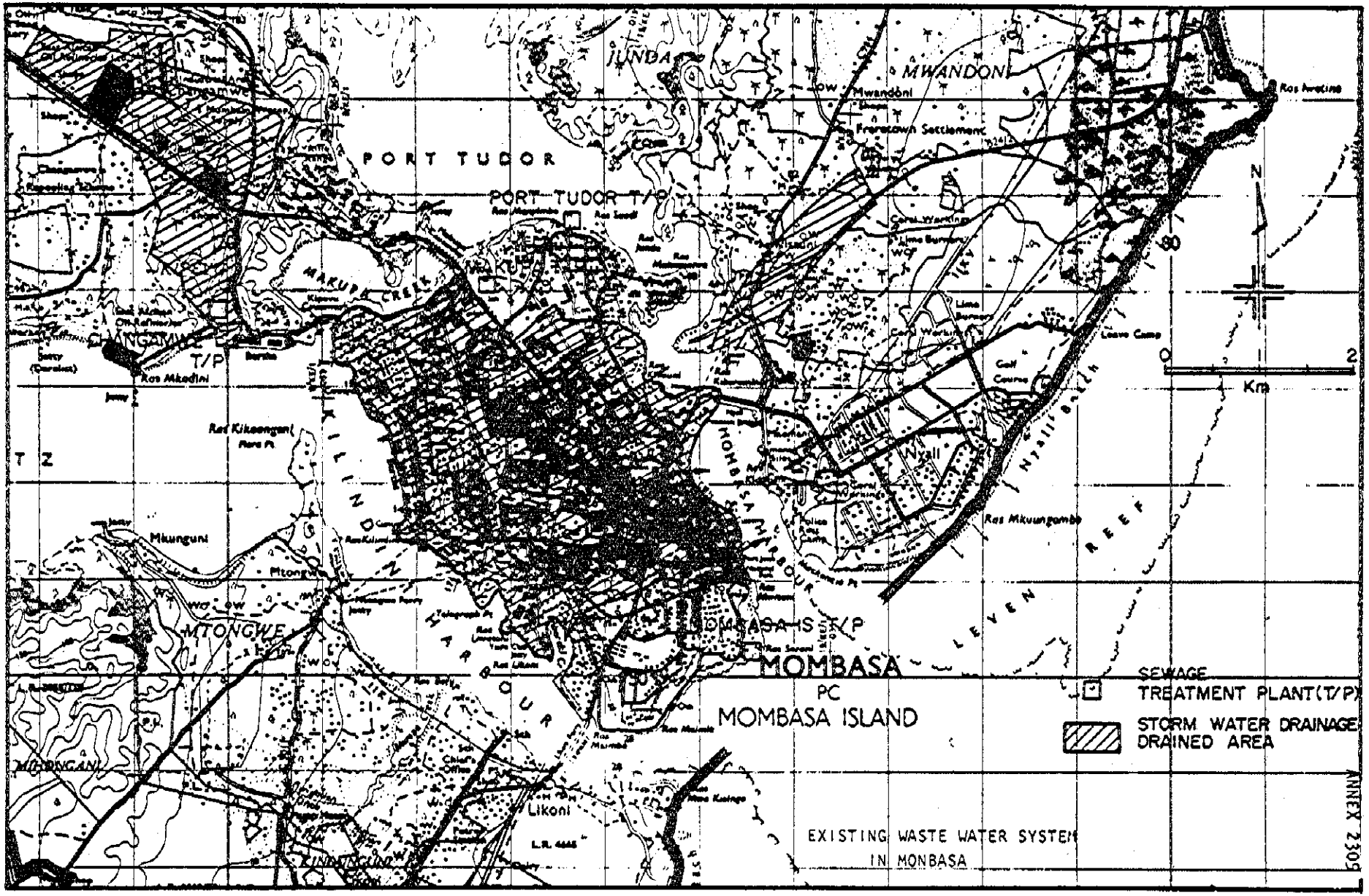
JUNDA
MWANDONI
PORT TUDOR
PORT TUDOR T/P
MAKUPA CREEK
KILINDINI
MOMBASA HARBOUR
MTONGWE
MOMBASA IS T/P
MOMBASA
PC
MOMBASA ISLAND
Likoni
Mwandoni
Freretown Settlement
Ras Mkadini
Ras Kikoengani
Mkunguni
Mtongwe
Ras Mkuumpamba
NYALI BEACH
LEVEN REEF
N
0
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2
Km
SEWAGE TREATMENT PLANT(T/P)
STORM WATER DRAINAGE DRAINED AREA
EXISTING WASTE WATER SYSTEM IN MONBASA
ANNEX 2305

HISTORICAL CENSUS POPULATION OF COAST PROVINCE

	1962		1969		1979	
	Population (10^3)	% to Nation (%)	Population (10^3)	% to Nation (%)	Population (10^3)	% to Nation (%)
Total Kenya	8,636	100	10,943	100	15,322	100
Coast Province	727	8.42	943	8.62	1,339	8.74
Project Area	625	7.24	815	7.45	1,123	7.33
Kilifi District	212	2.45	266	2.43	372	2.42
Southern Division	(94)	(1.08)	(113)	(1.03)	(151)	(0.99)
Northern Division	(38)	(0.44)	(47)	(0.43)	(64)	(0.42)
Central Division	(43)	(0.50)	(57)	(052)	(85)	(0.55)
Malindi Division	(37)	(0.43)	(49)	(045)	(72)	(0.47)
Gede Location	(5)		(11)		(17)	
Ganda Location	(27)		(31)		(44)	
Jilore Location	(5)		(7)		(10)	
Kwale District	158	1.83	206	1.88	287	1.87
Mombasa District	180	2.08	247	2.26	342	2.23
Taita Taveta District	75	0.87	96	0.88	123	0.80
Voi Division	(19)	(0.22)	(30)	(0.27)	(38)	(0.25)
Wundanyi Division	(56)	(0.65)	(66)	(0.60)	(85)	(0.55)

	1962		1969		1979	
	Population	% to Nation	Population	% to Nation	Population	% to Nation
	(10^3)	(%)	(10^3)	(%)	(10^3)	(%)
Non-Project Area	104	1.20	130	1.19	216	1.41
Kilifi District						
Malindi Division	36	0.42	42	0.38	57	0.37
Taita-Taveta District						
Taveta Division	15	0.17	15	0.14	25	0.16
Lamu District	23	0.27	22	0.20	42	0.27
Tana River District	30	0.35	51	0.47	92	0.60

Source: Population Census

N.B. Administrative boundary change was adjusted to that of 1979 Population Census based on information of Central Bureau of Statistics.

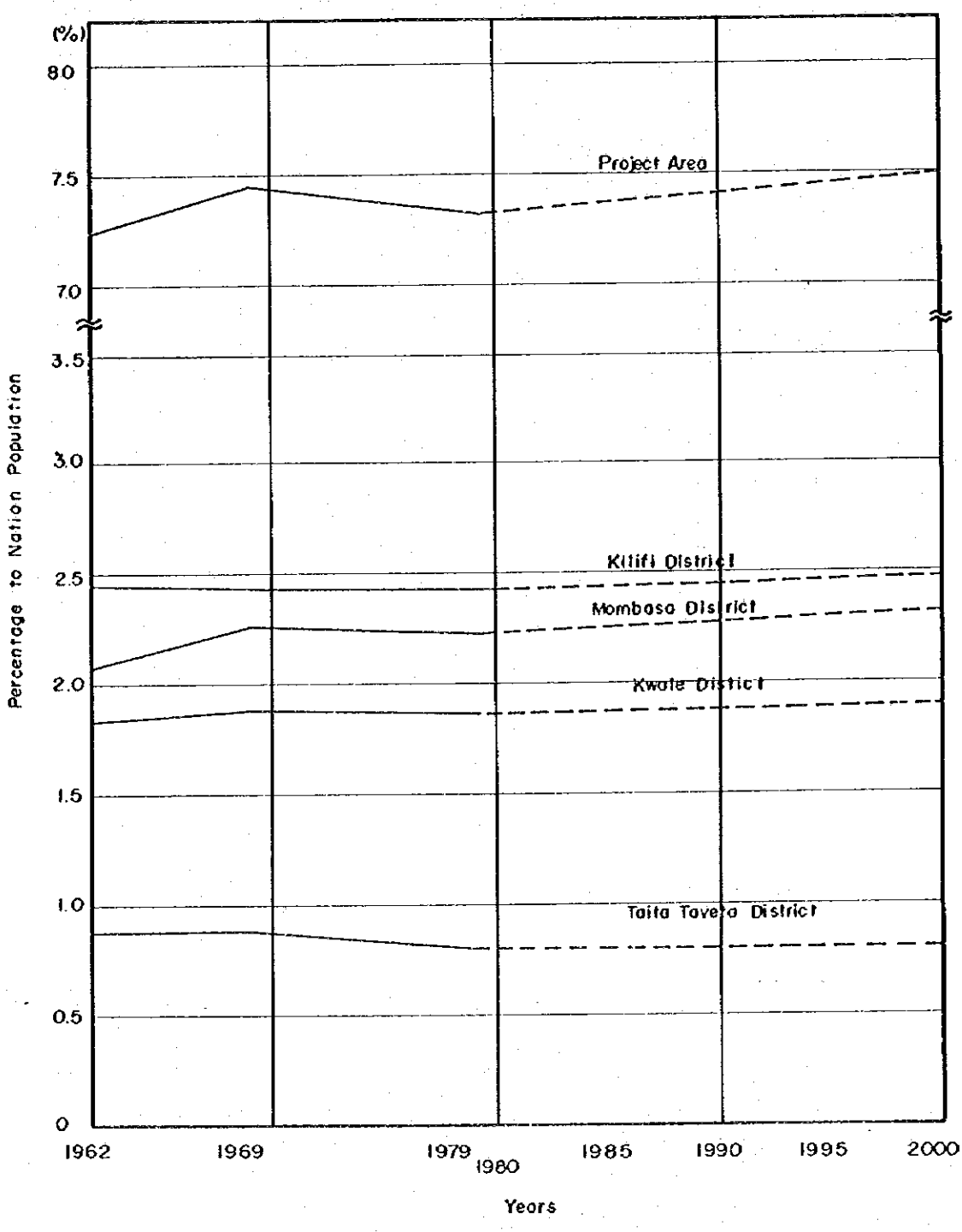
PROJECTED POPULATION OF COAST PROVINCE
AS PERCENTAGE OF NATION POPULATION

Unit: %

	Historical	Projected				
	1979	1980	1985	1990	1995	2000
Coast Province	8.72	8.74	8.83	8.89	8.94	8.96
Project Area	7.32	7.33	7.38	7.42	7.46	7.50
Kilifi District (1	2.42	2.42	2.44	2.45	2.47	2.48
Kwale District	1.87	1.87	1.88	1.89	1.89	1.90
Mombasa District (2	2.23	2.24	2.26	2.28	2.30	2.32
Taita-Taveta District	0.80	0.80	0.80	0.80	0.80	0.80
Non Project Area	1.40	1.41	1.45	1.47	1.48	1.46
Kilifi District	0.37	0.37	0.36	0.34	0.33	0.31
Taita-Taveta District	0.16	0.16	0.16	0.16	0.16	0.16
Lamu District	0.27	0.27	0.27	0.27	0.27	0.27
Tana River District	0.60	0.61	0.66	0.70	0.72	0.72

Remarks: (1 Excluding Malindi Division of northern bank of the Sabaki River

(2 Excluding Taveta Division



PROJECTED POPULATION OF PROJECT AREA
ASPERCENTAGE OF NATION POPULATION

PROJECTED POPULATION OF THE PROJECT AREA BY DISTRICT

Unit: 10^3

	Historical	Projected				
	1979	1980	1985	1990	1995	2000
A. Project Area						
Kilifi District (1	371	382	457	542	646	765
Kwale "	287	296	352	418	494	587
Mombasa "	342	355	423	505	601	716
Taita-Taveta District (2	123	128	150	177	209	247
Total	1,123	1,161	1,382	1,642	1,950	2,315
B. Non-Project Area						
Kilifi District	57	59	67	75	86	96
Taita Taveta District	25	25	30	35	42	49
Lamu District	42	43	51	60	71	83
Tana River District	92	97	124	156	189	223
Total	216	224	272	326	388	451
C. Coast Province Total	1,339	1,385	1,654	1,968	2,338	2,766

Remarks: (1 Including Malindi division of southern bank of the Sabaki River

(2 Excluding Taveta Division

ANNEX 2404-1

HISTORICAL POPULATION OF URBAN CENTRES

	1962		1969		1979	
	Population	% to Province	Population	% to Province	Population	% to Province
Coast Province	727,844	100	944,082	100	1,339,000	100
Malindi	5,818	0.80	10,757	1.14	23,306	1.74
Voi	2,533	0.35	5,313	0.56	7,329	0.55
Kilifi	2,081	0.29	2,662	0.28	5,861	0.44
Mariakani	1,454	0.20	3,956	0.42	2,853	0.21
Wundanyi	3,717	0.51	4,385	0.46	6,075	0.45
Kwale	1,008	0.14	1,092	0.12	2,193	0.16
Kinango	1,599	0.22	2,450	0.26	3,647	0.27
Total	18,210	2.51	30,615	3.24	51,264	3.82

PROJECTED POPULATION OF URBAN CENTRES

	Historical	Projected				
	1979	1980	1985	1990	1995	2000
Coast Province						
Population (10^3)	1,339	1,385	1,654	1,968	2,338	2,766
% to Nation (%)	8.72	8.74	8.83	8.89	8.94	8.96
Urban Centers (1						
Population (10^3)	51.3	53.6	67.8	84.6	105.0	128.4
% to Province (%)	3.82	3.87	4.10	4.30	4.49	4.64

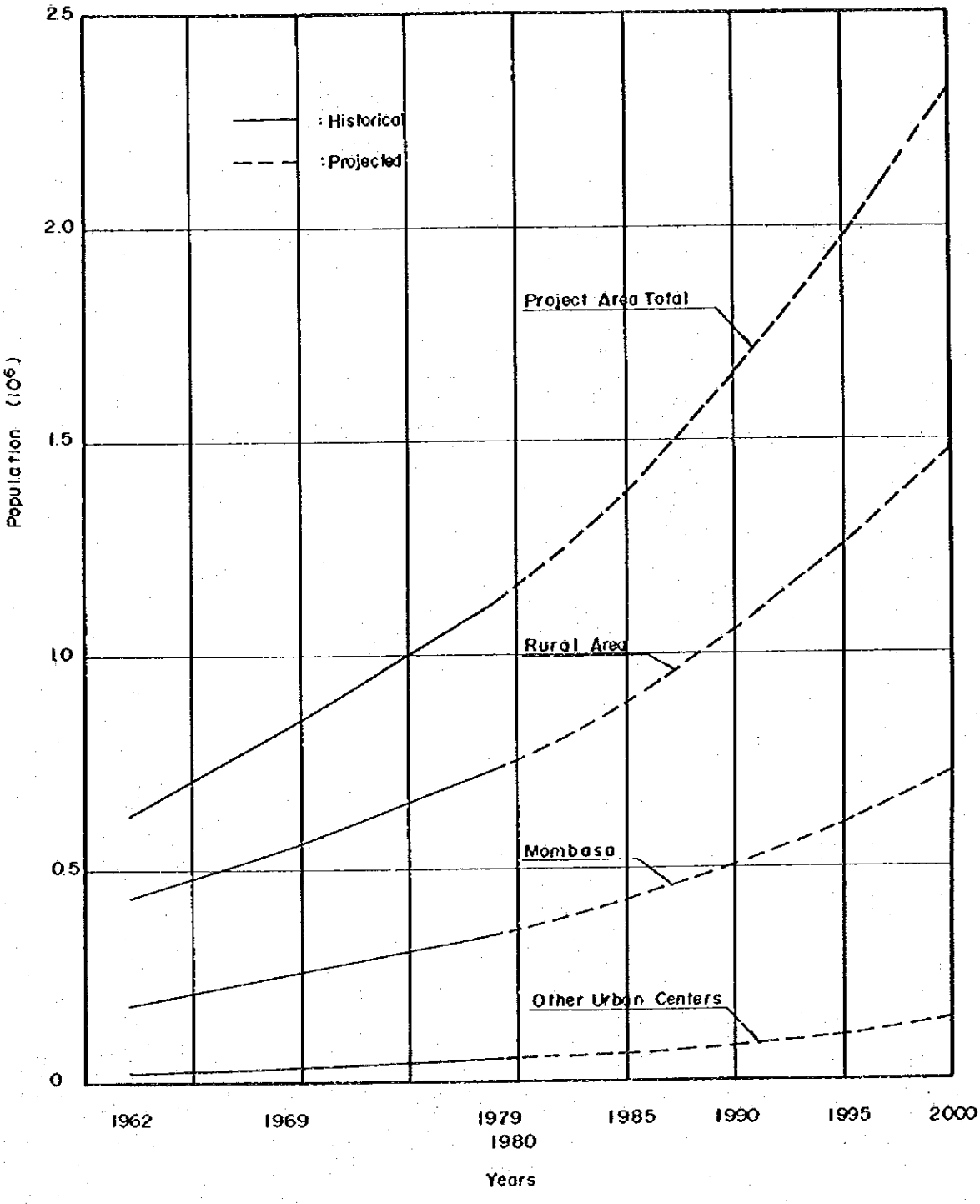
Remarks: (1 Total of seven urban centres i.e. Malindi, Voi, Kilifi, Mariakani, Kundanyi, Kwale and Kinango

HISTORICAL AND PROJECTED POPULATION OF PROJECT AREA

MEDIUM GROWTH PROJECTION (ADOPTED)

	MOMBASA			URBAN CENTER				RURAL			TOTAL PROJECT AREA	
Year	% to Nation	Population	Growth Rate	% to Province	Population	Growth Rate	% to Nation	Population	Growth Rate	% to Nation	Population	% to Nation
Historical	(%)	(10^3)	(%)	(%)	(10^3)	(%)	(%)	(10^3)	(%)	(%)	(10^3)	(%)
1962	2.08	180	-	2.51	18	-	0.21	427	-	4.94	625	7.24
1969	2.26	247	4.62	3.24	31	7.70	0.28	537	3.33	4.91	815	7.45
1979	2.23	342	3.31	3.82	51	5.29	0.33	730	3.12	4.76	1,123	7.32
Projected												
1980	2.24	355	3.80	3.87	54	4.54	0.34	752	3.01	4.75	1,161	7.33
1985	2.26	423	3.57	4.10	68	4.82	0.36	891	3.45	4.76	1,382	7.38
1990	2.28	505	3.61	4.30	85	4.53	0.38	1,052	3.38	4.75	1,642	7.41
1995	2.30	601	3.54	4.49	105	4.40	0.40	1,244	3.41	4.76	1,950	7.46
2000	2.32	716	3.56	4.64	128	4.11	0.41	1,471	3.41	4.76	2,315	7.49
Growth (1979-2000)			3.58% p.a.			4.48% p.a.			3.39% p.a.		3.50% p.a.	

ANNEX 2406-1



HISTORICAL AND PROJECTED POPULATION
OF THE PROJECT AREA

POPULATION PROJECTION OF PROJECT AREA

(HIGH AND LOW GROWTH)

Unit: 10^3

1. Nation Population

		1980	1985	1990	1995	2000
A. High Projection	(1	15,880	19,100	23,050	27,910	33,930
B. Medium "		15,850	18,730	22,140	26,150	30,870
C. Low "	(2	15,840	18,580	21,560	24,730	28,060

2. Population of Project Area

	1980	1985	1990	1995	2000
% To Nation (%)					
Mombasa	2.24	2.26	2.28	2.30	2.32
Other Urban Area	0.34	0.36	0.38	0.40	0.41
Rural Area	4.75	4.76	4.75	4.76	4.76
Project Area Total	7.33	7.38	7.41	7.46	7.49
A. High Projection					
Mombasa	356	432	526	642	787
Other Urban Area	54	69	88	112	139
Rural Area	754	909	1,095	1,329	1,615
Project Area Total	1,164	1,410	1,709	2,083	2,541
B. Medium Projection					
Mombasa	355	423	505	601	716
Other Urban Area	54	67	84	105	127
Rural Area	753	892	1,052	1,245	1,469
Project Area Total	1,162	1,382	1,641	1,951	2,312
C. Low Projection					
Mombasa	355	420	492	569	651
Other Urban Area	54	67	82	99	115
Rural Area	752	884	1,024	1,177	1,336
Project Area Total	1,161	1,371	1,598	1,845	2,102

Remarks: (1 Based on Case A projection made by Central Bureau of Statistics, June, 1971

(2 Based on Case B projection of the above

HOTELS AND BEDS AVAILABLE BY AREA

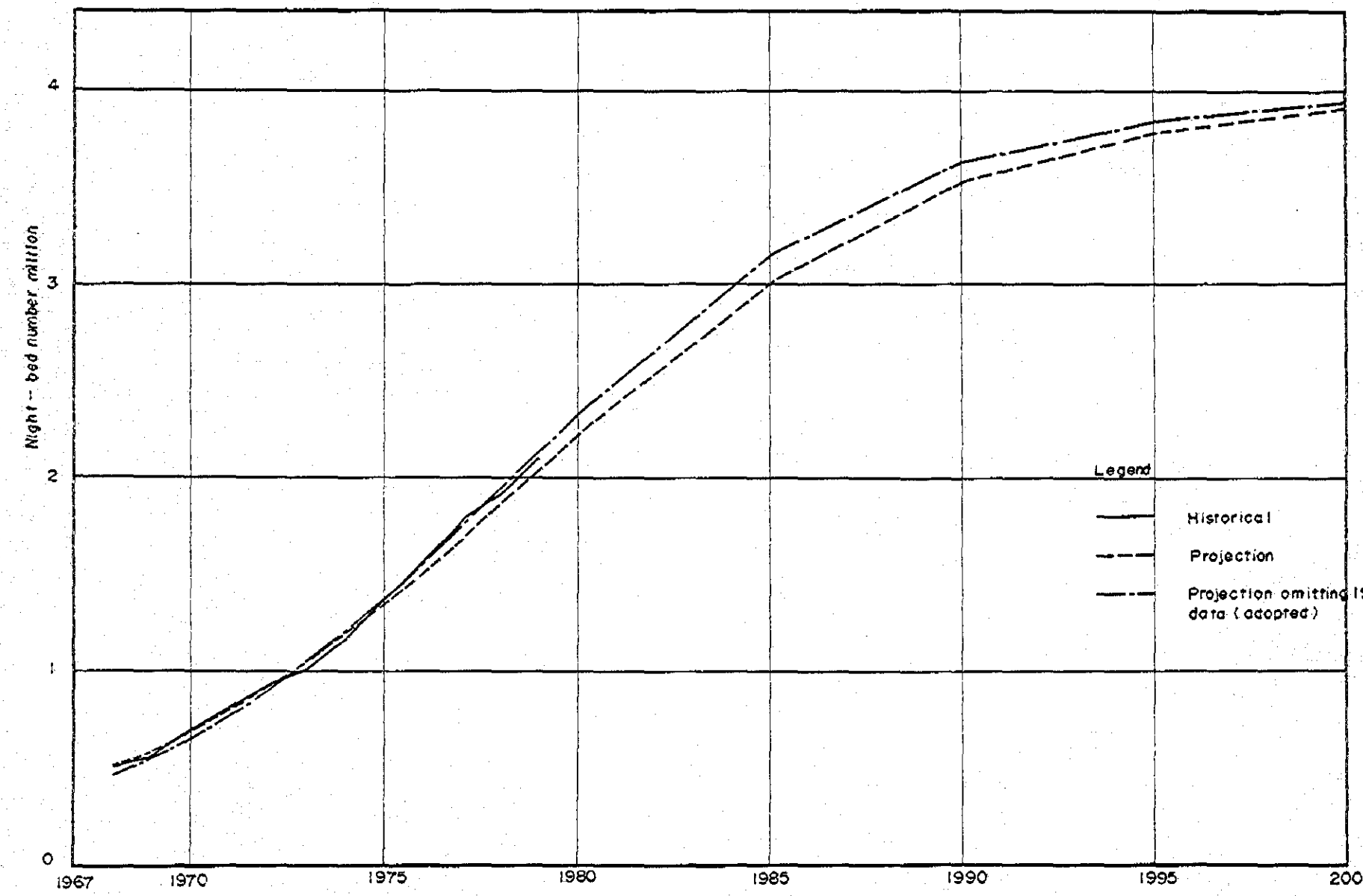
		1976		1977		1978	
		No. of Hotels	Beds Available	No. of Hotels	Beds Available	No. of Hotels	Beds Available
1.	Beach		(10^3)		(10^3)		(10^3)
	South	14	552.6	14	590.9	14	695.4
	North Mombasa	16	945.2	16	992.4	15	1,045.9
	Kilifi/Watamu	7	310.8	7	299.8	7	346.9
	Malindi/Lamu	11	393.8	12	285.3	15	435.2
	Sub-total	48	2,202.5	49	2,268.3	51	2,523.4
2.	Mombasa Island	30	506.7	30	509.9	33	531.4
3.	Coast Hinterland						
	East	5	84.2	4	80.5	5	90.8
	West	6	189.8	6	184.3	6	179.8
	Sub-total	11	274.0	10	264.8	11	270.6
	Total	89	2,983.2	89	3,043.0	95	3,325.4
cf.	Total Kenya	228	6,983.1	227	7,028.3	272	7,358.0

HISTORICAL AND PROJECTED HOTEL-BEDS OCCUPIED IN COASTAL AREA

Unit: 10^3 night-bed

Year	Hotel Night-beds	Growth (%)	Mombasa	Kilifi/Watamu	Malindi/ Lamu
Historical					
1968	508.2	-			
1969	569.0	12.0			
1970	696.7	22.4			
1971	815.4	17.0			
1972	923.9	14.4			
1973	1,008.4	8.1	739.9	122.0	146.5
1974	1,173.6	16.4	868.4	148.3	156.9
1975	1,371.6	16.9	1,051.4	146.6	173.6
1976	1,575.2	14.8	1,242.9	148.6	183.6
1977	1,778.6	12.9	1,415.6	167.8	195.1
1978	1,908.4	7.3	1,508.1	174.7	225.7
1979	2,111.1	10.6			
Growth (1968-79)	13.8% p.a.				
Growth (1973-78)	13.6% p.a.		15.3% p.a.	7.4% p.a.	9.0% p.a.
Projected					
1980	2,331.4	10.4			
1985	3,152.2	6.2			
1990	3,632.9	2.9			
1995	3,853.7	1.2			
2000	3,943.7	0.5			
Growth (1979-2000)	3.0%p.a.				

N.B. Coastal Area Covers: Mombasa Island, North Mainland, South Mainland Malindi/Lamu and Kilifi/Watamu



Historical and Projected Trend of Night- Beds of Tourists in Coastal Area

ANNEX 2418-2

WATER DEMAND PROJECTION OF DOMESTIC USE IN MOMBASA AND URBAN CENTRES

1. Estimate of Income Group Composition

1.1 Weighting Factor by Income Group

Income Group	1972 KSh/Month	Group Average	Weighting Factors
High income	6,000 +	8,500	0.644
Medium "	2,000 - 6,000	3,500	0.265
Low "	0 - 2,000	1,200	0.091
		13,200	1.000

1.2 Estimated Income

1979

Income Group	% of Population	Weighting Factors	Total Average Income (Index)
High income	5%	0.644	3.220
Medium "	45	0.265	11.925
Low "	50	0.091	4.550
	100	1.000	19.695

Mombasa Income Total: 19.695 x 0.342 mil. person = 6.736

2000

Income Group	% of Population	Weighing Factors	Total Average Income (Index)
High income	10%	0.644	6.440
Medium "	80	0.265	21.200
Low "	10	0.091	0.910
	100	1.000	28.550

Mombasa Income Total: 28.550 x 0.716 mil. person = 20.442

Growth rate of Mombasa Income in 1979-2000 : 5.43% p.a.

2. Estimate of Daily Per capita Domestic Use

1979

Income Group	% of Population	Per cap. Demand (1	Average Demand
High income	5%	200 lpcd	10
Medium "	45	100	45
Low "	50	50	25
	100		80 lpcd

(1 Based on "MOWD Design Manual"

Daily maximum demand inclusive of loss and leakage:

High cost housing : 300 lpcd

Medium " " : 150

Low " " : 75

Assuming daily maximum demand being 50% more than annual average demand.

2000

Income Group	% of Population	Per cap. Demand	Average Demand
High income	10 %	240 lpcd	24
Medium "	80	120	96
Low "	10	60	6
	100		126 lpcd

ANNEX 2426

WATER DEMAND BY USE IN MOMBASA IN 1979

(Estimated based on CPWB data)

Unit: CMD

Location	Domestic	Industrial	Tourism	Commercial Public & Others	Total
Mombasa Island	17,490	1,180	-	4,960	23,630
North Mainland	3,560	110	430	1,300	5,400
South Mainland	1,420	30	760	1,090	3,300
West Mainland	2,230	3,350	-	3,720	9,300
Total	24,700	4,670	1,190	11,070	41,630
% to Total	(59)	(11)	(3)	(27)	(100)
Per capita (lpcd)	72	14	3	32	122

WATER DEMAND PROJECTION BY USE OF CATEGORIES

1. Domestic Demand — Unit: CMD

Year	Mombasa	Urban	Rural	Total
Present Potential				
1979	27,360	4,080	18,980	50,420
Projected				
1980	29,110	4,430	20,300	53,840
1985	38,490	6,190	27,620	72,300
1990	51,010	8,590	35,770	95,370
1995	67,910	11,870	48,520	128,300
2000	90,220	16,130	64,720	171,070
Growth (1979/2000)	5.85%	6.76%	6.00%	5.99%
Per cap. (2000)	126 lpcd	126 lpcd	44 lpcd	

2. Industrial Demand

Year	Mombasa	Urban	Rural	Total
1979	4,670	140	-	4,810
Projected				
1980	5,220	160	-	5,380
1985	9,100	270	-	9,370
1990	15,870	480	-	16,350
1995	27,660	830	-	28,490
2000	48,230	1,450	-	49,680
Growth (1979/2000)	12%	12%		
Per ha (2000)	24 m^3/d.ha	16 m^3 /d.ha		

3. Tourism Demand

Unit: CMD

Year	Mombasa	Urban (1	Rural	Total
Present Potential				
1979	4,540	1,520	-	6,060
Projected				
1980	5,010	1,680	-	6,690
1985	6,780	2,270	-	9,050
1990	7,810	2,620	-	10,430
1995	8,290	2,780	-	11,070
2000	8,480	2,840	-	11,320
Growth (1979/2000)	3.02%	3.02%		3.02%

4. Commercial, Public and Other Demand

Year	Mombasa	Urban	Rural	Total
Present Potential			(Including Livestock Use)	
1979	13,840	2,050	33,000	48,890
Projected				
1980	14,670	2,170	34,140	50,980
1985	19,630	2,900	39,250	61,780
1990	26,270	3,890	44,450	74,610
1995	35,160	5,200	51,330	91,690
2000	47,050	6,960	58,840	112,850
Growth (1979/2000)	6.00%	6.00%	2.80%	

Remarks: (1 Including Coast Hinterland of East and West

5. Total Water Demand

Unit: CMD

Year	Mombasa	Other Urban	Rural	Total
Present Potential				
1979	50,410	7,790	51,980	110,180
Projected				
1980	54,010	8,440	54,440	116,890
1985	74,000	11,630	66,870	152,500
1990	100,960	15,580	80,220	196,760
1995	139,020	20,680	99,850	259,550
2000	193,980	27,380	123,560	344,920
Growth (1979/2000)	6.63% p.a.	6.17% p.a	4.2%p.a.	5.58% p.a.
Per cap. 2000	271 lpcd	214 lpcd	84 lpcd	

6. Water Demand by Use

6.1 Mombasa

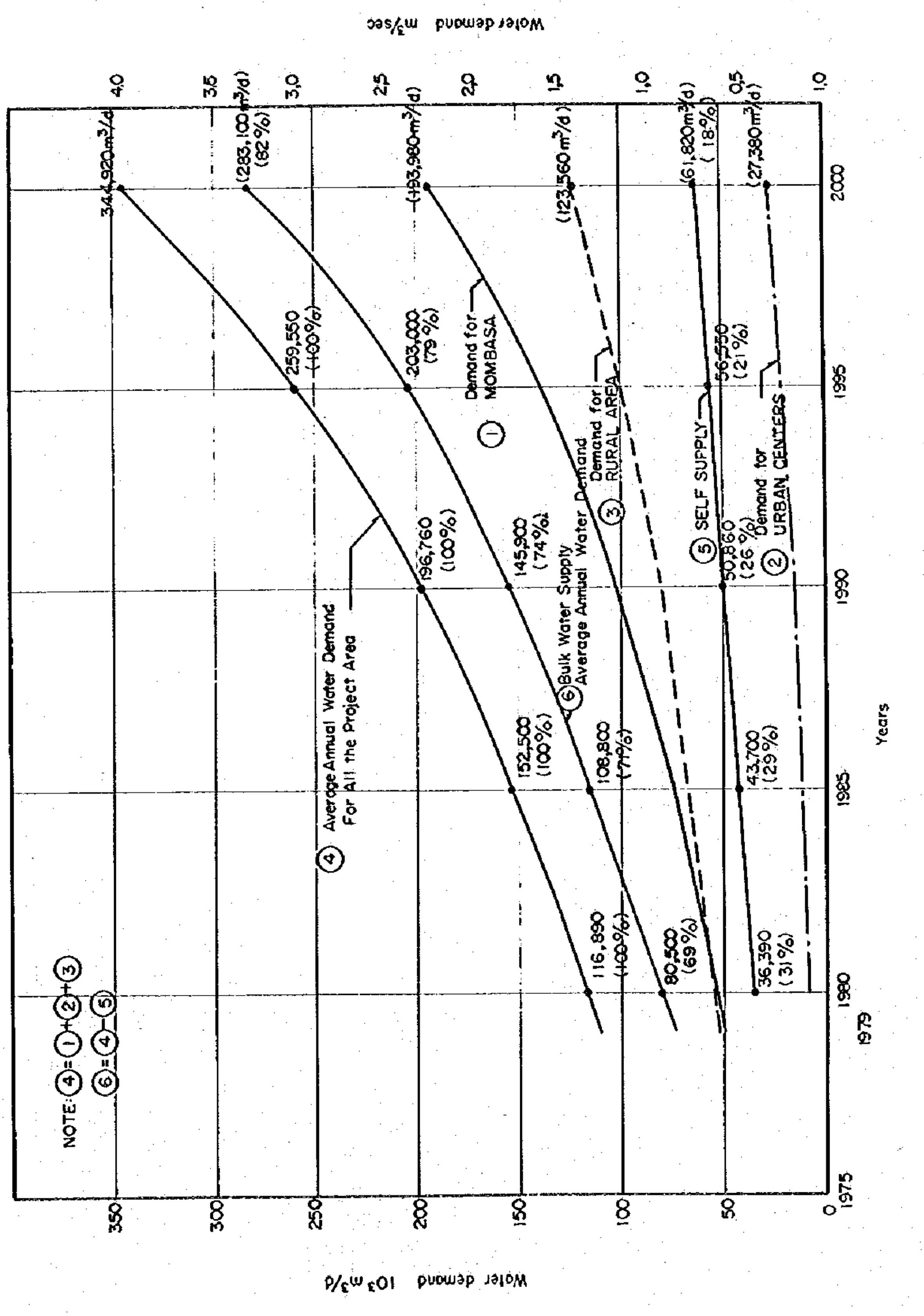
Year	Domestic	Industrial	Tourism	C.P. & Others	Total
1979	27,360 (54)	4,670 (9)	4,540 (9)	13,840 (28)	50,410 (100)
2000	90,220 (47)	48,230 (25)	8,480 (4)	47,050 (24)	193,980 (100)

6.2 Urban Centers

Year	Domestic	Industrial	Tourism	C.P. & Others	Total
1979	4,080 (52)	140 (2)	1,520 (20)	2,050 (26)	7,790 (100)
2000	16,130 (59)	1,450 (5)	2,840 (11)	6,960 (25)	27,380 (100)

6.3 Rural Areas

Year	Domestic	Livestock	Tourism	C.P. & Others	Total
1979	18,980 (37)	25,200 (48)	-	7,800 (15)	51,980 (100)
2000	64,720 (52)	40,310 (33)	-	18,530 (15)	123,560 (100)



Water Demand Projection

HIGH AND LOW GROWTH WATER DEMAND PROJECTION

1. High Growth Water Demand

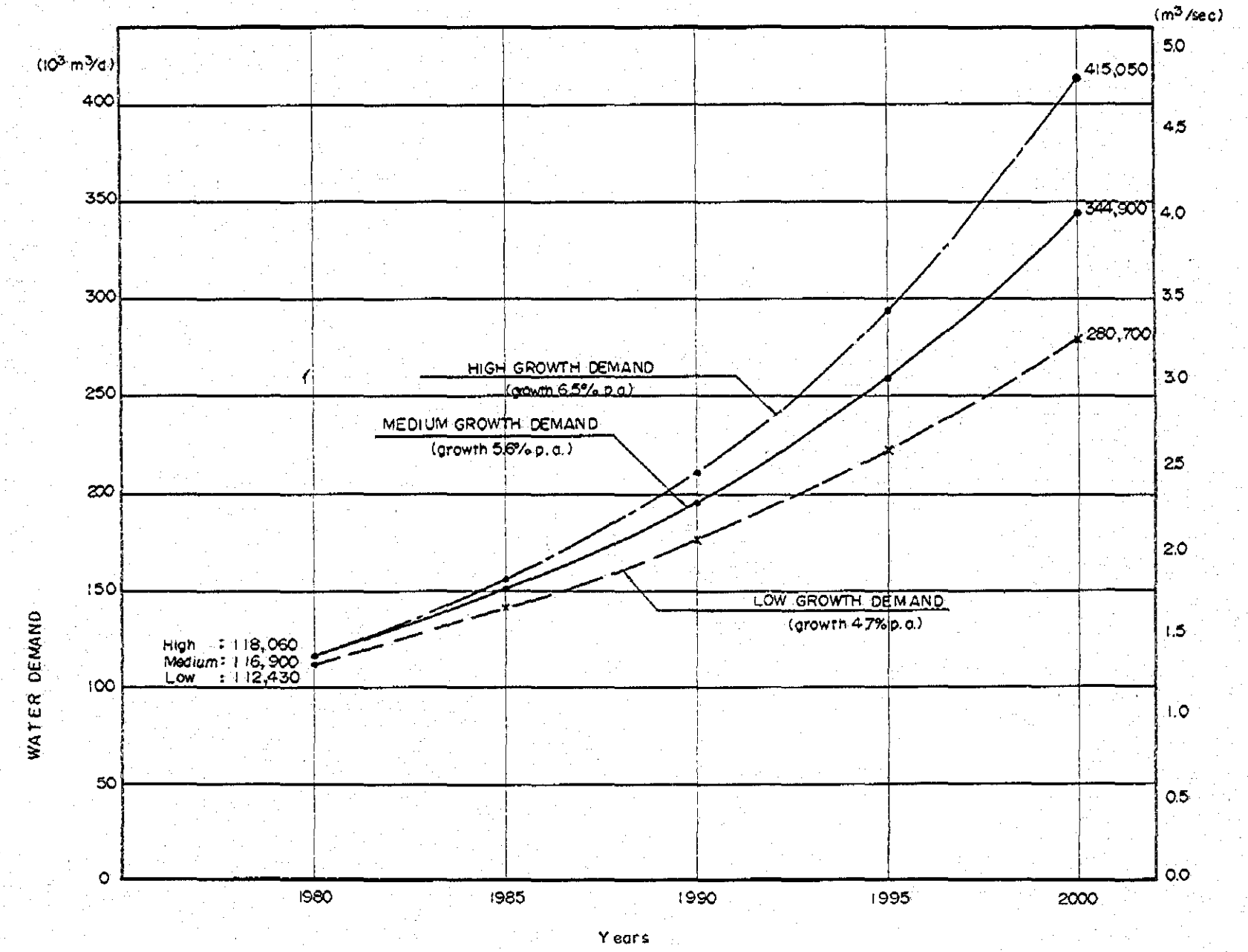
Unit: CMD

Year	Mombasa	Other	Rural	Total
1980	54,830	8,630	54,600	118,060
1985	78,220	12,240	68,500	158,960
1990	111,640	16,840	86,000	214,480
1995	161,810	23,130	111,100	296,040
2000	241,330	31,720	142,000	415,050
Growth p.a. (1979/2000)	7.7%	6.7%	4.9%	6.5%
Per Cap. 2000	307 lpcd	228 lpcd	88 lpcd	

