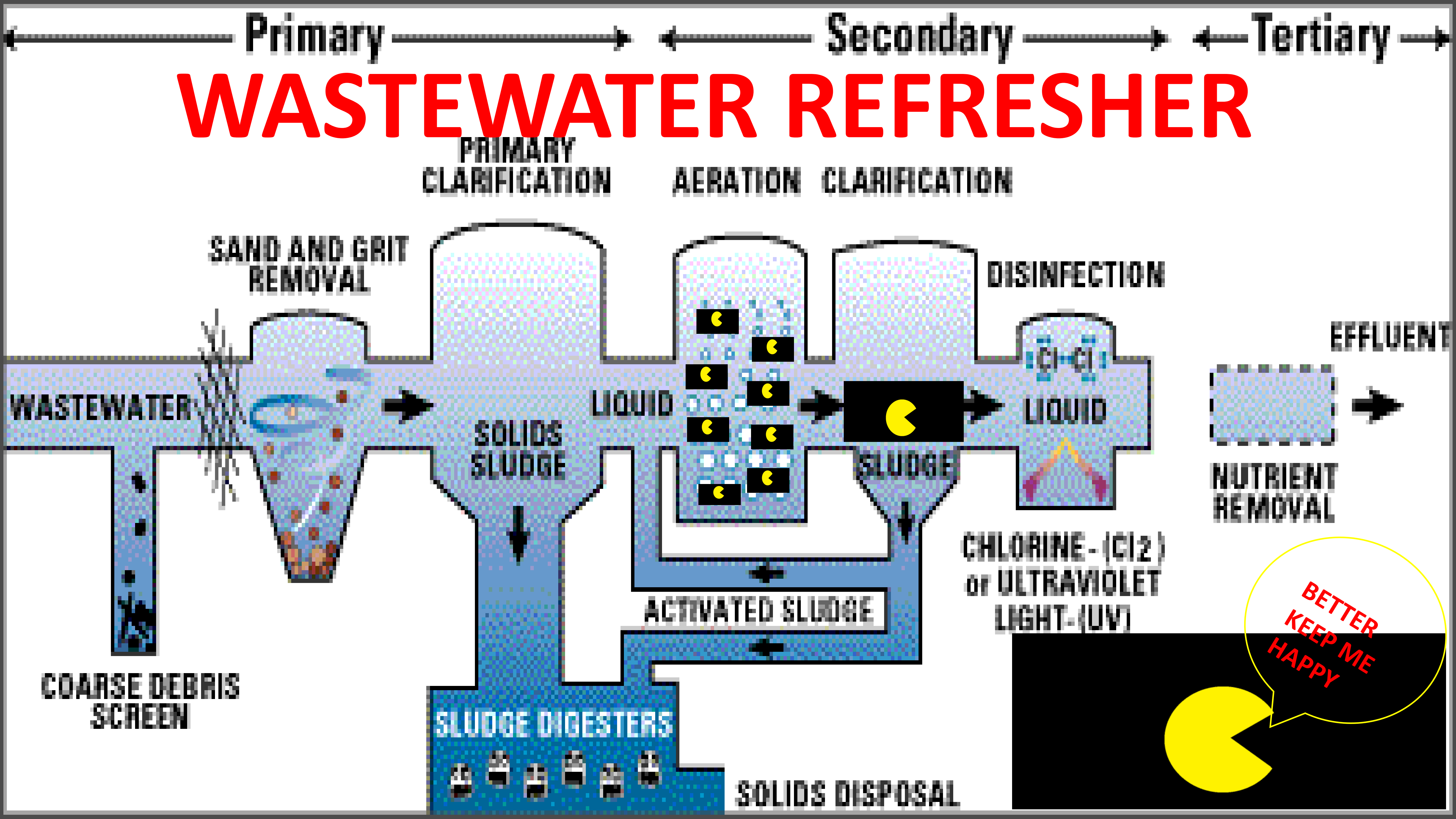
# WASTEWATER REFRESHER



# *Sewer conveying raw wastewater:*

A. No public gravity sewer conveying raw wastewater shall be less than 8 inches in diameter.

B. All sewers shall be designed and constructed to give mean velocities when flowing flow, of not less than 2.0 feet per second.

*Let's design a sewer pipeline for a 5 MGD flow*

$5.0\ MG \times \underline{1.55} = 7.75\ Ft^3/Second$

Where does 1.55 come from?

$$\frac{7.75\ Ft^3/Sec.}{X} = 2.0\ Ft/Sec.$$

$X = 3.875\ Ft^2\ /\ .785 = 4.936\ D^2$

$\sqrt{4.936} = 2.22\ ft.$

$= 2.22\ ft. \times 12''/ft. = 26.66\ In.$ Diameter pipe

24 inch pipe = 2.5 ft./sec.

# Step 2: Wastewater Enters the Plant through Screens

- Once the material is pumped into the wastewater treatment plant it enters **<u>Preliminary</u>**.
- The first step in preliminary is called **<u>“Screening”.</u>**
- Screening occurs using steel screens with **<u>5/8 inch openings.</u>**
- These screens remove larger materials such as paper and plastic, preventing the clogging of equipment further on in the treatment process.

# *Grit Channels:*

A. **Channel-type chambers shall be designed to control velocities during normal variations in flow as possible to 1 foot per second.**

# VELOCITY

$1.55\ Ft^3/sec. =$
1 MGD

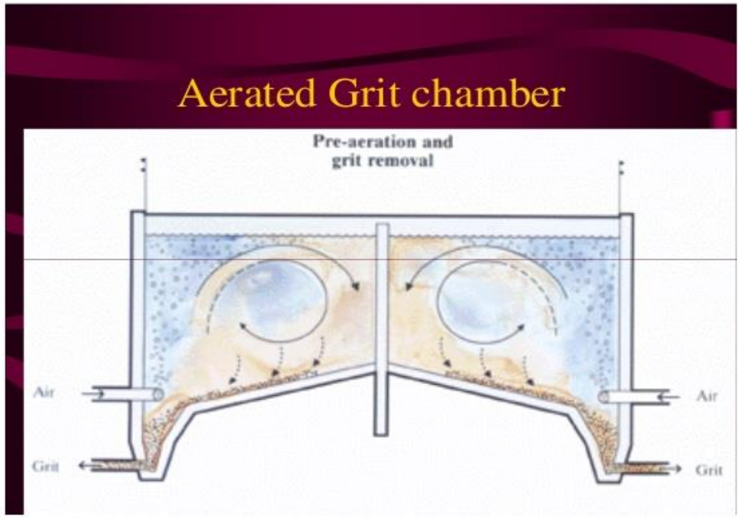
FLOW
Q
FT3/Sec.

÷ ÷

VELOCITY
V

FT2 X FT/Sec

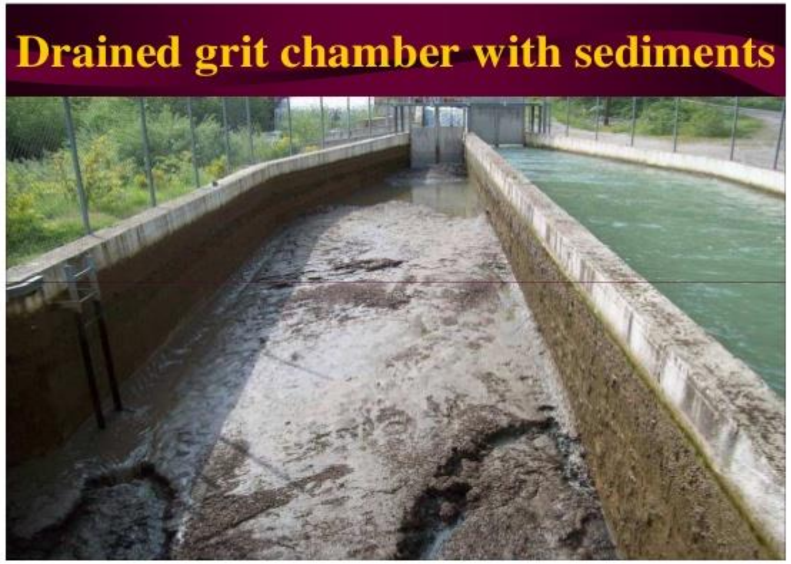
# Let's Build a grit chamber for 5.0 MGD; 15" Ht.




$\underline{7.75\ Ft^3/sec.}$ = 1.0 Ft/sec.

X = 7.75 $FT^2$

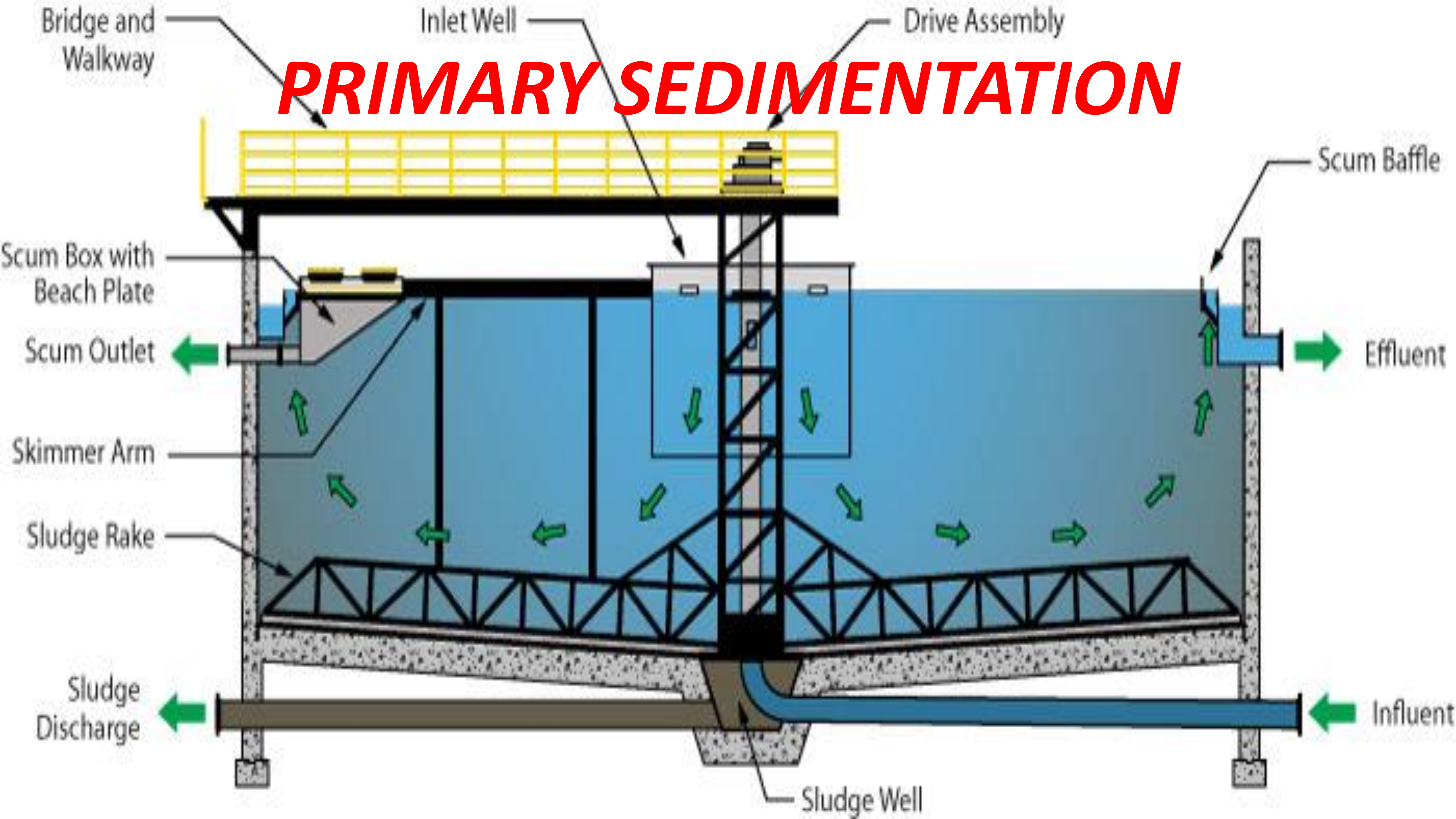
(wastewater height is 15")

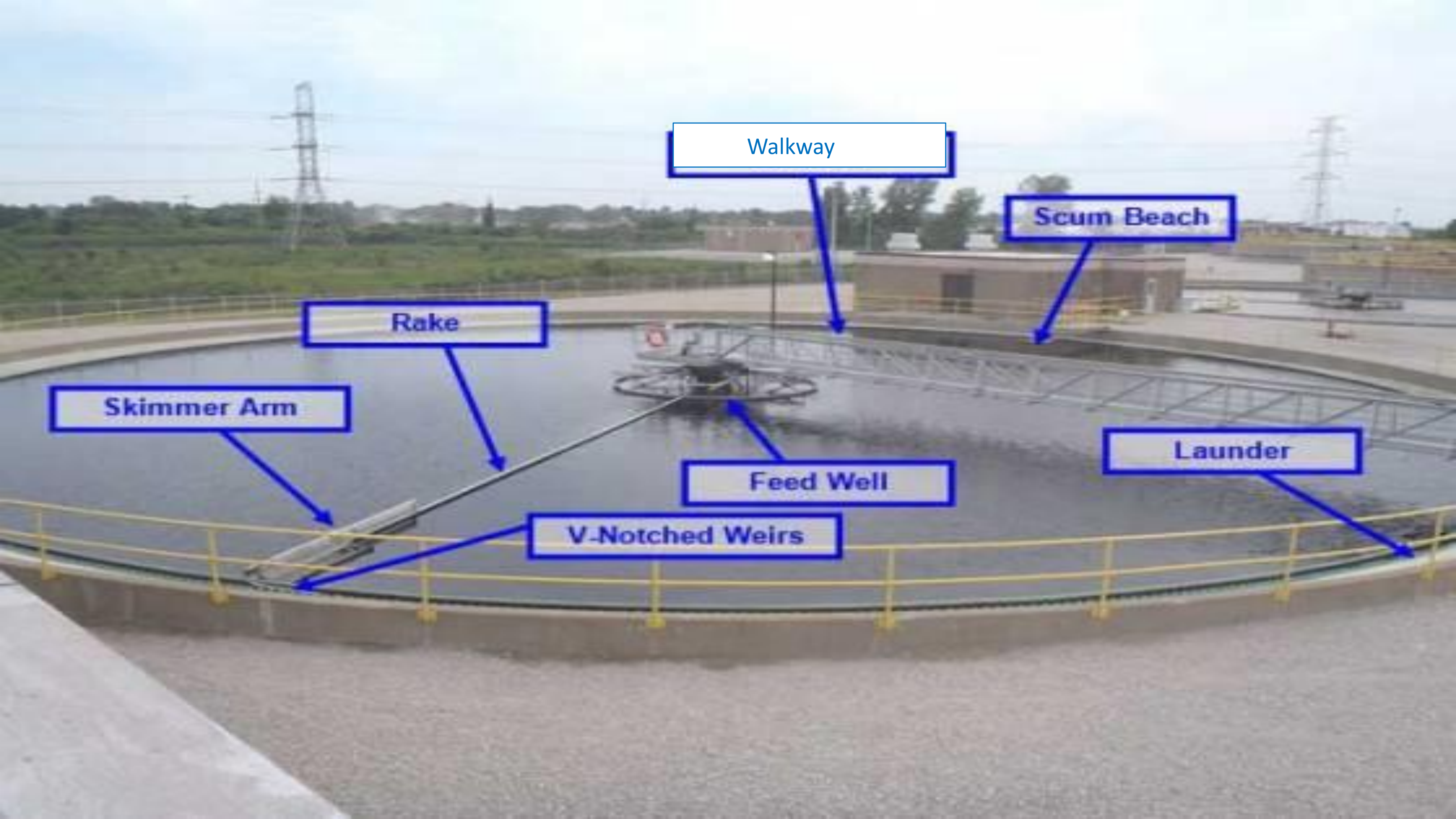



7.75 $Ft^2$ / 1.25 Ft. = 6.2 Ft. or 6 feet

(.2 x 12" = 2.4") 6'2.4" WIDE

# PRIMARY SEDIMENTATION




Walkway
Scum Beach
Rake
Skimmer Arm
Launder
Feed Well
V-Notched Weirs

# PRIMARY SEDIMENTATION

The most important function of the primary clarifier is to remove as much settle-able and suspended material as possible. Removal of organic settle-able solids is important because they cause a high demand for oxygen (BOD) in subsequent biological treatment units in the treatment plant or receiving waters.

Many factors influence settling characteristics in a particular clarifier. A few of the more common ones are

