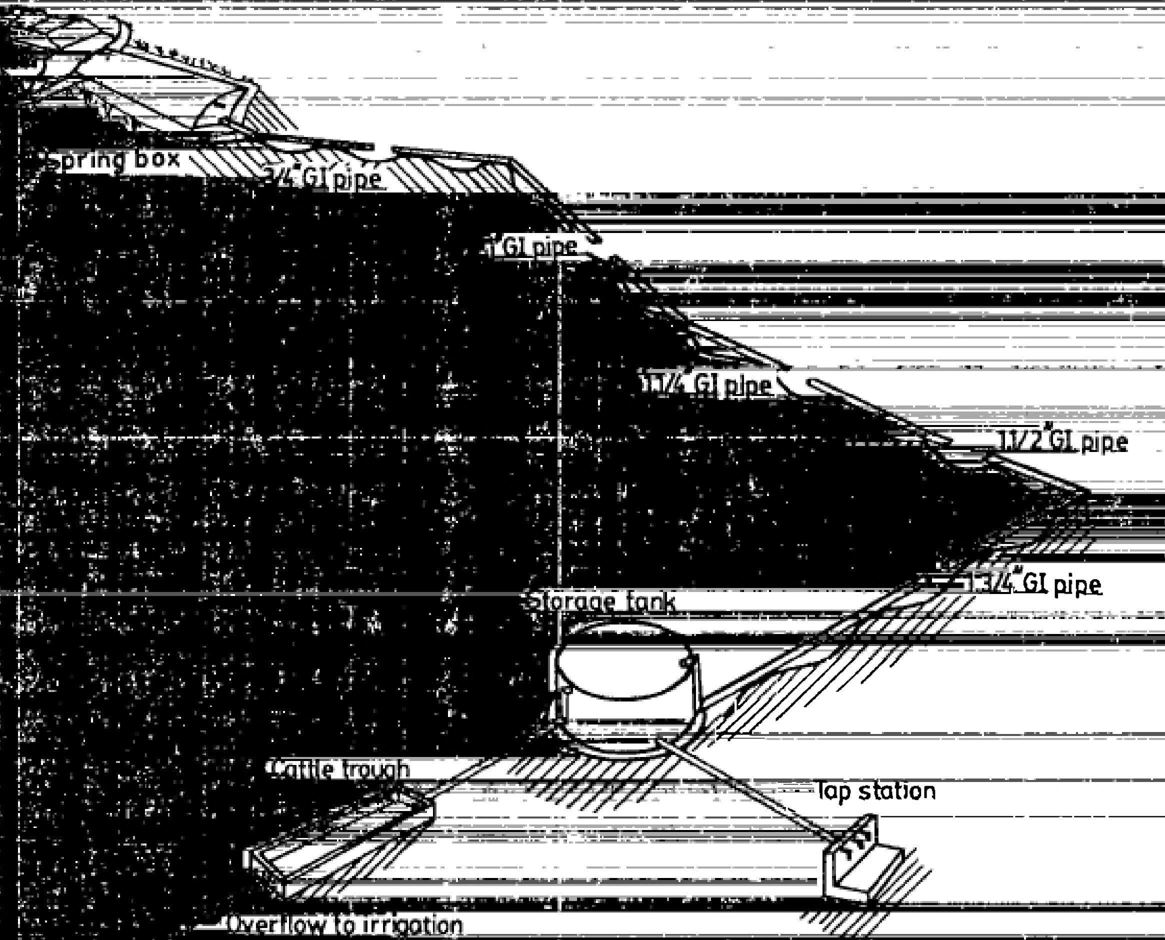
# HARVESTING RAINWATER IN SEMI-ARID AFRICA

## Manual No.6

## Spring Protections.




Erik Nissen-Petersen, Dr. Michael Lee.

Nairobi, 1990

**"Harvesting Rainwater in Semi-arid Africa" consists of 6 Manuals:**

Manual No. 1. Water Tanks with Guttering and Hand-pump.

Manual No. 2. Small Earth Dam built by Animal Traction.

Manual No. 3. Rock Catchment Dam with self-closing Watertap.

Manual No. 4. Shallow Wells with Bucketlift.

Manual No. 5. Sub-surface and Sand-storage Dams.

Manual No. 6. Spring Protections.

Each Manual deals with siting criteria, standard designs and bills of quantities in a simple text and drawings.

The Manuals are based on practical experience gained by building some 700 water structures for rainwater harvesting in semi-arid Kenya over the last 14 years.



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Much gratitude is also due to the Ministry of Agriculture in Kenya, which together with Danida afforded the opportunity of developing low-technology and labour-intensive methods of harvesting rainwater and thereby enabling people and livestock in a semi-arid region of the country to have access to a steady water supply.

Thanks are also due to the local inhabitants with and for whom these techniques were developed and implemented. Their understandable skepticism in starting up these demanding activities gave the process a sound and realistic foundation on which to build.

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**Erik Nissen-Petersen and Michael Lee**

**SURVEYORS AND CONTRACTORS MANUAL
ON
SPRING PROTECTIONS**

C O N T E N T S

## SURVEYORS MANUAL ON SPRING PROTECTIONS

### 1. Introduction

There are two types of spring protections which harvest water flowing out of the ground; the hill-side spring and the underground spring. Both types of springs are marked by marshy ground, dense vegetation and small streams that flow for only a short distance before they disappear into the earth again. The difference between them is that the underground springs are easily accessible by water users, but hill-side springs are not, involving long and steep climbs up to the outflow. Both springs are subject to damage in their natural state by people and animals digging down into them to try and improve their discharge as they begin to dry up, and to make it easier to fill their vessels. This can block the spring. In addition, the ground springs can be easily polluted by animals and livestock and the disease transferred to humans. These are the reasons for their protection.

### 2. Measuring yield of springs

Before starting on designing a spring protection, it must be determined whether the spring can deliver enough water to be worth the investment of labour and capital. An easy way of determining the yield of a spring is to count how many seconds it takes to fill a known volume of a container, e.g. a 20 litre jerrycan, from the flow of the spring. If for example it takes 10 seconds to fill a 20 litre jerrycan, then the yield is measured as $\frac{20 \text{ litres}}{10 \text{ seconds}}$ = 2 litres per second = 2 l/s.

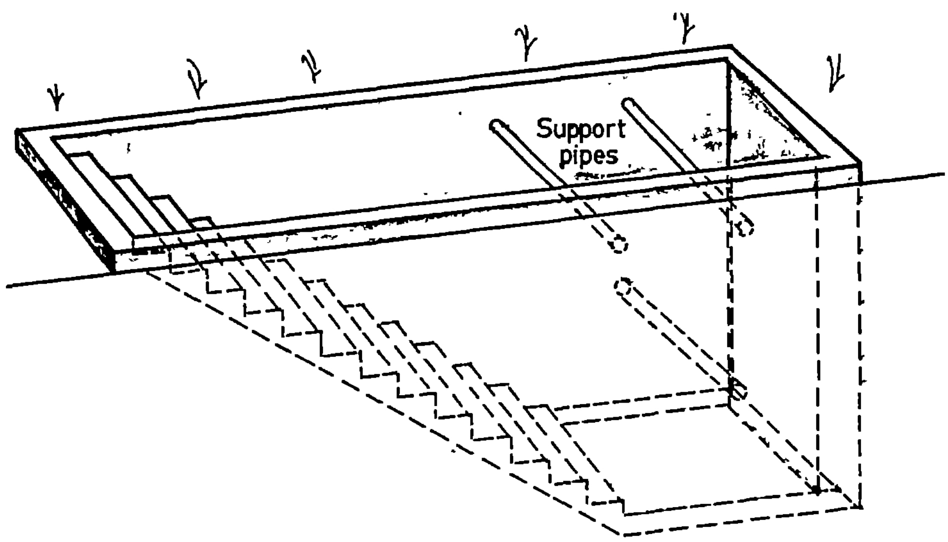
Such a measurement of the yield of water should be taken towards the end of a dry season in order to obtain reliable data which do not promise people more water than they will get.

### 3. Underground Spring Protection

Lowland springs are accessed by an open, walk-in well with a staircase leading down to the eye of the spring. Because the ground is rocky, a large number of large boulders may be encountered during the excavation and they should be left in place to be later incorporated into the staircase and side-walls.

The staircase is built of stones removed from the excavation. This is a cheaper method of accessing groundwater than a shallow well and could also be used to tap non-spring sites if the soil is too stony for sinking a well.

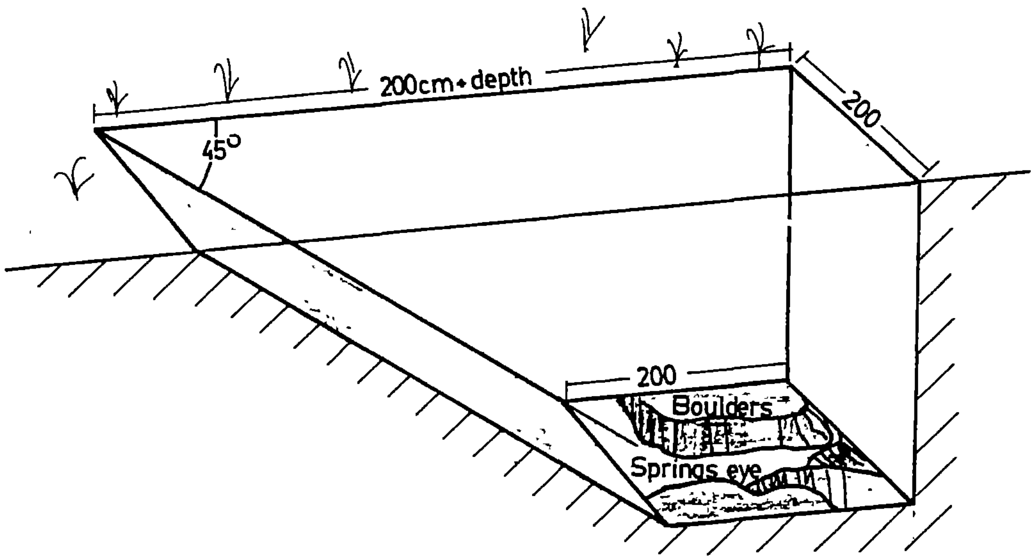
People draw water by walking down the steps until they reach the water level.