2. Low Growth Water Demand

Unit: CMD

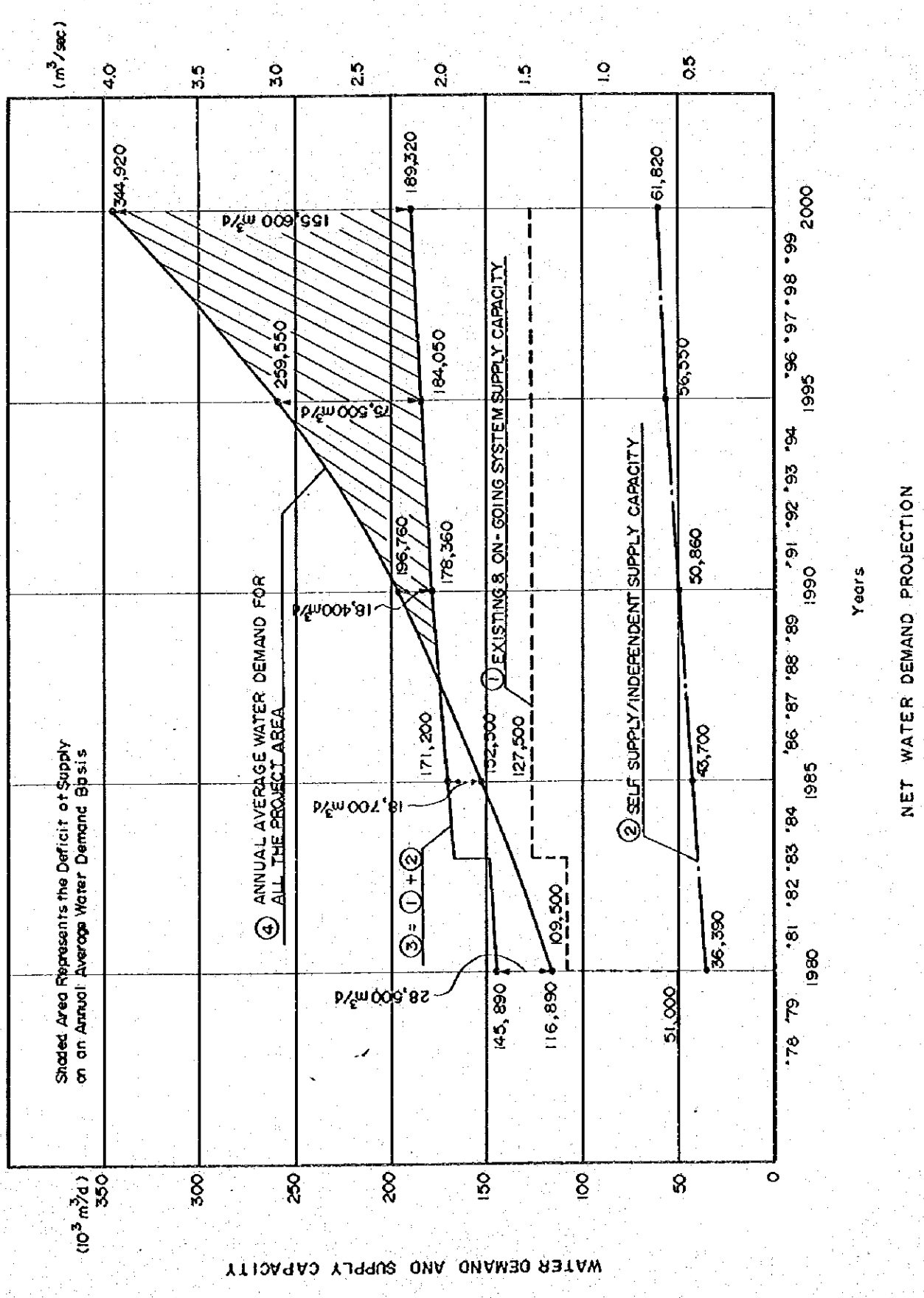
Year	Mombasa	Other	Rural	Total
1980	53,290	8,240	50,900	112,430
1985	70,730	11,070	61,400	143,200
1990	92,740	14,390	70,800	177,930
1995	121,730	18,500	85,900	226,130
2000	158,890	23,110	98,700	280,700
Growth p.a. (1979/2000)	5.6%	5.3%	3.4%	4.7%



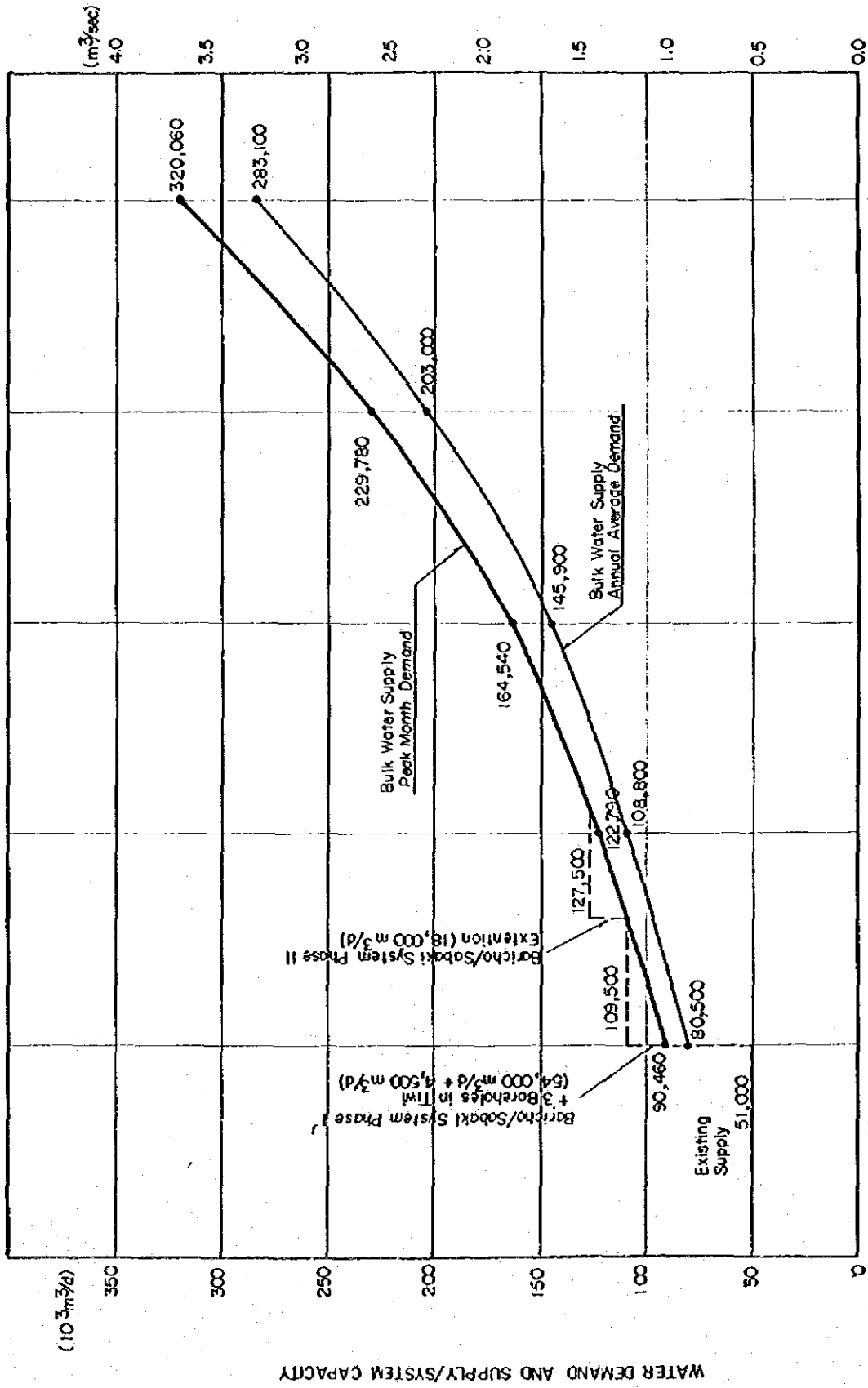
ANNUAL AVERAGE WATER DEMAND HIGH AND LOW PROJECTION

ANNEX 2439-2

ANNEX 2444-1



NET WATER DEMAND PROJECTION



WATER DEMAND VERSUS EXISTING AND ON-GOING SYSTEM SUPPLY CAPACITY

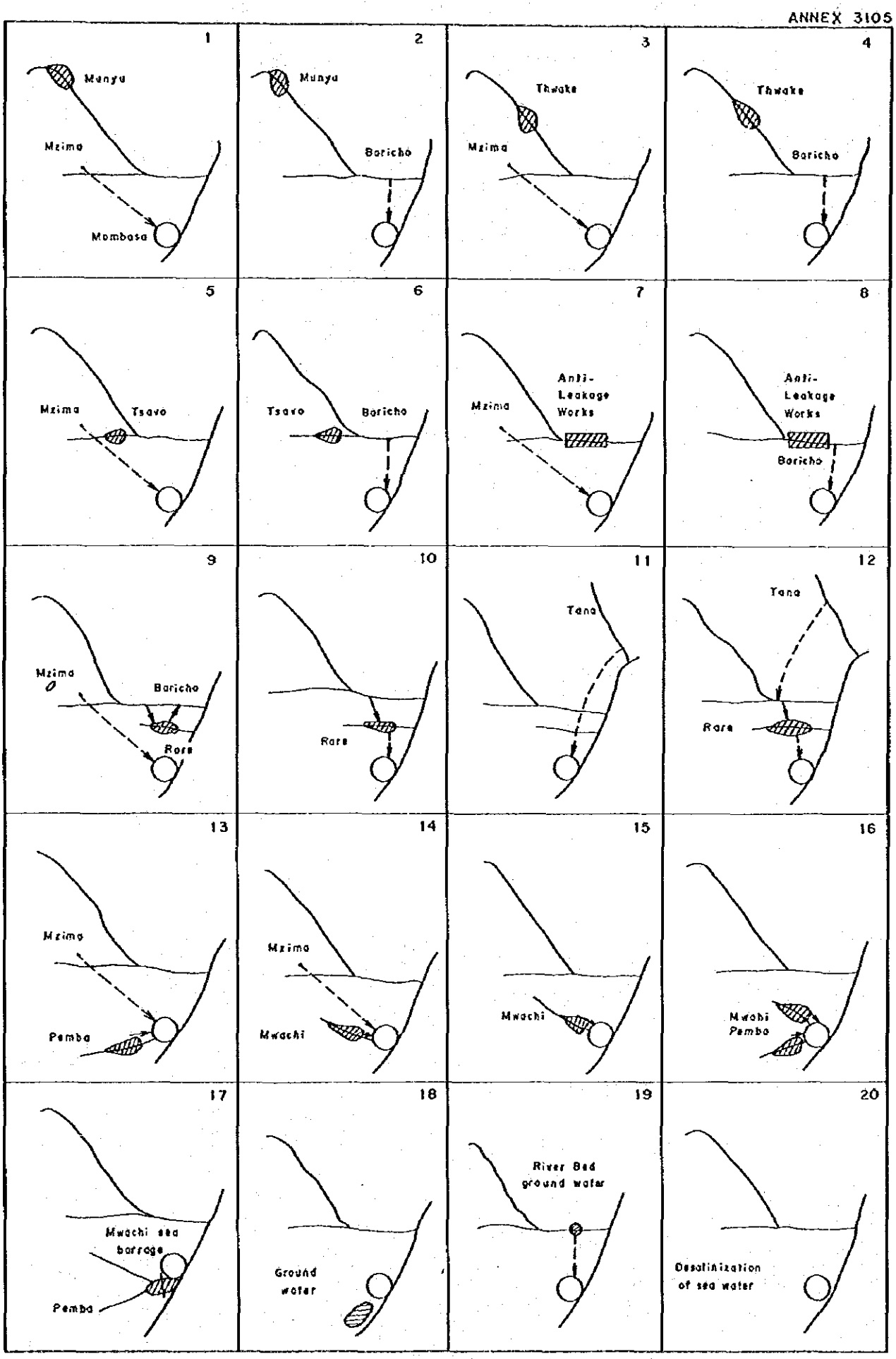
PEAK MONTH DEMAND PROJECTION FOR ALL AREAS

Unit: m^3/day

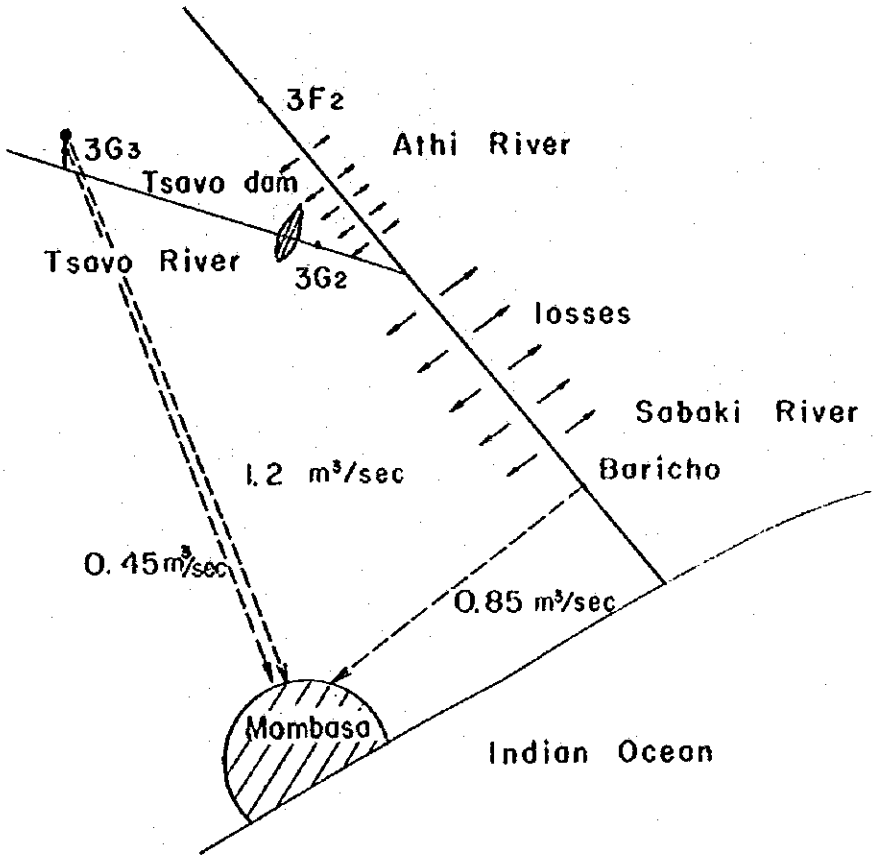
DEMAND AREAS	1980		1985		1990		1995		2000	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1. Kiriti										
(1) Urban center	5,650	7,350	7,680	9,990	10,190	13,200	13,630	17,710	17,160	22,310
(2) Rural	8,500	9,960	12,010	14,180	16,350	19,300	22,870	27,210	31,420	37,650
2. Kwale										
(1) Urban center	640	830	870	1,130	1,150	1,500	1,540	2,000	2,080	2,700
(2) Rural	8,760	9,440	10,410	11,480	12,400	13,670	19,980	22,310	30,550	34,240
3. Taita/Taveta										
(1) Urban center	1,200	1,560	1,640	2,130	2,180	2,800	2,900	3,770	3,920	5,100
(2) Rural	1,760	1,960	2,170	2,450	2,630	2,970	3,230	4,070	3,960	4,620
4. Sub-total										
(1) Urban center	7,490	9,740	10,190	13,250	13,520	17,500	18,070	23,480	23,160	30,110
(2) Rural	19,020	21,360	24,590	28,110	31,380	35,940	46,080	53,590	65,930	76,510
5. Mombasa	53,960	59,360	74,030	81,430	101,000	111,100	138,830	152,710	194,040	213,440
6. Grand-total	80,470	90,460	108,810	122,790	145,900	164,540	202,980	229,780	283,130	320,060
	($0.93m^3$/sec)	($1.05m^3$/sec)	($1.26m^3$/sec)	($1.42m^3$/sec)	($1.69m^3$/sec)	($1.90m^3$/sec)	($2.35m^3$/sec)	($2.66m^3$/sec)	($3.28m^3$/sec)	($3.70m^3$/sec)

Notes: (1) Annual Average Base
(2) Peak Month Base

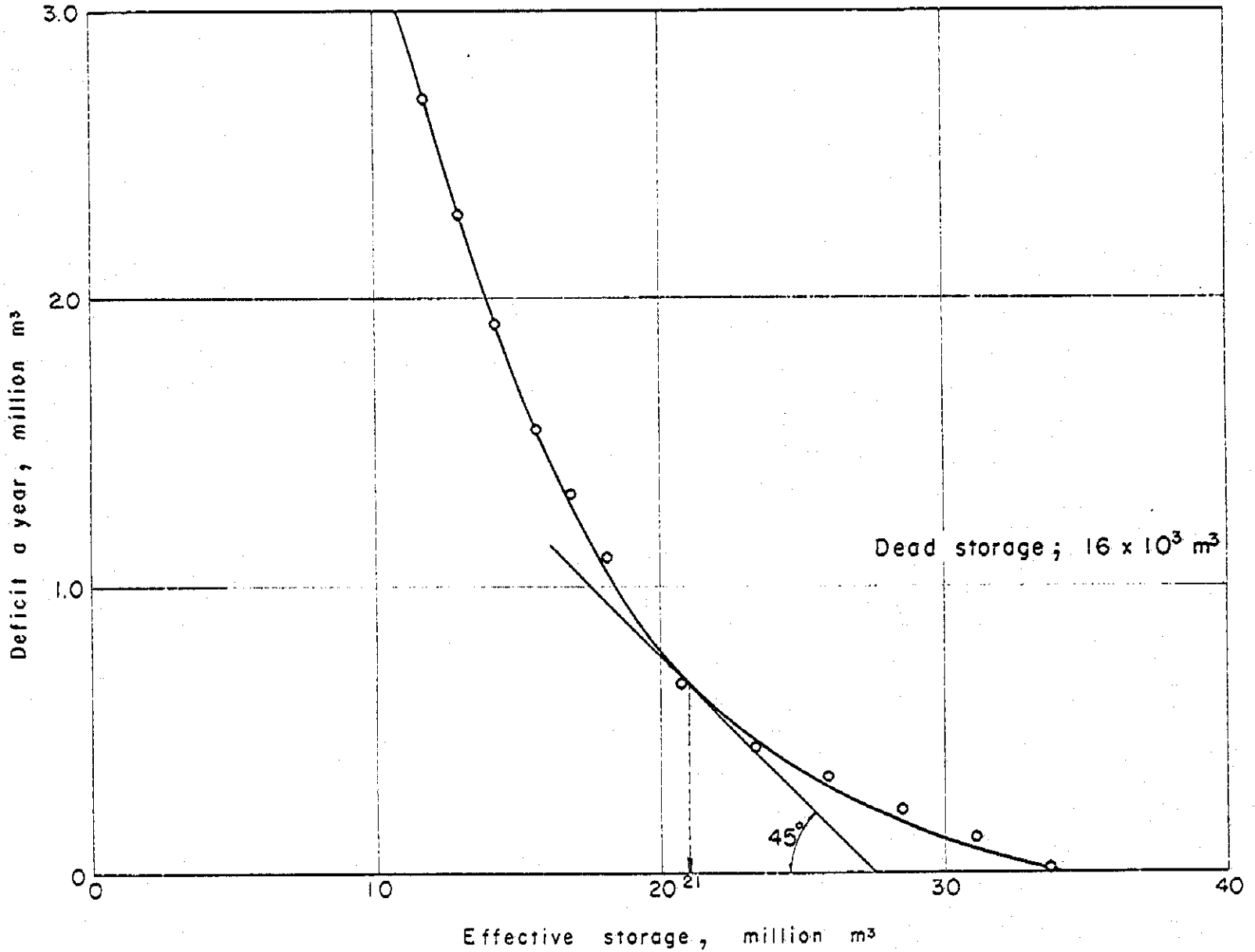
ANNEX 2444-3



CONCEIVABLE PLANS

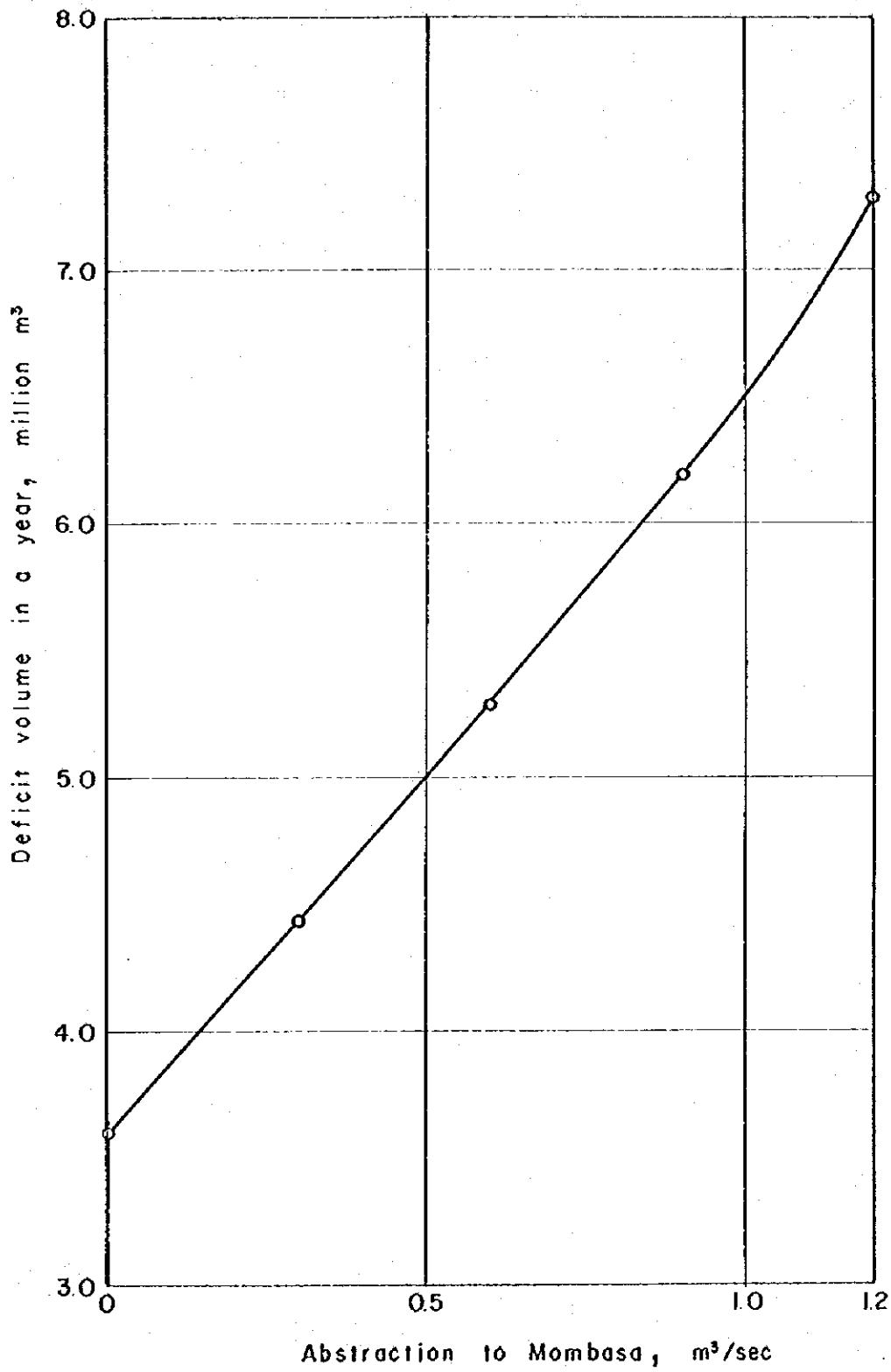


A Simulation Model to Estimate Reservoir Capacity Required for the Tsavo Reservoir

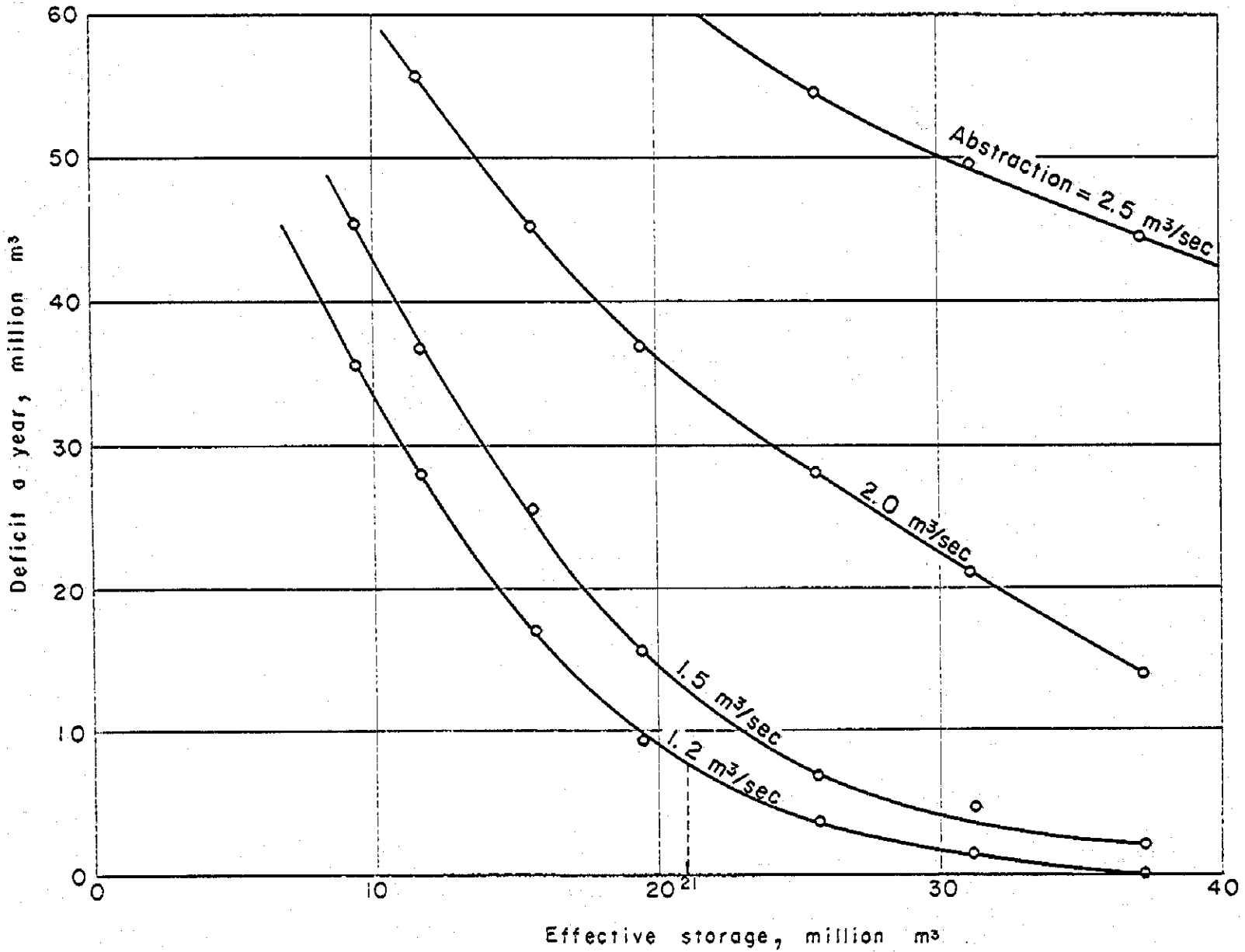


Reservoir Capacity Required for the Tsavo Reservoir

ANNEX 4208

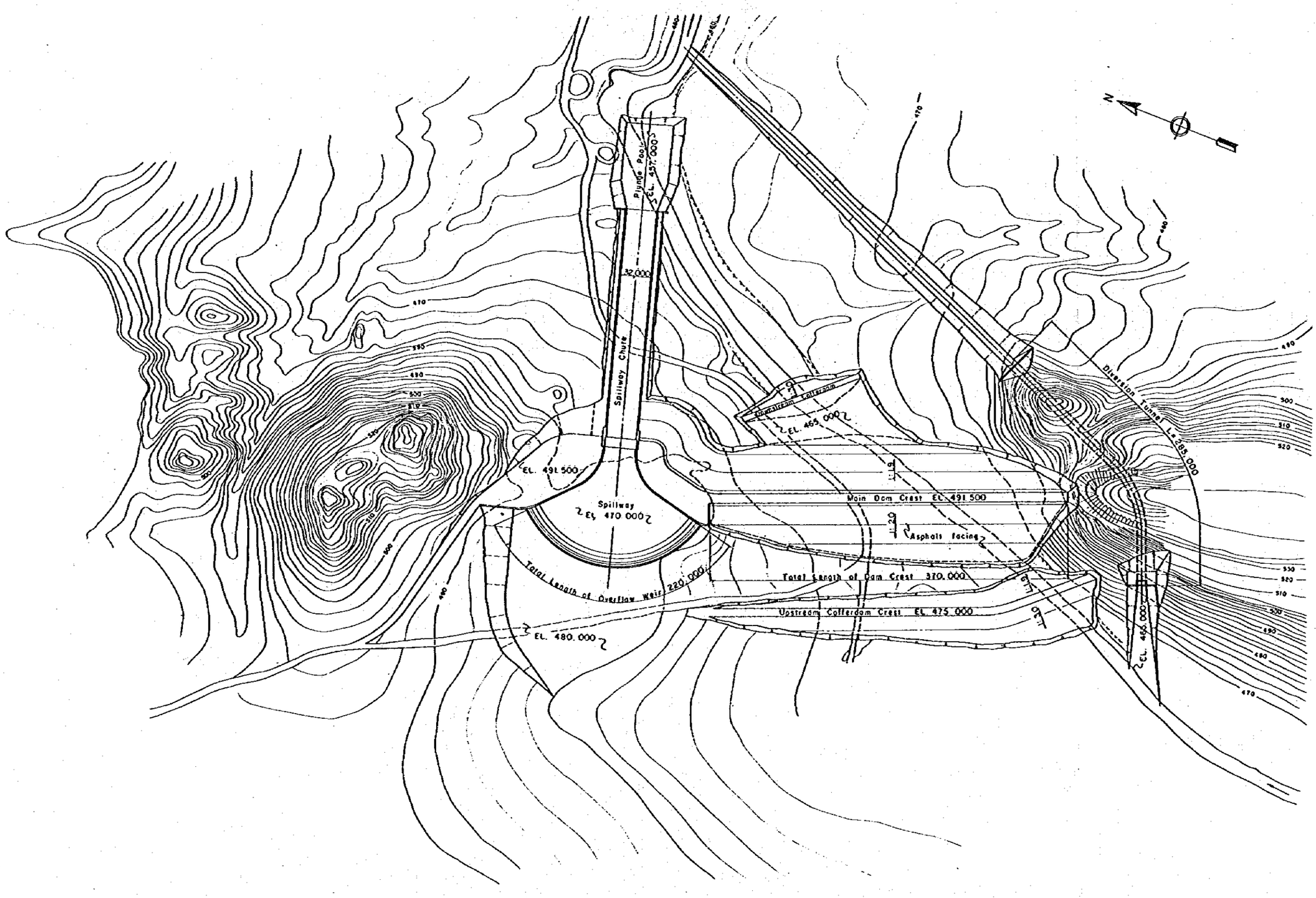


Deficit on the Sabaki River by Changing Abstraction to Mombasa without the Tsavo Dam

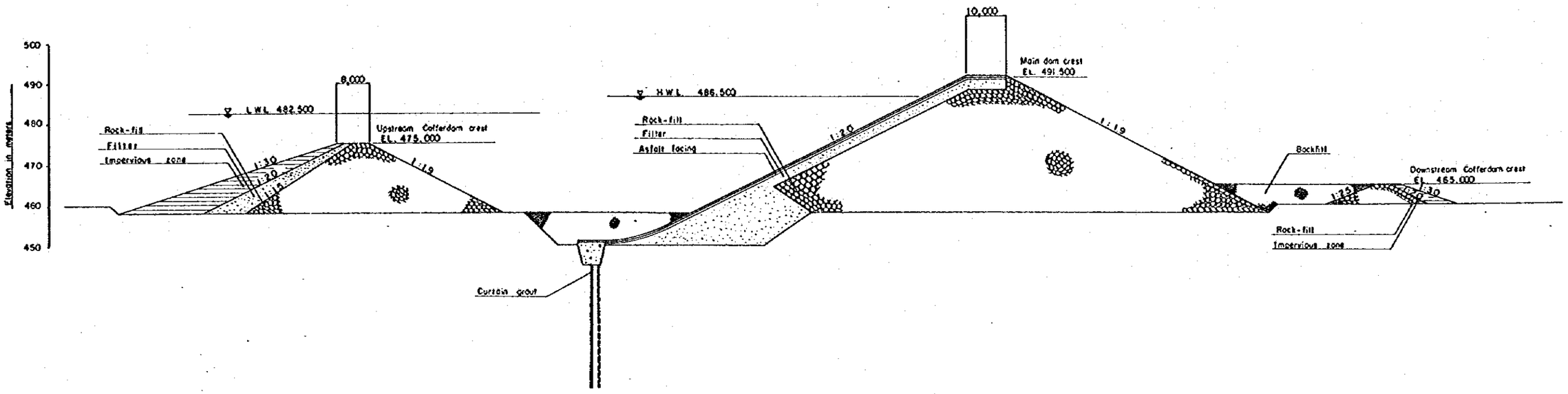


Reservoir Capacity Required for the Tsavo Reservoir
(Abstraction is made from the reservoir)

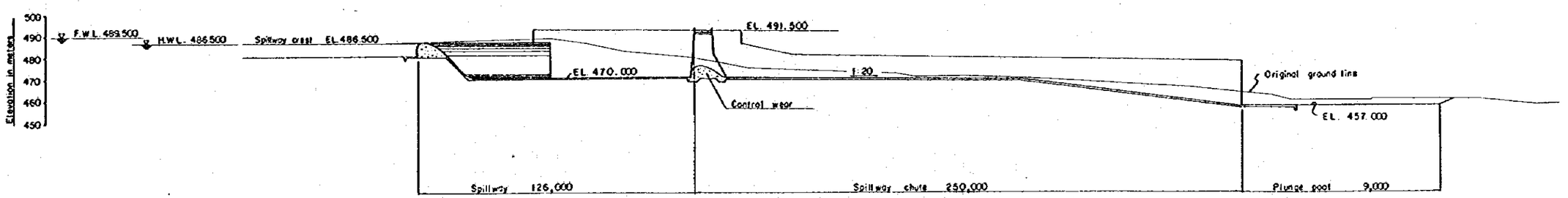
ANNEX 4211



PLAN OF TSAVO DAM SCALE 1: 2,000



CROSS SECTION OF TSAVO DAMS SCALE 1:500



PROFILE OF SPILLWAY SCALE 1:1000

サボダム地点における洪水予測

A. 概　　説

1. ダム地点（３Ｇ２）における月平均流量はインベントリーレポート第６章で述べたように、水資源開発のために収集されている。洪水流出は洪水吐および仮排水設備の設計に対して推定されるが、洪水量の推定は雨量と流量の関係を基にしている。なぜならば、１日に１度の水位観測では洪水のピークを正確に把握することはできないからである。

B. 頻度解析

a. 雨　量

2. 雨量観測所は、流域中および周囲に３個所ある。すなわち、ムジマ湧泉（93−38−17）、ヌグリア小屋（Ngulia lodge 、93−38−27）およびサボ水門(93−38−28）である。ムジマ湧泉の観測所では、西暦1950年３月観測が開始され年間の日最大雨量が利用できる。他の観測所は西暦1971年１月観測が開始されたが、雨量データが少なく頻度解析には使用できない。従って、全流域にわたって利用できるのはただ１個所の観測データのみである。

3. 上記３個所の観測点における毎年の日最大雨量は水資源省水文局で収集されており、このANNEXの４ページに示されている。頻度解析はこの雨量データを用いて行なった。

b. 頻度解析

4. この水文現象を包含する分布関数がわからないので、与えられた観測量xの再現期間を求めるために数個の頻度分布を採用した。頻度分布は、ガンベル（Gumbel）法による極値分布、ピアソンⅢ型および岩井法による対数正規分布を用いた。

5. 上記3手法による頻度分析の結果はこのANNEXの5ページに示されているが、それらの中で最大値をおのおのの再現期間に対する期待値として採用した。頻度解析は1個所の観測所のデータを使用しているが、そのデータが流域全体の雨量を代表するものであるとした。

6. 観測点93−38−17 における可能最大降雨量は、次式のHershieldの経験的手法によった。

$$Xmax : \quad \mu + 15\sigma$$

μ : 標本平均

σ : 標本標準偏差

Xmax : 24時間降雨の最大値

15 : 米国における経験的記録

7. 標本平均は50.5㎜/日また標本標準偏差は29.0㎜/日である。従って可能最大降雨は次のように求められる。

$$Xmax = 50.5 + 15 \times 29.0$$
$$= 485.5\text{㎜/日}$$

8. 降雨ー面積関係がわかっていないので、観測点での局所降雨から流域全体の面積降雨を求めるために、その比を0.6と仮定した。したがって、流域全体の可能最大降雨は局所降雨のそれに0.6を乗じて求められる。

$$PMP\,basin = 485.6 \times 0.6$$
$$= 291.3\text{㎜/日}$$

C. 洪水解析

a. 単位図法

9. 降雨から洪水流量を予測するために、入力としての降雨量および出力としての流量の間の応答関数を決定する。流域の応答関数を表現するために数個の数学モデルがあるが、それらの数学モデルに含まれる変数を検証するための雨量と洪水流量デー

タが不足しているので、ここでは洪水流量を求めるために単位図法を用いた。

10. 西暦１９６７年4月14日の洪水記録がこのANNEXの６ページに示されているように、単位図を決定するための洪水として選ばれた。第一の洪水ピークはANNEXの６ページに示した西暦１９６７年4月１２日の降雨により発生したと判断できるが、第２のピークに関しては何らの情報もない。従って、第２の洪水ピークは、図中の点線で示されるような第１の洪水の減水曲線を指数的に延長させることにより除外する。

11. 洪水に対する有効雨量を推定するために、洪水流量が季節的な沼地となって維持される、ルールテュレシュ（Loolturesh）川の上流は流域から除かれた。洪水予測のための流域は4,０５０km^2とし、西暦１９６７年4月１４日の洪水に対する流出係数は0.023と計算された。有効雨量は3.８㎜（＝0.０２３×１６３.3㎜）と推定される。

12. もし、有効雨量を１０㎜と定義すれば、その単位図はANNEXの７ページに示したものが得られる。１０年および２００年の再現期間に対応するハイドログラフをANNEXの７と８ページに示す。流出係数は0.４と仮定した。１０年確率洪水は仮排水設備の設計流量とした。

フィルタイプダムの日本における規準では、洪水吐の設計流量は２００年確率洪水の1.２倍の流量としているが、この基準を適用した場合の洪水吐の設計洪水量および可能最大降雨から推定された可能最大洪水をANNEXの８ページに示す。

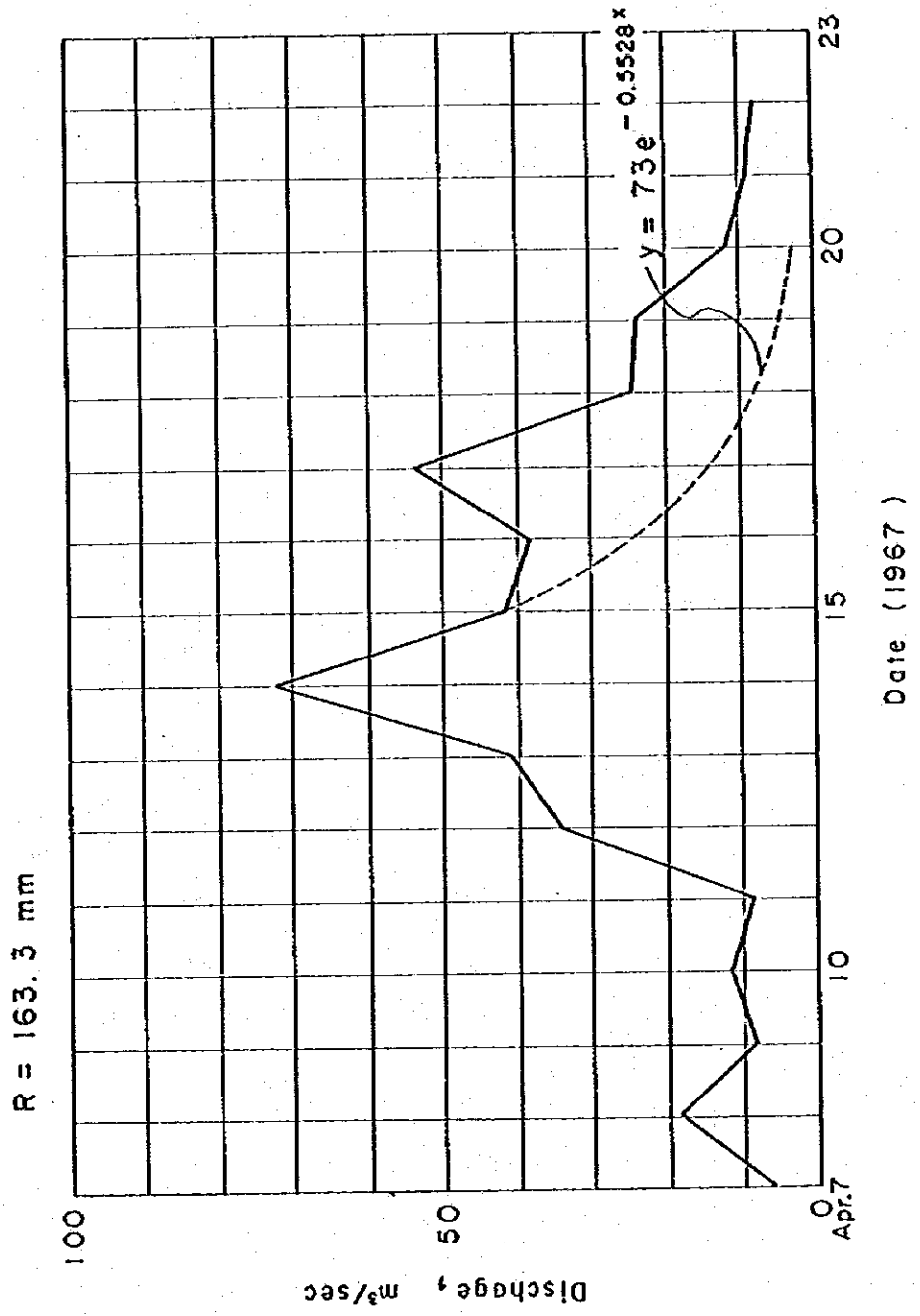
Annual Maximum Daily Rainfall

Year	Station 93.38.17		93.38.27		93.38.28	
	max. daily rainfall, mm	date	max. daily rainfall, mm	date	max. daily rainfall, mm	date
1950	31.8	Apr.27				
51	46.0	Apr.16				
52	89.2	Apr.13				
53	36.1	Jan. 1				
54	89.4	Apr. 8				
55	41.9	Dec.13				
56	-	-				
57	79.5	Jan.23				
58	-	-				
59	11.4	Nov.26				
1960	42.7	Jan.21				
61	27.9	Apr. 9				
62	33.3	Dec. 3				
63	39.1	-				
64	34.3	-				
65	37.3	Jan. 4				
66	34.5					
67	163.3	Apr.12				
68	44.7	Dec. 6				
69	53.1	Dec. -				
1970	37.6	Mar. -				
71	39.9	Dec. -	55.8	Dec. -	81.0	Apr. -
72	47.6	Feb. -	60.6	Nov. -	77.2	Dec. -
73	50.8	Apr. -	88.2	Nov. -	30.3	Jan. -
74	33.7	Mar. -	38.5	Apr. -	40.0	Oct. -
75	38.3	Apr. -	30.0	Nov. -	35.2	Nov. -
76	45.5	Apr. -	66.5	Nov. -	47.5	Sep. -
77	60.0	Jan. -	71.3	Dec. -	44.8	Apr. -
78	74.7	Jan. -	59.4	Nov. -	86.3	Dec. -
79	-	-	34.0	May -	60.0	Feb. -

