

REPUBLIC OF KENYA



MINISTRY OF WATER DEVELOPMENT

WATER RESOURCES ASSESSMENT PROJECT

SHORT NOTE

ON

PROSPECTS FOR WATER DEVELOPMENT

IN

WEST POKOT

MAY 1985

WATER RESOURCES BRANCH
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SUMMARY

This short note gives a brief account of the results of a water resources assessment study of West Pokot.

The number of existing water supplies is limited. Only 10 - 30% of the demand is met. In 1983 the demand for domestic use was 1.85 million m³/year: this will rise to 3.85 million m³/year by 2000. The demand for water for livestock in the year 2000 will be the same as in 1984, i.e. 3.24 million m³/year.

There is ample potential for developing surface water. To ensure a safe water supply for livestock, 90 - 100 small reservoirs can be constructed at a cost of KShs 100 000 to 200 000 each.

Small-scale irrigation is possible by extending the traditional system of damming small streams, or by constructing sand dams at suitable locations in which shallow wells with hand pumps can be installed. For proper site location and design, however, detailed investigations are still required.

Groundwater resources are limited. The total development potential is restricted to 4 million m³ per year.

Approximately 1.0 million m³ can be produced annually from the alluvial aquifers along the major streams. The exploitable amount from localized aquifers in weathered or fractured Basement rocks is estimated to be 3 million m³/year, requiring moderately deep boreholes equipped with hand pumps, costing approximately KShs 80 000 each. Detailed hydrogeological and geophysical site investigations are required in all locations where boreholes are planned.

TABLE OF CONTENTS

	Page
SUMMARY	i
1. INTRODUCTION	1
1.1 General	1
1.2 Physical features and climate	1
1.3 Water supply and demand	3
2. SURFACE WATER RESOURCES	9
3. POTENTIAL FOR DEVELOPING SURFACE WATER	12
4. GROUNDWATER RESOURCES	13
4.1 Groundwater conditions in the Basement rocks	13
4.2 Groundwater in fluviatile deposits	15
5. POTENTIAL FOR DEVELOPING GROUNDWATER	18
6. CONCLUSIONS	19
7. REFERENCES	19
Figure 1: Location map	2
2: Hydrogeology of Basement rock	16
Table 1: Rainfall data	4
2: Water supplies in West Pokot	6
3: Livestock data	7
4: Population data	8
5: Water demand 1984 - 2000	9
6: Annual runoff data	11
7: Borehole data	13
8: Chemical data on water from boreholes	17
Plate 1: Water availability map	

1. INTRODUCTION

1.1 General

A water resources assessment study of West Pokot was made as part of the co-operation between the Ministry of Water development and TNO-DGV Institute of Applied Geoscience, the Netherlands. This Short Note gives a brief account of the results of the investigations, with emphasis on the potential for water development. Full particulars are reported in:

Ministry of Water Development, Water Resources Assessment Study West Pokot, Main Report; Nairobi, 1984 (MoWD, 1984^a).

The investigated area, located between lat. 1°10' and 1°55'N and long. 34°50' and 35°45'E, covers the southern 6000 km² of West Pokot district. It includes Sigor, Chepararia and Kapenguria Divisions and the southern part of Kacheliba Division (Fig. 1). It has 150 000 inhabitants at present. It borders Uganda in the west, Trans Nzoia and Elgeyo-Marakwet Districts in the south, and Baringo and Turkana Districts in the east. The northern boundary is formed by the Kanyangareng and Suam Rivers.

1.2 Physical features and climate

High elevated areas notably the Cherangani Hills (3370 m above msl), the Sekerr Mountains (3325 m above msl) and isolated hills (up to 2300 m above msl) between the Iyon and Muruny Rivers separate the West Pokot Lowlands or Suam plains with an elevation of 1500 - 1200 m above msl from the Wei Wei and Kerio Lowlands (1200 - 900 m above msl). The latter two are separated by the Masol Range. The area is part of the Turkwell/Wei Wei drainage system. Only the extreme eastern part is drained by the Kerio River.

Nearly the whole project area lies on crystalline rocks of the Basement System ("Mozambique Belt"). They include gneisses, quartzites, schists and marbles, amphibolites and amphibolite schists. Tertiary sediments in the form of the Turkana grits series are found in a large belt northwest

