



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

AquaNereda® Aerobic Granular Sludge System





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

The Partnership and Our Progress



Aqua-Aerobic Systems, Inc.

Loves Park, IL



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- Founded in 1969
- 150 Employees (Office and Manufacturing)
- Applied Engineering Focus
- > 10% of Profits Back to R&D
- Manufacture Key Components
- > 45 Patented Products and Processes





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Profile Royal HaskoningDHV

- Independent international engineering and consultancy
- 6,500 team members in 150 countries
- Top 50 independently owned engineering companies





Aqua-Aerobic is the U.S. Licensee



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

27 Sep 2016

Royal HaskoningDHV's Nereda technology is entering the United States

Aqua-Aerobic Systems, Inc. becomes exclusive provider

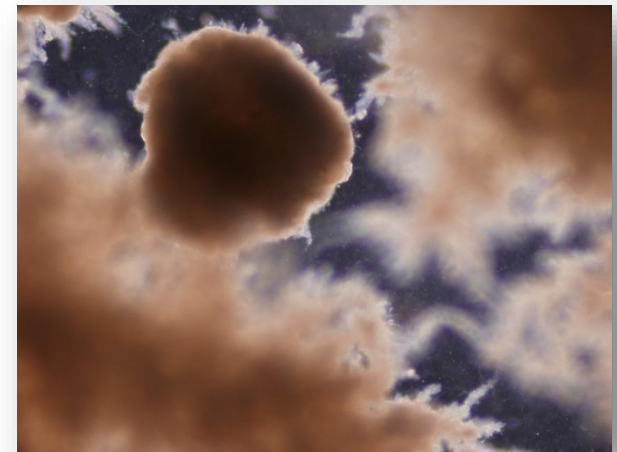
Aqua-Aerobic Systems, Inc. and Royal HaskoningDHV signed an agreement that confirms Aqua-Aerobic Systems will become the exclusive provider of the Nereda® granular biomass wastewater treatment system in the United States market.



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Short History of Granules

- Prior to 1914: Biofilms
- 1914: Activated sludge flocs
- 1970's: Anaerobic granules
- 1990's: Aerobic granules – RHDHV begins research
- 2005: Construction of first full scale plant (industrial)
- 2009: First full-scale plant (municipal)
- 2016: Aqua Aerobic signs licensee agreement
- 2017: Aqua starts construction of first US demonstration plant (municipal)



Aerobic Granular Sludge

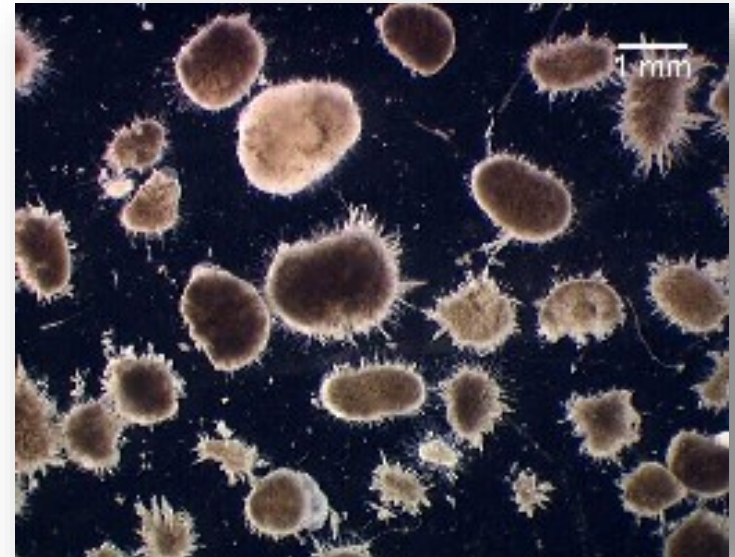
Definition



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

“Granules making up aerobic granular activated sludge are to be understood as aggregates of microbial origin, which do not coagulate under reduced hydrodynamic shear, and which subsequently settle significantly faster than activated sludge flocs.”

- True microbial biomass
- Minimum particle diameter of ~ 0.2 mm
- AGS SVI5 is comparable to SVI30 of typical activated sludge

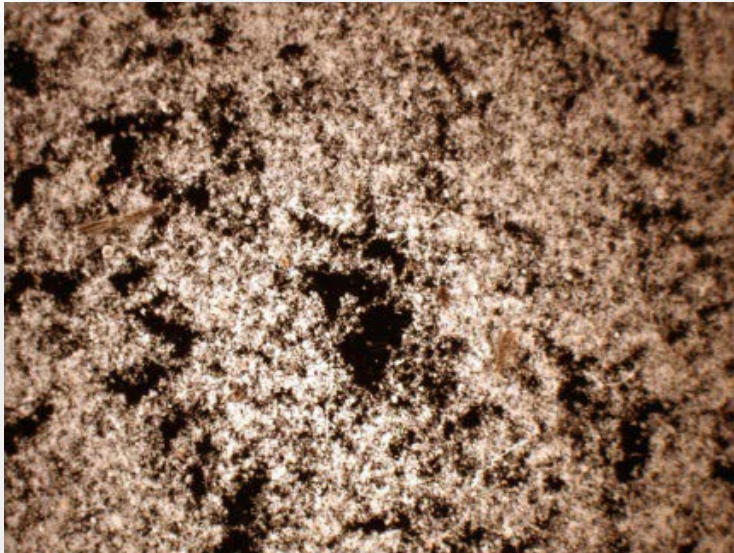




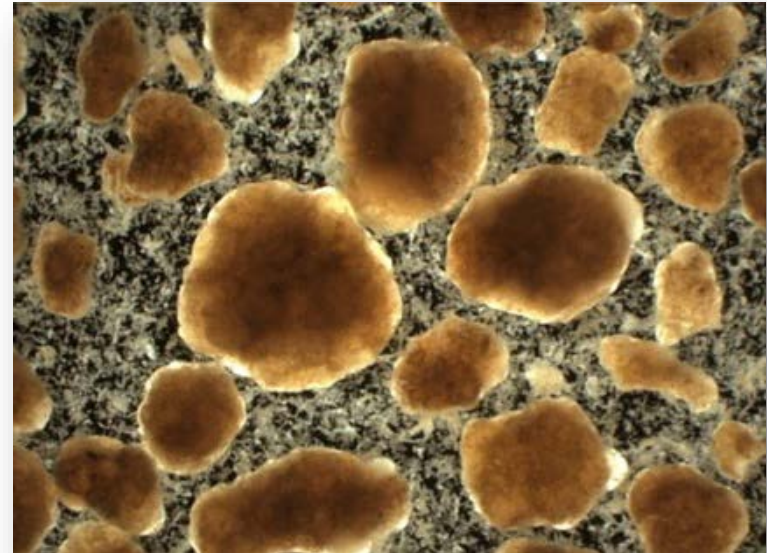
AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Aerobic Granular Sludge

