

REPUBLIC OF KENYA



MINISTRY OF WATER DEVELOPMENT

WATER RESOURCES ASSESSMENT STUDY
IN
LAIKIPIA DISTRICT

EXECUTIVE SUMMARY

MAY 1987

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The Water Resources Assessment Project

The Water Resources Assessment Project carried out a water resources assessment study of Laikipia as part of the co-operation between the Ministry of Water Development and the TNO-DGV Institute of Applied Geoscience, the Netherlands. This summary gives a brief account of the results of the investigations, with emphasis on the potential for water development.

Project Area

The area of investigations is bounded by the parallels 0° 20'S and 0° 45'N and the longitudes 36° 15'E and 37° 20'E (Figure 1). The surface water investigations (Figure 1) were basin-oriented, covering the Upper Ewaso Ngiro Basin upstream of the confluence of the Ewaso Ngiro and Ewaso Narok (7851 km²). Nevertheless, data from Archer's Post, which has a drainage area of 15 300 km², have also been used.

The groundwater investigations focused on Laikipia District (9723 km²), although some attention was paid to the upper parts of the basin in Ngeri and Meru Districts. The current (1987) population of the District is estimated at 215,000.

The Ewaso Ngiro Basin is bounded to the south-east by Mount Kenya (5,199 m) and to the south-west by the Aberdares (3,999 m). The central part of the basin is rather flat: this is the area of the Nanyuki and Rumuruti plains (1,500-2,000 m) which are underlain by lavas.

The Ewaso Ngiro river system rises on these volcanic landforms from a great number of small perennial streams. The dominant direction of flow of the Ewaso Ngiro river system is to the north. One lake (Lake Ol Bolossat), five large and numerous small swamps, of which the Ewaso Narok and Pesi swamps are the most important, are situated along the river system.

The geological base of Laikipia consists of Precambrian metamorphic rocks outcropping in the Mugogodo area. In the rest of the area they are overlain by Tertiary and Quaternary lavas interbedded with tuffs and sediments. The eastern part of the district, situated on the escarpment, is intensely faulted and fractured. Recent sedimentary deposits are restricted to small strips along the rivers.

Soils in Laikipia are generally moderately to highly fertile: fertility is not a major limiting factor for cultivation, but water is. Shallow stony soils with rock outcrops prevail in the semi-arid part of the area.

The climate is strongly associated with altitude. It is arid at altitudes of less than 1,600 m and semi-arid from 1,600-2,000 m (Figure 2 and Plate 4.1). Rainfall in the semi-arid zone is generally less than 700 mm while evaporation is more than 1,800 mm. The humid and semi-humid highlands experience rainfall of over 1,000 mm and evaporation of less than 1,500 mm. There is a transitional zone between the semi-humid and semi-arid zones. There are two distinct rainy seasons: the Long Rains in April-May and the Short Rains in November-December. In between there is a relatively dry period during which it rains occasionally. The period January-March is very dry.

Investigations

The basic data were gathered by studying and analysing the reports on previous studies and the archives in the MoWD, and through field investigations. Hydrological fieldwork included rehabilitation of raingauges, installation of additional evaporation pans, stream gauging, a water permit survey, and water sampling for chemical analysis. The groundwater fieldwork included geological analysis (remote sensing, ground survey), geophysical surveys, water level monitoring and water sampling.

Water Supplies

A water survey was done in 1986, during which 86 water supply systems were visited. Early in 1987 a water permit inventory was carried out to obtain information on the legal water abstractions.

Most water supplies in Laikipia District are based mainly on surface water. Nearly 90% of the population depends on such systems (Figure 3). Other types of water supplies are based on boreholes, springs, wells, dams and rock catchments, or a combination of these.

Valid surface water permits have been issued for 621 different abstraction points along the rivers, endorsing a total dry season abstraction of 1.4 cumec above the confluence of the Ewaso Narok and the Ewaso Ngiro. This is more than three times the level of abstraction reached in the early 1960s, which was 0.4 cumec.

There are 120 operational boreholes, mainly on the ranches, which supply water for both domestic and livestock use. These boreholes are concentrated in the Central Division, between Nanyuki Town and the Pesi Swamp. Water is also obtained from springs in Central, Rumuruti and Ng'arua Divisions. In Mukogodo Division, during the dry seasons, water is obtained from hand-dug wells in the riverbeds.

The water survey revealed that 137,000 people, 180,000 sheep and goats and 152,000 head of cattle are served by the water supply systems. These numbers are far below the corresponding census data: it is not clear whether this is due to errors of estimate, or because large groups are not being served by the inventoried systems.

Water Demand

Water demand projections for domestic use and cattle watering were made for the years 1987 and 2000, using the 1979 census for population and the 1983 figures for livestock estimates. Livestock can be expressed in LSU: livestock units. One livestock unit is equivalent to 2.5 cows, 20 goats or sheep, or 1.25 camels.

Water demand is specified as 25 litres/day/capita when served from communal water points, and at 50 litres/capita/day when served by individual connections. One LSU (livestock unit) is assumed to require 75 litres/day. Total annual water demand is an estimated 4.6 Mm³ for 1988 and 8.9 Mm³ for the year 2000 (Table 1). Rapid growth of the human population is the main cause of the increase.

