2-2 Present Medical Conditions in Kenya

2-2-1 General Sanitary and Health Conditions

Modernization of Health and Sanitary Conditions in Kenya has been developing recently through aid from the developing countries. An adequate policy of controlling communicable diseases and the problems of nutrition have been guided by international organizations such as WHO, FAO and UNICEF.

It will however take time for this aid to be extended and have an effect upon the people who are scattered in areas where there are severe natural conditions or circumstances. Although the present sanitary and health conditions in Kenya are undergoing a transitional period, the administrative and medical approach of the government of Kenya has an important role with regard to the impact on the other East African countries. Under these circumstances, basic studies such as the Virus research program, Machacos project, The Control of Tuberculosis and Cholera in cooperation with WHO and the Food Improvement Program by FAO are developing and they are being administered by the Ministry of Health.

2-2-2 Medical Institutions in Kenya

Though Kenyatta National Hospital in Nairobi is the only national hospital in the country, there is a Government hospital in the country, there is a Government hospital in each of the seven provinces. All 40 districts also have their own hospitals except where there is a provincial hospital. There are also a few hospitals in sub-district areas, but they have limited facilities.

In addition, there are mission hospitals administered by church organizations, hospitals owned by a factory and private clinics.

Two major institutes, National Public Health Laboratory Service (NPHLS) and Medical Research Center are regarded as medical study institutions. Considering the development of these functions, the Ministry of Health established the Kenya Medical Research Institute which is administered by the Ministry.
Table 2-5 and Table 2-6 show the present conditions in the medical institutions and the number of registered medical personnel respectively.

2-2-3 Major Diseases in Kenya

According to the data obtained, the major communicable diseases in the coastal area are Malaria, Diarrhea, Schistosomiasis, Chickenpox and Measles.
Communicable diseases which have a high rate of death are Tetanus, Dysentery, Cerebro-Spiral Meningitis and Hepatitis. Though Cholera and Typhoid are also diseases which have a high death rate, those diseases are not always prevalent. Statistical Data related to these diseases are tabulated in Tables 2-7, 2-8 and 2-9.

Table 2-5 Health Institutions and Hospital Beds and Cots by Province, 1981

Numbers

	Health Institutions				Hospital Beds and Cots	
	Hospitals	Health Centres	Health Sub-Centres and Dispensaries	Total	No. of Beds and Cots	No. per 100,000 Population
Nairobi	17	8	62	87	6,253	720
Central	45	38	180	263	4,351	179
Coast	24	22	133	179	2,930	211
Eastern	27	27	193	247	3,827	136
North-Eastern ..	3	3	18	24	354	91
Nyanza	38	39	142	219	2,937	109
Rift Valley ..	52	86	363	501	4,987	147
Western	15	39	39	93	2,469	130
Total 1981	221	262	1,130	1,613	28,108	177
Total 1980	216	241	1,087	1,544	27,691	174

Table 2-6 Registered Medical Personnel, 1979 - 1981

Numbers

	1979	1980	1981		IN TRAINING	
	Number	Number	Number	No. per 100,000 Population	1980/81	1981/82
Doctors	1,682	1,853	2,057	12·96	667	500
Dentists			197	1·24		100
Pharmacists ..	—	—	84	0·53	120	120
Pharmaceutical Technologists ..	272	299	326	2·05	103	120
Registered Nurses	6,542	6,692	6,892	43·44	608	640
Enrolled Nurses	8,317	8,722	9,190	57·92	1,911	1,138
Clinical Officers	1,534	1,681	1,723	10·86	314	330

Source;Economic Survey,1982

Table 2-7 Communicable Diseases Survey by th Ministry of Health (Kwale, Kitui and Mombasa in 1975)

Diseases	Number of Patients Surveyed	Infection Rate per 1000 peoples	Estimated Number of Patients in Kenya
Acute Poliomyelitis	829	0.20	2,681
Infectious Hapatitis	1,545	1.57	21,056
Kal-azar	1,074	1.10	14,752
Leprosy	722	0.73	9,790
Tetanus	144	0.15	2,011
Tuberculosis	1,464	1.49	19,983
Malaria	316,829	322.65	4,327,703
Diarrhea	143,163	145.78	1,955,347
Chickenpox	10,120	10.31	138,286
Measles	15,494	15.77	211,522
Meningitis	150	0.16	2,144
Mumps	5,590	5.69	76,318
Schistosomiasis	20,752	21.13	283,413
Whooping Cough	9,070	9.23	123,790
Pneumonia	24,372	24.83	333,046

Table 2-8 Reported Cases of Some Infectious Diseases 1975 - 1978

	1975		1976		1977		1978	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Acute Poliomyelitis	197	11	210	6	290	21	1,020	5
Anthrax	194	1	338	1	214	4	217	5
Brucellosis	256	14	244	—	513	3	495	—
Cerebro-Spinal Meningitis	511	81	947	169	1,557	196	1,640	145
Dysentry	17,726	120	14,532	87	24,933	104	29,743	37
Encephalitis (Primary)	27	2	10	1	27	4	20	1
Infectious Hepatitis	891	40	714	32	1,366	52	1,286	23
Kala-Azar	226	10	184	4	184	17	238	9
Leprosy	340	3	449	2	466	4	1,103	11
Schistosomiasis	8,800	6	9,567	1	15,198	2	14,118	—
Tetanus	604	204	691	250	718	248	645	187
Trypanosomiasis	19	—	7	—	20	2	13	—
Typhoid Fever	273	12	164	26	348	22	135	5
Cholera	1,120	31	1,291	20	—	—	—	—
Small Pox	—	—	—	—	5	—	—	—

Source: Ministry of Health.

Table 2-9 The Cause of Death in Mombasa in 1976

Infection Diseases (include parasite)		
A4	Dysentery	1
A5	Diarrhea	94
A6-9	Tuberculosis	64
A16	Whooping cough	1
A20	Tetanus (include infant)	44
A21	Other bacterial diseases	32
A25	Measles	94
A27	Virus Meningitis	4
A28	Infective Hepatitis	13
A29	Other Viral diseases	6
A31	Malaria	22
	Total	375
		(15.6%)

2-3 Present Status of Water Supply System

2-3-1 Present Status of Water Supply

The government of Kenya established as its goal the provision of a clean and adequate water supply for all citizens in the country by the year 2,000.

The number of people having access to safe and clean drinking water is summarized by province in Table 2-10.

Among the provinces unable to receive the benefits of the improved water supply, only the Western Province has relatively favourable natural conditions. The rest of the provinces, however, are covered to a much greater extent by dry areas. This is characteristic of the water supply problem in the Republic since more than 70% of the national population is distributed in these dry areas which occupy almost 80% of the land. (See Table 2-11)

Table 2-10 Size of Population Served by Improved Water Supply in Rural Areas by Province

Province	Population with Water Supply	Total Population	Percentage
Nairobi	877,000	965,000	91
Nombasa/Coast	880,000	1,331,000	66
Rift Valley	565,000	2,902,000	19
Nyanza	510,000	2,895,000	17
Eastern	435,000	2,485,000	17
Central	433,000	2,221,000	19
Western	430,000	1,795,000	24
Northern	21,000	278,000	7
Total	4,151,000	14,873,000	27.9

Source: Min. of Water Development

Table 2-11 Plan of Rural Water Supply

Province	June, 1980		June, 1981		June, 1982*	
	No.	Cost K£'000	No.	Cost K£'000	No.	Cost K£'000
Central	13	5,500	15	6,000	18	8,985
Coast	11	454	11	454	11	454
Eastern	19	2,180	20	2,780	21	2,880
North-Eastern ..	15	157	15	157	15	157
Nyanza	15	3,198	15	3,198	15	3,198
Rift Valley ..	32	917	33	1,035	34	1,309
Western	6	585	9	2,585	10	3,935
Total ..	111	12,991	118	16,209	124	20,918

*Provisional.

2-3-2 Working Body of Water Supply in Kenya

The Ministry of Water Development is responsible for all aspects of water development in the Republic of Kenya. Since the Ministry was established in 1974 as an organization of different groups concerned with water development, a lot of effort have gone into improving and reinforcing its functions. The Creation of the Water Resources Department is one example.

There have also been various kinds of international cooperation efforts from many donor countries and international organizations.

Presently, as water supply Developmen projects, Rural Water Supply, Ranch Water Development, Self-help Water Supply and Country Council Water Supply are being executed. Those projects are part of the Rural Water Supply Programme. (See Table 2-12)

Table 2-12 TIME SCHEDULE OF RURAL WATER SUPPLIES PROGRAMME PHASE Ⅳ

FEASIBILITY STUDY · PRELIMINARY DESIGN · FINAL DESIGN · TENDER PREPARATION · MATERIAL PROCUREMENT · CONSTRUCT

SER NO.	SCHEME	DISTRICT	DESIGN POPUL-ATION	MoWD/ CONSUL-TANT	MoWD/ CONTRA-CTOR	SPONS-OR	ESTIMATED CONSTRUCTION COST PRICES AS AT OCT.1981 100 x K sh: FOREIGN COMPONENTS	LOCAL COMPONENTS	TOTAL COST	PRINTED ESTIMATES F.Y. 1981/82 100 x K sh: DESIGN	CONSTR.	F.Y. 1981/82 – F.Y. 1982/83 – F.Y. 1983/84 (O N D J F M A M J J A S O N D J F M A M J J A S): schedule remarks	NOTES	SER NO.
1	BAHATI	NAKURU		KHS		IBRD	7,000	1,500	8,500	1,000	0		DESIGN WORK NOT ONGOING	1
2	BAMBA II	KILIFI	5,000	KITOLOLO	-	IBRD	11,000	1,000	12,000	300	0			2
3	BATHI III(KIJA	KIAMBU	7,000	MOWD		IBRD	6,000	1,200	7,200	400	0			3
4	BUNGOMA AURAL	BUNGOMA	133,000	KHS	-	IBRD	4,600	86,400	91,000	600	0			4
5	CHEPARERIA	W.POKOT	4,000	-	-	-	0	1,500	1,500	-	-		DESIGN WORK NOT YET STARTED	5
6	CHEPSIOOT II	E.MARAKWET	7,000	GAUFF	-	-	0	12,000	12,000	0	4,000			6
7	CHERENGAN	T.NZOIA	136,000	EAEC	-	IBRD	13,000	177,000	190,000	300	0			7
8	DAMASA (LEFI)	MANDERA	8,000	MOWD	-	IBRD	1,100	400	1,500	8	0		GROUNOW WORK TO BE CARRIED OUT	8
9	DUKANOTO	TANARIVER	2,000	MOWD	-	IBRD	200	100	300	10	0			9
10	DURKANA	MARSABIT	2,000	MOWD	-	IBRD	1,100	400	1,500	10	0			10
11	EBURRU	NAKURU	56,000	WANJOHI	-	-	0	70,000	70,000	0	0	THE DESIGN WORK ON EBURRU SCHEME HAS BEEN SUSPENDED		11
12	ENKARONI	KAJIADO	2,000	MOWD		-	0	1,500	1,500	0	0		GROUNOW INVEST. TO BE CARRIED OUT	12
13	FLAX CENTRE	UASINGISHU	47,000	COWI	-	-	0	50,000	50,000	200	0			13
14	FUNYULA II	BUSIA	62,000	-	-	-	0	60,000	60,000	100	-	FINAL DESIGN NOT STARTED	NEW DESIGN ENGINEER TO BE	14
15	GANZE	KILIFI	-	-		ICRD	-	-	-	-	-	GANZE W/S IS INCLUDED IN BAMBA II		15
16	GEMBE HILLS II	S. NYANZA	68,000	ITALCONS	-	-	0	82,000	82,000	1,500	0			16
17	GODOMA	MARSABIT	2,000	MOWD	-	IBRD	1,100	400	1,500	10	0		GROUNOW INVEST. TO BE CARRIED OUT	17
18	HANDAKI	WAJIR	2,000	MOWD	-	IBRD	1,100	400	1,500	8	0			18
19	HULUGHO	GARISSA	2,000	MOWD	-	IBRD	1,100	400	1,500	10	0			19
20	ITHANGA	MURANGA	30,000	NISHO	-	JAPAN	15,100	22	15,122	-	-	STHANGA W/S WAS COMPLETED IN JULY 1979		20
21	KAKUMA	TURKANA	2,400	MOWD	-	IBRD	1,100	400	1,500	10	0			21
22	KALACHA	MARSABIT	3,000	MOWD	-	IBRD	1,100	400	1,500	8	0		AVAITING REQUEST FROM FFC	22
23	KAPCHEROP	E.MARAKWET	14,000	C.BRO	-	-	0	12,000	12,000	100	0			23
24	KAPKONG II	BARINGO	5,100	C.K.P			0	31,500	31,500	100	13,500			24
25	KARINGANI II	MERU	19,200	G.MELVIN	-	(UK)	0	10,000	10,000	60	0			25
26	KERIO FISHING V	TURKANA	5,000	C.K.P	-	IBRD	2,000	600	2,600	50	0			26
27	KHOROF HARAR	WAJIR	2,000	MOWD	-	IBRD	1,100	400	1,500	8	0		GROUNOW INVEST. TO BE CARRIED OUT	27
28	KIGUMO II	MURANGA	230,000	GAUFF	-	-	11,000	88,000	99,000	50	0			28
29	KIKONENI DAM	KWALE	16,000	MOWD	-	-	0	8,500	8,500	0	1,000	CONSTRUCTION WORK COMPLETED		29
30	KINANGONI	KWALE	7,000	-	-	-	0	6,000	6,000	-	-	NO PLANNED ACTIVITIES AT PRESENT		30
31	KIPSIGAK	NANDI	49,000	C.A.LIBURD	-	-	0	61,000	61,000	0	0	THE DESIGN WORK ON KIPSIKAK SCHEME HAS BEEN SUSPENDED		31
32	KURGUNG	NANDI	213,000	C.A.LIBURD	-	IBRD	11,200	175,100	186,300	1,000	0			32
33	LAKE KENYATTA	LAMU	100,000	COWI	-	IBRD	9,000	61,000	70,000	500	0		GROUNOW INVEST. TO BE CARRIED OUT	33
34	LEKWA	RAKWET	3,000	MOWD	-	IBRD	1,100	400	1,500	10	0			34
35	LITEIN RURAL	KERICHO	220,000	COWI	-	-	0	51,500	51,500	0	8,000			35
36	LOKITAUNG	TURKANA	5,000	C.K.P	-	IBRD	5,500	4,500	10,000	40	0			36
37	LOKORI	TURKANA	2,600	MOWD		-	0	3,000	3,000	-	-	NO PLANNED ACTIVITIES AT PRESENT		37
38	MANGA	KISII	70,000	TANAS	-	-	0	30,000	30,000	50	0			38
39	MARMANET	LAIKIPIA	56,000	IBPM	-	-	0	42,100	48,800	0	12,000			39
40	MARUNGU	TAITA	4,300	MOWD	-	-	0	2,000	2,000					40
41	MASENO II	KISUMU	218,000	BISH	-	-	0	105,000	105,000	600	2,800			41
42	MATSYANI	KITUI	-	EAEC	-	-	-	-	-	-	-	MANYANI WATER SUPPLY IS INCLUDED IN KITUI W/S INCONSTRUCTION	UNDER MUWS PLOGRAMME	42
43	MATUNDA	UASIN	-	GIBSS	-	-	0				-	INCLUDED IN MOU'S BRIDGE W/S KWS III		43
44	MBALE III	KAKAMEGA	1,000	MOWD	-	IBRD	1,000	0	1,000	160	0		REHABILITATION	44
45	MIROGI	S.NYANZA	40,000	-	-	IBRD	4,300	35,700	40,000	250	0	NO PLANNED ACTIVITIES AT PRESENT	CONSULTANT NOT YET APPOINTED, DESIGN NOT STARTED	45
46	MORIJO LOITA	KAROK	3,000	-	-	-	0	1,500	1,500	-	-			46
47	MWIMBI II	MERU	60,000	VIAK	-	-	-	26,000	26,000	0	0		CONSTR. WORK CAN COMMENCE AS SON AS FUNDS ARE AVAILABLE	47
48	NAIVASHA RURALI	NAKURU	46,000	MOWD	-	IBRD	13,000	4,000	17,000	300	0			48
49	NAMADAK	TURKANA	2,000	MOWD	-	IBRD	1,100	400	1,500	10	0		GROUNOW INVEST. TO BE CARRIED OUT	49
50	NAUKOPIR	KAJIADO	3,000	-	-	-	0	1,500	1,500	0	-	NO PLANNED ACTIVITIES AT PRESENT		50
51	OL DONYO NGIRO	ISIOLO	3,000	-	-	-	0	2,000	2,000	-	-	NO PLANNED ACTIVITIES AT PRESENT		51
52	OYUGIS II	S.NYANZA	140,400	NORCONS	-	-	0	40,000	40,000	10	0			52
53	OZA	TAITA	4,000	-	-	-	0	2,000	2,000	-	-			53
54	RATAT	BARINGO	3,000	-	-	-	0	1,500	1,500	-	-			54
55	SABATIA	KAKAMEGA	-	-	-	-						INCLUDED THE SHIJOLI II		55
56	SHITOLI II	KAKAMEGA	160,000	COWI	-	-	0	160,000	160,000	-	-			56
57	SIOINDI II	SIAYA	310,000	WAP	-	-	0	120,000	120,000	-	-			57
58	SUBUKIA	NAKURU	90,000	S.K.P	-	IBRD	3,000	129,000	132,000	1,000	0		FINAL DESIGN NOV. STARTED	58
59	TAKABA	MANDERA	2,000	MOWD	-	IBRD	1,100	400	1,500	10	0		ON DESIGN BY A TEAM IN WAJIR	59
60	TARAKWA	UASIN	3,000	-	-	-	0	1,500	1,500	-	-	NO PLANNED ACTIVITIES AT PRESENT		60
61	TIGANIA II	MERU	30,000	COWI	-	(UK)	0	28,000	28,000	60	0		GROUNOW INVEST. TO BE CARRIED OUT	61
62	WAMBA	SAMBURU	6,900	WANJOHI	-	-	0	28,000	28,000	200	0			62
63	WANGURU	KIRINYAGA	236,000	RKL	-	IBRD	15,000	128,300	143,300	700	0			63
64	WARDEGLO	GARISSA	2,000	MOWD	-	IBRD	1,100	400	1,500	10	0		GROUNOW INVEST. TO BE CARRIED OUT	64
65	W. KARACHUONYO III&IV	S.NYANZA	105,000	BISH	-	IBRD	8,000	62,000	70,000	600	0			65

