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USSEC's In Pond Raceway System (IPRS) Technology Fixed Raceway Standard v2.0: Design and Principles

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IPRS is an enhanced pond production technology

Instead of a still water pond environment, it uses a CONSTANT FLOWING WATER PRINCIPLE

WE CANNOT OVER-EMPHASIZE THAT THIS APPROACH REQUIRES CONSTANT ROBUST WATER FLOW AROUND THE POND

WE USE WHITE WATER UNITS TO ACHIEVE THE FLOW THROUGH THE RACEWAYS AND ALSO FROM STRATEGIC POINTS IN OPEN WATER

PUT SIMPLY, IF YOU FOLLOW THE PRINCIPLES WE TEACH, YOU SHOULD SEE THE PERFORMANCE WE STATE;

IF YOU DO NOT FOLLOW THE PRINCIPLES, THE PERFORMANCE WILL SUFFER AND YOU MAY NOT MAKE MONEY

IPRS – Efficient and intensive pond use

- **Based on volume of the pond water: 10,000m3 of pond water volume can use 220m3 of raceway volume to produce:**
  - **33,000kg of fed species in the raceway production cell at peak biomass**
  - **7,500kg of service (filter) species in the pond at peak biomass**
- **Each standard raceway cell production area should be 22 x 5 x 2m effective water volume (220m3)**
- **System is flexible, can culture multiple species or sizes**
- **Waste collection is possible**

WHILE WE HOLD AND CULTURE FISH IN RACEWAYS IN THE POND, <u>THE REAL DIFFERENCE IN THIS APPROACH TO TRADITIONAL POND CULTURE IS THE WAY WE MANAGE WATER MIXING AND AERATION IN THE OPEN POND</u>

****THIS SHOULD BE YOUR MAIN TAKE-AWAY UNDERSTANDING TODAY!!!****

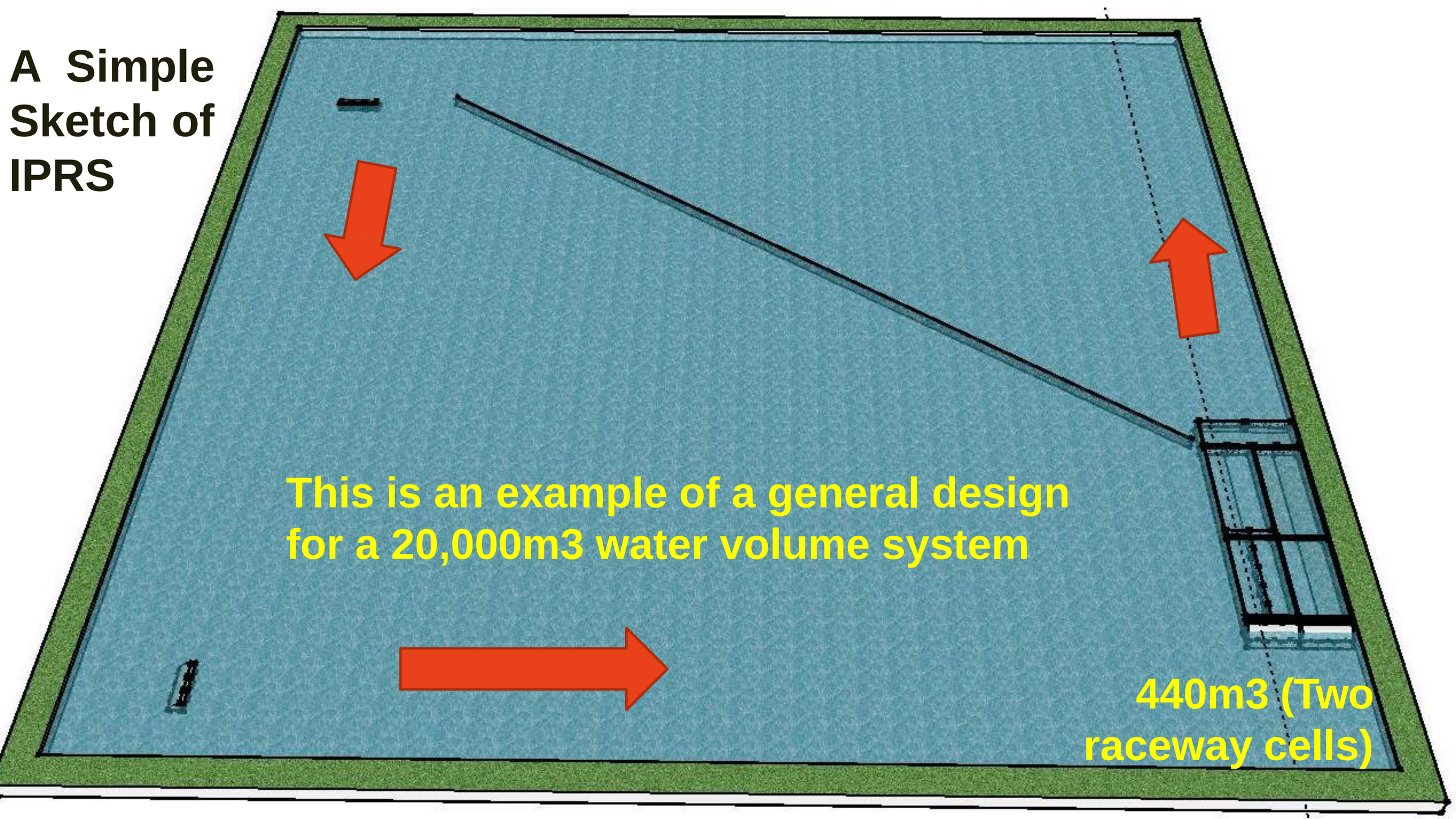
IPRS – Critical requirements

- **Minimum pond volume size of 10,000m3 (length, width and depth of pond water), but we suggest that economically it doesn't make sense to have a farm with less than at least two raceway cells, so 20,000m3 of water volume would be required**
- **System requires electrical service 100% of the time**
- **Only suited to high quality, floating feeds – no sinking feeds, "feed supplements" or organic material (leaves, etc.).**

IPRS – Critical requirements

- **Requires strict adherence to operational principles**
- **Requires careful management – a new technology system with specific design and management requirements**
- **Significant investment needed, including operating capital**
- **Specific equipment needed (including backup units)**

A Simple Sketch of IPRS



Pond water volume is EVERYTHING

- **Larger ponds are more efficient than smaller ones when using the IPRS system;**
- **It is more efficient to combine small ponds into larger ponds;**
- **There are established techniques for combining ponds without having to remove an entire levee/wall between adjacent pond(s).**

