Addis Ababa University School of Graduate Studies Faculty of Technology Department of Civil Engineering

Flood Generated from Tana Lake Basin

By

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Abstract

The computation of runoff usually consists of applying a stage- discharge relation to daily gage heights to determine mean daily discharges. However, for this particular study a hydrologic model, HEC-HMS is applied to compute the hourly base runoff generated from Lake Tana basin. The basin was sub divided in to eleven sub basins with a total area of 15046.32 square kilometers including the area of the lake.

The Basin has many streams of which the seven have daily gauged data. The gauged data from six streams are used for parameter estimation for the ungauged sub catchments. Since the study focuses on the computation of flood particularly peak flood, these daily discharge data are hourly distributed using the formula $Q_T = M*T^{½}$.Where T is time in hours and M is a coefficient of which value is determined from known discharges and respective time or return period.

The Probable Maximum Flood (PMF) entering Lake Tana from the sub basins would be determined based on the convolution of the Unit Hydrograph (UH) with the Probable Maximum Precipitation (PMP) using the storm frequency meteorological model built in HEC-HMS. The Bahir Dar 24 hours maximum annual rain fall depth values were the basis for the evaluation of 24 hours PMF values for the return period 25-years, 50-years, 100-years.The direct runoff contributed by each sub-basin is computed for return period of 10-, 25-, 50- and 100-years.Finally the calculated direct runoffs are combined to know the magnitude of peak runoff coming into Tana Lake.

Flood generated from Lake Tana basin is determined in such a way that adding the rivers base flow to the direct runoff and summing the floods from sub basins assuming all sub basins are active at a time. The highest combined incoming flood from all sub catchments to the Lake are 4,053 m3/sec ,4,241 m3/sec,5,040.0 m3/sec and 25372 m3/sec. While the corresponding total inflow are 235,474 m^3,250,687m3,235,474.2 m^3,292,258 m3,643611m^3 for

the respective return periods. The water surface elevation at the time of this highest incoming flood ranges from 1787.9 m a.m.s.l for 10 – years return period to 1789 m a.m.s.l for 100 –years return period.

The probable maximum flood (PMF) computed using the model is 56,526m3/s(or 9,522,011 m^3) and the corresponding lake water surface elevation is 1789.3m, too. This shows that the Lake level is raised by more than two meters. Hence, low laying area of Bahirdar and Fogera and Dembia flood plain will be affected.

Chapter 1. Introduction

Flood is any relatively high flow that overtops the natural or artificial banks in any reach of the stream. While Runoff is rainfall that does not soak into the soil but flows into surface waters. Flood-Runoff analysis can be regarded as an engineering application of the science of flood hydrology. The hydrologic system embodies all of the physical processes that are involved in the conversion of precipitation to the stream flow as well as physical characteristics of the watershed that influence runoff generation. The use of computer models to simulate the hydrologic system is of major significance in the performance of many flood-runoff analysis and /or flood determination. A fundamental problem in simulating hydrologic system is to employ the appropriate level of detail to represent those components of the system that have a significant influence on the phenomena being modeled. Rainfall runoff model for the determination of flood requires (i) modeling of Basin components, that is hydrologic elements, which are connected in a dendric network to simulate runoff processes (ii) the extraction of geospatial data for use in the model.

The goal of this research is to determine flood generated from Lake Tana Catchment using a computer model called Hydrologic Modeling System (HEC-HMS). The model will be useful to know and predict the magnitude of the incoming peak flood and its time of occurrence.

1.1 Problem statement

The level of Lake Tana sometimes (during rainy season) increases and sometimes (that of non-rainy season) gets much more reduced to the extent that there will be transportation problem to the islands where tourist attractive monasteries are located. During rainy season when the lake water surface reduced level rises there is a fear that down stream settlement of the town and the surrounding low laying area will be inundated.

Concerned higher officials, in the town, frequently give order to let the gates at the lake outlet be opened and reduce the lake water level so that the down stream settlements of the town not to be flooded. Actually the magnitude of incoming peak flood and its time of occurrence are not so far determined. But when the lake water surface reduced level increases, there is fear for flood damage at down stream settlements and southern parts of Bahirdar town and hence excess water is being released. During the wet season of 2006 G.C, water flowing more than 700m ^{3}/s was released and a team, comprising of different disciplines was assigned to asses the occurrence of flood damage at the down stream settlements. Fortunately, the team reported that there was no flood damage. This action, releasing of excess water without knowing the magnitude of the incoming peak flood and its time of occurrence, had problem by itself because during dry season the hydropower at the down stream of the lake exploited the lake water and transportation problem used to occur as the water surface level of the lake reduced much lower. As a result, dwellers of the islands could not have access to Bahir Dar town and tourists would not be able to visit those monasteries as well.

1.2 Objectives

The general objective of this project is to estimate flood generated from Tana Lake Catchment using Rainfall-Runoff model for the decision makers to take action regarding flood protection of Bahir Dar town and some other down stream settlements. While the specific objective of the thesis is to determine the peak flood generated from Tana Lake catchment using Hydrologic Modeling System (HEC-HMS).

1.3 Out line of the Report

This report has been divided into six chapters. The second chapter deals with general description of the study area. The third chapter also deals with literature review that is the literatures and studies which had been conducted by different persons and has direct relation to this project. The fourth Chapter discusses the requirements, availability and analysis of the data for this project. The fifth and six chapters also discuss optimization of parameters and conclusion respectively.

Chapter 2. Project Area

2.1 General

Tana is one of the largest lakes in the country and has surface area of about 3041.6 square kilometers. This lake is located in northern part of Abay basin or rather at Bahir Dar town which is 645 km from Addis Ababa through Adiss Ababa-Burie-Bahir Dar route. It has catchement, including the lake surface area, of size 15,054 square kilometers and within this catchment, there are about 23 rainfall gauging stations and seven gagged rivers namely, Koga, Gilgel Abay, Arno-Garno, Ribb, Megech, Gemero and Gumera which are monitored by Ministry of Water Resources. These rivers, except Koga which is tributary to Gilgel Abay, drain directly to the lake. At the islands of the lake there are also ancient, historical and tourist attractive monasteries. At the out let of the lake a weir called Chara Chara is constructed to control the water flow for the down stream uses such as Tis Abay hydropower which is located few kilometers downstream of Tana Lake and Tis esat fall. The level of the Lake water surface some times rises up from its normal and anticipated reduced level during wet season (Kiremt).

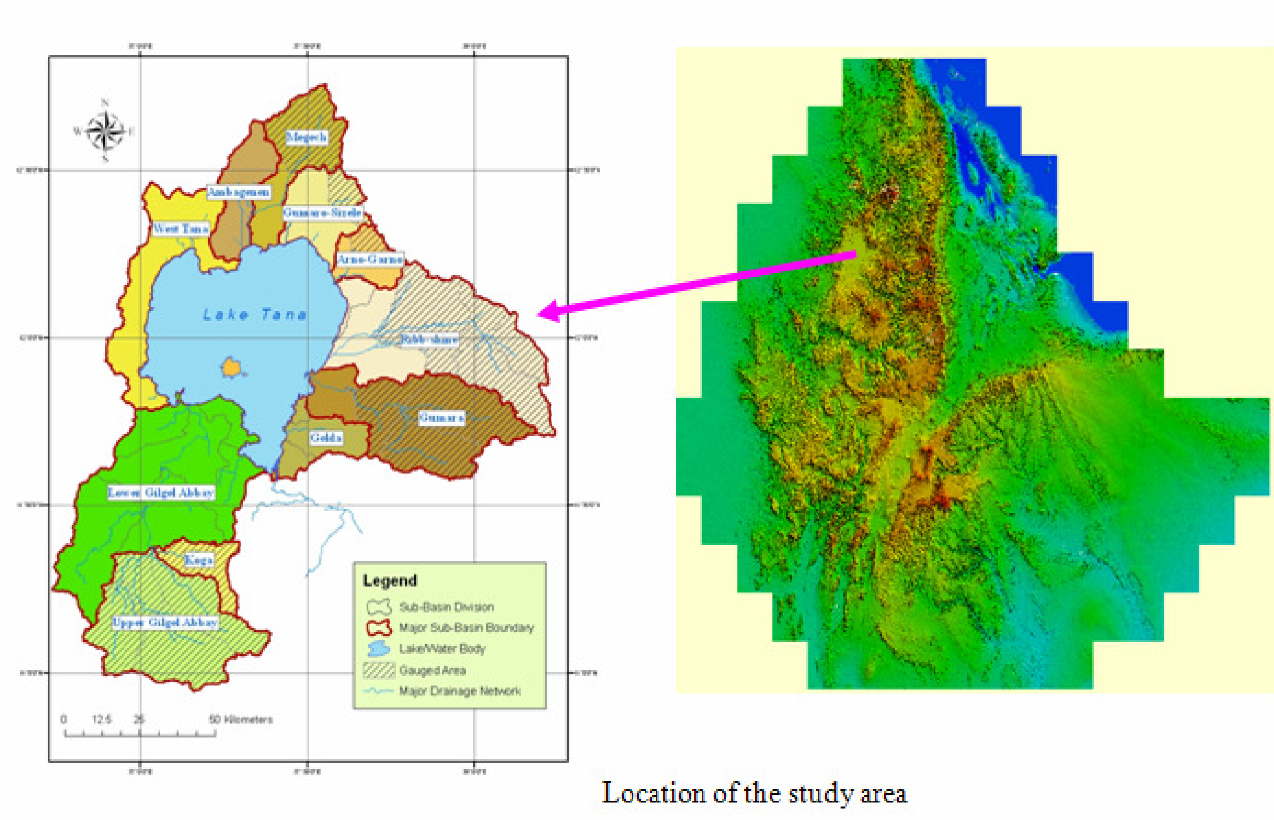


Figure 2-1:Location of study area

2.2 previous studies

Different organizations and individuals have conducted studies on Tana Lake basins and /or sub basins. The two, Studio Pietrangeli study (study of Tana Beles project) and study conducted by Yohanns Daniel for the partial fulfillment of his MSc. are presented as follows.

2.2.1 Lake Tana Bathymetry (studio Pietrangeli)

During the period 2nd April 1987 and 12thJune 1987, the Lake Tana bathymetry survey, based on about 900 km of profile, was carried out during the Tana-Beles project study. The purpose of this survey was to prepare charts of the depth of water in Lake Tana.The overall measurement work was performed using three diffident support bases on the Lake(Bahir Dar,Nargadaga,Gorgora)and it was based on as much as possible regular net of profiles ,15 in the East-West direction and 7 in the North – South direction. The first, longest profile runs (about 75 km) starts in the south extremity of the Bahir Dar gulf (Lat.37 deg. 23.23 min – Long.11 deg.35.73min,) and ends at the extreme north edge of the Lake (Lat.37 deg. 24.27 min-Long. 12 deg.16.44 min).The maximum depth recorded is 13.1m.

Orthogonal to the previous one, the profile starts from the low and prominent promontory formed by the Rib River and reaches the opposite Lakeshore with a 270 deg. heading. The maximum depth recorded is 13.6 m.

The deepest point of the Lake is at 1772 m a.s.l. i.e. 14 m below "normal" level (1786 m a.s.l).The maximum record level (Sep 1964) is 1787.54 m a.s.l

On the basis of the bathymetric profiles carried out on the Lake some bathymetric maps at a scale of 1:50,000 and 1:100,000 were prepared (Studio Pietrangeli, 1990) with contour interval of one meter. Using these maps the Volume-Area-Elevation relationships of the lake reservoir were estimated and associated curves were established. The reservoir volume versus area and area versus elevation curves are directly adopted from Tana Beless project study report (Executive Summary).

Table 2. 1:. ***Tana Level verses Surface Area and Volume***

Level m	Area m^2X10^6	Volume m^3X10^7
1780.0	2500.0	1250.0
1781.0	2625.0	1480.0
1782.0	2755.0	1750.0
1783.0	2875.0	2001.0
1784.0	2937.5	2333.3
1785.0	3010.0	2625.0
1786.0	3078.0	2666.7
1787.0	3125.0	3200.0
1788.0	3225.0	3510.0
1789.0	3260.0	3875.0
1790.0	3375.0	4570.5

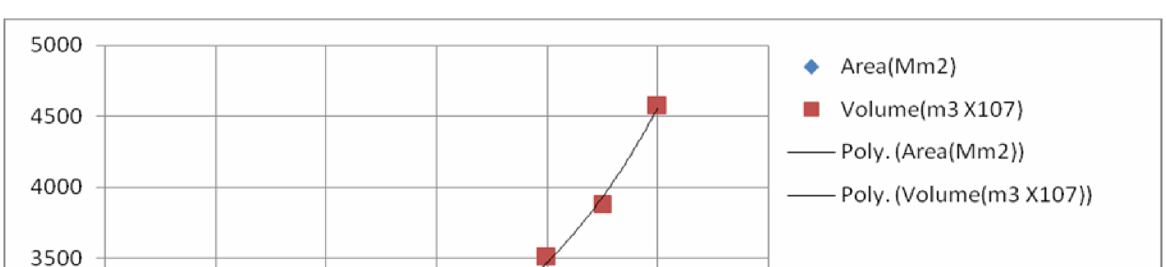


Figure2-2: Tana Lake Level vs. surface Area and Volume Curves

2.2.2 Catchment Area

As per the report for Tana Beless Project(Studio Pietrangeli 1990)Lake Tanan has a total catchment area of about 15320 $km.^2$ to which the following contributes:

Megech--2620 km^2

Reb --2464 km^2

Gumara--1893 km^2

Gilgel Abay---5004 km^2

Other tributaries---279 km^2

Lake Tana--3060 km^2

Total ---**15320** km^2

Yohanes Daniel, in three levels, carried out detail delineation of sub-catchments of Lake Tana basin.

Initially, a course resolution image was used to generally distinguish boundary of the Lake Tana basin.

Then two consecutive delineations were carried out in order to identify the major sub-basins and smaller catchment divisions within these sub-basins. Eleven major sub-basins were first identified corresponding to the main rivers that drain the area. Afterwards, sub-basins were further divided into smaller sub-catchments. Finally, areas of gauged and ungauged were determined from the subbasin map derived. Table 2.2 summarizes the identified sub-basins within Lake Tana basin along with the corresponding area.

Table 2. 2: Gauged and Un-gauged area estimate in Lake Tana Basin

Sub-basin Name	Gauged Area (sqr.km)	Un-Gauged Area (sqr.km)	Total (sqr.km)
Ambagenen	-	512.01	512.01
Arno-Garno	100.14	229.62	329.76
Gelda	-	436.37	436.37
Gumara	1354.20	250.12	1604.32
Gumaro-Sizele	158.71	442.17	600.88
Koga	300.70	-	300.70
Lower Gilgel Abbay	-	2558.57	2558.57
Megech	512.56	254.50	767.06
Ribb -Shine	1522.56	633.34	2155.91
Upper Gilgel Abbay	1657.89	-	1657.89
West Tana	-	1081.29	1081.29
Total Lake Tana Basin	**5606.76**	**6397.99**	**12004.76**
Average area of Lake Tana	-	-	3041.56
Total Including Lake area			**15046.32**

Figure2. 3: Study area sub basins (Yohanes Daniel,2007)

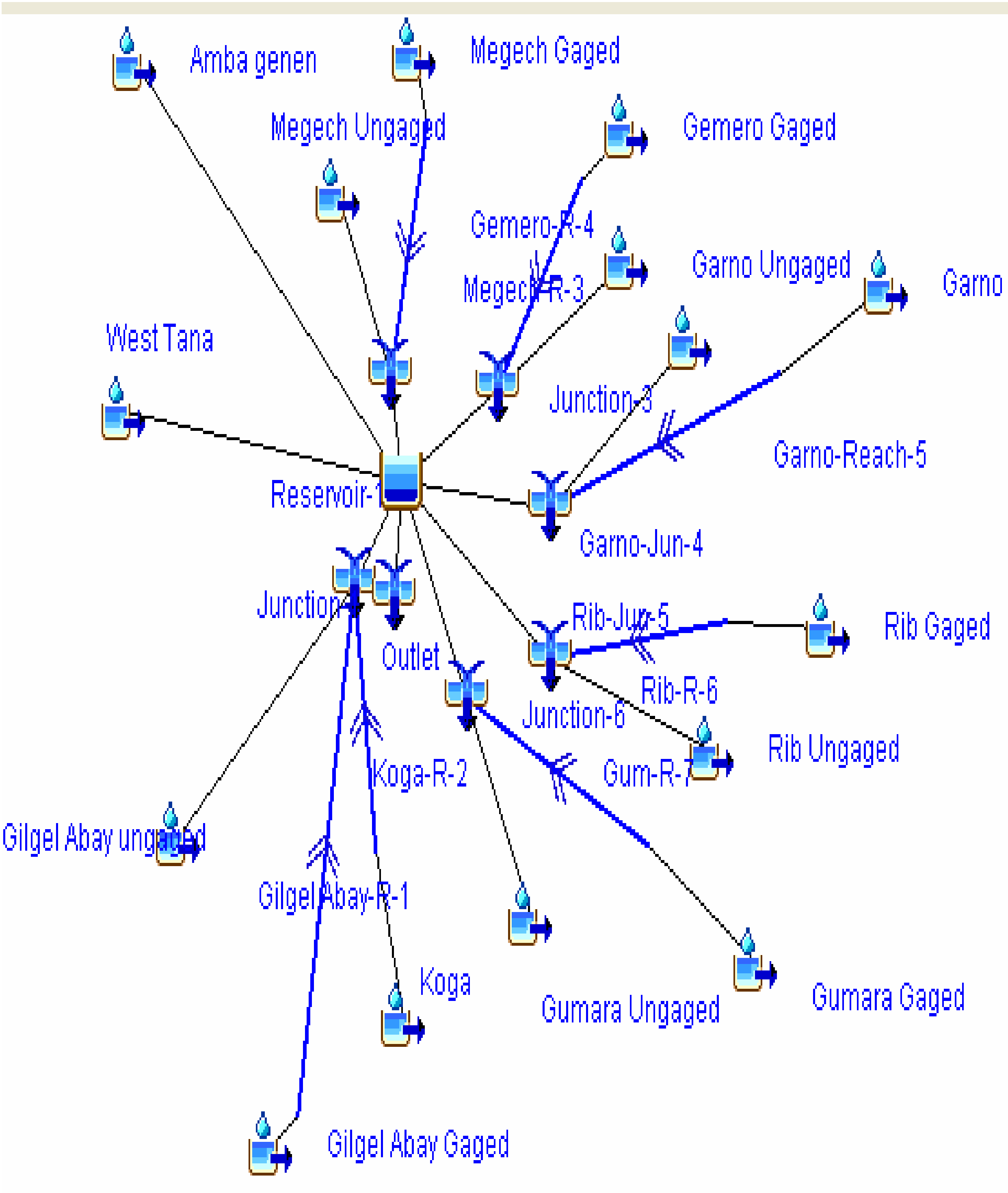


Figure 2.4: Basin model

2.3 Char Chara Weir and Control Gates

2.3.1 Chara Chara Weir

The Chara Chara weir is located about one km upstream of the Kamforo Bridge. The purpose of the weir is to improve only slightly the natural shape to control the water flow as necessary. The weir has, in plan, a shape of an inverted L, with a minor leg of 170 m and major of 600m totaling 720 m.The intake canal of about 350m in length (of which 250 m upstream and 100 m downstream)crosses the minor leg of the weir in correspondence with the gates.The Chara Chara weir is just a very long ogee spillway with a short gated structure. It is 660 meters long at level of 1787m a.s.l. with nominal design head of 1.5 m. Height varies from a minimum of one meter above ground to a maximum of six meters (short section near the gates)

Using the weir equation, $Q = CLH^{1.5}$, the elevation – discharge relation is developed

Where, C = discharge coefficient = 1.9

L = spillway crest length= 660 m

H = head over spillway crest (m)

Q = discharge over spillway (m^3/sec)

Elevation m	Discharge,Q m^3/sec
1787	0.00
1787.2	112.16
1787.4	317.24
1787.6	582.81
1787.8	897.29
1788	1254.00
1788.2	1648.43
1788.4	2077.25
1788.6	2537.92
1788.8	3028.35
1789	3546.85

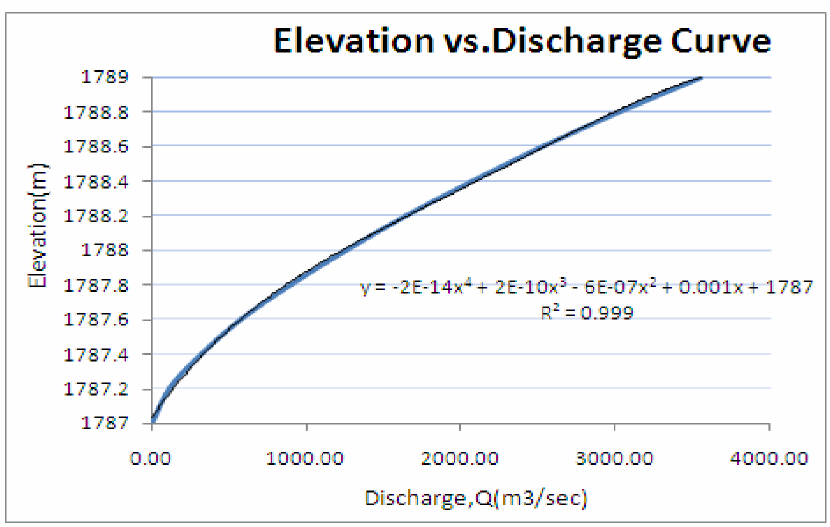


Figure2. 5:Chara char Weir Elevation vs Discharge Curve

2.3.2 Gates

The scope of the gates is to control the flow discharged from Lake Tana in to Blue Nile to satisfy the downstream water users such as Tis Abay Power Plant and the Tis Issat Falls. The gates are four in numbers having dimensions of 2 m X 3 m. The gates function as orifices. Upstream levels are controlled by Lake Tana and, at lowest levels, also by intake canal. At about minimum level(1784 m)the gates have to be fully open and water is therefore free flowing with a flow of about 30m3/sec. While at maximum level(1787 m)the gates if fully opened for Tis Issat Falls work as orifices with a flow of about 130m3/sec.

Chapter 3. Literature review

3.1 General

According to the source from which the flow is derived, runoff may be consist of surface runoff, subsurface runoff and ground water runoff .*The surface runoff* is that part of the runoff which travels over the ground surface and through channel to reach the basin outlet. That part of the surface runoff that flows over the land surface towards the stream channel is said to be over *land flow* while that one confined in the stream channels is *stream flow*. The *subsurface runoff* is the runoff due to that part of the precipitation which infiltrates the surface soil and moves laterally through the upper soil horizons towards the streams as ephemeral, shallow, perched ground water above the main ground water level. The *ground water runoff* or *ground water flow* is that part of the runoff due to deep percolation of the infiltrated water which has passed in to the ground and discharging in to the stream.

For practical purpose of runoff analysis, total runoff in the stream channel is generally classified as direct runoff and base flow. The *direct runoff* or *direct surface runoff* is that part of runoff which enters the stream promptly after the rainfall. It is equal to the sum of surface runoff and prompt subsurface runoff, plus channel precipitation. *Channel precipitation* is the precipitation that falls directly on the water surface of lakes and streams. The *base flow or base runoff* is defined as the sustained or fair-weather runoff. It is composed of ground water runoff and delayed subsurface runoff.

The phenomenon of runoff may be visualized as a cycle dependent on the nature of supply. As the rain starts, its amount is divided among channel precipitation, interception by vegetation, infiltration into soil, and temporary retention in surface depressions. The infiltrated water results in a gradual increase of water in the zone of aeration after the natural storage or field moisture capacity is satisfied. At this stage there is little overland flow except on impervious surfaces while evaporation and transpiration is slight.

From the hydrologic point of view, the runoff from a drainage basin may be considered as a product in the hydrologic cycle, which is influenced by two major groups of factors: climatic factors and physiographic factors. Climatic factors include mainly the effects of various forms and types of precipitation, interception, evaporation, and transpiration, all of which exhibit seasonal variations in accordance with the climatic environment. Physiographic factors may be classified into two kinds: basin characteristics and channel characteristics.

Figure 3-1 is a system diagram of the watershed runoff process. The processes illustrated begin with precipitation. In the simple conceptualization shown, the precipitation can fall on the watershed's vegetation, land surface, and water bodies (streams or lakes).

In the natural hydrologic system, much of the water that falls as precipitation returns to the atmosphere through evaporation from vegetation, land surfaces, and water bodies and through transpiration from vegetation. During a storm event, this evaporation and transpiration is limited. Some precipitation on vegetation falls through the leaves or runs down stems, branches and trunks to the land surface, where it joins the precipitation that fell directly onto the surface. Therefore, the water may pond, and depending upon the soil type, ground cover, antecedent moisture and other watershed properties, a portion action, moves horizontally as interflow just beneath the surface, or it percolates or may infiltrate. This infiltrated water is stored temporarily in the upper, partially saturated layers of soil. From there, it rises to the surface again by capillary vertically to the groundwater aquifer beneath the watershed. The interflow eventually moves into the stream channel. Water in the aquifer moves slowly, but eventually, some returns to the channels as base flow. Water that does not pond or infiltrate moves by overland flow to a stream channel. The stream channel is the combination point for the overland flow, the precipitation that falls directly on water bodies in the watershed, and the interflow and base flow. Thus, resultant stream flow is the total watershed outflow.

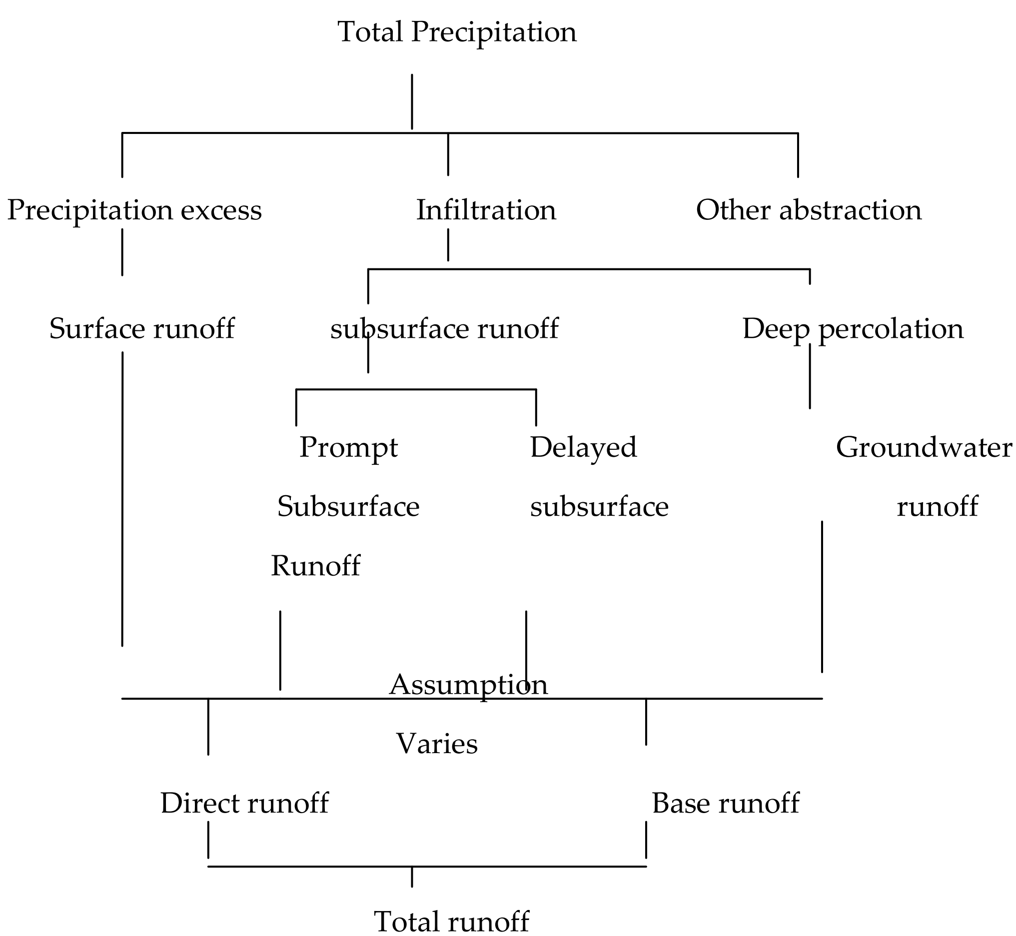


Figure 3.1: Systematic diagram of the runoff process, from total precipitation to total runoff.

3.2 Hydrologic Modeling

This section explains basic concepts of modeling and important properties of hydrologic modeling. A model relates something unknown (the out put) to something known(the input).In the case of models included in HEC-HMS ,the known input is precipitation and the unknown output is runoff, or the known input is the upstream flow and the unknown output is the downstream flow. Models take verities of forms such as physical and mathematical models. Physical models are reduced dimension representations of real world system, while mathematical models as symbolic, are usually mathematical representation of an idealized situation that has the important structural properties of the real system. To analyses the quantity of flood generated from the unguagged sub catchments the mathematical models are used in this study.USACE classified mathematical models as follows based on the mechanics of the model ,how it deals with time, how it addresses randomness, and so on.

1. Event or continues models
2. empirical or conceptual models
3. Lumped or distributed models
4. Deterministic or stochastic models
5. Measured-parameter or fitted-parameter models.

Knowing this classification is not necessary to use of Hydrologic Modeling System (HEC-HMS).It is, rather, helpful in deciding which of the models to use for intended application. Hence, the first and the fourth models are used in this study

3.2.1.1 The initial and constant-rate loss model

The underlying concept of the initial and constant-rate loss model is that the maximum potential rate of precipitation loss, f_c, is constant throughout an event. Thus, if p_t is the Mean

Areal Precipitation (MAP) depth during the time interval t to t + Δt ,the excess, pe_t, during the interval is given by:

$$pe_t = \begin{cases} (P_t - f_c) & \text{if } P_t > f_c \\ 0 & \text{otherwise} \end{cases}$$

An initial loss, I_a, is added the model to represent interception and depression storage. Until the accumulated precipitation on the pervious area exceeds the initial loss volume, no runoff occurs. Thus, the excess is given by:

$$pe_t = \begin{cases} 0 & \text{if } \sum \text{pi} < \text{I}_\text{a} \\ p_t - f_c & \textit{if } \sum p_i > I_a \textit{ and } p_{t_c} > f_c \\ 0 & \textit{if } \sum p_i > I_a \textit{ and } p_t < f_c \end{cases}$$

The initial and constant loss-rate model is very simple and appropriate for watersheds that lack detailed soil information**.** Infiltration is the major loss in pervious soil surface. As conceived by Horton, infiltration is the passage of water through the surface in to the soil. It is to be distinguished from percolation which is the movement of water with in the soil. Infiltration cannot continue unimpeded unless percolation provides sufficient space in the surface layer for in filtered water.

While the basic concept of infiltration is quite simple, practical applications are limited by the difficulty of determining quantitative relationships which are applicable to all conditions on natural basins. Precipitation on pervious surface is subject to losses. In order to compute losses different loss models are formulated by hydrologists. Of these loss models initial and constant-rate is selected and applied in this particular study. The initial and constant rate model, in fact, includes one parameter (the constant rate) and one initial condition (the initial loss).Respectively, these represent physical properties of the watershed soils and land use and the antecedent condition.

If the watershed is in a saturated condition, initial loss will approach zero. If the watershed is dry, initial loss will increase to represent the maximum precipitation depth that can fall on the watershed with no runoff; this will depend on the watershed terrain, land use, soil types, and soil treatment. The constant loss rate can be viewed as the ultimate infiltration capacity of the soils. The SCS (1986) classified soil on the basis of this infiltration capacity, and Skaggs and Khalell (1982) have published estimates of infiltration rates for those soils, as shown in Table 3.1. These may be used in the absence of better information. Because the model parameter is not a measured parameter, it and the initial condition are best determined by calibration.

Table 3. 1:SCS soil groups and infiltration (loss) rates (SCS, 1986; Skaggs and Khaleel, 1982)

Soil Group	Description	Range of Loss Rates(in/hr)
A	Deep sand, deep loess, aggregated silts	0.30-0.45
B	Shallow loess, sandy loam	0.15-30
C	Clay loams, shallow sandy loam, soil low in organic content, and soils usually high in	0.05 -0.15
D	Clay Soils that swell significantly when wet, heavy plastic clays, and certain saline soils	0.00-0.*05*

3.2.1.2. Deficit and Constant Loss Model (DCLM)

The program also includes a quasi-continuous variation on the initial and constant model of precipitation losses; this is known as the deficit and constant loss model. This model is different from the initial and constant loss model in that the initial loss can "recover" after a prolonged period of no rainfall.

To use this model, the initial loss and constant rate plus the recovery rate must be specified. The moisture deficit is tracked continuously, computed as the initial abstraction volume less precipitation volume plus recovery volume during precipitation-free periods. The recovery rate could be estimated as the sum of the evaporation rate and percolation rate, or some fraction thereof. Since the objective of this study is to compute the peak flood generated from the catchments during the storm period, event loss not continuous model is adopted.

3.2.2 Direct Runoff Computation Model

3.2.2.1 General

These models simulate the process of direct runoff of excess precipitation on a watershed. HEC-HMS refers to this process as "transformation "of precipitation excess in to point runoff. There are two options for these transform methods, viz. Empirical and Conceptual models. For this particular study empirical model is adopted.

3.2.2.2 Unit Hydrograph (UH) Models

The unit hydrograph is a well-known, commonly-used empirical model of the relationship of direct runoff to excess precipitation. As originally proposed by Sherman in 1932, it is "…the basin outflow resulting from one unit of direct runoff generated uniformly over the drainage area at a uniform rainfall rate during a specified period of rainfall duration." The underlying concept of the UH is that the runoff process is linear, so the runoff from greater or less than one unit is simply a multiple of the unit runoff hydrograph. To compute the direct runoff hydrograph with a UH, the program uses a discrete representation of excess precipitation, in which a "pulse" of excess precipitation is known for each time interval. It then solves the discrete convolution equation for a linear system:

$$Q_n = \sum P_m U_{n-m+1} \qquad (1)$$

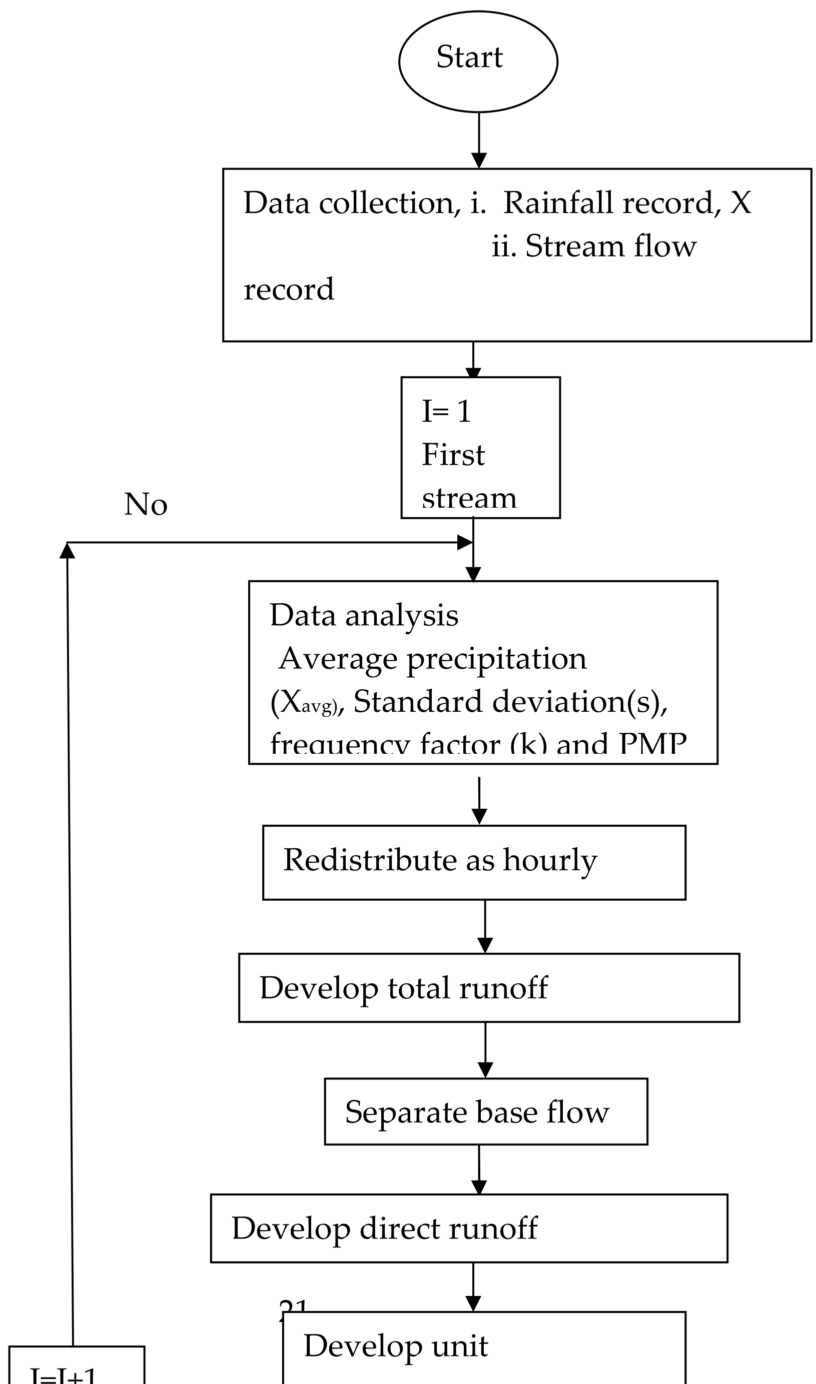
Where Q_n = storm hydrograph ordinate at time $n\Delta t$; P_m = rainfall excess depth in time interval $m\Delta t$ to $(m+1)\ \Delta t$; M = total number of discrete rainfall pulses; and U_{n-m+1} = UH ordinate at time $(n\text{-}m+1)\ \Delta t$. Q_n and P_m are expressed as flow rate and depth respectively, and U_{n-m+1} has dimensions of flow rate per unit depth.

3.2.2.3 Algorithm and flow chart:

1. Collect the data of rainfall and stream runoff for each of the tributaries Lake Tana;
2. Since the data are for 24 hours, distribute as hourly Using the formula $p=MT^{1/2}$;
3. Develop the Hydrograph(Total stream flow vs. time graph);
4. Separate base flow ;
5. Develop Direct Runoff Hydrograph(DRH);
6. Develop Unit Hydrograph(UH);
7. Compute excess rainfall hyetograph using Φ-index method;
8. Multiply UH ordinate by excess rainfall;
9. Compute runoff generated by convolution method;
10. Plot runoff hydrograph of flood;
11. Find maximum ordinate. This gives maximum flood value to the stream selected;
12. Repeat the steps 1 to 10for all other tributaries
13. Assuming the entire catchment is active simultaneously, add flood due to each stream.

