Basic Sanitary Wastewater Treatment

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Robert Garner – AECOM UAE

4 February 2013

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Vice President, Wastewater Technical Practice Leader

Project Manager – Wastewater Treatment, Biosolids, Water Reuse

35 years - Treatment Plant Planning and Design

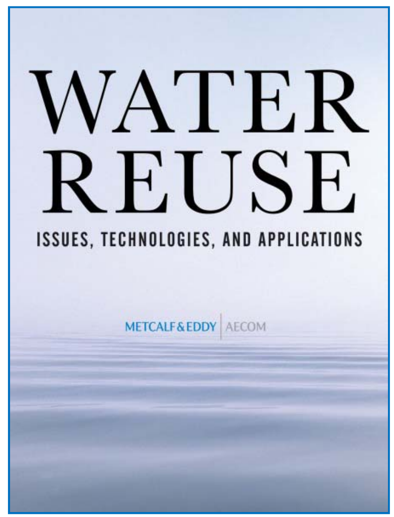
Experience – USA, Canada, Middle East, UK, Southeast Asia, South America

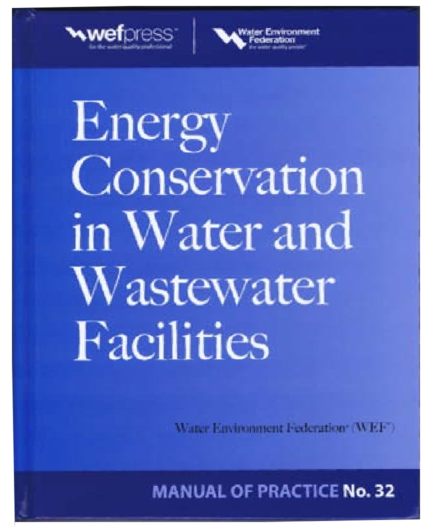
Middle East Experience: 1998 - Present

Contributing Author:

Metcalf & Eddy - Water Reuse

MOP 32 – Energy Conservation





Robert B. Garner robert.garner@aecom.com

Principal Engineer – Abu Dhabi / Gulf Region

Project Manager – Water & Wastewater Treatment, Water Reuse

27 years – Process Applications Design, Treatment Plant Design and Construction

Experience – UK, Middle East.

Middle East Experience: 1995 – Present

Specializations:-

Pumping Systems,Preliminary Treatment, Screening and Sludge Treatment.

Agenda

8:30 AM – 10:00 AM

- Introduction to Wastewater Treatment, Types of Treatment
- Pumping and Preliminary Treatment

10.00 AM – 10:30 AM Break

10:30 AM – 12:00

- Primary Treatment
- Biological Treatment - Overview
- Biological Treatment - Suspended Growth (Activated Sludge)
- Biological Treatment – Fixed Growth
- Clarification
- Filtration
- Disinfection

12:00 to 1:00 PM Lunch Break

1:00 PM – 2:00 PM

- Odor Control
- Process Modeling
- Discussion

2:00 – 2:30 Break

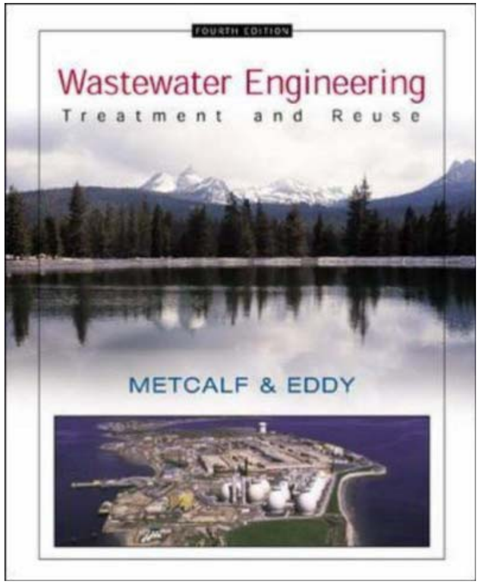
2:30 PM – 4:00 PM

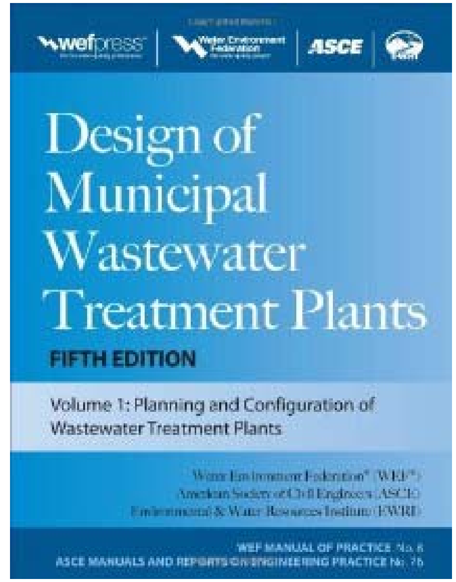
- Sludge Treatment Overview
- Thickening
- Digestion
- Dewatering/Drying

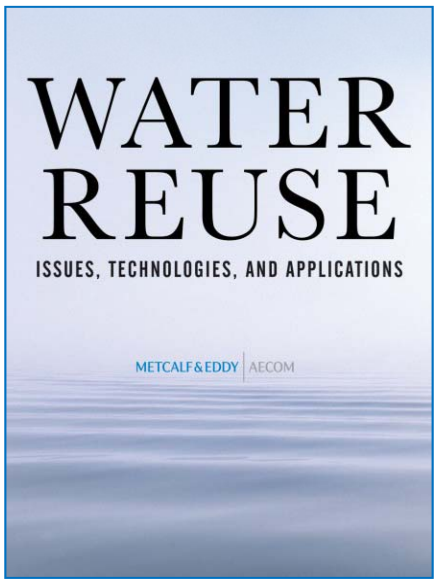
Session Objectives

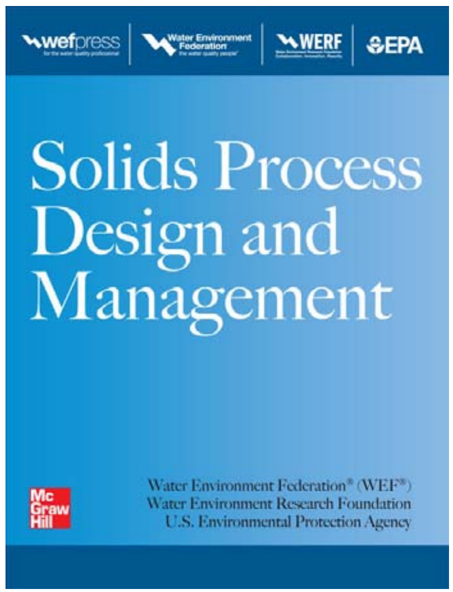
- Overview of Basic Sanitary Wastewater Treatment
- Design considerations
- Types of Treatment – Liquid Stream
- Treatment Systems – Residual Solids Stream
- Process descriptions and design parameters

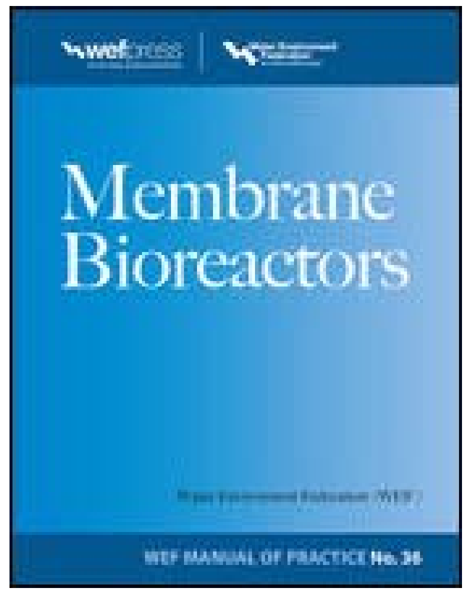
References


FOURTH EDITION
Wastewater Engineering
Treatment and Reuse
METCALF & EDDY


ASCE
Design of Municipal Wastewater Treatment Plants
FIFTH EDITION
Volume 1: Planning and Configuration of Wastewater Treatment Plants


WATER REUSE
ISSUES, TECHNOLOGIES, AND APPLICATIONS
METCALF & EDDY | AECOM


wefpress
Water Environment Federation
WERF
EPA
Solids Process Design and Management
Mc Graw Hill
Water Environment Federation® (WEF®)
Water Environment Research Foundation
U.S. Environmental Protection Agency


Membrane Bioreactors

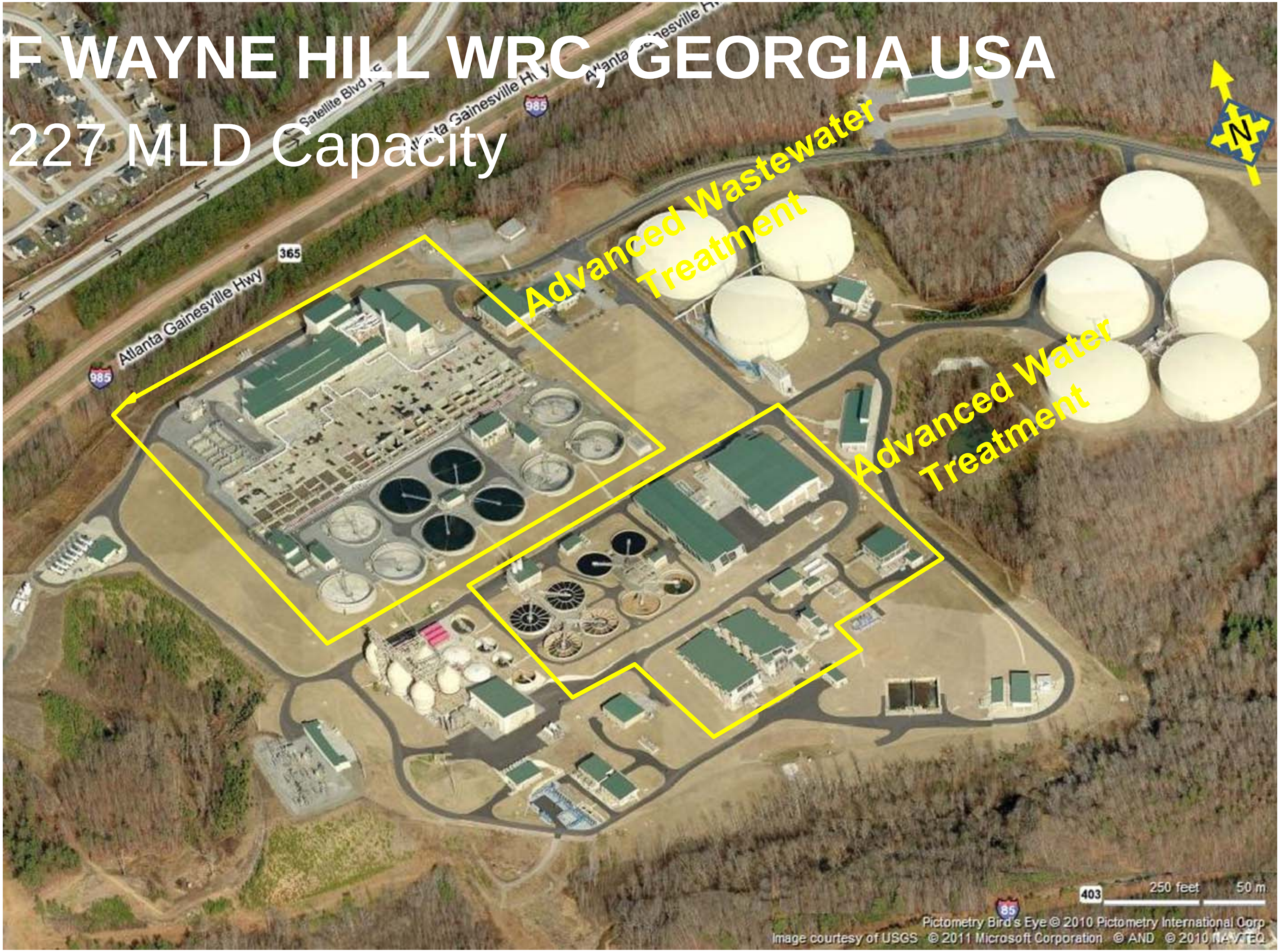
Overview of Basic
Sanitary Wastewater Treatment

DC WATER BLUE PLAINS WWTP, USA

1400 MLD Capacity

F WAYNE HILL WRC, GEORGIA USA

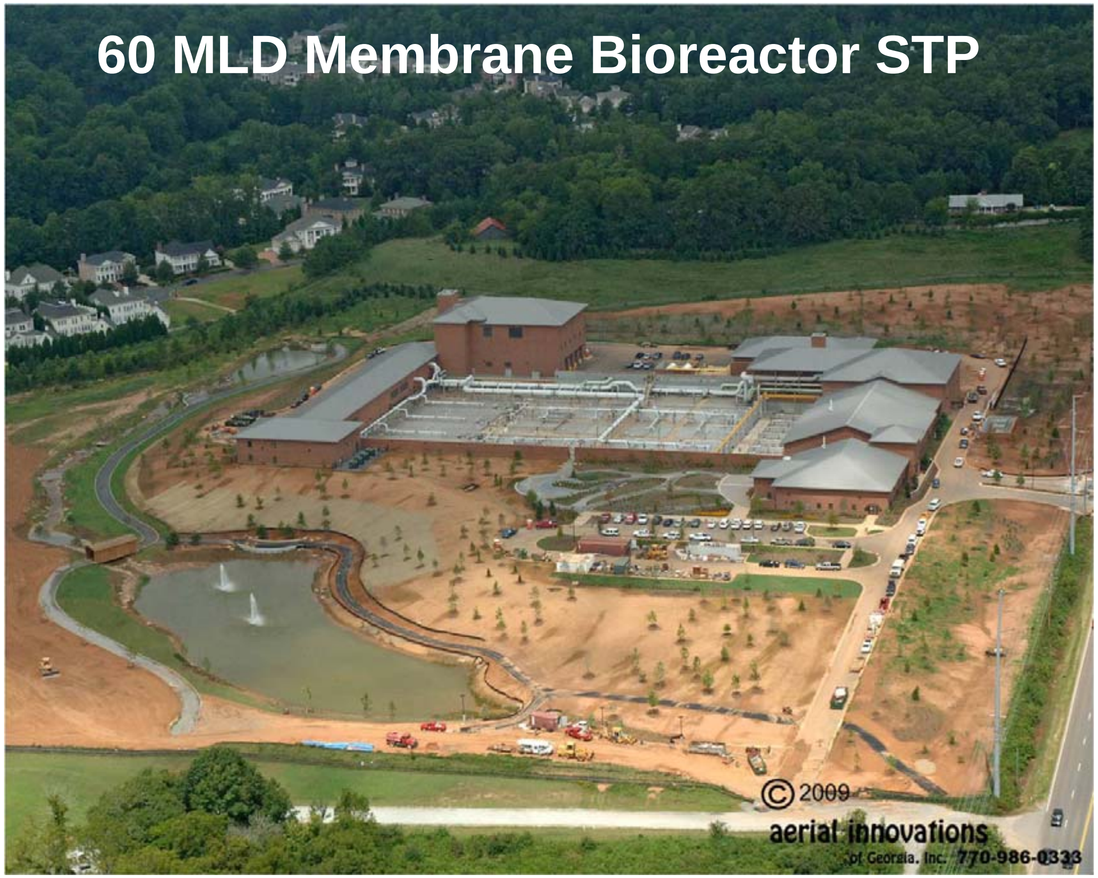
227 MLD Capacity



MALABAR STP, SYDNEY AUS

1000 MLD Capacity

Compact Treatment



Palm Jumeirah

Where is the Treatment Plant?

Suji STP (SAMSUNG Engineering)
Yong-in City, Korea
110 MLD

Terminology

Terminology

BOD – Biochemical Oxygen Demand

COD – Chemical Oxygen Demand

TSS – Total Suspended Solids

Coliform - Bacteria Colony Forming Units

DO – Dissolved Oxygen

Screenings – Floating debris removed by screening units

Grit – Inert debris (sand, coffee grounds, egg shells)

FOG – Fats, Oils, Grease

Sludge/Biosolids – Residual Waste from Biological Treatment

TSE – Treated Sewage Effluent

Mixed Liquor – Biomass in Activated Sludge Reactors

Terminology, Cont'd

Preliminary Treatment

Primary Treatment

Secondary Treatment

Biological Treatment

Activated Sludge /Suspended Growth Processes

Fixed Film/ Attached Growth Processes

Tertiary Treatment

Nutrient Removal

Return Activated Sludge

Waste Activated Sludge

Overview of Basic Sanitary Wastewater Treatment

- Wastewater is 99.97% Pure Water
- Wastewater Treatment is a series of physical, chemical and biological processes to improve quality before reuse or disposal
- Wastewater Treatment can be to any level, even drinking water quality, with the right selection of processes
- Astronauts recycle wastewater for potable use every day
- Treatment depends on end use of the water and environmental impact

Sewage

- Why treat it?
  - Reduce pollution in rivers
  - Reduce pollution in sea
  - Improve aesthetics
  - Bacteria and viruses are harmful to people
  - Fish need oxygen to live
  - Reuse – valuable resource

Pollutants/Contaminants in Wastewater

- **Floating Debris**
  - Unsightly in discharge and residual solids
  - Can damage equipment in plant
  - Plastics, sticks, paper
- **Grit**
  - Generally inert, not treatable
  - Damaging to equipment in plant
  - Sand, egg shells, plastic particles, coffee grounds
- **Oil and grease**
  - Can affect settling of sewage
  - Creates foam, scum
  - Unsightly in discharge
  - Organic and inorganic sources

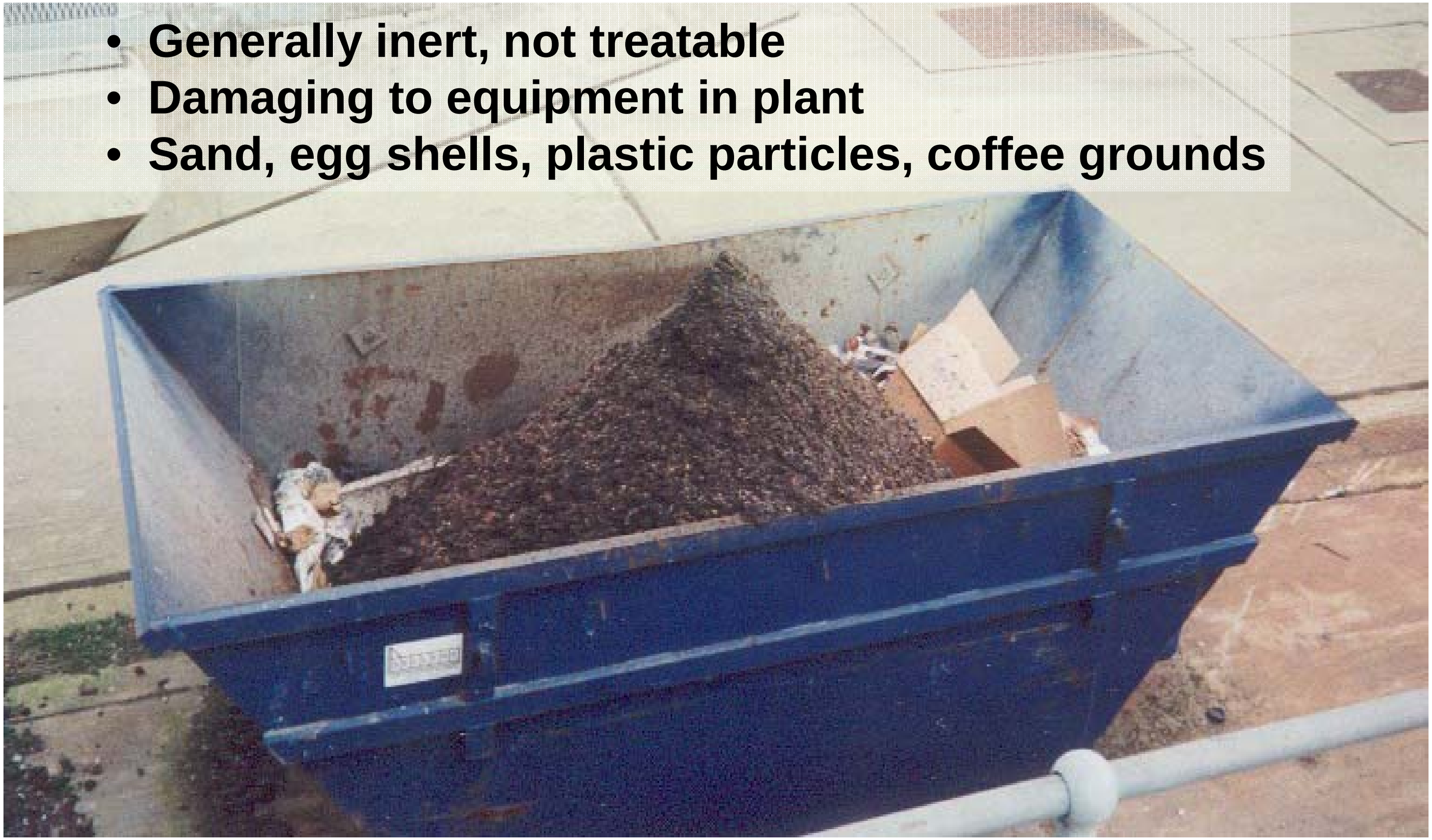
Raw Sewage

Screenings


• Unsightly in discharge and residual solids
• Can damage equipment in plant
• Floating debris - plastics, sticks, paper

Grit

- **Generally inert, not treatable**
- **Damaging to equipment in plant**
- **Sand, egg shells, plastic particles, coffee grounds**



Fats, Oil & Grease

- **Can affect settling of sewage**
- **Creates foam, scum**
- **Unsightly in discharge**
- **Organic and inorganic sources**

Pollutants/Contaminants in Wastewater

- **BOD – Biochemical Oxygen Demand**
  - Removes oxygen from river water
  - Harmful to fish if depletes oxygen in aquatic environment
  - Organic compounds
- **TSS – Total Suspended Solids**
  - Affects water clarity
  - Can carry BOD
  - Includes floating and colloidal material
  - Organic and inorganic compounds

Suspended Solids as Sludge

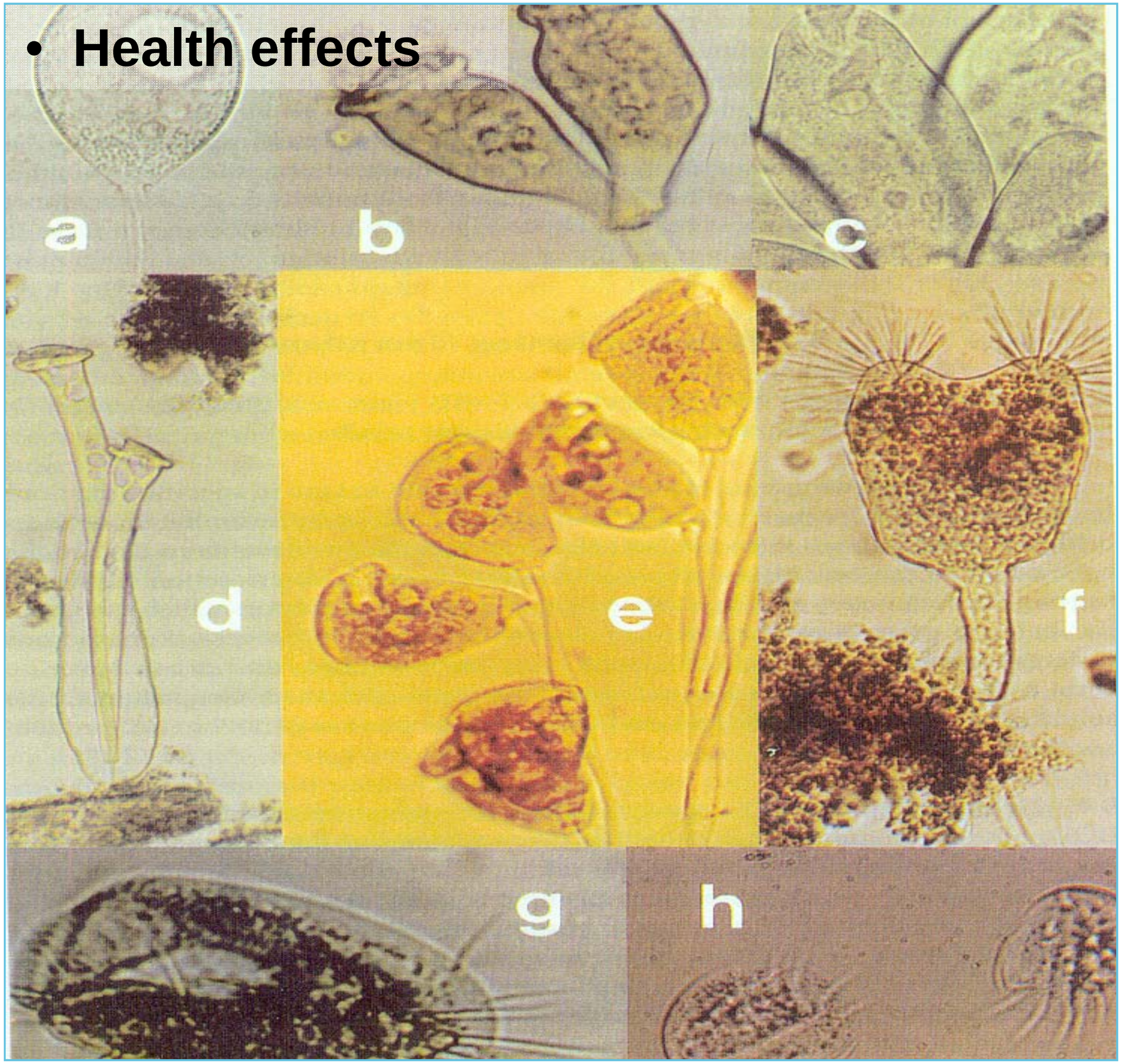
- **Affects water clarity**
- **Can carry BOD**
- **Includes floating and colloidal material**
- **Organic and inorganic compounds**

Pollutants/Contaminants in Wastewater

- **Nitrogen**
  - Ammonia toxic in aquatic environments
  - Promotes algae growth in water bodies
  - Ammonia, organic nitrogen, nitrates, nitrites
- **Phosphorus**
  - Promotes algae growth in aquatic environments
- **Bacteria and viruses**
  - Adverse health effects
- **Toxic Materials**
  - Can affect treatment
  - Toxic to humans and aquatic environments
  - Phenols, organic compounds, medical wastes, metals

Bacteria

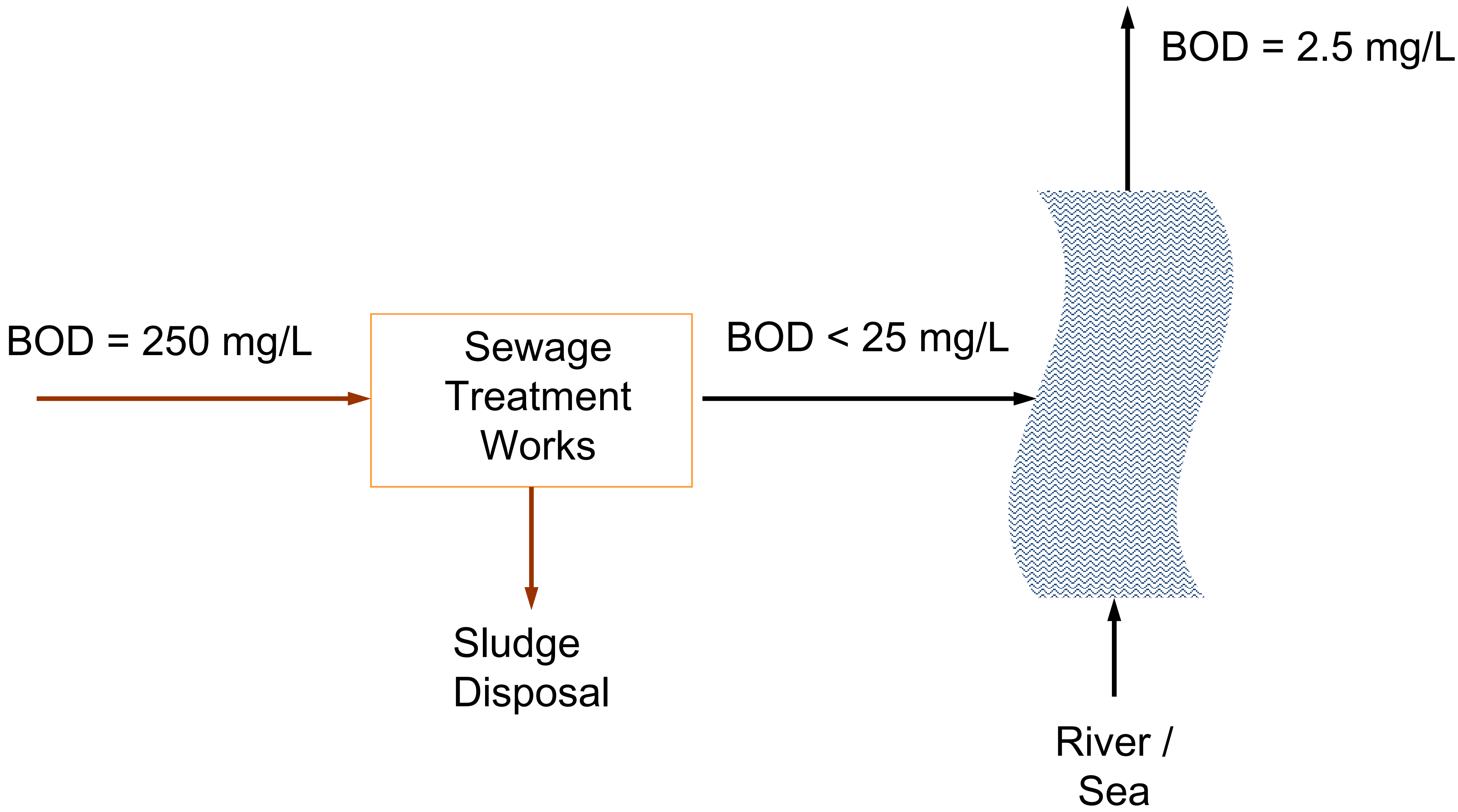
- **Health effects**



Toxic materials

- Can affect treatment
- Toxic to humans and aquatic environments
- Phenols, organic compounds, medical wastes, metals

