Comments on Facility Designs

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AST™

BEAD FILTER SOLUTIONS

Specializes in Floating Bead Filters

- RAS Aquaculture
- RAS/Aquaponics
- Zoos
- Industrial Wastewater
- Domestic Wastewater

Nitrification

Denitrification

TSS removal

BOD5 reduction

Sludge Digestion

Heavy R&D Component

- 50 % staff engineering
- several Consultants
- SBIR research
- Support of Univ. R&D

Develop RAS Layouts & production estimates for

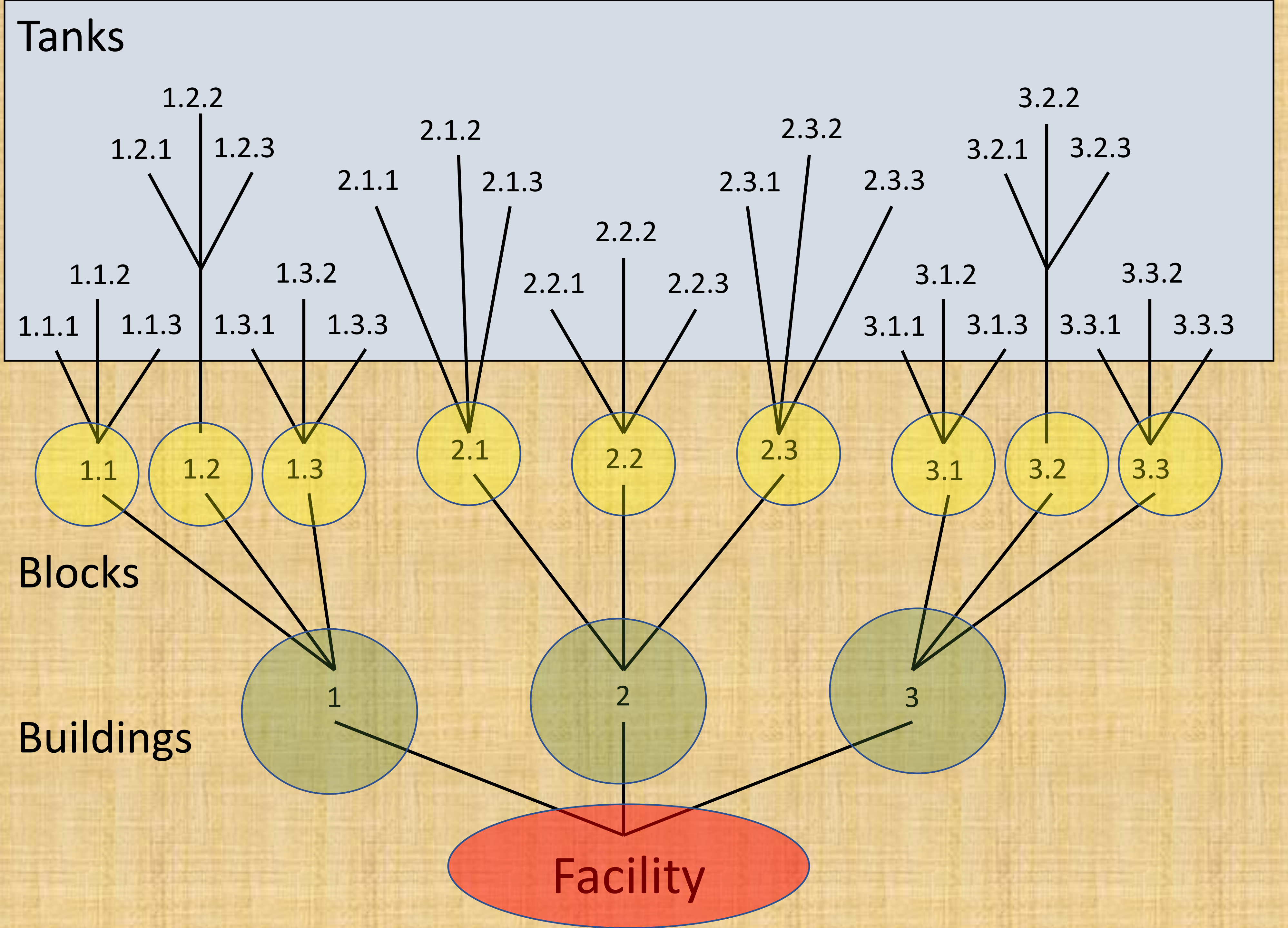
- Freshwater
- Marine
- Aquaponics

Work with local engineers

- Building Issues
  - Power
  - Heating
  - Water supply
  - Discharge issues

BeadFilters.com

AstFilters.com


Tanks
1.2.2
1.2.1
1.2.3
2.1.2
2.1.1
2.1.3
2.3.2
2.3.1
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3.2.2
3.2.1
3.2.3
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1.1.2
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1.1.1
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1.3.1
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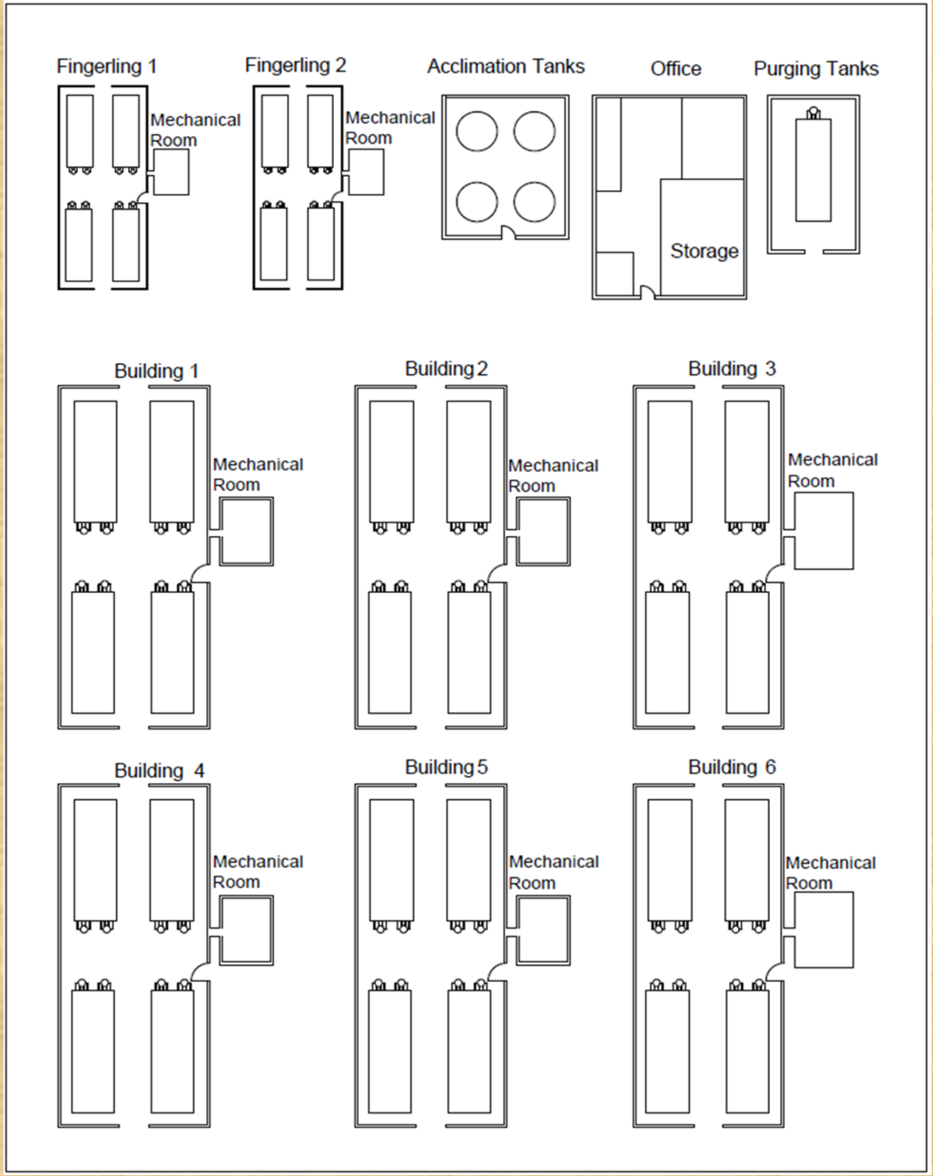
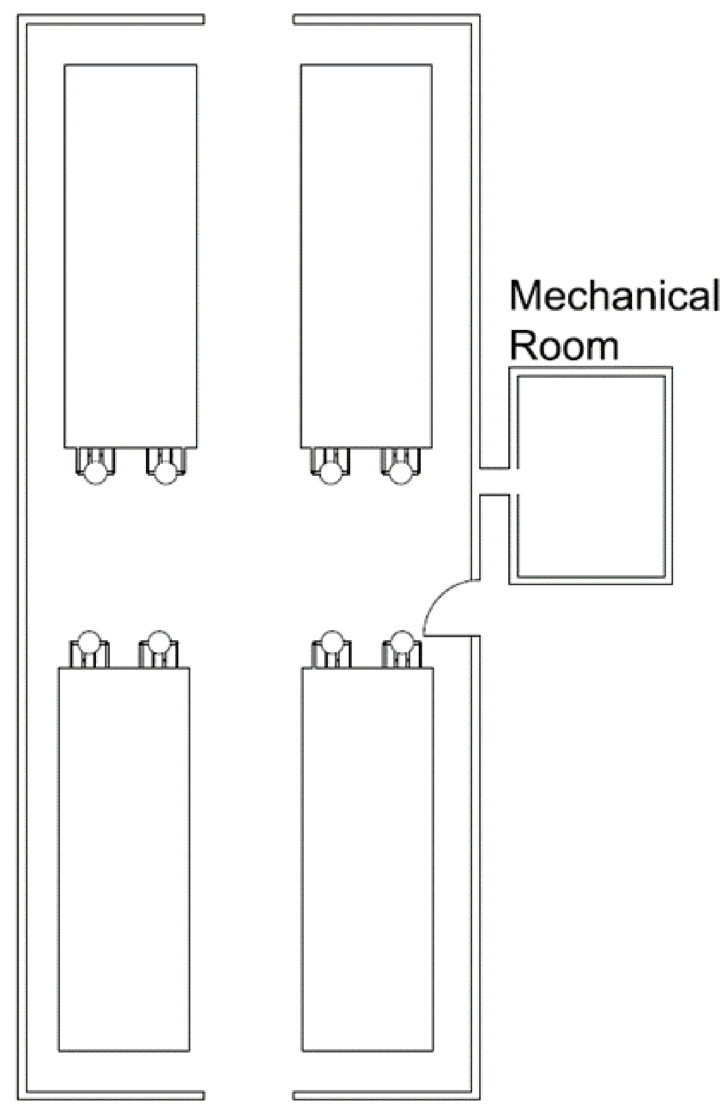
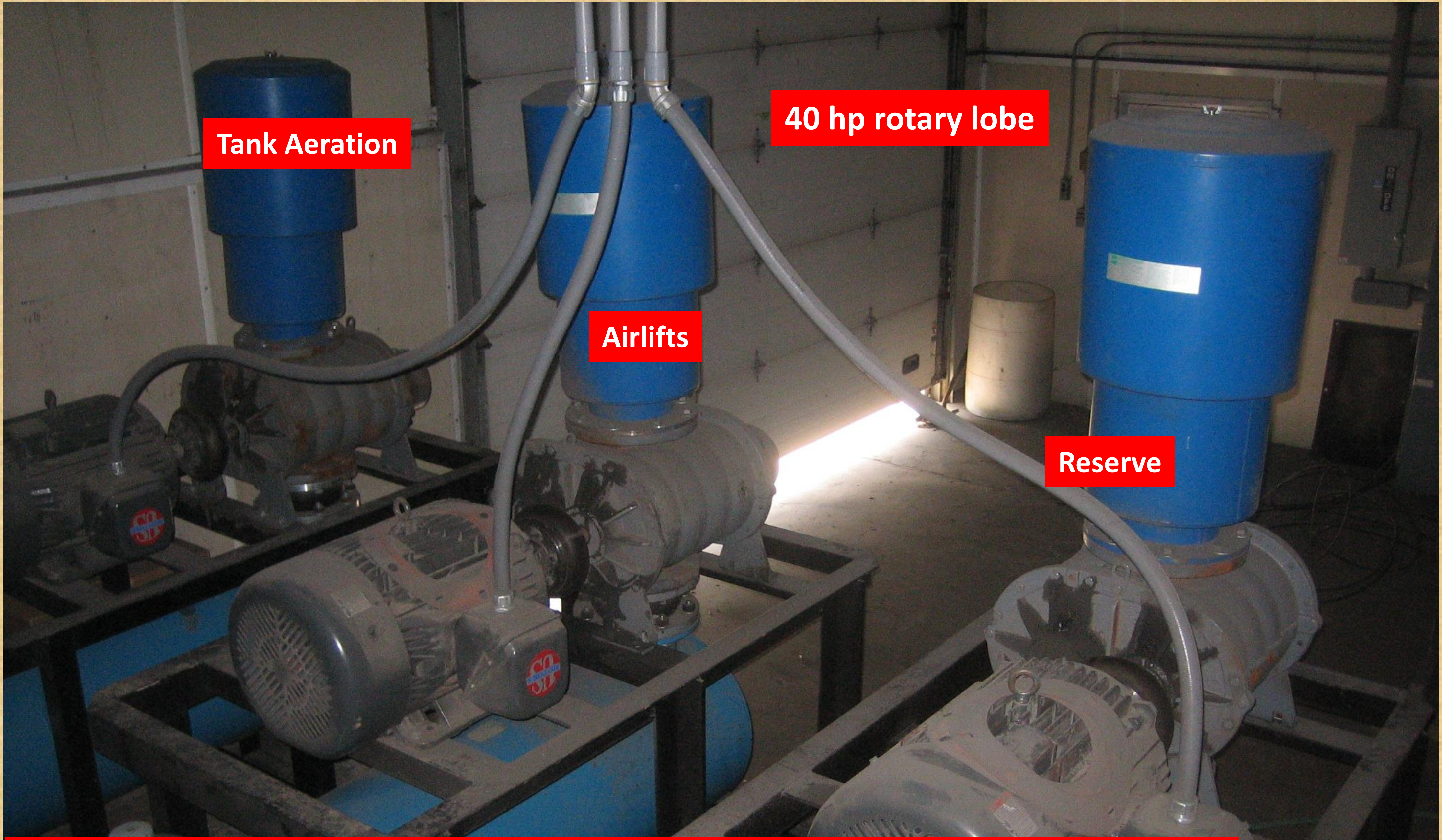
3.1.1
3.1.3
3.3.1
3.3.3
1.1
1.2
1.3
2.1
2.2
2.3
3.1
3.2
3.3
Blocks
1
2
3
Buildings
Facility