This gives the maximum flood generated from Lake Tana catchment

We have 24 hours rainfall records available in the catchment area. This record is considered and distributed over 24-hrs using the formula $p=MT^{1/2}$. After distribution over every hour of 24 hours, Unit Hydrograph (UH)of one hour duration was developed. Since, the flood is expected to be from a maximum of 3-hrs duration, a UH of 3-hrs duration is developed. The development of UH and direct runoff hydrograph (DRH) is presented as follow next to flow chart for Garno catchment. While, UH development for the remaining sub catchments is annexed at the end [VII]



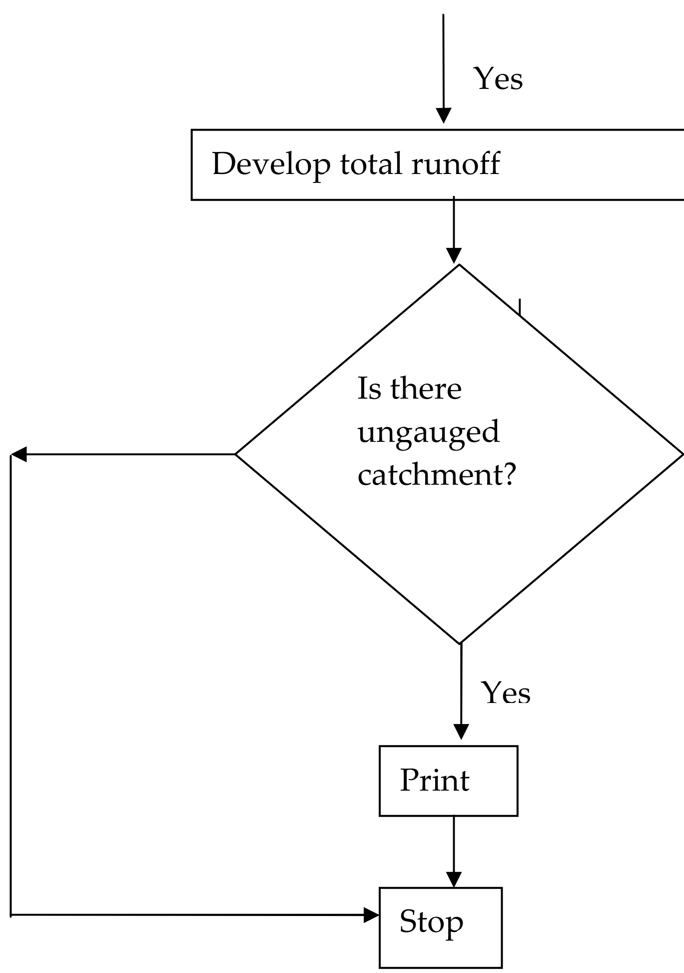


Figure 3-2: Flow Chart

Table-3.2 Rainfall and Stream flow data adopted from 24 hours record for Garno

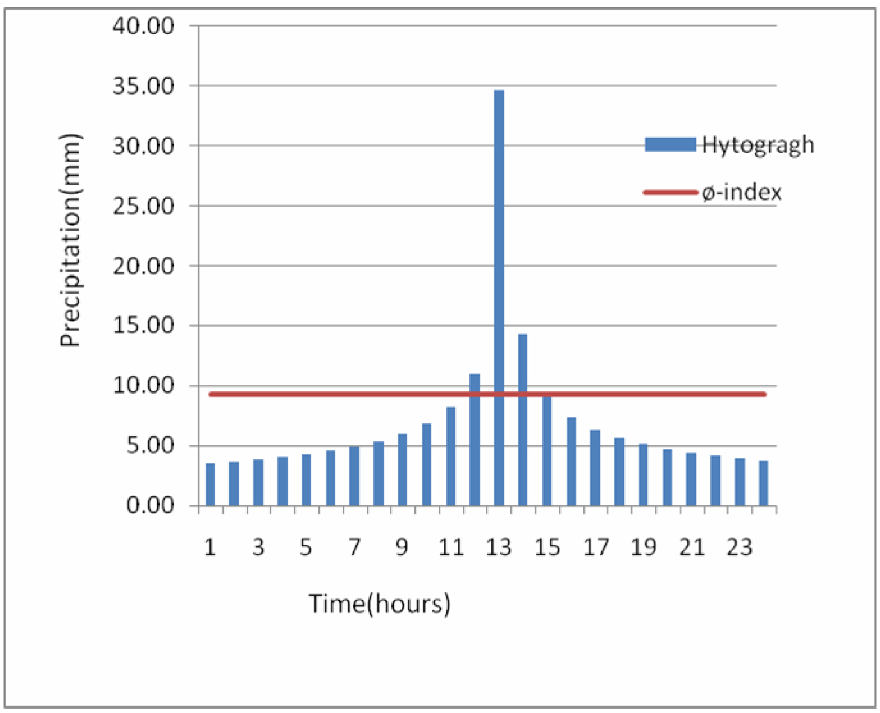
Garno-100,Area= 100.14

Time Hrs	Obs.Dis. m3/s	Baseflow m3/s	DRH m3/s	UHO	Precipit. mm	Excess Prec.	ø-index -335544.32
	15.71	15.71	0.00	0			9.32
	15.71	15.71	0.00	0.00	3.57		9.32
	15.71	15.71	0.00	0.00	3.65		9.32
	15.71	15.71	0.00	0.00	3.82		9.32
	15.71	15.71	0.00	0.00	4.02		9.32
	15.71	15.71	0.00	0.00	4.26		9.32
	15.71	15.71	0.00	0.00	4.55		9.32
	15.71	15.71	0.00	0.00	4.90		9.32
	15.71	15.71	0.00	0.00	5.34		9.32
0	15.71	15.71	0.00	0.00	5.94		9.32
1	27.22	15.71	11.51	0.36	6.79		9.32
2	35.14	15.71	19.43	0.61	8.17		9.32
3	41.58	15.71	25.87	0.81	11.00	1.68	9.32
4	47.14	15.71	31.43	0.98	34.62	25.30	9.32
5	52.12	15.71	36.41	1.14	14.34	5.02	9.32
6	56.66	15.71	40.95	1.28	9.28		9.32
7	60.86	15.71	45.15	1.41	7.39		9.32
8	64.79	15.71	49.08	1.53	6.32		9.32
9	68.50	15.71	52.79	1.65	5.62		9.32
10	72.01	15.71	56.30	1.76	5.11		9.32
11	75.37	15.71	59.66	1.86	4.71		9.32
12	76.99	15.71	61.28	1.91	4.40		9.32
13	73.71	15.71	58.00	1.81	4.14		9.32
14	70.28	15.71	54.57	1.71	3.92		9.32
15	66.67	15.71	50.96	1.59	3.73		
16	62.86	15.71	47.15	1.47			

17	58.80	15.71	43.09	1.35			
18	54.44	15.71	38.73	1.21			
19	49.69	15.71	33.98	1.06			
20	44.45	15.71	28.74	0.90			
21	38.49	15.71	22.78	0.71			
22	31.43	15.71	15.72	0.49			
23	22.22	15.71	6.51	0.20			
24	15.71	15.71	0.00	0.00			
	15.71	15.71	0.00			32.0006	

Volume,V=ΔtΣ(DRH)= 890.15 27.82

excess precipitation depth= 32.0006 1.00 Ok



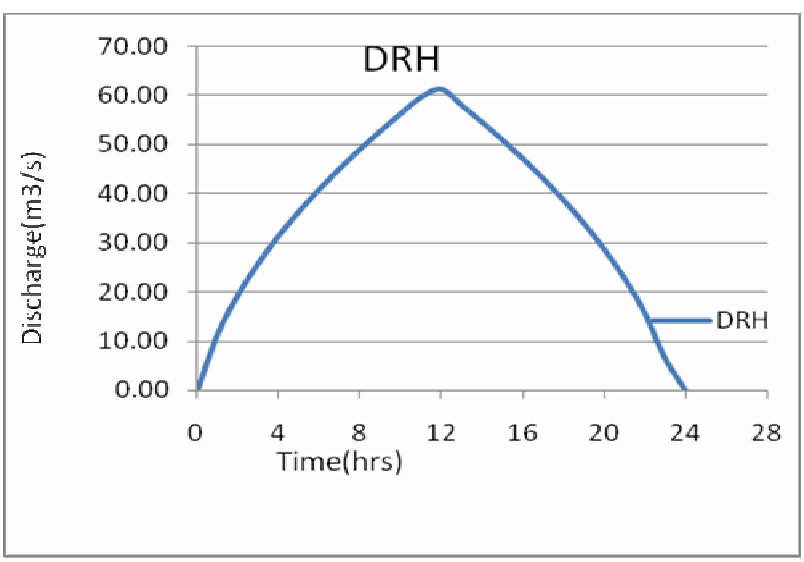


Table------- Rainfall and Stream flow data adopted from 24 hours record for Garno

Time Hrs	3 h U.H m3/s	Direct Runoff inm3/s from effective rainfall during three successive 3 h periods 5.05 mm	75.90 mm	15.06 mm	Flood hydrograph Ordinate(m3/s)
0	0	0.00			0.00
1	0.36	5.42			5.42
2	0.61	9.14			9.14
3	0.81	12.17	0.00		12.17
4	0.98	14.79	27.30		42.09
5	1.14	17.14	46.08		63.22
6	1.28	19.27	61.35	0.00	80.63
7	1.41	21.25	74.56	1.82	97.62
8	1.53	23.10	86.36	3.07	112.52
9	1.65	24.84	97.13	4.08	126.05
10	1.76	26.50	107.10	4.96	138.55
11	1.86	28.07	116.42	5.75	150.24
12	1.91	28.84	125.21	6.46	160.51
13	1.81	27.30	133.54	7.13	167.96
14	1.71	25.68	141.49	7.75	174.92
15			145.34	8.33	153.67
16			137.56	8.89	146.45
17			129.43	9.41	138.84
18			0.00	9.67	9.67
19				9.15	9.15
20				8.61	8.61
21				0.00	0.00

Table 3.3 Combined floods generated from Lake Tana sub basins

Time	Ordinates of Flood Hydrograph(m^3/s)																Flood generated From Tana Basin
Hrs	G/Abay	G/Abay-ug	Gelda	Gumara-ug	W/Tana	A/Genen	Garno-ug	Garno	Gem-ug	Gemero	Koga	Gumara	Meg-ug	Megech	Rib-ug	Rib	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	22.05	25.27	0.00	0.03	12.42	5.42	153.18	54.98	0.47	136.83	0.01	0.00	13.70	32.93	457.26
2	13.47	20.78	81.78	90.62	8.78	1.46	20.97	9.14	572.19	205.37	24.10	490.63	0.73	14.47	46.97	112.92	1714.39
3	48.29	74.52	174.27	188.54	31.49	2.90	27.91	12.17	1221.07	438.27	61.02	1020.80	1.44	37.41	82.95	199.42	3622.49
4	100.46	155.04	272.82	289.35	65.52	4.34	96.51	42.09	2075.40	744.91	91.04	1566.64	2.16	56.06	113.12	271.93	5947.40
5	154.18	237.95	358.67	375.27	100.56	5.78	144.96	63.22	3117.20	1118.84	117.02	2031.81	2.87	141.30	139.64	335.70	8445.00
6	199.97	308.60	434.54	451.59	130.42	7.22	184.87	80.63	4332.54	1555.06	140.26	2445.00	3.59	265.31	163.61	393.31	11096.51
7	240.63	371.36	503.35	521.00	156.94	8.66	223.85	97.62	5710.18	2049.53	161.47	2820.81	4.31	367.55	185.64	446.27	13869.16
8	277.62	428.44	566.80	585.12	181.06	10.10	258.02	112.52	7240.81	2598.91	181.09	3167.99	5.02	459.10	206.14	495.56	16774.31
9	311.79	481.17	625.99	645.02	203.35	11.54	289.04	126.05	8916.59	3200.39	199.47	3492.30	5.74	543.05	225.39	541.85	19818.73
10	343.70	530.43	681.69	701.44	224.17	12.98	317.70	138.55	10577.56	3796.55	216.77	3797.78	6.45	619.63	243.61	585.64	22794.66
11	373.77	576.82	734.46	754.93	243.77	14.42	344.50	150.24	12039.63	4321.33	233.19	4087.38	7.17	690.58	260.93	627.28	25460.40
12	402.27	620.81	777.71	797.87	262.36	15.86	368.04	160.51	13136.50	4715.02	248.71	4319.88	7.88	757.01	273.13	656.61	27520.18
13	425.15	656.12	789.83	806.45	277.29	17.30	385.14	167.96	13886.29	4984.14	255.83	4366.31	8.60	815.11	267.89	644.02	28753.44
14	429.72	663.17	768.31	780.71	280.27	18.74	401.09	174.92	14299.68	5132.52	240.50	4226.96	9.31	856.23	250.90	603.18	29136.20
15	416.01	642.01	720.00	728.52	271.32	20.18	352.36	153.67	14382.10	5162.10	224.42	3944.41	10.03	894.51	233.08	560.32	28715.03
16	388.20	599.09	666.47	673.63	253.19	21.62	335.80	146.45	14134.59	5073.26	207.54	3647.19	10.75	908.23	214.28	515.12	27795.40
17	358.95	553.95	609.86	615.55	234.11	23.06	318.36	138.84	13553.97	4864.86	189.68	3332.73	11.46	853.48	194.32	467.15	26320.33
18	328.00	506.19	549.58	553.64	213.92	24.50	22.17	9.67	12632.37	4534.08	170.67	2997.57	12.18	795.82	172.97	415.81	23939.14
19	295.01	455.28	484.77	487.04	192.41	25.94	20.99	9.15	11355.77	4075.87	150.24	2636.94	12.89	734.05	149.87	360.28	21446.49
20	259.52	400.51	414.22	414.42	169.26	27.38	19.75	8.61	9766.35	3505.39	128.01	2243.80	13.61	666.01	124.51	299.31	18460.65
21	220.83	340.80	335.99	333.75	144.03	28.81	0.00	0.00	8020.60	2878.80	103.40	1807.02	14.32	593.02	96.04	230.87	15148.28

Time	Ordinates of Flood Hydrogragh(m³/s)																Flood generated From Tana Basin
Hrs	G/Abay	G/Abay-ug	Gelda	Gumara-ungaged	W/Tana	A/Genen	Garno-ungaged	Garno	Gem-ungaged	Gemero	Koga	Gumara	Meg-ug	Megech	Rib-ungaged	Rib	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	177.84	274.46	246.65	241.34	115.99	30.25	0.00	0.00	6416.49	2303.04	75.44	1306.66	15.04	513.73	62.89	151.18	11930.99
23	128.60	198.46	138.55	128.89	83.87	31.69	0.00	0.00	4961.29	1780.73	42.20	697.86	15.75	425.85	21.30	51.21	8706.26
24	68.68	105.99	54.58	46.58	44.79	32.53	0.00	0.00	3663.53	1314.93	0.00	252.18	16.17	324.68	0.00	0.00	5924.64
25	24.82	38.30	5.04	0.00	16.19	0.00	0.00	0.00	2533.41	909.30	0.00	0.00	0.00	240.23	0.00	0.00	3767.30
26							0.00	0.00	1583.39	568.32				140.26	0.00	0.00	2291.97
27							0.00	0.00	829.21	297.62				10.42		0.00	1137.26
28										104.69				7.63			112.31
29														4.32			0.00

The total peak food estimated joining Tana Lake from all its tributaries is 29136.2 m3/s.The author is the first attempting to find the maximum flood generated from Lake Tana catchments. Further researchers can refer this value as a standing reference.

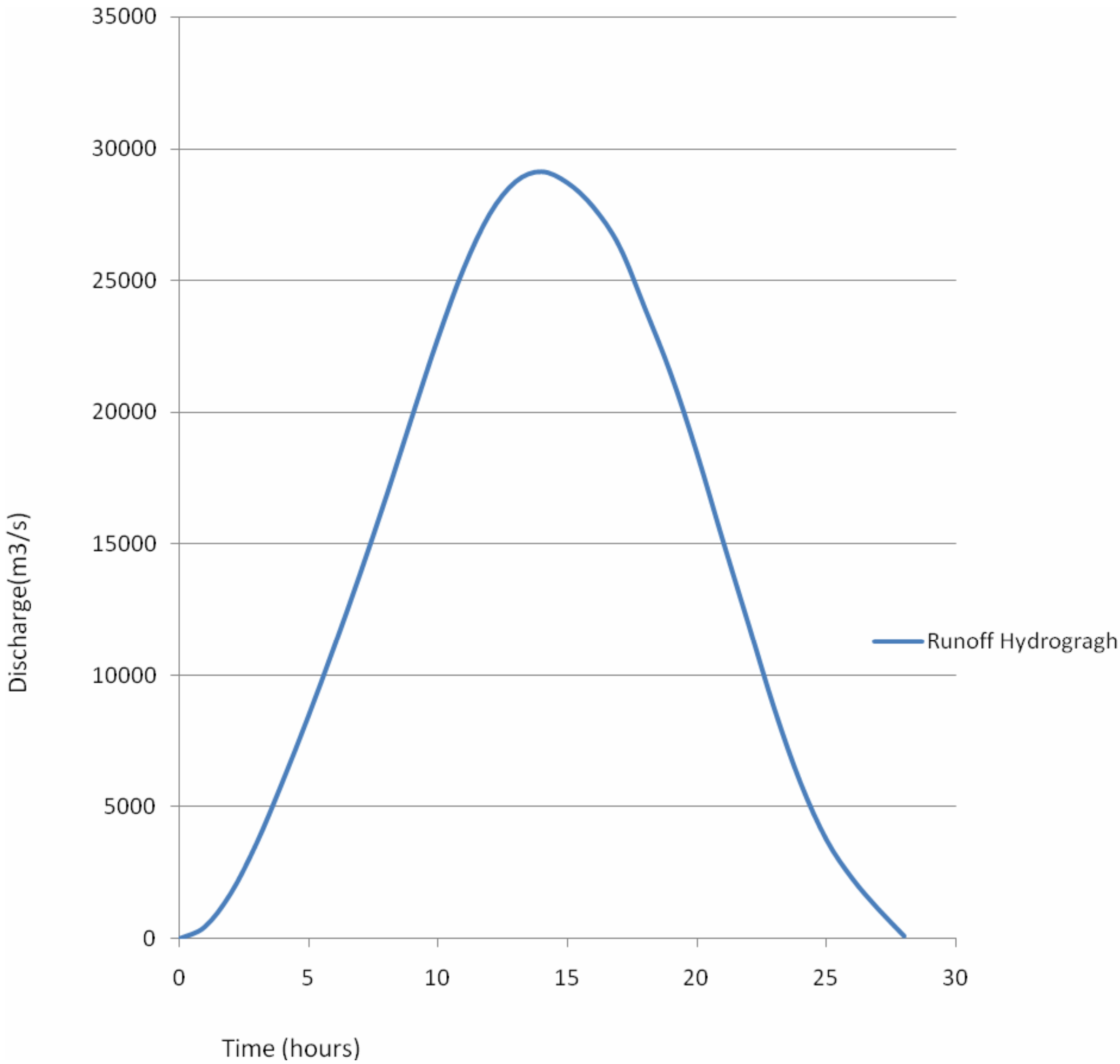


Figure 3.3 Flood Hydrograph

3.2.2.3 Snyder Unit Hydrograph Transform Method

In 1938, Snyder published a description of a parametric UH that he had developed for analysis of unguaged watersheds in the Appalachian Highlands in the US, and he provided relationships for estimating the UH parameters from watershed characteristics. HEC-HMS includes an implementation of Snyder's UH.

For his work, Snyder selected the lag, peak flow, and total time base as the critical characteristics of a UH. He defined a standard UH as one whose rainfall duration, tr, is related to the basin lag, tp, by:

$$t_p = 5.5t_r \quad \text{---}(2)$$

(Here lag is the difference in the time of the UH peak and the time associated with the centroid of the excess rainfall hyetograph. Thus, if the duration is specified, the lag (and hence the time of UH peak) of Snyder's standard UH can be found. If the duration of the desired UH for the watershed of interest is significantly different from that specified by the above Equation , the following relationship can be used to define the relationship of UH peak time and UH duration:

$$t_{pR} = t_p - \frac{t_r - t_R}{4} \quad \text{---}(3)$$

in which t_R = duration of desired UH; and t_{pR} = lag of desired UH.

For the ***standard case***, Snyder discovered that UH lag and peak per unit of excess precipitation per unit area of the watershed were related by:

$$\frac{U_p}{A} = C\frac{C_p}{t_p} \quad \text{---}(4)$$

Where Up = peak of standard UH; A = watershed drainage area; Cp = UH peaking coefficient; and C = conversion constant (2.75 for SI or 640 for foot-pound system).

For other durations, the UH peak, Q_{pR}, is defined as:

$$\frac{U_{pR}}{A} = C\frac{C_p}{t_{pR}} \quad \text{---(5)}$$

Snyder's UH model requires specifying the standard lag, t_p, and the coefficient, C_p. The HEC-HMS sets t_{pR} of Equation 3 equal the specified time interval, and solves Equation 3 to find the lag of the required UH. Finally, Equation 5 is solved to find the UH peak. Snyder proposed a relationship with which the total time base of the UH may be defined. Instead of this relationship, the program uses the computed UH peak and time of peak to find an equivalent UH with Clark's model. From that, it determines the time base and all ordinates other than the UH peak. Snyder collected rainfall and runoff data from gaged watersheds, derived the UH as described earlier, parameterized these UH, and related the parameters to measurable watershed characteristics. For the UH lag, he proposed:

$$t_p = CC_t (LL_c)^{0.3} \quad \text{---(6)}$$

Where C_t = basin coefficient; L = length of the main stream from the outlet to the divide; L_c = length along the main stream from the outlet to a point nearest the watershed centroid; and C = a conversion constant (0.75 for SI and 1.00 for foot-pound system).

The parameter C_t of Equation 6 and C_p of Equation 4 are best found via calibration, as they are not physically-based parameters. Bedient and Huber (1992) report that C_t typically ranges from 1.8 to 2.2, although it has been found to vary from 0.4 in mountainous areas to 8.0 along the Gulf of Mexico. They report also that C_p ranges from 0.4 to 0.8, where larger values of C_p are associated with smaller values of C_t.

3.2.2.4 Clark Unit Hydrograph Model

Clark's model derives a watershed UH by explicitly representing two critical processes in the transformation of excess precipitation to runoff:

- **Translation** or movement of the excess from its origin throughout the drainage to the watershed outlet.

- **Attenuation** or reduction of the magnitude of the discharge as the excess is stored throughout the watershed.

Short-term storage of water throughout a watershed (in the soil, on the surface, and in the channels) plays an important role in the transformation of precipitation excess to runoff. The linear reservoir model is a common representation of the effects of this storage. That model begins with the continuity equation:

$$\frac{dS}{dt} = I_t - O_t \text{ -----------------1}$$

in which dS/dt = time rate of change of water in storage at time t; I_t = average inflow to storage at time t; and O_t = outflow from storage at time t.

With the linear reservoir model, storage at time t is related to outflow as:

$$S_t = RO_t \text{ -------------------2}$$

Where R = a constant linear reservoir parameter. Combining and solving the equations using a simple finite difference approximation yields:

$$O_t = C_A\, I_t + C_B\, O_{t-1} \text{ -----3}$$

Where C_A, C_B = routing coefficients. The coefficients are calculated from:

$$C_A = \frac{\Delta t}{R + 0.5\Delta t} \text{ --------------4}$$

$$C_B = 1 - C_A \text{ --------------------5}$$

The average outflow during period t is:

$$\bar{O} = \frac{O_{t-1} + O_t}{2} \text{ --------------------6}$$

With Clark's model, the linear reservoir represents the aggregated impacts of all watershed storage. Thus, conceptually, the reservoir may be considered to be located at the watershed outlet.In addition to this lumped model of storage, the Clark model accounts for the time required for water to move to the watershed outlet. It does that with a linear channel model (Dooge, 1959), in which water is "routed" from remote points to the linear reservoir at the outlet with delay (translation), but without attenuation. This delay is represented implicitly with a so-called time-area histogram. That specifies the watershed area contributing to flow at the outlet as a function of time. If the area is multiplied by unit depth and divided by Δt, the computation time step, the result is inflow, I_t, to the linear reservoir.

Solving Equation 3 and Equation 6 recursively, with the inflow thus defined, yields values of $\bar{O}_t$ .However, if the inflow ordinates in Equation 18 are runoff from a unit of excess, these reservoir outflow ordinates are, in fact, U_t, the UH.

$$\frac{A_t}{A} = \begin{cases} 1.414\left(\frac{t}{t_c}\right)^{1.5} & for\ t \leq \frac{t_c}{2} \\ 1 - 1.414\left(1 - \frac{t}{t_c}\right)^{1.5} & for\ t \geq \frac{t_c}{2} \end{cases}$$

Where A_t = cumulative watershed area contributing at time t; A = total watershed area; and t_c = time of concentration of watershed. Application of this implementation only requires the parameter t_c, the time of concentration. This can be estimated via calibration.

The basin storage coefficient, R, is an index of the temporary storage of precipitation excess in the watershed as it drains to the outlet point. It, too, can be estimated via calibration if gagged precipitation and stream flow data are available. Though R has units of time, there is only a qualitative meaning for it in the physical sense. Clark (1945) indicated that R can be computed as the flow at the inflection point on the falling limb of the hydrograph divided by the time derivative of flow.

3.2.2.5 Base flow Modeling

Exponential Recession

The parameters of this model include the initial flow, the recession ratio, and the threshold flow. As noted, the initial flow is an initial condition. For analysis of hypothetical storm runoff, initial flow should be selected as a likely average flow that would occur at the start of the storm runoff. For frequent events, the initial flow might be the average annual flow in the channel. Field inspection may help establish this. As with the constant, monthly-varying base flow, for most urban channels and for smaller streams in the western and southwestern US, this may well be zero, as the base flow contribution is negligible.

The recession constant, k, depends upon the source of base flow. If k = 1.00, the base flow contribution will be constant, with all $Q_t = Q_0$. Otherwise to model the exponential decay typical of natural undeveloped watersheds, k must be less than 1.00. Table 3.2 shows typical values proposed by Pilgrim and Cordery (1992) for basins ranging in size from 300 to 16,000 km^2 (120 to 6500 square miles) in the US, eastern Australia, and several other regions. Large watersheds may have k values at the upper end of the range, while smaller watersheds will have values at the lower end.

Table 3. 2 Typical recession constant values.

Flow component	Recession Constant, Daily
Ground flow	0.9
Inter flow	0.8 -0.9
Surface runoff	0.3- 0.8

The recession constant can be estimated if gagged flow data are available. Flows prior to the start of direct runoff can be plotted, and an average of ratios of ordinates spaced one day apart can be computed. This is simplified if a logarithmic axis is used for the flows, as the recession model will plot as a straight line.

The threshold value can be estimated also from examination of a graph of observed flows versus time. The flow at which the recession limb is approximated well by a straight line defines the threshold value.

The parameters of this model include the initial flow, the recession ratio, and the threshold flow. As noted, the initial flow is an initial condition. For analysis of hypothetical storm runoff, initial flow should be selected as a likely average flow that would occur at the start of the storm runoff. For frequent events, the initial flow might be the average annual flow in the channel. Field inspection may help establish this. As with the constant, monthly-varying base flow, for most urban channels and for smaller streams in the western and southwestern US, this may well be zero, as the base flow contribution is negligible.

3.2.3 Meteorological Model

3.2.3.1 Specified Hyetograph

The specified hyetograph method allows the user to specify the exact time-series to use for the hyetograph at sub basins. This method is useful when precipitation data will be processed externally to the program and essentially imported without alteration. This method is also useful when a single precipitation gage can be used to represent what happens over a sub basin. Several options are available to increase control over how the data is processed.

A hyetograph must be stored as a precipitation gage before it can be used in the meteorological model. The data may actually be from a recording gage or could be the result of complex calculations exterior to the program. Regardless, the hyetograph must be stored as a gage. One may use the same gage for more than one sub basin. A total depth for each sub basin may optionally be entered. If no total depth is entered, the depth will be the sum of the data actually stored in the precipitation gage. However, if a total depth is entered for a sub basin, the exact pattern is maintained but the magnitude of precipitation at each time step is adjusted so that the specified depth is applied over the entire simulation. Total depth can be specified for no sub basins, one sub basin, many sub basins, or all sub basins. It is not required to enter the depth for all sub basins in order to specify it for just one sub basin. If no total depth is entered the depth will be the sum of the data actually stored in the precipitation gage.

3.2.3.2. Evapotranspiration

Evapotranspiration is the second of the three components of a meteorological model. It is the combination of evaporation from the ground surface and transpiration by vegetation. It is only required if the meteorological model will be used with sub basins that use continuous simulation loss rate methods: deficit constant, gridded deficit constant, soil moisture accounting, and gridded soil moisture accounting. Even if those methods are used in the sub basins, an evapotranspiration method is not required. If a continuous simulation loss rate method is used and no evapotranspiration is specified in the meteorological model, then zero evapotranspiration is used in the sub basins. In all cases, the meteorological model is computing the potential evapotranspiration and sub basins will calculate actual evapotranspiration based on soil water limitations.

3.2.3.3 Frequency Storm

The frequency storm method is designed to produce a synthetic storm from statistical precipitation data. This method uses the same parameter data for all sub basins in the meteorological model. Each storm has a single exceedance probability which must be selected from the list of available choices which ranges from 0.2 to 50 percent (in the program).

The frequency storm method is designed to accept partial duration precipitation data, as this is the most common type. However, the method is capable of computing either annual or partial-duration output. The difference between annual and partial-duration output is small for exceedance probabilities 4% and smaller.

The intensity duration specifies the shortest time period of the storm. Usually the duration is set equal to the time step of the simulation and less than the total storm duration.

Storm duration determines how long the precipitation will last. This is also longer than the intensity duration. If the simulation duration is longer than the storm duration, all time periods after the storm duration will have zero precipitation.

The intensity position determines where in the storm the period of peak intensity will occur. Changing the position does not change the total depth of the storm; it only changes how the total depth is distributed in time during the storm. 25%, 33%, 50%, 67%, or 75% may be selected from the list of choices. If the storm duration is selected to be 6 hours and the 25% position is selected, the peak intensity will occur 1.5 hours after the beginning of the storm.

The storm area is used to automatically compute the depth-area reduction factor. In most cases the specified storm area is taken equal to the watershed drainage area at the point of evaluation. The same hyetograph is used for all sub basins. Optionally the storm area may be left blank. When no storm area is specified, each sub basin will have a different hyetograph computed using the sub basin area as the storm area.

Precipitation depth values must be entered for all durations from the peak intensity to the total storm length. Values for durations less than the peak intensity duration or greater than the total storm duration cannot be entered. The values must be entered as partial-duration data. Values should be entered as the total precipitation depth expected for the specified duration.

3.2.3.4 Frequency-Based Hypothetical Storm

The objective of the frequency-based hypothetical storm that is included in the program is to define an event for which the precipitation depths for various durations within the storm have a consistent exceedance probability. The following steps are adopted to develop the storm:

1. The total point-precipitation depths for the selected exceedance probability for durations of an hour through the desired total duration of the hypothetical storm (24-hours) are

specified. Depths for durations less than the time interval selected for runoff modeling are ignored.

2. The program applies an area correction factor to the specified depths. Precipitation estimates from depth-duration-frequency studies, commonly are point estimates. However, intense rainfall is unlikely to be distributed uniformly over a large watershed. For a specified frequency and duration, the average rainfall depth over an area is less than the depth at a point. To account for this, the U.S. Weather Bureau (1958) derived, from averages of annual series of point and areal values for several dense, recording-rain gage networks, factors by which point depths are to be reduced to yield areal-average depths. The factors, expressed as a percentage of point depth, are a function of area and duration.

   In accordance with the recommendation of the World Meteorological Organization (1994), point values should be used without reduction for areas less than 9.6 sq. mi.(24.864 sq.km) Furthermore, in accordance with the recommendation of HEC (USACE, 1982), no adjustment should be made for durations less than 30 minutes. A short duration is appropriate for a watershed with a short time of concentration. The factors derived by U.S. Weather Bureau are not applied for sub basin of area greater than 400 sq.mils.

   For this study it seams reasonable to use the Area Reduction Factor (ARF) derived in East Africa (Fiddes et al 1974), where the expression

   $ARF = 1 - 0.044\,A^{0.275}$ is recommended

Where A = area (km^2)

3. The depths for durations that are integer multiples of the time intervals selected for runoff modeling are found by interpolation. Linear interpolation is used, with logarithmically transformed values of depth and duration specified in Step 1.

4. Successive differences in the cumulative depths from Step 3 are calculated, thus computing a set of incremental precipitation depths, each of duration equal to the selected computation interval.
5. The alternating block method (Chow, Maidment, Mays, 1988) is applied to develop a hyetograph from the incremental precipitation values (blocks). This method positions the block of maximum incremental depth at the middle of the required duration. The remaining blocks are arranged then in descending order, alternately before and after the central block.

3.2.3.5 Storm Selection

The selection of storm depends upon the goal and the information needs of the study. If the goal is to define a regulatory floodplain, such as the so-called 100-yr floodplain, a single hypothetical storm with the specified AEP selected and the runoff from that storm is computed, and then assigned to the flow, volume, or stage the same AEP as that assigned to the storm. On the other hand, if the goal is to define a discharge-frequency function, the solution is to define hypothetical storms with AEP ranging from small, frequent events (say 0.50 AEP) to large, infrequent events (such as the 0.002-AEP event.) With these, the runoff is computed and assigned to the runoff peaks, volumes or states the same AEP as the hypothetical storm.

The information need of the study would also determine the selection of the storm. The SPS may be chosen to provide hydrological estimates for design of a major flood-control structure. On the other hand, a different distribution, such as the triangular temporal distribution, may be selected if flows for establishing frequency functions for determining optimal detention storage are necessary.

For this particular project, as the objective is to determine the peak flood generated from the basin, a single hypothetical storm is selected. The selected storm must be sufficiently long so that the entire watershed is contributing to runoff at the concentration point. Thus, the duration must exceed the time of concentration of the watershed; some argue that it should be 3 or 4 times the time of concentration (Placer County, 1990). Using observed data, Levy and McCuen (1999) showed that 24 hr is a good hypothetical-storm length for watersheds in Maryland from 2 to 50 square miles. This leads to the conclusion that a 24-hr hypothetical storm is a reasonable choice if the storm duration exceeds the time of concentration of the watershed. Indeed, much drainage system planning in the US relies on use of a 24-hr event, and the SCS events are limited to storms of 24-hr duration. Hence, the duration of storm is also taken to be 24-hr for this particular study.

3.2.4 Parameter Calibration

Each model that is included in the program has parameters and the value of each parameter must be specified to use the model for estimating runoff or routing hydrographs. However, some of the models that are included have parameters that cannot be estimated by observation or measurement of channel or watershed characteristics. The parameter C_P in the Snyder UH model is an example; this parameter has no direct physical meaning If rainfall and stream flow observations are available, *calibration* is used to determine appropriate values for the parameters. Calibration uses observed hydro meteorological data in a systematic search for parameters that yield the best fit of the computed results to the observed runoff.

Given these initial estimates of the parameters, the models included in the program can be used with the observed boundary conditions (rainfall or upstream flow) to compute the output, either the watershed runoff hydrograph or a channel outflow hydrograph.

At this point, the program compares the computed hydrograph to the observed hydrograph. The goal of this comparison is to judge how well the model "fits" the real hydrologic system. If the fit is not satisfactory, the program systematically adjusts the parameters and reiterates. The algorithms for adjusting the parameters are described later in this chapter.

When the fit is satisfactory, the program will report the optimal parameter values. The presumption is that these parameter values then can be used for runoff or routing computations that are the goal of the flood runoff analyses.

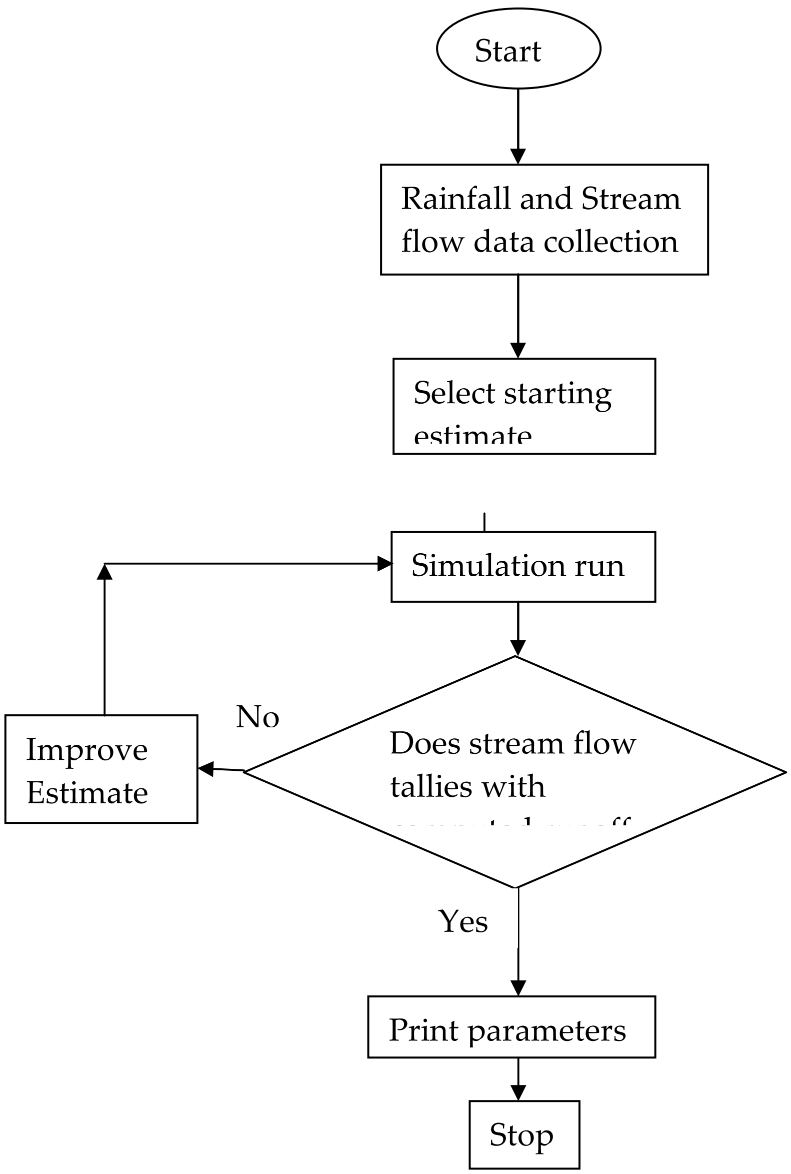


Figure2.1: Schematic of Calibration Procedure

3.2.5 Selection of Route Method

The Lake is considered as a reservoir with many inflows and one computed outflow. All the inflows from sub basins are added before computing the outflow. It is assumed that the water surface in the reservoir (Lake) pool is level. Several methods are available for defining the storage properties of the reservoir

Storage Method

The exact form of the characteristics depends on the selection of routing method The ***Outflow Curve*** routing method can accept three different forms of storage characteristics: storage-discharge, elevation-storage-discharge, or elevation-area-discharge. The ***Outflow Structures*** route method can accept two different forms of storage characteristics: elevation-storage, or elevation-area. The ***Specified Release*** route method can accept two different forms of storage characteristics: elevation-storage, or elevation-area. The ***Outflow Structures*** route method would be selected as the elevation-storage, or elevation-area function from Tana Beles Project Report [2.2.1 Lake Tana Bathymetry (studio Pietrangeli)] was to be directly used.

Tail water Method

The tail water method only applies to the Outflow Structures routing method. The selected method determines how submergence will be calculated for the individual structures specified as part of the reservoir. When a structure is submerged, the discharge through the structure will decrease in accordance with the physics of the structure and the tail water elevation for each time interval. Only one tail water method can be selected and it is applied to all structures specified as part of the reservoir. The Assume None method is used in cases where reservoir tail water has no affect on the reservoir outflow.

The Reservoir Discharge method is typically used with reservoirs that span the stream channel and are not influenced by backwater from downstream sources. For such cases, the tail water below the reservoir only comes from the reservoir releases. A rating curve defined by an elevation-discharge paired data function must be selected to convert reservoir outflow to stage.

Discharge Gage and Maximum Options

The selection of a discharge gage and optional maximum release and maximum capacity parameters only applies to the Specified Release routing method. The routing method is designed for situations where the outflow for a reservoir is measured and can be used instead of computing outflow on the basis of an outflow curve or outflow structures.

A time-series gage must be selected for discharge from the reservoir. The gage should represent actual measured outflows for time periods in the past and estimated outflows for any time periods in the future.

A maximum release flow rate and a maximum capacity may optionally be entered. The flow rate specified in the time-series gage will always be released from the reservoir. The storage in the reservoir will be tracked on the basis of the specified release and the computed inflow, using the storage function.

Chapter 4 Data Source and Analysis

4.1 Sources and Availability of Data

4.1.1 Hydrology Data

General

Hydrology is that branch of physical geography dealing with the waters of the earth with special reference to properties, phenomena, and the distribution. It treats specifically of the occurrence of water on the earth, the description of the earth with respect to water, the physical effects of water on the earth, and the relation of water to life on the earth. The hydrologic characteristics of an area are determined largely by the climatic of the region and the geological structure of the area.

Data Availability

There are seven gagged rivers which are monitored by Ministry of Water Resources .In addition to these, there is one river called Dirma that is recently installed but the coordinate of its location is not mentioned in the station list collected from Ministry of Water Resources. For this reason, it is ignored while the rest are analyzed and used for parameter calibration.

4.1.2 Rainfall Data Availability

In and/or nearby the study area there are about twenty three rainfall gagging stations. Few of these have long period missing data. Of these gauging stations Gorgora, Gondar air port, Bahir Dar ,Debretabor and Dangila are class one and two while the rest are class three and four. However, there is no adequate rainfall data available to develop highly accurate intensity-duration-frequency curves.Hence; Louice Berger International inc. in association with SABA Engineering Pvt.Ltd Company used the 24-hour rainfall depth records to project the frequency of 24-hour rainfall depths. Based on the monthly rainfall depths and patterns, Louice Berger divided the country into regions and sub-regions and analyzed the 24-hour depth frequency data for each sub-region. The result of the study is presented below and directly applied to compute the Probable Maximum Precipitation (PMP) in this study.