Simplified Principle

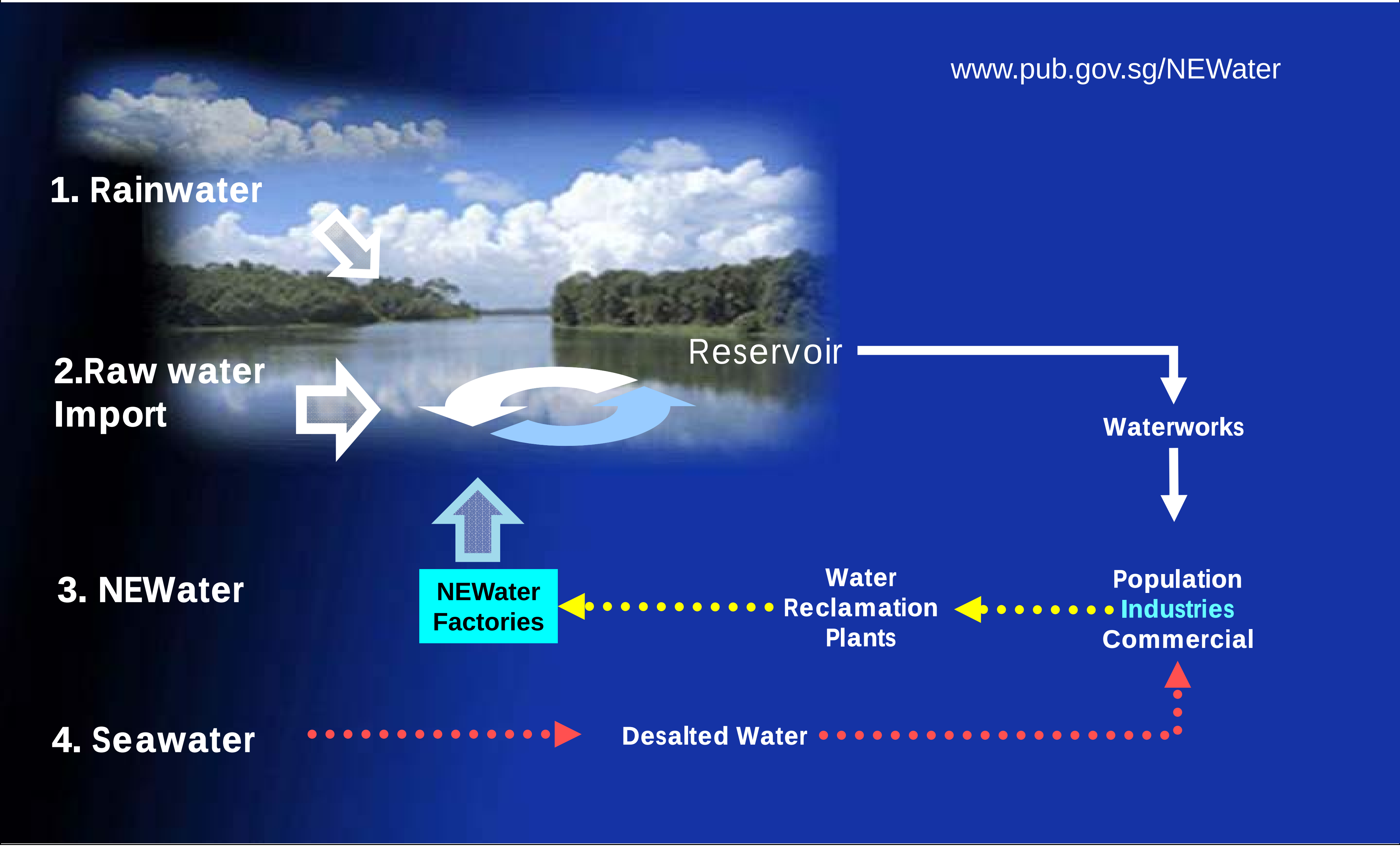


Surface Water Discharge

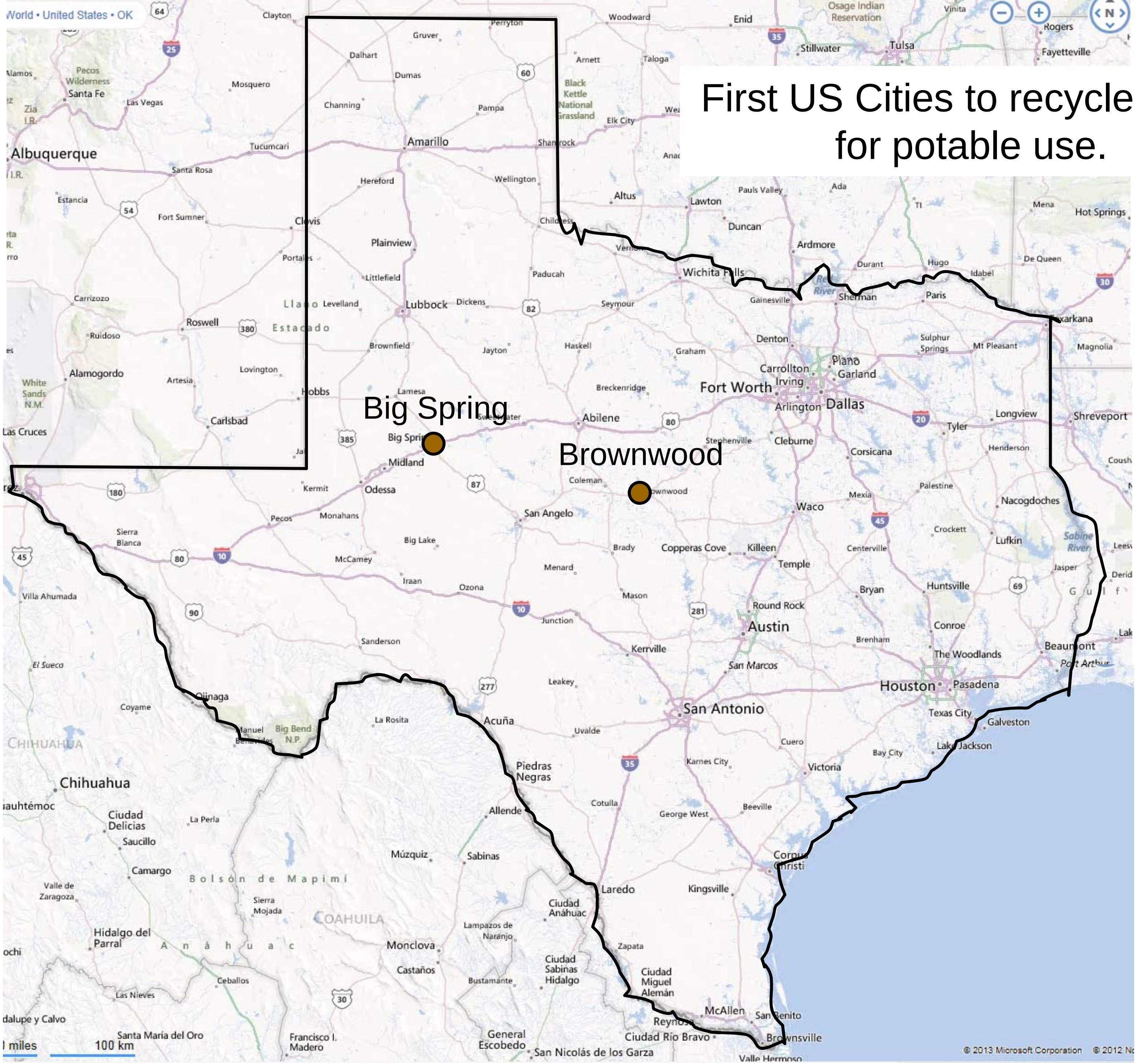
Treated Sewage Effluent (TSE)

- Irrigation
- Fire protection
- Industrial Water
- District Cooling
- Groundwater Recharge

Kranji – SINGAPORE
Water reclamation for sustainable water supply



First US Cities to recycle water for potable use.



Types of Treatment

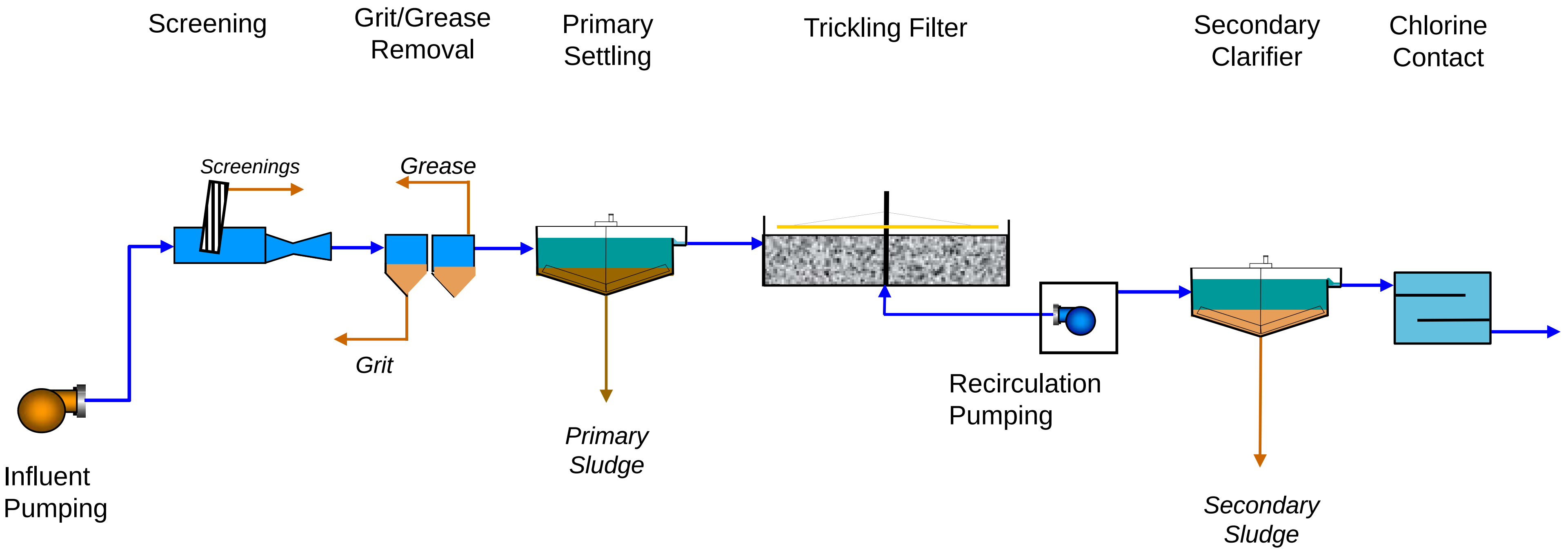
Types of Treatment

- Physical Treatment (Screening, settling, non-biological filters)
  - Removes debris, floatable material, coarse solids, fine solids

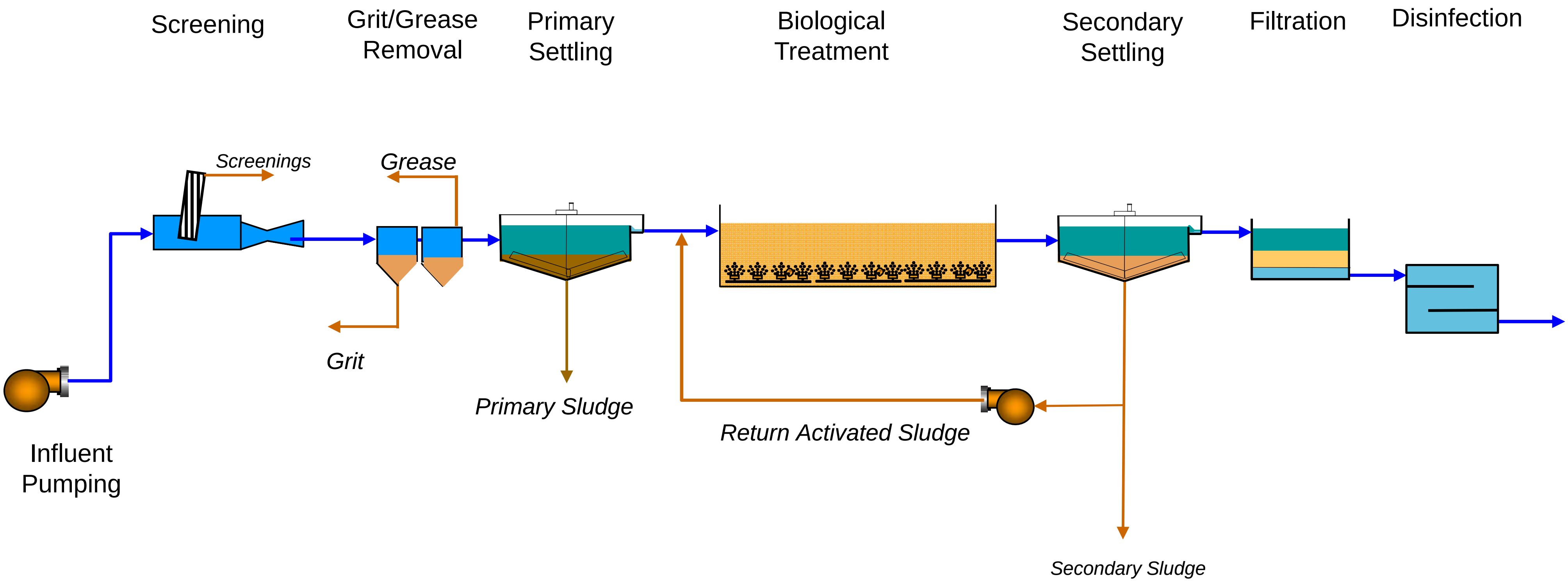
- Chemical Treatment (Disinfection, polymer, etc.)
  - Combines with soluble contaminants
  - Coagulation of solids for separation
  - Disinfection
  - Water quality adjustment – pH, buffering

- Biological Treatment (Biological Filter, activated sludge, SBR, MBR)
  - Removes or converts biodegradable organics
  - Converts Ammonia and nitrogen compounds
  - Removes soluble Phosphates

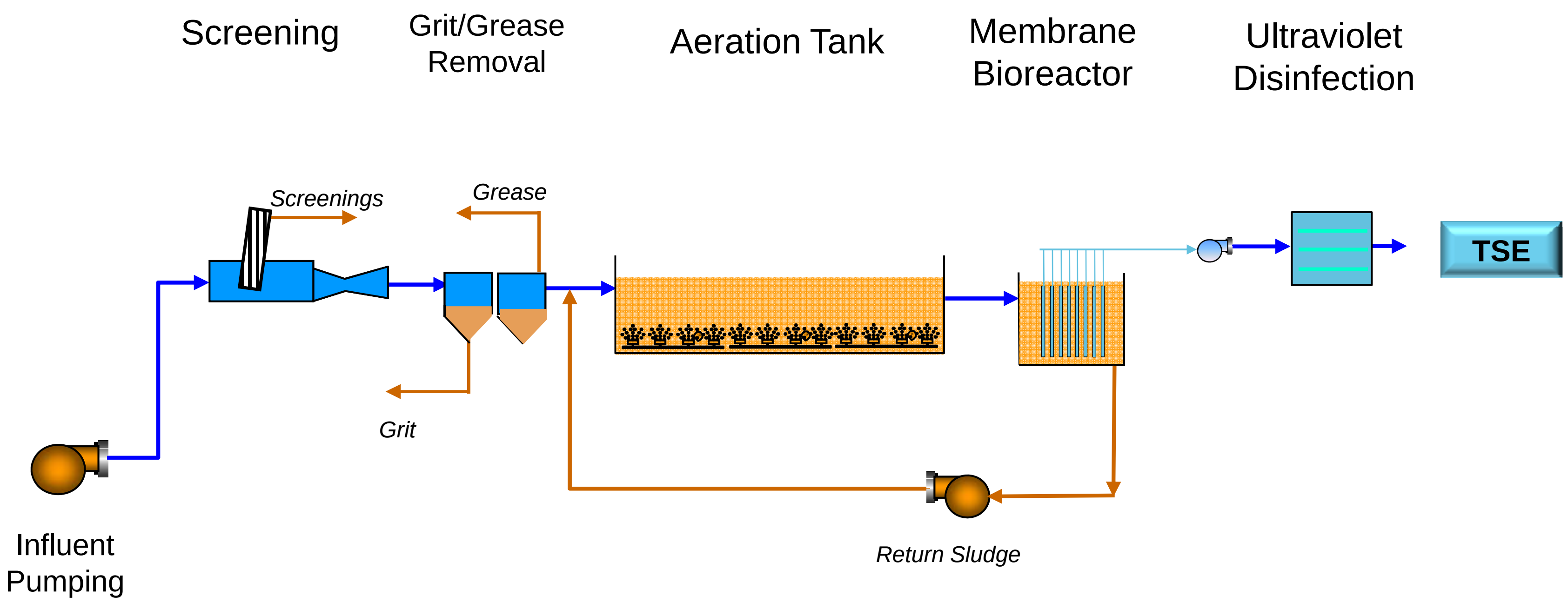
Process Flow Diagram – Trickling Filter



Process Flow Diagram – Activated Sludge with Tertiary Treatment



Process Flow Diagram – Membrane Bioreactor and UV



Treatment Selection

Treatment Selection

Population projections

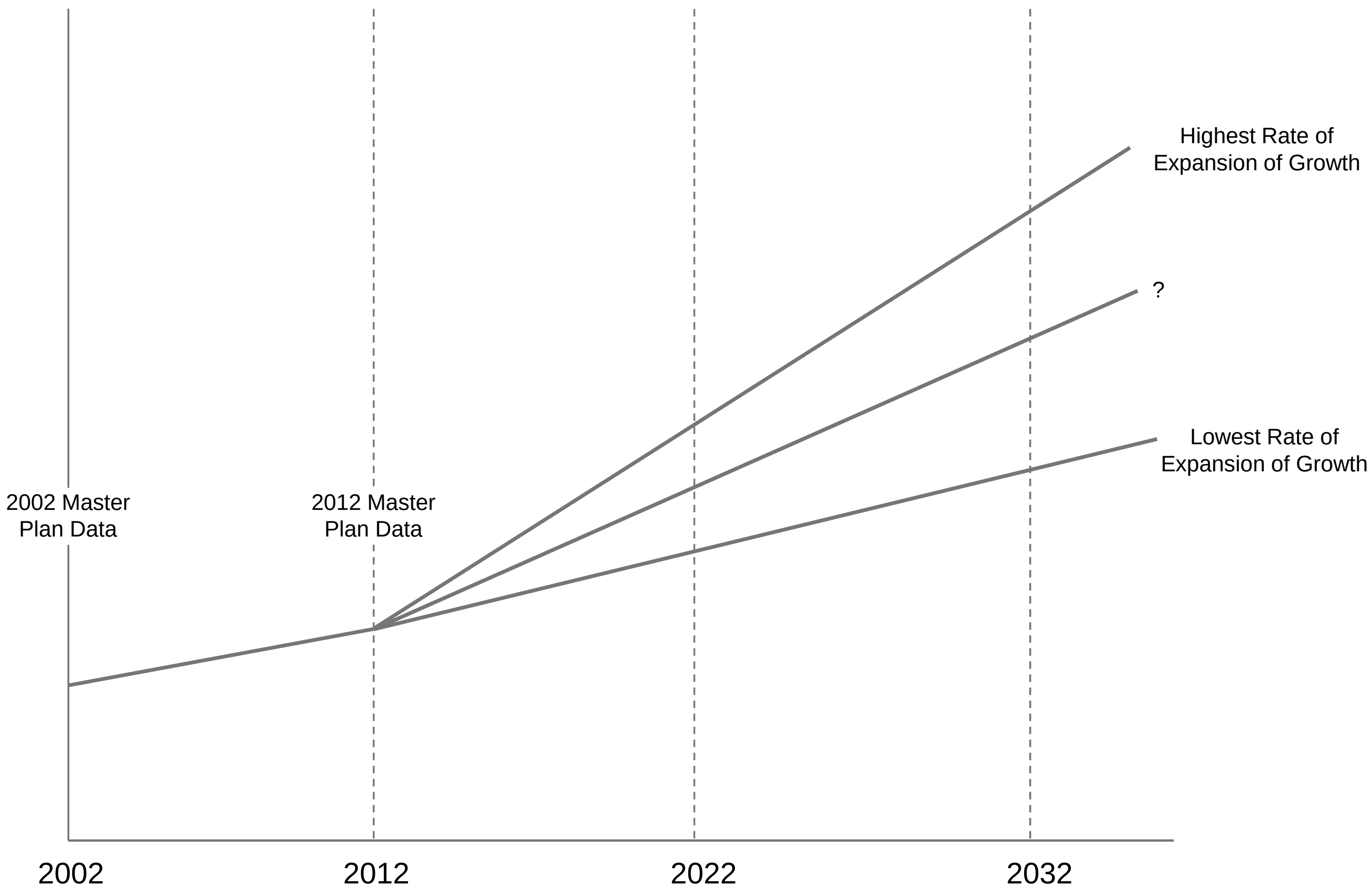
Location of treatment plants

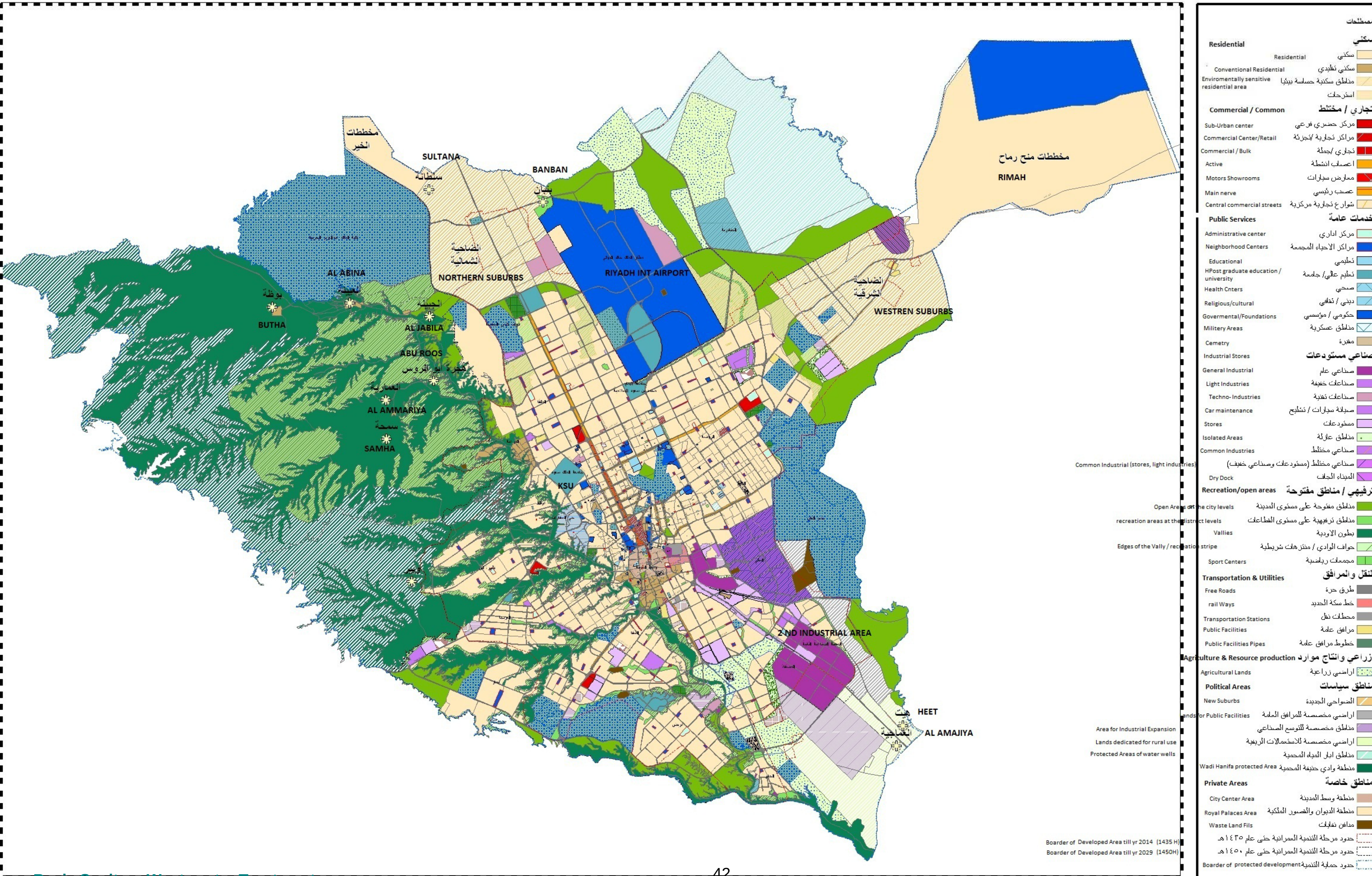
Disposal/reuse options

Value of land

Siting configurations (topography)

