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Aquaculture Conference
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System Design and its Impact on Water Quality Management

Edward D. Aneshansley, MPS PE.
EDA@eda-aquatics.com
Mobile: 978-578-2589

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Conservation Aquaculture	Commercial Aquaculture
Restoring or Enhancing aquatic plants/animals in public waters.	Cultivation or Farming of Aquatic plants and Animals intended for commercial sale

Conservation Aquaculture – Objectives

Environmental/Social

- Restoration, Enhancement Mitigation
- Protect Endangered Species
- Maintain a traditional food source for a community.

Economic

- Support Recreational Fishing industry
- Support commercial fishing industry

Commercial Aquaculture – Objectives

Economic

- Establish a company that produces and sells aquatic animals that generate a profit.

Environmental/Social

- Relieve pressure on the wild populations
- Provide a clean and healthy source of protein.
- More efficient protein production.

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Aquaculture Projects

Conservation Aquaculture

Often have established sites and water resources.

Goals include:

1. Increasing production with existing resources using more intensive technology.
2. Improve their discharge based on new restrictive regulations.

Commercial Aquaculture

Often do not have sites or water sources identified.

Goals include:

1. Consistent Production though-out the year.
2. Large scale production at efficient production costs.
3. Market Size products/processing/marketing strategy

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Planning and Design Associated with Water Quality Management

1. **Establish a Production Plan**

   -Species, Production goals

   -Bioprogram

2. **Establish Culture System Technology**

   -Flow Through System

   -Partial Reuse System

   -Recirculation Aquaculture System

3. **Calculate Water Requirements "Water Budget"**

   -Based on Production Plan and Tech.

4. **Predict Effluent Water Quality**

   -Based on feed-load intensity

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Project Siting

Establish a **Site Criteria List** based on the (4) stages of Planning and Design to evaluate possible site locations.

Criteria List related to WQM should include:

- **-Water Source Requirements**
  - -Quality/Quantity
- **-Discharge requirements**
  - -Discharge Quality/Quantity
    - -Nitrogen, Phosphorus (Conc./Mass)
  - -Existing discharge Infrastructure

Aquaculture Water Quality Management within an Aquaculture Facility

There are Three Primary areas of Water Quality Management within an aquaculture Facility.

1. **Source** Water Quality Management (WQM).
2. **Culture** Water Quality Management (WQM)
3. **Effluent** Water Quality Management (WQM)

Successful Facility Design Considers all three areas.

Source Water Criteria

Goal: Avoid the need for preconditioning and treatment.

Source Water Parameters that are Challenging to Manage:

- -Temperature
- -Biological Contaminants
- -Dissolved Minerals/Heavy Metals.
  - -Iron, hardness.
- -Alkalinity/Hardness
- -Gas Saturations
  - -Nitrogen, Carbon Dioxide

-Pretreatment of Source Water is continuous and critical.

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Effluent Water Criteria

Goal: Avoid sites with restrictive effluent permits

Effluent Restriction that are challenging to Manage:

-Total Nitrogen

-Total Phosphorus

-BOD

-Suspended Solids

-Biological disinfection

-Fish Exclusion

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Culture System Design Consideration

Culture Systems manage the water quality that the fish are exposed to.

Respiration and Metabolism has major impacts on the chemistry of the water.

The WQM requirements for tend to increase as the system become more intense.

