SPRING PROTECTION

A technical guide of how to protect a spring.
Masindi District, Uganda.

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1. Introduction

Spring water is usualy fed from a sand or gravel water-bearing ground formation (aquifer), or a water flow through fissured rock. Where solid or clay layers block the underground flow of water, it is forced upward and can come to the surface. The water may emerge either in the open as a spring, or invisibly as an outflow into a river, stream or a lake. Where the water emerges in the form of a spring, the water can easily be tapped (Protected). The oldest community water supplies were, in fact, often based on springs.

The best places to look for springs are the slopes of hill-sides and river valleys. Green vegetation at a certain point in a dry area may also indicate a spring, or one may be found by following a stream up to its source.
However, the local people are the best guides, as they usually know most springs in their area.

Real spring water is pure and usually can be used without treatment, provided the spring is **properly protected** with a construction (e.g. masonry, brick, or concrete) that prevents contamination of the water from outside sources.
One should be sure that the water is really fed from the **groundwater** and **not** a stream that has gone underground for a short distance.

The flow of water from a spring may be through openings of various shapes. There are several names: seepage or filtration springs where the water percolates from small openings in porous ground; fracture springs where the water issues from joints or fractures in otherwise solid rock; and tubular springs where the outflow opening is more or less round. However, to under-stand the possibilities of spring protection, the distinction between gravity springs and artesian springs is most important.

Gravity Springs is obtained where an outcrop of impervious material, such as a solid ground or clay fault zone, prevents the downward flow of the groundwater and forces it up to the ground surface. At such an overflow spring , all water from the tributary recharge area is discharged. The flow will be more regular than the recharge by rainfall. Even so, an appreciable fluctuation of discharge may occur and in periods of drought some springs may cease to flow completely. Annex 01
In appearance a gravity spring emerges horizontal out of the ground surface.

Artesian Springs are similar in appearance to gravity springs. However, the water is forced out under pressure so that the discharge is stronger and shows less fluctuation. A drop of the artesian water table during dry periods has little influence on the groundwater flow
Artisian springs have the advantage that the impervious layer protects the water in the aquifer against contamination. The water from these springs will be bacteriologically safe. Annex 02
In appearance an artesian spring emerges vertical out of the ground surface.

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2. Basic considerations

The spring chosen for protection is to be constructed in a structure from which one or more delivery pipes are used to supply water for collection. Five factors are of great importance and should be given careful attention.

1. A sanitary protection to prevent contamination of the spring water in the catchment area. There should be **No** latrines or garbage dumps within 30 Meters uphill of the spring.
2. The quality of the spring water is of importance. In particular with gravity springs, the water will generally be free from pathogenic organisms. However, if the water differs in temperature during the day and the night, the water quality is suspect.
3. An assessment of the yield of the spring and the seasonal variations of flow are needed. The yield and the reliability of a spring can only be slightly influenced by the construction of the spring water protection works.
4. A "spring" should only be protected if the delivery pipe(s) can be placed at least 30cm above the concrete platform and/or the drainage channel. In other words it is not a spring but a water hole.
5. If there are any trees within ±10 Meters of the catchment area they have to be removed. Consult with the community if they agree to remove the trees. If not do **not** protect the spring because the roots of the trees will destroy the spring in time.

3. Protecting gravity springs

The protection of a gravity spring is basically quite simple but care should be taken in the construction. First of all the source of the spring has to be exposed. That is the location of the "eyes" of the spring have to be located in order to make an assessment of the construction which should be used.
If the "eyes"have been located you will know if it is indeed a gravity spring.
A foundation and a retaining wall have to be constructed as close to the "eyes" as possible. Annex 03
There are two ways to eleminate the interference of the water from the spring when constructing the foundation and retaining wall.

1. Make a diversion channel for the spring water. To be closed with clay and hard-core after completion. Annex 04
2. Put a drain pipe into the foundation for the spring water. To be closed with an overflow pipe after completion. I prefer the latter.Annex 05

The first method is most common and known and if it is decided to use this method the diversion channel should be between the foundation and the back of the catchment area. **Not** next to the foundation.
After the diversion channel has been completed a water diversion dam has to be made in order to divert the water into the diversion channel.
The area where the foundation will be constructed should be dry. A channel should be made where you construct the foundation for the retaining wall. The channel is made 10cm deep and 30cm wide in the impervious layer of the catchment area. Be careful **not** to penetrate the impervious layer. The channel has to be the full width of the catchment area with the abutments (Borders) into the sides of the catchment area. Be sure there are no stones, rocks or other material burried in the ground where you are making the foundation. Water could escape underneath a stone or rock and you will have a leaking spring which is very difficult to close. Annex 06
Make a "mould" from timber or any other material. The foundation should be 30x30cm x the width of the spring. When you pour the concrete into the mould be sure to stamp the concrete into the bottom in order to make a water tight seal. The foundation has to be completed in one operation. Concrete **must** be placed within 5 minutes of mixing and left undisturbed for at least 12 hours.

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The second method with a drain pipe enclosed in the foundation has the advantage that you are able to drain the spring at any time for repairs plus the advantage that you do not have to make a diversion channel, which is some-times difficult to close water tight. There are two ways to make the foundation with a drainpipe, one way takes two days and the other one takes one day. (Annex 08/A or Annex 08/B) A 63mm or 75mm PVC pipe have to be made with a socket and a 90^{o} elbow for the drain pipe. Annex 07

Depending on the yield of the spring you have to determine which size or how many drainpipes you need. The first way is to dig a channel for the foundation $\frac{3}{4}$ of the width of the spring. Annex(08/A) The spring water has to be diverted into a diversion channel in the remaining $\frac{1}{4}$ of the width of the spring. Make that channel with clay. The channel for the foundation has to be 30cm wide and 10cm deep into the impervious layer of the spring. Be sure not to penetrate the impervious layer. Make a "mould" from timber or any other suitable material. The foundation measurements are 30x30cm x $\frac{3}{4}$ of the width of the spring. The drainpipe(s) have to be enclosed in the foundation. Annex 08

When you pour the concrete into the mould be sure to stamp the concrete into the bottom in order to make a water tight seal. The foundation have to be completed in one operation. Concrete **must** be placed within 5 minutes of mixing and left undisturbed for at least 12 hours.

After ± 20 hours you divert the spring water into the drainpipe(s) and proceed in make the remaining $\frac{1}{4}$ of the foundation using the same procedure as before. Be sure to clean the end of the already made $\frac{3}{4}$ of the foundation in order to obtain a water tight bond. Leave foundation undisturbed for at least 12 hours.

The second way is to make a wall from hardcore and clay with an overflow pipe embedded, to divert the spring water over the foundation construction area. Construct the foundation the same way as described above but this time the full width of the spring. Annex 08/B

Whichever method you have used for making the foundation,the retaining wall can now be made. When constructing the retaining wall make sure that the mortar 1:3 is wet and plyable and apply the mortar evenly with no more than 2cm between the courses of brick. **Wet the bricks before use.** The first layer of bricks on top of the foundation is critical and no sharp corners should be made at the bottom of the bricks, that is between the first course and the foundation. (Annex 09) The abutments (ends of the retaining wall) of the retaining wall have to be made into the sides of the catchment area in order to obtain a water tight seal. Annex 10

The delivery pipe(s) have to be placed between the 3rd and 4th course or if possible between the 4th and 5th courses of bricks. Clean the delivery pipe first to make sure that there be no leakage between the pipe and mortar. Only two courses of bricks are needed above the delivery pipe(s) but three courses are acceptable. The inside of the retaining wall should now be plastered with a mixure of 1:2 . Plaster only up to the height of the top of the delivery pipe (water level). The retaining wall and the inside plastering should all be done in one operation (same day), if time allows. Remember cement has a chemical reaction which will bond mortar together if the mortar is still wet. Mortar is not a glue!!. The construction of the foundation and retaining wall is the most important operation of protecting a spring successfully in order to make it trouble free for a long time.

Next the platform (floor), side wall(s), wingwall and stair(s) have to be made.(Annex 11) The platform is made of concrete 1:2:4 and should slope towards the drain so that water from the delivery pipe and water spilled will not remain on the platform. Crushed hardcore or small rocks should be placed on the ground first and than 10cm of concrete on top of this for the platform.(Annex12) The platform has to be made in one operation and it does not require plastering but it should be made smooth on the top with a trowel. I prefer to make a small channel underneath the delivery pipe so the water can drain away without touching the feet of the persons who collect the water. Any suitable material can be used as a mould to make the small channel. A granite stone has to be placed in the concrete underneath the delivery pipe where the water hits the platform. Annex 12

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The stair(s) (steps)have to be made according to the sketch. (Annex 11) Be sure to slope the steps and keep to the measurements. The retaining wall and side walls can now be plastered 1:5 . The construction of the spring is now completed, but not the protection!. Annex 12

4. Protecting Artesian Springs

The protection of artesian springs is quite simple if you already know how to protect a gravity spring. Depending on the nature and location of the "eyes" there are two methods of protecting an artesian spring.

1. If the "eyes" are located in the same way as most of the gravity springs then the protection is the same as for gravity springs exept for the placing of the hardcore.(See the placing of hardcore for the box spring)
2. If the "eyes" are located in a flat terrain,than a protection box have to be build. The location and number of "eyes" will determine the size of the spring box. Annex 13

If a spring box has to be build you have to locate all the "eyes" and include them into the box. If there are a few "eyes" with sufficient yield than a small box can be made but if there are many small "eyes" who together give a sufficient yield than a larger box have to be build. In both cases the ground around the "eyes" has to be cleared. Put stakes where you want to build the box,that is the 4 walls. Start with the front wall. Dig a channel 30cm wide and 10cm deep into the impervious layer at the front side of the box the length of the front wall. Do **not** penetrate the impervious layer. Use timber or any suitable material to make the"mould"for the foundation. Determine the size or numbers of drain pipes to be used. Divert the water from the place where you are going to construct the front foundation. The foundation have to be 30x30cm x the width of the box. The drainpipe(s) have to be placed in this foundation. Fill the"mould"with concrete 1:2:4 and stamp the concrete into the ground to make a good seal. This foundation has to be completed in one operation. The concrete must be placed within 5 minutes of mixing and left undisturbed for at least 12 hours. After the foundation has set divert all the water of the spring into the drainpipe(s) and proceed to make the other 3 foundations using the same proceedure. When the foundation has set proceed to build the 4 retaining walls with bricks using mortar 1:3 and no more than 2cm between the courses of brick. Use wet plyable mortar. **Wet the bricks before use.** The first layer of bricks on top of the foundation is critical and no sharp corners should be made at the bottom of the bricks, that is between the first course and the foundation. Annex 09

Place the delivery pipe(s) in the front wall. The water from artesian springs will rise so you are able to put the delivery pipe(s) at the required height. Plaster the inside of the box with a mixture of 1:2 to make it water tight. Put clay at the bottom of the box where the foundation is on the ground up to the first course of bricks. Annex 14

If the box is small you can cover the box with concrete slabs. If the box is large place hardcore around the "eyes" and build the box full with hardcore but be careful not to cover the "eyes" and leave room for the water to reach the delivery pipe(s). Cover the box with clay and soil the same as with the gravity springs. (Annex 15) The platform, steps (when steps are needed), side wall(s) and wingwall are made in the same way as with gravity springs. Annex 11

Be sure there is sufficient drainage.