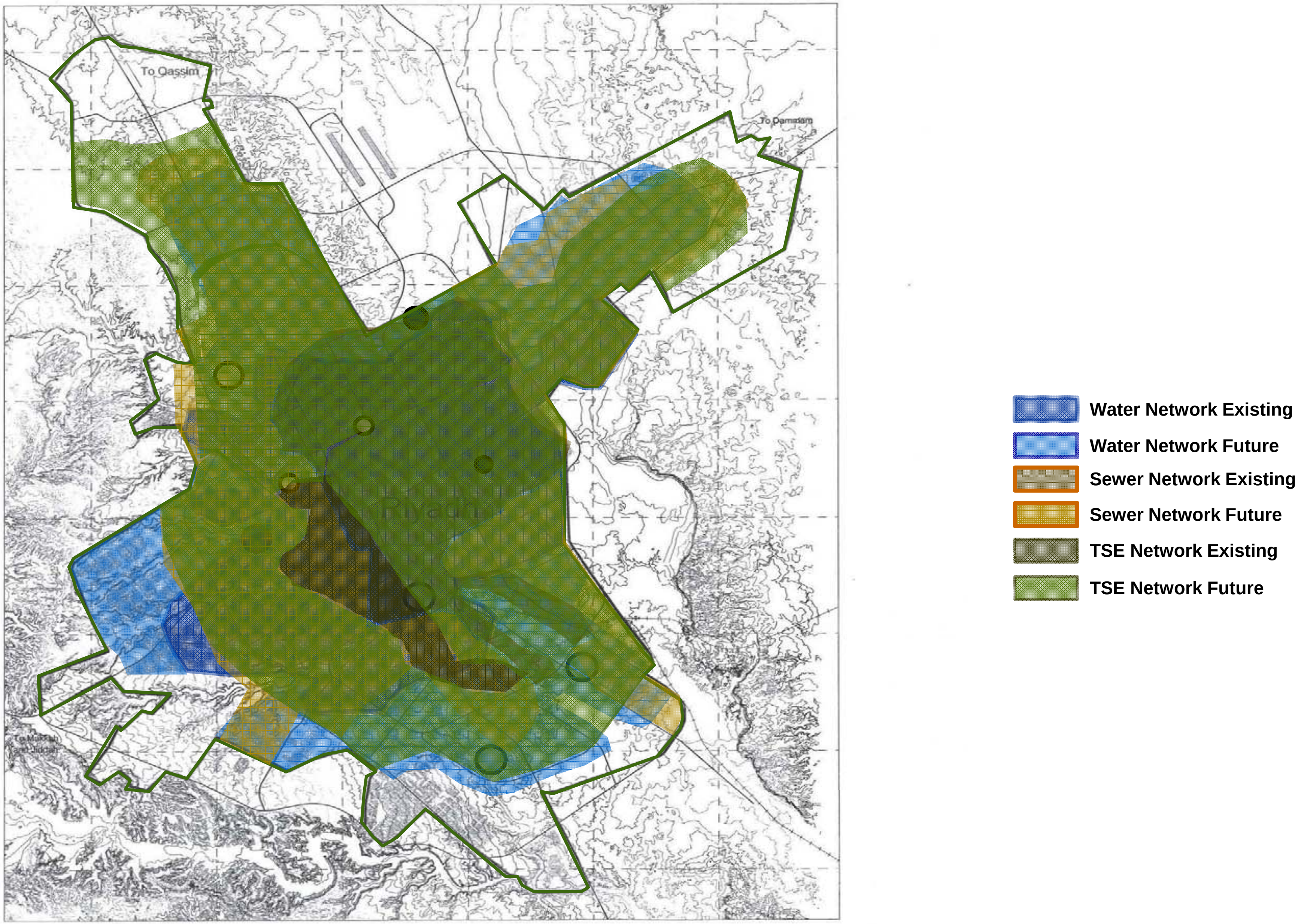
Population Projections





إدارة التخطيط الحضري الاستراتيجي

Service Area Conditions and Expansion



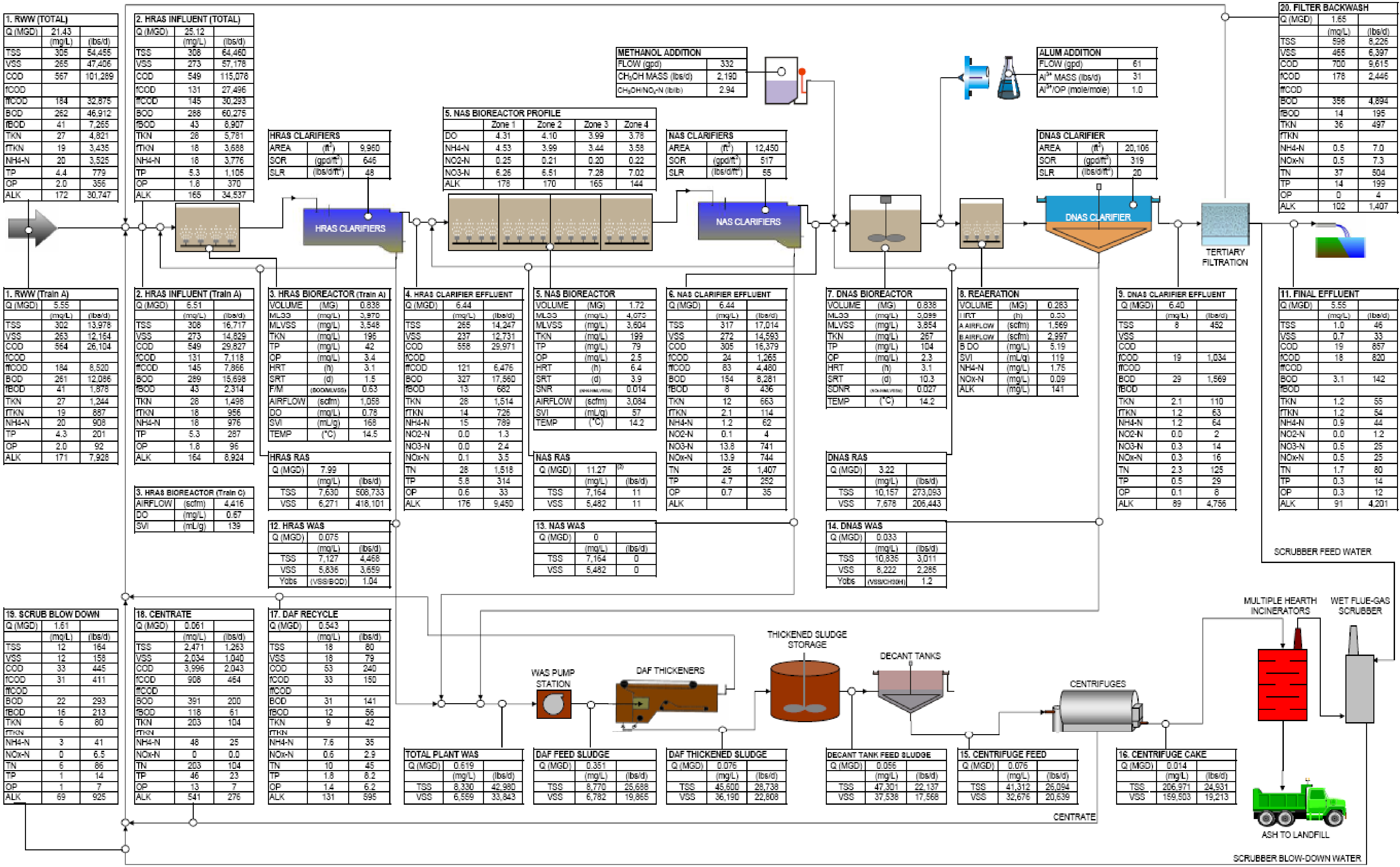
Treatment Process Considerations

There are an infinite number of configurations in wastewater treatment

Treatment Process Decisions can be affected by:

- **Site Configuration and Geology**
- **Initial and Future Capacity**
- **Effluent Standards**
- **Automation Required**
- **Flexibility of Treatment**
- **Proximity to Development**

Mass Balance



1. RWW (TOTAL)		
Q (MGD)	21.43	
	(mg/L)	(lbs/d)
TSS	305	54,455
VSS	265	47,406
COD	567	101,289
fCOD		
ffCOD	184	32,875
BOD	262	46,912
fBOD	41	7,265
TKN	27	4,821
fTKN	19	3,435
NH4-N	20	3,525
TP	4.4	779
OP	2.0	356
ALK	172	30,747

2. HRAS INFLUENT (TOTAL)		
Q (MGD)	25.12	
	(mg/L)	(lbs/d)
TSS	308	64,460
VSS	273	57,176
COD	549	115,076
fCOD	131	27,496
ffCOD	145	30,293
BOD	288	60,275
fBOD	43	8,907
TKN	28	5,781
fTKN	18	3,688
NH4-N	18	3,776
TP	5.3	1,105
OP	1.8	370
ALK	165	34,537

HRAS CLARIFIERS		
AREA	(ft^2)	9,960
SOR	(gpd/ft^2)	646
SLR	($lbs/d/ft^2$)	48

METHANOL ADDITION	
FLOW (gpd)	332
CH_3OH MASS (lbs/d)	2,190
CH_3OH/NO_x-N (lb/lb)	2.94

ALUM ADDITION	
FLOW (gpd)	61
Al^{3+} MASS (lbs/d)	31
Al^{3+}/OP (mole/mole)	1.0

5. NAS BIOREACTOR PROFILE				
	Zone 1	Zone 2	Zone 3	Zone 4
DO	4.31	4.10	3.99	3.78
NH4-N	4.53	3.99	3.44	3.58
NO2-N	0.25	0.21	0.20	0.22
NO3-N	6.26	6.51	7.28	7.02
ALK	178	170	165	144

NAS CLARIFIERS		
AREA	(ft^2)	12,450
SOR	(gpd/ft^2)	517
SLR	($lbs/d/ft^2$)	55

DNAS CLARIFIER		
AREA	(ft^2)	20,106
SOR	(gpd/ft^2)	319
SLR	($lbs/d/ft^2$)	20

20. FILTER BACKWASH		
Q (MGD)	1.65	
	(mg/L)	(lbs/d)
TSS	598	8,226
VSS	465	6,397
COD	700	9,615
fCOD	178	2,446
ffCOD		
BOD	356	4,894
fBOD	14	195
TKN	36	497
fTKN		
NH4-N	0.5	7.0
NOx-N	0.5	7.3
TN	37	504
TP	14	199
OP	0	4
ALK	102	1,407

1. RWW (Train A)		
Q (MGD)	5.55	
	(mg/L)	(lbs/d)
TSS	302	13,978
VSS	263	12,164
COD	564	26,104
fCOD		
ffCOD	184	8,520
BOD	261	12,086
fBOD	41	1,878
TKN	27	1,244
fTKN	19	887
NH4-N	20	908
TP	4.3	201
OP	2.0	92
ALK	171	7,928

2. HRAS INFLUENT (Train A)		
Q (MGD)	6.51	
	(mg/L)	(lbs/d)
TSS	308	16,717
VSS	273	14,829
COD	549	29,827
fCOD	131	7,118
ffCOD	145	7,866
BOD	289	15,698
fBOD	43	2,314
TKN	28	1,498
fTKN	18	956
NH4-N	18	976
TP	5.3	287
OP	1.8	96
ALK	164	8,924

3. HRAS BIOREACTOR (Train A)		
VOLUME	(MG)	0.838
MLSS	(mg/L)	3,970
MLVSS	(mg/L)	3,548
TKN	(mg/L)	196
TP	(mg/L)	42
OP	(mg/L)	3.4
HRT	(h)	3.1
SRT	(d)	1.5
F/M	(BOD/MLVSS)	0.63
AIRFLOW	(scfm)	1,058
DO	(mg/L)	0.78
SVI	(mL/g)	168
TEMP	(°C)	14.5

3. HRAS BIOREACTOR (Train C)		
AIRFLOW	(scfm)	4,416
DO	(mg/L)	0.67
SVI	(mL/g)	139

HRAS RAS		
Q (MGD)	7.99	
	(mg/L)	(lbs/d)
TSS	7,630	508,733
VSS	6,271	418,101

4. HRAS CLARIFIER EFFLUENT		
Q (MGD)	6.44	
	(mg/L)	(lbs/d)
TSS	265	14,247
VSS	237	12,731
COD	558	29,971
fCOD		
ffCOD	121	6,476
BOD	327	17,560
fBOD	13	682
TKN	28	1,514
fTKN	14	726
NH4-N	15	789
NO2-N	0.0	1.3
NO3-N	0.0	2.4
NOx-N	0.1	3.5
TN	28	1,518
TP	5.8	314
OP	0.6	33
ALK	176	9,450

5. NAS BIOREACTOR		
VOLUME	(MG)	1.72
MLSS	(mg/L)	4,075
MLVSS	(mg/L)	3,604
TKN	(mg/L)	199
TP	(mg/L)	79
OP	(mg/L)	2.5
HRT	(h)	6.4
SRT	(d)	3.9
SNR	(NH4-N/MLVSS/d)	0.014
AIRFLOW	(scfm)	3,084
SVI	(mL/g)	57
TEMP	(°C)	14.2

NAS RAS		
Q (MGD)	11.27	(2)
	(mg/L)	(lbs/d)
TSS	7,164	11
VSS	5,482	11

6. NAS CLARIFIER EFFLUENT		
Q (MGD)	6.44	
	(mg/L)	(lbs/d)
TSS	317	17,014
VSS	272	14,593
COD	305	16,379
fCOD	24	1,265
ffCOD	83	4,480
BOD	154	8,281
fBOD	8	436
TKN	12	663
fTKN	2.1	114
NH4-N	1.2	62
NO2-N	0.1	4
NO3-N	13.8	741
NOx-N	13.9	744
TN	26	1,407
TP	4.7	252
OP	0.7	35
ALK		

7. DNAS BIOREACTOR		
VOLUME	(MG)	0.838
MLSS	(mg/L)	5,099
MLVSS	(mg/L)	3,854
TKN	(mg/L)	267
TP	(mg/L)	104
OP	(mg/L)	2.3
HRT	(h)	3.1
SRT	(d)	10.3
SDNR	(NOx-N/MLVSS/d)	0.027
TEMP	(°C)	14.2

DNAS RAS		
Q (MGD)	3.22	
	(mg/L)	(lbs/d)
TSS	10,157	273,093
VSS	7,678	206,443

8. REAERATION		
VOLUME	(MG)	0.283
HRT	(h)	0.53
A AIRFLOW	(scfm)	1,569
B AIRFLOW	(scfm)	2,997
B DO	(mg/L)	5.19
SVI	(mL/g)	119
NH4-N	(mg/L)	1.75
NOx-N	(mg/L)	0.09
ALK	(mg/L)	141

9. DNAS CLARIFIER EFFLUENT		
Q (MGD)	6.40	
	(mg/L)	(lbs/d)
TSS	8	452
VSS		
COD		
fCOD	19	1,034
ffCOD		
BOD	29	1,569
fBOD		
TKN	2.1	110
fTKN	1.2	63
NH4-N	1.2	64
NO2-N	0.0	2
NO3-N	0.3	14
NOx-N	0.3	16
TN	2.3	125
TP	0.5	29
OP	0.1	8
ALK	89	4,756

11. FINAL EFFLUENT		
Q (MGD)	5.55	
	(mg/L)	(lbs/d)
TSS	1.0	46
VSS	0.7	33
COD	19	857
fCOD	18	820
ffCOD		
BOD	3.1	142
fBOD		
TKN	1.2	55
fTKN	1.2	54
NH4-N	0.9	44
NO2-N	0.0	1.2
NO3-N	0.5	25
NOx-N	0.5	25
TN	1.7	80
TP	0.3	14
OP	0.3	12
ALK	91	4,201

12. HRAS WAS		
Q (MGD)	0.075	
	(mg/L)	(lbs/d)
TSS	7,127	4,468
VSS	5,836	3,659
Yobs	(VSS/BOD)	1.04

13. NAS WAS		
Q (MGD)	0	
	(mg/L)	(lbs/d)
TSS	7,164	0
VSS	5,482	0

14. DNAS WAS		
Q (MGD)	0.033	
	(mg/L)	(lbs/d)
TSS	10,835	3,011
VSS	8,222	2,285
Yobs	(VSS/CH3OH)	1.2

19. SCRUB BLOW DOWN		
Q (MGD)	1.61	
	(mg/L)	(lbs/d)
TSS	12	164
VSS	12	158
COD	33	445
fCOD	31	411
ffCOD		
BOD	22	293
fBOD	16	213
TKN	6	80
fTKN		
NH4-N	3	41
NOx-N	0	6.5
TN	6	86
TP	1	14
OP	1	7
ALK	69	925

18. CENTRATE		
Q (MGD)	0.061	
	(mg/L)	(lbs/d)
TSS	2,471	1,263
VSS	2,034	1,040
COD	3,996	2,043
fCOD	908	464
ffCOD		
BOD	391	200
fBOD	118	61
TKN	203	104
fTKN		
NH4-N	48	25
NOx-N	0	0.0
TN	203	104
TP	46	23
OP	13	7
ALK	541	276

17. DAF RECYCLE		
Q (MGD)	0.543	
	(mg/L)	(lbs/d)
TSS	18	80
VSS	18	79
COD	53	240
fCOD	33	150
ffCOD		
BOD	31	141
fBOD	12	56
TKN	9	42
fTKN		
NH4-N	7.6	35
NOx-N	0.6	2.9
TN	10	45
TP	1.8	8.2
OP	1.4	6.2
ALK	131	595

TOTAL PLANT WAS		
Q (MGD)	0.619	
	(mg/L)	(lbs/d)
TSS	8,330	42,980
VSS	6,559	33,843

DAF FEED SLUDGE		
Q (MGD)	0.351	
	(mg/L)	(lbs/d)
TSS	8,770	25,688
VSS	6,782	19,865

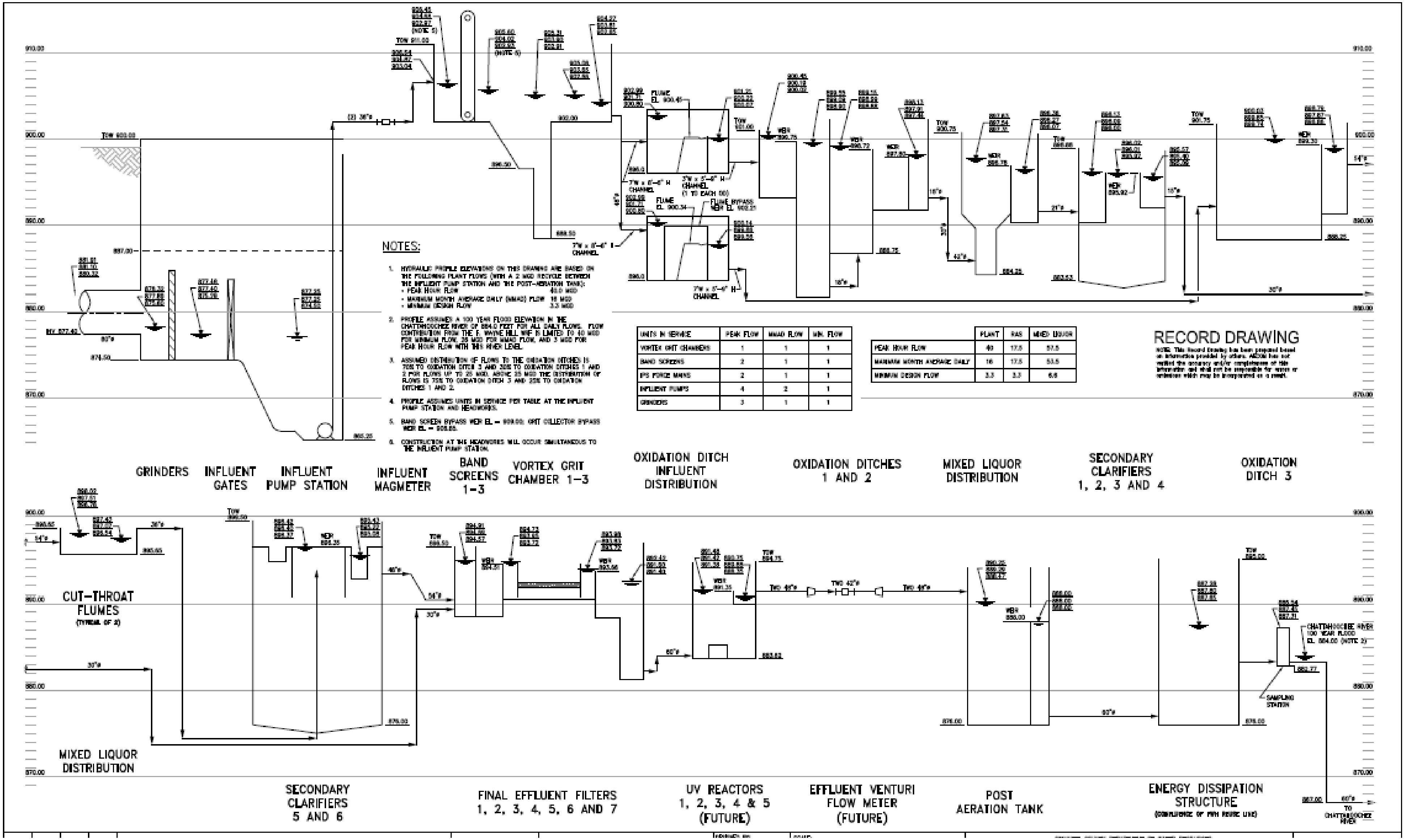
DAF THICKENED SLUDGE		
Q (MGD)	0.076	
	(mg/L)	(lbs/d)
TSS	45,600	28,738
VSS	36,190	22,808

DECANT TANK FEED SLUDGE		
Q (MGD)	0.056	
	(mg/L)	(lbs/d)
TSS	47,301	22,137
VSS	37,538	17,568

15. CENTRIFUGE FEED		
Q (MGD)	0.076	
	(mg/L)	(lbs/d)
TSS	41,312	26,094
VSS	32,676	20,639

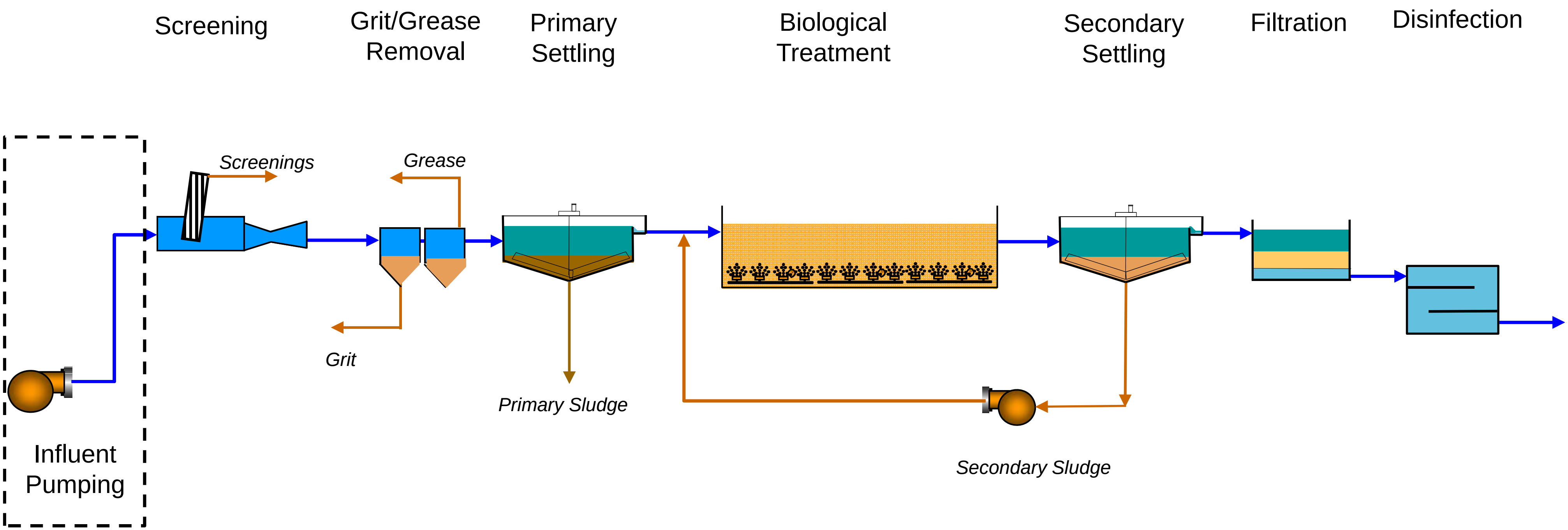
16. CENTRIFUGE CAKE		
Q (MGD)	0.014	
	(mg/L)	(lbs/d)
TSS	206,971	24,931
VSS	159,503	19,213

Hydraulic Profile



Preliminary Treatment

Influent Pumping/Flow Measurement



Influent Pumping sets the hydraulic profile for the treatment plant. It can provide dampened delivery of wastewater with large wetwell design and VFDs. Influent pumping stations often take plant recycles.

Coarse screening ahead of pumps can remove large solids before pumping. Alternatively, grinder systems are designed to allow pumps to deliver solids to the plant headworks. Flow measurement may be provided with flumes upstream of the wetwell, or pump discharge meters.

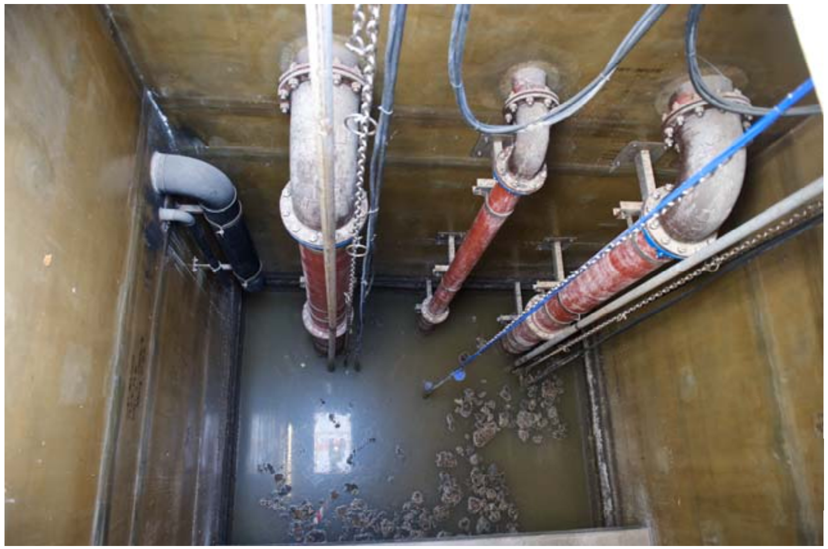
Influent Pumping

- Required in many plants, where plant hydraulics not available naturally
- Submersible or wet well/dry well
- Coarse screening frequently used
- Constant speed or variable speed pumps
- Odors and odor control
- Health and safety

Pump Station Scale

Small – Less than 100 l/s	Wet Well - Submersible
Medium – 100 to 300 l/s	Dry Well / Wet Well
Large – Greater than 300 l/sec	Dry Well

Wet Wells



Dry Well Installations

Large Scale


NEWATER TANK
TURBINE GENERATOR
WEST ELECTRICAL SUBSTATION

Influent Monitoring

- On pumped flow or in inlet works channel
- Flow monitoring with magnetic flow meter or Parshall flume
- Quality monitoring by influent sampling – Temperature, pH, TSS, BOD, Ammonia-N, alkalinity

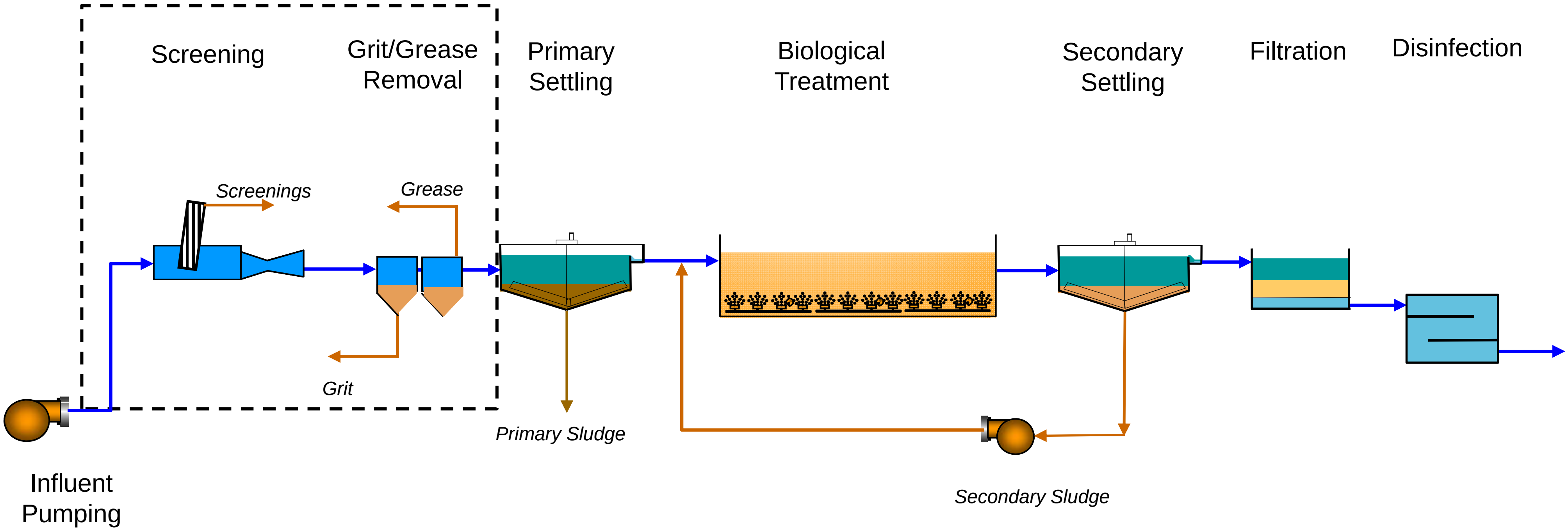
Surge Management / Control

Transient Effect Caused by:

- Power Failures
- Value Closures
- Pump Starts / Stops

What can go wrong

Preliminary Treatment



Preliminary treatment is required to remove inert materials that can be screened or settled from the raw sewage to prevent damage to equipment, and clogging of pipes and tanks (plastics, paper, inert floatables, etc.).

Preliminary Treatment includes pre-screening ahead of pumps, fine screens, grit removal and floatable grease removal.

