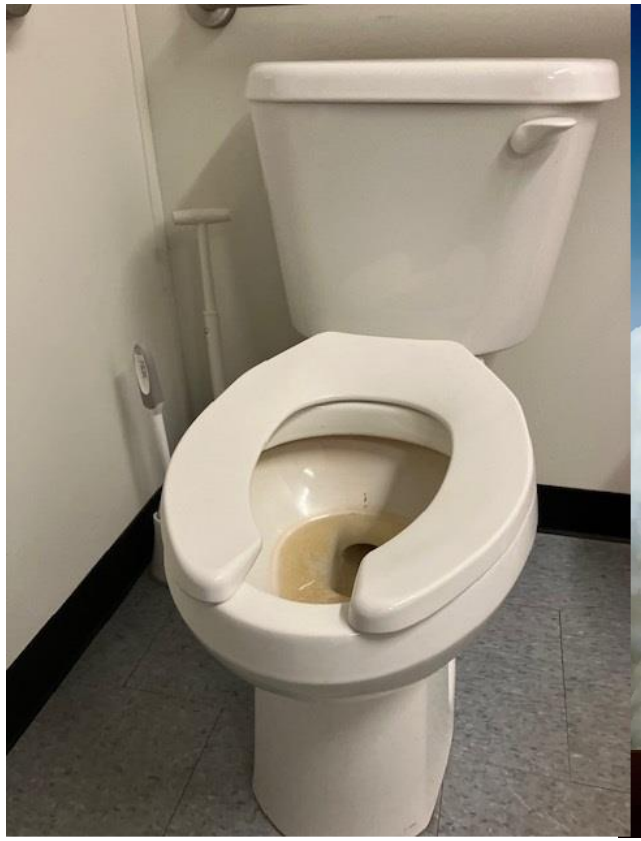
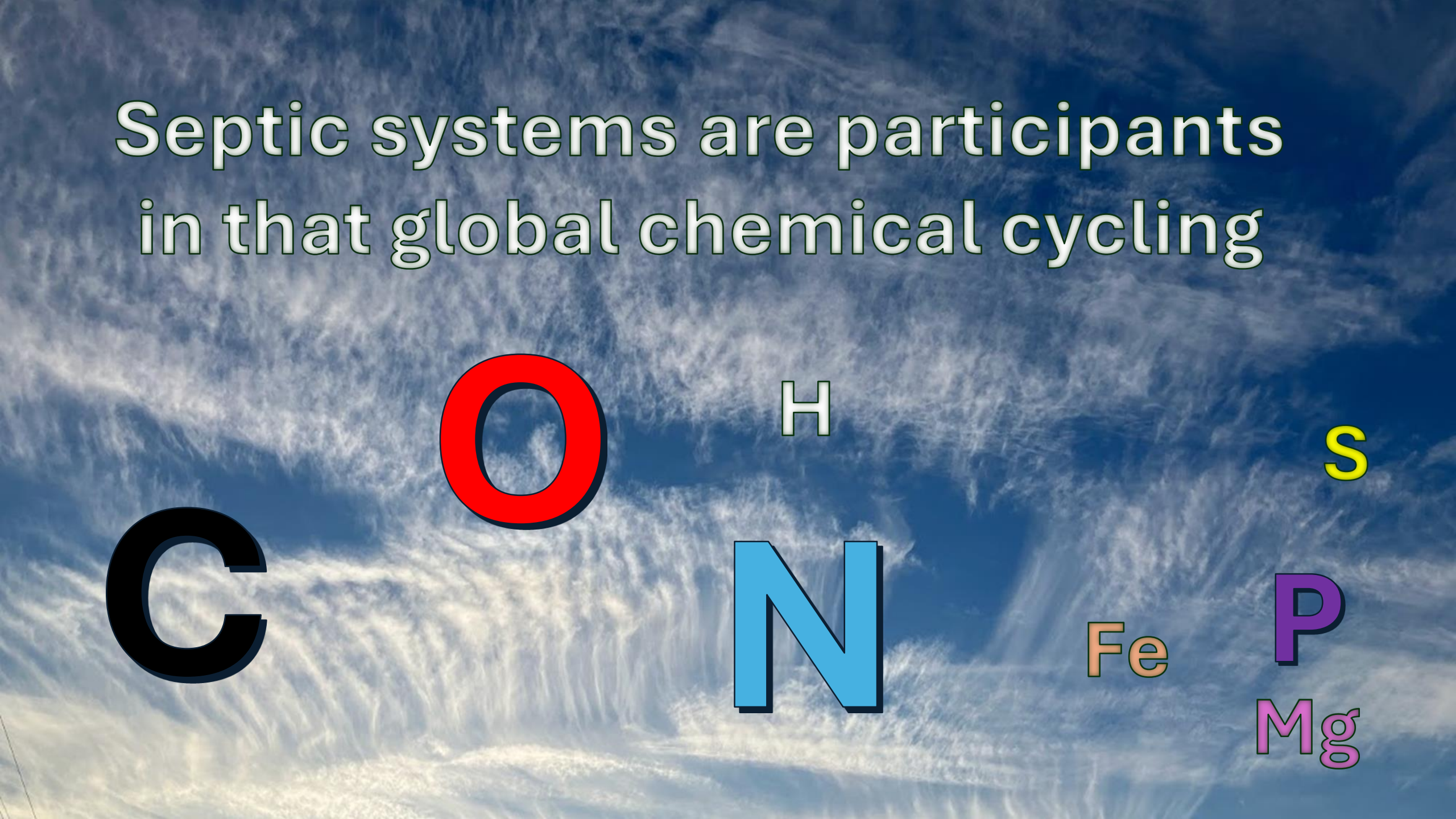
Transforming the flush – The marvelous transformative power of the unseen world of microorganisms.

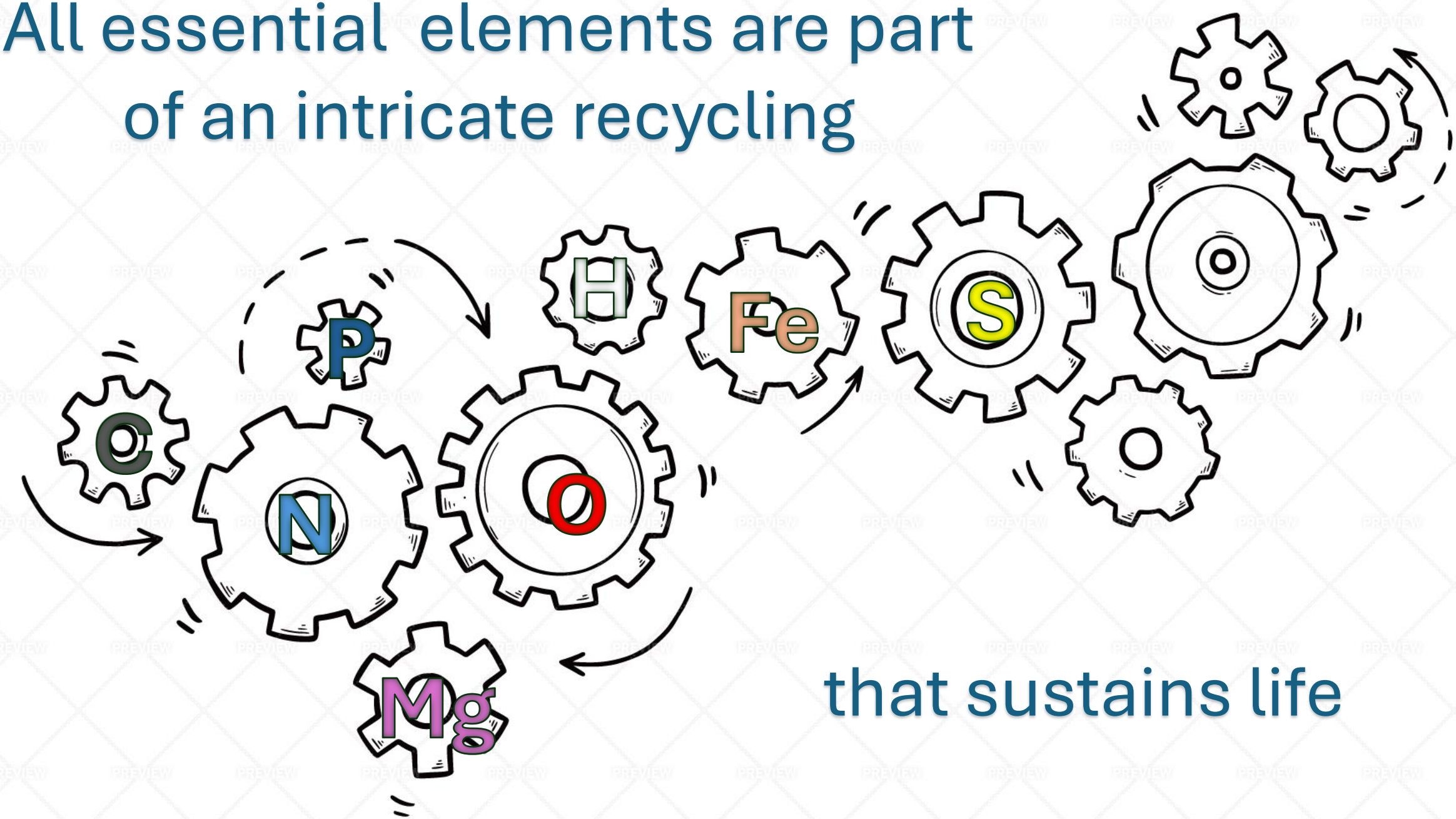


George Heufelder, M.S., R.S.
Environmental Specialist | Health and Environment
Massachusetts Alternative Septic System Test Center

The transformation from our various deposits to blue skies and green pastures can be by many routes


Septic systems are participants
in that global chemical cycling
O
H
S
C
N
Fe
P
Mg

All essential elements are part of an intricate recycling



that sustains life

Theoretically

Girl eats lobster

Girl “donates” to septic system

Septic tank converts protein in lobster from girl’s contribution to ammonium

Ammonium gets converted to nitrate in leachfield and enters estuary

Nitrate feeds algae that floats around and gets eaten by small fish

Small fish gets eaten by large bluefish

Bluefish is caught and eaten with carcass used as lobster bait

Lobster feeds on bluefish carcass

Lobster fisherman sells caught lobster to restaurant

Girl orders lobster for dinner

Girl eats lobster

Nitrogen

Our Focus

Biological processes controlling the treatment of waste in our septic systems

Useful information to consider when designing and operating a septic system

Section Objectives

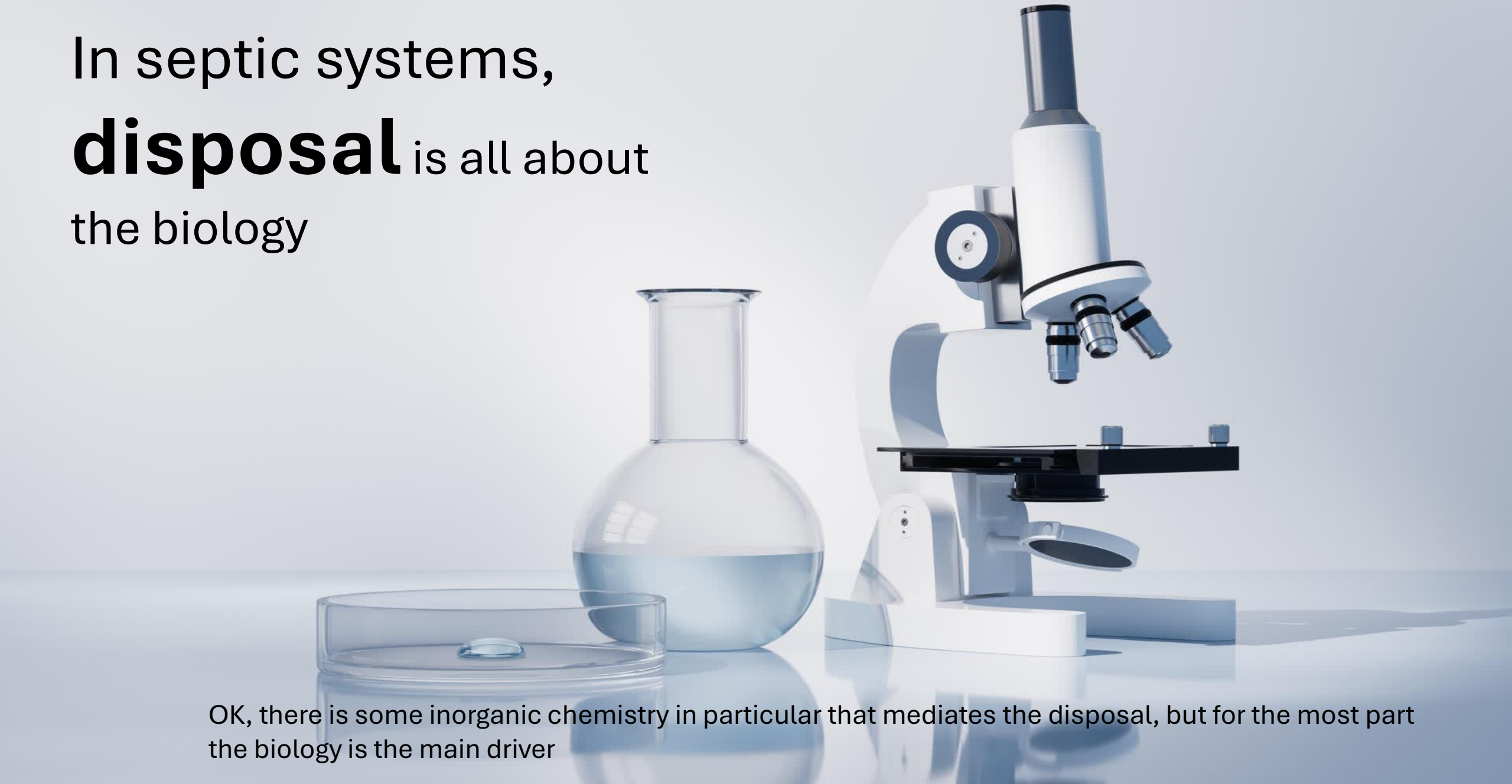
- Review the biology that drives treatment and disposal in septic systems
- Highlight the importance of the biomat in the soil treatment area (aka leachfield)
- Dispel common misconceptions about the biomat and how it functions
- Discuss ways to incorporate what we learn to optimize design and operation of septic systems