Water demand for irrigation during the dry season is virtually unlimited and cannot be satisfied from dry season flow. Demand for irrigation can only be satisfied from dams in which rainy season flows are stored.

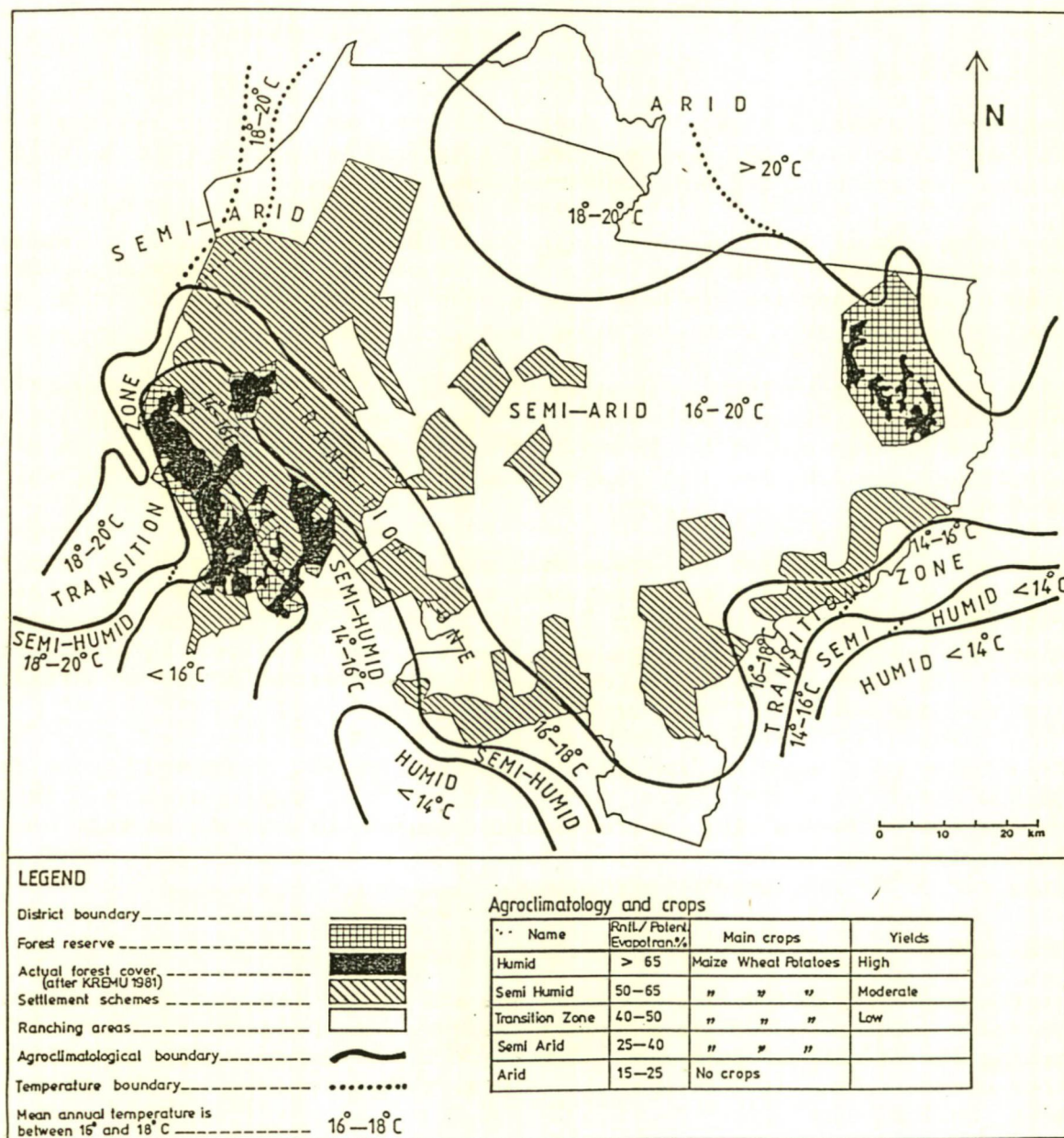


Fig. 2 Landuse, Main Crops and Agroclimatic Zones

Table 1 Water Demand from Households and Livestock in 1988 and 2000

DIVISION		DEMAND IN 1988				:	DEMAND IN 2000			
Name	Area Km ²	Demand per Capita - LSU				:	Demand per Capita-LSU			
		25 l/d	50 l/d	75 l/d	Total	:	25 l/d	50 l/d	75 l/d	Total
		Mm ³ /year				:	Mm ³ /year			
Central	3,161	0.50	0.25	0.78	1.53	:	0.82	0.43	1.53	2.78
Rumuruti	3,514	0.73	0.09	0.87	1.69	:	1.21	0.78	1.70	3.69
Mukogodo	1,205	0.17	0.02	0.30	0.49	:	0.29	0.03	0.58	0.90
Ng'arua	1,098	0.51	0.06	0.27	0.84	:	0.86	0.10	0.53	1.49
Total	8,978	1.91	0.42	2.22	4.55	:	3.18	1.34	4.34	8.86

Surface Water Resources

The higher parts (above 2,000 m) of Mount Kenya and the Aberdares are the most productive areas for streamflow generation. Here, rainfall is high and rather evenly distributed over the seasons. Infiltration conditions are favourable and aquifer transmissibilities are high. Groundwater emerges in many perennial springs and seepages, often in the river beds, thus becoming baseflow.