Influent Screening

- **Screen or bar rack**
  - **A device with openings, generally of uniform size, that is used to retain solids**
  - **Screening element may consist of parallel bars, wire mesh, or perforated plate**
  - **Usually mechanically cleaned with automatic screenings removal**
- **Classification of screens**
  - **Bar Racks: Screens with large openings to capture large debris which cannot be pumped**
  - **Fine screens: Common in all treatment plants to remove debris as small as cigarettes**
  - **Ultrafine screens: Used ahead of membrane treatment systems for capture of small solids that can accumulate in a membrane system**

Item	Location	Opening Size mm
Coarse Bar Racks/Trash Racks	Ahead of Influent Pumps	24 – 72
Fine Screens	Headworks - Typical	6 - 12
Ultra Fine Screens	Ahead of Membrane Systems	1 - 3

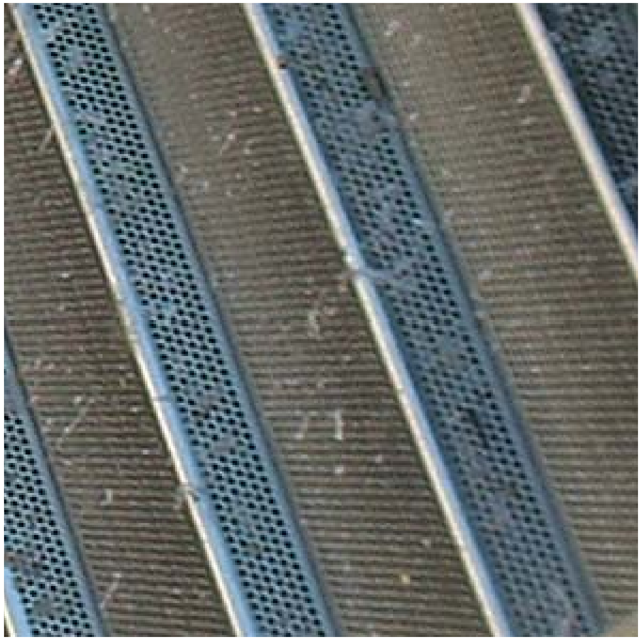
Coarse Screens (Bar Racks)

- Clear openings ranging from 6 to 150 mm
- Manually or mechanically, front (upstream) or back (downstream) cleaned
- Manually cleaned screens are usually used for small WWTPs or as standby/overflow in larger WWTPs
- Volume of screenings removed is 6 – 50 l/1,000 m^3
- Might not be needed if provided at the pump stations upstream from the WWTP

Design Parameters	
Clear opening	25 to 44 mm
Approach Velocity	0.3 to 0.6 m/sec
Width of the bar	5 to 15 mm

Fine Screens

- Clear openings less than 6 mm
- Openings as small as 1 mm
- Mechanically cleaned
- Usually following coarse screening
- Could remove up to 50% of TSS and BOD
- Washing is critical for the operation



Band Screens: 2 - 4 mm

- Flow goes in thru center and passes thru perforations on side screens
- Screenings are carried by lifting trays and are discharged via gravity/spray into a flume above deck level
- PE links form chains on either side to drive screen
- Screenings are dewatered in a screw compactor before discharging

Drum Screens: 6 - 9 mm

- The screening medium is mounted on a cylinder (drum) that rotates in a flow channel
- Flow goes in thru both sides and passes thru perforations in the screen panels out of the drum
- Screenings are carried by elevating plates and are discharged via gravity/spray water into a flume Inside the drum
- External Bypass channel required (no integral bypass)
- Screenings discharge into a common wet well and are pumped (or flow by gravity) to a liquid-solids separator unit, where they are dewatered before discharging into a screenings skip

Alternative Drum Screen

Screening – Design Considerations

- Size (clear openings)
- Approach velocity
- Straight approach
- Designed based on peak flow
- Headloss
- Head space required
- Screenings handling (raking), processing and disposal
- Duty and standby units
- Odour control
- Washing
- Control (Differential headloss and timer)

Grit Removal

- Grit Removal is done by gravity settling or by centrifugal separation of solids
- Located after bar screens and before primary sedimentation
- Types of Grit Removal
  - Aerated grit chamber
  - Horizontal settling
  - Vortex grit chamber
- Average grit removed is 4 - 40 l/1,000 m^3

Aerated Grit Chambers

- Air is introduced along one side of a rectangular tank to create a spiral flow pattern
- Heavier grit particles settle to the bottom
- Lighter particles pass through the tank
- Organics create odors and attract insects
- The velocity of roll governs the size of particles removed
- Normally designed to remove 0.21 mm diameter (65 mesh) or larger with 2-5 minute detention time at the peak hourly flow

- Grit is removed through grab buckets

  travelling on monorails, screw conveyor,

  grit pumps or airlift
- Covers maybe required if release of VOCs is a concern

Aerated Grit Chamber Design Parameters

Parameters	Range	Typical
Detention Time (Mins.) at Max. Flow	2 - 5	3
Depth (m)	2 - 5	-
Length (m)	7 - 20	-
Width (m)	2.5 - 7	-
Width - Depth Ratio	1:1 - 5:1	1.5 : 1
Length - Width Ratio	3:1 - 5:1	4:1
Air Supply (m^3/hr./m of length)	10 – 25	-
Grit Quantities (l/1000 m^3)	3.7 - 56	30

Vortex Grit Collectors

- Flow enters/exits chamber tangentially
- Vortex induced naturally thru tangential flow and by mechanical paddle at bottom of chamber, grit migrates to center of chamber and is stored in grit hopper
- Collector drive is on top of unit
- Grit removed from grit hopper by pumping to a cyclone separator and grit classifier
- Internal use water for grit washing
- Grit pumps can be in basement or top-mounted
- Detention time ~ 30 sec range
- Typically 1- 7 m in diameter and 2.5 – 5 m in depth

Civil construction and installation.

The effects of the continuous aeration can be clearly seen on the tank surface.

The completed Jetair installation.

The small additional blower is designed for quiet operation.

Vortex Design Parameters

Parameters	Range	Typical
Detention Time (s)	-	30
Diameter (ft)	4 - 24	-
Height (ft)	9 - 16	-
Removal Rates (%)	50 mesh (0.3 mm) 95+ 70 mesh (0.24 mm) 85+ 100 mesh (0.15 mm) 65+	-

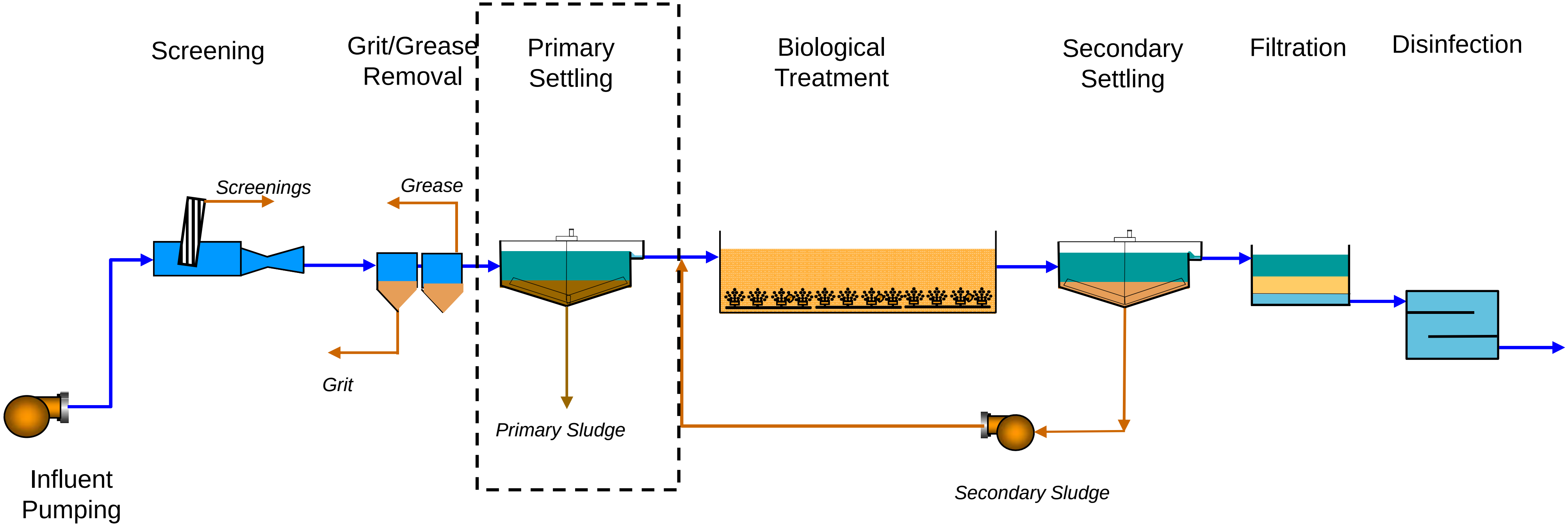
Grit Removal Design Considerations

- Detention time - based on peak flow
- Size of particle removed
- Headloss
- Grit handling (collection), dewatering and disposal
- Duty and standby units
- Oil and grease removal
- Odor control

Headworks Designs

Primary Treatment

Primary Clarification



Primary Treatment is the physical separation of settleable solids in rectangular settling tanks or circular clarifiers, with detention time of 2 hours or more. Settled solids are removed mechanical sludge collectors, and sludge is further treated. Floating solids are skimmed from the surface.

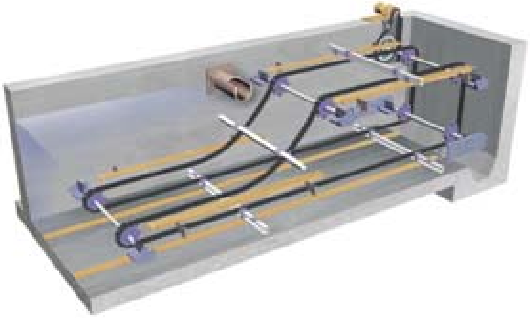
Primary Treatment

- Up to 70% removal of TSS and up to 50% removal of BOD
- Reduce power cost associated with secondary treatment
- Could be supplemented with chemical addition for enhanced sedimentation and/or P removal
- Mechanically cleaned sedimentation tanks of standardized circular or rectangular design.
- Multiple tanks should be provided so that the process may remain in operation while one tank is out of service for maintenance

Item	Hydraulic Retention, Hours	TSS Removal %	BOD removal %
Circular Clarifiers	2 - 3	40 – 60	20 – 30
Rectangular Clarifiers	2 – 3	40 – 60	20 – 30
Lamella Clarifiers	1.5 – 2	40 – 70	25 – 40
Chemically Enhanced Primary Treatment (CEPT)	1.5 - 2	50 - 75	30 – 50

Rectangular Tanks

- Horizontal flow
- Depth: 4 m; Width: 5 – 10 m;
  Length: 25 – 40 m
- Chain-and-flight solids collectors or traveling-bridge-type collectors



Circular Tanks

- Flow pattern is radial and wastewater is introduced in the center of the tank
- Require larger foot print
- Depth: 4 m; Diameter: 12 - 45 m

Lamella Clarifier/Plate Settlers

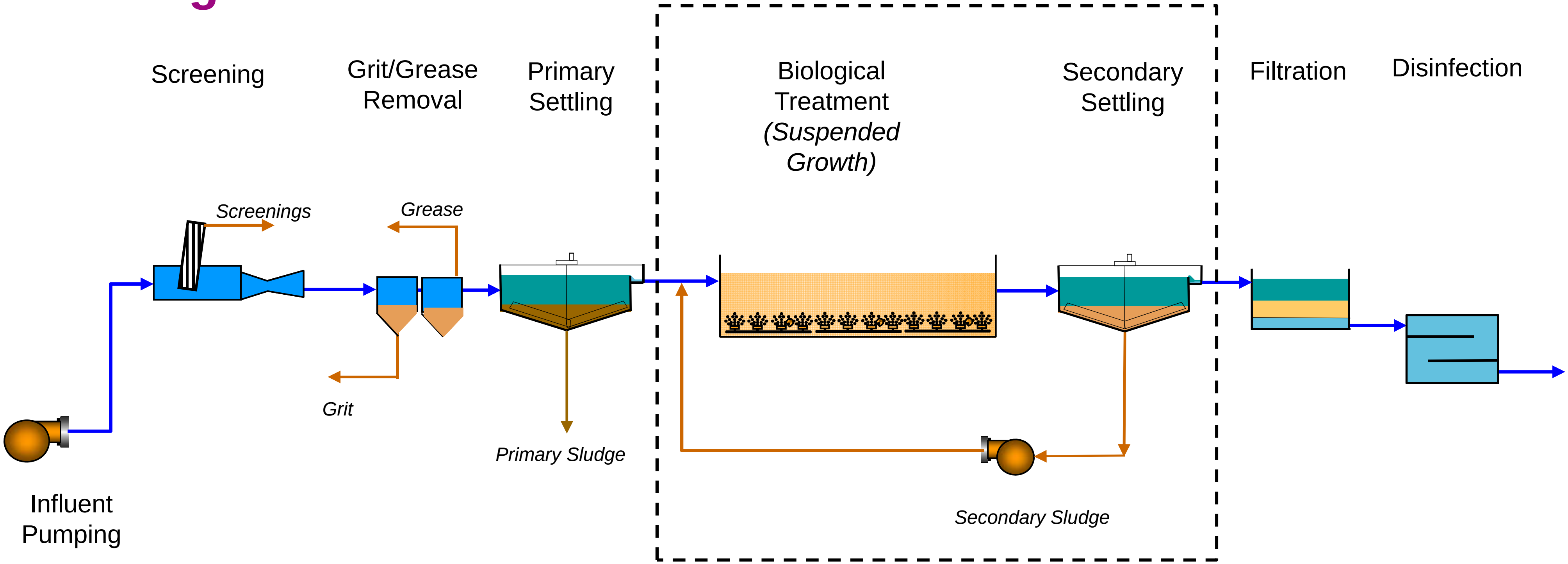
- A lamella clarifier features a rack of inclined metal plates, which cause flocculated material to precipitate from water that flows across the plates.
- Smaller footprint than conventional clarification equipment for the same solids removal capacity
- The compact design essentially eliminates any hydraulic disturbances caused by wind or temperature changes. Balanced flow distribution ensures equal flow to each plate and across the plate surface area, preventing short-circuiting. Units and plate packs arrive at the job site factory assembled which reduces installation time and lowers installed costs. Minimal moving parts means low maintenance costs.

Primary Settling Design Considerations

- Surface overflow rate (m3/m2/d) - based on peak flow
  Typically 80 – 120 m3/m2/d
- Baffling to reduce short circuiting
- Grit handling (collection), dewatering and disposal
- Duty and standby units
- Odor
- Pumping of primary sludge (3 -5 % solids)
- Scum removal
- Detention times ranging between 2 to 5 hours use a settleometer to check how long solids can be in the clarifier without floating

Biological Treatment Processes

Biological Treatment



Biological Treatment Processes

- Removes or converts biodegradable organics
- Converts Ammonia and Nitrogen compounds
- Removes soluble Phosphates

Activated Sludge Processes

- Extended aeration
- Oxidation ditch
- Step Feed
- SBR's

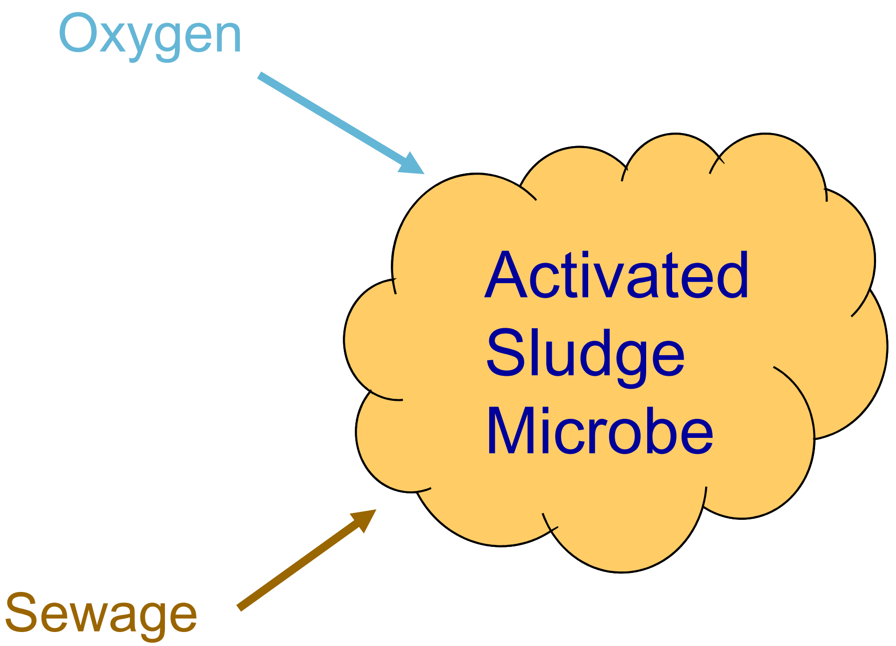
Fixed Film Processes

- Percolating filters
- Biological Aerated Filters (BAF's)
- Submerged Aerated Filters (SAF's)
- Rotating Biological Contactors

Activated Sludge Processes

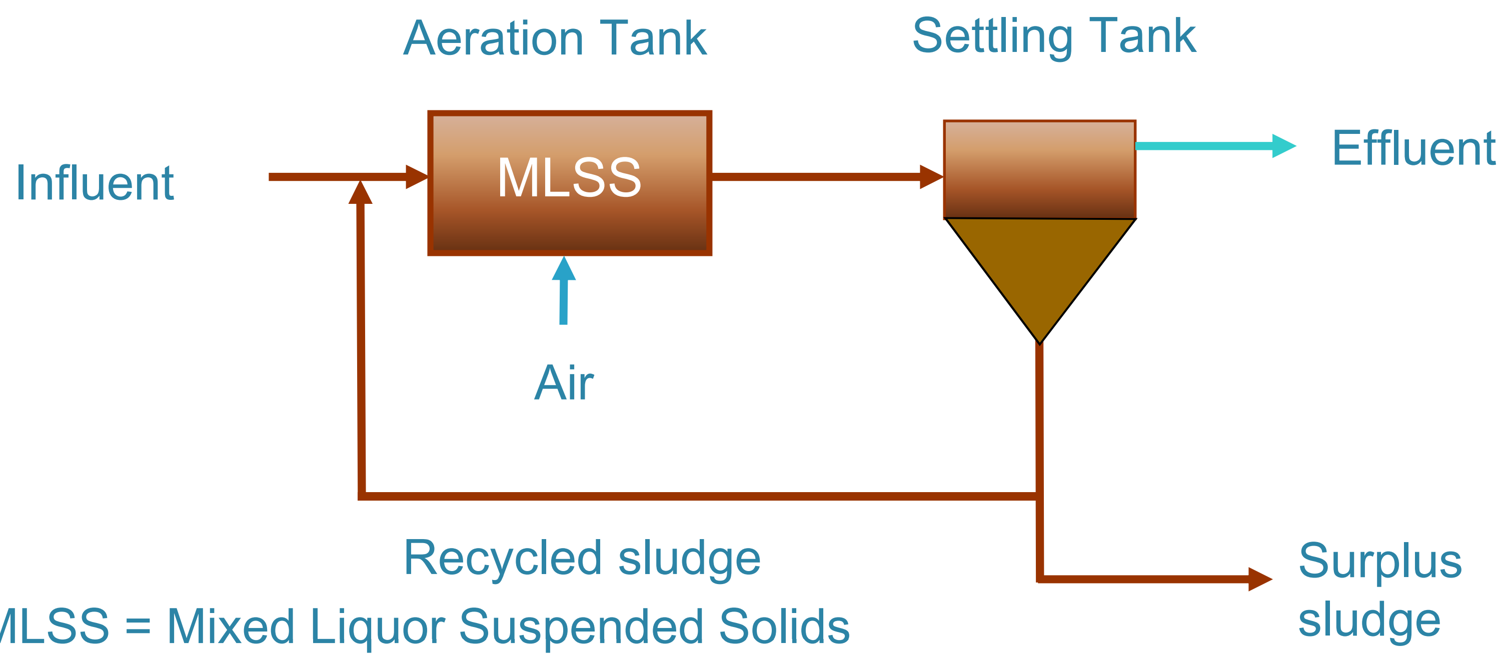
Activated Sludge Processes

- Activated sludge microbes (biomass)
- Oxygen rich environment
- Organic material in wastewater used as food source
- Generating growth of biomass and clean water
- Suspended growth process
- Biomass in free suspension to ensure adequate contact with wastewater
- Correct microbes settle well
- Settlement process allows treated effluent to be drawn off and biomass to settle
- Biomass kept alive by recycling a portion of settled biomass to activated sludge tank as growth medium to generate more biomass
- Excess bacteria removed as sludge



Activated Sludge Processes

- Many variations of activated sludge to treat municipal wastewaters
- Typically follows primary sedimentation in order to reduce the solids and organic (BOD and COD) loading
- Process includes an aeration stage followed by a settlement tank



MLSS = Mixed Liquor Suspended Solids

Activated Sludge Processes

- **Biomass is freely suspended in wastewater and feeds on the organic matter in the presence of oxygen**
- **Important operating and design parameters are HRT, MLSS, SRT, F/M, DO, SVI**
- **Sludge is produced as BOD is removed and needs to be removed to maintain optimum treatment conditions**
- **The dissolved oxygen required for the process can be provided by mechanical agitation or diffused air**
- **Varying degrees of treatment can be achieved:**
  - Carbonaceous : BOD removal
  - Nitrification : Ammonia Removal
  - Denitrification : Nitrogen Removal
- **There are many variants of the AS process which can be designed to achieve the required degree of treatment**
- **The sequencing batch reactor eliminates the requirement for primary and secondary settlement. All processes in one tank.**

Activated Sludge Processes

Step Feed

- Modification of conventional plug flow process. The feed is introduced at a number of places in the aeration tank. The concept is to even out F/M and reduce oxygen demand

Extended Aeration

- HRT and sludge age much higher than conventional process, encouraging greater degradation of the MLSS. Less sludge for disposal and BOD removals of 98%

Oxidation Ditch

- Best known extended aeration system. Mixed liquor circulates in a continuous channel or ‘race track’ aerated by a horizontal rotor which maintains velocity to prevent settlement

Typical Design Parameters

Process	SRT, d	F/M kgBOD/kg MLVSS-d	Volumetric Loading kgBOD/m3-d	MLSS mg/L	RAS % of influent
Conventional	3 -15	0.2-0.6	0.3-1.6	1500-4000	25 - 100
Conventional plug flow	3 – 15	0.2 – 0.4	0.3 – 0.7	1000 – 3000	25 - 75
Step feed	3 – 15	0.2 – 0.4	0.7 – 1.0	1500 – 4000	25 - 75
Extended aeration	20 – 40	0.04 – 0.1	0.1 – 0.3	2000 – 5000	50 - 150
Oxidation ditch	15 – 30	0.04 – 0.1	0.1 – 0.3	3000 – 5000	75 - 150

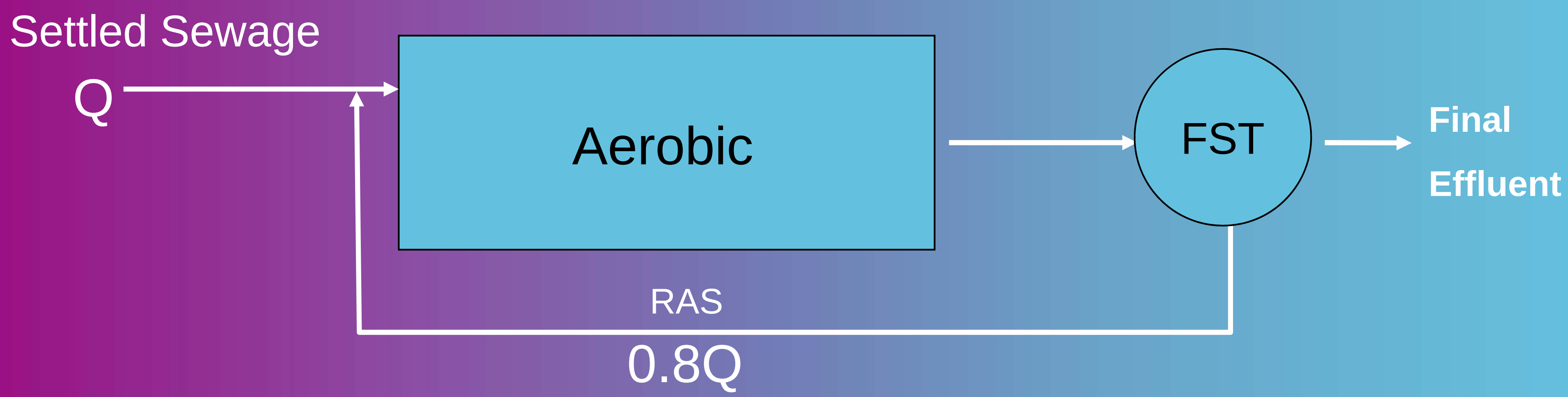
Activated Sludge Processes

Aeration Techniques

- Surface Aerators
  - Vertical shaft or Horizontal shaft
  - Throw activated sludge into atmosphere as fine droplets, the contact with the air allows the mass transfer of oxygen into the liquid phase
- Diffused Air
  - Compressed air is fed in to the bottom of the tank through fine pore diffusers.
  - The mass transfer of oxygen into the liquid phase is via bubbles traveling up through the tank

Carbonaceous Organics Treatment

BOD + bacteria + O_2 $\longrightarrow$ Solids + CO_2 + H_2O + Energy

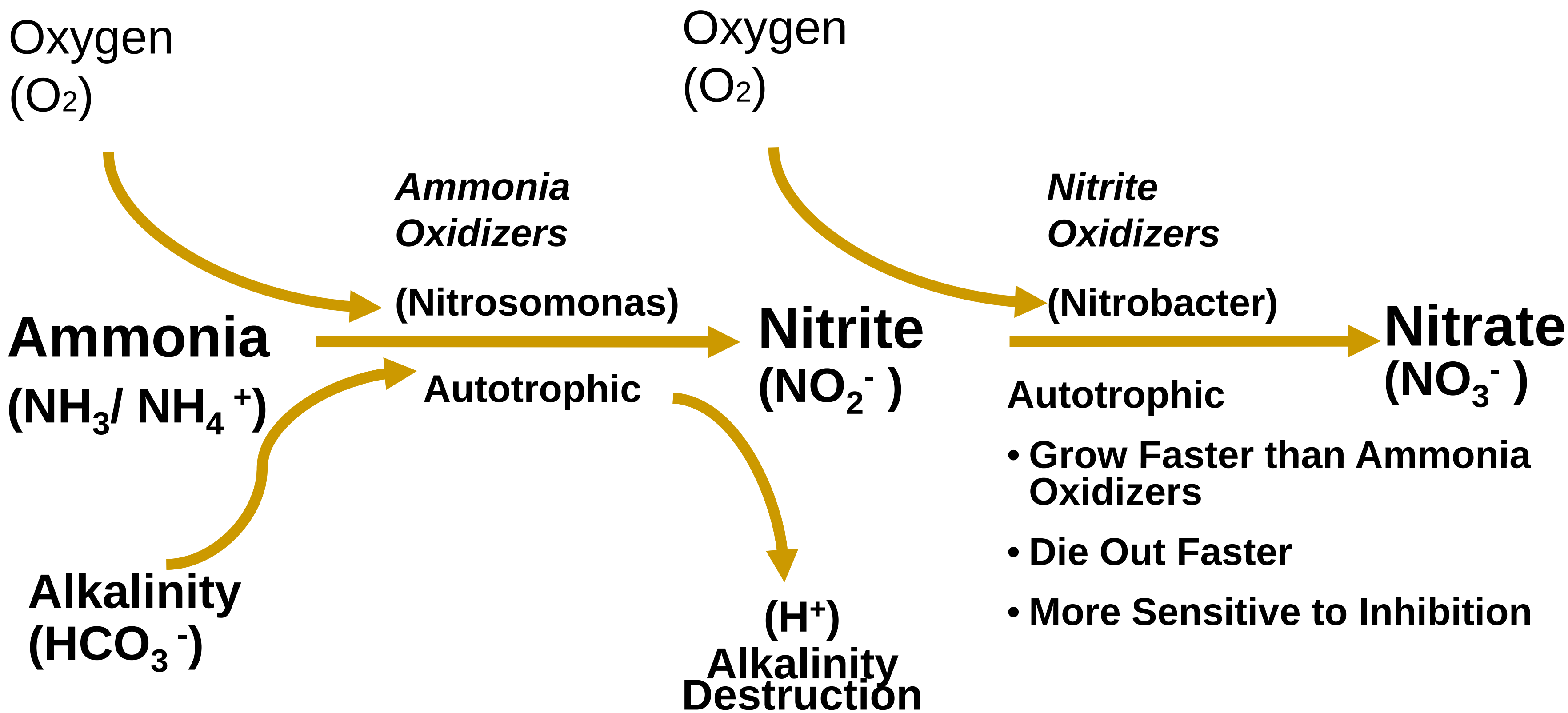


Single Reactor, Relatively Small Volume

BOD 20mg/L, COD 60mg/L, SS 30 mg/L

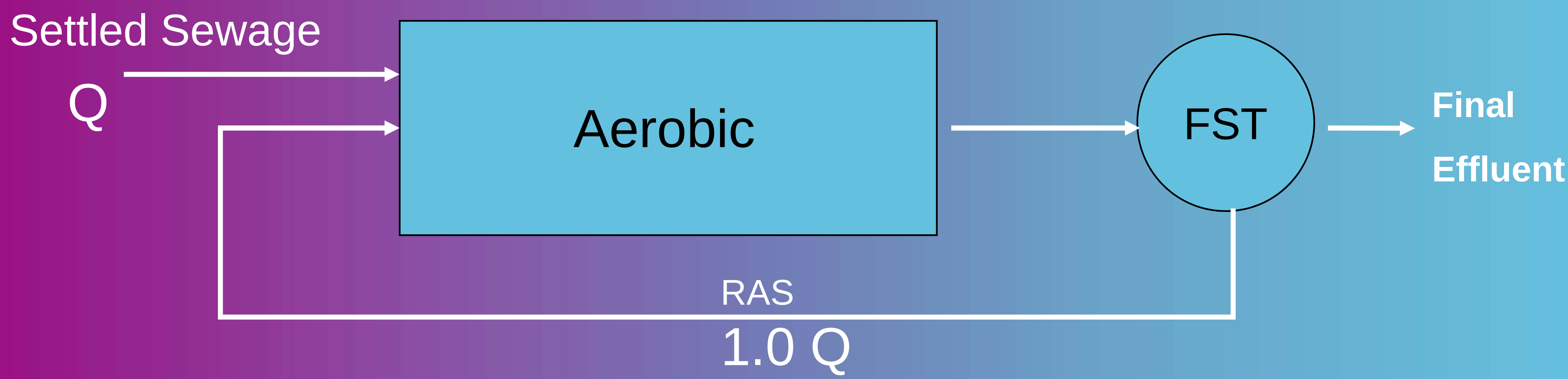
No reduction of Amm. N, TN, TP

Biological Processes - Nitrification



Nitrification

Amm. N (NH_3) + Autotrophs + O_2 → Nitrite + O2 → Nitrate (NO_3)

