Activated Sludge Design, Startup, Operation, Monitoring and Troubleshooting

- Ohio Water Environment Association
- Plant Operations Workshop
- Columbus, Ohio
- September 1, 2010

- Phil Anderson
- Operations Specialist

ARCADIS

Design - Activated Sludge

- Design Team
- Treatment Goals
- Activated Sludge Processes
- Engineering Standards
- Preliminary Treatment
- Tertiary Treatment

Treatment Goals

- BOD Removal
  - Dissolved wastes are consumed as food by the activated sludge microbes and converted to biomass, water, carbon dioxide, and other gases
- Nitrification
  - The process through which ammonia is oxidized to nitrite and nitrate
- Denitrification
  - A process by which nitrates and nitrites are converted to gaseous end products, primarily nitrogen gas.

Activated Sludge Processes

Conventional – CBOD Removal

- Plug or Step Feed

Single-Stage Nitrification

Oxidation Ditch - Vertical Loop Reactor

Extended Aeration

MBR

BNR

Additional Processes

- Preliminary Treatment
  - Screening
  - Grit Removal
- Tertiary Treatment
  - Filters
- Solids Handling
- Recycle Flows

Design – Engineering Standards

- Design of Municipal Wastewater Treatment Plants WEF Manual of Practice No. 8

- Wastewater Engineering, Treatment , Disposal, Reuse

  Metcalf & Eddy

Design – Engineering Standards

Recommended Standards for Wastewater Facilities

Policies for the Design, Review, and Approval of Plans and Specifications for Wastewater Collection and Treatment Facilities

MEMBER STATES AND PROVINCE
Illinois Indiana Iowa Michigan Minnesota Missouri
New York Ohio Ontario Pennsylvania Wisconsin

Ten States Standards

Process Design

- Physical
  - Aeration Tank Capacity - lbs. CBOD/1000 CF of Aeration
  - Temperature – Summer/Winter
  - Final Settling – Circular Center Feed or Peripheral Feed

Process Design

- Chemical
  - Ammonia Loading - Nitrification
  - Phosphorous Loading & Removal
  - pH & Alkalinity

Process Design

- Biological
  - CBOD Loading – 15lbs – 40 lbs
  - D.O. in Aeration - 1.1 CBOD – 4.6 NH3
  - MLSS, MLVSS, RAS
  - F/M Ratio - 0.5 – 1.0 – 2.0
  - MCRT Days

Nitrification

NH_3 → NO_2^- → NO_3^-

- Nitrosomonas, Nitrobacter
- Aerobic process (in the presence of DO)
- 4.6 lbs O_2 required per lb ammonia-nitrogen
- 7.14 lb alkalinity is consumed per pound of ammonia nitrogen
- pH sensitive with optimal range between 7.5 and 8.6

Denitrification

- Anoxic process (not in the presence of DO)
- Nitrification can decrease pH
- Denitrification recovers 3.57 lb alkalinity per lb of nitrogen removed
- DO is consumed by nitrification and denitrification recovers 2.9 lb per lb of nitrogen removed

Plant Startup

- Contractor – Wants to push to startup
- What are Ohio EPA expectations?
- Manufacturer Checkout
- Operator Training – Are You Ready
- What additional processes are available
- Do you and your Engineer have a Process Control Plan
- Are you seeding the aeration tanks?

Plant Operation

- Summer/Winter
- Dry Weather/Wet Weather
- DO Control
- RAS Rate - % Of Influent Flow
- Chemical Feed
- Wasting Sludge – Biological & Chemical

Summer Verses Winter

Summer

- **MCRT** - 22.17 days
- **F/M Ratio** - 0.13
- **BOD Loading Rate** - 16.5 lbs./1,000 cf

- **Required MCRT No.2 -** 7.6 days
- **DT for BOD Oxidation** - 13.20 hours
- **DT for NH3 Oxidation** - 2.64 hours

- **Aeration Tanks Required** - 4.0

- **MLSS** - 3,000 mg/l
- **MLVSS** - 2,100 mg/l

Winter

- **MCRT** - 35.47 days
- **F/M Ratio** - 0.08
- **BOD Loading Rate** - 16.5 lbs./1,000 c.f.

- **Required MCRT No.2** - 13.7 days
- **DT for BOD Oxidation** - 13.15 hours
- **DT for NH3 Oxidation** = 2.71 hours

- **Aeration Tanks Required** - 4.0

- **MLSS** - 4,800 mg/l
- **MLVSS** - 3,360 mg/l

Plant Operation

- Summer/Winter
- Dry Weather/Wet Weather
- DO Control
- RAS Rate - % Of Influent Flow
- Chemical Feed
- Wasting Sludge – Biological & Chemical

Plant Monitoring

- Regular Rounds – Visual
- Aeration Tanks & FST
- Blowers/Aerators
- RAS Pumps
- Clarity of the Effluent

Plant Monitoring

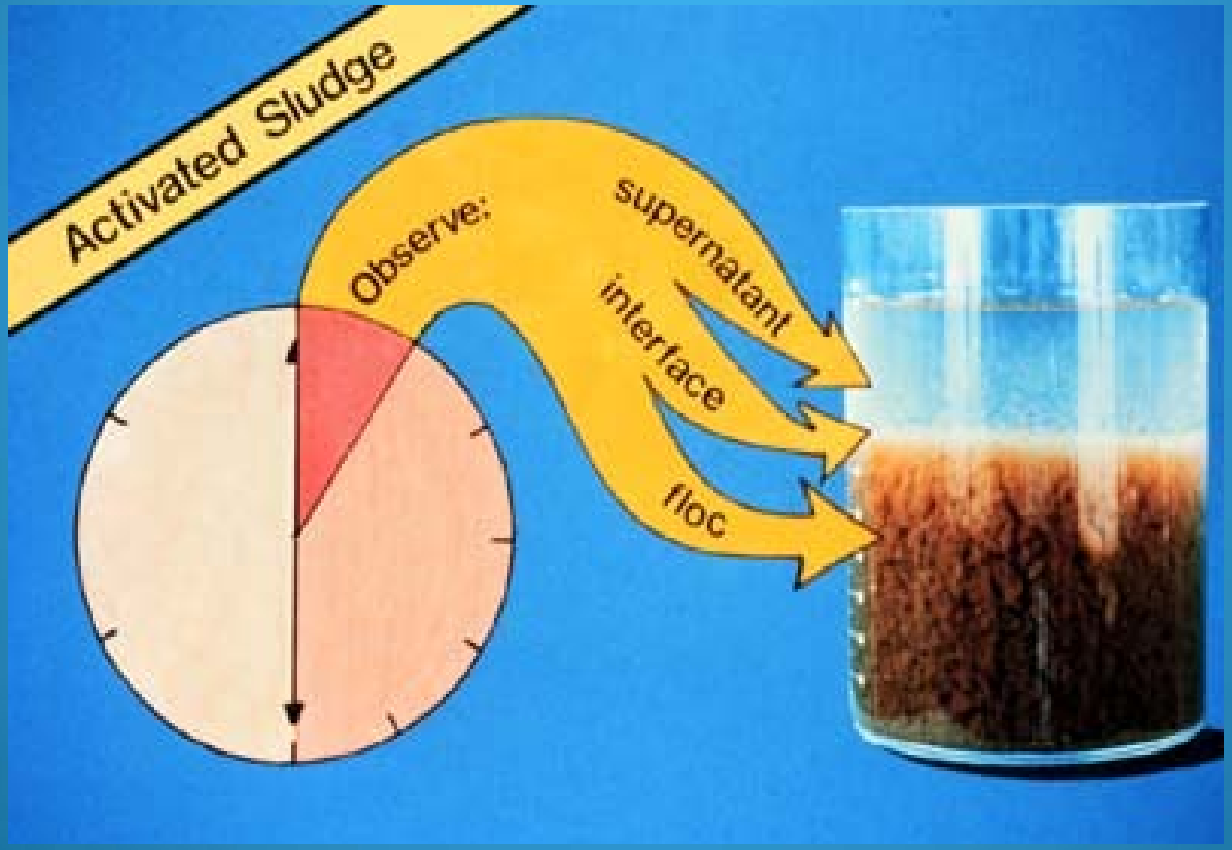
- SCADA – Trending Flow, DO, ORP, pH
- Regular Rounds – Visual
- Trending Instruments - Flow, DO, ORP, pH
- Lab Data – MLSS, RAS, Settling
- Microbiology