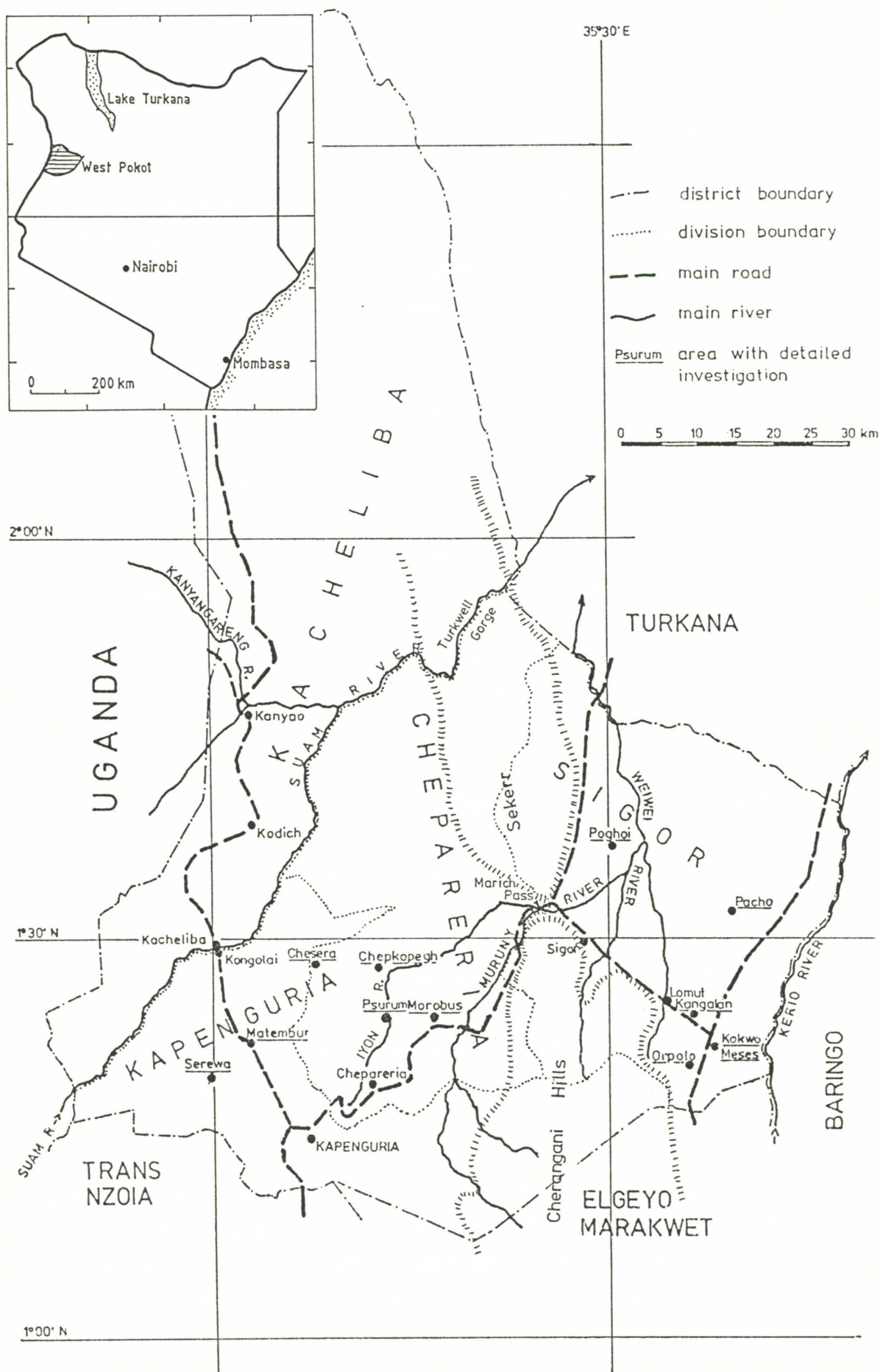


FIGURE 1 WEST POKOT PROJECT AREA

of Lomut. Quaternary deposits are restricted to alluvial sediments along the main rivers.

The major faults run north-south and are related to the formation of the Rift Valley. The Landsat images show a very complex pattern of lineaments running south-north or west-east. These lines are interpreted as being minor faults or fractures.

The climatic conditions in the project area are strongly affected by the variation in altitude. Two distinct climatic zones can be distinguished:

- a. The "modified tropical climate" zone that covers the Cherangani Hills and Mount Elgon regions. It is characterized by low temperatures (annual maximum temperature ranges from 5° - 25°C at higher altitudes, to 10° - 35°C at low levels), low evaporation (less than 1800 mm/year) and high annual rainfall (ranging from 1600 mm/year at high altitudes to 900 mm at lower levels).
- b. The semi-arid climate zone covers the rest of the region, except where there is a high relief, i.e. Sekerr Forest area. Compared with the modified tropical climate the semi-arid climate is characterized by higher temperatures (the annual maximum ranging from 25° - 40°C) higher evaporation (ranging from 1800 - 2200 mm/year), and lower rainfall (600 - 900 mm/year).

The rainy season is between April and September with two distinct peaks in April/May and July/August. The rainfall during June is lower than in the other months of the rainy season (Table 1). There is considerable variation in seasonal and annual rainfall, i.e. a large standard deviation from mean annual rainfall; this makes rainfall prediction very unreliable.

1.3 Water supply and demand

In collaboration with the Water Resources Assessment Project, a survey of water supply systems in West Pokot District was carried out through the ASAL Development programme. The existing improved water supplies and the