temperature,

short circuits,

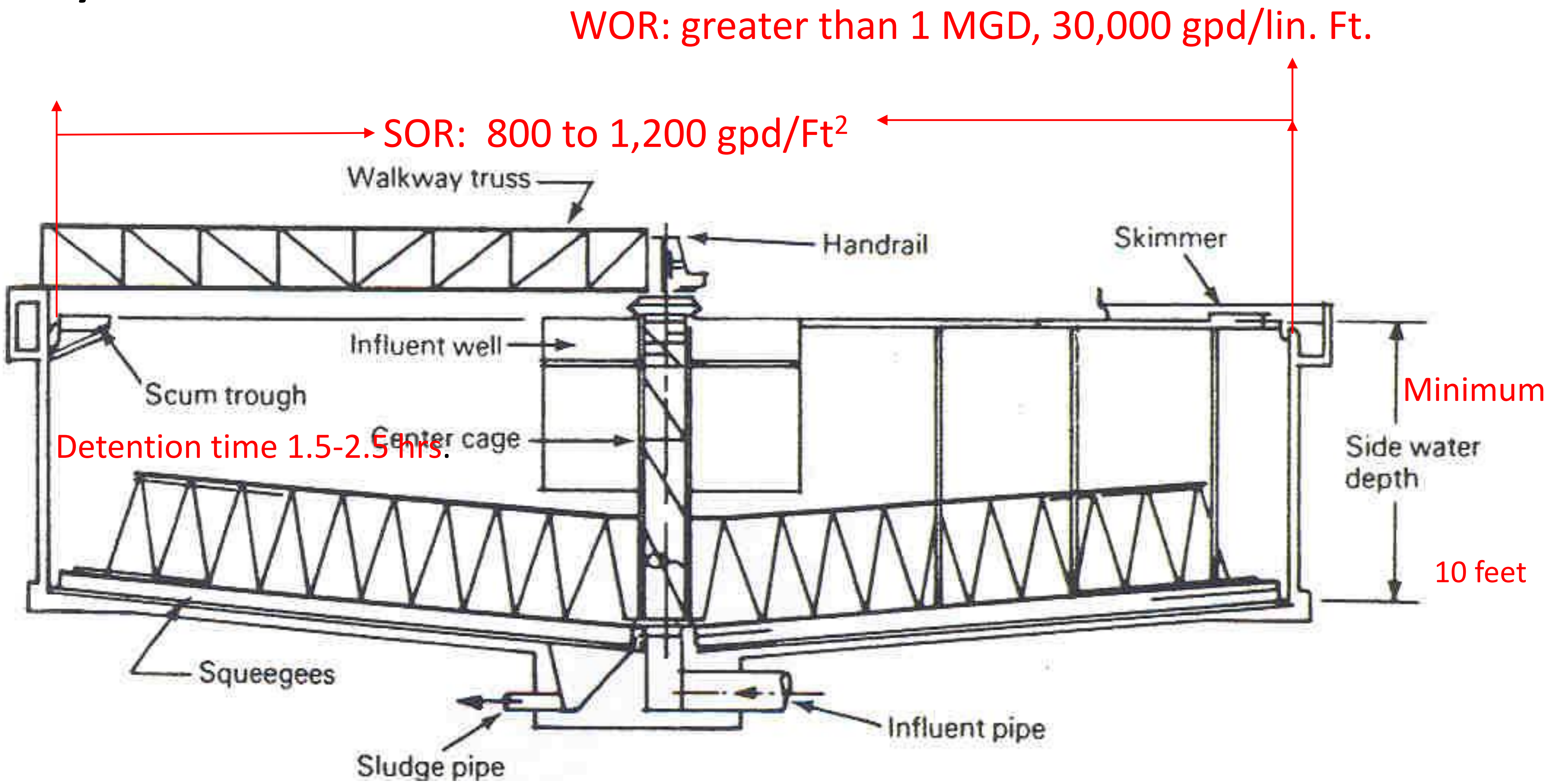
detention time,

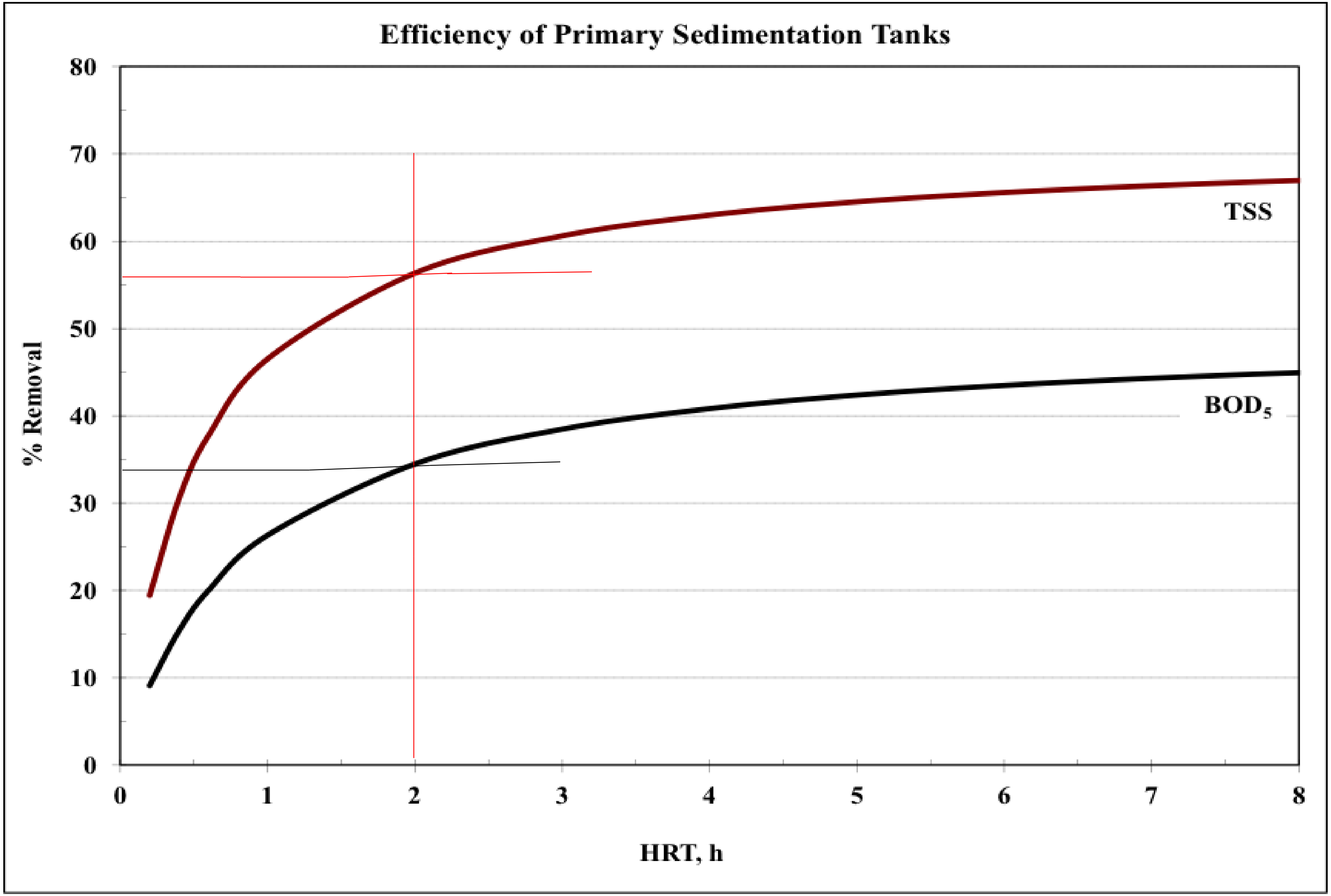
weir overflow rate,

surface loading rate,

solids loading.

# Primary Sedimentation




Efficiency of Primary Sedimentation Tanks
80
70
60
50
40
30
20
10
0
% Removal
0
1
2
3
4
5
6
7
8
HRT, h
TSS
BOD5

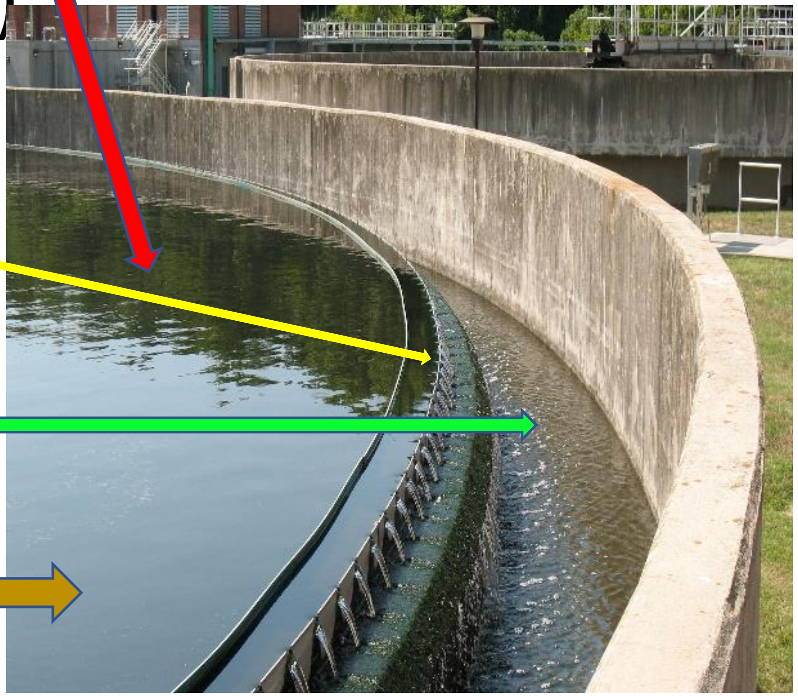
# PROCESS CONTROL EQUATIONS FOR SEDIMENTATION

DETENTION TIME: $\frac{\text{VOLUME}}{\text{FLOW}}$ (1.5 to 2.5 hours)

SURFACE OVERFLOW RATE: $\frac{\text{GALLONS PER DAY}}{\text{SURFACE AREA (Ft2)}}$

WEIR OVERFLOW RATE: $\frac{\text{GALLONS PER DAY}}{\text{LINEAR FEET}}$

% Efficiency: $\frac{\text{In} - \text{Out}}{\text{In}} = \%$



# TROUBLESHOOTING SHORT CIRCUITING

# PRIMARY CLARIFIER

The expected range for percent removal in a primary clarifier is:

- 90%-95% settleable solids
- 40%-60% suspended solids
- 25%-50% total $BOD_5$.

- Detention time of 1.5 – 2.5 hrs;
- Surface overflow rate of (800 – 1200 gpd/ft2) for average
- (2000 – 3000 gpd/ft2) for peak flow;
- Weir overflow rate,(10 000 – 40 000 gpd/ft)

| Bacterial group | Function | Generation time |
|---|---|---|
| Aerobic organotrophs | Floc formation and degradation of soluble organics in the activated sludge and trickling filter processes | 15 – 30 min. |
| Facultative and anaerobic organotrophs | Hydrolysis and degradation of organics in the anaerobic digester, besides floc formation and degradation of soluble organics in the activated sludge and trickling filter processes | 15 – 30 min. |
| Nitrifying bacteria | Oxidation of $NH_4$ and $NO_2$ in the activated sludge and trickling filter processes | 2 – 3 days |
| Sulfate reducing bacteria | Sulfate is reduced to $H_2S$ | 3 – 8 hrs. |
| Methane forming bacteria | Production of methane in the anaerobic digester | 3 – 30 days |

# Oxygen Usage Hierarchy

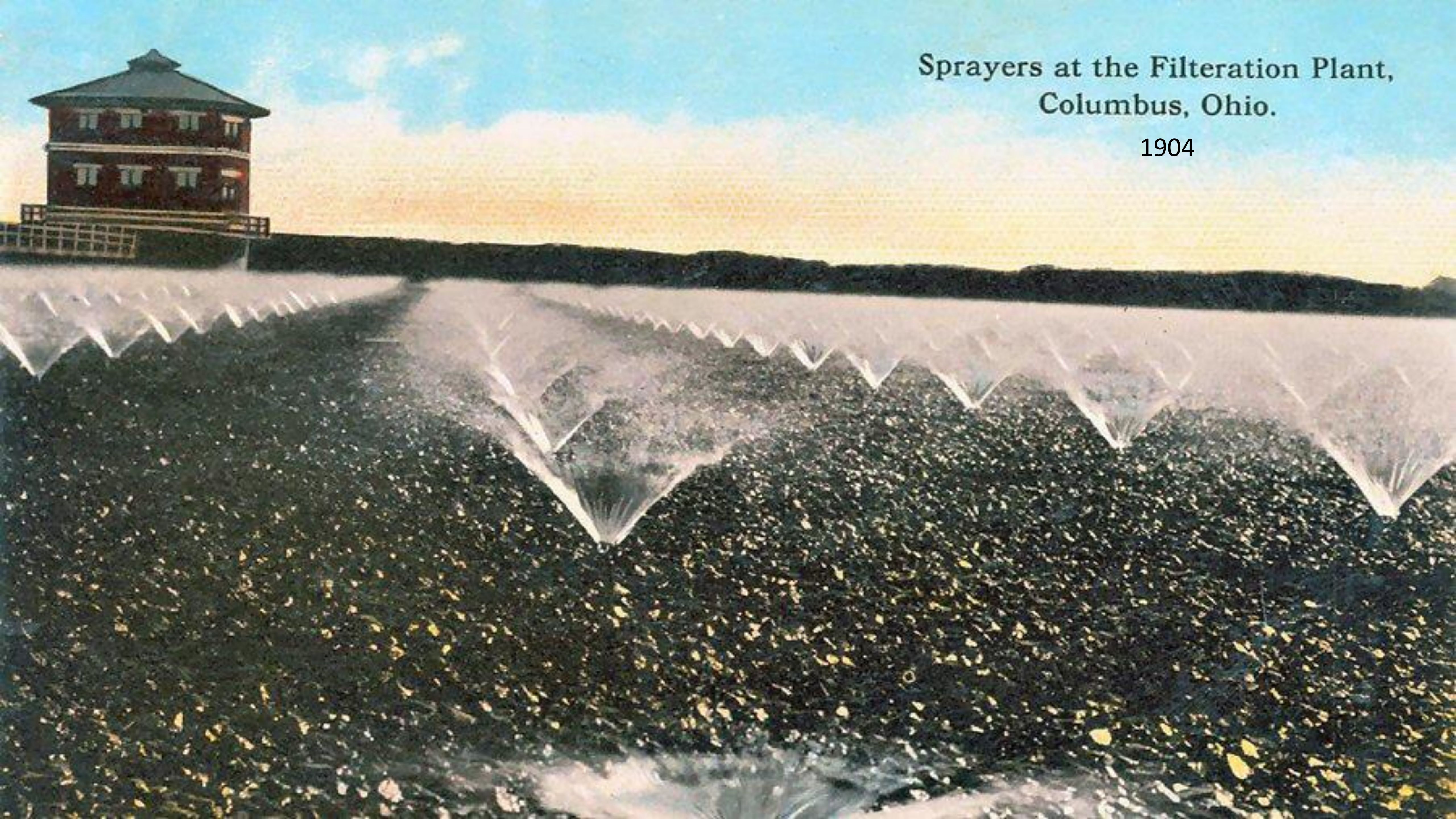
| | |
|---|---|
| Free Dissolved Oxygen | *Aerobic* or Oxic Treatment |
| Little or No Free Oxygen, But $NO_3$ Present | *Anoxic* Treatment |
| Sulfate, $SO_4$ Is the next choice of the Bugs | *Anaerobic* conditions are beginning, odors forming, $H_2S$ |

# *Trickling Filter Background*

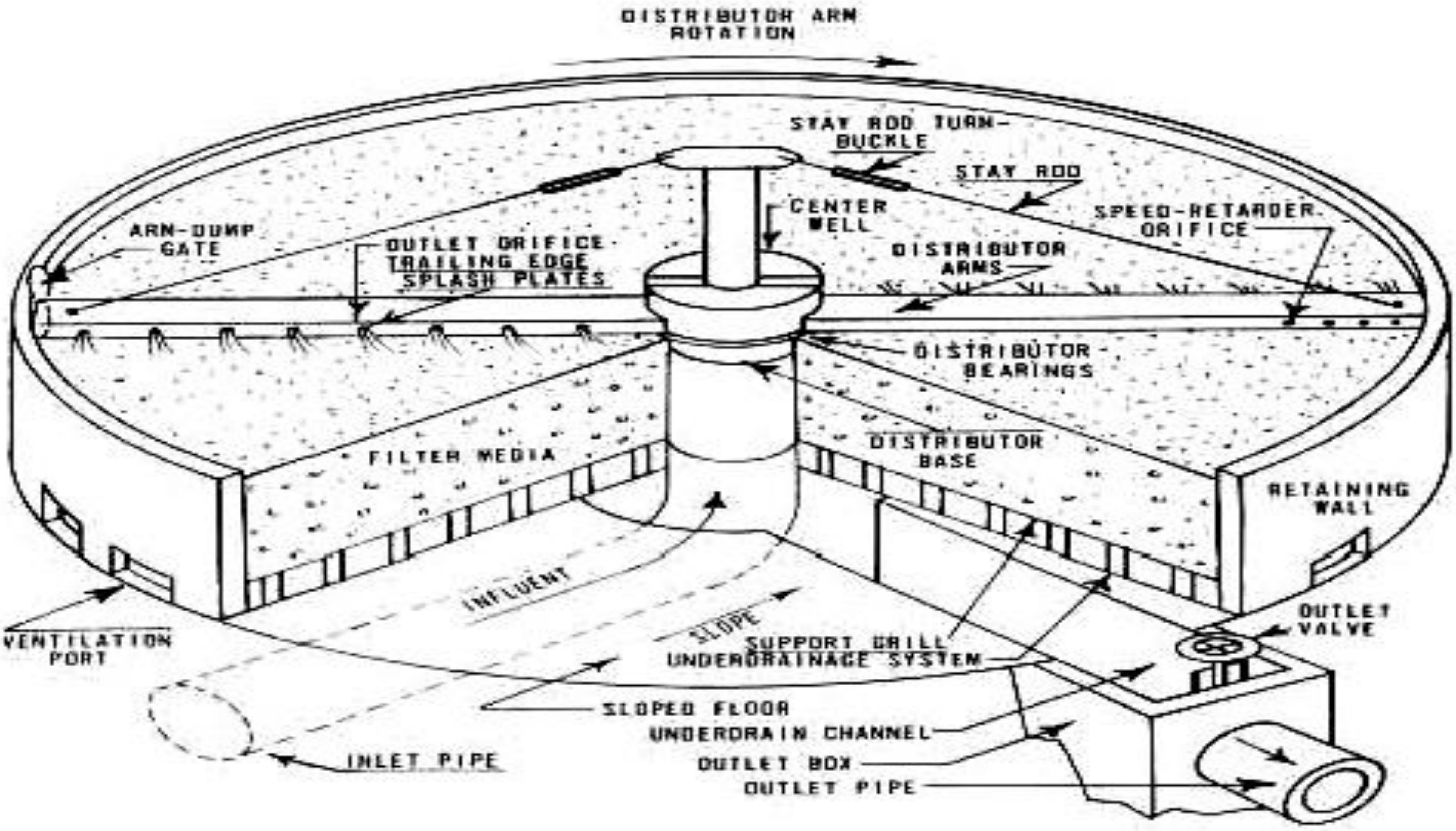
- Trickling filters were first introduced to the U. S. in 1901 at Madison, Wisconsin
- **1904, Columbus, Ohio** a sewage testing station was constructed near the Main Sewerage District Outfall to evaluate not only intermittent sand filters, but contact filters, coke strainers, chemical precipitation, septic treatment, plain sedimentation and sprinkling filters.

Trickling filters became the dominant secondary treatment process in the U.S. by the 1950s. Trickling filters fell out of favor in the 1970s when the U.S. Environmental Protection Agency issued its definition of secondary treatment standards — activated sludge was better able to meet the new standards.

Improvements in secondary clarifier design and the introduction of coupled processes — such as trickling filter/solids contact — and nitrifying trickling filters have led to a resurgence of the technology.




1904



DISTRIBUTOR ARM ROTATION
STAY ROD TURN-BUCKLE
STAY ROD
CENTER WELL
SPEED-RETARDER ORIFICE
ARM-DUMP GATE
OUTLET ORIFICE
TRAILING EDGE
SPLASH PLATES
DISTRIBUTOR ARMS
DISTRIBUTOR BEARINGS
DISTRIBUTOR BASE
FILTER MEDIA
RETAINING WALL
INFLUENT
SLOPE
OUTLET VALVE
VENTILATION PORT
SUPPORT GRILL
UNDERDRAINAGE SYSTEM
SLOPED FLOOR
UNDERDRAIN CHANNEL
OUTLET BOX
OUTLET PIPE
INLET PIPE

# *Aeration:*

Theoretically you can calculate Total Biological Oxygen Demand of any influent:

1.1 mg/L x CBOD + 4.6 mg/L x TKN

Ammonia Nitrogen
+
Organic Nitrogen

**Example:**

Raw municipal sewage commonly has the following values:

$CBOD_5$ = 200 mg/L ; TKN = 40 mg/L

1.1 x 200 mg/L $CBOD_5$ + 4.6 x 40 mg/L TKN =

404 mg/L Total Oxygen Demand

Using a 5.0 MGD Flow: 5.0 MGD x 8.34 x 404 mg/L = 16,847 Lbs./Day

16,847 Lbs./Day / 1440 = 11.7 Lbs./Minute

One cubic foot of Air weighs 0.0807 Lbs.

$$\frac{11.7 \text{ Lbs./Minute}}{0.0807} = 145 \text{ CFM (not including mixing)}$$

| Parameter | Range |
| --- | --- |
| **Food** | Proper amount of food to microorganisms |
| **Hydraulic Flow Rate** | Within plant design capacity. Excessive flows can result in suspended solids washout |
| **Oxygen** | Many of the bacteria in wastewater require between 1 mg/L to 3 mg/L or more of dissolved oxygen |
| **Temperature** | Most microorganisms in wastewater grow best between 10 and 25 degrees C. At >35 to 40 degrees C, thermophilic bacteria will take over |
| **Nutrients** | Conventionally a BOD: Nitrogen: Phosphorus ratio of 100:5:1 is recommended in addition to proper micronutrients such as iron and other trace minerals |
| **pH** | Between 6.5-8.5 is recommended |
| **Alkalinity** | There needs to be enough buffering capacity to maintain the pH. Typically 60 mg/L or more alkalinity at the end of treatment is desired |

**pH:** (6.5 – 8.5) The enzymes which regulate many of the biochemical reactions in bacteria are pH dependent. The optimum pH should be between 7.0 and 7.5 for the proper activated sludge microorganism to dominate.

