SOMALI DEMOCRATIC REPUBLIC
NATIONAL REFUGEE COMMISSION

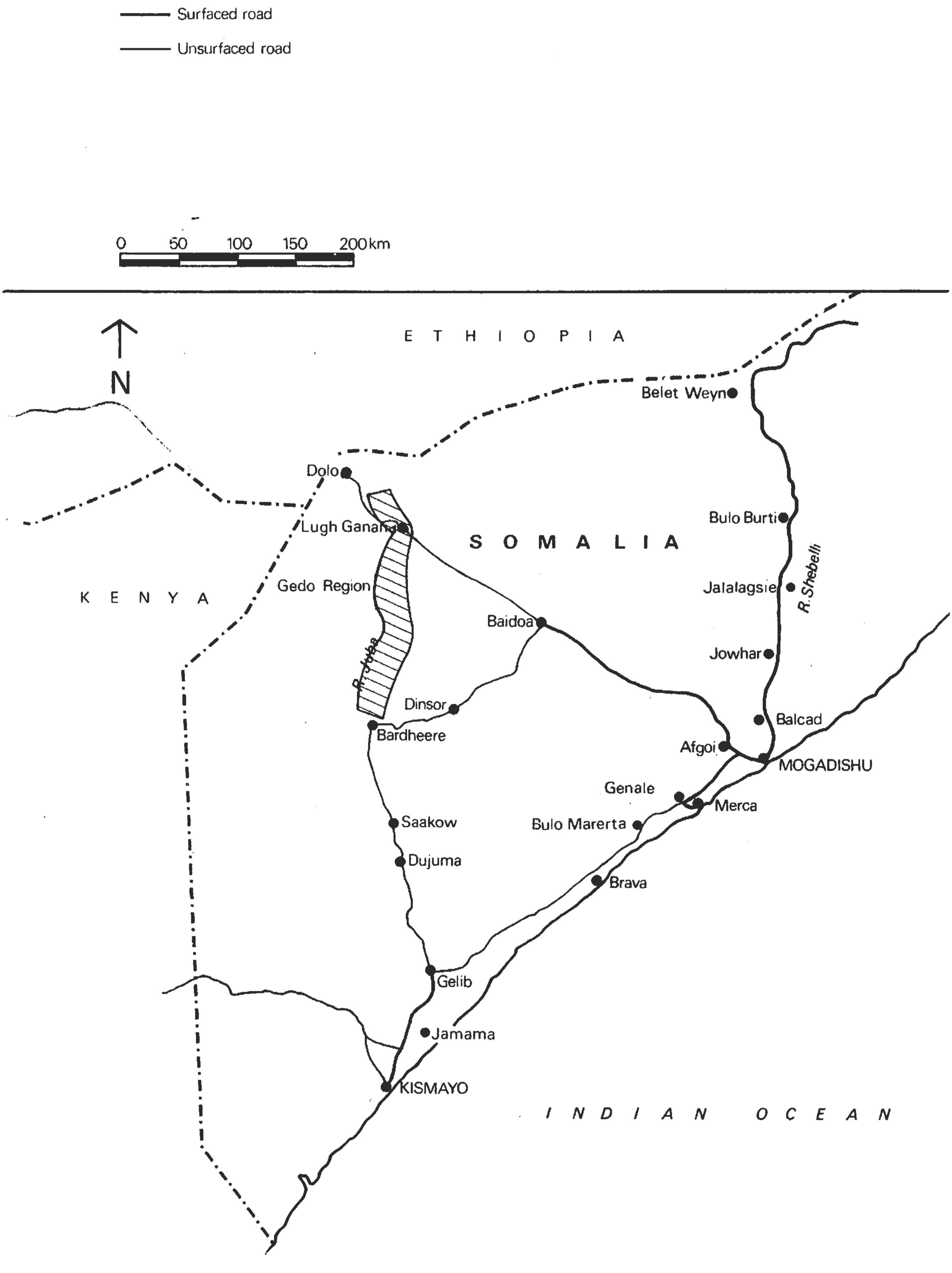
Reconnaissance and Pre-Feasibility Studies in Jalalagsie & Jowhar Districts and Gedo Region

Pre-Feasibility Report for Gedo Region

SIR M MACDONALD & PARTNERS LIMITED
Consulting Engineers
Demeter House, Station Road, Cambridge CB1 2RS, United Kingdom

OCTOBER 1980

PROJECT LOCATION MAP



PRE-FEASIBILITY REPORT

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ACKNOWLEDGEMENTS

Sir M. MacDonald & Partners Limited would like to thank the National Refugee Commission and the office of the United Nations High Commissioner for Refugees (UNHCR) in the Somali Democratic Republic together with Oxfam, the Menonite Central Committee and other relief organisations co-ordinated by UNHCR for their help and assistance received during the preparation of this Report.

They would also like to record their appreciation of the assistance and support given by the staff of other Government Ministries and Agencies both in Mogadishu and in the project areas.

Sir M. MacDonald & Partners Limited wish to thank Hunting Technical Services Limited who carried out the soil survey and provided the agricultural input for this report.

SUMMARY

An area for development at Halba some six kilometres north of Luuq on the right bank of the River Juba following topographic and soil surveys.

An irrigation and drainage layout has been prepared for a development covering 400 hectares nett cultivable area.

The soils in the area surveyed showed no Class 1 or Class 2 soils, 99.5% was classified as Class 3 and the remaining 0.5% as Class 4. Some gypsum was present in the soils and this has been taken into account in preparing the irrigation and drainage layout.

A cropping pattern of 150% intensity is proposed including pulses, maize, tomatoes, onions with some other vegetables and a fallow period in the gu season on 50% of the area is included.

It is suggested that the 20 ha watercourse units be allocated to 40 families, giving each a 0.5 ha holding, 38 of these could be refugee families and the remaining two for local farmers. Each watercourse unit would operate as a small co-operative.

The capital costs for the components of the project have been estimated at So.Sh. 14,037,000 with a foreign exchange component of So.Sh. 8,552.00. These costs do not include the provision of any housing for any project staff or any others employed on the scheme. Annual costs were estimated at So.Sh. 553,100.

Theses costs are based on best estimates for similar works in Somalia. Some reduction in costs may be possible at the design stage taking into account resources available and the Government's requirements.

Early implementation should be possible. Success of the development will depend on effective management, timely provision of plant, materials, equipment and farm inputs and satisfactory provision for obtaining imported spare parts for servicing the plant and equipment.

CHAPTER 1

INTRODUCTION

1.1 Background to the Study

Since 1978 substantial numbers of refugees have arrived in the Somali Democratic Republic from the Ogaden Region. Most of these refugees were originally nomadic and because of the loss of their livestock and most of their other possessions it was apparent that they would require total support from the host government.

The Government of Somalia to deal with these refugees has set up camps in separate areas of the country; one of these is the Gedo Region, located along the River Juba, north of the town of Baardheere. It is this area that this report deals with - or more specifically Luuq District, see Project Location Map.

In July 1980 the National Refugee Commission retained Sir M. MacDonald & Partners Limited to carry Reconnaissance and Pre-Feasibility Studies in the Jalagsie and Jowhar Districts and Gedo Region.

The reconnaissance studies were completed in August 1980 and the Reconnaissance Report submitted on 28th August 1980. This Report deals with the second stage - the pre-feasibility studies.

1.2 Scope and Objectives of Study

The Terms of Reference for the current study are set out in full in Appendix A. This report is only concerned with the terms of reference in Clause 2.3 for the development of 300 to 400 hectares at Halba.

1.3 Reconnaissance Report Findings

The recommendations in respect of Gedo Region are given in Section 5.5 of the Reconnaissance Report (MMP 1980) but may be briefly summarised as follows:-

a) That the semi-detailed soil survey should be made of the land last identified by Technital SpA (1975) as suitable for irrigation. That the soil survey of the present study should confirm this recommendation

b) There was no potential for agricultural development between Luuq and Baardheere because of the probable development of the Baardheere Dam and its reservoir. Because of this it was recommended that further arriving refugees should be directed to other areas. In this respect the positive identification of suitable new camp sites in Luuq District and elsewhere in Somalia is most urgent.

c) It had been suggested (Technital 1975) that maize, sorghum, wheat, oilseeds, cotton, jute, pulse and vegetables might be grown in the area. The Reconnaissance Report stressed the importance of growing as many vegetables as possible to provide a variation to the diet of the refugees which cannot be provided by outside agencies because of their perishable nature

d) The Baidoa-Luuq road is in poor condition due to the increased traffic required to service the refugee camps in the area. An adequate maintenance and repair programme was required with consideration given to obtaining international assistance to construct an improved road

e) It will be advantageous to include a proportion of indigenous farmers in any refugee development and in the initial years of construction and operation the need for expatriate assistance is essential if a successful project is to result. adequate funds must be available to purchase seed, fertilizer, pesticides, herbicides and to provide for the purchase of spares for pumps, motors and any other agricultural machinery on the project

f) If large numbers of refugees were to remain in the Luuq District then early efforts were needed to assess the total area available for agricultural development in the District. Such a study would show the number of refugees the area could reasonably sustain.

CHAPTER 2

EXISTING REFUGEE CAMPS

2.1 Refugee Problem

Recent reports from the Somali Government indicate that there are about 700,000 refugees housed in some 27 camps after fleeing from their homes in the disputed Ogaden region. In addition the United Nations officials say that another one and half million are living outside of the camps.

It would appear that the flow of refugees has not stopped and the latest estimates available refer to 700 refugees still arriving each day in Somalia. This would confirm that camp populations will increase.

The United Nations Commissioner for Refugees together with a large number of aid agencies are assitaing the Somali Government at this time.

2.2 Existing Refugee Camps in the Area

The National Refugee Commission has reported that there are fourteen camps in the Gedo Region three of which are transit camps.

Of the eleven 'permanent' refugee camps in the Region four are located in Garbahaarey District and the remainder, seven, in Luuq District. These are shown on Figure 2.1 which gives the other main features in the area.

The refugee population has expanded very rapidly in the last two years. A report by the State Planning Commission refers to a total refugee population, in two camps near Luuq of about 6,570 persons in July 1978. Exactly two years later there are about 350,000 refugees in eleven camps in the Region. The exact number of refugees is difficult to estimate and in spite of continued efforts by the camp commanders there is evidence of some inaccuracies in camp totals. However it is believed that the total number of refugees in the seven camps near Luuq is about 225,000 people and that the four camps in Garbahaarey District contain about 125,000 people. As in other areas the majority of the camp population comprises children under 15 years of age and there are very few adult males who permanently live in the camps. However there is evidence that substantial numbers of men visit the camps either from their disturbed homelands or from tending their livestock so that at any one time the number of men exceeds the total recorded by the camp commanders.

It is now clear that the refugees outnumber the population of the whole region by nearly two to one and that they outnumber the populations of the directly affected Districts by more than four to one.

2.3 Irrigation Development at Existing Camps

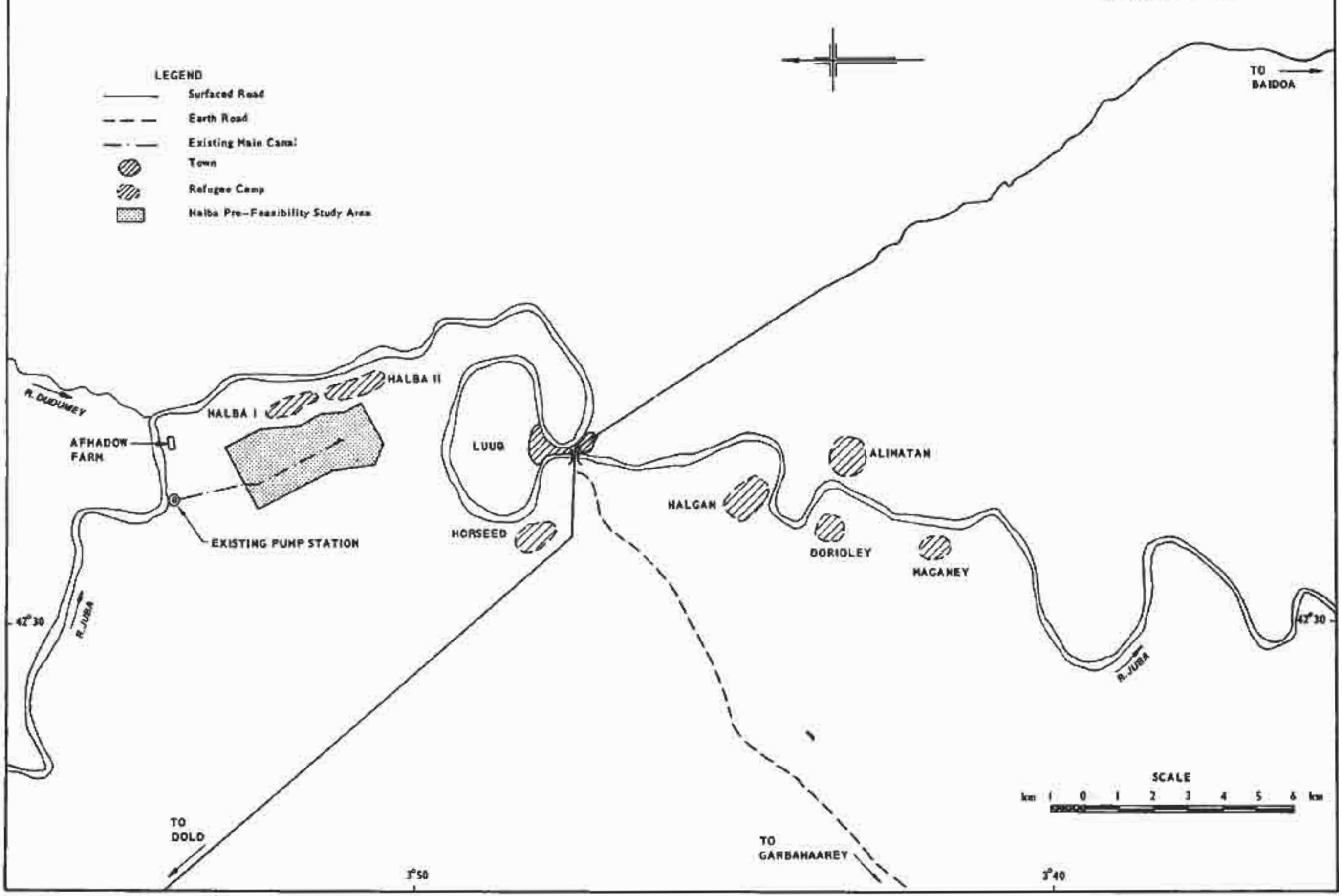
There were reported to be less than 200 hectares with irrigation facilities located at the four camps in the Garbahaarey District.

In the Luuq District the following irrigation facilities were observed during the fieldwork by the Consultant's Team. At Alimatan and Halgan, see Figure 2.1, very small areas have been developed. At Horseed 100 hectares were available for cropping and about half was under crop and at Halba between 300 and 450 hectares have been cleared and approximately 100 hectares was cultivated at the beginning of August 1980.

More details of the development at Halba is given in Chapter 6 - Present Situation.

FIGURE 2.1

LOCATION OF HALBA STUDY AREA



CHAPTER 3
HYDROMETEOROLOGY

3.1 Climate

Annual movement of the Inter Tropical Convergence Zone (ITCZ) is the dominant feature of Somalia's climate. The ITCZ marks the convergence of the north-east and south-west monsoons and moves north and south of the equator following relative movement of the sun's zenith. The converging air masses are forced to rise in a zone of atmospheric instability and low pressure: these conditions are responsible for almost all rain in the study area.

The south-west monsoons blow from June to September when the ITCZ is north of Somalia. These winds bring occasional moist air inland, causing showers near the coast. However, these showers rarely penetrate as far inland as the study area and average rainfall throughout the period is very low. The ITCZ passes from north to south over the study area during October and November, the der season, bringing variable amounts of cloud and rain. The north-east monsoons blow from December to March: these winds blow roughly parallel to the coast and are dry during their passage over Somalia. Very little rainfall therefore occurs during this period. The north-east monsoons subside as the ITCZ approaches from the south, bringing the gu season rains of April and May.

Table 3.1 summarises climatic data for Luuq, the nearest climate station to the Study area. These data are based on Fantoli (1965).

3.2 Rainfall

Rainfall within the study area is insufficient for rainfed agriculture except in the occasional good gu season. Table 3.2 gives average monthly rainfalls at Luuq and estimated

TABLE 3.1

Average Climate Data : Luuq

(03°45'N 42°35'E Altitude 193 m)

	Temp°C 1923-63 (21)	Humidity % 1923-63 (14)	Wind km/day 1953-63 (2)	Cloudiness 1/10 1924-58 (16)
Lugh Ganana (Ferrandi) 03° 45'00" N 42° 35' 00" E altitude 163 m				
January	31.2	52	66	1.5
February	32.1	47	83	1.1
March	33.0	51	97	2.5
April	31.6	61	79	4.4
May	30.0	65	73	4.0
June	29.4	60	100	4.0
July	28.1	62	110	5.0
August	28.2	59	110	4.4
September	29.5	56	120	3.4
October	30.1	60	86	4.7
November	30.2	61	60	4.0
December	30.4	55	60	2.3
Year	30.3	57	87	3.5

Source: HTS (1977)

rainfalls exceeded 3 years in 4 (75% reliability level) calculated by assuming monthly rainfall follows a normal distribution. A 75% reliability level has been previously used for assessing the depth of rainfall which can be reasonably expected by the farmer (HTS 1977).

Also shown in Table 3.2 are monthly effective rainfalls at the 75% reliability level assessed by the US Bureau of Reclamation method used in previous reports for Somalia (MMP 1978a). For monthly rainfalls within the ranges 0 to 25 and 50 to 75 mm the USBR method assumes 90% and 75% respectively are effective and contribute to crop evapotranspiration. The proportion of rainfall which is effective is a complex function of rainfall intensity and duration, soil parameters, topography and other factors. The USBR method is a crude assessment of effective rainfall but appropriate to Somalia in view of the small total rainfall.

TABLE 3.2

Rainfall at Luuq (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Average	1	2	30	128	27	0	0	0	1	25	61	14	289
75% reliable	0	0	0	84	11	0	0	0	0	6	21	0	122
Effective	0	0	0	63	10	0	0	0	0	5	19	0	97

(Based on monthly rainfalls 1954 to 1965 in Fantoli (1965))

3.3 Evapotranspiration

Table 3.3 gives values of monthly reference crop evapotranspiration (ET_o) extracted from HTS (1977) and Doorenbos and Smith (1977) and compares them with recalculated values based on the data of Table 3.1 and the modified Penman method given by Doorenbos and Pruitt (1977).

TABLE 3.3

Reference Crop Evapotranspiration at Luuq (mm/month)

	Source			Adopted for Study Area
	HTS (1977)	D&S (1977)	Recalculated	
January	170	210	192	210
February	168	195	195	195
March	193	243	222	243
April	160	203	178	203
May	156	190	172	190
June	148	188	171	188
July	141	180	166	180
August	151	195	179	195
September	167	208	196	208
October	158	205	176	205
November	148	188	162	188
December	158	205	180	205
Year	1918	2410	2189	2410

Values from HTS (1977) are based on the original Penman equation which gives less emphasis to the action of wind than the modified Penman method. It is therefore expected that these values are lower than recalculated values although the same base data are used. Doorenbos and Smith (1977) values are higher than recalculated, presumably because of correction factors not reported by them. These factors are said to account for local conditions and their values are therefore used in preference to other estimates.

CHAPTER 4

LAND RESOURCES

4.1 Geology

In the area around Luuq, Mesozoic sedimentary rocks and overlying Tertiary basalts dip gently to the south and lie adjacent to Quaternary alluvial formations along the Juba River. The Mesozoic succession includes limestones and marls with some gypsum of the upper Jurassic Garbeharre Suite (UNDP 1972), and Lower Cretaceous gypsum and anhydrites of the Main Gypsum Formation (Merla, Abbate 1973). The Study Area lies on Quaternary alluvium and is considered to be underlain by the Jurrassic limestones.

4.2 Geomorphology

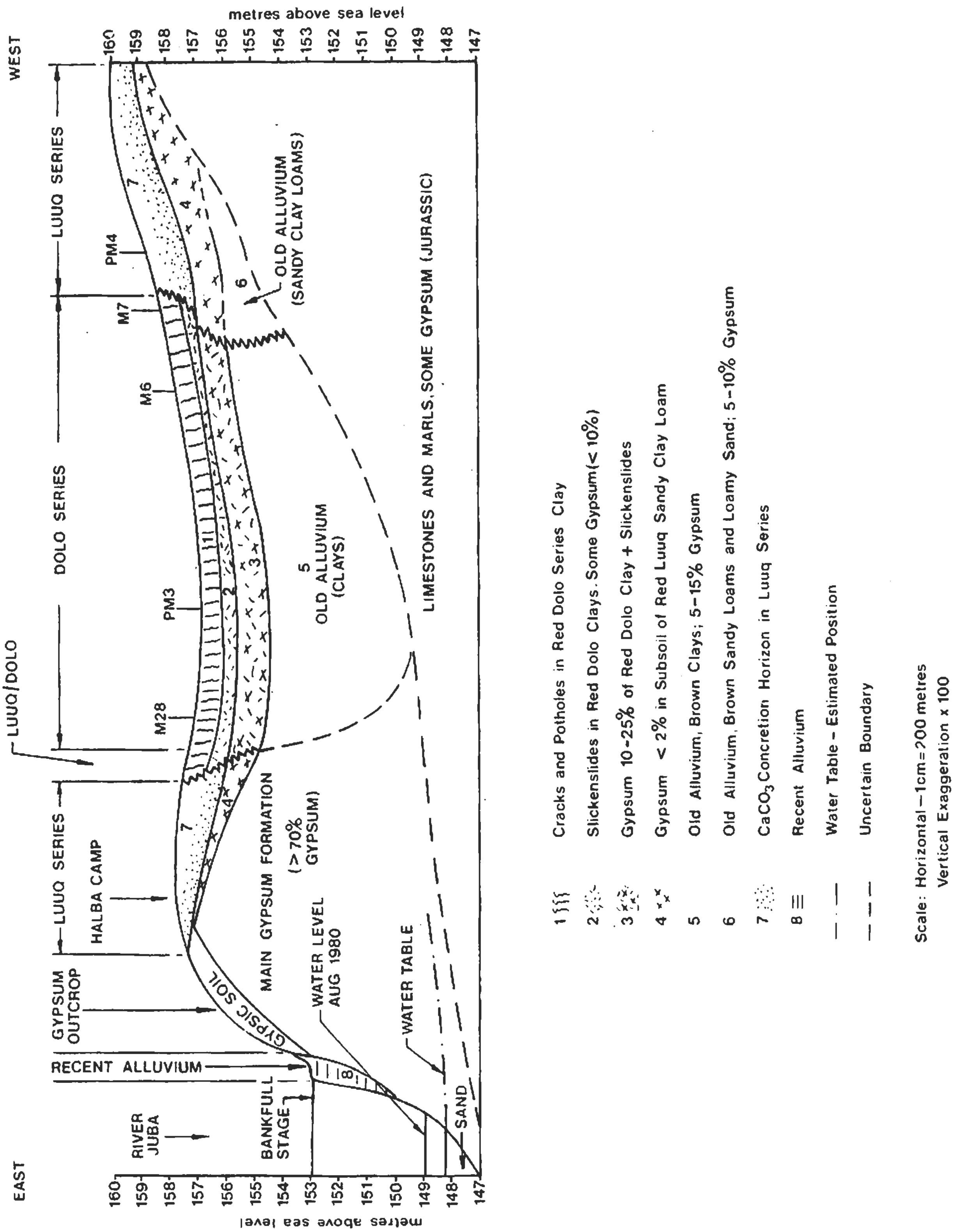
Geomorphological investigations were made to determine the relations of the alluvium to underlying rock formations and the evolution of slopes and sediments, in order that soil variation and engineering problems with gypsum beds and drainage hazards could be assessed.

In the early Pleistocene it is thought that the Juba River occupied a broad floodplain, some 5 to 9 km wide, along the boundary between Jurassic limestones and Cretaceous Gypsum.

Over a long period of time the Juba cut a trench down into the limestone marl beds, and the Main Gypsum beds were largely denuded. The old alluvium is at least 4 m thick (the maximum observed depth of the Study) and may be 8-10 m thick in total (Figure 4.1). The old floodplain consisted of a weakly braided channel system that is still very clearly shown on aerial and LANDSAT photography. Light photo tones indiçate the former sandy midchannel bars, that are in places 1.5 km wide, which are distinct from the dark tones of the slightly depressed channel features that are up to 1 km wide. Sediment of the mid-channel bars include sandy clay, sandy clay loam, and at the base sandy and some gravelly particle size classes. The channels are dominated by clayey sediments, locally with sandy alluvium below 1.5 m. Subsequently, after abandonment of this floodplain, pedogenesis affected the upper 2 m of the alluvium and the distinctive clayey Dolo and sandy clay loam Luuq soils were formed (4.6). The Study area lies astride one of the old channels of the Juba in the clayey Dolo soil, at about 157 m above sea level. The ground slopes gently up onto the adjacent sandy channel bards of the Luuq soil at 157 to 159 m above sea level. Gypsum occurs in both the clayey and sandy alluvium down to 4 m, but is not considered to be a serious problem since it is in the form of small irregular segregations and crystalline masses, rather than as hard thick layers which could lead to solution collapse problems.