## 4. Preparing the Site

Excavation will have been begun a long time ago by animals and then people trying to access water during dry years. The original excavation should be dug out to roughly 200 cm width during the dry season preferably when the spring has dried up. This will ensure the soil is dry and stones sticking out will be held in place.

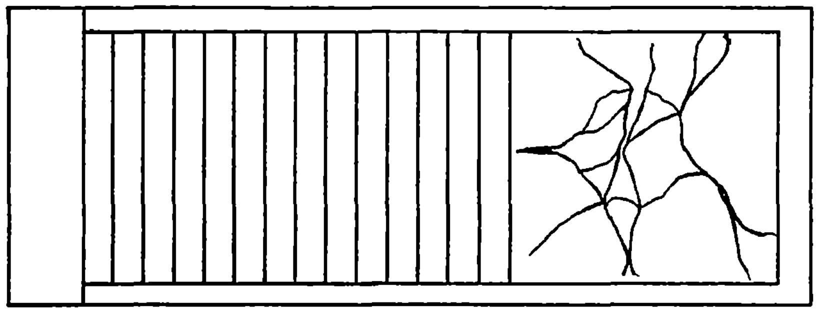
The floor of the staircase should have a slope of about 45 degrees and be as even as the rocks and bedrock will allow.



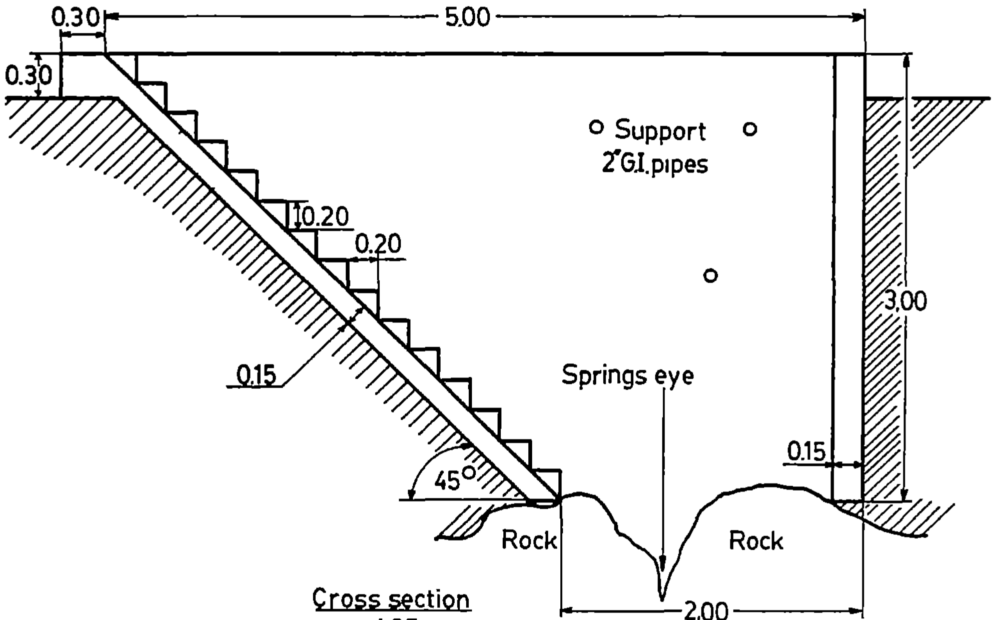

## Construction Method

The underground spring protection is lined with a 20 cm. thick wall of stone masonry, but with an open floor which allows water to flow into the spring protection. All stone masonry works consists of as many stones as possible being bond together and plastered with mortar 1:4.

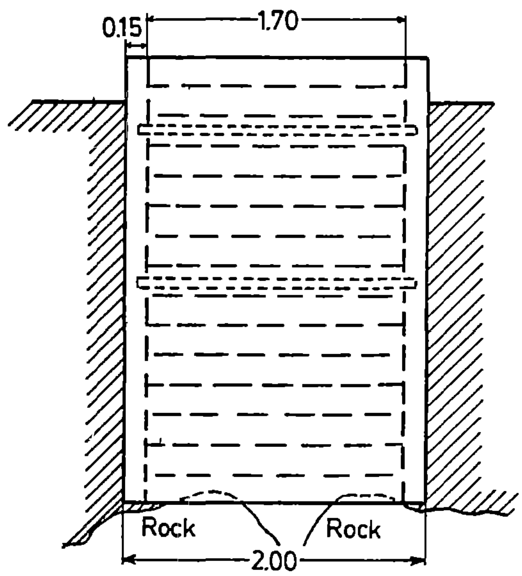
## 5. Standard Design



Top view
1:25



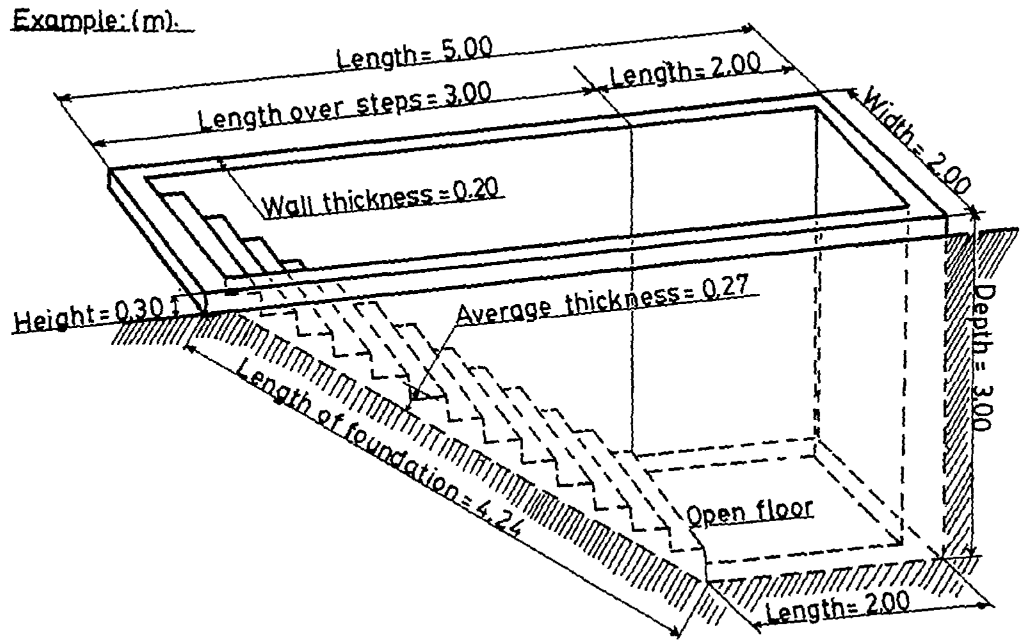

Cross section
1:25




Longitudinal section
1:25

6. **Material, labour and transport requirements.**

The requirements of materials, labour and transport are estimated by using a set of formulas which are explained with examples relating to the drawing seen below.




First calculate the total volume of the structure to be build by finding the volumes of the various parts of the structure and thereafter adding it all together. The result will be the total volume measured in cubic metres (cu.m.)

1. Formula for calculating volume of foundation and steps:
   length of staircase x width of staircase x average thickness of staircase

   Example: length 4.24 m x width 2.00 m x average thickness 0.27 m = 2.29 cu.m

2. Formula for calculating volume of walls over steps:
   $\frac{\text{length x depth}}{2}$ x thickness x 2 walls

   (The length and depth are divided by 2 because the wall is triangular).

   Example: $\frac{\text{length 3.00 m x depth 3.00 m}}{2}$ x thickness 0.20 m x 2 walls = 1.80 cu.m.

3. Formula for calculating volume of walls over open floor:
   length x depth x thickness x 3 walls.
   Example: length 2.00 m x depth 3.00 m x thickness 0.20 m x 3 walls = 3.60 cu.m
   Total volume of stone masonry 7.69 cu.m, say 7.7 cu.m.

4. Formula for calculating the volume of a 3 cm thick plaster:
   Area to be plastered x 0.03 m thickness of plaster = volume

   Example: $\frac{(3.20 \text{ x } 3.00 \text{ x } 2)}{2}$ + (2.20 + 2.20 + 2.20 x 3.00) + (4.24 x 2.00 x 2) x 0.03 = 1.4 cu.m.