Layout of the proposed facility





Blueprint of a grow-out building



Early systems were sized with a G:L 0f 2 about 0.25 hp/1000 gallon
These units used variable frequency drives to optimize energy usage

Condensation Problems


80,000 gal (300 m3)
80,000 gal (300 m3)
140 kg/day
Texas
2011


2.1 m³ beads
10 horsepower

Collins, South Dakota (2008)

Spring Lake, S.D. (2007)

Mississippi, 2007

Colorado, 2010

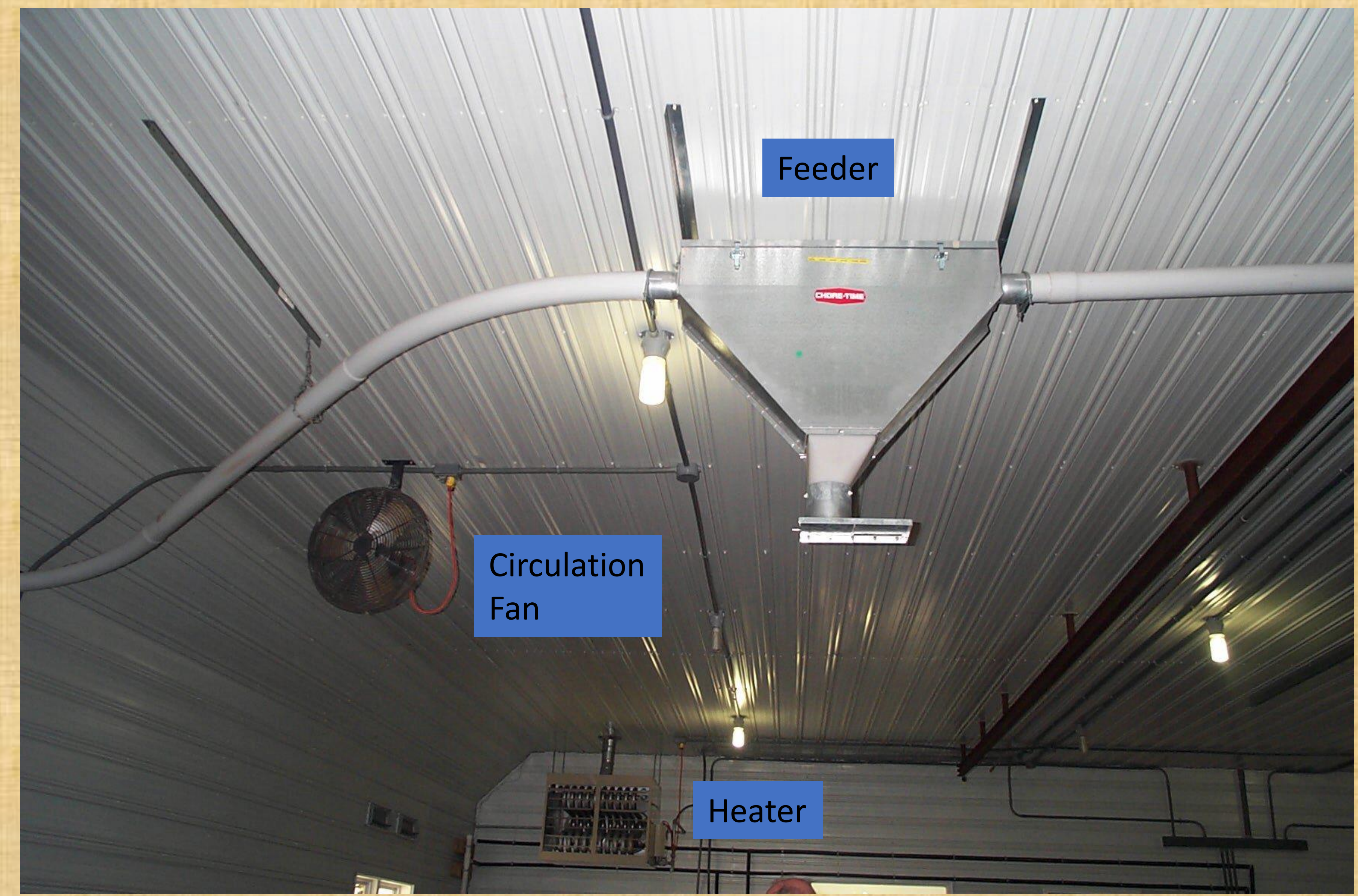
Illinois, 1997

Truck Access for
Feeding
Harvesting

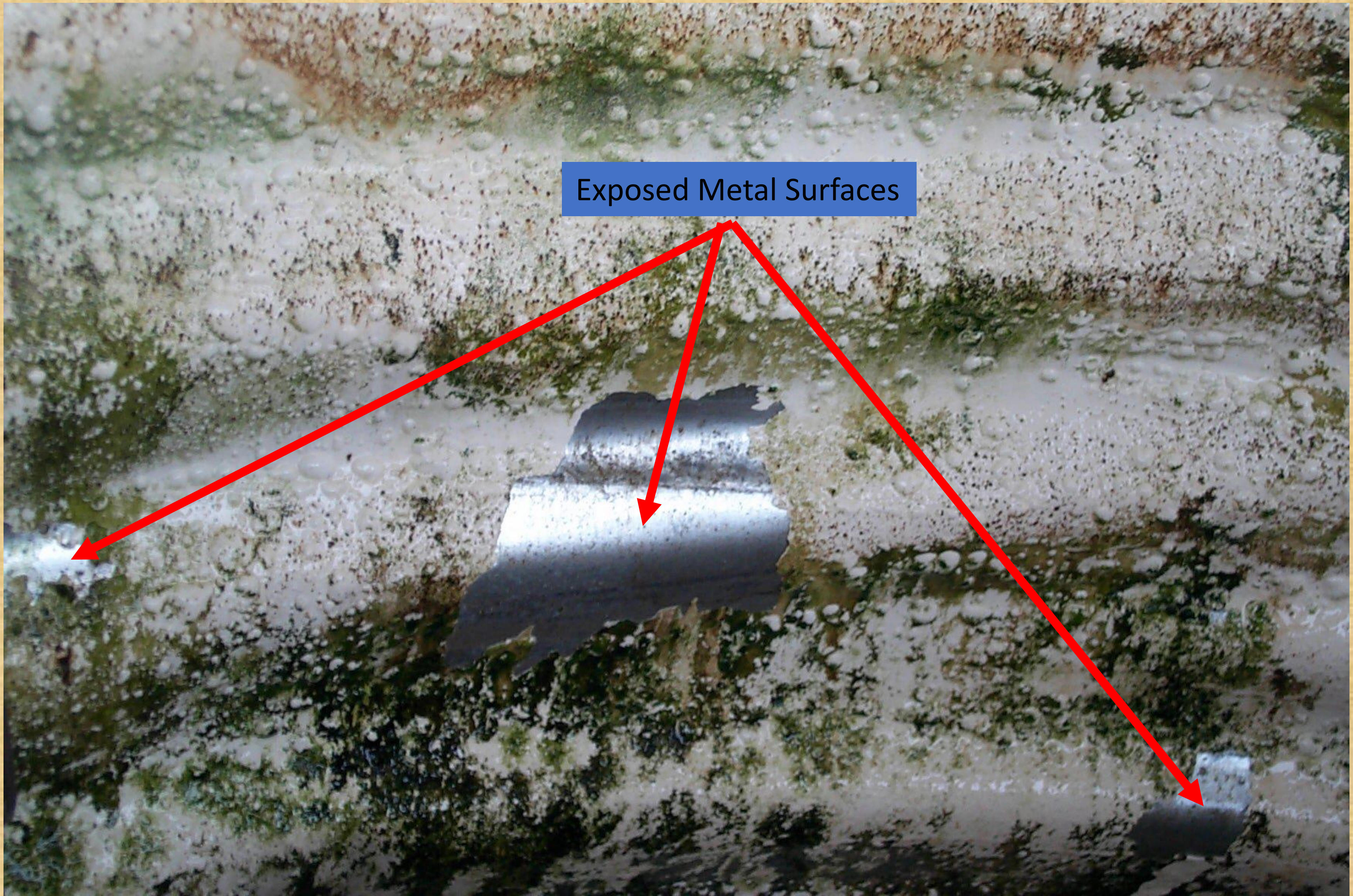
Ron@PolyGeyser.com

Aquaponics


Feed Storage Bins
Liquid Oxygen


Feeder
CHORE-TIME
Circulation Fan
Heater

Materials Selection?



Summary-Building-Marine

- Beware of condensation
- Avoid metal
- Minimize electronics and voltage in wet room
- Design and open format for access
- Retangular tanks are make for more efficient space utilization
- Green houses are used into the mid west as a cost effective alternatives
  Abandoned Chicken/turkey houses also widely used
- Design for energy conservation
- Pumps must draw external air to avoid CO2 buildup
- Avoid slick floors