The heart of the system – the FLOATING White Water Unit

- Very specific design
- Needs to be serviceable
- Multiple units needed in pond system (minimum two WWU per raceway cell)
- Units should be compatible (interchangeable) between raceway and pond
- No moving parts except for the blower supplying the air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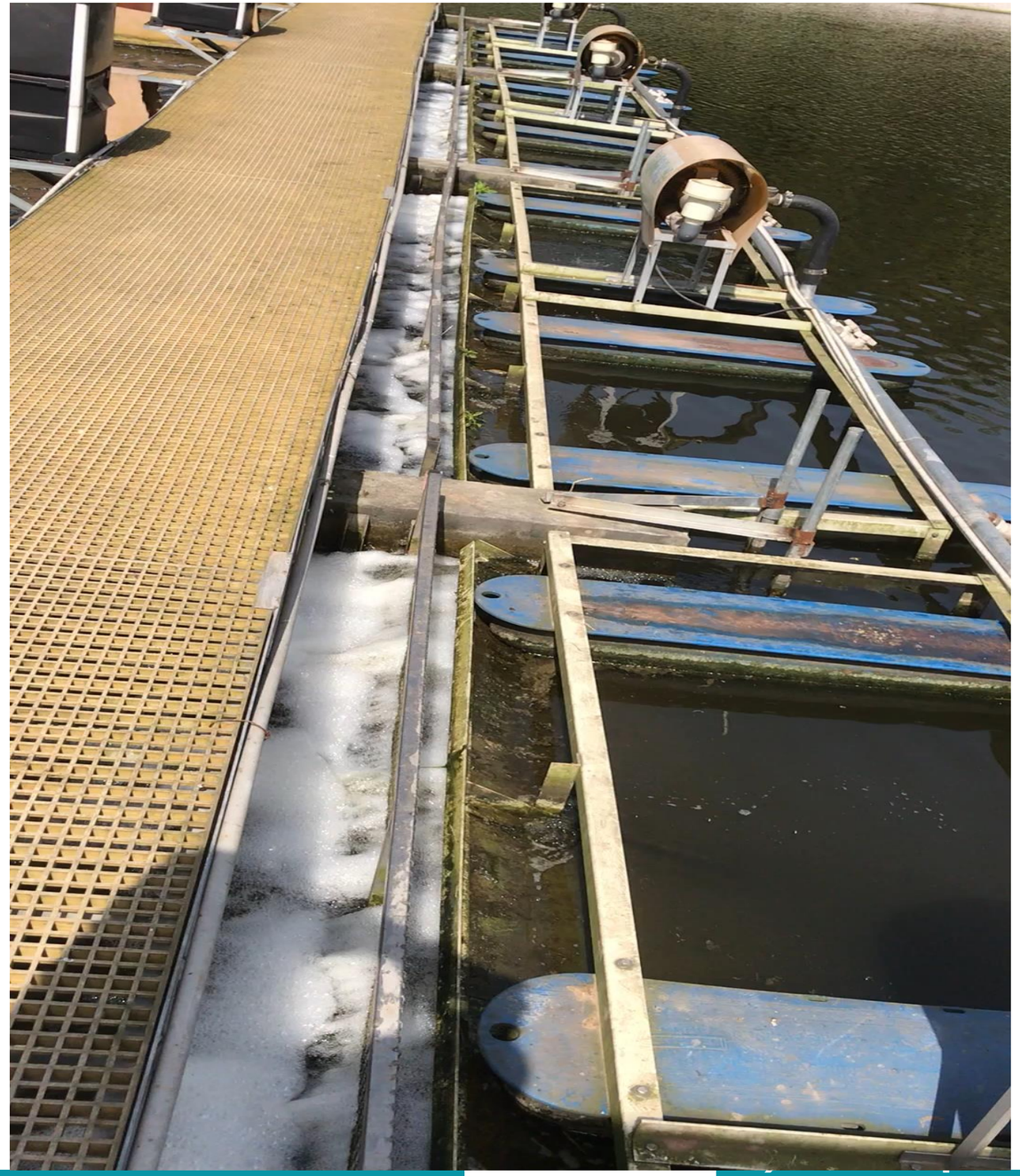
U.S. SOY FOR A GROWING WORLD



FLOATING White Water Unit (WWU) in Operation

Critical considerations of the IPRS system

- This system is based on over 25 years of research and testing.
- There are many details that may not be obvious, but allow a predictable, smoothly running system.
- Key calculations and designs should be used to achieve expected results

Pond Volume Ratio to Number of Raceways Installed

- **Important to correctly calculate pond water volume:**
  - **length x width x depth, typically ponds have somewhat irregular depths;**
- **Once we know the actual volume of the pond; we can calculate the size and number of raceways to install;**
- **This will also determine the maximum target biomass**
- **<u>**DO NOT INSTALL MORE RACEWAYS THAN THE CALCULATIONS INDICATE**</u>**

Pond Volume to Number of Raceway Installed

- **The actual percentage of raceway to pond volume is 2.2%; 0.5 hectare (5000m2) x 2 meters deep = 10,000 m3**
- **The preference is for a standard cell size of 22m x 5m x 2m (this volume is 220m3 within the raceway production area);**
- **This would require a minimum of 10,000m3 of pond volume (10,000m3 x 0.022 = 220 m3) but a minimum of two cells for economic production means that 20,000m3 of pond volume to support two raceway production cells (2 x 220m3 = 440m3)**

This Approach Raises Production Limits of Typical Pond Production Without Water Exchange

- **Each 10,000m3 of pond volume can support a 220m3 raceway production volume to produce (per cycle):**
  - **33,000kg of fed species in the raceways at peak biomass**
  - **7,500kg of service (filter) species in the pond at peak biomass**
- **<u>Peak biomass should only be a short-lived situation</u>; the actual biomass should never exceed the peak biomass calculated for the system at any time**

Matching of air blowers with air needed for FLOATING White Water Unit(s) and aeration/ mixing:

- **Air blowers must be highly reliable; under continual use;**
- **Minimum size 170m3 air per hour output;**
- **Blower output varies with type and emersion depth of the diffuser tubes;**
- **Need <u>at least three blowers</u> for a pond with one raceway unit (one for the raceway and one in the pond), should have an additional blower for the supplementary aeration system plus an optimally an extra blower in storage for backup**

The Heart of the System - White Water Unit (WWU): A FLOATING SYSTEM

- **The units should be standard between the unit placed on the raceway and those in the pond (interchangeable);**
- **Diffusers must be 0.5m above the bottom and 1-1.2 m below the water surface depending upon blower performance**
- **Diffuser tubes should be arranged every 6-7 cm and in at least two diffuser racks (~2.4m);**
- **Should be removable for cleaning;**
- **Hood angle should be 35°, a straight hood angle (not curved) is suggested**

The Heart of the System- White Water Unit (WWU): A FLOATING SYSTEM

- **Using the White Water Unit- We Seek to Accelerate the Waste Assimilation by Creating –AT LOW COST- a Continuous Robust Flow of Aerated Water Within the Production Pond;**
- **WWUs are electrically powered and are operated <u>continually</u> to aerate and mix the production pond and accelerate waste breakdown;**
- **Note: no other aeration system should be used in the pond at any time, i.e. paddlewheels, injection systems, etc. The WWU are all that is needed to correct mix and move the water for optimal results**

