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REPUBLIC
MINISTRY OF AGRICULTURE

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NORTH WEST REGION
AGRICULTURAL DEVELOPMENT
PROJECT

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Recd 15/8/82

FEASIBILITY STUDY AND TECHNICAL ASSISTANCE

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IMPLEMENTATION OF 20 ONE HECTARE IRRIGATED FARMS IN JALEELO AND XUNBAWEYNE AREA AND GEED-DEEBLE EXPERIMENTAL FARM

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STUDY OF IRRIGATION NETWORKS

TEXT

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INTRODUCTION

The study was performed according to the specifications set by the terms of reference, which state, page 3: "V. Technical Assistance:

1. Following the completion of the water resources investigations in the North West Region, the Consultants would provide technical assistance to the P.I.U.. (i) to locate, design and supervise construction of the 50 small-scale irrigated farms included in the Project. The work would involve (a) soils investigations; (b) the detailed design of the individual irrigation systems and advice (c) to the farmers on their operation and maintenance.

2. The Consultant would also provide technical assistance.... to the P.I.U. for design, procurement and supervision of construction for the irrigation system to be installed for the Geed Deeble Horticultural Station."

For reasons completely outside the Consultant's control, the water resources investigation has not yet been undertaken. At the request of the P.I.U. an initial group of 20 farms was studied. These are located in the Jaleelo and Xunbaweyne areas where preliminary investigations revealed the existence of unexploited water resources and soils which could be used for irrigation. Even though the characteristics of the wells have not yet been determined with any degree of precision, the Consultant was requested to carry out a topographical survey and study of the irrigation networks. Because of the anticipatory nature of this work, a great many solutions were studied so that subsequent adaptations can be made to deal with any situation which may arise once the wells have been drilled.

Similarly, with regard to the Geed Deeble experimental farm, as it is not known what the yield of the planned borehole will be, the development proposed is such that it may be adapted to meet any circumstances.

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PURPOSE OF THE STUDY

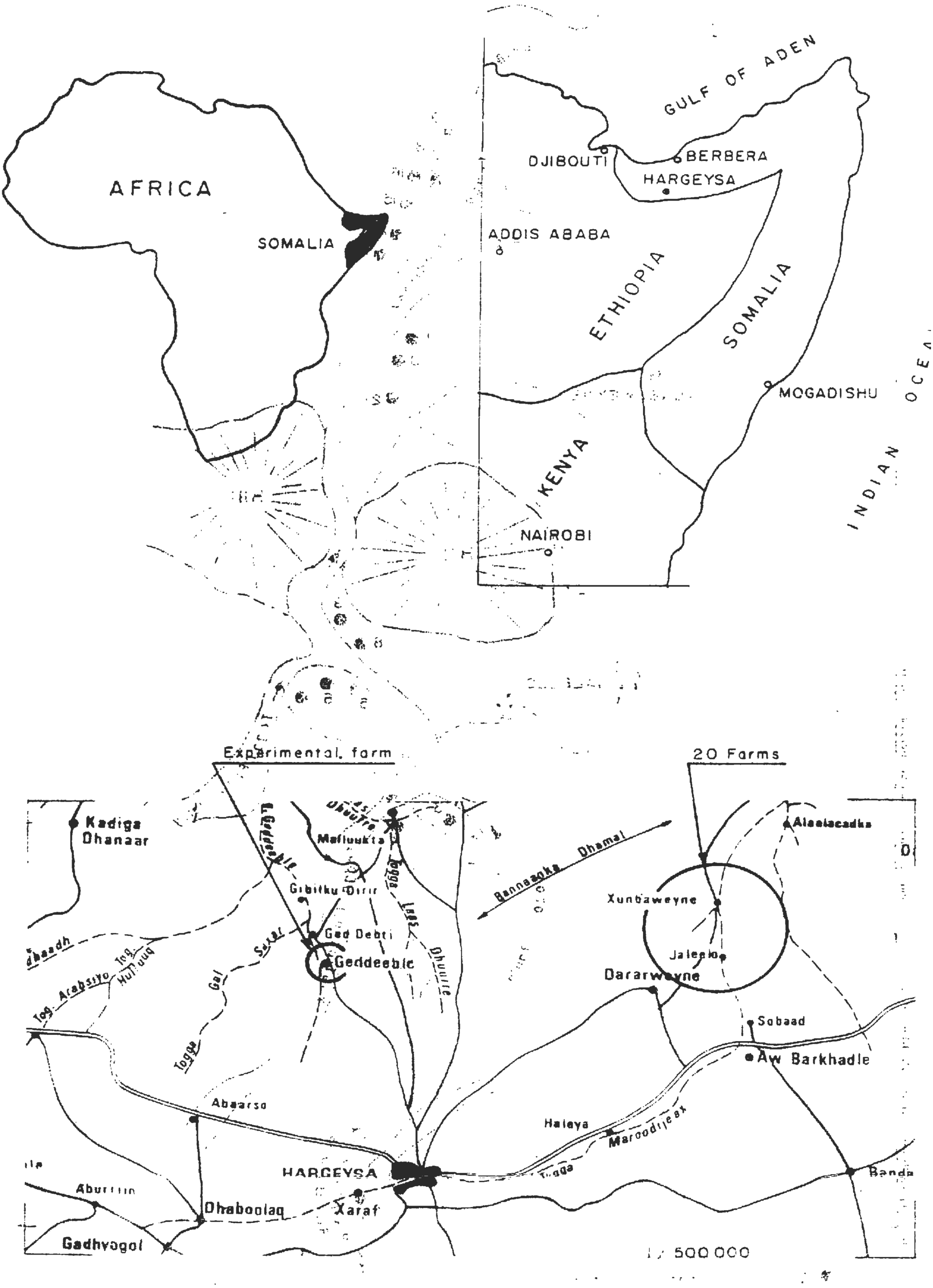
This study was aimed at preparing technical specifications and estimating the investment costs involved for developing irrigation networks on 20 one hectare farms previously selected in the areas of Jaleelo and Xunbaweyne, as well as for the Geed Deeble experimental farm.

It is based on the standards defined in the following documents:

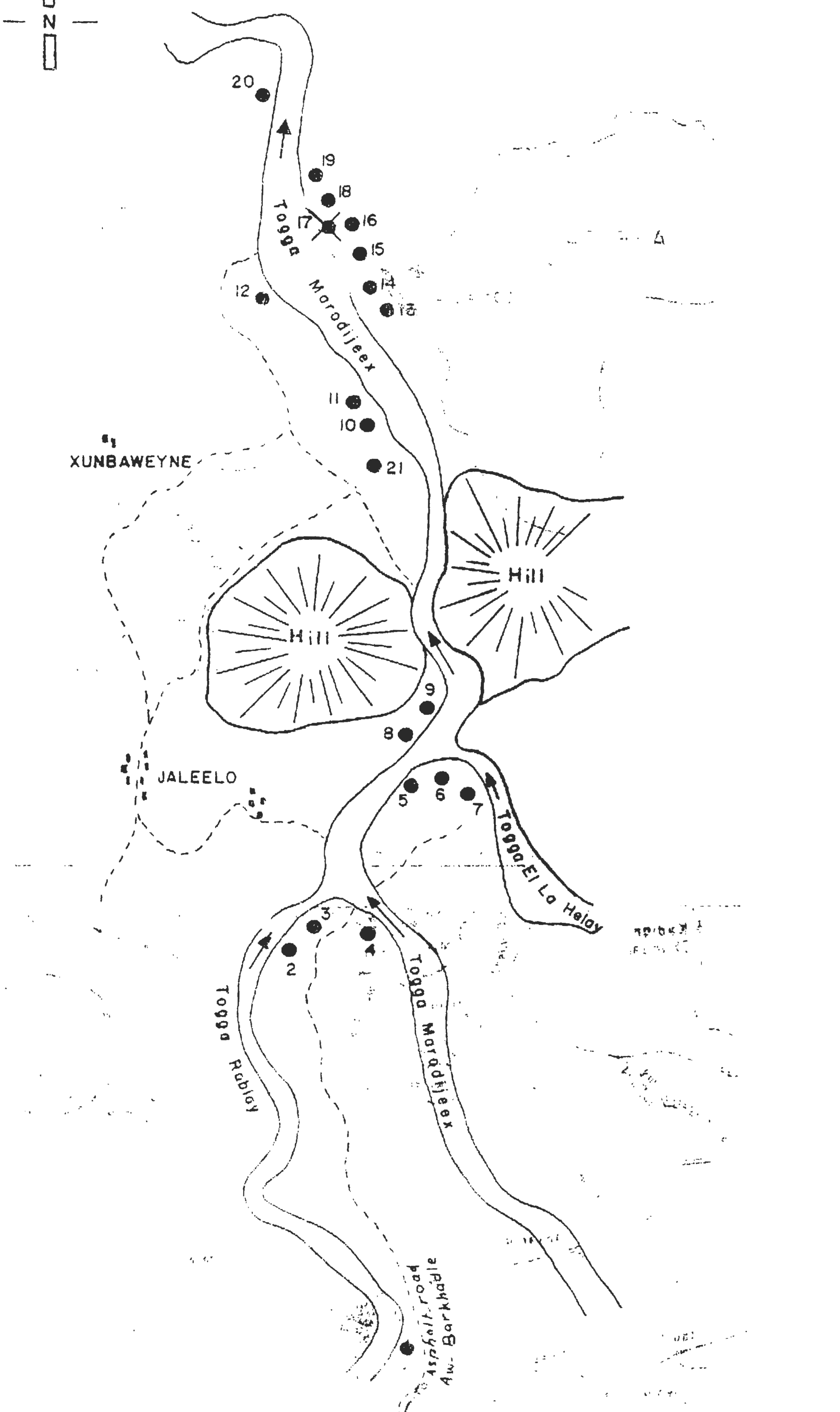
- Technical Notes no. 1 (Addendum to the Progress Report no. 5), August 1981;
- Irrigated Garden: Technical Note - Financial Note (provisional document drawn up for the P.I.U.), April 1982.

