APPENDIX L

PRELIMINARY COST ESTIMATES

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1 UNIT CONSTRUCTION PRICES

A review of current construction prices in Kenya has been conducted, based on a combination of recent tender rates for the construction of similar works, and suppliers quotations for materials.

The unit rates derived from this review are given in ***Table L-1***. These rates have been used to make a preliminary estimate of construction costs for the works identified under this Master Plan phase of the study. The table also provides "all in" costs for concrete, pipeline construction using different materials and estimates for the costs of standard reservoir sizes.

Preliminary and general items have not been included in the unit rates, as these will generally differ between different locations, and for different types of construction contracts. These have therefore been estimated separately for each scheme.

The base date for the costs is October 96, with an exchange rate of 1 US$ = 56 Kshs.

2 CONSTRUCTION COST ESTIMATES

Quantities have been taken off for each of the proposed schemes, and bills of quantities priced using the above unit construction prices, to prepare preliminary cost estimates of the proposals to meet the 2010 water demand requirements. Preliminary bills of quantities are included on the cost estimate sheets attached to this Appendix, with a separate breakdown for each treatment works. The treatment plant quantities are given for full treatment in each case, regardless of level of treatment proposed, so that the impact of changing the level of treatment, on costs, can be readily estimated. The costs of the proposed level of treatment only however, has been carried forward to the scheme estimates.

The resultant estimates are summarised on ***Table L-2***. This indicates that the cost per capita averages at about US $ 62 per capita, with 70% of the costs incurred during the initial phase, 20% during the second phase and 10% spread evenly over the design horizon for the construction of annual extensions to the distribution system.

The main costs are related to the transmission and distribution systems, followed by treatment, the costs of raw water pipelines and storage.

The electrical and mechanical components of the schemes represent less than 5% of the total, due to the conceptual basis of the designs to reduce operation and maintenance costs to a minimum.

3 RECURRENT COSTS

(1) Operation and Maintenance

Historic levels of operation and maintenance costs have generally been low. However, to safeguard investments so that they continue to provide a reliable service for their expected lifetimes, it is advisable to budget for higher levels of maintenance costs. The 1986 Design Manual suggests guidelines for annual maintenance budgets which are in reasonable agreement with figures used in other developing countries. These are based on a percentage of the investment costs, which can be simplified to the following categories:

Asset	Annual maintenance cost as % of investment costs
Civil works	1%
Pipelines	1%
Electrical & Mechanical works	5%

The actual maintenance costs will tend to increase as the assets become older. However, the above rates represent a reasonable average to be expected over the asset lifetime, and have therefore been applied to the investment costs to arrive at the annual maintenance cost of assets.

(2) Economic Life

All assets have an economic lifetime, after which it is no longer considered economic to maintain them. The 1986 Design Manual provides the following guidance:

Asset	Economic Lifetime Years
Civil works	30
Pipelines	30
Electrical & Mechanical works (assuming electrical power)	10

These economic lifetimes are again similar to those used in other developing countries, although they are much lower than those currently used in most developed countries. This is probably due to the harsher conditions in developing countries, and the higher levels of training and commercialisation in developed countries.

(4) Power Costs

Power costs are not generally very significant for the proposed schemes, due to the fact that they are all designed for gravity flow. Power however will be required for treatment plant site lighting and for backwashing. The annual costs have been calculated using the Kenya Power and Lighting Tariff Method B1, (Oct 1996) for supplies metered at a pressure of 240 volts single phase, or 415 volts three phase as follows:

1) a fixed charge of Shs 500 per month

2) unit consumption charge of Shs 4.40 per unit

3) Shs 250 per month per KVA of demand.

(5) Staffing Costs

Staffing requirements have been estimated for each treatment plant and distribution system. Staffing includes for local management, meter reading, billing and collection for each individual scheme, but does not include Ministry overheads at District and National headquarters. The annual projections are shown, using similar salary scales as currently applicable for Government staff, in the individual scheme cost estimate sheets attached to this appendix.

(6) Chemical Costs

Chemical costs have been estimated using current unit costs for supply of chemicals, as quoted by suppliers, and using dosage rates appropriate to the raw water quality for each scheme. The cost per m3 of treated water range from Shs 0.7 per m3 for chlorination alone, to Shs 1.3 per m3 when Aluminium sulphate (Alum) is added at a dosage rate of 20 mg/l. The annual cost of chemicals for each scheme is given in the cost estimate sheets for the individual schemes.

(7) Transport

The cost of some basic transport has also been included in the annual projections. Replacement of vehicles has been assumed to be every 5 years, and an operation and maintenance budget amounting to 20% of vehicle costs per annum has been allowed.

TABLES

Table L-1 Unit Construction Prices

Exchange rate..... Oct-96 ..... 1US $ = 56 Shs

Preliminaries and General Items are NOT included within the following rates

General Items	Unit	Rate Shs
General excavation in normal material not exceeding 3.0m depth	m3	350
EO for rock	m3	1,500
Earthworks for dams - Soft	m3	175
Earthworks for dams - Rock	m3	1,000
Earthfill for dams	m3	310
Filter/drainage material for dams	m3	1,550
Rip rap material for dams	m3	1,630
Concrete Class 25	m3	8,000
Concrete Class 30	m3	12,000
Mass concrete for dams	m3	6,000
Reinforcement	tonne	65,000
Formwork F1	m2	475
Formwork F2	m2	750
Blockwork walling	m2	1,200
"All in" cost for reinforced concrete	m3	20,175

Pipework

Assumptions — Type of pipe	uPVC	Steel	DI
Manufacturers discount	10%	0%	0%
Tax and duties	15%	15%	15%
Transport and handling	15%	15%	20%
Wastage	5%	1%	1%
Pipe trench width	700 mm + nominal dia.		
Average trench depth	1200 mm + nominal dia.		
Average rock excavation	10%		
Valves & specials - Add to "All in" pipe costs	15%		

uPVC Pipelines

			Materials delivered to site				"All in" pipe costs			
Dia mm	Trench Excav'n Shs/m	Lay, joint etc Shs/m	uPVC 6 bar Shs/m	uPVC 9 bar Shs/m	uPVC 12 bar Shs/m	uPVC 15 bar Shs/m	uPVC 6 bar Shs/m	uPVC 9 bar Shs/m	uPVC 12 bar Shs/m	uPVC 15 bar Shs/m
63	482	40	75	125	155	200	597	647	677	722
90	510	60	187	242	298	365	757	812	868	935
110	531	60	252	362	442	562	843	953	1033	1153
160	585	100	506	747	943	1155	1191	1432	1628	1840
225	659	140	1000	1380	1825	2104	1799	2179	2624	2903
280	725	180	1450	2125	2504	3262	2355	3030	3409	4167
315	769	200	1837	2660	3374	4124	2806	3629	4343	5093
400	880	280	3074	4374			4234	5534		

Steel and DI Pipelines

			Materials delivered to site			"All in" pipe costs		
	Trench Excav'n Shs/m	Lay, joint etc Shs/m		Steel Shs/m	DI Shs/m		Steel Shs/m	DI Shs/m
dia								
80	499	70			1235			1804
100	520	90		1115	1518		1725	2128
150	574	140		2049	2285		2763	2999
200	630	200		3154	3080		3984	3910
250	689	260		4408	4073		5357	5022
300	750	320		5794	5166		6864	6236
350	814	380		7301	6386		8495	7580
400	880	450		8921	7663		10251	8993
450	949	510		10036	9097		11495	10556
500	1020	580		11152			12752	

Reservoirs

Capacity (m3)	50	100	150	200	250	300	400	500	750
"All in" costs	550,000	780,000	940,000	1,070,000	1,290,000	1,520,000	1,940,000	2,350,000	3,360,000
Cost/m3	11,000	7,800	6,267	5,350	5,160	5,067	4,850	4,700	4,480

Boreholes	Unit	rate	quantity	Amount
Basic costs for 50 m deep borehole	Lump sum	87,500	1	87,500
Additional costs for deeper boreholes	m	875	50	43,750
Pump test	LS	37340	1	37,340
	Total costs			168,590

Land costs

Varies depending upon location, but without additional information take ..... 200000 Shs/ha

Pumps	Flow(l/s)	Head (m)	Efficiency	kW	Estimated costs Shs x 1,000
Civil costs	(l/s)	(m)	(eff'y)	(l/s) x (m)/(102 x (eff'y)	400 x KW^.675
E&M costs	(l/s)	(m)	(eff'y)	(l/s) x (m)/(102 x (eff'y)	360 x KW^.6

Table L-2 Summary of Investment and Operational Cost

Scheme	Investment Cost US$ x 1,000							
	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania	Totals
Rehabilitation	179	18	61	22	49	16		345
Intake	175	37	29	318	184	4	135	882
Raw Water Pipeline	1,139	93	466	697	331	20	191	2,937
Treatment Plant	1,542	551	312	337	284	552	294	3,872
Storage	960	92	111	200	96	59	95	1,613
Transmission	2,938	230	688	383	701	149	1,260	6,349
Ancillaries	1,733	255	417	489	411	200	494	3,999
Preliminaries	1,300	191	313	367	309	150	370	3,000
Total Phase 1	**9,963**	**1,467**	**2,396**	**2,814**	**2,365**	**1,150**	**2,839**	**22,994**
Borcholes			133					133
Treatment Plant	1,165	274		237	197		207	2,080
Storage	537	92	102	55	42	59	87	974
Transmission	963		105	76	105	44	81	1,374
Ancillaries	666	91	85	92	86	26	94	1,140
Preliminaries	500	69	64	69	65	19	70	856
Total Phase 2	3,830	526	489	529	495	147	540	6,556
Additional Distribution	1,158	55	199	489	200	55	384	2,540
TOTAL	**14,951**	**2,048**	**3,084**	**3,832**	**3,060**	**1,352**	**3,763**	**32,090**
Supply Area Details								
Design Population	251,668	15,611	43,648	64,433	44,376	13,344	83,121	516,201
Design Demand (m3/day)	22,725	1,915	6,372	4,403	2,886	1,496	3,778	43,575
Supply Area (km2)	185	4	45	88	58	5	92	477
Cost/capta (US$/capita)	59	117	71	59	69	101	45	521
Cost/m3/day(US$?m3/day)	658	955	484	870	1,060	906	996	731
Average Incremental Costs at 9%								0
Investment Costs (US$/m3)	0	0	0	0	1	1	1	0
Annual Costs (US$/m3)	0	0	0	0	0	0	0	0
Total Costs (US$/m3)	1	1	1	1	1	1	1	1
Total Costs (Shs/m3)	30	30	35	34	43	39	39	36
(1 US$= 56 Shs)								

Table L-3 Cost Estimates Meru Water Supply

Investment costs	Exchange rate	1 US $ =	56	KShs	Phase 1			1998	Phase 2			2003	3-Oct-97
Element	Description dia (mm Size		Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	
Rehabilitation					item	17.9	17.9	142.9					
Intake					item	174.5							
Raw pipeline	500	mm dia steel pipe	m	227.714	5,000			1,138.6					
Treatment	10,000	m3/d capacity plant	nr	1,541,589	1	1,310.4	231.2						
	10,000	m3/d expansion	nr	1,164,536					1.0	989.9	174.7		
Reservoirs	750	m3 reservoir	nr	60,000	12	720.0			6.0	360.0			
	400	m3 reservoir	nr	34,643	1	34.6			1.0	34.6			
	300	m3 reservoir	nr	27,143	1	27.1			1.0	27.1			
	250	m3 reservoir	nr	23,036	4	92.1			2.0	46.1			
	200	m3 reservoir	nr	19,107	2	38.2			2.0	38.2			
	150	m3 reservoir	nr	16,786	2	33.6			1.0	16.8			
	100	m3 reservoir	nr	13,929	1	13.9			1.0	13.9			
Transmission	400	mm dia uPVC (9 bar)	m	98.821	3,800			375.5					-
	315	mm dia uPVC (12 bar)	m	77.554	15,300			1,186.6					-
	280	mm dia uPVC (12 bar)	m	60.875	3,000			182.6	2,800				170.5
	225	mm dia uPVC (12 bar)	m	46.957	10,000			468.6	9,000				421.7
	160	mm dia uPVC (12 bar)	m	28,982	25,000			724.6	12,800				371.0
Ancillaries/contingencies				25%		615.6	62.3	1,054.8		381.7	43.7		240.8
Preliminaries				15%		461.7	46.7	791.1		286.2	32.8		180.6
Total						3,539.6	358.1	6,055.2		2,194.5	251.1		1,384.5
Total phased costs					Phase 1			9,902.9	Phase 2				3,830.2
Annual costs													
Annual distribution pipes	110	mm dia uPVC (12 bar)	m	18.446	3,000			55	3,000				55
	90	mm dia uPVC (12 bar)	m	15,500	2,000			31	2,000				31
	63	mm dia uPVC (12 bar)	m	12.089	3,000			36	2,000				24
Total								123					111
Transport Requirements				US$x1,000	1998				2003				
	Saloon car		nr	17.9	1			18	1				18
	4WD vehicle		nr	62.5	1			63	1				63
	Pickup		nr	21.4	2			43	3				64
	Lorry		nr	107.1	2			214	2				214
					Transpo	Civil	E&M	Pipes					
Annual O&M costs as % of Investments					20%	1.00%	4.00%	1.00%					
Economic life					5	30	10	30					
Power						1998	Fixed	Variable		2003	Fixed	Variable	
	Power tariff (Oct 1996)		Power Requirements				20	20			20	20	
	Unit energy cost		US$/unit	0.0785714									
	Fixed charge per month		US$/month	7.8571429									
	kVA demand charge		US$/month	4.4642857									
Human resources				Rate/yr US$x1,000	1998 TWks 1	TWks2	Dist'n	US$x1,000	2003 TWks 1	TWks2	Dist'n	US$x1,000	
	Engineer I		Shs/yr	3.86			1	3.86			1	3.86	
	Engineer II		Shs/yr	3.21			2	6.43			2	6.43	
	Inspector		Shs/yr	2.36	2		3	11.79	2	2	3	16.50	
	Senior Operator		Shs/yr	1.29	2		4	7.71	2	2	5	11.57	
	Operator		Shs/yr	0.96	2	2	5	8.68	2	2	5	8.68	
	Watchman/Line patrolman/Clerks		Shs/yr	0.64	3	2	20	16.07	3	3	29	22.50	
			Shs/yr					54.54				69.54	
Chemical costs				US$/kg	1998 Dosage (mg/l)			Cost/m3	2003 Dosage (mg/l)			Cost/m3	
	Alum			0.45		0		0.000		10		0.004	
	Chlorine			6.25		2		0.013		2		0.013	
	Soda ash			0.25		0		0.000		0		0.000	
	Total chemical cost per m3							0.013				0.017	

Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	Incremental supply m3/d	Investment Schedule Treatment Civil US$ x 1,000	E&M US$ x 1,000	Pipes US$ x 1,000	Transpo US$ x 1,0	Total Investmen US$ x 1,000	O&M Costs US$ x 1,0	Power Costs US$ x 1,000	Labour US$ x 1,0	Transpor US$ x 1,00	Chemica US$ x 1,00	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
1996																	
1997	165,980	10,302	31%	3,172	-										-	-	10,300
1998	171,606	11,219	28%	3,172	-	3,540	358	6,055	339	10,300							
1999	177,657	12,181	50%	6,090	2,918			123		123	112	15	55	68	13	262	385
2000	183,527	13,188	55%	7,253	4,081			123		123	113	16	55	68	19	269	392
2001	189,554	13,974	60%	8,384	5,212			123		123	114	16	55	68	24	276	399
2002	195,741	14,794	65%	9,616	6,444			123		123	115	17	55	68	29	284	406
2003	202,094	15,649	70%	10,954	7,782	2,195	251	1,385	359	4,189	161	18	70	72	36	355	4,545
2004	208,618	16,541	75%	12,406	9,234			111		111	162	18	70	72	57	379	489
2005	215,318	17,470	80%	13,976	10,804			111		111	163	19	70	72	67	390	501
2006	222,199	18,438	85%	15,673	12,501			111		111	164	20	70	72	77	403	513
2007	229,268	19,447	90%	17,502	14,330			111		111	166	21	70	72	89	416	527
2008	236,531	20,496	95%	19,471	16,299		358	111	359	828	181	21	70	72	101	445	1,272
2009	243,996	21,589	98%	21,049	17,877			111		111	182	22	70	72	111	456	567
2010	251,668	22,725	100%	22,725	19,553			111		111	183	23	70	72	121	468	579
2011	251,668	22,725	100%	22,725	19,553			111		111	184	23	70	72	121	470	580
2012	251,668	22,725	100%	22,725	19,553			111		111	185	23	70	72	121	471	581
2013	251,668	22,725	100%	22,725	19,553		251	111	359	721	197	23	70	72	121	482	1,202
2014	251,668	22,725	100%	22,725	19,553			111		111	198	23	70	72	121	483	593
2015	251,668	22,725	100%	22,725	19,553			111		111	199	23	70	72	121	484	595
2016	251,668	22,725	100%	22,725	19,553			111		111	200	23	70	72	121	485	596
2017	251,668	22,725	100%	22,725	19,553	-(1,298)	-(222)	(770)	-(72)	-(822)	186	23	70	72	121	471	-(351)
						Note: Residual values in (brackets)											
Net Present values					m3 x 1,000					US$ x 1,000						US$ x 1,000	US$ x 1,000
		15%			16,435					11,508						1,895	13,403
		12%			22,164					12,232						2,377	14,609
		9%			30,660					13,090						3,056	16,147
		6%			43,589					14,123						4,039	18,162
Average incremental costs (Shs/m3)										US$/m3						US$/m3	US$/m3
		15%								0.70						0.12	0.82
		12%								0.55						0.11	0.66
		12%								0.43						0.10	0.53
		6%								0.32						0.09	0.42

Table L-4 Cost Estimates Nkubu Water Supply

Investment costs	Exchange rate..... 1 US $ =	56	KShs	Phase 1			1998	Phase 2			2003	3-Oct-97
Element	Description dia (mm Size	Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	
Rehabilitation				item	1.8	1.8	14.3					
Intake			-	item	37.0		-					
Raw pipeline	150 mm dia steel pipe	m	49.339	1,013			50.0					
	200 mm dia steel pipe	m	71.143	600			42.7					
Treatment	1,000 m3/d capacity plant	nr	551,411	1	468.7	82.7						
	1,000 m3/d expansion	nr	273,464					1.0	232.4	41.0		
Reservoirs	500 m3 reservoir	nr	41,964	1	42.0			1.0	42.0			
	400 m3 reservoir	nr	34,643		-				-			
	300 m3 reservoir	nr	27,143	1	27.1				-			
	250 m3 reservoir	nr	23,036	1	23.0				-			
	200 m3 reservoir	nr	19,107		-				-			
	150 m3 reservoir	nr	16,786		-				-			
	100 m3 reservoir	nr	13,929		-				-			
Transmission	400 mm dia uPVC (9 bar)	m	98.821				-				-	
	315 mm dia uPVC (12 bar)	m	77.554				-				-	
	280 mm dia uPVC (12 bar)	m	60.875				-				-	
	225 mm dia uPVC (12 bar)	m	46.857	1,300			60.9				-	
	160 mm dia uPVC (12 bar)	m	28.982	2,300			66.7				-	
Ancillaries/contingencies			25%		149.9	21.1	58.6		68.6	10.3	-	
Preliminaries			15%		112.4	15.8	44.0		51.5	7.7	-	
Total					862.0	121.5	337.1		394.5	59.0	-	
Total phased costs				Phase 1.....			1,320.6	Phase 2			453.4	
Annual costs												
Annual	110 mm dia uPVC (12 bar)	m	18.446				-				-	
distribution	90 mm dia uPVC (12 bar)	m	15.500	200			3.1	200			3.1	
pipes	63 mm dia uPVC (12 bar)	m	12.089	200			2.4	200			2.4	
Total							5.5				5.5	

Transport Requirements		US$x1,000	1998			2003		
Saloon car	nr	17.9	0		-	0		-
4WD vehicle	nr	62.5	0		-	0		-
Pickup	nr	21.4	1		21.4	1		21.4
Lorry	nr	107.1	0		-	0		-

	Transpo	Civil	E&M	Pipes
Annual O&M costs as % of Investments	20%	1.00%	4.00%	1.00%
Economic life	5	30	10	30

Power			1998	Fixed	Variable	2003	Fixed	Variable
Power tariff (Oct 1996)	Power Requirements.....			10	10		10	10
Unit energy cost	US$/unit	0.0785714						
Fixed charge per month	US$/month	7.8571429						
kVA demand charge	US$/month	4.4642857						

Human resources		Rate/yr	1998				2003			
		US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000
Engineer I	Shs/yr	3.86			0	-			1	3.86
Engineer II	Shs/yr	3.21			1	3.21			1	3.21
Inspector	Shs/yr	2.36	2		2	9.43	2		2	9.43
Senior Operator	Shs/yr	1.29	2		2	5.14	2		3	6.43
Operator	Shs/yr	0.96	2		5	6.75	2		5	6.75
Watchman/Line patrolman/Clerks	Shs/yr	0.64	3		8	7.07	3		8	7.07
	Shs/yr					31.61				36.75

Chemical costs	US$/kg	1998 Dosage (mg/l)	Cost/m3	2003 Dosage (mg/l)	Cost/m3
Alum	0.45	0	0.000	20	0.009
Chlorine	6.25	2	0.013	2	0.013
Soda ash	0.25	0	0.000	5	0.001
Total chemical cost per m3.....			0.013		0.023

Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	Incremental supply m3/d	Investment Schedule Treatment Civil US$ x 1,000	E&M US$ x 1,000	Pipes US$ x 1,000	Transpo US$ x 1,000	Total Investmen US$ x 1,000	O&M Costs US$ x 1,000	Power Costs US$ x 1,000	Labour US$ x 1,000	Transport US$ x 1,000	Chemica US$ x 1,000	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
1996																	
1997	9,471	940		-	-												
1998	9,853	1,004		-	-	862.0	121.5	337.1	21.4	1,342.0					-	-	1,342.0
1999	10,246	1,071	50%	535	535			5.5		5.5	16.9	7.8	31.6	4.3	2.4	63.0	68.5
2000	10,648	1,142	55%	628	628			5.5		5.5	17.0	8.0	31.6	4.3	2.9	63.7	69.3
2001	11,064	1,204	60%	722	722			5.5		5.5	17.0	8.3	31.6	4.3	3.3	64.5	70.0
2002	11,497	1,270	65%	825	825			5.5		5.5	17.1	8.6	31.6	4.3	3.8	65.3	70.8
2003	11,946	1,338	70%	937	937	394.5	59.0	-	21.4	474.9	23.4	8.9	36.8	4.3	4.3	77.5	552.4
2004	12,412	1,410	75%	1,057	1,057			5.5		5.5	23.4	9.2	36.8	4.3	8.8	82.4	87.9
2005	12,896	1,485	80%	1,188	1,188			5.5		5.5	23.5	9.5	36.8	4.3	9.8	83.9	89.4
2006	13,398	1,563	85%	1,329	1,329			5.5		5.5	23.5	9.9	36.8	4.3	11.0	85.5	91.0
2007	13,920	1,646	90%	1,481	1,481			5.5		5.5	23.6	10.3	36.8	4.3	12.3	87.2	92.7
2008	14,462	1,731	95%	1,645	1,645		121.5	5.5	21.4	148.4	28.5	10.8	36.8	4.3	13.6	93.9	242.3
2009	15,025	1,821	98%	1,776	1,776			5.5		5.5	28.6	11.1	36.8	4.3	14.7	95.4	100.9
2010	15,611	1,915	100%	1,915	1,915			5.5		5.5	28.6	11.5	36.8	4.3	15.9	97.0	102.5
2011	15,611	1,915	100%	1,915	1,915			5.5		5.5	28.7	11.5	36.8	4.3	15.9	97.1	102.6
2012	15,611	1,915	100%	1,915	1,915			5.5		5.5	28.7	11.5	36.8	4.3	15.9	97.1	102.6
2013	15,611	1,915	100%	1,915	1,915		59.0	5.5	21.4	85.9	31.1	11.5	36.8	4.3	15.9	99.5	185.4
2014	15,611	1,915	100%	1,915	1,915			5.5		5.5	31.2	11.5	36.8	4.3	15.9	99.6	105.1
2015	15,611	1,915	100%	1,915	1,915			5.5		5.5	31.3	11.5	36.8	4.3	15.9	99.6	105.2
2016	15,611	1,915	100%	1,915	1,915			5.5		5.5	31.3	11.5	36.8	4.3	15.9	99.7	105.2
2017	15,611	1,915	100%	1,915	1,915	- 316.1	- 59.7	88.0	- 4.3	- 292.1	26.6	11.5	36.8	4.3	15.9	95.0	- 197.1
					Note: Residual values in (brackets)												
Net Present values				m3 x 1,000						US$ x 1,000						US$ x 1,000	US$ x 1,000
		15%		1,862						1,420.8						416.8	1,837.6
		12%		2,464						1,495.7						519.4	2,015.1
		9%		3,346						1,578.9						663.2	2,242.1
Average Incremental costs (Shs/m3)										US$/m3						US$/m3	US$/m3
		15%								0.76						0.22	0.99
		12%								0.61						0.21	0.82
		9%								0.47						0.20	0.67

Table L-5 Cost Estimates Isiolo Water Supply

Investment costs	Exchange rate..... 1 US $ =	56	KShs	Phase 1	1998			Phase 2	2003			3-Oct-97
Element	Description dia (mm Size	Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	
Rehabilitation				item	3.6	3.6	53.6					
Intake				item	29.1							
Raw pipeline	150 mm dia steel pipe	m	49.339	2,156			106.4					
	200 mm dia steel pipe	m	71.143	5,054			359.6					
Treatment	2,000 m3/d capacity plant	nr	311,964	1	265.2	46.8						
	2,000 m3/d expansion	nr	237,286					-	-	-		
Boreholes	100 m deep	nr	6,021	-		-		5.0	30.1			
Borehole pumps	7 kW borehole pumps	nr	29,662	-				5.0		103.3		
Reservoirs	750 m3 reservoir	nr	60,000	1	60.0	9.0		1.0	60.0			
	500 m3 reservoir	nr	41,964	1	42.0			1.0	42.0			
	300 m3 reservoir	nr	27,143		-				-			
	250 m3 reservoir	nr	23,036		-				-			
	200 m3 reservoir	nr	19,107		-				-			
	150 m3 reservoir	nr	16,786		-				-			
	100 m3 reservoir	nr	13,929		-				-			
Transmission	400 mm dia uPVC (9 bar)	m	98.821				-					-
	315 mm dia uPVC (12 bar)	m	77.554				-					-
	280 mm dia uPVC (12 bar)	m	60.875	4,700			286.1					-
	225 mm dia uPVC (12 bar)	m	46.857	5,300			248.3	1,000				46.9
	160 mm dia uPVC (12 bar)	m	28.982	5,300			153.6	2,000				58.0
Ancillaries/contingencies			25%		99.9	14.8	301.9		33.0	25.8		26.2
Preliminaries			15%		75.0	11.1	226.4		24.8	19.4		19.7
Total					574.7	85.3	1,735.9		189.9	148.5		150.7
Total phased costs				Phase 1.....			2,395.9	Phase 2				489.0
Annual costs												
Annual distribution pipes	110 mm dia uPVC (12 bar)	m	18.446	200			4	200				3.7
	90 mm dia uPVC (12 bar)	m	15.500	500			7.8	500				7.8
	63 mm dia uPVC (12 bar)	m	12.089	700			8.5	700				8.5
Total							19.9					19.9

Transport Requirements			US$x1,000	1998		2003	
	Saloon car	nr	17.9	0	-	0	-
	4WD vehicle	nr	62.5	1	62.5	1	62.5
	Pickup	nr	21.4	1	21.4	1	21.4
	Lorry	nr	107.1	0	-	0	-

	Transpo	Civil	E&M	Pipes
Annual O&M costs as % of Investments	20%	1.00%	4.00%	1.00%
Economic life	5	30	10	30

Power			1998	Fixed	Variable	2003	Fixed	Variable
	Power tariff (Oct 1996)	Power Requirements.....		10	10		10	35
	Unit energy cost	US$/unit	0.079					
	Fixed charge per month	US$/month	7.857					
	kVA demand charge	US$/month	4.464					

Human resources			Rate/yr	1998				2003			
			US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000
	Engineer I	Shs/yr	3.86			1	3.86			1	3.86
	Engineer II	Shs/yr	3.21			1	3.21			1	3.21
	Inspector	Shs/yr	2.36	1		2	7.07	1		2	7.07
	Senior Operator	Shs/yr	1.29	2		2	5.14	2		2	5.14
	Operator	Shs/yr	0.96	2		3	4.82	2		3	4.82
	Watchman/Line patrolman/Clerks	Shs/yr	0.64	3		7	6.43	3		9	7.71
		Shs/yr					30.54				31.82

Chemical costs		US$/kg	1998 Dosage (mg/l)	Cost/m3	2003 Dosage (mg/l)	Cost/m3
	Alum	0.45	0	0.000	0	0.000
	Chlorine	6.25	2	0.013	2	0.013
	Soda ash	0.25	0	0.000	0	0.000
	Total chemical cost per m3.....			0.013		0.013

Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	Increm-ental supply m3/d	Investment Schedule Treatment Civil US$ x 1,000	Treatment E&M US$ x 1,000	Pipes US$ x 1,000	Transpo US$ x 1,000	Total Investment US$ x 1,000	O&M Costs US$ x 1,000	Power Costs US$ x 1,000	Labour US$ x 1,000	Transport US$ x 1,000	Chemical US$ x 1,000	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
1996																	
1997	25,679	3,334	84%	2,800	-										-	-	2,479.8
1998	26,746	3,534	79%	2,800	-	574.7	85.3	1,735.9	83.9	2,479.8							
1999	27,862	3,745	90%	3,370	570					19.9	26.7	9.1	30.5	16.8	2.6	85.7	105.6
2000	29,029	3,968	100%	3,968	1,168					19.9	26.9	9.5	30.5	16.8	5.3	89.1	109.0
2001	30,243	4,160	100%	4,160	1,360					19.9	27.1	9.7	30.5	16.8	6.2	90.3	110.2
2002	31,505	4,361	100%	4,361	1,561					19.9	27.3	9.9	30.5	16.8	7.1	91.6	111.5
2003	32,817	4,572	100%	4,572	1,772	189.9	148.5	150.7	83.9	573.0	36.7	20.6	31.8	16.8	8.1	114.0	687.0
2004	34,183	4,794	100%	4,794	1,994					19.9	36.9	21.3	31.8	16.8	9.1	115.8	135.7
2005	35,604	5,026	100%	5,026	2,226					19.9	37.1	21.9	31.8	16.8	10.2	117.7	137.6
2006	37,084	5,270	100%	5,270	2,470					19.9	37.3	22.6	31.8	16.8	11.3	119.7	139.6
2007	38,625	5,526	100%	5,526	2,726					19.9	37.5	23.3	31.8	16.8	12.4	121.8	141.7
2008	40,230	5,794	100%	5,794	2,994		85.3		83.9	189.2	41.1	24.1	31.8	16.8	13.7	127.4	316.6
2009	41,903	6,076	100%	6,076	3,276					19.9	41.3	24.9	31.8	16.8	14.9	129.7	149.6
2010	43,648	6,372	100%	6,372	3,572					19.9	41.5	25.7	31.8	16.8	16.3	132.1	152.0
2011	43,648	6,372	100%	6,372	3,572					19.9	41.7	25.7	31.8	16.8	16.3	132.3	152.2
2012	43,648	6,372	100%	6,372	3,572					19.9	41.9	25.7	31.8	16.8	16.3	132.5	152.4
2013	43,648	6,372	100%	6,372	3,572		148.5		83.9	252.3	48.0	25.7	31.8	16.8	16.3	138.6	391.0
2014	43,648	6,372	100%	6,372	3,572					19.9	48.2	25.7	31.8	16.8	16.3	138.8	158.7
2015	43,648	6,372	100%	6,372	3,572					19.9	48.4	25.7	31.8	16.8	16.3	139.0	158.9
2016	43,648	6,372	100%	6,372	3,572					19.9	48.6	25.7	31.8	16.8	16.3	139.2	159.1
2017	43,648	6,372	100%	6,372	3,572	-(211)	-(106)	(450)	-(17)	(116)	46.7	25.7	31.8	16.8	16.3	137.4	253.6
						Note: Residual values in (brackets)											
Net Present values					m3 x 1,000					US$ x 1,000						US$ x 1,000	US$ x 1,000
		15%			3,372					2,569.8						581.3	3,151.1
		12%			4,484					2,721.7						724.1	3,445.8
		9%			6,117					2,909.6						924.1	3,833.7
Average incremental costs (Shs/m3)										US$/m3						US$/m3	US$/m3
		15%								0.76						0.17	0.93
		12%								0.61						0.16	0.77
		9%								0.48						0.15	0.63

Table L-6 Cost Estimates Chuka Water Supply

Investment costs	Exchange rate ..... 1 US $ =		56 KShs	Phase 1			1998	Phase 2			2003	3-Oct-97
Element	Description dia (mm Size	Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	
Rehabilitation				item	4.5	-	17.9					
Intake				item	318.4							
Raw pipeline	250 mm dia steel pipe	m	95.661	3,100			296.5					
	200 mm dia steel pipe	m	71.143	5,633			400.7					
Treatment	2,000 m3/d capacity plant	nr	336,964	1	286.4	50.5						
	2,000 m3/d expansion	nr	237,286					1.0	201.7	35.6		
Reservoirs	750 m3 reservoir	nr	60,000	1	60.0				-			
	500 m3 reservoir	nr	41,964	1	42.0				-			
	400 m3 reservoir	nr	34,643	1	34.6				-			
	300 m3 reservoir	nr	27,143	1	27.1			-	-			
	250 m3 reservoir	nr	23,036	-	-			-	-			
	200 m3 reservoir	nr	19,107	1	19.1			2.0	38.2			
	150 m3 reservoir	nr	16,786	1	16.8			1.0	16.8			
	100 m3 reservoir	nr	13,929		-				-			
Transmission	400 mm dia uPVC (9 bar)	m	98.821				-				-	
	315 mm dia uPVC (12 bar)	m	77.554				-				-	
	280 mm dia uPVC (12 bar)	m	60.875	2,900			176.5				-	
	225 mm dia uPVC (12 bar)	m	46.857	2,800			131.2	1,000			46.9	
	160 mm dia uPVC (12 bar)	m	28.982	2,600			75.4	1,000			29.0	
Ancillaries/contingencies			25%		202.2	12.6	274.6		64.2	8.9	19.0	
Ancillaries/contingencies			15%		151.7	9.5	205.9		48.1	6.7	14.2	
Total					1,162.9	72.7	1,578.7		369.0	51.2	109.0	
Total phased costs				Phase 1			2,814.3	Phase 2			529.2	

Annual costs												
Annual distribution pipes	110 mm dia uPVC (12 bar)	m	18.446	500			9	500			9.2	
	90 mm dia uPVC (12 bar)	m	15.500	1,000			15.5	1,000			15.5	
	63 mm dia uPVC (12 bar)	m	12.089	2,000			24.2	2,000			24.2	
Total							48.9				48.9	

Transport Requirements			US$x1,000	1998			2003		
	Saloon car	nr	17.9	0		-	0		-
	4WD vehicle	nr	62.5	1		62.5	1		62.5
	Pickup	nr	21.4	2		42.9	2		42.9
	Lorry	nr	107.1	0		-	0		-

	Transpo	Civil	E&M	Pipes
Annual O&M costs as %of investments	20%	1.00%	4.00%	1.00%
Economic life	5	30	10	30

Power				1998	Fixed	Variable	2003	Fixed	Variable
	Power tariff (Oct 1996)	Power Requirements			10	10		10	10
	Unit energy cost	US$/unit	0.0785714						
	Fixed charge per month	US$/month	7.8571429						
	kVA demand charge	US$/month	4.4642857						

Human resources			Rate/yr	1998				2003			
			US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000
	Engineer I	Shs/yr	3.86			0	-			1	3.86
	Engineer II	Shs/yr	3.21			1	3.21			1	3.21
	Inspector	Shs/yr	2.36	2		2	9.43	2		2	9.43
	Senior Operator	Shs/yr	1.29	2		2	5.14	2		3	6.43
	Operator	Shs/yr	0.96	2		4	5.79	2		5	6.75
	Watchman/Line patrolman/Clerks	Shs/yr	0.64	3		12	9.64	3		17	12.86
		Shs/yr					33.21				42.54

Chemical costs		US$/kg	1998 Dosage (mg/l)	Cost/m3	2003 Dosage (mg/l)	Cost/m3
	Alum	0.45	0	0.000	0	0.000
	Chlorine	6.25	2	0.013	2	0.013
	Soda ash	0.25	0	0.000	0	0.000
	Total chemical cost per m3			0.013		0.013

Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	Increm-ental supply m3/d	Investment Schedule Treatment Civil US$ x 1,000	E&M US$ x 1,000	Pipes US$ x 1,000	Transpo US$ x 1,000	Total Investmen US$ x 1,000	O&M Costs US$ x 1,000	Power Costs US$ x 1,000	Labour US$ x 1,000	Transport US$ x 1,000	Chemica US$ x 1,000	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
1996																	
1997	41,502	1,537		-	-												
1998	43,046	1,741		-	-	1,162.9	72.7	1,578.7	105.4	2,919.6					-	-	2,919.6
1999	44,622	1,959	50%	980	980			48.9		48.9	30.8	7.5	33.2	21.1	4.5	97.0	145.9
2000	46,238	2,192	55%	1,205	1,205			48.9		48.9	31.3	7.7	33.2	21.1	5.5	98.8	147.7
2001	47,904	2,375	60%	1,425	1,425			48.9		48.9	31.8	8.0	33.2	21.1	6.5	100.6	149.5
2002	49,616	2,568	65%	1,669	1,669			48.9		48.9	32.3	8.3	33.2	21.1	7.6	102.5	151.4
2003	51,373	2,770	70%	1,939	1,939	369.0	51.2	109.0	105.4	634.5	39.1	8.6	42.5	21.1	8.8	120.2	754.7
2004	53,169	2,980	75%	2,235	2,235			48.9		48.9	39.6	8.9	42.5	21.1	10.2	122.3	171.3
2005	55,001	3,199	80%	2,559	2,559			48.9		48.9	40.1	9.3	42.5	21.1	11.7	124.7	173.6
2006	56,861	3,426	85%	2,912	2,912			48.9		48.9	40.6	9.7	42.5	21.1	13.3	127.2	176.1
2007	58,749	3,661	90%	3,295	3,295			48.9		48.9	41.1	10.2	42.5	21.1	15.0	129.9	178.8
2008	60,638	3,902	95%	3,707	3,707		72.7	48.9	105.4	226.9	44.5	10.7	42.5	21.1	16.9	135.7	362.6
2009	62,538	4,150	98%	4,046	4,046			48.9		48.9	44.9	11.1	42.5	21.1	18.5	138.1	187.0
2010	64,433	4,403	100%	4,403	4,403			48.9		48.9	45.4	11.5	42.5	21.1	20.1	140.6	189.5
2011	64,433	4,403	100%	4,403	4,403			48.9		48.9	45.9	11.5	42.5	21.1	20.1	141.1	190.0
2012	64,433	4,403	100%	4,403	4,403			48.9		48.9	46.4	11.5	42.5	21.1	20.1	141.6	190.5
2013	64,433	4,403	100%	4,403	4,403		51.2	48.9	105.4	205.4	48.9	11.5	42.5	21.1	20.1	144.1	349.6
2014	64,433	4,403	100%	4,403	4,403			48.9		48.9	49.4	11.5	42.5	21.1	20.1	144.6	193.5
2015	64,433	4,403	100%	4,403	4,403			48.9		48.9	49.9	11.5	42.5	21.1	20.1	145.1	194.0
2016	64,433	4,403	100%	4,403	4,403			48.9		48.9	50.4	11.5	42.5	21.1	20.1	145.6	194.5
2017	64,433	4,403	100%	4,403	4,403	- 426.4	- 45.2	161.3	- 21.1	- 331.4	46.0	11.5	42.5	21.1	20.1	141.1	- 190.2
						Note: Residual values in (brackets)											
Net Present values				m3 x 1,000						US$ x 1,000						US$ x 1,000	US$ x 1,000
		15%		3,993						3,097.3						628.4	3,715.7
		12%		5,328						3,262.4						780.4	4,042.8
		9%		7,295						3,469.9						993.1	4,462.9
Average Incremental costs (Shs/m3)										US$/m3						US$/m3	US$/m3
		15%								0.77						0.16	0.93
		12%								0.61						0.15	0.76
		9%								0.48						0.14	0.61

Table L-7 Cost Estimates Chogoria Water Supply

Investment costs	Exchange rate	1 US $ =	56	KShs	Phase 1			1998	Phase 2			2003	3-Oct-97
Element	Description dia (mm Size		Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,0	Pipes US $ x 1,000	Quantity	Civil US $ x 1,0	E&M US $ x 1,0	Pipes US $ x 1,000	
Rehabilitation					item	8.9	-	40.0					
Intake					item	184.0							
Raw pipeline	150	mm dia steel pipe	m	49.339	-			-					
	200	mm dia steel pipe	m	71.143	4,654			331.1					
Treatment	1,500	m3/d capacity plant	nr	284,161	1	241.5	42.6						
	1,500	m3/d expansion	nr	196,932					1.0	167.4	29.5		
Reservoirs	750	m3 reservoir	nr	60,000		-				-			
	400	m3 reservoir	nr	34,643		-				-			
	300	m3 reservoir	nr	27,143	2	54.3				-			
	250	m3 reservoir	nr	23,036	1	23.0			1.0	23.0			
	200	m3 reservoir	nr	19,107	1	19.1			1.0	19.1			
	150	m3 reservoir	nr	16,786		-				-			
	100	m3 reservoir	nr	13,929		-				-			
Transmission	400	mm dia uPVC (9 bar)	m	98.621				-					-
	315	mm dia uPVC (12 bar)	m	77.554				-					-
	280	mm dia uPVC (12 bar)	m	60.875				-					-
	225	mm dia uPVC (12 bar)	m	46.857	5,000			234.3	1,000				46.9
	160	mm dia uPVC (12 bar)	m	28.982	16,100			466.6	2,000				58.0
Ancillaries/contingencies				25%		132.7	10.7	268.0		52.4	7.4		26.2
Preliminaries				15%		99.5	8.0	201.0		39.3	5.5		19.7
Total						763.1	61.3	1,541.0		301.3	42.5		150.7
Total phased costs					Phase 1			2,365.4	Phase 2				494.4
Annual costs													
Annual	110	mm dia uPVC (12 bar)	m	18.446				-					-
distribution	90	mm dia uPVC (12 bar)	m	15.500	500			8	500				8
pipes	63	mm dia uPVC (12 bar)	m	12.089	1,000			12	1,000				12
Total								20					20

Transport Requirements		US$x1,000	1998			2003		
Saloon car	nr	17.9	0		-	0		-
4WD vehicle	nr	62.5	1		63	1		63
Pickup	nr	21.4	1		21	2		43
Lorry	nr	107.1	0		-	0		-

Annual O&M costs as % of investments	Transpo	Civil	E&M	Pipes
	20%	1.00%	4.00%	1.00%
Economic life	5	30	10	30

Power			1998	Fixed	Variable	2003	Fixed	Variable
Power tariff (Oct 1996)	Power Requirements			10	10		10	10
Unit energy cost	US$/unit	0.079						
Fixed charge per month	US$/month	7.857						
kVA demand charge	US$/month	4.464						

Human resources		Rate/yr US$x1,000	1998 TWks 1	1998 TWks2	1998 Dist'n	1998 US$x1,000	2003 TWks 1	2003 TWks2	2003 Dist'n	2003 US$x1,000
Engineer I	Shs/yr	3.86			-				1	3.86
Engineer II	Shs/yr	3.21			1	3.21			1	3.21
Inspector	Shs/yr	2.36	1		2	7.07	1		2	7.07
Senior Operator	Shs/yr	1.29	2		3	6.43	2		3	6.43
Operator	Shs/yr	0.96	2		4	5.79	2		4	5.79
Watchman/Line patrolman/Clerks	Shs/yr	0.84	3		12	9.64	3		14	10.93
	Shs/yr					32.14				37.29

Chemical costs	US$/kg	1998 Dosage (mg/l)	Cost/m3	2003 Dosage (mg/l)	Cost/m3
Alum	0.45	0	0.000	0	0.000
Chlorine	6.25	2	0.013	2	0.013
Soda ash	0.25	0	0.000	0	0.000
Total chemical cost per m3			0.013		0.013

Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	Increm-ental supply m3/d	Investment Schedule Treatment Civil US$ x 1,000	Treatment E&M US$ x 1,000	Pipes US$ x 1,000	Transpo US$ x 1,0	Total Investmen US$ x 1,000	O&M Costs US$ x 1,0	Power Costs US$ x 1,000	Labour US$ x 1,00	Transpor US$ x 1,00	Chemica US$ x 1,00	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
1996																	
1997	32,134	1,131	0%	-	-										-	-	2,449
1998	33,096	1,274	0%	-	-	763	61	1,541	84	2,449							
1999	34,016	1,423	50%	711	711			20		20	26	8	32	17	3	85	105
2000	34,920	1,577	55%	867	867			20		20	26	8	32	17	4	97	106
2001	35,833	1,689	60%	1,013	1,013			20		20	26	8	32	17	5	88	108
2002	36,754	1,805	65%	1,173	1,173			20		20	26	8	32	17	5	89	109
2003	37,684	1,925	70%	1,348	1,348	301	42	151	105	600	33	9	37	21	6	106	706
2004	38,621	2,050	75%	1,537	1,537			20		20	33	9	37	21	7	107	127
2005	39,565	2,178	80%	1,742	1,742			20		20	33	9	37	21	8	109	128
2006	40,516	2,311	85%	1,964	1,964			20		20	33	10	37	21	9	110	130
2007	41,473	2,448	90%	2,203	2,203			20		20	33	10	37	21	10	112	132
2008	42,435	2,589	95%	2,459	2,459		61	20	105	186	36	11	37	21	11	116	303
2009	43,403	2,734	98%	2,665	2,665			20		20	36	11	37	21	12	118	138
2010	44,376	2,883	100%	2,883	2,883			20		20	36	11	37	21	13	119	139
2011	44,376	2,883	100%	2,883	2,883			20		20	37	11	37	21	13	120	139
2012	44,376	2,883	100%	2,883	2,883			20		20	37	11	37	21	13	120	140
2013	44,376	2,883	100%	2,883	2,883		42	20	105	168	39	11	37	21	13	122	289
2014	44,376	2,883	100%	2,883	2,883			20		20	39	11	37	21	13	122	142
2015	44,376	2,883	100%	2,883	2,883			20		20	39	11	37	21	13	122	142
2016	44,376	2,883	100%	2,883	2,883			20		20	39	11	37	21	13	122	142
2017	44,376	2,883	100%	2,883	2,883	-(280)	-(38)	(372)	-(21)	(34)	39	11	37	21	13	122	(155)

