# CHAPTER 5
# SEWER SYSTEM

*Dr. Mohamad Darwish*

# Sewer System

Sewers are underground conduits to convey wastewater and storm water to a treatment plant or to carry storm water to the point of disposal.

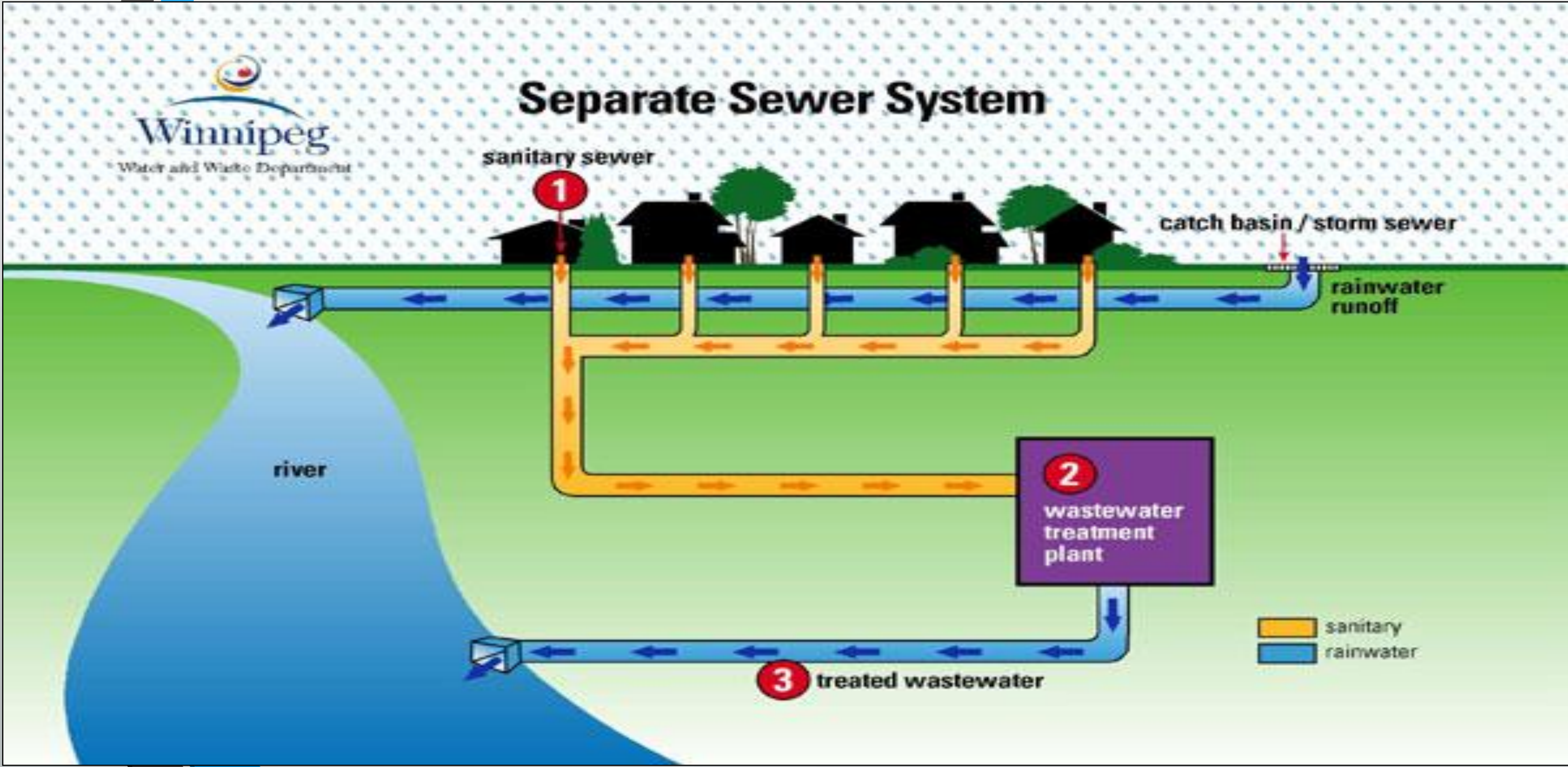
# CATEGORIZATION OF SEWER SYSTEM

## Separate Sewer System

- Consists of two separate types of sewers - one for domestic sewage and the other for storm water.
- Domestic sewage flows to treatment  plant. Storm water discharged untreated.
- Widely practiced in Malaysia

## Combined Sewer System

- Combines domestic sewage and storm water in one sewer.
- Large quantity of storm water require large sewers.
- High flow into treatment plant during storms


Winnipeg
Water and Waste Department
Separate Sewer System
sanitary sewer
1
catch basin / storm sewer
rainwater
runoff
river
2
wastewater
treatment
plant
sanitary
rainwater
3
treated wastewater


Winnipeg
Water and Waste Department
Combined Sewer System
sanitary sewer
1
catch basin / storm sewer
rainwater runoff
overflow during heavy rain events
weir/dam
river
2
wastewater treatment plant
no overflow during dry weather
3
treated wastewater
sanitary
rainwater
combined


A typical size of combined
sewer system

# LOCATION OF SEWERS

Adequate access to a sewer should be allowed for maintenance purposes e.g. within streets.


Manhole

# Manholes

Manholes permit inspection and cleaning of sewers and removal of obstructions


SEWER
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# LOCATION OF MANHOLES

- Every change in direction
- Every change in gradient
- Every change in size of sewer
- At intersections and junctions

# Location
(straight)

≥ 200 mm in diameter
Every about 100 m

≥ 450 mm in diameter
Every about 150 m

Hi .. !!


Pumping Station

Necessary if

- topography of the area does not permit flow by gravity
- Excessive construction costs due to deep excavation

Pumping stations should be avoided since the installation, operation and maintenance is expensive.


STP
Pumping station
Taman Senai Utama
Ridge
© 2010 MapIt
Image © 2011 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
©2007 Google
Pointer 1°36'35.07" N 103°38'35.58" E elev 104 ft Streaming |||||||||| 100%
Eye alt 4503 ft

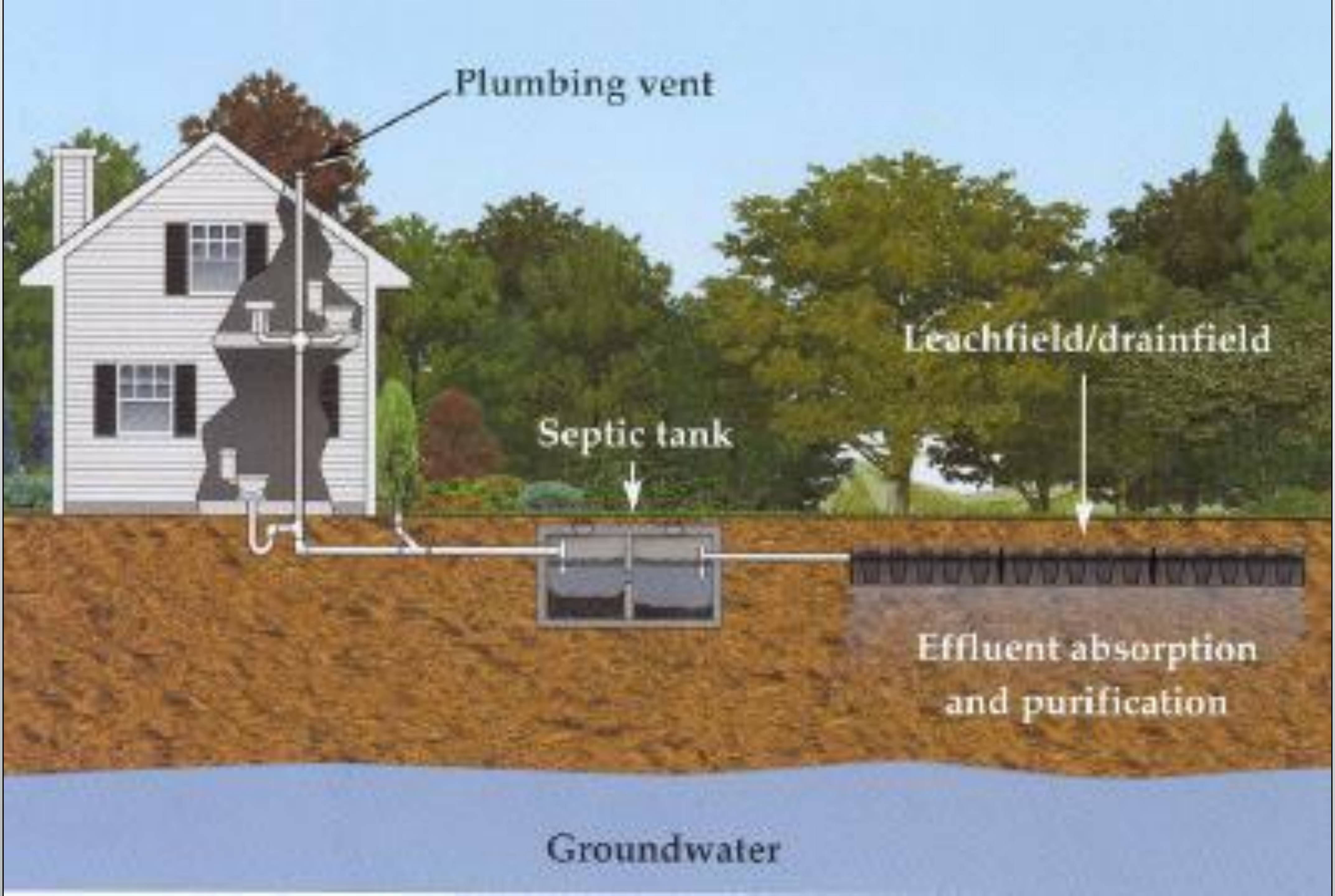
# CHAPTER 6
## SEWAGE TREATMENT SYSTEM

# CLASSIFICATION

- Individual Treatment System
- Communal (De-centralized) Treatment System
- Centralized Treatment System