Conventional Activated Sludge vs. Granule Structure



Conventional Activated Sludge



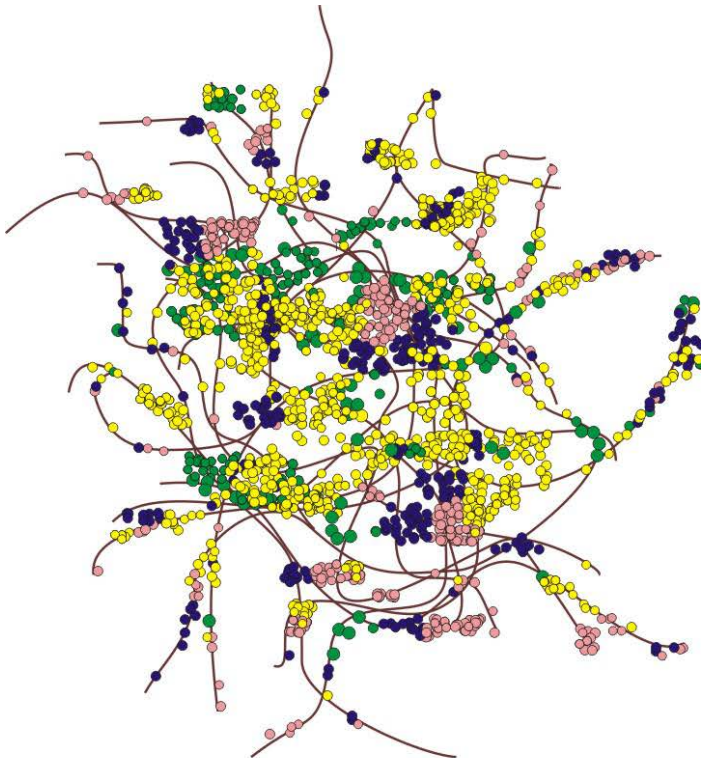
Aerobic Granular Sludge



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

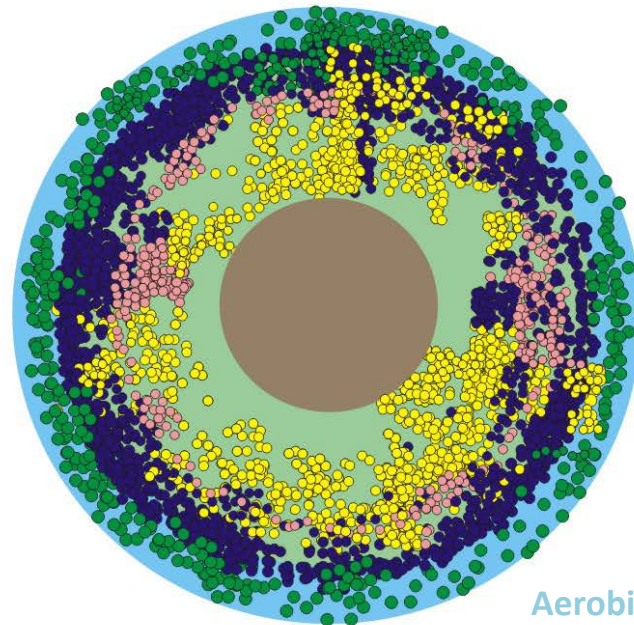
Aerobic Granular Sludge

Granule Structure



PAO
Denitrifiers
Nitrifiers
GAO

Conventional Activated Sludge
Mixed Microbial Community



Aerobic
Anoxic
Anaerobic

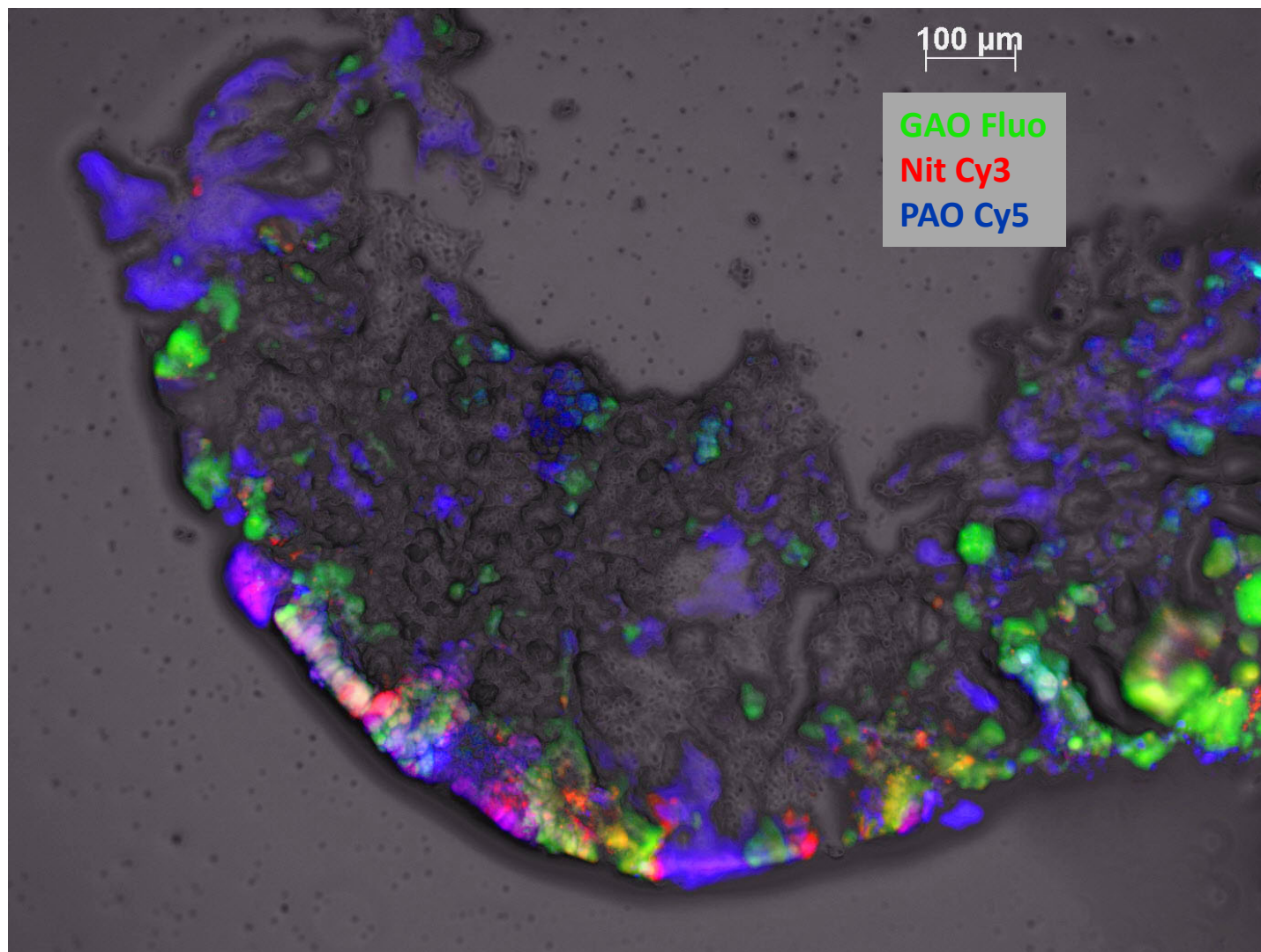
Aerobic Granular Sludge
Layered Microbial Community

