GEOGRAPHICA
BERNENSIA

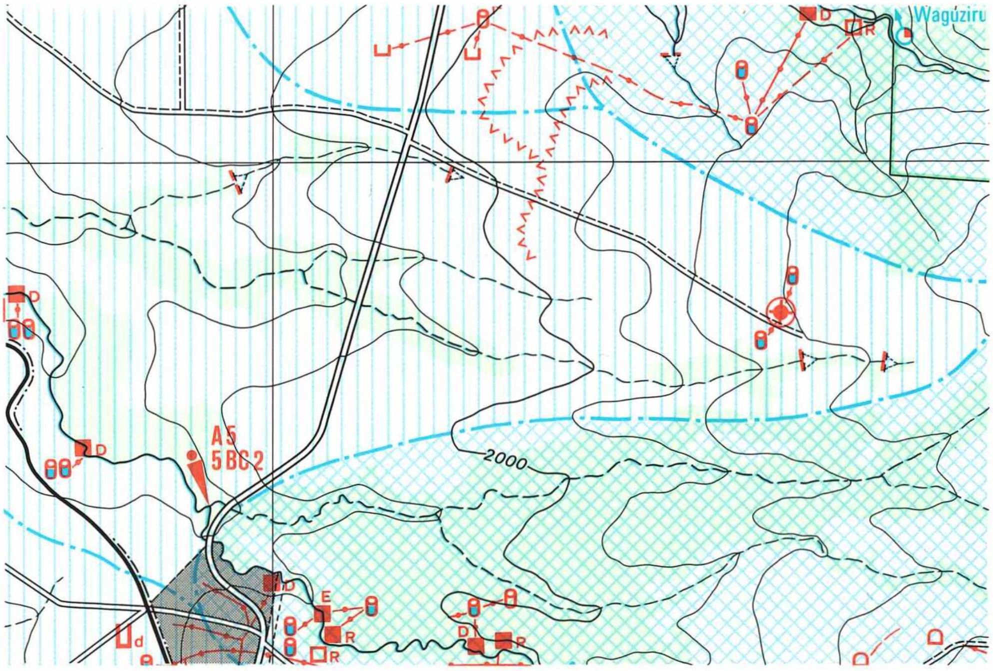
AFRICAN STUDIES SERIES A3

Christian Leibundgut

P. Berger, A. Brodbeck, R. Brunner, S. Decurtins, T. Kohler,
T. Moeri, I. Müller, U. Schotterer, M. Winiger

Hydrogeographical Map of Mount Kenya Area

1:50000
Map and explanatory text



UNIVERSITY OF BERNE SWITZERLAND INSTITUTE OF GEOGRAPHY

Cover picture: Detail of the Hydrogeographical Map of the Mount Kenya Area

Christian Leibundgut

P. Berger, A. Brodbeck, R. Brunner, S. Decurtins, T. Kohler, T. Moeri, I. Müller, U. Schotterer, M. Winiger

Hydrogeographical Map of Mount Kenya Area
1:50000
Map and explanatory text

THE PRINTING-COSTS OF THIS PUBLICATION WERE MAINLY FINANCED BY:
STIFTUNG MARCHESE FRANCESCO MEDICI DEL VASCELLO,
SWISS DEVELOPMENT CO-OPERATION

Christian Leibundgut

P. Berger, A. Brodbeck, R. Brunner, S. Decurtins, T. Kohler,
T. Moeri, I. Müller, U. Schotterer, M. Winiger

Hydrogeographical Map of Mount Kenya Area

1:50000

Map and explanatory text

GEOGRAPHICA BERNENSIA

AFRICAN STUDIES SERIES
Vol. A3

Publisher: GEOGRAPHICA BERNENSIA
and GEOGRAPHICAL SOCIETY OF BERNE
c/o Institute of Geography, University of Berne, Hallerstrasse 12
CH-3012 Berne, Switzerland

Printer: Merkur Druck AG, Langenthal

Reference: Ch. Leibundgut
Hydrogeographical Map of Mt. Kenya
Geographica Bernensia Vol. A3, Berne, 1986

ISBN - Nr. 3-906290-22-0

I Editorial Note

This issue of the 'African Studies Series' is the first one which focusses directly on application. We intend to provide information on one of the most limiting factors whithin semiarid areas: water for domestic and agricultural use. In an area which is in a phase of transition from large scale ranching to rather small scale agriculture the economical use of water and its related installations is a task of highest priority. We hope that the present map with its detailed description is of use to district authorities, to technical programmes, mainly the Laikipia Rural Development Programme, and to interested individuals.

The information provided is the result of a multidisciplinary approach, using data from official government river gauge networks, from University research activities (evaluation of data, own measurements, isotope analysis, geo-electric investigations, inventory of water installations, cartography) and includes numerous valuable contributions and information from different sources.

Thanks go to all those who contributed to this volume as scientists: *R. Brunner, S. Decurtins, Ch. Leibundgut, T. Moeri, I. Müller, U. Schotterer,* and as cartographer: *A. Brodbeck,* but also through their administrative help (Ministry of Water Resources, Office of the President, Embassy of Switzerland) and financial support (Stiftung Marchese Francesco Medici del Vascello, Swiss Directorate of Development Cooperation and Humanitarian Aid, University of Berne).

Extensive use, as well as helpful suggestions of how to improve the transfer of scientific information to practical decisions in a concrete technical programme would encourage us to continue the publication of this kind of information.

M. Winiger
Programme-Manager
Laikipia Research Programme
University of Berne, Switzerland

II Contents

III List of figures and tables

Figures

Tables

IV Abbreviations

a.s.l.	above sea level
GIUB	Geographical Institute of the University of Berne (Switzerland)
HQ	Maximum discharge
HHQ	Maximum discharge in the investigation period
MHQ/MNQ	Mean maximum discharge/minimum discharge
NQ	Minimum discharge
NNQ	Minimum discharge in the investigated period
MWD	Ministry of Water Development
r.g.s.	river gauging station
SDC	Swiss Development Co-operation
UNESCO	United Nations Educational, Scientific and Cultural Organization
WMO	World Meteorological Organization
∅	diameter

V Summary

In the north-west of Mount Kenya a research project is being carried out. Water is one of the limiting factors in regard to further development of the region. The most important results from the hydrological investigations made so far, are presented in the map. An inventory of the water supply installations is also given. All known features of the technical installations are listed for reasons of a practical use. The explanatory text gives supplementary information. The hydrological data base is given by the measurements of 23 years (1960–1982). The hydrological behaviour of 12 river basins is described by means of the terms 'long term discharge', 'yield', 'annual runoff regime' and 'duration curve of river runoff'. Preliminary results are given concerning precipitation, spring- and groundwater and concerning the study in the test drainage basin Naro Moru River.

1. Introduction

In the north-west of Mount Kenya a research project is being carried out by the Institute of Geography of the University of Berne. Data and results are now available in climatology, hydrology, pedology and socio-economy. Some of the studies are summarized in 'Mount Kenya Area – Contributions to Ecology and Socio-economy' (editor *Winiger,* 1986).

Water is one of the major limiting factors in regard to further development of agriculture. This is the reason why several hydrological studies were started within the last years.

With the implementation of the 'Laikipia Rural Development Programme' in 1984, supported by the SWISS DEVELOPMENT CO-OPERATION (SDC) , new requirements regarding the data and results had to be taken into account by the research team. For planning purposes and fieldwork the relevant facts must be presented clearly and made more easily accessible. Therefore a map is probably the best solution. Maps are commonly used to represent large amounts of information about the water regimes displaying the information in its spatial relationship and in relationship to the landscape configuration. The role of the rivers for the regional development is a distinct example (cf ch.3). There is also a need for clear thematic maps for further hydrological investigations.

In this map the most important results from the hydrological investigations made so far, are presented, and include an inventory of the water supply installations. The combination of hydrological elements and water resources management elements in the same map, makes it even more practical for planning purposes. Since the map also has to serve as a base for drafts and inventories, a discreet cartographic presentation was chosen.

The previous work and the edition of the map were only possible thanks to the willing cooperation of the participants and the support of different persons and institutions. I am indepted to all the collaborators, especially *A. Brodbeck* for the cartographical design and elaboration, *R. Brunner* for the field work which was also supported by *S. Decurtins,* who also provided a lot of information and constructive critisism of the manuscript. I also express my thanks to *P. Berger, T. Kohler, U. Stuker, J. White* and *M. Winiger* for their support. We would like to thank the Kenyan Authorities for supporting our work and supplying us with the data, particularly the 'Permanent Secretary, Office of the President', the 'Ministry of Water Development' in Nairobi and Nanyuki, the 'Ministry of Environment and Natural Recources' and Prof. *F. F. Ojani,* University of Nairobi. We express our special thanks to the 'Swiss Development Co-operation' and the Medici-foundation, who, after all, made it possible to print the map and this explanatory text through considerable financial contributions.

2. Structure of the map

Hydrological and especially hydrogeographical maps are defined as *presentations of hydrological information in its geographical relationship.* The choice of the symbols (related to points, lines, areas) was made in an attempt to be easily comprehensible. In particular the quantity of hydrological elements has been reduced to a minimum.

The presentation of the hydrological basics together with the technical installations makes it possible to decide which planning measures are to be taken. According to the classification of the UNESCO/WMO (1977) we have compiled a 'Derived data map' for general purposes combined with a 'Planning map', which shows hydrological information useful for the consideration of alternate solutions to water supply development problems and involving the use of water in any way (UNESCO, 1977).

With this *explanatory text* we intend to give supplementary information about the aim of the map and about the way chosen which led to the specific cartographical presentation. In the individual chapters the essential cartographic information is pointed out. Each cartographical element is described according to its significance. Several tables and figures complete the given information. Only the most important references are indicated.

2.1. General topographical situation

The information density of the general topographical situation is intentionally low. We tried to facilitate the orientation in the field as much as possible. The maps of the 'Survey of Kenya' (details cf. map) served as the topographic source. The boundaries which are important for the planning of water supply installations (forest reserve boundary and others) are also marked, but deliberately in a very discreet way. Since other scales must be consulted for the planning of water supply networks or irrigation schemes, the settlements are indicated by means of symbols. We refrained from marking the scattered settlements, which nowadays change very quickly. The forest is mapped as the most important hydrological natural basis. Its mapping is based on the official maps. The present forest boundaries are derived from Landsat-scene 3 and complementary field work in 1983 by *T. Kohler.*

The *isohypses* in feet have been converted and redrawn in metric measures with an *interval of 20 m.* In order to emphasize the topography this interval has been maintained over the whole map, even though there is a very high convergence of curves at the steepest parts of the Mount Kenya slopes.

2.2. Hydrographical and hydrological situation

The hydrographical phenomena have been mapped as completely as possible in view of the exploitation of the water resources. There is a great deal of surface water while there are only springs as natural phenomena of subsurface waters. The *map is dominated by the rivers* which are most attractive for settlements since they are the lifelines. The high density of symbols along the rivers is not only conspicuous but also caused some difficulties in the cartographical presentation. The network of hydrological measuring stations is decisive for the judging of the given data as well as for the planning of further investigations. The changes until 1984 have been included so that a complete picture can be shown.

The basic structure of the measuring network is given by the official gauging stations of the Ministry of Water Development. Where necessary and possible, it has been completed for the investigations of the GIUB-project. The official Kenyan names for the gauging stations have been adopted wherever they were available. The gauging stations are characterized as precisely as possible since the construction of a gauging station can have considerable effects on the gathering and the quality of the data. The river basins of the respective gauging stations have been defined according to the topographical situation laid down on the maps. Verifications in the field could only be made in a limited number. The basic units are formed by the watersheds of the mountain flank up to the altitude of the Naro Moru-Timau road. The Naro Moru river basin has been divided into subcatchments because of the zonal hydrological investigations which are taking place there.

2.3. Regional Hydrology

The hydrological situation is presented in chapter 4. In this section only the cartographical aspects will be discussed briefly. The *yield* ($l/(s.km^2)$) is the only reasonable two-dimensional representation of the river discharge. With this representation, however, only a mean value for the respective river basin can be indicated. In this region the knowledge of the low flow is more important for the use of water than the quantities of the mean and high flows; that is the reason why low flow values are indicated. The representation of the yield makes it possible to estimate the available water quantities for each river basin during dry periods. Moreover, the coloured map gives an idea of the spatial distribution of the water quantities during the dry seasons.

The representation of the *river regimes* for the individual river basins shows the temporal distribution of the surface water resources over the period of a year. Even though it is cartographically difficult, we chose the graphic form because this is the best way to provide this extremely important information. By means of diagrams we can partly resolve the obvious shortcoming of the maps which have to show three- (or four-) dimensional features on a two-dimensional frame. All information about the groundwater is expressed by the spring and borehole symbols.

2.4. Water resources management

This part is based on the mapping by *Brunner* (1982). All known changes up to 1984 have been taken into account. An inventory was compiled of all installations which serve either irrigation or water supply, or which depend in some way or other on water. It is also possible to read directly from the symbol if, at the time of the inventory, the respective installation was working or not (further information cf chapter 6).

3. Area of investigation

The investigation area lies northwest of Mount Kenya in the upper part of the *Ewaso Ng'iro river basin* as can be seen on the front page of the Hydrogeographical Map of Mount Kenya Area. It is the source of the Kenya's main rivers. Whereas the River Tana flows right across the East African Plateau to the Indian Ocean, the Ewaso Ng'iro can be called a perennial river only as far as the Lorian Swamp. This dissimilar flow behaviour reflects the features of the hydrological situation around Mount Kenya. The elevation of the *Tertiary volcanic massif on the East African Plateau,* rising to approximately 5200 m a.s.l., is the reason why the region around Mount Kenya has quite a high level of humidity. The relatively humid air masses of the tradewinds from the Indian Ocean lead to orographic precipitation. Thus, in the middle of the East African dry regions, the equatorial position of Mount Kenya gives rise to almost regular daily precipitation events characteristic of the humid tropics. The investigation area belongs to the dry and sub-humid climatic zone with the exception of the higher slopes of Mount Kenya.

Depending on the altitude there is a *vertical sequence of zones* on the slopes of Mount Kenya. The glacial-nival zone in the area around the summit is followed by the afro-alpine belt with the moorland zone. The dense humid montane forest begins at an altitude of about 3300 m. This region is characterized by the highest drainage density of the investigation area. Due to the intensive forestry the lower forest boundary is not connected. The zone at the foot of the mountain becomes savanna foreland at about 1800 m. The rivers carry the life-giving water far out into the semi-arid zone.

From a hydrological point of view, the investigation area, which is situated in the upper basin of Ewaso Ng'iro, can be divided into two parts. It is first the well watered part extending from the slopes of Mount Kenya to the foot of the mountain (Tarmac road), and secondly the dry savanna forelands to the north and the west of this line. The difference in drainage density between these two parts is evident. The water drains radially in ten main channels in narrow, elongated drainage basins into the Ewaso Ng'iro.

The northern rivers form the important subcatchment of the Nanyuki River. Their confluence with the Ewaso Ng'iro lies outside the map perimeter. In the furthest north the beginning of the Loldaika Hills can be seen. They are formed by the harder rocks of the basement. The plain region in the far north-west of the investigation area is only drained by periodic rivers.

The map clearly shows the role of the rivers as important economic factors for the formation and the development of centres. At the point of intersection of the two factors which favour settlements, 'water' and 'traffic', the regional centres can be found.

Further information concerning climate, geomorphplogy and soils can be obtained from *Ojany* (1968), *Winiger* and *Messerli* (1978), *Speck* (1982) and *Winiger* (1986).

4. The hydrological basis

4.1. General

The hydrological situation in the investigation area has been described in several publications (*Roberts* 1963, *Leibundgut* 1982, 1983, 1984). The inventory of the water supply installations is described in detail by *Brunner,* (1982).

New data have been included in the present map and through its compilation, knowledge of the regional hydrology could be broadened. Taking into account the number of results already published the features of hydrology are just briefly summarized. However, the summary is given in such a way that it is possible to understand the hydrological interrelations even without studying the literature. The new data are discussed. Together with the content of the map, this gives the possibility of gaining a complete insight into the regional hydrology. As a consequence of the revision of the topographical basis, the boundaries of the river basin have partly changed. Compared with the catchment areas published so far we therefore obtain different values. The surfaces of the subcatchments north-west of the 'Tarmac road' also had to be calculated (cf table 1). Considerable differences only resulted for the Naro Moru and Likii catchment respectively.

4.2. Long term discharge 1960–1982

River run-off is the most important regional water resource. The values set out in table 2, serve to provide a general view of this water balance component. The *mean discharge values* (MQ_{23}) vary greatly at the individual stations depending on the different sizes and the geographical position of the river basins. The values (HQ_y) and (NQ_y) represent the maximum and minimum annual mean discharge for the period 1960–1982. The maximum values are higher by a factor of 1.8–2.9, whereas the smallest annual discharge attains values of 0.10–0.55 of the period average. The river discharges for which the year is given show that the highest annual discharges occurred, with few exceptions, in 1961, while the lowest were recorded, with hardly any exceptions, in 1980. In wet years the river discharges are up to 10 times higher than in dry years.

The values of the yield are discussed later. On the top of the left panel of the map, the period values of the discharge are represented schematically as diagrams according to their geographical position. This illustration gives a general view of the regional discharge and an impression of the discharge in wet and dry years. Generally, the discharge fluctuations increase from the River Naro Moru – 5BC2 in the southwest to the River Kongoni – 5BE3 in the northeast.

The discharge from the River Teleswani – 5BE5 and the River Timau – 5BE6 is very steady.

Table 1: River basin areas and average altitudes

River basin and subcatchments	River gauge station	Area (km²)	Earlier published values (km²)	Average height (a.s.l.)
River basin at Mount Kenya down to the official gauging stations at the main road				
Naro Moru R.	5BC2	102,0	83,0	2917
Burguret R.	5BC6	98,1	98,0	2529
Rongai R.	5BC5	46,0		2305
Nanyuki R.	5BE1	67,8	68,0	2951
Likii R.	5BE7	172,0	184,0	2821
Ontulili R.	5BE2	61,1	61,0	2805
Kongoni R.	5BE3	16,4	14,0	2492
Sirimon R.	5BE4	59,5	62,0	3366
Teleswani R.	5BE5	38,9	36,0	2758
Timau R.	5BE6	58,3	64,0	2936
Subcatchments Naro Moru R.				
I	A1	4,95	4,76	4571
II	A2	8,38	16,0	4107
III	A3	25,5	26,0	3199
IV	A4	22,8		3041
V	A5	40,3	47	2239
VI	A6	67,3	84	
River basins between the official gauging stations and the folllowing confluence				
Naro Moru R.	A6	67,8		
Burguret R.	Confl. Ewaso Ng'iro	121,0		
Rongai		51,3		
Nanyuki R.		77,7		
Ontulili R.		47,0		
Sirimon R.		21,7		
Kongoni R.		13,4		
Teleswani R.		1,57		
Timau R.				
Superior drainage basins				
Nanyuki R.	5BE21	318,0	329,0	
Nanyuki R.	5BE20	860,0	860,0	
Ewaso Ng'iro R.	5BC4	1865,0	1865,0	

The biggest fluctuations appear in the total discharge of the River Nanyuki – 5BE20 and of the River Ewaso Ng'iro – 5BC4.

The period 1960–1980 shows hardly any changes compared with the period 1960–1982 already discussed. The discharge values of the years 1981 and 1982 are within the bounds of the mean values for the period. Therefore, there is only an imperceptibly change in the mean-, high-, and low flow discharge values of the period. Thus, the previous conclusions are still valid for both periods. The slight changes are of no consequence to the water use. Due to the newly determined surfaces of the river basins there are some small changes in values for the yield. This again, however, does not change the situation in principle. Only the Naro Moru River shows a considerably lower yield value.

The values discussed so far are average values for the period and the year. *The characteristic data of discharge* (Hauptzahlen des Abflusses) give further information, because daily values

Table 2: River discharge for the period 1960–1982. MQ_{23} is annual discharge; HQ_y is maximum annual mean discharge; NQ_y is minimum annual mean discharge; M_q, H_q, N_q are corresponding values for the yield.