**Type and weight of materials.**

When the total volume of the structure has been found, the type and weight of the requirements of materials for that volume can be estimated by using the following formula:

| Weight per 1 cubic metre (cu.m.) material. | Converted measurements. |
|---|---|
| Water. 1 cu.m. weighs 1000 kg = 1.00 tonne. | 1 tonne = approx. 5 drums of water. |
| Cement. 1 cu.m. weighs 1350 kg = 1.35 tonne. | 1 tonne = 20 bags of cement. |
| Sand. 1 cu.m. weighs 1600 kg = 1.60 tonne. | 1 tonne = approx. 8 wheelbarrows of sand. |
| Stones. 1 cu.m. weighs 2200 kg = 2.20 tonne. | 1 tonne = approx. 8 wheelbarrows of stones |

| | | | |
|---|---|---|---|
| 1 cu.m. Stone-masonry weighs | | 2900 kg = 2.9 tonne and consists of: | |
| | stones 75% | 1700 kg = 1.7 tonne | = 14 wheelbarrow of stones |
| | mortar 1:4 25%: | | |
| | cement | 200 kg = 0.2 tonne | = 4 bags of cement |
| | sand | 800 kg = 0.8 tonne | = 7 wheelbarrows of sand |
| | water | 200 kg = 0.2 tonne | = 1 drum of water |
| 1 cu.m. mortar, 1:3 with nil weighs | | 2400 kg = 2.4 tonne and consists of: | |
| | cement | 500 kg = 0.5 tonne | = 10 bags of cement |
| | sand | 1600 kg = 1.6 tonne | = 13 wheelbarrows of sand |
| | water | 300 kg = 0.3 tonne | = 1 drum of water |
| 1 cu.m. Mortar, 1:4 weighs | | 2200 kg = 2.2 tonne and consists of: | |
| | cement | 400 kg = 0.4 tonne | = 8 bags of cement |
| | sand | 1600 kg = 1.6 tonne | = 13 wheelbarrows of sand |
| | water | 200 kg = 0.2 tonne | = 1 drum of water |

For walls: Multiply volume with requirements for 1 cu.m. of stone masonry.

| Volume of wall | x 1 cu.m. requirements | = tonnes | = converted measurements |
|---|---|---|---|
| 7.7 cu.m. | x cement 0.2 tonne | = 1.6 tonnes x 20 | = 34 bags of cement |
| 7.7 cu.m. | x stones 1.7 tonne | = 13.1 tonnes x 8 | = 105 wheelbarrows of stones |
| 7.7 cu.m. | x sand 0.5 tonne | = 3.9 tonnes x 8 | = 31 wheelbarrows of sand |
| 7.7 cu.m. | x water 0.2 tonne | = 1.5 tonnes x 5 | = 8 drums of water |

For plastering: Multiply volume with requirements for 1 cu.m. mortar 1:3 with nil.

| Volume of plaster | x 1 cu.m. requirements | = tonnes | = converted measurements. |
|---|---|---|---|
| 1.4 cu.m. | x cement 0.5 tonne | = 0.7 tonnes x 20 | = 13 bags of cement |
| 1.4 cu.m. | x sand 1.6 tonnes | = 2.3 tonnes x 8 | = 18 wheelbarrows of sand |
| 1.4 cu.m. | x water 0.3 tonnes | = 0.5 tonnes x 5 | = 3 drums of water |

Total Requirements

| | | |
|---|---|---|
| Cement | 2.3 tonnes | = 46 bags of cement |
| Sand | 6.2 tonnes | = 50 wheelbarrows of sand |
| Stones | 13.1 tonnes | = 105 wheelbarrows of stones |
| Water | 2.0 tonnes | = 10 drums of water |

3. Labour requirements

From experience it is known that one skilled contractor with the help of 15 self-help labourers can prepare the site, carry material, mix mortar and build 1.0 cubic metre of stone mansonry with plaster per 3 days. The labour requirements can therefore be estimated as:

Formula: Volume cu.m. x 3 days = Number of skilled days
Volume cu. m. x 3 days x 15 labourers = Number of unskilled

Example: Volume 7.7 cu.m. x 3 days = 24 skilled days.

Volume 7.7 cu.m. x 3 days x 15 labourers = 360 unskilled days.

4. Transport requirements of materials.

Transport of materials is divided into two categories:

a. Transport of local materials, such as sand, stones and water, will be transported to the site by the self-help groups using oxen-donkey-and hand carts given to them by the project. The number of loads to be transported and the distances involved depends on local conditions and cannot be estimated here.

b. transport of purchased materials, e.g. cement, reinforcement wire and templates is estimated according to tonnage, distance and cost per km.

Formula: Tonnes x return distance in km x Shs per km = cost of hired transport.

Example: Tonnes 3 x return distance 75 km x km x Shs per km 6/50 = Shs. 1.462/50

Now when all requirements are known, enter them on the bills of quantities, page 8.

**Bills of Quantities and Costing.**

Two bills of quantities are needed, because about half of the items will be delivered by the donor/ministry and the other half will be delivered free of charge by the community concerned. Since the community is supposed to contribute about half the cost of the project, a value of their input has to be calculated.

Example:

Bill of Quantity for items to be delivered by the donor/ministry.

| | | | Cost |
|---|---|---|---|
| Skilled labour; 1 contractor for 24 days ....... | x Shs ............ | = Shs | ............ |
| cement; 2.3 tonnes = 46 bags .................... | x Shs ............ | = Shs | ............ |
| Support pipes: 6 metres of 2" galvanized iron pipe | x Shs ............ | = Shs | ............ |
| Polythene sheeting for curing; 10 metres ......... | x Shs ............ | = Shs | ............ |
| Transport of contractor and materials; 3 tonnes x km | x Shs ............ | = Shs | ............ |
| | Total cost | Shs | |

Bill of Quantity for items to be delivered free by the self-help groups.

| | | | | Value only |
|---|---|---|---|---|
| Unskilled labour; 360 labourers days | | x Shs ................ | = Shs | ............ |
| Sand; 6.2 tonnes | (= 50 wheelbarrows) | x Shs ................ | = Shs | ............ |
| Stones; 13.1 tonnes | (= 105 wheelbarrows) | x Shs ................ | = Shs | ............ |
| Water; 2.0 tonnes | (= 10 drums) | x Shs ................ | = Shs | ............ |
| Transport; 21 tonnes | (= 42 cart loads | x Shs ................ | = Shs | ............ |
| | | Total value of self-help | = Shs | |
| | | Grant total cost and value of project | Shs | |

## 8. Hillside Spring Protection

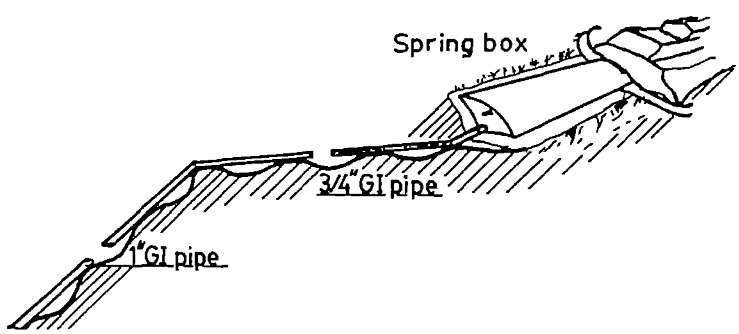
### The Spring Box

Hillside springs emerge from the hillsides where the landscape is a mixture of rocky outcrops and soil covered surfaces. Water is either transported under the soil or through the rock and flows out in an eye that might be a crack or pool in the rock or a marshy stream just above an area of rock outcrop.

The spring is usually too small to support a stream that will flow all the way down to the lowland where people live, so to take from the water source, users must climb up to the highlands and then transport water back again. This is obviously unsatisfactory. In addition, since the spring can be used by all the wild animals that live in the highland such as baboons or wild pigs, the water can be polluted by animal droppings.

When the spring begins to dry up, it can be damaged by digging as explained earlier. For these reasons, the spring is protected by a closed spring box and the water is piped down to the foot of the hillslope and into a storage tank for filling during times of low demand for water and more rapid supply at peak times.

The spring box is built around the point where the spring issues from the ground or rock. The spring box consists of a stone masonry wall situated a few metres downslope of the spring eye and running across the line of water flow. A draw-off pipe with a filter is placed at the lower end of the wall. The reservoir upstream of the wall and around the eye is cleared of vegetation and loose material and then filled up with large stones between which the water can flow freely. The stones form a large mound stretching from the ends of the wall over the springs eye to a distance of roughly one metre upslope. The mound should be very stable and solid and once finished, is covered with a 5 cm thick layer of mortar preventing dirty run-off and pollutants from entering the spring area and draw-off pipe. Cut-off drains are dug upslope of the spring box to lead away run-off water and prevent erosion near the spring box.



The Delivery System

a. The storage tank should be a raised cylindrical ferrocement tank with a capacity of 21 cubic metres as described in the manual on water tanks. The site for the storage tank should be on a small hill or rock so that the site will not be flooded during rainy seasons. It should be higher than the sites of the tapping station, the cattle trough or even the irrigated field so that water is provided by gravity alone.

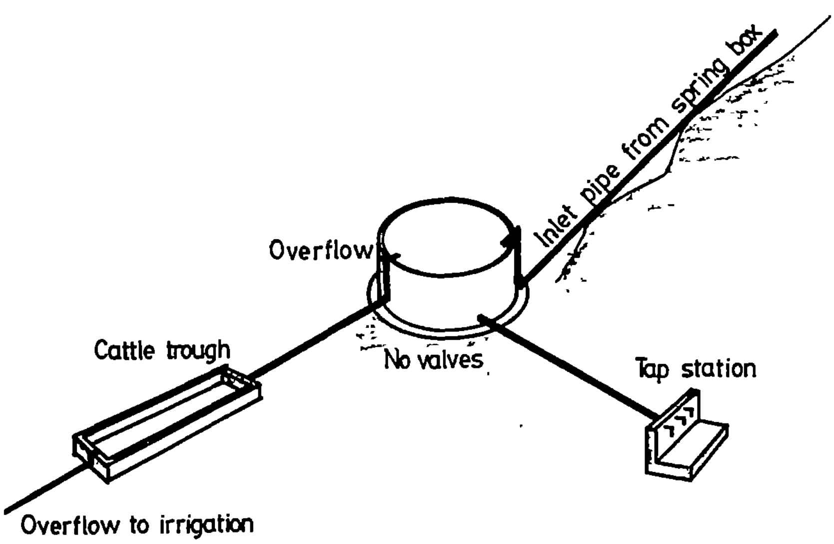
b. The inlet pipe to the tank, coming from the spring box should enter the tank at the top.

c. The overflow pipe 2.5 cm (1") diameter, should connect to the top of the tank a few centimetres lower than the inlet. The overflow goes first to a cattle trough some 100 metres downstream of the storage tank. An overflow pipe from the cattle trough leads surplus water further down to a terraced field for the irrigation of crops or fruit trees.

