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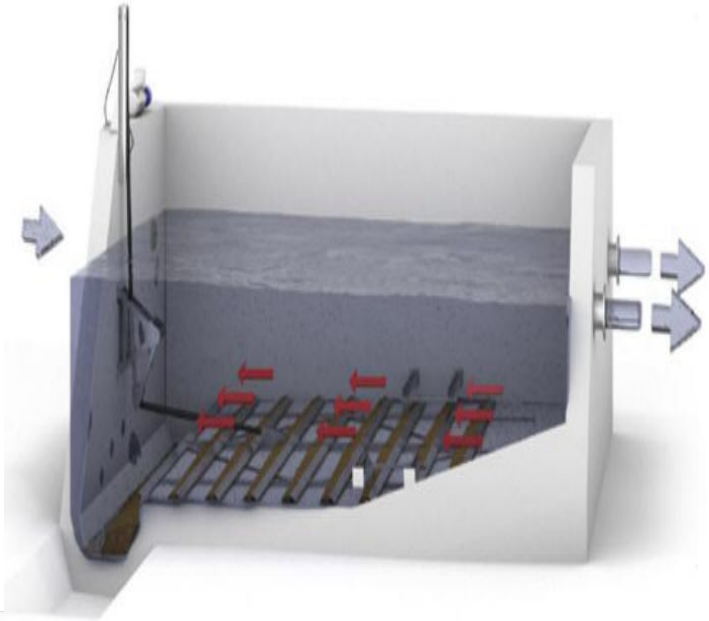
SEDIMENTATION

Wastewater Treatment Technology- course
Faculty of Environmental Engineering, Wroclaw University of Science and Technology

WROCŁAW, 2025



Plan prezentacji

1. Theory
2. Settlers

Theory

Theory

Depending on the nature and concentration of suspended solids, three types of sedimentation are distinguished:

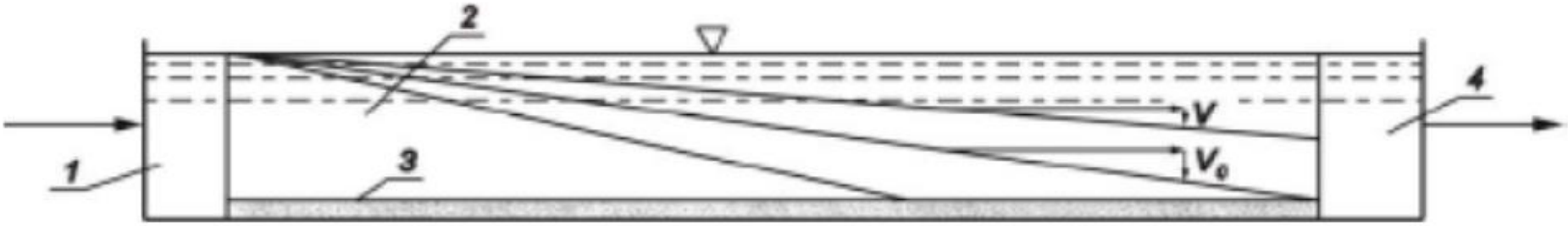
- discrete particle sedimentation (of granular suspensions),
- flocculent sedimentation,
- zone (or hindered) sedimentation.

Theory

Discrete particle sedimentation (of granular suspensions)

- Discrete particles
- Relatively low concentrations
- No changes in size, shape, or density

do not change: shape, size, or density → constant settling velocity



1 – inlet, 2 – sedimentation zone, 3 – sludge zone, 4 - outlet

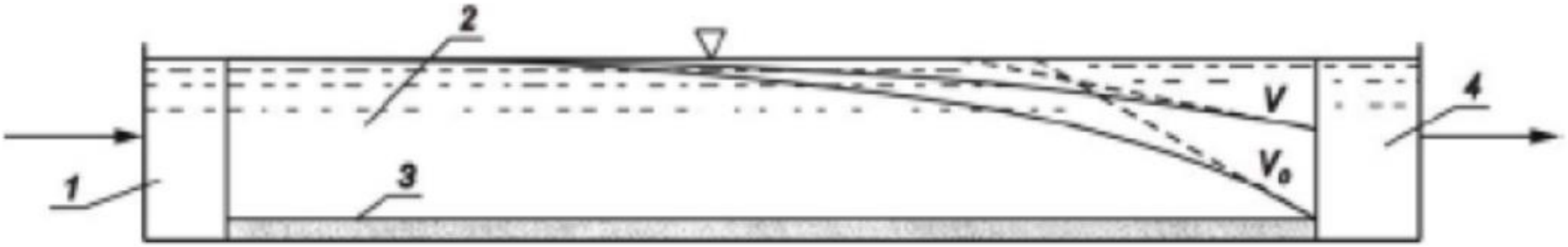
Theory

Flocculent sedimentation

- Common in municipal wastewater
- Particles settle at different velocities and agglomerate upon collisions

Particle agglomeration – flocculation

depends on the contact opportunity, which varies with:
- depth of the sedimentation tank
- flow velocity
- velocity gradient
- concentration of suspended solids
- particle size

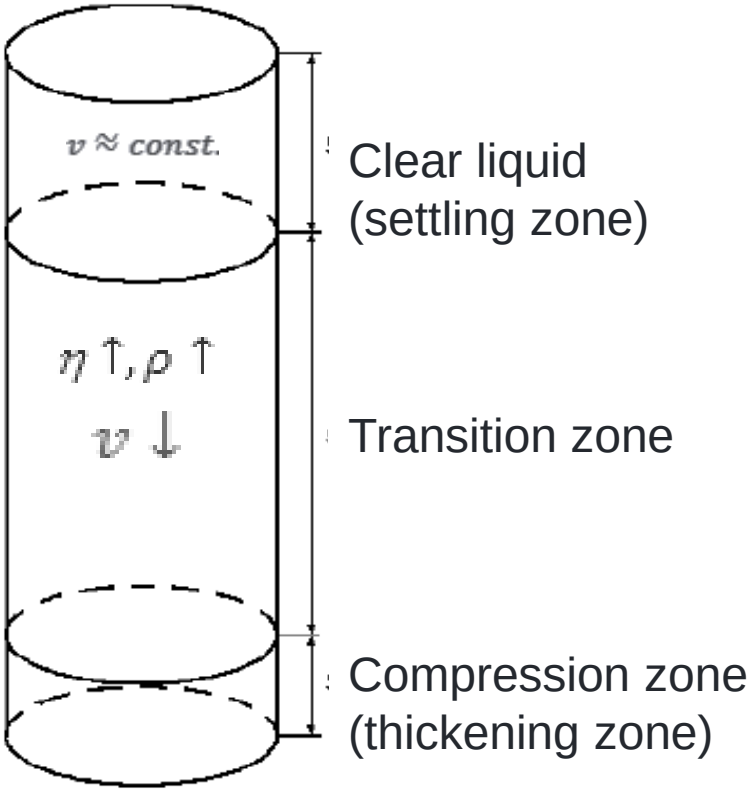


1 – inlet, 2 – sedimentation zone, 3 – sludge zone, 4 - outlet

Theory

Zone (or hindered) sedimentation

- High concentrations
- Flocs stick together
- A distinct sludge layer is formed



Settlers

Settlers

Separation of easily settling suspensions with a density greater than 1 g/cm³.

After coagulation: also poorly settling suspensions and colloidal compounds.

