I.M.A.
1
AQACULTURE SERIES

FISH FARM PONDS

A Manual for their Design, Construction and Maintenance

by

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FOREWORD

The last 25 years have seen a rapid increase in the development of aquaculture worldwide. In the Caribbean today, small scale operations which started out as family enterprises have begun to expand. That pattern of development is also taking place inTrinidad and Tobago.

The Institute of Marine Affairs (IMA) five years ago embarked upon an aquaculture research and development project aimed at providing the technical know-how to suit local conditions, whilst at the same time encouraging interested persons to seriously consider fish farming as a worthwhile investment.

Considerable potential exists for an economical viable aquaculture industry in Trinidad and Tobago, given the rising price of fish and shellfish, not only locally but also on the world market. This is partly due to declining catches of marine fish species and partly to the ever-increasing human population and the demand for protein at affordable prices.

This manual on pond construction and maintenance is the first in a series of IMA manuals on the principles and practice of aquaculture.

It is hoped that the information presented here will be found useful to readers and other persons interested in pursuing aquaculture.

Lennox Ballah
Director, IMA
(1988 - 1996)

1. INTRODUCTION

Aquaculture is the cultivation of aquatic plants and animals, under controlled conditions, in fresh, brackish or salt water. In Trinidad and Tobago, fish farming is practiced mostly at the backyard level, using ponds of poor design that are difficult to manage. It is therefore desirable to encourage the development of properly designed systems which are manageable and more productive. The species reared in Trinidad include the giant freshwater prawns or crayfish, and fish such as the cascadura and tilapia.

Aquaculture is not new and has been in existence for over 2,000 years. The first written account of fish culture in ponds was written in 475 B.C. by Fai Li, a Chinese fish farmer. While there have been many manuals and books written on the biological aspects of aquatic organisms, there is little available information on the application of engineering principles to the development of commercial aquaculture systems.

The design and construction of aquaculture ponds are specialised, depending on the species reared and methods used. This does not suggest that basic engineering principles are not used, but that the biological requirements of the species and the characteristics of the proposed farm site must be taken into consideration.

Aquaculture ponds may be of different sizes and shapes, depending on the layout of the available land and the use of the ponds. For example, production ponds tend to be larger than nursery ponds. Extensive systems utilize large bodies of water while intensive systems tend to utilize smaller, man-made ponds.

The aquaculture system, including pond design and use, would therefore depend on the resources, such as land and water, available to the farmer.

This manual attempts to describe how to design, construct and maintain ponds, and is geared towards the potential commercial aquaculturist or fish farmer.

2. SITE EVALUATION

Poor or inadequate engineering of farm ponds used for aquaculture is one of the major causes of low production and, ultimately, of failure of the business. In Trinidad and Tobago, there are ponds and aqua-farms which have been constructed on unsuitable sites and which are now partially or totally inoperative.

The evaluation of sites for aqua-farms involves a detailed and comprehensive survey to determine the suitability of the proposed site to provide the requirements of the species to be reared, and the cost and labour needs to develop and manage the business. Such a survey should be conducted by suitably trained and experienced personnel, and would provide the necessary information to the farmer. It would also assess any negative impacts the proposed aquaculture farm would have on the environment.

The basic requirements of a suitable site should include an adequate supply of good quality water, soil suitable for pond construction, and land that can be drained. Accessibility to electricity, communication and transport are factors which must also be considered.

Water is the medium in which all aquaculture animals live and it must therefore be maintained in sufficient quantity and quality to sustain life. It should be accessible and available all year round.

2.1 Water Quantity

The quantity of water required for any aquaculture system should be enough to fill ponds and constantly replace losses due to evaporation and seepages. Controlling quantity is never a major problem provided the facility is properly designed and constructed. There is no such thing as having too much water. By far the greatest and most frequent problem for aquaculturists or fish farmers is too little water.

The best time to assess water quantity is at the peak of the dry season when availability is expected to be at its lowest. The amount of water needed varies with species, management practices, and intensity level of the system i.e. extensive, semi-intensive or intensive.

Extensive culture is usually practised in large bodies of water such as naturally occurring lakes, large ponds or man-made dams. There are little, if any, inputs of feeds or fertilizer, and stocking densities are very low. Resulting production is low and there is little management or control of the system.

Semi-intensive and intensive cultures are usually practised in man-made ponds or tanks with large inputs of feed and sometimes fertilizer. Stocking densities and resulting production are high and the system requires close monitoring and management. With high stocking densities and large feed inputs, waste products accumulate rapidly. This leads to a higher oxygen demand and requires frequent water change for waste disposal and hence proper water quality.