Note: Residual values in (brackets)

Net Present values			m3 x 1,000					US$ x 1,000					US$ x 1,000	US$ x 1,000
		15%	2,713					2,540					545	3,085
		12%	3,605					2,685					675	3,360
		9%	4,915					2,860					858	3,718
Average incremental costs (Shs/m3)								US$/m3					US$/m3	US$/m3
		15%						0.94					0.20	1.14
		12%						0.74					0.19	0.93
		9%						0.58					0.17	0.76

Table L-8 Cost Estimates Maua Water Supply

Investment costs	Exchange rate..... 1 US $ =	56	KShs	Phase 1			1998	Phase 2			2003	3-Oct-97
Element	Description dia (mm Size	Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	
Rehabilitation				item	1.8		14.3					
Intake				item	4.2							
Raw pipeline	150 mm dia steel pipe	m	49.339	400			19.7					
	200 mm dia steel pipe	m	71.143	-			-					
Treatment	1,500 m3/d capacity plant	nr	552,357		469.5	82.9						
	0 m3/d expansion	nr	-						-	-		
Reservoirs	500 m3 reservoir	nr	41,964	1	42.0			1.0	42.0			
	400 m3 reservoir	nr	34,643		-				-			
	300 m3 reservoir	nr	27,143		-				-			
	250 m3 reservoir	nr	23,036		-				-			
	200 m3 reservoir	nr	19,107		-				-			
	150 m3 reservoir	nr	16,786	1	16.8			1.0	16.8			
	100 m3 reservoir	nr	13,929		-				-			
Transmission	400 mm dia uPVC (9 bar)	m	98.821				-				-	
	315 mm dia uPVC (12 bar)	m	77.554				-				-	
	280 mm dia uPVC (12 bar)	m	60.875				-				-	
	225 mm dia uPVC (12 bar)	m	46.857	1,500			70.3				-	
	160 mm dia uPVC (12 bar)	m	28.982	2,700			78.3	1,500			43.5	
Ancillaries/contingencies			25%		133.6	20.7	45.6		14.7	-	10.9	
Ancillaries/contingencies			15%		100.2	15.5	34.2		11.0	-	8.2	
Total					768.0	119.1	262.4		84.5	-	62.5	
Total phased costs				Phase 1			1,149.5	Phase 2			146.9	
Annual costs												
Annual distribution pipes	110 mm dia uPVC (12 bar)	m	18.446				-				-	
	90 mm dia uPVC (12 bar)	m	15.500	200			3.1	200			3.1	
	63 mm dia uPVC (12 bar)	m	12.089	200			2.4	200			2.4	
Total							5.5				5.5	

Transport Requirements		US$x1,000	1998				2003			
	Saloon car	nr	17.9	0		-	0			-
	4WD vehicle	nr	62.5	0		-	0			-
	Pickup	nr	21.4	1		21.4	1			21.4
	Lorry	nr	107.1	0		-	0			-

	Transpo	Civil	E&M	Pipes
Annual O&M costs as % of investments	20%	1.00%	4.00%	1.00%
Economic life	5	30	10	30

Power			1998	Fixed	Variable		2003	Fixed	Variable
Power tariff (Oct 1996)	Power Requirements.....			10	10			10	10
Unit energy cost	US$/unit	0.079							
Fixed charge per month	US$/month	7.857							
kVA demand charge	US$/month	4.464							

Human resources		Rate/yr	1998				2003			
		US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000	TWks 1	TWks2	Dist'n	US$x1,000
	Engineer I	Shs/yr	3.86			0 -			1	3.86
	Engineer II	Shs/yr	3.21			1 3.21			1	3.21
	Inspector	Shs/yr	2.36	2		1 7.07	2		2	9.43
	Senior Operator	Shs/yr	1.29	2		2 5.14	2		2	5.14
	Operator	Shs/yr	0.96	2		3 4.82	2		3	4.82
	Watchman/Line patrolman/Clerks	Shs/yr	0.64	3		8 7.07	3		10	8.36
		Shs/yr				27.32				34.82

Chemical costs	US$/kg	1998 Dosage (mg/l)	Cost/m3	2003 Dosage (mg/l)	Cost/m3
Alum	0.45	20	0.009	20	0.009
Chlorine	6.25	2	0.013	2	0.013
Soda ash	0.25	5	0.001	5	0.001
Total chemical cost per m3.....			0.023		0.023

Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	Increm-ental supply m3/d	Investment Schedule Treatment Civil US$ x 1,000	E&M US$ x 1,000	Pipes US$ x 1,000	Transpo US$ x 1,000	Total Investmen US$ x 1,000	O&M Costs US$ x 1,000	Power Costs US$ x 1,000	Labour US$ x 1,000	Transport US$ x 1,000	Chemica US$ x 1,000	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
1996																	
1997	5,537	552		-	-												
1998	5,925	603		-	-	768.0	119.1	262.4	21.4	1,170.9					-	-	1,170.9
1999	6,340	659	100%	659	659			5.5		5.5	15.1	8.6	27.3	4.3	5.5	60.8	66.3
2000	6,783	719	100%	719	719			5.5		5.5	15.2	8.8	27.3	4.3	6.0	61.6	67.1
2001	7,258	774	100%	774	774			5.5		5.5	15.2	9.0	27.3	4.3	6.4	62.2	67.8
2002	7,766	832	100%	832	832			5.5		5.5	15.3	9.2	27.3	4.3	6.9	63.0	68.5
2003	8,310	896	100%	896	896	84.5	-	62.5	21.4	168.4	16.8	9.4	34.8	4.3	7.4	72.7	241.1
2004	8,892	963	100%	963	963			5.5		5.5	16.8	9.7	34.8	4.3	8.0	73.5	79.1
2005	9,514	1,036	100%	1,036	1,036			5.5		5.5	16.9	9.9	34.8	4.3	8.6	74.5	80.0
2006	10,180	1,115	100%	1,115	1,115			5.5		5.5	16.9	10.2	34.8	4.3	9.2	75.4	81.0
2007	10,893	1,199	100%	1,199	1,199			5.5		5.5	17.0	10.5	34.8	4.3	9.9	76.5	82.0
2008	11,655	1,290	100%	1,290	1,290		119.1	5.5	21.4	146.0	21.8	10.8	34.8	4.3	10.7	82.4	228.4
2009	12,471	1,388	100%	1,388	1,388			5.5		5.5	21.9	11.1	34.8	4.3	11.5	83.6	89.1
2010	13,344	1,493	100%	1,493	1,493			5.5		5.5	21.9	11.5	34.8	4.3	12.4	84.9	90.4
2011	13,344	1,493	100%	1,493	1,493			5.5		5.5	22.0	11.5	34.8	4.3	12.4	84.9	90.4
2012	13,344	1,493	100%	1,493	1,493			5.5		5.5	22.0	11.5	34.8	4.3	12.4	85.0	90.5
2013	13,344	1,493	100%	1,493	1,493		-	5.5	21.4	26.9	22.1	11.5	34.8	4.3	12.4	85.0	112.0
2014	13,344	1,493	100%	1,493	1,493			5.5		5.5	22.1	11.5	34.8	4.3	12.4	85.1	90.6
2015	13,344	1,493	100%	1,493	1,493			5.5		5.5	22.2	11.5	34.8	4.3	12.4	85.1	90.7
2016	13,344	1,493	100%	1,493	1,493			5.5		5.5	22.2	11.5	34.8	4.3	12.4	85.2	90.7
2017	13,344	1,493	100%	1,493	1,493	- 281.6	- 23.8	26.8	- 4.3	- 282.9	18.7	11.5	34.8	4.3	12.4	81.7	- 201.2
						Note: Residual values in (brackets)											
Net Present values					m3 x 1,000					US$ x 1,000						US$ x 1,000	US$ x 1,000
		15%			1,688					1,133.2						381.5	1,514.8
		12%			2,193					1,178.3						472.8	1,651.1
		9%			2,924					1,225.1						600.1	1,825.1
Average incremental costs (Shs/m3)										US$/m3						US$/m3	US$/m3
		15%								0.67						0.23	0.90
		12%								0.54						0.22	0.75
		9%								0.42						0.21	0.62

Table L-9 Cost Estimates Tigania Water Supply

Investment costs	Exchange rate..... 1 US $ =		56 KShs	Phase 1			1998	Phase 2			2003	9-Oct-97
Element	Description dia (mm Size	Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	
Rehabilitation				item	-	-	-					
Intake				item	134.9							
Raw pipeline	250 mm dia steel pipe	m	95.661	2,000			191.3					
	200 mm dia steel pipe	m	71.143				-					
Treatment	2,000 m3/d capacity plant	nr	294,196	1	250.1	44.1						
	2,000 m3/d expansion	nr	207,018					1.0	176.0	31.1		
Reservoirs	500 m3 reservoir	nr	41,964	1	42.0				-			
	400 m3 reservoir	nr	34,643		-			1.0	34.6			
	300 m3 reservoir	nr	27,143		-				-			
	250 m3 reservoir	nr	23,036		-				-			
	200 m3 reservoir	nr	19,107	1	19.1			1.0	19.1			
	150 m3 reservoir	nr	16,786	2	33.6			2.0	33.6			
	100 m3 reservoir	nr	13,929		-				-			
Transmission	400 mm dia uPVC (9 bar)	m	98.821				-					-
	315 mm dia uPVC (12 bar)	m	77.554				-					-
	280 mm dia uPVC (12 bar)	m	60.875	11,800			718.3					-
	225 mm dia uPVC (12 bar)	m	46.857	8,900			417.0					-
	160 mm dia uPVC (12 bar)	m	28.982	4,300			124.6	2,800				81.2
Ancillaries/contingencies			25%		119.9	11.0	362.8		65.8	7.8		20.3
Preliminaries			15%		89.9	8.3	272.1		49.4	5.8		15.2
Total					689.5	63.4	2,086.2		378.5	44.6		116.7
Total phased costs				Phase 1			2,839.1	Phase 2				539.8
Annual costs												
Annual distribution pipes	110 mm dia uPVC (12 bar)	m	18.446	1,000			18	1,000				18.4
	90 mm dia uPVC (12 bar)	m	15.500	500			7.8	500				7.8
	63 mm dia uPVC (12 bar)	m	12.089	1,000			12.1	1,000				12.1
Total							38.3					38.3

Transport Requirements		US$x1,000	1998			2003			
Saloon car	nr	17.9	0			0			-
4WD vehicle	nr	62.5	1			62.5	1		62.5
Pickup	nr	21.4	2			42.9	2		42.9
Lorry	nr	107.1	0			-	0		-

	Transpo	Civil	E&M	Pipes
Annual O&M costs as % of Investments	20%	1.00%	4.00%	1.00%
Economic life	5	30	10	30

Power			1998	Fixed	Variable	2003	Fixed	Variable
Power tariff (Oct 1996)	Power Requirements.....			10	10		10	10
Unit energy cost	US$/unit	0.079						
Fixed charge per month	US$/month	7.857						
kVA demand charge	US$/month	4.464						

Human resources		Rate/yr US$x1,000	1998 TWks 1	1998 TWks2	1998 Dist'n	1998 US$x1,000	2003 TWks 1	2003 TWks2	2003 Dist'n	2003 US$x1,000
Engineer I	Shs/yr	3.86			1	3.86			1	3.86
Engineer II	Shs/yr	3.21			1	3.21			2	6.43
Inspector	Shs/yr	2.36	1		2	7.07	1		3	9.43
Senior Operator	Shs/yr	1.29	2		3	6.43	2		4	7.71
Operator	Shs/yr	0.96	2		4	5.79	2		5	6.75
Watchman/Line patrolmen/Clerks	Shs/yr	0.64	3		12	9.64	3		19	14.14
	Shs/yr					36.00				48.32

Chemical costs		US$/kg	1998 Dosage (mg/l)	Cost/m3	2003 Dosage (mg/l)	Cost/m3
Alum		0.45	0	0.000	0	0.000
Chlorine		6.25	2	0.013	2	0.013
Soda ash		0.25	0	0.000	0	0.000
Total chemical cost per m3.....				0.013		0.013

Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	Incremental supply m3/d	Investment Schedule Treatment Civil US$ x 1,000	Investment Schedule E&M US$ x 1,000	Pipes US$ x 1,000	Transpo US$ x 1,000	Total Investment US$ x 1,000	O&M Costs US$ x 1,000	Power Costs US$ x 1,000	Labour US$ x 1,000	Transport US$ x 1,000	Chemical US$ x 1,000	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
1996																	
1997	63,891	1,532		-	-										-	-	
1998	65,515	1,723		-	-	689.5	63.4	2,086.2	105.4	2,944.5							2,944.5
1999	67,103	1,921	50%	960	960			38.3		38.3	30.7	7.6	36.0	21.1	4.4	99.8	138.1
2000	68,650	2,125	55%	1,169	1,169			38.3		38.3	31.1	7.9	36.0	21.1	5.3	101.4	139.7
2001	70,186	2,271	60%	1,363	1,363			38.3		38.3	31.4	8.2	36.0	21.1	6.2	102.9	141.2
2002	71,708	2,421	65%	1,574	1,574			38.3		38.3	31.8	8.5	36.0	21.1	7.2	104.6	142.8
2003	73,214	2,576	70%	1,803	1,803	378.5	44.6	116.7	105.4	645.1	38.6	8.8	48.3	21.1	8.2	125.0	770.1
2004	74,702	2,735	75%	2,052	2,052			38.3		38.3	38.9	9.1	48.3	21.1	9.4	126.8	165.1
2005	76,169	2,899	80%	2,319	2,319			38.3		38.3	39.3	9.5	48.3	21.1	10.6	128.8	167.1
2006	77,613	3,067	85%	2,607	2,607			38.3		38.3	39.7	9.9	48.3	21.1	11.9	130.9	169.2
2007	79,033	3,239	90%	2,915	2,915			38.3		38.3	40.1	10.3	48.3	21.1	13.3	133.1	171.4
2008	80,425	3,415	95%	3,244	3,244		63.4	38.3	105.4	207.1	43.0	10.8	48.3	21.1	14.8	138.0	345.0
2009	81,789	3,595	98%	3,505	3,505			38.3		38.3	43.4	11.1	48.3	21.1	16.0	139.9	178.2
2010	83,121	3,778	100%	3,778	3,778			38.3		38.3	43.8	11.5	48.3	21.1	17.2	141.9	180.2
2011	83,121	3,778	100%	3,778	3,778			38.3		38.3	44.2	11.5	48.3	21.1	17.2	142.3	180.6
2012	83,121	3,778	100%	3,778	3,778			38.3		38.3	44.5	11.5	48.3	21.1	17.2	142.7	181.0
2013	83,121	3,778	100%	3,778	3,778		44.6	38.3	105.4	188.3	46.7	11.5	48.3	21.1	17.2	144.8	333.1
2014	83,121	3,778	100%	3,778	3,778			38.3		38.3	47.1	11.5	48.3	21.1	17.2	145.2	183.5
2015	83,121	3,778	100%	3,778	3,778			38.3		38.3	47.5	11.5	48.3	21.1	17.2	145.6	183.9
2016	83,121	3,778	100%	3,778	3,778			38.3		38.3	47.9	11.5	48.3	21.1	17.2	146.0	184.3
2017	83,121	3,778	100%	3,778	3,778	- 252.8	- 39.5	450.7	- 21.1	137.4	48.3	11.5	48.3	21.1	17.2	146.4	283.8
					Note: Residual values in (brackets)												
Net Present values				m3 x 1,000						US$ x 1,000						US$ x 1,000	US$ x 1,000
		15%		3,602						3,087.5						643.3	3,730.8
		12%		4,779						3,271.5						798.3	4,069.8
		9%		6,506						3,498.4						1,014.8	4,513.3
Average Incremental costs (Shs/m3)										US$/m3						US$/m3	US$/m3
		15%								0.86						0.18	1.04
		12%								0.68						0.17	0.85
		9%								0.54						0.16	0.69

Table L-10 Meru Water Supply Cash Flow

Water Sales		Projected flows (m3/day)													
Year		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs	1,370	1,878	2,410	2,965	3,341	3,732	4,138	4,559	4,994	5,445	5,909	6,388	6,881	7,388
	Kiosks	913	861	803	741	709	674	637	597	555	510	463	414	362	308
Urban demand	ICs	3,854	4,210	4,592	5,002	5,308	5,633	5,978	6,342	6,728	7,137	7,570	8,028	8,514	9,027
	Kiosks	560	545	526	504	515	524	534	543	552	560	568	575	581	587
Total		6,697	7,493	8,332	9,212	9,872	10,564	11,286	12,041	12,830	13,652	14,511	15,406	16,339	17,311
Livestock		237	241	246	251	256	261	267	272	277	283	289	294	300	306
Industry		2,392	2,473	2,558	2,645	2,729	2,817	2,907	3,001	3,097	3,196	3,299	3,405	3,514	3,627
Institutional		514	532	550	568	587	606	626	646	667	688	710	732	756	779
Health		143	148	153	158	163	168	174	179	185	191	197	204	210	217
Commcial		320	331	342	354	365	377	389	401	414	428	441	455	470	485
Total	m3/d	10,302	11,219	12,181	13,188	13,974	14,794	15,649	16,541	17,470	18,438	19,447	20,496	21,589	22,725

Revenue		US$ x 1,000		Exchange rate..... 1 US$ =			56	Shs							
		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs			165	203	229	255	283	312	342	372	404	437	471	505
	Kiosks			42	39	37	35	33	31	29	27	24	22	19	16
Urban demand	ICs			368	401	425	452	479	508	539	572	607	643	682	724
	Kiosks			27	26	27	27	28	28	29	29	30	30	30	31
Livestock				24	25	25	26	26	27	27	28	28	29	29	30
Industry				333	345	356	367	379	391	404	417	430	444	458	473
Institutional				32	33	34	36	37	36	39	40	42	43	44	46
Health				20	21	21	22	23	23	24	25	26	27	27	28
Commcial				45	46	48	49	51	52	54	56	58	59	61	63
Total				1,057	1,138	1,202	1,269	1,338	1,411	1,467	1,566	1,648	1,734	1,823	1,916

Expenditure			US$/yr x 1,000												
			1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
O&M	Costs	US$ x 1,000			112	113	114	115	161	162	163	164	166	181	182	183
Power	Costs	US$ x 1,000			15	16	16	17	18	18	19	20	21	21	22	23
Labour		US$ x 1,000			55	55	55	55	70	70	70	70	70	70	70	70
Transport		US$ x 1,000			68	68	68	68	72	72	72	72	72	72	72	72
Chemicals		US$ x 1,000			13	19	24	29	36	57	67	77	89	101	111	121
Total	Recurrent	US$ x 1,000			262	269	276	284	355	379	390	403	416	445	456	468
Depreciation																
Interest on foreign loan																
Total	Costs	Shs x 1,000			262	269	276	284	355	379	390	403	416	445	456	468
Revenue minus expenditure					794	869	926	985	983	1,032	1,096	1,163	1,232	1,289	1,367	1,447
Accumulated net revenue																
(Average tariff) .....(Shs/m3).....					13.3	13.2	13.2	13.2	13.1	13.1	13.1	13.0	13.0	13.0	13.0	12.9
Investment costs		US$ x 1,000		10,300	123	123	123	123	4,189	111	111	111	111	828	111	111

Table L-11 Nkubu Water Supply Cash Flow

Water Sales		Projected flows (m3/day)												
Year		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs	50	69	88	109	122	137	152	167	183	200	217	234	252	271
	Kiosks	33	32	29	27	26	25	23	22	20	19	17	15	13	11
Urban demand	ICs	614	654	697	742	782	825	870	917	967	1,020	1,075	1,134	1,195	1,260
	Kiosks	33	32	31	30	30	31	31	32	32	33	33	34	34	35
Total		730	786	845	908	961	1,017	1,076	1,138	1,203	1,271	1,342	1,417	1,495	1,577
Livestock		20	20	20	21	21	22	22	23	23	23	24	24	25	25
Industry		55	57	60	62	64	67	69	72	75	78	81	84	87	91
Institutional		53	55	57	59	62	64	66	69	72	74	77	80	84	87
Health		44	46	48	50	51	54	56	58	60	62	65	67	70	73
Commcial		38	40	41	43	44	46	48	50	52	54	56	58	61	63
Total	m3/d	940	1,004	1,071	1,142	1,204	1,270	1,338	1,410	1,485	1,563	1,646	1,731	1,821	1,915

Revenue		US$ x 1,000		Exchange rate..... 1 US$ =			56	Shs							
		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs			6.0	7.4	8.4	9.4	10.4	11.4	12.5	13.7	14.8	16.0	17.3	18.5
	Kiosks			1.5	1.4	1.4	1.3	1.2	1.1	1.1	1.0	0.9	0.8	0.7	0.6
Urban demand	ICs			55.8	59.5	62.7	66.1	69.7	73.5	77.5	81.7	86.2	90.9	95.8	101.0
	Kiosks			1.6	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8	1.8
Livestock				2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5
Industry				7.8	8.1	8.4	8.7	9.1	9.4	9.8	10.2	10.5	11.0	11.4	11.8
Institutional				3.3	3.5	3.6	3.7	3.9	4.0	4.2	4.4	4.5	4.7	4.9	5.1
Health				6.2	6.5	6.7	7.0	7.2	7.5	7.8	8.1	8.4	8.8	9.1	9.5
Commcial				5.4	5.6	5.8	6.0	6.3	6.5	6.8	7.1	7.3	7.6	7.9	8.2
Total				89.7	95.5	100.6	106.0	111.6	117.5	123.6	130.1	136.8	143.9	151.3	159.0

