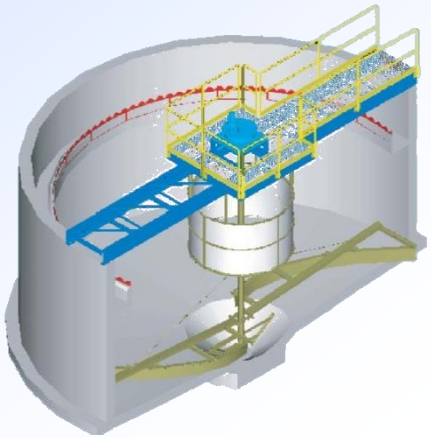
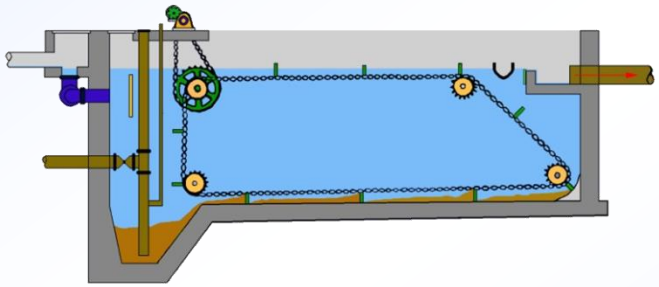
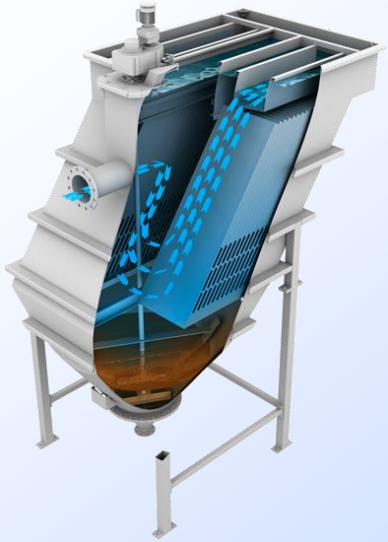
CLARIFIERS







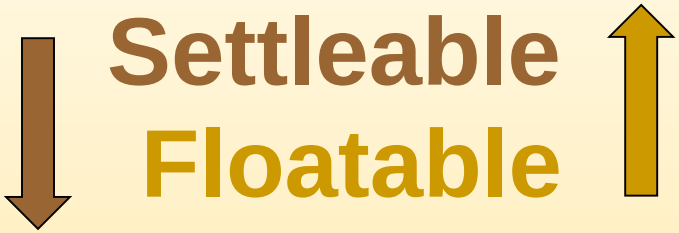
Prepared By
Michigan Department of Environmental Quality
Operator Training and Certification Unit

CLARIFIERS

Clarifiers
Sedimentation Basins
Settling Tanks

Provide Quiescent Area

Separation of Solids



Clarifiers

Efficiency of Solids Removal Related To:

1. Characteristics of the Solids

2. Characteristics of the Water

3. Characteristics of the Clarifier

Stoke's Law

$$VF = \frac{2(p - p_o)g}{9n} (d/2)^2$$

VF	= Fall Velocity
$(p - p_o)$	= Density difference between particle and water
n	= viscosity of water
g	= gravitational acceleration constant
d	= diameter of the particle

Stoke's Law

Forget the Formula
Remember the Removal Efficiency Depends on Several Factors

VF = Fall Velocity

$(p - p_o)$ = Density difference between particle and water

n = viscosity of water

g = gravitational acceleration constant

d = diameter of the particle

Particle Size versus Settling Time

Particle Size mm	Order of Size	Time to Settle
1.0	Coarse Sand	3 Seconds
0.1	Fine Sand	38 Seconds
0.01	Silt	33 Minutes
0.001	Bacteria	55 Hours
0.0001	Colloidal	230 Days
0.00001	Colloidal	6.3 Years

Clarifiers

Efficiency of Solids Removal Related To:

1. Characteristics of the Solids

2. Characteristics of the Water

3. Characteristics of the Clarifier

Stoke's Law

Forget the Formula
Remember the Removal Efficiency Depends on Several Factors

VF = **Fall Velocity**

$(p - p_o)$ = **Density difference between particle and water**

n = **viscosity of water**

g = **gravitational acceleration constant**

d = **diameter of the particle**

Settling Rate

Cold Water
- More Dense
- More Viscous

Warm Water
- Less Dense
- Less Viscous

Solids Settle More Readily in Warm Water Than in Cold Water

Warm Water - Greater Efficiency of Clarification

Cool Water- Less Efficiency of Clarification

Clarifiers

Efficiency of Solids Removal Related To:

1. Characteristics of the Solids

2. Characteristics of the Water

3. Characteristics of the Clarifier

Clarifiers

Efficiency of Solids Removal Related To:

3. Characteristics of the Clarifier

Surface Area
Depth
Hydraulic Loading
Solids Loading

Clarifiers

Efficiency of Solids Removal Related To:

3. Characteristics of the Clarifier

Surface Area
Depth
Hydraulic Loading
Solids Loading
Design
Operation
Maintenance

Clarifiers

Efficiency of Solids Removal Related To:

3. Characteristics of the Clarifier

Flow Characteristics in the Clarifier

Flow Must be Dispersed Evenly Throughout

Clarifier Short Circuiting

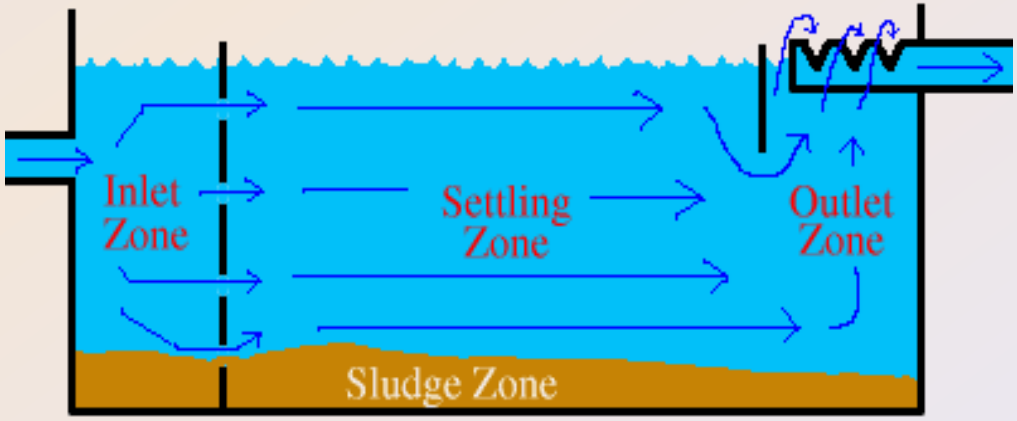
Higher Flow (Horizontal Velocity) in One Part of Tank

Density Currents

Currents Within the Tank Carry Solids Through the Tank.

Not the Same as Excessive Hydraulic Load

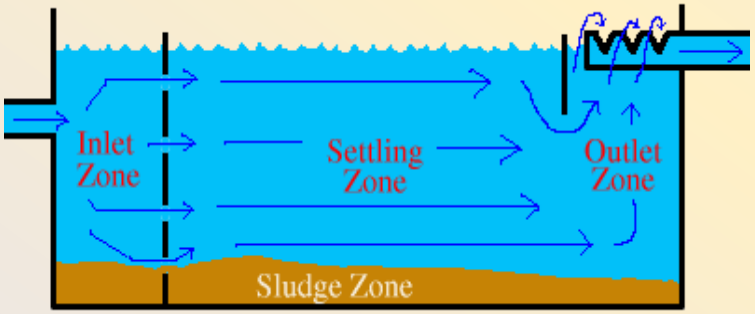
(Detention Time vs. Fall Velocity)

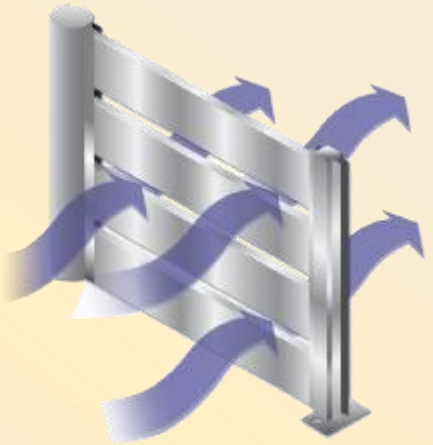


Clarifier Short Circuiting

Causes

Missing or poor influent baffling





Clarifier Short Circuiting

Causes

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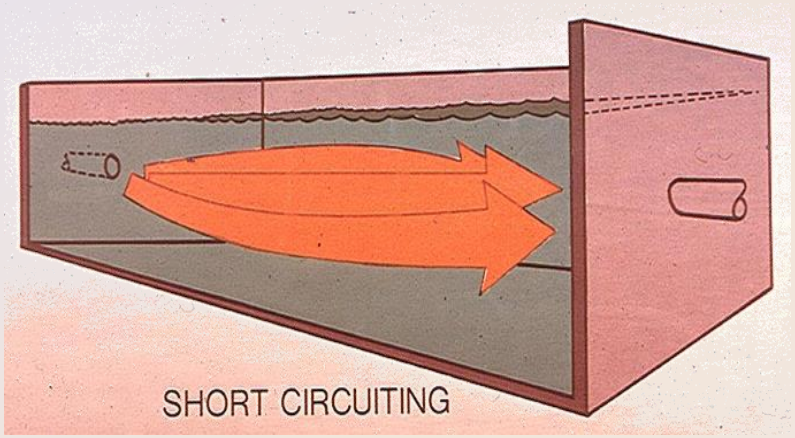

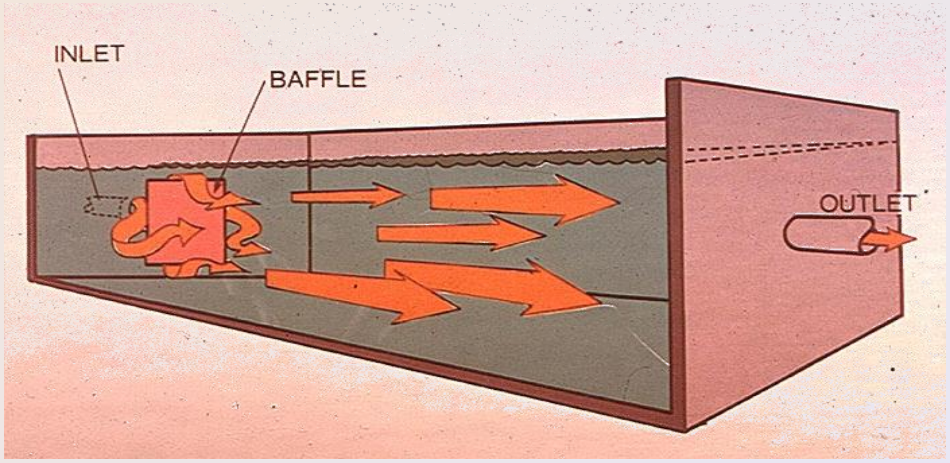

Clarifier Short Circuiting

Causes

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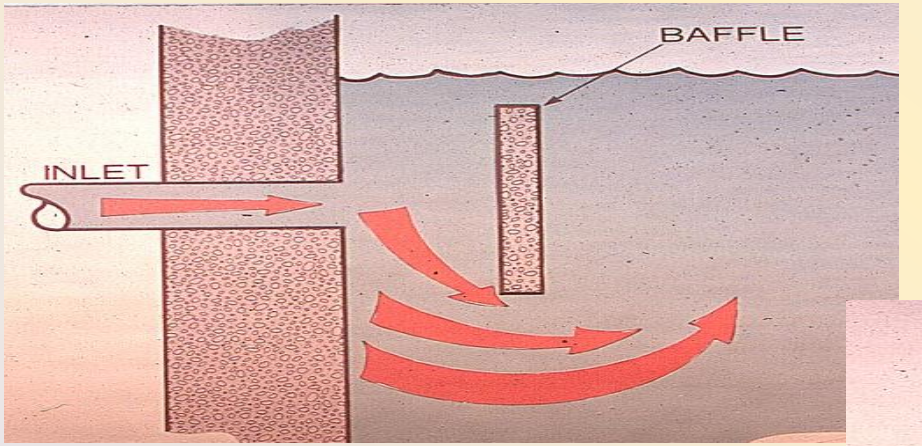
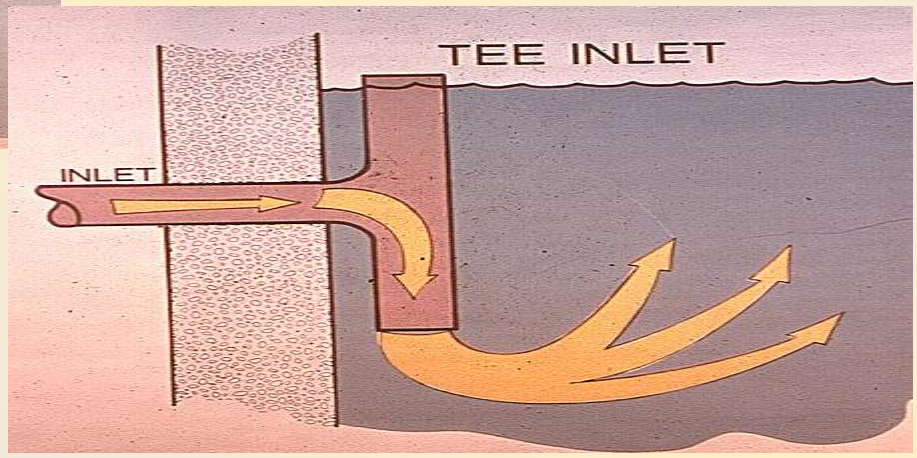




Clarifier Short Circuiting

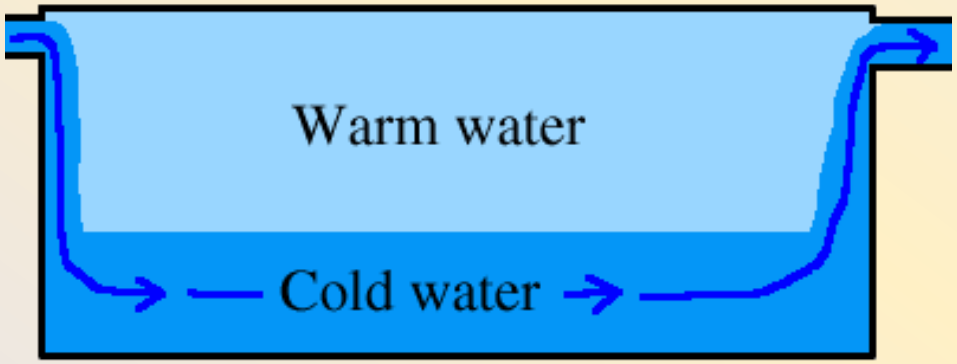
Causes

- Uneven effluent weirs
- Plant growth or thrash in effluent weirs

Clarifier Short Circuiting

Causes

Temperature stratification between influent & clarifier water temperatures.



Clarifier Short Circuiting

Monitoring for Short Circuiting

Visual Observation

Flow Over Weir

Solids Over Weir

Clarifier Short Circuiting

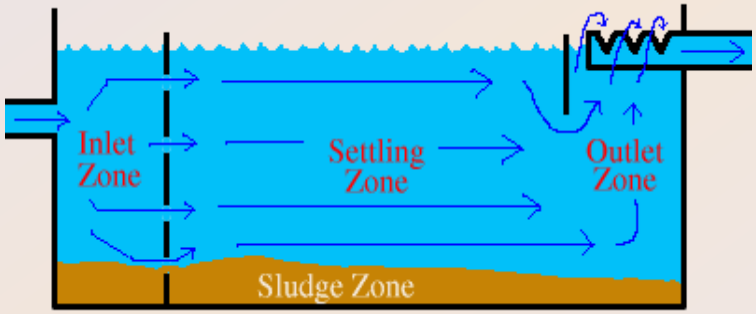
Monitoring for Short Circuiting

Dye Testing

Clarifier Short Circuiting

Higher Flow (Horizontal Velocity) in One Part of Tank

Density Currents



Clarifier Short Circuiting

Causes

- **Missing or poor influent baffling**
- **Uneven effluent weirs**
- **Plant growth or thrash in effluent weirs**
- **Temperature stratification between influent & clarifier water temperatures.**

Clarifiers

Efficiency of Solids Removal Related To:

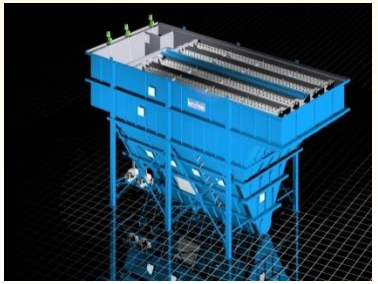
1. Characteristics of the Solids

2. Characteristics of the Water

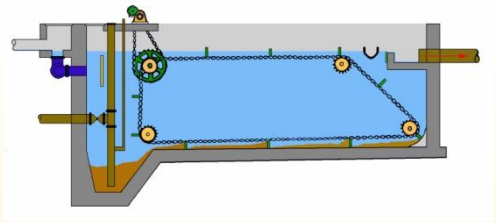
3. Characteristics of the Clarifier

Clarifiers

Types of Clarifiers



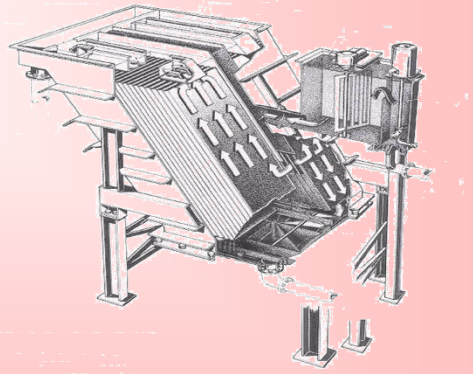
Inclined Plate
(Lamella)