2.2 Water Quality

Water quality must be evaluated according to the requirements of the particular culture organism. For example, water that is suitable for growing fish may not be suitable for growing prawns. It is therefore necessary for the fish farmer to be aware of the tolerance range of his culture species. It must be noted also that the quality of the intended water should be of an acceptable sanitary condition so as to protect the health of the consumer. Good quality water suitable for fish culture should be rich in oxygen and free from pollutants.

Trained personnel are needed to carry out the water quality measurements, some of which can be done on site and others in the laboratory. These measurements would include temperature, dissolved oxygen, nutrient levels and pH.

While water temperatures in Trinidad and Tobago are fairly constant and will usually support indigenous species, the diurnal, seasonal and annual water temperature variations for the site should be known. Most culture organisms will tolerate, and can live over, a fairly wide temperature range, but sudden changes in temperature cause stress and could lead to mortality. This is particularly so in the larval and fry stages. Temperature requirements of a selected culture species will, to a large extent, determine if the water is suitable. Temperature can also affect other water quality parameters, such as dissolved oxygen gases. Gases dissolve less in water as the water temperature increases.

Other factors which affect water quality include pH, salinity, hardness, alkalinity, suspended solids, nutrients and pollutants in the form of industrial effluent and agricultural pesticides and fertilizers. Coliform organisms and microbiological contaminants are undesirable.

2.3 Water Sources

Good sources of water for fish farm ponds include wells, springs, rivers, dams and large ponds.

Wells and springs usually provide year round water flow, while fluctuating flows may be obtained from rivers and streams. Well water is usually low in dissolved oxygen but this problem can be solved by splashing the water at the supply inlet or by using accessory aeration devices. Rivers and streams are particularly susceptible to siltation and flooding. They may also contain undesirable species that could infest ponds.

Dams and large ponds may be used to provide water for fish farm ponds. Sometimes they are actually used as the production pond. In most cases they are used for water storage or back-up water supply.

2.4 Soil

Pond construction requires certain soil characteristics, particularly those relating to texture, salinity, pH, organic content and compactibility.

Texture refers to the relative proportions of sand, silt and clay in the soil. These influence its relative impermeability, i.e. the degree to which it can hold water (Figure 1).

Soil tests should be performed over the entire area. Samples are usually taken at 50 - 100m intervals, using a soil auger, to a depth of approximately 1.5 - 2m. Laboratory tests should be performed to determine the percentage composition of clay, sand, silt and organic matter of the soil.

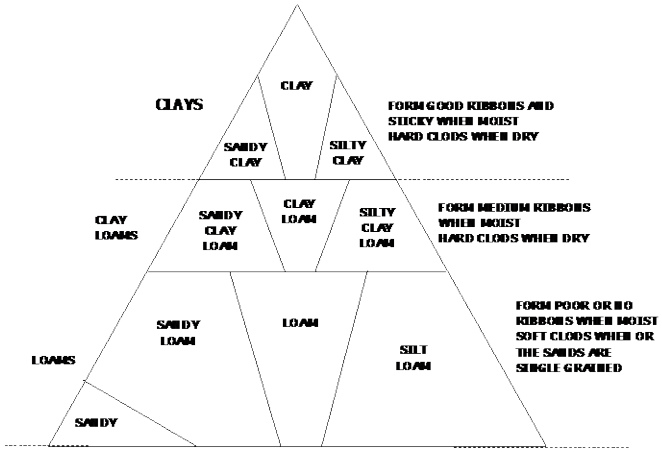


Figure 1: Textural triangle showing soil types and classifications for use in simple on-site testing.

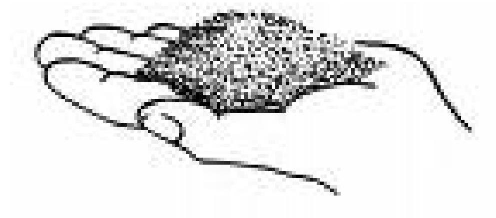
A very simple on-site soil test involves squeezing a handful of dampened soil. If the soil maintains its shape without crumbling, this indicates that the soil is probably suitable (Figure 2). Other on-site tests include seepage and ribbon tests. Seepage tests involve digging a hole in the ground, filling it with water and measuring the water loss over time. The soil with minimal seepage is most suitable. The ribbon test involves extruding the dampened soil between the thumb and forefinger to form long strings of soil or adhering ribbons. Soils which form the longest ribbons are most suitable.

Generally, soils which have above 20% clay are suitable for pond construction, since they are relatively impermeable and easily compacted.

2.5 Topography

Ponds for aquaculture can be constructed on a wide variety of topographic land surfaces.