In septic systems, **treatment** is all about the biology

In septic systems,

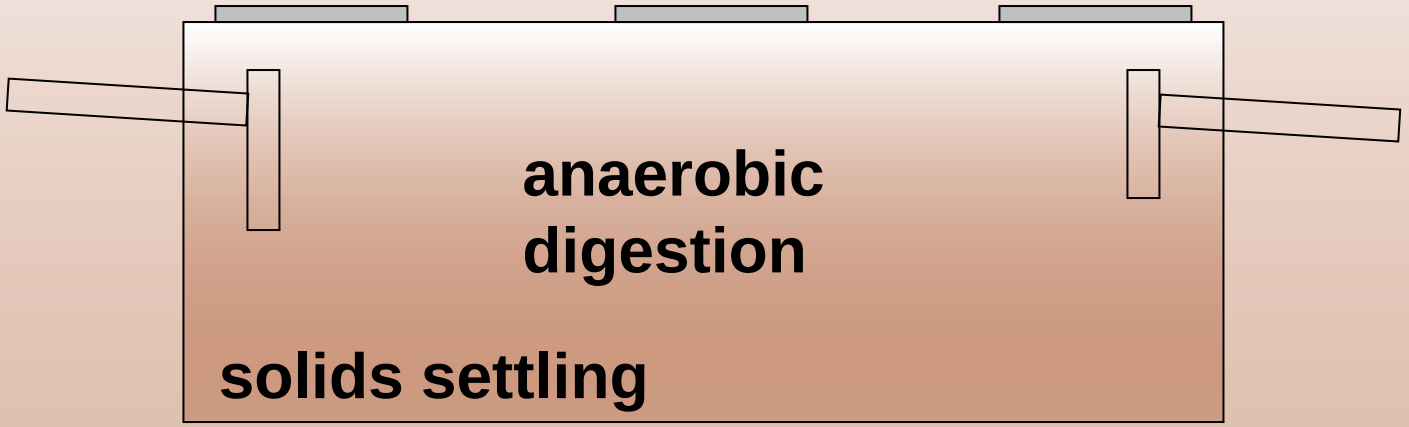
disposal is all about

the biology



OK, there is some inorganic chemistry in particular that mediates the disposal, but for the most part the biology is the main driver

First stop – Septic Tank



Liquifaction

Acid or non-methanogenic phase

Bacteria hydrolyze complex organic material to simple sugars amino acids and ammonia(um). Fats and greases remain intact.

as stability develops

Methanogenic phase

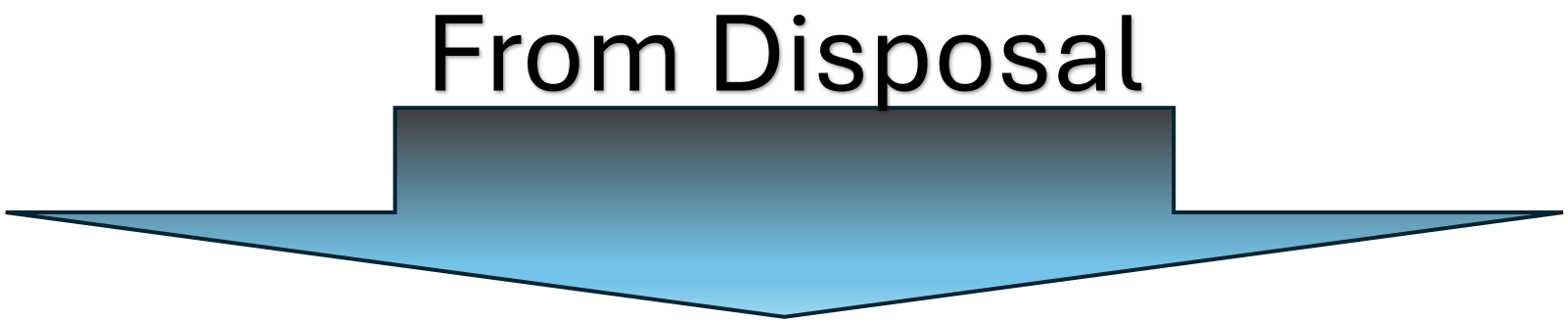
Methane forming bacteria convert organic acids to methane and carbon dioxide


On
to
the
leachfield
Where the real interesting things happen

Treatment vs Disposal

Age-old balance -Always some tradeoffs

THE STATE ENVIRONMENTAL CODE
Minimum Requirements For The Subsurface Disposal of Sanitary Wastes
1977 - TITLE 5



THE STATE ENVIRONMENTAL CODE
TITLE 5: STANDARD REQUIREMENTS FOR THE SITING, CONSTRUCTION, INSPECTION, UPGRADE AND EXPANSION OF ON-SITE SEWAGE **TREATMENT AND DISPOSAL** SYSTEMS AND FOR THE TRANSPORT AND DISPOSAL OF SEPTAGE
(1995 →→→→→→→→→→→→ revisions →→→2024)

Basically, the “new” code (1995) transitioned onsite wastewater treatment regulations from regulating “disposal” to encouraging “treatment” .

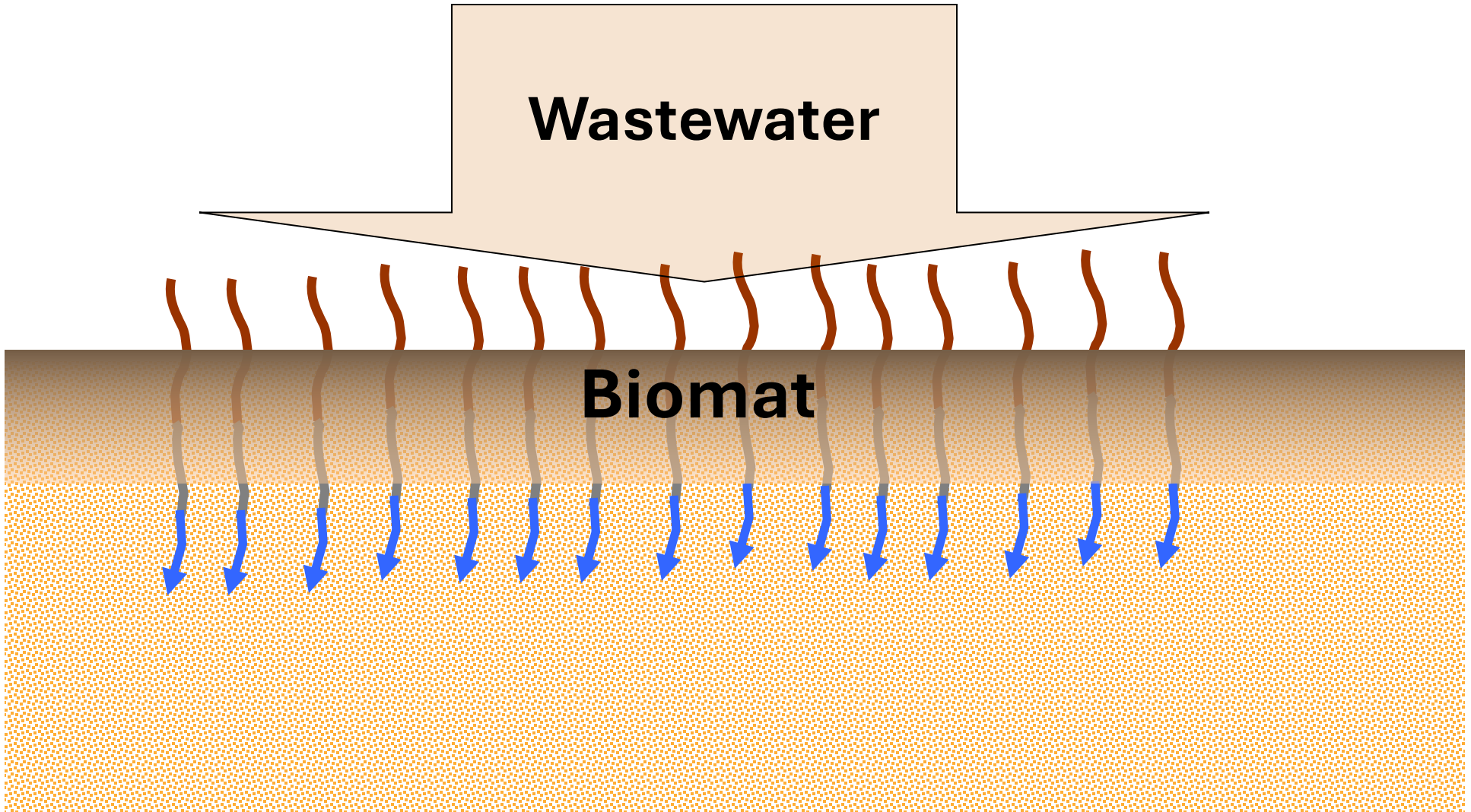
- ***Shallower placed systems***
- ***Lower hydraulic loading rates***

Focus on the biomat

The layer composed of microorganisms and organic material located below a soil absorption system which forms on the infiltrative surface of soil and which provides biological treatment of septic tank effluent. (Title 5)

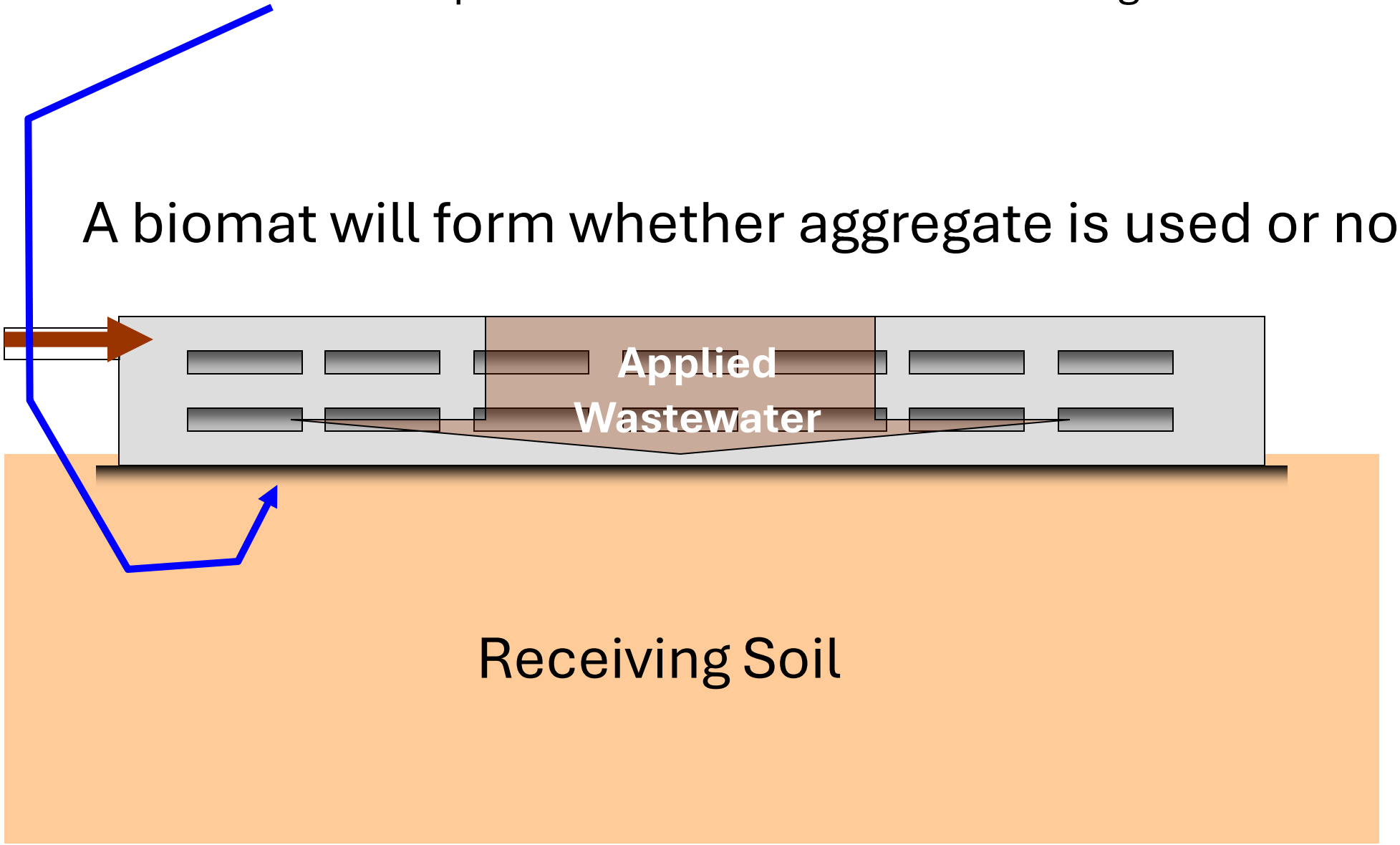
In general

BIOMAT – A layer of organic and inorganic material (biofilm) that develops on the soil interface in a soil absorption field as a result of microbial growth and intervention.

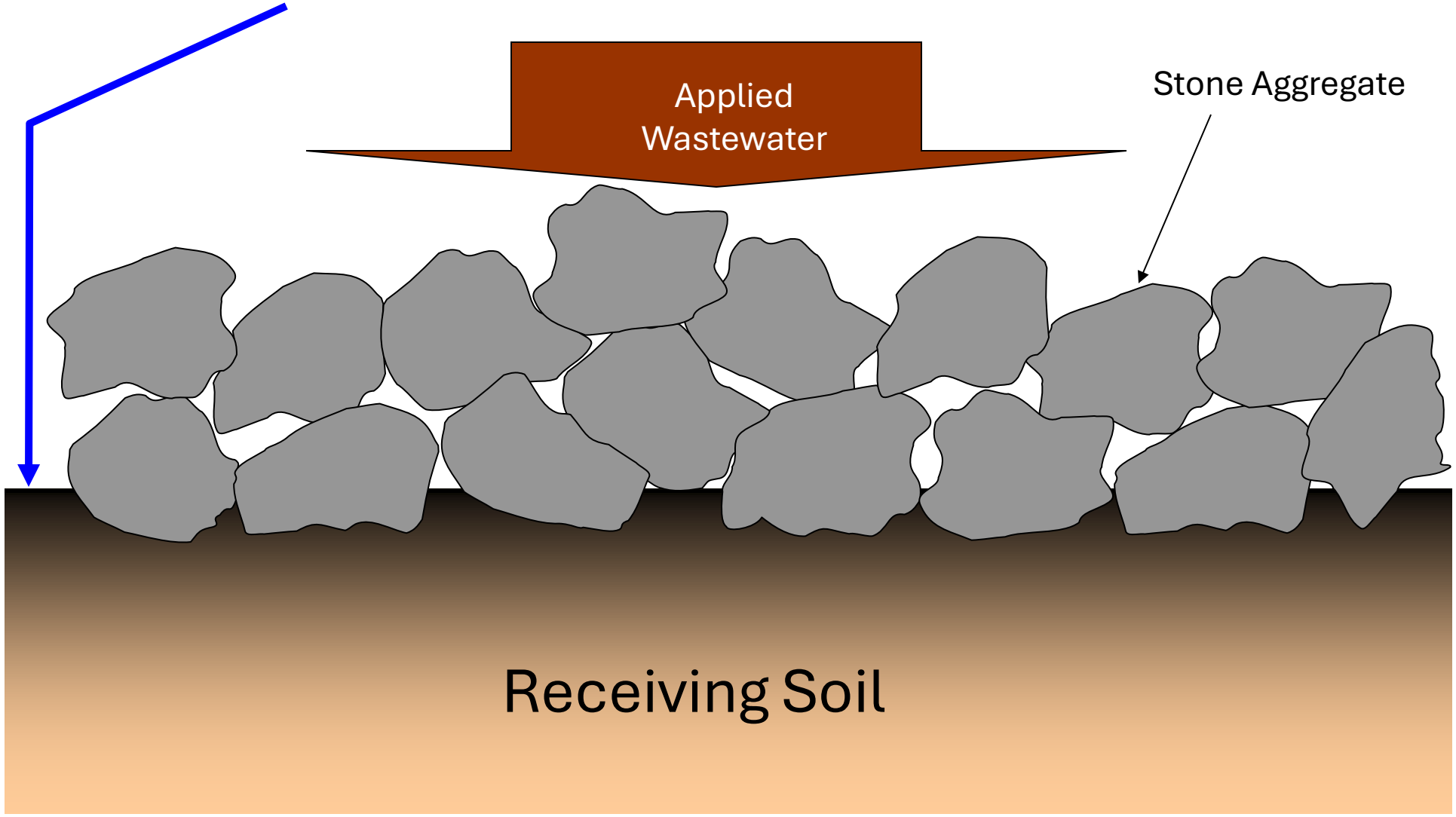


BIOMAT – A layer of organic and inorganic material that develops on the soil interface in a soil absorption field as a result of microbial growth.