-Higher fish densities and feed loads

-Higher Recirculation Rates

Culture System Design Considerations

FTS – <u>Flow Through Systems</u>

-HRT = 1 Hour

PRAS – <u>Partial Reuse Aquaculture Systems</u>

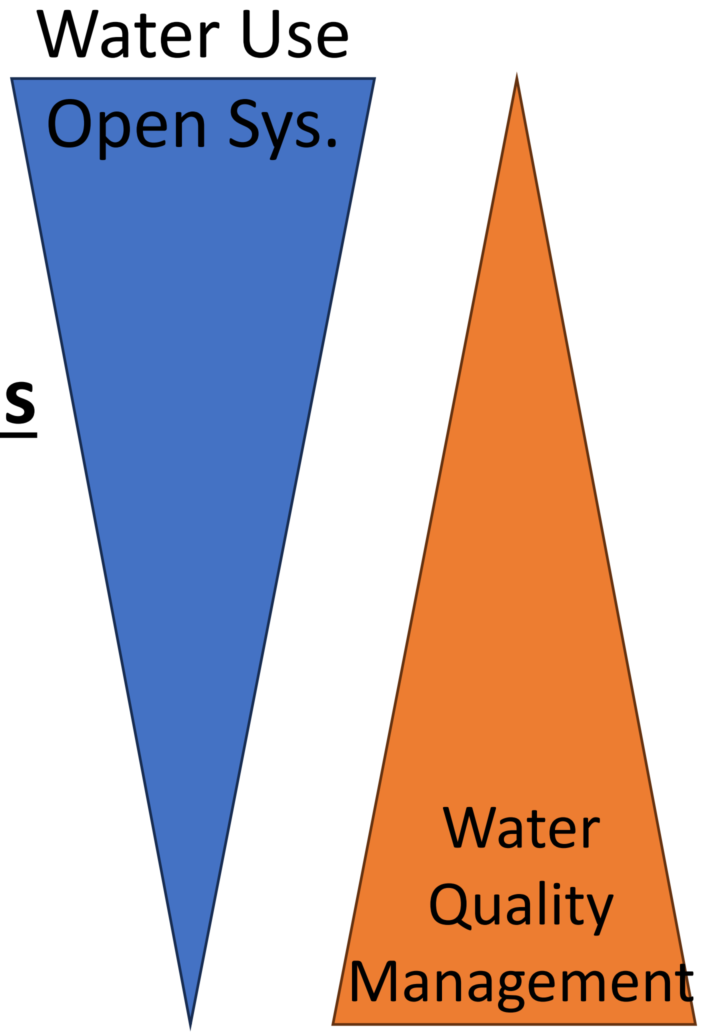
-HRT = 10 Hours

RAS – <u>Recirculation Aquaculture Systems</u>