# INDIVIDUAL TREATMENT SYSTEM

- 1 premise 1 treatment plant
- eg. House – septic tank
- eg. School – imhoff tank
- Old practice
- Suitable in remote area
- Owner is responsible for efficient operation and maintenance


Plumbing vent
Leachfield/drainfield
Septic tank
Effluent absorption
and purification
Groundwater


After the flush
Septic Tank
Leach Field

# COMMUNAL TREATMENT SYSTEM

- Common in Malaysia
- Treats sewage from a community
  eg. housing estate
- Requires regular maintenance (problem if too many plants)

# CENTRALIZED TREATMENT SYSTEM

- Cover large area eg. city, district
- Extensive sewerage system (need proper planning)
- Easy to operate and maintain (few in number)

# SEWAGE TREATMENT PLANTS (STP)

Design considerations:

- Effluent quality requirements should meet DOE Standards
- Proximity to residential areas
- Access to plants
- Wind direction **(Why ??)**
- Land availability including space for future expansion and upgrading
- Topography
- Soil characteristics, geological and hydrological conditions
- Costs (capital, operation and maintenance)
- Power supply
- Access to receiving waters
- Ultimate disposal of sludge.

# SAFETY OF STP

Adequate provision should be made to effectively protect the operator and public from hazards, for example:

- Hand rails around tanks, trenches, pits, stairwells and other hazardous structures
- Fencing of the plant to discourage entrance of unauthorized persons and animals
- Warning sign
- First aid equipment
- ‘No Smoking” sign in hazardous areas
- Protective clothing and equipment
- Portable lighting equipment

# SEWAGE TREATMENT PROCESS

4

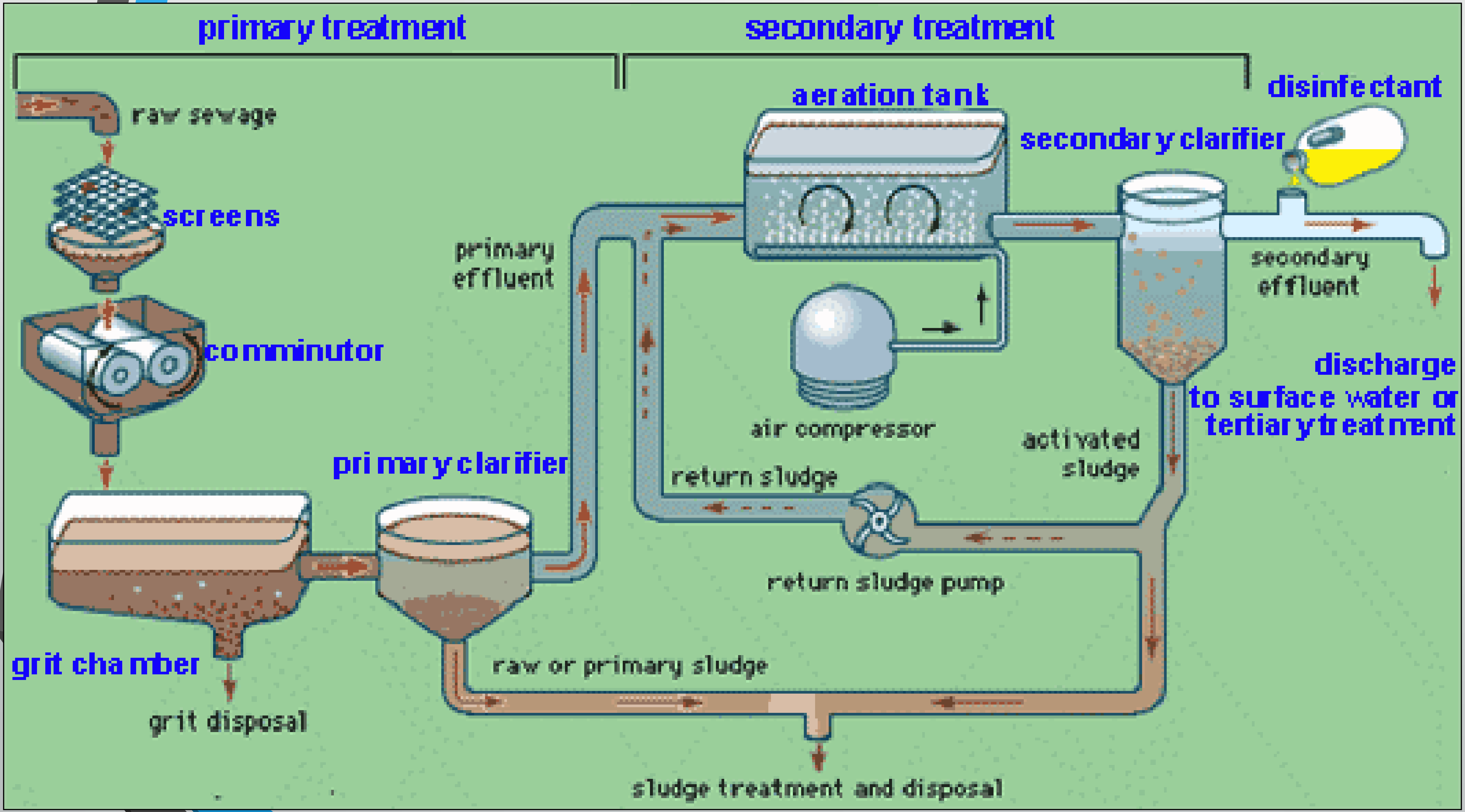
components

① Preliminary treatment/Pre-treatment

② Primary treatment

③ Secondary treatment

④ Treatment and disposal of sludge


primary treatment
secondary treatment
raw sewage
screens
comminutor
grit chamber
grit disposal
primary clarifier
primary effluent
aeration tank
air compressor
return sludge
return sludge pump
activated sludge
secondary clarifier
disinfectant
secondary effluent
discharge to surface water or tertiary treatment
raw or primary sludge
sludge treatment and disposal

# ① Preliminary treatment / Pre-treatment

Includes primary screen, secondary screen, grit removal and oil & grease removal

*Reduce BOD from 5 to 10 percent*

# Primary Screen

Protection against clogging and damage

Located upstream of pumps and mechanical equip.

Regular cleaning (manually or mechanically cleaned)