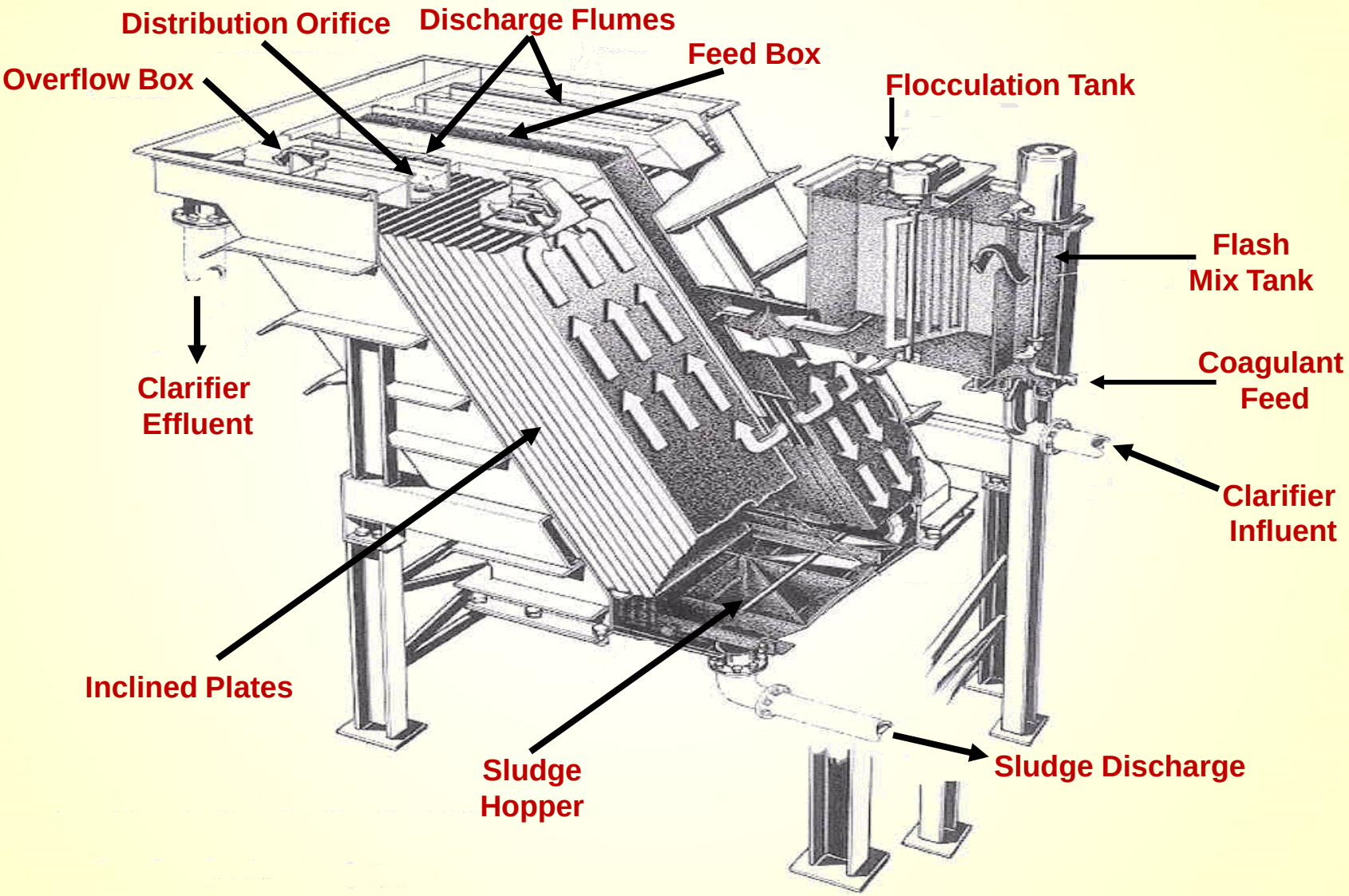
Rectangular

Circular

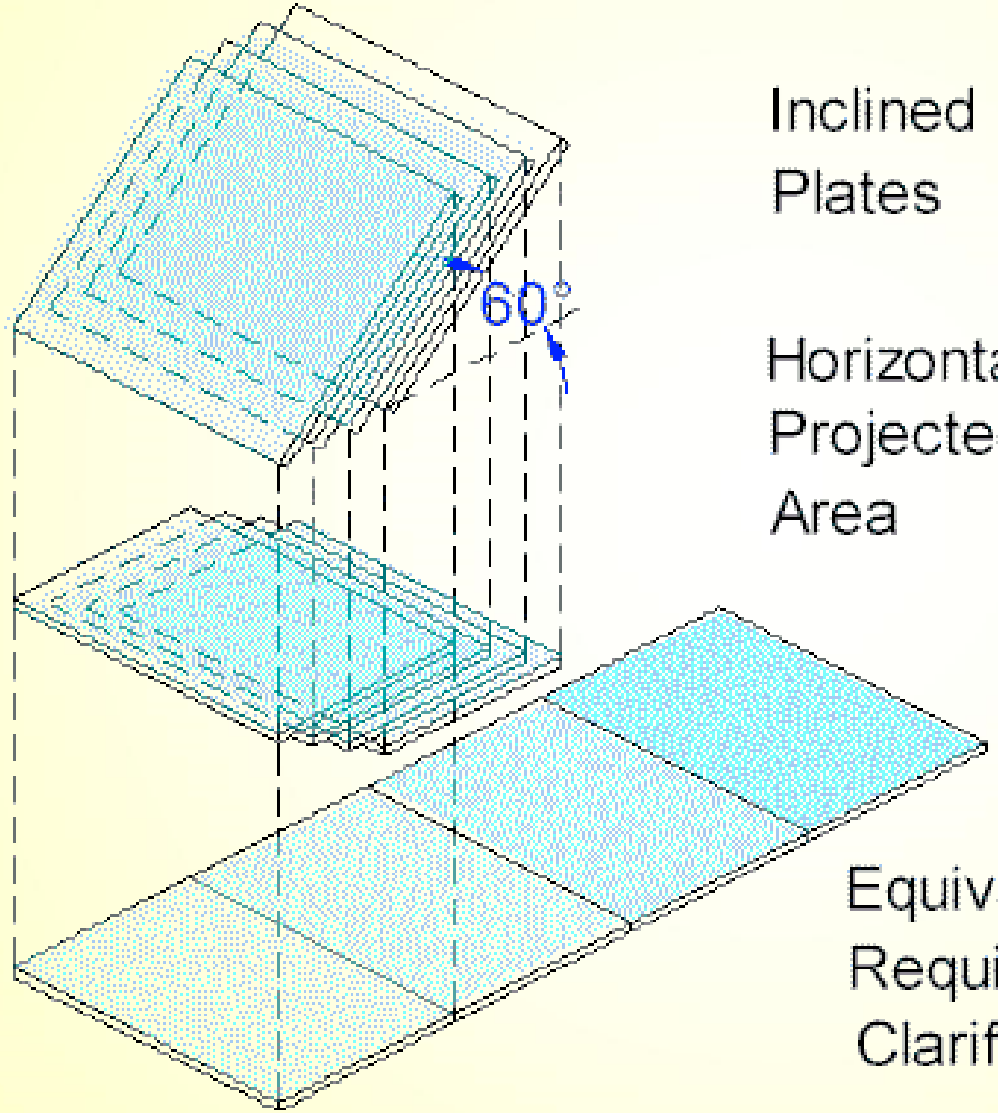
Inclined Plate
(Lamella)



Types of Clarifiers – Inclined Plate (Lamella)



Types of Clarifiers – Inclined Plate (Lamella)



Inclined Plates

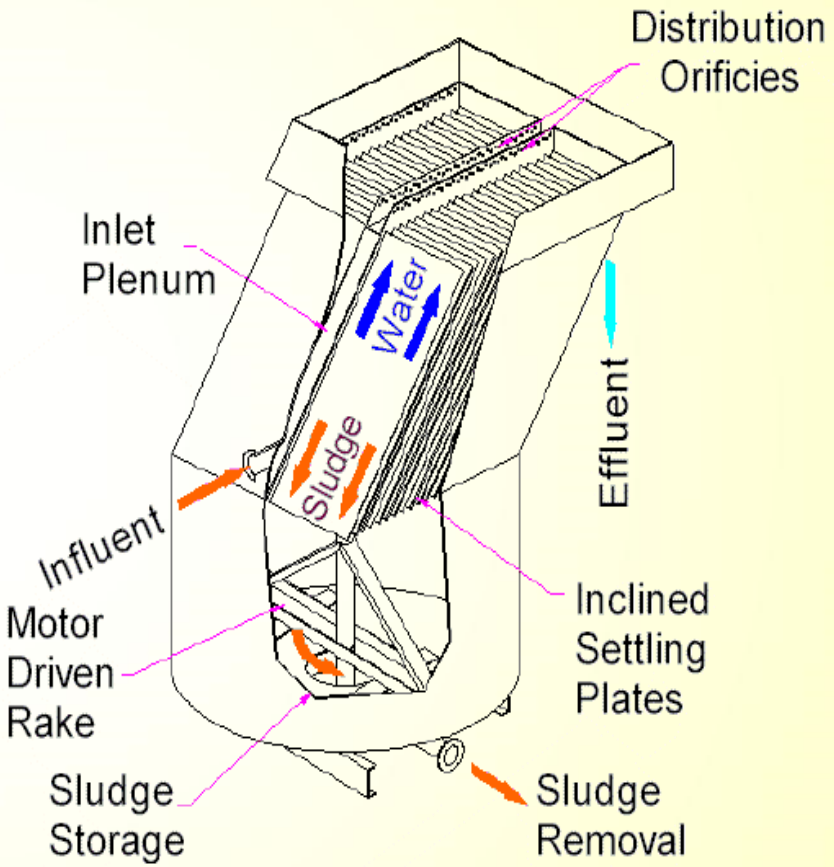
Horizontal Projected Area

Equivalent Floor Space Required by a Horizontal Clarifier

Types of Clarifiers – Inclined Plate (Lamella)

Increased settling efficiency due to increased surface area

Smaller Area Needed for Installation



Types of Clarifiers – Inclined Plate (Lamella)

Increased settling efficiency due to increased surface area

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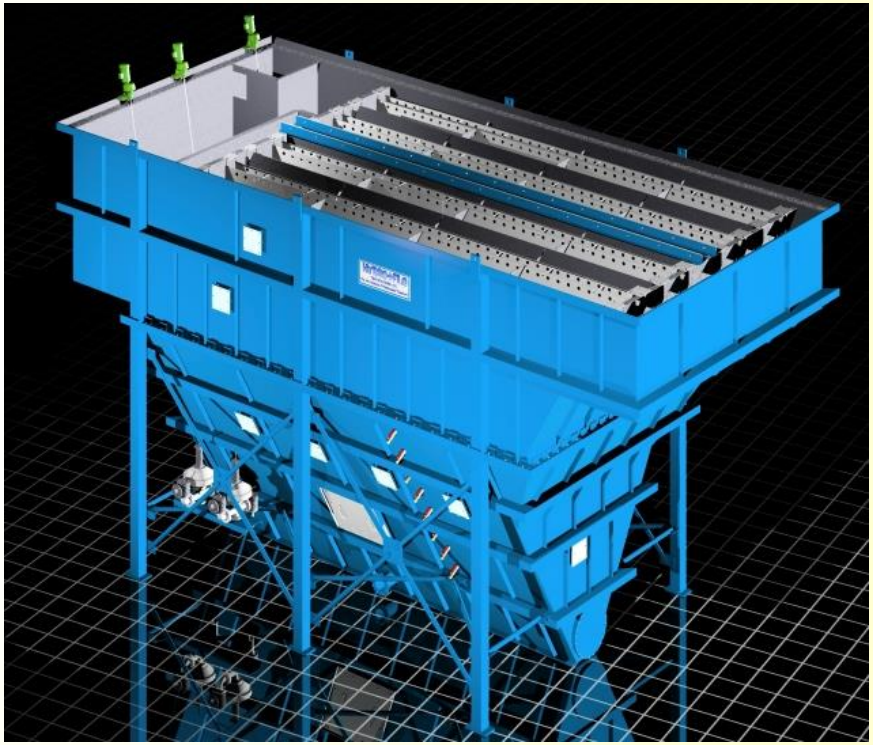
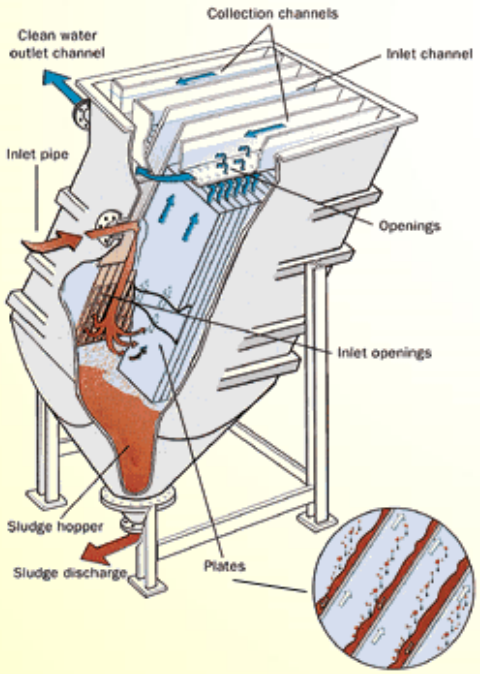


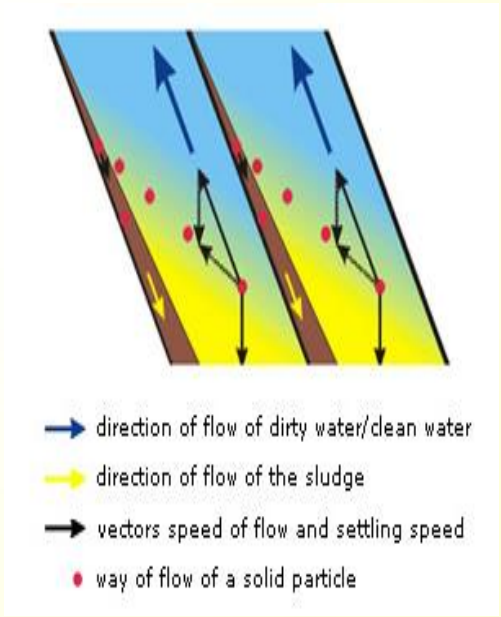
Types of Clarifiers – Inclined Plate (Lamella)