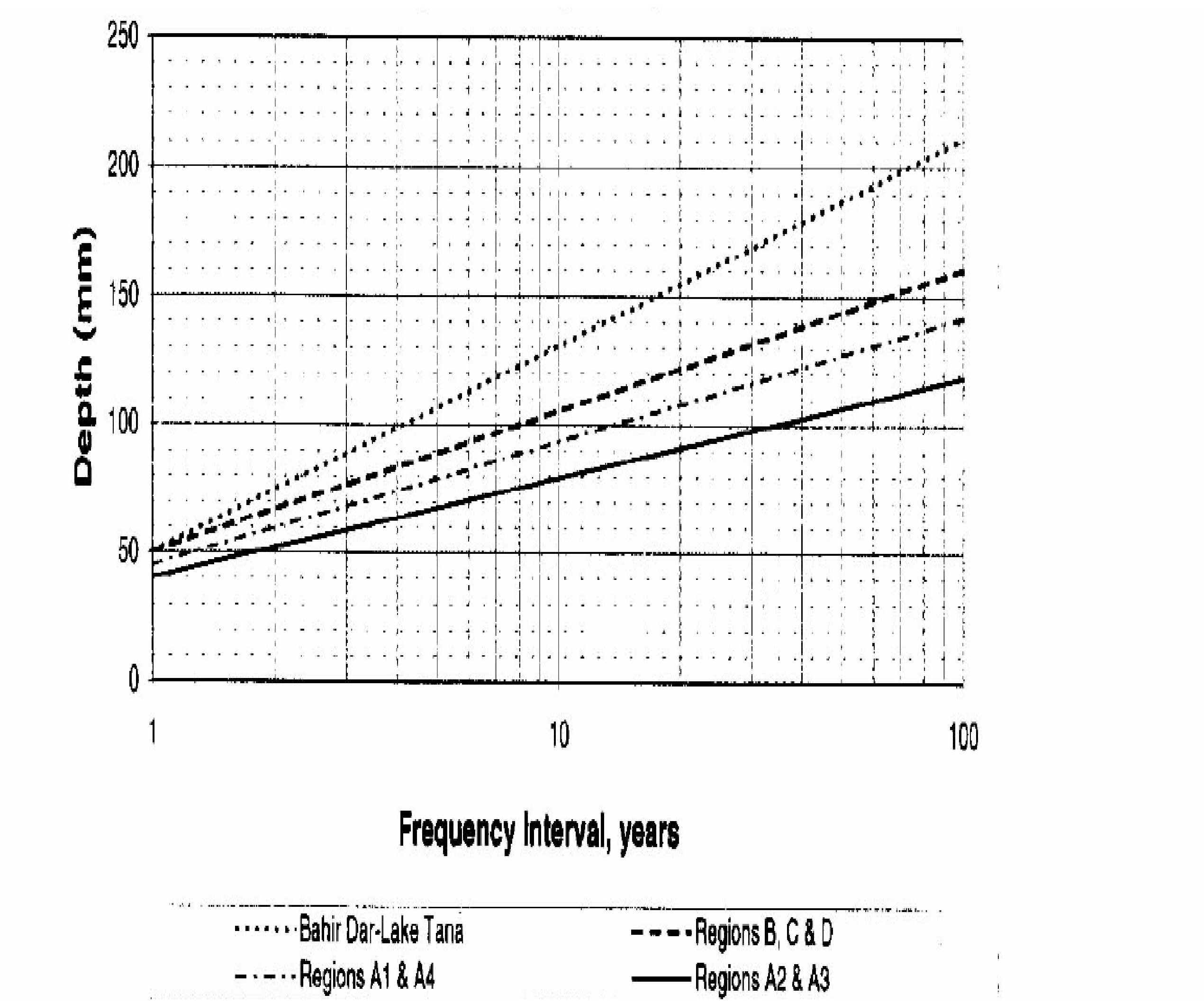


Figure 4. 2: 24-hour depth Frequency curves(ERA Drainage manual)

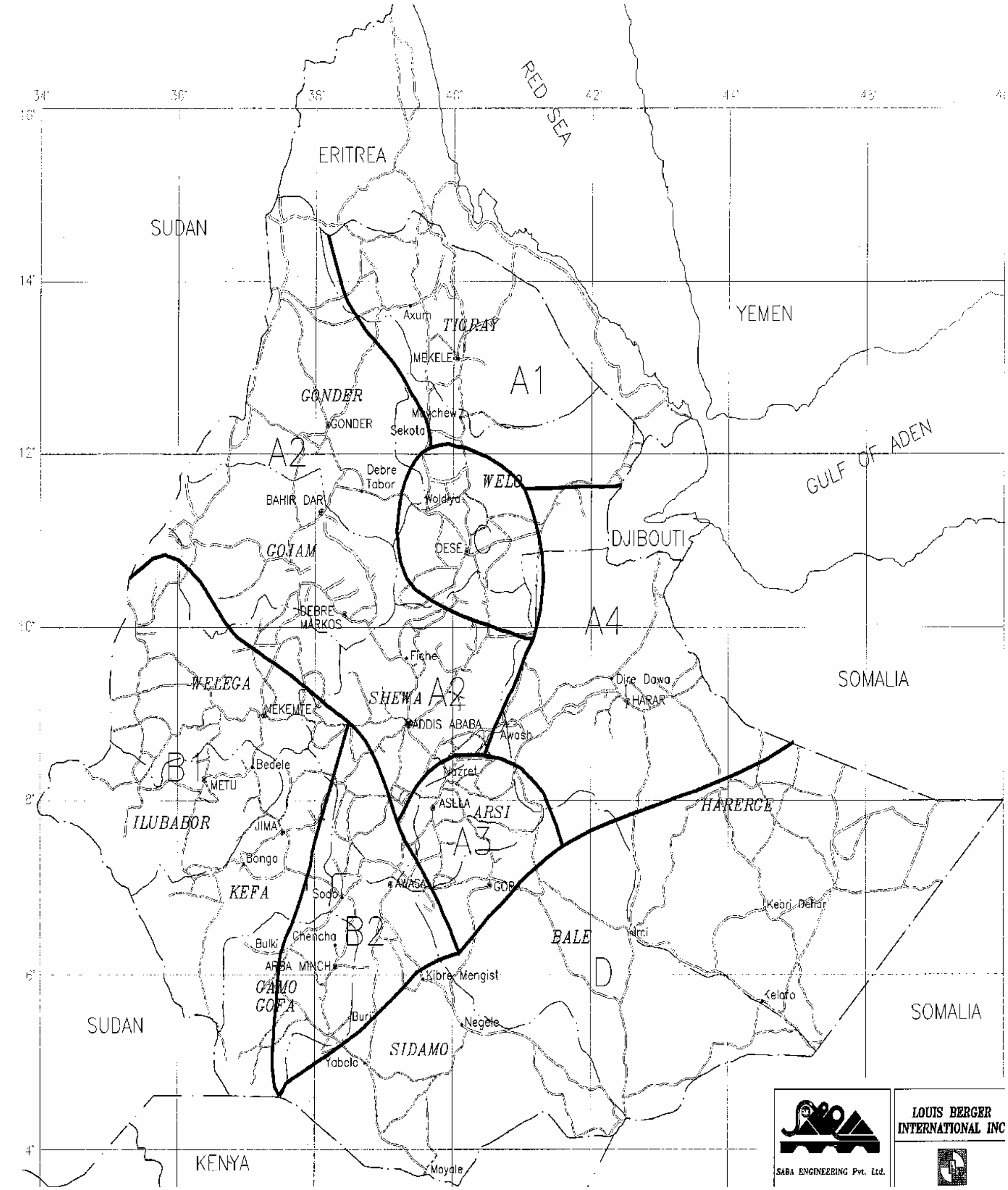


Figure 4. 1 Rainfall Regions(ERA Drainage Manual)

Table 4. 1:*24 - Hour Depth vs. Frequency Table*

Region	Frequency					
	2	5	10	25	50	100
A1,A4	60	79	93	113	127	142
A2,A3	52	67	79	95	107	118
B,C	65	84	98	118	132	147
D	67	89	105	127	144	161
Bahir Dar	74	106	131	163	187	211

4.2 Data Analysis

4.2.1 Probable Maximum Precipitation (PMP) Estimation

The special and temporal context of the upper bound on rainfall amount is incorporated into the definition of "Probable Maximum Precipitation", which is defined by the World Meteorological Organization (WMO) as "theoretically the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of years". A more troublesome problem than ascertaining whether an upper bound exists is determining what it is.

Having obtained a series of storms, PMP is determined by *envelopment*. Envelopment entails selection of the storm which has the largest maximized storm rainfall for a given time interval. The envelopment process is used because a single historical storm is generally not the critical event over the entire range of time scales required.

Based on worldwide records, the PMP can have a return period of as long as 500,000,000 years, corresponding approximately to a frequency factor of 15.Howcver, the return period varies geographically. Some would arbitrarily assign a return period say 10,000 years, to the PMP or PMF.

The development of PMP for a given region is an involved procedure and requires the knowledge of an experienced hydrometer logiest. Basically, two approaches are used

(i)Meteorological methods and (ii)the statistical study of rainfall data

In data limited areas, Hershfield suggested a statistical approach for computation of the PMP based on the 24 hour maximum depth of rainfall. The use of Hershfiled method in different countries (using over 2600 stations) has shown that computed PMP estimates are closely comparable to those obtained by the meteorological method. Statistical studies indicate that the PMP can be estimated as

$$X_{Max} = \overline{X}_n + K_m \sigma_n$$

$$X_{PMP} = 2(X_{Max})$$

Where X_{Max} is the daily maximum precipitation for a given station of specific duration, $\overline{X}_n$ and σ_n are the mean and standard deviation for a series of n annual maximum rainfall values of a given duration respectively. K_m is the frequency factor and is the largest of all calculated K values in the region.

One of the important applications of probable maximum precipitation (PMP) is to determine the greatest depth of precipitation that is possible meteorologically and may cause probable maximum flood (PMF) that may endanger the safety of large dams. Nowadays, Lake Tana is considered as a dam.

The Probable Maximum Flood (PMF) entering Lake Tana would be determined based on the convolution of the Unit Hydrograph (UH) with the PMP.The Bahir Dar 24 hours maximum annual rain fall depth values were the basis for the evaluation of 24 hours PMP values.
Since there is no information of the hourly distribution when the extreme storm events occur the 24 hours PMP values were hourly distributed by using the following equation (adopted from Megech Dam Design-Hydrologic investigation report):

$$P = M * T^{1/2}$$

Where P is rainfall depth is rainfall distribution and M is a constant. Using the known precipitation values and their durations in the equation, it was possible to determine the M values for each one of the Probable Maximum Precipitation durations.

4.2.2 Rainfall Frequency Analysis

Frequency is the number of times an event (rainfall or a flood) of a given magnitude can be expected to occur on average over a long period of time. Frequency analysis is the estimation of greatest rainfall depth for various recurrence intervals. Another way to express frequency is with probability. Probability analysis seeks to define the rainfall magnitude with a probability of being equaled or exceeded in any year.

A consultant called Louis Berger International Inc, in association with SABA Engineering Pvt Ltd Company, conducted the 24-hour depth frequency and develops curves for use of drainage design for different regions. Of this study the curves developed for Bahir Dar is directly applied for this particular study. The rainfall depth values are tabulated in table 4.1.These are point rainfall and to obtain rainfall values that represent the sub-watershed areas under study ,these values are multiplied by the reduction factors related to the sub-watershed area sizes as explained under 3.2.3.4

Table 4. 2:Area Reduction Factors for Sub basins (ARF = 1- 0.044A0.275)

Name of Subbasin	Area		Reduction Factor	
	Gaged	Ungaged	Gagged	Ungagged
Gilgel Abay	1,657.89	2,381.50	0.662	0.627
Koga	300.7		0.789	
Rib	1,522.56	527.12	0.67	0.753
Gumamra	1,354.20	250.12	0.68	0.799
Garno	100.14	229.62	0.844	0.804
Megech	512.56	254.5	0.755	0.798
Amba genen		512.01		0.755
Gemero	158.71	218.8	0.823	0.806
Tana west		605.19		0.744
Gelda		436.37		0.766

Table 4. 3: ***24 hours depth (mm) vs. frequency (year) Table***

Frequency	2	5	10	25	50	100

Bahir dar	74	106	131	163	187	211
Tana basin	52	67	79	95	107	118
$M_{B/Dar}$	15.11	21.64	26.74	33.27	38.17	43.07

Table 4. 4: Hourly rainfall distribution of 24-hrs storm *for different return periods*

4.2.3 Frequency Analysis *of* Discharge

Only the peak daily discharge from each year was taken from the stream flow data collected from ministry of water resources. These peak yearly daily discharges were then analyzed using Ven Te Chow method as follows:

$Q_P = A + B.X_T$; where , $X_T = \mathrm{Log}(\mathrm{Log}(\frac{T}{T-1}))$

Where A and B are regression constants

The following equations were derived from the method of Least Squares.

$\sum Q = A.n + B.X_T$

$\sum (Q.X_T) = A\sum X_T + B\sum X_T^2$ From which A and B can be solved as follow:

$$A = \frac{\sum Q - B\sum X_T}{n} \quad \text{and} \quad B = \frac{n.\sum(Q.X_T) - \sum X_T \sum Q}{n\sum X_T^2 - (\sum X_T)^2}$$

Table 4. 5: Daily maximum Flow(Q =m3/sec)

Year	Gilgel Abay	Koga	Gumara	Rib	Garno	Gemero	Megech	Abay	
								Year	
1973	312.693	58.411		58.411				1971	293.000
1974	295.444	38.108		38.108				1972	175.000
1975	384.922	47.718	378.289	47.718				1973	252.000
1976	295.444	78.27	208.929	78.279				1974	503.000
1977	349.739	24.288	261.704	24.288				1975	690.000
1978	313.837	53.407	266.589	53.407				1976	434.000
1979	280.194	25.852	191.465	25.852				1977	647.800
1980	412.617	59.502	129.77	59.502			199.297	1978	320.000
1981	513.21		228.539				317.967	1979	270.000
1982	321.92		187.195					1980	280.000
1983	324.641	44.892	209.293	83			142.38	1981	325.000
1984	330.124	25.29	300.322	84		59.43	160.708	1982	208.000

1985	655.373	15.713	300.322	85		10.725	186.201	1983	200.000
1986	230.509	11.913	278.281	10.824		237.605	143.544	1984	82.900
1987	234.997	10.824	211.438	12.653	4.452	14.88	57.739	1985	320.000
1988	277.699	20.16	400.07	119.52	17.696	15.171	72.487	1986	386.000
1989	438.188	20.16	211.438	20.16	6.891		47.642	1987	208.000
1990	387.944	20.368	226.235	19.952	8.17		65.939	1988	672.000
1991	352.596	26.393	304.235	26.393	10.857		135.775	1989	386.000
1992	412.617	17.299	354.127	15.517	17.475	35.913	96.695	1990	285.000
1993	381.915	51.706	338.431	51.706	20.78	141.777	130.124	1991	616.000
1994	308.515	22.462	266.448	216.72	50.617	55.67	136.884	1992	345.000
1995	464.665	216.724	279.374	216.72	15.42	31.67	274.802	1993	552.000
1996	355.466	87.639	245.036	87.639	25.157	16.792	89.792	1994	779.070
1997	358.35	30.386	364.798	30.386	10.717	23.65	56.571	1995	192.000
1998	298.031	38.921	274.72	38.921	20.911	63.667	190.848	1996	587.000
1999	298.031	53.678		53.678	31.353	62.161	242.3	1997	280.000
2000	381.915	99.873	231.384	99.873	64.6	75.845	83.946	1998	727.800
2001	303.247	89.338	99	89.338	14.325	57.782	261.069	1999	543.190
2002	303.247	29.887	278.669	31.907	17.68	142.336	137.88	2000	495.276
2003	378.921	60.517	297.285	42.391	8.278		214.65	2001	372.563
2004	287.76		243.722					2002	522.334
2005	319.212		268.535					2003	151.283

Table 4. 6: Computation for determining A and B:Ven Te Chow method

Order no (m)	Return period, $T = \frac{n+1}{n+1-m}$	X_T = Log Log T	X_T^2	Koga		Rib		Gumara				
				Daily Peak Flow,Q	$Q.X_T$	Daily Peak Flow,Q	$Q.X_T$	Return period = $\frac{n+1}{n+1-m}$	X_T = Log Log T	X_T^2	Daily Peak Flow,Q	$Q.X_T$
1	1.03	-1.83	3.36	216.72	-397.04	216.72	-397.03	1.03	-1.85	3.41	400.07	-738.72
2	1.07	-1.52	2.32	99.873	-152.15	216.72	-330.15	1.07	-1.54	2.37	378.289	-581.86
3	1.11	-1.34	1.79	89.338	-119.67	119.52	-160.10	1.11	-1.35	1.83	364.798	-494.13
4	1.15	-1.21	1.46	87.639	-105.74	99.873	-120.50	1.15	-1.22	1.49	354.127	-432.69
5	1.20	-1.10	1.21	78.27	-86.20	89.338	-98.39	1.19	-1.12	1.25	338.431	-378.02
6	1.25	-1.01	1.03	60.517	-61.34	87.639	-88.83	1.24	-1.03	1.06	304.235	-313.23
7	1.30	-0.94	0.88	59.502	-55.80	85	-79.71	1.29	-0.95	0.91	300.322	-286.53
8	1.36	-0.87	0.76	58.411	-50.85	84	-73.13	1.35	-0.89	0.79	300.322	-266.47
9	1.43	-0.81	0.66	53.678	-43.48	83	-67.23	1.41	-0.83	0.68	297.285	-245.85
10	1.50	-0.75	0.57	53.407	-40.28	78.279	-59.04	1.48	-0.77	0.60	279.374	-215.61
11	1.58	-0.70	0.49	51.706	-36.32	59.502	-41.80	1.55	-0.72	0.52	278.669	-200.78
12	1.67	-0.65	0.43	47.718	-31.20	58.411	-38.20	1.63	-0.67	0.45	278.281	-187.12
13	1.76	-0.61	0.37	44.892	-27.29	53.678	-32.63	1.72	-0.63	0.39	274.72	-172.23

14	1.88	-0.56	0.32	38.921	-21.95	53.407	-30.11	1.82	-0.58	0.34	268.535	-156.69
15	2.00	-0.52	0.27	38.108	-19.87	51.706	-26.96	1.94	-0.54	0.29	266.589	-144.43
16	2.14	-0.48	0.23	30.386	-14.59	47.718	-22.91	2.07	-0.50	0.25	266.448	-133.57
17	2.31	-0.44	0.19	29.887	-13.15	42.391	-18.65	2.21	-0.46	0.21	261.704	-120.88
18	2.50	-0.40	0.16	26.393	-10.56	38.921	-15.58	2.38	-0.42	0.18	245.036	-103.69
19	2.73	-0.36	0.13	25.852	-9.33	38.108	-13.75	2.58	-0.38	0.15	243.722	-93.81
20	3.00	-0.32	0.10	25.29	-8.13	31.907	-10.25	2.82	-0.35	0.12	231.384	-80.25
21	3.33	-0.28	0.08	24.288	-6.84	30.386	-8.56	3.10	-0.31	0.10	228.539	-70.53
22	3.75	-0.24	0.06	22.462	-5.41	26.393	-6.36	3.44	-0.27	0.07	226.235	-61.07
23	4.29	-0.20	0.04	20.368	-4.06	25.852	-5.15	3.88	-0.23	0.05	211.438	-48.72
24	5.00	-0.16	0.02	20.16	-3.14	24.288	-3.78	4.43	-0.19	0.04	211.438	-40.09
25	6.00	-0.11	0.01	20.16	-2.20	20.16	-2.20	5.17	-0.15	0.02	209.293	-30.72
26	7.50	-0.06	0.00	17.299	-1.00	19.952	-1.16	6.20	-0.10	0.01	208.929	-21.11
27	10.00	0.00	0.00	15.713	0.00	15.517	0.00	7.75	-0.05	0.00	191.465	-9.76
28	15.00	0.07	0.00	11.913	0.84	12.653	0.89	10.33	0.01	0.00	187.195	1.15
29	30.00	0.17	0.03	10.824	1.83	10.824	1.83	15.50	0.08	0.01	129.77	9.82
30								31.00	0.17	0.03	99	17.18
Total =	118.8	-17.2	17.0	1,379.7	-1,324.9	1,821.9	-1,749.4	123.8	-17.9	17.6	7,835.6	-5,600.4

Table 4-7 : Computation for determining A and B:Ven Te Chow method(continued)

Order no (m)	Return period= $\frac{n+1}{n+1-m}$	X_T = Log Log T	X_T^2	Gilgel Abay Daily Peak Flow,Q	Gilgel Abay $Q.X_T$	Abay Daily Peak Flow,Q	Abay $Q.X_T$	Garno Return Period = $\frac{n+1}{n+1-m}$	Garno X_T = Log Log T	Garno X_T^2	Garno Daily Peak Flow,Q	Garno $Q.X_T$
1	1.03	-1.89	3.56	655.37	-1,236.84	779.070	-1,470.28	1.06	-1.61	2.58	64.6	-103.69
2	1.06	-1.58	2.50	513.21	-810.65	727.800	-1,149.61	1.13	-1.29	1.67	50.617	-65.35
3	1.10	-1.40	1.95	464.67	-648.98	690.000	-963.70	1.20	-1.10	1.21	31.353	-34.53
4	1.13	-1.26	1.60	438.19	-554.19	672.000	-849.90	1.29	-0.96	0.93	25.157	-24.20
5	1.17	-1.16	1.35	412.62	-478.90	647.800	-751.86	1.38	-0.85	0.72	20.911	-17.77
6	1.21	-1.07	1.15	412.62	-443.18	616.000	-661.62	1.50	-0.75	0.57	20.78	-15.67
7	1.26	-1.00	1.00	387.94	-387.75	587.000	-586.71	1.64	-0.67	0.45	17.696	-11.85
8	1.31	-0.93	0.87	384.92	-359.38	552.000	-515.38	1.80	-0.59	0.35	17.68	-10.48
9	1.36	-0.87	0.76	381.92	-333.94	543.190	-474.96	2.00	-0.52	0.27	17.475	-9.11
10	1.42	-0.82	0.67	381.92	-313.27	522.334	-428.45	2.25	-0.45	0.21	15.42	-6.99
11	1.48	-0.77	0.59	378.92	-291.84	503.000	-387.40	2.57	-0.39	0.15	14.325	-5.54
12	1.55	-0.72	0.52	358.35	-259.23	495.276	-358.29	3.00	-0.32	0.10	10.857	-3.49
13	1.62	-0.68	0.46	355.47	-241.47	434.000	-294.82	3.60	-0.25	0.06	10.717	-2.73
14	1.70	-0.64	0.41	352.6	-224.75	386.000	-246.05	4.50	-0.18	0.03	8.278	-1.53
15	1.79	-0.60	0.36	349.74	-208.92	386.000	-230.58	6.00	-0.11	0.01	8.17	-0.89
16	1.89	-0.56	0.31	330.12	-184.46	372.563	-208.18	9.00	-0.02	0.00	6.891	-0.14
17	2.00	-0.52	0.27	324.64	-169.26	345.000	-179.88	18.00	0.10	0.01	4.452	0.44

18	2.13	-0.48	0.24	321.92	-156.12	325.000	-157.62					
19	2.27	-0.45	0.20	319.21	-143.42	320.000	-143.78					
20	2.43	-0.41	0.17	313.84	-129.97	320.000	-132.53					
21	2.62	-0.38	0.14	312.69	-118.61	293.000	-111.14					
22	2.83	-0.34	0.12	308.52	-106.31	285.000	-98.20					
23	3.09	-0.31	0.10	303.25	-93.92	280.000	-86.72					
24	3.40	-0.27	0.08	303.25	-83.25	280.000	-76.86					
25	3.78	-0.24	0.06	298.03	-71.12	270.000	-64.43					
26	4.25	-0.20	0.04	298.03	-60.13	252.000	-50.85					
27	4.86	-0.16	0.03	295.44	-48.29	208.000	-33.99					
28	5.67	-0.12	0.02	295.44	-36.34	208.000	-25.59					
29	6.80	-0.08	0.01	287.76	-22.91	200.000	-15.92					
30	8.50	-0.03	0.00	280.19	-8.91	192.000	-6.10					
31	11.33	0.02	0.00	277.7	6.38	175.000	4.02					
32	17.00	0.09	0.01	235	21.16	151.283	13.63					
33	34.00	0.19	0.03	230.51	42.67	82.900	15.35					
Total =	**139.02**	**-19.68**	**19.57**	**11,563.98**	**-8,156.12**	**13,101.22**	**-10,728.41**	**61.91**	**-9.98**	**9.32**	**345.38**	**-313.54**

Table 4-7 : Computation for determining Regration Constant A and B:Ven Te Chow method(continued)

	Megech					Gemero				
Order no (m)	Return period= $\frac{n+1}{n+1-m}$	X_T = Log Log T	X_T^2	Daily Peak Flow,Q	Q.X_T	Return period= $\frac{n+1}{n+1-m}$	X_T = Log Log T	X_T^2	Daily Peak Flow,Q	Q.X_T
1	1.04	-1.75	3.07	317.967	-556.86	1.06	-1.58	2.50	237.605	-375.31
2	1.09	-1.44	2.08	274.802	-396.03	1.13	-1.26	1.60	142.336	-180.02
3	1.14	-1.26	1.58	261.069	-327.79	1.21	-1.07	1.15	141.777	-152.28
4	1.19	-1.12	1.26	242.3	-271.57	1.31	-0.93	0.87	75.845	-70.81
5	1.25	-1.01	1.03	214.65	-217.58	1.42	-0.82	0.67	63.667	-52.22
6	1.32	-0.92	0.85	199.297	-184.11	1.55	-0.72	0.52	62.161	-44.97
7	1.39	-0.85	0.72	190.848	-161.40	1.70	-0.64	0.41	59.43	-37.88
8	1.47	-0.78	0.60	186.201	-144.49	1.89	-0.56	0.31	57.782	-32.29
9	1.56	-0.71	0.51	160.708	-114.52	2.13	-0.48	0.24	55.67	-27.00
10	1.67	-0.65	0.43	143.544	-93.87	2.43	-0.41	0.17	35.913	-14.87
11	1.79	-0.60	0.36	142.38	-85.27	2.83	-0.34	0.12	31.67	-10.91
12	1.92	-0.55	0.30	137.88	-75.38	3.40	-0.27	0.08	23.65	-6.49
13	2.08	-0.50	0.25	136.884	-67.97	4.25	-0.20	0.04	16.792	-3.39
14	2.27	-0.45	0.20	135.775	-60.81	5.67	-0.12	0.02	15.171	-1.87
15	2.50	-0.40	0.16	130.124	-52.07	8.50	-0.03	0.00	14.88	-0.47
16	2.78	-0.35	0.12	96.695	-34.12	17.00	0.09	0.01	10.725	0.97
17	3.13	-0.31	0.09	89.792	-27.43					
18	3.57	-0.26	0.07	83.946	-21.61					

19	4.17	-0.21	0.04	72.487	-15.06					
20	5.00	-0.16	0.02	65.939	-10.26					
21	6.25	-0.10	0.01	57.739	-5.72					
22	8.33	-0.04	0.00	56.571	-2.03					
23	12.50	0.04	0.00	47.642	1.91					
24	25.00	0.15	0.02	41.195	5.99					
Total =	**94.40**	**-14.21**	**13.76**	**3,486.44**	**-2,918.04**	**57.47**	**-9.38**	**8.70**	**1,045.07**	**-1,009.82**

Table 4. 7:Regeration constant

R.Con.	Koga	Rib	G/Abay	Gumara	Garno	Megech	Gemero	Abay
B	-75.04	-99.07	-160.85	-133.90	-31.96	-159.70	-123.97	-371.98
A	2.95	3.91	254.52	181.51	1.55	50.69	-7.33	175.22

Chapter 5. Optimization

This chapter describes how observed stream flow can be used to automatically estimate parameters. The 24-hours rainfall intensity frequency was adopted from ERA drainage Manual for 10, 25,50 and 100 years return periods. The corresponding Daily maximum discharge frequency analysis was done for gauged sub basins. Using these data parameters were estimated by optimization technique. Optimization begins from initial parameter estimates and adjusts them so that the simulated results match the observed stream flow as closely as possible. Two different search algorithms are provided that move from the initial estimates to the final best estimates. A variety of objective functions is provided to measure the goodness of fit between the simulated and observed stream flow in different ways. The value of the objective function is computed at the target element using the computed and observed hydrographs. Parameter values are adjusted by the search method and the hydrograph and objective function for the target element are recomputed. A minimum objective function is obtained when the parameter values best able to reproduce the observed hydrograph are found.

5.1 objective Function

The quantitative measure of the goodness-of-fit between the computed result from the model and the observed flow is called the objective function. An objective function measures the degree of variation between computed and observed hydrographs. It is equal to zero if the hydrographs are identical.

Peak weighted root mean square error objective function is applied to measure the goodness of fit between the computed and observed hydrographs. To minimize the value of the objective function two search methods such as Univariate-gradient Search Algorithm and Nelder and Mead Algorithm are available in HEC-HMS. Of these two search methods, Univariate-gradient Search Algorithm is used for this study

Table 5-1:Initial and Constant Loss, Snyder UH,Exponential Recession Base Flow(average value)

Sub basin Name	parameters	Unit	Initial value	Opt. Value	Sensi-tivity
Koga	Constant Loss Rate	MM/HR	7.414	7.405	0.000
	Initial Loss	MM	7.682	7.086	0.000
	Snyder Peaking Coefficient		0.965	0.982	0.000
	Snyder Time to Peak	HR	10.259	10.274	0.000
	Recession Constant		0.914	0.872	0.000
	Base flow Initial Flow	M3/S	30.250	30.695	0.000
	Base flow Threshold Ratio		0.309	0.297	0.000
Garno	Constant Loss Rate	MM/HR	8.400	8.397	0.000
	Initial Loss	MM	7.591	7.138	0.000
	Snyder Peaking Coefficient		0.939	0.945	0.000
	Snyder Time to Peak	HR	10.654	10.517	0.000
	Base flow Initial Flow	M3/S	13.875	13.966	0.000
	Base flow Threshold Ratio		0.215	0.215	0.000
	Recession Constant		0.885	0.816	0.000
Gemero Gagged	Snyder Peaking Coefficient		0.975	0.974	0.000
	Snyder Time to Peak	HR	8.929	8.575	0.000
	Initial Loss	MM	1.108	1.024	0.000

	Recession Constant		0.793	0.732	0.000
	Base flow Initial Flow	M3/S	58.250	57.588	-0.013
	Base flow Threshold Ratio		0.193	0.193	0.000
	Constant Loss Rate	MM/HR	0.577	0.579	0.000
Gumara Gagged	Initial Loss	MM	6.765	6.219	0.000
	Constant Loss Rate	MM/HR	8.636	8.628	0.000
	Snyder Time to Peak	HR	10.773	10.645	0.000
	Snyder Peaking Coefficient		0.959	0.981	0.000
	Base flow Initial Flow	M3/S	89.977	90.988	-0.308
	Base flow Threshold Ratio		0.225	0.225	0.000
	Recession Constant		0.932	0.859	0.000
Gilgel Abay gagged	Initial Loss	MM	8.248	7.759	0.000
	Constant Loss Rate	MM/HR	8.489	8.201	0.000
	Snyder Time to Peak	HR	10.780	10.675	0.000
	Snyder Peaking Coefficient		0.955	0.963	0.000
	Base flow Initial Flow	M3/S	90.940	110.728	-0.250
	Recession Constant		0.848	0.787	0.000
	Base flow Threshold Ratio		0.233	0.233	0.000
Rib Gagged	Initial Loss	MM	10.870	10.597	0.000
	Constant Loss Rate	MM/HR	10.865	10.566	0.000
	Snyder Time to Peak	HR	10.580	10.580	0.000
	Snyder Peaking Coefficient		0.956	0.958	0.000
	Base flow Initial Flow	M3/S	40.750	41.365	0.000
	Recession Constant		0.787	0.763	0.000
	Base flow Threshold Ratio		0.251	0.218	0.000

Table 5-1:Initial and Constant Loss, Snyder UH,Exponential Recession Base Flow

Sub basin Name	parameters	Unit	Initial value	Optimized Value	Sensi-tivity
Megech Gagged	Initial Loss	MM	4.132	3.735	0.000
	Constant Loss Rate	MM/HR	6.275	6.258	0.000
	Snyder Time to Peak	HR	10.155	10.162	0.000
	Snyder Peaking Coefficient		0.960	0.960	0.000
	Base flow Initial Flow	M3/S	72.500	73.706	-0.478
	Recession Constant		0.880	0.811	0.000
	Base flow Threshold Ratio		0.340	0.289	0.000
Amba genen	Initial Loss	MM	4.132	3.735	0.000
	Constant Loss Rate	MM/HR	6.275	6.258	0.000
	Snyder Time to Peak	HR	10.155	10.162	0.000
	Snyder Peaking Coefficient		0.960	0.960	0.000
	Base flow Initial Flow	M3/S	72.500	73.706	-0.478
	Recession Constant		0.880	0.811	0.000
	Base flow Threshold Ratio		0.340	0.289	0.000
Garno Ungag ed	Constant Loss Rate	MM/HR	8.400	8.397	0.000
	Initial Loss	MM	7.591	7.138	0.000

	Snyder Peaking Coefficient		0.939	0.945	0.000
	Snyder Time to Peak	HR	10.654	10.517	0.000
	Base flow Initial Flow	M3/S	13.875	13.966	0.000
	Base flow Threshold Ratio		0.215	0.215	0.000
	Recession Constant		0.885	0.816	0.000
Gelda	Initial Loss	MM	6.765	6.219	0.000
	Constant Loss Rate	MM/HR	8.636	8.628	0.000
	Snyder Time to Peak	HR	10.773	10.645	0.000
	Snyder Peaking Coefficient		0.959	0.981	0.000
	Base flow Initial Flow	M3/S	89.977	90.988	-0.308
	Base flow Threshold Ratio		0.225	0.225	0.000
	Recession Constant		0.932	0.859	0.000
Gemero Ungaged	Initial Loss		0.975	0.974	0.000
	Constant Loss Rate	HR	8.929	8.575	0.000
	Snyder Time to Peak	MM	1.108	1.024	0.000
	Snyder Peaking Coefficient		0.793	0.732	0.000
	Base flow Initial Flow	M3/S	58.250	57.588	-0.013
	Base flow Threshold Ratio		0.193	0.193	0.000
	Recession Constant	MM/HR	0.577	0.579	0.000
Gilgel Abay ungaged	Initial Loss	MM	8.248	7.759	0.000
	Constant Loss Rate	MM/HR	8.489	8.201	0.000
	Snyder Time to Peak	HR	10.780	10.675	0.000
	Snyder Peaking Coefficient		0.955	0.963	0.000
	Base flow Initial Flow	M3/S	90.900	110.728	-0.250
	Recession Constant		0.848	0.787	0.000
	Base flow Threshold Ratio		0.233	0.233	0.000

Table 5-1:Initial and Constant Loss, Snyder UH,Exponential Recession Base Flow

Sub basin Name	parameters	Unit	Initial value	Optimized Value	Sensi-tivity
Gumara Ungaged	Initial Loss	MM	6.765	6.219	0.000
	Constant Loss Rate	MM/HR	8.636	8.628	0.000
	Snyder Time to Peak	HR	10.773	10.645	0.000
	Snyder Peaking Coefficient		0.959	0.981	0.000
	Base flow Initial Flow	M3/S	89.977	90.988	-0.308
	Base flow Threshold Ratio		0.225	0.225	0.000
	Recession Constant		0.932	0.859	0.000
Megech Engaged	Initial Loss	MM	4.132	3.735	0.000
	Constant Loss Rate	MM/HR	6.275	6.258	0.000
	Snyder Time to Peak	HR	10.155	10.162	0.000
	Snyder Peaking Coefficient		0.960	0.960	0.000
	Base flow Initial Flow	M3/S	72.500	73.706	-0.478
	Recession Constant		0.880	0.811	0.000
	Base flow Threshold Ratio		0.340	0.289	0.000
Rib Ungaged	Initial Loss	MM	10.870	10.597	0.000
	Constant Loss Rate	MM/HR	10.865	10.566	0.000

	Snyder Time to Peak	HR	10.580	10.580	0.000
	Snyder Peaking Coefficient		0.956	0.958	0.000
	Base flow Initial Flow	M3/S	40.750	41.365	0.000
	Recession Constant		0.787	0.763	0.000
	Base flow Threshold Ratio		0.251	0.218	0.000
West Tana	Initial Loss	MM	8.248	7.759	0.000
	Constant Loss Rate	MM/HR	8.489	8.201	0.000
	Snyder Time to Peak	HR	10.780	10.675	0.000
	Snyder Peaking Coefficient		0.955	0.963	0.000
	Base flow Initial Flow	M3/S	109.940	110.728	-0.250
	Recession Constant		0.848	0.787	0.000
	Base flow Threshold Ratio		0.233	0.233	0.000

Chapter 6.Result, Conclusion and Recommendation

*6.*1 Results

The Maximum Flood (MF) entering Lake Tana from the sub basins would be determined based on the convolution of the Unit Hydrograph (UH) using the storm Specified hyetograph meteorological model built in HEC-HMS. The Bahir Dar 24 hours maximum annual rain fall depth values were the basis for the evaluation of 24 hours flood values for the recurrent interval of 10-, 25-years, 50-years, 100-years.

The highest combined incoming flood from all sub catchments to the Lake are 4052 m3/sec,4240m3/sec,5040 m3/sec and 25372 m3/sec While the corresponding total inflow are 235,474m^3,250,686 m^3,292,257 m3,450,653m^3 for the respective return periods. The water surface elevation at the time of this highest incoming flood ranges from 1787.9 m a.m.s.l for 10 – years return period to 1789.0 m a.m.s.l for 100 –years return period. The times of occurrence peak floods are all 1st August at 12:00 hour except that for 100-years return which is 03 Aug 22:00.

Probable maximum flood (PMF) computed using the model is 56526m3/s and the corresponding lake water surface elevation is 1789.3m, too. This shows that the Lake level is raised by more than two meters. Hence, it is concluded that low laying area of Bahirdar and Fogera and Dembia flood plain will be greatly affected particularly at the beginning of August.

6.2 Conclusion and recommendation

Tana Lake Basin has many streams and /or rivers. Of these many streams only the seven ones have daily gauged data. The eighth river called Dirma is installed very recently and hence it is not used for this study; the gauged data from six streams are used for parameter estimation. The parameters estimated for these gauged sub catchments are applied for the ungauged ones. For example, the parameter for gauged part of Gilge Abay catchment is directly applied for the ungauged part of the same river catchment. The discharges are measured daily and there are no hourly measured discharges. Since the study focuses on the computation of flood particularly peak flood, these daily discharge data are hourly distributed using the formula $Q_T = M*T^{½}$.

Where T is time in hours and M is a coefficient of which value is determined from known discharges and respective time or return period of, 10 -, 25-, 50- and 100 -years.

The Maximum Flood (MF) entering Lake Tana from the sub basins would be determined based on the convolution of the Unit Hydrograph (UH) using the storm frequency meteorological model built in HEC-HMS. The Bahir Dar 24 hours maximum annual rain fall depth values were the basis for the evaluation of 24 hours flood values for the recurrent interval of 10-, 25-years, 50-years, 100-years.

The total peak food estimated joining Tana Lake from all its tributaries is 12602.06m3/s (33,755,355,199m3).The author is the first attempting to fined the maximum flood generated from Lake Tana catchments. Further researchers can refer this value as a standing reference

The highest combined incoming flood from all sub catchments to the Lake are 4052 m3/sec,4240m3/sec,5040 m3/sec and 12602 m3/sec While the corresponding total inflow(in millions) are 235,474m^3,250,686 m^3,292,257 m3, 33,753m^3 for the respective return periods. The water surface elevation at the time of this highest incoming flood ranges from 1787.9 m a.m.s.l for 10 – years return period to 1789.0 m a.m.s.l for 100 –years return period. The times of occurrence peak floods are all 1st August at 12:00 hour except that for 100-years return which is 03 Aug 22:00.Probable maximum flood (PMF) computed using the model is 56526m3/s and the corresponding lake water surface elevation is 1789.3m, too. This shows that the Lake level is raised by more than two meters. Hence, it is concluded that low laying area of Bahirdar and Fogera and Dembia flood plain will be greatly affected particularly at the beginning of August.