Opening:  25 to 75 mm

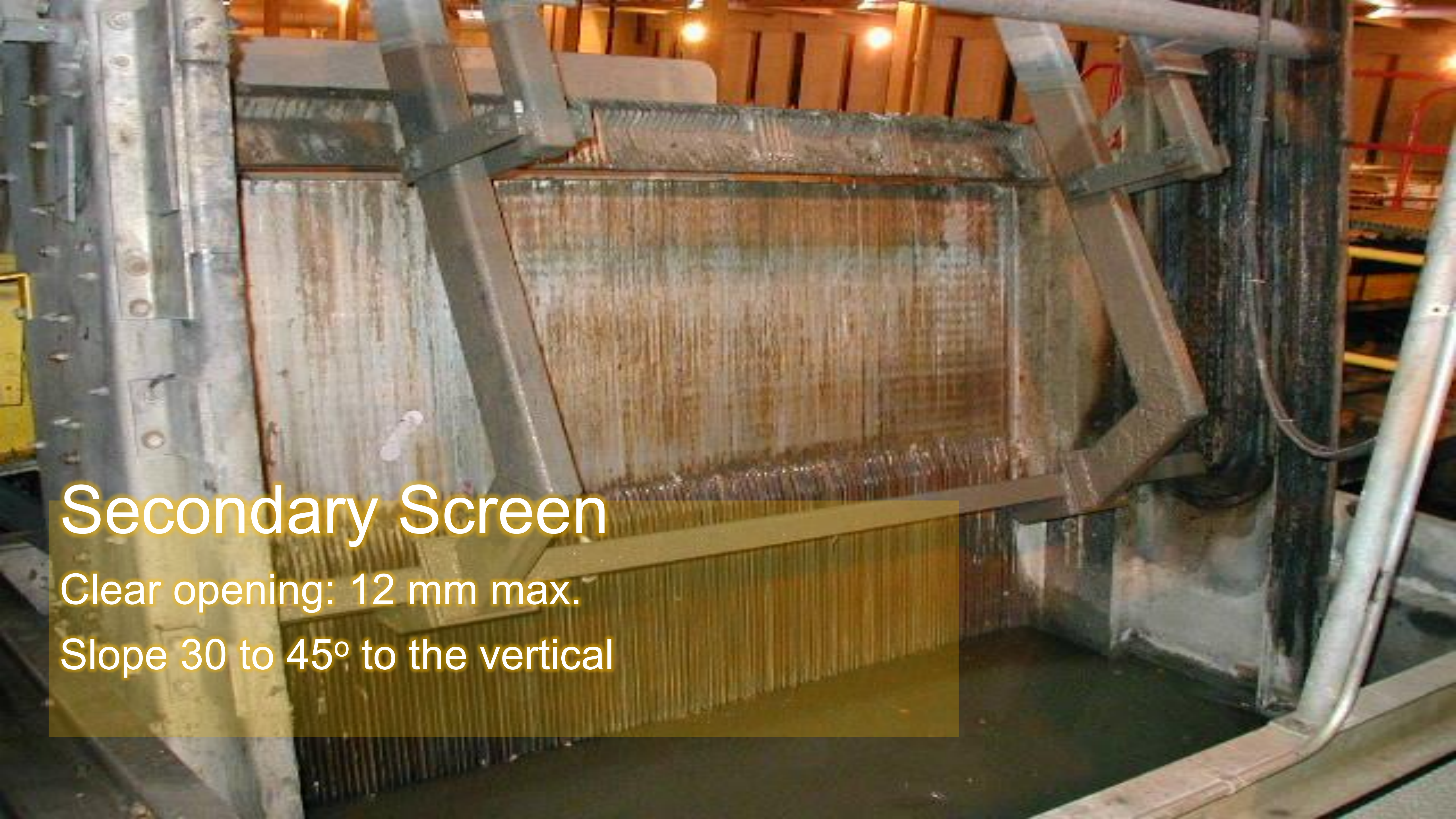
Slope of 0 to 45$^{o}$ to vertical

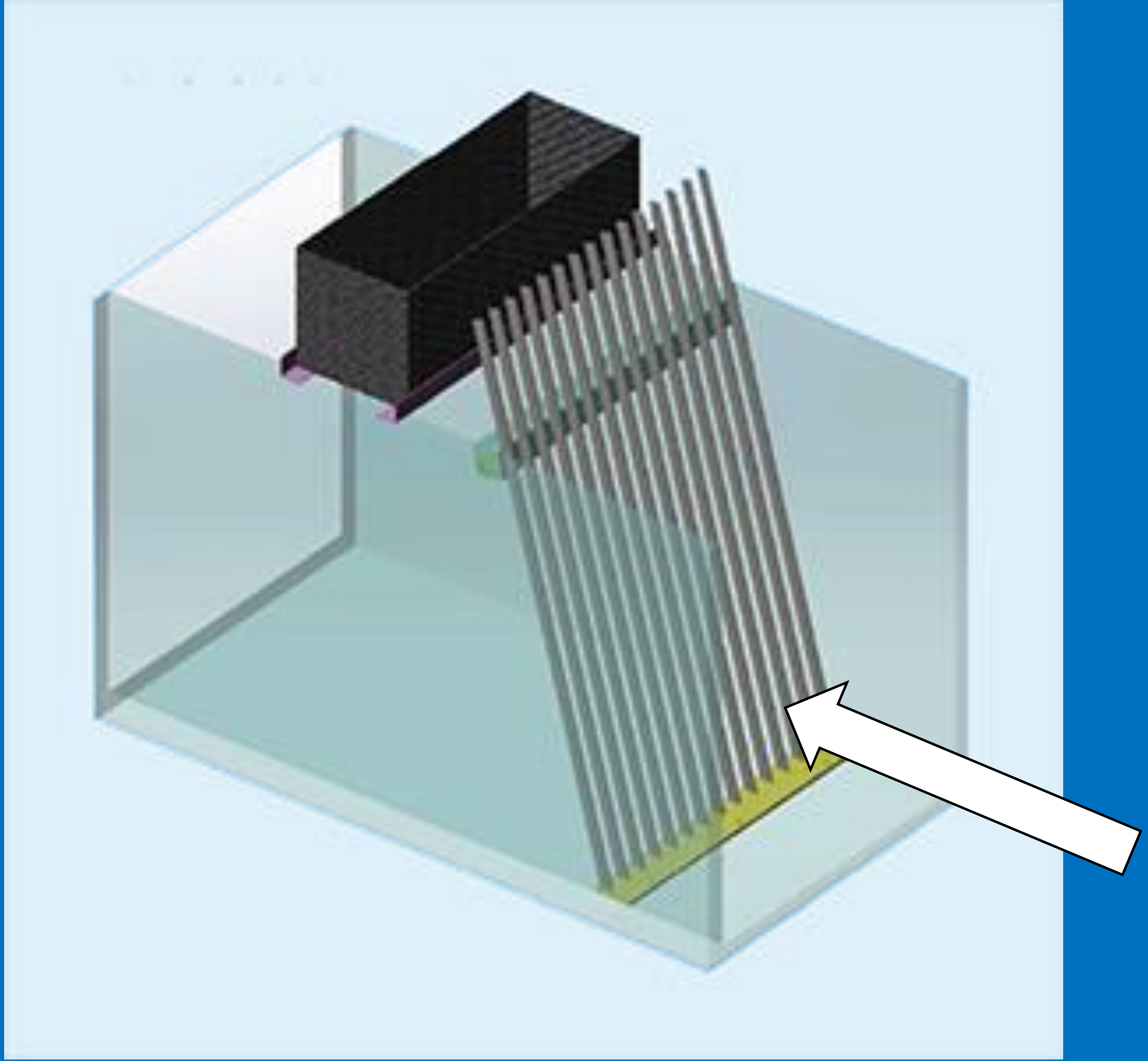
Velocity 0.2 to 1.0 m/s

# Secondary Screen

Clear opening: 12 mm max.

Slope 30 to 45$^{o}$ to the vertical





Coarse Screen

Fine Screen

The raw sewage passes through bar screens to remove large solids (rags, plastic, etc)

# How Screen Work


Screened residue

# Grit Removal

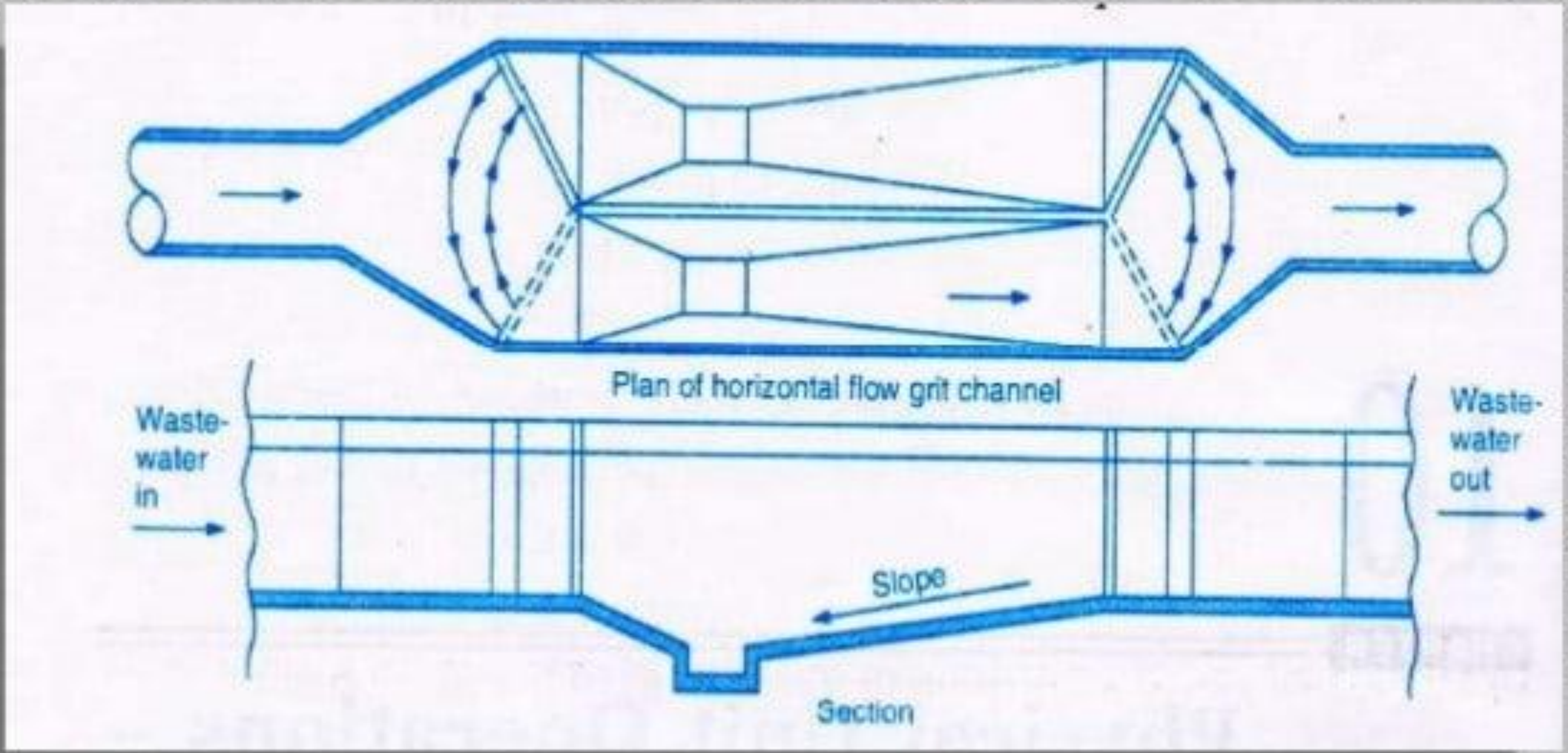
- removes grit (e.g. sand particles, broken glasses, metals etc.)
- removed due to abrasive action on impellers of pumps
- removed in grit chambers
- either horizontal velocity grit chamber or aerated grit chamber

# Grit Chamber

C. Ophardt c. 1999

Next the sewage moves to the grit tanks. These tanks reduce the velocity of the sewage so that heavy particles may fall to the bottom. The solids are pumped to an auger pump which separates the water from the grit while the water moves onward. The grit (mostly inorganic) goes to a dumpster which is then taken to a landfill.

