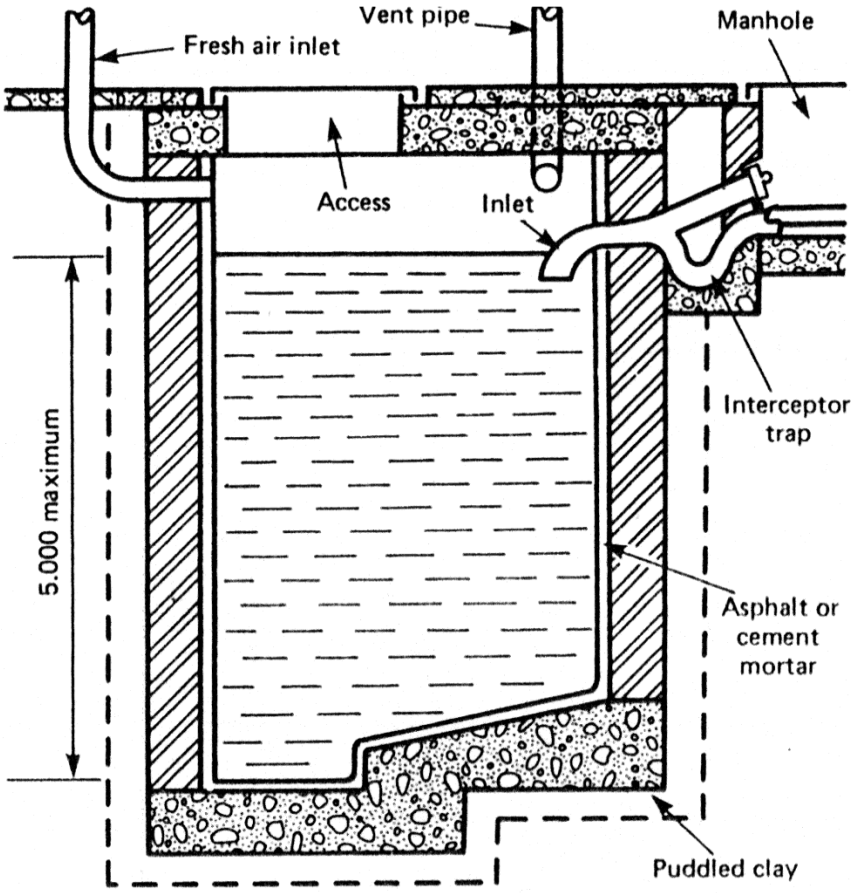


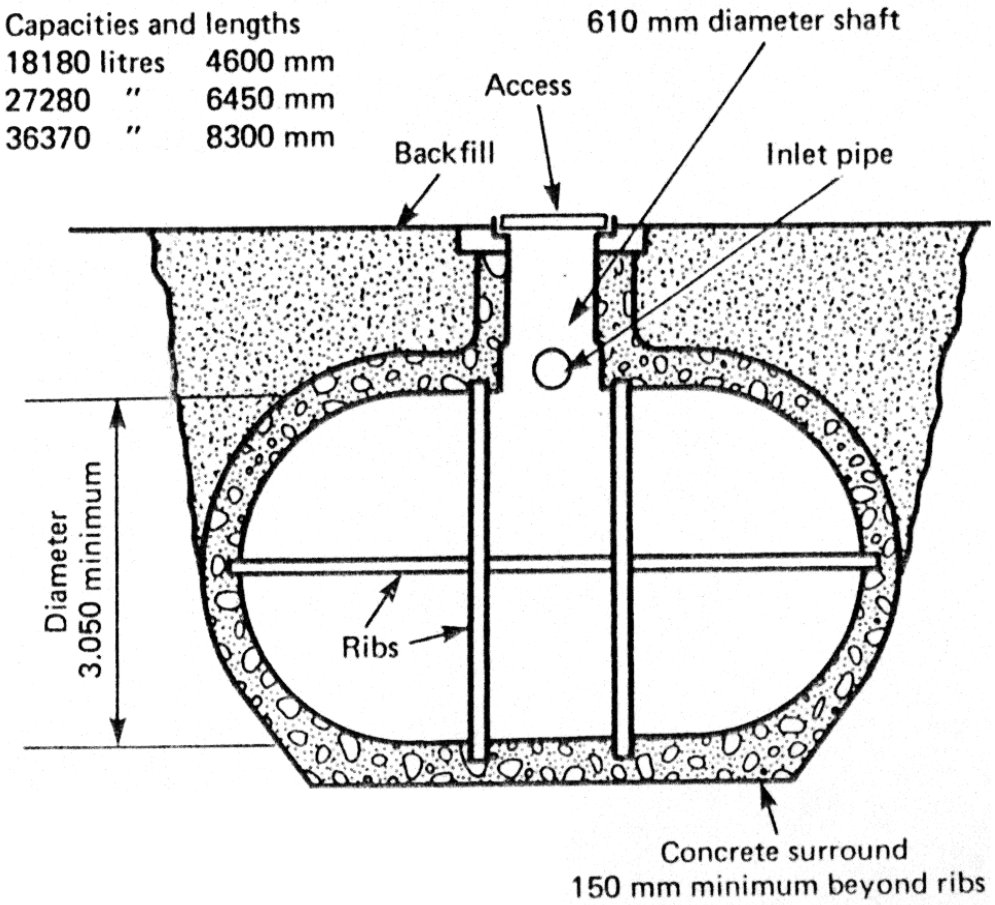
Chemical closets (化學處理廁所)

Methods of sewage disposal



- Conservancy (cont'd)
  - In other buildings, use cesspools (污水池) to receive & store the flow from drains
    - For temporary buildings or permanent buildings not served by sewers
    - Be watertight & ventilated (usually underground)
    - Pump-out from cesspools at intervals
    - Access road for cleaning & emptying is required
    - Cesspool capacity: (based on UK practice)
      - Often based on a 45-day flow; about 18-45 m^3
      - For dwelling, 0.11-0.14 m^3 per day per person



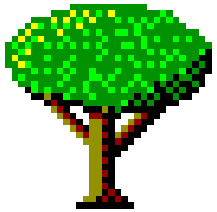


Brick cesspool

Glass reinforced polyester cesspool

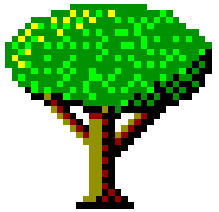
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Methods of sewage disposal



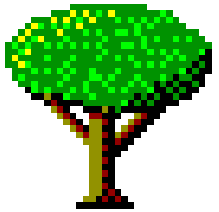
- Conservancy using cesspools in HK
  - Statutory requirements
    - Location: Not situated within 20m of any spring, stream of water or well, the water source for drinking or domestic purposes and for preparation of food/ drink for human consumption, etc
    - Disposal of contents: With adequate means for removal of its content without carrying through any building in which any person resides or works

Methods of sewage disposal



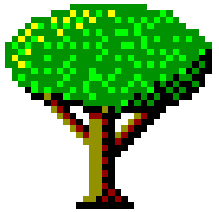
- Conservancy using cesspools in HK (cont'd)
  - Statutory requirements: Capacity
    - Minimum capacity determined by Building Authority
    - Capable of storing the quantity of soil and waste discharged during a period of a month
    - Soil and waste discharged is designed at 135 litres per day per person who uses soil/ waste fitments
    - Building Authority to determine the number of persons using soil or waste fitment

Methods of sewage disposal

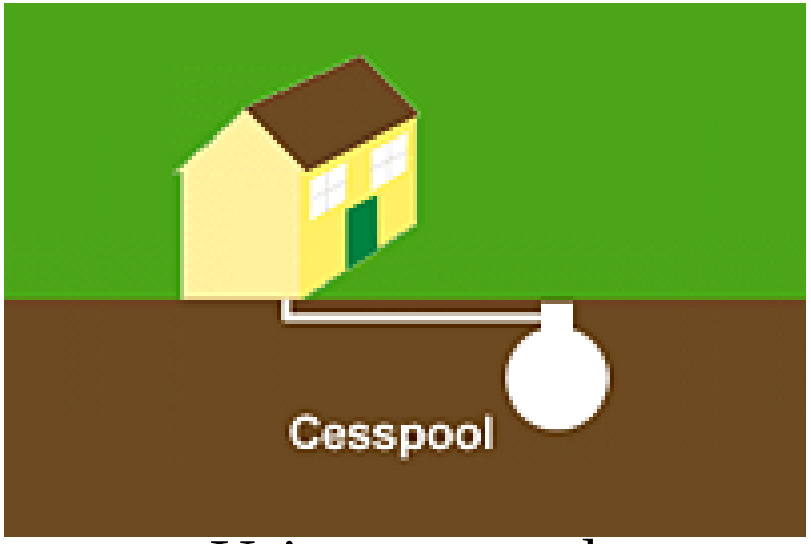


- Conservancy using cesspools in HK (cont'd)
  - Statutory requirements: Construction
    - Construct of brickwork in cement mortar/concrete/other approved material
    - Impervious (inside or outside)
    - Reinforced concrete cover
    - With access for cleaning
    - Adequately ventilated
    - Internal faces rendered with cement mortar