Chapter 3 Project Site

CHAPTER 3

PROJECT SITE

3-1 General

The project sites have been selected at sample areas of the Kenya Communicable Diseases Research and Control Project including their hinterlands. These areas are distributed in Kwale District, Coastal Province.

The areas are classified into two categories: coastal areas and inland areas. Administrative boundaries and an estimate of the population of Kwale District in 1979 are summarized in Tables 3-1, 3-2 and 3-3.

3-1-1 Coastal Areas

There are four project areas: Buibui, Fahamuni, Kanana and Kidimu distributing along the coastal area in the southern part of Kwale District. (Fig. 2) These areas are labour camps of the Associated Sugar Company Ltd., Ramisi.

Field surveys were made on the sources of safe domestic water supply. Since, no surface water suitable for domestic supply is available in these areas, hydrogeological investigations were undertaken. Although the time schedule for this study was very tight, site studies were made for field investigations of surface geology, reconnaisance of hydrogeological conditions, resistivity survey, simplified pumping test and chemical analysis of water quality.

Based on the analysis of the results derived from these field investigations, it was concluded that the objective of the safe water supply should not be limited to these four areas but also extended to the surroundings of the four project areas in order to evaluate the prevention of communicable diseases from spreading into the project areas.

The areas for safe water supply which have been proposed are shown in Fig. 3-1 to Fig. 3-4 including the surrounding area of each camp. Table 3-4 shows the population of the Sugar company, at Ramisi.

Table 3-1

Administrative Boundaries of The Republic of Kenya

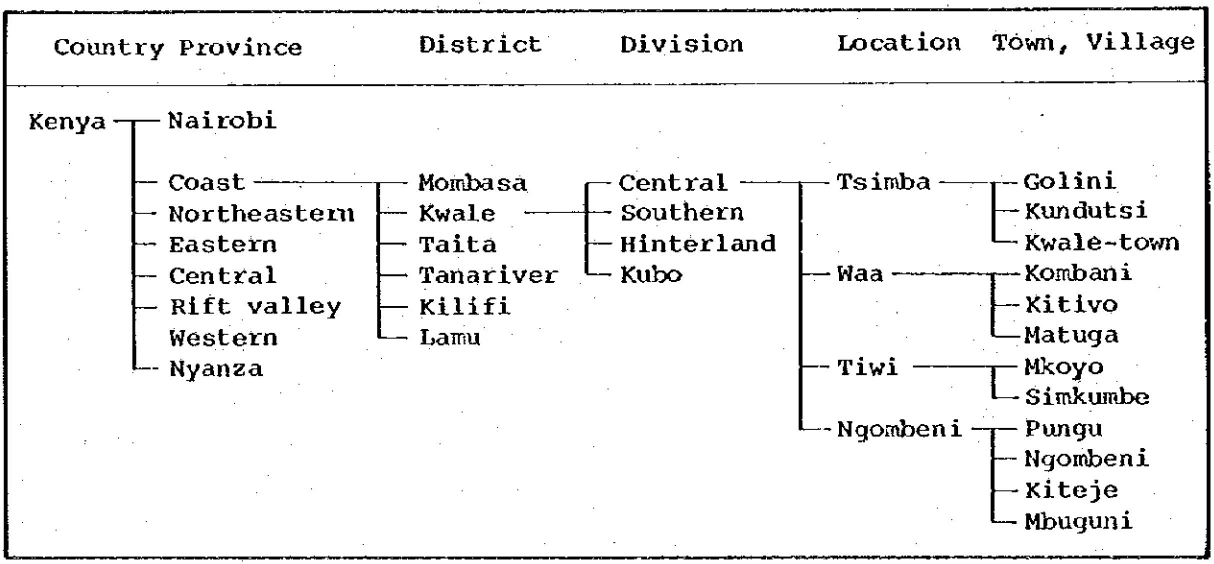

Table 3-2 Population in Kwale District

Division	Male	Female	Total	No. of households	Km^2	Density per kure
Central	23,377	22,950	46,327	8,431	340	135
Kubo	14,318	14,932	29,250	4,842	454	64
Hinterland	44,351	50,362	94,713	16,076	3,837	24
Southern	59,700	58,373	118,073	22,912	3,331	35
Total	141,746	146,617	288,363	52,261	8,257	34

Census, 1979

Table 3-3 Population in Central Division, Kwale District by Sex, and Age Group

	Male	Female	Total
0-4 yrs.	4,114	4,162	8,276
5-9	3,864	3,628	7,492
10-14	2,639	2,377	5,016
15-49	10,179	10,751	20,930
50+	2,515	1,995	4,510
NS	66	37	103
Total	23,377	22,950	46,327

Table 3-4 Associated Sugar Company Limited, Ramisi, Monthly Labour Population and Housing Company Report for Month October 1982

SECTION		MALE	FEMALE	1 - 6 YEARS OLD	7 - 13 YEARS OLD	16 YRS. & ABOVE	TOTAL POPULATION	HOUSE NO.	NO. of B/HOLE OR TAPS	NO. of LAVATORY OR PITS
FAHAMONI (*)		72	33	55	12	2	174	59	1	16
MILIMANI		70	11	17	8	-	106	25	1	4
KOLAGO		109	33	21	3	1	167	43	1	2
SHIRAZI		126	53	66	44	16	305	65	1	6
BUIBUI (*)		98	53	43	20	5	219	44	1	4
KOROMOJO		24	25	11	4	4	68	21	1	2
TOTAL	6	499	208	213	91	28	1,039	257	6	34
GAZI & MACHINE		189	45	35	32	6	307	99	TAPS	8
MAKONDE		56	18	17	7	2	100	63	1	6
MSAMBWENI		4	6	3	2	-	15	6	1	1
STAFF QRTS.		8	4	7	2	-	21	-	TAPS	4
TOTAL	4	257	73	62	43	8	443	168	2	19
MIRIMA/KIRUKU		117	37	30	24	9	217	36	1	4
STORE CAMP		71	21	22	16	5	135	30	1	4
BWITI CAMP		88	24	30	4	-	146	31	1	4
STAFF QRTS.		8	6	8	4	-	26	5	1	4
TOTAL	4	284	88	90	48	14	524	102	4	16
KANANA CAMP (*)		163	44	54	14	6	281	69	1	4
KIWAMBALE		56	19	18	8	-	101	30	1	4
KIDIMU (*)		44	20	30	5	-	99	21	1	2
MARURA		35	18	10	14	4	81	17	TAPS	2
DARAJA		131	71	66	34	13	315	66	TAPS	6
STAFF QRTS.		5	4	9	4	1	23	5	1	2
TOTAL	6	434	176	187	79	24	900	208	4	20
RAMISI JUNIOR		40	19	18	14	7	98	20	TAPS	4
HOSPITAL		42	14	17	10	-	83	23	TAPS	4
SENIOR QRTS.		99	73	72	50	27	321	69	TAPS	Flash
TOTAL	3	181	106	107	74	34	502	112	TAPS	8

SUMMARY

FAMONI	6	499	208	213	91	28	1,039	257	6	34
GAZI	4	257	73	62	43	8	443	163	2	19
MIRIMA	4	284	88	90	48	14	524	102	4	16
KANANA	6	434	176	187	79	24	900	208	4	20
RAMISI	3	181	106	107	74	34	502	112	-	8
GRAND TOTAL	23	1,655	651	659	335	108	3,408	847	16	97

Fig. 3-1 Buibui Camp

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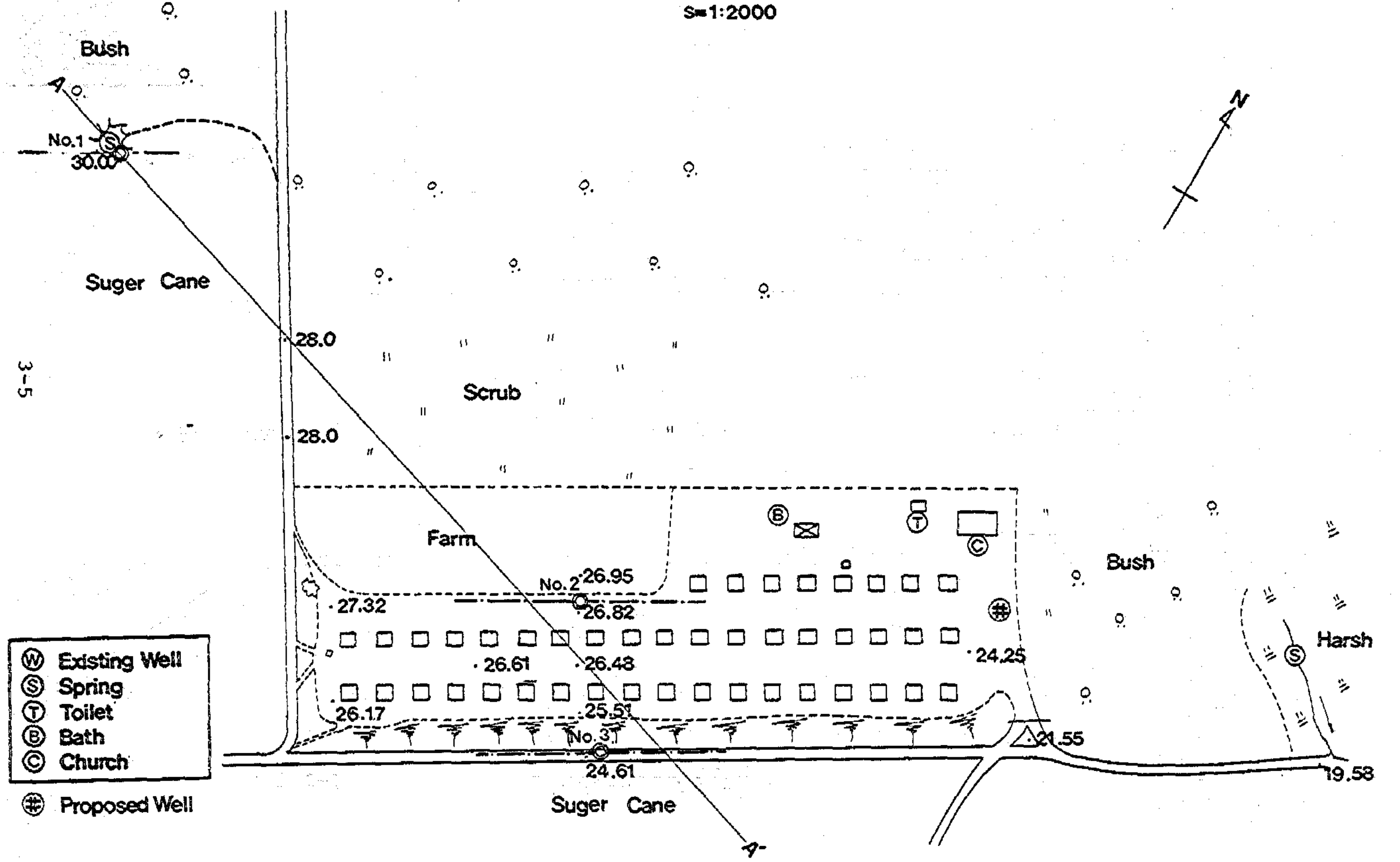