# Horizontal Flow Grit Chamber



# Oil and Grease Removal

O & G disturb biological process

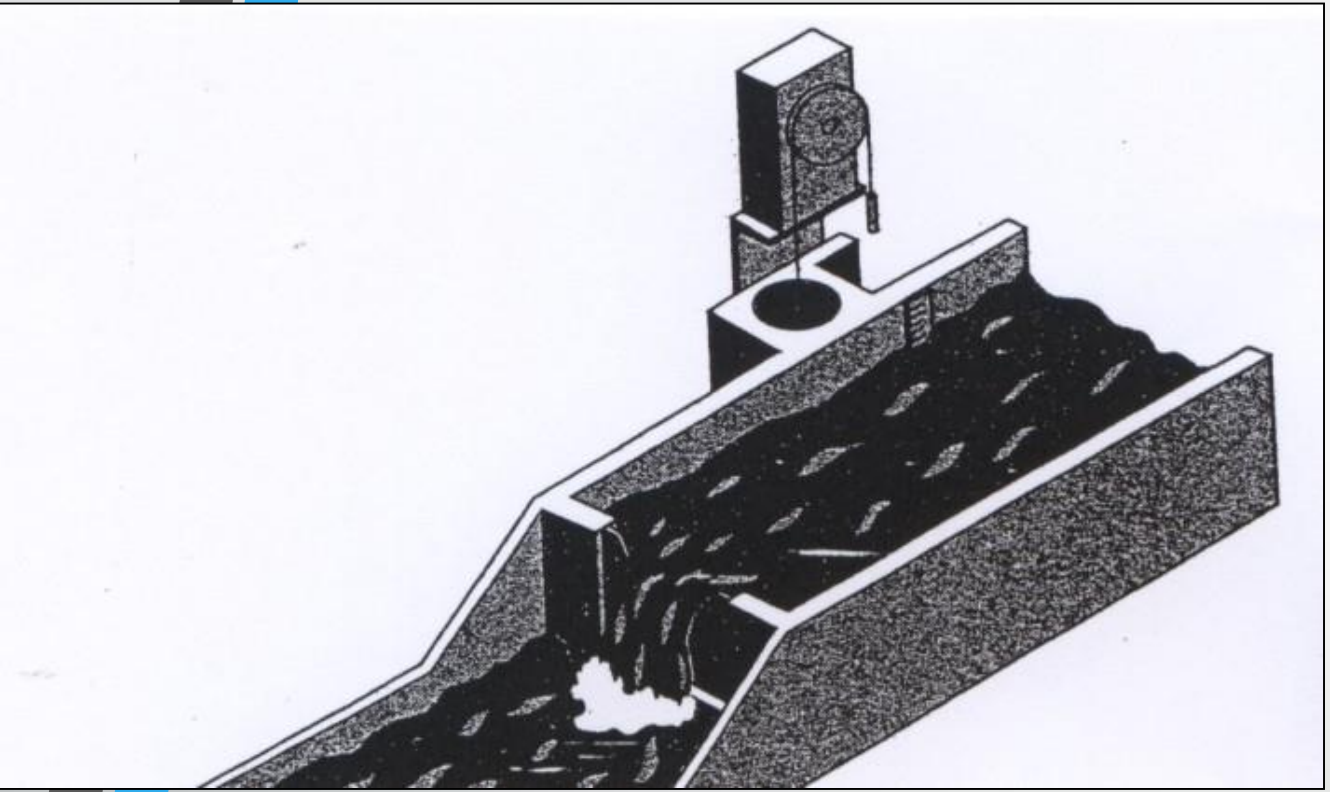
Removed by floatation (skimming)

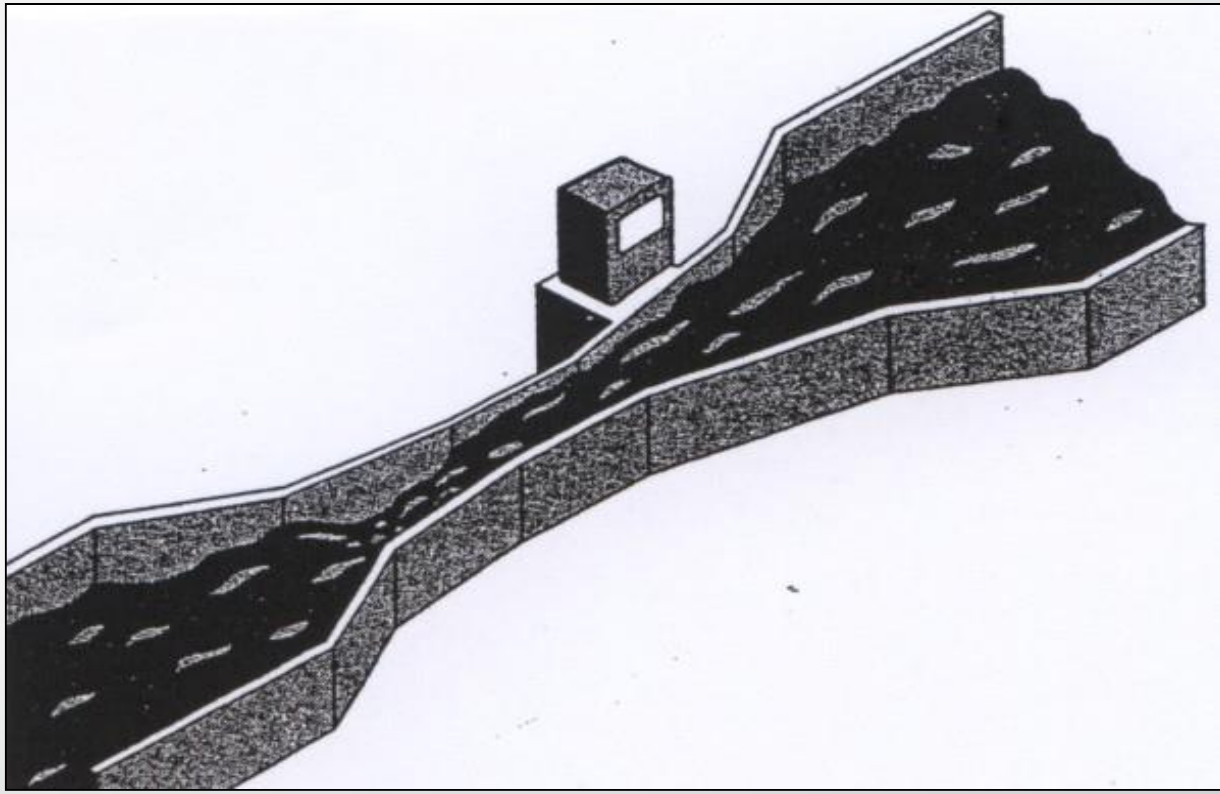
# Balancing or Equalization Tank

- required to even-out flow and load so that steady-state conditions can be attained in the downstream unit processes
- Designed hydraulic retention time of 1.5 hours at peak flow
- located downstream of screens and grit chambers to avoid settling in tanks
- tanks completely mixed and aerated to avoid septic conditions

# Flow Measurement

- Open channel flow is flow in any channel in which the liquid flows with a free surface. E.g. rivers, canals, flumes, storm and sanitary sewer systems, sewage treatment plants.
- The most commonly used technique of measuring the rate of flow in an open channel is hydraulic structures (known as primary measuring devices).
- Two categories of primary measuring devices:
  - weirs and flumes.

