LEPOLOSI WATER PROJECT

HYDROLOGICAL ASSESSMENT ON LEPOLOSIE SPRINGS FOR LEPOLOSI WATER PROJECT IN LEPOLOSI VILLAGE, LESHUTA SUB LOCATION, NAIKARA LOCATION, NAROK WEST SUB-COUNTY, NAROK COUNTY

HYDROLOGICAL ASSESSMENT STUDY REPORT

CONSULTING HYDROLOGIST:

DR. JOASH N. ORUTA, Ph D.

(Consulting Hydrologist and EIA Lead Expert)

P.O BOX 22- 40100, Narok, Kenya. Tel: 0722478616
E-mail: joash.okenyuri@gmail.com

DECEMBER, 2022

Report No. SW/16/2022

Table of Contents

Contents

List of Figures

List of Tables

List of Plates

1. INTRODUCTION

Moderate water scarcity first appeared, around 1800, but it commenced in earnest from about 1900 when 2% of the world population experienced chronic water shortage (with access to) less than 1000 cubic m/capital/year) Kummu (2010). Water shortage increased extremely rapidly from 1960 onward, with the proportion of the global population living under chronic water shortage increasing from 9%, or 280 million people, in 1960 to 35% (2,300 million) in 2005 Environmental Research Letters, ERL (2010):

The United Nations Economic Commission for Africa (2005) estimates that 300 million out of the 800 million people who live on the African continent live in a water-scarce environment. Specifically, in the very north of Africa, as well the very south of Africa, the rising global temperatures accompanying climate change have intensified the hydrological cycle. About 66% of Africa is arid or semi-arid and more than 300 of the 800 million people in sub-Saharan Africa live in a water-scarce environment meaning that they have less than 1,000 m3 per capita (NEPAD, 2006). Water scarcity as a relative concept that can occur at any level of supply or demand resulting from the consequence of altered supply patterns stemming from climate change has hardened the livelihoods of the nomadic pastoralists for long and the problems of water related diseases is so pronounced and their agriculture too decreased in the terms of production (Mooney, 2006).

Narok West Sub County comprises of mainly the pastoralist communities. The region is characterized by a fragile ecosystem — ravaged by the effects of climate change which has further increased need for mobility susceptible to insecurity due to regional ethnic and political inter play within the surrounding communities. The region is also drought prone, a situation that has depleted livestock, water and pasture. These conditions create an increased need for mobility — further and further afield for the survival of pastoralist livelihoods. More so those dependent on agriculture face a challenge of dwindling agricultural livelihoods because the region is already among the most water stressed areas. The dependence on rainfall rather than irrigation as the basis for agriculture puts these areas at much greater risk of crop failure.

In Naikara Location, water scarcity is a problem which is also resulting in drought and in drying up watering holes and causing grasslands to die or disappear. This is contributing to overgrazing and causing herders to travel further to find land to feed their cattle. Furthermore, water scarcity and the lack of food security have contributed to many social and cultural conflicts as well (Steece, 2011).

In Lepolosi Village, water scarcity is increasing and is resulting to the escalating poverty, persistent poor harvest as a result of dry spells and droughts, and poor farming practices, limited sources of income, and landlessness.

Achieving sustainable water resource use, harnessing the productive potential of water and limiting its destructive impacts, has been a constant struggle since the origins of human society. Throughout history, water has also been a source of dispute and even conflict between uses and between users at both local and larger scales.

Lepolosi community intends to abstract water from Enkiuosoito springs as they emerge to form Lepolosie stream. These Enkiuosoito springs feed into Lepolosie stream and further feeds into Okejo Rongai and finally into the Mara River. Lepolosi community thus engaged a consulting hydrologist to carry out a hydrological assessment with the purpose of ascertaining availability of water for continued sustainable abstraction and effective planning of the resource in the catchment. The abstraction point is located at Enkiuosoito springs Lepolosi Village, Leshuta sub-location, Naikara, Location, Narok West Sub-County, Narok County. The abstraction is done within a well conserved wetland and riparian land managed by the community. Geographically, it is defined by longitude E35.72581 and latitude S1.67644 at altitude of 2110m a.s.l. (Figure 1).

Plate 1: General layout at the abstraction point

1.1 Scope and Objectives of the Study

The objectives of the study were to:

i. Evaluate the hydrological characteristics of Lepolosie stream at the project site
ii. Establish the availability of surface water at Lepolosie stream for water abstraction
iii. Advice on the viability of a water abstraction at the site.

The detailed tasks included:

i. Desk review of the existing hydrological and other relevant data relating to Lepolosie stream and its catchment area;
ii. Evaluate the surface water potential on the basis of existing hydro-meteorological data in Lepolosie sub basin and
iii. Preparation of Hydrological Assessment Report

1.2 Methodology and Assessment Study

For a sound hydrological analysis, the study focused on four categories of data:

i. Climatological data for hydrological purposes
ii. Groundwater and soil moisture data
iii. Physiographic data
iv. Anthropogenic data.

In order to collect these data, the project was carried under the following sub-headings

1.2.1 Assessment of site physiography

To assess the water availability potential for a site utilizing a stream as a source of water the first step is to select potential intake positions, pipeline routes, the power house and pump house sites. This assessment is guided by several factors, which may include,

i. Flow analysis
ii. Maximizing the catchment area above the intake
iii. Catchment Analysis
iv. Rainfall Analysis
v. Land use analysis
vi. Soil formation analysis
vii. Environmental and visual impact

viii. Land ownership

1.2.2 Flow Analysis

A time series flow data are generally used to create a flow duration curve (FDC), which is essential to assess the potential water resource available for development. The flow duration curve is a cumulative frequency curve that shows the percent of time during which specified discharges were equaled or exceeded in a given period, which is a standard way of understanding the flow dynamics of a watercourse. FDCs are plotted on the basis of long-term annually registered flows (hydrographs) and represent an average for the period considered rather than the distribution of flow within a single year. FDCs represent stream flow data that combine in one curve the flow characteristics of a stream throughout the ranges of discharge.

The stream flow period on which the flow-duration curve is based represents the long-term flow of the stream, which may be considered a probability curve and thus used to estimate the percent of time that a specified discharge will be equaled or exceeded in the future. The curves are determined for the years of normal, wet and dry water conditions. They are graphical representation of flow data indicating flow levels, number of days at fixed flow, and percentages of such days annually, ordered according to flow level. For increased accuracy, gauged and measured flow data can be used from a monitoring station installed at or near the proposed intake position.

1.2.3 Assessment of the Catchment

Key catchment characteristics for consideration in the study include topography and overall catchment layout, drainage pattern, type and nature of vegetation cover, and land use practices.

1.2.4 Assessment of surface water Potential

In order to allocate surface water, further assessment of the following factors is then considered,

i. Flow duration curve(s)
ii. Availability of design flow and minimum flow required for abstraction.

2. CATCHMENT CHARACTERISTICS

2.1 Hydrological characteristics of the Catchment

Lepolosie stream form part of the source waters for Longaianiet (Sand River) River which drains into the Mara River. It originates at Enkioosoito hills and flows westwards. Because of the rock and soil type in the area, the stream get joined by several springs to form Lepolosie stream. This stream together with the others in the area flows under the sand and thus the name of the main tributary, that is, Sand River. The main tributaries joining downstream include: Anoliwo, Ladooru, Olositan, Olchoro Laboritai, Nolane, Irpoori, Lairako, Idepes, Orngaeenet, Enekoiireroi, Olormotioo, Olonkosuai, Olkojuasar, Olngaeene, Olodaaale, Nekiboitai among others. However, most of these tributaries are seasonal and others have underground water flowing through the sand and thus appearing dry. The streams which are just next to Lepolosie are Narutarakua and Entargotua.

For management purposes, the drainage where abstraction is intended to take place is proposed to be managed by Water Resource Users Association (WRUA) called Morijo. Morijo watershed will take the upper parts of the Sand River sub basin. This WRUA is not yet formed, however, when it will be formed it will take tributaries such as: Analiwa, Nasateretet, Ladooru, Enenkolireroi, Olormotioo, Olonkosuai, Ol Ongaianiet, Entargotua, Olodare and Kiboitai. This watershed will cover an area of 611.42km^2.