Steep slopes require small deep ponds if adequate water depth is to be ensured. This requires large amounts of soil movement during construction (Figure 3).



STEP 1: Dampen handful of soil

STEP 2: Squeeze soil firmly in your hand

STEP 3: Observe if soil maintains shape

Figure 2: Simple on-site soil testing procedure

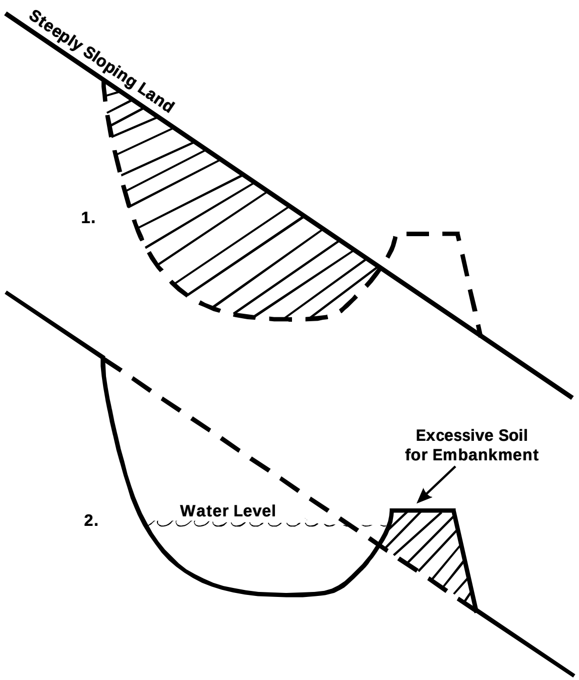


Figure 3: Pond construction on steeply sloping land

On very flat land or in swampy areas below sea level, problems with drainage are likely to occur (Figure 4). Ponds built under these topographical conditions usually require special heavy machinery for construction, suffer low dissolved oxygen conditions and require pumping for total drainage. These factors will increase the production costs of the cultured product.

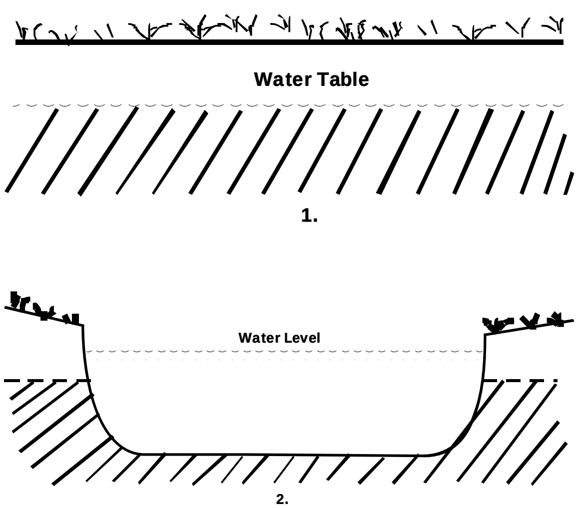


Figure 4: Pond construction in swampy area

Gently sloping land is most suitable for the construction of embankment type ponds (Figure 5). The slope is usually in the 1 - 5% range, i.e. 1 to 5m rise over a 100m distance.

As a general rule, gently sloping land, which can provide an adequate water supply without pumping, is preferred. This would also allow for easy gravity flow drainage.

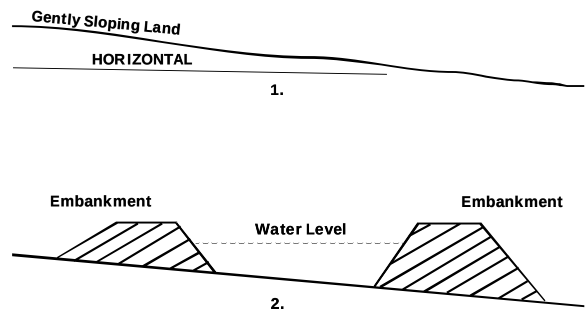


Figure 5: Pond construction on gently sloping land

2.6 Other Factors

The suitability of a site for fish culture also depends on effective means of communication and proper all-weather access roads to markets or airports. Adequate protection from praedial larceny is also important. In addition, a reliable supply of electricity is required.

Environmental factors that need to be assessed in site evaluation include wind direction, rainfall and incidence and susceptibility to flooding.

3. SITE SELECTION AND SYSTEM DESIGN

3.1 Site Selection

Site selection is one of the most important decisions in any aquaculture enterprise. It determines pond construction costs and influences the overall viability of the enterprise. Based on the results of initial site surveys and evaluations, the selected site should be the most suitable for the particular culture species and the intended culture system.