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5. Finishing the Protection

1. Put a large amount of clay at the corners where the retaining wall joints into the spring walls. Also put clay all around the catchment area walls to prevent any leakage. Put clay at the base of the retaining wall where the foundation is inbedded in the ground. The more clay you use the longer the spring will last !. Annex 16
2. In a spring where you have installed a drain pipe insert the overflow pipe first and let the water rise to look if there are any leaks before you place the hardcore.
3. Fill the catchment area (water collection area) between the "eyes" and the retaining wall with hardcore. Large stones should be used to the height just above the delivery pipe(s). Care should be taken not to block or damage the delivery pipe(s). If a drainpipe is present leave room to insert the overflow pipe. In case of an artesian spring place the hardcore as described in Annex 13. On top of the large stones place smaller stones and finish the top evenly with small pieces of hardcore. Remember fill the catchment area with the hardcore to a height 4cm above the delivery pipe(s) **only**.
   On top of this place a layer of clay 15cm thick. Be sure the clay covers the whole catchment area from back to front and from side to side.
   Put a small "hill" of ordinary soil on top of the clay layer to cover the whole catchment area. Rain water should not penetrate this layer of soil but should run off to the sides as not to damage the layer of clay.
4. A catchment drain has to be made all around the spring to avoid any rain of entering the catchment area.
5. A hedge around the catchment area and grass (flowers) on top of the soil ("hill") have to be planted to finish the catchment area using local materials.
6. The access roads (paths) to the spring and all the surrounding areas have to be cleared of any obstacles (brushes, stones, long grass. etc.)
7. The drainage channel has to be cleared and if possible dug out to improve on the drainage.
8. A fence has to made around the spring site in order to protect it from small children and animals.
9. Remove all the traces of the construction work at the site around the spring in order to blend the spring with the surroundings. In short clean the site and make it a good looking spring the community can be proud of.

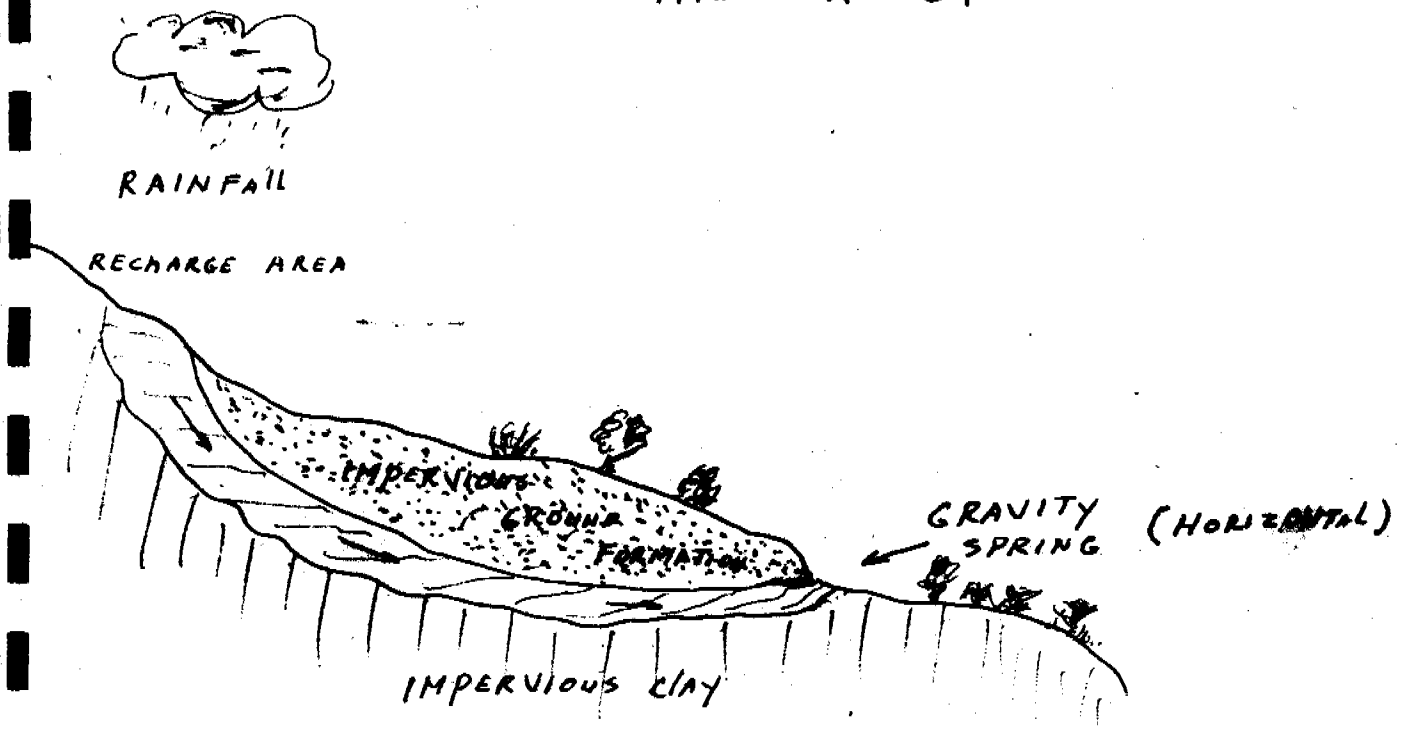
6. Summary

By following this working paper you should be able to protect a gravity or an artesian spring. Make sure to indentify the type of spring you are going to protect. Before you decide to protect a spring read carefully the five factors of basic considerations. Use cement economicly. Use the mixure and the amount as described in Annex 17.
Remember clay is cheap and use it in large amounts to protect a spring. In the construction of the masonry work all corners and edges have to be rounded.
The springwater, which comes out of a clay ground formation, can as a rule be raised to the required height. With springwater which comes from a soil or a sand ground formation you have to be careful to raise the springwater. Do not loose the Spring.To protect a spring follow the guide lines described. Keep in mind that they are guide lines and you have to use your own good judgement for every spring you protect. All the springs are not alike and you might have to deviate from the above guide lines. Annex 17 will give you the amount of cement to use for every operation in protecting a spring.

Explanation of terms used in this paper.

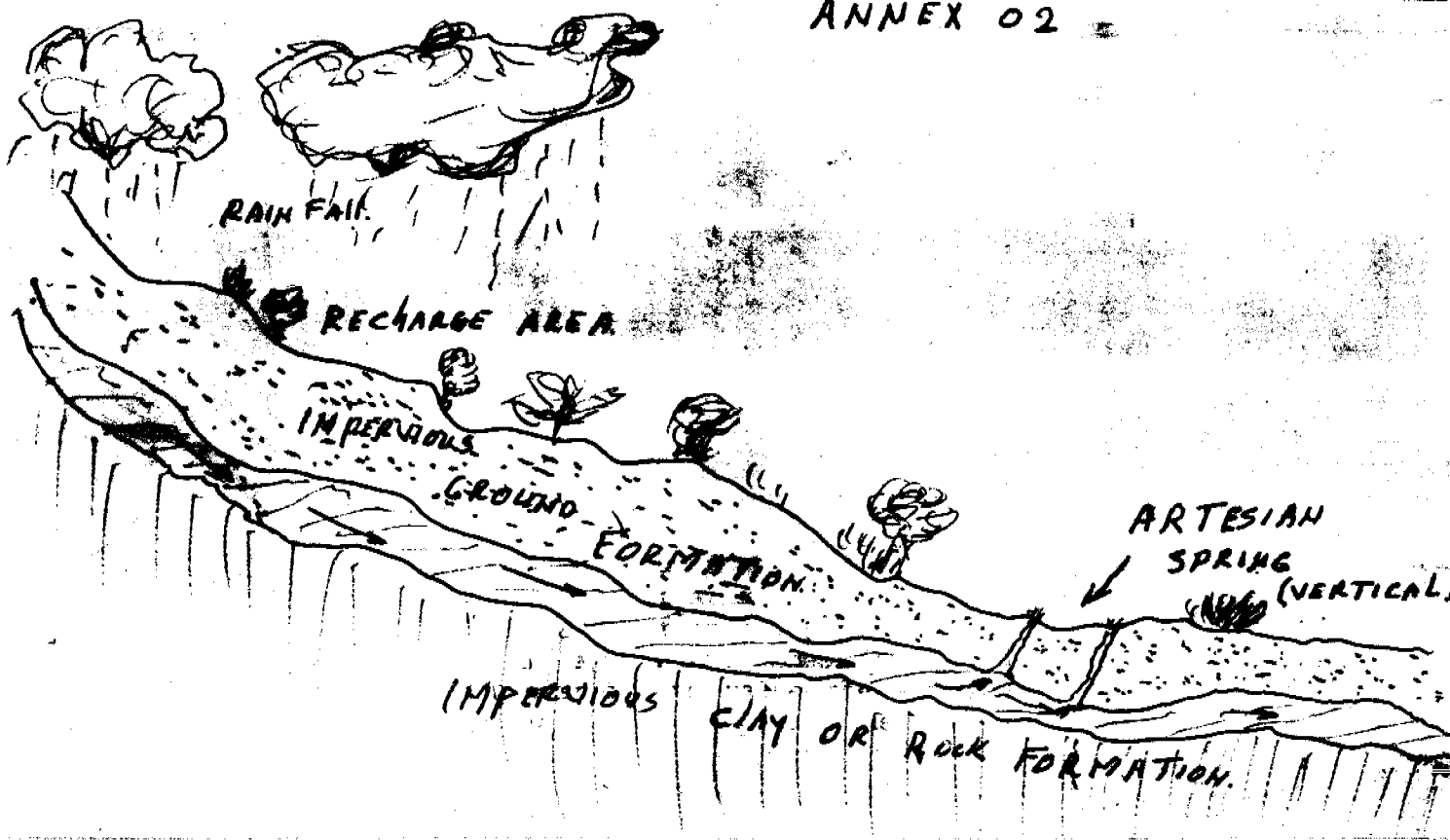
Spring "eye"	=	Water outflow opening from the ground.
Catchment area	=	Area between the spring "eye" and retaining wall.
Impervious layer	=	Ground layer not allowing the passage of water.
Abutment	=	Point of junction between a structure and the sides.
Mould	=	A guide to bring the concrete into required shape.
Plyable (Pliable)	=	Yielding, supple, easy to shape, soft.
Delivery pipe	=	Delivers the spring water from the catchment area.
Drainpipe	=	Pipe to drain the spring water from the catchment area.
Platform	=	Floor in front of the retaining wall.
Retaining wall	=	Wall to retain the spring water. (catchment area)
Hard core	=	Firm not yielding soft rock-ground formation which can be made into the required shape needed.
Spring protection	=	Protect the water from contamination from outside source
Catchment drain	=	Rainwater drain around the spring catchment area.
Loose a spring	=	When the springwater stops to come out of the ground where the spring has been protected.
Diversion	=	To guide the spring water in another direction.
Deviate	=	Turn aside, other way, to do in a different way.

