INNOVASEA

1. For a farm in the USA, based on round fish tanks and including all necessary support areas, equipment, and services, what are your reference design metrics for the following items, detailing any relevant assumptions used:
(Note: a 1,000-ton farm is used as the example)

a) Estimated CapEx range:

For the estimated CapEx range, we have broken our estimate into three categories: RAS equipment, complete RAS system estimate, inclusive of intake and discharge (primary settling) as well as other system related infrastructure, and complete facility estimate. We used parametric estimating techniques based off historical data from previous projects and production capacities to create the following estimates:

- *RAS Equipment: This includes equipment associated with solids filtration, biofiltration, degassing, oxygenation, ozonation, pumping, UV sterilizers, comprehensive MCAS & motor control panels, alkalinity dosing equipment and, culture tank inlet & outlet structures (w/mort and harvesting capabilities -does not include de-nitrification if required).*
  - *Range: $6-7,500 per ton*

- *Complete RAS System Estimate: All items included in the RAS Equipment Supplied in above section plus: Culture tanks, fish handling equipment, automated feeding systems, plumbing, filtration basin, storage tanks and influent & effluent treatment*
  - *Range: $11-13,000 per ton*

- *Complete Facility Estimate: All items included in the RAS System Estimate plus: the infrastructure of the building, processing, HVAC, lab equipment, cold storage, mechanical room, office space, etc.*
  - *Range: $28-32,000 per ton*

b) Estimated electricity consumption range (kWh):

In our design process we meticulously work through a bioplan/production plan, design features and, equipment efficiencies to develop consumption rates for electricity, oxygen, feed, water, alkalinity, and other factors. We used parametric *estimating techniques based off historical data from previous projects and production capacities to create the following estimates:*

Parameter	Units
Production per year	450 MT/yr.
FCR	1.3
Feed consumption per year	585 MT/yr.
Ave Daily Feed rate	1,603 kg/day
kW per Kg of feed	5.5 (4 – 7) kW/kg feed.
Total kW based on feed/month	268,905 kW/month

c) Estimated oxygen consumption range (Kg LOX per day):

The estimated oxygen requirements below are projected from historical data based on average oxygen consumption rates g per kg of feed. The range varies dependant on fish's size, oxygen application method, absorption efficiencies (many factors) and backup oxygen use.

Parameter	Units
Production per year	450 tons/yr.
FCR	1.3
Feed consumption per year	585 MT/yr.
Ave Daily Feed rate	1,602 kg/day
*Ave O_2 Consumption	750-800 gO_2/kg feed
O_2 consumed per day	1,241 kg/day
O_2 concentration (LOX)	99%
O_2 required per day (LOX)	1,254 kg/day
**O_2 concentration (GEN)	92% (Generated)
O2 required per day (GEN)	1,350 kg/day

** 750-800 Estimated average facility includes: safety factor and O_2 absorption efficiency. Typical application rate is ~500 g/kg for salmonids in the grow-out phase without accounting for safety factors.*
*** Included estimated oxygen generator requirements because in recent years many facilities have decide to go in this direction.*

d) Estimated freshwater consumption range (m^3/day, including drum filter operation):

The estimated new water additions below are projected from historical data based on litres of new water per kg feed to manage nitrate concentrations. The range varies dependant on the fish's size and feed protein concentrations.

Parameter	Units
Production per year	450 tons/yr.
FCR	1.3
Feed consumption per year	585 mt/yr.
Ave Daily Feed rate	1,602 kg/day
No Denitrification	
*400-600 l/kg feed	640 – 960 m^3/day
With Denitrification	
**50-399 l/kg feed	80– 640 m^3/day

**Assuming no need or desire to use denitrification*

*** High level estimate based on other similar production system with denitrification systems*

e) Average and maximum stocking densities (Kg/m^3 per tank type / system):

Stocking densities would need to be evaluated with the operational team for species specific allowances or any specific max densities defined by the bio-plan. Below is a general stocking density profile as a general baseline.

Fish Size (g)	Max Density (kg/m^3)
<1	10
1-5	20
5-30	30
30-50	40-50
50-100	50-65
100-1000	65-75
1000+	75-90

f) Average and maximum feed load (Kg feed per day per system).

Based on an estimated facility production of 450 tons/yr. and an average FCR of 1.3 the daily feed load for the facility is predicted to be ~1,600 kg/day. During the preliminary design phase, we work as a team to develop a production plan to meet your goals and harvest cadence. At that time, we would have a detailed summary of the production flow of fish through the facility with quantity and size of the RAS modules. The level of feed rates would be developed in conjunction with the development of the production plan.