Fish Analysis

Fluorescence In Situ Hybridization



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



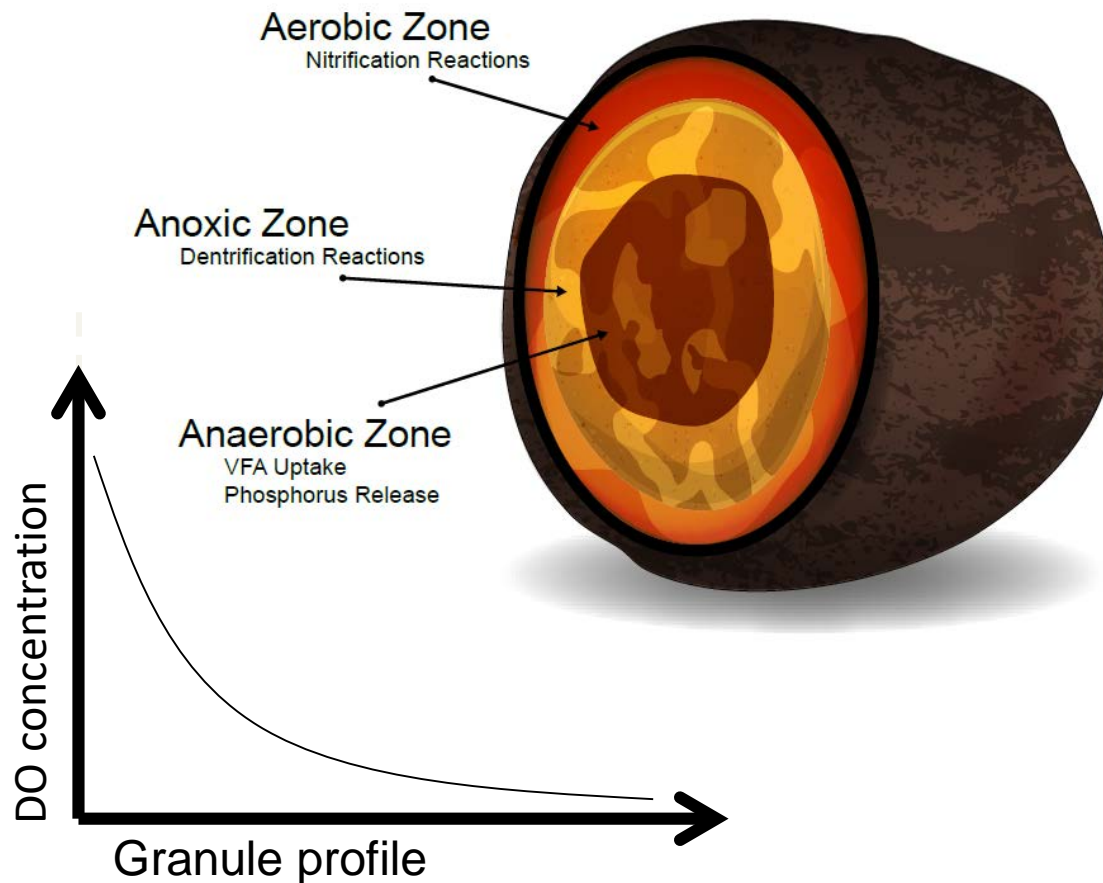
Aerobic Granular Sludge

Granule Structure



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Nereda® Granule



Aerobic Granular Sludge



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- Excellent Settling Properties
- Increased MLSS



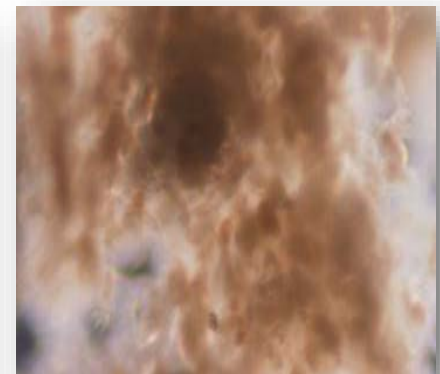
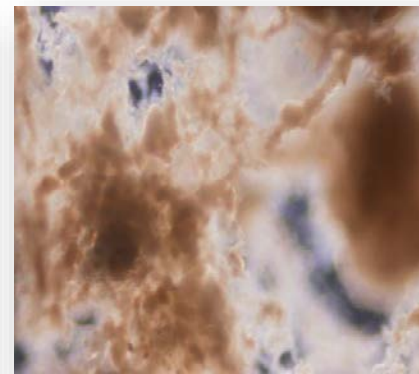
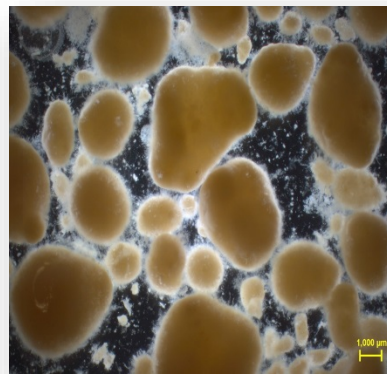
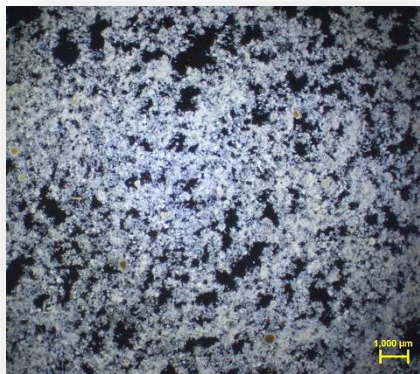
Granule Formation

Selection Mechanisms



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- 1) Hydraulic selection for fast settling particles
- 2) Biology selection of EPS forming microorganisms