Seldom Used With Organic Wastes

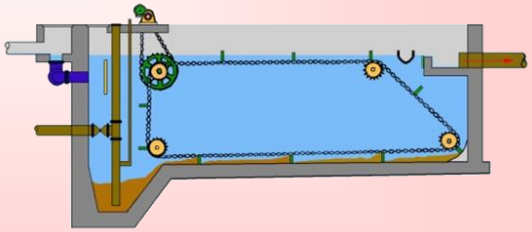
Biological Growths Reduce Efficiency

Mostly Industrial Applications

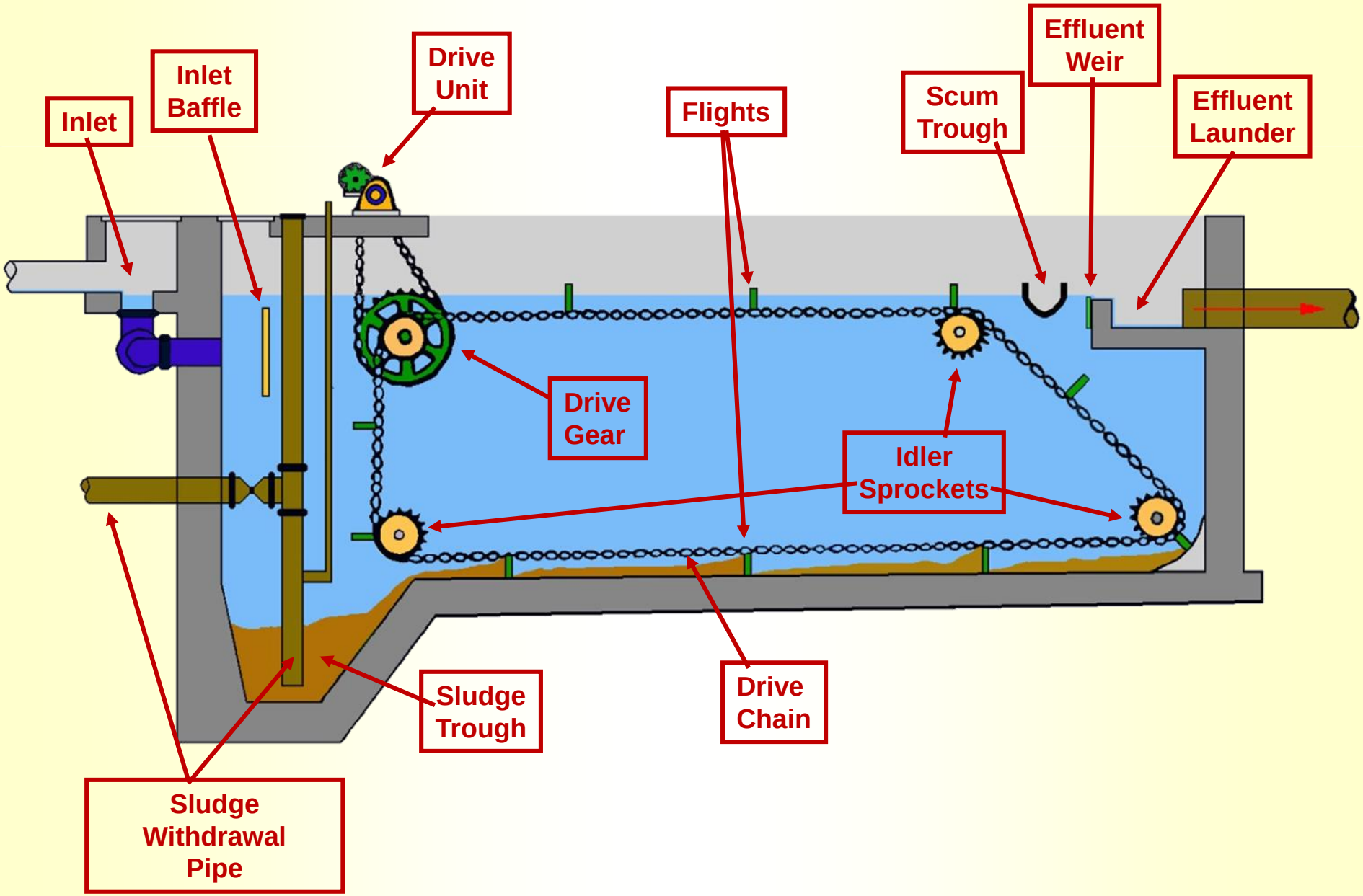




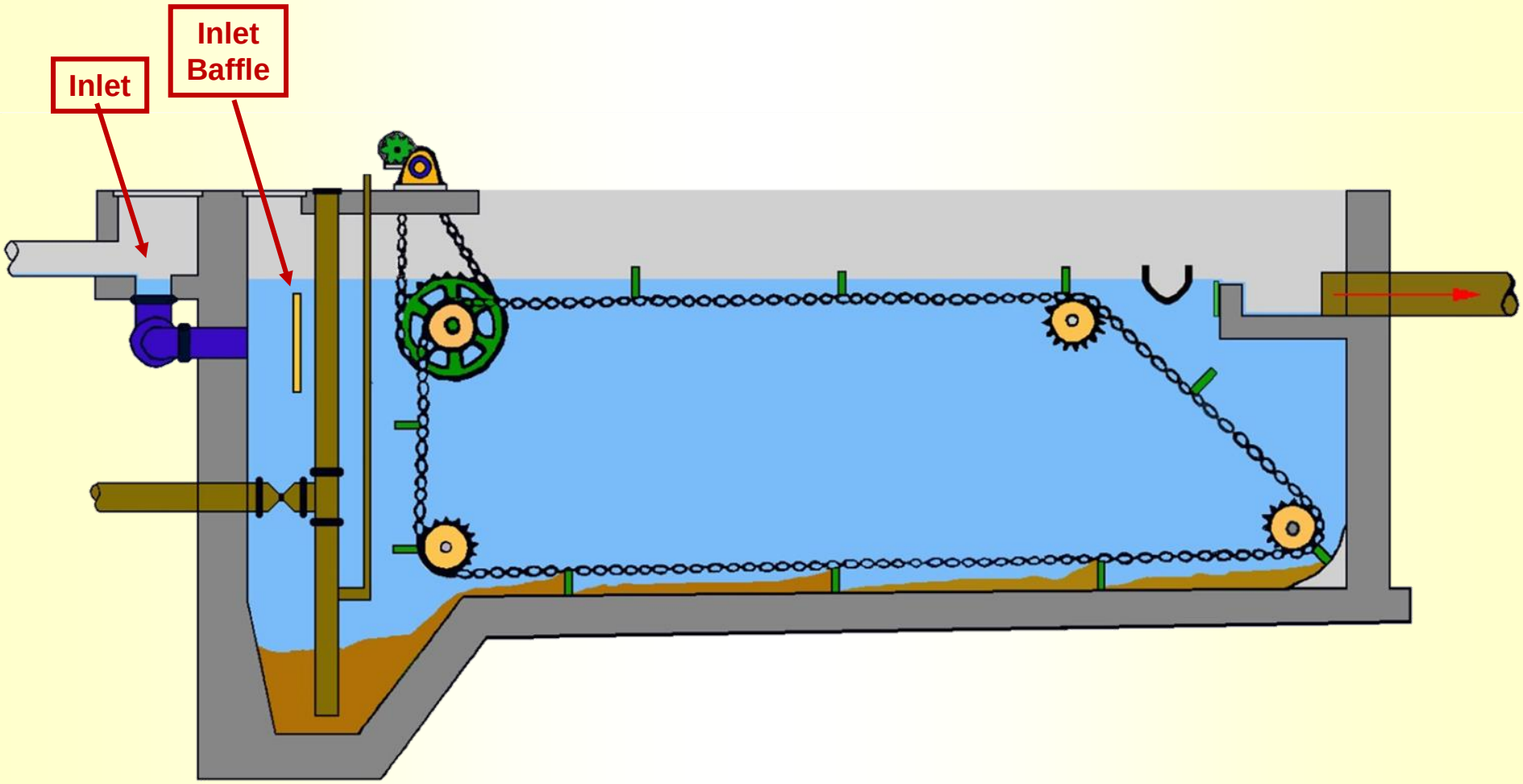
Rectangular Clarifiers



Types of Clarifiers – Rectangular

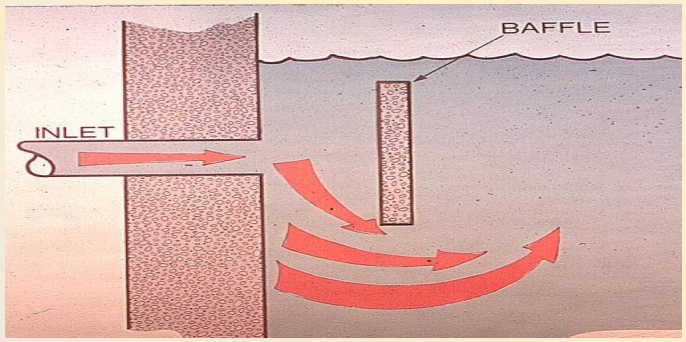


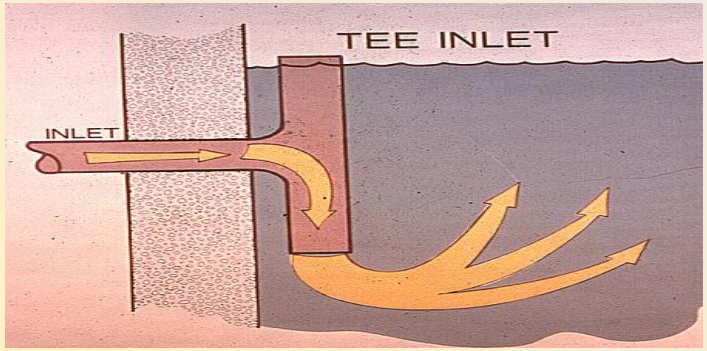
Types of Clarifiers – Rectangular

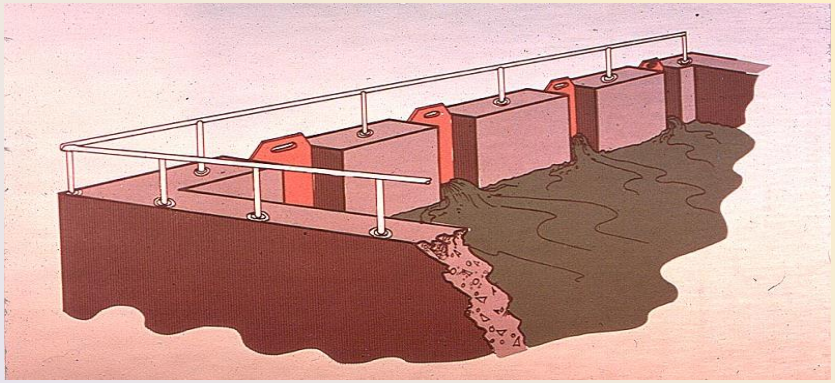


Types of Clarifiers – Rectangular

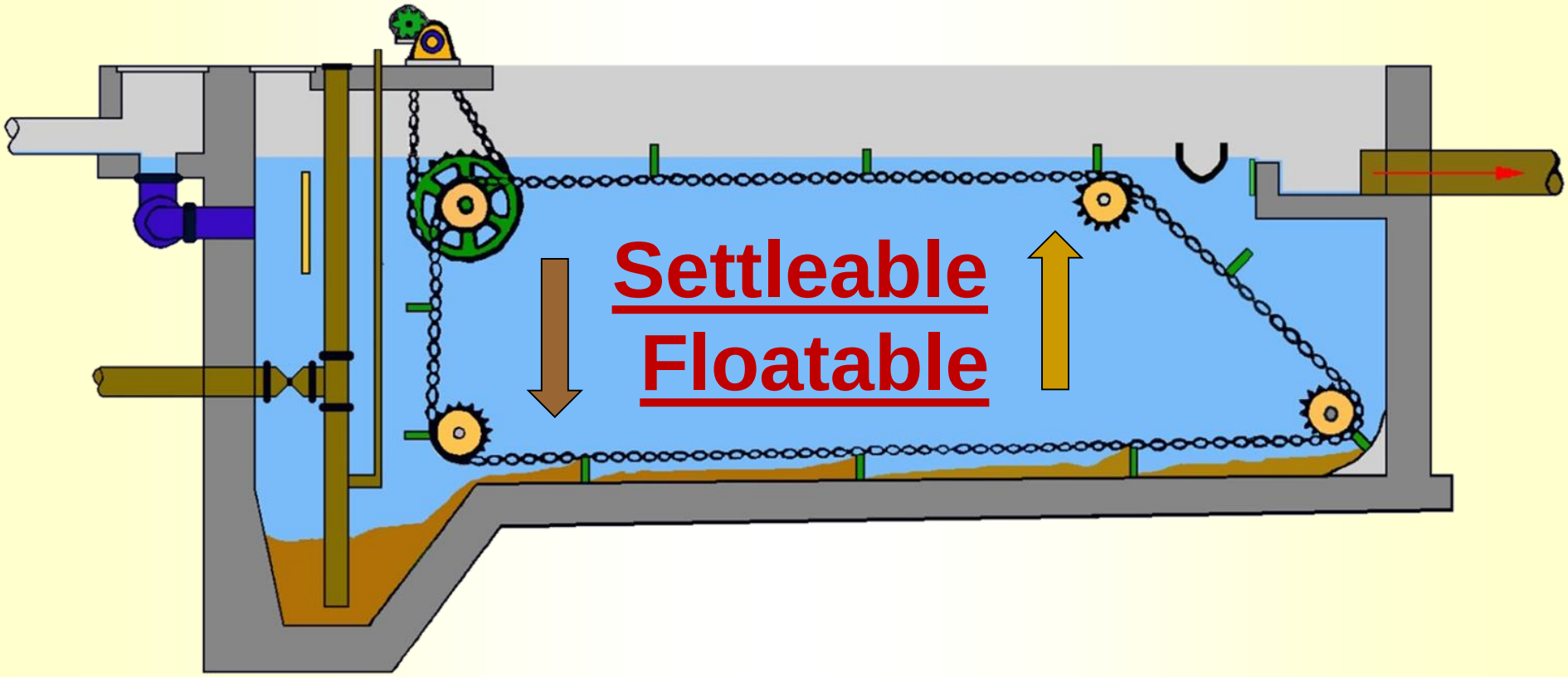
Influent baffling



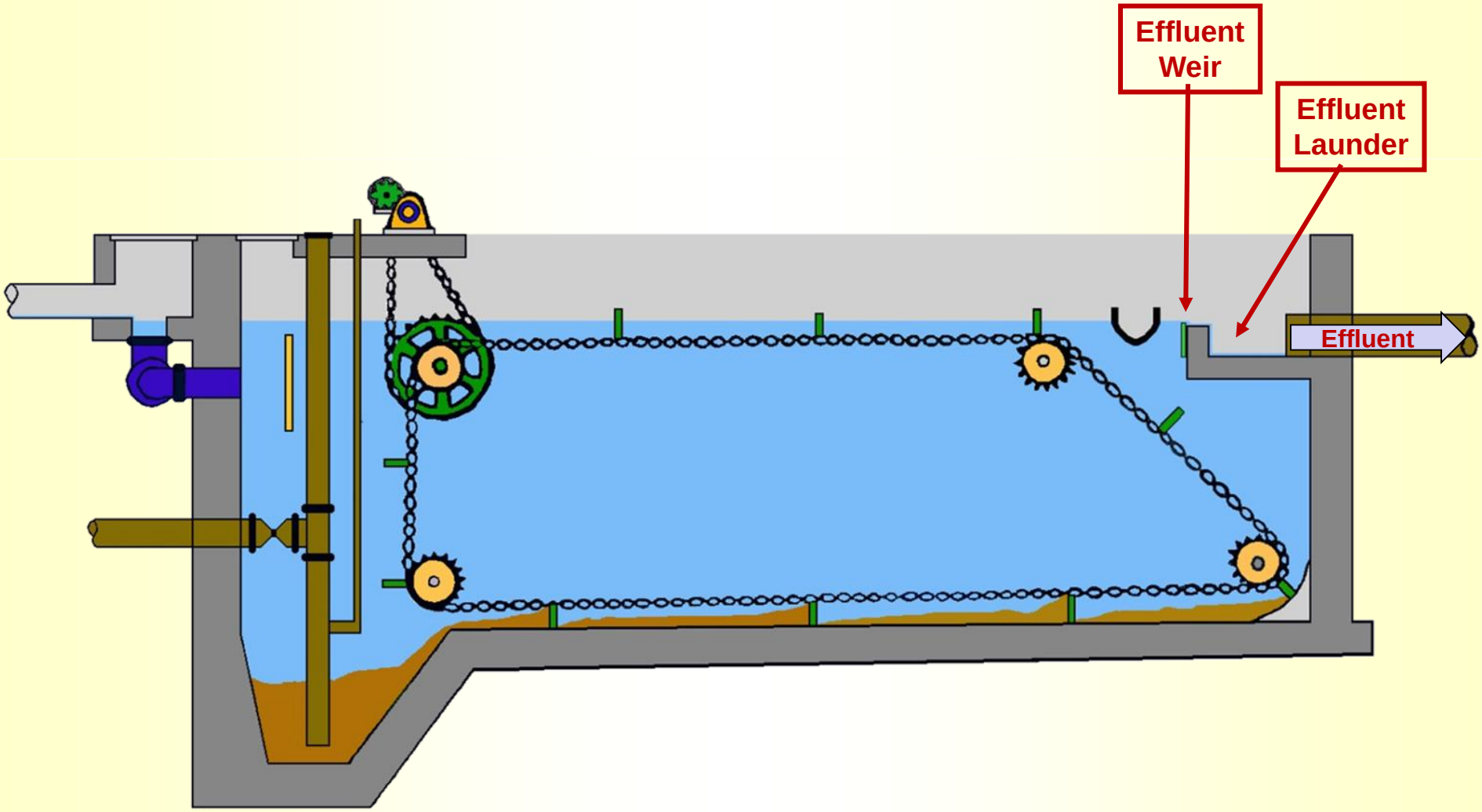




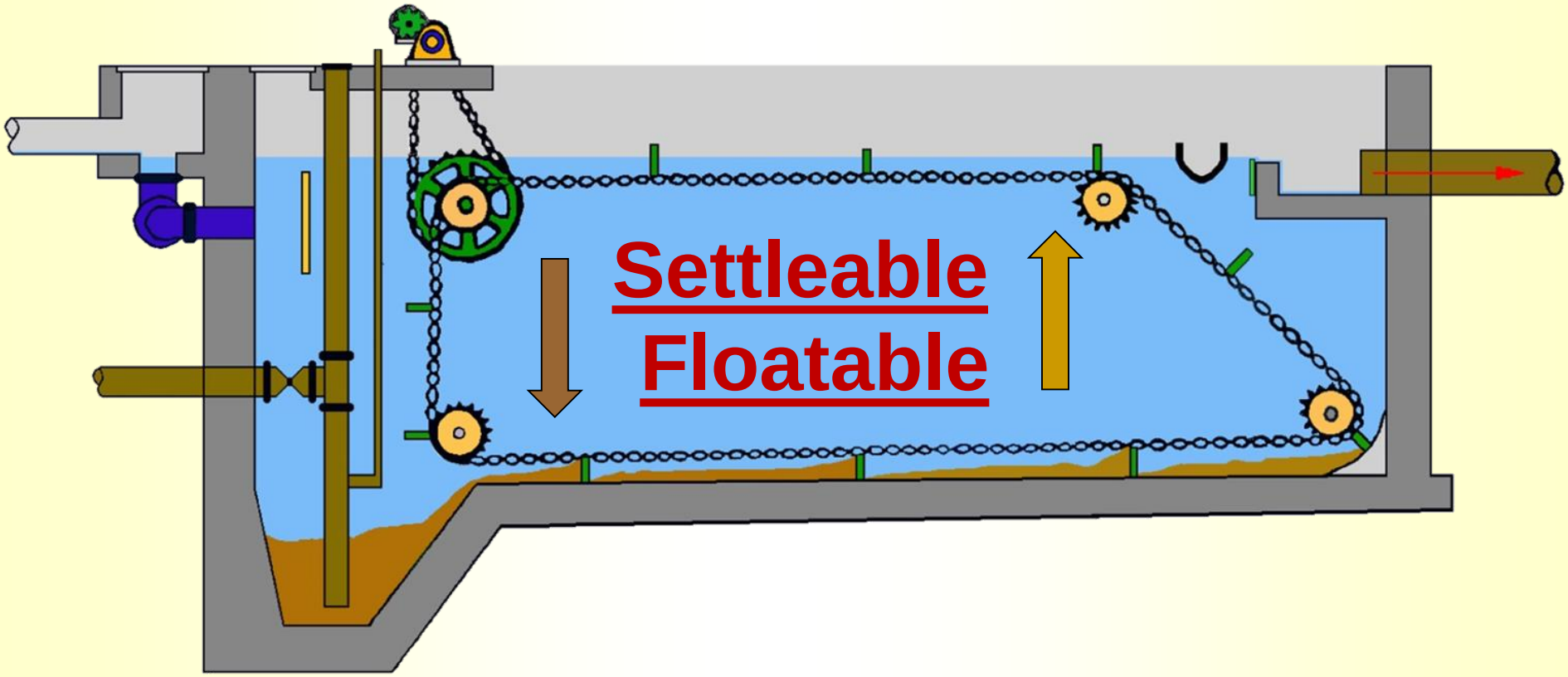
Types of Clarifiers – Rectangular



Types of Clarifiers – Rectangular

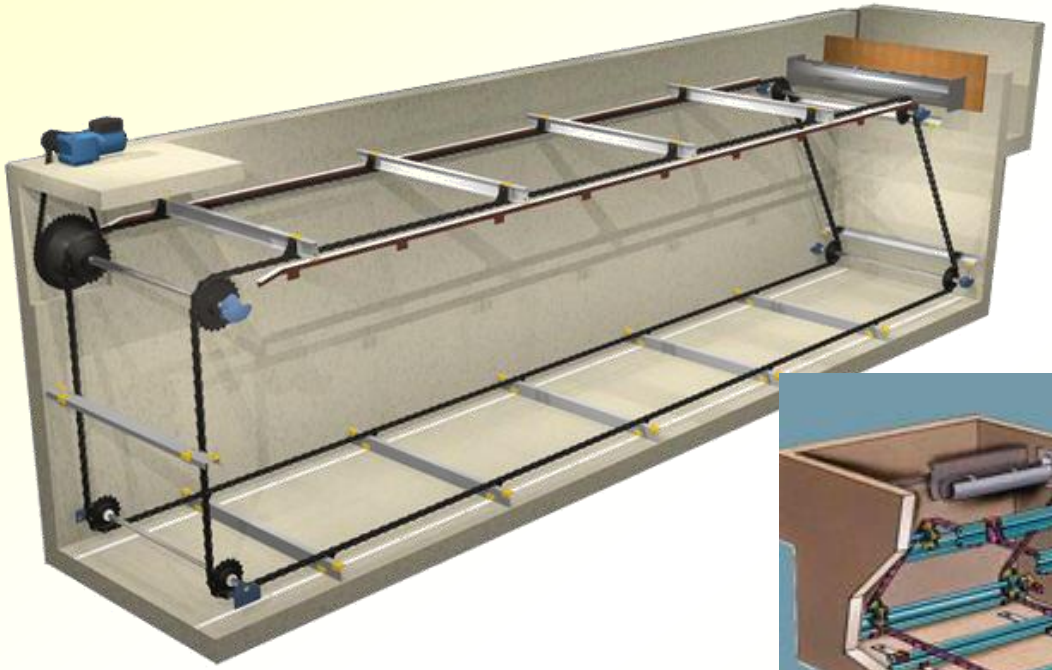


