Republic of Zambia

Hydrological/Hydrogeological Year Book
of the Mwembeshi and Chongwe Sub-catchments

2009/10 and 2010/11

Lusaka, November 2012

Hydrological/Hydrogeological Year Book of the Mwembeshi and Chongwe Sub-catchments

2009/10 and 2010/11

Authors

Chisanga Siwale and Roland Bäumle

Produced and published by:
Ministry of Mines, Energy and Water Development
Department of Water Affairs
November 2011

Acknowledgements

This document was produced under the technical cooperation project between the Governments of Zambia and the Federal Republic of Germany and implemented by the Department of Water Affairs, Ministry of Mines, Energy and Water Development, Zambia and the Federal Institute of Geosciences and Natural resources, Germany. It complements the project outputs with regards to groundwater balance and recharge assessment.

The GReSP project acknowledges, with thanks, valuable contributions from the Department of Water Affairs (DWA) members of staff, Lusaka Water and Sewerage Company (LWSC) and individuals who participated in the establishment of additional gauging stations, drilling of observation boreholes and collection of data. In particular, we wish to acknowledge remarkable contributions from the following:

Mr A. Hussen	Former Director of Water Affairs
Mr C. Chileshe	Acting Director-DWA
Mr P. Chola	Assistant Director (Surface Water)
Dr. N.H. Mpamba	Assistant Director (Groundwater)
Mr S. Kang'omba	Project Coordinator
Mr K. Nyundu	Principal Water Quality Officer
Mr. J. Kampata	Principal Water Resources Engineer-DWA
Mr. F.N Ngoma	Provincial Water Officer-Lusaka
Mr. P. Mwila	Principal Hydrogeologist
Mr C. Siwale	Senior Hydrologist/GRESP
Mrs B. Shamboko-Mbale	District Water Officer/GRESP
Ms R. Mweene	Hydro Informatics Officer/GRESP
Mr. L. Museteka	Water Quality Officer/GRESP
Ms A. Nchimunya	Water Quality Officer/DWA
Mr. T. Tena	GRESP/GIZ
Ms J. Liswaniso	Secretary GReSP/BGR
Mrs A. Nick	GReSP/BGR
Mr. T. Krekeler	GReSP/BGR
Mr M. Kayivwa	Hydrologist-DWA
Mr J. Siame	Lab Technician
Mr. J. Mwela	Driver/Technician-DWA
Mr. W. Mabuluki	Driver GReSP/BGR

Mr. C. Ntobolo	Technician-DWA
Mr. L. Chinkubala	Observer-DWA
Mr A. Sokoni	Technician-DWA
Ms M. Sampa	Gauge Reader
Mr. A. Chilala	Gauge Reader
Mr. D. Nyemba	Gauge Reader
Mr. A. Mubamba	Gauge Reader
Ms V. Hamukonka	Gauge Reader
Mr P. Phiri	Gauge Reader

The photos on the cover page were taken by Torsten Krekeler and Roland Bäumle.

Table of Contents

List of Figures

List of Tables

Abbreviations

BGR	Federal Institute for Geosciences and Natural Resources
DWA	Department of Water Affairs
GReSP	Groundwater Resources Management Support Programme
m amsl	meters above mean sea level
WMO	World Meteorological Organization

1 Introduction

Information is important in any planning exercise. For water resources, planning requires adequate and accurate information on which correct decisions can be based. This information describes the quantity, quality, occurrence and distribution of water in time and space. Such information is generated from measurements which are carried out at a specified time interval depending on the desired information output and application.

As an input into the development of a groundwater management strategy, the Groundwater Resources Management Programme for Lusaka (GReSP) focused on compiling a groundwater database. The database contains hydrogeological and water quality information. In addition, data on surface water was also collected to serve as an input in the overall analysis of the water balance for the project area.

This hydrological year book is thus a compilation of information on rainfall, quantity and quality of surface and groundwater which was collected from the monitoring network within the project area. The data presented in this publication covers two consecutive hydrological years (2009/2010 and 2010/2011). The data for the 2011/2012 hydrological will be published in the later yearbooks.

This publication has therefore been produced as a basis and model for subsequent productions of similar works in other sub-catchments. Besides, the publication serves as a means of disseminating information to stakeholders and those who desire to know the status of water resources. For planners, decision makers and researchers concerned with water resources management and development, this information will be an invaluable input in their respective works.

Stage and Discharge Data

The stage of a river, commonly known as water level, refers to the height of water surface in a river channel above an established datum or elevation. This is measured in meters either by a gauge staff, automatic or mechanical recorder which is installed on the river channel. The point at which the recorders are installed is referred to as a Gauging or Hydrometric station. The installations at a Gauging station are done with reference to a benchmark which is either linked to the mean sea level or set as an arbitrary local benchmark. The standard principles for the construction of a Gauging station are outlined

by the World Meteorological Organization (WMO), a specialized United Nations agency responsible for standardization of meteorological and hydrological observations to ensure uniform publication of observations and statistics. (WMO, 1994)[1]

Measurements at gauging stations in the project area are recorded manually by an observer up to three times on a daily basis. Stage measurements for the gauging stations in this publication are thus derived from manual recordings.

Discharge, which is flow of water in a river, is usually measured by a current meter (digital or non-digital) and the units are usually in cubic meters per second (m^3/s).

Groundwater levels

Groundwater levels are depths measured in meters from the ground surface to the water surface in a well or borehole. The depths can be measured from a fixed reference point which in most cases is offset casing pipe or concrete slab. Water levels can also be expressed in relation to the mean sea level. Groundwater levels are an indicator of fluctuation of groundwater over a specific time and can also show the response of groundwater to rainfall events and abstractions.

The groundwater levels in this report are generated from data loggers which are installed in the monitoring and production boreholes. The loggers are set to record the water levels every hour. However the graphical presentations of groundwater trends in this report are based on the daily recordings.

Groundwater quality

Water quality is affected by the natural environment and by human impact. If water resources are polluted by anthropogenic activities, they need to be treated in order to serve as safe drinking water. There is a broad spectrum of parameters which can be monitored in terms of water quality. Due to limited laboratory facilities however, few but specific parameters were chosen to be monitored on a monthly basis, comprising of in-situ measurements (temperature, electrical conductivity, pH, redox potential and oxygen saturation), microbiology (total coliforms and E. coli) and nitrate as a chemical parameter.

[1] World Meteorological Organization, 1994, A guide to hydrological practices, WMO No. 168, Geneva

2 Rain Gauges

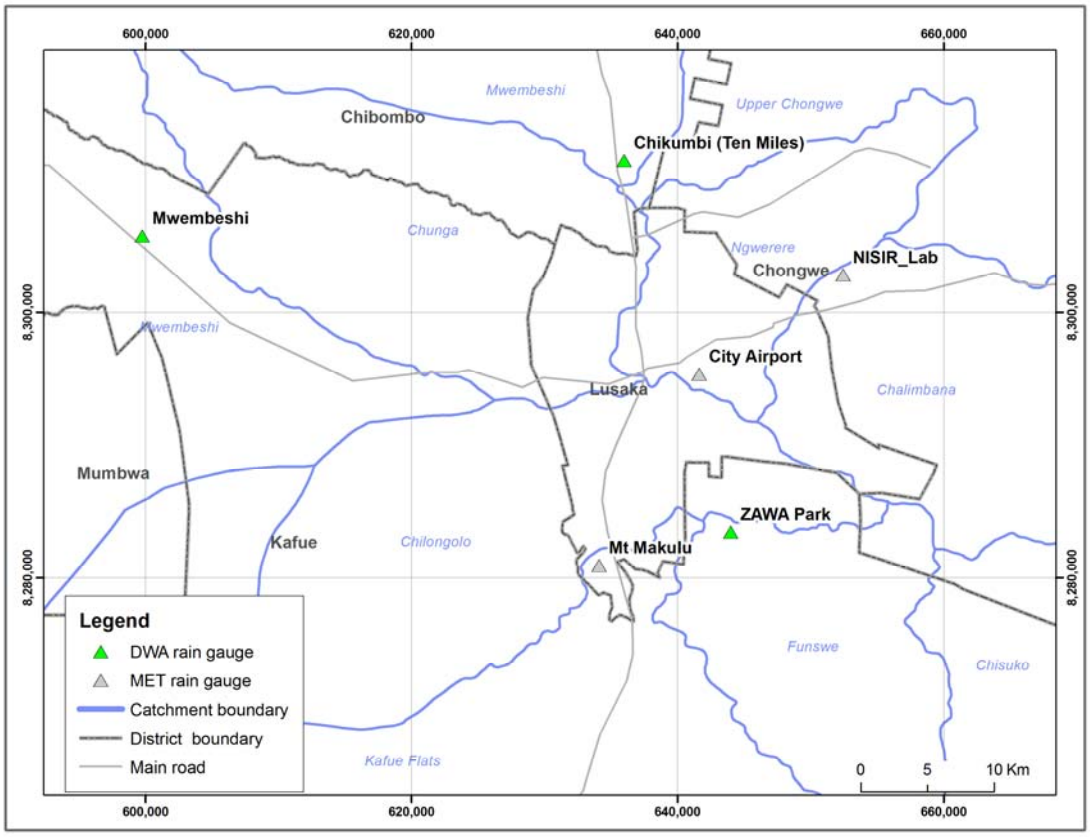

Figure 1 Location of automatic rainfall station within the project area

2.1 Chikumbi (Ten Miles)

Location	Latitude 15.27008 S Longitude 28.26655 E
Sub-catchment (Catchment)	Mwembeshi (Lower Kafue)
Rain gauge type	Recording (tipping bucket)
Measuring method	Automatic
Interval	Hourly

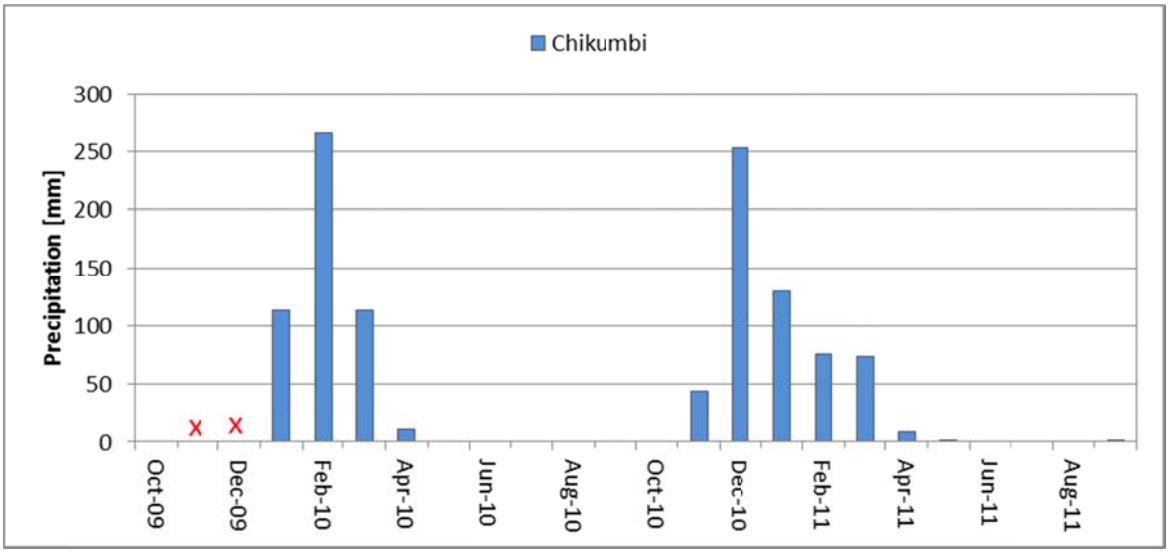

Figure 2 Monthly rainfall at Chikumbi (2009-2011)

Table 1 Daily rainfall at Chikumbi (2009-2010)

Chikumbi (2009/2010)								
Date	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10
1	0.0	0.0	0.0	-	0.0	16.4	0.1	0.0
2	0.0	0.0	0.0	-	0.0	51.5	0.5	0.0
3	0.0	0.0	0.0	-	0.0	3.7	7.5	0.0
4	0.0	0.0	0.0	-	0.0	1.9	1.9	0.0
5	0.0	0.0	0.0	-	0.0	38.5	23.4	0.0
6	0.0	0.0	0.0	-	0.0	22.1	9.6	0.0
7	0.0	0.0	3.6	-	8.9	23.1	0.0	0.0
8	0.0	0.0	3.5	-	0.0	0.8	0.0	10.0
9	0.0	0.0	4.2	-	1.7	0.2	0.0	0.1
10	0.0	0.0	0.0	-	26.8	0.1	0.0	0.5
11	0.0	0.0	0.0	-	32.1	0.0	0.6	0.0
12	0.0	0.0	-	-	0.0	0.0	0.1	0.0
13	0.0	0.0	-	-	0.0	0.1	0.0	0.0
14	0.0	0.0	-	-	0.0	0.1	0.0	0.0
15	0.0	0.0	-	-	0.0	0.0	9.4	0.0
16	0.0	0.0	-	-	9.2	0.0	0.1	0.0
17	0.0	0.0	-	-	6.2	0.0	0.1	0.0
18	0.0	0.0	-	-	3.5	0.1	0.6	0.0
19	0.0	0.0	-	-	14.7	20.9	11.7	0.0
20	0.0	0.0	-	-	0.4	12.3	38.9	0.2
21	0.0	0.0	-	-	0.1	4.1	8.1	0.0
22	0.0	0.0	-	-	0.0	9.7	0.4	0.0
23	0.0	0.0	-	-	4.5	9.0	0.0	0.0
24	0.0	0.0	-	-	1.8	3.4	0.1	0.0
25	0.0	0.0	-	-	1.5	5.8	0.0	0.0
26	0.0	0.0	-	-	0.7	7.8	0.0	0.0
27	0.0	0.0	-	-	0.0	0.9	0.0	0.0
28	0.0	0.0	-	-	0.6	34.5	0.1	0.0
29	0.0	0.0	-	-	0.0		0.0	0.0
30	0.0	0.0	-	14.9	0.2		0.4	0.0
31		0.0		0.2	0.1		0.1	0.0
Total (mm)	0.0	0.0	-	-	113.0	267.0	113.7	10.8

Table 2 Daily rainfall at Chikumbi (2010-2011)

Chikumbi (2010/2011)								
Date	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11
1	0.0	0.0	1.8	25.0	0.0	16.6	0.1	0.0
2	0.0	0.0	23.2	0.1	0.0	18.0	0.1	0.0
3	0.0	0.0	0.0	1.7	0.0	0.6	0.1	0.0
4	0.0	0.0	0.1	2.0	1.0	0.0	13.1	0.1
5	0.0	0.0	0.0	1.2	0.1	0.0	8.3	0.0
6	0.0	0.0	0.0	3.1	0.0	0.0	1.6	1.4
7	0.0	0.0	0.0	26.7	16.8	0.0	0.1	0.1
8	0.0	0.0	0.0	68.3	4.8	0.0	0.0	0.1
9	0.0	0.0	0.0	58.8	4.9	0.0	0.0	1.2
10	0.0	0.0	1.1	8.3	18.2	0.0	0.0	5.5
11	0.0	0.0	0.0	13.3	1.5	1.1	0.3	0.0
12	0.0	0.0	12.0	2.9	0.0	0.0	5.3	0.0
13	0.0	0.0	0.0	0.2	4.1	0.6	3.6	0.0
14	0.0	0.0	0.0	0.0	5.4	0.1	18.5	0.0
15	0.0	0.0	0.3	0.0	0.2	0.0	0.2	0.0
16	0.0	0.0	0.0	0.0	17.2	0.0	0.1	0.0
17	0.0	0.0	0.0	12.8	0.0	16.5	0.5	0.0
18	0.0	0.0	0.0	0.0	14.5	0.0	0.1	0.0
19	0.0	0.0	0.2	0.0	0.3	0.0	0.3	0.0
20	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0
21	0.0	0.0	0.6	0.1	3.7	0.0	0.0	0.1
22	0.0	0.0	0.0	0.0	5.2	0.9	7.7	0.1
23	0.0	0.0	0.0	0.5	4.9	0.0	0.2	0.0
24	0.0	0.0	0.0	0.1	8.4	0.0	1.5	0.0
25	0.0	0.0	1.2	0.0	0.3	0.0	0.0	0.0
26	0.0	0.0	1.3	0.0	0.4	0.7	0.0	0.0
27	0.0	0.0	0.7	7.2	0.5	4.3	2.9	0.0
28	0.0	0.0	0.0	2.5	2.0	16.2	5.9	0.0
29	0.0	0.0	0.0	6.5	2.4		3.5	0.0
30	0.0	0.0	1.1	12.2	3.7		0.2	0.0
31		0.0		0.1	6.3		0.0	
Total (mm)	0.0	0.0	43.6	253.6	130.1	75.6	74.2	8.6

2.2 Mwembeshi Prison

Location	Latitude 15.32222 S Longitude 28.92956 E
Sub-catchment (Catchment)	Mwembeshi (Lower Kafue)
Rain gauge type	Recording (tipping bucket)
Measuring method	Automatic
Interval	Hourly

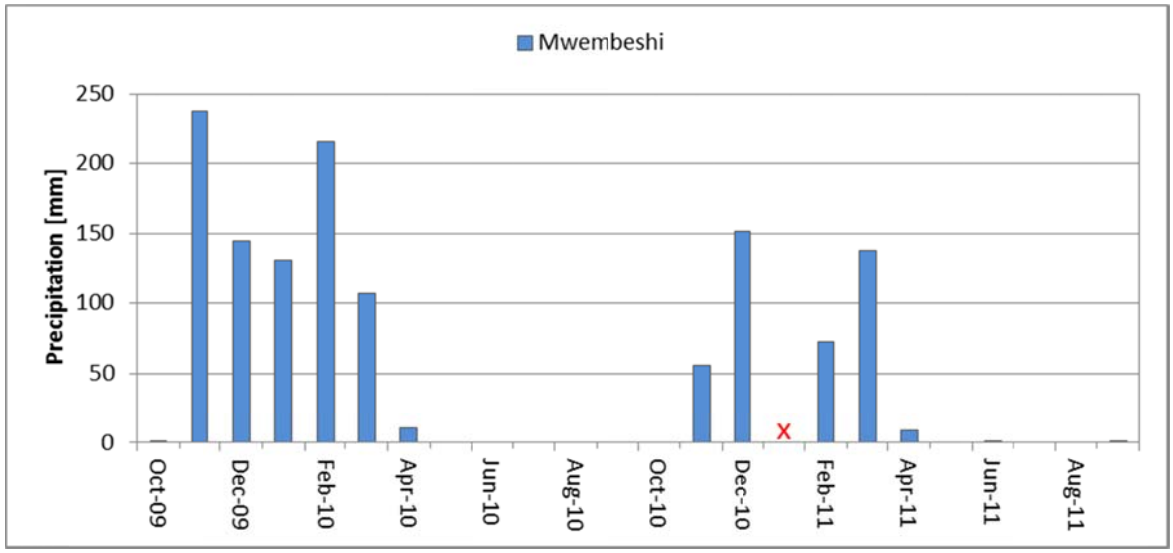

Figure 3 Monthly rainfall at Mwembeshi Prison (2009-2011)

Table 3 Daily rainfall at Mwembeshi (2009-2010)

Mwembeshi (2009/2010)								
Date	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10
1	0.0	0.0	0.0	0.0	0.3	2.6	0.1	0.0
2	0.0	0.0	0.0	27.0	0.0	26.3	1.0	0.0
3	0.0	0.0	0.0	0.2	0.0	51.6	1.1	0.1
4	0.0	0.7	0.0	1.0	0.0	0.4	3.4	0.0
5	0.0	0.9	0.0	0.0	0.0	3.7	5.4	0.0
6	0.0	0.0	1.4	34.0	7.7	3.3	0.9	0.0
7	0.0	0.0	0.0	0.3	0.9	11.7	0.0	0.0
8	0.0	0.0	25.4	0.0	24.8	0.0	0.0	8.0
9	0.0	0.0	8.7	0.0	1.4	0.0	0.0	2.4
10	0.0	0.0	0.0	0.0	8.4	0.0	0.0	0.0
11	0.0	0.0	6.5	6.8	0.2	0.0	0.0	0.0
12	0.0	0.0	20.9	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	18.0	50.5	0.6	0.0	0.0	0.0
14	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
15	0.0	0.0	17.5	0.1	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.3	5.7	0.0	2.3	0.0
17	0.0	0.0	2.2	0.0	0.0	0.0	0.1	0.0
18	0.0	0.0	2.1	0.0	1.1	0.8	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	3.3	42.9	0.0
20	0.0	0.0	0.0	0.0	0.0	19.5	36.8	0.0
21	0.0	0.0	60.9	0.3	0.2	0.6	8.3	0.0
22	0.0	0.0	20.1	0.0	2.1	17.0	2.3	0.0
23	0.0	0.0	39.2	10.9	28.0	2.2	0.1	0.0
24	0.0	0.0	5.8	3.4	0.0	10.9	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	45.9	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
27	0.0	0.0	0.0	4.7	0.0	10.1	0.0	0.0
28	0.0	0.0	0.0	0.0	18.1	1.1	1.1	0.0
29	0.0	0.0	0.2	2.9	8.2		0.0	0.0
30	0.0	0.0	9.1	0.0	1.6		0.3	0.0
31		0.0			21.6		0.1	
Total (mm)	0.0	1.6	238.0	144.2	130.9	214.9	106.2	10.5

Table 4 Daily rainfall at Mwembeshi (2010-2011)

Mwembeshi (2010/2011)								
Date	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11
1	0.0	0.0	0.0	0.0	1.1	10.5	1.2	0.0
2	0.0	0.0	4.1	1.0	0.1	0.0	4.0	0.0
3	0.0	0.0	0.0	1.1	0.0	1.7	0.0	0.0
4	0.0	0.0	4.3	7.5	0.0	0.0	36.9	0.5
5	0.0	0.0	0.0	0.1	0.0	0.0	4.5	0.2
6	0.0	0.0	0.0	4.4	0.0	0.0	1.4	1.4
7	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	9.2	-	1.3	0.3	0.0
9	0.0	0.0	0.0	60.7	-	0.0	0.0	0.0
10	0.0	0.0	0.8	7.7	-	2.0	0.0	5.3
11	0.0	0.0	0.0	2.5	-	4.6	10.7	0.0
12	0.0	0.0	16.8	2.9	-	1.5	0.1	0.0
13	0.0	0.0	0.0	0.0	-	22.1	9.4	0.0
14	0.0	0.0	0.0	0.1	-	0.1	45.0	0.0
15	0.0	0.0	7.5	0.0	-	0.2	0.1	0.0
16	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	-	0.0	0.5	0.0
19	0.0	0.0	0.0	0.0	-	0.0	2.2	0.0
20	0.0	0.0	1.5	12.6	-	0.0	3.0	0.0
21	0.0	0.0	5.7	1.9	-	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	-	1.2	0.0	0.0
23	0.0	0.0	0.0	2.5	-	0.7	0.0	0.0
24	0.0	0.0	0.0	1.9	-	0.1	12.6	0.0
25	0.0	0.0	13.5	0.0	-	12.7	1.0	0.0
26	0.0	0.0	1.1	0.6	-	0.0	0.0	0.0
27	0.0	0.0	0.0	1.0	-	13.5	2.6	0.0
28	0.0	0.1	0.0	2.7	34.9	0.0	1.9	0.0
29	0.0	0.0	0.0	10.1	2.7		0.0	1.4
30	0.0	0.0	0.0	10.3	27.8		0.0	0.1
31		0.0		3.2	7.5		0.0	
Total (mm)	0.0	0.1	55.3	151.7	-	72.2	137.4	8.9

2.3 ZAWA Park

Location	Latitude 15.52381 S Longitude 28.34267 E
Sub-catchment (Catchment)	Funswe (Lower Kafue)
Rain gauge type	Recording (tipping bucket)
Measuring method	Automatic
Interval	Hourly