Expenditure			US$/yr x 1,000												
			1997	1,998.0	1,999.0	2,000.0	2,001.0	2,002.0	2,003.0	2,004.0	2,005.0	2,006.0	2,007.0	2,008.0	2,009.0	2,010.0
O&M	Costs	US$ x 1,000			16.9	17.0	17.0	17.1	23.4	23.4	23.5	23.5	23.6	28.5	28.6	28.6
Power	Costs	US$ x 1,000			7.8	8.0	8.3	8.6	8.9	9.2	9.5	9.9	10.3	10.8	11.1	11.5
Labour		US$ x 1,000			31.6	31.6	31.6	31.6	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8
Transport		US$ x 1,000			4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Chemicals		US$ x 1,000			2.4	2.9	3.3	3.8	4.3	8.8	9.8	11.0	12.3	13.6	14.7	15.9
Total	Recurrent	US$ x 1,000			63.0	63.7	64.5	65.3	77.5	82.4	83.9	85.5	87.2	93.9	95.4	97.0
Depreciation																
Interest on foreign loan																
Total	Costs	Shs x 1,000			63.0	63.7	64.5	65.3	77.5	82.4	83.9	85.5	87.2	93.9	95.4	97.0
Revenue minus expenditure					26.7	31.8	36.1	40.7	34.0	35.1	39.8	44.6	49.6	50.0	55.9	62.0
Accumulated net revenue																
(Average tariff) .....(Shs/m3).....					12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.7	12.7	12.7
Investment costs	US$ x 1,000			1,342.0	5.5	5.5	5.5	5.5	474.9	5.5	5.5	5.5	5.5	146.4	5.5	5.5

Table L-12 Isiolo Water Supply Cash Flow

Water Sales		Projected flows (m3/day)													
Year		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs	14	20	25	31	34	38	42	46	50	54	58	62	67	71
	Kiosks	69	69	69	69	70	70	70	71	71	71	71	71	71	71
Urban demand	ICs	888	1,005	1,131	1,268	1,357	1,451	1,551	1,658	1,772	1,892	2,021	2,157	2,302	2,457
	Kiosks	249	242	234	224	229	233	237	241	245	249	252	256	258	261
Total		1,220	1,335	1,459	1,592	1,689	1,792	1,901	2,016	2,138	2,267	2,403	2,547	2,699	2,859
Livestock		199	203	207	212	216	220	225	229	234	238	243	248	253	258
Industry		138	143	149	156	162	169	176	183	191	199	207	216	225	234
Institutional		1,624	1,692	1,762	1,835	1,912	1,992	2,075	2,161	2,251	2,345	2,442	2,544	2,650	2,760
Health		71	74	77	80	83	87	90	94	98	102	106	111	115	120
Commcial		83	86	90	93	97	101	106	110	114	119	124	129	135	140
Total	m3/d	3,334	3,534	3,745	3,968	4,160	4,361	4,572	4,794	5,026	5,270	5,526	5,794	6,076	6,372

Revenue		US$ x 1,000		Exchange rate..... 1 US$ =			56	Shs							
		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs			1.7	2.1	2.4	2.6	2.9	3.2	3.4	3.7	4.0	4.3	4.6	4.8
	Kiosks			3.6	3.6	3.6	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Urban demand	ICs			90.7	101.6	108.7	116.3	124.3	132.9	142.0	151.7	162.0	172.9	184.5	196.9
	Kiosks			12.2	11.7	11.9	12.2	12.4	12.6	12.8	13.0	13.2	13.3	13.5	13.6
Livestock				20.3	20.7	21.1	21.5	22.0	22.4	22.8	23.3	23.8	24.2	24.7	25.2
Industry				19.5	20.3	21.1	22.0	22.9	23.9	24.9	25.9	27.0	28.1	29.3	30.5
Institutional				103.4	107.7	112.2	116.8	121.7	126.8	132.1	137.5	143.3	149.2	155.4	161.9
Health				10.0	10.4	10.9	11.3	11.8	12.3	12.8	13.3	13.9	14.4	15.0	15.7
Commcial				11.7	12.2	12.7	13.2	13.8	14.3	14.9	15.5	16.2	16.9	17.6	18.3
Total				273.0	290.3	304.6	319.6	335.4	352.0	369.4	387.7	406.9	427.1	448.4	470.7

Expenditure			US$/yr x 1,000												
			1997	1,998.0	1,999.0	2,000.0	2,001.0	2,002.0	2,003.0	2,004.0	2,005.0	2,006.0	2,007.0	2,008.0	2,009.0	2,010.0
O&M	Costs	US$ x 1,000			26.7	26.9	27.1	27.3	36.7	36.9	37.1	37.3	37.5	41.1	41.3	41.5
Power	Costs	US$ x 1,000			9.1	9.5	9.7	9.9	20.6	21.3	21.9	22.6	23.3	24.1	24.9	25.7
Labour		US$ x 1,000			30.5	30.5	30.5	30.5	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8
Transport		US$ x 1,000			16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8
Chemicals		US$ x 1,000			2.6	5.3	6.2	7.1	8.1	9.1	10.2	11.3	12.4	13.7	14.9	16.3
Total	Recurrent	US$ x 1,000			85.7	89.1	90.3	91.6	114.0	115.8	117.7	119.7	121.8	127.4	129.7	132.1
Depreciation																
Interest on foreign loan																
Total	Costs	Shs x 1,000			85.7	89.1	90.3	91.6	114.0	115.8	117.7	119.7	121.8	127.4	129.7	132.1
Revenue minus expenditure			-		187.3	201.2	214.2	228.0	221.4	236.1	251.6	267.9	285.1	299.7	318.6	338.6
Accumulated net revenue																
(Average tariff) .....(Shs/m3).....					11.2	11.2	11.2	11.2	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Investment costs		US$ x 1,000		2,479.8	19.9	19.9	19.9	19.9	573.0	19.9	19.9	19.9	19.9	189.2	19.9	19.9

Table L-13 Chuka Water Supply Cash Flow

Water Sales		Projected flows (m3/day)													
Year		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs	414	568	728	895	1,009	1,127	1,249	1,375	1,506	1,641	1,780	1,924	2,071	2,223
	Kiosks	301	286	268	250	240	230	219	207	195	182	167	153	137	121
Urban demand	ICs	282	330	385	450	508	571	639	711	788	869	954	1,042	1,132	1,225
	Kiosks	48	50	51	52	57	61	65	70	74	78	81	85	88	90
Total		1,045	1,232	1,433	1,648	1,814	1,989	2,172	2,363	2,562	2,769	2,983	3,203	3,429	3,659
Livestock		77	79	80	82	84	85	87	89	91	92	94	96	98	100
Industry		133	138	143	148	153	158	163	169	175	180	187	193	199	206
Institutional		103	107	111	115	119	123	128	132	137	141	146	151	155	160
Health		35	37	38	39	41	42	43	45	46	48	50	51	53	55
Commcial		143	149	154	160	165	171	177	183	189	195	202	208	216	223
Total	m3/d	1,537	1,741	1,959	2,192	2,375	2,568	2,770	2,980	3,199	3,426	3,661	3,902	4,150	4,403
Revenue		US$ x 1,000		Exchange rate..... 1 US$ =			56	Shs							
		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs			49.8	61.3	69.0	77.1	85.4	94.1	103.0	112.3	121.8	131.6	141.7	152.1
	Kiosks			14.0	13.0	12.5	12.0	11.4	10.8	10.2	9.5	8.7	8.0	7.2	6.3
Urban demand	ICs			30.9	36.1	40.7	45.8	51.2	57.0	63.1	69.6	76.4	83.5	90.8	98.2
	Kiosks			2.7	2.7	2.9	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.7
Livestock				7.9	8.0	8.2	8.3	8.5	8.7	8.9	9.0	9.2	9.4	9.6	9.8
Industry				18.6	19.3	19.9	20.6	21.3	22.0	22.8	23.5	24.3	25.1	26.0	26.9
Institutional				6.5	6.7	7.0	7.2	7.5	7.7	8.0	8.3	8.6	8.8	9.1	9.4
Health				4.9	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1
Commcial				20.1	20.8	21.5	22.3	23.0	23.8	24.6	25.4	26.3	27.2	28.1	29.0
Total				155.4	173.1	187.2	201.9	217.4	233.6	250.4	267.9	286.0	304.7	323.9	343.5
Expenditure		US$/yr x 1,000													
		1997	1,998.0	1,999.0	2,000.0	2,001.0	2,002.0	2,003.0	2,004.0	2,005.0	2,006.0	2,007.0	2,008.0	2,009.0	2,010.0
O&M Costs	US$ x 1,000			30.8	31.3	31.8	32.3	39.1	39.6	40.1	40.6	41.1	44.5	44.9	45.4
Power Costs	US$ x 1,000			7.5	7.7	8.0	8.3	8.6	8.9	9.3	9.7	10.2	10.7	11.1	11.5
Labour	US$ x 1,000			33.2	33.2	33.2	33.2	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5
Transport	US$ x 1,000			21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
Chemicals	US$ x 1,000			4.5	5.5	6.5	7.6	8.8	10.2	11.7	13.3	15.0	16.9	18.5	20.1
Total Recurrent	US$ x 1,000			97.0	98.8	100.6	102.5	120.2	122.3	124.7	127.2	129.9	135.7	138.1	140.6
Depreciation															
Interest on foreign loan															
Total Costs	Shs x 1,000			97.0	98.8	100.6	102.5	120.2	122.3	124.7	127.2	129.9	135.7	138.1	140.6
Revenue minus expenditure		-		58.3	74.3	86.6	99.5	97.3	111.3	125.8	140.7	156.2	169.1	185.8	202.9
Accumulated net revenue															
(Average tariff) .....(Shs/m3).....				12.2	12.1	12.1	12.1	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Investment costs	US$ x 1,000		2,919.6	48.9	48.9	48.9	48.9	634.5	48.9	48.9	48.9	48.9	226.9	48.9	48.9

Table L-14 Chogoria Water Supply Cash Flow

Water Sales		Projected flows (m3/day)													
Year		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs	362	497	637	784	884	987	1,095	1,206	1,321	1,440	1,563	1,690	1,820	1,954
	Kiosks	242	228	212	196	187	178	168	158	147	135	123	110	96	81
Urban demand	ICs	133	146	159	173	184	195	207	220	234	248	263	279	296	314
	Kiosks	20	19	19	18	18	19	19	19	20	20	20	21	21	21
Total		757	890	1,028	1,172	1,274	1,380	1,489	1,603	1,721	1,843	1,969	2,099	2,233	2,371
Livestock		47	48	49	50	51	52	53	54	55	56	57	59	60	61
Industry		77	79	81	83	85	87	90	92	94	96	99	101	103	106
Institutional		173	178	183	188	193	198	203	208	213	218	224	229	234	239
Health		51	53	54	56	57	58	60	61	63	64	66	67	69	71
Commcial		26	27	28	28	29	30	30	31	32	33	34	34	35	36
Total	m3/d	1,131	1,274	1,423	1,577	1,689	1,805	1,925	2,050	2,178	2,311	2,448	2,589	2,734	2,883

Revenue		US$ x 1,000		Exchange rate..... 1 US$ =			56	Shs							
		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs			44	54	60	68	75	82	90	99	107	116	125	134
	Kiosks			11	10	10	9	9	8	8	7	6	6	5	4
Urban demand	ICs			13	14	15	16	17	18	19	20	21	22	24	25
	Kiosks			1	1	1	1	1	1	1	1	1	1	1	1
Livestock				5	5	5	5	5	5	5	6	6	6	6	6
Industry				11	11	11	11	12	12	12	13	13	13	13	14
Institutional				11	11	11	12	12	12	13	13	13	13	14	14
Health				7	7	7	8	8	8	8	8	9	9	9	9
Commcial				4	4	4	4	4	4	4	4	4	4	5	5
Total				105	116	125	133	142	151	160	170	180	190	201	212

Expenditure			US$/yr x 1,000													
			1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
O&M	Costs	US$ x 1,000			26	26	26	26	33	33	33	33	33	36	36	36
Power	Costs	US$ x 1,000			8	8	8	8	9	9	9	10	10	11	11	11
Labour		US$ x 1,000			32	32	32	32	37	37	37	37	37	37	37	37
Transport		US$ x 1,000			17	17	17	17	21	21	21	21	21	21	21	21
Chemicals		US$ x 1,000			3	4	5	5	6	7	8	9	10	11	12	13
Total	Recurrent	US$ x 1,000			85	87	88	89	106	107	109	110	112	116	118	119
Depreciation																
Interest on foreign loan																
Total	Costs	Shs x 1,000			85	87	88	89	106	107	109	110	112	116	118	119
Revenue minus expenditure			-		20	30	37	44	36	44	52	60	68	74	83	93
Accumulated net revenue																
(Average tariff) .....(Shs/m3).....					11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Investment costs		US$ x 1,000		2,449	20	20	20	20	600	20	20	20	20	186	20	20

Table L-15 Maua Water Supply Cash Flow

Water Sales		Projected flows (m3/day)													
Year		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Kiosks	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Urban demand	ICs	357	400	447	499	540	585	633	686	742	803	869	941	1,018	1,101
	Kiosks	60	59	58	57	59	62	64	66	69	71	73	76	78	80
Total		417	459	505	556	599	646	697	752	811	874	942	1,016	1,095	1,181
Livestock		12	13	13	13	13	14	14	14	15	15	15	15	16	16
Industry		34	37	39	42	45	48	52	55	59	63	68	72	77	83
Institutional		22	24	26	27	29	31	34	36	38	41	44	47	50	54
Health		19	20	22	23	25	27	28	30	33	35	37	40	43	46
Commcial		47	51	54	58	62	66	71	76	81	87	93	99	106	114
Total	m3/d	552	603	659	719	774	832	896	963	1,036	1,115	1,199	1,290	1,388	1,493

Revenue		US$ x 1,000		Exchange rate..... 1 US$ =			56	Shs							
		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Kiosks			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban demand	ICs			35.8	40.0	43.3	46.9	50.8	54.9	59.5	64.4	69.7	75.4	81.6	88.2
	Kiosks			3.0	3.0	3.1	3.2	3.3	3.4	3.6	3.7	3.8	3.9	4.1	4.2
Livestock				1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.6
Industry				5.1	5.5	5.9	6.3	6.7	7.2	7.7	8.2	8.8	9.4	10.1	10.8
Institutional				1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.8	3.0	3.2
Health				2.8	3.0	3.2	3.5	3.7	3.9	4.2	4.5	4.8	5.2	5.6	5.9
Commcial				7.1	7.6	8.1	8.6	9.3	9.9	10.6	11.3	12.1	13.0	13.9	14.8
Total				56.7	61.9	66.6	71.6	77.1	82.9	89.2	96.0	103.3	111.2	119.6	128.7

Expenditure			US$/yr x 1,000												
			1997	1,998.0	1,999.0	2,000.0	2,001.0	2,002.0	2,003.0	2,004.0	2,005.0	2,006.0	2,007.0	2,008.0	2,009.0	2,010.0
O&M	Costs	US$ x 1,000			15.1	15.2	15.2	15.3	16.8	16.8	16.9	16.9	17.0	21.8	21.9	21.9
Power	Costs	US$ x 1,000			8.6	8.8	9.0	9.2	9.4	9.7	9.9	10.2	10.5	10.8	11.1	11.5
Labour		US$ x 1,000			27.3	27.3	27.3	27.3	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
Transport		US$ x 1,000			4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Chemicals		US$ x 1,000			5.5	6.0	6.4	6.9	7.4	8.0	8.6	9.2	9.9	10.7	11.5	12.4
Total	Recurrent	US$ x 1,000			60.8	61.6	62.2	63.0	72.7	73.5	74.5	75.4	76.5	82.4	83.6	84.9
Depreciation																
Interest on foreign loan																
Total	Costs	Shs x 1,000			60.8	61.6	62.2	63.0	72.7	73.5	74.5	75.4	76.5	82.4	83.6	84.9
Revenue minus expenditure			-		4.1	0.3	4.3	8.6	4.4	9.4	14.8	20.6	26.9	28.8	36.0	43.8
Accumulated net revenue																
(Average tariff) .....(Shs/m3).....					13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Investment costs	US$ x 1,000			1,170.9	5.5	5.5	5.5	5.5	168.4	5.5	5.5	5.5	5.5	146.0	5.5	5.5

Table L-16 Tigania Water Supply Cash Flow

Water Sales		Projected flows (m3/day)													
Year		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs	536	734	942	1,158	1,304	1,455	1,613	1,775	1,943	2,116	2,294	2,477	2,666	2,859
	Kiosks	545	527	507	485	475	463	451	438	423	408	391	373	354	334
Urban demand	ICs	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiosks	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		1,082	1,262	1,449	1,642	1,779	1,919	2,064	2,213	2,366	2,524	2,685	2,851	3,020	3,193
Livestock		98	100	102	104	106	108	111	113	115	117	120	122	125	127
Industry		49	51	52	53	54	55	56	57	58	59	61	62	63	64
Institutional		142	145	149	152	155	159	162	165	169	172	175	178	181	184
Health		39	40	41	42	43	44	45	46	47	48	48	49	50	51
Commcial		122	125	128	131	134	136	139	141	144	147	150	153	156	159
Total	m3/d	1,532	1,723	1,921	2,125	2,271	2,421	2,576	2,735	2,899	3,067	3,239	3,415	3,595	3,778

Revenue		US$ x 1,000		Exchange rate..... 1 US$ =			56	Shs							
		1997	1998	1999	2000	2001	2002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Rural Demand	ICs			64.4	79.2	89.2	99.6	110.3	121.4	132.9	144.7	156.9	169.5	182.3	195.5
	Kiosks			26.4	25.3	24.7	24.2	23.5	22.8	22.1	21.3	20.4	19.5	18.5	17.4
Urban demand	ICs			-	-	-	-	-	-	-	-	-	-	-	-
	Kiosks			-	-	-	-	-	-	-	-	-	-	-	-
Livestock				10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.5	11.7	11.9	12.2	12.4
Industry				6.7	6.9	7.0	7.2	7.3	7.5	7.6	7.7	7.9	8.0	8.2	8.4
Institutional				8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.4	10.6	10.8
Health				5.4	5.5	5.6	5.7	5.9	6.0	6.1	6.2	6.3	6.4	6.6	6.7
Commcial				16.7	17.1	17.4	17.7	18.1	18.4	18.8	19.2	19.5	19.9	20.3	20.7
Total				138.4	153.1	163.5	174.3	185.4	196.8	208.6	220.7	233.0	245.7	258.7	271.9

Expenditure			US$/yr x 1,000												
			1997	1,998.0	1,999.0	2,000.0	2,001.0	2,002.0	2,003.0	2,004.0	2,005.0	2,006.0	2,007.0	2,008.0	2,009.0	2,010.0
O&M	Costs	US$ x 1,000			30.7	31.1	31.4	31.8	38.6	38.9	39.3	39.7	40.1	43.0	43.4	43.8
Power	Costs	US$ x 1,000			7.6	7.9	8.2	8.5	8.8	9.1	9.5	9.9	10.3	10.8	11.1	11.5
Labour		US$ x 1,000			36.0	36.0	36.0	36.0	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3
Transport		US$ x 1,000			21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
Chemicals		US$ x 1,000			4.4	5.3	6.2	7.2	8.2	9.4	10.6	11.9	13.3	14.8	16.0	17.2
Total	Recurrent	US$ x 1,000			99.8	101.4	102.9	104.6	125.0	126.8	128.8	130.9	133.1	138.0	139.9	141.9
Depreciation																
Interest on foreign loan																
Total	Costs	Shs x 1,000			99.8	101.4	102.9	104.6	125.0	126.8	128.8	130.9	133.1	138.0	139.9	141.9
Revenue minus expenditure			-		38.6	51.7	60.6	69.8	60.4	70.0	79.8	89.8	99.9	107.7	118.8	130.0
Accumulated net revenue																
(Average tariff) .....(Shs/m3).....					11.1	11.1	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Investment costs		US$ x 1,000		2,944.5	38.3	38.3	38.3	38.3	645.1	38.3	38.3	38.3	38.3	207.1	38.3	38.3

Table L-17 Meru Water Supply Bill of Quantities

DESCRIPTION	Unit	Quantity	Rate	Amount
Intake				
Site clearance	m2	1,000	35	35,000
Excavation				
Normal excavation	m3	1,000	350	350,000
EO for rock excavation	m3	500	1,500	750,000
Bank protection	m3	500	1,630	815,000
River diversion	item			2,000,000
Roads	m2	12,000	350	4,200,000
Concrete "all in prices"		-		
Concrete 30/20 in base slab	m3	125	12,000	1,500,000
do in walls	m3	10	12,000	120,000
Sub total, intake				9,770,000
Raw Water Pipeline				
500 dia steel pipe	m	5,000	12,752	63,760,000
450 dia steel pipe	m	-	11,495	-
Sub total, raw water pipeline				63,760,000
Treatment Plant				
Site works				
Site clearance	m2	20,000	35	700,000
Roads	m2	8,000	350	2,800,000
Fence	m	600	1,500	900,000
Sub total, Site works				4,400,000
Horizontal Sedimentation Tanks				
Excavation				
Normal excavation	m3	6,303	350	2,205,941
EO for rock excavation	m3	3,001	1,500	4,501,920
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	990	20,000	19,808,448
do in walls	m3	1,148	20,000	22,952,160
Pipework	item	-	15%	7,420,270
Ancillaries	item		15%	7,420,270
Sub total Horizontal Sed. Tank	(8)	nr		64,309,009
Rapid Sand Filters				
Excavation				
Normal excavation	m3	1,849	350	647,002
EO for rock excavation	m3	770	1,500	1,155,360
Media inc. gravel	m3	280	1,500	420,480
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	212	20,000	4,236,320
do in walls	m3	713	20,000	14,260,000
Pipework	item	-	40%	8,267,665
Ancillaries	item		30%	6,215,748
Sub total Rapid Sand Filters	(8)	nr		35,222,575
Clear Water Storage				
Excavation				
Normal excavation	m3	3,710	350	1,298,531
EO for rock excavation	m3	1,031	1,500	1,545,870
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	680	20,000	13,603,656
do in walls	m3	366	20,000	7,319,520
Pipework	item	-	15%	3,565,137
Ancillaries	item		15%	3,565,137
Sub total Clear Water Reservoir(s)	(2)	nr		30,897,850
Buildings				
Chemical/Laboratory				
All in building costs	m2	207	22,000	4,554,000
Pipework and ancillaries	item		15%	683,100
Sub total Chemical building				5,237,100
Office/Store/Workshop				
All in building costs	m2	138	22,000	3,036,000
Add for furnishings etc	item		15%	455,400
Sub total Admin Building				3,491,400
Pumping station				
Excavation				
Normal excavation	m3	520	350	182,045
EO for rock excavation	m3	248	1,500	371,520
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	82	20,000	1,634,688
do in walls	m3	112	20,000	2,241,120
All in building costs	m2	124	22,000	2,724,480
Pipework	item	-	20%	1,430,771
Pumps	nr	2	1,782,403	3,564,806
Ancillaries	item		15%	1,073,078
Sub total Pumping Station				13,222,507
Sludge concentrators	Depth		4	m
Excavation		-		
Normal excavation	m3	564	350	197,437
EO for rock excavation	m3	282	1,500	423,078
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	254	20,000	5,076,939
do in walls	m3	194	20,000	3,872,955
Pipework	item	-	10%	957,041
Ancillaries	item		10%	957,041
Sub total Sludge concentrators	(4)	nr		11,484,492
Sludge drying Beds				
Excavation				
Normal excavation	m3	662	350	231,525
EO for rock excavation	m3	110	1,500	165,375
Sand bed	m3	300	1,200	360,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	303	20,000	6,063,750
do in walls	m3	59	20,000	1,178,750
Pipework Inc.drainage	item	-	25%	1,999,850
Ancillaries	item		10%	799,940
Sub total; Sludge drying beds	(10)	nr		10,799,190