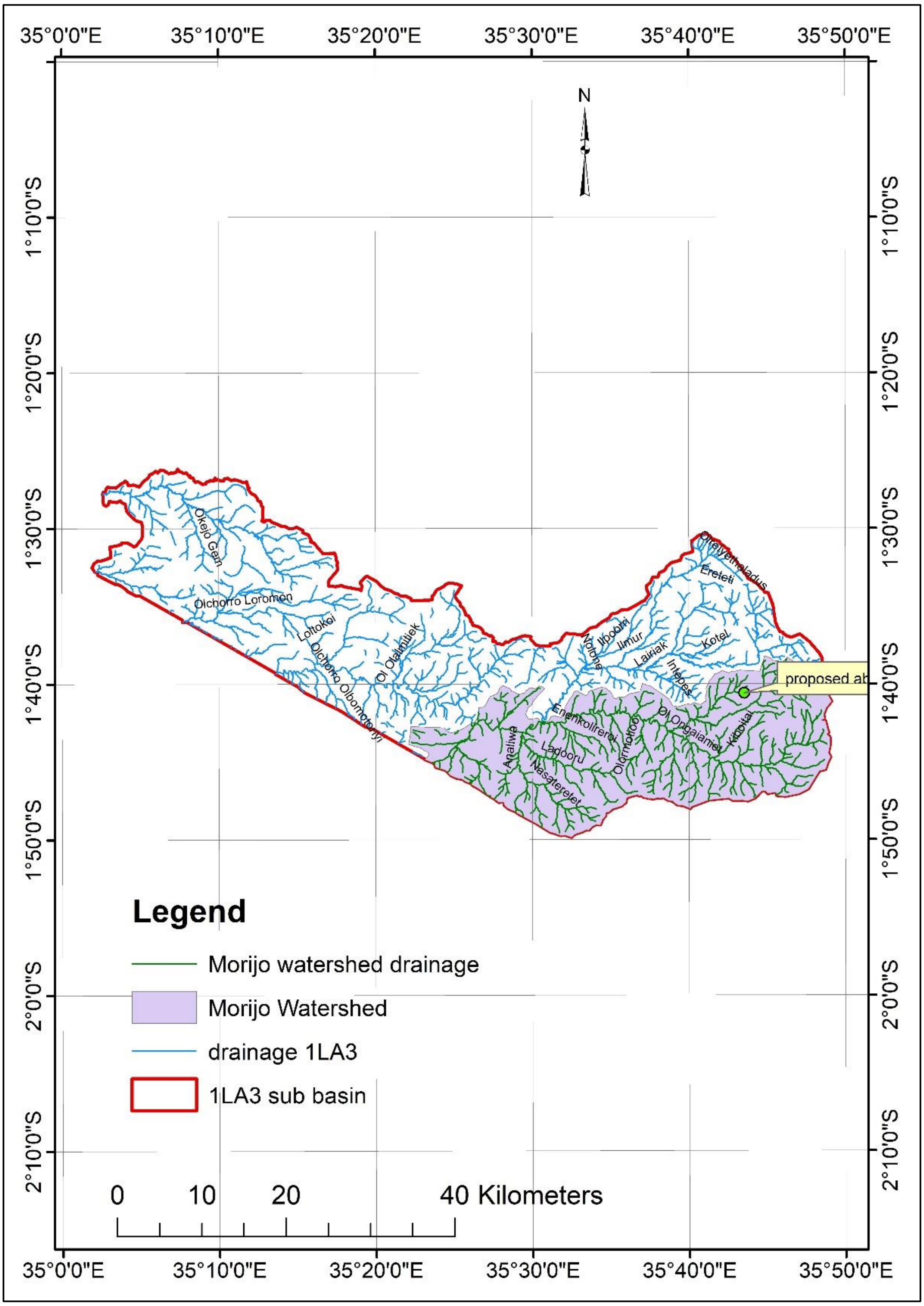

Figure 1: Position of Morijo Watershed within Lepolosie sub basin 1LA3

2.2 Climate of the Catchment

The climate of Naikara area where abstraction is taking place can be described using the weather station at Keekorok which is 40km away but in the same climatic zone. The sub basin has an average annual temperature of 20.4°C. The temperatures are highest on average in the month of February (21.6°C) while June is the coldest month with temperatures averaging 19.5°C (Figure

3). Throughout the year, temperatures vary by 2.1°C. The sub basin receives average annual rainfall of 820mm. The least amount of rainfall occurs in the month of July which is 11mm, while April receives most of the rainfall averaging 123mm. the variation in rainfall between the driest and wettest months is 112mm. On the side of humidity, the month with the highest humidity is April (67.74%), while the month the lowest humidity is October (50.27%).

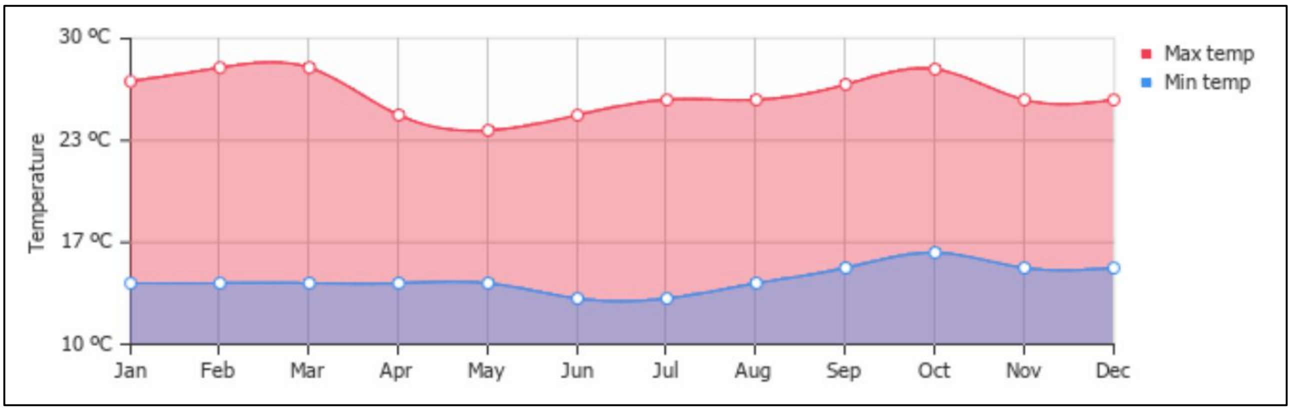

Figure 2: The mean minimum and maximum temperatures in Keekorok station.

2.3 Geology

The geology of the project area as was surveyed between 1947-1949 and published by Huddleston (1951). The geology of the area comprises of ancient igneous and metamorphic rock that dates back to Cambrian and Pre-Cambrian age. This area is part of Great Lake Victoria Basin, to the east the landscape is dominated by the Ngama Hills, granite and quartz rock formations created by volcanic activity. The natural northwest boundary is made up of the Oloololo escarpment once was wooded and cliffs were left barren after fires and elephants damaged the trees and currently mostly covered by grasses.

In general, the project area has tertiary extrusive and intrusive pre-Cambrian volcanic rocks of the Bukoban system within the Nyanzian and Kavirondian rock systems; consisting of mainly basalts and basaltic tuffs, quartizites and cherts, rhyolites and tuffs, Porphyritic and nonporphyritic felsites and Andesites (Figure 3) (Plate 2).

The aquifers are found within the weathered layer on the hard rock. Aquifer thickness increases from hilltops to valley bottoms. Due to the hilly topography in this area, there are fewer aquifers on the hill slopes, and hence groundwater is not of significant value. The average aquifer thickness in this area is about 100m and therefore the total groundwater storage can be estimated. Furthermore, the groundwater in this aquifer is saline which reduces its portability for most of the domestic uses. However, groundwater is used in flashing the toilets and watering the glasses.