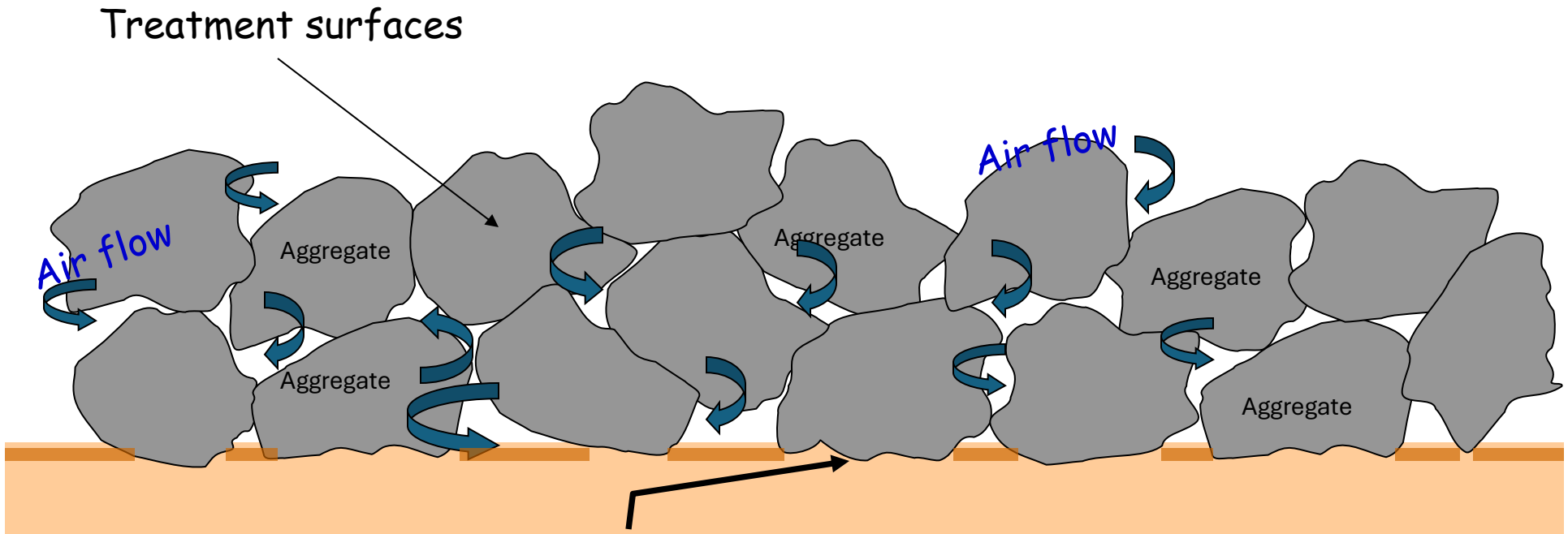
A biomat will form whether aggregate is used or not



BIOMAT – A layer of organic and inorganic material that develops on the soil interface in a soil absorption field as a result of microbial growth.

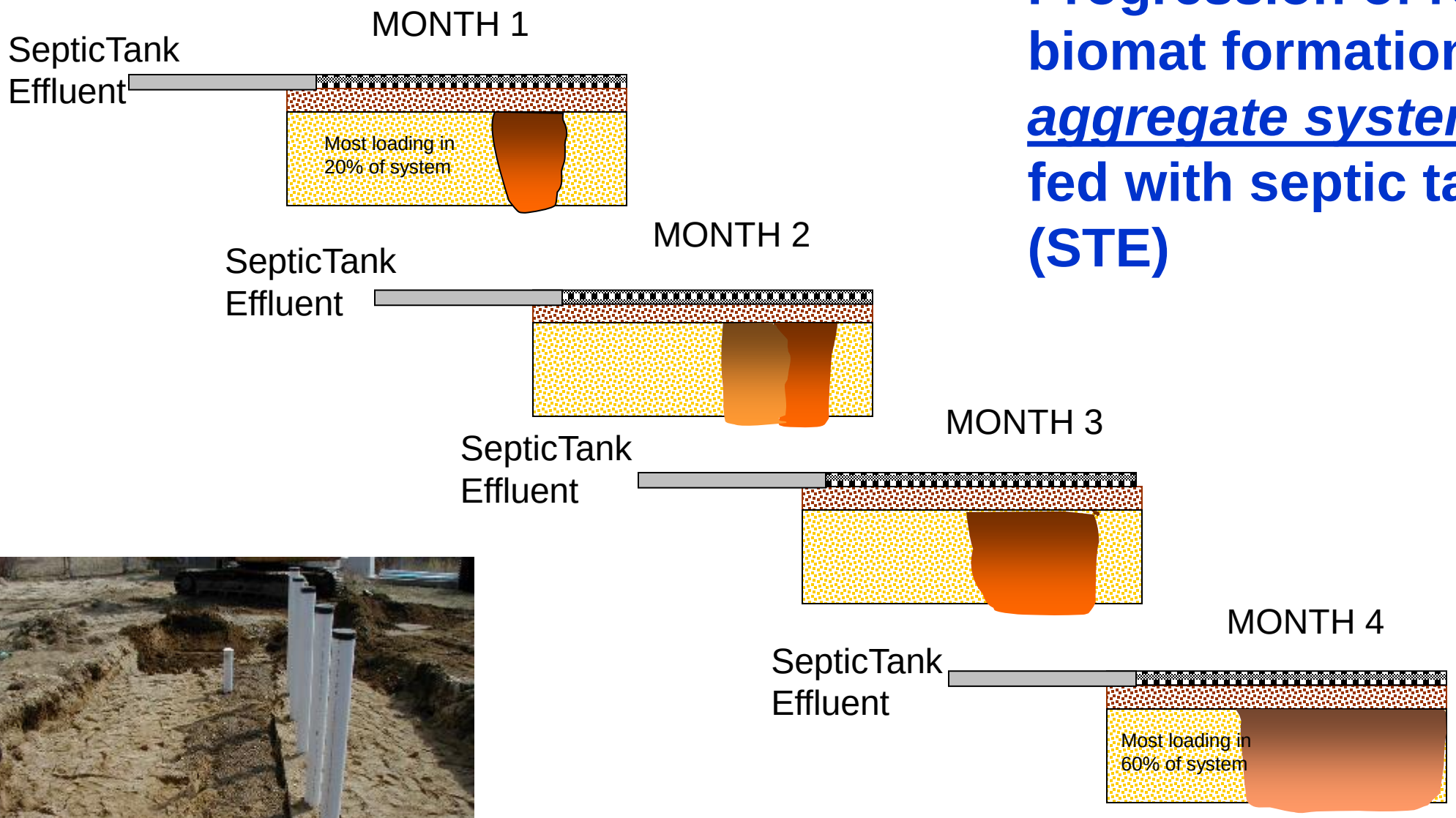


Septic Tank Effluent



Some believe that the area of contact between the individual aggregate units and the soil actually "masks" the possible treatment area – this has been given by some as a justification for decreased requirements for aggregate-free systems (which it is claimed have more actual treatment area per linear foot).

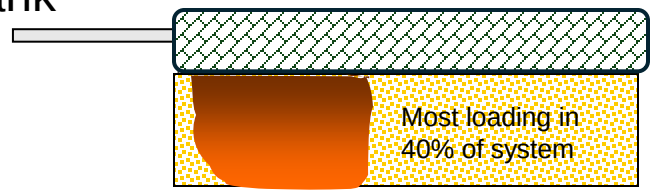
Progression of restrictive biomat formation in *aggregate system* gravity fed with septic tank effluent (STE)



Progression of restrictive biomat formation in *gravelless* system gravity fed with septic tank effluent (STE)

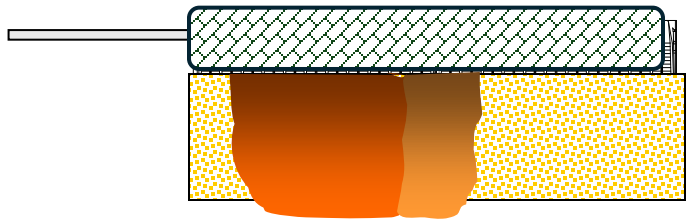
MONTH 1

SepticTank Effluent



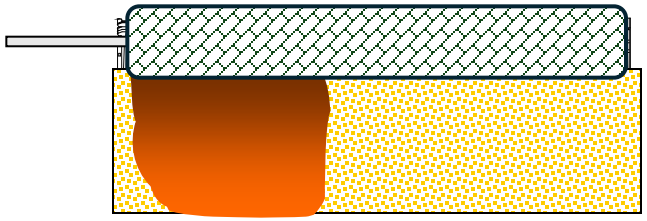
MONTH 2

SepticTank Effluent



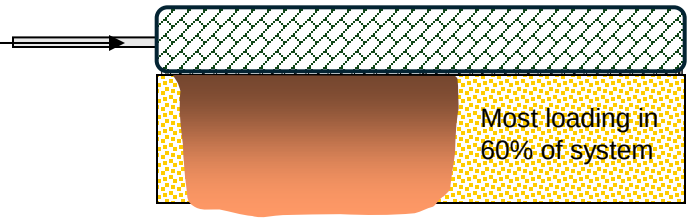
MONTH 3

SepticTank Effluent



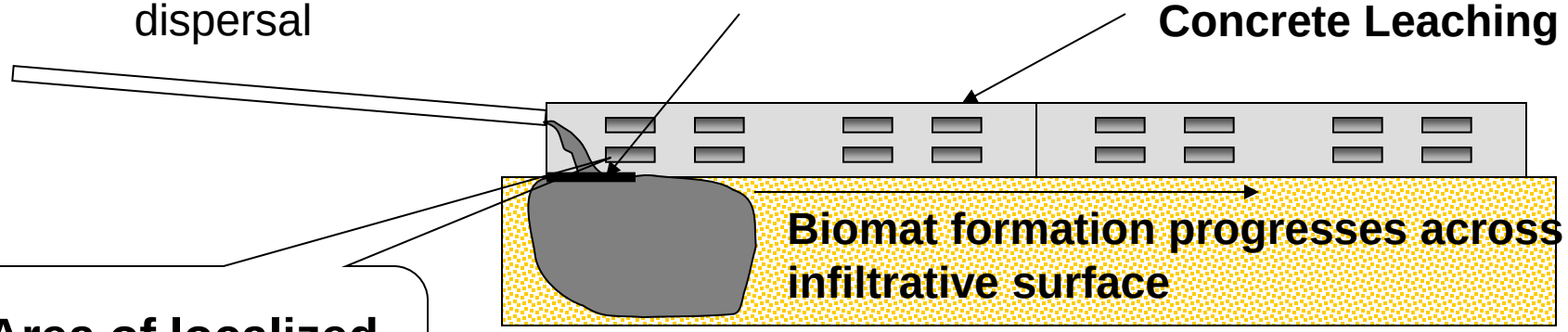
MONTH 4

SepticTank Effluent



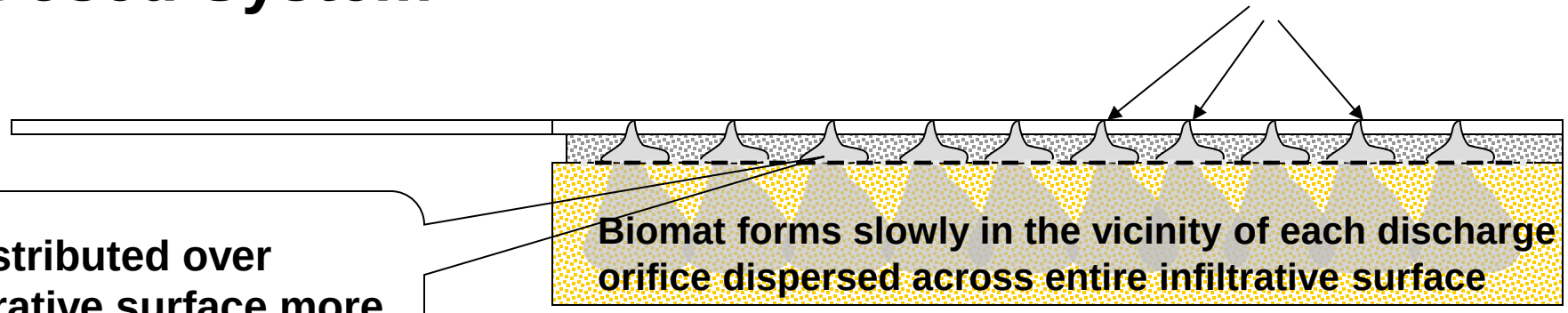
Gravity Fed System

Restrictive biomat forms at water distribution point, shunting water to adjacent soil surface. Clogging progresses away from point of dispersal



Pressure Dosed System

Discharge Orifices in Pressure Distribution System



Myth

Until a restrictive biomat forms, a soil treatment area does not treat wastewater