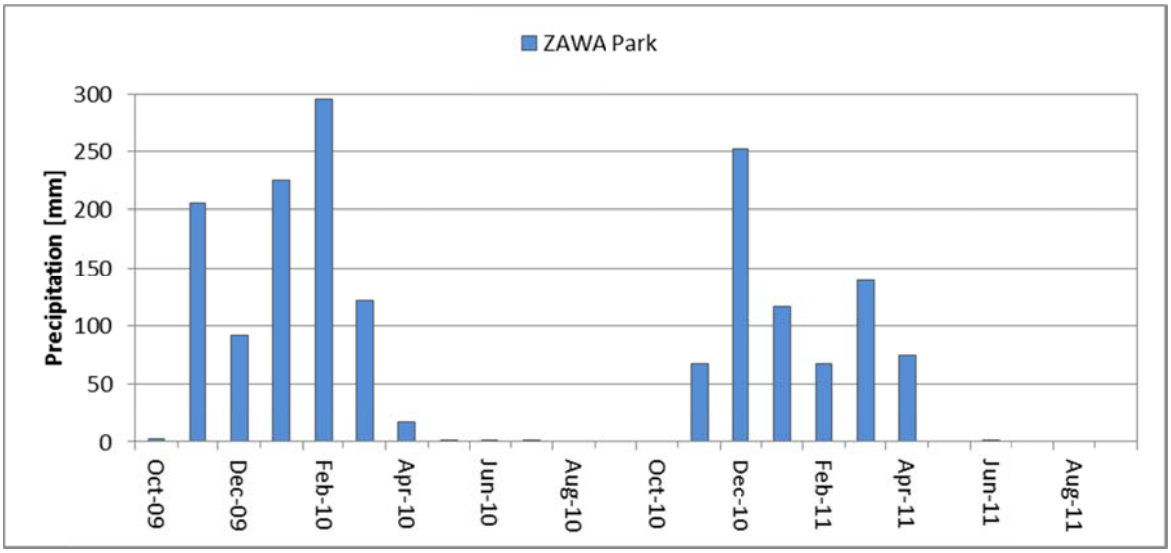

Figure 4 Monthly rainfall at ZAWA Park (2009-2011)

Table 5 Daily rainfall at ZAWA Park(2009-2010)

ZAWA (2009/2010)								
Date	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10
1	0.0	0.0	0.0	0.0	0.0	11.4	0.0	0.2
2	0.0	0.0	0.0	26.3	1.3	10.1	1.5	0.1
3	0.0	0.0	0.0	0.0	0.3	34.5	30.9	0.1
4	0.0	2.7	0.0	0.1	0.0	44.2	2.7	0.5
5	0.0	0.0	0.0	0.0	0.0	8.2	13.9	0.3
6	0.0	0.0	1.0	0.0	1.2	5.7	16.4	0.1
7	0.0	0.0	0.4	4.9	41.3	1.6	0.0	0.0
8	0.0	0.0	1.3	0.0	0.1	0.1	0.0	5.7
9	0.0	0.0	0.2	0.0	16.6	0.0	0.0	0.2
10	0.0	0.0	0.6	0.0	2.6	0.0	0.0	0.0
11	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	24.9	3.9	0.0	0.0	0.0	0.1
13	0.0	0.0	27.9	38.3	0.0	2.1	0.0	0.1
14	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0
15	0.0	0.0	5.7	0.7	0.0	0.8	0.0	0.0
16	0.0	0.0	0.0	0.2	10.9	0.0	1.0	0.1
17	0.0	0.0	11.0	0.0	5.1	0.0	0.1	4.8
18	0.0	0.0	2.3	0.0	0.1	4.7	0.1	0.0
19	0.0	0.0	0.1	0.0	22.0	29.8	12.9	0.0
20	0.0	0.0	5.0	0.0	34.1	11.0	3.6	0.0
21	0.0	0.0	50.3	2.3	0.0	7.2	19.4	4.3
22	0.0	0.0	22.5	0.0	2.5	16.1	4.2	0.1
23	0.0	0.0	1.2	0.9	0.0	13.6	0.0	0.1
24	0.0	0.0	44.4	5.5	46.6	8.3	0.0	0.1
25	0.0	0.0	0.0	0.0	8.5	44.3	0.1	0.1
26	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	33.4	0.8	0.0
28	0.0	0.0	0.0	0.0	17.1	0.1	13.7	0.0
29	0.0	0.0	4.0	1.5	5.0		0.1	0.1
30	0.0	0.0	0.0	2.7	0.3		0.3	0.1
31		0.0		0.8	9.3		0.1	
Total (mm)	0.0	2.7	205.3	91.4	224.9	295.2	121.8	17.2

Table 6 Daily rainfall at ZAWA Park(2010-2011)

ZAWA (2010/2011)								
Date	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11
1	0.0	0.0	0.1	29.0	0.0	12.8	0.1	0.1
2	0.0	0.0	0.0	5.0	0.6	0.1	2.4	0.0
3	0.0	0.0	0.0	0.4	0.1	3.4	0.0	0.0
4	0.0	0.0	0.0	0.2	0.2	0.3	0.4	6.9
5	0.0	0.0	0.0	4.6	0.3	0.0	1.2	53.3
6	0.0	0.0	0.0	0.4	0.0	0.0	5.8	0.1
7	0.0	0.0	1.4	39.1	0.4	0.0	1.0	0.0
8	0.0	0.0	0.6	46.3	18.5	9.3	0.0	0.0
9	0.0	0.0	0.0	51.6	16.7	0.0	0.0	4.9
10	0.0	0.0	4.0	16.4	3.7	2.2	0.4	10.2
11	0.0	0.0	0.1	0.1	2.9	1.4	0.0	0.0
12	0.0	0.0	25.5	0.7	0.4	0.0	0.3	0.0
13	0.0	0.0	0.7	7.8	3.6	0.0	39.2	0.0
14	0.0	0.0	2.8	0.0	4.2	0.0	14.4	0.0
15	0.0	0.0	1.9	0.0	0.2	0.0	0.3	0.0
16	0.0	0.0	0.0	0.0	5.2	0.0	0.1	0.0
17	0.0	0.0	0.0	11.3	7.5	0.0	0.0	0.0
18	0.0	0.0	0.0	4.5	3.8	0.0	2.5	0.0
19	0.0	0.0	0.0	0.0	13.9	0.0	0.0	0.0
20	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	9.9	0.2	3.0	0.0	2.0	0.0
22	0.0	0.0	0.2	0.1	7.1	6.1	0.0	0.0
23	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0
24	0.0	0.0	0.0	12.0	0.0	2.5	62.6	0.0
25	0.0	0.0	8.4	0.1	0.1	0.2	0.0	0.0
26	0.0	0.0	3.7	0.2	2.8	0.0	4.7	0.0
27	0.0	0.0	0.1	1.4	0.8	28.8	0.0	0.0
28	0.0	0.0	0.0	5.1	6.3	1.1	0.1	0.0
29	0.0	0.0	0.6	13.0	2.2		1.7	0.0
30	0.0	0.0	7.1	2.4	0.9		0.2	0.0
31		0.0		0.1	8.6		0.3	-
Total (mm)	0.0	0.0	67.4	252.0	116.7	68.2	139.7	75.5

3 River/Stream Gauges

3.1 Chunga River at Shandyongo Village

Gauge station No.	**4-935**
Location	Latitude 15.21236 S, Longitude 28.95058 E, on the left bank about 6m upstream on the Shandyongo-Mungule Road crossing
Catchment Area	560 km^2
Gauge Type	Graduated plates (0-1.5m, 1.4- 2.9m, 2.8-4.3m), read three times a day
Extreme stage (m)	Maximum: 3.22 Minimum: 0 (2009 to 2011)
Extreme flow (m^3/s)	Maximum: 85 Minimum: 0 (2009 to 2011)
Flow regime	Non-Perennial
Remarks	The station was opened in 2009 and has a short period of data series**.**
Rating equation	$\boldsymbol{Q = 17.06\,(h - 0.19)^{1.448}}$

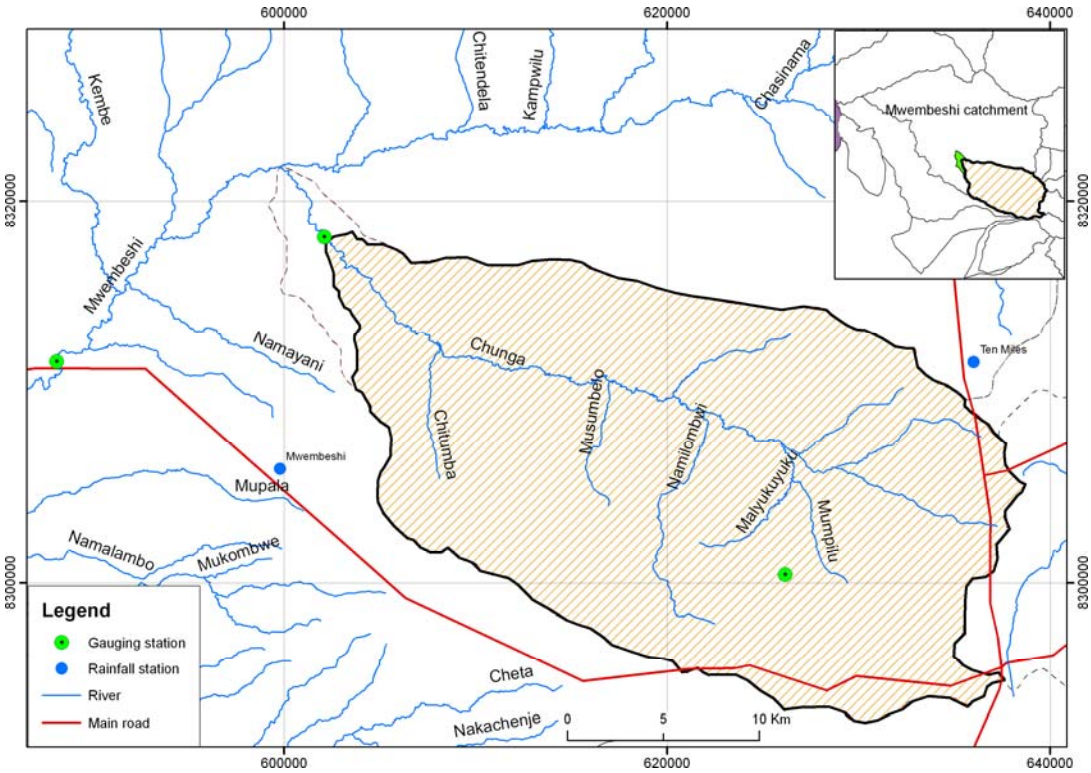

Figure 5 Chunga River sub-catchment at Shandyongo Village

Table 7 Stage in meters for the period 2009/2010- Chunga

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	-	-	0.27	0.59	0.60	0.54	0.39	0.27	0.26	0.32	0.22
2	-	-	-	0.27	1.76	0.54	0.51	0.39	0.27	0.26	0.32	0.21
3	-	-	-	0.26	3.22	0.54	0.56	0.37	0.27	0.27	0.31	0.21
4	-	-	-	0.25	1.54	0.61	0.52	0.35	0.27	0.27	0.31	0.21
5	-	-	-	0.25	1.45	0.64	0.56	0.34	0.27	0.27	0.30	0.21
6	-	-	-	0.24	1.71	0.67	0.62	0.32	0.27	0.27	0.27	0.21
7	-	-	-	0.30	1.27	0.61	0.67	0.32	0.27	0.27	0.28	0.21
8	-	-	0.28	0.41	0.83	0.53	0.73	0.31	0.27	0.27	0.28	0.21
9	-	-	0.27	0.32	0.67	0.49	0.60	0.30	0.27	0.27	0.26	0.21
10	-	-	0.26	0.29	0.59	0.47	0.52	0.30	0.27	0.27	0.25	0.21
11	-	-	0.30	0.44	0.55	0.46	0.43	0.29	0.27	0.27	0.23	0.20
12	-	-	0.25	0.58	0.52	0.45	0.37	0.29	0.27	0.26	0.23	0.19
13	-	-	0.74	0.42	0.49	0.44	0.36	0.29	0.27	0.26	0.23	0.19
14	-	-	0.51	0.38	0.46	0.43	0.57	0.28	0.27	0.26	0.23	0.19
15	-	-	0.44	0.34	0.45	0.43	0.56	0.28	0.27	0.26	0.23	0.19
16	-	-	0.45	0.36	0.45	0.47	0.56	0.28	0.27	0.26	0.23	0.19
17	-	-	0.42	0.33	0.43	0.42	0.55	0.28	0.27	0.27	0.23	0.19
18	-	-	0.37	0.31	0.53	0.67	0.54	0.28	0.27	0.27	0.23	0.19
19	-	-	0.35	0.30	0.58	1.14	0.50	0.29	0.27	0.27	0.23	0.18
20	-	-	0.33	0.27	0.56	2.62	0.47	0.30	0.27	0.28	0.23	0.18
21	-	-	0.32	0.40	0.55	1.43	0.42	0.33	0.27	0.28	0.23	0.19
22	-	-	0.33	0.33	0.88	1.06	0.36	0.33	0.27	0.28	0.23	0.19
23	-	-	0.27	0.36	1.00	0.86	0.35	0.32	0.27	0.29	0.23	0.20
24	-	-	0.28	0.67	0.77	0.72	0.35	0.30	0.27	0.29	0.23	0.19
25	-	-	0.26	0.51	1.93	0.64	0.35	0.29	0.27	0.29	0.23	0.18
26	-	-	0.27	0.48	0.92	0.59	0.35	0.29	0.27	0.30	0.23	0.18
27	-	-	0.28	0.39	0.75	0.54	0.41	0.28	0.27	0.33	0.23	0.18
28	-	-	0.28	0.40	0.67	0.51	0.40	0.28	0.27	0.33	0.22	0.19
29	-	-	0.27	0.45		0.50	0.39	0.28	0.27	0.33	0.22	0.19
30	-	-	0.27	0.42		0.47	0.39	0.28	0.26	0.32	0.21	0.19
31	-	-	0.27	0.45		-		0.27		0.32	0.21	
Max	-	-	-	0.67	3.22	-	0.73	0.39	0.27	0.33	0.32	0.22
Min	-	-	-	0.24	0.43	-	0.35	0.27	0.26	0.26	0.21	0.18

Table 8 Stage in meters for the period 2010/2011- Chunga

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.194	0.037	0.241	1.328	0.983	0.460	0.343	0.261	0.233	0.182	0.222	0.232
2	0.20	0.22	0.22	1.33	0.93	0.46	0.34	0.26	0.23	0.18	0.22	0.23
3	0.19	0.21	0.21	1.35	0.53	0.57	0.34	0.25	0.24	0.18	0.22	0.24
4	0.20	0.21	0.27	1.35	0.51	0.61	0.34	0.24	0.24	0.17	0.21	0.24
5	0.21	0.20	0.44	1.42	0.51	0.47	0.34	0.24	0.24	0.17	0.21	0.24
6	0.28	0.18	0.46	1.41	0.51	0.43	0.34	0.24	0.24	0.17	0.21	0.24
7	0.30	0.17	0.51	1.41	0.51	0.41	0.32	0.24	0.24	0.17	0.21	0.23
8	0.29	0.17	0.57	1.40	0.54	0.42	0.31	0.24	0.24	0.16	0.21	0.23
9	0.28	0.16	0.61	1.38	0.49	0.40	0.31	0.23	0.23	0.18	0.21	0.23
10	0.26	0.15	0.61	1.61	0.42	0.39	0.32	0.23	0.22	0.20	0.21	0.23
11	0.24	0.28	0.57	1.60	0.42	0.38	0.37	0.24	0.22	0.22	0.20	0.23
12	0.23	0.29	0.54	1.43	0.41	0.41	0.42	0.23	0.22	0.24	0.20	0.23
13	0.22	0.28	0.54	1.10	0.39	0.42	0.40	0.23	0.22	0.24	0.20	0.23
14	0.21	0.27	0.46	1.02	0.42	0.64	0.35	0.23	0.23	0.25	0.20	0.23
15	0.18	0.26	0.44	0.97	0.43	0.29	0.35	0.24	0.23	0.25	0.21	0.22
16	0.16	0.24	0.43	0.72	0.41	0.23	0.29	0.24	0.24	0.24	0.22	0.22
17	0.15	0.24	0.42	0.72	0.38	0.41	0.28	0.25	0.24	0.23	0.22	0.21
18	0.14	0.23	0.43	0.78	0.37	0.31	0.28	0.25	0.24	0.23	0.22	0.21
19	0.12	0.22	0.50	0.61	0.36	0.37	0.28	0.25	0.24	0.23	0.23	0.19
20	0.11	0.24	0.52	0.63	0.35	0.42	0.27	0.24	0.23	0.23	0.23	0.19
21	0.10	0.19	0.52	0.75	0.34	0.49	0.27	0.24	0.22	0.23	0.23	0.19
22	0.07	0.19	0.54	0.65	0.33	0.47	0.27	0.24	0.22	0.23	0.24	0.18
23	0.00	0.18	0.68	0.55	0.33	0.47	0.27	0.24	0.23	0.23	0.25	0.18
24	0.00	0.19	0.74	0.75	0.34	0.46	0.28	0.24	0.22	0.23	0.26	0.22
25	0.00	0.21	0.74	0.48	0.43	0.45	0.28	0.24	0.22	0.23	0.26	0.22
26	0.00	0.22	0.82	0.51	0.43	0.39	0.28	0.24	0.21	0.22	0.27	0.23
27	0.00	0.21	0.83	0.57	0.38	0.39	0.27	0.25	0.20	0.22	0.26	0.22
28	0.00	0.22	0.84	0.63	0.40	0.38	0.27	0.25	0.19	0.22	0.25	0.32
29	0.00	0.22	0.84	0.75		0.37	0.26	0.24	0.19	0.22	0.24	0.28
30	0.00	0.28	0.89	0.99		0.38	0.26	0.24	0.18	0.22	0.23	0.22
31	0.00		1.09	0.99		0.35		0.23		0.22	0.23	
Max	0.30	0.29	1.09	1.61	0.98	0.64	0.42	0.26	0.24	0.25	0.27	0.32
Min	0.00	0.15	0.21	0.48	0.33	0.23	0.26	0.23	0.18	0.16	0.20	0.18

Table 9 Flow (m^3/s) for the period 2009/2010 – Chunga

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	-	-	0.45	4.54	4.66	3.81	1.63	0.47	0.41	0.89	0.13
2	-	-	-	0.43	32.92	3.80	3.30	1.62	0.46	0.41	0.87	0.07
3	-	-	-	0.36	85.01	3.81	4.02	1.45	0.46	0.41	0.84	0.07
4	-	-	-	0.31	26.47	4.93	3.50	1.22	0.46	0.41	0.81	0.07
5	-	-	-	0.28	23.87	5.37	4.06	1.10	0.46	0.41	0.74	0.07
6	-	-	-	0.25	31.22	5.93	5.05	0.90	0.45	0.42	0.46	0.07
7	-	-	-	0.71	19.20	4.87	5.97	0.85	0.44	0.42	0.56	0.08
8	-	-	0.53	1.87	8.96	3.63	7.01	0.81	0.43	0.42	0.50	0.08
9	-	-	0.45	0.93	5.85	3.01	4.67	0.73	0.44	0.42	0.37	0.07
10	-	-	0.38	0.59	4.54	2.70	3.49	0.69	0.47	0.42	0.26	0.06
11	-	-	0.71	2.36	3.96	2.52	2.22	0.66	0.48	0.41	0.18	0.02
12	-	-	0.28	4.32	3.39	2.44	1.38	0.62	0.47	0.41	0.18	<0.001
13	-	-	7.20	2.01	2.95	2.24	1.36	0.58	0.47	0.41	0.18	<0.001
14	-	-	3.25	1.50	2.59	2.12	4.26	0.57	0.46	0.40	0.18	<0.001
15	-	-	2.34	1.07	2.49	2.18	4.11	0.56	0.46	0.40	0.18	<0.001
16	-	-	2.44	1.28	2.41	2.75	3.98	0.56	0.46	0.40	0.17	<0.001
17	-	-	2.04	0.97	2.20	2.07	3.85	0.56	0.45	0.42	0.17	<0.001
18	-	-	1.40	0.82	3.54	5.99	3.78	0.57	0.45	0.43	0.17	<0.001
19	-	-	1.26	0.69	4.34	15.86	3.19	0.64	0.43	0.45	0.17	<0.001
20	-	-	1.00	0.45	4.06	61.91	2.68	0.69	0.43	0.49	0.16	<0.001
21	-	-	0.87	1.83	3.92	23.42	2.04	0.97	0.43	0.51	0.16	0.01
22	-	-	1.01	0.97	9.92	13.89	1.30	0.96	0.42	0.52	0.16	0.01
23	-	-	0.42	1.36	12.60	9.57	1.22	0.91	0.42	0.58	0.15	0.03
24	-	-	0.56	5.85	7.84	6.83	1.19	0.67	0.42	0.59	0.15	0.01
25	-	-	0.35	3.34	37.98	5.38	1.18	0.62	0.42	0.63	0.15	<0.001
26	-	-	0.46	2.81	10.84	4.55	1.20	0.58	0.41	0.68	0.15	<0.001
27	-	-	0.51	1.73	7.32	3.80	1.90	0.54	0.41	1.01	0.15	<0.001
28	-	-	0.52	1.84	5.82	3.34	1.84	0.56	0.41	1.03	0.14	<0.001
29	-	-	0.46	2.48		3.19	1.71	0.56	0.41	0.99	0.12	0.002
30	-	-	0.44	2.00		2.74	1.66	0.52	0.41	0.95	0.08	0.004
31	-		0.44	2.48		-		0.48		0.92	0.07	
Max	-	-	-	5.85	85.01	-	7.01	1.63	0.48	1.03	0.89	0.13
Min	-	-	-	0.25	2.20	-	1.18	0.48	0.41	0.40	0.07	<0.001