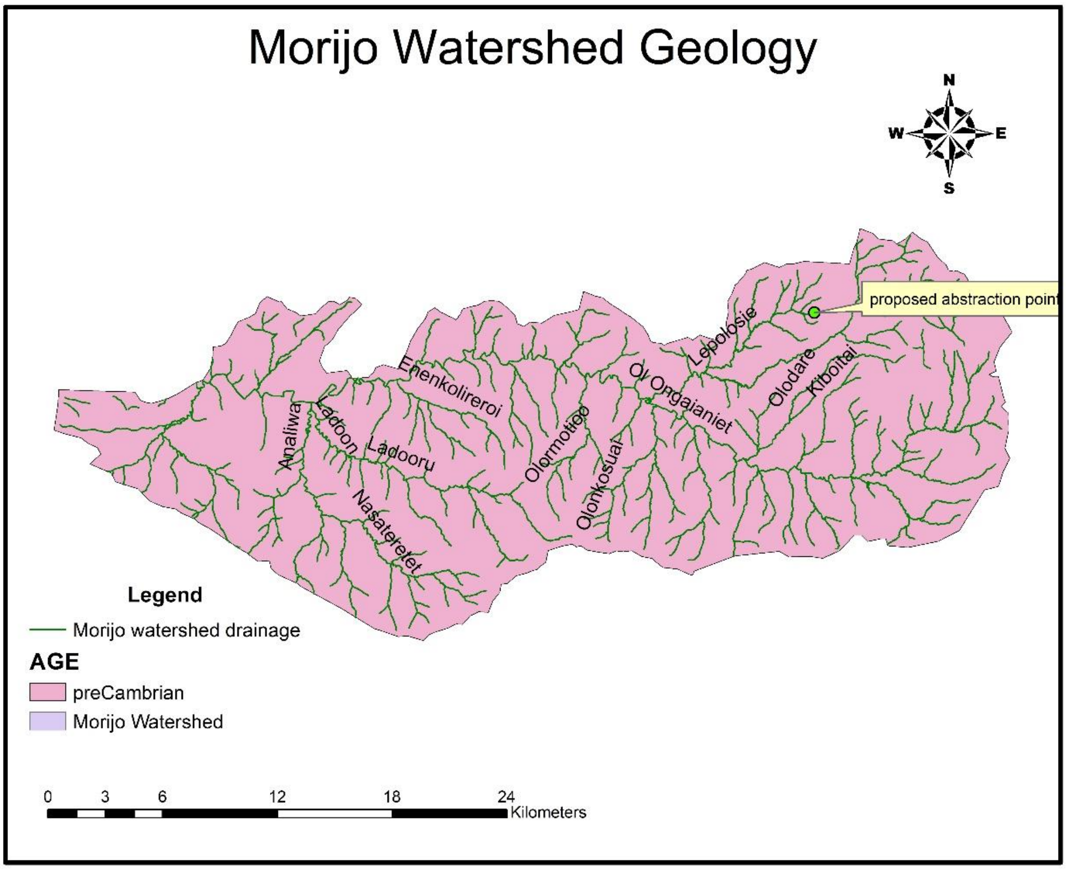

Figure 3: Map showing the geology of Watershedt within the project area

Plate 2: Geology of Lepolosie

2.4 Soils

Soil formation in Lepolosie watershed follows strictly the geological arrangement in the area. Where the Lepolosie stream is located is predominantly covered by sandy montmorillonitic soils (Up5). These soils are sandy found on the gentle undulating plains (Figure 5). Their depth is not known. Due to the undulating landscape the soils are well drained. The soils allow for water to percolate but due to impervious volcanic underlying the soils it comes out as a spring (Figure 5 and Plate 3). The eastern parts of the Lepolosie stream and its tributaries is dominantly covered by montmorillonitic (H16) soils which are loamy and found at the rolling medium gradient hills but their depths are not known. Also to the eastern parts is the montmorillonitic loamy soils Uh16 which equally are loamy found at the rolling medium gradient hills. Other soils to the western parts of the stream where many springs originate are: F17, L27 and Pn10. All these soils are well drained and range from loam to sand soils.

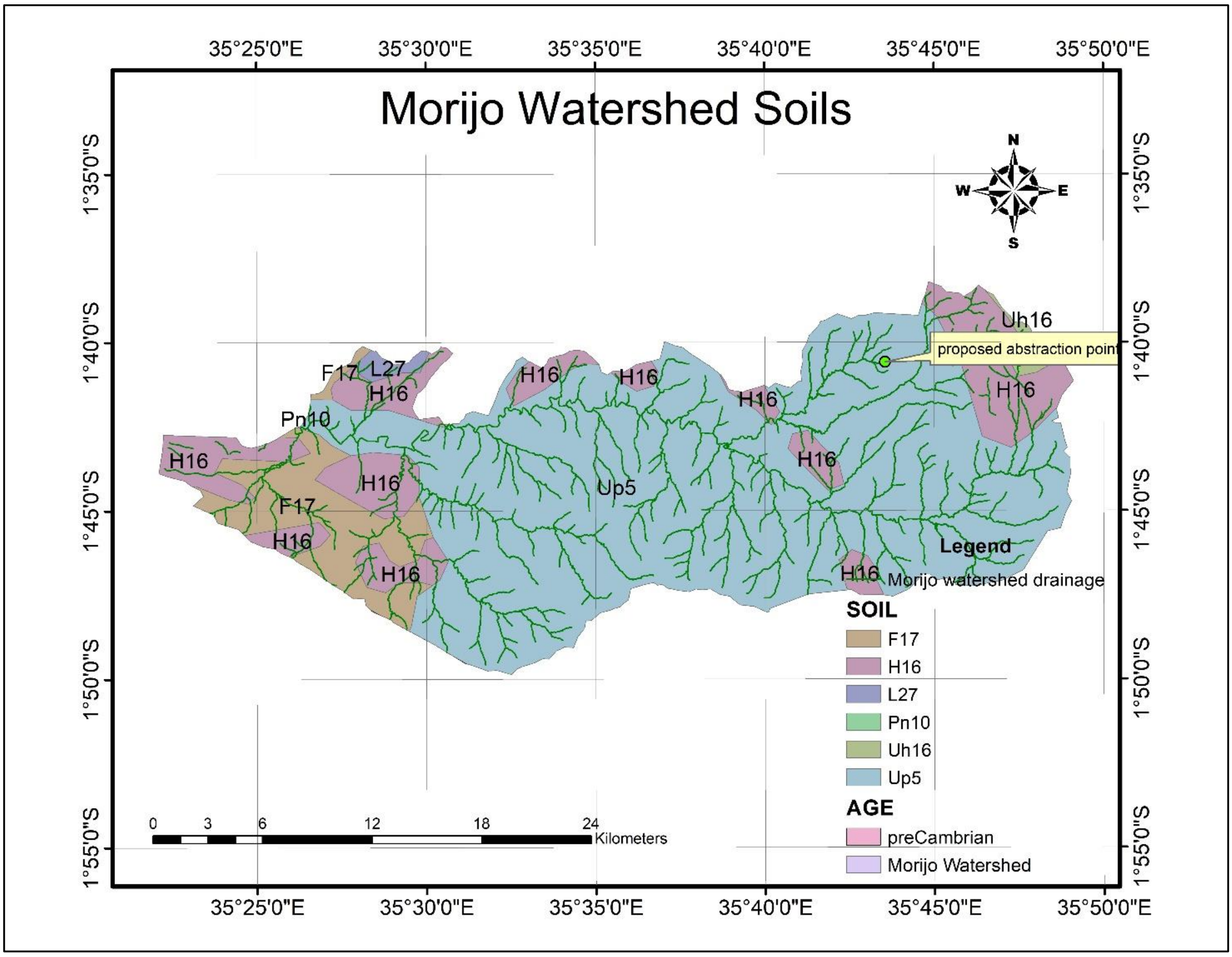

Figure 4: Soils in Lepolosie sub basin

Plate 3: A number of springs originating at Morijo watershed

2.5 Land use and Landcover

Land use affects land cover and changes in land cover affect land use. A change in either, however, is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply a degradation of the land. However, many shifting land use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that, cumulatively, affect global climate and biosphere [Akotsi & Gachanja, 2004]. There are also incidental impacts on land cover from other human activities such as forests and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by tropospheric ozone resulting from automobile exhaust [Baldyga et al., 2008].

Lepolosie sub basins is characterized by a semi-arid climate with wide valleys and escarpments. The reserve has diversified vegetation that includes grassland, Acacia woodland, riverine forest, non-deciduous thickets, Acacia, Tarchonanthus and Croton Scrub. Given other environmental conditions like drought, bush burning, encroachment by local population and over-population of the herbivores. Those factors have led to the low growth of trees at the reserve. The watershed has specific grass species that are drought resistant (Plate 2). The greatest and most common grass species is the Red Oat grass called Themeda triandra. Animals enjoy the grass at its early stages of growth as it is very nutritious.

It is well understood that changes in land-use pattern may lead fundamentally to spatial and temporal heterogeneity of the limnological characteristics thus influencing ecological structure and functioning of the aquatic ecosystems (Nogueira et al., 1999).

The major land use categories are bushland (dense), bushland (sparse), grassland, and woodland (Figure 6). It is noted that changes in land cover by land use do not necessarily imply a degradation of the land. However, any shifting land use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity, and water resources among others processes that, cumulatively, affect global climate and biosphere (Ayuya and Sweta, 2014). Nyangaga, (2008) observed that changes in land use from natural forest to agricultural reduce dry spell flows; sometimes leading to water shortages, but with a marked increase in total flow pointing to a high relationship of stream flow with expansion of agriculture and reduction of forest cover.

Within the sub catchment, the area under natural habitat such as bushland and grassland is recommendable but still need for continual management of the wild animals. The land cover in the sub catchment is dominated by rain fed vegetation and crops.