River	Station No.	Catchment Area (km²)	MQ_{23} (m³/s)	M_q [(l/(s·km²)]	HQ_y (m³/s)	Year	H_q [(l/(s·km²)]	NQ_y (m³/s)	Year	N_q [(l/s·km²)]
Naro Moru R.	5BC2	102,0	1,18	11,596	2,13	1968	20,9	0,493	1980	4,83
Burguret R. (without 1974–77)	5BC6	98,1	0,934	9,521	1,78	1968	18,1	0,289	1980	2,95
Nanyuki R.	5BE1	67,8	0,684	10,088	1,44	1961	21,3	0,238	1980	3,51
Likii R.	5BE7	172,0	1,57	9,128	2,90	1961	16,9	0,588	1980	3,42
Ontulili R.	5BE2	61,1	0,619	10,131	1,40	1961	22,9	0,135	1980	2,21
Kongoni R.	5BE3	16,4	0,063	3,841	0,175	1961	10,7	0,006	1980	0,37
Sirimon R.	5BE4	59,5	0,610	10,252	1,41	1961	23,7	0,260	1969	4,37
Teleswani R.	5BE5	38,9	0,318	8,175	0,621	1968	16,0	0,154	1980	3,96
Timau R.	5BE6	58,3	0,251	4,305	0,480	1961	8,2	0,138	1973	2,37
Nanyuki R. (from 1965)	5BE21	318,0	2,38	7,484	4,22	1977	13,3	0,846	1980	2,66
Nanyuki R.	5BE20	860,0	4,44	5,163	11,9	1961	13,8	1,170	1980	1,36
Ewaso Ng'iro R.	5BC4	1865,0	4,06	2,177	12,2	1961	6,5	1,30	1980	0,697

Table 3: Discharge characteristics (m³/s) for the period 1960–1982

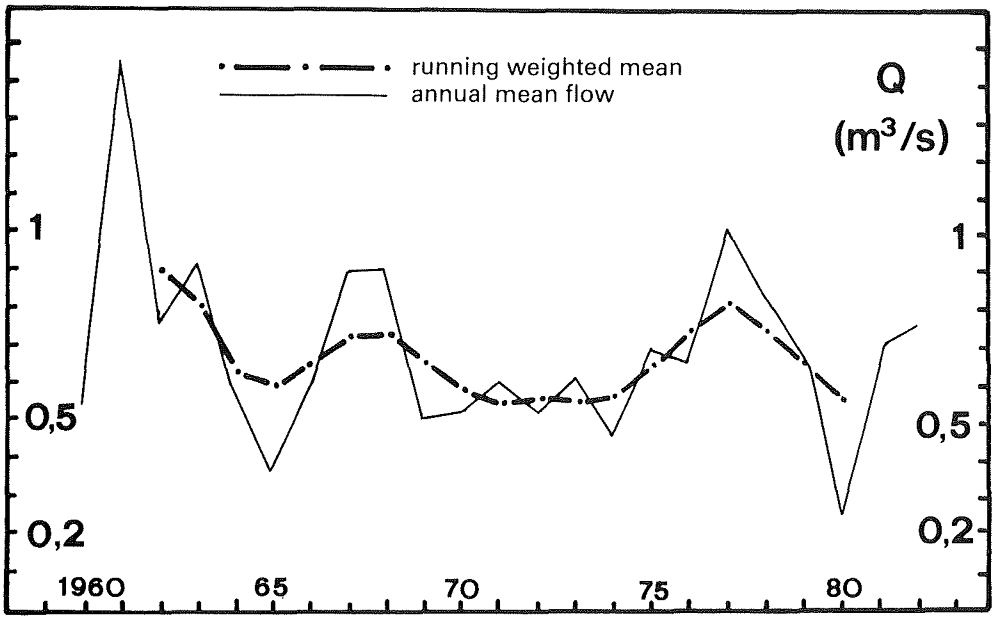
	BC 2	BC 4	BC 6*	BE 1	BE 2	BE 3	BE 4	BE 5	BE 6	BE 7	BE 20	BE 21⁺
HQ=HHQ	27,9	141,0	25,7	23,6	14,3	2,11	29,7	6,58	4,4	~100	193,0	217,0
MHQ	14,4	39,1	9,19	10,4	6,13	0,53	11,2	0,99	1,21	~ 25	43,4	47,4
s (MHQ)	6,97	36,29	6,42	7,32	4,09	0,55	8,47	1,23	1,31		46,42	60,22
MQ	1,18	4,06	0,934	0,684	0,610	0,063	0,610	0,318	0,251	1,57	4,44	2,38
MNQ	0,23	0,46	0,16	0,08	0,10	0,01	0,11	0,17	0,16	0,27	0,66	0,34
s (MNQ)	0,05	0,34	0,09	0,05	0,09	0,01	0,06	0,06	0,09	0,16	0,33	0,20
NQ=NNQ	0,107	0,118	0,013	0,008	0,013	0,0	0,054	0,061	0,079	0,008	0,259	0,126

* Data missing for 1974–1977
⁺ Data missing for 1960–1964

and extreme values are taken into consideration (table 3). HHQ is defined as the highest daily discharge measured at the station in question during the measurement period. This is defined on the basis of the highest annual water value (HQ). The quality of these HQ data is relatively poor due to the variation in the frequency of the gauge reading.

The daily value at river gauging station Ontulili – 5BE2 is determined by one *reading of the staff gauge* a day. At the river gauging station 5BE20 and 5BE21 (Nanyuki) it is obtained by one reading every second day, and at the 5BC4 Ewaso Ng'iro river gauging station by the daily mean calculated from the recorder. The other staffgauges are read twice a day. Thus, in some places, the HQ values do not represent the peak value of the discharge and the calculated discharge values might be too low. In view of the fact that the HQ values for the whole measurement period are taken into consideration, the highest discharge measured here corresponds to the highest high water level (HHQ). The *MHQ values* are defined as the arithmetic mean of the 21 HQ highest annual values in the measurement period. The standard deviation of the MHQ values show the very high variability of the flood flow in this region. The HHQ value of the River Likii – 5BE7 (298 m³/s) published in *Leibundgut* (1983) may be wrong. Judging from observations in the field, the maximum value amounts to approximately 100 m³/s.

The *low flow values* (NNQ, NQ, MNQ) are defined in the same way as the high flow values, but with respect to the low water level. The quality of the NQ values is considerably better than



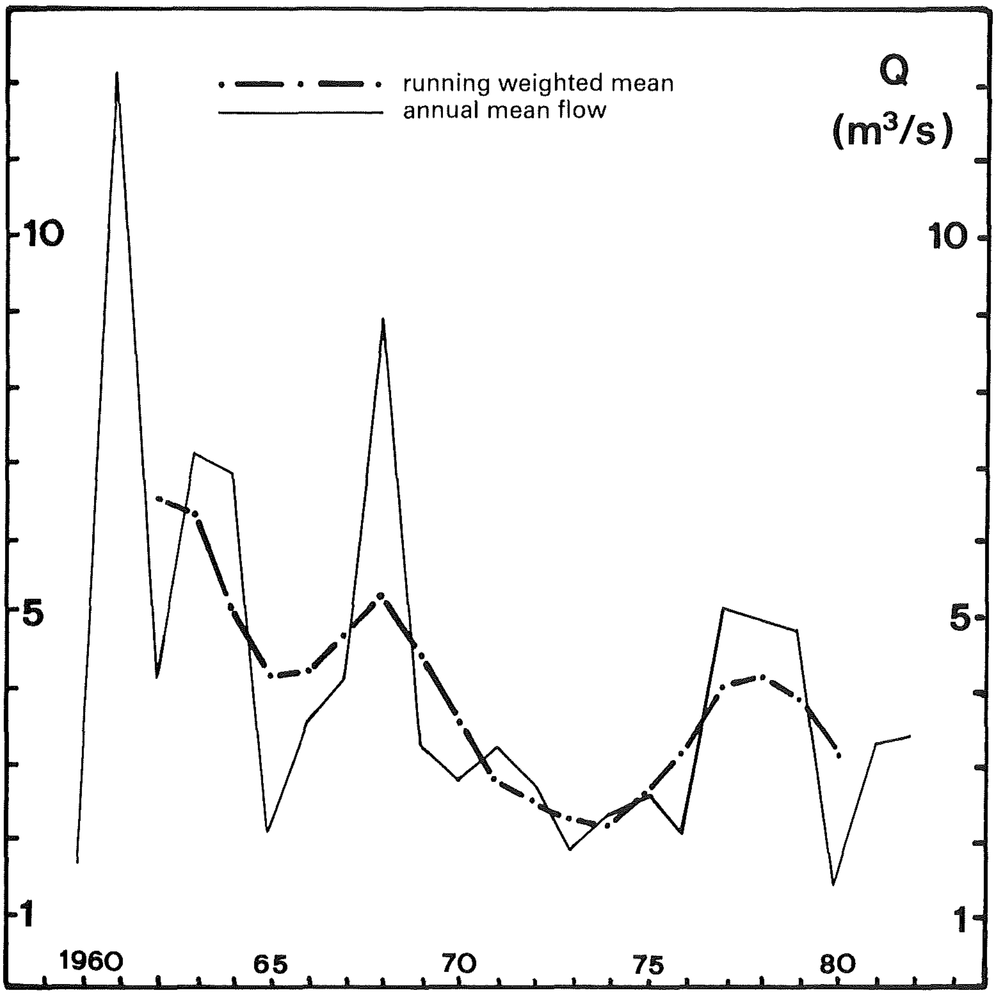


Figure 1: The running weighted five-year average of the annual mean flow of two typical rivers (1960–82) together with the annual mean flow hydrograph. Fig. 1a (above): River Nanyuki-5BE1 with a low amplitude in discharge; Fig. 1b (below): River Ewaso Ng'iro with a distinct amplitude and a negative trend in discharge.

that of the HQ values. Differences in the frequency of gauge reading are of far less consequence because there is far less variation in the low flow values. *Moeri* (1982) reckons for the low flow a maximum error of 5% as opposed to a maximum of 30% in the case of HQ values. The average high water levels (MHQ) are 9 to 20 times higher than the period averages at the individual river gauge stations. Exceptional behaviour is shown by the discharges of the Teleswani – 5BE5 and Timau – 5BE6 with the factors 3–4. The same situation can be seen in the case of the average low flow: with 53–64% average low flow, the Rivers Teleswani – 5BE5 and Timau – 5BE6 differ vastly from the fluctuation of all the others, which vary between 11 and 20% of the mean discharge. The standard deviation shows a variability in the low flow which must be taken into account regarding the availability of water. The extreme values (HHQ, NNQ) necessarily fluctuate very much and lie between 1 : 12000 (River Likii – 5BE7) and 1 : 56 (River Timau – 5BE6).

The hydrographs of the annual mean discharges over the period 1960–1982 demonstrate a certain similarity in the process, with a succession of periods showing higher and lower flow. The figure on the left panel of the map reveals a relation between precipitation and river flow. Apart from the absolute rainfall depths, the succession of years with more or less rain seems to be of particular significance for the annual discharge and appears to be characteristic of the test area.

The *running weighted five-year averages* of the annual mean flows show a sequence of drier and wetter periods (fig. 1). Three periods of high discharge can be distinguished around 1962, 1967 and 1977. Between these years relatively dry periods with minima in 1965, 1973 and 1980, occurred. One can distinguish two types of run- off: the Nanyuki River type (fig. 1a) with a low

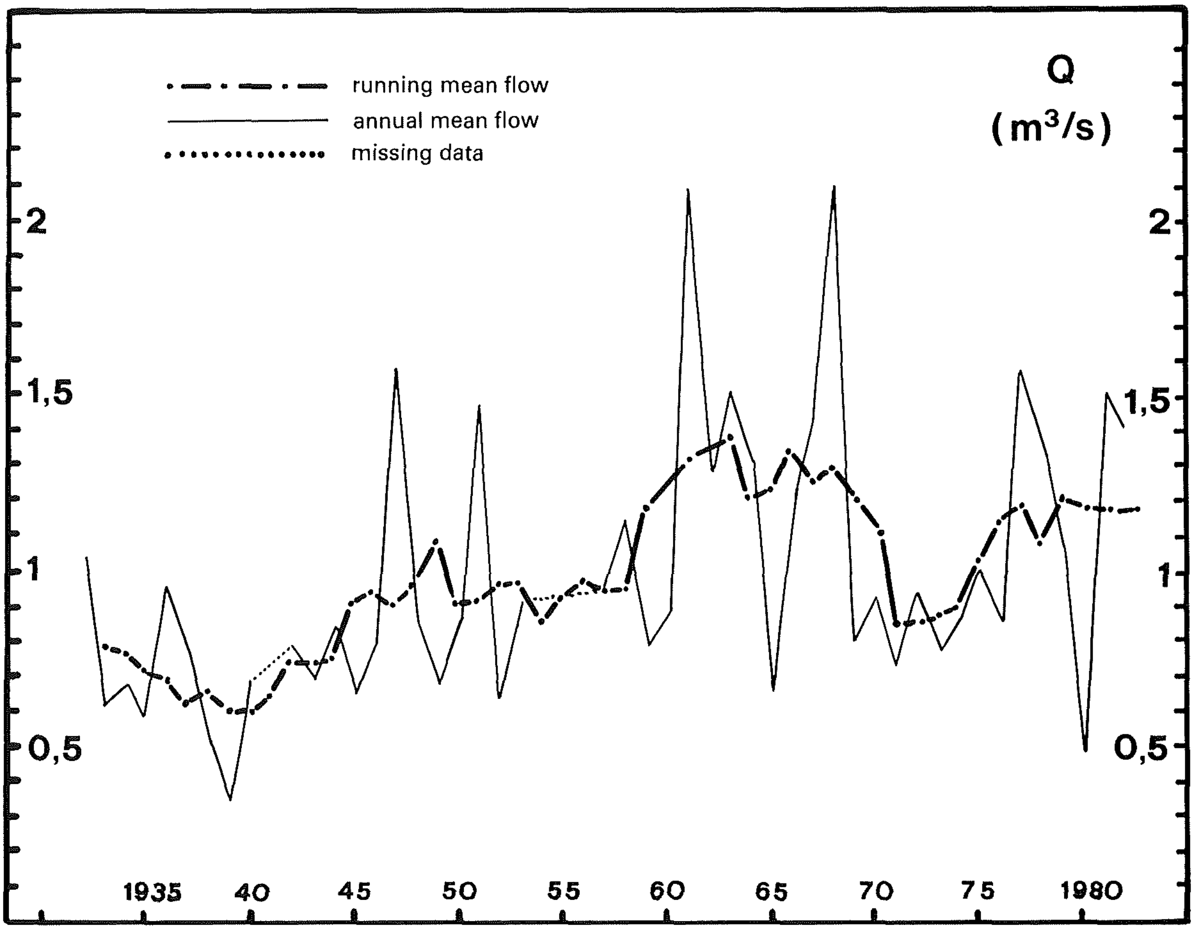


Figure 2: Long term discharge of the River Naro Moru from 1931–1982. The running mean shows a drier period in the decennia 1930–1960. The discharge values of the investigation period 1961–82 lie rather on the wet side.

amplitude in discharge and the Ewaso Ng'iro-type (fig. 1b) with a distinct amplitude in discharge during dry and wet periods respectively.

For the planning of the water resources managment it is useful to know how representative the present discharge values from the 23-year period are. The previous statistical analyses have shown that the data material does not completely meet the necessary requirements of consistency and homogenity; that is to say that the 23-year period is too short to permit conclusive statements. For the discharge of the Naro Moru River the monthly values from 1931–1982 are available. The differences in the mean values are not significant; the variabilities, however, show important differences. This indicates two basic totals during dry and wet periods. The 'Abbe-test' appears to be significant for cyclic mean value deviations. This is confirmed by the graph of the running mean. Thus, there is obviously no tendency towards higher or lower discharge, but during phases of several years there is definetely a succession of periods with higher and lower discharge. Figure 2 also shows distinctly that all in all, the investigation *period 1960–1982 belongs to a phase of above average discharge.* This aspect will have to be taken into account for water supply planning.

The *chemical quality of river water* is good but of a low to very low mineralization. The range of the electrical conductivity values measured is 8 – 160 µS for the rivers at the mountain slopes and 43–260 µS for the river water in the savanna. Most of the river waters are of the type of Ca-Na-HC_{03}-water followed by the type Na-HC_{03}-water. Whereas the cattle prefer this low salinated water, people prefer the higher salinated spring water with more taste. The river water is also for irrigation purposes. The sodium adsorption ratio (SAR-value) is low (*Leibundgut,* 1982).

4.3. The yields (period 1960–1982)

The yields ($l/(s \cdot km^2)$ give an overview of the spatial distribution of the water quantities which are avaiable in the river basins and allow the direct comparison between the discharges of the individual watersheds.

In the 23-year mean the Naro Moru River attains the highest yield for the mean discharge with 11 $l/(s \cdot km^2)$. The adjoining drainage basins as far as the Sirimon River show values between 9 and 11 $l/(s \cdot km^2)$, and the yield of Teleswani River amounts to 8–9 $l/(s \cdot km^2)$. A distinctly lower yield shows the Timau River with 4–5 $l/(s \cdot km^2)$. It can be seen that a well balanced water flow faces a relatively low discharge per square unit. Another interesting fact is that the Timau River, whose runoff regime is similar to that of the Teleswani river, shows a yield which is twice as low. For these differences and for the low value of the Kongoni River we do not yet have definitive explanation. The yields of the years with the highest discharge are about twice as high as those of the period mean; and the yields of the years with the lowest discharge are 2–5 times lower (cf Table 2). The yields of the dry weather periods are more important for the use of water than the mean values. This cartographically evaluated quantity is discussed in chapter 5.2.13.

4.4 The annual runoff regime

The graphs of the flows studied in the region of Mount Kenya show two peaks. This is clearly reflected in the principal mean annual climatic pattern, which has two rainy and two dry seasons. However, the second dry season is weakened by the continental rains (local anticyclones). The

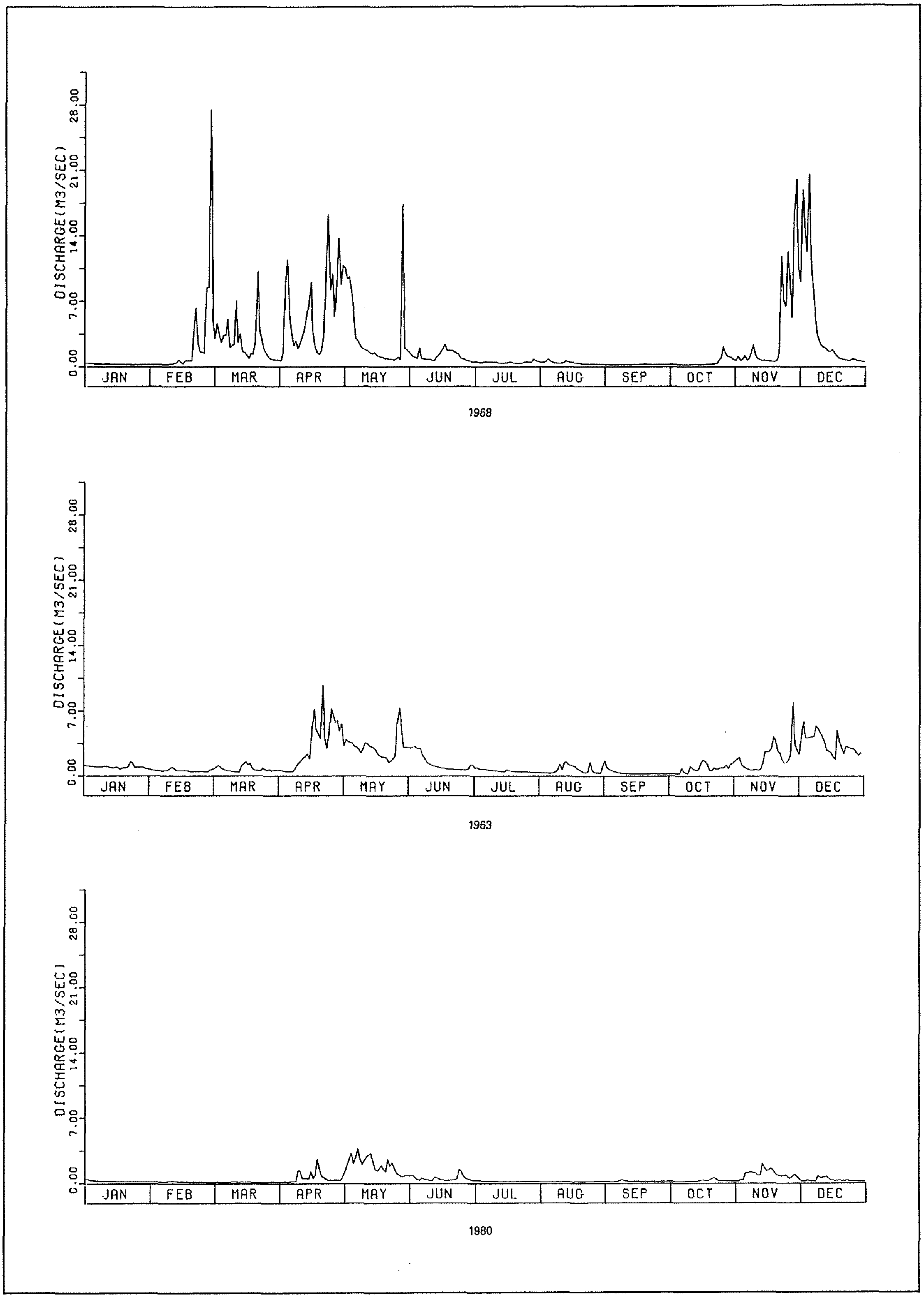


Figure 3: Daily discharge hydrographs of three typical years of River Naro Moru-5BC2. The discharge hydrographs of a wet year 1968, an average year 1963 and a water-short year 1980 show a considerably different course.

theoretical background concerning the classification of these river regimes is discussed in *Leibundgut* (1983). The river regimes of the research area can be called an *'equatorial runoff regime of high mountains with two maxima'*. It is characterized by more extreme coefficients than those found in the 'equatorial runoff regime of the rainforest' (cf *Balek,* 1977).

The runoff is slightly out-of-phase. The months with the highest discharge are April/May and October/November. During these four months, approximately half the annual amount of water is discharged. In the case of a few rivers, the months of June and December are also part of the rainy-season discharge, and approximately 60% of the annual amount is discharged during that time. Finally, the continental rains (August/September) lead in some of the catchment areas to above-average monthly discharges. During these five to eight months, about 80% of the annual amount is discharged with the exception of the rivers Teleswani – 5BE5 and Timau – 5BE6. The first maximum (April/May) is hardly distinguishable and only approximately 40% is discharged during the rainy season.The year to year variability is quite high, especially that of the low flow (cf chapter 5.2.14). The discharge hydrographs of an average year, of a water-short year and of a wet year show a considerably different course (fig. 3).

4.5. Flow duration curves of the discharge 1960–1982

The representation of the discharge values in the form of flow duration curves is especially significant for the judging of the discharge from a *water resources management* point of view. They allow a direct availability of decisive quantities for the planning of water supply projects or irrigation schemes.

The flow duration curves give very detailed information since they include all the daily values. In the middle curve the daily values of all 23 years are put in order of quantity and noted as the mean values of the respective days (average of the ordinate's data). The duration curves shown in the figures 4 to 6 consequently have a distinct character of mean values. The variation amplitude is given by the upper and lower envelope curve. Unlike the middle flow duration curve, however, this is the representation of a theoretical extreme situation. The values put down are the highest or/ and the lowest (realistic) ones of the 23 values of the respective day. *Leibundgut* (1982) shows the flow duration curves of the dry year 1980 with absolute low flow values.