Table 10 Flow (m^3/s) for the period 2010/2011 – Chunga

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.05	0.05	0.31	0.45	4.54	4.66	3.81	1.63	0.47	0.41	0.89	0.13
2	0.05	0.05	0.34	0.44	32.92	3.80	3.30	1.62	0.46	0.41	0.87	0.07
3	0.05	0.05	0.37	0.36	85.01	3.81	4.02	1.45	0.46	0.41	0.84	0.07
4	0.05	0.05	0.40	0.31	26.47	4.93	3.50	1.22	0.46	0.41	0.81	0.07
5	0.05	0.05	0.43	0.28	23.87	5.37	4.06	1.10	0.46	0.41	0.74	0.07
6	0.05	0.05	0.47	0.25	31.22	5.93	5.05	0.90	0.45	0.42	0.46	0.07
7	0.05	0.05	0.50	0.71	19.20	4.87	5.97	0.85	0.44	0.42	0.56	0.08
8	0.05	0.05	0.53	1.88	8.96	3.63	7.01	0.81	0.43	0.42	0.50	0.08
9	0.05	0.05	0.45	0.93	5.85	3.01	4.67	0.73	0.44	0.42	0.37	0.07
10	0.05	0.05	0.38	0.59	4.54	2.70	3.49	0.70	0.47	0.42	0.26	0.06
11	0.05	0.05	0.71	2.36	3.96	2.52	2.22	0.66	0.48	0.41	0.18	0.02
12	0.05	0.05	0.28	4.33	3.39	2.44	1.38	0.62	0.47	0.41	0.18	0.00
13	0.05	0.05	7.20	2.01	2.95	2.24	1.36	0.58	0.47	0.41	0.18	0.00
14	0.05	0.05	3.25	1.50	2.59	2.12	4.26	0.57	0.46	0.41	0.18	0.00
15	0.05	0.05	2.34	1.07	2.49	2.18	4.11	0.56	0.46	0.40	0.18	0.00
16	0.05	0.05	2.44	1.29	2.41	2.75	3.98	0.56	0.46	0.40	0.18	0.00
17	0.05	0.05	2.04	0.97	2.20	2.07	3.85	0.56	0.45	0.42	0.17	0.00
18	0.05	0.05	1.40	0.82	3.54	5.99	3.78	0.57	0.45	0.43	0.17	0.00
19	0.05	0.05	1.26	0.69	4.34	15.86	3.19	0.64	0.43	0.45	0.17	0.00
20	0.05	0.05	1.00	0.45	4.06	61.91	2.68	0.70	0.43	0.49	0.16	0.00
21	0.05	0.05	0.87	1.83	3.92	23.42	2.04	0.97	0.43	0.51	0.16	0.01
22	0.05	0.05	1.01	0.97	9.92	13.89	1.30	0.96	0.42	0.53	0.16	0.01
23	0.05	0.05	0.42	1.36	12.60	9.57	1.22	0.91	0.42	0.58	0.15	0.03
24	0.05	0.08	0.56	5.85	7.84	6.83	1.19	0.67	0.42	0.59	0.15	0.01
25	0.05	0.11	0.35	3.34	37.98	5.39	1.18	0.62	0.42	0.63	0.15	0.00
26	0.05	0.15	0.46	2.81	10.84	4.55	1.20	0.58	0.42	0.68	0.15	0.00
27	0.05	0.18	0.51	1.73	7.32	3.80	1.90	0.54	0.41	1.01	0.15	0.00
28	0.05	0.21	0.52	1.84	5.82	3.34	1.84	0.56	0.41	1.03	0.14	0.00
29	0.05	0.24	0.46	2.48		3.19	1.72	0.56	0.41	0.99	0.12	0.00
30	0.05	0.27	0.44	2.00		2.74	1.66	0.53	0.41	0.95	0.08	0.00
31	0.05		0.44	2.48		3.27		0.48		0.92	0.07	
Max	0.05	0.27	7.20	5.85	85.01	61.91	7.01	1.63	0.48	1.03	0.89	0.13
Min	0.05	0.05	0.28	0.25	2.20	2.07	1.18	0.48	0.41	0.40	0.07	0.00

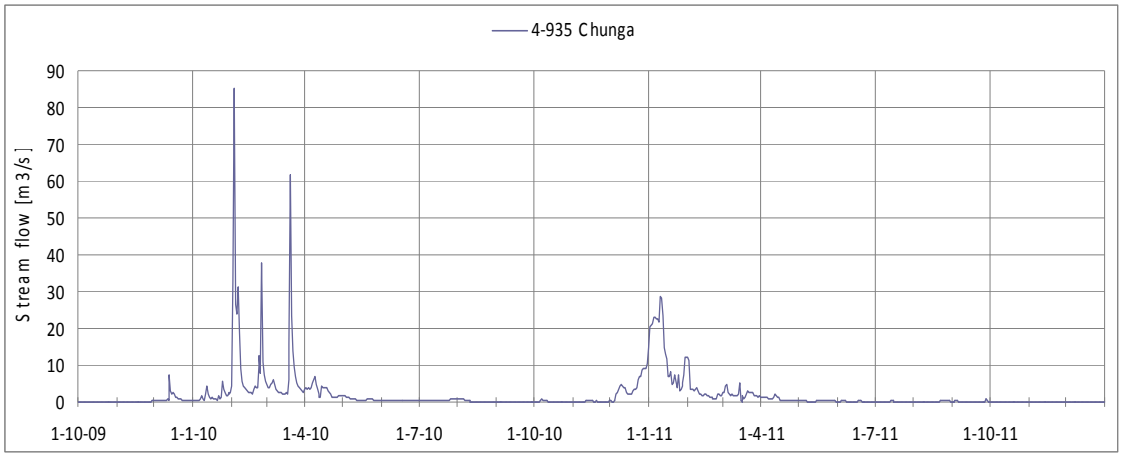

Figure 6 Flow trend on Chunga River at Shandyongo Village

3.2 Mwembeshi River at Mumbwa Road Bridge

Gauge station No.	**4-937**
Location	Latitude 15.272 S, Longitude 28.82078 E, on the left bank
Catchment Area	1,046 km^2
Gauge Type	Graduated plates (0-1.5m, 1.4- 2.9m, 2.8-4.3m), read three times a day
Extreme stage (m)	Maximum: 4.54 Minimum: 0 (historical)
Extreme flow (m^3/s)	Maximum: 31 Minimum: 0 (historical)
Flow regime	Seasonal
Remarks	–
Rating equation	$\boldsymbol{Q = 2.37\ (h - 0.78)^{1.434}}$

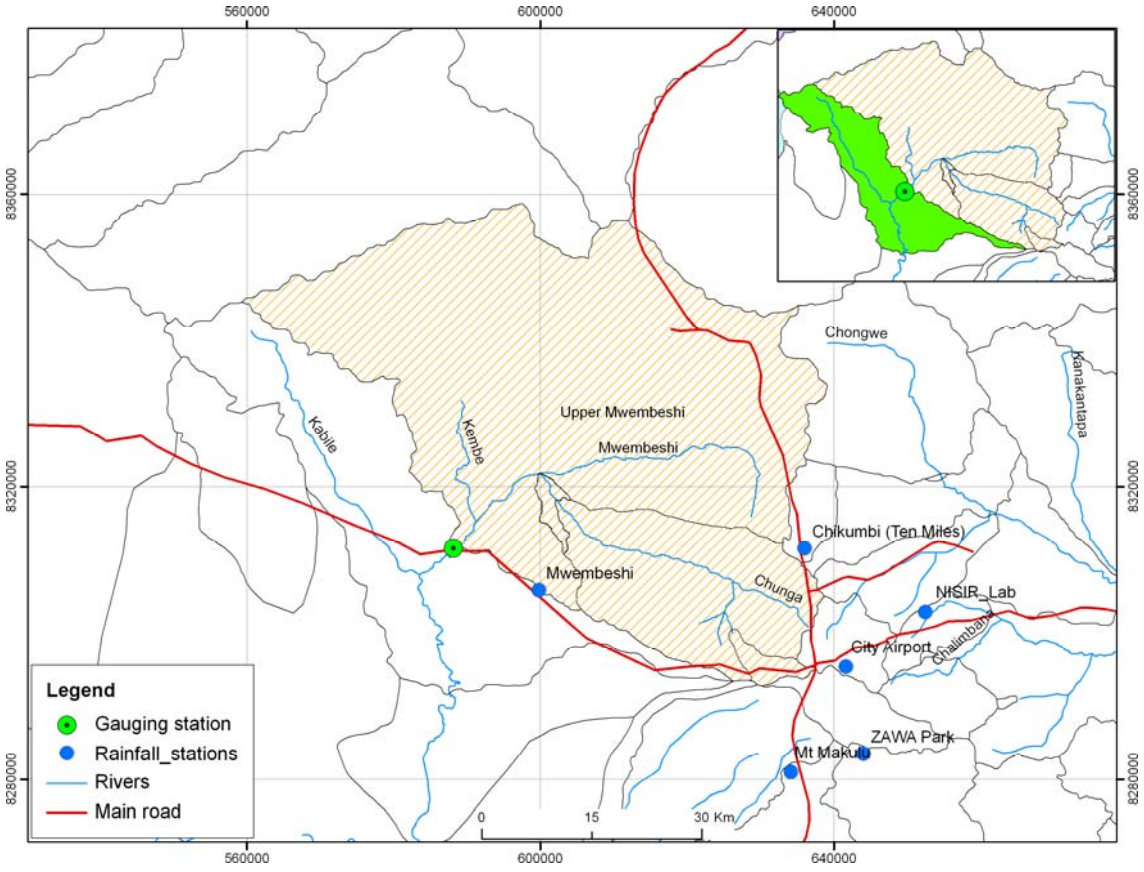

Figure 7 Mwembeshi River catchment at Mumbwa Road Bridge

Table 11 Stage in meters for the period 2009/2010- Mwembeshi

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	no flow	1.42	0.34	1.33	3.62	2.26	-	-	-	-	-
2	-	no flow	1.48	0.34	1.97	3.57	2.14	-	-	-	-	-
3	-	no flow	1.54	0.32	2.53	3.57	1.78	-	-	-	-	-
4	-	no flow	1.53	0.31	2.64	3.26	1.24	-	-	-	-	-
5	-	no flow	1.45	0.27	3.12	2.73	1.21	-	-	-	-	-
6	-	no flow	1.37	x	3.91	2.58	1.24	-	-	-	-	-
7	-	no flow	1.26	x	3.84	2.51	1.16	-	-	-	-	-
8	-	no flow	1.11	x	3.74	2.44	1.05	-	-	-	-	-
9	-	no flow	1.04	x	3.74	2.34	1.06	-	-	-	-	-
10	-	no flow	0.94	x	3.63	2.26	1.03	-	-	-	-	-
11	-	no flow	1.04	1.35	3.45	2.15	1.01	-	-	-	-	-
12	-	no flow	1.31	1.31	3.11	1.94	0.99	-	-	-	-	-
13	-	no flow	1.40	1.64	2.66	1.45	0.93	-	-	-	-	-
14	-	no flow	1.74	1.38	2.04	1.23	0.88	-	-	-	-	-
15	-	no flow	1.71	0.92	1.49	1.13	0.86	-	-	-	-	-
16	-	no flow	1.53	0.82	1.32	1.18	0.83	-	-	-	-	-
17	-	no flow	1.34	0.70	1.22	1.15	0.83	-	-	-	-	-
18	-	no flow	1.18	0.60	1.23	1.19	-	-	-	-	-	-
19	-	no flow	1.01	0.67	1.34	1.59	-	-	-	-	-	-
20	-	no flow	0.78	0.75	1.51	2.57	-	-	-	-	-	-
21	-	1.12	0.66	0.83	1.64	3.12	-	-	-	-	-	-
22	-	1.16	0.60	0.91	1.72	3.82	-	-	-	-	-	-
23	-	1.22	0.52	0.95	1.91	4.14	-	-	-	-	-	-
24	-	1.32	0.58	0.96	2.09	4.05	-	-	-	-	-	-
25	-	1.46	0.54	1.08	2.50	3.90	-	-	-	-	-	-
26	-	1.64	0.51	1.36	2.89	3.72	-	-	-	-	-	-
27	-	1.63	0.51	1.18	3.10	3.47	-	-	-	-	-	-
28	-	1.58	0.48	0.92	3.36	3.21	-	-	-	-	-	-
29	-	1.53	0.46	0.79		2.78	-	-	-	-	-	-
30	-	0.61	0.41	1.21		2.60	-	-	-	-	-	-
31	-		0.36	1.20		2.43	-	-	-	-	-	-
Max	-	-	1.74	1.64	3.91	4.14	-	-	-	-	-	-
Min	-	-	0.36	0.27	1.22	1.13	-	-	-	-	-	-

Note: No stage data collected during 2010/2011

3.3 Chongwe River at Great East Road Bridge

Gauge station No.	**5-025**
Location	Latitude 15.32342 S, Longitude 28.70336 E, on the right bank about 50m downstream on the Great East Road Bridge.
Catchment Area	1,849.7 km^2
Gauge Type	Graduated plates (0-1.5m, 1.4- 2.9m, 2.8-4.3m), read three times a day
Extreme stage (m)	Maximum: 2.90 Minimum: 0.63 (2009 to 2011)
Extreme flow (m^3/s)	Maximum: 53 Minimum: <0.001 (2009 to 2011)
Flow regime	Perennial
Remarks	The station has a long period of data record and is the last station on the Chongwe river**.**
Rating equation	$\boldsymbol{Q = 12.54\ (h - 0.088)^{2.051}}$

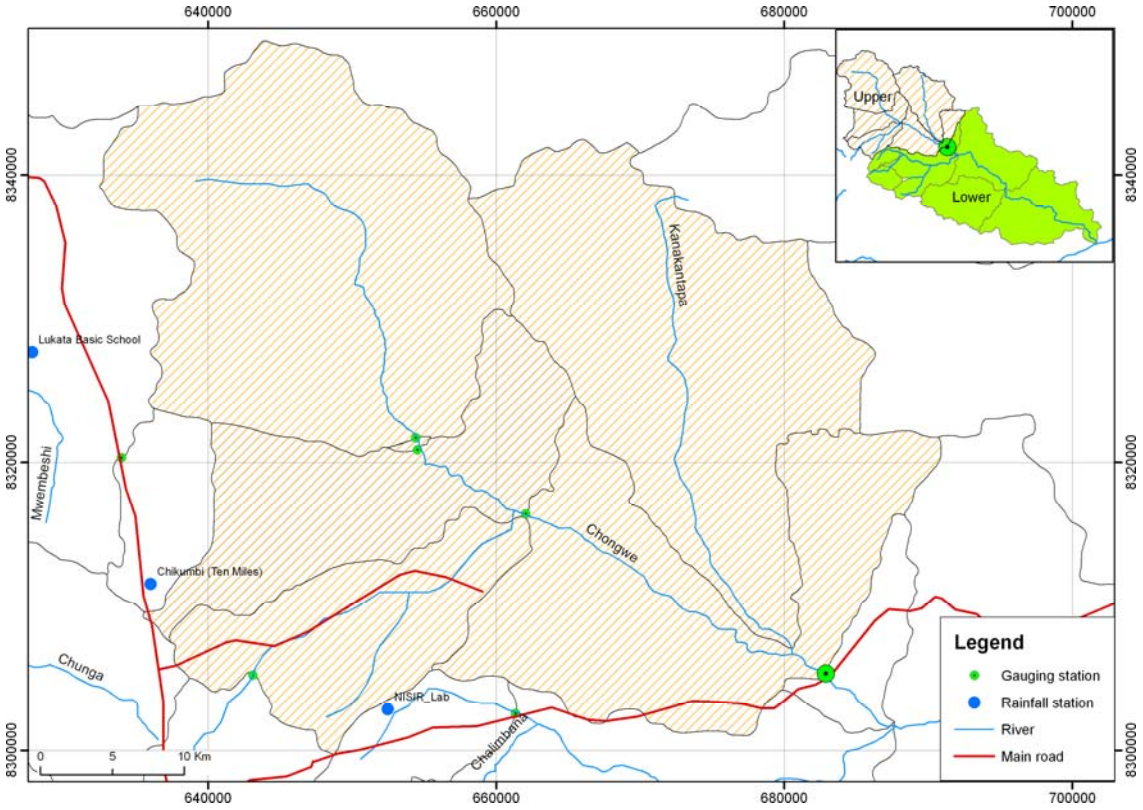

Figure 8 Chongwe River catchment at Great East Road Bridge

Table 12 Stage in meters for the period 2009/2010 - Chongwe

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.92	0.76	1.32	1.36	2.77	2.17	1.61	1.39	1.16	0.75	0.67	-
2	0.91	0.75	1.32	1.35	2.88	2.15	1.58	1.39	1.16	0.81	0.66	-
3	0.93	0.74	1.31	1.32	2.78	2.26	1.58	1.38	1.16	0.80	0.66	-
4	0.86	0.73	1.37	1.30	2.77	2.31	1.63	1.37	1.15	0.79	0.67	-
5	0.88	0.73	1.39	1.29	2.75	2.28	1.56	1.36	1.15	0.82	0.68	-
6	0.87	0.73	1.36	1.43	2.54	2.45	1.55	1.34	1.15	0.82	0.68	-
7	0.96	0.74	1.32	1.40	2.30	2.39	1.54	1.32	1.15	0.78	0.67	-
8	0.97	0.75	1.28	1.70	2.13	2.25	1.56	1.33	1.15	0.76	0.67	-
9	0.96	0.85	1.25	1.70	1.90	2.06	1.55	1.33	1.14	0.76	0.67	-
10	0.96	0.85	1.24	1.58	1.79	2.00	1.53	1.32	1.14	0.76	0.67	-
11	0.95	0.87	1.22	1.50	1.70	1.89	1.51	1.31	1.14	0.76	0.66	-
12	0.99	0.83	1.42	1.50	1.64	1.87	1.49	1.31	1.13	0.75	0.66	-
13	0.98	0.83	1.43	1.59	1.61	1.85	1.47	1.30	1.13	0.75	0.66	-
14	0.97	0.81	1.85	1.48	1.59	1.82	1.47	1.30	1.13	0.76	0.66	-
15	0.96	0.80	2.12	1.39	1.55	1.78	1.46	1.29	1.13	0.76	0.66	-
16	0.94	0.80	1.52	1.44	1.56	1.77	1.45	1.28	1.13	0.74	0.66	-
17	0.90	0.80	1.58	1.41	1.60	1.74	1.44	1.28	1.13	0.74	0.66	-
18	0.86	0.84	1.49	1.44	1.67	1.73	1.43	1.27	1.12	0.74	0.66	-
19	0.83	0.98	1.43	1.44	2.00	1.75	1.43	1.27	1.12	0.73	0.66	-
20	0.82	1.03	1.40	1.39	2.15	2.37	1.42	1.20	1.12	0.72	0.65	-
21	0.81	1.37	1.37	1.40	2.18	2.59	1.42	1.20	1.12	0.72	0.65	-
22	0.85	1.33	1.34	1.38	2.71	2.73	1.41	1.19	1.12	0.71	0.65	-
23	0.85	1.99	1.37	1.37	2.77	2.45	1.41	1.19	1.12	0.71	0.65	-
24	0.83	2.31	1.38	1.37	2.60	2.43	1.41	1.18	1.12	0.70	0.66	-
25	0.83	1.86	1.35	1.38	2.90	2.36	1.40	1.18	1.11	0.69	0.66	-
26	0.82	1.65	1.31	1.42	2.86	1.98	1.40	1.18	1.11	0.69	0.65	-
27	0.79	1.49	1.29	1.45	2.56	1.88	1.40	1.18	1.11	0.69	0.64	-
28	0.78	1.41	1.43	1.50	2.49	1.73	1.40	1.17	1.11	0.69	0.64	-
29	0.77	1.36	1.46	1.52		1.72	1.40	1.17	1.11	0.68	0.64	-
30	0.77	1.32	1.45	1.56		1.69	1.39	1.17	1.11	0.68	0.64	-
31	0.76		1.39	1.85		1.65		1.17		0.67	0.63	
Max	0.99	2.31	2.12	1.85	2.90	2.73	1.63	1.39	1.16	0.82	0.68	-
Min	0.76	0.73	1.22	1.29	1.55	1.65	1.39	1.17	1.11	0.67	0.63	-

Table 13 Stage in meters for the period 2010/2011 - Chongwe

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.44	-	1.35	1.44	1.91	1.54	1.45	1.30	1.15	1.14	1.07	0.99
2	0.43	-	1.35	1.46	1.80	1.55	1.45	1.30	1.15	1.14	1.07	0.99
3	0.66	-	1.34	1.45	1.82	1.62	1.45	1.30	1.13	1.14	1.07	0.99
4	0.41	-	1.34	1.45	1.82	1.67	1.44	1.29	1.12	1.20	1.06	0.99
5	0.40	-	1.33	1.56	1.82	1.65	1.44	1.29	1.12	1.13	1.06	0.99
6	0.40	-	1.33	1.57	1.79	1.62	1.44	1.29	1.12	1.13	1.05	0.99
7	0.39	-	1.25	1.57	1.79	1.62	1.44	1.28	1.11	1.13	1.05	0.98
8	0.39	-	1.23	1.58	1.65	1.61	1.47	1.28	1.11	1.13	1.05	0.98
9	0.38	-	1.22	1.58	1.63	1.61	1.50	1.27	1.10	1.13	1.04	0.97
10	0.38	-	1.21	1.58	1.57	1.61	1.49	1.26	1.04	1.12	1.04	0.97
11	0.37	-	1.21	1.57	1.49	1.61	1.49	1.26	1.09	1.12	1.04	0.96
12	0.36	-	1.20	1.60	1.48	1.77	1.48	1.25	1.09	1.12	1.04	0.94
13	0.36	-	1.20	1.60	1.47	1.74	1.48	1.23	1.09	1.12	1.03	0.93
14	0.35	-	1.96	1.60	1.46	1.67	1.47	1.20	1.09	1.12	1.03	0.92
15	0.33	-	1.89	1.60	1.43	1.66	1.43	1.19	1.09	1.12	1.03	0.92
16	0.33	-	1.79	1.60	1.40	1.66	1.40	1.19	1.09	1.11	1.03	0.92
17	0.34	-	1.70	1.71	1.41	1.58	1.40	1.19	1.09	1.11	1.03	0.91
18	0.33	-	1.64	1.83	1.41	1.66	1.40	1.18	1.09	1.11	1.02	0.91
19	0.33	-	1.56	1.85	1.39	1.65	1.40	1.18	1.10	1.11	1.02	0.91
20	0.33	-	1.49	1.86	1.37	1.65	1.38	1.18	1.11	1.10	1.07	0.92
21	0.33	-	1.49	1.91	1.35	1.65	1.37	1.18	1.12	1.10	1.06	0.93
22	0.32	-	1.48	2.21	1.35	1.64	1.37	1.17	1.12	1.09	1.01	0.92
23	0.32	-	1.45	2.15	1.34	1.63	1.36	1.17	1.13	1.09	1.01	0.89
24	0.32	-	1.45	2.06	1.33	1.63	1.35	1.16	1.13	1.09	1.01	0.88
25	0.32	-	1.45	1.95	1.34	1.58	1.35	1.16	1.13	1.09	1.01	0.88
26	0.31	-	1.43	1.90	1.34	1.55	1.33	1.16	1.13	1.08	1.01	0.87
27	0.30	-	1.43	1.80	1.43	1.55	1.33	1.17	1.14	1.08	1.01	0.87
28	0.29	-	1.43	2.21	1.44	1.57	1.33	1.17	1.14	1.08	1.01	0.86
29	0.29	-	1.42	2.17		1.64	1.33	1.16	1.14	1.08	1.00	0.85
30	0.28	-	1.42	2.10		1.64	1.30	1.16	1.14	1.08	1.00	0.84
31	0.27	-	1.42	1.99		1.61		1.16		1.07	1.00	
Max	0.66	-	1.96	2.21	1.91	1.77	1.50	1.30	1.15	1.20	1.07	0.99
Min	0.27	-	1.20	1.45	1.33	1.55	1.30	1.16	1.04	1.07	1.00	0.84

Table 14 Flow (m^3/s) for the period 2009/2010 – Chongwe

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.02	0.00	2.37	2.82	46.16	21.08	6.51	3.12	0.94	0.00	0.00	-
2	0.01	0.00	2.34	2.65	51.72	20.34	6.04	3.11	0.93	0.00	0.00	-
3	0.03	0.00	2.25	2.37	46.93	24.33	5.97	3.05	0.91	0.00	0.00	-
4	0.00	0.00	2.93	2.12	46.48	26.02	6.94	2.95	0.88	0.00	0.00	-
5	0.00	0.00	3.18	1.98	45.48	24.84	5.75	2.79	0.87	0.00	0.00	-
6	0.00	0.00	2.77	3.66	35.23	31.47	5.45	2.57	0.86	0.00	0.00	-
7	0.08	0.00	2.32	3.22	25.60	29.17	5.27	2.33	0.85	0.00	0.00	-
8	0.10	0.00	1.96	8.24	19.84	24.03	5.60	2.44	0.83	0.00	0.00	-
9	0.07	0.00	1.66	8.36	13.10	17.67	5.58	2.42	0.81	0.00	0.00	-
10	0.07	0.00	1.51	6.01	10.27	15.94	5.12	2.33	0.79	0.00	0.00	-
11	0.06	0.00	1.36	4.71	8.43	12.79	4.93	2.21	0.78	0.00	0.00	-
12	0.14	0.00	3.57	4.67	7.21	12.16	4.48	2.18	0.74	0.00	0.00	-
13	0.11	0.00	3.73	6.22	6.60	11.89	4.29	2.14	0.74	0.00	0.00	-
14	0.10	0.00	11.77	4.36	6.19	10.92	4.24	2.09	0.74	0.00	0.00	-
15	0.08	0.00	19.48	3.16	5.56	10.05	4.17	2.01	0.73	0.00	0.00	-
16	0.04	0.00	5.04	3.85	5.64	9.86	3.95	1.87	0.72	0.00	0.00	-
17	0.00	0.00	6.06	3.47	6.39	9.13	3.77	1.88	0.71	0.00	0.00	-
18	0.00	0.00	4.54	3.79	7.77	8.96	3.72	1.86	0.69	0.00	0.00	-
19	0.00	0.10	3.74	3.75	15.84	9.53	3.66	1.79	0.69	0.00	0.00	-
20	0.00	0.26	3.28	3.20	20.48	28.54	3.57	1.18	0.68	0.00	0.00	-
21	0.00	2.94	2.92	3.24	21.56	37.81	3.50	1.18	0.68	0.00	0.00	-
22	0.00	2.44	2.50	2.99	43.38	44.42	3.45	1.12	0.67	0.00	0.00	-
23	0.00	15.67	2.92	2.86	46.23	31.79	3.42	1.10	0.66	0.00	0.00	-
24	0.00	25.96	3.01	2.88	37.99	30.91	3.38	1.08	0.65	0.00	0.00	-
25	0.00	12.12	2.63	2.97	52.97	27.94	3.25	1.07	0.64	0.00	0.00	-
26	0.00	7.34	2.23	3.49	51.03	15.20	3.30	1.04	0.64	0.00	0.00	-
27	0.00	4.50	2.06	3.96	36.32	12.56	3.23	1.03	0.63	0.00	0.00	-
28	0.00	3.39	3.64	4.67	33.08	9.04	3.25	1.01	0.63	0.00	0.00	-
29	0.00	2.82	4.14	4.95		8.83	3.22	0.99	0.62	0.00	0.00	-
30	0.00	2.37	3.92	5.67		8.21	3.11	0.97	0.63	0.00	0.00	-
31	0.00		3.16	11.89		7.43		0.96		0.00	0.00	
Max	0.14	25.96	19.48	11.89	52.97	44.42	6.94	3.12	0.94	0.00	0.00	-
Min	0.00	0.00	1.36	1.98	5.56	7.43	3.11	0.96	0.62	0.00	0.00	-

Table 15 Flow (m3/s) for the period 2010/2011 - Chongwe.

