AQUACULTURE ENGINEERING
FIS 411
LECTURE GUIDE

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AQUACULTURE ENGINEERING

POND CONSTRUCTION

A pond is a water enclosure or a confined body of water where fish are raised or reared under a manageable controlled condition. Pond could either be earthen or concrete. Nowadays fish are raised in plastics, fiber-stars and wooden rafts which are either locally fabricated or imported from developed countries. But here, in this course, emphases are laid only on earthen and concrete pond constructions.

TYPE OF PONDS (Earthen**)**

There are two major types, namely:

(i). Excavated pond

(ii). Embankment/ pond

Sometimes, depending on the terrain or topography of the site, there is what we called excavated- levee pond, barrage pond and contour pond.

During the lecture the distinctions shall be made clear to students diagrammatically

Site selection for fish pond construction:

The failure or success of fish farm enterprise depends on the selection of a good site. The layout and the management of fish farm will largely be influenced by the kind of site selected. The site has the following influences:

(i). strongly affects the cost of construction

(ii). amount of fish that can be produced

(iii). ease of pond management

(iv). the economics of the enterprise

Decisions prior to site selection:

a) Do i have a clear ideal of the type of fish farm I want to construct
b) Of what production level is my target?
c) What is the system of culture to be adopted?
d) Which fish species should be produced?
e) Is it necessary to produce fingerlings for the farm?
f) At what stage of fish should you start selling?