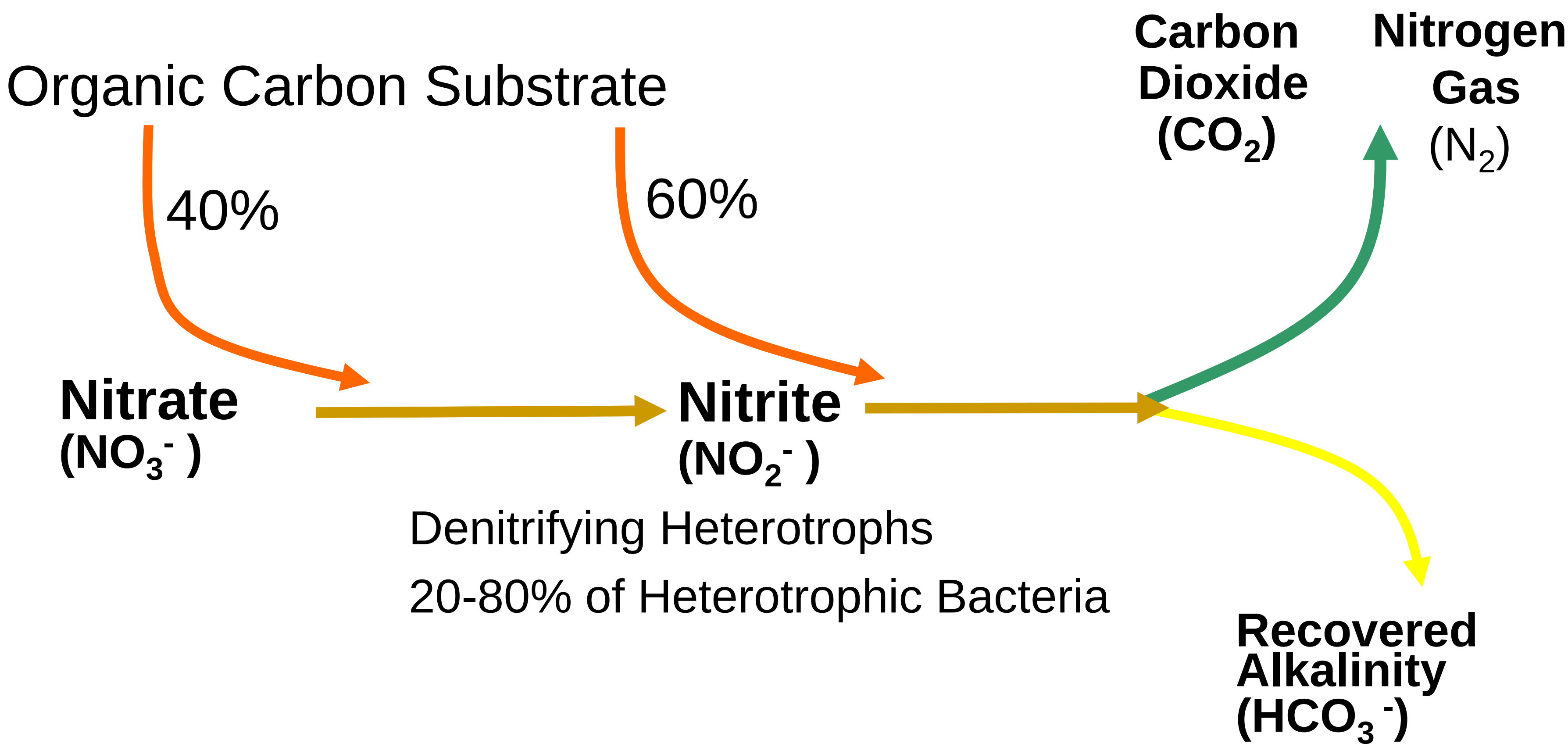


Single Reactor, Larger Volume

BOD 15mg/L, COD 50mg/L, SS 30mg/L, Amm.N 1mg/L

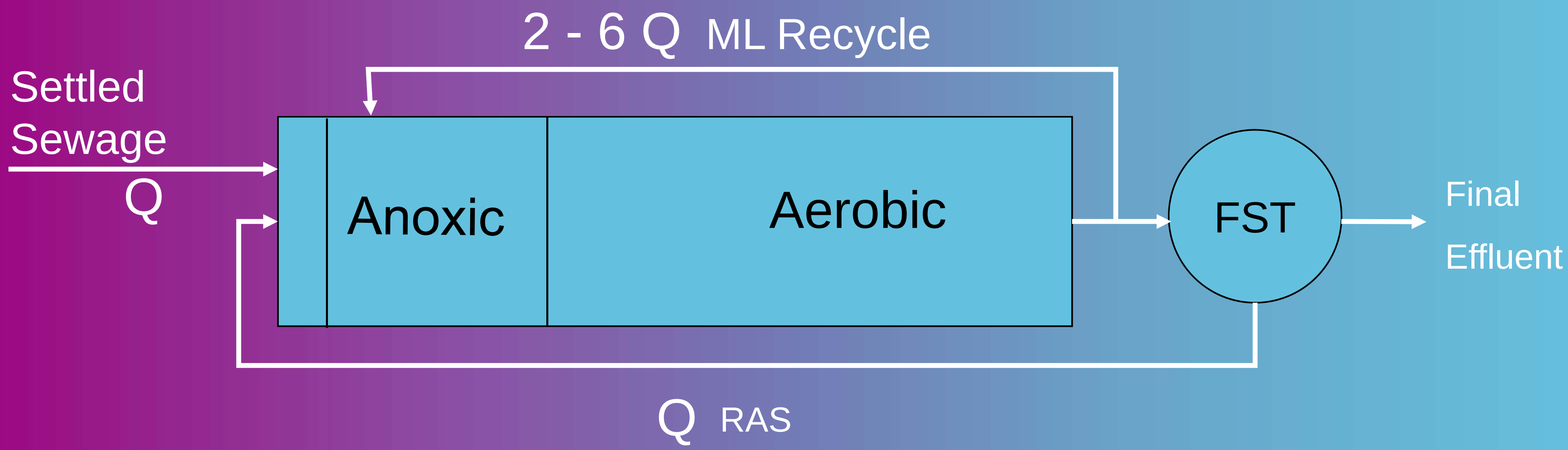
Some TN, No TP reduction

Biological Processes - Denitrification



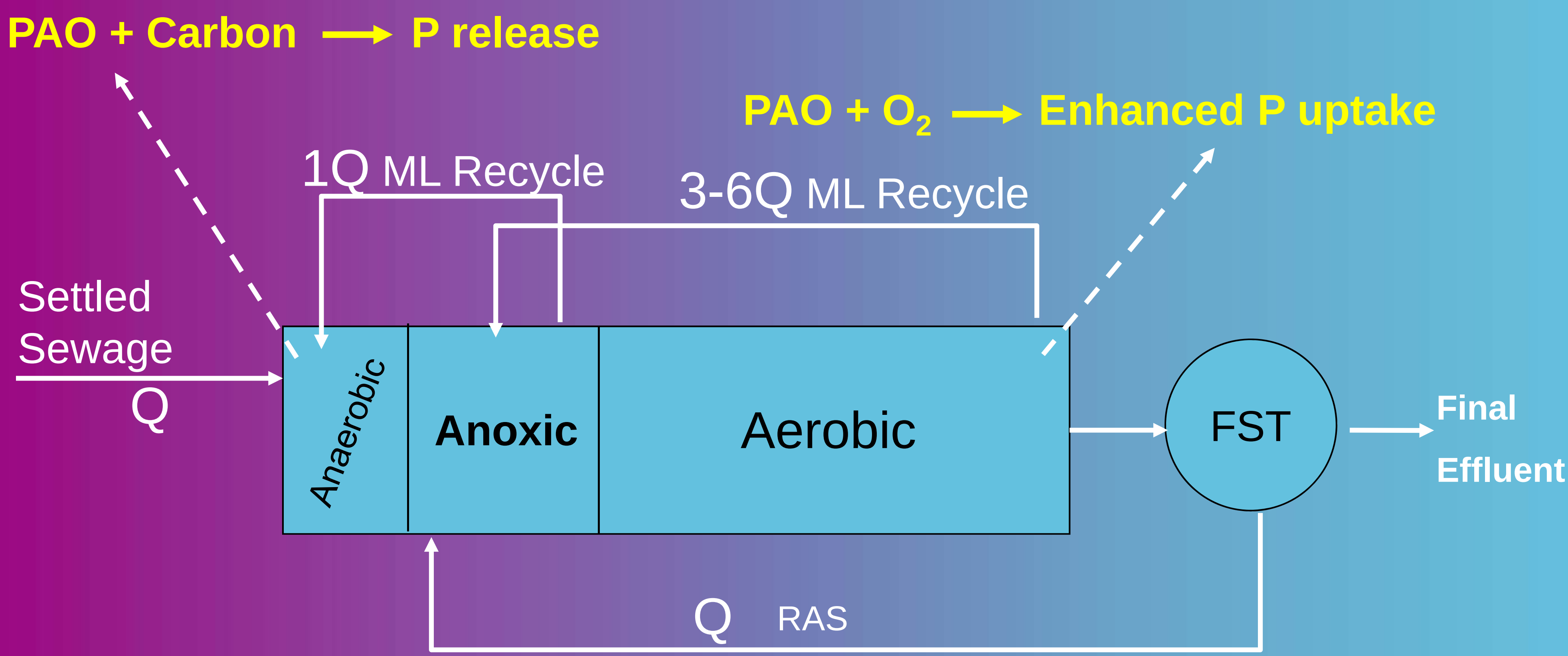
Denitrification

Nitrate (NO3) + Heterotrophs + Carbon → N_2 (Gas) ↑



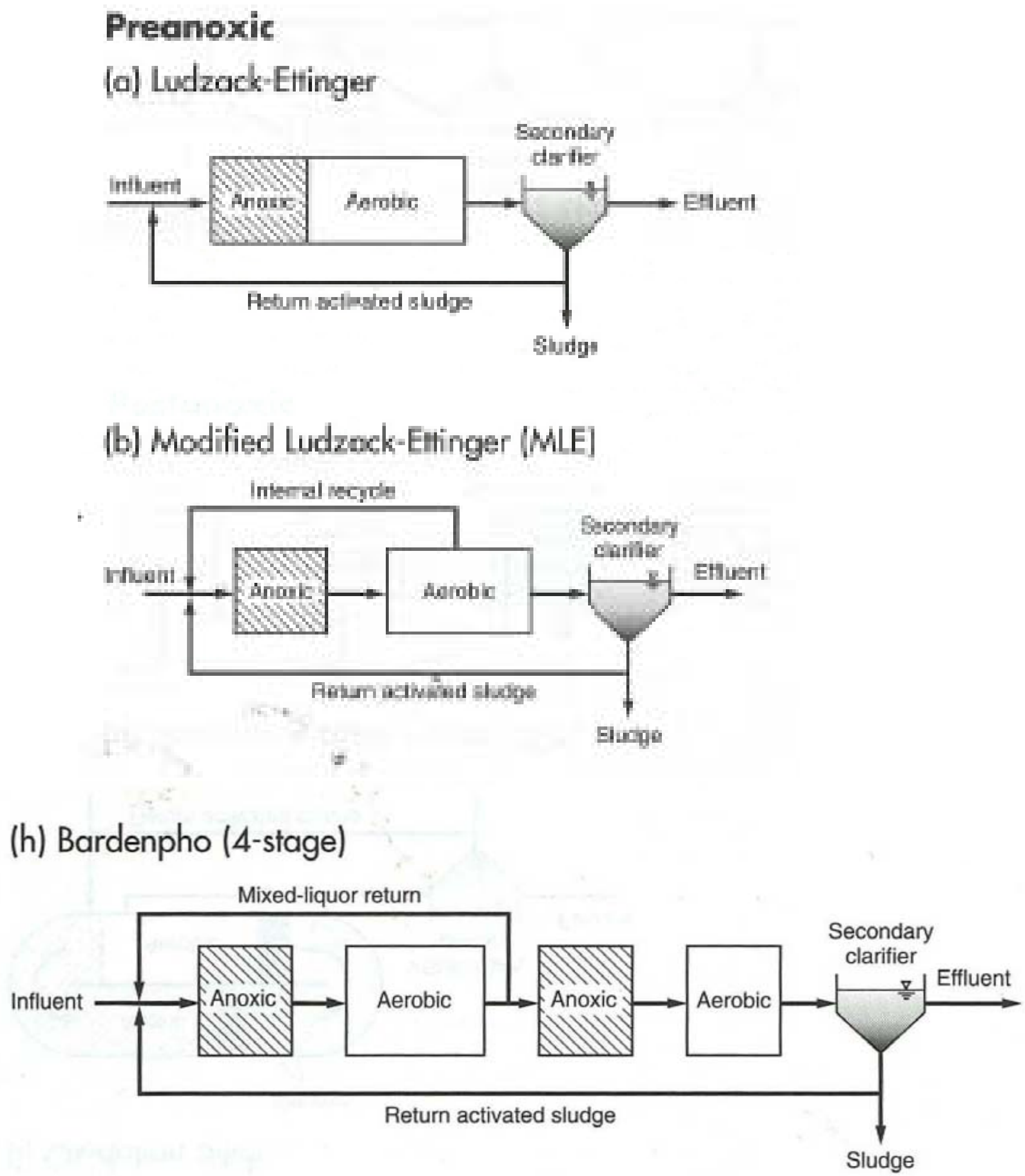
Multiple Reactors, Larger Volume
BOD 15mg/L, COD 50mg/L, SS 15mg/L, Amm. N <1mg/L, TN <10mg/L, No TP reduction