All in all the duration curves of all river flows have a similar graph. There are a great number of low flow and mean flow values, but only few high flow values (on approximately 60 days). Therefore, Ewaso Ng'iro – 5BC4 and Sirimon – 5BE4 show an extremely flat duration curve;

Table 4: Discharge values of the duration curves of 1960–1982 (m^3/s) reached or exceeded on .... days

Rivers days	 %	5BC2 Naro Moru	5BC4 Ewaso Ng'iro	5BC6 Bur-guret	5BE1 Na-nyuki	5BE2 Ontu-lili	5BE3 Kon-goni	5BE4 Siri-mon	5BE5 Teles-wani	5BE6 Timau	5BE7 Liki	5BE20 Nan-yuki	5BE21 Nan-yuki
347	95	0,270	0,581	0,219	0,103	0,099	0,010	0,135	0,194	0,150	0,350	0,826	0,426
329	90	0,298	0,664	0,256	0,123	0,112	0,011	0,147	0,203	0,162	0,404	0,927	0,481
274	75	0,440	1,000	0,359	0,222	0,189	0,013	0,198	0,221	0,177	0,629	1,495	0,762
228	62,5	0,572	1,452	0,452	0,333	0,286	0,024	0,275	0,244	0,195	0,901	2,249	1,138
182	50	0,737	2,059	0,589	0,452	0,403	0,034	0,370	0,270	0,217	1,192	3,035	1,530
137	37,5	0,978	2,996	0,768	0,604	0,541	0,050	0,477	0,310	0,242	1,544	4,016	2,083
91	25	1,382	4,805	1,060	0,842	0,759	0,078	0,677	0,368	0,276	2,064	5,580	2,960
55	15	2,014	7,343	1,529	1,204	1,106	0,123	0,990	0,462	0,352	2,727	7,994	4,325
18	5	3,690	15,314	2,996	2,141	2,003	0,242	1,898	0,599	0,471	4,194	13,616	7,502
9	2,5	4,823	20,161	4,091	2,718	2,568	0,296	2,704	0,674	0,551	5,245	16,734	9,720

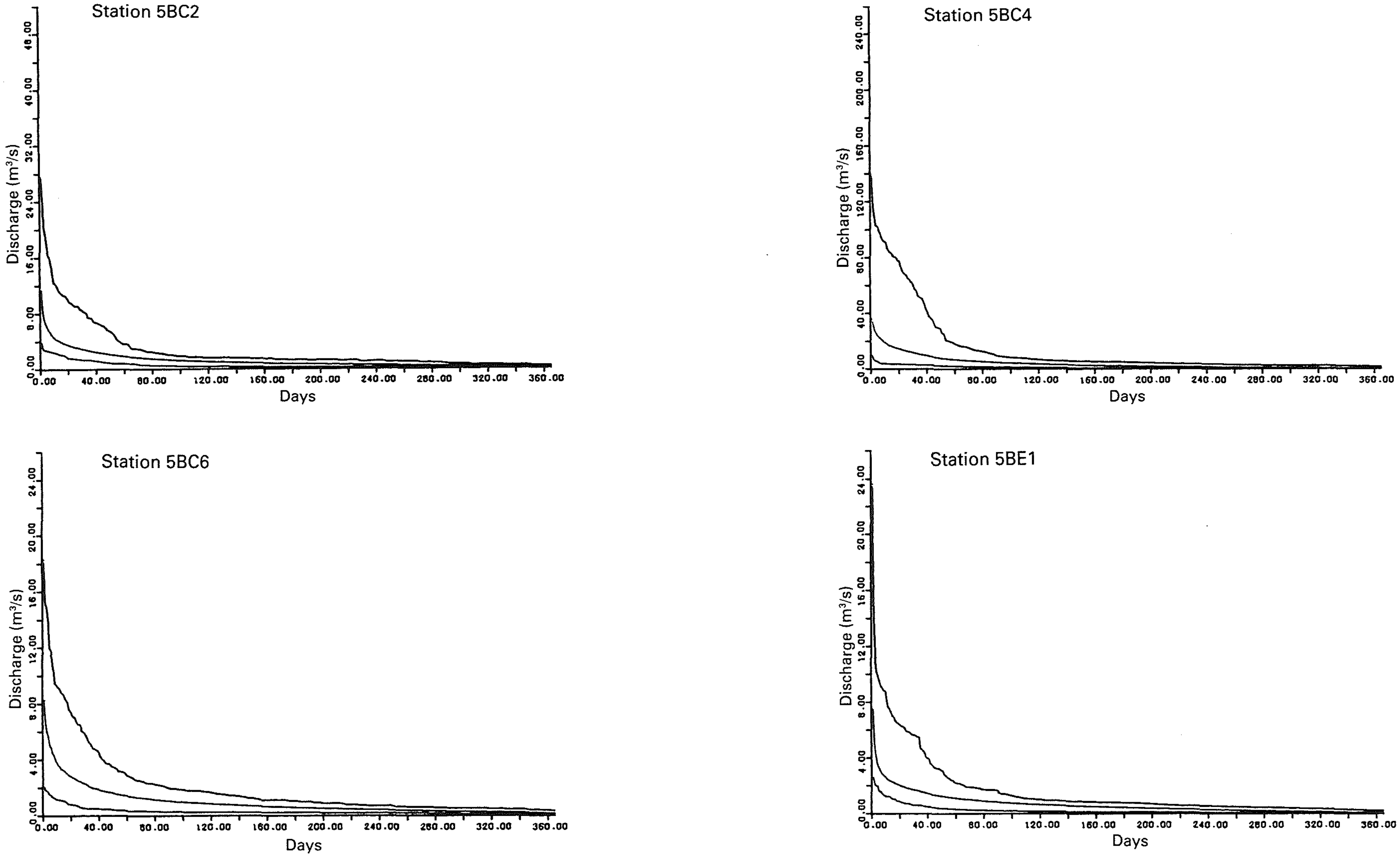


Figure 4: Duration curves of the river discharge at the gauge stations 5BC2-Naro Moru River, 5BC4-Ewaso Ng'iro River, 5BC6-Burguret River and 5BE1-Nanyuki River (period 1960–1982). Middle line: mean duration curve 1960–82, other lines: upper and lower envelope curve.

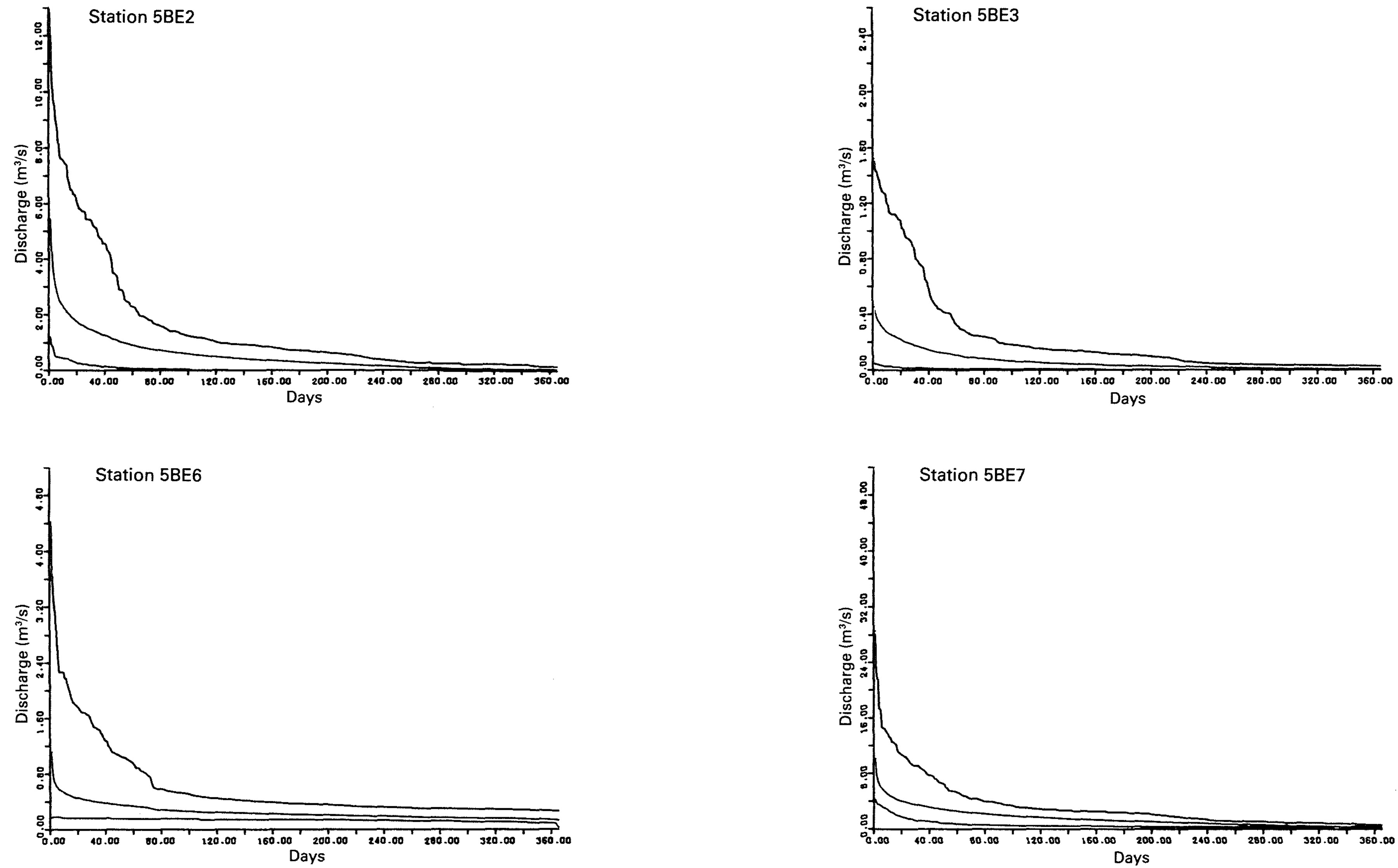


Figure 5: Duration curves of the river discharge at the gauge stations 5BE2-Ontulili River, 5BE3-Kongoni River, 5BE6-Timau River, 5BE7-Likii-River (cf legend fig. 4).

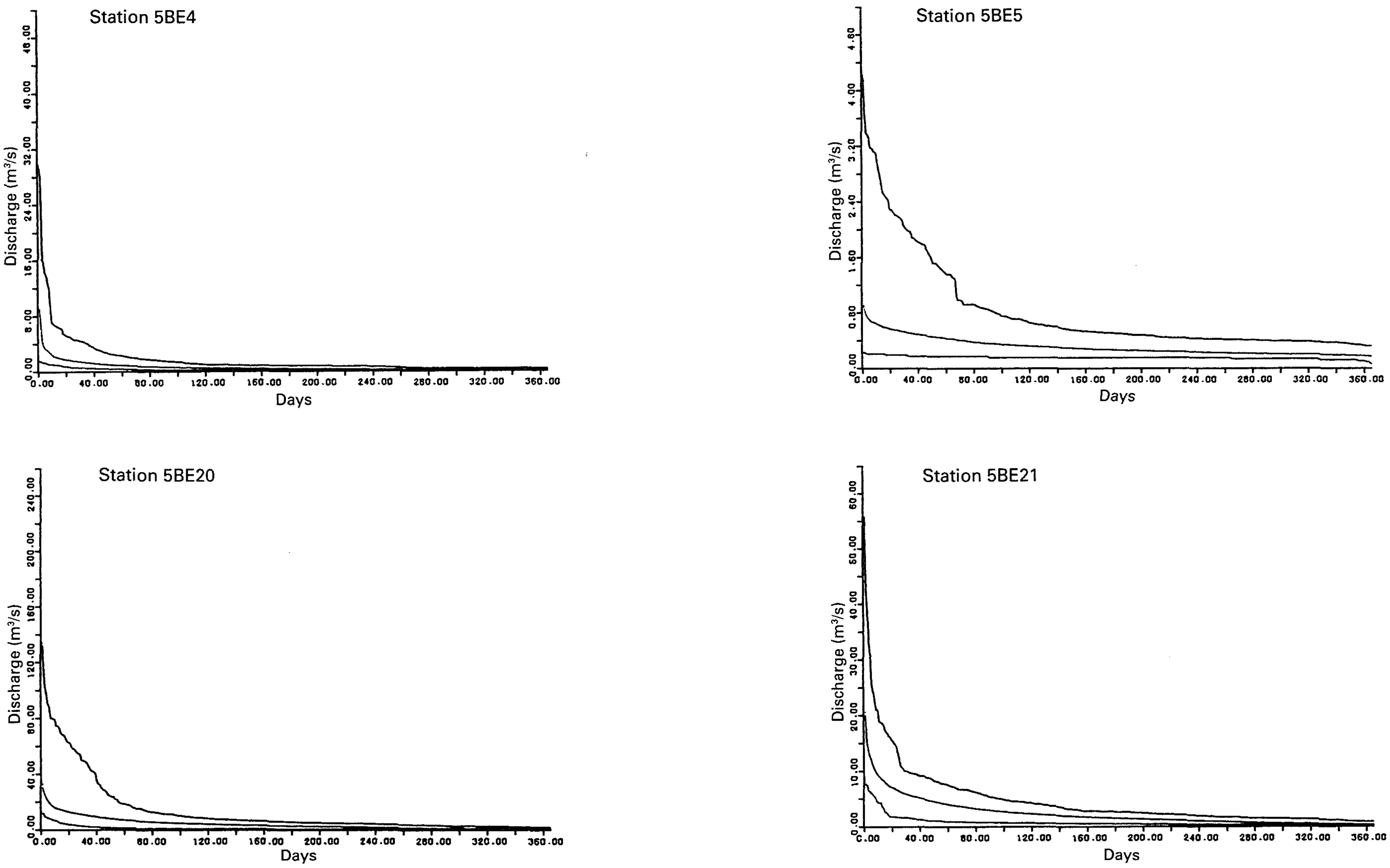


Figure 6: Duration curves of the river discharge at the gauge stations. 5BE4-Sirimon River, 5BE5-Teleswani River, 5BE20- and 5BE21-Nanyuki River (cf legend fig. 4).

Teleswani – 5BE5 and Timau – 5BE6 stand out, due to an almost horizontal lower envelope curve. The general runoff behaviour can be read at first glance from the graph of the flow duration curve. However, the exact figures are necessary in the case of detailed project planning. For this purpose, the 10 values between 347 and 9 days, listed in the statistical yearbooks, are normally sufficient. For all the river gauging stations, table 4 shows the discharges which have been reached or exceeded on the respective days. For agriculture purposes the flow duration curve is less important because the number of connected days cannot be read from the duration curve. This problem will be discussed by *Leibundgut* and *Decurtins* (1986).

4.6. Hydrometeorological elements

Precipitation is not cartographically represented because it is part of the running evaluation made by *Berger* (1986).

The rainfall in the investigation area is derived from the moisture-bearing north- and north-west monsoons. The air circulation is controlled by a sequence of low pressure areas which form the inter-tropical convergence zone. It moves with the sun north and south of the equator twice a year. The topography of the area controls the detailed pattern of precipitation. The rains of the respective seasons do not affect the drainage basins equally.

Therefore, the areal *rainfall distribution* seems to be very complicated, as shown by the figures for Cedarvale Farm and Jacobsen Farm (fig. 6). The magnitude of the rainy season is very different and also the number of rainfall peaks per year. This is a result of the overlapping of different rainfall regimes in the area (*Berger,* 1986). According to the principal annual climatic pattern there are two peaks in rainfall during the rainy seasons. The second season is weakend by the continental rains (local anticyclones). The precipitation falling outside of this season is of minor importance. The annual rainfall regime at Cedarvale Farm (map coordinate square Be) is distinctly affected by the continental rains, whereas at Jacobsen Farm (map coordinate square Ed) the continental rains are of less importance. If we compare these rainfall regimes with the river regimes, we can easily see the strong relation between both regimes.

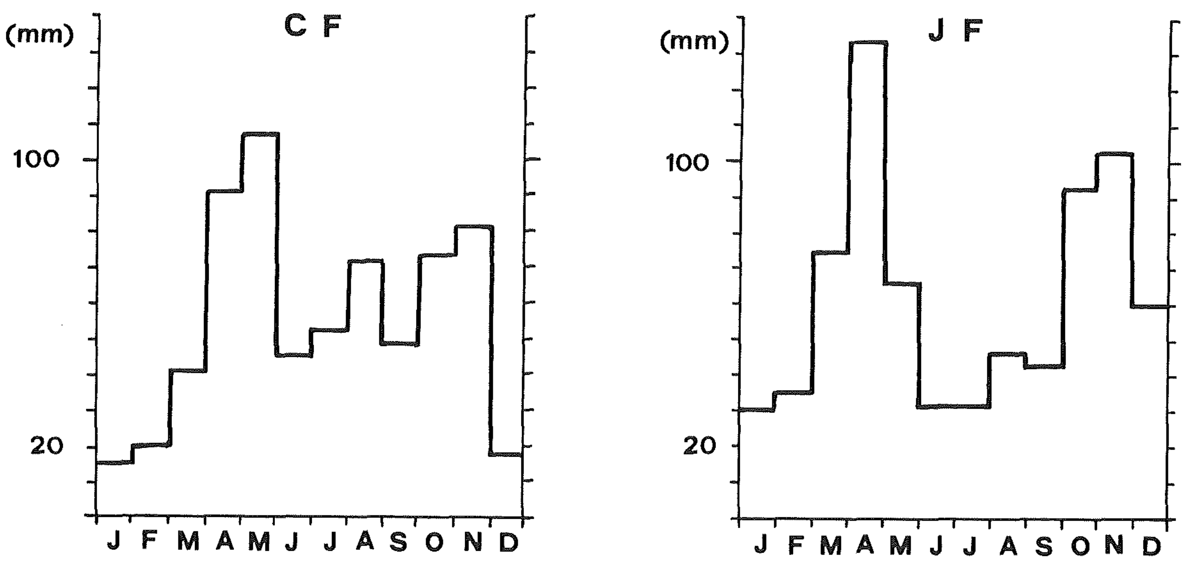


Figure 7: Cedervale Farm (left) and Jacobsen Farm (right). According to the principal annual climatic pattern there are two peaks in rainfall during the rainy season.

A first overview of the rainfall distribution was given by *Roberts* (1963). Rainfall increases with height. The maximum with values of 1500–2000 mm per year, is attained at 3000–3600 m a.s.l. on the western slopes of Mount Kenya. Distinctly less precipitation is measured in the higher regions (*Winiger* and *Messerli,* 1978). The block diagram of the annual totals, which is on the map's left panel, gives an idea of the long term precipitation regime. The mean values of the period 1960–1982 amounts to 662 mm at Cedarvale Farm and 752 mm at Jacobsen Farm respectively. Further data are listed in table 5. Because the measurement at Cedarvale Farm was stopped in 1982 the monthly values for 1982 were completed by means of the quotient method. The station of comparison was Nanyuki KAF (*Berger,* 1986). The year to year variability of rainfall is in the same order as that of the discharge (see chapter 4.2).

Concerning *evaporation,* hardly any statements can be made which might be hydrologically significant. *P. Berger* put the evaporation pan values of Nanyuki from 1965–1981 at our disposal. The mean annual pan-evaporation amounts to 1508 mm. In the same period only 745 mm precipition was measured at Nanyuki. The variation coefficient of 0.18 reveals an astonishingly low year to year variability. In the long term mean only one month (April) shows a higher value in precipitation (115 mm) than in evaporation (112 mm).

4.7. Groundwater and springs

This storage element of the regional water cycle is hardly known. Hydrogeological investigations on a larger scale have only been carried out by *Roberts* (1963) up to now.

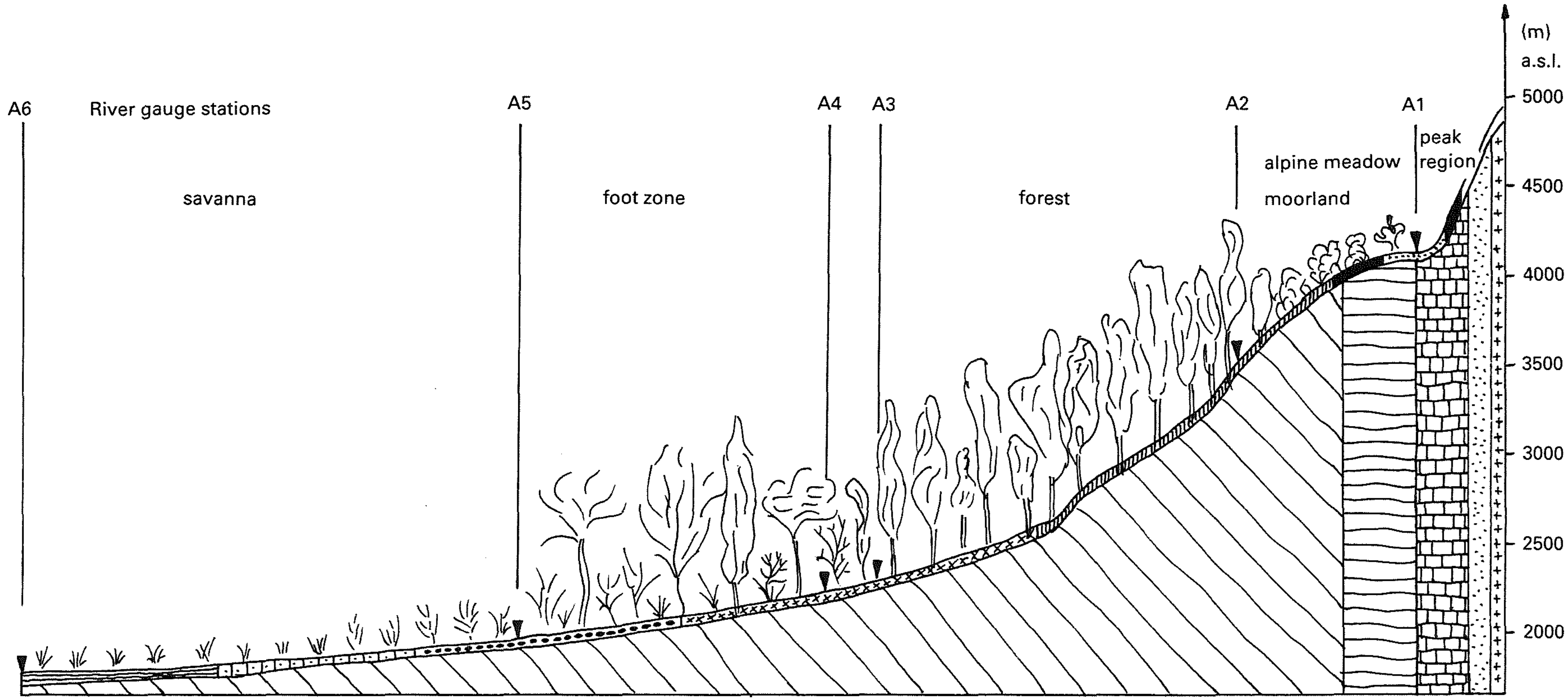
The analysis of the river regimes (cf chapter 5.2.14) lead to the following idea of the *principal function of the storage dynamic:* The long rains, which fall in March/April and are generally the heaviest rainfall, follow the most pronounced dry season. A large part of the rainwater is used to replenish the underground reservoir. Therefore, only a relative maximum (May) is reached in the annual flow regime. The refilled aquifer and the reduced evaporation, combined with continental rains, are able to supply the river discharge throughout the subsequent dry period in such a way that, generally, larger quantities are discharged than during the first dry period. Obviously the aquifer only partially diminished so that the short rains can produce the annual maximum discharge. As a result of the amplified potential evaporation in connection with minimum rainfall, the store is subsequently diminished very quickly and extensively.