ANNEX 01



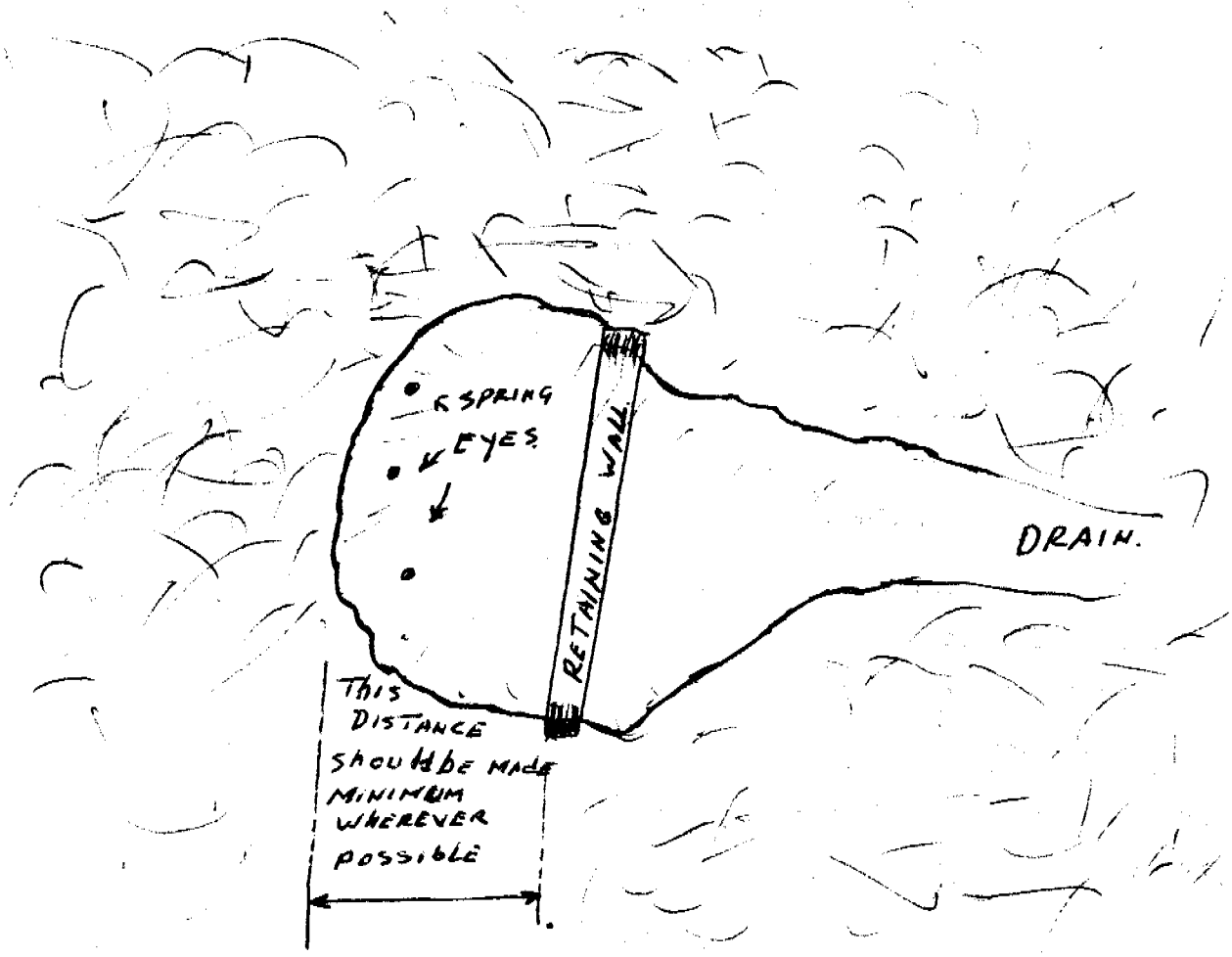
SIDE VIEW

ANNEX 02



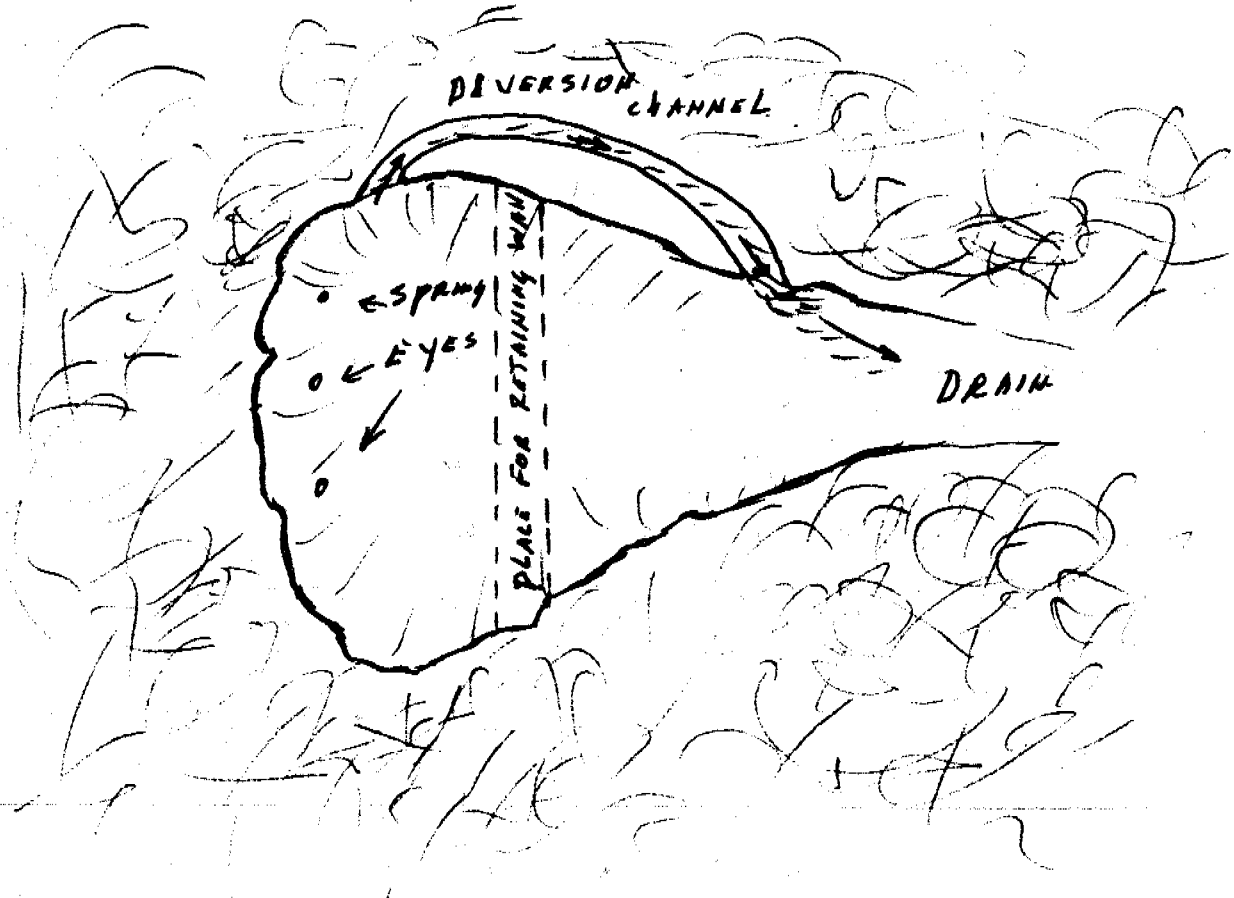
SIDE VIEW.

ANNEX 03



TOP VIEW

ANNEX 04

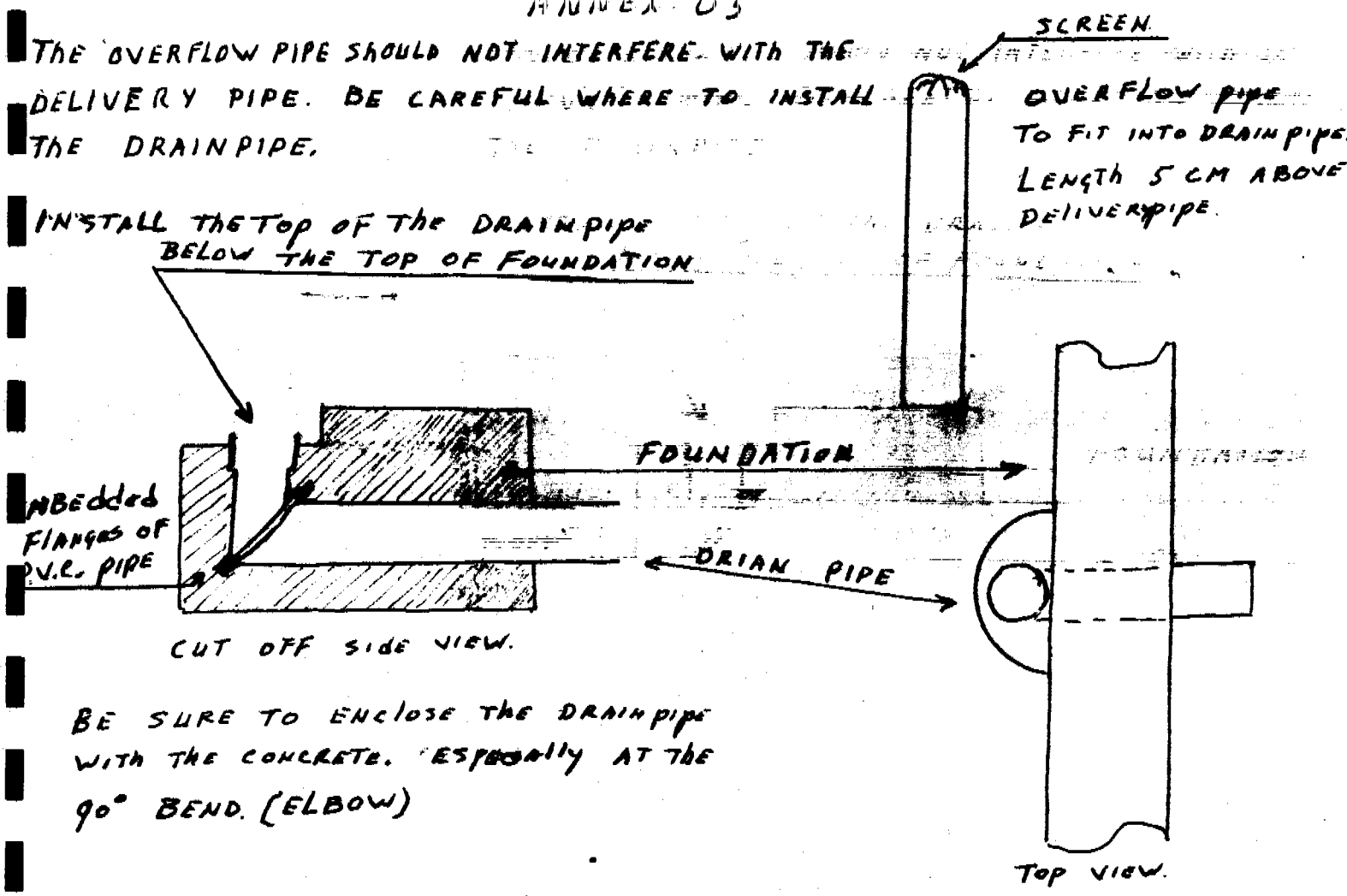


TOP VIEW

ANNEX 05

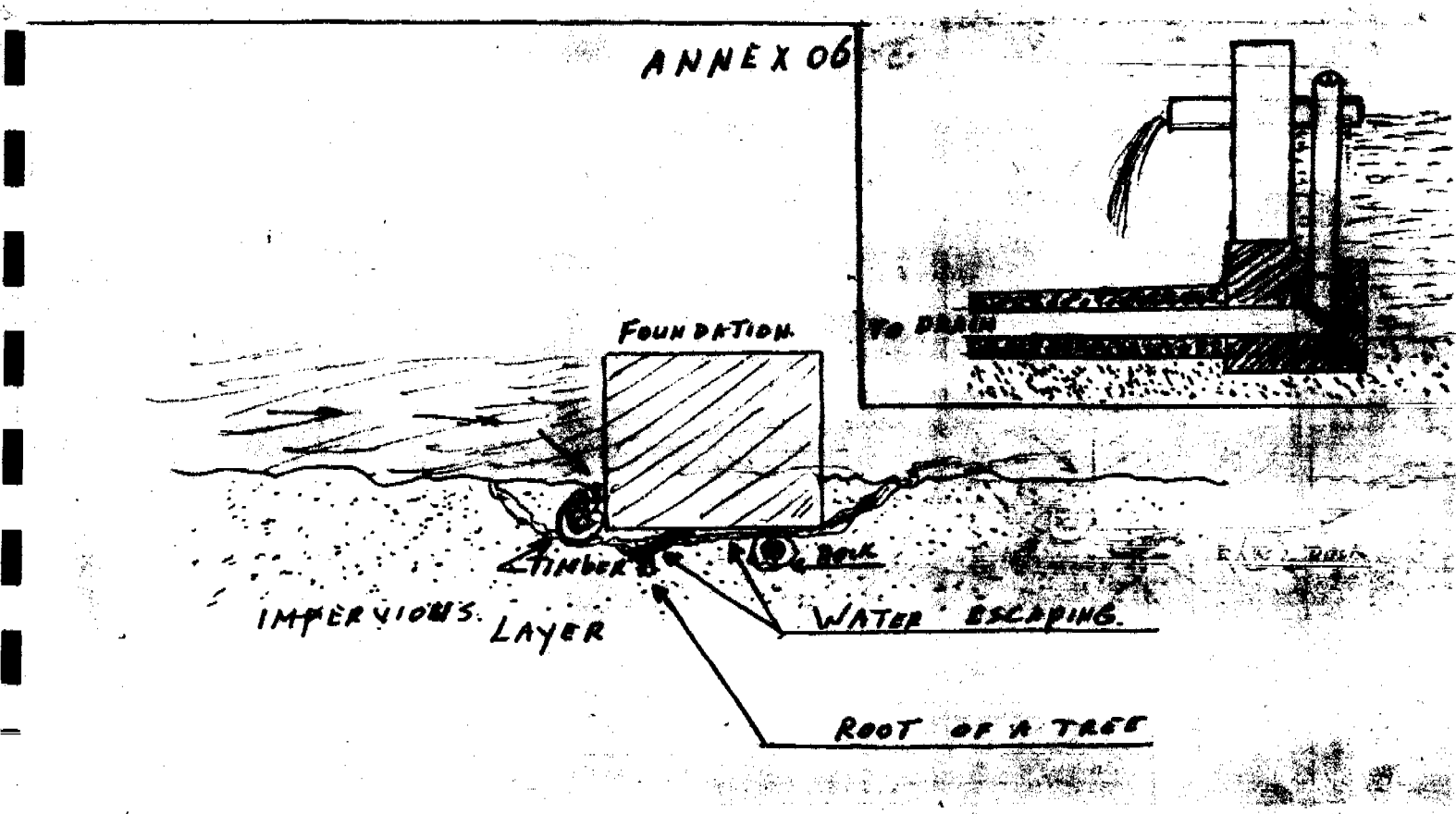
THE OVERFLOW PIPE SHOULD NOT INTERFERE WITH THE DELIVERY PIPE. BE CAREFUL WHERE TO INSTALL THE DRAINPIPE.