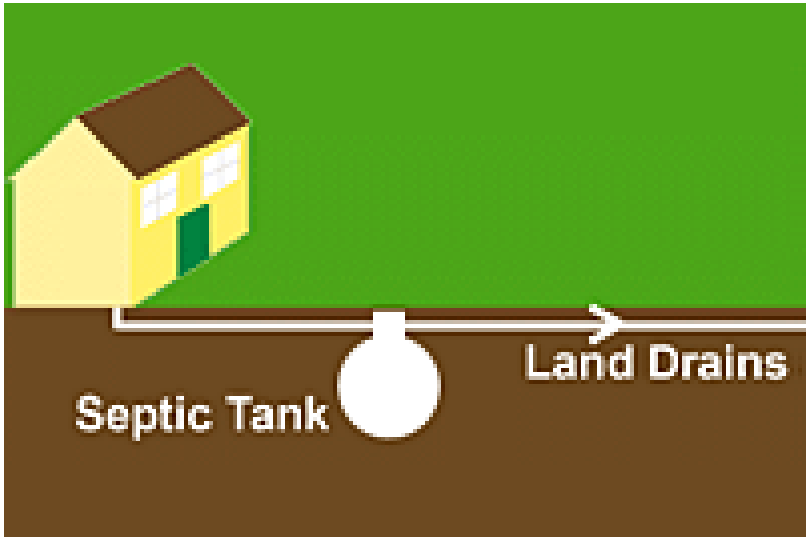
Methods of sewage disposal



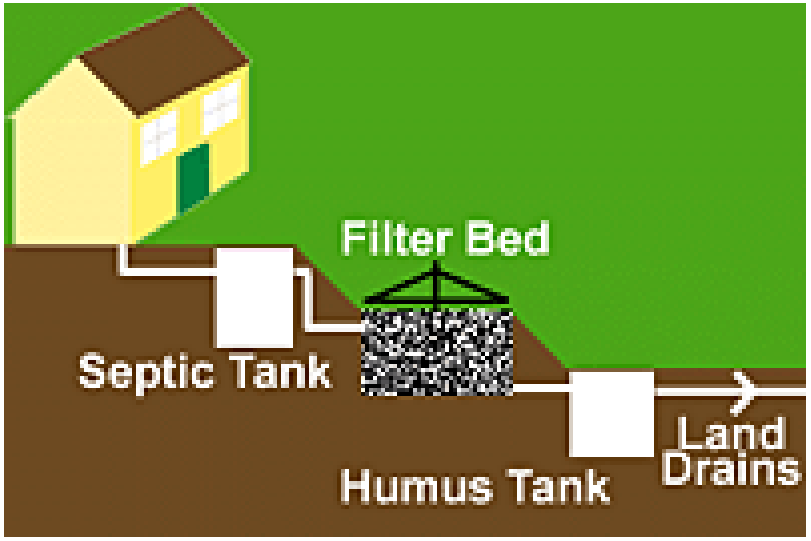
- Treatment
  - Sewage treatment plant to make the effluent sufficiently innocuous (harmless) before discharge to stream/soil
  - Process – (1) settling (2) oxidization (3) discharge
  - Alternatives
    - a) Septic tank + Soakaway
    - b) Septic tank + Biological filter + Humus tank
    - c) Package sewage treatment plant
    - d) (Large scale) sewage treatment plant



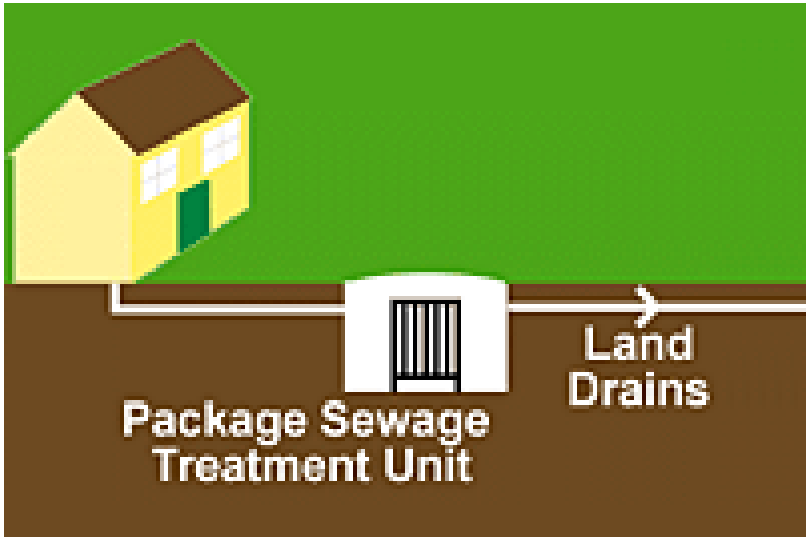
Using cesspool



Using septic tank



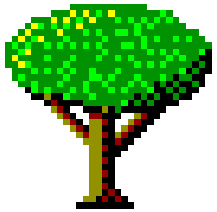
Sewage treatment plant with filter bed



Package sewage treatment unit

(Source: www.johnstonsmith.co.uk/fact2.html)

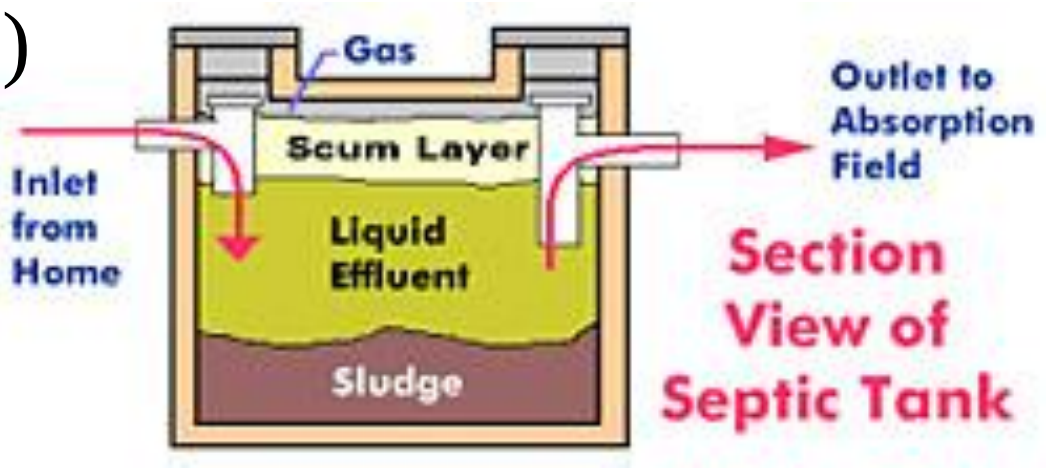
Methods of sewage disposal



- Treatment (cont'd)
  - Choice:
    - Small sewage treatment plant or
    - Septic tank + soakaway
  - Use septic tank + soakaway for
    - Small development with a population of less than 50
    - Site percolation test find it viable and no adverse conditions exist

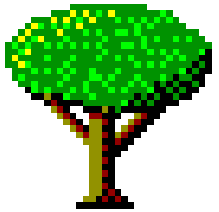
Methods of sewage disposal

- Septic tank (化糞池)
  - Effect on sewage
    - ‘Scum’ on the top
    - ‘Liquor’ in middle
    - ‘Sludge’ at bottom