East of the old floodplain, and probably contemporaneously with the old Juba alluvium a deep highly gypsic soil developed on the Main Gypsum formation. This soil shows characteristic solution cavities and light porous surfaces. It is considered that these porous and massive gypsum deposits do not lie underneath the older alluvium in the study area, but are some gypsum beds in the limestone formation that underlies much of the study area. The cross section (Figure 4.1) suggests the likely relationships of the underlying formations and soil features. The water table was not recorded in any bores down to 4 m, and from Figure 4.1 is estimated to be at about 7 m depth. The presence of largely impermeable limestone and marls at about 7 m may cause a rising of this water table, when irrigation begins on a large scale. There are gypsic horizons in the soils and these are considered later in Section 4.6 but thick gypsum deposits which could prove to be troublesome for engineering structures in terms of subsidence and solution collapse are lacking over most of the study area, and are confined to the land east of the channel landform of the old alluvium.

GEOMORPHOLOGY AND SOIL CROSS SECTION – HALBA AREA



When the Juba river abandoned its former floodplain, it moved eastwards cutting a new channel in the gypsum rocks and depositing a narrow strip of alluvium along its banks (Figure 4.1). This channel is now quite deeply incised and at Luuq is entrenched into Jurrasic limestones.

4.3 Natural Vegetation, Land Use and Erosion

Moderately dense riparian forest dominated by large trees, especially _Acacia nilotica_ with _Salvadora persica_ bushes, occupies the recent alluvium and gypsic rocks along the Juba river in the Halba area. Denudation of this forest is steadily progressing as greater numbers of refugees forage for firewood.

The camps themselves are partly placed under the _Acacia_ trees and some conservation is likely.

On the sandy Luuq soil the natural vegetation is a moderately dense _Commiphora sp_, and _Acacia sp_ thorn bush woodland. In wet years grasses and herbs cover the compact surface, but at present the surface is very bare. This woodland offers a ready supply of firewood, but when it is all removed, runoff on the slight slopes of the Luuq soil will increase and transport medium to coarse sand down onto the flat clayey Dolo soils. The Luuq soil is not cultivated due to, droughtiness, and a high coefficient of runoff on the slight slope. Tracks of heavy vehicles on the Luuq soil (and Lugh-Dolo intergrade) are deeply incised and there is a thick pulverised layer of dust.

On the Dolo soil the natural vegetation is largely destroyed at this time since water harvesting has been practised on these soils for a long time. The 1960 aerial photography, the most recent available, shows shallow bunds along the old channels, occupied by the Dolo soil, and runoff from adjacent slopes on Luuq soil was collected and used for growing one crop of sorghum. Only a few original trees remain, which are all _Dobera glabra_. Abandoned land on Dolo soil at present not yet under irrigated cultivation is often thickly colonised by the gall-Acacia *Acacia zanzibarica*. The *Commiphora-Acacia* thorn bush woodland occupies a narrow zone of the Dolo soil. There is only a slight water erosion hazard on the Dolo soil where gullying is encroaching onto the soil close to the south east edge of the area. Increased mechanisation of the clay soil could lead to depletion of the powdery mulch, but this mulch in general seems to be wind stable due to the presence of numerous small calcium carbonate concretions. Tracks of heavy vehicles on the Dolo soil are not accompanied by a loose dust layer, as on the Luuq and the surface remains very hard.

4.4 Soil Survey Methods

Soil and land classification studies were conducted during August 1980 in the Halba area, north of Luuq, on the right bank of the Juba River. The level of the survey was semi-detailed, and auger borings (to 2 m) and pits (2 m with a 2 m auger bore in the bottom) were made on a loose grid to give an overall density of 4 sites per square kilometre. In all 4 soil pits were described and sampled, and 28 auger borings were described and 3 sampled. In addition infiltration tests were conducted at two sites on the major soil types. The tests comprised measuring the rate of vertical movement into the soil using 3 replicates of double ring infiltrometers, with inner ring diameters of 300 mm. Hydraulic conductivity tests were also carried out at these sites, and in the absence of a shallow water-table the pour-in method was used.

The boundaries on the soil map were drawn up on the basis of soil auger and pit data points; field observations on traverses between bores; photo interpretation from the 1960 Hunting Services aerial photography (1:82160); and interpretation of boundaries between data points.

4.5 Previous Soil Studies

The soils of the Halba Study Area have not been examined in detail before. The Lockwood-FAO report (1968) showed two soil series west of the Juba river in the Halba area, which were named the Dolo and Lugh (Luuq). The Dolo was classified as a reddish brown calcic soil developed on the gypsiferous mantled plain landform. The Dolo was deep, fine textured, and non saline, but subsoil gypsum was substantial. Both subsequent studies by Technital-Juba River Development Study (1975), and HTS - InterRiverine Agricultural Study (1977) gave the Dolo soil a Class IV suitability because of high gypsum in the subsoil. It is important to note however that the only analysed Dolo soil of Lockwood-FAO was located some 50 km north west of Luuq on the road to Dolo, and is not necessarily representative of the very substantial area of Dolo soils mapped by Lockwood-FAO in this part of Somalia.

The Luuq soil was described as: a dark red to reddish brown calcic soil with medium sandy clay loam to sandy loam textures; calcium carbonate concretions in the subsoil; moderate alkalinity; non-saline; and low available water capacity. Two sites were analysed, 2 km south and 20 km north west of Luuq. These showed very different results, with the soil south of Luuq being high in gypsum, alkalinity and salinity; the other low in all these analyses. It appears that the first of these was wrongly described and represents another soil type. The soil was described as being formed on erosion products of limestone and sandstone. The HTS InterRiverine and Technital Juba River studies both gave the Luuq soil a Class III suitability for irrigation, downgraded because of coarser textures, and both in noting that salinity and sodium were low appear to have ignored the soil south of Luuq.

4.6 Soil Mapping Units

4.6.1 Introduction

In the present study of the Halba area, the broad findings of the previous investigations were confirmed. This study has mapped the two major soil series - the Luuq and the Dolo, which were first identified by Lockwood-FAO (1968). The soil mapping is given in Figure 4.2. The Luuq and the Dolo are considered to be fairly mature soils developed on alluvium deposited by a broad palaeo-river of the Juba. The evolution of this system has already been described in Section 4.2. The semi detailed study at Halba has further refined the soil series with phases defined on basis of high gypsum content; subsoil sandy layers; and intergrade Luuq-Dolo soils where features common to both occur (see Table 4.1). These soils and phases are now described and assessed.

4.6.2 Dolo Series

a) Description

The Dolo soil has formed on clayey alluvium of an old (Paldeo) channel of the Juba River. The surface of the soil consists of a loose granular mulch five to ten centimetres thick, which is wind stable, probably due to presence of many small manganese dioxide coated calcium carbonate concretions in the surface layers. There are also some small 'desert rose' clusters of gypsum which have probably come to the surface by churning. This natural mulch is easily worked when the soil is dry and provides a perfect seed bed. There are numerous potholes formed by the mulch falling down soil cracks.

Below the mulch are more stable and slightly hard subangular blocky clays becoming increasingly hard to very hard angular blocky and very coarse prismatic structured clays, with a hexagonal cracking pattern. Cracks extend to one metre, where the soil is already very compact and wedge structures are developing. Roots occur down to 150 cms, but cannot extend below this due to compaction and heaving of the soil. Slickenslides are quite common and occur between 80 and (to at least) 200 cms depth. Fine, hard, manganese dioxide coated concretions occur throughout the profile, becoming soft at about 150 cms, where hues change from 2.5 YR to 7.5 YR and where there is evidently neoformation of these concretions and of gypsum. The gypsum is in the form of globular crystals ('desert rose')

TABLE 4.1

Soil Mapping Units

Map Code	Series Name	Phase	Soil Classification (FAO)	Profile Characteristics	Soil Drainage	No. of Observations	Area ha	% of Area
D	Dolo	Normal	Chromic vertisol	Red clay; cracks; calcareous gypsum in sub-soil	Imperfect	19	570	73.5
D1	Dolo	Loamy deep subsoil	Chromic vertisol	Red clay; cracks; calcareous; loamy alluvium in subsoil	Moderate	4	23	3
D2	Dolo	Gypsic layers in subsoil	Chromic vertisol	Red clay; cracks; calcareous; hard gypsic subsoil	Imperfect	1	4	0.5
L	Luuq	Normal	Calcic cambisol	Dark red sandy clay loam; $CaCO_3$ concretions; gypsum in deep subsoil	Moderate to well	6	138	18
L/D	Luuq/ Dolo	Intergrade of Luuq and Dolo	Vertic cambisol	Dark red sandy loam over sandy clay	Imperfect to Moderate	2	40	5
					TOTAL	32	775	100

2 to 10 mm in diameter. The churning movement of the Dolo soil, with its assumed Montmorillonite clays, leads to upwards migration of gypsum crystals and the black concretions towards the surface. Material falls down cracks again, and there is thus a cyclical movement of soil and large particles, which is probably instrumental in maintaining low to moderate levels of salinity in a semi arid climate where natural rainfall leaching is poor. Similarly the presence and movement of gypsum in the profile in moderate quantities enables calcium to replace sodium in the exchange complex, and the exchangeable sodium percentage (ESP) can be lowered naturally. Gypsum levels in the Dolo soil at Halba increase from less than 3 per cent in the top metre, to between nine and fifteen per cent between 100-400 cm depth. As noted earlier, the gypsum is mostly in the form of discrete crystals, within a clayey matrix. Between 150 and 200 cms there is a distinct mottling in the clays where the 2.5 YR and 7.5 YR colours interchange. There is no water table within at least 2 metres of this feature, and it could be interpreted as a relic of the limit of pedogenesis in the Dolo soil. Residual moisture however is sufficient probably for neoformation of gypsum and black concretions at depth, but this zone is not considered to be an impediment to drainage. Between 2 and 4 metres, clay textures predominate, with some sandy clays, and a moderate amount of gypsum crystals dispersed throughout the profile. The Dolo series soil is classified as a Chromic Vertisol according to the FAO system (1974).

The Dolo has distinctive red colours, which show as a dark tone on aerial photos. The surface of the mulch is 5 YR 5/8 when dry, becoming 2.5 YR 4/6 when moistened. After rainfall a thin soft crust develops with a dry colour of 5 YR 6/6. Descriptions and analytical results are given in Appendix B.

b) Origin

Following abandonment of the old Juba floodplain the reddish brown colours developed in the Dolo under what was probably a climate wetter and less seasonal than the present and there was moderate to good drainage in the profile. Original colours were probably 7.5 YR to 5 YR. Gypsum crystals may have formed as a result of downward movement of water, rather than by capillary rise upwards from a water table. The brown colours of the underlying clays lay below the depth of pedogenic weathering, but were probably subject to water table fluctuations and accumulation of gypsum crystals.

c) Assessment

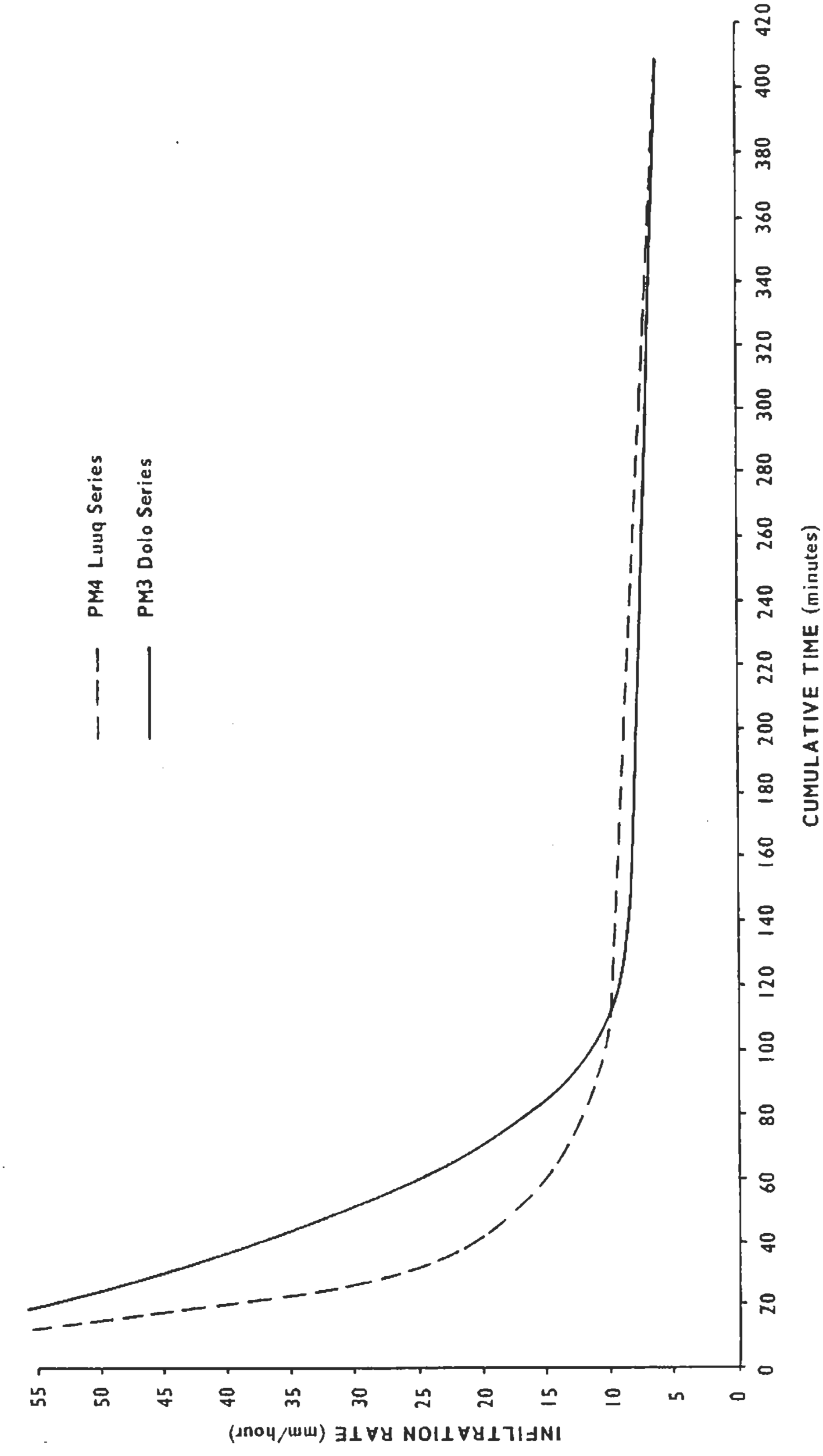
The Dolo soil is base saturated with calcium as the dominant cation. The high exchangeable calcium (Profile Description No.1) is related to moderate gypsum in the soil, but does not constitute a hazard. The high Ca + Mg : K ratio may reduce the availability of Potassium to plants despite the medium to high amounts of K in the exchange complex. Sodium is low, and exchangeable sodium percentages (ESP) are also low in the rooting zone. Calcium released from gypsum in the soil replaces sodium in the exchange complex, and allows sodium levels and ESP to be leached naturally. The churning action in the clays ensures also a turnover of soil particles so that salts do not accumulate in this zone.

The Dolo soil is very low in available nutrients for phosphorus, and total nutrients are very low for organic carbon and nitrogen, but moderate for total phosphorus and high for total carbonate. Nutrients can be added to the irrigation water to make up the deficiencies so that optimum soil conditions exist for crops.

Hydraulic conductivity tests carried out on the subsoil of the Dolo series at 100;200 cms depth gave an average value 0.06 m/day.

Vertical infiltration rates were measured at site PM3. The initial rate is about 55 mm/hour decreasing to 6 mm/hour after 7 hours (Figure 4.3). A normal irrigation of 80 mm,

HALBA STUDY AREA
INFILTRATION CURVES



would infiltrate in 6 hours. These are low rates, and it may be necessary to allow Dolo clays to dry and crack before each irrigation.

The chief problems in the Dolo soil are its low permeability, low infiltration rates and moderate gypsum in the subsoil. It is considered that the gypsum represents a moderate hazard to the engineering aspects of irrigation at Halba (on the Dolo soil). The gypsum however is generally not in the massive form that could lead to subsequent large scale solution of gypsum leading to collapse of the surface soil and irrigation structures. Where high concentrations of gypsum occur (D2 soil) there is a serious hazard, and it is likely that similar small pockets of high gypsum occur, which could not be detected at this scale of mapping. Downward leakage from canals into such areas should be expected.

The low permeability and low final rates of infiltration on the Dolo soil are characteristic of a heavy clay soil with limited open pores. It has gypsum segregations and the profile is expected to impede drainage of irrigation water, if excessive quantities are applied. At present varying quantities are applied to fields. Land which has been flooded next to the main canal was noted to drain only very slowly and compaction by machines may have been responsible; but large cracking patterns subsequently developed. Within the sorghum fields, one profile was slightly moist to 200 cms, the other dry at 80 cms, but salinity levels were moderate and there is insufficient leaching at present. Careful monitoring of any water table formation should be made during the development at Halba.

4.6.3 Dolo Series - Loamy Subsoil Phase

a) Description

This soil consists of a clayey profile down to one metre or more, but in the second metre there is an abrupt change into coarse and fine loamy alluvium. The clayey profile had identical properties to those of the normal phase of the Dolo series, with red (2.5 YR) colours; a surface mulch; cracks to about one metre; compact clay subsoil with gypsum crystals; and slickenslides. At a depth that varies from 120-190 cms below the surface the clay passes into strong brown (7.5 YR) alluvium, that appears to have been unaffected by the vertisolic heaving and cracking of the clay above. This older alluvium includes horizons with fine sandy loam, medium sand, sandy clay, sandy clay loam, silty clay loam and silty clay particle sizes.

b) Origin

This loamy and sometimes silty to clayey subsoil phase represents the levee deposits of the old alluvium laid down prior to deposition of the red Dolo clay. Laterally these sediments pass into the strong brown clays that underlie the clays elsewhere.

c) Assessment

The significance of these coarser textured subsoils to irrigation is important. Although subsoil permeability was not measured on the D2 soils it can be expected to be much faster than on adjacent soils where there is 2 or more metres of clay. It is not clear how deep these loamy layers extend to. They should improve drainage from the surface as they are generally permeable. As they occur at the base of the rooting zone, optimum irrigation efficiency could be made of the clays above, with little danger of a water table developing. Unfortunately these permeable layers are only of minor mapping occurrence in the study area. There is moderate amounts of gypsum in these soils both in the red clays and the underlying strong brown alluvium below, but (field estimates of) gypsum contents are about 5%, and there is thus only a slight hazard to solution of gypsum below engineering structures. Infiltration rates and permeabilities were not measured on this soil. Infiltration will be similar to that of normal phase of Dolo, but permeability should be more rapid.

4.6.4 Dolo Series - Gypsic Subsoil Phase

a) Description

This phase of the Dolo soil has dark red clay horizons with a surface mulch, a cracking pattern and a low gypsum content down to 60 cms. Below 60 cms there is an increase in gypsum with very hard layers down to 150 cms, where gypsum content decreases. This soil was described only at one locality within the Dolo (normal phase) mapping unit, and it is considered likely that other occurrences of this soil are present, but would only be located in a very detailed survey.

b) Origin

This phase of the Dolo with very hard gypsic layers at the base of the dark red Dolo clay, overlies yellowish red clays with decreasing gypsum. It represents shallow deposition of the Dolo clay over older gypsic alluvium, and subsequent accumulation of gypsum, in the subsoil.

c) Assessment

The hard gypsum layers of this soil will cause an impedance to drainage of irrigation water, and would also be subject to solution and collapse under prolonged irrigation. Downward leaching of salts will be reduced. The area mapped as D2 has not been irrigated before 1980, and could provide a useful data point for monitoring the gypsum hazards at Halba. Infiltration rates into the clayey soil will be similar to those of the Dolo normal phase.

4.6.5 Luuq Series

a) Description

The Luuq series is a dark red (2.5 YR 3/6) medium textured soil formed on former sand bars and levees of the former Juba floodplain. The profile commences with a loose layer of medium to coarse sand a few centimetres thick, which overlies a friable weakly structured surface horizon, with medium sandy loam to medium sandy clay loam textures, down to between 15 and 30 cms. There is a rain compacted surface pan, which, though easily broken with an implement, is strongly impervious to rainfall, and results in high surface runoff (down into the depressions of the Dolo soil) during rainstorms.

The surface soil is free of visible carbonate and gypsum but has a violent reaction to HCl which suggests calcium carbonate is in a finely divided form.

Around 30 to 50 cms in depth there is the appearance of soft calcium carbonate concretions, 2 to 5 mm in diameter, which increases in size and quantity with depth. The soil below 30 cms passes into a medium sandy clay loam textured layer with a moderate subangular blocky structure. This merges downwards at about 70 cms into a massive very hard subsoil, that breaks into angular blocky fragments. The proportion of calcium carbonate concretions is high and ranges in size up to 10 mm in diameter, and are most abundant between 70 and 200 cms depth. Small gypsum crystals appear at about 100 cms, in former root pores but amount to only a few per cent. At about 2.0 to 2.5 m there are small hard manganese coated concretions of calcium carbonate. Old root channels are common down to 2 m depth, but living roots are few in number below 40 cms, and it seems likely that the deeper pores are partially blocked by fine calcium carbonate or other salts such as gypsum. Roots cannot extend deeper in the very compact, uncracked soil.

The very hard nature of the subsoil which is difficult to excavate, yet slakes immediately in water, suggests fine calcium carbonate powder acting as a binding agent for soil particles. There is much evidence of former faunal activity in the soil including burrows, droppings, and some termite activity; but at present there is little activity. Lime secretion around soil particles by soil fauna is likely to have been an important process.

Below 2 metres the dark red (2.5 YR) colours either persist to 3 metres or pass into browner (5 YR, 7.5 YR) colours. The profile between 2 and 4 metres, as indicated from the two deep bores in Luuq series soils, showed in one bore sandy clay loams to 4 metres, and in the other loamy sand and sandy loam between 3 and 4 m. Gypsum content was variable generally below 5 per cent, and not a serious impediment.

The chemistry of the Luuq soil shows calcium base saturation, with low exchangeable sodium in the first metre of the profile. Exchangeable sodium percentages are also low despite the virtual absence of gypsum in top metre. Salinity and ESP increase down the profile, and are probably related to accumulation of fine and concretionary calcium carbonate. Salinity levels are moderate within the rooting zone.

The soil nutrients in the Luuq soil are low to very low for total nitrogen, organic carbon, and available phosphorus. Total phosphorus is evidently bound up in the largely insoluble calcium phosphate form.

The soil is classified as a calcic cambisol (FAO 1974). Soil colours vary from 7.5 YR 5/6 when dry, to 2.5 YR 3/6 moist, and the soil shows a light tone on aerial photography. Descriptions and analyses for the Luuq soil are given in Appendix B.

b) Origin

The Luuq series developed on medium textured alluvium of a former floodplain of the Juba river. The sand content shows angular particles characteristic of fluvial deposition, but there is little trace of non-resistant minerals. It is considered that pedogenesis under a warm humid subtropical climate produced the 2.5 YR red colouration and profile features from the original browner stratified alluvium. Micaceous minerals were weathered to clay size particles; there was intense faunal activity; and calcium carbonate and gypsum accumulated respectively at lower depths of the profile. In the deeper parts of the profile, dark manganese dioxide coated carbonate concretions were formed under poorly aerated conditions. Subsequently a more semi-arid climate followed and pedogenesis at present is limited to slight leaching of salts (carbonate, gypsum and chlorides) down the upper parts of the profile by rainfall.

c) Assessment

The Luuq series (normal phase) suffers from surface crusting which encourages runoff during rainstorm events. As a result little water enters the profile, and the soil below about 50 cms has few roots and is very hard and compact.

Under irrigation it is likely that the Luuq soil will drain moderately well. There is only slight gypsum content that would hardly impede water movement, but more serious is the $CaCO_3$ in powder form. When the Luuq is fully wetted by irrigation waters it will be the first time in an extremely long period that this will have happened. It is likely that powdery calcium carbonate will move into soil pores and could significantly lower subsoil permeability. Present permeability rates measured on dry Luuq subsoil (100-200 cms) showed a mean of 0.2 m/day. These are moderately slow values of permeability. Infiltration rates for the Luuq soil were measured at one site (PM4). The decrease in infiltration per hour is shown on Figure 4.2. From an initially moderate rapid rate of 55 mm per hour there is a quick decline to an approximate final rate of 6 mm per hour after 7 hours. Cumulative rates show that an average irrigation of 80 mm will take 6.5 hours to infiltrate. These rates are rather slow, and probably reflect low pore space with many pores partially filled with secondary salts (calcium carbonate, gypsum, and chlorides) which are impeding drainage.

No measurement of available water capcity on the Luuw series was made. The particle size distribution in most of the soil profile is favourable for moisture holding, but the sandier topsoil is prone to drought. Available water will generally be reduced at the present, because of soluble salts in soil pores, but would be expected to improve under irrigation. The tendency for the Luuq soil to form a hard surface rain crust could be a fairly serious problem during seed germination if the soil is allowed to crust over after an irrigation.

4.6.6 Luuq/Dolo Intergrade

a) Description

This soil has been mapped along the boundary of the Luuq and Dolo series mapping areas, where there is a slight slope of about half a per cent. The surface of this soil is distinguished by loose medium to coarse soil over a firm rain crusted sandy topsoil, features characteristic of the Luuq series. There are also potholes up to half a metre wide, and 30 cms deep; these are smaller than the Dolo potholes, and their occurrence is less frequent. The subsoil, between 25 and 200 cms has a sandy clay to sandy clay loam horizon that has some calcium carbonate concretions but less than in the Luuq series.

b) Origin

This soil has formed as a result of continued deposition of sand over the Dolo clay. The sand has been washed downslope, off the Luuq series mapping unit, a process which is particularly extensive today as there is very little herbaceous vegetation to check over land flow of sand-laden waters. Wind action may also blow sand off the Luuq series unit onto the Dolo.

c) Assessment

The Luuq-Dolo intergrade has a slight gypsum content, few calcium carbonate concretions and a cracking clay with moderate sand content. Salts should be washed down cracks, and drainage under irrigation will be satisfactory. Subsoil permeability was not measured but should be intermediate between the Dolo and Luuq, giving a value of around 0.13 m/day. The salinity in this soil is moderate and it is downgraded accordingly.