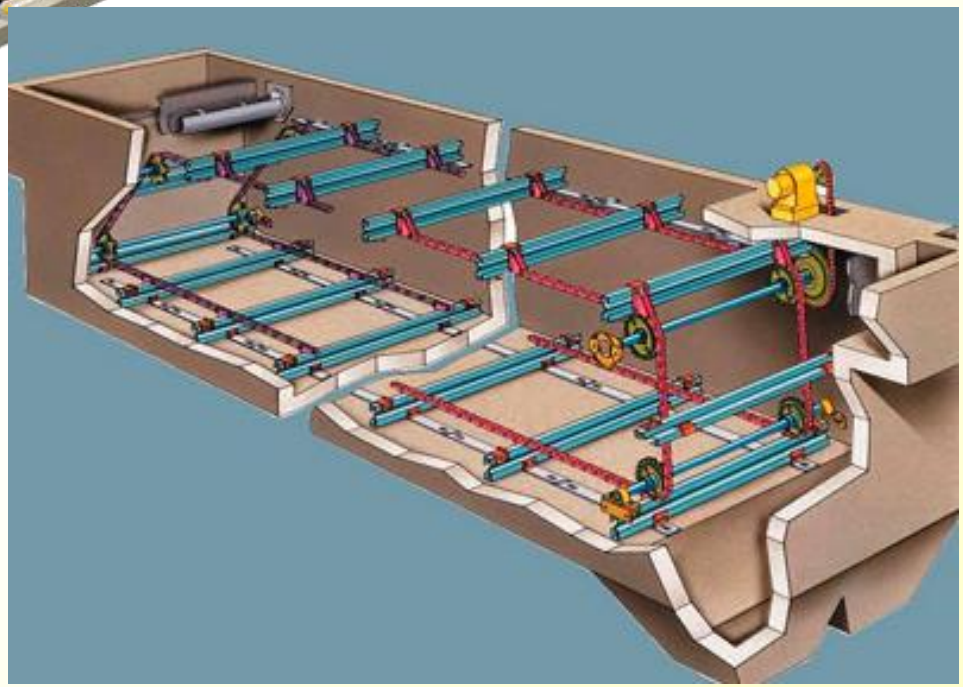
Types of Clarifiers – Rectangular



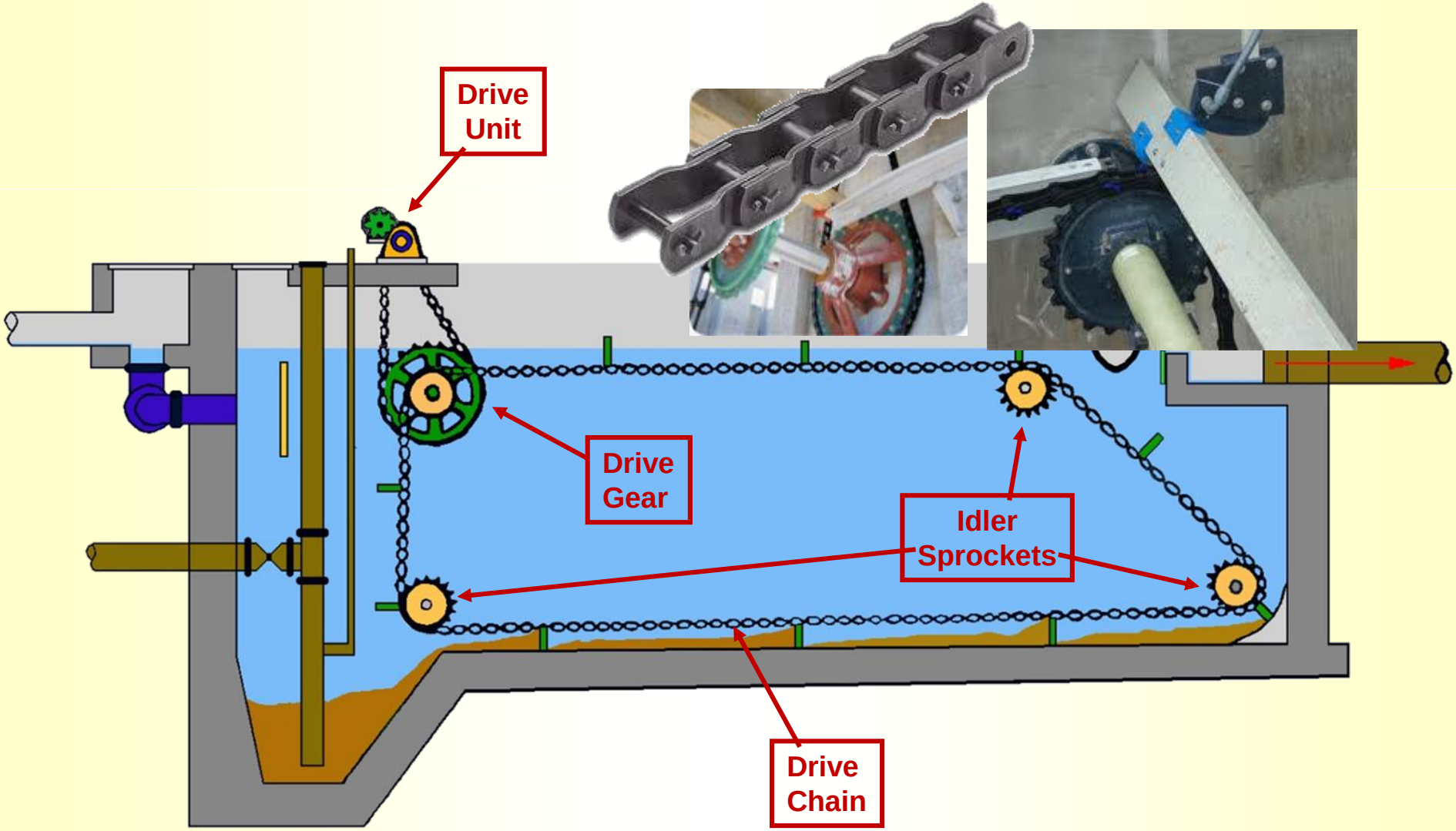
Types of Clarifiers – Rectangular

Solids Removal Mechanism

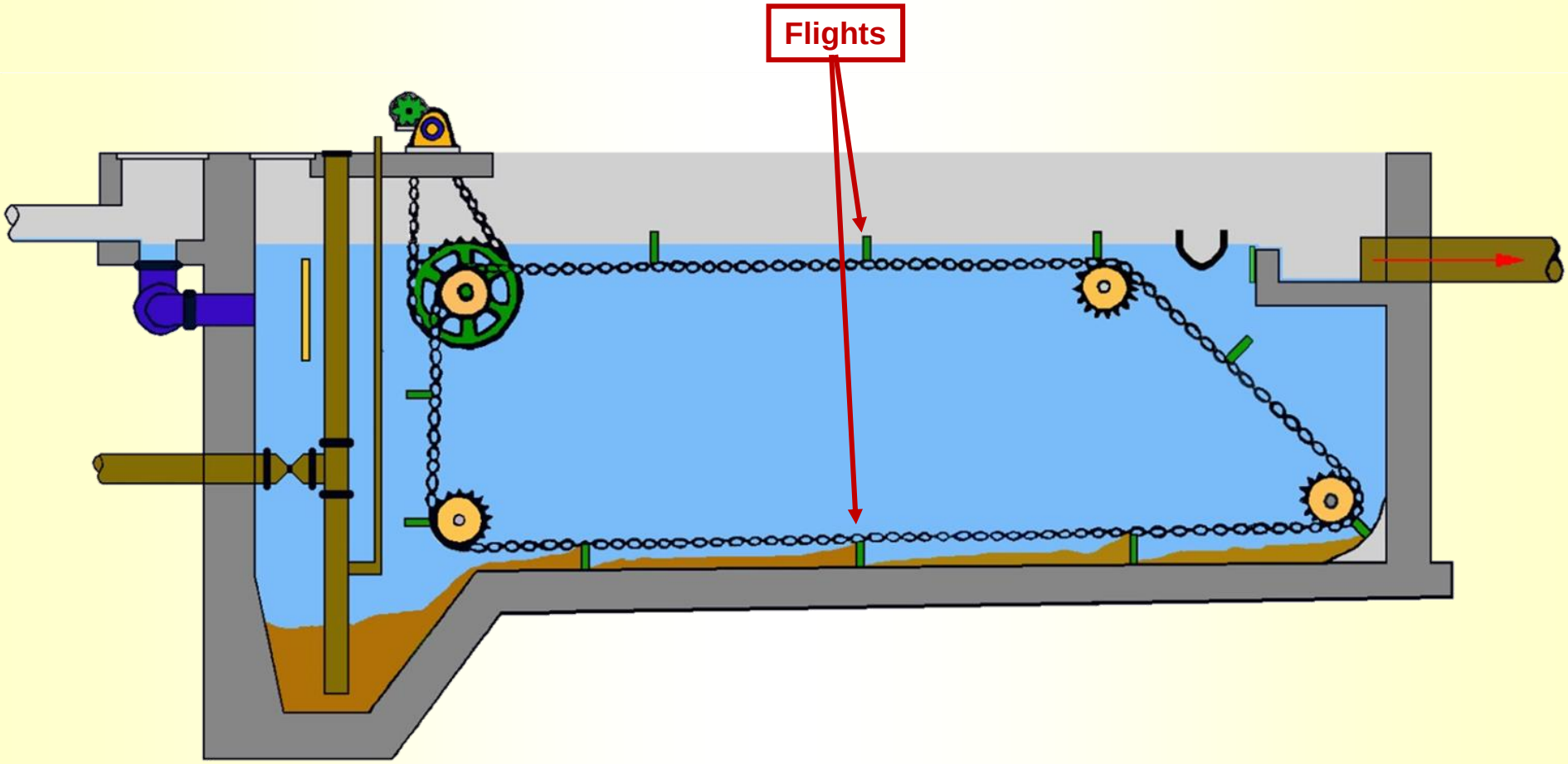




Types of Clarifiers – Rectangular

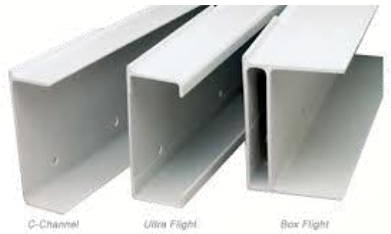


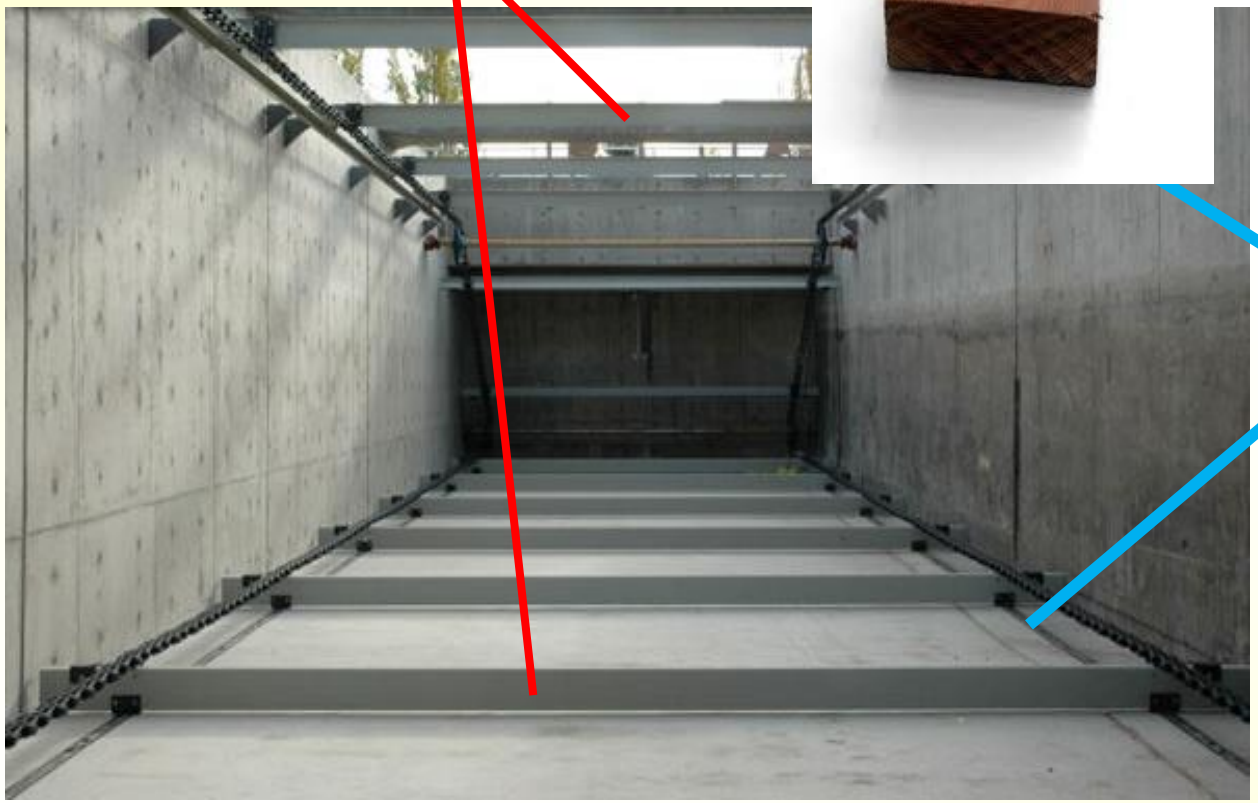
Types of Clarifiers – Rectangular



Types of Clarifiers – Rectangular

Flights

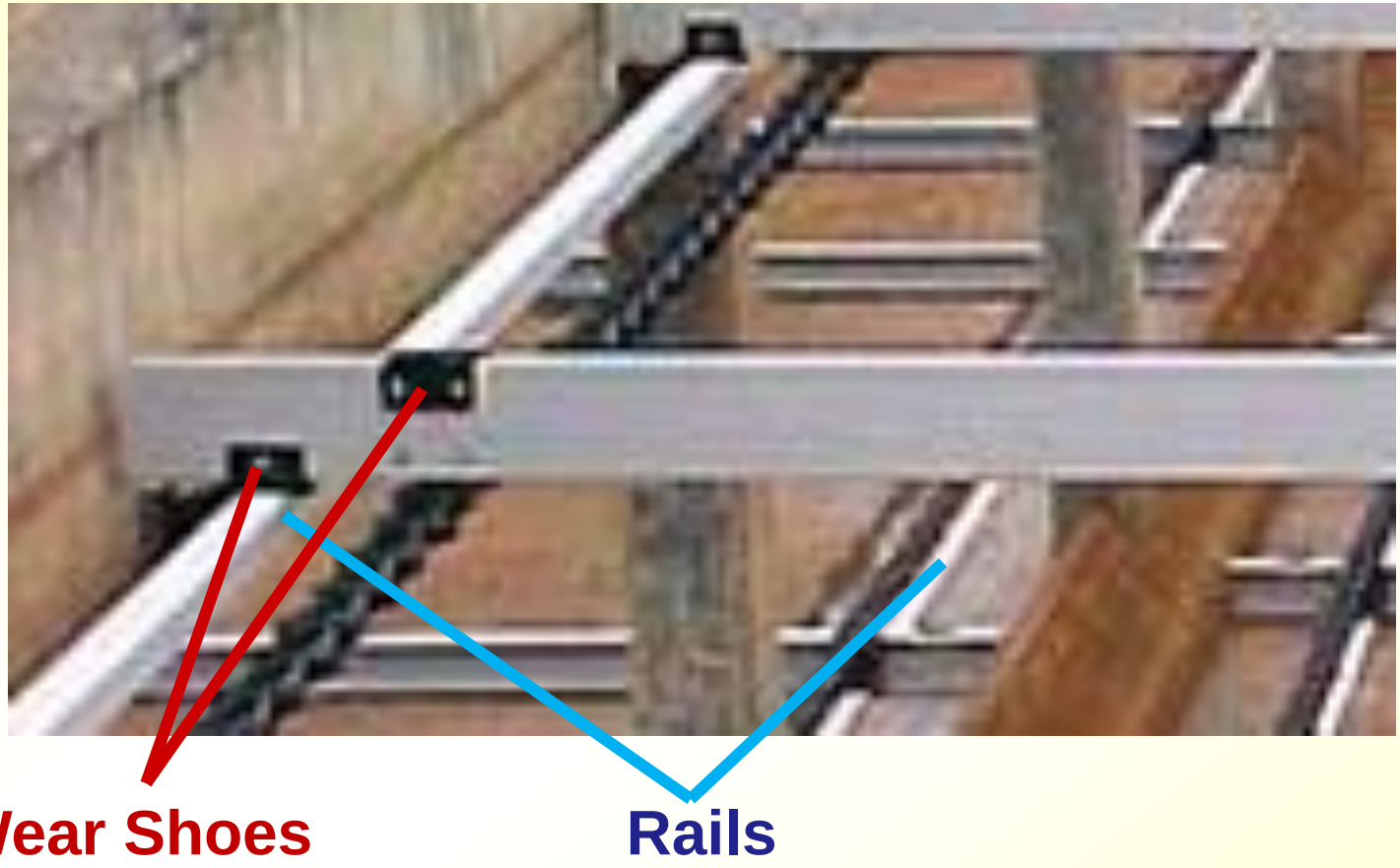




Rails

Types of Clarifiers – Rectangular

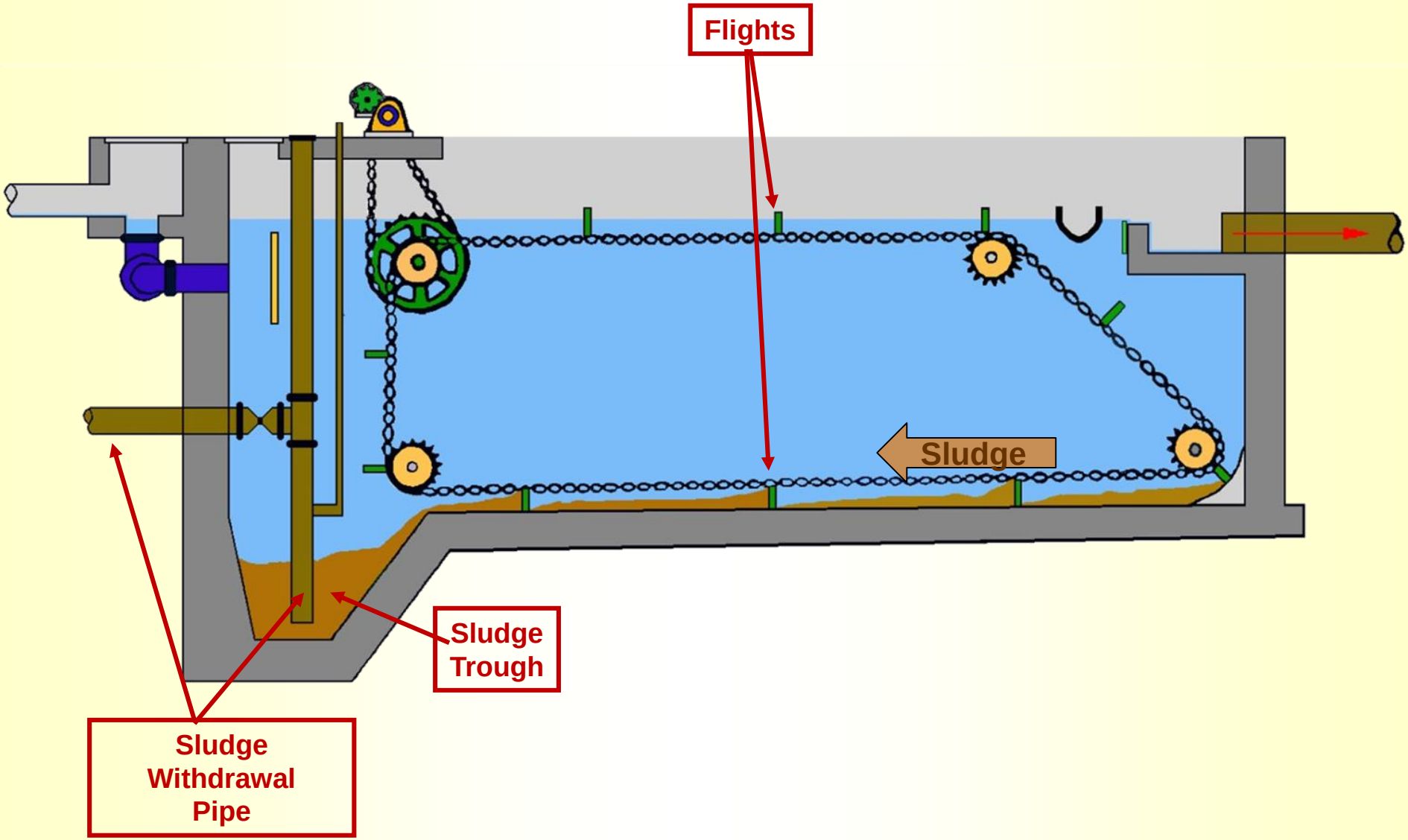
Types of Clarifiers – Rectangular



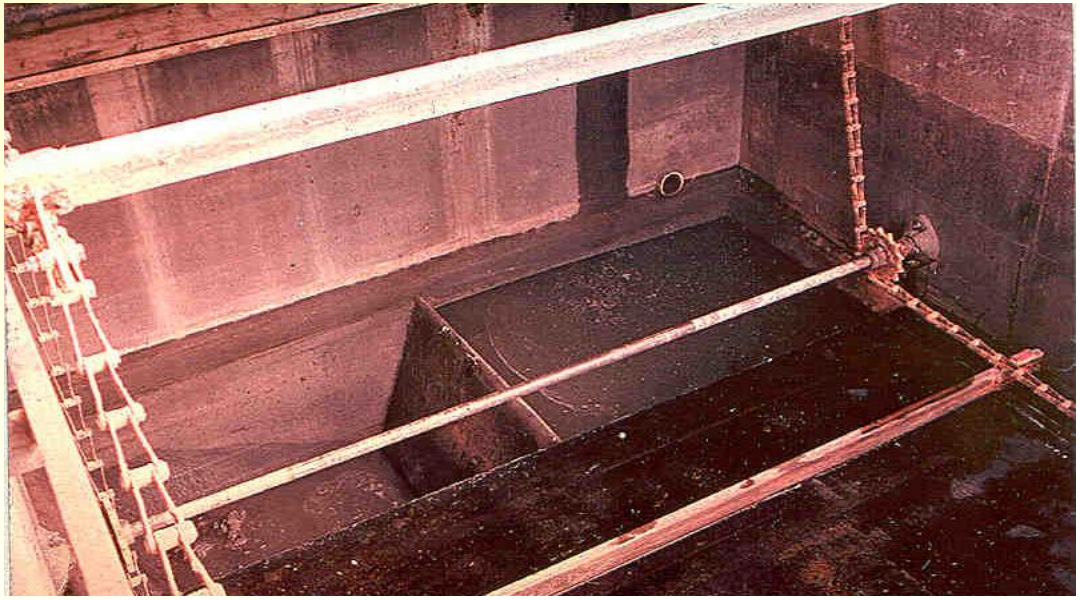
Prevent Wear on the Flights Where They Contact the Rails

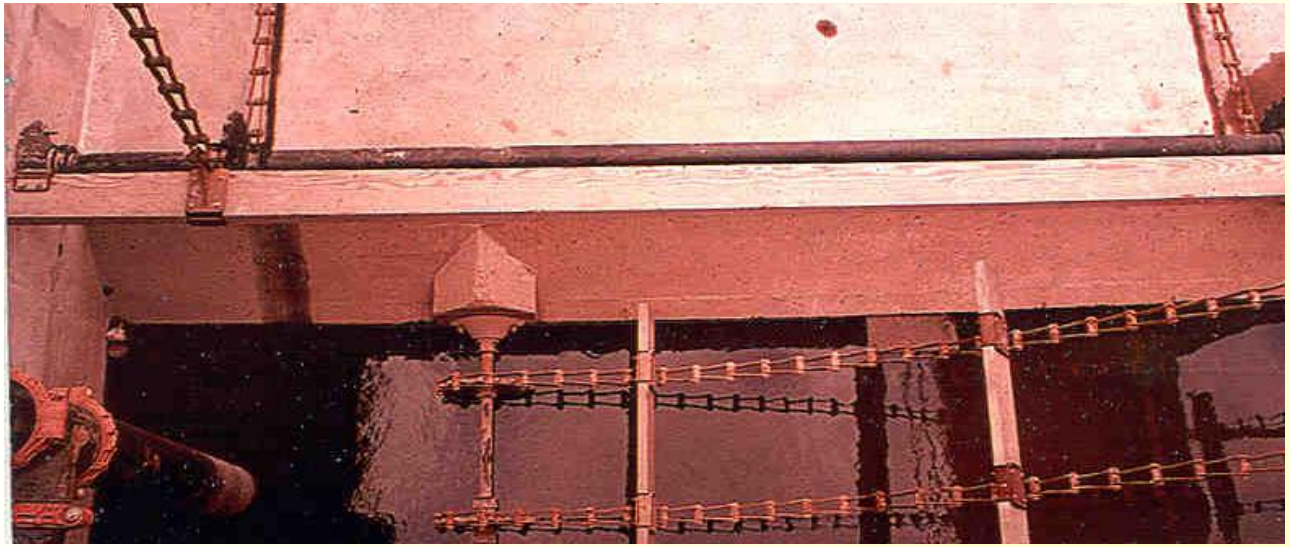
Transfer Wear to the Shoe Instead of the Flights