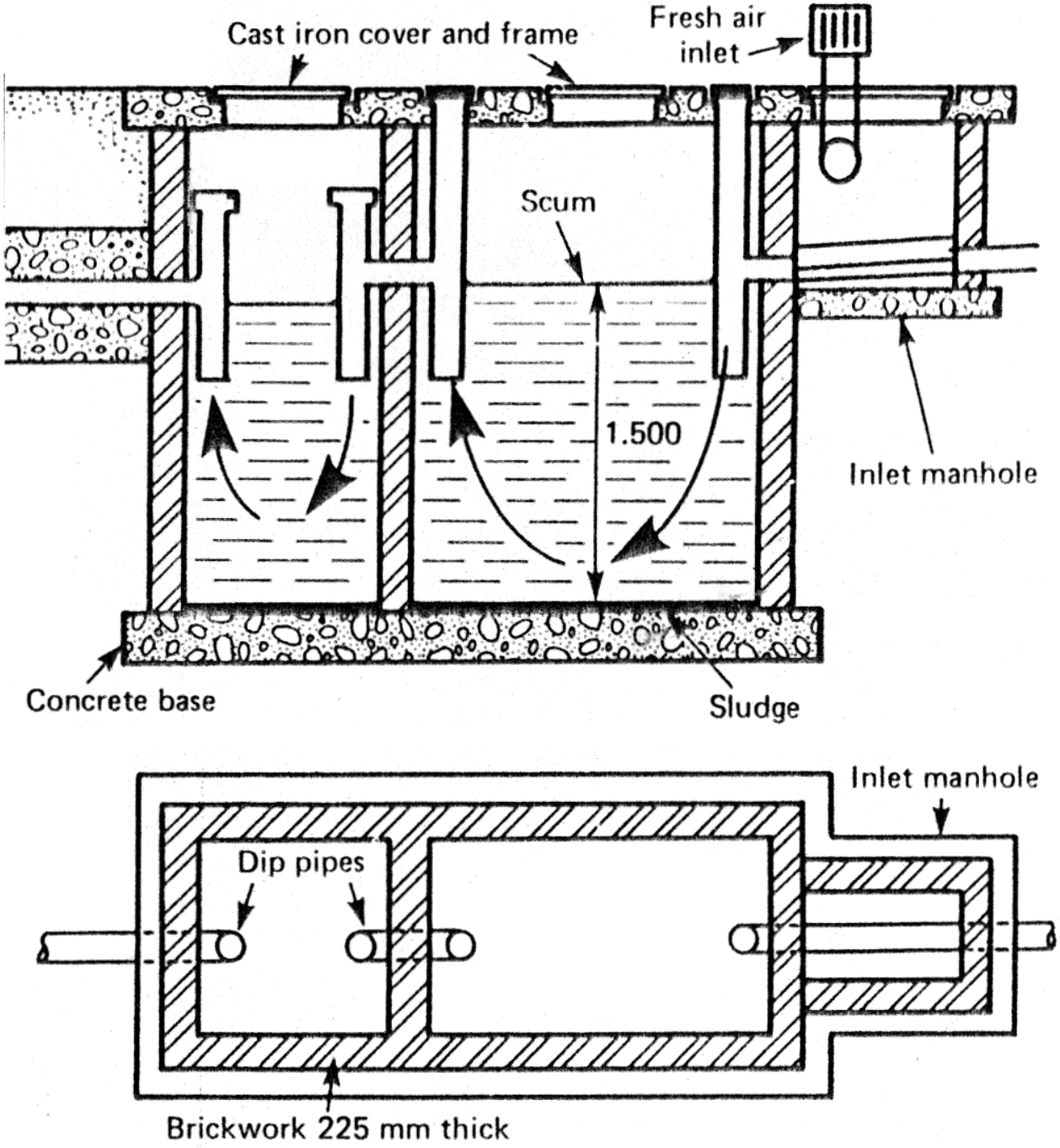


  - Break down organic content by anaerobic bacteria (no oxygen); reduce sludge quantity & odours
    - The process can take 2 months or more
    - In large plant, sludge gas (methane) can be used for power/heating

Methods of sewage disposal

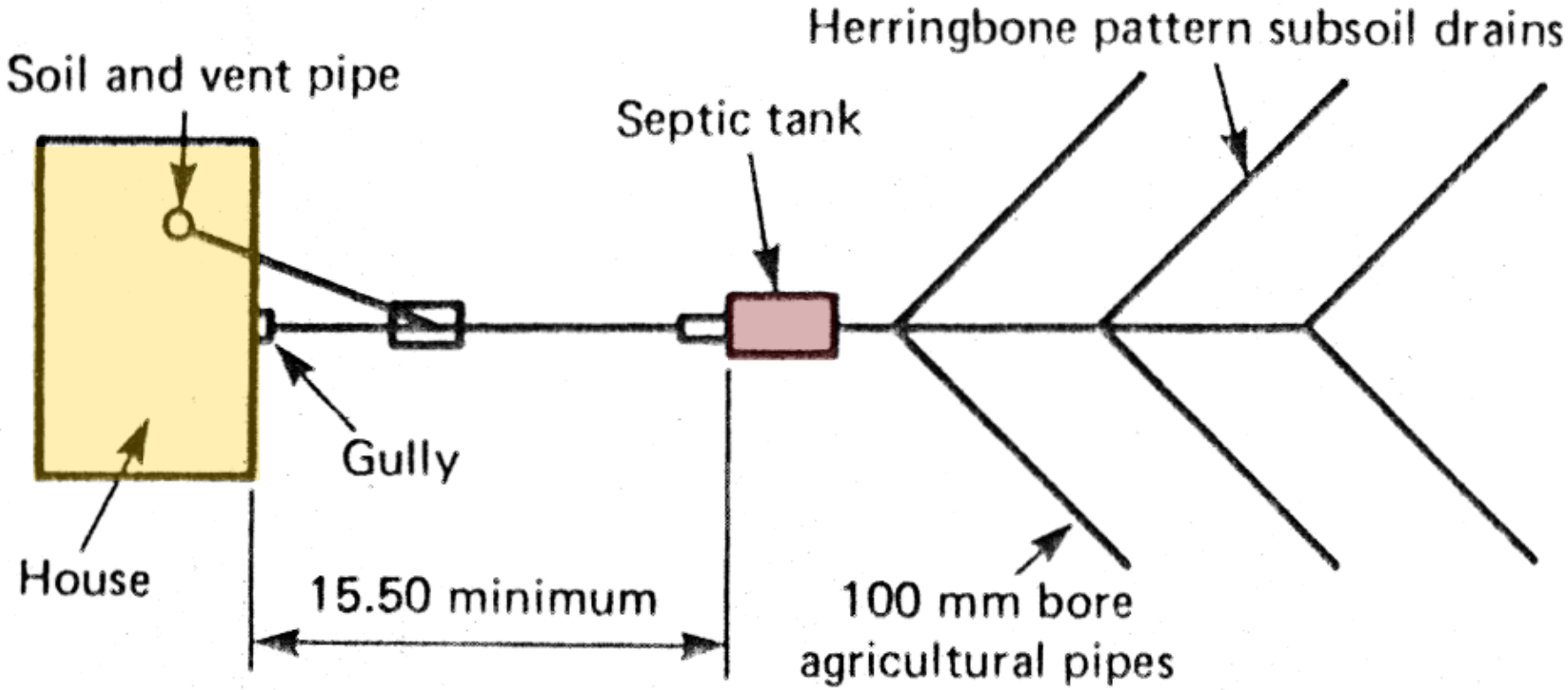


- Septic tank (cont'd)
  - Capacity: 16-48 hours flow; min. 3.5 m^3
  - Suitable dimensions
    - Content not disturbed by any entering flows
    - Contain the accumulation of sludge
      - Volume of sludge = 0.8 litres per person per day
  - Materials: concrete is most common
  - Single or multiple chambers can be used



Septic tank design

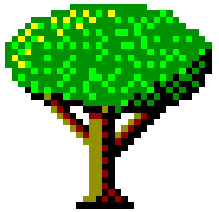
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)



Site plan of septic tank installation

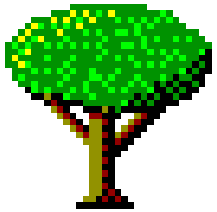
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Methods of sewage disposal



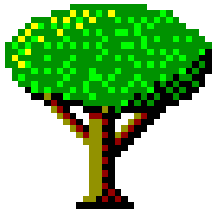
- Septic tank – statutory requirements in HK
  - Situation of septic tank
    - At a minimum of 18m away from stream of water or well, water source for drinking, domestic purposes, food preparation or manufacturing factory, etc
  - Disposal of effluent
    - Building owner who is about to install septic tank shall submit to the Building Authority for approval on method of disposal of effluent and sludge
    - Criteria – neither nuisance nor injury to health