Troubleshooting

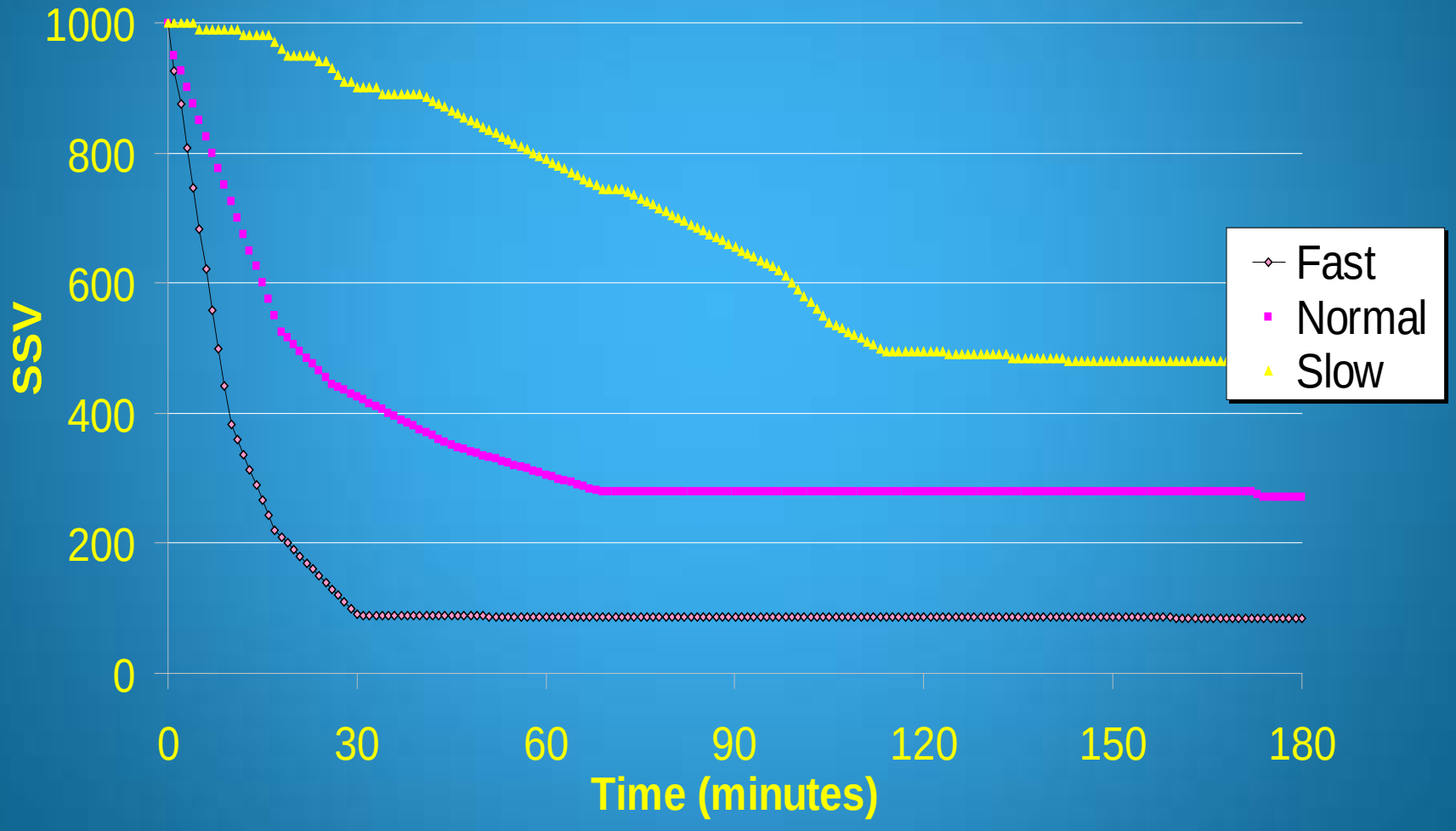
- Foaming
- Bulking
- Solids Loss
- Turbid Effluent
- Odor
- No CBOD or Ammonia Removal

Holy Crap!!

