UNITED REPUBLIC OF TANZANIA

MINISTRY OF WATER DEVELOPMENT,
ENERGY AND MINERALS

RURAL WATER QUALITY PROGRAMME IN TANZANIA FINAL REPORT

ANNEXES 1-10

BROKONSULT AB
ENGINEERS – ECONOMISTS – PLANNERS
PER SUNDBERGS VAG 1-3, S-18363 TABY
SWEDEN

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ANNEX 1

TERMS OF REFERENCE FOR A RURAL WATER QUALITY PROGRAMME IN TANZANIA

1. Background

The efforts in Tanzania to supply rural areas with water have so far been concentrated on providing water for the people with respect to quantity. However, the government of Tanzania now want to put greater emphasis on supplying safe drinking water. Worldwide the knowledge of the impact on health of bad drinking water quality is continously increasing but still the knowledge of the causal connections between water quality and health is limited due to lack of background data. To provide a basis for the future the first step is therefore to work out a programme for developing a system for water quality surveillance so that necessary steps can be taken in order to improve the health.

2. Objectives

The overall objective of the study is to make an investigation of relevant factors connected to the problems inidcated above. The scope of the study will be

- to review the most important aspects of the relation between water quality and health in Tanzania
- to evaluate the existing situation in Tanzania
- to recommend a water quality programme

3. Scope of the consulting services

The Consultant shall end up in detailed recommendations on a system of water quality surveillance including also specifications for laboratories and other facilities as possibly proposed as part of the system. The study objects for this purpose are outlined in the following subparagraphs in this section.

3.1 Relations between water quality/quantity and health

The Consultant will review the relation between water quality/quantity and health thereby confining himself to the quality aspects which are most important for public health in Tanzania. It is felt that the factors to be dealt with shall comprise, i.a. excreta pollution, flouride, nitrate and bilharzia.

3.2 Evaluation of the existing situation in Tanzania

3.2.1 The Consultant will review the existing situation in rural Tanzania considering following factors:

- Present water quality surveillance including water treatment plants
- Chemical and bacteriological standards
- Existing data and activities, e.g. health programmes related to water quality
- Regional differences with respect to water quality/ quantity and health
- Treatment of water

3.2.2 The Consultant will appraise the existing and potential base and resources in Tanzania for surveillance of drinking water quality and for sampling and analysis with respect to:

- Facilities and manpower
- Central and regional organisations (Maji[1], Afya[2], Kilimo[3] and other bodies).

3.2.3 The Consultant will review the existing legal background related to surveillance of drinking water quality and need for improvement in terms of laws and regulations.

3.3 Water quality programme

The Consultant will recommend a stagewise programme for developing a system of water quality surveillance, possibly for the periods 1978-1982 and 1983-1991. The Consultant will propose the feasible level of surveillance for each stage and analyse all investment and recurrent costs for the programme for each stage. The costs shall be subdivided in local and foreign costs. The Consultant will also include available resources when working out the programme.

3.3.1 The Consultant will analyse the need of water quality control and make detailed recommendations on:

- Regional priorities
- Timing and frequancy of sampling

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1) Ministry of Water, Energy and Minerals
2) Ministry of Health
3) Ministry of Agriculture

- Samling and sample handling procedures
- Extent of analyses; physical, chemical, bacteriological and biological
- Analysis procedures
- Guidelines, checklists and forms for recording water quality data
- Dissemination of records

3.3.2 As an integrated part of the quality programme the Consultant will recommend an action programme of remedial measures for correction of deficiencies of the water quality. The Consultant will:

- Formulate guidelines for possible campaigns to gain popular support for protection of water sources and for handling water properly
- In taking advantage of available literature draw attention to the most important technical precuations for protecting water sources from contamination
- In a comprehensive way recommend follow up action to be taken at various kind and level of deficiencies of the water quality
- Formulate criteria for closing a source of drinking water and for reopen the same taking into account the quality of alternative sources

3.3.3 The Consultant will make proposal for improving existing laboratories and establishing new ones and make recommendations covering the following aspects:

- Number of location of stationary and mobile laboratories
- Standard laboratory equipment including water treatment plants
- Standard analysis procedures
- Need of improvements in operation of water treatment plants
- Standardization of laboratory chemicals and other consumables
- Standard lay-outs of proposed laboratories considering possible extension for effluent testing

3.3.4 The Consultant will study suitable organisational frame-work and make his recommendations on:

- Division of central and regional responsibilities between Maji, Afya and other ministries
- Organisation set up required for the water quality programme
- Manpower requirements (stagewise)
- Training requirements and training programmes

4. Activities

The main activities of the study will be the following:

- Literature studies
- Collection of data from agencies, ministries and archives
- Interviews with authorities, central and regional
- Visits to rural water supply schemes and local laboratories
- Processing and analysis of data
- Summarizing and reporting

5. Estimated input, staff and time schedule

The total input required for the study is estimated to about 18 manmonths. The Consultant team ought to include expertness in following fields: hygiene, microbiology, epidemiology, water chemistry and water engineering. An limited input of statistics might also be needed. The team shall have experience of conditions in Africa in the field of study.

The study is expected to take about 5 months and the report available in draft 6 months after the start of the study.

6. Liaison and Co-operation

In connection with work by the Consultants that requires the co-operation of other government agencies, the government will provide liaison and will ensure that the consultant have access to all information required for the completion of the services.

The Consultants will have essentially perform the survey in Tanzania with headquarters in Dar es Salaam at office provided by the government. Work outside the country can comprise literature studies, backstopping and editing/printing of the final report.

It is foreseen that the government will form a Steering Committee for liaison and guidance on policy matters. It is hoped that the Chairman of the Committee will serve as Liaison Officer for day-to-day contacts as necessary.

The Liaison Officer will contribute in ensuring that the pertinent information is made available to the Consultants.

The Consultants shall allocate time for liaison and discussion an necessary and senior staff shall be available for discussing the Draft Final Report within 10 days of submittance.

7. Miscellaneous

7.1 Literature

For avoiding duplication of work already available literature of surveillance of water quality and health aspects related to water shall be studied by the Consultant and utilized as for as deemed relevant for the purpose of this study. Following literature seems to be particularly relevant.

1. Surveillance of Drinking Water Quality WHO, Geneva 1976

2. Drawers of Water, Gilbert F White, David J Bradly
   Anne U White
   University of Chicage Press
   Chicage and London 1972

3. Village Water Supply, Saunders and Warford
   World Bank Research
   Publication, 1976

4. AMBIO. A journal of the human environment research and managment, Royal Swedish Academy of Sciences, Volume VI, number 1, 1977

5. Rapport till länsläkarorganisationen i Kristianstads Län om nitrat och nitrit; tillförsel och omsättning hos människan, Ann-Sofi Sandberg, Näringsforskning Årg. 20, 1976

ANNEX 2

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ANNEX 2.1

OCCURRENCE OF FAECAL COLIFORMS AND STREPTOCOCCI IN DIFFERENT SOURCE TYPES

OWN RESULTS

Source type	Samples with given no. per 100 ml					No. sources	No. samples
	≤1	1-10	11-100	101-1000	>1000		
Borehole	6	2	-	1	-	9	9
Well - protected	4	8	5	4	-	21	21
- open	-	-	3	6	4	13	13
Spring - protected	2	5	7	2	-	16	16
- open	4	4	3	5	-	16	16
Stream-piped	2	7	11	10	1	31	31
- unpiped	4	5	6	13	6	34	34
Impoundment - piped	1	4	1	-	-	6	6
- unpiped	1	1	2	2	2	8	8
Pit	-	2	4	5	5	16	16
Treated water	10	-	8	1	1	19	20
Rainwater	1	1	2	-	-	4	4
TOTAL						193	194

Annex 2.1

Occurrence of Faecal Coliforms

Coast Region Water Master Plan

Source type	Samples with given no. per 100 ml					No. sources	No. samples
	<1	1-10	11-100	101-1000	>1000		
Borehole	21	1	-	-	-	4	22
Well-protected	25	21	9	1	-	17	56
-open	-	-	1	2	6	9	9
Spring -protected	-	-	-	-	-	-	-
-open	-	-	-	-	-	-	-
Stream-piped	2	3	2	-	-	2	7
-unpiped	-	1	15	17	9	15	42
Impoundment -piped	13	21	28	13	-	16	75
-unpiped	-	6	10	7	-	8	23
Pit	-	6	12	17	9	16	44
Treated water	-	-	-	-	-	-	-
Rainwater	-	-	-	-	-	-	-
TOTAL						87	278

Annex 2.1

Occurrence of Faecal Coliforms

Mara-Mwanza-West Lake Water Master Plan

Source type	Samples with given no. per 100 ml				No. sources	No. samples
	< 1	1-10	11-100	101-1000		
Borehole	8	8	7	1	19	24
Well-protected	-	3	5	2	7	10
-open	-	-	-	-	-	-
Spring-protected	-	-	-	-	-	-
-open	1	3	12	2	18	18
Stream-piped	-	3	5	3	11	11
-unpiped	-	-	-	-	-	-
Impoundment -piped	-	-	-	-	-	-
- unpiped	3	13	26	15	49	57
Pit	-	-	-	-	-	-
Treated water	-	-	5	-	5	5
Rainwater	1	2	1	-	4	4
TOTAL					113	129

Annex 2.1

Occurrence of Faecal Coliforms

Mtwara-Lindi Water Master Plan

Source type	Samples with given no. per 100 ml			No. sources	No. samples
	0-10	11-100	> 100		
Borehole	24	5	1	16	30
Well-protected	8	11	5	13	24
-open	4	5	9	14	18
Spring-protected	16	8	2	13	26
-open	5	3	4	8	12
Stream-piped	-	7	7	7	14
-unpiped	3	4	10	9	17
Impoundment -piped	5	3	2	6	10
-unpiped	-	4	3	4	7
Pit	-	-	1	1	1
Treated water	-	-	-	-	-
Rainwater	-	-	-	-	-
TOTAL				91	159

Annex 2.1

Occurrence of Faecal Coliforms

Shinyanga Water Master Plan

Source type	Samples with given no. per 100 ml			No. sources	No. samples
	0-10	11-100	> 100		
Borehole	11	2	1	5	14
Well-protected	15	4	3	9	22
-open	1	2	15	8	18
Spring-protected	-	-	-	-	-
-open	-	-	-	-	-
Stream-piped	4	3	5	4	12
-unpiped	-	2	15	6	17
Impoundment -piped	1	3	-	2	4
-unpiped	4	15	8	10	27
Pit	-	1	11	4	12
Treated water	8	-	-	4	8
Rainwater	-	-	-	-	-
				52	134

Annex 2.1

Occurrence of Faecal Streptococci

Own Results

Source type	Samples with given no. per 100 ml					No. sources	No. samples
	<1	1-10	11-100	101-1000	>1000		
Borehole	3	2	3	-	1	9	9
Well-protected	1	6	5	6	-	18	18
-open	-	-	1	3	7	10	11
Spring-protected	1	1	9	1	1	13	13
-open	1	1	9	5	-	16	16
Stream-piped	1	1	9	3	2	16	16
-unpiped	-	1	3	18	4	26	26
Impoundment -piped	1	3	4	2	-	10	10
-unpiped	-	-	3	6	7	16	16
Pit	-	-	3	2	8	13	13
Treated water	6	6	14	3	-	26	29
Rainwater	-	2	1	1	-	4	4
TOTAL						177	181

Annex 2.1

Occurrence of Faecal Streptococci

Coast Region Water Master Plan

Source type	Samples with given no. per 100 ml					No. sources	No. samples
	1	1-10	11-100	101-1000	> 1000		
Borehole	15	1	-	-	-	4	16
Well-protected	-	7	26	16	3	17	52
-open	-	-	1	2	4	7	7
Spring-protected	-	-	-	-	-	-	-
-open	-	-	-	-	-	-	-
Stream-piped	-	-	3	1	-	2	4
-unpiped	-	-	3	8	5	14	16
Impoundment -piped	2	7	14	25	6	16	54
- unpiped	-	-	3	4	2	7	9
Pit	-	-	1	6	7	14	14
Treated water	-	-	-	-	-	-	-
Rainwater	-	-	-	-	-	-	-
TOTAL						81	172

CATALOGUE OF ALL BACTERIOLOGICAL SAMPLES MADE IN THIS PROJECT

ANNEX 2.2

REGION	PLACE	NO	BACTERIA PER 100 ML		SOURCE TYPE
			FAECAL COLI-FORMS	FAECAL STPEPTO-COCCI	
PWANI	Mvuteni river	1	1 600	940	RU
	- " -	2	500	75	P
	Bungu	3	1 000	6 700	WO
	Nyanmbili	4	7	10	WP
	Kibiti	5	114	256	IU
	-"-	6	48	123	IP
	Mkongo	7	6	5	IP
	Kilimani	8	28	50	IP
	Ndundunyikanza	9	36	56	IP
	Nyaminwili	10	14	15	WP
MWANZA	Bukumbi	11	210	3 000	WO
ZIWA MAGHARIBI	Nyakakanga	12	800	78	SO
	Ihembe	13	8	190	SO
	-"-	14	0	19	RW
	-"-	15	0	40	SO
	-"-	16	-	53	SO
	-"-	17	0	1	RW
	Bwanja	18	9	31	SO
	-"-	19	32	830	SO
	-"-	20	10	470	SO
KIGOMA	Kibondo	21	53	360	TW
	-"-	22	950	390	RU
	Kifura	23	116	95	RP
	Malagarasi forest	24	1 200	230	RU
	Makere	25	470	62	RU
	-"-	26	1 800	270	RU
	Kasulu	27	10	60	TW
	-"-	28	0	210	RU
	Mwaki Zega	29	1 200	1 050	IU
	- " -	30	110	3 570	RU
	Kigoma	31	4	26	IP
	-"-	32	174	44	TW
	Simbo	33	0	4	RP
	-"-	34	490	570	RU
	Kasulu	35	0	23	TW
	Nyamuganza River	36	-	340	RU
	Site 24	37	-	490	RU
	Malagarazi River	38	-	350	RU

ANNEX 2.2

CATALOGUE OF ALL BACTERIOLOGICAL SAMPLES MADE

REGION	PLACE	NO	BACTERIA PER 100 ML		SOURCE TYPE
			FAECAL COLI-FORMS	FAECAL STREPTO-COCCI	
KIGOMA	Kibendo	39	-	1 060	RP
	Keza	40	-	580	WP
	-"-	41	-	1 290	RU
TABORA	Itobo	42	-	20	IP
	Nzega	43	-	15	TW
	Tumbi	44	1 360	1 600	WO
	Mabamba	45	480	16	IU
	Usoke	46	0	0	BH
	Usoke Mission	47	0	0	IP
	Tabora	48	0	0	TW
	Nkiniziwa	49	-	58	TW
	- " -	50	42	149	IP
SHINYANGA	Malasa	51	50	49	50
	Ibingo	52	7	520	WP
	-"-	53	0	95	WP
	Shinyanga	54	15	7	TW
	Negezi	55	0	4	WP
	-"-	56	-	46	P
	Ukenyenge	57	220	45	RP
	Nwaweja	58	153	190	WP
	Ngwamagunguli	59	3	46	WP
	Ibadakuli	60	-	44	IW
	Shinyanga	61	22	65	WP
	Bubiki	62	72 000	72 000	P
	-"-	63	72 000	72 000	P
MWANZA	Ngudu source	64	2	46	BH
	-"- tap	65	194	1 040	PH
	Misungwi	66	-	2	IP
	-"-	67	-	0	TW
	-"-	68	0	0	WP
	Ukiriguru	69	3	10	IP
	Bukumbi	70	940	3 720	WO
DODOMA	Kongwa	71	-	35	BH
	Mpwapwa	72	7	150	RP
	Gulwe	73	-	18 900	P
	Berege	74	-	100 000	IU
	Mima	75	1	66	PH
	-"-	76	-	17 800	CC (75)

CATALOGUE OF ALL BACTERIOLOGICAL SAMPLES MADE

ANNEX 2.2

REGION	PLACE	NO	BACTERIA PER 100 ML		SOURCE TYPE
			FAECAL COLI-FORMS	FAECAL STREPTO-COCCI	
)ODOMA	Iwondo	77	-	8 200	IU
	Keigwe	78	0	6	BH
	Bahi	79	210	460	RU
Capital	-"-	80	-	2 990	P
Singida	Kilimatinde	81	1 080	>2 000	RP
	Manyoni	82	52	17 900	WO
	Choda	83	60	40 000	P
	Singida	84	0	2	TW
	Mtipa	85	430	5 000	P
	-"-	86	386	425	WP
	-"-	87	10	1 800	P
	Kinyeto	88	860	9 300	WO
	-"-	89	3 190	45 000	IU
	-"-	90	1 340	2 080	IU
	Mgamu	91	6 780	1 360	P
	Haydom	92	0	0	BH
	-"-	93	0	0	BH
	-"-	94	0	4	WP
	-"-	95	1	5	RW
	-"-	96	56	185	WP
ARUSHA	Mbulu	98	121	59	RP
	Ishauri	99	720	103	SO
	Endabash	100	3	37	SP
	-"-	101	3	28	SP
MANYARA	Lake Manyara	102	8 100	2 500	IU
	Arusha/Ngarendola	103	56	40	SP
	- " -	104	114	13	SP
KILIMANJARO	Machame	105	163	50	RP
	-"-	106	32	56	RP
	-"-	107	4	28	SO
	Singakati	108	160	460	RU
	-"-	109	0	0	SO
	Kibosho	110	0	0	SP
	-"-	111	950	-	RU
	-"-	112	2 370	-	RU
	Moshi/Sewage	113	26 400	29 000	Sewage
	Moshi/filtered sew.	114	60 000	4 000	-"-
	Moshi/sew. effluent	115	0	3 000	-"-
	Moshi/downstream	116	0	4 000	RU

CATALOGUE OF ALL BACTERIOLOGICAL SAMPLES MADE

ANNEX 2.2

REGION	PLACE	NO	BACTERIA PER 100 ML		SOURCE TYPE
			FAECAL COLI-FORMS	FAECAL STREPTO-COCCI	
KILIMANJARO	Moshi/upstream	117	970	280	RU
NYUMBA	Nyumba ya Mungu	118	0	20	IU
TANGA	Mkumbara	119	1 100	520	WO
	Mombo	120	246	66	RP
	Lushoto	121	146	55	TW
	Kizara	122	260	750	SO
	Mamba	123	159	45	SO
	Bumbili	124	20	66	SP
	Korogwe	125	1	1	TW
	Kwamsisi	126	104	142	RP
	-"-	127	3 000	-	CC (126)
	Tanga	128	2	-	TW
	Lusanga	129	430	770	WO
	Muheza	130	38	206	IU
	-"-	131	4	14	TW
	Korogwe	132	66	15	TW
LINDI	Kivije	131A	63	50	SP
	-"-	132A	238	90	SP
	Mavuje River	133	1 550	440	RU
	Kiwawa	134	0	2	WP
	-"-	135	4	820	CC (134)
	Mandawa	136	20	750	SP
	Mkwajuni Pachani	137	400	330	WP
	Rutamba	138	72 000	1 320	RU
	Ngapa	139	72 000	72 000	WO
	Mingoyo	140	9 200	820	RP
	Ngali	141	72 000	990	TW
	Lindi	142	200	-	SP
	-"-	143	22	-	TW
	Mikindani	144	20	-	SP
	-"-	145	750	2 200	CC (144)
MTWARA	Mbawala	146	0	210	IU
	Nanyamba	147	700	310	IU
	Minta	148	20	1 580	IU
	Miule	149	40	280	RW
	Mahuta	150	3	26	SO
	-"-	151	70	1 610	SP
	Mkunya	152	6	29	SP
	-"-	153	0	1	TW

CATALOGUE OF ALL BACTERIOLOGICAL SAMPLES MADE

ANNEX 2.2

REGION	PLACE	NO	BACTERIA PER 100 ML		SOURCE TYPE
			FAECAL COLI-FORMS	FAECAL STREPTO-COCCI	
MTWARA	Mahumbika	154	21	19	TW
	Newala	155	26	10	TW
	Sululu	156	250	-	WO
	Nangomba	157	4	-	P
	-"-	158	6	-	P
Ruvuma	Nandembo	159	0	-	BH
	Mkingoti River	160	1	-	TW
	Tunduru	161	680	880	TW
	Ligunga	162	0	14	RU
	-"-	163	30	34	P
	Matemanga	164	12	660	RU
	Mchomoro	165	0	14	SP
	-"-	166	6	540	CC (165)
	Mamtumbu	167	124	98	RU
	-"-	168	60	40	TW
	Mtwango	169	288	196	CC (170)
	-"-	170	342	60	SO
	-"-	171	358	118	CC (170)
	Songea	172	46	42	TW
	Lyangamo	173	1	-	RP
	-"-	174	1	-	CC (173)
	Sinai	175	0	-	RP
	Likuyu Fussi	176	20	-	RP
	-"-	177	37	-	CC (176)
	Songea	178	3	-	TW
	Mvumi-Mtapa	179	0	-	RP
	Gumbaro	180	2	-	RP
	-"-	181	38	-	CC (180)
	Madaba	182	9	-	SP
	-"-	183	42	-	CC (182)
	Maweso	184	360	-	RP
	Njombe	185	17	-	TW
	Ramadhani	186	0	-	SO
	Ngerere	187	11	-	RP
	-"-	188	22	-	CC (187)
	Wangingombe	189	150	-	RP
	Ntita	190	88	-	RU
	Mambegu	191	10	-	RU
	-"-	192	-	-	CC (191)

CATALOGUE OF ALL BACTERIOLOGICAL SAMPLES MADE

ANNEX 2.2

REGION	PLACE	NO	BACTERIA PER 100 ML		SOURCE TYPE
			FAECAL COLI-FORMS	FAECAL STREPTO-COCCI	
MBEYA	Igawa bar	193	0	-	RU
	-"-	194	30	-	RU
	Igurusi	195	1	-	RP
	-"-	196	1 100	-	CC (195)
	Sarata Sanyegere	196A	4	6	SO
	- " -	197	36	176	CC (196A)
	Tukuyu	198	56	52	RP
	Kikusha	199	60	400	WO
	Kyela	200	0	4	BH
	Matema	201	24	20	CC (203)
	-"-	202	20	62	CC (203)
	-"-	203	1 260	102	IU
	Mbeya	204	0	28	TW
	Ukutani	205	-	-	P
RUKWA	Laela	206	16	90	WO
	Kalambazite	207	38	280	P
	Sumbawanga	208	12	18	TW
	Muva	209	38	138	IU
	Kizwite River	210	0	2	RU
	Changji	211	8	40	WP
MBEYA	Tunduma	212	0	8	SP
	Sisimba	212A	63	163	RU
	-"-	213	99	35	TW
	-"-	214	0	0	TW
	Meta	215	1	4	TW
	Mbeya	216	0	0	TW
IRINGA	Mafinga	217	0	0	RP
	-"-	218	0	4	CC (217)
	-"-	219	0	2	CC (217)
	Pomerini	220	16	26	CC (221)
	-"-	221	12	-	RP
	Ihimbe	222	30	820	P
MOROGORO	Doma	223	1	4	WP
	Mangai	224	24	7	WP
	Morogoro	225	0	0	TW
	-"-	226	0	0	TW
	-"-	227	250	700	RU
	Mlali	228	380	84	RP
	-"-	229	230	41	CC (228)

CATALOGUE OF ALL BACTERIOLOGICAL SAMPLES MADE

ANNEX 2:2

REGION	PLACE	NO	BACTERIA PER 100 ML		SOURCE TYPE
			FAECAL COLI-FORMS	FAECAL STREPTO-COCCI	
MOROGORO	Mlali	230	-	-	CC (228)
	-"-	231	440	190	RU
	Tungi	232	300	640	CC (234)
	-"-	233	-	58	CC (234)
	-"-	234	250	79	RP
	-"-	235	2 600	780	RU

KEY

BH	Borehole
WP	Well - protected
WO	Well - open
SP	Spring - protected
SO	Spring - open
RP	Stream - piped
RU	Stream - unpiped
IP	Impoundment - piped
IU	Impoundment - unpiped
P	Pit
TW	Treated water
RW	Rain water
CC (x)	Consumer container

ANNEX 2.3

POLLUTION BETWEEN COLLECTION AND USE

RESULTS FROM PRESENT WATER QUALITY SURVEY

Source Type *	Water Supply	Consumer's Container
Faecal Coliforms per 100 ml		
PU	104	3000
PU	0	4
PU	20	750
PU	1	680
U	0	6
U	342	288, 358
PU	1	1
PU	20	37
PU	2	38
PU	9	42
PU	11	22
PU	1	1100
U	4	36
PU	0	0, 0
PU	12	16
PU	380	230
PU	250	300
Faecal Streptococci per 100 ml		
PU	66	17800
PU	2	820
PU	14	540
U	60	118, 196
U	6	176
U	102	62, 20
PU	0	4, 2
PU	84	41
PU	79	640

* PU = piped, untreated
PT = piped, treated
U = unpiped, untreated

Annex 2.3

POLLUTION BETWEEN COLLECTION AND USE

TRI-REGION WATER MASTER PLAN RESULTS

Source Type*	Water Supply	Consumer's Container
Faecal Coliforms per 100 ml		
PU	86	180, 210, 90, 170, 160
PU	12	20, 18
PU	30	34, 50, 46, 58, 54, 56, 48
PU	38	36, 56, 58, 64, 42
PT	12	10, 4
PU	30	20, 40
PU	40	50, 30, 70
PU	10	20, 24, 30
PU	0	4, 2
PT	8	12, 16, 22
PU	0	4, 20, 12
PU	0	1, 0, 2
PU	2	8, 10, 12
PU	0	0, 0
PT	20	22, 26, 20
PT	40	38, 34
PT	18	22, 26, 40, 30
PU	14	18, 12, 20, 28
PU	36	40, 45, 50
PU	14	34, 30, 40
PU	6	10, 8, 12
PU	20	28, 40, 30
PU	12	24, 30, 10, 28
PU	0	0, 1, 2
PT	12	16, 10, 60, 19
PU	400	540, 380, 600
PU	10	6, 8, 12
PU	12	17, 10, 14
PU	300	410, 260
PU	78	86, 100, 120
PU	120	150, 100, 140
PU	14	8, 16, 20
Faecal Streptococci per 100 ml		
PU	34	90, 80, 60, 80, 60
PU	25	18, 20
PU	13	15, 20, 28, 26, 30, 34, 28
PU	120	140, 180, 160, 168, 120
PT	4	5, 8
PU	20	18, 26

Annex 2.3

Source Type *	Water Supply	Consumer's Containers
PU	32	28, 40, 20
PU	4	12, 16, 14
PU	2	0, 0
PT	0	1, 3, 2
PU	0	0, 6, 4
PU	0	0, 0, 0
PU	0	1, 0, 2
PU	0	0, 0
PT	12	10, 14, 16
PT	10	14, 12
PT	4	3, 12, 24, 10
PU	6	10, 5, 12, 14
PU	32	30, 38, 60
PU	10	18, 20, 16
PU	1	3, 2, 5
PU	10	6, 4, 12
PU	2	6, 14, 0, 8
PU	0	1, 4, 0
PT	0	2, 0, 20, 36
PU	260	300, 280, 420
PU	6	4, 1, 8
PU	4	12, 8, 10
PU	120	100, 140
PU	64	58, 68, 56
PU	48	60, 40, 80
PU	20	14, 9, 12

* PU = piped, untreated
PT = piped, treated

ANNEX 2.4
SUMMARY OF CHEMICAL WATER QUALITY DATA FROM UBUNGO LABORATORY
DATA FOR THE REGIONS GROUPED IN 5 (6) QUALITY CATEGORIES

WATER QUALITY DATA
CHEMICAL QUALITY
Number in group/percentage in group

Region ARUSHA

Colour Pt mg/l	0-25 90/52	25-50 39/23	51-100 31/18	101-200 6/3	201- 6/3	
Turbidity	137/81	19/11	9/5	2/1	3/2	
pH	0-5.5 1/1	5.6-6.5 7/5	6.6-8.5 108/81	8.6-9.2 15/11	9.3- 3/2	
Conductivity mS/m	0-50 139/66	51-100 39/18	101-200 18/8	201-400 13/6	401- 3/1	
Chloride mg/l	0-200 201/82	201-400 31/13	401-600 5/2	601-800 3/1	801- 5/2	
Nitrate N mg/l	0-6.7 127/96	6.8-11.3 4/3	11.4-22.6	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0 69/25	1.1-2.0 64/24	2.1-4.0 50/18	4.1-8.0 28/10	8.1-16.0 24/9	16.1- 37/14
Iron mg/l	0-0.1 60/38	0.2-1.0 63/40	1.1-2.0 20/13	2.1-4.0 5/3	4.1- 9/6	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permangarate O mg/l	0-10 164/89	11-20 18/10	21-40 1/1	41-80	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region COAST REGION

Colour Pt mg/l	0-25 46/24	25-50 42/22	51-100 45/24	101-200 27/14	201- 29/15	
Turbidity	56/29	35/18	30/16	38/20	34/18	
pH	0-5.5 1/1	5.6-6.5 8/4	6.6-8.5 187/94	8.6-9.2 2/1	9.3-	
Conductivity mS/m	0-50 121/61	51-100 40/20	101-200 19/9	201-400 12/6	401- 7/4	
Chloride mg/l	0-200 170/86	201-400 11/6	401-600 6/3	601-800 3/1	801- 8/4	
Nitrate N mg/l	0-6.7 179/98	6.8-11.3 2/1	11.4-22.6 0	22.7-45.2 1/1	45.3- 0	
Fluoride mg/l	0-1.0 108/94	1.1-2.0 5/4	2.1-4.0 1/1	4.1-8.0 0	8.1-16.0 0	16.1- 1/1
Iron mg/l	0-0.1 16/8	0.2-1.0 83/43	1.1-2.0 41/21	2.1-4.0 26/13	4.1- 29/15	
Manganese mg/l	0-0.05 1	0.06-0.1 0	0.11-0.5 0	0.6-2.0 0	2.1- 0	
Oxygen demand Permanganate O mg/l	0-10 162/82	11-20 18/9	21-40 16/8	41-80 2/1	81- 0	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region DODOMA

Colour Pt mg/l	0-25 38/42	25-50 28/31	51-100 15/16	101-200 5/5	201- 5/5	
Turbidity	84/85	6/6	4/4	1/1	4/4	
pH	0-5.5	5.6-6.5 4/4	6.6-8.5 105/96	8.6-9.2	9.3-	
Conductivity mS/m	0-50 22/13	51-100 73/25	101-200 54/32	201-400 38/22	401- 14/8	
Chloride mg/l	0-200 77/65	201-400 18/15	401-600 8/7	601-800 5/4	801- 11/9	
Nitrate N mg/l	0-6.7 90/94	6.8-11.3 2/2	11.4-22.6 3/3	22.7-45.2	45.3- 1/1	
Fluoride mg/l	0-1.0 80/100	1.1-2.0 17/15	2.1-4.0 9/8	4.1-8.0 8/7	8.1-16.0	16.1-
Iron mg/l	0-0.1 26/28	0.2-1.0 38/40	1.1-2.0 13/14	2.1-4.0 4/4	4.1- 13/14	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 74/76	11-20 15/15	21-40	41-80 3/3	81- 5/5	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region IRINGA

Colour Pt mg/l	0-25 62/32	25-50 46/24	51-100 47/25	101-200 20/10	201- 16/8	
Turbidity	127/73	32/18	5/3	1/1	10/6	
pH	0-5.5 3/2	5.6-6.5 34/18	6.6-8.5 154/79	8.6-9.2 2/1	9.3- 1/1	
Conductivity mS/m	0-50 144/82	51-100 18/10	101-200 9/5	201-400 3/2	401- 2/1	
Chloride mg/l	0-200 173/96	201-400 2/1	401-600 1/1	601-800 1/1	801- 2/1	
Nitrate N mg/l	0-6.7 71/97	6.8-11.3	11.4-22.6 1/1	22.7-45.2 1/1	45.3-	
Fluoride mg/l	0-1.0 118/88	1.1-2.0 11/8	2.1-4.0 4/3	4.1-8.0 1/1	8.1-16.0	16.1-
Iron mg/l	0-0.1 14/11	0.2-1.0 65/45	1.1-2.0 37/26	2.1-4.0 14/10	4.1- 15/10	
Manganese mg/l	0-0.05	0.06-0.1 1	0.11-0.5 1	0.6-2.0 1	2.1-	
Oxygen demand Permanganate O mg/l	0-10 157/86	11-20 24/13	21-40 1/1	41-80	81- 1/1	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region KIGOMA

Colour Pt mg/l	0-25 46/40	25-50 42/36	51-100 19/16	101-200 4/3	201- 5/4	
Turbidity	84/83	6/6	3/3	4/4	4/4	
pH	0-5.5	5.6-6.5	6.6-8.5	8.6-9.2	9.3-	
Conductivity mS/m	0-50 94/84	51-100 10/9	101-200 1/1	201-400 3/3	401- 3/3	
Chloride mg/l	0-200	201-400	401-600	601-800	801-	
Nitrate N mg/l	0-6.7 75/99	6.8-11.3	11.4-22.6 1/1	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0	1.1-2.0	2.1-4.0	4.1-8.0	8.1-16.0	16.1-
Iron mg/l	0-0.1 8/8	0.2-1.0 42/41	1.1-2.0 21/21	2.1-4.0 10/10	4.1- 20/20	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10	11-20	21-40	41-80	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region KILIMANJARO

Colour Pt mg/l	0-25 48/49	25-50 35/36	51-100 13/13	101-200 2/2	201-	
Turbidity	73/88	7/8	3/4			
pH	0-5.5 2/2	5.6-6.5 8/7	6.6-8.5 93/82	8.6-9.2 10/9	9.3-	
Conductivity mS/m	0-50 60/54	51-100 38/34	101-200 13/12	201-400 1/1	401-	
Chloride mg/l	0-200 100/100	201-400	401-600	601-800	801-	
Nitrate N mg/l	0-6.7 61/95	6.8-11.3	11.4-22.6 3/5	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0 60/62	1.1-2.0 20/21	2.1-4.0 8/8	4.1-8.0 5/5	8.1-16.0 3/3	16.1- 1/1
Iron mg/l	0-0.1 33/43	0.2-1.0 29/38	1.1-2.0 9/12	2.1-4.0 5/6	4.1- 1/1	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 100/91	11-20 7/6	21-40 3/3	41-80	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region LINDI

Colour Pt mg/l	0-25 39/48	25-50 19/23	51-100 14/17	101-200 6/7	201- 4/5	
Turbidity	55/79	8/11	4/6	2/3	1/1	
pH	0-5.5 4/4	5.6-6.5 7/7	6.6-8.5 89/88	8.6-9.2 1/1	9.3-	
Conductivity mS/m	0-50 21/21	51-100 17/17	101-200 26/26	201-400 25/25	401- 10/10	
Chloride mg/l	0-200 46/46	201-400 22/22	401-600 14/14	601-800 7/7	801- 12/12	
Nitrate N mg/l	0-6.7 68/93	6.8-11.3 3/4	11.4-22.6 1/1	22.7-45.2	45.3- 1/1	
Fluoride mg/l	0-1.0 71/86	1.1-2.0 7/8	2.1-4.0 4/5	4.1-8.0 1/1	8.1-16.0	16.1-
Iron mg/l	0-0.1 11/13	0.2-1.0 39/46	1.1-2.0 13/15	2.1-4.0 9/11	4.1- 13/15	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 81/81	11-20 10/10	21-40 4/4	41-80 1/1	81- 4/4	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region MARA