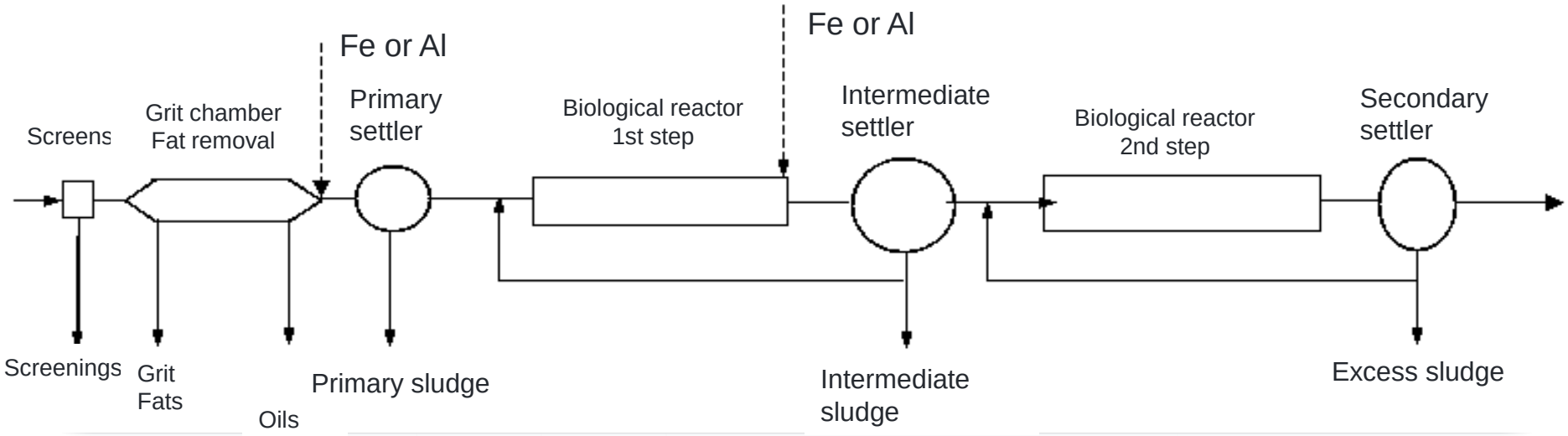
Partially possible removal of floating substances with a density lower than 1 g/cm³ in the process of natural – gravitational – flotation.

Operation: slowed flow, thanks to which, through the use of gravity, the separation of the liquid and solid phases occurs.

Settlers

Classification of settling tanks based on their position in the treatment plant process line:

- primary,
- intermediate (very rarely used),
- secondary (final).



Settlers

Primary settlers

Main functions:

- removal of 60–70% of total suspended solids from wastewater,
- removal of approx. 30% of the BOD_5 load,
- production of primary sludge – for methanogenic fermentation,
- production of primary sludge – for acidogenic fermentation,
- relief of the biological treatment unit,
- removal of fats and oils,
- partial equalization of flow and pollutant loads before the biological treatment stage.

Settlers

Secondary settlers

Main functions:

- Separation of activated sludge from treated wastewater
- Ensuring the appropriate quality of treated wastewater in terms of suspended solids concentration (indirectly nitrogen and phosphorus)

We will not talk about it today

Settlers

Design parameters

- Hydraulic loading rate – HLR
- Hydraulic retention time – HRT
- Solids loading rate – SLR

Settlers

Hydraulic loading rate – HLR

Established by experimental methods or adopted from the literature for all types of sedimentation

$$HLR = \frac{Q}{A}\left(\frac{m^3}{m^2 h} = \frac{m}{h}\right)$$

gdzie:
Q- flow, m^3/h
A – settler's active area, m^2

Settlers

Hydraulic retention time – HRT

The flocculation capacity of suspended solids in wastewater – the better the flocculation, the shorter the required retention time, and vice versa.

Determined experimentally or adopted from literature for all types of sedimentation.

$$\text{HRT} = \frac{V}{Q}\left(\frac{m^3}{m^3 h} = h\right)$$

gdzie:
Q- flow, m^3/h
V – settler's active volume, m^3

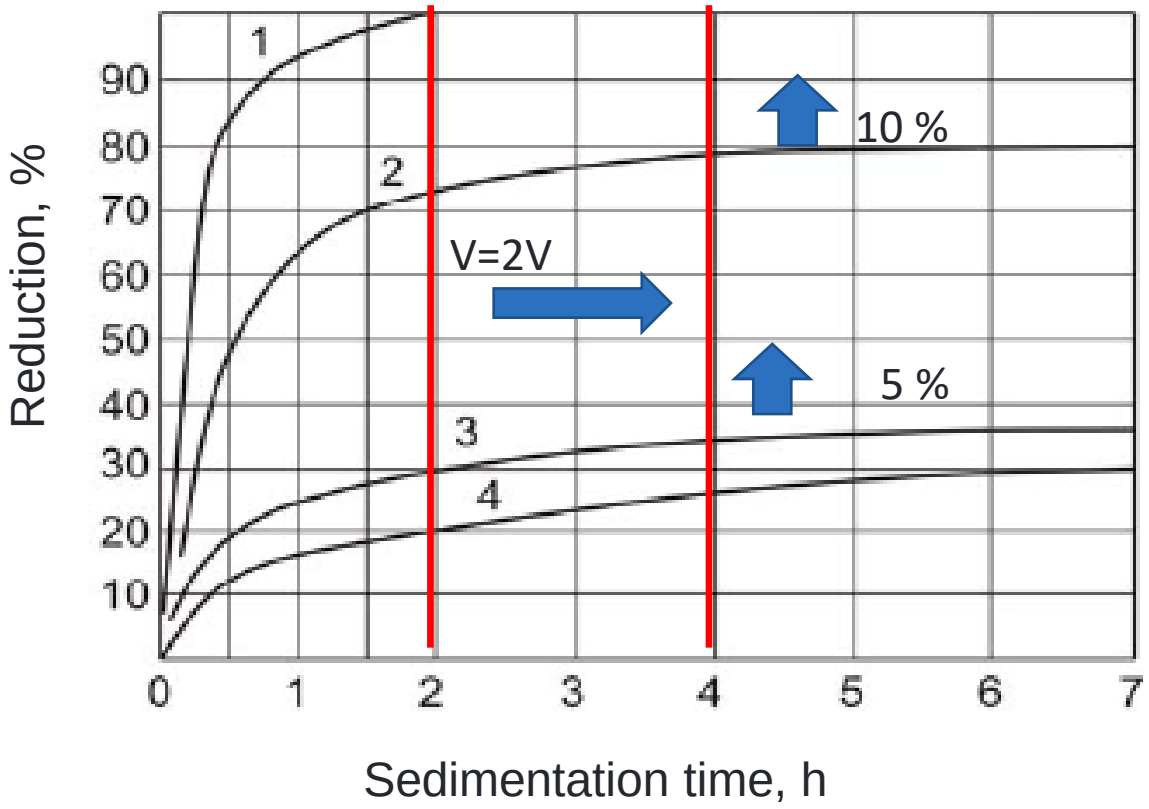
Settlers

HRL and HRT

Type	Hydraulic loading rate (HLR), m/h			HRT, h
	Longitudial	Radial	Vertical	
Primary sedimentation before trickling filters	<1.3	0.8-1.3	<1.3	1.5-2.3
Primary sedimentation before activated sludge	<4.0	2.5-4.0	<3	1.5-2.0

Settlers

Primary – Flow time (retention time) – why 2 hours?