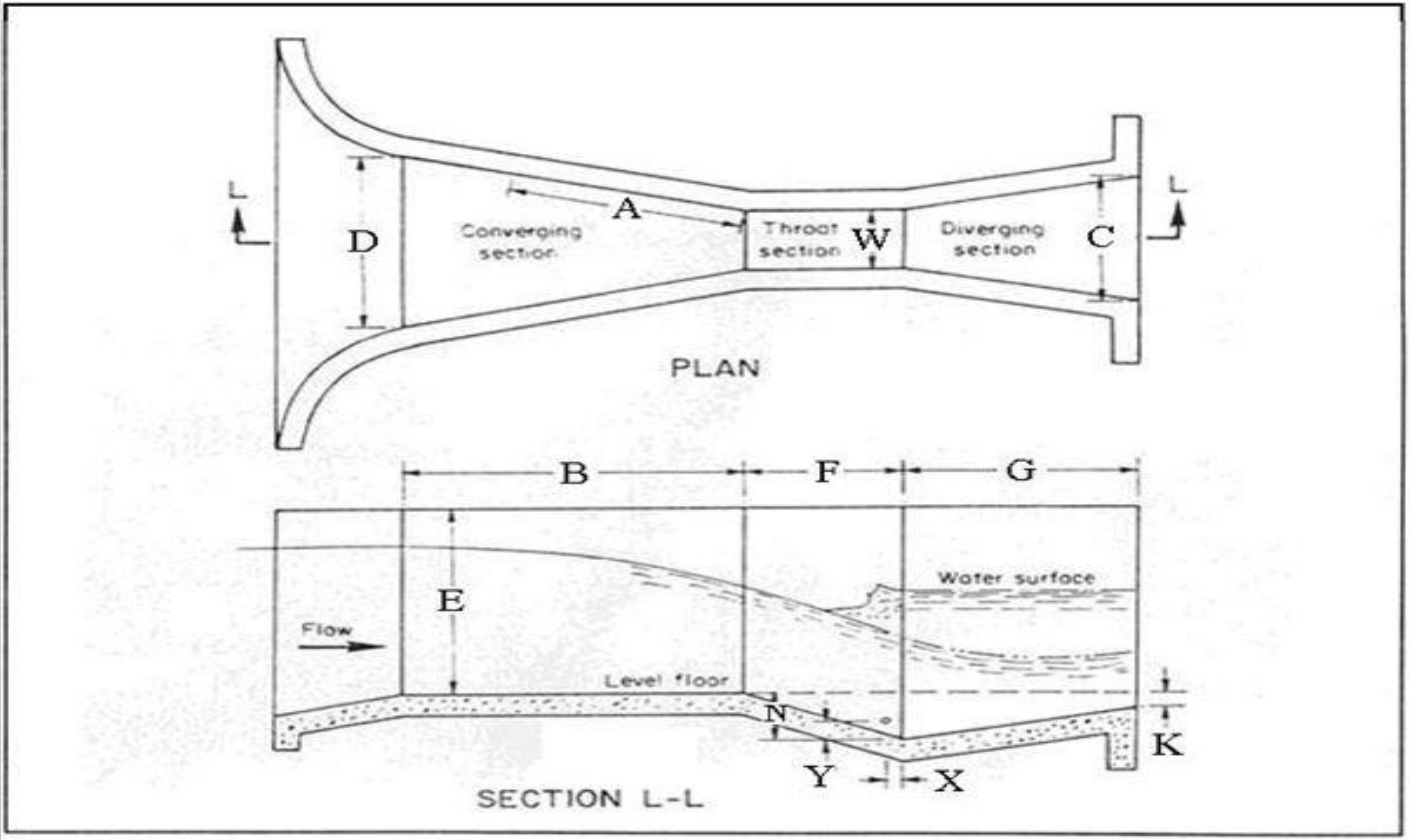




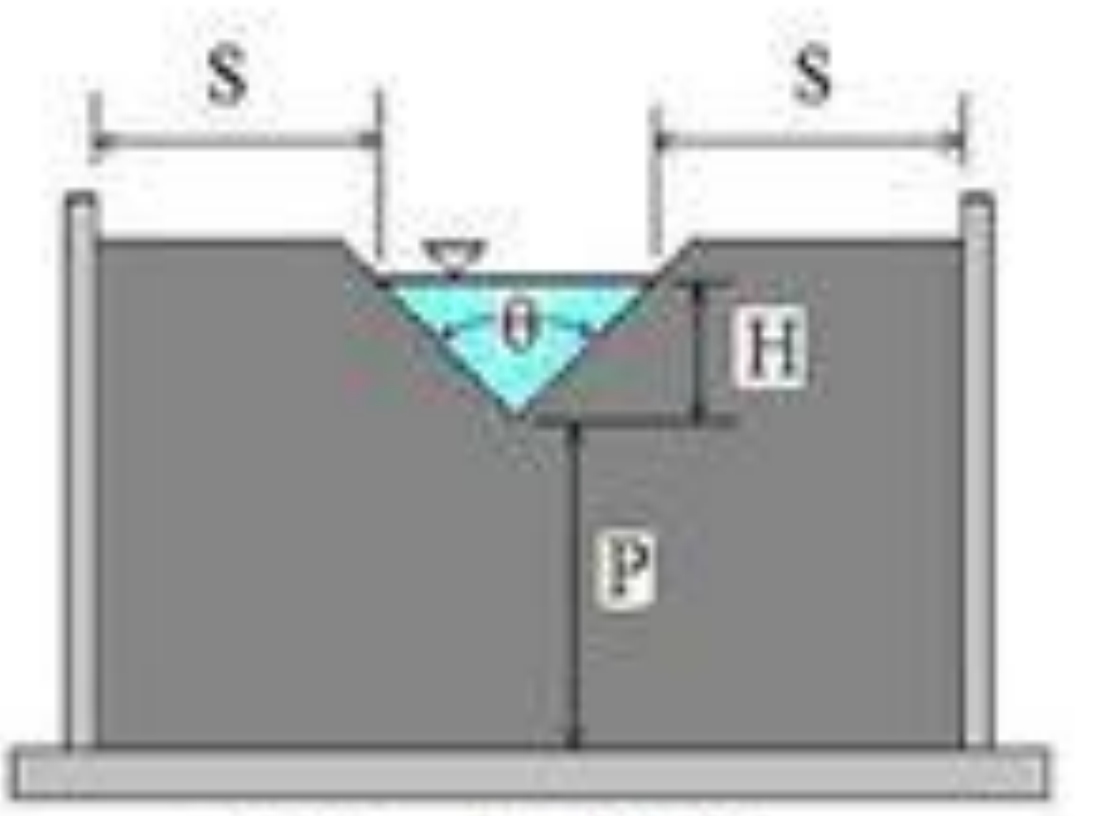
Weir

Flume

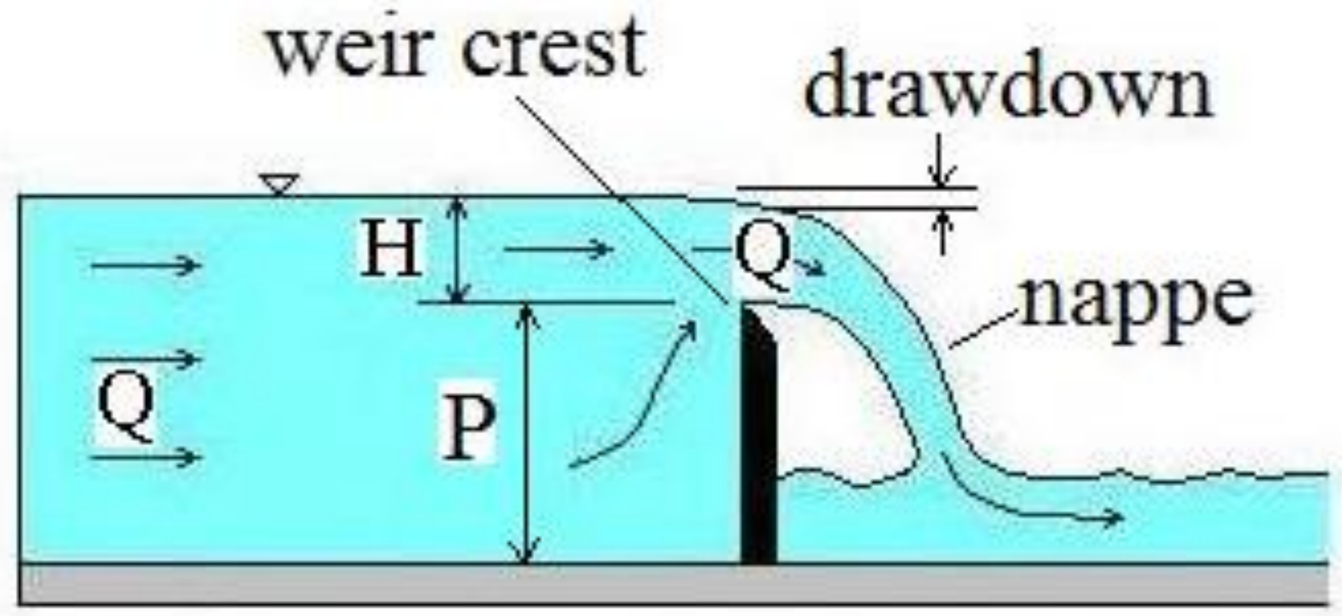
# Parshall Flume




Plan and Sectional Views of a Parshall Flume

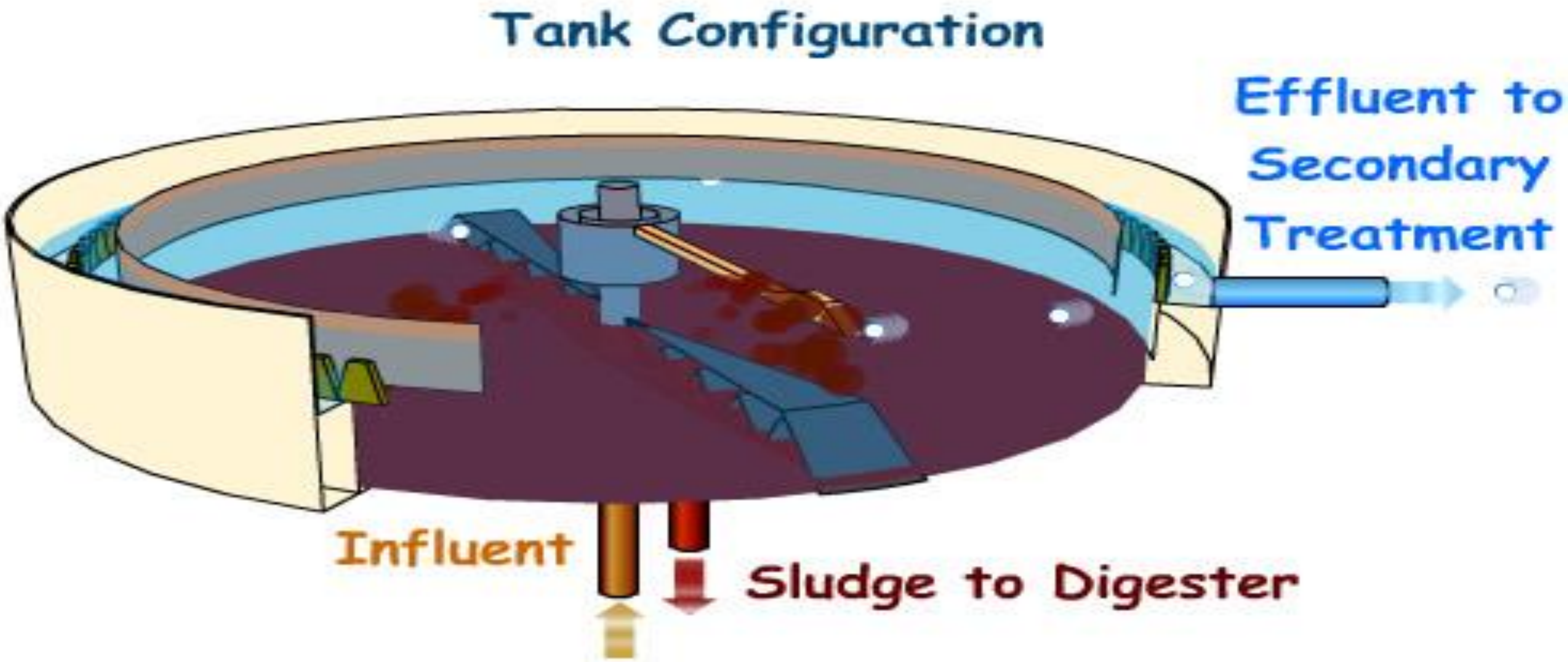
V Notch Weir



Flow Over a Sharp Crested Weir

# ② Primary treatment

- Consists of primary sedimentation (or settling) tank or clarifier.
- reduce organic loading to secondary treatment units
- remove 30% to 40% BOD
- remove 60% to 70% SS
- tanks either rectangular or circular in shape
- sludge removal mechanism required in tanks

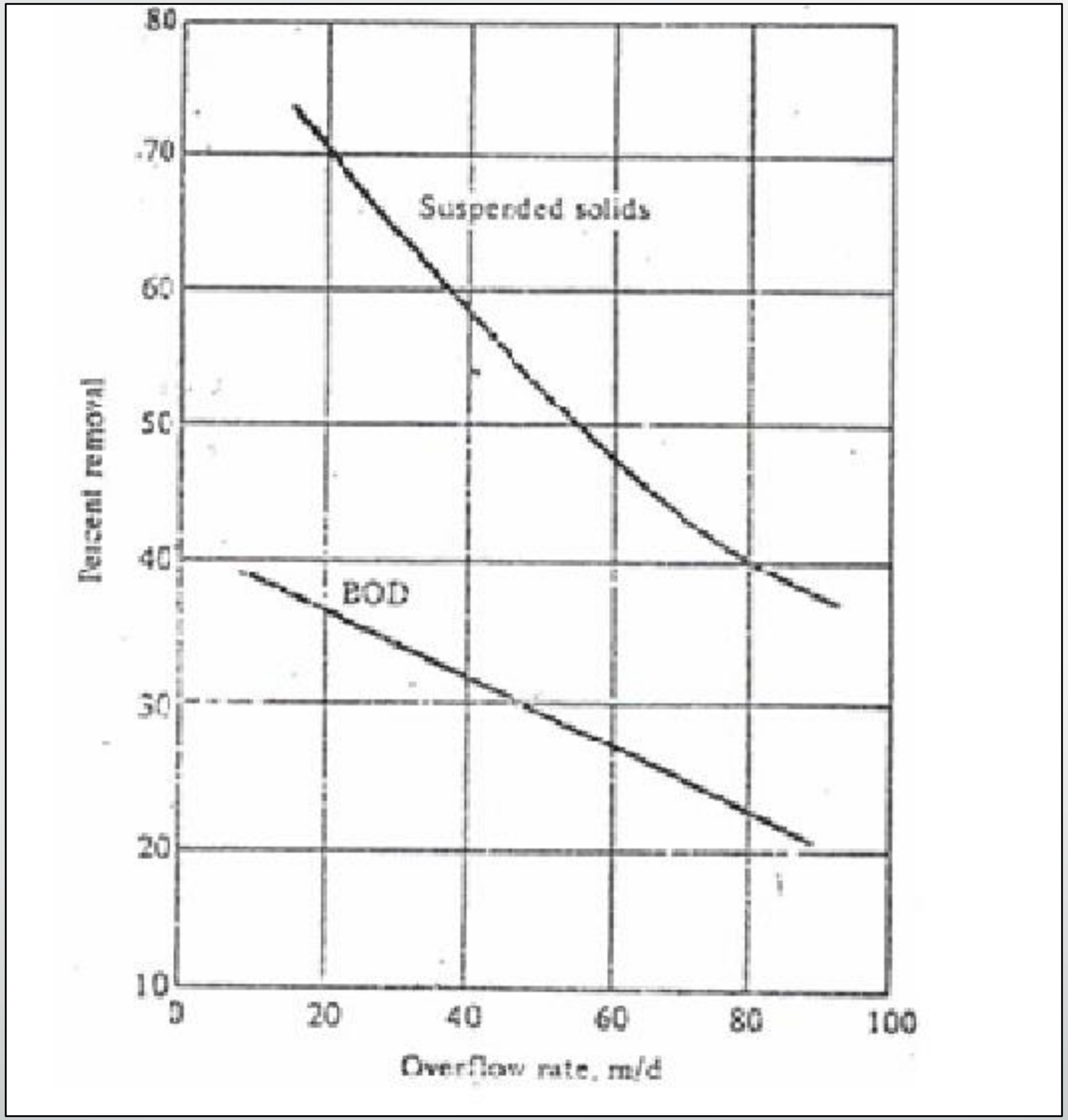

Tank Configuration
Effluent to Secondary Treatment
Influent
Sludge to Digester


Weirs provide uniformed removal of clarifier effluent from the surface of the **tank**

# DESIGN PARAMETERS:

- Detention time (HRT) at $Q_{peak}$ = 2 hr (min)
- Surface overflow rate ($v_o$) at $Q_{peak}$ :
  - Circular : 45 $m^3/m^2$.d (max)
  - Rectangular : 30 $m^3/m^2$.d (max)
- Weir loading at $Q_{peak}$ :
  - 100 $m^3/m$.d (min)
  - 200 $m^3/m$.d (max)

- **Overflow rate** is an empirical parameter describing the settling characteristics of solids in wastewater.
- **Overflow rate** is defined as the volume of water flow per unit of time divided by the **surface** area of the settling **basin**.