Colour Pt mg/l	0-25 68/51	25-50 29/22	51-100 17/13	101-200 10/7	201- 10/7	
Turbidity	93/19	8/7	9/8	5/4	2/2	
pH	0-5.5 2/1	5.6-6.5 6/4	6.6-8.5 130/91	8.6-9.2 5/3	9.3- 0	
Conductivity mS/m	0-50 58/42	51-100 53/38	101-200 21/15	201-400 5/4	401- 2/1	
Chloride mg/l	0-200 131/96	201-400 4/3	401-600	601-800	801- 2/1	
Nitrate N mg/l	0-6.7 62/97	6.8-11.3 1/1	11.4-22.6	22.7-45.2	45.3- 1/1	
Fluoride mg/l	0-1.0 49/32	1.1-2.0 54/35	2.1-4.0 30/20	4.1-8.0 14/9	8.1-16.0 3/2	16.1- 3/2
Iron mg/l	0-0.1 12/10	0.2-1.0 52/45	1.1-2.0 24/21	2.1-4.0 12/10	4.1- 18/10	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 124/93	11-20 4/3	21-40 5/4	41-80 4/3	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region MBEYA

Colour Pt mg/l	0-25 71/42	25-50 46/27	51-100 20/12	101-200 27/13	201- 11/7	
Turbidity	99/64	20/13	14/9	4/3	17/11	
pH	0-5.5 2/1	5.6-6.5 14/8	6.6-8.5 165/89	8.6-9.2 4/2	9.3- 0	
Conductivity mS/m	0-50 155/83	51-100 17/9	101-200 8/4	201-400 4/2	401- 2/1	
Chloride mg/l	0-200 179/97	201-400 6/3	401-600 0	601-800 0	801- 0	
Nitrate N mg/l	0-6.7 101/98	6.8-11.3 2/2	11.4-22.6 0	22.7-45.2 0	45.3- 0	
Fluoride mg/l	0-1.0 145/83	1.1-2.0 18/10	2.1-4.0 6/3	4.1-8.0 3/2	8.1-16.0 2/1	16.1- 0
Iron mg/l	0-0.1 24/16	0.2-1.0 75/49	1.1-2.0 27/18	2.1-4.0 8/5	4.1- 18/12	
Manganese mg/l	0-0.05 0	0.06-0.1 0	0.11-0.5 0	0.6-2.0 0	2.1- 0	
Oxygen demand Permanganate O mg/l	0-10 163/93	11-20 8/5	21-40 1/1	41-80 3/2	81- 0	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region MOROGORO

Colour Pt mg/l	0-25 33/36	25-50 34/37	51-100 16/17	101-200 5/5	201- 4/4	
Turbidity	77/84	8/9	6/7		1/1	
pH	0-5.5 5/4	5.6-6.5 6/5	6.6-8.5 100/89	8.6-9.2 1/1	9.3-	
Conductivity mS/m	0-50 68/60	51-100 22/19	101-200 13/12	201-400 7/6	401- 3/3	
Chloride mg/l	0-200 100/91	201-400 5/5	401-600 1/1	601-800 1/1	801- 3/3	
Nitrate N mg/l	0-6.7 36/97	6.8-11.3	11.4-22.6 1/3	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0 90/92	1.1-2.0 6/6	2.1-4.0 2/2	4.1-8.0	8.1-16.0	16.1-
Iron mg/l	0-0.1 17/16	0.2-1.0 48/46	1.1-2.0 12/11	2.1-4.0 15/14	4.1- 13/12	
Manganese mg/l	0-0.05	0.06-0.1 1	0.11-0.5 5	0.6-2.0 1	2.1-	
Oxygen demand Permanganate O mg/l	0-10 98/92	11-20 7/6	21-40 1/1	41-80 1/1	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region MTWARA

Colour Pt mg/l	0-25 44/46	25-50 27/28	51-100 11/12	101-200 8/8	201- 5/5	
Turbidity	72/81	7/8	3/3	2/2	5/6	
pH	0-5.5 8/8	5.6-6.5 20/20	6.6-8.5 73/72	8.6-9.2	9.3-	
Conductivity mS/m	0-50 57/56	51-100 22/22	101-200 13/13	201-400 7/7	401- 3/3	
Chloride mg/l	0-200 82/80	201-400 5/5	401-600 6/6	601-800	801- 10/10	
Nitrate N mg/l	0-6.7 50/86	6.8-11.3 4/7	11.4-22.6 3/5	22.7-45.2 1/2	45.3-	
Fluoride mg/l	0-1.0 87/98	1.1-2.0	2.1-4.0 2/2	4.1-8.0	8.1-16.0	16.1-
Iron mg/l	0-0.1 16/17	0.2-1.0 36/38	1.1-2.0 15/16	2.1-4.0 8/8	4.1- 21/22	
Manganese mg/l	0-0.05 2/14	0.06-0.1 2/14	0.11-0.5 7/50	0.6-2.0 2/14	2.1- 1/7	
Oxygen demand Permanganate O mg/l	0-10 71/73	11-20 21/22	21-40	41-80 2/2	81- 3/3	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region MWANZA

Colour Pt mg/l	0-25 56/50	25-50 39/35	51-100 5/5	101-200 1/1	201- 10/9	
Turbidity	90/85	2/2	7/7	4/4	3/3	
pH	0-5.5 1/1	5.6-6.5 3/3	6.6-8.5 109/95	8.6-9.2 1/1	9.3- 1/1	
Conductivity mS/m	0-50 68/57	51-100 17/14	101-200 24/20	201-400 1/1	401- 9/8	
Chloride mg/l	0-200 110/94	201-400 6/5	401-600 1/1	601-800	801-	
Nitrate N mg/l	0-6.7 69/91	6.8-11.3 4/5	11.4-22.6 3/4	22.7-45.2 1/1	45.3-	
Fluoride mg/l	0-1.0 57/52	1.1-2.0 10/9	2.1-4.0 14/13	4.1-8.0 16/15	8.1-16.0 11/10	16.1- 2/2
Iron mg/l	0-0.1 19/19	0.2-1.0 55/56	1.1-2.0 6/6	2.1-4.0 6/6	4.1- 12/12	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 92/79	11-20 18/15	21-40 3/3	41-80 3/3	81- 1/1	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region RUKWA

Colour Pt mg/l	0-25 15/41	25-50 11/30	51-100 10/27	101-200 1/3	201-	
Turbidity	25/89	2/7	1/3			
pH	0-5.5	5.6-6.5 1/2	6.6-8.5 40/98	8.6-9.2	9.3-	
Conductivity mS/m	0-50 39/93	51-100 2/5	101-200 1/2	201-400	401-	
Chloride mg/l	0-200 43/100	201-400	401-600	601-800	801-	
Nitrate N mg/l	0-6.7 28/100	6.8-11.3	11.4-22.6	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0 34/94	1.1-2.0 1/3	2.1-4.0 1/3	4.1-8.0	8.1-16.0	16.1-
Iron mg/l	0-0.1 3/8	0.2-1.0 23/61	1.1-2.0 4/11	2.1-4.0 5/13	4.1- 3/8	
Manganese mg/l	0-0.05 1	0.06-0.1	0.11-0.5	0.6-2.0 1	2.1-	
Oxygen demand Permanganate O mg/l	0-10 43/10	11-20	21-40	41-80	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region RUVUMA

Colour Pt mg/l	0-25 13/36	25-50 14/39	51-100 5/14	101-200 2/6	201- 2/6	
Turbidity	30/81	4/11		1/3	2/5	
pH	0-5.5	5.6-6.5 6/11	6.6-8.5 47/89	8.6-9.2	9.3-	
Conductivity mS/m	0-50 50/96	51-100 1/2	101-200 1/2	201-400	401-	
Chloride mg/l	0-200 49/98	201-400 1/2	401-600	601-800	801-	
Nitrate N mg/l	0-6.7 16/100	6.8-11.3	11.4-22.6	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0 72/93	1.1-2.0 2/7	2.1-4.0	4.1-8.0	8.1-16.0	16.1-
Iron mg/l	0-0.1 4/9	0.2-1.0 18/40	1.1-2.0 8/18	2.1-4.0 10/22	4.1- 5/11	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 50/100	11-20	21-40	41-80	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region TABORA

Colour Pt mg/l	0-25 1/3	25-50 4/13	51-100 3/10	101-200 6/19	201- 17/55	
Turbidity	7/23	7/23	7/23	7/23	3/9	
pH	0-5.5 2/6	5.6-6.5 16/52	6.6-8.5 13/42	8.6-9.2	9.3-	
Conductivity mS/m	0-50 35/97	51-100	101-200 1/3	201-400	401-	
Chloride mg/l	0-200 37/100	201-400	401-600	601-800	801-	
Nitrate N mg/l	0-6.7 15/79	6.8-11.3 4/21	11.4-22.6	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0	1.1-2.0	2.1-4.0	4.1-8.0	8.1-16.0	16.1-
Iron mg/l	0-0.1 19/68	0.2-1.0 9/32	1.1-2.0	2.1-4.0	4.1-	
Manganese mg/l	0-0.05	0.06-0.1 2/13	0.11-0.5 10/67	0.6-2.0 3/20	2.1-	
Oxygen demand Permanganate O mg/l	0-10	11-20	21-40	41-80	81-	

Only data for 1972 were available.

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region SHINYANGA

Colour Pt mg/l	0-25 20/22	25-50 29/31	51-100 4/4	101-200 11/12	201- 29/31	
Turbidity	41/43	8/8	22/23	19/20	5/5	
pH	0-5.5	5.6-6.5	6.6-8.5 86/84	8.6-9.2 15/15	9.3- 1/1	
Conductivity mS/m	0-50 66/73	51-100 6/7	101-200 14/16	201-400 4/4	401-	
Chloride mg/l	0-200 100/97	201-400 2/2	401-600 1/1	601-800	801-	
Nitrate N mg/l	0-6.7 93/98	6.8-11.3 1/1	11.4-22.6	22.7-45.2	45.3- 1/1	
Fluoride mg/l	0-1.0 52/57	1.1-2.0 11/12	2.1-4.0 10/11	4.1-8.0 16/17	8.1-16.0 1/1	16.1- 2/2
Iron mg/l	0-0.1 6/8	0.2-1.0 33/42	1.1-2.0 16/20	2.1-4.0 12/15	4.1- 12/15	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 82/91	11-20 7/8	21-40 1/1	41-80	81-	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region SINGIDA

Colour Pt mg/l	0-25 83/48	25-50 51/29	51-100 11/6	101-200 8/5	201- 20/12	
Turbidity	119/73	14/9	9/5	7/4	15/9	
pH	0-5.5 ?	5.6-6.5 5/25	6.6-8.5 179/90	8.6-9.2 8/4	9.3- 6/3	
Conductivity mS/m	0-50 153/83	51-100 19/10	101-200 6/3	201-400 4/2	401- 2/1	
Chloride mg/l	0-200 133/66	201-400 40/20	401-600 8/4	601-800 6/3	801- 15/7	
Nitrate N mg/l	0-6.7 116/75	6.8-11.3 5/3	11.4-22.6 12/8	22.7-45.2 10/7	45.3- 12/8	
Fluoride mg/l	0-1.0 63/34	1.1-2.0 47/26	2.1-4.0 25/14	4.1-8.0 16/9	8.1-16.0 24/13	16.1- 9/5
Iron mg/l	0-0.1 14/8	0.2-1.0 70/42	1.1-2.0 31/19	2.1-4.0 20/12	4.1- 32/19	
Manganese mg/l	0-0.05 0	0.06-0.1 2	0.11-0.5 0	0.6-2.0 0	2.1- 0	
Oxygen demand Permanganate O mg/l	0-10 177/93	11-20 8/4	21-40 1	41-80 2/1	81- 2/1	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region TANGA

Colour Pt mg/l	0-25 55/47	25-50 45/38	51-100 8/7	101-200 6/5	201- 3/3	
Turbidity	80/70	20/17	8/7	3/3	4/3	
pH	0-5.5 1/1	5.6-6.5 4/5	6.6-8.5 70/86	8.6-9.2 6/7	9.3-	
Conductivity mS/m	0-50 55/47	51-100 28/24	101-200 18/15	201-400 11/9	401- 5/4	
Chloride mg/l	0-200 105/78	201-400 15/11	401-600 3/2	601-800 4/3	801- 7/5	
Nitrate N mg/l	0-6.7 52/88	6.8-11.3 4/7	11.4-22.6 3/5	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0 51/75	1.1-2.0 13/19	2.1-4.0 2/3	4.1-8.0 2/3	8.1-16.0	16.1-
Iron mg/l	0-0.1 20/19	0.2-1.0 54/52	1.1-2.0 12/12	2.1-4.0 5/5	4.1- 13/12	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 67/85	11-20 5/6	21-40 6/8	41-80	81- 1/1	

Annex 2.4

WATER QUALITY DATA

CHEMICAL QUALITY

Region WEST LAKE

Colour Pt mg/l	0-25 43/50	25-50 19/22	51-100 17/20	101-200 3/4	201- 3/4	
Turbidity	71/89	4/5	2/3	3/4		
pH	0-5.5 10/10	5.6-6.5 29/28	6.6-8.5 62/60	8.6-9.2 2/2	9.3-	
Conductivity mS/m	0-50 97/97	51-100 2/2	101-200 2/2	201-400	401-	
Chloride mg/l	0-200 97/100	201-400	401-600	601-800	801-	
Nitrate N mg/l	0-6.7 66/100	6.8-11.3	11.4-22.6	22.7-45.2	45.3-	
Fluoride mg/l	0-1.0 63/88	1.1-2.0 4/6	2.1-4.0 2/3	4.1-8.0 3/4	8.1-16.0	16.1-
Iron mg/l	0-0.1 11/14	0.2-1.0 30/39	1.1-2.0 15/20	2.1-4.0 8/11	4.1- 12/16	
Manganese mg/l	0-0.05	0.06-0.1	0.11-0.5	0.6-2.0	2.1-	
Oxygen demand Permanganate O mg/l	0-10 98/96	11-20 3/3	21-40 1/1	41-80	81-	

ANNEX 2.5

CATALOGUE OF OWN PHYSICAL-CHEMICAL TESTS

Sample numbers are the same as in Annex 2.2

Sample No.	Fluoride mg/l	Nitrate-N mg/l	Nitrite-N mg/l	Iron mg/l	Colour	pH
3	0.8	0.8	0.012	-	-	6.3
7	-	-	0.005	-	-	6.9
8	-	-	0.005	-	-	7.2
23	-	0.8	-	-	30	6.0
26	-	0.9	0.007	-	60	8.9
28	-	-	0.004	-	20	6.9
33	-	-	0.008	4.5	70	6.7
38	-	-	0.008	0.5	30	6.9
47	1.0	-	-	-	0	6.9
50	0.3	-	-	-	50	6.9
53	9.6	3	-	-	-	7.9
55	3.0	0.8	0.022	-	10	7.4
57	3.0	1.0	0.009	-	10	8.4
58	3.0	0.7	0.012	-	10	8.3
67	-	-	-	-	-	6.0
71	0.75	3	-	-	10	7.2
73	0.6	0.5	-	-	40	7.7
75	-	5	-	-	5	6.9
78	1.3	2.5	-	-	-	7.1
80	1.3	1.0	-	-	-	7.7
81	2.7	3.5	-	-	-	8.1
83	1.3	0	-	-	-	8.3
90	0.35	5.5	-	-	-	5.5
92	2.0	0.16	-	-	-	7.5

Annex 2.5

CATALOGUE OF PHYSICAL-CHEMICAL TESTS

Sample numbers are the same as in Annex 2.2

Sample No.	Fluoride mg/l	Nitrate-N mg/l	Nitrite-N mg/l	Iron mg/l	Colour	pH
93	1.9	0.12	-	-	-	7.6
96	4.8	-	-	0.08	-	7.0
99	0.45	3.0	-	0.03	-	7.5
101	0.4	0.005	-	0.03	0	7.3
103	4.5	2.0	-	0.08	0	7.2
104	2.1	0.0	-	-	0	7.2
Maji ya chai (River)	11.5	0.05	-	0.3	20	8.5
Maji ya chai (tap)	2.7	0.03	-	-	0	7.2
Arusha Masa-na springs	3.1	0.08	-	0.03	0	7.8
Maju ya chai (spring)	21	0.08	-	-	-	8.4
105	0.25	-	-	0.08	-	6.6
106	0.4	-	-	-	-	7.7
110	0.2	1.3	-	0.00	0	6.1
116	0.6	2.0	0.045	-	10	7.1
117	-	1.8	0.005	-	-	7.1
118	1.8	0.8	-	0.08	-	8.7
119	0.6	4.0	-	0.07	-	6.9
121	0.3	0.9	0.008	0.6	5	6.4
122	-	2.5	-	0.6	20	-
123	-	-	0.003	1.0	30	-
124	0.3	0.9	0.002	0.15	5	7.0
129	-	3.0	-	0.02	0	6.4
130	-	0.8		0.6	5	7.3

ANNEX 3

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ANNEX 3.1

INVENTORY OF WATER TREATMENTS PLANT IN TANZANIA 1978 *

-1-

REGION	PLACE	TREATMENT	SOURCE	DESIGN		CONSTR YEAR
				VOLUME m^3/day	POPULATION	
ARUSHA	Babati (Hanang)	Chlorination	River	270	6 000	
DODOMA	Dodoma	Al-Sulphate[1]) Sedimentation Chlorination	Borehole, Dam		50 000	
	Mpwapwa	Rapid sand filter Pressure [1])				
IRINGA						
KIGOMA	Kigoma	Chlorination	Lake		35 000	
	Kibondo(Kibondo)	Al-Sulphate	Stream		2 577	
KILIMANJARO	Moshi	Chlorination[1])	Spring	6 000	52 000	
LINDI	Lindi	Chlorination	Spring	750	18 000	
	Mtua (Kivalala) (Lindi)	Lime Sedimentation Rapid sand filter	River		4 350	1971
	Nyengedi (Lindi)	Lime	River		4 350	1971
MBEYA	Mbeya Urban Sisimba	Al-Sulphate Sedimentation Chlorination	River			
	Meta	Al-Sulphate Sedimentation Chlorination	River			
MOROGORO	Morogoro	Al-Sulphate [1]) Sedimentation Soda Ash Rapid sand filter Chlorination				
MTWARA	Mtwara Urban	Aerator Al-Sulphate Hydrated lime Soda Ash Sedimentation Rapid sand filter Chlorination	Borehole	1 800	24 000	1959
	Kitaya (Mtwara)	Chlorination	Lake	100	3 000	
	Nanyamba (Mtwara)	Chlorination	Dam	100	5 000	
	Masasi (Masasi)	Al-Sulphate Sedimentation Chlorination	Dam			
	Ndanda Mission (Masasi)	Aeration	Spring		4 500	
	Mkunya Makonde W/S	Lime (Limbax) Al-Sulphate Chlorination	Spring	2 000		

REGION	PLACE	TREATMENT	SOURCE	DESIGN VOLUME m^3/day	DESIGN POPULATION	CONSTR. YEAR	
MWANZA	Mwanza	Microstrainer Chlorination	Lake		71 300	1955	V
	Geita (Geita)	Al-Sulphate Sedimentation	Dam	450		1957	
	Kasamwa (Geita)	Sand filter	Dam		3 400	1972	
	Magu (Magu)	Al-Sulphate Sedimentation Chlorination	Lake		3 200	1976	V
	Malya (Kwimba)	Al-Sulphate Sedimentation Chlorination	Dam	450		1954	
	Misungwi (Kwimba)	Al-Sulphate Sedimentation Chlorination	Dam			1955	V
	Sengerema (Sengerema)	Al-Sulphate Sedimentation Chlorination	Dam		8 560	1966 (1975)	
PWANI	Kimbuga	Sand filter[1])	Lake		3 000	1977	
	Mwaseni	Aeration[1])	Well	161	1 620	1970	
RUKWA							
RUVUMA	Namtumbo	Al-Sulphate Sedimentation Rapid sand filt.	River	75	12 000 (5 500)		V
SINGIDA							
SHINYANGA	Shinyanga	Al-Sulphate Sedimentation Chlorination	Dam			1978	V
	Kahama	Chlorination	Dam		13 200	1950	
	Maswa	Chlorination	Dam, Borehole		13 800	1955 1974	
	Mwadui Mines	Al-Sulphate Sedimentation Filtration Chlorination	Dam				
TABORA	Tabora	Chlorination	Dam				
	Chamachankola	Slow Sand filt.[1]	Borehole	141	2 615	1973	
	Igunga	Slow Sand filt.[1]	Dam				
	Igurubi	Slow Sand filt.[1]	Dam	83	1 615	1972	

REGION	PLACE	TREATMENT	SOURCE	DESIGN		CONSTR. YEAR
				VOLUME m^3/day	POPULATION	
TABORA	Nkiniziwa	Slow sand filter[1]	Dam	45	1 000	1971
	Nzega	Al-Sulphate Sedimentation Soda Ash Chlorination	Dam	400	10 000	
TANGA	Lushoto (Lushoto)	Rapid Sand filter Al-Sulphate Chlorination	River	220	3 000	
	Muheza (Tanga)	Al-Sulphate Sedimentation Chlorination[1]	Dam	126	4 500	1955
	Mlingano	Iron Removal Chlorination	Borehole	60	1 100	1977
	Handeni (Handeni)	Chlorination	Dam Borehole	180	3 500	1958
ZIWA MAGHARIBI	Bukoba Urban	Chlorination	Lake		11 000	1965,
	Magoti (Bukoba)	Aeration Sedimentation	Stream			1976

V) Visited by the team

1) Not in operation.

* Data from: Engström & Wann Inventory 1975
F.J. Gumbo Inventory on treatment plants
Water Master Plans
Own visits and interviews.

ANNEX 3.2

WATER SCHEMES WITH SAND FILTERS

FROM ANNEX 3.1

REGION	SCHEME NAME	TYPE
COAST	Kimbuga	Unknown [1]
DODOMA	Mpwapwa	Pressure rapid sand filter [1]
LINDI	Mtua	Rapid sand filter
	Nyengedi	Rapid sand filter [1]
MOROGORO	Morogoro	Rapid sand filter
MTWARA	Mtwara	Rapid sand filter
MWANZA	Kasamwa	Unknown
RUVUMA	Namtumbo	Rapid sand filter
SHINYANGA	Mwadui Mines	Unknown
TABORA	Chamachankola	Slow sand filter [1]
	Igunga	Slow sand filter [1]
	Igurubi	Slow sand filter [1]
	Nkiniziwa	Slow sand filter [1]
TANGA	Lushoto	Rapid sand filter
	Mlingano	Pressure rapid sand filter [1] (for iron removal)

[1] not in operation

ANNEX 3.3

WATER SCHEMES USING ALUMINIUM SULPHATE FLOCCULATION

FROM ANNEX 3.1

REGION	SCHEME NAME	DOSAGE
DODOMA	Dodoma	
KIGOMA	Kigoma	
MBEYA	Sisimba	
	Meta	
MOROGORO	Morogoro	
MTWARA	Mtwara	40 g/m^3
	Masasi	25 g/m^3
	Mkunya	2.5 g/m^3
MWANZA	Geita	
	Magu	44 g/m^3
	Malya	
	Misungwi	55 g/m^3
	Sengerema	
RUVUMA	Namtumbo	27 g/m^3
SHINYANGA	Shinyanga	29 g/m^3
	Mwadui	
TABORA	Nzega	72 g/m^3 (?)
TANGA	Lushoto	Only rainy season
	Muheza	

Note: The dosages are calculated from information given by plant operators or from analyses of sulphate.

ANNEX 3.4

WATER SCHEMES WITH CHLORINATION
FROM ANNEX 3.1

REGION	SCHEME NAME	CHLORINE AGENT	DOSAGE
ARUSHA	Babati		
DODOMA	Dodoma	Sodium hypochlorite	
KIGOMA	Kigoma	Chlorinated lime	
MOSHI	Moshi		
LINDI	Lindi	Sodium hypochlorite	
MBEYA	Sisimba	Chlorinated lime	
MTWARA	Mtwara	Sodium hypochlorite	
	Kitaya	Sodium hypochlorite	
	Masasi	Chlorinated lime	25 g/m^3
	Mkunya	Chlorinated lime	1 g/m^3
	Nanyamba		
MWANZA	Mwanza	Chlorine gas	
	Malya	Chlorinated lime	
	Magu	Chlorinated lime	
	Misungwi	Chlorinated lime	4 g/m^3
	Sengerema		
SHINYANGA	Shinyanga	Chlorinated lime	
	Kahama		
	Maswa		
	Mwadui Mines		
TABORA	Tabora		
	Nzega	Chlorinated lime	
TANGA	Lushoto	Chlorinated lime	12 g/m^3
	Muheza	1)	
	Mlingano	Sodium hypochlorite	
ZIWA MAGHARIBI			
	Bukoba	Chlorinated lime	

1) not in operation

ANNEX 3.5

WATER SCHEMES USING OTHER CHEMICALS

FROM ANNEX 3.1

REGION	SCHEME NAME	CHEMICAL	DOSAGE
LINDI	Mtua	Calcium carbonate	45 g/m^3
	Nyengedi	Calcium carbonate	45 g/m^3
MOROGORO	Morogoro	Soda ash	
MTWARA	Mtwara	Soda ash	100 g/m^3
		Hydrated lime	30 g/m^3
	Mkunya	Lime (limbax)	39 g/m^3
TABORA	Nzega	Soda ash	5 g/m^3
TANGA	Mlingano	Potassium permanganate (iron removal)	

Note: The dosages are calculated from information given by plant operators or from Mtwana-Lindi WMP.

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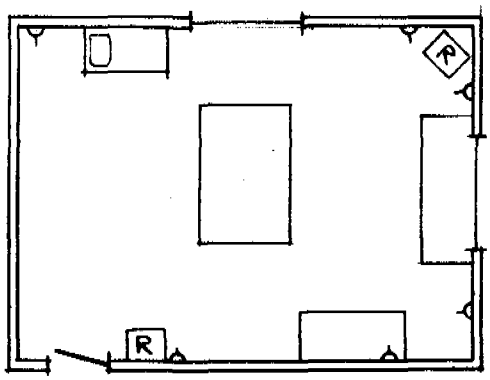
WATER QUALITY LABORATORY

MTWARA

Drawing:



Area: 26 m^2

Exhaust: none

Benches
Height: 0.85 - 0.9 m Length: 5 m Material: wood

Water
Borehole Reliability: poor Taps: 1

Hot water: -

Washing basins:
Material: stainless steel Size: 0.4 x 0.6 m No: 1

Airconditioning: 2 fans

Additional comments: No staff at present. The laboratory will be put into use by Mtwara WMP implementation programme in 1978.

WATER QUALITY LABORATORY

EQUIPMENT

General

Refridgerator: UPO 300 l
Electro-Helios KF about 300 l

Heating facilities:

Gasheating: Heating plates: W No

Oven: Heraeus T5042 40x35x30 cm 0-250° C

Distilled/demineralized water: broken and incomplete Production: l/h W

Balance:
Microwa 7730 (Swiss) Range: 160 g 0.01 g

Physical chemical

Conductivity meter: -

pH meter: Beckman Chemmate (combination electrode) 115/9 V

Photometer: 3 HACH DR (partly out of order)

Bacteriological

Filtration funnel: Sartorius stainless steel (incomplete) SM 16201

Incubator: Heraeus FB 420 0-100° 40x35x30

Autoclave: -

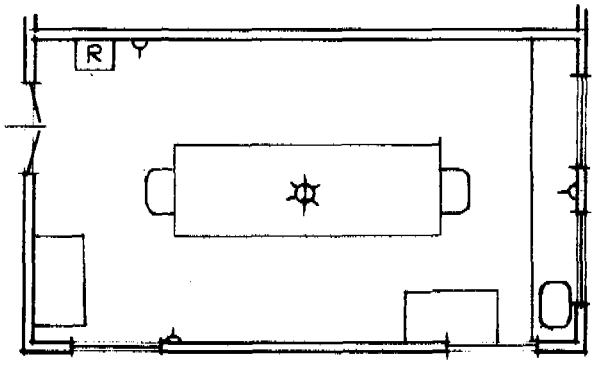
Additional Comments:

Annex 4.1

WATER QUALITY LABORATORY

MWANZA

Drawing:



Area: 29 m^2

Exhaust:

Benches
Height: 0.83 m | Length: 11 m | Material: white tile

Water
Source: lake | Reliability: good | Taps: 6

Hot water: -

Washing basins:
Material: porcelain | Size: 0.4 x 0.6 m | No: 3

Airconditioning: -

Additional comments: The laboratory is staffed

Annex 4.1

WATER QUALITY LABORATORY

EQUIPMENT

General

Refridgerator: Bosch 2 x 160 l

Heating facilities:

Gasheating: yes Heating plates: 600 W No: 1

Oven: -

Distilled/demineralized water: Fontavapor 71 all glass Production: 2-3 l/h

Balance: Sartorius Range: 1000 g 0.1 g

Physical chemical

Conductivity meter: HACH DR/EL 2 (combination)

pH meter: Metrohm E 603 (separate electrodes)

Photometer: 2 HACH DR/EL 2

Bacteriological

Filtration funnel: 2 Millipore stainless steel XX 63001 20

Incubator:

Autoclave: Certoclave

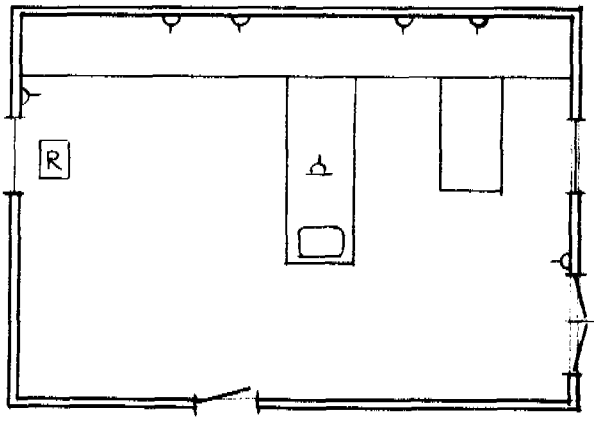
Additional Comments: The laboratory is equipped for full water quality testing.

Annex 4.1

WATER QUALITY LABORATORY

SHINYANGA

Drawing:



Area: 36 m^2

Exhaust: Evacuation hood (0.6 m) without fan.

Benches
Height: 0.90 (central) 1.00 (along wall) Length: 12,5 m Material: wood

Water
Source: dam Reliability: good Taps: 3

Hot water:

Washing basins:
Material: ceramic Size: 0.3 x 0.6 m No: 1

Airconditioning: 1 fan

Additional comments: Only on job trained staff. The laboratory, now run by Shinyanga Shallow Well Program, will be turned over to MAJI.

Annex 4.1

WATER QUALITY LABORATORY

EQUIPMENT

General

Refridgerator: Amcor 10 RE 160 l

Heating facilities:

Gasheating: Heating plates: W No

Oven:

Distilled/demineralized water: Manesty OB Production: l/h W

Balance:

Mettler P160	Range:	160 g	0.001 g
Cent-o-gram Ohaus		310 g	0.01 g

Physical chemical

Conductivity meter: CENCO L.F.T.D. (platinum standard electrode)
IVA VU meter (special electrode)

pH meter: Philips ion selectivity meter PW 9413 (separate electrodes)

Photometer: HACH DC/DR 2
HACH DR/B with conductivity meters (cond.meters not working)

Bacteriological

Filtration funnel: 2 Millipore XX63 001 20

Incubator: 2 Millipore XX63 -00 00

Autoclave: -

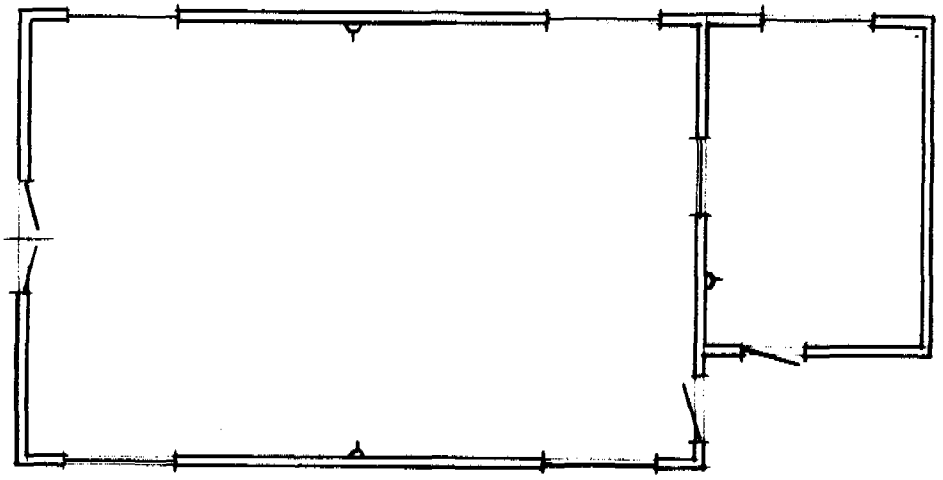
Additional Comments: Another incubator should be used for 44°C incubation temperature

Annex 4.1

WATER QUALITY LABORATORY

TANGA

Drawing:



Area: 61 m^2

Exhaust:

Benches
Height: Length: Material:

Water
Source: Reliability: Taps:

Hot water:

Washing basins:
Material: Size: No:

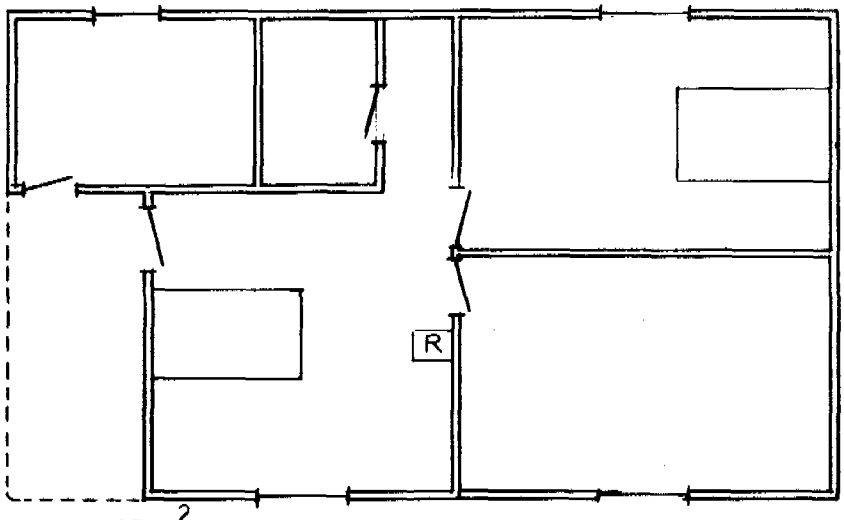
Airconditioning:

Additional comments: Newly constructed building with no equipment

WATER QUALITY LABORATORY

BUKOBA, Mineral Laboratory. Mineral Exploration in North West Tanzania

Drawing:



Area: 65 m^2

Exhaust: for atomic absorption spectrophotometer

Benches
Height: Length: Material:

Water
Source: lake Reliability: good Taps:

Hot water:

Washing basins:
Material: Size: No:

Airconditioning: -

Additional comments: Separate, mobile geochemical laboratory used for digestion of samples.