Observation of Settlometer Test

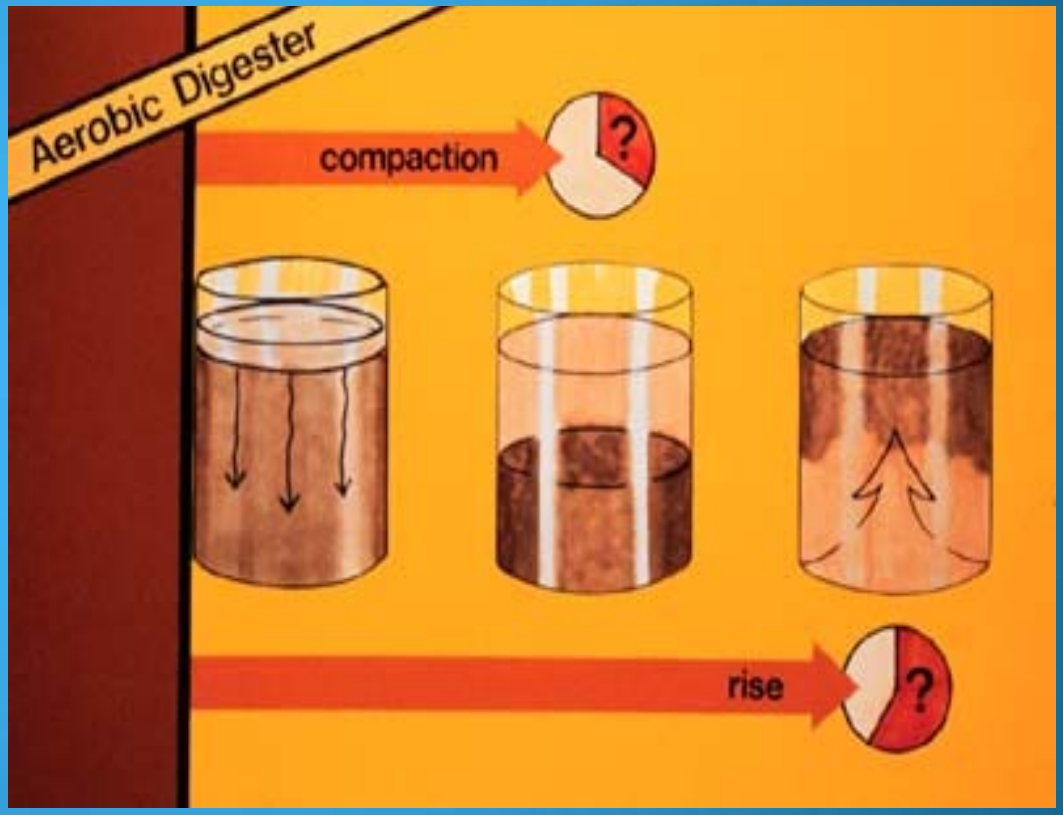


Characteristic Sludge Settling



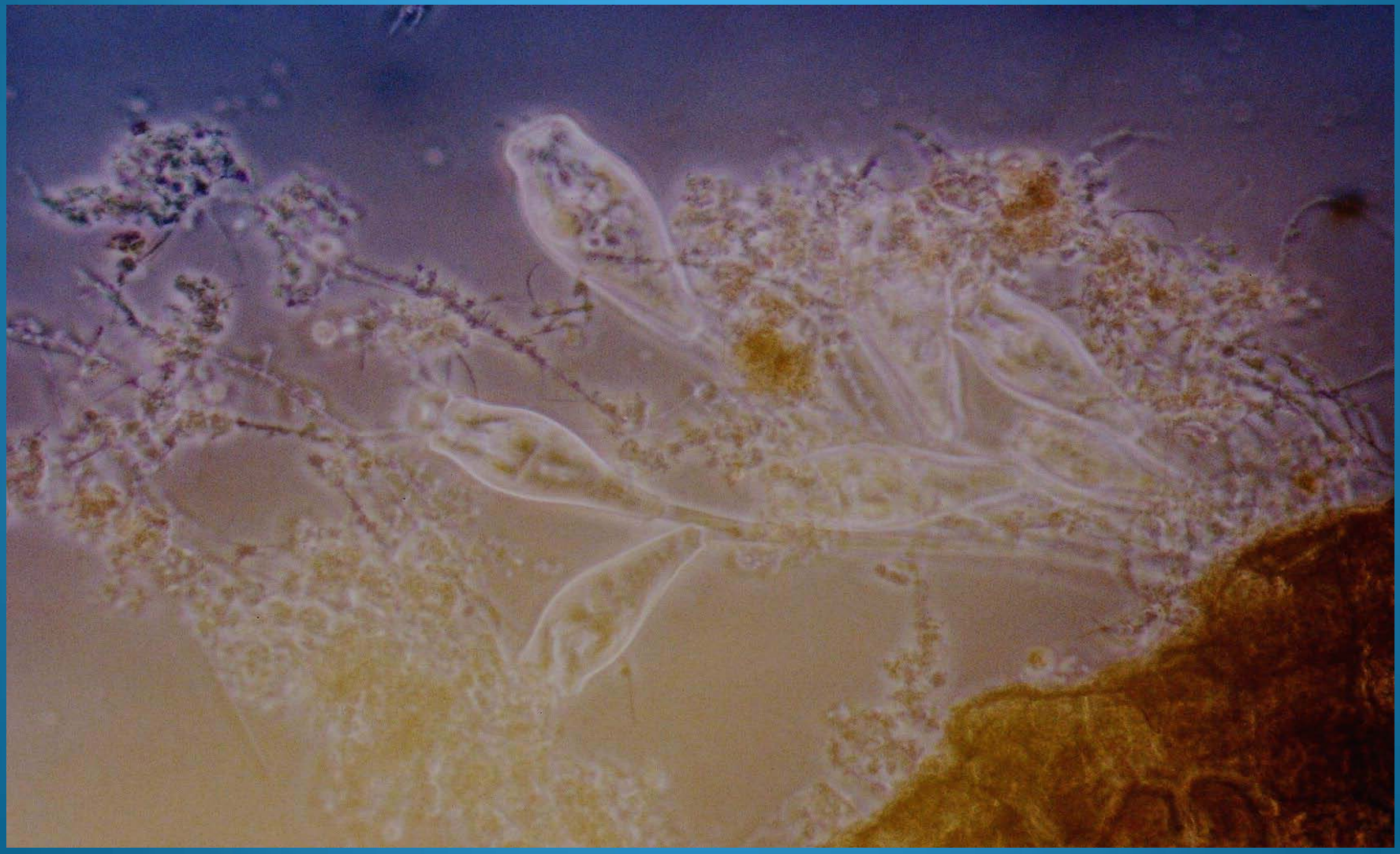
Length of Settleometer Test

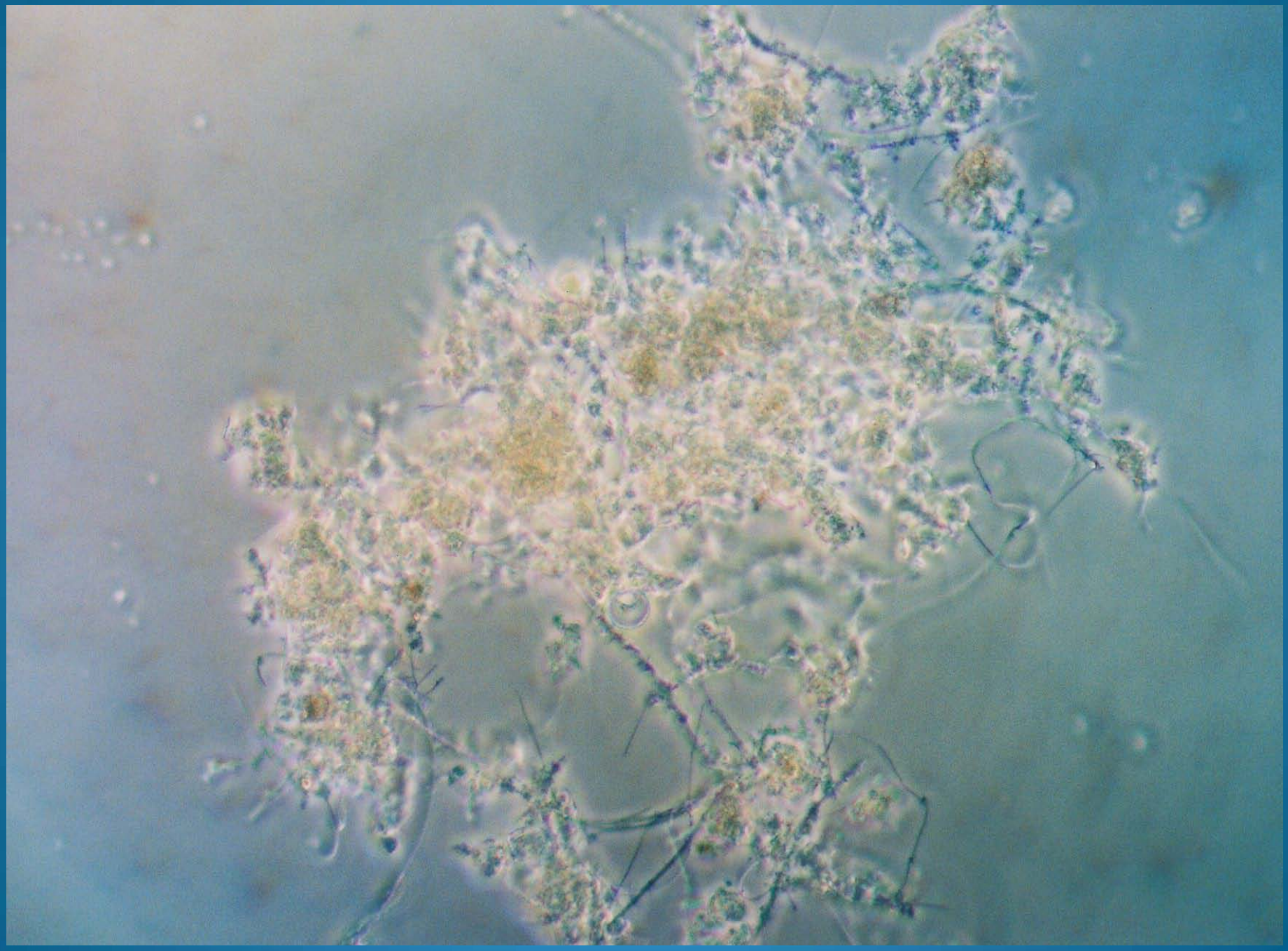
- Normal - 30 minutes to 2 hours - until complete compaction
- Extended - until the sludge begins to rise