It is important to remember that it is rare for any site to possess all the desirable characteristics for commercial aquaculture and the degree of suitability will vary from one site to another, since no two sites are identical. The site selection surveys do not only include an assessment of the physical, chemical and biological factors of the sites (i.e. the site specifics), but also provide invaluable information for the preparation of the overall design, layout and construction of the facility.

3.2 System Design

Fish farms that are properly designed and constructed should strike a balance between function, aesthetics and economy.

The fish farm consists of the pond system, which may include brood, nursery and production ponds, the dykes or embankments, and their water supply and drainage. It also includes a hatchery if needed, and the support facilities comprising buildings, store rooms and sheds. Access roadways and paths to ponds complete the design.

Hatchery facilities are almost always located in buildings where water quality can be better controlled. Brood and nursery pond usually similar in design, but smaller and more manageable than production ponds (Figure 6). The size of the production ponds is determined by the level of intensity of the operation.

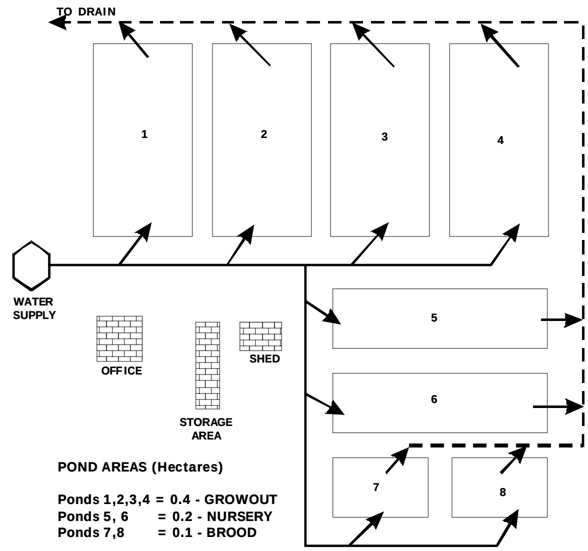


Figure 6: A generalized layout of a fish farm showing ponds and support facilities, water supply and drainage systems

Most aquaculture pond systems consist of brood, nursery and production ponds which may vary in number or combination (Figure 6). Their layout is based on the site specifics. For example, the shape of the ponds is dictated by the general shape of the land and larger ponds are laid out so that prevailing winds blow across them rather than along the long axes, to limit wave action and pond bank erosion (Figure 7). Slope of the land should, however, be given primary consideration for layout in order to effect proper drainage.

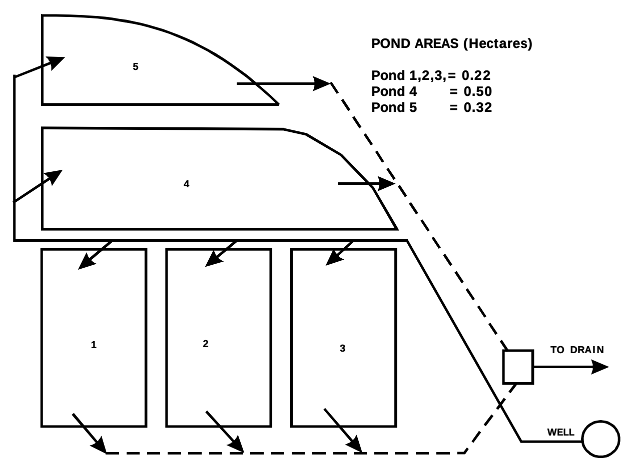


Figure 7: Layout and design of ponds to fit existing land shape

4. POND CONSTRUCTION

Most ponds used for commercial aquaculture are man-made and there are basically two types; embankment and excavated.

Embankment ponds are formed by building up a dyke or embankment above ground level to impound water and are the most common type of ponds used in fish farming. They can be constructed over a wide range of topographic conditions. They include dam type ponds which are formed when an embankment is built across a natural waterway or valley and have significant advantages over excavated ponds. These include more efficient drainage, easier harvesting, larger size and better water quality (Figure 8).

Excavated ponds are formed when the soil is removed from an area to make a hole that is then filled with water. They are sometimes dug below the water table and require mechanical aeration because of low dissolved oxygen. Harvesting is difficult since they cannot be drained without pumps. Pond size is usually limited by the cost of excavation.

There is also the excavated-embankment combination type, which is constructed in order to achieve increased depth and water-holding capacity. The excavated material is sometimes used to build the embankment. The best time of year for pond construction is during the dry season when earth movement is easiest. Nevertheless, it should be noted that moistened soil is more easily compacted than very dry earth.