1. Settleable solids
2. Total suspended solids (TSS)
3. BOD (Biochemical Oxygen Demand)
4. Oxidizability

Settlers

Design parameters

Having HLR and HRT we can calculate settler's active area and active volume

Active area:

$$A = \frac{Q}{HLR}, \text{ m}$$

where:

A – active area, m^2,

Q – flow, m^3/h,

HLR – hydraulic loading rate, m^3/m^2h.

Active volume:

$$HRT = \frac{V}{Q}, \text{ m}$$

$$V = Q \cdot HRT, \text{ m}$$

where:

V – active volume, m^3,

Q – flow, m^3/h,

HRT – hydraulic retention time, h.

Settlers

Design parameters

SLR– solids loading rate.

This is the suspended solids load in g/h per unit area in m².

$$SLR = \frac{L}{A}\ g/h \cdot m^2$$

$$L = Q \cdot C\ g/h$$

where:

SLR– suspended solids surface loading, in g/h·m²,

L – suspended solids load, in g/h,

A – surface area of the settler, in m²,

Q – flow, in m³/h,

C – concentration of suspended solids, in g/m³.

Settlers

Design solutions

Horizontal settlers

- Longitudinal
- Radial

Vertical settlers

Imhoff settlers

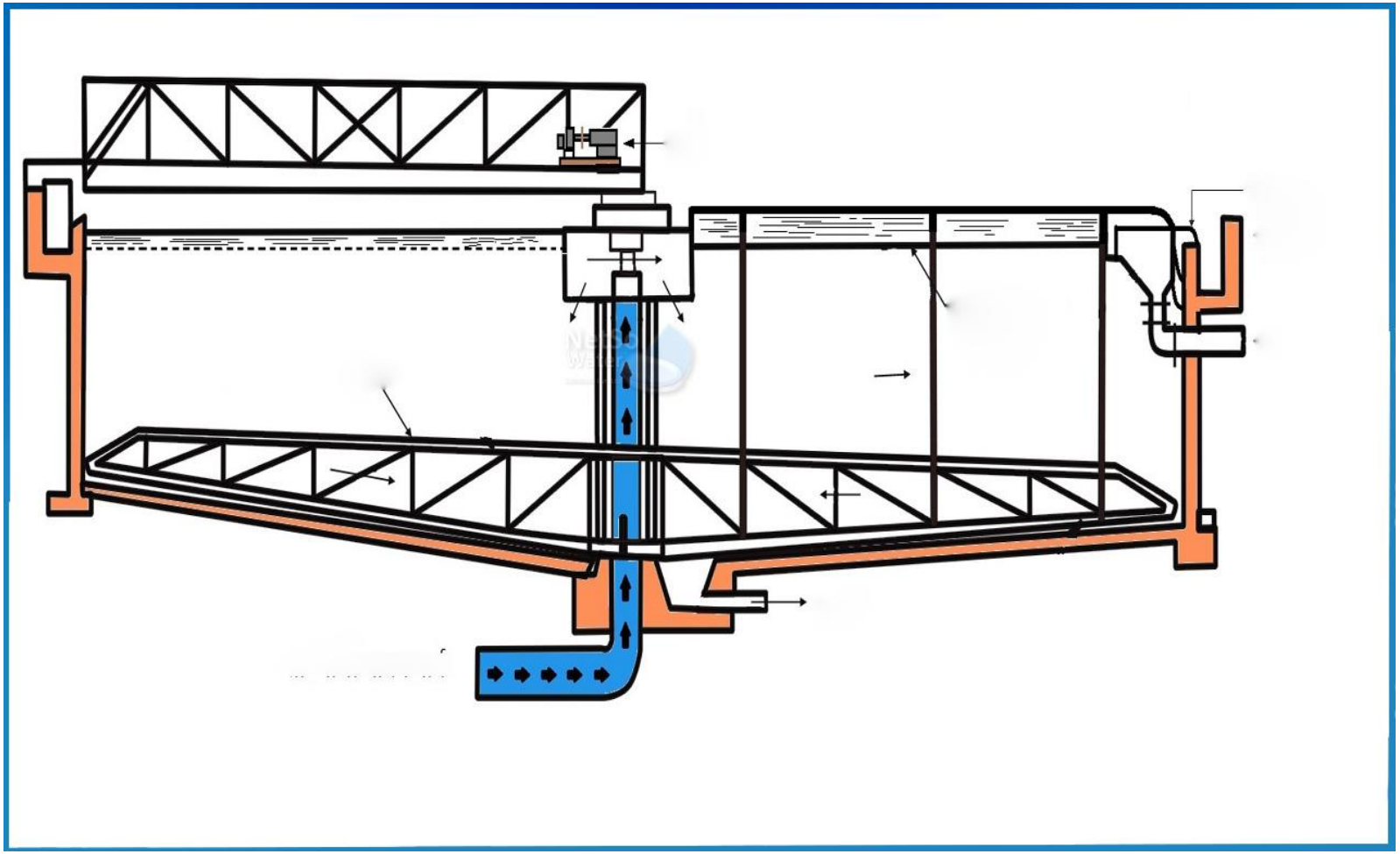
Multi-stream settlers

Settlers

Design solutions – horizontal longitudinal settlers

Settlers

Design solutions – horizontal radial settlers

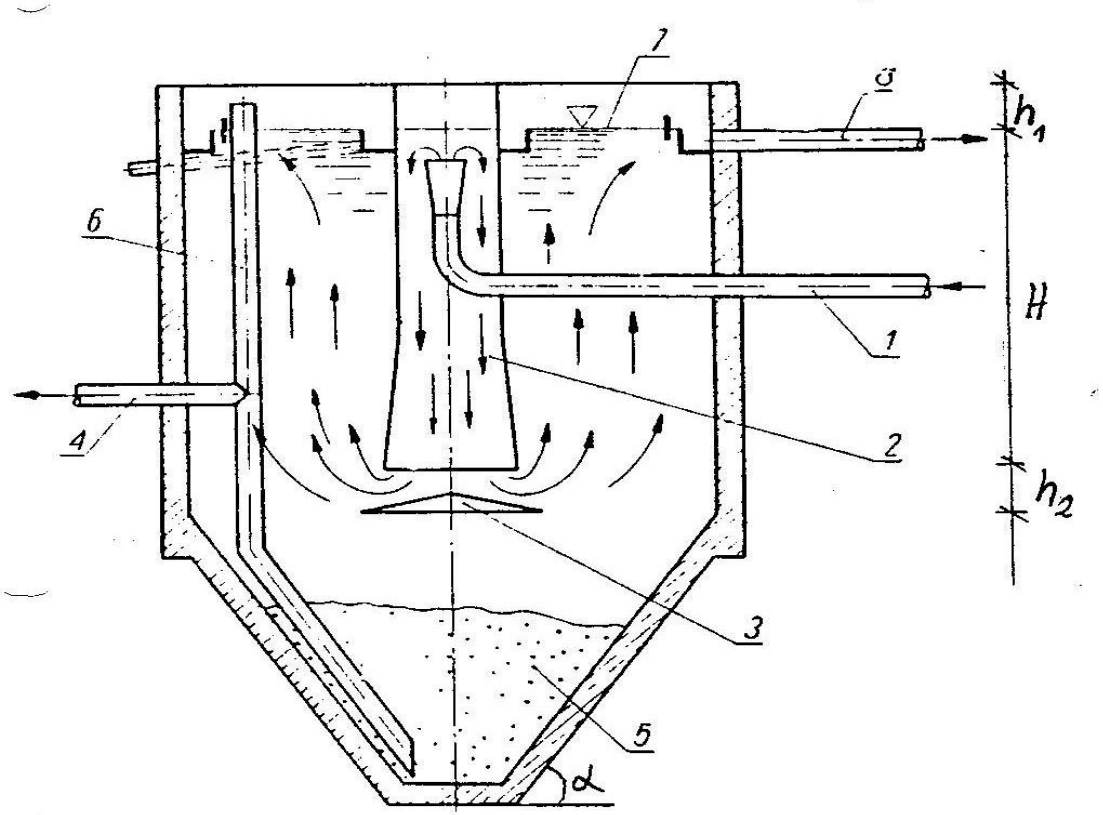


Settlers

Design solutions – horizontal radial settlers

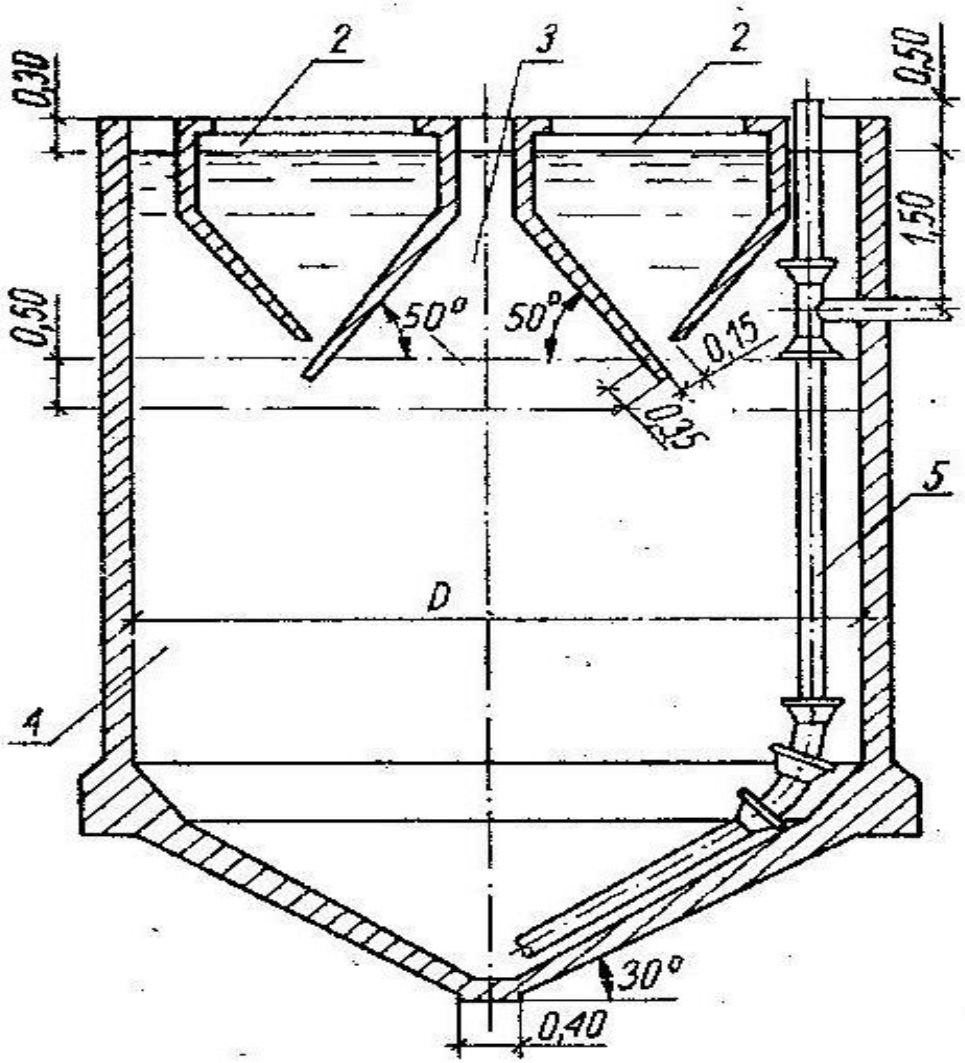
Settlers

Design solutions – vertical settlers



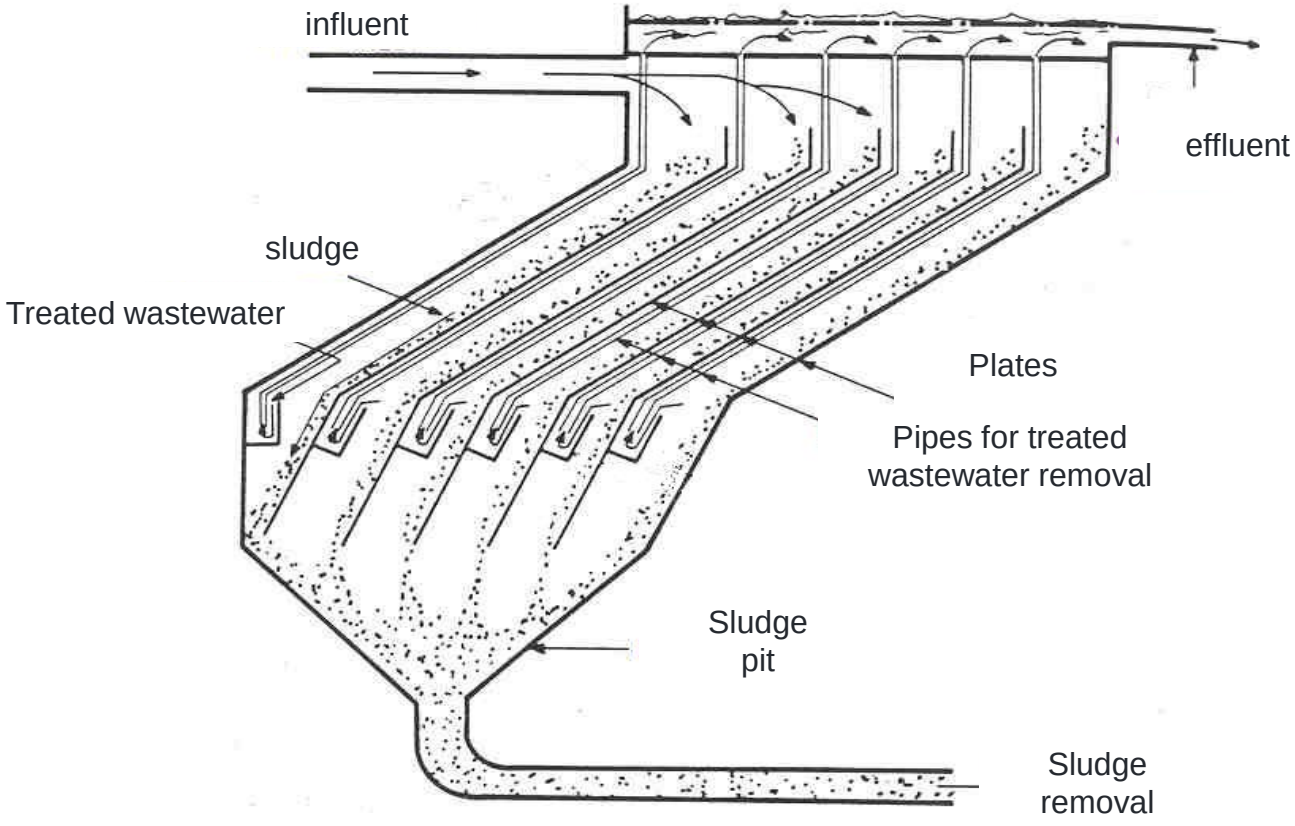
Settlers

Design solutions – Imhoff tanks



Settlers

Design solutions – multi-stream settlers



Settlers

Additional equipment – examples

Inlet to the settler:

- Central chamber
- Inlet baffle
- Flocculator

Wastewater outflow:

- Serrated weirs

Deflectors

Removal of floating parts

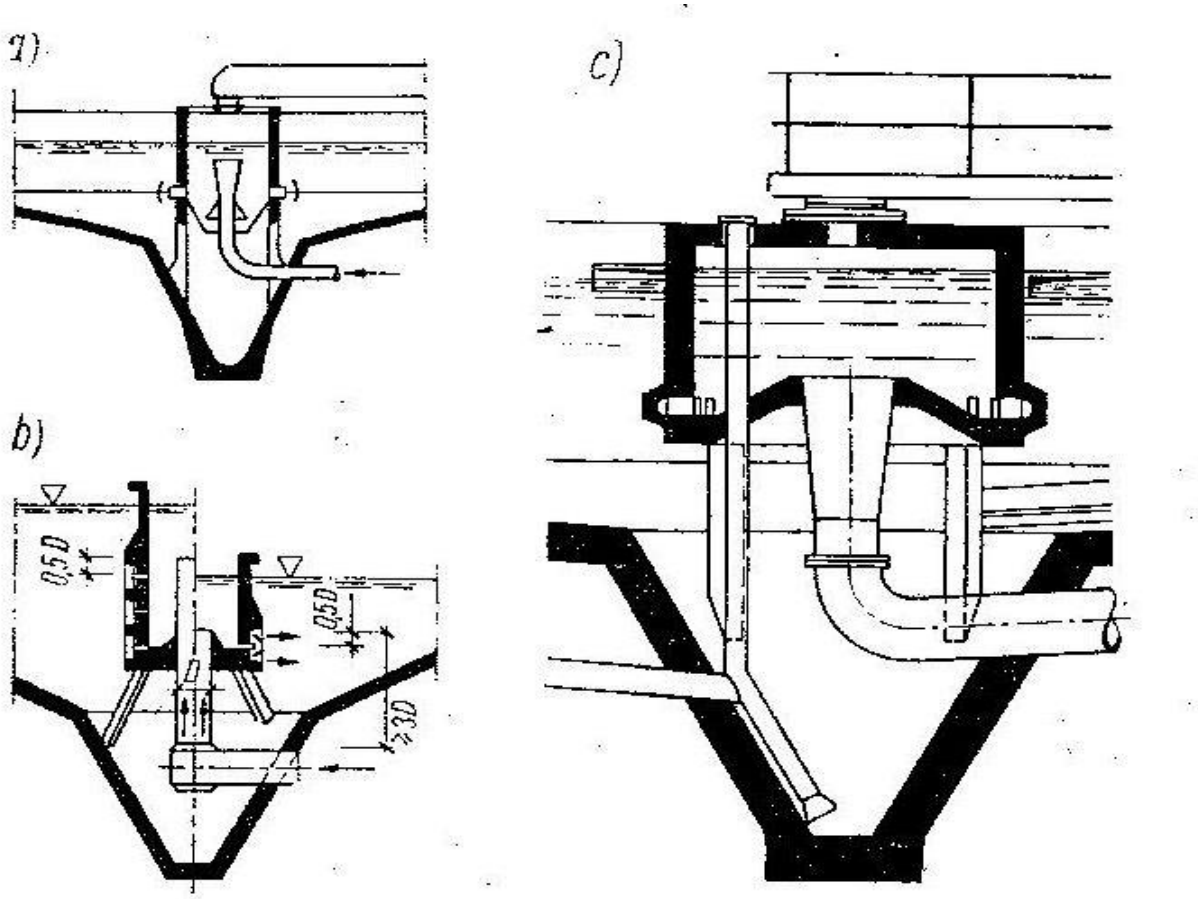
Sludge removal

Sludge scrapers:

- Chain-driven rake scraper
- Torsion scraper
- Multi-arm rake scraper
- Spiral scraper