Types of Clarifiers – Rectangular



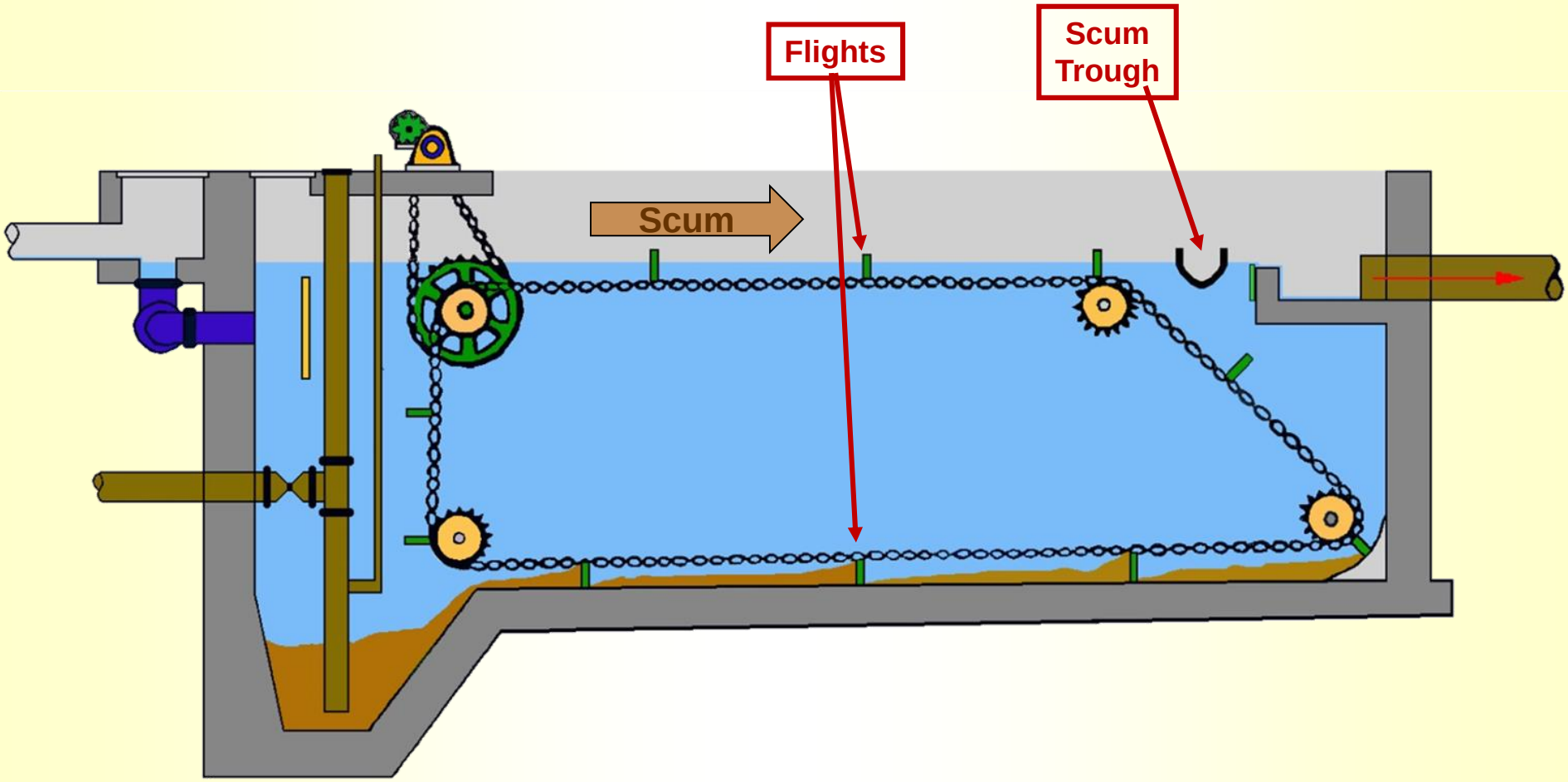
Types of Clarifiers – Rectangular





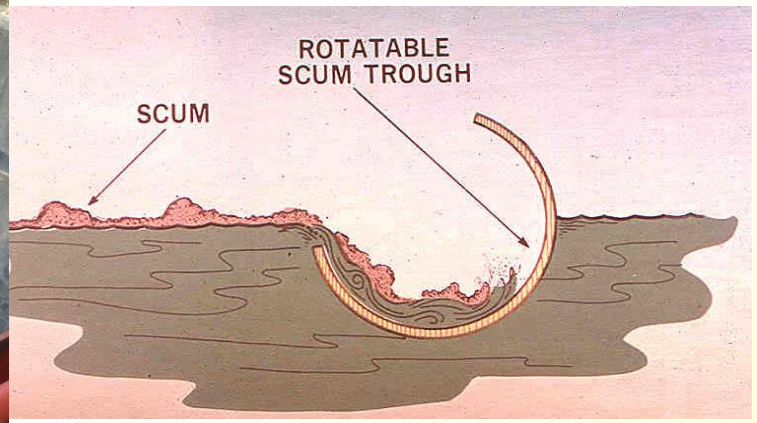
Types of Clarifiers – Rectangular

Scum Removal



Types of Clarifiers – Rectangular

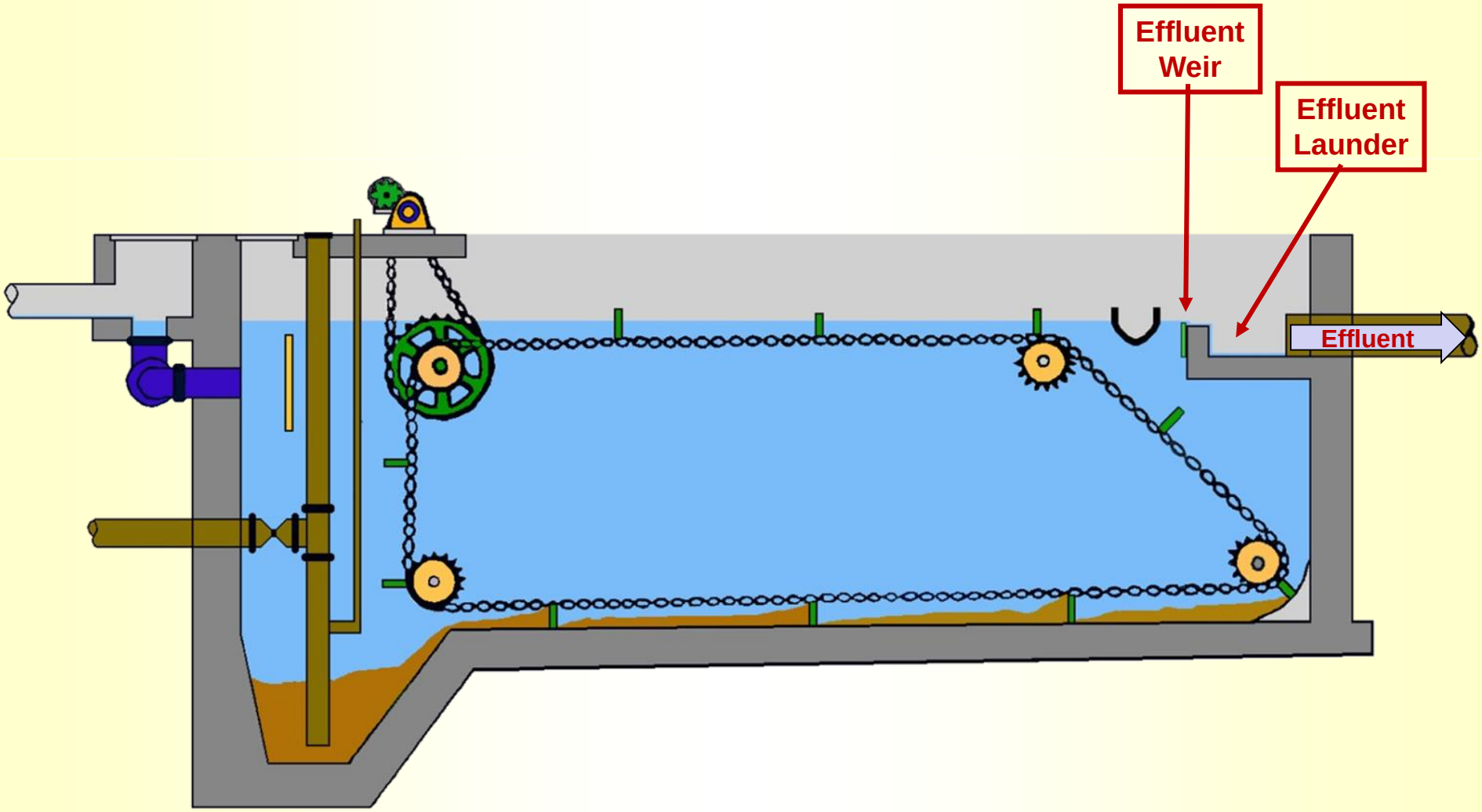
Scum Removal



Types of Clarifiers – Rectangular

Scum Removal

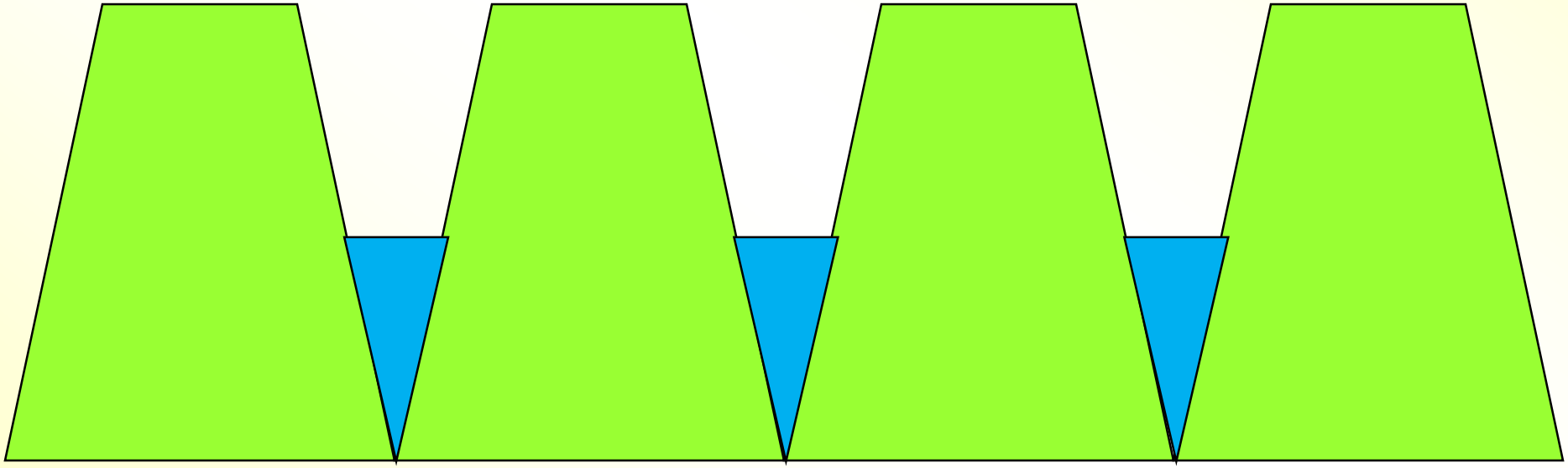
Types of Clarifiers – Rectangular



Types of Clarifiers – Rectangular

Effluent Weir – “V Notch”

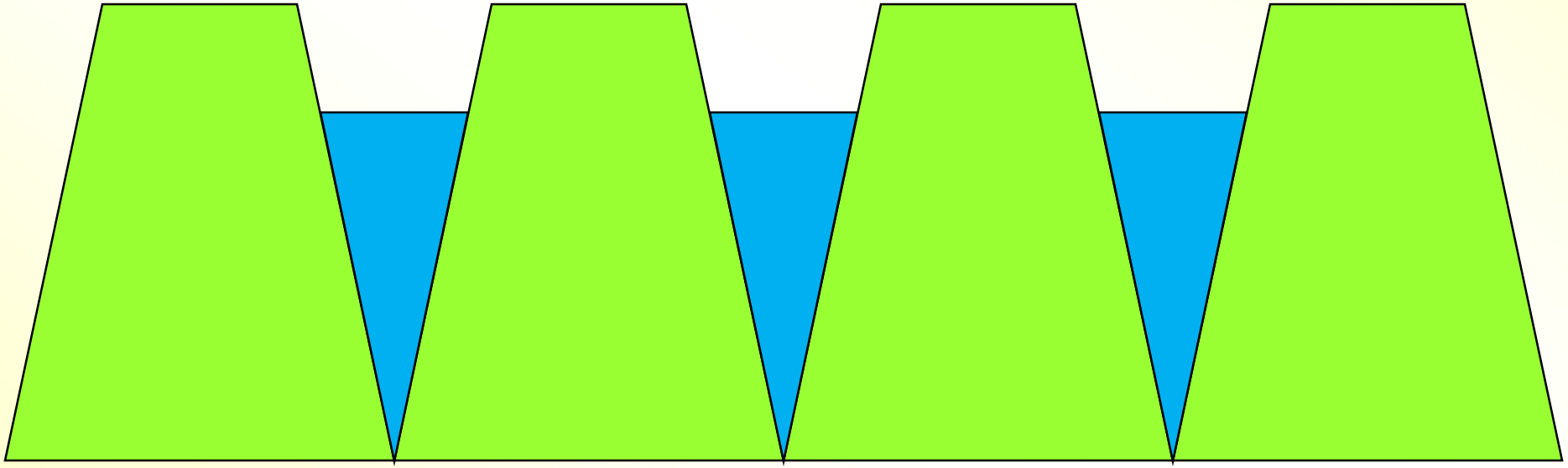
Flow = Velocity X Area



Types of Clarifiers – Rectangular

Effluent Weir – “V Notch”

Flow = Velocity X Area



As Flow Increases, Area Increases

And As Area Increases, Velocity Decreases

Types of Clarifiers – Rectangular

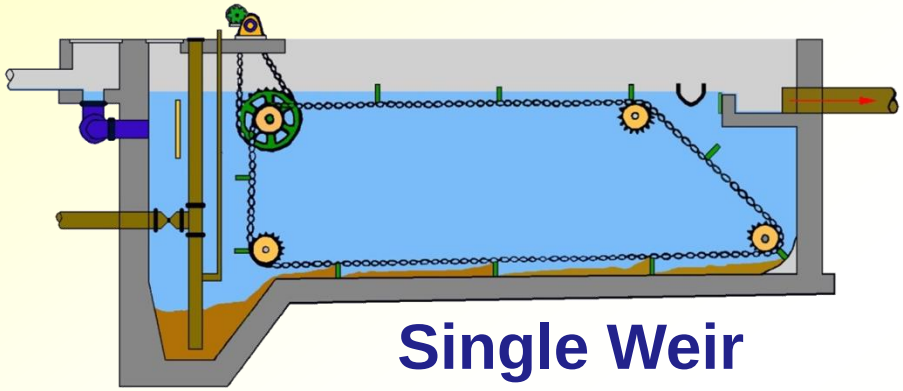
Effluent Weir – “V Notch”

Helps Keep Velocity Constant

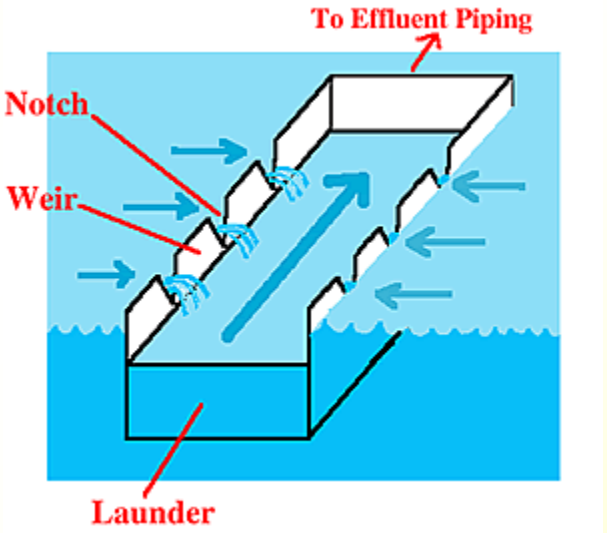
Reduces Solids Build-up Behind Weir

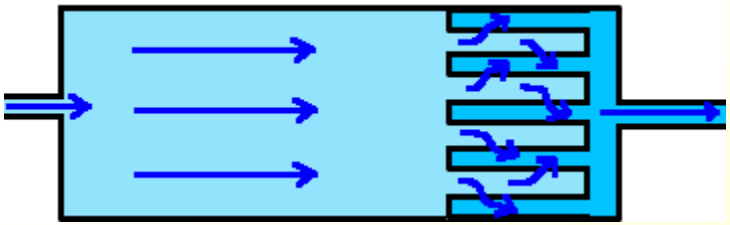
Types of Clarifiers – Rectangular

Effluent Weirs



Single Weir



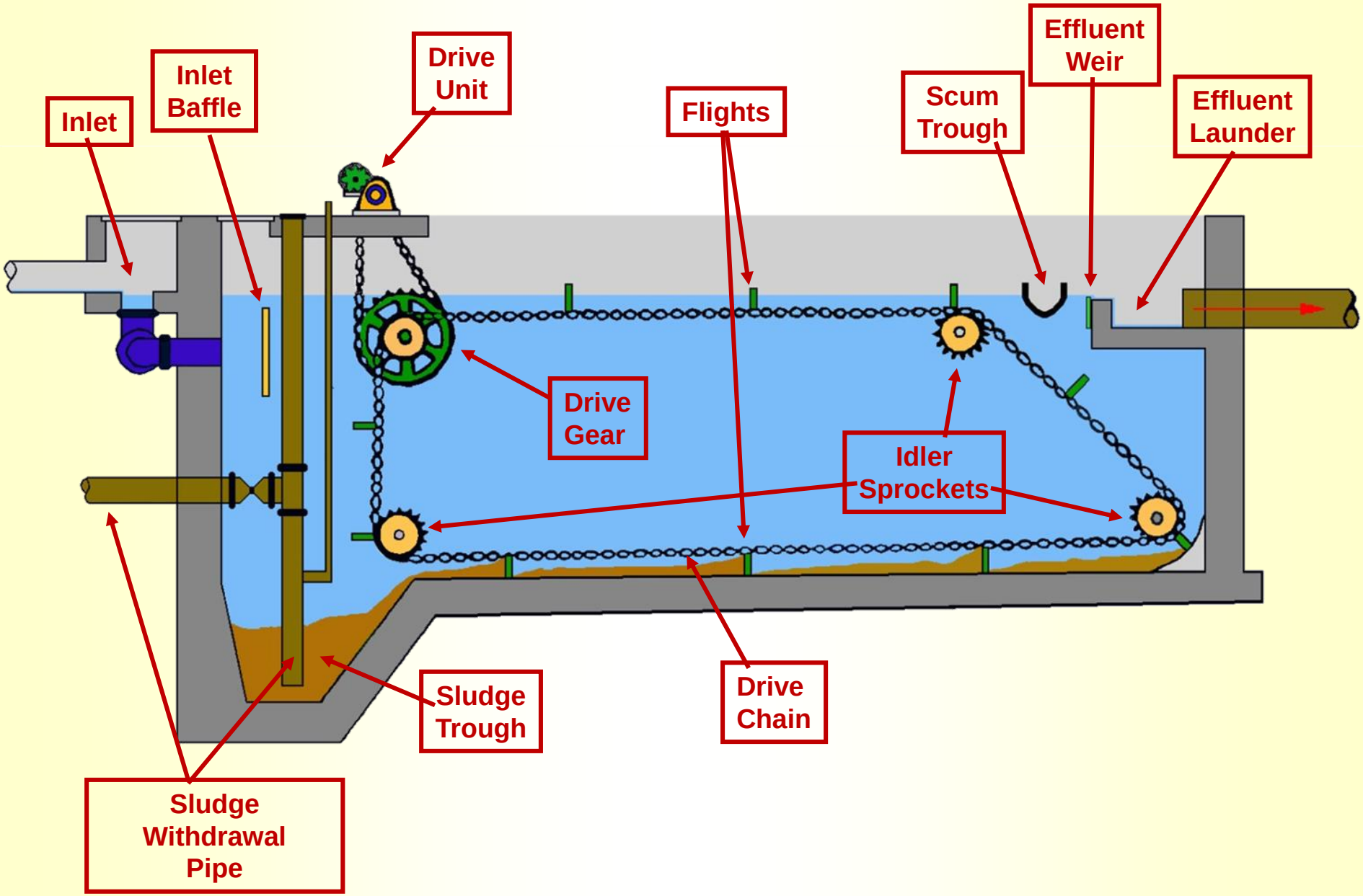


Finger Weirs

Types of Clarifiers – Rectangular

Effluent Weirs

Types of Clarifiers – Rectangular



Secondary Rectangular Clarifiers – Most Important

Monitor for Short Circuiting

Visual Observation

Flow Over Weir

Solids Over Weir

Dye Testing

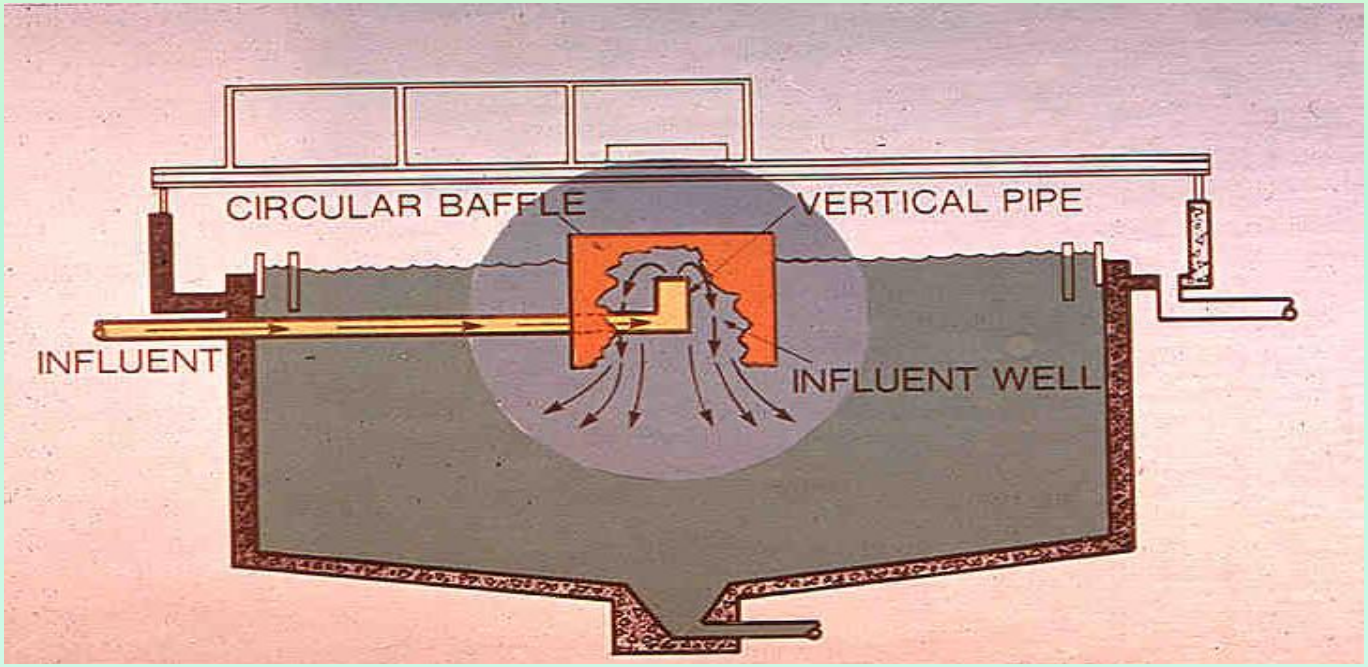
Consider Baffles

Circular Clarifiers

Circular Clarifier

Circular Clarifier

Influent typically enters the basin from the center rather than from one end.



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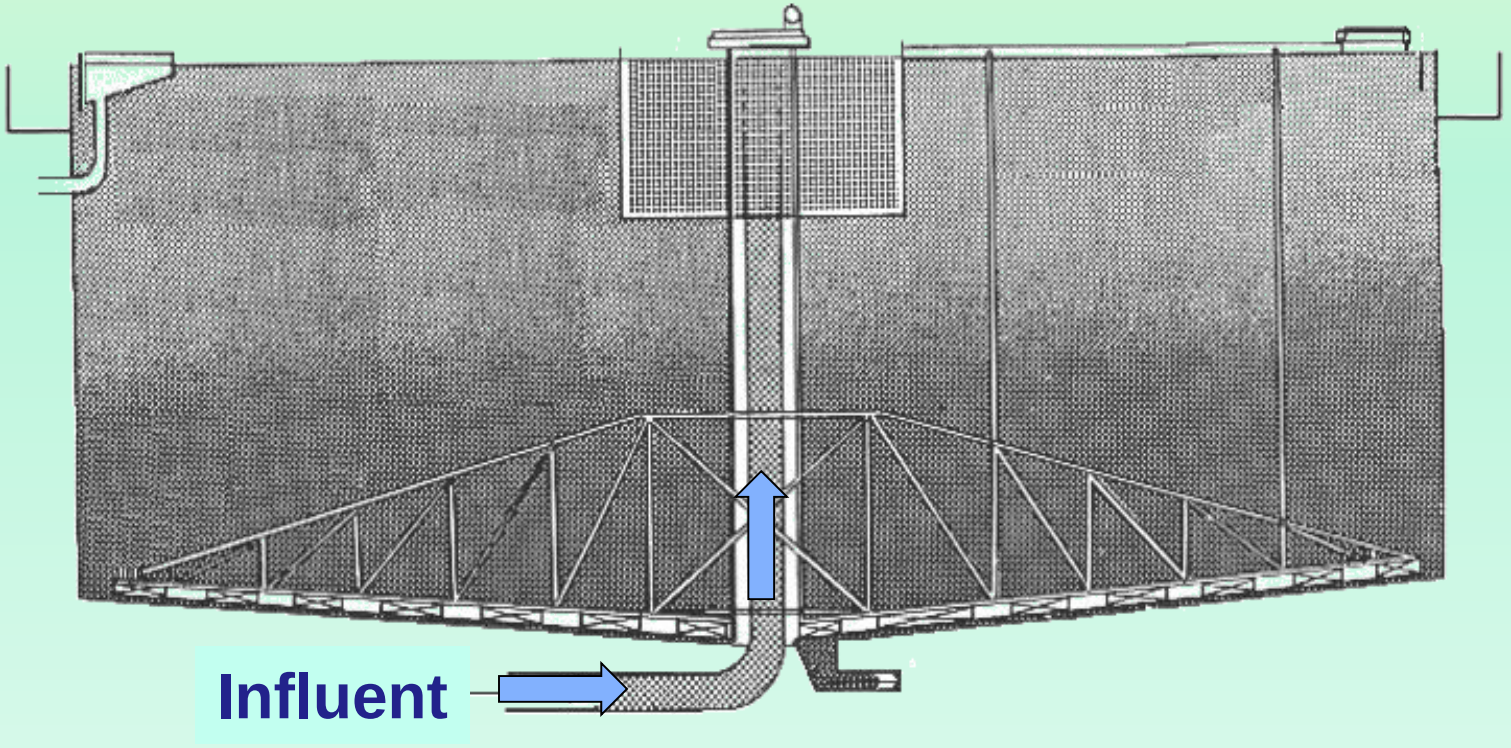
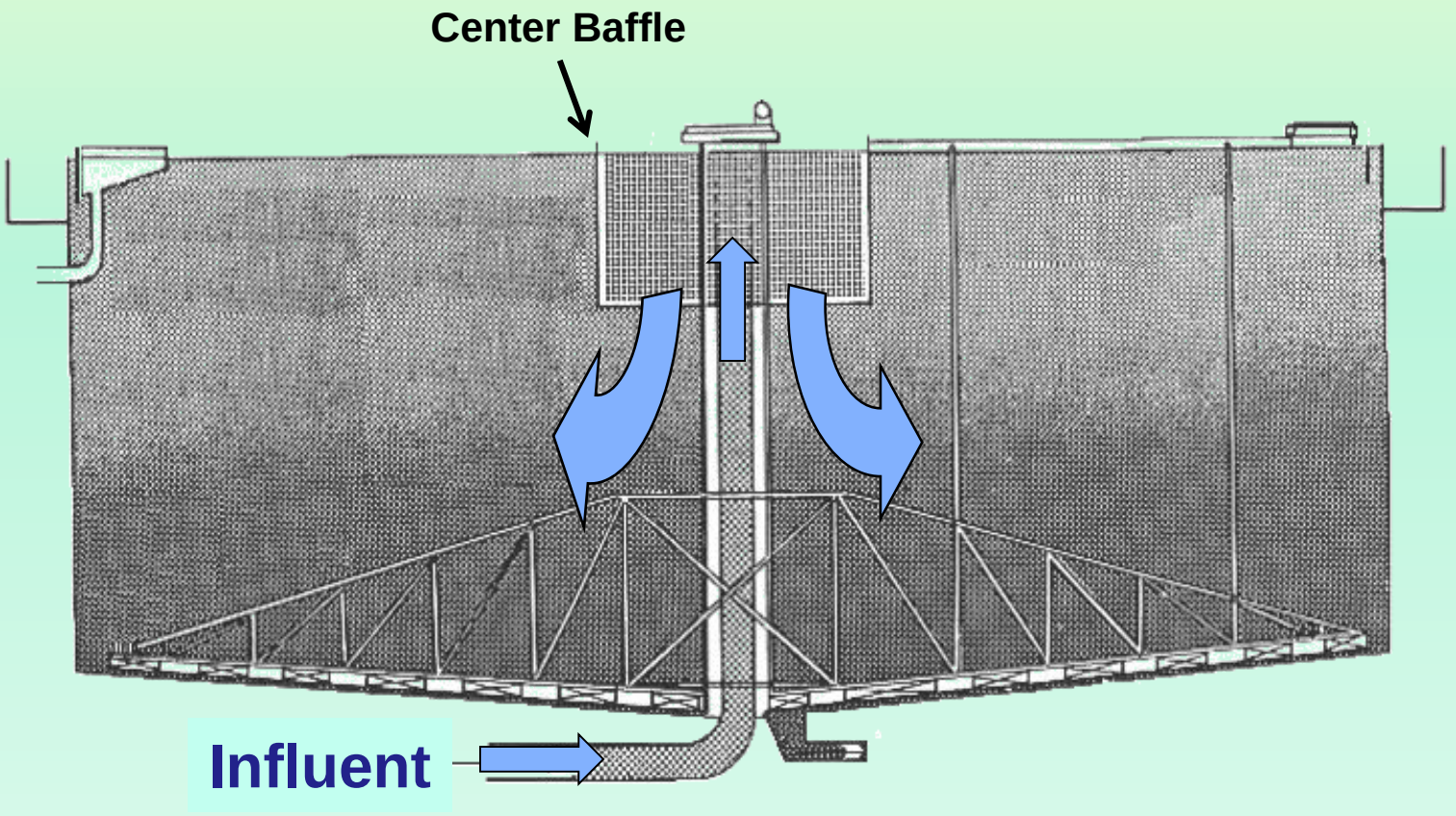