NB. In this note and the accompanying drawings, the 20 farms are numbered 1 to 16 and 18 to 21. Farm no. 17, though originally selected, was abandoned and replaced by farm no. 21 because its owner is not in permanent residence.

SITUATION MAP



SITUATION OF 20 ONE-HECTARE IRRIGATED FARMS IN JALEELO AND XUNBAWEYNE AREA



●12 _ Farm location and number

Approximate scale

SUMMARY AND CONCLUSIONS

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1. 20 ONE HECTARE FARMS

In view of the low yields obtained up to now from the traditional wells dug by the region's farmers, it was taken for granted that storage tanks would be required to carry out rational irrigation.

However, with the new deep wells which will be drilled according to modern engineering practice, there may be the chance of using other solutions.

For the time being, the systematic construction of storage tanks on all farms is to be discouraged until the new wells have been drilled. Analysis of the 11 alternatives shown in the following block diagram demonstrates that it would be advisable to proceed with development of the farms in two stages.

a) 1st stage (all farms):

- Installation of a 18 m3/h motor pump unit with a total delivery head of 17 m;
- Installation of a delivery pipe made of aluminium sections laid on the ground and with rapid acting couplings of the ABC type*;
- Construction of the irrigation network with canals lined with flat stones set in cement mortar.

The average cost per farm of this first stage is SoSh 51 000.

b) 2nd stage (farms where the capacity of the wells is inadequate):

Construction at the start of the irrigation network of a 36 m3 storage tank.

The cost of the storage tank is SoSh 45 000.

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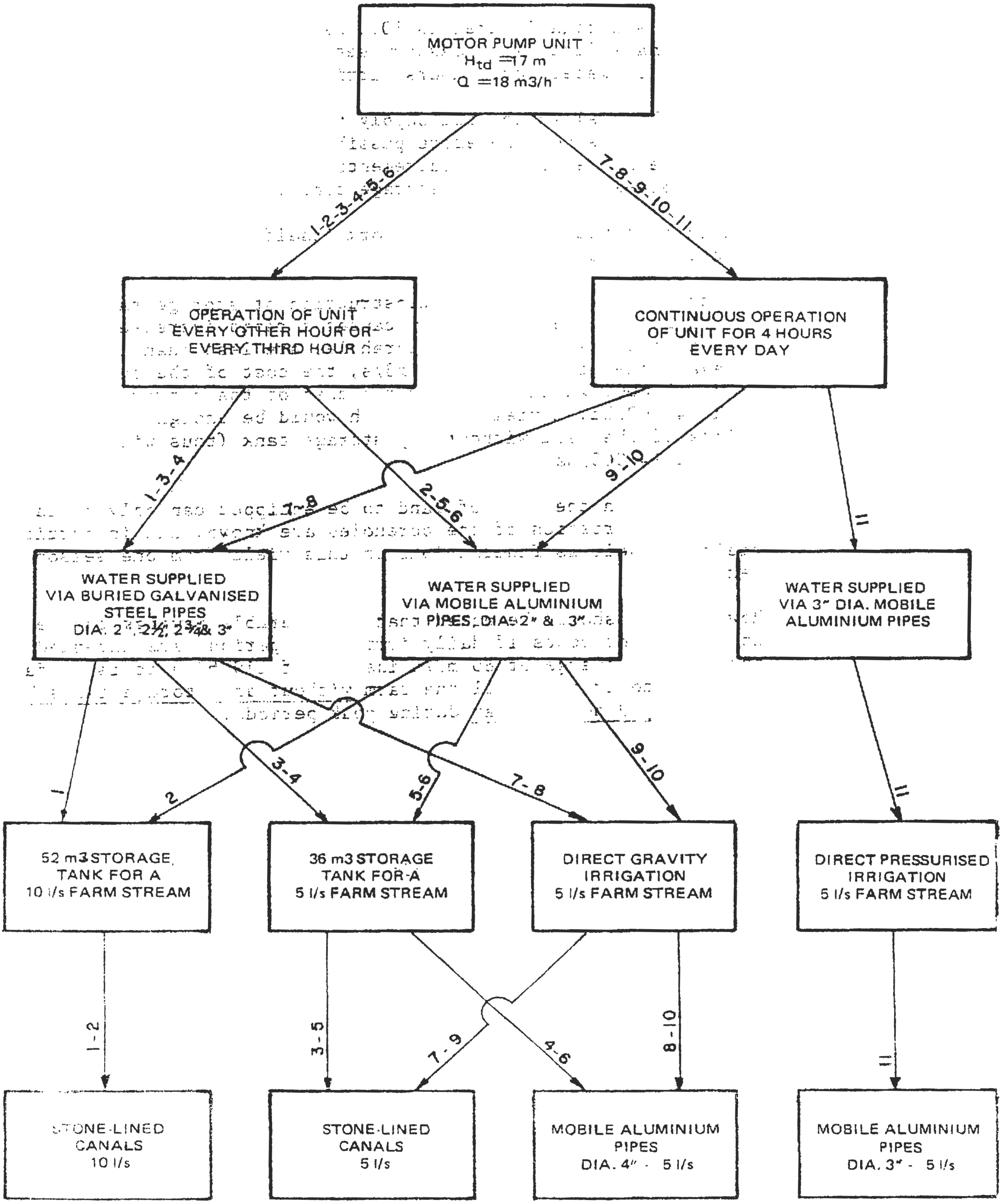
* Unless galvanised steel pipes, which are technically preferable, can be obtained [illegible] at a competitive price.

BLOCK DIAGRAM OF THE II SOLUTIONS STUDIED



5 - NUMBER AND PATH OF SOLUTION

2. GEED DEEBLE EXPERIMENTAL FARM

The farm's irrigable area is 10.2 ha. The irrigation network (with earth canals lined with masonry set in cement mortar) requires 119 m3/h of water for 6 hours' irrigation per day.

The borehole(s) which will supply the network have not yet been drilled. It is not therefore possible at this stage of the study to determine and evaluate requirements with regard to pumping, water supply pipes and possible storage tanks.

The cost of the irrigation network itself is SoSh 140 000, or about SoSh 14 000/ha.

All things being equal the construction of storage tanks enabling irrigation of the entire farm causes a rapid increase in the above cost if the yields from the boreholes are less than 119 m3/h. With an available discharge of 80 m3/s, the cost of the tanks is SoSh 200 000, which increases the cost of the network from 14 000 to SoSh 34 500/ha. A yield of 80 m3/h would be enough to irrigate two thirds of the farm without any storage tank (thus with a network cost of SoSh 14 000/ha).

A decision on the area of land to be equipped can only be taken when the characteristics of the boreholes are known, and in particular the yield, as well as fluctuations in this yield from one season to the next.

However, it should be noted that considerable savings can be made in investment costs if daily irrigation periods are extended. With the same discharge of 80 m3/h instead of 119 m3/h it is in fact possible to irrigate all the farm without any storage tanks by irrigating 9 hours a day during peak periods.

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Chapter 1

20 ONE HECTARE FARMS

1.1 STANDARDS ADOPTED

. Water recuirements during peak month ———— 1650 m3
. Net volume to be distributed each day ———— 55 m3
. Gross volume to be distributed each day
(allowing for 80% network efficiency) ———— 70 m3

1.2 BASIC DATA

1.2.1 AVAILABLE WATER

As the wells have not been drilled, it was not possible to carry out pumping tests to determine their exact characteristics. If data obtained with regard to the very shallow traditional wells in the area are extrapolated, it may be assumed with a reasonable margin or error that the new wells will be capable of providing a yield of about 5 l/s.

To give safer estimates, the following three situations were envisaged:

. well yielding a continuous flow of 5 l/s;

. well yielding 5 l/s every other hour;

. well yielding 5 l/s every third hour.

1.2.2 FARM STREAM

The farm stream traditionally used by farmers in this region is very low, of the order of 2 to 3 l/s. This is very likely due to the limitations on pumping imposed by the wells available. If more water were available the farmers would naturally have used a greater farm stream than that used at present. This must be the aim in creating more efficient wells and rational irrigation networks.

The following network calculations are based on hypotheses regarding the yields available from the new wells or storage tanks as well as on the type of soils, which are subject to much erosion.

Two situations were envisaged:

- 10 l/s farm stream* - the upper limit imposed by the tendency of the soils to erode;

- 5 l/s farm stream - lower limit corresponding to the situation with wells giving continuous yields. This is the flow which the canals must be capable of conveying.

In the absence of test results, the upper limit of the farm stream was estimated empirically at 10 l/s by allowing for the erodable nature of the sandy soils found on the farms. With traditional irrigation methods, even this flow may be excessive, and it may be necessary to take certain precautions either by dividing the flow in the canals into two distinct farm streams of 5 l/s each, to be used by two farmers, or (which would be preferable) by using siphons which would enable a farmer to divide up the flow as he saw fit.

The main advantage of this alternative is that it reduces irrigation time (to half that required with a 5 l/s discharge). The main disadvantage is that it costs more as the canals have to have a greater capacity. It therefore appeared worthwhile to consider the network designed for a 10 l/s flow so that each farmer could compare for himself the additional cost involved and the time that would be saved.

.2.3 IRRIGATION TIME AND NEED FOR STORAGE TANKS

With a farm stream of 10 l/s the theoretical irrigation time to distribute 70 m3 of water would be 1 h 56' 40", or about two hours. With a 5 l/s farm stream the time would be about 4 hours.