Table L-18 Nkubu Water Supply Bill of Quantities

DESCRIPTION	Unit	Quantity	Rate	Amount
Intake				
Site clearance	m2	200	35	7,000
Excavation				
Normal excavation	m3	100	350	35,000
EO for rock excavation	m3	100	1,500	150,000
Bank protection	m3	75	1,630	122,250
River diversion	item			500,000
Roads	m2	2,400	350	840,000
Concrete "all in prices"		-		
Concrete 30/20 in base slab	m3	25	12,000	300,000
do in walls	m3	10	12,000	120,000
Sub total, intake				2,074,250
Raw Water Pipeline				
200 dia steel pipe	m	600	3,984	2,390,400
150 dia steel pipe	m	1,013	2,763	2,798,919
Sub total, raw water pipeline				5,189,319
Treatment Plant				
Site works				
Site clearance	m2	8,400	35	294,000
Roads	m2	2,000	350	700,000
Fence	m	380	1,500	570,000
Sub total, Site works				1,564,000
Horizontal Sedimentation Tanks				
Excavation				
Normal excavation	m3	798	350	279,418
EO for rock excavation	m3	380	1,500	570,240
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	125	20,000	2,509,056
do in walls	m3	270	20,000	5,409,600
Pipework	item	-	15%	1,315,247
Ancillaries	item		15%	1,315,247
Sub total Horizontal Sed. Tank	(4)	nr.....		11,398,808
Rapid Sand Filters				
Excavation				
Normal excavation	m3	403	350	141,120
EO for rock excavation	m3	168	1,500	252,000
Media inc. gravel	m3	50	1,500	75,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	46	20,000	924,000
do in walls	m3	224	20,000	4,485,000
Pipework	item	-	40%	2,350,848
Ancillaries	item		30%	1,763,136
Sub total Rapid Sand Filters	(4)	nr.....		9,991,104
Clear Water Storage				
Excavation				
Normal excavation	m3	461	350	161,280
EO for rock excavation	m3	128	1,500	192,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	84	20,000	1,689,600
do in walls	m3	123	20,000	2,460,880
Pipework	item	-	15%	674,064
Ancillaries	item		15%	674,064
Sub total Clear Water Reservoir(s)	(2)	nr.....		5,841,888
Buildings				
Chemical/Laboratory				
All in building costs	m2	83	22,000	1,821,600
Pipework and ancillaries	item		15%	273,240
Sub total Chemical building				2,094,840
Office/Store/Workshop				
All in building costs	m2	104	22,000	2,277,000
Add for furnishings etc	item		15%	341,550
Sub total Admin Building				2,618,550
Pumping station				
Excavation				
Normal excavation	m3	157	350	55,037
EO for rock excavation	m3	75	1,500	112,320
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	25	20,000	494,208
do in walls	m3	54	20,000	1,081,920
All in building costs	m2	124	22,000	2,724,480
Pipework	item	-	20%	893,593
Pumps	nr	2	1,175,947	2,351,895
Ancillaries	item		15%	670,195
Sub total Pumping Station				8,383,647
Sludge concentrators	Depth		4	m
Excavation				
Normal excavation	m3	91	350	31,700
EO for rock excavation	m3	45	1,500	67,929
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	41	20,000	815,149
do in walls	m3	67	20,000	1,343,973
Pipework	item	-	10%	225,875
Ancillaries	item		10%	225,875
Sub total Sludge concentrators	(3)	nr.....		2,710,502
Sludge drying Beds				
Excavation				
Normal excavation	m3	79	350	27,720
EO for rock excavation	m3	13	1,500	19,800
Sand bed	m3	30	1,200	36,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	36	20,000	726,000
do in walls	m3	18	20,000	368,000
Pipework inc.drainage	item	-	25%	294,380
Ancillaries	item		10%	117,752
Sub total: Sludge drying beds	(8)	nr		1,589,652

Table L-19 Isiolo Water Supply Bill of Quantities

DESCRIPTION	Unit	Quantity	Rate	Amount
Dam River Intake				
Excavation				
Normal excavation	m3	54,000	175	9,450,000
EO for rock excavation	m3	22,500	1,000	22,500,000
Rockfill	m3	459,000	1,630	748,170,000
Filter/drainage material	m3	68,850	1,550	106,717,500
Rip-rap and underlayers	m3	45,900	1,630	74,817,000
Grout curtain	item	-		90,000,000
Concrete "all in prices"		-		
Concrete	m3	1,950	12,000	23,400,000
Bridge	item	-		15,000,000
Drawoff works				
Concrete in tower	m3	500	12,000	6,000,000
Pipework	item			3,000,000
Access bridge	item			10,000,000
Siteworks	item			25,000,000
Ancillaries	item			10,000,000
Contingencies	item			229,000,000
Sub total intake				1,373,054,500
Raw Water Pipeline				
300 dia steel pipe	m	1,108	6,864	7,605,312
250 dia steel pipe	m	2,110	5,357	11,303,270
Sub total raw water pipeline				18,908,582
Treatment Plant				
Site works				
Site clearance	m2	8,400	15	126,000
Roads	m2	1,200	350	420,000
Fence		-	1,500	-
Sub total Site works				546,000
Horizontal Sedimentation Tanks				
Excavation				
Normal excavation	m3	1,408	350	492,665
EO for rock excavation	m3	670	1,500	1,005,480
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	221	20,000	4,424,112
do in walls	m3	371	20,000	7,418,680
Pipework	item	-	15%	2,001,174
Ancillaries	item		15%	2,001,174
Sub total Horizontal Sed Tank	(4)	nr		17,343,504
Rapid Sand Filters				
Excavation				
Normal excavation	m3	624	350	218,400
EO for rock excavation	m3	260	1,500	390,000
Media inc. gravel	m3	83	1,500	123,750
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	72	20,000	1,430,000
do in walls	m3	316	20,000	6,325,000
Pipework	item	-	40%	3,394,860
Ancillaries	item		30%	2,546,145
Sub total Rapid Sand Filters	(5)	nr		14,428,155
Clear Water Storage				
Excavation				
Normal excavation	m3	840	350	293,933
EO for rock excavation	m3	233	1,500	349,920
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	154	20,000	3,079,296
do in walls	m3	169	20,000	3,378,240
Pipework	item	-	15%	1,065,208
Ancillaries	item		15%	1,065,208
Sub total Clear Water Reservoir(s)	(2)	nr		9,231,805
Buildings				
Chemical/Laboratory				
All in building costs	m2	83	22,000	1,821,600
Pipework and ancillaries	item		15%	273,240
Sub total Chemical building				2,094,840
Office/Store/Workshop				
All in building costs	m2	104	22,000	2,277,000
Add for furnishings etc	item		15%	341,550
Sub total Admin Building				2,618,550
Pumping station				
Excavation				
Normal excavation	m3	240	350	83,849
EO for rock excavation	m3	114	1,500	171,120
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	38	20,000	752,928
do in walls	m3	75	20,000	1,491,000
All in building costs	m2	124	22,000	2,724,480
Pipework	item	-	20%	1,044,675
Pumps	nr	2	1,344,417	2,688,833
Ancillaries	item		15%	783,507
Sub total Pumping Station				9,740,392
Sludge concentrators	Depth		4	m
Excavation				
Normal excavation	m3	143	350	50,173
EO for rock excavation	m3	72	1,500	107,513
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	65	20,000	1,290,158
do in walls	m3	65	20,000	1,690,605
Pipework	item	-	10%	313,865
Ancillaries	item		10%	313,865
Sub total Sludge concentrators	(3)	nr		3,766,379
Sludge drying Beds				
Excavation				
Normal excavation	m3	145	350	50,820
EO for rock excavation	m3	24	1,500	36,300
Sand bed	m3	60	1,200	72,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	67	20,000	1,331,000
do in walls	m3	24	20,000	483,000
Pipework inc.drainage	item	-	25%	493,280
Ancillaries	item		10%	197,312
Sub total Sludge drying beds	(8)	nr		2,663,712

Table L-20 Chuka Water Supply Bill of Quantities

DESCRIPTION	Unit	Quantity	Rate	Amount
Intake				
Site clearance	m2	600	35	21,000
Excavation				
Normal excavation	m3	400	350	140,000
EO for rock excavation	m3	200	1,500	300,000
Bank protection	m3	400	1,630	652,000
River diversion	item			5,000,000
Roads	m2	28,000	350	9,800,000
Concrete "all in prices"		-		
Concrete 30/20 in base slab	m3	140	12,000	1,680,000
do in walls	m3	20	12,000	240,000
Sub total, Intake				17,833,000
Raw Water Pipeline				
250 dia steel pipe	m	3,100	5,357	16,606,700
200 dia steel pipe	m	5,633	3,984	22,441,872
Sub total, raw water pipeline				39,048,572
Treatment Plant				
Site works				
Site clearance	m2	8,400	35	294,000
Roads	m2	6,000	350	2,100,000
Fence	m	380	1,500	570,000
Sub total, Site works				2,964,000
Horizontal Sedimentation Tanks				
Excavation				
Normal excavation	m3	1,408	350	492,685
EO for rock excavation	m3	670	1,500	1,005,480
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	221	20,000	4,424,112
do in walls	m3	371	20,000	7,418,880
Pipework	item	-	15%	2,001,174
Ancillaries	item		15%	2,001,174
Sub total Horizontal Sed. Tank	(4)	nr.....		17,343,504
Rapid Sand Filters				
Excavation				
Normal excavation	m3	624	350	218,400
EO for rock excavation	m3	260	1,500	390,000
Media inc. gravel	m3	83	1,500	123,750
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	72	20,000	1,430,000
do in walls	m3	316	20,000	6,325,000
Pipework	item	-	40%	3,394,860
Ancillaries	item		30%	2,546,145
Sub total Rapid Sand Filters	(5)	nr.....		14,428,155
Clear Water Storage				
Excavation				
Normal excavation	m3	840	350	293,933
EO for rock excavation	m3	233	1,500	349,920
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	154	20,000	3,079,296
do in walls	m3	169	20,000	3,378,240
Pipework	item	-	15%	1,065,208
Ancillaries	item		15%	1,065,208
Sub total Clear Water Reservoir(s)	(2)	nr.....		9,231,805
Buildings				
Chemical/Laboratory				
All in building costs	m2	83	22,000	1,821,600
Pipework and ancillaries	item		15%	273,240
Sub total Chemical building				2,094,840
Office/Store/Workshop				
All in building costs	m2	104	22,000	2,277,000
Add for furnishings etc	item		15%	341,550
Sub total Admin Building				2,618,550
Pumping station				
Excavation				
Normal excavation	m3	240	350	83,849
EO for rock excavation	m3	114	1,500	171,120
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	38	20,000	752,928
do in walls	m3	69	20,000	1,371,720
All in building costs	m2	124	22,000	2,724,480
Pipework	item	-	20%	1,020,819
Pumps	nr	2	1,344,417	2,688,833
Ancillaries	item		15%	765,615
Sub total Pumping Station				9,579,364
Sludge concentrators	Depth		4	m
Excavation				
Normal excavation	m3	143	350	50,173
EO for rock excavation	m3	72	1,500	107,513
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	65	20,000	1,290,158
do in walls	m3	85	20,000	1,690,805
Pipework	item	-	10%	313,865
Ancillaries	item		10%	313,865
Sub total Sludge concentrators	(3)	nr.....		3,766,379
Sludge drying Beds				
Excavation				
Normal excavation	m3	145	350	50,820
EO for rock excavation	m3	24	1,500	36,300
Sand bed	m3	60	1,200	72,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	67	20,000	1,331,000
do in walls	m3	24	20,000	483,000
Pipework inc.drainage	item	-	25%	493,280
Ancillaries	item		10%	197,312
Sub total: Sludge drying beds	(8)	nr		2,663,712

Table L-21 Chogoria Water Supply Cash Flow

DESCRIPTION	Unit	Quantity	Rate	Amount
Intake				
Site clearance	m2	600	35	21,000
Excavation				
Normal excavation	m3	200	350	70,000
EO for rock excavation	m3	100	1,500	150,000
Bank protection	m3	240	1,630	391,200
River diversion	item	-		1,000,000
Roads	m2	24,000	350	8,400,000
Concrete "all in prices"		-		
Concrete 30/20 in base slab	m3	18	12,000	210,000
do in walls	m3	5	12,000	60,000
Sub total, intake				10,302,200
Raw Water Pipeline				
200 dia steel pipe	m	4,654	3,984	18,541,536
Sub total, raw water pipeline				18,541,536
Treatment Plant				
Site works				
Site clearance	m2	8,400	35	294,000
Roads	m2	4,000	350	1,400,000
Fence	m	380	1,500	570,000
Sub total, Site works				2,264,000
Horizontal Sedimentation Tanks				
Excavation				
Normal excavation	m3	1,105	350	386,845
EO for rock excavation	m3	526	1,500	789,480
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	174	20,000	3,473,712
do in walls	m3	325	20,000	6,491,520
Pipework	item	-	15%	1,671,234
Ancillaries	item		15%	1,671,234
Sub total Horizontal Sed. Tank	(4)	nr		14,484,024
Rapid Sand Filters				
Excavation				
Normal excavation	m3	624	350	218,400
EO for rock excavation	m3	260	1,500	390,000
Media inc. gravel	m3	83	1,500	123,750
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	72	20,000	1,430,000
do in walls	m3	316	20,000	6,325,000
Pipework	item	-	40%	3,394,860
Ancillaries	item		30%	2,546,145
Sub total Rapid Sand Filters	(5)	nr		14,428,155
Clear Water Storage				
Excavation				
Normal excavation	m3	650	350	227,430
EO for rock excavation	m3	181	1,500	270,750
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	119	20,000	2,382,600
do in walls	m3	147	20,000	2,947,680
Pipework	item	-	15%	874,269
Ancillaries	item		15%	874,269
Sub total Clear Water Reservoir(s)	(2)	nr		7,576,998
Buildings				
Chemical/Laboratory				
All in building costs	m2	83	22,000	1,821,600
Pipework and ancillaries	item		15%	273,240
Sub total Chemical building				2,094,840
Office/Store/Workshop				
All in building costs	m2	104	22,000	2,277,000
Add for furnishings etc	item		15%	341,550
Sub total Admin Building				2,618,550
Pumping station				
Excavation				
Normal excavation	m3	187	350	65,621
EO for rock excavation	m3	89	1,500	133,920
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	29	20,000	589,248
do in walls	m3	59	20,000	1,178,520
All in building costs	m2	124	22,000	2,724,480
Pipework	item	-	20%	938,358
Pumps	nr	2	1,245,155	2,490,310
Ancillaries	item		15%	703,768
Sub total Pumping Station				8,824,225
Sludge concentrators	Depth		4	m
Excavation				
Normal excavation	m3	115	350	40,409
EO for rock excavation	m3	58	1,500	86,590
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	52	20,000	1,039,082
do in walls	m3	76	20,000	1,517,389
Pipework	item	-	10%	268,347
Ancillaries	item		10%	268,347
Sub total Sludge concentrators	(3)	nr		3,220,164
Sludge drying Beds				
Excavation				
Normal excavation	m3	119	350	41,580
EO for rock excavation	m3	20	1,500	29,700
Sand bed	m3	48	1,200	57,600
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	54	20,000	1,089,000
do in walls	m3	22	20,000	437,000
Pipework inc.drainage	item	-	25%	413,720
Ancillaries	item		10%	165,488
Sub total: Sludge drying beds	(8)	nr		2,234,088

Table L-22 Maua Water Supply Bill of Quantities

DESCRIPTION	Unit	Quantity	Rate	Amount
Intake				
Site clearance	m2	50	35	1,750
Excavation				
Normal excavation	m3	20	350	7,000
EO for rock excavation	m3	10	1,500	15,000
Bank protection	m3	20	1,630	32,600
River diversion	item			20,000
Roads	m2	200	350	70,000
Concrete "all in prices"		-		
Concrete 30/20 in base slab	m3	5	12,000	54,000
do in walls	m3	3	12,000	36,000
Sub total, intake				236,350
Raw Water Pipeline				
150 dia steel pipe	m	400	2,763	1,105,200
Sub total, raw water pipeline				1,105,200
Treatment Plant				
Site works				
Site clearance	m2	8,400	35	294,000
Roads	m2	1,600	350	560,000
Fence	m	380	1,500	570,000
Sub total, Site works				1,424,000
Horizontal Sedimentation Tanks				
Excavation				
Normal excavation	m3	553	350	193,423
EO for rock excavation	m3	263	1,500	394,740
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	87	20,000	1,736,856
do in walls	m3	162	20,000	3,245,760
Pipework	item	-	15%	835,617
Ancillaries	item		15%	835,617
Sub total Horizontal Sed. Tank (2)		nr		7,242,012
Rapid Sand Filters				
Excavation				
Normal excavation	m3	316	350	110,678
EO for rock excavation	m3	132	1,500	197,640
Media inc. gravel	m3	40	1,500	59,670
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	36	20,000	724,680
do in walls	m3	173	20,000	3,460,000
Pipework	item	-	40%	1,817,067
Ancillaries	item		30%	1,362,801
Sub total Rapid Sand Filters (3)		nr		7,722,536
Clear Water Storage				
Excavation				
Normal excavation	m3	318	350	111,334
EO for rock excavation	m3	88	1,500	132,540
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	58	20,000	1,166,352
do in walls	m3	73	20,000	1,457,280
Pipework	item	-	15%	430,126
Ancillaries	item		15%	430,126
Sub total Clear Water Reservoir(s) (1)		nr		3,727,757
Buildings				
Chemical/Laboratory				
All in building costs	m2	69	22,000	1,518,000
Pipework and ancillaries	item		15%	227,700
Sub total Chemical building				1,745,700
Office/Store/Workshop				
All in building costs	m2	83	22,000	1,821,600
Add for furnishings etc	item		15%	273,240
Sub total Admin Building				2,094,840
Pumping station				
Excavation				
Normal excavation	m3	157	350	55,037
EO for rock excavation	m3	75	1,500	112,320
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	25	20,000	494,208
do in walls	m3	54	20,000	1,081,920
All in building costs	m2	124	22,000	2,724,480
Pipework	item	-	20%	893,593
Pumps	nr	2	1,344,417	2,688,833
Ancillaries	item		15%	670,195
Sub total Pumping Station				8,720,586
Sludge concentrators	Depth		4	m
Excavation				
Normal excavation	m3	64	350	22,519
EO for rock excavation	m3	32	1,500	48,255
Concrete 'all in prices"		-		-
Concrete 30/20 in base slab	m3	29	20,000	579,058
do in walls	m3	46	20,000	924,885
Pipework	item	-	10%	157,472
Ancillaries	item		10%	157,472
Sub total Sludge concentrators (2)		nr		1,889,660
Sludge drying Beds				
Excavation				
Normal excavation	m3	59	350	20,790
EO for rock excavation	m3	10	1,500	14,850
Sand bed	m3	24	1,200	28,800
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	27	20,000	544,500
do in walls	m3	11	20,000	218,500
Pipework inc.drainage	item	-	25%	206,860
Ancillaries	item		10%	82,744
Sub total: Sludge drying beds (4)		nr		1,117,044

Table L-23 Tigania Water Supply Bill of Quantities

DESCRIPTION	Unit	Quantity	Rate	Amount
Intake				
Site clearance	m2	400	35	14,000
Excavation				
Normal excavation	m3	64	350	22,400
EO for rock excavation	m3	32	1,500	48,000
Bank protection	m3	80	1,630	130,400
River diversion	item			100,000
Roads	m2	20,000	350	7,000,000
Concrete "all in prices"		-		
Concrete 30/20 in base slab	m3	15	12,000	180,000
do in walls	m3	5	12,000	60,000
Sub total, intake				7,554,800
Raw Water Pipeline				
250 dia steel pipe	m	5,000	5,357	26,785,000
Sub total, raw water pipeline				26,785,000
Treatment Plant				
Site works				
Site clearance	m2	8,400	35	294,000
Roads	m2	4,000	350	1,400,000
Fence	m	380	1,500	570,000
Sub total, Site works				2,264,000
Horizontal Sedimentation Tanks				
Excavation				
Normal excavation	m3	1,408	350	492,685
EO for rock excavation	m3	670	1,500	1,005,480
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	221	20,000	4,424,112
do in walls	m3	371	20,000	7,416,880
Pipework	item	-	15%	2,001,174
Ancillaries	item		15%	2,001,174
Sub total Horizontal Sed. Tank (4)		nr		17,343,504
Rapid Sand Filters				
Excavation				
Normal excavation	m3	624	350	218,400
EO for rock excavation	m3	260	1,500	390,000
Media inc. gravel	m3	83	1,500	123,750
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	72	20,000	1,430,000
do in walls	m3	316	20,000	6,325,000
Pipework	item	-	40%	3,394,860
Ancillaries	item		30%	2,546,145
Sub total Rapid Sand Filters (5)		nr		14,428,155
Clear Water Storage				
Excavation				
Normal excavation	m3	461	350	161,280
EO for rock excavation	m3	128	1,500	192,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	84	20,000	1,689,600
do in walls	m3	123	20,000	2,450,880
Pipework	item	-	15%	674,064
Ancillaries	item		15%	674,064
Sub total Clear Water Reservoir(s) (2)		nr		5,841,888
Buildings				
Chemical/Laboratory				
All in building costs	m2	83	22,000	1,821,600
Pipework and ancillaries	item		15%	273,240
Sub total Chemical building				2,094,840
Office/Store/Workshop				
All in building costs	m2	104	22,000	2,277,000
Add for furnishings etc	item		15%	341,550
Sub total Admin Building				2,618,550
Pumping station				
Excavation				
Normal excavation	m3	240	350	83,849
EO for rock excavation	m3	114	1,500	171,120
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	38	20,000	752,928
do in walls	m3	69	20,000	1,371,720
All in building costs	m2	124	22,000	2,724,480
Pipework	item	-	20%	1,020,819
Pumps	nr	2	1,344,417	2,688,833
Ancillaries	item		15%	765,615
Sub total Pumping Station				9,579,364
Sludge concentrators	Depth		4	m
Excavation				
Normal excavation	m3	143	350	50,173
EO for rock excavation	m3	72	1,500	107,513
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	65	20,000	1,290,158
do in walls	m3	85	20,000	1,690,805
Pipework	item	-	10%	313,865
Ancillaries	item		10%	313,865
Sub total Sludge concentrators (3)		nr		3,766,379
Sludge drying Beds				
Excavation				
Normal excavation	m3	145	350	50,820
EO for rock excavation	m3	24	1,500	36,300
Sand bed	m3	60	1,200	72,000
Concrete "all in prices"		-		-
Concrete 30/20 in base slab	m3	67	20,000	1,331,000
do in walls	m3	24	20,000	483,000
Pipework Inc.drainage	item	-	25%	493,260
Ancillaries	item		10%	197,312
Sub total: Sludge drying beds (8)		nr		2,663,712