Answers to these questions will assist greatly during site selection exercise

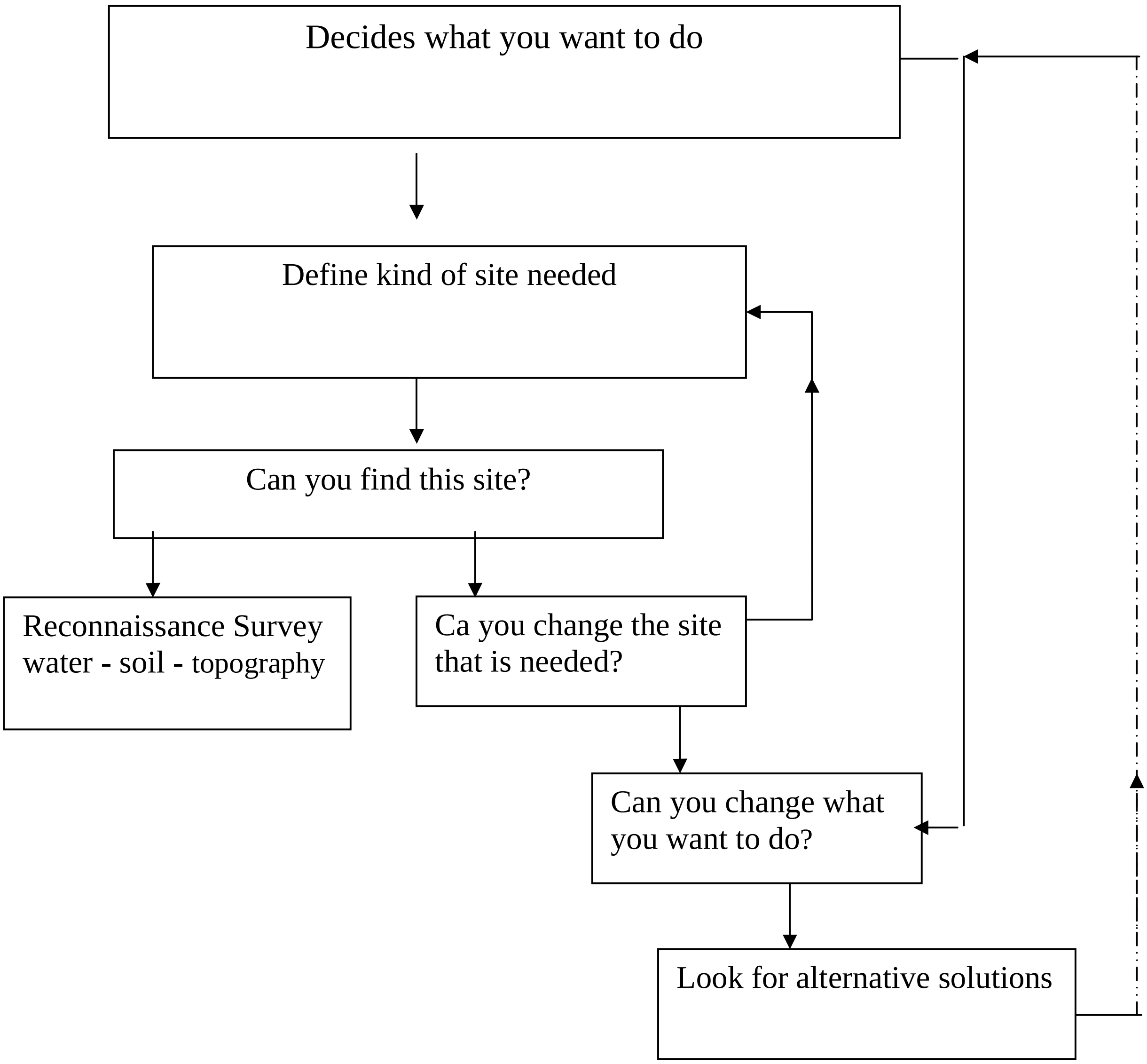


Figure 1: Site selection decision-making cycle

Factors to consider when selecting site for fish farm construction

a) Water — quantity, quality, source, activities around it
b) Nature of soil — texture, permeability, retention ability, etc
c) Topography of the land
d) Environmental consideration
e) Accessibility
f) Vegetations density/cover
g) Expertise

Other important factors include:

h) Proximity and size of market
i) Poaching
j) Availability of farm inputs

Students are to be given practical exposure with training manual on the necessity of these aforementioned factors

Detailed planning for fish farm construction

Once the site has been selected, then initiation of planning begins. There are two main related components of planning in construction. These include:

a) Organizational planning —decides where, how and which order the farm is to be built.
b) Physical planning — decides on layouts, detailed design and earthwork.

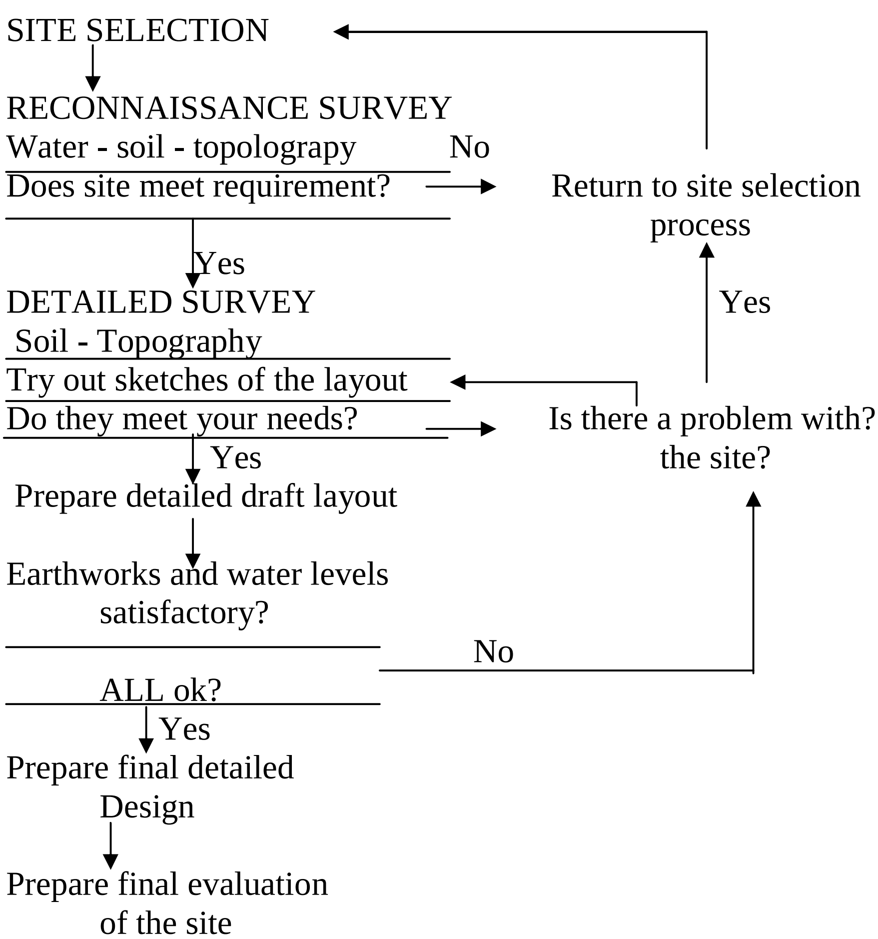


Figure 2: Flow - chart on matching the fish farm and its layout to the selected site

