BASIN STUDY FOR ENVIRONMENTAL FLOW ASSESSMENT IN HYDROPOWER DEVELOPMENT

A DISSERTATION

Submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF TECHNOLOGY
in
WATER RESOURCES DEVELOPMENT

By

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CANDIDATE'S DECLARATION

I hereby certify that present work, which is being in the dissertation entitled **"BASIN STUDY FOR ENVIRONMENTAL FLOW ASSESSMENT IN HYDROPOWER DEVELOPMENT"**, in partial fulfillment of the requirements for the award of degree of **Master of Technology in Water Resources Development (Civil)** in the Department of Water Resources Development and Management of Indian Institute of Technology Roorkee, is an authentic record of my own work carried out during a period from July 2009 to June 2010 under the guidance of Professor M.L. Kansal and Professor Devadutta Das, faculty members of Water Resources and Management Department of Indian Institute of Technology Roorkee.

This thesis or any matter embodied within this dissertation has not been submitted for the award of any other degree or diploma.

Dated: June 25th, 2010.
Place: Roorkee, India.

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CERTIFICATE

This is to certificate that the above mentioned statement made by the candidate is correct to the best of my knowledge.

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ABSTRACT

Most of the world energy demand is fulfilling with non-renewable and pollutant sources such as oil, coal and gas. Hence, more inversions are given to hydropower production to reduce greenhouse emissions and provide sustainable energy production.

In a River basin, different hydropower scheme can be developed like storage dams, run-of-the river scheme or pumping stations. These hydropower developments have significant impacts in the river ecosystem, reducing the total amount of flow and affecting both; the seasonality of flows and the size and frequency of floods. These changes in discharge patterns affect the abundance, species composition and viability of aquatic life in the river.

The aim of Environmental Flow (EF) is to enhance the management of river flows to ensure the sustainability of river ecosystem and provide a reliable tool for water allocation decisions, in this case between hydropower production and ecology needs. A common practice in reservoir operations is releasing a minimum fixed amount of water throughout the year, commonly 10% or 15% of 90% dependable flow. This amount of water may or may not sufficient for maintaining aquatic life downstream of dam. Environmental Flow Assessment (EFA) techniques are beyond of this old practice and studies have demonstrated that keeping modified flow regime in the river, rather than a fixed amount of water is more beneficial for downstream ecosystem (Waddle, 1992).

The present study focuses in various EFA techniques; based on a review of international literature and studying environmental flow practices from various parts of the world and these techniques are applied in two cases of study located in India. The first case study is located in Lohit river basin in Arunachal Pradesh. The river basin development is under cascade scheme with six proposed storage dams and power houses at toe of the dam. The second case study is located in Pabbar River basin in Himachal Pradesh. The project is run-off the river scheme which creates a dry river stretch of 11.55 km between diversion point and power house.

For every dam site in both cases of study; environmental flows are given and minimum flows are proposed under different seasons throughout the year. The hydrology and hydraulic characteristic of the rivers are linked with fish water requirements for different Himalayan fish species available in the river, based on water depth and water velocity habitat parameters.

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ABBREVIATIONS

NOTATIONS/ABBREVIATIONS	DESCRIPTION/FULL FORM
AAF	Annual Average Flow.
BBM	Building Block Method.
BOD	Biochemical Oxygen Demand.
CA	Catchment Area.
CWC	Central Water Commission.
DO	Dissolved Oxygen.
DRIFT	Downstream Response to Imposed Flow Transformation.
EC	Electrical Conductivity.
EF	Environmental Flow.
EFA	Environment Flow Assessment.
EFM	Environmental Flow Methodologies.
EIA	Environmental Impact Assessment.
EU	Europe Union.
EWR	Environmental Water Requirements.
FDC	Flow Duration Curve.
FRL	Full Reservoir Level.
G&D	Gage & Discharge.
HEP	Hydro-Electric Project.
HFR	High Flow Requirements.
HRM	Hydraulic Rating Methods.
HSC	Habitat Suitability Criteria.
IC	Install Capacity.
IEA	International Energy Agency.
IFIM	Instream Flow Incremental Methodology.
IITR	Indian Institute of Technology Roorkee.
LFR	Low Flow Requirements.
m.a.s.l.	meters about sea level.
MCM	Million Cubic meters.
MIF	Minimum Instream Flow.
Mtoe	Million tons of oil equivalent.
NTU	Nephelometric Turbidity Units.
PHABSIM	Physical Habitat Simulation.