Table 1 Long-term average monthly rainfall

Rain gauge station KMD. reg. no. Record period	Elevation m.m.s.l.	Monthly rainfall data (mm)													Annual mean (mm)
			Jan	Febr	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
Mt. Elgon F.S. 88.34.01 1930-81	2225	$\bar{x}$	24	51.3	91.3	153.3	157.9	119.1	168.4	173.2	99.4	97.5	77.1	38.8	1250.7
		$\%$	1.9	4.1	7.3	12.3	12.6	9.5	13.5	13.8	7.9	7.8	6.2	3.1	
		s	29.7	64.3	107.5	68.9	64.4	49.3	59.5	57.0	42.4	49.2	61.3	38.2	
Kapenguria D.C. 88.35.04 1931-80	2134	$\bar{x}$	18.0	42.1	74.8	159.4	206.0	123.9	189.7	181.7	111.6	76.5	61.9	27.8	1273.4
		$\%$	1.4	3.3	5.8	12.5	16.2	9.7	14.9	14.3	8.8	6.0	4.9	2.2	
		s	24.2	79.3	76.0	95.3	88.6	57.4	77.9	70.0	75.3	53.6	68.1	39.5	
Lomut 88.35.17 1953-78	975	$\bar{x}$	23.5	46.9	67.2	129.4	108.3	78.7	147.9	87.7	53.6	65.6	55.8	31.6	896.2
		$\%$	2.6	5.2	7.5	14.4	12.1	8.8	16.5	9.8	6.0	7.3	6.3	3.5	
		s	25.6	49.4	48.2	78.9	52.4	54.9	136.2	58.9	41.9	49.8	40.1	42.1	
Tamkal 88.35.18 1953-78	1219	$\bar{x}$	36.3	78.5	111.4	279.9	210.0	99.3	140.5	133.3	85.4	104.0	132.4	90.2	1501.2
		$\%$	2.4	5.2	7.4	18.7	14.0	6.6	9.4	8.9	5.7	6.9	8.8	6.0	
		s	33.3	83.2	72.2	138.1	114.1	60.0	67.7	51.3	59.6	62.4	103.7	90.5	
Kongolai 88.35.26 1953-78	1311	$\bar{x}$	25.9	35.2	51.6	95.9	140.5	85.6	149.4	150.9	87.0	62.5	50.7	28.4	963.6
		$\%$	2.7	3.7	5.0	10.0	14.6	8.9	15.5	15.7	9.0	6.5	5.3	2.9	
		s	29.9	35.8	49.5	74.3	69.0	47.0	76.1	73.1	60.0	36.7	72.4	39.3	
Sebit 88.35.27 1953-78	1311	$\bar{x}$	19.3	37.9	85.2	160.5	111.5	54.7	123.3	91.9	67.3	80.3	68.9	32.7	933.4
		$\%$	2.1	4.1	9.1	17.2	11.9	5.9	13.2	9.8	7.2	8.6	7.4	3.5	
		s	26.0	38.0	170.2	87.4	41.2	38.7	114.7	52.0	70.7	86.9	61.0	31.6	
Chepareria 88.35.28 1953-78	1800	$\bar{x}$	15.4	43.2	59.6	120.0	135.6	104.1	160.1	151.5	77.2	67.8	69.0	16.0	1019.5
		$\%$	1.5	4.2	5.8	11.8	13.3	10.2	15.7	14.9	7.6	6.6	6.8	1.6	
		s	16.5	87.5	72.4	95.0	67.1	66.7	54.3	97.2	50.0	40.0	116.9	24.1	
Sigor 88.35.29 1953-78	1067	$\bar{x}$	23.4	38.7	57.7	146.3	123.7	67.1	106.8	92.4	55.8	63.9	76.3	37.3	889.4
		$\%$	2.6	4.4	6.5	16.4	13.9	7.5	12.0	10.4	6.3	7.2	8.6	4.2	
		s	24.9	41.5	42.0	84.0	84.2	46.1	62.6	51.5	40.4	37.7	56.4	46.1	
Kaibuibich 88.35.31 1963-78	2743	$\bar{x}$	31.7	49.1	93.9	168.7	211.4	158.0	207.7	231.1	144.5	146.8	106.5	35.5	1586.1
		$\%$	2.0	3.1	5.9	10.6	13.3	10.0	13.1	14.6	9.2	9.3	6.7	2.2	
		s	35.2	47.4	92.8	104.8	99.7	68.4	70.1	64.5	67.7	57.4	80.8	56.9	
Chebunyal 88.35.32 1953-78	1960	$\bar{x}$	25.8	22.9	58.8	110.9	128.6	99.4	162.0	144.5	81.7	60.8	59.7	22.9	
		$\%$	2.6	2.3	6.0	11.3	13.2	10.2	16.6	14.8	8.4	6.2	6.1	2.3	
		s	29.2	19.8	66.6	78.8	75.9	56.3	102.7	70.7	57.2	40.6	61.3	2.3	
Labot 88.35.35 1957-78	2987	$\bar{x}$	32.1	57.4	62.9	110.5	151.8	112.8	172.3	209.4	80.0	94.3	80.4	42.4	1206.3
		$\%$	2.7	4.7	5.2	9.2	12.6	9.4	14.2	17.4	6.6	7.8	6.7	3.5	
		s	47.6	57.8	39.7	69.5	136.7	93.0	107.3	65.5	59.6	48.7	57.6	48.8	

water supplies currently under construction or in the design phase are listed in Table 2. Surface water is the major source, being abstracted from rivers and springs, either by gravity or by pumping, while groundwater is obtained from approximately 50 hand-pump equipped boreholes. During the anti-cholera campaign between 1980 and 1981 the Ministry of Health constructed 66 shallow wells equipped with Afro-Implex hand pumps in West Pokot. Most of these pumps are in the Kacheliba and Kapenguria Divisions. At present, however, none of these pumps is in operational condition. During the dry seasons groundwater is also obtained from hand-dug shallow wells in the river beds. Most water supplies are operated and maintained by the Ministry of Water Development, but some water supplies are under the control of church organizations. The WRAP project has drilled 15 boreholes in Kokwomesses, Morobus, Psurum, Chepkopegh, Chesera Serewa, Matembur and Kangalan. The successful boreholes will be equipped by the ASAL Development Programme for West Pokot.

Irrigation is carried out on a small scale: in 1980 only 515 ha out of 13 800 ha of cropped land. Traditional irrigation using surface water is dominant. There are no reliable data on the amount of water diverted for irrigation. The present irrigation efficiency is very low, because of poor water management. It has been estimated (ADEC, 1981), that 50-75% of the water is lost in the conveyance system before reaching the plots. Rehabilitation of existing schemes and training could increase the efficiency considerably.