Leaving aside the particular case of a well capable of yielding a continuous 5 l/s, rational irrigation for two or four consecutive hours would require a storage tank between the well and the irrigation network (unless it is assumed that irrigation would be intermittent following a rhythm imposed by the well**).

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* The practical farm stream [illegible] the farmers to control their water supply. During the apprenticeship period, the farmers will be able to reduce the irrigation flow as they wish without this having any effect on the operation of the irrigation networks. The advantage of the highest farm stream possible is that the time devoted to irrigation operations can be limited, leaving more time for other farming activities, and reducing losses through [illegible] in the main distribution furrows.

** This practice, which [illegible] major constraints on the farmer and increases running costs [illegible] water losses which reduce network efficiency [illegible]

.3 FARM EQUIPMENT

The farm equipment will include the following:

- a well;
- a motor pump unit;
- a delivery pipe;
- a storage tank (if required);
- an irrigation network;
- protection against runoff.

.3.1 THE WELL

Study of the wells and drilling techniques is outside the scope of this report. The 1:500 drawings included in the appendix show the well locations in accordance with the recommendations made by the hydrogeologists. The location of the wells is of prime importance in determining routes for the delivery pipes, which must of necessity run to the highest points in the farms.

In the absence of measurements, it was assumed that during dry weather the level of water in the well would be -8 m below ground level.

When a well is being constructed, it is recommended that platforms be prepared at the outset which will enable the motor pump units to be placed different levels so as to follow rises and falls in the water table level.

3.2 THE MOTOR PUMP UNIT

The motor pump unit must be compatible with the amount of water available and be able to raise it to the particular total delivery head of the farm in question.

The characteristics of the motor pump units must be such that the nominal discharge is 18 m3/h* in all farms with a total delivery head varying from 12.5 m to 17.5 m from one farm to another (see table 1). Given the slight difference in delivery head from one farm to another and the advantages to be derived from standardising the equipment, it would be advisable to to select a single model from all those available on the market which could be adapted to all the various circumstances.

These characteristics will have to be the following:

- Nominal discharge: 18 m3/h,
- Total delivery head: 17 m.

The diameter of the pump outlet at each : e the same as th
diameter of the delivery pipe (see table tor pump will be
connected to the delivery pipe by means c rced rubber tube
6 m long; the diameter of this tube will to the require-
ments of the farm in question (see table

1.3.3 THE DELIVERY PIPE

Two possibilities were envisaged:

water would be delivered to the high of the farm in
order to supply a gravity network c f large diamete
(4") pipes (with or without a stora

water would be supplied to a pressu rk consisting o
small diameter (3") pipes (without ank).

1.3.3.1 Supply to the highest part of the farm t gravity network
(with or without a storage tank)

Table 1 gives details of the calculation arious diameters
of delivery pipe which will need to be i n the farms. The
calculations were carried out on the ass galvanised stee
pipes being available on the Hargeysa ma adopting the
minimum diameter for each farm which is with the length
of pipe to be installed. The diameters a ows:

. 2" for pipe lengths of between 0 ar
. 2 1/2" for pipe lengths of between m;
. 2 3/4" for pipe lengths of between m;
. 3" in the particular case of farm e delivery head
makes this diameter necessary in s ipe length of le
than 210 m.

By way of comparison, an alternative wa olving quick
connecting aluminium pipes imported fro 2 1/2" and 2
pipes are not standard, the diameters a the evaluation

. 2" for pipe lengths of between 0 a
. 3" for all other cases.

1.3.3.2 Water supplied to a pressurised network torage tank)

This alternative, which would require c ting 3" alumini
pipes in every case, could only be adop characteristics
the wells allowed for a continuous 5 l/s for four
consecutive hours.

The diameter of the pump outlet at each farm will be the same as the diameter of the delivery pipe (see table 1). The motor pump will be connected to the delivery pipe by means of a reinforced rubber tube 6 m long; the diameter of this tube will be adapted to the requirements of the farm in question (see table 1).

1.3.3 THE DELIVERY PIPE

Two possibilities were envisaged:

- water would be delivered to the highest point of the farm in order to supply a gravity network consisting of large diameter (4") pipes (with or without a storage tank);
- water would be supplied to a pressurised network consisting of small diameter (3") pipes (without a storage tank).

1.3.3.1 Supply to the highest part of the farm to supply a gravity network (with or without a storage tank)

Table 1 gives details of the calculations of the various diameters of delivery pipe which will need to be installed in the farms. The calculations were carried out on the assumption of galvanised steel pipes being available on the Hargeysa market and by adopting the minimum diameter for each farm which is compatible with the length of pipe to be installed. The diameters are as follows:

- 2" for pipe lengths of between 0 and 45 m;
- 2 1/2" for pipe lengths of between 45 and 90 m;
- 2 3/4" for pipe lengths of between 90 and 210 m;
- 3" in the particular case of farm 21 where the delivery head H makes this diameter necessary in spite of a pipe length of less than 210 m.

By way of comparison, an alternative was costed involving quick connecting aluminium pipes imported from Europe. As 2 1/2" and 2 3/4" pipes are not standard, the diameters adopted for the evaluation were:

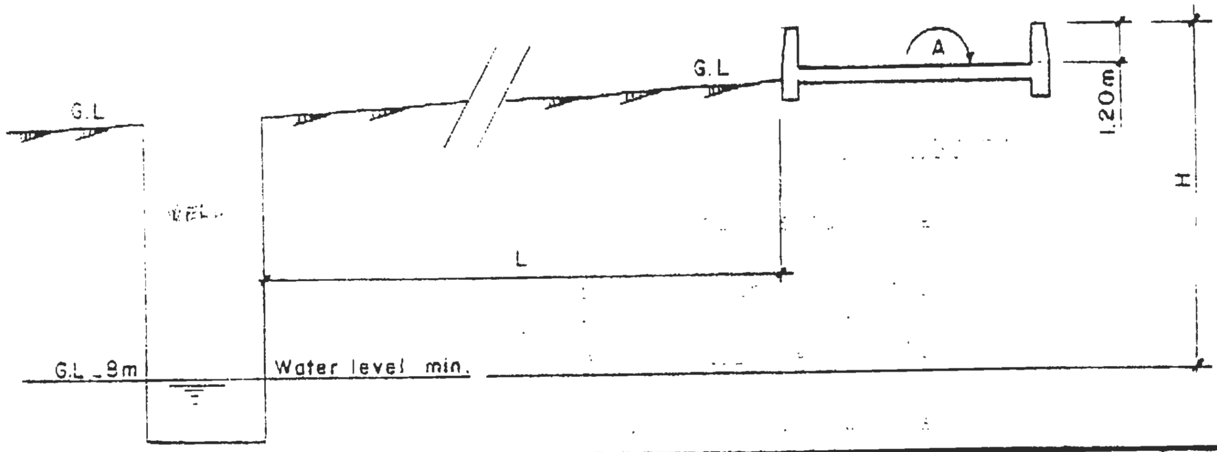
- 2" for pipe lengths of between 0 and 45 m;
- 3" for all other cases.

1.3.3.2 Water supplied to a pressurised network (without storage tank)

This alternative, which would require quick connecting 3" aluminium pipes in every case, could only be adopted if the characteristics of the [illegible] a continuous discharge of 5 l/s for four consecutive [illegible]

Table 1

. SETTING OF BASE SLAB OF STORAGE TANKS = A
LENGTH OF PIPE FROM WELL TO STORAGE TANK = L
. DIAMETER OF (GALVANISED STEEL) PIPES TO BE INSTALLED = Ø
. DELIVERY HEAD = H



Farm No	Well G.L. (m)	A (m)	H (m)	L (m)	J = head loss in the pipes where Q = 5 l/s (m)				Htd in round figures (m)	Lengths (m)*
					~~Ø 2" (0.18)**~~	~~Ø 2"1/2 (0.058)**~~	~~Ø 2"3/4 (0.035)**~~	~~Ø 3" (0.025)**~~		
1	10.0	10.12	9.32	30	5.40				14.8	45
2	10.2	10.47	9.47	30	5.40				14.9	45
3	8.9	9.10	9.40	30	5.40				14.8	45
4	9.5	10.37	10.07	70		4.06			14.1	125
5	10.2	10.60	9.60	90		5.22			14.8	130
6	9.2	9.94	9.94	150			5.25		15.2	210
7	10.2	10.50	9.50	50		2.90			12.4	135
8	9.0	9.86	10.06	30	5.40				15.5	40
9	8.6	9.27	9.87	35	6.30				16.2	40
10	10.6	11.00	9.60	210			7.35		16.2	220
11	9.6	9.30	8.90	210			7.35		16.3	240
12	9.9	10.40	9.70	120		6.96			16.7	130
13	19.8	21.07	10.37	115		6.67			17.0	120
14	19.3	19.50	9.40	45	8.10				17.5	45
15	17.6	17.58	9.18	45	8.10				17.3	45
16	[illegible]	[illegible]	[illegible]	50		2.90			12.6	125
18	13.2	13.50	[illegible]	60		3.48			[illegible]	135
19	[illegible]	[illegible]	[illegible]	20	3.60				[illegible]	45
20	[illegible]	[illegible]	[illegible]	20	3.60				12.8	45
21	[illegible]	[illegible]	[illegible]	205				5.23	16.7	230
Pipe diameters					Ø 2"	Ø 2"1/2	Ø 2"3/4	Ø 3"		
Total length [illegible]					285	555	570	205		
No of 6 m pipe sections [illegible] and losses					50	100	100	40		

* Use the [illegible] if 'L' is greater than the following lengths.

** Head [illegible]

1.3.4 THE STORAGE TANK

The dimensions of the storage tank must be such that 70 m3 of water will be available to the farmer during irrigation periods.