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

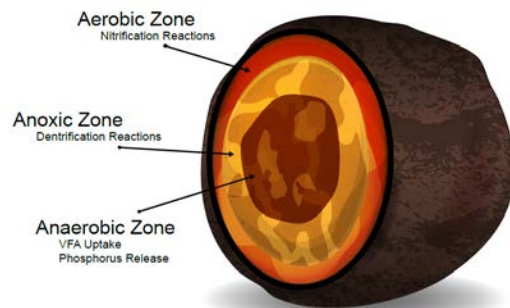
Operational Description

AquaNereda® Process



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

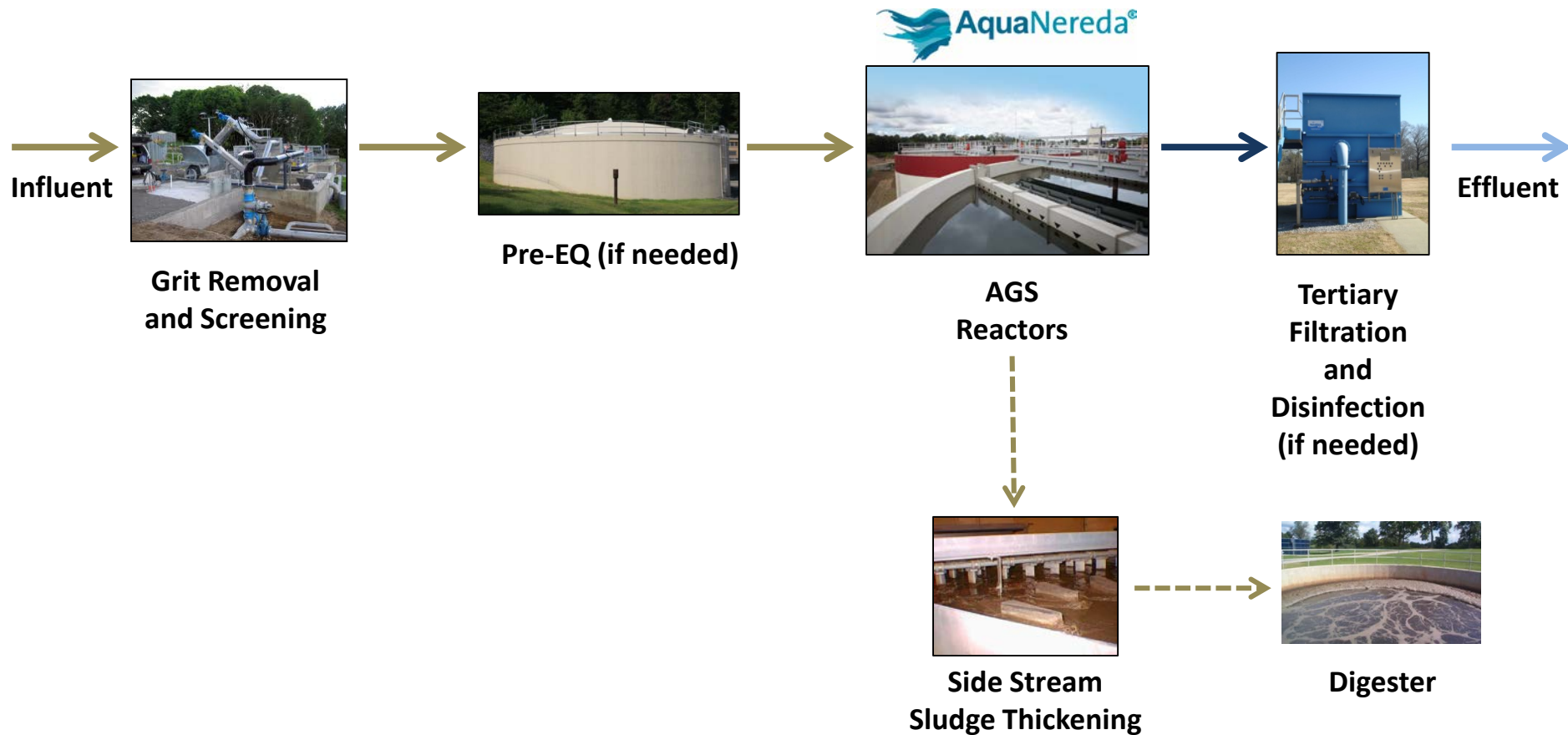
- Simple one-tank reactor concept
- No secondary clarifiers
- Timed cycle flexibility
- Enhanced biological nutrient removal
- No sludge recirculation



AquaNereda® Process Flow



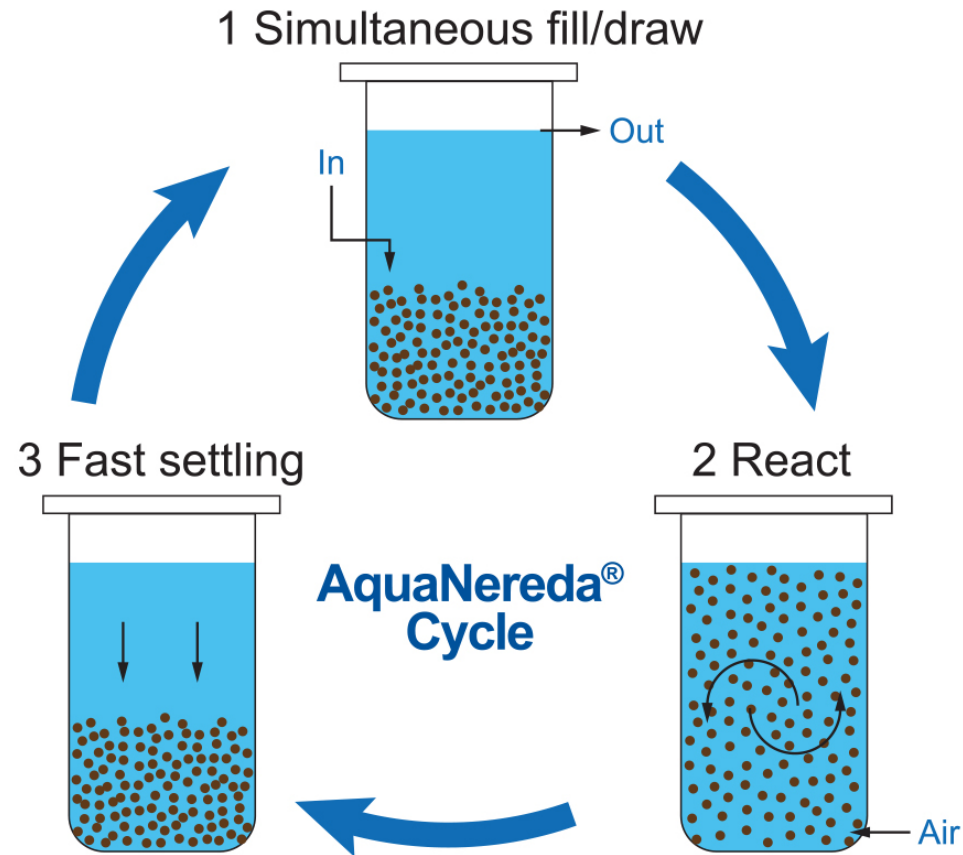
AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



AquaNereda® Process Cycle



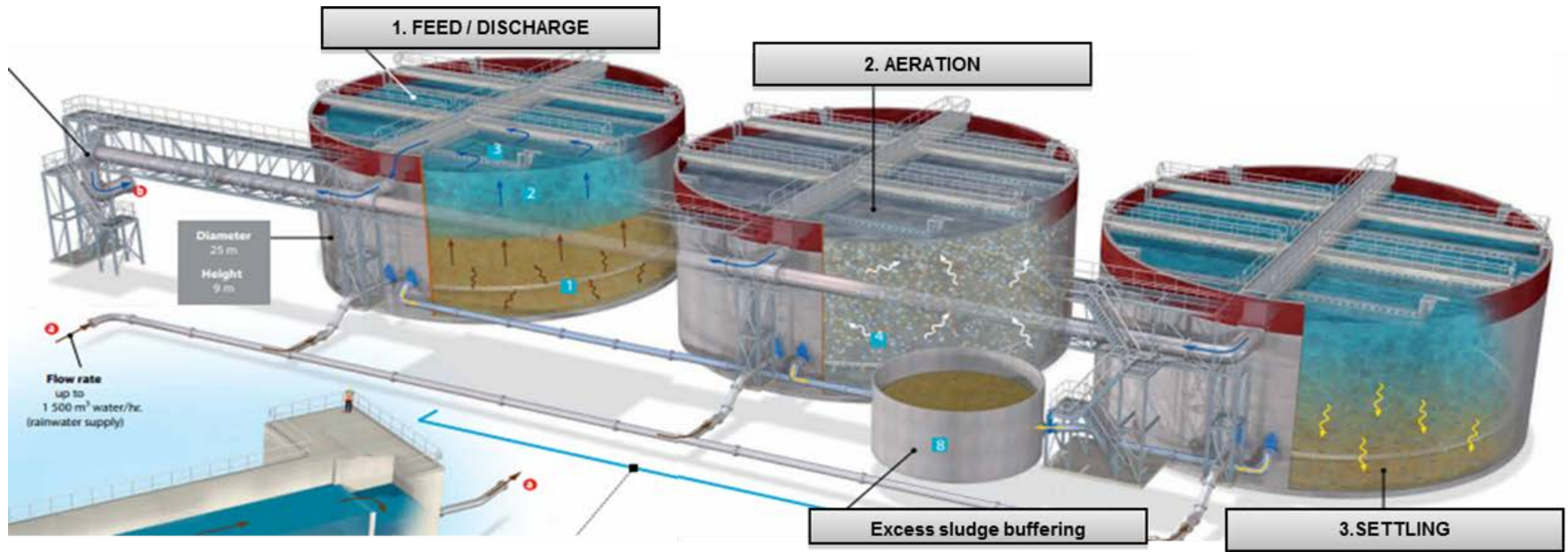
AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