Methods of sewage disposal

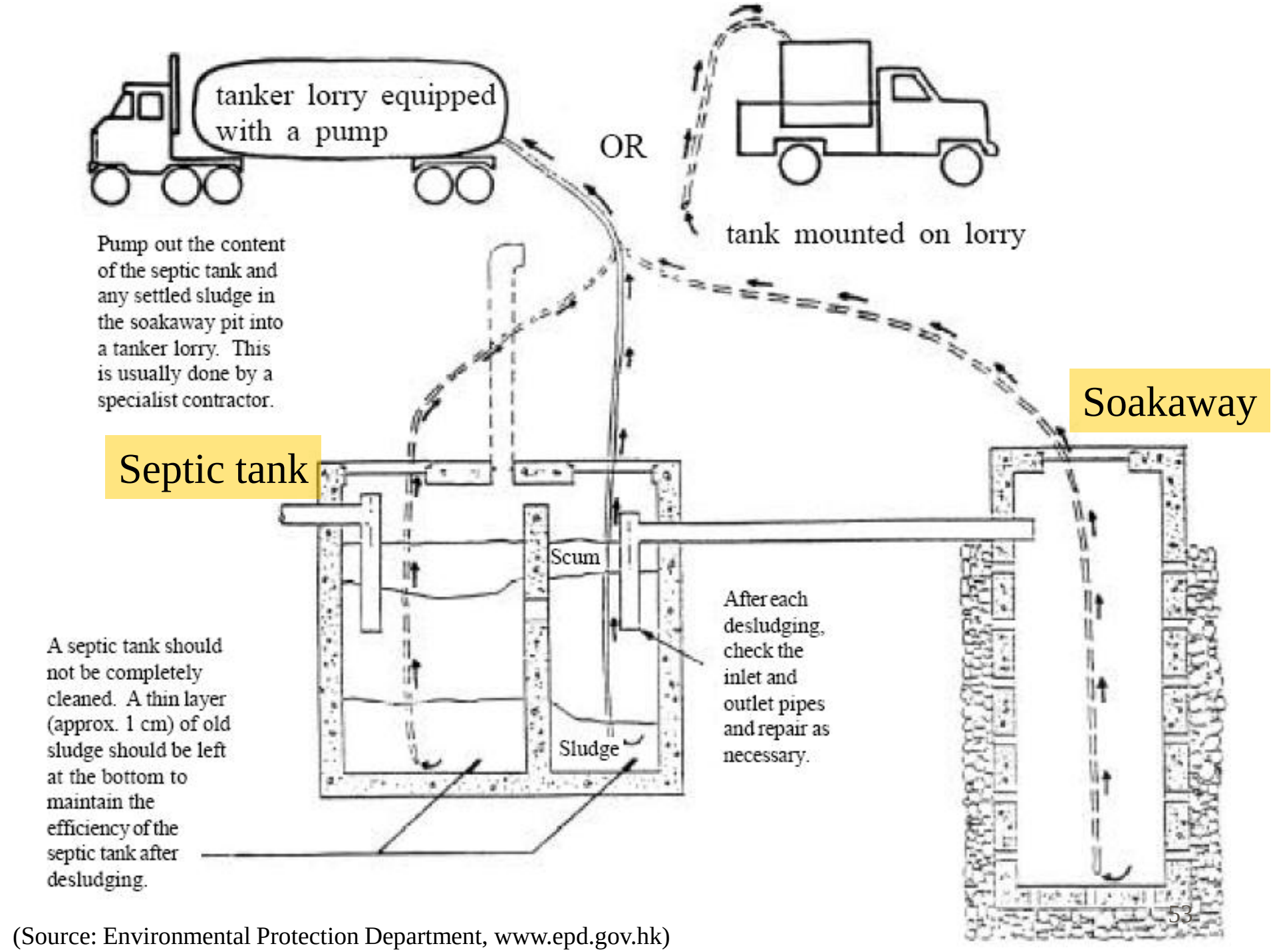


- Septic tank – statutory req's in HK (cont'd)
  - Capacity
    - Volume = 2.3 m^3 to 41 m^3
    - Store soil and waste for one day
    - Calculate soil and waste discharge based on the rate of consumption of potable and flushing water
  - Construction
    - Depth between 1.2m to 1.8m
    - Length = 3 to 4 times of width
    - Adequate means of access for inspection and cleaning

Methods of sewage disposal



- Septic tank – statutory req's in HK (cont'd)
  - Construction
    - Sides of the tank constructed with brickwork in cement mortar min. 215 mm thick or concrete min 125 mm thick, or other approved materials
  - Maintenance
    - Inspect and desludge at least once every 6 months
    - Prevent flooding and overflow
    - Control foul smell



(Source: Environmental Protection Department, www.epd.gov.hk)

Sewage treatment process

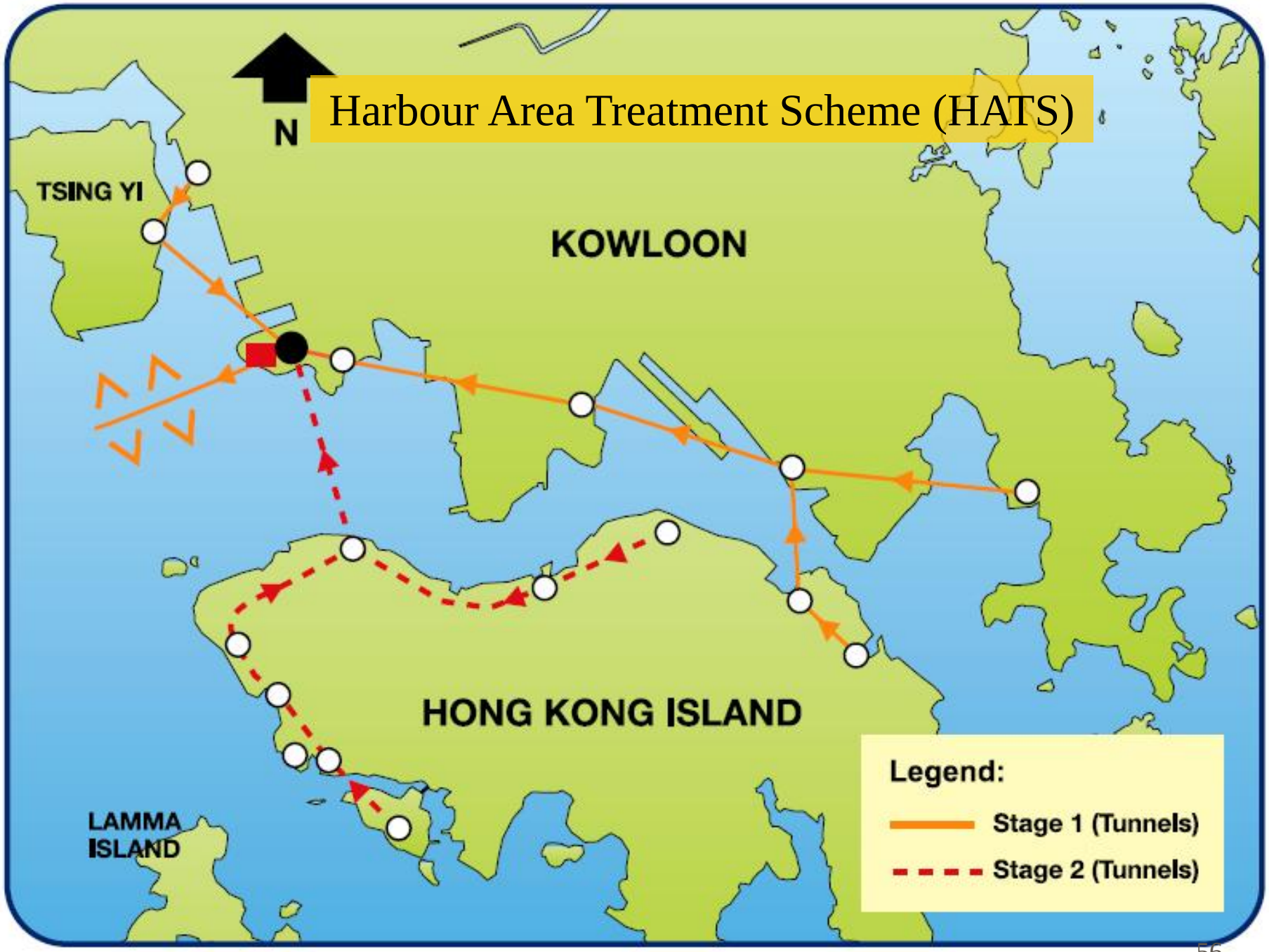
- Sewerage in Hong Kong
  - Everyday, we produce 2.6 million m^3 of sewage, enough to fill up over 1,400 Olympic-size swimming pools
  - About 93% of the population are now served by the public sewerage system with over 98% of the sewage produced being collected and treated
  - A sewerage network of over 1,579 km in total length and around 275 plants treating sewage prior to disposal to the sea for dilution and dispersion through submarine outfalls