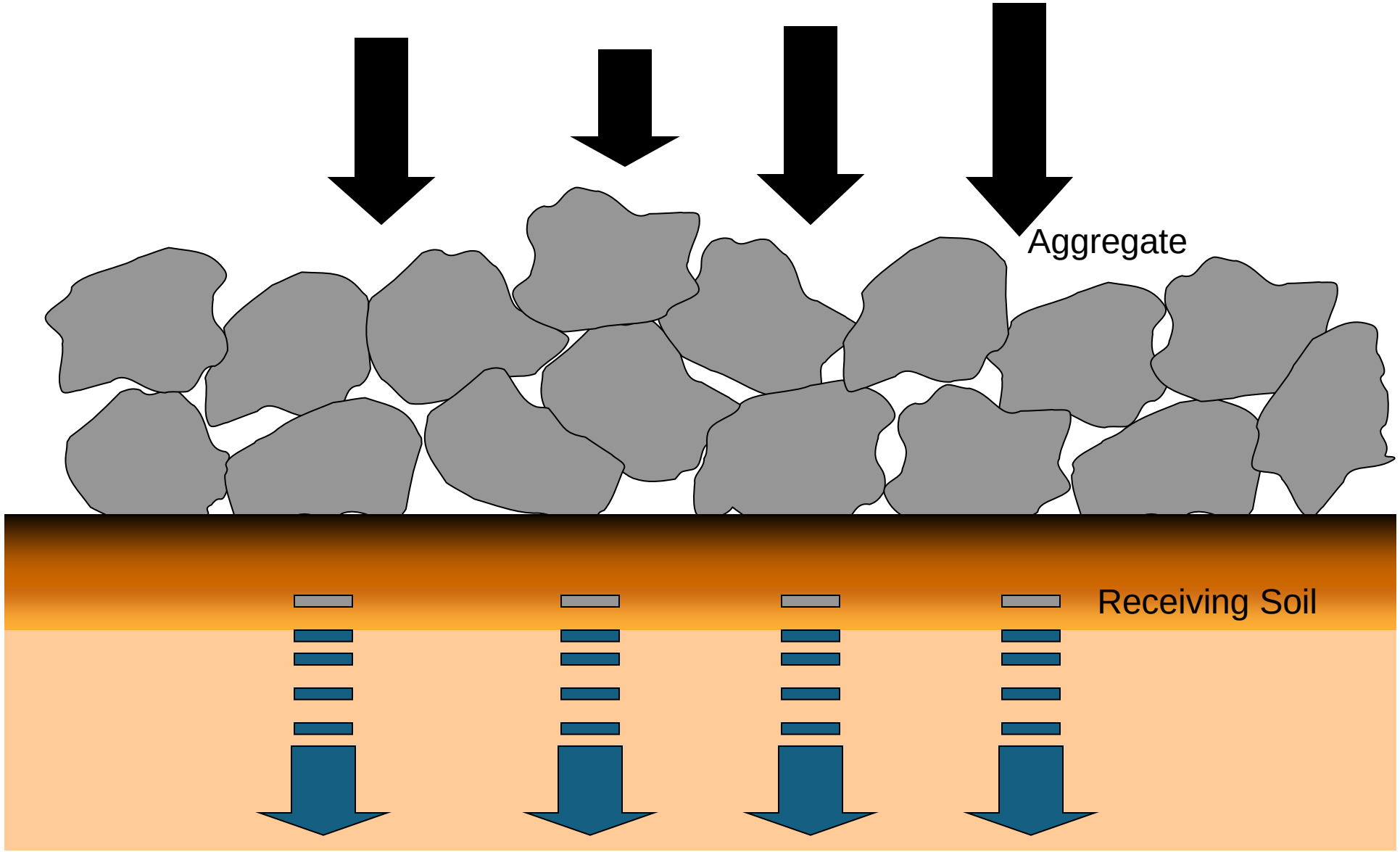
Myth

Until a restrictive biomat forms, a soil treatment area does not treat wastewater

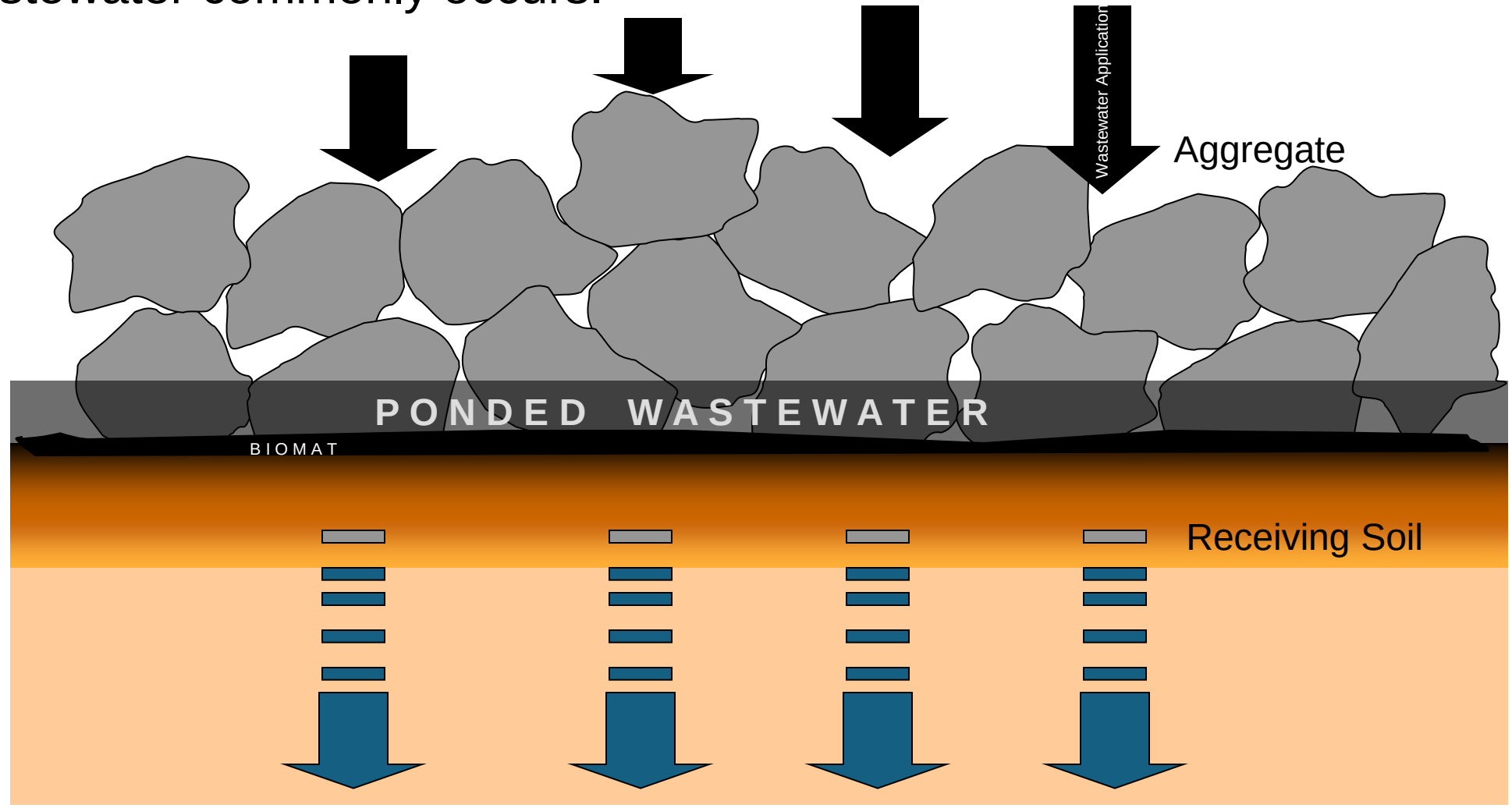
False - Biomats come in different forms – optimally, a dominantly aerobic biomat that does not promote ponding treats wastewater as well if not better than a biomat that promotes ponding.

The classic view of biomat

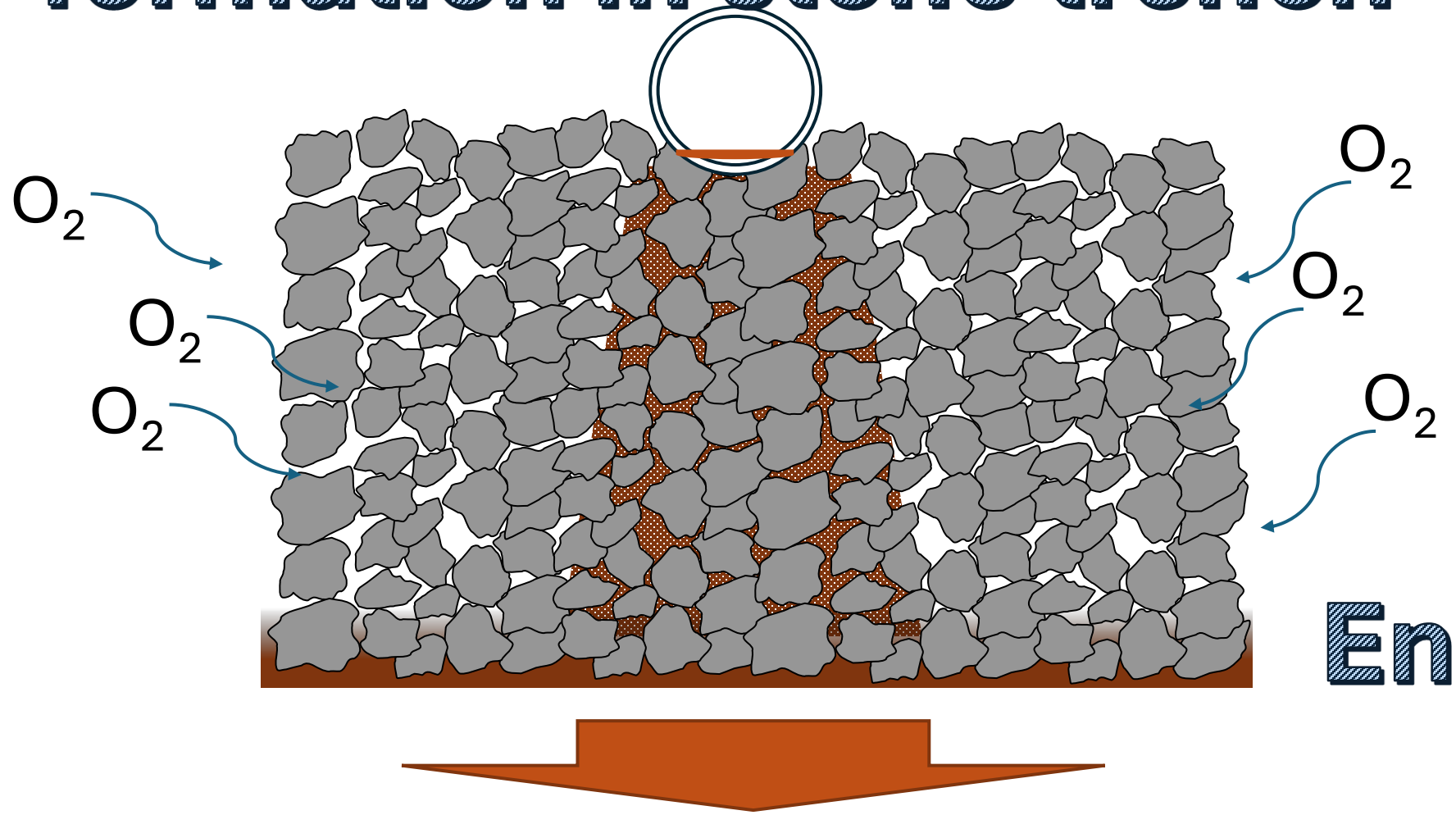
Wastewater Application



The biomat is mature when it reaches an equilibrium. This is characterized by the ability of the infiltrative soil interface to allow the percolation of the wastewater at the same rate that it is applied. Ponding of wastewater commonly occurs.