Elsewhere, streamflow production is largely confined to the rainy seasons.

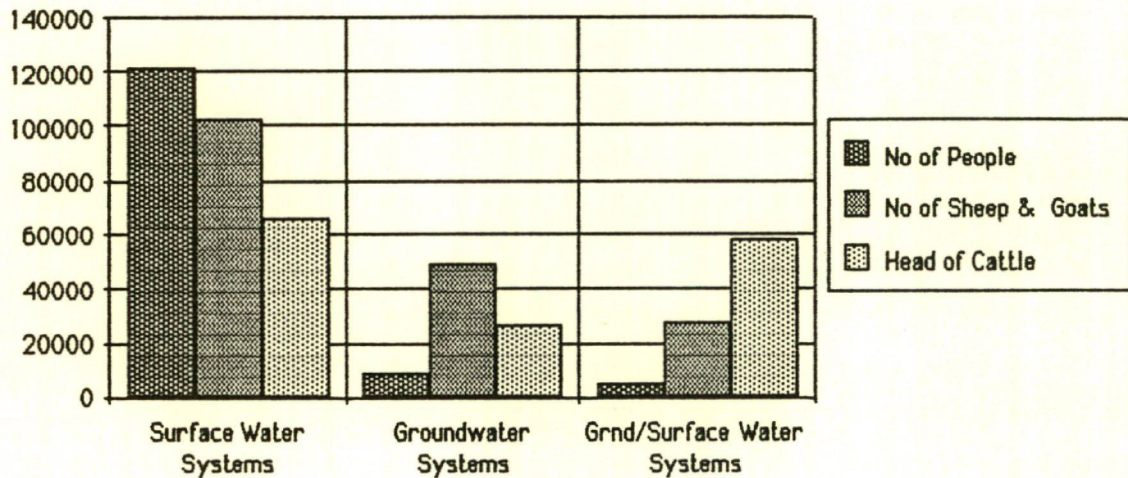
The mean recorded streamflow at the confluence of the Ewaso Ngiro and Ewaso Narok amounts to 370 Mm³/year, or 11.7 cumec. Because floods tend to pass during the evening and night when no staff gauge readings are made, actual flows could be higher. However, most of this water is generated during the rainy seasons, when demand is lowest. Without proper storage facilities these high flows remain unused.

Dry season streamflows are much lower. The 95% flows are generally used for the design of water supplies. Total discharge at this probability level, generated at the Upper and Middle Volcanic Slopes amounts to approximately 2.3 cumec. Including the Plateau there is only 1.2 cumec left and further down at the Junction only 1.0 cumec. This decrease is due to infiltration and abstractions. Including the legal abstractions, the corresponding flows amount to 3.2, 2.6 and 2.4 cumec respectively (Figure 4). Legal abstractions upstream of the Junction were up from 0.4 cumec in the early sixties, but 1.4 cumec in early 1987 (Figure 5).

As a result, dry season abstractions have already reached a critical level: in 1985, for the first time in living memory, a 50 km stretch of the Ewaso Ngiro upstream of Archer's Post fell dry for several weeks. This happened again in 1986.

The quality of surface water is good for domestic use, cattle watering and irrigation. Only in Lake Ol Bolossat is the water not potable, unsuitable for irrigation, and only marginally suitable for cattle.