4.1 Shape and Size

Ponds are usually rectangular in shape but there are variations. Long narrow ponds are generally easier to manage and may be sampled or harvested by relatively short seines. They have, however, the disadvantage of demanding more earth movement and hence higher construction costs. Square ponds require less earth movement per unit area, are less expensive to construct but require longer more expensive seines for sampling and harvesting than for a rectangular pond of the same area. Generally a compromise between these two extremes is obtained using rectangular ponds, with length to width ratio of 2:1 i.e. twice as long as wide.

Pond size will be determined by its intended usage. Brood ponds and nursery ponds are generally much smaller than production or growout ponds and occupy a smaller percentage of the whole farm area.

4.2 Pond Dykes or Embankments

In the ideal rectangular-shaped embankment type pond, soil removed from the bottom of the pond to a 0.3 m depth provides enough material to construct the embankment of the pond.

The dyke or embankment usually consists of a clay core, which extends approximately 0.5 m below the pond bottom and is about 1m thick. During construction, the soil is firmly compacted in 0.5m layers until the finishing height is achieved. The slope of the clay core should be not less than 1.5:1 (a 1.5:1 slope provides a 1m rise in elevation over a 1.5m linear distance (Figure 9).

The embankment slopes are then made and finished to approximately 2:1 or 3:1 depending on soil type and culture species. Top widths should not be less than 3m and should be finished with all-weather material such as gravel, marl or stones.

Secondary dykes or embankments need not have very wide tops but should not be so narrow as to allow lateral seepage or unwanted erosion. Generally the top widths are 0.6 to 0.8 times the height of the embankment. There are specifications for top width for dams according to depth, since hydrostatic pressure is a function of depth.

The freeboard is the vertical distance between the pond water level and the top of the embankment. It should be of an adequate distance so as to allow for water depth, wave action and possible settlement of pond embankment after construction. Well compacted pond embankments should not settle more than 15%, but they can settle up to 20%, and allowances for this should be made when fixing the dyke height (Figure 9).

Figure 8: A Dam type pond

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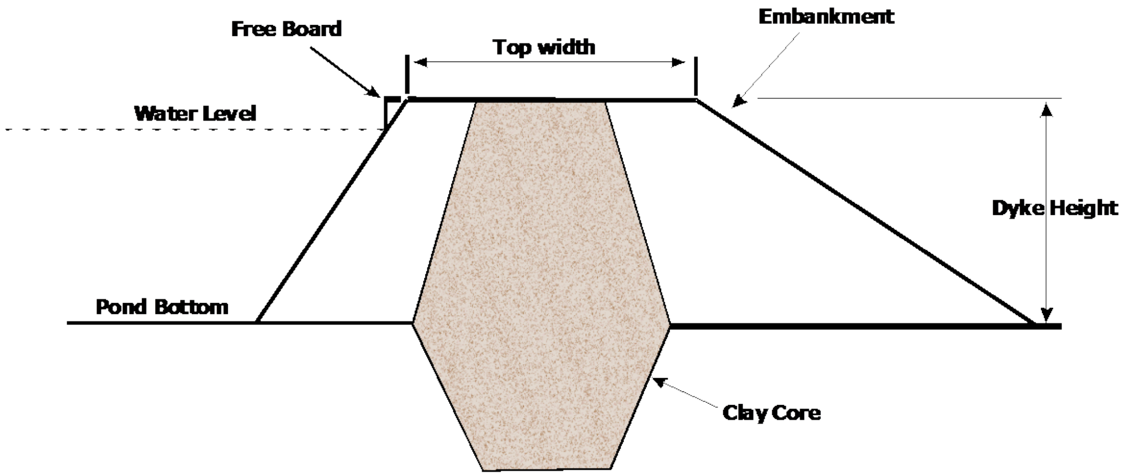

Figure 9: Typical cross-section of pond embankment

4.3 Pond Bottom and Drainage

Pond bottoms should be free of all foreign material such as stones, tree roots and stumps. These would make sampling or harvesting by seine difficult, and may adversely affect water quality. Pond bottoms should slope towards the deep end where a drainage system is installed (Figure 10). Usually this slope is 1 - 5% (i.e. 100:1 to 100:5 slope) depending on pond size and shape.

Ponds should be able to drain completely but should not have excessive depth variation between the deep and shallow ends. Drains should be properly screened to prevent the possible escape of culture organisms during drainage at harvest.

Drainage is affected by pushing down the drainage pipe which pivots at the threaded joint (Figure 10). The water depth is also controlled by the angle to which the drainpipe is tilted. While in the vertical position, the drainpipe allows maximum water depth in the pond. Complete drainage is achieved when the pipe is pushed to the horizontal position along the bottom of the pond.