Fractal design = disease avoidance

Mostly heated by air

Questions

Denitrification, Water Reuse, and Waste Management

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Reusing Water

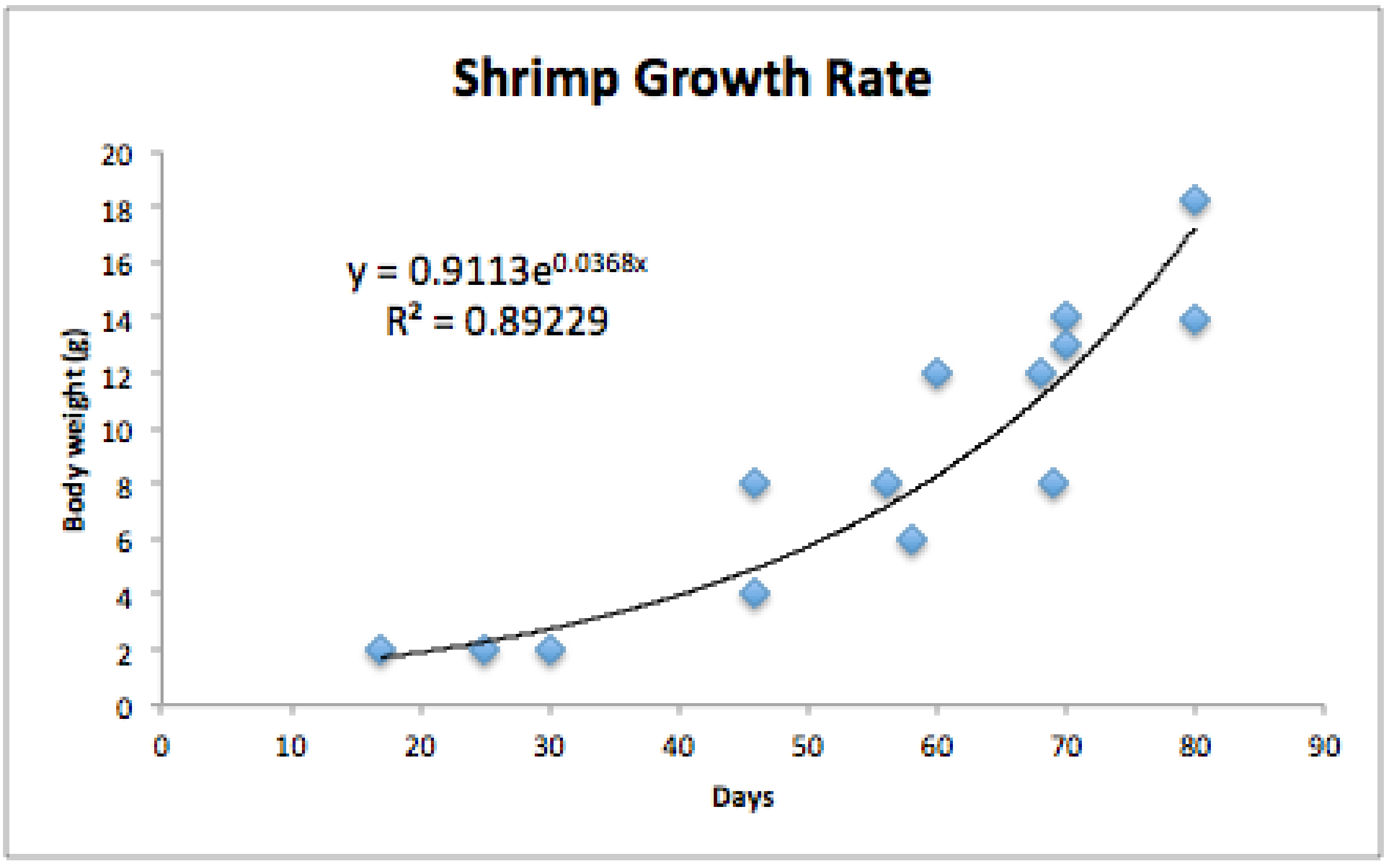
- Alkalinity exhaustion
- Nitrate accumulation
- Refractory Organic Accumulation

Solids management

- Treating Sludge
- Disposing of sludge

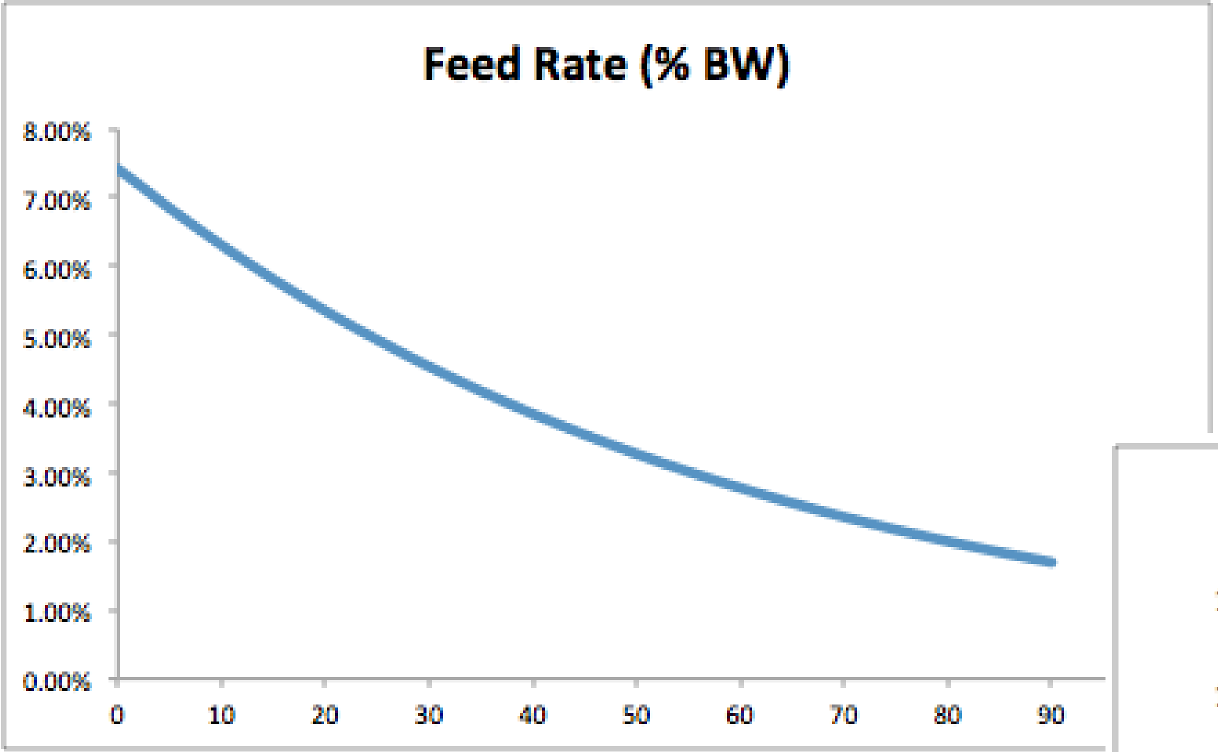
Water Reuse

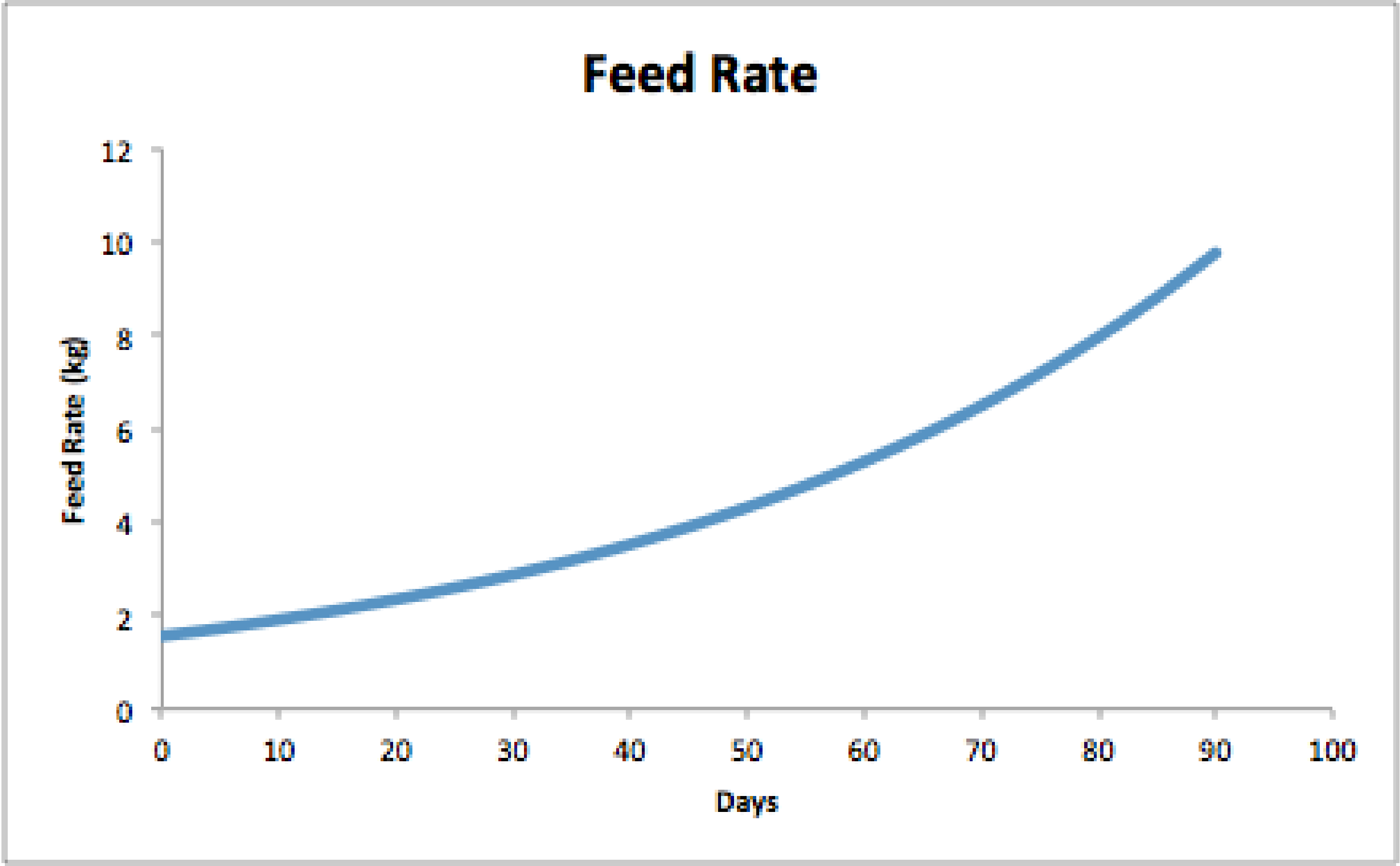
- Water does not "age"
- For shrimp growout
  - Salt level increases due to evaporation …..add freshwater
  - Alkalinity will decline at some point…….add bicarbonates
  - Refractory organics will accumulate….water browns…..ozonate if you care
  - Nitrates increase……denitrify or discharge
- Cumulative feed burden (CFB) an indicator of water resuse can range from 1,000-100,000 gm /m^3
  - No clear limit on water reuse once dentrification is implemented.



- Liao (1977)
- Delmendo & Rabanal (1956)
- Hirasawa (1985)

- This growout starts at a single shrimp weight of about 1gram. (only shows the final 3 months of growout)





Sara (2007) referenced for the change in feed rate (as % bw of shrimp)

Feed ➔ Fish ➔ Ammonia

- 30 grams nitrogen per kg feed @35 % protein
- From protein metabolism

- Feeding produces ammonia
- Ammonia is toxic at a few mg-N/L
- Ammonia has energy to give
- Nitrifier bacteria have the enzymes to unlock the energy

Ammonia ➔ Nitrite ➔ Nitrate

- Energy producing reaction
- Requires chemotrophic nitrifiers (slow growing)
- Oxygen > 2* mg/L (consumes 4.56 **mg/mg-N converted)
- Alkalinity >100* mg/L (consumes 7.5** mg/mg-N)
- pH>7.0 (impacted through alkalinity consumption)

That's 1/4 kg sodium bicarbonate per kg feed added. Adds 7-10 cents cost per kg fish produced