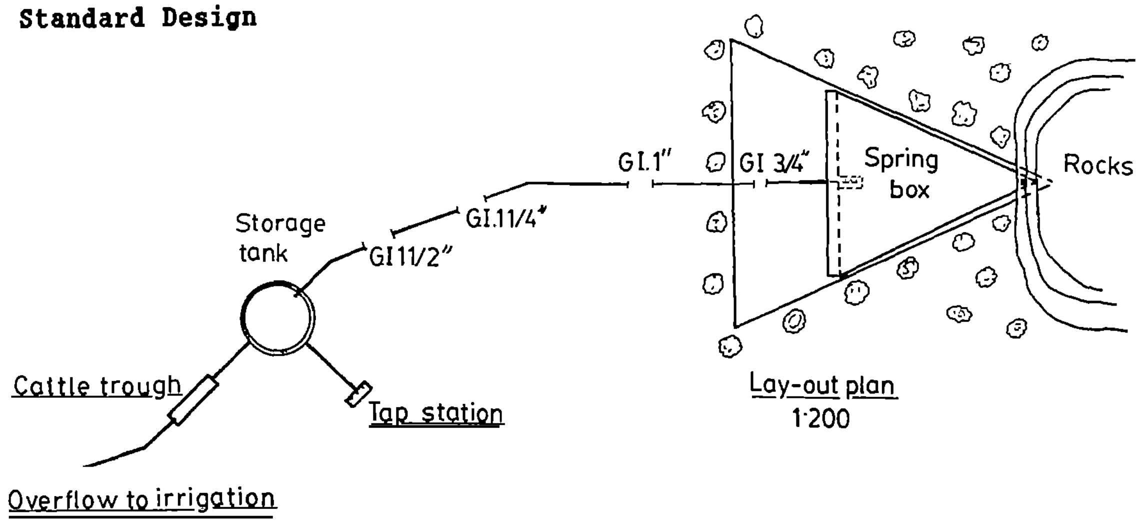
d. The outlet pipe, also a 2.5 cm (1") G.I. pipe is fixed to the bottom of the tank. This pipe leads water to the tapping station which must be more than 2 metres below the floor of the storage tank in order to provide enough pressure for the use of self-closing taps.

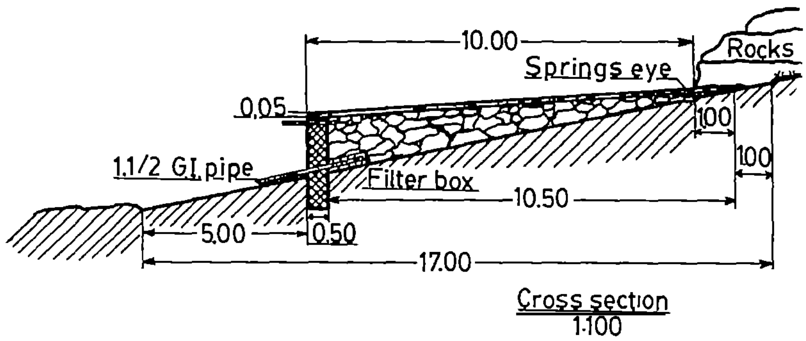
f. The difference in the elevations of the outflow pipe and the tap station can be determined using a spirit level.

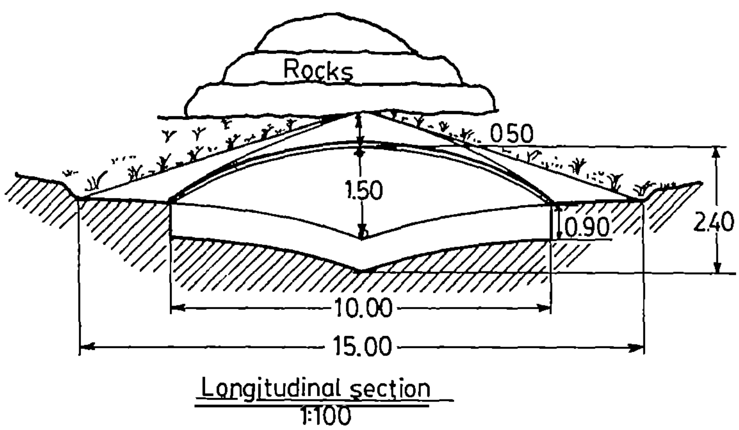
g. Build the station of stones or blocks under a shady tree. Divide the 2 cm GIP with tees to feed three water taps. Build the tapping station so that there is room for three jerrycans or gourds to stand under the three taps at the same time.



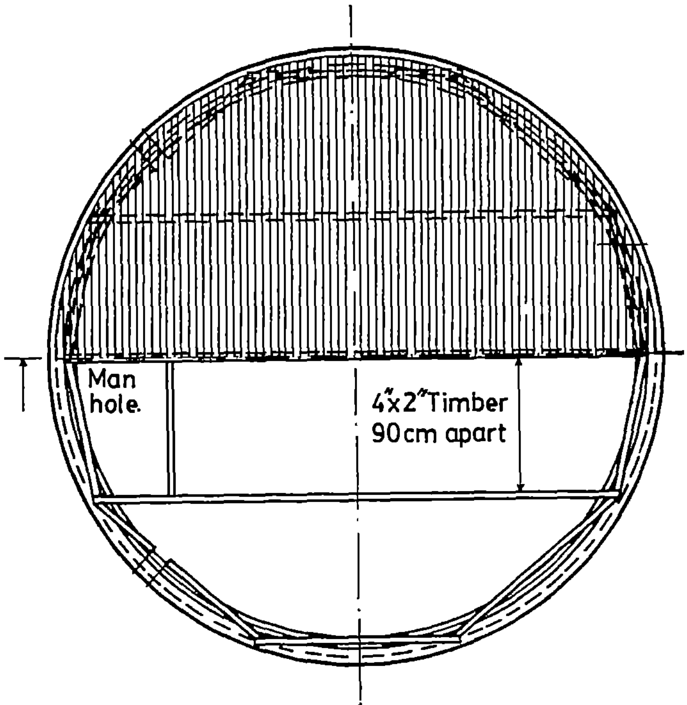
9. **Standard Design**

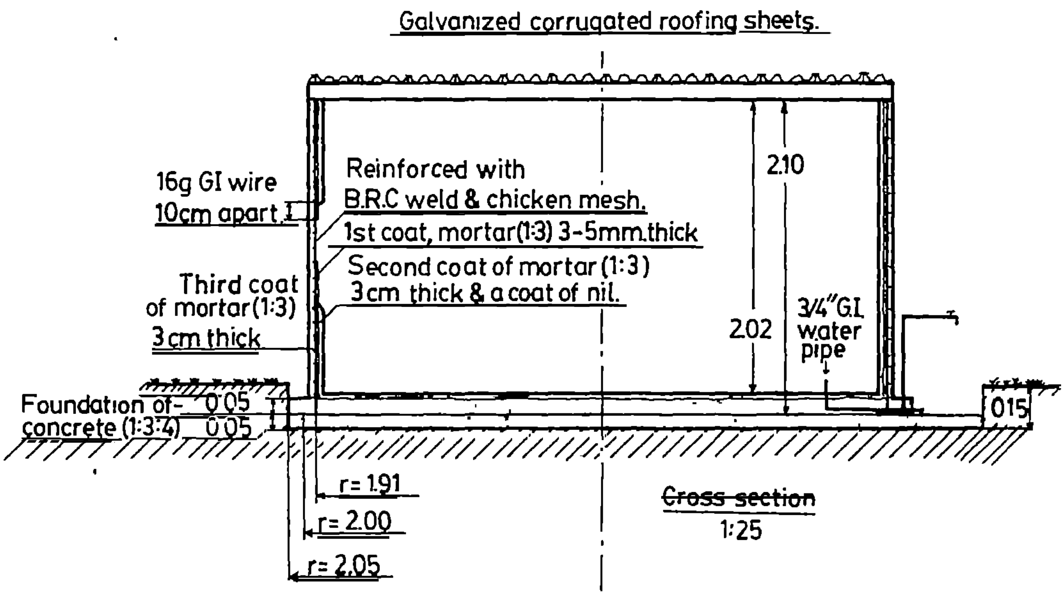


**Standard Design**



## 10. Materials, labour and transport requirements.

The requirements of materials, labour and transport are estimated by using a set of formulas which are explained with examples related to the standard drawings on the former pages.

First calculate the total volume of the various parts of the spring protection by:

1. Find the volume of the stone masonry for the spring protection box.

   Formula: Area of wall x thickness of wall 0.50 m = volume of stone masonry

   Example: Average height $\frac{2.40 + 0.90}{2}$ x length 10.00 x 0.50 m = 8.3 cu.m.of stone masonry

2. Find the volume of mortar 1:3 for plastering the wall.

   Formula: Area of wall to be plastered x thickness of plaster 0.03 cm

   Example: Average height $\frac{2.50 + 0}{2}$ x length 10.00 x 0.03 m = 0.38, say 0.4 cu.m of mortar 1:3

3. Find the volume of stones in the spring protection box.

   Formula: $\frac{\text{Height x width x length}}{6}$ of stone reservoir = volume of stones

   Example: $\frac{\text{Height 1.50 x width 10.00 x length 11.00}}{6}$ = 27.5 cu.m. of stones

4. Find the volume of mortar 1:4 for covering the stone reservoir.

   Formula: Area of cover x thickness of cover 0.05 m = volume of mortar

   Example: Area width $\frac{12.00 \text{ x length } 11.00}{2}$ x 0.05 m = 3.3 cu.m. of mortar 1:4

5. Find the types and lengths of piping required.

   Formula: Starting from the spring box and going downward measure the actual lengths in the field.

   First 180 metres use 3/4" galvanized iron pipe
   Next 180 metres use 1" galvanized iron pipe
   Next 180 metres use 1 1/4" galvanized iron pipe
   Thereafter use 1 1/2" galvanized iron pipe until the tank is reached.
   Measure the lengths of 3/4" galvanized iron pipes from the tank to the tapping station and cattle trough on the site.

6. Find the requirements for the storage tank, 21 c.u. m. in the manual on tanks.

7. Find the requirements for the tapping station and cattle trough.

   Enter the requirements on the bills of quantities.