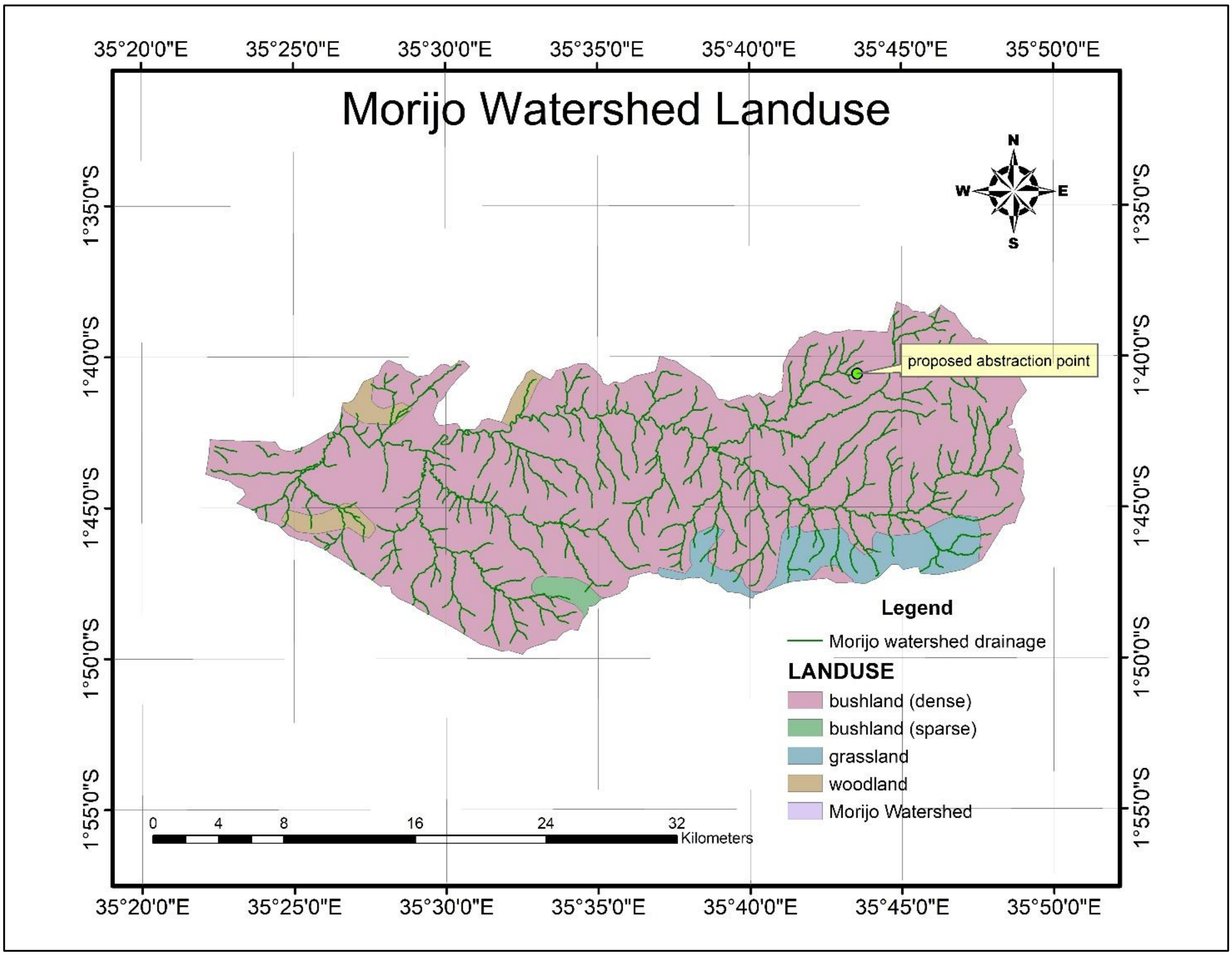

Figure 5: Landuse within Lepolosie sub basin

2.6 Abstractions at Lepolosie stream

There is no any other known abstraction at the same point. The main water use at this stretch of the river is environmental and there are numerous both wild animals depending on this water resource and livestock from the community.

3.0 HYDROLOGICAL CHARACTERISTICS AND ANALYSIS

3.1. Introduction

The hydrology of a region depends primarily on its climate, topography and its geology. The climate of the catchment is influenced by its position and altitude within the lake basin. The low-pressure belt which shifts with the apparent movement of the overhead sun, the inter-tropical convergence zone (ITCZ) is the main factor and cause of seasons in Africa. It is the major line of convergence of winds leading to the creation of rain and drought generating air flows. The two most important climatic elements for engineering hydrological studies are precipitation, its mode of occurrence and evapo-transpiration. Humidity, temperature, radiation and wind directly affect evapo-transpiration.

3.2 Rainfall Analysis

Rainfall impacts greatly on human activity, natural vegetation, surface runoff and groundwater recharge. The period of seasonal rainfall in the study area is characterized by spatially erratic short duration and high intensity rains. At the specific point there is no reliable rainfall station and thus Keekorok rainfall stations was considered for analysis for this task. Keekorok station is about 40km away from the point of abstraction but in the same climatic zone and inside the game reserve. As described above the stations receives a mean annual rainfall of about 820mm. Figures 7 and Figure 8 shows the amount of mean monthly rainfall over the year and average number of days each month receive rainfall at Keerokok. As it can be observed the rainfall here is just medium making the stream to be seasonal.

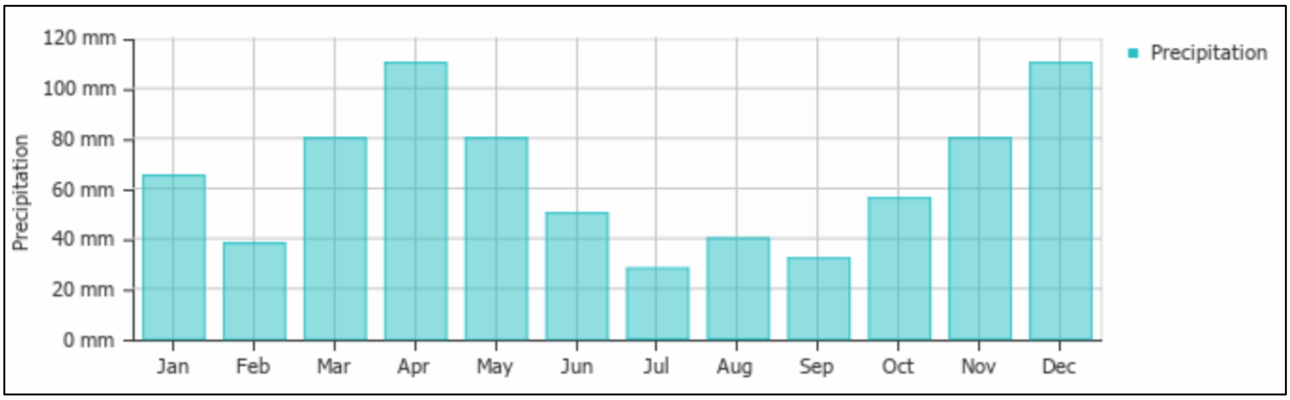

Figure 6: The mean monthly rainfall over the year at Keekorok rainfall station

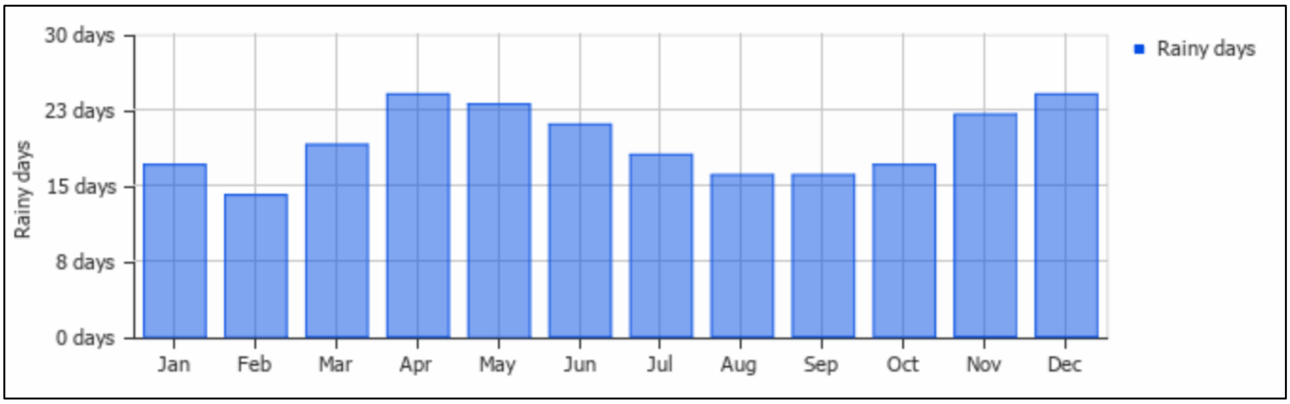

Figure 7: The average number of days each month has rainfall in Keekorok rain station

3.3 Hydrological Analysis

3.3.1 Data collection and processing

Measurement of water flow is important in selecting the best source for a water supply. The source has to be able to provide sufficient water to meet the demand either on its own or in conjunction with other sources. The flow of water sources should be measured to assess the amount of water they provide. It is recommended that the flow measurement should be done when the flow is at its lowest to assess the ability of the source to provide sufficient water all year round. In this study, long-term data was used to assess the availability of the water resource as but also volumetric method was used to get instantaneous measurement of the stream (Plate 4).