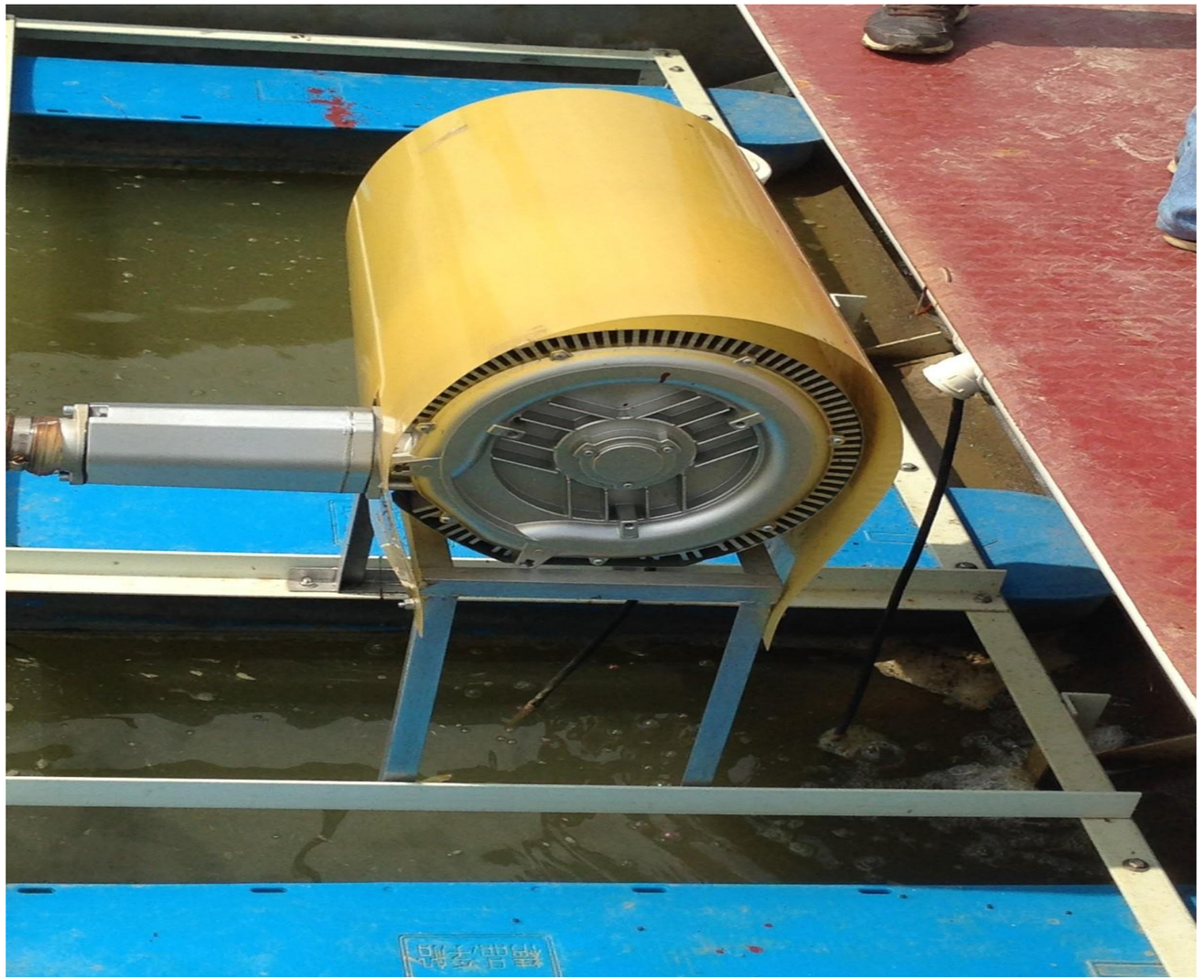
Correct ratio of WWU to Raceway Cells

- **To provide for each production cell, a minimum of two units of FLOATING WWUs are used per raceway cell:**
  - **One WWU attached to the upper end of the raceway, and:**
  - **One WWU in the open pond to facilitate pond volume mixing and aeration**
- **If your pond is over three meters deep, then a modified WWU design should be used that uses a "chimney" effect to correctly mix the water.**

Critical part of the WWU – diffuser tubing

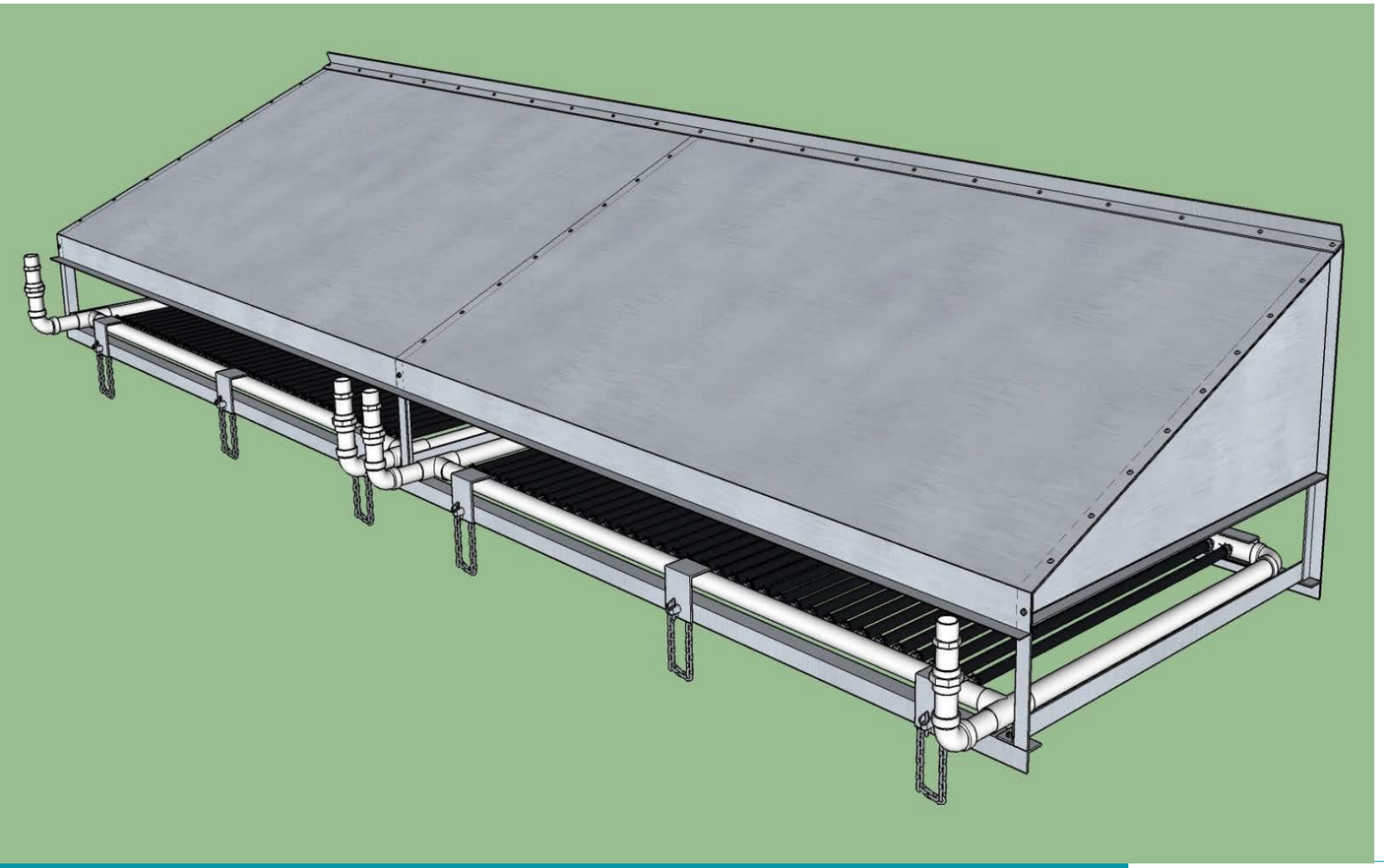
- **Colorite tubing is preferred (sometimes marketed as "Aerotube" with a blue stripe);**
- **Operates at optimum efficiency at 2.25m3 air per meter of diffuser per hour or 1.3 liters of air per meter per second (equivalent to 0.4 Cubic Feet per Minute in English units)**

A WIDE VARIETY OF BLOWER TYPES ARE AVAILABLE IN THE MARKET, THE STANDARD IS A “SWEETWATER” REGENERATIVE BLOWER MADE BY GAST