Laikipia District Water Supply Systems and their Users



Laikipia District Water Supply Systems and their Users

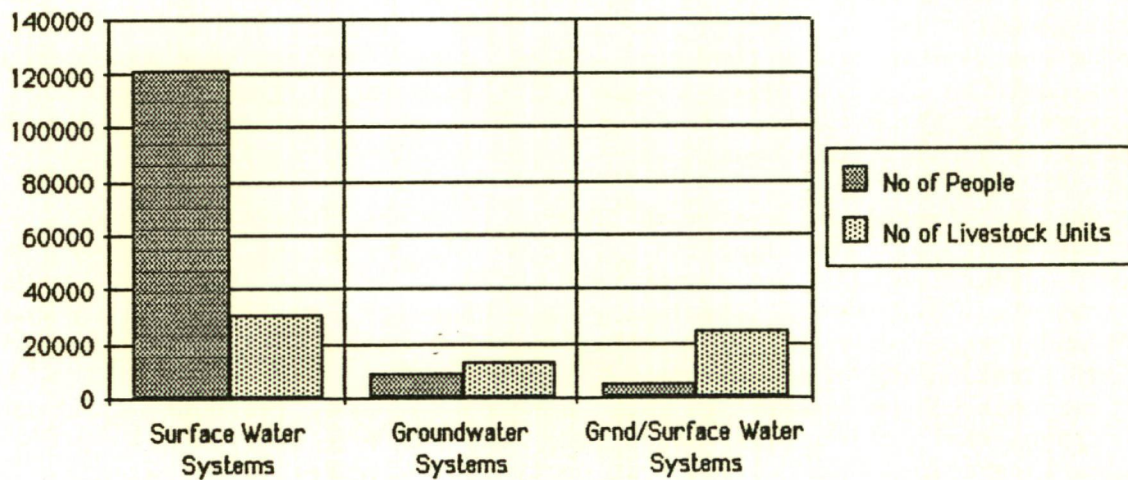


Fig. 3 Water Supply System and their Users

Potential for Developing Surface Water

It is clear that very little potential, if any, is left for development of low flows. This is particularly true for irrigation, for which peak demand coincides with periods of low flow. Strict law enforcement by curbing illegal abstractions could alleviate the situation during droughts and thus create some room for abstractions for domestic purposes.

The medium-to-high flows constitute the main source for further development of surface water. The building of large storage facilities is the only solution to meet demand when it is greatest. Each dam could service large-scale irrigation and fish production. A cost-benefit and social impact study for large scale irrigation was beyond the scope of this report.

Groundwater Resources

In the volcanic part of the area there is a regional aquifer (Plate 2). Virtually every borehole, provided that it is deep enough, strikes water. Locally, e.g. in the Lariak-Sipili Region, water-struck levels are more than 250 m below surface. Only in the area east of Nyahururu, which is underlain by Thomson Falls phonolites, were a number of very deep boreholes complete failures.

There is no regional aquifer in the Basement area. Nevertheless, prospects for water development are favourable in the valleys, notably where deep subsurface decay has produced thick zones of more or less permeable material. Elsewhere, prospects are not good, although small local aquifers may be found through careful geophysical surveys.

The total amount of groundwater that is replenished annually in the catchment above the Junction is estimated to be in the range of 120 to 220 Mm³. Most of this recharge (90%), however, emerges as baseflow. But even if the recoverable amount of groundwater were only 5% of the recharge, the estimated present and future groundwater demand in Laikipia (0.9 and 4.5 Mm³ respectively) could easily be met.

High potential areas are found on the Volcanic Slopes, most of which lie outside the district boundaries, on Mount Kenya and the Aberdares (Plate 3). The Nanyuki-Rumuruti-Sukuta Plains are areas of high to medium potential. In these areas, the mean water depth is 45 metres and the mean tested yield 5.7 m³/h. Thus, handpumps can be used almost everywhere. The Lariak-Sipili area and Basement area are classified as areas of medium potential. In the former area, the water is too deep for handpumps. In the Basement only a part of the area is underlain by aquifers, but water depths are such that water can be pumped by hand. The area east of Nyahururu is underlain by Thomson Falls phonolites and is classified as an area of low potential, because of the low yields, great water depths and the large number of failed boreholes. The intensely faulted and fractured area west of the watershed, situated in the Baringo and Bogoria catchments, is classified as variable because water depths and tested yields are expected to vary considerably.

Chemical quality is generally good, but in 10 to 20% of the cases high salinity or high fluoride concentrations may make the water less suitable for human consumption.

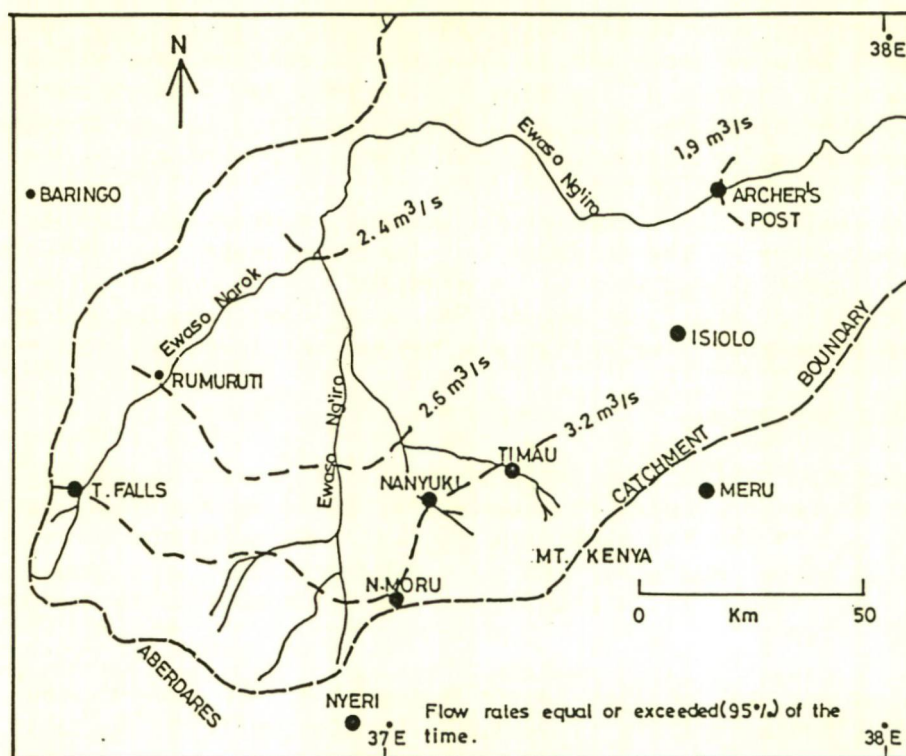


Fig. 4 Total available streamflow (95%) including abstractions

Potential for Developing Groundwater

Prospects for further development are favourable in the areas of high, high to medium, and medium potential.