4.7 Land Suitability Classification

4.7.1 Introduction

The soils of the Halba area have been classified according to specifications of the United States Bureau of Reclamation (USBR 1954), in order to rank the land units against their repayment capacity.

The main U.S.B.R. classes are defined briefly as follows:

a) Class 1. Arable. Lands that are highly suitable for irrigated farming being capable of producing sustained and relatively high yields of a wide range of climatically adapted crops; high repayment capacity.

b) Class 2. Arable. Lands that are moderately suitable for irrigation farming; adaptable to a narrower range of crops; they have certain correctable and non-correctable limitations; intermediate repayment capacity.

c) Class 3. Arable. Lands that are marginally suitable for irrigation development, and have more extreme deficiencies in the soil, topographic, or drainage characteristics, adequate repayment capacity.

d) Class 4. Special Use of Limited Arable. Lands which are suitable for irrigation only if used for special crops or systems of irrigation.

e) Class 5. Non Arable/Arable. Lands which are at present non-arable, but may become arable subject to particular engineering or agricultural conditions.

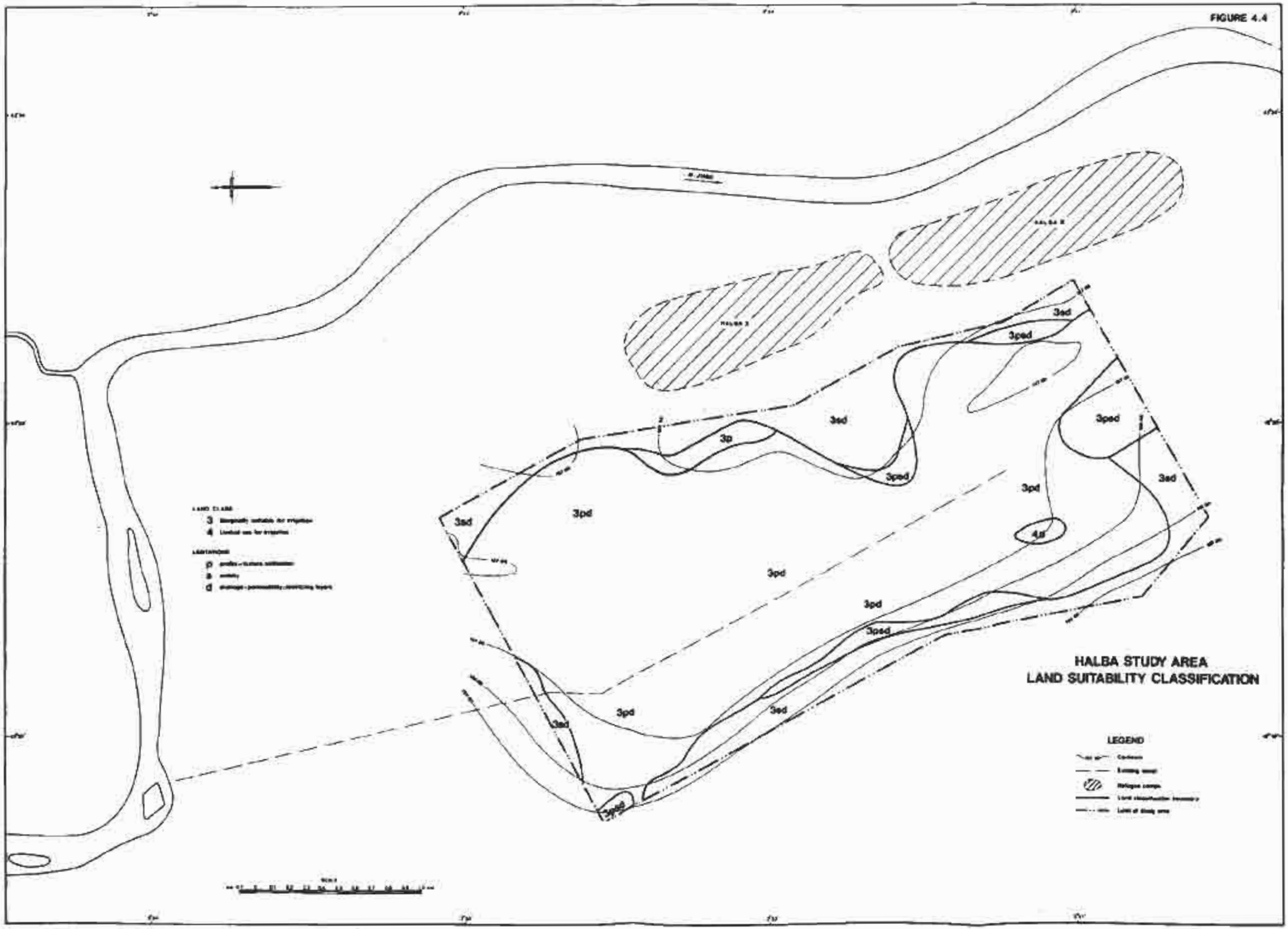
f) Class 6. Non Arable. Lands with severe limitations which do not have sufficient repayment capacity to warrant consideration for irrigation.

4.7.2 Land Suitability Class Limits

In the Halba area each soil series and phase has been given in land suitability class according to the U.S.B.R. system. Class limits have been drawn up using the basic limits of U.S.B.R. with special adaptions for Somali conditions. Much of this has been taken from previous soil studies in Somalia (HTS 1969; Lockwood/FAO 1968; HTS 1977; MMP 1978; MMP 1979; HTS 1978; HTS 1979).

The class limits are shown in Table 4.2 and on Figure 4.4 for Classes 1, 2, 3 and 4. No Class 5 or 6 soils were found in the Halba area.

Other factors commonly used, but which have been shown to be not critical to land classification at Halba include: slope of the land, which is here very flat and all falls within Class 1 land; susceptible to flooding from the Juba of which there is none present; and alkalinity, which is very low and both ESP and exchangeable sodium fall within normal class 1 limits.



HALBA STUDY AREA
LAND SUITABILITY CLASSIFICATION

TABLE 4.2

LAND SUITABILITY CLASS LIMITS

Criteria	Map Symbol	Land Class 1	2	3	4
Final Rate Infiltration (mm/hr)	p	7-35	2-7	> 1	Not limiting
Infiltration Time (hours) for 100 mm	p	1.5 - 8	8-20	20-40	Not limiting
Permeability 100-200 (m/day) cms	d	0.3 - 10	0.1 - 0.3	<0.1	<0.1
Salinity ECe number/cm 0-50 cm	s	0 - 2	2 - 4	4-8	<8
50-100 cm		0 - 2	2 - 8	2-8	<8
100-150 cm		0 - 4	4 - 8	8-16	<16
Texture	p	Loam to friable clay	Sandy loam to permeable clay	loamy sand to clay	loamy sand to clay
Rill erosion on slope	t	none	very slightly	moderate	not limiting
Profile drainage	d	wells to excessive	mod. well	imperfect	not limiting
Available water	p	good	moderate	poor	not limiting

Symbols - p = profile
d = drainage
s = salinity
t = topography

Available water was not measured and the groupings have been approximately estimated from comparison of other soil studies in Somalia.

4.7.3 Land Suitability Results

The assessment of soil suitability is shown in Table 4.3. Each characteristic was given a ranking in a particular soil, and the final soil land sub-class is the highest class limit that occurs. Thus a soil with six characteristics favouring Class 1, but only one characteristic for Class 2 would still be rated as Class 2.

The land classes with their areas and percentages of the total area are shown in Table 4.4.

The soils have a Class 3 rating except for the Class 4 given for the high gypsum levels of the D2 soil. Poor drainage potential due to clay content, gypsum segregations or fine carbonate are the chief reasons for downgrading of the soils from Class 2 to 3. The deficiencies are mostly unlikely to be much changed by irrigation. Certain improvements however are possible with fine carbonate if deep drainage improves with leaching, and soluble (chloride) salts in the Luuq soil have the potential to be reduced.

TABLE 4.4

Land Class Areas

Class	Soil	Hectares	% of Total
1	-	0	-
2	-	0	-
3P	D1	23	3
3pd	D	570	73.5
3psd	L/D	40	5
3sd	L	138	18
4d	D2	4	0.5
		775 ha	100

TABLE 4.3

LAND SUITABILITY CHARACTERISTICS OF SOIL MAPPING UNITS

Soil	Texture (p)	Infiltration (p)	Permeability (d)	Available Water (p)	Salinity (s)	Gilgai Relief	Soil Drainage		Erosion Rills (t)	Soil Sub-Class
							Gypsum impedance (d)	Fine $CaCO_3$ impedance (d)		
D	3	2	3	2	2	2	3	1	1	3 pd
D1	3	2	2	2	2	2	2	1	1	3 p
D2	2	2	3	2	2	2	4	1	1	4 d
L	2	2	2	2	3	1	3	3	2	3 sd
L/D	3	2	3	2	3	2	3	2	1	3 psd

4.7.4 Selection Of Land For 400 Hectare Farm

From the results of this investigation it is clear that the soil with the most favourable potential is the Dolo Series with the deep loamy subsoil phase (Dl). The Dolo normal phase is also selected in favour to the Luuq because of lower salinity, less blockage of soil pores by fine carbonate, absence of any slope, and a natural seedbed. The Luuq-Dolo intergrade has a firm crusted surface and is not selected.

The Luuq soil however, is similar to the Bio Addo soil of the Jalalagsie area, which is recommended there in preference to clayey soils (with gypsum). The difference is in the top-soil of the Bio Addo, which crusts only slightly is worked over at the present by termites, and has a less compact subsoil. Under irrigation it is considered the Luuq soil would mature and resemble more the Bio Addo. There is therefore potential for development of the Luuq soil, if development were to expand laterally. At the present time however the 400 hectares proposed for development can be adequately taken from within the D and Dl soil mapping units.

The slowly permeable gypsic layers are potential hazards to irrigation in the Halba area, and a monitoring programme to determine any watertable formation should be begun once development commences. The low permeability in the Dolo subsoil should still be adequate for deep percolation of drainage water.

CHAPTER 5

WATER RESOURCES

5.1 River Flows

The study area will be supplied with water from the Juba river which has been extensively reported upon during previous studies. The Mogambo Project Report (MMP 1979) updated previous studies of potential water use in the Juba region. The Baardheere Reservoir Review (MMP 1978b) considered the hydrology of the Juba in connection with a potential reservoir site at Baardheere.

The principal gauging station on the Juba within Somalia is at Luuq, very near the study area at Halba. Three different flow records have been published for Luuq: Selchozpromexport (1965) and (1973) and Lockwood/FAO (1968). Figure 5.1 gives mean monthly flows for the period 1951 to 1964 based on these records. It can be seen that significant percentage differences occur, particularly at low flows. Nevertheless, Figure 5.1 illustrates the salient features of river flow during a year. Table 5.1 gives average and 75% reliable flows based on the Selchozpromexport (1973) record, considered by MMP (1978b) to be the most reliable.

Low flows during the period January to March/April have proved a constraint to agricultural development throughout the Juba. Flows increase rapidly during April with onset of the gu rains in the Ethiopian plateaus. The highest river flows occur during October, during the der season, but decrease rapidly in November and December.

Baardheere Reservoir has been proposed for several years to attenuate flood flows and provide storage to conserve water for hydro-power and irrigation purposes. It is understood that funds for final design of the dam and preparation of contract documents are already available and selection of project

MEAN MONTHLY FLOWS AT LUUQ
JAN 1951 – OCT 1964

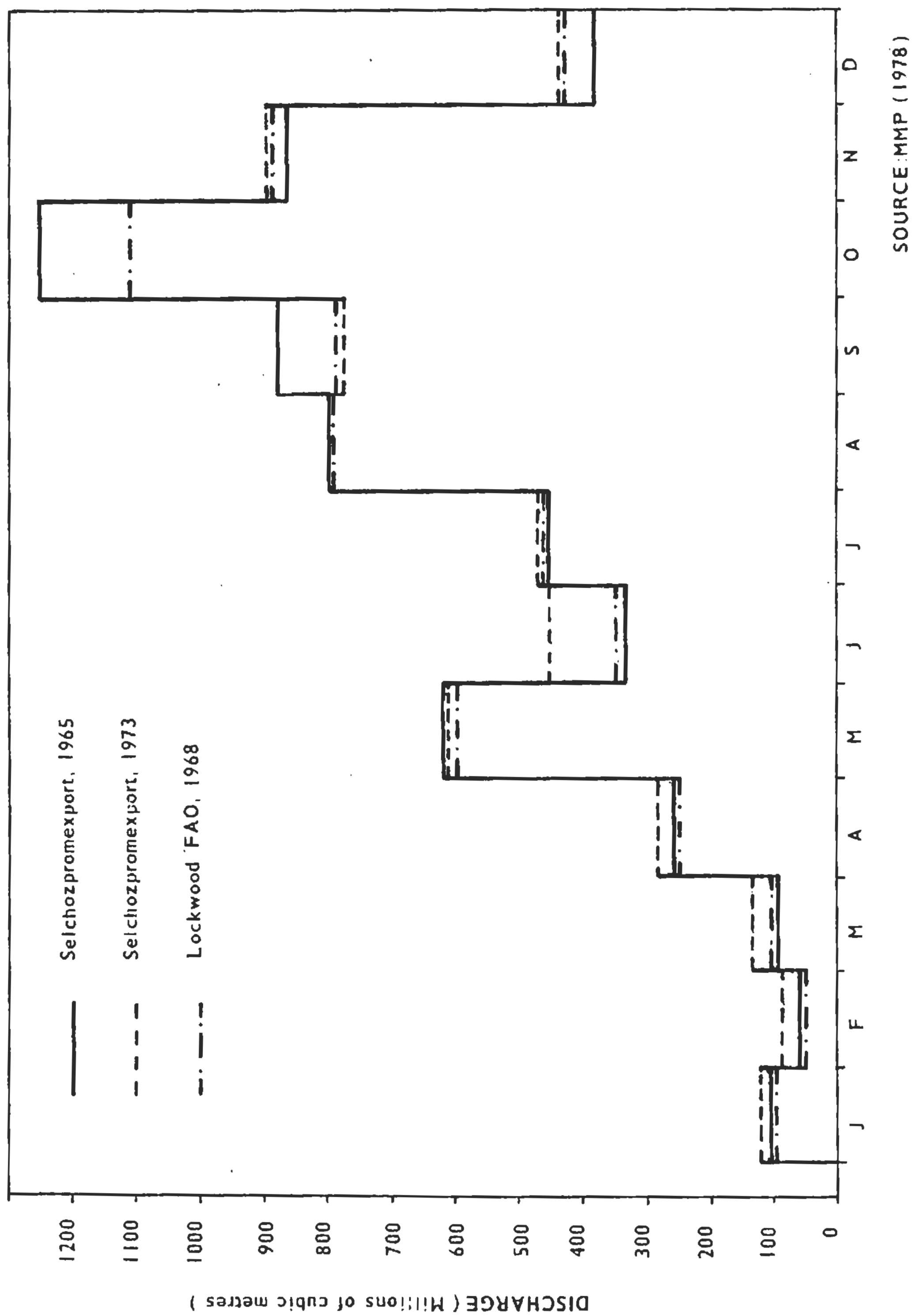


TABLE 5.1

Average and Reliable Juba Flows at Luuq (MCM)

	Average Flow	75% Reliable Flow
January	103	78
February	67	49
March	65	34
April	157	102
May	538	369
June	407	187
July	453	297
August	668	500
September	664	572
October	1433	807
November	819	703
December	329	186
YEAR	6194	4963

Source: MMP(1979)

Note: The sequences are not homogenous thus annual flows are not equal to the sum of monthly flows.

consultants is in progress. Some of the funds for construction are also available and construction might begin in three years. The main reservoir parameters given below are subject to review but are unlikely to change significantly:

Storage volume	:	4100 million cubic metres
Spillway crest level	:	145 m above sea level
Freeboard	:	3 m
Reservoir area	:	57000 ha.

The above parameters give the maximum water level which can be tolerated without endangering Luuq town at times of flood when the spillway is discharging at full capacity.

5.2 Previously Planned Development and Water Availability

Table 5.2 summarises likely irrigation development at three planning horizons indicating the short, medium and long term situations.

TABLE 5.2

Likely Irrigation Development (ha)

	by 1980	by 1985	by 1990
Small schemes above Fanoole (Technital 1976)	1 140	1 480	1 480
Saakow (Il Nuovo Castoro 1978)	0	3 000	6 000
Dujuma Settlement	40	40	40
Small schemes below Fanoole (Technital 1976)	5 260	8 550	8 550
Fanoole-Gelib	1 200	8 200	8 200
Fanoole-Homboy	0	4 500	9 000
Juba Sugar	2 000	10 000	15 000
Trans-Juba Livestock	-	300	600
Mogambo	-	6 400	6 400
Jamama Cotton	-	2 000	2 000
Ionte	100	100	100
TOTAL	9 740	44 570	57 370

Source: MMP (1979)

Table 5.3 summarises future net water availabilities from the Juba at each of the three time horizons, allowing for the requirements of all development in Table 5.2 and assuming Baardheere reservoir is not built. Almost all demand in the immediate future can be met but large deficits will occur in the medium and long term. MMP (1978b) used all three flow records at Luuq and a short flow record at Baardheere to evaluate reservoir inflows and maximum reservoir capacities required to serve a range of downstream demands. The inflows were also reduced to allow for upstream irrigation and other water use. It was shown that a reservoir with capacity of 4100 MCM will fulfil both flood control and regulation functions until upstream abstractions reach about 2350 MCM per year. This level of upstream use is equivalent to more than 70% of long-term downstream demand and is unlikely to occur for the foreseeable future.

Water requirements of the study area are less than 10 MCM per annum (see following section) and these requirements can be easily met without affecting other existing and potential users of Juba water.

Table 5.3

Net Water Availabilities without Regulation (MCM)

	1980	1985	1990
January	22	-76	-97
February	4	-73	-89
March	-8	-99	-117
April	45	-16	-26
May	248	166	151
June	166	64	43
July	250	154	136
August	459	372	357
September	493	377	355
October	629	482	451
November	535	401	374
December	159	35	7

Source: MMP (1979)

Notes: 1. Availabilities quoted with 80% reliability level

2. A negative value indicates a shortage of water.

5.3 Irrigation Water Requirements

Table 5.4 gives the calculation of irrigation water requirements of the study area, based on the following:

- design evapotranspiration is taken as 110% of average rates as recommended by Doorenbos and Pruitt (1977). This allows for short-term climatic deviations from average conditions
- effective rainfalls at the 75% level of reliability are taken from Table 3.2
- crop coefficients are taken from Annex VI: Potential for Agricultural Development of the Genale-Bulo Marerta Project report (MMP 1978a). These were calculated according to the procedure described by Doorenbos and Pruitt (1977) and are applicable to the study area: any slight inaccuracies caused by small climatic differences are insignificant compared with inherent uncertainties in calculation of reference crop evapotranspiration.
- an overall irrigation efficiency of 50% is used to calculate gross water requirements, corresponding to:
  field efficiency : 60%
  distribution (canal) efficiency : 85%
- the crop calendar of Chapter 7 is assumed. This was chosen to minimise water requirements, particularly during the gu season when there is greatest competition for water.

5.4 Flooding

During the Reconnaissance fieldwork in later July 1980 it was reported that during the last exceptional flood in 1977 the old canal at Halba was breached by floodwaters that year. Subsequent inspection did not confirm this report and a study of river levels at Luuq would indicate that there is little chance of the Halba project area being flooded with levels similar to those recorded in the 1977 flood.

Table 5.4

Irrigation Water Requirements

		J	F	M	A	M	J	J	A	S	O	N	D	Year
Design Evapotranspiration	mm	220	215	264	220	209	204	198	215	226	220	204	220	2615
Effective Rainfall	mm	0	0	0	63	10	0	0	0	0	5	19	0	97
CROP COEFFICIENTS														
Maize I, planted 15 April		-	-	-	0.30	0.75	1.05	0.90	-	-	-	-	-	-
Pulses, planted 15 April		-	-	-	0.30	0.85	1.05	0.45	-	-	-	-	-	-
Maize 2, planted 15 Aug		-	-	-	-	-	-	-	0.15	0.55	1.05	0.90	-	-
Tomatoes, planted 15 Aug		-	-	-	-	-	-	-	0.20	0.85	1.05	0.95	0.10	-
NET IRRIGATION REQUIREMENTS														
Maize 1	mm	-	-	-	3	146	214	178	-	-	-	-	-	
Pulses	mm	-	-	-	3	168	214	89	-	-	-	-	-	
Maize 2	mm	-	-	-	-	-	-	-	32	124	226	165	-	
Tomatoes	mm	-	-	-	-	-	-	-	43	192	226	174	22	
GROSS IRRIGATION REQUIREMENTS														
Maize 1, 100 ha	MCM	-	-	-	0.01	0.29	0.43	0.36	-	-	-	-	-	1.09
Pulses 100 ha	MCM	-	-	-	0.01	0.34	0.43	0.18	-	-	-	-	-	0.96
Maize 2, 300 ha	MCM	-	-	-	-	-	-	-	0.19	0.74	1.36	0.99	-	3.28
Tomatoes 100 ha	MCM	-	-	-	-	-	-	-	0.09	0.38	0.45	0.35	0.04	1.31
TOTALS	MCM	-	-	-	0.02	0.63	0.86	0.54	0.28	1.12	1.81	1.34	0.04	6.64

CHAPTER 6

PRESENT SITUATION

6.1 General

Figure 2.1 shows the topography and other details in the vicinity of the Halba development area some six kilometres north of Luuq on the River Juba. It is some 400 kilometres from Mogadishu by road.

Access to the area is via the main road from Mogadishu to Luuq which was once surfaced over the whole of its length is now in a poor condition in the Baidoa-Luuq section. About 40 km north west of Baidoa the road surface has been destroyed and the last 90 km to Luuq is in a very bad condition.

This road crosses the River Juba at Luuq by a bridge which is at present restricted to one vehicle at a time. The Project area, Halba, is reached on a dirt road which takes off from the Dolo road a few kilometres north of Luuq.

Taking into account that the indigenous population is partly self supporting and also the relative size of the indigenous and refugee populations it is probable that about 80% of the traffic along the Baidoa-Luuq road is generated by the need to service the refugee camps. The condition of this road is so poor that it reduces vehicle life substantially and with the continuing heavy traffic load the road will deteriorate further. Government attemps at improvement have been made in the last two years and are currently concentrated just south of Luuq town. However this programme appears inadequate for the increased traffic load and consideration should be given to obtaining international assistance for construction of an improved road if large numbers of refugees continue to be located in this area.

6.2 Agricultural Development

6.2.1 Existing Local Agriculture

Agriculture adjacent to the River Juba upstream of Baardheere is limited by the extent of suitable soils and also by the climate. Further factors which have inhibited development are the small indigenous population and the long distances to markets. Production has been limited to that required for local consumption. Many of the inhabitants are believed to be nomadic or semi nomadic and are therefore concerned with some kind of livestock activity, see Section 6.4.

Existing irrigation upstream of Baardheere is minimal. A number of cooperatives were established and previously operated and some have now been taken over for use by refugees or are being shared by the original cooperative members together with refugees. The main development at Halba is considered in Section 6.2.2.

There are a few small private irrigation systems and a small farm (11 ha) at Afmadow near Halba which is run by the Ministry of Agriculture but at present is growing fruits on a very limited scale.

Data on rainfed agriculture is scarce and of poor reliability. There is no firm information on areas of used and unused land. Also data on cropping systems, organisation of produce, distribution and consumption are lacking.

However, it is clear from both the population figures and the climatic parameters that the upper reaches of the Juba River are not suited to rainfed agriculture and that the amount of rainfed cropping is small. Most of the soils having agricultural potential are covered by thick thorn bush or acacia scrub and there are few signs of attempts at clearance except close to Luuq town and at a few places close to the river.

6.2.2 Refugee Camp Agriculture

At the three camps in Garbahaarey District the total area with irrigation facilities is estimated to be less than 200 ha. At Alimatan and Halgan camps (south of Luuq) very small areas have been developed but are suffering from mechanical problems with the pumps. At Horseed camp, the nearest to Luuq about 100 ha is available for cropping and more than half is currently under crop. At Halba an area of between 300 and 400 ha has been cleared and is the area which is the subject of this Report. All the systems seen suffer from a number of deficiencies the principal ones being lack of control structures, inadequate land preparation, lack of fertilisers and other agricultural inputs, absence of spare parts for pumps and probably most important no management organisation.

Indeed without proper management the other identified deficiencies are to be expected. The results are low yields and lack of security. In every case there is only one pump unit and therefore even a minor breakdown results in a complete loss of water supply. No farm machinery was seen although it is believed a tractor may be hired.