Lepolosie springs lack any form of a gauging station which is important to generate a flow duration curve. In fact the off take is to be at the spring eyes which may not be accurate if rainfall modelling is carried out (Figure 2). It is for this reason that volumetric method was used to determine the spring's yield (Plate 5).

It is critical to know how much water coming out of the spring. This is particularly crucial over dry seasons when levels drop and demand remains high and for planning for development/ abstraction. To achieve this goal, a Bucket method was used to determine the yield. The Bucket method is a simple way to measure the flow rate using household items. It requires a stopwatch, a large bucket, and preferably two to three people. To measure the flow rate using the bucket method the following procedure was used:

1. The volume of the bucket was measured.
2. Determined appropriate point to make measurement, which included two outlets (Plate 5).

3. With a stopwatch, timed how long it takes the outlet to fill the bucket with water. Start the stopwatch simultaneously with the start of the bucket being filled and stop the stopwatch when the bucket fills.
4. Recorded the time it takes to fill the bucket.
5. Repeated steps two and three six times and take the averaged
6. The flow rate is the volume of the bucket divided by the average time it took to fill the bucket.

Plate 4: Volumetric method of discharge measurement used at project site

Using the data obtained, the volumetric flow rate (Q) was calculated as the volume of the bucket (V) divided by the average time (t).

$$Q = v/t$$

This gave Q=18.1m^3/day

Lepolosie springs have a discharge of **18.1m^3/day**

For spring abstraction, it is recommended that 5% of the spring production remains as the environmental flows. The 5% of discharge of Lepolosie is 0.905m^3/day. Therefore, the available water for allocation is 17.195m^3/day.

3.3.2 Sub Basin analysis for 1LA3

Since the abstraction from this point may have an altimate effect on the whole of 1LA3 sub basin, it is good to look at the Flow Duration Curve for 1LA3 sub basin. A flow duration curve (FDC) for a particular point on a river shows the proportion of time during which the discharge equals or exceeds certain values. Flow duration curves for long periods of runoff are useful for deciding what proportion of flow should be used for particular purposes, since the area under a curve represents volume. For many rivers the ratio of peak to minimum discharges may be two or more orders of magnitude and FDCs for points on them are often more conveniently drawn with the ordinate (Q) to a logarithmic scale and a normal probability scale used for the frequency axis. The slope of the line of the FDC gives an indication of the character of a river. A gentle slope indicates a river with few floods that is extensively supplied from groundwater, while a steeply sloping curve indicates a river with frequent floods and low flow periods having little groundwater flow and being supplied mainly from runoff. Lepolosie stream at the water project site lacks any form of a gauging station which is important to generate a flow duration curve. The RGS found in this sub catchment are at different location rather than on Lepolosie stream.

The long term flow record was used to model 1LA3 sub basin and then used to generate FDC at the proposed project site. Further, the ratio method was employed to establish the time series for the Lepolosie stream. The technique is most valid in situations where watersheds are of similar size, land use, soil types, and experience similar precipitation patterns as is the case in the 1LA3 sub-basin. Discharge is estimated by drainage area weighting using the following equation:

$$Q_{ungaged} = \frac{A_{ungaged}}{A_{gaged}} \times Q_{gaged}$$

Where

$Q_{ungaged}$: Flow at the ungauged location

Q_{gaged}: Flow at surrogate gauge station

$A_{ungaged}$: Drainage area of the ungauged location

A_{gaged}: Drainage area at surrogate gauge station

After delineation, it was established that the catchment area for 1LA3 is 1734.94km^2. The area for Morijo watershed is about 611km^2. To determine the effect of the abstraction to the environment at Lepolosie watershed, the naturalized flow for the sub basin was used which gave the values discussed below.

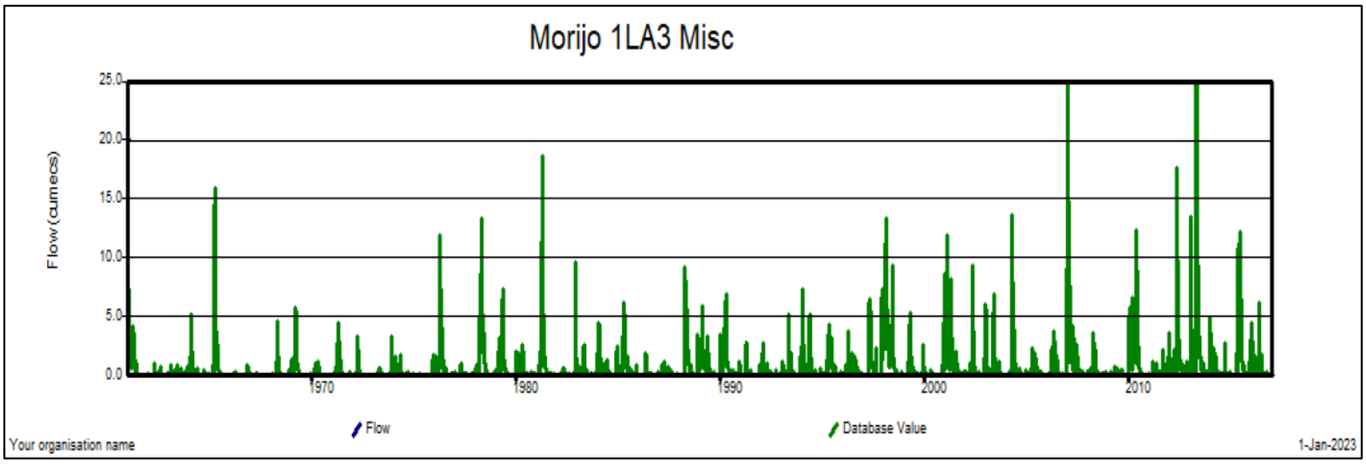

Figure 8: Long-term time series for Morijo watershed

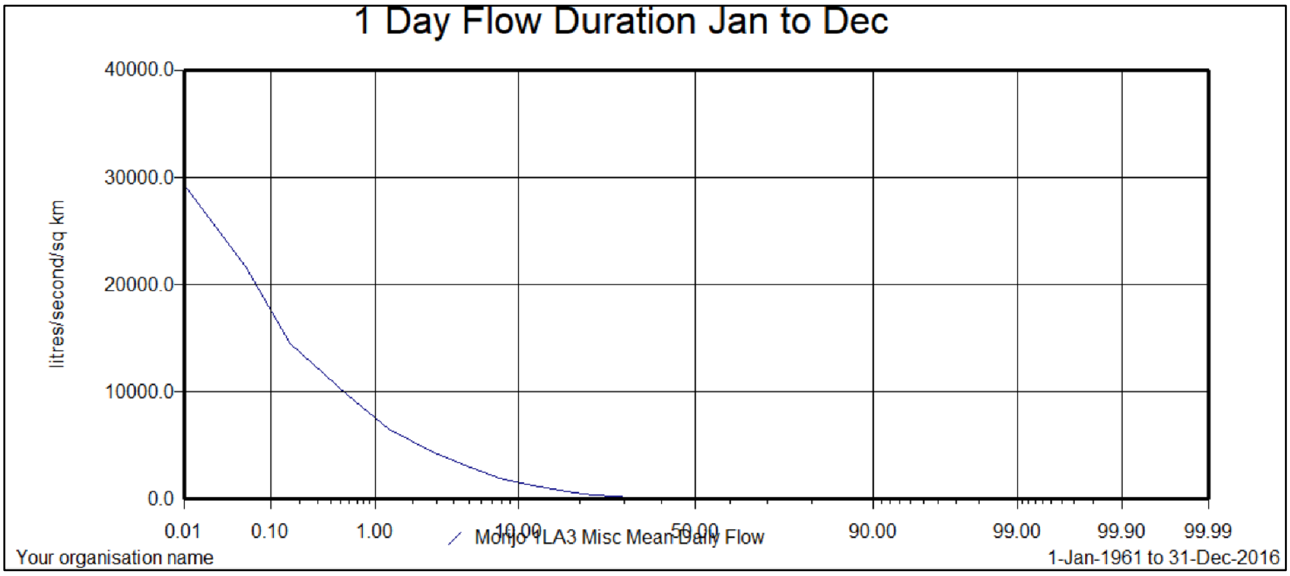

Figure 9: One day Flow Duration Curve at the outlet of Morijo watershed

Table 1: One day Flow Duration Table at the outlet of Lepolosie

FLOW DURATION TABLE	
Name:	Morijo 1LA3 Misc
Time-Series:	Mean Daily Flow
Period of analysis from: 1-Jan-1961 to 31-Dec-2016	
Seasonal flow duration analysis from Jan to Dec	
Time interval (days) = 1 Intervals in period = 20454	
Intervals with data	20454
Mean daily flow	0.551
95 percentile (Q95)	0.00004
90 percentile (Q90)	0.00028
80 percentile (Q80)	0.00161
50 percentile (Q50)	0.03849
25 percentile (Q25)	0.34010
10 percentile (Q10)	1.51903
5 percentile (Q5)	2.99043
Percentiles in m^3/second	
Mean daily flows from 1-Jan-1961 to 31-Dec-2016	