NOTATIONS/ABBREVIATIONS	DESCRIPTION/FULL FORM
SPM	Suspended Particulate Matter.
TDS	Total Dissolved Solids.
USA	United States of America
USD	United States Dollars
WRD&M	Water Resources Development and Management
WUA	Weighted Usable Area.

CHAPTER I

INTRODUCTION

1.1 GLOBAL ENERGY SCENARIO

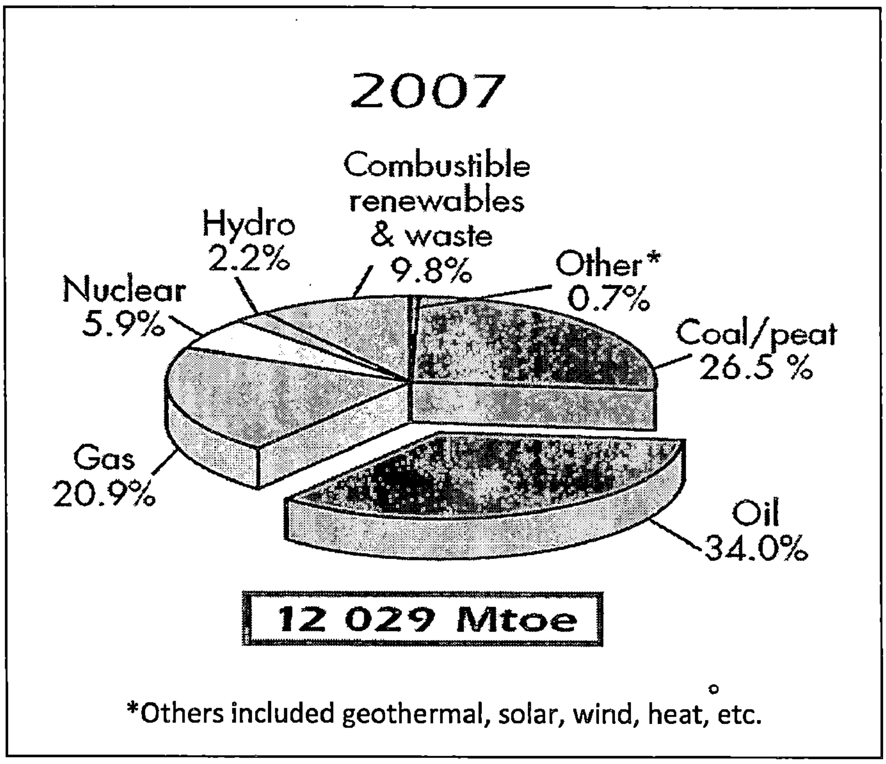
The mankind is nowadays facing big challenges to satisfy a growing demand of water supply, food and energy. This deficiency in supply is increased by global economic crisis and global warming.

A several number of policies are created to limit greenhouse gas emissions, enhance energy efficiency and promote renewable energy.

The International Energy Agency (IEA, 2009) estimates total primary energy supply in 12 029 Million tones of oil equivalent (Mtoe) for the year 2007.

The three principal sources of world energy are: oil (34.0%), coal (26.5%) and gas (20.9%) as shown in figure 1.1.