**Type and Weight of Materials.**

When the total volume of the structure has been found, the type and weight of the various components of that volume can be estimated by using the following formula:

| Weight per 1 cubic metre (cu.m.) material. | Converted measurements. |
|---|---|
| Water 1 cu.m. weighs 1000 kg = 1.00 tonne | 1 tonne = approx. 5 drums of water. |
| Cement 1 cu.m. weighs 1350 kg = 1.35 tonne | 1 tonne = 20 bags of cement. |
| Sand 1 cu.m. weighs 1600 kg = 1.60 tonne | 1 tonne = approx. 8 wheelbarrows of sand. |
| Stones 1 cu.m. weighs 2200 kg = 2.20 tonne | 1 tonne = approx. 8 wheelbarrows of stones. |

1 cu.m. stone-masonry weighs 2900 kg = 2.9 tonne and consists of:

| | | |
|---|---|---|
| stones 75% | 1700 kg = 1.7 tonne = | 14 wheelbarrow of stones |
| mortar 1:4 25% | | |
| cement | 200 kg = 0.2 tonne = | 4 bags of cement |
| sand | 800 kg = 0.8 tonne = | 7 wheelbarrows of sand |
| water | 200 kg = 0.2 tonne = | 1 drum of water |

1 cu.m. Mortar, 1:3 with nil weighs 2400 kg = 2.4 tonne and consists of:

| | | |
|---|---|---|
| cement | 500 kg = 0.5 tonne = | 10 bags of cement |
| sand | 1600 kg = 1.6 tonne = | 13 wheelbarrows of sand |
| water | 300 kg = 0.3 tonne = | 2 drums of water |

1 cu.m. Mortar, 1:4 weighs 2200 kg = 2.2 tonne and consists of:

| | | |
|---|---|---|
| cement | 400 kg = 0.4 tonne = | 8 bags of cement |
| sand | 1600 kg = 1.6 tonne = | 13 wheelbarrows of sand |
| water | 200 kg = 0.2 tonne = | 1 drum of water |

**Example:**

**For wall:** Multiply volume with requirements for 1 cu.m. of stone masonry.

1. **Volume of wall x 1 cu.m. requirements = tonnes = converted measurements.**

   8.3 cu.m. x cement 0.2 tonne = 1.7 tonnes x 20 = 34 bags of cement

   8.3 cu.m. x stones 1.7 tonne = 14.1 tonnes x 8 = 113 wheelbarrows of stone

   8.3 cu.m. x sand 0.4 tonne = 3.3 tonnes x 8 = 27 wheelbarrows of sand

   8.3 cu.m. x water 0.2 tonne = 1.7 tonnes x 5 = 9 drums of water

2. **For plastering:** Multiply volume with requirements for 1 cu.m. mortar 1:3 with nil.

   **Volume of plaster x 1 cu.m. requirements = tonnes = converted measurements**

   0.4 cu.m. x cement 0.5 tonnes = 0.2 tonnes x 20 = 4 bags of cement

   0.4 cu.m. x sand 1.6 tonnes = 0.7 tonnes x 8 = 5 wheelbarrows of sand

   0.4 cu.m. x water 0.3 tonnes = 0.2 tonnes x 5 = 1 drum of water

3. **Volume of stone fill in spring box**

27.5 cu.m. of stones x 2.20 tonnes = 60.90 tonnes = 484 wheelbarrows of stones

4. **Volume of Mortar 1:4 on stone fill in spring box**

Volume of mortar x 1 cu.m. requirements = tonnes = converted measurements

3.3 cu.m. x cement 0.4 tonne = 1.4 tonnes = 27 bags of cement.
3.3 cu.m. x sand 1.6 tonne = 5.3 tonnes = 43 wheelbarrows of sand
3.3 cu.m. x water 0.2 tonne = 0.7 tonnes = 3 drums of water

Total requirements for spring box (without tank, trough, tap station and pipeline)

| Work | Tonnes of cement | Tonnes of sand | Tonnes of stones | Tonnes of water | Total tonnes |
|---|---|---|---|---|---|
| 1 | 1.7 | 3.3 | 14.1 | 1.7 | 20.8 |
| 2 | 0.2 | 0.7 | Nil | 0.2 | 1.1 |
| 3 | Nil | Nil | 60.9 | Nil | 60.9 |
| 4 | 1.4 | 5.3 | Nil | 0.7 | 7.4 |
| TOTAL | 3.3 tonnes. + | 9.3 tonnes. + | 75.0 tonnes. + | 2.6 tonnes = | 90.2 tonnes |

**Labour requirements.**

On experience it is known that one skilled artisan with the help of 15 self-help labourers can prepare the site, carry material, mix mortar and build 0.8 cubic metre of stone masonry per day. The estimate for labour requirements is therefore as follows:

**Formula for wall:** $\frac{\text{Volume cu.m.}}{\text{0.8 cu.m. per day}}$ = skilled days required. Unskilled days = x 15

**Example:** $\frac{\text{Volume 8.3 cu.m.}}{\text{0.8 cu.m. per day}}$ = 11 days of skilled labour. Unskilled days 156

**Transport requirements of material**

Transportation of materials is divided into two categories:

a. Transport of local materials, such as sand, stones and water, will be transported to the site by the self-help groups using oxen-donkey-and hand carts given to them by the project. The number of loads to be transported and the distances involved depends on local conditions and cannot be estimated here.

b. Transport of purchased materials, e.g. cement, reinforcement wire and is estimated according to tonnage, distance and cost per km.

**Formula:** Tonnes x return distance (km) x Shs. per km.

**Example:** (a) 90.2 tonnes by self-help group.
(b) 5 tonnes x return distance 86 km x Shs. 6/50 per km = Shs. 2,795 by project.

Enter the requirements on the bills of quantities

Bills of Quantities and Costing.

Two bills of quantities are needed, because about half the items will be delivered by the donor/ministry and the other half will be delivered free of charge by the community concerned. Since the community is supposed to contribute about half the cost of the project, a value of their input has to be calculated.

Example.

Bills of Quantities for items to be delivered by the donor/ministry.

Materials

1. Spring Box

| | | |
|---|---|---|
| Cement 3.3 tonnes = 66 bags ........................... | x Shs ......... | = Shs .......... |
| G.I. piping, 1 1/2 " 6 metres = 1 length ............... | x Shs ......... | = Shs .......... |
| Polythene sheeting for curing: 20 metres ............... | x Shs ......... | = Shs .......... |
| | Total | Shs . |

2. Pipe line

| | | | |
|---|---|---|---|
| G.I. piping 3/4" 180 metres/6 | = 30 lengths | x Shs ......... | = Shs ......... |
| G.I. piping 1 " 180 metres/6 | = 30 lengths | x Shs ......... | = Shs ......... |
| G.I. piping 1 1/4" 180 metres/6 | = 30 lengths | x Shs ......... | = Shs ......... |
| G.I. piping 1 1/2" 210 metres/6 | = 35 lengths | x Shs ......... | = Shs ......... |
| Fittings ............................................................ | | | Shs ......... |
| | | Total | Shs . |

3. Storage Tank, 21 cu.m.

| | | | |
|---|---|---|---|
| Cement, 1,25 tonnes ...................... | = 25 bags | x Shs ......... | = Shs ........ |
| B.R.C. mesh No. 65 or 66 ................. | = 1 roll | x Shs ......... | = Shs ........ |
| Chicken mesh, 1" x 3 ft. x 30 m ........... | = 2 rolls | x Shs ......... | = Shs ........ |
| Binding wire ............................. | = 10 kg | x Shs ......... | = Shs ........ |
| Draw-off stand pipe and tap .............. | = 1 set | x Shs ......... | = Shs ........ |
| Empty sugar sacks for supporting plastering | = 20 nos | x Shs ......... | = Shs ........ |
| Sisal twine thread for sugar sacks ........ | = 2 kg | x Shs ......... | = Shs ........ |
| | | Total | Shs ........ |

4. Tap Station, Trough and Piping.

| | | | |
|---|---|---|---|
| Cement 1.0 tonnes .......................... | = 10 bags | x Shs ......... | = Shs ........ |
| G.I. piping 1" 60 metres .................... | = 10 lengths | x Shs ......... | = Shs ........ |
| 4 self-closing water taps and fittings ................................. | | | = Shs ........ |
| | | Total | Shs . |
| | | TOTAL FOR MATERIALS | SHS |

**Skilled Labour**

| | | | | |
|---|---|---|---|---|
| 1. | Spring box | 11 skilled days | x Shs ......... | = Shs ........ |
| 2. | Pipeline, 810 metres/36 m. = | 23 " " | x Shs ......... | = Shs ........ |
| 3. | Storage tank, | 24 " " | x Shs ......... | = Shs ........ |
| 4. | Tap station and trough | 10 " " | x Shs ......... | = Shs ........ |

Total for skilled labour Shs

## III. Tractor/Lorry Transport

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Spring box | 3.5 tonnes x contractor | x km | x Shs ......... | = Shs ........ |
| 2. | Pipe line | 2.0 tonnes + contractor | x km | x Shs ......... | = Shs ........ |
| 3. | Storage tank | 2.0 tonnes + contractor | x km | x Shs ......... | = Shs ........ |
| 4. | Tap station and trough | 1.0 tonne + contractor | x km | x Shs ......... | = Shs ........ |

Total for transport Shs .