INSTALL THE TOP OF THE DRAINPIPE BELOW THE TOP OF FOUNDATION



BE SURE TO ENCLOSE THE DRAINPIPE WITH THE CONCRETE. ESPECIALLY AT THE 90° BEND. (ELBOW)

ANNEX 06

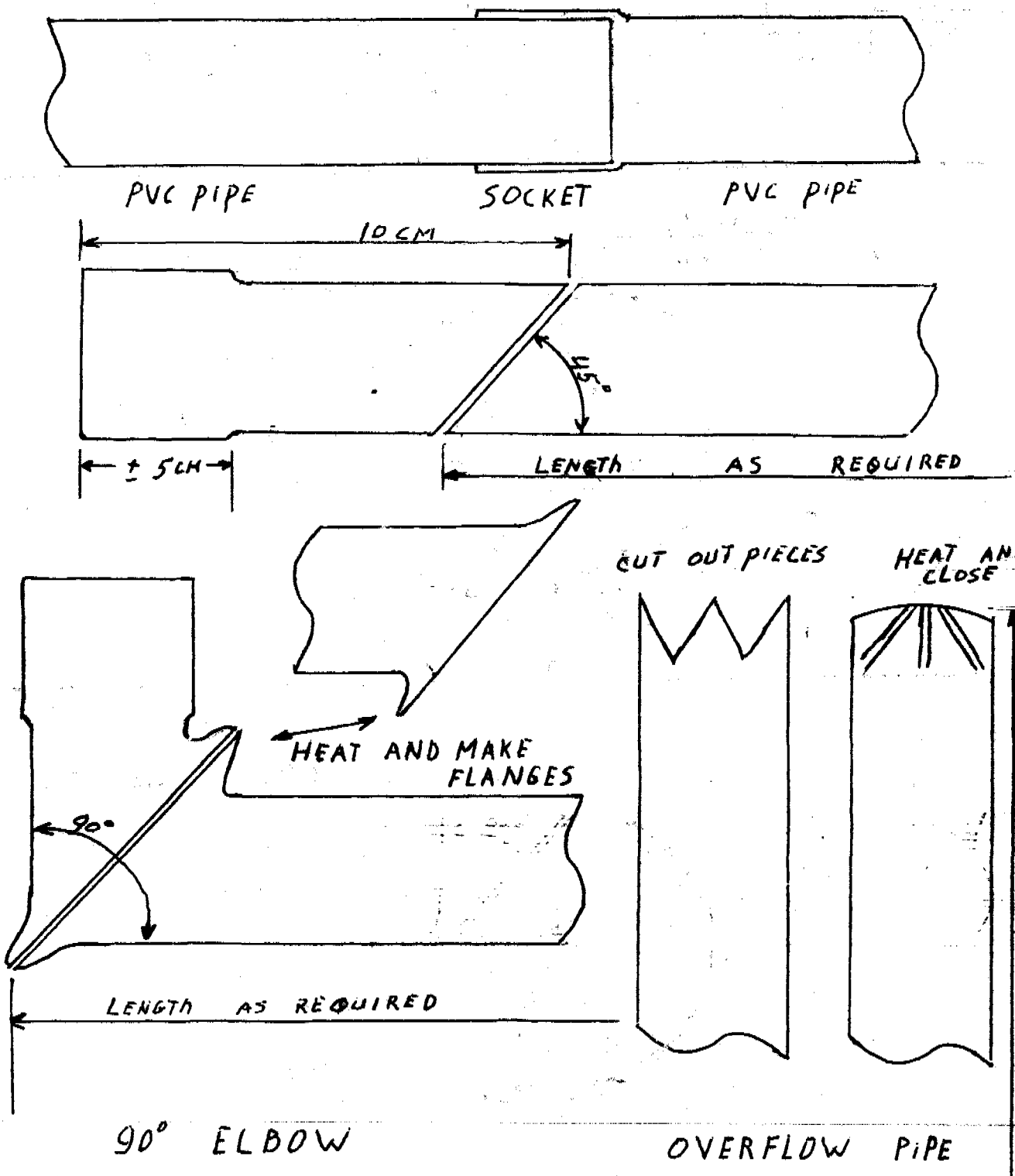


SIDE VIEW

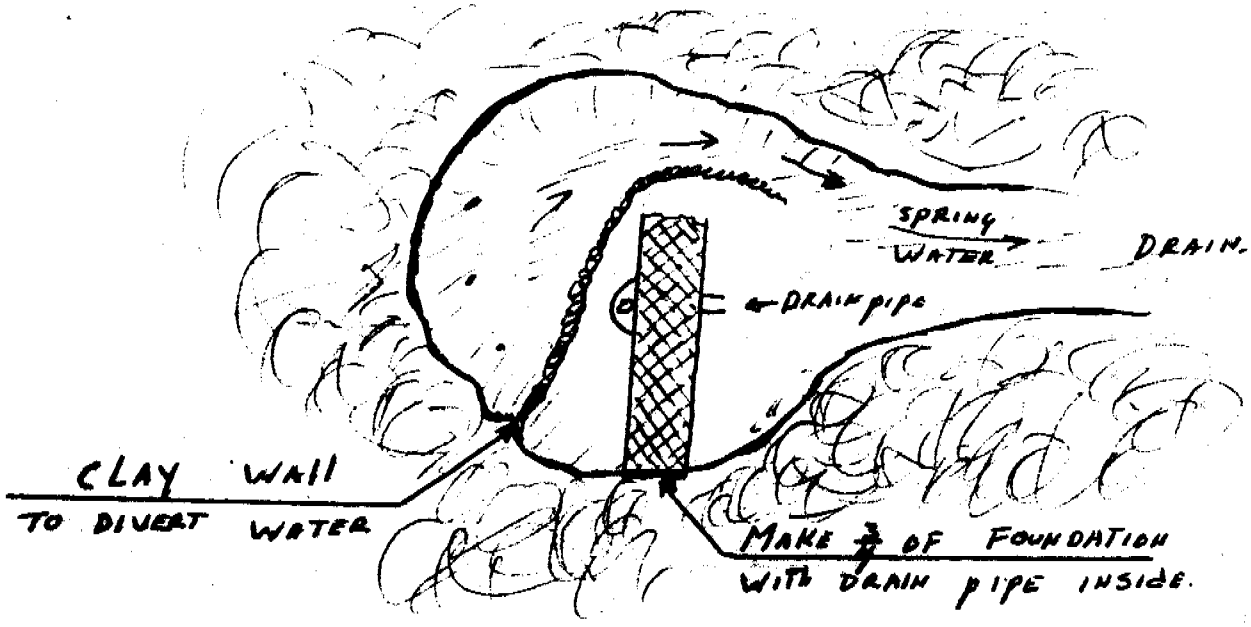
How to make a PVC Drainpipe

Take two pieces of PVC pipe of the same diameter. Heat the end of one of the pipes above an open flame and when it becomes soft and plyable force the end of the other pipe into the heated pipe to make a socket. Separate the two pipes when they are cool. Now cut the pipe with the socket at a 45° angle 10cm long. (look at the sketch). Heat both ends at the 45° cut off angle and make a flange. Put the two pieces of pipe together at the flanges to make a 90° elbow. Tape the two pipes together with any kind of tape. When the elbow is embedded in the concrete it will be water tight. It is important to make large flanges so the pipe is firmly embedded in the concrete.
For the overflow pipe, cut pieces out of the end of the pipe heat and bend over to make a screen.