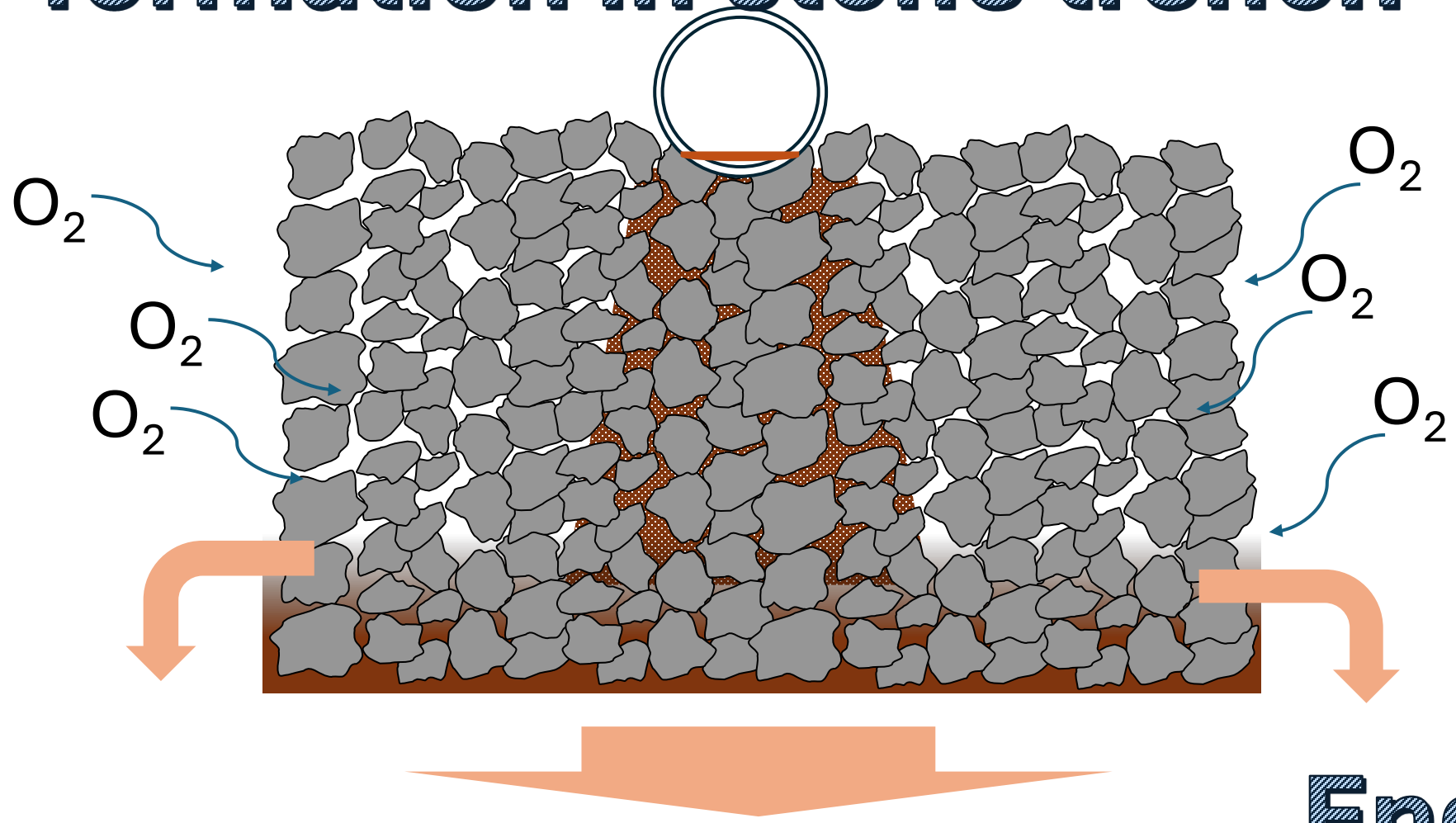


Progressive restrictive biomat formation in stone trench



End view

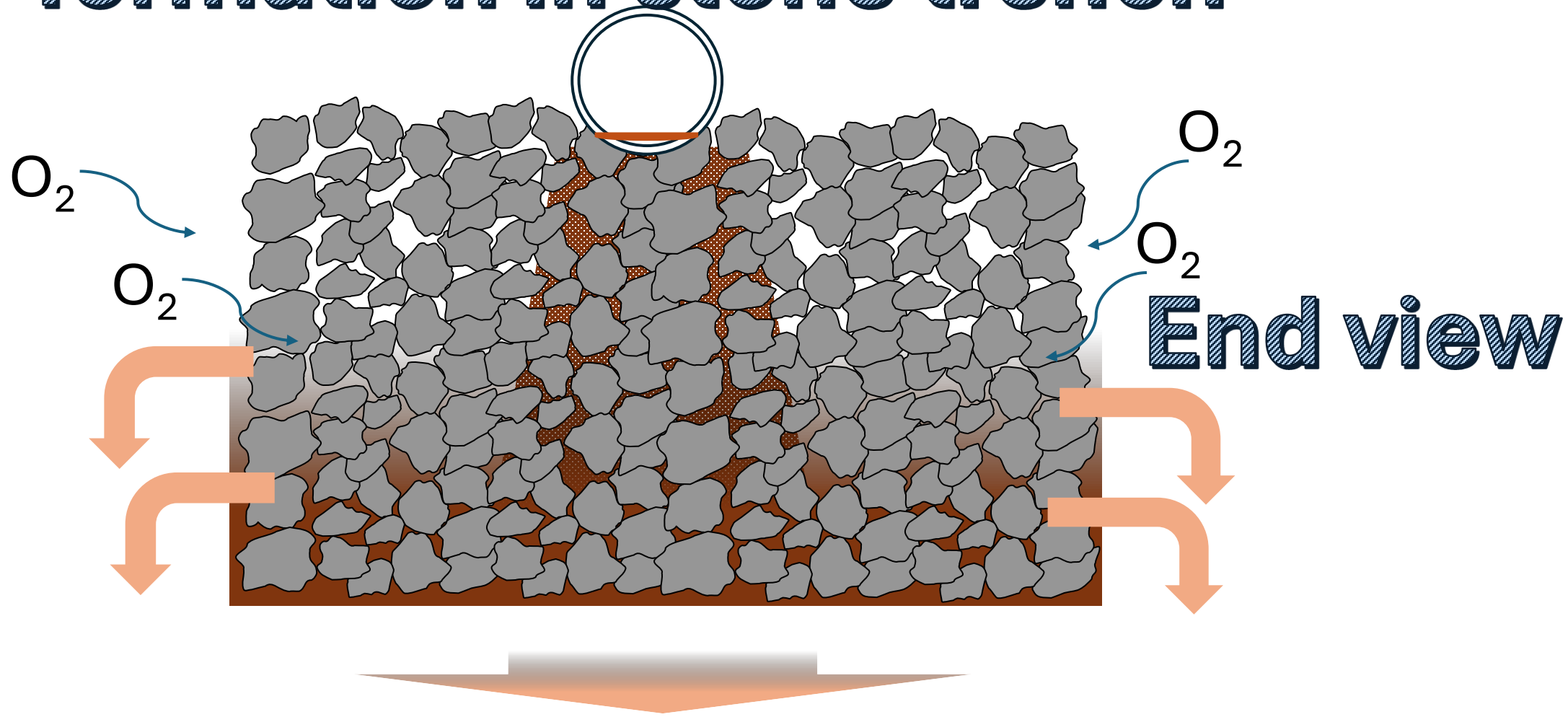
Progressive restrictive biomat formation in stone trench



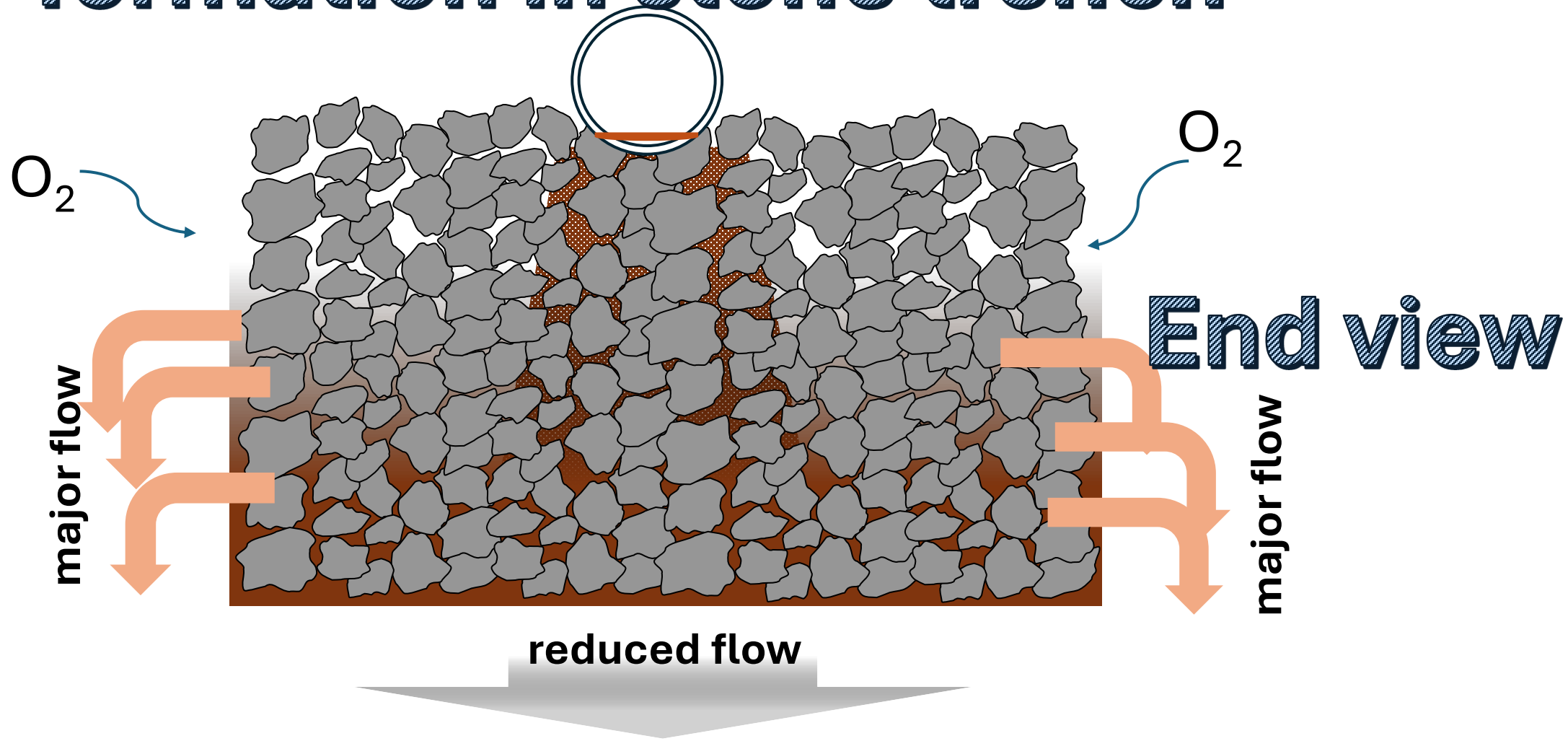
2

End view

Progressive restrictive biomat formation in stone trench



Progressive restrictive biomat formation in stone trench



"water always finds the path of least resistance" *Dutch proverb*

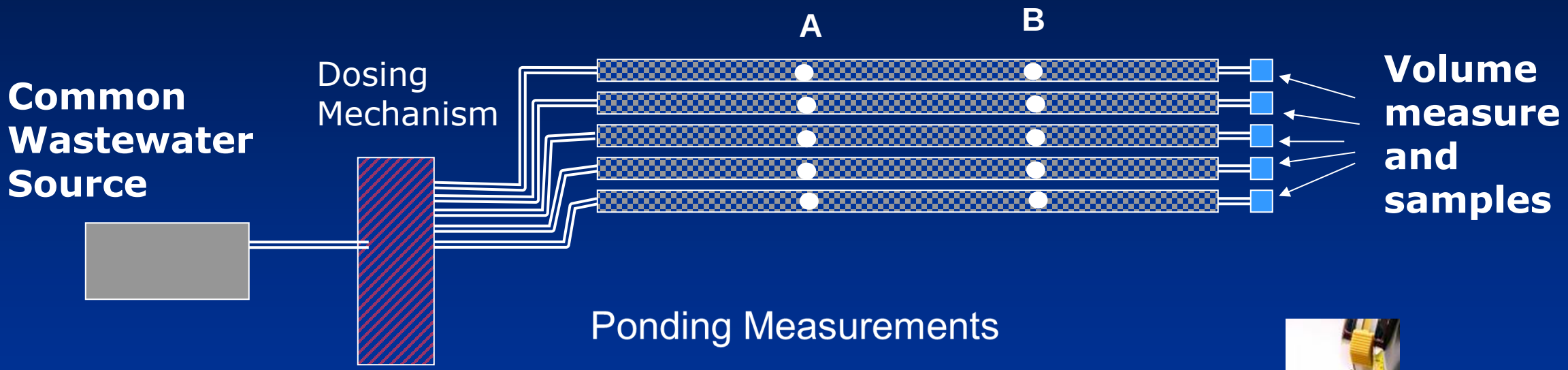
BUT what we found….

Ponding in stone aggregate trenches is not so uniform as many think.

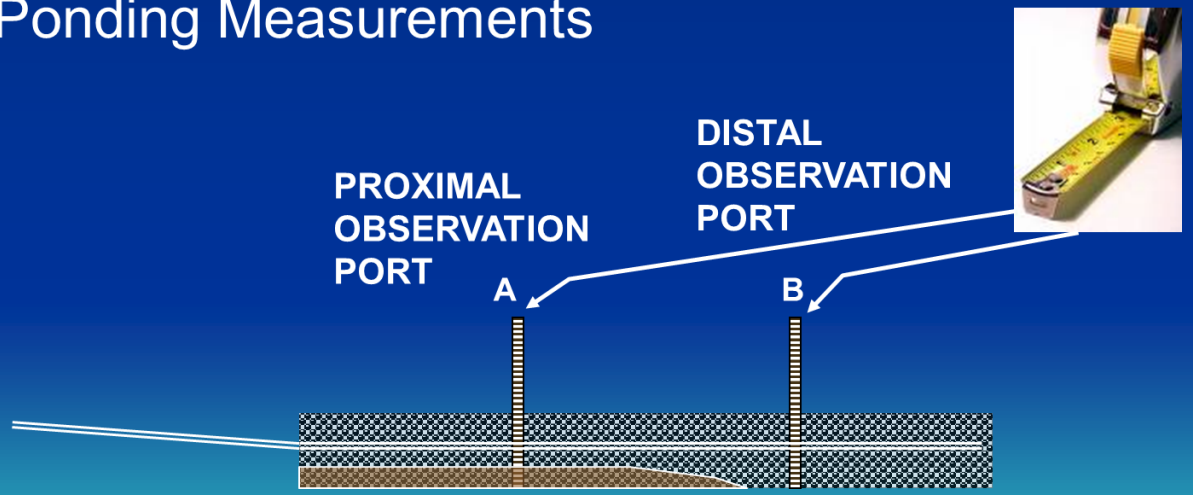
Ponding formation in trenches as the biomat progresses