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	0.00	2.67	3.85	13.42	5.35	3.99	3.12	0.94	0.62	0.24	0.12
2	0.00	0.00	2.65	4.08	10.62	5.50	3.92	3.11	0.93	0.99	0.24	0.12
3	0.23	0.00	2.58	4.02	10.93	6.67	3.89	3.05	0.91	0.91	0.23	0.11
4	0.00	0.00	2.52	4.03	11.14	7.71	3.88	2.95	0.88	0.86	0.25	0.11
5	0.00	0.00	2.49	5.74	11.12	7.30	3.83	2.79	0.87	1.03	0.27	0.11
6	0.00	0.00	2.41	5.78	10.44	6.72	3.79	2.57	0.86	1.03	0.28	0.10
7	0.00	0.00	1.59	5.93	10.40	6.68	3.79	2.33	0.85	0.79	0.25	0.10
8	0.00	0.00	1.45	5.96	7.26	6.62	4.22	2.44	0.83	0.70	0.24	0.09
9	0.00	0.00	1.36	5.95	6.96	6.52	4.76	2.42	0.81	0.65	0.24	0.09
10	0.00	0.00	1.32	5.98	5.87	6.51	4.56	2.33	0.79	0.68	0.24	0.09
11	0.00	0.00	1.28	5.91	4.53	6.50	4.56	2.21	0.78	0.65	0.24	0.08
12	0.00	0.00	1.25	6.36	4.34	9.93	4.46	2.18	0.74	0.60	0.24	0.08
13	0.00	0.00	1.19	6.44	4.23	9.13	4.39	2.14	0.74	0.61	0.23	0.07
14	0.00	0.00	14.80	6.38	4.07	7.67	4.23	2.09	0.74	0.66	0.22	0.07
15	0.00	0.00	12.78	6.33	3.69	7.63	3.69	2.02	0.73	0.70	0.21	0.07
16	0.00	0.00	10.29	6.33	3.30	7.61	3.34	1.87	0.73	0.59	0.22	0.06
17	0.00	0.00	8.35	8.61	3.43	5.99	3.24	1.88	0.71	0.57	0.23	0.06
18	0.00	0.00	7.14	11.34	3.37	7.46	3.22	1.86	0.69	0.55	0.21	0.05
19	0.00	0.00	5.75	11.66	3.19	7.36	3.22	1.79	0.69	0.50	0.21	0.05
20	0.00	0.00	4.62	12.09	2.93	7.32	3.01	1.18	0.68	0.48	0.19	0.05
21	0.00	0.00	4.47	13.26	2.70	7.25	2.91	1.18	0.68	0.45	0.18	0.04
22	0.00	0.00	4.34	22.33	2.63	7.05	2.87	1.12	0.67	0.42	0.18	0.04
23	0.00	0.00	3.97	20.49	2.50	7.03	2.78	1.10	0.66	0.39	0.20	0.03
24	0.00	0.00	4.02	17.67	2.49	6.95	2.65	1.08	0.65	0.36	0.21	0.03
25	0.00	0.38	3.91	14.38	2.50	5.96	2.64	1.07	0.64	0.35	0.21	0.02
26	0.00	0.76	3.71	13.16	2.51	5.58	2.49	1.04	0.64	0.32	0.20	0.02
27	0.00	1.14	3.64	10.58	3.61	5.53	2.48	1.03	0.63	0.31	0.18	0.02
28	0.00	1.53	3.62	22.58	3.85	5.81	2.44	1.01	0.63	0.31	0.15	0.01
29	0.00	1.91	3.58	21.18		7.22	2.38	0.99	0.62	0.31	0.15	0.01
30	0.00	2.29	3.56	18.78		7.17	2.16	0.97	0.63	0.29	0.17	0.00
31	0.00		3.50	15.39		6.61		0.96		0.24	0.13	
Max	0.23	2.29	14.80	22.58	13.42	9.93	4.76	3.12	0.94	1.03	0.28	0.12
Min	0.00	0.00	1.19	4.02	2.49	5.50	2.16	0.96	0.62	0.24	0.13	0.00

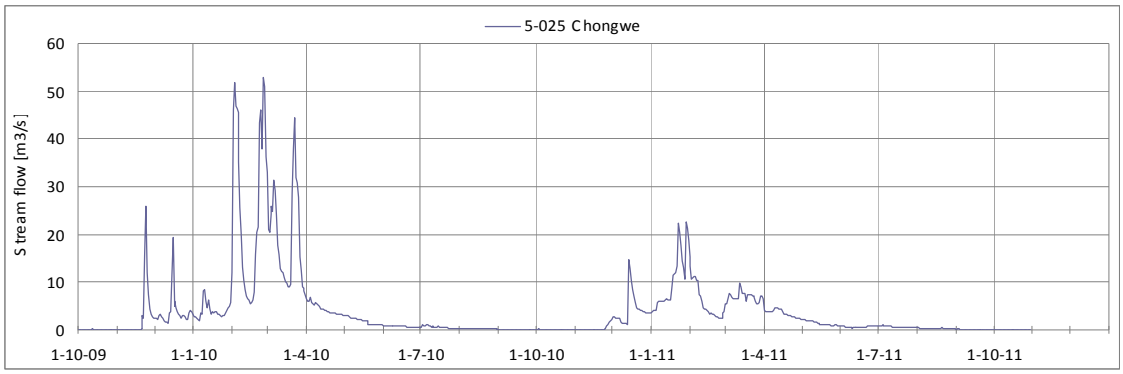

Figure 9 Flow trend on Chongwe River at Great East Road Bridge (2009-2011)

3.4 Ngwerere River at Estate Weir

Gauge station No.	**5-016**				
Location	Latitude 15.32694 S, Longitude 28.33294 E, on the left bank				
Catchment Area	109.4 km^2				
Gauge Type	Graduated plates (0-1.5m, 1.4- 2.9m, 2.8-4.3m), read three times a day				
Extreme stage (m)	Maximum:	1.57	Minimum:	0.32	(2009 to 2011)
Extreme flow (m^3/s)	Maximum:	19.6	Minimum:	0.02	(2009 to 2011)
Flow regime	Perennial				
Remarks	–				
Rating equation	$\boldsymbol{Q = 12.84\ (h - 0.24)^{1.470}}$ for h > 0.65m and $\boldsymbol{Q = 69.04\ (h - 0.24)^{3.196}}$ for h < 0.65m				

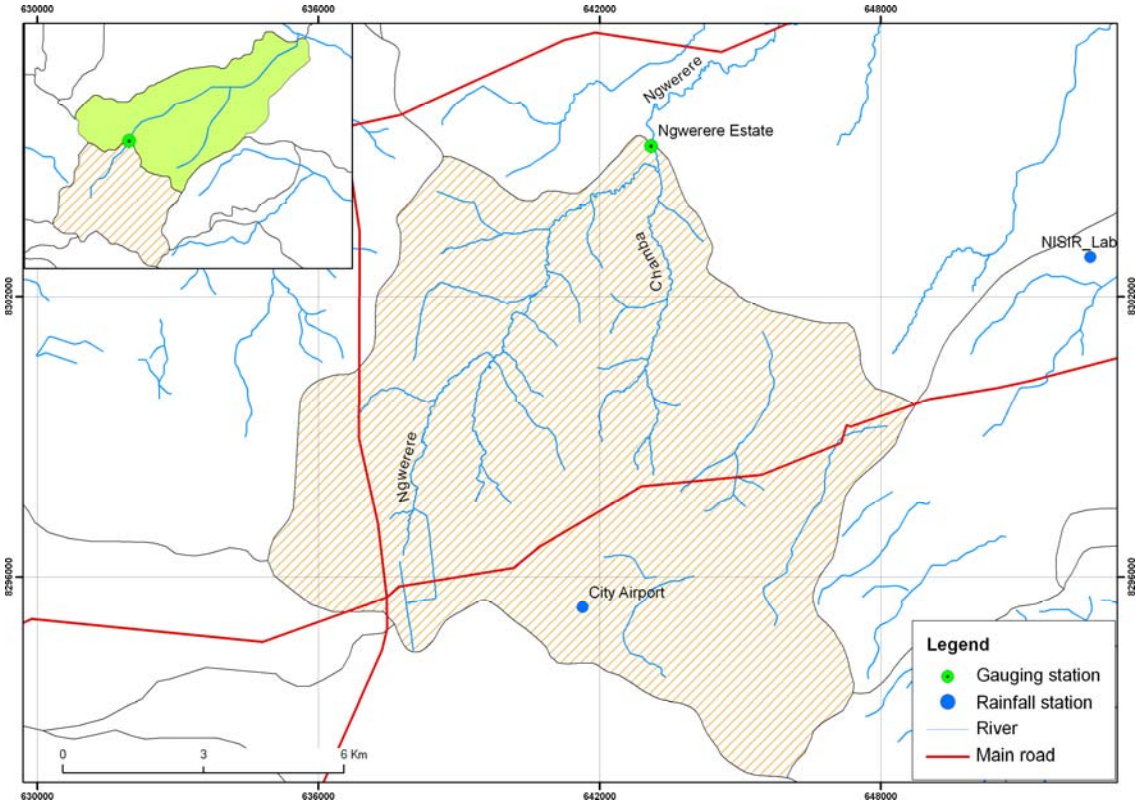

Figure 10 Ngwerere River sub-catchment at Estate Weir

Table 16 Stage in meters for the period 2009/2010- Ngwerere

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.38	0.37	0.56	0.57	1.21	1.26	0.64	0.56	0.47	0.45	0.45	0.54
2	0.38	0.39	0.55	0.56	1.35	0.78	0.67	0.57	0.46	0.46	0.44	0.53
3	0.38	0.38	0.55	0.56	1.46	0.88	0.67	0.58	0.47	0.44	0.46	0.55
4	0.37	0.37	0.58	0.61	0.91	0.91	0.66	0.58	0.46	0.46	0.44	0.48
5	0.37	0.38	0.55	0.57	0.87	0.86	0.65	0.58	0.47	0.46	0.47	0.47
6	0.37	0.38	0.53	0.56	0.98	0.83	0.65	0.57	0.47	0.47	0.48	0.48
7	0.37	0.36	0.53	0.56	0.82	0.83	0.65	0.56	0.49	0.48	0.45	0.46
8	0.37	0.36	0.53	0.55	0.76	0.72	0.64	0.57	0.47	0.46	0.46	0.58
9	0.37	0.35	0.54	0.57	0.69	0.67	0.67	0.58	0.49	0.47	0.44	0.50
10	0.40	0.35	0.54	0.56	0.59	0.67	0.62	0.63	0.46	0.44	0.44	0.52
11	0.40	0.37	0.55	0.62	0.61	0.63	0.64	0.63	0.46	0.46	0.44	0.56
12	0.39	0.37	0.57	0.75	0.59	0.62	0.65	0.62	0.47	0.46	0.46	0.58
13	0.38	0.35	0.55	0.67	0.56	0.60	0.64	0.57	0.48	0.45	0.45	0.48
14	0.37	0.35	0.54	0.55	0.55	0.97	0.64	0.56	0.46	0.45	0.44	0.48
15	0.37	0.36	0.52	0.70	0.59	0.84	0.66	0.56	0.45	0.44	0.45	0.52
16	0.36	0.36	0.52	1.06	0.74	0.94	0.66	0.55	0.46	0.45	0.45	0.50
17	0.36	0.36	0.53	0.76	1.13	1.44	0.67	0.57	0.50	0.46	0.45	0.55
18	0.36	0.35	0.54	0.91	1.41	1.44	0.67	0.57	0.49	0.44	0.44	0.52
19	0.37	0.37	0.56	0.85	1.27	1.19	0.68	0.58	0.50	0.47	0.44	0.46
20	0.36	0.41	0.57	0.61	1.00	1.33	0.67	0.60	0.48	0.43	0.45	0.48
21	0.35	1.11	0.57	0.55	0.93	1.15	0.66	0.62	0.48	0.43	0.45	0.47
22	0.40	0.81	0.55	0.67	1.08	0.83	0.65	0.62	0.47	0.45	0.44	0.44
23	0.36	0.84	0.56	0.74	1.57	0.79	0.66	0.57	0.48	0.44	0.46	0.44
24	0.37	0.78	0.58	0.82	0.92	0.66	0.66	0.56	0.49	0.45	0.47	0.45
25	0.36	0.94	0.57	0.64	1.16	0.65	0.65	0.57	0.48	0.45	0.44	0.43
26	0.34	0.83	0.55	0.57	0.94	0.62	0.58	0.53	0.46	0.45	0.45	0.47
27	0.36	0.83	0.66	0.70	1.05	0.58	0.57	0.55	0.46	0.45	0.46	0.46
28	0.35	0.85	0.56	0.69	0.71	0.56	0.57	0.56	0.48	0.44	0.43	0.46
29	0.35	0.61	0.54	0.68		0.59	0.56	0.56	0.47	0.43	0.44	0.47
30	0.35	0.56	0.54	0.70		0.56	0.56	0.54	0.46	0.45	0.45	0.46
31	0.35		0.53	0.94		0.57		0.54			0.45	
Max	0.40	1.11	0.66	1.06	1.57	1.44	0.68	0.63	0.50	0.48	0.48	0.58
Min	0.34	0.35	0.52	0.55	0.55	0.56	0.56	0.53	0.45	0.43	0.43	0.43

Table 17 Stage in meters for the period 2010/2011- Ngwerere

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.464	0.44	-	0.94	0.91	0.80	0.61	0.55	0.54	0.47	0.44	-
2	0.48	0.43	-	0.86	0.92	0.76	0.60	0.55	0.54	0.49	0.47	-
3	0.46	0.49	-	0.80	0.93	0.85	0.74	0.57	0.59	0.49	0.46	-
4	0.46	0.47	-	1.19	0.93	0.94	0.58	0.72	0.55	0.46	0.47	-
5	0.44	0.44	-	0.87	0.94	0.88	0.63	0.62	0.52	0.47	0.47	-
6	0.45	0.41	-	1.08	0.77	0.87	0.65	0.61	0.49	0.46	0.46	-
7	0.46	0.42	-	1.13	0.94	0.77	0.60	0.65	0.48	0.48	0.46	-
8	0.49	0.41	-	0.81	0.79	0.74	0.57	0.57	0.53	0.47	0.45	-
9	0.46	0.45	-	0.86	0.84	0.94	0.60	0.56	0.53	0.48	0.47	-
10	0.46	0.39	-	0.90	0.87	0.81	0.60	0.56	0.49	0.46	0.49	-
11	0.44	1.08	-	0.78	0.81	0.78	0.43	0.54	0.49	0.45	0.49	-
12	0.44	0.69	-	0.80	0.78	0.83	0.63	0.63	0.53	0.46	0.47	-
13	0.45	0.45	-	0.80	0.78	0.77	0.57	0.57	0.47	0.49	0.45	-
14	0.44	0.44	-	0.83	0.82	0.73	0.60	0.55	0.48	0.47	0.44	-
15	0.43	0.41	-	0.97	0.77	0.69	0.57	0.56	0.50	0.47	0.44	-
16	0.45	0.39	-	0.86	0.72	0.76	0.62	0.56	0.52	0.48	0.43	-
17	0.46	0.38	-	0.95	0.73	0.85	0.60	0.55	0.53	0.47	0.43	-
18	0.45	0.38	-	1.29	0.67	0.90	0.55	0.62	0.53	0.46	0.44	-
19	0.45	0.36	-	1.03	0.67	0.87	0.60	0.54	0.48	0.45	0.45	-
20	0.45	0.36	-	1.54	0.67	0.83	0.55	0.54	0.46	0.47	0.44	-
21	0.44	0.37	-	0.95	0.58	0.77	0.57	0.63	0.52	0.46	0.44	-
22	0.43	0.35	-	0.86	0.56	0.75	0.55	0.56	0.46	0.44	0.44	-
23	0.45	0.34	-	0.82	0.56	0.83	0.55	0.58	0.50	0.44	0.46	-
24	0.44	0.37	-	0.95	0.59	0.91	0.54	0.56	0.45	0.45	0.44	-
25	0.45	0.38	-	0.86	0.76	0.86	0.57	0.57	0.45	0.47	0.46	-
26	0.45	0.35	-	0.81	0.69	0.84	0.57	0.65	0.49	0.48	0.48	-
27	0.44	0.34	-	0.85	0.63	0.78	0.58	0.65	0.52	0.48	0.45	-
28	0.45	0.35	-	0.86	0.67	0.76	0.59	0.60	0.51	0.46	0.44	-
29	0.45	0.34	-	0.86		0.75	0.58	0.55	0.48	0.45	0.46	-
30	0.44	0.32	-	0.87		0.69	0.59	0.53	0.46	0.44	0.46	-
31	0.44	0.39	-	-		0.67		0.57		0.45	0.44	-
Max	0.49	1.08	-	-	0.94	0.94	0.74	0.72	0.59	0.49	0.49	-
Min	0.43	0.32	-	-	0.56	0.67	0.43	0.53	0.45	0.44	0.43	-

Table 18 Flow (m^3/s) for the period 2009/2010 - Ngwerere

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.12	0.11	1.85	2.06	12.30	13.16	3.74	1.90	0.64	0.48	0.44	1.40
2	0.12	0.15	1.70	1.88	15.02	5.20	3.76	1.92	0.53	0.52	0.42	1.31
3	0.14	0.13	1.67	1.86	17.13	6.71	3.75	2.10	0.64	0.43	0.53	1.67
4	0.11	0.10	2.12	2.88	7.10	7.19	3.65	2.10	0.54	0.53	0.43	0.72
5	0.11	0.13	1.70	2.09	6.58	6.39	3.52	2.27	0.61	0.58	0.61	0.61
6	0.10	0.13	1.35	1.81	8.23	5.87	3.50	2.01	0.67	0.64	0.74	0.73
7	0.11	0.09	1.26	1.76	5.81	5.97	3.87	1.90	0.87	0.69	0.50	0.54
8	0.11	0.08	1.38	1.65	4.92	4.33	3.60	2.05	0.67	0.58	0.53	2.25
9	0.09	0.06	1.41	1.97	3.98	3.75	3.65	2.10	0.80	0.64	0.43	0.91
10	0.19	0.07	1.54	1.82	2.38	3.72	3.24	3.43	0.57	0.43	0.39	1.14
11	0.18	0.09	1.57	3.14	2.88	3.33	3.81	3.37	0.59	0.55	0.41	1.79
12	0.15	0.09	1.92	4.75	2.31	3.26	3.50	3.17	0.63	0.55	0.52	2.20
13	0.12	0.06	1.67	3.76	1.82	2.62	3.77	2.09	0.72	0.50	0.48	0.73
14	0.11	0.06	1.54	1.57	1.65	8.03	3.81	1.88	0.51	0.44	0.43	0.70
15	0.09	0.09	1.24	4.12	2.32	6.12	3.62	1.88	0.48	0.43	0.51	1.25
16	0.09	0.08	1.13	9.52	4.62	7.66	3.56	1.70	0.56	0.48	0.50	0.98
17	0.07	0.09	1.26	4.86	10.87	16.86	3.75	2.01	0.90	0.53	0.45	1.70
18	0.09	0.06	1.50	7.05	16.24	16.75	3.76	2.08	0.87	0.40	0.41	1.16
19	0.10	0.09	1.88	6.25	13.46	11.93	3.80	2.17	0.89	0.61	0.43	0.54
20	0.09	0.24	2.04	2.91	8.52	14.51	3.65	2.72	0.71	0.37	0.45	0.76
21	0.06	10.49	1.92	1.58	7.51	11.13	3.58	3.12	0.75	0.37	0.50	0.64
22	0.18	5.61	1.70	3.77	9.91	5.88	3.52	3.08	0.67	0.46	0.41	0.41
23	0.09	6.06	1.85	4.68	19.59	5.34	3.55	2.08	0.74	0.43	0.52	0.43
24	0.09	5.26	2.28	5.81	7.21	3.60	3.55	1.88	0.85	0.50	0.63	0.50
25	0.07	7.55	1.92	3.81	11.38	3.50	3.51	1.91	0.71	0.45	0.43	0.35
26	0.05	5.94	1.70	2.09	7.55	3.08	2.27	1.37	0.55	0.45	0.46	0.64
27	0.08	5.94	3.54	4.16	9.37	2.16	2.09	1.72	0.57	0.45	0.53	0.52
28	0.06	6.24	1.88	4.02	4.24	1.77	2.05	1.87	0.70	0.40	0.37	0.59
29	0.06	2.95	1.50	3.81		2.32	1.88	1.76	0.59	0.37	0.40	0.67
30	0.06	1.88	1.41	4.09		1.88	1.87	1.55	0.57	0.47	0.48	0.57
31	0.07		1.38	7.55		1.95		1.40			0.45	
Max	0.19	10.49	3.54	9.52	19.59	16.86	3.87	3.43	0.90	0.69	0.74	2.25
Min	0.05	0.06	1.13	1.57	1.65	1.77	1.87	1.37	0.48	0.37	0.37	0.35