Total Phosphorus Removal

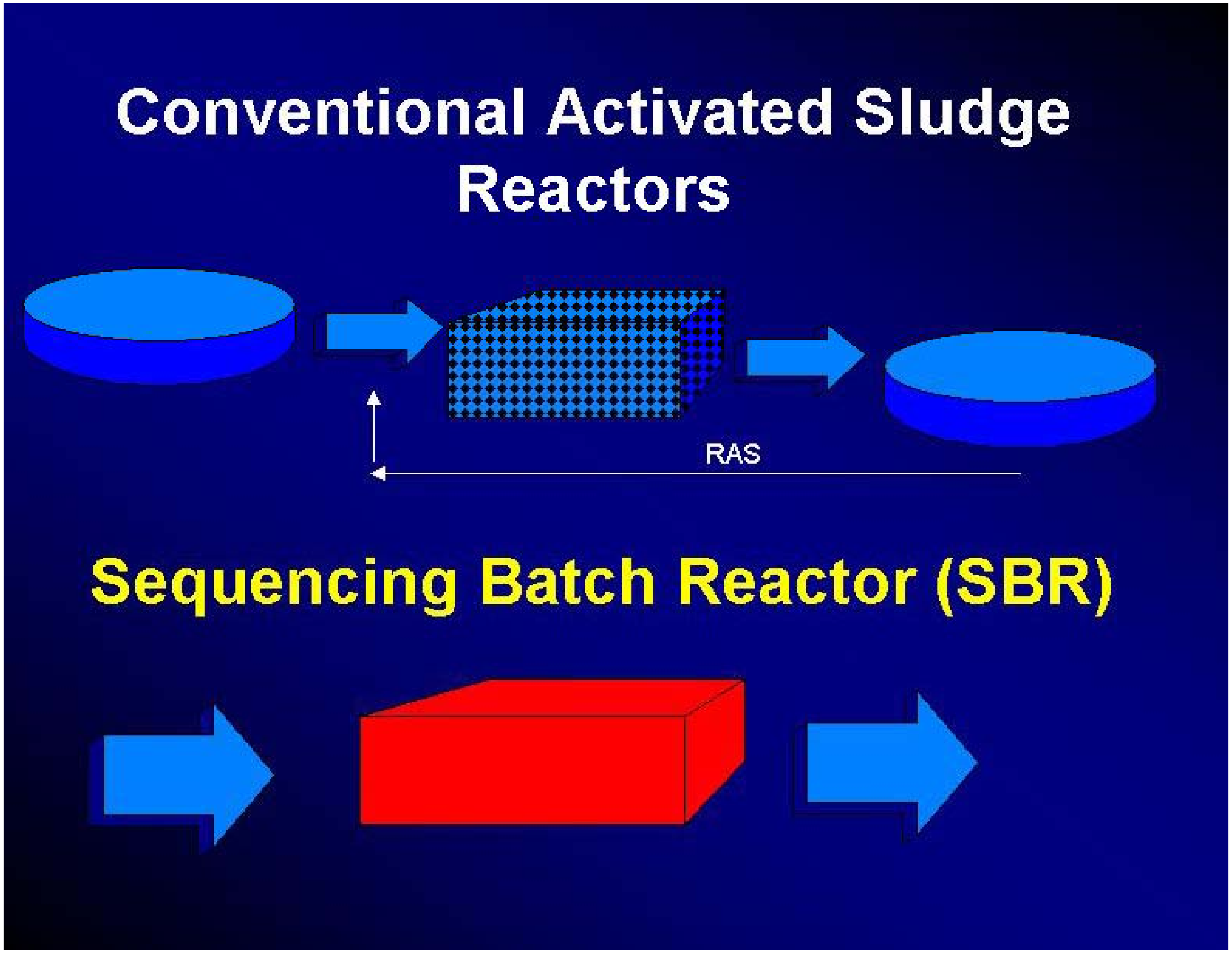


BOD 10mg/L, COD 30mg/L, SS 10mg/L, Amm. N <1mg/L, TN <10mg/L, TP 0.5 – 1.5mg/L

Advanced Activated Sludge Processes

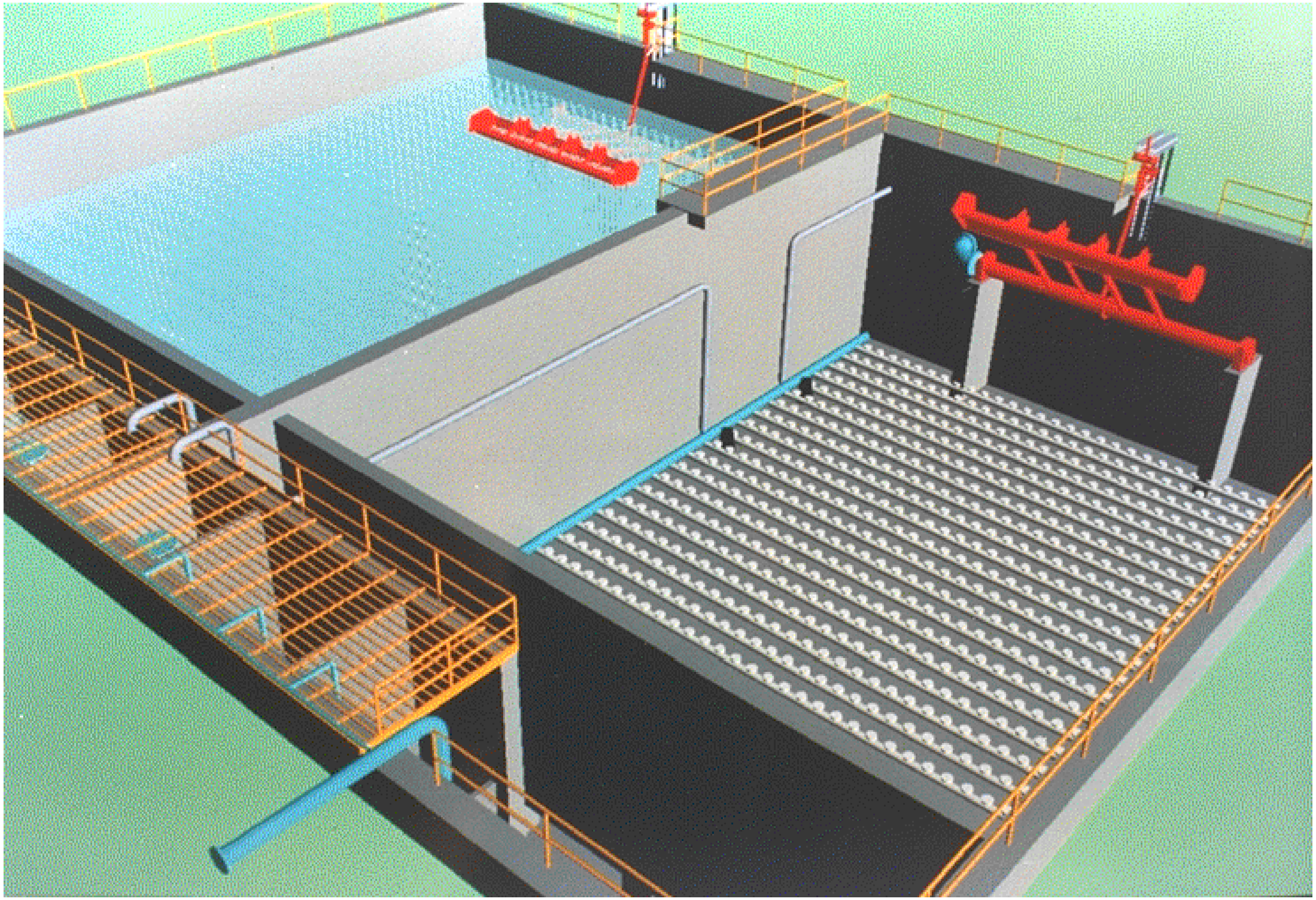


Sequencing Batch Reactor

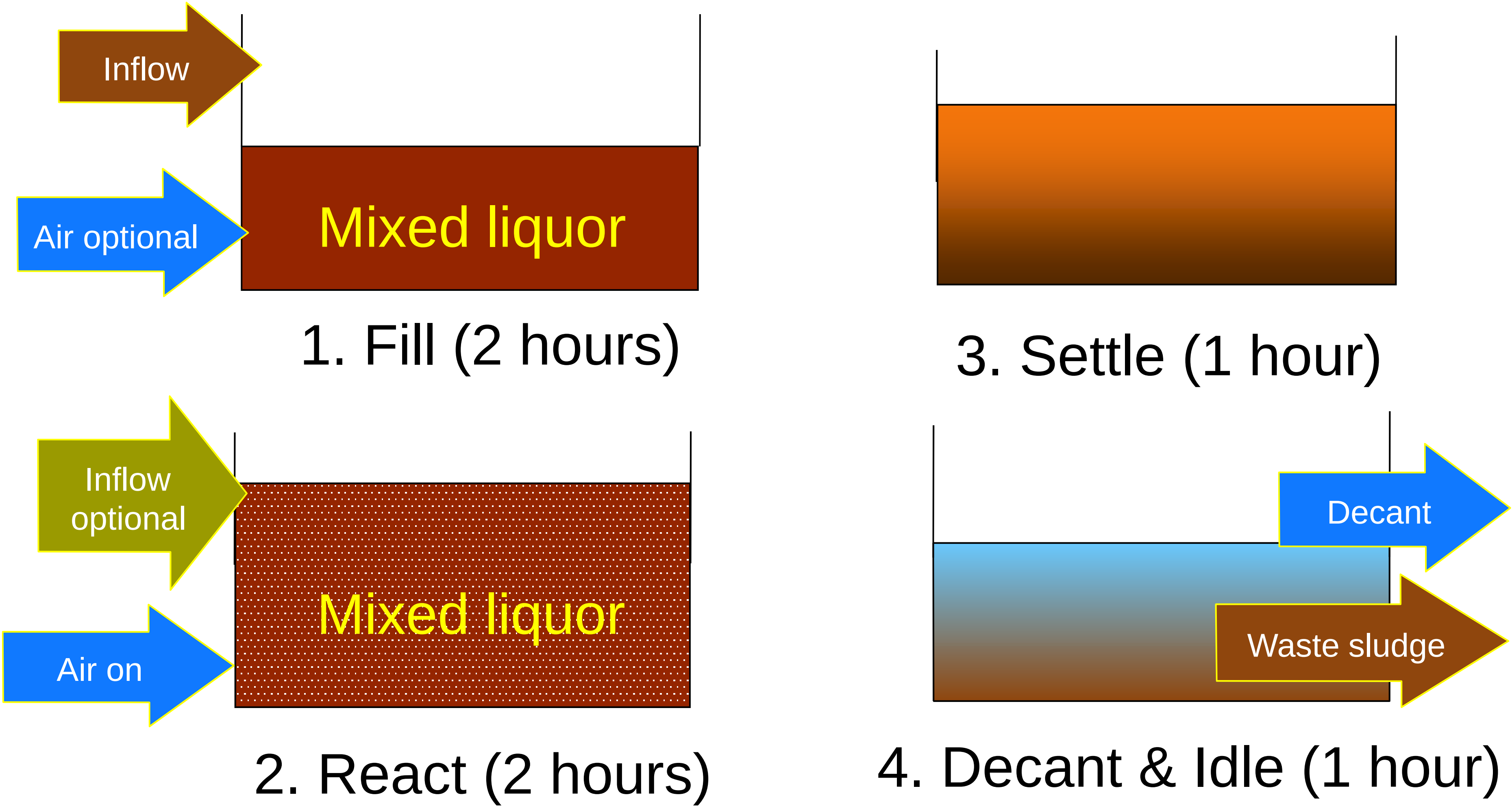


Sequencing Batch Reactor

Basin Configuration



Sequencing Batch Reactor



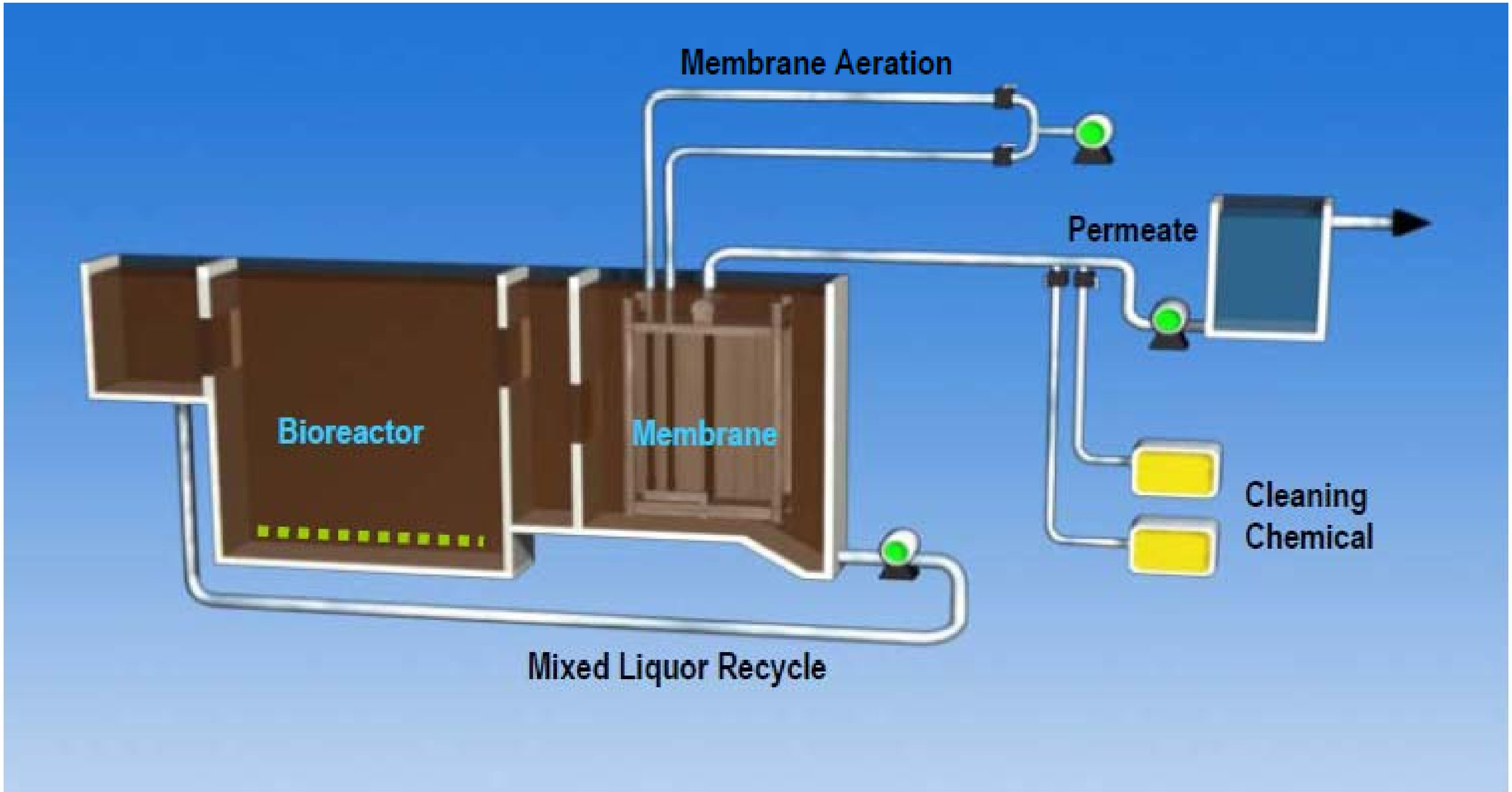
Sequencing Batch Reactor

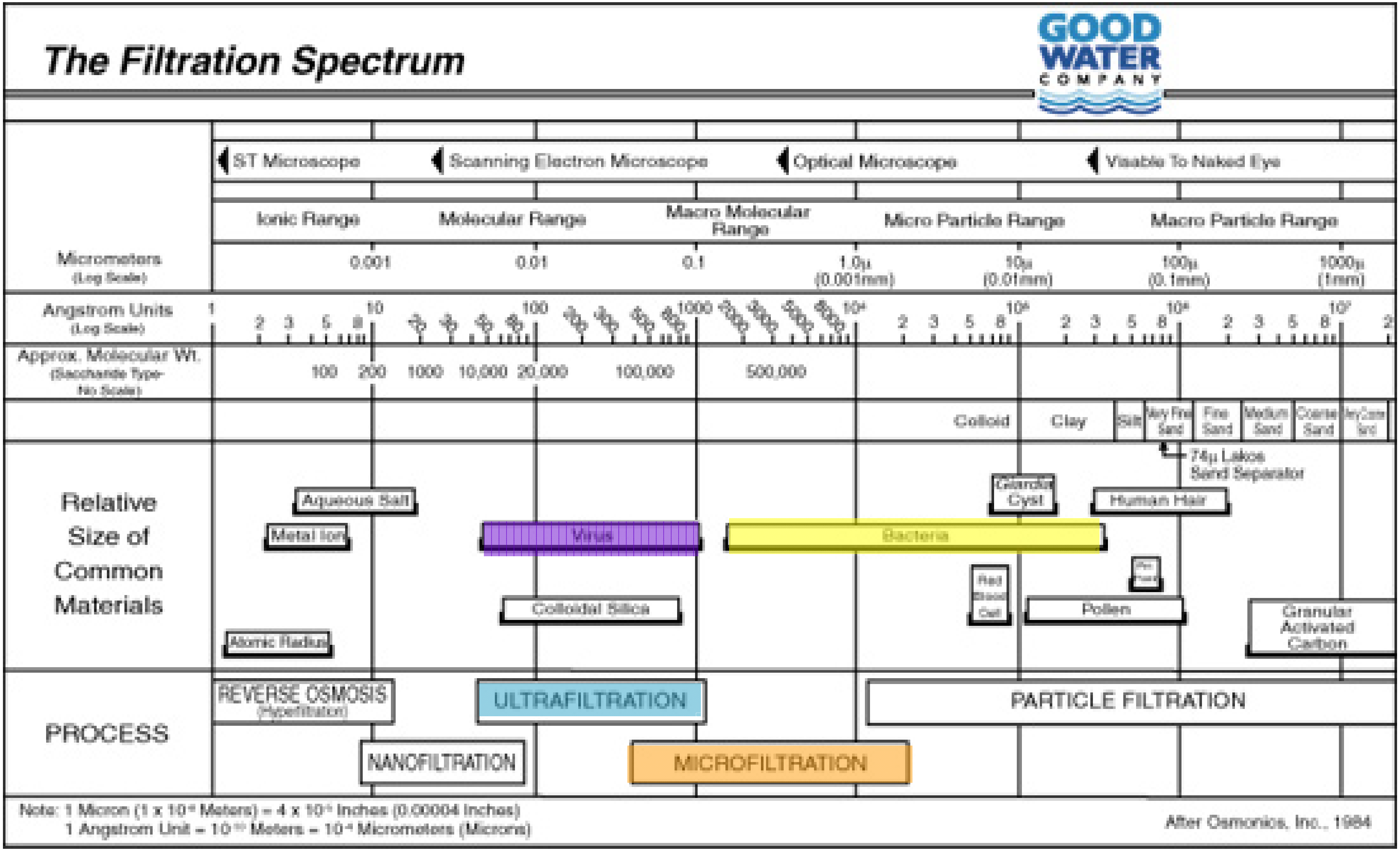
Effluent Decanter

Raised above liquid during aeration

Follows liquid level down during decant

Membrane BioReactor




The Filtration Spectrum
ST Microscope
Scanning Electron Microscope
Optical Microscope
Visable To Naked Eye
Ionic Range
Molecular Range
Macro Molecular Range
Micro Particle Range
Macro Particle Range
Micrometers (Log Scale)
0.001
0.01
0.1
1.0µ (0.001mm)
10µ (0.01mm)
100µ (0.1mm)
1000µ (1mm)
Angstrom Units (Log Scale)
1
10
100
1000
Approx. Molecular Wt. (Saccharide Type-No Scale)
100
200
1000
10,000
20,000
100,000
500,000
Colloid
Clay
Silt
Very Fine Sand
Fine Sand
Medium Sand
Coarse Sand
74µ Lakos Sand Separator
Relative Size of Common Materials
Aqueous Salt
Metal Ion
Atomic Radius
Virus
Colloidal Silica
Bacteria
Giardia Cyst
Human Hair
Red Blood Cell
Pollen
Granular Activated Carbon
PROCESS
REVERSE OSMOSIS (Hyperfiltration)
NANOFILTRATION
ULTRAFILTRATION
MICROFILTRATION
PARTICLE FILTRATION
After Osmonics, Inc., 1984

Membrane Bioreactor

- Compact System
- No Clarifiers or Filters
- High Mixed Liquor Concentrations Possible
- No TSS or bacteria in effluent
- Limits passage of viruses
- Small Footprint (0.3 ha/10 MLD)
- Highly automated
- Requires close monitoring

Fixed Film Processes

What are biofilms?

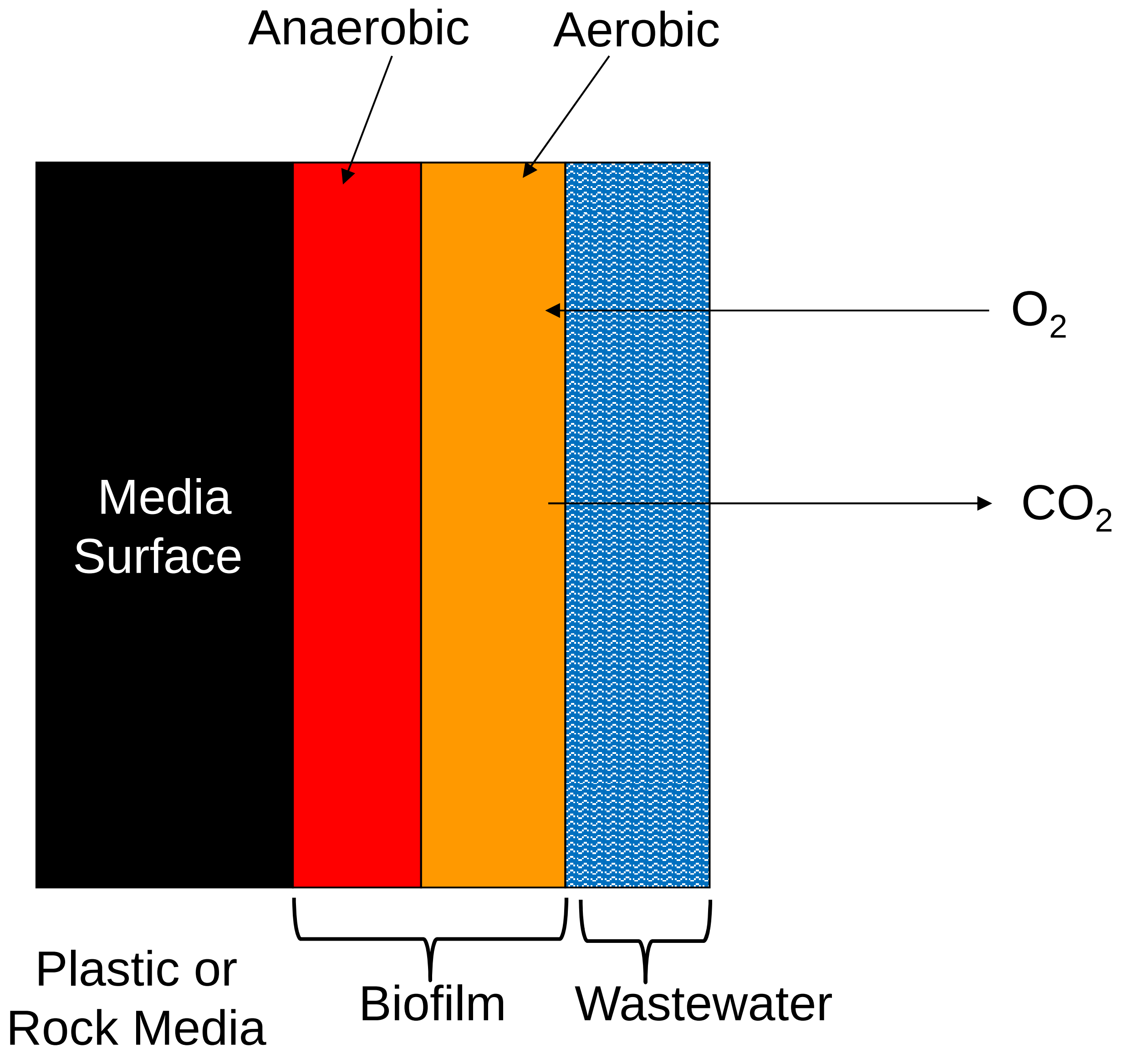
A cultured biomass attached to a support medium

The biofilm develops according to the availability of particular wastewater components and will vary according to loading and configuration

Aerobic biofilms require oxygen to function

As biofilms grow via the degradation of organic compounds they produce excess biomass which need to be removed from the system

Biofilm Structure



Fixed Film Reactors

Also known as attached growth reactors to differentiate them from activated sludge or ‘suspended growth’ systems

Biomass is cultured as a biofilm attached to a biomass support

Biofilm can be applied across the whole spectrum of wastewater treatment from low rate traditional trickling filters to ultra high rate fluidised bed reactors

Fixed Film Processes

- Non-submerged systems
  - Traditional approach
  - Biofilm wetted regularly but kept in an air environment
  - Developed in 1890's as rock filters
  - Simple, low energy

- Submerged systems
  - Biofilm grows on media whilst completely wetted
  - Air supplied through aeration system
  - High rate, small footprint
  - More complex with greater control required

Fixed Film Processes

Percolating Filters (Trickling Filters)

- Non-submerged fixed film biological reactor using rock or plastic packing over which wastewater is distributed continuously
- Advantages
  - No aeration costs
  - Simple to operate
  - Robust
  - Known process
  - Long-term experience

Fixed Film Processes

- **Percolating Filters (Trickling Filters)**
  - **Media Properties**
    - High surface area – maximum biofilm attachment
    - Voids – large pores for aeration
    - Non – toxic – biofilm growth
    - Strength – no crushing
    - Cost – Cheap
  - **Distribution**
    - Distribute wastewater evenly over filter
    - 2 or 4 arms
    - 30 – 55 mins / revolution
    - Improved BOD removal
    - Insect control
    - Hydraulic, motorized or static

Fixed Film Processes

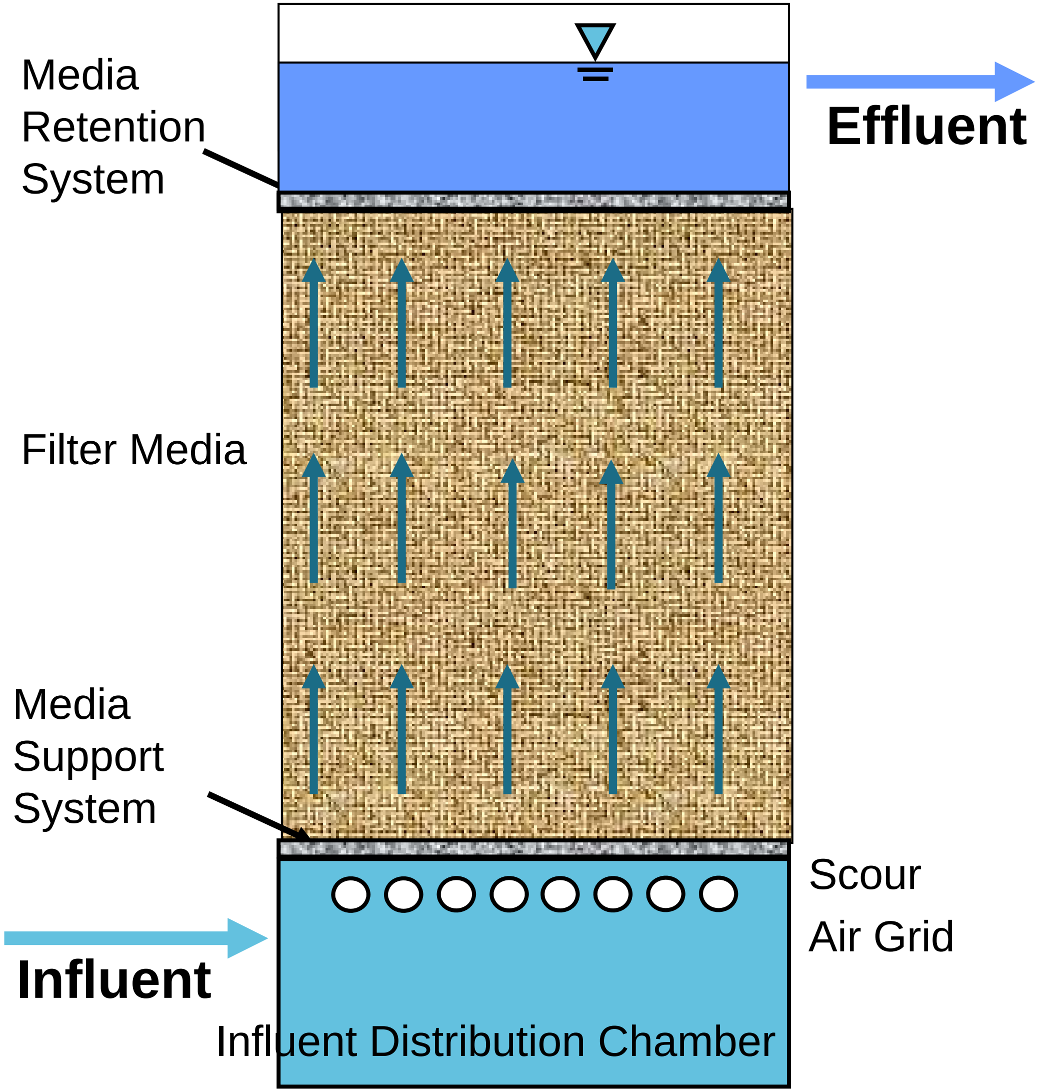
- **<u>Rotating Biological Contactors</u>**
  - More suitable for small works
  - Very low power requirement
  - Easily covered
  - Mechanically simple
  - Expensive
  - Tend to have mechanical problems
  - Unreliable

Biological Aerated Filter (BAF)

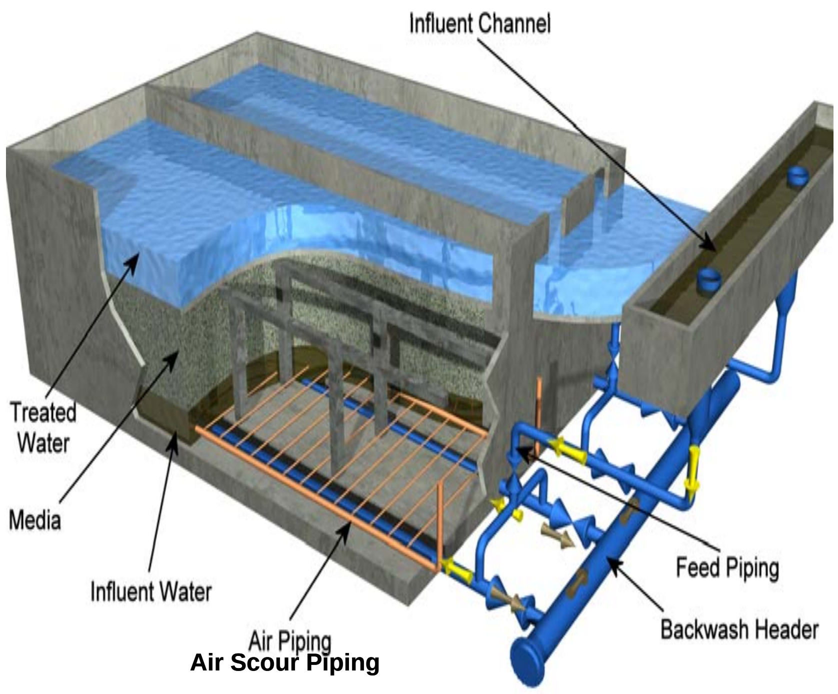
Attached Growth Biological Process

Upward Flow Through a Granular Media

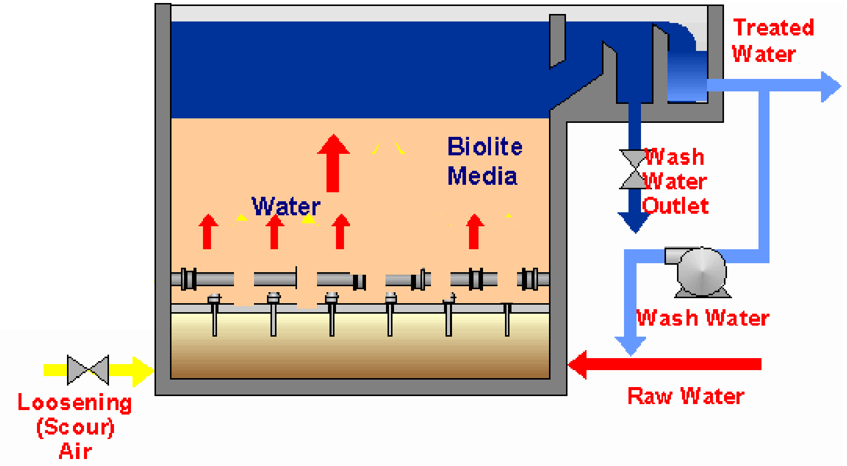
- Media - Surface for denitrifying organisms
- Media - Solids removal



Biological Aerated Filter (BAF)



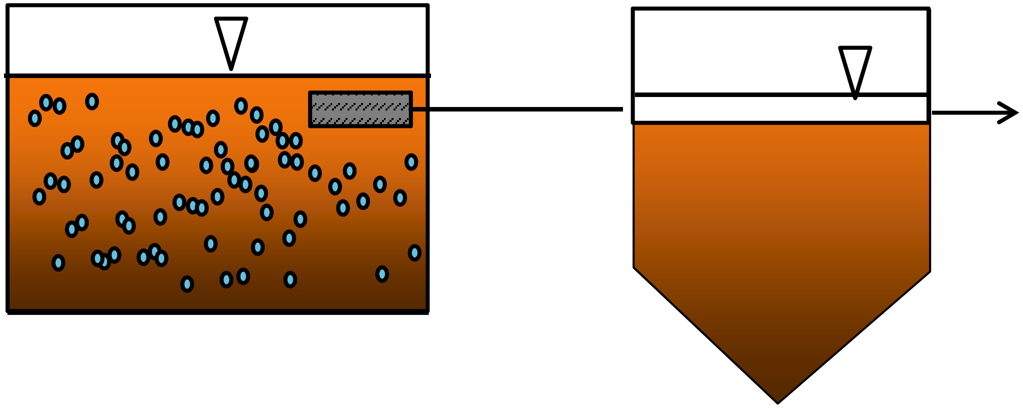
Kruger Biostyr



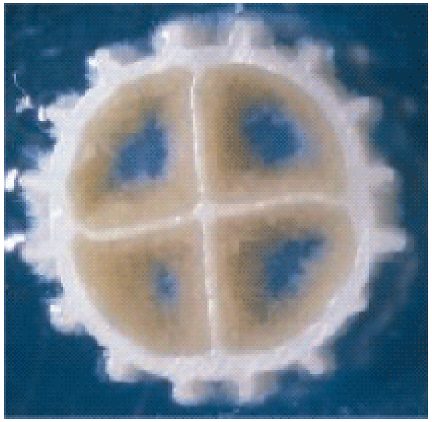
IDI Biofor

Hybrid Biological Systems

Moving Bed Biofilm Reactor (MBBR)

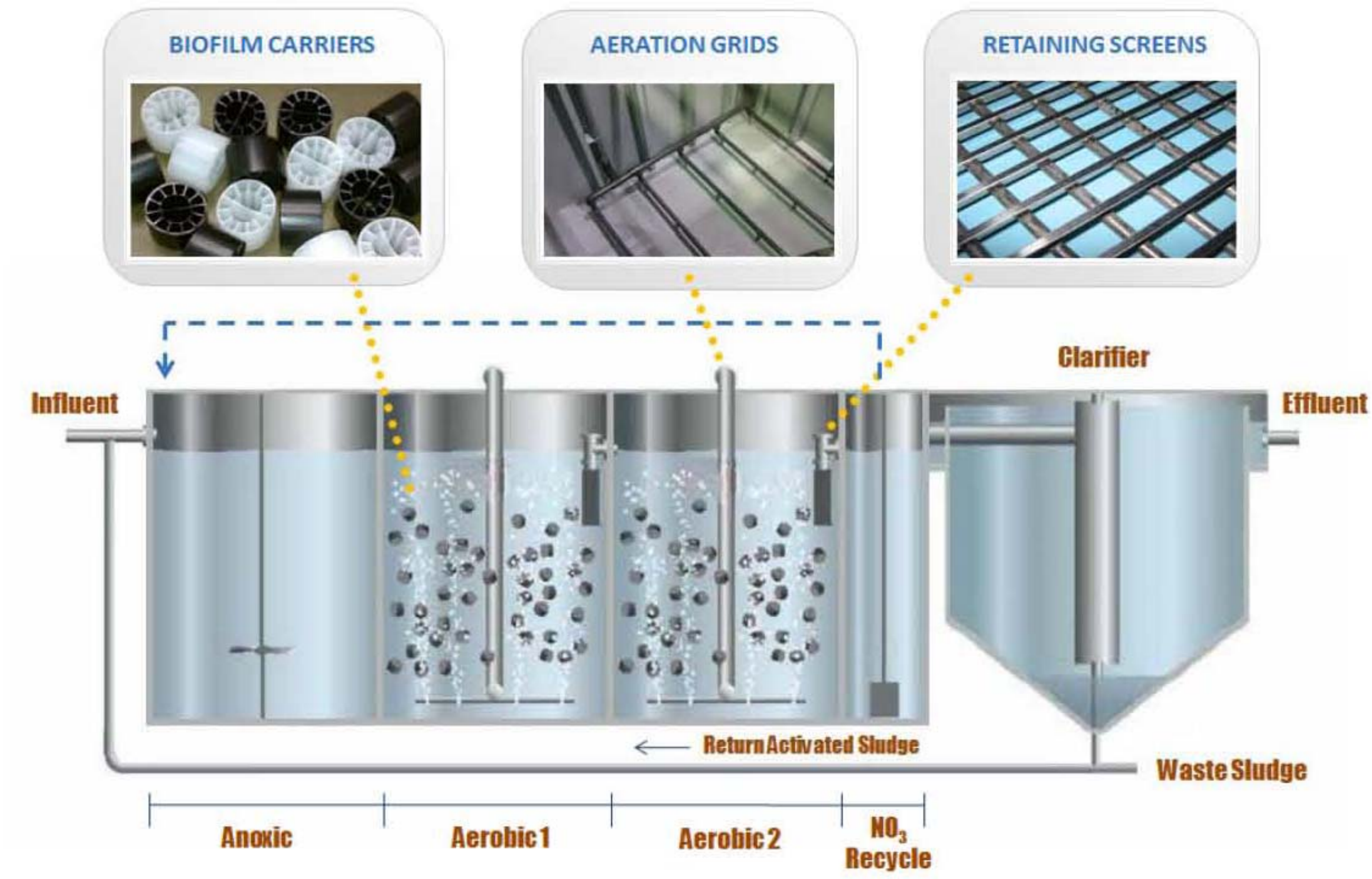


Moving bed plastic media



Bacteria in the plastic media

Integrated Fixed Film Activated Sludge



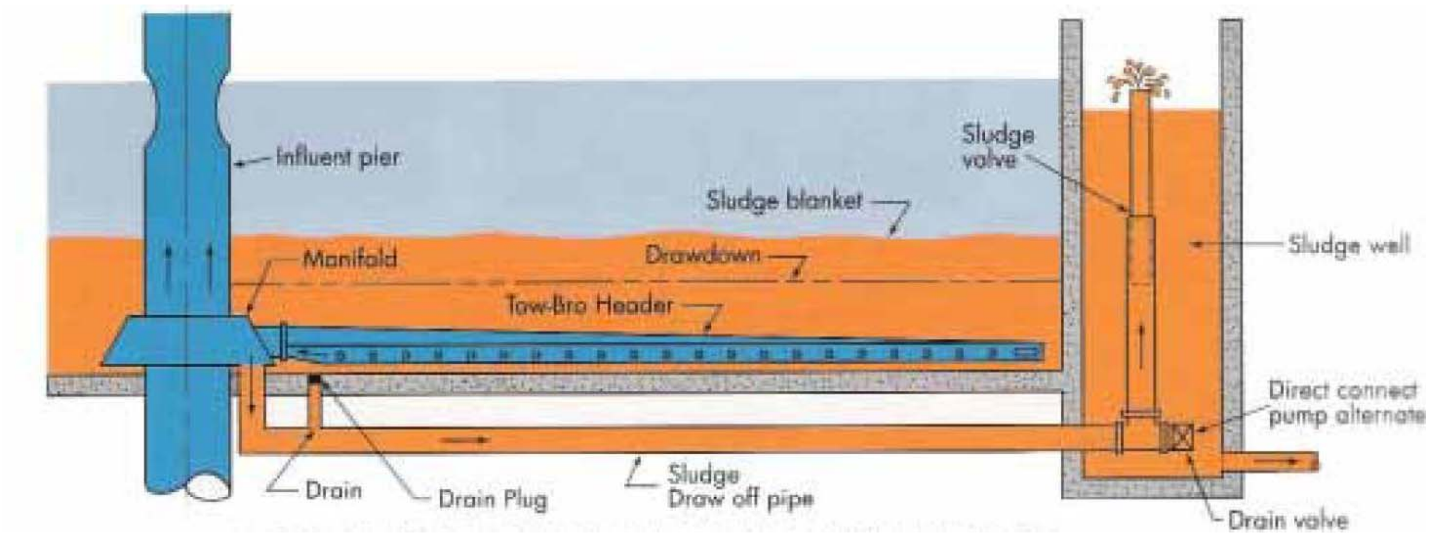
Secondary Clarification

Secondary Clarification

- Tanks in which settleable solids from the biological treatment process are separated from the wastewater
- Design considerations and tanks are similar to those used for Primary Settlement Tanks
- Most common are circular
  - (10 to 50 m)
- Rectangular tanks can also be used

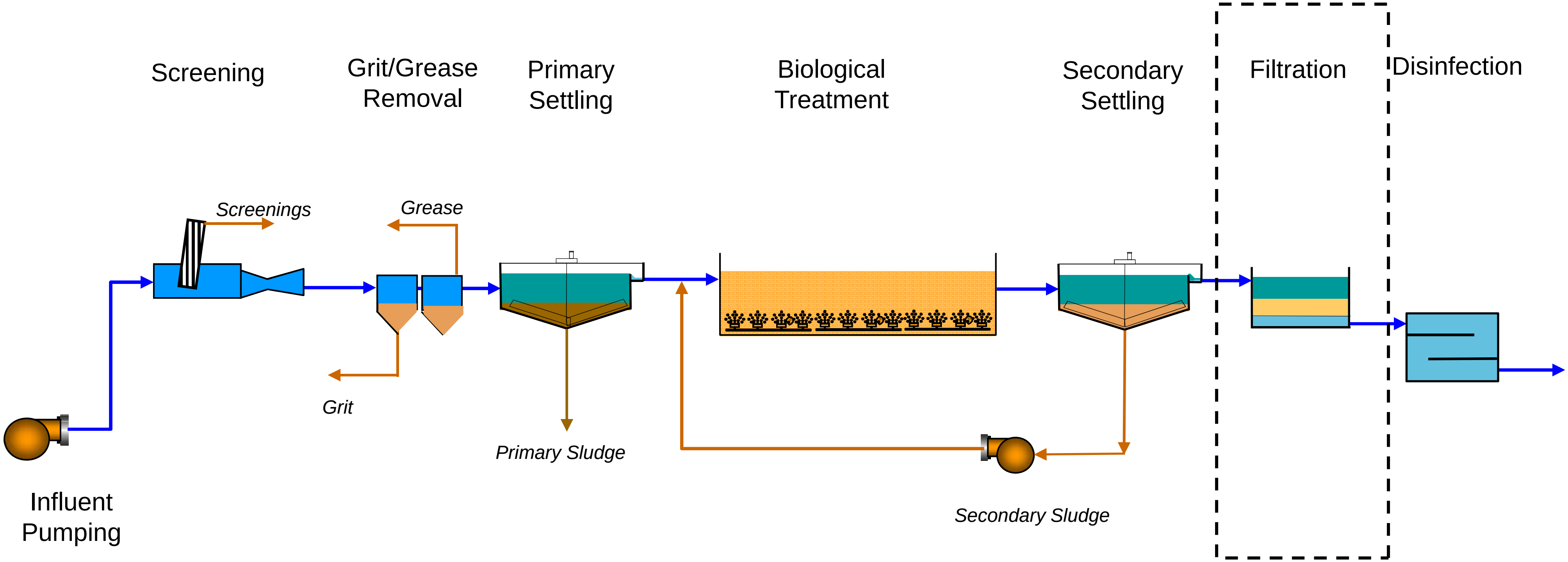
Secondary Clarification

Collectors with suction headers are the preferred type of equipment due to the nature of the sludge



Filtration

Filtration



Filtration is used to remove small solids that may leave the secondary clarifiers. It is used to achieve TSS levels of less than 5 mg/L. Microfilters and ultrafiltration can achieve TSS levels less than 1 mg/L and turbidity less than 1 NTU. Filtration can be used for tertiary treatment to remove contaminants such as phosphorus and nitrogen with chemicals or through biological activation.