Circular Clarifier

A Circular Baffle Directs Flow



Circular Clarifier

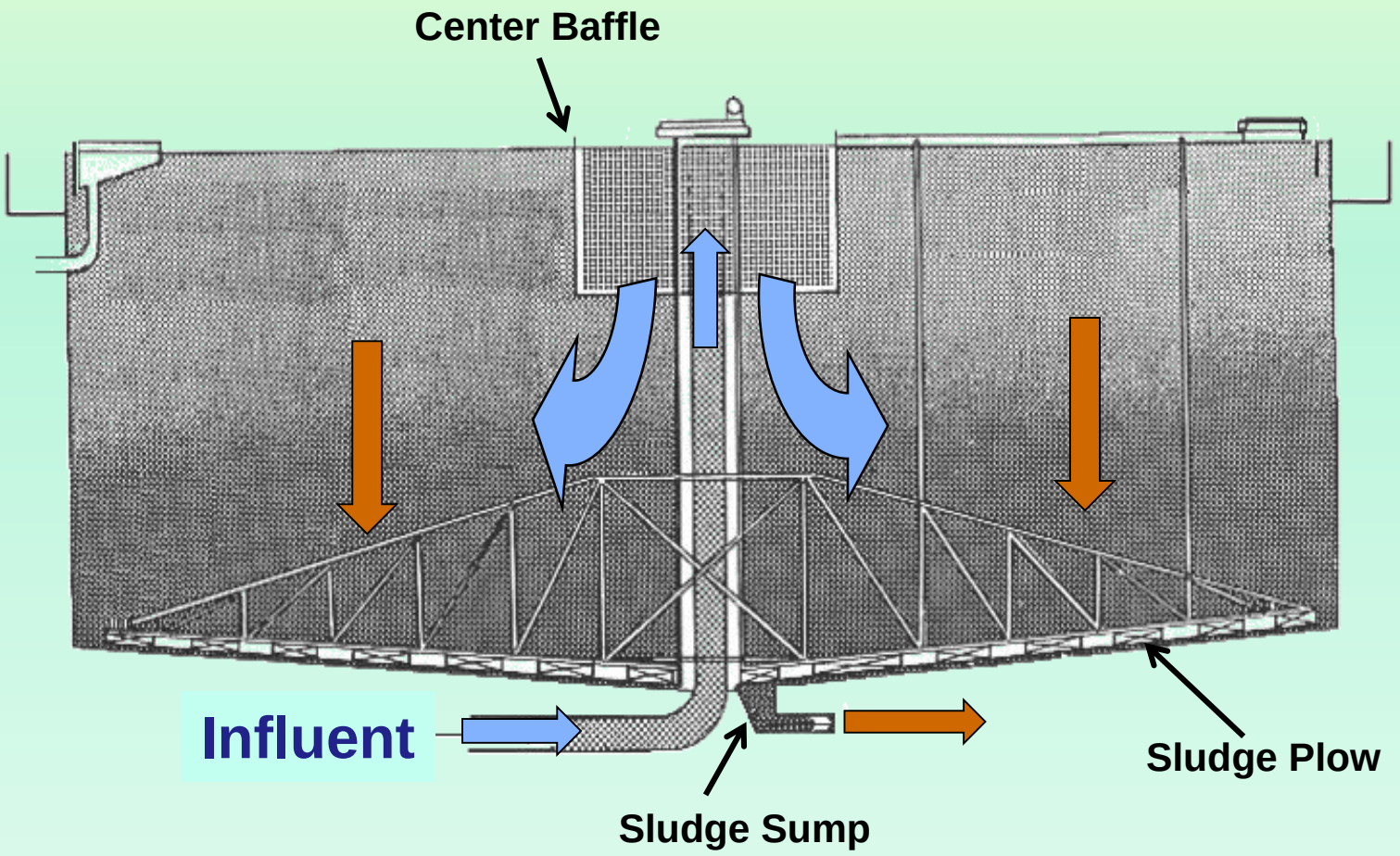
A Circular Baffle Directs Flow

Circular Clarifier

Solids Settle

Scraped to Sump

Removed by Pumping



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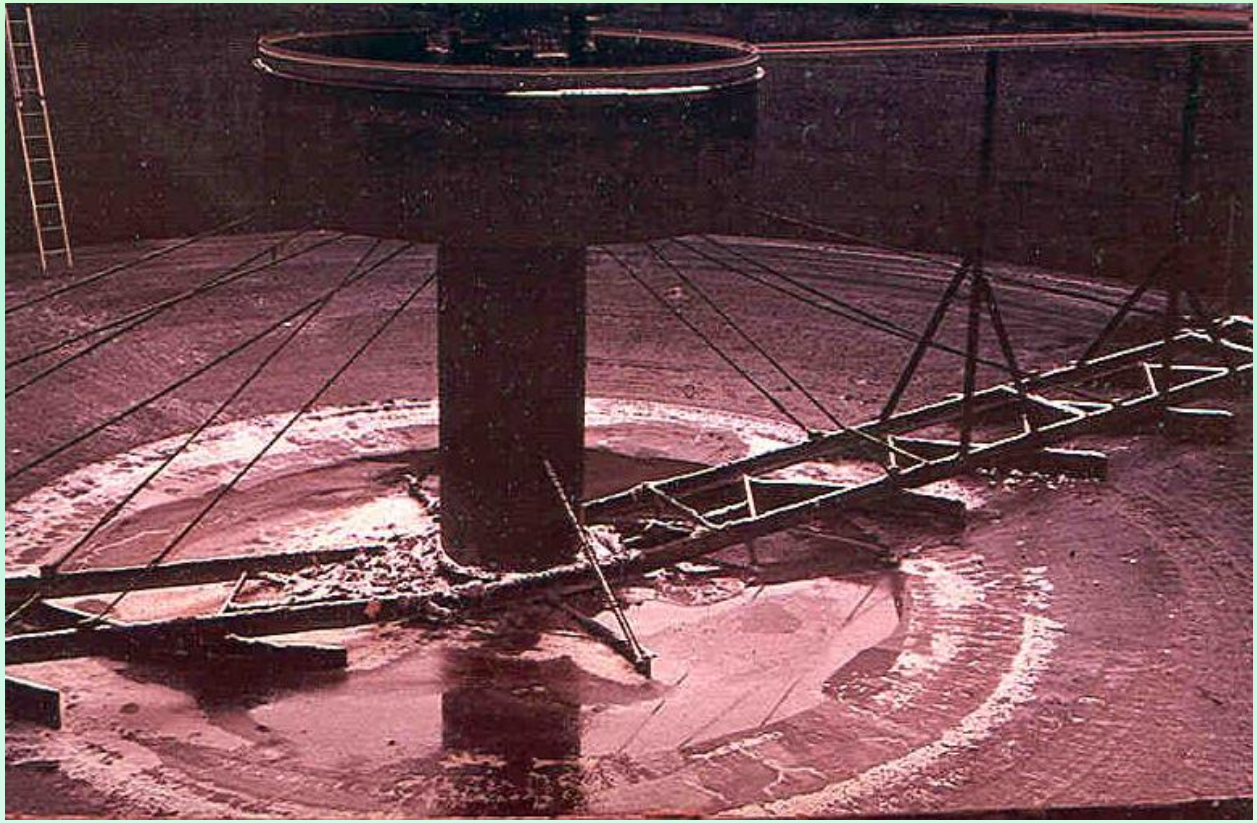