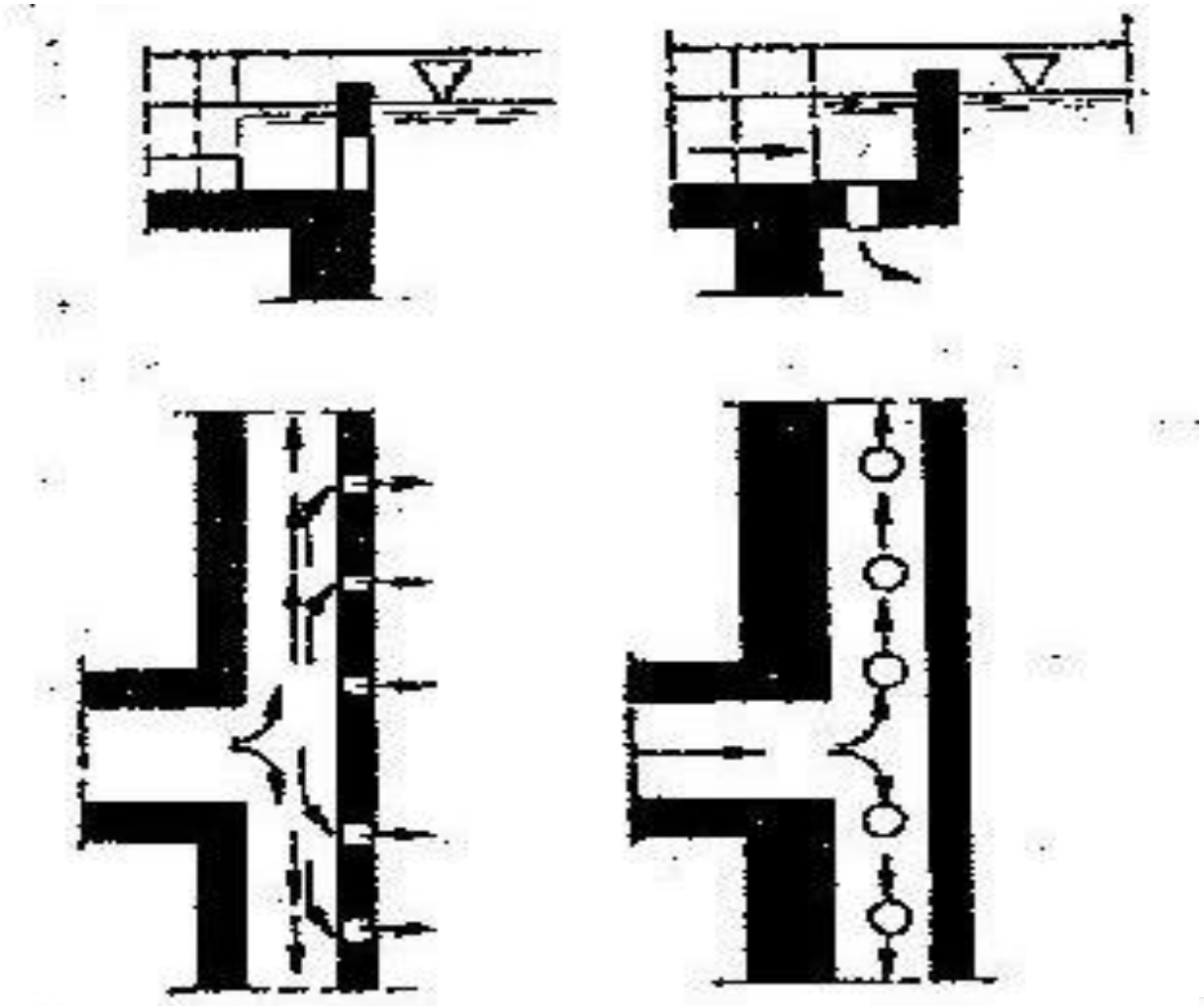
Settlers

Central chamber (radial settlers)



Settlers

Inlet baffle (longitudinal settlers)