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Annex I: Results for Simulation Run for 10-yrs Return Period

Graph for Lake Tana Simulation Result 0f 10-yrs Return Period

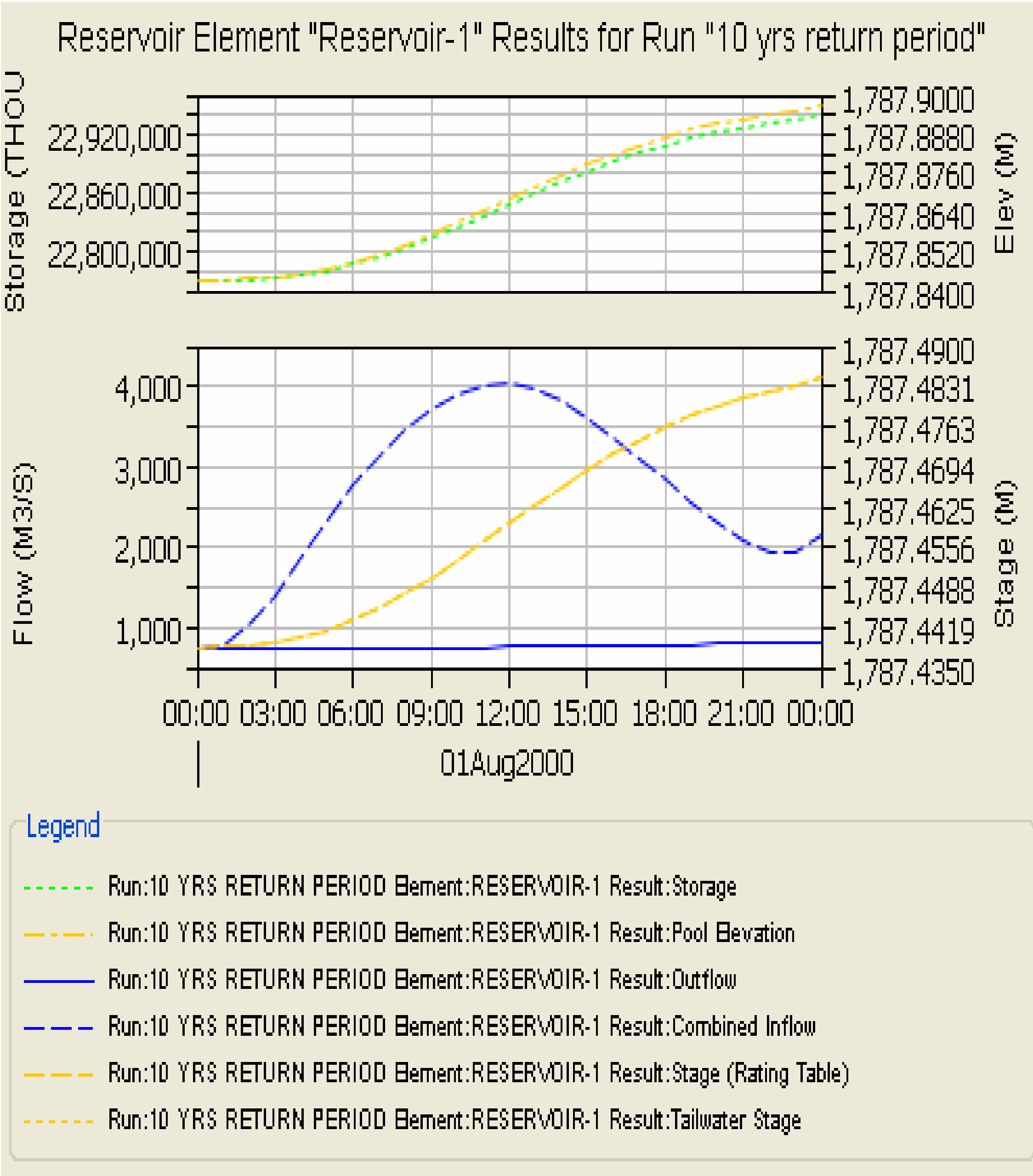


Table A-3(a):Time Serious Simulation Result of Lake Tana for 10- years Return Period

Project : Project 1-10 yrs R.P   Run : 10 yrs return period   Reservoir: Reservoir-1

Start of Run : 01Aug2000, 00:00   Basin Model : Outlet
End of Run : 02Aug2000, 00:00   Meteorologic Model : Storm
Compute Time : 13Jan2008, 11:52:06   Control Specifications : Control 1

Date	Time	Inflow (M3/S)	Storage (1000 M3)	Elevation (M)	Outflow (M3/S)	Stage (M)
01Aug2000	00:00	723.5	22769777.1	1787.8	723.5	1787.4
01Aug2000	01:00	787.4	22769892.6	1787.8	723.6	1787.4
01Aug2000	02:00	1015.4	22770532.3	1787.8	723.8	1787.4
01Aug2000	03:00	1398.9	22772270.8	1787.8	724.6	1787.4
01Aug2000	04:00	1859.5	22775524.7	1787.8	726.0	1787.4
01Aug2000	05:00	2325.4	22780439.8	1787.8	728.2	1787.4
01Aug2000	06:00	2754.7	22786957.2	1787.8	731.1	1787.4
01Aug2000	07:00	3135.3	22794921.1	1787.9	734.6	1787.4
01Aug2000	08:00	3459.8	22804140.5	1787.9	738.7	1787.4
01Aug2000	09:00	3717.4	22814392.2	1787.9	743.2	1787.5
01Aug2000	10:00	3904.3	22825426.9	1787.9	748.1	1787.5
01Aug2000	11:00	4018.9	22836986.2	1787.9	753.3	1787.5
01Aug2000	12:00	4052.5	22848793.4	1787.9	758.5	1787.5
01Aug2000	13:00	3985.6	22860521.8	1787.9	763.8	1787.5
01Aug2000	14:00	3817.3	22871808.2	1787.9	768.9	1787.5
01Aug2000	15:00	3591.1	22882366.9	1787.9	773.6	1787.5
01Aug2000	16:00	3357.8	22892082.0	1787.9	778.0	1787.5
01Aug2000	17:00	3109.2	22900914.5	1787.9	782.0	1787.5
01Aug2000	18:00	2838.2	22908798.1	1787.9	785.6	1787.5
01Aug2000	19:00	2558.5	22915678.3	1787.9	788.8	1787.5
01Aug2000	20:00	2300.1	22921579.5	1787.9	791.4	1787.5
01Aug2000	21:00	2089.5	22926627.4	1787.9	793.7	1787.5
01Aug2000	22:00	1951.5	22931040.0	1787.9	795.8	1787.5
01Aug2000	23:00	1946.7	22935188.6	1787.9	797.7	1787.5
02Aug2000	00:00	2145.5	22939679.4	1787.9	799.7	1787.5

Table A-3(b): Summary Results for Tana Lake Simulation Run

Project : Project 1-10 yrs R.P   Simulation Run : 10 yrs return period   Reservoir: Reservoir-1

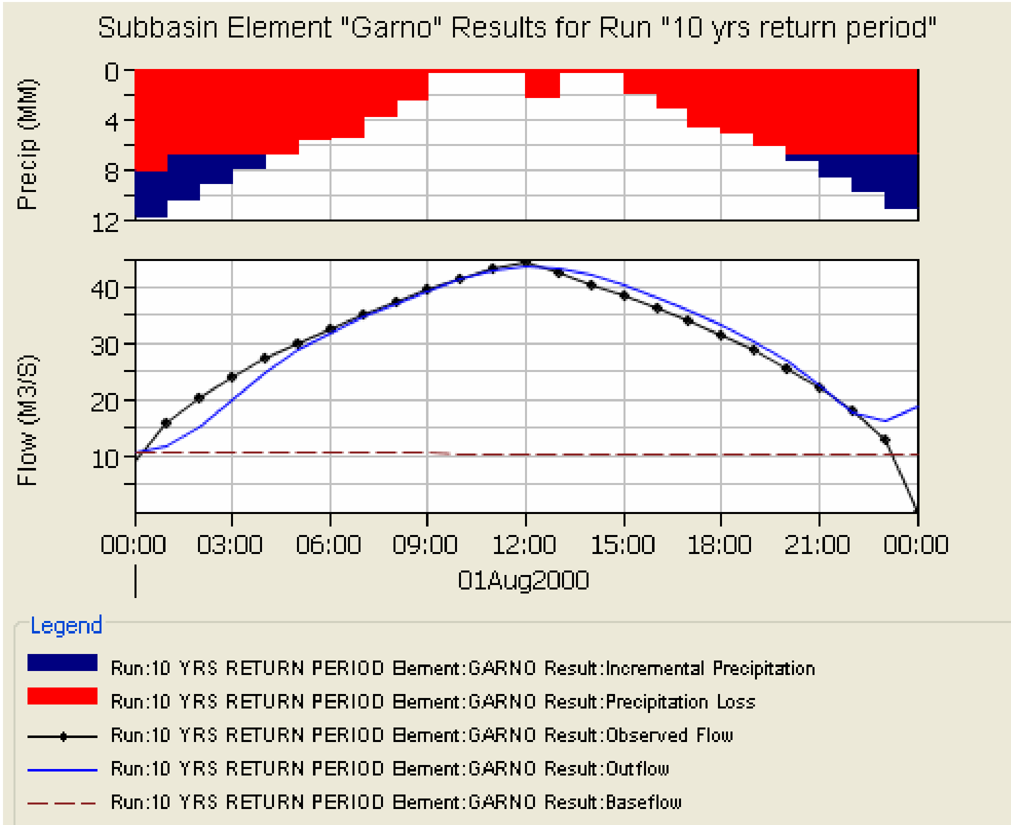
Start of Run : 01Aug2000, 00:00   Basin Model : Outlet
End of Run : 02Aug2000, 00:00   Meteorologic Model : Storm
Compute Time : 13Jan2008, 11:52:06   Control Specifications : Control 1

Volume Units : ○ MM ◉ 1000 M3

Computed Results

Peak Inflow :	4052.5 (M3/S)	Date/Time of Peak Inflow :	01Aug2000, 12:00
Peak Outflow :	799.7 (M3/S)	Date/Time of Peak Outflow :	02Aug2000, 00:00
Total Inflow :	235474.2 (1000 M3)	Peak Storage :	22939679.4 (1000 M3)
Total Outflow :	65572.4 (1000 M3)	Peak Elevation :	1787.9 (M)

Simulation Results Graph for Garno Gauged Sub basin



Summary of Result of Garno Gauged Subbasin

Project : Project 1-10 yrs R.P Simulation Run : 10 yrs return period Subbasin: Garno

Start of Run :	01Aug2000, 00:00	Basin Model :	Outlet
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 11:52:06	Control Specifications :	Control 1

Volume Units : ◯ MM ◉ 1000 M3

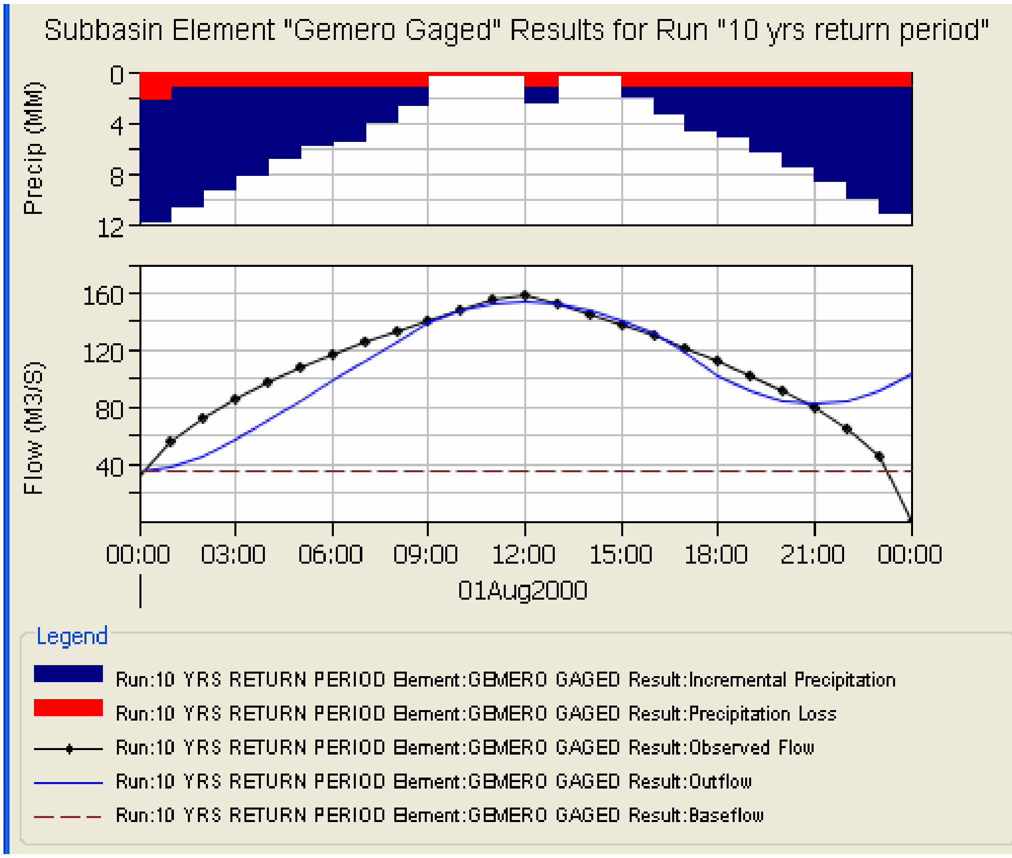
Computed Results

Peak Discharge :	43.8 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	19666.1 (1000 M3)	Total Direct Runoff :	1742.6 (1000 M3)
Total Loss :	16436.4 (1000 M3)	Total Baseflow :	898.1 (1000 M3)
Total Excess :	3229.8 (1000 M3)	Discharge :	2640.7 (1000 M3)

Observed Hydrograph at Gage Garno

Peak Discharge :	44.38 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	2.28 (M3/S)		
Total Residual :	27.0 (1000 M3)	Total Obs Q :	2613.67 (1000 M3)

Simulation Results Graph for Gemero Gauged Sub basin



<u>Summary of Result of Gemero Gauged Subbasin</u>

Project : Project 1-10 yrs R.P Simulation Run : 10 yrs return period Subbasin: Gemero Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	Outlet
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 11:52:06	Control Specifications :	Control 1

Volume Units : ◯ MM ◉ 1000 M3

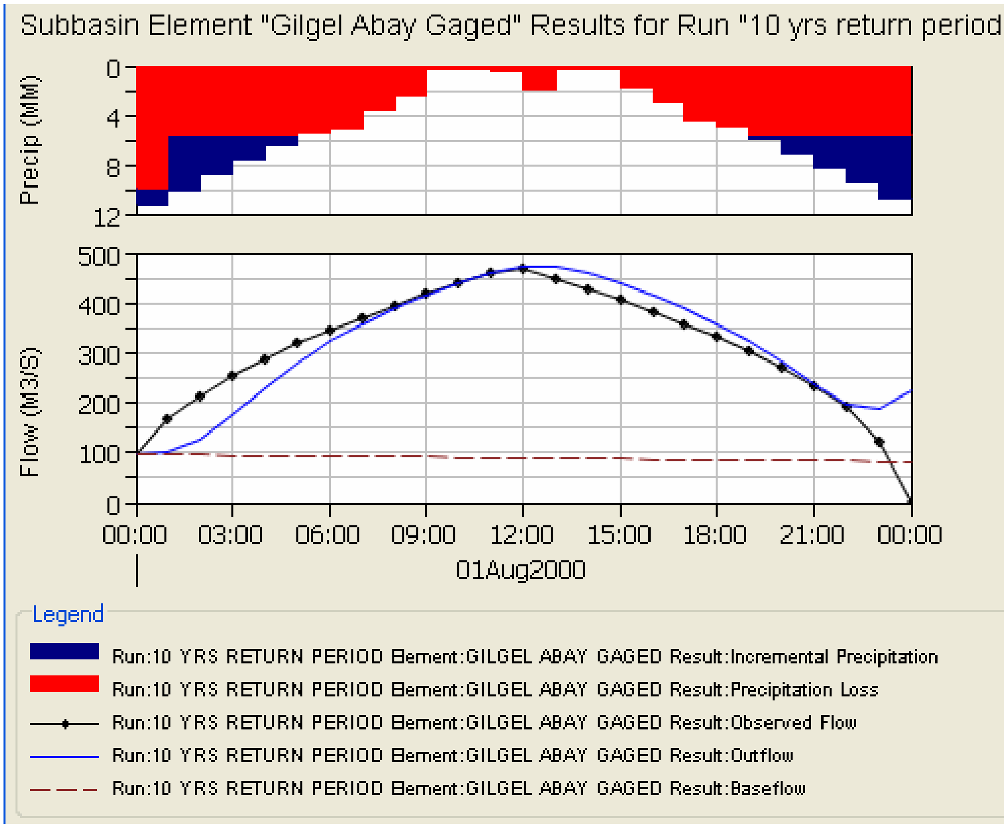
Computed Results

Peak Discharge :	153.4 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	12598.8 (1000 M3)	Total Direct Runoff :	6074.6 (1000 M3)
Total Loss :	2137.4 (1000 M3)	Total Baseflow :	2999.5 (1000 M3)
Total Excess :	10461.3 (1000 M3)	Discharge :	9074.1 (1000 M3)

Observed Hydrograph at Gage Gemero

Peak Discharge :	158.73 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	15.47 (M3/S)		
Total Residual :	-272.7 (1000 M3)	Total Obs Q :	9346.82 (1000 M3)

<u>Simulation Results Graph for Gilgel Abay Gauged Sub basin</u>



<u>Summary of Result of Gilgel Abay Gauged Subbasin</u>

Project : Project 1-10 yrs R.P   Simulation Run : 10 yrs return period   Subbasin: Gilgel Abay Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	Outlet
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 11:52:06	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

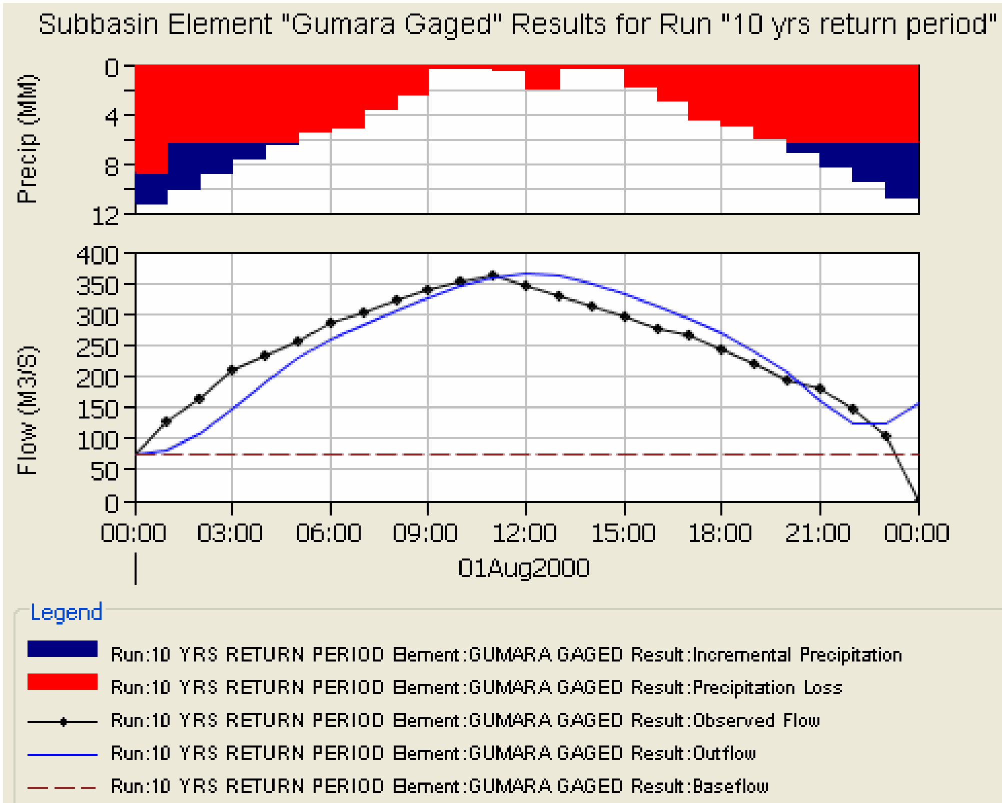
Computed Results

Peak Discharge :	474.5 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	197638.4 (1000 M3)	Total Direct Runoff :	20027.4 (1000 M3)
Total Loss :	156628.8 (1000 M3)	Total Baseflow :	7717.5 (1000 M3)
Total Excess :	41009.5 (1000 M3)	Discharge :	27744.9 (1000 M3)

Observed Hydrograph at Gage Gilgel Abay

Peak Discharge :	470.01 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	35.68 (M3/S)		
Total Residual :	122.5 (1000 M3)	Total Obs Q :	27622.44 (1000 M3)

<u>Simulation Results Graph for Gumara Gauged Sub basin</u>



<u>Summary of Result of Gumara Gauged Subbasin</u>

Project : Project 1-10 yrs R.P   Simulation Run : 10 yrs return period   Subbasin: Gumara Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	Outlet
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 11:52:06	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

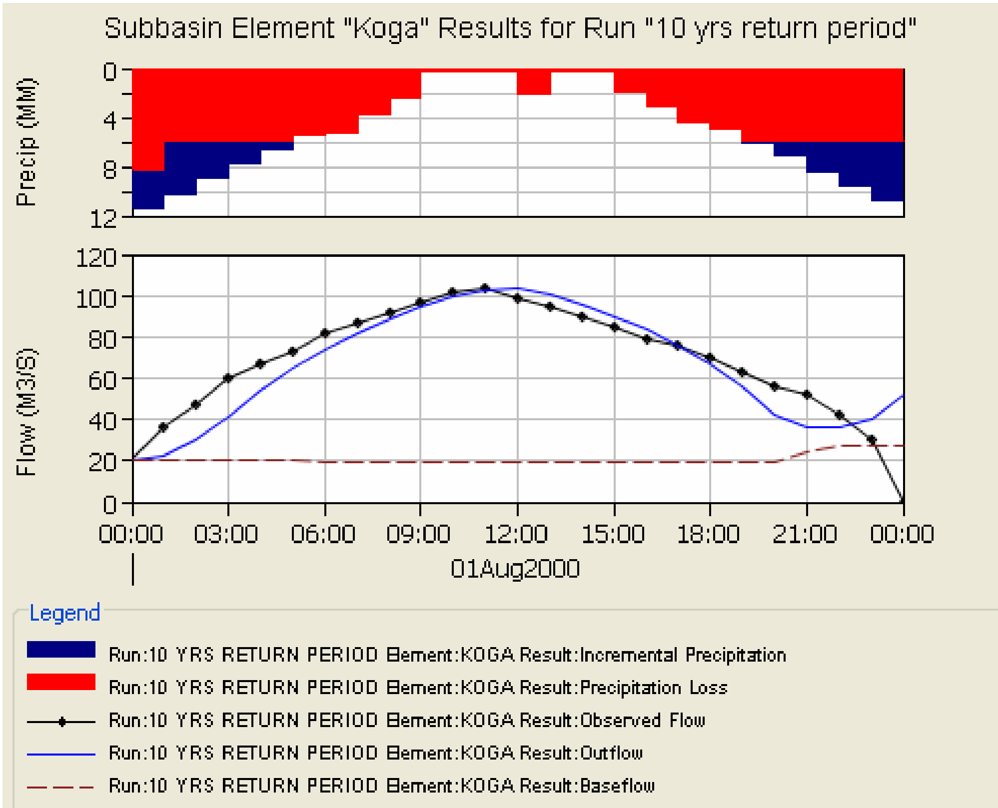
Computed Results

Peak Discharge :	365.6 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	161440.4 (1000 M3)	Total Direct Runoff :	14773.8 (1000 M3)
Total Loss :	132696.6 (1000 M3)	Total Baseflow :	6437.8 (1000 M3)
Total Excess :	28743.9 (1000 M3)	Discharge :	21211.6 (1000 M3)

Observed Hydrograph at Gage Gumara

Peak Discharge :	360.87 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 11:00
Avg Abs Residual :	31.30 (M3/S)		
Total Residual :	-38.4 (1000 M3)	Total Obs Q :	21249.97 (1000 M3)

<u>Simulation Results Graph for Koga Gauged Sub basin</u>



Summary of Result of Koga Gauged Subbasin

Project : Project 1-10 yrs R.P   Simulation Run : 10 yrs return period   Subbasin: Koga

Start of Run :	01Aug2000, 00:00	Basin Model :	Outlet
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 11:52:06	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

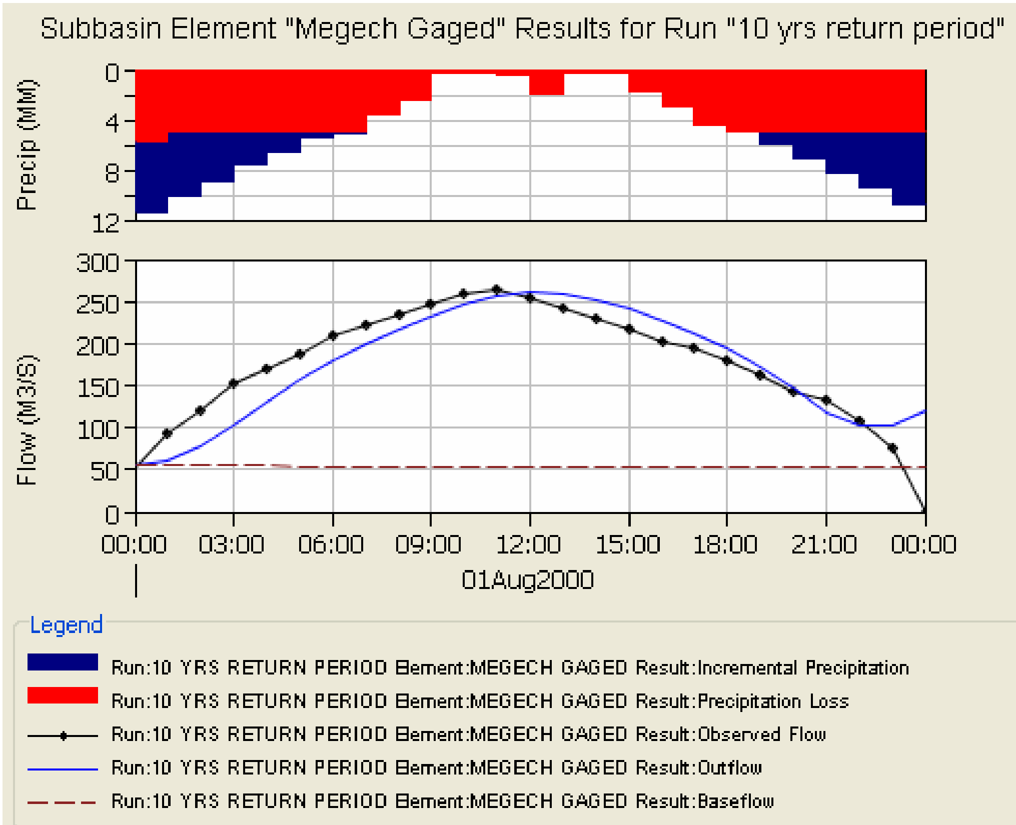
Computed Results

Peak Discharge :	103.1 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	36467.8 (1000 M3)	Total Direct Runoff :	4038.3 (1000 M3)
Total Loss :	28808.4 (1000 M3)	Total Baseflow :	1786.6 (1000 M3)
Total Excess :	7659.3 (1000 M3)	Discharge :	5824.8 (1000 M3)

Observed Hydrograph at Gage Koga

Peak Discharge :	103.47 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 11:00
Avg Abs Residual :	9.07 (M3/S)		
Total Residual :	-267.9 (1000 M3)	Total Obs Q :	6092.75 (1000 M3)

Simulation Results Graph for Megech Gauged Sub basin



Summary of Result of Megech Gauged Subbasin

Project : Project 1-10 yrs R.P   Simulation Run : 10 yrs return period   Subbasin: Megech Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	Outlet
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 11:52:06	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

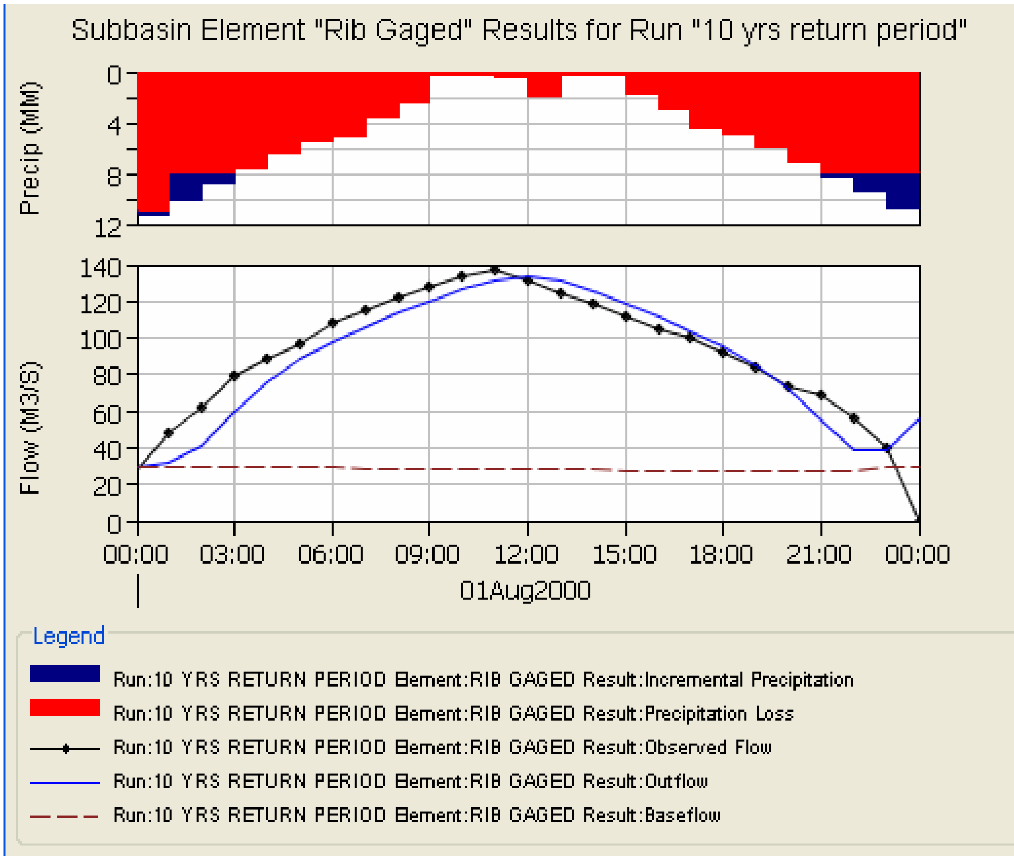
Computed Results

Peak Discharge :	260.6 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	61412.8 (1000 M3)	Total Direct Runoff :	10626.3 (1000 M3)
Total Loss :	42247.2 (1000 M3)	Total Baseflow :	4640.1 (1000 M3)
Total Excess :	19165.6 (1000 M3)	Discharge :	15266.4 (1000 M3)

Observed Hydrograph at Gage Megech

Peak Discharge :	264.62 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 11:00
Avg Abs Residual :	24.43 (M3/S)		
Total Residual :	-315.8 (1000 M3)	Total Obs Q :	15582.22 (1000 M3)

Simulation Results Graph for Rib Gauged Sub basin



<u>Summary of Result of Rib Gauged Subbasin</u>

Project : Project 1-10 yrs R.P   Simulation Run : 10 yrs return period   Subbasin: Rib Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	Outlet
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 11:52:06	Control Specifications :	Control 1

Volume Units : MM 1000 M3

Computed Results

Peak Discharge :	134.0 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	181507.0 (1000 M3)	Total Direct Runoff :	5279.4 (1000 M3)
Total Loss :	169581.5 (1000 M3)	Total Baseflow :	2445.5 (1000 M3)
Total Excess :	11925.5 (1000 M3)	Discharge :	7724.9 (1000 M3)

Observed Hydrograph at Gage Rib

Peak Discharge :	136.62 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 11:00
Avg Abs Residual :	10.19 (M3/S)		
Total Residual :	-319.9 (1000 M3)	Total Obs Q :	8044.83 (1000 M3)

Annex II: Results for Simulation Run for 25-yrs Return Period

Graph for Lake Tana Simulation Result 0f 25-yrs Return Period

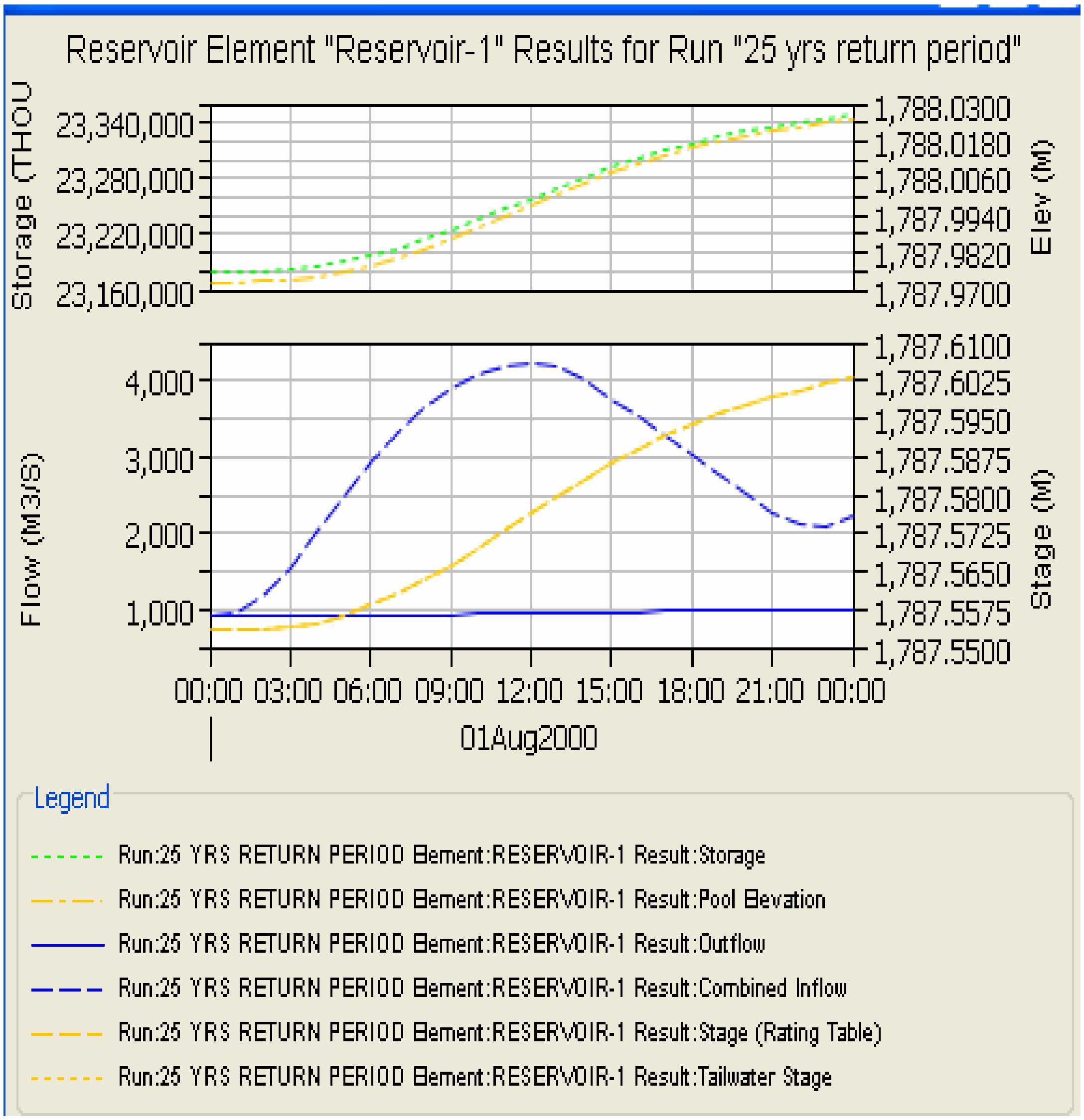


Table A-4(a):Time Serious Simulation Result of Lake Tana for 25- years Return

Project : Project 1-25years R.p   Run : 25 yrs return period   Reservoir: Reservoir-1

Start of Run : 01Aug2000, 00:00   Basin Model : TANA
End of Run : 02Aug2000, 00:00   Meteorologic Model : Storm
Compute Time : 13Jan2008, 23:43:32   Control Specifications : Control 1

Date	Time	Inflow (M3/S)	Storage (1000 M3)	Elevation (M)	Outfl... (M3/S)	Obs Flow (M3/S)	Residual (M3/S)	Stage (M)
01Aug2000	00:00	912.9	23180103.8	1788.0	912.9	744.2	744.2	1787.6
01Aug2000	01:00	964.9	23180197.2	1788.0	913.0	620.7	620.7	1787.6
01Aug2000	02:00	1172.1	23180756.4	1788.0	913.3	535.9	535.9	1787.6
01Aug2000	03:00	1550.0	23182367.0	1788.0	914.0	467.6	467.6	1787.6
01Aug2000	04:00	2020.1	23185500.1	1788.0	915.5	409.3	409.3	1787.6
01Aug2000	05:00	2497.4	23190331.5	1788.0	917.9	358.2	358.2	1787.6
01Aug2000	06:00	2934.1	23196798.2	1788.0	921.0	312.6	312.6	1787.6
01Aug2000	07:00	3319.4	23204731.8	1788.0	924.9	271.3	271.3	1787.6
01Aug2000	08:00	3647.2	23213933.9	1788.0	929.4	233.6	233.6	1787.6
01Aug2000	09:00	3905.0	23224173.1	1788.0	934.4	198.8	198.8	1787.6
01Aug2000	10:00	4089.2	23235189.2	1788.0	939.7	166.4	166.4	1787.6
01Aug2000	11:00	4202.5	23246720.9	1788.0	945.4	136.1	136.1	1787.6
01Aug2000	12:00	4240.7	23258504.8	1788.0	951.2	124.5	124.5	1787.6
01Aug2000	13:00	4181.0	23270229.4	1788.0	956.9	165.4	165.4	1787.6
01Aug2000	14:00	4012.8	23281524.1	1788.0	962.4	207.7	207.7	1787.6
01Aug2000	15:00	3770.7	23292059.8	1788.0	967.5	251.6	251.6	1787.6
01Aug2000	16:00	3520.1	23301691.2	1788.0	972.2	297.2	297.2	1787.6
01Aug2000	17:00	3264.7	23310395.7	1788.0	976.4	345.0	345.0	1787.6
01Aug2000	18:00	3014.4	23318175.6	1788.0	980.2	395.7	395.7	1787.6
01Aug2000	19:00	2765.8	23325044.8	1788.0	983.6	449.9	449.9	1787.6
01Aug2000	20:00	2508.4	23330991.8	1788.0	986.5	509.2	509.2	1787.6
01Aug2000	21:00	2279.3	23336053.4	1788.0	989.0	575.6	575.6	1787.6
01Aug2000	22:00	2119.4	23340406.7	1788.0	991.1	653.6	653.6	1787.6
01Aug2000	23:00	2078.1	23344390.6	1788.0	993.0	754.4	754.4	1787.6
02Aug2000	00:00	2242.7	23348589.2	1788.0	995.1	995.1	995.1	1787.6

Table A-4(b): Summary Results for Tana Lake Simulation.........