With this general description nothing has been said about the structure of the storage. From the hydrological point of view we expect a two- or three-component storage. More detailed information is given in chapter 5.2.15.

4.8. Test drainage basin Naro Moru River

As already described in chapter 2.1.2 a main part of the investigations consists of the hydrological clarification of the subcatchments along the Naro Moru profile. They represent the basic of the current thesis of *S. Decurtins,* whose results we expect in the near future.

With the aid of the water balance investigation, in six catchments of the Naro Moru River the *significance of the particular altitude belts* of the river runoff and the groundwater recharge should be discovered.



	savanna	foot zone	forest	alpine meadow moorland	peak region
Average height (m)	1899	2239	A3: 3199 A4: 3041	4107	4571
Area (m²)	67,3	40,3	A3: 22,5 A4: 22,8	8,38	4,95
River length (km)	22,3	A3–A5: 14,0 A4–A5: 11,7	12,7	5,9	1,9
Incline (%)	0,74	A3–A5: 2,43 A4–A5: 2,05	9,80	10,51	25,26
Drainage density	period. (km/km²): 0,51 perm. (km/km²): 0,33		A3: 2,5 A4: 1,94	1,34	1,43

SOILS	GEOLOGY
gleyic Cambisols, dystric Histosols	Porphyritic phonolites and agglomerates
verto-luvic Phaeozems, chromic Vertisols	Kenytes and kenyte agglomerates
Lithosols, ferric Luvisols (top reoded)	Trachytes, fissile phonolites, tuffs and agglomerates
humic Acrisols, dystric Regosols, dystric Gleysols	Nepheline syenites
dystric Regosols, Lithosols, Rankers	Porphyritic phonolites
Rankers, dystric Fluvisols, dystric and hummic Gleysols	
Lithosols, dystric Regosols	

Figure 8: Typeprofile through the Naro Moru test drainage basin. The schematic presentation shows the vertical sequence of the five respective zones and sub-drainage basins with important catchment features relevant for the hydrological processes.

Table 5: Annual rainfall (mm) at Cedarvale Farm (CF) and Jacobsen Farm (JF) 1960–1982.

	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	1960–82	n	s	cv
CF	570	1170	559	731	642	604	728	891	777	603	552	667	550	521	643	776	599	957	610	471	329	761	507	662	23	177	0,27
JF	716	1145	780	1067	961	503	760	720	986	830	526	719	589	514	701	781	743	860	731	811	474	768	587	752	23	176	0,23

Table 6: Water balance per subcatchment area

Subcatchment	Factor	February 84	May 84
1. Subcatchment	Rain	28 mm	16 mm
Peak Region	Discharge	41 mm (78 l/sec)	24 mm (43 l/sec)
r.g.s. A1	Watersurplus	13 mm	8 mm
2. Subcatchment	Rain	29 mm	34 mm
Moorland Region	Discharge	1 mm (6 l/sec)	2 mm (12 l/sec)
r.g.s. A2	Waterloss	28 mm	32 mm
3. Subcatchment	Rain	24 mm	27 mm
Forest Region	Discharge	4 mm (42 l/sec)	6 mm (58 l/sec)
r.g.s. A3	Waterloss	20 mm	21 mm
5. Subcatchment	Rain	0 mm	3 mm
Mountain Slope R.	Discharge	–2 mm (–38 l/sec)	–1 mm (–18 l/sec)
r.g.s. A5	Waterloss	2 mm	4 mm
6. Subcatchment	Rain	0 mm	0 mm
Savanna Region	Discharge	–2 mm (–67 l/sec)	–1 mm (–31 l/sec)
r.g.s. A6	Waterloss	2 mm	1 mm

from: Decurtins (1986)

For this purpose river gauge recorders have been installed in the sub-drainage basin and the P/Q-relation has been gauged. The precipitation is also measured with recorders (see map).The problem of the evaporation measurements could not yet be solved satisfactorily due to the high expenditure. Therefore we depend on estimates with the aid of evaporation formulas for this water balance.

The zonal vertical formation of Mount Kenya has already been discussed in chapter 3 and a short characterization of the Naro Moru drainage basin follows in chapter 5.3.1. Figure 7 shows the main features. The map represents the drainage basin with the subdivision in subcatchments. These are marked off in such a way that they show the zonal structure. The highest catchment represents the partially glaciated mountain top region. The second subcatchment lies in the moorland zone. The two subcatchments A3 (Northern NM) and A4 (Southern NM) are situated in the forest zone. The longterm river gauge station 5BC2 (A5) marks off the footzone. The savannna plain is summarized in subcatchment A6. Thus the test drainage basin includes a very interesting variety of environments in the short river course of 57 km. The catchment controlling factors correspond to the enormous difference of altitude. The typeprofile (fig. 7) shows a summary thereof. We can do without valuation of the hydrological significance of catchment controlling factors, as they represent the actual investigation.

Regarding the importance of the different zones at Mount Kenya for runoff and groundwater recharge, we are able to list quantities and tendencies (*Decurtins,* 1986). Table 6 shows the evaluation of discharge and rains of two dry periods (February and May 84) in the different subcatchments.

During both evaluation periods the mountain top region exhibits an absolute water surplus. Due to the reduced evaporation through elevated clouding this surplus is smaller in March. It is in effect a higher surplus because the evaporation is not balanced therein. There is no subsurface runoff, because the highest catchment can be considered as closed. The question still remains open as to whether possibly groundwater in the fissure system of the phonolytic and trachytic rocks at great depths, flows off, and therefore leaves the drainage basin in that particular way. The high discharge rate of the peak mountain region is mainly due to melting water from the Lewis glacier. In view of the future long term discharge development, the quantity should be relatively intensive. According to *Patzelt* et al (1985) the Lewis glacier lost between 1963–1983 50% of its volume through ablation. If the glacier decreases there will be a severe reduction of the amount of meltwater.

According to *Patzelt* a change in the trend is not in sight. The authors found a 'mass-loss' of $4.58 \cdot 10^6$ m^3. On the assumption of a 6-month dry period and no glacier decrease during the rain period approximately 5 l/s mean water portions out of the 'mass-loss' during the dry periods. At a constant meltwater discharge the present ice storages of $4.69 \cdot 10^6$ m^3 would be used in approximately ten years time.

The net discharge out of the subcatchments A2 and A3 is poor, but evaporation should be the most important factor. A better statement will be available, when it is known what happens during the rainy season. Although the discharge out of A3 with 4 mm respectively 6 mm is relatively small, the absolute contribution of the forest zone may not be underestimated. With 104 l/s it is somewhat lower than the peak mountain region discharge (120 l/s).

The two lowest subdrainage basins produce absolute water loss. A part of the water supplied from the upper catchments is used in these river sections.

The theory of cognition resulting from subcachments research should be transferred over the punctuated support measurements to the remaining drainage basins of the test region.

5. Explanations of the hydrogeographical map

5.1 Notes for the use of the map

An essential marginal condition, when the map was compiled, was that it should be easy to use in the field. With the creation of a relatively elementary topographical base, redrawn in metric measures and the sparing use of hydrological information, these circumstances were taken into account. A further requirement in this connection consists in the detection of the phenomena listed in the field and their classification in the corresponding hydrological basics.

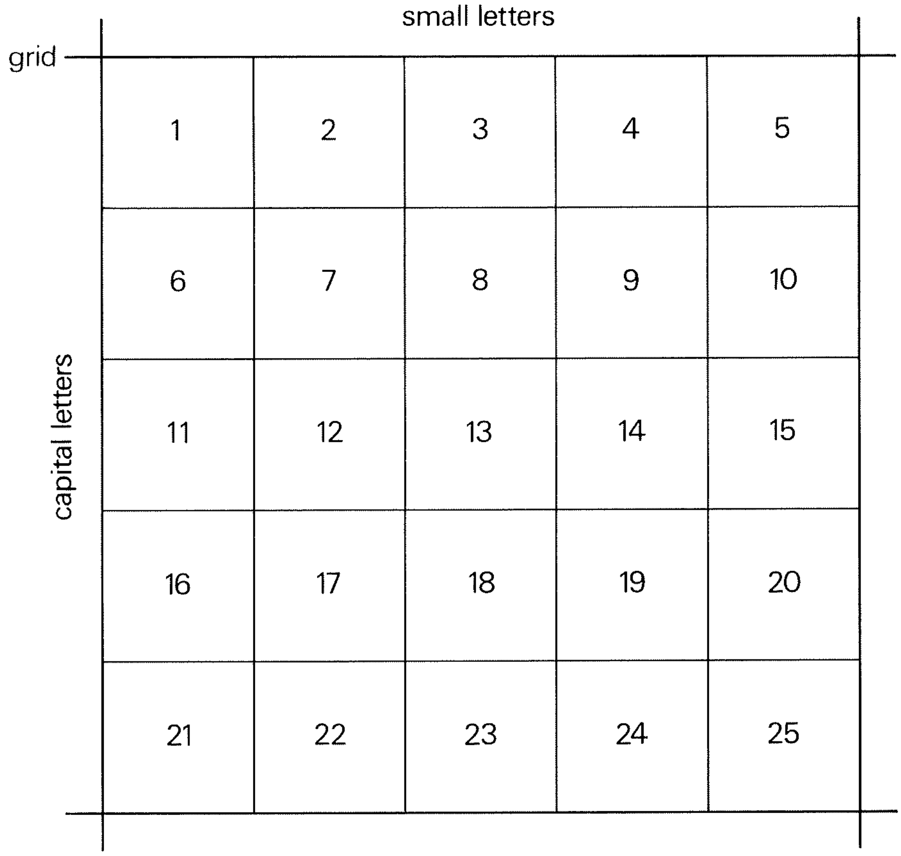


Figure 9: Pattern to index. Pattern to be used on the map in order to localise the features listed in the index. The capital letters indicate the 5 km grid on the map from north to south, the small letters from west to east. The figures indicate 1 km^2 within the square grid. Example: Ragati Spring Fd = square grid Fd, square km 14.

The most simple *guidance-system* of the coordinates is only useful within limits. The phenomena mapped in the field cannot be located so precisely, due to the lack of marks, in order to find them again with the help of coordinates at any time. The detail drawing of the coordinate network to the required density would be an unsatisfactory cartographic solution, in so far as the map image would have shown an additional screen.

As a result of these ideas we came to the following conclusion:

a) The coordinate 5 km squares of the official topographic map must be divided into 25 subsquares (cf fig. 9).

b) The sub-coordinates will not be drawn on the map but on a transparent film which will be enclosed and can be used at any time.

c) Information can be found by these squares on the transparent film. A certain phenomenon is localised within one subsquare. Instead of the exact coordinate number, the key number of the subsquares can be read off. Within this key number all map information is described in the explanatory comments. On the other hand the discovery of phenomena in the field is easily possible. In place of one symbol a group of symbols appears. Therefore its association is clear and/or is described accordingly.

d) As the river basins represent the fundamental hydrological units, the information to the map is described catchmentwise.

Example:

We are interested in the borehole in subsquare EC 13 in the Naro Moru catchment area. Provided that further information is available, we find the supplementary information in the chapter 5.3.1 to item EC 13. If there is more than one borehole in this subsquare it is indicated. In one respect the solution represents a distinct, not overcharged compilation of the map and on the other hand gives the required detailed information to each symbol.

5.2 Explanations on the group of symbols

General and summarizing information about the structure of the map legend, about the investigation area and the regional hydrology is given in the chapters 2–4. With the explanations on the groups of symbols it is intended to give the general information to each cartographical element. The area symbols are described in detail in this chapter. Further information to each symbol in the map is listed in chapter 5.3.

5.2.1. Perennial rivers

As an important property of the river network the perennial and the intermittent flow of the rivers are distinguished. The *main sources are within the forested areas* of Mount Kenya. A few rivers rise in the moorland and only two (Naro Moru River and Likii River) are fed by glaciers. The presence of forest and moorland is important in maintaining perennial flows. Below the forest belt the tributaries receive only minor increments of flow. The morphometric terms can be derived on the basis of the uniform topography of this map. This at least gives the possibility of making comparitive studies between the different river basins. In chapter 5.3. some terms are indicated. The hydrology of river flow is described in chapter 4.

5.2.2. Intermittent rivers

The respectively periodical and episodical rivers can only be found in the foothills and savanna area. In the *savanna* they represent the main part of the river network and are the *characteristic type of river* in this landscape. The river density in the lowest subcatchments is higher than that of the perennial rivers. In the Naro Moru subcatchment A6, for instance, the river density of the intermittent rivers amounts to 0.51 km/km^2 and the density of the perennial rivers to 0.33 km/km^2.

The periodical rivers mostly lie in surface hollows. Surface runoff can often be observed during storm runoff. After such events the channel runoff continues for a few days. It is obvious that this kind of runoff is fed by short-time storage.

5.2.3. Lakes

Natural lakes only occur in the peak region. There are small pools which have depths of less than 20 m and which originiate from Pleistocene or recent glaciers and are mostly the visible river sources. According to *Loeffler* (1968) all tarns show cold polymictic conditions. The highest of the African lakes, Curling Pound, is actually in an amictic state. This tarn may have originated between 1900 and 1930 due to the retreat of the Lewis glacier. According to the petrographic conditions all lakes are extremely poor in electrolytes, especiallly very low Mg-concentrations are characteristic.

5.2.4. Glaciers and snowfields

Both phenomena are limited to the peak region. Their hydrological significance is in a certain *storage effect,* but its relevance is not yet known definitely. The Lewis glacier in the catchment of Naro Moru River represents the largest glaciation of the Mount Kenya. According to *Patzelt* et al (1985) it covered an area of approximately 62 ha in 1920, and approximately 38 ha in 1958, corresponding to about 40% of the total glaciated area in the top region. In 1983 it only covered approximately 28 ha. Thus, the glaciers and snowfields have become rapidly exposed in recent times. During maximum glaciation the glaciers reached down to 3400 m a.s.l., which is the altitude of today's upper forest boundary. In 1893 the terminus of the Lewis glacier was situated near 4460 m a.s.l., 1934 near 4490 m and the today's altitude is about 4590 m a.s.l. (*Patzelt,* 1983). For the period 1899–1958 the average rate of retreat for the Lewis glacier per year amounts to approximately 7.3 m (*Baker,* 1967). Extended investigations into the glaciology of Mount Kenya are published by *Hastenrath* (1984) and *Patzelt* et al (1984).

5.2.5. Flood stage areas

The areas flooded by natural events in the lower catchment of the rivers Rongai (12 km) and Moyok (19 km) are called flood stage areas. Because of the periodical floods these areas turned into *swamps.* Whether they are perennial swamps in the strict sense of the word or rather intermittent swamps, called dambos, is not clear up to now (*Balek,* 1977). In any case the swamps can dry up, as was observed in 1984 (information by *Decurtins).*

5.2.6. Dams and periodic lakes

The white farmers constructed small dams (mostly earth dams) of between 1–3 m in height in order *to use the periodical discharge* in the intermittent rivers (*Brunner,* 1983). Due to the high content of swellable Montmorillonit-clay in the water the soils became impermeable. Thus, the dammed water could not infiltrate. The evaporation rate however is very high. An additional function is the reduction of soil erosion. After the rainy season these periodic lakes normally serve as reservoirs for the irrigation of small areas and as watering places for the cattle for weeks or even months. As a negative side effect water-born diseases can occur because the periodic lakes are biotopes for different pathogenic germs (MOCK, 1982).

5.2.7. Contour bounds

The contour bounds represent another *type of surface water storage.* Part of the surplus water is conducted into storage ponds. The main purpose of the contour bounds is the prevention of the soil from denudation by water erosion. Between Naro Moru and Timau we can only find some remains of contour bounds. They are either broken and overgrown or have been leveled in the case of farm division (*Brunner,* 1983). Large contour bounds systems are found on the Embori farm land in the far northeast which is off the map.

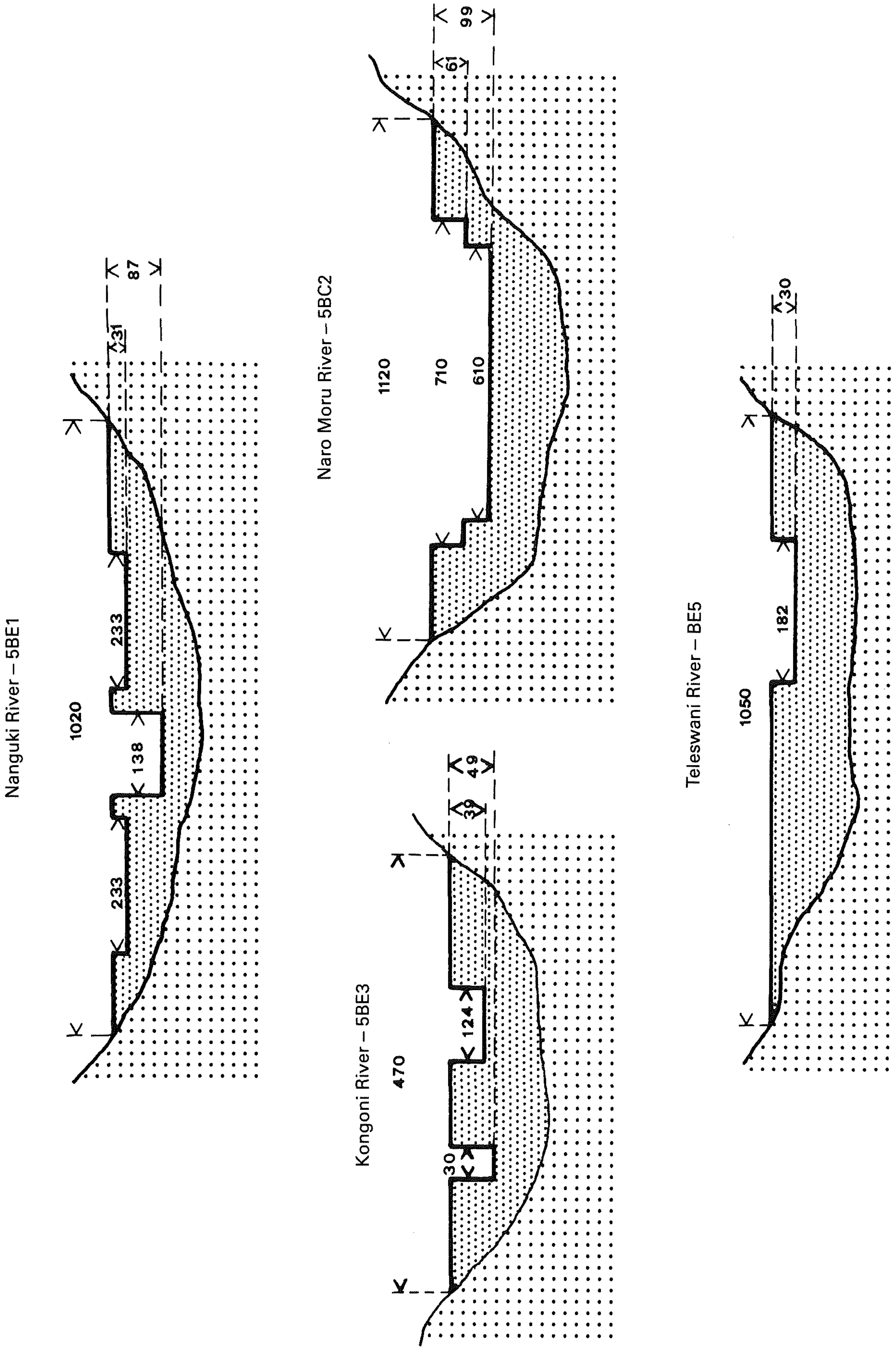
5.2.8. Springs

Springs, as we understand them, are all the tapped and untapped natural outflows of groundwater. According to the geology of Mount Kenya there might be so called contact springs. Three larger *spring-horizons* in 2700 m, 2300/2400 m and 2000/2100 m a.s.l. are known. Most of the springs rise in the foothill and the forest zone. Below this line, springs are much less common due to the depths of the aquifers below the surface. The inventory of the springs which has been mapped is probably incomplete. There may be more springs in the forest which is hardly accessible. Here the spring type 'river source' is dominant. There are springs without a visible outflow, but there are far more exfiltration sections. According to *Roberts* (1963) this large number of springs is fed by the occurance of several aquifers interspersed amongst the lavas. The hydrological significance of the springs is discussed in chapter 4. With a total discharge of 5000 l/min the springs known today, especially as the quality of the groundwater is generally good, have an *important role in the regional water supply.* The individual springs will be described in a more detailed way in chapter 6.