Filtration

Types of Filtration

- Sand Filters
  - Gravel, sand, other granulated material
  - Dual, multi layer or multi media filters
- Membranes
  - Ultra filters, act as sieves
  - .001- 10 micron
- Biofilm Filtration (Disc or Trickling)
  - Biofilter using microorganism

Disc Filters

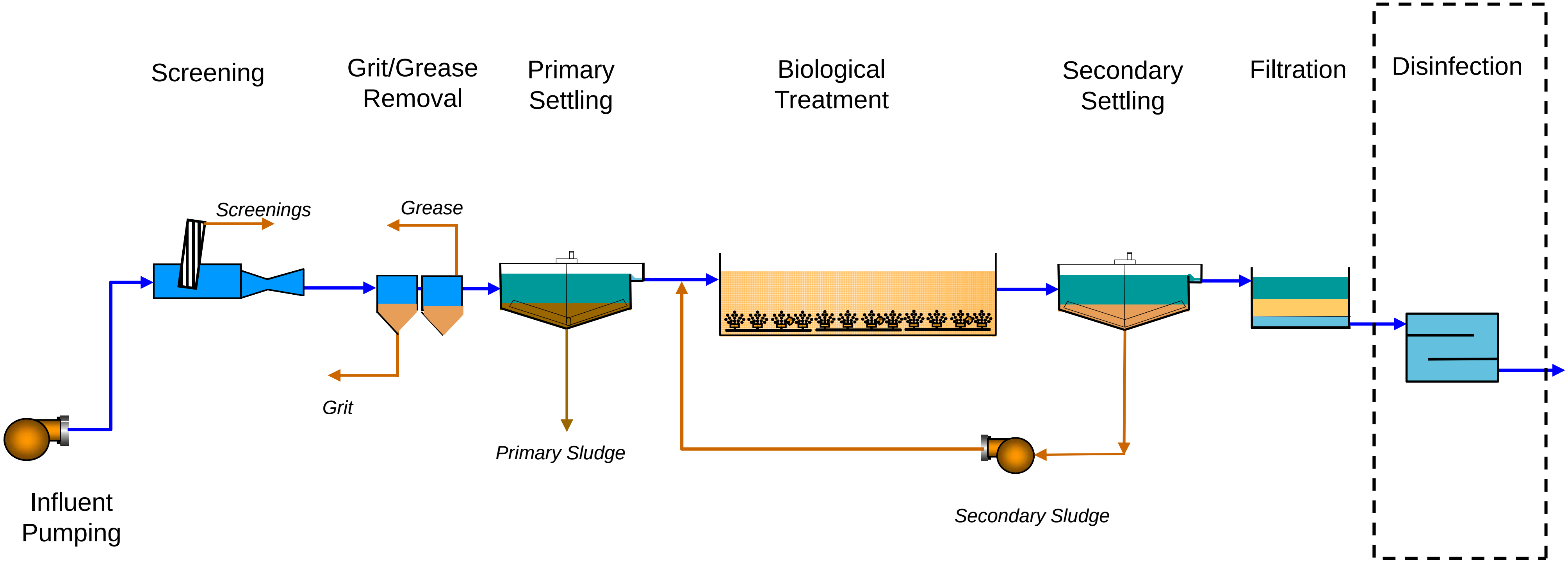
Deep Bed Filters

Low Head Filters

Fluidized Bed Filter

Disinfection

Disinfection



Disinfection removes remaining bacteria and viruses that could be harmful to fish or humans if in great concentration. All TSE is disinfected for health reasons and to reduce bacteria growth in reuse mains. Disinfection is required ahead of disposal or reuse under most conditions. May not be required for dedicated land application, subsurface disposal or disposal to non-critical waterways.

Disinfection

Chlorination

- Most commonly used
- 15 minutes contact time to remove most bacteria
- 30 minutes chlorine contact time to kill giardia cysts

Ultraviolet Radiation

- 20-30 second contact time
- Inactivates viruses
- No chemical addition
- No residual disinfectant

Ozone

- Strong Oxidant

Odour Treatment

Classification of odours

	Odour threshold (ppb)	Long Term OEL (8-Hour) (ppm)	Short term OEL (15 minutes) (ppm)
Hydrogen Sulphide	0.5	5	10
Methyl Mercaptan (methanethiol)	0.0014-18	0.5	-
Ethylmercaptan (ethanethiol)	0.02	0.5	2
Ammonia	130-15300	25	35
Methylamine	0.9-53	10	-
Ethylamine	2400	10	-
Dimethylamine	23-80	10	-

Why Hydrogen Sulphide

WHO guidelines for H_2S.

1000-2000 ppm	Immediate collapse with paralysis of respiration
530-1000 ppm	Strong Central Nervous system stimulation followed by respiratory arrest
320-530 ppm	Risk of Death
150-250 ppm	Loss of olfactory sense
50-100 ppm	Serious eye damage
10-20 ppm	Theshold for eye irritation

Why Hydrogen Sulphide

The importance of Hydrogen Sulphide in odour work

- It is almost always a component of wastewater odour
- It is always a component of septic wastewater odour
- It can be measured at concentrations close to its threshold
- Predictive models can be used
- In 99 cased out of 100, if the generation and release of H2S is controlled so is the odour problem.

Methods of Treatment

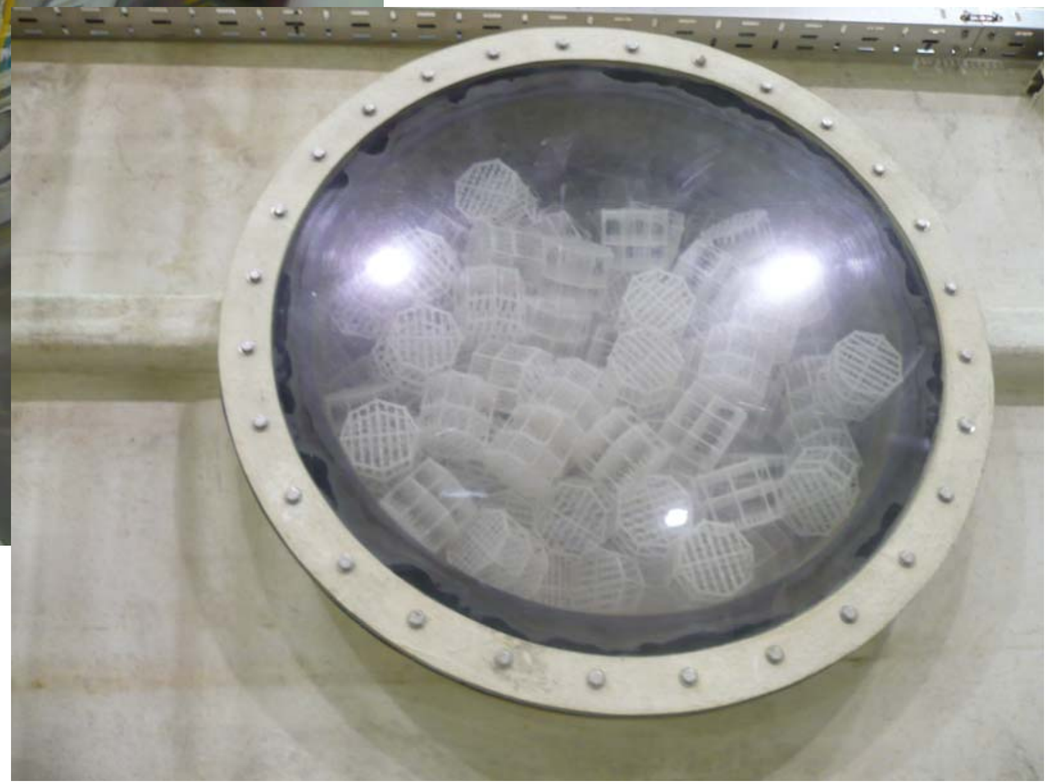
Process	Description	Typical Design Details	Typical H2S Inlet (ppm)	Typical % Removal Results	Approximate size of installation (m3/h)
Biofilters	A shallow bed containing a media such as compost or peat mixed with a bulking agent such as heather on which biological growth occurs.	35-100 m3/m3.h Bed Depth about 1m, Media life 2 - 5 years	Typically < 10 Maximum 50, if irrigated	70-95% H2S Up to 95% TON, Residual odour about 200 OU/m3	100-15000
Calcified Media Biofilters	A shallow bed containing calcified media such as shells or calcified seaweed sometimes mixed with peat.	35-100 m3/m3.h Bed Depth about 1m, Media life 2 - 5 years	Typical <100 Maximum 250, Irrigation Required	80-99% H2S	100-15000
Bioscrubbers	Tower packed with plastic media on which bio-film develops. Liquor is re-circulated over the bed against the air flow	Sizing dependent on inlet and required outlet concentrations (as wet scrubber) pH control required	10-1000	60-90% H2S, Residual 1 - 10 ppm	1000-2000
Dry Chemical Scrubbers	Impregnated particles, for example of alumina, held in a bed through which odourous air passes.	Dwell time 1 s	<10 (has been used for much higher concentrations)	95-99.9% H2S with fresh media. Efficiency of passive units likely to be lower than this	Similar to activated carbon 1-52000

Process	Description	Typical Design Details	Typical H2S Inlet (ppm)	Typical % Removal Results	Approximate size of installation (m3/h)
Activated Carbon	Granules of high surface area carbon are held in a bed through which odourous air passes	Bed Depth about 0.25m Velocity 0.2-0.38 m/s, Dwell time 2s, usually 2 or 3 beds	<10	95-99/9% H2S with fresh media. Efficiency of passive units likely to be lower than this	Fan assisted 360-72000 Passice 1-1800
Catalytic Iron Filter	Iron Oxide held in a vertical or horizontal unit over which sulphide containing air passes.		500	50%	100-15000
Wet Chemical Scrubbers	Odourous air is contacted with a flow of recirculating liquid which dissolves and removed the odourous chemicals.	Sizing dependent on inlet and required outlet concentrations, pH control required	<10-1000	95-99% H2S 85-95% Odour	1000-100000

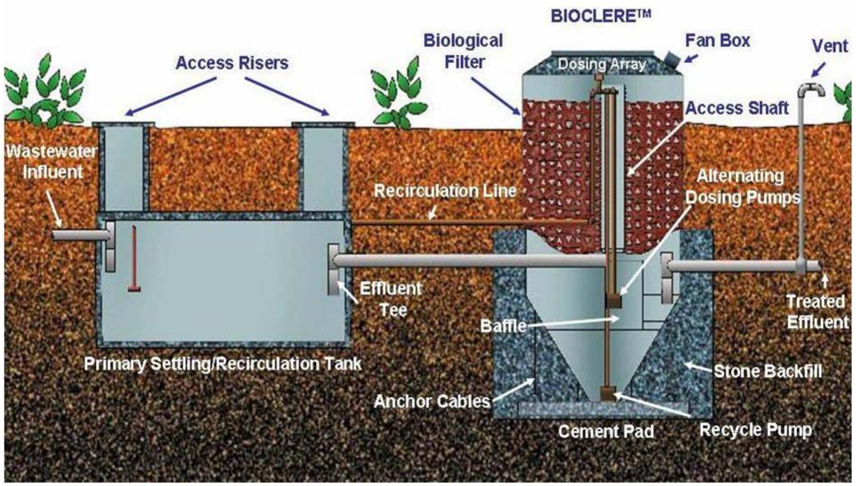
Activated Carbon Filters

Chemical Scrubbers

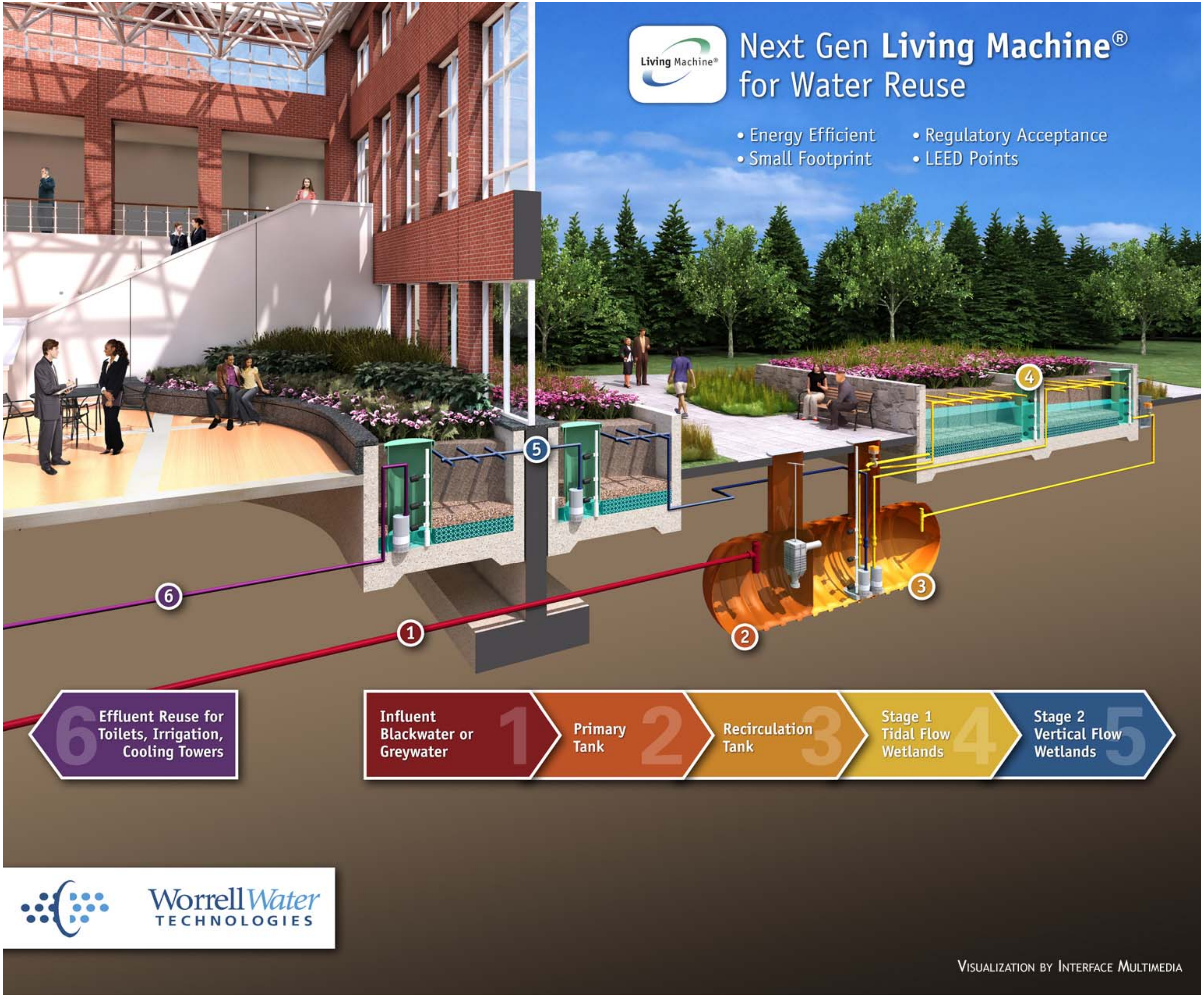
Biological Treatment



Small Treatment Systems


BIOCLERE™
Biological Filter
Fan Box
Vent
Access Risers
Dosing Array
Access Shaft
Wastewater Influent
Recirculation Line
Alternating Dosing Pumps
Effluent Tee
Baffle
Treated Effluent
Primary Settling/Recirculation Tank
Stone Backfill
Anchor Cables
Cement Pad
Recycle Pump


Anx
Aer 1
Aer 2
Waste Sludge



Living Machine®
Next Gen Living Machine® for Water Reuse
• Energy Efficient
• Small Footprint
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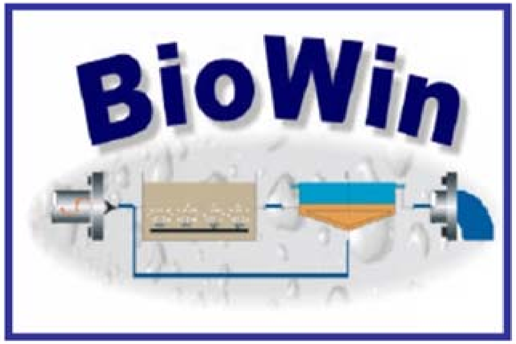
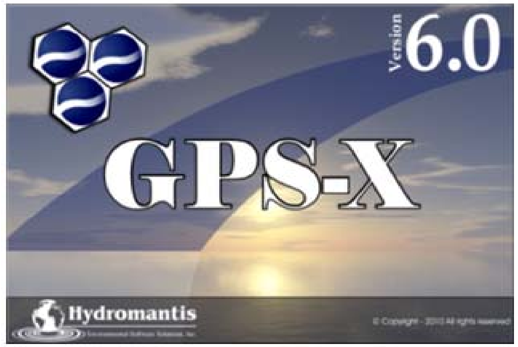
• LEED Points
6 Effluent Reuse for Toilets, Irrigation, Cooling Towers
Influent Blackwater or Greywater 1
Primary Tank 2
Recirculation Tank 3
Stage 1 Tidal Flow Wetlands 4
Stage 2 Vertical Flow Wetlands 5
Worrell Water TECHNOLOGIES
Visualization by Interface Multimedia

Biological Process Modeling

Wastewater Process Modeling Software



BIOWIN:
EnviroSim Associates, Ltd.
7 Innovation Drive
Suite 205
Flamborough, Ontario, Canada

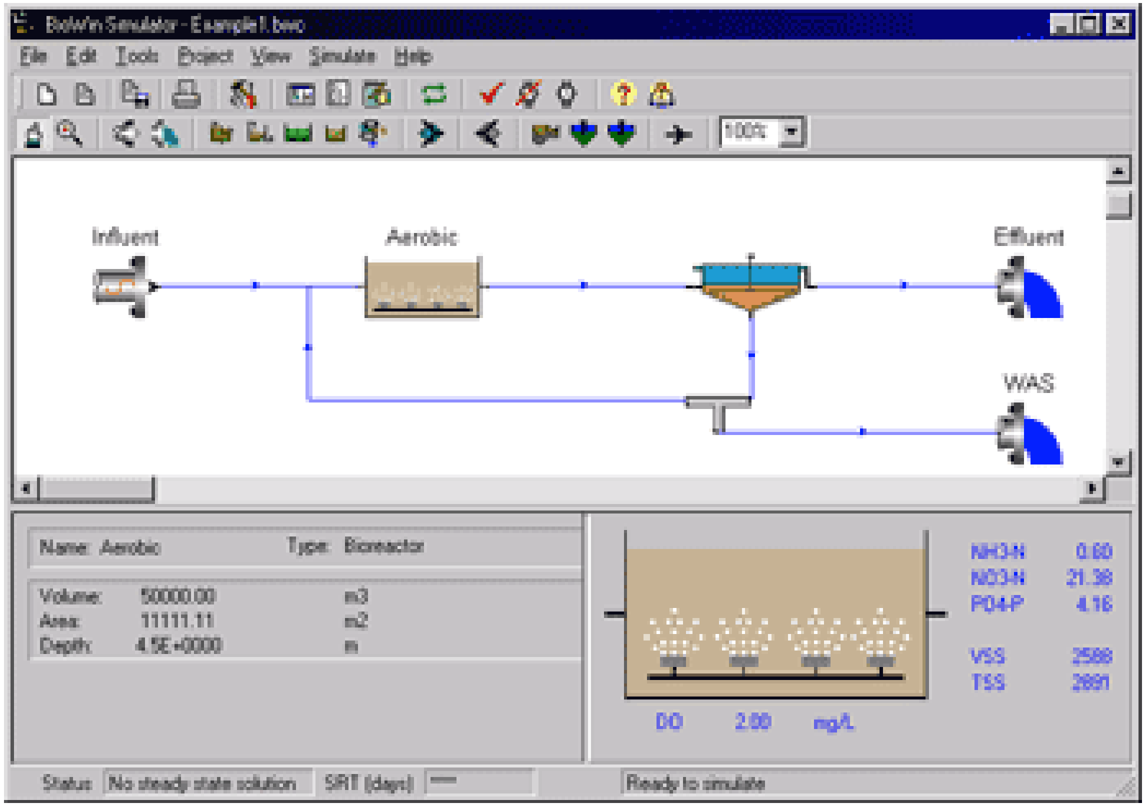


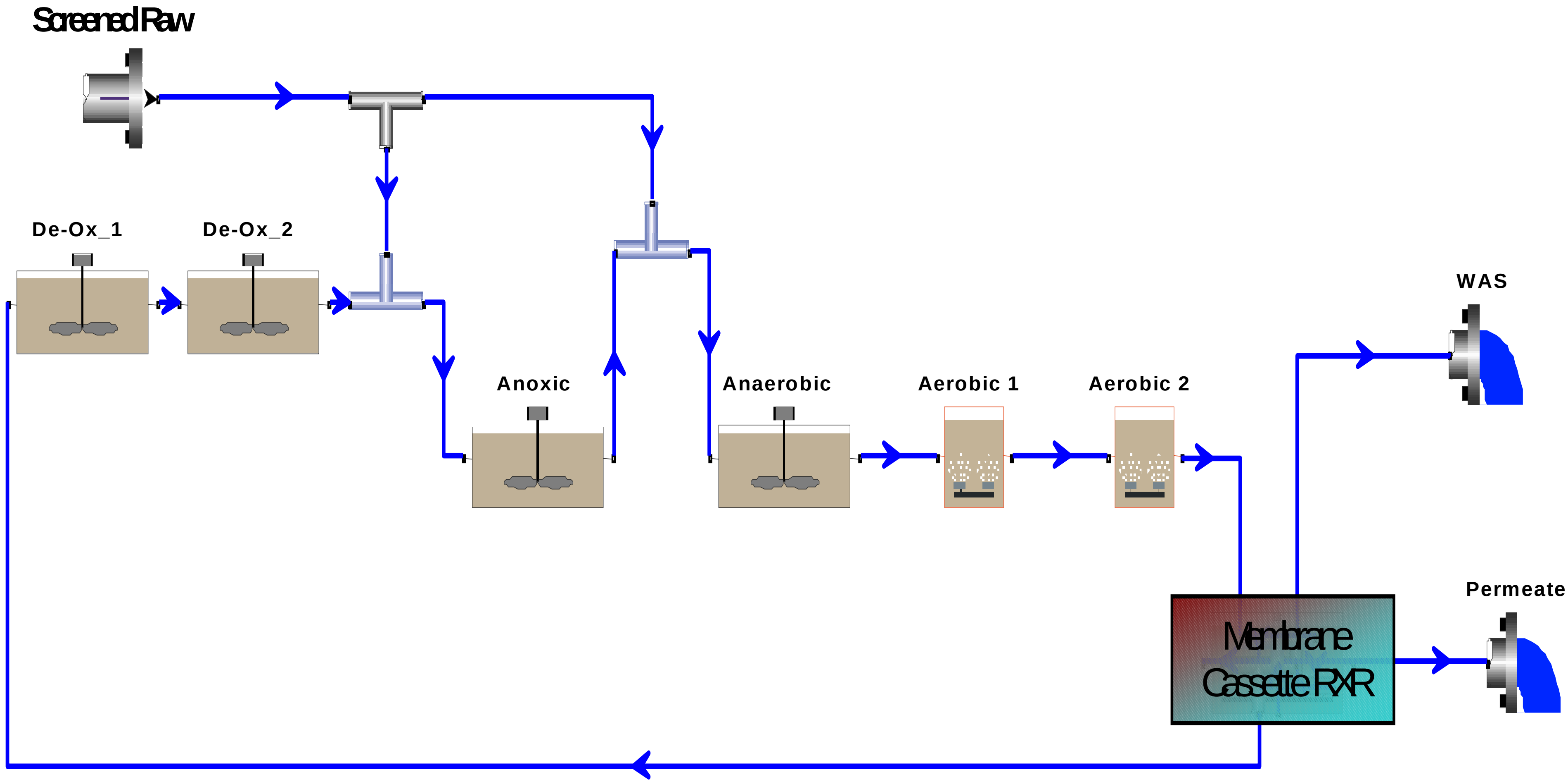
GPS-X:
Hydromantis ESS, Inc.
1 James Street South
Suite 1601
Hamilton, Ontario, Canada

WEST:
Hemmis N.V.
K. Leopold III-Iaan 2
8500 Kortrijk
Belgium

Biological Process Modeling

Different process units can be included to "build" a specific treatment plant configuration and model any condition




Screened Raw
De-Ox_1
De-Ox_2
Anoxic
Anaerobic
Aerobic 1
Aerobic 2
WAS
Permeate
Membrane
Cassette RXR

Sludge Treatment

Sludge Treatment

What is Sludge?