The volume will therefore be equal to 70 m3 minus the quantity of water which the pump can supply during irrigation. This gives the following possible combinations:

Pump operation	Every other hour		Every third hour		Continuous	
Farm stream (l/s)	10	5	10	5	10	5
Irrigation time (h)	2	4	2	4	2	4
Volume supplied by pump during irrigation (m3)	18	36	18	36	36	72
Volume of tank (m2)	52	34	52	36*	34*	0

Mathematically speaking a tank with a volume of 34 m3 would be adequate, but in practice, with the pump functioning every third hour it will be necessary to have a 36 m3 tank as shown by the following example:

EXAMPLE USING A STORAGE TANK WITH A PUMP OPERATING EVERY THIRD HOUR AND A 5 l/s FARM STREAM				
Hours	Supply to tank from pump (m3)	Water leaving tank (5 l/s farm steam	Volume of water in tank (m3)	Observations
			36	Tank filled night before
7 to 8	18	18	36	
8 to 9	-	18	18	
9 to 10	-	18	0	
10 to 11	18	16	2	
11 to 13	-	-	2	
13 to 14	18	-	20	
14 to 16	-	-	20	
16 to 16 h 55'	16	-	36	Tank ready for next day
Total	70	70		

In this particular case a 34 m3 tank would [illegible] a lack of water by the end of the third hour of irrigation [illegible] stoppage [illegible] the pump could be brought into operation.

** This solution can be eliminated from the [illegible] as with continuous discharge from the pump a farm stream of 5 l/s could be supplied without having recourse to a storage tank.

1.4 THE IRRIGATION NETWORK

For the purposes of comparison, three possible solutions were analysed:

- a network of open canals;
- a network of 4" non-pressurised mobile aluminium pipes;
- a network of 3" pressurised mobile aluminium pipes.

1.4.1 NETWORK OF OPEN CANALS WITH A FARM STREAM OF 5 l/s OR 10 l/s

Given the sandy nature of the soils on these farms, a solution involving unlined canals can be eliminated from the outset as this would result in excessive water losses.

Amongst the possible types of lining, the only one requiring labour and materials available in the area would be masonry set in cement mortar, stone being plentiful in the region.

The drawings given in the appendix and the typical longitudinal profiles and cross sections were prepared on the assumption that canals would be lined in this manner.

This arrangement can be used with or without a storage tank, and in the second case the delivery pipe would lead directly to the start of the network instead of emptying into the tank.

1.4.1.1 Distribution of water from one canal to another

Water can be distributed either by means of classic sheet steel gates sliding in grooves cut into the canals at the places shown on the drawings, or else by means of impermeable tarpaulin stop-logs which do not require any special arrangement in the canals. These stop-logs consist of a rectangular piece of material 0.40 m by 1.5 m with one of the shorter sides folded over 15 cm and sewn down, thus forming a sheath through which a rod (a pipe, concrete reinforcement bar or wooden stake, etc.) 90 cm long is introduced.

In order to shut off the canal and thus divert flow into the lateral canal, the rod is laid across the canal on the waste banks and the tarpaulin simply pressed by hand against the bottom and sides of the canal in an upstream direction. The water pressure on the tarpaulin is enough to make is adhere perfectly to the canal without any further measures being required, thus cutting off all flow downstream.

1.4.1.2 Distribution of water to the plots

a) Traditional irrigation using notches in the irrigation canal

The same procedure as above can be followed. However, whereas with metal gates is is simply necessary to create grooves at the points where there are to be openings, if tarpaulin stop-logs are to be used a 1.50 m section of canal should be created at each opening as this is necessary to obtain the required watertightness.

The openings for water distribution to the plots are not shown on the drawings. These will have to be decided one by one as a function of the arrangement adopted for each farm's cropping pattern.

It should simply be pointed out that in the case of citrus plantations, the openings should enable the irrigation of two rows of trees at once, thus requiring one opening every 14 m, while in the case of papaya plantations and vegetable crops, openings closer together (for example 10 m) would be preferable.

Whatever the farm stream used (10 l/s or 5 l/s), traditional irrigation involving diversion of all the flow from the feeder canal into the plot will require some form of soil protection where the water enters the plot. This will consist of dry stones placed manually by the farmers and rearranged or made up whenever necessary.

b) Siphon irrigation

With this form of irrigation, no special arrangement is required on the feeder canal. It is simply a question of placing a tarpaulin stoplog immediately downstream of the area to be irrigated, so that the water level in the canal rises and it is possible to divert flow into the plot via siphons crossing the waste bank of the canal on the side where the land to be irrigated is situated.

A practical solution would involve supplying the farmers with sections of plastic tubing 1 m long and 25 to 30 mm in diameter which can easily be manipulated and primed.

The number of siphons needed will be determined experimentally by the farmers in the following manner:

. placing stop-log in the feeder canal;

. allowing the water level to rise in the canal upstream of the stop-log;

. priming an arbitrary number of siphons in the upstream reach (for example 10 siphons);

. observing the behaviour of the water level in the canal and flow through the siphons. If the water level in the canal stabilises and all the siphons remain in operation, the number is appropriate. If the water level in the canal continues to rise and tends to overflow, then the number of siphons is insufficient. If the water level in the canal drops to the point where several of the siphons are deprived of water, then there are too many siphons.

By repeating the operation with a different number of siphons, either fewer or more, the farmer can rapidly determine by himself the correct number of siphons to use.

It should be noted that a farm stream of 10 l/s is easy to use with siphons. This form of irrigation is therefore strongly recommended as it removes the need for any diversion structure in the canal, prevents problems of erosion and improves the farmers' technical capacity and control of the water supply.

1.4.1.3 Regulation of flow in the canals

In the case of a network supplied by a storage tank, the flow delivered by the gate valve at the tank varies, with the same valve opening, in accordance with the level of water in the tank. The farmer will be able to increase or reduce the flow in the canals by altering the valve opening from time to time. Table no. 2 gives the means of estimating the inflow to each farm network with heads of water in the canals of between 5 cm and 17 cm*.

In the case of a network supplied directly by the delivery pipe, where there is no storage tank, the farmer will not be able to regulate the flow. This will be imposed by the pump unit in relation with the level of the water table in the well. However, table 2 is still valid for estimating the discharge used.

1.4.1.4 Sizing of canals

As can be seen from table 2, the same flow can be conveyed with different depths of water from one canal to another.

However, as the variations involved are of the order [illegible] centimetres, it was felt better to adopt a single canal [illegible] section for a 10 l/s farm stream and a single one for a 5 l/[illegible] farm stream, taking into account the most unfavourable circumstan[illegible] namely:

Farm stream (l/s)	Maximum depth of water (cm)	Depth of canal (cm)
10	17	20
5	12	15

(see appendix for typical cross sections).

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*[illegible] measurement is to be taken [illegible] and 5 m downstream of the [illegible] level in the canal has sta[illegible] the slope [illegible] the canal [illegible] in the network [illegible] for the start of the [illegible]

		Flow in l for a depth of water in the canal in cm of:												
		5	6	7	8	9	10	11	12	13	14	15	16	17
1		2.0	2.5	3	4.5	5.5	7.0	8.5	10.0					
		1.0	1.5	2	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
2		2.0	2.5	3.	4.5	5.5	7.0	8.5	10.0					
3		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
4		3.0	4.0	5.	7.0	9.0	11.0							
		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
5		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
		3.0	4.0	5.	7.0	9.0	11.0							
6		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
		1.5	2.0	3.	4.0	5.0	6.0	7.5	9.0	10.5				
7		1.5	2.0	3.	4.0	5.0	6.0	7.5	9.0	10.5				
		2.5	3.0	4.	5.5	7.0	8.5	10.5						
8		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
9		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
10		2.5	3.5	5.	6.5	8.0	10[illegible]							
		3.0	4.0	5.	7.0	8.5	10.5							
11		2.5	3.0	4.	5.5	7.0	8.5	10.5						
		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
12		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
		1.5	2.0	3.	4.0	5.0	6.0	7.5	9.0	10.5				
13		2.5	3.5	5.	6.5	8.0	10.0							
		1.0	1.5	2.	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
14		3.0	4.0	5	7.0	9.0	11.0							
15		1.0	1.5	2	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
16		2.5	3.0	4	5.5	7.0	8.5	10.5						
		3.0	4.0	[illegible]	7.0	9.0	11.0							
18		1.5	2.0	[illegible]	3.0	4.0	5.0	6.0	7.0	8.5	10.0			
		2.0	2.5	[illegible]	4.5	5.5	7.0	8.5	10.0					
19		3.0	4.0		7.0	9.0	11.0							
		1.0	1.5		2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
20		1.0	1.5	[illegible]	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5
21		1.0	1.5	[illegible]	2.5	3.0	3.5	4.5	5.0	6.0	7.0	8.0	9.5	10.5

1.4.1.5 Setting of canals

Land in the farms to be irrigated is often steeply sloping and for this reason a compromise solution was adopted in order to achieve the (contradictory) aims of limiting canal slopes as much as possible (to reduce the water velocity as much as possible and thus the force of erosion at the entrance to the plots) and the height of the embankments (to reduce the height from which the water would fall - causing even more erosion - the areas lost for the canal land takes and the amount of compacted fill to be used).

The solution adopted means that in a few cases the canals have to be set at elevations lower than the plots to be irrigated. In these particular cases, the plots in their present state will not be commanded by the irrigation canals, and it will be necessary either to level areas which are too high (in the case of vegetable crops)* or else create deeper basins which the water can reach via excavated furrows (in the case of the citrus and papaya plantations)*.