5.2.9. Rain gauge stations

In the investigation area we have to distinguish three different rain gauge networks. The first is the official network of the MWD. An important addition to this basic network is maintained by private people, mostly white farmers. Normally there are rain gauges with daily readings. A third network is that of the Geographical Institute (GIUB) for the current research purposes.

All individual stations are described in a more detailed way in chapter 5.3. We thank *P. Berger* for his information concerning the rain gauge stations. A detailed study can soon be expected from this author (*Berger,* 1986).


Nanguki River – 5BE1
1020
233
138
233
31
87
Naro Moru River – 5BC2
1120
710
610
61
99
Kongoni River – 5BE3
470
124
30
39
49
Teleswani River – BE5
1050
182
30

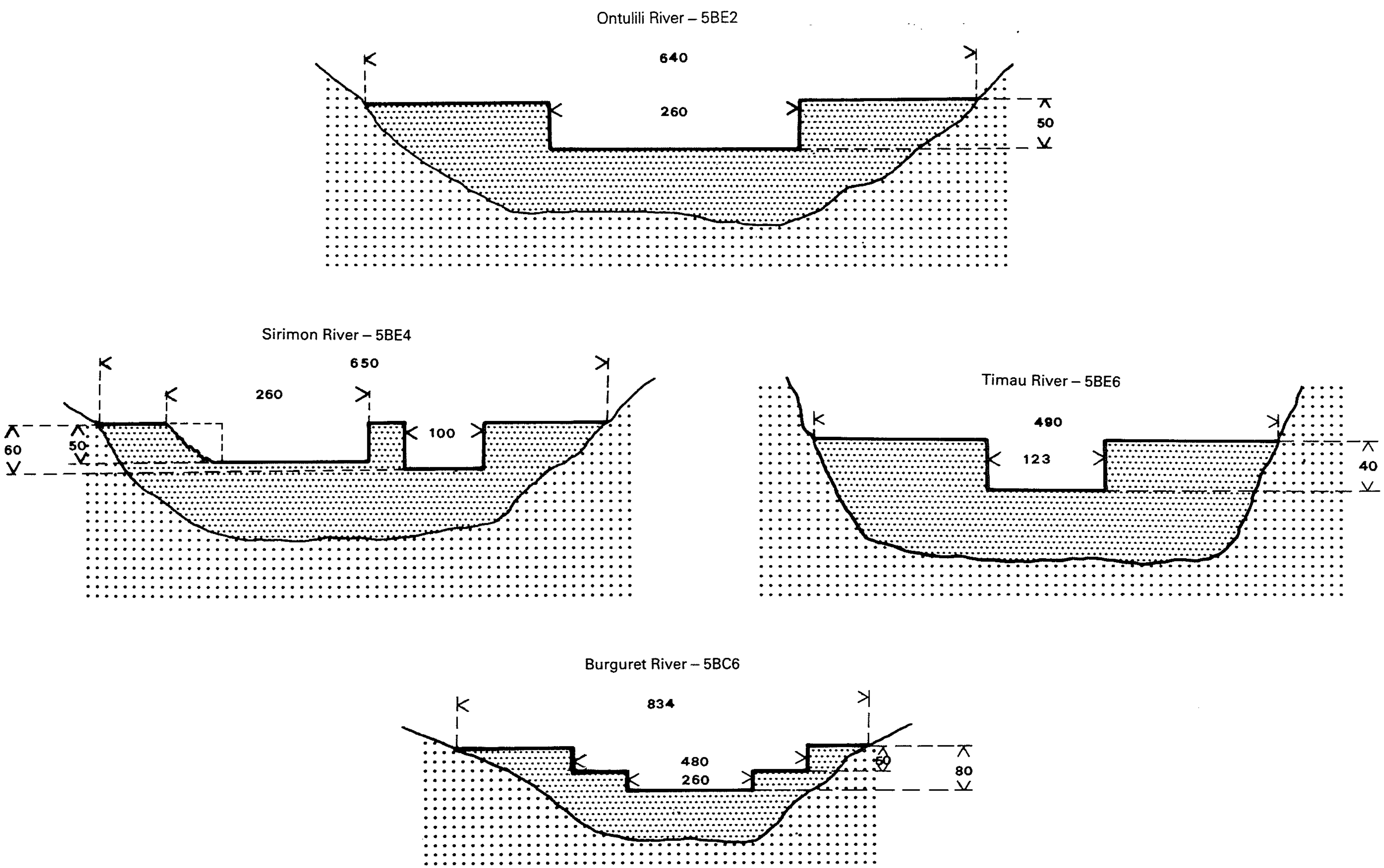


Figure 10: Cross profile of the river gauge stations. Dense half-tone screen: weir. Dimension: cm.

5.2.10. Hydrometeorological stations

Except for the stations in Nanyuki we have no other information about hydrometeorological measurements.

5.2.11. River gauge station

The basic measuring network is the official river gauge network of the MWD. Since 1982 six gauging stations with recorders complete the basic network. In 1985 five recording stations have been installed to replace the staff gauges. The recorder networks are maintained by the GIUB. Each station is described in detail in chapter 5.3. The primary data collected at the river gauge stations are water level readings. The staff values are gauged and converted by the PQ-relation in discharge values. Due to the usual once a day readings, which are considered as a daily mean (see chapter 4.2 and 5.3), we expect, in general, discharge values which are calculated somewhat too low. For the calculation of missing data graphic-, interpolation- and regression-methods have been applied (*Moeri,* 1982). The figure 10 shows the weir cross profiles of each river gauge station mapped by *Brunner* (1983).

5.2.12. River basin boundaries

The river basin boundaries are based on the new topography of this map. We consider that the drainage basins of the rivers on the slopes of Mount Kenya are a basic unit. The rivers southwest and northwest form two superior watersheds. The river basin of Naro Moru is divided into six sub-drainage basins (catchments). The areas and the average altitudes are listed in table 1. The average catchment altitudes have been based on the 500 m-contour isohypses. The mean elevation lies between 2300 and 3400 m a.s.l.

5.2.13. Low flow yield Q95

For the regional water use the low flow is of essential significance. Therefore, it is represented in the map. The Q_{95} is the reference value. It is the *discharge which is reached or exceeded in 95 % of the time* in the long-term average. 95% corresponds to 347 days of the year. This value can be read directly from the duration curve.The real values of the Q_{95}-yield lie between < 0 l/(sec·km^2) and 5.09 l/(sec·km^2). For the cartographical presentation they are divided into five classes (table 7). As we can see, the low flow yields are about 2–10 times lower than those of the mean flow yields. In comparison with the mean flow yields it is obvious that the differences between the low flow of the individual river basins are only small.

The exceptionally high amount of the low flow yield of the river Teleswani is striking. The main cause for this phenomenon might be the regular discharge of the springs in the seep at an altitude of about 2400 m a.s.l.

Concerning the spatial distribution the map shows three zones with high yields: Naro Moru and Burguret river basins in the south, the Likii catchment in the central part and the river basins of Teleswani and Timau in the north. The areas which are between these zones have a lower yield. The most significant difference between areas with more available or less available river water, however, is between the catchments on the slopes of Mount Kenya and those of the savanna.

Table 7: Q_{95}-yields of the river discharges of the Mount Kenya region for the period 1960–82

Drainage basin	Gauge station	Yield [(l/s·km²)]	Class [(l/s·km²)]
Naro Moru	5BC2	2,65	2–3
Burguret	5BC6	2,23	2–3
Rongai	estimated		1–2
Nanyuki	5BE1	1,52	1–2
Likii	5BE7	2,03	2–3
Ontulili	5BE2	1,62	1–2
Kongoni	5BE3	0,61	0–1
Sirimon	5BE4	2,269	2–3
Teleswani	5BE5	4,987	>3
Timau	5BE6	2,573	2–3
Ewaso Ng'iro (subcatchment)	5BC4	<0,06>0	0–1
Nanyuki	BE21	<0	<0
Nanyuki	BE20	<0	<0

5.2.14. River regime

The river regime can be described by the river regime coefficient according to *Pardé* (1933). In this way the long term river regime in the time distribution of months is found (*Keller* et al, 1972). The absolute discharge, as a long term mean value, corresponds to the river regime coefficient 1 (left ordinate in the graph). In the map the river regime is drawn as a graph, which is placed in the respective river basin; the regime is valid for the whole catchment down to the river gauge stations along the main road.

Both the *hydrograph* and the *coefficients* of the regime show groups of runoffs with different regimes which are, nonetheless, uniform in themselves. The flow of the rivers Likii, Ontulili, Kongoni, Sirimon and Nanyuki evince a similar hydrograph during the period 1960–1982 with coefficients around the maximum for the second wet period. High coefficients in the first wet period in connnection, however, with a pronounced second dry period from June to September (coefficient <1), are also features of the river Naro Moru, the Burguret and the Ewaso Ng'iro. At this latter station the spring maximum is reached as early as April, and not in May as is the case with all the others. The northern river flow from the Teleswani and Timau region demonstrates a very different behaviour as regards the fluctuation, with coefficients from 0.76 to 1.38. Although, amongst the mountain rivers, these are situated in the driest zone, the fluctuations are least pronounced indicating special conditions in the aquifer.

Obviously rainfall is also a main controlling factor in the annual river regime. As regards the long term average, the rainfall on the northwest slope of Mount Kenya in April/May (long rains) is above that in October/November (short rains). This is followed by a pronounced dry season. The second dry season is far less pronounced as a result of the continental rains. In view of the fact that the monthly mean temperatures are practically constant (Nanyuki station 15.9° C), evaporation is also substantially limited during the continental rains by increased cloud and moisture bearing air (*Roberts,* 1963). Clear *regional differentiations* appear according to the varying influences of the different wind systems in the equatorial low-pressure convergence and the strong modification due to the mountain topography. The drainage basin areas of Naro Moru, Burguret and Ewaso Ng'iro clearly lie in the lee of the north easterlies which dominate in northern summers. Here the continental rains only have a marginal effect. The runoff regimes largely reproduce these rainfall conditions. Only the two maximum levels are interchanged.

The *coefficient of variability* (c_v) provides further information on the graph (see key of the map). The rivers from the Naro Moru to the Sirimon show a high variability during low flow periods (river regime coefficient <1). This fact must be taken into consideration for the water use planning concerning the important low flow. The rivers Teleswani and Timau show very different behaviour. The spring discharge in these river catchments produce a regular low flow and the wet periods with the floods show a high variability.

5.2.15. Spring discharge and age of water (*U. Schotterer* and *I. Müller*)

Geology and water resources of the investigation area were already discussed in earlier papers (*Roberts,* 1963, *Baker,* 1967). In this study, modern methods of geophysics, hydrochemistry and isotope measurements were combined to get more insight into questions such as:
- Can one expect a renewal of the groundwater sources known to exist? This question is of major importance for water conservation.
- What is the storage capacity of the underground reservoir(s)?
- Where is the main recharge area for the groundwater?

In the following, a summary of the new data is given. A more detailed study is published elsewhere (*Schotterer* and *Muller,* 1986).

The regional difference between the mountanous area and the plain between Mount Kenya and Nyanda Range is clearly expressed by the available data: The mountain slopes including the rainforest have high to sufficient precipitation supply for groundwater formation. The geophysical measurements show permeabilities which should permit groundwater recharge. The high apparent resistivities of the underground material are dependent on the directions measured. These variations are due to the presence of a fracture system and can be measured from the Teleki Valley at 4300 m a.s.l. down to the beginning of the forest area. With decreasing altitude, resistivities become lower and the pronounced anisotropy smoothes because of the presence of conductive material. In tropical climates, igneous rocks are altered to clay and lateritic soils which clog the fractures more and more and lead to low permeabilities. This fact is important in understanding the mechanism of rain infiltration in this region. Though only one large spring is known, emerging from good permeable pyroclastites (Logiladu), the existence of a number of other, possibly diffuse outflows of the groundwater in the rainforests is quite likely. The presence of tritium, which has been produced by nuclear weapon tests since 1952 and thus marking the global water cycle, indicates that these waters are younger than 30 years (symbol on the map). In general a residence time of a few years can be expected, the recharge area is situated in the upper forest region and those parts, where the peak bog does not clog the fractures. Some small springs in the summit region are of minor importance because of their shallow reservoirs. Mineralization is low and the anthropogenic influence is – up to now – negligable. All these waters belong to local flow systems. If there is any important contribution to a regional flow system by infiltration at the mountain site it cannot be decided from the available data and the limited natural discharge today. The foothills of the mountain and the great plain between Mount Kenya and Nyandarna Range show very limited infiltration possibilities for groundwater formation today. The permeability down to 120 m is poor. Based on isotope data, all springs and wellwaters (with very few exeptions which can be seen on the map) are at least 30 years older. From the first radiocarbon dating the formation of these groundwaters took place thousands of years ago, most likely during other climatic conditions. The estimate of the mean recharge area (3000–3500 m a.s.l.) is based on modern precipitation data of oxygen-18 values from today, and as a consequence this would shift the possible recharge area of these waters to lower altitudes and diminish the importance of the mountain as the only recharge area for the regional flow system.

The waters are hyperthermal and the aquifer is confined. From the empirical findings of a dynamic relation of precipitation and waterhead elevation in some boreholes, together with the geophysical measurements, it must be concluded that the reservoirs are formed as lenses. Such heterogenically distributed formations with relatively better permeability are possibly tied together by poor permeable connections. The high variability supports this idea, too.

In general, springwater has a lower mineral content than wellwater. Mineralization is dominated by sodium carbonates. The SAR (Sodium Adsorbtion Rate) as a qualification for irrigation waters is tolerable with few exceptions. Dissolved oxygen is often below, the fluoride content above tolerable limits for drinking waters, but this can be solved by technical procedures.

The rainforest region is a site of young rechargeable groundwaters of good quality, but the natural outflows are limited. It is highly probable that in the great plain, there is groundwater at variable depths nearly everywhere. In the great plain, groundwater can, with great probability, be expected almost everywhere at variable depths. It must be taken into consideration that quality and yield of these waters are poor, and since there is no (or negligable) recharge today the amount available is very limited.

5.2.16. Technical installations for the water resources management (water supply, irrigation and others)

The technical installations were mostly constructed at the time of the white settlers. In the meantime the allotment to the African settlers went on rapidly. *Brunner* (1983), who has mapped the technical installations in the field, said: 'The allotment took place in a chessboard-like way without regard to existing water systems, relief and distance to any kind of water resource. As a result, the extended old watertechnical installations were destroyed. Lacking technical knowledge, failure of the responsible water organization, lack of cooperation between the new settlers and absenteeism created a desperate water supply climate for most of the new settlers.' *Brunner* gives an example of the water supply on Tegessi Farm.

The map shows the conception and the structures of the original water prospecting by the white farmers. The detailed mapping of the technical installations for water use, ought to help to judge the recent situation and to plan future water supply development projects. In many cases a simple rehabilitation of the ancient installations would be enough to reach a better situation for the new African settlers. In the map the situation of 1984 is represented. Further information about the state of each installation is given in chapter 5.3. In the following, important groups of technical installations are described briefly:

Although the yields are normally low the *boreholes* play an important role in the decentralized water supply. Each borehole is registered at the Geological Department of the MWD in Nairobi. Further information as to borehole profiles can be found there. The borehole depths vary between 26 to 200 m. The depths increase with the distance from the mountain. Multiaquifer formations have often been drilled.

The white settlers have dug many kilometres of *furrows* for irrigation purposes. The water loss in these canals is very high (up to 25% according to *Brunner,* 1983). Only a little of this system is still in function today. The control of the water distribution by the Water Bailiff is not sufficient. In the last years more and more open furrows have been replaced by pipelines.

The type of *pump* mainly used is the ram. Its maximum pumping capacity amounts to 15–1500 l/min. They are very common because they do not need much maintenance and because they only use natural water power energy. Nevertheless most of the rams are out of use today.

The increasing application of the more modern and higher capacity *diesel engines* and electrical pumps is limited because of the high costs for fuel and more difficult maintenance.

Most of the windmills are also derilict. This is astonishing when we think of the low need of maintenance for these reliable pumps with a capacity of up to 300 l/min.

The white farmers were obliged to conduct the water from the river to a common land, due to the protection of the river banks. These watering places are out of use today. The regular use of the same watering places along the rivers by the herds of the African settlers led to a lot of damage to these bank sections. These common lands suffer from a serious erosion problem.

5.3 Explanations of the individual symbols in each river basin

In this chapter the individual symbols of each river basin between the top region and the Ewaso Ng'iro are discussed. The individual catchment areas are looked at the south to the north. The symbols of the remaining areas in the north-western part are described in the subchapter 5.3.11 'Ewaso Ng'iro river basin'. The discussion of the individual subsquares in each catchment starts at its headwaters and moves downstream to the junctions (fig. 11).

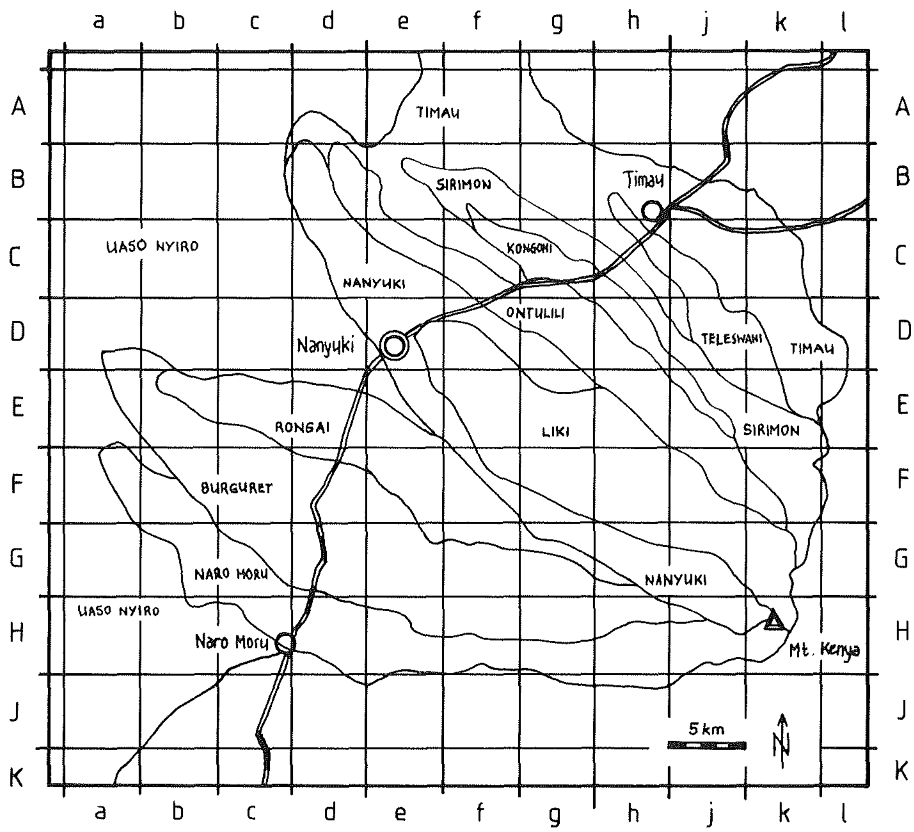


Figure 11: Situation of the drainage basins used in the inventory (ch. 5.3.).

Only those symbols are listed which provide further information to the map legend.

For cartographical reasons sometimes only one, out of several similar installations at the same location, is mapped (as a collective symbol). However, the explanations are in the text.

Where not explicitly indicated the indication 'good' is reliable. Thus, no indication of condition always means that the installation was in a good state at the time of mapping.

The area symbols (yields) and the graphical ones (river regimes) are not discussed in this chapter. These elements are described in the former chapter. The detailed information concerning the individual symbols make it easier for the field hydrologist and the field engineer to find all the available data.

5.3.1. Naro Moru River basin

Two main headwaters form the Naro Moru River. Only the northern tributary has its source in the top region. The head of the Naro Moru South is at about 4000 m a.s.l. in the moorland. It is therefore completely in the area of the fluvial formed valleys, in contrast to Naro Moru North which crosses a mainly glacial formed valley. In the forest both rivers are almost inaccessible due to the distinctly steep V-shaped valleys which are densely forested. Below the junction the relief becomes gradually flatter. Therefore the riverbed material changes from rubble to sandy-loam. A dense gallery grows along the rivers.

The catchment of the Naro Moru River is distinctly elongated. The density of the perennial rivers amounts to 1,47 km/km^2 (down to A5). Therefore the total river length of 151 km is high. Approximately half of the drainage basin is covered by forest (51% = 52,5 km^2).

Coordinate square **Hk**

2 Rain gauge stations	Hk 11/13	Information: Mr. Truman Young.
Recording rain gauge R1	Hk 11	Type Belford, universal recording rain gauge No. 5–780, recordings since 1982, maintenance by GIUB.
Rain gauge station	Hk 16	MWD No. 9037218, daily readings since 1978, Teleki Camp.
River gauge station A1	Hk 16	Type Ott-R16, stable natural gauge cross section, recordings since 1982, maintenance by GIUB.

Coordinate square **Hh**

2 Rain gauge stations	Hh 18/20	Information: Mt. Kenya National Park Administration, Ranger Station.
2 Recording rain gauges R2, R3	Hh 20/17	R2: Type Belford, universal recording rain gauge No. 5–780; R3: recording rain gauge type Hellmann, recordings since 1982, maintenance by GIUB.
Rain gauge station	Hh 17	MWD Station No. 9037217, daily readings, Naro Moru Meteorological Station Lodge.
River gauge station A2	Hh 15	Type Ott-R-16, stable natural gauge cross section, recordings and maintenance since 1982 by GIUB.

Coordinate square **Hf**

River gauge station A3	Hf 12	Type Ott-R-16, stable natural gauge cross section, under bridge, recordings since 1982, maintenance by GIUB.
Dieselpump, tank, pipe	Hf 19	Dieselpump with 4 tanks (36 m^3), pipe 350 m (∅ 5 cm), water supply for the Ranger Station, Mt. Kenya National Park, river water.
Rain gauge station	Hf 24	MWD Station No. 9037149, daily readings since 1968, Naro Moru Park Gate.
Pipeline, tank	Hf 23	Water intake from Southern Naro Moru River and transport by pipe (∅ 15 cm) into 2 main tanks (272 m^3), diversion by 5 pipelines into 10 tanks (473 m^3); intake with concrete weir and sedimentation basin; water supply of the Naro Moru settlement scheme (Chairman: Mr. Jason Mungai).