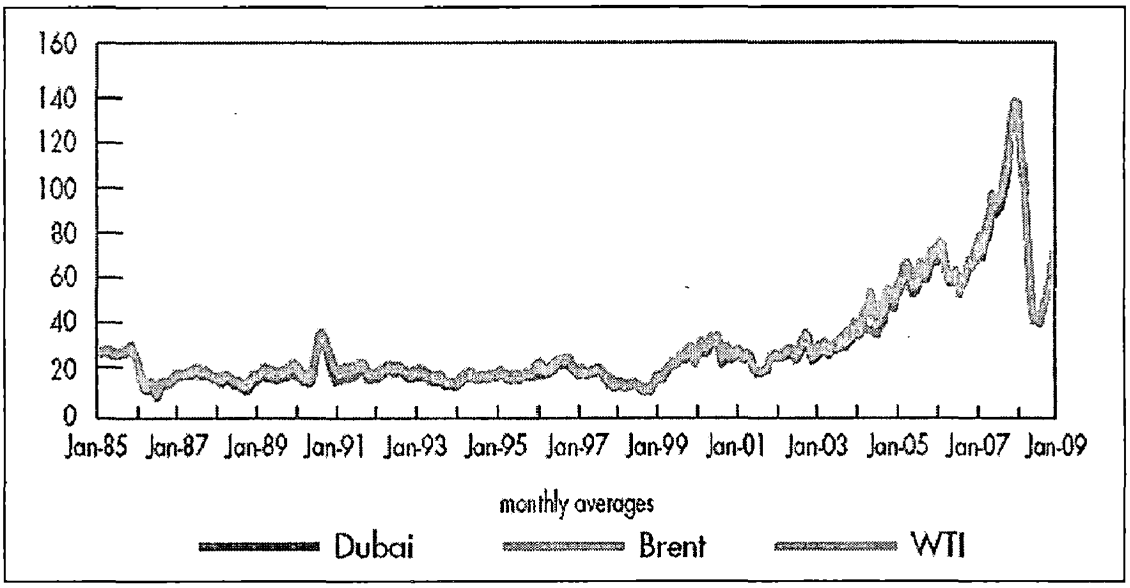
Figure 1.1 Total World Primary Energy Supply. Source: IEA, 2009.



These three main sources of energy have big limitations:

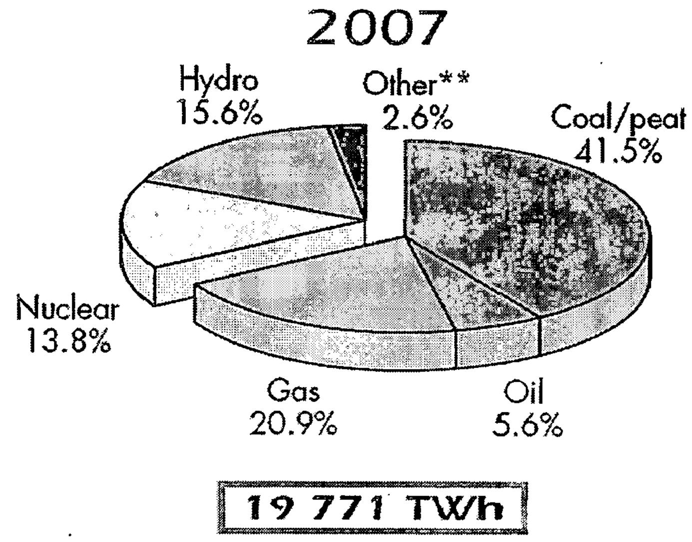
- *Availability:* the sources of fossil fuels are finite (non-renewable) i.e., these energy sources are not sustainable.
- *Pollution:* these sources of energy produce a lot of greenhouse gases, responsible for global warming. From the total amount of CO_2 produced in the world, estimated in 28 962 Million of tones (Mt) of CO_2 in 2007, these three main sources of energy combined produce 99,6% of total CO2 emissions in the world (IEA, 2009).
- *Increasing international prices:* the high demand of fossil fuels enable rising oil prices. Similarly behavior, as is showing in figure 1.2, occurs with coal and natural gas prices.

Figure 1.2 Crude oil spot prices in US dollars/barrel. Source: IEA, 2009.



Taking in account this actual energy scenario, mankind is looking for alternative energy sources based in low-carbon power generation technologies. The investment in renewable energy has experienced a huge increase in last 4 years (from 2004 to 2008). Annual investment has increased fourfold from 20 billion USD in 2004 to reach 120 billion USD in 2008 (REN21, 2009). Renewable energy contributes to world energy supply security, reducing dependency on fossil fuel resources and mitigating greenhouse gases. Renewables are the third largest contributor to global electricity production. They accounted 18.2% of total production. Almost 90% of electricity generated from renewable comes from hydropower plants, like is showing in figure 1.3.