Project : Project 1-25years R.p   Simulation Run : 25 yrs return period   Reservoir: Reservoir-1

Start of Run : 01Aug2000, 00:00   Basin Model : TANA
End of Run : 02Aug2000, 00:00   Meteorologic Model : Storm
Compute Time : 13Jan2008, 23:43:32   Control Specifications : Control 1

Volume Units : ○ MM ◉ 1000 M3

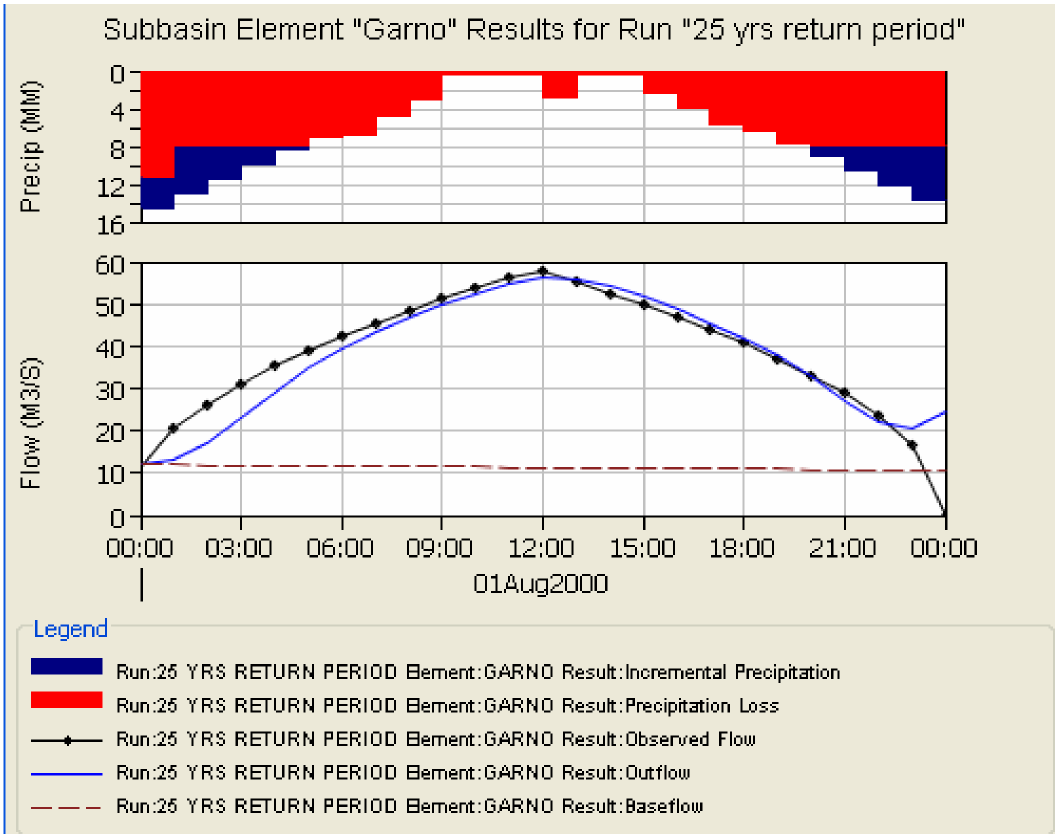
Computed Results

Peak Inflow : 4240.7 (M3/S)   Date/Time of Peak Inflow : 01Aug2000, 12:00
Peak Outflow : 995.1 (M3/S)   Date/Time of Peak Outflow : 02Aug2000, 00:00
Total Inflow : 250686.6 (1000 M3)   Peak Storage : 23348589.2 (1000 M3)
Total Outflow : 82196.6 (1000 M3)   Peak Elevation : 1788.0 (M)

Observed Hydrograph at Gage Abay

Peak Discharge : 826.68 (M3/S)   Date/Time of Peak Discharge : 01Aug2000, 12:00
Avg Abs Residual : 407.19 (M3/S)
Total Residual : 33516.5 (1000 M3)   Total Obs Q : 48680.12 (1000 M3)

Simulation Results Graph for Garno Gauged Sub basin



Summary of Result of Garno Gauged Subbasin

Project : Project 1-25years R.p   Simulation Run : 25 yrs return period   Subbasin: Garno

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 23:43:32	Control Specifications :	Control 1

Volume Units : MM 1000 M3

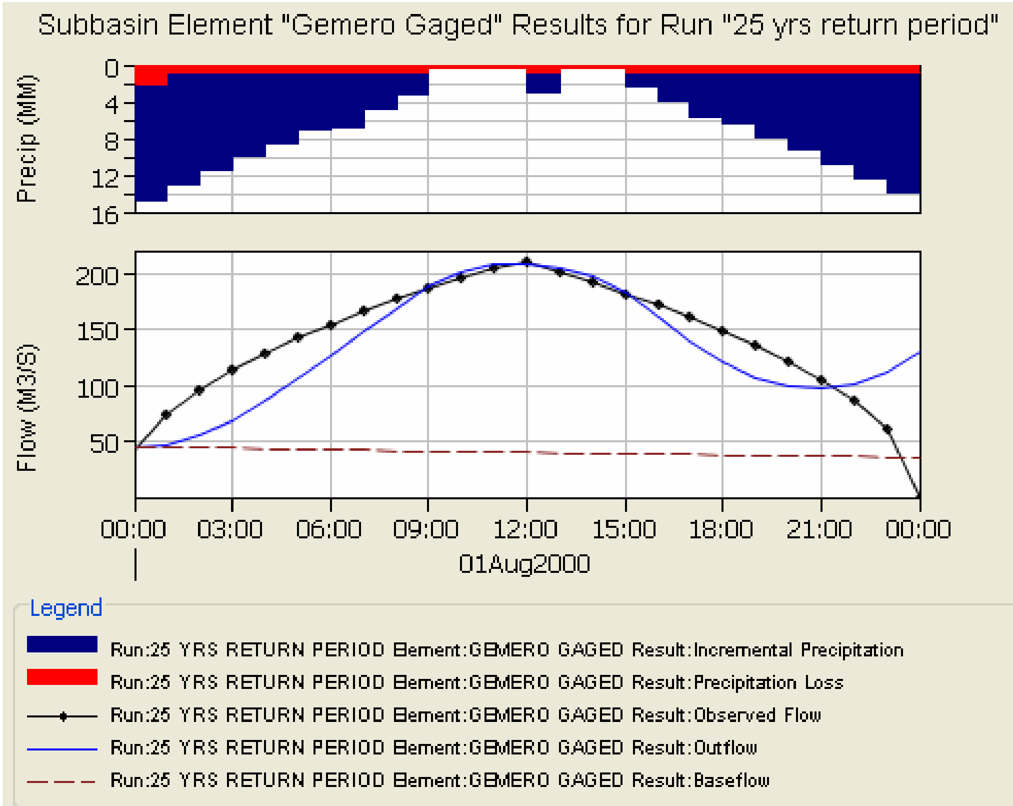
Computed Results

Peak Discharge :	56.1 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	24470.1 (1000 M3)	Total Direct Runoff :	2324.9 (1000 M3)
Total Loss :	19958.9 (1000 M3)	Total Baseflow :	976.9 (1000 M3)
Total Excess :	4511.2 (1000 M3)	Discharge :	3301.8 (1000 M3)

Observed Hydrograph at Gage Garno

Peak Discharge :	57.53 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	3.56 (M3/S)		
Total Residual :	-86.0 (1000 M3)	Total Obs Q :	3387.78 (1000 M3)

Simulation Results Graph for Gemro Gauged Sub basin



Summary of Result of Garno Gauged Subbasin

Project : Project 1-25years R.p   Simulation Run : 25 yrs return period   Subbasin: Gemero Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 23:43:32	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

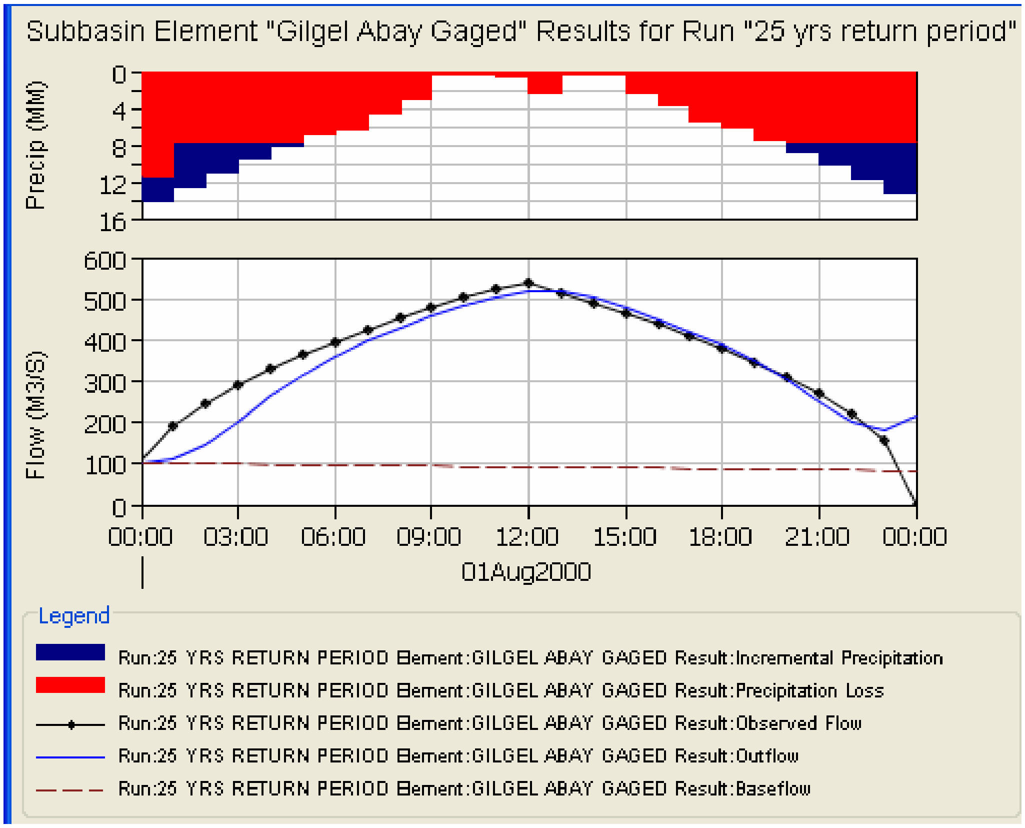
Computed Results

Peak Discharge :	208.8 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	15676.3 (1000 M3)	Total Direct Runoff :	8106.8 (1000 M3)
Total Loss :	1720.3 (1000 M3)	Total Baseflow :	3484.8 (1000 M3)
Total Excess :	13956.0 (1000 M3)	Discharge :	11591.6 (1000 M3)

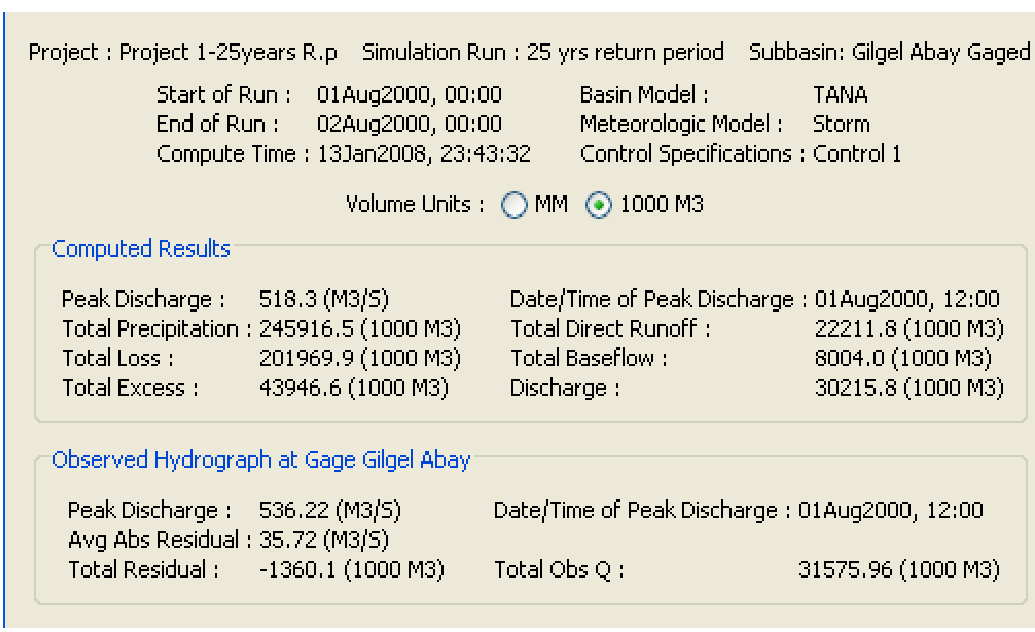
Observed Hydrograph at Gage Gemero

Peak Discharge :	209.78 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	23.07 (M3/S)		
Total Residual :	-761.3 (1000 M3)	Total Obs Q :	12352.97 (1000 M3)

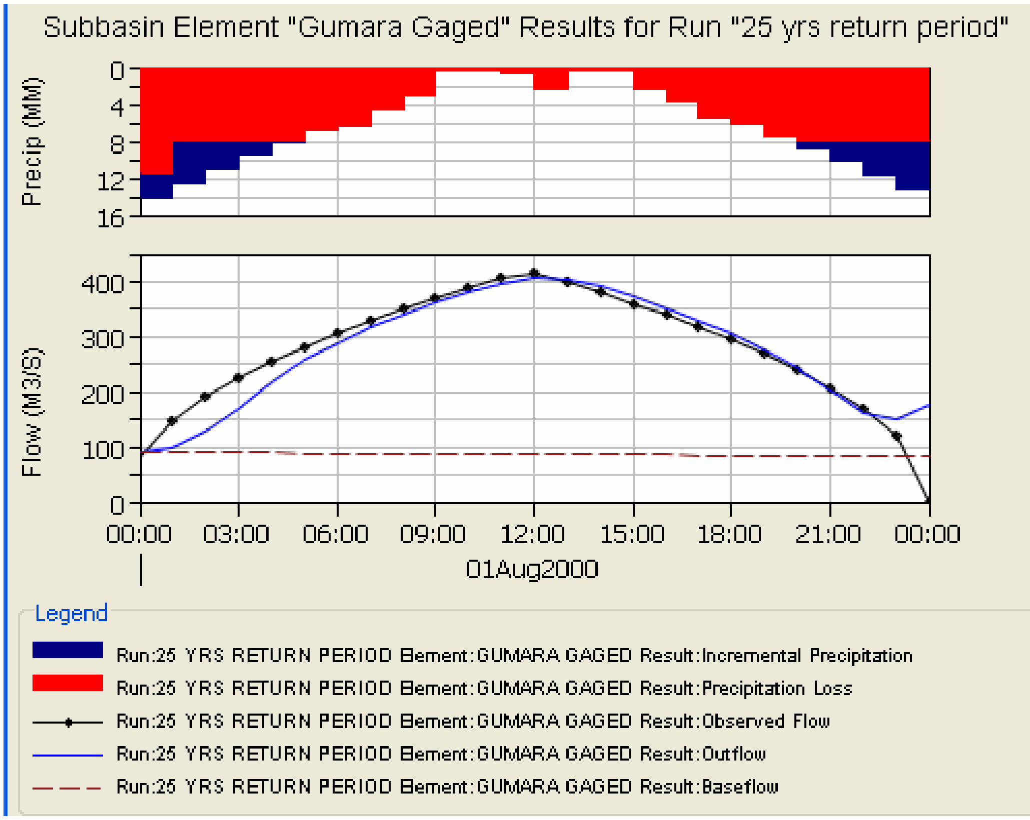
Simulation Results Graph for Gilgel Abay Gauged Sub basin



Summary of Result of Gilgel Abay Gauged Subbasin



<u>Simulation Results Graph for Gumara Gauged Sub basin</u>



<u>Summary of Result of Gumara Gauged Subbasin</u>

Project : Project 1-25years R.p   Simulation Run : 25 yrs return period   Subbasin: Gumara Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 23:43:32	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

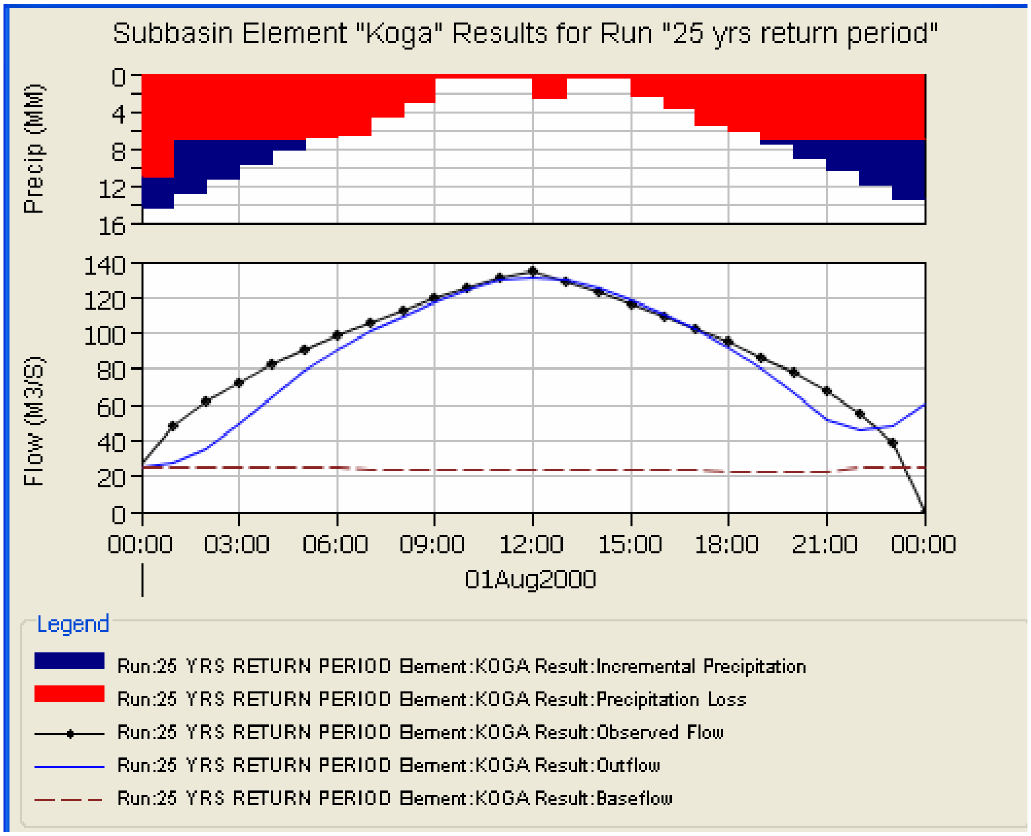
Computed Results

Peak Discharge :	406.3 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	200876.3 (1000 M3)	Total Direct Runoff :	16572.8 (1000 M3)
Total Loss :	168091.4 (1000 M3)	Total Baseflow :	7512.0 (1000 M3)
Total Excess :	32784.9 (1000 M3)	Discharge :	24084.8 (1000 M3)

Observed Hydrograph at Gage Gumara

Peak Discharge :	416.00 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	24.46 (M3/S)		
Total Residual :	-411.9 (1000 M3)	Total Obs Q :	24496.74 (1000 M3)

<u>Simulation Results Graph for Koga Gauged Sub basin</u>



<u>Summary of Result of Koga Gauged Subbasin</u>

Project : Project 1-25years R.p   Simulation Run : 25 yrs return period   Subbasin: Koga

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 23:43:32	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

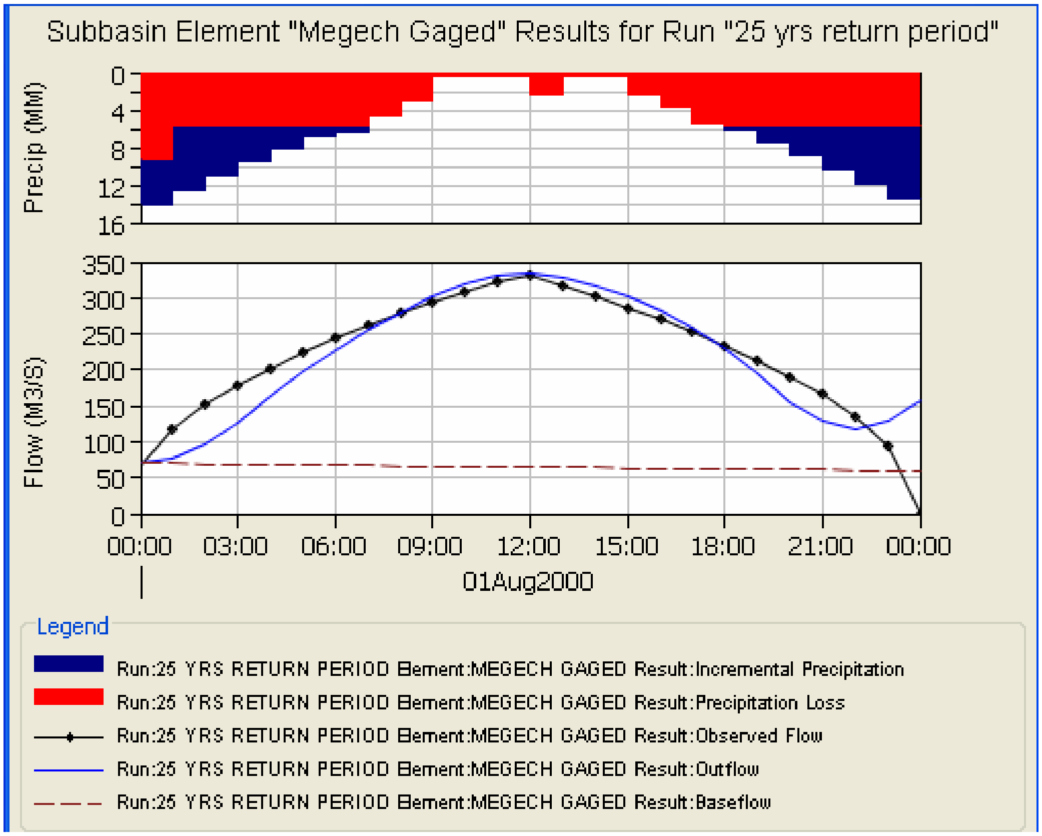
Computed Results

Peak Discharge :	131.5 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	45375.9 (1000 M3)	Total Direct Runoff :	5401.6 (1000 M3)
Total Loss :	34836.4 (1000 M3)	Total Baseflow :	2073.3 (1000 M3)
Total Excess :	10539.5 (1000 M3)	Discharge :	7474.9 (1000 M3)

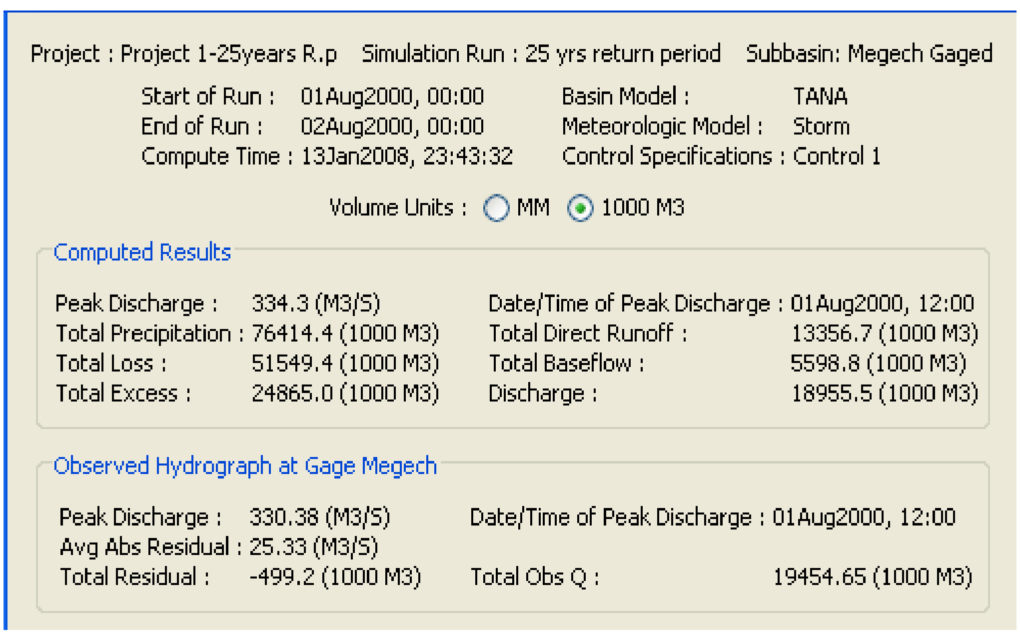
Observed Hydrograph at Gage Koga

Peak Discharge :	134.37 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	9.87 (M3/S)		
Total Residual :	-437.4 (1000 M3)	Total Obs Q :	7912.28 (1000 M3)

Simulation Results Graph for Koga Gauged Sub basin



Summary of Result of Koga Gauged Subbasin



Project : Project 1-25years R.p Simulation Run : 25 yrs return period Subbasin: Megech Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 23:43:32	Control Specifications :	Control 1

Volume Units : MM 1000 M3

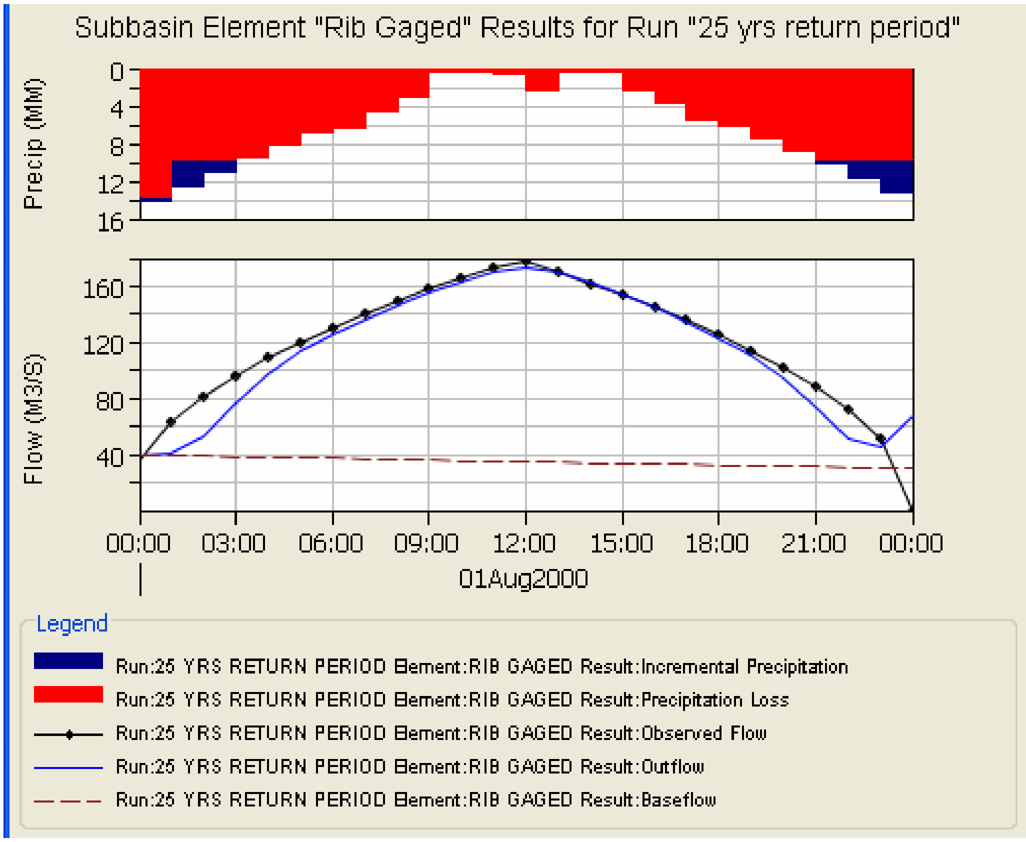
Computed Results

Peak Discharge :	334.3 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	76414.4 (1000 M3)	Total Direct Runoff :	13356.7 (1000 M3)
Total Loss :	51549.4 (1000 M3)	Total Baseflow :	5598.8 (1000 M3)
Total Excess :	24865.0 (1000 M3)	Discharge :	18955.5 (1000 M3)

Observed Hydrograph at Gage Megech

Peak Discharge :	330.38 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	25.33 (M3/S)		
Total Residual :	-499.2 (1000 M3)	Total Obs Q :	19454.65 (1000 M3)

Simulation Results Graph for Koga Gauged Sub basin



Summary of Result of RibGauged Subbasin

Project : Project 1-25years R.p   Simulation Run : 25 yrs return period   Subbasin: Rib Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	13Jan2008, 23:43:32	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

Computed Results

Peak Discharge :	173.4 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	225844.6 (1000 M3)	Total Direct Runoff :	6965.3 (1000 M3)
Total Loss :	209863.3 (1000 M3)	Total Baseflow :	3017.0 (1000 M3)
Total Excess :	15981.3 (1000 M3)	Discharge :	9982.3 (1000 M3)

Observed Hydrograph at Gage Rib

Peak Discharge :	177.41 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	9.62 (M3/S)		
Total Residual :	-464.8 (1000 M3)	Total Obs Q :	10447.04 (1000 M3)

Annex III: Results for Simulation Run for 50-yrs Return Period

Graph for Lake Tana Simulation Result 0f 50-yrs Return Period

Table A-5(a):Time Serious Simulation Result of Lake Tana for 50- years Return Period

Project : 50 years R.P   Run : 50 yrs return period   Reservoir: Reservoir-1

Start of Run : 01Aug2000, 00:00   Basin Model : TANA
End of Run : 02Aug2000, 00:00   Meteorologic Model : Storm
Compute Time : 12Jan2008, 21:26:00   Control Specifications : Control 1

Date	Time	Inflow (M3/S)	Storage (1000 M3)	Elevation (M)	Outflow (M3/S)	Stage (M)
01Aug2000	00:00	992.9	23344084.2	1788.0	992.9	1787.6
01Aug2000	01:00	1069.2	23344221.3	1788.0	993.0	1787.6
01Aug2000	02:00	1348.1	23344996.9	1788.0	993.3	1787.6
01Aug2000	03:00	1829.0	23347137.5	1788.0	994.4	1787.6
01Aug2000	04:00	2412.6	23351188.6	1788.0	996.4	1787.6
01Aug2000	05:00	2998.4	23357335.4	1788.0	999.4	1787.6
01Aug2000	06:00	3528.2	23365477.6	1788.0	1003.4	1787.6
01Aug2000	07:00	3990.5	23375389.3	1788.0	1008.3	1787.6
01Aug2000	08:00	4380.6	23386817.9	1788.0	1014.0	1787.6
01Aug2000	09:00	4685.4	23399475.9	1788.0	1020.2	1787.6
01Aug2000	10:00	4898.8	23413043.1	1788.0	1027.0	1787.6
01Aug2000	11:00	5019.3	23427186.4	1788.0	1034.1	1787.6
01Aug2000	12:00	5040.0	23441558.1	1788.1	1041.2	1787.6
01Aug2000	13:00	4938.9	23455759.4	1788.1	1048.4	1787.6
01Aug2000	14:00	4710.3	23469342.2	1788.1	1055.2	1787.6
01Aug2000	15:00	4391.1	23481915.2	1788.1	1061.6	1787.6
01Aug2000	16:00	4036.8	23493254.2	1788.1	1067.3	1787.6
01Aug2000	17:00	3728.2	23503378.9	1788.1	1072.4	1787.6
01Aug2000	18:00	3430.5	23512394.8	1788.1	1077.0	1787.7
01Aug2000	19:00	3102.6	23520269.2	1788.1	1081.0	1787.7
01Aug2000	20:00	2772.8	23526946.6	1788.1	1084.4	1787.7
01Aug2000	21:00	2494.4	23532518.2	1788.1	1087.3	1787.7
01Aug2000	22:00	2316.5	23537259.0	1788.1	1089.7	1787.7
01Aug2000	23:00	2296.7	23541635.5	1788.1	1091.9	1787.7
02Aug2000	00:00	2534.9	23546396.6	1788.1	1094.4	1787.7

Table A-5(b): Summary Results for Tana Lake Simulation Run

Project : 50 years R.P   Simulation Run : 50 yrs return period   Reservoir: Reservoir-1

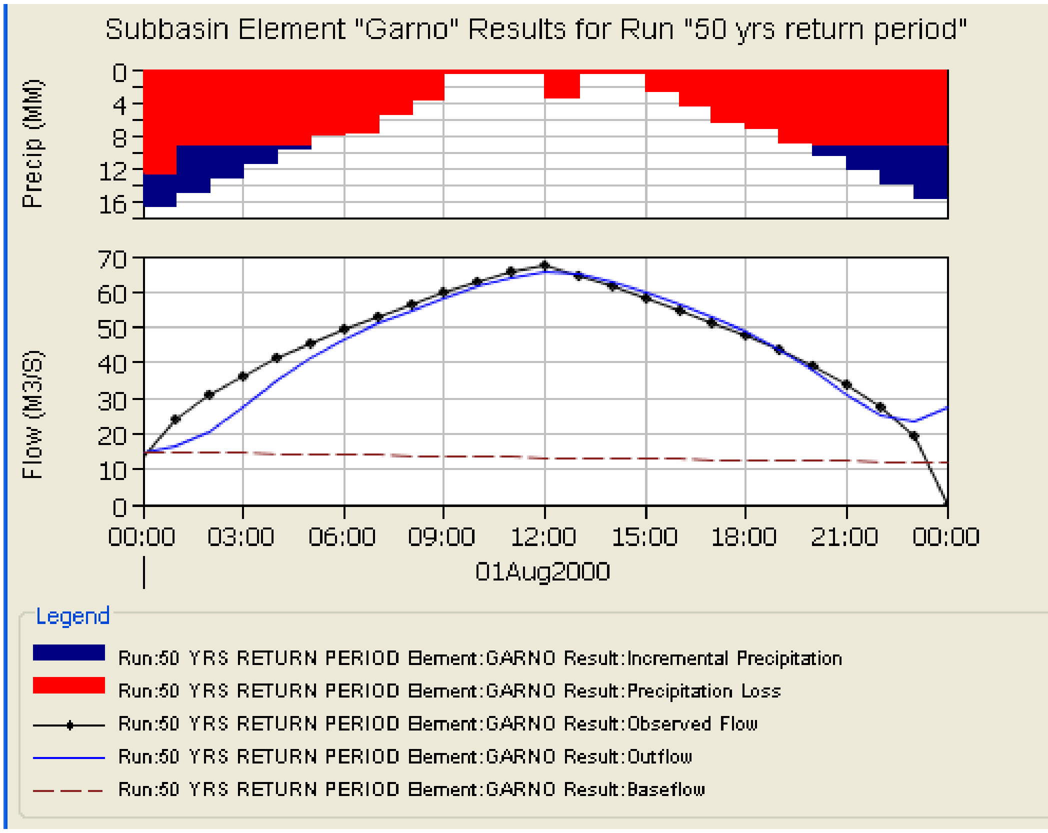
Start of Run : 01Aug2000, 00:00   Basin Model : TANA
End of Run : 02Aug2000, 00:00   Meteorologic Model : Storm
Compute Time : 12Jan2008, 21:26:00   Control Specifications : Control 1

Volume Units : ○ MM ◉ 1000 M3

Computed Results

Peak Inflow :	5040.0 (M3/S)	Date/Time of Peak Inflow :	01Aug2000, 12:00
Peak Outflow :	1094.4 (M3/S)	Date/Time of Peak Outflow :	02Aug2000, 00:00
Total Inflow :	292257.6 (1000 M3)	Peak Storage :	23546396.6 (1000 M3)
Total Outflow :	89944.9 (1000 M3)	Peak Elevation :	1788.1 (M)

Simulation Results Graph for Garno Gauged Sub basin



Summary of Result of Garno Gauged Subbasin

Project : 50 years R.P   Simulation Run : 50 yrs return period   Subbasin: Garno

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	12Jan2008, 21:26:00	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

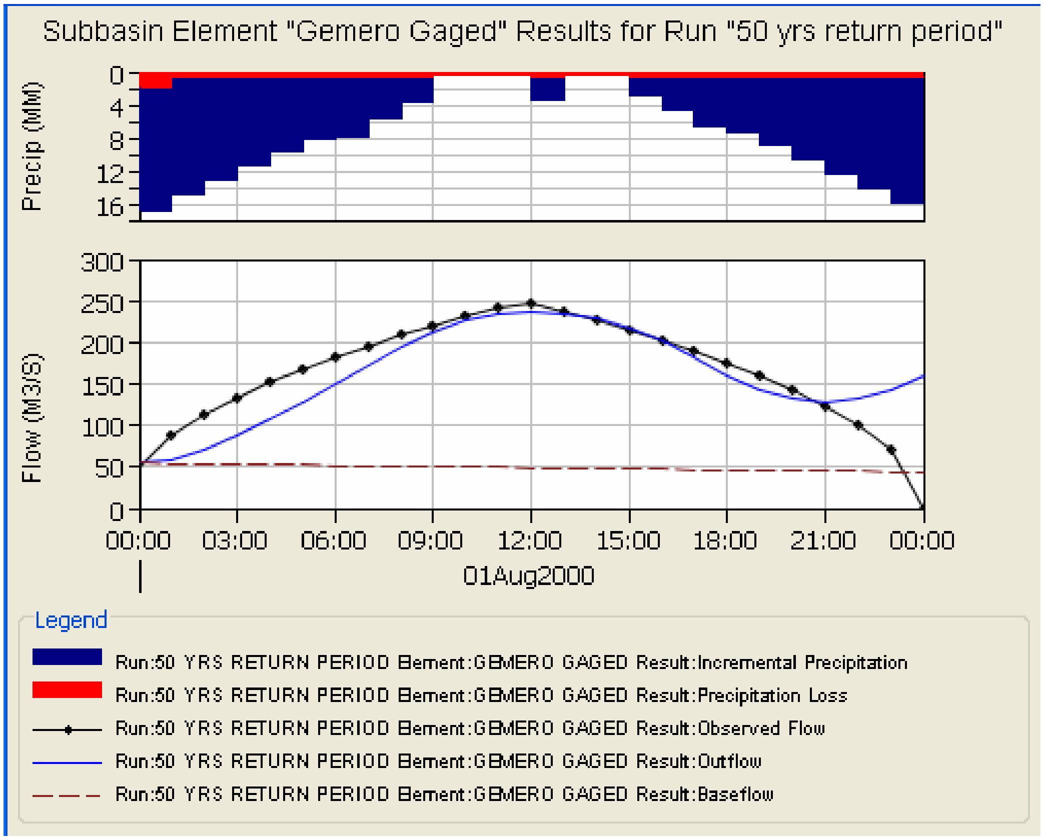
Computed Results

Peak Discharge :	65.4 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	28073.0 (1000 M3)	Total Direct Runoff :	2704.1 (1000 M3)
Total Loss :	22857.3 (1000 M3)	Total Baseflow :	1152.3 (1000 M3)
Total Excess :	5215.8 (1000 M3)	Discharge :	3856.4 (1000 M3)

Observed Hydrograph at Gage Garno

Peak Discharge :	67.29 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	3.91 (M3/S)		
Total Residual :	-106.4 (1000 M3)	Total Obs Q :	3962.77 (1000 M3)

Simulation Results Graph for Gemero Gauged Sub basin



Summary of Result of Gemero Gauged Subbasin

Project : 50 years R.P   Simulation Run : 50 yrs return period   Subbasin: Gemero Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	12Jan2008, 21:26:00	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

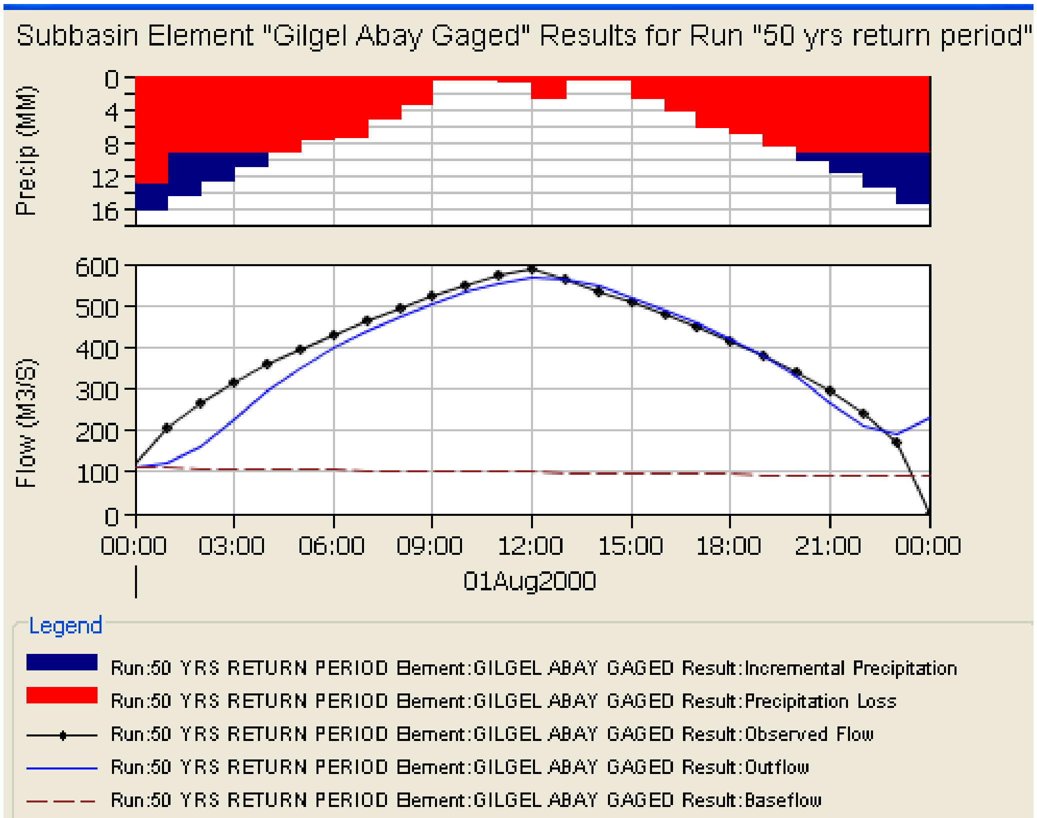
Computed Results

Peak Discharge :	236.8 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	17984.5 (1000 M3)	Total Direct Runoff :	9751.6 (1000 M3)
Total Loss :	1273.6 (1000 M3)	Total Baseflow :	4259.2 (1000 M3)
Total Excess :	16710.9 (1000 M3)	Discharge :	14010.8 (1000 M3)

Observed Hydrograph at Gage Gemero

Peak Discharge :	247.65 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	25.21 (M3/S)		
Total Residual :	-572.4 (1000 M3)	Total Obs Q :	14583.19 (1000 M3)

Simulation Results Graph for Gilgel Abay Gauged Sub basin



Summary of Result of Gilgel Abay Gauged Subbasin

Project : 50 years R.P   Simulation Run : 50 yrs return period   Subbasin: Gilgel Abay Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	12Jan2008, 21:26:00	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

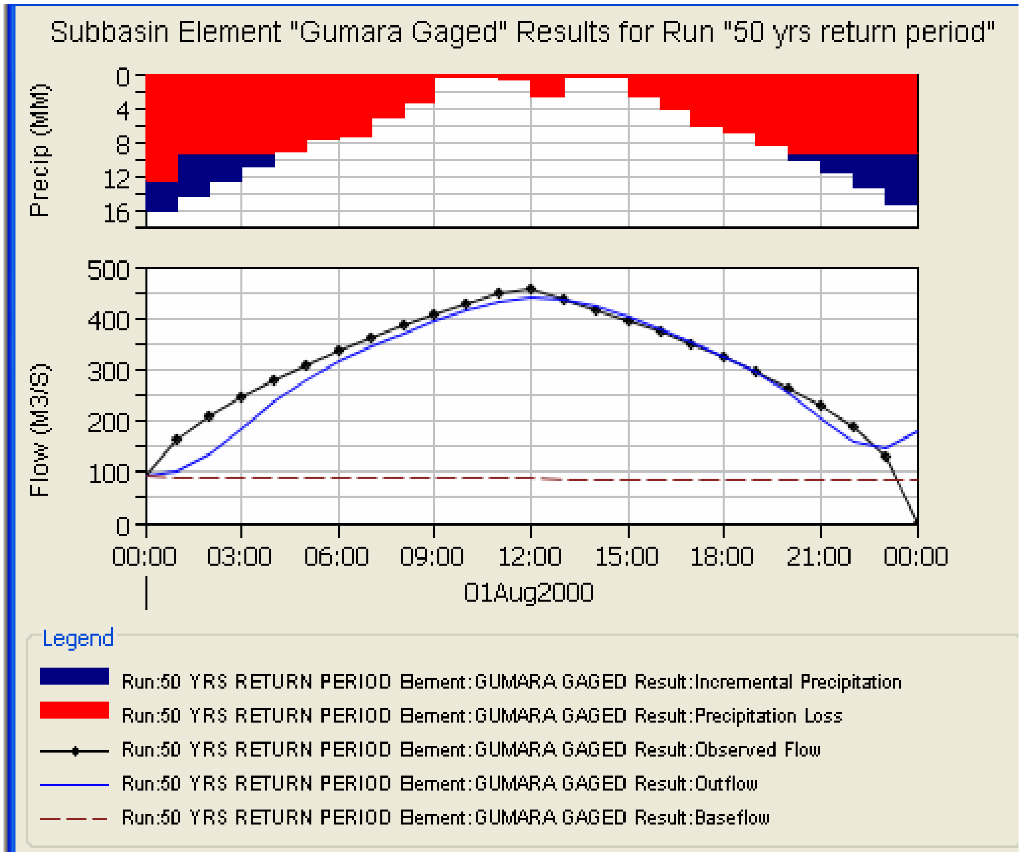
Computed Results

Peak Discharge :	568.1 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	282125.0 (1000 M3)	Total Direct Runoff :	24353.3 (1000 M3)
Total Loss :	234273.8 (1000 M3)	Total Baseflow :	8629.4 (1000 M3)
Total Excess :	47851.2 (1000 M3)	Discharge :	32982.7 (1000 M3)

Observed Hydrograph at Gage Gilgel Abay

Peak Discharge :	585.36 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	36.97 (M3/S)		
Total Residual :	-1486.9 (1000 M3)	Total Obs Q :	34469.66 (1000 M3)

Simulation Results Graph for Gumara Gauged Sub basin



Summary of Result of Gumara Gauged Subbasin

Project : 50 years R.P   Simulation Run : 50 yrs return period   Subbasin: Gumara Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	12Jan2008, 21:26:00	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