Research from MASSTC
2006 - 2007

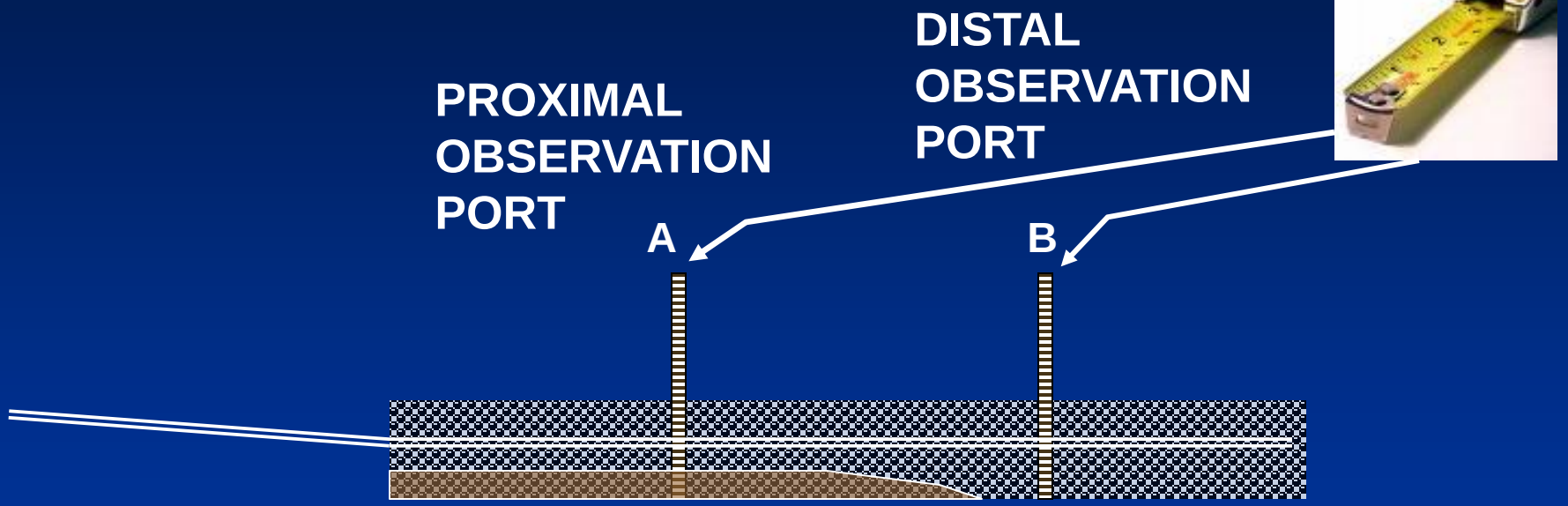
25’ Trenches x 5



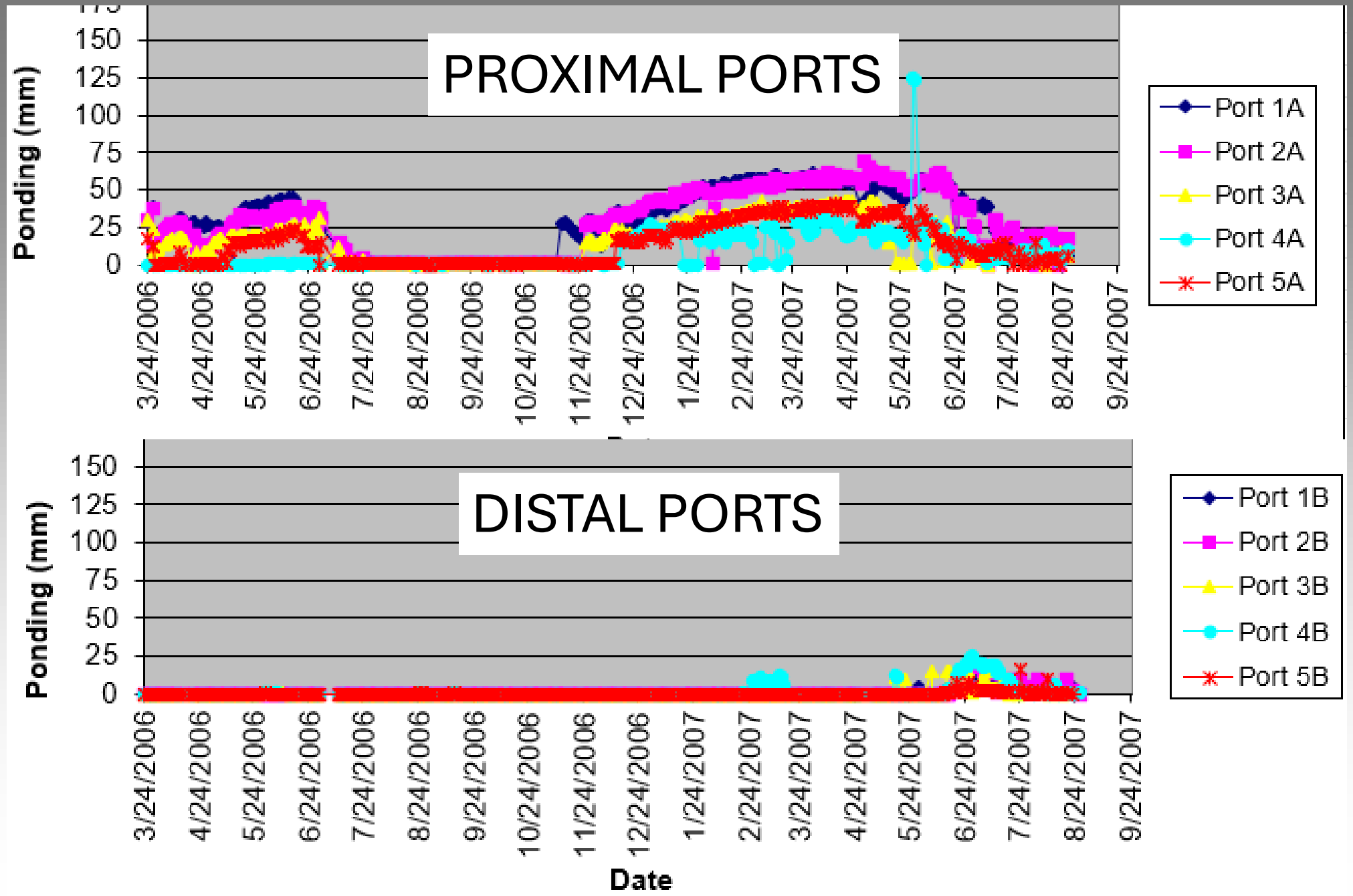
Ponding Measurements

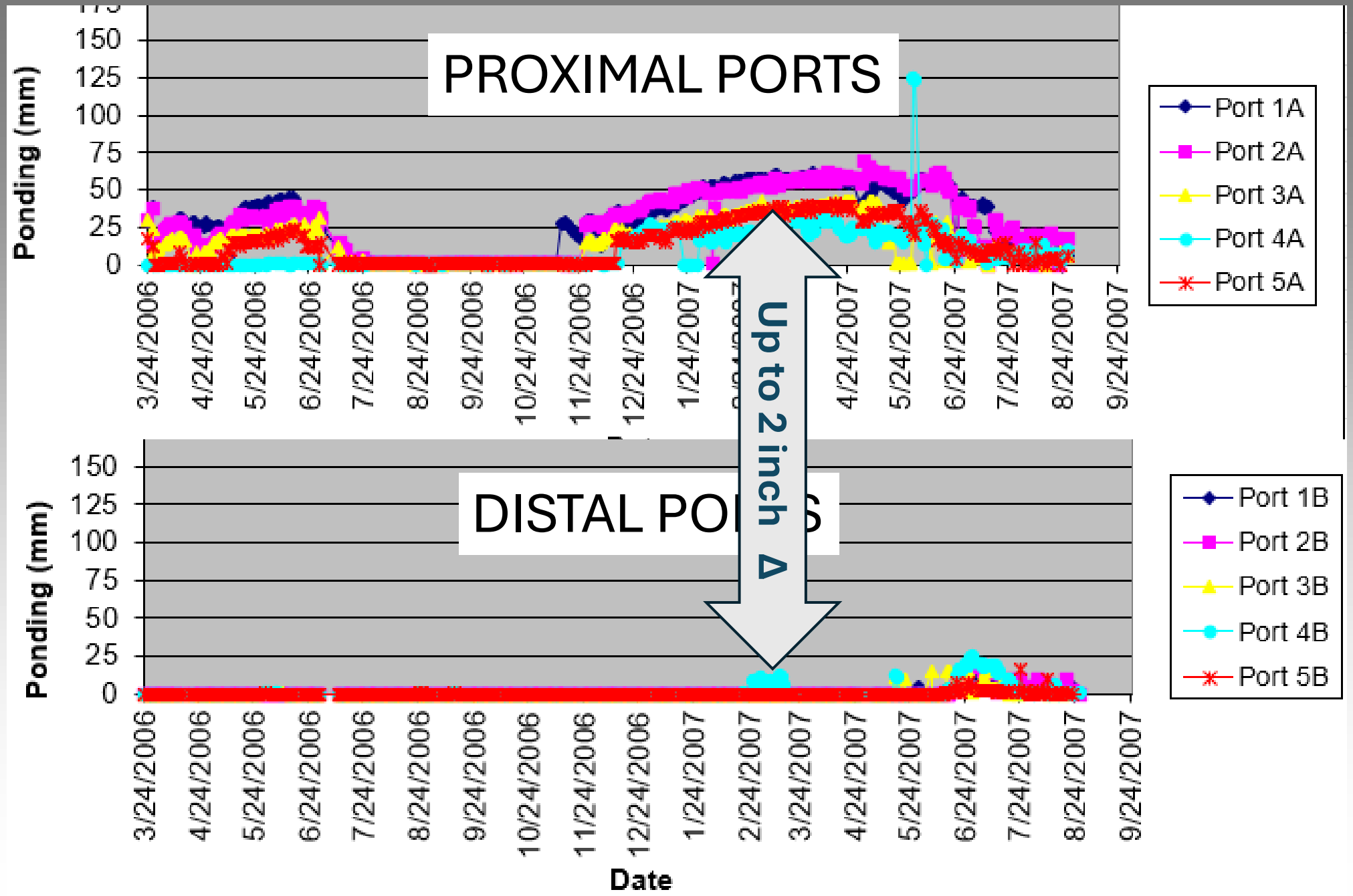


Ponding Measurements



PIPE WAS LEVEL ON TOP OF THE AGGREGATE AND BOTTOM OF AGGREGATE WAS LAID LEVEL


PROXIMAL PORTS
Ponding (mm)
150
125
100
75
50
25
0
3/24/2006
4/24/2006
5/24/2006
6/24/2006
7/24/2006
8/24/2006
9/24/2006
10/24/2006
11/24/2006
12/24/2006
1/24/2007
2/24/2007
3/24/2007
4/24/2007
5/24/2007
6/24/2007
7/24/2007
8/24/2007
9/24/2007
Port 1A
Port 2A
Port 3A
Port 4A
Port 5A
DISTAL PORTS
Ponding (mm)
Date
Port 1B
Port 2B
Port 3B
Port 4B
Port 5B


PROXIMAL PORTS
DISTAL PORTS
Ponding (mm)
150
125
100
75
50
25
0
3/24/2006
4/24/2006
5/24/2006
6/24/2006
7/24/2006
8/24/2006
9/24/2006
10/24/2006
11/24/2006
12/24/2006
1/24/2007
2/24/2007
3/24/2007
4/24/2007
5/24/2007
6/24/2007
7/24/2007
8/24/2007
9/24/2007
Port 1A
Port 2A
Port 3A
Port 4A
Port 5A
Port 1B
Port 2B
Port 3B
Port 4B
Port 5B
Up to 2 inch Δ
Date

Lessons Learned

- The ponding does not develop uniformly across the entire bottom of a stone trench configuration (possibly due to bridging in the stone aggregate)
- There is a seasonality to the restrictive quality of the biomat when it forms.

A more balanced view

A biomat is a simply a biologically active area beneath the area of wastewater distribution. Whether the layer allows for ponding or not is not a measure of its ability to remove contaminants.

Tale of Two Biomats

Ida Dunn Seenit
with forward by
Dewey Knowit PhD

Underground Press Inc.
Toiletbowl, Iowa

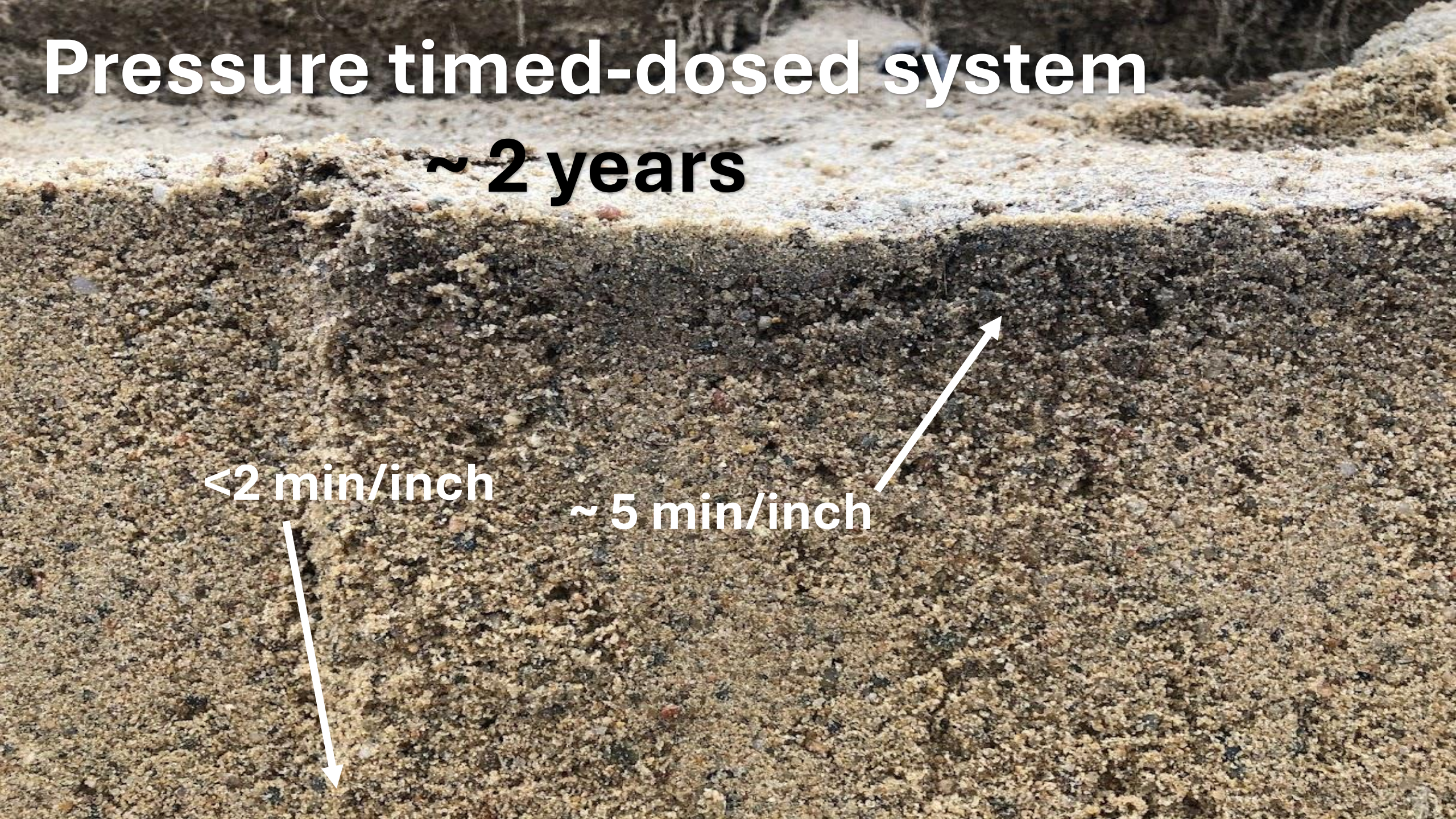
Reviews

"Riveting …held me in suspense 'till the very end" Entero Coccus STOMACH NEWS

"A must-read for those with insomnia" Wynot B. Sleeping WASTELAND NEWS

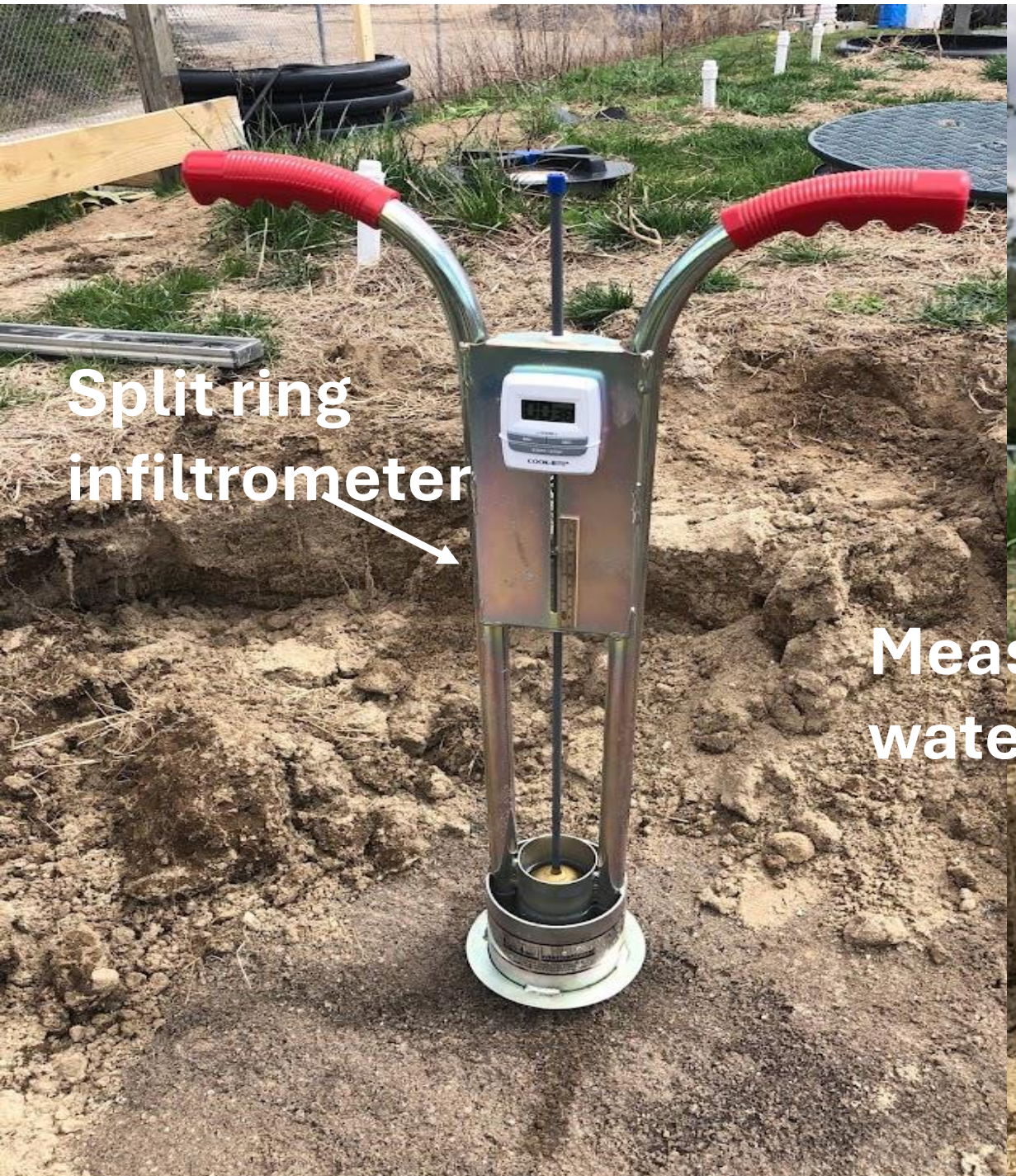
"*An epoch tale that needed telling – I just don't know where to tell it"* Ima Fibber MOTHER EARTH SNOOZE


Gravity fed aggregate-free
System ~ 2 years
Storage volume above biomat
Restrictive biomat
~ 18 min/inch
~ 5 min/inch
6” down
<2 min/inch


Pressure timed-dosed system
~ 2 years
<2 min/inch
~ 5 min/inch

Biomat beneath a drip dispersal emitter ~ 3 years operation


Measuring
biomat
permeability


Split ring
infiltrometer


Timer
Measure
water drop
COOK-RITE

1. Position device on the soil base without fracturing soil structure
2. Set time to zero
3. Fill outer and inner ring with water to the top. I usually do this 2x before starting a test.
4. Test start with water levels at the top of both rings
5. Begin timer when it reaches an arbitrary height (say 1”)
6. Stop time when it reaches two inches below start height.
7. Record and calculate drop rate in desired metric.