At present, new irrigation schemes are being developed near Kodich (Suam River) and Sigor (Wei Wei River). Sogreah (1981) has proposed various major irrigation schemes:

- between Marich Pass and the confluence of the Muruny and Wei Wei Rivers 2600 - 3200 ha.
- Sigor-Wei Wei River 1000 - 1500 ha.
- Kangolai-Suam River 1000 - 1400 ha.

The livestock in West Pokot mainly consists of cattle, sheep, goats and camels. The livestock data are presented in Table 3. It has been calculated (ADEC 1981) that the maximum potential carrying capacity of live-

Table 2 Water supplies in West Pokot

Name of supply Division and year commissioned	Source	Technical data										Remarks	
		System pumped/ gravity	Yield m ³ / day	Number of metered con.	Kiosk/ W.P.	Population	Area km ²	Piping km	Storage m ³	Treat- ment	Respon- sible agent		
1. Kapenguria	Kap 1952	river	pump	312	290	-	3000	16	10	200	Full	MoWD	Over-utilized: to be augmented To be extended
2. Makutano	Kap 1972	river	pump	400	220	1	2500	10	9	180	Full	MoWD	
3. Tartar-Keringet	Kap 1979	river	pump	80	70	-	1000	50	15	180	Full	MoWD	Under-utilized, should be extended Self-help, due for rehabilitation
4. Kwanza Centre	- 1973	spring- dam	pump	100	35	-	1200	10	8	45	Nil	MoWD	
5. Kanyarkwat	Kap 1975	sub dam	hand pump	-	-	-	-	-	-	-	Nil	MoWD	Not working, hand pump broken, source not adequate
6. Kacheliba	Ka 1982	well/ river	pump	90	35	-	2000	9	8	270	Cl	MoWD	
7. Talau	Kap 1982	spring	gravity	45	-	15W/P	1000	6	4	-	Nil	MDA	Small inexpensive system, meeting peoples's demand -
8. Kabichbich	Kap 1983	stream	pump	110	-	10W/P	1500	19	12	135	Nil	MoWD	
9. Cheperaria	Che 1981	stream	gravity	400	50	3W/P	2000	36	30	90	Nil	MoWD	(Care-Kenya, DDC)
10. Sigor	Si 1972	river	pump	30	25	-	1200	4	3	20	Nil	MoWD/ CC	
11. Ortum	Che 1975	stream	gravity	190	30	-	2000	8	10	135	Cl	MoWD	New gravity system of much greater capacity under construction (Mission, DDC) New system under con- struction
12. Alale	Ka 1980	gravity	gravity	?	2	3	200	-	-	-	Nil	AIC	
13. Karas	Kap 1979	stream	pump	100	35	-	1000	9	15	135	Nil	MoWD	Needs to be extended Lines to be ex- tended, treatment works and standby unit to be provided -
14. Kanyerus	Ka 1980	spring	gravity	20	-	-	400	2	2	45	Nil	MDH	
15. Chesta	Si 1975	stream	gravity	?	-	-	-	-	-	-	Cl	Church	-
16. Lonut	SI 1979	stream	gravity	-	-	-	-	-	-	-	Nil	MDH	
17. March Pass	Si 1979	C4557	pump	100	-	-	800	-	-	45	Nil	MoWD	Abandoned for lack of funds Borehole drilled for construction Lodwar road
Boreholes:	2 Kap	-	-	20	-	2	800				Nil	MoWD	Including one WRAP borehole WRAP-boreholes
	7 Che	-	-	50	-	7	2000				Nil	MoWD	
	- Si	-	-	-	-	-	-				-	-	
	50 Ka	-	-	200	-	50	12 000				-	MoWD/ Church AOCK	

stock in West Pokot is 121 500 LSU: this figure will be reached before the year 2000.

Table 3 Livestock data (ADEC, 1981)

Type of Livestock	1980/1981	LSU 1980	Estimated growth rate (%)	LSU 1984	LSU 2000 projection
Cattle	189 550	75 800	3	85 300	91 300
Sheep	88 300	4 200	3	4 700	5 000
Goats	280 000	14 000	4	16 400	19 900
Camels	14 516	11 600	0.5	11 800	12 800
Total LSU		105 600		118 200	129 000

The increasing demand for water has been calculated taking the following assumptions into account:

- Population growth according to the figures given in Table 4, which are based on the population census of 1979.
- Water use in rural areas according to the MoWD Design Manual: 25 litres per head per day when served by communal water points (Wp, Kiosks); 50 litres per head per day when served by individual connection (2.5 per cent of population in 1984; 5 per cent in 2000); 75 litres per day per livestock unit (LSU) i.e. 2.5 cows, 20 goats or sheep or 1.25 camels.
- Livestock evenly distributed over the district, except for camels, which are concentrated in Alale (50%), Kasei (25%) and Masol (25%). The numbers of livestock units, excluding camels, per square kilometre, are: 11.8 LSU/km² in 1984 and 12.1 LSU/km² in 2000.

The total demand for water (Table 5) will increase from 5.1×10^6 m³/year in 1984 to approximately 7.5×10^6 m³/year in the year 2000. The demand for livestock will remain constant at 3.3×10^6 m³/year, thereby representing 63% and 44% of the total demand for water in 1984 and 2000, respectively.