Some ponds are constructed with a harvest basin, which is an area 0.3 to 0.5m deeper than the surrounding pond bottom at the drainage end. Cultured organisms will concentrate in this basin on total 'drain-down' at harvest, making it easier and less time-consuming to collect them.

4.4 Pond Depths

Ponds need not be constructed deeper than 1.5m unless they are being used for water storage. Depths less than 1m would encourage the growth of rooted plants which foul nets during sampling and harvesting. Predatory wading birds are also attracted to the shallower waters. Depths greater than 1.6m at the drainage end increase the difficulty of handling sample or harvest gear.

4.5 Water Inlets

Water inlets should be designed to deliver water as fast as possible. In designing an inflow system, volume of water delivered should be given priority over water pressure.

Water may be delivered to the pond by pipe or open drain. Low pressure polyvinyl chloride (PVC) pipes of suitable diameter should be buried to prevent breakdown by sunlight. Open delivery drains are susceptible to water contamination, and loss due to evaporation is increased. Gravity flow from reservoirs is preferable, as pumping incurs added costs. However, well-water is usually pumped from underground.

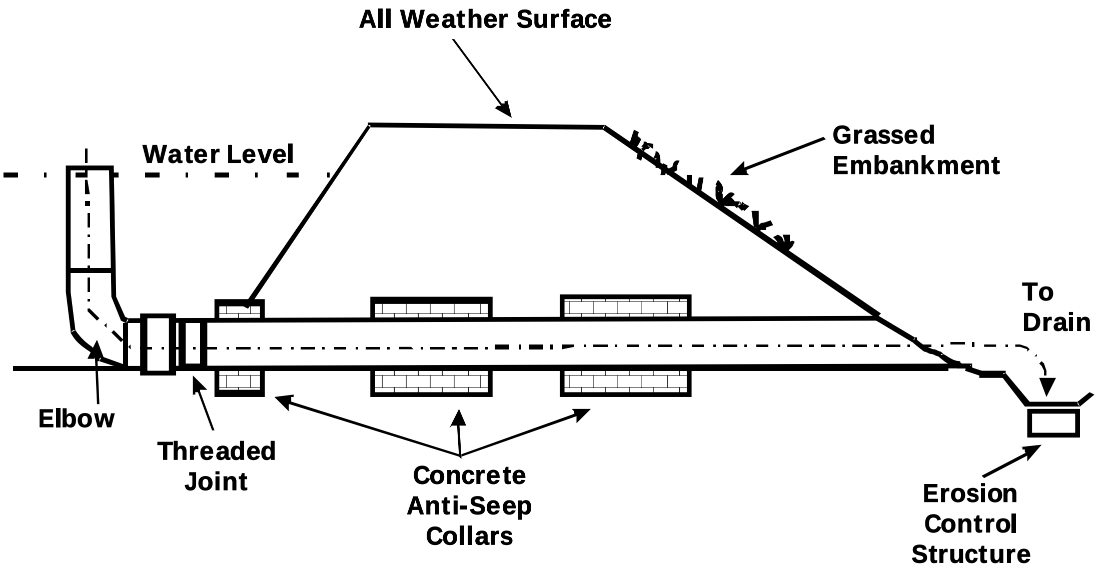

Figure 10: Cross-section of drainage system and pond embankment

Water with low dissolved oxygen levels, such as that from wells, should be splashed into the pond to enhance aeration. This may be further achieved by sprinkling inflow water thereby increasing the water surface-to-air ratio.

In production ponds, water inlets should be situated opposite to the drainage end so that good quality water entering the pond will replace water of a poorer quality. In some nursery ponds, water inlets are also installed at the drainage end. This enhances survival of the young fish when the pond is drained.

Surface water, e.g. from natural ponds or rivers, should be properly screened by wire mesh in order to minimize the entry of undesirable species into the fish farm pond. These may be predators of, or may compete for food and space with, the cultured organisms.

5. MAINTENANCE AND MANAGEMENT

The proper maintenance and management of ponds is critical to the efficiency of the production system. Many ventures fail due to poor system management. Unlike other forms of livestock, aquatic organisms cannot be closely scrutinised, as they are at most times out of sight. It is therefore important to provide as close to optimum conditions as possible.

5.1 Grassing

A newly constructed pond is first 'water-lined' and filled to the required depth. Grass is planted above the water-line on the dykes to prevent erosion of the banks and the washing of soil in the pond. Grass on the dykes should be cut regularly to allow easy access to the ponds. Insect pests sometimes present a prob1em. The mole cricket which destroys the root system of some grasses, eventually kills the grass and loosens the soil, promoting erosion. This insect problem can be controlled, to some extent, with the application of soap water to the soil. Use of insecticides should be avoided.