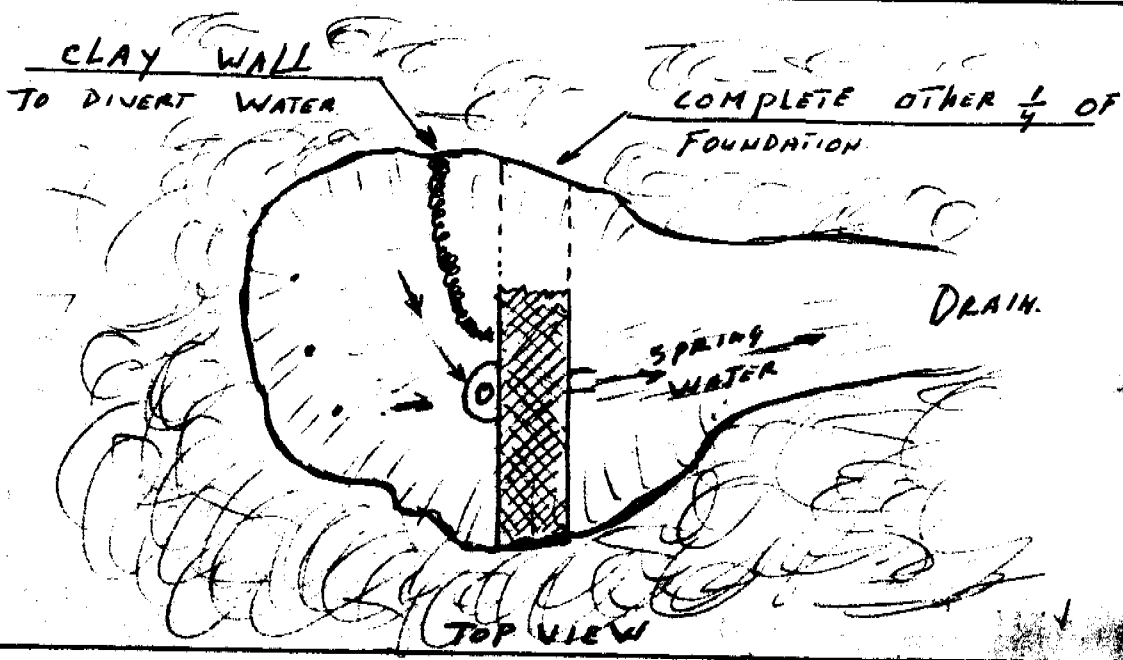
Annex 05

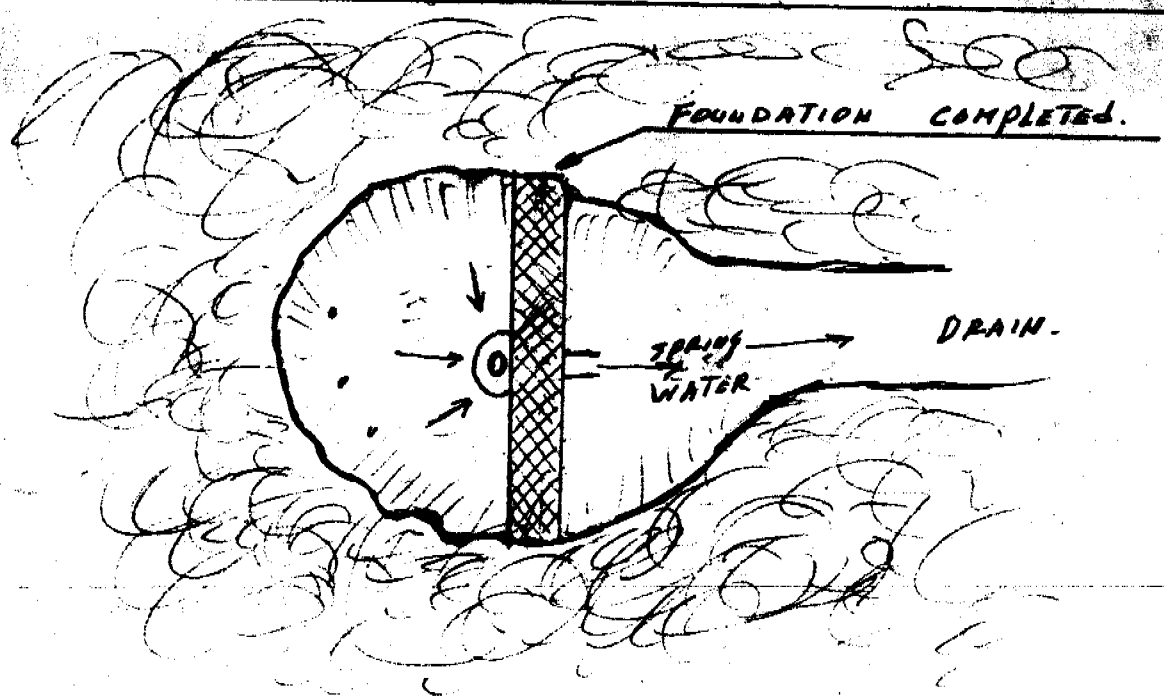


ANNEX 2/A



TOP VIEW

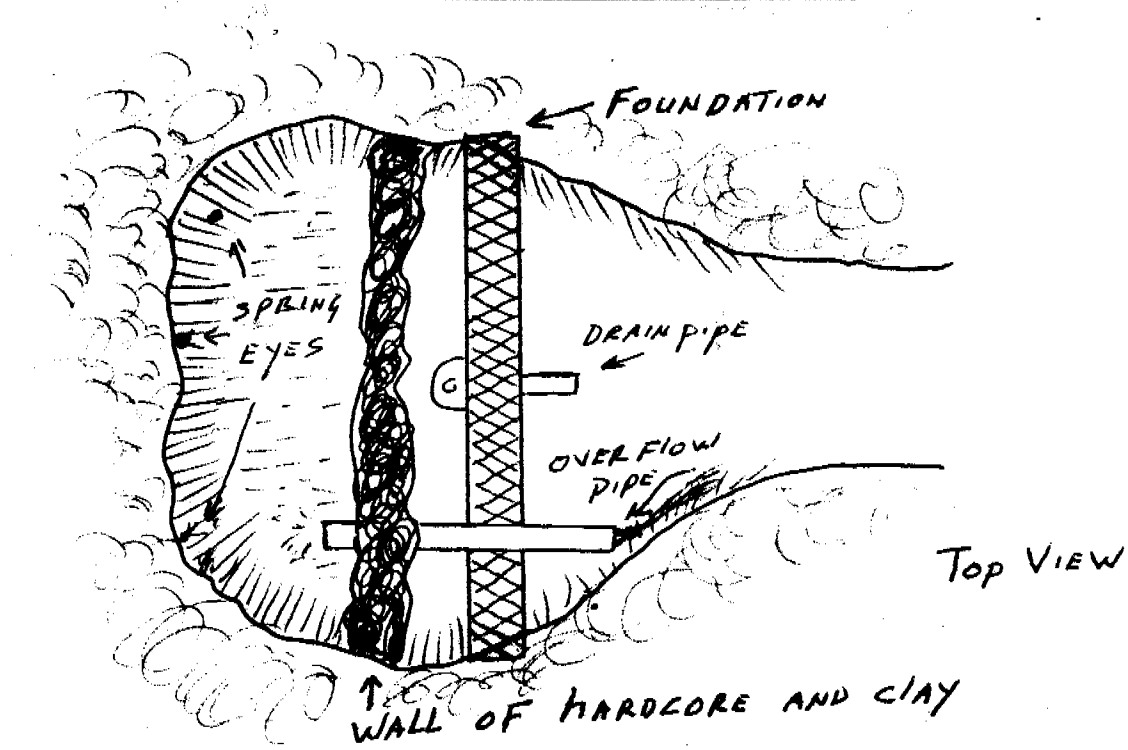


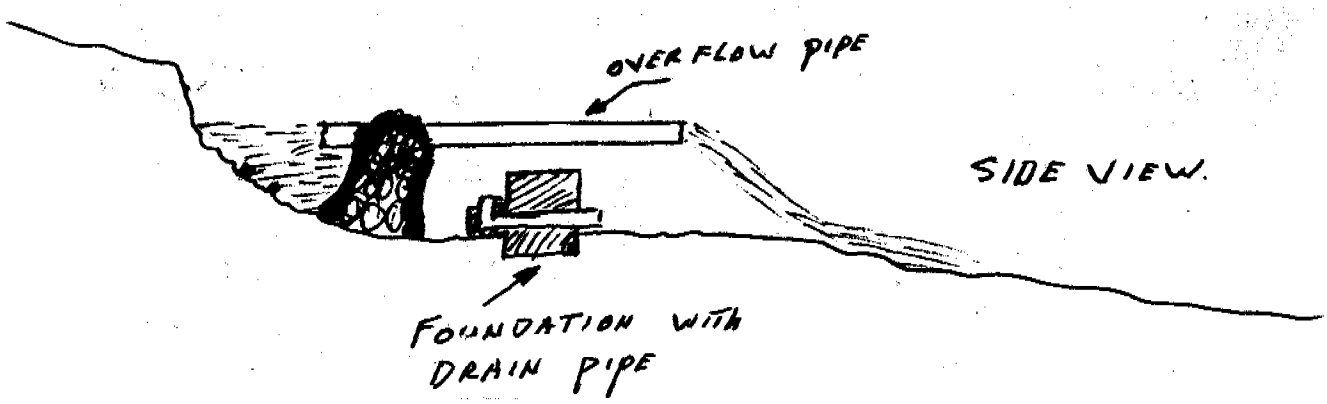


TOP VIEW

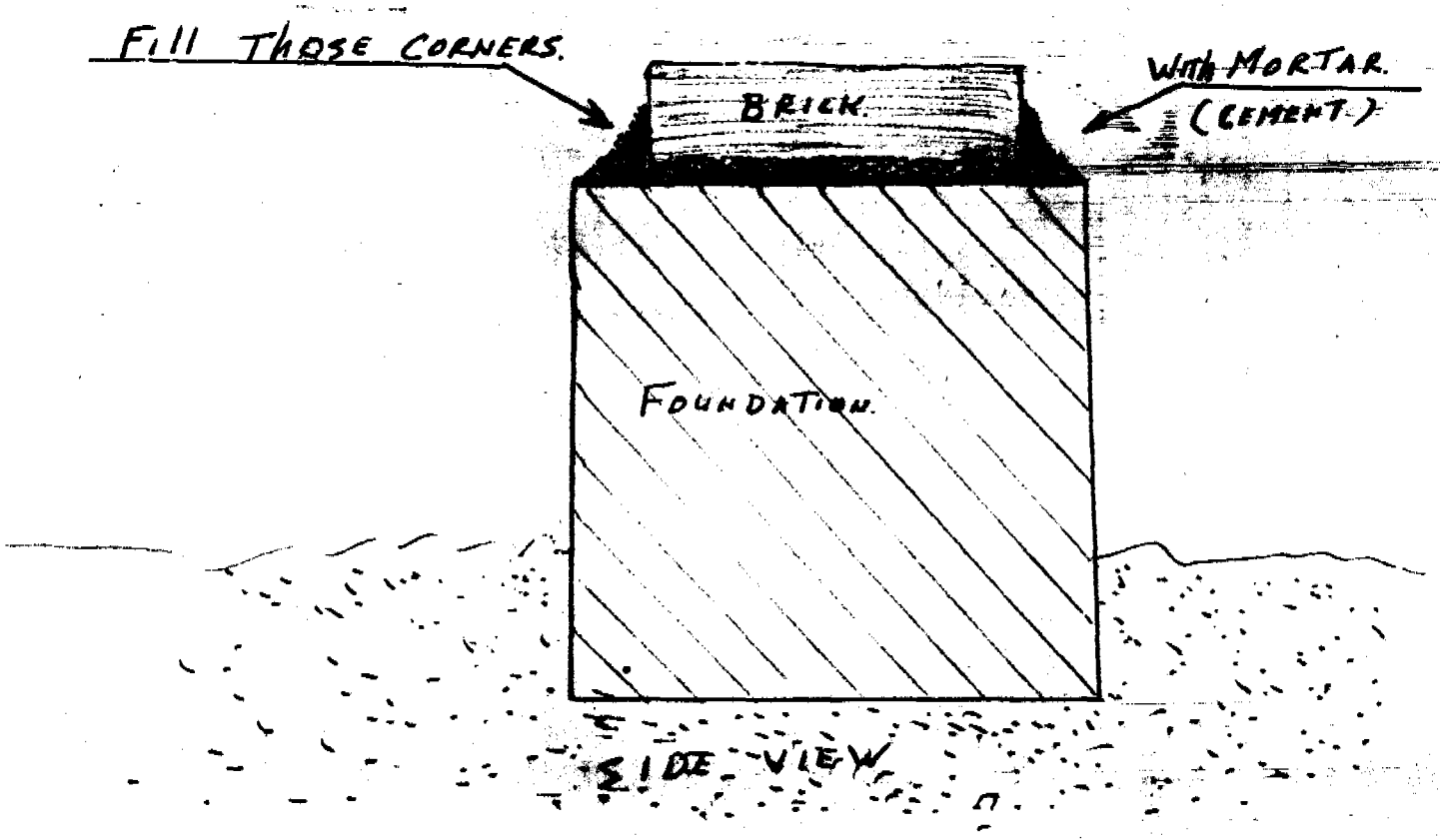
ANNEX 08/B

To construct the foundation in one operation make a wall of hardcore and clay. Insert an overflow pipe into the wall at a height of ±30cm from the ground floor. Now you are able to construct the foundation,including the drainpipe(s) in one operation while the springwater is flowing through the overflow pipe above the place where you make the foundation as shown.