Table 4 Population data 1979, 1984 and estimate for the year 2000

Location	Population 1979 (Census data)	Growth rate	Population 1984	Population 2000
Kapenguria Division				
Mnoge	35 186	6	47 000	120 000
Riwoa	9 619	6	13 000	33 000
Lelan	11 149	6	15 000	38 000
Total	55 954	6	75 000	191 000
Chepararia Division				
Kipkomo	14 628	4	18 000	33 000
Sook	9 325	2	10 000	14 000
Batei	11 136	6	15 000	38 000
Total	35 089	4	43 000	85 000
Sigo Division				
Wei Wei	5 515	5	7 000	13 000
Lomut	6 687	5	8 000	15 000
Sekerr	7 154	3	8 000	13 000
Mwino	7 157	3	8 000	12 000
Masol	3 474	2	4 000	5 000
Cheptukel	4 238	3	5 000	6 000
Total	34 225	3	40 000	64 000
Kara Pokot Division				
Suam	7 513	4	9 000	16 000
Kapchok	7 452	4	9 000	16 000
Alale	13 542	3	16 000	23 000
Kasei	4 877	2	5 000	7 000
Total	33 384	3	39 000	62 000
Total West Pokot	158 652	4.3	197 000	402 000

Table 5 Water demand 1984 - 2000

Division	Demand in 1984 ($\text{m}^3/\text{yr} \times 10^6$)				Demand in 2000 ($\text{m}^3/\text{yr} \times 10^6$)			
Name and Area (km^2)	Demand per capita/LSU		Total		Demand per capita/LSU		Total	
	25 l/d	50 l/d	75 l/d	1/d	25 l/d	50 l/d	75 l/d	1/d
Kapenguria 1638	0.67	0.03	0.53	1.23	1.66	0.17	0.54	2.37
Chepareria 1358	0.38	0.02	0.44	0.84	0.74	0.08	0.45	1.27
Sigor 1980	0.36	0.02	0.72	1.10	0.55	0.06	0.74	1.35
Kara Pokot 4013	0.35	0.02	1.54	1.91	0.54	0.06	1.59	2.19
Total								
West Pokot 9090	1.76	0.09	3.23	5.08	3.49	0.37	3.32	7.18

To meet the present standards of water requirement, the total annual water production in West Pokot should be more than tripled, in Sigor and Kara Pokot Division the total annual water production is now only 10% of the present requirements.

2. SURFACE WATER RESOURCES

West Pokot District can be subdivided into three main catchment areas: the Suam-Turkwel Basin upstream of the Turkwel Gorge (5900 km^2), the Muruny Basin upstream of Marich Pass (1355 km^2) and the Wei Wei - Malmalte Basin upstream of the confluence of the Turkwel and Malmalte Rivers (2044 km^2). The total catchment area covers circa 9360 km^2 . The WRAP activities concentrated mainly on the Suam River upstream of Kongolai (1134 km^2) and the Muruny River upstream of Marich Pass (1355 km^2).

During the rainy season the river discharges are characterized by flash floods. The river flow shows extreme fluctuations from hour to hour. There is very little time lag between rainfall and runoff. Peak flows of the established river gauging stations generally occur at night. Runoff

figures based on daily staff gauge readings are therefore considerably underestimated. The actual daily flow calculated from hydrographs is 2 - 20 times the estimated flow based on daily staff gauge readings. For annual flows the underestimation ranges between 20% to 30%.

The maximum instantaneous flows observed at Kongolai (Suam River) and Marich Pass (Muruny River) were 320 m³/s and 150 m³/s respectively. Minimum flows observed were 0.2 m³/s and 4 m³/s.

In Table 7 the annual runoff data are summarized together with rainfall: runoff ratio and pan evaporation figures. The ratios of annual runoff to rainfall were 0.18 for the Suam River and 0.14 for the Muruny River, indicating that the base flow component of the Muruny River is higher than that of the Suam River.

A comparison between the 1982/1983 and long-term mean data on runoff and rainfall shows that the rainfall: runoff ratio is not consistent. The inconsistency could result from the tentative character of the rating curves applied and the unreliable water level and rainfall records. Also, the difference between flows calculated from staff gauge readings and automatic water level records has to be taken into account.

Chemical analyses of surface water are available for the three major rivers, Suam, Muruny and Wei Wei - and for 18 minor rivers and streams. Generally speaking, the surface water at all sampling sites is of good inorganic quality when judged against the WHO International Standards for drinking water. The total content of dissolved solids in the majority of samples did not exceed 150 mg/l and the fluoride concentration in all samples was below 1 mg/l. Only the iron concentrations exceed the recommended standards.

It must be stressed that the composition of surface water is subject to rapid changes over time. A single sample can therefore never be considered as being representative for a long period. Frequent sampling is necessary to monitor any changes in the water quality.

Table 6 Annual runoff data

		1982- 1983	Long-term mean	"Average"
RGS - 287, Suam River at Kangolai		April-March	1956-1972	
Total outflow	m ³ x 10 ⁶	303.8	420	285
Mean annual flow	m ³ /s	9.6	13.5	9
Runoff depth	mm/yr	225	315	210
Rainfall depth	mm/yr	1250	1175*	1175*
Runoff: rainfall	ratio	0.8	0.27	0.18
Evaporation	mm/yr	1950		
RGS - 2831, Muruny River at Marich Pass		June-May	1957-1972	
Total outflow	m ³ x 10 ⁶	196.7	175	220
Mean annual flow	m ³ /s	6.2	5.5	6.9
Runoff depth	mm/yr	145	130	160
Rainfall depth	mm/yr	1065	1150*	1150*
Runoff: rainfall	ratio	0.14	0.11	0.14
Evaporation	mm/yr	1925		

* Estimated from isohyet map of long-term annual rainfall (MoWD, 1984^a)

3. POTENTIAL FOR DEVELOPING SURFACE WATER

There is ample potential for developing surface water for domestic use and livestock watering, even for small- and large-scale irrigated agriculture and hydropower. However, the latter two aspects are beyond the

scope of this project.