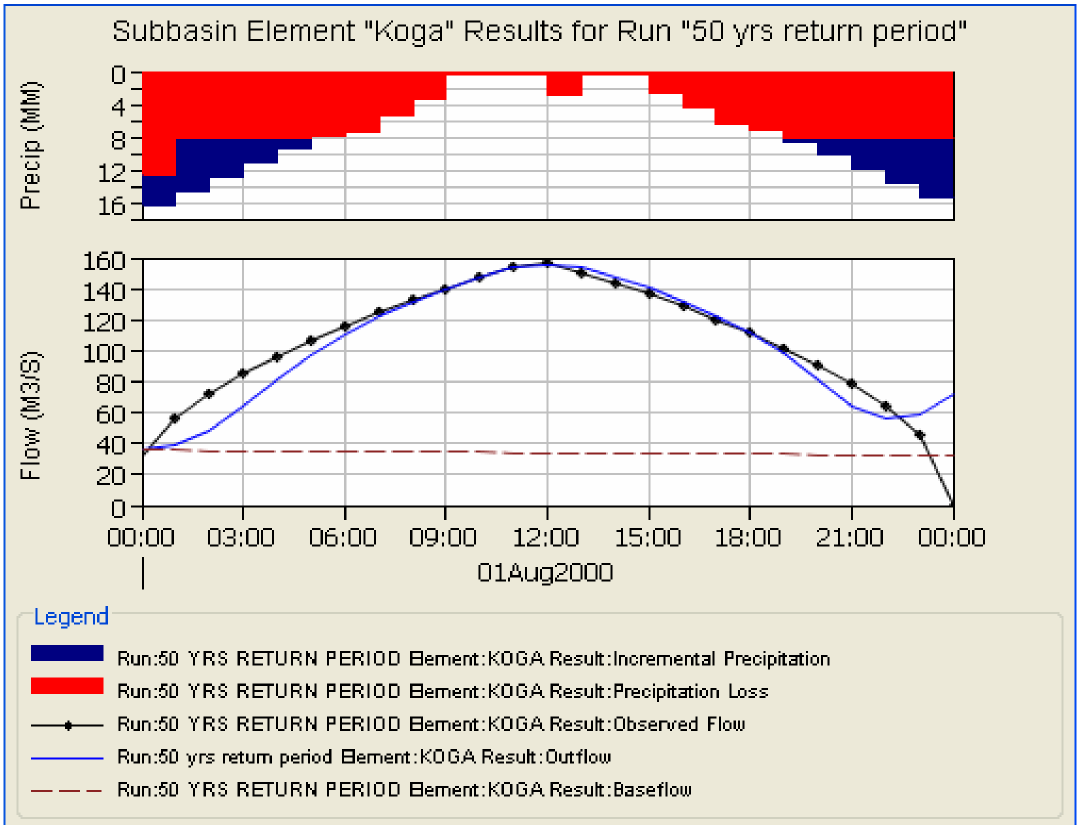
Computed Results

Peak Discharge :	441.1 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	230453.2 (1000 M3)	Total Direct Runoff :	18300.9 (1000 M3)
Total Loss :	195051.1 (1000 M3)	Total Baseflow :	7512.0 (1000 M3)
Total Excess :	35402.1 (1000 M3)	Discharge :	25812.8 (1000 M3)

Observed Hydrograph at Gage Gumara

Peak Discharge :	456.90 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	26.10 (M3/S)		
Total Residual :	-1092.4 (1000 M3)	Total Obs Q :	26905.23 (1000 M3)

Simulation Results Koga Gauged Sub basin



Summary of Result of Koga Gauged Subbasin

Project : 50 years R.P   Simulation Run : 50 yrs return period   Subbasin: Koga

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	12Jan2008, 21:26:00	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

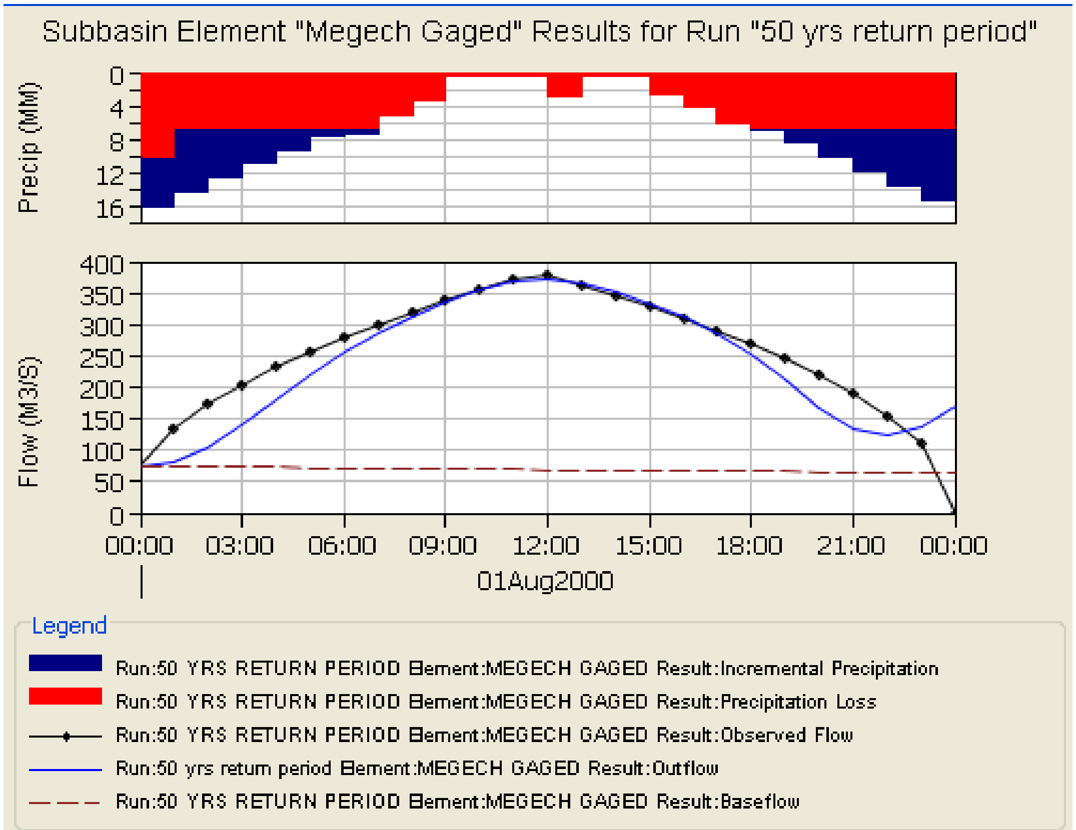
Computed Results

Peak Discharge :	155.6 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	52057.0 (1000 M3)	Total Direct Runoff :	6080.3 (1000 M3)
Total Loss :	40201.3 (1000 M3)	Total Baseflow :	2952.2 (1000 M3)
Total Excess :	11855.7 (1000 M3)	Discharge :	9032.4 (1000 M3)

Observed Hydrograph at Gage Koga

Peak Discharge :	157.29 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	9.63 (M3/S)		
Total Residual :	-229.6 (1000 M3)	Total Obs Q :	9261.99 (1000 M3)

Simulation Results Megech Gauged Sub basin



Summary of Result of Megech Gauged Subbasin

Project : 50 years R.P   Simulation Run : 50 yrs return period   Subbasin: Megech Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	12Jan2008, 21:26:00	Control Specifications :	Control 1

Volume Units : MM 1000 M3

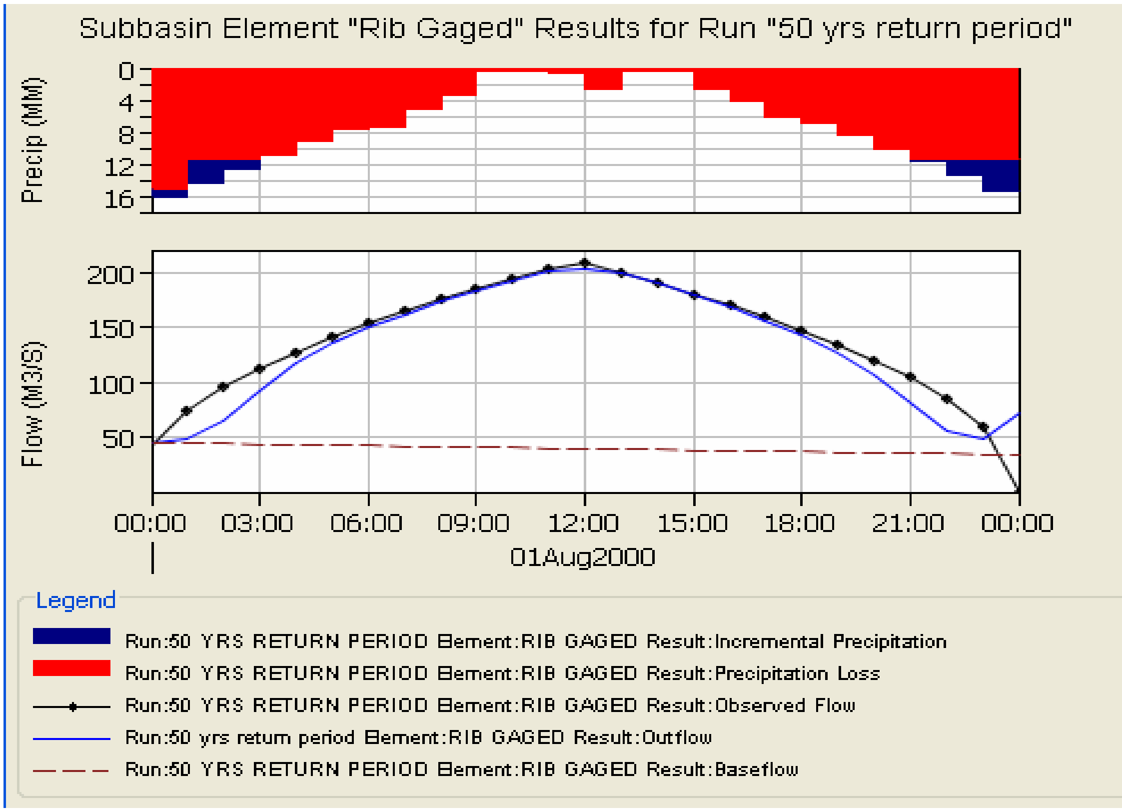
Computed Results

Peak Discharge :	372.5 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	87665.6 (1000 M3)	Total Direct Runoff :	14972.9 (1000 M3)
Total Loss :	59944.2 (1000 M3)	Total Baseflow :	5998.7 (1000 M3)
Total Excess :	27721.3 (1000 M3)	Discharge :	20971.6 (1000 M3)

Observed Hydrograph at Gage Megech

Peak Discharge :	379.16 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	29.04 (M3/S)		
Total Residual :	-1355.8 (1000 M3)	Total Obs Q :	22327.42 (1000 M3)

<u>Simulation Results Rib Gauged Sub basin</u>



<u>Summary of Result of Rib Gauged Subbasin</u>

Project : 50 years R.P   Simulation Run : 50 yrs return period   Subbasin: Rib Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	12Jan2008, 21:26:00	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

Computed Results

Peak Discharge :	203.2 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	259097.8 (1000 M3)	Total Direct Runoff :	8235.8 (1000 M3)
Total Loss :	241297.2 (1000 M3)	Total Baseflow :	3394.1 (1000 M3)
Total Excess :	17800.6 (1000 M3)	Discharge :	11630.0 (1000 M3)

Observed Hydrograph at Gage Rib

Peak Discharge :	207.68 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	11.18 (M3/S)		
Total Residual :	-599.3 (1000 M3)	Total Obs Q :	12229.22 (1000 M3)

Annex IV: Results for Simulation Run for 100-yrs Return Period

Graph for Lake Tana Simulation Result 0f 100-yrs Return Period

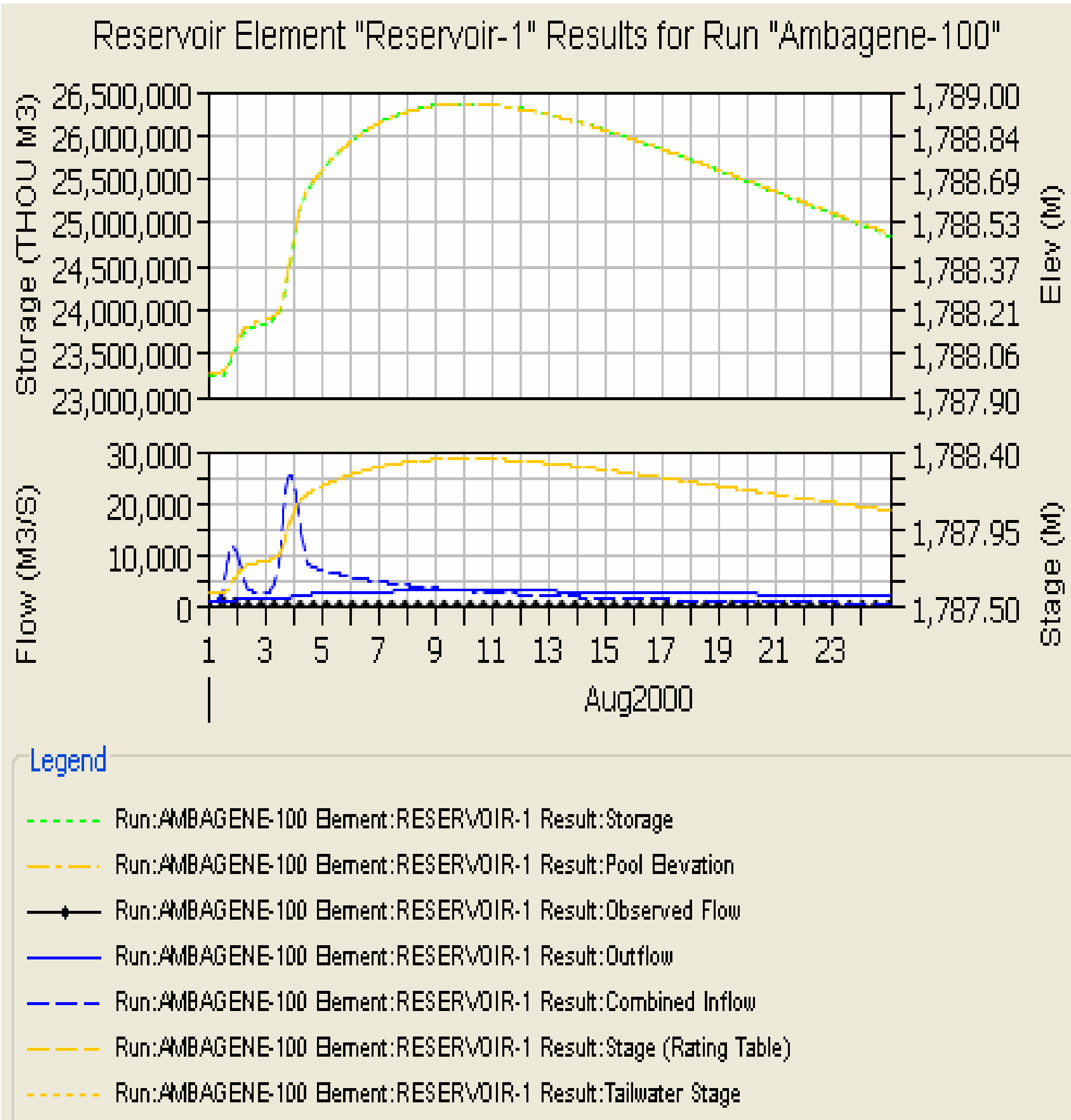


Table A-6(a): Time Serious Simulation Result of Lake Tana for 100- years Return Period

Project : 100 Years R.P   Run : 100 yrs return period   Reservoir: Reservoir-1

Start of Run : 01Aug2000, 00:00   Basin Model : TANA
End of Run : 02Aug2000, 00:00   Meteorologic Model : Storm
Compute Time : 14Jan2008, 01:33:00   Control Specifications : Control 1

Date	Time	Inflow (M3/S)	Storage (1000 M3)	Elevation (M)	Outflow (M3/S)	Stage (M)
01Aug2000	00:00	1020.7	23400298.7	1788.0	1020.7	1787.6
01Aug2000	01:00	1098.1	23400437.9	1788.0	1020.7	1787.6
01Aug2000	02:00	1389.7	23401240.4	1788.0	1021.1	1787.6
01Aug2000	03:00	1929.6	23403536.9	1788.0	1022.3	1787.6
01Aug2000	04:00	2656.2	23408106.9	1788.0	1024.5	1787.6
01Aug2000	05:00	3489.0	23415472.7	1788.0	1028.2	1787.6
01Aug2000	06:00	4368.3	23425904.2	1788.0	1033.4	1787.6
01Aug2000	07:00	5252.4	23439489.7	1788.1	1040.2	1787.6
01Aug2000	08:00	6090.0	23456146.7	1788.1	1048.6	1787.6
01Aug2000	09:00	6824.4	23475600.4	1788.1	1058.4	1787.6
01Aug2000	10:00	7410.9	23497394.1	1788.1	1069.4	1787.6
01Aug2000	11:00	7806.6	23520914.2	1788.1	1081.4	1787.7
01Aug2000	12:00	7973.5	23545402.8	1788.1	1093.9	1787.7
01Aug2000	13:00	7904.7	23570022.8	1788.1	1106.5	1787.7
01Aug2000	14:00	7640.8	23593999.0	1788.1	1118.9	1787.7
01Aug2000	15:00	7248.6	23616750.7	1788.1	1130.7	1787.7
01Aug2000	16:00	6786.9	23637924.5	1788.1	1141.7	1787.7
01Aug2000	17:00	6271.0	23657300.6	1788.1	1151.8	1787.7
01Aug2000	18:00	5737.8	23674753.7	1788.1	1161.0	1787.7
01Aug2000	19:00	5294.0	23690417.1	1788.1	1169.2	1787.7
01Aug2000	20:00	4930.1	23704598.4	1788.1	1176.7	1787.7
01Aug2000	21:00	4680.9	23717650.4	1788.1	1183.6	1787.7
01Aug2000	22:00	4586.0	23730058.9	1788.1	1190.2	1787.7
01Aug2000	23:00	4722.7	23742519.0	1788.1	1196.8	1787.7
02Aug2000	00:00	5157.8	23755983.3	1788.2	1203.9	1787.7

Table A-(b): Summary Results for Tana Lake Simulation Run

Project : Project 2-Red.   Simulation Run : Ambagene-100   Reservoir: Reservoir-1

Start of Run : 01Aug2000, 00:00   Basin Model : 100-yrs r.p
End of Run : 25Aug2000, 00:00   Meteorologic Model : Amba-gen-100
Compute Time : 28Feb2008, 10:04:28   Control Specifications : Control 1

Volume Units : ○ MM ◉ 1000 M3

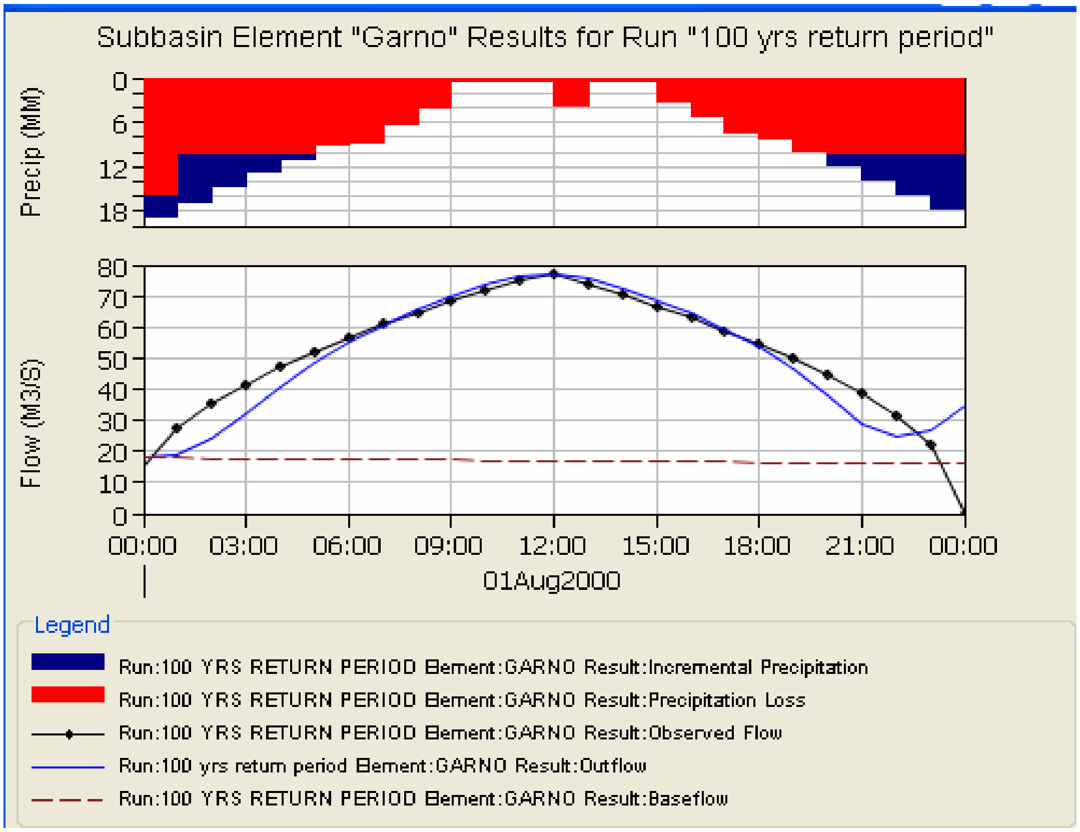
Computed Results

Peak Inflow : 25372.1 (M3/S)   Date/Time of Peak Inflow : 03Aug2000, 22:00
Peak Outflow : 2885.5 (M3/S)   Date/Time of Peak Outflow : 10Aug2000, 01:00
Total Inflow : 6436111.2 (1000 M3)   Peak Storage : 26366164.6 (1000 M3)
Total Outflow : 4826481.4 (1000 M3)   Peak Elevation : 1789.0 (M)

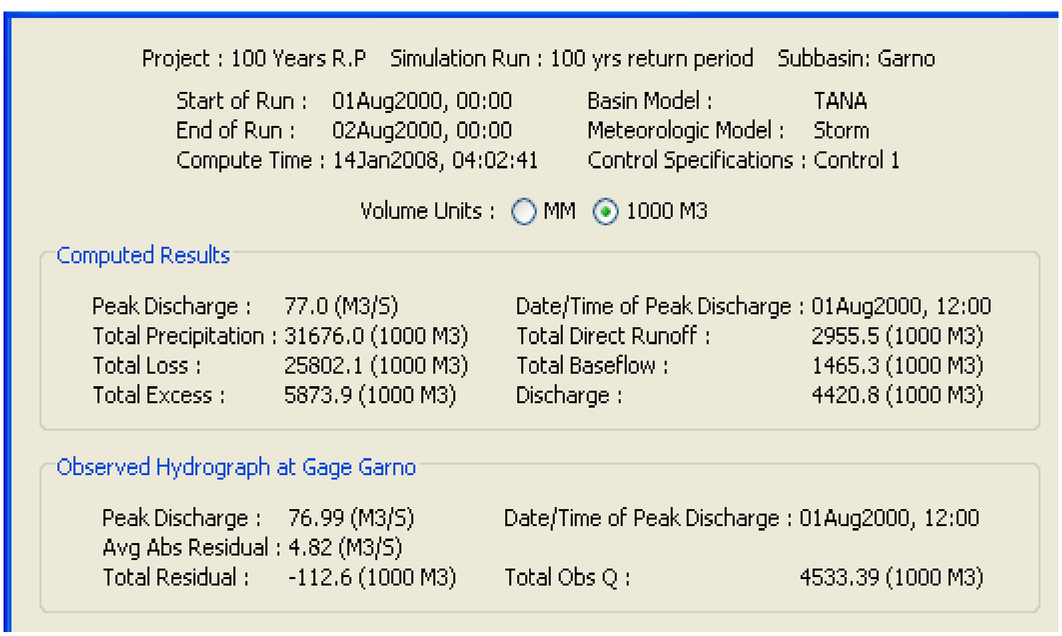
Observed Hydrograph at Gage Abay-100

Peak Discharge : 1053.11 (M3/S)   Date/Time of Peak Discharge : 01Aug2000, 12:00
Avg Abs Residual : 2296.98 (M3/S)
Total Residual : 4764467.7 (1000 M3)   Total Obs Q : 62013.69 (1000 M3)

Simulation Results Garno Gauged Sub basin



Summary of Result of Garno Gauged Subbasin


Project : 100 Years R.P Simulation Run : 100 yrs return period Subbasin: Garno

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	14Jan2008, 04:02:41	Control Specifications :	Control 1

Volume Units : MM 1000 M3

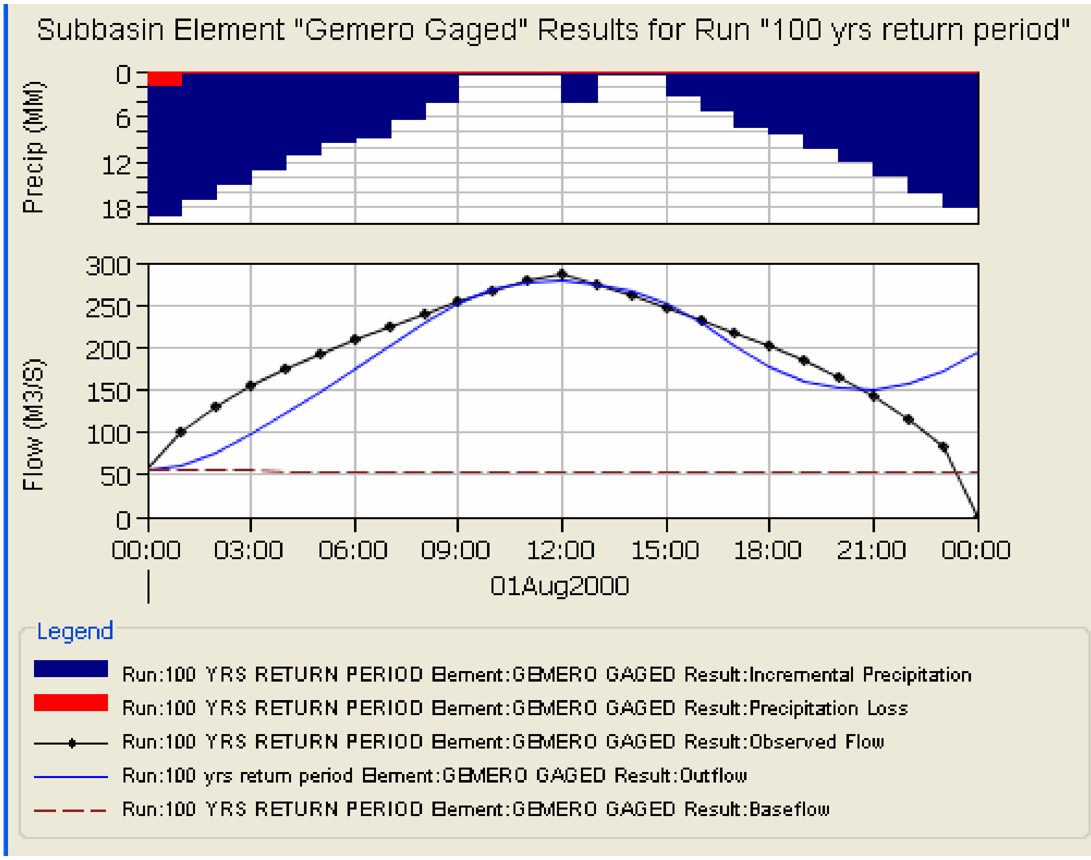
Computed Results

Peak Discharge :	77.0 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	31676.0 (1000 M3)	Total Direct Runoff :	2955.5 (1000 M3)
Total Loss :	25802.1 (1000 M3)	Total Baseflow :	1465.3 (1000 M3)
Total Excess :	5873.9 (1000 M3)	Discharge :	4420.8 (1000 M3)

Observed Hydrograph at Gage Garno

Peak Discharge :	76.99 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	4.82 (M3/S)		
Total Residual :	-112.6 (1000 M3)	Total Obs Q :	4533.39 (1000 M3)

Simulation Results Gemero Gauged Sub basin



Summary of Result of Gemeroo Gauged Subbasin

Project : 100 Years R.P Simulation Run : 100 yrs return period Subbasin: Gemero Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	14Jan2008, 04:02:41	Control Specifications :	Control 1

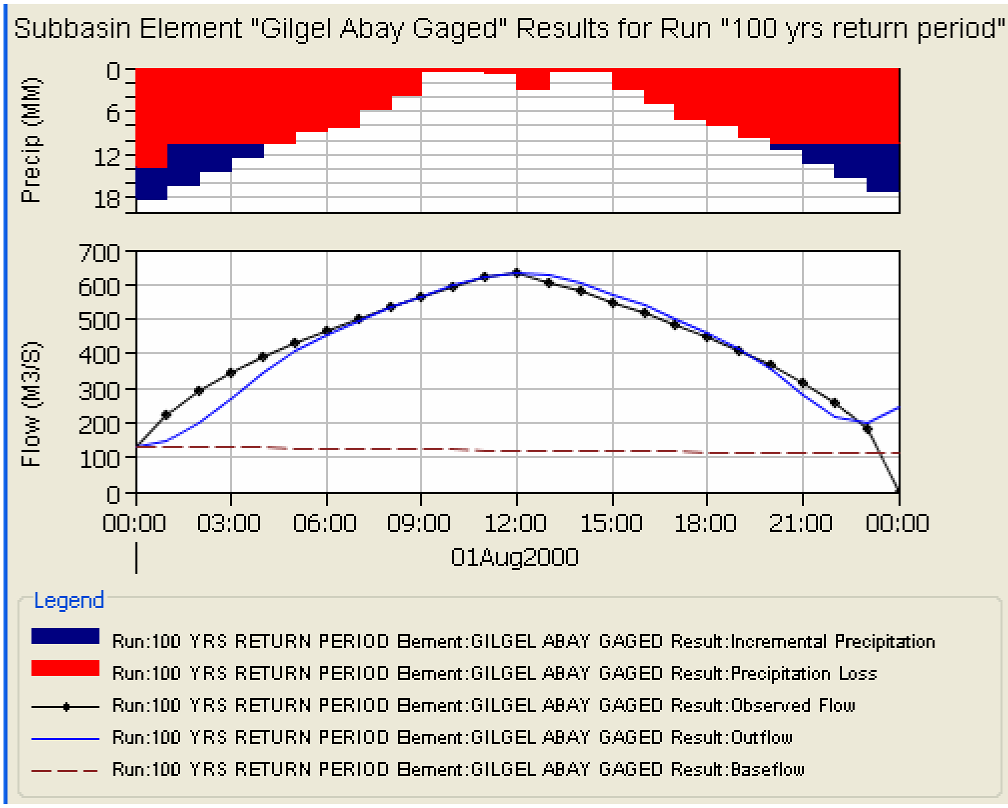
Volume Units : ○ MM ◉ 1000 M3

Computed Results

Peak Discharge :	278.8 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	20292.7 (1000 M3)	Total Direct Runoff :	11601.7 (1000 M3)
Total Loss :	629.3 (1000 M3)	Total Baseflow :	4632.2 (1000 M3)
Total Excess :	19663.4 (1000 M3)	Discharge :	16233.9 (1000 M3)

Observed Hydrograph at Gage Gemero

Peak Discharge :	285.24 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	30.36 (M3/S)		
Total Residual :	-562.9 (1000 M3)	Total Obs Q :	16796.77 (1000 M3)



Project : 100 Years R.P   Simulation Run : 100 yrs return period   Subbasin: Gilgel Abay Gaged

Start of Run :	01Aug2000, 00:00	Basin Model :	TANA
End of Run :	02Aug2000, 00:00	Meteorologic Model :	Storm
Compute Time :	14Jan2008, 08:29:47	Control Specifications :	Control 1

Volume Units : ◯ MM ◉ 1000 M3

Computed Results

Peak Discharge :	633.2 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Total Precipitation :	318333.6 (1000 M3)	Total Direct Runoff :	26373.9 (1000 M3)
Total Loss :	267984.8 (1000 M3)	Total Baseflow :	10415.5 (1000 M3)
Total Excess :	50348.7 (1000 M3)	Discharge :	36789.4 (1000 M3)

Observed Hydrograph at Gage Gilgel Abay

Peak Discharge :	634.14 (M3/S)	Date/Time of Peak Discharge :	01Aug2000, 12:00
Avg Abs Residual :	68.00 (M3/S)		
Total Residual :	3732.7 (1000 M3)	Total Obs Q :	37341.72 (1000 M3)

Annex V: Results for Simulation Run for PMP

Graph for Lake Tana Simulation Result 0f PMP

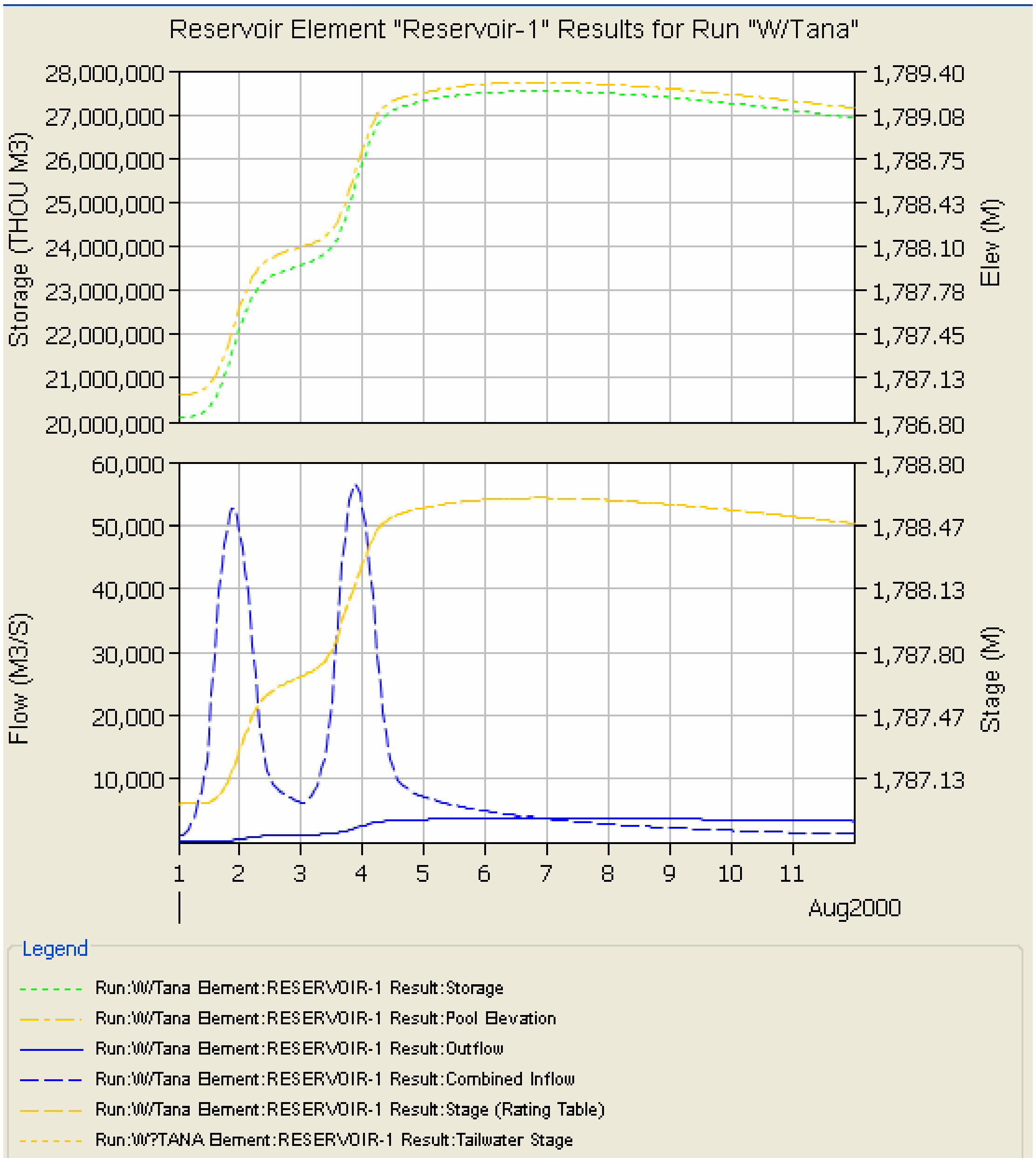


Table B: Time Serious Simulation Result of Lake Tana for PMP

Project : Project-PMP   Simulation Run : W/Tana   Reservoir: Reservoir-1

Start of Run :	01Aug2000, 00:00	Basin Model :	Amba genen
End of Run :	12Aug2000, 00:00	Meteorologic Model :	W/Tana
Compute Time :	27Feb2008, 09:16:58	Control Specifications :	Control 1

Volume Units : ○ MM ◉ 1000 M3

Computed Results

Peak Inflow :	56526.2 (M3/S)	Date/Time of Peak Inflow :	03Aug2000, 21:00
Peak Outflow :	3762.5 (M3/S)	Date/Time of Peak Outflow :	06Aug2000, 21:00
Total Inflow :	9522010.9 (1000 M3)	Peak Storage :	27540686.5 (1000 M3)
Total Outflow :	2691291.9 (1000 M3)	Peak Elevation :	1789.3 (M)

Table B 1: Time Serious Simulation Result of Lake Tana for PMP

Date	Time	Inflow M^3/s	Storage 1000m3	Elevation (m)	Outflow M^3/s	Stage (m)
01-Aug-00	00:00	1007	20092048	1787	0	1787
01-Aug-00	01:00	1023	20095751	1787	0	1787
01-Aug-00	02:00	1166	20099691	1787	0.1	1787
01-Aug-00	03:00	1520	20104526	1787	0.2	1787
01-Aug-00	04:00	2080	20111005	1787	0.4	1787
01-Aug-00	05:00	2835	20119849	1787	0.7	1787
01-Aug-00	06:00	3783	20131758	1787	1.1	1787
01-Aug-00	07:00	4943	20147459	1787	1.9	1787
01-Aug-00	08:00	6343	20167764	1787	3	1787
01-Aug-00	09:00	8033	20193627	1787	4.7	1787
01-Aug-00	10:00	10108	20226261	1787	7.1	1787
01-Aug-00	11:00	12831	20267520	1787.1	10.6	1787
01-Aug-00	12:00	17275	20321664	1787.1	15.9	1787
01-Aug-00	13:00	23302	20394630	1787.1	24.2	1787
01-Aug-00	14:00	29263	20489136	1787.1	36.6	1787
01-Aug-00	15:00	34601	20603927	1787.2	53.9	1787
01-Aug-00	16:00	39368	20736835	1787.2	76.8	1787
01-Aug-00	17:00	43536	20885733	1787.2	105.9	1787.1
01-Aug-00	18:00	47042	21048328	1787.3	141.5	1787.1
01-Aug-00	19:00	49780	21222022	1787.4	183.6	1787.1
01-Aug-00	20:00	51690	21403919	1787.4	231.9	1787.1
01-Aug-00	21:00	52672	21590836	1787.5	285.7	1787.2
01-Aug-00	22:00	52529	21779062	1787.5	344.3	1787.2
01-Aug-00	23:00	51231	21964477	1787.6	406.4	1787.2
02-Aug-00	00:00	49032	22143373	1787.6	470.4	1787.3
02-Aug-00	01:00	46271	22313110	1787.7	534.6	1787.3
02-Aug-00	02:00	43147	22472024	1787.7	597.8	1787.4
02-Aug-00	03:00	39561	22618637	1787.8	658.5	1787.4
02-Aug-00	04:00	35519	22751308	1787.8	715.4	1787.4
02-Aug-00	05:00	31192	22868718	1787.9	767.5	1787.5
02-Aug-00	06:00	26620	22969934	1787.9	813.6	1787.5
02-Aug-00	07:00	21965	23054388	1787.9	853	1787.5
02-Aug-00	08:00	18067	23123315	1788	885.7	1787.5
02-Aug-00	09:00	14929	23179470	1788	912.6	1787.6
02-Aug-00	10:00	12743	23225952	1788	935.2	1787.6
02-Aug-00	11:00	11203	23265652	1788	954.7	1787.6
02-Aug-00	12:00	10030	23300404	1788	971.6	1787.6
02-Aug-00	13:00	9161	23331422	1788	986.7	1787.6
02-Aug-00	14:00	8631	23359870	1788	1000.7	1787.6
02-Aug-00	15:00	8208	23386555	1788	1013.8	1787.6
02-Aug-00	16:00	7846	23411780	1788	1026.4	1787.6
02-Aug-00	17:00	7530	23435740	1788.1	1038.3	1787.6
02-Aug-00	18:00	7293	23458663	1788.1	1049.8	1787.6

Table B: Time Serious Simulation Result of Lake Tana for PMP(continued)