Annex 4.1

WATER QUALITY LABORATORY

EQUIPMENT not recorded

General

Refridgerator:

Heating facilities:

Gasheating:	Heating plates:	W	No

Oven:

Distilled/demineralized water:	Production:	l/h	W
Balance:	Range:	g	

Physical chemical

Conductivity meter:

pH meter:

Photometer:

Bacteriological

Filtration funnel:

Incubator:

Autoclave:

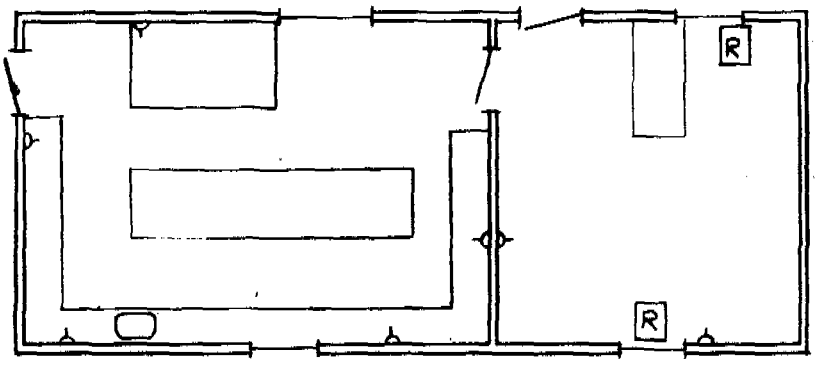
Additional Comments: Atomic absorption spectrophotometer Perkin Elmer 372
Lamps for, Cu, Zn, Pb, Li, Ag, Cr, Co.

Annex 4.1

WATER QUALITY LABORATORY

BUKOBA, Soil Laboratory. Kagera River Basin Project

Drawing:



Area: 47 m^2

Exhaust:

Benches
Height: 1.10 (center) Length: 21 m Material: chipboard
1.00 (walls) wood

Water
Source: lake Reliability: Taps: 2

Hot water: yes

Washing basins:
Material: stainless steel Size: No: 1

Airconditioning: -

Additional comments: In good condition in spite that it has been closed.

Annex 4.1

WATER QUALITY LABORATORY

EQUIPMENT

General

Refridgerator: Frigidaire RD 1600 160 l

Heating facilities:

Gasheating: yes	Heating plates:	1500 W	No: 1
Oven: Nemmert TV 40 U, 60x50x40		250°C	2200 W
JDX Belgium, 60x50x50		250°C	

Distilled/demineralized water:	Production:	l/h	W
Deminenalizer	Christ AG		

Balance:			
Microwa 7730	Range:	160 g	0.001 g

Physical chemical

Conductivity meter: Philips PW 504 (standard platinum cells)

pH meter: Radiometer 29b, Metrohm Batterie E 280A

Photometer: Zeiss Elko II (should be exchanged)

Bacteriological -

Filtration funnel:

Incubator:

Autoclave:

Additional Comments: Centrifuge WIFUG XI,
Digestion stand 6x500 ml Bevac 1650 W
Flame photometer EEL Li, Na, K
Microscope Olympus Tokyo KHC

ANNEX 4.2

COMMENTS ON UBUNGO LABORATORY BUILDING

A short catalogue of observations made on the Ubungo laboratory:

Building (I) is used for common laboratory purposes.

I:1 Washing basin out of order, air-conditioned store room for chemical.

I:2 All samples arrive here and washing is made. One washing basin out of order.

I:3 Balance room in decent condition.

I:4 Staff office, small for the present three persons.

I:5 Office for head of the laboratory, air-conditioned.

I:6 General laboratory. Bacteriological testing is made here. The evacuation hood is not working properly.

II:1 Typist room. Too small for a typist, only about 1.2 m.

II:2-5 These rooms are now used for office work. They are not provided with water. The lever windows have lost their glass.

II:5 The fan is not working and part of the inner roof has fallen down.

II:6 This room was planned for bacteriological work. Lever windows, as in the whole of building II, are built 0.5 m above floor. This will prevent good siting of benches in the room. Also the room is too large to be used as a bacteriological laboratory. This room has only one tap and stainless steel bench (both badly mounted). This is too little for such a large room (30 m^2). The adjacent room (II:8) has a similar stainless steel basin.

III Existing stores (50 m^2). Have not been evaluated.

IV Block under construction (about 50 m^2).

IV:3 Distilled water room. There is no need for such large space for this activity.

V Block under construction (about 125 m^2).

V:2-5 These rooms are very small for large scale water research projects. At present the total area is about 465 m^2, including 75 m^2 of stores. After completion of the parts under construction these areas will be 640 and 140 m^2 respectively.

ANNEX 5

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ANNEX 5.2

Seasonality of Diarrhoea

1) Haydom-Singida region (zone E2)

Average Rainfall (mm)

J	F	M	A	M	J	J	A	S	O	N	D
211	153	127	165	49	0	4	0	9	25	70	121

Wettest months Nov-April

	Wet	Dry	
Diarrhoeal Diseases	1324	1219	$\frac{\%\ DD\ wet}{\%\ DD\ dry} = 1.01$
Total Attendance	27805	25918	
DD as % total	4.8	4.7	

% Diarrhoeal Disease in wet season = 50 %

2) Mvumi-Dodoma region (zone F)

Average Rainfall (mm)

J	F	M	A	M	J	J	A	S	O	N	D
162	104	119	52	6	2	0	0	0	11	45	97

Wettest months Nov-April

	Wet	Dry	
Diarrhoeal Diseases	1596	1194	$\frac{\%\ DD\ wet}{\%\ DD\ dry} = 1.26$
Total Attendance	40998	38721	
DD as % of total	3.9	3.1	

% Diarrhoeal Disease in wet season = 56 %

Seasonality of Diarrhoea cont.

3) KCMC Pediatric Dept. - Kilimanjaro region (zone A2)

Average Rainfall (mm)

J	F	M	A	M	J	J	A	S	O	N	D
21	30	121	255	188	24	14	9	25	25	33	71

Wettest months Nov-Dec and Feb-May

	Wet	Dry	
Diarrhoeal Disease	3471	2884	$\frac{\%\ DD\ wet}{\%\ DD\ dry} = 1.20$
Total Attendance	10448	10458	
DD as % of total	33.2	27.6	

% Diarrhoeal Disease in wet season = 55 %

4) Kibosho-Kilimanjaro region (zone A2)

Average Rainfall (mm)

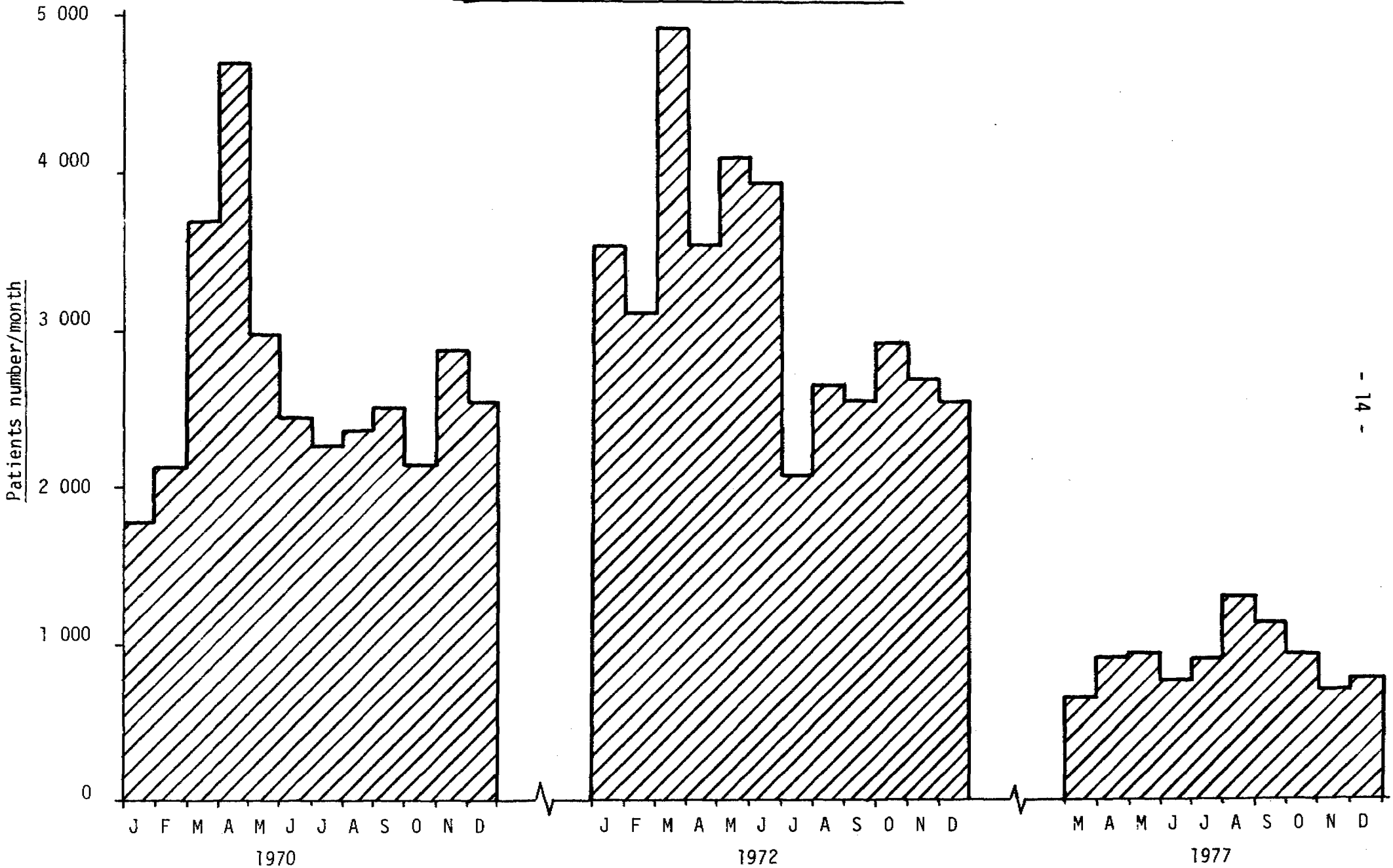
J	F	M	A	M	J	J	A	S	O	N	D
71	50	121	525	326	178	117	71	25	44	57	64

Wettest months Mar-Aug

	Wet	Dry	
Diarrhoeal Disease	3995	7092	$\frac{\%DD\ wet}{\%DD\ dry} = 0.69$
Total Attendance	57979	70364	
DD as % of total	6.9	10.0	

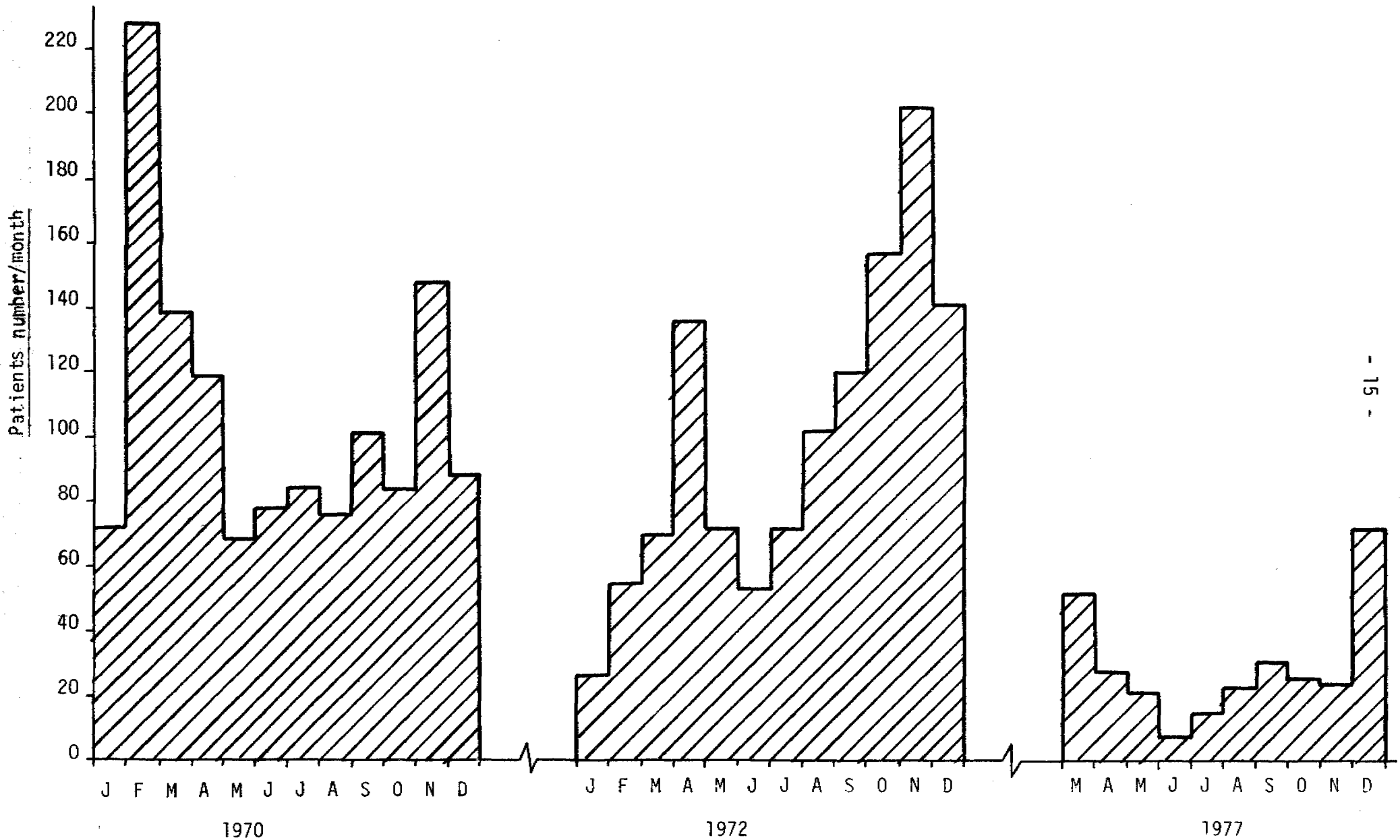
% of Diarrhoeal Disease in wet season = 41 %

MVUMI - TOTAL MONTHLY OUTPATIENT ATTENDANCES

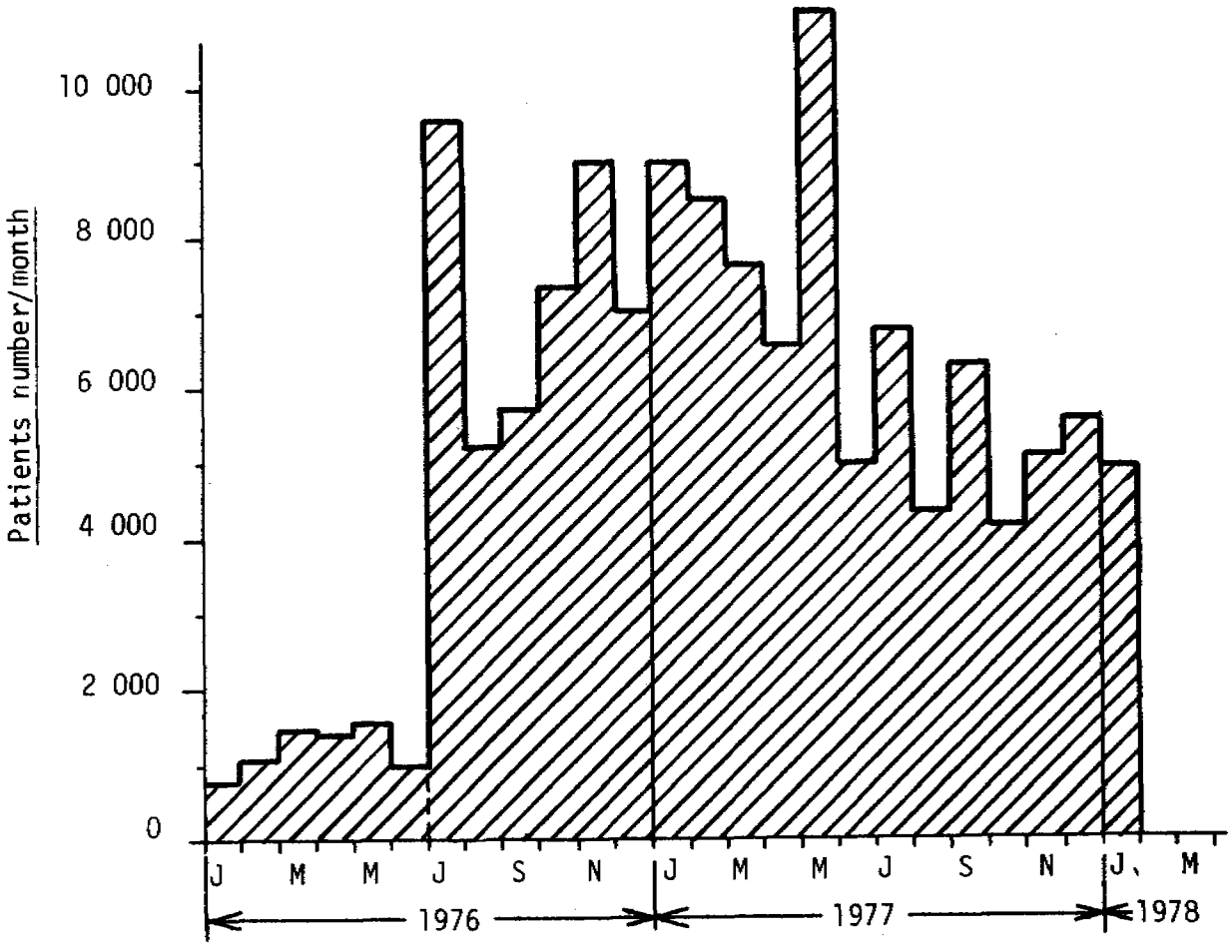


ANNEX 5.2

MVUMI - MONTHLY OUTPATIENT ATTENDANCES FOR FAECAL-ORAL DISEASE

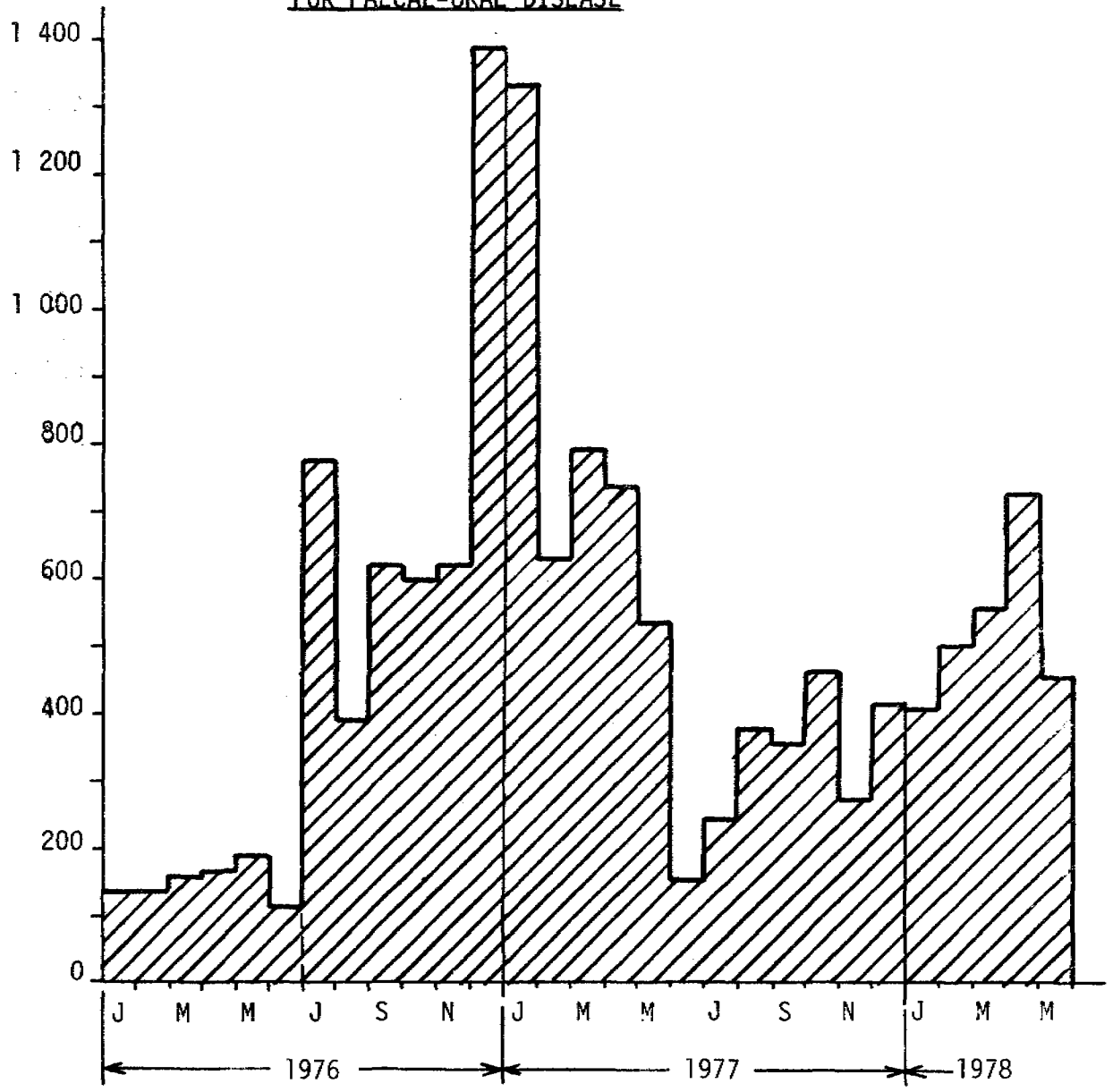


KIBOSHO - TOTAL MONTHLY OUTPATIENT ATTENDANCE



ANNEX 5.2

KIBOSHO-MONTHLY OUTPATIENT ATTENDANCE FOR FAECAL-ORAL DISEASE



ANNEX 5.3

Relative Abundance of Intestinal Parasites

Region	Group	Hookworm	Ascaris	Strongy-loides	S. mansoni	Taenia	Protozoans	Trichuris
Iringa		1.00	0.53	0.12	0.10	0.27	0.01	0.10
Mbeya		1.00	2.29	0.14	0.26	0.43	1.94	0.16
	A1	1.00	1.78	0.13	0.21	0.38	1.38	0.14
Tanga					N/A			
Kilimanjaro		1.00	2.84	0.05	0.17	0.09	0.06	0.92
		1.00	2.60	0.08	0.13	0.12	0.18	2.00
	A2	1.00	2.77	0.06	0.17	0.09	0.09	1.15
Kigoma		1.00	0.69	-	0.06	0.02	-	-
Ziwa Magharibi		1.00	2.26	0.09	0.02	0.07	0.01	0.44
Rukwa		1.00	0.07	0.35	0.55	0.14	0.22	0.03
	B	1.00	1.92	0.10	0.06	0.07	0.02	0.36
Ruvuma		1.00	0.02	0.23	0.29	0.01	0.02	0.02
Morogoro		1.00	0.67	0.09	0.04	0.04	0.47	0.07
	C	1.00	0.48	0.13	0.12	0.03	0.20	0.06
Pwani					N/A			
Mtwara		1.00	0.01	0.38	0.01	0	0	0
Lindi		1.00	0.01	0.19	0.01	0	0.00	0.01
	D	1.00	0.01	0.25	0.01	0	0.00	0.00
Mwanza		1.00	0.01	0.27	0.26	-	-	-
Mara		1.00	0.15	0.29	0.20	0.21	0.01	0.07
	E1	1.00	0.08	0.28	0.23	0.11	0.01	0.04
Tabora		1.00	0.07	0.13	0.02	0.01	0.00	0.02
Shinyanga					N/A			
Singida		1.00	0.03	0.02	0.07	0.07	0.07	0.02
	E2	1.00	0.05	0.08	0.04	0.04	0.03	0.02
Dodoma	F	1.00	0.42	0.17	0.03	0.11	0.01	0.21

\- not recorded N/A no data available
0 none
0.00 less than 0.005

Rates relative to Hookworm

ANNEX 5.4

Mortality due to Faecal-Oral Disease

This table is based on 100 persons

Age	No. in age group	Mortality rate (1)	Proportion F-O	Total Deaths (3)	F-O deaths (4)	$ex^{(1)}$ (5)	$Ex^{(2)}$ (6)	Productive years lost (3)
0-1	3.25	0.1564	0.14	0.5083	0.0172	45.30	38.60	0.6639
1-2	3.25	0.0418	0.41	0.1359	0.0557	51.90	40.50	2.2559
2-3	3.25	0.0191	0.53	0.0621	0.0329	53.10	40.90	1.3456
3-4	3.25	0.0113	0.43	0.0367	0.0158	53.11	41.10	0.6494
4-5	3.25	0.0076	0.55	0.0247	0.0136	52.69	41.25	0.5610
5-10	14.58	0.0037	0.41	0.0539	0.0221	52.34	41.48	0.9167
10-15	10.84	0.0030	0.41	0.0325	0.0133	53.07	40.16	0.5341
15-20	10.41	0.0049	0.16	0.0510	0.0082	47.81	35.84	0.2939
20-25	9.17	0.0064	0.16	0.0587	0.0094	43.91	31.15	0.2928
25-30	8.75	0.0067	0.16	0.0586	0.0094	40.29	26.48	0.2489
30-35	6.67	0.0070	0.16	0.0467	0.0075	36.56	21.79	0.1634
35-40	5.41	0.0080	0.16	0.0433	0.0069	32.77	17.10	0.1180
40-45	5.92	0.0090	0.16	0.0533	0.0085	29.00	12.40	0.1054
45-50	3.67	0.0118	0.16	0.0433	0.0069	25.21	7.73	0.0533
50-55	2.50	0.0155	0.16	0.0388	0.0062	21.60	4.97	0.0308
55-60	2.50	0.0211	0.16	0.0528	0.0084	18.14	4.13	0.0347
60-65	0.83	0.0306	0.16	0.0254	0.0041	14.87	3.35	0.0137
65-70	0.83	0.0441	0.16	0.0366	0.0059	11.92	2.64	0.0156
70-75	0.84	0.0690	0.16	0.0580	0.0093	9.23	2.03	0.0189
75-80	0.83	0.1031	0.16	0.0856	0.0137	7.03	1.52	0.0208
			All people	1.5062	0.2750			8.3368
			All over 5 years	0.7385	0.1388			2.8610

Notes

(1) Life expectancy

(2) Productive life expectancy (inc. reduced productivity

ANNEX 5.4 (cont.)

ESTIMATES OF PRODUCTIVE TIME LOST DUE TO FAECAL-ORAL DISEASES

Total rural population	14 178 000
FO deaths per 100 people over five years (Column 4)	0.1398
∴ FO deaths in over-fives	14 178 000 x 0.001398 19 821 per year
Productive years lost by over-fives (Column 7)	2.861 per 100 people
Number of FO deaths in people over-fives (Column 4)	0.1398 per 100 people
∴ Lost time per FO death in over-fives	2.8610/0.1398 20.46 years
FO death-rate for all ages (Column 4)	0.275 per 100 people
Total death-rate for all ages (Column 3)	1.5062 per 100 people
∴ Fraction of deaths due to FO disease	0.275/1.5062 = 0.183 = 18.3%

ANNEX 6

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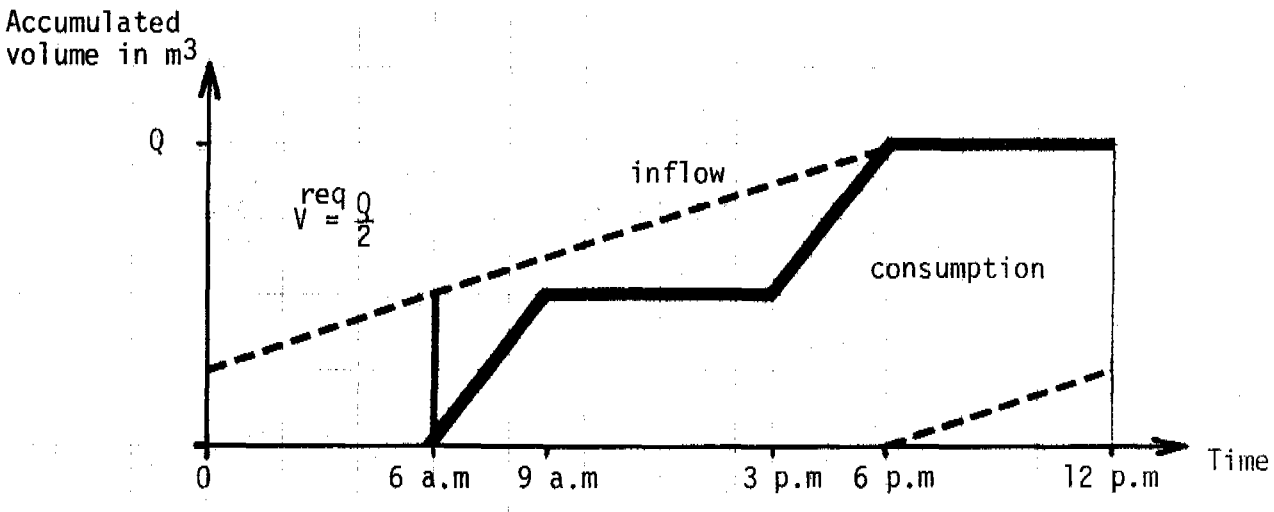
ANNEX 6.1

The attached diagrams illustrate the basic calculation for the storage requirements. The first diagram shows the requirements for the gravity fed storage systems. We assume the tank is empty at 6 p.m. when final consumption of water takes place and then the tank fills at a rate Q/24 per hour. The maximum storage is just before 6 a.m. when consumption begins. As it is necessary to store 12 hours of water flow the storage tank is Q/2 m^3 in size.

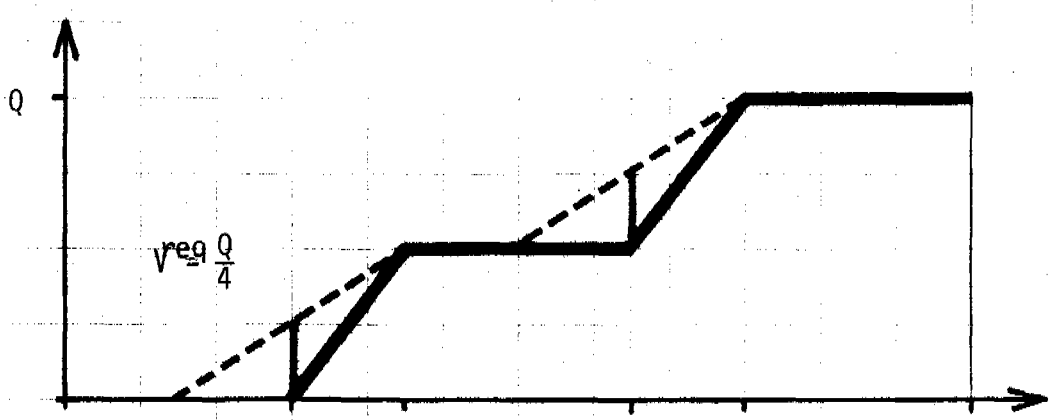
In the second diagram the situation with a deep borehole source is shown. For this case pumping with six hours for each 3 hour consumption period implies that maximum storage is required after three hours of pumping; with a pumping rate of Q/12 per hour, storage of Q/4 m^3 is required. Finally in the third diagram representing a pumped surface scheme pumping is for eight hours or Q/8 per hour and for each three hour consumption period there is a pumping period of 4 hours. Maximum storage requirements comes after one hour so that the maximum storage required is Q/8 m^3.

STORAGE VOLUME
REQUIRED FOR
BALANCING PURPOSES

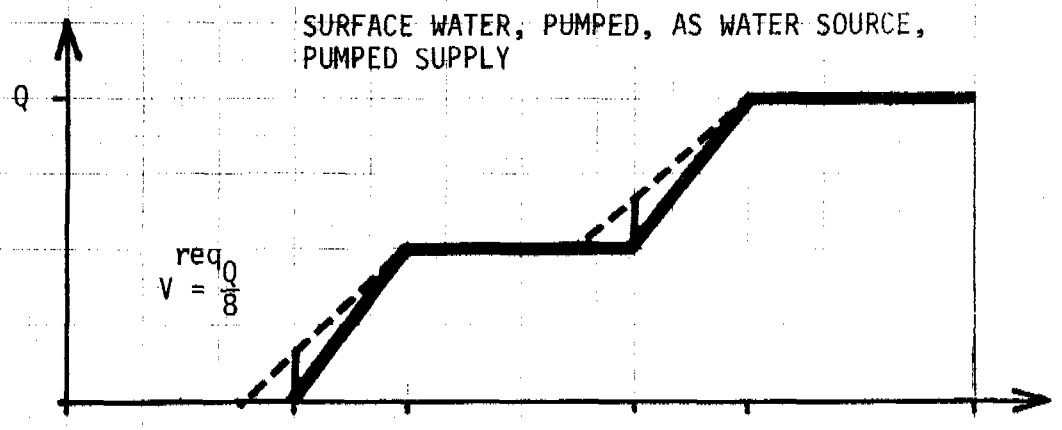
GRAVITY SUPPLY



DEEP BOREHOLE AS WATER SOURCE



SURFACE WATER, PUMPED, AS WATER SOURCE,
PUMPED SUPPLY



ANNEX 6.2
COST OF STORAGE AS TREATMENT

Water Demand in m^3/Day	Pumped Surface Supply			
	Increase Storage Volume m^3	Minimum Storage Volume m^3	Difference in Cost, Financ. 10^3 x TSh. (A-B)	Difference in Cost, Economic 10^3 x TSh. (A-B)
20	42.5	10*	12.0	17.5
40	85	10*	24.5	37.0
50	106.25	10*	30.5	46.0
75	159.38	10*	45.5	64.5
100	212.5	12.5	57.5	80.0
120	255	15	64.0	91.0
150	318.75**	18.75	93.0	139.0
200	425**	25	121.0	172.0

* Minimum storage tank to be constructed assumed 10 m^3.

* * Two storage tanks together equals the increased storage volume. 260 m^3 is considered as maximum size for a storage tank.