6.3 Present Cropping

At present, in the study area at Halba the low lying, level, clayey soils are being cultivated by hand by refugees and cooperative members, using irrigation water from the Juba conducted down a 3 km canal. An area of about 400 ha has been cleared and about 250 ha are under cropping (100 ha irrigated). Sorghum, maize and some sesame are the main crops grown and some details of these are:-

Sorghum

After sowing sorghum at about 1 m by 1 m spacing in small fields (jibal), the fields are flood irrigated. Sowing is in March/April for the gu season crop and again in September for der crop, and the schedule of irrigation is as follows:

(1) After sowing (20 cm depth of water)
(2) 15 days after sowing
(3) 30 days after sowing.

Yields of around 400 Kg per hectare are claimed, low for irrigated sorghum which can yield twice this amount.

Maize and Sesame

Maize and sesame are planted in the der season in August/ September. Yields are anticipated to be low, as is to be expected where there is a lack of water control structures, inadequate land preparation, lack of fertilisers and other agricultural inputs and no management organisation. There is only one pump unit so that a minor breakdown of this results in a complete loss of water supply.

6.4 Livestock

Over eighty per cent of the local population are concerned partially or entirely with livestock. There are no accurate figures on the total numbers of animals in the Region and in any case a large proportion migrate to the interriverine area around Baidoa during the rainy seasons.

However, there are probably over 2 million animals in the whole region with over half of these being in Garbahaarey District. In Luuq District about seventy per cent of the animal population comprises camels and goats in roughly equal numbers. Of the remainder sheep and cattle comprise about twenty per cent and ten per cent respectively. (1975 census data).

There are some signs of overgrazing in various places, particularly close to Luuq and to the refugee camps. The large increase in population and also to a lesser extent of livestock is putting a severe strain on the local environment.

CHAPTER 7

AGRICULTURE

7.1 Agricultural Planning

7.1.1 Introduction

The Halba project is the irrigation project which has been identified on the flood plain of the Juba river, to provide a supplementary source of fresh food for refugees from the Ogaden region.

Substantial numbers of refugees began to arrive in Somalia from this region in 1978, and required total support having lost their livestock and other possessions. The numbers of refugees rapidly increased during 1979 and this year, making it necessary for more camps to be established. It is estimated that there are now approximately 225,000 refugees (mostly women and children) in camps in the Luuq area.

Early in 1980 a mission from the United Nations High Commissioner for Refugees (UNHCR) in Somalia investigated, for the Ministry of Planning, the suitability of developing irrigated farms at some of the camps. The mission recommended further investigations and a Reconnaissance Study (MMP 1980) was carried out in the Gedo Region which identified a 400 hectare site requiring soil studies, irrigation design and plans for agricultural development as a refugee farm.

In respect of this site the Commissions report raised a further question to be resolved. A farmer cooperative had already been established, with the assistance of the Ministry of Agriculture; 480 ha of land had been cleared and the agricultural coordinator of the District planned that when irrigation water was available 300 hectares of land would be given to the refugees as a start, and 180 ha to this cooperative; a decision was required on this proposed division of the limited land available which was not seen as a satisfactory long-term solution because of the increasing number of refugees, and social factors. Currently (1980) about 100 ha are under irrigation at Halba, in the cooperative, which operates under a farm manager.

As the refugees are nearly all former nomads, and are also mainly women and children the initial period of adoptation and acclimatisation to the discipline of irrigated agriculture is likely to be prolonged and the successful development of the project will require a strong management team, as well as training facilities at all levels.

Agricultural planning must take into account the full range of relevant information that is available including both natural and human resources. The land and water resources of the Halba area provide adequate scope for irrigated agriculture, within the limitations described later. The human resources, on the other hand, limit the development possibilities in terms of farming skills.

7.1.2 Human Resources

In order to put the problems facing the scheme into perspective it is necessary to discuss the human resources available to the scheme and the composition of the refugee population requires careful consideration in relation to a suitable organisation of the Halba farm.

The paper of the State Planning Commission (now Ministry of Planning), on identification of Settlement areas for Displaced People; Gedo Region, 1978 indicated that 79 per cent of the refugees in two camps then totalling 6,570 persons were children, and it is understood, most of the remainder were women. Approximate average family size was 5 persons.

In the refugee camps most of the people are nomads who have left behind their livestock to take refuge and only a very few, in particular those who have come from riverine areas, have any experience in the production of cultivated crops.

7.1.3 Land and Water Resources

A 400 ha site of suitable soil some 14 km upstream of Luuq on the right bank of the Juba River has been soil surveyed, and the soils described in detail in Chapter 4. However a summary of some of the soil survey findings is given below.

Most of the proposed development will be on the Dolo clay soil (45-50 per cent clay). This has a loose soft surface mulch (0-5) over slightly hard blocky clay (5-15). Below 15 cm the soil is very hard when dry, but conversely very plastic and sticky when wet. In the dry state tracks over the clay do not go any deeper than 15 cm and remain quite rough, but firm. Strong mechanised power to break up the soil below 15 cm would need to be taken into account, but the soil has a natural seed bed in the mulch, which forms if the soil is left non irrigated for a season and the mouldboard plough with sharp shares should plough down to 30 cms in such soil. Under irrigation this mulch does not form so easily and the surface requires breaking up. The soils are slightly to moderately saline with ECes in the root zone of less than 3.0 mmhos/cm (range 0.5 to 2.7 in 0-100 cms).

Potholes are common in this cracking clay but will not effect mechanised power as they fill in when the land is smoothed.

Climate and water resources have also been fully described in Chapter 3 and 5; aspects of these particularly relevant to the agricultural planning are however summarised below.

Rainfall is very variable from year to year; it falls in two wet seasons, the gu (april to June) and der (October to December) with no rainfall in the Hagai (July and August) season.

The fact that rainfall is distributed in two season, the relatively small amounts of rain in these seasons and the great variability in rainfall from year to year place a very severe limitation on crop production under rainfed conditions of farming.

Mean monthly rainfall, and evapotranspiration data for Luuq, the nearest meterological station to the identified site, are given in Tables 3.2 and 3.3.

Other reports give slightly different figures for the evapotranspiration but these do not materially alter the general conclusion that with such low and erratic rainfall there is virtually no chance of successful rainfed agriculture except in the occasional good gu season.

The water resources of the Juba river have been discussed in Chapter 5 which shows the water availability is not a constraint to the irrigation development proposed even with all other planned projects operating.

Salinity values are substantially below those recorded for the Shebelli with E.C. values of 250 micromhos/cm during high flow months and would not adversely affect crop yields. In the dry season (January to April) and at the beginning of the flood conductivities may rise for short periods up to 2,000 micromhos/s, but since these values are for short periods only most crops should not be seriously affected. River water records are given in Appendix D.

Irrigation of pulses and some vegetables (onion, pepper) should not be carried out with salinities over 1,500 micromhos/cm, and maize is sensitive to salinities of over 2,000 micromhos/cm, so irrigation water should not be abstracted at the beginning of the gu flood.

Sediment concentrations in the Juba river are also lower than those in the Shebelli.

7.1.4 The proposed Form of Development

Although the National Refugee Commission has not laid down criteria for the refugee farm proposed for Jalalagsie, consideration of the limited labour resource within familes on the one hand, and a desire for a degree of self-sufficiency, particulary for fresh food, on the other leads to the proposal of the provision of 0.5 hectare per selected family, or the accommodation of 800 families on a 400 hectare development. There is also the precedent of this area of land per family in the cooperative farm already established at Halba.

In developing the irrigation layout it has not been found practicable to have field units smaller than about 20 hectares and problems in relation to water distribution and to the use of farm machinery designed for large fields precludes any possibility for farming 0.5 ha units as independent units. The form of development proposed will therefore have to provide for some form of amalgamation.

Cooperative farming is the dominant national policy for development of smallholder agriculture in Somalia.

Although in the long term and with the development of a stable settled community of farmers, a formal cooperative organisation could be achieved at Halba, this would not be immediately attainable. Particularly because of the nomadic background of the refugees, a high level of supervision will be essential. What is proposed is a series of committees based on traditional family groupings, on the lines established at the Kurtan Waarey Settlement for example (HTS 1980). There, with the social disturbances associated with the resettling of a group of nomads on a permanent site with a very different pattern of life in mind, such committees brought a sense of community and provided a stabilising affect, as well as being used extensively by the farm management to disseminate orders and organise production. At Kurtan Waarey there were committees established at 10 family, 50 family and 400 family levels. Chairmen of the committees received a small remuneration for their services.

It is proposed that committees be established at the 40 family 20 ha level, and at the 500 family level. Overall is the senior committee whose chairman would be the District Commissioner as at Kurtan Waarey. Through this structure refugees views are represented at several levels and social problems arising from the resettling of nomadic people can be resolved.

Although it is not practicable to allocate fixed parcels of land to individual participants (or families), it is desirable however that small groups of families can identify their individual efforts, and reap ensuing benefits; it would not be difficult, after mechanised initial cultivation and ridging to allocate, each season, the appropriate number of ridges for each crop to groups of, say, 10 families, who would then have the responsibility for planting, weeding, applying fertiliser and harvesting those portions of the field.

7.2 Crop Selection, Cropping Patterns, and Agronomy

7.2.1 Crop Selection

It is appropriate to note here the present rainfed cropping along the Juba as it is not considered wise to introduce completely unfamiliar crops in such a scheme. There are two recognised cropping seasons in rainfed agriculture:

(i) Planting in April-May during the 'gu' rains,
(ii) Planting in October during the 'der' rains.

The 'gu' rains are generally more reliable and of longer duration, (particularly in coastal areas which receive the 'hagai' showers of July). Moreover during the growing season of crops planted at the beginning of the 'gu' rains, rates of evapotranspiration are much lower than during the growing season of crops planted in the 'der' rains. Thus the chances of crop failure due to drought are generally much less in the 'gu' season and it is for this reason that greater emphasis is placed on cropping at this time of year.

Maize is the major 'gu' season crop under rainfed conditions along the Juba, being planted in April and harvested in July or early August. It is commonly interplanted with green gram (Phaseolous aureus), cowpea (Vigna sinensis) and sesame, local cherry type tomatoes, pumpkin and squash or gourds. Cotton may also be interplanted in the maize crop.

Sorghum is the major 'der' season crop and, like maize, it is commonly interplanted. Sesame is also widely grown in this season, usually in pure stand.

It is also appropriate to consider the present diet of the refugees, the supplementation of which is a prime purpose of the establishment of the Halba farm.

It is understood that the refugee population receive regular rations daily including a total of 450 g of rice and maize and 60 g of oil and a weekly ration of 350 g of meat, and that the project should be designed to provide a supplement to the diet, particularly with respect to vegetables and vegetable protein (pulses).

The most commonly grown vegetables are local tomatoes and onions under irrigation. These vegetable crops require four months in the field after transplanting and have comparatively prolonged irrigation requirements (and would therefore not be proposed for the project for the short gu season). On the other hand the pulse crops, green gram and cowpea grown rapidly and harvesting can be completed in approximately 110 days. Furthermore, green pods of cowpea are used as a vegetable by the local people. The main gu season crops proposed would therefore be these pulses (which also are drought resistant).

Maize is a staple food in Somalia and is a crop which responds well to irrigation and fertiliser use; it can be consumed as green corn or as dry grain products. This crop is proposed as the main der season crop (75 per cent of the cropped area).

It is proposed that this crop be accompanied in the der season by the vegetable crops of tomatoes and onions. Tomatoes have a similar water requirement to August sown maize. One quarter of the total farm area would be devoted to these crops, (rotated round the fields), and to provide some dietary variety, aubergines and sweet peppers could be substituted for a proportion of the tomatoes (say 10 percent) if desired by the particular field committees.

Pulse crops (cowpeas, green grain) to provide a protein supplement to the diet are proposed for the gu season, planted over 25 percent of the area, and a second crop of maize planted on 25%, leaving 50% as fallow to provide a 3 year break between pulses and tomatoes and to allow more time for mechanised cultivations including land planing.

7.2.2 Cropping Pattern

As shown in Chapter 5 there is a substantial flow in the Juba available for irrigation for a least the 8 months of the year of May to December. If planting is done during April with the first rains, it is thus possible to fit in two crops in the April to December period, planting short duration crops (105 day Maize and 110 day pulses) in the gu season and allowing one month for cultivation (re-ridging) between the two seasons.

Apart from some of the vegetables, rotational constraints do not impose any major limitation on cropping patterns. However, tomatoes should not be grown more than one year in four on a given parcel of land if soil borne disease problems are to be avoided and so should never occupy more than 25 percent of the land area. It is also preferable that tomatoes do not follow cowpeas/green gram in the rotation.

The cropping pattern, and cropping calendar that have been used for planning the Halba project are illustrated in Figure 7.1 and the proposed crop rotation and cropping intensity are shown in Table 7.1. The basis for crop selection has already been discussed. The cropping patterns have been determined by taking into account rotational constraints, water availability, likely preferences for consumption and mechanisation constraints.

TABLE 7.1

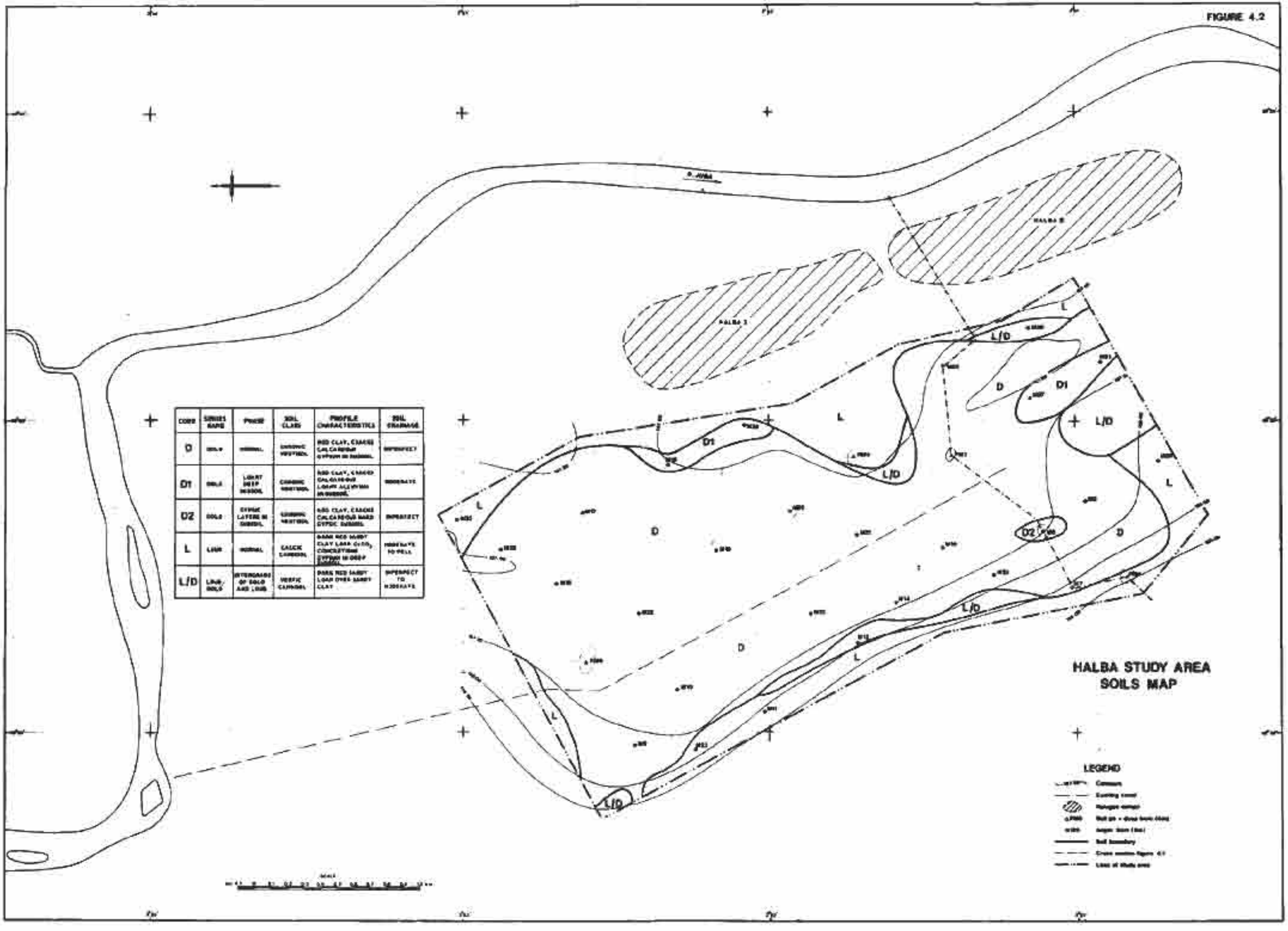
Proposed Crop Rotation and Cropping Intensity by Season

Year	Season	Crop	Seasonal Intensity
1	Gu	Fallow Pulses Maize Fallow	50%
	Der	Maize Onion Tom	100%
2	Gu	Fallow Maize Fallow Pulses	50%
	Der	Onion Tom. Maize	100%
3	Gu	Pulses Fallow Fallow Maize	50%
	Der	Maize Onion Tom Maize	100%
4	Gu	Maize Fallow Pulses Fallow	50%
	Der	Maize Onion Tom Maize	100%
5	Gu	Fallow Pulses Maize Fallow	50%
	Der	Maize Tom Onion	100%

7.2.3 Agronomy

Recommendations are made here on the agronomic practices to be followed in the cultivation of the selected crops, including varieties, times of planting, seed rates, and fertiliser use. Mechanisation of operations are discussed in a separate section; it is anticipated that land preparation including re-ridging between the 'gu' and 'der' crops would be mechanised but that all other operations including weeding would be by hand.

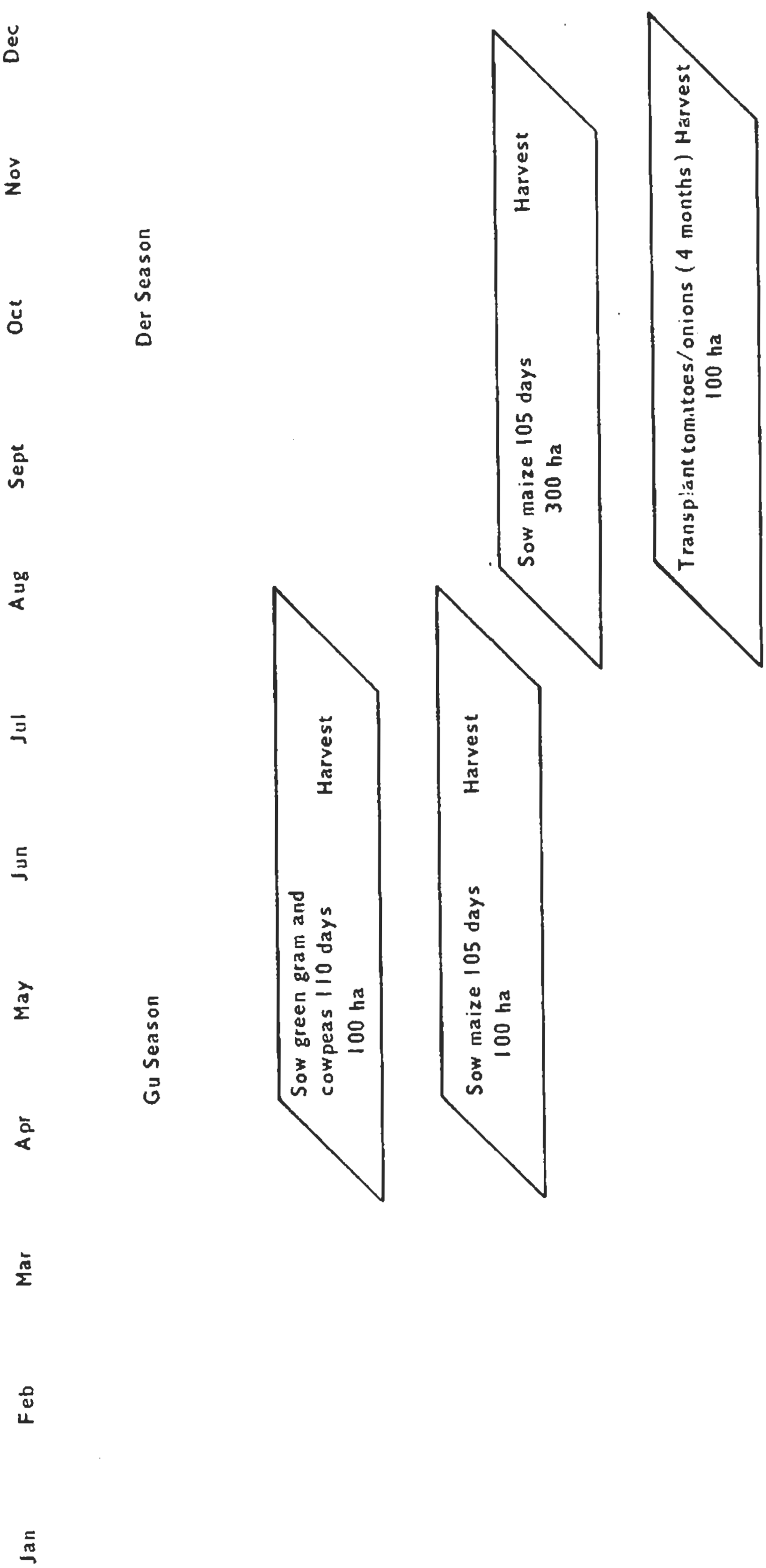
FIGURE 4.2



CODE	SERIES NAME	PHASE	SOIL CLASS	PROFILE CHARACTERISTICS	SOIL DRAINAGE
D	DOLO	NORMAL	CHROMIC VERTISOL	RED CLAY, CRACKS CALCAREOUS GYPSUM IN SUBSOIL	IMPERFECT
D1	DOLO	LIGHT DEEP SUBSOIL	CHROMIC VERTISOL	RED CLAY, CRACKS CALCAREOUS LIGHT ALLUVIUM IN SUBSOIL	MODERATE
D2	DOLO	GYPSIC LAYERS IN SUBSOIL	CHROMIC VERTISOL	RED CLAY, CRACKS CALCAREOUS HARD GYPSIC SUBSOIL	IMPERFECT
L	LUUQ	NORMAL	CALCIC CAMBISOL	DARK RED SANDY CLAY LOAM $CaCO_3$ CONCRETIONS GYPSUM IN DEEP SUBSOIL	MODERATE TO WELL
L/D	LUUQ, DOLO	INTERGRADE OF DOLO AND LUUQ	VERTIC CAMBISOL	DARK RED SANDY LOAM OVER SANDY CLAY	IMPERFECT TO MODERATE

HALBA STUDY AREA
SOILS MAP

CROPPING CALENDAR
(HALBA : 400 HA FARM)



a) Maize

Introduction

Maize is the staple food of a large proportion of the population living in southern Somalia and is one of the most important crops grown in the Juba Valley. It is however, sensitive to drought and at Halba irrigation is essential for good crops.

Varieties

Both the local varieties and the recently developed Somali composite maize are early maturing varieties requiring 100 to 105 days. Early maturing varieties are favoured for the following reasons:-

- These varieties are short-statured and can withstand the strong seasonal winds. Later, taller varieties would be prone to lodging.
- A decreased risk of drought compared to longer season varieties.
- Double cropping, longer season varieties (120 to 150 days) could not be double-cropped and would interfere with other crops in a rotation.

The Somali composite variety is the only variety that has been developed for recommendation in Somalia and is known to greatly outyield the local variety at other development projects and under research conditions (CARS, unpublished data). However, because it is a yellow-seeded variety it is recommended only until a new white-seeded composite can be developed in Somalia to meet local tastes.

Planting Dates

Optimum planting dates depend upon the following factors:-

- Maximising use of effective rainfall.
- Irrigation is required until 75 to 80 days after planting.
- Maturation and harvest periods should avoid periods of heavy rainfall.

- 100 to 105 day varieties are recommended.
- Maximising use of irrigation water (August-October).

Recommended planting dates are therefore in mid April and mid August.

Land Preparation and Planting

Pre-planting operations would comprise ridging for the furrow irrigation system proposed. Inter-row cultivation would be necessary during the early stages of growth.

Planting would be by hand at a rate of 20 kg of seed per hectare giving a population of around 40,000 plants. (2-3 seeds every 30 cm thinned to one plant per position by thinning at the first weeding).

Fertilisers

Without specific trials in the area, it is difficult to make precise recommendations on the levels which should be applied. There is enough information available however, from CARS and the FAO Pilot Project (between 1965 and 1974) to give an indication of the levels at which economically worthwhile responses are likely to be achieved. Rates of 50 kg per hectare of diammonium phosphate and 100 kg per hectare of urea supplying 57 kg nitrogen and 25 kg of P_2O_5 per hectare would probably be of the correct order.

Pests and Diseases

The only serious pest or disease problem in the area is maize stalkborer (Chilo partellus). Attacks commence soon after emergence of the crop. Furadan granules applied to the soil at planting time, at 2.0 kg/ha a.i. or Busudin 10G (Diazinon) applied down the whorl at 13 and 35 days after convergence at a total of 1 kg/ha a.i. provide control.

Weed Control

It is expected that weed control could be achieved by hand weeding. Three weedings at 10, 20 and 40 days after planting would probably suffice.

Irrigation

The maximum irrigation interval at full crop development should be 15 days and six irrigations are needed; with 100 to 105 day varieties, the final irrigation will be at about 75 days after planting.

Harvest

Hand harvesting is recommended. Direct picking of cobs would probably be the most practical method. It would allow full grain drying to take place and as harvest would be in December there should be little risk of rain damage.