Figure 2 is to be used in ensuring proper and appropriate appraisal of the work to be done. Assignment: students are expected to visit any chosen location at COLERM field and carry-out fish farm site selection exercise and prepare a report

Things include:

1. Time of construction
2. who will construct the fish farm ?
3. How will the construction be carried -out?

These when critically considered, may lead to further activities such as

a) Some more detailed plan and drawings
b) A series of specifications for the contractor
c) A detailed schedule of activities will be drawn.

Steps involved in earthen ponds construction

The following steps are required:

- Clearing of proposed site
- Setting-out which involves site clearing
- Mark-out the areas inlet and outlet
- Topsoil removal and storage
- Construction of embankment
- Construction of inlet drainage pipes / water control structures
- Construction of screen at both inlet and outlet.

Steps involved in block tanks for fish farming

- Clearing of proposed site
- Settings-out which involves pegging and lining with the rope
- Topsoil stripping to form strong basement
- Surface blinding with concrete mixture (sharp sand, cement , and gravel/ granite at ratio 3:1:6)
- Block laying and stuffing of holes with concrete mixture
- Placement of water inlet and outlet pipes
- Plastering of tanks

Calculating dike and excavation volumes

Width of the dike base

Base width = crest width + (CH x SD) + (CH x SW)
Where CH (in m) = construction height
SD = slope ratio of dry side
SW = slope ratio of wet side
While estimating this, use the constructing height as well as the settlement

EXERCISE:
A 0.04ha pond has to be built in clayey soil with dikes 1.50m high and 1m wide at the top. If SD = 1.5: 1 and SW = 2:1. Calculate the base width of the dike (Hint : settlement allowance of expanded clay volume is 20%).

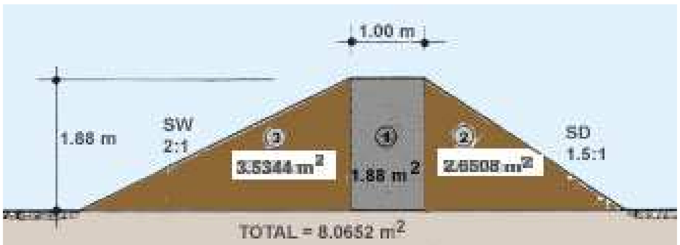
Solution:
Design height = (100% – 20%) = 80% of constructing height
Construction height = 1.50m/0.80 = 1.88m
Dike base width = 1m + (1.88m x 1.5) + (1.88m x2) = 7.55m

Note: Design height, DH, is the height dike should have after settling down to safely provide the necessary water depth in the pond = Water depth + Free board. Construction height, CH, is the height the dike should have when newly built and before any settlement takes place. =design height + settlement height

$$CH = DH \div [(100 - SA) \div 100]$$

Calculating the cross-section of a dike on horizontal ground

For the above 0.04-ha pond to be built in clayey soil, calculate the size of the cross-section of the dike as:



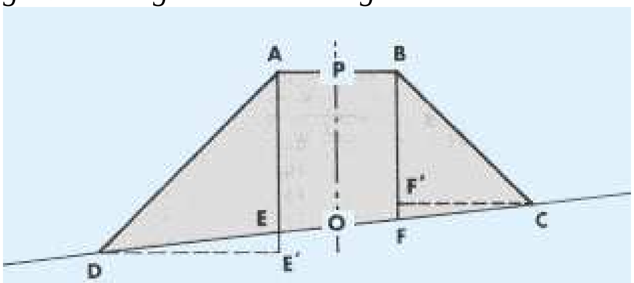
- area 1 = 1 m x 1.88 m = 1.88 m^2;
- area 2 = (1.5 x 1.88 m) x (1.88 m ÷ 2) = 2.6508 m^2;
- area 3 = (2 x 1.88 m) x (1.88 m ÷ 2) = 3.5344 rn^2
- cross-section = 1.88 m^2 + 2.6508 m^2 + 3.5344 m^2 =8.0652 m^2.