-HRT = 100 hours

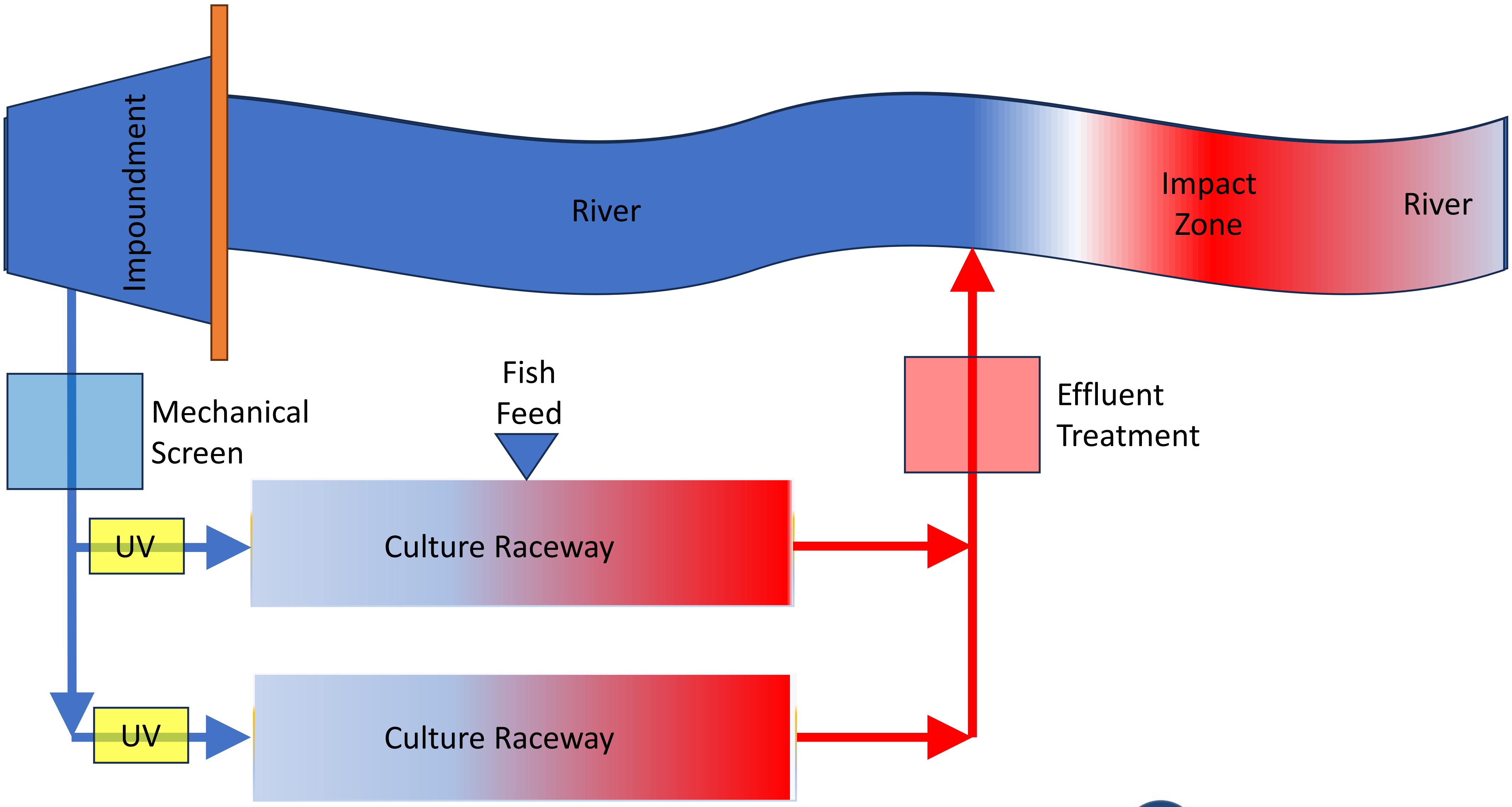
ZDS- <u>Zero Discharge System</u>

-HRT= NA



HRT-Hydraulic Retention Time

Evolution of Technology



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PRAS

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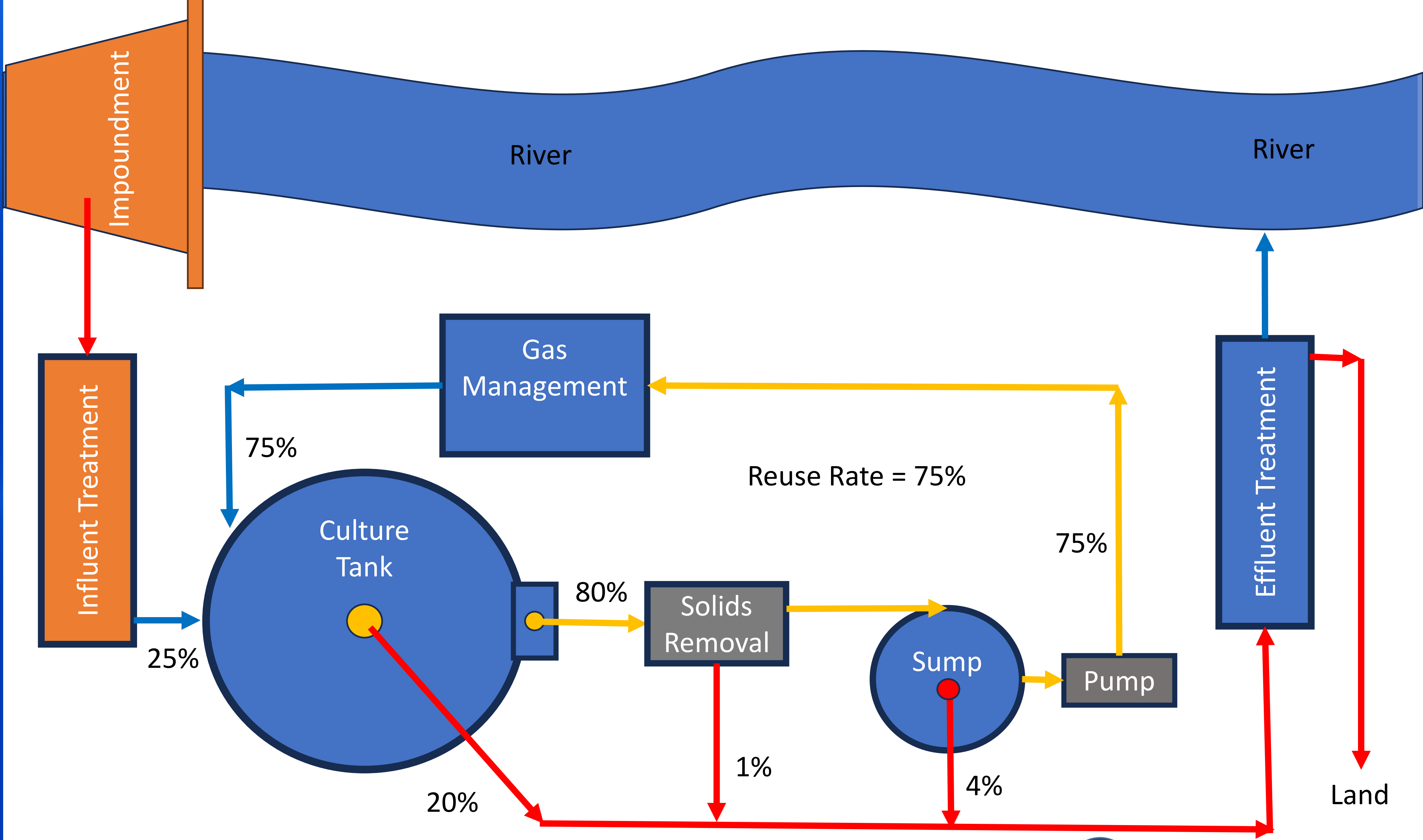