Priority should be given to the development of relatively cheap methods of surface water exploitation, such as small reservoirs for livestock watering in the valley bottoms and sand dams with shallow wells in the riverbeds of intermittent streams.

To provide livestock with water during the four-month dry period between November and April, 90 - 100 small reservoirs, each of 8000 - 25 000 m³ storage capacity and costing KShs 100 000 - 200 000, would be sufficient. Properly dimensioned spillways are required to prevent overtopping of the embankments.

To guarantee domestic water supply and the supply for small-scale irrigation from surface water, the various possibilities must be investigated in detail. In most of the area the required amount of surface water is available, but a cost-benefit analysis is always needed to identify the most feasible way of diverting water to a specific location.

4. GROUNDWATER RESOURCES

The groundwater in West Pokot occurs either in weathered or fractured Basement rock or in the fluviatile sediments. The analysis of groundwater conditions is mainly based on data obtained from 15 newly drilled boreholes (Table 7).

4.1 Groundwater conditions in the Basement rocks

There is no regional aquifer in the Basement rocks. Detailed investigations showed great variations in depth to groundwater, specific capacity of wells and groundwater quality. These variations, occurring even over short distances in the same geological unit, greatly complicate the systematic search for potential aquifers. Nevertheless, the best prospects for finding groundwater are offered by zones underlain by weathered and fractured rocks, provided that these zones are sufficiently recharged.

Table 7 Borehole data

Borehole Number	Location	Coordinates		Sheet No.	Surface Elevation (m + msl)	Total depth (m)	Completion date	Water struck level		Water rest level		Geol. log	Geoph. log	Well test	W. sample	Rock form.	Yield ** (m ³ /h)
		X	Y					depth elevation (m) (m + msl)	depth elevation (m) (m + msl)								
C 5414	Norobus 1	7527	1539	75/2	1620	48	31-10-83	24 42	1596 1578	14.9 17.5	1605 1602	X	X	X	X	B	3
C 5415	Norobus 2	7529	1541	75/2	1620	47.5	07-11-83	31 43	1599 1577	21.7 14.9	1598 1605	X	X	X	X	B	2
C 5416	Psurum 1	7461	1543	75/1	1560	68	11-11-83	24	1536	20.9	1539	X	X	X	X	B	0.5
C 5428	Psurum 2	7466	1541	75/1	1560	50	22-11-83	24	1536	11.4	1559	X	X	X	X	B	1
C 5429	Chepkopegh 1	7478	1619	75/1	1500	47	30-11-83	30 42	1470 1458	12.3 12.4	1488 1488	X	X	X	X	B	0.5
C 5430	Chesera	7366	1603	75/1	1360	41	16-12-83	12 18	1348 1342	8.5 8.6	1351 1351	X		X	X	S	100***
C 5431	Serewa	7225	1476	75/1	1400	36.5	02-04-84	24	1376	17.1	1383	X	-	X	X	S	18
C 5432	Matembur 1	7273	1503	75/1	1440	61	27-03-84	23	1317	41.1	1399	X	-	-	-	B	-
C 5488	Kokwomeses 1	7927	1455	76/1	1000	51	14-11-83	38	962	27.8	972	X	-	-	-	S	<0.1
C 5489	Kokwomeses 2	7926	1455	76/1	1000	72	30-01-84	52	948	26.9	973	X	-	-	X	S	<0.5
C 5538	Psurum 3	7457	1532	75/1	1580	67	25-01-84	35	1545	19.2	1561	X	X	X	X	B	1
C 5539	Chepkopegh 2	7478	1609	75/1	1510	64	06-02-84	43	1467	33.3	1477	X	X	-	X	B	<0.5
C 5540	Chepkopegh 3	7480	1621	75/1	1500	68	27-02-84	18	1482	6.5	1493	X	X	X	X	B	<1
C 5541	Kangalan	7891	1543	76/1	1150	64	28-02-84	dry	-	-	-	X	-	-	-	S	-
C 5807	Matembur 2	7225	1494	75/1	1420	50	19-04-84	dry	-	-	-	X	-	-	-	B	-

* B = Basement
S = Sediments

** Yield per S = 10m

*** Uncertain

The weathering profile of Basement rocks, as observed in the borehole logs and geophysical measurements, shows the same sequence in all areas investigated: a clayey (lateritic) top layer grading into partly decomposed rock and finally into fresh rock. The thickness of the clayey top layer varies from less than 1 metre to more than 10 m. Fresh Basement rock was found at depths between 10 and 60 m.

The permeability of the weathered zone depends on the degree of decomposition of parent rocks. The weathering products of gneisses, which are the main Basement rocks at all drilling sites, generally have a high clay and mica content. Pegmatite veins within the gneisses may weather into coarser material.

The yields of boreholes that abstract water from the weathered zone do not exceed 1 m³/hour.

The permeability of unweathered Basement rocks depends on the presence of fractures, their geometry and interconnection. Observations at the surface can give only a rough indication of the fracture pattern of deeper layers. The major structures, which appear on the aerial photographs, presumably continue to greater depths. The minor fractures can only be located with geophysical methods. The yields of boreholes tapping fractured rock is 2 - 3 m³/hour. This is the same order of magnitude or is slightly higher than the yields of wells that tap the weathered zones. Whether this should be attributed to a more developed fracture system or to an additional recharge from nearby rivers is not clear.