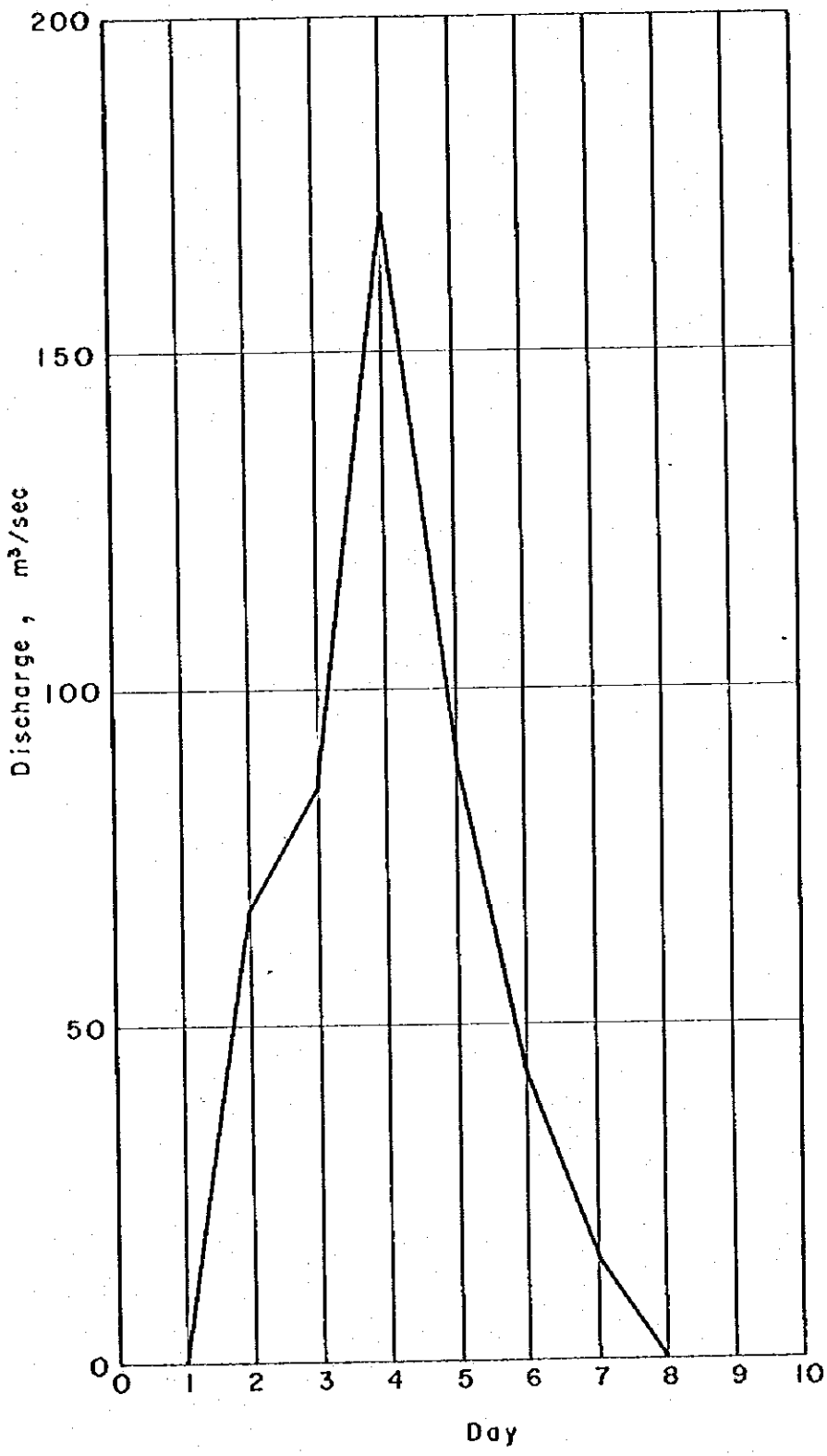
Probable Daily Rainfall

Unit; mm/day

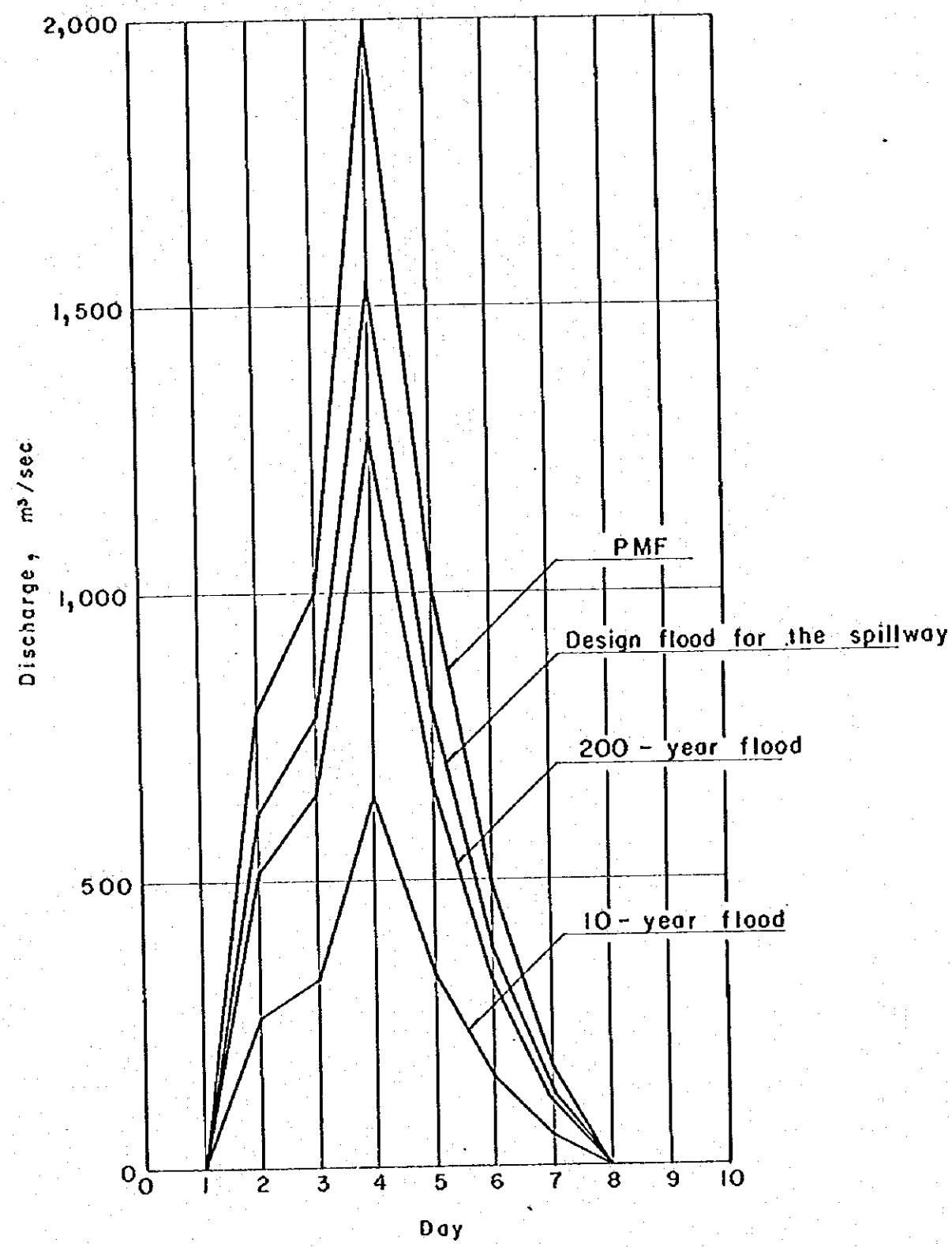
Return period (Year)	Method applied		
	Gumbel	Pearson III	Iwai
2	46	40	45
5	76	66	67
10	95	87	83
20	114	109	99
25	119	116	104
50	138	140	121
100	156	163	138
200	174	188	155
500	198	223	180
1000	215	253	199



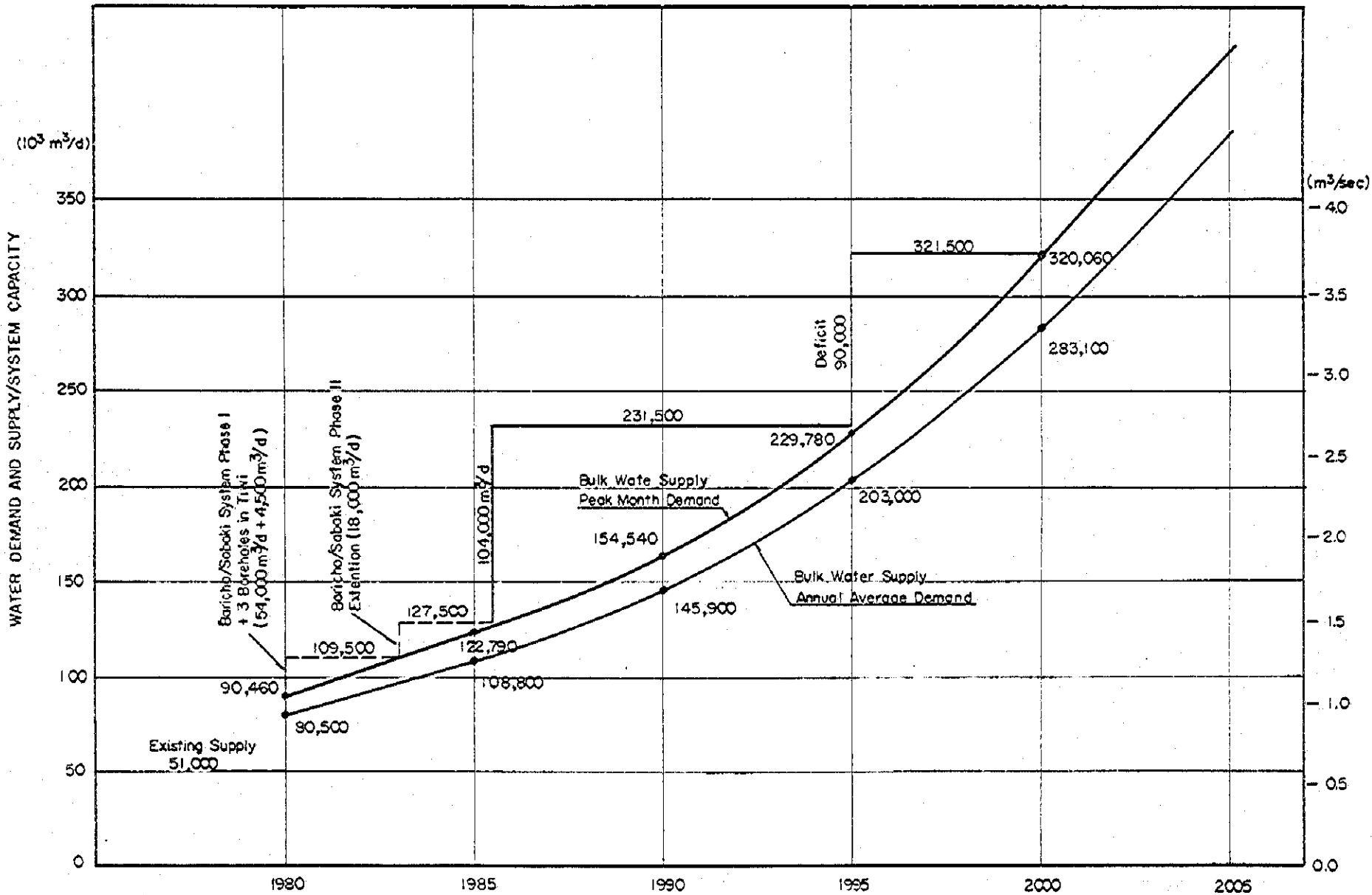
Flood Dated April 14, 1967



Unit Hydrograph at Tsavo Dam Site



Design Floods at Tsavo Dam Site


WATER DEMAND AND SUPPLY/SYSTEM CAPACITY
(10^3 m^3/d)
(m^3/sec)
350
300
250
200
150
100
50
0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2000
2005
Years
Baricho/Soboki System Phase I + 3 Boreholes in Tiwi (54,000 m^3/d + 4,500 m^3/d)
Baricho/Soboki System Phase II Extention (18,000 m^3/d)
104,000 m^3/d
109,500
127,500
231,500
321,500
Deficit 90,000
Bulk Wate Supply Peak Month Demand
Bulk Water Supply Annual Average Demand
90,460
90,500
122,790
108,800
154,540
145,900
229,780
203,000
320,060
283,100
Existing Supply 51,000
ANNEX 4401
WATER DEMAND VERSUS 2ND MZIMA PIPE LINE SYSTEM SUPPLY CAPACITY

(2nd MZIMA P/L PLAN)

ESTIMATED 1995 DEMAND AND SOURCES OF SUPPLY

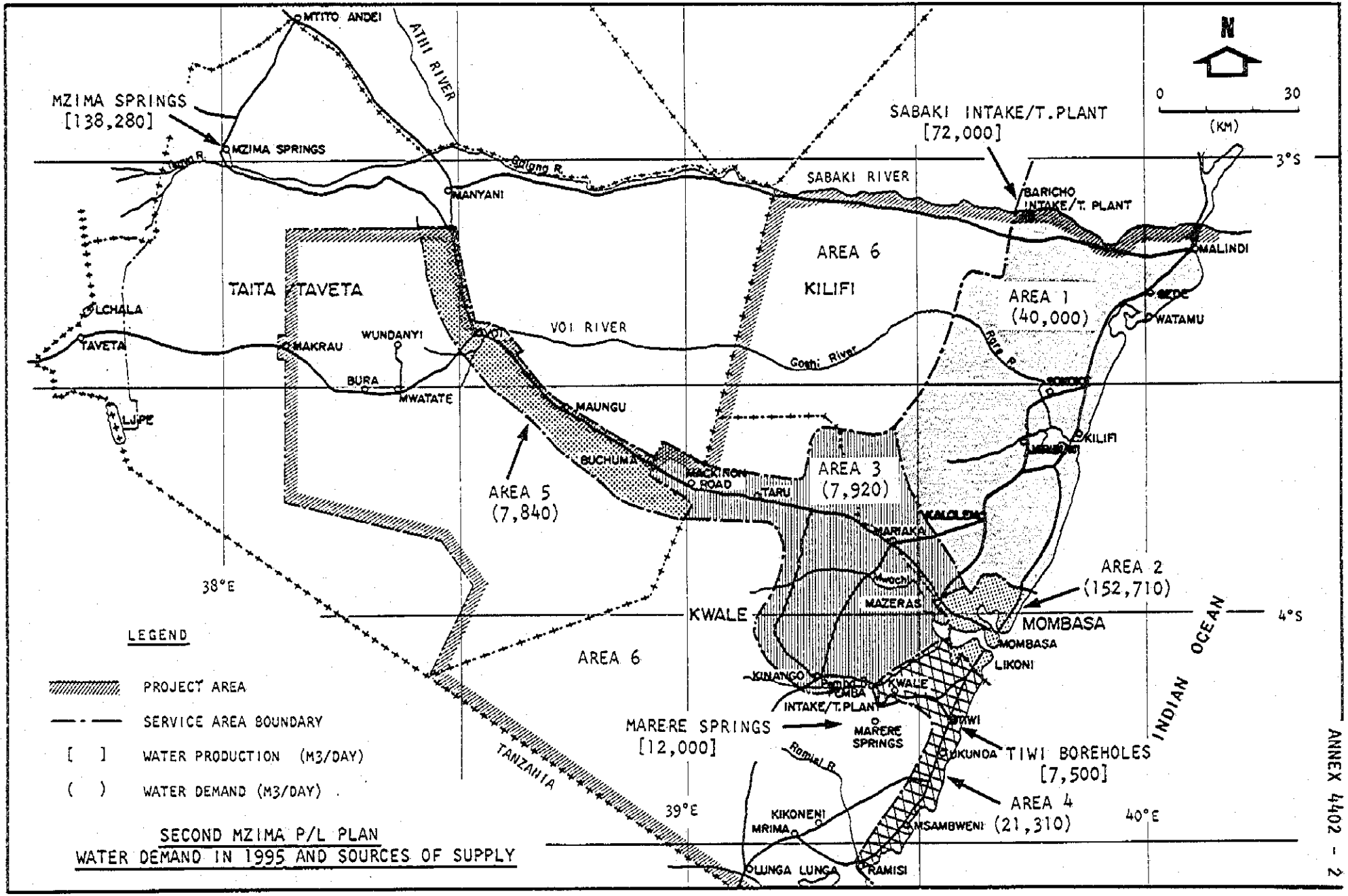
(PEAK MONTH DEMAND)

AREA	Total Demand m^3/d	SOURCES OF SUPPLY: Mzima P/L I&II m^3/d	Marere P/L m^3/d	Tiwi B.H. P/L m^3/d	Sabaki P/L m^3/d
1. Mombasa Is	55,000	55,000	-	-	-
2. West Mainland	42,710	42,710	-	-	-
3. North Mainland	40,000	8,000	-	-	32,000
4. South Mainland	15,000	15,000	-	-	-
5. Kilifi District	40,000	-	-	-	40,000
6. Kwale District North	500	500	-	-	-
7. Kwale District Central	2,500	2,500	-	-	-
8. Kwale District South	21,310	1,810	12,000	7,500	-
9. Taita District	7,840	7,840	-	-	-
10. Kilifi South	4,920	4,920	-	-	-
	229,780	138,280	12,000	7,500	72,000

(2nd MZIMA P/L PLAN)

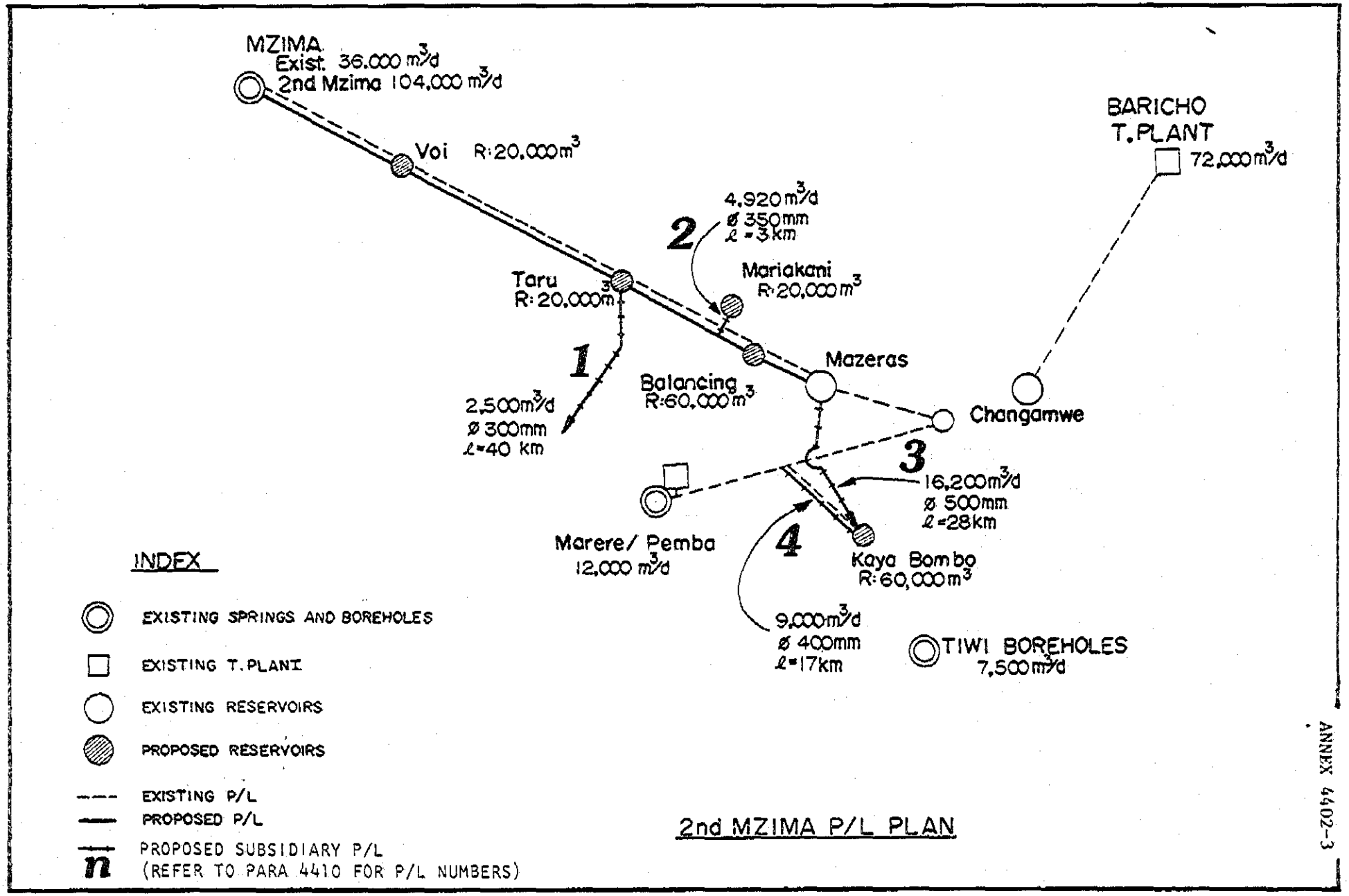
ESTIMATED 1990 DEMAND AND SOURCES OF SUPPLY

AREA	Total Demand m^3/d	SOURCES OF SUPPLY: Mzima P/L I&II m^3/d	Marere P/L m^3/d	Tiwi B.H. P/L m^3/d	Sabaki P/L m^3/d
1. Mombasa	39,000	39,000	-	-	-
2. West Mainland	33,100	33,100	-	-	-
3. North Mainland	28,000	-	-	-	28,000
4. South Mainland	11,000	4,670	6,330	-	-
5. Kilifi District	29,500	-	-	-	29,500
6. Kwale District North	500	500	-	-	-
7. Kwale District Central	1,500	1,500	-	-	-
8. Kwale District South	13,170	-	5,670	7,500	-
9. Taita District	5,770	5,770	-	-	-
10. Kilifi South	3,000	3,000	-	-	-
	164,540	87,540	12,000	7,500	57,500



SECOND MZIMA P/L PLAN
WATER DEMAND IN 1995 AND SOURCES OF SUPPLY

ANNEX 4402 - 2


MZIMA
Exist. 36.000 m³/d
2nd Mzima 104.000 m³/d
Voi R:20.000m³
BARICHO
T.PLANT
72.000m³/d
4.920m³/d
ø 350mm
ℓ = 3km
2
Mariakani
R:20.000m³
Taru
R:20.000m³
1
2,500m³/d
ø 300mm
ℓ=40 km
Balancing
R:60.000m³
Mazeras
Changamwe
3
16,200m³/d
ø 500mm
ℓ=28km
Marere/ Pemba
12,000 m³/d
4
Kaya Bombo
R:60,000m³
9,000m³/d
ø 400mm
ℓ=17km
TIWI BOREHOLES
7,500m³/d
INDEX
EXISTING SPRINGS AND BOREHOLES
EXISTING T.PLANT
EXISTING RESERVOIRS
PROPOSED RESERVOIRS
EXISTING P/L
PROPOSED P/L
n
PROPOSED SUBSIDIARY P/L
(REFER TO PARA 4410 FOR P/L NUMBERS)
2nd MZIMA P/L PLAN

ANNEX 4402-3

Design Criteria for the Project

1. Design capacity

General

(1) Intake facilities including intake pumps:
peakmonth demand x 1.10 (loss of treatment 10%)

(2) Treatment plant: peakmonth demand x 1.10 (loss of treatment 10%)

(3) Transmission pumps: peakmonth demand x 1.0

(4) Transmission P/L: peakmonth demand x 1.0

(5) Distribution reservoirs:

(a) Mombasa area: average annual daily demand x 1 1/2 days

(b) For all other areas: average annual daily demand x 2 1/2 days

Capacity of Augmentation Plans

(2nd Mzima P/L)

(1) Intake: Max. 1.2 m^3/sec (103,680 m^3/d)

(2) Transmission main: ditto

(Rare P/L)

(1) Intake: Max. 3.18 m^3/sec (275,000 m^3/d)

(2) Treatment Plant: ditto

(3) Transmission main: Max. 2.89 m^3/sec (250,000 m^3/d)

2. Rare Treatment Plant Design Parameters Used

General

(1) Design output in 2000: 200,000 m^3/d (2.31 m^3/sec)

(2) Maximum design output: 250,000 m^3/d (2.89 m^3/sec)

Major Facilities

(1) Intake Pumps: a. @19.1 m^3/min x 2 units - 20% to Max.
b. @38.2 m^3/min x 4 units - 80% to Max.
c. Stand by @19.1 m^3/min x 1 unit
@38.2 m^3/min x 2 units
Stand by Total 50%

(2) Raw water main: Max. 3.18 m^3/sec flow capacity
Dia. 1,500 mm, C=130, v=1.8 m/sec, L=4.8 km

(3) Receiving/Distributing Tank: Detention time - 2 min.
Effective volume - 300 m^3
Diameter - 5 m
Depth of water - 4m

(4) Mixing chamber: Detention time - 1 min.
Baffle cone type

(5) Flocculation basin: Detention time - 30 min.
Vertical flocculators

(6) Sedimentation basins: Surface loading 1.0 m^3/m^2h
Conventional type 27 m x 85 m x 6 units
(including one unit stand by)
Detention time - 3 hrs

(7) Filtration: Flow rate 120 m/d (5 m/h)
Rapid sand filters 9.2 m x 10 m x 30 units
Total filter area = 2,760 m^2
(including 5 units stand by)
Wash water a. back washing 0.6 m/min
b. surface washing 0.2 m/min
Rate per filter = 0.8 x 92 = 73.6 m^3/min
Max. 6 min operation = 442 m^3
Wash water storage = 1,000 m^3

(8) Chemical dozing: a. Alum Max. 200 mg/1
Aveg. -
b. Chlorine Max. 5 mg/1
Normal 1 mg/1
c. Soda ash

(9) Transmission Pumps: a. @17.4 m^3/min x 2 units - 20% to Max.
b. @34.8 m^3/min x 4 units - 80% to Max.
c. Stand by
@17.4 m^3/min x 1 unit
@34.8 m^3/min x 2 units
Stand by Total 50%

水需要量の変動と本計画の施設規模の検討

1. 需要量の変動

給水事業は需要のピーク期に対応できるよう設計されるので、年間を通じての需要の変動を把握することは重要である。しかし、正確な需要の変動を求めることは不可能なので、過去の報告書*に基づき、また熱帯地方にある類似の都市における水需要の年、月および日変化を参考にして推定した。同報告書で検討・採用された最大係数を以下に引用して示す。

系　統	平均最大係数	
	最大月間	日最大
モンバサ配水系	1.075	1.225
本土側北部（全域）	1.23	1.50
本土側北部（工業地域を除く）	1.29	1.63
マリンディ系	1.30	1.45
ゲディ／ワタム系	1.30	1.85
マリンディ／ゲディ／ワタム系（総合）	1.30	1.55
キリフィ系	1.25－1.30	－

本検討における慎重な分析の結果、最大月間需要量の係数をモンバサで1.10、その他の地域に対しては1.30をそれぞれ適用することとした。

2. 施設規模

現在進行中のサバキパイプライン計画を考慮に入れて本用水卸し供給計画の施設規模はピーク月の水需要（Peak monthly damand）に見合うものでなければならない。各地域ごとのピーク月の1日当り水需要を予測してANNEX 2444－2に示す（ANNEX 4401－1「本計画の設計規準」参照）。

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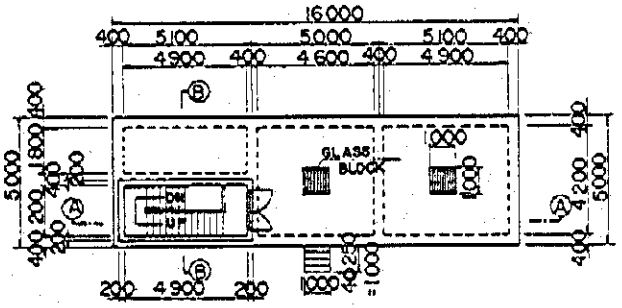
* Scott-Wilson Kirkpatrik and Partners, "Draft Supplementary Report and Alternative Schemes for Supplying Water to Mombasa and the North Coast", July 1972.

サボ貯水池付き第2ムジマパイプライン計画

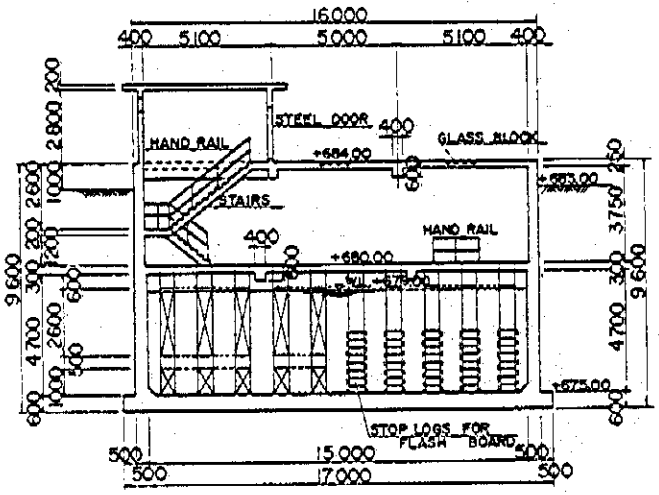
主要施設の規模

施設	内容
湧水取水施設	—延長2kmの矢板工とφ1,000㎜からφ500㎜の集水用埋設コンクリート管。流量調節弁付き鉄筋コンクリート(RO)造取水井と600㎜のスルースゲート付き余剰水排水口。
送水本管	—φ1,350㎜：86,000m，φ1,100㎜：43,310m，φ1,000㎜：88,230m。最大動水圧12.5kg/cm²(水撃圧による上昇分を含む)。最大流量毎秒1.2m³。取水井にて流量調節を行なう。 —制水弁(2km間隔)。 —空気弁および排水設備を9kmにつき10個所。
接合井	—容量各720m³。最大通水時の滞流時間10分。 —口径600㎜のバイパス。 —合計6井建設予定。
配水池	—ボイ配水池　2万m³ —タル配水池　2万m³ —マリアカニ配水池　2万m³ —調整池(既設の第10接合井の近く)　6万m³ —カヤポンポ配水池　6万m³ —以上すべての水槽は、円形、プレストレスコンクリート造(ANNEX 4408—2 参照)。
送水支管	—φ500㎜ …… 28,000m —φ400㎜ …… 17,000m —φ350㎜ …… 3,000m —φ300㎜ …… 40,000m —最大動力圧12.5kg/cm²(水撃圧を含む)。

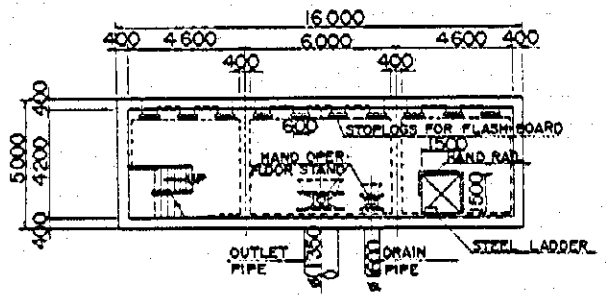
PLAN



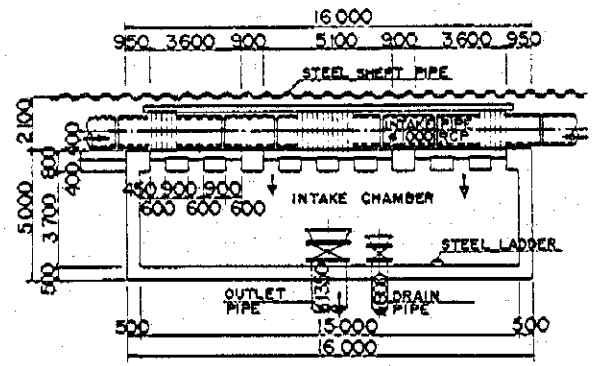
SECTION A - A



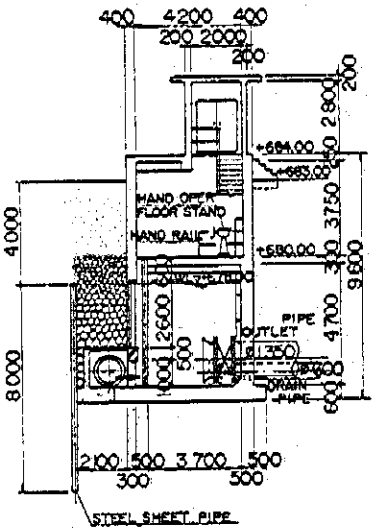
SECTIONAL PLAN



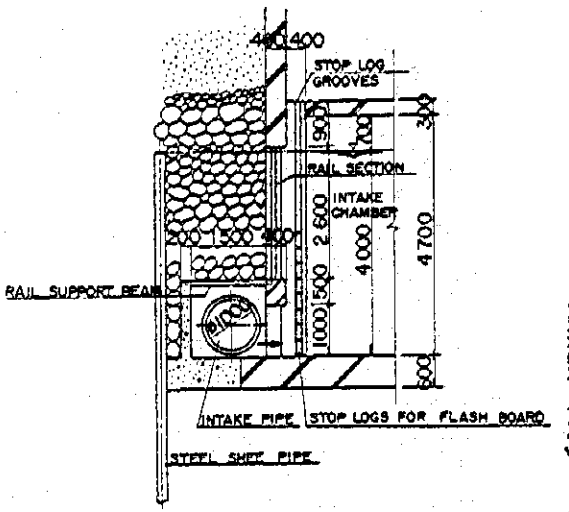
SECTIONAL PLAN



SECTION B-B

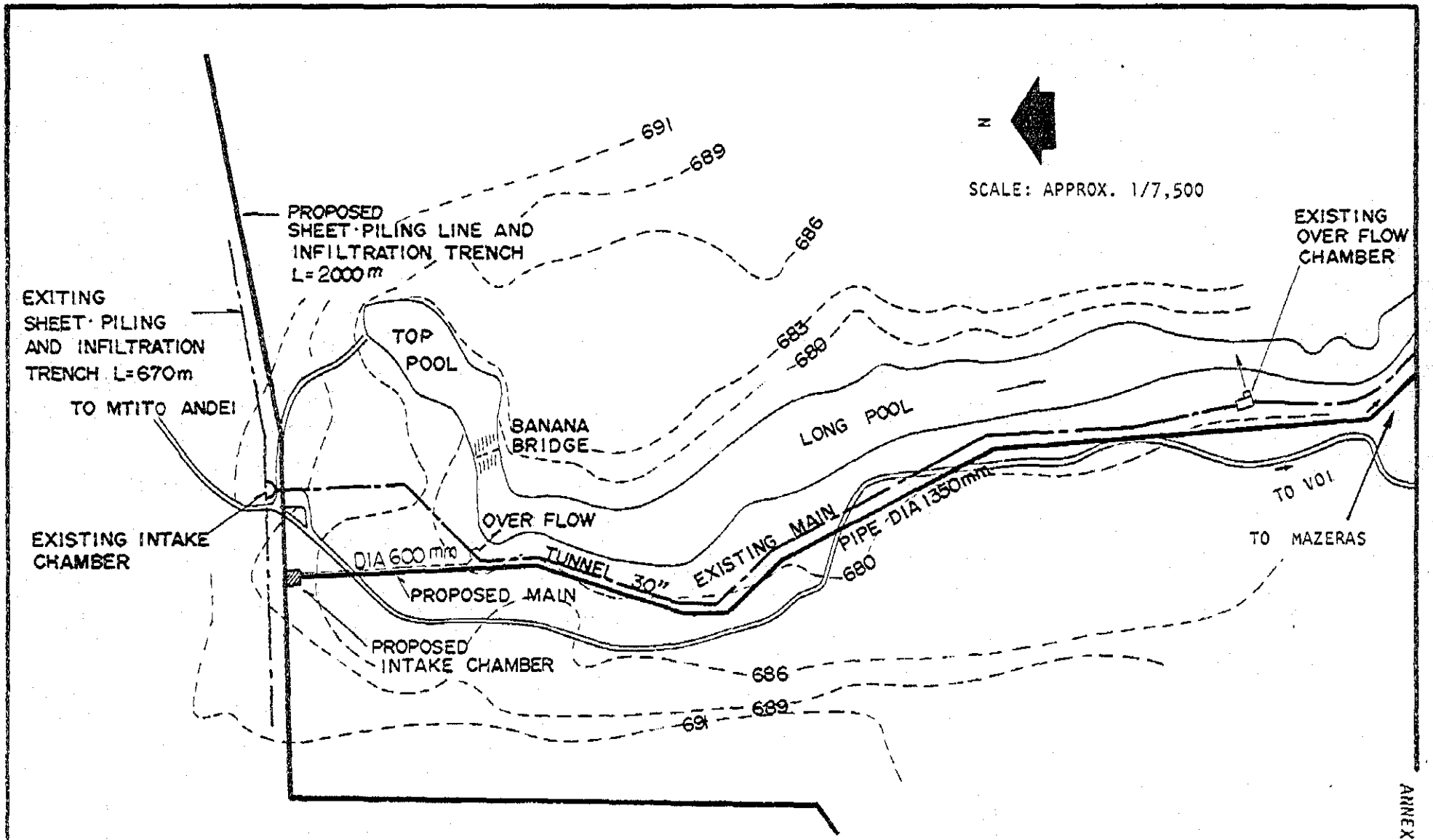


DETAIL

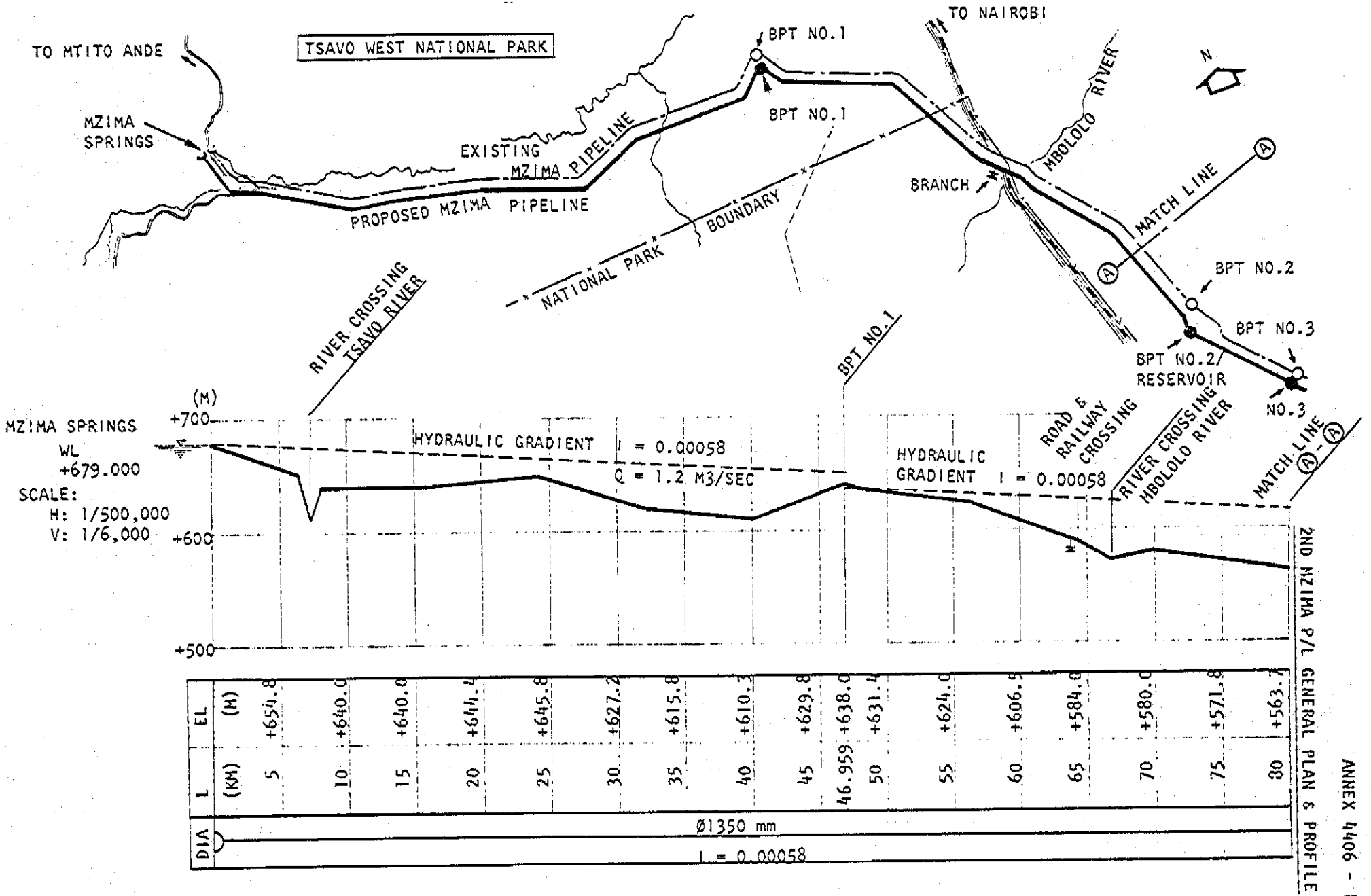


2ND MZIMA PIPELINE SPRING INTAKE (NOT TO SCALE)