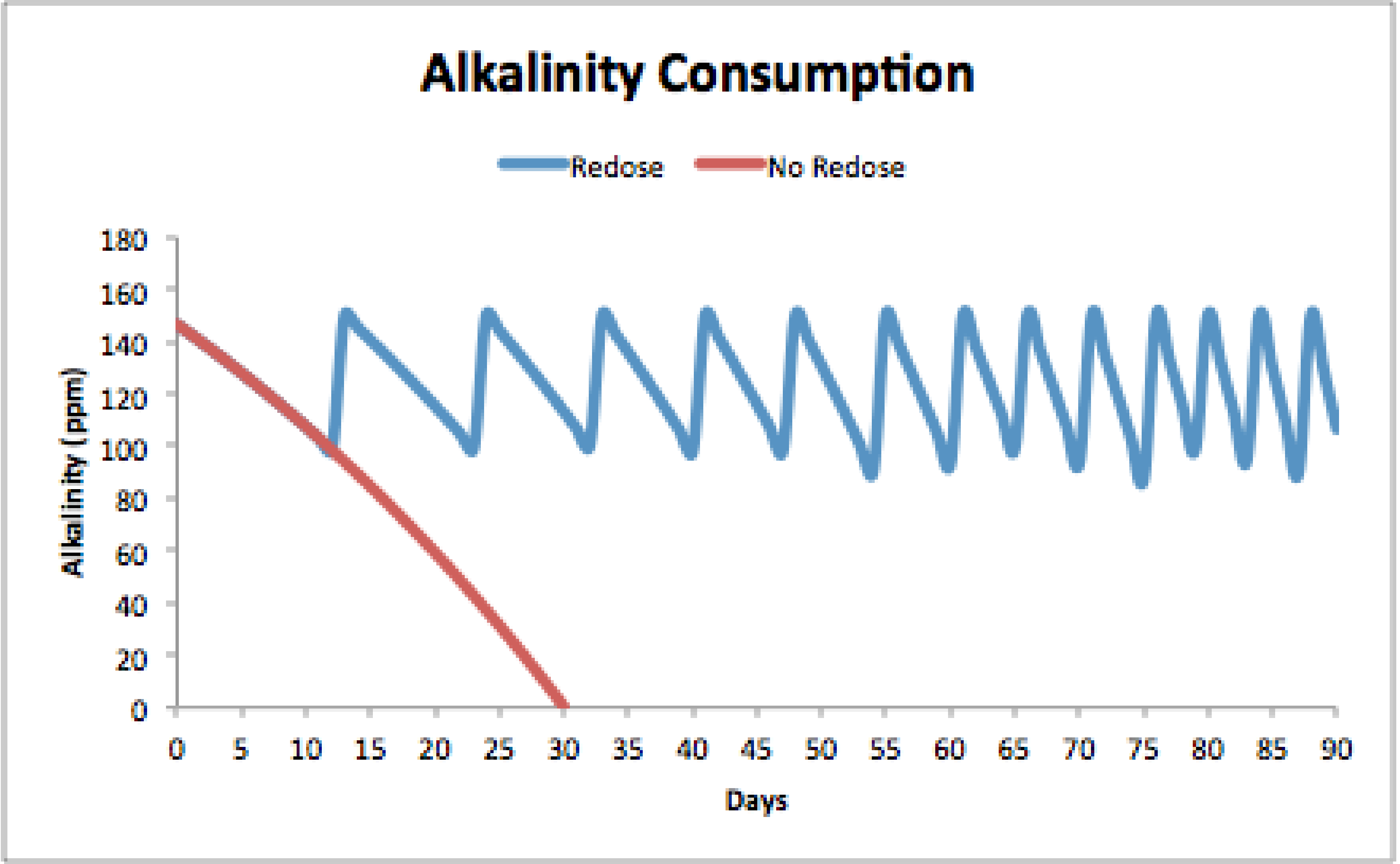
Produces Nitrate

- stable under aerobic conditions (forever)
- Toxic as in the range of 300-500 mg/L

- Practical management minimums
- **stochiometric ratios

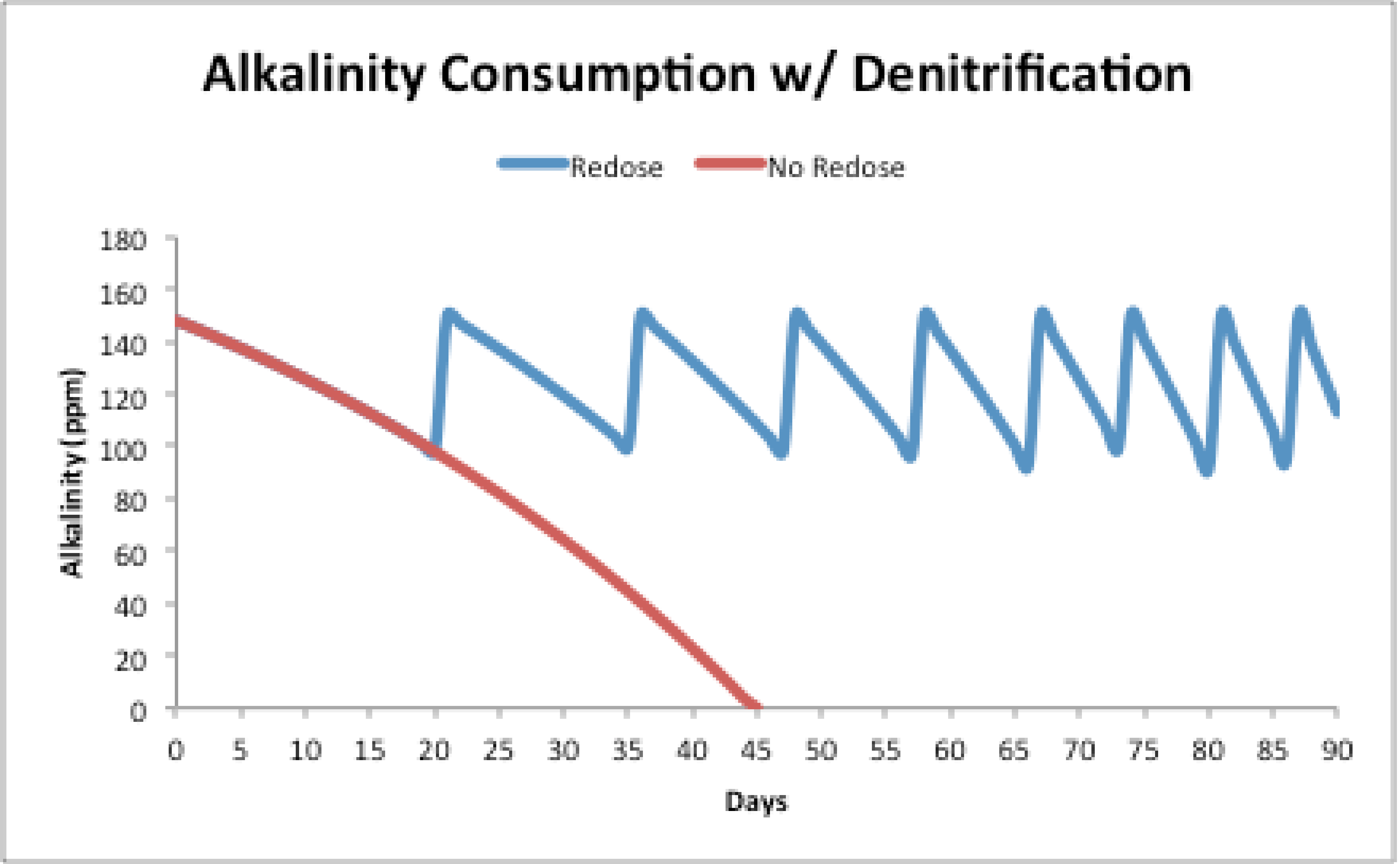
Here is the pattern of alkalinity exhaustion

-No denitrifcation
-No carbon added



Add

- Sodium bicarbonate (safest, dosage insensitive)
- Hydrated Lime (cheapest, calcium precipitates, dosage highly sensitive)
- Soda Ash (moderately unstable pH)



Alkalinity Consumption w/ Denitrification
Redose
No Redose
Alkalinity (ppm)
180
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
Days

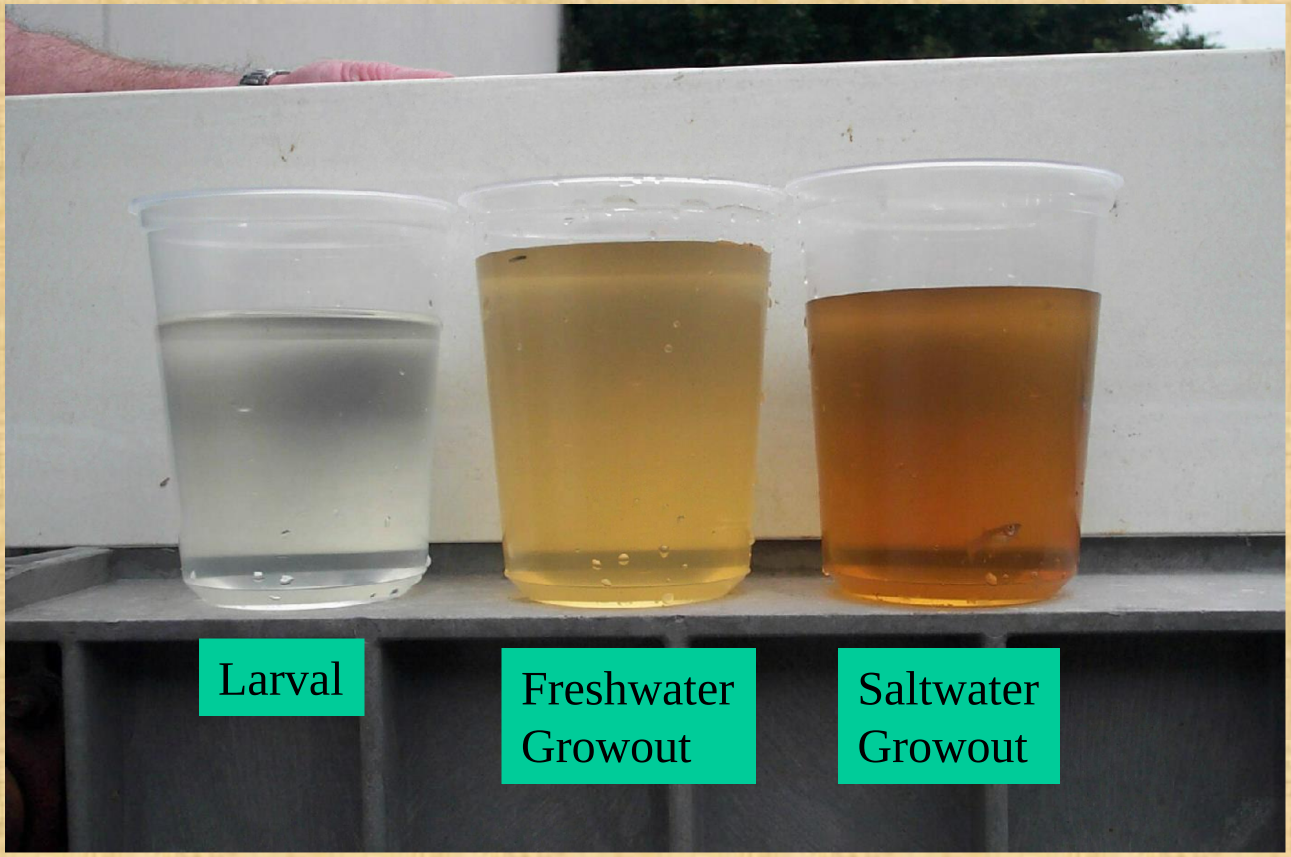
Summary -Alkalinity

- Akalinity declines accelerate as shrimp grow
- Low alkalinity impairs nitrification
-
- Correctable by Bicarbonate/Lime addition
- Denitrifcation reduces Alkalinity declines by 50%

Common Reuse Characterization

Type	HRT (days)	CFB (mg/l)
Open	1-5	1,000-3,000
Closed	20-60	10,000-30,000
No Discharge	100+	100,000+

CFB→



Different CFB values induced by water exchange

Ozone

$O_3 + H_2O \rightarrow HO_3^+ + OH^-$

$HO_3+ + OH^- \rightarrow 2HO_2$

$O_3 + HO_2 \rightarrow HO + 2O_2$

$HO + HO_2 \rightarrow H_2O + O_2$

Free Radicals responsible for disinfection

These are only two of the many ozone generators that are commercially available.

Photos from AquaticEco.com

Ozone Energy Requirements (color control)

Component	Median Energy Consumption kWh/kg ozone
Air Preparation	5.5
Ozone Generation (Air Feed)	16.5
Ozone Generation (Pure Oxygen)	9.9
Ozone Contacting	4.4
All other components	1.7
Total (Air Feed)	**28.1**
Total (Pure Oxygen)	**21.5**

Source: Metcalf and Eddy 2003

Ozone Dosing: 7 – 15 g O3/kg feed (Christensen et. al. 2000)