Grand Total Cost Shs

Bill of Quantity for items to be delivered free of charge by the self-help group

## I. VALUE OF LOCAL MATERIALS

### 1. Spring Box

| | | | | |
|---|---|---|---|---|
| 9.3 tonnes of sand ........ | x 8 = 75 wheelbarrows ...... | x Shs ......... | = Shs ........ |
| 75.0 tonnes of stones ...... | x 8 = 600 wheelbarrows ...... | x Shs ......... | = Shs ........ |
| 2.6 tonnes of water ....... | x 5 = 13 drums of water .... | x Shs ......... | = Shs ........ |
| 90.2 tonnes | | Total | Shs |

### 2. Pipe line

| | | | | |
|---|---|---|---|---|
| 6.0 tonnes of stones ...... | x 8 = 48 wheelbarrows of stones | x Shs ......... | = Shs ........ |
| 6.0 tonnes | | Total | Shs ........ |

### 3. Storage Tank

| | | | |
|---|---|---|---|
| 4.0 tonnes of sand ....... | x 8 = 32 wheelbarrows | x Shs ......... | = Shs ........ |
| 2.0 tonnes of | x 8 = 16 wheelbarrows | x Shs ......... | = Shs ........ |
| 2.0 tonnes of water ...... | x 5 = 10 drums of water | x Shs ......... | = Shs ........ |
| 8.0 tonnes | | Total | Shs |

### 4. Tap station and trough

| | | | |
|---|---|---|---|
| 2.0 tonnes of sand ....... | x 8 = 16 wheelbarrows | x Shs ......... | = Shs ........ |
| 8.0 tonnes of stones ..... | x 8 = 64 wheelbarrows | x Shs ......... | = Shs ........ |
| 2.0 tonnes of water ...... | x 5 = 10 drums of water | x Shs ......... | = Shs ........ |
| 12.0 tonnes | | Total | Shs |

Value total materials Shs

## II. VALUE OF LOCAL TRANSPORT

| | | | | |
|---|---|---|---|---|
| 1. Spring box ............ | 90.2 tonnes/0.4 = | 180 cart loads | x Shs ........ | = Shs ........ |
| 2. Pipe line ............. | 6.0 tonnes/0.4 = | 15 cart loads | x Shs ........ | = Shs ........ |
| 3. Storage tank .......... | 8.0 tonnes/0.4 = | 20 cart loads | x Shs ........ | = Shs ........ |
| 4. Tap station and trough | 12.0 tonnes/0.4 = | 30 cart loads | x Shs ........ | = Shs ........ |

Value of total transport Shs ........

III. VALUE OF UNSKILLED LABOUR

1. Spring box .......... 11 skilled days x 15 = 165 unskilled days x Shs .... = Shs .....
2. Pipe line ........... 23 skilled days x 10 = 230 unskilled days x Shs .... = Shs .....
3. Storage tank ........ 24 skilled days x 10 = 240 unskilled days x Shs .... = Shs .....
4. Tap station and tough 10 skilled days x 10 = 100 unskilled days x Shs .... = Shs .....

Value of total unskilled days Shs

Grand total value of self-help Shs

Total cost and value of projects

Grand total cost for donor/ministry Shs ..................................

Grand total value of self-help Shs ..................................

Grand total cost of project Shs ..................................

# CONTRACTORS MANUAL ON SPRING PROTECTIONS

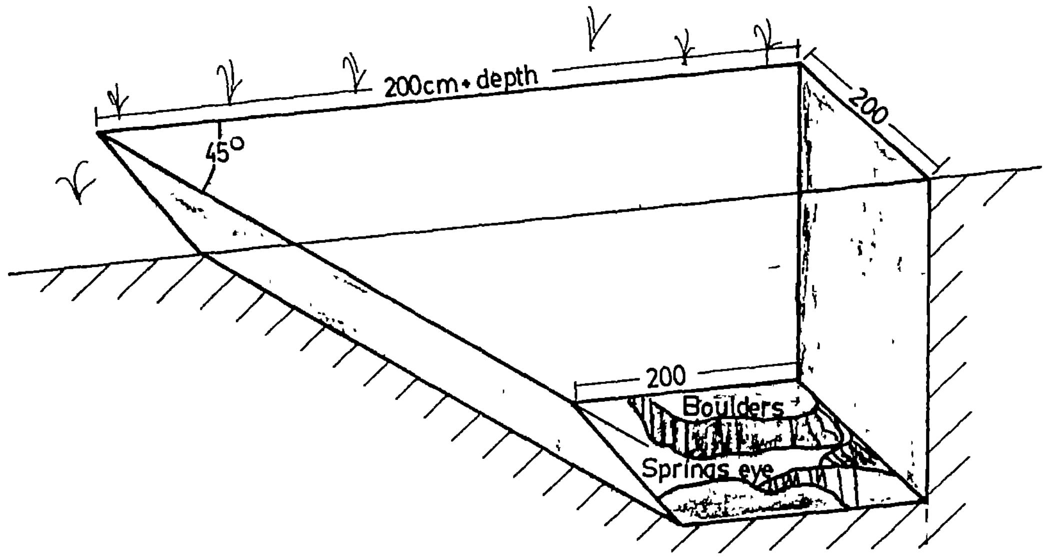
## C O N T E N T S

Under-Ground Spring Protection (Walk-in-Wells)

1. Preparing the site

Excavation will have been begun a long time ago by animals and then people trying to get access to water during dry years. The original excavation should be dug out to roughly 200 cm width during the dry season preferably when the spring has dried up. This will ensure the soil is dry and stones sticking out will be held in place.

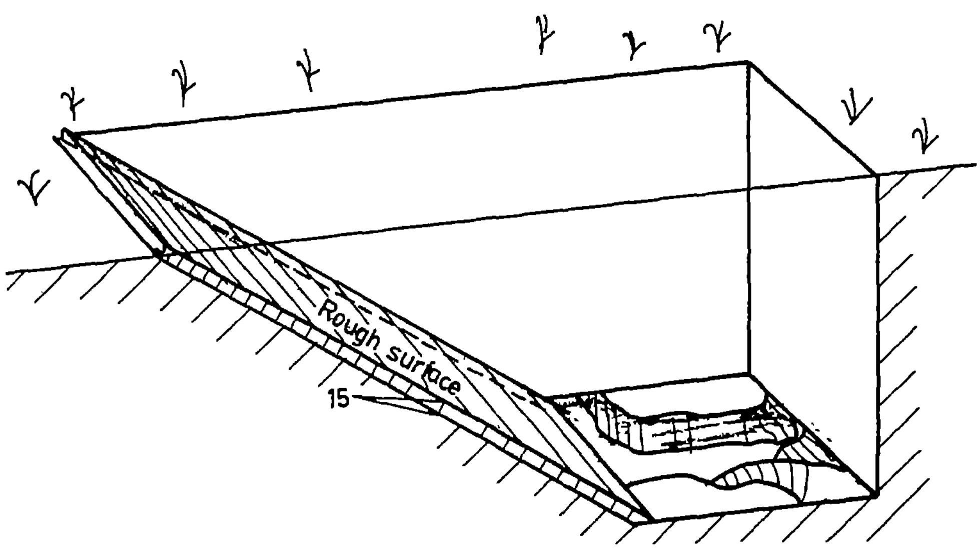
The floor of the staircase should have a slope of about 45 degrees and be even as the rocks and bedrock will allow.




2. Building Instructions

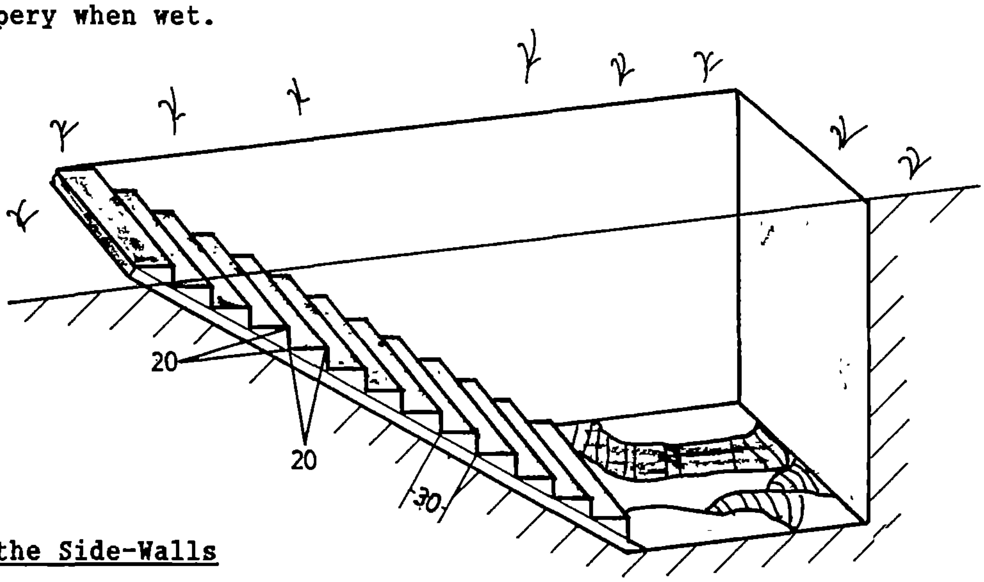
Building the Steps

a. The foundation of the staircase is a 15 cm thick layer of concrete (1 cement:4 sand: 6 stones) which is poured and compacted onto the sloping staircase floor with a rough surface to which the steps can be securely fastened.



b. The steps are built of stones from the excavation set in mortar. Mark horizontal lines spaced 30 cm apart, along the whole length of the concrete floor of the staircase. Set flat stones 15 to 20 cm· high mortar (1:4) along the lines and with the flat sides of the stones facing the line. This is the front face of the step.

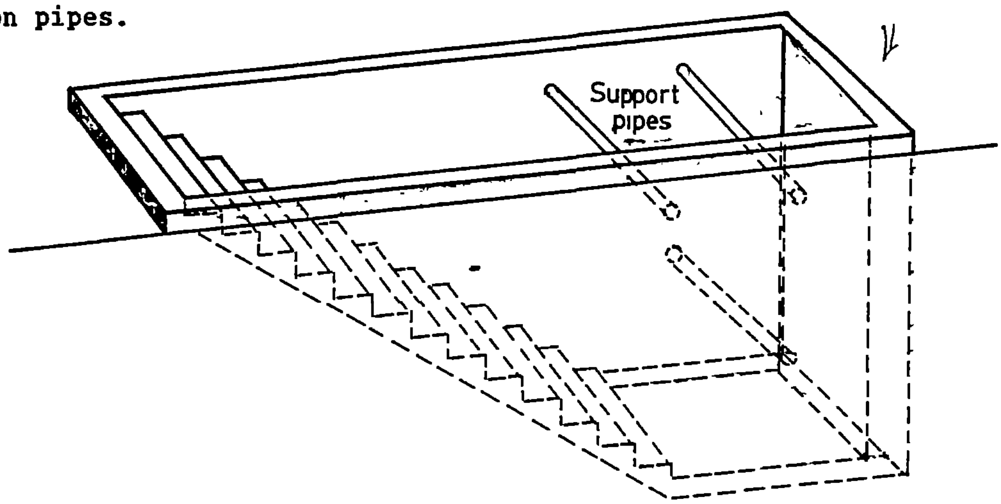
c. The following day, fill the spaces behind the lines of stones with mortar (1:4) and smooth them with a wooden float roughen the surface on the steps before it dries otherwise they will be slippery when wet.