ANNEX 6.3

SUMMARY OF COSTS
SMALL STORAGE TANK (HEIGHT 1.5M)

(TSh)

Item	Financial Cost				Economic / Financial	Economic Cost			
	Radius m					Radius m			
	1.49	1.83	2.35	3.33		1.49	1.83	2.35	3.33
Labour (I+II)	4521	5655	7665	12111	0.9	4069	5090	6899	10890
Cement (III)	911	1187	1674	2808	0.1·2.5 + 0.9	1048	1366	1926	3230
Local material (IV)	645	979	1599	3182	0.05·2.5 + 0.95	694	1053	1719	3421
Imported material (V)	2726	3106	3755	5200	2.3	6270	7144	8637	11960
Transport (VI)	1918	2357	3136	4973	2.125	4076	5009	6664	10568
TOTAL	10721	13284	17829	28274	-	16157	19662	25845	40069

ANNEX 6.3

SUMMARY OF COSTS
MEDIUM STORAGE TANK (HEIGHT 3.0 M)

(TSh)

Item	Financial Cost				Econ. Financ.	Economic Cost			
	Radius m					Radius m			
	2.39	3.33	4.05	4.66		2.39	3.33	4.05	4.66
Labour (I+II)	10663	16313	21382	26187	0.9	9597	14682	19244	23569
Cement (III)	2516	3930	5188	6372	1.15	2894	4520	5967	7328
Local material (IV)	1652	3181	4689	6195	1.075	1776	3420	5041	6660
Imported material (V)	5303	7954	10512	13034	2.3	12197	18295	24178	29979
Transport (VI)	4373	6729	5895	10974	2.125	9293	14230	18902	23320
TOTAL	24507	35237	50666	62762	-	35757	55147	73332	90856

ANNEX 6.3

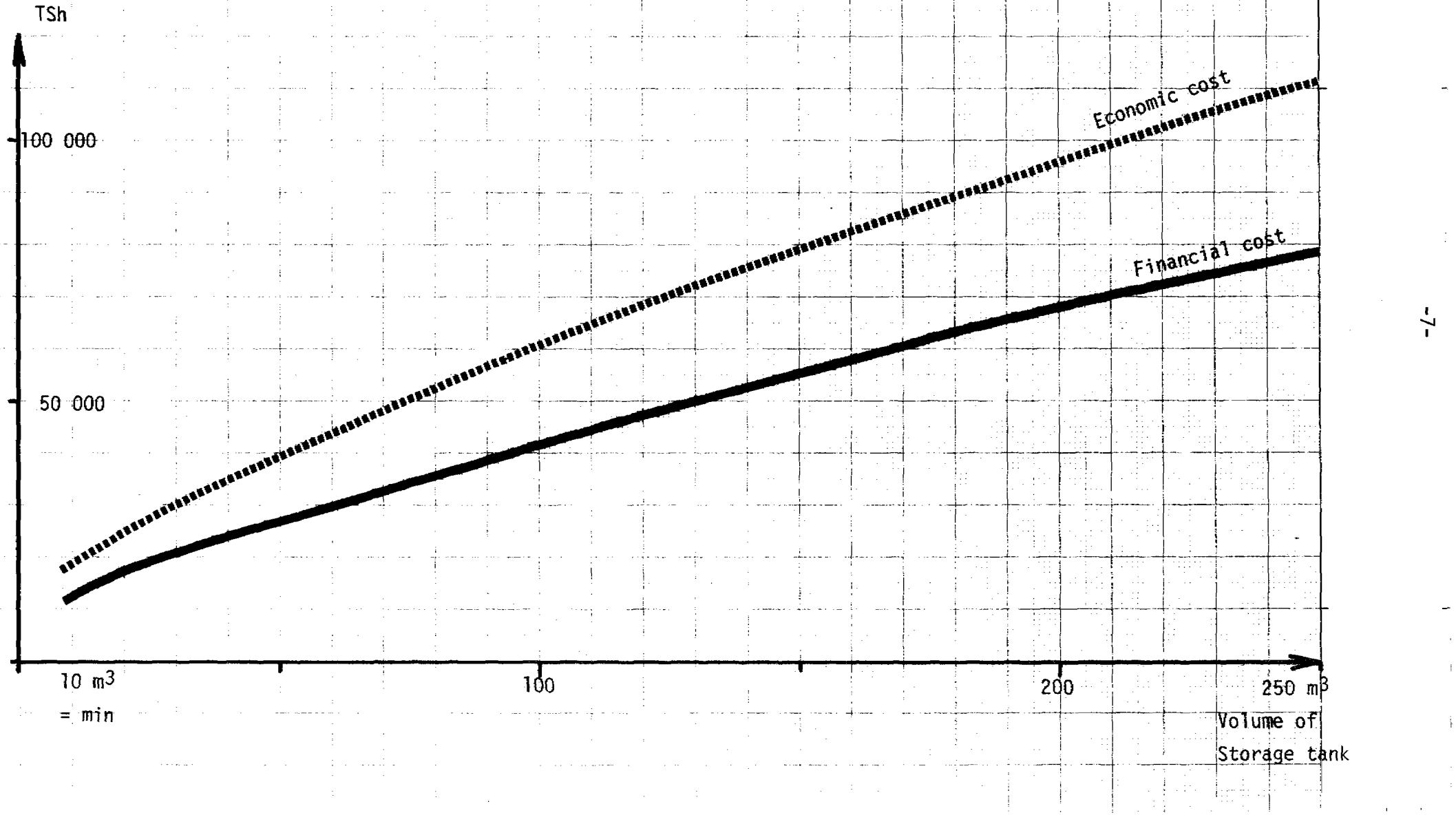
SUMMARY OF COSTS
LARGE STORAGE TANK (HEIGHT 4 M)

(TSh)

Items	Financial Cost				Econ. Finan.	Economic Cost			
	Radius m					Radius m			
	3.61	4.13	4.60	5		3.61	4.13	4.60	5
Labour (I+II)	14503	17248	19898	22283	0.9	13053	15524	17909	20055
	8848	10616	12324	13859	0.9	7964	9555	11092	12474
Cement (III)	5634	6751	7828	8795	1.15	6480	7764	9003	10115
Local material (IV)	3733	4875	6038	7125	1.075	4013	5241	6491	7660
Imported material (V)	9256	11229	13216	15061	2.3	21289	25827	30397	34641
Transport (VI)	9299	11166	12993	14652	2.125	19761	23728	27611	31136
TOTAL	51273	61885	72297	81775	-	72560	87639	102503	116081

ANNEX 6.3

COST FOR STORAGE TANK VERSUS EFFECTIVE VOLUME



ANNEX 6.4

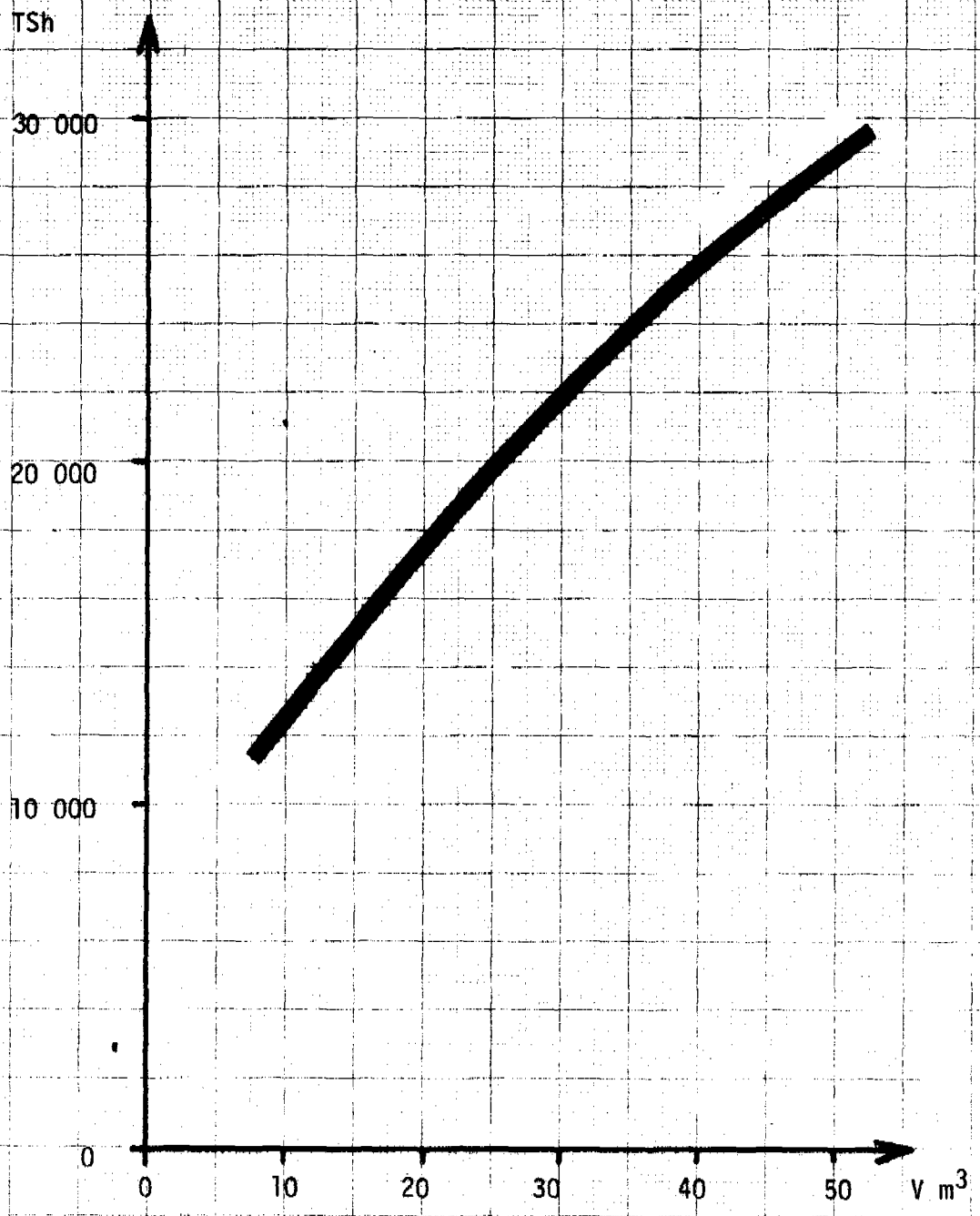
COST ESTIMATES FOR SEDIMENTATION UNITS
(TShs.)

Items	Financial Cost				Econ. / Financ	Economic Cost			
	Radius m					Radius m			
	1.49	1.83	2.35	3.33		1.49	1.83	2.35	3.33
I + II	3132	3933	5324	8228	0.9	2819	3540	4792	7405
III	775	993	1368	2221	1.15	891	1142	1573	2554
V	2214	2495	2980	4126	2.3	5092	5739	6854	9490
VI	1536	1841	2371	3599	2.125	3264	3912	5038	7648
TOTAL	7657	9262	12043	18174	-	12067	14333	18258	27098

ANNEX 6.4

SEDIMENTATION BASIN

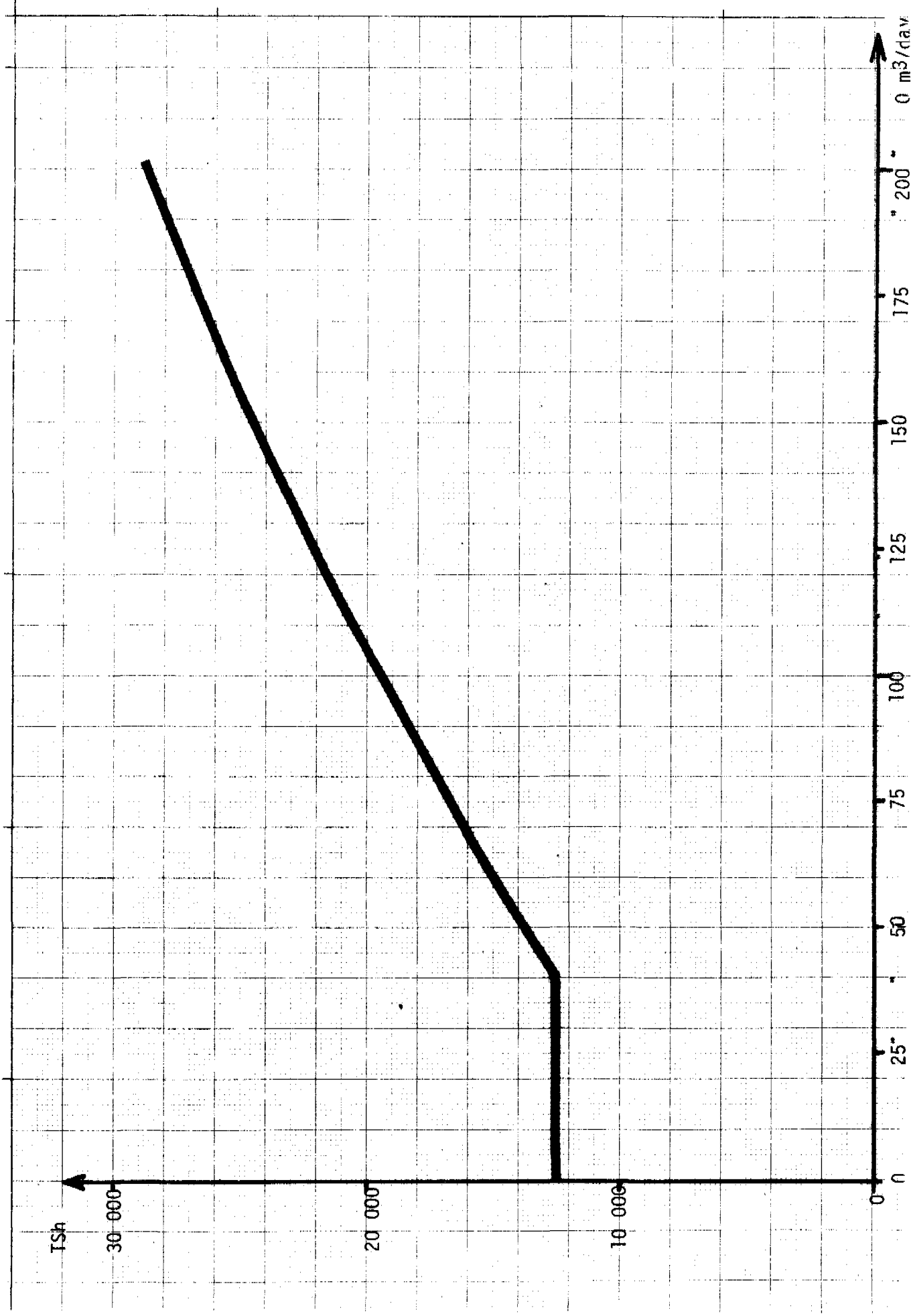
ECONOMIC COST/VOLUME



ANNEX 6.4

SEDIMENTATION BASIN

ECONOMIC COST/DAILY WATER DEMAND



ANNEX 6.4

ASSUMPTIONS FOR COSTING OF FLOCCULATION AND SEDIMENTATION

a. The sedimentation tanks are assumed to have 20 years lifetime.

b. Maintenance is calculated as 1% of the construction cost.

c. One filter unit is assumed to have 10 years lifetime and the cost is assumed to be TSh. 5,000/- which will be TSh. 10,000/- as economic cost.

d. Maintenance, annual 1% of construction cost.

e. Dosing equipment, lasting 5 years, is imported.

Financial cost: TSh. 3,000/-.
Economic cost: TSh. 7,500/-.

f. Equipment needed to be replaced annually, imported:

Financial value: TSh. 300/-.
Economic value: TSh. 750/-.

g. Maintenance:

Financial value: TSh. 300/-
Economic value: TSh. 450/-.

h. Chemicals: Filter alum:

Financial value: TSh. 1,130/- per 1000 kg.
Economic value: TSh. 2,000/- per 1000 kg.

Soda ash:

Financial value: TSh. 750/- per 1000 kg.
Economic value: TSh. 1,300/-

Transportation:

Financial value: TSh. 1,050/- per 1000 kg.
Economic value: TSh. 2,235/- per 1000 kg.

i. Pumping units: See Slow sand filtration and Annex 6.10. Maintenance and operations, see Annex 6.10.

j. Pump house extension, see Annex 6.10.

SAND CHARACTERISTICS

$0.15 < d_{10} < 0.35$

$1.5 < \frac{d_{60}}{d_{10}} < 2.0$

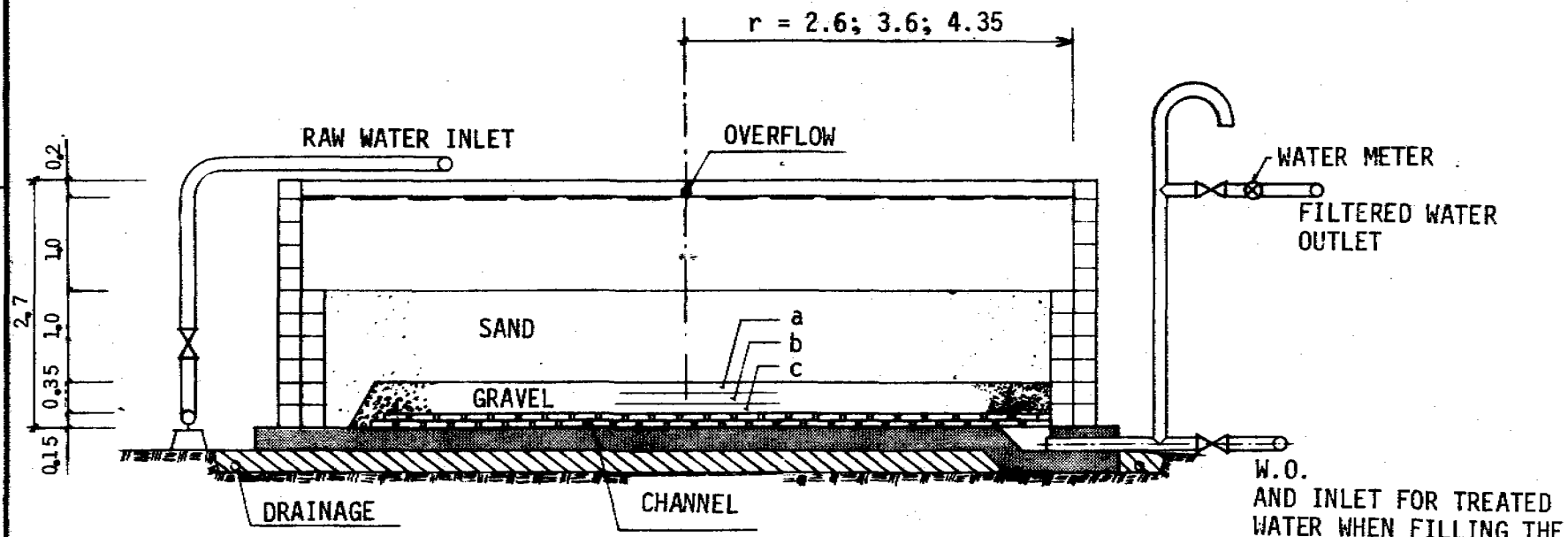
GRAVEL CHARACTERISTICS

TOP LAYER (a) $4 \times d_{15}^{sand} < d_{10}^{a} < 4 \times d_{85}^{sand}$ $d_{90}^{a} = d_{10}^{a} \times \sqrt{2}$

MID LAYER (b) $4 \times d_{10}^{a} < d_{10}^{b} < d_{90}^{b} = d_{10}^{b} \times \sqrt{2}$

LOWER LAYER (c)

THE OPENINGS IN THE BRICK CHANNEL
DRAINAGE SYSTEM = $0.5 \times d_{10}$ BOTTOM GRAVEL LAYER



TYPE SKETCH OF SLOW SANDFILTER

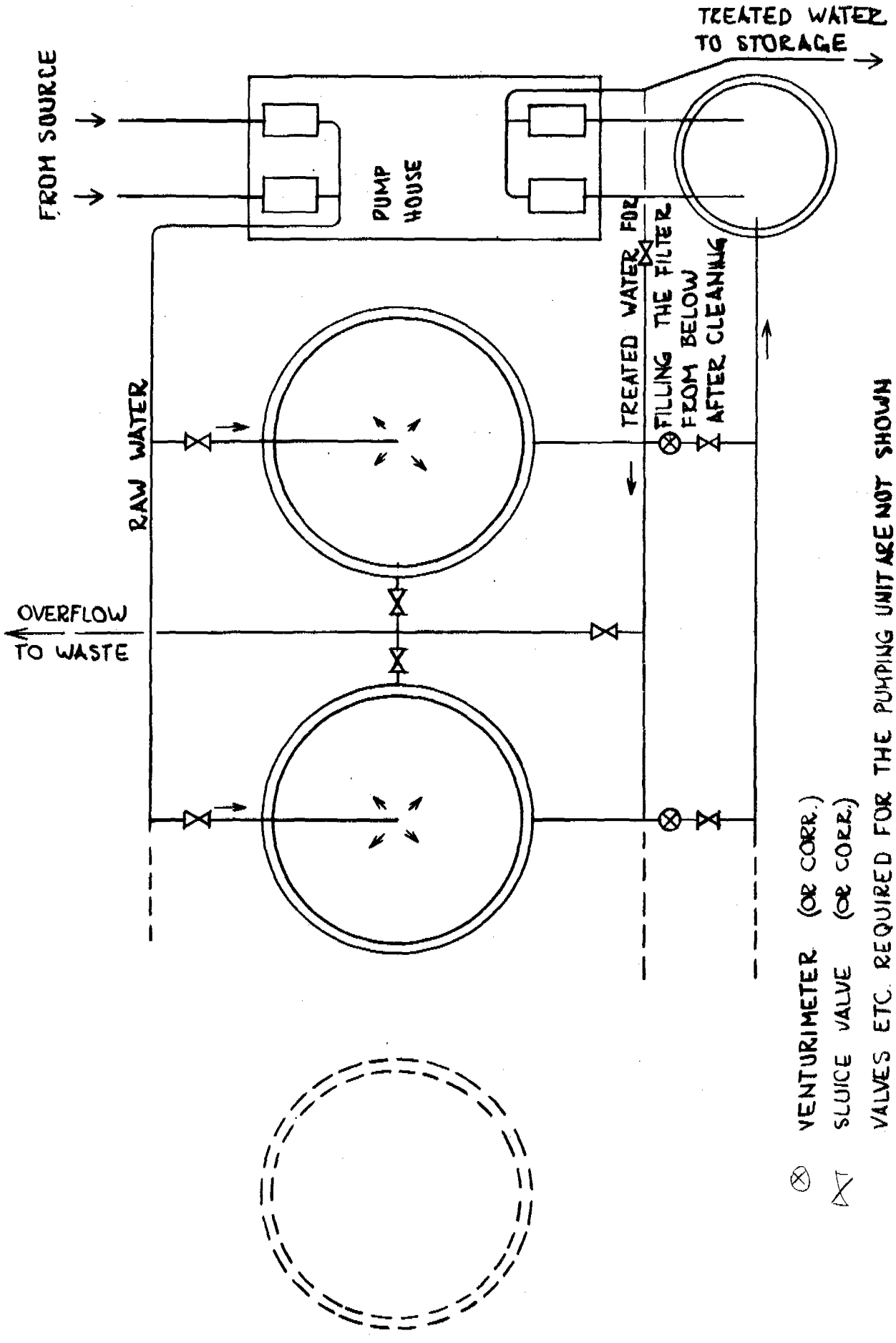
SLOW SANDFILTER

BROKONSULT AB
CONSULTING ENGINEERS AND ECONOMISTS
PER SUNDBERGS V 1-3 S-18363 TÄBY SWEDEN

6.5

ANNEX 6.6

LAY-OUT FOR INCLUSION OF SLOW SAND FILTRATION



ANNEX 6.7

FILTER AREA REQUIRED
SLOW SAND FILTER

A m^3/d	=	water demand
V_f m/h	=	filtration rate ~ 0.15 m/h
Pumping hours	=	8 hours per day
n	=	number of filter units required
N	=	n+1 = number of filter units to be constructed (1 unit added for maintenance purposes).

Circular blockwork tanks corresponding to existing standard sizes of storage tanks (10,000 g; 20,000 g; 30,000 g) with radius r m assumed to be used.

Type: A: r = 2.6 m; B: r = 3.6 m; C: r = 4.35 m

Qm^3/day	N = n + 1				V_f m/h
	2	3	4	5	
<30	A				~ 0.14
30 - 45	B				~ 0.14
45 - 65	C				~ 0.12
65 - 85		B			~ 0.13
85 - 110		C			~ 0.12
110 - 130			B		~ 0.14
130 - 175			C		~ 0.12
>175				C	~ 0.12

ANNEX 6.8

SUMMARY OF COSTS
SLOW SAND FILTERS
(TSh)

Items	Financial Cost			Economic / Financial	Economic Cost		
	Radius m				Radius m		
	A:2.6	B:3.6	C:4.35		A:2.6	B:3.6	C:4.35
Labour (I+II)	11261	17689	23403	0.9	10135	15921	21063
Cement (III)	6432	9230	11456	0.1+2.5+0.9	7397	10615	13175
Materials (IV)	1885	2838	3643	2.3	4336	6528	8379
Pipes & Fittings (V)	3378	3378	3378		7381	7381	7381
Transports (VI)	6591	9242	11412	0.25 + 2.5· 0.75	14006	19640	24251
TOTAL	29547	42377	53292	-	43255	60085	74249

ANNEX 6.9

ANNUAL SAND REPLACEMENT IN SLOW SAND FILTERS

A filter depth of 0.5 m assumed to be cleaned annually corresponding to following volumes for different filter sizes:

A:r = 2.6 x V = 11 m^3
B:r = 3.6 x V = 21 m^3
C:r = 4.35 x V = 30 m^3
} per filter unit

The cost for scraping the filter bed is included in the cost for the operator.

Washing and replacing filter sand will be done by unskilled labour at a price of:

4 x 14.60 = 58/40 per m^3

expressed as financial cost and

0.9 x 58/40 = 52/55 as economic cost.

ANNEX 6.10
ESTIMATED COST OF PUMPING STAGE

1. Pump Units

Movi 40/2 + Stl (1800). Two units required.

Financial cost per unit:	TShs.	28,306
Economic cost per unit:		63,932

Lifetime 5 years.

Discounted average annual cost:

Financial: $2 \times 28{,}306 \times \frac{1.18^5 \cdot 0.18}{1.18^5 - 1}$ = 18,104

Economic: 40,889

Maintenance, annual:

Financial cost (5%)	2,831
Economic cost (5%)	6,394

Operation, annual:

Q m^3/day	H m	η	Financial* Annual Cost	Economic** Annual Cost
20	30	0.41	1287	2733
40	38	0.50	2056	4367
50	36	0.54	2254	4789
75	32	0.60	2705	5746
100	26	0.61	2882	6123
120	20	0.59	2750	5844
150	33	0.60	5577	11852
200	25	0.61	5541	11775

* = 0.5 TSh/HPh $\times \frac{1000 \times Q \times H \ 365}{3600 \times 75 \cdot \eta}$ = $0.676 \times \frac{Q \times H}{\eta}$

** = Economic = Financial x 2.125

2. Extension of Pumphouse

Size	Labour Cost Tsh.	Material Cost Tshs.	
		Imported Material	Local Material
Large	10104	680	6104
Small	6278	410	3686
Difference	3826	270	2418

Difference in financial cost: 6514

Difference in economic cost:

3826 x 0.9	3444
270 x 2.5	675
2418	2418
TOTAL	6537

Lifetime: 10 years

Discounted annual cost:

Financial 1450
Economic 1455

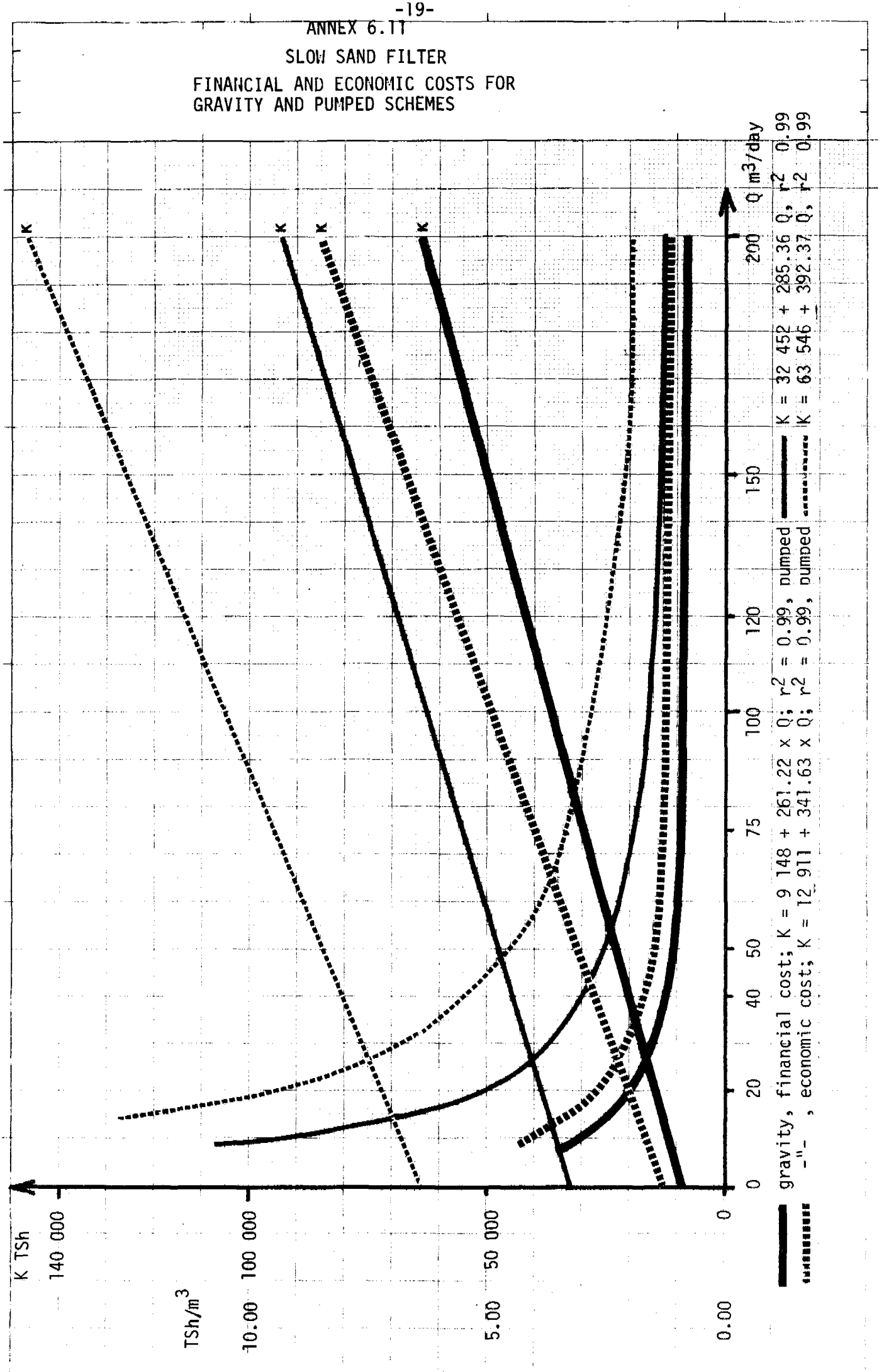
Difference in maintenance cost:

Financial = economic Tsh. 66/-.