Circular Clarifier

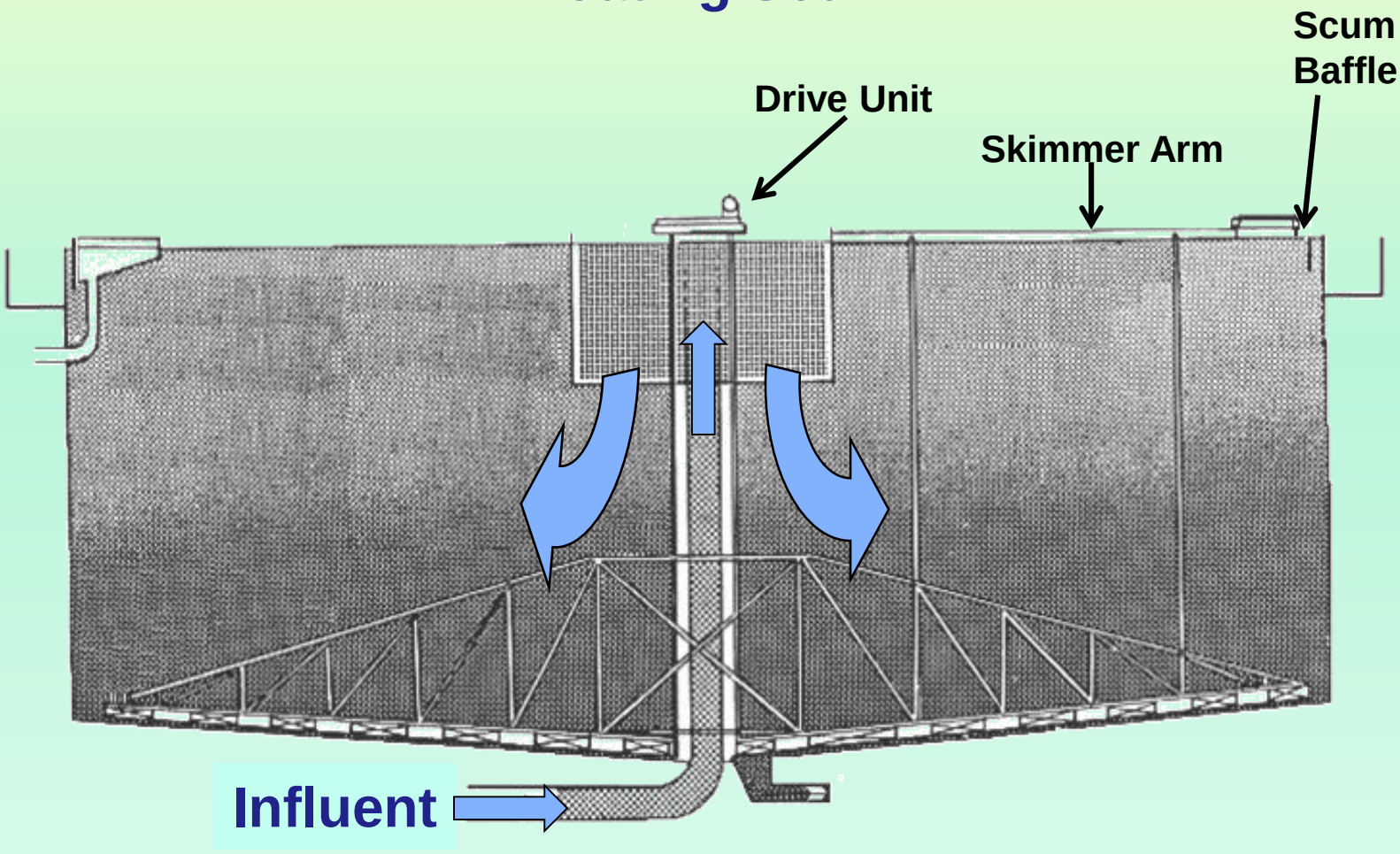
Solids Settle

Scraped to Sump

Removed by Pumping

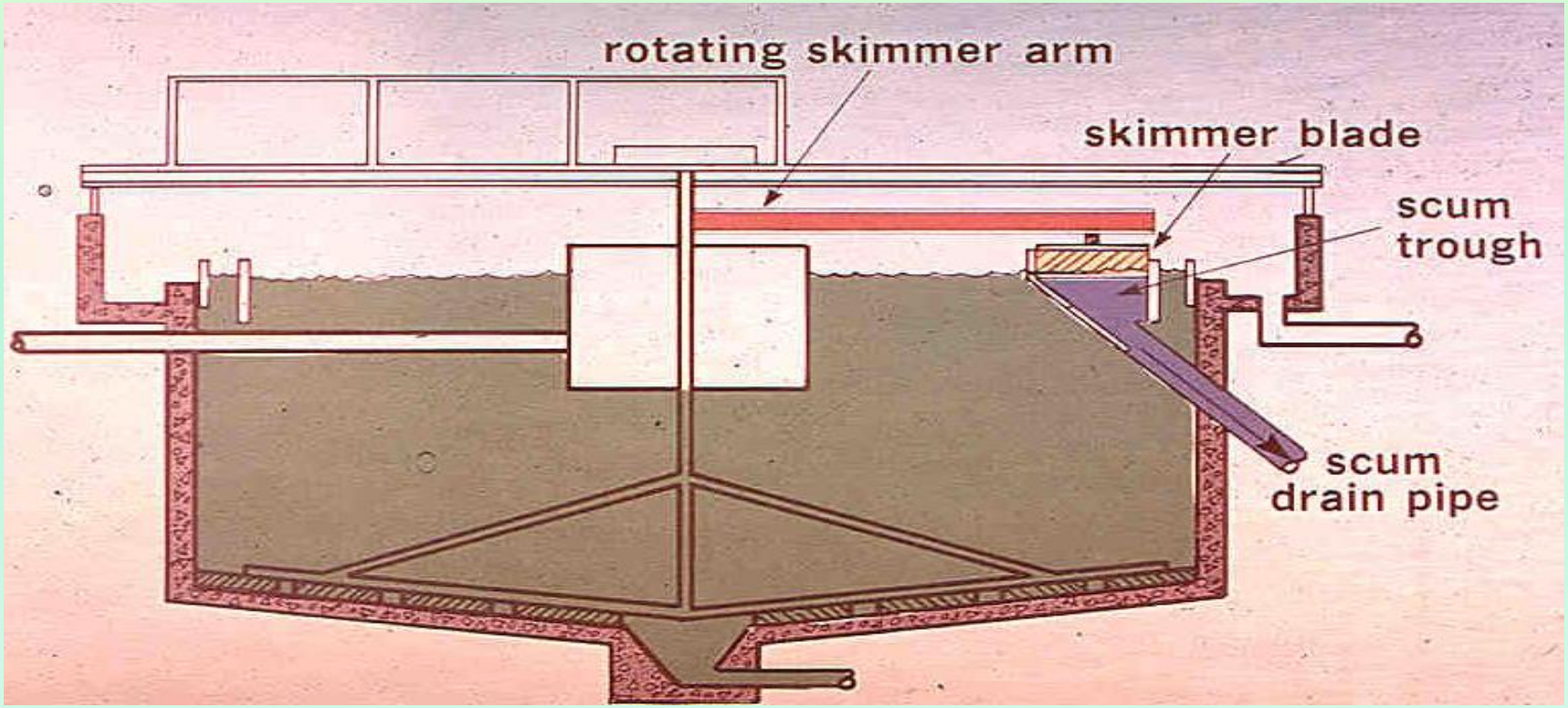
Circular Clarifier

Drive Mechanism Also Drives Skimmer Arm to Remove Floating Scum



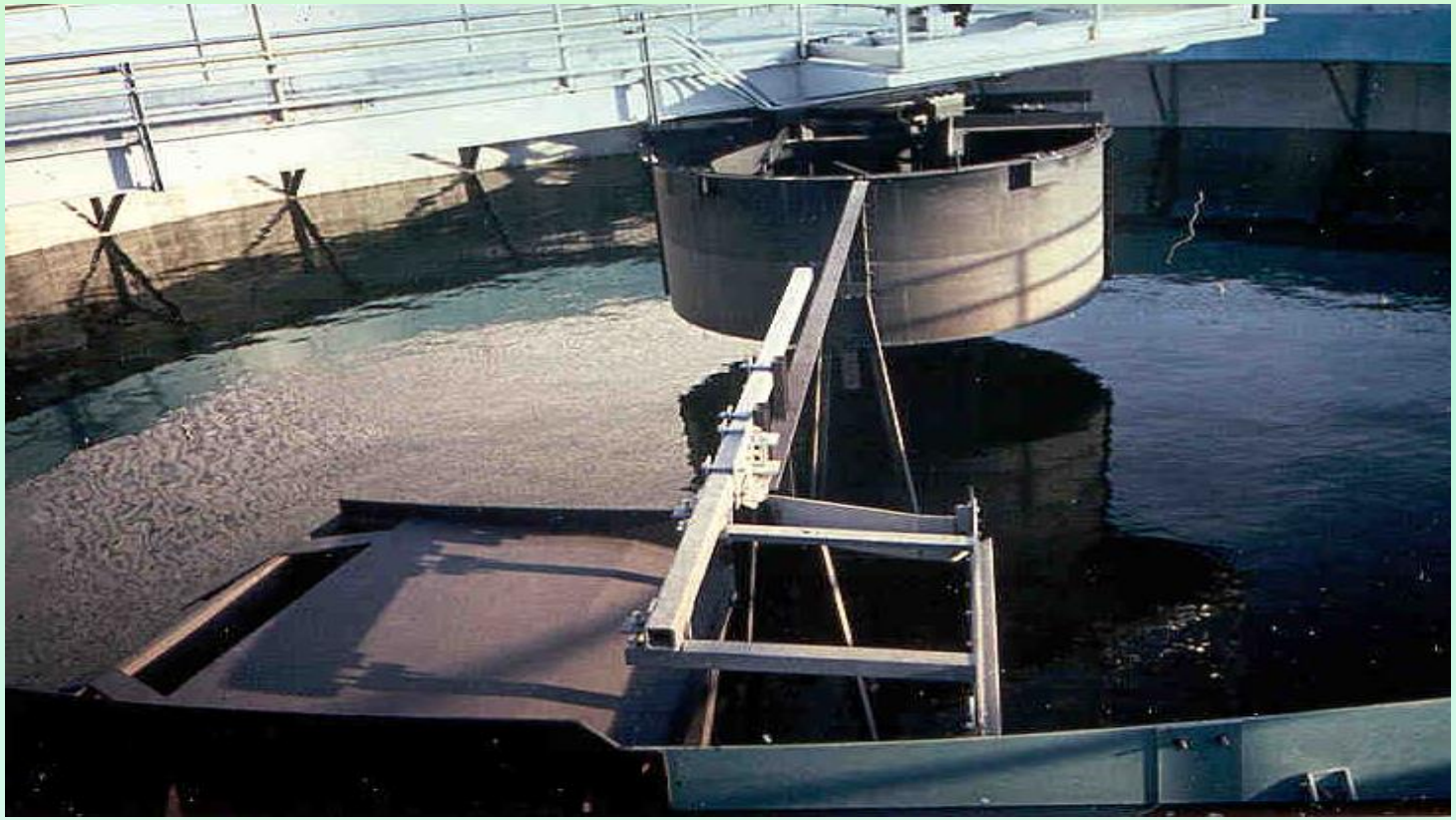
Circular Clarifier

Drive Mechanism Also Drives Skimmer Arm to Remove Floating Scum



Circular Clarifier

Drive Mechanism Also Drives Skimmer Arm to Remove Floating Scum



Circular Clarifier

Drive Mechanism Also Drives Skimmer Arm to Remove Floating Scum

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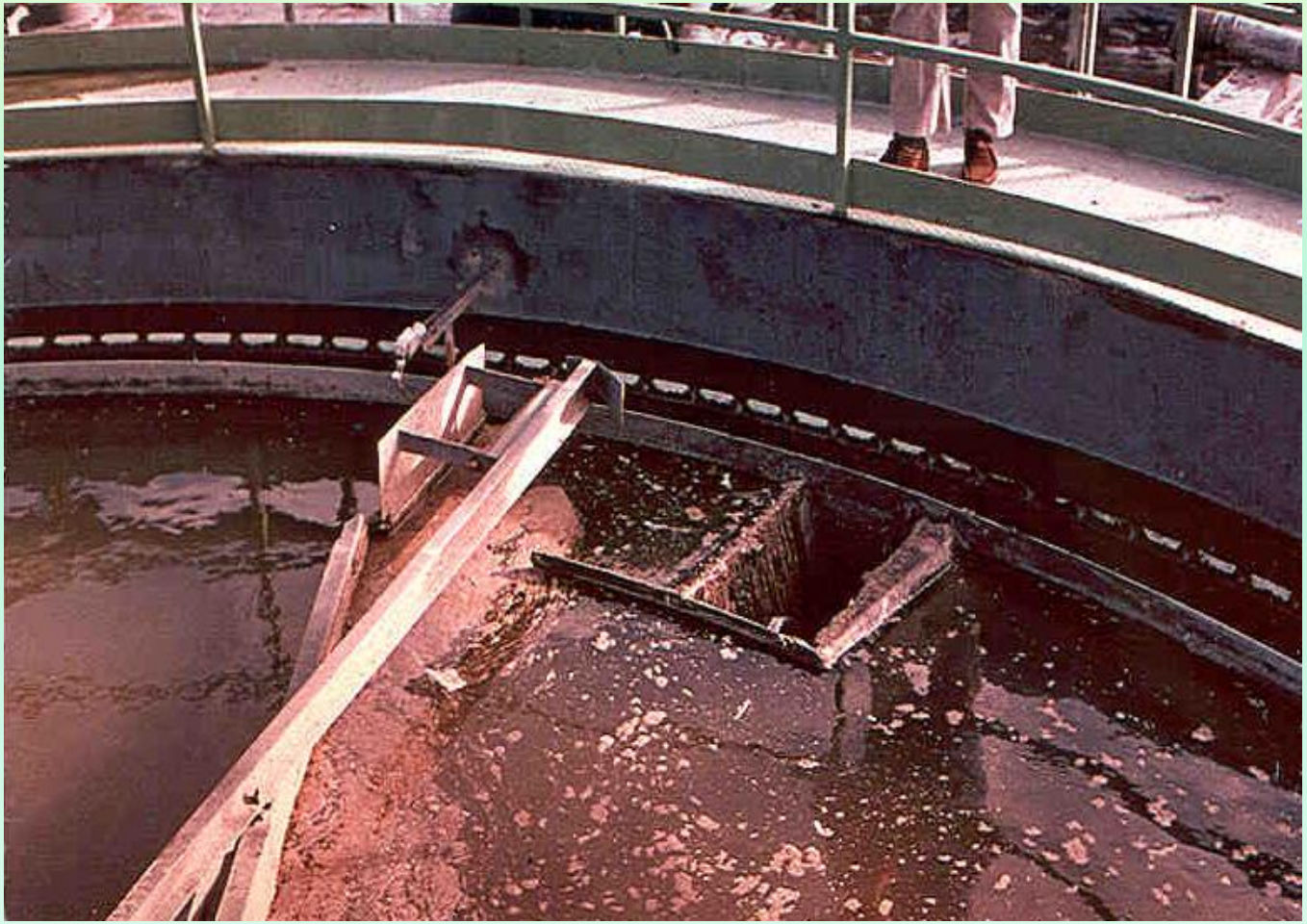
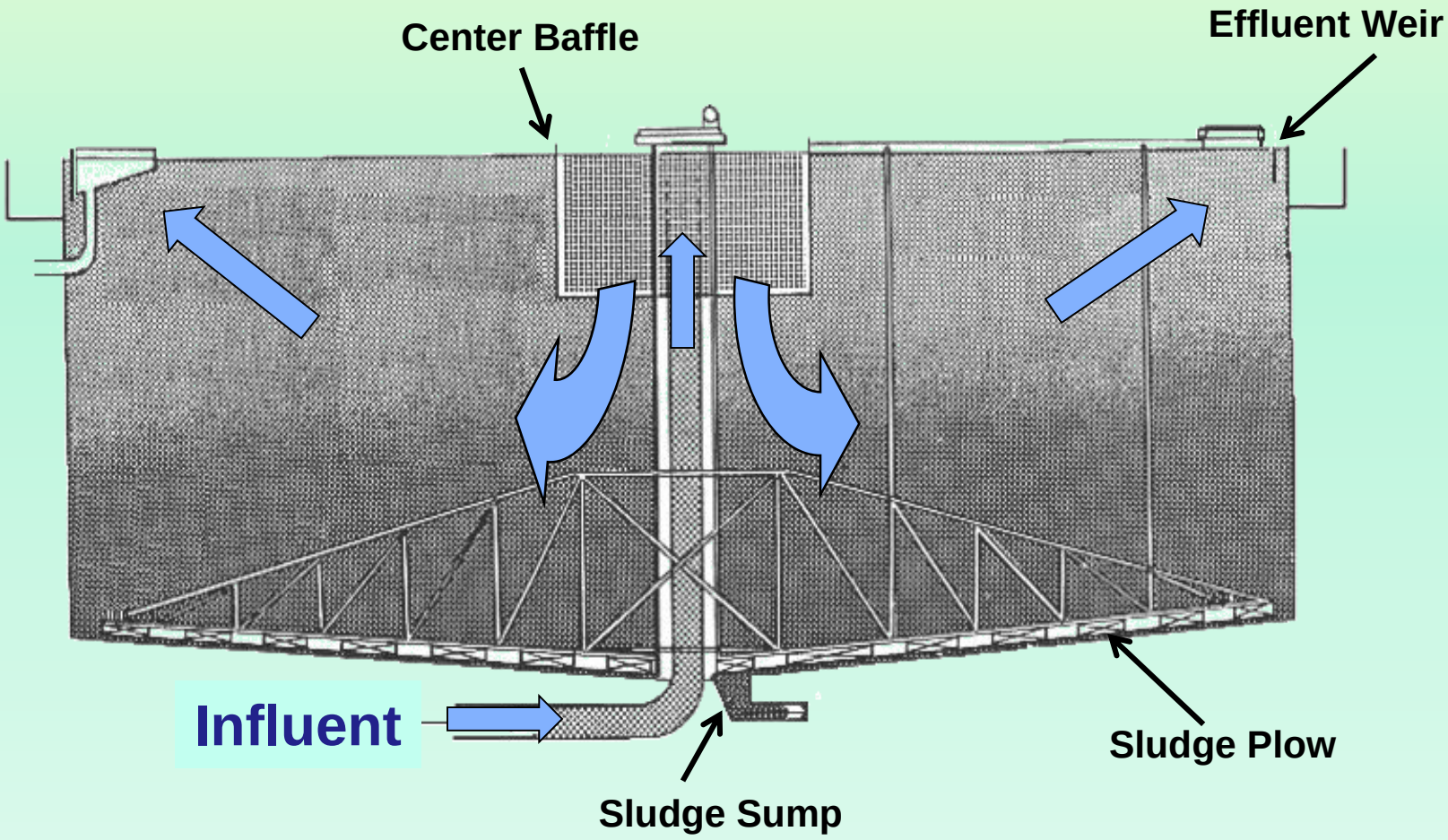
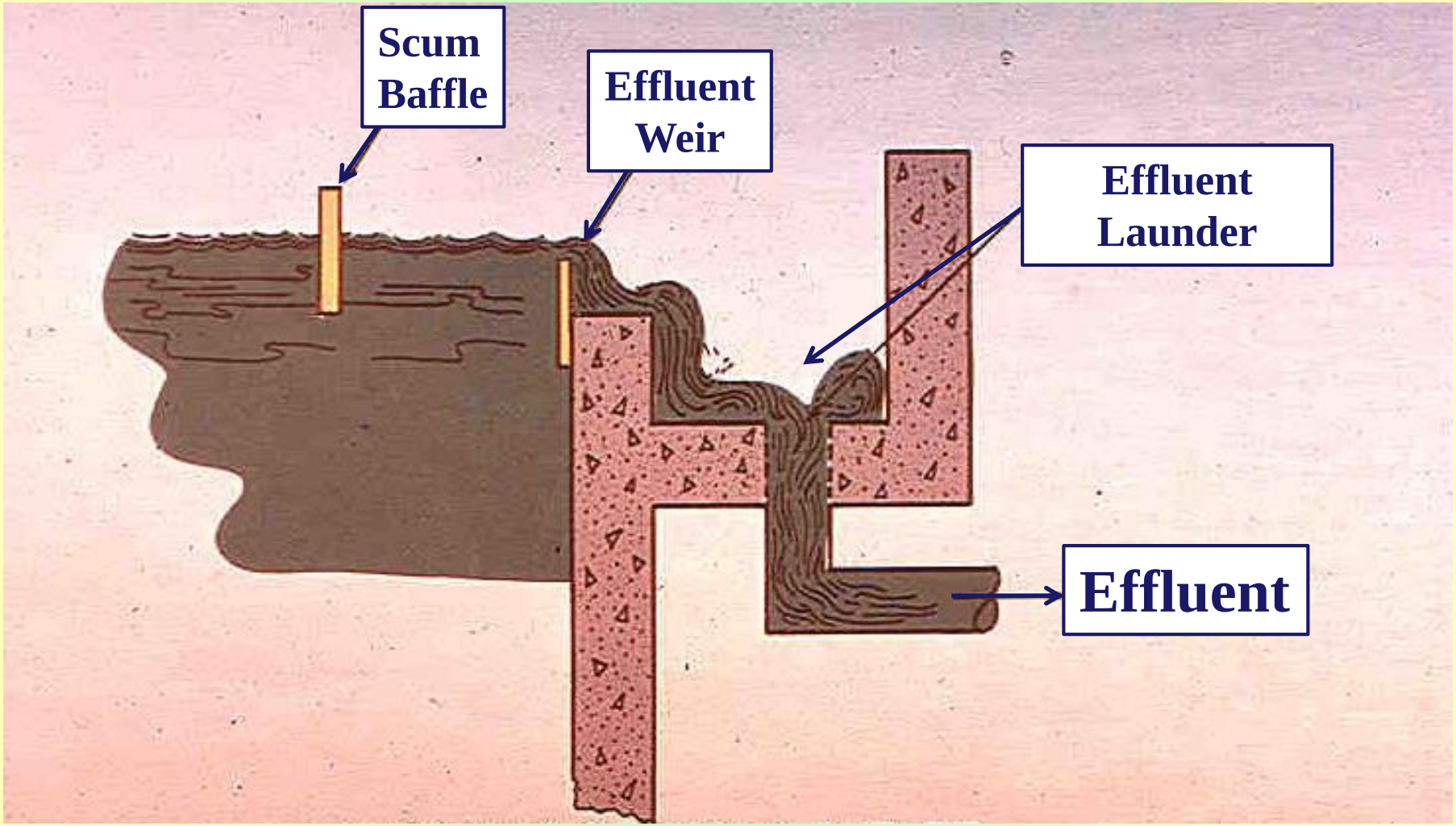


Circular Clarifier

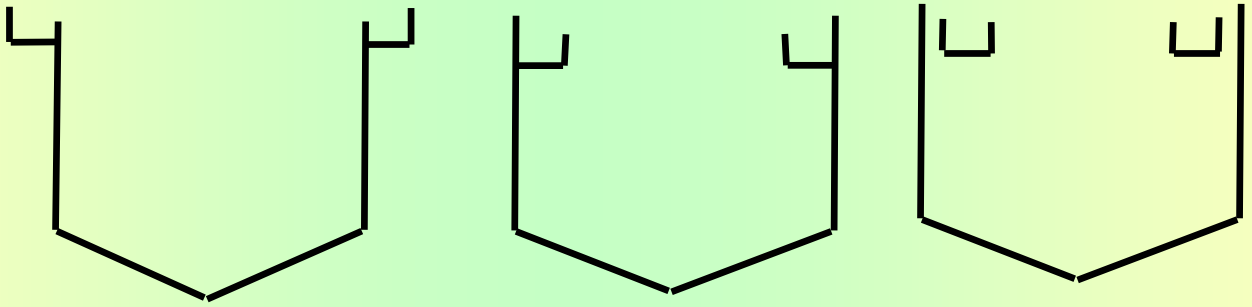
The Water Flows to the Effluent Weir Around the Circumference of the Clarifier





Circular Clarifier Outlet

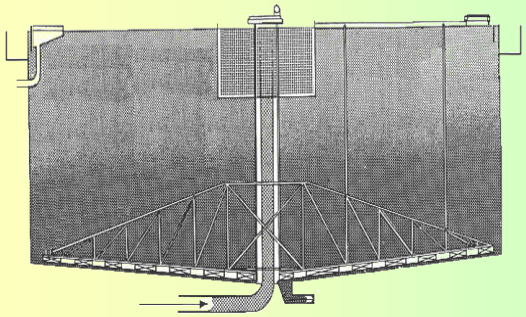
The Launder and Weir May Be



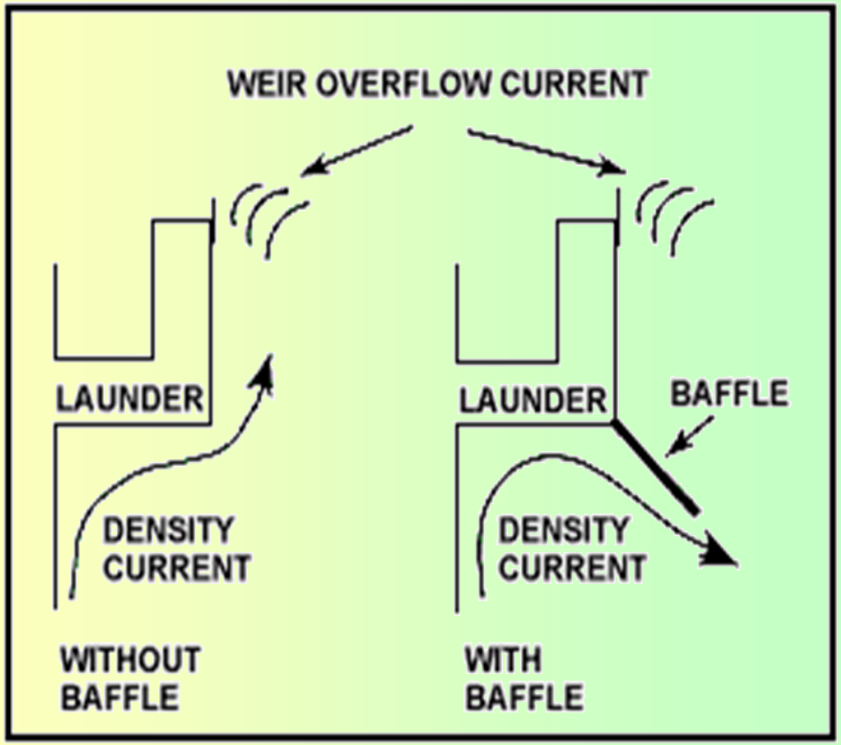
1 Outer Wall

2 Inner Wall

3 Suspended In Clarifier

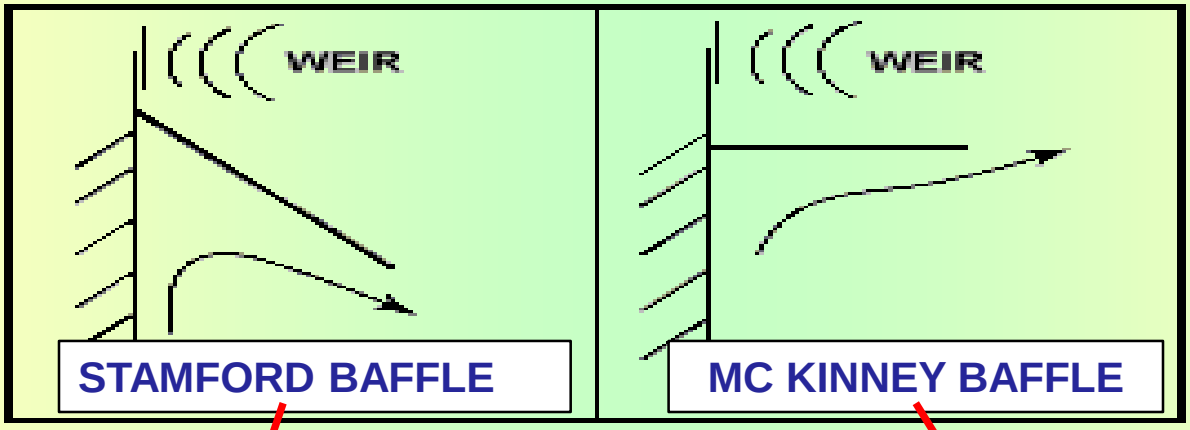


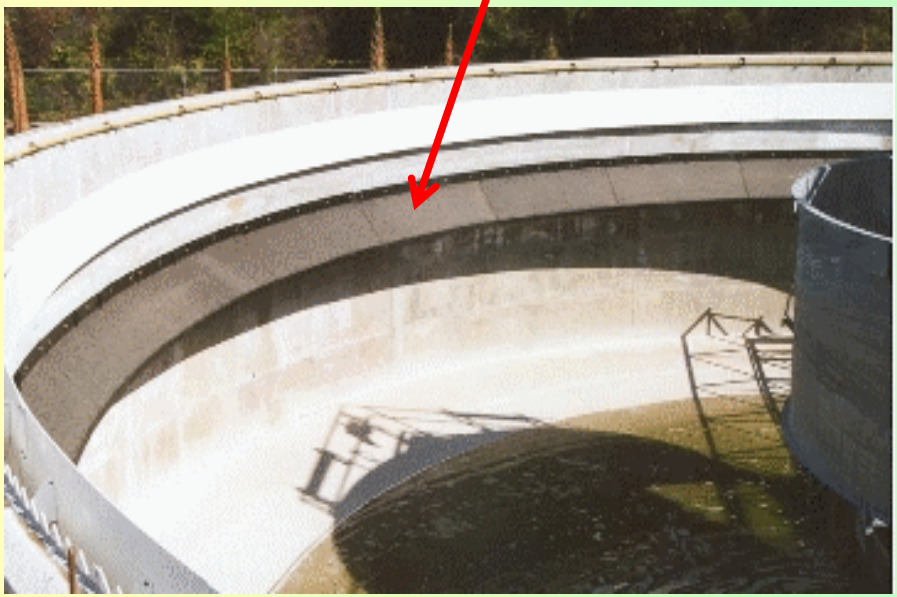
Effluent Launder/Weir Inside Clarifier (#2) Can Create Water Current



- **Loss of solids over weir.**
- **Baffles used to redirect & slow water currents.**

Other Clarifier Baffles





Clarifier Short Circuiting

- **Missing or poor effluent baffling**
- **Uneven effluent weirs**
- **Plant growth or thrash in effluent weirs**
- **Temperature stratification between influent & clarifier water temperatures.**