Fig. 3-2

Fahamuni Camp
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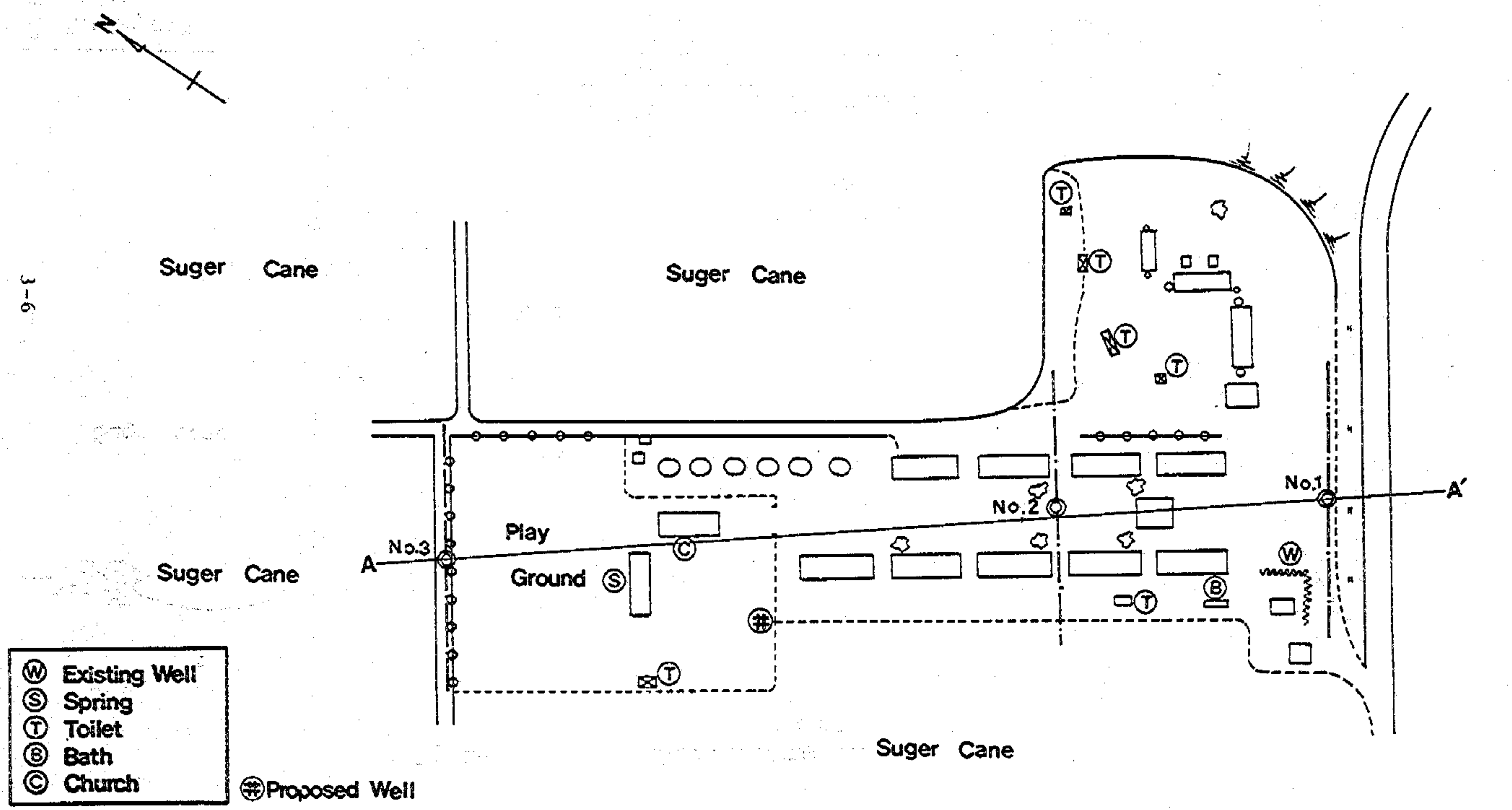


Fig. 3-3

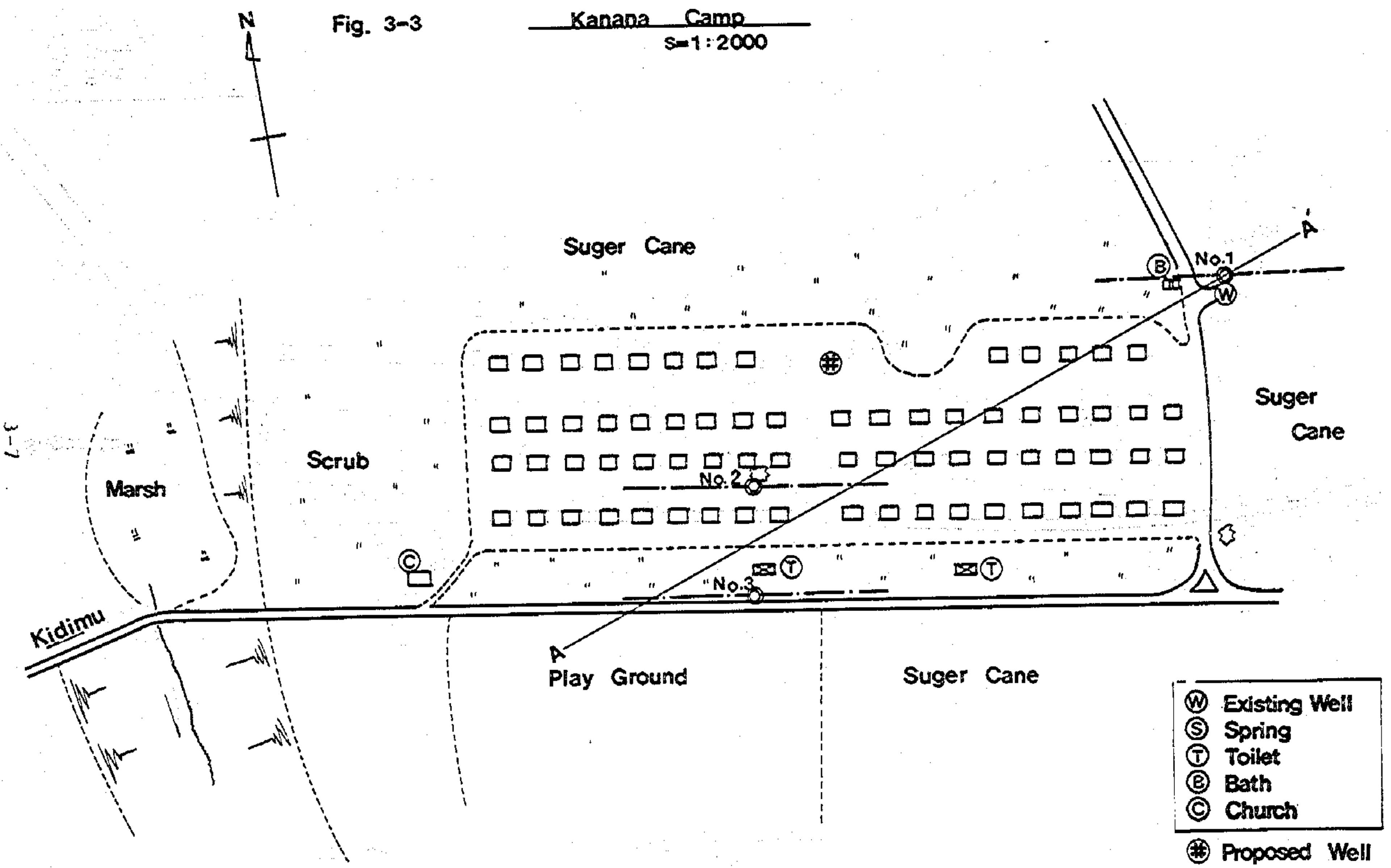
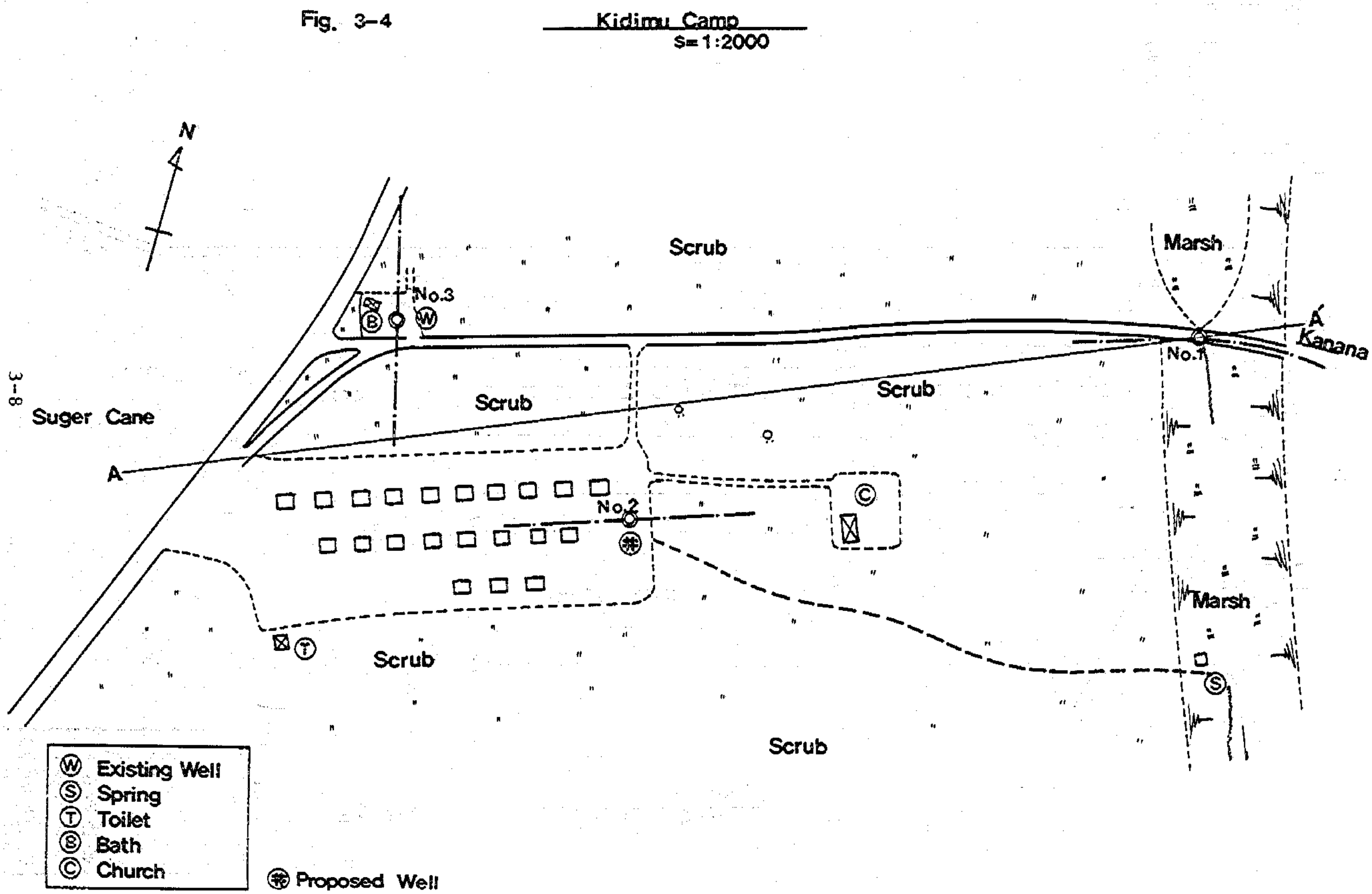

Kanana Camp
S=1:2000
N
Suger Cane
Suger
Cane
No.1
No.2
No.3
A
A'
Marsh
Scrub
Kidimu
Play Ground
Suger Cane
Ⓦ Existing Well
Ⓢ Spring
Ⓣ Toilet
Ⓑ Bath
Ⓒ Church
Proposed Well

Fig. 3-4


Kidimu Camp
S=1:2000
N
Scrub
Scrub
Scrub
Scrub
Scrub
Marsh
Marsh
No.1
No.2
No.3
A
A′
Kanana
Suger Cane
Ⓦ Existing Well
Ⓢ Spring
Ⓣ Toilet
Ⓑ Bath
Ⓒ Church
Proposed Well

3-1-2 Hinterland

This sample area is for schistosomiasis: Mwachinga Village located inland about 20 km from the coast.

The project area extends over 10 km^2 where water sources for domestic use are limited to seasonal rivers, most of them being contaminated by chronic schistosomiasis.

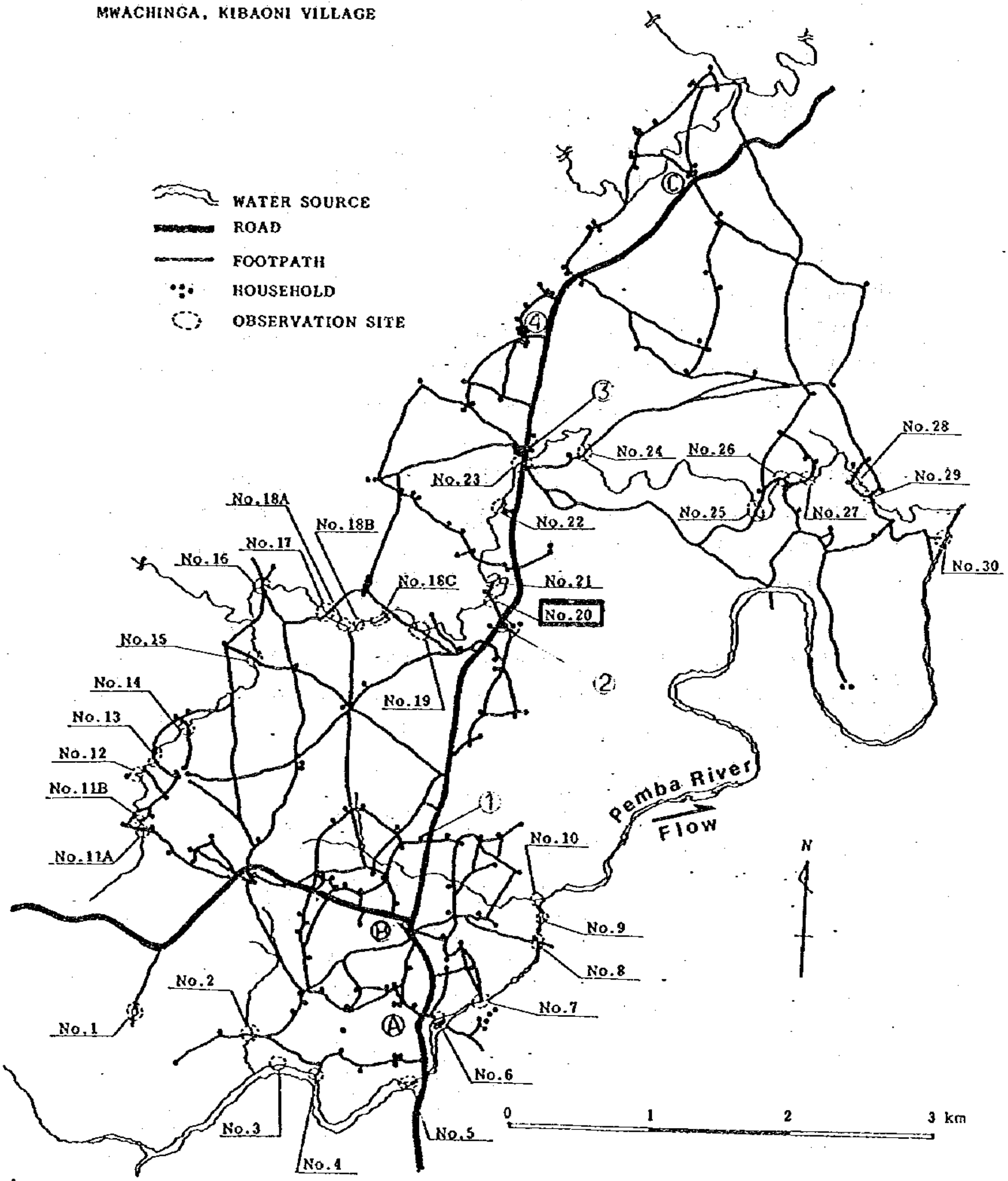
For this reason, a resistivity survey was made at the site shown as survey site No. 20 in Fig. 3-5. The geological conditions were found to be not very favourable to the development of productive aquifers since the surface of metamorphic rocks lies in very shallow layers.

It was concluded therefore that the best solution for the water source of supply in this area was to obtain safe water from the water pipeline running through the center of the project area.

Due to the hydraulic pressure of this piped water it would be possible to distribute the safe water for a distance up to 50 m from the pipe line.