ANNEX 6.11

SLOW SAND FILTER

FINANCIAL AND ECONOMIC COSTS FOR
GRAVITY AND PUMPED SCHEMES



ANNEX 6.12
TOTAL COST FOR TREATMENT
AS PRESENT VALUES OF THE ECONOMIC COSTS

REGIONAL TABLES

COST FOR WATER TREATMENT IN TShs x 1000

ARUSHA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			4 097	496
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	4 097	496
Med.	Storage		2 972		
	Chlorination			3 359	560
	Slow sand filtr.				
	Flocc+coag+filtr.				3 948
	Manpower			29	859
	Total	0	2 972	3 318	5 367
High	Transmission				6 810
	Storage	3 969	1 451	3 289	424
	Chlorination		18 489		
	Slow sand filtr.			22 930	3 732
	Flocc+coag+filtr.				
	Manpower	50	1 694	5 038	859
	Total	447	21 634	31 257	11 825

Grand total for low quality level 4 593
medium " " 11 727
high " " 65 163

COST FOR WATER TREATMENT IN TShs x 1000

COAST REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			2 609	804
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	2 609	804
Med.	Storage		3 132		
	Chlorination			2 094	900
	Slow sand filtr.				
	Flocc+coag+filtr.				6 337
	Manpower			185	1 378
	Total	0	3 132	2 279	8 615
High	Transmission				10 932
	Storage	257	1 529	2 094	681
	Chlorination		19 485		
	Slow sand filtr.			14 601	5 991
	Flocc+coag+filtr.	40	1 786	3 208	1 378
	Manpower				
	Total	297	22 280	19 903	18 982

Grand total for low quality level	3 413
medium " "	14 026
high " "	61 982

COST FOR WATER TREATMENT IN TShs x 1000 DAR ES SALAAM RURAL REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			110	
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	110	0
Med.	Storage		239		
	Chlorination			88	
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower			8	
	Total	0	239	96	0
High	Transmission				
	Storage				
	Chlorination	61	160	88	
	Slow sand filtr.		2 568		
	Flocc+coag+filtr.			617	
	Manpower	13	313	136	
	Total	74	3 041	841	0

Grand total for low quality level 110
medium " " 335
high " " 3 956

COST FOR WATER TREATMENT IN TShs x 1000

DODOMA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			1 006	1 006
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	1 006	1 006
Med.	Storage		1 084		
	Chlorination			807	1 122
	Slow sand filtr.				
	Flocc+coag+filtr.				5 182
	Manpower				
	Total	0	1 084	864	7 298
High	Transmission				9 216
	Storage				
	Chlorination	2 554	553	807	807
	Slow sand filtr.		7 544		
	Flocc+coag+filtr.			4 683	4 683
	Manpower	401	769	994	994
	Total	2 955	8 866	6 484	15 700

Grand total for low quality level	2 012
medium " "	9 246
high " "	34 005

COST FOR WATER TREATMENT IN TShs x 1000

IRINGA REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			2 034	551
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	2 034	551
Med.	Storage		3 040		
	Chlorination			1 632	604
	Slow sand filtr.				
	Flocc+coag+filtr.				3 340
	Manpower			116	678
	Total	0	3 040	1 748	4 622
High	Transmission				5 947
	Storage				
	Chlorination	1 389	1 484	1 632	442
	Slow sand filtr.		18 916		
	Flocc+coag+filtr.			9 473	3 085
	Manpower	173	1 734	2 011	678
	Total	1 562	22 134	13 116	10 152

Grand total for low quality level 2 585
medium " " 9 410
high " " 46 964

COST FOR WATER TREATMENT IN TShs x 1000

KIGOMA REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			617	331
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	617	331
Med.	Storage		2 400		
	Chlorination			495	362
	Slow sand filtr.				
	Flocc+coag+filtr.				2 004
	Manpower			35	407
	Total	0	2 400	530	2 773
High	Transmission				3 568
	Storage				
	Chlorination	825	1 172	495	265
	Slow sand filtr.		14 934		
	Flocc+coag+filtr.			2 874	1 851
	Manpower	103	1 369	610	407
	Total	928	17 475	3 979	6 091

Grand total for low quality level 948
medium " " 5 703
high " " 28 473

COST FOR WATER TREATMENT IN TShs x 1000

KILIMANJARI REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			5 418	
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	5 418	0
Med.	Storage		2 949		
	Chlorination			4 345	
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower			309	
	Total	0	2 949	4 654	0
High	Transmission				
	Storage				
	Chlorination	449	1 440	4 345	
	Slow sand filtr.		18 347		
	Flocc+coag+filtr.			25 227	
	Manpower	56	1 681	5 354	
	Total	505	21 468	34 926	0

Grand total for low quality level	5 418
medium " "	7 603
high " "	56 899

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			426	862
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	426	862
Med.	Storage		1 849		942
	Chlorination			360	
	Slow sand filtr.				
	Flocc+coag+filtr.				4 880
	Manpower			42	971
	Total	0	1 849	402	6 793
High	Transmission				8 638
	Storage				
	Chlorination	963	898	360	685
	Slow sand filtr.				
	Flocc+coag+filtr.			3 147	4 474
	Manpower	149	1 017	723	971
	Total	1 112	13 014	4 230	14 768

Grand total for low quality level	1 288
medium " "	9 044
high " "	33 124

COST FOR WATER TREATMENT IN TShs x 1000

MARA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			106	376
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	106	376
Med.	Storage		2 799		
	Chlorination			87	390
	Slow sand filtr.				
	Flocc+coag+filtr.				3 970
	Manpower			11	452
	Total	0	2 799	98	4 812
High	Transmission				3 965
	Storage				
	Chlorination	1 777	1 365	87	390
	Slow sand filtr.		20 394		
	Flocc+coag+filtr.			1 313	3 970
	Manpower	253	1 940	181	452
	Total	2 030	23 699	1 581	8 777

Grand total for low quality level 482
" " medium " " 7 709
" " high " " 36 087

COST FOR WATER TREATMENT IN TShs x 1000

MEBEYA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			2 172	
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	2 172	0
Med.	Storage		3 246		
	Chlorination			1 742	
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower			124	
	Total	0	3 246	1 866	0
High	Transmission				
	Storage				
	Chlorination	1 650	1 585	1 742	
	Slow sand filtr.		20 196		
	Flocc+coag+filtr.			10 112	
	Manpower	206	1 851	2 146	
	Total	1 856	23 632	14 000	0

Grand total for low quality level	2 172
medium " "	5 112
high " "	39 488

COST FOR WATER TREATMENT IN TShs x 1000

MOROGORO REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			1 874	514
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	1 874	514
Med.	Storage		2 789		
	Chlorination			1 503	564
	Slow sand filtr.				
	Flocc+coag+filtr.				3 117
	Manpower			107	633
	Total	0	2 789	1 610	4 314
High	Transmission				5 551
	Storage				
	Chlorination	1 420	1 362	1 503	413
	Slow sand filtr.		17 351		
	Flocc+coag+filtr.			8 728	2 879
	Manpower	177	1 590	1 853	633
	Total	1 597	20 303	12 084	9 476

Grand total for low quality level 2 388
medium " " 8 713
high " " 43 442

COST FOR WATER TREATMENT IN TShs x 1000

MTWARA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			1 278	757
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	1 278	757
Med.	Storage		1 186		
	Chlorination			1 017	833
	Slow sand filtr.				
	Flocc+coag+filtr.				5 326
	Manpower				1 130
	Total	0	1 186	1 104	7 289
High	Transmission				9 288
	Storage	807	591	1 017	622
	Chlorination		7 142		
	Slow sand filtr.			6 920	4 997
	Flocc+coag+filtr.	102	782	1 514	1 130
	Manpower				
	Total	909	8 515	9 451	16 037

Grand total for low quality level 2 035
medium " " 9 579
high " " 34 912

COST FOR WATER TREATMENT IN TShs x 1000 MWANZA REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			528	
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	528	0
Med.	Storage		6 086		
	Chlorination			436	
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower			52	
	Total	0	6 086	488	0
High	Transmission				
	Storage				
	Chlorination	2 682	2 968	436	
	Slow sand filtr.		44 346		
	Flocc+coag+filtr.			5 666	
	Manpower	343	4 219	903	
	Total	3 025	51 533	7 005	0

Grand total for low quality level 528
medium " " 6 574
high " " 61 563

COST FOR WATER TREATMENT IN TShs x 1000

RUVUMA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			1 737	625
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	1 737	625
Med.	Storage		2 903		
	Chlorination			1 393	684
	Slow sand filtr.				
	Flocc+coag+filtr.				3 785
	Manpower			99	768
	Total	0	2 903	1 492	5 057
High	Transmission				6 740
	Storage	178	1 417	1 393	501
	Chlorination		18 063		
	Slow sand filtr.			8 090	3 496
	Flocc+coag+filtr.	22	1 655	1 717	768
	Manpower				
	Total	200	21 135	11 200	11 505

Grand total for low quality level	2 362
medium " "	9 632
high " "	44 040

COST FOR WATER TREATMENT IN TShs x 1000

RUKWA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			1 525	475
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	1 525	475
Med.	Storage		1 966		
	Chlorination			1 224	531
	Slow sand filtr.				
	Flocc+coag+filtr.				3 740
	Manpower			108	813
	Total	0	1 966	1 232	5 084
High	Transmission				6 452
	Storage				
	Chlorination	149	1 002	1 224	402
	Slow sand filtr.		13 68.		
	Flocc+coag+filtr.			8 535	3 536
	Manpower	23	1 395	1 875	813
	Total	172	16 078	11 634	11 203

Grand total for low quality level	2 000
medium " "	8 282
high " "	39 087

COST FOR WATER TREATMENT IN TShs x 1000

SHINYANGA REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			2 228	2 076
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	2 228	2 076
Med.	Storage		5 806		
	Chlorination			1 886	2 274
	Slow sand filtr.				
	Flocc+coag+filtr.				12 580
	Manpower			220	2 553
	Total	0	5 806	2 106	17 407
High	Transmission				22 401
	Storage				
	Chlorination	1 742	2 835	1 886	1 667
	Slow sand filtr.		36 125		
	Flocc+coag+filtr.			16 599	11 619
	Manpower	371	3 311	3 8.8	2 553
	Total	2 113	42 271	22 303	38 240

Grand total for low quality level	4 304
medium " "	25 319
high " "	104 927

COST FOR WATER TREATMENT IN TShs x 1000

SINGIDA REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			643	685
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	643	685
Med.	Storage		643		
	Chlorination			516	767
	Slow sand filtr.				
	Flocc+coag+filtr.				5 402
	Manpower			46	1 175
	Total	0	643	562	7 344
High	Transmission				9 319
	Storage				
	Chlorination	1 739	328	516	580
	Slow sand filtr.		4 475		
	Flocc+coag+filtr.			3 599	5 107
	Manpower	314	456	791	1 175
	Total	2 053	5 259	4 906	16 181

Grand total for low quality level	1 328
medium " "	8 549
high " "	28 339

COST FOR WATER TREATMENT IN TShs x 1000

TABORA REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			2 609	804
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	2 609	804
Med.	Storage		3 362		
	Chlorination			2 094	900
	Slow sand filtr.				
	Flocc+coag+filtr.				6 337
	Manpower			185	1 378
	Total	0	3 362	2 279	8 615
High	Transmission				10 932
	Storage				
	Chlorination	296	1 714	2 094	681
	Slow sand filtr.		23 399		
	Flocc+coag+filtr.			14 601	5 991
	Manpower	53	2 385	3 208	1 378
	Total	349	27 498	19 903	18 982

Grand total for low quality level 3 413
" " medium " " 14 256
" " high " " 66 732

COST FOR WATER TREATMENT IN TShs x 1000

TANGA REGION

Qual. level	Treatment blocks	WATER SOURCE (1)	(2)	(3)	(4)
Low	Storage			3 566	1 102
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	3 566	1 102
Med.	Storage		4 595		
	Chlorination			2 860	1 208
	Slow sand filtr.				
	Flocc+coag+filtr.				679
	Manpower			203	1 356
	Total	0	4 595	3 063	9 243
High	Transmission				11 894
	Storage				
	Chlorination	373	2 243	2 860	885
	Slow sand filtr.		28 587		
	Flocc+coag+filtr.			16 605	6 170
	Manpower	59	2. 620	3 524	1 356
	Total	432	33 450	22 989	20 305

Grand total for low quality level 4 668
medium " " 16 901
high " " 77 176

COST FOR WATER TREATMENT IN TShs x 1000

WEST LAKE REGION

Qual. level	Treatment blocks	WATER SOURCE			
		(1)	(2)	(3)	(4)
Low	Storage			1 058	113
	Chlorination				
	Slow sand filtr.				
	Flocc+coag+filtr.				
	Manpower				
	Total	0	0	1 058	113
Med.	Storage		2 000		
	Chlorination			818	117
	Slow sand filtr.				
	Flocc+coag+filtr.				1 191
	Manpower			60	136
	Total	0	2 000	878	1 444
High	Transmission				1 190
	Storage	1 886	947	818	117
	Chlorination		13 182		
	Slow sand filtr.			9 301	1 191
	Flocc+coag+filtr.				
	Manpower	241	1 113	1 038	136
	Total	2 127	15 242	11 157	2 634

Grand total for low quality level 1 171
medium " " 4 322
high " " 31 160

ANNEX 7

ANNEX 7.1

EVALUATION OF PRESENT VALUE INTEGRALS

We must evaluate

$$I = P(0)A\gamma \int_0^{20} (1.027)^t \; t\, e^{-rt}\, dt \quad \text{where } A = .01805$$

Putting

$$(1.027)^t = e^{at} \qquad a = \ln 1.027 = .02664$$

$$I = P(0)\, A\gamma \int_0^{20} te^{(.02664-r)t}\, dt$$

Note that

$$\int_0^{20} te^{t} = \frac{te^{\alpha t}}{\alpha}\Bigg|_0^{20} - \frac{e^{\alpha t}}{\alpha^2}\Bigg|_0^{20}$$

$$= \frac{20e^{20\alpha}}{\alpha} - \left(\frac{e^{20\alpha}}{\alpha^2} - \frac{1}{\alpha^2}\right)$$

$$I = P(0)A\gamma \left[\frac{20e^{20(.02664-r)}}{(.02664-r)} - \frac{e^{20(.02264-r)} - 1}{(.02664-r)^2}\right]$$

As an example we evaluate the bracket for various values of r

r	$\left[\quad\right]$
.02	218.621
.06	129 888
.12	63 888
.18	34 468

This integral is typical of what must be done in these calculations.

ANNEX 8

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ANNEX 8.1

THE WATER UTILIZATION (CONTROL AND REGULATION)

ACT, 1974

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THE UNITED REPUBLIC OF TANZANIA

NO. 42 OF 1974

I ASSENT,

J.K. NYERERE,
President

30th OCTOBER, 1974

AN ACT TO REPEAL AND REPLACE THE WATER ORDINANCE

Enacted by the Parliament of the United Republic of Tanzania.

PART I

PRELIMINARY

1. This Act may be cited as the Water Utilization (Control and Regulation) Act, 1974 and shall come into operation on such date as the Minister may, by notice in the GASETTE, appoint. Short title and commencement

2.-(1) In this Act, unless the context otherwive requires- Interpretation

"appointing authority" means, in the case of the Central Water Advisory Board, the Minister and in the case of a Regional Water Advisory Board, the Regional Commissioner of the region for which the Board is established;

"Cental Water Advisory Board" means the Central Water Advisory Board established by section 5;

"domestic purposes" includes the watering, spraying and dipping of stock;

"easement" means a right to enter on the land of another for the purpose of constructing or maintaining works thereon or storing water thereon or carrying water under, through or over such land or for all or any of such purposes;

"existing right" in relation to the use of water means a right, registered under the provisions of the Water Ordinance hereby repealed and subsisting immediately prior to the date upon which this Act comes into operation, to divert, dam, store, abstract or use water; Cap. 410

"Minister" means the Minister for the time being responsible for water development;

"national water supply" means a water supply declared as such under the provisions of section 9;

"Principal Secretary" means the Principal Secretary of the Ministry for the time being responsible for water development;

"Principal Water Officer" means the Principal Water Officer appointed under the provisions of section 4;

"Regional Water Advisory Board" means a Regional Water Advisory Board established by section 5;

"Regional Water Officer" means a Regional Water Officer appointed under the provisions of section 4;

"regional water supply" means a water supply other than a national water supply which is wholly or partly within a region;

"underground water" means water naturally stored or flowing below the surface of the ground and not apparent on the surface of the ground;

"water" means all water flowing over the surface of the ground or contained in or flowing in or from a spring or stream or natural lake or swamp or in or beneath a watercourse and all water made available from subterranean sources by means of works, but does not include any tidal water, nor water which is used solely for the purpose of extracting minerals therefrom;

"Water Officer" in relation to an application for, or an objection to, or a grant of, or refusal to grant, a water right in respect of a national water supply means the Principal Water Officer, and in relation to an application for, or an objection to, or a grant of, or refusal to grant, a water right in respect of a regional water supply means the Regional Water Officer of the region in which such supply is situate;

"works" include canals, channels, reservoirs, embankments, weirs, dams, wells, boreholes and other works constructed for or in connection with the diversion, damming, storage or abstraction of water or for drainage or for the generation of water power or the use of water for industrial or other purposes or for the conservation of rainfall.

(2) Nothing in this Act shall be construed as conferring upon an appointing authority the right to exercise his functions under this Act in relation to any Water Advisory Board other than the Water Advisory Board in respect of which he is the appointing authority.

lication Act to Government, the munity, etc. . 281

3. Without prejudice to the generality of the application of this Act, it is hereby declared that the provisions of this Act shall apply to and be carried into effect by departments of the Government, public and local authorities, the East African Community and all Corporations within the Community and all Water Authorities appointed under the Water Works Ordinance.

PART II

APPOINTMENT OF OFFICERS AND ESTABLISHMENT OF WATER ADVISORY BOARDS

Appointment of Officers

4.-(1) There shall be a Principal Water Officer and also, for every region in Tanganyika, a Regional Water Officer who shall be appointed by the Minister from among persons in the public service.

(2) The Minister may appoint such other officers as, in his opinion, may be necessary for the purpose of the administration of this Act and the subsidiary legislation made hereunder.

(3) Officers appointed under this section shall have such functions as are conferred upon them by or under this Act.

Establishment of Water Advisory Boards

5.-(1) There shall be established a Central Water Advisory Board and also, for every region in Tanganyika, a Regional Water Advisory Board.

(2) Every Water Advisory Board shall consist of not less than five and not more than twenty members one of whom shall act as the Secretary.

(3) The members of the Central Water Adivsory Board shall be appointed by the Minister. The members of a Regional Water Advisory Board shall be appointed by the Regional Commissioner of the region for which the Board is established.

(4) Each member of a Water Advisory Board shall hold office for such term as the appointing authority may determine at the time of his appointment and shall be eligible for re-appointment from time to time on the expiration of his term of office.

(5) Where a member of a Water Advisory Board is absent from Tanganyika or is unable to perform his functions for any reason, the appointing authority may appoint another person to be a temporary member of the Water Advisory Board to perform and discharge the functions of such person for the period during which such person is so absent of disabled from acting.

(6) Every Water Advisory Board shall sit on such occasions and at such places as it may in its descretion determine.

(7) The business of a Water Advisory Board shall be conducted in such manner as may be prescribed:

Provided that until such precedure has been prescribed a Water Advisory Board shall conduct its business in such manner as it shall determine.

Functions of Central Water Advisory Board

6.-(1) The Central Water Advisory Board shall advise the Principal Water Officer on all matters concerning the apportionment of national water supplies, the determination, diminution or modification of water rights, the measures to be taken in case of drought and the priorities to be given from time to time and in accordance with prevailing circumstances for the different purposes for which water is required in any area of Tanganyika.

(2) The Principal Water Officer shall consider the advice of the Central Water Advisory Board before granting or refusing any application for a water right, before determining, revising, diminishing or modifying any water right or existing right and before specifying a quantity of water under section 21, but shall not be bound to follow such advice:

Provided that nothing in this subsection shall require the Principal Water Officer to make any reference to, or to consider the advice of the Central Water Advisory Board in respect of any suspension or variation of a right under the provisions of section 20 or in respect of any modification, variation, determination or diminution of a right with the consent of the holder thereof.

Functions of Regional Water Advisory Boards

7.-(1) The provisions of section 6 shall apply mutatis mutandis in relation to a regional water supply as if references therein to the Central Water Advisory Board and the Principal Water Officer were references respectively to a Regional Water Advisory Board and a Regional Water Officer:

Provided that all such functions as are provided for or referred to in section 6 shall, in the application of that section to a Regional Water Advisory Board and a Regional Water Officer, be restricted to regional water supplies within such region.

PART III

OWNERSHIP OF AND INHERENT RIGHTS TO THE USE OF WATER

All water vested in the United Republic

8. All water in Tanganyika is vested in the United Republic.

Declaration of national water supplies

9. Where the Minister is of the opinion that it is in the public interest to regulate the use of water from any source in any area of Tanganyika on a national basis, he may by notice in the GAZETTE, declare such source to be a national water supply for the purpose of this Act.

Right to water for domestic purposes

10. Any person having lawful access to any water may abstract and use the same for domestic purposes:

Provided that nothing in this section shall be construed as authorizing the construction of any works.

Right to limited quant ties of underground water and to casual water

11.-(1) The owner or occupier of any land may-

(a) sink or enlarge any well or borehole thereon and abstract water therefrom, not exceeding 22 700 litres in any one day:

Provided that this section shall not authorize the sinking of any well or borehole within 230 metres of any other well or borehole or within 90 metres of any body of surface water or enlargement of any well or borehole which is within those distances from any other well or borehole or body of surface water, as the case may be;

(b) construct any works thereon for the conservation of rainfall, otherwise than in a river or stream and abstract and use the water so conserved.

(2) A Water Officer may determine for the purposes of paragraph (b) of subsection (1) whether any watercourse is a river or stream, and the determination of the Water Officer thereon shall be final and conclusive for the purposes of this Act.

Right to water for mining purposes
Cap. 123
Capl 399

12.-(1) The older of a mining lease granted under the Mining Ordinance or of a lease granted under the Mining (Mineral Oil) Ordinance shall have in respect of the land comprised in his lease the same rights as are conferred by section 11 on the owner or occupier of any land and may also abstract and use any underground water encountered in any working and construct any works required for or in connection with the use of such water.

Cap. 123
Cap. 124

(2) The holder of a claim registered under the Mining Ordinance or of a disc claim under the Mining (Controlled Areas) Ordinance shall have in respect of the land comprised in such claim the same rights as are conferred on the holder of a lease subsection (1) and may in addition, in respect of water to which he has lawful access, abstract and use the same for prospecting and mining purposes, returning the same to the stream or body of water from which it was taken, substantially undiminished in quantity.

Cap. 399

(3) The holder of a prospecting right or of an exclusive prospecting licence granted under the Mining Ordinance or of a prospecting or exploration licence granted under Mining (Mineral Oil) Ordinance may, within the area specified in such licence, subject to all other rights to the use of water-

(a) abstract and use for prospecting purposes any water to which he has lawful access, returning the same to the stream or body of water from which it was taken;

(b) sink or enlarge any well or borehole in any land on which he has the right to explore or prospect, and abstract water therefrom, not exceeding 22 700 litres in any one day; and

(c) abstract and use any underground water encountered in any workings and construct any works required for or in connection with the use of such water.

(4) Any person abstracting underground water from any workings under the powers conferred by this section shall comply with any directions of the Water Officer regarding the disposal of such water as is not used.

(5) Every person exercising the powers in this section contained shall, as regards the owners of any surface rights, exercise such powers and pay compensation in the same manner and to the same extent as if the powers exercised under this Act were exercisable under the Mining Ordinance.

ight to ater for orestry urposes ap. 389

13. The holder of an exclusive licence to take trees and timber granted under the Forests Ordinance may, within the area specified in such licence, subject to all other rights to the use of water-

(a) abstract and use any water to which he has lawful access-

(i) for logging or sawmilling operations of a temporary nature:

Provided that no such operation shall be deemed to be of a temporary nature unless no substantial plant is maintained in any one place for more than one year nor is intended to be so maintained; or

(ii) for fighting forest fires; or

(b) sink or enlarge any well or borehole and abstract water therefrom not exceeding 22 700 litres in any one day.

rohibition f use of ater except ith lawful uthority

14. Subject to the provisions of this Part and to the provisions of section 53 of the Mining Ordinance, no person shall divert, dam, store, abstract or use water or for any such purpose construct or maintain any works, except in accordance with an existing right or with a water right granted under this Act.

PART IV

GRANT OF WATER RIGHTS

nant of ter rights

15.-(1) A Water Officer may grant to any person the right to divert, dam, store, abstract and use water from such source, in such quantity, for such period, whether definite or indefinite, and for such purpose as may be specified in the water right, subject to such terms and conditions as he may deem fit.

(2) Upon receipt of an application for the grant of a water right, the Water Officer shall give notice of the same in the

prescribed manner. Any interested person may notify the Water Officer that he objects to the grant of a water right and may specify the grounds for such objection, and shall, if he so requires, have a right to be heard thereon by the Water Advisory Board.

(3) The Water Officer-

(a) shall consider every application and any objections made to him in respect thereof, and shall refer the same to the Water Advisory Board; and

(b) may, after considering the advice of the Water Advisory Board, grant such right as he may consider appropriate or may dismiss the application.

(4) Nothing in any such water right shall be deemed to imply any guarantee that the quantity of water thereon referred to is or will be available.

Right may be made appurtenant to land

16.-(1) A Water Officer may, either at the time of the grant or at any time after the grant of any water right, declare that such right shall be appurtenant to land described in the water right and may at any time declare an existing right to be appurtenant to land affected thereby.

(2) Where a water right or existing right has been declared to be appurtenant to any land, the benefit of the right shall be enjoyed and the right may be enforced by the person who is for the time being entitled to the possession of the land.

(3) Where in consequence of any transfer, lease or partition, any person becomes entitled to the possession of part of the land to which a water right or existing right has been declared appurtenant, he may abstract and use such proportion of the water the abstraction and use of which is permitted by the water right or existing right as may have been assigned to him in the transfer, lease or partition or as may be agreed between him and the persons entitled to the possession of the remainder of the land, or, in the absence of any such assignment or agreement, as may be determined by the Water Officer.

(4) Where any apportionment of water has been made under the provisions of this subsection in respect of any partition of land, the several amounts of water so apportioned shall be deemed to be appurtenant to the several parcels of such land and the benefit thereof shall be enjoyed and all rights thereof may be enforced, in accordance with such apportionment by the persons who are for the time being entitled to the possession of such parcels, and such rights shall prevail until the parcels shall again become merged with each other.

(5) Any person acquiring a right to abstract and use water by agreement in accordance with the provisions of subsection (3) of this section shall within thirty days give notice thereof in the prescribed form to the Water Officer.

Conditions implied in certain rights

17. The following conditions shall be implied in every water right granted for mining, forestry or industrial purposes or for the generation of power-

(a) that the water used thereunder-

(i) shall be returned to the stream or body of water from which it was taken or to such other stream or body of water as may be authorized by the Water Officer;

(ii) shall be substantially undiminished in quantity:

(iii) shall not be polluted with any matter derived from such use to such extent as to be likely to cause injury either directly or indirectly to public health, to livestock or fish, to crops, orchards or gardens which are irrigated by such water or to any product in the processing of which such water is used; and

(b) that precautions shall be taken to the satisfaction of the Water Officer to prevent accumulations in any river, stream or watercourse of silt, sand, gravel, stones, sawdust refuse, sewerage, sisal waste or any other substance likely to affect injuriously the use of such water.

Rights conditional on construction of works

18.-(1) Where a Water Officer has granted a water right subject to the construction of works within a specified period, he may, from time to time at any time notwithstanding that the period previously allowed may have expired, extend the period for the construction of such works.

(2) At the expiration of the period allowed for the construction of the works, the Water Officer shall cause the works to be inspected by such officer as the Principal Secretary may approve who, if they have been constructed to his satisfaction, shall so certify in writing to the Water Officer.

(3) No certificate issued under this section shall be deemed to imply any guarantee by the Government that the works are properly designed or constructed nor shall support of justify any claim whatsoever against the Government or any Government officer in connection with such works.

PART V

REVISION, VARIATION, DETERMINATION AND DIMINUTION OF WATER RIGHTS

Position when volume inadequate to satisfy all rights granted in respect thereof

19. If, at any time, in the opinion of the Minister, in any specified area, the volume of water to which rights of use exist is insufficient to satisfy all such rights, he may

direct the appropriate Water Officer to review the use, diversion, control and appropriation of water in that area and in so doing the Water Officer may revise the quantity allowed by any right and the terms and conditions of any right to the use of water in that area:

Provided that the Water Officer shall have regard to the principle that where beneficial use of the whole right has been maintained, no right shall be cancelled or reduced except in proportion with all other rights in the same area.

Suspension or variation of rights on account of drought

20. Where in the opinion of the Water Officer on account of drought the supply of water from any source is insufficient or likely to become insufficient for the needs of the persons using it, the Water Officer may at any time and from time to time by notice in writing addressed to the holders of water rights suspend or vary all or any rights to abstract or use water from that source, for such period as he may deem necessary, and thereupon such rights shall cease for the period of the suspension or shall be exercisable only as so varied, as the case may be.

Where quantity unspecified Water Officer may specify quantity

21. In respect of any existing right to the use of an unspecified quantity of water, the Water Officer may at any time specify the quantity of water for which that right shall be valid, and record the same in the register of water rights and so to inform the holder of that existing right.

Variation of water rights with consent

22. A Water Officer may at any time on the application or with the consent of the holder of a water right, determine or diminish the right or vary any of the conditions thereof.

Determination for breach of condition

23. Where the holder of a water right has failed to comply with any condition, express or implied, subject to which the right was granted, or has abstracted or used water in excess of that authorized or has used water for a purpose not authorized by the grant, the Water Officer may by notice in writing addressed to the holder declare the right to be determined:

Provided that where the default is one capable of being remedied, the Water Officer shall first serve on the Holder notice in writing specifying the default and requiring the holder to remedy the same within such time as may be specified in the notice.

Determination or diminution for non use

24.(1) If at any time a Water Officer has reason to believe that the holder of a water right has not, during the preceding three years, made full beneficial use of that right, the Water Officer may by notice in writing addressed to such holder call upon him to show cause why such right should not be determined or diminished or modified in such respects as may be specified in the notice.

(2) If within three months of the service of such notice no reply has been received by the Water Officer, he may declare the right determined or diminished or modified, as the case may be.

(3) The Holder of a water right upon whom a notice has been served under subsection (1) may, within three months of such service, submit to the Water Officer as statement in writing of reasons why the right should not be determined or diminished or modified, as the case may be, or may require to be heard in the matter.

(4) The Water Officer shall consider any statement submitted to him under subsection (3) and shall, if so required, give the holder an opportunity of being heard in person or by an advocate and may thereafter by notice in writing addressed to the holder-

(a) declare the right determined; or

(b) declare the right diminished or modified in such respects as may be specified in the declaration; or

(c) declare the right to be subsisting unchanged.

Determination or diminution for public purposes

25.-(1) Where a Water Officer is satisfied that water is required for a public purpose he may, by notice in writing addressed to the holder of any water right, determine or diminish that right to the extent that such water is required for the aforesaid public purpose, and thereupon the right shall cease or shall be exercisable only as so diminished, as the case may be.

(2) The holder of any right determined or diminished under the provisions of this section shall be entitled to receive compensation from the Government for all loss resulting from the determination or diminution of the right. The amount of compensation payable shall in the absence of agreement be determined by the High Court upon the application fo the holder or the Minister.

(3) The Minister may be notice in the GAZETTE declare any purpose to be a public purpose within the meaning of this section.

Application of Part V to existing rights

26. The provisions of this Part shall apply to all existing rights in the same manner as they apply to water rights granted under this Act.

PART VI

MISCELLANEOUS POWERS

Power to create easements

27.-(1) Where any person who is the holder of a water right or who has applied for the grant of water right is unable fully to enjoy the benefit of that right without an easement, and has failed to secure an easement by agreement with the owner or occupier of the land over which the easement is required, he may apply to the appropriate

Water Office for the creation of such easement.

(2) Upon receipt of any such application, the Water Officer shall serve notice of the application on the owner or occupier of the land over which an easement is sought and on any other persons known to be interested in that land.

(3) Any interested person may notify the Water Officer that he objects to the creation of an easement under this section or that he desires to be heard on the subject of compensation.

(4) The Water Officer shall consider any objections made to him and shall give an opportunity of being heard to all persons who so require, and may thereafter by a certificate in the prescribed form create such easement as he may consider appropriate of refuse to create an easement.

(5) Where the water right in respect of which an easement is created has been made appurtenant to the land of the holder of the water right, then an easement created by the Water Officer may also be made appurtenant to such land, but not otherwise.

(6) Every easement created under this section shall be subject to the payment of such compensation, either by way of a capital sum or of periodical payments, as the Water Officer may decide, to such persons as the Water Officer may consider to be injuriously affected by the creation of the easement and in such proportion as the Water Officer may decide and may be made conditional on the construction and maintenance of such bridges and other works as may in the opinion of the Water Officer be necessitated by the severance of the land subject to the easement.

(7) If the person enjoying the benefit of an easement fails to pay such compensation as directed or to construct such bridges and other works within such time as is therefor allowed by the Water Officer, or fails to maintain or repair such bridges or other works after being required so to do by the Water Officer, the Water Officer may by notice in writing addressed to that person determine the easement.

(8) Any compensation due under this section which remains unpaid may be sued for as a civil debt.

(9) Any easement created by agreement between the holder of a water right and any other person may be made appurtenant to the land of the holder of the water right where the water right in respect of which the agreement is made is appurtenant to such land:

Provided that no such agreement shall operate to create an easement appurtenant to the land unless and until a copy of the agreement shall have been forwarded to the Water Officer by the holder of the water right.

Right to call for information

28. A Water Advisory Board, or a Water Officer may, for the purpose of this Act, call upon any person to give information on such matters and in such manner as may be prescribed.

Power to inspect works and require reparation etc.

29.-(1) A Water Officer and all persons authorized by him in writing and such officers as the Principal Secretary shall approve may, at all reasonable times, enter upon any land and may inspect any works constructed or under construction thereon and may take measures to ascertain the amount of water abstracted or capable of being abstracted by means of such works or otherwise.

(2) If in the opinion of the Water Officer any works are so constructed, maintained or used or are being so constructed as to constitute a danger to life, health or property, he may require any person for the time being enjoying the benefit of those works to carry out such repairs or to effect such additons or modifications to such works or to carry out such demolitions or to change the use of the works in such manner as he may consider necessary and may by notice in writing suspend any water right until he is satisfied that such requirement has been fulfilled, and thereupon the right shall cease for the period of the suspension.

(3) No compensation shall be payable to the owner or occupier of any land by reason that entry has been made upon such land in pursuance of the provisions of subsection (1) of this section.

Power to require demoliton of unlawful works

30.-(1) A Water Officer may by notice in writing require any person-

(a) who has constructed or extended or caused to be constructed or extended any works contrary to the provisions of this Act or of any other written law, not inconsistent with the provisions of this Act, under which such person was required or authorized to construct or extend the same or cause them to be constructed or extended; or

(b) whose water right or existing right in respect of which any works are in existence has been determined under the provisions of this Act or has otherwise come to an end,

to modify, demolish or destroy such works within such period, not being less than thirty days, as may be specified in the notice.

(2) If any person fails to comply with a notice served on him under subsection (1) of this section, it shall be lawful for the Water Officer to cause such works to be modified, demolished or destroyed and to recover the cost of the modification, demolition or destruction from the person in default by civil suit.

Power to establish hydrographic stations and make surveys

31.-(1) The Principal Secretary and all persons authorized by him may at all reasonable times enter upon any land for the purpose of making such investigations and surveys as the Principal Secretary may consider necessary in the interest of the conservation and best use of water, and may establish and maintain on any such land, without other authority than this Act, hydrographic stations and other works for the purpose of

obtaining and recording information and statistics as to hydrographic conditions.

(2) No compensation shall be payable to the owner or occupier of any land by reason that entry has been made upon such land in pursuance of the provisions of subsection (1) of this section but compensation shall be payable for all damage done and for any land occupied for the construction of works. In the absence of agreement such compensation shall be determined by the High Court on the application of the owner of occupier or of the Minister.

PART VII

APPEALS

Appeals

32.-(1) Any person who is aggrieved by the refusal of a Water Officer to grant or renew a water right, or by any conditions imposed when granting or renewing a water right, or by the determination or diminution or modification or suspension of any water right, or by the grant of or refusal to grant any easement or by the conditions subject to which any easement is created, or by any direction regarding the disposal of underground water abstracted from any workings or by any requirement that any work should be repaired, added to, altered, demolished or destroyed, or that the use of any works be changed may appeal to the appellate authority whose decision in the matter shall be final.

(2) Notwithstanding the provisions of subsection (1) of this section, no person may appeal against the grant or renewal of a water right or the grant of any easement, who did not make objection to such grant or renewal to the Water Officer under the provisions of subsection (2) of section 15 or subsection (3) of section 27, as the case may be.

(3) In this section, "appellate authority" means, in the case of an appeal against a decision of the Principal Water Officer, the Minister, and in the case of an appeal against a decision of a Regional Water Officer, the Regional Commissioner of the region in which the relevant regional water supply is situate.

PART VIII

OFFENCES

Offences and penalities

33.-(1) Any person who in order to procure the grant of a water right wilfully makes any statement knowing the same to be false in any material particular or not having reason to believe the same to be true shall be guilty of an offence and liable upon conviction to a fine not exceeding five thousand shillings or to imprisonment for a period not exceeding two years or to both such fine and such imprisonment.

(2) Any person who constructs or extends any works contrary to this Act or fails, without reasonable excuse, to comply with a requirement made under section 29 or wilfully obstructs, damages or destroys any works or destroys, defaces or moves any level mark, beacon or other structure or appliance or obstructs, molests or hinders any public officer in the lawful exercise of his powers or duties under this Act shall be guilty of an offence and liable upon conviction to a fine not exceeding two thousand shillings or to imprisonment for a period not exceeding twelve months, or to both such fine and such imprisonment or in the case of a second or subsequent conviction to a fine not exceeding five thousand shillings or to imprisonment for a period not exceeding two years, or to both such fine and such imprisonment, and in every case where the offence is a continuing one to an additional fine not exceeding one hundred shillings in respect of every day during which the offence has continued.

(3) Any person who, contrary to the provisions of this Act, diverts, dams, stores, abstracts or uses water or who, being the holder of an existing right or a water right granted under this Act or the occupier of any land to which an existing right or a water right has been made appurtenant, abstracts or uses water in excess of that authorized or for a purpose other than that authorized shall be guilty of an offence and liable upon conviction to a fine not exceeding one thousand shillings or in the case of a second or subsequent offence to such fine or to imprisonment for a term not exceeding six months or to both such fine and such imprisonment, and in every case where the offence is a continuing one to an additional fine not exceeding one hundred shillings in respect of every day during which the offence continued.

(4) Any person who pollutes the water in any river, stream or watercourse or in any body of surface water to such extent as to be likely to cause injury directly or indriectly to public health, to livestock or fish, to crops, orchards or gardens which are irrigated by such water or to any products in the processing of which such water is used shall be guilty of and offence and liable upon conviction to a fine not exceeding two thousand shillings or to imprisonment for a period not exceeding twelve months or to both such fine and such imprisonment or in the case of a second or subsequent conviction to a fine not exceeding five thousand shillings or to imprisonment for a period not exceeding two years or to both such fine and such imprisonment and in every case where the offence is a continuing one to an additional fine not exceeding one hundred shillings in respect of every day during which the offence has continued.

(5) Any person who being required to give information under any provision of this Act or under any regulation made under this Act refuses without reasonable excuse to give such information or gives information knowing the same to be false, or having reason to believe the same not to be true, shall be guilty of

an offence and liable upon conviction to a fine not exceeding five thousand shillings or to imprisonment not exceeding two years or to both such fine and such imprisonment.

PART IX

MISCELLANEOUS PROVISIONS

Registration

34.-(1) Every Water Officer shall keep a register for the registration of every grant or renewal of a water right made by him and of the variation, determination or modification or suspension of a water right or existing water right, and of any easement created or determined by him.

(2) The Principal Water Officer shall establish a central registry of water rights registered under this Act.

(3) Every Regional Water Officer shall supply without delay to the Principal Water Officer a copy of every entry made in his register of water rights and shall, upon application being made to him by any other Regional Water Officer or public officer, forthwith provide without fee a copy of any entry in his register of water rights.