ATTACHMENT

Unit Construction Prices

Notes

Exchange rate: Mar-97 ... 1US $ = 56 Shs

Preliminaries and General Items are NOT included within the following rates

Costs of imported materials are assumed to be Tax free,

Tax on salaries, fuel costs and local materials have been included

Foreign/Local currency breakdown			
Cost Breakdown	%F	%L	%Tax
1. Foreign materials	90%	10%	0%
2. Local materials	15%	70%	15%
3. Labour	5%	75%	20%
4 Construction plant	85%	5%	10%

General Items

	Unit	Rate Shs	Materials %F	Materials %L	Lab	Plnt	%F	%L	%Tax
General excavation in normal material not exceeding 3.0m depth	m3	350	0%	0%	75%	25%	25%	58%	18%
EO for rock	m3	1,500	0%	0%	50%	50%	45%	40%	15%
Earthworks for dams - Soft	m3	175	0%	0%	25%	75%	65%	23%	13%
Earthworks for dams - Rock	m3	1,000	0%	0%	20%	80%	69%	19%	12%
Earthfill for dams	m3	310	0%	0%	20%	80%	69%	19%	12%
Filter/drainage material for dams	m3	1,550	0%	0%	25%	75%	65%	23%	13%
Rip rap material for dams	m3	1,630	0%	0%	20%	80%	69%	19%	12%
Concrete Class 25	m3	8,000	0%	82%	14%	4%	16%	68%	16%
Concrete Class 30	m3	12,000	0%	83%	13%	4%	17%	68%	15%
Mass concrete for dams	m3	6,000	0%	80%	16%	4%	16%	68%	16%
Reinforcement	tonne	65,000	80%	10%	9%	1%	75%	22%	3%
Formwork F1	m2	475	0%	10%	77%	13%	16%	65%	18%
Formwork F2	m2	750	0%	14%	73%	13%	17%	65%	18%
Blockwork walling	m2	1,200	0%	10%	80%	10%	14%	68%	19%
"All in" cost for reinforced concrete	m3	20,175	25%	45%	25%	5%	35%	53%	12%

Pipework

Assumptions — Type of pipe

	uPVC	Steel	DI	Materials %F	Materials %L	Lab	Plnt	%F	%L	%Tax
Manufacturers discount	10%	0%	0%							
Tax and duties	15%	15%	15%							
Transport and handling	15%	15%	20%	0%	0%	20%	80%	69%	19%	12%
Wastage	5%	1%	1%							
Pipe trench width	700 mm + nominal dia.									
Average trench depth	1200 mm + nominal dia.									
Average rock excavation	10%									
Valves & specials - Add to "All in" pipe costs	15%									

uPVC Pipelines

	Trench	Lay, joint	Materials delivered to site				"All in" pipe costs				Currency breakdown for 12 bar uPVC						
Dia	Excav'n	etc	uPVC	uPVC	uPVC	uPVC	uPVC	uPVC	uPVC	uPVC	Materials		Lab	Plnt	%F	%L	%Tax
mm	Shs/m	Shs/m	6 bar Shs/m	9 bar Shs/m	12 bar Shs/m	15 bar Shs/m	6 bar Shs/m	9 bar Shs/m	12 bar Shs/m	15 bar Shs/m	%F	%L					
63	482	40	75	125	155	200	597	647	677	722	9%	14%	58%	19%	30%	55%	16%
90	510	60	187	242	298	365	757	812	868	935	14%	21%	49%	16%	32%	54%	15%
110	531	60	252	362	442	562	843	953	1033	1153	17%	26%	43%	14%	34%	53%	14%
160	585	100	506	747	943	1155	1191	1432	1628	1840	23%	35%	32%	11%	37%	51%	13%
225	659	140	1000	1380	1825	2104	1799	2179	2624	2903	28%	42%	23%	8%	39%	50%	12%
280	725	180	1450	2125	2504	3262	2355	3030	3409	4167	29%	44%	20%	7%	40%	49%	11%
315	769	200	1837	2660	3374	4124	2806	3629	4343	5093	31%	47%	17%	6%	41%	49%	11%
400	880	280	3074	4374			4234	5534									

Steel and DI Pipelines

	Trench	Lay, joint	Materials delivered to site			"All in" pipe costs			Currency breakdown for Steel pipes						
	Excav'n	etc		Steel	DI		Steel	DI	Materials		Lab	Plnt	%F	%L	%Tax
	Shs/m	Shs/m		Shs/m	Shs/m		Shs/m	Shs/m	%F	%L					
dia															
80	499	70			1235			1804							
100	520	90		1115	1518		1725	2128	39%	26%	27%	9%	48%	42%	10%
150	574	140		2049	2285		2763	2999	44%	30%	19%	6%	51%	40%	9%
200	630	200		3154	3080		3984	3910	48%	32%	16%	5%	53%	39%	8%
250	689	260		4408	4073		5357	5022	49%	33%	13%	4%	54%	38%	8%
300	750	320		5794	5166		6864	6236	51%	34%	12%	4%	55%	38%	8%
350	814	380		7301	6386		8495	7580	52%	34%	11%	4%	55%	37%	8%
400	880	450		8921	7663		10251	8993	52%	35%	10%	3%	55%	37%	7%
450	949	510		10036	9097		11495	10556	52%	35%	10%	3%	56%	37%	7%
500	1020	580		11152			12752		52%	35%	9%	3%	56%	37%	7%

Reservoirs

										Materials %F	Materials %L	Lab	Plnt	%F	%L	%Tax
Capacity (m3)	50	100	150	200	250	300	400	500	750							
"All in" costs	550,000	780,000	940,000	1,070,000	1,290,000	1,520,000	1,940,000	2,350,000	3,360,000	25%	45%	25%	5%	35%	53%	12%
Cost/m3	11,000	7,800	6,267	5,350	5,160	5,067	4,850	4,700	4,480							

1. Phased Investment Costs	Exchange rate ..... 1 US $ =		56 KShs	Phase 1 1998				Phase 2 2005			
Element	Description dia (mm)/ Size	Unit	Rate US $	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000	Quantity	Civil US $ x 1,000	E&M US $ x 1,000	Pipes US $ x 1,000
Rehabilitation				item	17.9	17.9	142.9				
Intake				item	224.0						
Raw pipeline	500 mm dia steel pipe	m	227.7	5,825			1,326.4				
Treatment	10,000 m3/d capacity plant	nr	949,017	1	806.7	142.4					
	10,000 m3/d expansion	nr	703,083					1	667.9	35.2	
	Staff housing	nr	35,268	3	105.8			1	35.3		
Office	168 m2 floor area	m2	446	168	75.0			-	-		
Reservoirs	4,500 m3 reservoir	nr	360,000	1	360.0			1	360.0		
	750 m3 reservoir	nr	60,000	3	180.0			2	120.0		
	400 m3 reservoir	nr	34,643	2	69.3			2	69.3		
	300 m3 reservoir	nr	27,143	-	-			2	54.3		
	250 m3 reservoir	nr	23,036	1	23.0			5	115.2		
	200 m3 reservoir	nr	19,107	1	19.1			3	57.3		
	150 m3 reservoir	nr	16,786	-	-			3	50.4		
	100 m3 reservoir	nr	13,929	-	-			2	27.9		
Transmission	400 mm dia steel pipe	m	183.1	3,800			695.6				-
	350 mm dia steel pipe	m	151.7	6,800			1,031.5				-
	315 mm dia uPVC (12 bar)	m	77.6	8,500			659.2				-
	280 mm dia uPVC (12 bar)	m	60.9	5,800			353.1				-
	225 mm dia uPVC (12 bar)	m	46.9	11,800			552.9	7,200			337.4
	160 mm dia uPVC (12 bar)	m	29.0	12,900			373.9	24,900			721.7
	110 mm dia uPVC (12 bar)	m	18.4	8,200			151.3				-
	90 mm dia uPVC (12 bar)	m	15.5	3,400			52.7				-
Ancilaries/contingencies			15%		282.1	24.0	800.9		233.6	5.3	158.9
Preliminaries			15%		324.4	27.6	921.1		268.7	6.1	182.7
Total					2,487.3	211.9	7,061.4		2,059.8	46.5	1,400.6
Total phased costs				Phase 1			9,760.6	Phase 2			3,506.8

2. Annual Investment Costs												
Annual distribution pipes	110 mm dia uPVC (12 bar)	m	18.446	2,650			49	2,650				49
	90 mm dia uPVC (12 bar)	m	15.500	2,010			31	2,010				31
	63 mm dia uPVC (12 bar)	m	12.089	3,000			36	2,000				24
Total							116					104

3. Transport purchase costs		US$x1,000	1998				2003			
Saloon car	nr	17.9	1			18	1			18
4WD vehicle	nr	62.5	1			63	1			63
Pickup	nr	21.4	2			43	3			64
Lorry	nr	107.1	2			214	2			214

4. Annual O&M costs and Economic life		Transport	Civil	E&M	Pipes
Annual O&M costs as % of investment costs		20%	1.00%	4.00%	1.00%
Economic life of assets		5	30	10	30

5. Power costs			1998	Fixed	Variable	2005	Fixed	Variable
Power tariff (Oct 1996)	Power Requirements			20	20		20	20
Unit energy cost		US$/unit	0.08					
Fixed charge per month		US$/month	7.86					
kVA demand charge		US$/month	4.46					

6. Human Resources Costs		Rate/yr	1998				2005			
		US$x1,000	TWks 1	TWks2	Distn	US$x1,000	TWks 1	TWks2	Distn	US$x1,000
Engineer I	Shs/yr	3.86			1	3.86			1	3.86
Engineer II	Shs/yr	3.21			2	6.43			2	6.43
Inspector	Shs/yr	2.36	2		3	11.79	2	1	3	14.14
Senior Operator	Shs/yr	1.29	2	1	4	9.00	2	1	5	10.29
Operator	Shs/yr	0.96	2	2	5	8.68	2	2	5	8.68
Watchman/Line patrolman/Clerks	Shs/yr	0.64	3	5	20	16.71	3	4	29	23.14
	Shs/yr					56.46				66.54

7. Chemical Costs	US$/kg	1998 Dosage (mg/l)	Cost/m3	2003 Dosage (mg/l)	Cost/m3
Alum	0.45	0	0.000	0	0.000
Chlorine	6.25	2	0.013	2	0.013
Soda ash	0.25	0	0.000	0	0.000
Total chemical cost per m3			0.013		0.013

8. Annual Projection of Costs					Incremental	Investment Schedule					Annual recurrent costs						
Year	Population	Water Demand m3/d	Population Coverage %	Water Supplied m3/d	supply m3/d	Treatment Civil US$ x 1,000	E&M US$ x 1,000	Pipes US$ x 1,000	Transport US$ x 1,000	Total Investment US$ x 1,000	O&M Costs US$ x 1,000	Power Costs US$ x 1,000	Labour US$ x 1,000	Transport US$ x 1,000	Chemicals US$ x 1,000	Total Recurrent US$ x 1,000	Total Costs US$ x 1,000
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(15)	(16)	(17)
1997	165,980	10,302	31%	3,194	-												
1998	171,806	11,219	29%	3,253	60	2,487	212	7,061	338	10,098					0	0	10,098
1999	177,657	12,181	30%	3,654	460			116		116	105	14	56	68	2	245	362
2000	183,527	13,188	35%	4,616	1,422			116		116	106	15	56	68	6	251	368
2001	189,554	13,974	40%	5,589	2,396			116		116	107	15	56	68	11	257	374
2002	195,741	14,794	45%	6,657	3,463			116		116	109	16	56	68	16	264	380
2003	202,094	15,649	50%	7,824	4,631			116	359	475	110	15	67	72	21	285	761
2004	208,618	16,541	55%	9,097	5,904			116		116	111	17	67	72	27	293	409
2005	215,318	17,470	60%	10,482	7,288	2,060	46	1,401		3,507	147	17	67	72	33	336	3,843
2006	222,199	18,436	68%	12,538	9,344			104		104	148	18	67	72	43	348	452
2007	229,268	19,447	76%	14,779	11,586			104		104	149	19	67	72	53	360	464
2008	236,531	20,496	84%	17,217	14,023		212	104	359	675	159	20	67	72	64	382	1,057
2009	243,996	21,589	92%	19,861	16,668			104		104	160	22	67	72	76	396	500
2010	251,668	22,725	100%	22,725	19,531			104		104	161	23	67	72	89	411	516
2011	251,668	22,725	100%	22,725	19,531			104		104	162	23	67	72	89	412	517
2012	251,668	22,725	100%	22,725	19,531			104		104	163	23	67	72	89	413	518
2013	251,668	22,725	100%	22,725	19,531			104	359	463	164	23	67	72	89	415	878
2014	251,668	22,725	100%	22,725	19,531			104		104	165	23	67	72	89	416	520
2015	251,668	22,725	100%	22,725	19,531		46	104		151	168	23	67	72	89	418	569
2016	251,668	22,725	100%	22,725	19,531			104		104	169	23	67	72	89	420	524
2017	251,668	22,725	100%	22,725	19,531	-(2,148)	-(80)	-(3,863)	-(72)	-(6,163)	106	23	67	72	89	356	-(5,806)
						Note: Residual values in (brackets)											

9. Net Present Values				m3 x 1,000					US$ x 1,000						US$ x 1,000	US$ x 1,000
		15%		12,398					10,432						1,661	12,093
		12%		17,335					10,891						2,076	12,957
		9%		24,823					11,295						2,660	13,955
		6%		36,450					11,572						3,504	15,076
10. Average Incremental Costs (Shs/m3)									US$/m3						US$/m3	US$/m3
		15%							0.84						0.13	0.98
		12%							0.63						0.12	0.75
		9%							0.46						0.11	0.56
		6%							0.32						0.10	0.41

Meru Water Supply - Phasing costs broken down into major components

	Phase 1		1998	Phase 1			Phase 2		2005	Phase 2			Currency breakdown		
Description	Civil	E&M	Pipes	Local	Foreign	Taxes	Civil	E&M	Pipes	Foreign	Local	Taxes			
dia (mm)/ Size	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	US $ x 1,000	Foreign	Local	Tax
Rehabilitation	17.9	17.9	142.9	53.6	98.2	26.8	-	-	-	-	-	-	30%	55%	15%
Intake	224.0	-	-	78.4	118.7	26.9	-	-	-	-	-	-	35%	53%	12%
Raw water pipeline				-	-	-				-	-	-			
500 mm dia steel raw water pi	-	-	1,326.4	742.8	490.8	92.9	-	-	-	-	-	-	56%	37%	7%
Treatment plant				-	-	-				-	-	-			
10,000 m3/d capacity plant	806.7	142.4	-	332.2	503.0	113.9	-	-	-	-	-	-	35%	53%	12%
10,000 m3/d expansion	-	-	-	-	-	-	667.9	35.2	-	246.1	372.6	84.4	35%	53%	12%
Staff housing	105.8	-	-	26.5	64.5	14.8	35.3	-	-	8.8	21.5	4.9	25%	61%	14%
Branch offices	75.0	-	-	18.8	45.8	10.5	-	-	-	-	-	-	25%	61%	14%
Storage reservoirs				-	-	-				-	-	-			
4,500 m3 reservoir	360.0	-	-	126.0	190.8	43.2	360.0	-	-	126.0	190.8	43.2	35%	53%	12%
750 m3 reservoir	180.0	-	-	63.0	95.4	21.6	120.0	-	-	42.0	63.6	14.4	35%	53%	12%
400 m3 reservoir	69.3	-	-	24.3	36.7	8.3	69.3	-	-	24.3	36.7	8.3	35%	53%	12%
300 m3 reservoir	-	-	-	-	-	-	54.3	-	-	19.0	28.8	6.5	35%	53%	12%
250 m3 reservoir	23.0	-	-	8.1	12.2	2.8	115.2	-	-	40.3	61.0	13.8	35%	53%	12%
200 m3 reservoir	19.1	-	-	6.7	10.1	2.3	57.3	-	-	20.1	30.4	6.9	35%	53%	12%
150 m3 reservoir	-	-	-	-	-	-	50.4	-	-	17.6	26.7	6.0	35%	53%	12%
100 m3 reservoir	-	-	-	-	-	-	27.9	-	-	9.8	14.8	3.3	35%	53%	12%
Transmission pipelines				-	-	-				-	-	-			
400 mm dia steel pipe	-	-	695.6	389.5	257.4	48.7	-	-	-	-	-	-	56%	37%	7%
350 mm dia steel pipe	-	-	1,031.5	567.3	381.7	82.5	-	-	-	-	-	-	55%	37%	8%
315 mm dia uPVC (12 bar)	-	-	659.2	270.3	316.4	72.5	-	-	-	-	-	-	41%	48%	11%
280 mm dia uPVC (12 bar)	-	-	353.1	141.2	173.0	38.8	-	-	-	-	-	-	40%	49%	11%
225 mm dia uPVC (12 bar)	-	-	552.9	215.6	270.9	66.3	-	-	337.4	131.6	165.3	40.5	39%	49%	12%
160 mm dia uPVC (12 bar)	-	-	373.9	138.3	186.9	48.6	-	-	721.7	267.0	360.8	93.8	37%	50%	13%
110 mm dia uPVC (12 bar)	-	-	151.3	51.4	78.7	21.2	-	-	-	-	-	-	34%	52%	14%
90 mm dia uPVC (12 bar)	-	-	52.7	16.9	27.9	7.9	-	-	-	-	-	-	32%	53%	15%
	282.1	24.0	800.9	490.6	503.9	112.6	233.6	5.3	158.9	142.9	206.0	48.9	44%	46%	10%
	324.4	27.6	921.1	564.2	579.5	129.5	268.7	6.1	182.7	164.3	236.9	56.3	44%	46%	10%
Total for major components	2,487.3	211.9	7,061.4	4,325.6	4,442.5	992.5	2,059.8	46.5	1,400.6	1,259.7	1,815.9	431.3	44%	46%	10%
Total phased costs	Phase 1.....		9,760.6			9,760.6	Phase 2..	-	3,506.8						
Annual extensions to transmission system															
110 mm dia uPVC (12 bar)	-	-	48.9	16.6	25.4	6.8	-	-	48.9	16.6	25.4	6.8	34%	52%	14%
90 mm dia uPVC (12 bar)	-	-	31.2	10.0	16.5	4.7	-	-	31.2	10.0	16.5	4.7	32%	53%	15%
63 mm dia uPVC (12 bar)	-	-	36.3	10.9	19.6	5.8	-	-	24.2	7.3	13.1	3.9	30%	54%	16%

Note:

Foreign, local and tax components determined from an analysis of materials, labour and plant requirements for each element, as indicated on Table 5.1

BILL OF QUANTITIES - Summary

Feasibility Study

Exchange rate Shs/US $..... 56.0

Item	DESCRIPTION	Phase 1	Phase 2	Phase 1 KShs	Phase 2 KShs	Phase 1 US $	Phase 2 US $
	Summary						
	Rehabilitation			10,007,200		178,700	-
						-	-
	Intake			12,551,175		224,128	
	Raw water pipeline			74,280,400		1,326,436	-
						-	-
	Treatment plant			53,144,962	39,372,650	949,017	703,083
						-	-
	Staff housing			5,925,000	1,975,000	105,804	35,268
						-	-
	District Offices (168m2@25,000)			4,200,000		75,000	-
						-	-
	Reservoirs					-	-
	4500 m3	1	1	20,160,000	20,160,000	360,000	360,000
	750 m3	3	2	10,080,000	6,720,000	180,000	120,000
	400 m3	2	2	3,880,000	3,880,000	69,286	69,286
	300 m3	-	2	-	3,040,000	-	54,286
	250 m3	1	5	1,290,000	6,450,000	23,036	115,179
	200 m3	1	3	1,070,000	3,210,000	19,107	57,321
	150 m3	-	3	-	2,820,000	-	50,357
	100 m3	-	2	-	1,560,000	-	27,857
						-	-
	Transmission mains			216,729,200	59,305,500	3,870,164	1,059,027
						-	-
	Add for ancillaries and contingencies			61,997,691	22,273,972	1,107,102	397,750
	Add for preliminary items			71,297,344	25,615,068	1,273,167	457,412
						-	-
	Totals			546,612,972	196,382,190	9,760,946	3,506,825

Item	DESCRIPTION	Unit	Quantity	Rate	Amount
1	**Intake**				
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Structures	m3	840	350	294,000
	EO for rock	m3	840	1500	1,260,000
	Gabions	m2	-	1000	-
	CONCRETE inc formwork and reinforcement		-		-
	Blinding 15/20 80mm thick	m3	23	8000	184,000
	Concrete 30/20 base	m3	63	20175	1,271,025
	Concrete 30/20 base	m3	8	20175	161,400
	Concrete 30/20 walls	m3	68	20175	1,371,900
			-	20175	-
	PIPEWORK		-		-
	The following pipes and fittings		-		-
	1000 dia steel pipe	m	23	26000	598,000
	600 dia steel pipe	m	16	15300	244,800
	Sluice gate 1000x1000	nr	1	120000	120,000
	Sluice gate 300x300	nr	1	40000	40,000
			-		-
	Access	m2	17,100	200	3,420,000
	Add for ancillaries				3,586,050
Total	Intake				12,551,175
2	**Rehabilitation works**				8,002,400
3	**Raw water pipeline 500 dia**	m	5,825.00	12752	74,280,400
4	**Phase 1 Pipelines**				-
	Transimission and distsribution mains				-
	400 dia steel pipelins	m	3,800	10251	38,953,800
	350 steel pipe	m	6,800	8495	57,766,000
					-
	315 dia uPVC pipelines	m	8,500	4343	36,915,500
	280	m	5,800	3409	19,772,200
	225	m	11,800	2624	30,963,200
	160	m	12,900	1623	20,936,700
	110	m	8,200	1033	8,470,600
	90	m	3,400	868	2,951,200
					-
	Ancillaries and contingencies				44,851,800
	Preliminaries				51,579,570
Total					395,443,370
5	**Phase 2 Pipelines**				-
					-
	Transimission and distsribution mains				-
	400 dia steel pipelins	m	-	10251	-
	350 steel pipe	m	-	8495	-
					-
	315 dia uPVC pipelines	m	-	4343	-
	280	m	-	3409	-
	225	m	7,200	2624	18,892,800
	160	m	24,900	1623	40,412,700
					-
	Ancillaries and contingencies				8,895,825
	Preliminaries				10,230,199
Total	Phase 2 Pipelines				78,431,524

Item	DESCRIPTION	Alternative	Full Works	Phase 1 KShs	Phase 2 KShs
	Treatment Plant Summary				
1	Inlet chamber		317,228	317,228	317,228
2	Flocculation Basins		4,340,713		
3	Sedimentation tanks		29,900,328	29,900,328	29,900,328
4	Rapid sand filters		18.054,841		
5	Slow sand Filters	80,880,688			
6	Chlorination building		850,493	850,493	
7	Clear water reservoir		5,785.491	5,785.491	5,785.491
8	Sludge concentrators		7.529,525		
9	Sludge drying beds		8,390,801		
10	Administrative building		3,552,217	3,552,217	
11	Chemical building		2,478,750		
12	Site works		12,739,206	12,739,206	3,369,603
	Total for treatment works		93.939,591	53,144,962	39,372,650
	Equivalent costs in US $ @ (Shs/US$).....	*56*	*1,677,493*	*949,017*	*703,083*
13	Staff housing (3 nr in Phase 1, 1 in Phase 2) 3 nr in phase 1 1 nr in phase 2			5,925,000	1,975,000
	Equivalent costs in US $ @ (Shs/US$).....	*56*		*105,804*	*35,268*