Available recharge is the factor determining the amount of abstractable groundwater. In the semi-arid parts of West Pokot, the recharge probably does not exceed 1% of total precipitation. A thick clay layer that developed on top of the weathered zone prevents infiltration of rain water. The Basement aquifers are recharged mainly through open fractures or partly weathered rock surfaces. Infiltration of river water will considerably increase the amount of recharge, assuming there is a hydraulic connection between the river and aquifer.

Figure 2 is a schematic sketch of hydrogeological conditions in a Basement area.

The chemical composition of the water from the boreholes in Basement rocks varies considerably, even over short distances (Table 8). Total dissolved solid content (TDS) varies from 174 mg/l to 1920 mg/l. For drinking water the WHO recommends a maximum TDS content of 500 mg/l. This value is exceeded in 50 per cent of the samples. The fluoride content is within the WHO limit.

The water from all boreholes can be used to water livestock, although a high sulphate content is undesirable. The water of the Chesera and Serewa boreholes, the only boreholes to be considered for irrigation, is of good quality for irrigation.

No general conclusion can be drawn about the regional hydrochemical pattern. Like the water quantity, the water quality varies considerably between sites.

4.2 Groundwater in fluviatile deposits

Floodplains

The extensive floodplain deposits along the rivers Wei Wei and Kerio consist mostly of fine-grained sediments that make poor aquifers. Two boreholes drilled in floodplain deposits in Kokwomeses have a very low yield and the Kangalan borehole is dry; this confirms the results from Kerio Valley (MoWD, 1984^b).

The groundwater sample from the floodplain aquifer in Kokwomeses consists of saline water of sodiumbicarbonate type.

Turkana grits

The extensive deposits of Turkana grits are coarser than the floodplain deposits and offer better possibilities for finding groundwater. Because of the inaccessibility of the terrain and the small number of people living in the area, these possibilities were not investigated by WRAP.

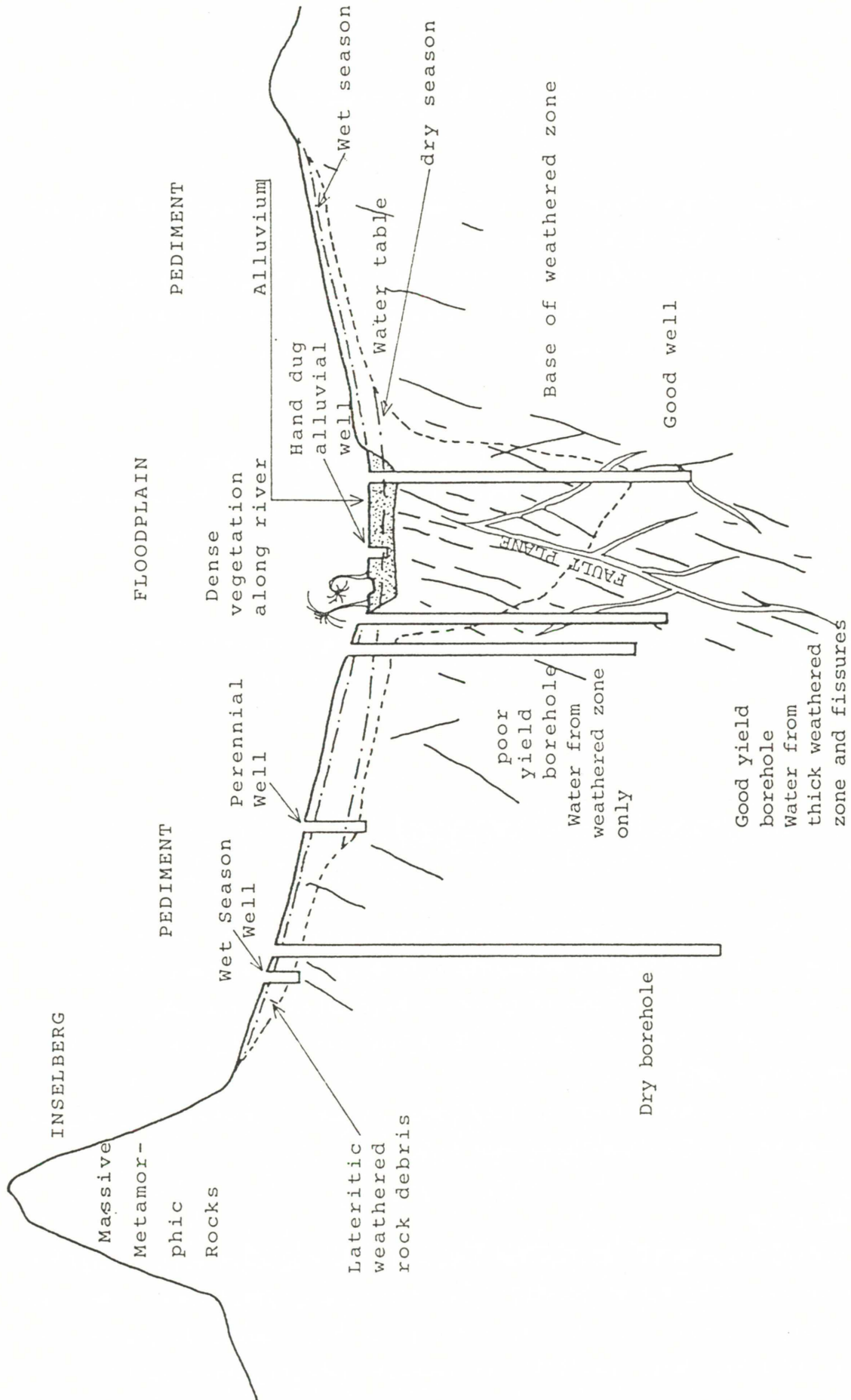


Figure 2 Hydrogeology of Basement rock (after Clark, 1982)