Calculating the cross-section of a dike on sloping ground

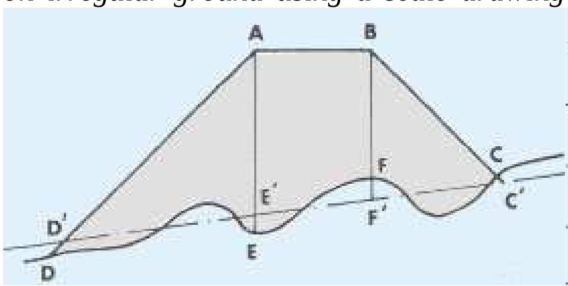
The cross-section of a dike *on sloping ground* can be calculated most easily using a scale drawing.

(a) Draw a horizontal line from D, meeting AE at E'.
(b) Draw a horizontal line from C, meeting BF at F'.
(c) Draw a vertical line PO down the centre line of the dike.
(d) Cross-section = ADE + AEFB + BFC = 0.5(AE x DE') + (AB x PO) + 0.5(BF x F'C).

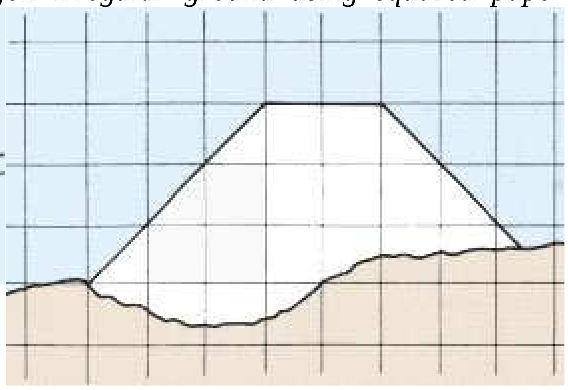
Calculating the cross-section of a dike on sloping ground using a scale drawing



Calculating the cross-section of a dike on irregular ground using a scale drawing



Calculating the cross-section of a dike on irregular ground using squared paper



1 cm = 0.5 m
1 square of 0.5 m x 0.5 m = 0.25 m^2
15.2 squares x 0.25 m^2 = 3.8 m^2

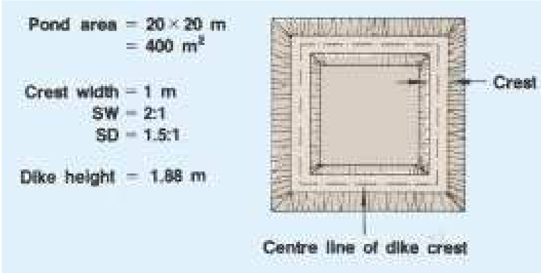
Calculating the volume of dikes on horizontal and regular ground

To estimate how much soil will be needed for the construction of a dike, you need to know its volume. The calculation method depends on the site topography and on the type of pond to be built.

If *the topography* of the construction *site is reasonably flat* (less than 0.30 m difference in average site levels) and regular, you can calculate the volume of the dike (in m^3) by multiplying the *cross-section of the dike*(in m^2 and halfway along the dike for an average area) *by its length* measured along the centre line (in m).

EXAMPLE

Using the figures from the example above, the cross-section of the dike equals 8.0652 m^2. If the length of the dike to be built is 20 m x 4 = 80 m, its volume is 8.0652 m^2 x 80 m = 653.216 m^3.



Calculating the volume of dikes on sloping or irregular ground

If the topography of the site is more steeply sloping or more irregular, you cannot calculate the volume of the pond dikes just by using one cross-section. There are several possible methods, depending on the type of ground and the accuracy you require.

With a first group of methods you can calculate the dike volumes by using *averages of the dike cross-sections* or you could use the average of the *cross-sections at the corners* of the dike.

EXAMLPE

A 400-m^2 (20 x 20 m) pond is to be constructed with wall heights of 0.5 m at corner A, 0.3 m at corner B, 1.1 m at corner C and 1.5 m at corner D. Crest width is 1 m and side slope 2:1 on both sides. The cross-section areas at each corner are:
A: (1 m x 0.5 m) + 2 x (0.5 m x 0.5 m x 1 m) = 1.5 m^2,
B: (1 m x 0.3 m) + 2 x (0.5 m x 0.3 m x 0.6 m) = 0.48 m^2,
C: (I m x 1. 1 m) + 2 x (0. 5 m x 1. 1 m x 2.2 m) = 3.52 m^2,
D: (1 m x 1.5 m) + 2 x (0.5 m x 1.5 m x 3 m) = 6.0 m^2.