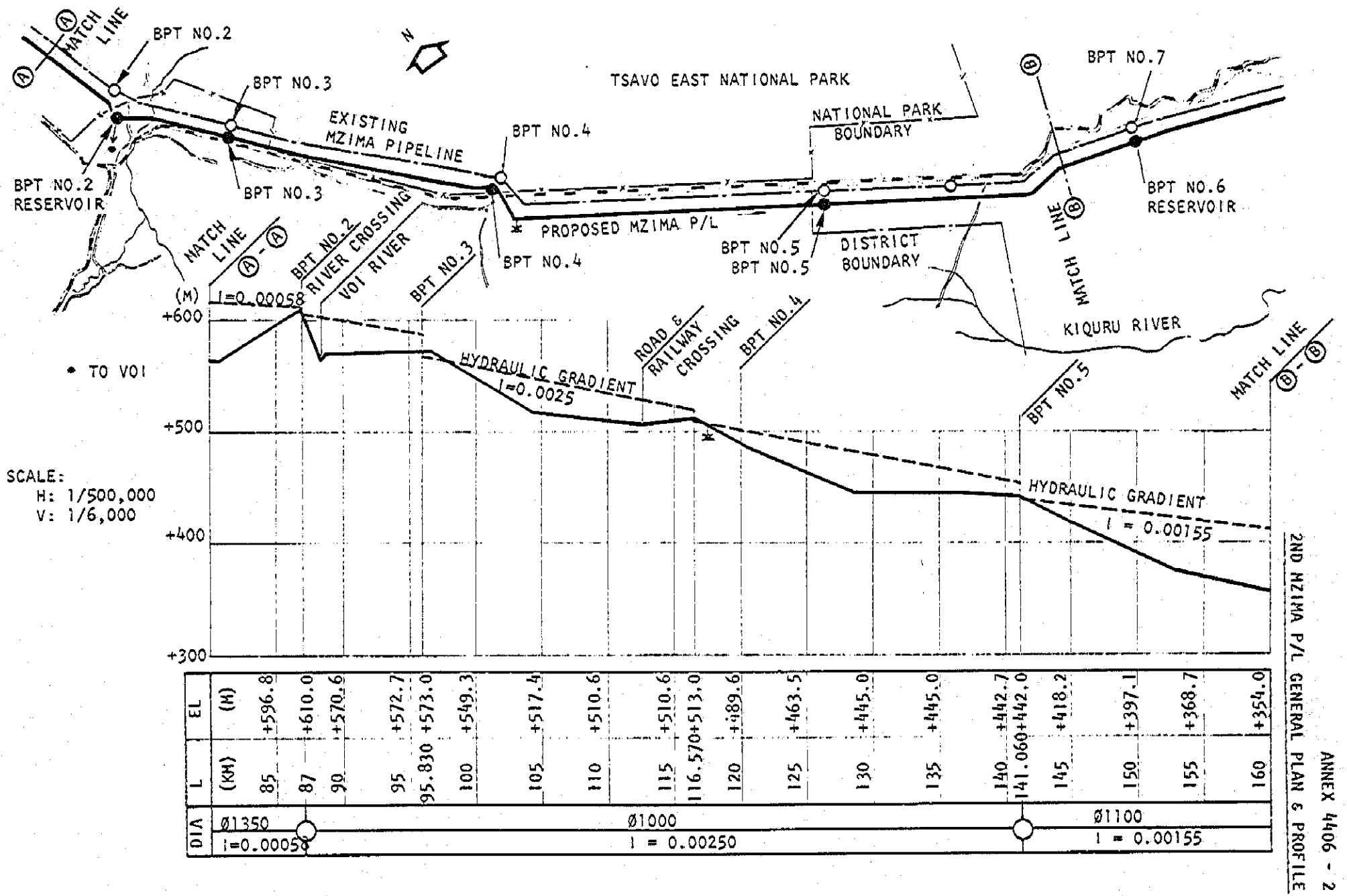
ANNEX 4405 - 1



MZIMA SPRINGS INTAKE
VICINITY AND LOCATION MAP


TO MTITO ANDE
TSAVO WEST NATIONAL PARK
BPT NO.1
TO NAIROBI
MZIMA SPRINGS
EXISTING MZIMA PIPELINE
BPT NO.1
MBOLOLO RIVER
N
PROPOSED MZIMA PIPELINE
BRANCH
MATCH LINE
NATIONAL PARK BOUNDARY
BPT NO.2
BPT NO.3
RIVER CROSSING TSAVO RIVER
BPT NO.1
BPT NO.2/ RESERVOIR
NO.3
(M)
MZIMA SPRINGS WL +679.000
SCALE: H: 1/500,000 V: 1/6,000
+700
+600
+500
HYDRAULIC GRADIENT I = 0.00058
Q = 1.2 M3/SEC
HYDRAULIC GRADIENT I = 0.00058
ROAD & RAILWAY CROSSING
RIVER CROSSING MBOLOLO RIVER
MATCH LINE
EL (M)
L (KM)
DIA
Ø1350 mm
I = 0.00058
2ND MZIMA P/L GENERAL PLAN & PROFILE

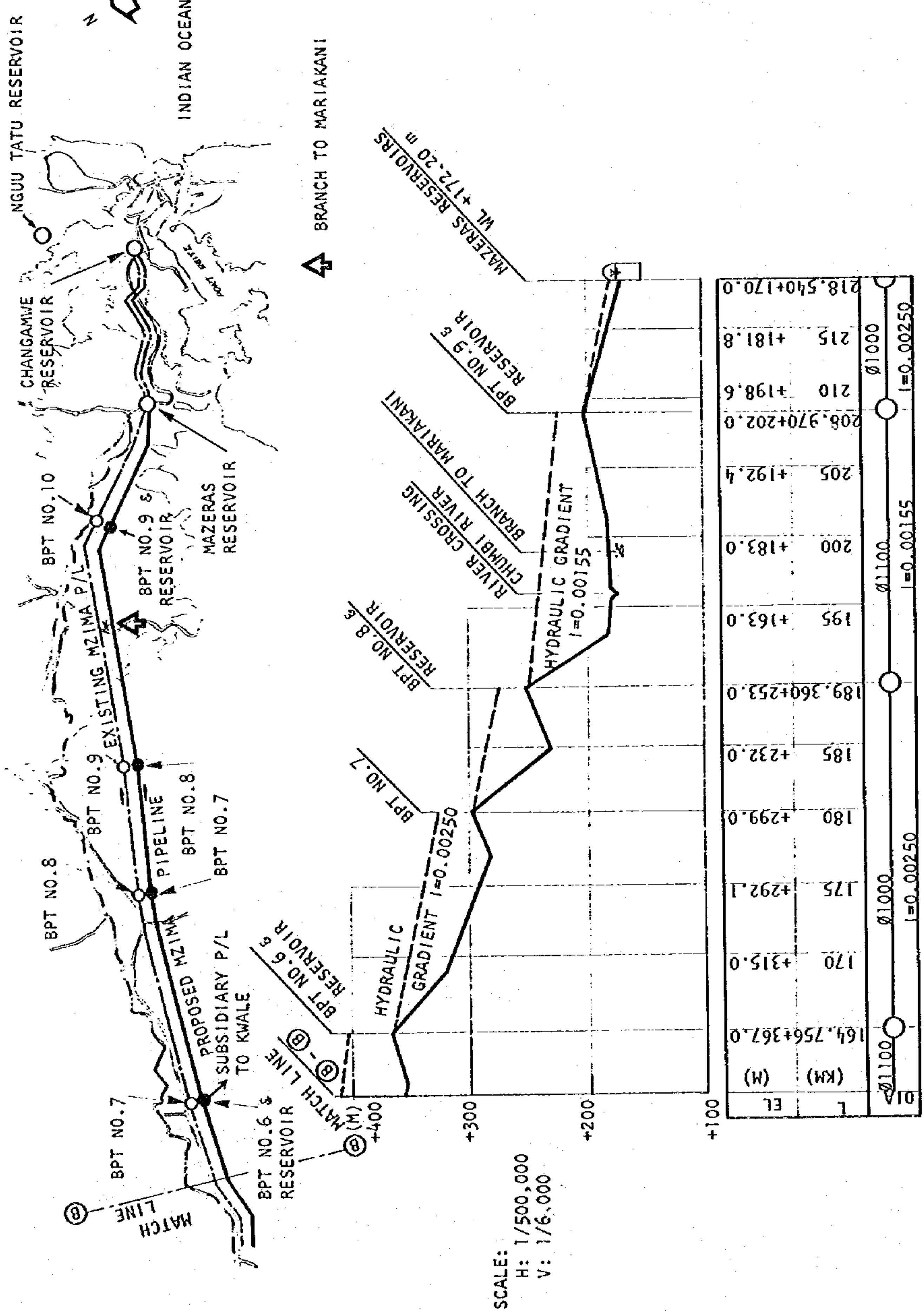
ANNEX 4406 - 1



2ND MZIMA P/L GENERAL PLAN & PROFILE

ANNEX 4406 - 2

2ND MZIMA P/L GENERAL PLAN & PROFILE



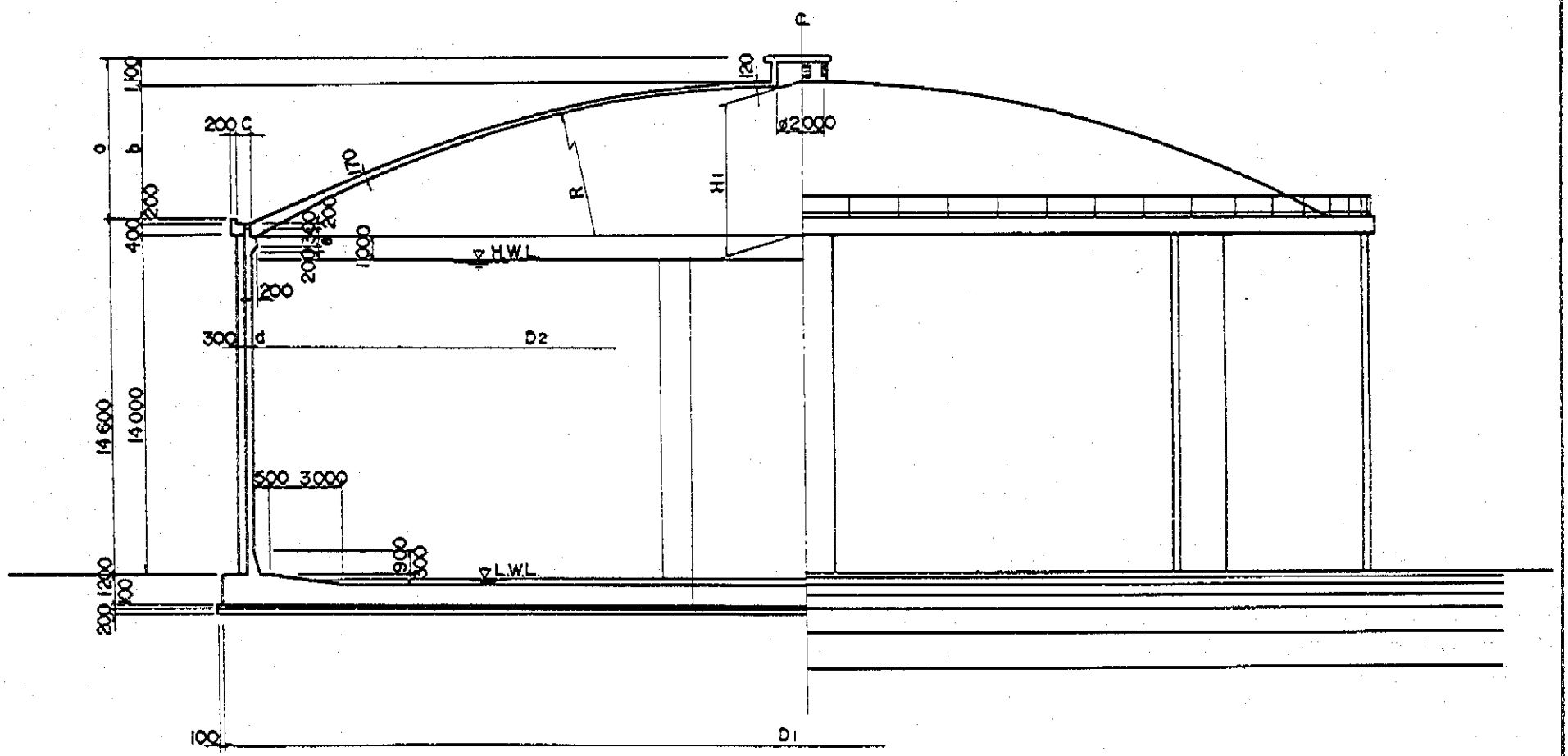
(2nd MZIMA P/L PLAN)

DISTRIBUTION RESERVOIR CONSTRUCTION SCHEDULE

	Location	System	Provision in 1986 m^3	Provision in 1995 m^3	Total
1.	Voi	2nd Mzima P/L	20,000	-	20,000
2.	Taru	"	20,000	-	20,000
3.	Maliakani	"	20,000	-	20,000
4.	Nguee Tatu	Sabaki P/L	20,000	20,000	40,000
5.	Kaya Bambo	Marere P/L	30,000	30,000	60,000
6.	Changamwe	Sabaki P/L	13,600 1/	-	13,600
7.	Balancing	2nd Mzima P/L	30,000	30,000	60,000
	Total		153,600	80,000	233,600 m^3

Note: 1/ Shall be provided in the Sabaki P/L system in 1984.

Standard @20,000 x 5 = 100,000 m^3
" @30,000 x 4 = 120,000 m^3
Total 220,000 m^3



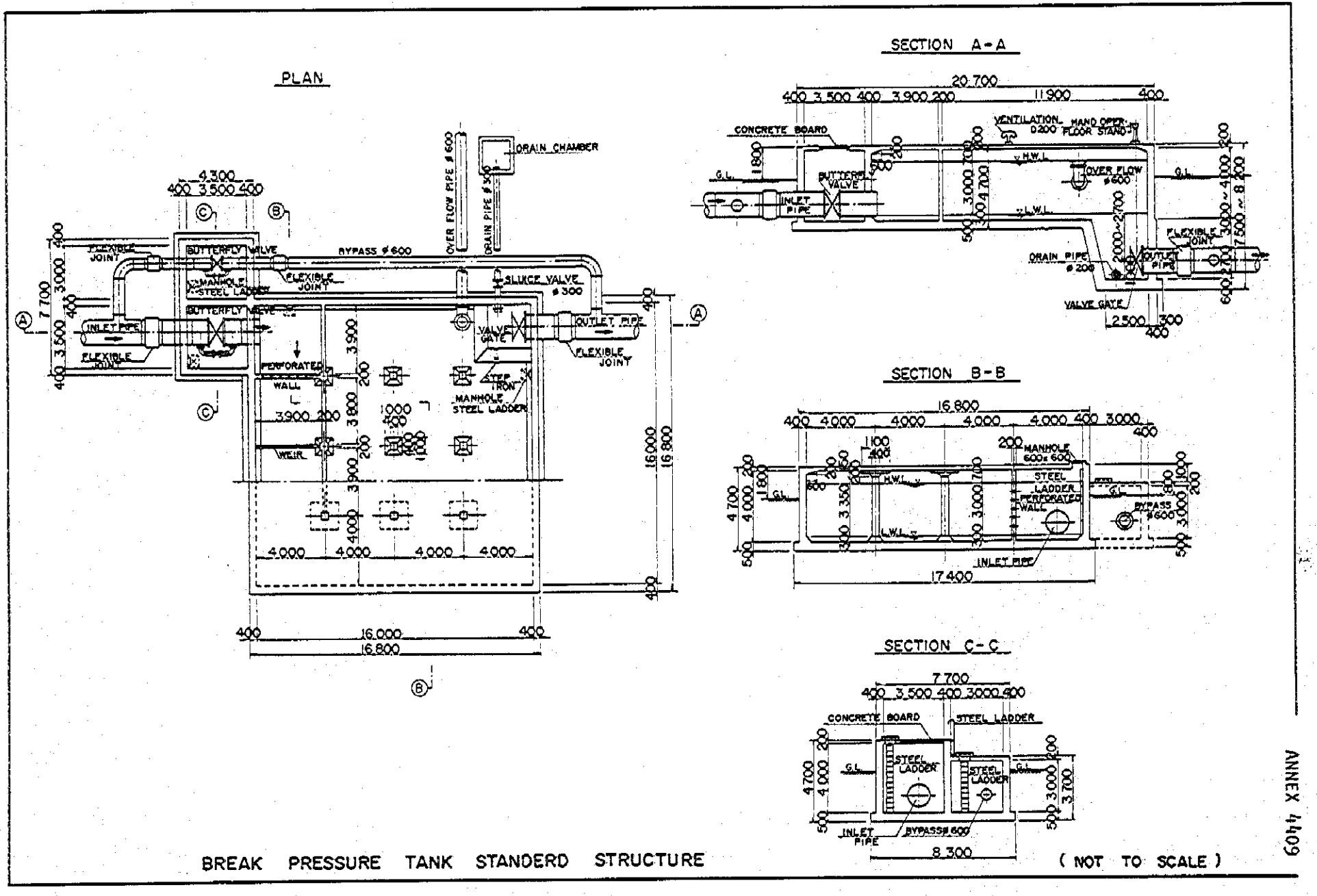
DIMENSIONS

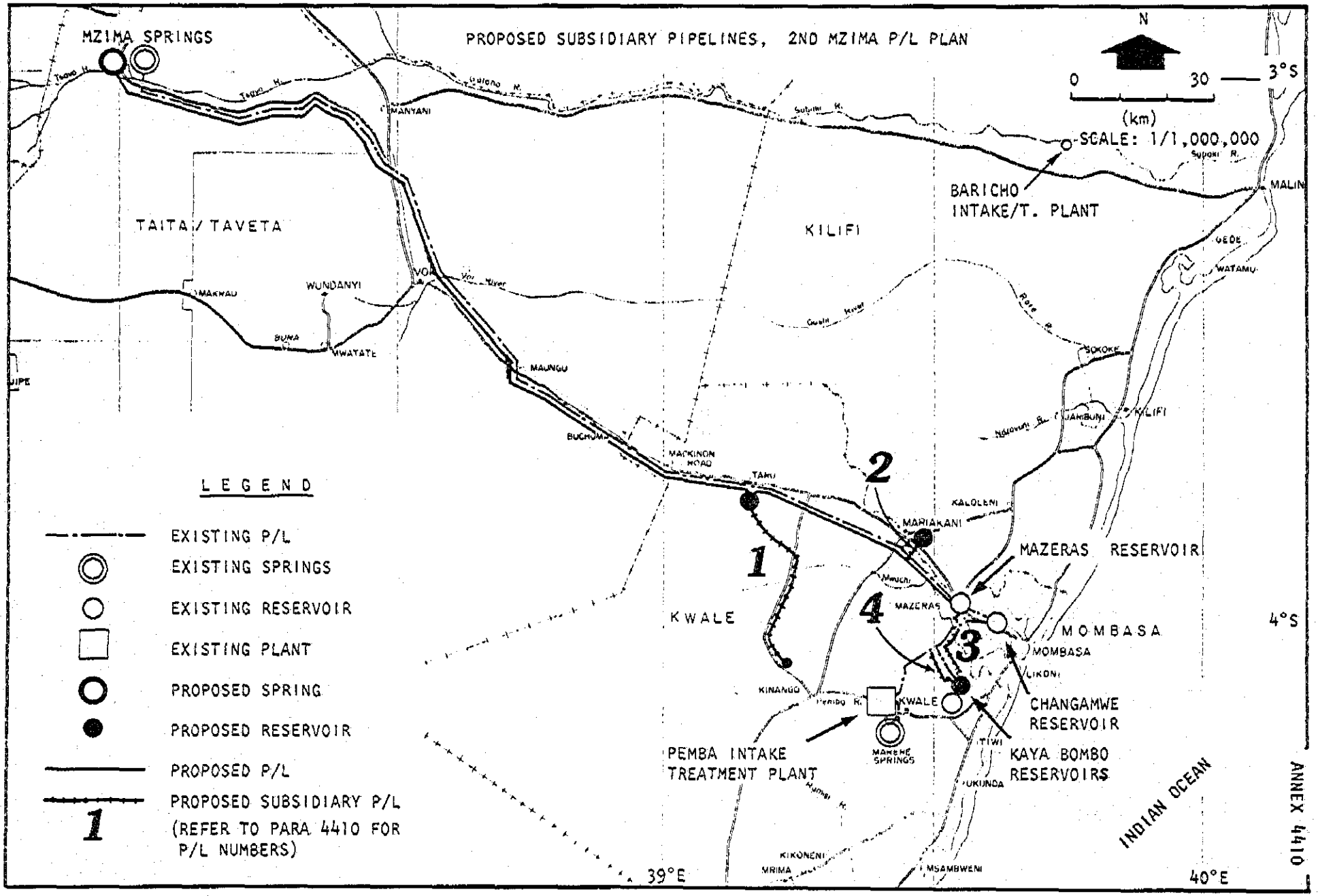
(mm)

CAPACITY	D1	D2	H1	R	a	b	c	d	e
20 000 cum	ø47,600	ø45,000	6,030	45,000	6,430	5,330	600	300	400
30 000 cum	ø57,700	ø55,000	7,370	55,000	7,870	6,770	650	350	500

DISTRIBUTION RESERVOIR
STANDARD MODEL
(NOT TO SCALE)

ANNEX 4408 - 2


PLAN
SECTION A-A
SECTION B-B
SECTION C-C
BREAK PRESSURE TANK STANDERD STRUCTURE
(NOT TO SCALE)
ANNEX 4409


PROPOSED SUBSIDIARY PIPELINES, 2ND MZIMA P/L PLAN
MZIMA SPRINGS
N
0
30
(km)
SCALE: 1/1,000,000
3°S
4°S
39°E
40°E
BARICHO INTAKE/T. PLANT
TAITA / TAVETA
KILIFI
KWALE
MOMBASA
MAZERAS RESERVOIR
CHANGAMWE RESERVOIR
KAYA BOMBO RESERVOIRS
PEMBA INTAKE TREATMENT PLANT
INDIAN OCEAN
MANYANI
MAKWAU
WUNDANYI
MWATATE
MAUNGU
BUCHUMA
MACKINON ROAD
TAKU
MARIAKANI
KALOLENI
MAZERAS
KINANGO
KWALE
MAKENE SPRINGS
TIWI
KIKONENI
MRIMA
MSAMBWENI
SOKOKE
JAMBUNI
KILIFI
MALIN
GEDE
WATAMU
LIKONI
MOMBASA
1
2
3
4
LEGEND
EXISTING P/L
EXISTING SPRINGS
EXISTING RESERVOIR
EXISTING PLANT
PROPOSED SPRING
PROPOSED RESERVOIR
PROPOSED P/L
PROPOSED SUBSIDIARY P/L
(REFER TO PARA 4410 FOR P/L NUMBERS)

ANNEX 4410

サボ貯水池付き第2ムジマパイプライン計画

主要施設の規模

施設	内容
湧水取水施設	—延長2kmの矢板工とφ1,000㎜からφ500㎜の集水用埋設コンクリート管。流量調節弁付き鉄筋コンクリート（RC）造取水井と600㎜のスルースゲート付き余剰水排水口。
送水本管	—φ1,350㎜：86,000m，φ1,100㎜：43,310m，φ1,000㎜：88,230m。最大動水圧12.5kg/㎠（水撃圧による上昇分を含む）。最大流量毎秒1.2㎥。取水井にて流量調節を行なう。 —制水弁（2km間隔）。 —空気弁および排水設備を9kmにつき10個所。
減圧井	—容量各720㎥。最大通水時の滞流時間10分。 —口径600㎜のバイパス。 —合計6井建設予定。
配水池	—ボイ配水池　2万㎥ —タル配水池　2万㎥ —マリアカニ配水池　2万㎥ —配水池（既設の第10減圧井の近く）　6万㎥ —カヤボンボ配水池　6万㎥ —以上すべての水槽は、円形、プレストレスコンクリート造（ANNEX 4408—2 参照）。
送水支管	—φ500㎜ …… 28,000m —φ400㎜ …… 17,000m —φ350㎜ …… 3,000m —φ300㎜ …… 40,000m —最大動力圧12.5kg/㎠（水撃圧を含む）。

ANNEX 4502

MAIN FEATURES OF 2ND MZIMA P/L WITH TSAVO RESERVOIR PLAN

Development scale: 1.2 m^3/sec

1. Dam

Catchment (km^2)	4050 excluding the area of the Loolturesh River
Type	Rockfill
Height above river bed (m)	34
Reservoir, effective storage ($10^6 m^3$)	21
Fill volume ($10^3 m^3$)	450
Design flood (m^3/sec)	1,550
Annual mean discharge (m^3/sec)	6.2

2. Water supply facilities

Type of intake	Underground
Trunk main P/L, diameter (mm) and length (m)	1,350mm - 86,000m 1,100mm - 43,310m 1,000mm - 88,230m

COST ESTIMATES OF 2ND MZIMA P/L WITH TSAVO RESERVOIR

Unit: US$10^3
Development Scale: 1.2 m^3/sec

	Economic Costs			Sales Taxes	Financial Costs		
	L.C.	F.C.	Total	L.C.	L.C.	F.C.	Total
Capital Cost							
A Water Supply Facilities							
1 Underground intake	3,980,4	1,760.0	5,740.4	635.6	4,616.0	1,760.0	6,376.0
2 Transmission main P/L	36,428.4	101,280.0	137,708.4	12,487.6	48,916.0	101,280.0	150,196.0
3 Pipes for B.P.T.'s and distribution reservoirs	14,572.6	896.0	15,468.6	1,693.8	16,266.4	896.0	17,162.4
4 Communication equipments	150.0	400.0	550.0	50	200.0	400.0	600.0
5 Subsidiary P/L	3,965.0	7,420.0	11,385.0	1,058.9	5,023.9	7,420.0	12,443.9
B Dam							
6 General items	2,279.2	1,584.1	3,863.3	335.9	2,615.1	1,584.1	4,199.2
7 Coffer dam and diversion tunnel	8,298.7	5,913.4	14,212.1	1,235.8	9,534.5	5,913.4	15,447.9
8 Main dam	5,168.5	7,018.0	12,186.5	1,059.7	6,228.2	7,018.0	13,246.2
9 Spillway	9,290.9	2,746.1	12,037.0	1,046.7	10,337.6	2,746.1	13,083.7
10 River outlet facilities	34.5	163.3	197.8	17.2	51.7	163.3	215.0
C Engineering and Administration	8,416.8	12,918.1	21,334.9	1,962.1	10,378.9	12,918.1	23,297.0
Base Cost Total	92,585.0	142,099.2	234,684.2	21,583.3	114,168.3	142,099.2	256,267.5
D Physical Contingency	13,887.8	21,315.0	35,203.7	3,237.5	17,125.3	21,315.0	38,440.3
Capital Cost Total	106,472.8	163,415.0	269,887.9	24,820.8	131,293.6	163,415.0	294,708.6
E Price Contingency	-	-	-	-	75,700	51,072	126,772
F Financial Cost Total	-	-	-	-	206,994	214,487	421,481

ANNEX 4507-1

ECONOMIC COSTS ESTIMATED FOR WATER FACILITIES AND CIVIL WORKS ON 2ND MZIMA P/L WITH TSAVO RESERVOIR

Development Scale: 1.2 m^3/sec.

	Items	Unit	Quantity	L. C.		F. C.	
				Unit Price (US$)	Amount (US$10^3)	Unit Price (US$)	Amount (US$10^3)
A.	Water Supply Facilities						
1.	Underground intake	L.S.			3,980.4		1,760.0
2.	Transmission main P/L						
	ø 1350	m	87,000	215.90	18,780.0	600.00	52,200.0
	ø 1100	m	43,310	149.90	6,490.7	416.90	18,056.0
	ø 1000	m	88,230	126.50	11,156.9	351.60	31,024.0
	Sub-total				36,428.4		101,280.0
3.	Break pressure tanks and reservoirs						
	Break pressure tanks	No.	6	85x10^3	510.0	65x10^3	390.0
	30,000 m^3 reservoirs	No.	4	1,600x10^3	6,400.0	52x10^3	208.0
	20,000 m^3 reservoirs	No.	5	1,400x10^3	7,000.0	51x10^3	255.0
	Miscellaneous	L.S.			662.6		43.0
	Sub-total				14,572.6		896.0
4.	Communication system	L.S.			150.0		400.0
5.	Subsidiary P/L						
	ø 500	m	28,000	64.5	1,805.6	120.3	3,368.4
	ø 400	m	17,000	45.7	776.9	85.2	1,448.4
	ø 350	m	3,000	37.3	111.8	69.6	208.8
	ø 300	m	40,000	31.8	1,270.7	59.9	2,394.4
	Sub-total				3,965.0		7,420.0
B.	Dam						
6.	General items	L.S.			2,279.2		1,584.1
7.	Coffer dam and diversion tunnel						
	Excavation in oepn cut	m^3	153,300	6	919.8	3	459.9
	Excavation in tunnel	m^3	40,200	45	1,809.0	75	3,015.0
	Embankment	m^3	273,300	5	1,366.5	5	1,366.5
	Concrete	m^3	23,400	100	2,340.0	30	702.0
	Reinforcement bars	ton	1,000	900	900.0	80	80.0
	Miscellaneous	L.S			963.4		290.0
	Sub-total				8,298.7		5,913.4

	Items	Unit	Quantity	L. C.		F. C.	
				Unit Price (US$)	Amount (US$10^3)	Unit Price (US$)	Amount (US$10^3)
8.	Main dam						
	Excavation	m^3	162,400	6	974.4	3	487.2
	Embankment	m^3	452.700	5	2,263.5	5	2,263.5
	Asphalt concrete facing	m^2	29,600	15	444.0	100	2,960.0
	Concrete in cut-off wall	m^3	2,500	100	250.0	20	50.0
	Curtain grouting	m	6,000	25	150.0	100	600.0
	Miscellaneous	L.S.			1,086.6		657.3
	Sub-Total				5,168.5		7,018.0
9.	Spillway						
	Excavation	m^3	502,500	6	3,015.0	3	1,507.5
	Backfill	m^3	10,000	1	10.0	0.50	5.0
	Concrete	m^3	49,300	100	4,930.0	20	986.0
	Reinforcement bars	ton	1,000	900	900.0	80	80.0
	Steel anchor bars	ton	100	1,300	130.0	700	70.0
	Miscellaneous	L.S.			305.9		97.6
	Sub-Total				9,290.9		2,746.1
10.	River outlet facilities	L.S.			34.5		163.3
	Grand Total				84,168.2		129,180.9

ECONOMIC LIFE OF EQUIPMENT AND MATERIALS

Second Mzima P/L with Tsavo Reservoir

Items	Economic Life (Years)
1. Intake Facilities	
Valves	30
R.C.	40
2. Transmission Main	
Pipes	40
Valves	30
R.C.	30
3. BPTs & Reservoir	
Valves	30
Pipes	40
R.C.	30
4. Communication	
Equipment	15
R.C.	30

Rare P/L with Rare Reservoir

Items	Economic Life (Years)
1. Intake & Transmission Pumping Facilities	
- Pumps & Elec.	10
- Pipe & Valves	30
- Structure	50
2. Raw Water Main	
- Pipes	40
- Valves	30
- Ancillary works	30
3. Treatment Plant	
- Equipment	15
- Pipes & Valves	30
- Structure	50
4. Transmission Main	
- Pipes	40
- Valves	30
- Ancillary works	30
5. Distribution Reservoir	30
6. Communication Equip.	15

Remarks: R.C. stands for "Reinforced Concrete".

BREAKDOWN OF O&M COST ON SECOND MZIMA P/L

Unit: US$10^3

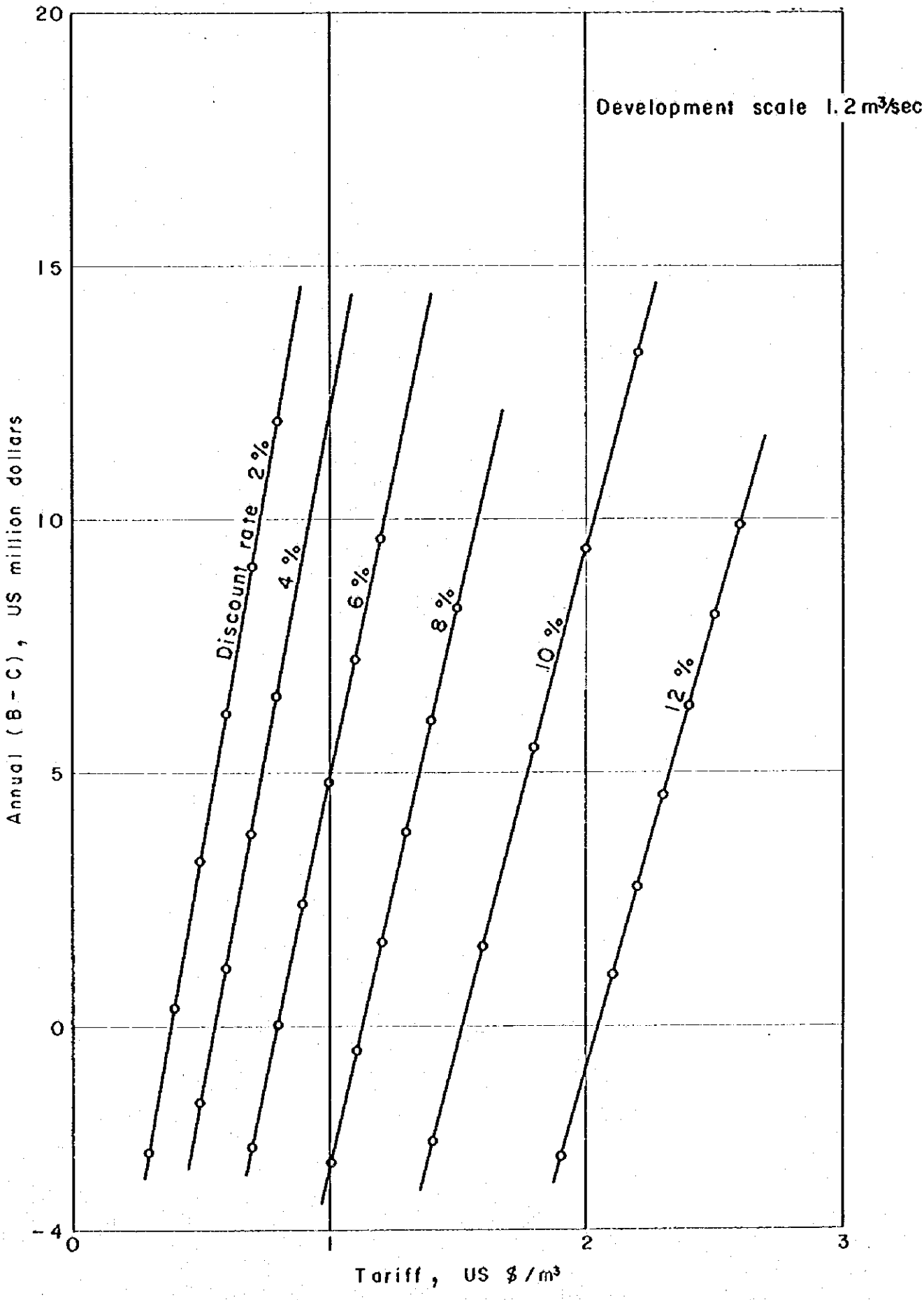
Year	Proposed System Supply, m^3/d	Staff Salary	Chemical	Repair	Total
1986	1,990	32.17	0.54	16.2	48.91
1987	5,510	⋮	1.51	⋮	49.88
1988	8,480	⋮	2.29	⋮	50.66
1989	12,000	⋮	3.26	⋮	51.63
1990	18,400	56.44	5.01	⋮	77.65
1991	28,000	⋮	7.64	⋮	80.28
1992	39,890	⋮	10.88	⋮	83.52
1993	52,000	⋮	14.16	⋮	86.80
1994	63,990	⋮	17.42	⋮	90.06
1995	75,990	⋮	20.73	⋮	93.37
1996	89,760	⋮	24.55	⋮	97.19
1997	102,810	⋮	28.03	⋮	100.67
1998	104,000	⋮	28.32	⋮	100.96
1999	⋮	⋮	⋮	⋮	⋮
2000	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮
2035	⋮	⋮	⋮	⋮	⋮