To meet the foreseen groundwater demand of 4.5 Mm³/year by the year 2000, two options are available.

- Submersible Pumps

Assuming a mean annual production of 16,000 m³ per well, about 300 boreholes should be in operation by the year 2000. At present, 120 boreholes are being operated, while 71 additional boreholes are in good condition and can be equipped with pumps. Furthermore, there are 23 boreholes that are blocked but can be cleaned and brought into operation. So, approximately 100 additional boreholes should be made to meet the anticipated groundwater demand by the year 2000. Theoretically, 300 evenly distributed boreholes in this area of 9,000 km² implies an average distance of 5 to 6 km between adjacent boreholes.

- Handpumps

In most of the area, handpumps can be used. Assuming an annual production of 6000 m³ per well, a total of 750 boreholes must be in operation by the year 2000. This scenario requires an additional 550 boreholes to be drilled. The average spacing between adjacent boreholes will be 3 to 4 km. Groundwater rest levels in the Sipili - Kinamba area are so deep that hand-pumps cannot be used. Fortunately, this area is relatively small.

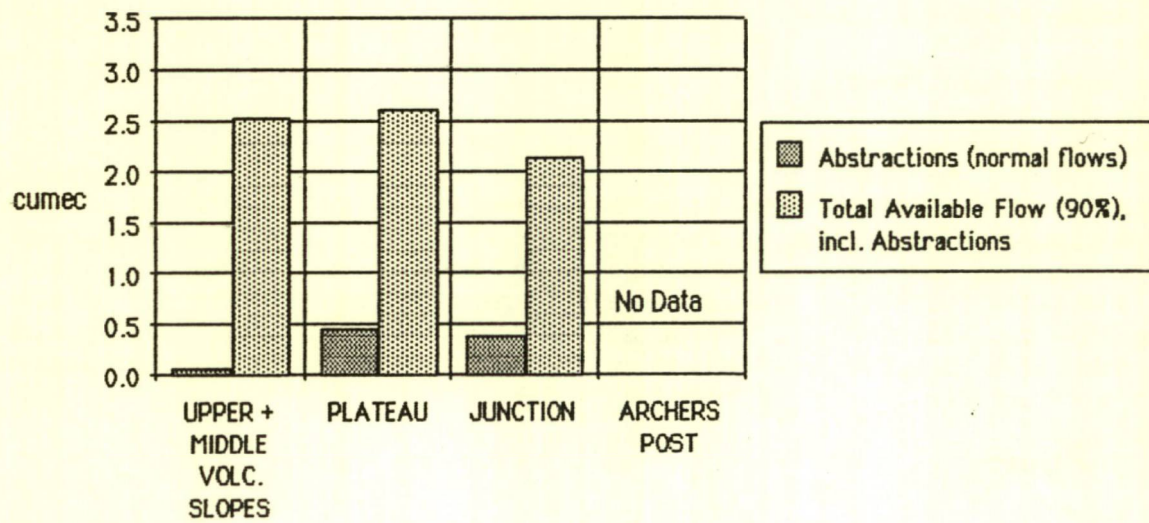
However, the prospects of drilling successful boreholes in the area of low potential east of Nyahururu are not good. Fortunately, this area is small and use of surface water may be feasible.

The groundwater in the volcanic area is 4,000 to 10,000 years old indicating that recharge is low. Therefore the use of groundwater for irrigation does not seem to be feasible. Any groundwater development in this area should be monitored carefully if groundwater is developed beyond the scale foreseen above.

Conclusion

The studied area has sufficient potential to meet the current and future (year 2000) water demand. Water demand for domestic use and cattle watering can be met by drilling boreholes. Technically speaking, water demand from irrigation can be met by building large-scale storage facilities in order to increase dry season flows. Current dry season flows are already overcommitted. Groundwater development in the Nanyuki, Rumuruti and Suguta Plains should take place in stages. Although the demand until 1990 would not adversely affect the storage, any development beyond the foreseen demand should be subject to additional study, as the age of the water suggests that recharge is limited.