(Source: Drainage Services Department, www.dsd.gov.hk)

Sewage treatment process

- Controls in Hong Kong
  - Water Pollution Control Ordinance
    - See Environmental Protection Dept's website
  - In rural areas not served by public sewers, private developers need to provide their own sewage treatment facilities
    - See EPD guidebook on small sewage treatment plants
  - In most areas, by Government's treatment plants
    - Sewage Treatment Works, by DSD

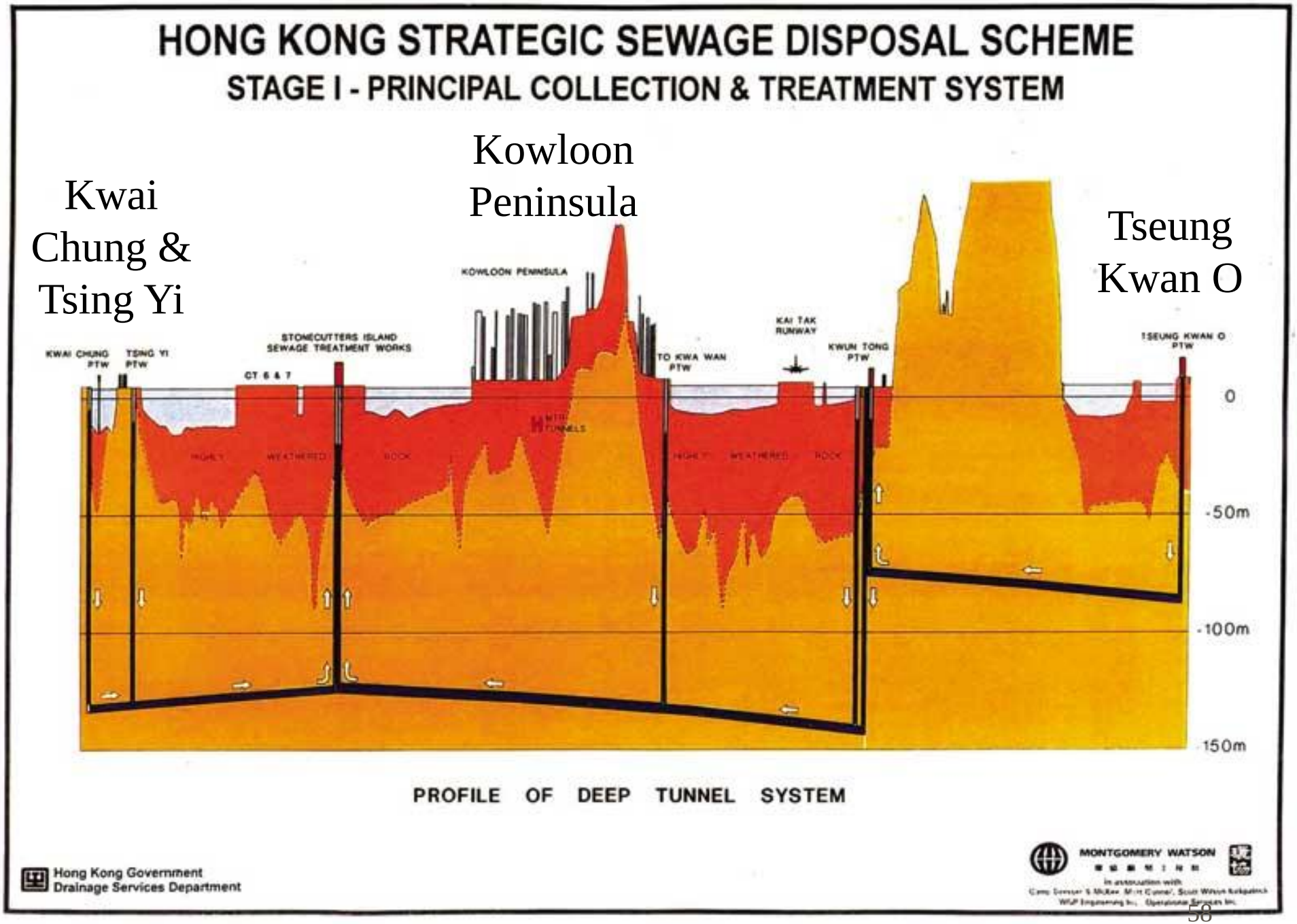
Harbour Area Treatment Scheme (HATS)



(Source: www.cleanharbour.gov.hk)

Stage I Tunnels of Strategic Sewage Disposal Scheme (SSDS)

(Source: Drainage Services Department, www.dsd.gov.hk)



(Source: Drainage Services Department, www.dsd.gov.hk)

Sewage treatment process

- Sewage charge in HK
  - For 1995-2008, it is $1.2 per m^3 of water supplied
    - For each domestic account, the first $12m^3$ supplied in each 4 monthly consumption period is exempted
  - From 2008 to 2017, the rate started to increase incrementally, from $1.31 to $2.92
- Trade effluent surcharge
  - For industries or commerce where pollution level of the wastewater discharged exceeds that of domestic level

Sewage treatment process

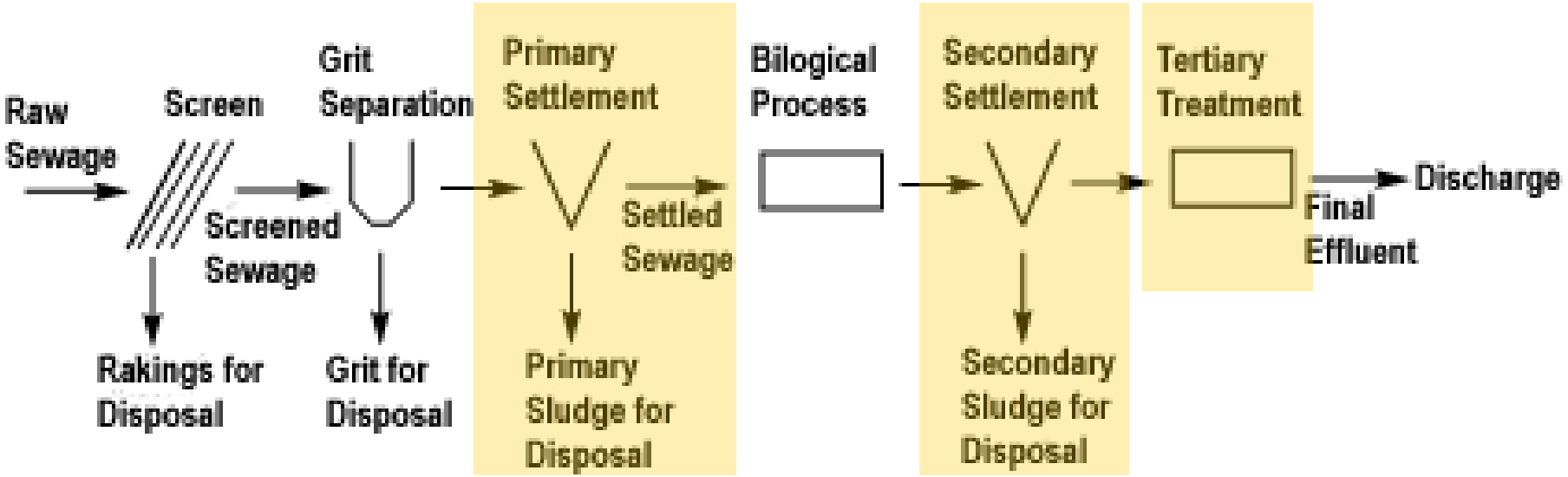
- Sewage treatment plant
  - Usually done by natural or biological system
    - Can be done by chemical & electrical means (expensive)
  - Typical steps
    - Sedimentation (in septic and settlement tanks)
    - Oxidation of organic matter (using biological agencies)
    - Treated effluent is discharged to watercourse or by surface/subsurface irrigation
    - Sludge (污泥) in tanks is removed, say, every 6 months
      - Either dumped or used as fertilizer