2. How would you typically integrate sensors, monitoring, control, automation, and data processing & analysis in your design, in terms of both function, construction, service and responsibility?

We approach monitoring, control and automation with the fish's health, production goals and staff at the forefront of the design. There is a wide range of capabilities ranging from a minimalistic approach to very sophisticated and somewhere in *between. Through the design process we will work directly with you to narrow down your requirements.*

Typical monitoring, control and automation systems:

- *DO/Temp probes located at injection point (IE LHO, cone, etc.)*
  - *Automatically controls oxygen in water delivered to the tanks.*
- *DO/Temp probes located at each culture tank*
  - *Automatically controls backup oxygen solenoid*
- *pH probes located in the sump*
  - *Controls alkalinity dosing system*
- *ORP & TRO probes located down stream of Ozone injection site*
  - *Automated control of ozone generator*
- *Water level monitoring in the sump*
  - *Interlocks with pump station to flow pace the system with water flow required*
- *Pressure or Flow Sensor at pump station*
  - *Pump speed automatically maintained based on line pressure or flow*
- *Pressure Sensor located at blower station*
  - *Blower speed automatically maintains pressure*
- *Pump Motor Control Panels*
  - *VFD drives with Hand/off/auto (HOA) functionality*
- *Blower Motor Control Panels*
  - *VFD drives with Hand/off/auto (HOA) functionality*
- *Drum Filter Control Panels*
  - *Automated backwash and status*
- *UV Control Panels*
  - *Interlock control with system flow*
  - *Run Status*
  - *Fault status*
- *Feeder Control Panels*
  - *Time Based Automated Feeding*
- *Facility Power Monitoring*
  - *Alarms for power outages*
- *RAS Automation Panel*
  - *Main panel with graphical user interface (GUI)*
  - *Ethernet output, allowing for interlinked operation, integration with the site monitoring and control system, access though network connected devices (PC or tablet)*
  - *Cloud storage capabilities*
  - *Includes Uninterruptable Power Supply (UPS) for operation in the event of power failure.*
- *Alarm faults and strobes*
  - *Notifications via: Call, Text, Email, and strobes onsite*

Our systems are tailored to the client's needs. We use state of the art equipment designed for aquaculture conditions. We have the capabilities to custom manufactured control panels (with UL certification) to meet the customers exact requirements.

Additionally, we will be able to monitor your systems total power consumption as well as implement efficiencies that use data to reduce energy cost, for example by monitoring your CO_2 we will be able to ramp up or down the gas extraction fans on the system by controlling the blower VFD's.

We supply the complete control package with comprehensive specification documents, wiring diagrams, manuals, installation support, start-up/testing, commissioning, and training on all the equipment.

3. How would you typically integrate provisions to prevent sludge build-up anywhere on the farm in your design?

We would use a multifaceted approach with the primary focus on a holistic design that uses hydraulics to our advantage to prevent sludge build-up. By using this approach, we make it a priority to minimize the requirements for the staff's labour so they can dedicate their time towards growing fish and not managing the systems.

- *We design our culture tanks to create an optimal flow profile for the fish while promoting self-cleaning flow dynamics in the tanks. These flow dynamics allow for removing solids as quickly as possible. Furthermore, we have the capability to run computational fluid dynamics models to verify tank design (not in current design proposal).*
- *We design the plumbing systems to maintain critical velocities to prevent solids from settling in the pipes. The return plumbing runs are designed with cleanouts to allow for access. We strive to use as short a plumbing run as possible in the design.*
- *We use drum filters or disc filter for the passive removal of solids from the process water. We typically size the drum filters for 30 – 60 µm (dependant on fish size) filtration capacity but we can supply drum filters with capacities as low as 10µm.*
- *We use Moving Bed Bioreactors (MBBR) for the nitrification process. The MBBRs have aerations grid designed for mixing and supplying oxygen to the bio-media but just importantly they are specifically designed to keep solids from settling on the bottom of the MBBR.*
- *For gas management and degassing we use a proprietary design which utilizes cross flow degassing. Among the many benefits of our design the degas media is easily visible for walk by inspections to ensure there are no solids build-up. In the event that the media requires cleaning the media can be easily removed horizontally and does not require vertical lifting out of the vessel.*

- *We employ Low Head Oxygenators (LHO) for oxygenation of the process water with the capacity to add ozone. With the addition of ozone, we are able to oxidize the dissolved organics and promote micro-flocculation of the particulate matter to allow for easier removal of these fine particulates.*

4. How would you typically integrate effluent / sludge / organic waste management in your design?

Innovasea's systems typically have two effluent streams, RAS effluent (clean/low TSS) and Solids Backwash (dirty/high TSS). Treatment of these two streams are site and client specific based on a multitude of factors, including discharge locations, effluent regulations as well as the client desire to potentially monetize aspects of the sludge effluent.