**Relationship between over flow rate and efficiency of primary sedimentation tanks**

# DESIGN PARAMETERS (CONT' ):

- Rectangular tanks
  - Length : width ratio equal to or greater than 3:1
  - Side water depth 2.5 m to 3.0 m
- Circular tanks
  - diameter not more than 50 m
  - side water depth more than 3.0 m

## Surface overflow rate:

$$v_o = Q/A$$

Where

$v_o$ = surface overflow rate, $m^3/m^2.day$

$Q$ = average daily flow, $m^3/day$

$A$ = total surface area of tank, $m^2$

Weir loading = Q / weir length

## HRT:

$$t = 24\,(\forall / Q)$$

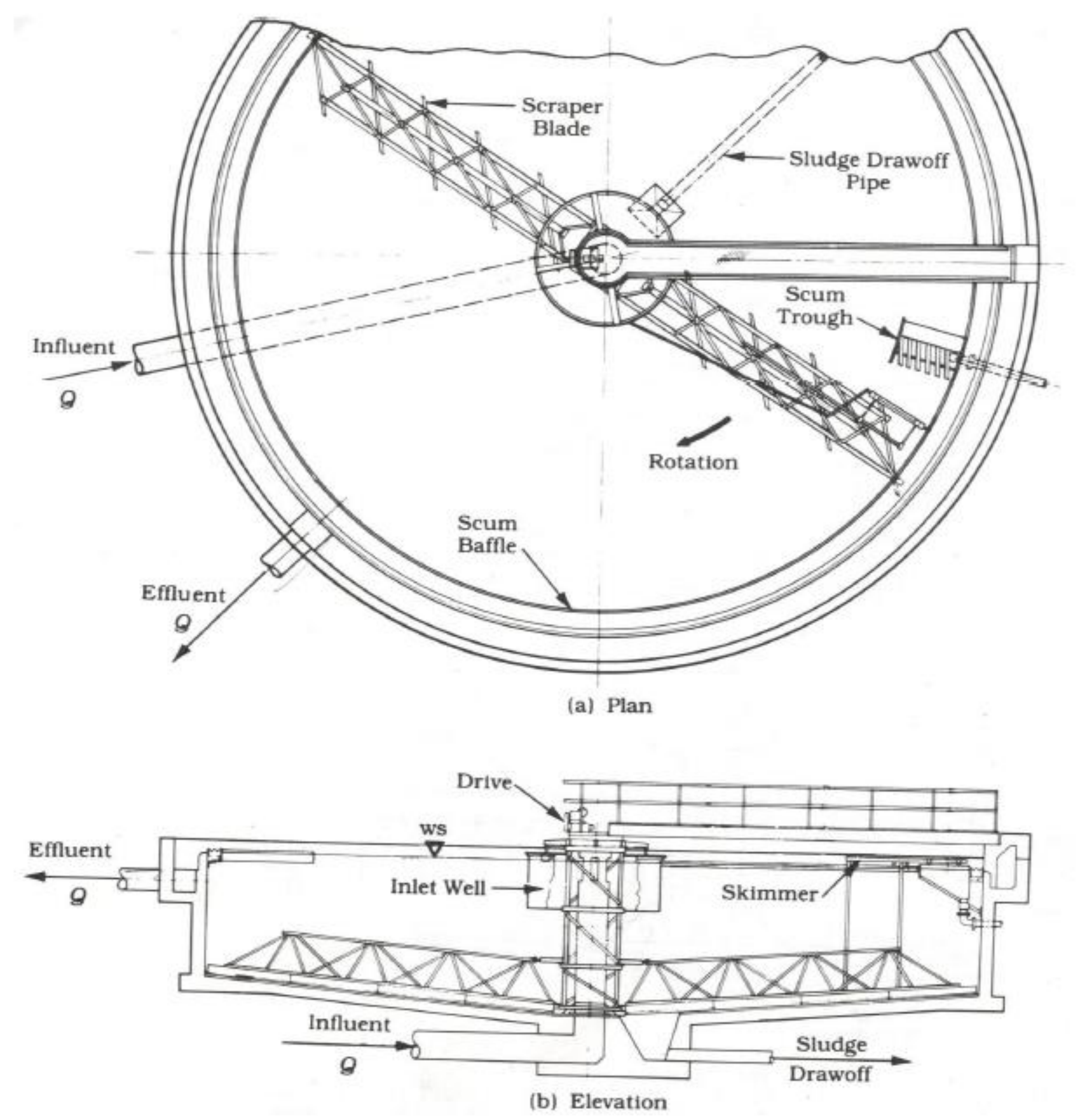
Where

$t$ = detention time, hours

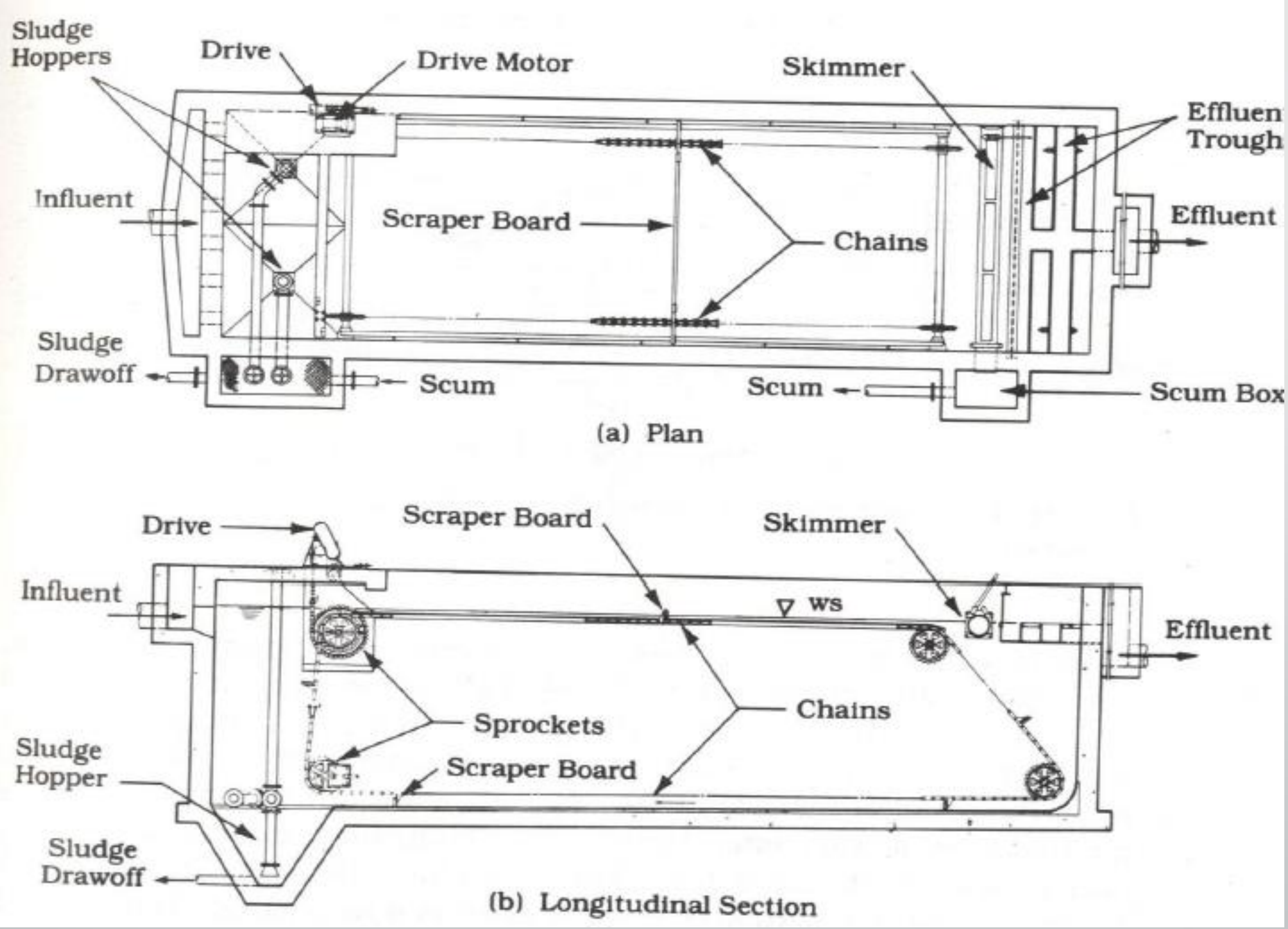
$\forall$ = tank volume, $m^3$

$Q$ = average daily flow, $m^3/day$

# Circular sedimentation tank



# Rectangular sedimentation tank



# EXAMPLE:

Two primary settling tanks are 29 m in diameter with a 3.0 m side water depth. Single effluent weirs are located on the peripheries of the tanks. For an average design flow of 32000 $m^3$/d and peak flow of 58000 $m^3$/d, calculate the overflow rate, detention time, and weir loadings.