1.4.2 NETWORK OF 4" DIAMETER NON-PRESSURISED MOBILE ALUMINIUM PIPES WITH A FARM STREAM OF 5 L/S

This is a variant of the network of open canals and uses the same layout. Water circulates by gravity through the pipes, either from the storage tank or by direct connection at the end of the delivery pipe. However, with a network of this type the farmer may modify the layout as he wishes in order to bring the water to the foot of each tree or to the entrance to each plot without having recourse to earth distribution furrows.

This system constitutes a limiting factor for the farm stream in comparison with the canals. A 10 l/s farm stream would require a 5" diameter arrangement which is not competitive due to the high investment cost entailed. In contrast with the canals, which can be constructed using local labour and with locally available materials, aluminium pipes have to be imported from Europe.

1.4.2.1 Composition of the network

The network consists of 6 m long pipe sections and fittings 4" in diameter. These are fitted at each end with watertight ABC type quick acting couplings which are simple to join up.

1.4.4.2, Network operation (Example of farm no. 1 - cf. plan of the farm).

The pipes and fittings are connected up as far as the section of network which is to irrigate the farthest plot (S3).

* It is felt that this work should be carried out by the farmer as the areas which are not commanded are very small and only require minor earthworks.

The network is then supplied with water by opening the gate valve at the storage tank (or by starting up the pump if the development does not include a tank).

When the depth of irrigation in the plot has been reached the last 6 m section of pipe is disconnected and the adjacent plot irrigated (without flow being stopped).

These operations are repeated until the area commanded by the section of network (S3) has been completely irrigated.

Flow into the network is cut off by closing the valve at the tank (or shutting down the pump).

The pipes are transferred from section S3 to section S2.

The network is once more supplied with water, and the process repeated as before until the entire area is irrigated.

1.4.2.3 Features of the network

The fact that pipes are moved from one section of the network to another reduces the total length of pipes by over 50% as compared with the lengths of the corresponding canals.

In contrast, because of the fragility of the equipment (resulting in breakage, loss, damage to joints) a large stock of spare parts should be envisaged.

Details of the various parts of the network at each farm are given in table No. 3.

1.4.2.4 Setting of the network

No particular setting is required as the pipes are simply placed on the ground, avoiding particularly high points and rough ground.

1.4.2.5 Flow regulation and measurement

With this arrangement, it is impossible to measure the flow. It is up to the farmer to use his experience to judge whether the flow is excessive or inadequate. He will have the same means as with a canal network of modifying or accepting the flow delivered (depending on whether or not the farm is equipped with a storage tank).

Table 3

ITEMS FORMING THE MOBILE ALUMINIUM PIPE NETWORKS
(Units)

Farm No	6 m pipe sections	Female coupling	Tees		Cap	Bends		Seals
			In line	At end of line		90°	45°	
1	37	1		1	1	2	2	(*)
2	29	1		1	1	3		
3	28	1	1		1	2		
4	30	1		1	1	2		
5	44	1		1	1	2	2	
6	29	1	1		1	2		
7	44	1		1	1	2	2	
8	31	1		1	1	2		
9	29	1		1	1	2	2	
10	29	1		1	1	3		
11	33	1	1		1	3		
12	36	1		1	1	2		
13	41	1		1	1	2	2	
14	34	1	1		1	1	2	
15	30	1	1		1	2	1	
16	31	1		1	1	2	2	
18	33	1		1	1	2	2	
19	27	1		1	1	2		
20	29	1			1	3		
21	29	1	1		1	2		
Sub-total	653	20	6	13	20	43	17	-
Spare parts	(10%) 65	(50%) 10	(100%) 6	(100%) 13	(50%) 10	(50%) 22	(50%) 9	(50%) 400
GRAND TOTAL	718	30	12	26	30	65	26	400

(*) The pipe sections and fittings are delivered with seals.

1.4.3 NETWORK OF 3" DIAMETER PRESSURISED ALUMINIUM PIPES WITH A FARM STREAM OF 5 L/S

This network is identical to the previous one except that the pipes are 3" in diameter instead of 4".

With the same discharge of 5 l/s it therefore requires a greater input pressure than could be provided by the delivery pipes adopted up to now (cf. table no. 1) and even less by the storage tank.

It therefore needs to be supplied directly by the delivery pipe, and this must be sized so that the residual pressure at the start of the network will be compatible with distribution of a 5 l/s farm stream to all parts of the farm.

This condition is met at all the farms* with a 3" diameter delivery pipe. This is the same diameter as the network and can thus be made of the same mobile pipes.

The start of the network is in fact the pump outlet in this case. In the following costed section of the report, the ideas of 'delivery pipes' and 'irrigation networks' have been kept in order to give a better understanding of the differences between comparable quantities.

1.5 PROTECTION AGAINST RUNOFF

Observation of soil behaviour at Jaleelo during and after the heavy rains which fell in the region at the start of May 1982 led to the following major conclusions:

- In places where the runoff was channelled along flow paths, gullies formed very rapidly and there was considerable headward erosion;
- In places where the water lay because there was no outlet, it disappeared within two hours. When questioned about this, the local farmers confirmed that this was in fact the period of submersion.

In view of these observations, the idea of an internal drainage network consisting of ditches was abandoned, as the effects would be more damaging than beneficial.

On the other hand, the farms should be protected against water from upstream, which can cause considerable damage to crops and development works.

A surrounding ditch is not to be recommended as this would require disproportionately extensive rockfill protection at the outlet into the togga, which is always close to the farm and forms the only possible escape. It is therefore preferable to protect the farms with bunds on the sides which are exposed to runoff.

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* With the exception of farm No. 21 where the total delivery head at the farthest point from the well would be 18.5 m. Though higher than 17 m, this is still acceptable if there is slight decrease in discharge during irrigation of this remote spot.

1.6 COST OF DEVELOPMENT WORK

The information used in preparing the cost estimates was obtained by means of enquiries carried out in Hargeysa by P.I.U. employees in May 1982 (with regard to the supplies which can be obtained in the region) and by reference to January prices in France, increased by the cost of land and air freight via Djibouti (in the case of imported equipment and materials).

All possible combinations of the various cases studied give 11 alternatives which are analysed and costed in table No. 4.

1.7 SUMMARY

1.7.1 ALTERNATIVES TO BE ELIMINATED (cf. table No. 4)

a) Alternative No. 11

Although second cheapest, this solution has to be eliminated because of the uncertainty surrounding the real capacity of the wells to be drilled on the first 20 farms. This alternative, which involves direct connection to the motor pump unit, calls for a continuous discharge of 5 l/s which cannot be guaranteed at present. It must however be borne in mind in the event of similar development in the future where the amount of water available can be guaranteed beforehand.

b) Alternatives 4, 6, 8 and 10

These solutions, which call for imported mobile aluminium pipes, are more costly than the same solutions involving canals dug by local labour.

c) Alternatives 1 and 2

These solutions are technically the best because they provide a farm stream of 10 l/s and thus short duration irrigation. However, it is felt that they should be eliminated because of the high investment cost involved.

Table 4

SUMMARY AND COSTS OF THE VARIOUS POSSIBLE COMBINATIONS

				Alternatives										
				1	2	3	4	5	6	7	8	9	10	11
Cost of the 20 farms in Sosh x 10^3				2292	2126	2088	2457	1922	2291	1192	1561	1026	1395	1149
Motor pump unit H_{td} = 17 m Q = 5 l/s			424	●	●	●	●	●	●	●	●	●	●	●
Water supply		Buried galvanised steel pipes dia. 2", 2 1/2", 2 3/4", 3"	352	●		●	●			●	●			
		Mobile aluminium pipes laid on the ground - dia. 2" & 3"	186		●			●	●			●	●	
		3" dia. mobile aluminium pipes laid on the ground	200											●
Storage		52 m3 storage tank for irrigation with a 10 l/s farm stream	1 022	●	●									
		36 m3 storage tank for irrigation with a 5 l/s farm stream	896			●	●	●	●					
Delivery to plots	Gravity flow	Masonry lined canals Q = 10 l/s	494	●	●									
		Masonry lined canals Q = 5 l/s	416			●		●		●		●		
		4" mobile aluminium pipes laid on the ground - Q = 5 l/s	785				●		●		●		●	
	Under pressure	3" mobile aluminium pipes laid on the ground - Q = 10 l/s	525											●
Pump operation for 4 hours' pumping a day delivering 5 l/s				1 hour's operation 1 hour's stoppage or 1 hour's operation 2 hours' stoppage						4 hours' continuous operation				
Farm stream distributed per farmer				10 l/s		5 l/s								
Irrigation time				2 hours' continuous operation		4 hours' continuous operation								
Volume of storage tank				52 m3		36 m3				No tank				

1.7.2 ALTERNATIVES TO BE DEFERRED (cf. table No. 4)

a) Alternative No. 3

This is technically similar to alternative No. 5 but more costly simply because of the cost of the galvanised steel pipe, which is double that of the mobile aluminium pipes. Such a difference in cost is not very realistic and the prices obtained in Hargeysa for galvanised steel pipes should be checked , for example by questioning other suppliers. With similar or even slightly higher costs, galvanised steel pipes are preferable to aluminium pipes. The latter, laid on the ground, are more vulnerable and can cause interruptions in the water supply, which practically never occur with buried steel pipes.

b) Alternative No. 7

Same remark as above with respect to alternative No. 9.

1.7.3 ALTERNATIVES TO BE ADOPTED (cf. table 4)

a) Alternatives 5 and 9

These two alternatives are identical, apart from the fact that No. 5 includes the construction of a storage tank and No. 9 does not, giving a difference in cost of SoSh 896 000.

This difference in cost is significant, and is connected simply with the well capacities, which are as yet unknown. It is felt that the decision of whether or not to construct the storage tank should be taken only when full information is available.

The construction of storage tanks should therefore not be started before wells have been drilled and representative pumping test results obtained by equipping the wells with the pumps which will finally be allocated to the farms.