AquaNereda® Process



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

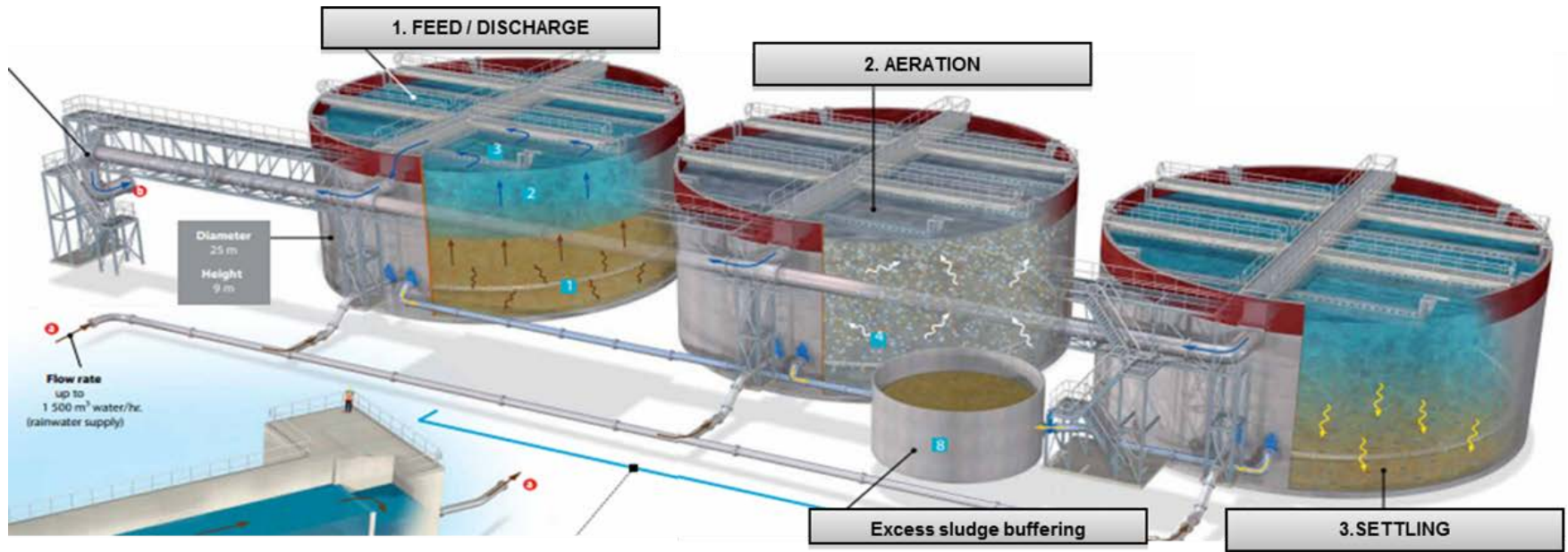


Three reactor design, allowing one reactor to always be in fill stage

AquaNereda® Process



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



Three reactor design, allowing one reactor to always be in fill stage

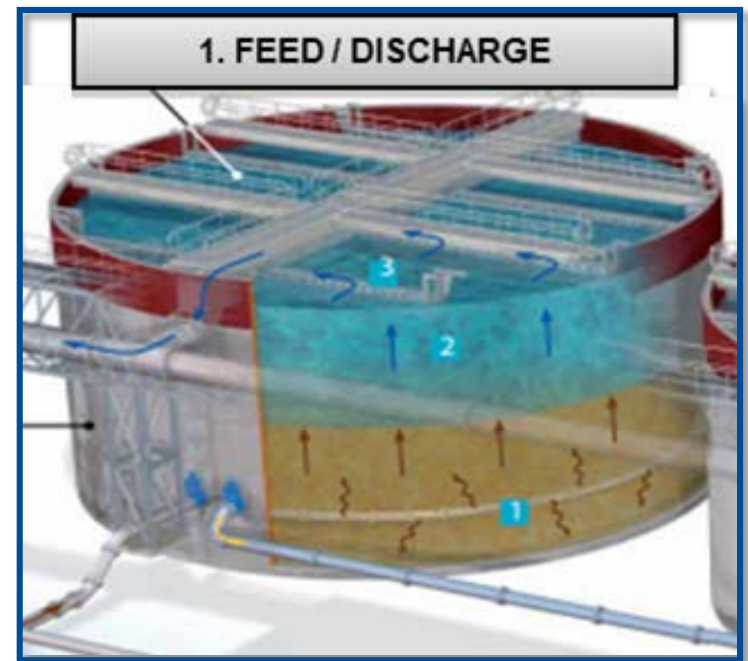
AquaNereda® Process Cycle



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Fill/Draw

- Influent enters
- Readily Available Carbon
- High F/M
- P-release
- Effluent is displaced



AquaNereda® Process Cycle



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

React

- Influent flow is terminated
- Aerobic and anoxic conditions
- Simultaneous nitrification/ denitrification
- Nitrate transported by diffusion into granule layers
- P-Uptake
- Automated control of the process



AquaNereda® Process Cycle

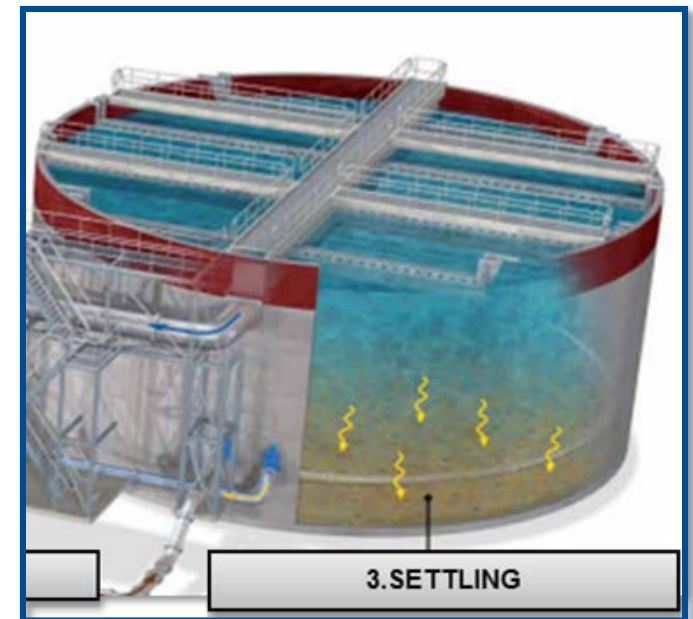


AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Settle

- Influent flow still terminated
- Granules separate from treated water
- Sludge is wasted
- Maintain desired concentration of biomass

...ready for a new cycle.