**D.O.:** (2 mg/L – 4 mg/L) To know that a system is fully mixed and aerobic, dissolved oxygen of 2.0 mg/L is a good target. Need oxygen for respiration.

$$C_6H_{12}O_6 + O_2 \longrightarrow 6CO_2 + 6H_2O + \text{ENERGY}$$

(glucose) (Oxygen) (Carbon Dioxide)

# Nutrient Ratio needed to complete Biochemical Oxygen Demand by Microorganisms
# Carbon : Nitrogen : Phosphorous

100 : 5 : 1

180 mg/L CBOD / 100 = 1.8

25 mg/L $NH_3$ / 1.8 = 13.9

5 mg/L Phosphorous / 1.8 = 2.8

# Your Turn Using the 100:5:1 Calculation

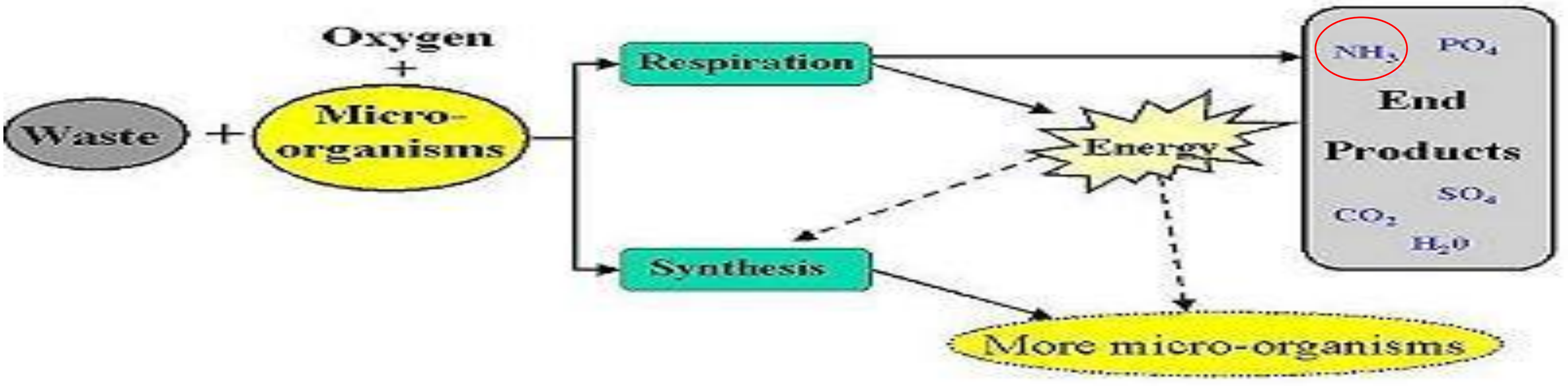
**Raw Data:** CBOD 170 mg/L ; $NH_3$ 25 mg/L ; $PO_4$ 10 mg/L

CBOD: 170 / 100 = 1.7

$NH_3$ (14/17 x 25 = 23 mg/L as Nitrogen) 23 / 1.7 = 13.5

$PO_4$ (31/95 x 10 = 3.3 mg/L as Phosphorous) 3.3 / 1.7 = 1.9

Did We meet the requirements ?

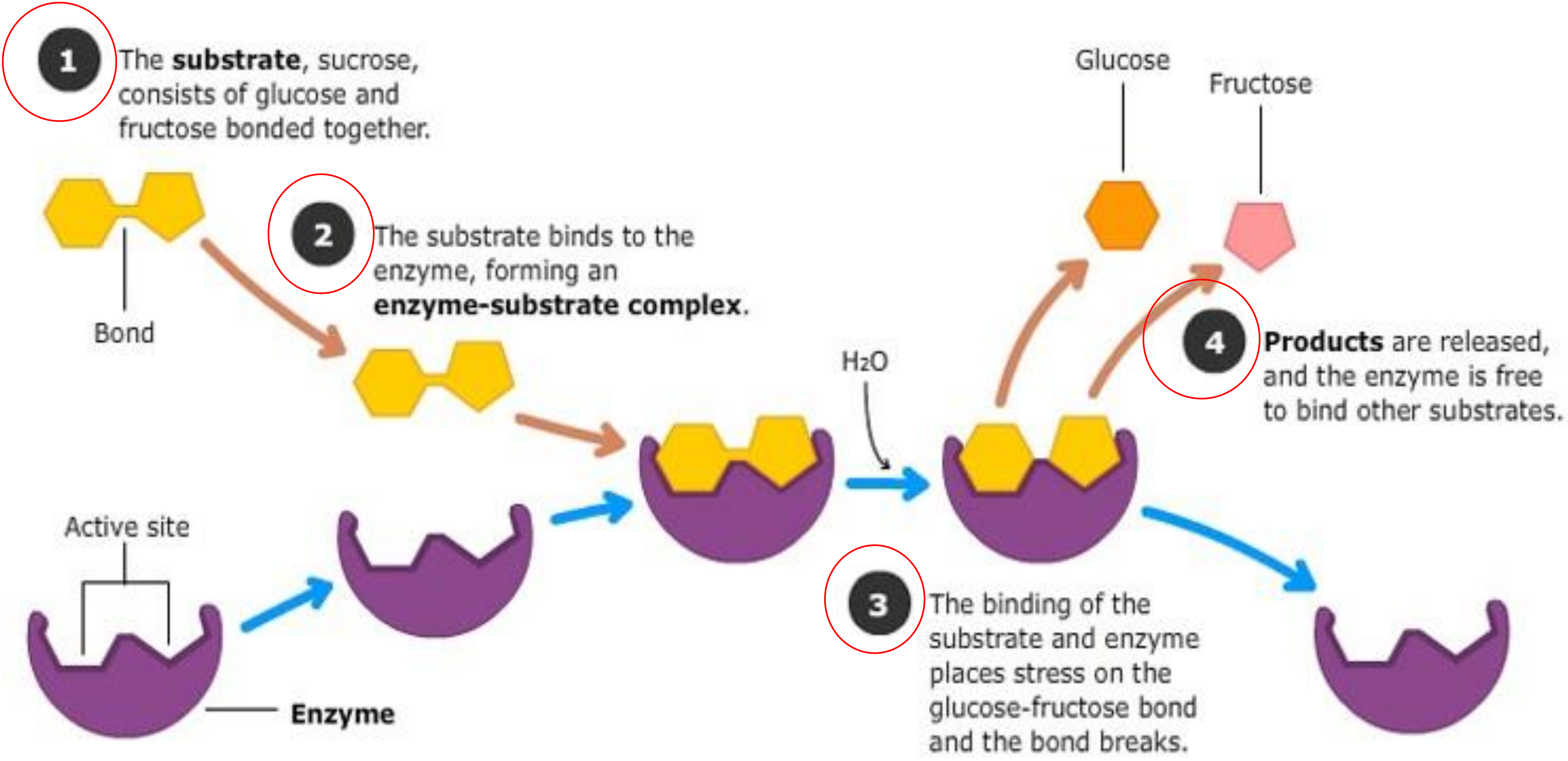



Carbon Source

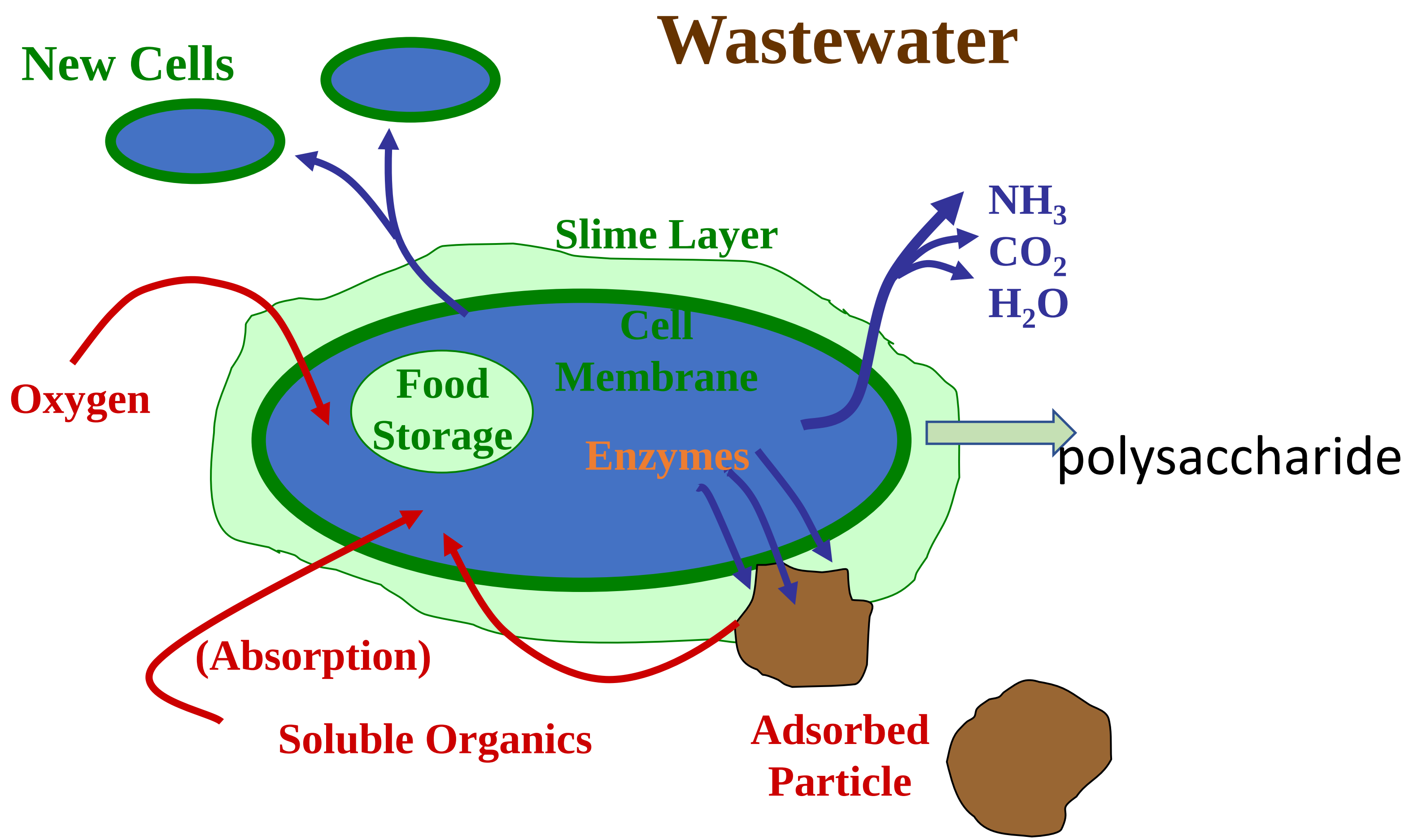
$$C_6H_{12}O_6 + O_2 \longrightarrow 6CO_2 + 6H_2O + \textbf{ENERGY}$$

**(glucose) (Oxygen) (Carbon Dioxide)**

RESPIRATION PROCESS



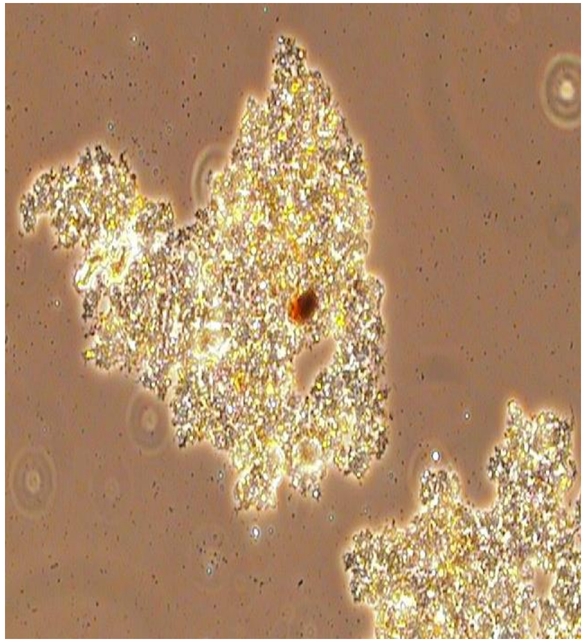

*This is why pH is so important !*



Wastewater
New Cells
Slime Layer
$NH_3$
$CO_2$
$H_2O$
Cell
Membrane
Food
Storage
Oxygen
Enzymes
polysaccharide
(Absorption)
Soluble Organics
Adsorbed
Particle

Need Food to create Polysaccharide so they can stick together

Biomass 400X



7200X

# Carbonaceous BOD AND NITRIFIERS

Soluble and simplistic forms of CBOD can inhibit the activity of nitrifying bacteria. They are able to enter the cells of nitrifying bacteria and inactivate their enzyme systems. This form of CBOD must be degraded significantly or completely by organotrophs in order for nitrifying bacteria to oxidize ammonium and nitrite ions. Nitrifiers are dependent on organotrophs to reduce CBOD to relatively low concentrations (<40 – 50 mg/L).

# B.O.D.

## Biochemical Oxygen Demand

The Quantity of Oxygen Used in the Biochemical Oxidation of Organic Material.

Under:

| | |
|---|---|
| Specified Time | 5 Days |
| Specified Temperature | $20^0$ C |
| Specified Conditions | In the Dark<br>In the Presence of Bacteria |

# BOD PROCEDURE

## DILUTE SAMPLE

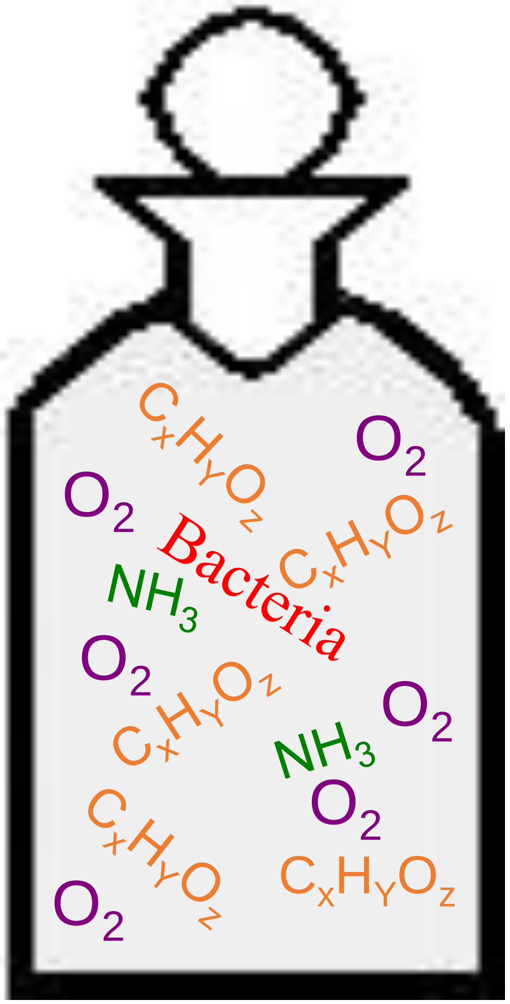
Minimum Residual, 1.0 mg/L
Minimum Depletion, 2.0 mg/L
At Least Two Dilutions
Thoroughly Mix Sample

## ADD NITRIFICATION INHIBITOR

If Required for CBOD

TCMP
0.10 gram/bottle
Two "shots"

# Dilution Water Added




## Dilution Water Contains:

Nutrients

- Magnesium sulfate solution
- Calcium chloride solution
- Ferric Chloride solution
- Phosphate buffer

Oxygen

Measure
D.O. Concentration

# Initial D.O. Example Problem


20 mls. of sample / 300 = 0.067 or 6.7%

D.O. of sample 3.0 mg/L  SO

3.0 mg/L  x  0.067 = 0.2145 mg/L

280 mls. Of Dilution Water/ 300 = 93.3%

D.O. of Dilution Water 8.2 mg/L  SO

8.2 mg/L  x  0.933 = 7.6506 mg/L

ADD the two 0.2145 + 7.6506 = 7.8651mg/L

***INTIAL D.O. IS 7.8651 mg/L weighted average***

# BOD PROCEDURE, (cont.)

INCUBATE

20 ± 1°C

5 Days ± 6 hour


MEASURE FINAL D.O.

(wash bottles)

# CALCULATING $BOD_5$

$$\text{B.O.D. mg/L} = \frac{\text{D.0. DEPLETION (mg/L)}}{\text{SAMPLE VOLUME (mL)}} \times 300\ \text{mL}$$

D.O. DEPLETION = D.O. Initial - D.O. 5-Day

Minimum Depletion - 2.0 mg/L

Minimum Residual - 1.0 mg/L

# B.O.D. Example Problem

Calculate the B.O.D.:

Initial Sample D.O. = 7.8651 mg/L
5-Day Sample D.O. = 2.1 mg/L ***remaining***
Vol. Of Sample in 300 mL Bottle = 20 mL

$$\text{B.O.D., mg/L} = \frac{\text{D.O. Depletion, mg/L}}{\text{Volume Sample, mL}} \times 300 \text{ mL}$$

$$= \frac{\text{Initial D.O. - Residual D.O.}}{\text{Volume Sample, mLs}} \times 300 \text{ mL}$$

$$= \frac{7.8651 \text{ mg/L} - 2.1 \text{ mg/L}}{20 \text{ mL}} \times 300 \text{ mL}$$

***uptake***

$$= \frac{5.7651 \text{ mg/L}}{20 \text{ mL}} \times 300 \text{ mL}$$

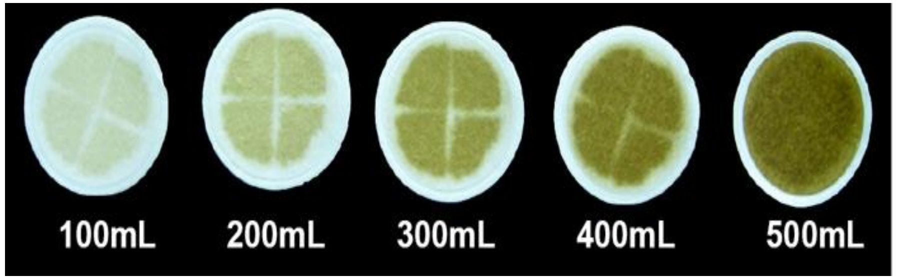
$$= 0.288 \text{ mg/L} \times 300 = 86.5 \text{ mg/L}$$