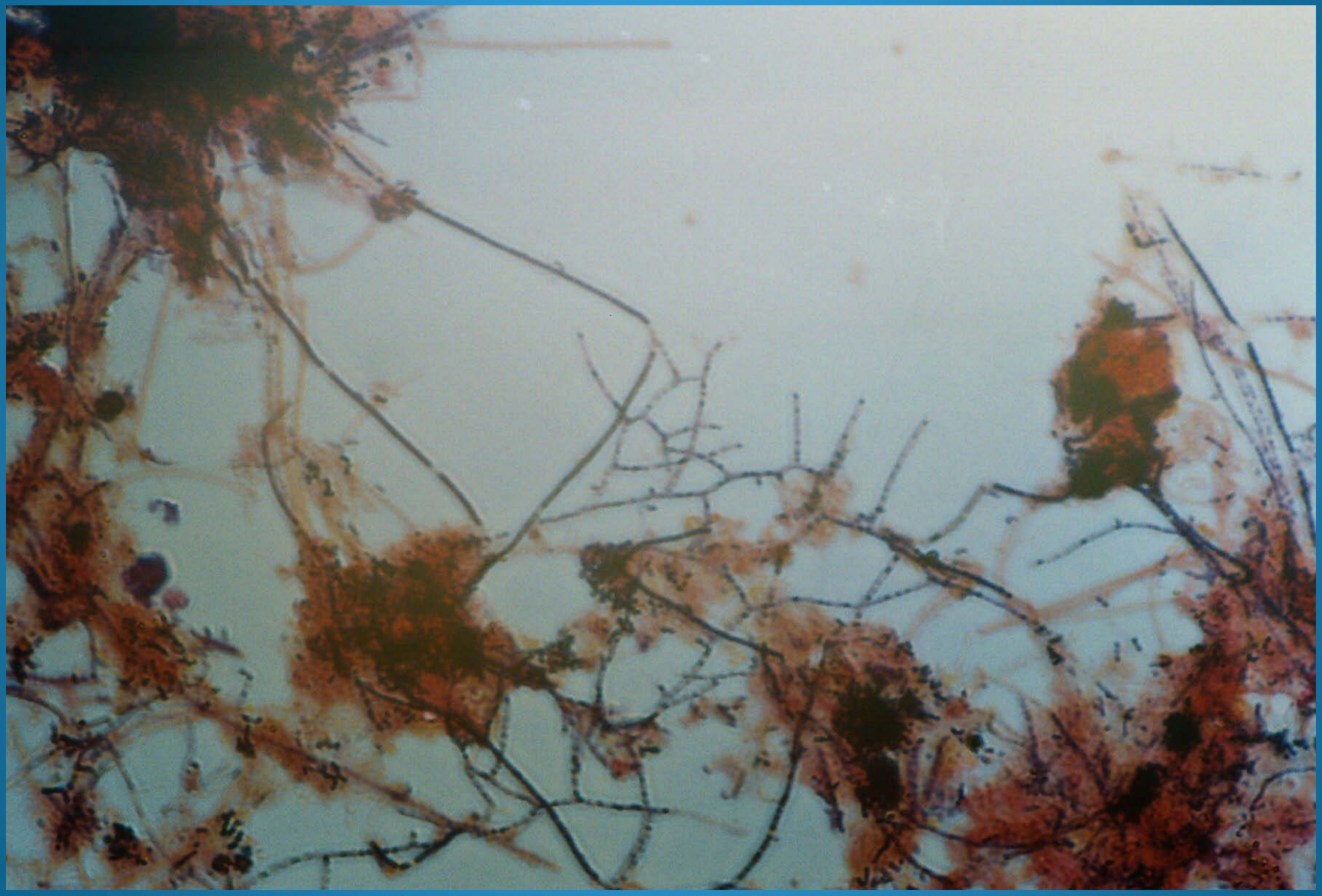
Look Under the Microscope

The Bugs - Good/Bad/Ugly

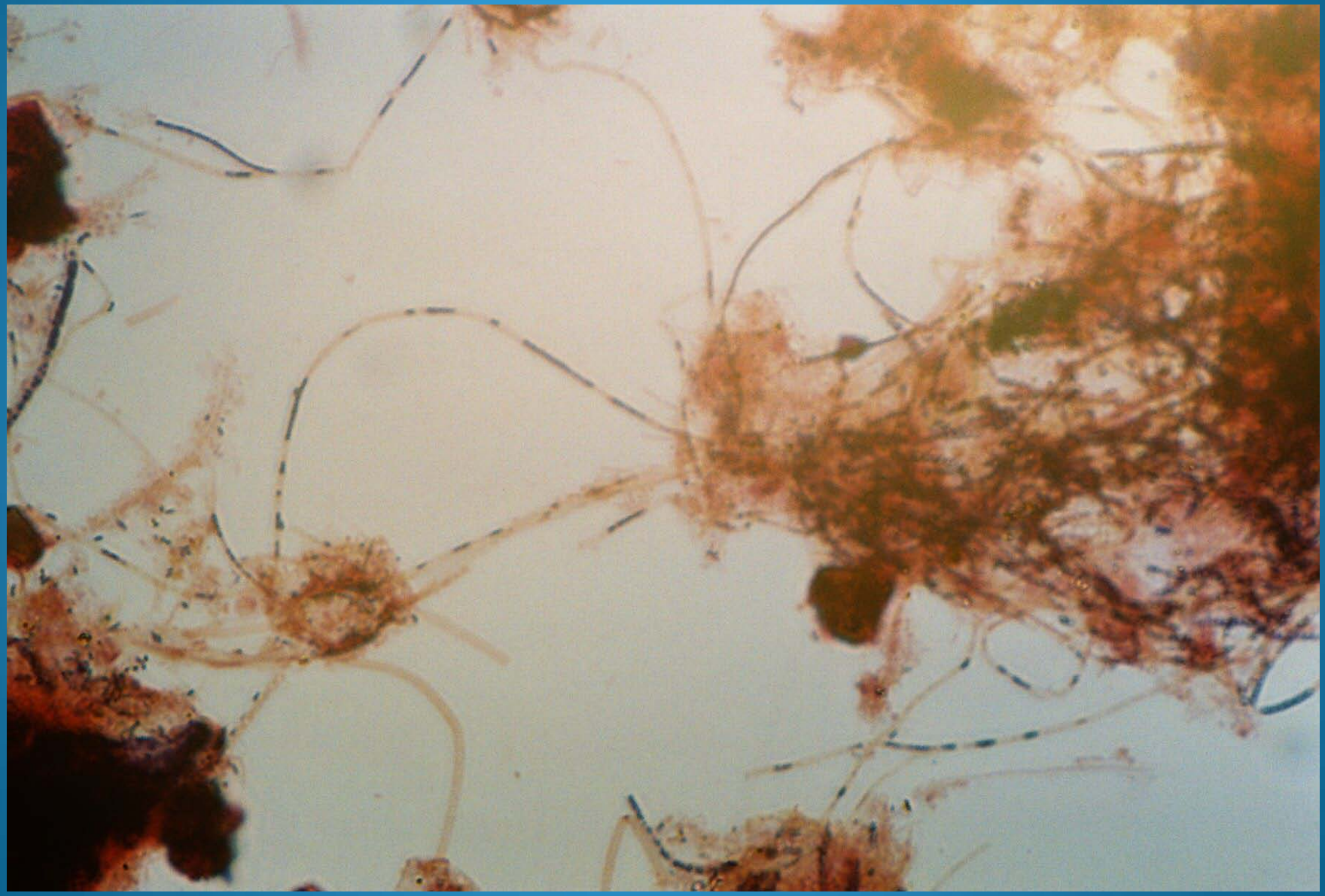




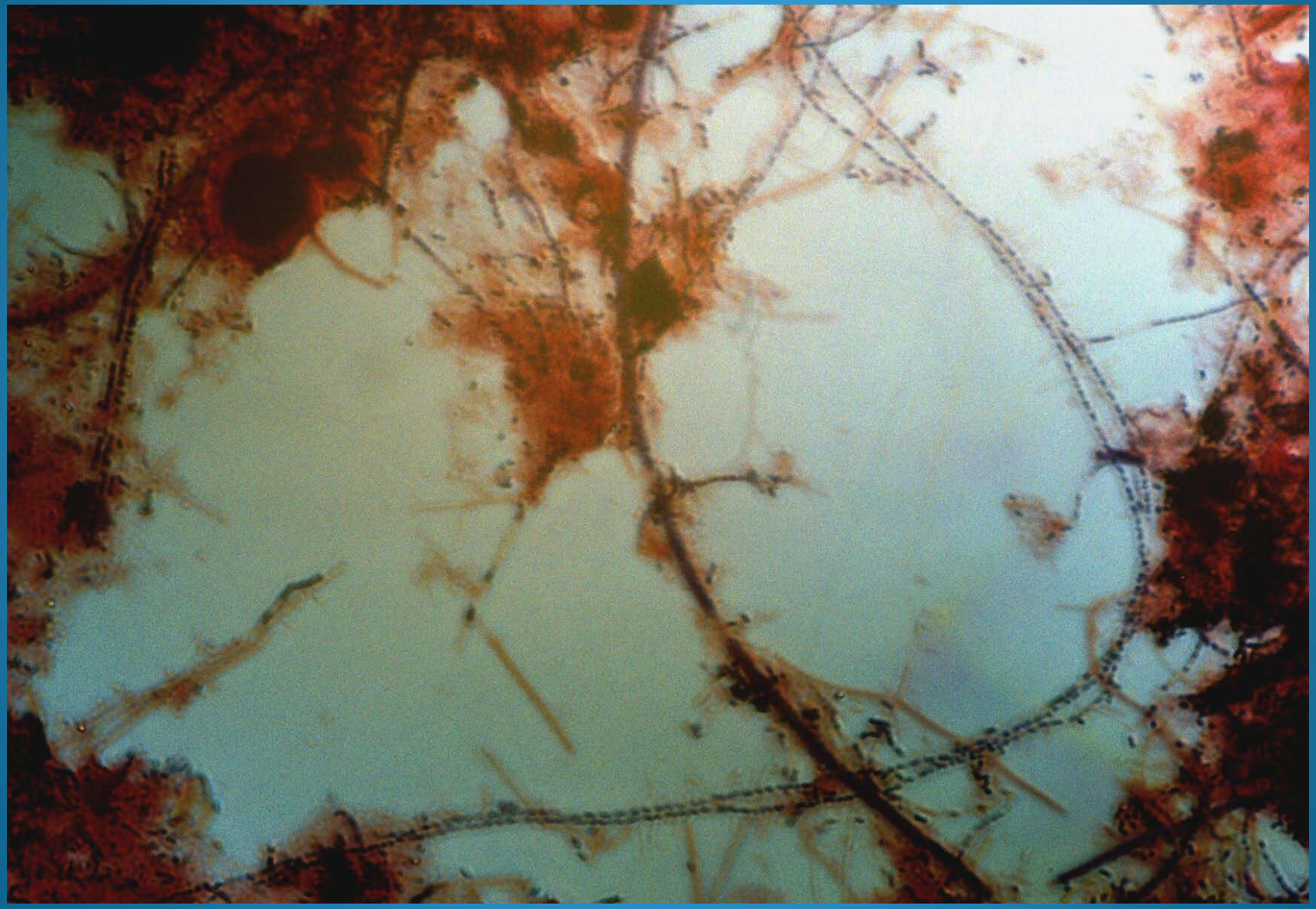
Nocardia



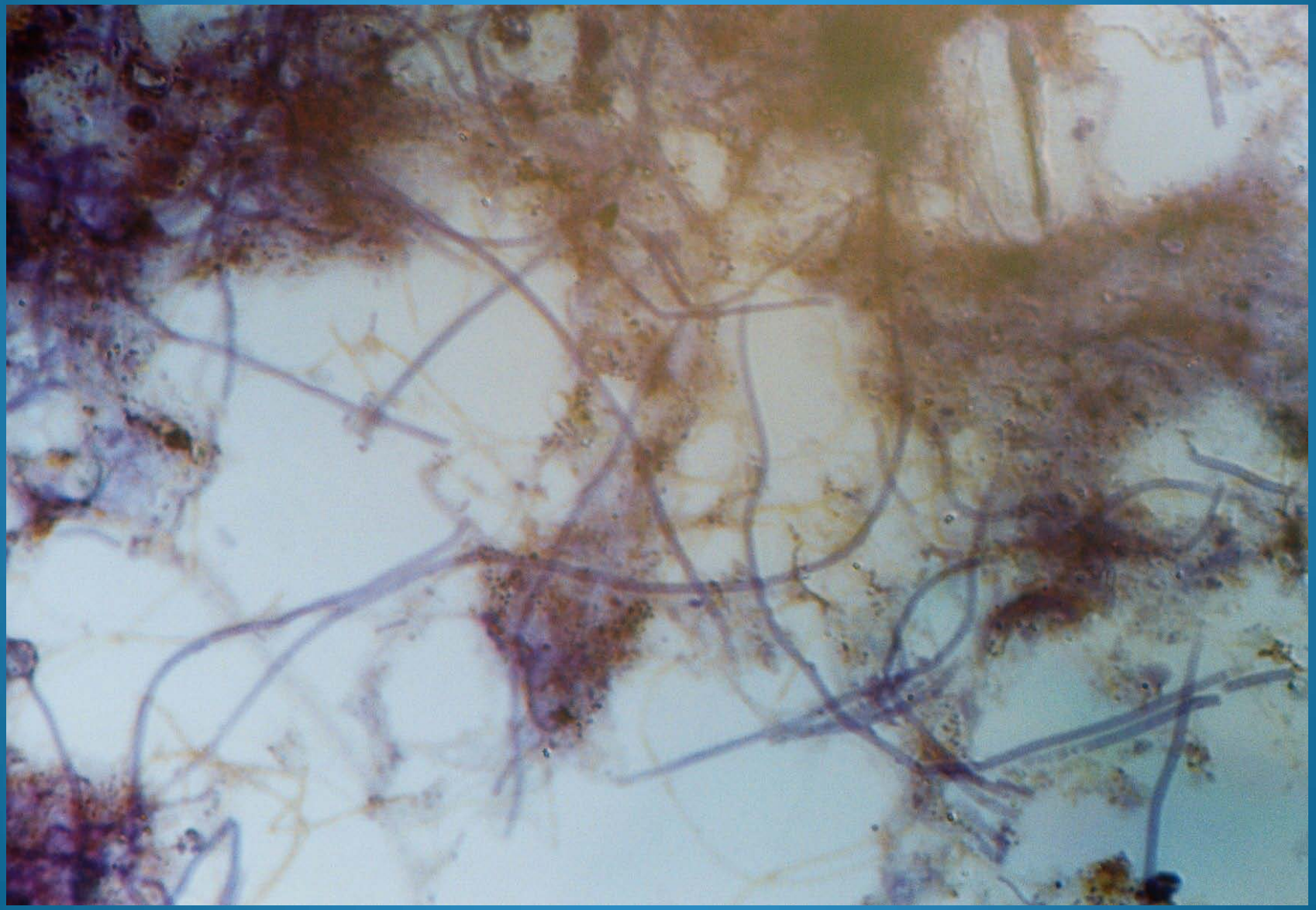
Microthrix parvicella



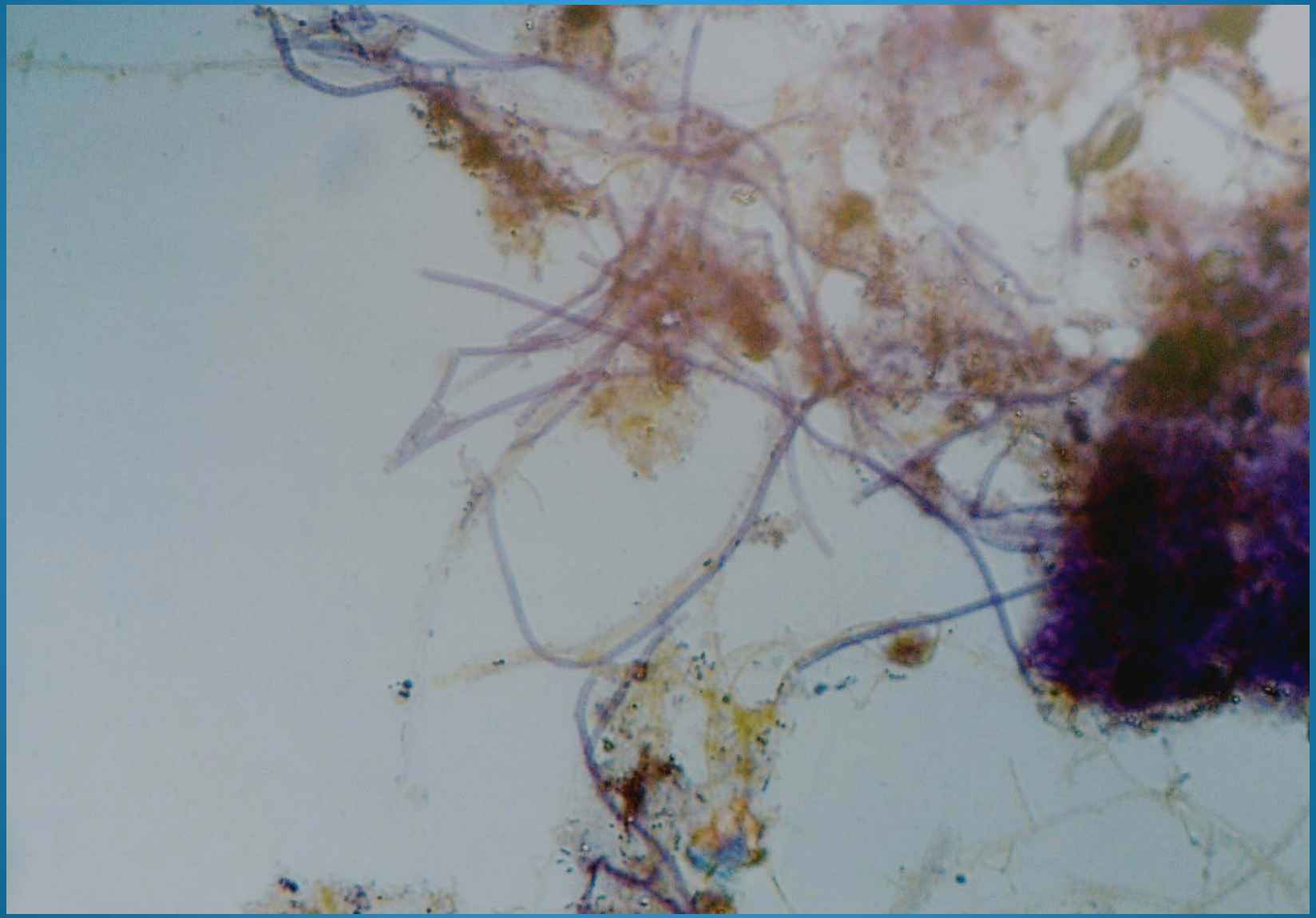
Filaments 1851 and 0041



Filament Type 0092



Filament type 0092



WWTP: WWTP

By: Phil Anderson - ARCADIS panderson@arcadis-us.com

Operation: Activated Sludge

Date: Summer 2009

MEAN CELL RESIDENCE TIME (MCRT)

INPUT DATA:

a	**2.827**	(MG) - Aeration tank volume (total)
b	**2,250**	(mg/l) - Mixed liquor VOLATILE suspended solids (MLVSS)
c	**0.033**	(MGD) - Daily flowrate of waste activated sludge (WAS) [See below]
d	**10,000**	(mg/l) - WAS suspended solids
e	**7.600**	(MGD) - Plant flow
f	**10**	(mg/l) - Effluent suspended solids

20.0 Influent Ammonia

3,000	MLSS, mg/l	
20.0	Degrees C	
7.1	pH	
5.0	D.O. Aeration	
1.7	Effluent Ammonia	
6	Aeration Tanks On Line	
0.471	Aeration Tank MG Each	

Summer Summary

MCRT	7.30 days
F/M Ratio	0.24
BOD Loading Rate	33.54 lbs./1,000 c.f.
Required MCRT No.1	3.61 days
Required MCRT No.2	3.93 days
DT for BOD Oxidation	6.02 hours
DT for NH3 Oxidation	1.49 hours
Aeration Tank Vol Required	2.38 MG
Aeration Tanks Required	5.05
Aeration Tanks On Line	6.00
MLSS	3,000 mg/l
MLVSS	2,250 mg/l
Nitrifiers (8% of MLVSS)	180 mg/l

SUPPLEMENTAL CALCULATIONS (MLVSS):

a	**3,000**	(mg/l) Assumed mixed liquor suspended solids (MLSS)
b	**75.0**	(%) - Assumed percent volatile
	2,250	(mg/l) - MLVSS

EFF LIMIT
CBOD Weekly 15 mg/l
TSS Weekly 18 mg/l
Fecal Weekly 2,000 (S Only)
Ammonia WK 1.7 mg/l (S Only)
Ammonia Winter WK NA
P Weekly 1.5 mg/l

WASTE SLUDGE VOLUME:

a	**0.70**	Assumed sludge yield (lb. SS generated/lb. BOD removed)
b	**7.600**	(MGD) - Plant flow
c	**200**	(mg/l) - BOD concentration entering aeration tanks
d	**10**	(mg/l) - BOD concentration following settling
e	**8,430**	lbs. biological sludge/day
f	**10.0**	(mg/l) - chemical sludges produced
h	**634**	lbs. chemical (Fe/AL) sludge generated/day
i	**9,064**	Total lbs. WAS/day