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

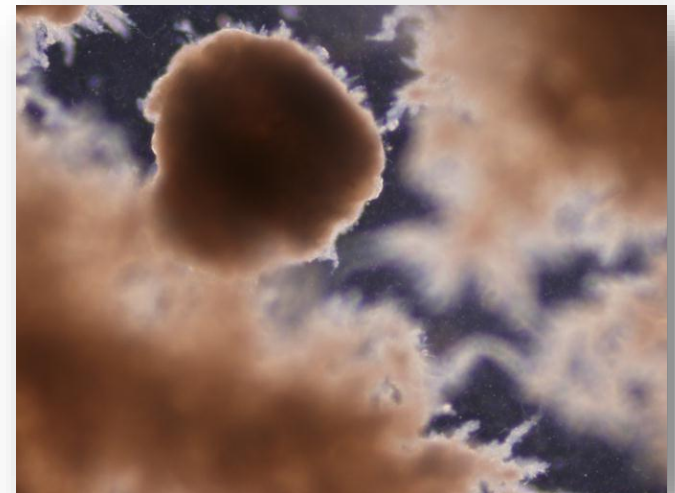
Process Characteristics

Characteristics



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- Excellent settling properties
- Up to 75 % smaller footprint
- Up to 50% energy savings
- Increased capacity
- Sustainable robust technology
- No support media
- No bulking sludge
- Chemical savings



Process Robustness



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- Robust during less favorable conditions:
 - Salinity fluctuations
 - Chemical spikes
 - pH fluctuations
 - Load variations



CAS

AGS

Activated sludge and granular sludge with shock addition of 5,000 ppm NaCl after 5 min of settling



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Applications and Scope

Ideal Applications



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- Retrofit Applications
 - Any existing process
 - Higher flows and loads
- New construction
- Limited footprint
- Plant expansion
- Upgrade to BNR requirements
- Industrial plants



Typical System Components



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- Aeration system
- Pumps
- Valves
- Internal process piping
- Effluent weir assembly
- Instrumentation
- Controls





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Process Comparison

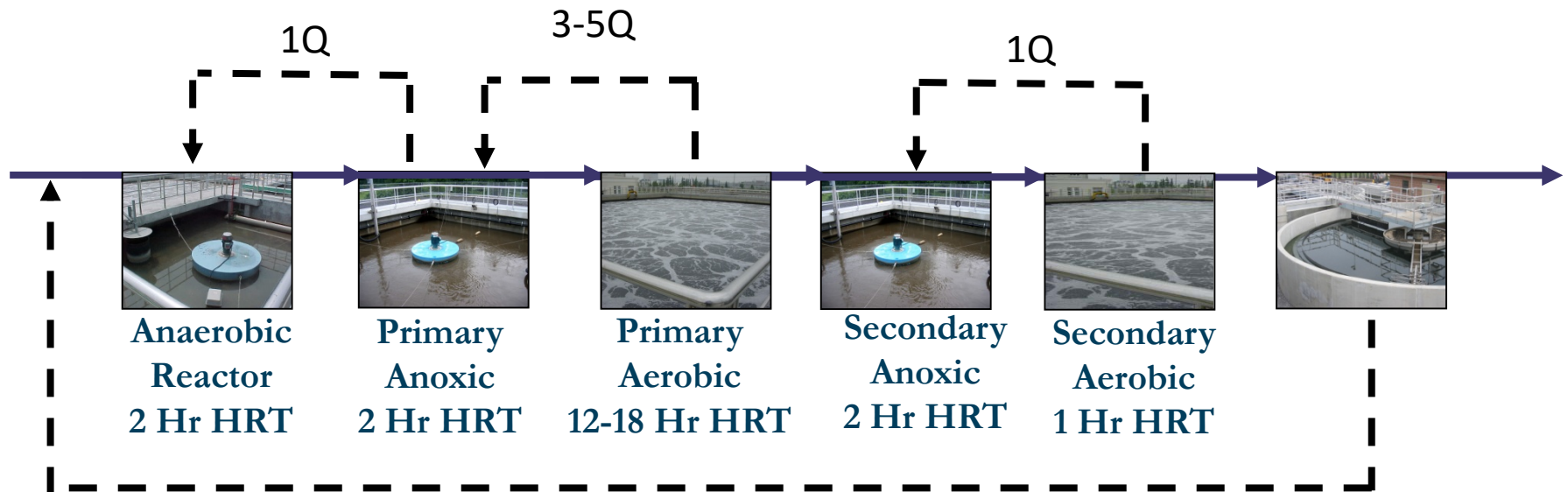
Comparison

5-Stage BNR System



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Comparison to Typical Multi-Stage BNR System



Comparison



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Comparison to Typical Multi-Stage BNR System



Simple Single Tank Design



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Existing Installations

Nereda® Plants Around the World



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

40 Plants Worldwide

	Daily average flow (MGD)	Peak flow (MGD)	Startup
Vika, Ede (NL)	0.07	0.07	2005
Cargill, Rotterdam (NL)	0.18	0.18	2006
Fano Fine Foods, Oldenzaal (NL)	0.10	0.10	2006
Smilde, Oosterwolde (NL)	0.13	0.13	2009
STP Gansbaai (RSA)	1.32	2.54	2009
STP Epe (NL)	2.11	9.51	2011
STP Garmerwolde (NL)	7.93	26.63	2013
STP Vroomshoop (NL)	0.40	2.54	2013
STP Dinxperlo (NL)	0.82	3.61	2013
STP Wemmershoek (RSA)	1.32	3.96	2013
STP Frielas, Lisbon (PT)	3.17	3.17	2014
STP Ryki (PL)	1.40	2.73	2015
Westfort Meatproducts, IJsselstein	0.37	0.37	2015
STP Clonakilty (IRL)	1.29	3.97	2015
STP Carrigtwohill (IRL)	1.78	5.35	2015
STP Deodoro, Rio de Janeiro (BR)	22.82	38.80	2016
STP Jardim Novo, Rio Claro (BR)	0.47	11.18	2016
STP Hartebeestfontein (RSA)	1.32	7.93	2016
STP Kingaroy (AUS)	0.71	2.85	2016
STP Ringsend SBR Retrofit 1 Cell, Dublin (IRL)	21.66	42.80	2016
STP Highworth (UK)	0.37	1.27	2017
STP Cork Lower Harbour (IRL)	4.83	11.60	2016
STP Simpelveld (NL)	0.97	5.99	2016
STP Ringsend Capacity Upgrade, Dublin (IRL)	30.91	58.58	2019
STP Alphach (CH)	3.70	11.70	2017
STP Österröd, Strömstad (Swe)	0.99	2.28	2017
STP Tatu, Limeira (BR)	15.06	22.14	2017
STP São Lourenço, Recife (BR) 1st phase	5.04	10.61	2017
STP São Lourenço, Recife (BR) 2nd phase	6.64	10.61	2024
STP Jaboatão, Recife (BR) 1st phase	28.97	73.47	2017
STP Jaboatão, Recife (BR) 2nd phase	40.81	73.47	2025
STP Jardim São Paulo, Recife (BR)	5.16	37.15	2017
STP Jardim São Paulo, Recife (BR)	20.64	37.15	2025
STP Utrecht (NL)	14.53	83.69	2018
STP Faro-Olhão (PT)	7.44	24.99	2018