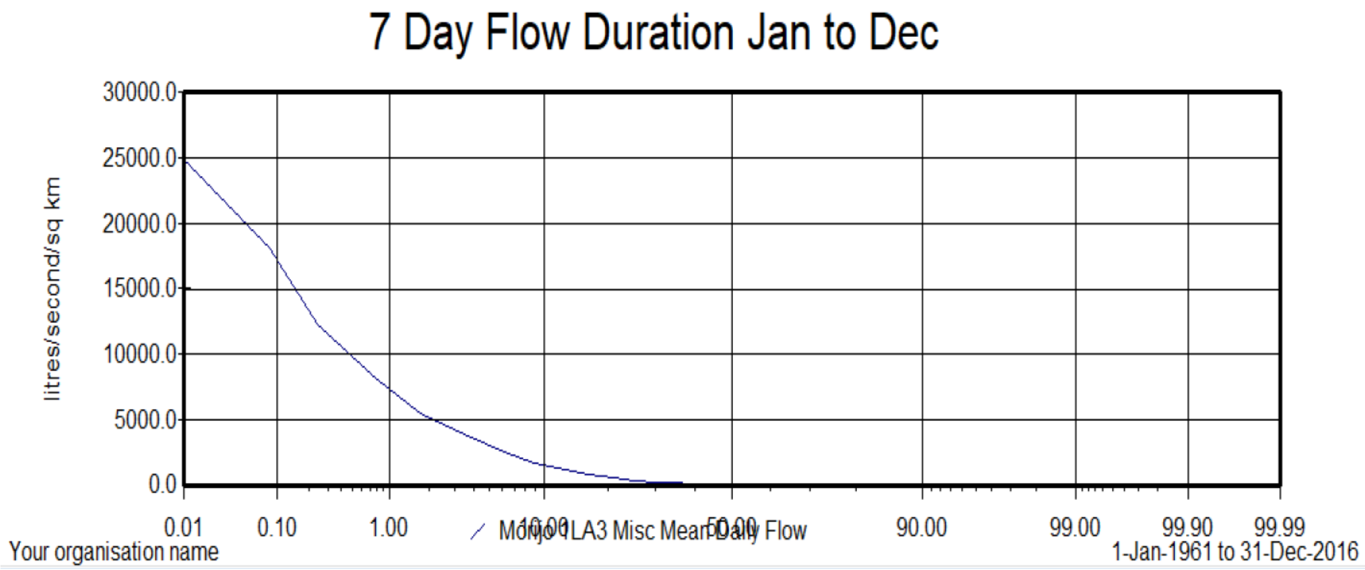

Figure 10: Seven day Flow Duration Curve Curve at the outlet of Morijo watershed

Table 2: Seven day Flow Duration Table at the outlet of Lepolosie stream

FLOW DURATION TABLE	
Name:	Morijo 1LA3 Misc
Time-Series:	Mean Daily Flow
Period of analysis from: 1-Jan-1961 to 31-Dec-2016	
Seasonal flow duration analysis from Jan to Dec	
Time interval (days) = 7 Intervals in period = 20448	
Intervals with data	20448
Mean daily flow	0.551
95 percentile (Q95)	0.00009
90 percentile (Q90)	0.00047
80 percentile (Q80)	0.00227
50 percentile (Q50)	0.04593
25 percentile (Q25)	0.35834
10 percentile (Q10)	1.53392
5 percentile (Q5)	3.06574
Percentiles in m^3/second	
Mean daily flows from 1-Jan-1961 to 31-Dec-2016	

3.4 Low discharge Analysis

Information on low flow characteristics provides threshold values for different water-based activities and is required for such water resource management issues as water supply, irrigation, and water quality and quantity estimates. An understanding of the outflow process from groundwater or other delayed sources is essential in studies of catchment response. In the study, Low flow assessment was considered in the analysis as given below.

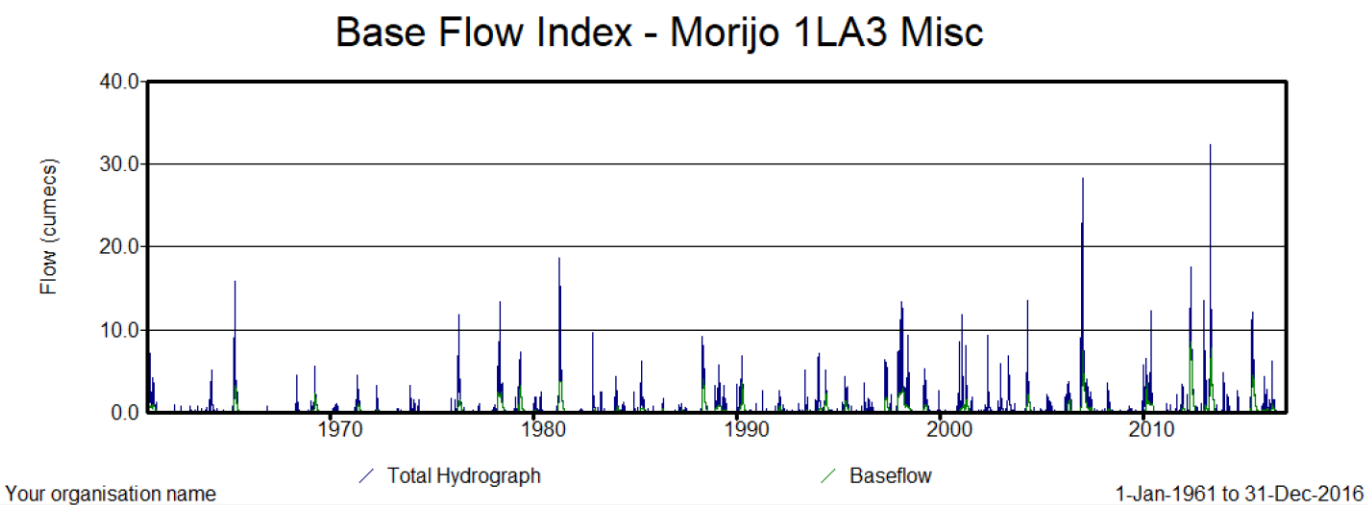

Figure 11: Baseflow Index time series for Morijo watershed

Table 3: Baseflow Index calculation for Morijo watershed (Modelled data)

BASEFLOW INDEX CALCULATION			
Name:	Morijo 1LA3 Misc		
Time-Series:	Mean Daily Flow		
Period of analysis from: 1-Jan-1961 to 31-Dec-2016			
BFI calculated over whole period			
Number of days in period	20454		
Number of days with data	20454		
Number of days for BFI	19876		
BFI	0.4576		
BFI in each hydrological year			
Year start	Days	BFI days	BFI
Jan-61	365	344	0.3681
Jan-62	365	334	0.1784
Jan-63	365	365	0.1378
Jan-64	366	366	0.0516
Jan-65	365	365	0.466
Jan-66	365	258	0.009
Jan-67	365	282	0.1084
Jan-68	366	366	0.1797
Jan-69	365	365	0.5969
Jan-70	365	365	0.4486
Jan-71	365	349	0.3915
Jan-72	366	319	0.2946
Jan-73	365	336	0.1124
Jan-74	365	357	0.1771
Jan-75	365	288	0.0052
Jan-76	366	366	0.3656
Jan-77	365	365	0.1171
Jan-78	365	365	0.4991
Jan-79	365	365	0.5698
Jan-80	366	366	0.2957
Jan-81	365	347	0.5181
Jan-82	365	336	0.1191
Jan-83	365	365	0.2545
Jan-84	366	366	0.3357
Jan-85	365	365	0.3038
Jan-86	365	365	0.4907
Jan-87	365	365	0.3531
Jan-88	366	366	0.5746
Jan-89	365	365	0.4117
Jan-90	365	365	0.6091
Jan-91	365	363	0.1264
Jan-92	366	364	0.5027
Jan-93	365	365	0.2
Jan-94	365	365	0.4476