5.2 Fertilizing

The newly filled pond is often muddy in appearance due to suspended solids. Organic fertilizers added to the pond serve to flocculate the solids which settle to the bottom. The fertilizer also serves to increase the productivity of the pond by promoting phytoplankton growth. This may also be initiated by adding 'green' water from another pond. Inorganic fertilizers, especially those high in phosphates, are also used in pond fertilization.

5.3 Water Monitoring

Strict water quality monitoring and management is necessary to provide the optimum conditions mentioned earlier. This involves regular monitoring of a number of parameters including dissolved oxygen, algal concentrations, pH and nutrient levels.

Dissolved Oxygen (DO) and free carbon dioxide are the characters most likely to change drastically within hours or even minutes. Combined, they become one of the major limiting factors to aquaculture production. Carbon dioxide is usually released at night by aquatic plants but the concentrations can be controlled by regulating the pH and aerating enough to maintain suitable oxygen levels. Since most aquatic processes (respiration and decomposition) consume oxygen, aquatic systems are usually monitored for oxygen depletion (low dissolved oxygen), rather than for high carbon dioxide concentrations as a means of determining their suitability for the culture organisms.

Dissolved oxygen is critical, particularly in semi-intensive and intensive systems where stocking densities are relatively high. Low dissolved oxygen levels adversely affect growth, survival, incidence of disease, food conversion, overall production and profit.

Aeration devices such as paddle wheels, blowers or agitators are used to increase dissolved oxygen. These are operated mainly at night or on very overcast days when production of oxygen by photosynthesis drops.

Low oxygen levels at night are often attributed to high algal concentrations when oxygen demand for respiration is high. While oxygen production by photosynthesis during daytime is high, oxygen demand for respiration is high at night. Thus there is direct competition for dissolved oxygen with the culture species.

Algal concentration is monitored by visibility tests, using a Secchi-disc, and is controlled by partial replacement of the water to the required algal concentration.

The solubility of gases in water decreases with increased water temperatures. This is very relevant in tropical ponds which have high daytime water temperatures and resulting lower dissolved oxygen concentrations. Dissolved oxygen is usually expressed as mg/l and varies from a minimum of 0mg/l to 15mg/l at saturation.

5.4 Sampling

Sampling of ponds at regular intervals provides information on the size, growth and overall health of the culture organisms. This is done using a seine of suitable mesh size. The size, weight and condition of the organism are recorded. Feeding rate is calculated as a percentage of the total biomass in the pond and is adjusted if necessary. Before sampling or harvesting, all rooted aquatic plants and filamentous algae should be removed from the pond, as these tend to foul nets.

5.5 Post Harvest

After the pond has been harvested, excess sludge should be removed from the pond bottom and the slope reconditioned for proper drainage. During the short fallow period, the bottom of the pond should also be tilled and left exposed to sunlight for a few days to effect oxidation of the anaerobic mud. The embankment slopes should also be reconditioned after any erosion that may have occurred during the production period.

5.6 Maintenance Schedule

General maintenance of electrical and mechanical equipment should follow a maintenance schedule as recommended by the manufacturer.

SUGGESTED READING

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APPENDICES

APPENDIX I

GLOSSARY OF TERMS

Algae	Microscopic plants that live in the water. These may be unicellular or filamentous. They provide food for some filter feeding fish and produce oxygen during the day.
Alkalinity	The measure of the ability to neutralize acids.
Anaerobic	The absence of free oxygen.
Biomass	The total weight of cultured animals in the pond at any given time.
Brackish	The term used to describe water that has some dissolved salt, but less than sea water. It is found where river water mixes with the sea.
Compactability	The extent to which anything can be compressed e.g. soil.
Coliform Organisms	Organisms (usually bacteria) normally found in the intestinal tract of man and warm blooded animals. Their presence in water indicates poor conditions.
Culture System	Methods and facilities used to culture an animal. This includes layout of the facilities, the intensity of culture, the method of feeding and the harvest (partial or total).
Dissolved Gas	Gases that mix with the water and go into solution. These include oxygen and carbon dioxide.
Diurnal	Daily; Daytime.
Drain-Down	The point at which the pond is completely drained. Usually done at harvest or to effect repairs to the pond bottom.
Effluent	Outflow of material, usually wastes.
Flocculate	To aggregate into groups e.g. small suspended particles group and sink to the bottom of the pond on addition of organic fertilizer.
Extensive	Refers to a type of culture in which large natural bodies of water are stocked with small numbers of fish. There is little management and little inputs of food and fertilizer.
Fry	Very young fish (under 4 weeks old).
Hatchery	Facility used to hatch eggs of fish or prawns. Usually specialised in design and situated inside buildings.
Hardness	A measure of the amount of mineral salts, usually Calcium Carbonate, dissolved in water. Measured in parts per million or milligrams per litre.