SECOND MZIMA P/L WITH TSAVO RESERVOIR PLAN

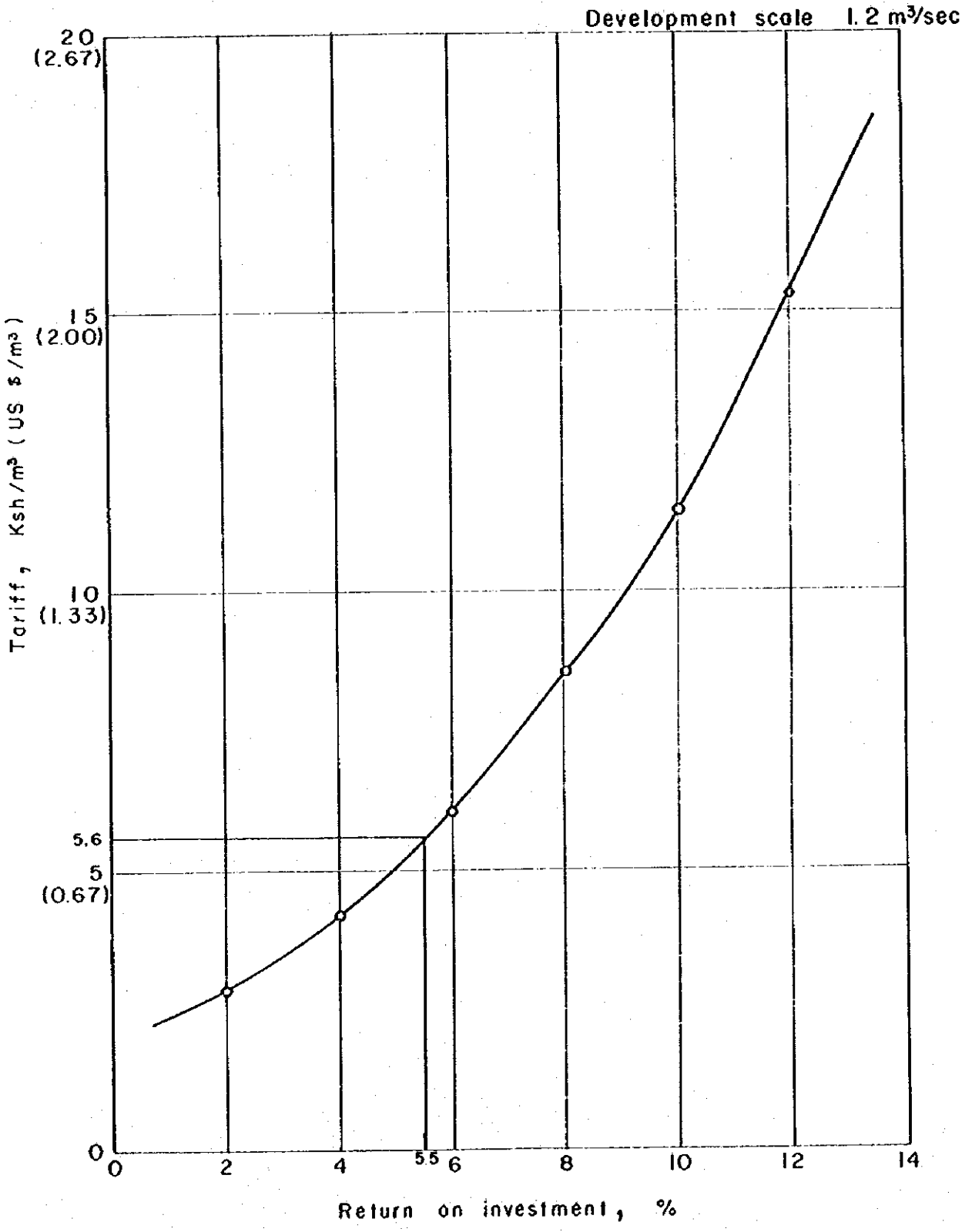
COST AND WATER VOLUME STREAMS

Unit: US$ 10^6
Development scale: 1.2 m^3/sec

End of fiscal year	No.	Water volume $10^6 m^3$	Capital cost	O & M cost
1983	-3	-	40.5	-
84	-2	-	161.9	-
85	-1	-	67.5	-
86	1	0.73	-	0.05
87	2	2.01	-	0.05
88	3	3.10	-	0.05
89	4	4.38	-	0.08
1990	5	6.57	-	0.08
91	6	10.22	-	0.08
92	7	14.60	-	0.09
93	8	18.98	-	0.09
94	9	23.36	-	0.09
95	10	27.74	-	0.10
96	11	32.85	-	0.10
97	12	37.53	-	0.10
98	13	37.96	-	0.10
99	14	:	-	
2000	15	:	0.5	:
2000-'14	16-29	:	-	:
2015	30	:	31.9	:
2016-'24	31-39	:	-	:
2025	40	:	125.9	:
2026-'29	41-44	:	-	:
2030	45	:	0.5	
2031-'35	46-50	37.96	-	0.10

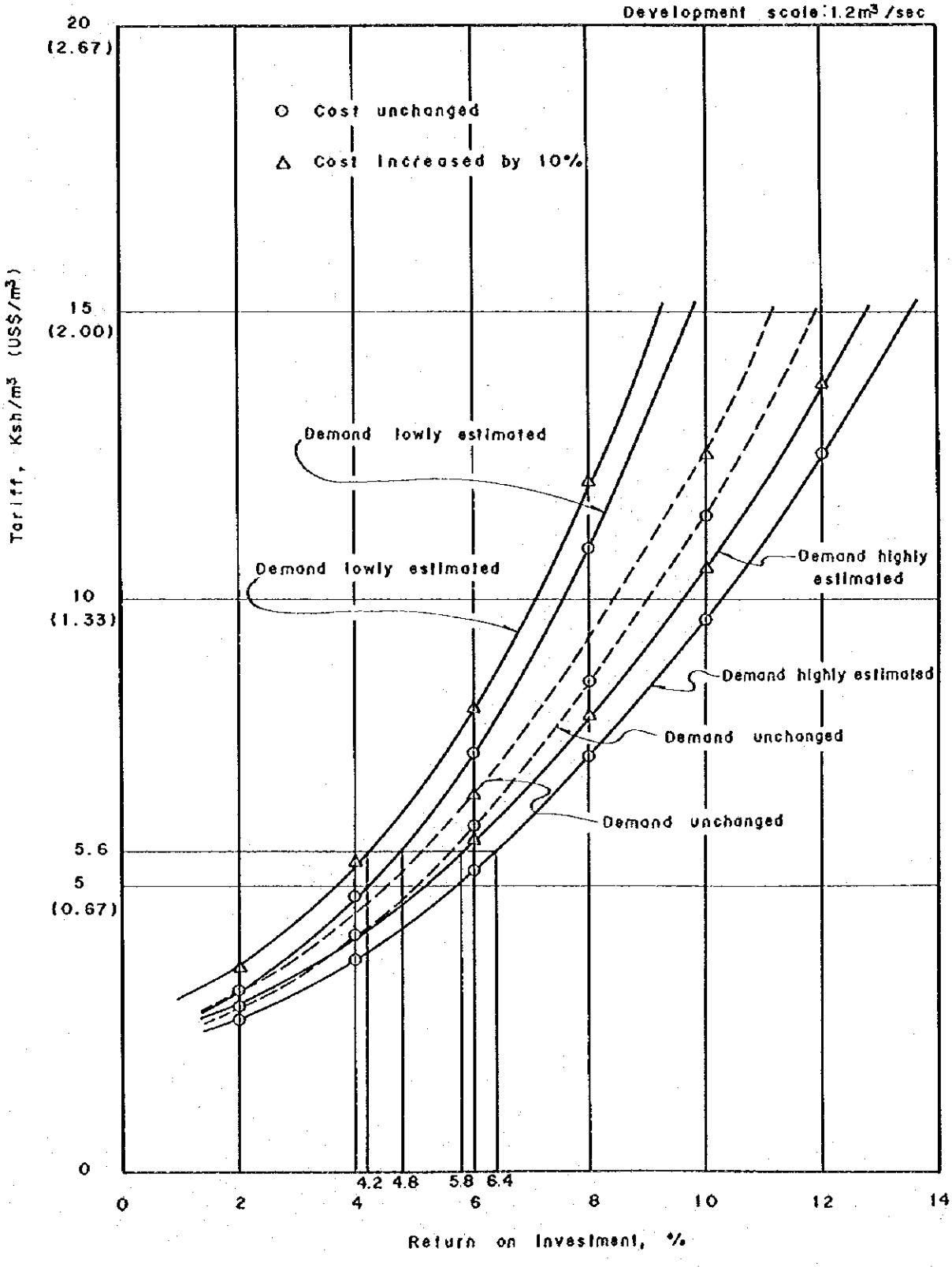


Variation of Annual (B - C) by Changing Tariff on the 2nd Mzima Plan



Return on Investment on the Development Scale of 1.2 m³/sec

(Mzima Plan)



Sensitivity Tests for the Second Mzima Plan

ROI AND WATER RATES (AT CURRENT PRICES) BY VARIOUS ANNUAL INCREASE RATES OF WATER RATE

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	at Current Price		at 1980 Price			
Annual Increase for 1980 - 1986	Water Rate /1 1980 (KSh/m³)	1986	Water Rate /1 1980 (KSh/m³)	1986	ROI 2nd Mzima	Rare
13 %	5.88	12.24 ($1.63/m³)	5.60	6.58	6.5 %	9.4 %
15 %	5.88	13.60 ($1.81/m³)	5.60	7.31	7.1 %	10.1 %
17 %	5.88	15.08 ($2.01/m³)	5.60	8.11	7.7 %	10.8 %
20 %	5.88	17.56 ($2.34/m³)	5.60	9.44	8.7 %	11.8 %

(8)	
at Current Price	
Annual Increase for 1980 - 1986	Consumer's Water Tariff in 1986 /2 (KSh/m³)
13 %	17.49 ($2.33/m³)
15 %	19.43 ($2.59/m³)
17 %	21.54 ($2.87/m³)
20 %	25.09 ($3.35/m³)

/1 Evaluated at the outlet of distribution reservoir.

/2 (8) = (3)/0.7 Assuming the cost of distribution system constitutes 30% of the consumer's water tariff.

SECOND MZIMA P/L WITH TSAVO RESERVOIR PLAN

FIRR CALCULATION

Unit: US$10^3

No.	Fiscal Year	Capital Cost & Replacement F.C.	Capital Cost & Replacement L.C.	O&M Cost	Gross Revenue	Net Benefit
1	1983	29,292	25,555	-		-54,847
2	1984	124,139	112,390	-		-236,529
3	1985	54,828	51,522			-106,350
4	1986	-	-	91	1,251	1,160
5	1987	-	-	93	3,463	3,370
6	1988	-	-	94	5,348	5,254
7	1989	-	-	96	7,542	7,446
8	1990	6,228	17,527	144	11,313	-12,586
9	1991	-	-	149	17,604	17,455
10	1992	-	-	155	25,146	24,991
11	1993	-	-	161	32,688	32,527
12	1994	-	-	168	40,230	40,062
13	1995	-	-	174	47,773	47,599
14	1996	-	-	181	56,584	56,403
15	1997	-	-	187	64,633	64,446
16	1998	-	-	188	65,377	65,189
17	1999	-	-	⋮	⋮	65,189
18	2000	(R) 584	186	⋮	⋮	64,419
19	2001	-	-	⋮	⋮	65,189
20	2002	-	-	⋮	⋮	65,189

Discount Rate	Net Benefit
0%	+215,576
3%	+16,588
4%	-28,690

FIRR = 3.4%

(R): Replacement Cost

PROJECTED INCOME STATEMENTS FOR SECOND MZIMA P/L WITH TSAVO RESERVOIR PLAN

Unit: US$10^3

No.	Year	Water Sold (10^3 m^3)	Average Water Rate (Ksh/m^3)	Operating Revenue	Operating Expense		Income Before Interest	Interest Payment	Net Income
				Water Sales	O & M Cost	Depreciation			
1	1983	-	-	-	-	-	-	-	-
2	1984	-	-	-	-	-	-	-	-
3	1985	-	-	-	-	-	-	-	-
4	1986	690	13.6($1.813)	1,251	91	13,357	-12,197	17,152	-29,349
5	1987	1,910		3,463	93		- 9,987	16,617	-26,604
6	1988	2,950		5,348	94		- 8,103	16,057	-24,160
7	1989	4,160		7,542	96		- 5,911	15,425	-21,336
8	1990	6,240		11,313	144		- 2,188	14,768	-16,956
9	1991	9,710		17,604	149		4,098	14,501	-10,403
10	1992	13,870		25,146	155		11,634	13,710	- 2,076
11	1993	18,030		32,688	161		19,170	12,892	6,278
12	1994	22,190		40,230	168		26,705	11,976	14,729
13	1995	26,350		47,773	174		34,242	11,010	23,232
14	1996	31,210		56,584	181		43,046	9,970	33,076
15	1997	35,650		64,633	187		51,089	8,855	42,234
16	1998	36,060		65,377	188		51,832	7,667	44,165
17	1999							6,379	45,453
18	2000							4,992	46,840
19	2001							3,506	48,326
20	2002							1,897	49,935

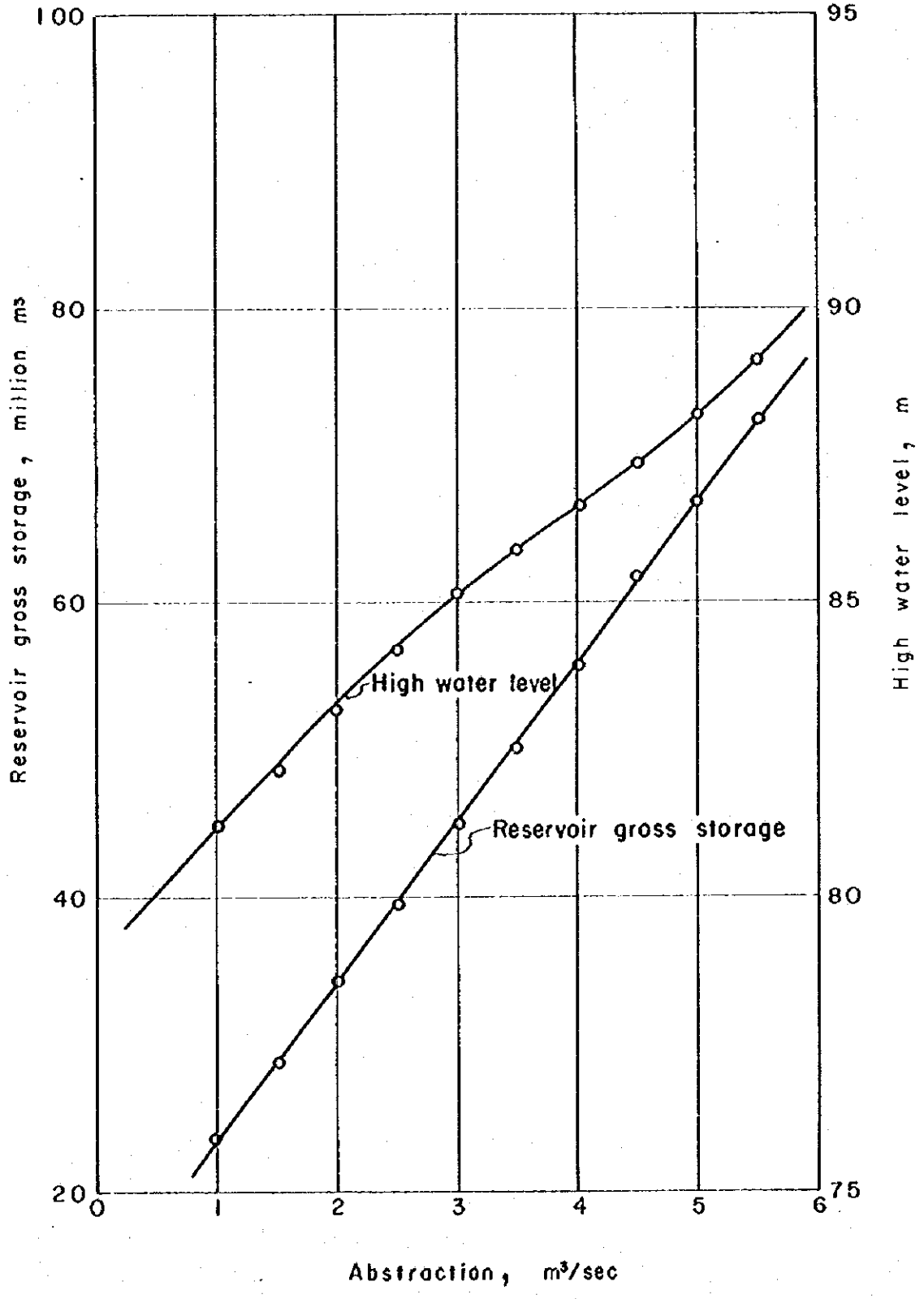
ANNEX 4718-1

PROJECTED CASH FLOW FOR SECOND MZIMA P/L WITH TSAVO RESERVOIR PLAN

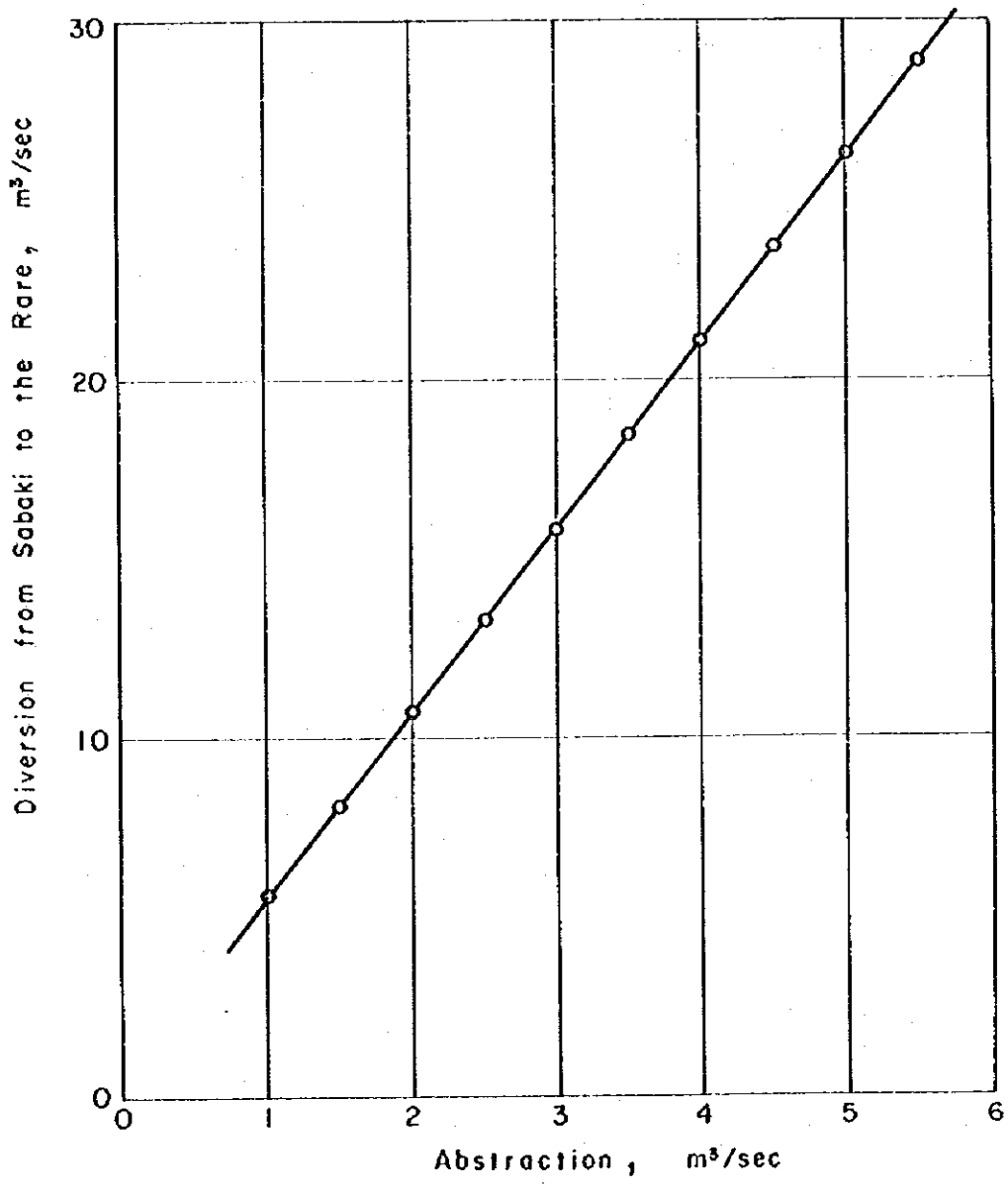
Unit: US$10^3

No.	Year	Income Before Interest	Depreciation	Foreign Loan	Government Equity	Total Source	Capital Cost		Debt Service		Total Application	Increase in cash	Cash at End	Debt Service Coverage
							Foreign Currency	Local Currency	Interest	Principal				
1	1983	-	-	29,292	25,555	54,847	29,292	25,555	-	-	54,847	0	0	-
2	1984	-	-	124,139	112,390	236,529	124,139	112,390	-	-	236,529	0	0	-
3	1985	-	-	54,828	51,522	106,350	54,828	51,522	-	-	106,350	0	0	-
4	1986	-12,197	13,357	-	-	1,160	-	-	17,152	7,177	24,329	-23,169	- 23,169	0.048
5	1987	- 9,987		-	-	3,370	-	-	16,617	7,712	24,329	-20,959	- 44,128	0.139
6	1988	- 8,103		-	-	5,254	-	-	16,057	8,272	24,329	-19,075	- 63,203	0.216
7	1989	- 5,911		-	-	7,446	-	-	15,425	8,904	24,329	-16,883	- 80,086	0.306
8	1990	- 2,188		6,228	17,527	34,924	6,228	17,527	14,768	9,561	48,084	-13,160	- 93,246	0.459
9	1991	4,096		-	-	17,455	-	-	14,501	10,451	24,952	- 7,497	-100,743	0.700
10	1992	11,634		-	-	24,991	-	-	13,710	11,242	24,952	39	-100,704	1.002
11	1993	19,170		-	-	32,527	-	-	12,892	12,060	24,952	7,515	- 93,129	1.304
12	1994	26,705		-	-	40,062	-	-	11,976	12,976	24,952	15,110	- 78,019	1.606
13	1995	34,242		-	-	47,599	-	-	11,010	13,942	24,952	22,647	- 55,372	1.908
14	1996	43,046		-	-	56,403	-	-	9,970	14,982	24,952	31,451	- 23,921	2.260
15	1997	51,089		-	-	64,446	-	-	8,855	16,097	24,952	39,444	15,573	2.583
16	1998	51,832		-	-	65,189	-	-	7,667	17,285	24,952	40,237	55,810	2.613
17	1999			-	-		-	-	6,379	18,573	24,952		96,047	
18	2000			-	-		-	-	4,992	19,960	24,952		136,284	
19	2001			-	-		-	-	3,506	21,446	24,952		176,521	
20	2002			-	-		-	-	1,897	23,055	24,952		216,758	

ANNEX 4718-2

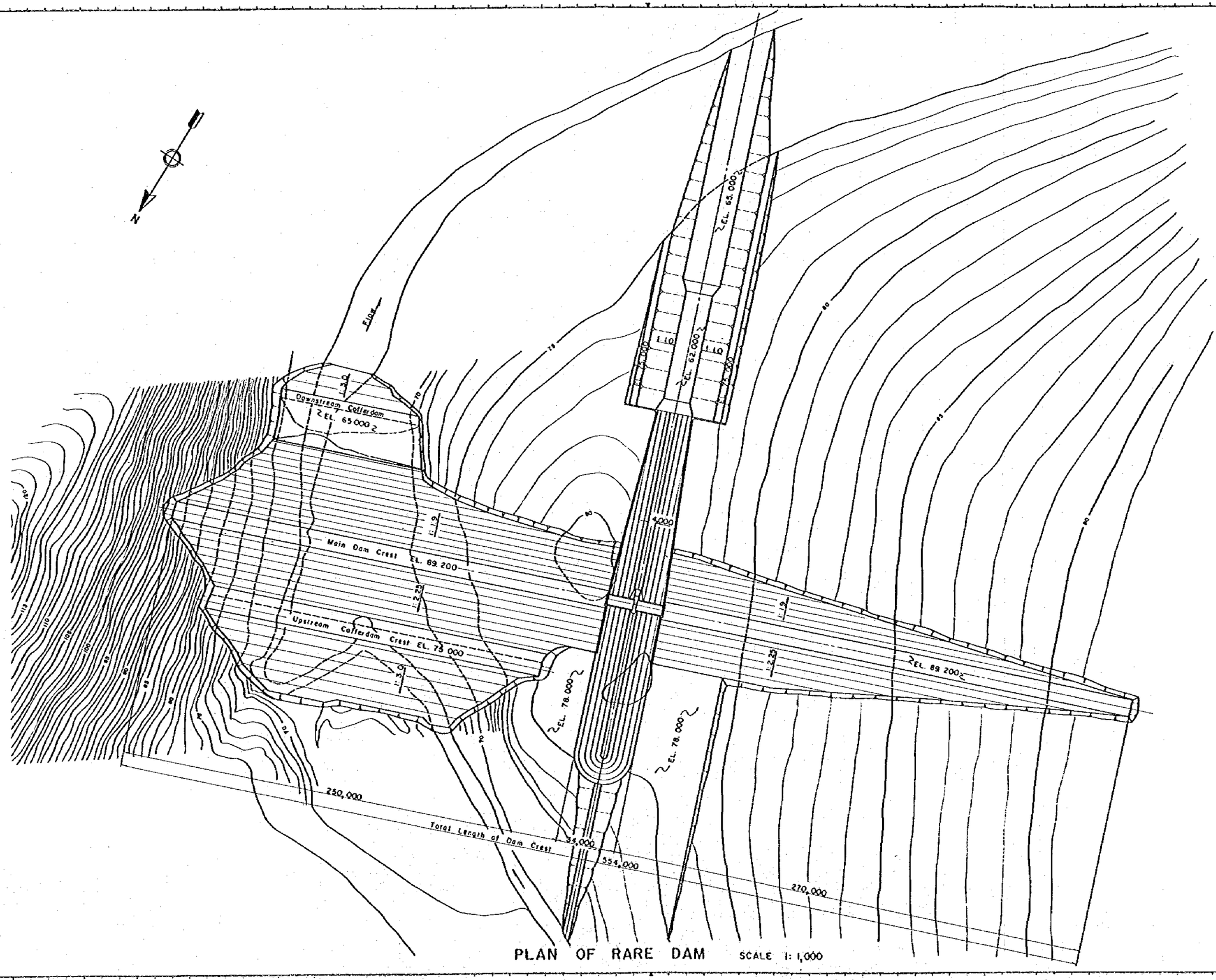


Reservoir Gross Storage and High Water Level of Rore Reservoir

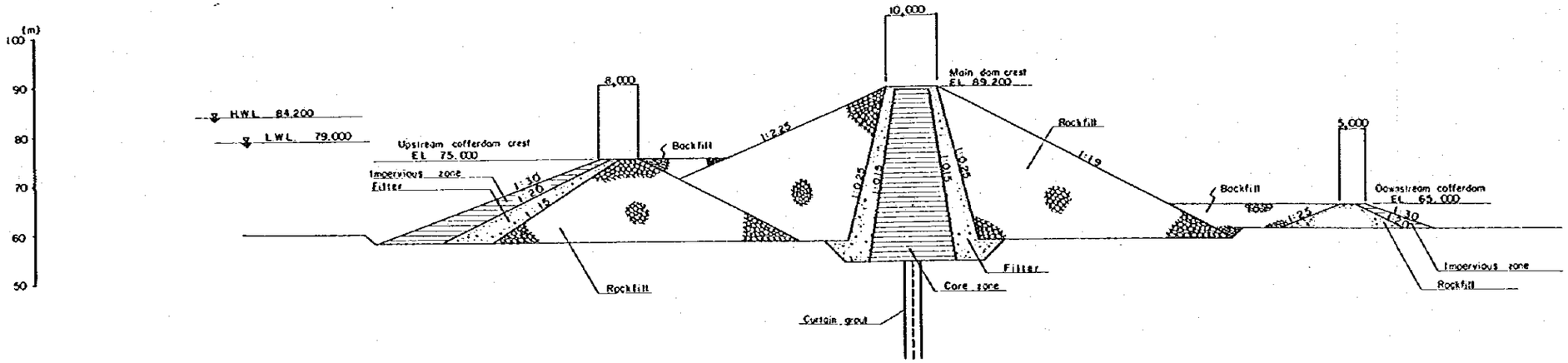


Flow Capacity of Diversion Canal
from the Sabaki to the Rore

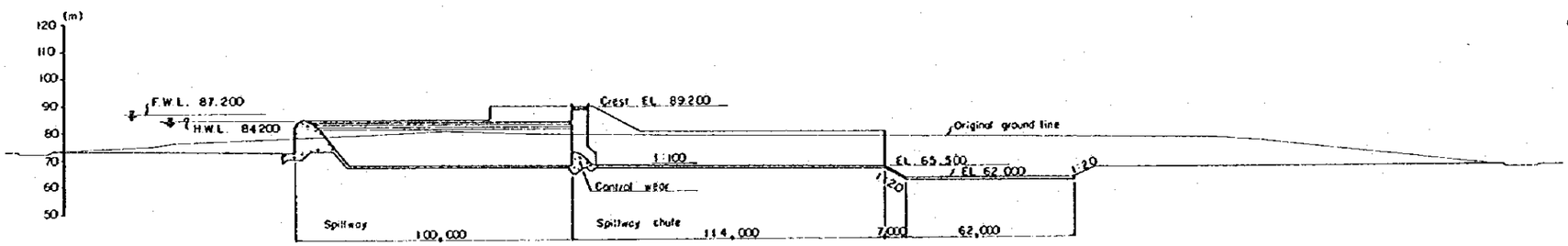
ANNEX 5303-1



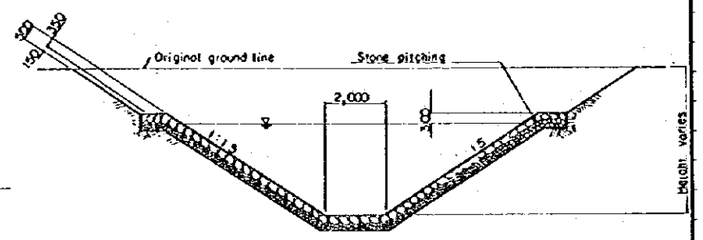
PLAN OF RARE DAM SCALE 1: 1,000



CROSS SECTION OF RARE DAMS SCALE 1:500



PROFILE OF SPILLWAY SCALE 1:1000



CROSS SECTION OF DIVERSION CANAL FROM THE SABAKI TO THE RARE RESERVOIR (40Km) SCALE 1:100

ラレダム地点における洪水予測

A. 概　　説

1. ダム地点における洪水を推定するために、既存の観測所（3LA2）における流量データを使用することが望ましいが、この観測所では1度も洪水流量観測が行なわれていない。さらに、ボイ（Voi）川の流域を除くと他には雨量観測所がないのが現状である。従って、流域の洪水予測に十分利用できるデータがないため、洪水流量は他流域の比流量より推定した。

B. 比　流　量

2. 比流量は単位流域面積当りのピーク流量として定義される。サボダム地点における洪水流量についてはANNEX 4307において既に検討したが、計画されたムワチダム地点の設計流量は西暦1972年5月14日の洪水およびマジ・ヤ・チュムビ（Majiya Chumbi、93−39−23）の雨量データに基づき推定した。

3. ダムサイトにおける設計洪水に対する比流量を以下にまとめる。

		比　流　量 $m^3/sec/km^2$		
ダム	流域面積 km^2	仮排水路の設計洪水	洪水吐の設計洪水	可能最大洪水
サ　ボ	4050	0.16	0.38	0.49
ムワチ	2090	0.34	0.87	1.27

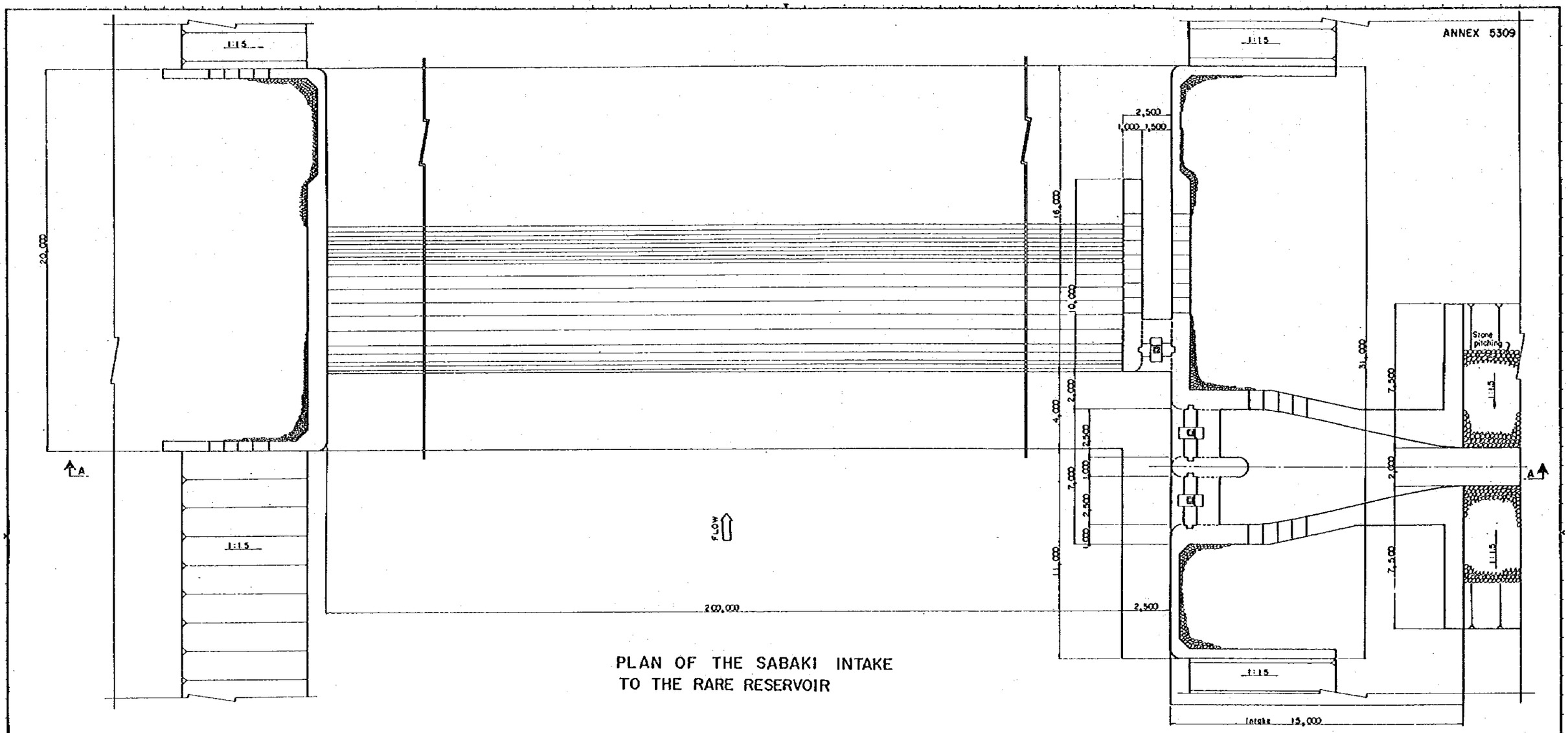
4. ムワチ川の流域面積2,090 km^2は、雨季にしか川に流水が認められないような流域を除いたものである。またラレダムの流域は、5201項で述べた上流域を除いて1,500 km^2とした。仮締切ダムや仮排水路の設計洪水流量推定のため流域面積を580 km^2としたが、これは仮排水設備を縮少するために、ゴシ川をEL400ftで横切るようなもうひとつの仮締切ダムを設置するためである。

5. ゴシ川の仮締切ダムは洪水時のピークを遅らせるためにのみ使用するものであり、仮排水設備なしでその堤頂を越流することも許容するものである。ダム本体の完成後、仮締切ダムは取り壊される。

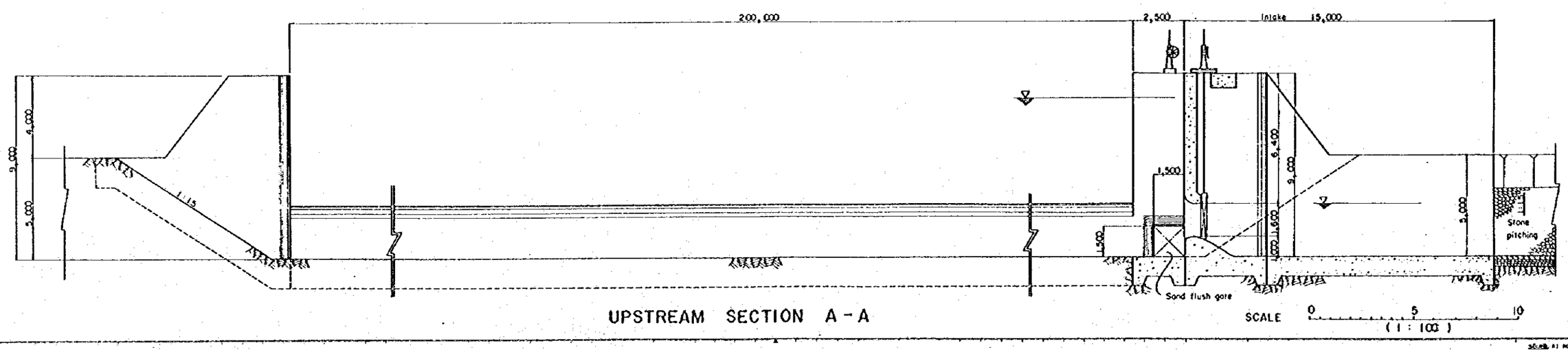
6. 比流量は流域面積が増加するにしたがって指数的に減少するといわれている。即ち、ラレ川の比流量はムワチ川のそれより大きいと考えられる。しかしながら、ムワチ川で推定された比流量はラレダムの洪水流量の推定にそのまま適用された。これはラレ川がムワチ川よりも、より乾燥した地域に位置しているからである。ラレダムにおける洪水のピーク流量として以下の値が推定された。

仮排水設備に対する設計流量	260 m^3/sec
洪水吐に対する設計流量	1,305 m^3/sec
可能最大洪水	1,905 m^3/sec

ANNEX 5309



PLAN OF THE SABAKI INTAKE
TO THE RARE RESERVOIR

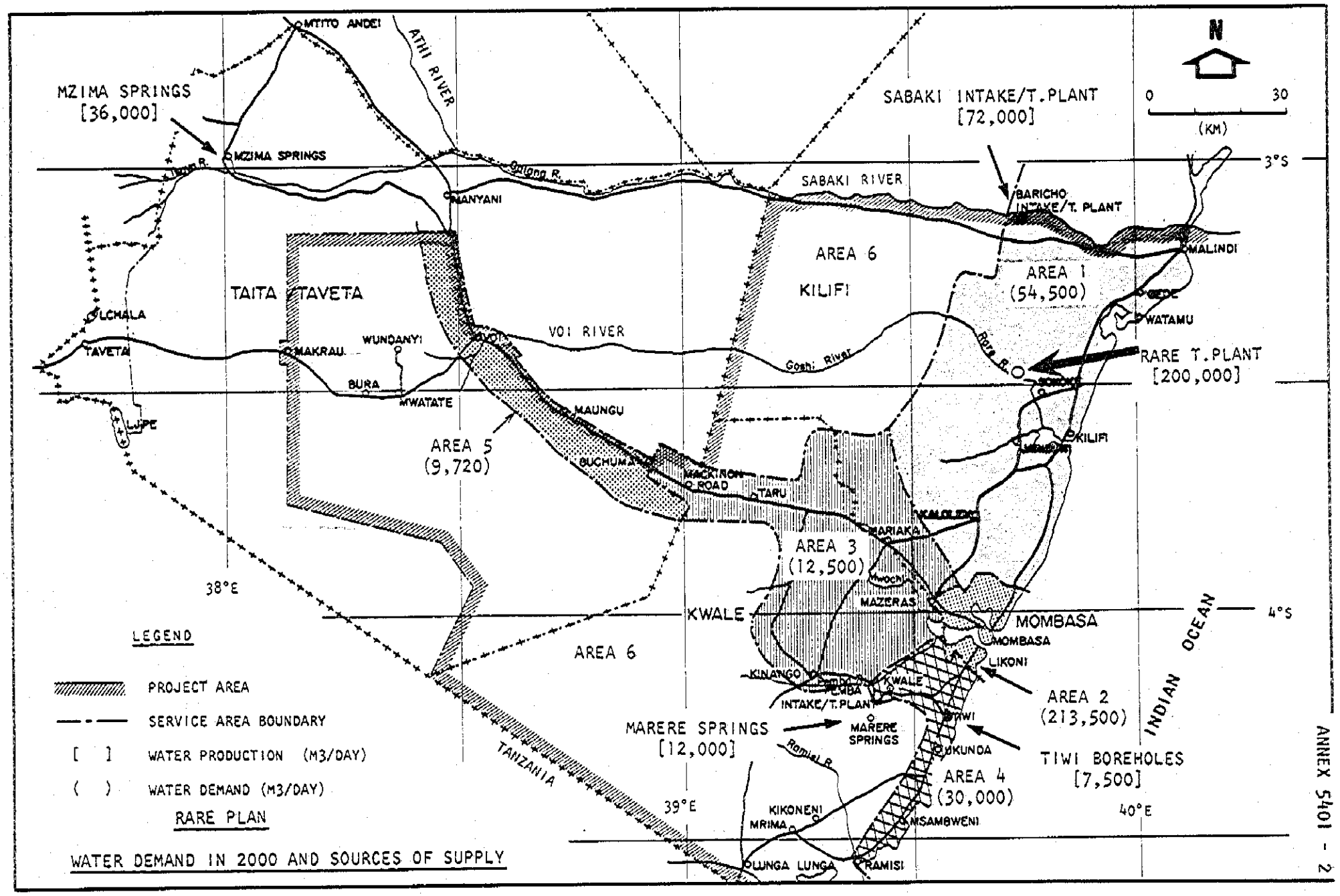


UPSTREAM SECTION A - A

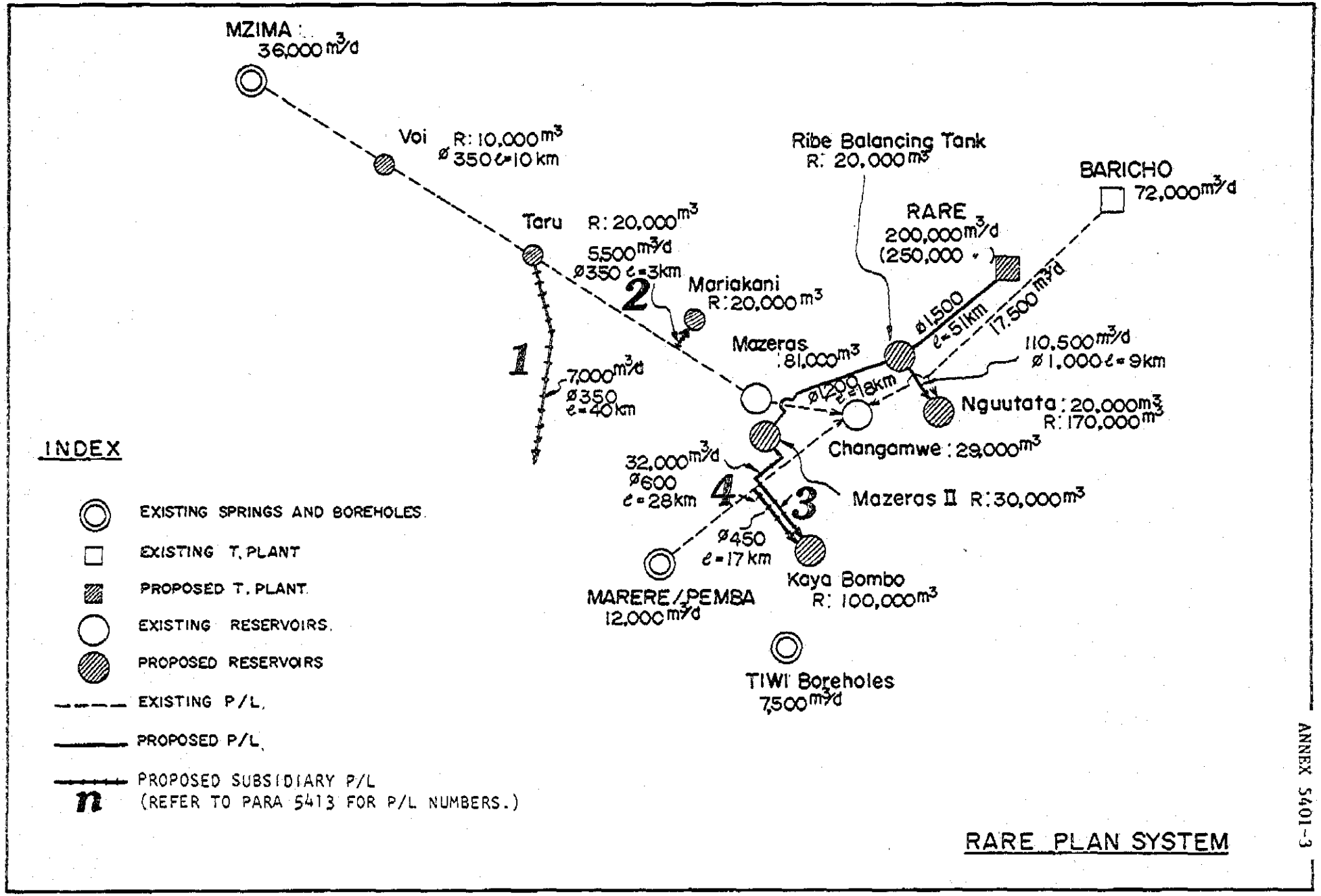
(RARE PLAN)