Yields

Although there is little information available on the current maize yields in the Halba area, with the development of irrigation and the introduction and acceptance of recommended practices, there is sufficient evidence within Somalia and from neighbouring countries (e.g. Kenya) that under reasonable husbandry conditions, yields of 3,500 kg per hectare can be achieved with composite varieties.

b) Tomatoes

Introduction

Under rainfed agriculture a local cherry type of tomato is very popular in most areas, and this variety seems to be remarkably resistant to pests and diseases which attack the large fruited exotic varieties. In a rotation tomatoes should not be planted on land that previously carried cowpeas, which are liable to root knot eel-worm, and four years should be allowed before repeating tomatoes on a given piece of land.

Varieties

Because of susceptibility of the large-fruited imported varieties to curly top virus transmitted by whitefly, the major part of the tomato field should be planted to the local variety. Some planting of the best imported plum tomato variety, Roma, may be included. (Following several years of research this variety outyielded 24 other varieties under test).

Planting Date; Nursery

Seed is sown in raised beds about 1 m wide in drills 15 cm apart, at about 100 seeds per metre of drill. 20 g of seed are required for 10 m long beds and 10 beds, (200 g seed) will plant one hectare. Shade is required from time of sowing for about 20 days (gradually reduced between 10 and 20 days from sowing). Planting date is mid July for transplanting in mid August. Seedlings are thinned to 2.5 cm spacing about 10 days after sowing.

Transplanting

Transplanting of seedlings at one month old is at a spacing of 60 cms apart of 90 cm ridges.

Fertilisers

Fertiliser requirements should be of the order of 50 kg/ha of DAP as a basal dressing before transplanting, and 100 kg/ha of Urea applied to the growing crop, split into two applications at 1 and 4 weeks after transplanting, banded 10 cm away from the plants.

Pests and Diseases

Curly Top virus disease is the major cause of yield losses of tomatoes in Somalia, hence the recommendation of growing predominantly local tomatoes. Although symptoms of curly top do not appear until about four weeks after transplanting, the disease is carried in the nursery (by the white-fly vector, Bemisia tabaci) and reasonable control of the vector would necessitate four or five sprays (of Dimecron) at the nursery stage and a further 8-10 weekly sprays after transplanting.

Apart from damage caused by curly top virus disease, yield losses also occur through fruitworm (Heliothis sp), but this pest is most severe on tomatoes grown in the gu season. If chemical control of fruitworm becomes necessary, Vetox 85 (Carbaryl) at 1.5 kg/ha per spray can give very good control, applied weekly from the time of first fruit set until a week before first harvest. Gu season crops also suffer most from fungal diseases (Alternaria and Phytopthora).

Weed Control

Several weedings are required to control weed regrowth which is encouraged by regular irrigation.

Irrigation

A minimum of six irrigations by furrow irrigation are required.

Harvest; Yields

Harvesting takes place 2½ to 3 months after transplanting and with irrigation, can continue for up to 2 months. Yields over 5 tonnes per ha can be obtained from the local tomato variety when irrigated.

c) Onions

The recommended onion varieties are 'Red Criole and White Criole'.

Planting Date; Nursery

For transplanting at 6-7 weeks old in mid-August, nursery seedbeds should be sown at the end of June. Seed is sown on raised beds, 1 m wide, in drills 15 cm apart. A fine seed bed is required.

2 kg of seed should be sufficient for 1 transplanted hectare.

Seedbeds should be covered with a light mulch of dry grass, removed after germination.

Transplanting

Two rows (30 cm apart) are planted on flat-topped standard 90 cm ridges at 15 cm between the stands.

Fertilisers

To achieve reasonable yields, onions should receive a basal dressing of about 50 kg/ha of DAP, and a top dressing of 50 kg/ha of Urea.

Pest and Diseases; Weeding

At least three sparyings of Malathion are required to control thrips. It is to avoid bulb rotting that the onions are planted on ridges.

Weed free conditions should be maintained throughout the actively growing stage of the crop.

Irrigation

Because onions are shallow rooting, frequent irrigations are necessary; during very rapid growth commencing about 30 days after transplanting, irrigation at no more than 7 day intervals is normally required. Irrigation is stopped as soon as the crop begins to mature.

Harvest; Yields

Seedlings transplanted after 40 days in the nursery take four months to mature. A yield of 8-10 tonnes of onions per hectare can be achieved.

d) Minor Vegetable Crops

Sweet Peppers

Sweet peppers are grown with similar culture to tomatoes (but they are slower growing, particularly during the propagation stage, and on average will take 2-3 weeks longer from sowing to transplanting than tomatoes).

The recommended cultivar is Californian Wonder. Spacing in the field is at 50 cm on standard 90 cm ridges.

This crop grows well on clay soils if the drainage is good and soil moisture is maintained by irrigation; large fluctuations of soil moisture reduce yields. Apart from the basal dressing of DAP fertiliser applied as for tomatoes, a top dressing of Urea at 50 kg/ha should be applied as soon as the first flowers open.

Fruits are normally harvested when green but can be allowed to ripen to deep red. Production commences about 2½ months after transplanting and yields up to 4 t/ha can be obtained.

Aubergines

Black Beauty is the recommended aubergine variety to grow. Spacing at transplanting is as for tomatoes, 60 cm apart on 90 cm ridges. Fertiliser is applied as for sweet pepper, the top dressing again being applied when the first flowers appear.

The first fruits should be ready to pick about 2½ months after transplanting and production should continue for up to four months.

Green Grams and Cowpeas

Cowpeas and Green Grams are both used with chopped boiled maize in the traditional dish of cambuulo. Although cowpeas are preferred, the local variety of green gram has a higher yield potential being determinate in growth habit and capable of moderate pod production. The local cultivar of cowpeas is a mixture of lines (based on seed colour) with a lower yield potential. Cowpeas are also more susceptible to several pests, including pod-borers and leaf-miners.

Cowpeas are widely grown along the Juba River in both 'gu' and 'der' seasons. Customarily interplanted with maize or sorghum it appears to have considerable drought resistance and yields well in the dry conditions which prevail after the maize or sorghum have been harvested. Occasionally it is grown in pure stand but only in small plots.

Both green pods and mature seed are eaten by the people and it is an important source of protein for the farmers who do not keep livestock. The leaves can also be eaten as a vegetable.

Green gram (Phaseolus aureus) is widely grown (in both 'gu' and 'der' season; usually interplanted). It grows quickly and the time from planting to completion of harvesting is approximately 110 days. It is drought resistant. The Somali green gram is relatively large seeded and pods may be in excess of 12 cm in length. Green gram is well liked by the local people and is a valuable source of vegetable protein.

Field Operations

Planting should be done as soon as possible after the first rains. Spacing for Grams on standard 90 cm ridges at 15 cm apart; this requires about 12 kg/ha of seed. Cowpeas spaced about 30 cm on 90 cm ridges (15 kg seed per ha).

Three weedings may be necessary, weeding in the early stages of growth being critical; later the crop spreads and suppresses weeds.

Fertilisers - 50 kg/ha of Diammonium phosphate, applied at planting time.

Grams mature quickly, in 2½ - 3 months and are therefore well suited to the short 'gu' season.

Harvesting and Yields

Grams are usually harvested by removing individual pods as they ripen (although the plants can be uprooted with the pods still attached). The local variety of green gram can produce over 1,000 kg per ha under irrigation, in experimental plots. Grams are used as a subsistence pulse crop, their seeds being prepared in the same way as cowpeas.

7.2.4 Water Requirements

The soils at the Halba site exhibit a fairly even topography with only small local irregularities and a very low infiltration rate. Under these conditions surface irrigation is considered preferable to sprinkler irrigation which would, in addition, have higher capital and running costs with a large foreign exchange component. Sprinkler irrigation is also unsuitable for growing tomatoes and onions because of the encouragement of foliage diseases and onion neck and bulb rot.

Two methods of surface irrigation are considered - furrow and basin Furrow irrigation is accomplished by introducing water into the furrows either directly from the watercourse by means of plastic siphon pipes or by breaching the bank of a small field channel running parallel to the watercourse. The furrows then carry the water across the field following the ground slope. Basin irrigation involves the formation of small horizontal basins surrounded by a small bund. The basins are filled with water until the required depth has infiltrated into the soil.

Furrow irrigation has been chosen as the recommended method for the following reasons

- basins require very accurate landlevelling otherwise uneven distribution and low application efficiencies result.

- furrow irrigation is particularly suited to row crops.

- vegetables, in particular onions, cannot tolerate waterlogging and should be planted on ridges. This would not be possible under basin irrigation.

In addition, basin irrigation requires a higher labour input than furrow irrigation, although this should not be a problem due to the relatively large labour force available.

Crop water requirements are calculated in Chapter 5 using evapotranspiration data given by Doorenbos and Smith (1977) and mean monthly crop coefficients previously calculated for the Genale Bulo Marerta Project (MMP 1978).

7.2.5 Agricultural Inputs

a) Mechanised Field Operations

The mechanisation techniques recommended are based on the assumption that labour will be available for planting, weeding and harvesting operations. Mechanisation will be necessary for primary cultivations, for ridging up prior to planting in the Gu season, for re-ridging (splitting) prior to the der season planting and for land levelling (planing) operations. It is envisaged that only half the total area will be land-planed each year but that two passes of the land plane will be required to achieve the necessary finish.

As all tractor operations are to be draught operations, it is recommended that four wheel drive tractors be used throughout the project. The landplane will require a minimum 45 kw drawbar power, therefore one of the tractors at each project will need a drawbar power in the region of 45 kw to perform this operation adequately. This tractor would also be able to carry out the other tillage operations, albeit at an increased output.

Recommended practices are detailed below for gu and der season crops as well as methods of final land preparation.

b) Gu Season Cropping

Immediately after harvesting Der crops, land must be disc-harrowed to destroy remaining weeds and stubble as well as to work the surface soil layer and flatten ridge remnants. For this operation, scalloped discs are more effective than plain discs. During the jilal (dry) season, disced land should be further prepared using a mouldboard plough to bury remaining weeds and residues. It is considered that weed levels at harvest may be too great to allow clean burial by ploughing without the initial discing. A reasonable period of several weeks between discing and ploughing should be left to allow for complete desiccation of weeds.

Land planing is necessary after every two to three cropping seasons and should also be carried out in the jilal season. Eversman levellers are suitable. Prior to any planing, a second discing will be necessary to break down any clods to provide a suitable surface for levelling.

c) Der Season Crops

There will be insufficient time between gu and der season crops to enable full land preparation as recommended for the jilal season. Re-ridging (splitting) prior to the der season planting will be the only operation at this time. It is recommended that the stover is removed from the field prior to this operation; it can be used as cattle fodder.

This particular operation is the most time-restrictive, and therefore determines the number of tractors required, as discussed below. There are about 25 days available between the gu and der crops for re-ridging of the 1,000 hectares of the farm. Using 60 kw (80 H.P.) four wheel drive tractors, 900 mm wide rows and 3.60 m working width of the ridger, 0.88 hours per hectare is required (see Table 7.2). Thus in an 8 hour day, 8-9 hectares per tractor can be achieved; two tractors working six days out of seven, could then cover 400 hectares in 28 days. The timing of this operation could then be jeopardised by the breakdown of just one tractor and as this is an isolated area and there are requirements too for tractors for purposes of transport a total of three tractors is recommended.

Total machinery requirements and recommendations are shown in Table 7.2.

TABLE 7.2

Mechanised Field Operations, Assumed Performance and Ouputs

Operations (1)	Working Width (m)	Operating Speed (Km/h)	Efficiency Factor (%)	Operation Time (h/ha)
Ploughing (mouldboard)	1.21	5.5	70	2.15
Disc harrowing	2.16	6.5	75	0.95
Land levelling (2)	3.60	5.0	75	1.48 (2 passes) –
Ridging (900 mm rows)	3.60	4.5	70	0.88

Notes (1) Data based on 60 Kw 4WD tractors
(2) Two passes required.

TABLE 7.3

Machinery Requirements and Recommendations (1)

Recommended		Machinery	Numbers Required (2)
Tractor	-	55-60 kw (pto max) four wheel drive	2
Tractor (3)	-	65-70 kw (pto max)	1
Plough	-	4 x 0.3 m furrows; mounted mouldboard; (Category II)	2
Disc harrows	-	Heavy duty offset mounted (Cat II)	2
Land Plane (4)	-	Bucket width 2.9 m	1
Ridger	-	Heavy duty mouldboard 4 x 900 mm rows; Adjustable bodies Depth wheels.	2

Notes: (1) Based on 28 days available for re-ridging between gu and der.

(2) Based on 8 hour working day.

(3) High power required for landplaning operations.

(4) Two passes over half total area per annum.

Workshop and labour requirements for the operation of this machinery is shown below:-

1 Mechanic/Driver

3 Tractor drivers

Tractor drivers to do their own daily and routine maintenance.

Workshop facilities will be required at the project site. This should include an enclosed covered area with concrete floor with room for three tractors. Sufficient tools and equipment should be available for all repairs and maintenance. Major breakdowns requiring engine overhauls etc should be referred to the dealer.

Bulk storage of fuel will be required as will a stock of regularly needed spares and consumable items such as lubrication, oil, fitters, and wearing parts. A secure area within the workshop building will be required for the storage of such parts. Transport (one landrover or similar vehicle) will be required for the collection of urgently needed spares and supplies and for servicing field breakdowns.

Labour Requirements

Assuming that families selected to participate in the project can each provide two persons (women/older children) able to do farm work there should be no difficulty in each family providing the labour for 0.5 hectares of land and two crops per year, particularly as land preparation and ridging is mechanised. This is the case even assuming that the norm will be a 4 hour working day, six days a week, because of the problems of low output and lack of stamina associated with the introduction of nomads to regular agricultural work.

However it is useful to present the man-day requirements of the proposed crops and identify periods when most hand labour effort will be required. Man/day requirements (4 hour days), are shown in Table 7.4 for major crops and tomatoes on a per hectare basis.

Since the harvesting of maize and cowpeas will be spread over a number of weeks, some of these crops being consumed 'green' and the hectarage of tomatoes (and onions) will be small (in total 0.125 ha per family) the period of most intense labour requirements will be for weeding (0.5 hectares per family). However, families with two workers should have no difficulty in controlling weeds, having in six day weeks an average of 52 4-hour working days per month per family.

Capital Costs of Tractors and Equipment

Capital costs of tractors and equipment required for the Halba farm are given in Chapter 10.

TABLE 7.4

Man Day Requirements Per Hectare for Selected Crops[1]

Crop Operation			Cowpeas
Basal fertiliser dressing	1.5		
Nursery operations		10(per transplanted hectare)	1.5
Planting/Transplanting	6	25(+5 for gapping)	10
Fertiliser side dressing	6	7.5	-
Weed control	38(3 x over 45 days)	45	45
Irrigation	22(6 applications)	27	22
Harvesting	15(includes dehusking)	40	50
Shelling/threshing	5(Hand operated sheller)		12
Uprooting stover	10	-	-

Notes: (1) Basis: 4 hour day

Main Sources: Homboy Irrigated Settlement Project, HTS 1980
Genale Bulo Marerta Project, Sir M. MacDonald & Partners 1978.

CHAPTER 8

ENGINEERING AND INFRASTRUCTURE

8.1 The Irrigation System

8.1.1 Identification of Irrigable Area

The study area of approximately 775 hectares was identified during the Reconnaissance Survey and is located adjacent to the refugee camps at Halba. Within the area about 330 ha have already been cleared and are being partly developed as an irrigation project by the refugees.

The soil investigation revealed that the soils in the Dolo series (D and D1) have the most development potential and the irrigable area has been confined to these soils (defined as marginally suitable for irrigation - Class 3). The existing main canal which is at present being used for irrigation runs through the middle of the irrigable area.

It is proposed to develop a net area of 400 hectares (480 hectares gross) using a surface irrigation system with a maximum 12 hour watering day.

The proposed irrigation and drainage layout is shown in Figure 8.1.

8.1.2 The Gypsum Problem

The presence of gypsum in large quantities in soil creates a problem in the design of an irrigation system. When it comes into contact with water, the gypsum slowly dissolves causing a subsidence of ground level and subsequent collapse of canal banks and hydraulic structures.

The Luuq/Dolo intergrade and Luuq soils at Halba have only a negligible amount of gypsum. However gypsum levels in the Dolo soils (which constitute the irrigable area) increase from less than 3 percent in the top metre to between 9 and 15 per cent in the next 3 metres. It is considered that this level of gypsum could result in collapse of hydraulic channels and structures and wherever possible the channels should be located in the Luuq/Dolo intergrade and Luuq soils.

Where channels run through the gypsic soils it is proposed to take the following precautions:-

(i) To reduce seepage of water into the gypsic layers the supply and distributary canals will be lined with buried polyethylene sheeting. It is proposed to leave the watercourses and drains unlined and to carry out any repairs to these channels when necessary.

(ii) To avoid collapse of hydraulic structures they should be made watertight and particular attention paid to tying in the canal lining to the structure.

(iii) To avoid seepage beneath the canals from the fields, the edge of the irrigated area should be at least 40 m from the canal centreline (i.e. 20 m from the canal reservation). This is referred to as the gypsum reservation in the cross sections.

The level of the soil survey was only semi detailed and at the construction stage the need for these precautions should be determined by hand augering along the proposed canal lines and at structure sites.

FIGURE 8.1

8.1.3 The Watercourse Unit

Due to the irregular shape of the irrigable area it was found impossible to standardise on unit dimensions. However, the net area of each unit has been kept constant at 20 hectares (23 ha gross) with families being allocated ½ hectare net each. The unit size is based on a maximum watercourse discharge of 60 l/s. A typical watercourse unit is shown in Figure 8.2.

Crops will be grown in furrows with a maximum length of 300 m and the slope not exceeding 0.3%. The water level in the watercourse is maintained by portable checks or earth bunds.

Surface drainage water from the unit is carried away by shallow field drains which have 1 in 8 side slopes to permit the passage of agricultural vehicles. Access into the unit is provided by a 4 m wide field road at ground level.

In the east and west fringes of the project area the Luuq soils encroach into the watercourse units. These areas have not been included in the calculation of the net irrigated area.

8.1.4 Water Requirements

The monthly net water requirements for each crop, allowing for effective rainfall are given in Table 5.4.

The watercourses and distributary canals are designed for a maximum requirement of 226 mm per month which is required for maize or tomatoes in October. Assuming a 12 hour watering day this is equivalent to a net requirement for a 20 ha watercourse unit of:-

$$\frac{226}{31 \times 12 \times 3600} \times 20 \times 10^4 \text{ l/s} = 33.7 \text{ l/s}$$

Assuming 60% field efficiency and 10% watercourse losses the required watercourse discharge is:-

$$\frac{33.7}{0.6} \times 1.1 \text{ l/s} = 61.8 \text{ say } 60 \text{ l/s}$$

8.1.5 Distribution System

Canals are defined briefly as follows:-

Supply Canal	-	The canal into which supplies from the River Juba are pumped and which bring water to the Project Area.
Distributary Canal	-	the two canals offtaking from the supply canal and distributing water around the Project Area.
Watercourse	-	a small channel offtaking from a distributary canal or in one instance from the Supply Canal. These are the channels which supply water to individual watercourse units.

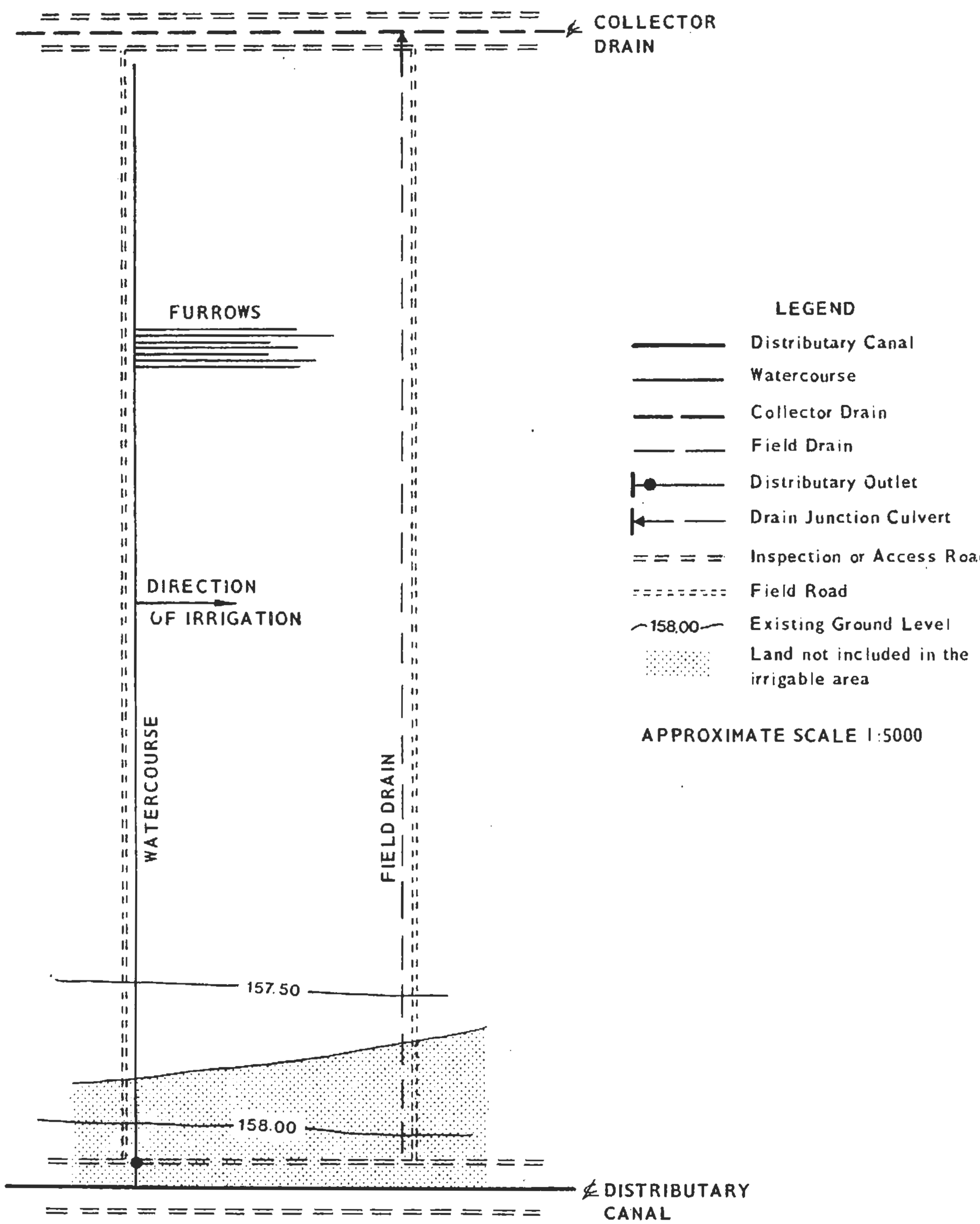
Typcial canal cross-sections are shown in Figures 8.3 and 8.4.

It is proposed to run the distributary canals along the Luuq soils wherever possible to reduce the amount of canal lining. By doing this there will be some watercourse units with a small area of Luuq soils adjacent to the distributary canal. Although in practise this area would probably be irrigated, it has not been included in the calculation of the net irrigated area. Where the supply or distributary canals do run through the Dolo soils it will be necessary to take the precautions laid out in Section 8.1.2.