1.8 CONCLUSIONS

In conclusion, it is recommended that the canal network be lined with masonry and designed to convey a yield of 5 l/s, and that it be supplied initially directly from the delivery pipe from the pump (alternative 9). This pipe will be in galvanised steel or aluminium pipes depending on the market survey carried out in the meantime. Operation will show whether or or not it is necessary at each farm to construct a storage tank. This may then be constructed (alternative 5) on those farms where the wells will not provide a continuous yield.

Chapter 2

GEED DEEBLE EXPERIMENTAL FARM

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2.1 STANDARDS

The cropping pattern for this farm has not yet been defined, as it depends on the available water, and this can only be determined after the borehole(s) have been drilled during the second part of 1982.

The proposals contained in Technical note No. 11 of the feasibility study (Research and Extension, p. 29) will be taken as working hypotheses:

Activity	Area (ha)	Peak daily water requirements (m3/ha/day)		Total water requirements (m3/day)	
		Net	Gross*	Net	Gross*
Orchard	2	30	37.5	60	75
Nursery	1	60	75.0	60	75
Vegetable	2	54	70.0	108	140
Seed Xion	5	66	82.0	330	410
Wind break	1	30	37.5	30	40
Total	11			588	740
Average per ha	1			54	67

* Assuming 80% efficiency.

It is therefore justified to use the same standards as those for the small farms, namely:

- Water requirements for the peak month ———— 1650 m3
- Net volume to be distributed each day ———— 55 m3
- Gross volume to be distributed each day (allowing for 80% efficiency) ———— 70 m3

2.2 BASIC INFORMATION

2.2.1 IRRIGABLE AREA

The total farm area is 15 ha. Leaving aside those areas which are not suitable for cultivation and the land to be used for access, the net irrigable area of the farm is 10.2 ha, divided up as follows (see appendix below):

Area A	3.7 ha
Area B	3.0 ha
Area C	3.5 ha
Total	10.2 ha

2.2.2 WATER REQUIREMENTS

On the basis of 70 m3/ha per day during peak periods, the water requirements will be as follows:

Area A	3.7 x 70 = 259 m3/day
Area B	3.0 x 70 = 210 m3/day
Area C	3.5 x 70 = 245 m3/day
Total	714 m3/day

2.2.3 IRRIGATION TIME

On a farm of this type, the irrigation time is determined by the length of the working day, ie. 8 hours.

In order to allow for lost time and other farm activities, the daily duration of irrigation operations has been fixed at 6 hours.

2.2.4 DESIGN DISCHARGE OF THE BOREHOLE(S)

The borehole(s) must meet water demand over the period of irrigation, ie:

714 m3/6 hours = 119 m3/hour (≈ 33 1/s)

2.2.4.1 Distribution of yield from the borehole(s)

Area A	259/6 = 43.17 m3/hour (≈ 12 1/s)
Area B	210/6 = 35.00 m3/hour (≈ 10 1/s)
Area C	245/6 = 40.83 m3/hour (≈ 11 1/s)
Total	714/6 = 119.0 m3/hour (≈ 33 1/s)

2.2.5 FARM STREAM

In this case the farm stream is automatically limited to the above values, namely:

. 12 l/s for Area A
. 10 l/s for Area B
. 11 l/s for Area C.

These farm streams can easily be utilised on an experimental farm which has an efficient technical management. Initially, if required, the above flows may be divided up by doubling the number of farmers practising irrigation (6 farmers instead of 3 on the farm).

2.2.6 IRRIGATION METHOD

The system will involve gravity irrigation, using masonry-lined canals and tubular siphons, with water being supplied on a continuous basis over the six hours during which irrigation is practised each day.

This means that the borehole(s) must be capable of delivering a continuous yield of 119 m3/h.

2.2.7 STORAGE TANKS

If yields from the boreholes are less than 119 m3/hour, a storage tank will have to be constructed at the start of each network (A, B and C, cf. drawing in the appendix), whose live storage capacity would depend on the real discharge from the borehole(s).

By way of indication, the following table gives the volumes of the tanks which would be required for the three areas for yields from the borehole(s) varying from 30 to 100 m3/hour and providing water on a continuous basis throughout the period of irrigation:

Borehole yield (m3/W)	Volume of storage tank (m3)*				Time taken to fill tank after irrigation (hours)	Total period of pump operation (hours)
	Area A	Area B	Area C	Total		
30	195	157	183	535	18	24
40	173	139	162	474	12	18
60	129	104	121	353	6	12
80	85	69	80	234	3	9
100	41	34	39	114	1	7

* By linear interpolation it is possible to calculate the tank volumes for any other borehole yield.

2.3 FARM EQUIPMENT

The farm will be equipped with the following:

. one or several boreholes;
. one or several pump units;
. one or several delivery pipes;
. 3 irrigation hydrants;
. 3 storage tanks (if required);
. 3 irrigation networks;
. protection against runoff.

2.3.1 THE BOREHOLES - PUMP UNITS - DELIVERY PIPES - IRRIGATION HYDRANTS

The boreholes do not form part of this report. As their location and the elevation of the water table are not yet known, it is not possible at this stage of the study to formulate reasonably accurate working hypotheses.

A rough calculation from a borehole situated 400 m from the farm* and with the water table stationary at -30 m gives the following results (with a yield of 119 m3/hour):

6" diameter pipes	400 m
5" diameter pipes	160 m
4" diameter pipes	180 m
Total delivery head	66 m

This purely hypothetical calculation underlines the importance of equipment for the boreholes and delivery pipes, whose components (model of pump, number of impellers, power of motor, diameter of pipes, water hammer protection, type of hydrants, pressure regulators, discharge regulators, etc.) require special study, and this can only be undertaken when the characteristics of the boreholes (ie. location, elevation, discharge, drawdown) are known exactly.

2.3.2 THE IRRIGATION NETWORKS

On the basis of the alternatives studied for the development of the 20 one hectare farms, the irrigation networks for the experimental farm will consist of earth canals lined with flat stones set in cement mortar.

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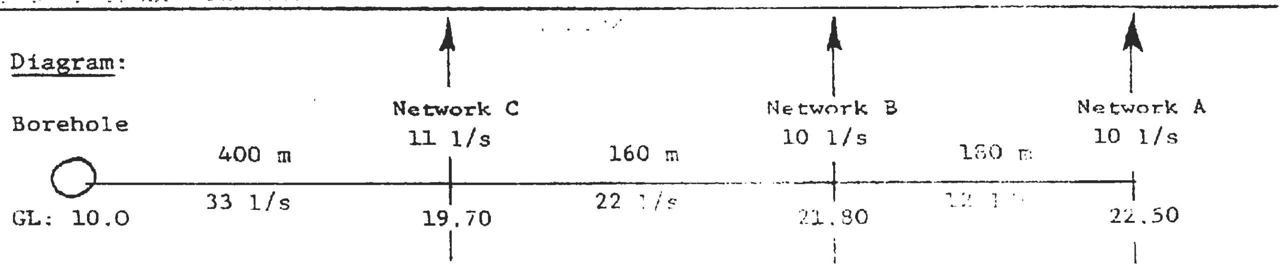
* Diagram:



The setting for the bottom of the canals is given in the longitudinal profiles contained in the appendix.

The dimensions of the canals are the same in the three areas and identical to those shown in the 'typical cross section' for a 10 l/s flow ie. with a depth of 20 cm (the most unfavourable case being that of the last section of canal C1 in which the 11 l/s flow is conveyed normally with a depth of 17 cm, leaving 3 cm freeboard).

2.3.2.1 Distribution of water to the plots

The canal layout was designed so that water could be distributed on both sides of the irrigation canals.

Distribution by means of siphons is felt to be the only solution which can be recommended for an experimental farm. The method of using stop-logs and tubular siphons is the same as that for the 20 farms.

2.3.2.2 Regulation of flow in the canals

In the case of networks supplied directly from the borehole(s) the flow will be automatically regulated by the flow regulator installed at the outlet from the irrigation hydrant.

In the case of networks supplied from storage tanks, water supply to the canals will be regulated by means of the tank outlet valve. The following table gives the method of estimating flow entering the networks with depths of water in the canals of between 5 and 16 cm.

Farm stream	Area		FLOW IN l/s WITH A DEPTH OF WATER IN cm IN THE CANAL OF*											
			5	6	7	8	9	10	11	12	13	14	15	16
12 l/s	A	A1	2.5	3.0	4.5	5.5	7.0	8.5	10.5	12.5				
		A2	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.5	10.0	11.5	13.5
10 l/s	B	B1	2.0	2.5	3.5	4.5	5.5	7.0	8.5	10.5				
		B2	2.5	3.5	4.5	6.0	7.5	9.5	11.5					
11 l/s	C	C1	2.5	3.5	4.5	6.0	7.5	9.5	11.5					

* The measurement is to be taken at least 5 m downstream of the storage tank, when the water level in the canal has stabilised. This table is only valid for the start of the networks.

2.3.2.3 Setting of canals

As with the one hectare farms, the se canals in pla
involves lower elevations than that o o be irrigate
In order to irrigate these particular same methods
be adopted as described for the one h (see 1.4.1.5

2.4 PROTECTION AGAINST RUNOFF

The farm is partially protected at pr bunds const
on those sides most frequently expose and also wit
the farm itself.

These bunds, which are not maintained amaged and sh
be repaired and extended.

In addition, the bank of the togga ru he eastern si
the farm has been severely eroded dur d is now only
from the boundary of the farm. This p d by a cross
the drawing. At this spot the togga b towards the
and flood water strikes the bank perp In the very n
future this erosion may reach the lim rm if nothing
done to prevent it.