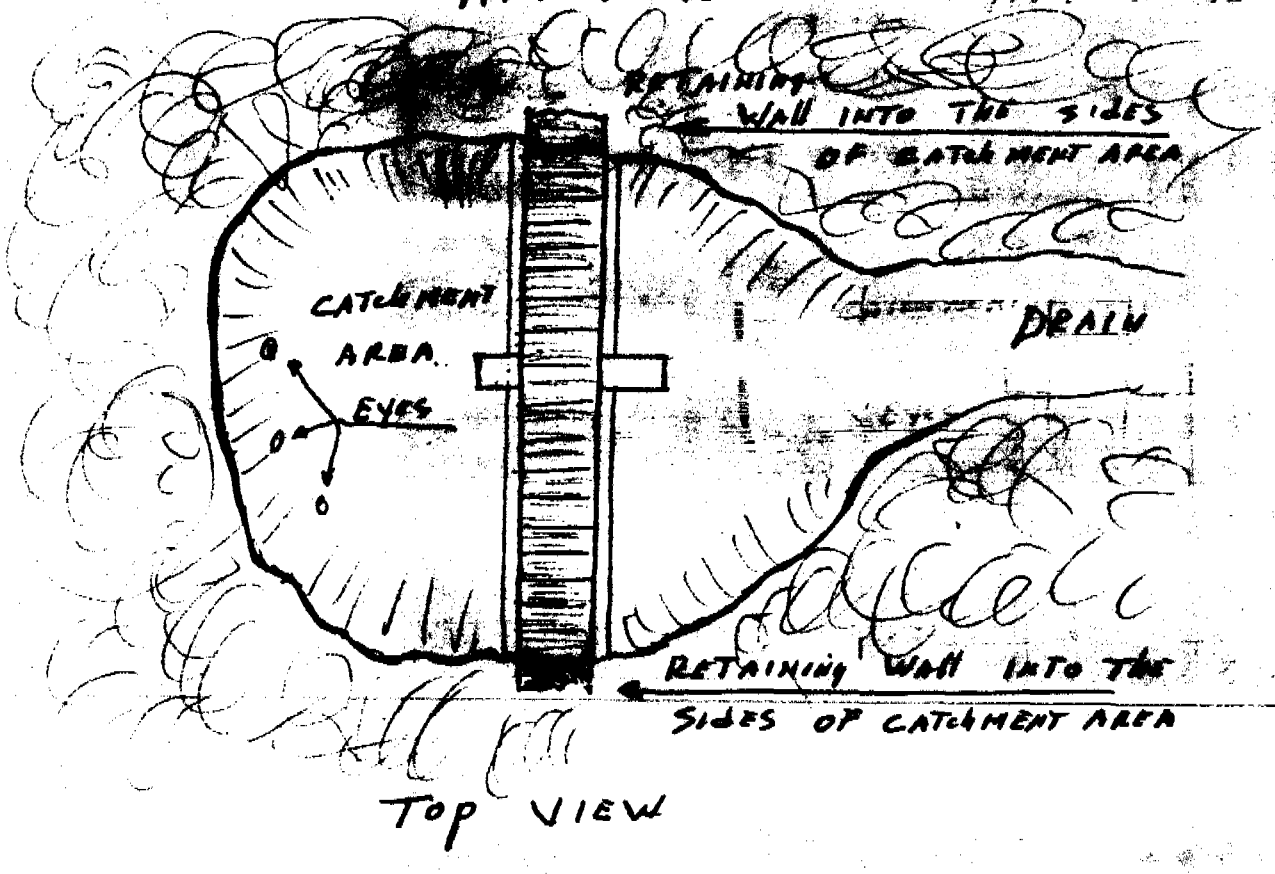


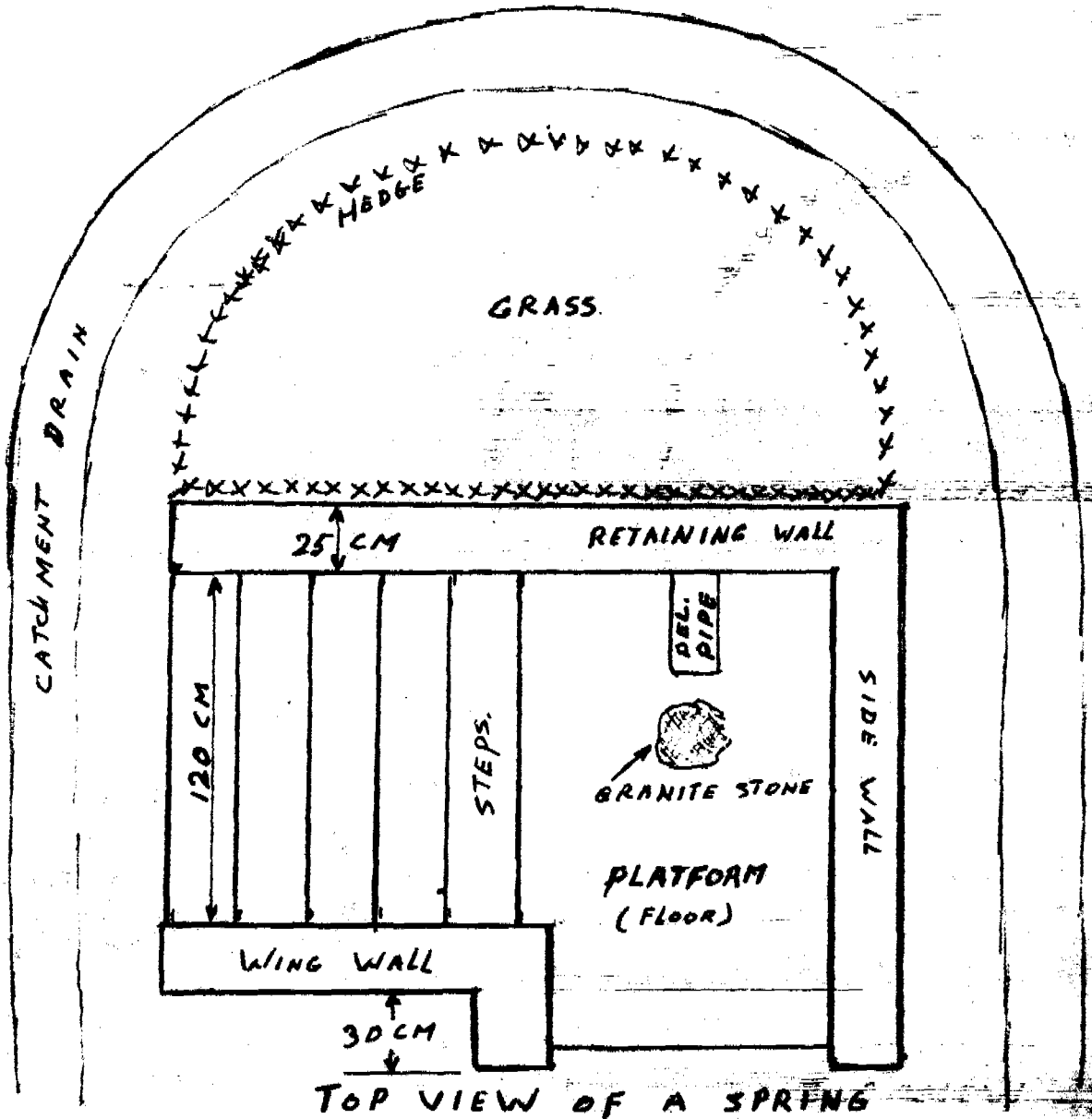
ANNEX 09



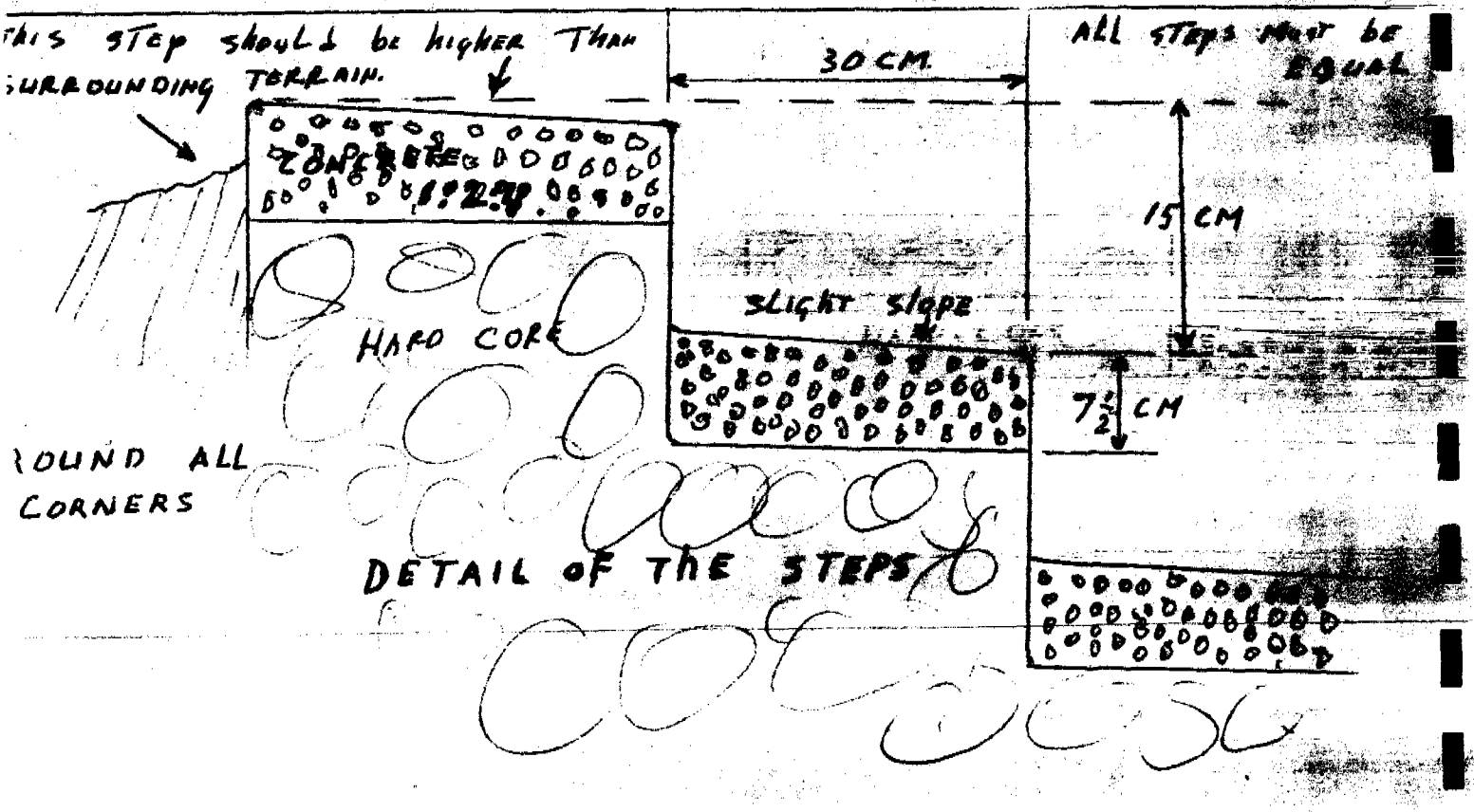
ANNEX 10

ANNEX 10



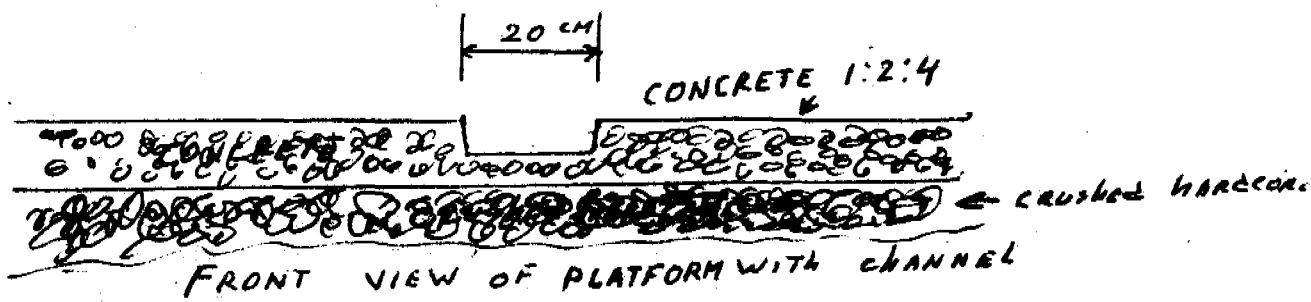


TOP VIEW OF A SPRING



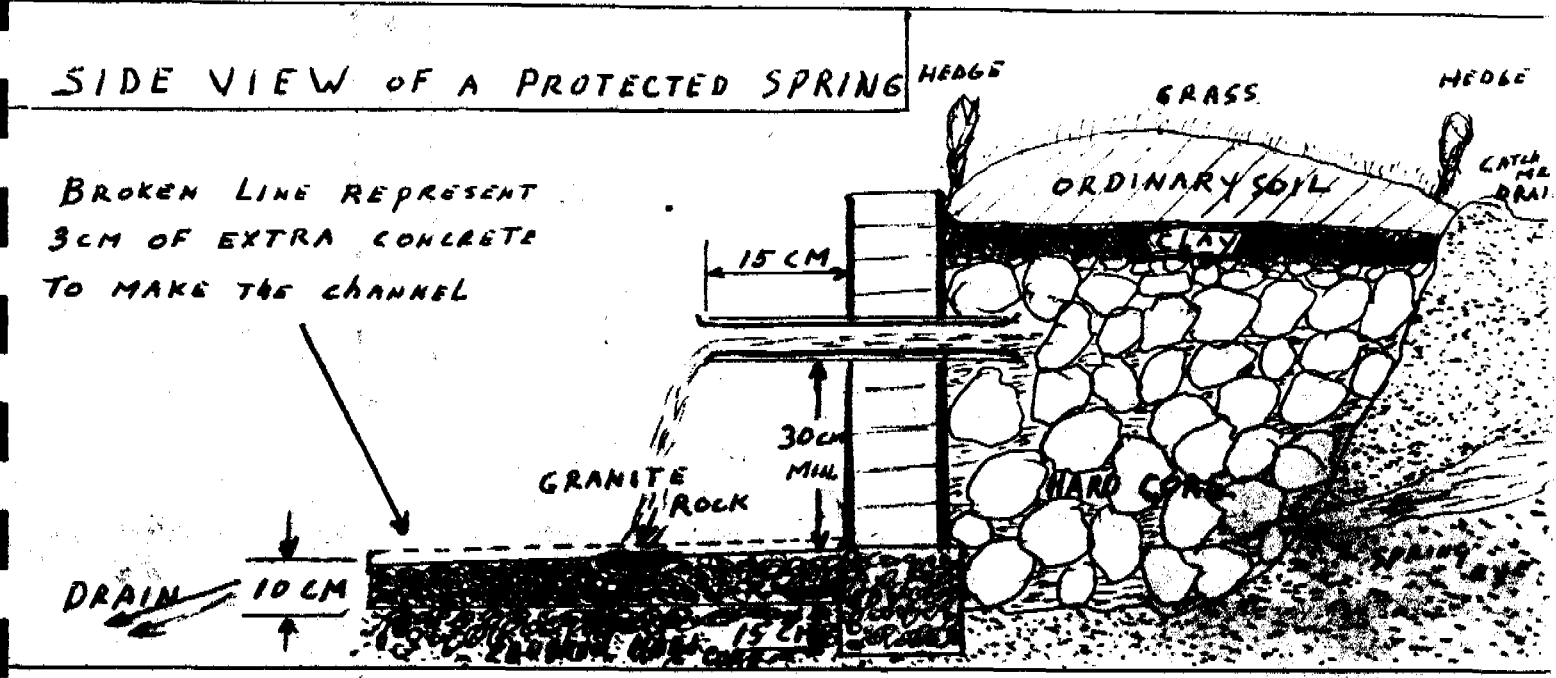
DETAIL OF THE STEPS

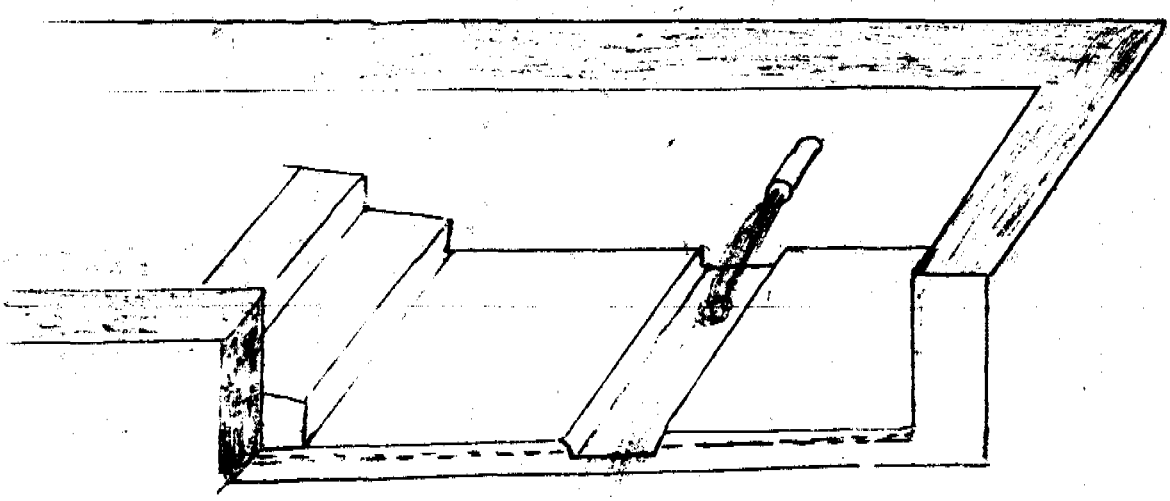
ANNEX 12



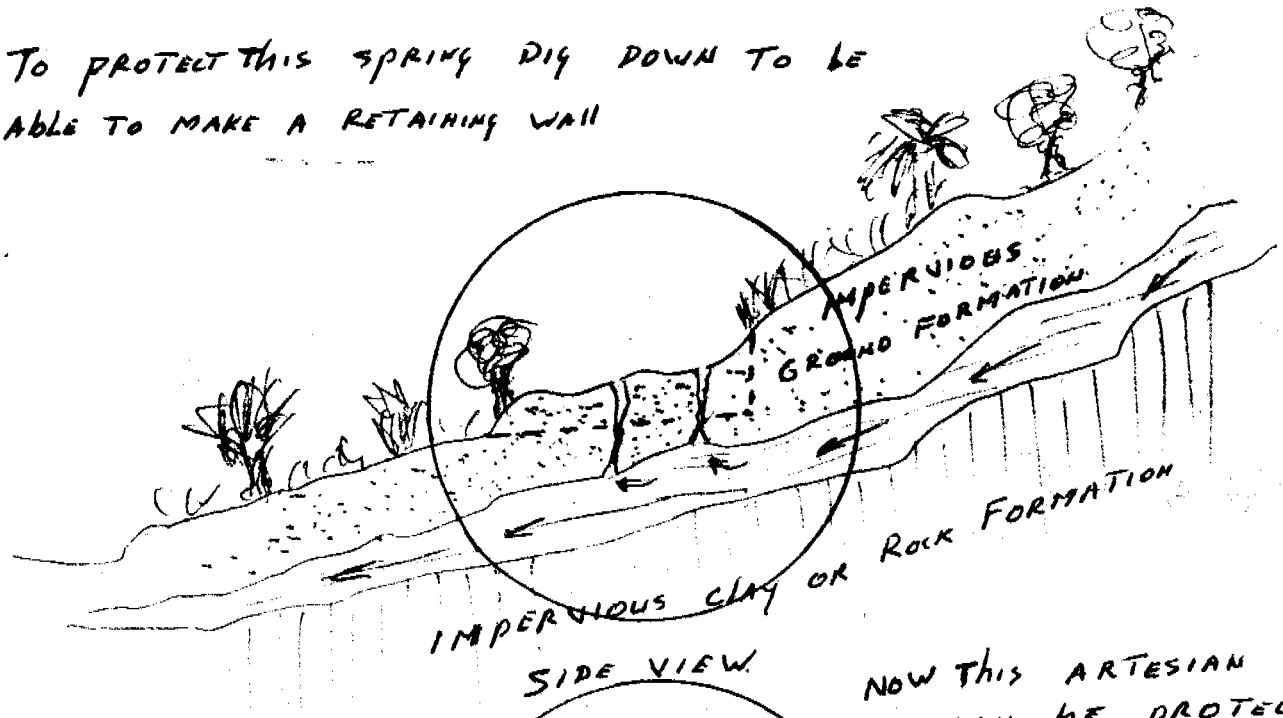
FRONT VIEW OF PLATFORM WITH CHANNEL

SIDE VIEW OF A PROTECTED SPRING