ESTIMATED 2000 DEMAND AND SOURCES OF SUPPLY

AREA	Total Demand (m^3/d)	SOURCES OF SUPPLY			
		Mzima P/L (m^3/d)	Marere P/L Tiwi B.H. (m^3/d)	Rare P/L (m^3/d)	Sabaki P/L (m^3/d)
1. Mombasa Is.	75,000	-	-	75,000	-
2. West Mainland	64,000	13,780	-	50,220	-
3. North Mainland	53,000	-	-	35,500	17,500
4. South Mainland	21,500	-	-	21,500	-
5. Kilifi District Coast	54,500	-	-	-	54,500
6. Kilifi District South	5,500	5,500	-	-	-
7. Kwal District North	1,500	1,500	-	-	-
8. Kwal District Central	5,500	5,500	-	-	-
9. Kwal District South	30,000	-	19,500	10,500	-
10. Taita District	9,720	9,720	-	-	-
	320,220	36,000	19,500	192,720	72,000

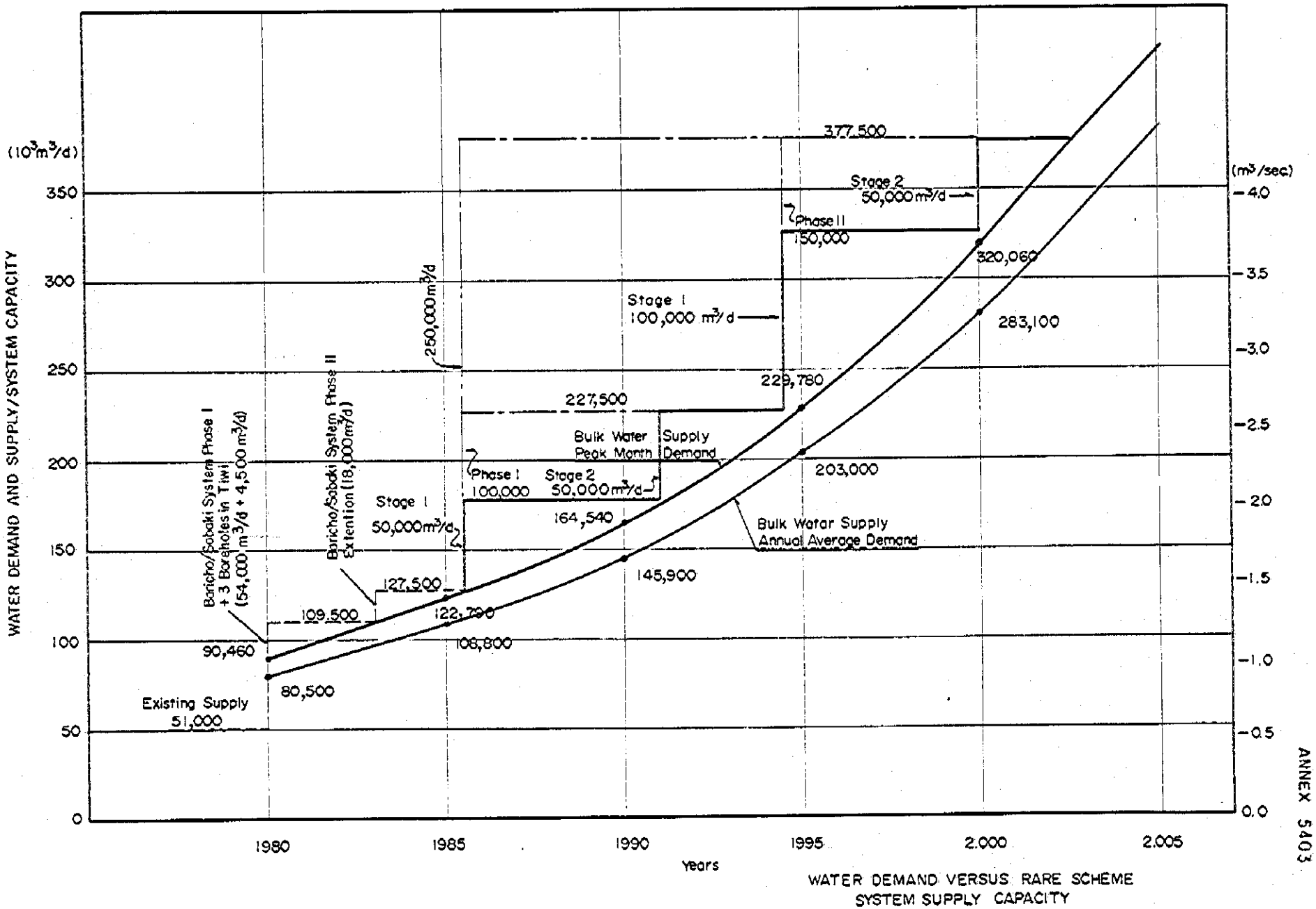

MZIMA SPRINGS
[36,000]
MTITO ANDEI
ATHI RIVER
MZIMA SPRINGS
Lumi R.
Ongonga R.
MANYANI
SABAKI INTAKE/T.PLANT
[72,000]
SABAKI RIVER
BARICHO INTAKE/T. PLANT
MALINDI
GEDE
WATAMU
AREA 6
KILIFI
AREA 1
(54,500)
TAITA TAVETA
VOI RIVER
Goshi River
Rare R.
RARE T.PLANT
[200,000]
LCHALA
TAVETA
MAKRAU
WUNDANYI
BURA
MWATATE
LUPE
MAUNGU
KILIFI
AREA 5
(9,720)
BUCHUMA
MACKINON ROAD
TARU
MARIAKA
AREA 3
(12,500)
MAZERAS
38°E
KWALE
MOMBASA
4°S
AREA 6
MOMBASA
LIKONI
KINANGO
KWALE
LUMBA
INTAKE/T.PLANT
AREA 2
(213,500)
INDIAN OCEAN
MARERE SPRINGS
[12,000]
MARERE SPRINGS
TIWI
TIWI BOREHOLES
[7,500]
Ramisi R.
UKUNDA
AREA 4
(30,000)
TANZANIA
39°E
KIKONENI
MRIMA
MSAMBWENI
40°E
LUNGA LUNGA
RAMISI
3°S
N
0
30
(KM)
LEGEND
PROJECT AREA
SERVICE AREA BOUNDARY
[ ] WATER PRODUCTION (M3/DAY)
( ) WATER DEMAND (M3/DAY)
RARE PLAN
WATER DEMAND IN 2000 AND SOURCES OF SUPPLY

ANNEX 5401 - 2



RARE PLAN SYSTEM

ANNEX 5401-3

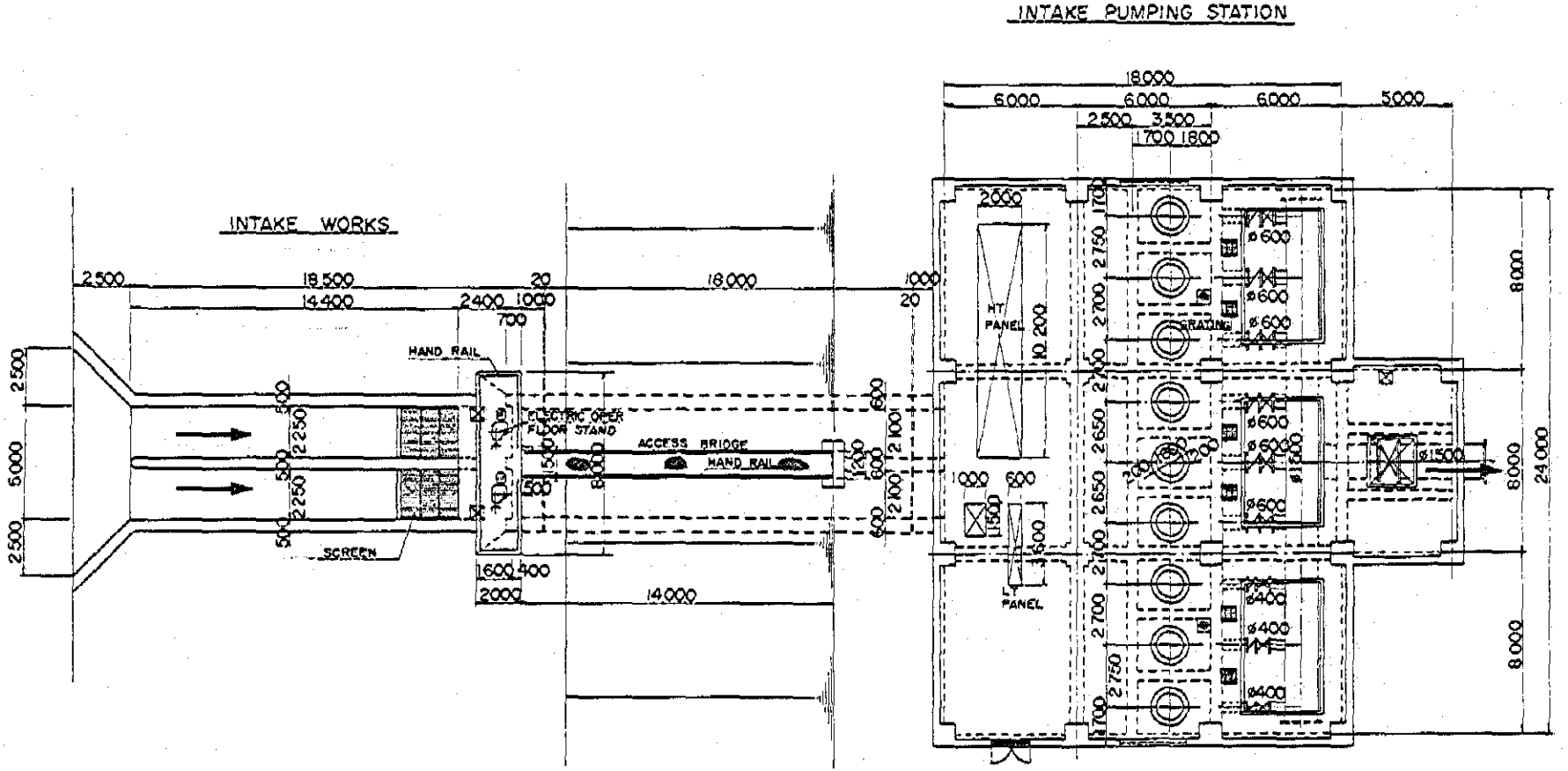

WATER DEMAND AND SUPPLY/SYSTEM CAPACITY
($10^3 m^3/d$)
(m³/sec)
350
300
250
200
150
100
50
0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2.000
2.005
Years
377,500
Stage 2
50,000 m³/d
Phase II
150,000
320,060
250,000 m³/d
Stage 1
100,000 m³/d
283,100
229,780
227,500
Bulk Water Supply
Peak Month Demand
Phase I
100,000
Stage 2
50,000 m³/d
203,000
Stage 1
50,000 m³/d
164,540
Bulk Water Supply
Annual Average Demand
Baricho/Sabaki System Phase I
+ 3 Boreholes in Tiwi
(54,000 m³/d + 4,500 m³/d)
Baricho/Sabaki System Phase II
Extention (18,000 m³/d)
127,500
109,500
122,790
145,900
90,460
108,800
80,500
Existing Supply
51,000
WATER DEMAND VERSUS RARE SCHEME
SYSTEM SUPPLY CAPACITY
ANNEX 5403

ラレ貯水池付きラレパイプライン計画

主要施設の規模

施設	内容
取水施設およびポンプ場	—鉄筋コンクリート造(RC)ゲート2門と導水路2本。 —9台の竪軸タービン・ポンプ 毎分 19.1m^3 × 390kWのモーター × 3台 毎分 38.2m^3 × 750kWのモーター × 6台
原水導水管	—延長4.5 km、φ1,500㎜の本管で取水口から浄水場まで。
ラレ浄水場	—計画施設規模日量25万m^3(第1期日量10万m^3、第2期日量15万m^3)。
a) 受水／分水井	—RC造円形、滞流時間1分(約175m^3)。
b) 凝集・薬品沈でん池	—6池(内1池予備)。 —凝集剤として硫酸ばん土、補助剤にソーダ灰。
c) ろ過池	—重力式急速ろ過池30池。逆洗、表洗設備付。計画浄水量日量25万m^3。
d) 薬品貯蔵・注入設備	—ばん土、石灰、ソーダ灰の貯蔵および注入設備。
e) 管理本館	—屋上に洗浄水タンク設置。
送水ポンプ設備	—RC造上屋。 —9台の横軸タービン・ポンプ 毎分 17.4m^3 × 570kWのモーター × 3台 毎分 34.8m^3 ×1,100kWのモーター × 6台
送水本管	—総延長78 km : φ1,500, φ1,200, φ1,000 ㎜。 —5 km毎に制水弁。 —2 kmにつき約3個所の空気弁および排水設備。
減圧井およびワンウェイサージタンク	—調圧槽2個所。 —ラビ調整池(2万m^3)
配水池	—新マゼラス(3万m^3) —ヌダタトゥ(17万m^3)

施　　設	内　　容
	—カヤポンポ　（１０万　m^3）
	—ポイ　　（　２万　m^3）
	—タル　　（　２万　m^3）
	—マリアカニ　（　２万　m^3）
送　水　支　管	—φ６００㎜　……　２８,０００m
	—φ４５０㎜　……　１７,０００m
	—φ３５０㎜　……　５３,０００m
	—最大動水圧１２.５kg／cm^2　（水撃圧を含む）。

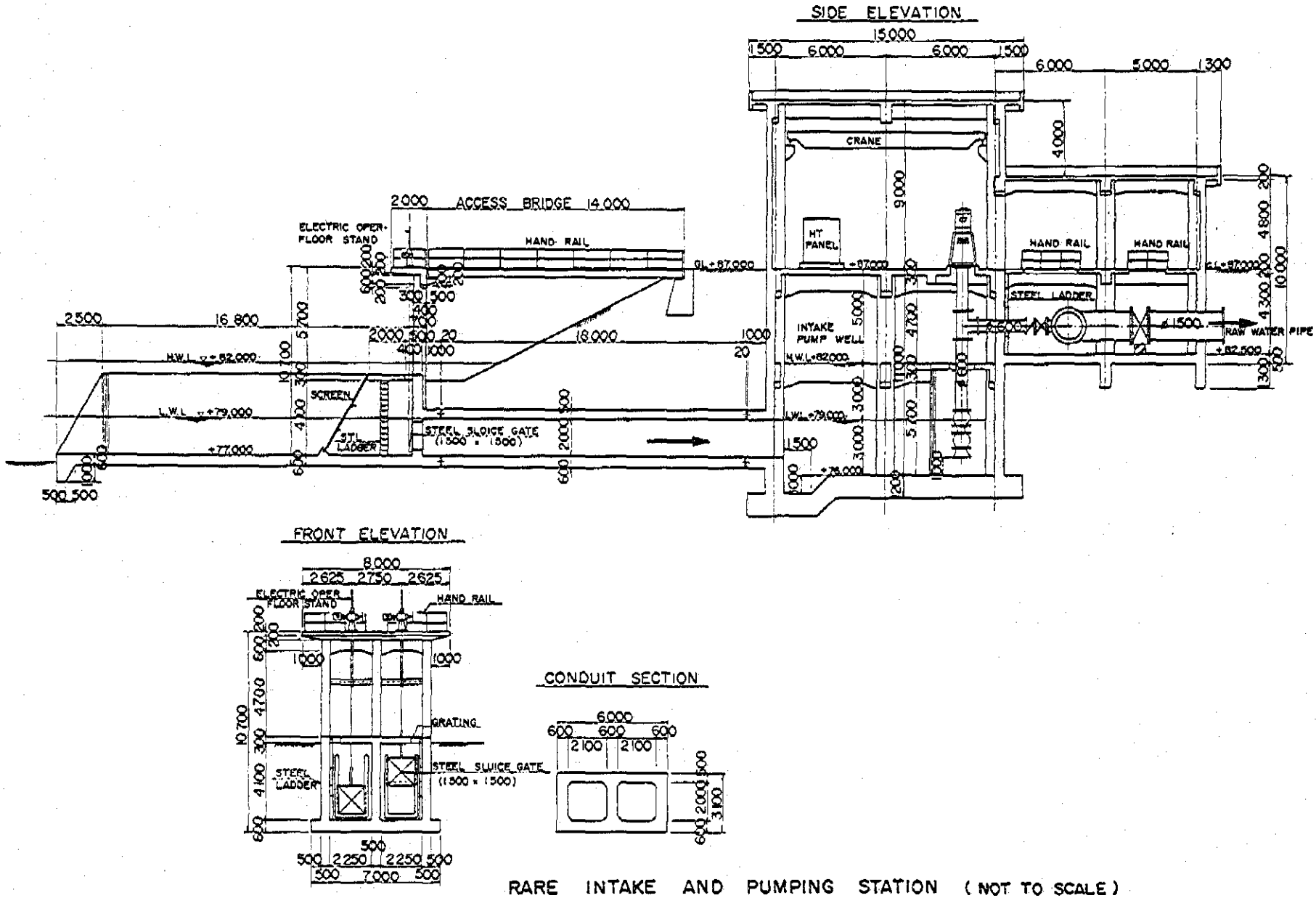


INTAKE PUMPS

Ø600 x 38.2 M3/MIN x 32 M x 750 KW x 980 RPM x 6 UNITS
Ø400 x 19.1 M3/MIN x 32 M x 390 KW x1470 RPM x 3 UNITS

RARE INTAKE AND PUMPING STATION GENERAL PLAN (NOT TO SCALE)

ANNEX 5406-2



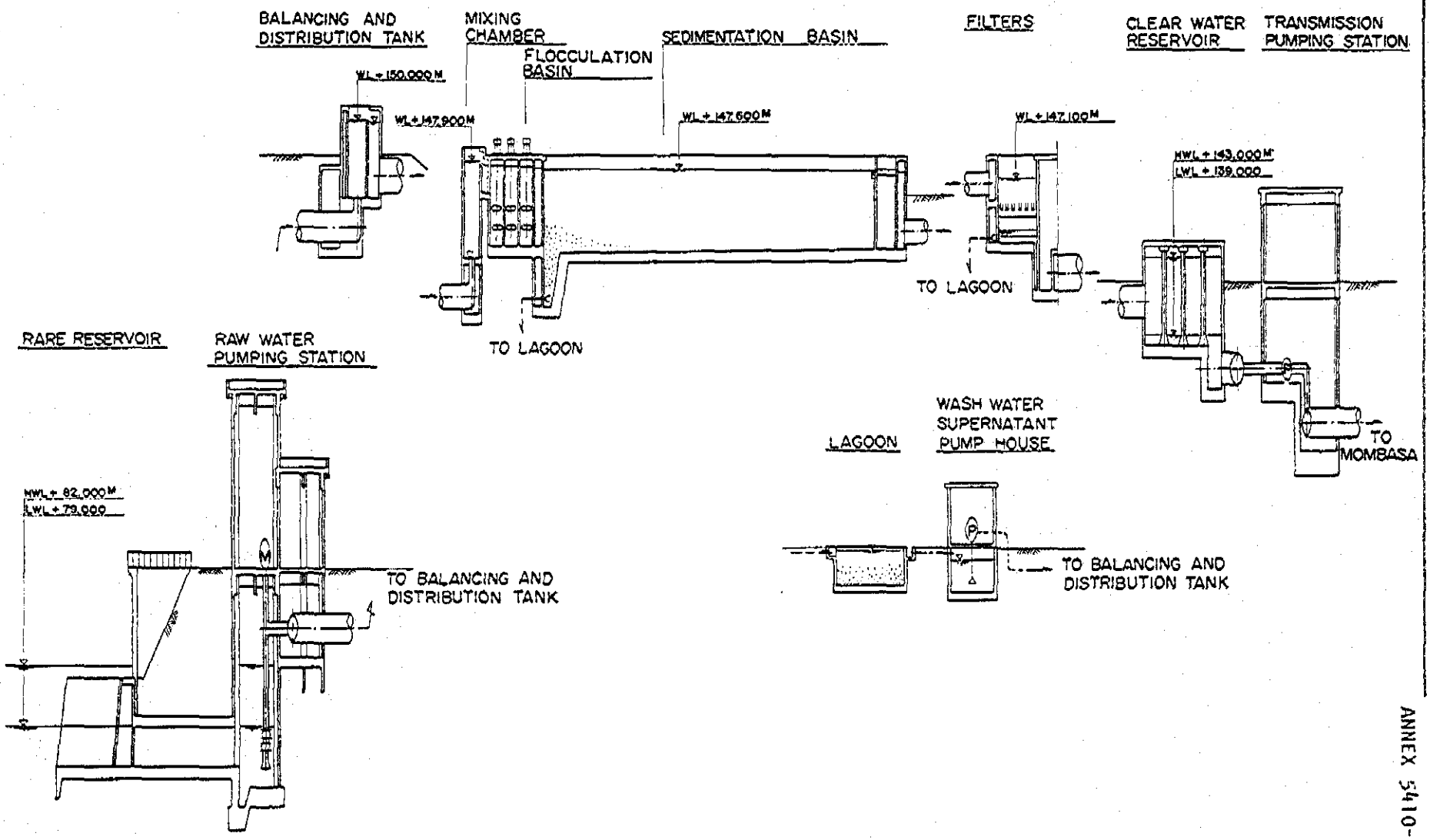
RARE INTAKE AND PUMPING STATION (NOT TO SCALE)

Water Quality Standard

(WHO and Japanese Standards for Drinking Water)

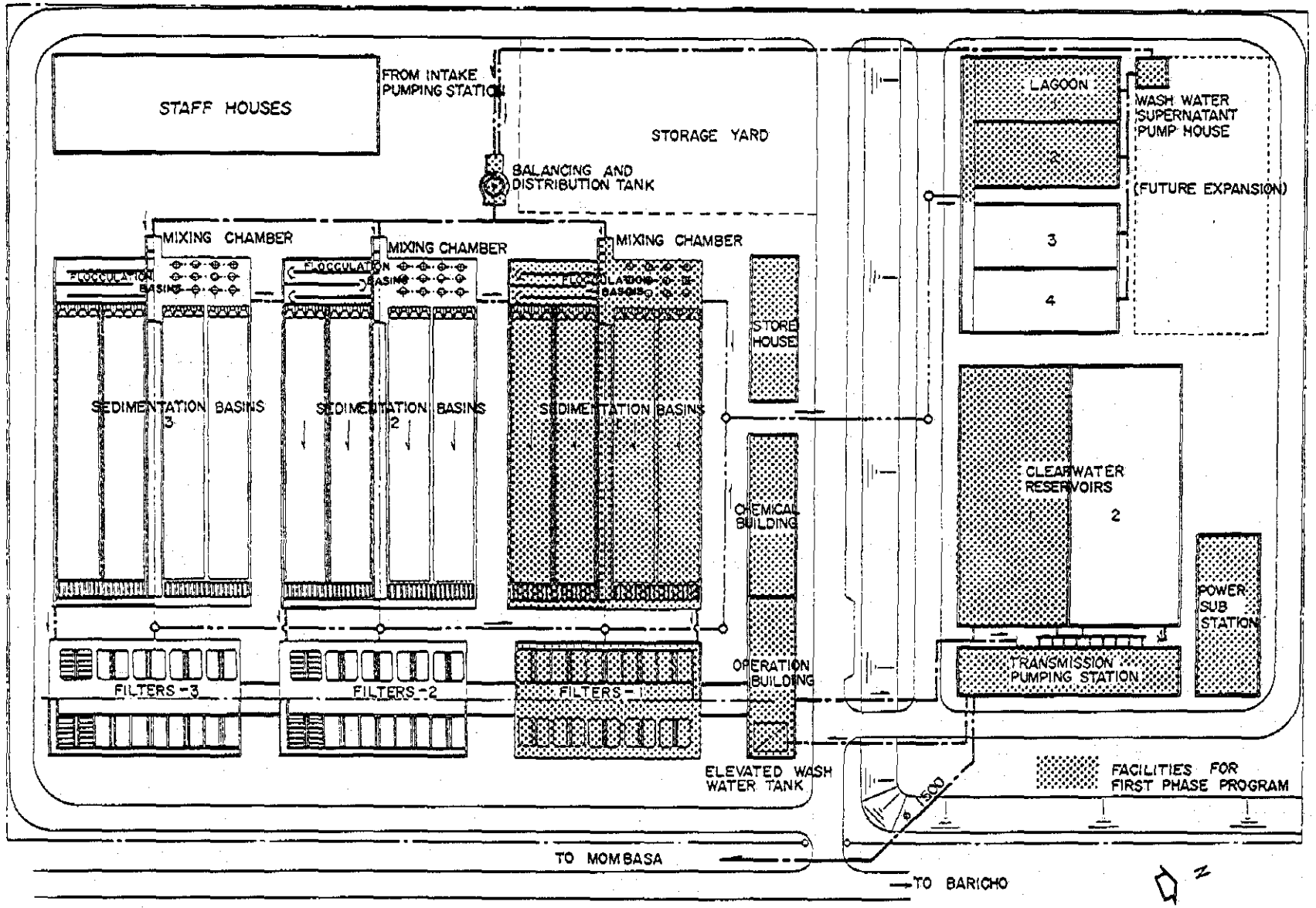
Substance or characteristic		WHO Standards Highest Desireble Level	WHO Standards Maximum permissible Level	Japanese Standards
Color as Pt.Co.	unit	5	50	Max. 5
Turbidity	FTU	5	25	Max. 2
Total Solids	mg/l	500	1500	Max. 500
pH		7-8.5	6.5-9.2	From max.8.6 to min.5.8 as pH value
Detergents	mg/l	0.2	1.0	-
Mineral Oil	mg/l	0.01	0.3	-
Phenol	mg/l	0.001	0.002	Max. 0.005
Total Hardness (as CaCO3)	mg/l	100	500	Max. 300
Calcium as Ca	mg/l	75	200	-
Magnesium as Mg	mg/l	30	150	-
Chloride as Cl2	mg/l	200	600	Max. 200
Copper as Cu	mg/l	0.05	1.5	Max. 1.0
Total Iron as Fe	mg/l	0.1	1.0	Max. 0.3
Manganese as Mn	mg/l	0.05	0.5	Max. 0.3
Sulfates as SO4	mg/l	200	400	-
Zinc as Zn	mg/l	5	15	Max. 1.0
Coliform Groups	/100 ml	-	-	Not to be detected
Total Bacteria	/1 ml	-	-	Max. 10

Note : The water quality is recommended to conform to criteria established by WHO. These criteria may be superseded by local standards.

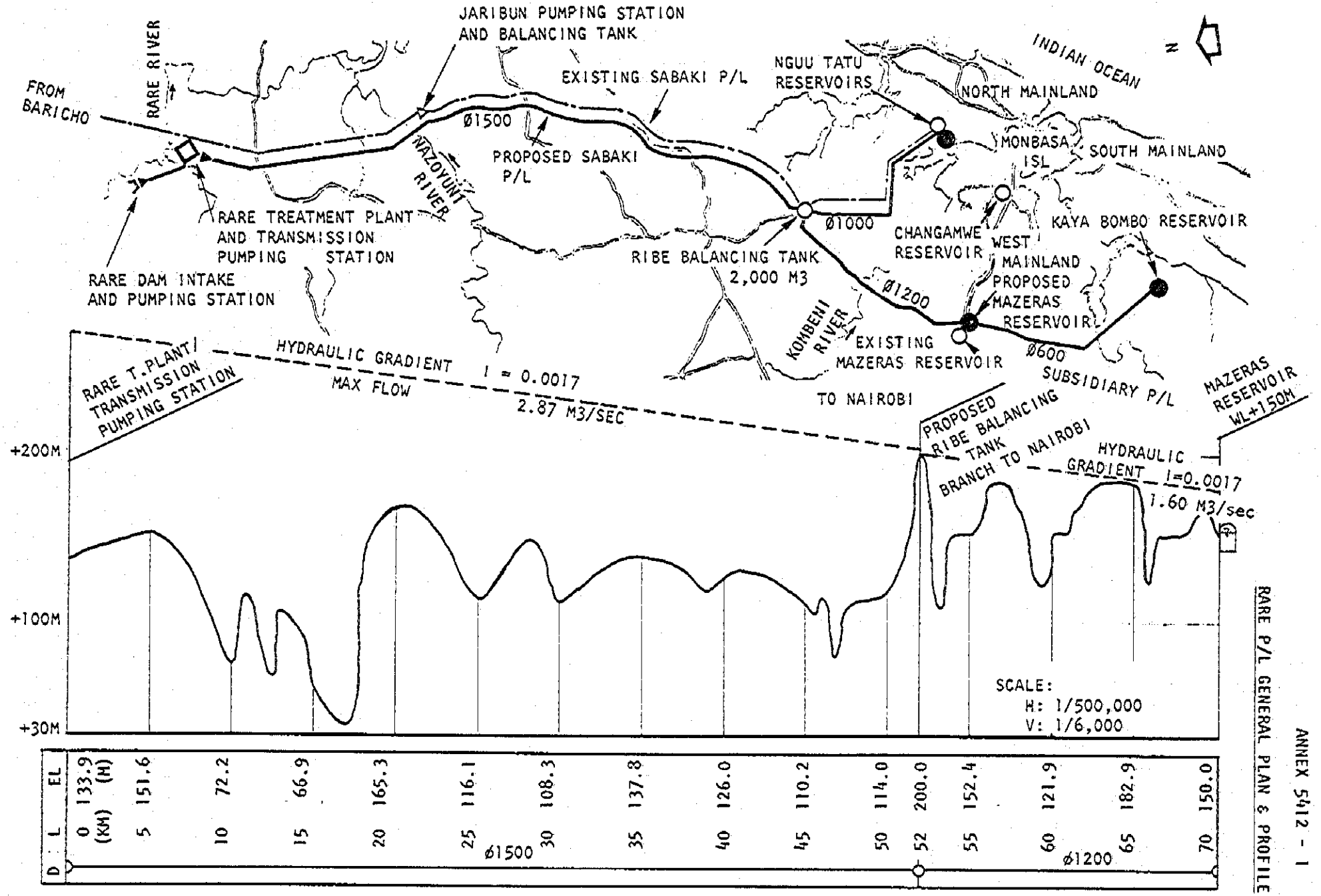


RARE TREATMENT PLANT FLOOR DIAGRAM (NOT TO SCALE)

ANNEX 5410-1



RARE TREATMENT PLANT GENERAL SITE PLAN (NOT TO SCALE)



RARE P/L GENERAL PLAN & PROFILE

ANNEX 5412 - 1

(RARE PLAN)

DISTRIBUTION RESERVOIR CONSTRUCTION SCHEDULE

	Location	System Name	Existing m^3	Provision in 2000 m^3	Total m^3
1.	Mazeras	Mzima P/L	81,000	-	81,000
2.	Changamwe	"	29,600	13,600 1/	43,200
3.	Nguu Tatu	Sabaki P/L	9,100	170,000	270,100
		Rare P/L	18,000		
4.	Voi	Mzima	580	10,000	10,580
5.	Kaya Bombo	Marere P/L	1,125	100,000	101,125
		Mwachi P/L			
6.	Tiwi	Tiwi B.H.	2,250	-	2,250
7.	Mazeras II	Mwachi P/L	-	30,000	30,000
8.	Taru	Mzima P/L	-	20,000	20,000
9.	Mariakani	"	-	20,000	20,000
10.	Ribe Tank	Rare P/L	-	20,000	20,000
	Total		141,660	383,600	525,260

Note: 1/ Sabaki P/L project.

MAIN FEATURES OF RARE RESERVOIR WITH P/L

Item	Development Scale 1.5 m^3/sec	2.5 m^3/sec
Dam		
Catchment (km^2)	1,500	1,500
Type of dam	rockfill	rockfill
Height (m)	31	33
Reservoir effective storage ($10^6/m^3$)	16.8	27.6
Fill volume ($10^3 m^3$)	306	380
Design flood (m^3/sec)	1,305	1,305
Diversion canal		
Length (km)	40	40
Excavation ($10^3/m^3$)	1,084	1,339
Capacity (m^3/sec)	8.0	13.3
Water supply facilities		
Pumping station (units)	2	2
Intake pumps (units) (@19.1 m^3/min)	3	3
(@38.2 m^3/min)	3	6
Transmission pumps (units) (@17.4 m^3/min)	3	3
(@34.8 m^3/min)	3	6
Raw water main P/L		
Diameter (mm) and length (km)	1,200mm-4.5km	1,500mm-4.5km
Treatment plant (@55,000 m^3/d) (units)	3	5
Transmission main P/L		
Diameter (mm) and length (km)	1,200mm-51km	1,500mm-51km
	1,000mm-18km	1,200mm-18km
	800mm- 9km	1,000mm- 9km

COST ESTIMATES OF RARE RESERVOIR WITH P/L

ECONOMIC COSTS

Unit: US$10^3

	Development scale, m^3/sec					
	1.5			2.5		
	L.C.	F.C.	Total	L.C.	F.C.	Total
Capital Cost						
A. Water Supply Facilities						
1. Pumping equipments	1,170	3,831	5,001	1,651	5,405	7,056
2. Raw water main P/L	1,368	2,240	3,608	1,682	3,332	5,014
3. Treatment plants	19,550	6,436	25,986	24,734	9,654	34,388
4. Transmission main P/L including trans. pumping st. and distribution res.	31,278	32,533	63,811	49,147	52,056	101,203
5. Communication equip.	300	800	1,100	300	800	1,100
6. Subsidiary P/L	4,170	7,467	11,634	5,549	9,936	15,485
B. Dam						
7. General items	3,003	1,307	4,310	3,282	1,457	4,739
8. Sabaki intake and diversion canal	17,530	7,195	24,725	19,661	8,175	27,836
9. Coffer dam and diversion channel	4,501	1,444	5,945	4,501	1,444	5,945
10. Main dam	3,418	3,130	6,548	4,076	3,649	7,725
11. Spillway	4,543	1,142	5,685	4,543	1,142	5,685
12. River outlet facilities	35	163	198	35	163	198
C. Engineering and Adm.	9,087	6,769	15,856	11,916	9,721	21,637
Base Cost Total	99,953	74,457	174,410	131,074	106,934	238,008
D. Physical Contingency	14,993	11,169	26,162	19,661	16,040	35,701
Capital Cost Total	114,946	85,626	200,572	150,735	122,974	273,709

ECONOMIC COSTS ESTIMATED FOR WATER FACILITIES AND CIVIL WORKS ON RARE RESERVOIR WITH P/L

Development Scale: 2.5 m^3/sec

	Items	Unit	Quantity	L. C. Unit Price (US$)	L. C. Amount (US$10^3)	F. C. Unit Price (US$)	F. C. Amount (US$10^3)
A.	Water Supply Facilities						
1.	Pumping Equipment (Intake/Transmission)	L.S.			1,651.0		5,405.0
2.	Raw Water Main P/L ø 1500	m	4,500	373.8	1,682.0	740.5	3,332.0
3.	Treatment Plant	L.S.			24,734.0		9,654.0
4.	Transmission Main P/L	m					
	ø 1500		51,000	373.8	19,063.8	740.5	37,765.5
	ø 1200	m	18,000	157.6	2,836.8	498.1	8,964.9
	ø 1000	m	9,000	126.5	1,138.5	351.6	3,164.6
	Power Supply Facilities	L.S.			3,112.3		2,160.0
	Reservoirs 30,000 m^3	units	8	1600x10^3	12,800.0		
	20,000 m^3	"	6	1400x10^3	8,400.0		
	10,000 m^3	"	1	750x10^3	750.0		
	Miscellaneous	L.S.			1,045.6		
	Sub-Total				49,147.0		52,056.0
5.	Communication Equipment	L.S.			300.0		800.0
6.	Subsidiary P/L ø600	m	28,000	101.8	2,850.4	179.1	5,015.3
	ø450	m	17,000	64.4	1,094.7	113.4	1,927.9
	ø350	m	43,000	37.3	1,603.9	69.6	2,992.8
	Sub-Total				5,549.0		9,936.0
B.	Dam						
7.	General Item	L.S.			3,282.0		1,457.0
8.	Sabaki intake and diversion channel						
	Excavation	m^3	1,338,500	6	8,031.0	3	4,015.5
	Stone pitching	m^2	722.600	2	1,445.2	1	722.6
	Sabaki intake	L.S.			7,000.0		2,500.0
	Miscellaneous	L.S.			3,184.8		936.9
	Sub-Total				19,661.0		8,175.0

	Items	Unit	Quantity	L. C.		F. C.	
				Unit Price	Amount	Unit Price	Amount
				(US$)	(US$10^3)	(US$)	(US$10^3)
9.	Cofferdam and diversion channel						
	Excavation	m^3	100,300	6	601.8	3	300.9
	Embankment	m^3	51,400	5	257.0	5	257.0
	Concrete	m^3	25,200	100	2,520.0	30	756.0
	Reinforcement bars	ton	760	900	684.0	80	60.8
	Miscellaneous	L.S.			438.2		69.3
	Sub-Total				4,501.0		1,444.0
10.	Dam						
	Excavation	m^3	201,400	6	1,208.4	3	604.2
	Embankment	m^3	381,800	5	1,909.0	5	1,909.0
	Concrete, in cap for grouting	m^3	1,100	100	110.0	20	22.0
	Curtain and blanket grouting	m	7,700	25	192.5	100	770.0
	Miscellaneous	L.S.			656.1		343.8
	Sub-Total				4,076.0		3,649.0
11.	Spillway						
	Excavation	m^3	94,000	6	564.0	3	282.0
	Backfill	m^3	2,600	1	2.6	0.50	1.3
	Concrete	m^3	30,700	100	3,070.0	20	614.0
	Reinforcement bars	ton	620	900	58.0	80	49.0
	Steel anchor bars	ton	210	1,300	273.0	700	147.0
	Miscellaneous	L.S.			75.4		48.1
	Sub-Total				4,543.0		1,142.0
12.	River outlet facilities	L.S.			35.0		163.0
	Grand Total				119,161		97,213