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RAS

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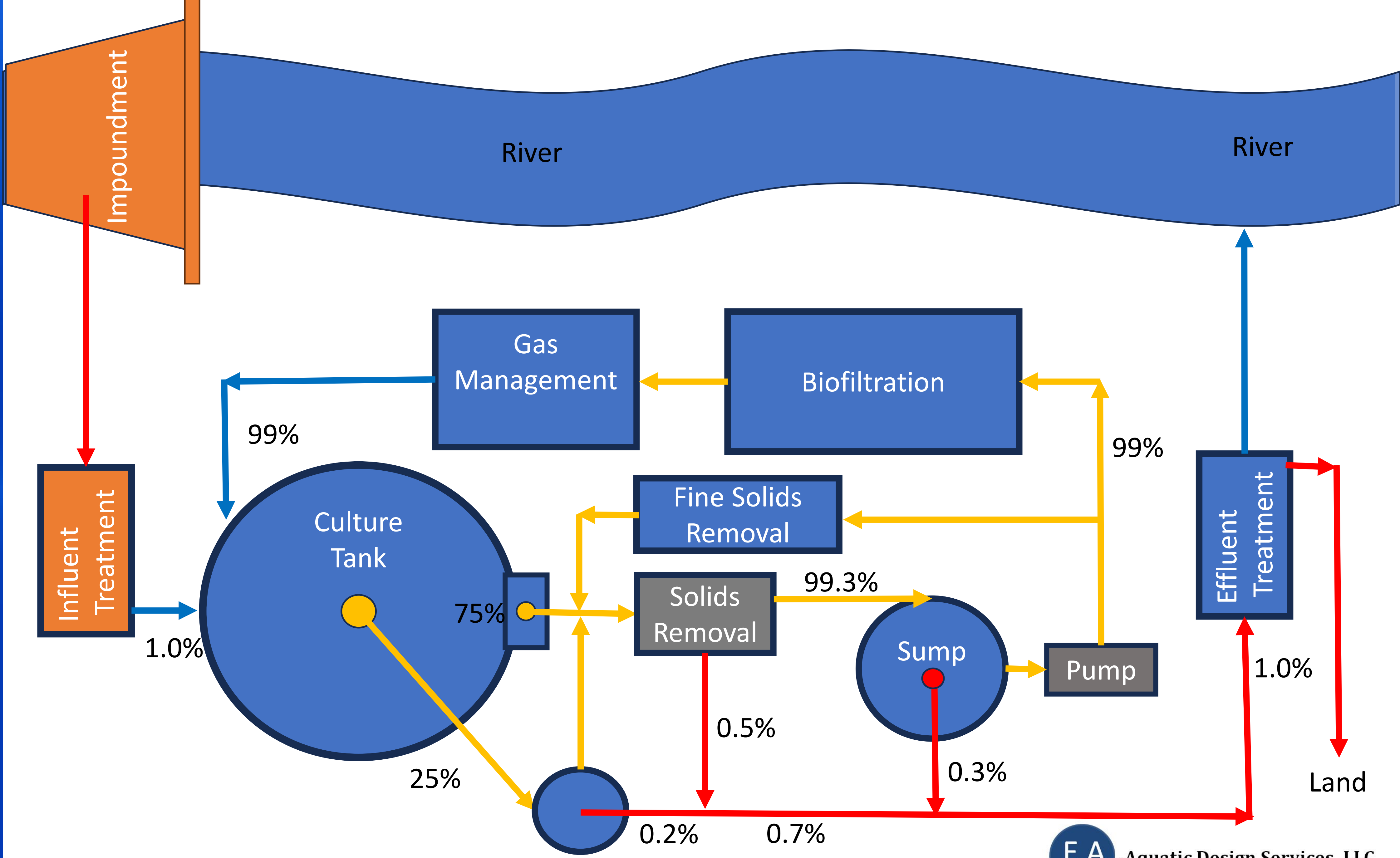