(4) Any person shall, on application to a Water Officer, be entitled to receive certified or uncertified extracts from the register of water rights maintained by such Water Officer.

(5) Extracts from any register of water rights certified to be under the hand of a Water Officer shall be admissible in evidence in all legal proceedings, civil or criminal, without proof that they are under the hand of the Water Officer purported to have certified the same and shall also be PRIMA FACIE evidence of the facts recorded therein.

(6) The entry of any easement in a register of water rights under this section shall not affect any requirements as to registration contained in, or be construed as being an effective registration for the purposes of, or in lieu of registration under the provisions of, the Registration of Documents Ordinance or the Land Registration Ordinance.

Cap. 117
Cap. 334

35. A Notice under this Act shall be deemed to have been served on, or given to, any person-

(a) if served on him personally; or

(b) if left for him at his last known address; or

(c) if sent by registered post addressed to his last known address.

Civil liability not affected

36. Subject to any express provisions in this Act, nothing contained in this Act shall affect the civil liability of any person for any damage resulting from the construction, alteration or destruction of any works or the failure to maintain the same in proper repair of from the obstruction, storage or diversion of any water.

Indemnity
Cap. 16
Acts 1970
No 7

37. Without prejudice to the provisions of section 284A of the Penal Code or of the Specified Officers (Recovery of Debts) Act, 1970, no member of a Water Advisory Board or public officer shall be personally liable for any act or default which is done or omitted to be done in good faith in the exercise of purported exercise of the powers conferred by this Act.

Power to make rules and Regulations

38.-(1) The Chief Justice may make rules of court for regulating proceedings before the High Court and applications thereto under the provisions of this Act and for the fees to be paid in respect thereof.

(2) Subject to the provisions of subsection (1), the Minister may make regulations prescribing anything which may be prescribed under this Act and for the better carrying into effect of the provisions of this Act, and without prejudice to the generality of the foregoing, such regulations may-

(a) prescribe the registers and records to be kept and the manner in which they are to be kept;

(b) provide for the forms to be used and the fees to be paid in respect of any matter required or permitted to be done under this Act;

(c) provide for the advertisement of applications for the use of water and for the giving of notice to interested persons;

(d) provide for and regulate the making of objections to a Water Officer and the time within which such objections shall be made;

(e) regulate the procedure of appeals under section 32 of this Act;

(f) provide for the formation, functions and conduct of local associations of water users;

(g) in the case of a water right or existing right enjoyed by an association of persons, regulate the division and distribution of water between those persons;

(h) prescribe the matters on which and the manner in which persons may be required to give information as provided in section 28;

(i) prescribe the quorum of, and the procedure to be adopted by Water Advisory Boards, the manner in which and the extent to which they shall receive evidence and hear arguments by objectors and others, and the manner in which they shall record their findings;

(j) provide for the transfer, to the land register under the Land Registration Ordinance or to a register maintained under the Registration of Documents Ordinance, of particulars of easements which were registered in the Water Grants Record maintained under the Water Ordinance hereby repealed and which subsist on the date upon which this Act comes into operation. Cap. 334 Cap. 410 Cap. 117

Repeal and saving
Cap. 410

Acts 1972
No. 30

39.-(1) The Water Ordinance is repealed.

(2) For the avoidance of doubts it is hereby declared that the provision of sections 14 and 15 of the Interpretation of Laws and General Clauses Act, 1972 shall apply in respect of the repeal of the Water Ordinance and its re-enactment by this Act.

(3) All certificates, permits and authorities granted under the Water Ordinance and which are valid immediately before the commencement of this Act shall remain valid and continue in effect if the same had been granted under this Act notwithstanding the repeal of the Water Ordinance by this Act.

Passed in the National Assembly on the twenty-second day of October, 1974.

W.J. Maina,
Acting Clerk of the National Assembly.

NOTES AND DRAFT OF PROPOSED AMENDMENTS TO WATER UTILIZATION ACT

This section states that the Act is comprenhensive, regulating all aspects of water. "Water" shall be defined in §2 (c.f. WUA §2). Possibly there is a need for provisions for shipping etc. (but not for pollution etc. from vessels). Such provisions could be introduced immediately after the first subsection.

The application to Government etc. can with necessary changes be based upon §3 in the WUA.

PART I

1. Short title etc.
2. Interpretation (legal definition)
3. (1) This act applies to:
   (i) all use of water within Tanzania
   (ii) all use of land which directly or indirectly in any way may affect water;
   (iii) all activities and factors which may directly or indirectly pollute any water.

   (2) Without prejudice to the generality of the application of this Act, it is hereby declared that the provisions of this Act shall apply to and be carried into effect by ... (c.f. WUA §3).

In this Act we are proposing to remove the Regional Water Officers and Regional Water Advisory Board. The Principal Water Officer will be responsible for the legal regulation of extraction, and quality of effluent, and receiving waters.

The Water Basin Board might comprise, and this could be specified in the Act,

(a) A Board containing certain officials particularly regional development directions but also representatives of the major central agencies involved (Kilimo, MAJI, Afya, Lands)

(b) The secretariat would be within PPD, MAJI, separate section for each Water Basin and include hydrologist, information system specialist, water engineer, economist, representatives from the associated ministries. The secretariat would do the work, planning, and maintain extraction records.

PART II APPOINTMENT OF OFFICERS AND ESTABLISHMENT OF /AUTHORITIES/ .....

Under this subtitle, the administration for implementing the Act and for granting of Water Rights and Permits as well as for supervision shall be laid down. So far, we have no expressed proposals, and the proposed outlines for legislation presented below are just based upon the assumption that there will be:

- Principal Secretary
- Principal Water Officer
- Central Water Advisory Board
- Water Basin Board
- Water Basin Planning Secretariat

There are at least two alternatives as to who shall make certain decisions: (1) The Water Basin Board may take over the task of the Regional Water Officers and the Principal Water Officer (the latter is proposed to have ultimate responsibility for the enforcement of the rules in this Act);
(2) The Water Basin Plan is enforced partly or totally by the Regional Authorities who, under sections proposed in the following, are bound by the regulations in the Plan once it is approved.

By this is meant the principal drainage basins of Tanzania.

PART III: WATER BASIN PLANS

1. The Minister or, upon delegation, the Principal Secretary (MAJI) shall specify Water Basins.

2. For each Water Basin of Water Basin Board shall be established and, an appropriate comprehensive Water Basin Plan prepared including monitoring of progress and regular reporting.
The Principal Secretary shall approve a Water Basin Plan only when the Plan is sufficient for the purpose of this Act. If the Plan is sufficient, but the Principal Secretary deems it possible to make it more effective for the purpose of this Act and with respect to the benefits at a whole for the region or the Republic, such approval may be preliminary and include a specific period within which the Plan shall be revised to fulfill the effectiveness in question, and delivered to the Principal Secretary for approval.

   If the Plan is not sufficient for the purpose of this Act, the Principal Secretary shall lay down interim regulations for the Basin as he deems necessary for the purpose of this Act, and specify a period within which a revised Plan shall be delivered to him for approval.

   The Principal Water Officer shall advise the Principal Secretary on all legal and regulatory aspects of the Basin Plans.

3. Water Basin Plans shall contain such regulations which are necessary or suitable to fulfill the purpose of this Act and to meet the requirements and standards applicable for any water or and any water use.

   Without prejudice to the generality of the foregoing, a Water Basin Plan shall:

   (1) identify current use of water from each source or source area

   (2) identify all existing rights to water in the Basin

   (3) identify current and expected pollution of all water in the Basin, whether water borne, airborne or other

   (4) specify Receiving Water Quality Standards for the Basin

   (5) propose projects for implementation over a five year period covering rural water supplies, urban water supplies, irrigation, drainage, hydroelectric, fishing, water transport with appropriate justification, cost estimates, etc. and within cost guidelines laid down by the Principal Secretary, Ministry of Finance.

   (6) lay down any restrictions and regulations on any or all discharge, land use or any other activity, whether temporary, intermittent or permanent, as deemed necessary to achieve and maintain Drinking Water Standards and, Receiving Water Quality Standards for the Basin.

(7) lay down regulations for the use of the water within the Basin

(8) the Water Basin Plan will specify the responsible officers for implementation of the various policies, prespects, programmes, and regulatory functions that it may contain.

This section states explicitly what is contained in other proposed rules, i.e. that regulations in approved Water Basin Plans and regulations which the Principal Secretary has laid down when a Plan is not sufficient, are to be treated as law, and therefore have the same status for any person as if the regulation was taken into the Act.

4. Any regulation laid down in a Water Basin Plan and any regulation laid down by the Principal Secretary under 2(3) and V.5 shall be considered as part of this Act.

This rule is the same kind of safety valve as is introduced in the WUA §15-(4).

5. Nothing in any Water Basin Plan or regulations under 2(3) and V.5 shall be deemed to imply any guarantee that the quantity or quality of water thereon referred to is or will be available.

There are no detailed proposals as to which rules shall be laid down for the purposes in §1 through 5 (corresponding to the so called inherent rights to the use of water in Part III of the WUA). One difference, being in consequence with the proposal of Water Basin Plans, is abolishing the legal institute National Water Supply (WUA §9), also, §11 of the WUA is split into two sections (one for groundwater, one for casual water). This section should be general but sketch out what the Water Basin Plan should contain.

This wording is found in the WUA §14 (without brackets). The reference to §53 of the Mining Ordinance we do not understand, since §54 not 53 of that Ordinance gives surface rights of lease i.e. to lay water-pipes, make dams, etc. whereas §53 regulates mining for minerals other than that for which lease is granted; according to the text we have available. If that text is correct, reference should be made to §54, if such a provision shall be made at all.

This rule aims at such activities which, without being classified as use of water, may affect the level of groundwater, the volume of suppliable water etc. (quarrying, construction work, etc.).

PART IV: WATER USE

1. Water for domestic purposes.
2. Underground water.
3. Casual Water.
4. Mining purposes.
5. Forestry purposes.
6. Any right under section 1 through 5 may be restricted or terminated under the provisions of this Act.

7. Subject to the provisions of this Part (and to the provisions of section 53 of the Mining Ordinance), no person shall divert, dam, store, abstract or use water or for any such purpose construct or maintain any works, except in accordance with an existing right or with a Water Right granted under this Act.

8. No person shall conduct any other activity which affects or is likely to affect the volume of water in any water supply, without a permit.

   The minister may specify categories of such activities.

General basic rule (cf WUA §17-(a) (iii). "Water" defined in the interpret. §I:2 cf WUA. "Activity" defined in the interpret. §I:2. Includes anything that a person directly or indirectly can do, including but not restricted to industry, quarrying, digging, draining, damming, discharging, waste deposit, littering, constructing and using highways, airports etc. housing....

"Protective measure" defined to include any measures, whether it as abatement or process technology or other measures such as restricting the activity in any way.

"Guiding effluent standards" defined as standards for discharge from certain categories of sources, the standards are not mandatory but guiding for the decision makers, i.e. if there is special reason because of new technology being available (which was not foreseen when specifying the standards) or if the receiving water will not degrade to such extent that it is beneficial to apply the standards, then the discharge permit may include other standards which apply to the provisions of this section.

PART V: WATER QUALITY

1. Water shall not be polluted as a result of any activity to such extent as to be likely to cause injury either directly or indirectly to public health, to livestock or fish, to crops, orchards or gardens which are irrigated by such water or to any product in the processing of which such water is used.

2. No person shall carry out any activity without taking protective measures to prevent degradation of the quality of any water.

   The protective measures shall be based upon the best available technology which is feasible with respect to economics and to benefit from such measures in each case.

   The Principal Secretary may prescribe guiding effluent standards for the purpose of this section.

   Any industrial activity must be sited where it causes least degradation of water quality. Provided that if an approved Water Basin Plan explicitly allows such industry and such discharge, a siting according to that Plan may be permitted.

Receiving Water Quality Standard defined as a standard set for a body of water or a part of it or a groundwater resource in a Water Basin Plan or by regulation by the Principal Secretary.

Domestic Water Standard defined as temporary or other standard for domestic water laid down under any Tanzanian legislation.

COOMENT to the offset clause. This clause gives the possibility to allow certain beneficial activities, provided that other contributions of the same pollutant (equivalent) as a result from the starting of the new activity (but only then, not if the other activities would have terminated even if the new activity had not started) decreases with more than the new activity contributes with. Contribute defined as affecting the quality, but not as adding a quantity of pollutants. This type of clause has been found necessary just recently in the US Clean Air enforcement, to allow for a certain growth in areas which do not comply with the Ambient Air Quality Standards, without having to abandon or indefinitely postpone the achievement of the standards. This technique for legislation is probably quite necessary for Tanzania to integrate a water policy with the needs of growth. Still it does not allow such growth which completely stops the improvement of water quality.

3. No person shall carry out any activity which will, directly or indirectly, contribute to the violation of any Receiving Water Quality Standard or any Domestic Water Standard.

   Provided that an activity may be started which although contributing to the violation, if the new activity directly provides for the termination of other activities or pollution contributing to the same violation, and this offset causes the total contribution to the violation to decrease.

"Quality Standard" includes Receiving Water Quality Standards and Domestic Water Standards, The Domestic Water Standards are primarily enforced under special legislation.

4. If any Quality Standard is not met, all necessary measures must be taken to achieve and maintain the Standard.

   If each person who carries out an activity complies with conditions in a granted Water Right or Discharge Permit or with the inherent right of this act, and any Standard is not met, the Water Basin Plan shall be revised within 12 months to achieve and maintain the Standard.

   Provided that if the Authority can achieve the Standard by consent from a holder of a Right or Permit, revision is not mandatory.

5. The Principal Water Officer shall by regulations enforce such Quality Standard which is not met, provided that the Authority does not comply with section 4 to the satisfaction of the Principal Water Officer.

ANNEX 8.3

TEMPORARY STANDARDS OF QUALITY OF DOMESTIC WATER IN TANZANIA PRESENTED BY THE RURAL WATER SUPPLY HEALTH STANDARDS COMMITTEE

1. Definitions

1.1 Temporary Standards of Quality of Domestic Water in Tanzania are those Standards which will be in use until such time that circumstances permit the full application of International Standards of quality of domestic water.

1.2 Urban Water Supplies are those water systems serving cities, municipalities and townships.

1.3 Large Scale Rural Water Supplies are those water systems serving a rural population of more than 5 000 people.

1.4 Small Scale Rural Water Supplies are all other organised water sources not defined under 1.2 and 1.3 above.

2. Applicability

International Standards of Quality of Domestic Water will apply to waters distributed through water sources defined under 1.2 and 1.3, and all those water systems which have treatment systems more complex than simple sedimentation and/or rapid filtration appliances.

2.2 Temporary Standards of Quality of Domestic Water will apply for water defined under 1.4.

3. Temporary Standards

The Temporary Standards of Quality of Domestic Water in Tanzania are divided into three categories, as shown below:

3.1 Bacteriological Standards

3.1.1 Frequency and location of sampling

(i) Distances from the source to the testing laboratory should be such as to enable effective supervision of the bacteriological quality of the water supply.

(ii) All waters defined under 1.2 and 1.3 should be examined according to International Standards of Quality of Domestic Water.

(iii) Frequency of sampling should be based on (a) size of the population served, (b) risk of pollution i.e. distance from and nature of pollution source, (c) nature and extent of sanitary protection of the source.

(iv) All waters defined under 1.4 should be examined at the following intervals:

Population served Type of Source	Up to 1 000	Up to 2 000	Up to 5 000
Borehole deeper than 8 m (26.25 feet)	6 months	4 months	3 months
Well less than 8 m (26.25 feet)	2 months	1 month	1 month
Surface water, lakes, rivers, springs, dams	1 month	2 weeks	2 weeks

(v) The minimum number of samples to be taken from a distribution system is calculated at the rate of one sample per 500 population in addition to the intake or source.

(vi) The above prescribed frequency of sampling refers to those water supplies which on previous examination showed total absence of faecal coli. If the result of bacteriological examination indicates faecal pollution, the water supply in question should be re-examined within a fortnight, at the latest, irrespective of the type of source or population served.

(vii) Water engineers should determine key points on the distribution system from which samples should be collected. On each occasion samples should be taken from different points.

3.1.2 Standards of bacteriological quality of drinking water. Drinking water should not contain any organism of faecal origin. The presence of coliform organism should be considered as an indication of remote faecal pollution. The presence of Escherichia coli (faecal coliforms) indicates recent faecal pollution, and hence dangerous condition if found in consecutive samples of water tested. Coliform organisms are those organisms which are capable of fermenting lactose with the production of acid and gas at 35 - 37°C in less than 48 hours, and are Indole negative. Escherichia coli (faecal coliforms), are those organisms which are capable of fermenting lactose with the production of acid and gas at 44°C in less than 24 hours, and which are indole positive. The bacteriological standard to be aimed at is the same as the WHO one which demand that there be no coliforms (E. coli) in each 100 ml portions (piped water supplies).

3.1.3 Standard and classification of non-chlorinated piped water supplies:

Class of piped water	Type of test count	Coliform count per 100 ml at 37°C	E. Coli (faecal coliform) count per 100 ml at 44°C
Excellent		0	0
Satisfactory		1 - 3	0
Suspicious		4 - 10	0
Unsatisfactory		More than 10	1 or more

For each individual sample coliforms should be estimated in terms of the "Most Probable Number" in 100 ml of drinking water, which is often designated as MPN index or Coli index. Occurrance of E. coli (faecal coli) in consecutive samples, in less than 100 ml of drinking water is an indication of faecal pollution and hence a dangerous situation needing urgent ratification.

3.1.4 Methods for bacteriological examination of rural waters. Whenever conditions permit (see below) the microfilter technique, as described in the various microfilter water testing guides or in the Standard Methods for the Examination of Water, Sewage and Industrial Wastes, 12th Edition, published by the American Public Health Association, Inc., employing faecal coli selective M-FC medium (Difco) at 44.5°C temperature of incubation, should be employed, as described by Geldreich inter alia. (I) If, on the other hand high turbidity or thick sediments of water of overgrowth of algae or colonies other than E. coli render filtration impossible technique at 44°C followed by the confirmatory indole test as described in the Standard Methods Book mentioned above, as well as the WHO Operation and Control of Water Treatment Process should be employed.

3.2 Physical and Chemical Standards

3.2.1 Frequency of Sampling: Irrespective of the size of population, all types of waters should be tested at least two times per year - once under dry conditions and once under rainy conditions.

3.2.2 The Tanzania Temporary Standards of Physical and Chemical quality of drinking water are given on Table 1 (see page 5 & 6) and compared with Standards of other countries as well as WHO (International Standards).

3.3 Standards of Sanitary Protection of Water Intake and Surrounding Land.

3.3.1 The Committee urges the Ministry of Water, Development and Power and/or Ministry of Health to expedite the formation of an advisory Board which should define and set up sanitary zones, basing these should be an integral part of every Rural Water Supply System.

3.3.2 Distance to Source of Contamination: When considering the following suggested distances from sources of pollution, the views of experienced Health Officers and/or Water Engineers, after inspecting each installation, should always be taken into account:

50 meters for pit privies, septic tanks, sewers. 100 meters from borehole latrines, seeping pits, trenches and sub-surface sewage disposal fields, 150 meters from cesspools, sanitary land field areas and graves.

In addition to the above minimum distances, the following precautions must also be observed:

(i) Domestic livestock and other animals should be kept away from the intake by fencing the area of a minimum radius of 50 meters from the installation.

(ii) Defecation and urination around the intake should be completely prohibited, by law.

(iii) Drainage and run off waters should be led away from intakes.

(iv) The water source should be guarded against inundation by the flooding of nearby rivers.

(v) Soil erosion should be prevented by reforestation and other methods.

(vi) Algal growth should be prevented by draining swamps and pools around the intake or reservoir.

TABLE 1.—THE TANZANIAN TEMPORARY STANDARDS OF PHYSICAL AND CHEMICAL QUALITY OF POTABLE WATER COMPARED WITH STANDARDS OF OTHER COUNTRIES AND OF WORLD HEALTH ORGANISATION

No.	Water Classification and Substances	STANDARDS OF WATER QUALITY OF DIFFERENT COUNTRIES								
		Units	International (a)		European (b)	American (c)	Swedish (d)	French (e)	Bulgarian (f)	Tanzanian (g)
			Acceptable	Allowable						
1.	Water causing toxic effects									
1.1	Lead, Pb	mg/l	n.m.	0.05	0.10	0.05	0.02/0.05	n.m.	0.10	0.10
1.2	Arsenic, As	mg/l	n.m.	0.05	0.05	0.05	0.01/0.05	n.m.	0.05	0.05
1.3	Selenium, Se	mg/l	n.m.	0.01	0.01	0.01	0.01/0.05	n.m.	0.05	0.05
1.4	Chromium (b+), Cr	mg/l	n.m.	0.05	0.05	0.05	0.02	n.m.	0.05	0.05
1.5	Cyanide, CN	mg/l	n.m.	0.20	0.05	0.01	0.01/0.20	n.m.	0.01	0.20
1.6	Cadmium,Cd	mg/l	n.m.	0.01	0.01	0.01	0.01	n.m.	0.05	0.05
1.7	Barium, Ba	mg/l	n.m.	1.00	1.00	1.00	n.m.	n.m.	1.00	1.00
1.8	Mercury,Hg	mg/l	n.m.	n.m.	n.m.	n.m.	0.001/0.005	n.m.	n.m.	n.m.
1.9	Silver, Ag	mg/l	n.m.	n.m.	n.m.	0.05	n.m.	n.m.	n.m.	n.m.
2.	Water affecting human health									
2.1	Fluoride, F	mg/l	n.m.	1,5	0.7—1.7	0.8—1.7	1.5	n.m.	0.7—1.0	8.0
2.2	Nitrate, No_3	mg/l	n.m.	30.0	50/100	45	30	44	30	(100)
3.	Water for general domestic use									
3.1	Water being organo-septic									
3.1.1	Colour	mgPt/l	5	50	n.m.	15	10	n.m.	15	50*
3.1.2	Turbidity	mgSiO_2/l	5	25	n.m.	3	weak	n.m.	30cm(y)	30*
3.1.3	Taste	—	*n.o.*	*n.o.*	*n.m.*	nil	weak	n.m.	nil	n.o.*
3.1.4	Odour	—	n.o.	n.o.	n.m.	3(x)	n.m.	n.m.	2bal(y)	n.o.*
3.2	Water of salinity and hardness									
3.2.1	pH	—	7.0—8.5	6.5—9.2	n.m.	n.m.	6.0—8.0	n.m.	6.5—8.5	6.5—9.2*
3.2.2	Total filtrable residue	mg/l	500	1500	n.m.	n.m.	200	2000	n.m.	2000*
3.2.3	Total hardness	mg$CaCO_3$/l	n.m.	n.m.	500	n.m.	n.m.	300	450	600*

TABLE 1.—THE TANZANIAN TEMPORARY STANDARDS OF PHYSICAL AND CHEMICAL QUALITY OF POTABLE WATER COMPARED WITH STANDARDS OF OTHER COUNTRIES AND OF WORLD HEALTH ORGANISATION

No.	Water Classification and Substances	STANDARDS OF WATER QUALITY OF DIFFERENT COUNTRIES								
		Units	International (a)		European (b)	American (c)	Swedish (d)	French (e)	Bulgarian (f)	Tanzanian (g)
			Acceptable	Allowable						
3.2.4	Calcium, Ca	mg/l	75	200	n.m.	n.m.	n.m.	n.m.	150	n.m.
3.2.5	Magnesium, Mg	mg/l	*50*	*150*	*125*	*n.m.*	n.m.	125	50	n.m.
3.2.6	Magnesium—Sodium Sulphate	mg/l	500	1000	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
3.2.7	Sulphate, SO_4	mg/l	200	400	250	250	25/250	250	250	600*
3.2.8	Chloride, Cl	mg/l	200	600	600	250	25/250	250	250	800*
3.3	Water with non toxic metals									
3.3.1	Iron, Fe	mg/l	0.3	1.0	1.0	0.3	0.2	0.2	0.2	1.0*
3.3.2	Mangenese, Mn	mg/l	0.1	0.5	0.05	0.05	0.05	0.1	0.1	0.5*
3.3.3	Copper, Cu	mg/l	1.0	1.5	0.05/3.00	1.0	0.05/1.0	0.2	0.2	3.0*
3.3.4	Zinc, Zn	mg/l	5.0	15.0	5.0	5.0	0.3/5.0	3	3	15.0*
3.4	Water with organic pollution of natural origin									
3.4.1	BOD 5	mgO_2/l	n.m.	6.	n.m.	n.m.	2	n.m.	2.6	6.0
3.4.2	PV (Oxygen abs. $KMnO_4$)	mgO_2/l	n.m.	10	n.m.	n.m.	20	n.m.	nil	20
3.4.3	Ammonium, NH_3	mg/l	n.m.	0.5	0.05	n.m.	0.1	n.m.	n.m.	n.m.
3.4.4	Total Nitrogen, exclusive Nitrate	mg/l	n.m.	*0.1*	n.m.	n.m.	n.m.	n.m.	n.m.	1.0
3.5.	Water with organic pollution introduced artificially									

TABLE 1.—THE TANZANIAN TEMPORARY STANDARDS OF PHYSICAL AND CHEMICAL QUALITY OF POTABLE WATER COMPARED WITH STANDARDS OF OTHER COUNTRIES AND OF WORLD HEALTH ORGANISATION

No.	Water Classification and Substances	STANDARDS OF WATER QUALITY OF DIFFERENT COUNTRIES								
		Units	International (a)		European (b)	American (c)	Swedish (d)	French (e)	Bulgarian (f)	Tanzanian (g)
			Acceptable	Allowable						
3.5.1	Surfactants ABS	mg/l	0.5	1.0	n.m.	n.m.	n.m.	n.m.	n.m.	2.0*
3.5.2	Organic matter as carbon in chloroform extract	mg/l	0.2	0.5	0.5	0.2	nil	n.m.	1.0	0.5
3.5.3	Phenolic substance as phenol	mg/l	0.001	0.002	0.001	0.001	n.m.	n.m.	0.001	0.002

Notes:

n.m. = not mentioned
n.o. = unobjectionable
(x) = Odour scale in use in U.S.A.
(y) = Transparency measured as thickness of water layer through which standard type can be read.
(z) = Bal-unit of odour in the scale used in U.S.S.R.
(a) = Intern. Standards for Drinking Water, WHO, Geneva, 1963
(b) = Europ. Standards for Drinking Water, WHO, Geneva, 1970
(c) = U.S. Public Health Service Drinking Water Standards.
(d) = Report on Water Quality Criteria for Swedish Surface Waters, National Swedish Conserv. Office, 1969.
(e) = Handbook of Water Treatment, Societe Degremont, Paris, 1965.
(f) = Date of issue unknown, similar standards are in force in Eastern Europe.
(g) = Proposed temporary standards for Rural Water Supplies by RWSHSC, 1973.
* = tentative figures.

3.3.3 Surface Water Intakes: When water is drawn from rivers, streams, lakes and reservoirs, the following shall be observed in respect of intakes:

Intakes should be so placed and designed as to draw water that is clean and palatable as the source of water supply can provide:

(a) River intake should be constructed up-stream from villages and industrial factories, and the intake should be in deep water close to a stable bottom.

(b) Small Stream Intake should comprise an intake-pool which can also act as a settling "basin".

(c) Lake Intake should as much as possible avoid shore water, avoid stirring up of sediments, and seek the clean bottom water.

3.3.4 Sanitary Protection: Chlorination of newly built water supplies is advisable before handing over the water supply to the public.

4. Comments

4.1 Bacteriological Standards: No further comments

4.2 Comments on Physical and Chemical Standards:

International Standards as well as the proposed Tanzanian Temporary Standards categories the standards into three district sub-sections.

(i) Substances which are toxic

(ii) Substances which effect human health, which would result in chronic states if ingested in large quantities over a long period.

(iii) Substances which affect palatability of drinking water or affect the suitability of water for general domestic purposes.

4.2.1 Standards for substances classified as toxic for Tanznia are those that are designated toxic in the International Standards.

(a) These substances, if present in water, may cause immediate and serious toxic effect to the water consumer's health.

(b) They are not very common in natural water but are usually introduced to the body of water as result of human activities, such as discharged industrial effluents etc.

(c) Wherever factories or other sources of pollution are known to discharge their wastes into water sources, the waters should be checked, and remedial measures taken, in order to minimise the toxic hazards.

4.2.2 Standards of substances which effect human health

4.2.2.1 Fluorides

In Tanzania 95% of the population live in rural areas where from 3.5% (Coast Region) to 59% (Mwanza Region) of the water supplies contain concentrations of fluorides which are well above the International (WHO) recommended level (2). Although dental surgeons (3) are very firm about the negative effects of high levels of fluorides in drinking waters, the WHO Manual on fluorides and Hyman Health (4) insinuates that the dental damage caused by excessive concentrations of fluoride in water may not be per se reflection of the fluoride concentration, but may in fact be the result of the combination of excess fluoride levels in water plus other as yet unspecified dietary habits. Medical and veterinary evidence regarding systematic changes attributable to high concentrations of fluorides in water in Tanzania is still scanty. Judging from the questionnaires returned by doctors from all over Tanzania (5), fluorosis appears to be rare in all parts of Tanzania except in Kilimanjaro and Arusha. In view of this scanty information regarding systematic fluorosis, the Ministries of Health and Agriculture, in conjunction with the Ministry of Water Development and Power should conduct sample surveys in areas of high and low endemicity.

In view of the fact that concentrations of fluoride in drinking water of up to 8 mg/l do not produce abnormal effects on bones in man but do in fact benefit the elderly from bone decalcification, the Committee has deemed it fit to recommend this level of 8 mg/l as the maximum tolerable concentration, in declaring drinking waters temporarily adequate for human comsumption. If this figure of 8 mg/l is observed, then up to 95.5% of all waters in Tanzania would require no defluoridation whereas only 24% in Singida, 18% in Arusha, 12% in Shinyanga and 10% in Mwanza Regions would require defluoridation.

77 In the cases of excessive levels of fluorides, treatment by the filtration method (3) should be employed.

4.2.2.2 Nitrates

These have been know to cause methaemoglobinaemia in infants who are fed on artificial diets when nitrate/nitrite Nitrogen concentration is higher than 10.2 mg/l in the water utilised for preparing such infants diets.

High nitrate/nitrite Nitrogen levels are unlikely to cause methaemoglobinaemia in Tanzania where the great majority of infants in the rural areas are breast fed for at least one

year, and since the toxic agents are not normally secreted into mother's milk.

This, coupled with the facts that most surface water and ground waters in Tanzania, particularly in central regions, certain high levels of nitrates and there being no feasible means of denitrating such water the Committee deemed it fit to stipulate no strict limit to nitrates occurring in water due to natural causes other than artificial pollution. However, when nitrate concentration of a water exceeds the International (WHO) limit of 100 mg/l the water authorities concerned will have to alert the appropriate health authorities to the possibility of infantile methaemoglobinaemia.

4.2.3 Standards of substances which affect the palatability of water or its suitability for general domestic use. The figures appearing on the Table 1 and market with asterisk are tentative because the Committee feels that considerable volume of investigation of purely sociological nature still remains to be carried out to ascertain at what levels of these ingredients in water palatability or suitability of water for domestic use is interfered with.

It should be emphasised that no severe harm to human health can be done by ingesting or using for domestic purposes a water which contains the concentration of these substances shown on Table I. Thus, the tentative limits quoted for these substances in Table I should be regarded as their concentration limits above which the majority of water consumers would feel discomfort, and would consider the water unpalatable and a nuisance due to their slightly purgative effects or due to their accompanying scalling, deposits formation, or corrosion, etc.

When more data on the extent of this discomfort and unacceptability is obtained for a much wider cross section of the population, the pros and cons of altering these tentative limits may be considered.

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(5) Central Pathology Laboratory: Occurrence of Waterborne and related Diseases Questionnaire
Ministry of Health, Dar es Salaam, 1972

ANNEX 8.4

REPORT OF THE EFFLUENT STANDARDS COMMITTEE. JUNE/JULY 1977.
EXCERPT.
CHAIRMAN Government Chemist P.J. Madati

5.7 RECOMMENDATIONS

5.7.1 The Attorney General's Chambers and relevant Ministries such as Ministry of Water, Energy and Minerals, Ministry of Health, Ministry of Industries, Ministry of Agriculture, Ministry of Natural Resources and Tourism, Ministry of Land, Housing and Urban Development, Ministry of Communications and Transport alongwith some prominent representatives of Dar es Salaam University and W.H.O., should sit and seriously review laws and regulations relating to environmental pollution. If they deem it fit, a new Environmental Pollution Act may be drafted. For example the existing laws, include AFYA's proposed Public Health Act (section 3 - Environmental Health and Liquid Wastes, 4 - Water supply, 11 - Building/sanitation, 13 - Port Health Sanitation, 20 - The Occupational Health, 21 - The Radiation Law). They also include Water Utilization (Control and Regulation) Act 1974. The Fisheries Act of 1970 and its Regulations of 1973, The Forestry Act, and anyother, with a view of consolidating control measures against environmental pollution and in particular, water pollution.

5.7.1.1 Since the Urban Planning Section of the Ministry of Land and Urban Planning is the current custodian of all UNEF affairs in Tanzania, and is supposed to coordinate all matters pertaining to environmental protection and management, ARDHI should convence a series of meeting of all relevant parties with the aim of forming an Environmental Pollution Control Authority which will at present be confined to water pollution only separately or as a part of Tanzanian Environmental Protection and Management Authority which will deal with desertation or reaforestation as well.

5.7.1.2 Such an Authority or Board must be a full time organ with an active secretariat, and located in a powerful Ministry such as IKULU or WAZIRI MKUU.

5.7.1.2.1 It should be borne in mind that these suggestions may be violently opposed, more out of ignorance than malice; since other countries even have full Ministries of Environment, while most of our neighbouring countries have strong Environment Boards, often directly in the President's office.

5.7.1.3 It is not altogether impossible to establish such an Environmental Pollution (or Protection and Management) Authority as subsidiary legislations to one of the Acts mentioned in 5.7.1 above.

5.7.1.3.1 Similarly, the Effluent Standards or Standards of Receiving Waters could be incroporated as part of the regulations of one of the above mentioned Acts, presumably of Water Utilisation (Control and Regulation) Act of 1974, which already exists and also contains some description regarding pollution control.

5.7.1.4 The Environmental Pollution (or Protection and Management) Authority's main preoccupation would be to promulgate the proposed Standards within its own new Act or as regulations to one of the existing Acts; and to emphasise obligations of the users and provide for the strictest possible penalties in cases of indicriminate pollution offences.

5.7.2.2 Since the major pollution carrier is water and the not results of any pollution is to affect the health of people and livestock, let the active participants to the meeting to be called by ARDHI (see 5.7.1.1) be the Ministry of Health and Ministry of Water, Energy and Minerals. The other members may be representatives from the various relevant Ministries and institutions.

5.7.2.3 Major responsibilities, authority and power of the Authority, should be as proposed briefly hereunder:

5.7.2.3.1 Responsibiliteis of the Tanzania Water Pollution Control Authority

- To conduct studies, investigations research and surveys of the existing pollution problems of the country; assess and prepare comprehensive national Plans for control of Pollution.

- To study harmfull effects of pollution (presently water pollution only) and enforce the proposed effluent standards; study the effects and incorporate ammendments, addition or deletion of the proposed standards, after reviewing them from time to time.

- To make the law more effective, leaving no room for any ambiguity, include all such terms in the formulation of laws and define them very clearly and explicitly.