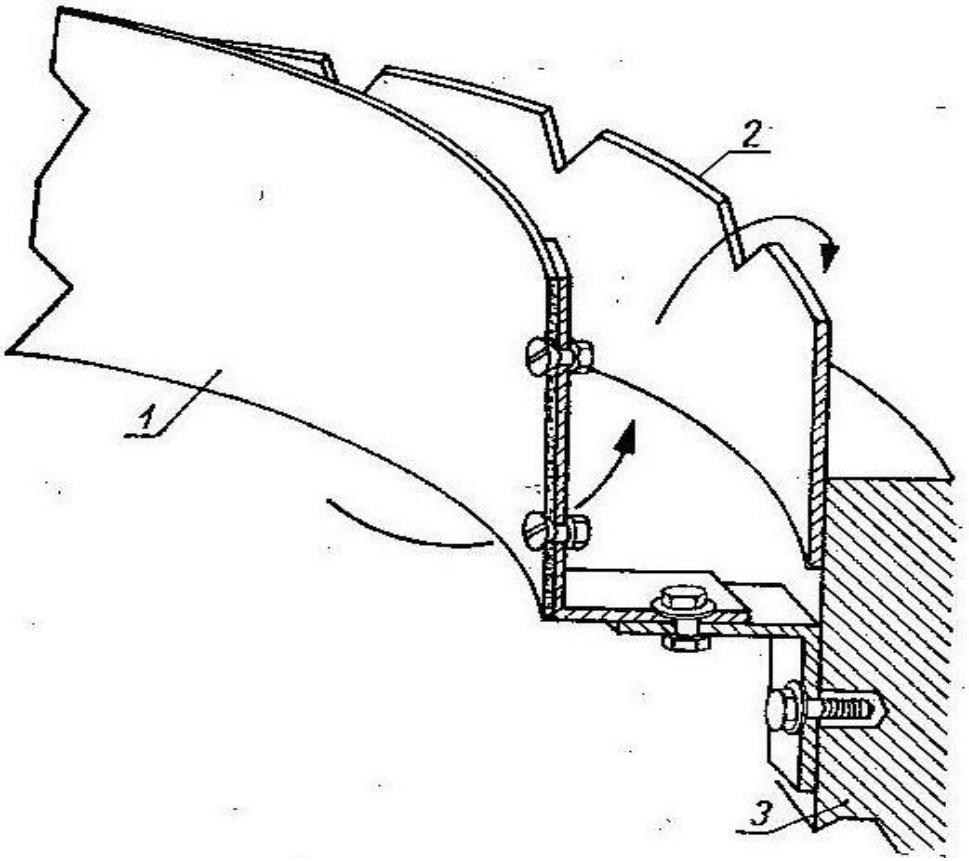


Settlers

Flocculator

Settlers

Sawtooth weirs

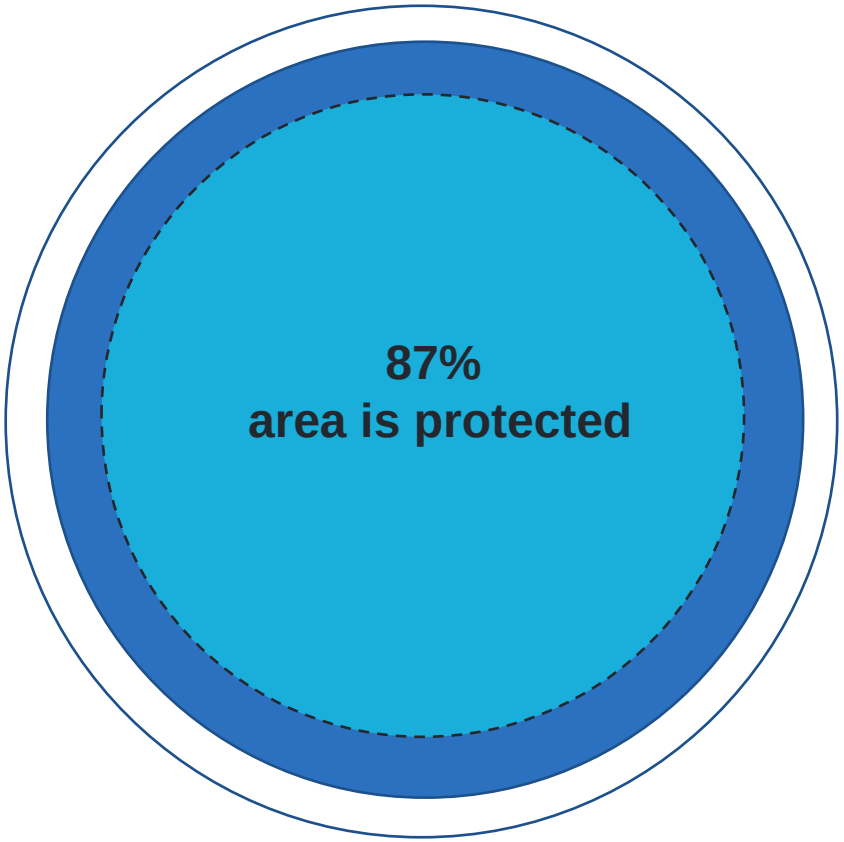


Settlers

Deflector

Settlers

Deflector



Diameter of the settler: 30m

Area of the settler: 707m²

Distance from the overflow to the settler wall: 0.4m

Overflow width: 0.3m

Distance from the deflector to the overflow: 0.3m

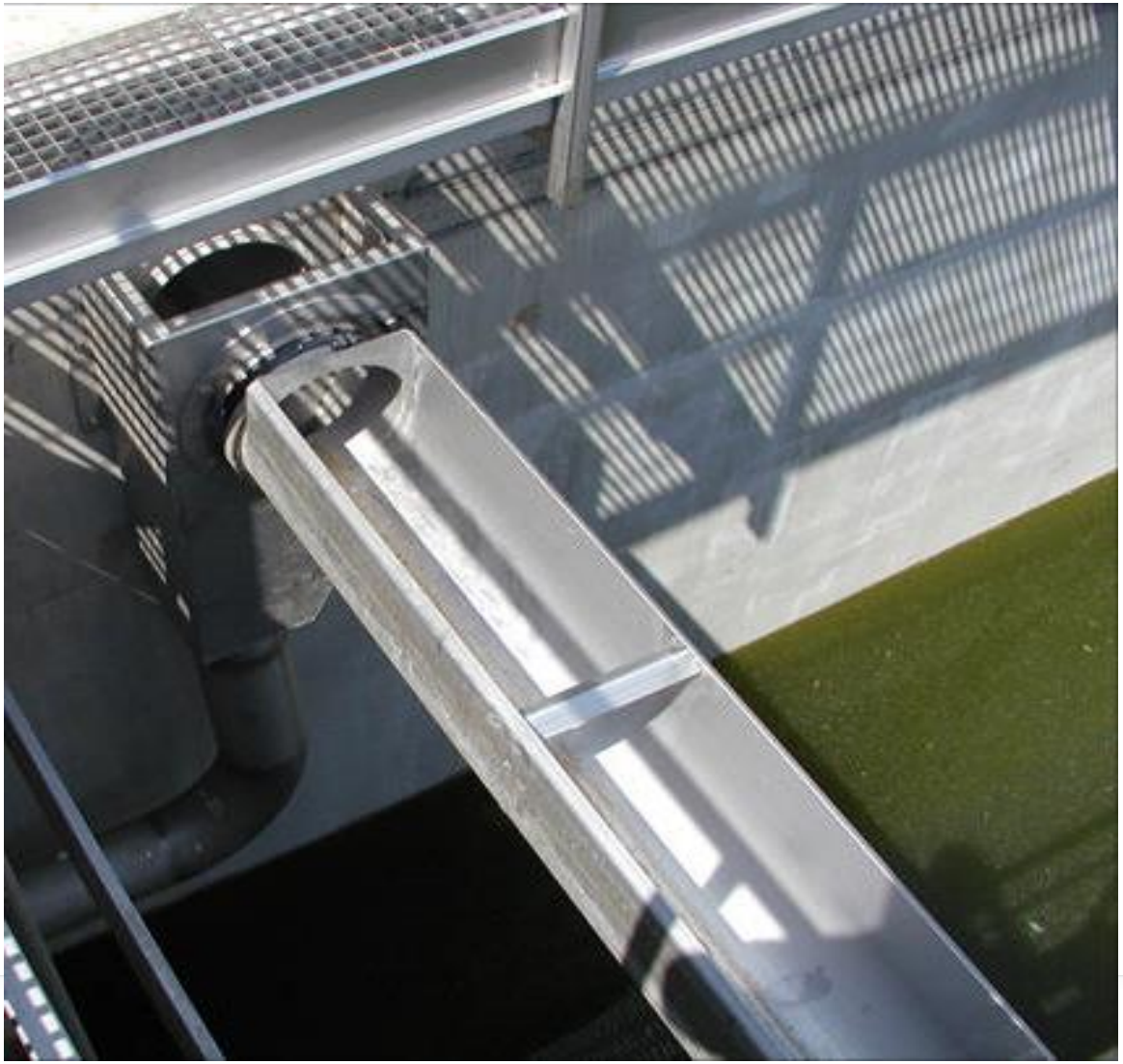
Diameter of the deflector: 29m

Area protected by the deflector: 616m²

Unprotected area: 91m² (~13%)

Settlers

Removal of floating matter – longitudinal clarifiers



Settlers

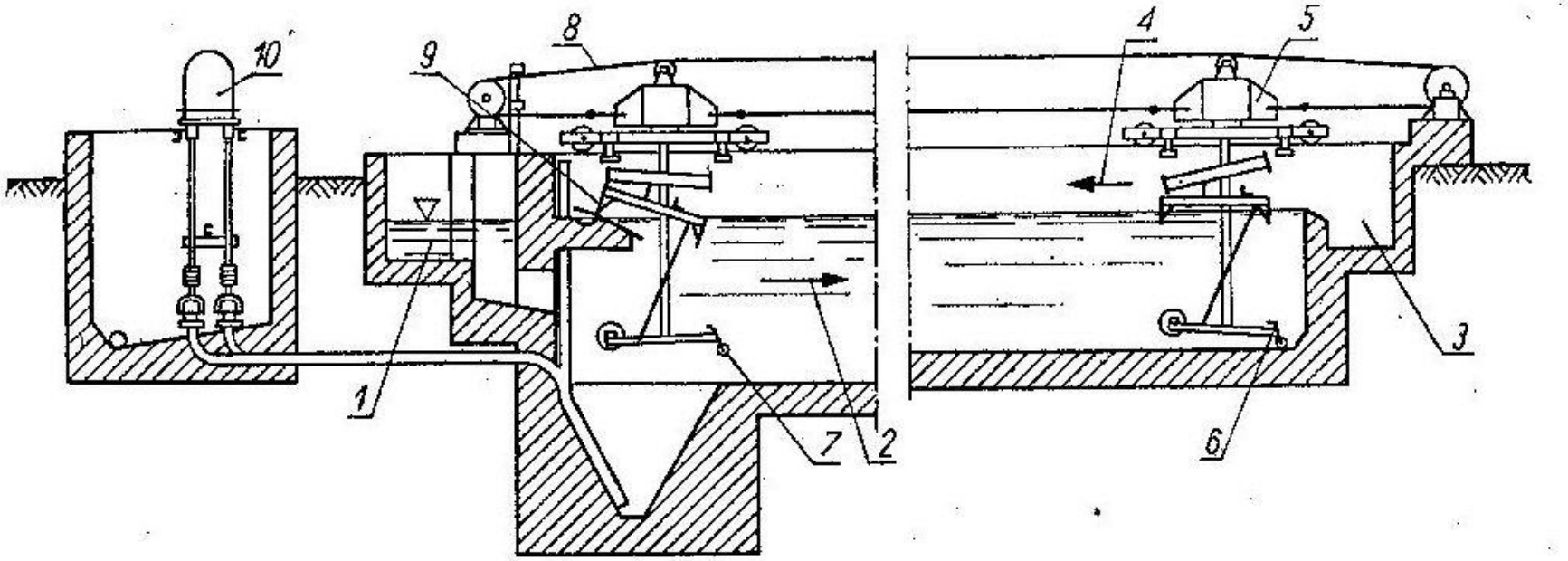
Removal of floating matter – radial clarifiers