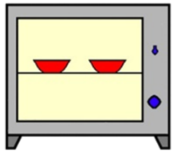
# Total Suspended Solids

103°C +2°C

**Analytical Balance**
Weigh

**Drying Oven**



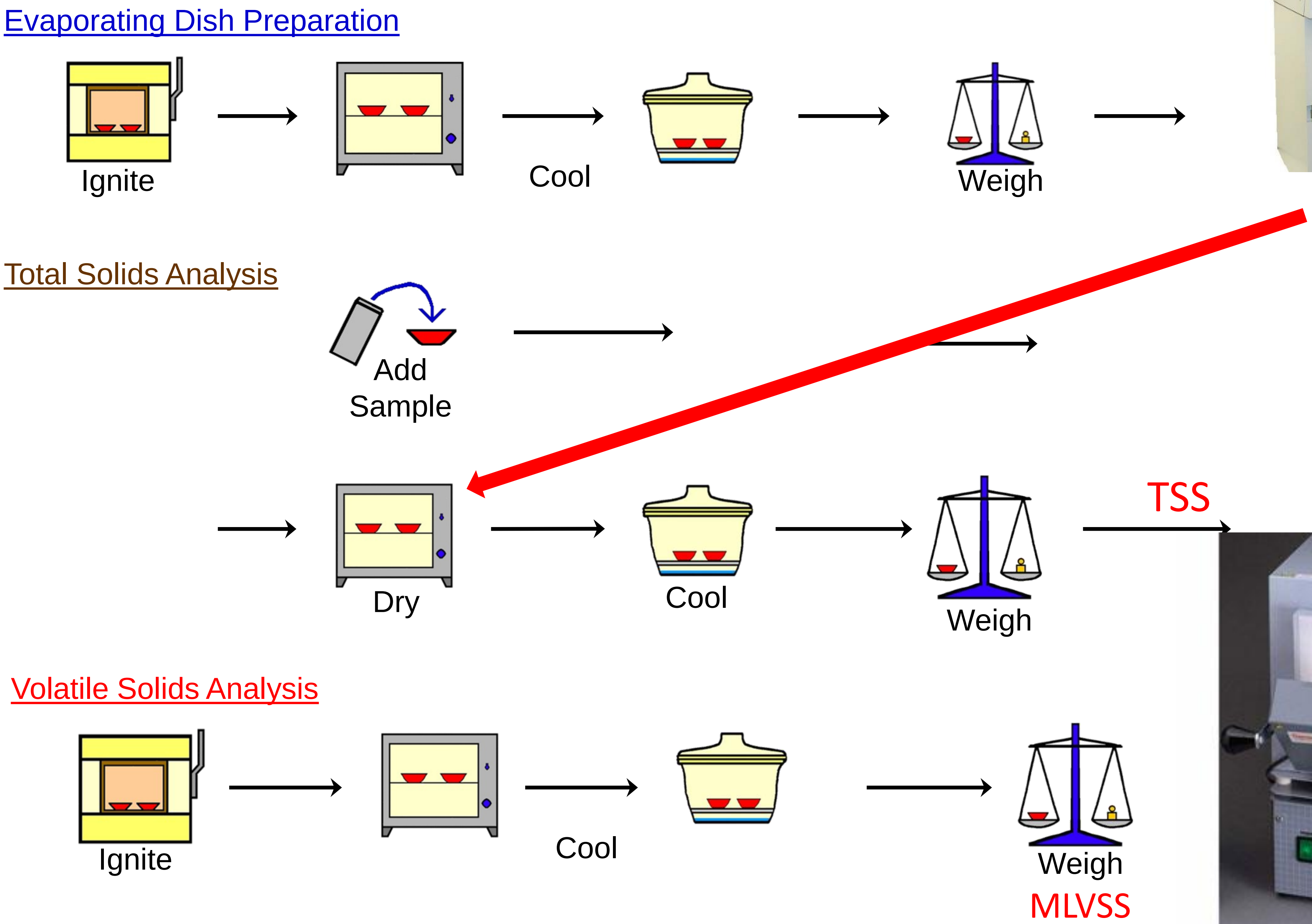
**After Drying Oven**

**Cool**

**Weigh**

# Finding MLVSS

ANALYTICAL BALANCE




Drying Oven

550℃

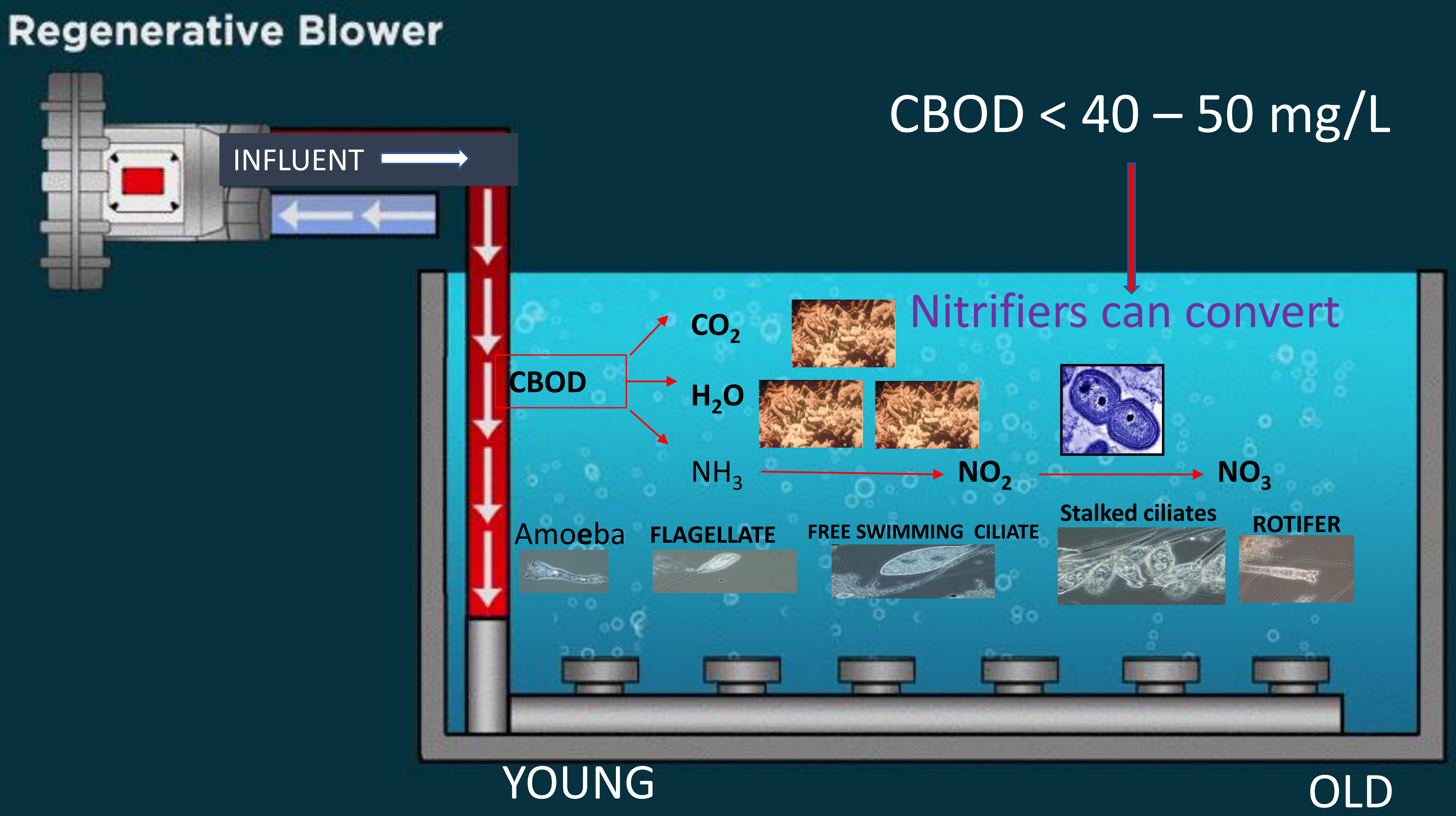
What is the mixed liquor suspended solids concentration given the following?

- Initial weight of filter disk = 0.45 grams
- Volume of filtered sample = 60 mls
- Weight of filter disk and filtered residue = 0.775 gms

$$\text{Suspended Solids} = \frac{(0.775\text{gms} - 0.45\text{gms})(1{,}000{,}000)}{60 \text{ mls}}$$

← Note: While the formula sheet doesn't say so, the 1,000,000 figure is really a conversion factor that changes gms/mls to mg/L.

Suspended Solids = 5,417 mg/L Answer


Regenerative Blower
INFLUENT
CBOD < 40 – 50 mg/L
Nitrifiers can convert
CBOD
$CO_2$
$H_2O$
$NH_3$
$NO_2$
$NO_3$
Amoeba
FLAGELLATE
FREE SWIMMING CILIATE
Stalked ciliates
ROTIFER
YOUNG
OLD

# Nitrification

## Nitrification of Ammonia Occurs in Two Steps

*Autotrophic Bacteria Utilize Inorganic Compounds
(and $CO_2$ as a Carbon Source)

$NH_3$-N → $NO_2$-N

Ammonia N → Nitrite N

Nitrosomonas

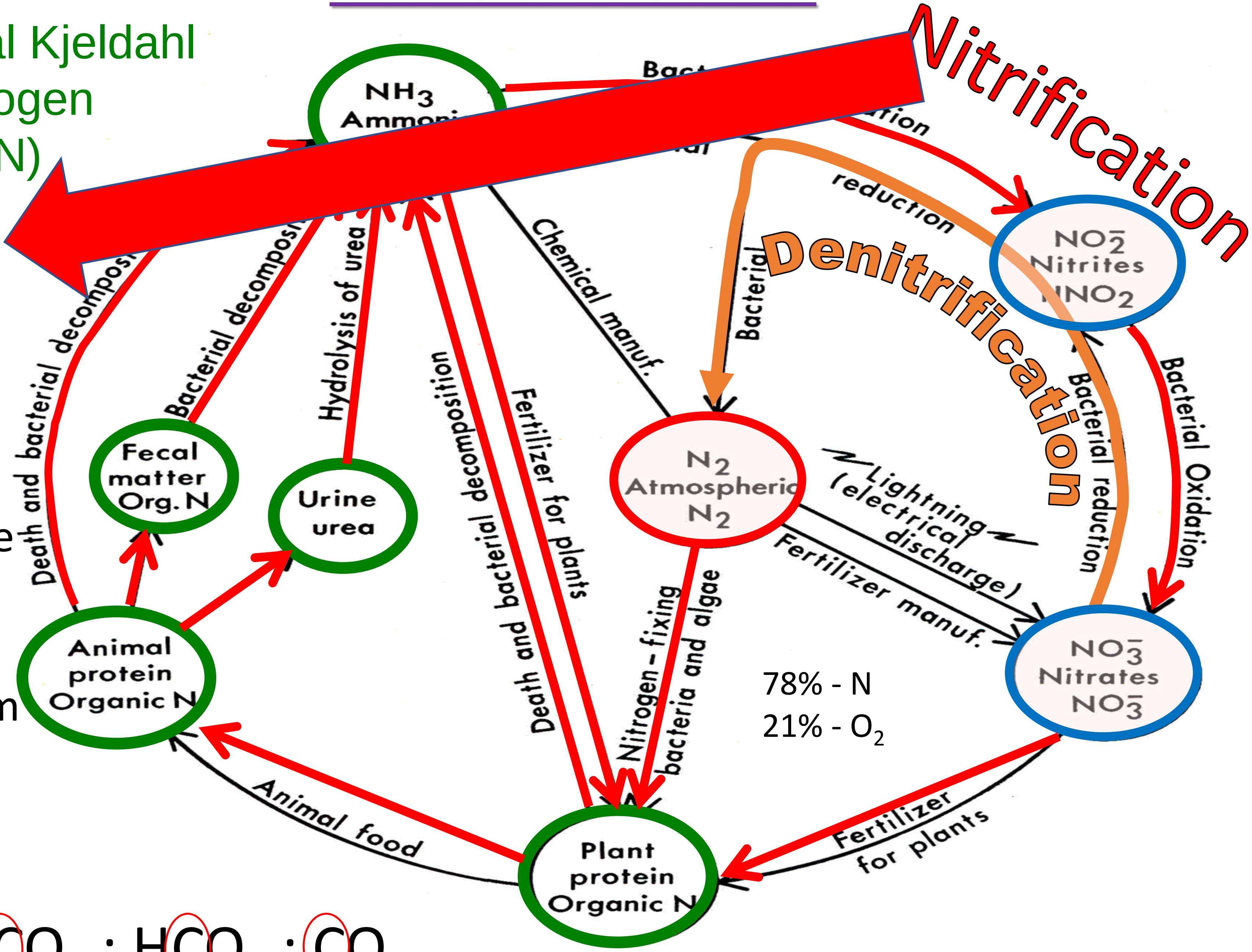
$NO_2$-N → $NO_3$-N

Nitrite N → Nitrate N

Nitrobacter

# NITROGEN CYCLE

Two species of bacteria are involved in the process – Nitrosomonas and Nitrobacter. These bacteria are collectively known as nitrifiers and are autotrophic, i.e. they get their carbon source from inorganic carbon (carbonates, bicarbonates) or carbon dioxide.




$CO_3$ ; $HCO_3$ ; $CO_2$

# Nitrogen Constituents in wastewater:

The principal forms of nitrogen found in wastewater are:

Organic Nitrogen (Organic – N)

Ammonia Nitrogen ($NH_3$ – N)

Ammonium Nitrogen ($NH_4$ – N)

Nitrite Nitrogen ($NO_2$ – N)

Nitrate Nitrogen ($NO_3$ -N)

# What is Nitrification ?

Nitrification is the sequential conversion of ammonia to nitrite and ultimately nitrate:

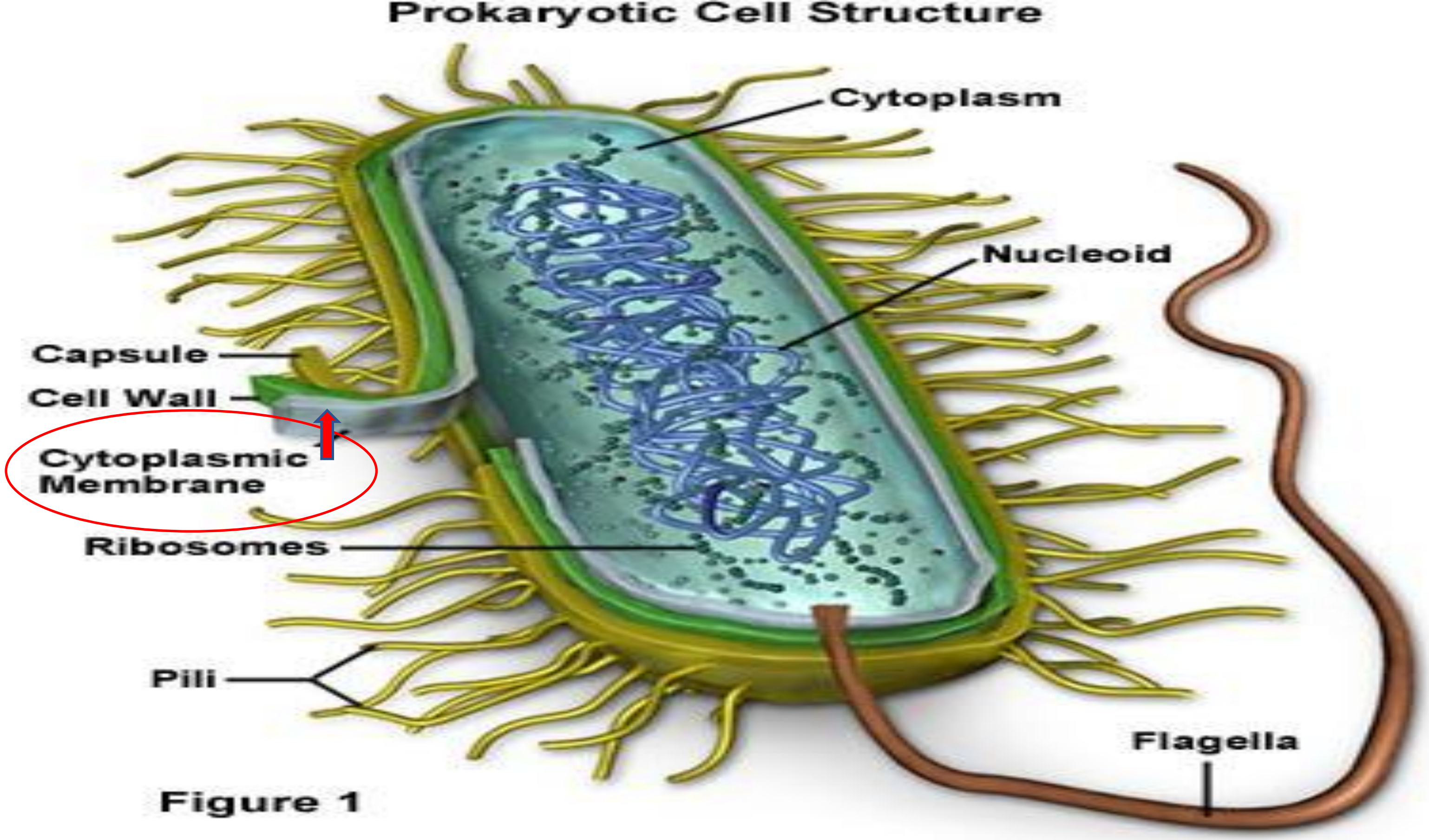
Ammonium $\longrightarrow$ Nitrite $\longrightarrow$ Nitrate

$$NH_4^+ + 1.5O_2 \longrightarrow NO_2^- + H_2O + 2H^+$$

$$NO_2^- + 0.5O_2 \longrightarrow NO_3^-$$

**The overall reaction is as follows:**

$$NH_4^+ + 2O_2 \longrightarrow NO_3^- + 2H^+ + H_2O$$

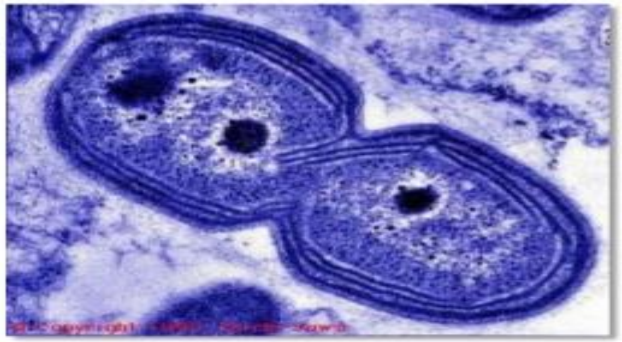



on the cytomembranes of Nitrosomonas and Nitrobacter, where ammonium ions and nitrite ions, respectively, come in contact with enzymes that add oxygen to each ion.

In the first step of nitrification, ammonia-oxidizing bacteria oxidize ammonia to nitrite according to equation

$$NH3 + O2 \rightarrow NO2 - + 3H+ + 2e-$$

***Nitrosomonas*** is the most frequently identified genus associated with this step, although other genera, including ***Nitrosococcus***, and ***Nitrosospira***



- **$NH_4^+$ → *Nitrosomonas* → $NO_2^-$**
- **$NO_2^-$ → *Nitrobacter* → $NO_3^-$**
- **Notes:**
  - **Aerobic process**
  - **Control by SRT (4 + days)**
  - **Uses oxygen → 1 mg of $NH_4^+$ uses 4.6 mg $O_2$**
  - **Depletes alkalinity → 1 mg $NH_4^+$ consumes 7.14 mg alkalinity**
  - **Low oxygen and temperature = difficult to operate**

# How does nitrification take place in an activated sludge system ?

It is important to note that it is the ammonium ion ($NH_4^+$) and not ammonia ($NH_3$) that is oxidized during nitrification. When proteins and organic nitrogen compounds, e.g. urea ($NH_2CONH_2$), are hydrolysed, and degraded amino acids are released.

The amino group is removed by bacterial activity – this is known as de-amination- and is quickly converted to the ammonium ion.

In water, ammonia occurs in two forms, which together are called total ammonia nitrogen, or TAN. Chemically, these two forms are represented as NH4+ and NH3. NH4+ is called ionized ammonia because it has a positive electrical charge, and NH3 is called un-ionized ammonia (UIA) because it has no charge. ***This difference is important to know because NH3, un-ionized ammonia, is the form more toxic to fish.*** Both water temperature and pH affect which form of ammonia is predominant at any given time in an aquatic system.