- To classify all the National Waters into the categories proposed in the Standards for Receiving water (see Appendix 2.1).

- To formulate procedures for sampling and examination of water, sewage and industrial effluents and to designate the units for expressing the results to make a uniform pattern for comparison.

- To set up the organisational net work including an efficient inspectorate group as well as the laboratory net work for adequate studies and proper implementation of the control measures.

- To persuade, cooperate, advise and assist all the public or private, commercial, industrial or other enterprises technically, on water pollution problems.

- To keep a routine, regular and close watch on all the individuals and agencies causing pollution by taking representative samples at regular intervals and also at other approporiate periods and point; or by taking remedial measures, in case of default.

5.7.2.3.2 Authority and Power of the Water Pollution Control Authority

The Authority must be authorised and empowered to:

- Assess the pollution even within the premises of any institution/agency/industry at any hour of the process, by taking samples and submitting them for analysis.

- Order all new commercial, industrial government or private concerns that are responsible for pollution directly or indirectly, to submit the necessary documents as prescribed by the Authority, before the setting up of a new industry. Also, order the existing industries to produce plans and specifications of sewerage, industrial and other wastes; to institute treatment and disposal systems at factories, and to offer reports of operation of these works and details of operational staff and their technical competence.

- Issue permits of certifications to such enterprises who comply with the norms prescribed by the Authority, or withdraw permisions, for non-compliance until the enterprise conforms to the norms or standards as prescribed in Appendix 2.1 and 2.2 or as the Authority may direct.

- Inspect the construction of treatment or disposal works to ensure compliance with approved plans and standards.

- Order any enterprise to discontinue the discharge of waste and specify the conditions and periods within such discharge shall continue to remain suspended.

- The Authority can tighten the Effluent Standards or other norms in those circumstances and for those quality parameters where the desired receiving water quality can otherwise not be maintained or achieved.

- The Authority can relax the Effluent Standards or norms in those circumstances and for those parameters where technical and/or economic considerations require this, given that the Standards of Receiving Waters can ultimately be maintained or achieved.

- The Authority will prevent the disposal of any solid, liquid, and gaseous substances into water bodies, or near the water bodies particularly if the latter may be endangered by the disposed substances. Disposal by infiltration or seepage shall only be allowed if the Authority is convinced of their harmlessness and care is teken that ground and surface waters are not advesely effected, at any time.

- Issue summons to parties causing pollution, hold public hearings and inflict penalties, in case of violation of regulations.

5.7.3 Till such time that the Authority comes into being, a Committee of Ministry of Health, Ministry of Water, Energy and Minerals and W.H.O. be formed to do some preliminary preparations as outlined hereunder:

5.7.3.1 Make an inventory of all existing laboratory facilities e.g. Government Chemist; Maji, Ubungo Lab.; DSM Pathology Laboratory Dept. and Division of Laboratory Temeke; and any other laboratory and Research Centres and even science based collages and schools in Dar es Salaam and those upcountry.

5.7.3.2 Strengthen the analytical facilities and know how in the various laboratories, whenever necessary, particularly in readiness for this major survey.

5.7.3.3 For tests which will be difficult to perform in these upcountry laboratories arrangements be made either to fly the samples to control laboratories in Dar es Salaam, and/or to procure and use mobile (motor vehicle) laboratories, fully equipped with equipment and personnel to analyse these samples in the field.

5.7.3.4 Compile standard methods of analysis of effluents and receiving waters, and prepare sufficient copies for various laboratories, R.W.E.'s, field staff (who will collect samples) and the industries having analytical facilities.

5.7.3.5 Collect reports and data on the sewerage and industrial waste sytem, and their receiving waters their disposal from D.D.D.'s, and from the industries.

5.7.3.6 Officers of Departments such as Health, Labour (Factory Inspectors), and others should be specially instructed so as to carry out the gigantic work of taking samples of effluents and receiving waters.

5.7.4 Apart from above, the Committee strongly recommends the following:

- A receiving water study for Dar es Salaam (where final disposal of sewage/industrial waste to the sea, is perhaps the only logical solution), so as to find the proper positions and design of outfalls. This inevitably includes oceanographic studies, viz behaviour of tides, currents and winds, on the disposal of effluent.

- An overall study of Dar es Salaam sewerage and drainage system with recommendations, along with detailed designs etc. by a competent consultant to make it a functional proposition. It may be considered in the form of a development project and it shall also include operational and maintainance details and costs.

- To study and give recommendations on industrial waste disposal, and program a plan of action for putting such methods into effect, emphasising on the pretreatment of effluents, whenever feasible, before they can enter a drainage or sewarage systems.

- Conduct a studies, encourage and assist industries to design, build and operate treatment plant.

- It should be born in mind that several surveys and studies of how to conduct studies have been done already, and reports are sitting in obscure corners of certain offices or lost altogether. These should be dug up and consulted, and some of their recommendations implemented, or made to assist the lauching of similar projects.

Other general recommendations on the control of water pollution are as follows:

- Decrease the waste loads by:

  (i) Reducing the generation of waste waters to minimum levels, and recycling the wastes that must be produced, whenever feasible, thereby conserving rew materials.

  (ii) Utilising other measures such as collection and use of waste waters that are proven less harmful, conditioning of wastes, reclamation and burning wastes etc; together with other modifications to internal processes which produce wastes.

(iii) Preventing incidental seepage of effluents to watercourses.

(iv) Ensuring that waste treatment or disposal plants, once installed are well maintained and repaired, and safety installed measures should always be in hand in case of emergencies, in order to prevent the effluents reaching and polluting the water or any other environment by accident.

(v) Selecting wisely discharge points of waste waters and all activities causing pollution.

(vi) Transfering were necessary and feasible recreational or industrial areas; incase flow, aeration and precipitation of effluents; and increase the proliferation of appropriate aquatic flora of fauna etc. so as to improve suitability of waters.

- Institute immediate water pollution control measures in all regions simultaneously, taking their hazards and size into consideration, so as to reduce the risk of pollution and their resultant hazards of one region reaffecting an already controlled region.

- Institute ways of making full use of all the sewage and drainage systems already in existence.

- Repair all effluent treatment plants and disposal facilities to minimize the health hazards and avoid the enormous less of having idle treatment or disposal facilities.

- Giude all existing institutions and industries which have no proper effluent treatment and disposal systems, to establish such control measures immediately.

- Devise a system of channelling applications to put up new industries to relevant authorities e.g. the Ministry of Health and also the Ministry of Water, particularly for water rights and waste water disposal procedures, who should clear them from all environmental pollution aspect.

- The picture of water and general environmental pollution would also decide on the positioning of industries, particularly new ones where the Ministry of Industries should devise application forms in such a way that factory plans get certificates of approval from sanitary as well as all other environmental pollution aspects before being established.

- Ministries of Health and Water should each designate an office of at least two officers who shall scrutinies such plans and issue certificates of approval or disapproval, without undue delay, and also offer pertinent advise.

- More urgent control measures should be speeded up where:

  (i) The wholesameness of the environment is in grave danger e.g. the Msasani Bay, Salender Bridge, Ocean Road and Harbour areas of Dar es Salaam marine environents.

  (ii) The pollution of the watercourse e.g. Msimbazi valley waters, by domestic and industrial wastes, exists, or any other activities which pose serious health hazards e.g. cultivation of vegetables in Msimbazi and Jangwani valleys using those polluted waters full of metals which preferentially accumulate in vegetables grown therein.

  (iii) Extensive or accelerating pollution is cause to a water course of source e.g. low water table areas to Tabora region or Iringa region, whose piped water supplies are prepetually contaminated and/or water borne diseases never cease.

  (iv) The state of a water body preserved in its natural state is abruptly disturbed e.g. by an oil tanker breaking and suddenly spewing its crude oil on a large sector of our harbours or sea.

- Last, but not least, the Committee strongly recommends that the Tanzania Temporary Standards of Quality for Domestic Waters (see Appendix 3), should immediately be given legal backing along with the Tanzanian Temporary Standards of Receiving Waters and Effluents, so that they start operating, and any contravention or non-compliance of such standards be severely discouraged.

differing from the Standards, have to be either maintained if they are already satisfaied at the time these Standards become enacted, or to be ultimately achieved on the basis of Effluent Standards and waste load allocations, as well as other proper water pollution control measures and strategies.

5.8.3 Effluent Standards

5.8.3.1 Basic Considerations

5.8.3.1.1 None of the following materials and substance shall be passed on, by discharge, into sewers, be it for direct discharge into receiving waters, or discharge via a municipal treatment plant:-

5.8.3.1.1.1 Solid wastes

5.8.3.1.1.2 Radioactive substance

5.8.3.1.1.3 Slowly or non-biodegradable organic substance such as hydrocarbons, solvents, mineral oils, etc.

5.8.3.1.1.4 Concentrated liquid wastes of any kind.

5.8.3.1.1.5 Any material or substance which could obstruct flow in, cause demage to, or prevent entry into sewers for maintainance and repair.

5.8.3.1.1.6 Infectious wastes e.g. from hospitals.

5.8.3.1.1.7 Septic tank sludge.

5.8.3.1.1.8 Sewage Treatment Plant sludge.

5.8.3.1.2 The competent authorities may, if this should prove necessary for the protection of receiving waters, specify additional materials and substances to be include in the above list.

5.8.3.1.3 Effluent Standards as set forth in Appendix 2.2 shall not be obtained by dilution by means of unpolluted, supplied or cooking waters.

5.8.3.1.4 Wastewater of non-domestic origin from ships and oil tankers circulating within the borders of Tanzania have to meet the Effluent Standards.

5.8.3.1.5 Wastewater of non-domestic characteristic from a trade or industrial enterprise may be discharged into a sewer loading to a municipal treatment plant only if it is assured that such a wastewater does not adversely affect the sewerage material, treatment plant or process, and only if it meets the Effluent Standards for indirect discharge as set forth in Appendix 2.2.

ANNEX 9

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ANNEX 9.1

JOB DESCRIPTIONS FOR STAFF AT WATER HYGIENE DEVISION

1. Planning Officer (Central Administration)

The Planning Officer is, within the Division, in charge of normal planning functions.

Preferably the Planning Officer has previous experience as Zonal Water Hygiene Engineer.

His duties are:

- He will particularily handle the reporting from the Water Hygiene Centres.
- Provide supporting information to the National Water Hygiene Committe.
- Organise and maintain records on the Water Quality Emergency Fund.

He should have the following qualifications:

- Have a good understanding of source protection and intermediate technology for treatment of water and with these associated costs.
- Have engineering practice or planning and construction of water schemes.

2. Special Programmes Officers (Central Administration)

The Special Programmes Officer is in charge of various supporting actions within the division.

His duties are:

- He will prepare reports and recommendations on treatment methods and review costs of treatment.
- Prepare recommendations on source protection and design.
- Prepare materials for public education campaigns.
- Organise seminars on water quality issues.

He should have the following qualifications:

- Have a good knowledge of legislation dealing with domestic, receiving and effluent water.
- Have engineering practice of planning and construction of water schemes with as well without treatment.
- Have a working knowledge in public health, both practical and legislative aspects.

3. Head of Central Laboratory

The Head of Central Laboratory is in charge of all functions at the laboratory.

His duties are:

- He will lead and plan the work at the laboratory and work in close cooperation with the research officers and the chief technician. He should also be the Division expert on analytical and evaluating (standards) aspects on water quality.

He should have the following qualifications:

- Be able to evaluate and develop the work at the laboratory.
- Be able to direct on all aspects of water testing both physical-chemical and bacteriologica.
- Participate in seminars.
- Have a good knowledge in the management of water quality laboratories.
- Have a good experience of research work within these fields.

4. Research Officer (Central Laboratory)

The Research Officer is under the Head of Laboratory in charge of the functions of the laboratory. The responsabilities of the research officers are preferably split to fit one chemist and one microbiologist.

His duties are:

- He will develop and evaluate the work within his field at the laboratory.
- Supervise the analytical parts of the work at the Zonal Water Hygiene Centres.
- Collect information on and de research within the field of water quality.
- Participate in training of laboratory technicians, treatment plant operators and in seminars.

He should have the following qualifications:

- Have a good knowledge in water chemistry or microbiology and a working knowledge in tha alternative field.
- Have a good knowledge in engineering aspects of water quality.
- Have a working knowledge in the management of water quality laboratories.
- Have experience in teaching.

5. Water Hygiene Engineer (Zonal Water Hygiene Centre)

The Water Hygiene Engineer is the head of the Zonal Water Hygiene Centre and/or mobile water hygiene unit.

His duties are:

- He will lead and plan the work at the Zonal Water Hygiene Centre. At first only for one mobile water hygiene unit and a stationary laboratory. Later on plan for additional mobile hygiene units.

- Be able to organise and perform surveys on present and planned water schemes within the area of the Zonal Water Hygiene Centre.

- During such surveys utilize all means for collection of information such as interviews, surveys, measurements, sampling and testing.

- During such surveys utilize knowledge in engineering to be able to propose optimal solution for improving or planning of the water scheme.

He should have the following qualifications:

- Have a working knowledge in legislation dealing with domestic, receiving and effluent water.

- Have good understanding of source protection, intermediate technology for treatment of water and engineering practice for planning and construction of water schemes.

- Have a working knowledge in general public health, both practical and lagislative aspects.

ANNEX 9.2

PROPOSAL FOR
FORM FOR RURAL WATER HYGIENE SURVEY

Adapted from WHO Surveillance of Drinking Water Quality.

Date of survey

day ☐ month ☐ year ☐

1. Name of supply .....
2. Location (attach sketch if necessary) .....
   .....
3. Mail address .....
4. Person in charge .....
5. Population served: by house connections ☐
   by standposts or public hydrants ☐
   Population unserved by public water system ☐
6. Water Quality control: yes ☐ no ☐
   A. Minimum number of inspections year prescribed ☐
   B. Number of inspections during last 12 months ☐
      when last ☐ day ☐ month ☐ year
   C. Number of samples during last 12 months in which standards were not met for:
      (a) water quality ☐
      (b) number of samples collected ☐
      (c) No samples collected ☐
   D. Samples are representative for distribution system (judge from map of distribution system):
      yes ☐ no ☐
   E. Test results are immediately reported to the Regional Water Engineer: yes ☐ no ☐

7. Sanitary survey

A. Date of last survey (not this one): ☐ ☐ ☐
day month year

B. Facilities surveyed: source ☐ transmission ☐
treatment ☐ storage ☐ distribution ☐
other facilities ..... (identify)

8. Facilities and operations (describe deficiencies on back of this sheet of paper)

	yes	no
A. There is a cross-connection control program:	☐	☐
(a) for new construction work only:	☐	☐
(b) for continuous re-inspection:	☐	☐
B. Finished water reservoirs are properly covered:	☐	☐
C. New construction work and repairs are disinfected prior to being placed in service:	☐	☐
D. There are areas of low pressure (i.e. less than 138 kPa or 1.4 kgf/cm^2) in the distribution system:	☐	☐
E. Distribution pressure is maintained at all times:	☐	☐

F. Operating problems most often encountered:
taste and odour ☐ turbidity ☐
colour ☐ other problems ..... (identify)

9. Source and distribution (describe deficiencies on back of this sheet of paper)

A. Are the following adequate?

	yes	no
(a) source with respect to		
(i) quantity	☐	☐
(ii) bacteriological quality	☐	☐
(iii) chemical quality	☐	☐
(iv) physical quality	☐	☐
(v) adequate protection	☐	☐
(b) transmission of raw water	☐	☐
(c) treatment (see attached sheet)	☐	☐

	yes	no
(d) distribution with respect to:		
(i) storage	☐	☐
(ii) booster pumping	☐	☐
(iii) pressure	☐	☐
(iv) continuity of supply	☐	☐
(v) leakage	☐	☐
(e) maintenance		
(i) source	☐	☐
(ii) distribution	☐	☐

(g) records for operation

B. During the past 3 years raw water quality has:
improved ☐ deteriorated ☐ remained the same ☐

C. During the past 3 years treated water quality has:
improved ☐ deteriorated ☐ remained the same ☐

D. During the past 3 years distributed water quality has:
improved ☐ deteriorated ☐ remained the same ☐

10. Personnel

A. Water scheme operators

(a) level of formal training in water treatment:
technical institute ☐ trade school ☐
short courses ☐

(b) length of time in formal training: ☐ weeks

(c) length of time in present plant: ☐ years

(d) total experience in water treatment: ☐ years

(e) operator is a full-time employee: yes ☐ no ☐

	yes	no
(f) present staff is adequate		
(i) in number:	☐	☐
(ii) in quality:	☐	☐
(g) management is adequate:	☐	☐

B. Operator's major complaint:

.....

.....

.....

C. Management's most frequent complaint:

.....

.....

.....

D. Most frequent comsumer complaint received by the water supply system: .....

E. Most frequent consumer complaint received by the water hygiene centre: .....

.....

11. Waterborne disease in community (information to be obtained from medical and health officers)

12. Mandatory corrections of deficiencies in order of priority (attach additional sheets if necessary: number of additional sheets). Give cost estimate and time allowed for improvement.

Should the emergency fund be used: yes ☐ no ☐

13. Suggested improvements (Attach additional sheets if needed)

Survey made by: .....
Printed name and signature

Date: ☐☐ day ☐☐ month ☐☐ year

Title: .....

Agency: .....

Notification and acknowledged by: .....
Printed name and signature

Date: ☐☐ day ☐☐ month ☐☐ year

Title: .....

Agency: .....

.....

PROPOSAL FOR:

FORM FOR RURAL WATER HYGIENE SURVEY
ATTACHED FORM FOR TREATMENT PLANTS

Date ☐ ☐ ☐
day month year

Name of supply .....

	yes condition good	bad	no
1. Treatment with respect to			
A. aeration	☐	☐	☐
B. chemical flocculation	☐	☐	☐
C. sedimentation	☐	☐	☐
D. filtration (rapid ☐ or slow ☐)	☐	☐	☐
E. disinfection	☐	☐	☐

	yes	no
2. Facilities and operations		
A. The treatment plant can be bypassed	☐	☐
B. Is maintenance adequate	☐	☐
3. Operating problems		
A. Filtration		
(a) short filter runs	☐	☐
(b) lack of washing facilities or sand	☐	☐
B. Flocculation		
(a) dosing equipment failure	☐	☐
(b) lack of chemicals ..... identify	☐	☐
(c) other ..... identify	☐	☐
C. Sedimentation		
(a) ..... identify	☐	☐
D. Chlorination		
(a) dosing equipment failure	☐	☐
(b) lack of chemical ..... identify	☐	☐
(c) other	☐	☐

4. Chemical supply and availability

   A. Flocculation chemical ..... on hand sufficient
   identify

   for ☐ days

   B. Chlorine agent ..... on hand sufficient
   identify

   for ☐ days

   C. Other chemical ..... on hand sufficient
   identify

   for ☐ days

   D. Chemical delivery time is about ☐ days

5. Are tests run for

	yes	no
A. chlorine residual		
(i) at storage tank	☐	☐
(ii) at distant parts of distribution system	☐	☐
B. pH	☐	☐
C. other ..... identify	☐	☐

6. Are the following records adequate

	yes	no	frequency
A. Filter runs	☐	☐	☐
B. Chemical consumption	☐	☐	☐
C. Residual chlorine	☐	☐	☐
C. Other ..... identify	☐	☐	☐

7. Suggested improvements given on main form ☐ ☐

8. Survey made by: .....
   Printed name and signature

   Date: ☐ day ☐ month ☐ year

   Title: .....

   Agency: .....

9. Notification and acknowledged by: .....
Printed name and signature

Date: ☐ ☐ ☐
day month year

Title: .....

Agency: .....

.....

FOR OFFICE USE ONLY

Remedial action completed .....

Date: ☐ ☐ ☐
day month year

Verified by: .....
Printed name and signature

Remedial action NOT completed as of ☐ ☐ ☐
day month year

Following measures taken: .....

.....

.....

Verified by: .....

.....

ANNEX 9.3
ZONAL WATER HYGIENE CENTRE
BUILDINGS

Present laboratory buildings and their status is reported in Chapter 4. As additional buildings will be required a standard laboratory building will be discussed before going into details of the required building construction program.

A Standard Zonal Water Hygiene Centre

The Consultanta considers it improtant to keep as much contact as possible between the Hygiene Centre and RWE's office and when possible, the Centre should be constructed on the MAJI yard.

The area required is based on a full laboratory with three mobile units. The total staff proposed is 15 out of which we suppose 3 (drivers) to be accommodated elsewhere. This leaves a staff of 10 + 2 cleaners to take care of. With an estimated requirement of 7 m^2 per person, 70 m^2 will be needed. To that should be added space for storage room of 10 m^2. As part of the staff always is on surveys, a total area of 75 m^2 is estimated to be sufficient.

Even though the Consultant considers it very important to have the staff at the zonal centre working as one unit, we find it necessary to divide the building into six rooms as follows:

1)	main laboratory	5 x 6 m	30 m^2
2)	additional laboratory room	3 x 5 m	15 m^2
3)	staff room	3 x 3 m	9 m^2
4)	head office	3 x 3 m	9 m^2
5)	typist room	3 x 2 m	6 m^2
6)	store room	3 x 2 m	6 m^2
		TOTAL	75 m^2

This should allow for the following activities:

1) Main laboratory room. General physical-chemical analysis; spectrophotometer.

2) Additional laboratory room. Preparations for bacteriological testing; balance space ; oven; refrigerator; water still.

3) Staff room. Will accommodate as necessary two water hygiene engineers and other staff when office work is required.

4) Head office.

5) Typist room, should accommodate two typists.

A lay-out for such a building is found in Figure 1. A building of this size and provided with electricity and water is calculated to cost 60 000 TShs out of which 5 700 is foreign.

A summary of the building programme required is given below in Table 1. and a more detailed discussion follows.

TABLE 9

Year	Place	Situation for building
1	Dar es Salaam	available
	Mbeya	construct
	Moshi	construct
	Mtwara	available (26 m^2)
	Mwanza	available (29 m^2)
	Shinyanga	available (32 m^2)
6	Dodoma	construct
7	Bukoba	available (65 m^2)
8	Iringa	construct
10	Tanga	(new building 61 m^2)
11	Morogoro	construct

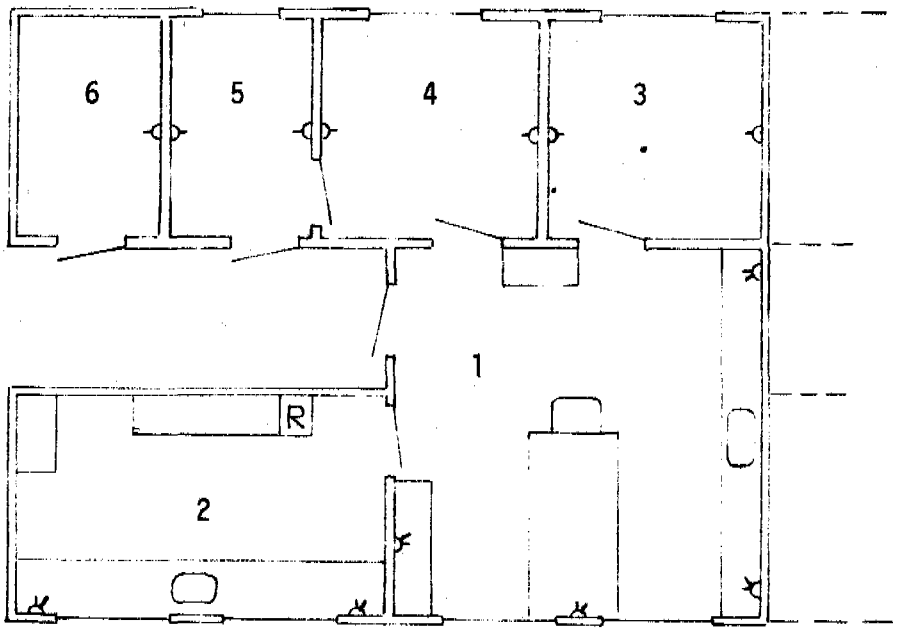
FIGURE 1

LAY-OUT FOR ZONAL WATER HYGIENE CENTRE

WATER QUALITY LABORATORY

Annex 9.3

Drawing:



Socket

Area: 75 m^2

Exhaust: –

Benches
Height: 75 m^2 Length: 15 m Material: wood

Water
Source: _ Reliability: Taps: 6

Hot water: –

Washing basins:
Material: Ceramic/ porcelain Size: 1.0x0.8x0.3 m No: 3

16 A main fuse for the electricity.

Room 1	main laboratory	30 m^2
Room 2	additional laboratory	15 m^2
Room 3	staff	9 m^2
Room 4	chief	9 m^2
Room 5	typist	6 m^2
Room 6	store	

Comments: Toilets are supposed to be provided at RWE's office.
Possible way of expansion is indicated.

Estimated costs and quipment are as follows:

Office equipment	Cost (TShs)
Typewriters 2	12 000/-
Calculators 2	1 000/-
Additional office material, staplers etc	1 000/-
TOTAL	14 000/-

Duplicating machines supposed to be available at RWE's office.

Furniture		Cost (TShs)
Laboratory benches wood with drawers		4 500/-
Tables	5 á 800/-	4 000/-
Chairs (4 laboratories)	15 á 200/-	3 000/-
Cupboards	6 á 600/-	3 600/-
Shelves		1 000/-
	TOTAL	16 100/-
Sink (stainless)	3 á 3 000/-	9 000/-
	TOTAL	25 100/-

The total costs are as follows

House with electricity and water		60 000/-
Office equipment		14 000/-
Furniture		25 100/-
	TOTAL	99 100/-

ANNEX 9.4

DETAILED DISCUSSION OF CONSTRUCTION SCHEDULE OF LABORATORY BUILDINGS

Year 1

Buildings suitable for use as laboratories are available in Dar es Salaam, Mtwara, Mwanza, and Shinyanga. In Shinyanga the existing laboratory needs to be reconstructed. No buildings are available at Mbeya and Moshi, thus these should be constructed as soon as possible, in advance of establishment of the zonal laboratories. We estimate one year is sufficient. All buildings are assumed to be constructed near to RWE:s offices.

Year 2

An expansion of the Mwanza laboratory is required. Provision of office and store area is sufficient.

Year 5

An expansion of Mtwara laboratory is required. Provision at office and store area is sufficient.

An expansion of Mwanza laboratory with an additional laboratory room at 15 m^2 is required.

Year 6

One new centre is established in Dodoma. The consultant expects that no space is available at the Mineral laboratory and proposes a construction of a water hygiene centre.

Year 7

In Bukoba we propose that the present soil laboratory established by the Kagera project be used as the water hygiene centre.

Year 8

No building is at present available in Iringa. Some planning for an establishment of a laboratory has been undertaken by UNICEF. The Consultant proposes a laboratory to be constructed to be available for the water hygiene centre in year 9.

Year 10

A building is available in Tanga. It needs to be supplied with water, additional electrical installations and furniture.

Year 11

Construction of building in Morogoro. An expansion of the Mwanza laboratory is required. Provision of office and store area is sufficient.

Year 13

An expansion of the Shinyanga laboratory is required. One additional room for laboratory has to be supplied.

ANNEX 9.5

ZONAL WATER HYGIENE CENTRE

Equipment Requirements

General equipment

Bacteriological equipment

Physical-chemical equipment

General Laboratory Equipment	Swed. Crowns
Water still Büqhi	2 500:-
Balance 0 - 200 g 0.01 g sensitivity	3 400:-
Refridgerator 300 l	1 500:-
Hot plates 2	260:-
Oven about 40 x 40 x 60 cm 250°	1 400:-
TOTAL	9 260:-
Depreciation 10 years	926:-
Tanzanian shillings	1 520/-

Bacteriological Equipment

The bacteriological equipment described in this table is to be a full set for a mobile unit. Tests for faecal coliforms and as a complement faecal streptococci can be made with the membrane filtration technique. Millipore equipment is proposed to be used. No alternative complete system for bacteriological work in the field is available.

1	MF Incubator Petri Dish	XX63 004 05		Skr	10 052:-
1	Portable water laboratory with stainless steel funnel	XX63 001 50		"	6 503:-
3	Sterifil Aseptic System	XX11 047 00	x3:-"		639:-
2	Hand vacuum pump assembly	XKEM 001 07	x2:- "		184:-
2	MF Foreceps	XX62 000 06	x2:- "		80:-
				Skr	17 458:-

Glassware

Glass bottles for sampling 500 ml	50x8:-	Skr	400:-
Measuring cylinders low model glass 100 ml	50x6:50	"	325:-
Bacteriological pipets 10 ml	50x9:-	"	450:-
Bottles for media 100 ml	10x6:-	"	60:-
Bottles for TTC and Rosolic acid 10 ml	10x5:75	"	57:50
Plastic bottle for distilled water 10 l	2x51:-	"	102:-
		Skr	1 394:50

Additional equipment

Autoclave pressure cooker (DOFT) (high to be able to include pipets)	Skr	1 100:-
Sufuria 2	"	50:-
Kerosene cooker	"	100:-
	Skr	1 250:-
TOTAL cost for equipment	Skr	20.102:50

Consumables[1)]

Millipore

Filters HAWG 04752 Sterile 1000 pc	Skr	1 214:-
Plastic Petri dishes 1000 pc	"	1 260:-
	Skr	2 474:-

Recently Gelman (USA) started selling the same type of filters and plastic dishes suitable for the Millipore incubators at a lower cost. The costs are given below as a reference.

Gelman

Filters sterile 66068 1000 pc	Skr	974:-
Plastic Petri dishes 7230 1000 pc	"	570:-
	Skr	1 544:-

Bacterial media (dehydrated media to be weighed in the laboratory and dissolved in the field)

Faecal Coliform M-FC broth (DIFCO, Oxoid) dehydrated	103:-	
Rosolic acid	53:-	
	Skr 153:-	
Faecal Streptococcus KF broth dehydrated	100:-	
TTC indicator 20 g	50:-	
	Skr 150:-	
Reagents required for 1000 tests (due to deteriation)		Skr 612:-
TOTAL consumables for 1000 tests		Skr 3 086:-

Total annual cost for Bacteriological Testing per Mobile Unit

4000 tests per year (1000 samples) (allowing for 10 samples per day during 100 days, tested at two volumes for FC and FS)

Depreciation (quantities are adjusted so that all items have a 5 year lifetime)		Skr 4 020:-
Consumables for 4000 tests 4 x 3 086:-		" 12 344:-
	TOTAL	Skr 16 364:-
	"	TShs 26 840/-

1) Filters and disposable Petridisheds are also available from Gelman. At present at a slightly lower price.

Physical-Chemical Equipment required for the Performance of Priority Levels I and II (see Annex 9.8)

Instruments (covers the requirements of a full water hygiene centre)

Spectrophotometer (Hitachi 100-1003 or Unicam)	Skr	10 250:-
Cuvettes 8	"	800:-
pH meter (Radiometer or Orion 407 A)	"	4 915:-
Separate electrodes for pH (one consumable)	"	450:-
Fluoride electrode (Radiometer) (treated as consumable)	"	1 265:-
Conductometer (Switch Gear)	"	1 640:-
Comparameter (Lovibond)	"	450:-
Total	Skr	19 770:-

Depreciation 5 years (19 770 - 1 590) Skr 3 636:-

Consunables (covers the costs of one mobile unit)

Glassware

Glassware has to be chosen in accordance with the methods used for testing. However, the following may be used as a guide line:

Burets	10 ml	5
Pipets	50 ml	10
	25 ml	10
	15 ml	10
	10 ml	10
	5 ml	10
	2 ml	10
Volumetric flasks	1000 ml	3
	500 ml	4
	250 ml	5
	100 ml	10
	50 ml	5
Beakers	500 ml	4
	250 ml	10
	100 ml	10
E-flasks	1000 ml	4
	500 ml	5
	250 ml	5
	100 ml	50

Sampling bottles for physical-chemical tests, plastic	500 ml 250		
Bottles for reagents and distilled water, plastic	10 l 4 1000 ml 40 500 ml 5		
Bottles for reagents and distilled water, glass	1000 ml 4 500 ml 4	Skr 3 200:-	
Other utensils: Reductors, buret stands, wash bottles, etc.		" 1 000:-	
	Total	Skr 4 200:-	
Glassware renewal once per 2 years			Skr 2 100:-

Chemicals (annual cost)

Estimated cost 2.50 x 300 samples	TShs 750/-		
Additional chemicals	TShs 400/-		
Total	TShs 1 150/-		Skr 701:-

Other consumables:

Glass electrode		Skr 225:-	
Fluoride electrode		" 1 265:-[1)]	
Total		Skr 1 590:-	Skr 1 590:-

Total annual cost for physical-chemical testing

	Number of Mobile units		
	1	2	3
Skr	8 027:-	10 318:-	12 609:-
TShs	13 160/-	16 920/-	20 680/-

1) In areas with a low fluoride concentration should the cheaper SPADNS method be used instead of the electrode method.

ANNEX 9.6

PRESENT SITUATION AND PROPOSAL FOR REVISION

Sampling Frequency and Number of Samples to be taken

The present Tanzanian Standards of Quality of Domestic Water give the frequency of sampling and number of samples as follows in Table 1.

TABLE 1

MAXIMUM INTERVALS BETWEEN SUCCESSIVE SAMPLES AND MINIMUM NUMBER OF SAMPLES ACCORDING TO TANZANIAN DOMESTIC WATER STANDARD

Population served / Type of Source	Up to 1 000	Up to 2 000	Up to 5 000
Borehole deeper than 8 m (26.25 feet)	6 months	4 months	3 months
Well less than 8 m (26.25 feet)	2 months	1 month	1 month
Surface water, lakes, rivers, springs, dams	1 month	2 weeks	2 weeks

The minimum number of samples to be taken from a distribution system is calculated at the rate of one sample per 500 population in addition to the intake or source.

International Drinking Water Standards (WHO) apply for other greater water schemes serving more than 5 000 persons. The number of samples required under these standards seems high when compared with WHO which requires one sample per 5 000 population per month as seen in Table 2.

TABLE 2

MAXIMUM INTERVALS BETWEEN SUCCESSIVE SAMPLES AND MINIMUM NUMBER OF SAMPLES TO BE TAKEN

Population served	Maximum interval between successive samples	Minimum number of samples to be taken from whole distribution system each month
Less than 20 000	1 month	
20 000 to 50 000	2 weeks	1 sample per 5 000 population/month
50 001 to 100 000	4 days	
More than 100 000	1 day	1 sample per 10 000 population/month

TABLE 3

ANNUAL NUMBER OF SAMPLINGS (VISITS) AND SAMPLES REQUIRED ACCORDING TO TEMPORARY DOMESTIC WATER STANDARD

Source Type		POPULATION PER WATER SCHEME										
		- 1000	1001 - 2000	2001 - 3000	3001 - 4000	4001 - 5000	5001 - 7000	7001 - 10000	10001 - 20000	20001 - 50000	50001 -	
Borehole	W	121	107	67	23	14	10	7	6	2	2	
	V	242	321	268	92	56	120	84	72	52	180	
	S	484	1284	1608	736	560	240	504	216	168	240	
Shallow well	W	16	26	17	4	2	3	1	2	0	0	
	V	96	312	204	48	24	36	12	24			
	S	192	1248	1224	384	240	72	36	72			
Spring	W	21	35	24	12	10	11	13	7	2	2	
	V	252	910	624	312	260	132	156	84	52	180	
	S	504	3640	3774	2496	2600	264	468	252	168	240	
Lake/dam	W	21	40	25	13	15	17	12	12	2	2	
	V	252	1040	650	338	390	204	144	144	52	180	
	S	504	4160	3900	2704	3900	408	432	432	168	240	
River/ stream	W	55	58	55	25	36	14	16	14	5	1	
	V	660	1508	1430	650	936	168	192	168	130	90	
	S	1320	6032	8580	5200	9360	336	576	504	420	120	
Total	W	234	266	188	77	77	55	49	41	11	7	1005
	V	1502	4091	3176	1440	1666	660	588	492	286	630	14531
	S	3004	16364	19056	11520	16660	1320	2016	1476	924	840	73180

W number of waterschemes

V number of visits

S number of samples

A calculation of the number of visits and samples required today according to Tanzanian standard is given in Table 3. The assumptions on water schemes are taken from the Engström & Wann inventory report for 1975.