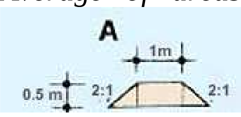
Average area for wall AB = (1.5 m^2 + 0.48 m^2) ÷ 2 = 0.99 m^2 and volume for wall AB = 0.99 m^2 x 20 m = *19.8 m^3*.

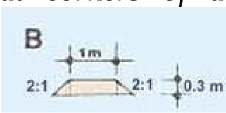
Similarly:

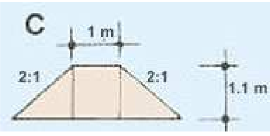
- for BC, average area = 2 m^2 and volume = *40* m^3;
- for CD, average area = 4.76 m^2 and volume = *95.2* m^3;
- for DA, average area = 3.75 m^2 and volume = *75* m^3.

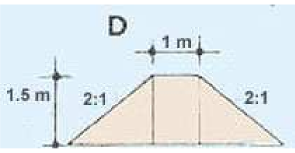
Consequently, total volume of dikes = 19.8 m^3 + 40 m^3 + 95.2 m^3 + 75 m^3 = 230 m^3.

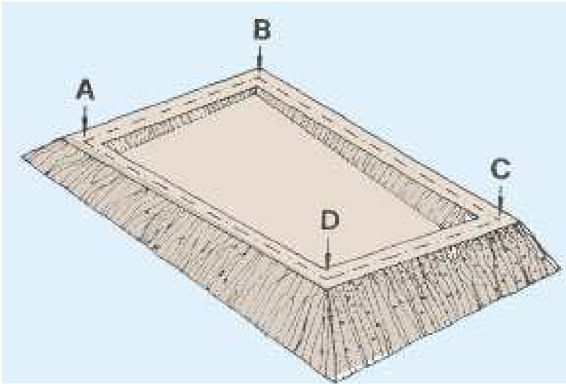
Average of areas at corners of dike











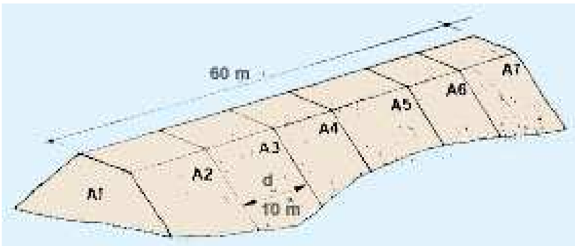
For a more accurate measurement of dike volume on rough ground, you should apply the following formula, known as Simpson's rule, where: $V = (d \div 3) \times [A_1 + A_n + 4(A_2 + A_4 + \ldots A_{n-1}) + 2(A_3 + A_5 + \ldots A_{n-2})]$. Proceed as follows:

(a) Divide the length of the dike into an *odd number n* of cross-sections at equal intervals of *d* metres.

(b) Calculate the area *A* of each cross-section as explained earlier.

(c) Introduce these values into the above formula.

The dike is 60 m long.
(a) At intervals d = 10 m, identify seven cross-sections A_1 ... A_7 and calculate their respective areas to obtain $A_1 = 10\ m^2$; $A_2 = 16\ m^2$; $A_3 = 18\ m^2$; $A_4 = 11\ m^2$; $A_5 = 8\ m^2$; $A_6 = 10\ m^2$; $A_7 = 12\ m^2$.



(b) Introduce these values into the Simpson's rule formula:
$V = (d \div 3)\ [A1 + A7 + 4(A2 + A4 + A6) +2\ (A3 + A5)]$.

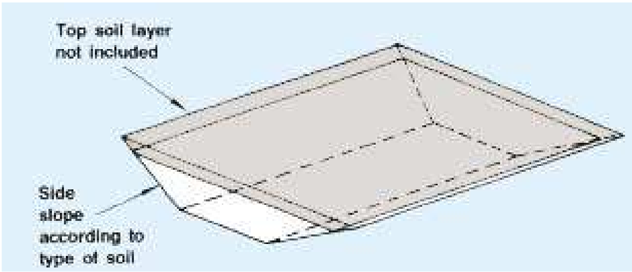
(c) Calculate $V = (10\ m \div 3)\ [10\ m^2 + 12\ m^2 + 4(16\ m^2 + 11\ m^2 + 10\ m^2 + 2(18\ m^2 \div 8\ m^2)] = 740\ m^3$.