PREDOMINANTLY

$NH_4$

PREDOMINANTLY

$NH_3$

| pH | Temperature | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 42.0 (°F) | 46.4 | 50.0 | 53.6 | 57.2 | 60.8 | 64.4 | 68.0 | 71.6 | 75.2 | 78.8 | 82.4 | 86.0 | 89.6 |
| | 6 (°C) | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| 7.0 | .0013 | .0016 | .0018 | .0022 | .0025 | .0029 | .0034 | .0039 | .0046 | .0052 | .0060 | .0069 | .0080 | .0093 |
| 7.2 | .0021 | .0025 | .0029 | .0034 | .0040 | .0046 | .0054 | .0062 | .0072 | .0083 | .0096 | .0110 | .0126 | .0150 |
| 7.4 | .0034 | .0040 | .0046 | .0054 | .0063 | .0073 | .0085 | .0098 | .0114 | .0131 | .0150 | .0173 | .0198 | .0236 |
| 7.6 | .0053 | .0063 | .0073 | .0086 | .0100 | .0116 | .0134 | .0155 | .0179 | .0206 | .0236 | .0271 | .0310 | .0369 |
| 7.8 | .0084 | .0099 | .0116 | .0135 | .0157 | .0182 | .0211 | .0244 | .0281 | .0322 | .0370 | .0423 | .0482 | .0572 |
| 8.0 | .0133 | .0156 | .0182 | .0212 | .0247 | .0286 | .0330 | .0381 | .0438 | .0502 | .0574 | .0654 | .0743 | .0877 |
| 8.2 | .0210 | .0245 | .0286 | .0332 | .0385 | .0445 | .0514 | .0590 | .0676 | .0772 | .0880 | .0998 | .1129 | .1322 |
| 8.4 | .0328 | .0383 | .0445 | .0517 | .0597 | .0688 | .0790 | .0904 | .1031 | .1171 | .1326 | .1495 | .1678 | .1948 |
| 8.6 | .0510 | .0593 | .0688 | .0795 | .0914 | .1048 | .1197 | .1361 | .1541 | .1737 | .1950 | .2178 | .2422 | .2768 |
| 8.8 | .0785 | .0909 | .1048 | .1204 | .1376 | .1566 | .1773 | .1998 | .2241 | .2500 | .2774 | .3062 | .3362 | .3776 |
| 9.0 | .1190 | .1368 | .1565 | .1782 | .2018 | .2273 | .2546 | .2836 | .3140 | .3456 | .3783 | .4116 | .4453 | .4902 |
| 9.2 | .1763 | .2008 | .2273 | .2558 | .2861 | .3180 | .3512 | .3855 | .4204 | .4557 | .4909 | .5258 | .5599 | .6038 |
| 9.4 | .2533 | .2847 | .3180 | .3526 | .3884 | .4249 | .4618 | .4985 | .5348 | .5702 | .6045 | .6373 | .6685 | .7072 |
| 9.6 | .3496 | .3868 | .4249 | .4633 | .5016 | .5394 | .5762 | .6117 | .6456 | .6777 | .7078 | .7358 | .7617 | .7929 |
| 9.8 | .4600 | .5000 | .5394 | .5778 | .6147 | .6499 | .6831 | .7140 | .7428 | .7692 | .7933 | .8153 | .8351 | .8585 |
| 10.0 | .5745 | .6131 | .6498 | .6844 | .7166 | .7463 | .7735 | .7983 | .8207 | .8408 | .8588 | .8749 | .8892 | .9058 |
| 10.2 | .6815 | .7152 | .7463 | .7746 | .8003 | .8234 | .8441 | .8625 | .8788 | .8933 | .9060 | .9173 | .9271 | .9389 |

Ammonia Levels $NH_3$ mg/L


Present in large numbers during rapid nitrification. These protozoa can nitrify.

# These factors are necessary for effective Nitrification!

## Oxygen

- Nitrifiers are obligate aerobes, i.e. they require free molecular oxygen. Maximum nitrification occurs at a D.O. level of 3.0 mg/L. Significant nitrification occurs at a D.O. level of 2.0 to 2.9 mg/L. Nitrification ceases at D.O. levels of < 0.5 mg/L.
- Approximately, 4.6 kg of oxygen are required for every kg of ammonium ions oxidized to nitrate.

# Oxygen Continued

(This compares with a requirement of 1 kg of oxygen to oxidize 1 kg of carbonaceous BOD).

An absence of oxygen for <4 hours does not adversely affect nitrifiers when oxygen is restored.  An absence of D.O. for $\geq$ 24 hours can destroy a population of nitrifiers.

***To ensure effective nitrification always maintain a D.O. level of $\geq$ 1.5 mg/L.***

# Temperature

Nitrification is temperature sensitive.  The optimum temperature for nitrification is generally considered to be 86° F.

# Temperature Continued

| Temperature | Effect upon Nitrification |
| --- | --- |
| >113° F | Nitrification ceases |
| 82 - 89° F | Optimum temperature range |
| 61° F | Approx. 50% of nitrification rate at 86° |
| 50° F | Significant reduction in nitrification |
| <41° F | Nitrification ceases |

# Alkalinity and pH

Alkalinity is lost in an activated sludge process during nitrification. Nitrifiers use alkalinity as a carbon source i.e. they use an inorganic form of carbon. ($CO_3$ ; $HCO_3$ ; $CO_2$)

Hydrogen ions ($H^+$) are produced when ammonium ions are oxidized to nitrite:

$$NH_4^+ + 1.5O_2 \longrightarrow 2H^+ + NO_2^- + H_2O$$

Nitrous acid ($NHO_2$) is also produced during the oxidation of ammonium ions, destroying alkalinity:

$$H^+ + NO_2 \longrightarrow NHO_2$$

# Alkalinity and pH Continued

7.14 mg of alkalinity as $CaCO_3$ are destroyed for every mg of ammonium ions oxidized. If the pH drops below 6.7 there is a significant decrease in nitrification. Therefore, it is important to maintain an adequate alkalinity in the aeration tank to provide pH stability and, also, to provide inorganic carbon for nitrifiers. *After complete nitrification, a residual alkalinity of 60 mg/L in the aeration tank is desirable*. If this alkalinity is not present, then alkalinity should be added to the aeration tank.

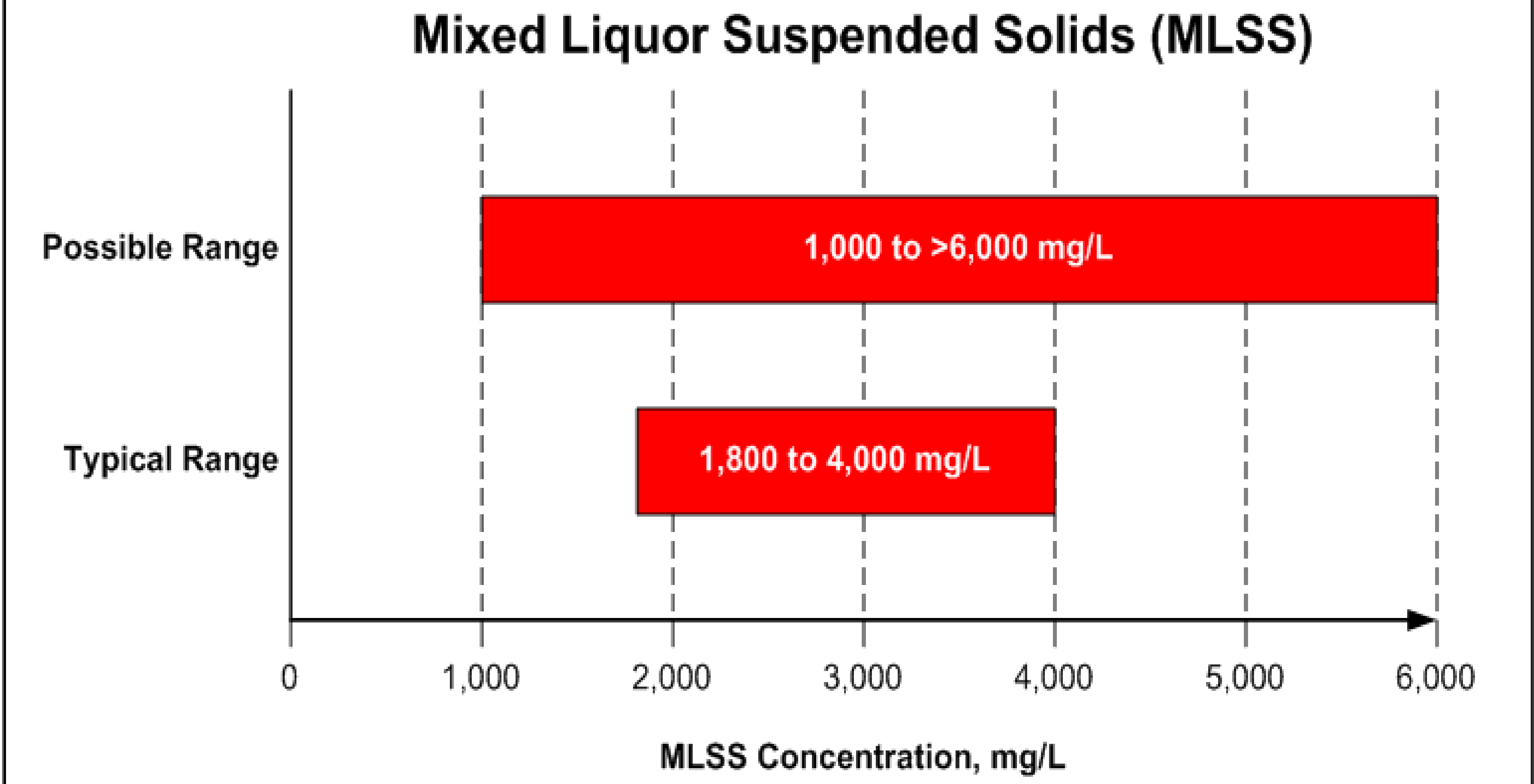
# pH

The optimal pH range for nitrification is 7.2 to 8.0. A substantial reduction in nitrification activity occurs at pH levels below 6.7

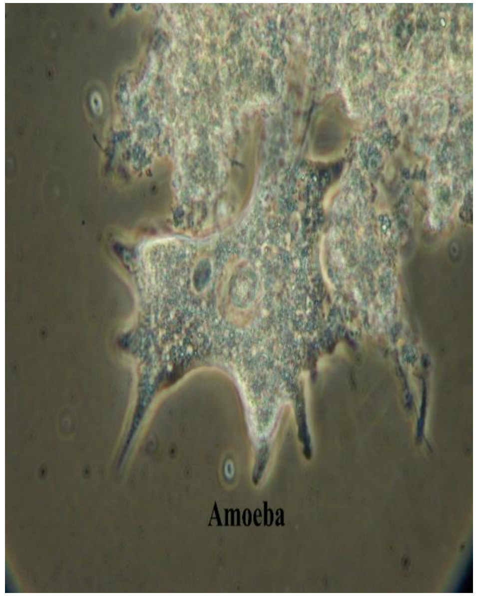
Coming into aeration your $NH_4$ is 15 mg/l and the alkalinity concentration is 60 mg/l.  Exiting the aeration tank your $NH_4$ is 8mg/l and $NO_3$ is 7mg/L. What would be your expected alkalinity concentration?

7 mg/L converted to $NO_3$ x 7.14 = 50 mg/L ALK.

Remaining Alkalinity 10 mg/L


Mixed Liquor Suspended Solids (MLSS)
Possible Range
1,000 to >6,000 mg/L
Typical Range
1,800 to 4,000 mg/L
0
1,000
2,000
3,000
4,000
5,000
6,000
MLSS Concentration, mg/L

# Amoeba




Amoeba can only multiply when there is an abundance of nutrients in the aeration tank.

They feed on small organic particulates. When amoeba are present in large numbers in the aeration basin this usually indicates that there has been some sort of shock loading to the plant (a lot of food available). Their presence may also indicate that there is a low D.O. environment in the aeration basin, because they can tolerate very low amounts of D.O.


AMOEBA

# Flagellates

Most flagellates absorb dissolved nutrients.  If large amounts of flagellates are present in the later stages of the activated sludge development this usually indicates that the wastewater still contains a large amount of soluble organic nutrients.

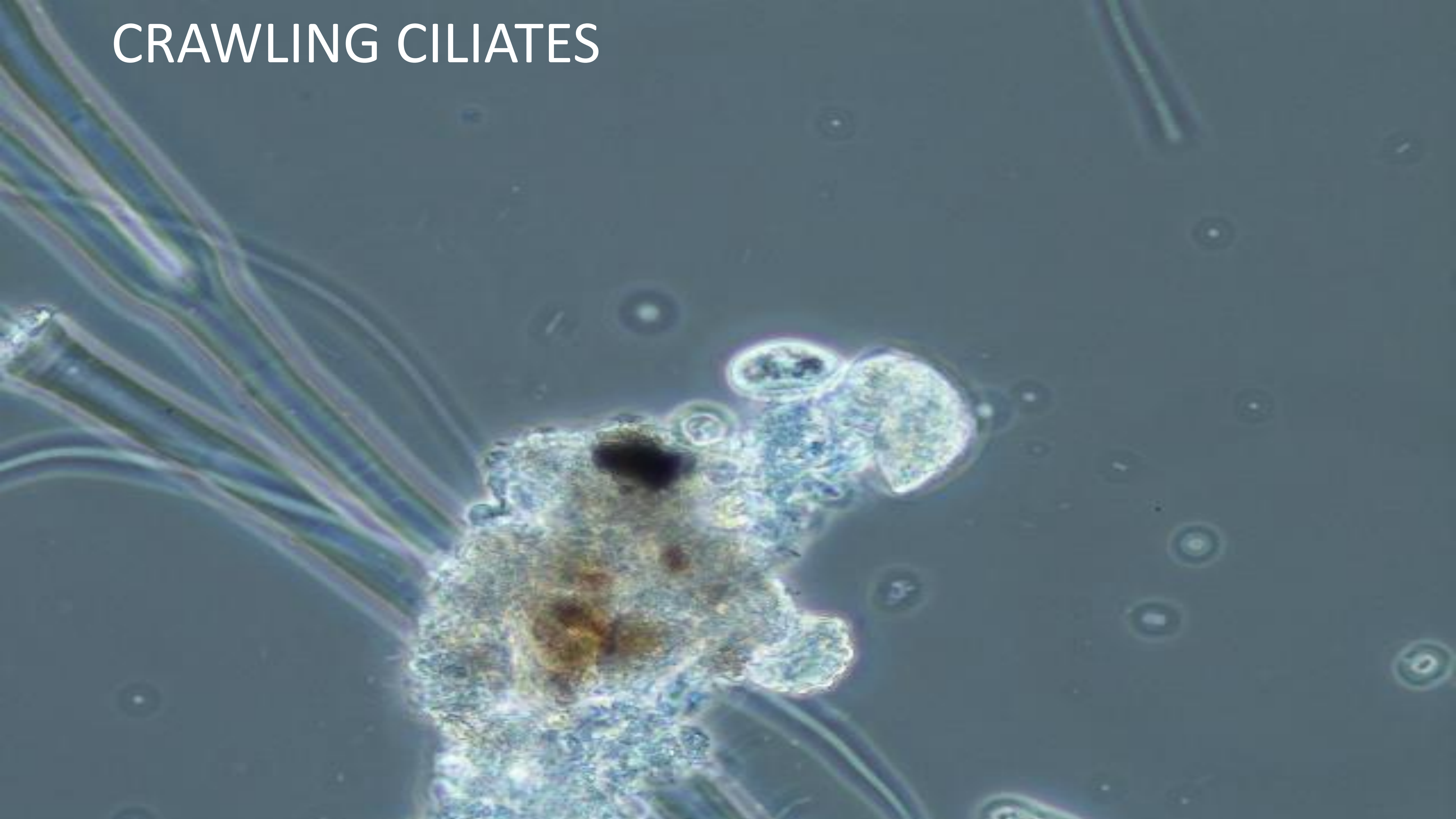
# FLAGELLATES

# CILIATES

Ciliates feed on bacteria not on dissolved organics. While bacteria and flagellates compete for dissolved nutrients, ciliates compete with other ciliates and rotifers for bacteria. The presence of ciliates indicate a good sludge, because they dominate after the floc has been formed and after most of the organic nutrients have been removed.