IPRS TECHNOLOGY REQUIRES A BLOWER WHICH DELIVERS HIGH VOLUME AIR AT RELATIVE LOW PRESSURE WITH HIGH RELIABILITY

Design of the WWU Main Unit



- **Hood should have a 35° angle**
- **Top raised edge lip**
- **Floats should be installed (see next slide)**
- **Typical WWU (5m wide) has 2-4 diffuser racks holding diffuser tubes**
- **Racks should be easily removable to allow cleaning and repair;**
- **PVC rack should be 75mm, schedule 80 PVC;**
- **Standard 5m size WWU will need a blower supplying 170m3 at the diffuser installation depth**

1.5 HP FLOATING White Water Unit (5m wide)

- **Typical floating WWU – note the float orientation and that the WWU is independent of anything but an electrical connection. WWU should be quickly interchangeable and removeable from the system. Should be able to self-regulate depth (free floating)**

Diffuser rack front showing C-clamp and diffuser pipe spacing

Rear view of diffuser rack with removable C-clamp for easy removal and servicing

Typical raceway structural design

Raceway location and construction

- **Raceways are installed at pond locations that facilitate efficient water flow and access for stocking, feeding, harvest and general management;**
- **Raceways are generally constructed with a mix of materials, importance is to have a strong enough structure to maintain integrity. (brick, concrete and steel re-bar are typical components);**
- **Raceway floor can be in two parts:**
  - **Bases or footers below the walls that are thicker to accommodate the weight of the vertical wall**
  - **The raceway "floor" between the walls that form the base of the raceway (7-8cm thick)**

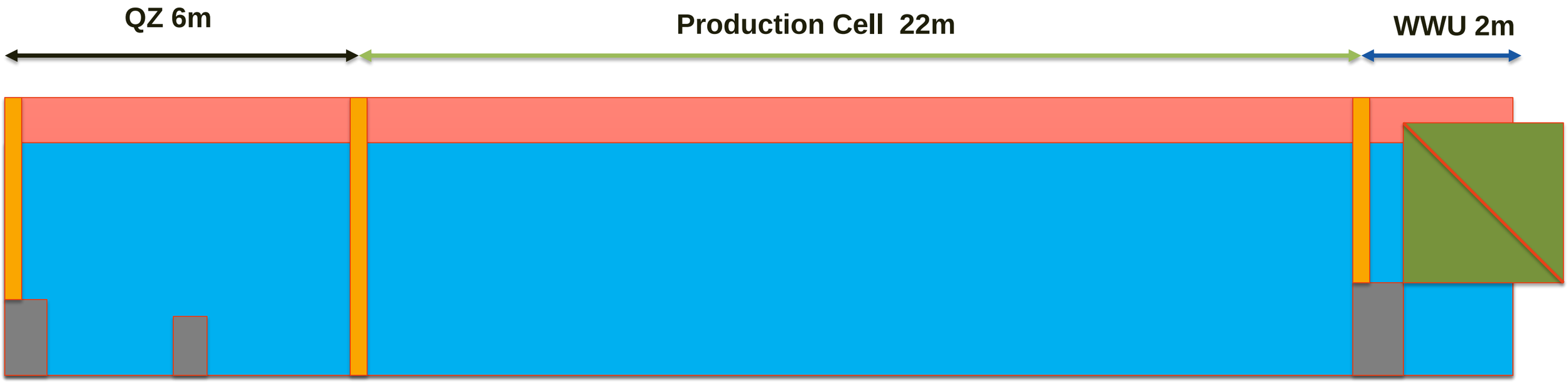
CONCRETE FOOTER WITH RE-BAR FOR WALL STRENGTHENING

A Good Example of a Newly Finished Raceway

Knee wall placement

- A knee wall (cement or other material may be used under the FLOATING White Water Unit – but at the downstream side of the FLOATING WWU, 0.8m tall and X wide
- A cement knee wall is required at the end of the raceway to form the quiescent zone area, this should be about 0.6m tall and X wide
- If a 6m QZ is used (suggested) then there should be an internal knee wall at the 3m mark, 0.35m tall and X wide

Raceway side view and water flow



NOT TO SCALE!

Key: Red and Blue (raceway wall and effective water area), Orange (gates), Grey (knee walls), Green (WWU)

Working walkways

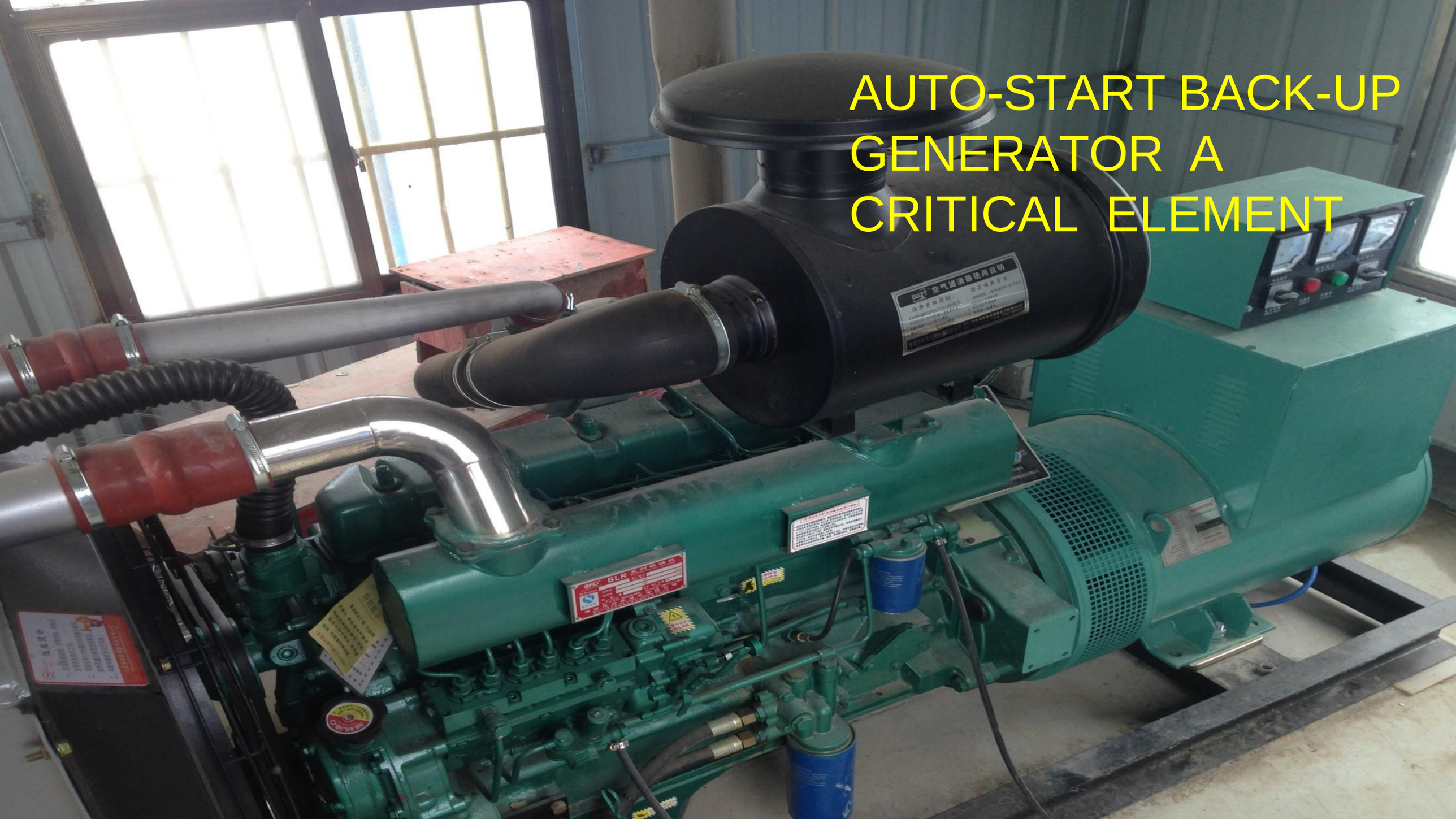
- **Working walkways are installed on the top of each raceway at both the upstream and downstream ends**
- **Should be ~1.2m wide and strong enough to used for supporting feed and harvest activities**
- **Walkways should not impede the raising and lowering of gates**