The same calculations using WHO standards give the following results in Table 4.

TABLE 4

REQUIRED SAMPLES UNDER WHO STANDARDS

Population served	Number of Schemes	Visits	Samples
- 5 000	842	10 104	10 104
5001-10 000	104	1 248	2 496
10 - 20 000	41	492	1 476
20 - 50 000	11	286	924
50 000 -	7	630	840
	1 005	12 760	15 840

Both these standards give results indicating a very costly surveillance system. Provided 300 water schemes can be visited a year by one team there should be a need for 48 mobile units under Tanzanian standards and 42 using WHO standards. Even with a doubled capacity per team, which is likely after some years of work, this would be too large a surveillance programme. The cost for transport would also be very high.

A revision of the standards for sampling is therefore proposed with the objective of reducing the transport cost. The revision is based on the same criteria as used for Tanzanian Domestic Water Standards namely

(a) Size of the population served,

(b) risk of pollution, and

(c) nature and extent of protection of the source.

The proposal for change in the standards covers water schemes up to 10 000 persons served and is shown in Table 5.

TABLE 5

PROPOSED MAXIMUM INTERVALS BETWEEN SUCCESSIVE SAMPLES

Population served	2 000	2 001 - 5 000	5001 - 10 000	10 000-20 000	20 001-50 000
Borehole, protected spring	1 year	6 months	3 months	1 month	2 weeks
Large lakes, protected shallow well	6 months	3 months	1 month	WHO standard	WHO standard
Other surface waters, unprotected shallow well	3 months	2 months	1 month		

The number of samples to be taken according to different present standards are found in Tables 1 and 2. The Tanzanian value seems to be very demanding resulting in a high number of samples.

The Consultant proposes that the number of samples per visit should be three based on the following: Even a medium-sized water scheme will be covered sufficiently well be three samples and three results will also give a reasonably good basis for judgement of eventual non-compliance.

A detailed calculation of the outcome of the proposed sampling program is found in Table 6. The required number of visits and samples for the 1975 set up of water schemes according to the three programs are as follows:

	Tanzanian standard	WHO standard	Proposed standard
Visits	14 531	12 760	4 798
Samples	73 180	15 840	13 290

A situation with the whole population served by water schemes (to be reached in 20 years) would increase the program by a factor of about 7.

TABLE 6

ANNUAL NUMBER OF SAMPLINGS (VISITS) AND SAMPLES REQUIRED ACCORDING TO PROPOSED STANDARD

Source		- 1000	1001 - 2000	2001 - 3000	3001 - 4000	4001 - 5000	5001 - 7000	7001 - 10000	10001 - 20000	20001 - 50000	50001 -	Total
Borehole	W	121	107	67	23	14	10	7	6	2	2	
	V	121	107	134	46	28	40	28	72	52	180	
	S	363	321	402	138	84	120	84	216	168	240	
Shallow well	W	16	26	17	4	2	3	1	2	0	0	
	V	32	52	68	16	8	36	12	24			
	S	96	156	204	48	24	108	36	72			
Spring	W	21	35	24	12	10	11	13	7	2	2	
	V	21	35	48	24	20	44	52	84	52	180	
	S	63	105	144	72	60	132	156	252	168	240	
Lake/ dam	W	21	40	25	13	15	17	12	12	2	2	
	V	84	160	150	78	90	204	144	144	52	180	
	S	252	480	450	234	270	612	432	432	168	240	
River/ stream	W	55	58	55	25	36	14	16	14	5	1	
	V	220	232	330	150	216	168	192	168	130	90	
	S	660	696	990	450	648	504	576	504	420	120	
Total	W	234	266	188	77	77	55	49	41	11	7	1005
	V	478	586	730	314	362	492	428	492	286	630	4798
	S	1434	1638	2190	942	1086	1476	1284	1476	924	840	13290

W number of waterschemes

V number of visits

S number of samples

ANNEX 9.7

CHECKLIST FOR COLLECTION OF BACTERIOLOGICAL SAMPLES

Adapted from WHO Surveillance of Drinking Water Quality.

Sampling

- ☐ Representative points throughout distribution system
- ☐ Location and frequency of sampling adequate
- ☐ Minimum yearly number of samples adequate for population
- ☐ Number of samples per visit required for this
- ☐ Repetitive samples from points with unsatisfactory history
- ☐ Proportionately more samples from critical parts of distribution system subject to higher risks

Sample bottles

- ☐ Samples collected in sterilized glass bottles provided with ground-glass stoppers or sterilizable caps.
- ☐ Stopper and neck of the bottle protected by a paper/parchment cover or aluminium foil
- ☐ Sampling bottle unopened till sampling, stopper replaced immediately after sampling

Collection procedure

- ☐ Volume of water sample 500 ml
- ☐ Ample air space left in bottle to facilitate mixing
- ☐ Representative samples collected without incurring contamination
- ☐ Tap samples collected from taps connected directly to water main by service pipe
- ☐ Sampling not collected from taps connected to storage tanks
- ☐ Taps allowed to waste water until service lines have been cleared

☐ River, stream, lake or reservoir samples collected by plunging opened bottles neck downwards below the surface

☐ Samples collected with mouth end of bottle facing into current (or away from hand)

☐ Pump allowed to waste water for 5 minutes before samples are taken

☐ Prompt identification of samples in legible, indelible writing

☐ Samples accompanied by complete and accurate data

Dechlorination

☐ Sodium thiosulfate used for dechlorination

☐ Sodium thiosulfate added before sterilization of bottle

☐ Thiosulfate concentration approximately 100 milligrams per litre

Transportation and storage

☐ Temperature maintained as close as possible to the water temperature at time of collection

☐ Sample examined as soon as possible after collection

☐ Examination within 1 hour after collection recommended

☐ Established procedure for transporting sterile sample bottles to field

ANNEX 9.8

PROPOSED PRIORITY LIST FOR PHYSICAL-CHEMICAL ANALYSIS OF RAW WATER AND DOMESTIC WATER

Priority		
I Compulsary Analyses	II Supplementary Analyses	III Additional Analyses 3)
Conductivity	Iron	Sodium
pH	Manganese	Potassium
Fluoride	Total Hardness	Zinc
Nitrate	Alkalinity	Copper
Colour (Turbidity)	Sulphate	Other Heavy Metals
Chlorine 1)	Nitrite 2)	Calcium
	Chloride	Magnesium
	Permanganate Value	Organic Pollutants

1) Comparators should be used for testing in the field of residual Chlorine.

2) Has to be tested soon after sampling (24 hours).

3) All these constituents can be determined on preserved samples within six months. Provision for analysis of these is available at Ubungo laboratory and at the laboratory of Government Chemist

Analysis proposed to be deleted for drinking water testing (as compared with water analysis report from WE&ID H26A. Figure 4.3):

Albuminoid Nitrogen

As bacteriological tests are always to be made has this test no relevance.

Phenolphtalein Alkalinity

Can easily be calculated from total alkalinity and pH.

BOD

This analysis indicates organic pollution which will be revealed by other tests performed.

Methods for Physical-Chemical Analysis

No detailed list of methods for physical-chemical testing will be given as there is a continuous improvement in methodology. On the whole, good methods are used at the Ubungo laboratory. Methods for physical-chemical analysis are found in Standard Methods for the Examination of Water and Waste Water (last edition 14th, 1975) or Analysis of Raw, Potable and Waste Water. The work within ISO/TC 147 Water Quality is slowly producing ISO standard methods for the determination of water quality and should be reviewed for. Some comments will, however, be made on methods.

Ammonia

The Nessler method, although simple, is frequently interferred by coloured and turbid matter in water. This method is proposed to be replaced by the indophenol method (using salicylic acid) giving a blue colour less susceptible to such disturbances.

Fluoride

The best method for testing is considered to be an ion selective electrode. A comparison between the photometric SPADNS method and electrode indicates that the cost for chemicals for the SPADNS method is about Skr 0:10 per sample to be compared with the cost of Skr 1 265:- for the electrode. The electrode has thus to be used for about 12 000 samples in order to equalize the costs. Since the electrode has a lifetime of approximately one year, this will seldom be the case.

It is thus proposed that electrodes should only be used where fluoride problems are to be found. This means that Mtwara (at year 1 and later Bukoba, Iringa and Morogoro) should use the SPADNS method.

Nitrate

Several methods are tentatively proposed in Standard Methods. To the Consultant's experience the cadmium-reduction method is working well. The choice of method should, however, be based on latest experience. Results should be given as nitrate nitrogen mg/l.

Turbidity

The proper determination of turbidity requires a special instrument (turbidimeter). Turbidity can, however, be resonable well determined in an ordinary spectrophotometer at a wave length of 420 nm as used partly in several Nordic countries and are easily calibrated to a relevant level for the estimation of standards. This eliminates the cost for a special turbidimeter.

Iron and Manganese

Samples for iron and manganese should be very well shaken on arrival to the laboratory, a subsample poured and preserved with acid to pH 4. Neutralize before analysis.

Alkalinity (Total)

The method used in some Nordic countries (SIS Sveriges standardiseringskommission) utilizes blowing off the carbon dioxide during titration. This results in a higher precision, the theoretical background for this procedure is found in Stumm-Morgan (1970).

Permanganate Value

The test determines the amount of oxidizable organic matter. Since the procedure only allows for a partial oxidization (40-90%) and this varies with the conditions, are these important to keep constant. Both the temperature and time allowed for reaction should be well controlled. The Consultant proposes incubation boiling water bath for 20 minutes as also is proposed as an ISO Standard.

Other Tests

All additional tests for metals only require sampling and preservation at the zonal laboratory. Special care should be exercised not to contaminate the sample. Those tests should be performed at the Ubungo laboratory. For tests of other constituents the Consultant proposes the use of the Government Chemist laboratory.

Cost Estimate

The costs for consumables (reagents) has been estimated for priority levels I (with photometric fluoride analysis) and II to be TSh 0/80 and TSh 1/70 respectively per sample.

The cost for level III has been estimated from depreciation costs for the atomic absorption spectrophotometer and flame photometer. The staff at Ubungo laboratory evaluates this to be TShs 50 000/- to which is added the cost for consumables (as lamps and gas bottles) giving a total of 59 400/-. In 1977, 1 214 samples were tested implying a cost of TShs 49/- for analysis of constituents mentioned under priority level III. This figure will be lower whenever the equipment is used more.

ANNEX 9.9

EQUIPMENT FOR TESTING AT TREATMENT PLANTS USING CHLORINATION

At present chlorination is known to be used at 28 water schemes. It is essential that the chlorine agent is properly dosed, something requiring test equipment. Only few of the water schemes have complete sets for testings however, many have Lovibond or HACH comparameters without tubes and/or colour discs. Colour discs are found for o-tolidine as well as DPD.

For testing of free residual chlorine the following equipment is proposed:

Comparator (Lovibond 1000 or HACH) with colour disc and 4 tubes:	Skr 450:-
The Consultant estimates that 25 sets will be required to provide all present treatment plants with working comparators at a total cost of:	Skr 11 250 = Tsh 18 450/-
The Consultant proposes use of DPD as reagent. It is somewhat more costly than orthotolidine but less sensitive to interferences. Cost for reagents (1000):	Skr 135:-
Based on two tests per day and water scheme the cost for reagents will be:	Skr 100:-
Reagents will be required for about 35 plants:	Skr 3 500 = Tsh. 5 750/-.

ANNEX 9.10
INDICATOR BACTERIA - RESEARCH NEEDS

1. Technical Discussion

As outlined in Chapter 2.1 on water quality, there are serious doubts surrounding both the specificity and selectivity of faecal coliform measurements. In order to reduce the range of uncertainty, there are two ways in which this problem might be tackled.

Isolation of Escherichia Coli

The idea underlying this approach is to select bacteria which are more specifically faecal than the thermotolerant coliforms (some of non-faecal origin) selected by the M-FC test presently in use. A test specifically for E. coli would satisfy this requirement. It is true that many of the non-E. coli bacteria isolated by the M-FC technique are Klebsiella species, some of which have been indicated (along with Enterobacter) as major causes of diarrhoea and malabsorption in adults living in the tropics. Nevertheless, other species are completely non-faecal and non-enteropathogenic and thus it is better to exclude this group of bacteria.

Any research to establish a suitable technique would be laborious but straightforward. Several media (e.g. M-FC, M-TEC and LES) could be chosen and compared. This would involve:

(i) Membrane filtration of about 1000 water samples and subsequent incubation on the media under investigation, in parallel tests. The colony counts would be recorded.

(ii) Subculturing a representative number of colonies (perhaps 20%) into a nutrient broth.

(iii) Typing of these colonies using a multiple biotechnical test series, such as the api 20-E.

The data would then be analysed for three factors:

a. Highest recovery
b. Lowest number of false positives
c. Lowest number of false negatives

This would allow a rational selection of a technique. At present, the M-FC technique has only been tested in the United States and there are many indications that it is not satisfactory for use in the tropics. It would be sensible to introduce a better test before the M-FC method becomes too well-established.

Isolation of Anaerobes

Further work on the isolation of Bacteroides fragilis and studies of its survival in natural water would yield interesting results. It is a more human-specific species than E. coli although its survival in water would have to be comparable to that of E. coli to make it a suitable choice for an indicator organism. A second advantage is that an incubator is not required to grow B. fragilis, as it is not temperature sensitive.

Present experience indicates that the isolation techniques must be improved, and the survival in water studied. This would involve:

(i) Culturing presumptive B. fragilis from natural water samples; and comparing the results with parallel tests for faecal coliforms.

(ii) Typing a representative sample of the colonies (this would probably have to be done outside Tanzania) to determine the optimum recovery conditions.

(iii) Studying the death-rate in various natural waters over a range of conditions.

2. Estimated Cost and Manpower

(1) Manpower Requirements

(1)	Scientific advisor	2 mm
(2)	Principal research scientist	18 mm
(3)	Laboratory technician (Tanzania)	18 mm
(4)	Laboratory technician - European research laboratory	4 mm

STAFF Skr 450 000

(2)	Equipment, Working Space, Laboratory			
	(1) One laboratory room at Ubungo			
	(2) Bacteriological equipment	maximum	Skr	25 000
	(3) Laboratory consumables			50 000
(3)	Transportation			
	(1) International:			
	People - 5 roundtrip Stockholm/DSM		Skr	50 000
	Things		Skr	15 000
	(2) Domestic		Skr	30 000
(4)	Report			
	Report preparation, drafting, computers		Skr	10 000
	ESTIMATED TOTAL COST:	Skr		630 000

ANNEX 9.11

STORAGE AS A WATER TREATMENT METHOD

During storage, two main processes occur which improve water quality. These are the death of micro-organisms and sedimentation of solid particles. These particles may be the eggs or cysts of parasites or inorganic particles. The mineral particles will absorb a significant proportion of the bacteria and viruses and thus remove them as they sediment out. Let us examine these factors in turn.

Death of Micro-organisms

There are three categories of interest, namely, bacteria, schistosome cercariae, and viruses.

(a) Bacteria

Much work has been carried out on the survival of bacteria in water. From this, several points emerge:

(i) Death rates approximately double for each $10^{o}C$ rise in temperature.

(ii) Relatively clean waters, (e.g. groundwater) are less hostile to bacteria than river waters where competition with and predation from other micro-organisms may greatly increase death rates.

Experiments giving a consistent set of death rate measurements have been carried out by McFeters et al (1974) using sterilised groundwater at 9^{o} - $12^{o}C$. Because of the factor mentioned above, bacteria in surface waters in Tanzania die at a greater rate than in the cool, sterile water used in this study. In the experiment described in Section 2.2 the death rate of faecal coliforms in surface water from around Dar es Salaam is measured. This is 1.7 times the death rate of E-Coli measured by McFeters et al. Therefore, in Table 1 their data are presented with all the death rates multiplied by this factor. The figure for Vibrio cholerae biotype el Tor is taken directly from measurements by W. Spira in tank waters in Bangladesh.

TABLE 1

REDUCTION OF BACTERIA DURING 48 HR STORAGE

Bacteria Species	% Reduction in 48 hr
Salmonella typhi	99.9
Salmonella paratyphi A	96.9
Salmonella paratyphi B	99.9
Salmonella paratyphi D	94.4
Salmonella typhimurium	96.9
Shigella flexneri	87.4
Shigella dysenteriae	91.7
Shigella sonnei	87.7
Vibrio cholerae	99.9
Vibrio cholerae bio-type el Tor	99.0
Escherichia coli	96.3

(b) Schistosome cercariae

Experiments (Oliver, 1966) have shown that cercariae will survive for up to 48 hours after being shed. However, they seem to lose their infectivity after about 24 hours, when they become too weak to penetrate the skin.

(c) Viruses

The death of viruses in water is much slower than for bacteria. Due to the complexity of the experimental techniques, less work has been done, but there are nevertheless enough published results to enable reasonable estimates to be made. One of the more comprehensive studies has been carried out by Clarke et al (1962) and their results for various viruses in river waters are summarised in Table 2.

TABLE 2

REDUCTION OF VIRUS DURING 48 HR STORAGE

Virus	% Reduction in 48 hr					
	Clean River Water			Polluted River Water		
	4°C	20°C	28°C	4°C	20°C	28°C
Polio 1	40.1	49.9	55.6	51.7	65.4	71.5
Echo 7	46.9	57.8	68.4	60.2	86.1	93.7
Echo 12	34.2	68.4	93.7	49.9	51.7	93.7
Coxsackie	74.9	82.2	82.2	49.9	82.2	93.7

These data indicate that reductions of the order 50% - 80% in viral numbers can be expected to result from 48 hours' storage. The sensitivity of viruses to changes in temperature is also clear, and may be more marked than for bacteria, with certain viruses.

Sedimentation Processes

Many diseases caused by intestinal parasites are rarely, if ever, waterborne. This can be partially attributed to the removal of their eggs and cysts accounted for by the high rate of settling in water. The most commonly waterborne parasites are also those with the slowest settling infective agents. They are the intestinal protozoa, with cyst settling velocities around 0.03 m/h (Chang, 1945). Therefore, any sedimentation system should be designed with this settling velocity in mind.

Although conventional sedimentation systems operate at an overflow rate of around 1-2 m/h, a storage system would have a much lower effective overflow rate. For a tank providing 48 hours' storage, 3 m high, the overflow rate (corresponding to the minimum settling velocity for a particle to be removed) is around 0.06 m/h. Under these conditions a certain proportion (probably small) of protozoan cysts would be removed, and about 90% of the turbidity-causing

matter (Tariq& Yao, 1976). This performance can easily be improved by the use of lamellar sedimentation devices, although the precise design parameters for untreated water as opposed to flocculated water are not yet established.

The extent of virus and bacteria adsorption on suspended matter in water has been partially studied. Present knowledge indicates that adsorption is favoured by the presence of dissolved salts and hindered by organic matter, which competes for the adsorption sites. The nature of the lateritic soil of many parts of Tanzania with their small particle size (and therefore large surface area) and low organic content would indicate that river sediments should adsorb viruses and bacteria quite effectively. The effect is enhanced by the very heavy sediment loads of many rivers (particularly in the rainy seasons). Although it is not possible to quantify this effect it is certain that a substantial proportion of viruses might be removed in this way.

Current Design Practice

To promote both maximum retention time (even flow with minimal short-circuiting) and sedimentation a good distribution of the flow at the tank inlet and outlet must be achieved.

This has been studied in relation to sedimentation tank design, and the following design criteria should be used.

(a) Inlets

The best inlets take the form of two slotted baffles in series, as shown in Figure 1. Design criteria suggested by Mau (1959) and Cox (1969) are as follows:

Water velocity through slot 0.03 m/s.

$b = t+60$ mm
$d = 90\text{-}150$ mm
$\theta = 15^{o}$

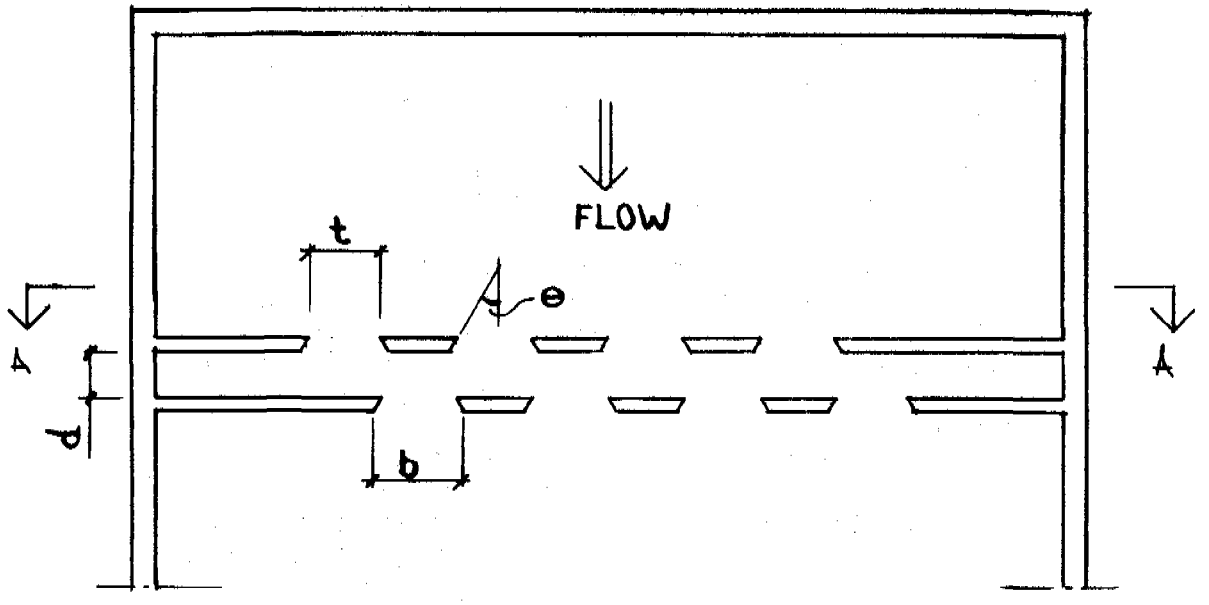
where t = slot width, mm
b = distance between slots, mm
d = distance between baffles, mm
θ = angle of "flare" of slots

The slots should take up the central 2/3 of the baffles.

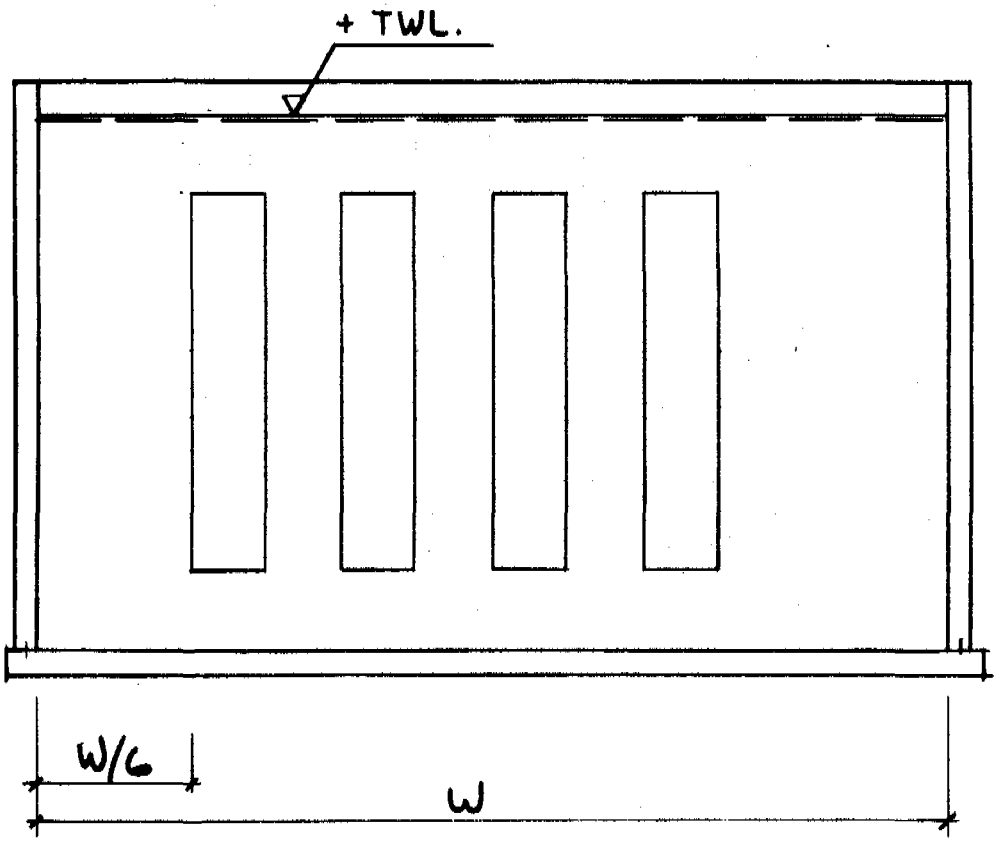
FIGURE 1

STORAGE AS A WATER TREATMENT METHOD

An optimum form of inlet to a sedimentation tank.



PLAN



SECTION A-A

(b) Outlets

Weirs are the most suitable type of outlet. They should be designed with a minimal flow rate per unit length, and constructed so that their heights are adjustable. One alternative form is shown in Figure 2.

Needs for Applied Research

Although the effect of storage on water quality, is broadly understood, a substantial amount of work remains to be done to optimise the engineering design of storage systems. The most important factors are:

(i) The survival of bacteria and viruses in water under natural conditions.

(ii) The extent of adsorption of bacteria and viruses on suspended solids, and the factors affecting this.

(iii) The optimisation of lamellar sedimentation systems for solids removal from unflocculated water, and the investigation of the biological layers so formed on the lamellae.

These topics form the basis of a study already being undertaken at the Ross Institute of the London School of Hygiene and Tropical Medicine. The experience ground from their laboratory work will provide a useful basis for field experiments in Tanzania. They also have a working relationship with experts in engineering, bacteriology and virology who would be able to offer advice, and assistance on the more sophisticated tests required. It may be considered useful to train a Tanzanian worker in some of the techniques to be used, and provide a practical review of the current experiments.

The fieldwork itself would have to be carried out at several different sites. This is because we are concerned with natural systems, and thus to get different parameters for the raw water quality (enabling general relationships to be established, to derive general design criteria) several different types of raw water source would be required. A nearby laboratory would also greatly facilitate the setting up of the various analytical tests.

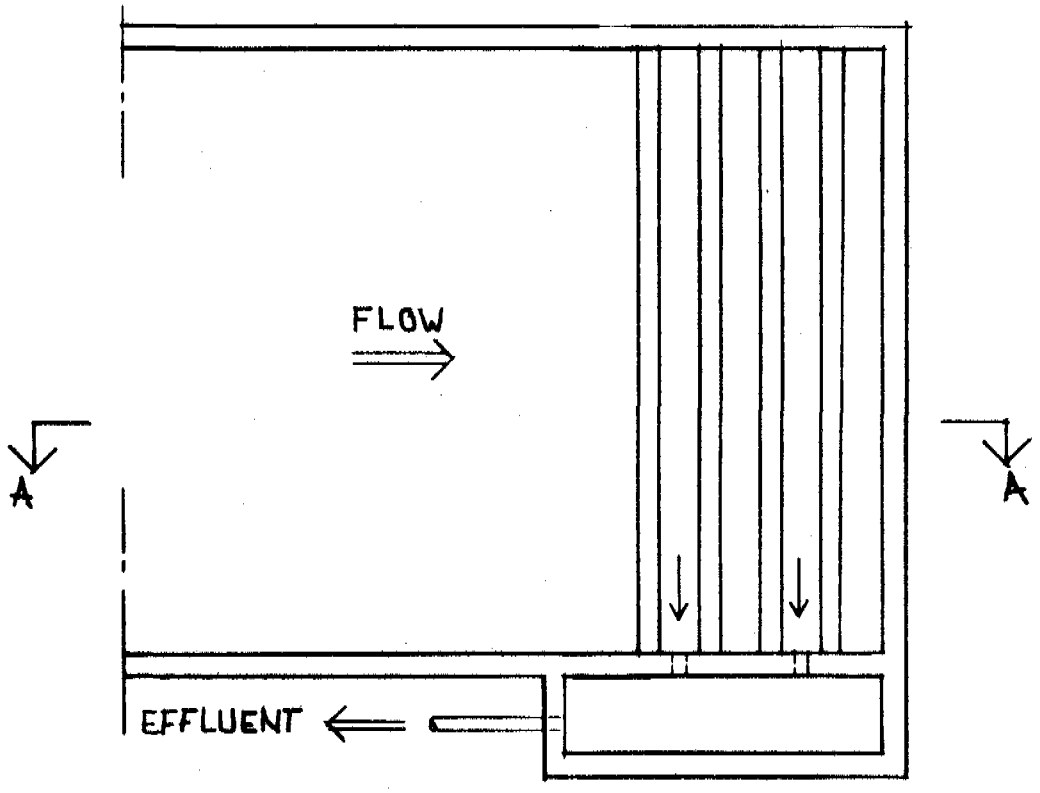
Suggested Procedure

(1) A summary should be made of the experience gathered so far at the Ross Institute and time allowed to round off any experiments in progress.

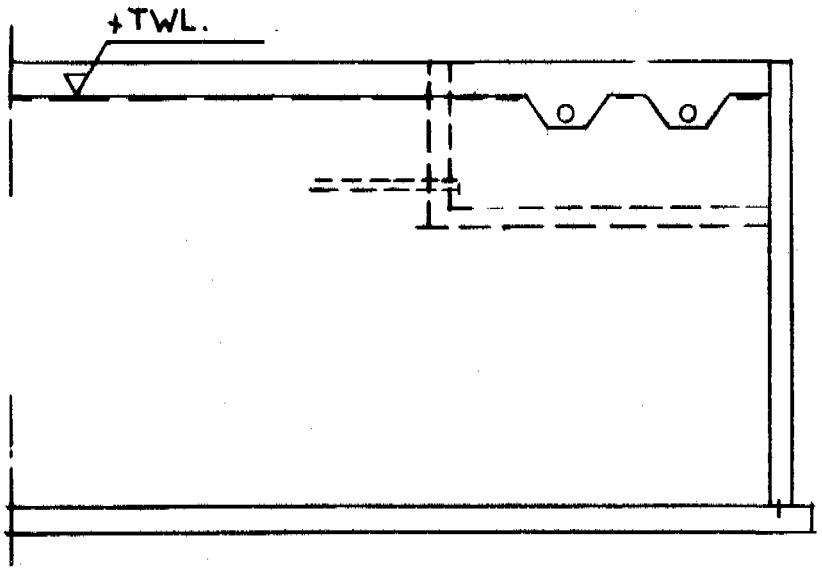
FIGURE 2

STORAGE AS WATER TREATMENT METHOD

One form for weirs at outlet of sedimentation tank.



PLAN



SECTION A-A

(2) If required, a Tanzanian project worker could be trained in techniques and the state of the art, during this initial phase.

(3) Three field sites should be established. Possible places are:

(i) Lower Ruvu treatment works
(ii) Mwanza
(iii) Moshi

These represent areas of different water quality (lowland river, dam and upland river respectively) and different temperatures. They also have conveniently situated laboratories; the treatment plant laboratory and the Ubungo laboratory for Lower Ruvu, the EAIMR and the water laboratory at Mwanza and KCMC at Moshi.

(4) Pilot storage tanks, perhaps 3-4 in parallel, would be built at the three sites, and a planned series of experimental runs conducted, varying all the engineering parameters and monitoring the effect on water quality. This will almost certainly highlight the need for laboratory experiments, which can either be carried out on site or at other more sophisticated laboratories. The tests would cover studies of deliberately inocculated pathogens in addition to the naturally occuring particles and organisms.

(5) The experiments should continue for at least a whole year to cover the cyclical variation of water quality and temperature with the seasons.

(6) The data gathered would be processed and reduced to a set of criteria to produce optimal storage system design. The cost-effectiveness would be compared with that of other water treatment systems to indicate the circumstances where storage would be the most appropriate method. The very low maintenance and operational needs of the system would be taken into account.

ESTIMATED COST AND MANPOWER

(1) Manpower Requirements

(1)	Scientific Advisor	2 mm
(2)	Principal Results Scientist	24 mm
(3)	Counterpart Design Engineer	24 mm
(4)	Engineer	6 mm
(5)	Lab. Technician (Tanzania)	18 mm
	STAFF	SKr 700 000

(2) Equipment, Construction

(1)	Equipment	SKr 35 000
(2)	Laboratory consumables	65 000
(3)	Construction of storage tanks	180 000
(4)	Workshop	25 000

(3) Transportation

(1)	International	
	People	SKr 60 000
	Things	20 000
(2)	Domestic	SKr 85 000

(4) Report

Preparation, drafting, computer	SKr 25 000
TOTAL	SKr 1 195 000

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ANNEX 9.12

TRAINING AND REFERENCE MATERIALS

As outlined in the main text it would be relatively simple but effective to prepare manuals and guidelines for regional MAJI staff for both reference and training purposes, Brief discussions between the Consultant and representatives for MAJI, The University of Dar es Salaam and Chuo cha MAJI highlighted the need for manuals covering the points set out below. It should be pointed out that some of these are already contained in the Standards of Quality of Domestic Water. Nevertheless it is felt that extra material contributed by relevant experts would make a considerable improvement.

1. Source Selection Checklist

   (i) Cost and cost estimation - notes.

   (ii) Quality - present and potential pollution.

   (iii) Yield - adequacy in the dry season.

   (iv) Potential for upgrading.

   (v) Successive construction of small units compared to large single schemes, related to availability of funds.

   (vi) Independence - needs for minimal manpower and chemical supplies.

2. Survey Manual

   To be prepared in simple English.

3. Design Manual

   (i) Improved type drawings paying attention to source protection.

   (ii) Standard drawings for standpipes.

   (iii) Notes on mechanical design.

   (iv) Preparation of bills of quantity and efficient operation of procurement procedures.

4. Construction Manual

(i) Engineering matters - pipe-laying
- concrete construction
- pump installation

(ii) The importance of a manager for ensuring all required supplies are available.

(iii) Proper testing procedures prior to commissioning.

(iv) Guidelines for public education during construction.

5. Operation Manual

(i) Operation and maintenance of engines and pumps.

(ii) Organisation of fuel supplies.

(iii) Maintenance of standpipes and surroundings.

(iv) Log sheets for pump attendants.

ANNEX 10

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Wilson A.L. 1974 — The Chemical Analysis of Water. Analytical Sciences Monograph No. 2

Winblad, U., Kilama, W. & Thorstensson, K., 1978 — Sanitation without water.

Journals

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Journal of Water Pollution Control Federation

Water Research

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ANNEX 10

SELECTED LIST OF LITERATURE

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