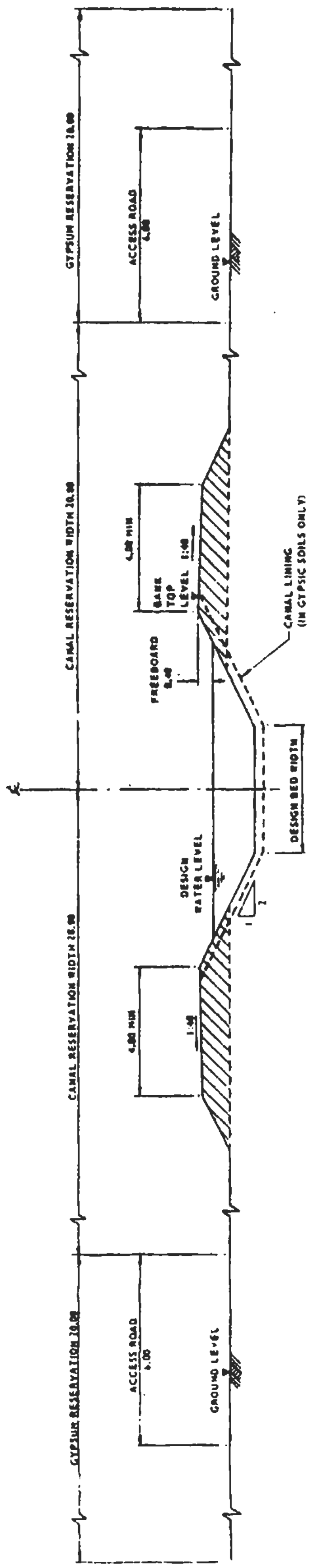
8 .1.6 Canal Design

The canal system is designed for maximum requirements with irrigation only taking place during the day for a maximum of

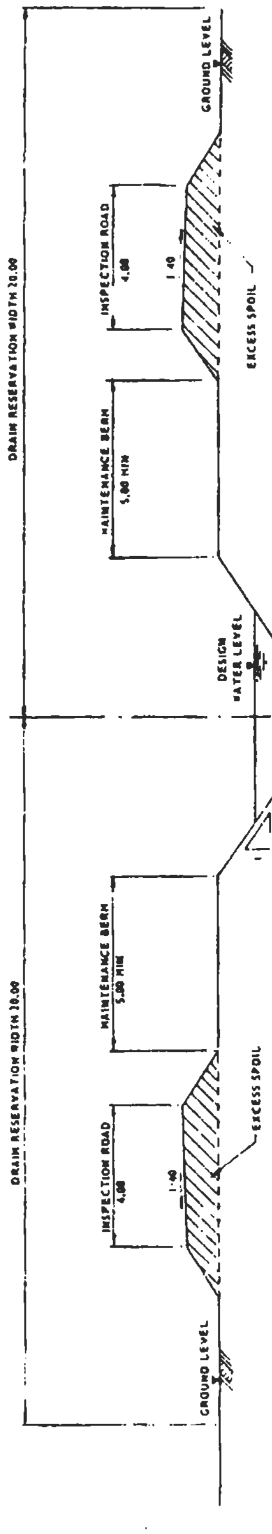
TYPICAL WATERCOURSE UNIT



MAIN CHANNELS-TYPICAL CROSS SECTIONS



TYPICAL SUPPLY OR DISTRIBUTARY CANAL CROSS SECTION

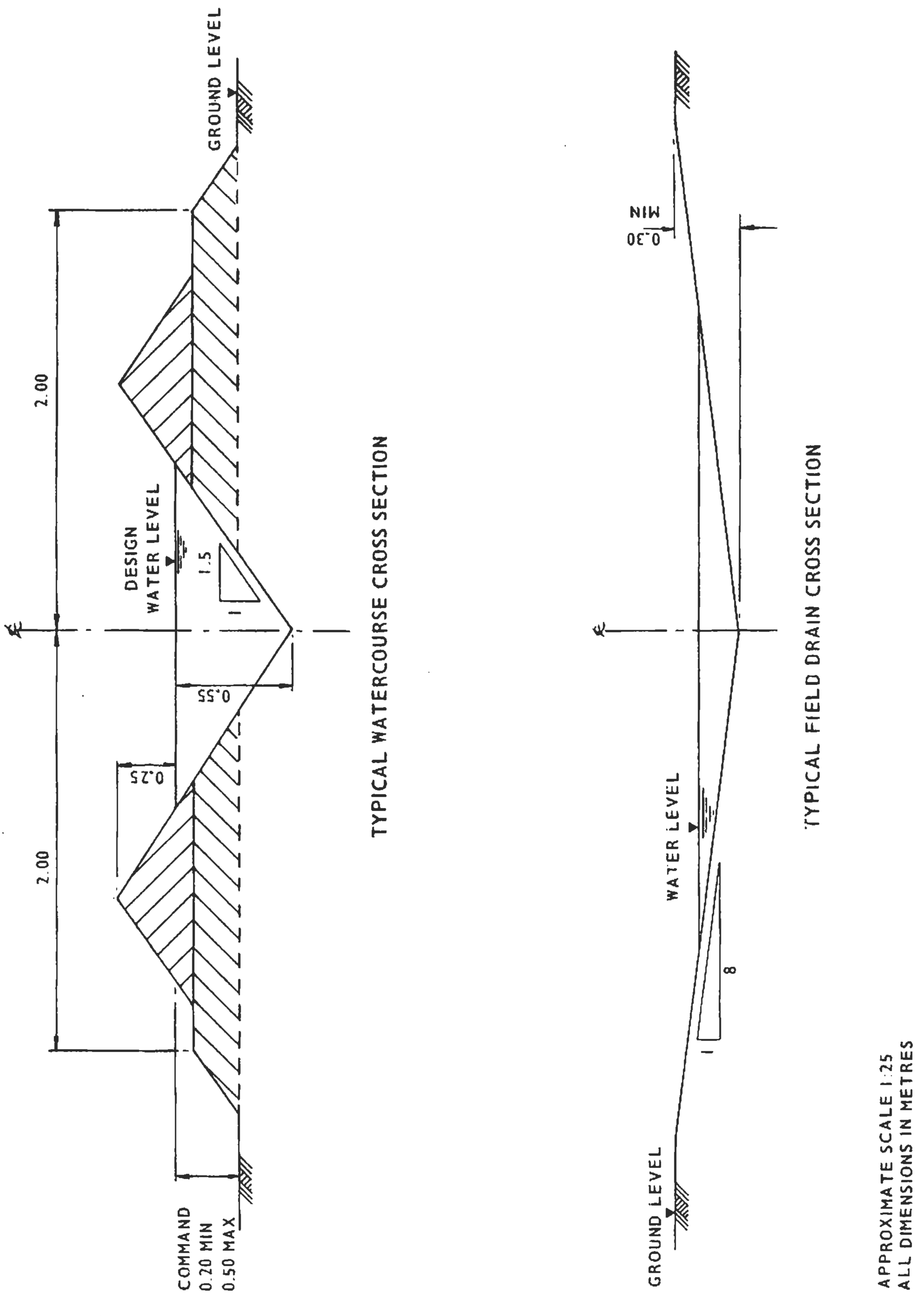


TYPICAL COLLECTOR DRAIN CROSS SECTION

APPROXIMATE SCALE 1:200

FIGURE 8.4

INFIELD CHANNELS – TYPICAL CROSS SECTIONS



12 hours. As the system is relatively short it will be possible to fill the canals each morning directly from the pump station without the need for any night-time storage.

The supply and distributary canal design is based on the Lacey regime equations with the Lacey silt factor in the range 0.4 to 1.0. The canals have a trapezoidal cross section and will generally be unlined except where they pass through the gypsic soils. The design freeboard is 0.4 m and the minimum bed width 1.0 m. Transit losses have been calculated at a rate of 2.50 m^3/s per million square metres of wetted perimeter. The watercourse design is based on Mannings equation assuming a value for n of 0.025.

8.1.7 Canal Structures

A brief description of the four canal structures that will be incorporated in the project are:-

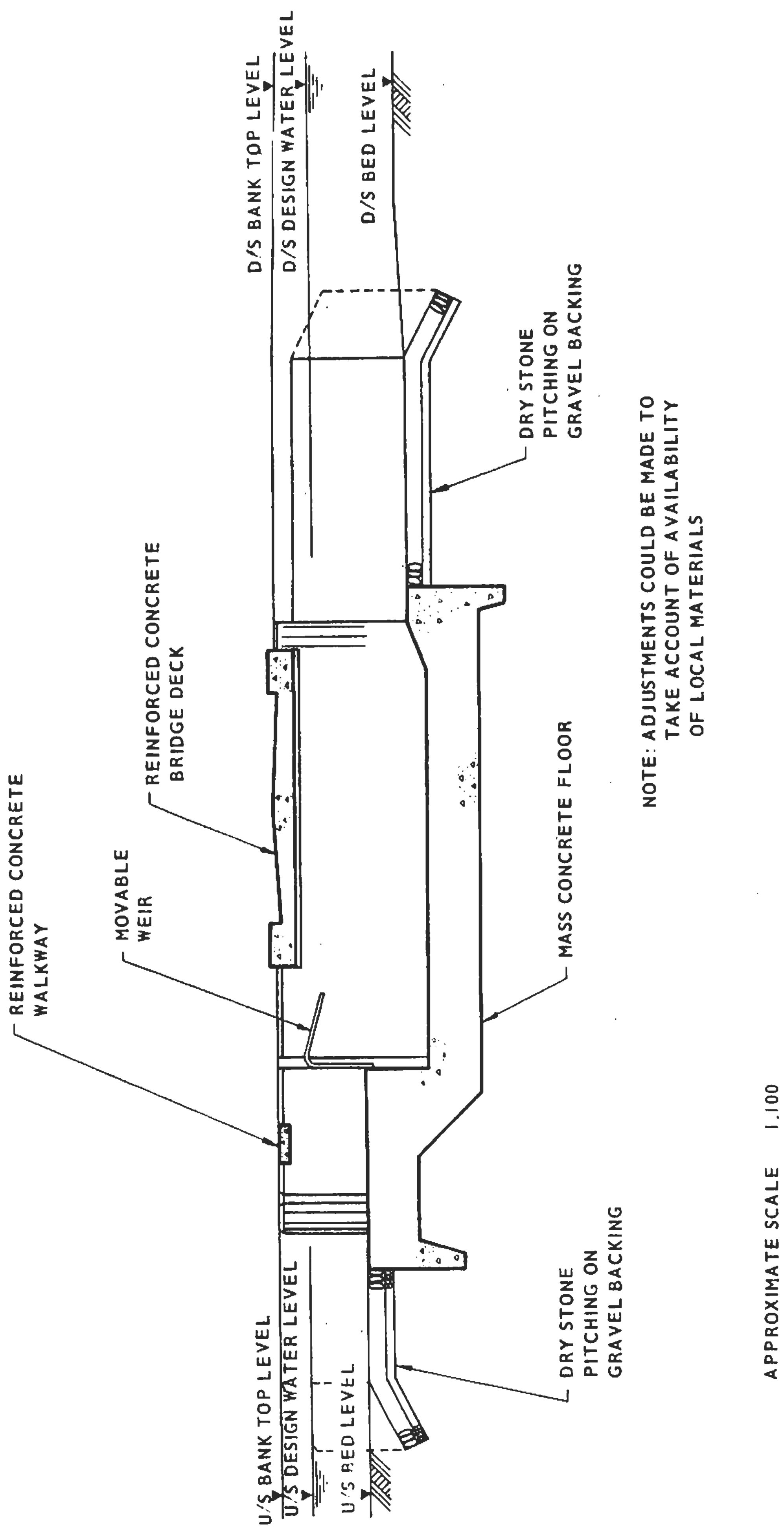
a) Movable Weir Head Regulators

These are located at the head of each distributary canal where it offtakes from the Supply Canal to control and measure the flow. The structure is of mass concrete with a reinforced concrete bridge deck to provide a crossing point. Flow regulation is achieved by a metal weir plate which can be easily adjusted by hand to obtain the required discharge in the distributary canal. A typical movable weir head regulator is shown in Figure 8.5.

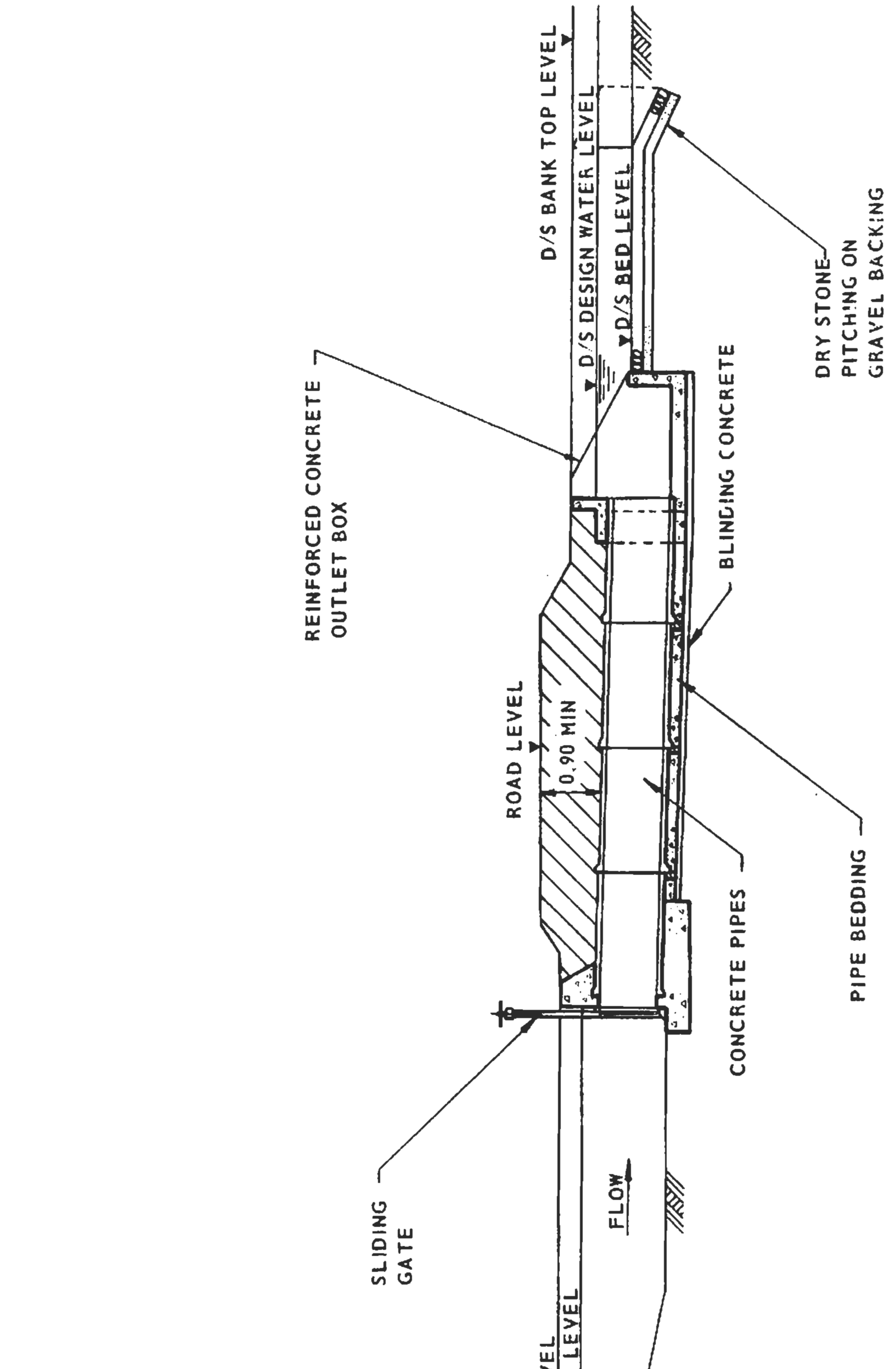
b) Distributary Canal Cross Regulators

These are located at intervals along each distributary canal to regulate water levels so that efficient operation of the distributary outlets can be achieved. They have been positioned such that the furthest upstream distributary outlet is less than 1 km away. The structure consists of a gated pipe with a reinforced concrete outlet box and also provides access across the canal for vehicles. A typical canal cross regulator is shown in Figure 8.6.

TYPICAL MOVABLE WEIR HEAD REGULATOR



TYPICAL CANAL CROSS REGULATOR



NOTE: ADJUSTMENTS COULD BE MADE TO TAKE ACCOUNT OF AVAILABILITY OF LOCAL MATERIALS

APPROXIMATE SCALE 1:100

c) Distributary Outlets

These take water from the distributary canal (or Supply Canal) and discharge into a watercourse. The structure consists of a gated pipe 0.30 m diameter and nominal capacity 60 l/s situated through the canal bank and discharging into the watercourse via a mass concrete outlet box. A typical distributary outlet is shown in Figure 8.7.

d) Distributary Tail Escapes

Each of the distributary canals has been provided with a tail escape to prevent the canal from breaching or overtopping in an emergency. The structure consists of a 0.45 m diameter pipe through the canal bank with an inlet box set just above the design water level in the canal. In the event of a sudden rise in water level, flow will pass through the pipe and into the drainage system to be safely disposed off.

It was recognised during the pre-design survey that stone was available in the area. It may be economic therefore to use masonry structures in preference to mass concrete. This would be investigated in more detail at the design stage.

8.1.8 Irrigation Pump Station

The existing pump station is on the right bank of the River Juba about 10 kilometres north of Luuq. At present water is pumped into the main canal by means of centrifugal pump of East German manufacture. The pump has a capacity of about 350 l/s at a head of 12 m and is powered by a direct drive diesel engine.

There are some signs of bank erosion at the existing site and it is proposed that the pump station will be relocated about 200 m downstream where the river bank is more stable.

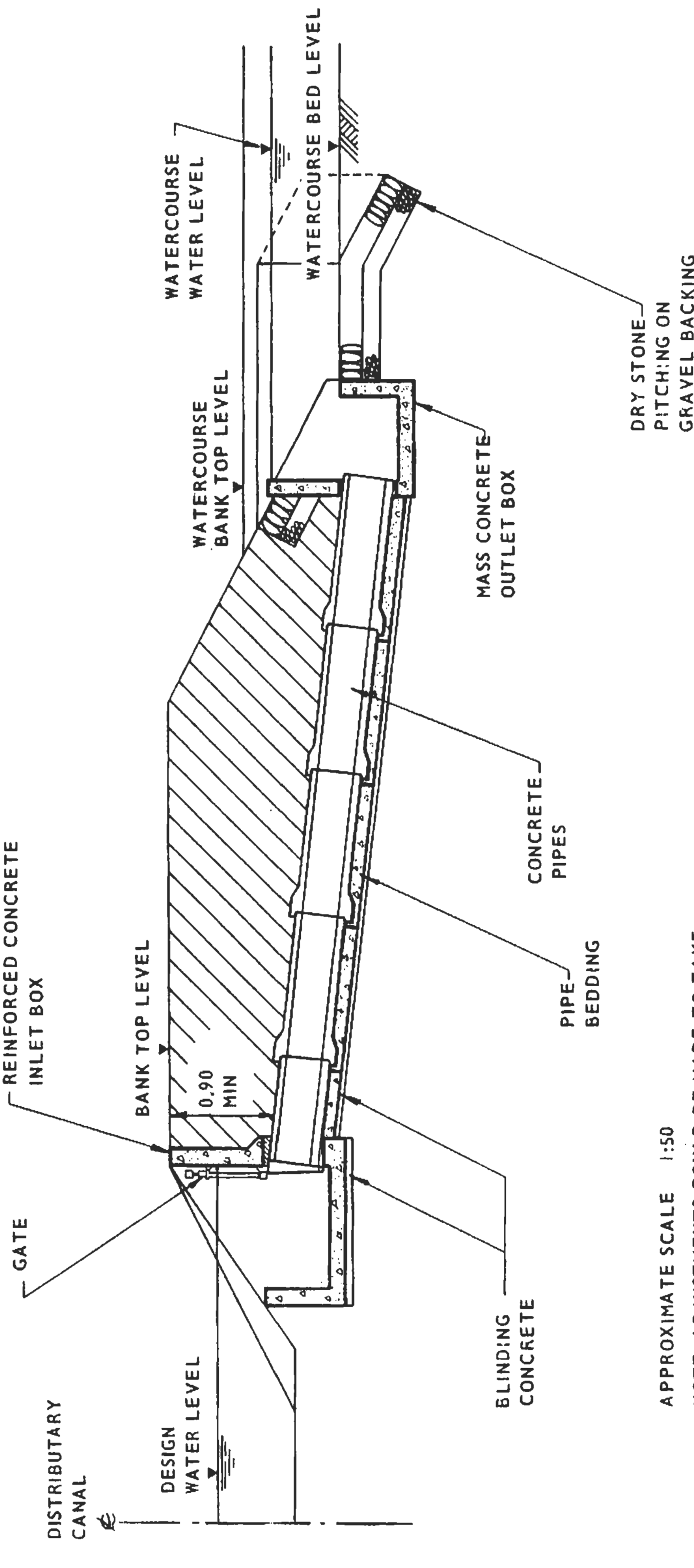
Flood lifter type pumps have been chosen as the most suitable type of pumps to meet the requirements. These are inclined axial flow pumps well suited to a high discharge/low lift duty and requiring a minimum of concrete support works. In addition they are relatively insensitive to changes in head and are therefore suitable for use on rivers such as the Juba and Shebelli where there is a high seasonal variation in water level. They are simple to operate and maintain, and individual units may be completely removed if required for major overhauls. These type of pumps have been used successfully on similar installations both in Somalia and elsewhere and the total cost of the station is considerably less than the alternative of conventional vertically mounted pumps which require extensive structural works.

Electric power supplies are not available at the pump station site and so direct drive diesel engines have been chosen to operate the pumps. This is considered preferable to a local generator with electric motors as the overall efficiency is greater and by adjusting the engine speed a degree of flow regulation may be achieved in the range 0.8Q to 1.05Q where Q is the pump design flow.

The pump station is required to deliver a maximum of 1.25 m^3/s and to meet this 4 Nr 16 inch pumps would be provided (3 operational and 1 standby), each delivering about 0.4 m^3/s under the maximum design static head of 7.5 m. By selective use of the pumps and adjustment of the running speed it should be possible to match any requirement during the year.

For economy an intake channel has not been provided and the pumps will draw water directly from the river. Thus it is imperative that the pump station is located on a stable reach of the river.

TYPICAL CANAL OUTLET STRUCTURE



APPROXIMATE SCALE 1:50

NOTE: ADJUSTMENTS COULD BE MADE TO TAKE ACCOUNT OF AVAILABILITY OF LOCAL MATERIALS

A settling basin has been provided downstream of the pumping station to trap the majority of the suspended load before it can enter the canal. The settling basin would consist of an enlarged section of the supply canal and as such would not result in a considerable increase in the earthworks. To prevent long term build up of sediment the settling basin will require regular desilting.

The proposed pump station layout is shown on Figure 8.8. It is not considered necessary to provide any pump station buildings and generally the structural works have been kept to a minimum for economy.

8.2 The Drainage System

8.2.1 Introduction

Drainage systems in irrigation schemes generally take two forms depending on whether the prime function is surface or sub-surface drainage. A surface drainage system is designed to remove from the fields run-off resulting from rainfall and also, to a lesser extent, excess irrigation water. A sub-surface drainage system is needed where there is a problem of rising ground water table which is in danger of waterlogging and/or causing salinization of the root zone with consequent reduction in yield or, in extreme cases, crop failure.

8.2.2 Drainage rates from cropped areas

Soils can be broadly classified into Dolo and Luuq types with the following characteristics

Dolo soils : heavy textured cracking clay with slickenslides and some fine sand. Some drainage patters below 150 cm.

Luuq Soils : medium textured sandy loam/sandy clay loam.

The Dolo soils are preferred for agriculture by the local population and preliminary findings of the reconnaissance reinforce this preference because of higher water holding capacity.

Crops will be grown on a ridge and furrow system, drainage down the furrows being led to an outlet structure into a collector drain. The outlet structure will impede discharge from a field and cause ponding of water. The design discharge from the field is chosen to limit the duration of ponding resulting from the design rainfall to about 3 days : longer durations will result in low yields or loss of crops. The required design discharge is a function of soil infiltration rate, furrow geometry and design rainfall.

Infiltration rates measured during the reconnaissance study were about 6 mm per hour on Dolo soils and this value has been used in calculation of required drainage rates.

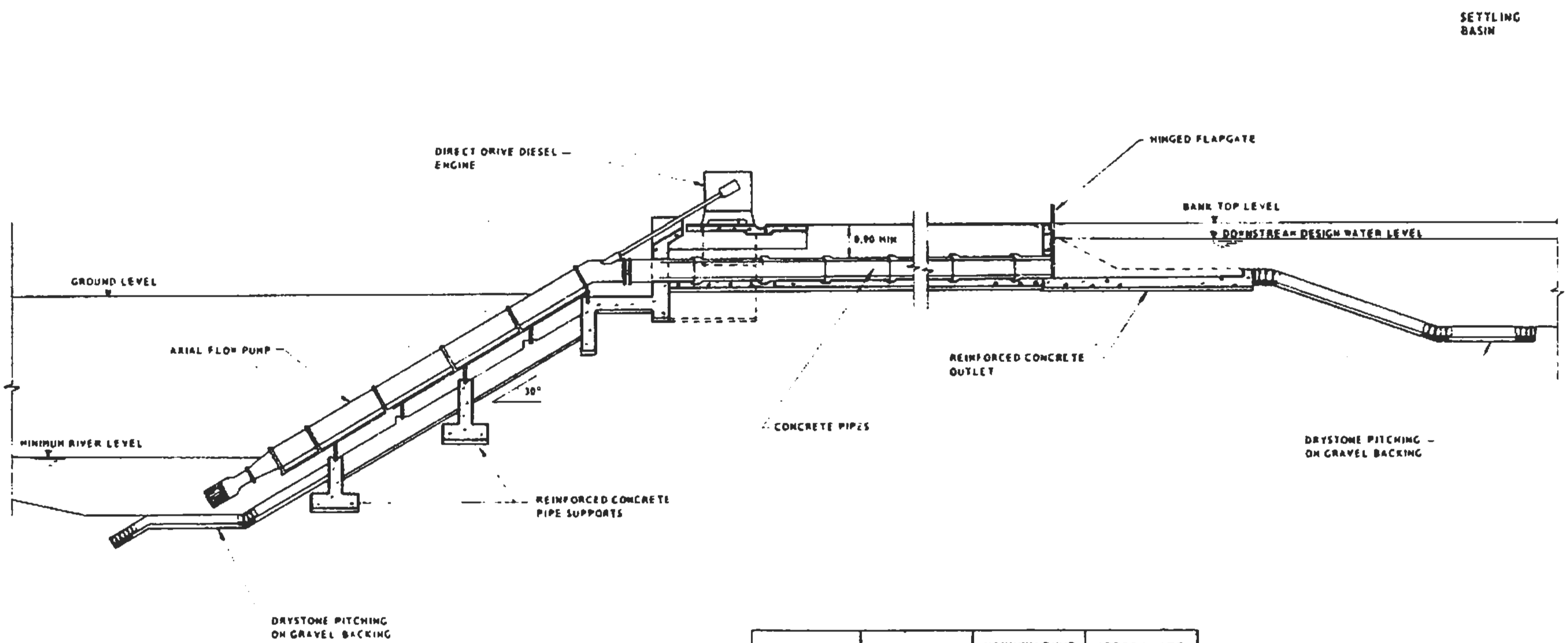
The nearest available record of daily rainfall is for Baardheere, approximately 170 km south of the project area. However, rainfall patterns are expected to be similar at the two locations and Baardheere rainfall record has been used to estimate maximum rainfalls expected once in 5 years (20% exceedence probability) in one, two and three days. The adopted severity of once in 5 years is a commonly used criteria for selecting design rainfalls for drainage design. Table 8.1 shows design rainfalls

Table 8.1

Design Rainfalls for Drainage Design

Duration of rainfall	Rainfall Depth	Daily Increment
1 day	81 mm	81 mm
2 days	95 mm	14 mm
3 days	105 mm	10 mm

IRRIGATION PUMP STATION



APPROXIMATE SCALE 1 : 200

NUMBER OF PUMPS	PUMP SIZE	MAXIMUM PUMP STATION DISCHARGE (m^3/s)	APPROXIMATE STATIC LIFT (MAX) (m)
4	16 INCH	1.25	7.5

For the purposes of calculation, the daily increments in Table 8.1 are assumed to fall during the first 5 hours of the day under consideration.