To meet most urgent needs, it is reco a bulldozer b
immediately to modify the togga bed b nannel on the
bank and dumping the excavated materi a at present
to erosion. Such action may in itself there is per
maintenance (according to the amount served after
flood). As a further measure, the ero ld be protect
by large diameter rockfill (between 3 This would p
further protection but does not allev for the peri
maintenance described above.

2.5 COST OF DEVELOPMENT WORK

At the moment, estimates can only be etwork itsel
and these give the figure of SoSh 14 irrigated he
tares or about SoSh 14 000/ha.

To this must be added the cost of the pump unit(s
water supply line(s) and possible st e cost of th
may be obtained to within an order o adopting the
following formula*:

Cost of storage tank = Live stora 10 + 21 000
(in SoSh) (in

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* This formula is derived from the cost estimates for storage tanks
calculated for the 20 one hectare farms and from a c up for a maxim
volume of 195 m3.

For example, the cost of storage tanks for an available flow of 80 m3/hour (see § 2.2.7) is obtained as follows:

	Area A	Area B	Area C	Round figures
Volume of storage tanks (m3)	85	69	80	-
Cost of storage tanks (SoSh)	72 850	63 090	69 800	200 000

In the above example the cost of the network increases from SoSh 141 000 to SoSh 341 000 and the per hectare cost from SoSh 14 000 to SoSh 34 500.

However, this example calls for two important comments. Firstly, with an available flow of 80 m3/hour, it is possible to irrigate areas A and B (6.7 ha) without a storage tank, at a cost of SoSh 14 000/ha. Secondly, if it was decided with this same flow to irrigate area C (3.5 ha) it would be necessary to construct storage tanks. In this case the cost of the three tanks would have to be put down to area C alone, whose marginal cost would amount to SoSh 71 000/ha.

2.6 CONCLUSIONS

Once the borehole(s) have been drilled and their characteristics defined, it will be possible to select the most suitable alternative: either adjusting the area irrigated to the available flows or else irrigating all the farm (10.2 ha) by constructing the necessary storage tanks.

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Appendices A

SPECIFICATIONS

Appendix A.1

ONE HECTARE FARMS
SPECIFICATIONS FOR THE MOTOR PUMP UNITS

-

. On-line motor pump mounted on a metal frame;

. Direct flexible coupling;

. Tropicalised 4-stroke diesel motor;

. Air cooling;

. Power of motor: 3 hp;

. Centrifugal pump;

. Discharge: 18 m3/hour;

. Total delivery head: 17 m;

. The delivery orifice must be capable of taking flanges with internal diameters of 2", 2 1/2", 2 3/4" and 3";

. Suction pipe in reinforced rubber 6 m long equipped with a screen and foot valve;

. Delivery tube in reinforced rubber 6 m long, with diameter varying according to the diameter of the flange on the delivery orifice.

oOo

Appendix A.2

ONE HECTARE FARMS
SPECIFICATIONS FOR THE DELIVERY PIPES

-

1. GALVANISED STEEL PIPES

Supply

- 2", 2 1/2", 2 3/4" and 3" pipes 6 m long, threaded at each end;
- Assembly by means of a pipe coupling and sealing compound.

Laying

- Excavate a trench 50 cm wide along the pipe route (depth of between 0.5 and 1.0 m);
- Place 10 cm thick layer of sand at the bottom of the trench;
- Smooth the sand layer by hand;
- Install the pipe,
- Carry out pumping tests to check that there are no leakages along the pipeline;
- Cover the pipe with sand (10 cm thick layer);
- Backfill the trench;
- Mark out the pipe route by means of cement bench marks placed at points where there are changes in the direction of the pipeline.

ALUMINIUM PIPES

Supply

- 6 m long pipe sections of the ABC type, with male and female rapid-action couplings and seals at each end; diameters 2" and 3".

Laying

- Assemble the pipes laid on the ground simply by pushing them together.

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Appendix A.3

ONE HECTARE FARMS AND GEED DEEBLE EXPERIMENTAL FARM SPECIFICATIONS FOR THE CONSTRUCTION OF STORAGE TANKS

1. Construct a horizontal platform at least 10 m x 10 m at the point planned for the tank.

2. Compact the platform with a frog rammer or vibrating roller.

3. Level the platform to 0.4 m below the level of the base slab of the tank.

4. Peg out the tank.

5. Excavate the foundations.

6. Lay the foundations, using stones larger than 5 cm in diameter and less than 15 cm, set in cement mortar containing 250 kg of cement to each m3.

7. Construct the base slab for the tank, using stones greater than 15 cm in diameter set in cement mortar containing 350 kg of cement per m3, up to elevation -0.05 m with respect to the final level of the base slab.

8. Position the 4" outflow pipe equipped with the valve and pipe bend, with the pipe invert at the final elevation of the base slab.

9. Construct the walls of the tank in masonry identical to that used for the base slab up to elevation -0.05 m with respect to the final height of the walls.

10. Pour a concrete finish 5 cm thick (using 350 kg of cement per m3) on to the base slab and crest of the walls.

11. Fill in joints between the pieces of masonry both inside and outside the walls using a cement mortar containing 350 kg of cement per m3.

Appendix A.4

ONE HECTARE FARMS AND GEED DEEBLE EXPERIMENTAL FARM
SPECIFICATIONS FOR THE CONSTRUCTION OF CANALS

1. Compact the soil along the canal layout over an area extending 1.5 m on either side of the canal centre line (using a frog rammer or vibrating roller.

2. Construct an earth embankment compacted (as above) in 20 cm layers up to a level at least 20 cm above that of the bottom of the canals as shown on the longitudinal profiles. The crest width will be 1 m and the banks will have a slope of 1/2

3. Excavate a canal at the top of this embankment with a trapezoidal section and banks with a 1/1 slope. The bottom of the canal will be set at 5 cm below the level shown on the longitudinal profiles. The bottom width will be 15 cm.

4. Line the canal with flat stones set in cement mortar containing 250 kg of cement per m3, respecting the slope of the bed as shown on the longitudinal profiles and the shape of the canal as shown on the typical cross sections.

5. Fill in the joints between pieces of masonry with the same cement mortar and smooth off the surface to remove any roughness and irregularity.

6. Finish off the compacted embankments so that they conform to the typical cross sections.

oOo

Appendix B

COST ESTIMATE

Appendix B1

COST ESTIMATE
ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	MOTOR PUMP UNITS (20 farms)				
	SUPPLY				
	Diesel motor pump unit equipped with reinforced flexible draft tube, screen and foot valve.	u	20	20 000	400 000
	Delivery orifice:				
	. 2" dia.	u	9		
	. 2 1/2" dia.	u	7		
	. 2 3/4" dia.	u	3		
	. 3" dia.	u	1		
	Reinforced delivery tube, 6 m long:				
	. 2" dia.	u	9	1 000	9 000
	. 2 1/2" dia.	u	7	1 000	7 000
	. 2 3/4" dia.	u	3	1 000	3 000
	. 3" dia.	u	1	1 000	1 000
	Fixture collars	u	80	50	4 000
	TOTAL SUPPLY				424 000

Appendix B2

COST ESTIMATE
ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	WATER SUPPLY FROM WELLS TO RETENTION BASINS THROUGH GALVANISED STEEL PIPES (20 farms)				
	SUPPLY				
	Fixed supply pipes to fields made of galvanised steel (in 6-metre lengths) including couplings				
	. 2" dia.	u	50	900	45 000
	. 2 1/2" dia.	u	100	1 105	110 500
	. 2 3/4" dia.	u	100	1 210	121 000
	. 3" dia.	u	40	1 415	56 600
	TOTAL SUPPLY				333 100
	LABOUR				
	Skilled worker (1)	day	20	200	4 000
	Labourer (1)	day	180	80	14 400
	TOTAL LABOUR				18 400
	TRANSPORT				
	For reference (personnel transported with the field and canal teams)				0
	GENERAL TOTAL				351 500

Appendix B3

COST ESTIMATE

ONE-HECTARE FARMS

WATER SUPPLY FROM WELLS TO RETENTION BASINS
IN 2" AND 3" DIAMETER ALUMINIUM TUBES (20 FARMS)

SUPPLY		Unit weight
Mobile 2" diameter lengths	: 50 U	3.0 kg
Mobile 3" diameter lengths	: 240 U	5.8 kg
Female couplings 2" dia.	: 7 U	0.5 kg
Female couplings 3" dia.	: 13 U	1.9 kg
Joints 2" dia.	: 30 U	0.003
Joints 3" dia.	: 150 U	0.06

3.0 kg × 50 = 150 kg (+ one 50 kg case)	= 200 kg
5.8 kg × 240 = 1392 kg (+ two 100 kg cases)	= 1600 kg
0.5 kg × 7 = 4 kg; 1.9 kg × 13 = 25 kg; 0.003 kg × 30; 0.06 kg × 150 (+ one 20 kg case)	= 60 kg
	1860 kg

PURCHASE PRICE FF :

50 × 103	5 150
240 × 163	39 120
7 × 19	133
13 × 33	429
30 × 114	342
150 × 15	2 250
	47 724
Transport in France	5 000
Transport France-Djibouti 1860 × 10.8	20 000
Transport Djibouti-Hargeisa	5 000
Contingencies 20 %	15 500
	92 724 FF
	= 186 000 SoSh

Appendix B4

COST ESTIMATE

ONE-HECTARE FARMS

WATER SUPPLY FROM WELLS TO PRESSURE NETWORKS
IN 3" DIAMETER ALUMINIUM PIPES

		Unit weight
SUPPLY		
Mobile pipes in 6 m lengths 3" dia.	: 290 U	5.8 kg
Female couplings 3" dia	: 20 U	1.9 kg
Joints 3" dia	: 180 U	0.06 kg