Coordinate square **He**

Ram, pipe, tank	He 21	Pipes (120 m) and ram missing, tanks still in place, water supply for the farmhouse, Mwichwiri Coop. Soc.
Ram, pipe, tank	He 21	Pipe 120 m (∅ 2.5 cm), tank 2.2 m^3, water supply for the American School (NOLS).
Ram, pipe, tank	He 22	Pipe 200 m (∅ 2,5 cm), tank 2.2 m^3, water supply for the youth hostel, often troubles with ram.
Furrow	He 22	Furrow 8000 m, unfixed earth dam, big loss of water as a result of growing plants, formerly used for feeding two dam basins at the Kwony Farm, today water supply for parts of the Naro Moru Settlement Scheme.
Ram, pipe	He 23	Pipe 180 m (∅ 2.5 cm), tank missing, water supply for the ancient farmhouse, Naro Moru Settlement Scheme.
Recording rain gauge R4	He 24	Pluviograph, type Hellmann, recordings since 1983 by GIUB.
River gauge station A4	He 25	Type Ott-R-16, stable natural gauge cross section, under bridge, recordings from 1982 till today, maintenance by GIUB.
Rain gauge station	He 25	MWD No. 9037064, daily readings, Naro Moru Forest Guard Post.

Coordinate square **Je**

Dam	Je 12	Earth dam, length 30 m, fed by surface runoff, water for cattle, Naro Moru Settlement Scheme.

Coordinate square **Jd**

Rain gauge station R6	Jd 4	Naro Moru Catholic Mission.

Coordinate square **Hd**

Dam	Hd 2	Earth dam length 15 m, formerly fed by surface runoff, in bad state, Weruini Lands, Mureru Farm.
Borehole, tank, windmill-pump	Hd 4	No. C2682, 105 m deep, groundwater level –40 m, windmill pump, 2 tanks (51 m^3), water supply for settlers and cattle of Gitero.
2 Dams	Hd 9/10	Earth dam, length 20 m, in bad state, fed by surface runoff, in bush, poor accessibility, formerly Iirima Farm.
Electrical pump ram, pipe, tank	Hd 16	Pipe 550 m (∅ 4 cm), metal tank 13 m^3, concrete tank (35 m^3) water supply and garden irrigation for Mr. Oldman and Mr. N.T. Ready.
Dieselpump, tank, pipe	Hd 17	Pipe 250 m (∅ 4 cm), storage 12 m^3 in 3 tanks, water supply for the house and for the cattle, Mr. M. Cready.
Ram, tank, pipe	Hd 17	Pipe 700 m (∅ 2.5 cm), metal tank (2 m^3), concrete tank (57 m^3), Mwichwiri.
Flood irrigation, furrow	Hd 17	2.5 ha, corn, napir-grass, supply by furrow Hd 18, Mwichwiri, Mr. Ch. Gaiko.
Pipeline, tank, pipe	Hd 17	Pipes 2600 m (∅ 7,5 cm), 48 m^3 in 2 tanks, formerly used for the Naro Moru Railway Station, today many supplies in Naro Moru Town, tapping with filter, maintenance by Kenya Rail.
Rain gauge station	Hd 17	Private, daily readings since 1955, readings back to 1936, Ruare Estate.
Irrigation canal	Hd 18	cf Hd 17, unlined earth dam, length 1500 m up to the farm, no provisions for returning surplus water, flood irrigation of 2.5 ha corn and napir-grass.
Ram, tank, pipe	Hd 24	3 rams, pipes 500 m (∅ 5 cm), tanks 50 m^3, water supply and irrigation (1 ha) for the Catholic Mission.
Furrow	Hd 25	Unlined earth dam, length 2800 m, overgrown and damaged, Mwichwiri Coop. Soc.
Furrow	Hd 25	Unlined earth dam, length 1600 m, damaged, mostly dry as a result of the obstructed admittance, for irrigation, information by the Catholic Mission.

Coordinate square **Hc**

Pump, tank, pipe	Hc 4	New installation: water driven pump (motor pump), pipe 100 m (∅ 4 cm), 3 tanks, water supply for the house and garden irrigation, Mr. Nelson, Satima Farm.
2 Rain gauge stations	Hc 4	Daily readings since 1973, private, Mr. Nelson (Satima House), daily readings, Naro Moru Chief's Camp.
Dieselpump, tank, pipe	Hc 9	Pipes 150 m (∅ 5 cm), 30 m^3 in 6 tanks, water supply for the Naro Moru River Lodge.

Dam	Hc 5	Earth dam, length 20 m, feeding by surface runoff, in bad state, in bush, poor accessibility.
2 Dieselpumps, tank, pipe	Hc 15	2 Dieselpumps with pipes 500 m (∅ 5 cm), tanks (45 m^3), no water treatment, water supply for the Naro Moru Town.
River gauge station 5BC2/A5	Hc 15	Recorder type Ott-R-16, rectangular weir of concrete, recordings since 1961, maintenance by MWD and GIUB.

Coordinate square **Gc**

2 Dams	Gc 6/12	Earth dam, length 120 m, water supply for cattle, fed by surface runoff, high sediment suspension.
Dieselpump, tank, pipe	Gc 21	Diesel-engine, pipe 800 m (∅ 5 cm), concrete tank, supply for the Kihato Farmers.

Coordinate square **Gb**

Borehole, diesel-pump, tank	Gb 1	Borehole and dieselpump, 4 m^3 in small tank, of concrete, 160 m^3 in big tank of concrete. Pump should be looked after, water supply for the Thome Farmers.
Flood irrigation, watermill, tank	Gb 10	Flood irrigation of 200 ha grass and garden, pump driven by watermill, information from Mr. Brown, farm manager.
Ram, pipe	Gb 15	Ram, pipe 80 m (∅ 2.5 cm), water supply for the house.
Ram, dieselpump, waterwheel, pipe, tank	Gb 15	Pipes 150 m (∅ 2.5 cm and 4 cm), tank of metal (2.5 m^3), ram and dieselpump working, waterwheel damaged, pipes intact, used for flood irrigation and water supply for the house, Carissa Farm, Mr. Nderi.
Recording rain gauge R5	Gb 15	Pluviograph, type Hellmann, recordings by GIUB since 1977, Carissa Farm.
Dieselpump, tank, pipe	Gb 20	Pipes 1200 m (∅ 5 cm), 160 m^3 in tank of concrete, cattle dip.
Dam	Gb 20	Earth dam, length 100 m, water from surface runoff, water for the cattle.

Coordinate square **Fb**

Dam	Fb 3	Earth dam, length 60 m, Weruini Lands-Tigithi-Farm, Burguret.
Flood irrigation	Fb 7	Flood irrigation of 60-80 ha grass and garden, furrow, today irrigation of some shambas, Matanya.
Dam	Fb 8	Earth dam, level with the ground, reservoir and cattle dip, fed by the channel to the farm, only rarely used, Matanya.
Dieselpump, tank, pipe	Fb 8	Pipe 300 m, (∅ 5 cm), 320 m^3 in 2 tanks of concrete, pump was removed, water supply for farmers and cattle, pump was fixed at the earth channel from the Naro Moru River, Matanya.

Ram, tank, pipe	Fb 11	Pipes 100 m, (Ø 4 cm), two damaged tanks on piles, out of operation, pump and pipes still there, water supply for the house, garden irrigation, pools pump was fixed at the earth channel from the Naro Moru River, Thome.
Flood irrigation	Fb 11	Flood irrigation of 160-200 ha grass, today out of use, Thome.
Dam	Fb 16	Earthdam, made even with the ground, Thome.
Flood irrigation	Fb 18	Flood irrigation of 0.8 ha corn, potatoes, beans. Owners: 2 settler families, irrigation system damaged, furrow, Matanya.
Dam	Fb 21	Earth dam, length 80 m, cattle dip, Thome.
Furrow	Fb 23	Unlined dam of stones, length 7000 m, in good state for the first km, then overgrown and damaged by cattle, flood irrigation of little tracts, drinking water supply, cattle dip, conflicts between settlers at Matanya and Tigithi, information from the teachers of the Tigithi-Secondary School. Matanya Coop. Soc.
Furrow	Fb 23	Dam built of stone, badly damaged,length 600 m, water runs with big loss only within the first 3 km, cattle dip, irrigation of little tracts, only a few settlers, information from the teachers of the Olechugu-School, Thome.

Coordinate square **Fa**

River gauge station A6	Fa 3	Recording station type Ott-R-16, stable natural gauge cross section, recordings since 1982.
Flood irrigation, pipe	Fa 15	Furrow irrigation of 0.8 ha corn and potatoes, channel to the farm, pipe in bad state, Thome.
Rain gauge station R7	Fa 15	Temporary readings by the GIUB, Silvio Decurtins.

Coordinate square **Ea**

Dam	Ea 24	Earth dam, length 30 m, in bad state, in bush, Weruini Lands, Tigithi Farm.

5.3.2. Burguret River basin

The Burguret River rises in the upper moorland. There is no distinct main course. Down to the river gauge station 5BC6 the channel morphometry is similar to that of the Naro Moru River. In the lower part of the river it changes into a large swamp (appr. 880 ha). The water losses by evapotranspiration seem to be very high. The total river length is 119 km. From the forest zone to the junction, the catchment is quite broad. The forested part, 71% of the catchment area, is the highest of all drainage basins considered. In spite of this high part of forest, the Burguret River is characterized by a considerable sediment load after heavy rains.

Coordinate square **Hf**

Spring 1979	Hf 1	Characteristic seepage spring in a small tributary of the Burguret River, the spring is now tapped for water supply, estimated discharge 2–3 l/sec, low salination (52–60 μs/cm), measurements in April 1985.

Coordinate square **Gf**

Rain gauge station	Gf 1	MWD No. 9037097, daily readings, Gathiuru.
Dam	Gf 6	Earth dam, length 25 m, watering place for the cattle, water from surface runoff, Gathiuru Forest Station.

Coordinate square **Ge**

Dam	Ge 9	Earth dam, length 40 m, water for cattle, fed by surface runoff, Gathiuru Forest Station.

Coordinate square **Gd**

Furrow, fishpond	Gd 1	Channel with 2 m high concrete dam, length 80 m, water used for 39 fishponds, information by Mr. John, Burguret Fishfarm.
River gauge station	Gd 7	Daily readings (twice a day) since 1961, once a day from 1981 onwards by MWD, gauge measurement near the road bridge.
Dieselpump, tank, pipe	Gd 13	Pipe 100 m (∅ 5 cm), tank (18 m^3) with sandfilter, water supply for the Bantu-Utamaduni Lodge.
Furrow, fishponds	Gd 14	Earth channel with cemented weir, length 1000 m, badly overgrown in parts, water supply for the lodge and the 3 fishponds, no pipe back to the river for the surplus water, Bantu Utamaduni Lodge.
Spring Mureru	Gd 16	Contact spring with outflow consisting of fractures.
Furrow	Gd 16	Earth channel for the spring, length 900 m, heavy seepage losses on the sides, water supply for the farm houses, feeding of a dam basin and a cattle dip, important water point for new settlers, Mureru.
Dam	Gd 16	Earth dam, length 50 m, badly silted earth channel with spring water, cattle dip, Mureru.
Dam	Gd 23	Earth dam, level with the ground.
Dieselpump, tank, pipe	Gd 24	Pipes 700 m (∅ 7.5 cm), 160 m^3 in concrete tank, 1.5 m^3 in metal tank, water supply for the school, Naro Moru Secondary School.
Ram, tank, pipe	Gd 24	Pipe 750 m (∅ 5 cm), 160 m^3 in tank of cement, ram missing, pipes and cemented supply in good state, water supply for the farmhouse and irrigation of the garden, has fed the same tank as the dieselpump, Naro Moru Secondary School.

Spring Waguziru	Gd 25	Spring gallery with a main spring called 'Waguziru'.
Rain gauge station	Gd 7	MWD No. 9037125, daily readings since 1960, Burguret Forest Guard Post.

Coordinate square **Fd**

Dam	Fd 6	Earth dam, level with the ground, Loigulu Farm.
Dug well, windmill, tank	Fd 8	Well in shaft, 12 m deep, groundwater level –12 m, 35 m^3 in open concrete tank, windmill not fixed, cattle dip, well only has water after heavy rainfalls.
Dam	Fd 12	Earth dam, Mr. Orla P. Jacobson, Ol Loigulu-Farm.
Borehole, windmill tank	Fd 13	Borehole, depth 69 m, groundwater level –13 m, yield 0,6 l/min, 53 m^3 in open concrete tank, valves of the pump have a leak, tower of the windmill destroyed by the wind, drinking water for the Ragati Village.
Spring Ragati	Fd 14	Fracture spring out of basalt, estimated discharge 100 l/min.
3 Dams	Fd 16	Earth dams, level with the ground, Burguret.
Spring Burguret	Fd 17/22	Spring gallery with two main springs.
Rain gauge station	Fd 21	Information: Mr. Nicolson, Nanyuki, private, daily readings since 1970.
2 Dieselpumps, ram	Fd 21	See Fc 25.

Coordinate square **Gc**

Dam	Gc 3	Earth dam, length 80 m, dry, fed by surface runoff, for cattle, Burguret.

Coordinate square **Fc**

Borehole, diesel-pump, tank	Fc 3	Borehole, depth 154 m, groundwater level –20 m, yield 2.5 l/min, 45 m^3 in open tank of cement, pump is missing, opening for the pump is obstructed, water for cattle, Burguret.
3 Dams	Fc 6	Earth dams level with the ground, Burguret.
Borehole, diesel-pump, tank, pipe	Fc 12	Borehole, depth 159 m, groundwater level –23 m, diesel-pump, yield 10.2 l/min, 460 m^3 in 2 tanks of cement, pipes existing, pump missing, water for cattle, Burguret.
Flood irrigation	Fc 16	Flood irrigation of 20 ha, channel to the farm does not exist any more, channel overgrown, Burguret.
Dam	Fc 16	Earth dam, length 140 m, dry, furrow obstructed, water for fish-hatch and cattle, Burguret.
Furrow	Fc 18	Unlined dam of stones, obstructed and dry, feeding of the reservoir of Burguret.
Furrow	Fc 18	Unlined dam of stones, no longer in existance, water for cattle dip, flood irrigation, swimming pool, on the first 250 m irrigation of little allotments, Burguret.

Flood irrigation	Fc 18	Flood irrigation of 0.4 ha of corn, channel is dry at low surface runoff, Burguret.
Dieselpump, tank, pipe	Fc 19	Mobile dieselpump, pipes 900 m (∅ 12,5 cm), 770 m^3 in 4 tanks of cement, tanks and mobile pump are still there, most of the pipes are removed, water supply for the houses, in 1979 3 tanks were enlarged.
Ram, tank, pipe	Fc 25	Pipes 250 m (∅ 4 cm), 50 m^3 in concrete tank, water supply for the farmhouse, working only at low water level, Burguret.
Dieselpump, pipe	Fc 25	Pipes 200 m (∅ 5 cm), water supply for the house, Dr. Ngatia.
Dieselpump, tank, pipe	Fc 25	Pipes 250 m (∅ 3 cm), 50 m^3 in tank of cement, water supply for the house and for the cattle.

Coordinate square **Ec**

Dam	Ec 21	Earth dam, length 60 m, fed by surface runoff, Burguret.

Coordinate square **Fb**

Dam	Fb 3	Earth dam, length 60 m, channel out of use, Weruini Lands, Tigithi.
Dieselpump, pipe	Fb 4	Pipe 400 m, pump is missing, pipes damaged, water supply for the farmhouse, Kabanga Women's Group.

Coordinate square **Eb**

Furrow	Eb 1	Furrow, length 3200 m, dry and very badly overgrown, structure of concrete, feeding of a dam basin, Ol Pejeta Sweetwaters.
Furrow	Eb 13	Furrow, length 10'000 m, fallen into ruin and obstructed, diversion of cement, drainage of the Burguret-Rongai-Swamp, unclear responsibilities as a result of quarrels about the boundary, Matanya.

5.3.3. Rongai River basin

The catchment only reaches up to the upper forest line. Therefore it is considerably smaller than the neighbouring river basins. In the dry years the Rongai River dries up several kilometers upstream of the swamp, due to insufficient feeding from the higher part of the mountain. For this reason this river is of only subordinate significance for the water supply. The total river length amounts to 31 km.

Downstream from the foothills the Rongai River is eroded into soft volcanic ashes (murram). This section is, according to *Brunner* (1983), very much endangered by erosion caused by cattle.

Coordinate square **Gf**

Dieselpump, tank, pipe	Gf 1/2	Pipe 2000 m (∅ 5 cm), 10 m^3 in tank of cement, 2 m^3 in tank of metal, water supply for the station and the forest village, Gathiuru Forest Station.
Rain gauge station	Gf 1	MWD Nr. 9037097, daily readings, Gathiuru

Coordinate square **Ee**

6 Dams	Ee 11 and Ee 12	Earth dams, length 15 m and 10 m, badly overgrown and filled with sediment, out of use, fed by surface runoff, Katheri Farm.
	Ee 17 and Ee 18	Earth dams, length 120 m, 60 m, 30 m and 30 m cultivation on the crown of the dams, partially destroyed, fed by surface runoff, used to irrigate nearby shambas.
Borehole, diesel-pump, tank	Ee 16	Borehole, depth 108 m, groundwater level –24 m, diesel-pump, yield 54 l/min, 45 m^3 in open tank of cement, borehole obstructed, pump was removed, water for cattle, Ragati.
River gauge station 5BC5	Ee 21	Readings of staff gauge once a day, no staff/discharge relation available.
Rain gauge station	Ee 25	Private, daily readings since 1963 at least, further years probably lost, Loruku Farm.

Coordinate square **Ed**

Dam	Ed 14	Earth dam, length 30 m, badly overgrown and filled up with sediment, fed by surface runoff, out of use, Icuga.
Dam	Ed 15	Earth dam, length 15 m, very much overgrown and filled up with sediment, fed by surface runoff, out of use, Katheri.
Windmill, tank, pipe	Ed 23	Pipe 50 m (∅ 5 cm), 13 m^3 in 3 tanks of metal, 27 m^3 in tank of cement, water supply for the house and irrigation of the garden, Colonel Harris.
Windmill, diesel-engine, borehole, tank	Ed 23	Borehole, depth 127 m, groundwater level –37 m, windmill combined with diesel-engine, yield 68 l/min, 10 m^3 in 2 metal tanks, water supply for the house and irrigation of the garden, yield always constant, independent from precipitation.
Windmill, tank, pipe	Ed 23	Pipe 20 m (∅ 5 cm), 4.5 m^3 in metal tank, water supply for the house and irrigation of the garden, Mr. Orla P. Jacobson, Ol Loigulu Farm.
Rain gauge station	Ed 23	Information: Mr. Jacobsen, Nanyuki, private, daily readings since 1934.

Windmill, dug well	Ed 24	Well in shaft, depth 8 m, groundwater level –8 m, windmill, bars of the pump damaged, water supply of the house, yield depends on precipitation, Ragati.
Furrow	Ed 25	Unlined dam of stones, length 1000 m, dry and very badly overgrown, water supply for the farmhouse, cooling of the milk, production of bricks, Ragati.

Coordinate square **Ec**

Windmill, diesel-engine, borehole	Ec 13	Borehole, depth 109 m, groundwater level –47,5 m, windmill combined with diesel-engine, yield 100 l/min, borehole obstructed, pump was removed, water-supply for the house and for the cattle, Weruini, Sweetwaters Farm.
Furrow	Ec 19	Unlined dam of earth and stones, length 2400 m, working, but badly overgrown, water supply for the farmhouse, feeding 2 dam basins, there is a school in the farmhouse, Weruini Sweetwaters Farm.

Coordinate square **Eb**

Furrow	Eb 1	Furrrow, length 5400 m, intake: concrete weir (badly damaged), channel has a leak and is dry after 2500 m, drainage of the swamp, irrigation and feeding of a dam basin, Ol Pejeta-Sweetwaters.
Furrow	Eb 8	Unlined channel of earth and stones, length 3200 m, dry and very badly overgrown, feeding a dam basin, Ol Pejeta-Sweetwaters.
Furrow, flood irrigation	Eb 8	Flood irrigation of 0.5 ha maize, only during rainy season, furrow on unlined dam of stones, length 300 m, badly overgrown but working, Mr. S. Kioko.
Furrow, flood irrigation	Eb 9	Flood irrigation of 0.4 ha maize, only during rainy season, furrow with unlined dam of stones, length 350 m, working, badly overgrown, Mr. M. Wagoci.
Furrow, flood irrigation	Eb 9-14	Flood irrigation of 1.2 ha maize and vegetables, irrigation also after the harvest, furrow with dam of stones fixed with trees, length 890 m, partially obstructed, big waterlosses as a result of seepage, Mr. P. Mwai

Coordinate square **Da**

Flood irrigation	Da 18	Flood irrigation of 25 ha grass, not existing any more, irrigation was done by the former owner Mr. S. S. Bastard, furrow from Burguret-Rongai-Swamp, Ol Pejeta Farm.

5.3.4. Nanyuki River basin

The junction with the Ewaso Ng'iro lies 30 km to the north. All other rivers of the Mount Kenya slopes between Nanyuki and Timau reach this regional main river upstream of the river gauge station 5BE20. Between the flat plateau the rivers have eroded deep valleys with steep slopes and of a sectional ravine character.

The catchment reaches up to the peak region and it is distinctly elongated and narrow (total river length: 99 km). The wet forest- and moorland zones, however, are not larger than 50 km^2. The part of the drainage basin covered with forest amounts to 45% (30 km^2).