Figure 1.3 World electricity generations by fuel in 2007. Source: IEA, 2009.



** Others include geothermal, solar, wind, combustible renewable & waste, and heat.

1.2 HYDROPOWER

Hydropower (or water power) is power that is derived from the energy of moving water, used in irrigation and operation of various machines, such as watermills, textile machines and turbines (Wikipedia, 2009). Hydroelectric power plant converts the potential energy of water into mechanical energy to generated electricity. A flow of water is directly pushing a turbine, which rotates a coil of wire in a magnetic field (generator) to produce electricity (Arora, 1996). There are three types of hydroelectric power plants:

- *Run-of-river plants:* It uses affluent water as it comes. These plants are feasible only on perennial rivers. They use a weir or barrage for diverting water and small poundage to take care of daily fluctuations in demand.
- *Storage power plants:* These power stations use a large reservoir to storage water on wet season to supply on dry season taking care of seasonal fluctuations. Reservoir is created by construction of dam across the river.
- *Pumped-storage plants:* This type of plant is suitable for cover peak demand. They generated energy in peak hours only. During lack demand hours they pumped water from lower level poundage to upper level poundage to reuse water.

Hydropower's flexibility supports the deployment of intermittent renewable such as wind or solar power. Multipurpose hydropower can also support adaptation to increasingly difficult hydrology by strengthening a country's ability to regulate and store water and resist flood and drought shocks (The World Bank, 2009). The advantages of hydropower projects include stable energy costs, renewable energy source and a very efficient and effective source of alternative energy. Besides the various advantages, there are certain disadvantages. Due to several uncertain and high impacts, hydropower projects are catalogue like a "high-risk" infrastructure projects from social, financial and environmental point of view (Hirji & Davis, 2009). The main disadvantages are:

- High initial cost and the rate of benefits return are low.
- The period of design and construction are large (around 10 years or more).
- Change of groundwater level and fill up of the river bed with rubble.
- Risk of dam breaks.
- Great demand for land space for the reservoir (large submergence areas).
- Generation of CO_2 gases due the decomposition of organic matter under submergence.
- Loss of flora and fauna.
- High environmental impact especially during construction period.
- Social negative impacts; like displaced people.
- The hydropower is dependent upon the natural flow in rivers. Since the flow is extremely variable, the dependable power or the firm power is considerable less as compared to the total capacity.

Many of these disadvantages can be addressed by implementation of low impact practices, in other cases; adverse impacts can be only mitigated or compensated. This is the big challenge for Water Resources Development and Management, make hydropower projects reliable, affordable and sustainable.

Environmental Flow (EF) plays an important role in planning and design of hydropower projects providing a reliable tool for water allocation decision between hydroelectric production and ecology needs. EF focuses in the quality, quantity and timing of water flows required to maintain the aquatic ecosystem downstream of a dam. Environmental Flow Assessment is carried out in two different cases of study located in India. The first case study is located in Lohit river basin in Arunachal Pradesh. The river basin development is under cascade scheme with six proposed storage dams and power houses at toe of the dam. The second case study is located in Pabbar River basin in Himachal Pradesh. The project is run-off the river scheme which creates a dry river stretch of 11.55 km between diversion point and power house.

1.3 OBJECTIVES OF THE STUDY

The objective of the present study is to enhance the management of river flows and water allocation decisions through the review of different environmental flows assessment techniques to ensure the sustainability of river ecosystem within hydropower production. The achievement of main objective will be done following these specific objectives:

- Give a general overview of world energy scenario and the importance of hydropower production within this scenario.
- Explain different hydropower schemes and the main advantages and disadvantages of hydropower development.
- Review of environmental flow assessment techniques in literature and current techniques used around the world.
- Review of fish water requirements and fishes distribution in Himalayan region.
- Apply environmental flow assessment techniques in two cases of study.
- Make hydraulic simulations with proposed environmental flows and make a link between hydraulic variables such as water depth and water velocity with water fish requirements for different fish species available in the river.
- Give conclusions and recommendations for both cases of study.