# Solution:

Calculating surface area and volume:

Surface area = $2\pi r^2 = 2 \times 3.14 \times (29/2)^2$

$= 1320\ m^2$

Volume $= 1320 \times 3.0 = 3960\ m^3$

At design flow:

Overflow rate, $v_o = 32000/1320 = 24.2\ m^3/m^2.d$

HRT = (3960/32000)24 = 2.97 hr

At peak flow:

Overflow rate, $v_o = 58000/1320 = 44.0\ m^3/m^2.d$

HRT = (3960/58000)24 = 1.64 hr

Weir length = circumference of both tanks

= $2\pi d$

<u>At design flow:</u>

Weir loading = $32000/(2\pi \times 29)$

= 175.6 $m^3/m.d$

<u>At peak flow:</u>

Weir loading = $58000/(2\pi \times 29)$

= 318.3 $m^3/m.d$

# ③ Secondary treatment

Principles of Aerobic Biological Treatment:

Organic Matter [Food] + Oxygen + Biomass [Microorganisms]

→ [$CO_2$ + $H_2O$ + $NH_3$ + $NO_3$ + $SO_4$ ] + sludge

# TYPES OF BIOLOGICAL PROCESS

## Suspended Growth

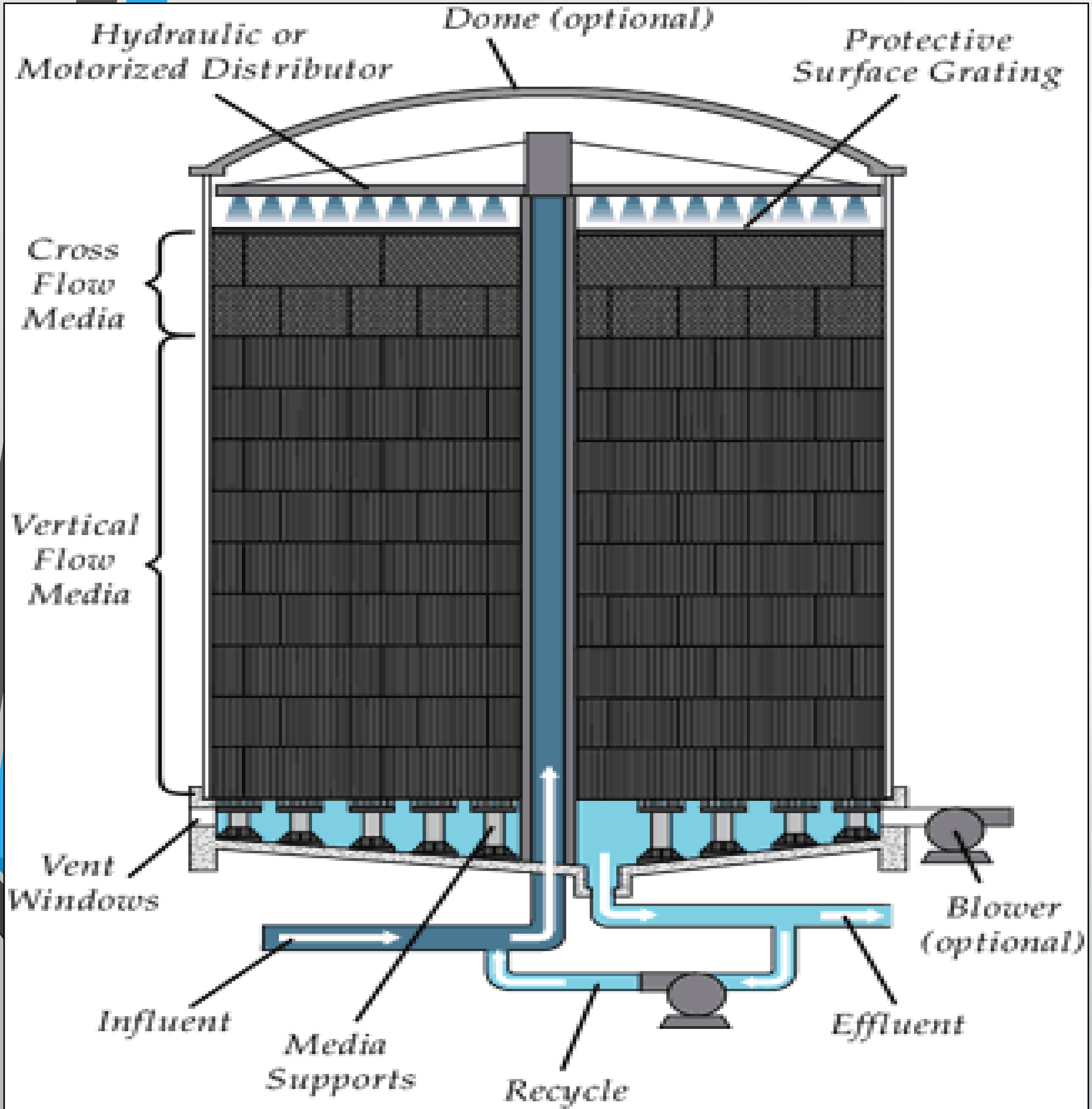
- Microorganisms present and reproduce in suspension
- e.g. activated sludge, aerated lagoon

## Attached Growth (or Fixed-film)

- Microorganisms present and reproduce on media surface
- e.g. trickling filter

In a **suspended-growth system**, the waste flows around and through the free-floating microorganisms, gathering into biological flocs that settle out of the wastewater. The settled flocs retain the **microorganisms**, meaning they can be recycled for further treatment. (e.g. Activated Sludge)

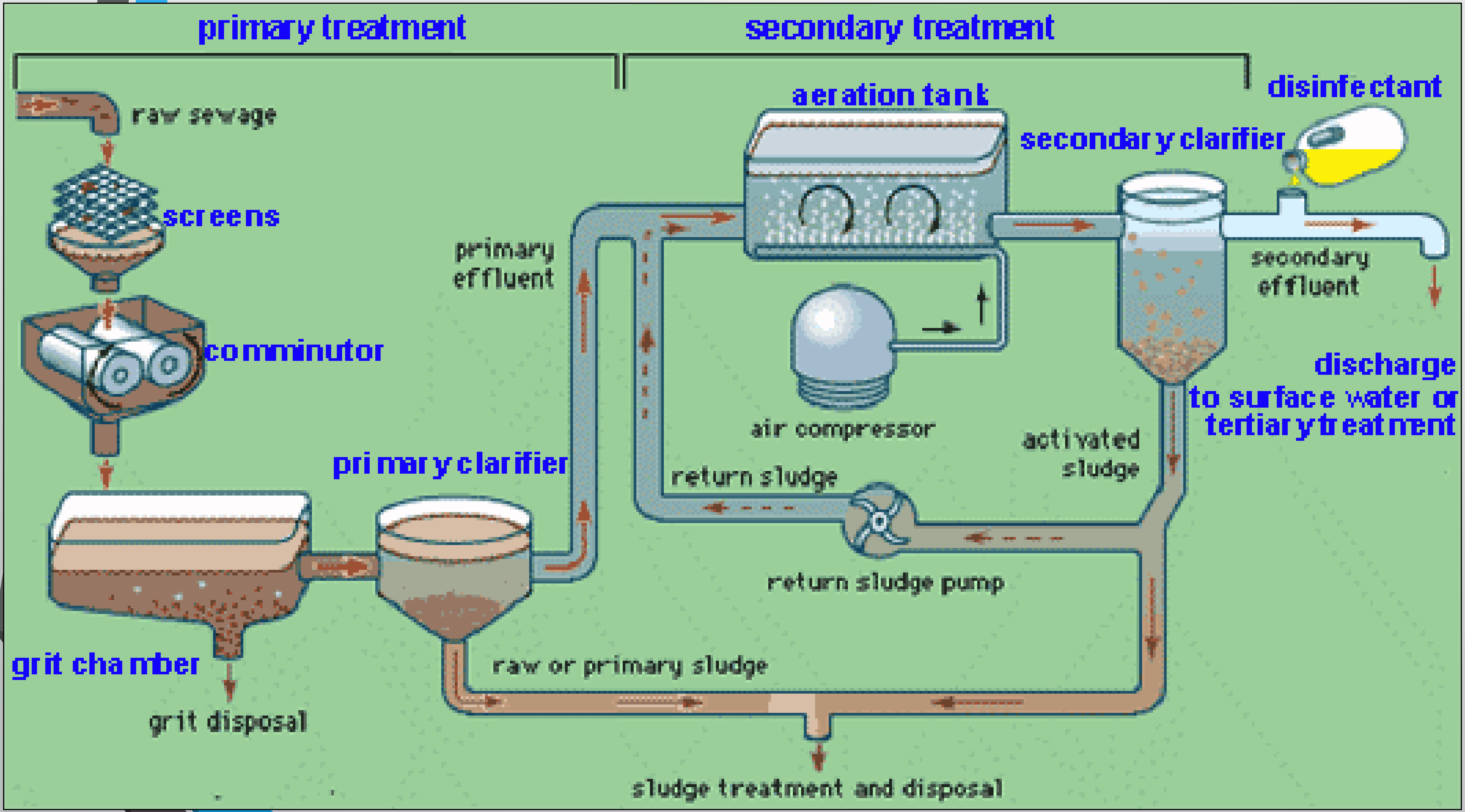
# Suspended growth




# Attached growth

# Secondary Sedimentation / Clarifier

- Removal of solids before final discharge into receiving waters
- Sludge either return to aeration tank or treated before disposal
- Either rectangular or circular in shape
- Surface overflow rate less than 30 $m^3/m^2$.day
- Hydraulic Retention Time (HRT) : minimum 2 hours at peak flow


primary treatment
secondary treatment
raw sewage
screens
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grit chamber
grit disposal
primary clarifier
primary effluent
aeration tank
air compressor
return sludge
return sludge pump
activated sludge
secondary clarifier
disinfectant
secondary effluent
discharge to surface water or tertiary treatment
raw or primary sludge
sludge treatment and disposal

# DISINFECTION

- Destruction of disease causing organisms in sewage effluent
- Required where discharge have a detrimental effect on receiving water
- Chlorination most common  (others include ultra-violet, ozonation)
- Operational skill required
- Chlorination chamber required


THANK YOU FOR YOUR ATTENTION
FINALLY OVER!
quickmeme.com