Coordinate square **Ff**

Rain gauge station	Ff 9	MWD No. 9037156, daily readings (Kahurura Forest Station), Nanyuki Forest Station.
Dieselpump, pipe	Ff 14	Pipe 580 m (∅ 4 cm), water supply of the station, Kahurura Forest Station.

Coordinate square **Ee**

Furrow	Ee 2	Unlined dam of stones, length 2200 m, water supply for the neighbourhood, name: Nanyuki Lower Furrow, Nanyuki Municipality.
Pipeline	Ee 2	Pipe 1992 m (∅ 10 cm), concrete intake with filter, formerly for the railway, today used as water supply for the railway station, Kenya Railway-Watersupply.
Dieselpump, pipe	Ee 2	Pipe 100 m (∅ 4 cm), water supply for the house, irrigation of the garden, Mr. J. M. Kirathi
Electrical pump, tank, pipe	Ee 2	Pipe 75 m (∅ 4 cm), tank (9 m^3), water supply for the house and irrigation of the garden, S. W. Gichuhi.
Dieselpump, tank, pipe	Ee 7	Pipe 1500 m (∅ 4 cm), tank (86 m^3) water for the house and cattle, irrigation of the garden, in very good state, Mrs. Holmes, Loruku Farm.
Electrical pump, pipe	Ee 7	Pipe 180 m (∅ 3 cm), water supply for the house, Mr. G. Gitumbi.
Dieselpump, pipe	Ee 8	Portable dieselpump, pipe 50 m (∅ 3 cm), water for the irrigation of the garden, Mr. Mwangi.
Dieselpump, tank, pipe	Ee 14	Pipe 280 m, tank (2.5 m^3), pump and pipes removed, pumphouse is still there, water supply for the farm house.
Furrow	Ee 14	Unlined dam of stones, length 1500 m, after the first 500 m completely blocked, irrigation of the garden, name: Nanyuki Upper Furrow, Katheri.
Ram, tank, pipe	Ee 20	Ram, pipe 150 m (∅ 5 cm), tank (1.5 m^3), in very good state, water supply for the house, Benedictine Monastery.

Rain gauge station	Ee 25	Private, daily readings since 1963 at least, further years probably lost, Loruku Farm.

Coordinate square **Df**

Dam	Df 2	Earth dam, length 40 m, damaged, out of use, fed by surface runoff, Nturukuma.

Coordinate square **De**

Electric pump, tank, pipe	De 1	Pipe 850 m (∅ 10 cm), tank (227 m^3), sometimes problems from breaks in the pipe, industrial use, Mount Kenya Textiles.
Borehole, electric pump, tank	De 3	Borehole, depth 72 m, groundwater level –40 m, electric pump, pumpage 45 l/min, tank (90 m^3), use: drinking water for the nearby village and industrial use, information: Mr. S. Pal, Project-Manager, Kenya Fiber Coop. Ltd.
Dam	De 5	Earth dam, length 30 m, damaged, out of use, fed by surface runoff, Nturukuma Farm.
Electric pump, tank, pipe	De 6	Pipe 200 m (∅ 10 cm), tank (227 m^3), industrial use, average daily consumption 36 m^3, Mount Kenya Textiles.
Electric pump, pipe	De 7	Pipe 1700 m (∅ 10 cm), industrial use, daily pumping capacity 730 m^3, Kenya Fiber Coop. Ltd.
Dam	De 9	Earth dam, length 30 m, filled up with sediment, out of use, fed by surface runoff, Nkando Coop. Soc.
Electric pump, sprinkler irrigation, pipe	De 11/12	Pipe 650 m (∅ 5 cm), water supply for the house, sprinkler irrigation for 2 ha maize and vegetable.
River gauge station	De 12	Readings twice a day since 1961 by MWD, the weir is only sufficient up to a water level of 1,4 m.
Dieselpump, tank, pipe	De 13	Pipe 80 m (∅ 4 cm), tank (7.5 m^3), production of bricks, Babu & Partner.
Dieselpump, tank, pipe	De 17	Pipe 15 m (∅ 4 cm), tank (13.5 m^3), water supply for a tree-nursery.
2 Rain gauge stations	De 17	Nanyuki Aberdare C.C. MWD No. 8937040, daily readings; Nanyuki MOW, MWD No. 9037114, daily readings.
Hydrometeorological station, recording rain gauge	De 18	Evaporation pan, temperature.

Coordinate square **Dd**

Rain gauge station	Dd 5	Information Mr. Trench, Nanyuki, private, daily readings since 1982, MWD No. 8937022, Nanuyki KAF (Nanuyki Met. Stn.).

Ram, tank, pipe	Dd 5	Pipe 1400 m (∅ 4 cm), tank (5 m^3), water supply for house and cattle.
Ram, pipe	Dd 5	Pipe 40 m (∅ 2.5 cm), water supply for the house, private owner.
Dam	Dd 10	Furrow on unlined dam of stones, length 5500 m, damage by cattle on the territory of the Allus Farm, water supply for the cattle and irrigation of the garden, feeds two dam basins on territory of Mr. Schacky if the water level is high; owner: Mr. Trench.

Coordinate square **Ce**

Dam	Ce 7/12	Earth dam, length 180 m, filled up with sediment, watering place for cattle, channel out of the Ontulili River, Mr. Mugambi.
Borehole, pump	Ce 7	Borehole, depth 108 m, groundwater level –52 m, yield 113 l/min, new, water supply for the new lodge, not yet working.
2 Dams	Ce 16/19	Earth dams, length: both 50 m, defective, out of use, fed by surface runoff, Nturukuma Farmers.

Coordinate square **Cd**

Flood irrigation	Cd 4	Flood irrigation of 10 ha grass and vegetable-garden, channel does not exist any more, Mukima.
Ram, tank, pipe	Cd 9	Pipe 300 m (∅ 7.5 cm), tank (2.5 m^3), ram was removed to be repaired, water supply for the house, information: Mr. Macharia Kamegue, farm manager, Muhima.
Irrigation, pipe	Cd 13	Irrigation of 6 ha with 800 avocado-trees, irrigation: per week 50 l per tree, pipes and tubes, earth channel, Mr. Schacky.
Furrow	Cd 14	Earth channel from unlined dam of stones, length 2500 m, feeding a cattle dip, water partly used for irrigation, Mukima.
Dieselpump, tank, pipe	Cd 19	Pipe 230 m (∅ 10 cm), tank (2.7 m^3), drinking water supply, Mr. Schacky.

Coordinate square **Bd**

Waterwheel, turbine, tank, pipe	Bd 1	Turbine and waterwheel, pipes 300 m (∅ 15 cm), tanks (24 m^3), turbine defective, pipes still there, partly irrigation, water for cattle, storage in big round barrage, Kariunga.
River gauge station 5BE21	Bd 1	Readings every second day since 1965 by MWD.

Borehole, pump, tank	Bd 2	Borehole, depth 48 m, groundwater level –33 m, tank (5 m^3), pump damaged, pipes still there, use for the house, yield was very constant in former days, Kariunga.
Flood irrigation	Bd 2	Flood irrigation of 60 ha grass, maize, fruit and vegetable, information: Mr. S. Mwai, farm manager, Kariunga.

5.3.5. Likii – River basin

This catchment also reaches up to the top region. The parts of moorland (appr. 38 km^2) and of forest (87 km^2) which are drained by the river are important (total river length: 199 km). The large size of the river basin in the forest zone is striking. Half of the drainage basin is covered with forest (51% = 87 km^2). The main tributaries Likii North and Likii South join below the lower forest line. This is still connected and lies at about 2200–2300 m a.s.l. The catchment area as well as the discharge show the highest values of all the river basins in the investigation area. At 2180 m a.s.l. the tapping, which is very important for the urban water supply of Nanyuki Town, has been installed.

Coordinate square **Ff**

Pipeline	Ff	4 pipes 3000 m (Ø 30 cm), tank (339 m^3), concrete intake with grating and filter, not trouble-free, drinking water supply, information: Mr. Geoffrey, Maina, engineer, Mount Kenya Safari Club.
Furrow	Ff 4	Furrow with dam of stones, length 3500 m, water supply for the Safari Club and the game ranch, irrigation of the garden, return of surplus water through pipes, Mount Kenya Safari Club.
Rain gauge station	Ff 9	See Nanyuki Ff 9

Coordinate square **Ef**

Flood irrigation	Ef 3	Flood irrigation of 20 ha grass and grain, not existing any more, furrow from Likii North, old furrows, widely ramified, Miarage Farmers.
4 Dams	Ef 8/9	Earth dam, length 15 m, fed by surface runoff and by furrow from the Likii River, used for the water reservoirs of the neighbourhood and the cattle, Miarage Farmers.
Turbine pump, pipe	Ef 14	Pipe 1300 m, badly damaged, important components are missing, current supply for the house, Miarage Farmers.
Furrow	Ef 15	Unlined dam of stones, length 4000 m, feeding 2 barrages, water supply for the new settlers, irrigation, in former days also water supply for a cattle dip, Miarage Farmers.
2 Electric pumps, tank, pipe	Ef 18	Pipe 150 m (Ø 6 cm), tank (339 m^3), drinking water supply, only working if the gravity pipeline should fail, Mount Kenya Safari Club (cf pipeline Ff 4).

Coordinate square **De**

River gauge station	De 13	Readings twice a day from 1961 to 1980, once a day since 1981 by MWD.
2 Pumps, tanks, pipe	De 13	Electric pumps, pipes 30 m and 100 m (∅ 4 cm and ∅ 2.5 cm), two tanks (9 m^3 and 4.5 m^3), both used for garden irrigation, Mr. J. Alexander and Mrs. M. Wanjiki.
Dam	De 15	Earth dam, length 80 m, filled up with sediment, water for cattle, fed by surface runoff, Nkando Coop. Soc.
Dieselpump, tank, pipe	De 19	Pipe 300 m (∅ 2,5 cm), tank (2.5 m^3), water supply for the house, Mr. A. Barkas.
Dieselpump, tank, pipe	De 25	Portable dieselpump, pipe 200 m (∅ 2.5 cm), tank (2 m^3), used for production of bricks, Modern Sanitary Store.
Ram, tank, pipe	De 25	Pipe 700 m (∅ 5 cm), tank (136 m^3), tank and pipes still there, ram was stolen, water supply for the farmhouse and for the cattle, Nkando Coop. Soc.

5.3.6. Ontulili River basin

The headwaters of the Ontulili River lie in the moorland. Today the further forest boundary is situated at about 2400 m a.s.l. In 1961 it still reached down to approximately 2000 m a.s.l. Nearly half of the drainage basin (48% = 29 km^2) is covered by forest. The total river length is 83 km.

Coordinate square **Dg**

Rain gauge station	Dg 12	MWD No. 8937040, daily readings, Ontulili Forest Station.
Dieselpump, tank, pipe	Dg 13	Pipe 1700 m (∅ 4 cm), tank (10 m^3), water supply for the forest station and the forest village, the capacity is not sufficient, Ontulili Forest Station.

Coordinate square **Cg**

Dam	Cg 21	Earth dam, length 40 m, feeding by surface runoff, for cattle, Kalalu.

Coordinate square **Df**

Electric pump, tank, pipe	Df 3	Pipe 360 m (∅ 4 cm), tank (4.5 m^3), shut down as a result of high electricity costs, Nanyuki Timber Sales.
River gauge station	Df 3	Daily readings since 1961 by MWD, the weir is flooded by a water level >2 m.
Electric pump, tank, pipe	Df 4	Pipe 200 m (∅ 5 cm), tank (9 m^3), use for the house, irrigation of 48 ha fruit plantation is planned, Mr. Davis.
Rain gauge station	Df 4	Private, Mr. Davis, Ontulili Farm.

Coordinate square **Cf**

Furrow	Cf 11	Dam made of stones and fixed with trees, length 3500 m, in bad state, water is completely lost through seepage after the first 2 km, irrigation of a few allotments, Nturukuma Farmers.
Dieselpump, 2 rams, tank, pipe	Cf 11	Pipe 210 m (∅ 7.5 cm), tank (9 m^3), dieselpump working, both rams damaged, water supply for the house and irrigation of 0.4 ha, ram should be repaired, Mr. P. M. Mahindu.
Sprinkler irrigation	Cf 11	Sprinkler irrigation of 1–2 ha maize and vegetable, dieselpump, Mr. P. M. Mahindu.
Ram, pipe	Cf 16	Pipe 750 m (∅ 4 cm), pump is missing, ram was removed 10 years ago.
Ram, tank, pipe	Cf 17	Pipe 420 m (∅ 2,5 cm), tank (4.5 m^3), water supply for the house, Mr. P. Bindi.
Furrow	Cf 22	Furrow, length 2500 m, badly overgrown, big loss by seepage, concrete intake with prepared connections for the pipes, irrigation and water supply, no pipes to return the surplus water, Nturukuma Farmers, Kangaita.
Furrow, ram, pipe	Cf 22	Furrow from lined dam of earth and stones, length 950 m, big loss by seepage, irrigation, water drives a ram-pump, pipes to return the surplus water, Mr. P. Bindi.
Ram, pipe	Cf 22	Pipe 220 m, pipes and pump are missing, repair planned, Mr. Mahindu.
Flood irrigation, ram	Cf 22	Flood irrigation of 16 ha grass, does not exist any more, ram, Mr. P. M. Mahindu.
Sprinkler irrigation	Cf 22	Sprinkler irrigation of 1 ha maize and vegetable, simple sprinklers for garden, Nturukima Farmers.
Dam	Cf 23	Earth dam, length 40 m, filled up with sediment, fed by surface runoff and possibly groundwater, water for cattle, is even not dry after the end of the dry season, Mr. P. M. Mahindu.

Coordinate square **Ce**

Furrow	Ce 2	2 m high dam of stones, length 5500 m, in bad state, 20 % loss through seepage up to the farm, water supply for the farm house, for the cattle, feeding 2 barrages, almost the whole Ontulili River is directed to the farm area, without pipes for the return of surplus water, Mr. Mugambi.

Coordinate square **Bd**

Dam	Bd 4	Dam (∅ 50 m), round barrage, furrow from the Ontulili River, water for cattle, Mr. Mugambi.

Flood irrigation	Bd 15	Round barrage (∅ 40 m), furrow from the Ontulili River, water for the cattle, Mr. Mugambi.
Dam	Bd 15	Flood irrigation of 10 ha maize, furrow from the Ontulili River, obstructed, Mr. Mugambi.

5.3.7. Kongoni River basin

Due to the inequal flow behaviour this smallest river in the investigation area is only of minor significance (total river length: 22 km). Normally it dries up just downstream of the river gauge station 5BE3 during two to three months a year. The very narrow catchment reaches only a little above the upper forest line. Nearly two thirds of the drainage basin area are covered by forest (64% = 10 km^2).

Coordinate square **Cg**

Dieselpump, tank, pipe	Cg 6	Dieselpump, pipe 180 m (∅ 2.5 cm), tank (1.5 m^3), water supply for the house, Kalalu.
Dam	Cg 6	Earth dam, length 70 m, dam has a leak, badly overgrown, reservoir, site for a dieselpump, furrow from the Kongoni River, they were cleaning it in 1982, Kalalu.
Flood irrigation	Cg 11	Flood irrigation of 20 ha grass and grain, does not exist any more, furrow from the Kongoni River, Kalalu.
Dam	Cg 17	Furrow on unlined dam of stones, length 2200 m, badly overgrown in parts, water supply for the school, feeding of a barrage, cooling of the milk. When the Kongoni River has dried up, the water is brought by a tractor from the Sirimon River, Kalalu.
River gauge station 5BE3	Cg 19	Daily readings since 1961 by MWD, stable natural cross profile, the weir is flooded by a water level >1.4 m.

Coordinate square **Bf**

Furrow	Bf 23	Furrow from dam of stones fixed with trees, length 4200 m, irrigation, feeding of a barrage; periodical cleaning by a tractor and a special plough, Mr. T. G. Webb.

5.3.8. Sirimon River basin

This catchment has a high share of moorland and alpine meadows. In the forest zone, however, the drainage basin is very narrow. The total river length is 63 km. Only 22% of the area is covered by forest. This is considerably less than the total mean of 48% of all the drainage basins. The V-shaped valley of this river is characteristic up to the junction with the Timau river. Its clear water is typical for this river.

Coordinate square **Ch**

Dam	Ch 16	Old pit dammed-up with loam, furrow, 15 m, water for cattle, Kalalu.

Coordinate square **Cg**

Ram, tank, pipe	Cg 1	Pipes 300 m (∅ 2.5 cm), tank (40 m^3), pump is missing, some pipes in existance, fed by the furrow, water supply for the house and the cattle, Kalalu.
Dam	Cg 1	Old dammed-up loam-pit, 20 m, fed by surface runoff, water for cattle, Kalalu.
Dieselpump, tank, pipe	Cg 2	Pipe 600 m (∅ 7.5 cm), tank (120 m^3), pipes damaged, water supply for the Umande Village and the school, cattle dip, Umande Primary School.
Furrow	Cg 8	Furrow from unlined dam of stones with concrete intake, length 4500 m, great loss of water after the first 2 km, after the farmhouse dry, water supply for the farm, feeding of a barrage, irrigation of a garden, furrow is hewn into conglomeratic rock (= < 5 m) on the first 1.5 km, Kalalu.
Ram, pipe	Cg 14	Pipe 350 m (∅ 5 cm), ram damaged, control valve was stolen, used for the house and the irrigation of the garden, Ngenia Farmers.
2 Dieselpumps, tank, pipe	Cg 15	Pipe 380 m (∅ 7.5 cm), tank (22 m^3), both dieselpumps damaged, pipes and tank in good state, supply for the house and the irrigation of the garden, Ngenia.
Dieselpump, tank, pipe	Cg 15	Pipe 1000 m (∅ 5 cm), tank (6.8 m^3), pump was stolen, pipes transferred, water supply for the market place Ngenia and the Primary School, Ngenia.
River gauge station 5BE4	Cg 20	Daily readings since 1961 by MWD, the right hand side of the weir is damaged, this one is flooded at a water level > 1.2 m, the staff gauge is fixed on the bridge.

Coordinate square **Bf**

4 Dams	Bf 11	Earth dam, length 60 m.
	Bf 16	Earth dam, length 40 m.
	Bf 17	2 Earth dams, length 40 m and 50 m, water for cattle, furrows, Mr. T. G. Webb.
Rain gauge station	Bf 11	Cedarvale Farm, private, daily readings from 1956 to 1981.
2 Dieselpumps, tank, pipe	Bf 11	Pipe 550 m (∅ 5 cm), tank (120 m^3), supply for the house and the irrigation of the garden, Mr. T. G. Webb.
Flood irrigation	Bf 11/12	Flood irrigation of 180 ha grass, furrow, extensive irrigation of 160 ha, intensive irrigation of the rest, Mr. T. G. Webb.

Furrow	Bf 24	Furrow on unlined dam of stones, feeding of a barrage, flood irrigation, periodical cleaning with a tractor and a special plough, Mr. T. G. Webb.
Dieselpump, tank, pipe	Bf 25	Pipe 120 m (∅ 2.5 cm), tank (4.5 m^3), water supply for the police station, Umande Police Station.

Coordinate square **Dh**

Rain gauge station	Dh 20	MWD No. 9037155, readings since 1926, Sirimon Gate.

5.3.9. Teleswani River basin

The catchment is distinctly situated on the rainy lee side of Mount Kenya. The total river length is 47 km. The headwaters lie at about 3400 m a.s.l. in the moorland-heather-zone, which is similar to a heath-landscape due to the decreased precipitation. The forest is less dense than in the former catchments. The total forest area amounts to 42% (16 km^2) of the drainage basin. The regular flow behaviour is maintained by the feeding from large springs. Between the main road and the junction there are several steps on the slopes. These points are to be used for water power production with rams or for the feeding of gravity pipelines *(Brunner,* 1983).

Coordinate square **Dj**

Springs Teleswani	Dj 2	Type of seepage spring.

Coordinate square **Cj**

Furrow, fishpond	Cj 11	Furrow from dam of cement, length 600 m, feeding 21 fishponds, Kentrout Fishfarm.
Flood irrigation	Cj 16	Flood irrigation of 1–2 ha vegetable, potatoes and maize, furrow, Timau Settlement Scheme.
Spring	Cj 17/22	cf Springs Teleswani Dj 2.
Furrow	Cj 22	Furrow with unlined dam of stones, length 1500 m, flood irrigation, feeding of a barrage, furrow is mostly dry before the barrage, Timau Settlement Scheme.
Rain gauge station	Cj 2	MWD No. 8937034, daily readings since 1948, Ardencaple Farm.

Coordinate square **Ch**

Dieselpump, tank, pipe, irrigation	Ch 2	Pipe 150 m (∅ 5 cm), tank (9 m^3), irrigation of 4 ha, Mr. D. Mathai.
Ram, tank, pipe	Ch 3	Pipe 300 m (∅ 2.5 cm), tank (9 m^3), water supply for the house and for the cattle, Mia Moja School.
Sprinkler irrigation	Ch 3	Sprinkler irrigation of 4 ha maize and vegetable, enlargement of the irrigation area is planned, Mia Moja.

Furrow	Ch 4	Furrow with lined dam of stones, length 4700 m, high water loss by seepage, irrigation, supply for the house, furrow water drives on a pump, feeding of fishponds, fish-hatchery is not in operation, Mia Moja.
River gauge station 5BE5	Ch 4	Readings twice a day since 1961 by MWD.
Sprinkler irrigation, dieselpump	Ch 5	Sprinkler irrigation of 4 ha maize, mobile dieselpump, irrigation only in the months of December and January, Mr. B. A. Blackbeard.
Rain gauge station	Ch 5	Private, Mr. Blackbeard, Kentrout, Mr. Shong, private.
Dieselpump, tank, pipe	Ch 9	Pipe 100 m (∅ 5 cm), tank (9 m^3), supply for the house and the irrigation of the garden, Mrs. N. Andrew.
Pipeline, fishpond	Ch 10	Pipe 1380 m (∅ 10 cm), cemented intake, water supply for the Mission, the Secondary School and some connections in Timau, irrigation of a garden (0.5 ha), fishponds, Catholic Mission Timau.
Ram, tank, pipe	Ch 10	Pipe 70 m (∅ 2.5 cm), tank (5.5 m^3), use for the house and irrigation, sometimes the tractor power drives the sprinkler irrigation, Mr. Blackbeard.