Settlers

Removal of floating matter – radial settlers

Settlers

Scrapers – longitudinal settlers – trolley-type rake scraper

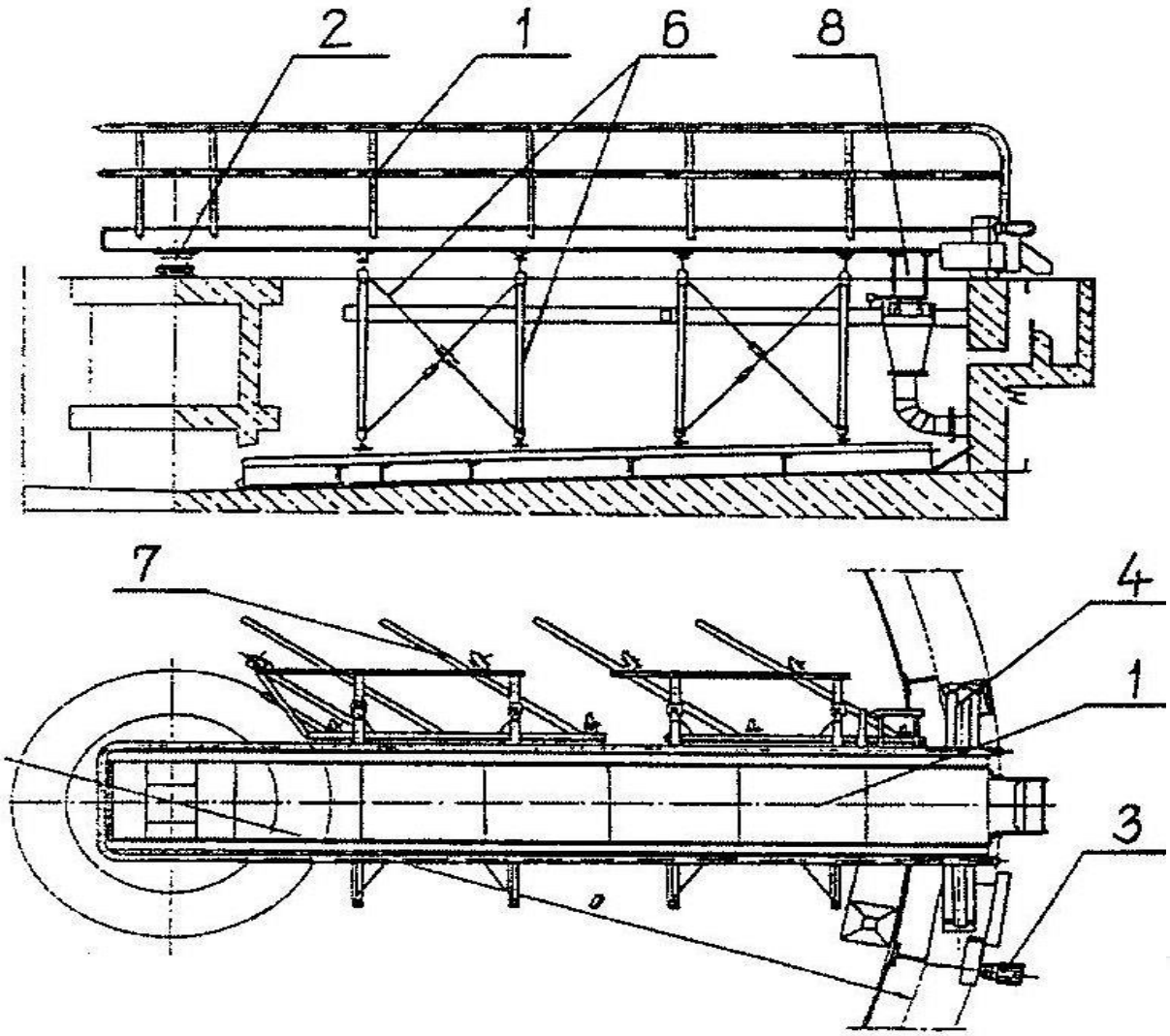


Settlers

Scrapers – longitudinal settlers – torsion scraper

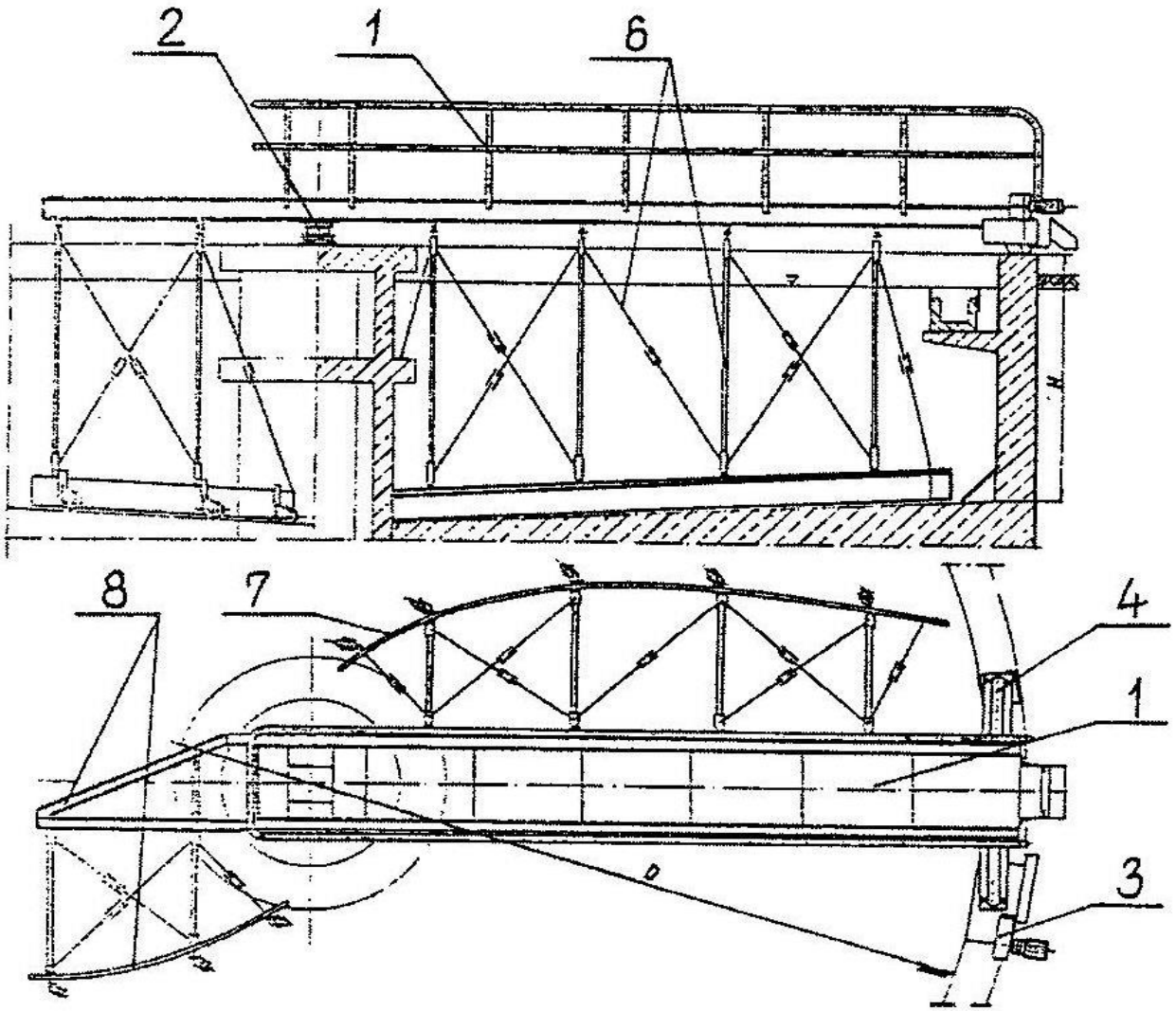
Settlers

Scrapers – radial settlers – multi-arm rake scraper



Settlers

Scrapers – radial settlers – spiral scraper



Control questions

- What is the importance of primary settlers?
- What are the consequences of a failure of the primary settler?
- Describe the known types (theories) of sedimentation – what are their characteristics and in which devices do they occur?
- What is the purpose of a deflector in settlers?
- What types of settlers are there?
- How would the ratio of organic carbon to nitrogen change if the primary settler is eliminated?