Fig 3-5 LOCATION MAP

MWACHINGA, KIBAONI VILLAGE



①, ②, : Existing Taps
Ⓐ, Ⓑ, : Propsed Taps
No.20 : Electical Prospecting Survey

3-2 General Information in the Project Areas

The groundwater development survey was conducted in two areas with different environmental conditions namely:

1. The coastal area
2. The hinterland area

The coastal area is a plain which is located about 50 ∿ 60 km south of Mombasa, containing four private camps, Buibui, Fahamuni, Kanana and Kidimu which belong to the Ramisi sugar factory. The hinterland area is an undulating hilly district located west of Mombasa, which has an elevation of about 150 m and belongs to Mwachinga Village.

3-2-1 The Coastal Area

3-2-1-1 Topographic Conditions

The coastal plain has an elevation of about 10 ∿ 30 m and gently slopes from inland to coastline. Typical plants which grow in the coastal plane, include palms and cashew nuts. Sugar cane is also widely cultivated. South of the Ramisi sugar factory, the Ramisi River flows from north to south into the Indian Ocean. At the south end of Ramisi River, a low land zone runs parallel to the river from north to south. Some springs in the low land zone as used as an intake source for water supply.

3-2-1-2 Present Condition of Water Intake

Judging from the existing well data and well survey, the water level may be deep in the northern part, and shallow in the southern part, because in the northern part, red or ivory-colored clay or silt layer exists extensively near the surface. Therefore, both the depth and the static level of the well are deep.

The well along the national road about 2.5 km northwest of Diana Beach in Ukunda area dried up last year and was drilled deeper. The present depth is 25 m.

A well is being drilled at some house which is located at a point about 3.5 km northwest of Diani Beach. Its depth is 20 m and water was not found. According to the house owner, however, water should be encountered, if the well is drilled 5 ∿ 6 m deeper. There is a well located about 500 m north of this well, and there is a well located 1 km south of this well, which are 23 m and 21 m in depth respectively, and water has been found at these locations. Judging from the well samples, for this well, the soil between the ground surface and a depth of 20 m is ivory-colored silty sand or clay.

In the southern part of the Ukunda area near Fahamuni, a few wells have been observed. The static level of o/w 24 well located about 500 m north of Fahamuni is 5 m, which is much shallower than the static level in the Ukunda area. The depth and the static level of o/w 25 well in Fahamuni are 7.43 m and 5.65 m respectively. The static level is 0.65 m lower than o/w 24 well based on the quantity of water intake. The depth and the static level of o/w 26 well at Kwabuda Village in Shirazi area located southeast of Fahamuni are 5.90 m and 4.13 m respectively, and of o/w 27 well of Darigube Barabarani, 4.36 m and 2.16 m respectively. This well is dried up during the dry season, and it is drilled deeper every dry season.

At Buibui camp the west of the national road about 3.7 km north of Fahamuni, well water is not used and the only water resource is the spring about 200 m west of the village. The quality of spring water is good. There was a spring on the east side of the camp which was used for washing clothes, but it dried up after some days when a resurvey was made.

The water of the Ramisi river flowing near the Ramisi sugar factory is not used because of the pollution. South of the river, a low land zone runs from north to south, and there are some springs along the low land zone. There is a big spring located the north of the national road, about 1 ∿ 2 km northwest of the sugar factory. Pump houses are established at two spots around the spring and the water is used as industrial water for the sugar factory.

South of national road in the low land zone between Kanana camp and Kidimu camp, a clear stream flows, but the quantity of water is small. About 140 m downstream, there is a spring, where a weir is surrounded by coral. People at the camp call it 'Well'. The water from this spring is used as potable water, but its quality is not good evidenced by turbidity and a white colour.

South of Kidimu camp, Kidimu Village is located. The only water resource for this village are the springs scattered in the low land zone. They are reconstructed by wood or coral as wells and water is pumped from them at three locations. There is no bore hole well.

At Kanana camp, a well on the northeast end of the site is used. Its depth and static level are 3.65 m and 2.10 m respectively. The quality of the water is relatively good with little turbidity and the quantity is large.

Northwest of Kidimu camp, there is a shallow well made of Hume concrete pipes. The lowest part of the hume concrete pipe collapsed and got out of alignment. The depth is shallow and the water is only used for bathing. The depth is 3.09 m and the static level is 2.90 m.

3-2-2 The Hinterland Area

The area is a gently undulated hilly district, 150 m above

the sea. A river flows in the area. Including tributary rivers, there is contamination from Schistosomiasis Hematobium. The soil is mostly poor. Various types of shrubs grow there sparsely.
The ridge is spotted with houses located to avoid flooding. It is therefore difficult to acquire underground water.

3-3 Hydrogeological Conditions in the Project Areas

3-3-1 The Coastal Area

3-3-1-1 Outline of Hydrogeology

The soil is mostly sand and in some places, silt or clay. Along the coastline, under the sea bottom and moving inland, coral reef or red clay of the Pleistocene (Quaternary period) are encountered. This layer is underlain by Kilindini Sand of the Pleastocene period. Magarini Sands of the Pliocene (Tertiary period) underlie the Kilindini Sands and form a hill. The Tertiary period layer and Quaternary period layer do not onform. There are some springs in the plane of unconformity. A fossil of Pectem was collected near the spring at Buibui camp on the plane of unconformity.

The above-mentioned four camps are in the area where Kilindini Sands of Pleistocene are distributed. The permeability of the soil is comparatively good. The amount of rainfall in the area averages over 1000 mm. In 1981, the amount of railfall was recorded to be 1550 mm at Ramisi sugar factory.

There are swampy ground zones and springs located at several places in the low land of the survey area. Some of them were not dried up even in March which is the end of the dry season. Judging from many data of existing shallow wells, the survey area and its vicinity contains a large quantity of free water. The free water level is deep in the northern area and shallow in the southern area according to the permeability of the surface soils. In the northern area, a thick layer of clay is found, and in the southern area sand is found.

When the intake source is investigated in the areas except for the four survey areas, it is desirable to install a shallow well in southern areas where soils of the Quaternary Pleistocene period exist.

3-3-1-2 Geoelectrical Resistivity Survey

(1) Method of survey

In locating underground water supplies which are indispensable for agriculture and industry as well as for daily life, in selecting construction sites for dams and tunnels, in prospecting for mineral deposits, and in preparing earth works for power and communication systems, it is necessary to conduct a preliminary survey of geological conditions in order to determine whether or not the subsurface conditions are suitable for the particular purpose.

The most reliable method available for this type of geological survey is a test boring. A test boring, however, is expensive to install and therefore cannot always be employed. If, by means of some other machine, the general underground conditions can be revealed prior to the boring operation, the effort will be minimized and yet the effect of the test boring will be maximized so that the survey will be improved greatly in terms of time and economy.

Underground soil condtions are generally complex. Even if elaborate equipment is used, it would be impossible to disclose the subsurface conditions completely from the ground surface down. A preliminary survey can determine certain physical quantities which have some relation with the nature of the subsurface conditions. Based on such physical quantities, the underground conditions may be interpreted. Careful interpretation is necessary to eliminate errors.

The survey of geological conditions requires measurement of physical properties and their interpretation. How the data is interpreted greatly affects the outcome of the survey. Correct judgement of geological conditions hinges solely on the interpretation.
It is important to have sufficient knowledge about the physical properties of the subsurface soils or rock.

There are many kinds of physical properties. Investigation of the subsurface conditions based on such physical properties is referred to as the Geophysical Prospecting Method.

Geoelectric prospecting, one of the common geophysical prospecting tests, measures electrical properties of the subsoils or rock. The resistivity method is the most widely used type of geoelectric prospecting because resistivity differs from aquifer to aquiclude and because the soil to be explored is stratified in most instances. Determining the soil resistivity gives a clue to its geophysical nature.

The resistivity of soil is influenced by the following factors:-

1. Mineral content
2. Mineral crystallization
3. Density of soil constituents

4. Soil porosity

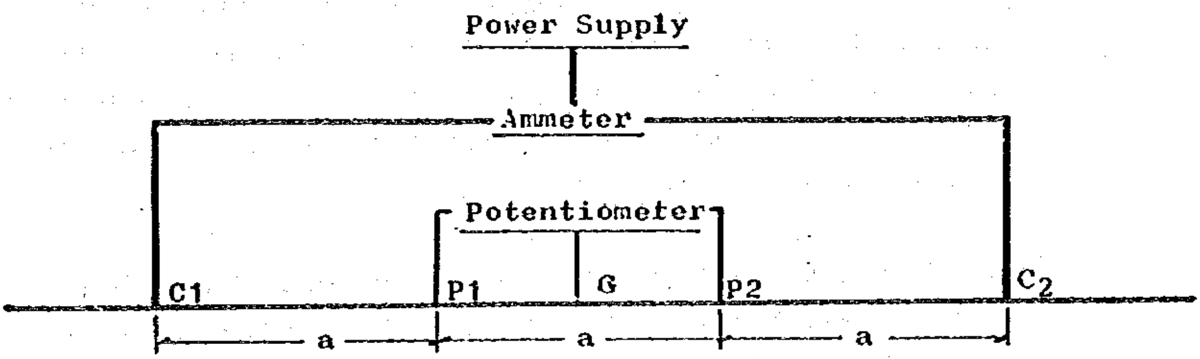
5. Resistivity value of water and water content in aquifer

The specific earth resistance tester model 3244 Yokogawa Electric Works, Ltd. was used in this survey, for an objective survey depth of fifty meters.
The resistivity survey was carried out using the Wenner four-electrode method and the record of formations passed through during geoelectric prospecting was interpretated by the direct vision method.

Fig. 3-6 Geoelectric Resistivity Survey by Wenner's Method

(Wenner's Method)

P1, P2 : Potential Electrode
C1, C2 : Current Electrode



$$\text{Apparent resistivity } (\rho) = 2\pi \times \frac{\text{Potential difference (V)}}{\text{Total current (I)}} \times \text{Electrode spacing (a)}$$

(2) Results of geoelectric resistivity survey

i) Buibui camp

This camp has no well and the only potable water is the underground water flowing from the Magarini Sands which form the plane of unconformity between the Pliocene and Pleistocene about 200 m northwest of the village.

Observation point No. 1 was set up near the spring. In the center of the northern part of the camp site and in the center of the southern part of the camp site, observation points Nos. 2 and 3 were set up, and an electrical resistivity survey was performed respectively.

Compared with other three areas, the resistivity of the upper part was found to be high because the soil is sandy and dense. It is presumed taht ground water level is 2 ∿ 5 m low from 3 ρ_a curves.

With regard to a specification for a drilling well, a shallow well, 2500 mm in diameter and 10 m in depth is considered desirable.

ii) Fahamuni camp

Observation point No. 1 was established near the existing o/w 25 well along the A 14 national road. In the center of the camp site and on the road at the northern end of the camp site, observation points No. 2 and No. 3 were established.

The resistivity in the area is much lower than that in other areas, because the soil of the aquifer contains much silt or clay compared with aquifers in other areas. The resistivity of the water in the aquifer is 1460 Ω·cm which is half the resistivity in Kidimu or Kanana. The static level of existing o/w 25 well is 5.65 m and that of the newly drilled well is 3 ∿ 4 m.

Since the catchment area should be large, a shallow well of large diameter (2500 mm) and 15 ∿ 20 m in depth is desirable.

iii) Kanana camp

Observation point No. 1 was established near the existing well at the end of northeast of the camp site. Observation point No. 2 was installed near the center of the camp site. On the road, which leads to Kidimu, on the south of the camp, No. 3 was installed.

The upper layer of subsurface soil here is sandy, judging from the resistivity. The static level is very shallow - 2 m. This indicates that there is a large quantity of free water.

Since the static level is shallow, it is desirable to obtain underground water using a shallow well which is 2500 mm in diameter and 10 ∿ 18 m in depth.

iv) Kidimu camp

Measurements were carried out at three locations - on the road in the low land zone which is the boundary between Kanana camp and Kidimu camp, at the northeastern end of the camp site, and near the existing well.

The resistivity of the upper layer is high at Kanana camp and judging from the value, the soil is sandy. The static level is shallow - 2 ∿ 3 m. Judging from the driving of Hume concrete pipe for the existing well, the upper portion is loose sand. The well must therefore be drilled carefully.

A well 2500 mm in diameter an 10 ∿ 15 m in depth is desirable here just as in Kanana camp.

(3) Yield test

Based on existing conditions, continuous yield and recovery tests were carried out for a short time at the existing wells in both Fahamuni camp and Kanana camp.

A hand pump was installed at the proper depth, and the water was pumped continuously. The quantity of pumped water and the pumping time were recorded. The relationship between the time and the water level at the recovery test was then determined.

Using the water level recovery method based on the pumping test data, the coefficient of permeability 'k' was calculated as a Hydrogeological constant and the capacity of each well was evaluated.

i) Fahamuni camp o/w 25 well

Diameter	2080 mm
Depth	7.43 m
S.W.L.	5.65 m

Pumping water volume using Hand pump Q : 0.9 l/sec
Pumping period using Hand pump : 12 min. 40 sec (760 sec)

Table 3-5 Water Level Recovery Test (Fahamusi)

S' (cm)	t (sec)	t' (sec)	t/t'
18.0	1060	300	3.52
16.9	1360	600	2.26
15.0	1660	900	1.84
13.5	1960	1200	1.63
12.5	2260	1500	1.50
11.0	2560	1800	1.42
8.5	3460	2700	1.28
5.5	4360	3600	1.21
4.0	5260	4500	1.17
3.0	6160	5400	1.14
1.0	7960	7200	1.10
0.0	9760	9000	1.08

$$T = \frac{0.183Q}{\Delta S} \qquad k = \frac{T}{M}$$

where,

S' : difference of water level between static level and recovery level. (cm)

t : elapsed time from start of pumping (sec)

t' : elapsed time from stoppage of pumping (sec)

ΔS : water level difference in one cycle of log t/t' (cm)

Q : pumping capacity of well water (cm^3/sec)

T : coefficient of permeable quantity (cm^2/sec)

M : estimated aquifer thickness (cm)

k : coefficient of permeability (cm/sec)

$\Delta S' = 25.8$ cm

$Q = 9 \times 10^2\ cm^3/sec$

$M = 178$ cm

$$T = \frac{0.183 \times 9 \times 10^2}{25.8} \log 2\ cm^2/sec$$

$$= 1.92\ cm^2/sec$$

$$k = \frac{1.92}{178}$$

$$= 1.07 \times 10^{-2}\ cm/sec$$

The calculated "k" indicates that the surrounding soil is sandy and the permeability of this well is consdiered superior.

ii) Kanana Well

Diameter	2850 mm
Depth	3.65 m
S.W.L.	2.10 m

Pumping water volume using Hand pump Q : 1.2 l/sec
Pumping period using Hand pump : 16 min 40 sec (1,000 sec)

Table 3-6 Water Level Recovery Test (Kanana)

S' (cm)	t (sec)	t' (sec)	t/t'
19.4	1300	300	4.33
19.5	1600	600	2.66
18.5	2200	1200	1.83
17.5	2800	1800	1.55
17.0	4600	3600	1.27
16.2	6400	5400	1.18
15.5	8200	7200	1.14
-	-	9000	-
-	-	10800	-
7.2	13600	12600	1.08
7.1	24400	14400	1.07
6.5	26200	16200	1.06
5.7	28000	18000	1.055
4.7	29800	19800	1.05