1.4 SCOPE AND LIMITATIONS

The scope of the study includes the application of various EFA techniques using extended ten-daily flows records from various discharge and gage stations near to the area of study. History flow records were completed and transferred by area proportion methodology to those locations where the data is missing or not available.

The quantity of cross-sections along the river are limited and given only for specific locations downstream of proposed dam sites and may do not represent the entire river length. The estimation of water depth and water velocity at different cross-sections of the river was done for one-dimensional steady flow with the help of Excel sheets and HEC-RAS software version 4.0. These computations are based on energy equation and Manning's equation, where the main variables are: discharge, area and wetted perimeter of each cross-section, average river bed slope and roughness coefficient. All these variables have uncertain in their estimated values.

The ecology components of river are huge and it is practically impossible to address the impact of flow modification on all the elements in the river ecosystem. Therefore, different techniques for assessing environmental flows are focused on a target fish-species. Fish water quality requirements and fish habitat requirements available in literature are provided only for a few species and for specific sites of study.

1.5 ORGANIZATION OF THE DISSERTATION

The dissertation is organized on 6 chapters and they are described as follow:

- Chapter I. This chapter is the introduction of dissertation work in which is presented a briefly review of world energy scenario and the importance of hydropower development under current world energy trends. Here different hydropower schemes are explained and also main features of two cases of study are discussed.

- Chapter II. A summary of different techniques for environmental flow assessment is given; based on a review of international literature and studying environmental flow practices from various parts of the world. At the end of the chapter a schematic figure highlights the most important techniques within advantages and disadvantages for each methodology.

- Chapter III. This chapter is dedicated to Limnology in which is briefly explains the different component of river ecosystem and the interrelation between drainage basin characteristics and river flows. A general review of freshwaters fishes and their water quality requirements is given in this chapter and then it focuses in freshwater fishes available in Himalayan region. Finally, the chapter highlights the main impacts in fishes due to hydropower development.

- Chapter IV. It presents the case of study I: Environmental Flow Assessment for storage based hydropower project in Lohit River basin. The chapter starts with a summary of main features of the background of the project. The chapter continues with a hydrology data availability, data generation and data analysis. The results obtained in hydrology study are used for Environmental Flow Assessment in Lohit basin. The chapter develops a stage-discharge relationships using Manning's equation in which proposed environmental flows are validated comparing water depth and water velocity obtained at various cross-section along the river with water depth and water velocity requirements for different fish species available in Lohit basin. Data of water quality sampling is also provided in this case of study. Discussion of results and specific conclusions for this case of study is provided at the end of the chapter.

- Chapter V. It presents a case of study II: Environmental Flow Assessment for run-of the river scheme at Dhamwari Sunda hydropower project. The chapter starts with a summary of main features of the background of the project. The chapter continues with a hydrology data availability, data generation and data analysis. The results obtained in hydrology study are used for Environmental Flow Assessment in Dhamwari Sunda HEP.
  The chapter gives a briefly explanation of River System Analysis and hydraulic modeling used in HEC-RAS simulations for different flow scenarios. Similarly to previous chapter, environmental flows are validated through comparing hydraulic variables such a water depth and water velocity at different cross-sections in the river with water depth and water velocity habitat parameters for different fish species available in Dhamwari Sunda HEP. Data of water quality sampling is also provided in this case of study. Discussion of results and specific conclusions for this case of study is provided at the end of the chapter.

- Chapter VI. This chapter presents the general conclusions of the dissertation work. It highlights the main results and proposed further steps in environmental flow studies.

CHAPTER II

ENVIRONMENTAL FLOW ASSESSMENT TECHNIQUES

2.1 INTRODUCTION

Environmental Flow (EF) is the water that is left in a river ecosystem, or released into it, for the specific purpose of managing the ecosystem. EF refers to quality, quantity and timing of water flows required to maintain the components, functions, processes and resilience of aquatic ecosystem that provides goods and services to people (Brown & King, 2003 & De Freitas, 2008).