Calculating volumes of excavated material

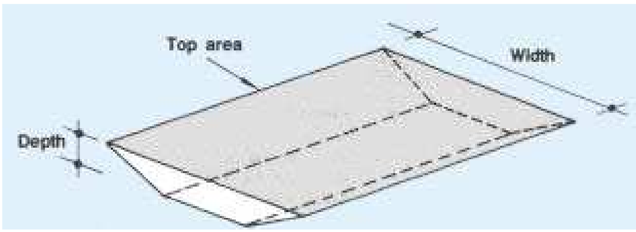
You will need to know excavation volumes for:

- topsoil;
- borrow pits, dug near an earth structure to provide the material for its construction;
- excavated ponds, to provide the pond volume required;
- other structures such as harvest pits, supply channels, etc.

You will normally have to remove the topsoil before you reach soil good for construction material. Levels should therefore be taken *from the base of the topsoil* layer. In most cases, the sides of the excavation should be sloped to prevent them from collapsing. In many cases (ponds, channels, etc.) these will be of specified gradients.



For reasonably flat, level surfaces, where *excavated width is at least 30 times the depth*, volume of excavation can be estimated as:



V = top area x depth of excavation.

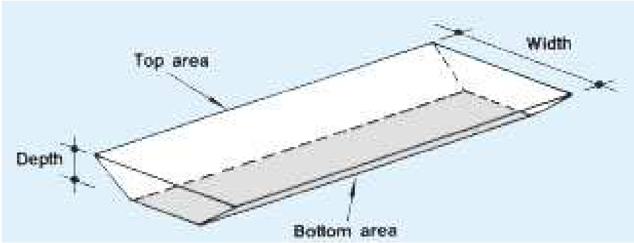
Where the *width is less than 30 times the depth*, you should correct for side slopes as follows:

V = [(top area + bottom area) ÷ 2] x depth.

EXAMPLE

A 400 m^2 (40 x 10 m) area is to be excavated, 1 m deep, with side slopes 2:1. As the width (10 m) is less than 30 times the depth (30 x 1 m), the first method is not accurate (estimated volume would be 400 m^2 x 1 m = 400 m^3).

Use the second method, where top area = 400 m^2 and base area=base length x base width.
Base length = 40 - (2 x slope x depth) = 40 - (2 x 2 x 1 m) = 36 m
Base width = 10 - (2 x slope x depth)= 10 - (2 x 2 x 1 m) = 6 m
Base area = 36 m x 6 m = 216 m^2
Average area = (400 m^2 + 216 m^2)÷ 2 = 308 m^2
Volume therefore = 308 m^2 x 1 m= 308 m^3.



Above all, for precision, prismodal formula can be used to calculate the volume of soil excavated from pond area (excluding topsoil area):

$$V= (A+4B+C)/6 *D$$

Where
A = Top surface area
B = Mid-depth surface area
C = Bottom surface area
D = Average depth of excavation

How to calculate the volume of water in the pond

You have thus calculated the surface area of the pond and the average water depth of the pond. Now, using the figures you have found, you can calculate the volume of water in the pond by multiplying the surface in square metres (m^2) by the average water depth in metres (m) to get the volume of the pond in cubic metres (m^3).

SURFACE AREA x AVERAGE DEPTH = VOLUME

Examples

Surface area (m^2)		Average water depth (m)		Water volume (m^3)
235	x	1.0	=	235
450	x	1.2	=	540
2500	x	1.5	=	3750

Note: 1 cubic metre (m^3) = 1000 litres (l). To express water volume (in m^3) in litres (l) multiply by 1000. To express water volume (in l) in cubic metres (m^3) divide by 1000.

Examples

$$80\ m^3 \times 1\,000 = 80\,000\ l$$

$$540\ m^3 \times 1\,000 = 540\,000\ l$$

$$\frac{75\,000\ l}{1\,000} = 75\ m^3$$

$$\frac{400\,000\ l}{1\,000} = 400\ m^3$$

References

FOA Training Series: simple methods of Aquaculture pond construction