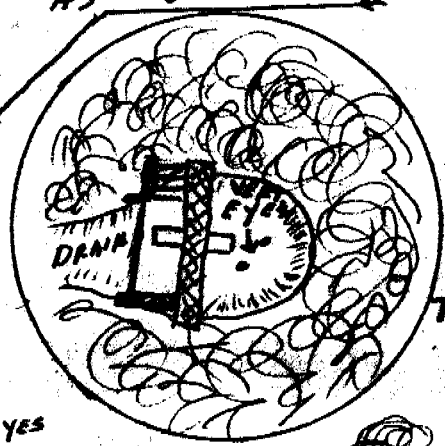


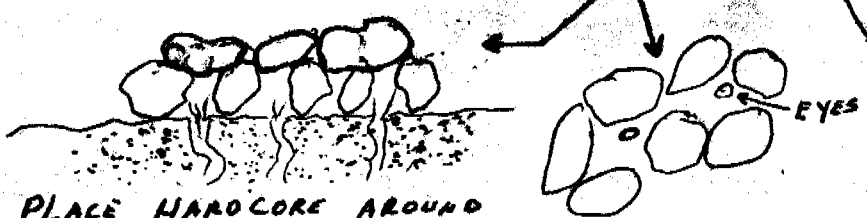
To protect this spring dig down to be able to make a retaining wall



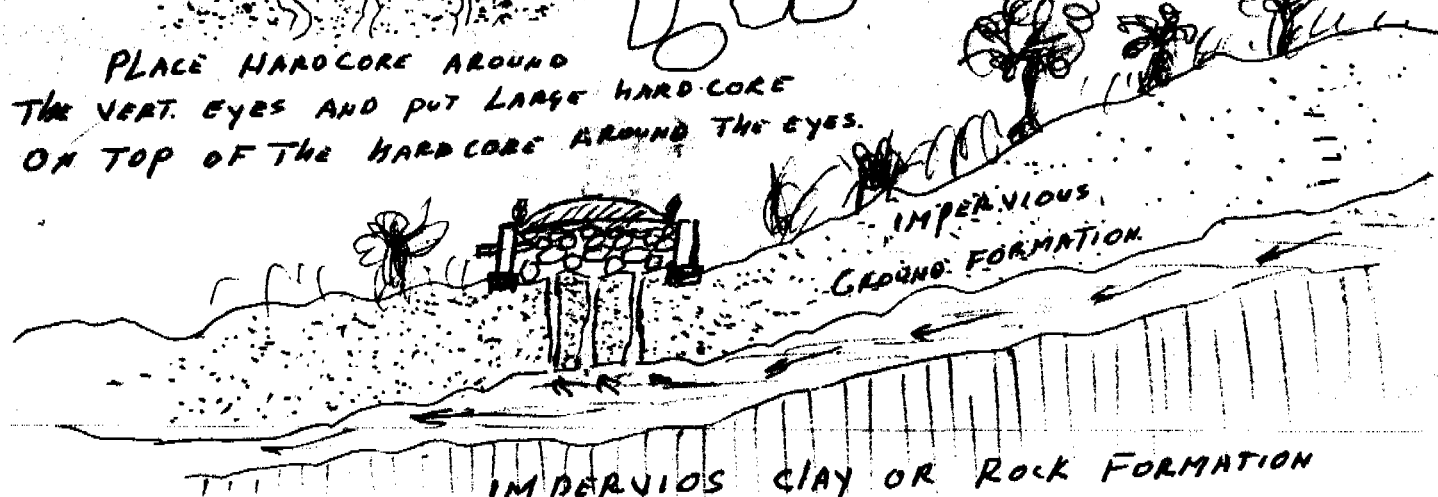
SIDE VIEW

Now this artesian spring can be protected the same as a gravity spring but place the hard core as below (follow arrow)





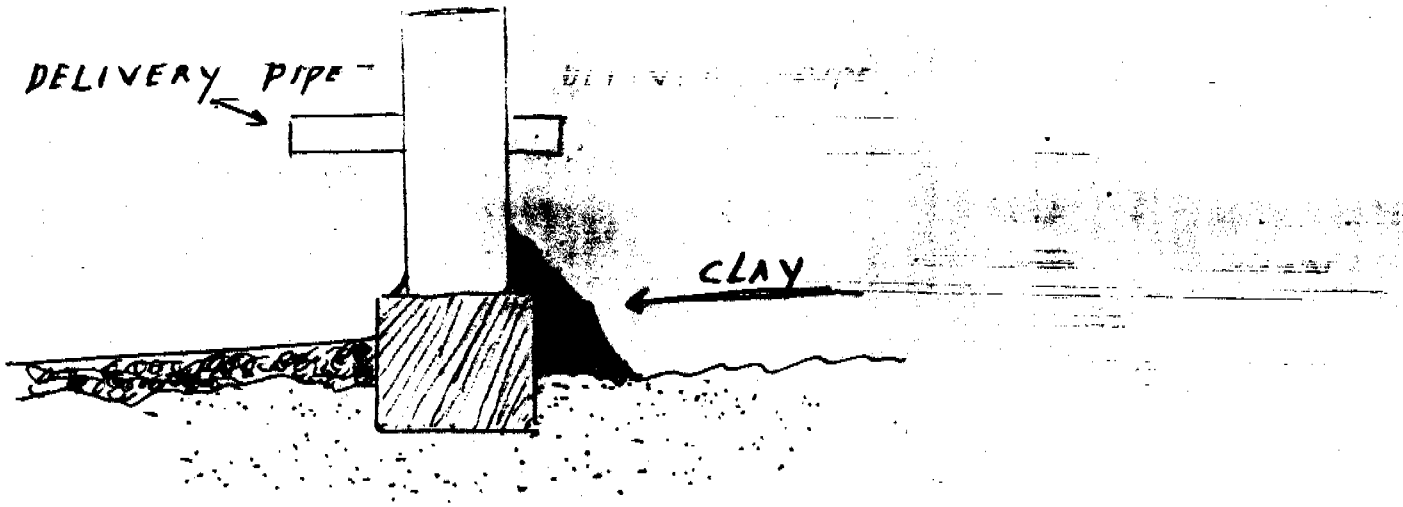
Place hardcore around the vert. eyes and put large hard core on top of the hard core around the eyes.