Sewage treatment process

- Sewage treatment (cont'd)
  - Activated sludge process (a biological method):
    - Performed by a variable and mixed community of microorganisms in an aerobic aquatic environment
      - These microorganisms derive energy from carbonaceous organic matter in aerated wastewater (synthesis)
      - A variable number of microorganisms in the system obtain energy by converting ammonia nitrogen to nitrate nitrogen (nitrification)
  - Anaerobic digestion:
    - It involves bacteria that thrive in the absence of oxygen
      - In this sludge process, organics are converted into carbon dioxide and methane gas

Sewage treatment process

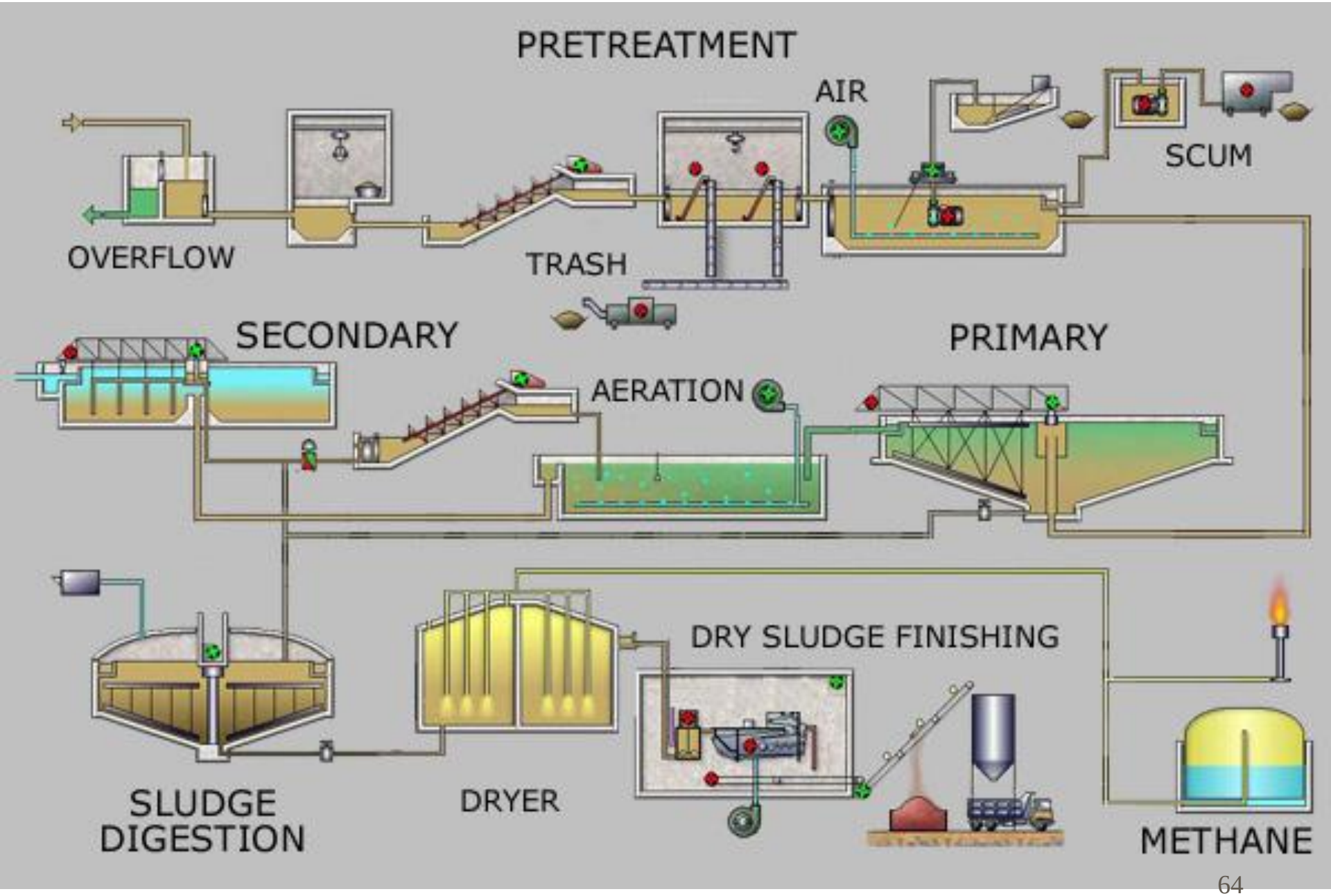
- Main stages of sewage treatment
  - 1. Preliminary works (screens & grit channels)
  - 2. Primary settlement (settlement tanks)
  - 3. Biological treatment (in filter beds, biological contactors or activated sludge)
  - 4. Secondary settlement (humus tanks)
  - 5. Tertiary treatment (needed for high discharge standard or poor raw effluent)



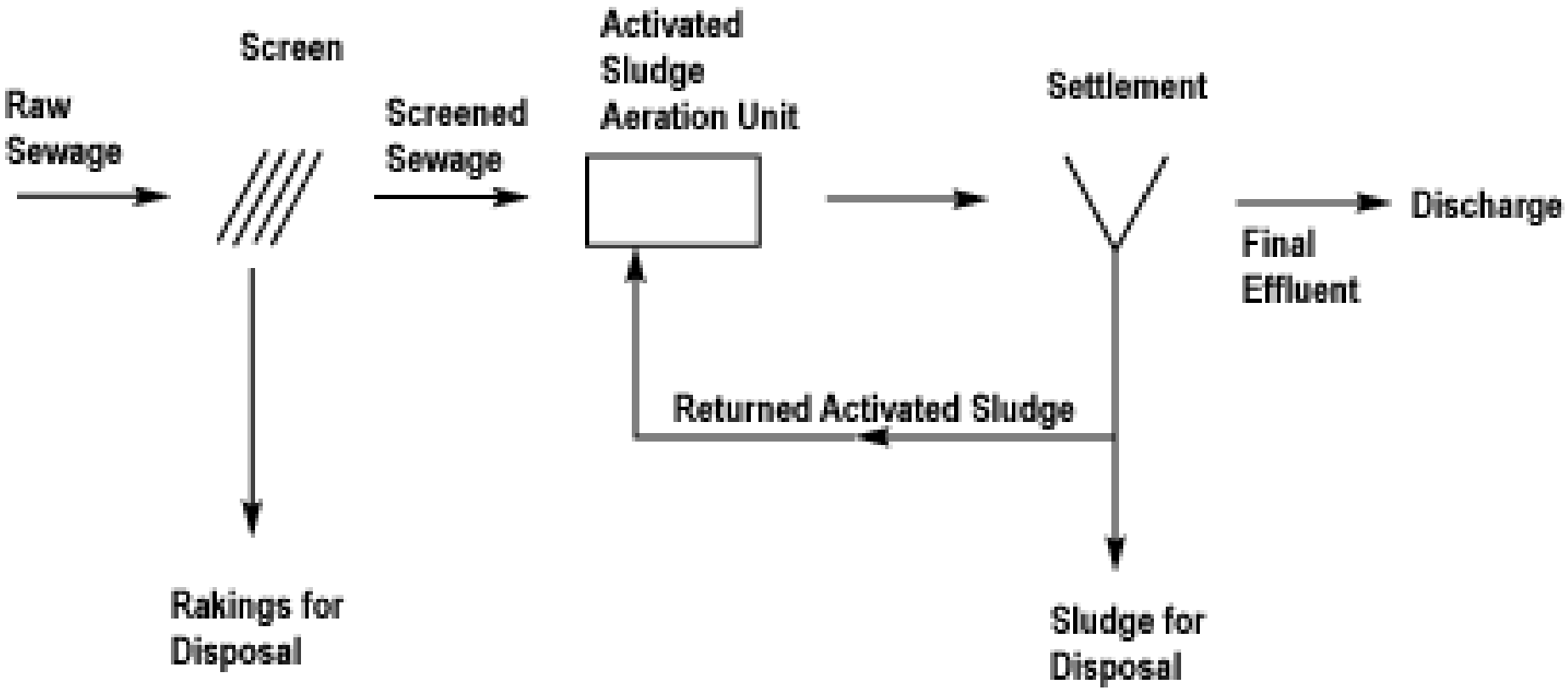
Diagrammatic representation of the process of sewage treatment

(Source: www.johnstonsmith.co.uk/fact16.html)