5.3.10. Timau River basin

In comparison to the former rivers the Timau catchment shows another morphology. The main feature is the formation of the catchment like a flat depression. The river has eroded into volcanic ashes. Near the Ardencaple Farm there is a basalt barrier with a height of 5 m. As for the Teleswani River it is fed mainly by large springs. The river discharge is therefore very regular. After storm rains the river water gets a red colour. In the Masai language 'Timau' means 'red water'. Only 21% (12 km^2) of the area is covered by forest. The total river length amounts to 63 km.

Coordinate square **Dk**

Spring Logiladu	Dk 6	Large spring like a karstic spring.
Pipeline, tank, pipe	Dk 6	Pipe 24 km (∅ 15 cm), tank (100 m^3), cemented tapping installation, water supply for the Timau Settlement Scheme and for Timau Town, often problems with the mains, information: Mr. Josua, chairman, Timau Settlement Scheme.
Rain gauge station	Dk 8	Timau Forest Guard Post.

Coordinate square **Ck**

Rain gauge station	Ck 11	Upper Ngusishi.

Dam	Ck 12	Earth dam, length 40 m, water for the cattle, water overflow, tapping at the Hickson Stream, Ngusishi.
Pipeline	Ck 16	Pipe 13 km (∅ 8 cm), cemented intake, not working, feeding a net of pipes with watering places for the cattle, many pipes were removed after the subdivision of the land, Ngushishi.

Coordinate square **Cj**

Turbine, pipe	Cj 1	Pipe 6 m (∅ 25 cm), power generating for the farm, Mr. A. Thompson.
Sprinkler irrigation	Cj 2	Sprinkler irrigation of 2 ha grass, grain, maize and potatoes, furrow, gravity pipeline, Mr. A. Thompson.
Spring	Cj 3	Spring gallery
Pipeline	Cj 3	Open tapping of the spring, pipe 1800 m (∅ 10 cm), irrigation, Mr. A. Thompson.
Furrow	Cj 4	Furrow with dam of earth and stone, length 4600 m, irrigation, Mr. A. Thompson.
Dam	Cj 8	Earth dam, length 60 m, overgrown, a furrow follows alongside the reservoir, Mr. A. Thompson.
Ram, pipe	Cj 10	Pipe 300 m (∅ 7.5 cm), use for sprinkler irrigation, Oldonyo Farm.
Sprinkler irrigation, dieselpump	Cj 10	Sprinkler irrigation of 2 ha grass and grain, dieselpump, Oldonyo Farm.

Coordinate square **Bk**

Pipeline	Bk 21	Pipe 2850 m (∅ 10 cm), cemented tapping of the spring, water supply for the houses of the Oldonyo- and Lolomarik Farm, Oldonyo Farm.

Coordinate square **Bj**

Flood irrigation	Bj 23	Flood irrigation of 5–10 ha grass, grain, maize and potatoes, furrow, gravity pipeline.

Coordinate square **Ch**

Dieselpump, tank, pipe	Ch 2	Pipe 150 m (∅ 5 cm), tank (9 m^3), irrigation of 4 ha, also at the Teleswani River, Mia Moja.
Sprinkler irrigation, dieselpump	Ch 3	Sprinkler irrigation of 4 ha maize and vegetable, extension of the area is planned, dieselpump, Mia Moja.
Sprinkler irrigation, dieselpump	Ch 5	Sprinkler irrigation of 4 ha grain, irrigation only in December and January, mobile dieselpump, Mr. B. A. Blackbeard.

2 dams	Ch 14/25	Earth dam, length 20 m, filled up with sediment, fed by surface runoff, Timau, Settlement Scheme.
Spring	Ch 11	Trickling spring, pool.

Coordinate square **Bh**

Dam	Bh 21	Earth dam, length 15 m, water for the barrage and for the cattle, furrow, Mia Moja.
River gauge station 5BE6	Bh 25	Readings twice a day since 1961 by MWD.

Coordinate square **Bf**

Flood irrigation	Bf 2	Flood irrigation of 10 ha napir and lucerne, dieselpump.
3 dieselpumps, tank	Bf 3	3810 m^3 in 42 tanks of cement and 58 dams, for the cattle and irrigation, information: Mr. R. Minns, farm manager.
Dam	Bf 6	Dam, length 40 m, furrows, water for the cattle, Mr. T. G. Webb.
Furrow	Bf 14	Furrow with unlined dam of stones, length 5200 m, irrigation, feeding of a dam, Mr. T. G. Webb.

Coordinate square **Be**

Ram, dieselpump, tank, pipe	Be 3/5	Pipe 80 m (∅ 7.5 cm), 3810 m^3 in 42 tanks of cement and 58 dams, information: Mr. R. Minns, farm manager, water supply for the cattle and irrigation, Loldaiga Farm.
Flood irrigation, ram	Be 5	Flood irrigation of 2 ha napir and lucerne, ram, Loldaiga Farm.

Coordinate square **Ad**

River gauge station 5BE20	Ad 16	Readings every second day since 1961 by MWD.
Rain gauge station	Ad 22	MWD No. 8937064, daily readings, Kimugandura Farm.

5.3.11. Ewaso Ng'iro River basin

The remaining area on the map in the west and north of the river basins described is called 'Ewaso Ng'iro river basin'. Of course it is only a part of the whole Ewaso Ng'iro river basin. This area has a savanna character. The river runoff is mainly fed by the upstream areas. Concerning water supply the groundwater is of increasing significance. The knowledge of the hydrology is relatively poor.

Coordinate square **Ha**

Windmill, diesel-pump	Ha 4	Shaft, depth 15 m, groundwater level –15 m, yield 20 l/min, shaft was given up because of possible caving in, replacement by a dieselpump in Moyok River, information: Mr. Fernandez, Tharua Farm.

Coordinate square **Ga**

Dieselpump, tank, pipe	Ga 19	Pipe 5000 m (∅ 5 cm), water in 6 tanks of cement, watering places for the cattle, pump is standing in the swamp of the Moyok River, Tharua Farm.

Coordinate square **Gb**

Borehole, diesel-pump, tank	Gb 1	Borehole, dieselpump, yield 80 l/min, 4 m^3 in small concrete tanks, 160 m^3 in big concrete tanks, pump should be looked after, water supply, Thome.
Borehole, windmill	Gb 17	Borehole, depth 121 m, groundwater level –11 m, pumpage 133 l/min, bars of the pump were stolen, borehole intact, water for the cattle, information: Mr. Fernandez, Tharua Farm.

Coordinate square **Ea**

Dam	Ea 24	Earth dam, length 30 m, in bad state, furrow in bush, Weruini.

Coordinate square **Ed**

Borehole, diesel-pump, tank	Ed 1	Borehole, depth 86 m, groundwater level –45 m, dieselpump, yield 18 l/min, tank (2.7 m^3), water supply for the cattle, damaged tank of cement (100 m^3).

Coordinate square **Dd**

Borehole, windmill, tank	Dd 13	Borehole, depth 33 m, groundwater level –15 m, windmill combined with electric engine, yield 75 l/min, tank (18 m^3), water supply for the cattle; if there is no wind the electric engine works, Mr. Trench.
Borehole	Dd 20	Borehole, depth 121 m, groundwater level –54 m, connected with the urban water supply, KCC-dairy, Nanyuki.
2 Dams	Dd 17/24	Earth dams, length 30 m, overgrown and filled up with sediment, fed by surface runoff, Sweetwaters Farm.

Coordinate square **Dc**

Borehole, diesel-pump	Dc 5	Borehole, depth 120 m groundwater level –25 m, dieselpump 18 l/min, water for the cattle, Mr. Allus.

Dam	Dc 18	Earth dam, length 50 m, overgrown and filled up with sediment, fed by surface runoff, Weruini Lands Co. Sweetwaters Farm.
Dam	Dc 21	Earth dam, length 50 m, fed by surface runoff, Ol Pejeta-Sweetwaters Farm.

Coordinate square **Cd**

Flood irrigation	Cd 13	Flood irrigation of 6 ha with 8000 avocado trees, pipes, furrow, irrigation: 50 l per tree per week, Mr. Schacky.
2 dams	Cd 17/6	2 Earth dams, length 80 m and 60 m, fed by surface runoff, furrow from Nanyuki, water supply for the cattle mainly from borehole C 2277, Mr. Schacky.
Dam	Cd 22	Earth dam, length 30 m, damaged, fed by surface runoff, Mr. Allus.

Coordinate square **Db**

Borehole	Db 4	Borehole obstructed, rehabilitated, but not yet working, Ol Pejeta.
2 Dams	Db 3/4	Earth dams, length 70 m and 50 m, fed by surface runoff, water for the reservoirs, shield against erosion, water supply for cattle, Ol Pejeta-Sweetwaters Farm.
Borehole, windmill, tank	Db 9	Borehole, depth 60 m, windmill, tank (111 m^3), water supply for the cattle, Ol Pejeta Farm.
2 Dams	Db 17/18	Earth dams, lenght 80 m and 70 m, fed by surface runoff, Ol Pejeta-Sweetwaters.

Coordinate square **Cc**

Borehole, diesel-pump	Cc 1	Borehole, depth 59 m, groundwater level –50 m, diesel-pump, yield 72 l/min, water supply for the cattle, Ereri Farm.
Dam	Cc 5	Earth dam, length 30 m, fed by surface runoff and by the furrow of Nanyuki River, water for the cattle mainly from borehole C 2277, Mr. Schacky.
Borehole, diesel-pump, tank	Cc 13	Borehole, depth 190 m, groundwater level –139 m, diesel-pump, yield 60 l/min, tanks (227 m^3), water supply for the cattle, Mr. Schacky.
3 Dams	Cc 22 23 24	Earth dams, length 40 m, 40 m and 60 m, fed by surface runoff, water for the cattle, the superficial runoff of the K.A.F. runway is deverted into the dam basins, Mr. Schacky.

Coordinate square **Da**

Dam	Da 15	Earth dam, length 50 m, overgrown and filled up with sediment, feeding by surface runoff and by a furrow, Ol Pejeta-Sweetwaters.
Flood irrigation	Da 18	Flood irrigation of 25 ha grass, does not exist any more, irrigation had taken place under the former owner S. S. Bastard, furrow from Burguret-Rongai-Swamp, Ol Pejeta Farm.

Coordinate square **Cb**

Borehole, windmill, tank	Cb 15	Tank (86 m^3), water for the cattle, Ol Pejeta.
3 Dams	Cb 17	Earth dams, length 20 m, 20 m and 60 m, overgrown and filled up with sediment, fed by surface runoff, water for the reservoir, and for the cattle, shield against erosion, Ol Pejeta-Sweetwaters.

Coordinate square **Ca**

Dam	Ca 4	Earth dam, length 30 m, fed by surface runoff, water for the reservoir and for the cattle, shield against erosion, Ol Pejeta-Sweetwaters.

Coordinate square **Ba**

River gauge station 5BC4	Ba 22	Stable gauge cross section under the bridge, recordings since 1961 by MWD, a part of the station's catchment is situated on the Abardare ranges.

6. REFERENCES

Baker, B.H., 1967: Geology of the Mount Kenya Area. Report No. 79 Geol. Survey Kenya, Nairobi.

Balek, J., 1977: Hydrology and water resources in tropical regions. Developments in water science; 18. Elsevier.

Berger, P., 1986: Die Niederschlagsverhältnisse am Mount Kenya. Arbeitstitel der Dissertation. GIUB.

Brunner, R., 1983: Die rurale Wasserversorgung an der Nordwestflanke des Mount Kenya in Vergangenheit und Gegenwart. Diplomarbeit GIUB.

Decurtins, S., 1986: Hydrogeographical investigations on Mt Kenya and its W and NW slopes. Laikipia Report No 5, GIUB.

Hastenrath, St., 1984: The Glaciers of Equatorial East Africa. D. Reidel, Dordrecht.

Keller, R., 1972: Methoden zur Klassifikation von Abflussregimen. In: 2. Ber. d. Comm. IGU on the IHD: 86–118.

Leibundgut, Ch., 1982: Beitrag zum Gerinneabfluss am Mount Kenya. Jahrbuch der Geographischen Gesellschaft, Bern 1980–82. Bern.

Leibundgut, Ch., 1983: Runoff regime of a tropical high mountain region. In: IAHS-Publ. No. 140:313–324, Hamburg.

Leibundgut, Ch., 1984: Abflussregimeforschung und ihre praktische Bedeutung. Geographica Helvetica 1984 – Nr. 3.

Leibundgut, Ch., Decurtins, S., 1986: Low water potential and water supply NW of Mount Kenya. Laikipia Report No 6. GIUB.

Loeffler, H., 1968: Die Hochgebirgsseen Ostafrikas. In: Hochgebirgsforschung. Universitätsverlag Wagner, Innsbruck-München.

Mock, J.F. 1982: Wassergebundene Krankheiten. In: Wasser und Boden. 12 – 1984.

Moeri, T., 1982: Die täglichen Abflussmengen ausgewählter Flüsse am Mount Kenya von 1960 bis 1980. Hausarbeit GIUB.

Ojani, F.F., 1968: The Geography of East Africa. EAPF/Longmans, Nairobi. Parde, M., 1933: Fleuves et rivières. A. Coun, Paris.

Patzelt, G., 1983: Karte Lewis Glacier, Mount Kenya. In: Zeitschrift für Gletscherkunde und Glazialgeologie Vol. 20/2, 1984.

Patzelt, G., 1984: Der Lewis-Gletscher, Mount Kenya. Begleitworte zur Gletscherkarte 1983. In: Zeitschrift für Gletscherkunde und Glazialgeologie Vol. 20/2, 1984.

Roberts, I.L., 1963: An investigation into the Water Resources of the Ewaso Ng'iro Basin, Kenya. London.

Schotterer, U., Müller, I., 1986: The use of isotopes, hydrochemistry and geophysics in groundwater research in Laikipia District, Kenya. Laikipia Reports No 4. GIUB.

Speck, H., 1982: Soils of the Mount Kenya area, their formation, ecological and agricultural significance (with soil map, scale 1:125 000). Mountain Research and Development, Vol. 2, No 2:201-221, Boulder (Colorado).

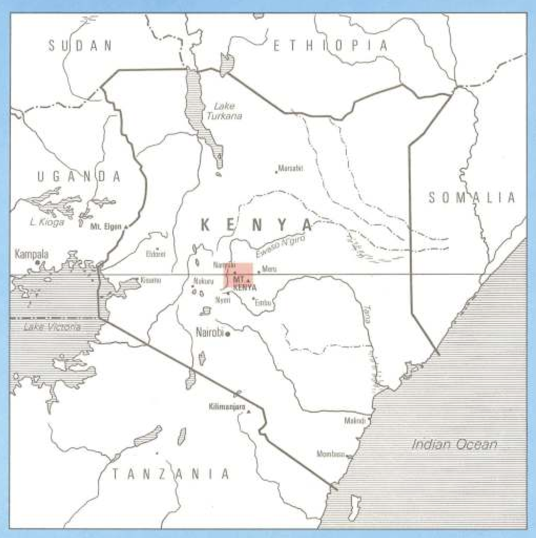
UNESCO/WMO, 1977: Hydrological maps. A contribution to the International Hydrological Decade. Paris.

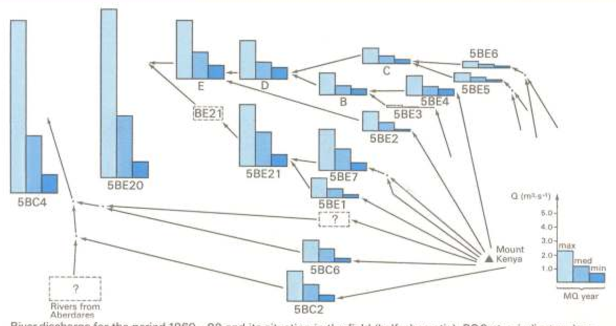
Winiger, M., Messerli, B., 1978: Rezente und kaltzeitliche klimaökologische Gliederung der afrikanischen Hochgebirge, Veröffentlichung der SMA, No 40.

Winiger, M. (editor), 1986: Mount Kenya Area – Contributions to Ecology and Socio-Economy. Geographia Bernensia, African Studies Series, A-1.

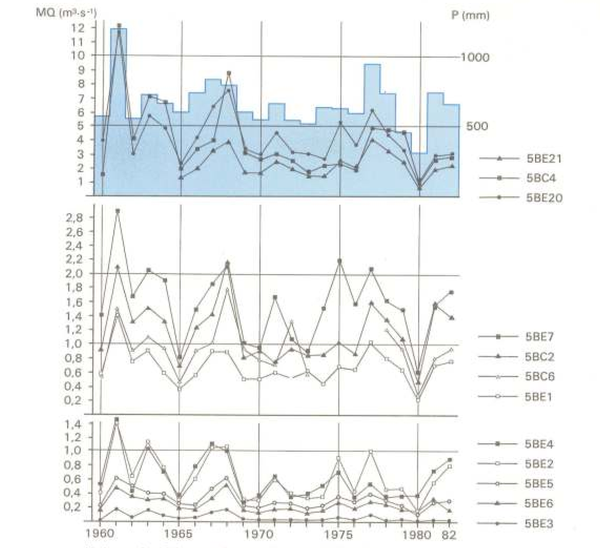
Hydrogeographical Map of Mount Kenya Area

1: 50 000





River discharge for the period 1960 – 82 and its situation in the field (halfschematic). BC 2 etc.: indicates river gauging stations. B, C, D, E: river sections without a gauging station (calculated discharge).



Hydrographs of the annual mean discharge 1960 – 82.
The block diagram shows rainfall at Cedarvale Farm.

LEGEND

1. General topographical situation

1.1. Boundaries

1.1.1 District or provincial boundary
1.1.2 Township boundary
1.1.3 Forest reserve boundary
1.1.4 Mount Kenya National Park boundary

1.2. Traffic

1.2.1 Tarmac road
1.2.2 All weather road
1.2.3 Dry weather road
1.2.4 Track and Footpath
1.2.5 Railway, station

1.3. Settlements

1.3.1 Town
1.3.2 Local centre
1.3.3 Forest station
1.3.4 Mountain hut

1.4. Others

1.4.1 Forest
1.4.2 Contour interval 20 m, elevation in metres
1.4.3 4985 Height in metres

2. Hydrographical and hydrological situation

2.2. Surface water

2.1.1 Perennial river
2.1.2 Intermittent river
2.1.3 Lake
2.1.4 Glacier and snowfield
2.1.5 Flood-stage area
2.1.6 Dam with periodical lake
2.1.7 Contour bund (surface runoff)

2.2. Springs

2.2.1 Spring, natural outflow
2.2.2 Spring, tapped

2.3. Hydrological measuring network

2.3.1 Rain gauge stations

- daily readings
- monthly readings
- yearly readings
- Pluviograph, recording rain gauge
- R1 - 7 Rain gauge stations in the sub-drainage basins of Naro Moru River

2.3.2 Hydrometeorological station

2.3.3 River gauge stations

- staff gauge
- staff gauge with recorder
- staff gauge and weir
- staff gauge with recorder and weir
- 5BC2 Official terms for the river gauging stations
- A1 - 6 River gauge stations in the sub-drainage basin of Naro Moru River

2.3.4 River basin boundaries

- Superior drainage basin
- Drainage basin (basic unit)
- Sub-drainage basin of Naro Moru River

3. Hydrology

3.1. Low flow yield – q_{95}

$< 0\ l/s \cdot km^{-2}$	Yield reached or exceeded in 95% of the time corresponding to 347 days
$0 - 1\ l/s \cdot km^{-2}$	
$1 - 2\ l/s \cdot km^{-2}$	
$2 - 3\ l/s \cdot km^{-2}$	
$> 3\ l/s \cdot km^{-2}$	
$< 0\ l/s \cdot km^{-2}$	estimated
$2 - 3\ l/s \cdot km^{-2}$	

3.2. River regime

River regime coefficient

Coeff. coefficient of the mean monthly discharge, Coeff = $MQ_m : MQ_y$

1.181 Mean annual discharge 1961 – 82 in m^3/s corresponds to coeff. 1

C_v coefficient of variability in %

3.3. Spring discharge and age of water

age of water: fossil > 30 y < recent

- no measurement
- < 100 l/min
- 100 – 500 l/min
- 500 – 1000 l/min
- > 1000 l/min
- Borehole
- Dug well

4. Technical installations for the use of water

4.1. Water supply

(working / dry or out of use)

4.1.1 Borehole
4.1.2 Dug well
4.1.3 Pipeline
4.1.4 Storage tank
4.1.5 Cistern
4.1.6 Handpump
Dieselpump
Electric pump
Turbine
Waterwheel
Ram
Windmill

4.2. Irrigation

(working / dry or out of use)

4.2.1 Irrigation canal, furrow
4.2.2 F (F) Flood irrigation
4.2.3 S (S) Sprinkler irrigation
4.2.4 Dam with periodical lake

4.3. Others

(working / dry or out of use)

4.3.1 Fishpond
4.3.2 Cattle trough
4.3.3 Common place

0 1 2 3 km

Scientific editing: Ch. Leibundgut

Compilation and survey: Ch. Leibundgut, R. Brunner, S. Decurtins, T. Kohler, M. Winiger

Field work: R. Brunner, S. Decurtins, Ch. Leibundgut, T. Moeri, U. Schotterer, I. Müller, Ministry of Water Development

Reasearch Permit No.: CAB. 13/001/11 C 80/9

Cartography: A. Brodbeck

Support production: SDC (Swiss Development Co-operation)

Topographic source materials:

Topographic situation based on maps 1 : 50 000 of the Survey of Kenya, Nairobi, Kenya (Sheet No.: 106/4, 107/3, 107/4, 120/2, 121/1, 121/2). Altitudes and contours in feet converted and redrawn in metric measures. Forest boundaries derived from Landsat-scene 3, E-30930-06483 c