Table 8 Chemical data on water from boreholes in Basement rocks and floodplain sediments

Location	Borehole no.	Date of sampling	pH	EC (μs/cm)	mg/l										Hardness (CaCO ₃) (mg/l)	TDS (mg/l)		
					Na	K	Ca	Mg	Fe	Mn	Cl	HCO ₃	SO ₄	NO ₃			F	SiO ₂
Morobus 1	C 5414	18-01-84	8.0	960	-	-	75	78	5.4	0.0	108	373	19	-	0.2	-	420	576
	C 5415	23-01-84	8.1	740	-	-	55	47	0.3	0.0	15	515	57	-	0.6	-	328	444
	C 5415	24-01-84	7.9	760	-	-	36	58	0.6	0.0	14	312	88	-	0.6	-	326	456
Psurum 1	C 5416	17-02-84	7.8	1330	-	-	111	18	1.2	0.0	34	237	370	-	0.6	-	386	810
	C 5416	18-02-84	8.0	1440	-	-	119	19	0.0	0.0	43	278	374	-	0.5	-	412	840
Psurum 2	C 5428	11-02-84	7.8	290	-	-	29	9	2.2	0.0	5	151	5	-	0.2	-	110	174
Chepkopegh 1	C 5429	26-03-84	8.2	660	-	-	54	54	0.1	0.0	15	365	5	-	1.0	-	266	396
Chesera	C 5430	30-03-84	7.7	440	-	-	35	15	0.2	0.0	7	224	13	-	0.6	-	146	264
Serewa	C 5431	02-05-84	7.8	300	-	-	24	12	1.7	-	8	192	2	-	0.4	-	110	180
Kokwomeses *	C 5489	02-02-84	7.7	2100	-	-	53	55	15.0	0.0	368	624	30	-	0.5	-	358	1260
Psurum 3	C 5538	31-01-84	8.0	1500	-	-	134	72	1.0	0.0	41	312	512	-	0.5	-	630	900
Chepkopegh 2	C 5539	19-03-84	8.0	3200	-	-	282	139	0.0	-	370	405	576	-	0.5	-	1272	1920
Chepkopegh 3	C 5540	13-03-84	7.8	495	-	-	37	26	0.1	0.0	9	180	24	-	1.1	-	200	294
	C 5540	13-03-84	7.9	730	-	-	70	31	0.1	0.0	12	207	132	-	1.0	-	300	438

* floodplain sediments

Alluvial deposits

Along the major rivers and their tributaries, alluvial deposits and torrent wash fans are found. They consist largely of coarse material and are recharged by the river and make small but good aquifers.

Several shallow wells draw water from the alluvial aquifers; moreover, buried river channels may contain large quantities of groundwater, as shown by the boreholes in Chesera and Serewa.

5. POTENTIAL FOR DEVELOPING GROUNDWATER

Sustained yield

It is difficult to estimate the amount of abstractable water stored in the isolated Basement aquifers because neither the extent of the aquifers nor the amount of recharge is known. Assuming a recharge of one per cent of the rainfall, it can be estimated that the total annual sustained yield is about $3 \times 10^6 \text{ m}^3$ for an area of 4000 km^2 Basement rocks. The sustained yield of coarse alluvial deposits along the major rivers is probably in the order of $1 \times 10^6 \text{ m}^3/\text{year}$, and thus the total amount of extractable water is approximately $4 \times 10^6 \text{ m}^3/\text{year}$. Although the available groundwater is unevenly distributed, it is sufficient to meet domestic water requirements in most of the area. Local shortages may occur in silty floodplain areas.

Potential for development

Because of the low specific capacity (yield divided by drawdown) of most boreholes the opportunities for developing groundwater are, in general, restricted to hand pump wells. Assuming an annual production of 2000 m^3 per hand pump, the estimated amount of available groundwater would be sufficient for 2000 hand pumps.

In the first phase of exploitation the construction of 20 - 30 shallow wells in the alluvial deposits near the major rivers could be considered. One dug well costs approximately KShs 20 000. In addition, a few moderately deep boreholes (circa 50 m) should be drilled in the scree fans

along the hill scarps. Each borehole will cost approximately KShs 50 000. The purpose of these wells is not only water production but also further reconnaissance.

Location of borehole sites

To tap the very localized groundwater bodies in the Basement rock much attention has to be given to the location of the borehole sites. Detailed hydrogeological investigations are required in the area where the borehole is planned. Geological and geophysical methods should be applied. The geological methods consist of studying Landsat images and aerial photographs, then doing a field reconnaissance survey and selecting locations for geophysical surveys. The latter will include resistivity profiling, electro-magnetic profiling, resistivity sounding and - when indispensable - the more costly seismic refraction survey.

6. CONCLUSIONS

The potential for water development in West Pokot is considered to be fairly good and in fact is much better than anticipated before the study began. The water availability is shown on plate 1.

Surface water resources can be developed to provide a safe supply for watering livestock and even for small-scale irrigation. The groundwater resources in localized aquifers in alluvial deposits along the major streams, in fractured zones in Basement rocks and in weathered Basement material can be exploited to give an estimated total of up to 4×10^6 m³/year. The yields are usually low, less than 5 m³/hour, and boreholes must be sited carefully.

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