- Wastewater sludge is comes from:
  - Primary Sludge: Settled solids from raw wastewater, mostly TSS, from Primary Settling Tanks
  - Secondary Sludge: Live and dead bacteria from biological treatment processes, which are settled in the Secondary Settling Tanks

Sludge Treatment

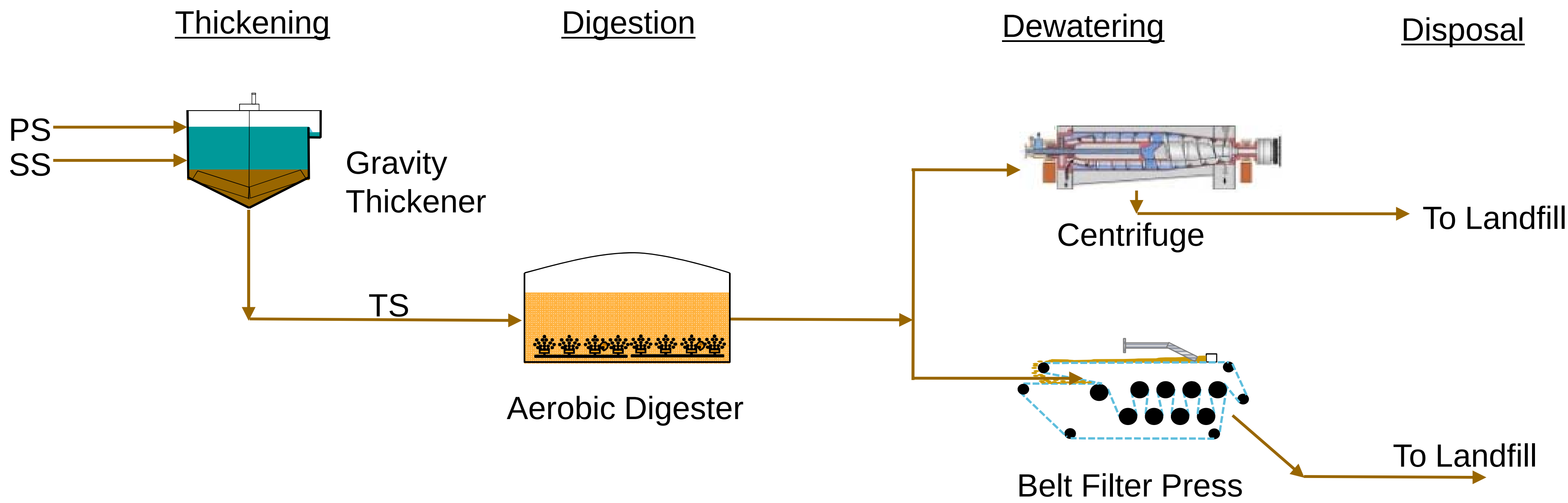
Why treat sludge?

- Need to dispose of the sludge
  - Wastewater sludge smells
  - Contains high level of fecal bacteria
- Disposal Options
  - Burning
  - Recycle to land
- Sludge from the settlement tanks is low in solids contents, concentrations between 0.5% and 2% solids.
- Treatment will concentrate the solids and reduce the volume to be disposed
- Treatment will also reduce odors and the level of fecal bacteria

Sludge Treatment

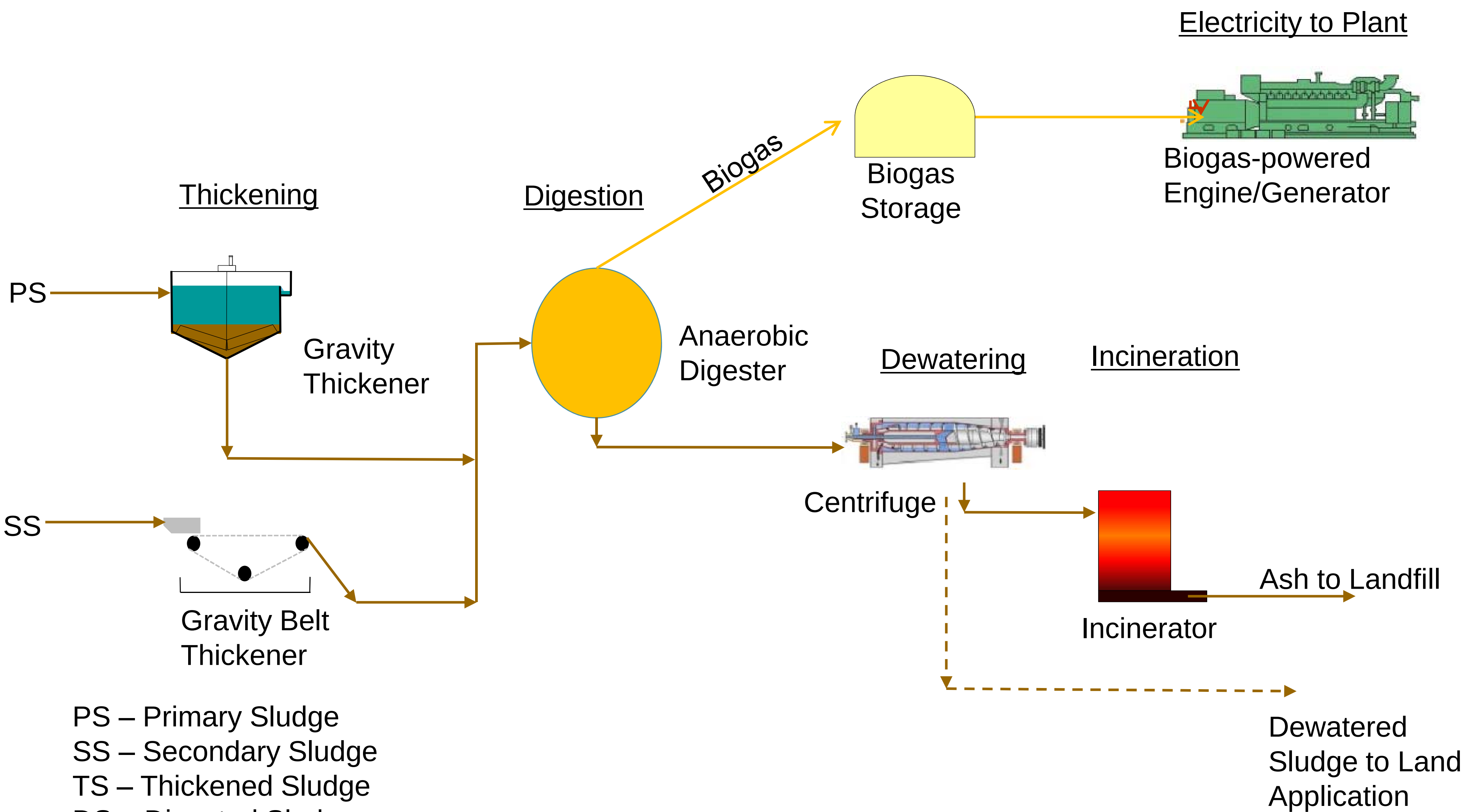
- Thickening
  - Gravity Thickening
  - Gravity Belt Thickening
  - Rotary Drum Thickening
  - Dissolved Air Flotation Thickening
- Digestion
  - Aerobic Digestion
  - Anaerobic Digestion
- Dewatering
- Drying
- Incineration

Sludge Treatment – Aerobic Digestion



PS – Primary Sludge
SS – Secondary Sludge
TS – Thickened Sludge
DS – Digested Sludge

Sludge Treatment – Anaerobic Digestion

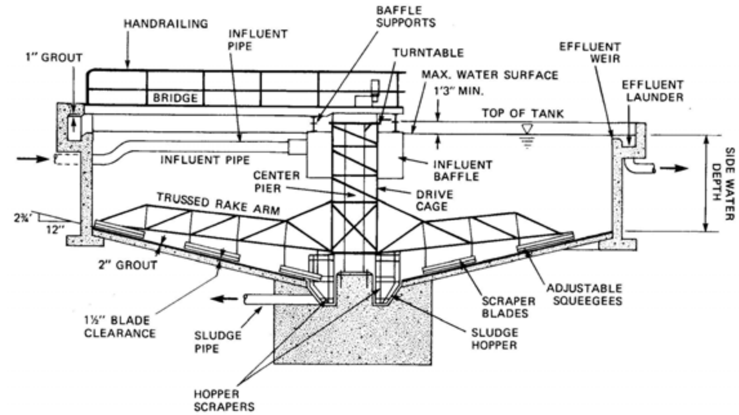


PS – Primary Sludge
SS – Secondary Sludge
TS – Thickened Sludge
DS – Digested Sludge

Sludge Thickening

Sludge Thickening

- Gravity Thickening
  - Process similar to settlement tanks in the liquid stream process
  - Works well for primary sludge but can be used for secondary sludge with polymer addition
  - Requires cover and odor control in case of process upset
  - Can increase solids from 1.5 – 2% to 4 – 6%



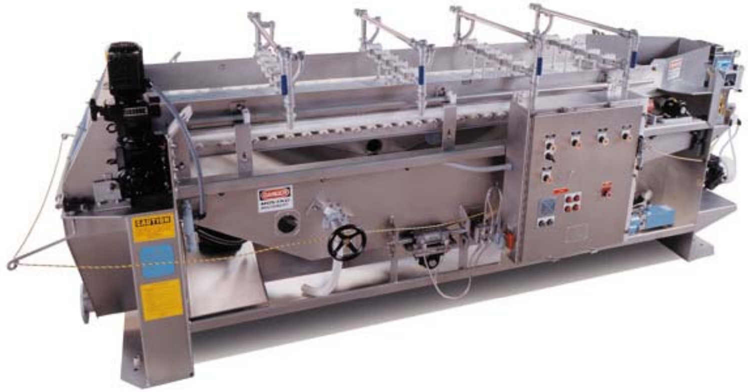
Sludge Thickening

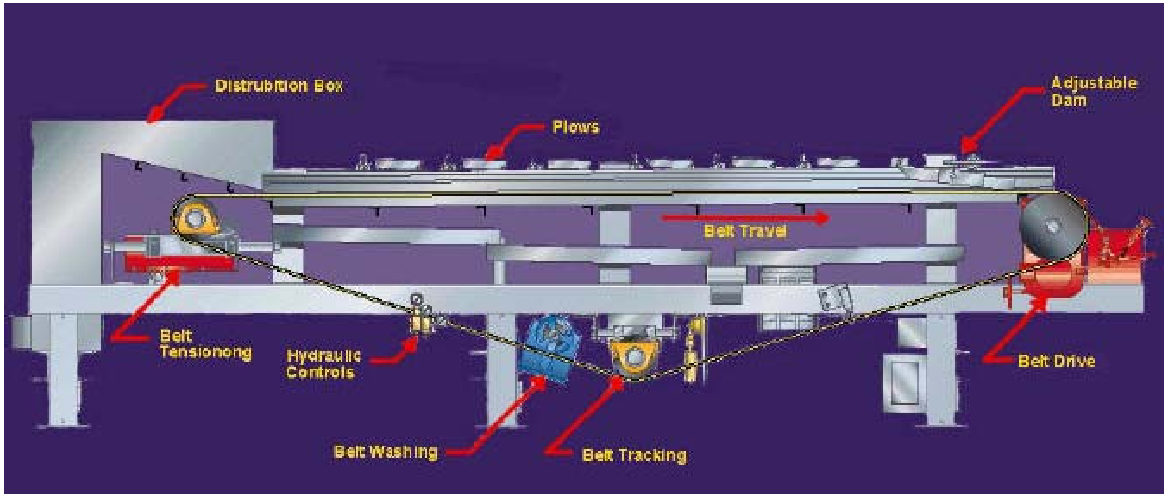
- Gravity Thickening Design Parameters

Design Parameter	Range
Diameter	10 – 25 m
Sidewater Depth	3 – 5 m
Solids Loading Rate	100 – 150 $kg/m^2/d$ (PS) 25 – 70 $kg/m^2/d$ (Combined PS & SS)
Hydraulic Overflow Rate	15.5 – 31 $m^3/m^2/d$ (PS) 6 – 12 $m^3/m^2/d$ (Combined PS & SS)
Sludge Blanket Depth	0.5 – 2.5 m

Sludge Thickening

- Gravity Belt Thickening
  - Liquid from sludge is removed through pores in woven plastic belt
  - Works well for secondary sludge
  - Polymer addition required for efficient operation
  - Can increase solids from 0.5 – 2% to 4 – 8%





Sludge Thickening

- Gravity Belt Thickening Design Parameters

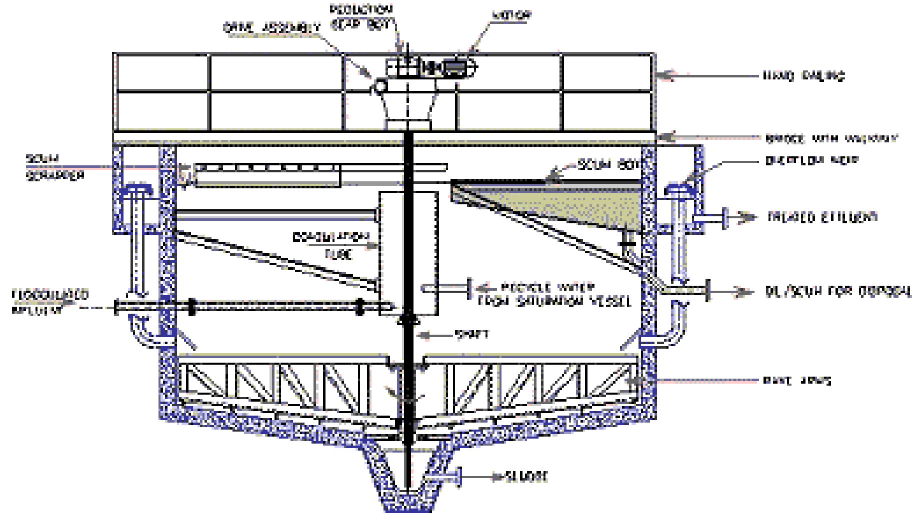
Design Parameter	Range
Belt Width	1 – 3 m
Solids Loading Rate	200 – 600 kg/m/hr
Hydraulic Overflow Rate	20 – 58 m^3/m/hr
Polymer Dosage	3 – 7 kg of dry polymer/metric ton

Sludge Thickening

- Rotary Drum Thickening
  - Slowly rotating drum aids removal of liquid from sludge and concentrates solids
  - Liquid from sludge is removed through pores in metal screen inside drum
  - Works well for both primary and secondary sludge
  - Polymer addition improves efficiency
  - Can increase solids from 0.5 – 2% to 4 – 8%
  - Up to 85 m3/hr capacity

Sludge Thickening

- Dissolved Air Flotation Thickening
  - Uses small air bubbles to which sludge particles attach and float to water surface
  - Works well for secondary sludge
  - Polymer addition required for efficient operation
  - Can increase solids from 0.5 – 2% to 4 – 8%
  - Requires additional support equipment (pressure vessels, air compressors and circulation pumps)
  - Solids loading rates
    - 1 – 6 kg/m^2/hr without chemical addition
    - Up to 10 kg/m2/hr with chemical addition



Sludge Thickening

- Centrifuge Thickener
  - Performance by percent capture
  - Liquid from sludge is removed through centrifugal action
  - Works well for secondary sludge
  - Polymer addition required for increased solids content
  - Can increase solids from 0.5 – 2% to 3 – 8%

Digestion

Sludge Digestion

- Process
  - Reduces the concentration of organic solids in sludge
  - Results in less sludge to process, decreases operating time and reduces size of dewatering equipment
- Anaerobic Digestion
  - Uses heated sludge in a tank with a low concentration of air
  - Process produces methane gas which can be utilized to heat the sludge and for cogeneration
  - Results in varying degrees of destruction of harmful bacteria
  - Must be used if dewatered sludge is to be recycled
- Aerobic Digestion
  - Uses diffused air to reduce organic solids
  - Dewatered solids must be incinerated or transported to a landfill
  - Tanks can be either circular or rectangular

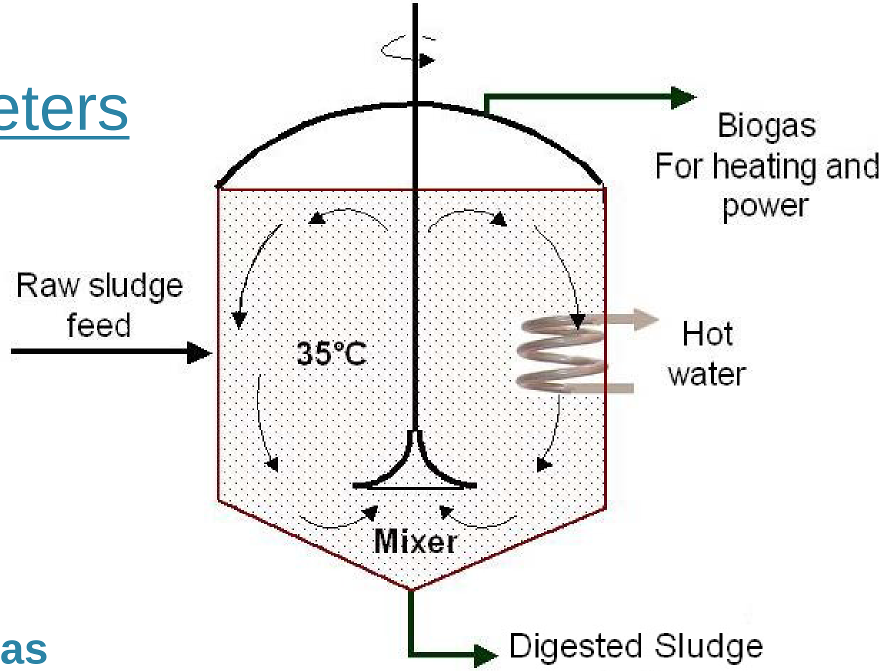
Egg-shaped Digesters

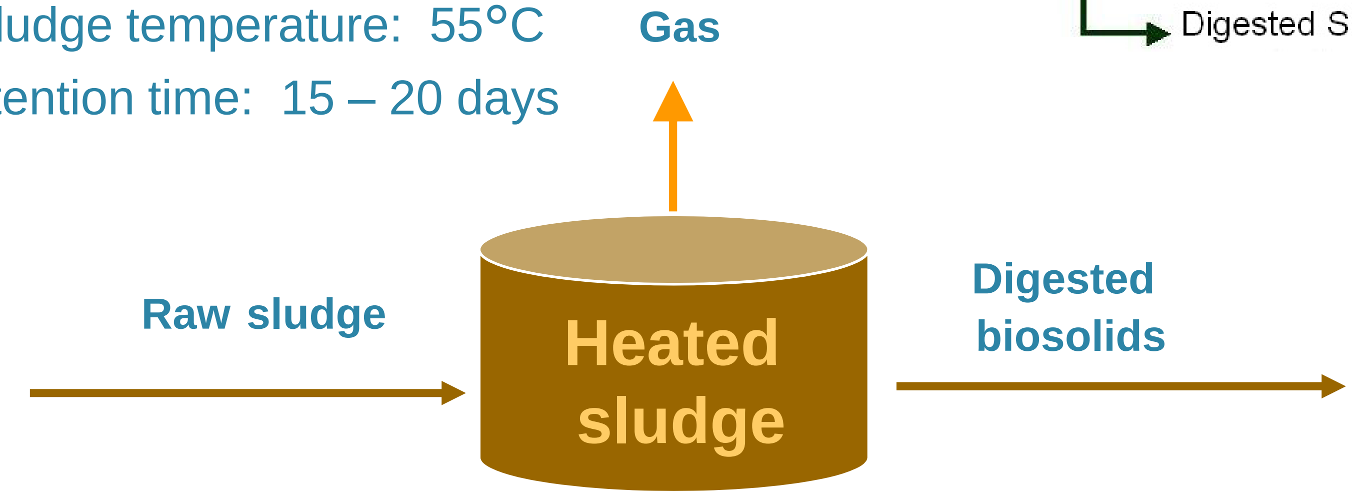
Conventional Anaerobic Digesters

Sludge Digestion

Anaerobic Digestion Design Parameters

- Mesophilic Process
  - Heated sludge temperature: 35°C
  - Solids retention time: 15 – 20 days
  - Solids Loading Rate: 1.6 – 4.8 kg/d/m3
- Thermophilic Process
  - Heated sludge temperature: 55°C
  - Solids retention time: 15 – 20 days





Aerobic Digestion Design Parameters

Design Parameter	Range
Volatile Solids Loading Rate	1.6 – 4.8 kg/d/m^3
Solids Retention Time	40 – 60 days
Diffused Air for Mixing	0.02 – 0.04 m^3/min/m^3

Sludge Dewatering

Sludge Dewatering

Centrifuge

- High speed rotating drum uses centrifugal force to remove liquid from sludge
- High capacity is a small footprint
- Solids and odors are completely contained within the drum
- Produces higher dry solids content that Belt Filter Press
- 70% moisture content cake

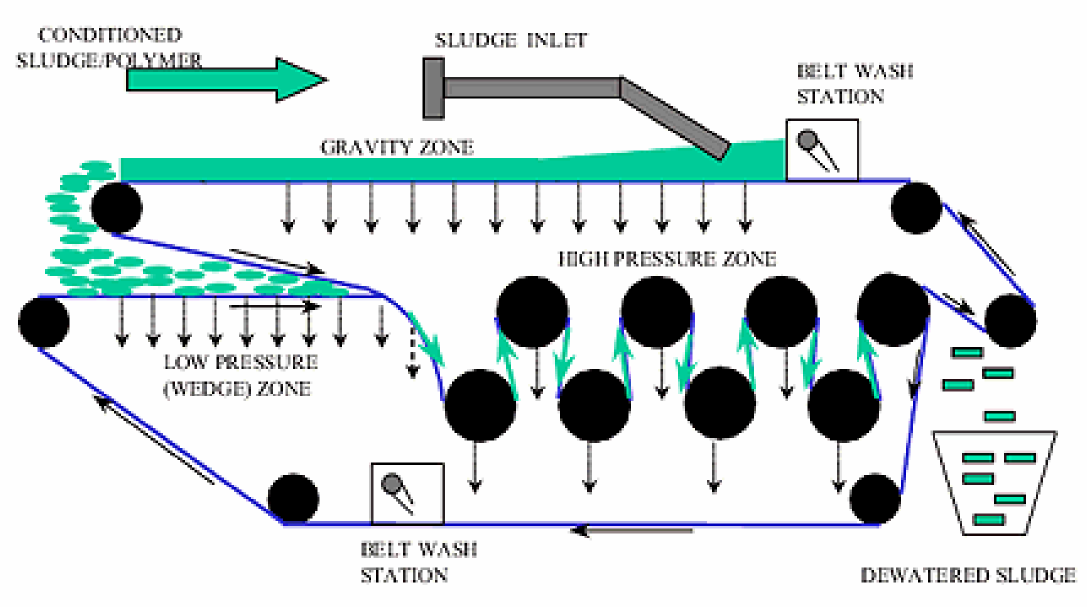
Belt Filter Press

- Uses pressure to squeeze liquid through two woven plastic belts
- Requires more maintenance
- 70-80% moisture content cake

Sludge Dewatering

Belt Filter Press Design Parameters

Design Parameter	Range
Belt Width	0.5 – 3 m
Feed Rate	5 – 12 m^3/hr/m
Solids Loading Rate	180 – 320 kg/hr/m
Polymer Dosage	4 – 10 kg of dry polymer/metric ton



Sludge Dewatering

- Dewatered sludge from Centrifuges and Belt Filter Presses is usually in the range of 20 – 30% dry solids
- Sludge can burned in incinerators, trucked to a landfill or used as a soil amendment if it has been adequately digested

Sludge Dewatering

Sludge Drying

– Increases Solids to 90% or greater
- Reduces pathogens and vectors

In-vessel Thermal Drying

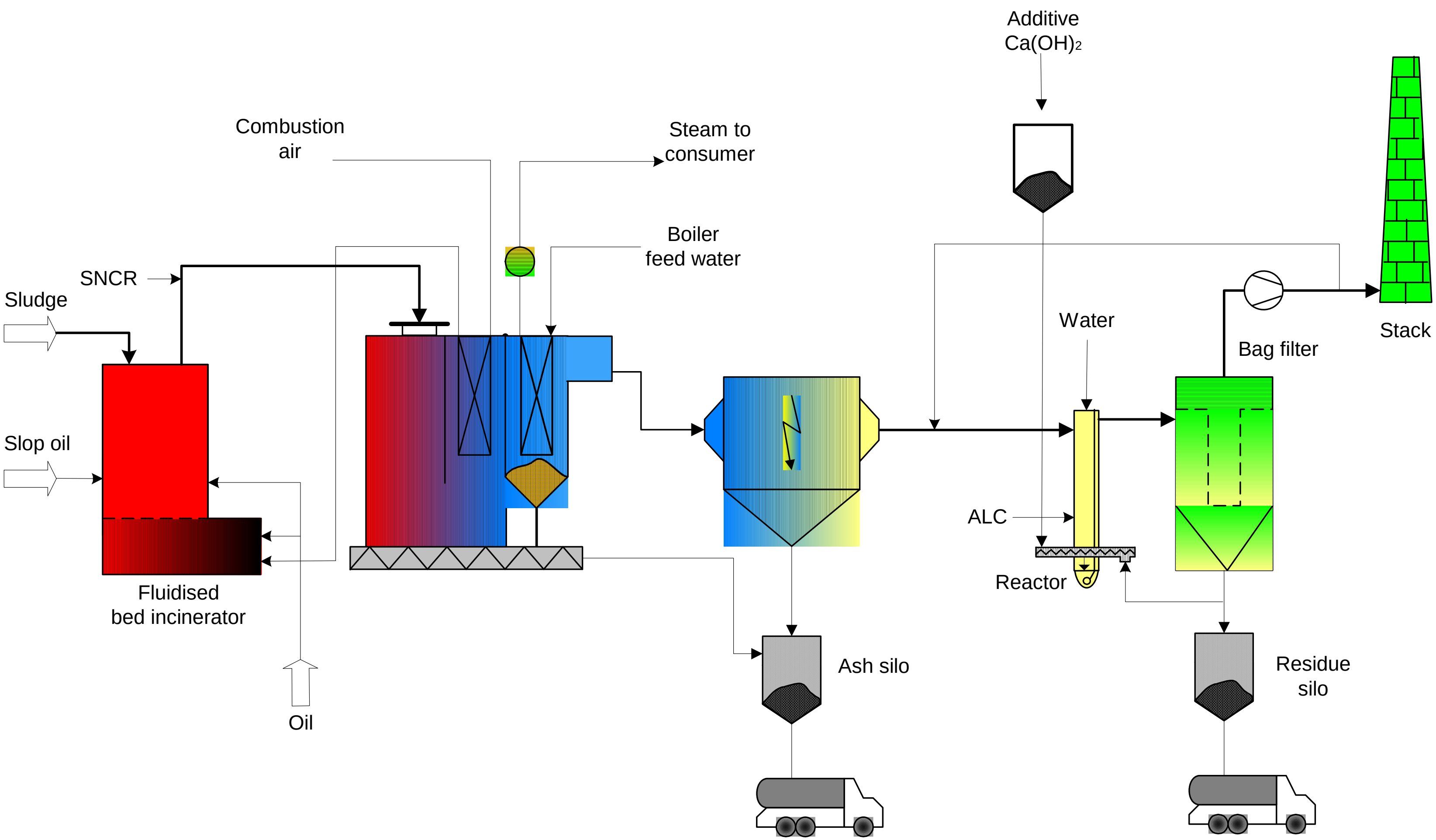
Sand Bed Drying

Incineration

Sludge Incineration

- Burns the dewatered sludge to produce ash, reducing the volume for disposal
- Destroys pathogens and toxic compounds making disposal safer

Sludge Incineration



Cogeneration

Cogeneration

- Also called Combined Heat and Power (CHP)
- Provides the opportunity to use biogas generated in Anaerobic Digestion Process
- Biogas can be collected and stored for use to:
  - Heat water used to maintain a suitable temperature in the digesters to sustain biological degradation
  - Power combustion engines to generate electricity which powers treatment plant equipment
  - Heat water to maintain a comfortable environment in buildings in cold climates

Sludge Treatment

Cogeneration

Biogas Engine/Generator

Biogas Storage Dome

Sludge Treatment Summary

Sludge Treatment Summary

- Sewage sludge generally comprises settled solids and dead and living biomass
- It is treated to reduce volume for disposal, kill bacteria and reduce odors
- Treated sludge can be burned to further reduce the volume for disposal or can be applied on land as a soil amendment
- Belt thickeners, centrifuges and belt presses are used to remove water from the sludge to thicken & dewater with the addition of polymer
- Sludge can be digested at elevated temperature to break down the volatile solids and produce gas for power generation, producing a stable sludge for disposal

Thank You

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Robert B. Garner robert.garner@aecom.com