Building the Side-Walls

a. The walls are built onto the steps. The walls consists of stones from the excavation or elsewhere which have been well cleaned. These stones are mortared together (1:4) with their flattest sides facing the staircase. Any protruding boulders are cleaned and incorporated into the wall.

b. The top of the wall is levelled off horizontally 30 cm above ground level. Wall supports can be made of 5 cm (2") galvanized iron pipes.

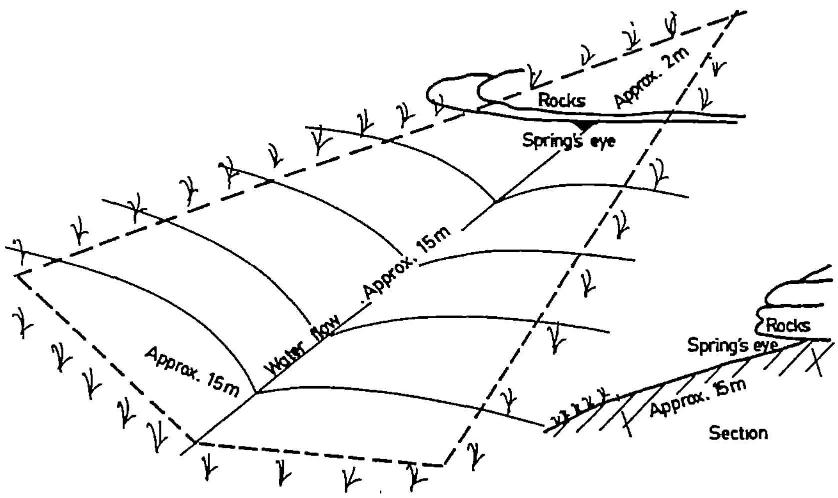



c. The walls should be plastered with mortar (1:4) once the support pipes are in position so that the plaster will help to keep them there.

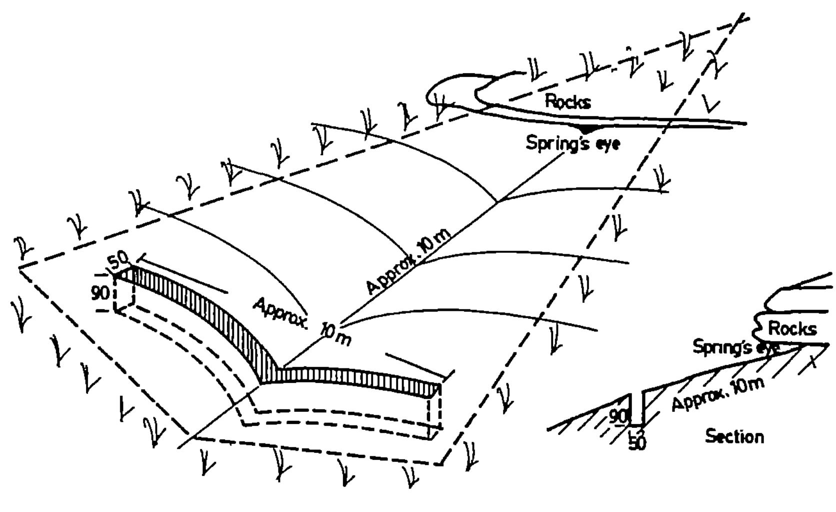
Hillside Spring Protection (Spring Capping)

1. Building Instructions

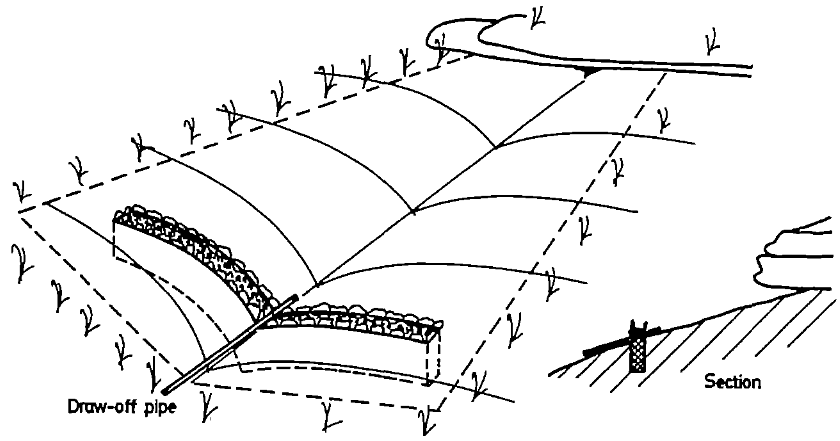
a. Remove all vegetation and loose debris in a triangular area stretching from about 2 metres upslope of the springs eye to two points marking the ends of a wall to be built about 15 metres downstream of the eye across the line of spring flow. The wall fills the small valley through which the stream flows and acts as a dam. The length of the wall depends on the site.



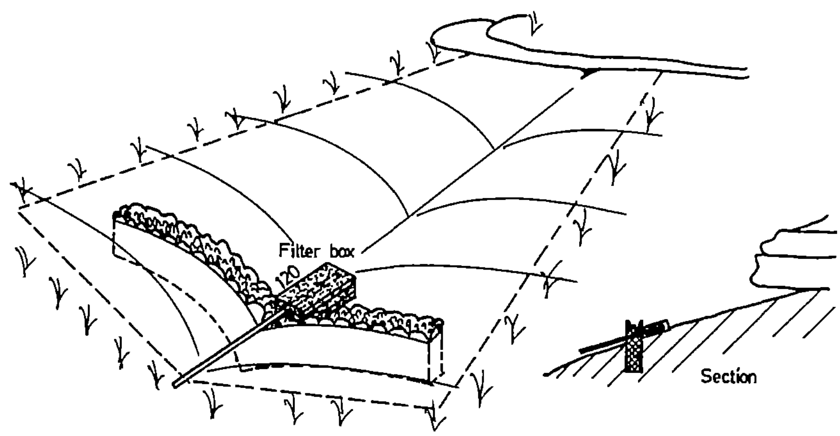

b. If there is soil where the dam wall is to be built, dig a 50 cm wide trench across the lower boundary of the cleared area so that the bottom of the trench reaches bedrock or very firm soil. Otherwise the wall will not provide a water-tight dam in the valley.



c. Fill the trench with mortar in the ratio 1 cement to 3 sand to 4 stones. Compact the concrete well so as to make the material in the trench water-tight and leave a rough surface as a foundation for a masonry wall.

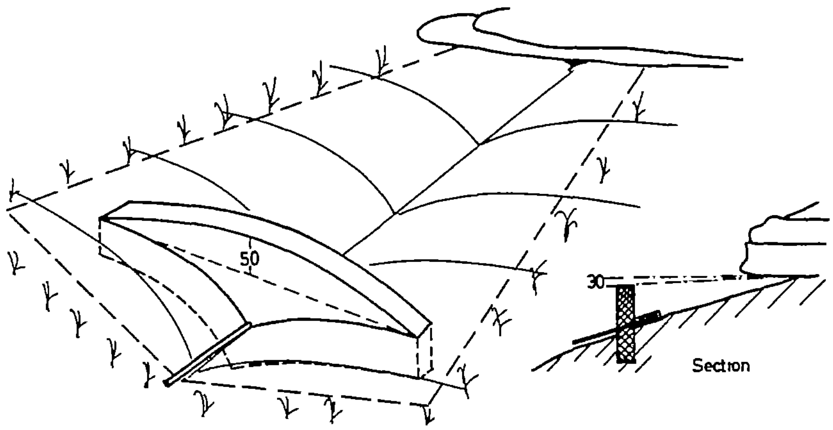



d. Place a draw-off pipe of galvanized iron (GI) 3.8 cm (1.5") upon this foundation along the line of the spring water flow in the valley. Screw a perforated 100 cm long PVC pipe with a closed end onto the end of the GI pipe so that it points up towards the springs eye. This is part of the filter.
Build a filterbox made of every porous concrete blocks (made of cement and a fine gravel ballast) all around the PVC pipe so that nothing can damage it and so water must pass through the filter box first.

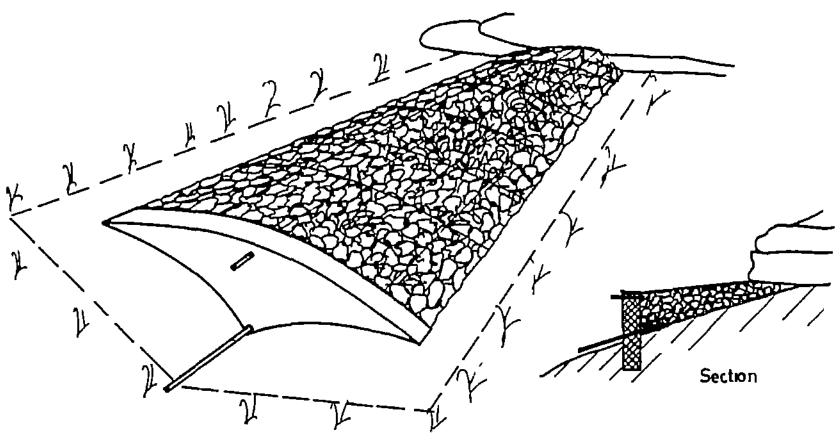


e. Extend the 50 cm thick stone-masonry wall up and around the GI pipe up to a level that is about 50 cm lower than the level of the spring eye. It should form a triangular shape wall filling the valley through which the spring flows.