$\Delta S' = 53$ cm

$Q = 12 \times 10^2$ cm/sec

$M = 155$ cm

$$T = \frac{0.183 \times 12 \times 10^2}{53} \log 2$$

$$= 1.24 \text{ cm}^2/\text{sec}$$

$$k = \frac{T}{M}$$

$$= 8 \times 10^{-3} \text{ cm/sec}$$

Fig. 3-7 Fahamuni O/W 25 Well

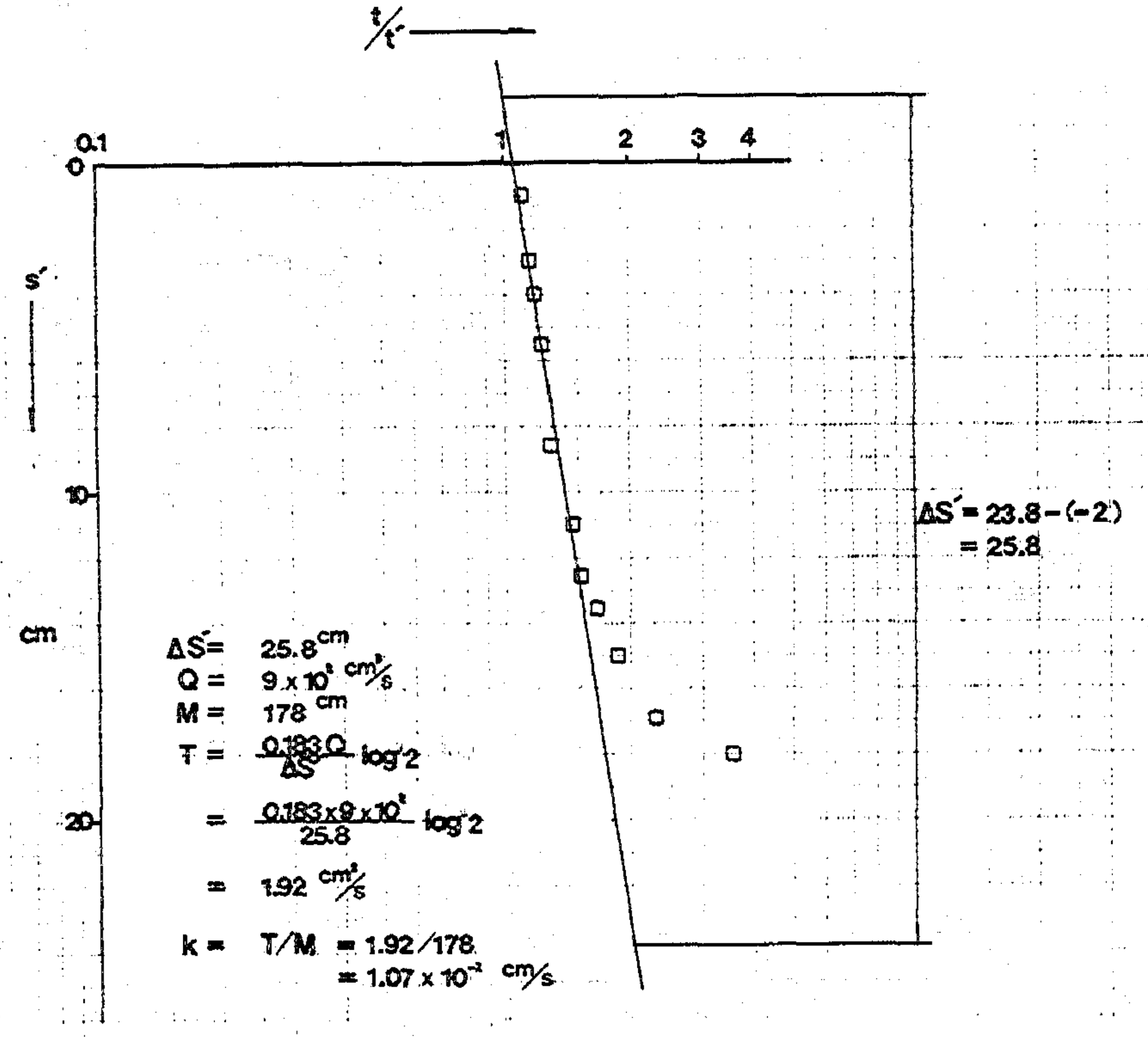
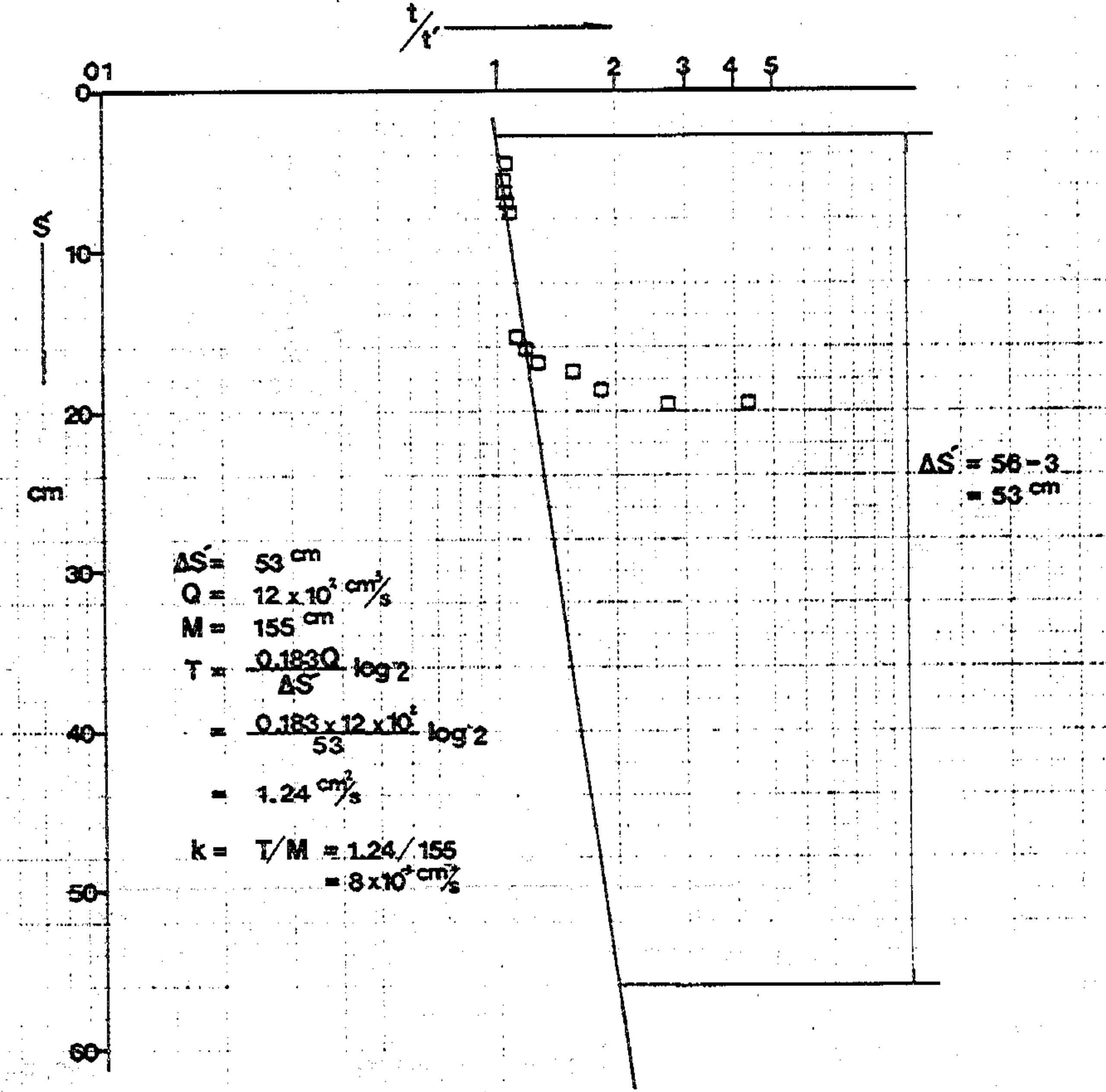


Fig. 3-8

Kanana Well



The relationship between the coefficient of permeability and the soil formations can generally be expressed as shown in Table 3-7.

Table 3-7 Coefficient of Permeability (k cm/sec)

10^{-2} – 1.0	1.0 – 10^{-3}	10^{-3} – 10^{-4}	10^{-4} – 10^{-6}	10^{-6} – 10^{-7}	10^{-7} –
(stratum) gravel	fine gravel or sand	fine sand and silt combination			impervious soil
aquifer			aquiclude	impervious stratum	

The above-mentioned is the Hydrogeology in the coastal area and the specification for drilling wells in the four surveyed areas.
Sea water intrusion is discussed in the following paragraphs.

In the coastal areas, the fresh water area flowing from land to sea and the sea water area intruding into the land is balanced by specific gravity as shown in Fig. 3-9. Balance sheet between sea water and fresh water.

This fact can be easily accounted for by the theory of static equilibrium based on the difference in specific gravity between fresh water and sea water. The weight of a body of fresh water having a thickness of $(H + h)$ is equal to thickness H of salt water. Accordingly, if the specific gravity of salt water is ρ' and that of fresh water is ρ, we obtain the following equation:

$$(H + h)\rho = H\rho'$$

$$\frac{H}{h} = \frac{\rho}{\rho' - \rho} \quad \text{----------------} \quad (1)$$

where, ρ is assumed to be 1,000 and ρ' 1,024.

Substituting these assumed values for ρ and ρ', we obtain:

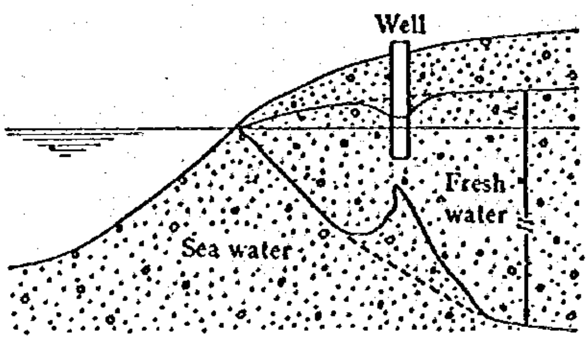
$$\frac{H}{h} = \frac{1,000}{1,024 - 1,000} = \frac{1,000}{24}$$

$$H = 42\ h \quad \text{-------------------} \quad (2)$$

This series of calculations indicates that if the thickness of fresh water above the sea surface is given, the thickness of fresh water below the sea surface can be obtained.
Therefore, if h is to be 0, H is 0 and sea water can permeate the water well in the coastal area. This is the law of Ghyben-Herzberg.

The quantity of intake water from shallow wells in this area is extremely low and only used for daily living. Every camp in the survey area has an elevation of about 10 ∿ 30 m. The present pumping water level is located some distance from the sea. The resistivity by geoelectric survey in each survey area is not low enough to indicate sea water intrusion.
Threfore, under existing conditions, there is no fear of sea water intrusion.

Fig. 3-9 Balance Sheet Between Sea Water and Fresh Water



3-3-2 Hinterland

3-3-2-1 Outline of Hydrogeology

The base rock is Shimba Grit and Mazeras Sand Stone of Permo-Triassic. Its solidity is high. The upper portion is covered with red clay or silty sand. In the highland area, where there are some houses, underground water is hardly ever obtained.

In order to prevent Schistosomiasis Hematobium, the underground water intake source should be investigated in areas far from the rivers. Since the low land near the river is under water during the rainy season, it is difficult to drill a well.

Another way to acquire underground water is by means of a deep well, which attempts to obtain water from fissures in the rock. The cost of test drilling such a well will be expensive.

3-3-2-2 Electrical Survey

At observation point No. 20, location in a small valley, and in the surrounding vicinity, the geoelectric survey by specific resistance method was performed.

Since the resistivity was extremely low and the water quality is not good and the base rock is shallow, it is hard to collect free water. The rivers are polluted by Schistosomiasis Hematobium and therefore, the only intake source in this area is the conduit Water Supply pipeline leading to Mombasa.

3-4 Present State of Water Use

3-4-1 Coastal Areas

3-4-1-1 General

The water supply facility in the sugar factory for production purposes is the only one improved supply facility in the coastal areas. Although, the office and some engineers' residences are supplied potable water from this water supply facility, in the rest of the people are dependent on small springs and shallow dug wells (5 ∿ 10 m deep) for their domestic water supply.

Further details of water consumption in the project areas are described in the following sections and the existing conditions of these water sources are summarized in Table 3-8.

3-4-1-2 Buibui Camp

The source of domestic water for this camp, the population of which is 219 people is a spring located 200 m to the northwest of the camp. Although, the quantity of the spring yield is insufficient, the water quality is suitable as a source of safe water supply. This is the only reliable water source for domestic use in the area.

The importance of the underground spring as a domestic water supply source is well understood by the people and they are therefore carefully protected from contamination.

Throughout our field investigation, it was observed that it is unlikely that this spring water plays any role in spreading intestinal disease or epidemies.

There is one more spring about 150 m from the camp to the east. The yield of this spring, however is not perennial and it dries up during dry season.

The people therefore rely entirely on the first spring and must carry domestic water from the spring to their residence by buckets or other similar water vessels.

Under these circumstances, the problem to be solved is that the quality of the above perennial spring is satisfactory for domestic use, however the quantity does not meet the domestic requirements for maintaining a safe and healthy everyday life.

3-4-1-3 Fahamuni Camp

The population of this camp is 174 people at the present time. The source of domestic water for this camp is a shallow dug well. The diameter of the well is about 2 meters and its depth is about 7 meters.

The yield of the well is quite sufficient for the water consumption of the camp and some people from outside of the camp also obtain water from the well for domestic use.

The well is well protected by concrete and clothes washing is done on a part of this concrete floor. There used to be a windmill and pump to lift water, however it has been abandoned due to mechanical problems at the present time.

The water quality of this well appears to be satisfactory compared with the water used at Kidimu and Kanana Camps.

There is a record of identification of cholera bacillus in the past, however it was attributed to the contamination of well water from the ground surface when somebody took water from the well. Since the well top is open to the air and a storage vessels are dropped down from the opening to obtain water, some contamination is possible if these vessels are not absolutely clean.

It is, therefore necessary to provide measures to conserve this precious water source.

3-4-1-4 Kanana Camp

The population of this camp is estimated to be 281 people at present. There is a shallow dug well just outside the camp. The diameter of the well is 2.8 m and its depth is 3.7 m. This is the only one water source for this camp. Once a hand pump was installed on the well, however it has been abandoned due to a lack of spare parts. At present, water is lifted by bucket through a small opening in the wooden well cover. No protective concrete has been provided and clothes are washed 10 m away from the well.

3-4-1-5 Kidumu Camp

The population of this camp is estimated to be 99 people at the present time. The water sources for domestic use in this camp consist of a spring and an open dug well a few hundred meters away from the camp.

The water for drinking and cooking depends entirely on the spring, however, the water appears to be unsuitable for drinking since it is turbid with a whitish-green colour and suspended algae.

No protective works have been provided at this well, however coralline rocks are piled to prevent the side wall of the well from collapsing.

A definite problem for this water source is that the well is completely innundated during seasonal floods.

There is one other dug well, however it is used for washing when water is available. Appendix 4 shows the result of the existing well survey.

3-4-2 Hinterland

The available water sources in this area are water obtained from the Mombasa Pipeline and from the Pemba River. There are four water faucets from the pipeline, however this water is only available at a charge of 10 cents for every 20 liters. For this reason, this tapped water is used only to a limited extent. Most of the people, therefore take water from the Pemba River and its tributaries.