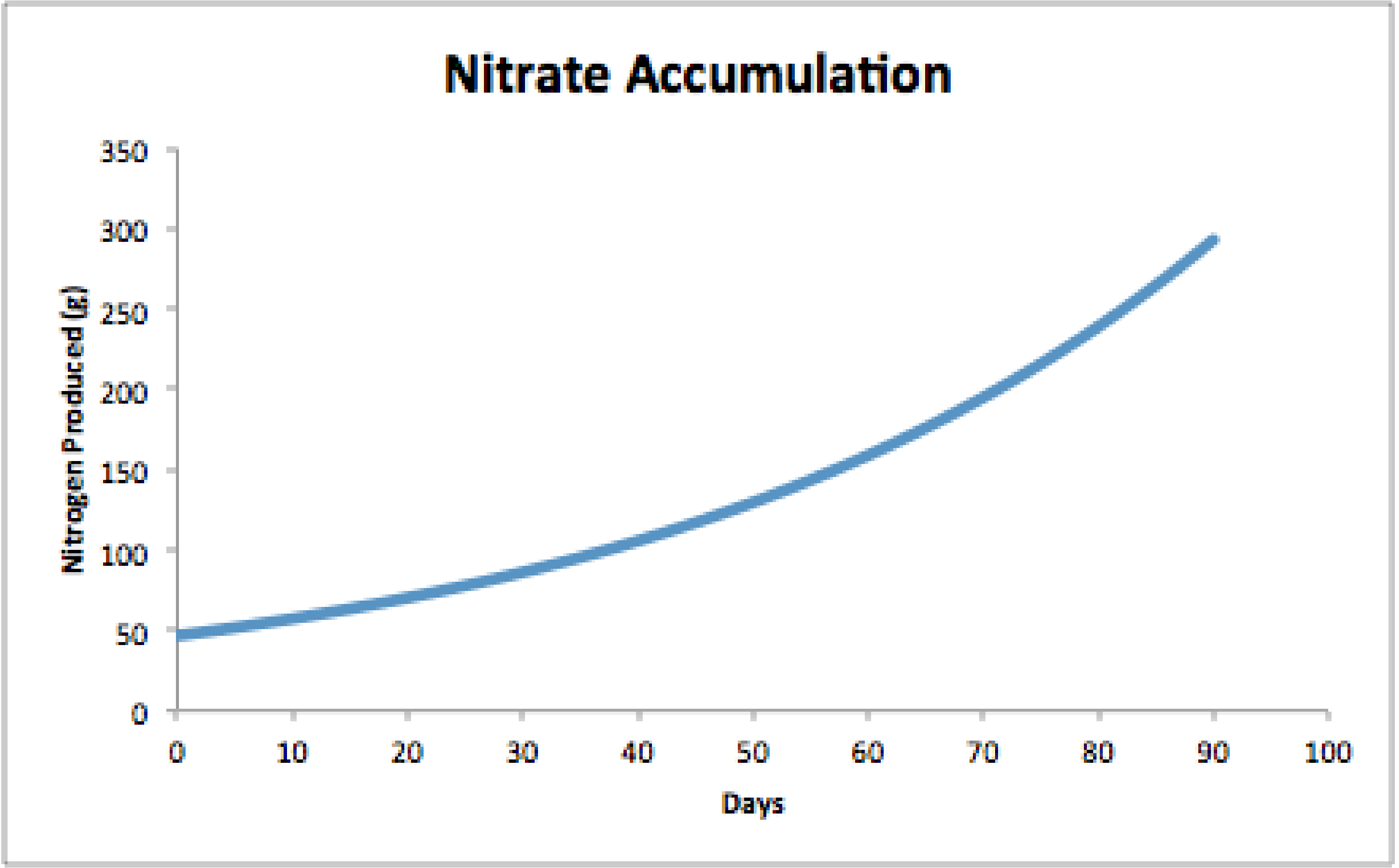
Feed	**Operating Disinfection Cost ($/kg shrimp or fish produced)**
Air	0.03 – 0.06
Pure Oxygen	0.02 – 0.05

Assumes an energy cost of 0.08/kWh

Capital costs not included

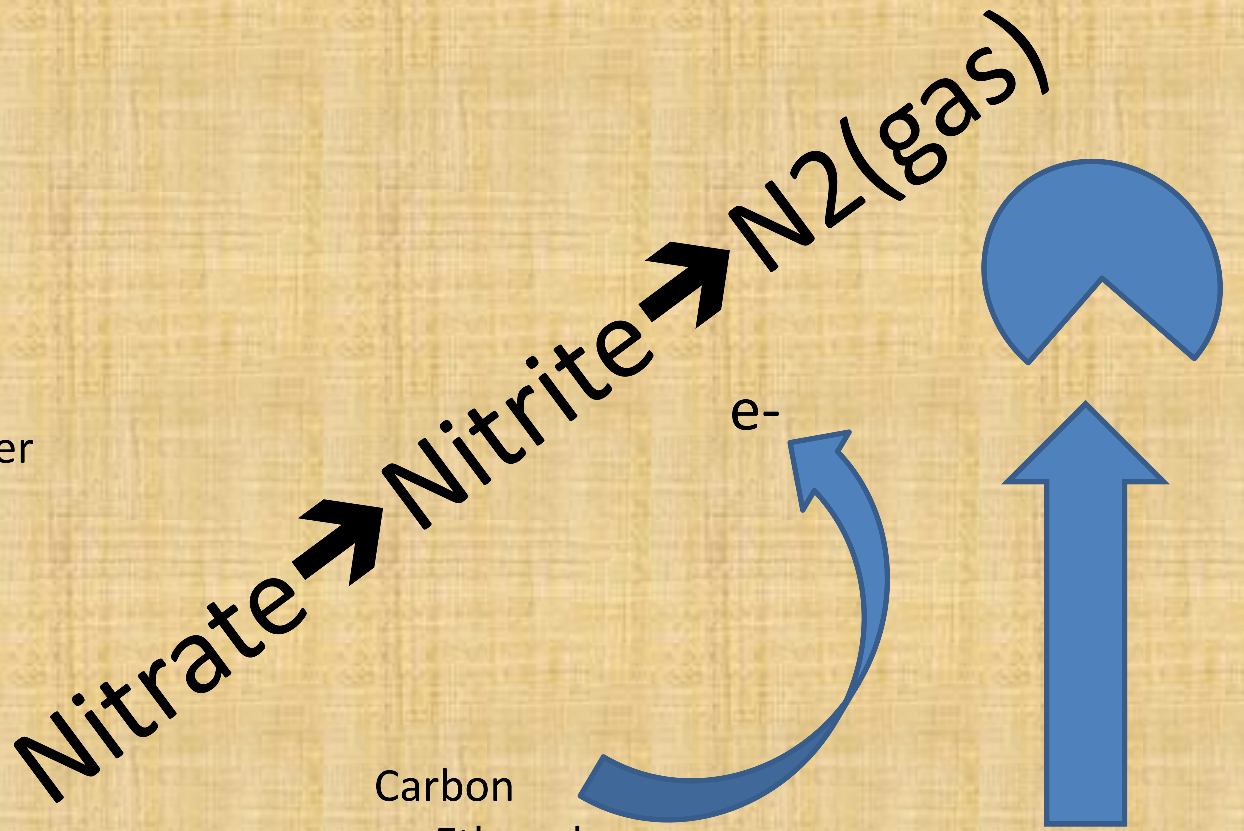
Food conversion ratio at 1.5

Here is the pattern of nitrate accumulation for the first season ….



Anaerobic Denitrification

- Heterotrophic bacteria (fast growing)
- Oxygen < 0.5 mg/L
- Nitrate must be present
- Conversion of Nitrate to N2 gas id an energy loser
- A source of energy (carbon) required to provide the energy



Carbon
- Ethanol
- Methanol
- Starches
- Sugars
- Manure

energy

Once the N2 gas is formed it leaves the water
…No More problem

Low Dissolved Oxygen

A carbon source

Nitrate➔N2

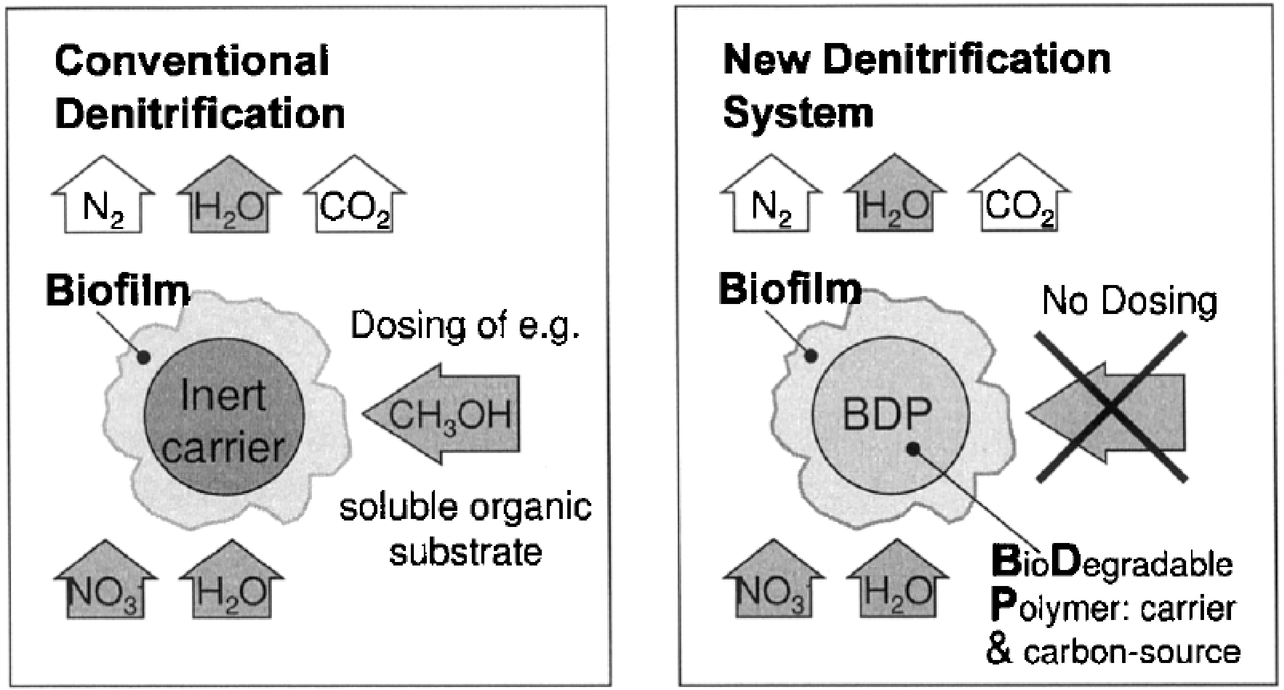


Fig. 2. Denitrification processes with different organic substrates.

Not Complicated

ELSEVIER

Aquacultural Engineering 22 (2000) 75–85

aquacultural engineering

www.elsevier.nl/locate/aqua-online

Biodegradable polymers as solid substrate and biofilm carrier for denitrification in recirculated aquaculture systems

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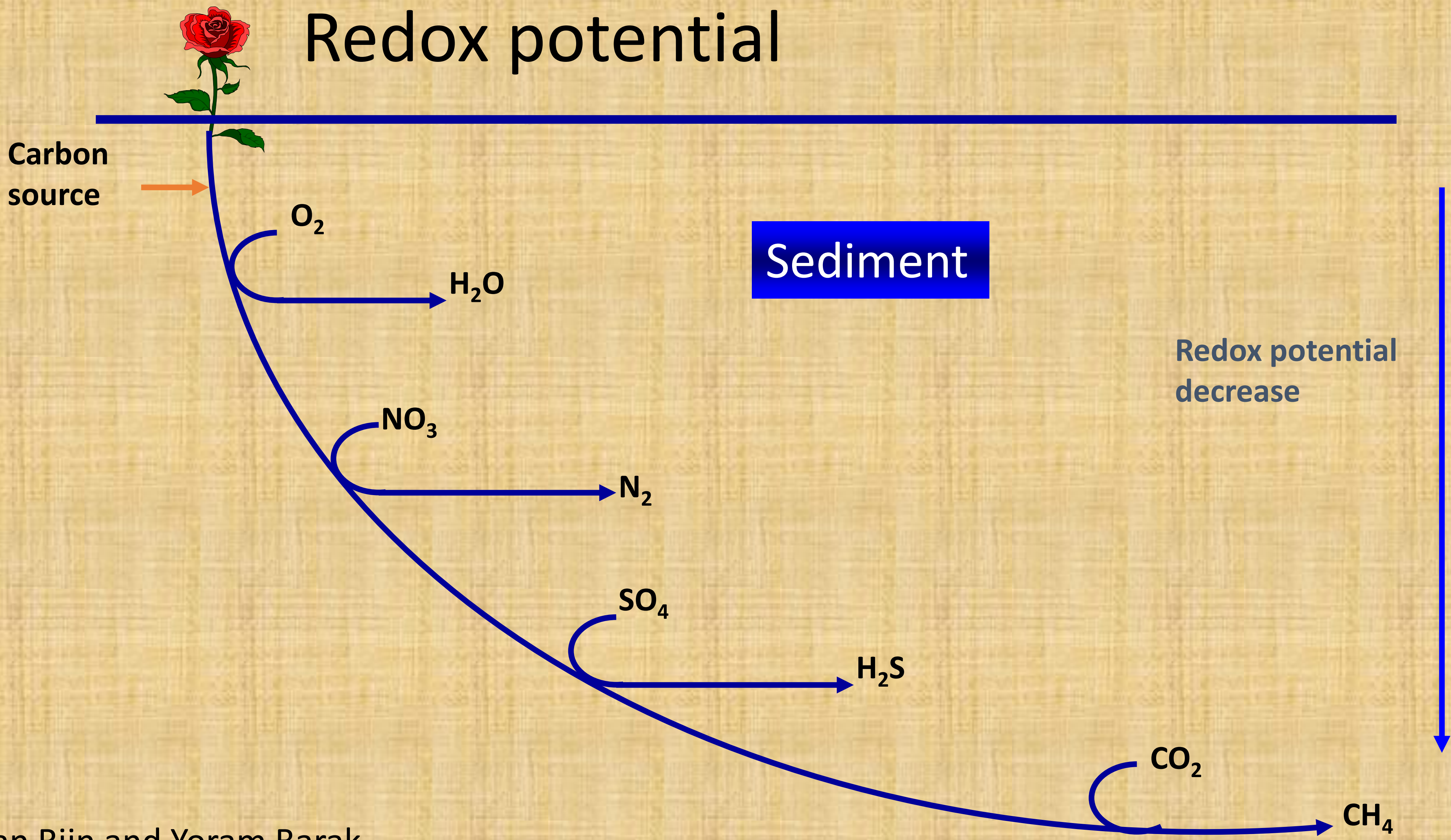
Table 4
Estimated costs of substrates for nitrate removal