NORTH CAROLINA
Environmental Quality

Test good for small areas with multi levels

Myth

Storage volume above the biomat is necessary for proper treatment and operation in a soil treatment area.

Myth

Storage volume above the biomat is necessary for proper treatment and operation in a soil treatment area.

False – An alternate (arguably better) way to achieve treatment in a biologically active area (biomat) is to allow a **wetting-drying cycle** which can be achieved by timed dosing. “Storage volume” is best located in a pump chamber. Evidence Perc-Rite™ drip dispersal, GeoMat™ and other timed-dosed drainfields. This will generally limit actual ponding.

Differences in the Biology of a Biomat

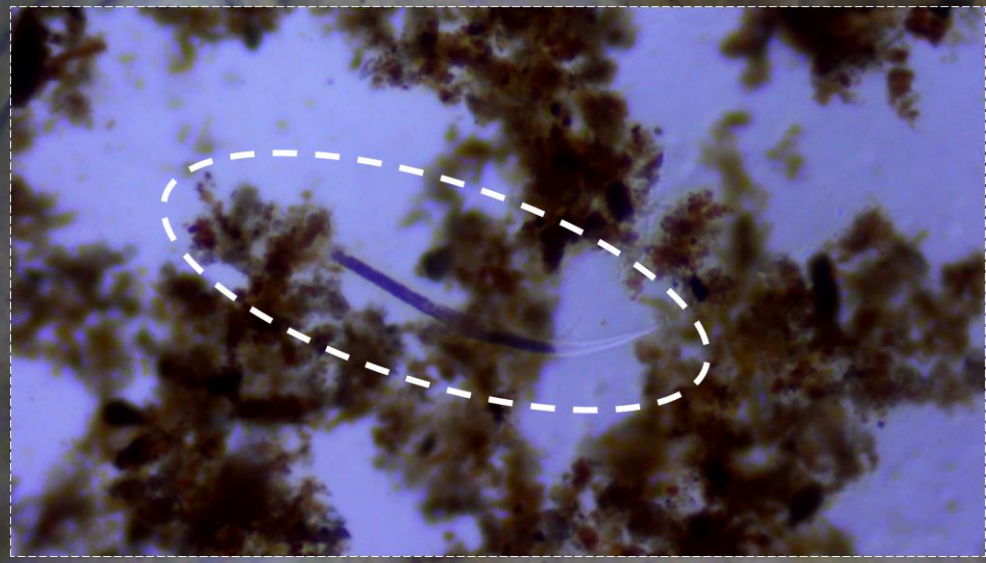
Restrictive → Less Restrictive

Biology of a Very Restictive Biomat

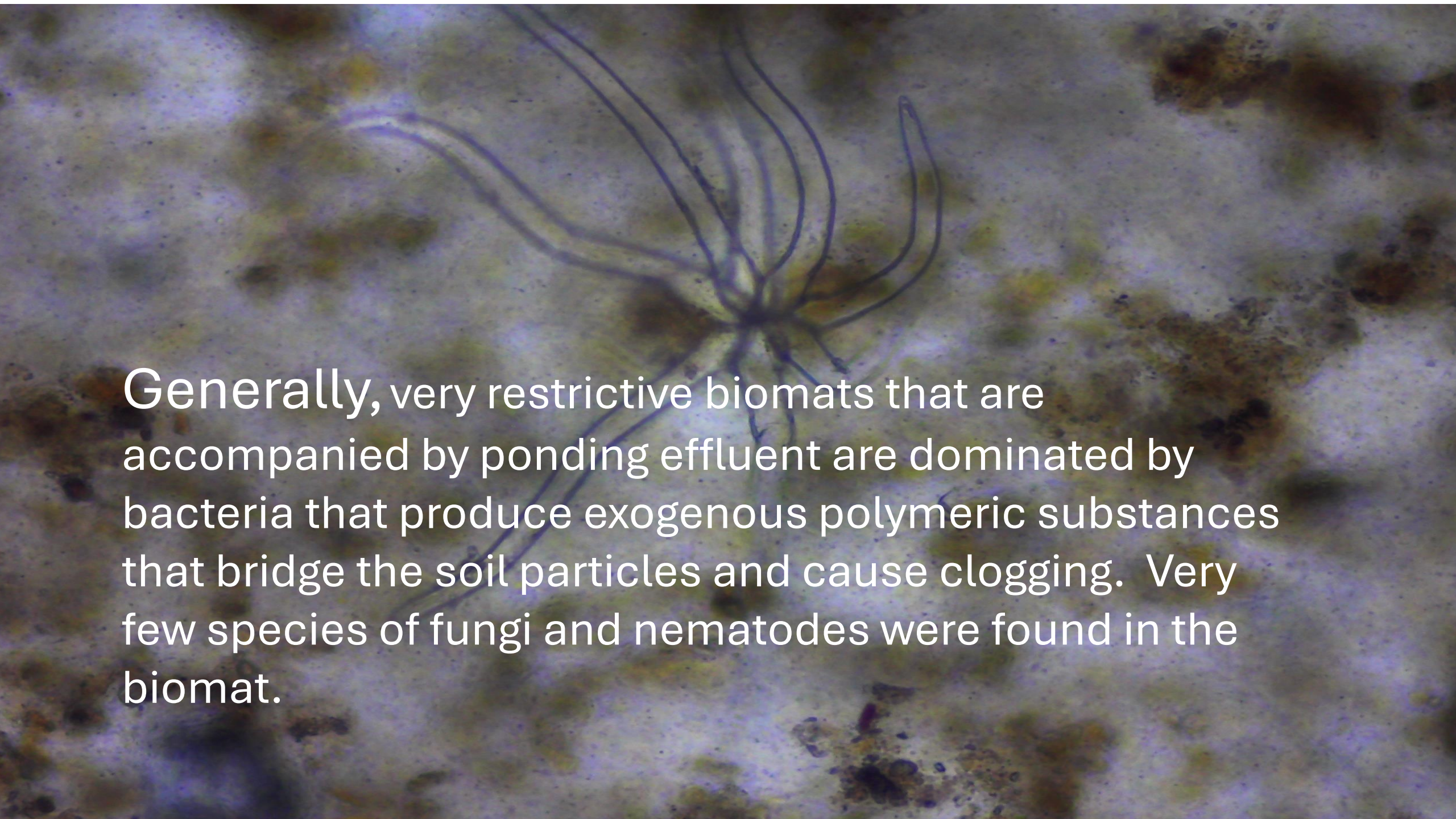
(pronounced ponding)

Helpers to Digest Organic Matter in the anoxic world

Facultative anaerobic bacteria, some nematodes, some fungi



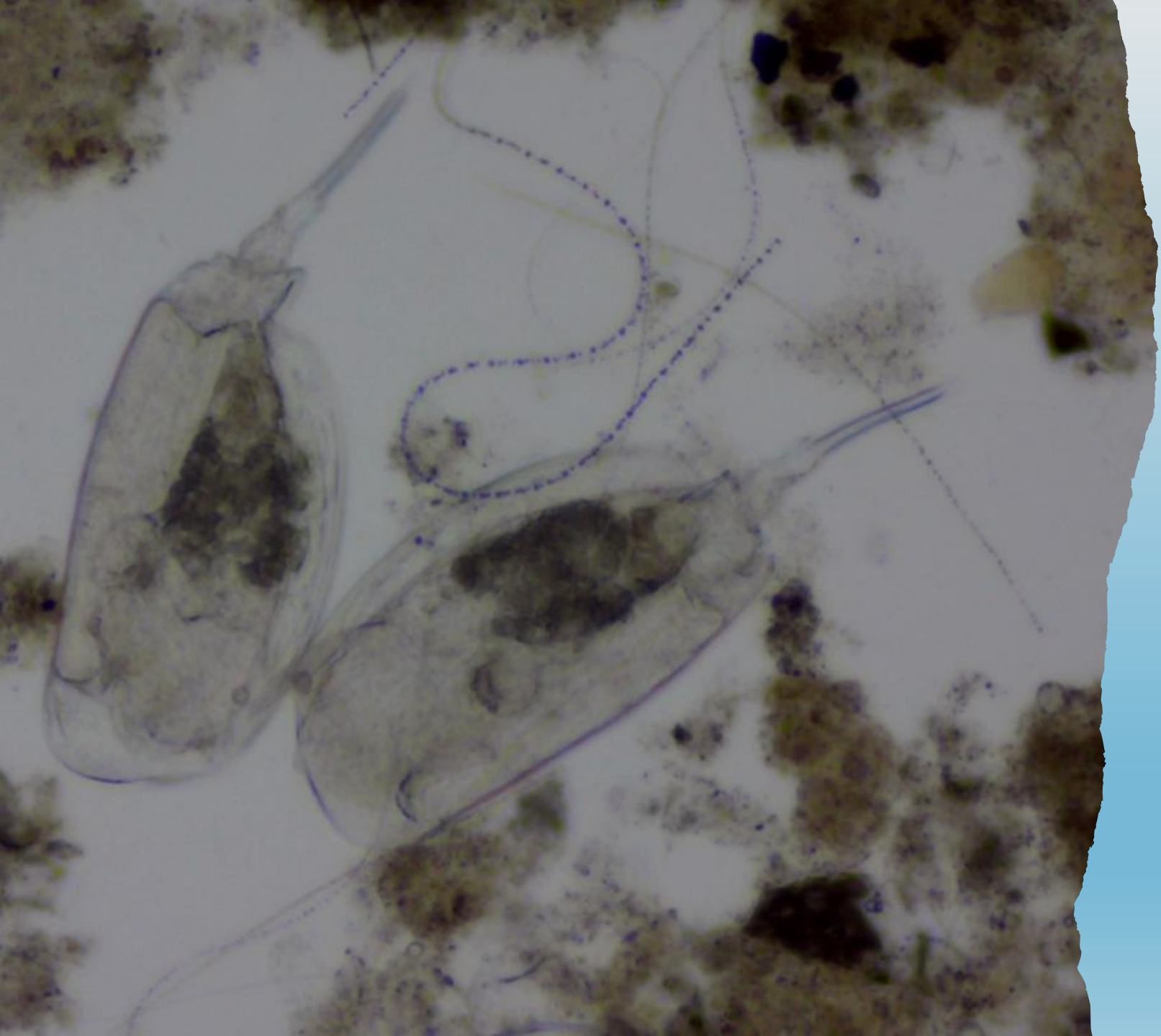
Restrictive biomat scan at 400 x
MASSTC October 2024



Generally, very restrictive biomats that are accompanied by ponding effluent are dominated by bacteria that produce exogenous polymeric substances that bridge the soil particles and cause clogging. Very few species of fungi and nematodes were found in the biomat.

Biology of a Biomat

Having transient or no ponding



Helpers to digest organic matter in the aerobic world

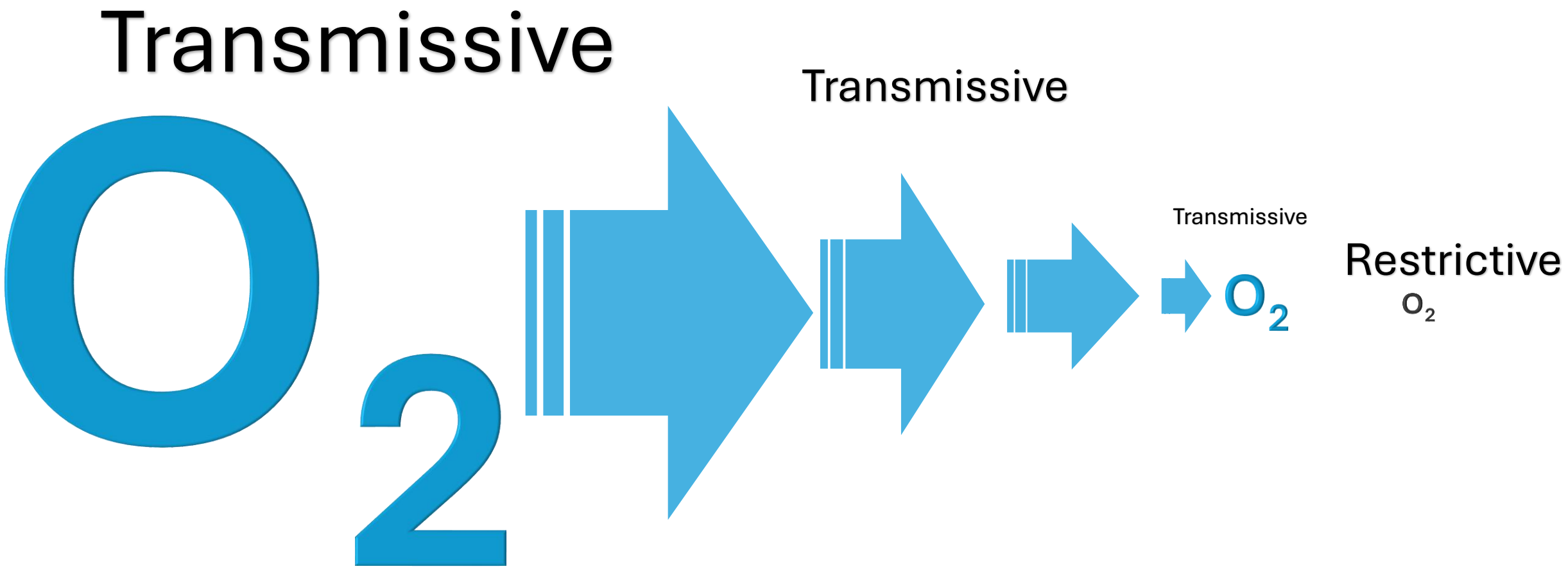
Many bacteria, protozoa, annelids, amoeba, nematodes some arthropods, fungi and others

Oxygen

The ultimate electron acceptor

The more oxygen supplied to the soil interface, the better treatment of the wastewater for enteric bacteria and viruses, nitrogen transformation, biochemical oxygen demand, suspended organic solids and certain endocrine disrupting compounds and contaminants of emerging concern.