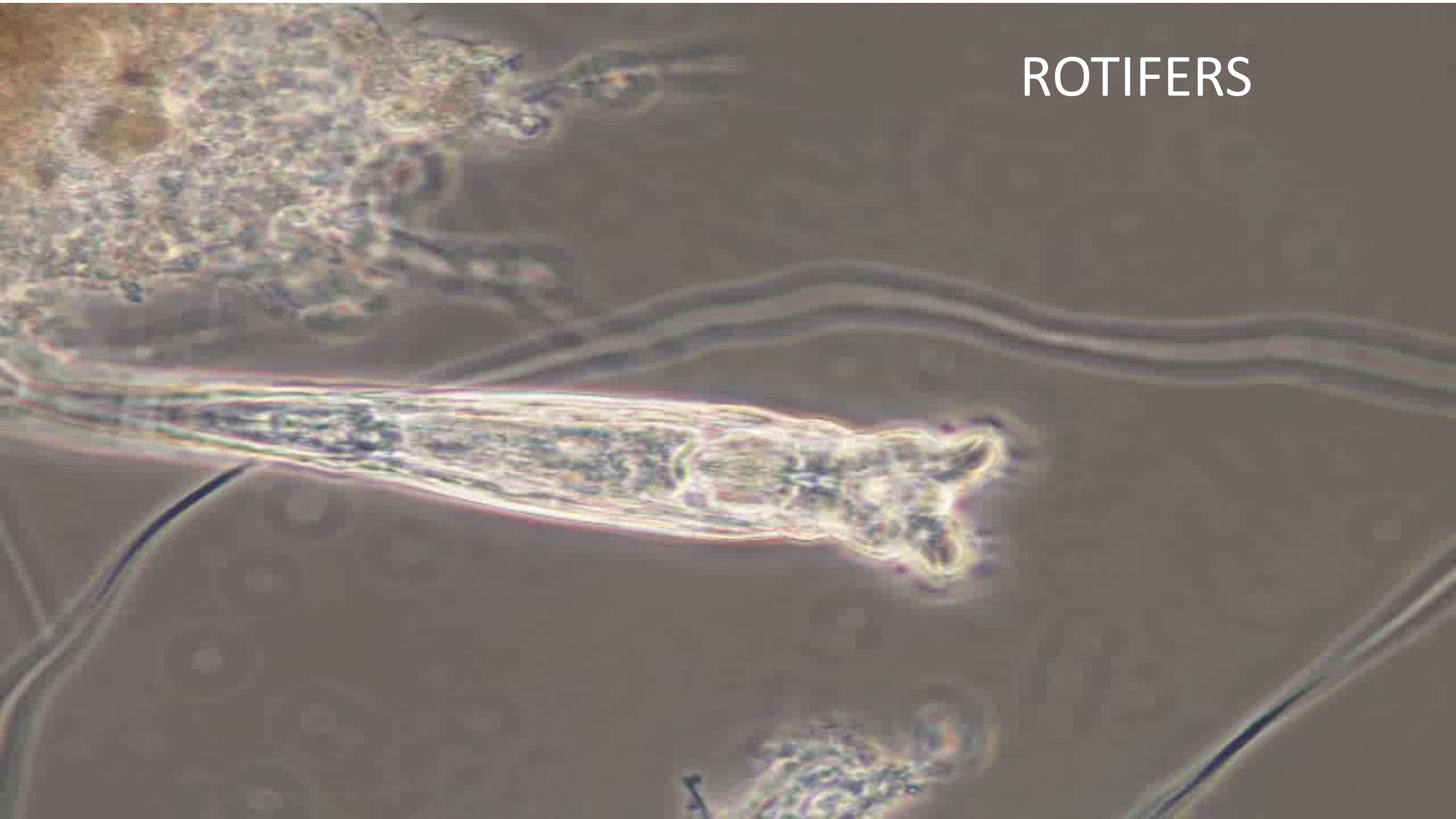
# FREE SWIMMER

# CRAWLING CILIATES



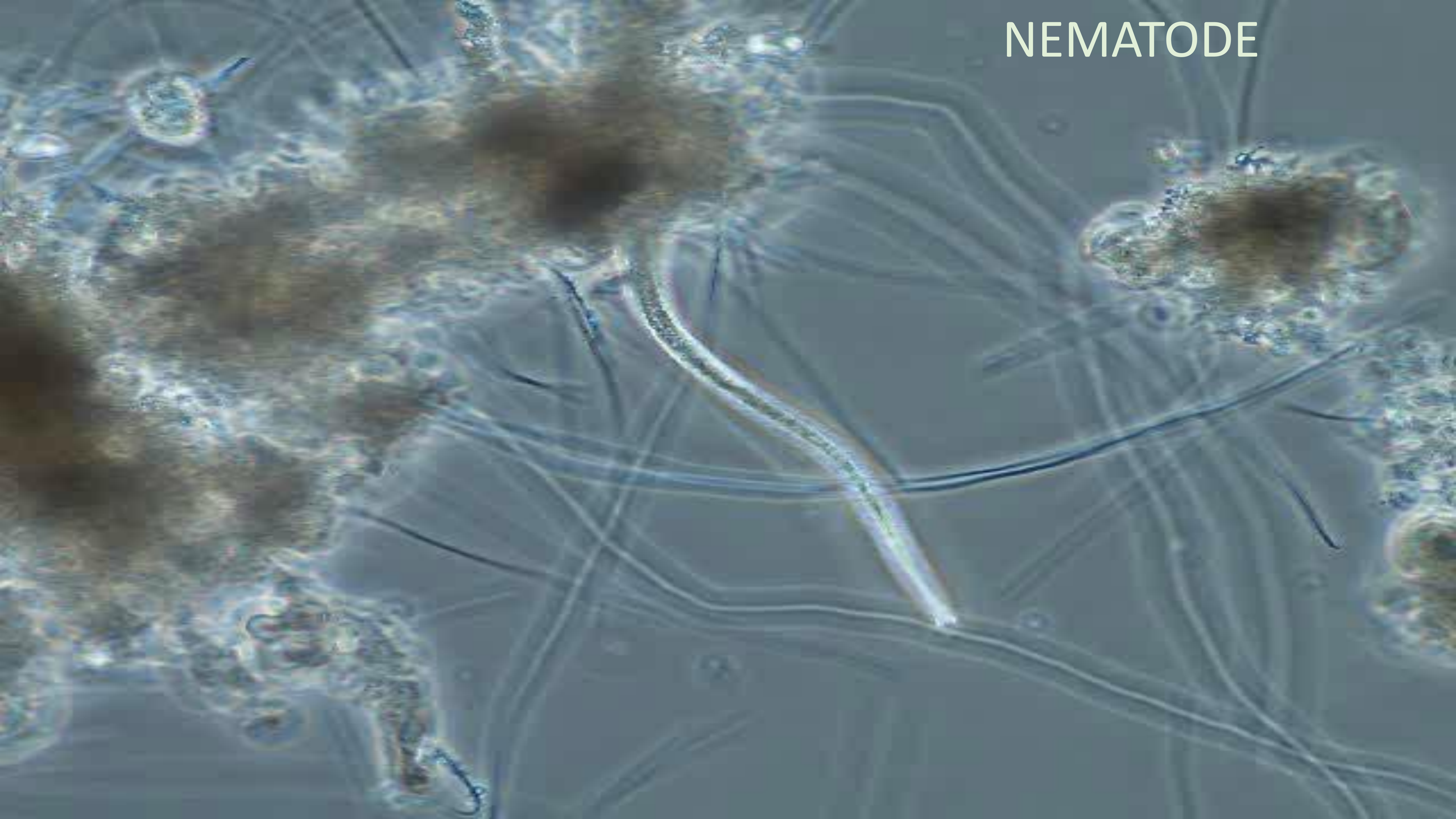

STALKED CILIATES

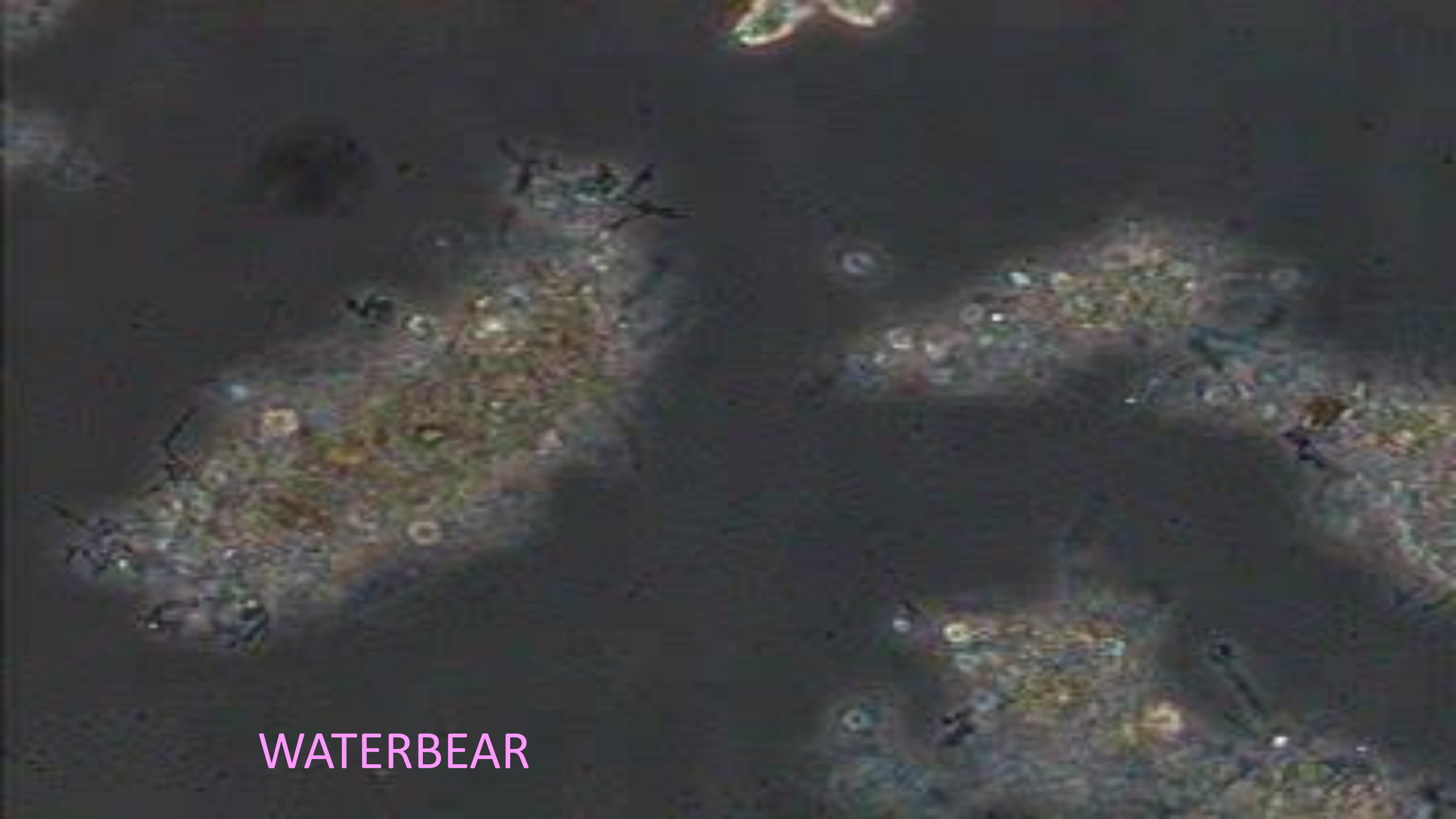
# ROTIFERS

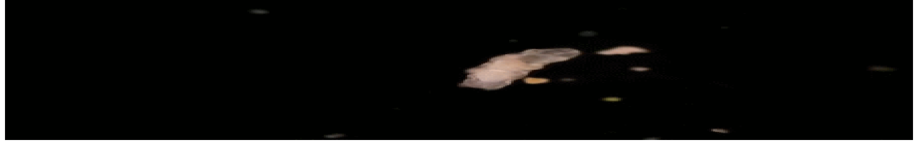


# SHELLED ROTIFER

# NEMATODE




WATERBEAR



*TOUGHEST ANIMAL IN THE WORLD*

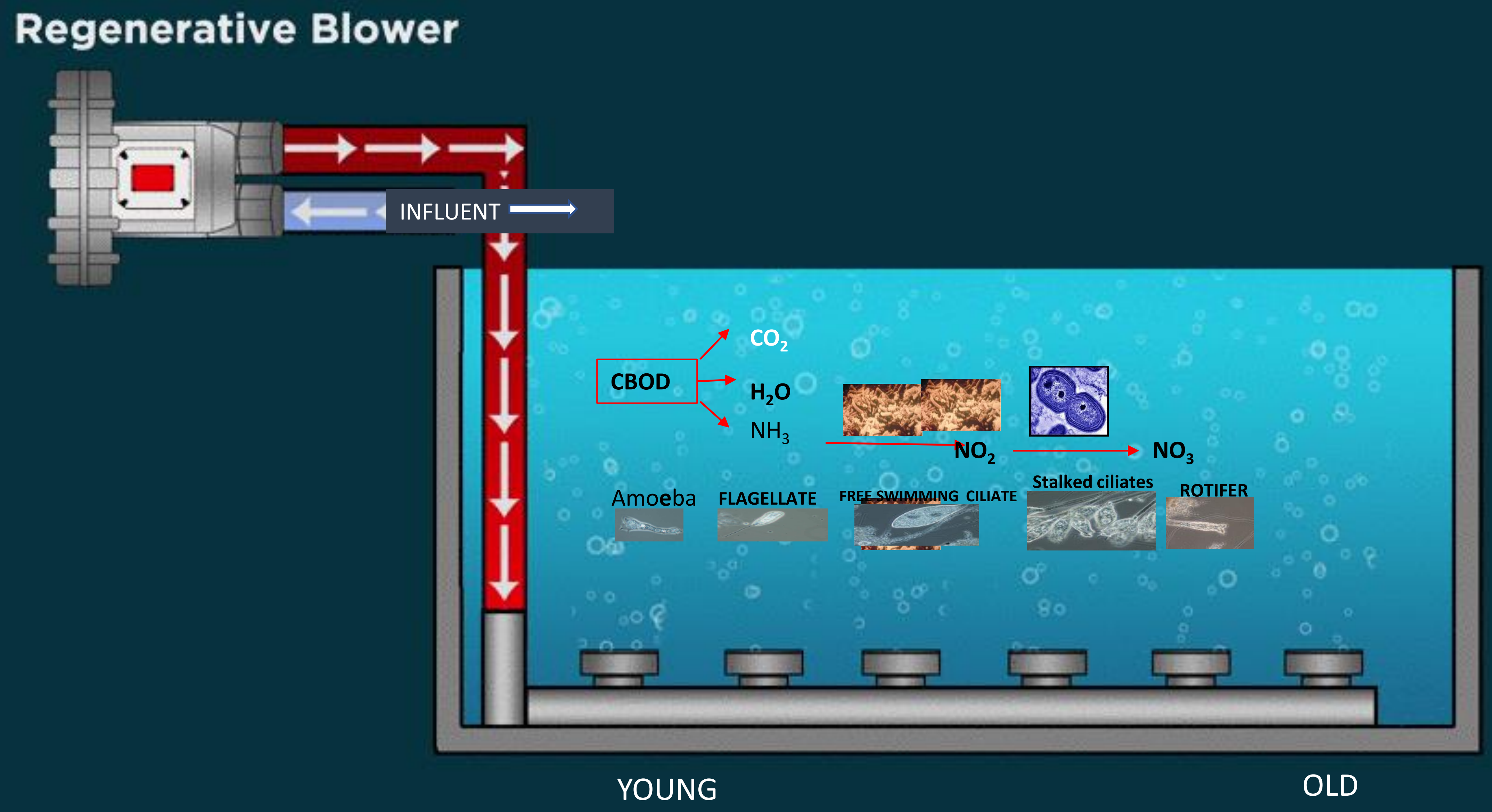
**Withstand temperature** ranges from –458 °F to 300 °F

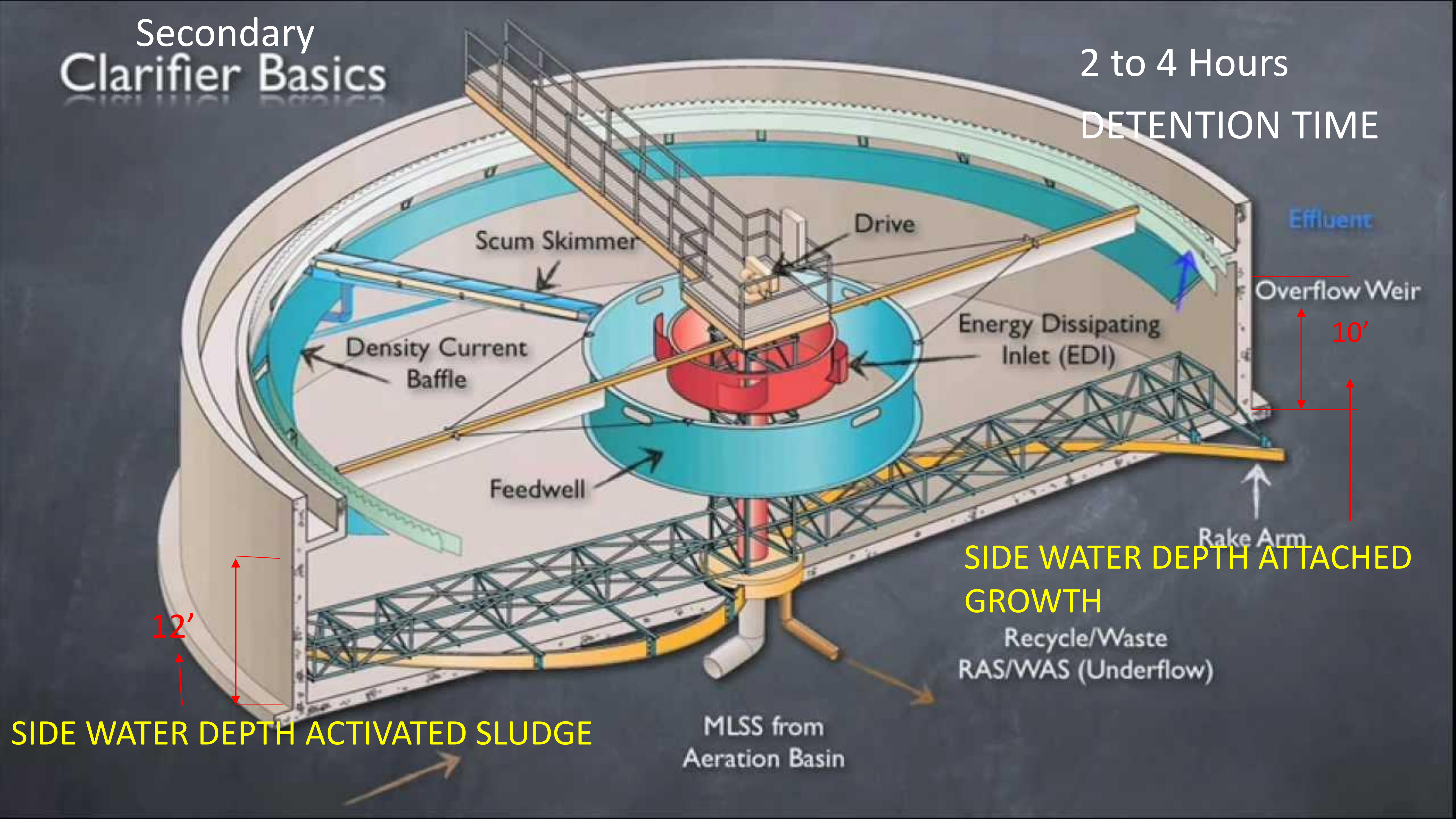
**Survive dehydration** for years. When exposed to extremely low temperatures, their body composition goes from 85% water to only 3%. This dehydration ensures they don't get torn apart by water expanding as it freezes in extreme temperatures.

**Withstand pressure** ranges up to six times greater than is found in the deepest ocean trenches.

**Survive ionizing radiation** at doses hundreds of times higher than the lethal dose for a human.

**Probably survive other extreme conditions** like environmental toxins.


Regenerative Blower
INFLUENT
CBOD
$CO_2$
$H_2O$
$NH_3$
$NO_2$
$NO_3$
Amoeba
FLAGELLATE
FREE SWIMMING CILIATE
Stalked ciliates
ROTIFER
YOUNG
OLD

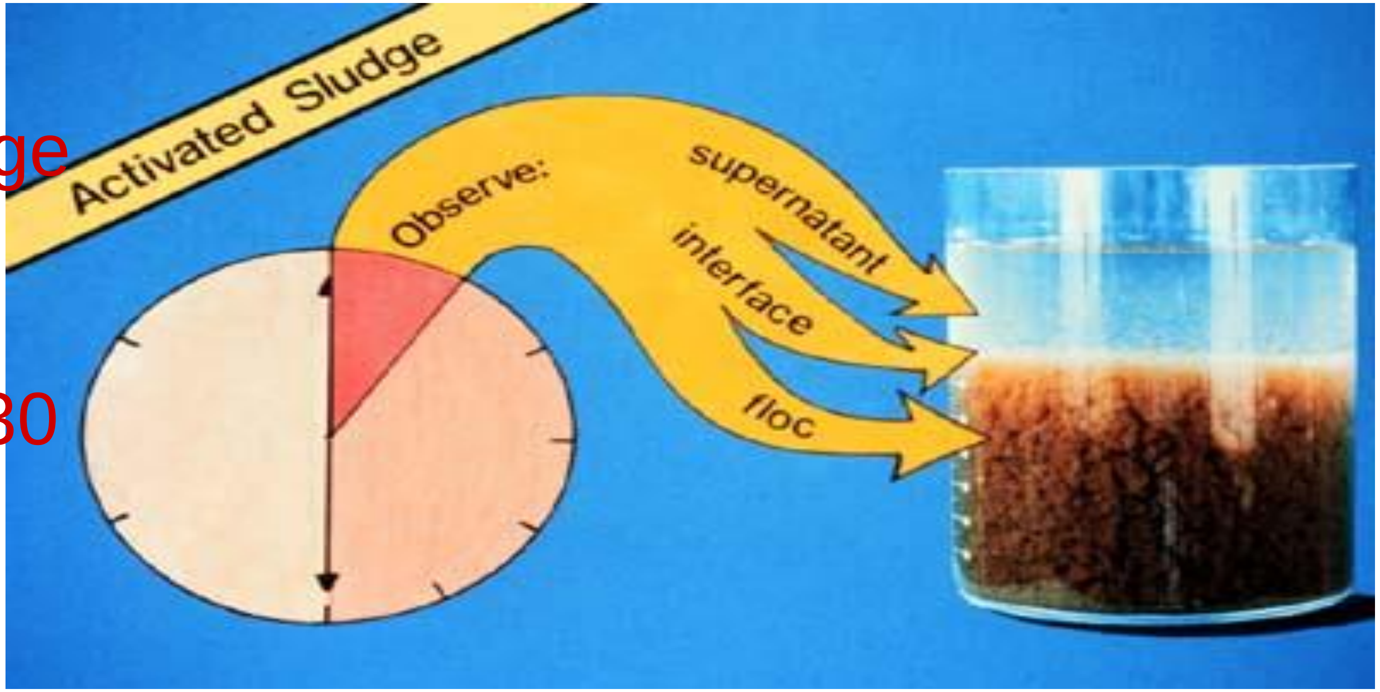

Secondary
Clarifier Basics
2 to 4 Hours
DETENTION TIME
Effluent
Drive
Scum Skimmer
Overflow Weir
10’
Energy Dissipating
Inlet (EDI)
Density Current
Baffle
Feedwell
Rake Arm
SIDE WATER DEPTH ATTACHED
GROWTH
Recycle/Waste
RAS/WAS (Underflow)
12’
SIDE WATER DEPTH ACTIVATED SLUDGE
MLSS from
Aeration Basin