j	**10,000**	(mg/l) - Assumed WAS concentration (Note: 10,000 mg/l = 1.0%)
k	**0.109**	(MGD) - Waste activated sludge quantity

MCRT **7.30** days

F/M Ratio = **0.24**

BOD Loading Rate = **33.5** lbs./1,000 c.f.

WWTP: WWTP

Phil Anderson - ARCADIS
By: panderson@arcadis-us.com

Operation: Activated Sludge

Date: Winter

MEAN CELL RESIDENCE TIME (MCRT)

			4,500	MLSS, mg/l	
			11.0	Degrees C	
			7.0	pH	
			4.0	D.O. Aeration	
		20.0	Influent Ammonia	4.0	Effluent Ammonia
				6	Aeration Tanks On Line
				0.471	Aeration Tank MG Each

INPUT DATA:

a	2.827	(MG) - Aeration tank volume (total)
b	3,375	(mg/l) - Mixed liquor VOLATILE suspended solids (MLVSS)
c	0.109	(MGD) - Daily flowrate of waste activated sludge (WAS) [See below]
d	10,000	(mg/l) - WAS suspended solids
e	7.600	(MGD) - Plant flow
f	10	(mg/l) - Effluent suspended solids

Winter Summary

MCRT	10.95 days
F/M Ratio	0.16
BOD Loading Rate	33.54 lbs./1,000 c.f.
Required MCRT No.1	12.00 days
Required MCRT No.2	8.66 days
DT for BOD Oxidation	10.96 hours
DT for NH3 Oxidation	2.13 hours
Aeration Tank Vol Required	3.47 MG
Aeration Tanks Required	7.36
Aeration Tanks On Line	6.00
MLSS	4,500 mg/l
MLVSS	3,375 mg/l
Nitrifiers (8% of MLVSS)	270 mg/l

SUPPLEMENTAL CALCULATIONS (MLVSS):

a	4,500	(mg/l) Assumed mixed liquor suspended solids (MLSS)
b	75.0	(%) - Assumed percent volatile
	3,375	(mg/l) - MLVSS

EFFLUENT LIMITS

CBOD Weekly 15 mg/l

TSS Weekly 18 mg/l

Fecal Weekly 2,000 (S Only)

Ammonia WK 1.7 mg/l (S Only)

Ammonia Winter WK NA

P Weekly 1.5 mg/l

WASTE SLUDGE VOLUME:

a	0.70	Assumed sludge yield (lb. SS generated/lb. BOD removed)
b	7.600	(MGD) - Plant flow
c	200	(mg/l) - BOD concentration entering aeration tanks
d	10	(mg/l) - BOD concentration following settling
e	8,430	lbs. biological sludge/day
f	10.0	(mg/l) - chemical sludges produced
h	634	lbs. chemical (Fe/AL) sludge generated/day
i	9,064	Total lbs. WAS/day
j	10,000	(mg/l) - Assumed WAS concentration (Note: 10,000 mg/l = 1.0%)
k	0.109	(MGD) - Waste activated sludge quantity

MCRT **10.95** days

F/M Ratio = **0.16**

BOD Loading Rate = **33.5** lbs./1,000 c.f.