One problem with this river water, however is contamination of chronic schistosomiasis. The people in this area have been exposed directly to infection of schistosomiasis by taking domestic water from the river and through bathing and washing with the river water.

Furthermore, even this river dries up during the dry season and people must obtain water from small turbid water ponds remaining on the river bed. Finally, at the end of the dry seasons, the only available domestic water is tapped water which must be purchased and they must go to the main river course far away for washing and water bathing to avoid schistosomiasis infection.

3-5 Existing Sanitary System in the Study Area

In the Study Area, the Pit Latrine as described in Fig. 3-10 is normally used. The current sanitary conditions at each camp and the problems of domestic sanitation and hygiene conditions in these areas are discussed below.

Buibui Camp

There are 4 Pit Latrines in the northern part of Buibui Camp and they seem to be used by the residents of the camp frequently.

Fahamuni Camp

In Fahamuni Camp, there are 3 pit latrines, located in the center of the camp, near the primary school and beside the sugar cane field west of the camp.

Kanana Camp

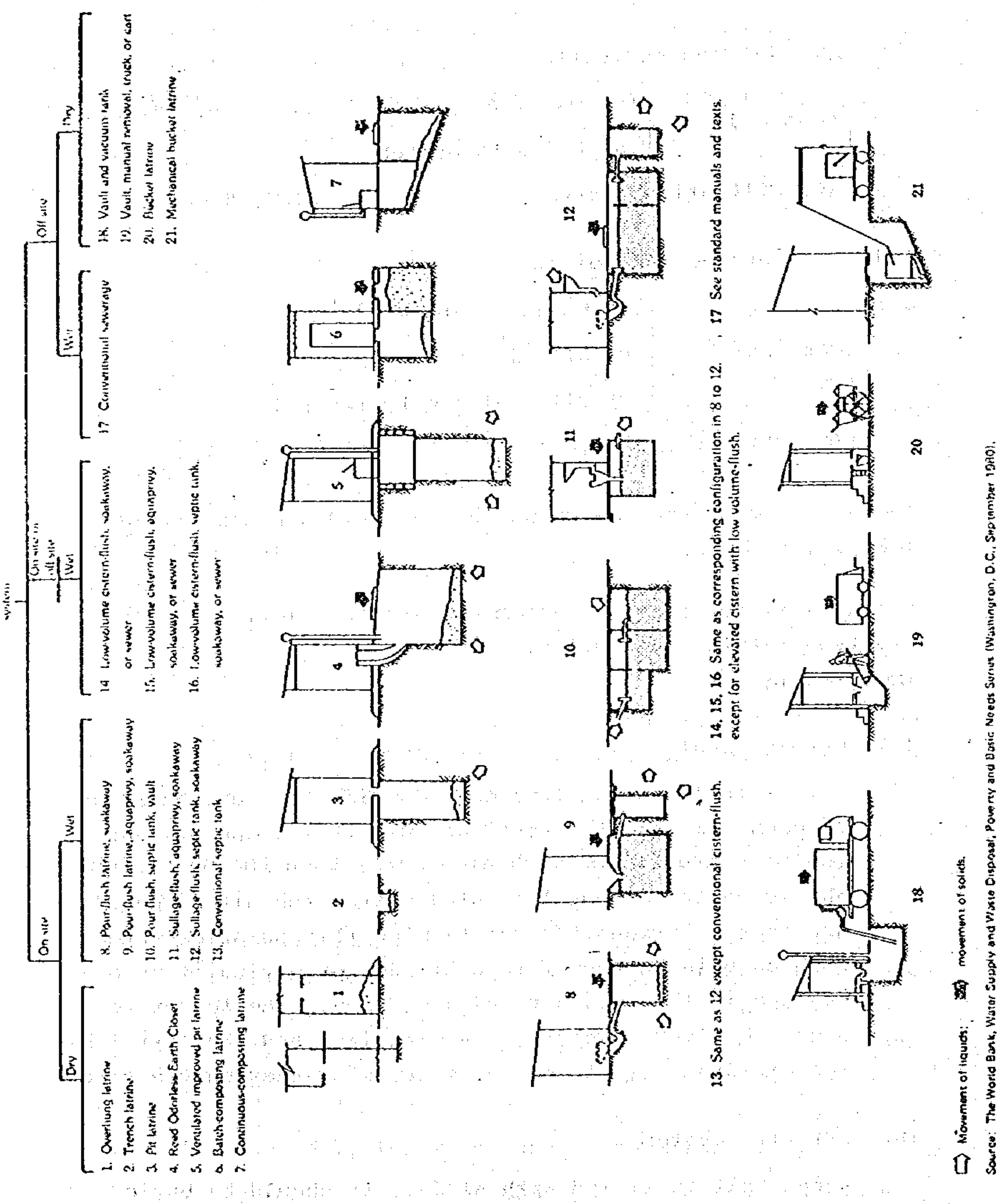
Along the road, there are 3 pit latrines located in the southern part of the camp. They seem to be seldom used, however because some nightsoil was found along the road.

Kidimu Camp

There were 4 pit latrines at the south end of Kidimu Camp. Now only one of them is still used, however. The method of constructing latrine in this camp is defferent from other camps. The latrine in this camp has a drum can for protecting the breakdown of the pit because of the soil conditions which exist in this camp. The soil becomes very loose when it is wet. In the rainy season, therefore, the pit is brokendown easily unless a drum can should be protected.

The sanitary system in the rural area of a developing country is now discussed. The sanitary system will be divided into

Fig. 3-10 Generic Classification of Sanitation Systems



Source: The World Bank, Water Supply and Waste Disposal, Poverty and Basic Needs Series (Washington, D.C., September 1980).

two systems, one is the dry type, the other is the wet type. The former does not have a flush water system and the latter has such a system. The sanitary system is classified as follows:

Dry type latrine and toilet

- Cesspool
  - (A) On site system 4, 6, 7, 18, 19, 20, 21
  - (B) Off site system
- (C) Filtration system 1, 2, 3, 5

Wet type latrine and toilet

- Cesspool
  - (D) On site system 17
  - (E) Off site system
  - (F) Filtration only for urine 8, 9, 10, 11, 12,
- (G) Filtration system 13, 14, 15, 16

The sanitary systems as shown in Fig. 3-10 are classified in (A) to (G) above.

Charactaristics of each system are stated below.
Dry type latrine and toilet.
Cesspool system.

(A) <u>On-site system</u>

If a latrine is constructed according to the population of each camp and the residents use them properly, and the pits are filled with nightsoil, then the only problem should be the disposal of sludge from the pit. There are some solutions for maintaining this on-site system such as using sludge for fertilizer or drying it on a dry bed in the open air and sun-shine. The former technique, however, protects the parasites and the latter has the disadvantage of the necessity of gathering the sludge.

(B) <u>Off-site system</u>

When a pit is filled with sludge, it should be buried or covered with soil. A new one should be built near the old one. Before the pit is buried or covered with soil the sludge should be solidified and disinfected so that the old pit can be reused for other purposes. If the pit is used for other purposes, at least, for a definite period of years it should then be confirmed that the sludge has changed to soil.

Filtration System

(C) Filtration system

Urine penetrates underground through a pit latrine or a certain length of small ditch latrine. Considering the population and frequency of latrine use in this area, the quantity of urine penetrating underground is limited and therefore it is rather difficult to adopt the filtration system.

Wet Type Latrine and Toilet

Cesspool System

(D) On-site system

This system is almost the same as the system stated above (A). The pit for latrine, however, should be larger than that of dry type considering the quantity of flush water required.

(E) Off-site system

The same system stated above (B) is employed. The pit for latrine, however, should be larger than that of dry type considering the water quantity for flushing. The facilities such as pipe for flush water should be transferred when the pit is filled up and transferred.

(F) Filtration only for urine and flush water

This system unable urine and flush water to penetrate into underground. The same problem as system (A) and (B), however, will remain.

Filtration System

(G) Filtration system

The system stated above system (C) is employed. The pit for latrine, however, should be larger than that of dry type considering the quantity of flush water.

In case of filtration system such as (C), (F) and (G), the distance between the well and the latrine should be at least 30 m in order to avoid the pollution of domestic water.

In case of system (A), (B), (D) and (E), the distance between the well and the latrine should be kept at least 2 m to 5 m considering structure of a well.

The system (B) is recommendable as an appropriate dry type system and the compounded system (E) with (F) is also considered as an appropriate wet type system in this area.

On the condition that the cesspool system is employed, the system (A), (D) and the compounded system (D) with (F) are appropriate.

Due to the un-employment of might-soil sludge treatment and flush toilets, and the unavailabilities of sanitation facilities in the country, one of the off-site systems should be recommended as the most appropriate one.

The pit latrine especially that is now used in each camp will be recommended and this system can be extended and the residents should be convinced to use them positively. The latrine should be located lower than the water source and the distance between the latrine and the water source should be at least 30 m.

3-6 Necessity of the Safe Water Supply

3-6-1 Coastal Areas

At present, it is unlikely that the domestic water sources in the project areas are contribution as a source of communicable disease contamination except at Kidimu camp.

The fact that cholera patients were identified in all sample areas during the two years of the research and control project can be the result of infection through the contaminated foods or insufficient water to maintain a good clean sanitary environment for the residents.

This can also be attributed to the fact that the only available water source is limited to the far distance from the residences and to the volume of water to be carried. Therefore, water consumption for an average family with four to five people is estimated to be 40 liters/day to 50 liters/day which is insufficient to keep their sanitary environment at a satisfactory hygienic level.

Another reason for the limited domestic water consumption is caused by limited availability of the water resource among these areas except at Fahamuni Camp.

Apart from the limited volume of water available, it should be kept in mind that most of the water sources are open to the air. In this respect, these water sources of which quality itself is safe, have high potential to be a source of communicable intestinal epidemic once it is contaminated. It is therefore necessary to provide protection from contamination for the water source.

Similarily for a safe water supply for these project areas, it is necessary to provide a sufficient volumes of clean water and protection from contamination for the water sources.

The protection of water sources has two aspects; protection of water source from contamination and prevention of waste water circulation into the water source.

In addition to the above, economic considerations are also another important aspects of the project. Since most of the people living in the project areas belong to a low income group, the price of water must be reasonably low. At the same time a sufficient amount of water should be easily obtained at minimum operation and maintenance cost.

It is proposed therefore that the safe water supply system for the project has confined to shallow wells and hand pumps with sufficient water source protection from contamination.

Because of the nature of the water-born disease to spread over a wide area within a short period of time, it is also proposed that the provision of the safe water supply should be limited not only to the project areas but also consideration must be given to the surrounding areas of the project site.

The effectiveness of the above mentioned approach to eliminate intestinal epidemics will be proven by the follow-up investigation of the occurrence of those kind of disease after the project has been implemented.

3-6-2 Hinterland

The major problem in this area is the chronic schistosomiasis. A safe water supply can contribute to the elimination of schistosomiasis to a great extent, however it is not as effective to control cholera and dysentery as indicated in Tables 3-8 and 3-9. In order to eliminate schistosomiasis, other factors must be considered.

There are three patterns of schistosomiasis contagion as shown in Fig. 3-11. This figure clearly explains that there are three methods to prevent contagion of schistosomiasis.

These methods are:

1. Cure patients and provide a sewerage system to control eggs of cercariae in feces of patients.

2. Application of chemicals in the water and improvement of river system to control snails as an intermediate host.

3. Provision of bridges to prevent people from having contact with polluted and infected water.

These are two methods which can prevent contagion of schistosomiasis considering the relationship with the water source.

1. To change a contaminated water source to a water source free from schistosomiasis.

2. To preserve water before use for more than 48 hrs. until no cercariae can survive in the fresh water.

In this project area, there are two water sources free from schistosomiasis. One is the groundwater and the other is

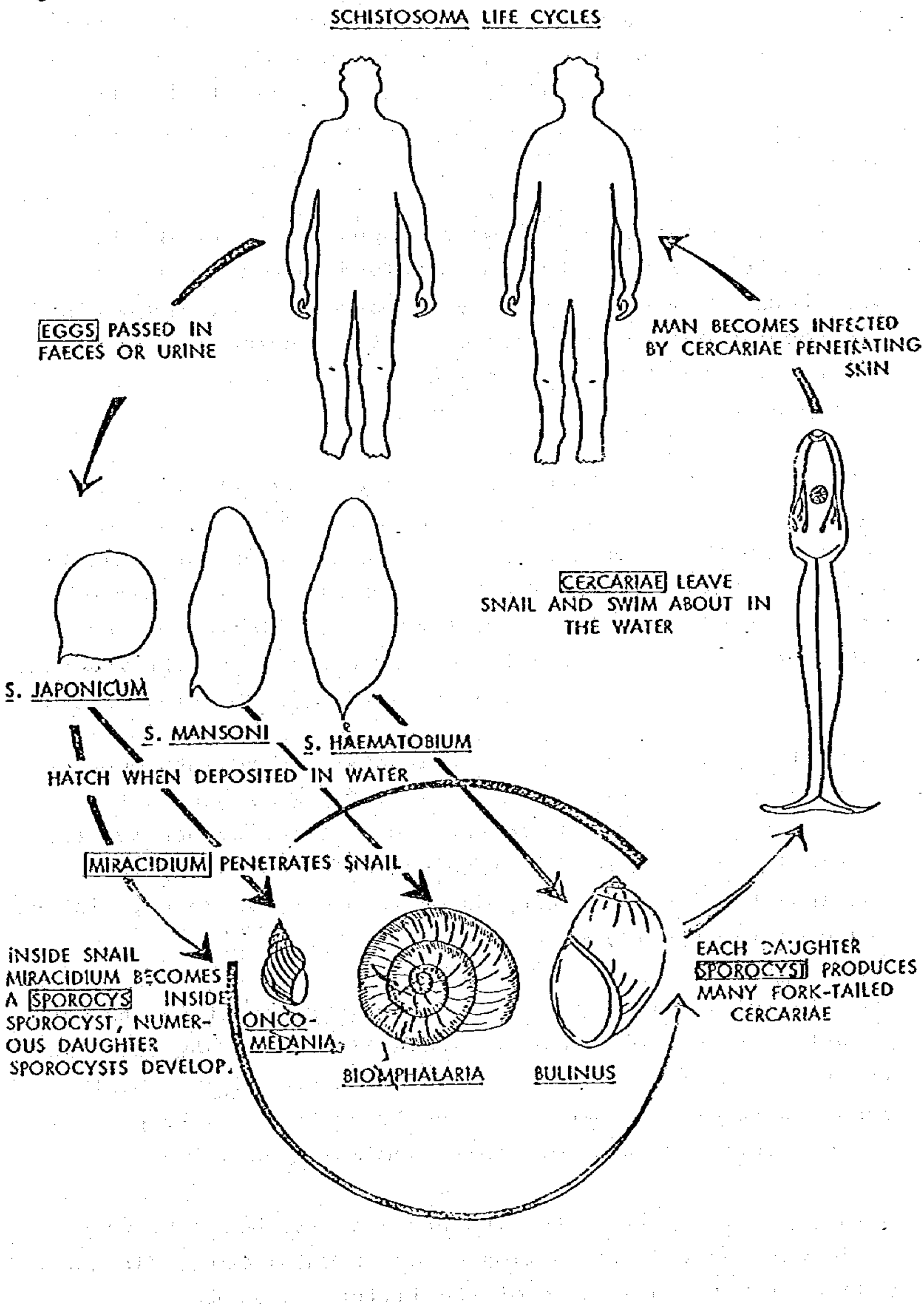
Table 3-8 Main Infective Diseases in Relation to Water Supplies

Category	Disease	Frequency	Severity	Chronicity	Percentage suggested reduction by water improvements
Ia	Cholera	+	+++		90
Ia	Typhoid	++	+++		80
Ia	Leptospirosis	+	++		80
Ia	Tularaemia	+	++		40?
Ib	Paratyphoid	+	++		40
Ib	Infective hepatitis	++	+++	+	10?
Ib	Some enteroviruses	++	+		10?
Ia, IIb	Bacillary dysentery	++	+++		50
Ia, IIb	Amoebic dysentery	+	++	++	50
Ib, IIb	Gastroenteritis	+++	+++		50
IIa	Skin sepsis and ulcers	+++	+	+	50
IIa	Trachoma	+++	++	++	60
IIa	Conjunctivitis	++	+	+	70
IIa	Scabies	++	+	+	80
IIa	Yaws	+	++	+	70
IIa	Leprosy	++	++	++	50
IIa	Tinea	+	+		50
IIa	Louse-borne fevers		+++		40
IIb	Diarrhoeal diseases	+++	+++		50
IIb	Ascariasis	+++	+	+	40
IIIa	Schistosomiasis	++	++	++	60
IIIb	Guinea worm	++	++	+	100
IVa	Gambian sleeping sickness	+	+++	+	80
IVb	Onchocerciasis	++	++	++	20?
IVb	Yellow fever	+	+++		10?