Date	Time	Inflow M^3/s	Storage 1000m3	Elevation (m)	Outflow M^3/s	Stage (m)
02-Aug-00	19:00	7090	23480754	1788.1	1061	1787.6
02-Aug-00	20:00	6911	23502118	1788.1	1071.8	1787.6
02-Aug-00	21:00	6723	23522783	1788.1	1082.3	1787.7
02-Aug-00	22:00	6568	23542792	1788.1	1092.5	1787.7
02-Aug-00	23:00	6432	23562240	1788.1	1102.5	1787.7
03-Aug-00	00:00	6299	23581169	1788.1	1112.3	1787.7
03-Aug-00	01:00	6262	23599757	1788.1	1121.9	1787.7
03-Aug-00	02:00	6421	23618530	1788.1	1131.6	1787.7
03-Aug-00	03:00	6783	23638206	1788.1	1141.9	1787.7
03-Aug-00	04:00	7333	23659483	1788.1	1153	1787.7
03-Aug-00	05:00	8068	23683031	1788.1	1165.3	1787.7
03-Aug-00	06:00	8992	23709518	1788.1	1179.3	1787.7
03-Aug-00	07:00	10121	23739646	1788.1	1195.2	1787.7
03-Aug-00	08:00	11483	23774198	1788.2	1213.7	1787.7
03-Aug-00	09:00	13128	23814091	1788.2	1235.1	1787.7
03-Aug-00	10:00	15151	23860501	1788.2	1260.2	1787.8
03-Aug-00	11:00	17805	23915234	1788.2	1290.1	1787.8
03-Aug-00	12:00	22158	23982458	1788.2	1327.2	1787.8
03-Aug-00	13:00	28077	24068016	1788.2	1375.2	1787.8
03-Aug-00	14:00	33927	24174562	1788.3	1436	1787.9
03-Aug-00	15:00	39161	24300818	1788.3	1509.5	1787.9
03-Aug-00	16:00	43823	24444602	1788.4	1594.3	1788
03-Aug-00	17:00	47880	24603754	1788.4	1690.6	1788
03-Aug-00	18:00	51273	24775952	1788.5	1797.6	1788
03-Aug-00	19:00	53886	24958556	1788.5	1913.3	1788.1
03-Aug-00	20:00	55660	25148630	1788.6	2035.4	1788.1
03-Aug-00	21:00	56526	25343005	1788.6	2163.7	1788.1
03-Aug-00	22:00	56286	25538039	1788.7	2295.6	1788.2
03-Aug-00	23:00	54918	25729706	1788.8	2427.7	1788.2
04-Aug-00	00:00	52663	25914379	1788.8	2557.9	1788.3
04-Aug-00	01:00	49843	26089455	1788.9	2684.2	1788.3
04-Aug-00	02:00	46659	26253282	1788.9	2802.7	1788.3
04-Aug-00	03:00	43018	26404411	1789	2913.8	1788.4
04-Aug-00	04:00	38924	26541232	1789	3015.4	1788.4
04-Aug-00	05:00	34489	26662357	1789	3105	1788.4
04-Aug-00	06:00	29640	26766473	1789.1	3181.6	1788.4
04-Aug-00	07:00	24713	26852741	1789.1	3244.6	1788.5
04-Aug-00	08:00	20561	26922463	1789.1	3295.8	1788.5
04-Aug-00	09:00	17211	26978513	1789.1	3337.2	1788.5
04-Aug-00	10:00	14761	27023987	1789.2	3371	1788.5
04-Aug-00	11:00	12943	27061667	1789.2	3399.1	1788.5
04-Aug-00	12:00	11557	27093488	1789.2	3422.8	1788.5
04-Aug-00	13:00	10503	27120838	1789.2	3443.3	1788.5

Table B: Time Serious Simulation Result of Lake Tana for PMP(continued)

Date	Time	Inflow M^3/s	Storage 1000m3	Elevation (m)	Outflow M^3/s	Stage (m)
04-Aug-00	14:00	9803	27144962	1789.2	3461.4	1788.5
04-Aug-00	15:00	9252	27166770	1789.2	3477.8	1788.5
04-Aug-00	16:00	8821	27186755	1789.2	3492.9	1788.5
04-Aug-00	17:00	8472	27205283	1789.2	3506.9	1788.5
04-Aug-00	18:00	8216	27222672	1789.2	3520	1788.5
04-Aug-00	19:00	7993	27239154	1789.2	3532.5	1788.5
04-Aug-00	20:00	7794	27254831	1789.2	3544.4	1788.5
04-Aug-00	21:00	7597	27269754	1789.2	3555.7	1788.6
04-Aug-00	22:00	7428	27283979	1789.2	3566.5	1788.6
04-Aug-00	23:00	7280	27297596	1789.2	3576.9	1788.6
05-Aug-00	00:00	7136	27310651	1789.2	3586.8	1788.6
05-Aug-00	01:00	7001	27323167	1789.2	3596.4	1788.6
05-Aug-00	02:00	6870	27335172	1789.2	3605.5	1788.6
05-Aug-00	03:00	6746	27346684	1789.3	3614.3	1788.6
05-Aug-00	04:00	6625	27357725	1789.3	3622.7	1788.6
05-Aug-00	05:00	6510	27368312	1789.3	3630.7	1788.6
05-Aug-00	06:00	6398	27378460	1789.3	3638.4	1788.6
05-Aug-00	07:00	6290	27388186	1789.3	3645.8	1788.6
05-Aug-00	08:00	6186	27397503	1789.3	3652.9	1788.6
05-Aug-00	09:00	6085	27406426	1789.3	3659.7	1788.6
05-Aug-00	10:00	5987	27414968	1789.3	3666.2	1788.6
05-Aug-00	11:00	5892	27423140	1789.3	3672.4	1788.6
05-Aug-00	12:00	5800	27430955	1789.3	3678.4	1788.6
05-Aug-00	13:00	5711	27438423	1789.3	3684.1	1788.6
05-Aug-00	14:00	5625	27445556	1789.3	3689.5	1788.6
05-Aug-00	15:00	5541	27452362	1789.3	3694.8	1788.6
05-Aug-00	16:00	5459	27458853	1789.3	3699.7	1788.6
05-Aug-00	17:00	5380	27465036	1789.3	3704.4	1788.6
05-Aug-00	18:00	5303	27470920	1789.3	3709	1788.6
05-Aug-00	19:00	5228	27476515	1789.3	3713.2	1788.6
05-Aug-00	20:00	5154	27481827	1789.3	3717.3	1788.6
05-Aug-00	21:00	5083	27486864	1789.3	3721.2	1788.6
05-Aug-00	22:00	5013	27491634	1789.3	3724.8	1788.6
05-Aug-00	23:00	4945	27496144	1789.3	3728.3	1788.6
06-Aug-00	00:00	4879	27500400	1789.3	3731.6	1788.6
06-Aug-00	01:00	4814	27504409	1789.3	3734.6	1788.6
06-Aug-00	02:00	4751	27508177	1789.3	3737.5	1788.6
06-Aug-00	03:00	4689	27511709	1789.3	3740.2	1788.6
06-Aug-00	04:00	4629	27515012	1789.3	3742.8	1788.6
06-Aug-00	05:00	4570	27518091	1789.3	3745.1	1788.6
06-Aug-00	06:00	4512	27520951	1789.3	3747.3	1788.6

Table B: Time Serious Simulation Result of Lake Tana for PMP(continued)

Date	Time	Inflow M^3/s	Storage 1000m3	Elevation (m)	Outflow M^3/s	Stage (m)
06-Aug-00	07:00	4455	27523598	1789.3	3749.4	1788.6
06-Aug-00	08:00	4400	27526036	1789.3	3751.3	1788.6
06-Aug-00	09:00	4346	27528269	1789.3	3753	1788.6
06-Aug-00	10:00	4292	27530304	1789.3	3754.5	1788.6
06-Aug-00	11:00	4240	27532143	1789.3	3756	1788.6
06-Aug-00	12:00	4189	27533792	1789.3	3757.2	1788.6
06-Aug-00	13:00	4139	27535254	1789.3	3758.3	1788.6
06-Aug-00	14:00	4090	27536533	1789.3	3759.3	1788.6
06-Aug-00	15:00	4041	27537633	1789.3	3760.2	1788.6
06-Aug-00	16:00	3994	27538559	1789.3	3760.9	1788.6
06-Aug-00	17:00	3948	27539313	1789.3	3761.5	1788.6
06-Aug-00	18:00	3902	27539900	1789.3	3761.9	1788.6
06-Aug-00	19:00	3857	27540322	1789.3	3762.2	1788.6
06-Aug-00	20:00	3813	27540583	1789.3	3762.5	1788.6
06-Aug-00	21:00	3770	27540687	1789.3	3762.5	1788.6
06-Aug-00	22:00	3727	27540635	1789.3	3762.5	1788.6
06-Aug-00	23:00	3685	27540433	1789.3	3762.3	1788.6
07-Aug-00	00:00	3644	27540081	1789.3	3762.1	1788.6
07-Aug-00	01:00	3604	27539584	1789.3	3761.7	1788.6
07-Aug-00	02:00	3564	27538945	1789.3	3761.2	1788.6
07-Aug-00	03:00	3525	27538165	1789.3	3760.6	1788.6
07-Aug-00	04:00	3486	27537248	1789.3	3759.9	1788.6
07-Aug-00	05:00	3448	27536196	1789.3	3759.1	1788.6
07-Aug-00	06:00	3411	27535012	1789.3	3758.2	1788.6
07-Aug-00	07:00	3374	27533698	1789.3	3757.2	1788.6
07-Aug-00	08:00	3338	27532257	1789.3	3756	1788.6
07-Aug-00	09:00	3303	27530692	1789.3	3754.8	1788.6
07-Aug-00	10:00	3268	27529003	1789.3	3753.5	1788.6
07-Aug-00	11:00	3233	27527195	1789.3	3752.1	1788.6
07-Aug-00	12:00	3199	27525268	1789.3	3750.7	1788.6
07-Aug-00	13:00	3166	27523226	1789.3	3749.1	1788.6
07-Aug-00	14:00	3133	27521070	1789.3	3747.4	1788.6
07-Aug-00	15:00	3100	27518802	1789.3	3745.7	1788.6
07-Aug-00	16:00	3068	27516425	1789.3	3743.9	1788.6
07-Aug-00	17:00	3037	27513940	1789.3	3742	1788.6
07-Aug-00	18:00	3006	27511350	1789.3	3740	1788.6
07-Aug-00	19:00	2975	27508656	1789.3	3737.9	1788.6
07-Aug-00	20:00	2945	27505860	1789.3	3735.7	1788.6
07-Aug-00	21:00	2915	27502963	1789.3	3733.5	1788.6
07-Aug-00	22:00	2886	27499969	1789.3	3731.2	1788.6
07-Aug-00	23:00	2857	27496878	1789.3	3728.9	1788.6
08-Aug-00	00:00	2829	27493692	1789.3	3726.4	1788.6
08-Aug-00	01:00	2800	27490414	1789.3	3723.9	1788.6

Table B: Time Serious Simulation Result of Lake Tana for PMP(continued)

Date	Time	Inflow M^3/s	Storage 1000m3	Elevation (m)	Outflow M^3/s	Stage (m)
08-Aug-00	02:00	2773	27487043	1789.3	3721.3	1788.6
08-Aug-00	03:00	2745	27483583	1789.3	3718.7	1788.6
08-Aug-00	04:00	2718	27480035	1789.3	3715.9	1788.6
08-Aug-00	05:00	2692	27476400	1789.3	3713.2	1788.6
08-Aug-00	06:00	2665	27472680	1789.3	3710.3	1788.6
08-Aug-00	07:00	2639	27468877	1789.3	3707.4	1788.6
08-Aug-00	08:00	2614	27464991	1789.3	3704.4	1788.6
08-Aug-00	09:00	2589	27461024	1789.3	3701.4	1788.6
08-Aug-00	10:00	2564	27456979	1789.3	3698.3	1788.6
08-Aug-00	11:00	2539	27452855	1789.3	3695.1	1788.6
08-Aug-00	12:00	2515	27448655	1789.3	3691.9	1788.6
08-Aug-00	13:00	2491	27444379	1789.3	3688.6	1788.6
08-Aug-00	14:00	2467	27440030	1789.3	3685.3	1788.6
08-Aug-00	15:00	2444	27435608	1789.3	3681.9	1788.6
08-Aug-00	16:00	2421	27431115	1789.3	3678.5	1788.6
08-Aug-00	17:00	2398	27426552	1789.3	3675	1788.6
08-Aug-00	18:00	2375	27421920	1789.3	3671.5	1788.6
08-Aug-00	19:00	2353	27417221	1789.3	3667.9	1788.6
08-Aug-00	20:00	2331	27412455	1789.3	3664.3	1788.6
08-Aug-00	21:00	2310	27407623	1789.3	3660.6	1788.6
08-Aug-00	22:00	2288	27402728	1789.3	3656.9	1788.6
08-Aug-00	23:00	2267	27397770	1789.3	3653.1	1788.6
09-Aug-00	00:00	2246	27392749	1789.3	3649.3	1788.6
09-Aug-00	01:00	2226	27387668	1789.3	3645.4	1788.6
09-Aug-00	02:00	2205	27382528	1789.3	3641.5	1788.6
09-Aug-00	03:00	2185	27377328	1789.3	3637.5	1788.6
09-Aug-00	04:00	2165	27372071	1789.3	3633.6	1788.6
09-Aug-00	05:00	2146	27366757	1789.3	3629.5	1788.6
09-Aug-00	06:00	2126	27361388	1789.3	3625.4	1788.6
09-Aug-00	07:00	2107	27355964	1789.3	3621.3	1788.6
09-Aug-00	08:00	2088	27350486	1789.3	3617.2	1788.6
09-Aug-00	09:00	2070	27344955	1789.3	3613	1788.6
09-Aug-00	10:00	2051	27339373	1789.3	3608.7	1788.6
09-Aug-00	11:00	2033	27333740	1789.2	3604.4	1788.6
09-Aug-00	12:00	2015	27328057	1789.2	3600.1	1788.6
09-Aug-00	13:00	1997	27322325	1789.2	3595.7	1788.6
09-Aug-00	14:00	1979	27316544	1789.2	3591.3	1788.6
09-Aug-00	15:00	1962	27310717	1789.2	3586.9	1788.6
09-Aug-00	16:00	1944	27304843	1789.2	3582.4	1788.6
09-Aug-00	17:00	1927	27298924	1789.2	3577.9	1788.6
09-Aug-00	18:00	1911	27292959	1789.2	3573.4	1788.6
09-Aug-00	19:00	1894	27286951	1789.2	3568.8	1788.6
09-Aug-00	20:00	1877	27280900	1789.2	3564.2	1788.6

Table B: Time Serious Simulation Result of Lake Tana for PMP(continued)

Date	Time	Inflow M^3/s	Storage 1000m3	Elevation (m)	Outflow M^3/s	Stage (m)
09-Aug-00	21:00	1861	27274806	1789.2	3559.6	1788.6
09-Aug-00	22:00	1845	27268671	1789.2	3554.9	1788.6
09-Aug-00	23:00	1829	27262495	1789.2	3550.2	1788.5
10-Aug-00	00:00	1813	27256278	1789.2	3545.5	1788.5
10-Aug-00	01:00	1798	27250023	1789.2	3540.7	1788.5
10-Aug-00	02:00	1782	27243728	1789.2	3536	1788.5
10-Aug-00	03:00	1767	27237396	1789.2	3531.2	1788.5
10-Aug-00	04:00	1752	27231026	1789.2	3526.3	1788.5
10-Aug-00	05:00	1737	27224620	1789.2	3521.5	1788.5
10-Aug-00	06:00	1722	27218178	1789.2	3516.6	1788.5
10-Aug-00	07:00	1708	27211701	1789.2	3511.7	1788.5
10-Aug-00	08:00	1693	27205189	1789.2	3506.8	1788.5
10-Aug-00	09:00	1679	27198643	1789.2	3501.9	1788.5
10-Aug-00	10:00	1665	27192064	1789.2	3496.9	1788.5
10-Aug-00	11:00	1651	27185452	1789.2	3491.9	1788.5
10-Aug-00	12:00	1637	27178808	1789.2	3486.9	1788.5
10-Aug-00	13:00	1623	27172133	1789.2	3481.9	1788.5
10-Aug-00	14:00	1610	27165427	1789.2	3476.8	1788.5
10-Aug-00	15:00	1596	27158690	1789.2	3471.8	1788.5
10-Aug-00	16:00	1583	27151924	1789.2	3466.7	1788.5
10-Aug-00	17:00	1570	27145129	1789.2	3461.6	1788.5
10-Aug-00	18:00	1557	27138305	1789.2	3456.4	1788.5
10-Aug-00	19:00	1544	27131453	1789.2	3451.3	1788.5
10-Aug-00	20:00	1532	27124574	1789.2	3446.1	1788.5
10-Aug-00	21:00	1519	27117668	1789.2	3440.9	1788.5
10-Aug-00	22:00	1507	27110736	1789.2	3435.7	1788.5
10-Aug-00	23:00	1494	27103777	1789.2	3430.5	1788.5
11-Aug-00	00:00	1482	27096793	1789.2	3425.3	1788.5
11-Aug-00	01:00	1470	27089785	1789.2	3420.1	1788.5
11-Aug-00	02:00	1458	27082752	1789.2	3414.8	1788.5
11-Aug-00	03:00	1446	27075695	1789.2	3409.5	1788.5
11-Aug-00	04:00	1434	27068615	1789.2	3404.2	1788.5
11-Aug-00	05:00	1423	27061512	1789.2	3398.9	1788.5
11-Aug-00	06:00	1411	27054386	1789.2	3393.6	1788.5
11-Aug-00	07:00	1400	27047239	1789.2	3388.3	1788.5
11-Aug-00	08:00	1389	27040070	1789.2	3383	1788.5
11-Aug-00	09:00	1378	27032880	1789.2	3377.6	1788.5
11-Aug-00	10:00	1367	27025669	1789.2	3372.2	1788.5
11-Aug-00	11:00	1356	27018438	1789.2	3366.9	1788.5
11-Aug-00	12:00	1345	27011188	1789.2	3361.5	1788.5
11-Aug-00	13:00	1334	27003918	1789.1	3356.1	1788.5
11-Aug-00	14:00	1324	26996629	1789.1	3350.7	1788.5
11-Aug-00	15:00	1313	26989322	1789.1	3345.3	1788.5

Table B: Time Serious Simulation Result of Lake Tana for PMP(continued)

Date	Time	Inflow M^3/s	Storage 1000m3	Elevation (m)	Outflow M^3/s	Stage (m)
11-Aug-00	16:00	1303	26981997	1789.1	3339.8	1788.5
11-Aug-00	17:00	1292	26974654	1789.1	3334.4	1788.5
11-Aug-00	18:00	1282	26967293	1789.1	3328.9	1788.5
11-Aug-00	19:00	1272	26959916	1789.1	3323.5	1788.5
11-Aug-00	20:00	1262	26952522	1789.1	3318	1788.5
11-Aug-00	21:00	1252	26945112	1789.1	3312.5	1788.5
11-Aug-00	22:00	1242	26937687	1789.1	3307.1	1788.5
11-Aug-00	23:00	1233	26930246	1789.1	3301.6	1788.5
12-Aug-00	00:00	1223	26922790	1789.1	3296.1	1788.5

Annex VI: Tables for Hourly Rainfall and Discharges Distribution of 24-hrs Record data

Table C-1: Alternating Block Method for Histogragh Development

Time (hrs.)	P_{10}		Garno		Gemero		G/Abay	
	Incre-mental	Rear-ranged	Gaged 0.844	Ungaged 0.62	Gaged 0.82	Ungaged 0.765	Gaged 0.66	Ungaged 0.619
1	26.74	2.88	2.43	1.79	2.37	2.21	1.91	1.79
2	11.08	3.03	2.56	1.88	2.49	2.32	2.00	1.88
3	8.50	3.20	2.70	1.98	2.63	2.45	2.12	1.98
4	7.17	3.40	2.87	2.10	2.79	2.60	2.25	2.10
5	6.31	3.64	3.07	2.25	2.99	2.78	2.41	2.25
6	5.71	3.94	3.33	2.44	3.24	3.02	2.61	2.44
7	5.25	4.34	3.66	2.69	3.57	3.32	2.87	2.69
8	4.88	4.88	4.12	3.02	4.02	3.74	3.23	3.02
9	4.59	5.71	4.82	3.53	4.70	4.37	3.78	3.53
10	4.34	7.17	6.05	4.44	5.89	5.48	4.74	4.44
11	4.13	11.08	9.35	6.86	9.11	8.47	7.33	6.86
12	3.94	26.74	22.56	16.56	22.00	20.46	17.70	16.56
13	3.78	8.50	7.17	5.26	6.99	6.50	5.63	5.26
14	3.64	6.31	5.33	3.91	5.19	4.83	4.18	3.91
15	3.51	5.25	4.43	3.25	4.32	4.02	3.47	3.25
16	3.40	4.59	3.87	2.84	3.77	3.51	3.04	2.84
17	3.29	4.13	3.48	2.56	3.40	3.16	2.73	2.56
18	3.20	3.78	3.19	2.34	3.11	2.89	2.50	2.34
19	3.11	3.51	2.96	2.17	2.89	2.69	2.32	2.17
20	3.03	3.29	2.78	2.04	2.71	2.52	2.18	2.04
21	2.95	3.11	2.62	1.93	2.56	2.38	2.06	1.93
22	2.88	2.95	2.49	1.83	2.43	2.26	1.96	1.83
23	2.82	2.82	2.38	1.75	2.32	2.16	1.87	1.75
24	2.76	2.76	2.33	1.71	2.27	2.11	1.83	1.71

Table C-1: Alternating Block Method for Histogragh Development(continued)

Time (hrs.)	P_{10} Incre-mental	P_{10} Rear-ranged	Gumara Gaged 0.680	Gumara Ungaged 0.80	Megech Gaged 0.76	Megech Ungaged 0.800	Koga Gaged 0.79
1	26.74	2.88	1.96	2.30	2.18	2.31	2.27
2	11.08	3.03	2.06	2.42	2.29	2.42	2.39
3	8.50	3.20	2.17	2.55	2.41	2.56	2.52
4	7.17	3.40	2.31	2.71	2.57	2.72	2.68
5	6.31	3.64	2.48	2.91	2.75	2.91	2.87
6	5.71	3.94	2.68	3.15	2.98	3.15	3.11
7	5.25	4.34	2.95	3.47	3.28	3.47	3.42
8	4.88	4.88	3.32	3.90	3.69	3.91	3.85
9	4.59	5.71	3.88	4.56	4.31	4.57	4.50
10	4.34	7.17	4.87	5.73	5.41	5.73	5.65
11	4.13	11.08	7.54	8.85	8.37	8.86	8.74
12	3.94	26.74	18.19	21.37	20.20	21.39	21.09
13	3.78	8.50	5.78	6.79	6.42	6.80	6.70
14	3.64	6.31	4.29	5.04	4.77	5.05	4.98
15	3.51	5.25	3.57	4.19	3.96	4.20	4.14
16	3.40	4.59	3.12	3.67	3.47	3.67	3.62
17	3.29	4.13	2.81	3.30	3.12	3.30	3.26
18	3.20	3.78	2.57	3.02	2.86	3.03	2.98
19	3.11	3.51	2.39	2.81	2.65	2.81	2.77
20	3.03	3.29	2.24	2.63	2.49	2.63	2.60
21	2.95	3.11	2.12	2.48	2.35	2.49	2.45
22	2.88	2.95	2.01	2.36	2.23	2.36	2.33
23	2.82	2.82	1.92	2.25	2.13	2.26	2.22
24	2.76	2.76	1.88	2.20	2.08	2.21	2.18

Table C-1: Alternating Block Method for Histogragh Development(continued)

Time (hrs.)	P10 Incre-mental	P10 Rear-ranged	Rib Gaged 0.670	Rib Ungaged 0.74	Gelda Ungaged 0.77	Tana west Ungaged 0.700	A/Genen Ungaged 0.76
1	26.7	2.9	1.9	2.1	2.2	2.0	2.2
2	11.1	3.0	2.0	2.2	2.3	2.1	2.3
3	8.5	3.2	2.1	2.4	2.4	2.2	2.4
4	7.2	3.4	2.3	2.5	2.6	2.4	2.6
5	6.3	3.6	2.4	2.7	2.8	2.5	2.7
6	5.7	3.9	2.6	2.9	3.0	2.8	3.0
7	5.2	4.3	2.9	3.2	3.3	3.0	3.3
8	4.9	4.9	3.3	3.6	3.7	3.4	3.7
9	4.6	5.7	3.8	4.2	4.4	4.0	4.3
10	4.3	7.2	4.8	5.3	5.5	5.0	5.4

Table C-1: Alternating Block Method for Histogragh Development(continued)

Time (hrs.)	P_{10} Incre-mental	P_{10} Rear-ranged	Rib Gaged 0.670	Rib Ungaged 0.74	Gelda Ungaged 0.77	Tana west Ungaged 0.700	A/Genen Ungaged 0.76
11	4.1	11.1	10.6	11.7	12.1	11.1	11.9
12	3.9	26.7	25.6	28.3	29.2	26.7	28.8
13	3.8	8.5	8.1	9.0	9.3	8.5	9.2
14	3.6	6.3	6.0	6.7	6.9	6.3	6.8
15	3.5	5.2	5.0	5.5	5.7	5.2	5.7
16	3.4	4.6	4.4	4.9	5.0	4.6	4.9
17	3.3	4.1	3.9	4.4	4.5	4.1	4.5
18	3.2	3.8	3.6	4.0	4.1	3.8	4.1
19	3.1	3.5	3.4	3.7	3.8	3.5	3.8
20	3.0	3.3	3.1	3.5	3.6	3.3	3.5
21	3.0	3.1	3.0	3.3	3.4	3.1	3.4
22	2.9	3.0	2.8	3.1	3.2	2.9	3.2
23	2.8	2.8	2.7	3.0	3.1	2.8	3.0
24	2.8	2.8	2.6	2.9	3.0	2.8	3.0

Table C-1: Alternating Block Method for Histogragh Development(continued)

Time (hrs.)	P_{25} Incre-mental	P_{25} Rear-ranged	Gumara Gaged 0.680	Gumara Ungaged 0.80	Megech Gaged 0.76	Megech Ungaged 0.80	Koga Gaged 0.79
1	33.3	3.6	2.4	2.9	2.71	2.87	2.8
2	13.8	3.8	2.6	3.0	2.85	3.01	3.0
3	10.6	4.0	2.7	3.2	3.00	3.18	3.1
4	8.9	4.2	2.9	3.4	3.19	3.38	3.3
5	7.9	4.5	3.1	3.6	3.42	3.62	3.6
6	7.1	4.9	3.3	3.9	3.71	3.93	3.9
7	6.5	5.4	3.7	4.3	4.08	4.32	4.3
8	6.1	6.1	4.1	4.9	4.59	4.86	4.8
9	5.7	7.1	4.8	5.7	5.36	5.68	5.6
10	5.4	8.9	6.1	7.1	6.73	7.13	7.0
11	5.1	13.8	9.4	11.0	10.41	11.03	10.9
12	4.9	33.3	22.6	26.6	25.13	26.62	26.2
13	4.7	10.6	7.2	8.5	7.99	8.46	8.3
14	4.5	7.9	5.3	6.3	5.93	6.28	6.2
15	4.4	6.5	4.4	5.2	4.93	5.22	5.2
16	4.2	5.7	3.9	4.6	4.31	4.57	4.5
17	4.1	5.1	3.5	4.1	3.88	4.11	4.1
18	4.0	4.7	3.2	3.8	3.55	3.77	3.7
19	3.9	4.4	3.0	3.5	3.30	3.50	3.4
20	3.8	4.1	2.8	3.3	3.09	3.28	3.2
21	3.7	3.9	2.6	3.1	2.92	3.09	3.1
22	3.6	3.7	2.5	2.9	2.78	2.94	2.9
23	3.5	3.5	2.4	2.8	2.65	2.81	2.8
24	3.4	3.4	2.3	2.7	2.59	2.75	2.7

Table 4-5: Alternating Block Method for Histogragh Development (continued)

Time (hrs.)	P25 Incre-mental	P25 Rear-ranged	Rib Gaged 0.670	Rib Ungaged 0.74	Gelda Ungaged 0.77	Tana west Ungaged 0.700	A/Genen Ungaged 0.76
1	33.3	3.6	2.4	2.7	2.7	2.5	2.7
2	13.8	3.8	2.5	2.8	2.9	2.6	2.8
3	10.6	4.0	2.7	2.9	3.0	2.8	3.0
4	8.9	4.2	2.8	3.1	3.2	3.0	3.2
5	7.9	4.5	3.0	3.4	3.5	3.2	3.4
6	7.1	4.9	3.3	3.6	3.8	3.4	3.7
7	6.5	5.4	3.6	4.0	4.1	3.8	4.1
8	6.1	6.1	4.1	4.5	4.7	4.3	4.6
9	5.7	7.1	4.8	5.3	5.4	5.0	5.4
10	5.4	8.9	6.0	6.6	6.8	6.2	6.7
11	5.1	13.8	9.2	10.2	10.6	9.6	10.4
12	4.9	33.3	22.3	24.6	25.5	23.3	25.1
13	4.7	10.6	7.1	7.8	8.1	7.4	8.0
14	4.5	7.9	5.3	5.8	6.0	5.5	5.9
15	4.4	6.5	4.4	4.8	5.0	4.6	4.9
16	4.2	5.7	3.8	4.2	4.4	4.0	4.3
17	4.1	5.1	3.4	3.8	3.9	3.6	3.9
18	4.0	4.7	3.2	3.5	3.6	3.3	3.6
19	3.9	4.4	2.9	3.2	3.3	3.1	3.3
20	3.8	4.1	2.7	3.0	3.1	2.9	3.1
21	3.7	3.9	2.6	2.9	3.0	2.7	2.9
22	3.6	3.7	2.5	2.7	2.8	2.6	2.8
23	3.5	3.5	2.3	2.6	2.7	2.5	2.6
24	3.4	3.4	2.3	2.5	2.6	2.4	2.6

Table C-1: Alternating Block Method for Histogragh Development(continued)

Time (hrs.)	P50 Incre-mental	P50 Rear-ranged	Garno Gaged 0.844	Garno Ungaged 0.62	Gemero Gaged 0.82	Gemero Ungaged 0.765	G/Abay Gaged 0.66	G/Abay Ungaged 0.619
1	38.2	4.1	3.5	2.5	3.4	3.1	2.7	2.55
2	15.8	4.3	3.6	2.7	3.6	3.3	2.9	2.68
3	12.1	4.6	3.9	2.8	3.8	3.5	3.0	2.83
4	10.2	4.8	4.1	3.0	4.0	3.7	3.2	3.00
5	9.0	5.2	4.4	3.2	4.3	4.0	3.4	3.22
6	8.1	5.6	4.8	3.5	4.6	4.3	3.7	3.49
7	7.5	6.2	5.2	3.8	5.1	4.7	4.1	3.84
8	7.0	7.0	5.9	4.3	5.7	5.3	4.6	4.32
9	6.5	8.1	6.9	5.0	6.7	6.2	5.4	5.04
10	6.2	10.2	8.6	6.3	8.4	7.8	6.8	6.33

Table C-1: Alternating Block Method for Histogragh Development (continued)

Time (hrs.)	P50		Garno		Gemero		G/Abay	
	Incre-mental	Rear-ranged	Gaged 0.844	Ungaged 0.62	Gaged 0.82	Ungaged 0.765	Gaged 0.66	Ungaged 0.619
11	5.9	15.8	13.3	9.8	13.0	12.1	10.5	9.79
12	5.6	38.2	32.2	23.6	31.4	29.2	25.3	23.64
13	5.4	12.1	10.2	7.5	10.0	9.3	8.0	7.51
14	5.2	9.0	7.6	5.6	7.4	6.9	6.0	5.58
15	5.0	7.5	6.3	4.6	6.2	5.7	5.0	4.64
16	4.8	6.5	5.5	4.1	5.4	5.0	4.3	4.06
17	4.7	5.9	5.0	3.6	4.8	4.5	3.9	3.65
18	4.6	5.4	4.6	3.3	4.4	4.1	3.6	3.34
19	4.4	5.0	4.2	3.1	4.1	3.8	3.3	3.10
20	4.3	4.7	4.0	2.9	3.9	3.6	3.1	2.91
21	4.2	4.4	3.7	2.7	3.7	3.4	2.9	2.75
22	4.1	4.2	3.6	2.6	3.5	3.2	2.8	2.61
23	4.0	4.0	3.4	2.5	3.3	3.1	2.7	2.49
24	3.9	3.9	3.3	2.4	3.2	3.0	2.6	2.44

Table C-1: Alternating Block Method for Histogragh Development (continued

Time (hrs.)	P50		Gumara		Megech		Koga
	Incre-mental	Rear-ranged	Gaged 0.680	Ungaged 0.80	Gaged 0.76	Ungaged 0.80	Gaged 0.79
1	38.2	4.1	2.4	2.9	2.71	2.87	2.8
2	15.8	4.3	2.6	3.0	2.85	3.01	3.0
3	12.1	4.6	2.7	3.2	3.00	3.18	3.1
4	10.2	4.8	2.9	3.4	3.19	3.38	3.3
5	9.0	5.2	3.1	3.6	3.42	3.62	3.6
6	8.1	5.6	3.3	3.9	3.71	3.93	3.9
7	7.5	6.2	3.7	4.3	4.08	4.32	4.3
8	7.0	7.0	4.1	4.9	4.59	4.86	4.8
9	6.5	8.1	4.8	5.7	5.36	5.68	5.6
10	6.2	10.2	6.1	7.1	6.73	7.13	7.0
11	5.9	15.8	9.4	11.0	10.41	11.03	10.9
12	5.6	38.2	22.6	26.6	25.13	26.62	26.2
13	5.4	12.1	7.2	8.5	7.99	8.46	8.3
14	5.2	9.0	5.3	6.3	5.93	6.28	6.2
15	5.0	7.5	4.4	5.2	4.93	5.22	5.2
16	4.8	6.5	3.9	4.6	4.31	4.57	4.5
17	4.7	5.9	3.5	4.1	3.88	4.11	4.1
18	4.6	5.4	3.2	3.8	3.55	3.77	3.7
19	4.4	5.0	3.0	3.5	3.30	3.50	3.4
20	4.3	4.7	2.8	3.3	3.09	3.28	3.2
21	4.2	4.4	2.6	3.1	2.92	3.09	3.1
22	4.1	4.2	2.5	2.9	2.78	2.94	2.9
23	4.0	4.0	2.4	2.8	2.65	2.81	2.8
24	3.9	3.9	2.3	2.7	2.59	2.75	2.7

Table C-1: Alternating Block Method for Histogragh Development(continued)

Time (hrs.)	P50 Incre-mental	P50 Rear-ranged	Rib Gaged 0.670	Rib Ungaged 0.74	Gelda Ungaged 0.77	Tana west Ungaged 0.700	A/Genen Ungaged 0.76
1	38.2	4.1	2.4	2.7	2.7	2.5	2.7
2	15.8	4.3	2.5	2.8	2.9	2.6	2.8
3	12.1	4.6	2.7	2.9	3.0	2.8	3.0
4	10.2	4.8	2.8	3.1	3.2	3.0	3.2
5	9.0	5.2	3.0	3.4	3.5	3.2	3.4
6	8.1	5.6	3.3	3.6	3.8	3.4	3.7
7	7.5	6.2	3.6	4.0	4.1	3.8	4.1
8	7.0	7.0	4.1	4.5	4.7	4.3	4.6
9	6.5	8.1	4.8	5.3	5.4	5.0	5.4
10	6.2	10.2	6.0	6.6	6.8	6.2	6.7
11	5.9	15.8	9.2	10.2	10.6	9.6	10.4
12	5.6	38.2	22.3	24.6	25.5	23.3	25.1
13	5.4	12.1	7.1	7.8	8.1	7.4	8.0
14	5.2	9.0	5.3	5.8	6.0	5.5	5.9
15	5.0	7.5	4.4	4.8	5.0	4.6	4.9
16	4.8	6.5	3.8	4.2	4.4	4.0	4.3
17	4.7	5.9	3.4	3.8	3.9	3.6	3.9
18	4.6	5.4	3.2	3.5	3.6	3.3	3.6
19	4.4	5.0	2.9	3.2	3.3	3.1	3.3
20	4.3	4.7	2.7	3.0	3.1	2.9	3.1
21	4.2	4.4	2.6	2.9	3.0	2.7	2.9
22	4.1	4.2	2.5	2.7	2.8	2.6	2.8
23	4.0	4.0	2.3	2.6	2.7	2.5	2.6
24	3.9	3.9	2.3	2.5	2.6	2.4	2.6

Table C-1: Alternating Block Method for Histogragh Development (continued)

Time (hrs.)	P100 Incre-mental	P100 Rear-ranged	Garno Gaged 0.844	Garno Ungaged 0.62	Gemero Gaged 0.82	Gemero Ungaged 0.765	G/Abay Gaged 0.66	G/Abay Ungaged 0.619
1	43.1	4.6	3.5	2.5	3.4	3.1	2.7	2.55
2	17.8	4.9	3.6	2.7	3.6	3.3	2.9	2.68
3	13.7	5.1	3.9	2.8	3.8	3.5	3.0	2.83
4	11.5	5.5	4.1	3.0	4.0	3.7	3.2	3.00
5	10.2	5.9	4.4	3.2	4.3	4.0	3.4	3.22
6	9.2	6.4	4.8	3.5	4.6	4.3	3.7	3.49
7	8.5	7.0	5.2	3.8	5.1	4.7	4.1	3.84
8	7.9	7.9	5.9	4.3	5.7	5.3	4.6	4.32
9	7.4	9.2	6.9	5.0	6.7	6.2	5.4	5.04
10	7.0	11.5	8.6	6.3	8.4	7.8	6.8	6.33

Table 4-5: Alternating Block Method for Histogragh Development (continued)

Time (hrs.)	P100 Incre-mental	P100 Rear-ranged	Garno Gaged 0.844	Garno Ungaged 0.62	Gemero Gaged 0.82	Gemero Ungaged 0.765	G/Abay Gaged 0.66	G/Abay Ungaged 0.619
11	6.6	17.8	13.3	9.8	13.0	12.1	10.5	9.8
12	6.4	43.1	32.2	23.6	31.4	29.2	25.3	23.6
13	6.1	13.7	10.2	7.5	10.0	9.3	8.0	7.5
14	5.9	10.2	7.6	5.6	7.4	6.9	6.0	5.6
15	5.7	8.5	6.3	4.6	6.2	5.7	5.0	4.6
16	5.5	7.4	5.5	4.1	5.4	5.0	4.3	4.1
17	5.3	6.6	5.0	3.6	4.8	4.5	3.9	3.6
18	5.1	6.1	4.6	3.3	4.4	4.1	3.6	3.3
19	5.0	5.7	4.2	3.1	4.1	3.8	3.3	3.1
20	4.9	5.3	4.0	2.9	3.9	3.6	3.1	2.9
21	4.8	5.0	3.7	2.7	3.7	3.4	2.9	2.7
22	4.6	4.8	3.6	2.6	3.5	3.2	2.8	2.6
23	4.5	4.5	3.4	2.5	3.3	3.1	2.7	2.5
24	4.4	4.4	3.3	2.4	3.2	3.0	2.6	2.4

Table C-1: Alternating Block Method for Histogragh Development (continued)

Time (hrs.)	P100 Incre-mental	P100 Rear-ranged	Gumara Gaged 0.680	Gumara Ungaged 0.80	Megech Gaged 0.76	Megech Ungaged 0.80	Koga Gaged 0.79
1	43.1	4.6	2.4	2.9	2.71	2.87	2.8
2	17.8	4.9	2.6	3.0	2.85	3.01	3.0
3	13.7	5.1	2.7	3.2	3.00	3.18	3.1
4	11.5	5.5	2.9	3.4	3.19	3.38	3.3
5	10.2	5.9	3.1	3.6	3.42	3.62	3.6
6	9.2	6.4	3.3	3.9	3.71	3.93	3.9
7	8.5	7.0	3.7	4.3	4.08	4.32	4.3
8	7.9	7.9	4.1	4.9	4.59	4.86	4.8
9	7.4	9.2	4.8	5.7	5.36	5.68	5.6
10	7.0	11.5	6.1	7.1	6.73	7.13	7.0
11	6.6	17.8	9.4	11.0	10.41	11.03	10.9
12	6.4	43.1	22.6	26.6	25.13	26.62	26.2
13	6.1	13.7	7.2	8.5	7.99	8.46	8.3
14	5.9	10.2	5.3	6.3	5.93	6.28	6.2
15	5.7	8.5	4.4	5.2	4.93	5.22	5.2
16	5.5	7.4	3.9	4.6	4.31	4.57	4.5
17	5.3	6.6	3.5	4.1	3.88	4.11	4.1
18	5.1	6.1	3.2	3.8	3.55	3.77	3.7
19	5.0	5.7	3.0	3.5	3.30	3.50	3.4
20	4.9	5.3	2.8	3.3	3.09	3.28	3.2
21	4.8	5.0	2.6	3.1	2.92	3.09	3.1
22	4.6	4.8	2.5	2.9	2.78	2.94	2.9
23	4.5	4.5	2.4	2.8	2.65	2.81	2.8
24	4.4	4.4	2.3	2.7	2.59	2.75	2.7

Table C-1: Alternating Block Method for Histogragh Development(continued)

Time (hrs.)	P100		Rib		Gelda	Tana west	A/Genen
	Incre-mental	Rear-ranged	Gaged 0.670	Ungaged 0.74	Ungaged 0.77	Ungaged 0.700	Ungaged 0.76
1	43.1	4.6	2.4	2.7	2.7	2.5	2.7
2	17.8	4.9	2.5	2.8	2.9	2.6	2.8
3	13.7	5.1	2.7	2.9	3.0	2.8	3.0
4	11.5	5.5	2.8	3.1	3.2	3.0	3.2
5	10.2	5.9	3.0	3.4	3.5	3.2	3.4
6	9.2	6.4	3.3	3.6	3.8	3.4	3.7
7	8.5	7.0	3.6	4.0	4.1	3.8	4.1
8	7.9	7.9	4.1	4.5	4.7	4.3	4.6
9	7.4	9.2	4.8	5.3	5.4	5.0	5.4
10	7.0	11.5	6.0	6.6	6.8	6.2	6.7
11	6.6	17.8	9.2	10.2	10.6	9.6	10.4
12	6.4	43.1	22.3	24.6	25.5	23.3	25.1
13	6.1	13.7	7.1	7.8	8.1	7.4	8.0
14	5.9	10.2	5.3	5.8	6.0	5.5	5.9
15	5.7	8.5	4.4	4.8	5.0	4.6	4.9
16	5.5	7.4	3.8	4.2	4.4	4.0	4.3
17	5.3	6.6	3.4	3.8	3.9	3.6	3.9
18	5.1	6.1	3.2	3.5	3.6	3.3	3.6
19	5.0	5.7	2.9	3.2	3.3	3.1	3.3
20	4.9	5.3	2.7	3.0	3.1	2.9	3.1
21	4.8	5.0	2.6	2.9	3.0	2.7	2.9
22	4.6	4.8	2.5	2.7	2.8	2.6	2.8
23	4.5	4.5	2.3	2.6	2.7	2.5	2.6
24	4.4	4.4	2.3	2.5	2.6	2.4	2.6