Process flow diagram for a typical sewage treatment plant



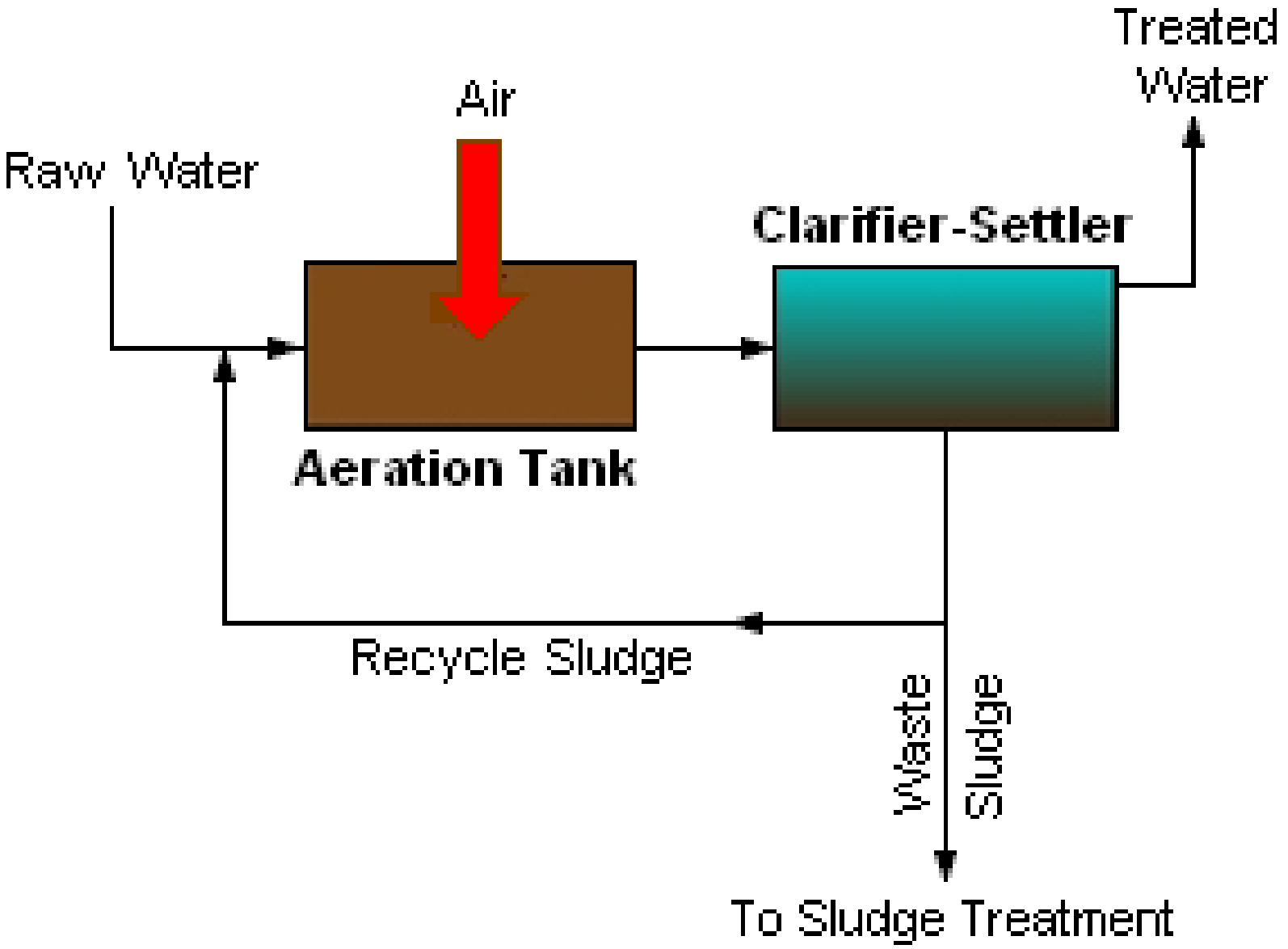
(Source: http://en.wikipedia.org/wiki/Sewage_treatment)



Diagrammatic representation of sewage treatment at a small activated sludge plant

(Source: www.johnstonsmith.co.uk/fact16.html)

A simplified schematic diagram of an activated sludge process



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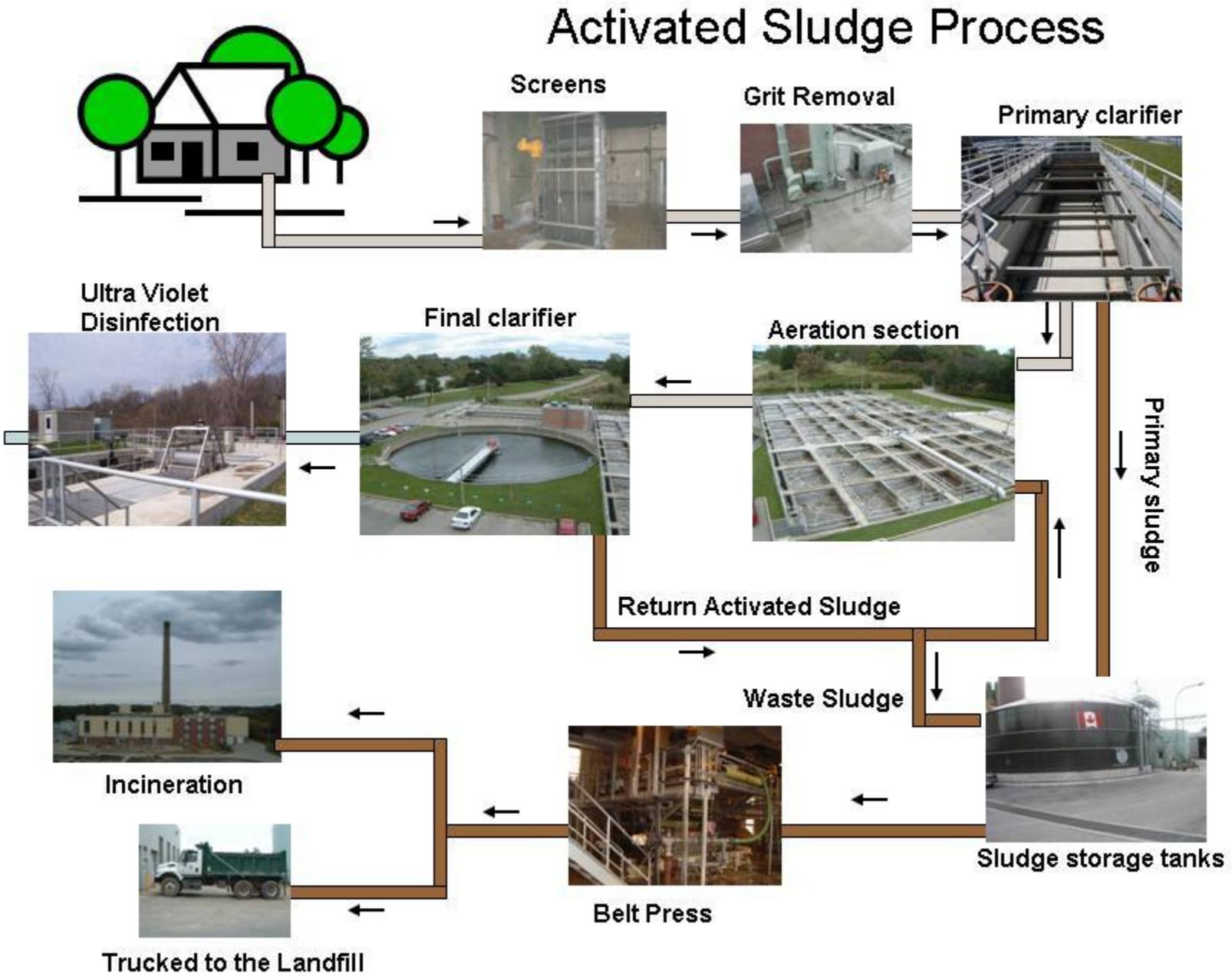
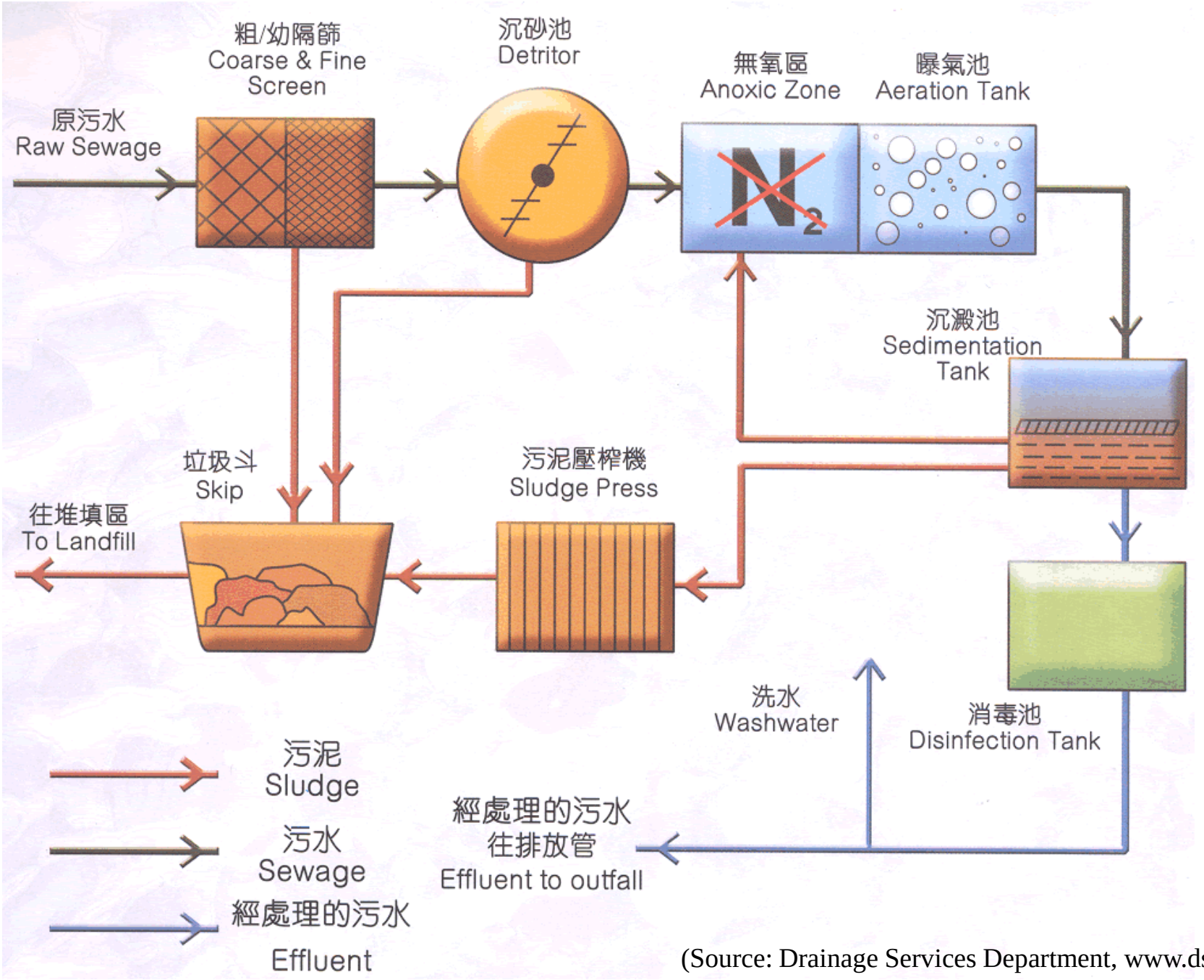