Based on historical data Innovasea typically assumes the waste stream from a drum/disc filter's backwash can be thickened to a solids content of 5-6% with just the use of Radial Flow Settlers (RFS) Dependent on the goals of the client, further treatment to higher solids content levels is possible through application of several technologies. At 1000 tons per annum, the investment in biogas sludge reduction may not be economically feasible, whereas further dewatering of the sludge to reduce volume with a belt filter press or vacuum drum dryer could be investigated to meet your requirements.

Treatment of the total discharge from the facility, including clean effluent (typically leaving RAS systems post solids and biofiltration steps) and supernatant from solids processing step(s) will be dependent on discharge permits and standards that may be required for the facility. In the event of comprehensive treatment is required, a 3rd party effluent treatment design firm can be recommended.

5. Will you be able to design a RAS farm for fin fish guaranteeing that off flavours will be absent, and fish can therefore be harvested directly from the production tanks, with no need to undergo a purge / finishing period to remove off-flavours?

We are evaluating and vetting new technologies to reduce off-flavours in RAS systems with the goal to deliver systems that require no off-flavour purging. Unfortunately, at this time, even with the most technologically advance filtration equipment, the aquaculture industry cannot assure harvesting fish directly from the production tanks without some form of purging and guarantee an off-flavour free fish. Currently we work directly with our clients to evaluate operational approaches for purging to allow for harvesting directly from the grow-out tanks or alternatively in the design of stand-alone purge systems. We make it an effort that the water used in purging will not be wasted and rather used for makeup water on the RAS systems

6. Will you be able to design a RAS farm where live fish handling and feed storage & distribution design are fully integrated with the fish tank & RAS design; where sump/water storage tank volumes will be adequate to accommodate live fish handling operations with no water losses to the sewer / discharge point?

Yes, we can tailor your system design to meet these goals and objectives. We would work with you in defining these requirements early in the design phase.

7. How would you typically integrate ergonomics, work & process flows, ease of access for staff and equipment, ease of access to equipment for service & replacement, etc. in your design?

We design aquaculture facilities to allow for easy flow of fish from egg to harvest with consideration of strict biosecurity protocols. We design tank field layouts to allow for access around the culture for day-to-day work and harvests but also keep in mind the cost of floor space. In addition to giving workable space around the culture tanks we give an effort to set the tanks no higher than 42" above floor grade or recommend decking for access.

For the filtration equipment we also use these same standards with the addition of decking to service specialized equipment and incorporating bridge cranes and hoists to allow for servicing large equipment. One of the criteria we use in selecting equipment is the ease for service and model/manufacturer redundancy such that spares/replacement parts can be utilized across the entire facility.

We deploy MCAS systems that allow for monitoring and controlling the RAS systems tank side or remotely from a centralized office or even from home. We can incorporate automated feeding systems with our MCAS to manage the feeding program with minimal physical effort.

Staff safety is a priority in our designs. We advocate for safety railings, escape manways, ladders, control boxes with Lockout/Tag capabilities in and around the RAS equipment.

8. How would you typically integrate backups and redundancies in your design? For which specific components?

Back up and redundancies are an integral part of our design philosophy. Redundancy requirements and decisions are driven based on risk analysis and the customer's tolerance towards risk. We work with our clients to tailor their system design based on their risk tolerances and requirements.

One design feature we always incorporate is culture tank oxygen monitoring with backup O_2 capabilities. We monitor the dissolved oxygen levels in real-time using *optical or galvanic probes in conjunction with our backup oxygen solenoid dosing system. If the dissolved oxygen concentration falls below a setpoint or during power loss the solenoid valve will automatically open allowing for diffused oxygen to enter the culture tanks. The diffusers will be sized to maintain the required DO at max stocking/feeding capacity. If oxygen concentrators are used it would be highly recommended to have complete redundancy such that one unit can be serviced while the other is operational. During normal operation one would operate while the other is in standby with auto transfer capabilities. The units should be periodically cycled to keep them in good operational condition.*

Ideally for a risk adverse client the RAS pumps would be designed with the capacity that if one pump fails the full flow can be maintained with the remaining pumps. Each pump would be controlled by a VFD based on flow or line pressure. For example, if a RAS system requires a flow of 12,000 gpm, qty (4) pumps would each operate at 3,000 gpm but they would have the capacity to run at 4,000 gpm. During normal operation qty (4) pumps would maintain the 12,000 gpm flow but if one pump failed the remaining pumps would automatically ramp up to meet the require flow of 12,000 gpm.