This spring has to be protected with a springe

The drainage could be a problem with a springbox

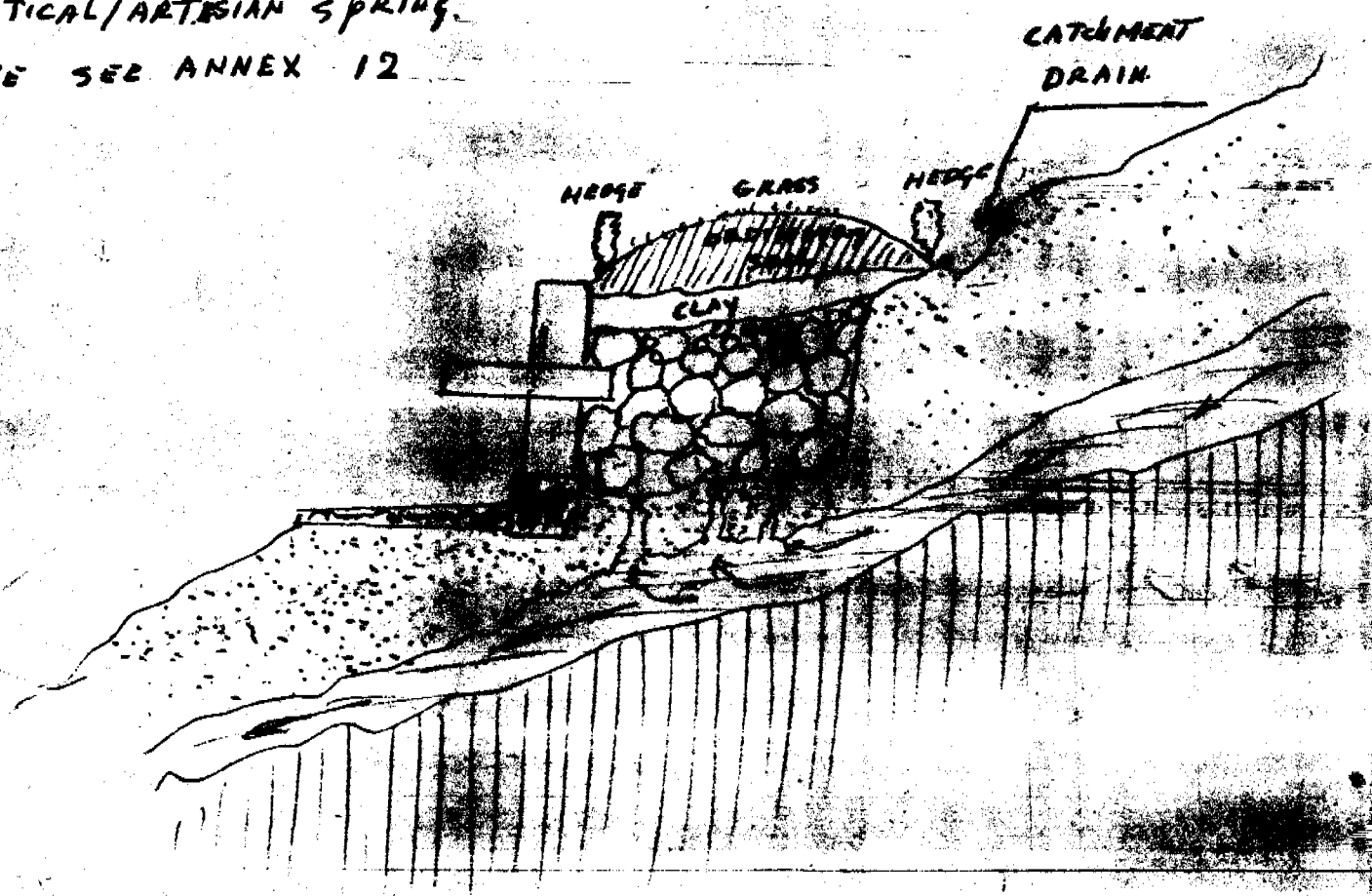
ANNEX 14



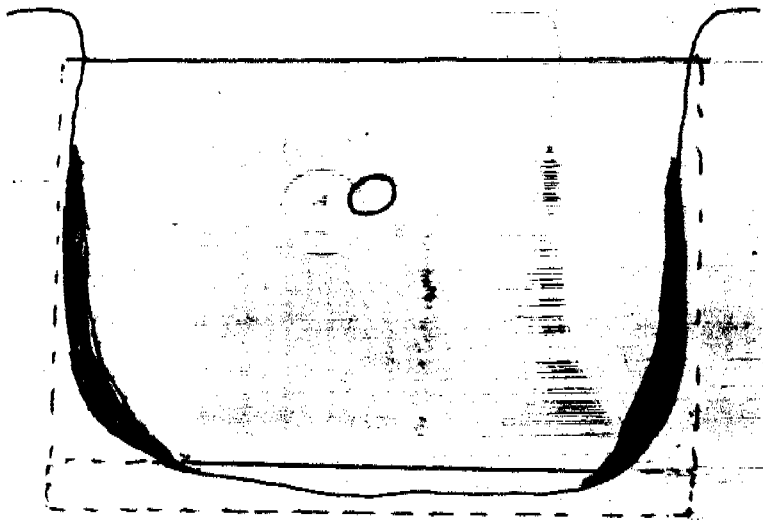
ANNEX 15

SIDE VIEW OF A PROTECTED VERTICAL/ARTESIAN SPRING.

NOTE SEE ANNEX 12



(1)



PUT THE CLAY TO THE HEIGHT OF THE DELIVERY PIPE BOTH FOR GRAVITY AND ARTESIAN SPRING

VIEW FROM THE BACK.

FOR A GRAVITY SPRING PUT CLAY AS SHOWN TO THE RETAINING WALL INCLUDING FOUNDATION

(2)

FOR A SPRING BOX PUT CLAY AS SHOWN TO ALL 4 WALLS AND FOUNDATION

BE CAREFUL NOT TO COVER THE EYES OF THE GRAVITY SPRING

EYES OF ARTESIAN SPRING

SIDE VIEW

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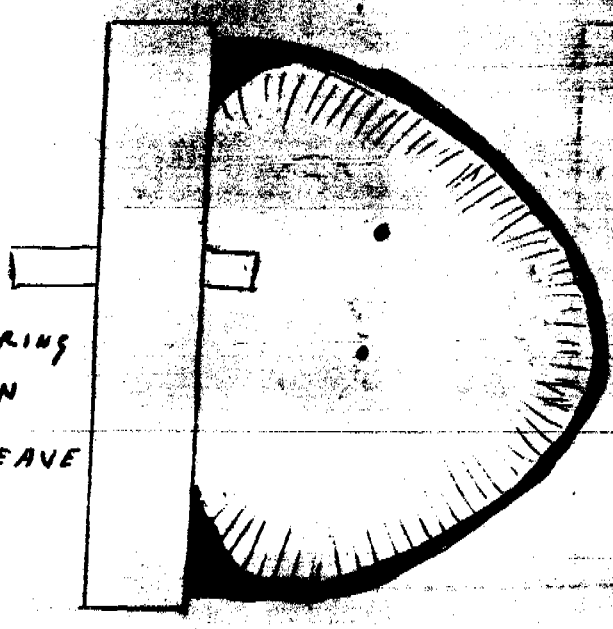
(3)

FOR A GRAVITY SPRING PUT CLAY AS SHOWN ALL AROUND BUT LEAVE EYES EXPOSED



FOR AN ARTESIAN SPRING PUT CLAY INSIDE FROM HEIGHT OF DELIVERY PIPE TO THE BOTTOM

TOP VIEW

Annex 17 Cement Requirements for Springs.

Cement Mix;

Concrete	1:2:4	Cement/Sand/Aggregate
Mortar	1:3	Cement/Sand
Outside Plaster	1:5	Cement/Sand
Inside Plaster	1:2	Cement/Sand

Cement Required;

1 Bag of Cement = 50 kg

Foundation	30^{cm} X 30^{cm} X 1^{M}	Requires	25 kg-* of Cement
Spring Platform	10^{cm} X 1 $^{M^2}$	" "	25 kg " " "
Brick Work	1^{M} of Retaining Wall	" "	37½kg+** " " "
Outside Plaster	1^{M^2} X 2^{cm}	" "	5½ kg-* " " "
Inside Plaster	1^{M^2} X 2^{cm}(Water Proof)	" "	12½kg+** " " "
For each Step	120 X 30 X 7½ cm	" "	8 Kg-* " " "
Side/Wing Wall	1.50 x 1 M	" "	20 KG+** " " "

*- = Little Less. **+ = Little More.

Note: Mortar between layers of bricks should be no more than 2^{cm}.

All corners and edges should be rounded.

35 Bags of Cement = 1^{M^3}

1^{M^3} of Concrete	Requires	5	Bags of Cement.
" of Mortar	" "	9	" " "
" of Outside Plaster	" "	6	" " "
" of Inside Plaster	" "	11½	" " "

SPRING PROTECTION

Notes

Read the Technical guide of how to protect a spring before you start the protection of a spring and discuss process with the community.

1-Together with the community make a plan for the spring. Determine how much local materials are needed according to the plan.

2-Annex 17 will let you know how much cement is required for the spring.

3-Each day discuss with the community the work that should be done that day and instruct the community what work is expected of them for that day.

4-Instruct the fundi that the wall has to be watertight, the mortar has to be wet and plyable and use **no** more than **2cm** of mortar between the courses of bricks. (Bricks are cheaper than cement.)

5-As stated in the guide the **first course** of bricks on top of the foundation is critical and should be constructed very carefully. **Follow** ANNEX 09.

6-All concrete to be 1:2:4 Cement/Sand/Aggregate.

7-Mortar for building should be 1:3 Cement/Sand.

8-Plaster for Inside the wall sould be 1:2 Cement/Sand.

9-Plaster for Outside the wall and wing/sidewall should be 1:5 Cement/Sand.

10-All sand to be free of clay and soil.

11-Concrete MUST be placed within 5 minutes of mixing and left undisturbed for at least 12 hours. (Initial setting time)

12-When wall is completed plaster the inside to the height of the delivery pipe but do **not** plaster the outside.

13-After ± 20 Hours insert the overflow pipe and let the water rise in order to check if there are any leaks in the construction.

14-Height of delivery pipe from platform determined by the height of jerrycan.

15-Al steps to have a rise of 15cm and treads of 30cm. This in order to open water source to All members of the community.

16-All treads to have a non-wearing surface of 1:2:4 Concrete. Thickness 7½cm with a slope away from the rise.

17-Last Step from up should be higher than surrounding terain in order to keep storm water off the steps and concrete floor.

18-Rise and Treads Must be Equal.

19-Make steps of hardcore first and place the concrete on top of this.

20-Place crushed hardcore on the ground first where you make the platform.

21-**Do not** plaster the platform or the steps.