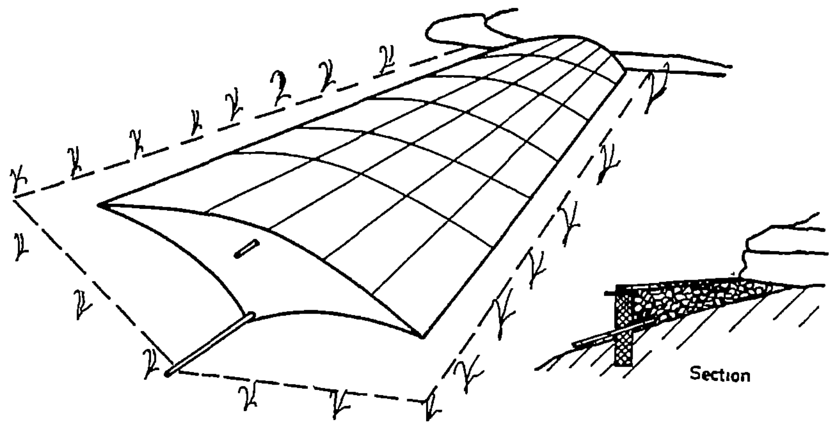
Build-in an overflow pipe, 60 cm. long of 1 1/2" G.I. pipe.




f. Fill the cleared area upslope of the wall with large stones in such a way that the water flowing out of the eye can pass between them down to the point where the draw-off pipe is sited. The stones should form a curved mound stretching from the edges of the wall back up to a point about 50 cm taller than the wall at its middle point and level with the wall.



g. The holes in between the large stones on the top of the mound need to be filled in with smaller stones until an even surface with no gaps larger than 1 cm diametre is achieved. On top of this, a 5 cm layer of mortar (1:4:5) should be plastered over the stones to make the spring box water tight and closed to pollutants.




h. Cut-off drains should be dug a few metres upslope of the spring box to prevent erosion damaging the spring box. If the surface is rock, masonry gutters should be built using mortar and pieces of flat stone.

2. Constructing the Piping

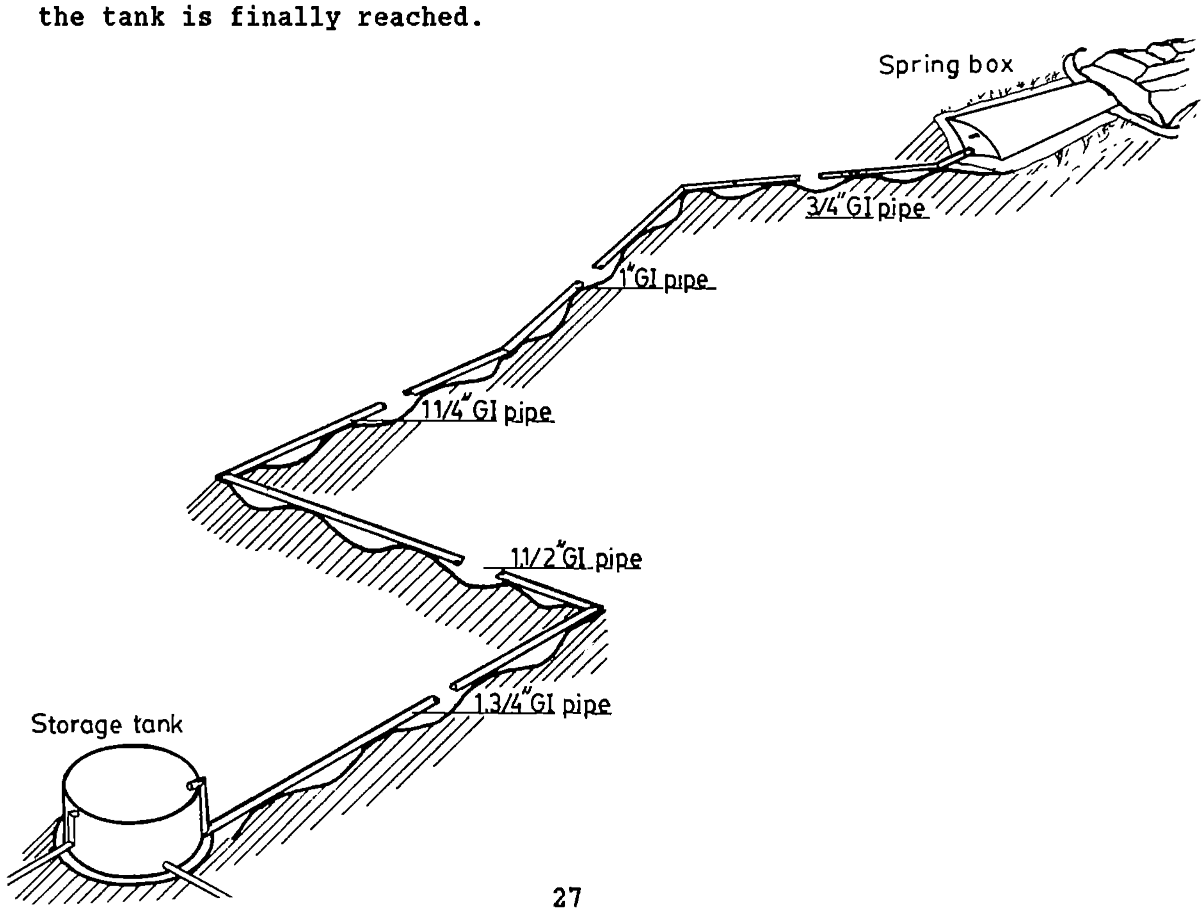
a. Once the spring box is complete, the piping can be assembled down to the lowlands. Fitting pressure release valves or break pressure stations along the pipe as it reaches lower elevations does not prevent breakages and pressure bursts because they do not usually function well over a longer period.

By trial and error a method has been developed based on pipe diametre expansion which has proved successful and maintenance free in each of the highland spring protections built even those dropping several hundred metres in height over several kilometres.

Increase the diametre of the pipe by 0.65 cm (1/4") for every 180 metres of pipe you lay. Whilst that increases the cost, it provides trouble free-use and is more economical in the long-run.

Starting from the spring box, reduce the draw-off pipe to 2 cm (3/4") GI pipe. The pipe can be left above ground, supported by and anchored to mortar and stone rests until it can be buried in a ditch further down the slope 30 cm wide and 30 cm deep.

Starting with the 2 cm (3/4") outlet pipe, connect 30 lengths of 2 cm GI pipe each 6 metres long. Thereafter insert a reducing socket 2.5 cm to 2 cm (1" to 3/4") and lay 30 lengths of the 2.5 cm GI pipe or less until the storage tank site is reached. If the tank is not yet reached insert a reducing socket 2.5 cm to 3.2 cm (1.25" to 1") and lay another 30 lengths or less to the storage location. If the tank site is still out of reach, continue with 3.8 cm (1.5") GI pipe until the tank is finally reached.



3. **The Storage Tank**

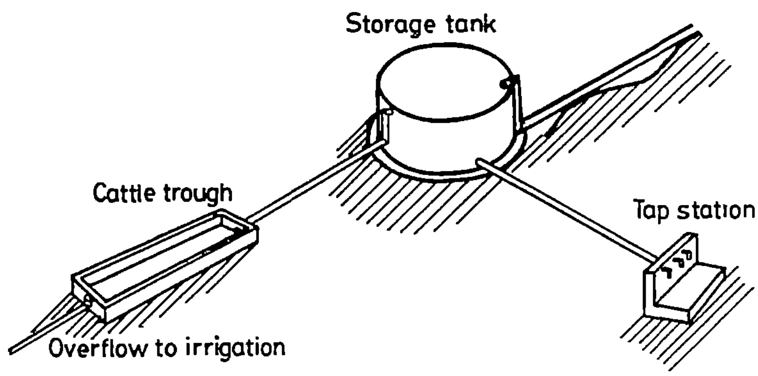
a. The storage tank should be a raised cylindrical ferrocement with a capacity of 21 cubic metres as described in the manual on the construction of water tanks. The site for the storage tank should be on a small hill or rock so that the site will not be flooded during rainy seasons. It should be higher than the site of the tapping station, the cattle trough or even the irrigated field so that water is provided by gravity alone.

b. The inlet pipe to the tank, coming from the spring box should enter the tank at the top.

c. The overflow pipe. 2.5 cm (1") diametre, should connect to the top of the tank a few centimetres lower than the inlet.

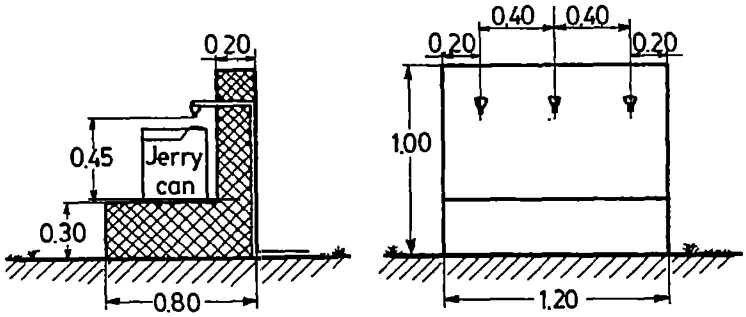
The overflow goes first to a cattle trough 20 to 100 metres downstream of the storage tank. An overflow pipe from the cattle trough leads surplus water further down to a terraced field for the irrigation of crops or fruit trees.

d. The outlet pipe, also 2.5 cm (1") is fixed to the bottom of the tank. This pipe leads water to the tapping station and must be more than 3 metres below the floor of the storage tank in order to provide enough pressure for the use of self-closing taps.




g. Build the tapping station of stones or blocks under a shady tree. Divide the 2 cm GI pipe with tees to feed three water taps. Build the tapping station so that there is room for three jerrycans or gourds to stand under the three taps at the same time.

Tapping Station




Cattle Trough