Furrow geometries are difficult to quantify and have been assumed as:

bed slope	=	0.005
side slope	=	1:1
ridge width, bed width, depth	=	0.25 m

In practice, furrow geometries will vary but the assumed values above are representative of field valves.

The design rainfalls, infiltration rate and furrow geometry were used with assumed field outlet discharge rates to model the rise and fall of water level in a typical furrow. It was found that water depths at the field outlet declined to less than half the furrow depth in a few hours after the end of rainfall, even with zero field outlet discharge rates. Increasing furrow bed slopes to 0.01 and decreasing infiltration rate to 3 mm/hour gives a 72 hour duration of flooding when design drainage rate is one litre/sec/ha. It is recommended that this design rate be used for preliminary design purposes.

8.2.3 Drainage Layout

The surface drainage system is designed for a drainage rate of 1 lit/sec/ha. Field drains collect drainage water from the watercourse units and discharge into a collector drain.

Typical drain cross sections are shown in Figures 8.3 and 8.4. The field drain is a shallow vee-shaped depression with 1 in 8 side slopes to allow the passage of agricultural vehicles. The collector drains are trapezoidal in section and direct the drainage water away from the irrigated area. Since the volume of surface run-off will only be small it is assumed that once outside the project area the water will drain into local depressions and either evaporate or infiltrate into the ground.

The only drainage structures are the field drain junctions which take water from the field drain and discharge into the collector drain. They comprise mass concrete inlet and outlet boxes linked by a 0.45 m diameter pipe. The orifice type inlet box provides a throttle on the inflow to the drainage system. There are quantities of stone available in the area and as with the canal structures it may be more economical to use masonry for the drain structures.

Although the drains run through the gypsic soils they will not be lined for economy, and will therefore require occasional maintenance.

8.2.4 Future subsurface Drainage

Because of the heavy soils, subsurface drainage will be required eventually but installation should be delayed so as to postpone the expenditure until it is necessary. It will also give sufficient time for an actual system of cropping to be established because this may differ from the planned cropping pattern due to settlers preference for certain crops. This could affect the allowable depth to watertable which is dependent on crop rooting depth.

A surface drainage system is planned for the area and the collector drains will be approximately one metre deep. These can be deepened when required and the berms should be of such a width that they are 5 m wide with a drain 2.5 m deep, 1 m bed width and side slopes 1½ hor : 1 vert. Outlets from field drains will be concrete pipes laid on a granular bed and the pipes could be reused if the drain was made deeper in the future.

The quality of the Juba River water varies, maximum and minimum EC values of 2.0 and 0.17 mmhos/cm respectively have been reported together with a mean of 0.40 mmhos/cm (MacDonald Genale-Bulo Marerta Project Report 1978).

Leaching Requirements are given by:-

$$LR = \frac{EC_{iw}}{EC_{dw}} = \frac{EC_{iw}}{5EC_e - EC_{iw}}$$

where EC_{iw} = EC irrigation water

EC_{dw} = EC drainage water

EC_e = EC soil extract for given crop yield depression; usually taken as 10%

The least salt tolerant crop is beans, with an EC_e of 1.5 mmhos/cm for 90% of maximum yield. Using a river water salinity of 0.4 mmhos/cm gives:-

$$LR = \frac{0.4}{7.5 - 0.4} = 0.056$$

This must be increased to allow for the leaching efficiency which can be taken as 0.4 in this case; hence the actual leaching requirement is 0.14.

Anticipated field efficiency is 60% which infers that 60% of the applied water is used by the crop and 40% goes to waste. Of the 40%, 75% will go to deep percolation and 25% to evaporation and other miscellaneous losses. On this basis the leaching fraction will be 0.3 which is sufficiently close to the Leaching Requirement of 0.14 to be adequate.

Only an indication of the required drain spacings will be given because more investigation will be necessary before an accurate assessment can be made. Based on the following data:-

Hydraulic conductivity	1 m/d
Total soil depth	4 m

Drain depth	2 m
Depth to watertable	1 m
Drainage rate	3.5 m/d

When a subsurface drainage system becomes necessary the drain spacing required would be at some 70 metre intervals.

8.3 General

8.3.1 Bush Clearance

The Gross Project Area is about 480 hectares of which about 300 hectares have already been cleared. The remainder of the area is covered with moderately dense thorn bush woodland which will require bush clearance.

Mechanical methods of bush clearance are preferred to the use of chemicals or burning in situ since the latter methods will only partially clear the bush. Furthermore burning is difficult to control and the careless use of chemicals can cause damage to soil micro-organisms.

Of the mechanised methods the use of a crawler tractor with a front mounted rock rake is recommended since it results in minimum disturbance of top soil. Any roots remaining after the primary bush clearance can be removed by root ploughing. The uprooted vegetation will be pushed into windrows for use later on either as firewood or for charcoal preparation or building material.

8.3.2 Land Levelling

Land levelling is of fundamental importance to the success of any surface irrigation scheme. If the accuracy of land levelling is low it will prove impossible to achieve an even distribution of water across the fields and as a result, the efficiency of the system will drop dramatically.

Land levelling will be carried out after the formation of the canals and collector drains but generally before the construction of watercourses and field drains. Each watercourse unit would be set out and levels taken on a grid. It will then be possible to calculate the plane of best fit within the range of allowable furrow slopes. The plane should be designed such that the cut and fill within any one watercourse unit balances, so that there is no need to borrow or dispose of excess material.

The method of land levelling which is considered most suitable for this area uses a combination of scrapers and motor graders working to ground reference pegs and profile boards set to define the required finished plane. The scrapers carry out initial earth movement by cutting high areas of the plot and transporting material to provide fill in the low areas. Final smoothing is then achieved by the graders.

It is considered that alternative methods of land levelling using laser control would not be economic or applicable to this sort of project.

To obtain the desired degree of levelling the average volume of excavation is estimated to be between 300-400 m^3/hectare.

8.3.3 Earthworks

The earthwork operations will involve considerable volumes of fill for the canals and cut from the drains. Wherever possible the fill will be provided by drain excavation, but due to the non-suitability of gypsic soils for canal construction this is unlikely to occur very often. The majority of fill will come from the non-gypsic soils outside the Project Area.

The watercourses will be formed by laying a strip of fill obtained from the adjacent surface drain and then cutting a vee-shaped channel with a ditching machine.

8.4 Infrastructure

8.4.1 Buildings

For economy the infrastructure works will be kept to a minimum. Buildings in the Project Area will comprise a workshop, store and office. These will require a water supply and power facilities. The latter could be provided by a 25 KVA diesel generator.

The workshop will have a concrete hardstanding, a covered area, and sufficient tools and equipment to carry out all routine repairs and maintenance. The floor area would be approximately 500 m^2.

A store is required for seed, chemicals, fertilisers etc., for which a total floor area of about 200 m^2 should be sufficient.

A small office (floor area 75-100 m^2) will be provided for the Farm Manager and his staff.

8.4.2 Access

At present there is an earth track that runs from Luuq to the refugee camp at Halba, and although this is in reasonable condition access might be impeded in times of heavy rain. Access to the Project Area could be improved by constructing a coral surfaced road.

In the Project Area itself, access roads 6.0 m wide have been provided along both sides of supply and distributary canals. These will be graded earth roads at ground level and where the canals run through the gypsic soils will be located in the 20 m gypsum reservation. The drain bank tops will be used as inspection roads with a 1 in 40 outwards camber to prevent excessive bank erosion.

Access into the watercourse units will be along 4.0 m wide field roads at ground level which will be adjacent to the non-irrigating side of each watercourse.

Access across the canals is provided at the pump station and the distributary canal head and cross regulators. Crossing points are also provided at each canal outlet. These should be quite sufficient so that no additional culverts will be required.

CHAPTER 9

COST ESTIMATES

9.1 Unit Rates

The unit rates used in the engineering cost estimates take account of those for the Homboy and Mogambo Irrigation Projects assuming the work is substantially executed by the refugees with some experienced staff providing management and assistance. The rates are slightly higher than those adopted in the Pre-feasibility Report for Jalalagsie to take account of the remoteness of the Halba Project. A list of typical unit rates used for this Report is given in Table 9.1.

All unit rates quoted are for an October 1980 time base; earlier rates being updated by a suitable percentage to allow for inflation. It should be noted that all costs given in this Chapter are economic costs and include no customs duty or taxes.

TABLE 9.1

Typical Unit Rates Used in Cost Estimates

October 1980 Prices

		RATE (SoSh)
Bush Clearance	ha	2087
Land Levelling	ha	3830
Excavation to form embankments (short haul)	m^3	13.3
Excavation for foundations of structures	m^3	26.6
Compacted backfill for structures	m^3	31.2
Concrete Class D blinding (0.1 m thick)	m^2	112
Reinforced concrete class A	m^3	1272
Mild steel reinforcement	tonne	13824
Back shuttering	m^2	360
Dry stone pitching and gravel backing	m^2	242
Spigot and socket concrete pipe and bedding 0.45 m Ø	m	706
Canal Lining	m^2	10.3
Distributary Outlet Gate	Nr	3527
Diesel	litre	1.5

9.2 Capital Costs

9.2.1 Engineering and Infrastructure

The capital costs for the engineering and infrastructure works have been built up using unit rates and quantities and are summarised below in Table 9.2 along with probable foreign exchange components.

TABLE 9.2

Capital Costs for Engineering and Infrastructure Works

	Capital Cost (1000 SoSh)	Foreign Exchange Component (1000 SoSh)
Bush Clearance	383	192
Land Levelling	1568	784
Earthworks		
a) Canals	2433	1338
b) Drains	141	78
c) Infield works	301	166
Canal Lining	214	161
Canal Structures		
a) 2 Nr Head Regulators	642	353
b) 6 Nr Cross Regulators	347	191
c) 50 Nr Canal Outlets	375	206
d) 2 Nr Tail Escapes	83	46
Drain Structures		
50 Nr Drain Junction Calverts	410	226
Irrigation Pump Station		
a) Civil Works	417	229
b) Pumping Plant	1259	944
Infrastructures		
a) Workshop	1249	812
b) Store	492	320
c) Office	231	150
d) Power Supply	127	95
e) Water Supply	125	94
Sub Total	10797	6385
Contingencies 10 percent	1080	639
Sub Total	11877	7024
Engineering & Supervision 10 %	1188	702
TOTALS	13065	7726

9.2.2 Tractors and Agricultural Equipment

Capital costs of tractors and agricultural equipment required for the Halba farm are summarised in Table 9.3.

TABLE 9.3

Capital Costs of Tractors and Agricultural Equipment

Recommended Machinery		Number	Unit Cost (1) (1000 So.Sh)	Capital Cost (1000 SoSh)	Foreign Exchange Component (1000 SoSh)
Tractors	55-60 kw (pto max) Four wheel drive	2	140	280	238
Tractor	65-70 kw (pto max)	1	160	160	136
Plough	4 x 0.3 Furrows Mounted mouldboard (Category II)	2	20	40	34
Disc Harrows	Heavy Duty offset Mounted (Cat II)	2	22	44	37
Land Plane	Bucket width 2.9 m	1	75	75	64
Ridgers	Heavy Duty mouldboard 4 x 900 mm Rows Adjustable bodies Depth wheels	2	20	40	34
Trailers	4 tonnes	2	20.5	41	35
Landrover		2	146	292	248
			TOTAL	972	826

(1) Source: Homboy Irrigated Settlement Project, HTS 1980.

9.2.3 Summary of Capital Costs

Table 9.4 summarises the capital costs for the engineering works and agricultural machinery and gives the probable foreign exchange component.

TABLE 9.4

Capital Cost Summary

Item	Capital Cost 1000 SoSh	Foreign Exchange 1000 SoSh
Land Preparation	1951	976
Earthworks	2875	1582
Structures - canal	1661	957
drain	410	226
Irrigation pump station	1676	1173
Infrastructure - buildings*	1972	1282
services	252	189
Engineering & Supervision	1080	639
Contingencies	1188	702
Agricultural Equipment & Tractors	972	826
TOTALS	14037	8552

Note: *this does not include for the provision of any housing for project staff or others.

9.3 Annual Recurring Costs

9.3.1 Spare Parts, Materials and Maintenance

Annual recurring costs cover the price of spare parts and skilled labour for vehicles and machinery and the price of mateials, plant and labour for repairs to structures and buildings. These costs have been assessed on a percentage basis of the original capital cost. Table 9.5 lists these percentages and summarises the annual costs, based on the capital costs given in Table 9.2.

TABLE 9.5

Annual Cost for Spare Parts, Materials and Maintenance

Item	Percentage of Capital Cost (%)	Annual Cost (1000 SoSh)
Canal and Drain structures	1.5	31
Pumps, engines	3.5	44
Buildings	1.5	30
Vehicles and Machinery	10.0	97
	TOTAL	202

9.3.2 Seeds, Fertilisers and Agrochemicals

Quantities and costs are summarised below for the total hectarage proposed.

TABLE 9.6

Annual Costs of Seeds, Fertilisers and Agrochemicals

Crop	Hectares	Requirement	Unit Cost SoSh/kg	Cost (1000 SoSh)
Maize	400	Seed 20 kg/ha	1.13	9.0
		Furadon (carbofuran) insecticide 2.0 kg/ha	17.2 (1)	13.8
		or Diammonium phosphate 50 kg/ha	2.05 (1)	41.0
		Urea 100 kg/ha	1.84	73.6
Cowpeas	50	Seed 15 kg/ha	2.50	1.9
		Diammonium phosphate 50 kg/ha	2.05	5.1
Green Gram	50	Seed 12 kg/ha	2.50	1.5
		Diammonium phosphate 50 kg/ha	2.05	5.1
Tomatoes	45	Seed 200 g/ha	3.09	2.8
		Diammonium phosphate 50 kg/ha (50 ha)	2.05	5.1
		Urea, 100 kg/ha (50 ha)	1.84	9.2
Onions	50	Seed, 2 kg/ha	190	19.0
		Diammonium phosphate 50 kg/ha	2.05	5.1
		Urea, 50 kg/ha	1.84	4.6
Pepper	up to 2.5	Seed 550 g/ha	380	0.5
		Fertiliser included under tomatoes		
Aubergines	up to 2.5	Seed 450 g/ha	250	0.3
		Fertiliser included under tomatoes		
			Total	197.6

Note: (1) Estimated 1980

Source: BTF 1980

9.3.3 Fuel, Oil and Lubricants

The annual fuel costs for the pump station have been calculated using the volume of water pumped, head and pumping hours.

Oil and lubricants have been assumed to cost 15% of the full cost.

Cost of fuel, oil and lubricants for pump station is So.Sh.80,500.

In addition the cost of fuel, oil and lubricants for the vehicles and farm machinery and equipment is expected to be So.Sh73,000.

9.3.4 Summary of Annual Recurring Costs

Table 9.7 summarises the annual recurring costs.

TABLE 9.7
Annual Recurring Cost Summary

Item	Annual Recurring Cost (1000 So Sh)
Spare Parts, Materials and Maintenance	202
Seeds, Fertilisers and Agrochemicals	197.6
Fuel, Oil and Lubricants	
(a) Pump Station	80.5
(b) Vehicles and Farm Machinery	73.0
TOTAL	553.1

9.4 Possible Capital Cost Savings

The costings have been based on normal works of a permanent nature but it may be considered that some lesser standard could be adopted using local materials immediately available. This would be taken into account during design and implementation.

CHAPTER 10

ORGANISATION AND IMPLEMENTATION

10.1 Introduction

Success in achieving this development will depend on effective management and skilled assistance during both implementation, operation and maintenance and some experienced personnel will be essential for its execution.

10.2 Farm Organisation

It is envisaged that under the completed development each refugee family will be allocated 0.5 hectares of irrigated land and thus there will be 40 families working in each 20 ha watercourse unit. This group would elect a field supervisor who would be responsible for operation of the distributary outlet gate, maintenance of the watercourse and equitable distribution of irrigation water. The field supervisor would be responsible for liaising with the Irrigation Engineer and Farm Manager, and should preferably have some agricultural knowledge although he would receive on-the-job training.

At the end of each growing season the crop harvest would be pooled and distributed equally to the refugee farmers. Any surplus being sold and the profits shared or used to purchase equipment.

It is suggested that some of the 0.5 hectare plots should be allocated to the indigenous farmers who have some previous experience of irrigated agriculture in the area. These will help to demonstrate to the refugee farmers, many of whom have no agricultural knowledge, the tasks to be undertaken and how and when to do them. About 5% or two local farming families per watercourse unit of 20 hectares might be acceptable.

The farm management organisation will grow out of the organisation for implementation.

10.3 Implementation

Implementation of the development will require careful planning and use of resources. Tasks to be undertaken comprise:-

a) Engineering

i) Design

ii) Construction of works including procurement of plant, materials and equipment and management of construction using the refugees and local resources.

iii) Maintenance of plant and equipment.

b) Agriculture

i) Agricultural planning, execution and training.

ii) Procurement of farm machinery and equipment.

iii) Procurement of seed, fertiliser, spray, chemicals etc.

iv) Maintenance of farm machinery and equipment.

c) Establishment of Farm organisation to operate and maintain the completed development providing for:

i) Settlement and training

ii) Agriculture

iii) Engineering

iv) Administration and accounts.

To undertake these tasks will require an experienced irrigation engineer, agriculturalist and mechanical engineer all with executive authority together with other appropriately trained assistance depending on resources available and the rate of implementation to be achieved.

Whilst engineering design work proceeded, preparations for implementation could be undertaken by the executive engineers and the executive agriculturalist.

The engineering and agricultural tasks would be carried out as far as possible in parallel, with the objective of starting agricultural production as soon as irrigation supplies could be made available to a small area for cultivation.

The cultivated area would progressively increase as the engineering works were completed and the farm organisation would develop at the same time so that it would be fully staffed and operational when the construction works were complete.

APPENDIX A

TERMS OF REFERENCE

RECONNAISSANCE AND PRE-FEASIBILITY STUDIES IN JALALAGSIE AND JOWHAR DISTRICT AND GEDO REGION

TERMS OF REFERENCE

A.1 Introduction

The Terms of Reference for the Reconnaissance and Pre-feasibility Studies are given in Section 1, Clause 2 of the Agreement signed 16th August 1980.

For convenience these are reproduced in Section A.2 of this Agreement.

A.2 Terms of Reference

The Terms of Reference for the Reconnaissance Study are contained in Clauses 2.1 and 2.2 for the Gedo Region and Jalalagsie and Jowhar Districts respectively. The complete Terms of Reference for the assignment are as follows:

2. Terms of Reference

2.1 Reconnaissance Survey in Gedo Region

Using aerial photography and data from earlier studies supplemented by visits to the area by engineering and soils specialists, the agricultural and water resources potential of the Region (excluding Dolo district) should be briefly identified and described.

The consultant shall make use of recent reports by the State Planning Commission and surveys by the Oxfam and Menonite Central Committee teams at present assisting the National Refugee Commission.

The Consultant should also identify existing, on-going and planned developments in the Region as it may affect long or short term plans for refugees.

2.2 Reconnaissance Survey in Jalalagsie and Jowhar Districts

The Consultant shall carry out a similar survey to that described in 2.1 above but in Jalalagsie and Jowhar Districts between the towns of Jalalagsie and Jowhar.

2.3 Pre-feasibility Studies

The areas to be studied shall be defined by the National Refugee Commission and U.N.H.C.R. near the Jalalagsie and Halba I camps. The areas allocated for study shall be sufficient to allow for development of 1000 ha at Jalalagsie and 300 to 400 ha at Halba.

The detailed studies required are described below:-

A. Availability and Quality of Water for Irrigation

A.1 Check availability and quality of water for irrigation from the river and, if wells exist in the area check their quality for water supply. Samples of water should be tested.

B. Soil Types and Quality in Relation to Crop Production

B.1 Examine the soils at areas adjacent to the camps of Halba No. 1 (400 ha), and Jalalagsie (1000 ha) and assess their suitability for the development of irrigated agriculture.

B.2 In each area examine the soil profile to a depth of 2 m by augering and pitting. It is estimated that two pits will be required at Halba, 5 at Jalalagsie. Samples from the auger holes shall be collected for routine analysis and from selected pits for detailed analysis.

B.3 In each area, at selected pit excavations, infiltration tests using the double ring method shall be carried out.

B.4 In each area the crops being grown and their quality shall be recorded.

B.5 The final report should include information on the salt and sodium hazards and in particular the analyses of pH, EC, CEC (sodium, potassium, calcium magnesium) ESP, and particle size distribution.

B.6 The final report will provide an assessment of the soils potential for crop production under irrigation. It will also provide recommendations for any ameliorative measures that could be taken to improve on the soils suitability for irrigated agricultural production.

B.7 The report will define the basic agricultural requirements of the projects assuming the labour intensive methods will be employed whenever possible.

C. Topography

C.1 Take levels along lines approximately 400 m apart with groundlevels at 100 m intervals or slope changes. Where possible these lines should follow existing tracks. Bush clearance is not required to be undertaken by the Consultants. Major features encountered should be recorded.

C.2 Level in from existing Somali Survey and Mapping Department Bench Mark distant not exceeding 20 km from the area being surveyed. If no Somali Survey and Mapping Department

Bench Mark is available levels should be related to suitable reference in area and one permanent Bench Mark established in each area. Temporary Bench Mark's should be established throughout each area at approximately 2 km intervals.

C.3 Outline maps should be prepared on the basis of the above levelling at a scale of 1:10,000 with form lines at 50 cm intervals in level. Major features should be shown.

D. Suitable Irrigation Methods (System)

D.1 Advise on the most suitable system of irrigation for each area.

D.2 Prepare outline drawings of proposed irrigation layout.

D.3 Advise on the best method for implementation of the proposed system taking into account the need for rapid development.

D.4 Estimate the capital costs of development and the annual operation and maintenance costs for the engineering works.

APPENDIX B

SOIL PROFILE DESCRIPTIONS
AND
ANALYTICAL RESULTS

SOIL PROFILE DESCRIPTIONS AND ANALYTICAL RESULTS

B.1 General

The descriptions and analysis for the seven sites in the Halba area are given together in this Appendix.

The soils were described according to the definitions of FAO Guidelines to Soil Descriptions (FAO 1964), Soil Survey Manual (USDA 1951) and Soil Taxonomy (USDA 1975).

Description No: 1
Profile No: PM3
Date: 1st August 1980
Series: Dolo (D)
Land Suitability : 3 pd
Location: Halba, 7 km North 8^{o} East of Luuq bridge.
Geomorphology: clayey channel fill of former Juba Floodplain.
Vegetation/Land Use: cultivated land, fallow at present with few *Dobera glabra*.
Microrelief: Slight gilgai 15 cm relief with potholes.
Remarks: Deep clayey, red Chromic Vertisol with subsoil gypsum; formed on alluvium; increase of salinity down profile.

Depth (cms)	Profile Data
0-5	Red (2.5 YR 4/6) clay; dry and soft surface mulch; weak fine crumb structure; common fine to medium roots; violent reaction to HCl; common fine black $CaCO_3$ concretions; few small gypsum rosettes crystals; abrupt wavy to:-
5-10(15)	Red (2.5 YR 4/6) clay; dry and slightly hard; moderate fine to medium subangular blocky structure; common vertical cracks; many fine pores, common fine to coarse roots; violent reaction to HCl; common black concretions of $CaCO_3$; few gypsum rosettes; clear wavy to:-
10-35	Red (2.5 YR 4/6) clay; dry and very hard, to wet and plastic; moderate medium to coarse angular blocky; common vertical cracks; many very fine and medium pores; common fine to medium roots; few gypsum crystals; common black concretions of $CaCO_3$; violent reaction to HCl; clear wavy to:-
34-150	Red (2.5 YR 4/6) clay; dry and very hard, to wet and plastic; very slightly moist and very firm below 80 cms; moderate very coarse prismatic breaking to medium coarse angular blocky structure; few vertical cracks with cavities; few fine pores; few fine and medium roots slightly compressed; common

Depth (cms)	Profile Data
35-150 cont	gypsum crystals <10 mm; violent reaction to HCl; fine black concretions of $CaCO_3$; gradual to:-
150-250	Reddish brown to Dark Brown (5 YR 4/4-7.5 YR 4/4) clay; slight moist and very firm; few vertical cracks with mottled (2.5 YR 4/6) clay; massive structure with slickenslides; few fine pores; no roots visible; common gypsum crystals (<20%) recently formed; soft black concretions; slight to violent reaction to HCl.
250-400	Strong brown (7.5 YR 4/6) sandy clay to clay; moist and very firm to dry hard common gypsum crystals; few black concretions.

Description No: 2
Profile No: PM4
Date: 1st August 1980
Series: Luuq (L)
Land Suitability: 3 sd
Location: Halba, 5.8 km N 2^{o} W of Luuq bridge
Geomorphology: medium textured alluvium of sand bar/levee on former Juba floodplain.
Vegetation/Land Use: moderately dense *Commiphora sp* thornbush woodland; also *Acacia sp*; not cultivated.
Slope and Altitude: about half a percent up to south; 160 m above sea level.
Microrelief: even
Remarks: Red, deep, sandy clay loam Calcic Cambisol formed on old Juba alluvium; gradual increase in salinity down the profile.