Garmerswolde, NL

Side-by-Side Operation



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

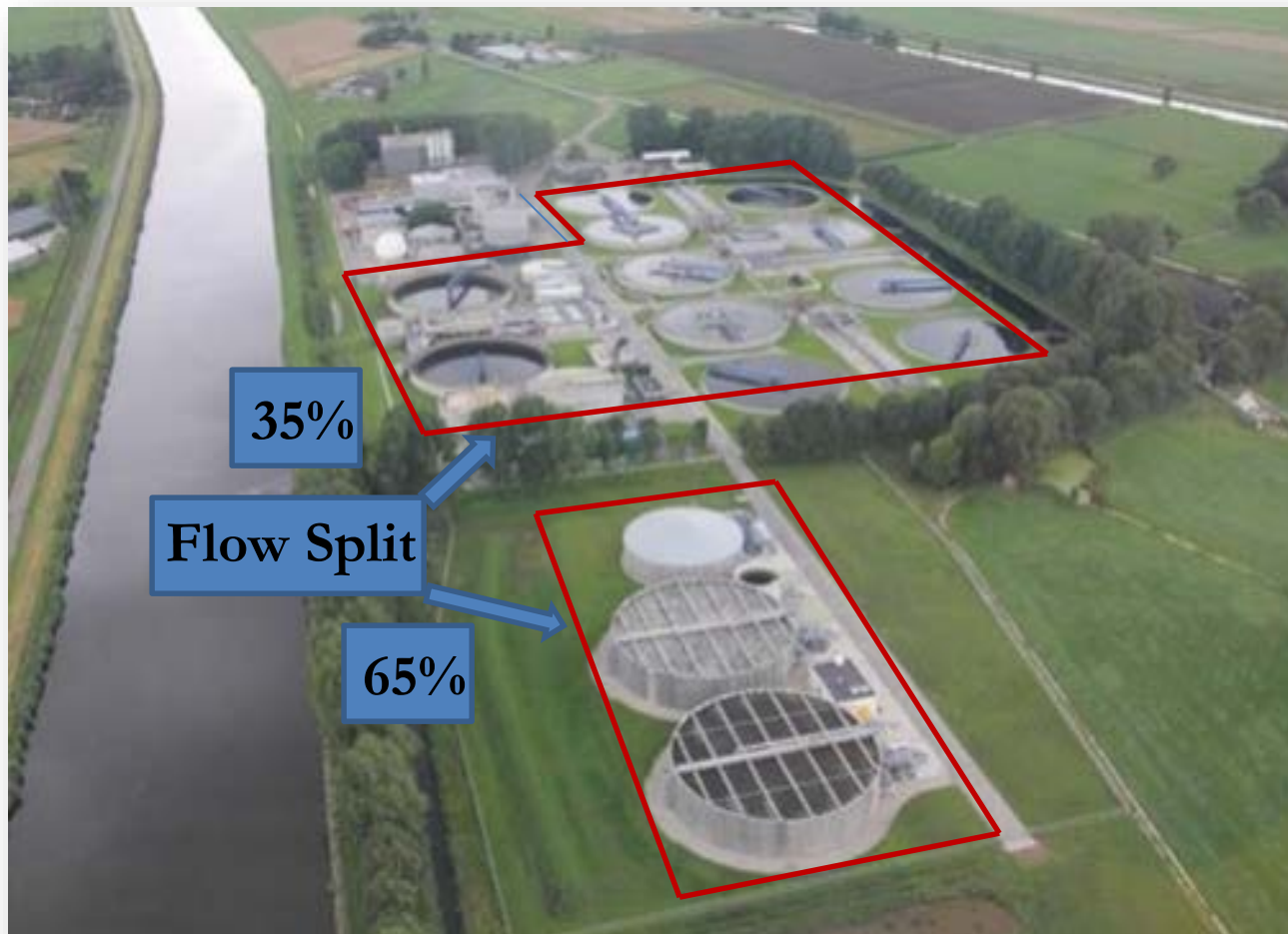


Garmerswolde, NL

Footprint



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



Frielas WWTP, Portugal

Partial Retrofit



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



- 1 of 6 Aeration basins was retrofitted into a Nereda[®] reactor
- Combined effluent of CAS and AGS meets effluent permit requirement
- 33% energy savings on aeration alone

Epe, Netherlands 2011

Remote Operation / Low TN



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



Flows	
Average Flow (MGD)	Peak Flow (MGD)
2.1	9.5

Parameters		
	Influent	Effluent
BOD ₅	333	2
TSS	341	5
TN	-	4
TP	9.3	0.34

Effluent quality is after filtration

Rio de Janeiro, Brazil, 2016

Mid-to-large size plant



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



Flows

Average Flow (MGD)	Peak Flow (MGD)
22.8	38.8

Parameters

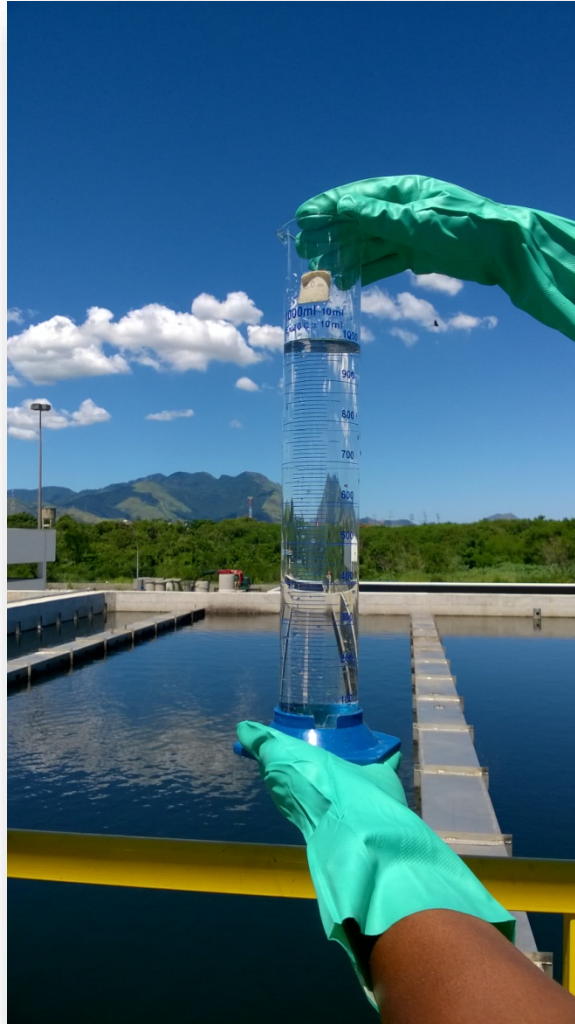
	Effluent
BOD ₅	25
TSS	10
NH ₄ -N	1
PO ₄ -P	1.5

Rio de Janeiro, Brazil, 2016

Mid-to-large size plant



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



- Operational just prior to the start of the 2016 Olympic games
- Exceeding effluent requirements