Utility hookups

- **Air, electrical, feed tubes and any other utilities are typically at the upper end of each raceway cell**
- **Only other potential installation requiring power or air is if a waste collection system is put on the downstream end**

Electrical issues: line power and emergency generator

- **All IPRS systems need constant power supply, primary supply should be line power (not necessarily three phase);**
- **Also must have an emergency backup system (generator) for when line power is interrupted;**
- **Ideally this should be a generator with an automatic startup (alarm should also be installed);**
- **Generator should be tested under full load at least every week**


AUTO-START BACK-UP
GENERATOR A
CRITICAL ELEMENT

Confinement Gate systems:

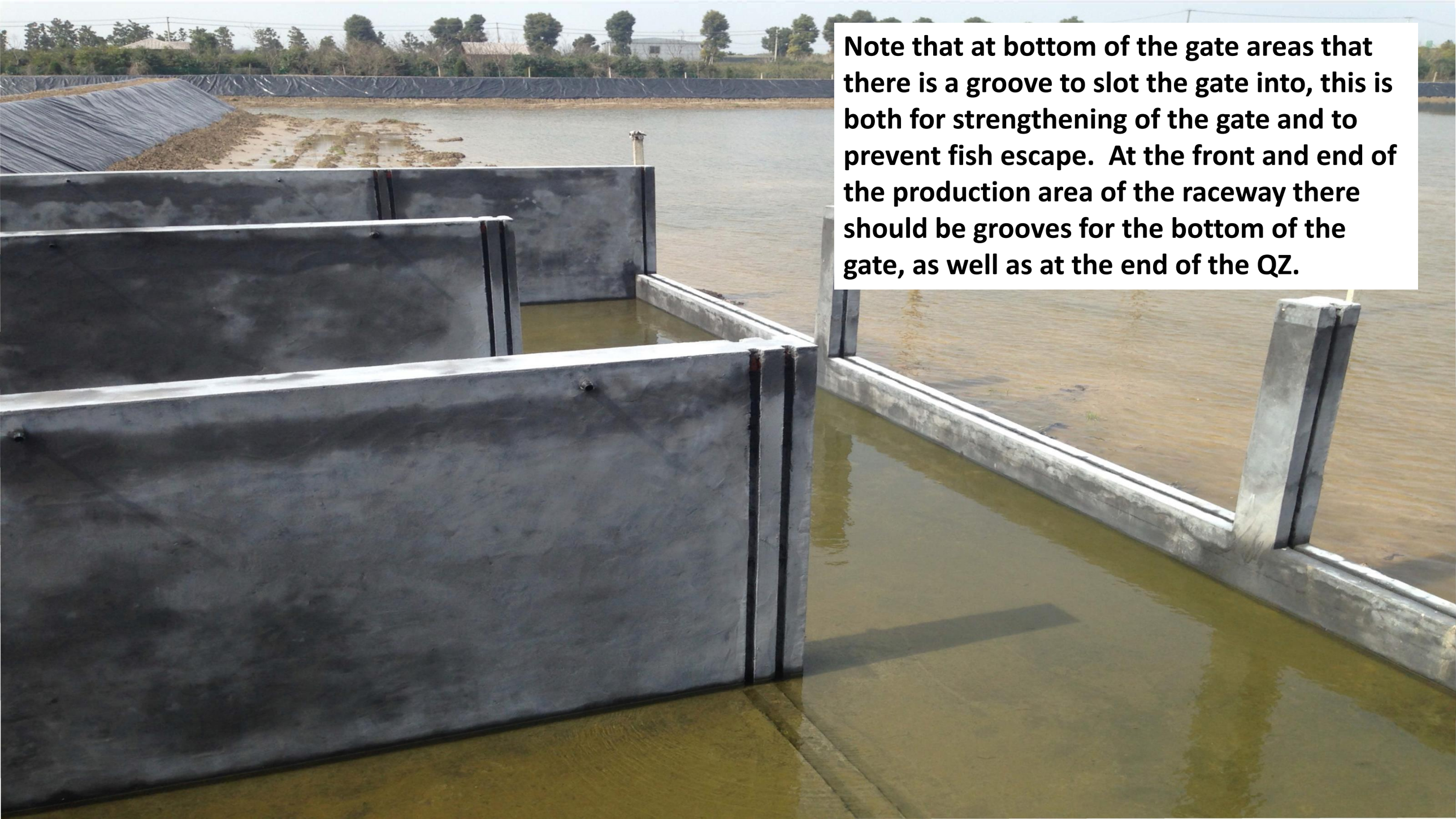
- To keep your fish with in the raceway system gates needed on both ends;
- Frame should be 4-5cm aluminum or steel (wood not recommended);
- Mesh should be PVC coated metal or stainless mesh of the appropriate opening size for the species and age class;
- Gates and mesh should not significantly reduce water flow (don't use too small a mesh);
- Gates should be mounted into a slot in the raceway wall (a second slot should be created 10-20 cm from the first to allow easy exchange of gate panels

Gates keep your fish in, allow water to flow and keeps other things out.

- Gates are needed within the production area of the raceway, but also at the end of the QZ to prevent entry of fish in the pond into the QZ.
- Within the production area of the raceway, two slots side-by-side will allow managers to change gates without allowing fish to escape