Substrate	Price of substrate (€/kg substrate)	Consumption of substrate (kg substrate/kg N-NO_3^-)	Costs of denitrification (€/kg N-NO_3^-)
Methanol: CH_3OH	1.00	2.08–3.98	2.0–4.0
Ethanol: C_2H_5OH	1.20	2.0	2.4
Acetic acid: CH_3COOH	2.40	3.5	8.0
PCL $(C_6H_{10}O_2)_n$	5.00	1.33–1.77	6.6–8.9
PHB $(C_4H_6O_2)_n$	10.00	2.1–2.7	21.0–37.2
Bionolle #6010 $(C_6H_4O_2)_n$	Commercially not available		

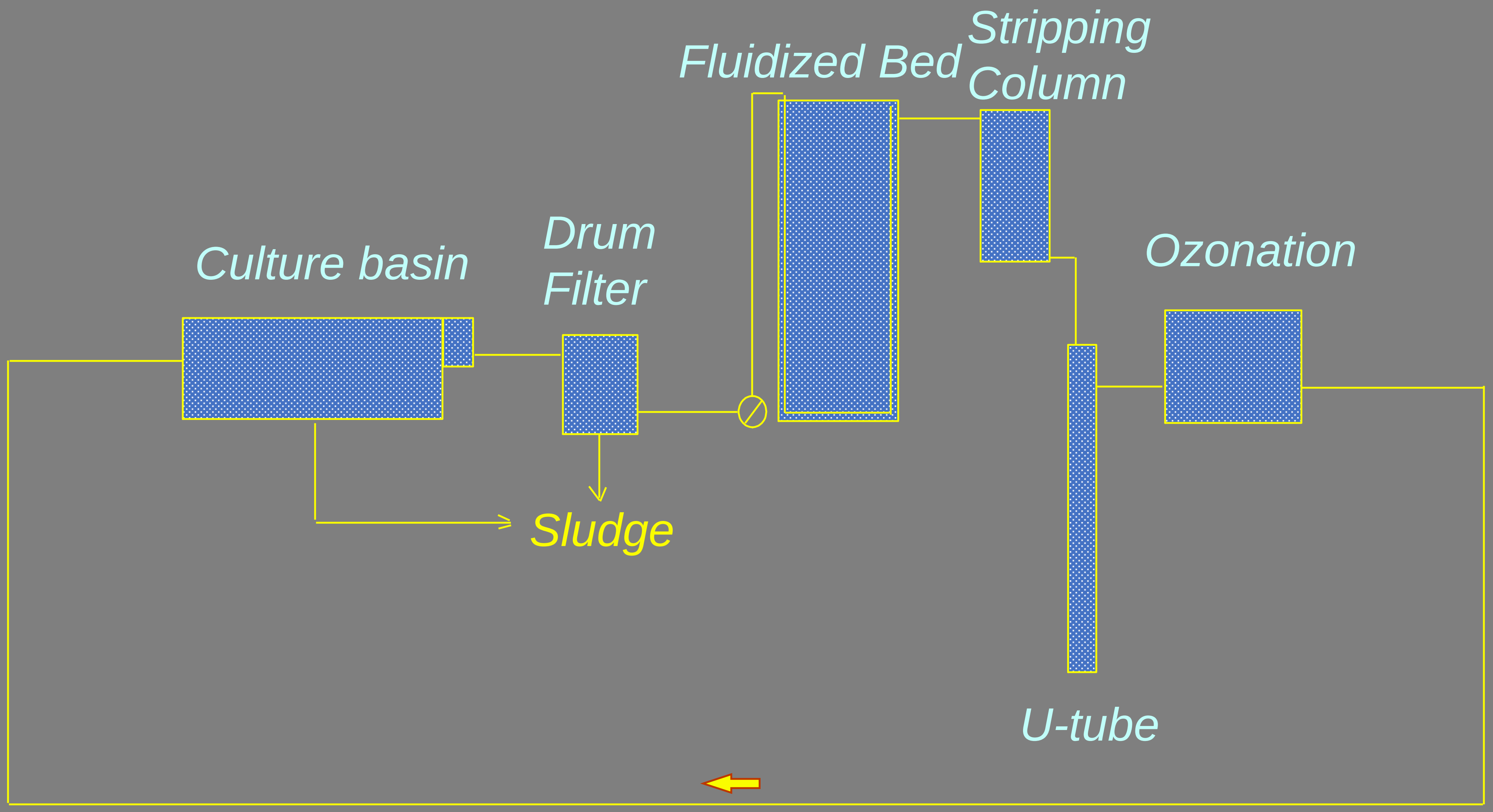
Respiratory processes as a function of Redox potential



Jaap van Rijn and Yoram Barak

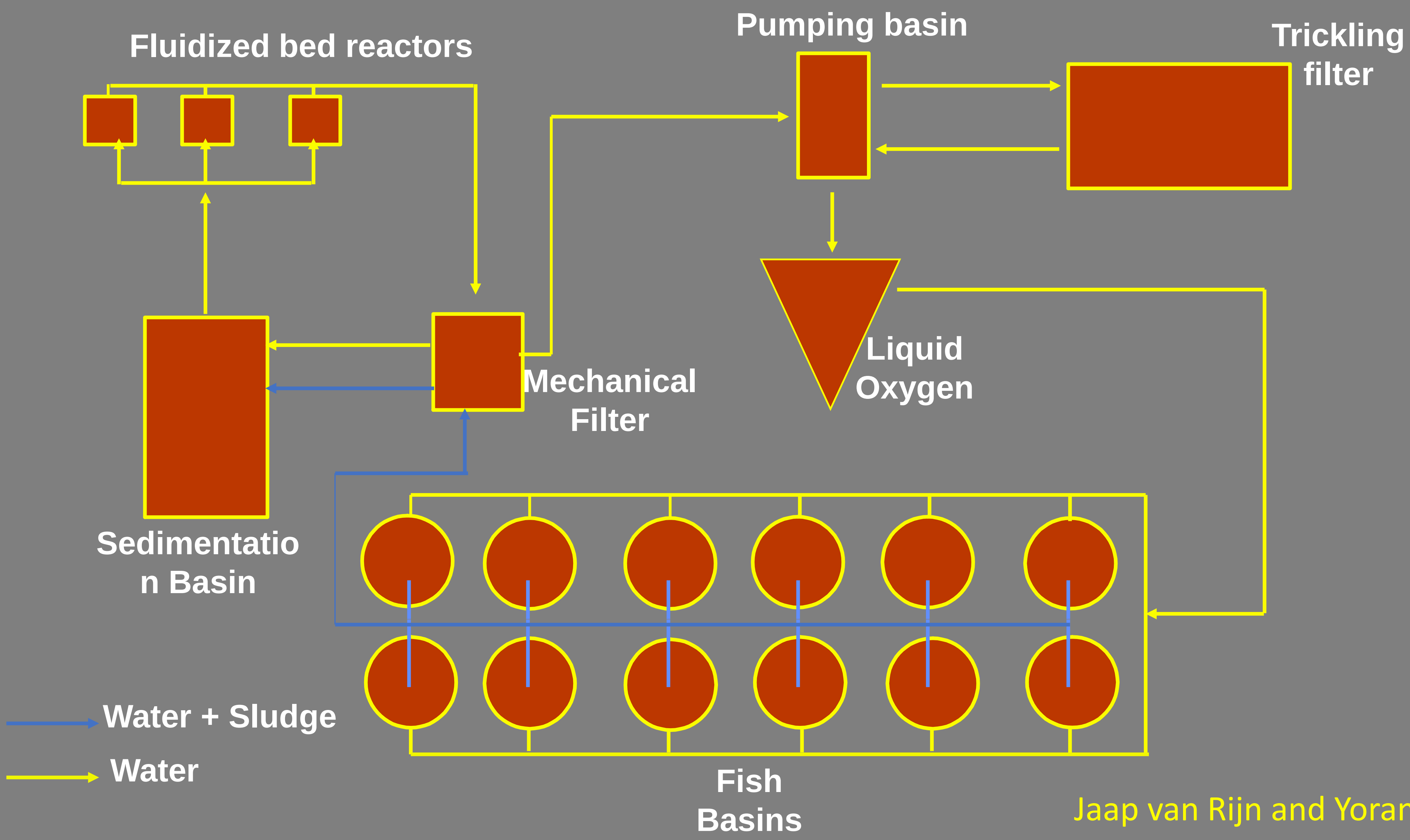
Recirculating aquaculture system

(Wade et al., 1996)