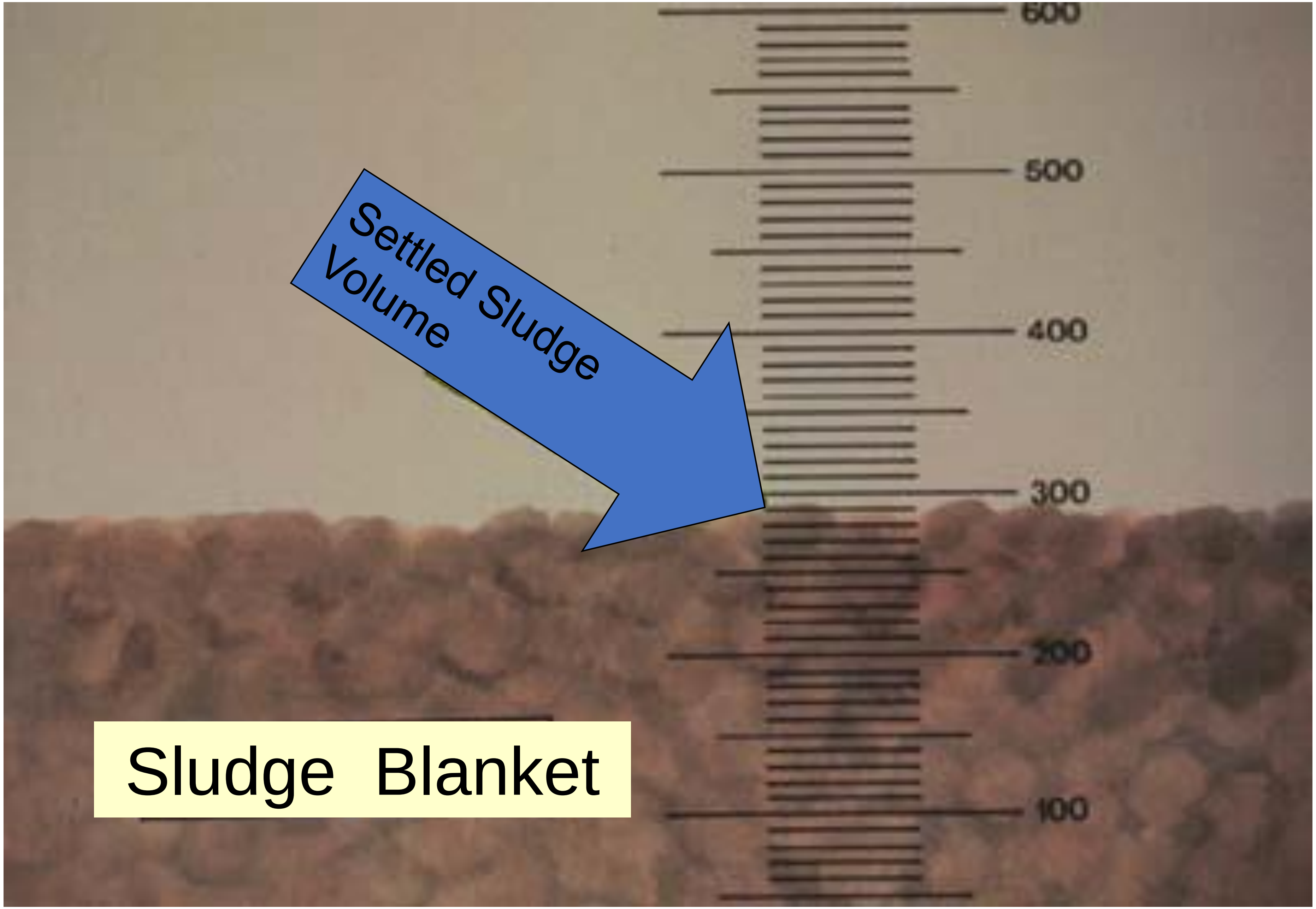
# Settleometer Test

While Settling Observe:

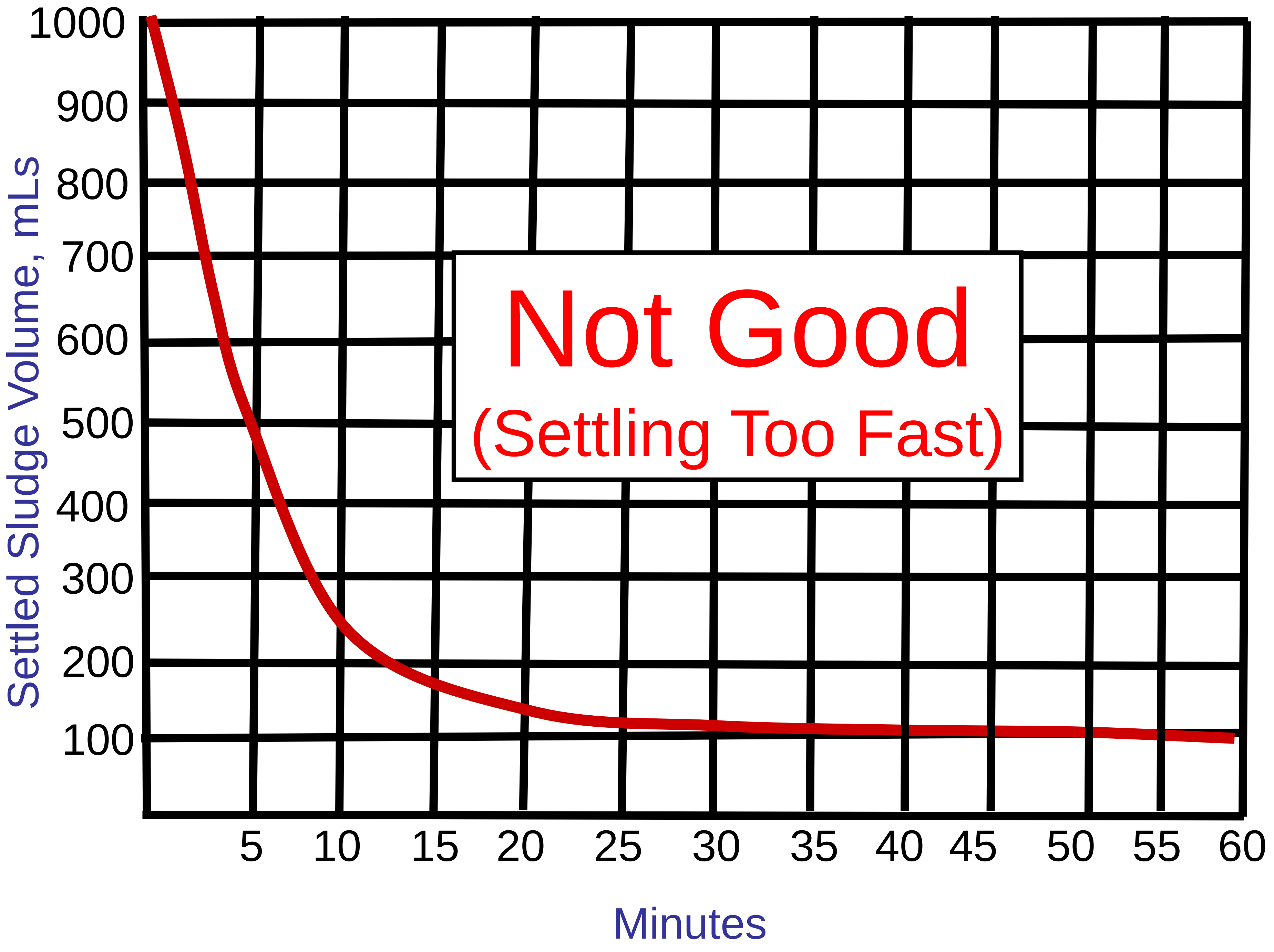
Color of ML and Supernatant
Supernatant Turbidity
Straggler Floc

Record
Settled Sludge
Volume
Every 5
Minutes for 30
Minutes




600
500
400
300
200
100
Settled Sludge Volume
Sludge Blanket

Good
Settled Sludge Volume, mLs
1000
900
800
700
600
500
400
300
200
100
5
10
15
20
25
30
35
40
45
50
55
60
Minutes



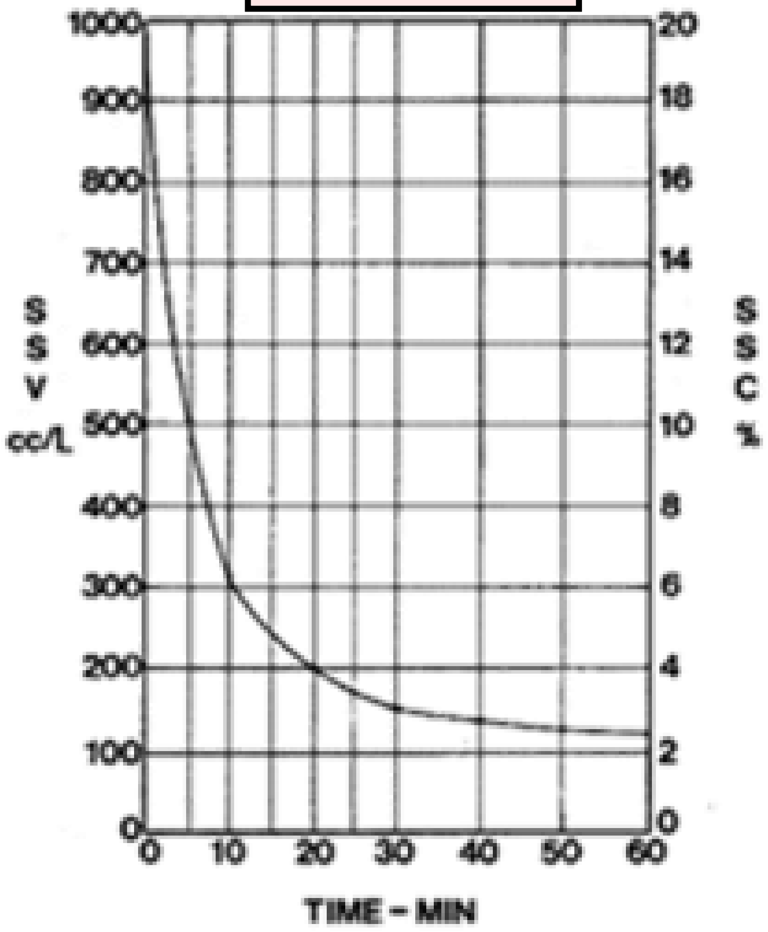
1000
900
800
700
600
500
400
300
200
100
Settled Sludge Volume, mLs
Not Good
(Settling Too Fast)
5
10
15
20
25
30
35
40
45
50
55
60
Minutes

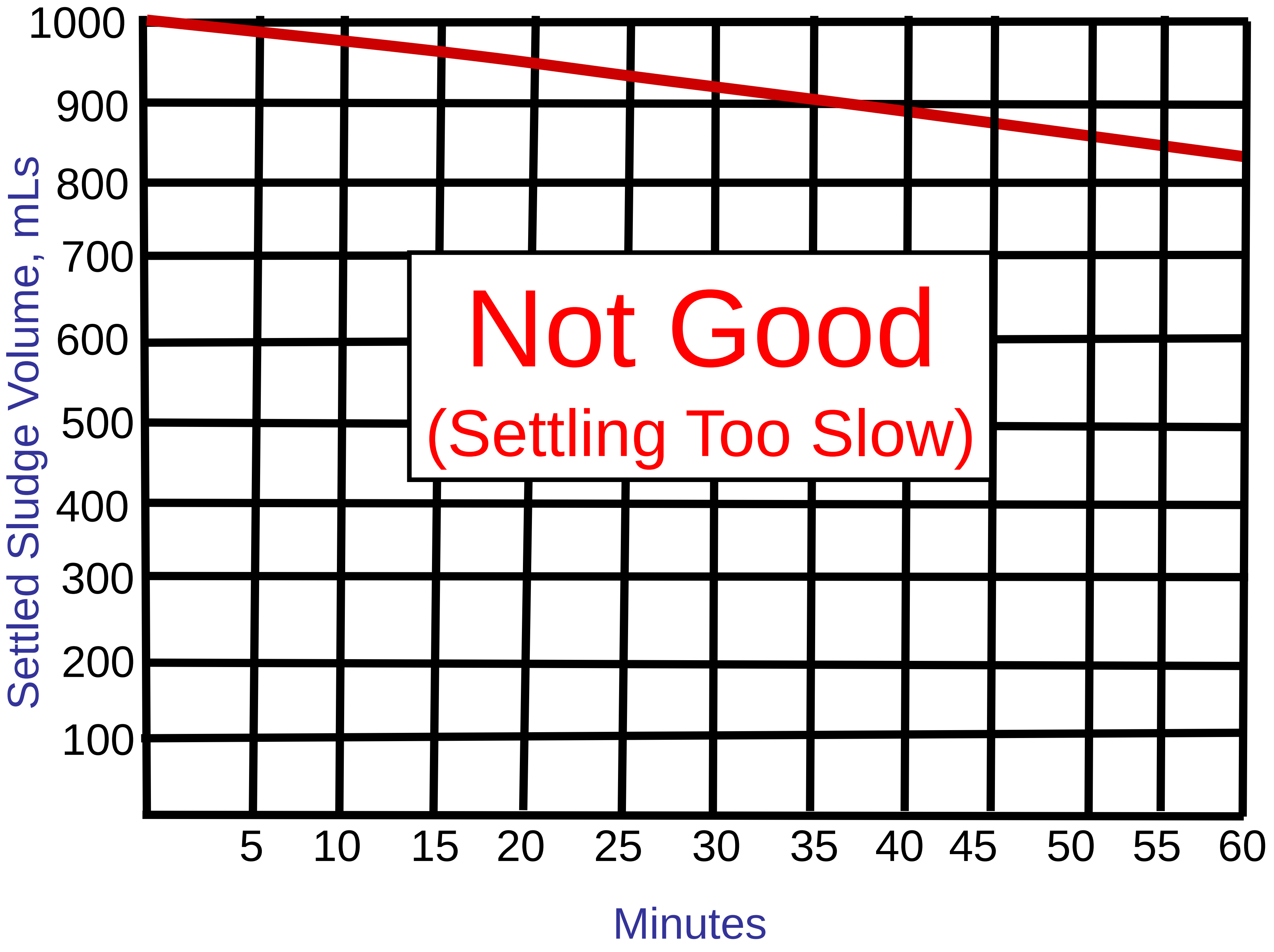
# Settleometer Test

Indication of “Old” Sludge

Leaves Straggler Floc
in Effluent

Too Fast

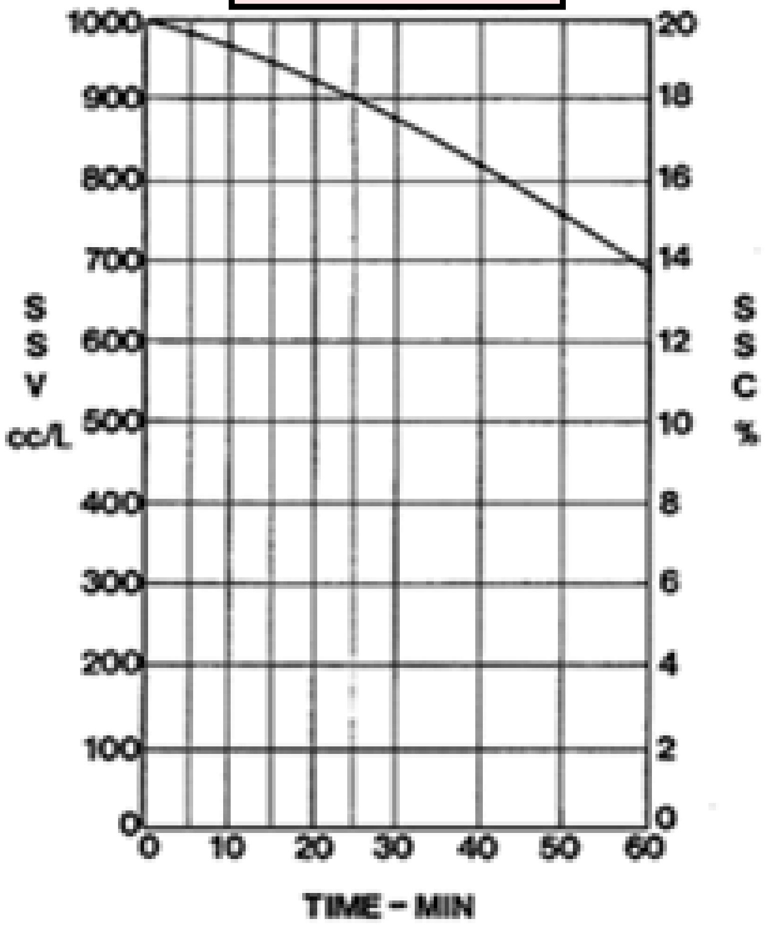




Settled Sludge Volume, mLs
1000
900
800
700
600
500
400
300
200
100
5
10
15
20
25
30
35
40
45
50
55
60
Minutes
Not Good
(Settling Too Slow)

# Settleometer Test

Too Slow



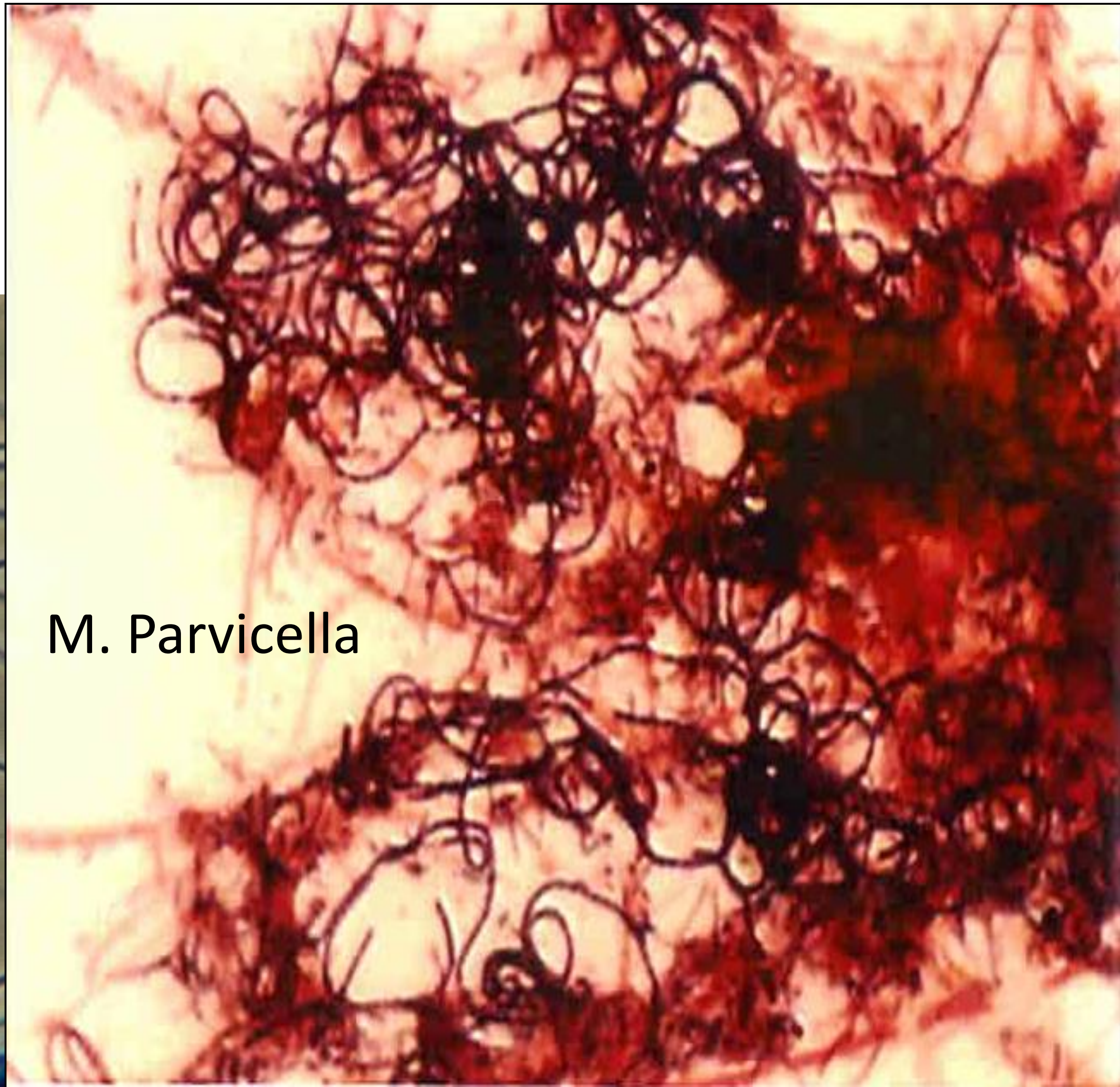

Not Compacting (Bulking)

Solids Washed Out
in High Flows

BULKING is an indicator of filamentous organisms.