Metal gates and metal mesh the width of the raceway

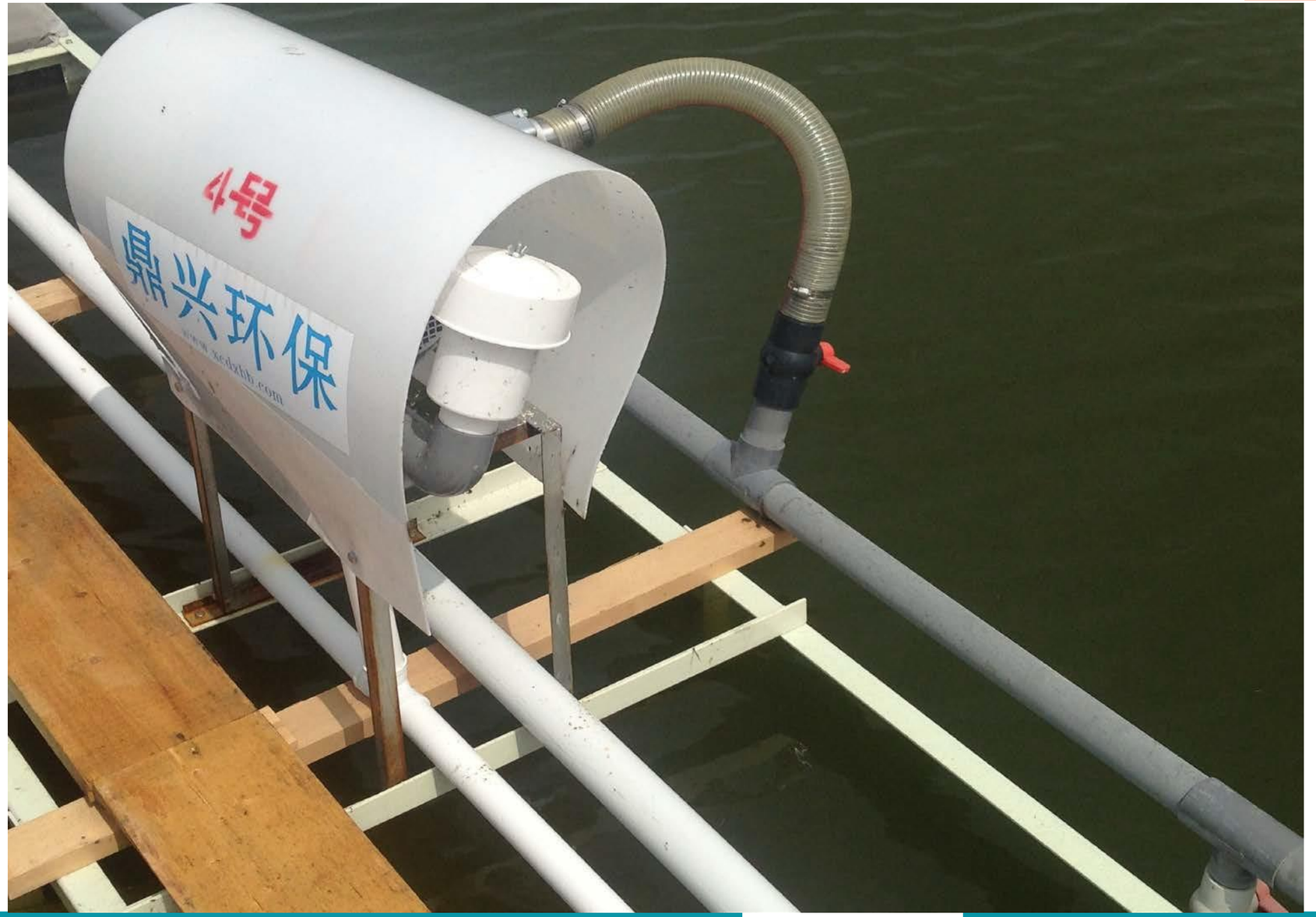
Slots for gates in the raceway, can be inset in the wall or with brackets, note width between slots, should not be directly adjacent



Note that at bottom of the gate areas that there is a groove to slot the gate into, this is both for strengthening of the gate and to prevent fish escape. At the front and end of the production area of the raceway there should be grooves for the bottom of the gate, as well as at the end of the QZ.

Supplementary air systems:

- **Supplementary air systems should be used when biomass is 60% or more of target biomass;**
- **Install this system in the first 15m of the raceway (not all the way to end, or it will cause issues in the QZ);**
- **Air supply tubes should be fitted in a groove on top of both raceway walls with airline drops every 1.2-1.5m to supply diffuser tubing;**
- **Diffuser tubes should be located at the base of the side wall (both sides); rebar can be used to weigh down the diffuser tubes (or a "U" created with diffuser piping and connected to two outlets;**
- **Blower must be able to supply sufficient air volume and pressure to diffuser near the bottom, if necessary it may be raised to 0.5m above the bottom to accommodate blower**
- **Ensure that the supplementary airlines will not impede the harvest of the cell, i.e. once air pipes are removed then the raceway wall should have not air nipple extending past into the raceway.**



Supplementary Air Blower Plumbed to Air Manifold on Top of Raceway Wall

Supplementary Air Manifold Installed in Formed Slot Atop the Wall

Tubing Pushes air to Diffuser Tubing Below

Quick view of supplementary aeration in China

Please note that in this video shows the supplementary airlines on top of the raceway wall, these should be inset into a groove in the top of the wall as in the previous slide.

Design and orientation of pond water baffle:

- This is a critical element important to the circulation and mixing of the pond water volume;
- Baffles are simply barriers to water taking any path other than fully mixing the pond;
- The baffle is installed to cause water to move continually through the raceway and around the complete pond area;
- WWUs are placed to optimize mixing of the whole pond environment

Design and orientation of water baffle:

- **Should extend across the pond with an opening that is 200-300% of the total width raceway(s);**
- **Typically the first pond WWU will be placed in the opening;**
- **Orientation of baffle wall and the WWU is important;**
- **Baffle made of materials that require no maintenance and are long-lasting, can be many materials (soil, metal sheets, plastic membrane, tightly woven synthetic fabric, etc.**

Baffle extending along the center of the pond to direct water around the pond, fabric and fence construction

Correct water movement

- Pond bottom should be regularly shaped to allow efficient water mixing and flow;
- Critical that baffles not restrict water flow – that is that baffle length should allow an opening for water flow that is 2-300% (three times) the total width of the production raceway(s);
- Raceway units set up correctly should exchange their volume every 5-7 minutes;
- Therefore an IPRS unit holding 220m3 exchanges its water volume 8-9 times per hour;
- A single IPRS unit will pass >50,000m3 of water per day!

Waste Management

- **While the pond acts as a biological filter, the IPRS technology allows solid waste removal prior to it entering the pond.**
- **This helps to maintain water quality for the long term and may provide additional revenue.**

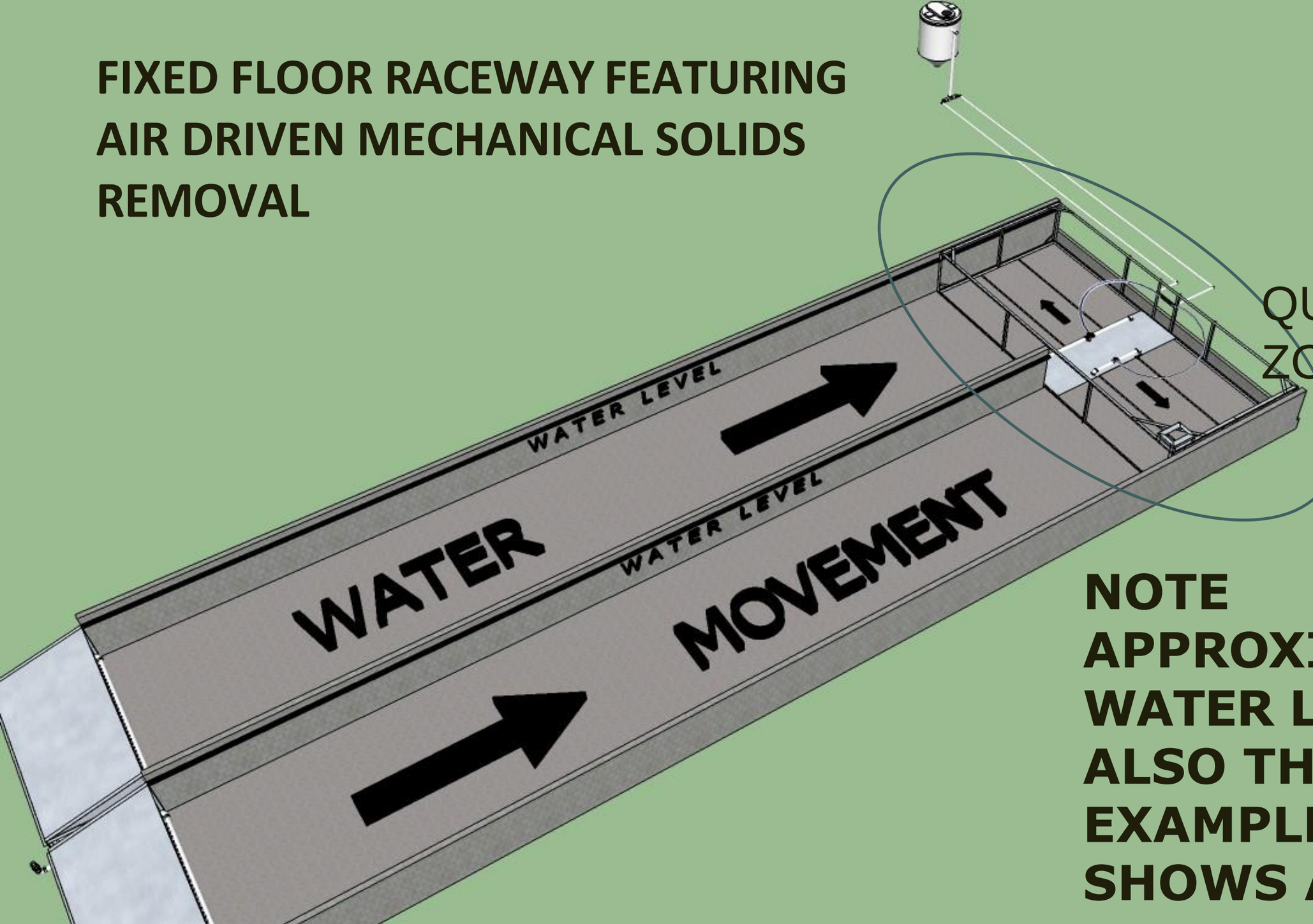
Design of the waste collection system:

- **Waste from fish will reduce pond performance over time, seek to collect and remove as much as possible;**
- **From the 22m standard length of the raceway, the last 6m are used to develop a quiescent zone (QZ) where manure and other solids can be collected and removed;**
- **Manure and solids removal can be manual, but mechanized systems have also been developed and are the most common method today**

Design of the waste collection system:

- **Removal of waste from the quiescent zone (QZ) should be a minimum of three times per day if not continual;**
- **Can be driven by a pump or an airlift system;**
- **Need to have a receiving area for the waste material– we do not want to have the removed solids flowing back into the pond;**
- **Wastes may present a possible alternative revenue source, but more importantly removal of waste maintains water quality and fish feeding efficiency**

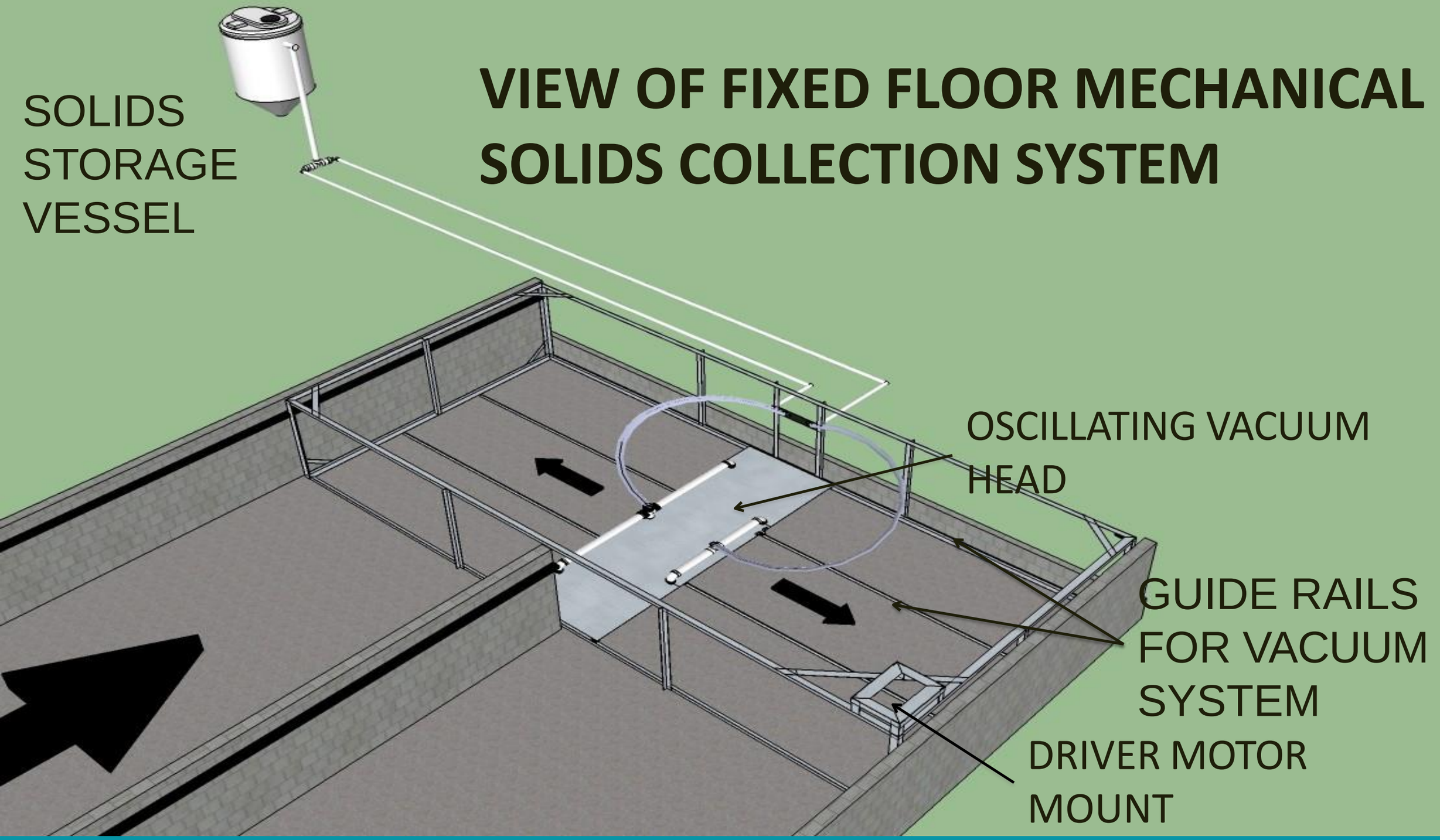
FIXED FLOOR RACEWAY FEATURING AIR DRIVEN MECHANICAL SOLIDS REMOVAL



QUIESCENT ZONE

NOTE APPROXIMATE WATER LEVEL, ALSO THIS EXAMPLE ONLY SHOWS A 3m QZ

VIEW OF FIXED FLOOR MECHANICAL SOLIDS COLLECTION SYSTEM




VACUUM
HEAD

NOTE VACUUM PORTS AND DIRECTIONAL SCRAPERS FOR FUNNELING SOLIDS TO SUCTION THROAT


QUIESCENT ZONE
FOR SOLIDS
COLLECTION AND
HARVEST
Note, this is a 3m
version, 6m with an
intermediate knee wall is
the v2.0 standard


WORK
WALKWAY
QUIESCENT
ZONE

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SOLIDS REMOVAL SYSTEM USING A CENTRIFUGAL PUMP DEVICE

Oscillating Pump and Carriage for Solids Removal

SLUDGE COLLECTION VESSEL

Identification of appropriate quality equipment

- A farmer/operator will not save money by purchasing low quality equipment for the IPRS system
- The system components will be used very intensively, and they must operate correctly 100% of the time
- Suggestion is to stay with branded product and not copies as copied equipment is usually not as high a quality as that of the original design – and will fail when is least convenient
- An IPRS system is a long term investment, it is worth spending the money if serious about using the technology