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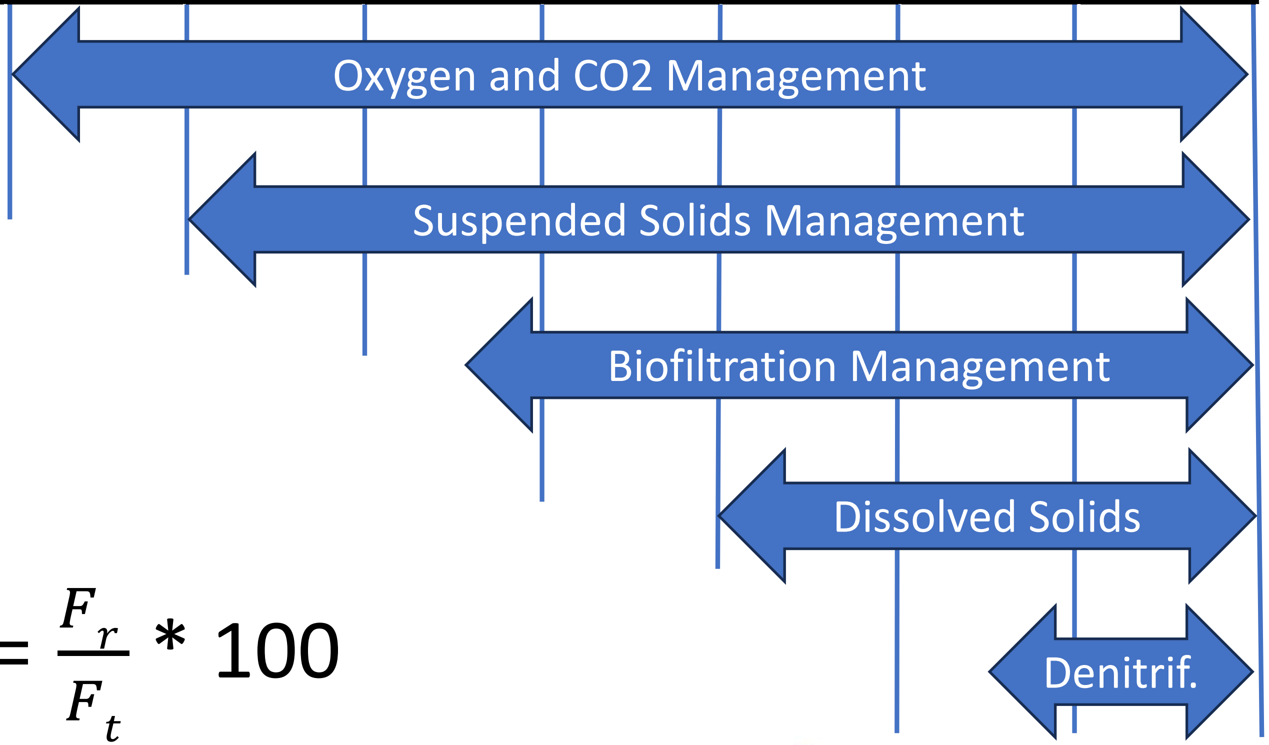
System Metric	(Units)	REUSE RATE (% Flow that is Recirculated (Reused))							
		0%	50%	75%	90%	96%	99.0%	99.6%	100%
Total System Culture Vol.	m3	1000	1000	1000	1000	1000	1000	1000	1000
Density	kg/m3	50	50	50	50	50	50	50	50
Feeding Rate	% BM/day	0.80%	0.80%	0.80%	0.80%	0.80%	0.80%	0.80%	0.80%
Feed Load	kg feed/m3 CV - day	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Hydraulic Retention time	min	30	30	30	30	30	30	30	30
Total Flow Rate	m3/hr	2000	2000	2000	2000	2000	2000	2000	2000
Recirculated Flow	m3/hr	0	1000	1500	1800	1920	1980	1992	2000
Makup Flow	m3/hr	2000	1000	500	200	80	20	8	0
Makup Flow (HRT)	Hours	0.5	1.0	2.0	5.0	12.5	50	125	NA
Makup Flow	% CV/day	4800%	2400%	1200%	480%	192%	48%	19%	0%
Makup Flow	l/kg feed	120000	60000	30000	12000	4800	1200	480	0
BM = Fish Biomass CV = Culture Volume		FTS	PRAS			RAS			ZDS