Ringsend, Ireland, 2019

Large Plant – Retrofit and Expansion



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



Flows	
Average Flow (MGD)	Peak Flow (MGD)
159	314

- Retrofit SBR
 - To be built in stages
 - Handles high salinity
 - Increased MLSS to 8 g/l
-
- This plant demonstrates that there are not upper limits to increasing capacity



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

AquaNereda®

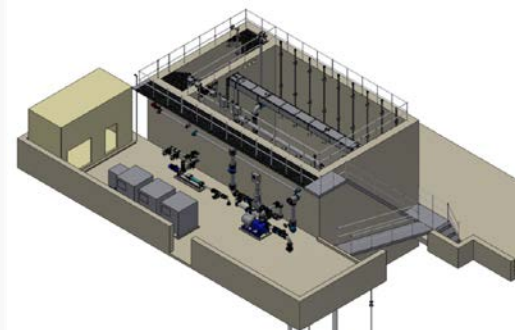
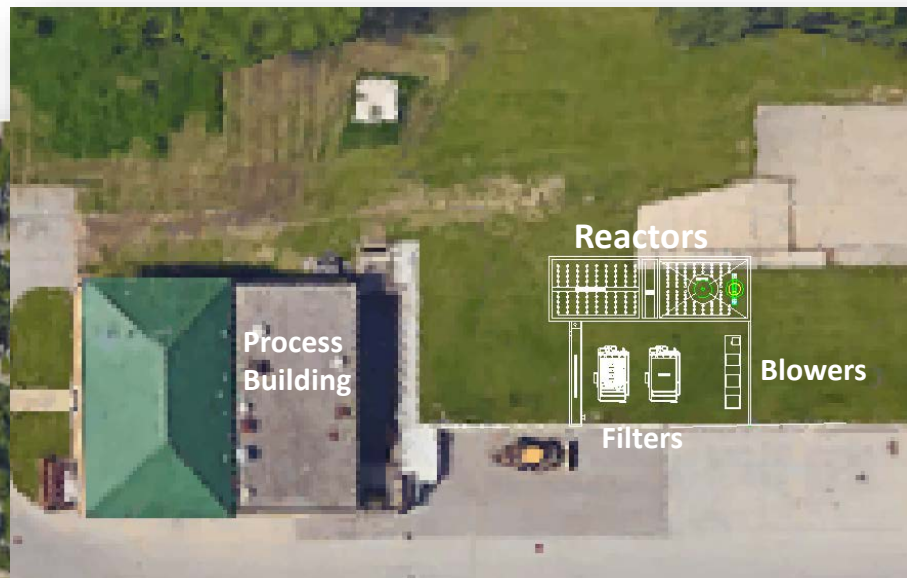
Demonstration Facility

Aerobic Granular Sludge

Demonstration Facility – Rockford, IL
0.2 MGD AGS



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company



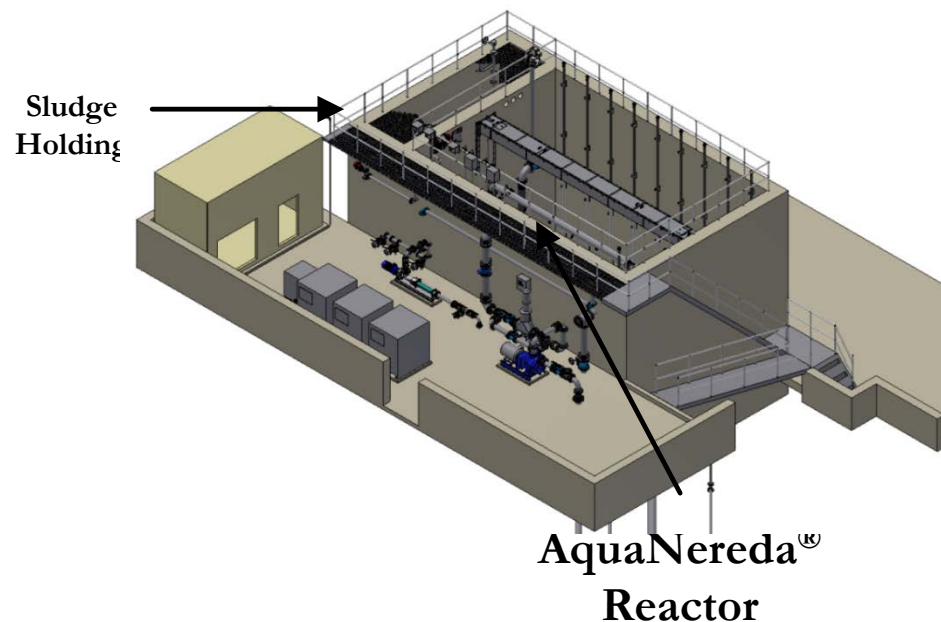
Demonstration Facility – Rockford, IL

0.2 MGD AGS



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Construction of a 0.2 MGD AquaNereda[®] reactor with associated pretreatment, instrumentation and mechanical equipment





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

AquaNereda®

Pilot Plant

Aerobic Granular Sludge

Pilot Plant



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

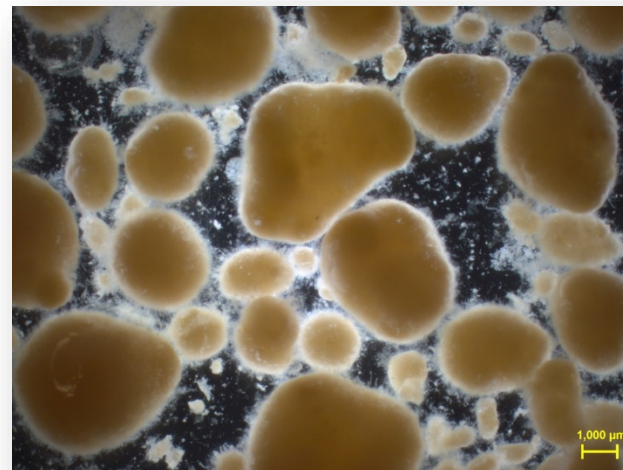
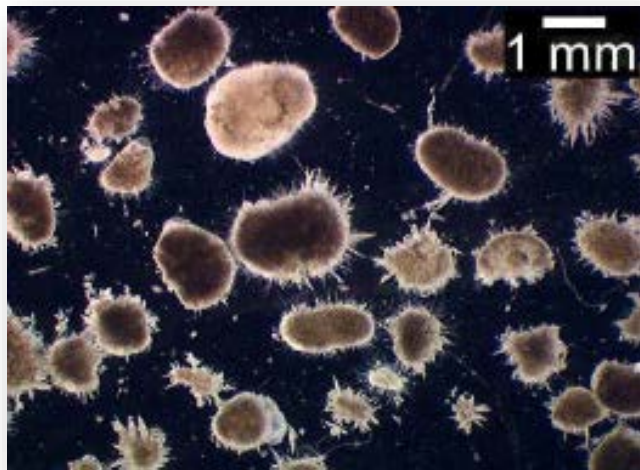
Summary

AquaNereda® Summary



AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- AGS reduces footprint, increases capacity and reduces energy
- Compact, sustainable, robust
- Achieves BNR and Bio-P removal
- Over 30 full scale installations worldwide
- Demo facility and pilot are resources to assist with implementation in the U.S.





AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Questions?