Table D-1: Daily Discharge vs. Frequency

Frequ-ency	Log(Log (T/(T-1)))	Daily Flow,Q(m3/sec)							
		Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech	*Abay*
2	-0.52	42.08	55.56	338.39	251.32	57.30	18.22	133.96	369.17
5	-1.01	79.01	104.33	417.57	317.23	118.33	33.95	212.57	552.28
10	-1.34	103.47	136.62	469.99	360.87	158.73	44.37	264.62	673.51
25	-1.75	134.37	177.41	536.22	416.00	209.78	57.53	330.38	826.68
50	-2.06	157.29	207.68	585.36	456.90	247.65	67.29	379.16	940.32
100	-2.36	180.04	237.72	634.14	497.51	285.24	76.99	427.59	1053.11

Table D-1: Value of Coefficient M($M = Q/24^{0.5}$)

Frequ-ency	Value of M							
	M_{kog}	M_{rib}	$M_{G/Ab}$	M_{gum}	M_{gem}	M_{garn}	M_{meg}	M_{Abay}
2	8.5889	11.342	69.073	51.3004	11.697	3.7187	27.344	75.36
5	16.128	21.296	85.235	64.7539	24.153	6.9303	43.39	112.7
10	21.12	27.887	95.936	73.6614	32.4	9.0567	54.014	137.5
25	27.427	36.214	109.46	84.9159	42.821	11.743	67.438	168.7
50	32.106	42.392	119.49	93.2652	50.551	13.736	77.396	191.9
100	36.751	48.524	129.44	101.553	58.225	15.715	87.281	215

Table D-1:Hourly Distribution of Daily Discharge of 10-years Return Period

Time hours	(a) 10 years return period flow,Q m3/sec						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	21.12	27.89	95.94	73.66	32.40	9.06	54.01
2	29.87	39.44	135.67	104.17	45.82	12.81	76.39
3	36.58	48.30	166.17	127.59	56.12	15.69	93.56
4	42.24	55.77	191.87	147.32	64.80	18.11	108.03
5	47.23	62.36	214.52	164.71	72.45	20.25	120.78
6	51.73	68.31	234.99	180.43	79.36	22.18	132.31
7	55.88	73.78	253.82	194.89	85.72	23.96	142.91
8	59.74	78.88	271.35	208.35	91.64	25.62	152.78
9	63.36	83.66	287.81	220.98	97.20	27.17	162.04
10	66.79	88.19	303.38	232.94	102.46	28.64	170.81
11	70.05	92.49	318.18	244.31	107.46	30.04	179.15
12	73.16	96.60	332.33	255.17	112.24	31.37	187.11
13	76.15	100.55	345.90	265.59	116.82	32.65	194.75
14	79.02	104.34	358.96	275.62	121.23	33.89	202.10
15	81.80	108.00	371.56	285.29	125.49	35.08	209.20
16	84.48	111.55	383.74	294.65	129.60	36.23	216.06
17	87.08	114.98	395.55	303.71	133.59	37.34	222.71

Time hours	(a) 10 years return period flow,Q m3/sec						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
18	155.92	205.87	549.18	430.85	247.03	66.67	370.30
19	160.19	211.51	564.23	442.66	253.80	68.50	380.45
20	164.35	217.01	578.88	454.16	260.39	70.28	390.33
21	168.41	222.36	593.18	465.37	266.82	72.01	399.97
22	172.38	227.60	607.14	476.32	273.10	73.71	409.39
23	176.25	232.71	620.78	487.03	279.24	75.37	418.59
24	180.04	237.72	634.14	497.51	285.24	76.99	427.59

Time hours	(b) 10 years return period flow, Q m3/sec(Rearranged)						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	21.12	27.89	95.94	73.66	32.40	9.06	54.01
2	36.58	48.30	166.17	127.59	56.12	15.69	93.56
3	47.23	62.36	214.52	164.71	72.45	20.25	120.78
4	59.74	78.88	271.35	208.35	91.64	25.62	152.78
5	66.79	88.19	303.38	232.94	102.46	28.64	170.81
6	73.16	96.60	332.33	255.17	112.24	31.37	187.11
7	81.80	108.00	371.56	285.29	125.49	35.08	209.20
8	87.08	114.98	395.55	303.71	133.59	37.34	222.71
9	92.06	121.56	418.17	321.08	141.23	39.48	235.44
10	96.78	127.79	439.63	337.56	148.48	41.50	247.53
11	101.29	133.74	460.09	353.27	155.39	43.43	259.04
12	103.47	136.62	469.99	360.87	158.73	44.37	264.62
13	99.06	130.80	449.98	345.50	151.97	42.48	253.35
14	94.45	124.71	429.04	329.42	144.90	40.50	241.56
15	89.60	118.31	407.02	312.52	137.46	38.42	229.16
16	84.48	111.55	383.74	294.65	129.60	36.23	216.06
17	79.02	104.34	358.96	275.62	121.23	33.89	202.10
18	76.15	100.55	345.90	265.59	116.82	32.65	194.75
19	70.05	92.49	318.18	244.31	107.46	30.04	179.15
20	63.36	83.66	287.81	220.98	97.20	27.17	162.04
21	55.88	73.78	253.82	194.89	85.72	23.96	142.91
22	51.73	68.31	234.99	180.43	79.36	22.18	132.31
23	42.24	55.77	191.87	147.32	64.80	18.11	108.03
24	29.87	39.44	135.67	104.17	45.82	12.81	76.39

Table D-1:Hourly Distribution of Daily Discharge of 25-years Return Period

Time hours	(a) 25 years return period flow (m^3/sec)						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	27.43	36.21	109.46	84.92	42.82	11.74	67.44
2	38.79	51.21	154.79	120.09	60.56	16.61	95.37
3	47.51	62.72	189.58	147.08	74.17	20.34	116.81
4	54.85	72.43	218.91	169.83	85.64	23.49	134.88
5	61.33	80.98	244.75	189.88	95.75	26.26	150.80
6	67.18	88.71	268.11	208.00	104.89	28.77	165.19
7	72.57	95.81	289.59	224.67	113.29	31.07	178.42
8	77.58	102.43	309.59	240.18	121.12	33.22	190.74
9	82.28	108.64	328.37	254.75	128.46	35.23	202.31
10	86.73	114.52	346.13	268.53	135.41	37.14	213.26
11	90.97	120.11	363.02	281.63	142.02	38.95	223.67
12	95.01	125.45	379.17	294.16	148.34	40.68	233.61
13	98.89	130.57	394.65	306.17	154.39	42.34	243.15
14	102.62	135.50	409.55	317.73	160.22	43.94	252.33
15	106.22	140.26	423.92	328.88	165.84	45.48	261.19
16	109.71	144.86	437.82	339.66	171.28	46.97	269.75
17	113.09	149.31	451.30	350.12	176.55	48.42	278.05
18	116.36	153.64	464.38	360.27	181.67	49.82	286.12
19	119.55	157.85	477.11	370.14	186.65	51.19	293.96
20	122.66	161.95	489.50	379.76	191.50	52.52	301.59
21	125.69	165.95	501.59	389.13	196.23	53.81	309.04
22	128.64	169.86	513.39	398.29	200.85	55.08	316.31
23	131.54	173.68	524.93	407.24	205.36	56.32	323.42
24	134.37	177.41	536.22	416.00	209.78	57.53	330.38

Time hours	***(b)*** 25-years return period flow,m^3/sec(Rearranged)						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	27.43	36.21	109.46	84.92	42.82	11.74	67.44
2	47.51	62.72	189.58	147.08	74.17	20.34	116.81
3	61.33	80.98	244.75	189.88	95.75	26.26	150.80
4	72.57	95.81	289.59	224.67	113.29	31.07	178.42
5	82.28	108.64	328.37	254.75	128.46	35.23	202.31
6	90.97	120.11	363.02	281.63	142.02	38.95	223.67
7	98.89	130.57	394.65	306.17	154.39	42.34	243.15
8	106.22	140.26	423.92	328.88	165.84	45.48	261.19
9	113.09	149.31	451.30	350.12	176.55	48.42	278.05
10	119.55	157.85	477.11	370.14	186.65	51.19	293.96
11	125.69	165.95	501.59	389.13	196.23	53.81	309.04
12	131.54	173.68	524.93	407.24	205.36	56.32	323.42

Time hours	(*b*) 25-years return period flow,m3/sec(Rearranged)						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
13	134.37	177.41	536.22	416.00	209.78	57.53	330.38
14	128.64	169.86	513.39	398.29	200.85	55.08	316.31
15	122.66	161.95	489.50	379.76	191.50	52.52	301.59
16	116.36	153.64	464.38	360.27	181.67	49.82	286.12
17	109.71	144.86	437.82	339.66	171.28	46.97	269.75
18	102.62	135.50	409.55	317.73	160.22	43.94	252.33
19	95.01	125.45	379.17	294.16	148.34	40.68	233.61
20	86.73	114.52	346.13	268.53	135.41	37.14	213.26
21	77.58	102.43	309.59	240.18	121.12	33.22	190.74
22	67.18	88.71	268.11	208.00	104.89	28.77	165.19
23	54.85	72.43	218.91	169.83	85.64	23.49	134.88
24	38.79	51.21	154.79	120.09	60.56	16.61	95.37

Table D-1:Hourly Distribution of Daily Discharge of 50-years Return Period

Time hours	(a) 50 years return period flow m^3/sec						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	32.11	42.39	119.49	93.27	50.55	13.74	77.40
2	45.40	59.95	168.98	131.90	71.49	19.43	109.46
3	55.61	73.42	206.96	161.54	87.56	23.79	134.05
4	64.21	84.78	238.97	186.53	101.10	27.47	154.79
5	71.79	94.79	267.18	208.55	113.04	30.72	173.06
6	78.64	103.84	292.68	228.45	123.82	33.65	189.58
7	84.94	112.16	316.13	246.76	133.75	36.34	204.77
8	90.81	119.90	337.96	263.79	142.98	38.85	218.91
9	96.32	127.18	358.46	279.80	151.65	41.21	232.19
10	101.53	134.05	377.85	294.93	159.86	43.44	244.75
11	106.48	140.60	396.29	309.33	167.66	45.56	256.69
12	111.22	146.85	413.91	323.08	175.11	47.58	268.11
13	115.76	152.85	430.81	336.27	182.27	49.53	279.06
14	102.62	135.50	409.55	317.73	160.22	43.94	252.33
15	106.22	140.26	423.92	328.88	165.84	45.48	261.19
16	109.71	144.86	437.82	339.66	171.28	46.97	269.75
17	113.09	149.31	451.30	350.12	176.55	48.42	278.05
18	116.36	153.64	464.38	360.27	181.67	49.82	286.12
19	119.55	157.85	477.11	370.14	186.65	51.19	293.96
20	122.66	161.95	489.50	379.76	191.50	52.52	301.59
21	125.69	165.95	501.59	389.13	196.23	53.81	309.04
22	128.64	169.86	513.39	398.29	200.85	55.08	316.31
23	131.54	173.68	524.93	407.24	205.36	56.32	323.42
24	134.37	177.41	536.22	416.00	209.78	57.53	330.38

Time hours	(b) 50 years return period flow,Q m^3/sec(Rearanged)						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	32.11	42.39	119.49	93.27	50.55	13.74	77.40
2	55.61	73.42	206.96	161.54	87.56	23.79	134.05
3	71.79	94.79	267.18	208.55	113.04	30.72	173.06
4	84.94	112.16	316.13	246.76	133.75	36.34	204.77
5	96.32	127.18	358.46	279.80	151.65	41.21	232.19
6	106.48	140.60	396.29	309.33	167.66	45.56	256.69
7	115.76	152.85	430.81	336.27	182.27	49.53	279.06
8	124.35	164.18	462.77	361.21	195.78	53.20	299.76
9	132.38	174.79	492.65	384.54	208.43	56.64	319.11
10	139.95	184.78	520.83	406.53	220.35	59.88	337.36
11	147.13	194.26	547.56	427.39	231.66	62.95	354.67
12	153.98	203.30	573.04	447.28	242.44	65.88	371.18
13	157.29	207.68	585.36	456.90	247.65	67.29	379.16
14	150.59	198.83	560.44	437.45	237.11	64.43	363.02
15	143.58	189.58	534.36	417.09	226.07	61.43	346.13
16	136.21	179.85	506.94	395.69	214.47	58.28	328.37
17	128.42	169.57	477.95	373.06	202.21	54.95	309.59
18	120.13	158.62	447.08	348.97	189.15	51.40	289.59
19	111.22	146.85	413.91	323.08	175.11	47.58	268.11
20	101.53	134.05	377.85	294.93	159.86	43.44	244.75
21	90.81	119.90	337.96	263.79	142.98	38.85	218.91
22	78.64	103.84	292.68	228.45	123.82	33.65	189.58
23	64.21	84.78	238.97	186.53	101.10	27.47	154.79
24	45.40	59.95	168.98	131.90	71.49	19.43	109.46

Table D-1:Hourly Distribution of Daily Discharge of 100-years Return Period

Time hours	(a) 100 years return period flow,Q m^3/sec						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	36.75	48.52	129.44	101.55	58.22	15.71	87.28
2	51.97	68.62	183.06	143.62	82.34	22.22	123.43
3	63.65	84.05	224.20	175.89	100.85	27.22	151.18
4	73.50	97.05	258.88	203.11	116.45	31.43	174.56
5	82.18	108.50	289.44	227.08	130.19	35.14	195.17
6	90.02	118.86	317.07	248.75	142.62	38.49	213.79
7	97.23	128.38	342.47	268.68	154.05	41.58	230.92
8	103.95	137.25	366.12	287.23	164.68	44.45	246.87
9	110.25	145.57	388.33	304.66	174.67	47.14	261.84
10	116.22	153.45	409.33	321.14	184.12	49.69	276.01
11	121.89	160.94	429.31	336.81	193.11	52.12	289.48
12	127.31	168.09	448.40	351.79	201.70	54.44	302.35
13	132.51	174.96	466.71	366.15	209.93	56.66	314.70

Time hours	(a) 100 years return period flow,Q m3/sec						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
14	137.51	181.56	484.33	379.98	217.86	58.80	326.58
15	142.33	187.93	501.33	393.31	225.50	60.86	338.04
16	147.00	194.10	517.77	406.21	232.90	62.86	349.13
17	151.53	200.07	533.70	418.71	240.07	64.79	359.87
18	155.92	205.87	549.18	430.85	247.03	66.67	370.30
19	160.19	211.51	564.23	442.66	253.80	68.50	380.45
20	164.35	217.01	578.88	454.16	260.39	70.28	390.33
21	168.41	222.36	593.18	465.37	266.82	72.01	399.97
22	172.38	227.60	607.14	476.32	273.10	73.71	409.39
23	176.25	232.71	620.78	487.03	279.24	75.37	418.59
24	180.04	237.72	634.14	497.51	285.24	76.99	427.59

Time hours	(b) 100 years return period flow,Q,m^3/sec(Rearranged)						
	Koga	Rib	G / Abay	Gumara	Gemero	Garno	Megech
1	36.75	48.52	129.44	101.55	58.22	15.71	87.28
2	63.65	84.05	224.20	175.89	100.85	27.22	151.18
3	82.18	108.50	289.44	227.08	130.19	35.14	195.17
4	97.23	128.38	342.47	268.68	154.05	41.58	230.92
5	110.25	145.57	388.33	304.66	174.67	47.14	261.84
6	121.89	160.94	429.31	336.81	193.11	52.12	289.48
7	132.51	174.96	466.71	366.15	209.93	56.66	314.70
8	142.33	187.93	501.33	393.31	225.50	60.86	338.04
9	151.53	200.07	533.70	418.71	240.07	64.79	359.87
10	160.19	211.51	564.23	442.66	253.80	68.50	380.45
11	168.41	222.36	593.18	465.37	266.82	72.01	399.97
12	176.25	232.71	620.78	487.03	279.24	75.37	418.59
13	180.04	237.72	634.14	497.51	285.24	76.99	427.59
14	172.38	227.60	607.14	476.32	273.10	73.71	409.39
15	164.35	217.01	578.88	454.16	260.39	70.28	390.33
16	155.92	205.87	549.18	430.85	247.03	66.67	370.30
17	147.00	194.10	517.77	406.21	232.90	62.86	349.13
18	137.51	181.56	484.33	379.98	217.86	58.80	326.58
19	127.31	168.09	448.40	351.79	201.70	54.44	302.35
20	116.22	153.45	409.33	321.14	184.12	49.69	276.01
21	103.95	137.25	366.12	287.23	164.68	44.45	246.87
22	90.02	118.86	317.07	248.75	142.62	38.49	213.79
23	73.50	97.05	258.88	203.11	116.45	31.43	174.56
24	51.97	68.62	183.06	143.62	82.34	22.22	123.43

Annex VII Calculations for Development of Unit and Direct Runoff Hydrograph

Table 3.3 Calculation of the direct runoff hydrograph for Gemero catchment

Gemero-100,Area= 158.71 km2

Time Hrs	Obs.Dis. m3/s	Base flow m3/s	DRH m3/s	UHO	Precipit. mm	Excess Prec.	ø-index
0	58.22	116.45			3.82		6.89
1	100.85	116.45		0.00	4.01		6.89
2	130.19	116.45	13.74	0.29	4.24		6.89
3	154.05	116.45	37.60	0.80	4.50		6.89
4	174.67	116.45	58.22	1.23	4.82		6.89
5	193.11	116.45	76.66	1.63	5.23		6.89
6	209.93	116.45	93.48	1.98	5.75		6.89
7	225.50	116.45	109.05	2.31	6.47	0.00	6.89
8	240.07	116.45	123.62	2.62	7.56	0.68	6.89
9	253.80	116.45	137.35	2.91	9.49	2.61	6.89
10	266.82	116.45	150.37	3.19	14.68	7.79	6.89
11	279.24	116.45	162.79	3.45	35.44	28.55	6.89
12	285.24	116.45	168.79	3.58	11.26	4.38	6.89
13	273.10	116.45	156.65	3.32	8.37	1.48	6.89
14	260.39	116.45	143.94	3.05	6.95	0.07	6.89
15	247.03	116.45	130.58	2.77	6.08		6.89
16	232.90	116.45	116.45	2.47	5.47		6.89
17	217.86	116.45	101.41	2.15	5.01		6.89
18	201.70	116.45	85.25	1.81	4.65		6.89
19	184.12	116.45	67.67	1.44	4.36		6.89
20	164.68	116.45	48.23	1.02	4.12		6.89
21	142.62	116.45	26.17	0.56	3.91		6.89
22	116.45	116.45	0.00	0.00	3.74		6.89
23	82.34	116.45	0.00	0.00	3.66		6.89
			2008.0	44.0		45.548	
			45.548	1.00	Ok		

Table 3.4 3 hours U.H developed from 6 hr U.H

Time Hrs	6 h U.H m3/s	S-hydrograph	S-hydrograph lagged by 3 hrs	ΔS (2)+(3)	3-hrs S-hrs U.H (4)/3*6	DRH ordinates f m3/s
1	2	3	4	5.00	6	7
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.30	0.30	0.00	0.30	0.60	13.75
2	0.83	1.13	0.00	1.13	2.25	51.34
3	1.28	2.41	0.00	2.41	4.81	109.57
4	1.68	4.09	0.30	3.79	7.57	172.48
5	2.05	6.14	1.13	5.01	10.03	228.37
6	2.39	8.54	2.41	6.13	12.26	279.20
7	2.71	11.25	4.09	7.16	14.32	326.15
8	3.02	14.26	6.14	8.12	16.25	370.02
9	3.30	17.57	8.54	9.03	18.06	411.33
10	3.57	21.14	11.25	9.89	19.78	450.50
11	3.71	24.85	14.26	10.58	21.16	481.95
12	3.44	28.28	17.57	10.72	21.44	488.23
13	3.16	31.44	21.14	10.30	20.61	469.38
14	2.87	34.31	24.85	9.47	18.93	431.17
15	2.56	36.87	28.28	8.58	17.17	390.97
16	2.23	39.09	31.44	7.65	15.30	348.43
17	1.87	40.97	34.31	6.65	13.31	303.10
18	1.49	42.45	36.87	5.58	11.17	254.33
19	1.06	43.51	39.09	4.42	8.83	201.16
20	0.57	44.08	40.97	3.12	6.24	142.08
21	0.00	44.08	42.45	1.63	3.27	74.41
22	0.00	44.08	43.51	0.57	1.15	26.17
23	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.5- Rainfall and Stream flow data adopted from 24 hours record for G/Abay

Gilgel Ab-100,Area= 1,657.89 km^2

Time Hrs	Obs.Dis. m3/s	Base flow m3/s	DRH m3/s	UHO	Precipit. mm	Excess Prec.	ø-index
0	129.44	129.44					
1	129.44	129.44			3.08		12.60
2	129.44	129.44			3.23		12.60
3	129.44	129.44			3.41		12.60
4	129.44	129.44			3.62		12.60
5	129.44	129.44			3.88		12.60
6	129.44	129.44			4.21		12.60
7	129.44	129.44			4.63		12.60
8	129.44	129.44			5.21		12.60
9	129.44	129.44			6.09		12.60
10	129.44	129.44			7.64		12.60
11	129.44	129.44			11.81		12.60
12	129.44	129.44			28.52	15.9184	12.60
13	224.20	129.44	94.76	0.06	9.06		12.60
14	289.44	129.44	160.00	0.10	6.73		12.60
15	342.47	129.44	213.03	0.13	5.60		12.60
16	388.33	129.44	258.88	0.16	4.89		12.60
17	429.31	129.44	299.87	0.18	4.40		12.60
18	466.71	129.44	337.27	0.20	4.03		12.60
19	501.33	129.44	371.89	0.22	3.74		12.60
20	533.70	129.44	404.26	0.24	3.51		12.60
21	564.23	129.44	434.78	0.26	3.32		12.60
22	593.18	129.44	463.74	0.28	3.15		12.60
23	620.78	129.44	491.34	0.30	3.01		12.60
24	634.14	129.44	504.69	0.30	2.94		12.60
25	607.14	129.44	477.70	0.29		15.918383	12.60
26	578.88	129.44	449.44	0.27			12.60
27	549.18	129.44	419.74	0.25			12.60
28	517.77	129.44	388.33	0.23			12.60
29	484.33	129.44	354.89	0.21			12.60
30	448.40	129.44	318.96	0.19			12.60
31	409.33	129.44	279.89	0.17			12.60
32	366.12	129.44	236.68	0.14			12.60
33	317.07	129.44	187.63	0.11			12.60
34	258.88	129.44	129.44	0.08			12.60
35	183.06	129.44	53.62	0.03			12.60

Volume=ΔtΣ(DRH)=	7330.81	460.52	
excess precipitation	15.91838		
depth,d=	3	1.00	Ok

Table 3.6 3- hours U.H developed from 1 hr U.H

Time	Ordinate of 1 hr U.H(m3/s)				Combined hydrograph(m3/s)	Ordinate of 3 hr U.H (m3/s)=col.(6)/3	Ordinate of DRU.H (m3/s)
	Without lag	Laged by 1 hr	Laged by 1 hr	Laged by 1 hr			
	1 h U.H	15.92	15.92	15.92			
Hrs	m3/s	mm	mm	mm			
1	2	3	4	5	6	7	8
0	0.0	0	0	0	0	0	0.00
1	2.5	0.00	0.00	0.00	0.00	0.00	0.00
2	6.6	2.54	0.00	0.00	2.54	0.85	13.47
3	9.8	6.56	2.54	0.00	9.10	3.03	48.29
4	12.7	9.83	6.56	2.54	18.94	6.31	100.46
5	15.19	12.66	9.83	6.56	29.06	9.69	154.18
6	17.50	15.19	12.66	9.83	37.69	12.56	199.97
7	19.63	17.50	15.19	12.66	45.35	15.12	240.63
8	21.63	19.63	17.50	15.19	52.32	17.44	277.62
9	23.51	21.63	19.63	17.50	58.76	19.59	311.79
10	25.30	23.51	21.63	19.63	64.78	21.59	343.70
11	27.00	25.30	23.51	21.63	70.45	23.48	373.77
12	27.83	27.00	25.30	23.51	75.82	25.27	402.27
13	26.16	27.83	27.00	25.30	80.13	26.71	425.15
14	24.42	26.16	27.83	27.00	80.99	27.00	429.72
15	22.59	24.42	26.16	27.83	78.41	26.14	416.01
16	20.65	22.59	24.42	26.16	73.17	24.39	388.20
17	18.59	20.65	22.59	24.42	67.65	22.55	358.95
18	16.37	18.59	20.65	22.59	61.82	20.61	328.00
19	13.96	16.37	18.59	20.65	55.60	18.53	295.01
20	11.29	13.96	16.37	18.59	48.91	16.30	259.52
21	8.27	11.29	13.96	16.37	41.62	13.87	220.83
22	4.68	8.27	11.29	13.96	33.52	11.17	177.84
23	0.00	4.68	8.27	11.29	24.24	8.08	128.60
24	0.00	0.00	4.68	8.27	12.94	4.31	68.68
25	0.00	0.00	0.00	4.68	4.68	1.56	24.82
26	0	0	0	0.00	0.00	0	0.00

Table-3.7 Rainfall and Stream flow data adopted from 24 hours record for Gumara

Gumara-100,Area= 1354.203 km2

Time Hrs	Obs.Dis. m3/s	Base flow m3/s	DRH m3/s	UHO	Precipit. mm	Excess Prec.	ø-index 0.00
0	101.55	143.62	0.00	0.00	3.16	0.00	16.59
1	175.89	143.62	32.28	2.54	3.32	0.00	16.59
2	227.08	143.62	83.46	6.56	3.50	0.00	16.59
3	268.68	143.62	125.07	9.83	3.72	0.00	16.59
4	304.66	143.62	161.04	12.66	3.99	0.00	16.59
5	336.81	143.62	193.20	15.19	4.32	0.00	16.59
6	366.15	143.62	222.54	17.50	4.76	0.00	16.59
7	393.31	143.62	249.69	19.63	5.35	0.00	16.59
8	418.71	143.62	275.10	21.63	6.25	0.00	16.59
9	442.66	143.62	299.04	23.51	7.85	0.00	16.59
10	465.37	143.62	321.76	25.30	12.14	0.00	16.59
11	487.03	143.62	343.41	27.00	29.30	12.72	16.59
12	497.51	143.62	353.89	27.83	9.31	0.00	16.59
13	476.32	143.62	332.71	26.16	6.92	0.00	16.59
14	454.16	143.62	310.54	24.42	5.75	0.00	16.59
15	430.85	143.62	287.23	22.59	5.03	0.00	16.59
16	406.21	143.62	262.59	20.65	4.52	0.00	16.59
17	379.98	143.62	236.36	18.59	4.14	0.00	16.59
18	351.79	143.62	208.17	16.37	3.85	0.00	16.59
19	321.14	143.62	177.52	13.96	3.61	0.00	16.59
20	287.23	143.62	143.62	11.29	3.41	0.00	16.59
21	248.75	143.62	105.14	8.27	3.24	0.00	16.59
22	203.11	143.62	59.49	4.68	3.09	0.00	16.59
23	143.62	143.62	0.00	0.00	3.02		16.59
24	143.62	143.62	0.00	0.00	3.02		16.59
25		0.00	0.00	0.00	0.00		

Volume,V=ΔtΣ(DRH)= 4783.83 376.17 12.7173

excess precipitation depth,d= 12.717 1.00 Ok

Table3.8-development of 3-hr UH and Direct runoff hydrograph ordinate

Time Hrs	Ordinate of 1 hr U.H(m3/s)				Combined hydrograph(m3/s)	Ordinate of 3 hr U.H (m3/s)=col.(6)/3	Ordinate of DRH (m3/s)
	Without lag	Lagged by 1 hr	Lagged by 1 hr	Lagged by 1 hr			
		12.72 mm	12.72 mm	12.72 mm			
1	2.	3	4	5	6	7	8
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2.54	32.28	0.00	0.00	32.28	10.76	136.83
2	6.56	83.46	32.28	0.00	115.74	38.58	490.63
3	9.83	125.07	83.46	32.28	240.81	80.27	1020.80
4	12.66	161.04	125.07	83.46	369.57	123.19	1566.64
5	15.19	193.20	161.04	125.07	479.30	159.77	2031.81
6	17.50	222.54	193.20	161.04	576.77	192.26	2445.00
7	19.63	249.69	222.54	193.20	665.43	221.81	2820.81
8	21.63	275.10	249.69	222.54	747.33	249.11	3167.99
9	23.51	299.04	275.10	249.69	823.83	274.61	3492.30
10	25.30	321.76	299.04	275.10	895.89	298.63	3797.78
11	27.00	343.41	321.76	299.04	964.21	321.40	4087.38
12	27.83	353.89	343.41	321.76	1019.06	339.69	4319.88
13	26.16	332.71	353.89	343.41	1030.01	343.34	4366.31
14	24.42	310.54	332.71	353.89	997.14	332.38	4226.96
15	22.59	287.23	310.54	332.71	930.48	310.16	3944.41
16	20.65	262.59	287.23	310.54	860.37	286.79	3647.19
17	18.59	236.36	262.59	287.23	786.19	262.06	3332.73
18	16.37	208.17	236.36	262.59	707.12	235.71	2997.57
19	13.96	177.52	208.17	236.36	622.05	207.35	2636.94
20	11.29	143.62	177.52	208.17	529.31	176.44	2243.80
21	8.27	105.14	143.62	177.52	426.27	142.09	1807.02
22	4.68	59.49	105.14	143.62	308.24	102.75	1306.66
23	0.00	0.00	59.49	105.14	164.62	54.87	697.86
24	0.00	0.00	0.00	59.49	59.49	19.83	252.18
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Koga-100,Area= 300.7013 km²

Time Hrs	Obs.Dis. m3/s	Base flow m3/s	DRH m3/s	UHO 0	Precipit. mm	Excess Prec.	ø-index
0	36.75	51.97	0	0	3.66	0	13.66
1	63.65	51.97	11.68	0.56	3.85	0.00	13.66
2	82.18	51.97	30.21	1.46	4.06	0.00	13.66
3	97.23	51.97	45.26	2.18	4.31	0.00	13.66
4	110.25	51.97	58.28	2.81	4.62	0.00	13.66
5	121.89	51.97	69.92	3.37	5.01	0.00	13.66
6	132.51	51.97	80.54	3.89	5.51	0.00	13.66
7	142.33	51.97	90.36	4.36	6.21	0.00	13.66
8	151.53	51.97	99.56	4.80	7.25	0.00	13.66
9	160.19	51.97	108.22	5.22	9.10	0.00	13.66
10	168.41	51.97	116.44	5.62	14.07	0.41	13.66
11	176.25	51.97	124.28	6.00	33.97	20.31	13.66
12	180.04	51.97	128.07	6.18	10.80	0.00	13.66
13	172.38	51.97	120.41	5.81	8.02	0.00	13.66
14	164.35	51.97	112.38	5.42	6.67	0.00	13.66
15	155.92	51.97	103.95	5.02	5.83	0.00	13.66
16	147	51.97	95.03	4.58	5.24	0.00	13.66
17	137.51	51.97	85.54	4.13	4.80	0.00	13.66
18	127.31	51.97	75.34	3.63	4.46	0.00	13.66
19	116.22	51.97	64.25	3.10	4.18	0.00	13.66
20	103.95	51.97	51.98	2.51	3.95	0.00	13.66
21	90.02	51.97	38.05	1.84	3.75	0.00	13.66
22	73.5	51.97	21.53	1.04	3.58	0.00	13.66
23	51.97	51.97	0	0.00	3.50	0.00	13.66
			1731.28	83.528		20.727	
			20.727	1	Ok		

Table -3.9 Calculation of the direct runoff hydrograph for Koga catchment

Time Hrs	2 h U.H m3/s	Direct Runoff in m3/s from effective rainfall during three successive 2 h periods		Flood hydrograph Ordinate(m3/s)
		0.83 (mm)	40.63 (mm)	
0	0	0	0	0
1	0.56	0.47	0.00	0.47
2	1.46	1.21	22.89	24.10
3	2.18	1.81	59.21	61.02
4	2.81	2.33	88.71	91.04
5	3.37	2.79	114.23	117.02
6	3.89	3.21	137.05	140.26
7	4.36	3.61	157.87	161.47
8	4.80	3.97	177.11	181.09
9	5.22	4.32	195.15	199.47
10	5.62	4.65	212.12	216.77
11	6.00	4.96	228.23	233.19
12	6.18	5.11	243.60	248.71
13	5.81	4.80	251.03	255.83
14	5.42	4.48	236.02	240.50
15	5.02	4.15	220.28	224.42
16	4.58	3.79	203.75	207.54
17	4.13	3.41	186.27	189.68
18	3.63	3.01	167.67	170.67
19	3.10	2.56	147.67	150.24
20	2.51	2.07	125.94	128.01
21	1.84	1.52	101.89	103.40
22	1.04	0.86	74.58	75.44
23	0.00	0.00	42.20	42.20

Table 3.10 Rainfall and Stream flow data adopted from 24 hours record for Rib

Rib-100,Area= 1522.56 km2

Time Hrs	Obs.Dis. m3/s	Base flow m3/s	DRH m3/s	UHO	Precipit. mm	Excess Prec.	ø-index
0	48.52	68.62	0.00	0.00	3.11		23.45
1	84.05	68.62	15.42	2.85	3.27		23.45
2	108.50	68.62	39.88	7.38	3.45		23.45
3	128.38	68.62	59.76	11.06	3.66		23.45
4	145.57	68.62	76.95	14.24	3.93		23.45
5	160.94	68.62	92.31	17.08	4.26		23.45
6	174.96	68.62	106.33	19.67	4.68		23.45
7	187.93	68.62	119.31	22.08	5.27		23.45
8	200.07	68.62	131.45	24.32	6.16		23.45
9	211.51	68.62	142.89	26.44	7.73		23.45
10	222.36	68.62	153.74	28.45	11.95		23.45
11	232.71	68.62	164.09	30.36	28.85	5.405	23.45
12	237.72	68.62	169.09	31.29	9.17		23.45
13	227.60	68.62	158.97	29.41	6.81		23.45
14	217.01	68.62	148.38	27.45	5.66		23.45
15	205.87	68.62	137.25	25.39	4.95		23.45
16	194.10	68.62	125.47	23.22	4.45		23.45
17	181.56	68.62	112.94	20.90	4.08		23.45
18	168.09	68.62	99.47	18.40	3.79		23.45
19	153.45	68.62	84.82	15.69	3.55		23.45
20	137.25	68.62	68.62	12.70	3.35		23.45
21	118.86	68.62	50.24	9.29	3.19		23.45
22	97.05	68.62	28.42	5.26	3.04		23.45
23	68.62	68.62	0.00	0.00	2.98		23.45

Volume,V=ΔtΣ(DRH)=	2285.80 4	422.934		5.4046
excess precipitation depth,d=	5.4046	1	Ok	

Table 3.11 3 hours U.H developed from 1 hr U.H

	Ordinate of 1 hr U.H(m3/s)			Combined hydrograph(m3/s)	Ordinate of 3 hr U.H (m3/s)=col.(6)/3	Ordinate of DRH (m3/s)
	Without lag	Laged by 1 hr	Laged by 1 hr			
Time	5.40	5.40	5.40			
Hrs	mm	mm	mm			
1	2	3	4	5	6	7
0	0	0	0	0	0	0
1	2.85	15.42	0.00	18.28	6.09	32.93
2	7.38	39.88	15.42	62.68	20.89	112.92
3	11.06	59.76	39.88	110.70	36.90	199.42
4	14.24	76.95	59.76	150.94	50.31	271.93
5	17.08	92.31	76.95	186.34	62.11	335.70
6	19.67	106.33	92.31	218.32	72.77	393.31
7	22.08	119.31	106.33	247.72	82.57	446.27
8	24.32	131.45	119.31	275.08	91.69	495.56
9	26.44	142.89	131.45	300.77	100.26	541.85
10	28.45	153.74	142.89	325.07	108.36	585.64
11	30.36	164.09	153.74	348.19	116.06	627.28
12	31.29	169.09	164.09	364.47	121.49	656.61
13	29.41	158.97	169.09	357.48	119.16	644.02
14	27.45	148.38	158.97	334.81	111.60	603.18
15	25.39	137.25	148.38	311.02	103.67	560.32
16	23.22	125.47	137.25	285.93	95.31	515.12
17	20.90	112.94	125.47	259.30	86.43	467.15
18	18.40	99.47	112.94	230.81	76.94	415.81
19	15.69	84.82	99.47	199.99	66.66	360.28
20	12.70	68.62	84.82	166.14	55.38	299.31
21	9.29	50.24	68.62	128.15	42.72	230.87
22	5.26	28.42	50.24	83.92	27.97	151.18
23	0.00	0.00	28.42	28.42	9.47	51.21
24	0.00	0.00	0.00	0.00	0.00	0.00

Table-3.12 Rainfall and Stream flow data adopted from 24 hours record for Megech
Megech,Area = 512.56 km2

Time Hrs	Obs.Dis. m3/s	Base flow m3/s	DRH m3/s	UHO	Precipitation mm	Excess Prec.	ø-index
0	87.28	123.43	0.00	0.00	3.66	0.00	9.99
1	151.18	123.43	27.74	0.96	3.85	0.00	9.99
2	195.17	123.43	71.73	2.48	4.06	0.00	9.99
3	230.92	123.43	107.49	3.72	4.31	0.00	9.99
4	261.84	123.43	138.41	4.79	4.62	0.00	9.99
5	289.48	123.43	166.04	5.75	5.01	0.00	9.99
6	314.70	123.43	191.26	6.62	5.51	0.00	9.99
7	338.04	123.43	214.60	7.43	6.21	0.00	9.99
8	359.87	123.43	236.44	8.19	7.25	0.00	9.99
9	380.45	123.43	257.02	8.90	9.10	0.00	9.99
10	399.97	123.43	276.54	9.58	14.07	4.08	9.99
11	418.59	123.43	295.15	10.22	33.97	23.98	9.99
12	427.59	123.43	304.15	10.53	10.80	0.81	9.99
13	409.39	123.43	285.95	9.90	8.02	0.00	9.99
14	390.33	123.43	266.90	9.24	6.67	0.00	9.99
15	370.30	123.43	246.87	8.55	5.83	0.00	9.99
16	349.13	123.43	225.69	7.82	5.24	0.00	9.99
17	326.58	123.43	203.14	7.03	4.80	0.00	9.99
18	302.35	123.43	178.92	6.20	4.46	0.00	9.99
19	276.01	123.43	152.57	5.28	4.18	0.00	9.99
20	246.87	123.43	123.43	4.27	3.95	0.00	9.99
21	213.79	123.43	90.36	3.13	3.75	0.00	9.99
22	174.56	123.43	51.13	1.77	3.58	0.00	9.99
23	123.43	123.43	0.00	0.0	3.50	0.00	9.99
24	124.43	123.43	1.00	0.03	3.50	0.00	9.99

Volume,V=ΔtΣ(DRH)=	4111.55	142.378	28.88
excess precipitation depth,d=	28.88	1 Ok	

Table -3.13 -Calculation of the direct runoff hydrograph for Megech catchment

Time Hrs	2 h U.H m3/s	Direct Runoff in m3/s from effective rainfall during three successive 2 h periods 12.25 (mm)	71.95 (mm)	2.44 (mm)	Flood hydrograph Ordinate (m3/s)
0	0	0	0	0	0
1	0.96	14.47	0.00	0.00	14.47
2	2.48	37.41	0.00	0.00	37.41
3	3.72	56.06	0.00	0.00	56.06
4	4.79	72.18	69.12	0.00	141.30
5	5.75	86.59	178.72	0.00	265.31
6	6.62	99.75	267.81	0.00	367.55
7	7.43	111.92	344.84	2.34	459.10
8	8.19	123.30	413.69	6.06	543.05
9	8.90	134.04	476.52	9.07	619.63
10	9.58	144.22	534.68	11.68	690.58
11	10.22	153.92	589.07	14.02	757.01
12	10.53	158.62	640.34	16.15	815.11
13	9.90	149.13	688.99	18.12	856.23
14	9.24	139.19	735.36	19.96	894.51
15	8.55	128.74	757.79	21.70	908.23
16	7.82	117.70	712.44	23.34	853.48
17	7.03	105.94	664.97	24.92	795.82
18	6.20	93.31	615.06	25.68	734.05
19	5.28	79.57	562.30	24.14	666.01
20	4.27	64.37	506.12	22.53	593.02
21	3.13	47.12	445.76	20.84	513.73
22	1.77	26.66	380.13	19.05	425.85
23	0.00	0.00	307.53	17.15	324.68
24	0.00	0.00	225.13	15.10	240.23
25	0.00	0.00	127.38	12.88	140.26
26	0.00	0.00	0.00	10.42	10.42
27	0.00	0.00	0.00	7.63	7.63
28	0.00	0.00	0.00	4.32	4.32
29	0	0	0	0	0