Table 19 Flow (m^3/s) for the period 2010/2011 - Ngwerere

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.58	0.40	-	7.62	7.07	5.48	2.96	1.70	1.53	0.61	0.42	-
2	0.72	0.34	-	6.32	7.32	4.92	2.75	1.61	1.46	0.79	0.62	-
3	0.56	0.86	-	5.44	7.48	6.14	4.63	1.95	2.47	0.80	0.57	-
4	0.52	0.62	-	11.83	7.48	7.52	2.28	4.33	1.70	0.57	0.60	-
5	0.43	0.38	-	6.50	7.66	6.66	3.37	3.10	1.25	0.65	0.66	-
6	0.47	0.23	-	9.94	5.00	6.58	3.89	3.00	0.80	0.53	0.57	-
7	0.55	0.29	-	10.84	7.66	5.01	2.73	3.50	0.74	0.70	0.56	-
8	0.83	0.26	-	5.66	5.34	4.64	1.92	2.01	1.30	0.64	0.49	-
9	0.58	0.47	-	6.42	5.99	7.60	2.56	1.82	1.32	0.70	0.62	-
10	0.53	0.16	-	6.90	6.47	5.63	2.56	1.73	0.84	0.52	0.78	-
11	0.39	9.86	-	5.24	5.65	5.20	0.33	1.50	0.86	0.50	0.81	-
12	0.38	3.95	-	5.49	5.14	5.98	3.33	3.33	1.30	0.56	0.61	-
13	0.45	0.49	-	5.44	5.15	5.10	2.01	2.09	0.66	0.87	0.50	-
14	0.43	0.37	-	5.91	5.83	4.55	2.72	1.59	0.75	0.67	0.43	-
15	0.36	0.24	-	8.10	5.01	4.03	1.93	1.76	0.94	0.67	0.39	-
16	0.48	0.16	-	6.42	4.42	4.97	3.01	1.80	1.22	0.73	0.37	-
17	0.58	0.13	-	7.77	4.55	6.21	2.64	1.69	1.26	0.62	0.37	-
18	0.49	0.12	-	13.77	3.72	6.95	1.69	3.07	1.33	0.53	0.41	-
19	0.51	0.09	-	9.15	3.72	6.47	2.75	1.55	0.74	0.45	0.48	-
20	0.47	0.07	-	18.97	3.68	5.97	1.68	1.48	0.57	0.65	0.41	-
21	0.37	0.10	-	7.74	2.12	5.06	1.96	3.54	1.14	0.55	0.39	-
22	0.37	0.06	-	6.33	1.83	4.84	1.67	1.80	0.59	0.41	0.43	-
23	0.45	0.04	-	5.83	1.88	5.97	1.60	2.30	0.91	0.38	0.54	-
24	0.43	0.10	-	7.77	2.52	7.10	1.44	1.83	0.44	0.44	0.37	-
25	0.50	0.14	-	6.39	4.92	6.43	2.02	1.95	0.51	0.61	0.52	-
26	0.50	0.07	-	5.59	3.94	6.06	2.08	3.52	0.82	0.69	0.70	-
27	0.41	0.04	-	6.20	3.54	5.22	2.20	3.51	1.19	0.71	0.50	-
28	0.45	0.07	-	6.38	3.76	4.91	2.44	2.67	1.01	0.55	0.40	-
29	0.47	0.04	-	6.33		4.81	2.23	1.60	0.74	0.48	0.55	-
30	0.43	0.02	-	6.55		4.00	2.35	1.32	0.58	0.41	0.54	-
31	0.43	0.18	-	-		3.72		1.93		0.45	0.38	
Max	0.83	9.86	-	-	7.66	7.60	4.63	4.33	2.47	0.87	0.81	-
Min	0.36	0.02	-	-	1.83	3.72	0.33	1.32	0.44	0.38	0.37	-

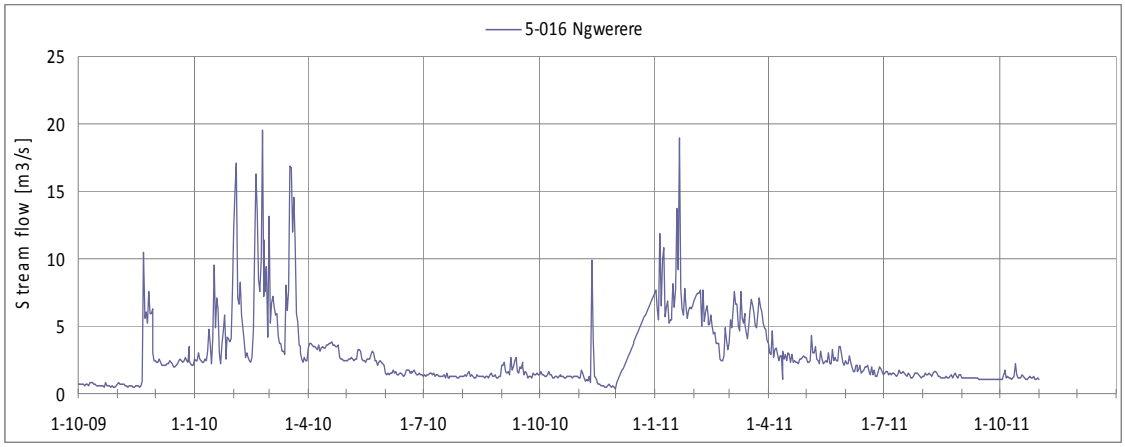

Figure 11 Flow trend on Ngwerere River at Estate Weir (2009-2011)

3.5 Chalimbana River at Romor Farm

Gauge station No.	5-029
Location	Latitude 15.40597 S, Longitude 28.46300 E, on the left bank
Catchment Area	114.6 km^2
Gauge Type	Graduated plates (0-1.5m, 1.4- 2.9m, 2.8-4.3m), read three times day
Extreme stage (m)	Maximum: 1.58 Minimum: 0.37 (2009 to 2011)
Extreme flow (m^3/s)	Maximum: 6.0 Minimum: 0.05 (2009 to 2011)
Flow regime	Perennial
Remarks	–
Rating equation	$\boldsymbol{Q = 4.21\ (h - 0.32)^{1.507}}$

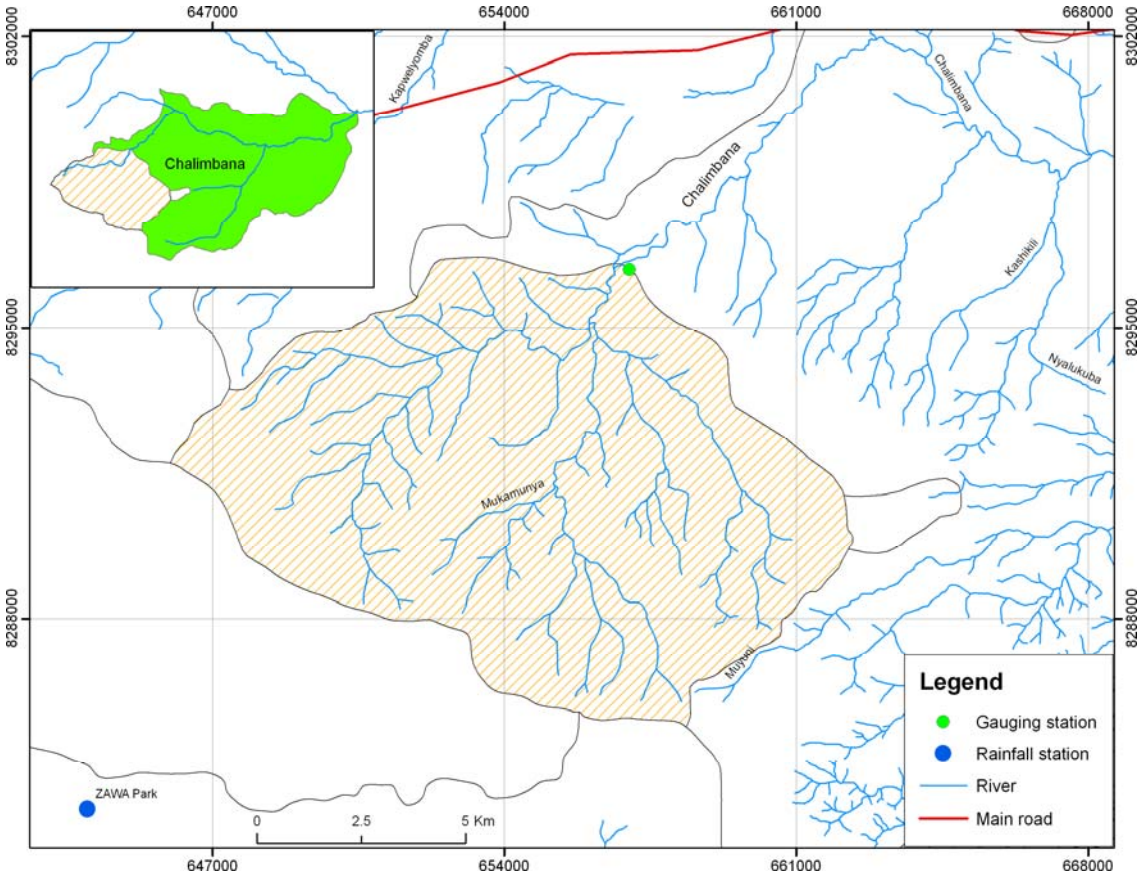

Figure 12 Chalimbana River catchment at Romor Farm

Table 20 Stage in meters for the period 2009/2010- Chalimbana

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.42	0.40	0.44	0.44	0.63	1.00	0.65	-	-	-	0.49	0.48
2	0.42	0.39	0.48	0.44	0.90	0.89	0.64	-	-	-	0.50	0.48
3	0.42	0.39	0.49	0.43	0.76	1.05	0.63	-	-	-	0.50	0.44
4	0.44	0.39	0.48	0.43	1.54	1.11	0.62	-	-	-	0.49	0.48
5	0.42	0.39	0.46	0.43	1.15	1.58	0.62	-	-	-	0.49	0.44
6	0.42	0.40	0.46	0.48	0.87	1.16	0.62	-	-	-	0.49	0.45
7	0.42	0.40	0.46	0.48	0.80	1.00	0.62	-	-	-	0.48	0.48
8	0.42	0.40	0.44	0.45	0.62	0.93	0.60	-	-	-	0.49	0.48
9	0.42	0.40	0.44	0.44	0.54	0.95	0.58	-	-	-	0.48	0.48
10	0.41	0.40	0.43	0.44	0.54	0.82	0.58	-	-	-	0.49	0.48
11	0.41	0.40	0.43	0.43	0.52	0.81	0.58	-	-	-	0.48	0.48
12	0.40	0.41	0.55	0.42	0.52	0.72	0.58	-	-	-	0.48	0.50
13	0.40	0.42	0.59	0.42	0.52	0.73	0.58	-	-	-	0.48	0.49
14	0.40	0.42	0.65	0.42	0.50	0.71	0.58	-	-	-	0.47	0.50
15	0.41	0.42	0.70	0.42	0.49	0.72	0.57	-	-	-	0.47	0.49
16	0.41	0.43	0.52	0.42	0.52	0.70	0.56	-	-	-	0.47	0.46
17	0.41	0.46	0.49	0.43	0.52	0.67	0.56	-	-	-	0.46	0.46
18	0.41	0.46	0.47	0.42	0.84	0.94	0.56	-	-	-	0.46	0.49
19	0.41	0.45	0.46	0.43	0.65	0.83	0.56	-	-	-	0.47	0.48
20	0.41	0.45	0.46	0.42	0.65	0.94	0.55	-	-	-	0.46	0.48
21	0.40	0.79	0.44	0.42	0.69	0.84	0.55	-	-	-	0.49	0.49
22	0.41	0.54	0.45	0.42	0.74	0.84	0.55	-	-	-	0.48	0.49
23	0.41	0.98	0.45	0.45	0.67	0.75	0.56	-	-	-	0.46	0.49
24	0.41	0.61	0.44	0.53	0.65	0.71	0.54	-	-	-	0.47	0.47
25	0.41	0.50	0.44	0.44	1.34	0.69	0.55	-	-	-	0.47	0.50
26	0.40	0.47	0.44	0.45	1.32	0.66	0.54	-	-	-	0.47	0.46
27	0.40	0.45	0.44	0.44	1.19	0.72	0.54	-	-	-	0.47	0.50
28	0.40	0.45	0.44	0.44	1.12	0.68	-	-	-	-	0.48	0.48
29	0.40	0.47	0.44	0.44		0.66	-	-	-	-	0.47	0.48
30	0.40	0.46	0.44	0.46		0.66	-	-	-	-	0.48	0.48
31	0.40		0.44	0.58		0.65		-	-	-	0.48	
Max	0.44	0.98	0.70	0.58	1.54	1.58	-	-	-	-	0.50	-
Min	0.40	0.39	0.43	0.42	0.49	0.65	-	-	-	-	0.46	-

Table 21 Stage in meters for the period 2010/2011- Chalimbana

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.47	0.44	0.44	0.51	0.58	0.54	0.54	0.42	0.40	0.42	0.46	-
2	0.48	0.46	0.44	0.57	0.54	0.54	0.55	0.42	0.40	0.42	0.46	-
3	0.48	0.47	0.45	0.50	0.54	0.54	0.53	0.42	0.39	0.44	0.46	-
4	0.48	0.47	0.49	0.50	0.54	0.53	0.53	0.42	0.43	0.44	0.46	-
5	0.48	0.46	0.66	0.50	0.52	0.53	0.52	0.42	0.42	0.44	0.46	-
6	0.48	0.45	0.57	0.46	0.52	0.60	0.52	0.42	0.41	0.44	0.46	-
7	0.47	0.45	0.72	0.46	0.50	0.51	0.49	0.42	0.42	0.44	0.42	-
8	0.48	0.44	0.75	0.50	0.50	0.51	0.50	0.42	0.44	0.45	0.40	-
9	0.49	0.45	1.21	0.50	0.50	0.50	0.50	0.42	0.42	0.45	0.40	-
10	0.49	0.44	0.78	0.52	0.50	0.49	0.50	0.42	0.40	0.44	0.43	-
11	0.48	0.47	0.62	0.52	0.48	0.48	0.50	0.47	0.42	0.45	0.38	-
12	0.48	0.49	0.62	0.51	0.46	0.51	0.49	0.42	0.42	0.43	0.45	-
13	0.49	0.47	0.63	0.51	0.46	0.63	0.53	0.41	0.41	0.45	0.43	-
14	0.48	0.46	0.56	0.54	0.45	0.52	0.50	0.40	0.42	0.43	0.44	-
15	0.48	0.44	0.54	0.53	0.48	0.52	0.51	0.37	0.42	0.45	0.44	-
16	0.48	0.44	0.52	0.52	0.46	0.52	0.50	0.39	0.42	0.46	0.43	-
17	0.47	0.44	0.52	0.52	0.47	0.51	0.50	0.39	0.42	0.46	0.43	-
18	0.47	0.44	0.52	0.52	0.45	0.52	0.50	0.39	0.42	0.44	0.39	-
19	0.47	0.44	0.52	0.52	0.45	0.52	0.50	0.39	0.44	0.45	0.42	-
20	0.47	0.43	0.52	0.52	0.45	0.51	0.49	0.39	0.43	0.45	0.44	-
21	0.47	0.44	0.52	0.54	0.44	0.48	0.49	0.40	0.42	0.42	0.44	-
22	0.46	0.46	0.50	0.52	0.45	0.48	0.48	0.40	0.42	0.45	0.44	-
23	0.47	0.45	0.50	0.54	0.44	0.49	0.49	0.40	0.43	0.46	0.43	-
24	0.46	0.46	0.50	0.54	0.44	0.48	0.49	0.40	0.44	0.44	0.45	-
25	0.46	0.44	0.52	0.54	0.47	0.51	0.51	0.40	0.43	0.46	0.39	-
26	0.47	0.46	0.51	0.52	0.48	0.52	0.51	0.40	0.42	0.43	0.40	-
27	0.47	0.44	0.51	0.52	0.52	0.50	0.42	0.39	0.43	0.44	0.40	-
28	0.47	0.44	0.51	0.52	0.55	0.48	0.51	0.39	0.42	0.44	0.42	-
29	0.45	0.44	0.50	0.51		0.46	0.49	0.39	0.42	0.43	0.44	-
30	0.44	0.44	0.52	0.54		0.46	0.50	0.40	0.44	0.44	0.44	-
31	0.44		0.51	0.58		0.46		0.40		0.46	0.42	
Max	0.49	0.49	1.21	0.58	0.58	0.63	0.55	0.47	0.44	0.46	0.46	-
Min	0.44	0.43	0.44	0.46	0.44	0.46	0.42	0.37	0.39	0.42	0.38	-

Table 22 Flow (m^3/s) for the period 2010/2011- Chalimbana

Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.14	0.10	0.19	0.19	0.73	2.36	0.79	-	-	-	0.31	0.29
2	0.14	0.09	0.27	0.19	1.89	1.82	0.77	-	-	-	0.32	0.27
3	0.14	0.08	0.30	0.17	1.22	2.64	0.72	-	-	-	0.32	0.18
4	0.17	0.08	0.28	0.16	5.69	2.99	0.70	-	-	-	0.31	0.28
5	0.15	0.08	0.24	0.16	3.22	5.96	0.71	-	-	-	0.31	0.18
6	0.15	0.10	0.22	0.28	1.71	3.24	0.72	-	-	-	0.31	0.20
7	0.15	0.10	0.22	0.27	1.41	2.39	0.69	-	-	-	0.29	0.28
8	0.14	0.10	0.18	0.21	0.70	2.00	0.64	-	-	-	0.30	0.28
9	0.14	0.10	0.19	0.17	0.45	2.09	0.58	-	-	-	0.29	0.28
10	0.12	0.10	0.16	0.17	0.44	1.52	0.58	-	-	-	0.29	0.28
11	0.11	0.10	0.16	0.15	0.39	1.47	0.57	-	-	-	0.28	0.27
12	0.11	0.11	0.47	0.14	0.38	1.08	0.57	-	-	-	0.29	0.33
13	0.10	0.14	0.60	0.14	0.39	1.13	0.57	-	-	-	0.28	0.30
14	0.11	0.14	0.80	0.14	0.33	1.03	0.57	-	-	-	0.24	0.32
15	0.11	0.14	0.99	0.14	0.31	1.08	0.53	-	-	-	0.24	0.30
16	0.11	0.17	0.39	0.14	0.39	0.98	0.51	-	-	-	0.24	0.23
17	0.11	0.23	0.30	0.15	0.37	0.87	0.52	-	-	-	0.23	0.23
18	0.11	0.23	0.26	0.15	1.61	2.09	0.51	-	-	-	0.23	0.29
19	0.11	0.21	0.23	0.15	0.79	1.54	0.49	-	-	-	0.24	0.27
20	0.11	0.21	0.23	0.14	0.80	2.08	0.47	-	-	-	0.24	0.29
21	0.11	1.38	0.19	0.14	0.96	1.61	0.47	-	-	-	0.29	0.30
22	0.11	0.44	0.19	0.14	1.14	1.57	0.47	-	-	-	0.28	0.30
23	0.11	2.29	0.19	0.20	0.89	1.20	0.49	-	-	-	0.24	0.29
24	0.11	0.66	0.19	0.42	0.81	1.05	0.45	-	-	-	0.25	0.25
25	0.11	0.34	0.17	0.18	4.38	0.96	0.46	-	-	-	0.24	0.32
26	0.10	0.25	0.17	0.21	4.21	0.86	0.45	-	-	-	0.25	0.24
27	0.11	0.21	0.17	0.19	3.44	1.08	0.45	-	-	-	0.24	0.32
28	0.10	0.19	0.18	0.19	3.01	0.94	-	-	-	-	0.28	0.29
29	0.10	0.24	0.17	0.19		0.86	-	-	-	-	0.26	0.26
30	0.10	0.22	0.18	0.23		0.84	-	-	-	-	0.28	0.28
31	0.10		0.18	0.56		0.82	-	-	-	-	0.28	
Max	0.17	2.29	0.99	0.56	5.69	5.96	-	-	-	-	0.32	0.33
Min	0.10	0.08	0.16	0.14	0.31	0.82	-	-	-	-	0.23	0.18

Table 23 Flow (m^3/s) for the period 2010/2011- Chalimbana

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.25	0.19	0.18	0.35	0.55	0.44	0.45	0.14	0.10	0.13	0.23	-
2	0.28	0.22	0.17	0.52	0.45	0.43	0.47	0.14	0.11	0.13	0.23	-
3	0.28	0.24	0.20	0.34	0.44	0.43	0.40	0.14	0.08	0.18	0.23	-
4	0.27	0.24	0.30	0.34	0.44	0.42	0.40	0.14	0.15	0.18	0.21	-
5	0.27	0.23	0.82	0.31	0.39	0.41	0.37	0.14	0.14	0.18	0.21	-
6	0.27	0.20	0.53	0.22	0.38	0.62	0.40	0.14	0.12	0.18	0.21	-
7	0.25	0.19	1.05	0.22	0.34	0.35	0.30	0.14	0.13	0.19	0.14	-
8	0.28	0.19	1.19	0.33	0.33	0.35	0.33	0.14	0.17	0.19	0.11	-
9	0.30	0.19	3.55	0.33	0.33	0.33	0.33	0.14	0.14	0.20	0.10	-
10	0.30	0.18	1.33	0.39	0.33	0.29	0.34	0.14	0.10	0.19	0.16	-
11	0.29	0.24	0.69	0.39	0.29	0.28	0.32	0.24	0.15	0.19	0.07	-
12	0.28	0.30	0.69	0.34	0.24	0.36	0.31	0.14	0.14	0.16	0.20	-
13	0.29	0.24	0.72	0.35	0.23	0.72	0.42	0.12	0.12	0.20	0.16	-
14	0.27	0.23	0.52	0.43	0.19	0.39	0.33	0.09	0.15	0.16	0.17	-
15	0.27	0.19	0.43	0.41	0.27	0.37	0.35	0.05	0.14	0.21	0.18	-
16	0.28	0.18	0.38	0.40	0.24	0.37	0.33	0.09	0.15	0.22	0.16	-
17	0.26	0.19	0.38	0.38	0.25	0.36	0.33	0.09	0.13	0.23	0.16	-
18	0.25	0.18	0.38	0.38	0.20	0.38	0.32	0.09	0.13	0.19	0.08	-
19	0.25	0.18	0.38	0.38	0.20	0.38	0.32	0.09	0.17	0.20	0.13	-
20	0.24	0.16	0.38	0.38	0.20	0.35	0.31	0.09	0.15	0.20	0.18	-
21	0.25	0.18	0.37	0.44	0.18	0.29	0.30	0.09	0.14	0.13	0.19	-
22	0.24	0.23	0.33	0.40	0.19	0.28	0.29	0.09	0.13	0.21	0.17	-
23	0.25	0.19	0.33	0.44	0.18	0.29	0.30	0.09	0.15	0.23	0.16	-
24	0.23	0.23	0.34	0.44	0.18	0.28	0.30	0.09	0.17	0.17	0.20	-
25	0.23	0.18	0.37	0.45	0.25	0.35	0.35	0.10	0.16	0.23	0.08	-
26	0.24	0.22	0.36	0.38	0.29	0.37	0.35	0.10	0.14	0.16	0.10	-
27	0.24	0.18	0.35	0.38	0.40	0.32	0.14	0.09	0.16	0.18	0.11	-
28	0.24	0.19	0.36	0.38	0.46	0.26	0.37	0.08	0.15	0.18	0.13	-
29	0.20	0.18	0.33	0.36		0.23	0.29	0.08	0.13	0.16	0.18	-
30	0.18	0.19	0.40	0.43		0.23	0.32	0.10	0.17	0.17	0.18	-
31	0.19		0.34	0.57		0.23		0.10		0.23	0.14	-
Max	0.30	0.30	3.55	0.57	0.55	0.72	0.47	0.24	0.17	0.23	0.23	-
Min	0.18	0.16	0.17	0.22	0.18	0.23	0.14	0.05	0.08	0.13	0.07	-