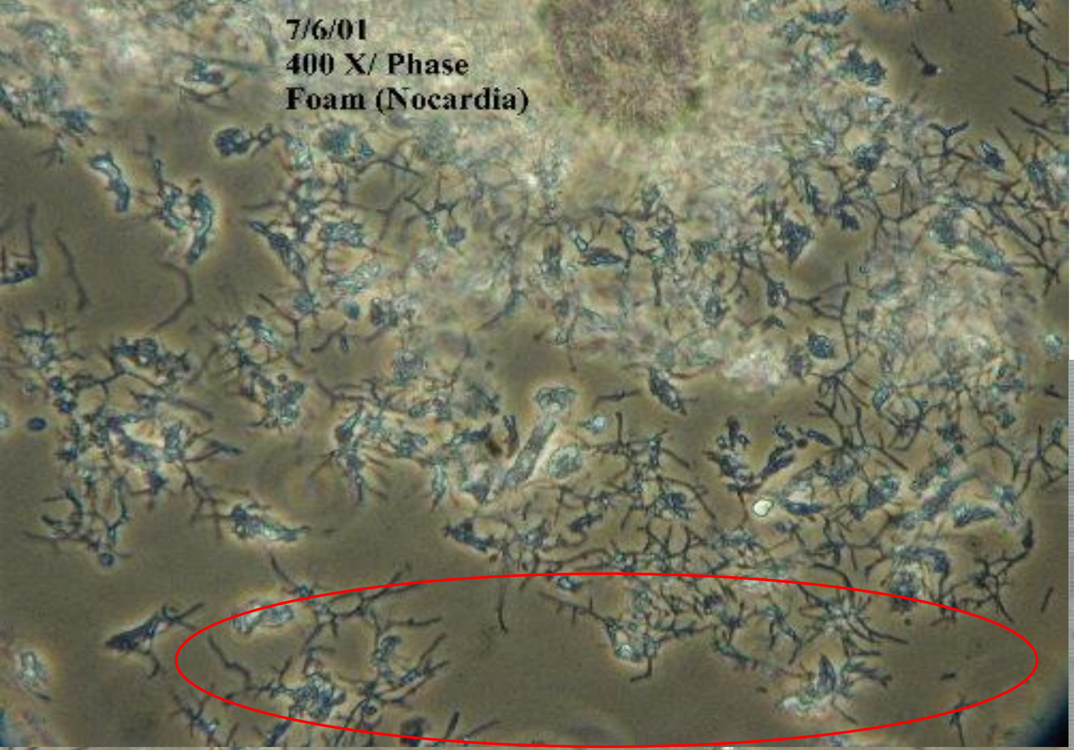
# Filaments

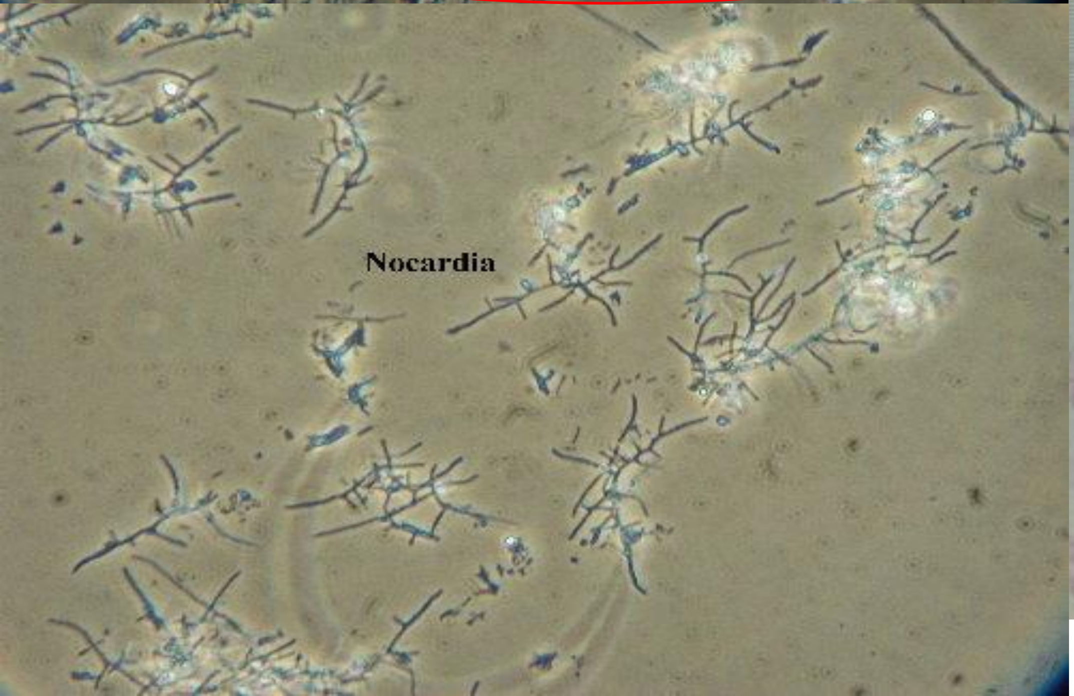
- 1701, S. natans, M. parvicella
- Strains associated with poor settling

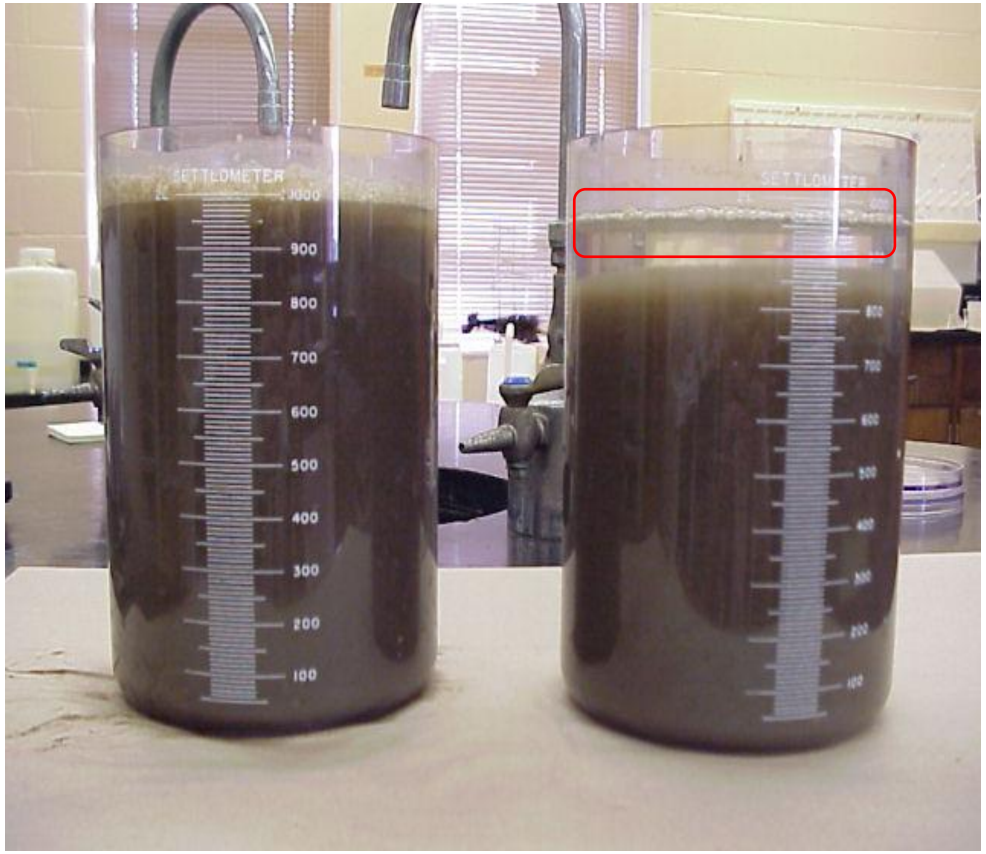
# Filaments

- Major filaments
- 021N, thiothrix and Beggiatoa can use hydrogen sulfide and organic acids for substrates
- Sources are septage, nutrient deficient wastewater



7/6/01
400 X/ Phase
Foam (Nocardia)


Nocardia

# DENITRIFYING




Rising sludge indicates denitrification, look for small nitrogen bubbles on top of clarifier.

Maintain 1 to 3 Feet

# Typical Operating Parameters — Secondary Clarifiers

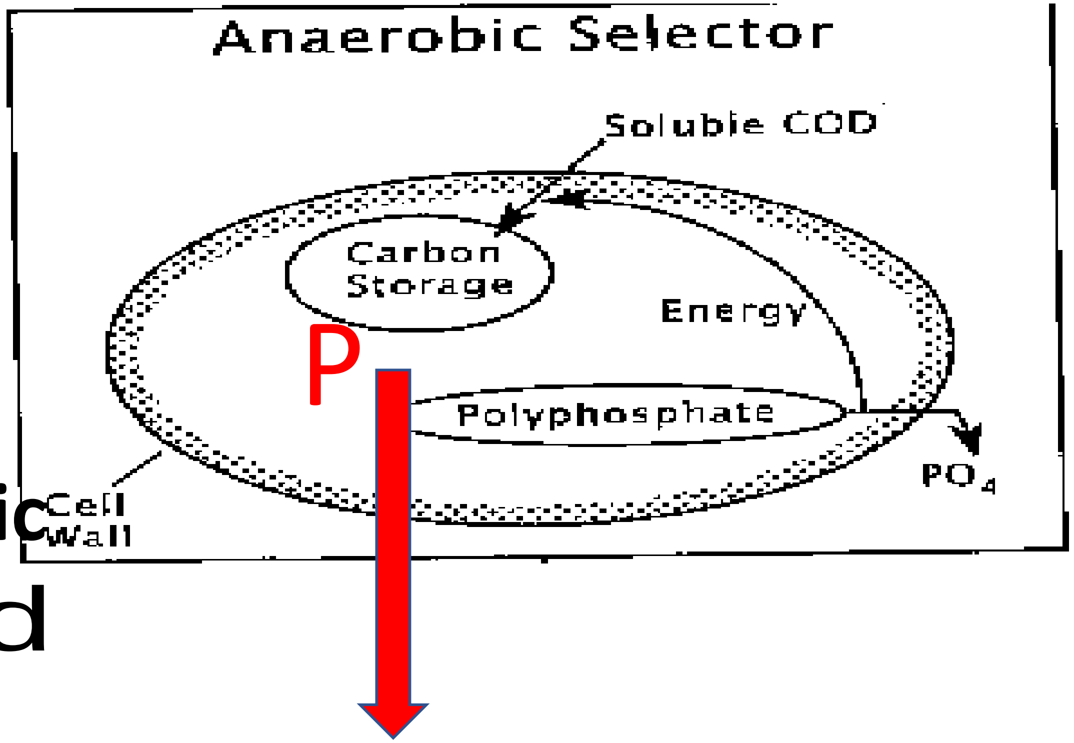
| Parameter | Operating Range |
|---|---|
| Detention Time | 2.0 to 3.0 hours |
| Weir Overflow Rate<br>> 1.0 MGD | 5,000 to 15,000 gallons per day per lineal foot of weir<br>30,000 gpd/linear foot |
| Surface Settling Rate or Surface Loading Rate | 300 to 1,200 gallons per day per square foot of clarifier surface area |
| Solids Loading Rate | 12 to 30 pounds of solids per day per square foot of clarifier surface area |

**In activated sludge processes, the sludge blanket should never exceed 25% of the sidewall depth of the secondary clarifier.**

Sludge Blanket 1 – 3 feet

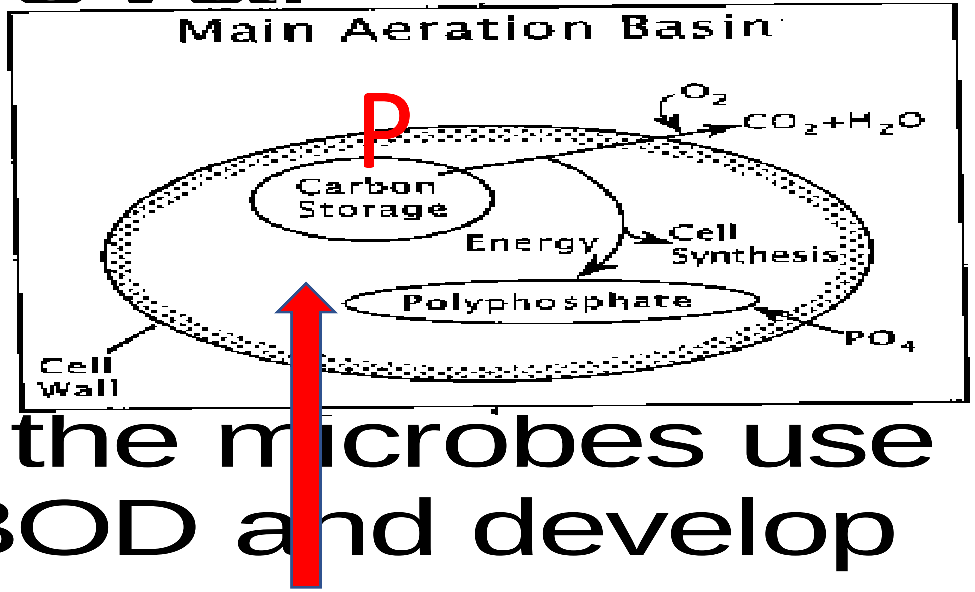

WWTP practicing BNR
EBPR
PHOSPHORUS UPTAKE
5
Influent
9
Effluent
7
4
1
ANOXIC ZONE
6
Inside Channel
Middle Channel
Outer Channel
2
PHOSPHOROUS RELEASE
8
3

# Biological Phosphorus Removal



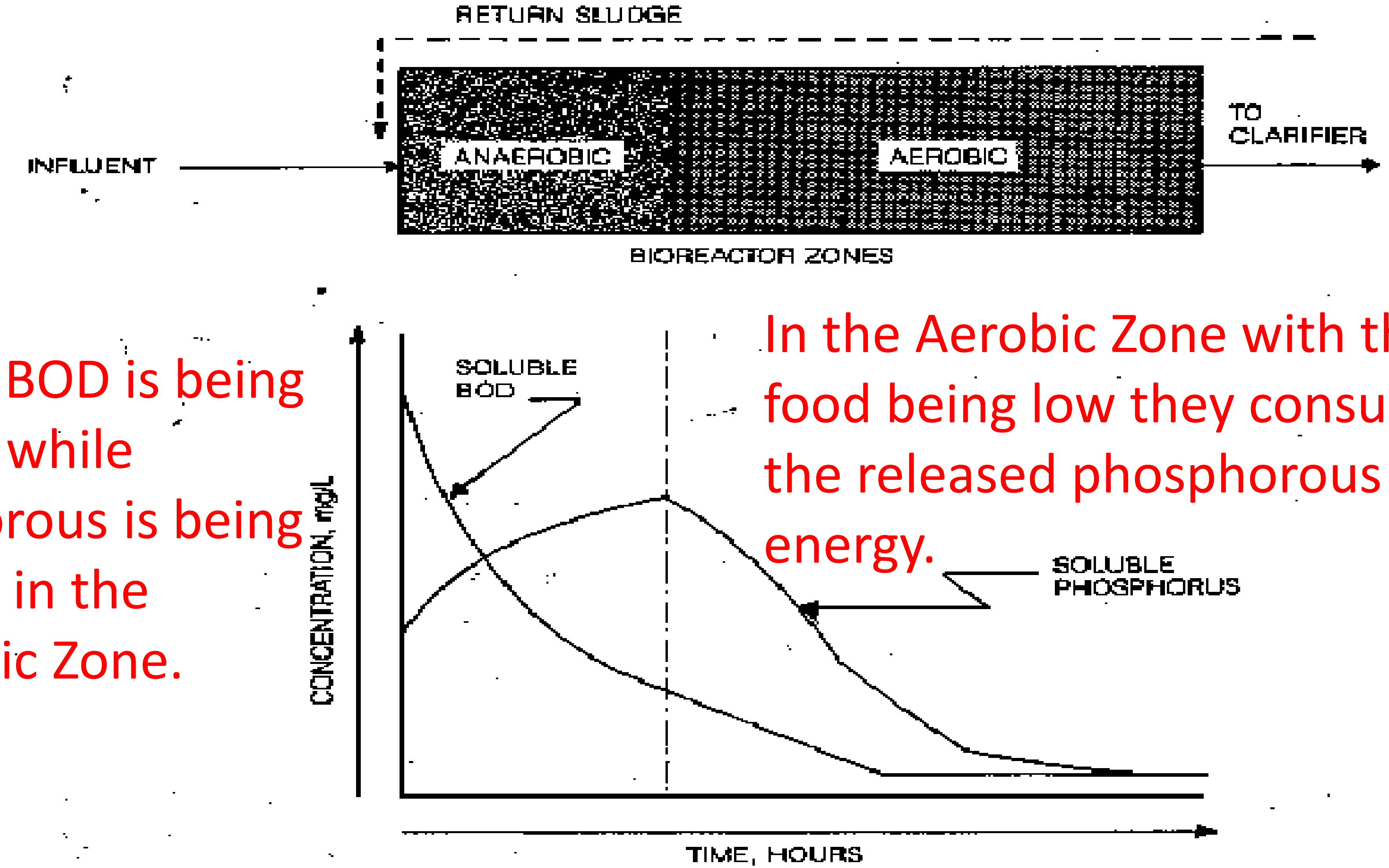

- Two Zone Process
  - 1st Zone – Anaerobic
    - Acinetobacter and Pseudomonas
    - Release Stored Phosphorus and take in Soluble BOD in the form of Acetate and Fatty Acids under Anaerobic conditions.

# Biological Phosphorus Removal



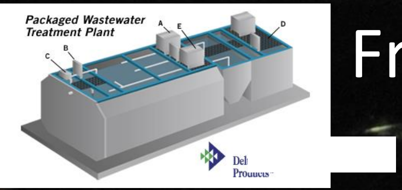

- 2nd Zone – Aerobic
  - In the aerobic zone the microbes use the stored soluble BOD and develop new cells
  - With low soluble BOD, microbes consume large amounts of soluble phosphorus
  - Phosphorus contained within the microbes are wasted.

# Biological Phosphorus Removal




NOTICE: BOD is being reduced while phosphorous is being released in the Anaerobic Zone.

In the Aerobic Zone with the food being low they consume the released phosphorous for energy.




From Package Plants to

SOUTHERLY 120 MGD

We're all in this together

# *THANK YOU & QUESTIONS*

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*Mike Maringer*

*mnmaringer400@gmail.com*