Table 3-9 Classification if Infective Diseases in Relation to Water Supplies

Category	Examples	Relevant water improvements
I Water-borne infections		
(a) Classical	*Typhoid, cholera*	*Microbiological sterility*
(b) Non-classical	Infective hepatitis	Microbiological improvement
II Water-washed infections		
(a) Skin and eyes	Scabies, trachoma	Greater volume available
(b) Diarrhoeal diseases	Bacillary dysentery	Greater volume available
III Water-based infections		
(a) Penetrating skin	Schistosomiasis	Protection of user
(b) Ingested	Guinea worm	Protection of source
IV Infections with water-related insect vectors		
(a) Biting near water	Sleeping sickness	Water piped from source
(b) Breeding in water	*Yellow fever*	*Water piped to site of use*
V Infections primarily of defective sanitation	Hookworm	Sanitary faecal disposal

Fig. 3-11



SCHISTOSOMA LIFE CYCLES
EGGS PASSED IN FAECES OR URINE
MAN BECOMES INFECTED BY CERCARIAE PENETRATING SKIN
CERCARIAE LEAVE SNAIL AND SWIM ABOUT IN THE WATER
S. JAPONICUM
S. MANSONI
S. HAEMATOBIUM
HATCH WHEN DEPOSITED IN WATER
MIRACIDIUM PENETRATES SNAIL
INSIDE SNAIL MIRACIDIUM BECOMES A SPOROCYS INSIDE SPOROCYST, NUMEROUS DAUGHTER SPOROCYSTS DEVELOP.
ONCOMELANIA
BIOMPHALARIA
BULINUS
EACH DAUGHTER SPOROCYST PRODUCES MANY FORK-TAILED CERCARIAE

rain water. Considering the results of the field investigation and the soil conditions in this area, it is difficult to utilize the groundwater as the water source for this area. With regard to the use of rain water, the dry season is quite long in this area, and it is therefore difficult to utilize rain water for the water source continually throughout the year.

Using the latter method, a water supply facility should be constructed. This method is therefore not suitable for this area because of the difficulty of operation and maintenance, high operation cost and lack of skilled engineers. Fortunately, however the Mombasa Pipeline exists through the center of this project area.

Permission from the MOWD Mombasa office was obtained to get water from this pipeline for this area. Therefore, obtaining water from this pipeline seems the most appropriate for this area. In this case, however water obtaining from this pipeline requires a charge and will result in limited use of the water probably only for drinking and cooking and the residents will go to the river for washing clothes and bathing as usual.

In Table 3-10, occurrence of residents coming into contact with infected river water is indicated. As shown in the table, there are many different types of occurrence for the people in the area to come into contact with water, including washing, bathing, obtaining domestic water, swimming, fishing and crossing the river.

This table clearly indicates that an improvement in the way of obtaining potable water for domestic use is not sufficient to prevent contagion from schistosomiasis. In this hinterland, therefore, a safe water supply system is only part of the prevention method for schistosomiasis contagion.

A safe water supply system in this area is, however, very efficient for the elimination of other water-borne disease as well as for the upgrading of the living standard.

Table 3-10 Water Contact Occurrence

Age	Sex	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		ITEMS														
0 ∿ 4	m	0	1	0	0	1	0	0	3	0	0	1	2	0	1	1
	f	0	1	1	0	2	0	2	14	0	7	3	0	0	2	2
5 ∿ 9	m	2	0	0	0	0	0	0	20	7	3	16	10	1	5	7
	f	4	0	4	0	3	0	0	19	7	13	13	13	0	2	3
10 ∿ 14	m	6	8	3	0	3	0	0	29	27	7	10	22	1	12	5
	f	5	0	0	0	1	0	1	11	7	12	2	4	0	2	2
15 ∿ 19	m	5	0	1	0	3	0	4	31	24	1	2	20	0	10	5
	f	6	0	1	0	2	0	2	14	18	20	0	11	0	0	0
20 ∿ 29	m	2	1	0	0	2	0	2	20	15	0	0	30	0	8	0
	f	12	1	4	0	4	0	5	24	19	38	0	16	0	1	0
30 ∿ 39	m	1	0	0	0	1	0	0	6	6	0	0	10	0	3	1
	f	11	2	4	0	6	0	6	25	26	40	0	30	0	3	0
40 ∿ 49	m	1	0	1	0	1	0	0	8	6	0	0	21	0	1	0
	f	2	0	1	0	2	0	3	4	18	16	0	9	0	2	0
50 ∿ 59	m	0	0	1	0	1	0	0	5	2	1	0	9	0	1	0
	f	4	0	0	0	1	0	2	5	9	14	0	9	0	0	0
over 60	m	0	0	0	0	0	0	0	4	3	0	0	6	0	0	0
	f	0	0	0	0	0	0	0	4	0	8	0	3	0	0	0
Unknown	m	1	0	0	0	1	0	0	2	3	0	1	2	0	0	0
	f	1	0	1	0	0	0	0	2	0	3	0	0	0	0	0
Subtotal	m	18	2	6	0	13	0	6	128	93	12	30	132	2	41	19
	f	45	4	16	0	21	0	21	122	184	171	18	95	0	12	7
Total		63	6	22	0	34	0	27	250	197	183	48	227	2	53	26

Item
- 1 : Washing clothes in river with soap
- 2 : Washing clothes in river without soap
- 3 : Washing clothes in buckets with soap
- 4 : Washing clothes in buckets without soap
- 5 : Rinsing in river
- 6 : Rinsing in buckets
- 7 : Washing utensils or things
- 8 : Bathing (entire body)
- 9 : Washing body (part)
- 10 : Drawing water
- 11 : Swimming, Playing
- 12 : Crossing river
- 13 : Watering animals
- 14 : Fishing
- 15 : Drinking
- 16 : Others

Chapter 4 Facilities for Safe Water Supply

CHAPTER 4

FACILITIES OF SPARE WATER SUPPLY

4-1 Basic Considerations

In order to plan the facilities for a safe water supply project, the following considerations were made.

4-1-1 Coastal Area

1) To provide the entire population with sufficient portable domestic water in terms of both quality and quantity.

2) Water sources are shallow wells with average deptshs of 10 ∿ 20 m.

3) Well shall be confined to prevent water contamination.

4) The method for pumping water will be either by wind mill or hand pump. At the site where a wind mill is installed, an elevated tank is to be provided together with public taps, a washing floor and a water bathing facility.

5) One shallow well is provided at each project site.

6) Considering economic operation and maintenance, compact, simplified and durable facilities should be provided.

7) The beneficiaries of the safe water supply system should be responsible for operation and maintenance although safe water will be provided free of charge.

8) Materials and equipment required for the project should be obtained locally.

4-1-2 Hinterland

1) In this area, the only available water source is the Mombasa Pipeline.

2) Three service pipes are to be installed branching off the Pipeline. The dimensions of the branch pipes are approximately 50 m long with a diameter of 50 mm.

3) The major components of the supply system are public taps, washing floors, water bathing facilities and drainage facilities.

4) Considerations should be given to minimizing operation/ maintenance costs.

5) Beneficiaries of the safe water supply will be responsible for operation and maintenance of the facilities.

4-2 Service Areas and Population

4-2-1 Service Areas

4-2-1-1 Coastal Area

The project sites in this area are the camps of the Ramisi Sugar Factory in Kwale District located about 50 km to the south of Mombasa. These four camps; Buibui, Fahamuni, Kanana and Kidimu were sample study areas for the Communicable Diseases Research and Control Project which was executed by Japanese experts. The study of this safe water supply project also included these 4 camps and their surroundings. The outline of these camps are indicated in Table 3-4.

4-2-1-2 Hinterland

The study area is in Mwachinga Village which is located 30 km southwest of Mombasa city. The elevation of Mwachinga Villaage is 150 meter above sea level and the area is about 10 km^2. The summary of this study area is described in Fig. 3-5. The population of this village is about 1,100.

4-2-2 Population in the Study Area

4-2-2-1 Coastal Area

The population of each camp is changeable in season. This is caused by the seasonal labour required for the sugar factory. The population of each camp was surveyed in October 1982, and the results of that survey are shown in Table 3-4.

The population to be served in this project is determined based on the results of that survey. (See Table 4-1).

Table 4-1 Service Population of Each Camp

Camp	Male	Female	Children	Students	Total	Number of Houses
Buibui	98	53	68	-	219	44
Fahamuni	72	33	69	100	274	59
Kanana	163	44	74	-	281	69
Kidimu	44	20	35	-	99	21

The service ratio of 4 camps was determined to be 100%, which means that the service of this safe water supply covers all the residents in each camp. There is one elementary school in Fahamuni camp, and therefore the service population of that camp includes about 100 students at this school.

4-2-2-2 Hinterland

The population of the Communicable Diseases Research and Control Project for Mwachinga Village is about 1,100. The population to be served by this safe water supply project is limited to about 500 or 45% of the total population in this village, because of a limited service area.

4-3 Design Criteria

The design criteria for the safe water supply project is established based on the results of the field survey.

4-3-1 Unit Demand

50 liters per head per day was adopted as the Unit demand for this safe water supply project.
The current water consumption per household is about 40 l per day. Water consumption per head per day is therefore between 8 and 10 liters. This data was obtained by field observation and this amount of water was only used for drinking and cooking.

Unit demand is described in the Design Manual, Ministry of Water Development for the Republic of Kenya indicated in Table 4-2.

For this project, the communal water point system was adopted as the water distribution system instead of the house connection system. One shallow well, Kiosk water, washing place and bathing sheds are planned for each camp. For this proposed water supply facility, the unit water demand is limited to about 20 liters per head per day. Considering the existing sanitary conditions where cholera could break out in the camp where residents could obtain good quality of water but not a sufficient amount, the study team determined the following

Table 4-2 Unit Demand of Various Consumers

CONSUMERS	UNITS	RURAL AREAS		URBAN AREAS			REMARKS
		HIGH & MED. POTENTIAL	LOW POTENTIAL	LOCAL/MARKET CENTRES	RURAL CENTRES	URBAN CENTRES	
OVERALL CONSUMPTION RATES	LIT/HEAD/DAY	50	50	70	110	135	
PEOPLE WITH INDV. CONNECTIONS	LIT/HEAD/DAY	50	50	300 150 75	300 150 75	300 150 75	HIGH CLASS HOUSING MED. CLASS HOUSING LOW CLASS HOUSING
PEOPLE USING CWP AND KIOSKS	LIT/HEAD/DAY	25	20	25	25	25	
LIVESTOCK UNITS (1 GRADE CATTLE, 2 NOS=15 SMALL STOCK)	LIT/L.U./DAY	75	75	75			
FARMS OVER 4 ha.	LIT/FARM/DAY	1000					
FARMS/PLOT 2-4 ha.	LIT/FARM/DAY	600					
FARMS LESS THAN 2 ha.	LIT/FARM/DAY	400					
FARMS WHERE ONLY NOS. OF PLOTS ARE AVAILABLE	LIT/FARM/DAY	600	300				
HOSPITALS REGIONAL DISTRICT OTHER	LIT/BED/DAY	400 200 100	400 200 100	400 200 100	400 200 100	400 200 100	TO BE CHECKED WITH M.O.H. IN EACH CASE
HEALTH CENTRES & DISPENSARIES	LIT/OUTPATIENT/ PER DAY	20	20	20	20	20	NOT TO EXCEED A BULK OF $10m^3$/DAY BUT NOT LESS THAN $5m^3$/DAY (ACC. TO M.O.H.)
HOTELS	LIT/BED/DAY	600 300 50	600 300 50	600 300 50	600 300 50	600 300 50	HIGH CLASSES MED. CLASSES LOW CLASSES
ADMINISTRATIVE OFFICE	LIT/HEAD/DAY	25	25	25	25	25	
BOARDING SCHOOLS	LIT/HEAD/DAY	50	50	50	50	50	
DAY SCHOOLS	LIT/STD./DAY	25 10	25 10	25 10	25 10	25 10	WITH WCs WITHOUT WCs
BARS	LIT/DAY	200	200	300	300	300	
SHOPS	LIT/DAY	50	50	100	100	100	

Source: Design Manual, Ministry of Water Development in Republic of Kenya.

amount of water for unit demand for the project area in order to prevent communicable diseases using sufficient quantity of water.

Unit Demand		
Drinking and cooking		8 ∿ 10 l/d
Bathing and washing hands		20 ∿ 25 l/d
Washing clothes		10 ∿ 15 l/d
Cleaning etc.		1 ∿ 3 l/d
	Total	39 ∿ 53 l/d
	say 50	l/head/day

4-3-2 Water Quality

In the planning of a shallow well, the waste water drainage facility is carefully considered because the shallow well is adopted as the water source for the coastal area. The well is planned to be the closed type, but for emergency, purposes bleaching powder is prepared for disinfection.

In the water supply system for the hinterland area, raw water can be obtained from the Mombasa Pipeline, whose water source is the Marere spring and the quality of that water seems to be good.

4-3-3 Standardized of Water Supply Facility

The safe water supply facility for this project is standardized considering planning, construction, operation and maintenance.

Standardized facilities are combined based on the differences in the population served.

4-4 Safe Water Supply Facilities

4-4-1 Service level

The service levels were classified as follows:

1) House connection

2) Yard connection

A public water tap used by some residents

3) Communal tap

A public water tap was used by many residents

4) Well

A well in the village is used by residents

Considering the improvements in sanitary conditions, a house connection is the most appropriate system. However, the construction cost for house connections is almost 6 times that of well construction.

On the occasion of spreading the water supply service for many residents using a limited budget, a well system or communal tap system should be adopted as the water supply system.

In this project, one shallow well will be built for each camp. It will also be better to establish a simple facility for operation and maintenance after completion.

For the coastal area, the shallow well is adopted as the water source and a pump is installed for pumping the water. The power supply requirements for the pump are determined as follows.

1) Human 2) Animal 3) Wind 4) Motor and 5) Engine

In these powers, only those methods which require low operating cost and easy maintenance are accepted for the power supply for the pump in this study area. For these reasons, hand pump and wind mill are adopted as the most suitable. (See Fig. 4-1.)