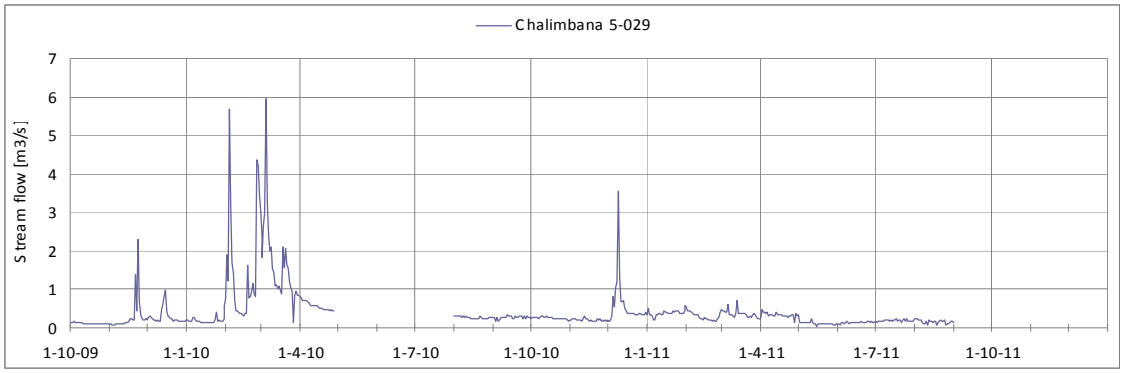

Figure 13 Flow trend on Chalimbana River at Romor Farm (2009-2011)

4 Groundwater Level Monitoring

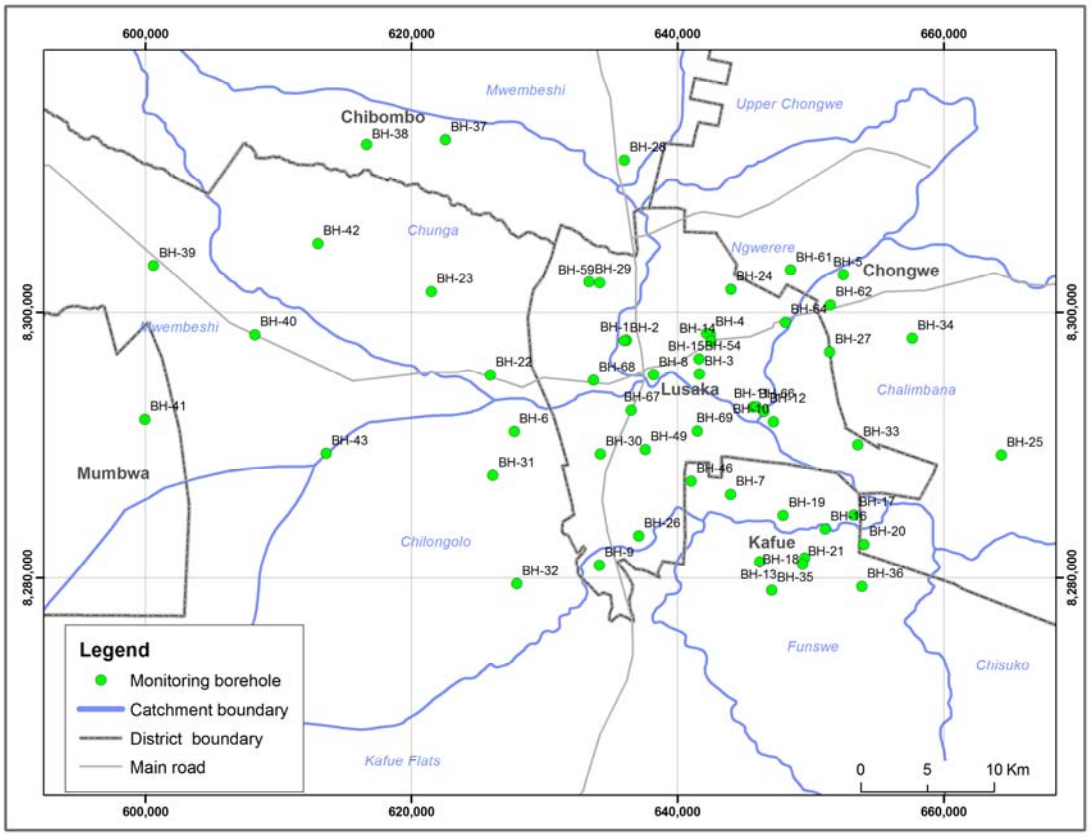

Figure 14 Location of monitoring boreholes

4.1 Chelstone 3 (BH-64)

Location	Latitude 15.38066 S Longitude 28.37992 E
Sub-catchment /Catchment	Ngwerere- Chongwe
Borehole type	Production borehole
Borehole No	5040402
Depth	62m
Altitude	1229m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

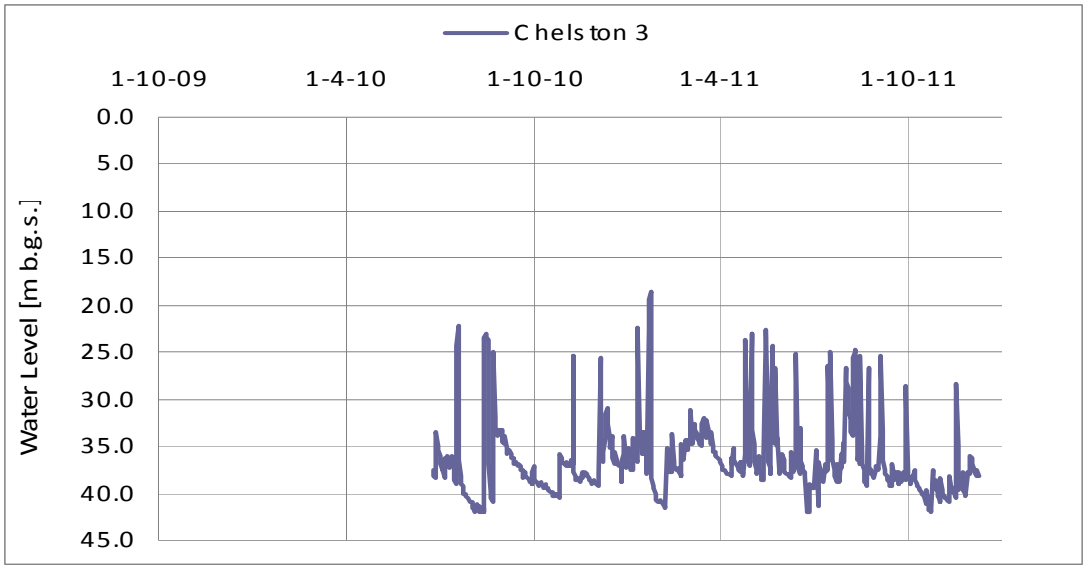

Figure 15 Groundwater level trend at Chelstone production borehole

4.2 Chikumbi (BH-28)

Location	Latitude 15.27008 S Longitude 28.26648 E
Sub-catchment /Catchment	Mwembeshi - Kafue
Borehole type	Observation borehole
Borehole No	1010776
Depth	42.5m
Altitude	1194m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	The observation borehole is located near a rainfall station

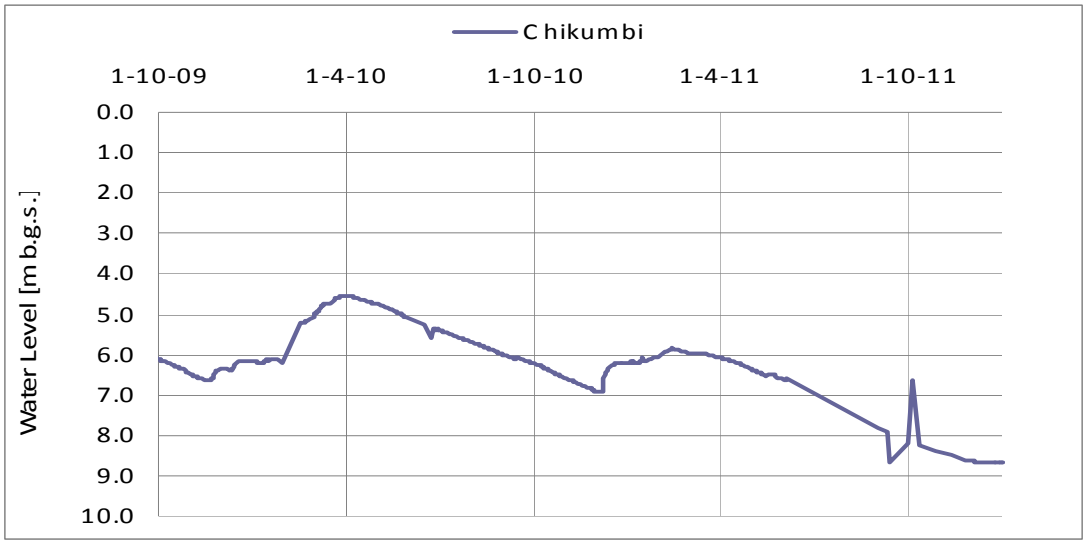

Figure 16 Groundwater level trend at Chikumbi observation borehole

4.3 Chinyanja Basic School (BH-40)

Location	Latitude 15.39106 S Longitude 28.00845 E
Sub-catchment /Catchment	Chunga-Mwembeshi
Borehole type	Observation borehole
Borehole No	5020746
Depth	50m
Altitude	1179m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

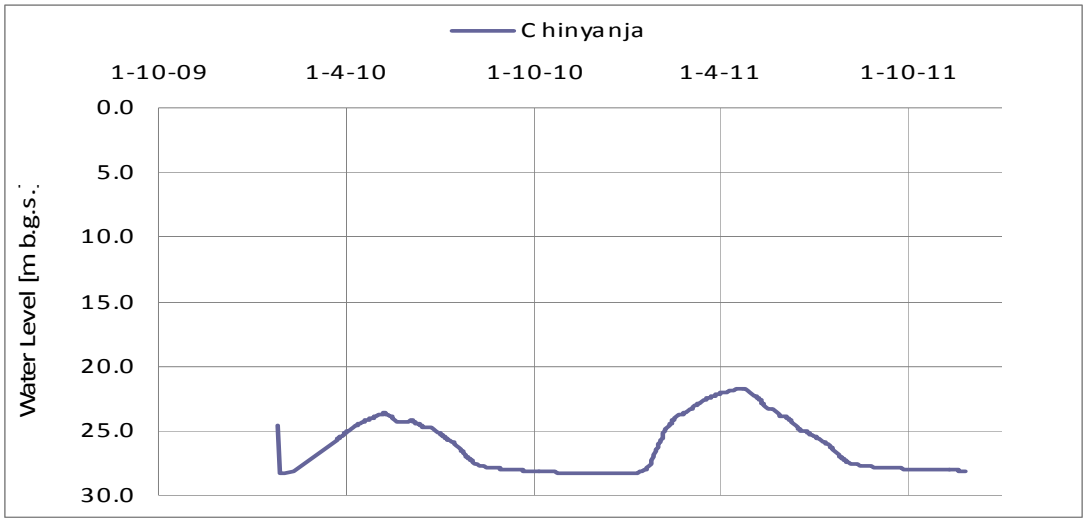

Figure 17 Groundwater level trend at Chinyanja B. School observation borehole

4.4 City Airport (BH-03)

Location	Latitude 15.41615 S, Longitude 28.31992 E
Sub-catchment /Catchment	Ngwerere-Chongwe
Borehole type	Observation borehole
Borehole No	5040361
Depth	50m
Altitude	1284m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	The observation borehole is located near a rainfall station

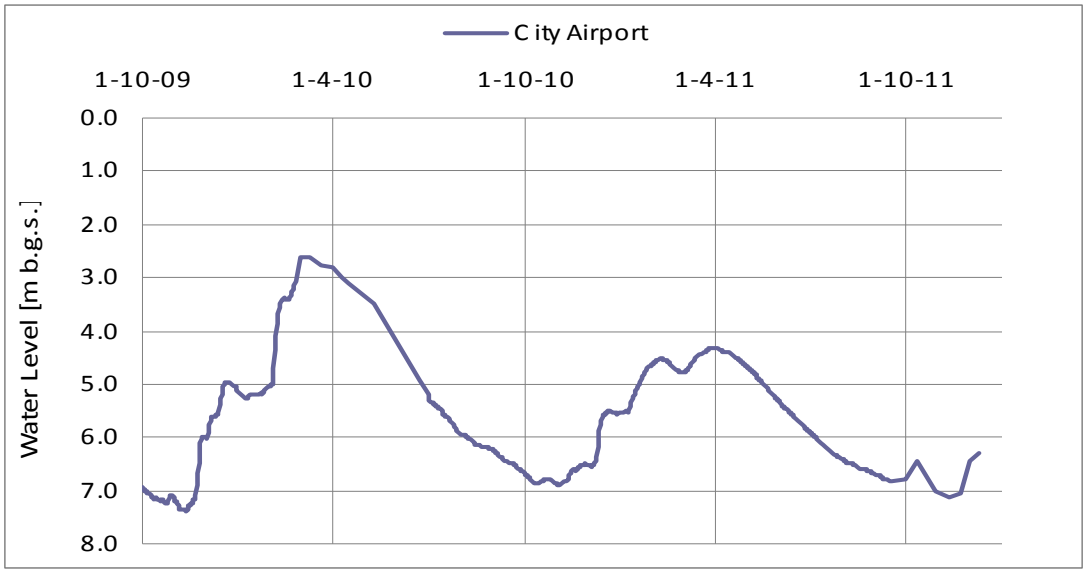

Figure 18 Groundwater level trend at City Airport observation borehole

4.5 Cooperative College (BH-10)

Location	Latitude 15.44857 S Longitude 28.37209 E
Sub-catchment /Catchment	Chalimbana – Chongwe
Borehole type	Observation borehole
Borehole No	5040915
Depth	55.5m
Altitude	1296m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

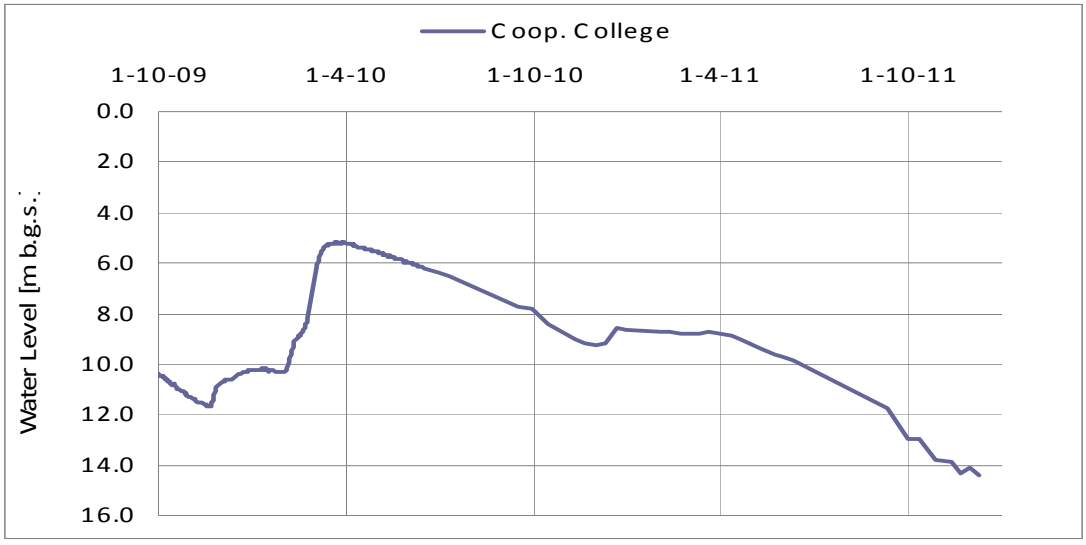

Figure 19 Groundwater level trend at Cooperative College observation borehole

4.6 Evelyn Hone College (BH-08)

Location	Latitude 15.41695 S Longitude 28.28790 E
Sub-catchment /Catchment	Ngwerere- Chongwe
Borehole type	Observation borehole
Borehole No	5040366
Depth	51m
Altitude	1280m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

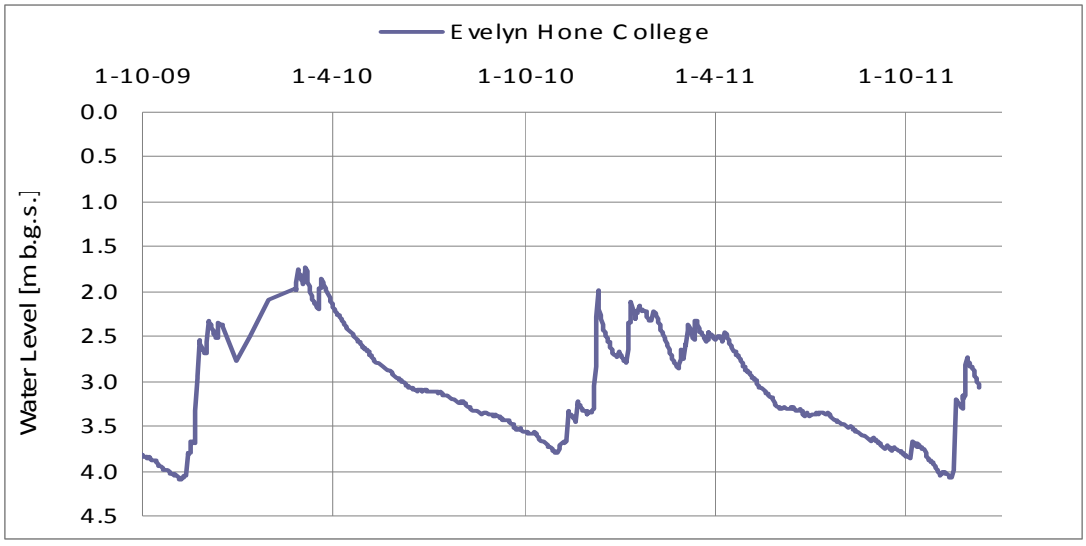

Figure 20 Groundwater level trend at Evelyn Hone College observation borehole

4.7 Forest 26 ZAWA Park (BH-07)

Location	Latitude 15.4983 S Longitude 28.34234 E
Sub-catchment /Catchment	Funswe- Kafue
Borehole type	Observation borehole
Borehole No	5020198
Depth	97.5m
Altitude	1312m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

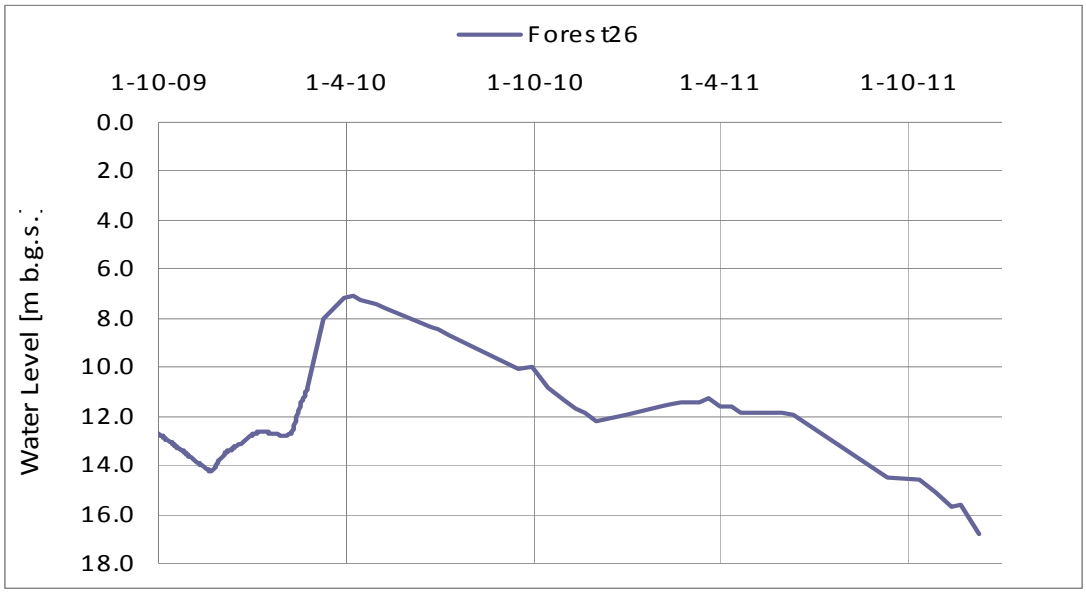

Figure 21 Groundwater level trend at F26 ZAWA Park observation borehole

4.8 Forest 55 ZAWA Park 4 (BH-19)

Location	Latitude 15.51232 S Longitude 28.37930 E
Sub-catchment /Catchment	Funswe- Kafue
Borehole type	Observation borehole
Borehole No	5020205
Depth	-
Altitude	1312m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

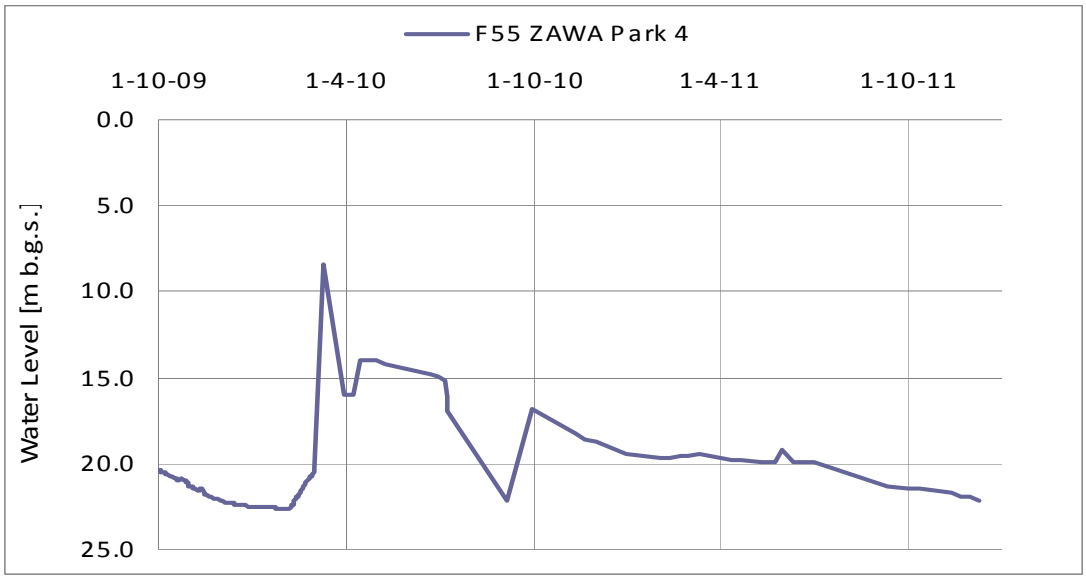

Figure 22 Groundwater level trend at F55 ZAWA Park 4 observation borehole

4.9 John Laing (BH-67)

Location	Latitude 15.34787 S Longitude 28.42040 E
Sub-catchment /Catchment	Chilongolo-Kafue
Borehole type	Production borehole (LWSC)
Borehole No	5040419
Depth	-
Altitude	1277m amsl
Measuring method	Data logger
Interval	Hourly (data logger)
Remarks	–

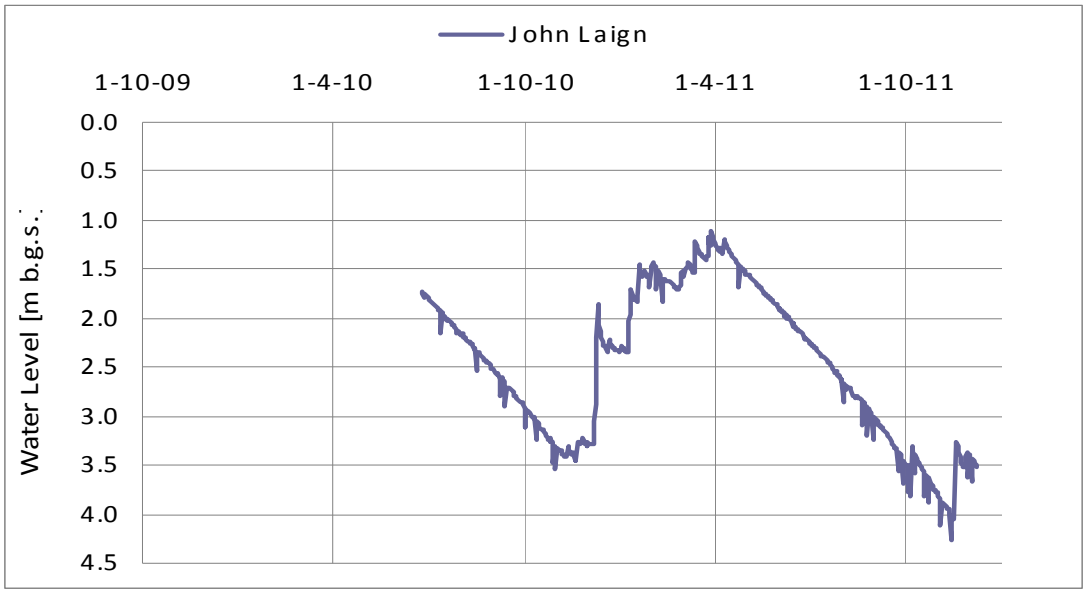

Figure 23 Groundwater level trend at John Laing production borehole

4.10 Kacheta (BH-43)

Location	Latitude 15.47177 S Longitude 28.05876 E
Sub-catchment /Catchment	Chilongolo-Kafue
Borehole type	Observation borehole
Borehole No	5020749
Depth	27m
Altitude	1190m amsl
Measuring method	Data logger
Interval	Hourly (data logger)
Remarks	–