4.8 kg x 290 = 1682 kg (+ three 100 kg cases) = 2000 kg
1.9 kg x 20 = 38 kg }
0.06 kg x 180 = 11 kg } (+ one 20 kg case) = 70 kg

2070 kg

PURCHASE PRICE FF :

290 x 163	47 270
20 x 33	660
180 x 15	2 700
	50 630
Transport in France	5 000
Transport France-Djibouti 2070 x 10.8	22 400
Transport Djibouti-Hargeysa	5 000
Divers 20 %	16 600
	99 630 FF
	= 200 000 SoSh

Appendix B5

COST ESTIMATE

ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	CONSTRUCTION OF A 52 m3 WATER RETENTION BASIN				
	SUPPLY				
	. Rockfill for foundations (100 mm < D < 200 mm)	m3	3	180	540
	. Rockfill for floor and sides (200 mm < D < 400 mm)	m3	24	210	5 040
	. Cement	t	5	5 000	25 000
	. Sand	m3	14	180	2 520
	. Gravel	m3	2.5	210	525
	. 4" dia. galvanised steel pipe	lm	1	300	300
	. 4" dia. cast iron 90° bend	u	1	300	300
	. 4" dia. brass valve	u	1	1 000	1 000
	TOTAL SUPPLY				35 225
	LABOUR				
	. Mason - Site foreman (1)	day	12	300	3 600
	. Mason (1)	day	12	200	2 400
	. Labourers (6)	day	72	80	5 760
	. Watchman (1)	month	0.5	700	350
	. Surveyor (1)	month	0.5	1 800	900
	TOTAL LABOUR				13 010
	TRANSPORT				
	. Land Rover station wagon (12 days x 80 km)	km	960	3	2 880
	TOTAL TRANSPORT				2 880
	GENERAL TOTAL FOR ONE RETENTION BASIN				51 115
	or 1 022 000 SoSh for the 20 farms				

Appendix B6

COST ESTIMATE

ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	CONSTRUCTION OF A 36 m3 WATER RETENTION BASIN				
	SUPPLY				
	. Rockfill for foundations (100 mm < D < 200 mm)	m3	3	180	540
	. Rockfill for floor and sides (200 mm < D < 400 mm)	m3	20	210	4 200
	. Cement	t	4	5 000	20 000
	. Sand	m3	12	180	2 160
	. Gravel	m3	2	210	420
	. 4" dia. galvanised steel pipe	lm	1	300	300
	. 4" dia. cast iron 90° bend	u	1	300	300
	. 4" dia. brass valve	u	1	1 000	1 000
	TOTAL SUPPLY				28 920
	LABOUR				
	. Mason - Site foreman (1)	day	12	300	3 600
	. Mason (1)	day	12	200	2 400
	. Labourers (6)	day	72	80	5 760
	. Watchman (1)	month	0.5	700	350
	. Surveyor (1)	month	0.5	1 800	900
	TOTAL LABOUR				13 010
	TRANSPORT				
	. Land Rover station wagon (12 days x 80 km)	km	960	3	2 880
	TOTAL TRANSPORT				2 880
	GENERAL TOTAL FOR ONE RETENTION BASIN				44 890
	or 896 000 SoSh for the 20 farms				

Appendix B7

COST ESTIMATE
ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	<u>STONE-FACED CANALS</u> (20 farms) 10 l/s h = 0.20 m 8 545 lm				
	SUPPLY				
	. Flat stone chips E < 0.05	m3	200	180	36 000
	. Cement	t	32	5 000	160 000
	. Sand	m3	130	180	23 400
	TOTAL SUPPLY				219 400
	LABOUR				
	. Mason - Site foreman (1)	day	240	300	72 000
	. Assistant mason (1)	day	240	200	48 000
	. Labourers (4)	day	960	80	76 800
	. Watchman . Surveyor — For reference, the same as those for the retention basin works				
	TOTAL LABOUR				196 800
	TRANSPORT				
	. Land Rover station wagon (240 days x 80 km)	km	19 200	3	57 600
	TOTAL TRANSPORT				57 600
	<u>GENERAL TOTAL FOR CANALS</u>				473 600
	<u>STOPLOGS</u>				
	SUPPLY				
	. Watertight tarpaulin stoplogs 0.50 m x 1.20 m with support rods	u	400	50	20 000
	GENERAL TOTAL STOPLOGS				20 000
	GENERAL TOTAL FOR FULLY-EQUIPPED CANALS				493 800

Appendix B8

COST ESTIMATE

ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	STONE-FACED CANALS (20 FARMS) 5 l/s h = 0.15 m 8545 lm				
	SUPPLY				
	Flat stone chips E < 0,05	m3	160	180	28 800
	Cement	T	27	5000	135 000
	Sand	m3	110	180	19 800
		TOTAL SUPPLY			183 600
	LABOUR				
	Mason - Site foreman (1)	day	200	300	60 000
	Assistant mason (1)	day	200	200	40 000
	Labourers (4)	day	800	80	64 000
		TOTAL LABOUR			164 000
	TRANSPORT				
	Land Rover station wagon (200 days x 80 km)	km	16 000	3	48 000
		TOTAL TRANSPORT			48 000
	GENERAL TOTAL FOR CANALS				395 600
	COFFERDAMS				
	SUPPLY				
	Watertight tarpaulin stoplogs 0.40 m x 1.50 m with support rods	U	400	50	20 000
	GENERAL TOTAL STOPLOGS				20 000
	GENERAL TOTAL FOR FULLY-EQUIPPED CANALS				415 600

Appendix B9

COST ESTIMATE
ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	MOBILE ALUMINIUM PIPES FOR IRRIGATION 3" DIAMETER				
	SUPPLY				
	. 6-metre lengths 5.8 × 718 = 4164 kg (+ seven 100 kg cases) ≃ 4 900 kg				
	. Female couplings 0.9 × 30 = 27 kg + (one 20 kg case) ≃ 50 kg				
	. In-line and end tees 2.2 kg × 38 = 84 kg + (two 20 kg cases) ≃ 120 kg				
	. Caps 0.7 × 30 = 21 kg + (one 20 kg case) ≃ 40 kg				
	. 90° bends 1.7 kg × 65 = 110 kg (+ two 20 kg cases) ≃ 150 kg				
	. 45° bends 2.0 kg × 26 = 52 kg + (one 20 kg case) ≃ 70 kg				
	. Joints 0.06 kg × 400 = 24 kg+(one 20 kg case) ≃ 40 kg				
	≃ 5370 kg ≃ 5400 kg				
	PURCHASE OF EQUIPMENT FF	U	718	163	117 034
		U	30	33	990
		U	38	134	5 092
		U	30	34	1 020
		U	65	110	7 150
		U	26	110	2 860
		U	400	15	6 000
					140 146
	Transport in France				10 000
	Transport France-Djibouti (5400 kg × 10.8)				58 320
	Transport Djibouti-Hargeisa				10 000
	Contingencies + Commission 20 %				44 000
3"	DIAMETER PRESSURE IRRIGATION				262 466 FF 525 000 SoSh

Appendix B10

COST ESTIMATE
ONE-HECTARE FARMS

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	MOBILE ALUMINIUM PIPES FOR IRRIGATION 4" DIAMETER				
	SUPPLY				
	. 6-metre lengths				
	8.8 kg x 718 = 6318 kg (+ seven 100 kg cases) ≃ 7000 kg				
	. Female couplings				
	1.9 kg x 30 = 57 kg + (one 20 kg case) ≃ 80 kg				
	. In-line and end tees				
	4.5 kg x 38 = 171 kg + (two 20 kg cases) ≃ 210 kg				
	. Caps				
	1.3 kg x 30 = 39 kg + (one 20 kg case) ≃ 60 kg				
	. 90° bends				
	3.4 kg x 65 = 201 kg + (three 20 kg cases) ≃ 260 kg				
	. 45° bends				
	2.6 kg x 26 = 68 kg (+ one 20 kg case) ≃ 90 kg				
	. Joints				
	0.17 kg x 400 = 68 kg (+ one 20 kg case) ≃ 90 kg				
	7790 kg				
	≃ 7800 kg				
	PURCHASE OF EQUIPMENT FF	U	718	264	189 552
		U	30	70	2 100
		U	38	205	7 790
		U	30	48	1 440
		U	65	150	9 750
		U	26	150	3 900
		U	400	21	8 400
					222 392
	Transport in France				10 000
	Transport France-Djibouti (7800 x 10.8)				84 240
	Transport Djibouti-Hargeisa				10 000
	Contingencies + Commission 20 %				65 000
					391 732 FF
4"	DIAMETER GRAVITY IRRIGATION				785 000 SoSh

Appendix B11

COST ESTIMATE

GEED DEEBLE FARM

Price No	Description	Units	Quantity	Unit price	Cost SoSh
	STONE-FACED CANALS				
	SUPPLY				
	. Flat stones E < 0.05	m3	55	180	9 900
	. Cement	T	9	5000	45 000
	. Sand	m3	36	180	6 480
	TOTAL SUPPLY				61 380
	LABOUR				
	. Mason -Site foreman (1)	day	70	300	21 000
	. Assistant mason (1)	day	70	200	14 000
	. Labourers (4)	day	280	80	22 400
	. Watchman (1)	month	3	700	2 100
	. Surveyor (1)	month	3	1 800	5 400
	TOTAL LABOUR				64 900
	TRANSPORT				
	. Land Rover station wagon (90 j × 50 km)	km	4 500	3	13 500
	TOTAL TRANSPORT				13 500
	GENERAL TOTAL				139 780
	STOPLOGS				
	SUPPLY				
	. Watertight tarpaulin stoplogs 0.40 m × 1,50 with support rods	u	20	50	1 000
	GENERAL TOTAL FOR FULLY-EQUIPPED CANALS				140 780

Appendix C

DRAWINGS

LIST OF DRAWINGS

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