BREAKDOWN OF O&M COST ON RARE PLAN

Unit: US$10^3

Development Scale: 2.5 m^3/sec

Year	Proposed System Supply, m^3/d	Staff Salary	Chemical	Repair	Electricity	Total
1986	1,990	108.1	12.85	107.0	40.05	268.00
1987	5,510	⋮	35.62	⋮	110.91	361.63
1988	8,480	⋮	55.05	⋮	171.14	441.29
1989	12,000	⋮	77.67	⋮	241.53	534.30
1990	18,400	⋮	119.09	⋮	370.35	704.54
1991	28,000	⋮	193.65	⋮	602.19	1,010.94
1992	39,890	⋮	268.20	⋮	834.03	1,102.23
1993	52,000	⋮	342.76	⋮	1,065.86	1,623.72
1994	63,990	⋮	417.31	⋮	1,297.70	1,930.11
1995	75,990	210.7	491.87	⋮	1,529.54	2,339.11
1996	89,760	⋮	595.48	⋮	1,851.75	2,764.93
1997	106,010	⋮	699.09	⋮	2,173.95	3,190.74
1998	121,990	⋮	802.70	⋮	2,496.16	3,616.56
1999	138,000	⋮	906.31	⋮	2,818.36	4,042.37
2000	155,600	⋮	1,009.92	⋮	3,140.57	4,468.19
2001	170,490	⋮	1,087.56	⋮	3,382.01	4,787.27
2002	186,500	⋮	1,165.19	⋮	3,623.45	5,106.34
2003	202,480	⋮	1,242.83	⋮	3,864.90	5,425.43
2004	214,660	⋮	1,320.46	⋮	4,106.34	5,426.80
2005	216,000	⋮	1,398.10	⋮	4,347.78	6,063.58
⋮	⋮	⋮	⋮	⋮	⋮	⋮
2035	⋮	⋮	⋮	⋮	⋮	⋮

FINANCIAL COST ESTIMATES OF RARE RESERVOIR WITH RARE P/L

Unit: US$10^3
Development Scale: 2.5 m^3/sec

	Economic Costs			Sales Taxes	Financial Costs		
	L.C.	F.C.	Total	L.C.	L.C.	F.C.	Total
Capital Cost							
A. Water Supply Facilities							
1. Pumping equipments	1,651	5,405	7,056	634	2,285	5,405	7,690
2. Raw water main P/L	1,682	3,332	5,014	465	2,147	3,332	5,479
3. Treatment plants	24,734	9,654	34,388	3,553	28,287	9,654	37,941
4. Transmission main P/L including trans. pumping st. and distribution res.	49,147	52,056	101,203	9,859	59,006	52,056	111,062
5. Communication equip.	300	800	1,100	100	400	800	1,200
6. Subsidiary P/L	5,549	9,936	15,485	1,445	6,994	9,936	16,930
B. Dam							
7. General items	3,282	1,457	4,739	412	3,694	1,457	5,151
8. Sabaki intake and diversion canal	19,661	8,175	27,836	2,421	22,082	8,175	30,257
9. Coffer dam and diversion channel	4,501	1,444	5,945	517	5,018	1,444	6,462
10. Main dam	4,076	3,649	7,725	672	4,748	3,649	8,397
11. Spillway	4,543	1,142	5,685	494	5,037	1,142	6,179
12. River outlet facilities	35	163	198	17	52	163	215
C. Engineering and Adm.	11,916	9,721	21,637	2,059	13,975	9,721	23,696
Base Cost Total	131,074	106,934	238,008	22,648	153,722	106,934	260,656
D. Physical Contingency	19,661	16,040	35,701	3,397	23,058	16,040	39,098
Capital Cost Total	150,735	122,974	273,709	26,045	176,780	122,974	299,754
E. Price Contingency	-	-	-	-	111,487	40,758	152,245
F. Financial Cost Total	-	-	-	-	288,267	163,733	452,000

ANNEX 5507

RARE RESERVOIR WITH P/L PLAN

COST AND WATER VOLUME STREAMS

Unit: US$ 10^6
Development scale: 2.5 m^3/sec

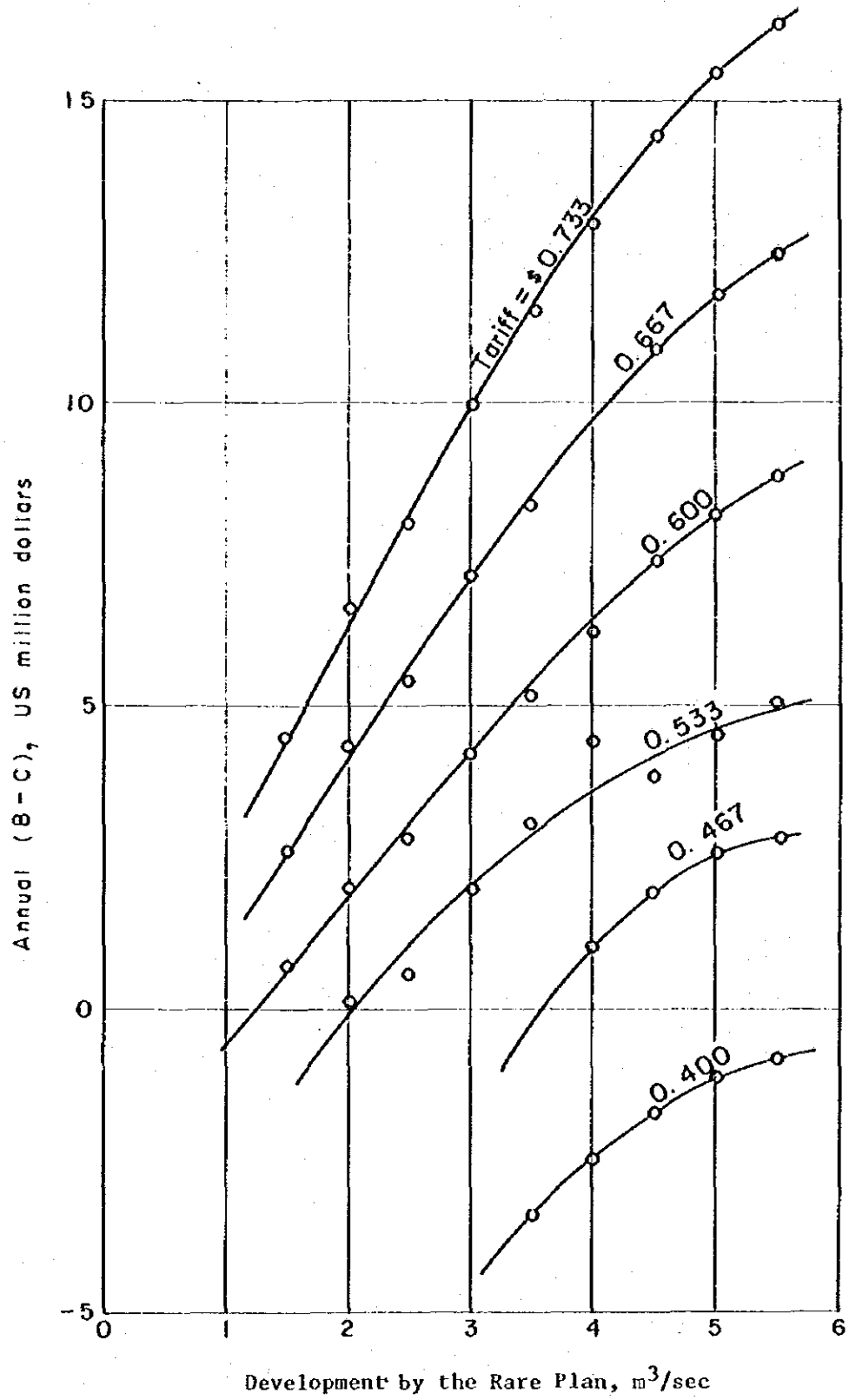
End of fiscal year	No.	Water volume $10^6 m^3$	Capital cost	O & M cost
1983	-3	-	34.3	-
84	-2	-	137.1	-
85	-1	-	57.1	-
86	1	0.73	-	0.3
87	2	2.01	-	0.4
88	3	3.01	-	0.4
89	4	4.38	-	0.5
1990	5	6.57	5.7	0.7
91	6	10.22	5.7	1.0
92	7	14.60	-	1.3
93	8	18.98	11.3	1.6
94	9	23.36	11.3	1.9
95	10	27.74	-	2.3
96	11	32.85	1.1	2.7
97	12	38.69	-	3.1
98	13	44.53	5.7	3.5
99	14	50.37	5.7	4.0
2000	15	56.21	-	4.5
01	16	62.23	4.3	4.8
02	17	68.07	-	5.1
03	18	73.91	-	5.4
04	19	78.57	-	5.7
05	20	78.84	2.1	6.1
06	21	⋮	3.1	⋮
07	22	⋮	-	⋮
08	23	⋮	-	⋮
09	24		-	

- to be continued -

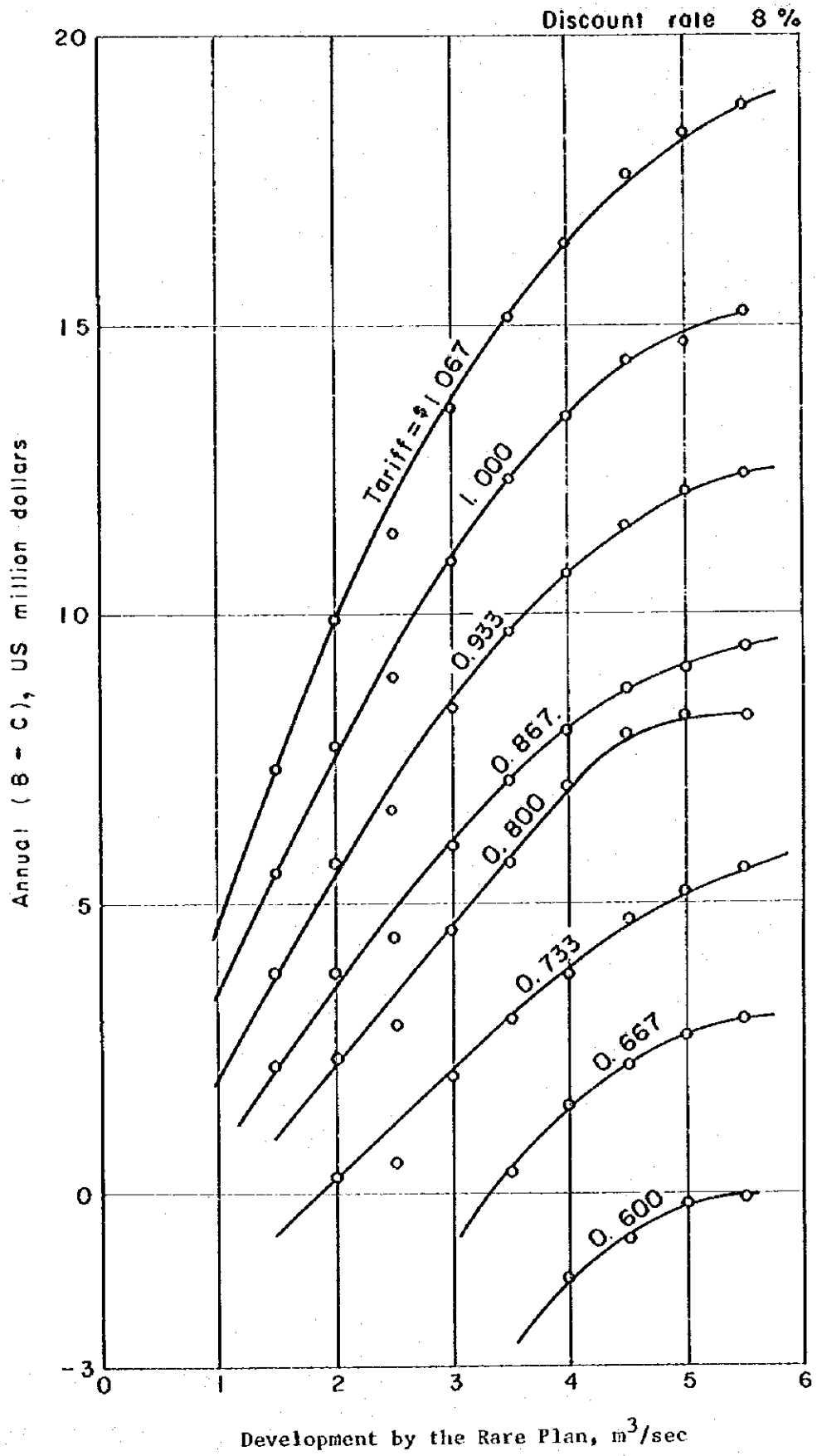
Unit: US$ 10^6
Development scale: 2.5 m^3/sec

End of fiscal year	No.	Water volume $10^6 m^3$	Capital cost	O & M cost
2010	25	78.84	5.2	6.1
11	26		1.1	
12	27		-	
13	28		-	
14	29		-	
15	30		4.0	
16	31		44.7	
17	32		-	
18	33		-	
19	34		-	
2020	35		1.1	
21	36		3.9	
22	37		-	
23	38		-	
24	39		-	
25	40		7.8	
26	41		69.5	
27	42		-	
28	43		-	
29	44		-	
2030	45		3.9	
31	46		-	
32	47		-	
33	48		-	
34	49		-	
2035	50	78.84	-	6.1

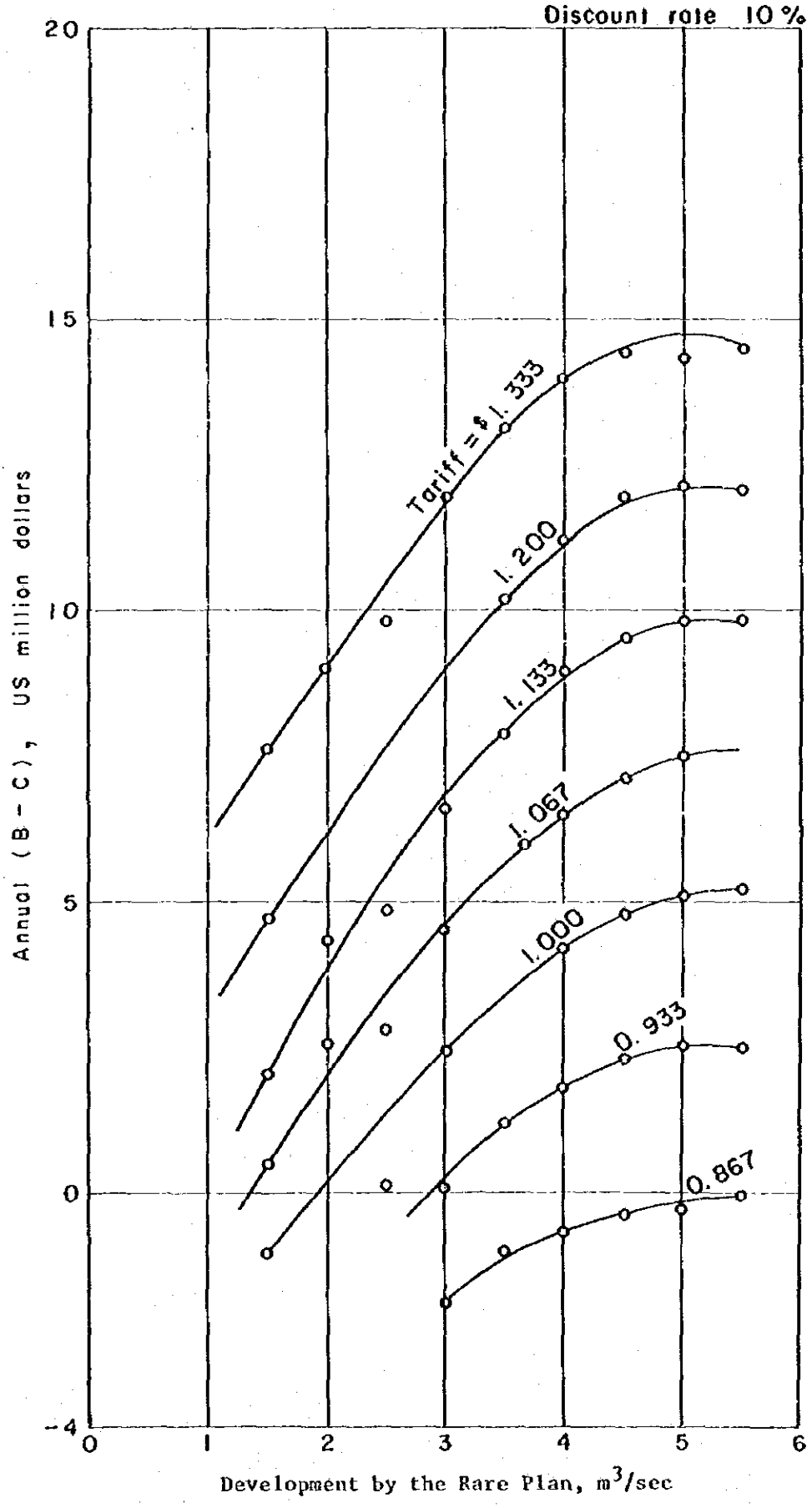
Discount rate 6 %



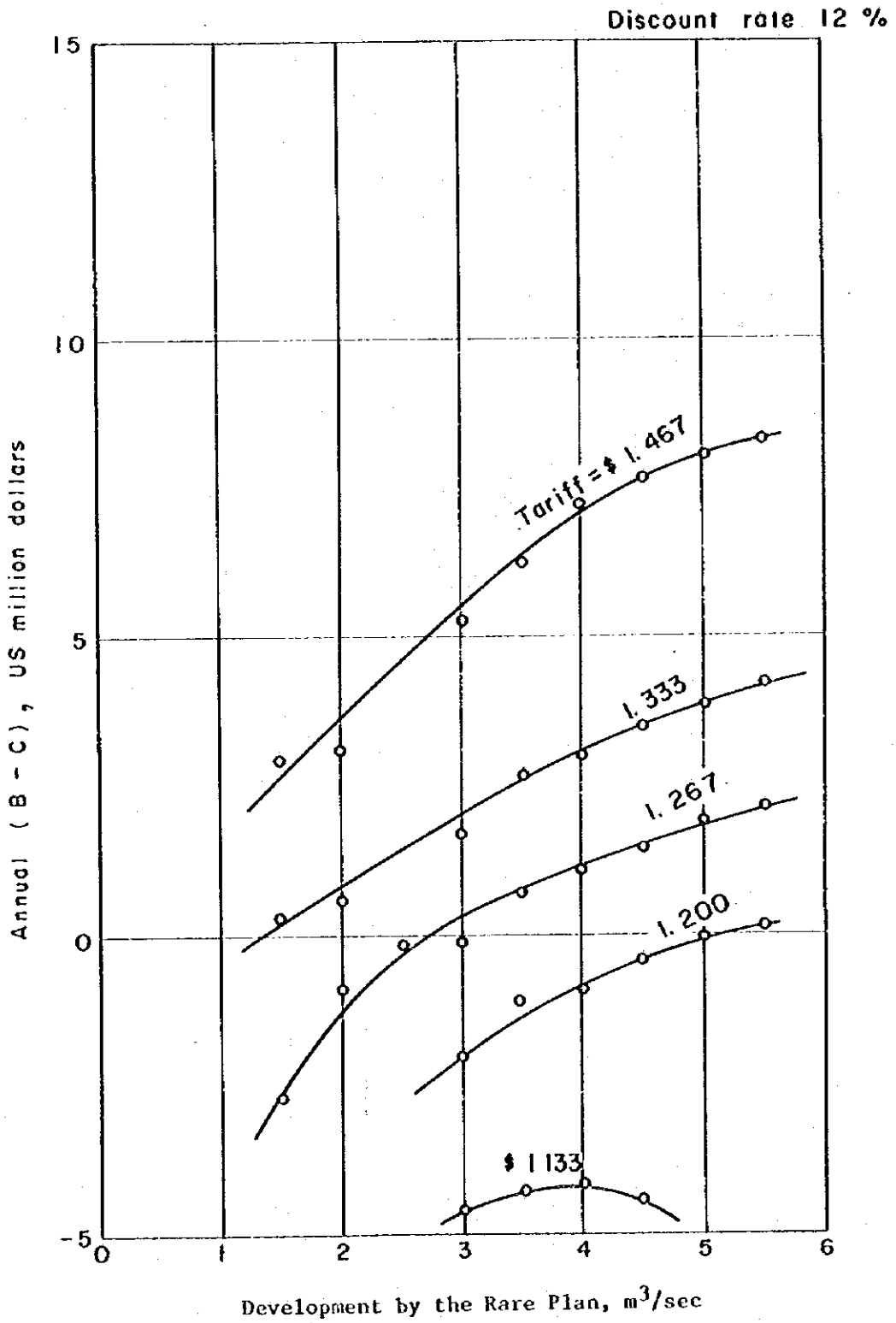
Movement of Optimal Development Scale
by Changing Toriff



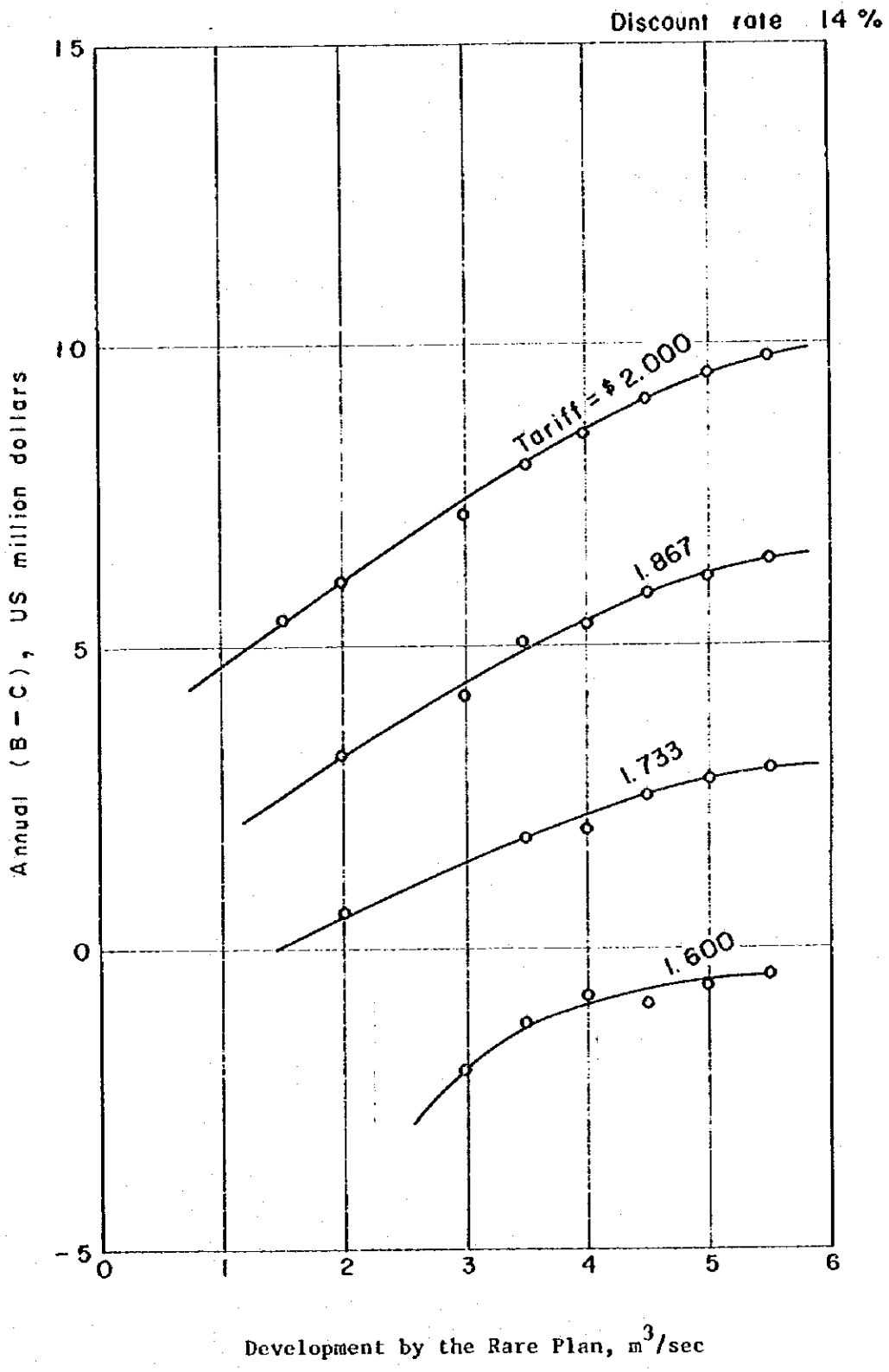
Movement of Optimal Development Scale by Changing Tariff



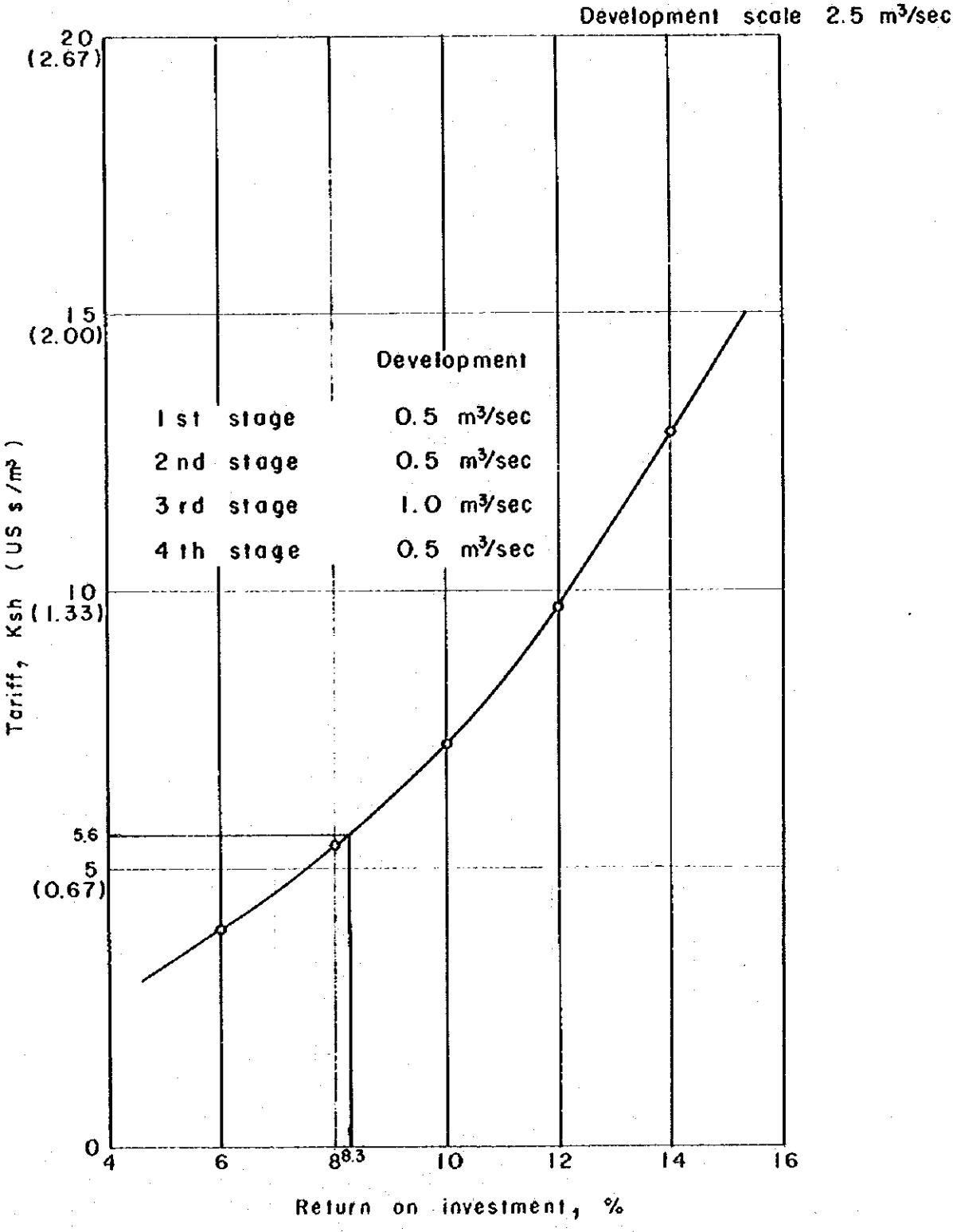
Movement of Optimal Development Scale by Changing Tariff



Movement of Optimal Development Scale by Changing Tariff

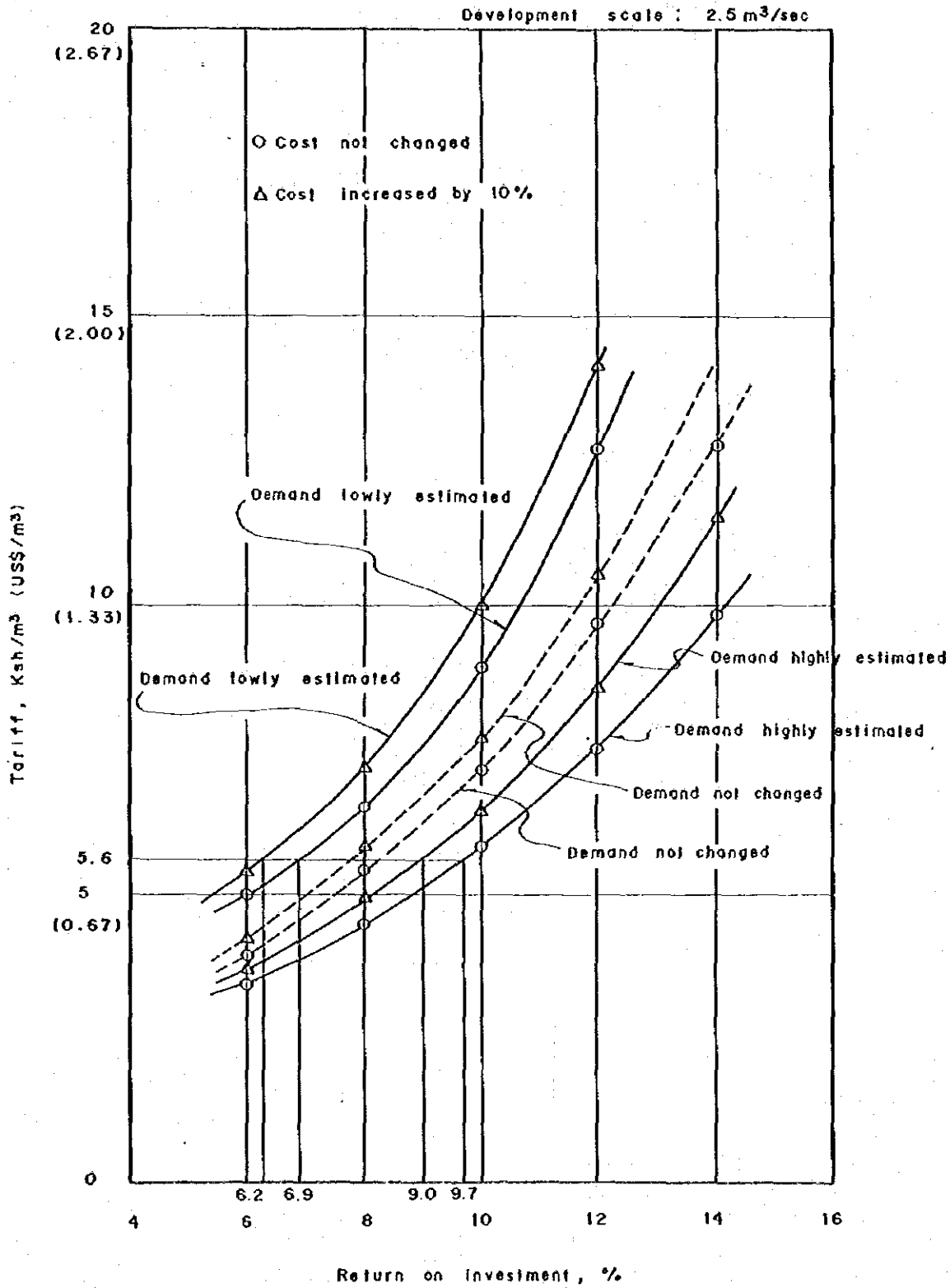


Movement of Optimal Development Scale by Changing Tariff



Return on Investment on the Development Scale of 2.5 m³/sec

(Rare Plan)



Sensitivity Tests for the Base Plan

RARE P/L WITH RARE RESERVOIR PLAN
(FIRST PHASE DEVELOPMENT)

FINANCIAL INTERNAL RATE OF RETURN

Unit: US$10^3

No.	Fiscal Year	Capital Cost F.C.	Capital Cost L.C.	O&M Cost	Gross Revenue	Net Benefit
1	1983	19,236	27,844	-	-	-47,080
2	1984	81,521	122,447	-	-	-203,968
3	1985	36,004	56,132	-	-	-92,136
4	1986	-	-	498	1,251	753
5	1987	-	-	673	3,463	2,790
6	1988	-	-	821	5,348	4,527
7	1989	-	-	994	7,542	6,548
8	1990	5,352	14,871	1,310	11,313	-10,220
9	1991	5,352	14,871	1,666	17,604	- 4,285
10	1992	-	-	2,118	25,146	23,028
11	1993	-	-	2,692	32,688	29,996
12	1994	-	-	3,422	40,230	36,808
13	1995	-	-	4,351	47,773	43,422
14	1996	(R) 5,859	1,866	4,904	53,846	41,217
15	1997	-	-	4,937	54,209	49,272
16	1998	-	-	⋮	⋮	⋮
17	1999	-	-	⋮	⋮	⋮
18	2000	-	-	⋮	⋮	49,272
19	2001	(R) 12,454	4,261	⋮	⋮	32,557
20	2002	-	-	4,937	54,209	49,272

Discount Rate	Net Benefit
0%	+110,317
2%	+6,154
3%	-33,195

FIRR = 2.2%

Remarks: (R) stands for Replacement Cost

PROJECTED INCOME STATEMENTS FOR RARE P/L WITH RARE RESERVOIR PLAN
(FIRST PHASE DEVELOPMENT)

Unit: US$10^3

No.	Year	Water Sold ($10\ m^3$)	Average Water Rate(Ksh/m^3)	Operating Revenue	Operating Expense		Income Before Interest	Interest Payment	Net Income
				Water Sales	O&M Cost	Depreciation			
1	1983	-	-	-	-	-	-	-	-
2	1984	-	-	-	-	-	-	-	-
3	1985	-	-	-	-	-	-	-	-
4	1986	690	13.6($1.813)	1,251	498	25,351	-24,598	11,264	-35,862
5	1987	1,910	⋮	3,463	673	⋮	-22,561	10,912	-33,473
6	1988	2,950	⋮	5,348	821	⋮	-20,824	10,545	-31,369
7	1989	4,160	⋮	7,542	994	⋮	-18,803	10,129	-28,932
8	1990	6,240	⋮	11,313	1,310	⋮	-15,348	9,698	-25,046
9	1991	9,710	⋮	17,604	1,666	⋮	- 9,413	9,235	-18,648
10	1992	13,870	⋮	25,146	2,118	⋮	- 2,323	9,581	-11,904
11	1993	18,030	⋮	32,688	2,692	⋮	4,645	9,029	- 4,384
12	1994	22,190	⋮	40,230	3,422	⋮	11,457	8,412	3,045
13	1995	26,350	⋮	47,773	4,351	⋮	18,071	7,762	10,309
14	1996	29,700	⋮	53,846	4,904	⋮	23,591	7,060	16,531
15	1997	29,900	⋮	54,209	4,937	⋮	23,921	6,734	17,187
16	1998	⋮	⋮	⋮	⋮	⋮	⋮	5,921	18,000
17	1999	⋮	⋮	⋮	⋮	⋮	⋮	5,039	18,882
18	2000	⋮	⋮	⋮	⋮	⋮	⋮	4,093	19,828
19	2001	⋮	⋮	⋮	⋮	⋮	⋮	3,076	20,845
20	2002	⋮	⋮	⋮	⋮	⋮	⋮	2,880	21,041

PROJECTED CASH FLOW FOR RARE P/L WITH RARE RESERVOIR PLAN (FIRST PHASE DEVELOPMENT)

Unit: $US\$10^3$

No.	Year	Income Before Interest	Depreciation	Foreign Loan	Government Equity	Total Source	Capital Cost		Debt Service		Total Application	Increase in Cash	Cash at End	Debt Service Coverage
							Foreign Currency	Local Currency	Interest	Principal				
1	1983	-	-	19,236	27,844	47,080	19,236	27,844	-	-	47,080	0	0	-
2	1984	-	-	81,521	122,447	203,968	81,521	122,447	-	-	203,968	0	0	-
3	1985	-	-	36,004	56,132	92,136	36,004	56,132	-	-	92,136	0	0	-
4	1986	-24,598	25,351	-	-	753	-	-	11,264	4,713	15,977	-15,224	-15,224	0.047
5	1987	-22,561	⋮	-	-	2,790	-	-	10,913	5,065	15,977	-13,187	-28,411	0.175
6	1988	-20,824	⋮	-	-	4,527	-	-	10,545	5,432	15,977	-11,450	-39,861	0.283
7	1989	-18,803	⋮	-	-	6,548	-	-	10,129	5,848	15,977	- 9,429	-49,290	0.410
8	1990	-15,348	⋮	5,352	14,871	30,226	5,352	14,871	9,698	6,279	36,200	- 5,974	-55,264	0.626
9	1991	- 9,413	⋮	5,352	14,871	36,161	5,352	14,871	9,235	6,742	36,200	- 39	-55,303	0.998
10	1992	- 2,323	⋮	-	-	23,028	-	-	9,581	7,578	17,159	5,869	-49,434	1.342
11	1993	4,645	⋮	-	-	29,996	-	-	9,029	8,130	17,159	12,837	-36,597	1.748
12	1994	11,457	⋮	-	-	36,808	-	-	8,412	8,747	17,159	19,649	-16,948	2.145
13	1995	18,071	⋮	-	-	43,422	-	-	7,762	9,397	17,159	26,263	9,315	2.531
14	1996	23,591	⋮	-	-	48,942	-	-	7,060	10,099	17,159	31,783	41,098	2,852
15	1997	23,921	⋮	-	-	49,272	-	-	6,734	11,011	17,745	31,527	72,625	2.777
16	1998	⋮	⋮	-	-	⋮	-	-	5,921	11,824	17,745	⋮	104,152	⋮
17	1999	⋮	⋮	-	-	⋮	-	-	5,039	12,706	17,745	⋮	135,679	⋮
18	2000	⋮	⋮	-	-	⋮	-	-	4,093	13,652	17,745	⋮	167,206	⋮
19	2001	⋮	⋮	-	-	⋮	-	-	3,076	14,669	17,745	31,527	198,733	2.777
20	2002	⋮	⋮	-	-	⋮	-	-	2,880	16,111	18,991	30,281	229,014	2.594

ANNEX 5304-3

RARE P/L WITH RARE RESERVOIR PLAN
(FULL DEVELOPMENT)

FIRR CALCULATION

No.	Fiscal Year	Capital Cost F.C.	Capital Cost L.C.	O&M Cost	Gross Revenue	Net Benefit
1	1983	19,236	27,844	-	-	-47,080
2	1984	81,521	122,447	-	-	-203,968
3	1985	36,004	56,132	-	-	-92,136
4	1986	-	-	498	1,251	753
5	1987	-	-	673	3,463	2,790
6	1988	-	-	821	5,348	4,527
7	1989	-	-	994	7,542	6,548
8	1990	5,352	14,871	1,310	11,313	-10,220
9	1991	5,352	14,871	1,666	17,604	- 4,285
10	1992	-	-	2,118	25,146	23,028
11	1993	4,067	17,417	2,692	32,688	8,512
12	1994	4,067	17,417	3,422	40,230	15,324
13	1995	-	-	4,351	47,773	43,422
14	1996	(R) 5,859	1,866	4,952	56,584	43,907
15	1997	-	-	5,636	66,646	61,010
16	1998	4,067	8,632	6,415	76,690	57,576
17	1999	4,067	8,632	7,302	86,752	66,751
18	2000	-	-	8,311	96,814	88,503
19	2001	(R) 12,454	4,261	8,834	107,185	81,636
20	2002	-	-	9,390	117,247	107,857

Discount Rate	Net Benefit
0%	+254,455
3%	+39,432
4%	-2,225

FIRR 3.95%

Remarks: (R) stands for Replacement Cost

PROJECTED INCOME STATEMENTS FOR RARE P/L WITH RARE RESERVOIR PLAN
(FULL DEVELOPMENT)

Unit: US$10^3

No.	Year	Water Sold (10 m^3)	Average Water Rate(Ksh/m^3)	Operating Revenue	Operating Expense		Income Before Interest	Interest Payment	Net Income
				Water Sales	O&M Cost	Depreciation			
1	1983	-	-	-	-	-	-	-	-
2	1984	-	-	-	-	-	-	-	-
3	1985	-	-	-	-	-	-	-	-
4	1986	690	13.6($1.813)	1,251	498	29,100	-28,347	11,264	-39,611
5	1987	1,910		3,463	673		-26,310	10,912	-37,222
6	1988	2,950		5,348	821		-24,573	10,545	-35,118
7	1989	4,160		7,542	994		-22,552	10,129	-32,681
8	1990	6,240		11,313	1,310		-19,097	9,698	-28,795
9	1991	9,710		17,604	1,666		-13,162	9,235	-22,397
10	1992	13,870		25,146	2,118		- 6,072	9,581	-15,653
11	1993	18,030		32,688	2,692		896	9,029	- 8,133
12	1994	22,190		40,230	3,422		7,708	8,412	- 704
13	1995	26,350		47,773	4,351		14,322	8,414	5,908
14	1996	31,210		56,584	4,952		22,532	7,693	14,839
15	1997	36,760		66,646	5,636		31,910	7,347	24,563
16	1998	42,300		76,690	6,415		41,175	6,514	34,661
17	1999	47,850		86,752	7,302		50,350	5,608	44,742
18	2000	53,400		96,814	8,311		59,403	5,290	54,113
19	2001	59,120		107,185	8,834		69,251	4,228	65,023
20	2002	64,670		117,247	9,390		78,757	3,983	74,774