Figure 1 Effect of MCRT On Nitrification

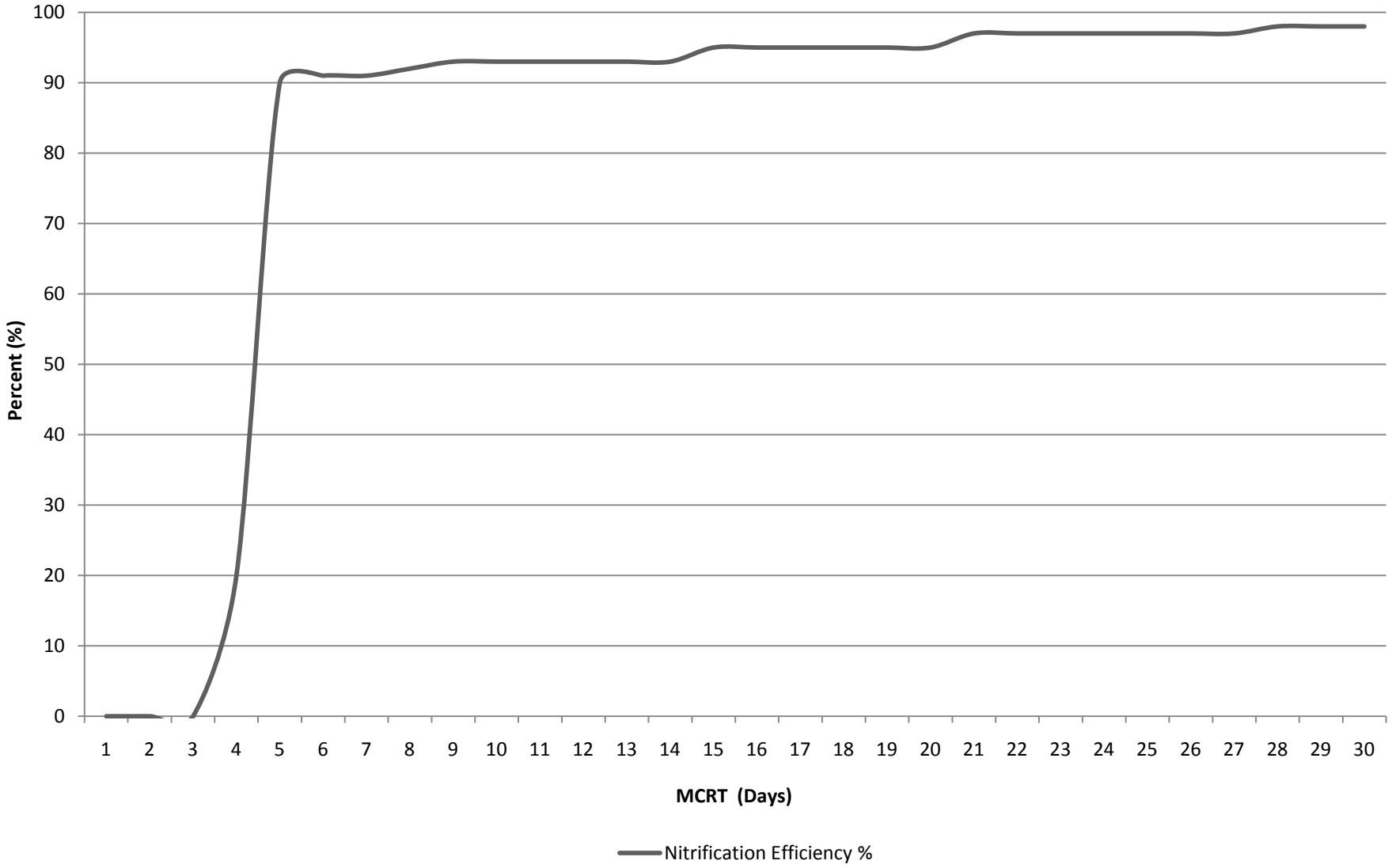


Figure 2 Relationship Between MCRT and F/M Ratio

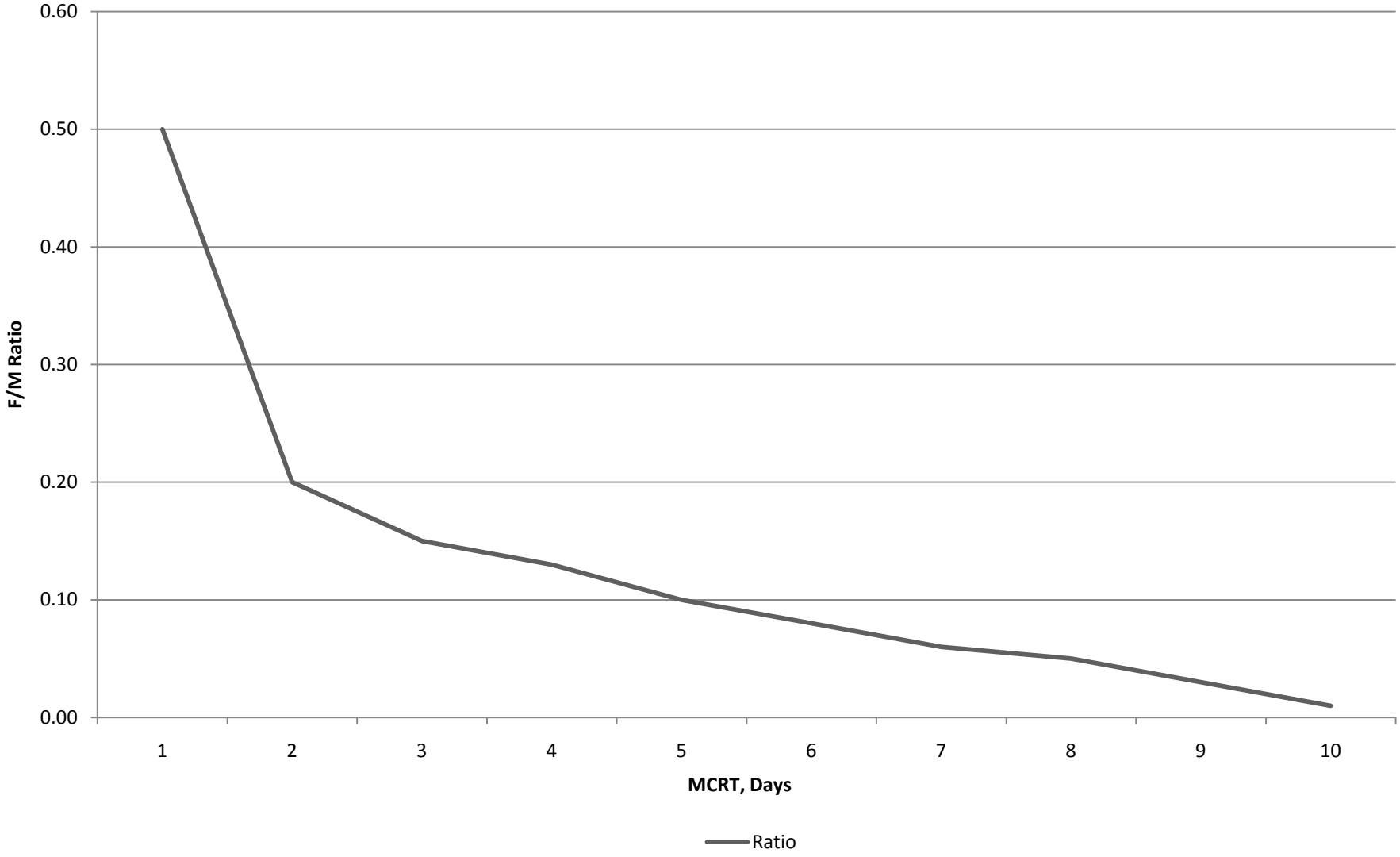


Figure 3 Ammonia Removal vs Time

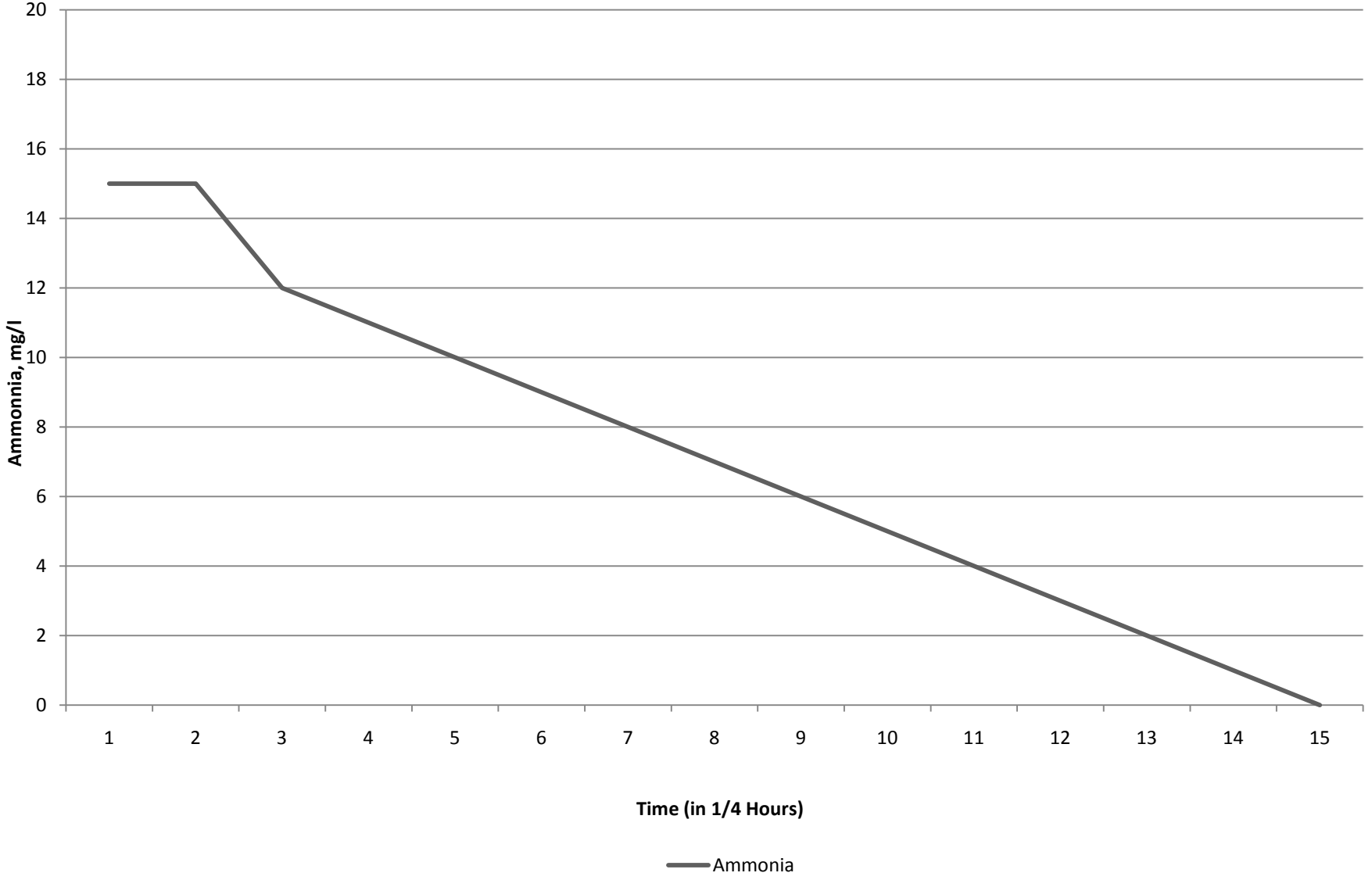