Waste water drainage system is just as important as a safe water supply system for control of communicable diseases in the rural areas of developing countries. In this project, waste water drainage facility is planned based on the weather and soil conditions which are shown in Fig. 4-2. The facility will be built at the same location as the washing and bathing facilities at each camp.

Details of the safe water facility in each camp and Mwachinga Village are discussed in the following paragraphs.

4-4-1-1 Coastal Area

Buibui Camp

The existing spring which is used for the water source by residents is remained. One shallow well will be built at the south end of the camp. A windmill, reservoir tank, hand pump, drawing facility, washing facility and bathing sheds will also be installed. The depth of the well will be 10 meters.

Fahamuni Camp

The existing well was replaced and a windmill, reservoir tank, drawing facility, washing facility, bathing sheds, and hand pump were installed. Since there is a primary school in this camp, a new shallow well will also be constructed in that school considering the sanitary education for the students of that school.

Fig. 4-1 Water Supply System

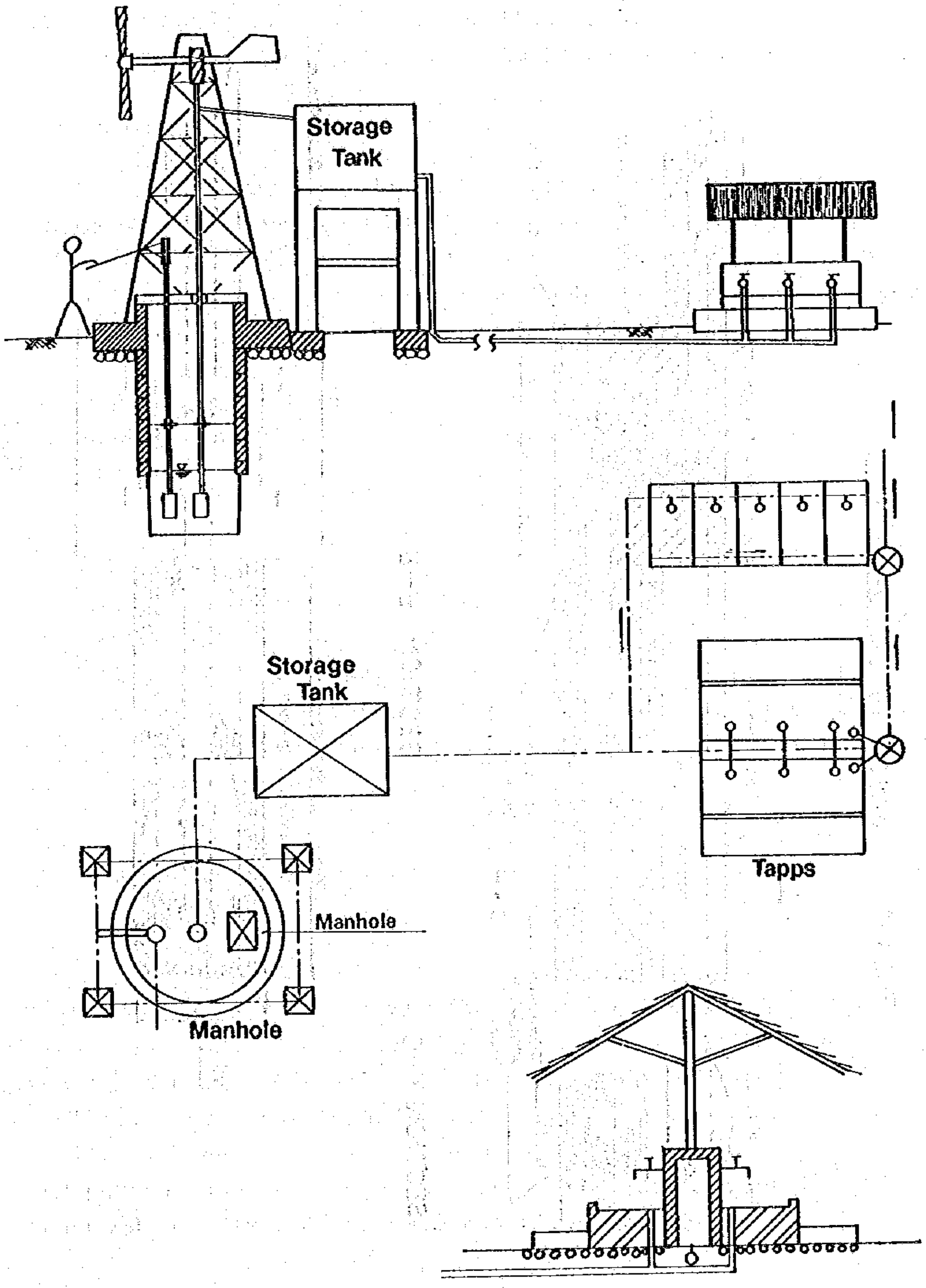
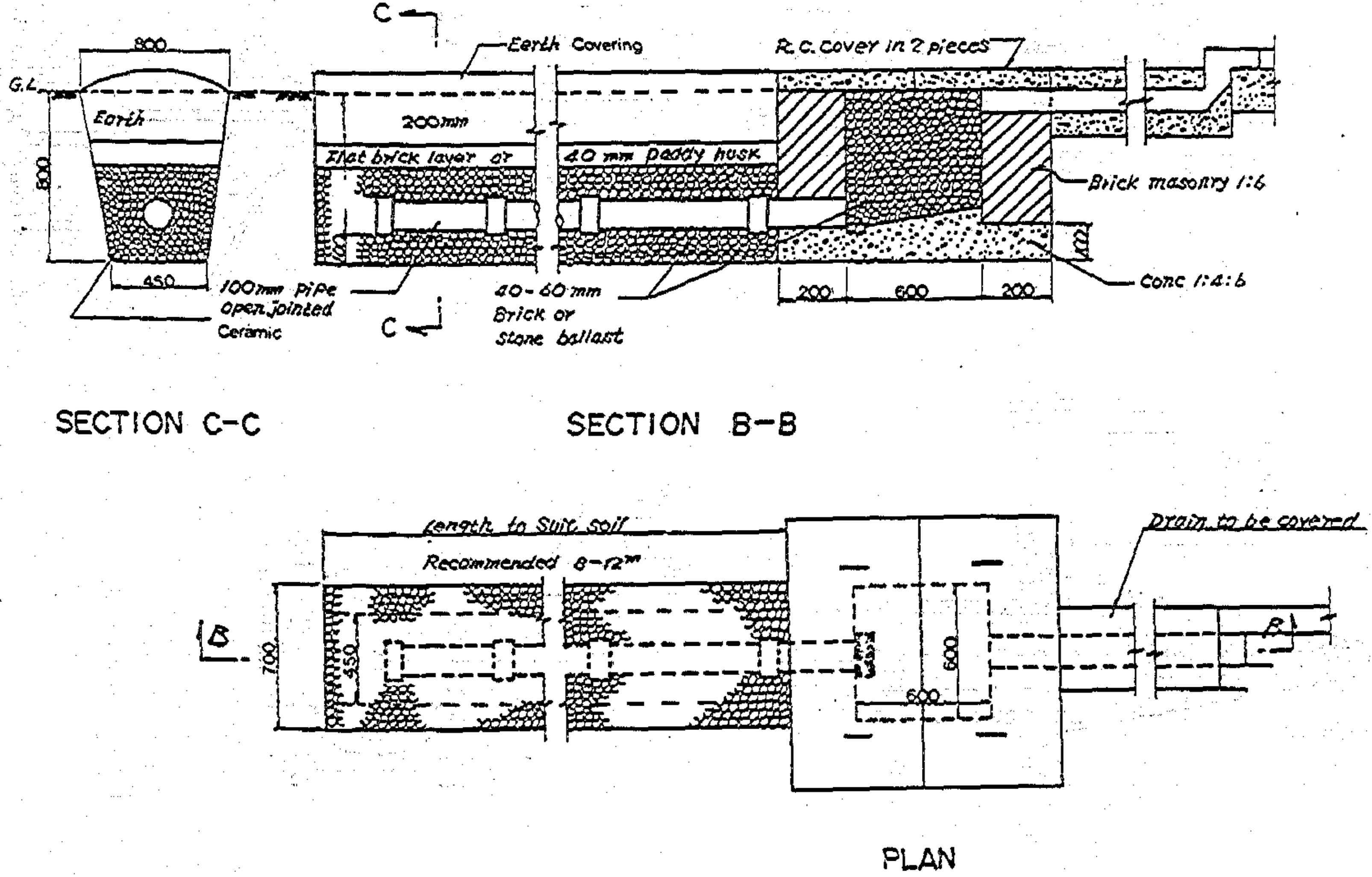


Fig.4-2 **WASTE WATER DRANAGE**



The new well has hand pump equipment and the students will be educated to wash their hands frequently. This well will also be used by the residents of this camp.
The depth of the well is planned to be 20 meters.

Kanana Camp

There is one existing well in this camp. The well has been repaired and a hand pump has been installed. A shallow well with windmill equipment is built in the northern part of this camp. This well system has a reservoir tank, drawing facility, washing facility and bathing sheds.

The population of this camp is large, the number of persons being 281. In this camp, therefore it is planned that 2 wells will be installed.

Kidimu Camp

The existing spring which is used for the water source by residents will be closed. The new shallow well which has a windmill, reservoir tank, drawin facility, washing facility and bathing sheds is built in the north east part of this camp. The existing well which is located at the north end of this camp will be closed.

4-4-1-2 Hinterland

Mwachinga Village

In this area, safe water will be obtained from the Mombasa Pipeline. Three Public faucets will be constructed along the pipeline in this village. Drawing facility, Washing facility and bathing sheds will be installed at each facility. The population served is expected to be about 500 persons and the amount of water will be about 30 m^3 consumed per day from the Mombasa Pipeline.

Table 4-3 SUMMARY OF PROPOSED FACILITIES

Facility \ Campe & Village	BUIBUI Camp	FAHAMUNI Camp	KANANA Camp	KIDIMU Camp	OTHER Camp	MWACHINGA Village	Remarks
Supply Population	219	174 + 100	281	99	100～200	about 200	
Water Demand (20% allowance)	13 m^3	11 m^3	17 m^3	6 m^3	6～12 m^3	30 m^3	
Well Ø 2500 (mm)	Dep. 10 m	Dep. 20 m	Dep. 15 m	Dep. 15 m	Dep. 15～20 m	---	
Wind Mill	O	O	O	O	---	---	
Hand Pump	O	O X2	O X2	O	O	---	
Water Reservoir (Elevated 12 m)	O	O	O	O	---	---	
Water Taps for general use	O	O	O	O	---	O	
Water Taps for bathing	O	O	O	O	---	O	
Bathing Sheds (1 Unit=4Sheds)	1 each for M & W	1 each for M & W	2 for M & 1 for w	1 for M & W	---	3 Units	
Water Dranage Facility	O	O	O	O	O	O	
Distribution Pipe	---	---	---	---	---	O	

4-5 Estimate of Construction Cost

The construction cost of the safe water supply facility in the coastal area has been estimated based on a quotation from a local contractor.

The construction cost for the safe water supply system in the hinterland, was estimated using unit prices (Feb. 1983) from Ministry of Water Development for the Republic of Kenya. Cost of construction for each facility was estimated and is indicated in Table 4-4.

The total construction cost of 1,444,000 Ksh which includes the 15 percent price increase and contingency is also estimated at 5 percent.

4-6 Estimated Execution Schedule

This project was carried out as one part of the Communicable Diseases Research and Control Project. The execution schedule for this project has been determined considering the close relation with that project, as well as the construction capacity of local contractors. The construction efficiency for well installation during the rainy season was also been considered. The estimated execution schedule is established as shown in Table 4-5.

At the beginning of the construction stage, qualified consulting engineers will be needed for reinvestigation of well sites (except at four camps), negotiation with local contractors and arrangements for the construction. At the end of the construction stage, one consultant engineer will be dispatched as a supervisor for the testing of the system.

Table 4-4 Construction Cost of Safe Water Supply Facility (Unit: Ksh)

Camp & Village / Facility	Buibui Camp	Fahamuni Camp (1)	Fahamuni Camp (2)	Kanana Camp (1)	Kanana Camp (2)	Kidium Camp	Other camps (10 camps)	Muachinga Village (3 points)
Well Construction	Dep=10m 10,000	———	Dep=20m 20,000	———	Dep=15m 15,000	Dep=15m 15,000	Dep=15-20 17,000 x 10	———
Existing Well Reparing	———	4,500	———	4,500	———	———	———	———
Windmill Construction	44,505	———	———	———	44,505	44,505	———	———
Existing Well Repairing	———	33,350	———	———	———	———	———	———
Hand Pump	8,200	8,200	8,200	8,200	8,200	8,200	8,200 x 10	———
Water Reservoir (Elevated)	29,350	29,350	———	———	29,350	29,350	———	———
Communal Water Point	25,000	25,000	3,000	3,000	25,000	25,000	3,000 x 10	25,000 x 3
Bathing Shed	40,000	40,000	———	———	60,000	40,000	———	20,000 x 3
Water Dranage Facility	7,000	7,000	2,000	2,000	7,000	7,000	2,000 x 10	5,000 x 3
Distribution Pipe	———	———	———	———	———	———	———	8,000 x 3
Sub Total	164,055	147,400	33,200	17,700	189,055	169,055	302,000	174,000
Price advance (15%)	24,545	22,100	4,900	2,600	28,345	25,345	45,000	26,000
Total	188,600	169,500	38,100	20,300	217,400	194,400	347,000	200,000
	1,375,300							
Contingency	68,700 (Total x 5%)							
Ground Total	1,444,000							

Table 4-5 Execution Schedule of Facilities

	Year 1983									Year 1984		
	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Well construction & Facilities												
Buibui			Construction		Pumping Test							
Fahamuni			Construction	Pumping Test								
Kanana			Construction		Pumping Test							
Kidimu			Construction		Pumping Test							
Others			Field Survey		Construction			Pumping Test				
Preparing the Existing Well												
Fahamuni			Repairing									
Kanana				Repairing								
Water Supply Facilities												
Muachinga Village			Construction by MOWD									
Engineering Supervision		Reinvestigation and arrangement 3 persons						1 person				

4-7 Operation and Maintenance

After completion of this project, operation and maintenance of the facility will be entrusted to the beneficiaries namely the residents of each camp and village.

In the coastal area, however, almost all of the project sites belong to the private sugar factory. The director of the sugar factory indicated to the study team that the sugar factory should undertake the responsibility to operate and maintain that facility. In these private camps, therefore the manager will be selected among the residents in each camp. He will maintain the facility under the control of the sugar factory. In other villages in the coastal area, the manager will be selected among the residents in each village and will have the responsibility for operation and maintenance of the facility. Both of these maintenance systems will be under the control of the Division, District and Provincial Medical Office. It is recommended that the Ministry of Health has responsibility for the control of the operation and maintenance system. (See Fig. 4-3)

The operation and maintenance functional chart for this system is shown in Fig. 4-3. After completion, the manager of the facilities will be educated to have the ability to repair minor breakdown of the facility by himself. If serious trouble develops, then the manager will request help from a higher section for repairs. This project will maintain close relations with the Communicable Diseases Research and Control Project and it is recommended therefore that sanitary education be undertaken for the residents in order to improve their sanitary standards. Such education should be inplemented by Division or District officers.

Fig. 4-3 Water Supply Facilities Operation and Maintenance Function Chart