Situation in the early Sixties



Current Situation

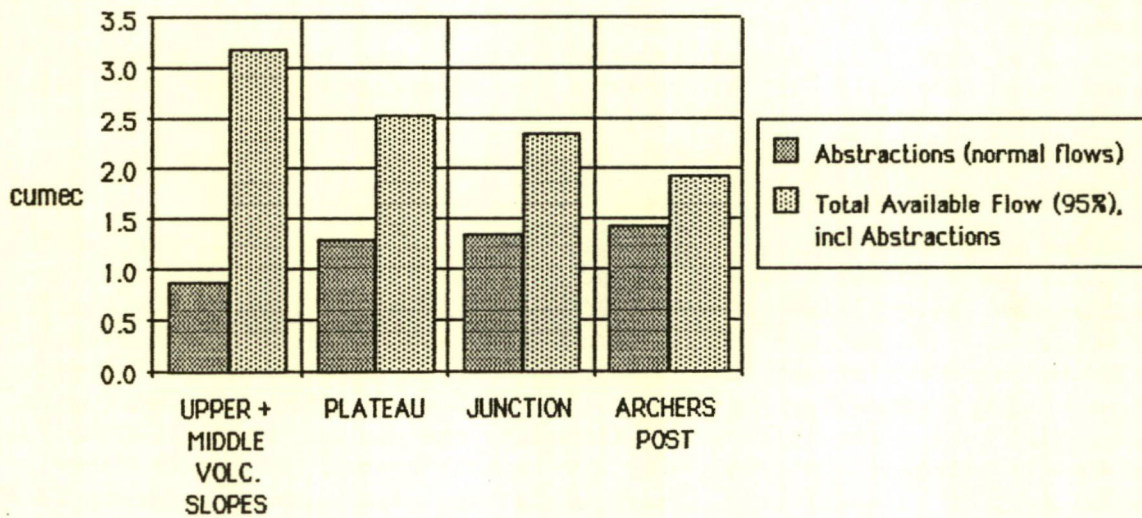
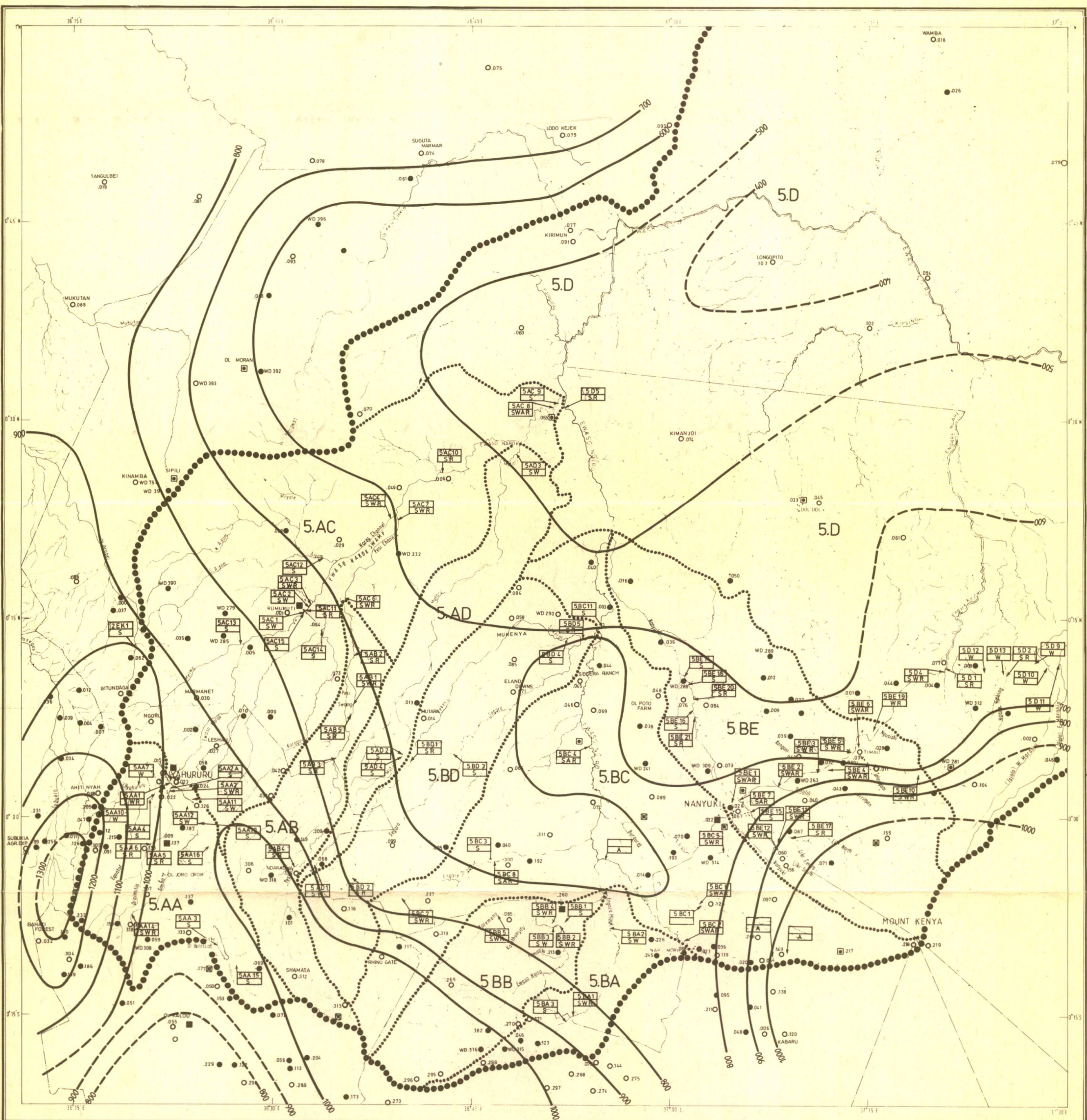