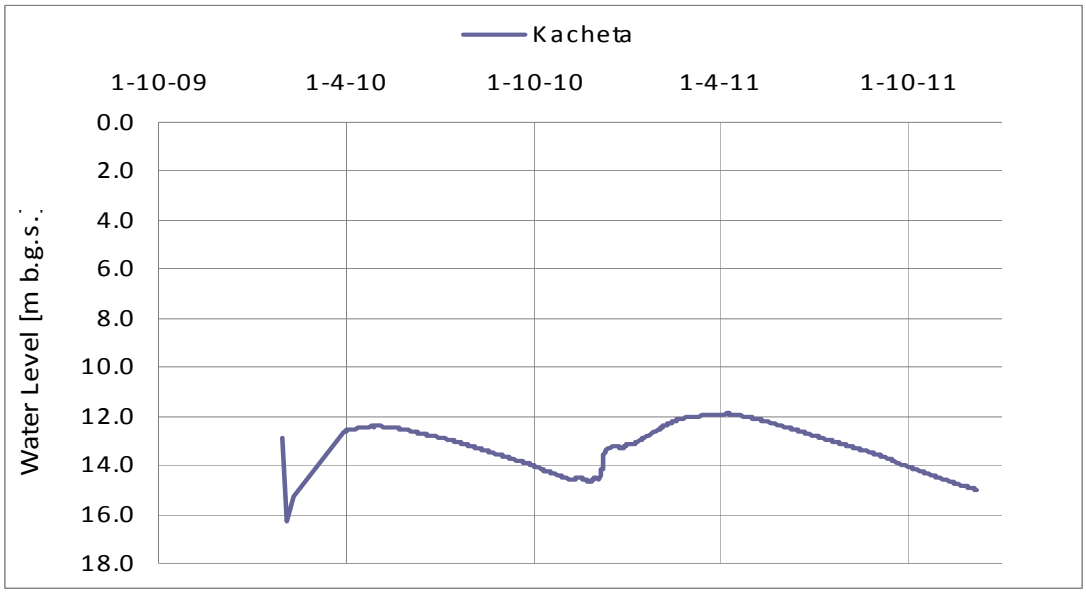

Figure 24 Groundwater level trend at Kacheta B. School observation borehole

4.11 Lemyada Christian School (BH-06)

Location	Latitude 15.45614 S Longitude 28.19051 E
Sub-catchment /Catchment	Chilongolo-Kafue
Borehole type	Observation borehole
Borehole No	5020199
Depth	54m
Altitude	1254m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

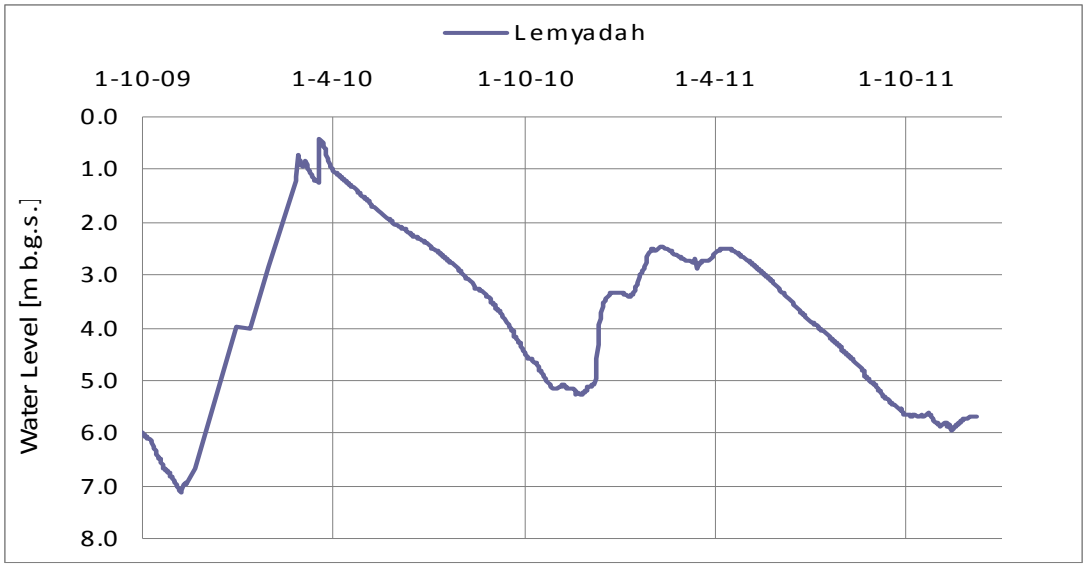

Figure 25 Groundwater level trend at Lemyada Christian School observation borehole

4.12 Leopards Hill 1 (BH-66)

Location	Latitude 15.43853 S Longitude 28.35773 E
Subcatchment /Catchment	Ngwerere- Chongwe
Borehole type	Production borehole
Borehole No	5040422
Depth	88m
Altitude	1289m amsl
Measuring method	Data logger
Interval	Hourly

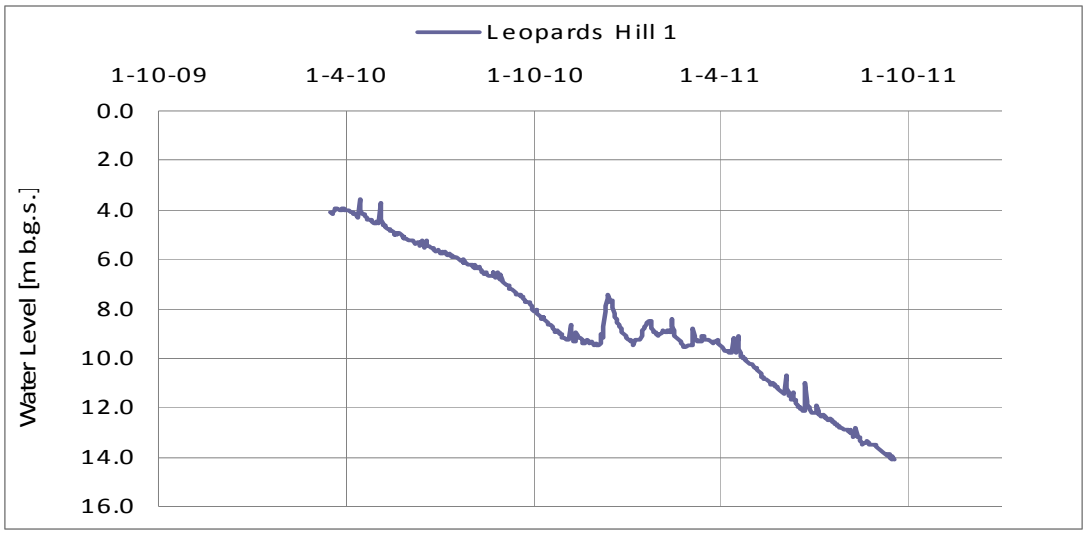

Figure 26 Groundwater level trend at Leopards Hill1 production borehole

4.13 Malo Farm (BH-62)

Location	Latitude 15.36854S Longitude 28.41145 E
Sub-catchment /Catchment	Ngwerere- Chongwe
Borehole type	Production borehole
Borehole No	5010125
Depth	62m
Altitude	1206m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

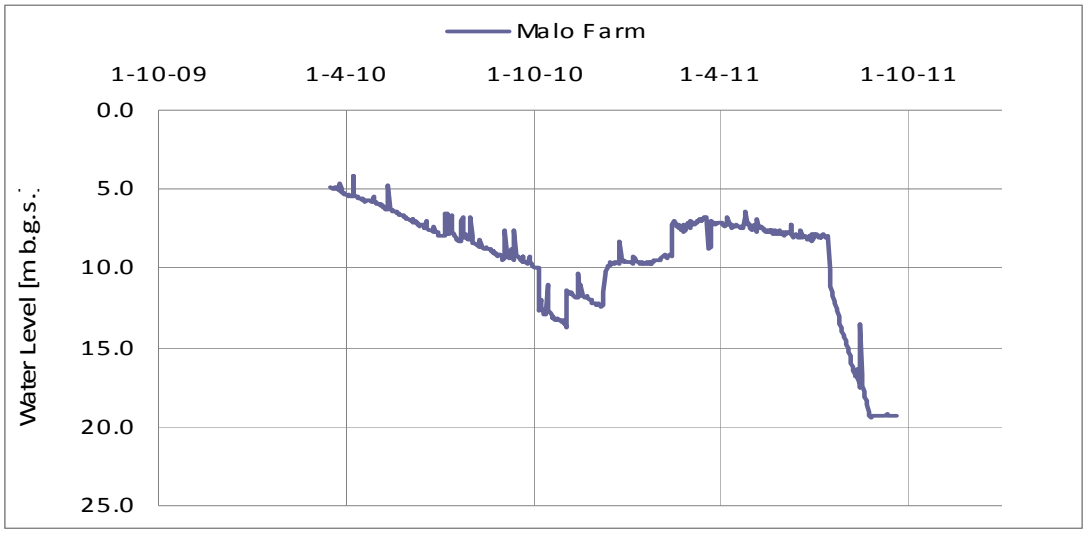

Figure 27 Groundwater level trend at Malo Farm production borehole

4.14 Mass Media (BH-54)

Location	Latitude 15.40904 S Longitude 28.32750 E
Sub-catchment /Catchment	Ngwerere- Chongwe
Borehole type	Production borehole
Borehole No	5040430
Depth	70m
Altitude	1266m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

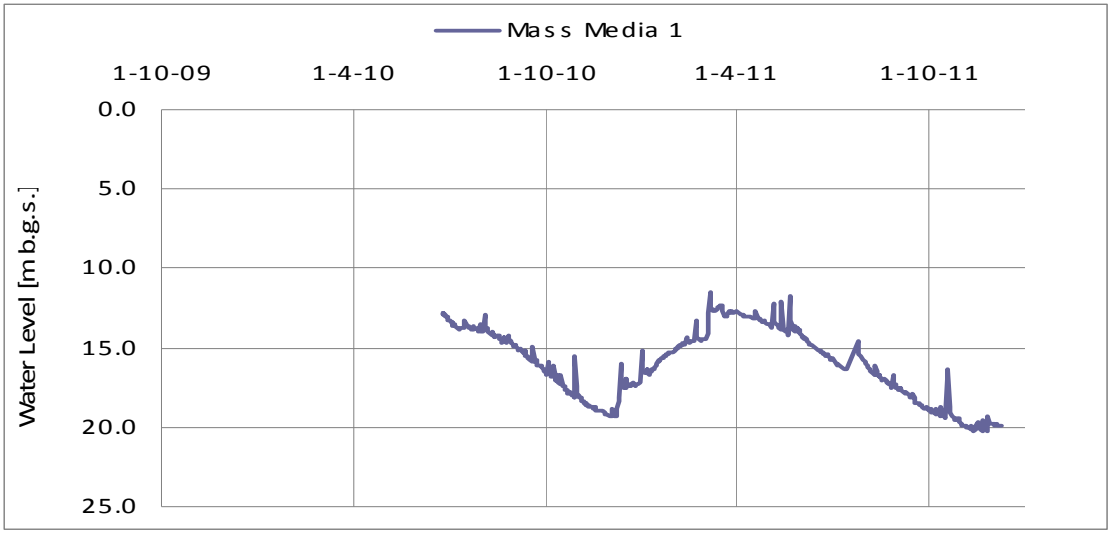

Figure 28 Groundwater level trend at Mass Media 1 production borehole

4.15 Mayaba Village at Katete B. School (BH-37)

Location	Latitude 15.25686 S Longitude 28.1417 E
Sub-catchment /Catchment	Chunga-Mwembeshi
Borehole type	Observation borehole
Borehole No	1010777
Depth	51m
Altitude	1145m amsl
Measuring method	Data logger
Interval	Hourly (data logger)
Remarks	–

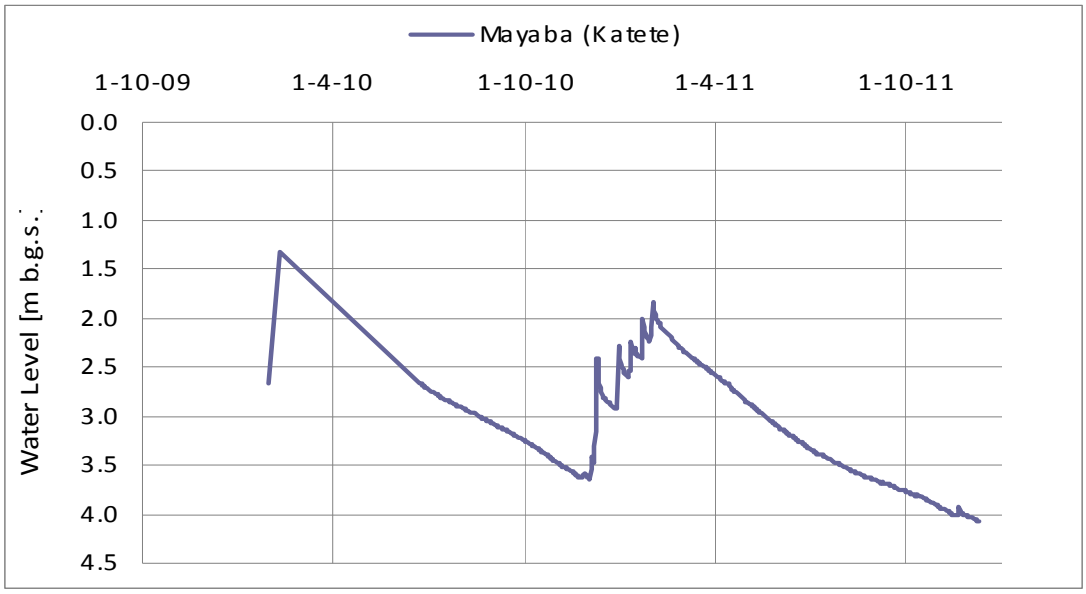

Figure 29 Groundwater level trend at Mayaba Village observation borehole

4.16 Mumbwa Road (BH-68)

Location	Latitude 15.42086 S Longitude 28.24582 E
Sub-catchment /Catchment	Chunga- Mwembeshi
Borehole type	Production borehole
Borehole No	5040453
Depth	38m
Altitude	1270m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

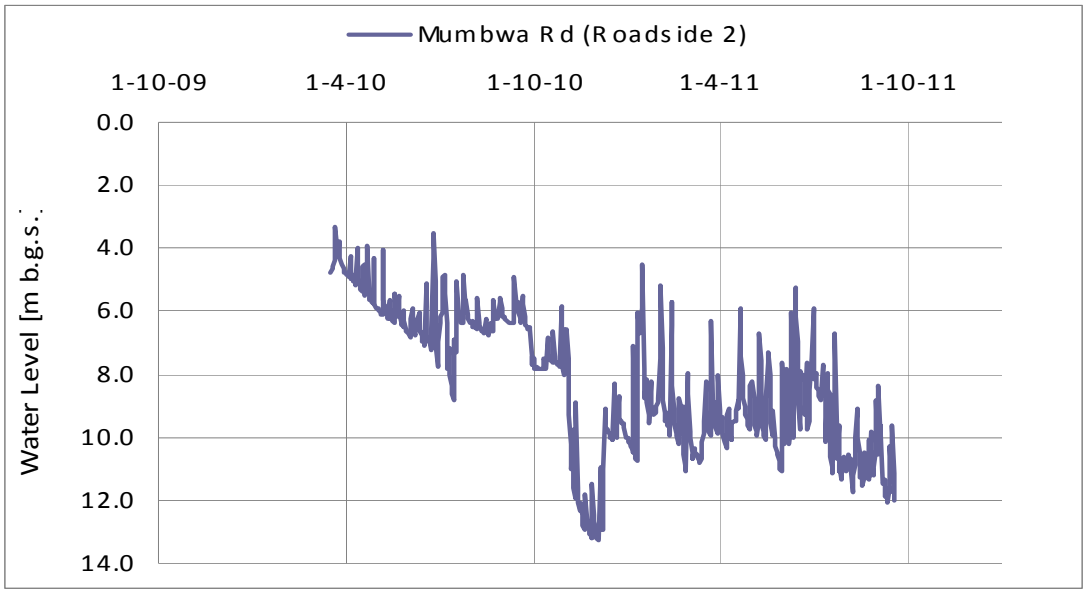

Figure 30 Groundwater level trend at Mumbwa Road production borehole

4.17 Musopelo Basic School (BH-38)

Location	Latitude 15.26030 S Longitude 28.08602 E
Sub-catchment /Catchment	Chunga-Mwembeshi
Borehole type	Observation borehole
Borehole No	1010778
Depth	50m
Altitude	1102m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

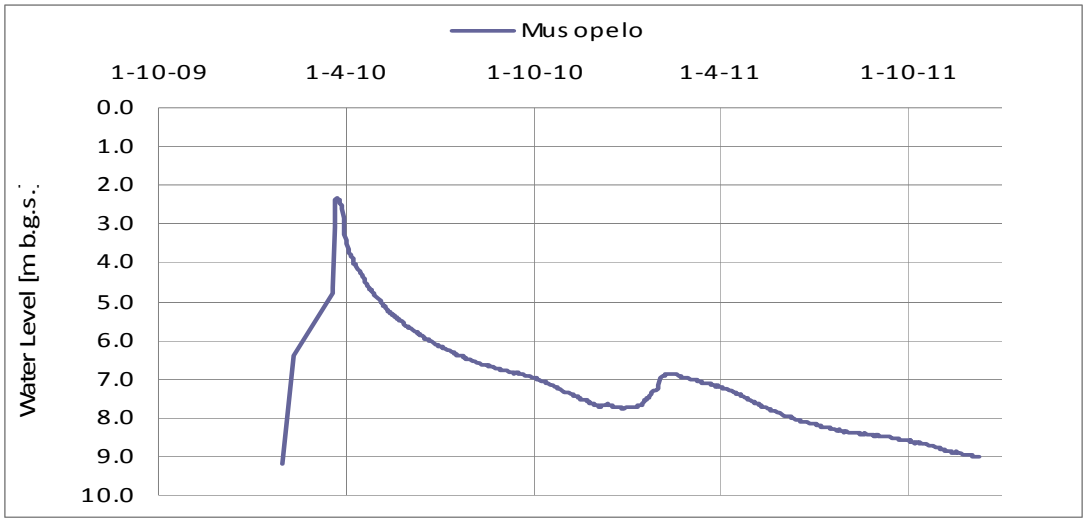

Figure 31 Groundwater level trend at Musopelo B. School observation borehole

4.18 Mwembeshi Basic School (BH-39)

Location	Latitude 15.34417 S Longitude 28.93735 E
Sub-catchment /Catchment	Mwembeshi-Kafue
Borehole type	Observation borehole
Borehole No	5020745
Depth	51m
Altitude	1135m amsl
Measuring method	Data logger
Interval	Hourly (data logger)
Remarks	–

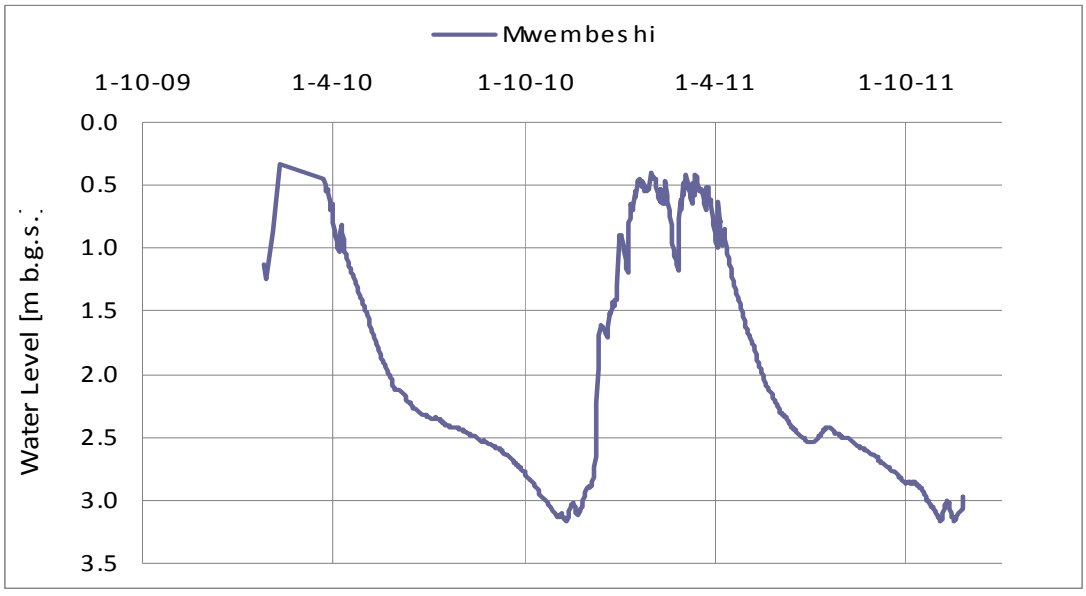

Figure 32 Groundwater level trend at Mwembeshi B. School observation borehole

4.19 NISIR (BH-05)

Location	Latitude 15.34787 S Longitude 28.42040 E
Sub-catchment /Catchment	Chalimbana- Chongwe
Borehole type	Observation borehole
Borehole No	5010019
Depth	54m
Altitude	1173m amsl
Measuring method	Data logger and manual recording
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

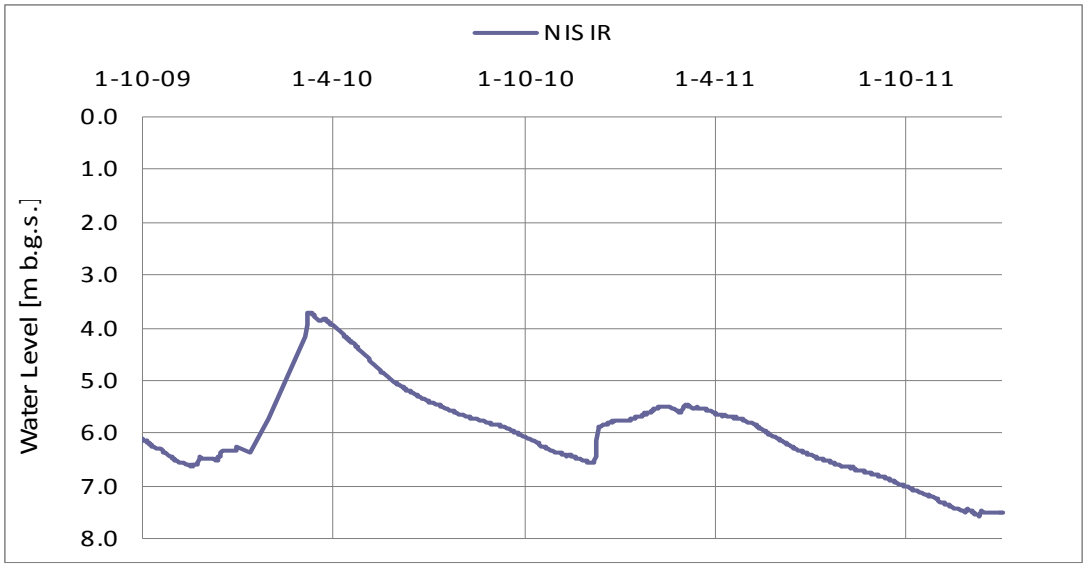

Figure 33 Groundwater level trend at NISIR observation borehole

4.20 NRDC 1 (BH-61)

Location	Latitude 15.34492 S Longitude 28.38330 E
Sub-catchment /Catchment	Ngwerere-Chongwe
Borehole type	Production borehole
Borehole No	5010128
Depth	31m
Altitude	1202m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	Drawn water level periodically below position of data logger