Jaap van Rijn and Yoram Barak

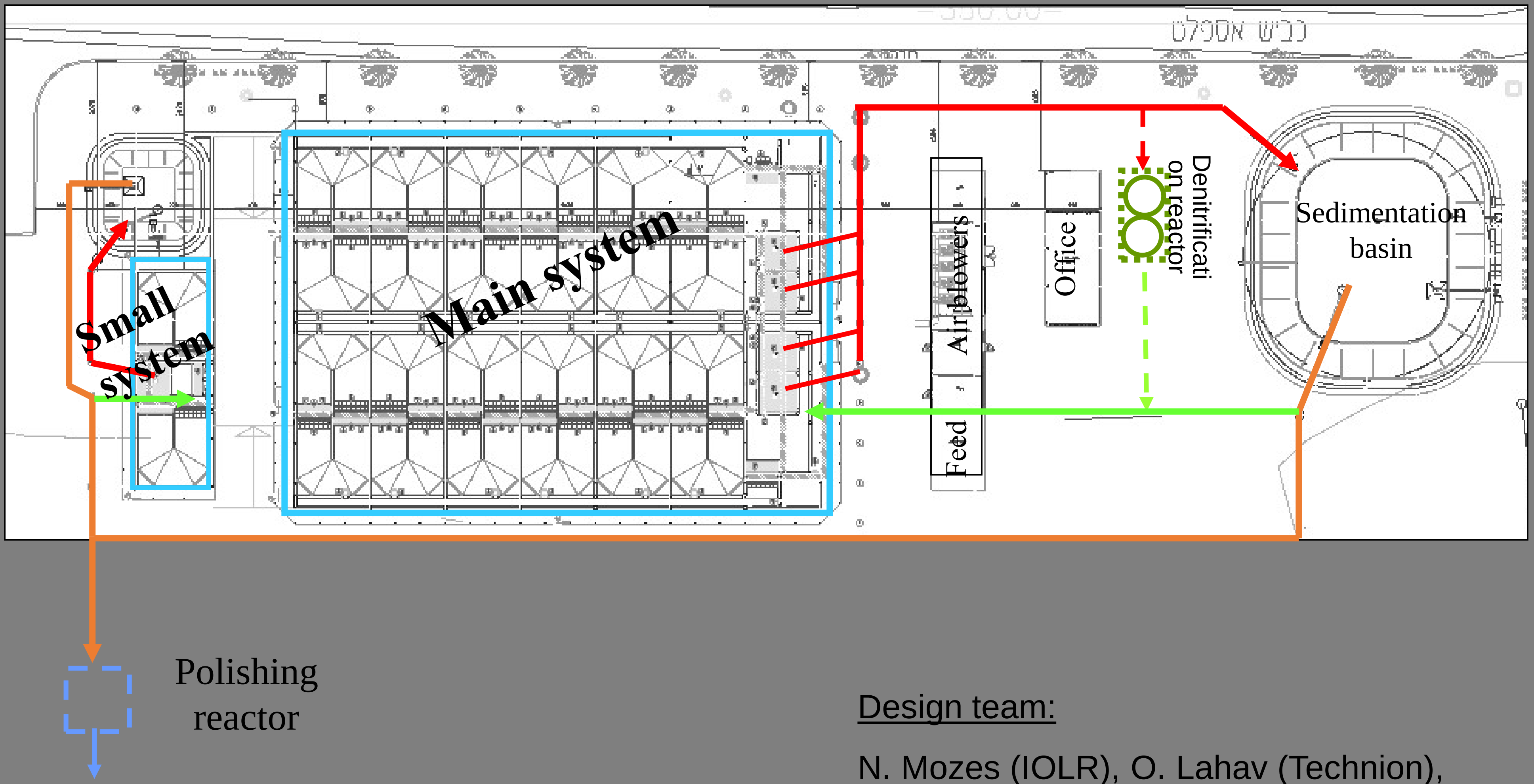
Intensive Fish Culture Unit - Ginosar



Jaap van Rijn and Yoram Barak

Pilot system – general layout

Effluent treatment stages

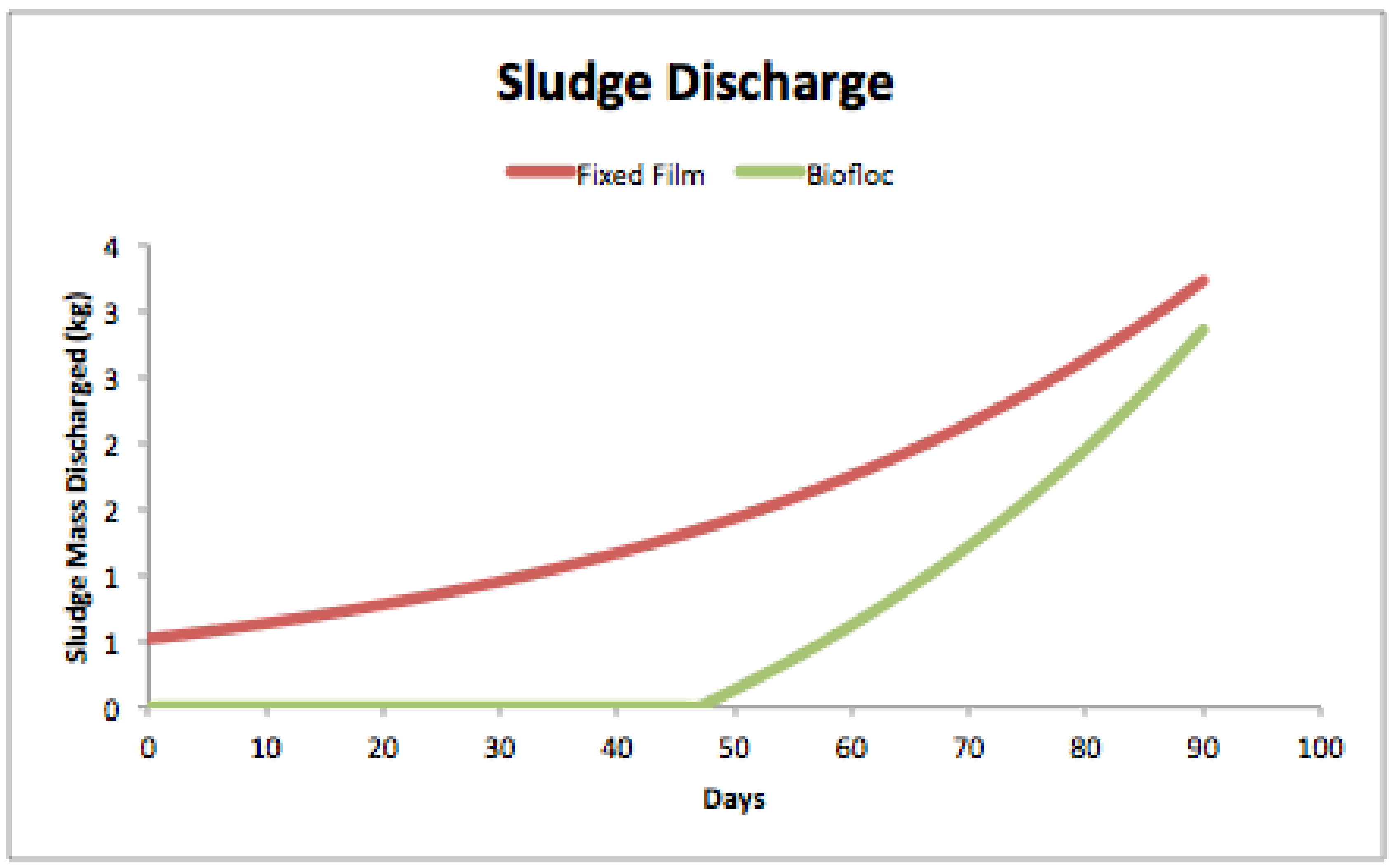


Design team:

N. Mozes (IOLR), O. Lahav (Technion), I. Haddas (Kora), M. Shnitzer (Chagam)

Summary: Nitrate control

- Internal denitrification (block level) is recommended
  - Consider the Israeli model that use sludge for carbon
  - Extends water reuse through several growout cycles
  - Reduces salt costs
  - Reduces alkalinity costs
- Supplemental Denitrification
  - Passive de-nitrification for small operations
  - Traditional denitrification for larger facilities



- Assumed 33% conversion of feed to sludge mass for fixed film system
- Biofloc system was set to maintain solids at 500 ppm in system, sludge production stays at zero up until day 65 due to internal sludge digestion keeping system below 500ppm
- @ 4% solids, 311 gallons of sludge for fixed film system (total sludge * 0.25)
- @ 4% solids, 356 gallons of sludge for biofloc system (with 67% stabilization (accounting for indigestible minerals)

Sludge (solids)

Feed ➔ Shrimp ➔ Feces ➔ Biofloc ➔ Sludge digestor ➔ Disposal

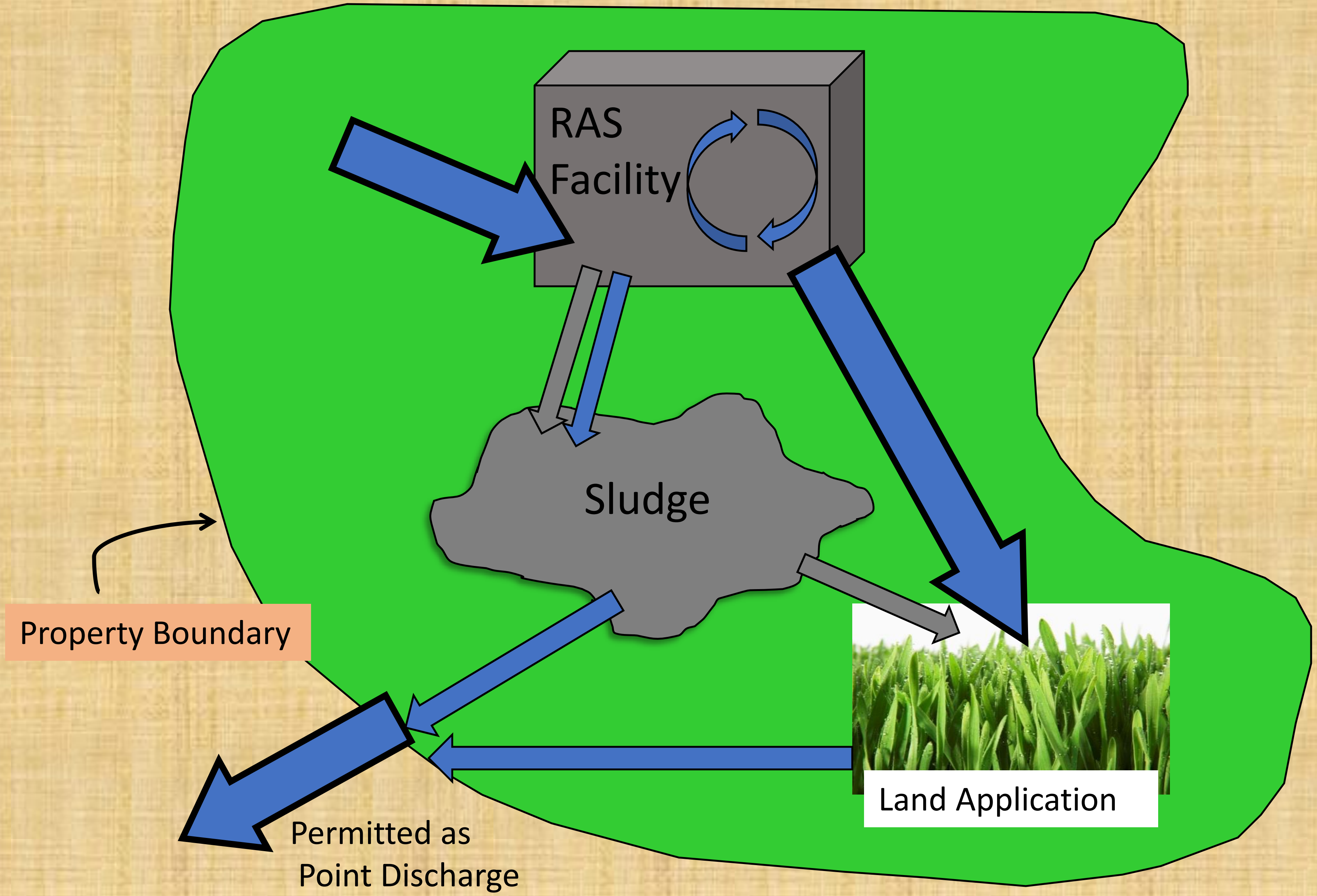
Feed ➔ Shrimp ➔ Feces ➔ Clarifier ➔ Sludge digestor ➔ Disposal

300 gal/1000 lb shrimp

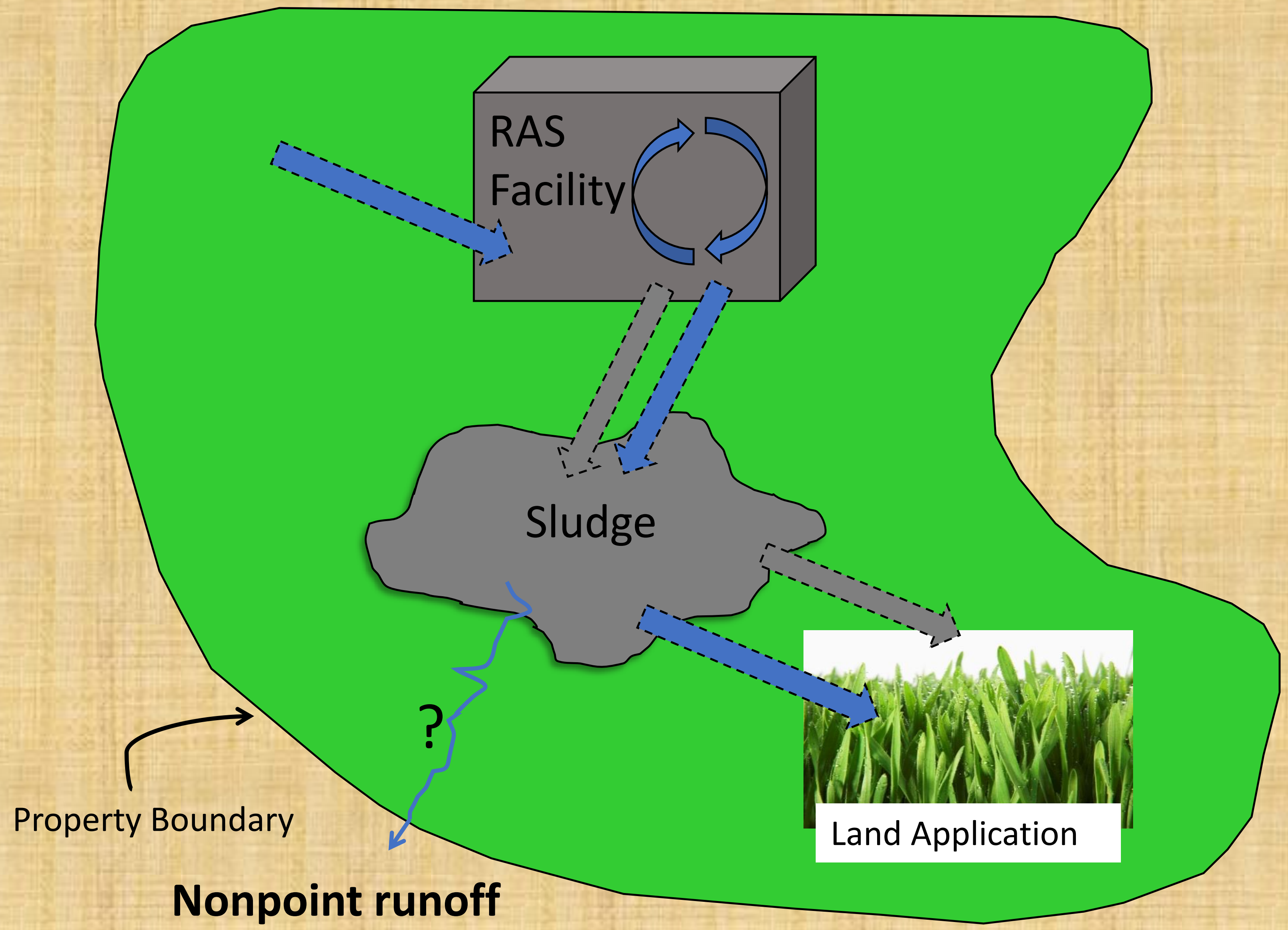
Sludge Stabilization-Objectives

- Reduce Organic Content
  - Eliminate Odor
  - Improve Physical Characteristics
  - Reduces solids volume (70-90% reduction)