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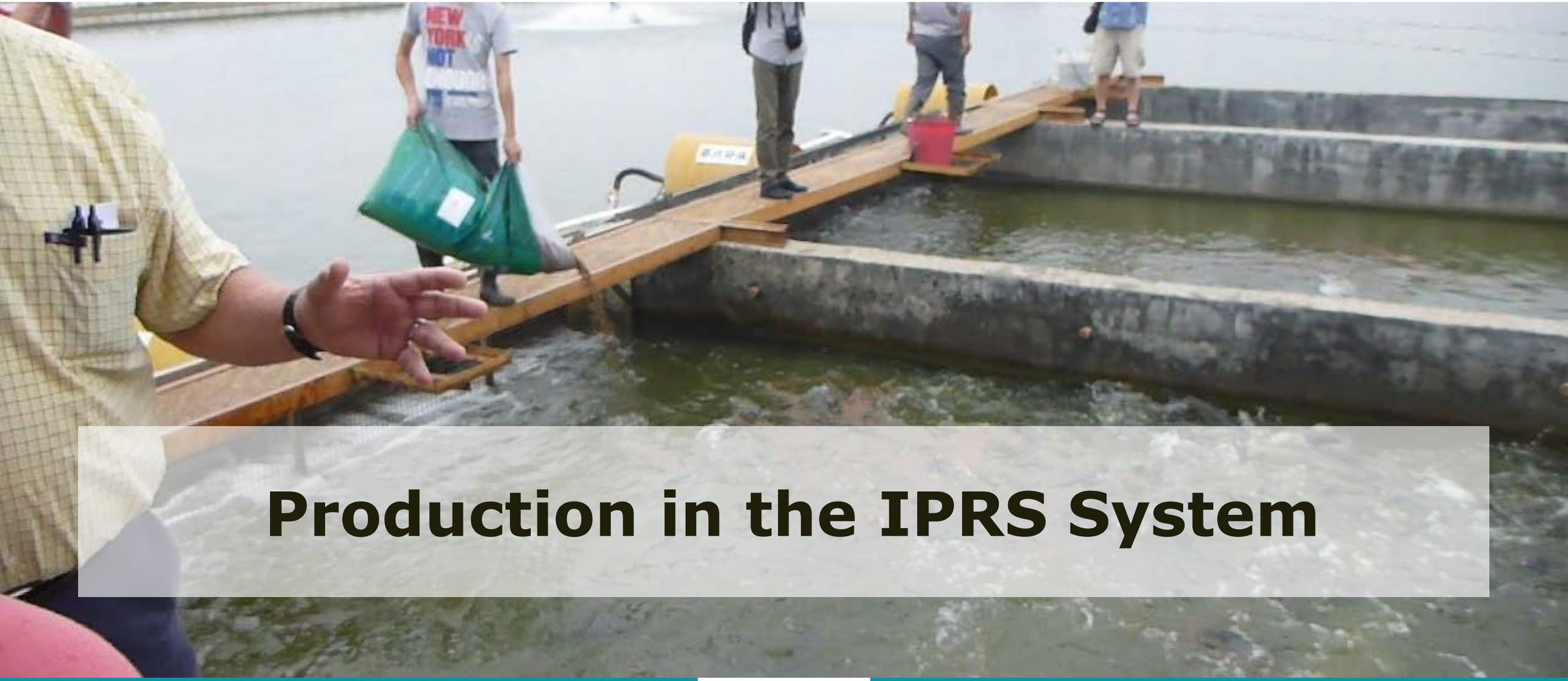

Production in the IPRS System

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Target biomass: Raceway cell and pond

- **Target biomass for per raceway cell with the correct 220m3 production volume to 10,000m3 pond volume is:**
  - 150kg/m3 at peak biomass in the raceway for growout
  - 125kg/m3 at peak biomass for fingerling production
  - The raceway cell is the only area that feeds should be added to the system and should contain feed-taking species
- **Target biomass for the outside pond for service species is 7,500kg fish/10,000m3 pond volume**
  - Service species ARE NOT FED, NO FEEDS SHOULD BE ADDED TO, OR ALLOWED TO ENTER THE OPEN POND
  - Service species may be filter feeders, detritus feeders or may help with recruitment issues (i.e. silver carp, prawns/shrimp, snakehead respectively)

Stocking the production raceway: Planning and calculation

- **In order to optimize production and Return On Investment (ROI) we need to carefully plan the stocking of the IPRS raceway unit.**
- **Stocking is based on the average size of the desired fish at harvest and the maximum biomass target for the raceway.**
- **Remember, maximum biomass for a standard raceway (220m3 of raceway volume per 10,000m3 pond volume) is:**
  - **150kg/m3 at peak biomass in the raceway for grow out**
  - **125kg/m3 at peak biomass for fingerling production**

- **Multiple cells in a pond should be stocked in a staggered fashion – not all at once!**

Calculating stocking rate in the raceway production unit

- **Target biomass (kg/m3): 150kg/m3**
- **Target harvest size of fish (in kg): 1.5kg/fish**
- **Total volume of production unit (in m3): 220m3**
- **Stocking rate (fish/production unit) = (Target biomass x Total volume of production unit) ÷ Target harvest size of fish**
- **Stocking rate (fish/production unit) = (150kg/m3 x 220m3) ÷ 1.5kg/fish = 22,000 fish/unit**

Other aspects of stocking in the raceway production unit

- When larger fingerlings are stocked, the target size of the fish will be reached faster
- The IPRS raceways can be used to efficiently develop larger fingerlings for stocking on-site by using one (or part of one) raceway for advanced fingerling development
- When using raceways for advanced fingerling development, target biomass is 125kg/m3 (less than for growout fish)
- To produce 100g fingerlings in a standard raceway volume:
- Stocking rate (fish/production unit) = (125kg/m3 x 220m3) ÷ 0.1kg/fish = 275,000 fish/unit

Other aspects of stocking in the raceway production unit

- **Stock fish which are healthy and that have been graded for size and uniformity;**
- **Fingerling size and gate mesh must be carefully matched or fish may escape from raceway production area;**
- **Planning of fingerlings well of advance of stocking will help to reduce surprises – this has been an issue in SE ASIA in particular. Poor uniformity in stocked fish will likely result in reduced efficiency and FCR at harvest.**

Scheduling of fish stocking and biomass in the raceway production unit

- **Important to stock fish in a way to spread out the time each cell reaches peak biomass;**
- **Achieved by stocking at intervals or by initially stocking different size fish in each cell**
- **On-site production of appropriately sized juveniles in IPRS systems is a great benefit**
- **Peak biomass planning needs to coincide with market demand optimal pricing**

Service species stocking in pond (not raceway) to improve water quality

- **Important to stock fish in a way to spread out the time to reach peak biomass;**
- **Achieved by stocking at intervals or by initially stocking different size fish;**
- **Partial harvest will need to take place to maintain the biomass at safe levels;**
- **AGAIN, NO FEEDING OF SERVICE SPECIES IN THE POND!**

IPRS Production Records

- **It is critical to keep good production records including stocking, feed, sampling, chemicals, energy etc. for better improvement of IPRS operation.**


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IPRS Harvest

- **Market price**
- **Harvest time**
- **Harvest quantity**

Thank you!

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