The process air blowers would be designed with the same redundancy philosophy as the RAS pumps.

For drum or disc filters when reasonable our design will plan for redundancy within individual systems. For the risk adverse a RAS system with 100% drum filter redundancy allows for one drum filter to be taken offline for maintenance while the other filters maintain normal filtration at full capacity.

9. How would you typically integrate provisions for minimum impact of power loss on tank and sump volumes in your design?

We use a couple of different approaches to minimize water loss during a power failure. Our first line of defence is to have a backup generator onsite with an automatic transfer switch to quickly restore power to the essential equipment at the facility. However, we also plan for a complete power loss as well. We hydraulically design our culture tanks to minimize the working head within the tanks. By minimizing the working head within the culture tanks, we minimize the amount of water that will be lost when the pumps are shut down. In addition, we design our integrated sumps (drum filter basin, MBBR and Pumping station) to have the capacity to capture the water lost from the culture tanks. For clients with limited water supplies we have added automatic actuated valves on the return lines or system overflow that close during power loss and hold the water level within the culture tanks. Another option is to have a collection basin downstream of the integrated sump sized to collect water loss through the system during a power failure. We would tailor this aspect of the system design to match your goals and objectives.

10. What would your ongoing support services typically look like, post-design and during the construction, commissioning, and operation stages?

The Innovasea RAS design is only the first step of our potential engagement as we will provide an opinion of probable cost and description for all the RAS equipment and arrange for all the logistics to deliver this to site and to supervise the installation of the equipment during construction.

- *The operation may choose to work with their own Engineering Procurement & Construction (EPC) firm to build the farm infrastructure or discuss with Innovasea having us provide these services through a collaborating firm if the project is in the US.*
- *Innovasea will start-up, commission, and train staff in the systems operation.*
- *For extended training, service, or maintenance Innovasea would craft a tailored agreement with the company that would apply to all installations or facilities.*

11. What performance guarantees would you be able to provide in relation to your design?

Innovasea performance guarantees are provided based on the following operational areas:

- *Hydraulic performance of the system – design conditions related to proper tank functionality and design flows will be to design parameters to promote a healthy rearing environment*
- *Functional performance of motor and control systems – control functionality will perform as designed.*
- *Culture environment – systems fed at design feed loads and schedule, and with assumption of using RAS specific feeds, will maintain water quality parameters within design guidelines and provide the proper environment to promote quality growth.*

12. How much would be your fees to design a complete (as per 3. above) 1,000ton farm based on round fish tanks, and what would be the cost of the ongoing support services as per 10. above?

Design:

We will stand behind our design proposal to cover development of a production plan and the RAS design. If we are requested to cover additional work not already included in our proposal such as integrated feeding, fish handling, or additional items, then we would work with the company to define these requirements and would provide a revised integrated proposal or separate proposal to cover those items.

<u>Post Design:</u>

We typically enter into two subsequent contracts with clients: Equipment procurement and Field & Support Services.

<u>Field and Support Services:</u>

Field Services – Field services can include equipment offloading oversight, equipment installation oversight support, system start-up and commissioning, staff training and post fish stocking system & operational reviews. Innovasea provides, at no charge, two 4-day site visits at 3- and 6-months posts fish stocking to review system operations with staff. These visits are valuable as they provide staff time to understand system operations and ask more refined questions than during initial start-up and training. As clients have a wide range of requirements and budget allowance for onsite services, the scope, scale, and budget of the field services contract are defined by mutual agreement between Innovasea and the client.

Support Services – Remote services, associated with process control operation and programming, will be provided for 12 months at no cost during normal business hours. Thereafter, the company and Innovasea may enter into a services contract, if requested. Outside of a specific service contract, remote services will be billed at $150/hour and, quotation for specified tasks shall be provided for customer acceptance prior to performing the work. Remote support allows Innovasea at the company's request to review critical processes and help the team troubleshoot issues, such as pumping, oxygen, ozone, or other process control parameters.