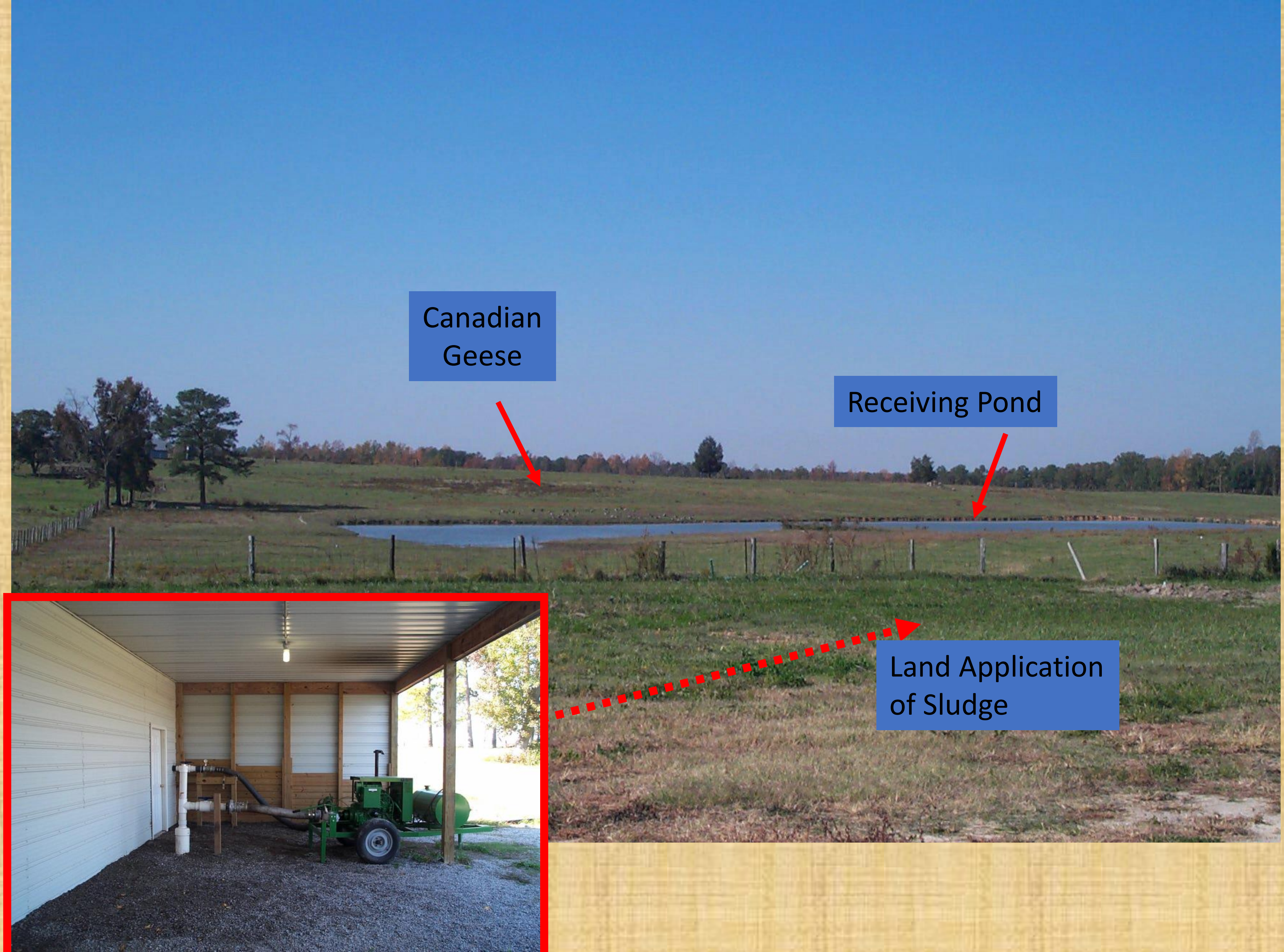
Typical Open RAS



Closed RAS


RAS
Facility
Sludge
?
Land Application
Property Boundary
Nonpoint runoff


Anaerobic Sludge Pit


Canadian Geese
Receiving Pond
Land Application of Sludge

Sodium Accumulation and Land Application

- Specific Ion Toxicity
- Water Infiltration Problems
  - High Na+ can cause
    - Formation of Crusts
    - Waterlogging
    - Reduced Permeability

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

SAR = Sodium Adsorption Ratio
Concentrations in meq/L

SAR > 9 can cause severe restrictions on surface irrigation of soils thus requiring large areas for disposal

Sludge Disposal

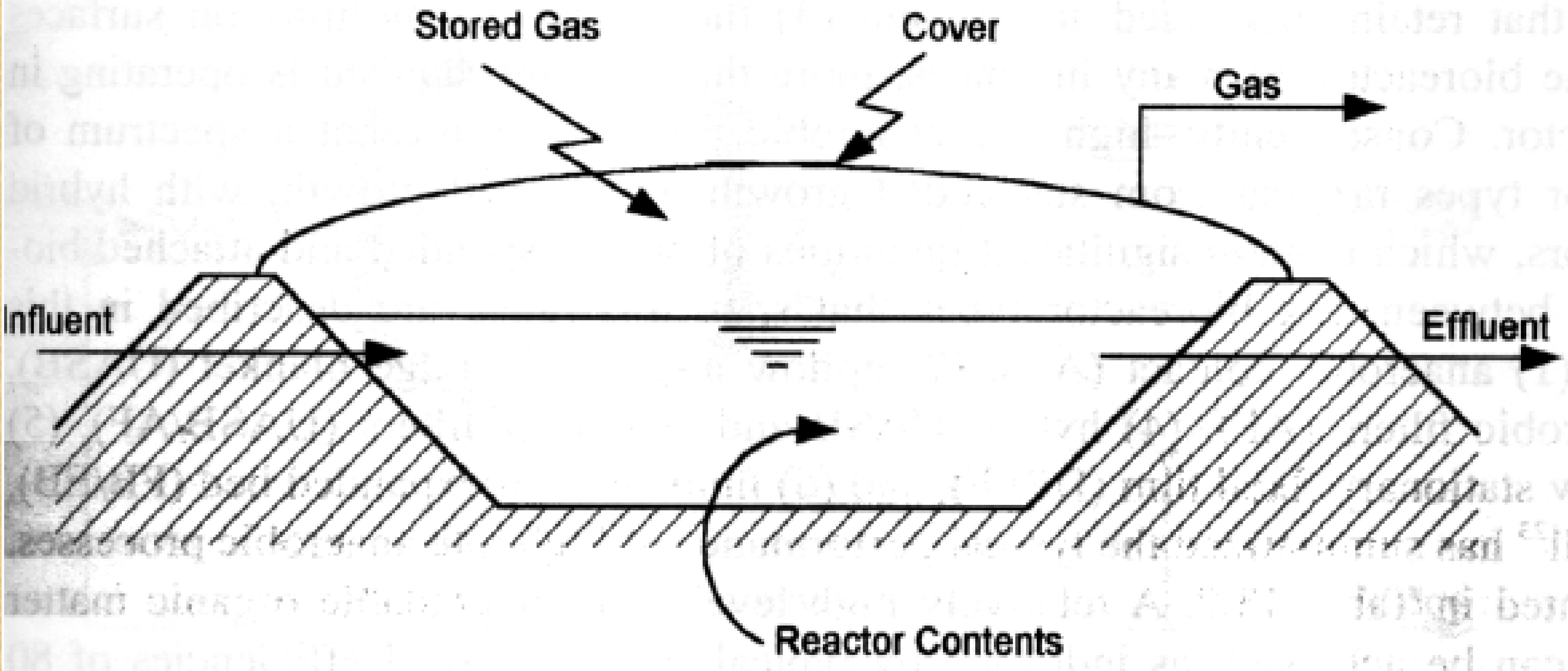
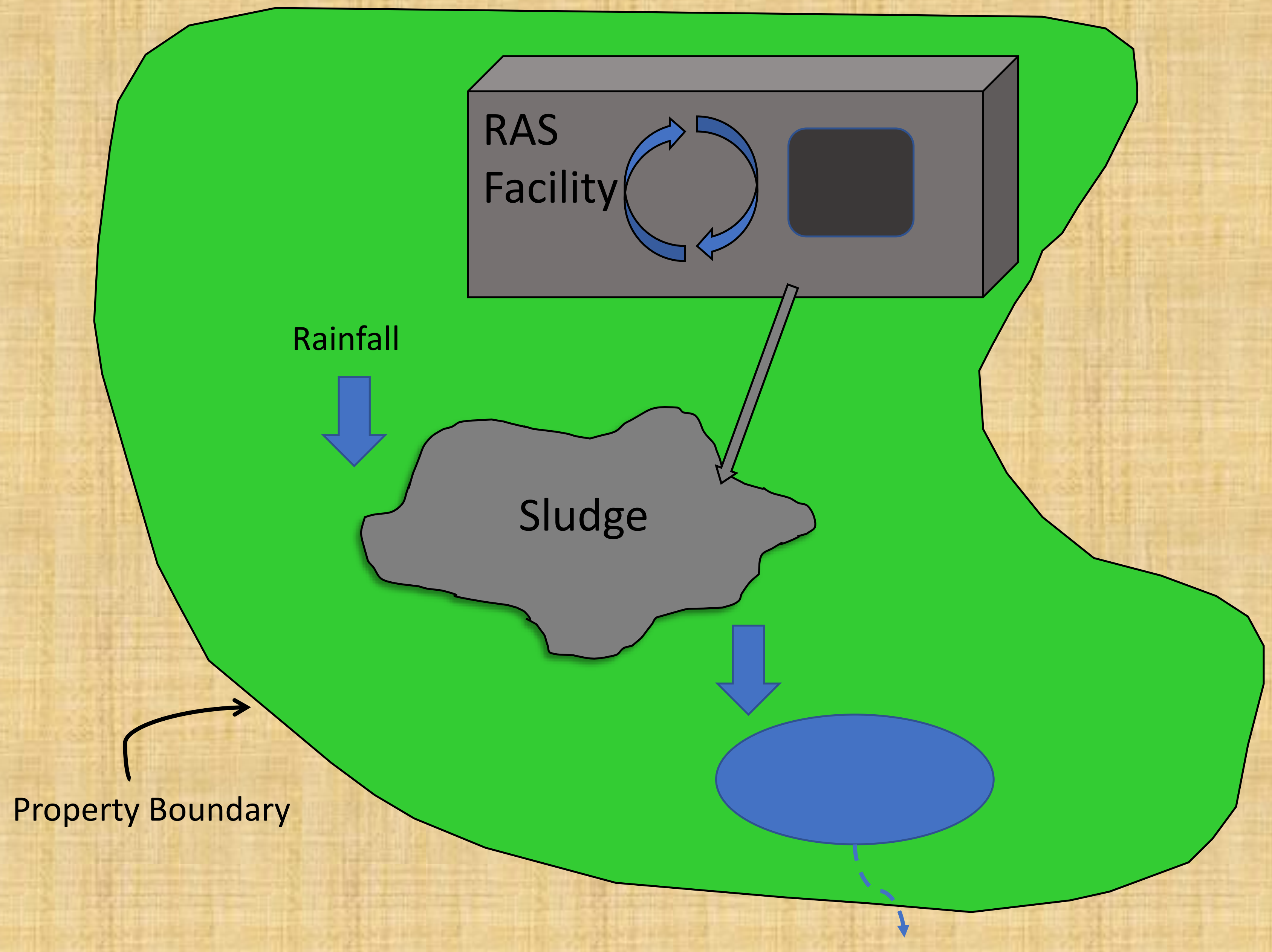


Figure 13.5 Low rate anaerobic process using an earthen basin.

Grady et al 1999

“No Discharge” Marine Inland System?



References

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3. Hirasawa, Y. (1985). Economics of shrimp culture in Asia. In Y. Taki, J. H. Primavera, & J. A. Llobrera (Eds.), Proceedings of the First International Conference on the Culture of Penaeid Prawns/Shrimps, 4-7 December 1984, Iloilo City, Philippines (pp. 131–150). Iloilo City, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center.
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