Item	DESCRIPTION	Unit	Quantity	Rate	Amount
TP1	**Inlet Structure**				-
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Structures	m3	7	350	2,150
	EO for rock	m3	2	1500	3,000
					-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	0.6	8000	4,800
	Concrete 30/20 in base slab	m3	2.0	20175	40,350
	do in walls	m3	3.9	20175	78,683
					-
	PIPEWORK				-
	The following pipes and fittings	nr			-
	500 dia valve	nr	1	51000	51,000
	500 dia penstock	nr	1	51000	51,000
					-
	STEELWORK				-
	Weir plate	m	1	10000	10,000
					-
	MISCELLANEOUS METALWORK				-
	Handrailing	m	5	2500	12,500
					-
	Add for ancillaries works				63,446
Total	Inlet Structure				317,228
TP2	**Flocculation basins**				-
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Structures	m3	314	350	109,900
	EO for rock	m3	105	1500	157,500
	Compacted fill beneath floor	m3			-
		m3			-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	8.4	8000	67,200
	Concrete 30/20 in base slab	m3	52.3	20175	1,055,153
	do in walls 500 thick	m3	58.5	20175	1,180,238
	do in walls 300 thick	m3	17.6	20175	355,080
					-
	PIPEWORK				-
	The following pipes and fittings	nr			-
					-
	600 dia control penstocks	nr	6	50000	300,000
	150 dia drainage penstocks	nr	3	10000	30,000
					-
	MISCELLANEOUS METALWORK				-
	Handrailing	m	87	2500	217,500
					-
	Add for ancillaries				868,143
Total	Flocculation basins				4,340,713
TP3	**Sedimentation tank**				-
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Structures	m3	2,464	350	862,400
	EO for rock	m3	1,056	1500	1,584,000
					-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	56.4	8000	451,200
	Concrete 30/20 in base slab	m3	563.1	20175	11,360,543
	do in walls	m3	370.1	20175	7,466,768
			55.1	20175	1,111,643
					-
	PIPEWORK				-
	150 dia sludge drawoff pipework	m	50	2763	138,150
	150 dia sludge drawoff valves	nr	4	21500	86,000
	300 dia drainag pipework	m	40	6864	274,560
	300 dia penstock	nr	4	31000	124,000
	500 dia outlet	nr	1	51000	51,000
					-
	STEELWORK				-
	Weir plate	item	1	50000	50,000
					-
	MISCELLANEOUS METALWORK				-
	Handrailing	m	144	2500	360,000
					-
	Add for ancillaries				5,980,066
Total	Sedimentation tank				29,900,328

Item	DESCRIPTION	Unit	Quantity	Rate	Amount
TP4	**Rapid Sand Filters**				
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Structures	m3	798	350	279,300
	EO for rock	m3	532	1500	798,000
	Filter sand	m3	96	2500	240,000
	Gravel	m3	44	2500	110,000
			-		-
	CONCRETE inc formwork and reinforcement		-		-
	Blinding 15/20 80mm thick	m3	22	8000	176,000
	Concrete 30/20 in base slab	m3	213	20175	4,297,275
	do in walls	m3	238	20175	4,801,650
			-	20175	-
	PIPEWORK		-		-
	The following pipes and fittings		-		-
	Inlet pipework	m	20	6864	137,280
	Outlet pipework	m	20	6864	137,280
	Backwash pipework	m	30	10251	307,530
	control valves	nr	12	36000	432,000
			-		-
	STEELWORK		-		-
	Underdrainage system	nr	4	250000	1,000,000
			-		-
	MISCELLANEOUS METALWORK		-		-
	Handrailing	m	72	2500	180,000
			-		-
	Add for ancillaries				5,158,526
Total	Rapid Sand Filters				18,054,841
TP5	**Slow Sand Filters**				
	(design loading rate of 0.15 m/hr)				
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m	-		-
	Excavation - Structures	m3	9,752	350	3,413,200
	EO for rock	m3	3,251	1500	4,876,500
	Filter sand	m3	3,072	2500	7,680,000
	Gravel	m3	922	2500	2,305,000
		m3	-		-
	CONCRETE inc formwork and reinforcement		-		-
	Blinding 15/20 80mm thick	m3	261	8000	2,088,000
	Concrete 30/20 in base slab	m3	1,626	20175	32,804,550
	do in walls 500 thick	m3	536	20175	10,813,800
			-		-
	PIPEWORK		-		-
	The following pipes and fittings	nr	-		-
			-		-
	Control penstocks	nr	1	41000	41,000
	150 dia drainage penstocks	nr	1	25000	25,000
			-		-
	MISCELLANEOUS METALWORK		-		-
	Handrailing	m	263	2500	657,500
			-		-
	Add for ancillaries				16,176,138
Total	Slow Sand Filters				80,880,688
TP6	**Chlorination Building**				
	EXCAVATION				
	Excavation - pipelines (included in all in rate)	m	-		-
	Excavation - Footings	m3	16	350	5,600
	Excavation - bulk	m3	11	350	3,850
	EO for rock	m3	9	1500	13,500
			-		-
	CONCRETE inc formwork and reinforcement		-		-
	Blinding 15/20 80mm thick	m3	3	8000	24,000
	Concrete 30/20 in footing	m3	4	20175	80,700
	Concrete 30/20 in base slab	m3	7	20175	141,225
	do in walls	m3	6	20175	121,050
			-	20175	-
	BLOCKWORK (plastering and painting inc.)		-		-
	200 Thick blockwork	m	85	1500	127,500
	ROOFING	nr	-		-
	GMS roofing	m2	38	3600	136,800
		nr	-		-
			-		-
	Add for ancillaries				196,268
Total	Chlorination Building				850,493

Item	DESCRIPTION	Unit	Quantity	Rate	Amount
TP7	Clear Water Reservoir				-
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Structures	m3	432	350	151,200
	EO for rock	m3	180	1500	270,000
	Embankment	m3	288	500	144,000
					-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	9.7	8000	77,600
	Concrete 30/20 in base slab	m3	72.0	20175	1,452,600
	do in walls	m3	77.0	20175	1,553,475
	do in roof slab	m3	30.3	20175	611,303
	PIPEWORK				-
	The following pipes and fittings				-
	Inlet pipework	m	5	10250	51,250
	Outlet pipework	m	5	10250	51,250
	Overflow	m	20	8495	169,900
	control valves	nr	2	41000	82,000
	Washout pipework	m	5	2763	13,815
					-
	Add for ancillaries				1,157,098
Total	Clear Water Reservoir				5,785,491
TP8	**Sludge concentrators**				-
					-
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Structures	m3	366.44	350	128,252
	EO for rock	m3	219.86	1500	329,792
		m3			-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	14.70	8000	117,600
	Concrete 30/20 in base slab	m3	146.60	20175	2,957,655
	do in walls 300 thick	m3	101.80	20175	2,053,815
					-
	PIPEWORK				-
	The following pipes and fittings	nr			-
	draw off pipes	m	4.00	2763	11,052
	Overflow and outlet pipes	m	12.00	3984	47,808
	Control valves	nr	8	26000	208,000
					-
	MISCELLANEOUS METALWORK				-
	Handrailing	m	67.86	2500	169,646
					-
	Add for ancillaries				1,505,905
Total	Sludge concentrators				7,529,525
TP9	**Sludge drying beds**				-
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation bulk	m3	652.68	350	228,438
	EO for rock	m3	163.17	1500	244,755
					-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	52.30	8000	418,400
	Concrete 30/20 in base slab	m3	163.20	20175	3,292,560
	do in walls	m3	87.80	20175	1,771,365
	do in channels	m3	31.10	20175	627,443
	PIPEWORK				-
	The following pipes and fittings	nr			-
	handstops	nr	10	5000	50,000
	Outlet	nr	20	3984	79,680
					-
	Add for ancillaries				1,678,160
Total	Sludge drying beds				8,390,801

Item TP4	DESCRIPTION	Unit	Quantity	Rate	Amount
TP10	**Administration building**				-
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Footings	m3	129	350	45,150
	Excavation - floor	m3	150	350	52,500
	EO for rock	m3	39	1500	58,500
					-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	15.6	8000	124,800
	Concrete 30/20 in footings	m3	12.9	20175	260,258
	Concrete 30/20 in floor	m3	37.5	20175	756,563
	do in ring beam	m3	6.5	20175	131,138
		m3	-		-
	BLOCKWORK (plastering and painting inc)				-
	200 Thick blockwork	m	258.00	1500	387,000
	ROOFING	nr	-		-
	GMS roofing	m2	182	3600	655,200
					-
					-
					-
	Include for furnishing	nr	0		370,666
	Add for ancillaries				710,443
Total	Administration building				3,552,217
TP11	**Chemical Building**				-
	(12 5 x 8 m)				
	EXCAVATION				-
	Excavation - pipelines (included in all in rate)	m			-
	Excavation - Footings	m3	77	350	26,950
	Excavation - floor	m3	100	350	35,000
	EO for rock	m3	25	1500	37,500
					-
	CONCRETE inc formwork and reinforcement				-
	Blinding 15/20 80mm thick	m3	10.8	8000	86,400
	Concrete 30/20 in footings	m3	7.7	20175	155,348
	Concrete 30/20 in floor	m3	25.0	20175	504,375
	do in ring beam	m3	1.0	20175	20,175
		m3	-		-
	BLOCKWORK (plastering and painting inc)				-
	200 Thick blockwork	m	258.00	1500	387,000
	ROOFING	nr	-		-
	GMS roofing	m2	131	3600	471,600
					-
					-
					-
	Include for furnishing	nr	0		258,652
	Add for ancillaries				495,750
Total	Chemical Building				2,478,750
TP12	**Site works**				-
					-
	General site clearance	m2	15,000	50	750,000
	Remove trees girth 1 - 2 m	nr	2	5000	10,000
			-		-
	Precast paving slabs	m2	180	1800	324,000
	Precast manholes	Nr	10	40000	400,000
			-		-
	PIPEWORK		-		-
	The following pipes and fittings	nr	-		-
	400 dia pipework	m	50	10251	512,550
	300 dia pipework	m	75	6864	514,800
	200 dia pipework	m	80	3984	318,720
			-		-
	150 dia drain	m	200	1100	220,000
	300 dia drain	m	200	3500	700,000
	Roads	m2	1,250	350	437,500
			-		-
			-		-
	Fencing	m	500	1500	750,000
	Gates	nr	2	20000	40,000
	Septic tank and soakaway	nr	1	100000	100,000
			-		-
	Electricity supply	item	-		6,000,000
			-		-
	Add for ancillaries+B24				1,661,636
Total	Site works				12,739,206

Reservoir Quantities

Capacity (m3)	50	100	150	200	250	300	400	500	750
Excavation vol	25	50	75	100	125	150	200	250	375
Concrete									
Floor slab	4.53	6.80	8.31	9.54	11.78	14.25	18.70	23.09	34.05
Walls	4.75	5.85	6.48	6.95	7.74	8.52	9.78	10.88	13.23
Roof + supports	3.90	5.82	7.09	8.13	10.01	12.10	15.83	19.52	28.71
Valve chambers	1.32	1.85	2.19	2.46	2.95	3.49	4.43	5.35	7.60
Total conc. volume	14.49	20.32	24.07	27.09	32.49	38.36	48.75	58.84	83.59

Reservoir Costs

Assuming 10% rock excavation

Excavation	12,500	25,000	37,500	50,000	62,500	75,000	100,000	125,000	187,500
Concrete	292,427	410,044	485,690	546,451	655,388	773,912	983,489	1,187,001	1,686,369
Pipework etc	45,739	65,257	78,478	89,468	107,683	127,337	162,523	196,800	281,080
Site works	70,133	100,060	120,334	137,184	165,114	195,250	249,203	301,760	430,990
Ancillaries	58,912	84,050	101,080	115,234	138,696	164,010	209,330	253,479	362,032
Contingencies	67,328	96,058	115,520	131,696	158,510	187,440	239,234	289,690	413,750
Res'rcosts	**550,000**	**780,000**	**940,000**	**1,070,000**	**1,290,000**	**1,520,000**	**1,940,000**	**2,350,000**	**3,360,000**

Cost per unit of storage volume

Cost/m3 storage	11,000	7,800	6,267	5,350	5,160	5,067	4,850	4,700	4,480

THE STUDY ON WATER SUPPLY FOR
SEVEN TOWNS IN EASTER PROVINCE
IN THE REPUBLIC OF KENYA

APPENDIX M

GROUNDWATER SURVEY IN ISIOLO

APPENDIX M GROUNDWATER SURVEY IN ISIOLO

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1 ELECTRIC PROSPECTING

A reconnaissance electrical prospecting survey was conducted in the Isiolo area in order to obtain information on underground soil and geological strata, and to determine the most suitable locations for drilling exploratory wells.

1.1 Basic Theory and Implementing Methodology

The Vertical Electric Sounding (VES) method of electrical prospecting was used. As shown in the fugure below, this method uses the Wenner configuration by applying an electric current to the ground at electrodes C1 and C2, and the potential difference is measured from two other electrodes, P1 and P2, located symmetrically from a central point, and equi-distant from C1 and C2 along a straight line. Variations of the potential difference are recorded as the distance between electrodes is gradually increased, keeping them symmetrical from the central point. The apparent resistivity at this central point is calculated from the difference of the measurement between the applied current and the resulting potential difference between electrodes P1 and P2 using the following formula:

$$\rho = 2\pi a \frac{V}{I}$$

where,	ρ	=	Apparent resistivity	$(\Omega - m)$
	a	=	Electrode interval	(m)
	V	=	Potential difference	(mV)
	I	=	Applied current	(mA)

The illustration of Wenver's Configuration is given in the figure below

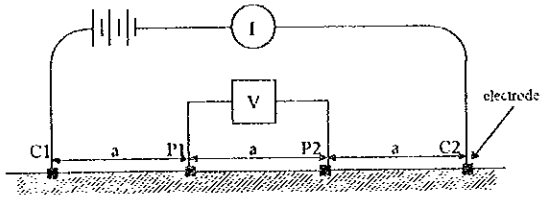

Figure M-1 Illustration of Wenner's Configuration

where, C1, C2 = Current Electrode
P1, P2 = Potential Electrode
a = Electrode Interval

The instruments used in the prospecting were a resistivity meter, (OYO McOHM model – 2115), details of which is given in the table below and a 12V battery for power supply. The current and voltage were read from the digital display of the resistivity meter. For the surveys, 25 VES points were established with 30 measurements at each point, with the electrodes interval raging from 0.5 m to 200 m.

Table M-1 Specification of McOHM (MODEL - 2115)

1)	Transmitter	
	Output voltage	400 Vp-p max.
	Output current	1, 2, 5, 10, 20, 50, 100, 200 mA
	Operating potential	12 V DC
2)	Receiver	
	Input impedance	1 M-Ω
	Measurement potential	±0.6V, ±6V (auto range)
	Resolution	20 micro - V
	Noise reduction ratio	90 dB (with 50/60 Hz power)
	No. of stackings	1, 4, 16, 64 (Stackings can be stopped, as desired)
	Time of one measurement Cycle	3.5 sec.
3)	Power	DC 12 V battery
4)	Operable temperature range	0-50 °C
5)	Dimensions	206 x 281 x 200 mm
6)	Weight	Approx. 7.5 kg

1.2 Selection of Inspecting Location

As described in the following section 2.3, data from existing wells around the town of Isiolo was collected and assessed. These wells are partly used for drinking purpose, however the great majority of them are used for irrigation and industrial purposes. Of these wells, saline water is evident, especially in the immediate vicinity and in the northern part of the town, where the alluvial plain prevails. Taking this and following reasons in account, the location for electric inspecting was chosen to be in the southern part of Isiolo.

(1) Topographic Configuration

Mt. Kenya which is located to the south of Isiolo is the origin of most of the surface and groundwater sources of the peripheral area. The groundwater being

constantly recharged from the high rainfall area around the summit and descends through permeable lava and tuff layers and a part of it reaches near the town of Isiolo. Thus, the more one travels southward, the higher the potential of groundwater.

(2) Geological Aspect

To the west of Isiolo, deposits of Pre-Cambrian schists and gneisses are found, and deep weathering may not have progressed in these deposits. The potential of groundwater is not therefore generally high in such geological conditions. Whereas, the south and southeastward areas are mainly covered by lava, tuff and tuff breccia of lower Nyambeni volcanic products of Quaternary age, which generally contain a large amount of groundwater in this region.

(3) Accessibility

VES points are mainly established along the existing roads due to ease of accessibility. When considerably high potential for groundwater has been identified, the water extracted will be transmitted by pipeline for drinking purpose as a part of source water of Isiolo water supply system. The location of VES points are shown in ***Figure M-2***.

1.3 Results of Surveys

According to the analysis of the p-a curves obtained from the surveys, the under ground strata on each VES point was identified to constitute three to four layers. The first layer consists of weathered surface soil, and the second, basaltic lava of lower Nyambeni volcanic products. The third layer consists of tuff and tuff breccia of lower Nyambeni volcanic products, and the fourth layer, tuff of lower Nyambeni volcanic products or Pre-Cambrian layer.

The apparent resistivity on the VES points is tabulated for each profile line as given in the table shown below. In compliance with the geological configuration and measured apparent resistivities, the third layer is interpreted as an aquifer extending over the fourth layer which is identified as an impermeable layer. This aquifer tends to decrease its thickness towards Isiolo.

The aquifer was found to have a thickness of more than 50 m was at VES points No. 2, 3, 4, 21 and 22 on the profile line No. 1 - No. 22, the VES points No. 8 to 13 on the profile line No. 13 - No. 24 and the VES point No. 16 on the profile line No. 20 - No. 25.

Out of these potential VES points, No. 8, No. 10 and No. 16 were accordingly selected for the exploratory well sites in this Study. The resistivity sections for each profile line is given in ***Figure M-3 to M-5.***

Table M-2 Apparent Resistivity on the Profile Line

Profile Line	Apparent Resistivity $(\Omega - m)$			
	1st Layer	2nd Layer	3rd layer	4th Layer
No. 1 - No. 22	4 ~ 460	162 ~1360	90 ~ 390	11 ~ 83
No. 24 - No. 13	3 ~ 690	200 ~ 1380	100 ~ 630	18 ~ 190
No. 25- No. 20	4 ~ 310	75 ~ 900	54 ~ 300	30 ~ 190

2 GEOLOGY AND HYDROGEOLOGY

2.1 Introduction

Following the reconnaissance study of geology in the Study Area as presented in the Interim Report, a detail geological investigation was carried out in the Isiolo area under this Study. The geological investigation mainly consisted of an Electrical Prospecting (Electrical Resistively Survey) and exploratory well drilling followed by a series of pumping tests in the drilled wells.

2.2 Regional Geology

Isiolo region is underlain by the following three geological systems; (1)Pre-Cambrian Basement System, (2) Pleistocene Series and (2) Recent Deposits.

Pre-Cambrian Basement System consists of schist and gneiss and this system underlie the area to the west of Isiolo as the geological basement. The system is partly covered by the Colluvium deposit, resulting that the system outcrops discontinuously.

The Pleistocene Series is subdivided into Lower Nyambene Volcanic Series, Upper Kenya Volcanic Series, and Parasitic Volcano in ascending order.

The Lower Nyambene Volcano Series consists of basaltic lava and pyroclastic rocks; and underlies the south-east area of the Study Area including Isiolo town. The Lower Nyambene Volcano Series is the main target geological unit as a possible groundwater resources in this Study as explained later. Upper Kenya Volcanic Series consisting of basaltic lava, underlies the area about 13 km south to Isiolo and covers the Lower Nyambene Volcano Series. Parasitic Volcano consists of volcanic products and outcrop sporadically in the areas more the 10 km to the east of Isiolo.

Colluvium deposit underlies the western area, and alluvium deposit does the northern area of Isiolo. These resent deposits are considered to consist of unconsolidated sand and gravel intercalated by clayey layers.

The regional Geological map in and around Isiolo town is shown in ***Figure M-6.***

2.3 Target Geological Unit as the Groundwater Resource

As Pre-Cambrian basement system usually consists of compact hard rocks such as schist and gneiss, the system is not likely to bear groundwater unless it is deeply weathered or highly fractured. Whereas, the Pleistocene volcanic products consisting of lava and pyroclastic rocks (tuff, tuff breccia, volcanic sand etc.) has relatively large porosity, therefore it is likely that the volcanic products bear sufficient groundwater to be developed.

It is believed that the most of the surface and groundwater originate from Mt. Kenya, which is located to the south of Isiolo. It is also believed that being constantly recharged from the high rainfall area around the summit of Mt. Kenya, the groundwater flows from higher elevation toward lower elevation through permeable lava and pyroclastic rocks of Pleistocene volcanic products and a part of the groundwater reaches the areas near Isiolo town. Thus, it is considered that the more south the location is from Mt. Kenya, the higher groundwater potential will be.

2.4 Information of the Existing Wells

Figure M-7 and ***Table M-6*** show the locations of the existing wells, their specification and test results, respectively.

An existing well IW5 (C10573) located to the west, was drilled to a depth of 150m but did not reach the Pre-Cambrian basement at the bottom of the well. The drilling record available indicates that the well IW5 was drilled in talus deposit that consists of clay, claycy sand and gravel, and limnological deposit (lake deposit) . It is generally understood that this sort of geological constitutions does not form a good aquifer. Whereas, the other existing wells located south of Isiolo, IW6 to IW9 were penetrated in a different type of geological units consisting of volcanic products that are considered to form good aquifers.

Available information of water quality of the existing wells IW1, IW3, IW4 IW5, IW7 and IW8 revealed that the wells IW1, IW3, IW4 and IW5 that are located in the

northern area to an altitude of approximately 1100m, show higher electric conductivity values above 1700-7000 μs/cm. On the other hand the existing wells IW7 and IW8 that are located in the southern area to the altitude of approximately 1100m, show lower electrical conductivity values of around 700 μs/cm. This information implies that the above-mentioned northern area might bear saline groundwater, whereas the southern area bear fresh groundwater, and that the boundary might exist at the altitude of approximately 1100 m as shown in ***Figure M-8***.

2.5 Determination of the Locations of Ground Water Development

The review of the geological and hydrogeological information mentioned above are summarized as follows.

(1) Pre-Cambrian System, and Talus deposit will not bear sufficient groundwater to be developed.

(2) Pleistocene Lower Nyambene volcanic products might bear sufficient groundwater to be developed.

(3) The more south a location is from Mt. Kenya, the higher groundwater potential will be.

(4) However, the northern area of the possible hydrogeological boundary that is located at the altitude of approximately 1100m might bear saline groundwater, whereas the southern area from the boundary might bear fresh water.

Having considered the above information, the Study team resolved that the investigation was therefore to be carried out in the area of Upper Kenya Volcanic Series of Pleistocene Era southern area to Isiolo town as shown in ***Figure M-9***.