Fig. 5 Streamflow and Abstractions



LEGEND

- Rainfall station (last 3 digits) — ○
- Closed rainfall station — ●
- Evaporation station — □
- Closed evaporation station — ■
- Full meteorological station — ■
- Main catchment boundary — ———
- Sub-catchment boundary — ———
- Sub-catchment number — 5BE
- River gauging station (in operation) — SBE1, SBA1, SBA2, SBA3, SBA4, SBA5, SBA6, SBA7, SBA8, SBA9, SBA10, SBA11, SBA12, SBA13, SBA14, SBA15, SBA16, SBA17, SBA18, SBA19, SBA20, SBA21, SBA22, SBA23, SBA24, SBA25, SBA26, SBA27, SBA28, SBA29, SBA30, SBA31, SBA32, SBA33, SBA34, SBA35, SBA36, SBA37, SBA38, SBA39, SBA40, SBA41, SBA42, SBA43, SBA44, SBA45, SBA46, SBA47, SBA48, SBA49, SBA50, SBA51, SBA52, SBA53, SBA54, SBA55, SBA56, SBA57, SBA58, SBA59, SBA60, SBA61, SBA62, SBA63, SBA64, SBA65, SBA66, SBA67, SBA68, SBA69, SBA70, SBA71, SBA72, SBA73, SBA74, SBA75, SBA76, SBA77, SBA78, SBA79, SBA80, SBA81, SBA82, SBA83, SBA84, SBA85, SBA86, SBA87, SBA88, SBA89, SBA90, SBA91, SBA92, SBA93, SBA94, SBA95, SBA96, SBA97, SBA98, SBA99, SBA100
- River gauging station (closed) — SBE1, SBA1, SBA2, SBA3, SBA4, SBA5, SBA6, SBA7, SBA8, SBA9, SBA10, SBA11, SBA12, SBA13, SBA14, SBA15, SBA16, SBA17, SBA18, SBA19, SBA20, SBA21, SBA22, SBA23, SBA24, SBA25, SBA26, SBA27, SBA28, SBA29, SBA30, SBA31, SBA32, SBA33, SBA34, SBA35, SBA36, SBA37, SBA38, SBA39, SBA40, SBA41, SBA42, SBA43, SBA44, SBA45, SBA46, SBA47, SBA48, SBA49, SBA50, SBA51, SBA52, SBA53, SBA54, SBA55, SBA56, SBA57, SBA58, SBA59, SBA60, SBA61, SBA62, SBA63, SBA64, SBA65, SBA66, SBA67, SBA68, SBA69, SBA70, SBA71, SBA72, SBA73, SBA74, SBA75, SBA76, SBA77, SBA78, SBA79, SBA80, SBA81, SBA82, SBA83, SBA84, SBA85, SBA86, SBA87, SBA88, SBA89, SBA90, SBA91, SBA92, SBA93, SBA94, SBA95, SBA96, SBA97, SBA98, SBA99, SBA100
- Isohyet — 900
- District boundary — ———

Scale: 1:500,000

GN

NOTE

Only the last three digits of the raingauge numbers are shown on this map. The full number of any Kenya Meteorological Department raingauge can be derived by obtaining the latitude and longitude of a particular gauge. If the station is situated on the southern hemisphere the latitude obtained is added to 90; if it is on the northern hemisphere it is subtracted from 89.

For example, the complete number of station 033 at D.I. Dol is 89.37.033 and of station 219 at Mount Kenya is 90.37.219. This map is based on all available data upto 1985.

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PO BOX 30521 NAIROBI

Groundwater Survey
Delft Netherlands

UPPER EWASO NG'IRO BASIN

Plate 1 ISOHYETAL MAP OF MEAN ANNUAL RAINFALL

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LEGEND

- Equipped and operational
- Not equipped, but in good condition
- Cased but blocked
- No details available
- Abandoned and/or not traced
- Main catchment boundary
- District boundary
- Groundwater contours in m. 2000
- Basement system and volcanic rocks contact
- Spring
- Groundwater elevation a.m.s.l. in metres (1804)
- Borehole test pumped by W.R.A.P. C2895
- Transmissivity from well test in m²/day T [20.4]