(Source: www.london.ca/Sewer_and_Wastewater)

Sewage treatment process

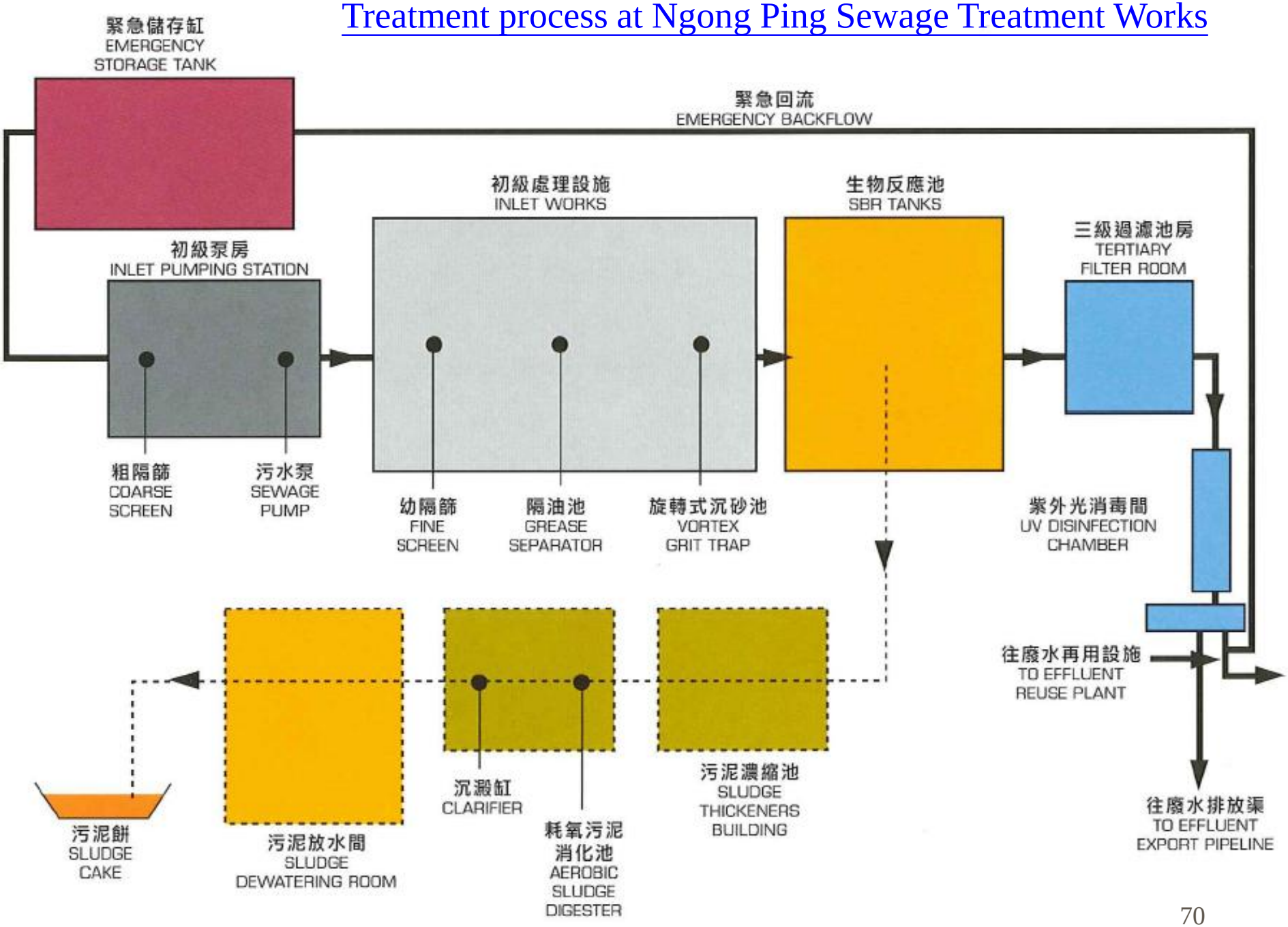
- Types of sewage treatment facilities in HK
  - Preliminary Treatment (Screening) - includes screening and removal of grit (remove solids > 6 mm in diameter)
  - Primary Treatment - includes screening, removal of grit and a primary sedimentation process. Solid waste and settleable suspended solids are removed
  - Chemically Enhanced Primary Treatment (CEPT) - chemicals are added to enhance the removal of suspended solids and the biochemical oxygen demand
  - Secondary Treatment - the sewage is purified by means of a biological treatment process after the primary treatment has been completed. The organic matter is decomposed by micro-organisms

Treatment process at Stanley Sewage Treatment Works



(Source: Drainage Services Department, www.dsd.gov.hk)

Treatment process at Ngong Ping Sewage Treatment Works



(Source: Drainage Services Department, www.dsd.gov.hk)

Sewage treatment process

- Reclaimed water (再造水) trial scheme in HK
  - For flushing at public toilets in Ngong Ping & cable car terminal; at Shek Wu Hui, for toilet flushing & non-potable uses
  - Highly treated wastewater:
    - Clear in appearance, odourless and is safe for use
    - Contains a low level of nutrients (nitrogen and phosphorus)
    - Can be beneficial to plant growing (reduce fertilizer use)

Sewage treatment process

- Reclaimed water (再造水) (cont'd)
  - Benefits: better use of treated wastewater, save water, protect our environment, better quality water for irrigation
- In Singapore, the brand name is NEWater (新生水)
  - Treated wastewater purified using dual-membrane (via microfiltration and reverse osmosis) and ultraviolet technologies, in addition to the water treatment processes
    - The water is potable and is consumed by humans
    - But is mostly used for industry requiring high purity water