Jan-95	365	365	0.4621
Jan-96	366	366	0.1701
Jan-97	365	340	0.4542
Jan-98	365	365	0.4709
Jan-99	365	365	0.3852
Jan-00	366	347	0.1398
Jan-01	365	365	0.3672
Jan-02	365	365	0.093
Jan-03	365	365	0.1268
Jan-04	366	366	0.4509
Jan-05	365	356	0.2422
Jan-06	365	359	0.3203
Jan-07	365	365	0.5759
Jan-08	366	366	0.2863
Jan-09	365	362	0.1377
Jan-10	365	365	0.4226
Jan-11	365	365	0.2669
Jan-12	366	366	0.6725
Jan-13	365	365	0.4423
Jan-14	365	365	0.1816
Jan-15	365	357	0.5571
Jan-16	366	328	0.4168

Table 4: Lowflow Frequency Analysis for Morijo watershed (Modelled data)

Low Flow Frequency Analysis				
Name:	Morijo 1LA3 Misc			
Time-Series:	Mean Daily Flow			
Period of analysis from: 1-Jan-1961 to 31-Dec-2016				
Average daily flow over the period: 1-Jan-1961 to 31-Dec-2016				
Start Month : Jan	Maximum days missing per year : 20			
Season start : Apr	Season end : Mar			
Analysis Interval `D` days : 1				
Water year	Start Date	Rank	Flow (cumecs)	Return Period
2015	26-Oct-15	1	0.008	1
2012	26-Oct-12	2	0.003	1
1997	02-Nov-97	3	0.001	1
1988	03-Nov-88	4	0.001	1.1
2013	14-Nov-13	5	0.001	1.1
2002	07-Nov-02	6	0	1.1
2006	24-Oct-06	7	0	1.1
1978	11-Dec-78	8	0	1.2
1993	01-Nov-93	9	0	1.2
1984	07-Nov-84	10	0	1.2
2011	23-Apr-11	11	0	1.2
1995	17-Dec-95	12	0	1.3
1999	25-Oct-99	13	0	1.3

1989	19-Dec-89	14	0	1.3
1979	12-Dec-79	15	0	1.4
1987	28-Jan-87	16	0	1.4
2004	12-Jan-04	17	0	1.4
1963	16-Oct-63	18	0	1.5
1991	05-Mar-91	19	0	1.5
1962	08-Apr-62	20	0	1.6
1995	26-Jan-95	21	0	1.6
2009	10-Dec-09	22	0	1.6
1973	10-Oct-73	23	0	1.7
1988	23-Feb-88	24	0	1.7
1999	23-Feb-99	25	0	1.8
1986	25-Jan-86	26	0	1.9
2001	31-Dec-01	27	0	1.9
1977	20-Oct-77	28	0	2
2011	12-Feb-11	29	0	2.1
1977	23-Mar-77	30	0	2.2
1982	18-Sep-82	31	0	2.2
2005	25-Feb-05	32	0	2.3
1983	21-Dec-83	33	0	2.4
1991	20-Nov-91	34	0	2.6
1965	01-Mar-65	35	0	2.7
1970	16-Jan-70	36	0	2.8
1992	10-Dec-92	37	0	3
1968	02-Apr-68	38	0	3.1
1972	08-Feb-72	39	0	3.3
2006	12-Feb-06	40	0	3.5
2008	12-Mar-08	41	0	3.8
1971	23-Jan-71	42	0	4.1
2009	22-Jan-09	43	0	4.4
1962	21-Feb-62	44	0	4.8
1966	03-Mar-66	45	0	5.2
1997	24-Mar-97	46	0	5.8
1982	25-Mar-82	47	0	6.4
1981	14-Feb-81	48	0	7.3
1975	27-Feb-75	49	0	8.4
1973	20-Mar-73	50	0	9.9
2000	17-Oct-00	51	0	12.1
2015	14-Feb-15	52	0	15.5
1975	18-May-75	53	0	21.5
1966	16-Jun-66	54	0	35.3
1967	05-Oct-67	55	0	98.4
1961	Insufficient data			
1964	Insufficient data			
1969	Insufficient data			
1974	Insufficient data			
1976	Insufficient data			
1980	Insufficient data			

1985	Insufficient data			
1990	Insufficient data			
1994	Insufficient data			
1996	Insufficient data			
1998	Insufficient data			
2003	Insufficient data			
2007	Insufficient data			
2010	Insufficient data			
2014	Insufficient data			
2016	Insufficient data			
Average number of days the minimum starts from the beginning of the water year : 176				
Average Daily Flow	Mean Annual Minimum	Units		
0.551	0	cumecs		

3.6 Groundwater Resources

The sub-catchment does have reliable groundwater resource as the water is saline. The borehole drilled at Ole Nguya Primary School had a yield of $0.5m^3$/hour only at 230m depth. This yield could not sustain the community and thus need for the alternative source.

Plate 5: Low yield borehole drilled at Ole Nguya Primary School

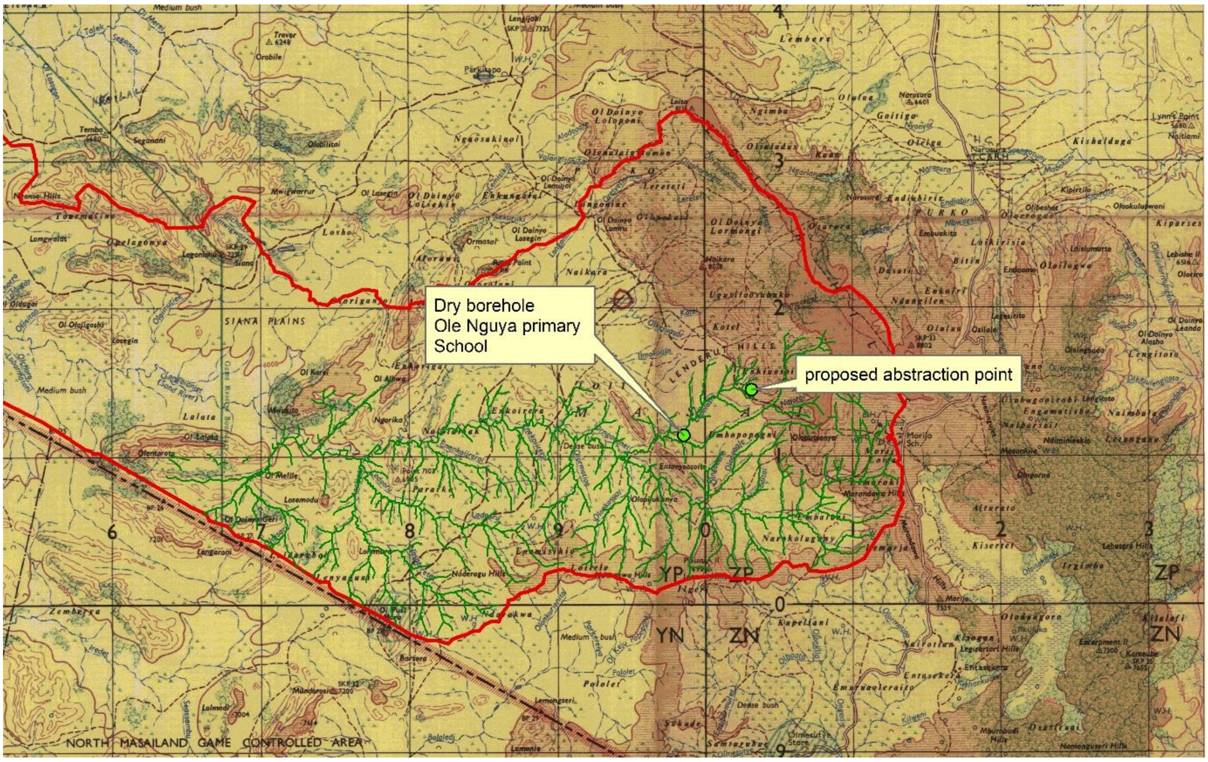

Figure 12: Low yeid borehole at Ole Nguya Primary School

The low yield from this borehole cannot sustain the community and the school and therefore need for other reliable sources such as the surface water. However, community members indicated that there is one good yield borehole located about 10km away from this low yield one.