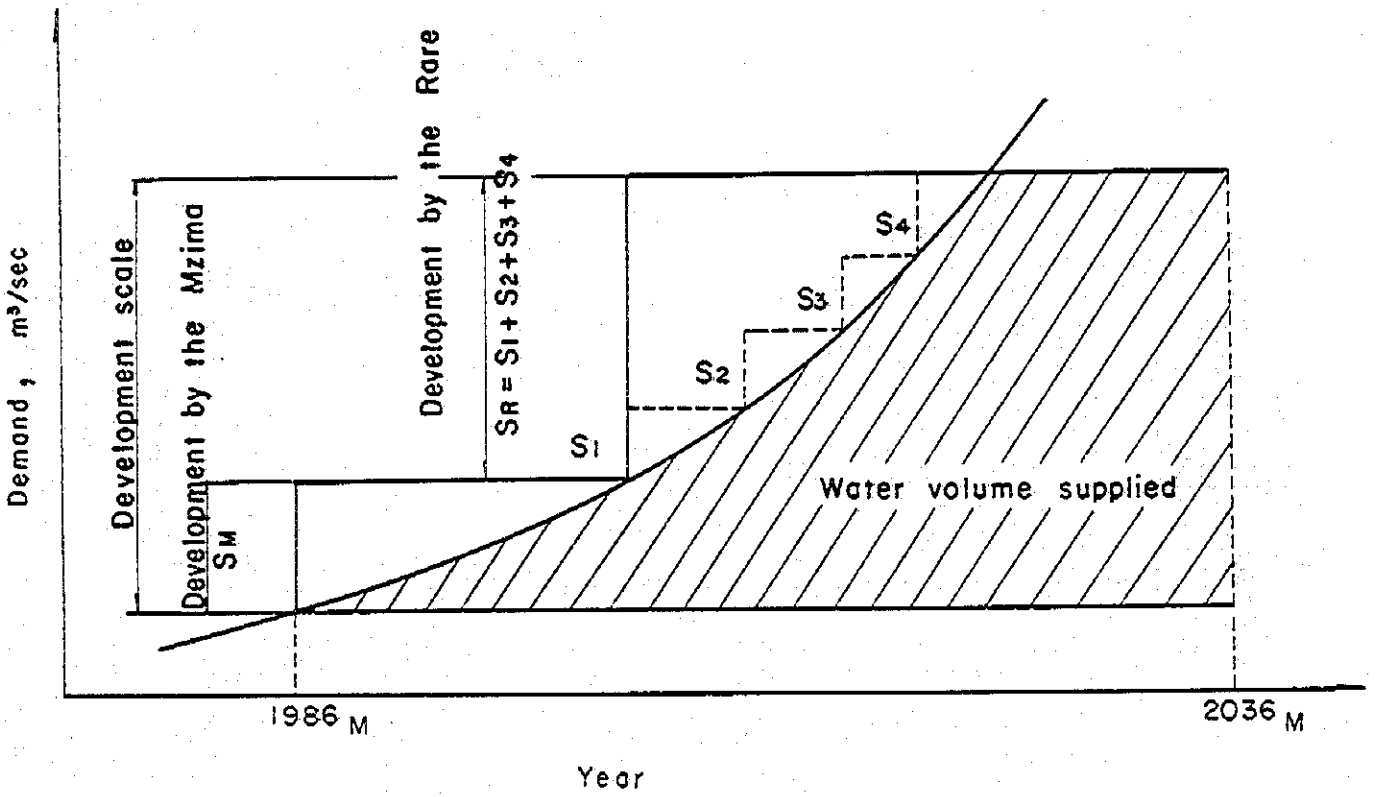
ANNEX 5706-1

PROJECTED CASH FLOW FOR RARE P/L WITH RARE RESERVOIR PLAN (FULL DEVELOPMENT)

Unit: US$10^3

No.	Year	Income Before Interest	Depreciation	Foreign Loan	Government Equity	Total Source	Capital Cost		Debt Service		Total Application	Increase in Cash	Cash at End	Debt Service Coverage
							Foreign Currency	Local Currency	Interest	Principal				
1	1983	-	-	19,236	27,844	47,080	19,236	27,844	-	-	47,080	0	0	-
2	1984	-	-	81,521	122,447	203,968	81,521	122,447	-	-	203,968	0	0	-
3	1985	-	-	36,004	56,132	92,136	36,004	56,132	-	-	92,136	0	0	-
4	1986	-28,347	29,100	-	-	753	-	-	11,264	4,713	15,977	-15,224	-15,224	0.047
5	1987	-26,310		-	-	2,790	-	-	10,912	5,065	15,977	-13,187	-28,411	0.175
6	1988	-24,573		-	-	4,527	-	-	10,545	5,432	15,977	-11,450	-39,861	0.283
7	1989	-22,552		-	-	6,548	-	-	10,129	5,848	15,977	- 9,429	-49,290	0.410
8	1990	-19,097		5,352	14,871	30,226	5,352	14,871	9,698	6,279	36,200	- 5,974	-55,264	0.626
9	1991	-13,162		5,352	14,871	36,161	5,352	14,871	9,235	6,742	36,200	- 39	-55,303	0.998
10	1992	- 6,072		-	-	23,028	-	-	9,581	7,578	17,159	5,869	-49,434	1.342
11	1993	896		4,067	17,417	51,480	4,067	17,417	9,029	8,130	38,643	12,837	-36,597	1.748
12	1994	7,708		4,067	17,417	58,292	4,067	17,417	8,412	8,747	38,643	19,649	-16,948	2.145
13	1995	14,322		-	-	43,422	-	-	8,414	9,643	18,057	25,365	8,417	2.405
14	1996	22,532		-	-	51,632	-	-	7,693	10,364	18,057	33,575	41,992	2.859
15	1997	31,910		-	-	61,010	-	-	7,347	11,296	18,643	42,367	84,359	3.273
16	1998	41,175		4,067	8,632	82,974	4,067	8,632	6,514	12,129	31,342	51,632	135,991	3.770
17	1999	50,350		4,067	6,632	92,149	4,067	8,632	5,608	13,035	31,342	60,807	196,798	4.262
18	2000	59,403		-	-	88,503	-	-	5,290	14,251	19,541	68,962	265,760	4.529
19	2001	69,251		-	-	98,351	-	-	4,228	15,313	19,541	78,810	344,570	5.033
20	2002	78,757		-	-	107,857	-	-	3,983	16,804	20,787	87,070	431,640	5.189

ANNEX 5706-2



Development Order and Scale of the Plans

ANNEX 6103

WATER SUPPLY AUGMENTATION PROJECT OF MOMBASA-COASTAL AREA-HINTERLAND

DISCOUNT RATE IN PERCENT 10

TARIFF,KSH (US DOLLAR) 6.50 (0.87)

STAGE DEVELOPMENT

DEVELOPMENT SCALE IN CMS	MZIMA PLAN 1	2	3	4	RARE PLAN 1	2	3	4	ANNUAL NET BENEFIT MIL. DOL.
3.0	0.	0.	0.	0.	0.5	0.3	1.2	1.0	-1.9
3.5	0.	0.	0.	0.	0.5	0.4	1.7	0.9	-1.1
4.0	0.	0.	0.	0.	0.5	1.8	1.3	0.4	-0.8
4.5	0.	0.	0.	0.	0.5	1.8	1.8	0.4	-0.4
5.0	0.	0.	0.	0.	0.5	1.8	2.5	0.4	-0.3
5.5	0.	0.	0.	0.	0.5	1.8	2.4	0.8	-0.1

ANNEX 6301-1

WATER SUPPLY AUGMENTATION PROJECT OF MOMBASA-COASTAL AREA-HINTERLAND

DISCOUNT RATE IN PERCENT 10

TARIFF,KSH (US DOLLAR) 7.00 (0.93)

STAGE DEVELOPMENT

DEVELOPMENT SCALE IN CMS	MZIMA PLAN 1	2	3	4	RARE PLAN 1	2	3	4	ANNUAL NET BENEFIT MIL. DOL.
3.0	0.	0.	0.	0.	0.5	0.4	1.2	0.9	0.5
3.5	0.	0.	0.	0.	0.5	0.4	1.7	0.9	1.2
4.0	0.	0.	0.	0.	0.5	1.6	0.9	1.0	1.8
4.5	0.	0.	0.	0.	0.5	1.6	1.4	1.0	2.3
5.0	0.	0.	0.	0.	0.5	1.6	1.9	1.0	2.5
5.5	0.	0.	0.	0.	0.5	1.6	2.4	1.0	2.5

ANNEX 6301-2

WATER SUPPLY AUGMENTATION PROJECT OF MOMBASA-COASTAL AREA-HINTERLAND

DISCOUNT RATE IN PERCENT 10

TARIFF,KSH (US DOLLAR) 7.50 (1.00)

STAGE DEVELOPMENT

DEVELOP-MENT SCALE IN CMS	MZIMA PLAN 1	2	3	4	RARE PLAN 1	2	3	4	ANNUAL NET BENEFIT MIL. DOL.
1.5	0.	0.	0.	0.	0.5	0.1	0.	0.9	-1.1
2.0	0.	0.	0.	0.	0.5	0.4	1.1	0.	0.7
2.5	0.	0.	0.	0.	0.5	0.4	1.0	0.6	0.8
3.0	0.	0.	0.	0.	0.5	0.4	1.2	0.9	2.4
3.5	0.	0.	0.	0.	0.5	0.4	1.7	0.9	3.4
4.0	0.	0.	0.	0.	0.5	1.4	0.9	1.2	4.2
4.5	0.	0.	0.	0.	0.5	1.4	1.2	1.4	4.8
5.0	0.	0.	0.	0.	0.5	1.4	1.6	1.5	5.1
5.5	0.	0.	0.	0.	0.5	1.4	2.1	1.5	5.2

ANNEX 6301-3

WATER SUPPLY AUGMENTATION PROJECT OF MOMBASA-COASTAL AREA-HINTERLAND

DISCOUNT RATE IN PERCENT 10

TARIFF,KSH (US DOLLAR) 8.00 (1.07)

STAGE DEVELOPMENT

DEVELOPMENT SCALE IN CMS	MZIMA PLAN 1	2	3	4	PARF PLAN 1	2	3	4	ANNUAL NET BENEFIT MIL. DOL.
1.5	0.	0.	0.	0.	0.5	0.1	0.1	0.8	0.5
2.0	0.	0.	0.	0.	0.5	0.4	0.7	0.4	2.6
2.5	0.	0.	0.	0.	0.5	0.4	1.0	0.6	2.8
3.0	0.	0.	0.	0.	0.5	0.4	1.2	0.9	4.5
3.5	0.	0.	0.	0.	0.5	0.4	1.7	0.9	5.6
4.0	0.	0.	0.	0.	0.7	1.2	0.9	1.2	6.5
4.5	0.	0.	0.	0.	0.7	1.2	1.2	1.4	7.1
5.0	0.	0.	0.	0.	0.7	1.2	1.6	1.5	7.5
5.5	0.	0.	0.	0.	0.7	1.2	1.7	1.9	7.7

ANNEX 6301-4

WATER SUPPLY AUGMENTATION PROJECT OF MOMBASA-COASTAL AREA-HINTERLAND

DISCOUNT RATE IN PERCENT 10

TARIFF,KSH (US DOLLAR) 8.50 (1.13)

DEVELOPMENT SCALE IN CMS	MZIMA PLAN 1	2	3	4	RARE PLAN 1	2	3	4	ANNUAL NET BENEFIT MIL. DOL.
	STAGE DEVELOPMENT								
1.5	0.	0.	0.	0.	0.5	0.1	0.2	0.7	2.0
2.0	0.	0.	0.	0.	0.5	0.4	0.5	0.6	4.3
2.5	0.	0.	0.	0.	0.5	0.4	1.0	0.6	4.7
3.0	0.	0.	0.	0.	0.5	0.4	1.0	1.1	6.6
3.5	0.	0.	0.	0.	0.5	0.4	1.3	1.3	7.9
4.0	0.	0.	0.	0.	0.5	0.4	1.6	1.5	8.9
4.5	0.	0.	0.	0.	0.5	0.4	1.6	2.0	9.5
5.0	0.	0.	0.	0.	0.5	0.4	1.8	2.3	9.8
5.5	0.	0.	0.	0.	0.5	0.4	2.3	2.5	9.8

ANNEX 6301-5

WATER SUPPLY AUGMENTATION PROJECT OF MOMBASA-COASTAL AREA-HINTERLAND

DISCOUNT RATE IN PERCENT 10

TARIFF/KSH (US DOLLAR) 9.00 (1.20)

STAGE DEVELOPMENT

DEVELOPMENT SCALE IN CMS	YZIMA PLAN 1	YZIMA PLAN 2	YZIMA PLAN 3	YZIMA PLAN 4	RARE PLAN 1	RARE PLAN 2	RARE PLAN 3	RARE PLAN 4	ANNUAL NET BENEFIT MIL. DOL.
1.5	0.	0.	0.	0.	0.5	0.4	0.7	0.4	4.6
2.0	0.	0.	0.	0.	0.5	0.4	0.5	0.6	6.1
2.5	0.	0.	0.	0.	0.5	0.4	1.0	0.6	6.6
3.0	0.	0.	0.	0.	0.5	0.4	1.0	1.1	8.7
3.5	0.	0.	0.	0.	0.5	0.4	1.5	1.3	10.2
4.0	0.	0.	0.	0.	0.5	0.4	1.6	1.5	11.2
4.5	0.	0.	0.	0.	0.5	0.4	1.6	2.0	11.9
5.0	0.	0.	0.	0.	0.5	0.4	2.1	2.0	12.1
5.5	0.	0.	0.	0.	0.5	0.4	2.5	2.1	12.1

ANNEX 6301-6

WATER SUPPLY AUGMENTATION PROJECT OF MOMBASA-COASTAL AREA-HINTERLAND

DISCOUNT RATE IN PERCENT 10

TARIFF/KSH (US DOLLAR) 10.00 (1.33)

STAGE DEVELOPMENT

DEVELOPMENT SCALE IN CMS	MZIMA PLAN 1	2	3	4	RARE PLAN 1	2	3	4	ANNUAL NET BENEFIT MIL. DOL.
1.5	0.	0.	0.	0.	0.5	0.4	0.3	0.3	7.6
2.0	0.	0.	0.	0.	0.5	1.5	0.	0.	9.0
2.5	0.	0.	0.	0.	0.9	1.0	0.6	0.	9.8
3.0	0.	0.	0.	0.	0.9	1.7	0.4	0.	11.9
3.5	0.	0.	0.	0.	0.9	2.2	0.4	0.	13.1
4.0	0.	0.	0.	0.	0.9	2.6	0.5	0.	14.0
4.5	0.	0.	0.	0.	0.9	3.0	0.6	0.	14.4
5.0	0.	0.	0.	0.	0.9	3.5	0.3	0.3	14.3
5.5	0.	0.	0.	0.	1.9	2.5	1.5	0.	14.8

ANNEX 6301-7

目的関数及びダイナミックプログラミング

1. 限りある資源が有効な方法で配分されているかどうかの問題は多くの分野で現われている。与えられた問題は簡単ではあるが、この簡単な問題を取り扱う時に多くの困難に遭遇する。

2. 上記の問題を解く為にはまず、問題を正確な数学的表現で表わさなければならない。問題は次の様に表わされる。

(1) $R(x_1, x_2, \cdots\cdots x_n) = g_1(x_1) + g_2(x_2) + \cdots\cdots + g_n(x_n)$

条件は

(2) (a) $x_1 + x_2 + \cdots\cdots + x_n = x$

(b) $x_i \geq 0$

ここに、x_iは i 番目の活動に割り当てられた資源の量を表わし、$g_i(x_i)$は i 番目の活動より得られる利益の関数である。又、R(・)は目的関数である。問題は式(1)を条件式(2)の下で最大にすることである。

3. 上記問題はラグランジェの演算子法(Lagrange multiplier)やリニアプログラミングによって解くことが考えられる。しかし、演算子法においては利益関数が関数形で表現されなければならない。たとえ関数形で表現されたとしても、実際に起る問題はくりかえし計算に直しがたい。リニアプログラミングにおいて、(1)及び(2)式の目的関数及び条件式は線形関数に表示されなければならない。ベルマン(R. E. Bellman)によって開発されたダイナミックプログラミング*と呼ばれる手法は演算子法やリニアプログラミングによって解くことが出来ない問題に応用することが出来るので、ダイナミックプログラミングを最適化問題に適用する。

4. ダイナミックプログラミングは古典的問題となった駅馬車問題によって説明される。100年前憶病なセールスマンが交戦的なインディアンの領地を旅行しなければならなかった。彼の出発地及び目的地は決められているが、このANNEX の4ページに示されるように、彼は通ることが出来るルートの組合わせによって旅行出来る。彼は最も安全なルートでインディアンの領地を旅行しようとしている。

---

* R.E.Bellman, Applied Dynamic Programming, Princeton University Press, Princeton New Jersey , 1962.

5. 数字がふられたブロック間に示された数字は駅馬車の乗客が生命保険に入るのに必要な費用である。最も安全なルートは生命保険にかかる費用が最も安いルートであると定義される。

6. 最も安いルートをみつけるのは、すべての通行可能なルートを調べることによってなされよう。しかし、問題が大きくかつ複雑な場合、最も安いルートのすべての可能なルートを評価することによって見出すことは不可能ではないが、多大な時間がかかる。計算時間を節約する為に、問題はダイナミックプログラミングによって解かれる。

7. ダイナミックプログラミングによる最も安価なルートを見つける手法は次の通りである。まず、番号がつけられたブロックはステート（State）と定義される。そして出発点から目的地までに５つのステージがある。最初のステージから２番目のステージの各ステートへ行く最も安価なルートは1－2，1－3及び1－4の様に一義的に決められる。生命保険にかかる費用はブロックの中のかっこを持った数字で示される。第２番目のステージから第３番目のステージのステート５へ進む最も安価なルートは、第２番目ステージの各ステートまでにかかる最も安価な費用と、第２番目のステージの各ステートからステート５へかかる当座の費用の合計を比較することによって得られる。その結果、ステート５に来る最も安価なルートは1－2－5であり、費用は５である。

8. 上記手法によって、各ステージの各ステートへの最も安価なルートは得られる。第４番目のステージからステート１０に来るには唯一の道しかなく、その結果ステート１からステート１０への最も安価なルートは決定され、そのルートは逆方向の矢印によって跡をおうことができる。

9. プロジェクトから生ずる利益とプロジェクトにかかる費用の差を最大にする目的関数は次の様に表現される。

$$\max \sum_j \sum_i (B_{ij} - C_{ij})$$

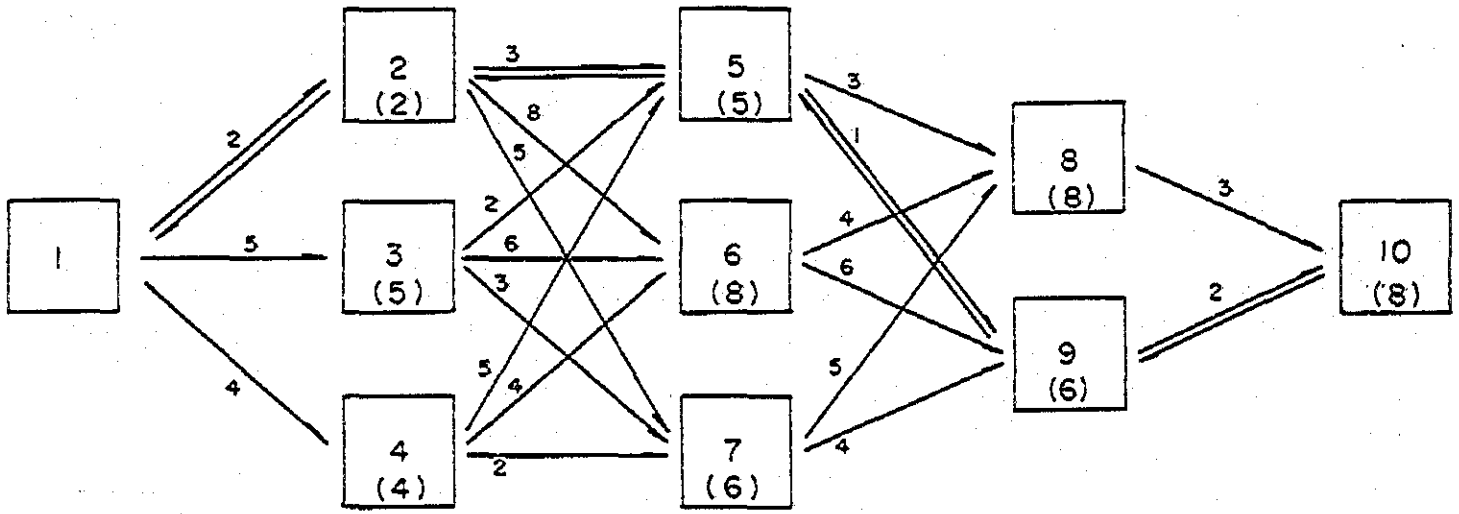
条件は

$$\sum_i x_{ij} \leq x_{ij} \quad , \quad \sum_j \sum_i x_{ij} \leq Y \quad 及び$$

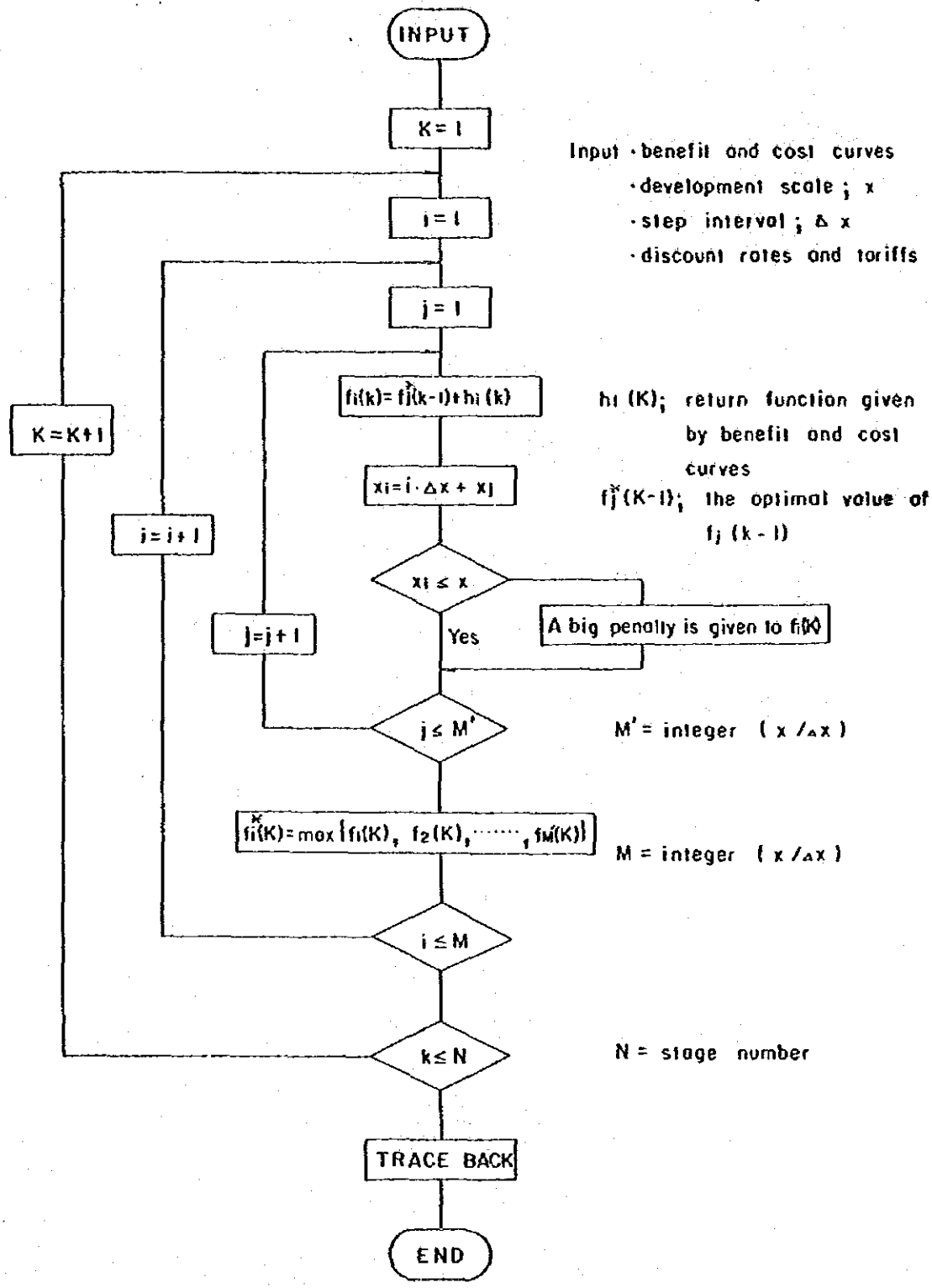
$$x_{ij} \geq 0$$

ここに、x_{ij}はj案におけるiステージの開発規模であり、x_jは j案の物理的限界である。任意に選ばれた開発規模Yに対して、最大純利益が求められる。上記の式の最大値を求めるのは無数の組合わせが考えられるのでむずかしい。この状態に打勝つ為にダイナミックプログラミングが適用される。

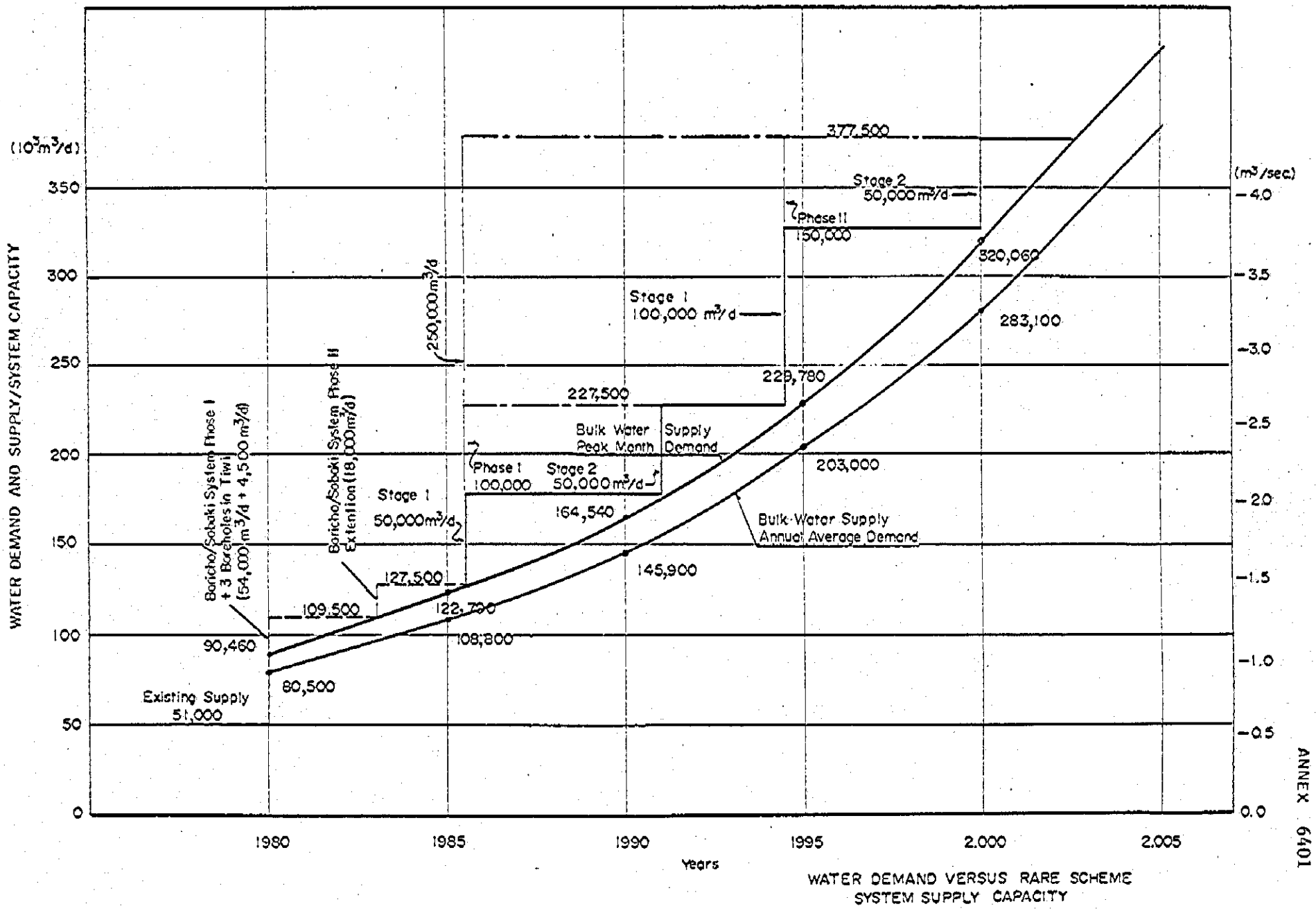
10. この最適化問題のコンピュータープログラムが作られた。そのフローチャートはこのANNEXの5ページに示される。



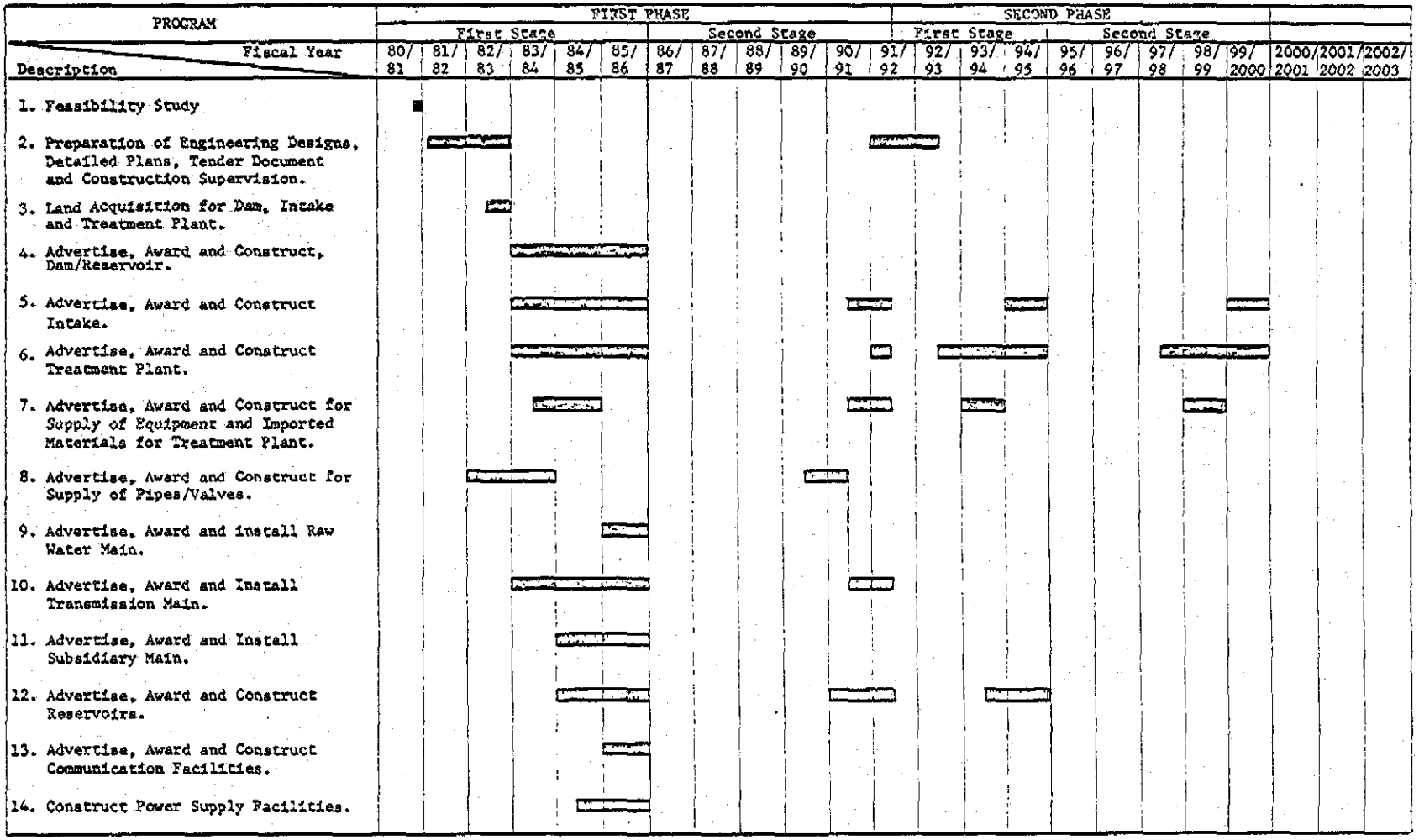
Transportation Routes of Stagecoach



Flow Chart of Dynamic Programing


WATER DEMAND AND SUPPLY/SYSTEM CAPACITY
($10^3 m^3/d$)
(m³/sec)
350
300
250
200
150
100
50
0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2.000
2.005
Years
377,500
Stage 2
50,000 m³/d
Phase II
150,000
320,060
Stage 1
100,000 m³/d
250,000 m³/d
283,100
229,780
227,500
Bulk Water
Peak Month
Supply
Demand
Phase I
100,000
Stage 2
50,000 m³/d
203,000
Stage 1
50,000 m³/d
164,540
Bulk Water Supply
Annual Average Demand
Baricho/Sobaki System Phase I
+ 3 Bacholes in Tiwi
(54,000 m³/d + 4,500 m³/d)
Baricho/Sobaki System Phase II
Extention (18,000 m³/d)
127,500
109,500
122,700
145,900
90,460
108,800
80,500
Existing Supply
51,000
WATER DEMAND VERSUS RARE SCHEME
SYSTEM SUPPLY CAPACITY
ANNEX 6401

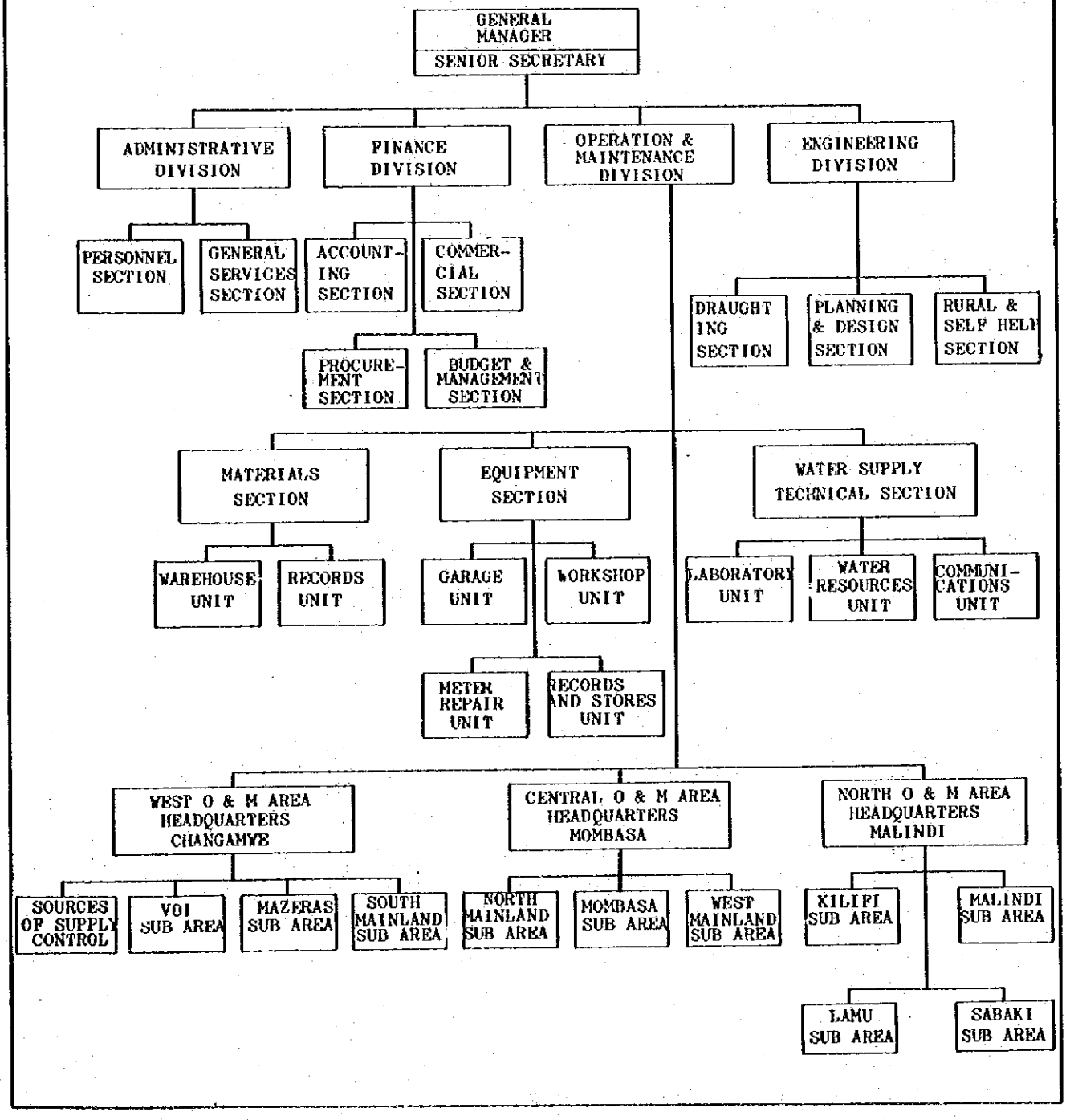
DEVELOPMENT SCHEDULE OF RARE PLAN



ANNEX 6404

ANNEX 6503

COAST PROVINCE WATER BRANCH ORGANIZATION



MINISTRIES AND AGENCIES INVOLVED IN COMMUNITY WATER SUPPLIES

a. The Nairobi City Council is responsible for the water supply and sewage systems of Nairobi.

b. Five municipalities and two county councils operate their urban water supply systems under the direction of the Ministry of Local Government.

c. Several hundred small rural water supply schemes are operated by county councils.

d. The Kenya Railways operates about 100 water schemes supplying staff houses and adjacent villages.

e. The President's Office plans and budgets water supplies for new settlement areas, usually with the Water Engineering Department of MOWD as the executing agency.

f. The Ministry of Cooperative Development administers government grants to all self-help schemes in rural areas.

g. The Ministry of Health is responsible for potable water supply quality surveillance from the community-health point of view.

MAIN FEATURES OF THE SECOND MZIMA PLAN AND THE RARE PLAN

	Items	Second Mzima Plan	Rare Plan
I.	Development Scale (m^3/s)	1.2	2.5
II.	Dam and Reservoir		
	Catchment Area (km^2)	4,050	1,500
	Type of Dam	Rockfill	Rockfill
	Height of Dam (m)	34	33
	Reservoir Effective Storage (10^6m^3)	21	27.6
	Fill Volume (10^3m^3)	450	380
	Design Flood (m^3/s)	1,550	1,305
III.	Diversion Canal		
	Length (km)	-	40
	Excavation (10^3m^3)	-	1,339
	Capacity (m^3/s)	-	13.3
IV.	Water Supply Facilities		
	Raw Water Main P/L		
	Diameter (mm) & Length (km)	-	1,500mm - 4.5km
	Transmission Main P/L		
	Diameter (mm) & Length (km)	1,350mm - 86km 1,100mm - 43km 1,000mm - 88km	1,500mm - 51km 1,200mm - 18km 1,000mm - 9km
	Pumping Station (unit)	-	2
	Treatment Plant (@55,000m^3/d)(unit)	-	5
V.	Costs/1		
	Economic Cost (US$ million)	270	274
	Foreign Currency Portion	163	123
	Local Currency Portion	107	151

Items	Second Mzima Plan	Rare Plan
Financial Cost[/2] (US$ million)	421	452
Foreign Currency Portion	214	164
Local Currency Portion	207	288
O&M Cost[/3] (Economic) (US$10^3)	101	6,064
VI. Evaluation		
Return on Investment[/4] (%)	5.5	8.3
FIRR[/5] (%)	3.4	4.0

/1 Excluding replacement cost.

/2 Excluding replacement cost and interest during construction.

/3 Under full supply conditions.

/4 When the estimated water rate of 5.6 KSh/m^3 is applied to evaluate the water at the outlet of distribution reservoir.

/5 When the water rate of 13.6 KSh/m^3 is applied under the same conditions as mentioned in /4.