Total Flow……………..$F_{(t)}$
Makeup Flow……….$F_{(m)}$
Recirculated Flow….$F_{(r)}$
Reuse Rate (%)………R

$$F_{(t)} = F_{(r)} + F_{(m)}$$

$$R = \frac{F_r}{F_t} * 100$$

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Feed Load Calculation		
Inputs		
Density	20	kg/m3
Feeding Rate	1.50%	Biomass (BM)/day
Calculation		
Feed Load	0.30	kg feed /m3 CV-day

CV = Culture Volume
BM = Biomass

Key Metrics Associated with Production Intensity

Feed Load (kg/m^3-day)								
Feeding Rate	**Fish Density (kg/m3)**							
(% BM/day)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**
0.10%	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08
0.20%	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16
0.30%	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24
0.40%	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32
0.50%	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4
0.60%	0.06	0.12	0.18	0.24	0.3	0.36	0.42	0.48
0.70%	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
0.80%	0.08	0.16	0.24	0.32	0.4	0.48	0.56	0.64
0.90%	0.09	0.18	0.27	0.36	0.45	0.54	0.63	0.72
1.00%	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80
1.10%	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88
1.20%	0.12	0.24	0.36	0.48	0.6	0.72	0.84	0.96
1.30%	0.13	0.26	0.39	0.52	0.65	0.78	0.91	1.04
1.40%	0.14	0.28	0.42	0.56	0.7	0.84	0.98	1.12
1.50%	0.15	0.3	0.45	0.6	0.75	0.9	1.05	1.2
1.60%	0.16	0.32	0.48	0.64	0.8	0.96	1.12	1.28
1.70%	0.17	0.34	0.51	0.68	0.85	1.02	1.19	1.36
1.80%	0.18	0.36	0.54	0.72	0.9	1.08	1.26	1.44
1.90%	0.19	0.38	0.57	0.76	0.95	1.14	1.33	1.52
2.00%	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60

Feed Load:

KG Feed per Cubic Meter of Culture Volume per day

Key Components that Impact Culture WQM

- Culture Tank Design
- Automatic feeding equipment
- Fish grading and movement
- Monitoring and Control Systems (SCADA)

Key Building Coordination that Impact WQM

- HVAC Specifications
  - Building Temperature
  - Humidity Control
  - Air Exchanges

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Managing your Water Quality Management

1. Starts with Site Selection!

2. Is impacted by your bioplan and production intensity.

3. Has three distinct areas that require distinct tech.

4. Is impacted by the culture components that you choose.

5. Needs to coordinate with building design.

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Thank You!!

Ed Aneshansley

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