Depth (cms)	Profile Data
0-2	Light brown (7.5 YR 6/4), coarse sand; dry and loose on surface; abrupt and smooth to:-
2-15	Dark red (2.5 YR 3/6) medium sandy clay loam; dry and soft; weak fine subangular blocky structure; few small vertical cracks; common fine pores; abundant fine to very fine roots; violent reaction to HCl; clear and wavy to:-
15-42	Dark red (2.5 YR 3/6) medium sandy clay loam; dry and slightly hard; moderate fine to medium subangular blocky; common small vertical cracks; common fine proes; few fine very fine and medium roots; rare dry and slightly hard $CaCO_3$ concretions (<5 mm); violent reaction to HCl; gradual wavy to:-
42-70	Dark red (2.5 YR 3/6) medium sandy clay loam; dry and very hard; few small vertical cracks; common fine pores; few fine and very fine roots; few $CaCO_3$ concretions; violent reaction to HCl; gradual wavy to:-

Depth (cms)	Profile Data
70-150	Dark red (2.5 YR 3/6) medium sandy clay loam; dry and very hard; moderate medium angular blocky to massive; few vertical cracks; common fine pores; few fine roots; few gypsum crystals, very common white $CaCO_3$ concretions (5-10 mm); violent reaction to HCl; gradual to:-
150-190	Red (2.5 YR 4/6) sandy clay loam; dry and very hard; moderate fine to medium subangular blocky, to massive; rare vertical cracks; few fine pores; no roots; no gypsum; common white $CaCO_3$ concretions; few black concretions; violent reaction to HCl;
190-240	Red (2.5 YR 4/6) heavy sandy clay loam; dry and hard; 4% gypsum; black concretions;
240-300	Red (2.5 YR 4/6) sandy clay loam; dry and hard; 2% of gypsum; limestone fragments.
300-375	Yellowish red (5 YR 5/6) gravelly fine sandy clay loam; no gypsum; many small white $CaCO_3$ concretions; limestone fragments (gravel?).

Description No: 3

Profile No: PM5

Date: 3rd August 1980

Series: Luuq (L)

Land Suitability: 3 sd

Location: Halba, 7.5 km N 6^{o} E of Luuq bridge.

Geomorphology: medium textured alluvium of sand bar/levee on former Juba floodplain.

Vegetation/Land Use: moderately dense, *Commiphora sp* thornbush; Few tall *Acacia sp*; not cultivated

Slope and Altitude: horizontal; about 158 m above sea level.

Microrelief: even.

Remarks: red, deep, sandy clay loam with $CaCO_3$ accumulation at depth; Calcic Cambisol; low salinity to 2 metres.

Depth (cms)	Profile Data
0-10	Reddish brown (2.5 YR 4/4) loamy medium sand; dry and soft; weak fine to medium subangular blocky; few small vertical cracks; very fine pores; abundant very fine and fine few medium roots; slight reaction to HCl; gradual wavy to:-
10-30	Dark red (2.5 YR 3/5) medium sandy loam; dry and slightly hard; moderate fine to medium subangular blocky; few vertical cracks; many fine and very fine cracks; many very fine to medium roots; slight reaction to HCl; gradual wavy to:-
30-65	Dark red (2.5 YR 3/6) medium sandy clay loam; dry and slightly hard; common fine to very fine pores; many very fine to medium roots; rare small white $CaCO_3$ concretions; slight reaction to HCl; clear smooth to:-
65-200	Red to yellowish red (2.5 YR - 5 YR 4/6) medium sandy clay loam; dry hard to dry very hard; moderate medium coarse subangular blocky breaking from massive; very rare vertical cracks; many fine and very fine pores; few fine and medium roots; common $CaCO_3$ concretions; violent reaction to HCl;

Depth (cms)	Profile Data
200-240	Yellowish red (5 YR 4/6) fine sandy clay loam; no gypsum; violent reaction to HCl;
240-310	Yellowish red (5 YR 4/6) fine sandy clay loam; less than 5% gypsum; violent reaction to HCl.
310-340	Strong brown (7.5 YR 4/6) loamy medium sand to medium sandy loam; strong reaction to HCl; no gypsum.
340-400	Strong brown (7.5 YR 4/6) loamy medium sand to medium sandy loam; violent reaction to HCl; common powdery calcium carbonate.

Description No: 4
Profile No: PM6
Date: 9th August 1980
Series: Dolo (D)
Land Suitability: 3 pd
Location: Halba, 9 km N 2° W of bridge at Luuq
Geomorphology: clayey channel fill of former Juba floodplain
Vegetation/Land Use: Open <u>Commiphora sp</u> thornbush with few shrubs; not cultivated.
Slope and Altitude: horizontal; 157 m above sea level.
Microrelief: slightly uneven gilgai and sinkholes in clay; 20 cm relief.
Remarks: similar to Site PM3 with deep cracking clay profile and gypsum accumulation; moderate to high salinity in soil never irrigated.

Depth (cms)	Profile Data
0-10	Red (2.5 YR 4/6), clay loam; dry and loose surface mulch, weak fine crumb; violent reaction to HCl; clear wavy to:-
10-30	Red (2.5 YR 4/6) clay loam; dry and slightly hard; moderate fine to medium subangular blocky; common vertical cracks; common very fine and fine, pores and roots; violent reaction to HCl; gradual smooth to:-
30-110	Red (2.5 YR 4/6) clay; dry and very hard to wet and plastic;moderate medium to coarse angular blocky; few vertical cracks extend to base of next horizon; common very fine pores; few fine roots; less than 5% gypsum crystals; common black $CaCO_3$ concretions (1-4 mm); violent reaction to HCl; gradual smooth to:-
110-130	Dark red (2.5 YR 3/6) clay; dry and very hard to wet and plastic; weak very coarse prismatic breaking to medium coarse angular blocky; few vertical cracks to 130 cms; common very fine pores; few

Depth (cms)	Profile Data
110-130 cont	fine roots; 5 to 10% gypsum; common black $CaCO_3$ concretions; violent reaction to HCl; gradual wavy to:-
130-160	Dark reddish grey (5 YR 4/2) clay; common medium distinct 2.5 YR mottles; dry and very hard; wet and plastic; moderate medium to coarse angular blocky; common slickenslides; common very fine pores; few fine roots; 5% gypsum; violent reaction to HCl; diffuse to:-
160-200	Dark reddish brown (5 YR 3/3) clay; slightly moist and firm; moderate fine to medium angular blocky; common slickenslides; common very fine pores; no roots; about 15% gypsum; strong reaction to HCl;
200-300	Dark reddish brown (5 YR 3/4) clay; dry and hard; 5% gypsum; strong reaction to HCl;
300-400	Dark red (2.5 YR 3/6) clay; dry and hard; 5% gypsum.

Description No: 5
Profile No: M6
Date: 3rd August 1980
Series: Dolo 2 (D2)
Land Suitability: 4 d
Location: Halba; 6.3 km N 2^{o} E of bridge at Luuq.
Geomorphology: clayey channel fill of old Juba floodplain.
Vegetation/Land Use: under irrigated cultivation in August 1980 for first time. Formerly *Acacia* scrub.
Slope and Altitude: horizontal; 157 m above sea level.
Microrelief: slightly uneven gilgai 20 cms.
Remarks: Auger bore; very hard gypsic layers a potential problem for water table development and possible collapse of irrigation structures; low to moderate salinity down to 150 cms.

Depth (cms)	Profile Data
0-5	Dark red (2.5 YR 3/6) clay; dry and loose surface mulch; common block $CaCO_3$ concretions; violent reaction to HCl;
5-10	Dark red (2.5 YR 3/6) clay; dry and soft; weak subangular blocky structure; violent reaction to HCl;
10-60	Dark red (2.5 YR 3/6) clay; dry and hard; violent reaction to HCl; blocky structure; few loose gypsum crystals, and small black $CaCO_3$ concretions;
60-120	Yellowish red (5 YR 4/6) clay; dry and hard; about 25% gypsum.
150-170	Yellowish red (5 YR 4/6) clay; dry and hard; less than 10% gypsum.

Description No: 6

Profile No: M19

Date: 5th August 1980

Series: Dolo (D)

Land Suitability: 3 pd

Location: Halba; 8.3 km N of bridge at Luuq.

Geomorphology: clayey channel fill of old Juba floodplain.

Vegetation/Land Use: Cultivated land-sorghum 2 m high generally down to 1 m; few Dobera glabra.

Slope and Altitude: Horizontal; 157 m above sea level.

Microrelief: even; cultivation bunds 30 cm.

Remarks: moist to 80 cm but dry below; low salinity throughout profile.

Depth (cms)	Profile Data
0-25	Red (2.5 YR 4/6) clay; dry and hard to moist and very firm; weak fine to medium subangular blocky structure; violent reaction to HCl.
25-80	Red (2.5 YR 4/6) clay; moist and very firm to wet and plastic; violent reaction to HCl; 5% of gypsum.
80-200	Red (2.5 YR 4/6) clay; moist and very firm; wet and plastic; about 10% gypsum; strong reaction to HCl.

Description No: 7

Profile No: M20

Date: 5th August 1980

Series: Dolo (D)

Land Suitability: 3 pd

Location: Halba; 8.2 km N of bridge at Luuq

Geomorphology: clayey channel fill of old Juba floodplain.

Vegetation/Land Use: cultivated with sorghum (2.0 m high).

Slope and Altitude: horizontal; 157 m above sea level.

Microrelief: even with cultivation bunds 30 cm high.

Remarks: Dry at surface from crop. Moist from 40-200 cms; small gypsum crystals, not layers; moderate salinity despite irrigation, suggests inadequate leaching water.

Depth (cms)	Profile Data
0-30	Red (2.5 YR 4/6) clay; dry and soft; weak sub-angular blocky; no mulch;
30-140	Red (2.5 YR 4/6) clay; moist and very firm, to dry and very hard; up to 5% gypsum crystals.
140-200	Reddish brown (5 YR 4/4) clay; moist and very firm; 10% gypsum crystals.

Description Nr: 1 Area: Halba

Profile Nr: PM3 Series: Dolo (D)

Horizon Nr.	Depth (cm)	Particle Size Analysis (%)						
		Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay
1	0-10	2	3	4	5	14	27	45
2	10-35	1	3	3	5	14	26	48
3	35-80	2	3	4	4	15	24	48
4	80-110	2	3	3	3	15	39	35
5	125-150							
6	150-175							
7	175-200							
8	220-250							
9	250-275							
10	300-350							
11	350-400							

Horizon Nr.	pH paste	E.S.P.	$E.C._e$ (mmhos/cm)	Exchangeable Cations (me/100 g)				C.E.C. (me/100g)
				Ca	Mg	Na	K	
1	7.6	0.1	1.9	30.94	2.24	0.05	1.18	35.8
2	7.7	0.1	1.9	34.69	2.80	0.02	0.98	36.0
3	7.7	0.9	2.7	43.75	5.32	0.26	0.94	30.8
4	7.8	1.0	4.2	56.25	7.04	0.25	0.82	25.5
5		6.5	7.6			1.38		21.0
6		14.1	9.0			3.38		23.9
7			8.6					
8			10.3					
9			12.0					
10			12.0					
11			11.6					

Horizon Nr.	Gravel (%)	Gypsum (%)	Total $CaCO_3$ (%)	Available P (ppm)	Total P (mg/100g)	Organic C (%)	Total N (%)	Saturation Percentage
1	0	0.4	13.5	0.52	48.0	0.298	0.028	40
2	0	1.5	12.6	0.26	45.0	0.266	0.021	39
3	0	2.8	11.3					38
4	9	9.6	11.4					45
5		12.0						
6		14.0						

Description Nr: 2 Area: Halba
Profile Nr: PM4 Series: Luuq (L)

Horizon Nr.	Depth (cm)	Particle Size Analysis (%)						
		Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay
1	0-15	2	14	22	14	5	14	28
2	15-42	4	17	22	15	10	7	25
3	42-70	5	16	20	14	13	7	25
4	70-110	4	13	17	13	11	14	28
5	110-150							
6	150-190							
7	200-240							
8	240-300							

Horizon Nr.	pH paste	E.S.P.	$E.C._e$ (mmhos/cm)	Exchangeable Cations (me/100 g)				C.E.C. (me/100g)
				Ca	Mg	Na	K	
1	7.7	0.4	0.6	13.30	1.82	0.06	1.44	17.3
2	7.8	1.1	1.0	10.93	2.29	0.16	0.56	15.0
3	7.5	2.7	6.0	10.66	2.67	0.50	0.28	18.3
4	7.6	8.0	7.5	8.94	4.34	1.66	0.34	20.8
5		8.2	7.0			1.73		21.0
6		11.3	7.5			2.55		22.5
7		5.2	9.5			0.84		16.0
8		5.4	10.2			1.05		19.5

Horizon Nr.	Gravel (%)	Gypsum (%)	Total $CaCO_3$ (%)	Available P (ppm)	Total P (mg/100g)	Organic C (%)	Total N (%)	Saturation Percentage
1	0	0.05	8.8	4.82	35.0	0.60	0.045	22
2	0	0.03	8.4	0.67	29.0	0.33	0.028	26
3	1	0.02	13.1					31
4	0	0.01	19.4					30
5			19.7					
6			12.0					
7			9.4					
8			10.7					

Description Nr: 3

Profile Nr: PM5

Area: Halba

Series: Luuq (L)

Horizon Nr.	Depth (cm)	Particle Size Analysis (%)						
		Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay
1	0-30							
2	30-65							
3	65-100							
4	120-180							

Horizon Nr.	pH paste	E.S.P.	$E.C._e$ (mmhos/cm)	Exchangeable Cations (me/100 g)				C.E.C. (me/100g)
				Ca	Mg	Na	K	
1		0.3	1.0			0.03		9.0
2		0.6	0.4			0.06		9.3
3		0.4	1.0			0.06		16.0
4		0.7	1.7			0.13		17.8

Horizon Nr.	Gravel (%)	Gypsum (%)	Total $CaCO_3$ (%)	Available P (ppm)	Total P (mg/100g)	Organic C (%)	Total N (%)	Saturation Percentage

Description Nr: 4

Profile Nr: PM6

Area: Halba

Series: Dolo (D)

Horizon Nr.	Depth (cm)	Particle Size Analysis (%)						
		Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay
1	0-30							
2	30-100							
3	110-130							
4	130-160							
5	160-200							

Horizon Nr.	pH paste	E.S.P.	$E.C._e$ (mmhos/cm)	Exchangeable Cations (me/100 g)				C.E.C. (me/100g)
				Ca	Mg	Na	K	
1			2.3					
2			5.6					
3			13.3					
4			16.0					
5			15.4					

Horizon Nr.	Gravel (%)	Gypsum (%)	Total $CaCO_3$ (%)	Available P (ppm)	Total P (mg/100g)	Organic C (%)	Total N (%)	Saturation Percentage

Description Nr: 5
Profile Nr: M6

Area: Halba
Series: Dolo 2 (D2)

Horizon Nr.	Depth (cm)	Particle Size Analysis (%)						
		Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay
1	0-30							
2	30-60							
3	60-100							
4	100-150							

Horizon Nr.	pH paste	E.S.P.	$E.C._e$ (mmhos/cm)	Exchangeable Cations (me/100 g)				C.E.C. (me/100g)
				Ca	Mg	Na	K	
1			1.1					
2			2.4					
3			2.4					
4			3.9					

Horizon Nr.	Gravel (%)	Gypsum (%)	Total $CaCO_3$ (%)	Available P (ppm)	Total P (mg/100g)	Organic C (%)	Total N (%)	Saturation Percentage

Description Nr: 6
Profile Nr: M19

Area: Halba
Series: Dolo (D)

Horizon Nr.	Depth (cm)	Particle Size Analysis (%)						
		Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay
1	0-25							
2	25-50							
3	50-80							
4	80-100							

Horizon Nr.	pH paste	E.S.P.	$E.C._e$ (mmhos/cm)	Exchangeable Cations (me/100 g)				C.E.C. (me/100g)
				Ca	Mg	Na	K	
1			1.3					
2			0.8					
3			1.2					
4			1.1					

Horizon Nr.	Gravel (%)	Gypsum (%)	Total $CaCO_3$ (%)	Available P (ppm)	Total P (mg/100g)	Organic C (%)	Total N (%)	Saturation Percentage

Description Nr: 7 | Area: Halba

Profile Nr: M20 | Series: Dolo (D)

Horizon Nr.	Depth (cm)	Particle Size Analysis (%)						
		Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay
1	0-25							
2	25-50							
3	50-80							
4	80-100							

Horizon Nr.	pH paste	E.S.P.	$E.C._e$ (mmhos/cm)	Exchangeable Cations (me/100 g)				C.E.C. (me/100g)
				Ca	Mg	Na	K	
1			1.3					
2			0.8					
3			1.2					
4			1.1					

Horizon Nr.	Gravel (%)	Gypsum (%)	Total $CaCO_3$ (%)	Available P (ppm)	Total P (mg/100g)	Organic C (%)	Total N (%)	Saturation Percentage

APPENDIX C

INFILTRATION TESTS DATA

INFILTRATION TESTS DATA

TABLE C1 Infiltration Rates (means from 3 replicates at each site)

Soil Series	Site No.	Time Interval (minutes)	Mean Infiltration (mm/hour)	Rate Instantaneous (mm/hour)	Cumulative Infiltration (mm)	Time (Minutes)
Dolo	PM3	20	18	54	18	20
		20	13	39	31	40
		20	9	27	40	60
		30	5	10	45	90
		30	6	12	51	120
		30	4	8	55	150
		65	10	9	65	215
		75	9	7	74	290
		60	8	8	82	350
		60	6	6	88	410
			Wetted Depth after 7 hours 40-50 cms			
Luuq	PM4	15	13	53	13	15
		23	8	22	21	38
		21	5	15	26	59
		36	6	10	32	95
		40	9	15	41	135
		45	10	15	51	180
		60	9	9	60	240
		60	7	7	67	300
		75	10	8	77	375
		30	53	6	83	405
			Wetted depth after 7 hours 40-45 cms			

APPENDIX D

WATER QUALITY DATA

WATER QUALITY DATA

D.1 Introduction

Table D.1, from the Mogambo Project Study (MMP 1979), shows the chemical analysis of water samples taken from the River Juba between February and mid April 1979. They clearly show the effect of the freshet at the start of the gu season.

TABLE D.1

Chemical Analysis of Juba River Water Samples

Date of sample	EC x10^3	pH	TDS (ppm)	Ca	Mg	Na (milli equivalents per litre)	K	CO_3	HCO_3	SO_4	Cl	Silt (g/l)	B (ppm)	SAR	River Flow (m^3/s)
8.2.79	0.4	8.0	180	2.9	0.8	1.1	0.05	0	2.4	1.1	1.6	0.04	0.14	0.6	-
16.2.79	0.4	7.8	370	4.7	0.7	1.0	0.07	0	3.1	0.9	1.4	0.13	0.14	0.3	90
4.3.79	0.4	7.7	320	2.4	0.6	1.5	0.05	0	2.1	0.9	2.0	0.09	0.14	0.9	65
11.3.79	0.3	7.9	225	2.7	0.6	1.2	0.07	0	2.6	0.9	1.4	0.1	0.06	0.7	46
16.3.79	0.3	8.0	200	2.9	0.7	0.7	0.07	0	2.3	0.7	1.6	0.1	-	0.4	37
25.3.79	0.5	7.9	365	2.9	0.8	1.9	0.09	0	2.0	1.0	2.2	0.01	0.08	1.0	42
1.4.79	0.6	8.2	595	2.7	1.2	1.9	0.1	0	2.7	1.3	3.2	0.2	0.05	0.9	52
4.4.79	2.7	7.7	2 080	10.6	3.3	15.8	0.1	0	1.8	9.0	18.4	0.4	0.1	2.2	72
6.4.79	0.7	7.8	560	5.0	1.1	2.4	0.05	0	1.9	2.6	2.4	1.1	-	0.8	84
8.4.79	0.8	7.8	550	5.5	1.7	2.7	0.1	0	2.1	5.8	2.4	1.4	-	0.7	278
9.4.79	0.6	8.1	385	3.2	0.9	1.5	0.1	0	2.7	2.4	2.0	8.7	-	0.7	205
10.4.79	0.4	8.3	330	3.0	0.7	0.9	0.08	0	3.0	0.8	2.0	12.1	0.09	0.5	160
12.4.79	0.5	7.7	420	4.2	0.7	1.5	0.09	0	2.8	1.4	2.0	5.5	-	0.6	92

Note: Samples taken from 1.4.79 onwards clearly show effect of first flush in river at start of gu season.

APPENDIX E

SURVEY DATA

SURVEY DATA

Topographical Survey & Benchmark Data

A total area of 775 hectares was surveyed of which about 450 hectares was covered with light to medium bush.

The datum used for the survey was BM 243 A which was located at the base of the flagpole in the square behind the District Commissioner's office in Luuq. The value was taken as 153.313 above mean sea level Mogadishu.

One permanent bench mark using a ground anchor was established on the track between Luuq and Halba. The base line for the survey was set out adjacent to the existing main canal and permanent benchmarks were established along this line. Temporary benchmarks were also established at the existing pump station (H6) and on the headwall of the main canal culvert 1.5 kilometres from the pump station (H5).

The base line ran approximately down the centre of the Study Area and lines at 400 metre intervals were surveyed up to and into the bush on either side of the main canal.

The survey information and extent of bush cover in the study area are shown in Figure E.1 which includes a tabulation of the benchmark reduced levels.

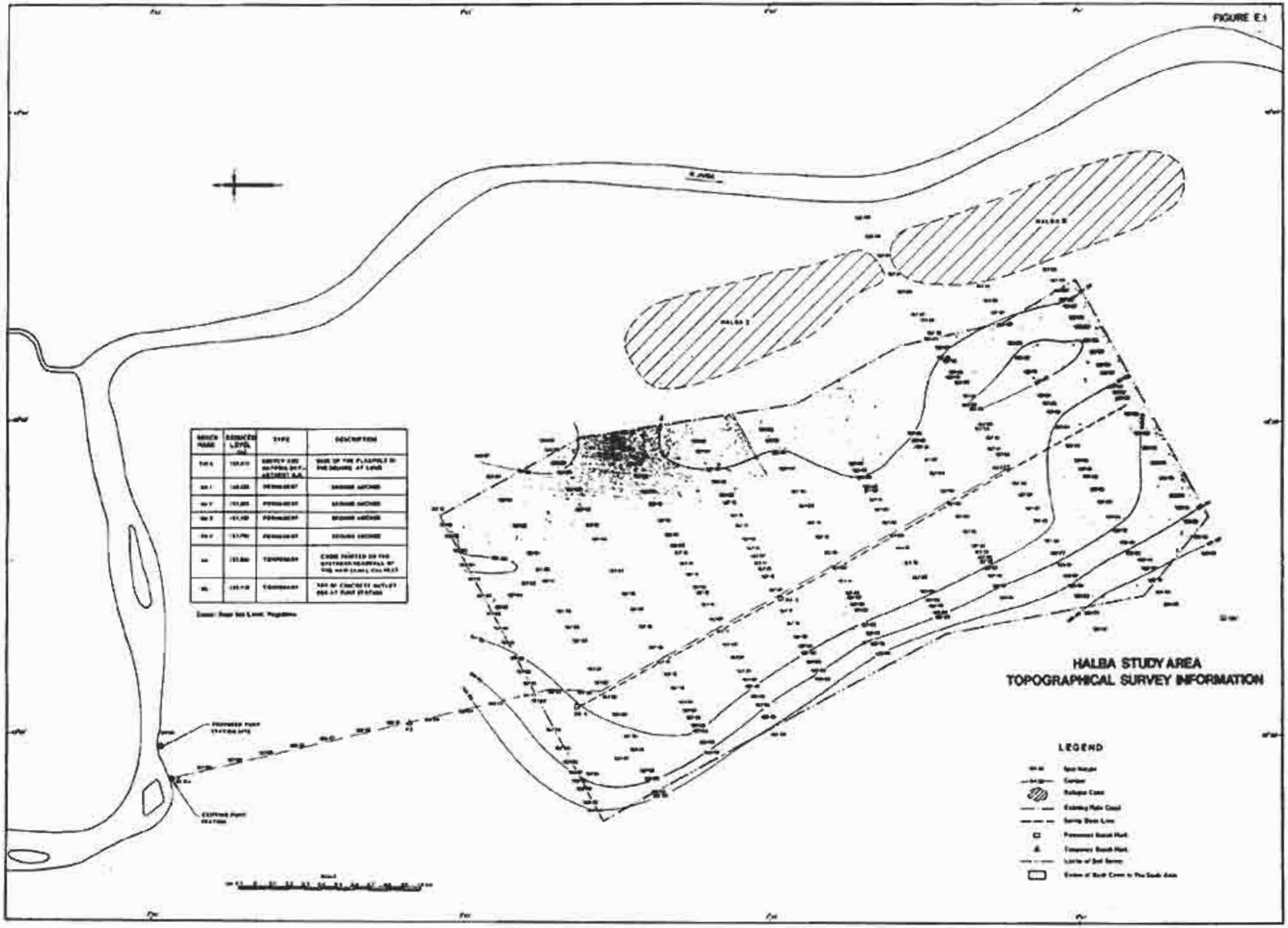


FIGURE E.1

HALBA STUDY AREA
TOPOGRAPHICAL SURVEY INFORMATION

APPENDIX F

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REFERENCES

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