Clarifier Variations

Clarifier Variations

Rectangular Tank

Circular Sludge Collection and Skimming

“Squirqular” Clarifier

Clarifier Variations

Peripheral Feed
Peripheral Discharge

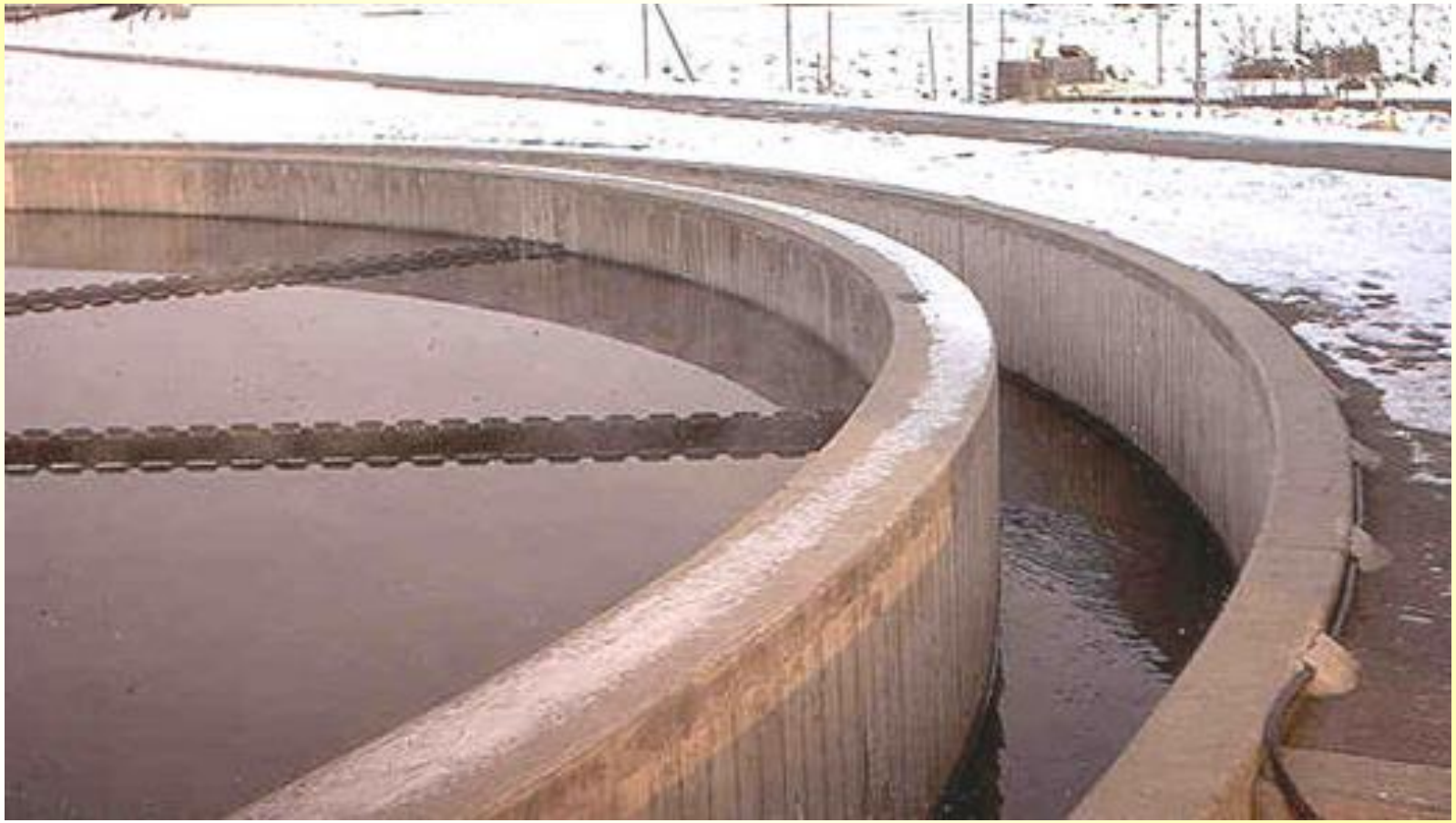
Clarifier Variations

Peripheral Feed

Center Discharge

Clarifier Variations

Radial Discharge **Peripheral Feed**

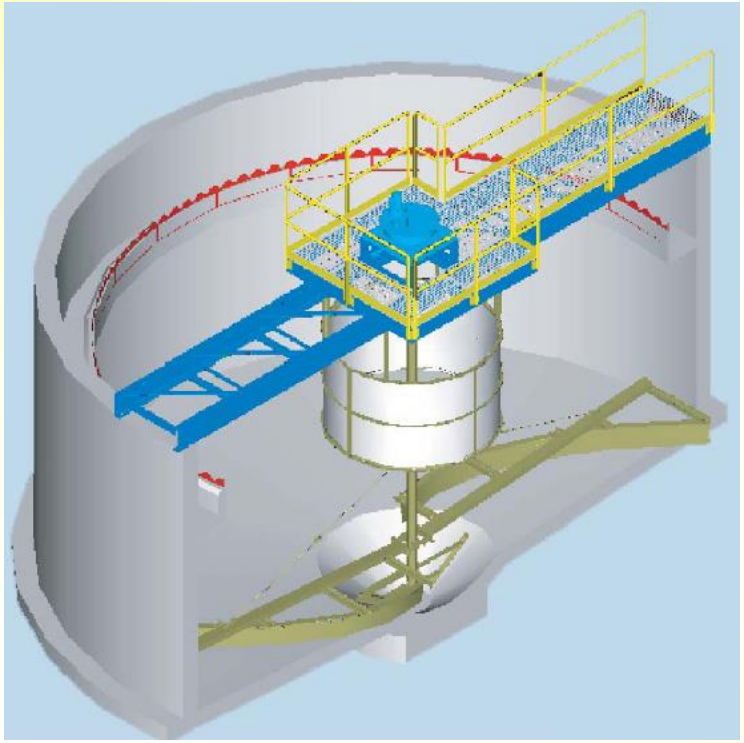


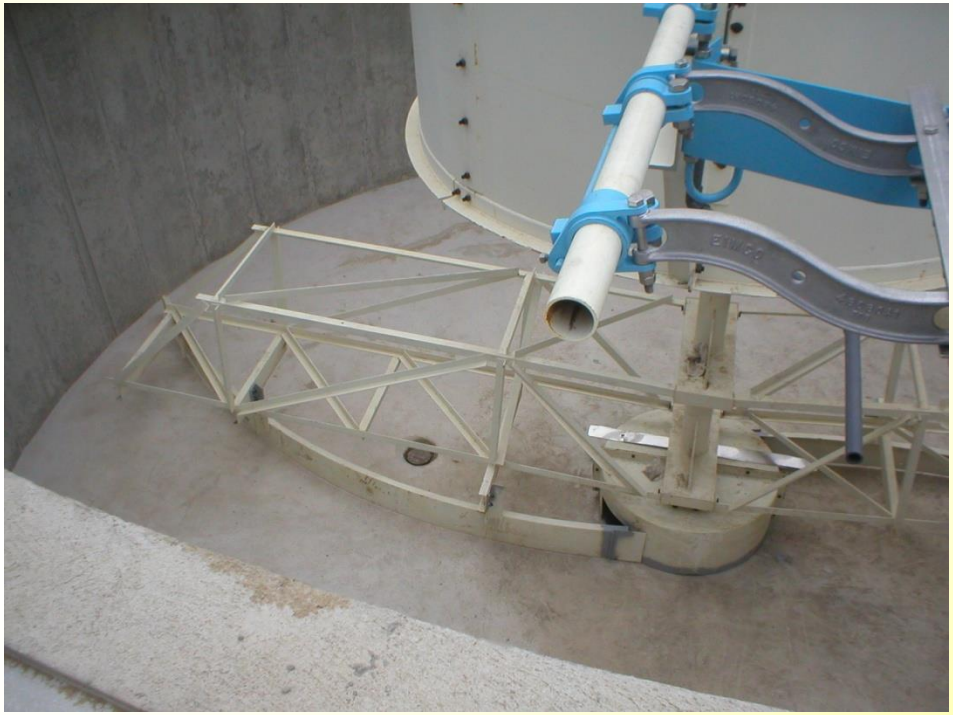
Clarifier Variations

Tow Bro Clarifier

Clarifier Variations

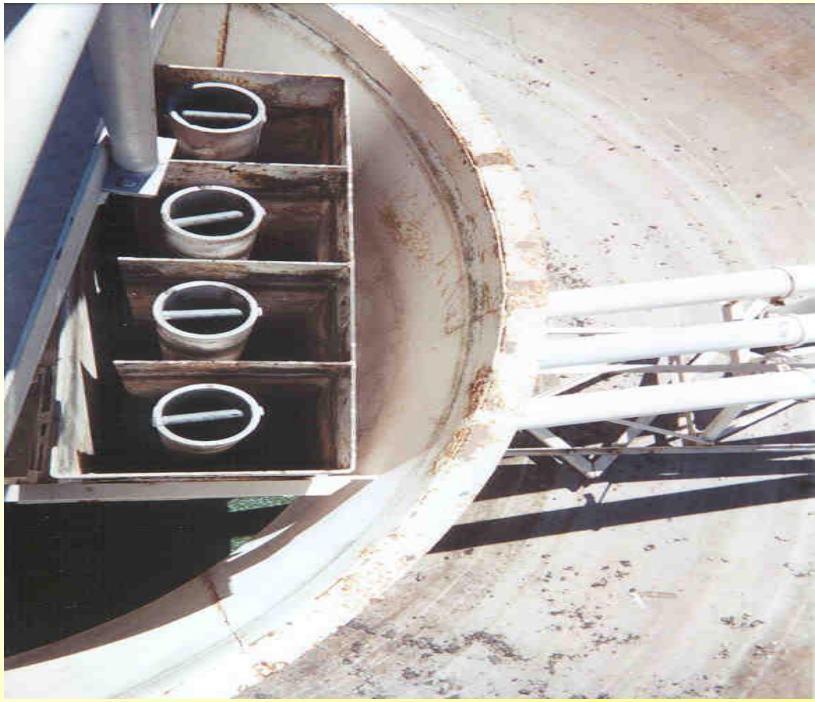
Spiral Sludge Collector





Clarifier Variations

Telescoping Valves for RAS Return



Clarifier Variations

Many Others

Each Designed to Address Particular Concern

Clarifier Operation

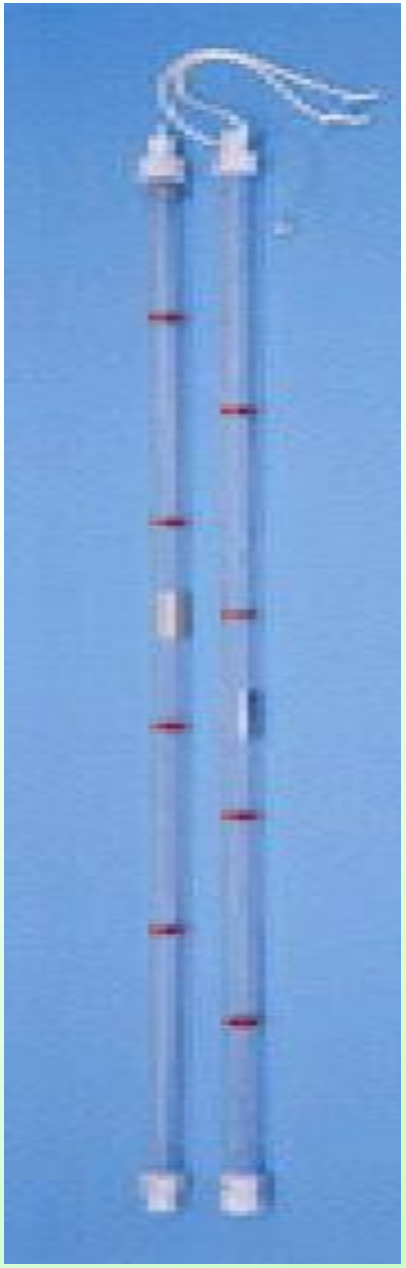
Routine Inspection & Maintenance

Drive Mechanism

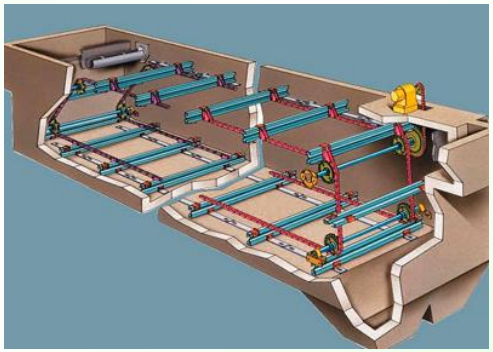
- Lubrication (Manufacturers Specs.)
- Observe Proper Operation (2/Day)

Clarifier Operation

Sludge Judge Daily (Each Shift)



Clarifier Operation



Rectangular Clarifiers

Sludge Collection System

Operating Smoothly

Floating Sludge

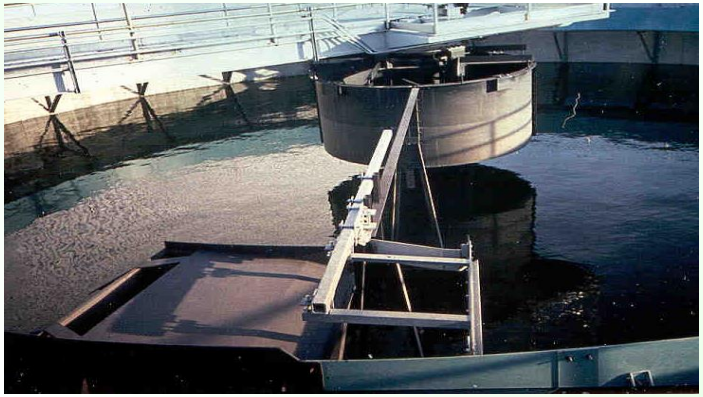
Frequent Shear Pin or Breaker Failure

Circular Clarifiers

Skimmer/Sludge Collector

Operating Smoothly

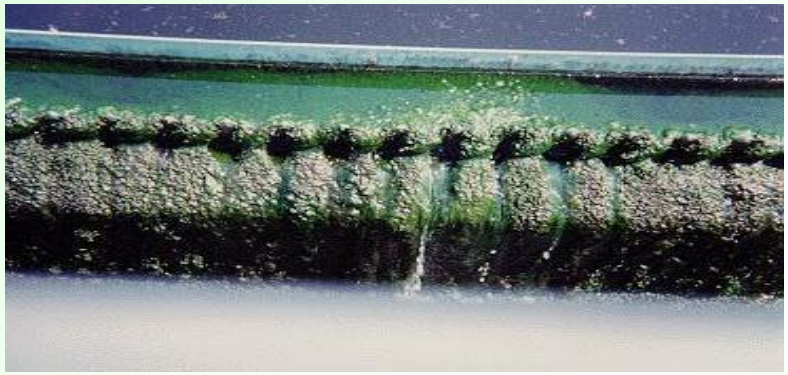
Scum Trough Plugged



Clarifier Operation

Cleaning

Weirs – Launder - Center Well

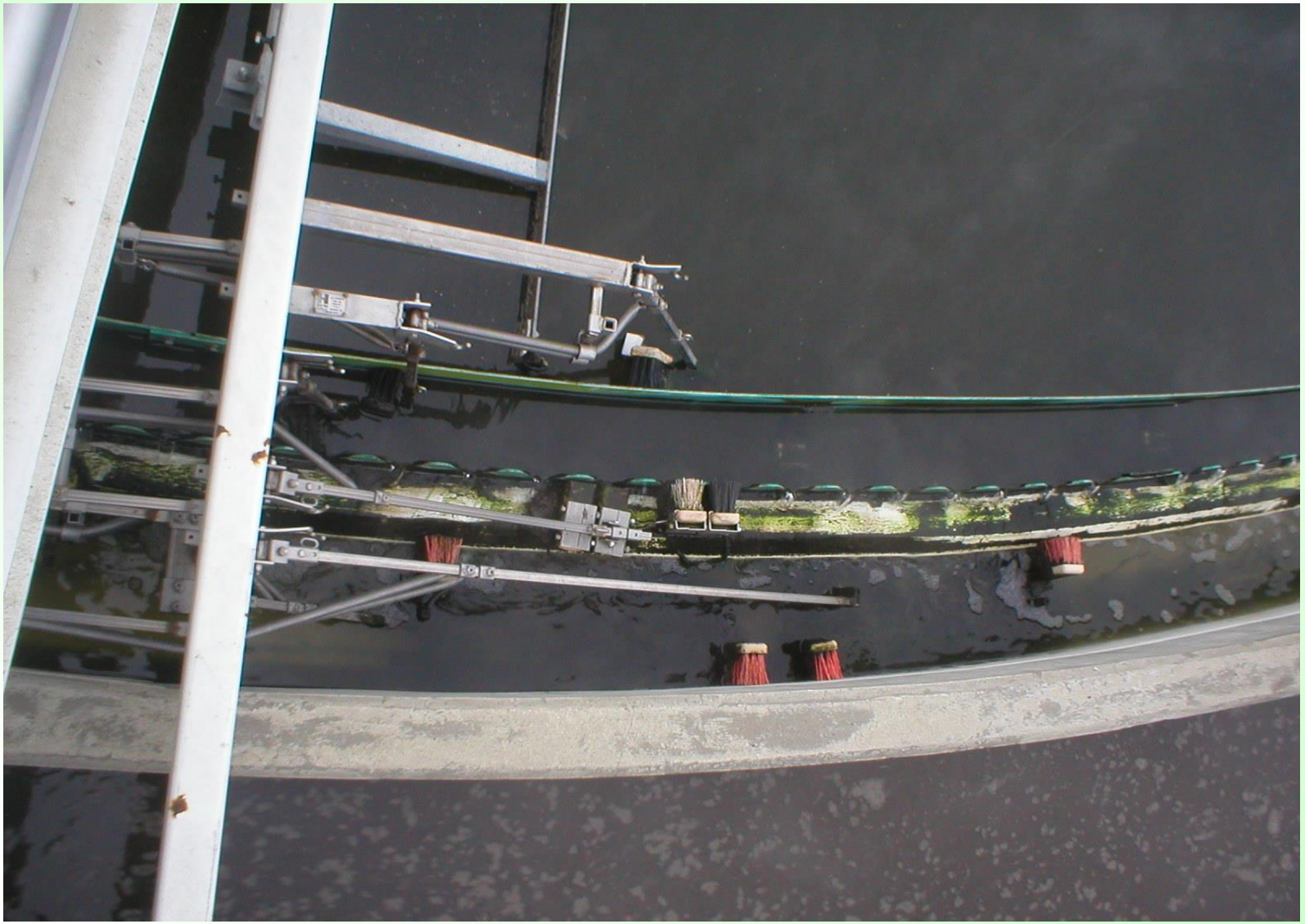


Clarifier Operation

The Hard Way

The Easy Way

Clarifier Operation



Clarifier Operation

Limit Growth ?

Clarifier Operation

Limit Growth ?

Covers Block Sunlight Limits Algae Growth

Clarifier Operation

Limit Growth ?

Covers Block Sunlight Limits Algae Growth

Provides Cold Weather Protection

Clarifier Operation

Monitoring for Short Circuiting

Visual Observation

- Flow Over Weir
- Solids Over Weir

Dye Testing

Clarifier Operation

Routine Inspection & Maintenance

Sludge Judge Daily (Each Shift)

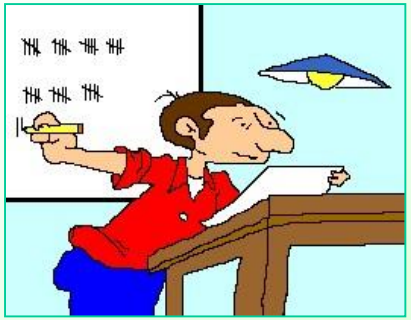
Cleaning

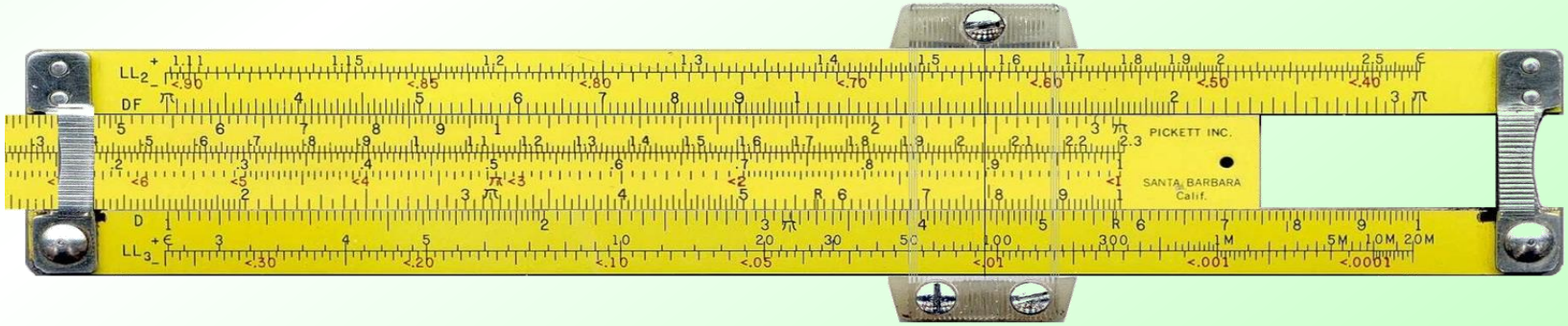
Monitoring for Short Circuiting

Clarifier Operation

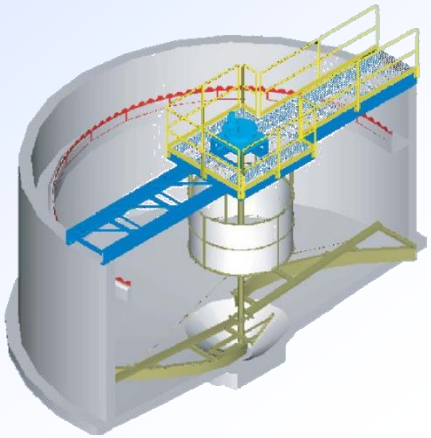
Also Includes
Calculating and Monitoring Loading

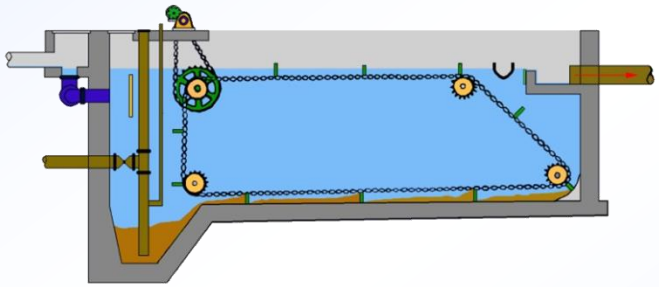
Detention Time
Surface Overflow Rate
Weir Overflow Rate
Solids Loading Rate

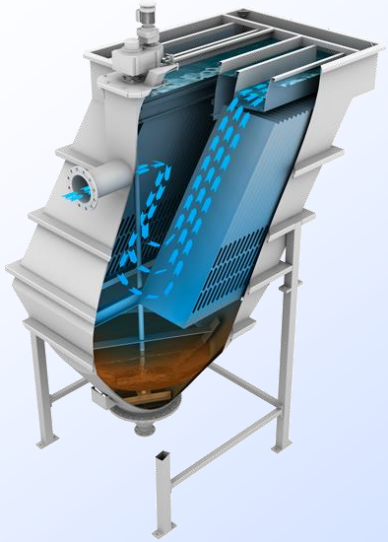




CLARIFIERS







Prepared By
Michigan Department of Environmental Quality
Operator Training and Certification Unit