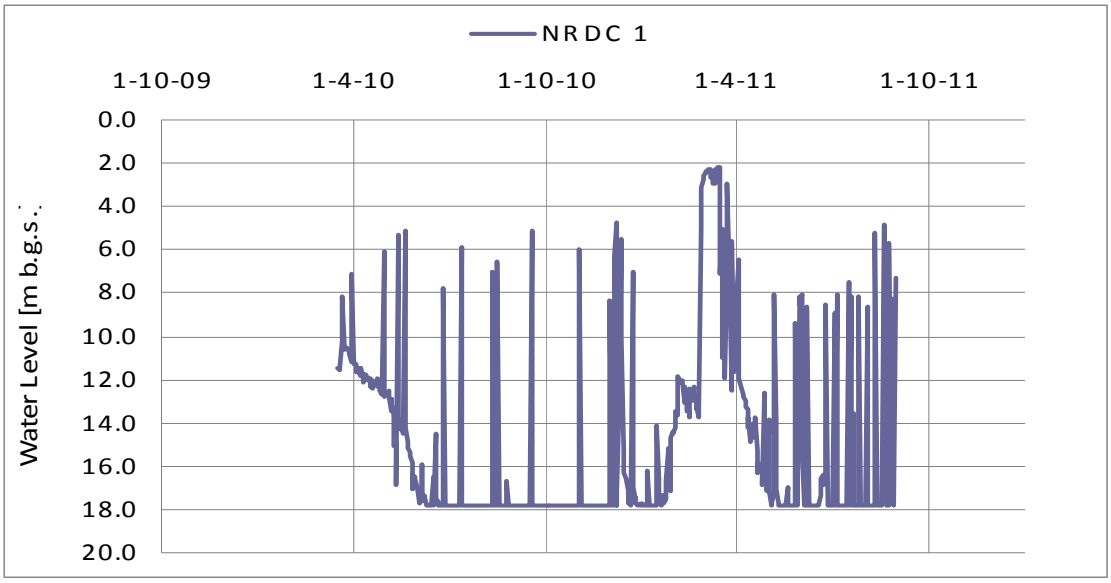

Figure 34 Groundwater level trend at NRDC 1 production borehole

4.21 SDA Camp (BH-42)

Location	Latitude 15.32845 S Longitude 28.05244 E
Sub-catchment /Catchment	Chunga-Mwembeshi
Borehole type	Observation borehole
Borehole No	5020748
Depth	42m
Altitude	1160m amsl
Measuring method	Data logger and manual
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

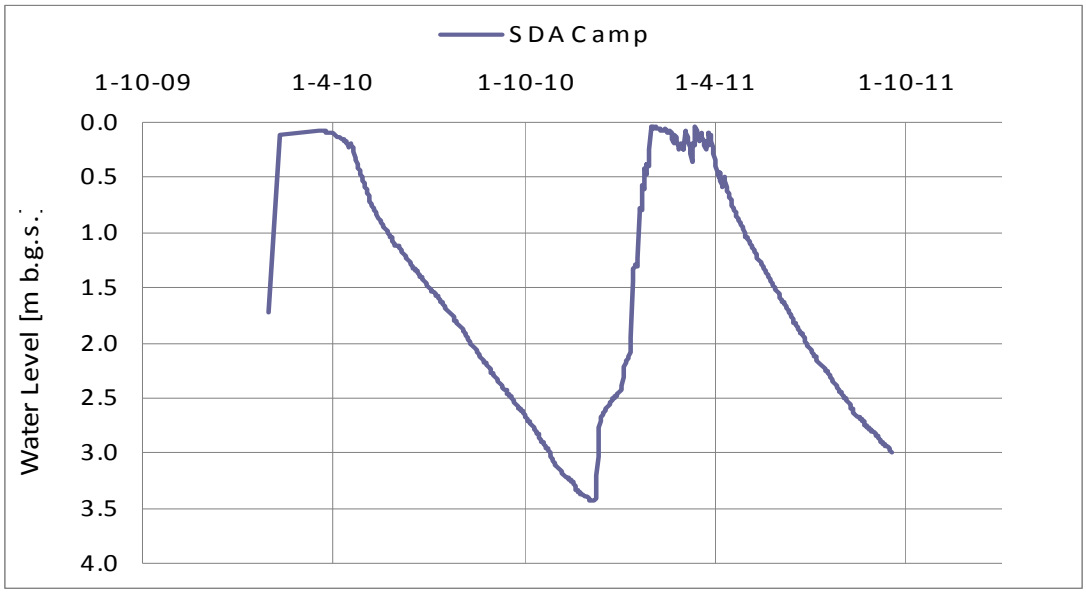

Figure 35 Groundwater level trend at SDA Camp observation borehole

4.22 Shamilimo Basic School (BH-41)

Location	Latitude 15.44914 S Longitude 28.93178 E
Sub-catchment /Catchment	Mwembeshi Kafue
Borehole type	Observation borehole
Borehole No	1051003
Depth	43.5m
Altitude	1061m amsl
Measuring method	Data logger
Interval	Hourly (data logger)
Remarks	–

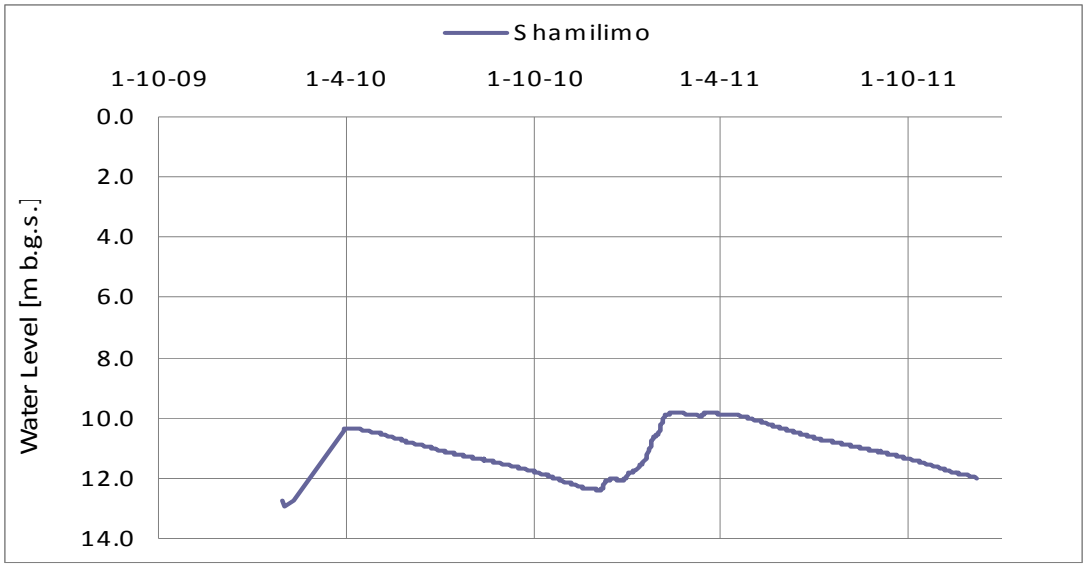

Figure 36 Groundwater level trend at Shamilimo B. School observation borehole

4.23 Water Works (BH-69)

Location	Latitude 15.45512 S Longitude 28.31880 E
Sub-catchment /Catchment	Chilongolo-Kafue
Borehole type	Production borehole
Borehole No	5040461
Depth	70m
Altitude	1289m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

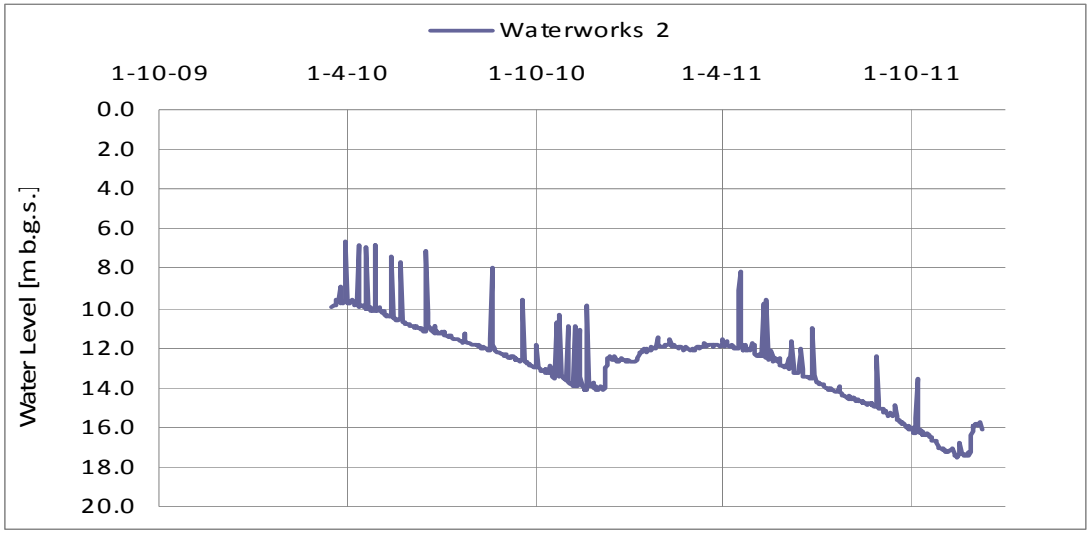

Figure 37 Groundwater level trend at Water Works production borehole

4.24 Shaft 5 (BH-46)

Location	Latitude 15.48950 S Longitude 28.31463 E
Sub-catchment /Catchment	Chilongolo-Kafue
Borehole type	Production borehole
Borehole No	5020631
Depth	66m
Altitude	1287m amsl
Measuring method	Data logger
Interval	Hourly
Remarks	–

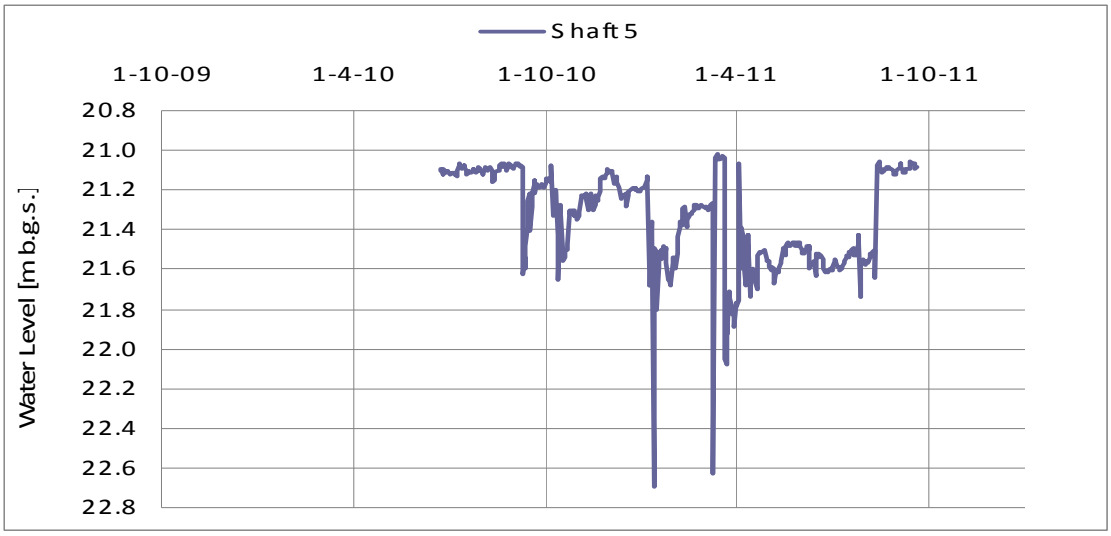

Figure 38 Groundwater level trend at Shaft 5 production borehole

4.25 University of Zambia (BH-04)

Location	Latitude 15.38942 S Longitude 28.32742 E
Sub-catchment /Catchment	Ngwerere-Chongwe
Borehole type	Observation borehole
Borehole No	5040362
Depth	47.6m
Altitude	1261m amsl
Measuring method	Data logger and manual
Interval	Hourly (data logger), every 10 days (manual)
Remarks	–

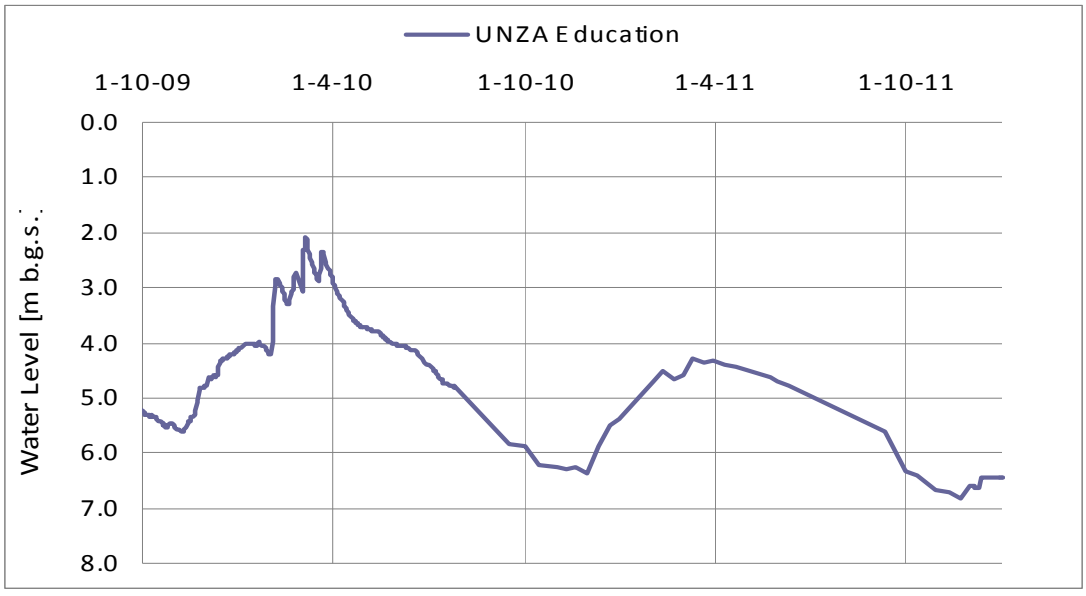

Figure 39 Groundwater level trend at UNZA observation borehole

5 Groundwater Quality Monitoring

Groundwater quality monitoring has so far focused on the following 10 public water supply boreholes of Lusaka Water and Sewerage Company: Chunga 1, Mazyopa, George 7 (Machinery House), Chainda, Avondale 3, Chelston 1, Water Trust Chibolya, John Howard, Bauleni, and Water Works 2.

Due to recent developments the locations have slightly been shifted, so that the Bauleni borehole has been replaced by Leopards Hill, John Howard by Shaft 5 and Mass Media has been taken up as additional monitoring location.

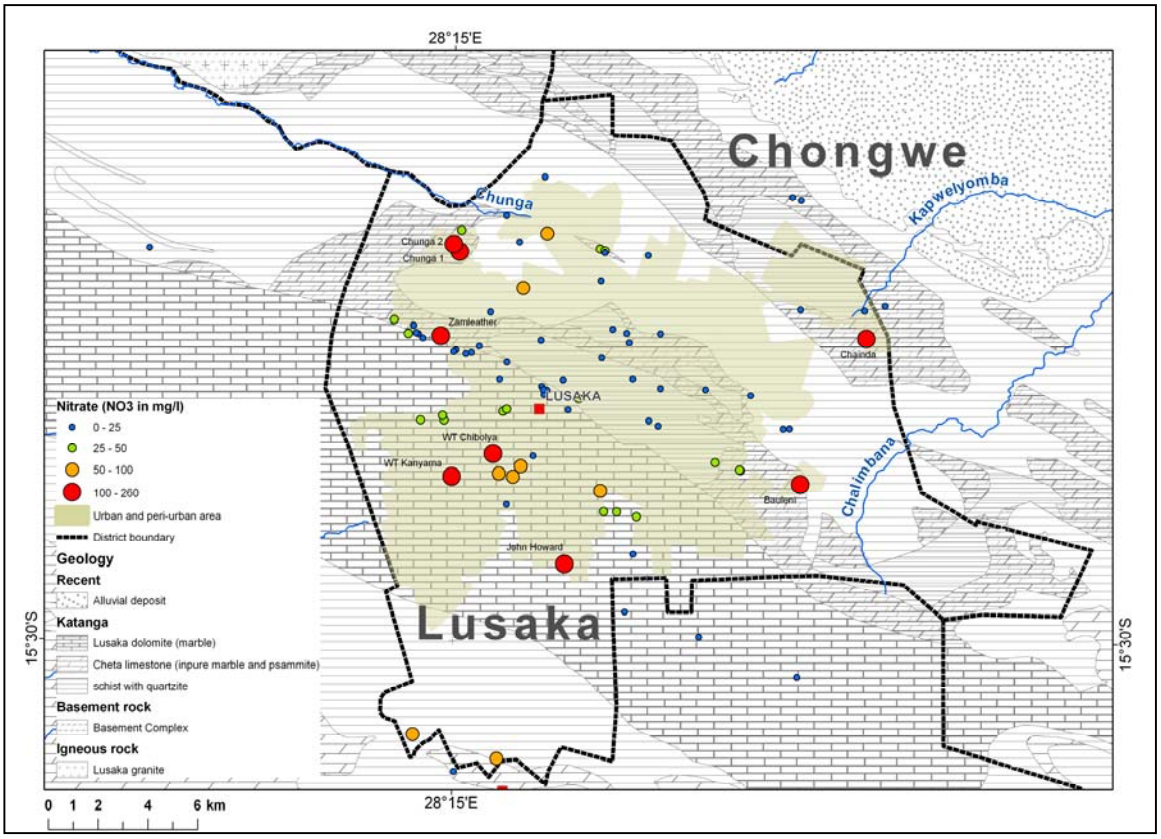

Figure 40 Nitrate levels in public and private boreholes (sampling campaign of 2010)

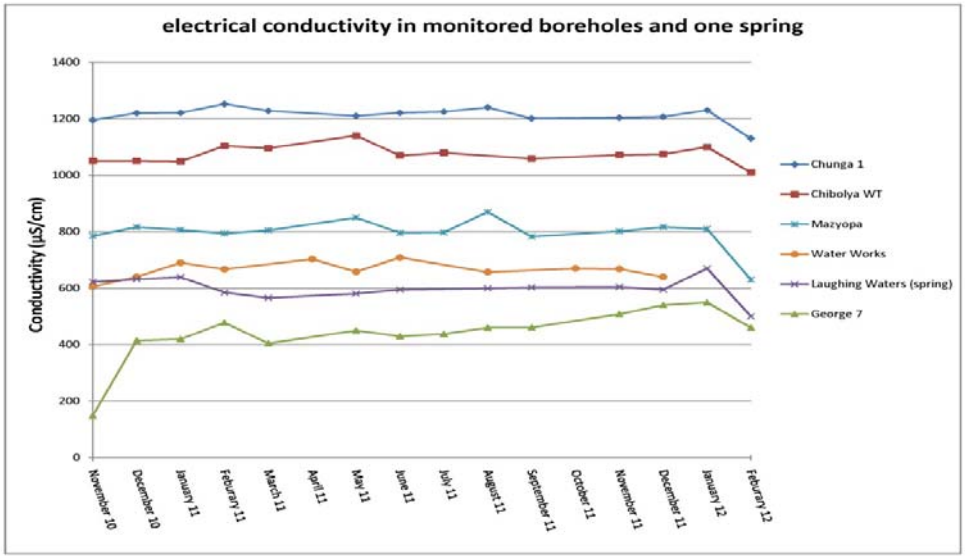

Figure 41 Electrical conductivity in selected monitoring boreholes

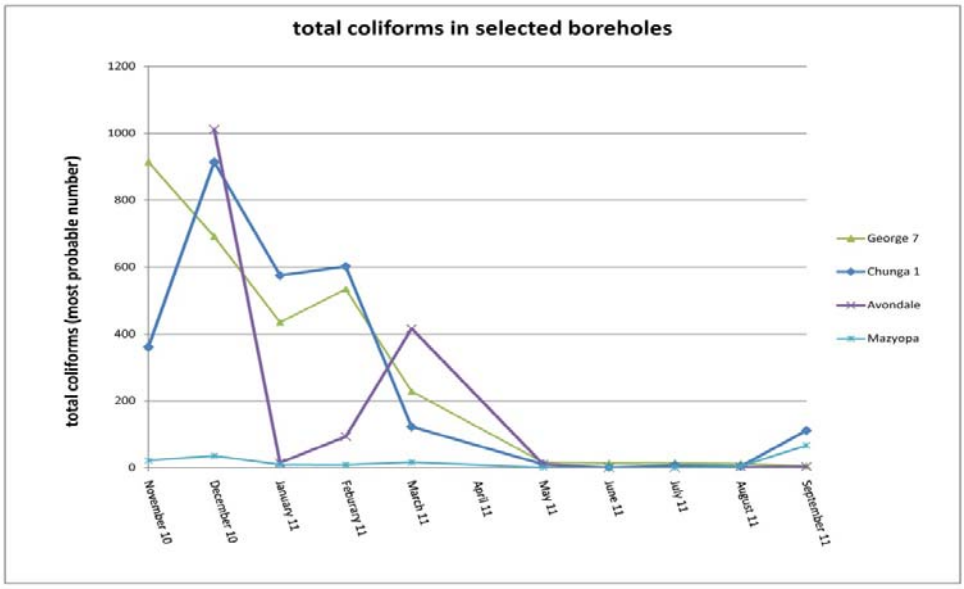

Figure 42 Total coliforms in selected monitoring boreholes

Table 24 Results from 2010 campaign for selected water points serving as quality monitoring stations

B/h ID	B/h Name	EC	TC	Ecoli	NO_3	NO_2	Cl	SO_4	Mn	Fe	Pb	Cd
		µS/cm	MPN	MPN	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	µg/l	µg/l
5010124	Avondale 3	519	791.5	2	11.9	0	3.2	1.42	1	0.041	0.18	0.023
5040393	Bauleni	994	298.7	2	112	0.02	52	13.8	1	0.018	2.78	0.02
5040396	Chainda	1330	4.1	1	260	0.07	100	28.7	1	0.003	0.18	0.003
5040404	Chunga 1	1207	416	33.2	107	0	109	53.2	9	0.005	0.17	0.009
5040924	George 7	406	344.1	152.9	1.3	0.01	10	11.9	1	0.003	0.08	0.001
5040418	John Howard	924	3.1	<1	175	0	48.6	10.2	0	0	0.11	0.005
5040460	Waterworks 1	*663	12.6	<1	37.9	0.01	7.9	3.93	0	0	0.27	0.007
5041093	WT Chibolya	1096	1	0	155	0.22	91.7	30.7	1	0.005	0.5	0.008
5041102	WT Chipata	664	<1	<1	60.4	0	37.1	3.16	0.001	0.003	0.21	0.007
Zambian Drinking Water Standard			10	0	44	1	250	400	100	1	50	5
* values taken from Waterworks 2 (WW 1 was not sampled in 2010 nor 2008)												