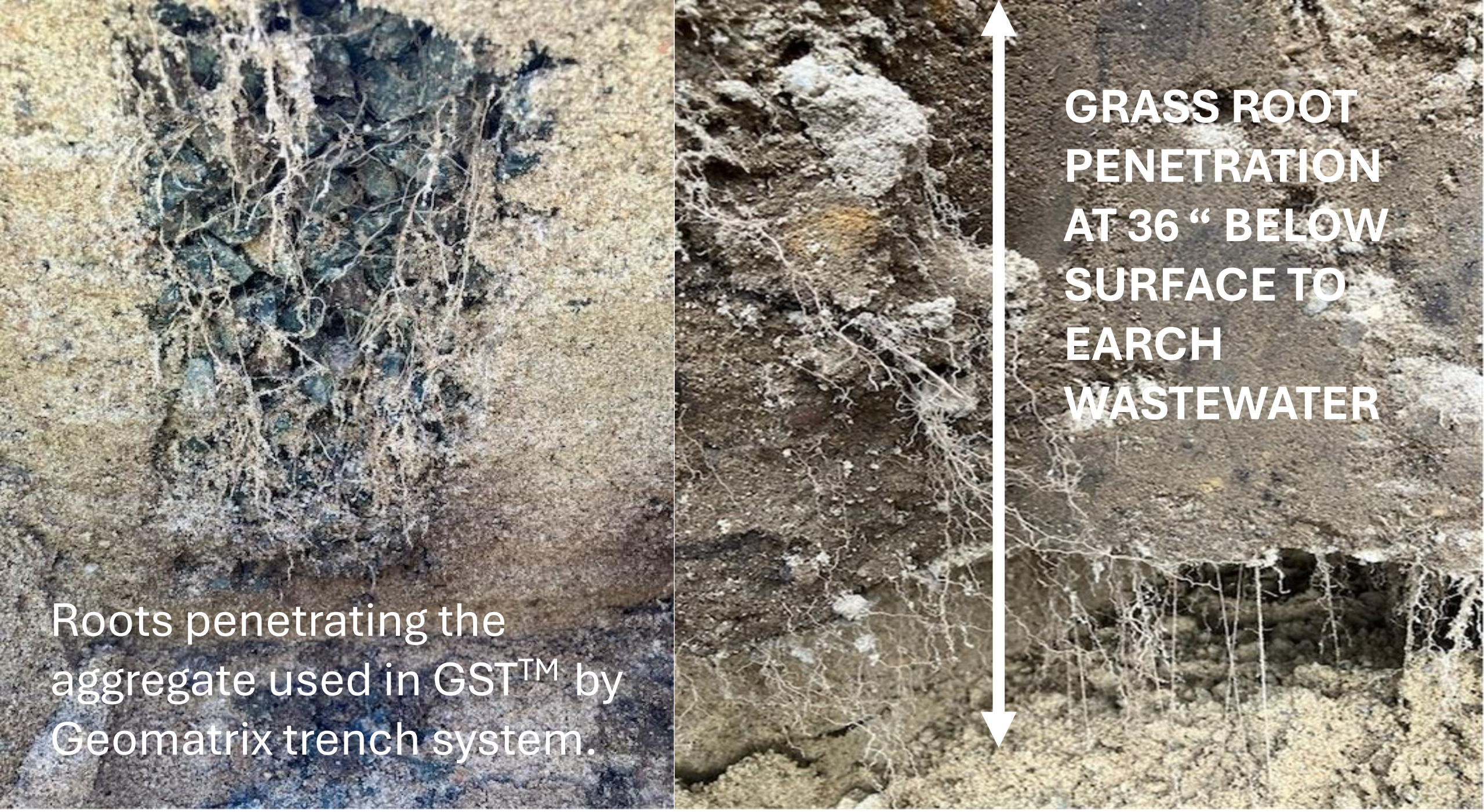
Biomats – two extremes and anywhere in between



Another helper in the recycling of nutrients

Roots of grass exude sugars and other nutrients that support a rich biome of organisms that help degrade wastewater constituents.

organic acids, amino acids, soluble sugars.



Roots penetrating the aggregate used in GST™ by Geomatrix trench system.


If there was any doubt

Semi- Finally light reading for those with insomnia

"There are more things in a biomat, Horatio, than are dreamt of in your philosophy" ***(original line in Shakespeare)***

ELSEVIER

Journal of Contaminant Hydrology
Volume 232, June 2020, 103654

The influence of pre-treatment on biomat development in soil treatment units

Jan Knappe [a b], Celia Somlai [a 1], Andrew C. Fowler [b], Laurence W. Gill [a]

Bull Math Biol (2013) 75:1985–2001
DOI 10.1007/s11538-013-9881-y

Society for Mathematical Biology

ORIGINAL ARTICLE

Biomat Development in Soil Treatment Units for On-site Wastewater Treatment

H.F. Winstanley · A.C. Fowler

Long-term flow rates and biomat zone hydrology in soil columns receiving septic tank effluent

C.D. Beal [a b], E.A. Gardner [c], G. Kirchhof [d], N.W. Menzies [d]

Show more

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https://doi.org/10.1016/j.watres.2006.04.018 ↗ Get rights and content ↗

Spatial Variation of the Microbial Community Structure of On-Site Soil Treatment Units in a Temperate Climate, and the Role of Pre-treatment of Domestic Effluent in the Development of the Biomat Community

Alejandro Javier Criado Monleon[1*] Jan Knappe[1,2] Celia Somlai[1] Carolina Ospina Betancourth[3]
Muhammad Ali[1,4] Thomas P. Curtis[3] Laurence William Gill[1]

Soil Science Society of America Journal

SSSA Soil Science Society of America

Numerical solutions, math solutions

Gravel Effect on Wastewater Infiltration from Septic System Trenches

D. E. Radcliffe ✉ L. T. West, J. Singer

First published: 01 July 2005 | https://doi.org/10.2136/sssaj2004.0302 | Citations: 24

Soil Survey Horizons

Article

Spreadsheet for Converting Saturated Hydraulic Conductivity to Long-Term Acceptance Rate for On-Site Wastewater Systems

D. E. Radcliffe ✉ L. T. West

First published: 04 August 2015 | https://doi.org/10.2136/sh2009.1.0020 | Citations: 2

Volume 50, Issue 1
Spring 2009
Pages 20-24

References Related Information

water ENVIRONMENT RESEARCH

Water Environment Federation the water quality people

Research Article

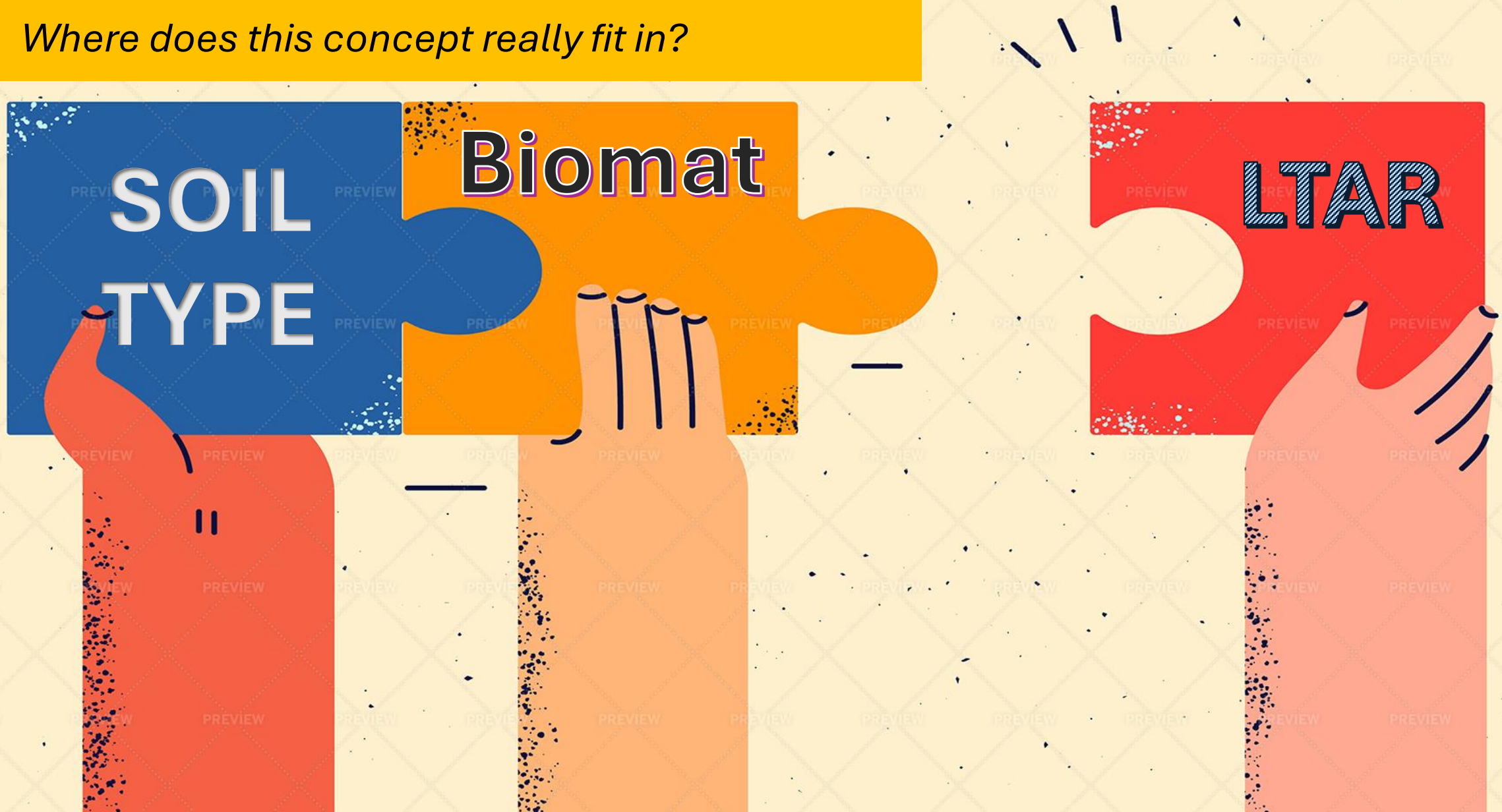
Field Demonstration of the Combined Effects of Absorption and Evapotranspiration on Septic System Drainfield Capacity

Ken Rainwater, Andrew Jackson, Wesley Ingram, Chang Yong Lee, David Thompson, Tony Mollhagen, Heyward Ramsey, Lloyd Urban

First published: 01 March 2005 | https://doi.org/10.2175/106143005X41726 | Citations: 6

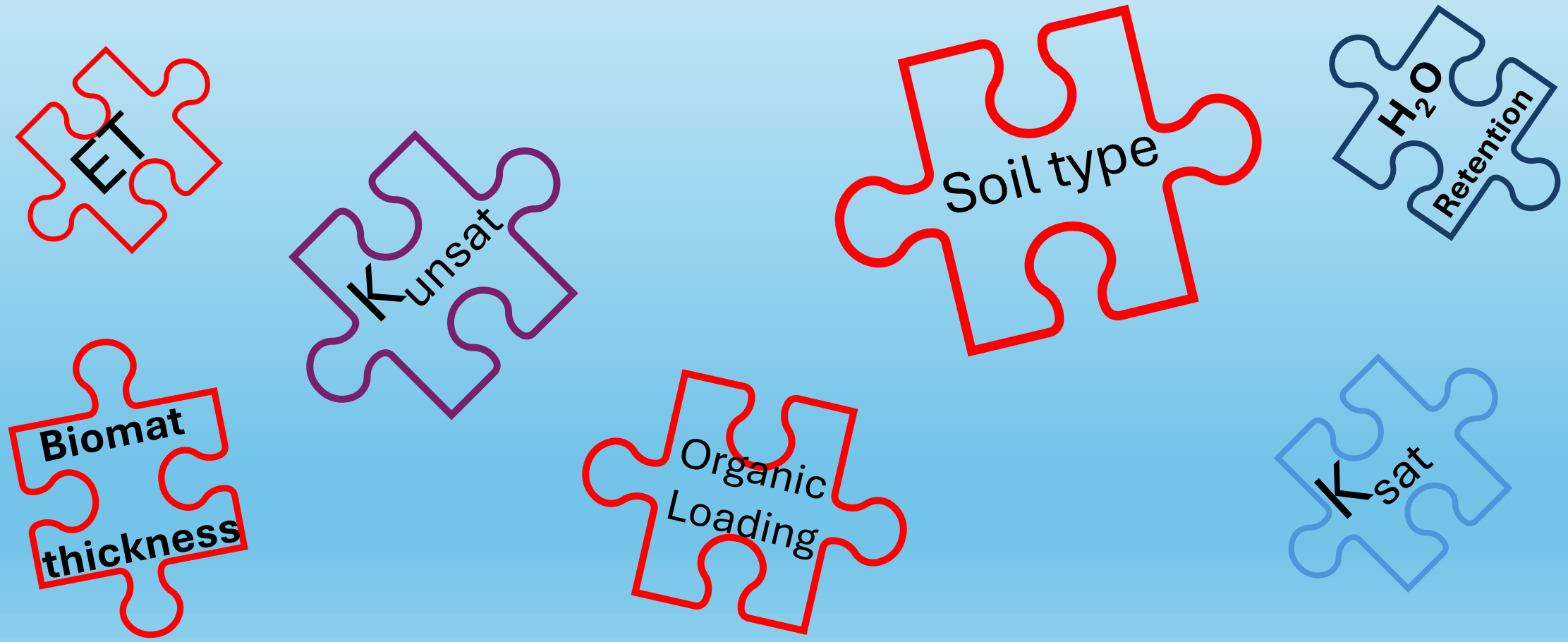
Long Term Acceptance Rate

Where does this concept really fit in?



LTAR

a puzzle unto itself



How should all this inform our designs and operation ?

- More air is better in all situations. Consider the vents and vent sizing when designing any system
- Pressure dosing and resting a system prolongs the life and overall performance of a system (actually recommended in the DeFeo, Wait & Associates report).
- Timed dosing which allows a rest between doses should be considered.
- Products which aerate a soil treatment area should be researched and considered (one such is Soil Air™).

Thank you

MASSTC

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Questions?