4. WATER QUALITY

The quality of water determines the extent to which water can be used for various purposes. The examination of the physical, chemical and biological characteristics of any water resource is an important undertaking as this enables the determination of the chemical, physical and biological constituents in water and the determination of the extent to which a particular water resource can be utilized for variety of purposes. In this study, water quality for Lepolosie springs was determined. All measured parameters were found to be within accepted KeBS and WHO portable water standards

FORM F/9/1/4

WATER RESOURCES AUTHORITY

Water Resources Authority
LVSBA Regional Office
P.O. Box 666 - 40100, Kisumu
Tel: Tel: 057072025493
Email: kisumuro@gmail.com

Kisumu water quality laboratory
P.O. Box 666-40100
Tel: 057072025493
Email: kisumuro@gmail.com

Physical Chemical Laboratory Results Certificate

Report Issue Date: 16/1/2023	**Sample No:** 0275/22-23
Name of Customer: Lepolosi Spring	**Received By:** Beryl **Date Received:** 9/1/2023 **Type of Sample:** Potable water – Spring
Sampled/submitted by: Dr. Joash Oruta (PhD) **Purpose of Sampling:** Water Quality Assessment **Date of Sampling:** 22/12/2022	**County:** Narok

PARAMETERS	UNIT	RESULTS	WHO GUIDELINES	KEBS(KS 459-1:2007) STANDARDS.
pH	pH Scale	7.53	6.5-8.5	6.5-8.5
Colour	mgPt/l	5	Max 15	Max 15
Turbidity	N.T.U	2.82	Max 5	Max 5
Conductivity (25^{0}C)	µS/cm	144	Max 2500	-
Calcium	mg/l	9.8	Max 100	Max 150
Magnesium	mg/l	2.65	Max 100	Max 100
Total Hardness	$mgCaCO_3/l$	38	Max 500	Max 300
Total Alkalinity	$mgCaCO_3/l$	64	Max 500	-
Chloride	mg/l	12	Max 250	Max 250
Fluoride	mg/l	0.2	Max 1.5	Max 1.5
Nitrate	$mgNO_3N/l$	0.7	Max 50	Max 50
Nitrite	$mgNO_2N/l$	0.02	Max 0.1	Max 0.003
Sulphate	mg/l	12.9	Max 450	Max 400
Total Dissolved Solids	mg/l	73	Max 1500	Max 1000
Ortho Phosphate	mg/l	0.8	Max 2	Max 2
Oil + Grease	mg/l	0	Nil	Nil
Iron	mg/l	0	Max 0.3	Max 0.3

Comments:

The water has performed as shown. Based on the analyzed parameters the water has met the Kebs physical chemical water quality standards

Signature of the Head of the Lab.............................. Signature of the Unit Head/Analyst.................Date: **16/1/2023**
Name of the Head of the Lab......**Fanuel Onyango**............Name of the Unit Head/Analyst.........**Beryl Akinyi**......
Title of the Head of the Lab......**WQ&PCO**......................Title of the Unit Head/Analyst)...... **WQ&PCO** ....

Disclaimer:
The results contained herein apply to the particular sample(s) tested, whose sample number and tests carried out as detailed in these results. The information contained here reflects the laboratory's findings at the time of analysis and based on the samples submitted by the customer.

WATER RESOURCES AUTHORITY
LAKE VICTORIA SOUTH BASIN AREA
P. O. Box 666 - 40100, KISUMU
TEL: 057 2025493

Figure 13: Physical Chemical Water Quality Certificate for Lepolosi springs

5.0 CONCLUSION

From the foregone discussion, it is noted that the sub basin receives moderate annual rainfall averaging 820mm. The analysis indicates that the average daily flow for Lepolosie stream is 0.551 m^3/s (47,606.4m^3/day) and the Base-Flow Index for the sub basin is 0.4576. This BFI index for catchment is generally somehow low indicating an unstable flow regime, a good storage capacity and ability of the catchment to sustain river flow during extended dry periods is minimal. Lepolosie stream has the following statistics which are important to be considered in water allocation. The one-day average flow has Q95 0.00004m^3/s (3.46m^3/day), Q80 0.00161 m^3/s (13.91m^3/day) and Q50 0.03849 m^3/s (3,325.54m^3/day). The seven-day flow average statistics are: Q95 0.00009m^3/s (7.78m^3/day), Q80 0.00227 m^3/s (196.13m^3/day) and Q50 0.04593 m^3/s (3,968.35m^3/day). The instantaneous gauging of the springs gave a discharge of **18.1m^3/day**. For such a case of abstracting from the eye of the spring it is more advisable to use the spring discharge than the watershed statistics which is a combination of many downstream springs.

The available water for abstraction from these springs is 17m3/day. However, during abstraction provision of cattle troughs should be provided for far communities to water their animals during the dry period. These springs acts as refuge for many communities during the dry spell. It is therefore recommended that the application to abstract water from this river for purposes of supplying to clients for domestic use be positively considered since there is sufficient amount of water at these springs. During the low flow only controlled abstraction should take place as may be advised from time to time by the Water Resources Authority (WRA) office.

The community should fence off these springs and keep the springs catchment well preserved. Animals should not be allowed into these springs as they may contaminate the water beyond the portable standards.

The results provided are only as reliable as the data they have been derived from, and several factors could cause the scheme described in the document to differ from what a scheme installed on site could produce. Flows may also be affected by climate change or land use changes in the catchment area. System efficiency can be affected by many aspects of design and construction and will vary from scheme to scheme, with yearly output being affected accordingly.

REFERENCES

Willson, K.C., 1999. Coffee Cocoa and Tea. CAB International, Wallingford, UK.

Food and Agrigulture Organisation (FAO), 2001. World Production Statistics. FAO, Rome, pp: 51.

Kenya Meteorological Department (1984): Climatic Statistics for Kenya, KMD Nairobi

Republic of Kenya, 2002: - The Water Act 2002, Kenya Gazette Supplement No.107 (Act No.9). Government Printers, Nairobi, Kenya

Sanders L. D. (1965) Geology of the contact between The Nyanzian Shield and The Mozambue belt in Western Kenya.Bull. no. 7, Surv. Kenya

Akotsi, E., & Gachanja, M. (2004). Changes in forest cover in Kenya's five'Water Towers' 2000-2003.

Baldyga, T. J., Miller, S. N., Driese, K. L., & Gichaba, C. M. (2008). Assessing land cover change in Kenya's Mau Forest region using remotely sensed data. African Journal of Ecology, 46(1), 46-54.

Ayuyo, I. O. and Sweta, L. (2014). Land Cover and Land Use Mapping and Change Detection of Mau Complex in Kenya Using Geospatial Technology. International Journal of Science and Research (IJSR) Volume 3 Issue 3, March 2014

Ondijo, B. (2014). Geoelectric structure beneath a 14 km transect across the boundary between Nakuru and Kericho Counties and its relation to the groundwater occurrence in the area. Unpublished BSc Report, University of Nairobi.

Khroda, G.O. (1988). The impact of deforestation on the hydrology of Wetlands.

Water Resources Management Authority (2007). Water Resources Allocation Thresholds for Classification of Permits. 1st Ed. Nairobi, Kenya.

Sanders L. D. (1965) Geology of the contact between The Nyanzian Shield and The Mozambue belt in Western Kenya.Bull. no. 7, Surv. Kenya

Water Resources Management Authority (2010). Guidelines for Water Allocation. 1st Ed. Nairobi, Kenya.

JICA, 1980. National water master plan, stage 1 study report. In. Sangale, F., Okungu, J., and Opango, P., 2001. Variation of flow of water from Rivers Nzoia, Yala and Sio into Lake. Victoria. LVEMP, First Regional Scientific Conference 3rd-7th December 2001, Kisumu, Kenya.

JICA, 1991. National water master plan. Republic of Kenya, Ministry of Water Development. In. Sangale, F., Okungu, J., and Opango, P., 2001. Variation of flow of water from Rivers Nzoia, Yala and Sio into Lake. Victoria. LVEMP, First Regional Scientific Conference 3rd-7th December 2001, Kisumu, Kenya. Johnson, T. C., Kelts, K., Odada, E., 2000. The holocene history of Lake Victoria. AMBIO: A Journal of the Human Environment 29 (1), 2-11.

Government-of-Kenya (1970). National Development Plan. Nairobi, Government Printer.

Government-of-Kenya (2010). Tourism Act 2010. . Nairobi, Government Printer.

Maui Kammu(2010), Facts and Historytf Water Scarcity. Aalto University, Finland.

Mooney (2006), water scarcity in History.