2.6 Exploratory Well Drilling and Pumping Test

(1) Location of Exploratory Wells and Work Quantity

The review of the existing information of drilling and geological investigations, and the electrical resistivity survey carried out in this study all suggest that there is a potential for groundwater development from the tuff breccia strata of the Lower Nyambene Volcanic Products in the area located to the south and south east of Isiolo. Exploratory drilling sites were therefore selected in this area as shown in ***Figure M-10.*** The detail of the drilling works is as shown in ***Table M-4***.

(2) Method and Drilling Procedure

The drilling works were performed with a drilling rig of DRILL TECH using an air percussion drilling method.

The operation time of the drilling wells is summarized in ***Table M-5***. The Table shows that actual drilling operation totaled to approximately 37% in the whole operation between the commencement of a drilling and the demobilization, whereas the works were suspended for approximately 10% of working time due to machine troubles.

The standard working procedure for drilling operation is summarized as follows.

Drilling a hole was commenced with 8 inch drilling bid first to a certain depth. The drilling bid was replaced with 6 inch bid if the geological conditions required so, and drilling was continued to the required depth. Temporary work casing pipe of 8 inch or/and 10 inch were also installed to a hole to protect the drilled hole from caving or collapsing.

Geological log was prepared by observing rock-cuttings ejected from the hole while drilling, and the geological log of each hole is presented in ***Figure M-11***, ***Figure M-12*** and ***Figure M-13***.

(3) Geophysical Logging

The purpose of geophysical logging is to obtain information on the lithological condition and determine the exact location of each aquifer. Gamma-ray logging was carried out as geophysical logging in the well TW1 and TW2. The logging was not carried out in TW3 due to a trouble of the logging equipment. The results of the logging are shown in ***Figure M-11*** and ***Figure M-12***.

(4) Casing and Screen

Steel pipes of a diameter 6 inch were used as casings for the test wells. The screen installed was of slotted casing pipes; size of a slot is 14cm long, 0.15cm wide; number of the slots is six (6) around a circle and forty two (42) in a casing pipe of 6 m long. Depth of casing pipe to be installed was determined by lithology and geophysical logging to the depths of water bearing formations. The casing pipes were joined by threaded and coupled joints.

The detail schedule of the casing pipes and screen pipes is as shown in ***Table M-6***.

(5) Gravel packing

Sieved gravel of 2mm - 4mm size consisting of volcanic rocks was used for filling the annular space between the casing pipes/slotted screens of the test wells. Above the gravel filling rock-cuttings were filled and on top of the cutting, cement was placed to the ground surface. The detail of gravel packing to the test holes is shown in ***Figure M-11***, ***Figure M-12*** and ***Figure M-13***.

(6) Partial Backfilling of the Test Wells

During the drilling of TW2 and TW3, it was observed that electric conductivity became larger as the drilling progressed deeper. The maximum electric conductivity value reached 2,099 micro-S/cm at the bottom of TW2 and 2,320 micro-S/cm at the bottom of TW3 respectively. It was therefore decided that the bottom part of these two (2) holes be backfilled with cement grout. The detail depths of the backfilling are as shown in ***Figure M-12*** and ***Figure M-13***.

(7) Development

Development was carried out by airlift method using air pipes that were lowered down to the bottom of a drilled hole and compressed air was continuously sent for about 6 hours down to the bottom through the pipes to blow accumulated cuttings out of the hole until the water became free of sand particles. Thereafter, water was pumped up at a higher pumping rate than normal until the water became clearer.

(8) Pumping Test

1) General

The objectives of the pumping test are to determine the hydraulic characteristics of the water bearing formation, and ascertain the performance of the test well. There are three types of tests involved in a pumping test: the step drawdown test, the time drawdown test, and recovery test. The step drawdown test is performed to evaluate the efficiency of the test well. The time drawdown test and time recovery test are performed to determine the hydraulic properties of aquifer.

Pumping tests were carried out in the three holes TW1, TW2 and TW3 and

the results are summarized in ***Table M-7*** and in ***Figure M-11*** and ***Figure M-12.***

2) Step Drawdown Test

The step drawdown test was performed to ascertain the aquifer behavior at different discharge rates and evaluate the well loss of a well. Test duration of two (2) hours was adopted for one step; relations between yield and drawdown of the rest wells were plotted to estimate 'well loss' and 'aquifer loss' of the wells. The test results are shown in ***Figure M-11*** and ***Figure M-12***. As it can be seen in ***Figure M-12***, the maximum discharge of the pump used for the test appeared to be insufficient.

3) Time Drawdown and Time Recovery Test

Time drawdown test and Time recovery test were carried out to determine the hydraulic characteristic of aquifers. The time drawdown and time recovery test data were interpreted by Jacob's non-equilibrium equation. The summary of the pumping test analysis is shown in ***Table M-7*** and Time-Drawdown curves of the test wells are shown in ***Figure M-11*** and ***Figure M-12*** and the curves of the existing wells are shown in ***Figures M-14*** to ***M-18.***

2.7 Regional Groundwater Behavior

Static groundwater level available from the existing well and the test wells drilled in this study clearly demonstrate that the apparent groundwater elevation gradually decreases from the south area to the north, which is a direct information that the groundwater is being supplied from the south area to the north area.

2.8 Recommendation of Pumping Ratio

In this study, the optimum pumping ratio is recommended based on permissible maximum drawdown in a hole[1].

(1) Permissible Maximum

Permissible maximum drawdown may be determined from the following two

[1] *Study with a consideration of water balance among (1)rainfall, (2)runoff, (3)evaporation and (4)recharge to aquifer was not made within the scope of works.*

factors.

1) Water drawndown level should be kept above the installed submerged pump or the top of the screens in the well.

2) Water flow velocity at the entrance of the installed screens must be kept below an allowable level so that sand particles should not be sucked into the well.

For an assessment of the permissible maximum pumping ratio under the factor 1), the following equation is applicable. By using this equation permissible drawdown, Sw that should be above the screens or the pump whichever at a shallower depth, is calculated.

$$Sw = BQ + CQ^2$$

Where,

Sw : Total Drawdown,
Q : Discharge from a Well
B : Aquifer Coefficient
C : Well Loss Coefficient

For an assessment of the permissible pumping rate under the factor 2), the maximum velocity of 3 cm/sec that was empirically determined and is widely accepted for design of wells, is adopted as the permissible velocity at an entrance of screens.

The results of the assessment of permissible maximum pumping rate is shown in ***Table M-8***. As can be seen in the table, permissible maximum pumping rate is given as 10 l/sec for TW1 and TW3; 3 l/sec for TW2 respectively.

(2) Recommended Pumping Rate

1) TW-1

It is noted that the permissible maximum discharge estimated from both entrance velocity and drawdown for TW1 is in the same range. If the static water level should be lower than the current level, drawdown might take place below an upper part of the installed screens when the maximum

permissible pumping water of 10 l/sec should be discharged. Furthermore, due to insufficient capacity of the used pump for the test, the well has not experienced discharge more than 5 l/sec approximately. It is therefore prudent that the pumping rate from the well TW-1 should be kept at around 5 l/sec.

2) TW-2

Table M-8 indicated that the permissible maximum pumping rate is 3 l/sec. Although sand particles were not observed when approximately 5 l/sec was discharged during the pumping test of TW-2, it is recommended that 3 l/sec should be adopted as the optimum pumping rate for a long term operation of the well TW-2.

3) TW-3

The calculation results shown in Table M-8 shows that the permissible maximum discharge of TW-3 is over 10 l/sec. However, because the well TW-3 has not experienced a discharge more that approximately 5 l/sec during the pumping test due to the capacity limitation of the pump, it is considered to be prudent that the maximum pumping ratio from the well should be kept at around 5 l/sec.

The summary of the recommended Pumping Rate from the test wells is as shown below.

Well	Permissible Maximum Discharge (l/sec)		Recommended Pumping Rate (l/sec)
	Estimated from Entrance Velocity	Estimated from Total Drawdown	
TW1	10	10	5
TW2	3	16	3
TW3	10	23	5

It should be noted that the permissible maximum discharge will increase, if openness of screen or the number of casing pipes increases.

4) Recommendation

Pumping rate for each well was recommended based on the assessment of entrance velocity and total drawdown. However no consideration has been

given, within the scope of this study, to water balance in a groundwater basin around Isiolo town. It is therefore uncertain if the development of additional groundwater from wells to be constructed might affect the existing well conditions. Thus, a further study is recommended in which water balance is to be analyzed on the basis of information on rainfall, surface runoff, evaporation, and recharge to the groundwater. To facilitate to the further study, long term monitoring of groundwater level in as many wells as possible is strongly recommended.

TABLES

Table M-3 List of Existing Wells in Isiolo Area

Well No.		Loation	Well Depth	Diamater	Static Water Level	Pumping Water Level	Pumping Rate	EC	Completipon Day
No.	Code		(m)	(mm)	(m)	(m)	(m3/day)	(μs/cm)	
IW1	C-8976	Ngare Mara Village	45.7	-	-	21.00	750	1700	10-Jan-90
IW2	C-7925	Ngare Mara River	48.0	-	-	19.00	600	-	26-Oct-89
IW3	C-7927	Near 79 Barracks	78.0	-	-	15.00	720	1696	25-Sep-89
IW4	C-7924	Isiolo Air Strip	184.0	-	-	18.00	-	7278	31-Jul-89
IW5	C-10573	Isiolo Asal Kldp	150.6	152	121.60	132.00	345	1800	5-Dec-93
IW6	C-10558	Isiolo Asiamka Farm	101.0	203	33.65	75.50	184	-	25-Jul-93
IW7	C-10575	Isiolo Barka Farm	82.0	160	14.70	15.48	277	610	6-Oct-93
IW8	C-10576	Isiolo Barka Farm	106.0	160	23.15	27.82	264	860	27-Nov-96
IW9	C-10574	Isiolo Barka Farm	106.0	168	22.23	35.67	230	-	26-Oct-93

Data Source: NLRRWD -:Data Not Availale

Table M-4 List of Test Wells

Well No.	Location	Elevation (m)	Well Completed Date	Drilling Rig	Diameter (mm)	Depth (m)	Screen Position (m)	Screen Length (m)	Static Water Level (m)	Pumping Water Level (m)	Pumping Test Yeild (l/sec.)
TW1	Ruisi Meru	1254.74	7-Mar-93	Drill TECH	155	109.70	67.00 - 79.00	12.00	24.71	38.17	5.28
							85.00 - 109.00	24.00			
TW2	Ruisi Meru	1280.00	16-Mar-93	Drill TECH	155	96.00	82.00 - 94.00	12.00	0.90	13.33	4.90
						(122.00)	(100.00) - (118.00)	18.00			
TW3	Ruisi Meru	1262.51	23-Mar-93	Drill TECH	155	83.00	30.00 - 36.00	6.00	2.53	6.25	5.38
							42.00 - 54.00	12.00			
							60.00 - 78.00	18.00			
						(120.00)					

Note: * Elevation data based on the leveling survey
* Depth in parenthesis was drilled depth
* Depth without parenthesis was final well depth after backfilling.

Table M-5 Operatation Time of Well Drilling

	Well No.	Unit	TW1	TW2	TW3	Total	Total/(12)	Total/(13)
	Drilling Depth	(m)	109.7	122.0	120.0			
(1)	Site Preparation, Transportation and Assembly of rig	(hrs)	51.5	6.0	7.5	65.0	9.7%	
(2)	Drilling Operation	(hrs)	100.0	46.0	64.5	210.5	31.3%	37.1%
(3)	Electrical Logging	(hrs)	4.0	4.0	0.0	8.0	1.2%	1.4%
(4)	Instalation of Casing and Screen	(hrs)	22.0	14.0	15.0	51.0	7.6%	9.0%
(5)	Gravel Packing and Cementing	(hrs)	1.0	1.0	9.0	11.0	1.6%	1.9%
(6)	Development	(hrs)	7.0	7.0	6.0	20.0	3.0%	3.5%
(7)	Pumping test	(hrs)	72.0	62.0	72.0	206.0	30.6%	36.3%
(8)	Mechanicl Trouble	(hrs)	26.5	0.0	35.0	61.5	9.1%	10.8%
(9)	Disassemble	(hrs)	12.0	12.0	15.5	39.5	5.9%	
(10)	Transportation	(hrs)						
(11)	Off Day	(hrs)						
(12)	Total<(1)to(11)>	(hrs)	296.0	152.0	224.5	672.5		
(13)	Total<(2)to(8)>	(hrs)	232.5	134.0	201.5	568.0		

Table M-6 Schedule of Casing and Screen in Test Wells

WI1				WI2				WI3			
Depth		Type	Unit Length	Depth		Type	Unit Length	Depth		Type	Unit Length
(m)	(m)		(m)	(m)	(m)		(m)	(m)	(m)		(m)
109.63	101.93	SCREEN	7.70	121.19	118.19	PLAIN	3.00	83.46	77.43	PLAIN	6.03
101.93	95.83	SCREEN	6.10	118.19	112.08	SCREEN	6.11	77.43	71.39	SCREEN	6.04
95.83	89.76	SCREEN	6.07	112.08	105.98	SCREEN	6.10	71.39	65.34	SCREEN	6.05
89.76	83.67	SCREEN	6.09	105.98	99.88	SCREEN	6.10	65.34	59.32	SCREEN	6.02
83.67	77.61	PLAIN	6.06	99.88	93.78	PLAIN	6.10	59.32	53.17	PLAIN	6.15
77.61	71.50	SCREEN	6.11	93.78	87.68	SCREEN	6.10	53.17	47.13	SCREEN	6.04
71.50	65.40	SCREEN	6.10	87.68	81.58	SCREEN	6.10	47.13	41.09	SCREEN	6.04
65.40	59.30	PLAIN	6.10	81.58	75.48	PLAIN	6.10	41.09	35.06	PLAIN	6.03
59.30	53.27	PLAIN	6.03	75.48	69.37	PLAIN	6.11	35.06	29.04	SCREEN	6.02
53.27	47.19	PLAIN	6.08	69.37	63.26	SCREEN	6.11	29.04	23.01	PLAIN	6.03
47.19	41.12	PLAIN	6.07	63.26	57.16	PLAIN	6.10	23.01	16.94	PLAIN	6.07
41.12	35.06	PLAIN	6.06	57.16	51.08	PLAIN	6.08	16.94	10.70	PLAIN	6.24
35.06	28.98	PLAIN	6.08	51.08	44.98	PLAIN	6.10	10.70	4.70	PLAIN	6.00
28.98	22.92	PLAIN	6.06	44.98	38.88	PLAIN	6.10	4.70	-1.34	PLAIN	6.04
22.92	16.83	PLAIN	6.09	38.88	32.76	PLAIN	6.12				
16.83	10.77	PLAIN	6.06	32.76	26.66	PLAIN	6.10				
10.77	4.72	PLAIN	6.05	26.66	20.54	PLAIN	6.12				
4.72	-1.35	PLAIN	6.07	20.54	14.17	PLAIN	6.37				
				14.17	8.07	PLAIN	6.10				
				8.07	1.97	PLAIN	6.10				
				1.97	-4.14	PLAIN	6.11				
	Total	SCREEN	38.17		Total	SCREEN	36.62		Total	SCREEN	30.16
	Total	PLAIN	72.81		Total	PLAIN	88.71		Total	PLAIN	54.64
	TOTAL		110.98		TOTAL		125.33		TOTAL		84.80
								GroundTotal		SCREEN	104.95
										PLAIN	216.16

Diameter of casing: 6"

Screen: Slotted casing pipe;

* a slot of 14cm long and 0.15cm wide;
* 6 slots around a circle, 42 slots in a casiing pipe.

Table M-7 Summary of The Pumping Test

Well No.	TestType	Statistic Water Level (m)	Discharge (Q) (l/sec)	Drawdown(Sw) (m)	Specific Capacity (l/sec/m)	Sw/Q (m/l/s)	Aquifer Loss Coeffient B	Well Loss Coeffient C	Aquifer Loss (BxQ) (m)	Well Loss (CxQ2) (m)	Total Drawdown(BQ+C (m)	Ratio of Well Loss (CQ2)/(BQ+CQ2 (%)	Transmissivity <Jacob/TimeDrawdown> (m2/day)	Transmissivity <RecoveryTest> (m2/day)
TW1	C.	24.71	5.28	13.46	0.39	2.55	1.67	0.17	8.82	4.71	13.53	34.8	55.6	52.5
	ST-1	23.72	1.94	3.85	0.50	1.98	1.67	0.17	3.24	0.64	3.88	16.4		
	ST-2		3.33	9.55	0.35	2.87	1.67	0.17	5.56	1.87	7.44	25.2		
	ST-3		4.44	11.05	0.40	2.49	1.67	0.17	7.42	3.33	10.75	31.0		
	ST-4		5.13	12.85	0.40	2.50	1.67	0.17	8.57	4.45	13.02	34.2		
TW2	C.	0.90	4.90	12.43	0.39	2.54	2.70	0.11	13.25	2.54	15.79	16.1	129	129
	ST-1	0.00	3.19	9.70	0.33	3.04	2.70	0.11	8.63	1.07	9.70	11.1		
	ST-2		3.70	11.45	0.32	3.09	2.70	0.11	10.00	1.45	11.45	12.6		
	ST-3		4.10	11.78	0.35	2.87	2.70	0.11	11.09	1.78	12.86	13.8		
	ST-4		4.90	12.12	0.40	2.47	2.70	0.11	13.25	2.54	15.79	16.1		
TW3	C.	2.53	5.40	6.25	0.86	1.16	0.35	0.10	1.89	2.92	4.81	60.7	76	80
	ST-1	2.24	3.20	1.63	1.96	0.51	0.35	0.10	1.12	1.02	2.14	47.8		
	ST-2		4.40	2.86	1.54	0.65	0.35	0.10	1.54	1.94	3.48	55.7		
	ST-3		4.90	3.26	1.50	0.67	0.35	0.10	1.72	2.40	4.12	58.3		
	ST-4		5.50	3.52	1.56	0.64	0.35	0.10	1.93	3.03	4.95	61.1		
C10573	C.	116.16	4.00	132.05	0.03	33.01							105	126
	ST-1													
	ST-2													
	ST-3													
	ST-4													
C10574	C.	15.88	2.67	35.67	0.07	13.36							42.2	-
	ST-1		1.70	24.20	0.07	14.24								
	ST-2		2.27	29.27	0.08	12.89								
	ST-3		2.65	35.67	0.07	13.46								
	ST-4													
C10575	C.	24.71	5.28	13.46	0.39	2.55							417	-
	ST-1													
	ST-2													
	ST-3													
	ST-4													
C10576	C.	21.94	3.05	27.82	0.11	9.12							241	-
	ST-1		1.82	24.20	0.08	13.30								
	ST-2		2.46	25.60	0.10	10.41								
	ST-3													
	ST-4													
C10558	C.	31.74	2.13	75.50	0.03	35.45							6.7	5.6
	ST-1		1.33	51.30	0.03	38.57								
	ST-2		1.80	58.80	0.03	32.67								
	ST-3													
	ST-4													

Table M-8 Estimation of Permissible Pumping Rate

Well No.	Discharge(Q)	Permissible Entrance Velocity	Estimated Entrance Velocity	Aquifer Loss Coefficient	Well Loss Coefficient	Aquifer Loss (BxQ)	Well Loss (CxQ2)	Total Drawdown(BQ+CQ2)	Distance between Static Water Level and Screen or Pump
	(l/sec)	(cm/sec)	(cm/sec)	B	C	(m)	(m)	(m)	(m)
TW1	1.00		0.29	1.67	0.17	5.88	0.17	6.05	
	2.00		0.58	1.67	0.17	3.34	0.68	4.02	
	3.00		0.88	1.67	0.17	5.01	1.52	6.53	
	4.00		1.17	1.67	0.17	6.68	2.70	9.39	
	5.00		1.46	1.67	0.17	8.36	4.23	12.58	
	6.00		1.75	1.67	0.17	10.03	6.08	16.11	
	7.00		2.05	1.67	0.17	11.70	8.28	19.98	
	8.00		2.34	1.67	0.17	13.37	10.82	24.18	
	9.00		2.63	1.67	0.17	15.04	13.69	28.73	
	10.00	3.00	2.92	1.67	0.17	16.71	16.90	33.61	40.29
	12.00		3.51	1.67	0.17	20.05	24.34	44.39	
	14.00		4.09	1.67	0.17	23.39	33.12	56.52	
	16.00		4.68	1.67	0.17	26.74	43.26	70.00	
	18.00		5.26	1.67	0.17	30.08	54.76	84.83	
	20.00		5.85	1.67	0.17	33.42	67.60	101.02	
TW2	1.00		0.93	2.70	0.11	2.70	0.11	2.81	
	2.00		1.85	2.70	0.11	5.41	0.42	5.83	
	3.00	3.00	2.78	2.70	0.11	8.11	0.95	9.06	
	4.00		3.70	2.70	0.11	10.82	1.69	12.51	
	5.00		4.63	2.70	0.11	13.52	2.64	16.16	
	6.00		5.56	2.70	0.11	16.22	3.80	20.03	
	7.00		6.48	2.70	0.11	18.93	5.17	24.10	
	8.00		7.41	2.70	0.11	21.63	6.76	28.39	
	9.00		8.33	2.70	0.11	24.34	8.55	32.89	
	10.00		9.26	2.70	0.11	27.04	10.56	37.60	
	12.00		11.11	2.70	0.11	32.45	15.21	47.65	
	14.00		12.96	2.70	0.11	37.86	20.70	58.55	
	16.00		14.81	2.70	0.11	43.26	27.03	70.30	79.91
	18.00		16.67	2.70	0.11	48.67	34.21	82.89	
	20.00		18.52	2.70	0.11	54.08	42.24	96.32	
TW3	1.00		0.31	0.35	0.10	10.00	0.10	10.10	
	2.00		0.62	0.35	0.10	0.70	0.40	1.10	
	3.00		0.93	0.35	0.10	1.05	0.90	1.95	
	4.00		1.23	0.35	0.10	1.40	1.60	3.00	
	5.00		1.54	0.35	0.10	1.75	2.50	4.25	
	6.00		1.85	0.35	0.10	2.10	3.60	5.70	
	7.00		2.16	0.35	0.10	2.45	4.90	7.35	
	8.00		2.47	0.35	0.10	2.80	6.40	9.20	
	9.00		2.78	0.35	0.10	3.15	8.10	11.25	
	10.00	3.00	3.09	0.35	0.10	3.50	10.00	13.50	
	12.00		3.70	0.35	0.10	4.20	14.40	18.60	
	14.00		4.32	0.35	0.10	4.90	19.60	24.50	
	16.00		4.94	0.35	0.10	5.60	25.60	31.20	
	18.00		5.56	0.35	0.10	6.30	32.40	38.70	
	20.00		6.17	0.35	0.10	7.00	40.00	47.00	
	21.00		6.48	0.35	0.10	7.35	44.10	51.45	
	22.00		6.79	0.35	0.10	7.70	48.40	56.10	
	23.00		7.10	0.35	0.10	8.05	52.90	60.95	63.00
	24.00		7.41	0.35	0.10	8.40	57.60	66.00	