Figure 4 Effect of Temperature On Nitrification

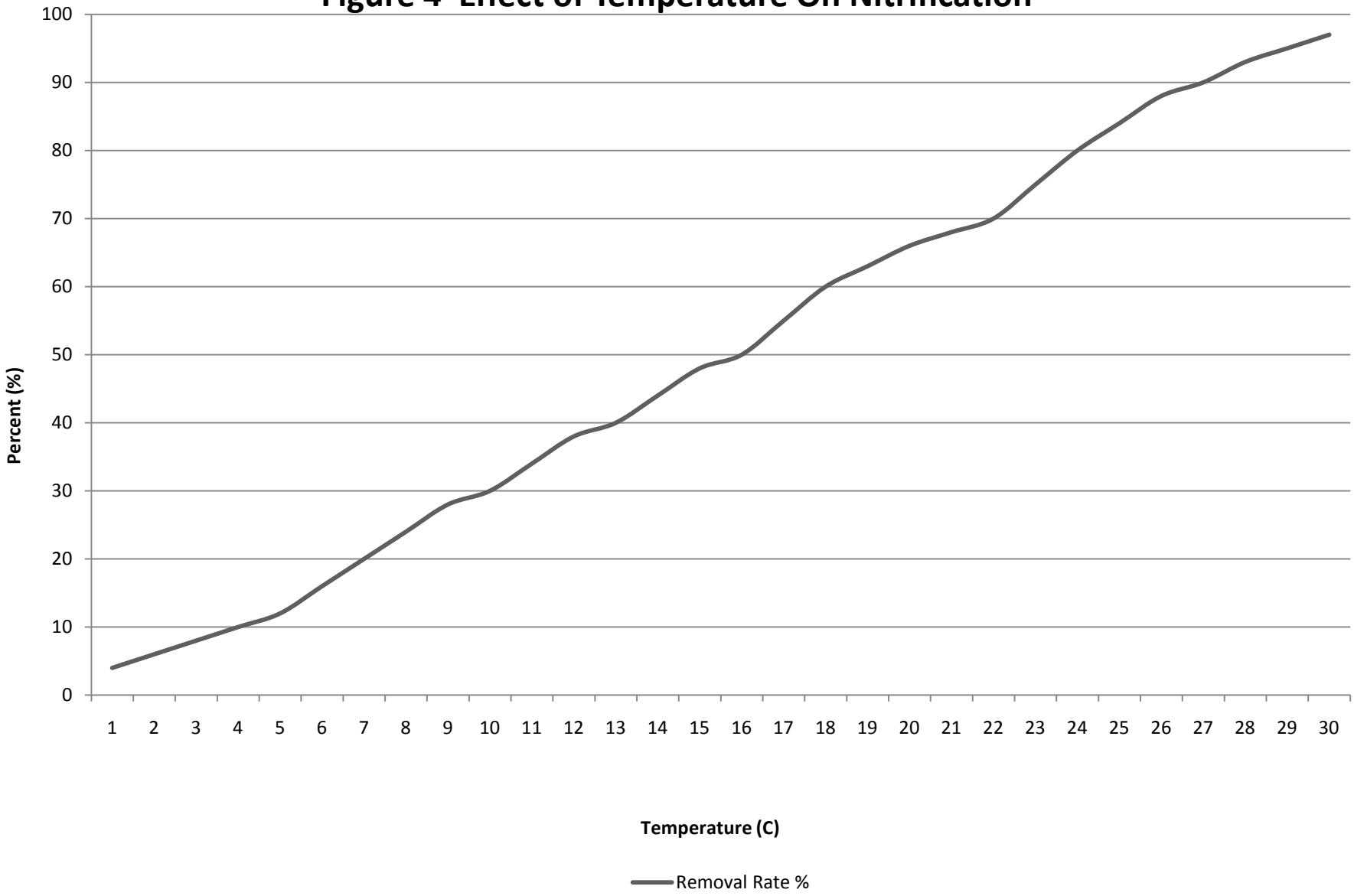


Figure 5 Effect of D.O. on Nitrification

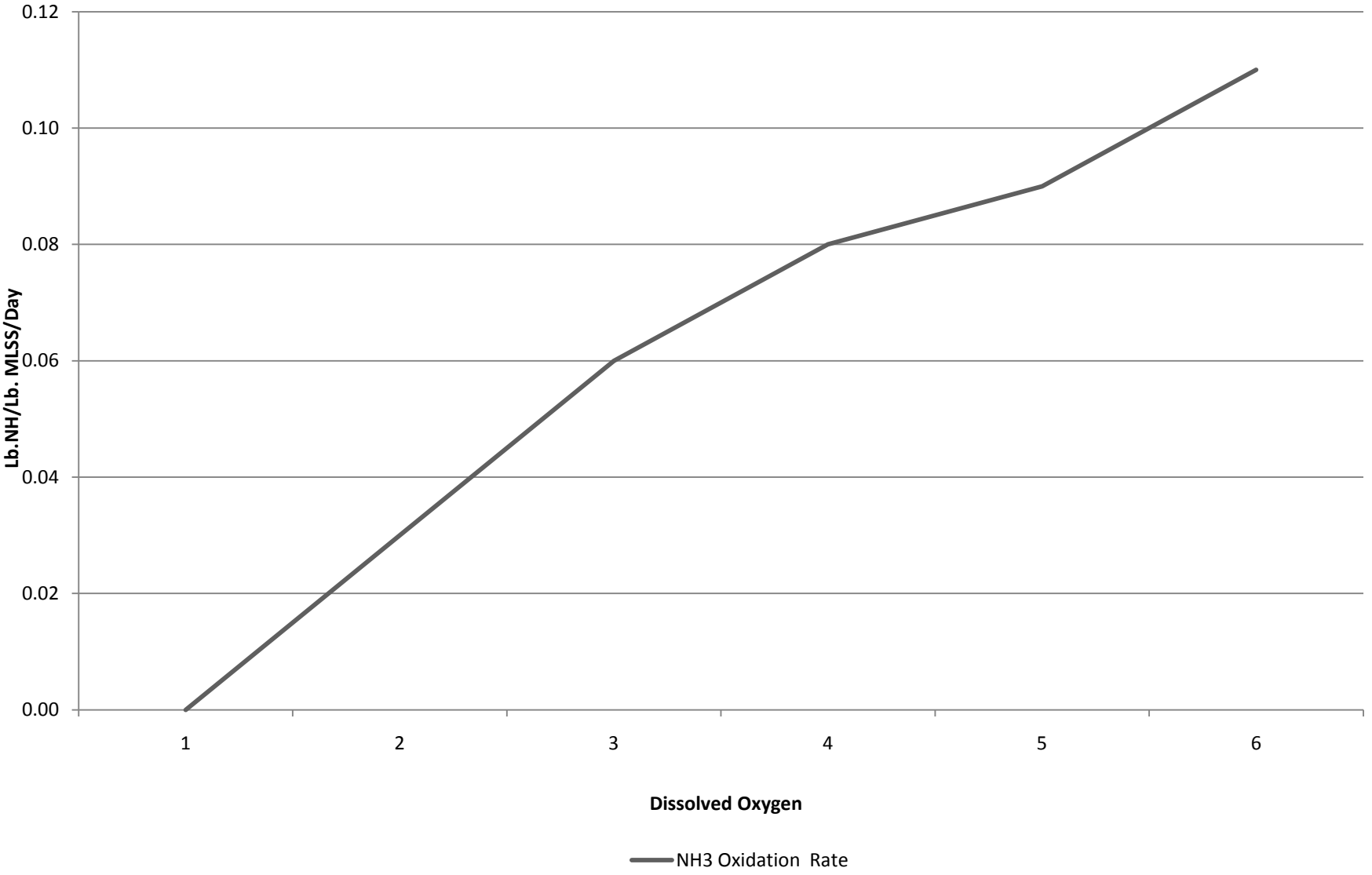


Figure 6 Effect of pH on Nitrification

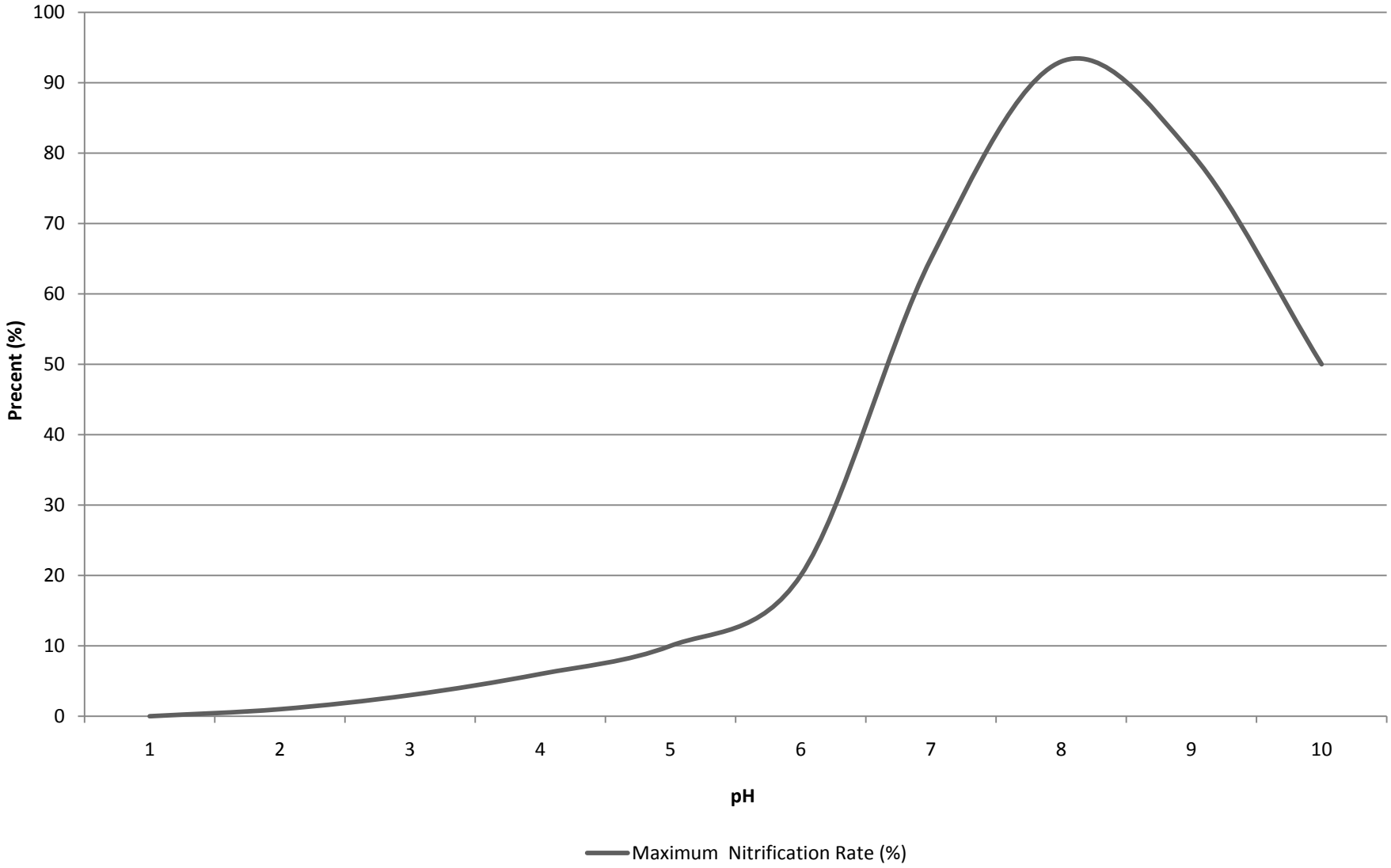
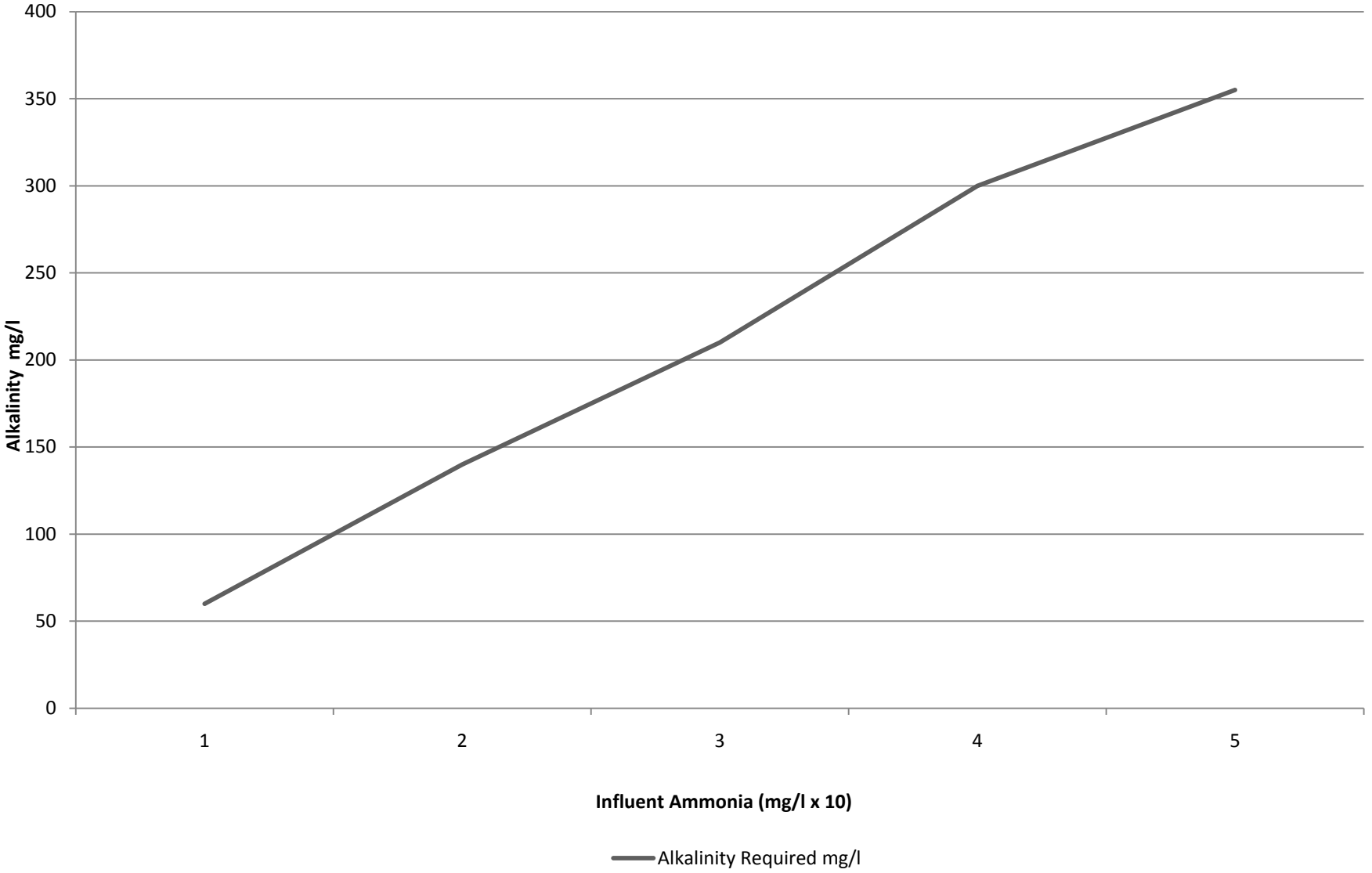


Figure 7 Alkalinity Used in Nitrification



Maumee River WWTP

DO Probe

Single Stage Blower

Center Feed FST

Center Feed FST

Peripheral Feed FST

Peripheral Feed FST

Center Feed FST

QUESTIONS???

PHIL.ANDERSON@ARCADIS-US.COM

Imagine the result