WATER RESOURCES ASSESSMENT PROJECT

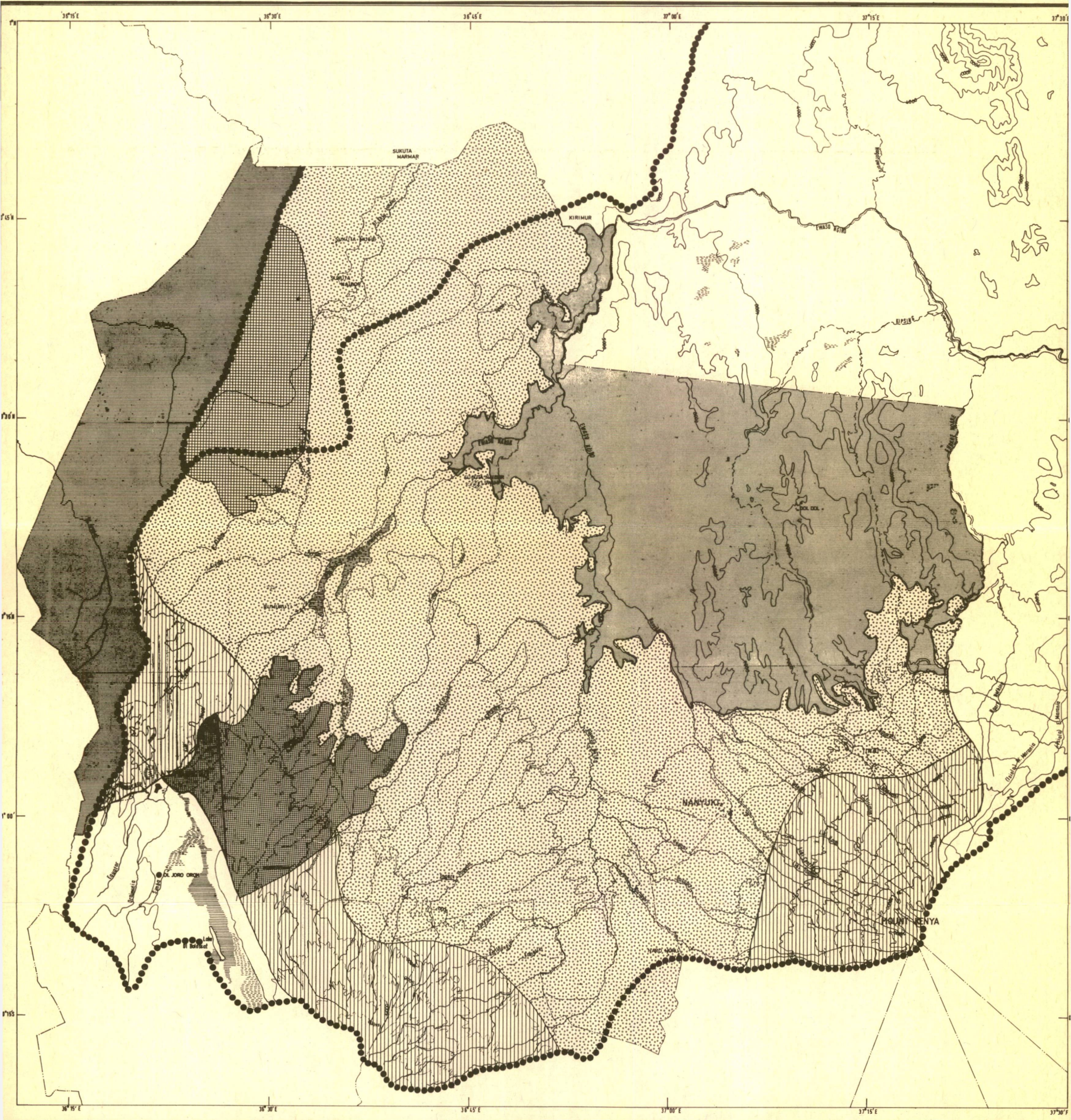
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Groundwater Survey
Delft Netherlands

LAIKIPIA DISTRICT

Plate 2 PIEZOMETRIC MAP

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LEGEND	HIGH POTENTIAL	HIGH TO MEDIUM POTENTIAL	MEDIUM POTENTIAL	MEDIUM POTENTIAL	LOW POTENTIAL	VARIABLE POTENTIAL
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
PHYSIOGRAPHICAL DESCRIPTION	Upper and Medium Volcanic Slopes (above 2000-2500m)	Nanyuki-Rumuruti-Sukuta Plain and Marmanet Ridge Region.	Lariak-Sipili Plateau Region	Basement System Region	Nyahururu-Upper Pesi Region	Mukutan-Ol Arabel faulted region, east of the watershed
NATURE OF AQUIFER	Volcanics: cinder layers, ashes, faults fissures.	Fissures and old land surfaces	Fissures and old land surfaces	Metamorphic: fissures and weathered zones.	Volcanic: Phonolitic lavas	Volcanic: faults, fissures, old land surfaces unweathered tuffs.
DEPTH TO WATER TABLE LEVEL	Probably < 50m below Medium Slopes > 50m below Upper Slopes	Mean 45m, Range: 0-84m	Mean 105m, Range: 60-120m	Mean 31m, Range: 6-50m	Mean 60m	Highly variable.
DEPTH TO AQUIFERS	Shallow below Medium Slopes Deep below Upper Slopes	Mean 100m, Range: 0-204m	Mean 200m, Range: 140-270m	Mean 72m, Range: 20-140m	Mean 100m	Highly variable.
ESTIMATED YIELD	High	5.7 ± 3.6 m³/h, Range: 1-15 m³/h	7.0 ± 4.1 m³/h, Range: 3-11 m³/h	4.1 ± 3.2 m³/h, Range: 0.4-14 m³/h	1 m³/h	Highly variable.
WATER QUALITY	No data but probably generally good	TDS 1200mg/l F 3.8mg/l	TDS 200mg/l (except C 2318) F 1.5mg/l	TDS 1000mg/l F 2mg/l	TDS 500mg/l F 1.5mg/l Poor aquifers boreholes were failure.	TDS 500mg/l F 1.5mg/l

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Plate 3 GROUNDWATER AVAILABILITY MAP

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