Intensive	Refers to a type of culture in which small ponds or tanks are used to stock large numbers of fish. There are high energy inputs in the form of oxygen, feeds and fast water exchange rates. Usually employed when the land area is limited.
Lateral Seepage	Outflow of water from the pond through the embankments.
Microbiological Contaminants	Disease causing micro-organisms.
Nursery	A facility used to grow fry or young prawns to a size at which they can be stocked into production ponds.
Organic Content	The amount of organic material contained in soil or water.
Oxidation	In combination with oxygen.
pH	The measure of the acidity or alkalinity of a substance. Pure water is neutral (pH = 7); and pH below 7 is acidic; above 7 is alkalinity.
Photosynthesis	A process in which green plants or algae utilise carbon dioxide in the presence of sunlight to produce organic matter and oxygen.
Pollutants	Anything that contaminates culture water e.g. insecticides, industrial wastes.
Predator	Animal that preys on another.
Production Pond	Pond used for the final growth phase prior to harvesting in aquaculture system. Also known as the grow-out pond.
Respiration	A process which takes place within living organisms whereby oxygen reacts with sugars to provide energy and carbon dioxide.
Salinity	The 'saltiness' of water. Expressed as parts per thousand or ppt
Saltwater	Water in which sodium chloride is dissolved. Sometimes used synonymously with 'seawater'.
Secchi-disc	A disc painted half black and half white of diameter 20cm used to test light penetration in pond water and indicates algal concentration. Good light penetration indicates low algal concentrations; poor light penetration indicates high algal concentrations.
Seine	Type of net used in sampling or harvesting of ponds. May vary in mesh size according to size of organism to be sampled or harvested. Length of the seine is usually 1.3 times the width of the pond.
Site specifications	Features of a particular site.
Sludge	Soft mud containing organic waste which is usually devoid of oxygen.

Stocking Density	Refers to the number of organisms per unit area stocked into pond. e.g. 50,000/ha.
Suspended Solids	Small solid particles distributed in the water.
Topography	A detailed description of natural and artificial features of a land area, whether there are hills, valleys, steep slopes etc.
Water-line	To determine the exact position of the water surface on the inside of the pond embankments.

APPENDIX II

CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
Acres	43,560	Square feet
Acres	4,017	Square metres
Acres	4,840	Square yards
Acre-feet	43.560	Cubic feet
Acre-feet	325,851	Gallons
Acre-feet	1233.49	Cubic metres
Centimetres	0.3937	Inches
Centimetres	0.01	Metres
Centimetres	10	Millimetres
Cubic feet	0.02832	Cubic metres
Cubic feet	0.03704	Cubic yards
Cubic feet	7.48052	Gallons
Cubic feet	28.32	Litres
Cubic feet / minute	0.1217	Gallons / second
Cubic feet / minute	0.4720	Litres / second
Cubic feet / second	0.646317	Millions gals. / day
Cubic feet / second	448.831	Gallons / minute
Cubic metres	35.31	Cubic feet
Cubic metres	1.308	Cubic yards
Cubic metres	261.2	Gallons
Cubic yards	202.0	Gallons
Cubic yards	264.6	Litres
Feet	30.48	Centimetres
Feet	0.3048	Metres
Gallons	0.1337	Cubic feet
Gallons	3.785	Litres
Gallons, Imperial	1.20095	U.S. Gallons
Gallons, U.S.	0.83267	Imperial Gallons
Gallons / min.	0.06308	Litres / second
Hectares	2.471	Acres

APPENDIX II

CONVERSION FACTORS (continued)

MULTIPLY	BY	TO OBTAIN
Inches	2.540	Centimetres
Kilograms	2.205	Pounds
Litres	0.03531	Cubic feet
Litres	0.2642	Gallons
Metres	3.281	Feet
Metres	1.094	Yards
Ounces	28.349527	Grams
Pounds	453.5924	Grams
Pounds of water	0.1198	Gallons
Square metres	10.76	Square feet
Square yards	0.8361	Square metres
Tons (long)	1016	Kilograms
Tons (long)	2240	Pounds
Tons or Tonnes (metric)	2205	Pounds
Tons (short)	2000	Pounds
Tons (short)	907	Kilograms
Yards	0.9144	Metres

The word gallon used above represents U.S. gallons. To convert to Imperial gallons multiply by 0.83267.

NOTES