EF is designed to maintain or upgrade a river in desired, agreed or pre-determined status referred to as an "environmental management class" ranging from the natural (pristine) environment to critically modified ecosystem (Tharme 2003).

Environmental Water Requirements (EWR) refers to the total annual volume of EF. The EWR may be understood by the concept of "environmental demand" similarly to crop water requirements, industrial or domestic water demand (Smakhtin & Anputhas, 2006).

The process for estimating EWR is also referred to as Environmental Flow Assessment (EFA) and it covered a lot of different techniques. Environmental flow assessment techniques determine the volume and temporal distribution of EF. The difficulty of estimation EWR values lies in the lack of understanding the relationship between river flow and multiple components of river ecology and the scarcity of data concern to these relationships, for example, flow requirements for survival of aquatic biota are available only for a target fish species in a given river basin and this information is very specific and may not applicable for a different fish species or different river basin (Hirji & Davis, 2009).

EF is concerned with the equitable sharing and sustainable use of water resources and these concepts should be extended beyond rivers to groundwater, lakes, estuaries and even coastal area. In the specific case of hydropower production, EF deals with water allocation between two main destinations: energy production and ecology. Also, water allocation deals with spatial and temporal distribution of water resource:

- *Temporal distribution:*
  The critical period from allocation point of view occurs during dry season, when the quantity of water is less and the competition from different sectors to satisfy their own needs become critical. During dry season the aim of hydropower plant it is storage water as maximum as possible for energy production, but not all

water (inflow) can be storage since downstream ecology needs water to survive during this critical period.

- *Spatial distribution:*
  In some hydropower schemes, the critical portion of the river ecosystem is called the "stretch". This is the length of the river, which lies between the point where the water is diverted (barrage or dam site) and the point where the water is reintegrated in the river (outlet) after passing through turbines. Sometimes the "stretch" has 10 Km, 15 Km or more, depending on topographically and geology conditions.

EFA must be done in the preliminary studies of hydropower projects. The availability of water for hydropower production defines the size and capacity of hydropower plants. In the case of run-of-river plants, the EWR defines how much water can be diverted from river; hence, EWR influences the design and dimension of different structures like power channels, penstock and number and sizes of turbines. Similarly, in the case of storage hydropower plants, the EWR influences reservoir operations and total power production.

2.2 REVIEW OF ENVIRONMENTAL FLOW ASSESSMENT TECHNIQUES

In a recent review of international environmental flows assessments; (Tharme, 2003) recorded 207 different methods within 44 countries. Broadly, these can be divided into four categories:

1. **Hydrological Index Methods**
2. **Hydraulic Rating Methods**
3. **Habitat Simulation Methodologies**
4. **Holistic Approaches**

These methodologies are described as follows:

1. Hydrological Index Methods:

These are the simplest and most widespread EFA techniques. They are often referred to as desk-top or look-up table methods and they rely primarily on historical flow records; usually long-term virgin or naturalized, historical monthly or daily flow records, to derive EF recommendations.

Hydrological Index Methods provide a relatively rapid, non-resource intensive, but low resolution estimate of environmental flows. The methods are most appropriate at the planning level of water resources development, or in low controversy situations where they may be used as preliminary estimates. Hydrological Index methods may be used as tools within habitat simulation, holistic or combination environmental flow methodologies (IWMI, 2007).

Environmental flow is usually given as a percentage of Annual Average Flow (AAF) or as a percentile from the flow duration curve, on annual, seasonal or monthly basis.

The most frequently used methods under this category are:

(i) Tennant Method:

This method was developed by Donald Tennant in Montana region in USA through several field observations and measurements. The Tennant study used 58 cross sections from 11 streams in Montana, Nebraska and Wyoming (Mann, 2006).

The technique utilizes only the AAF for the stream. It then states that certain flows relate to the qualitative fish habitat rating, which is used to define the flow needed to protect fish habitat, expressed in tabular form (Tennant, 1975).

Tennant concluded that 10% of AAF is the minimum for short term fish survival, 30% of AAF is considered to be able to sustain fair survival conditions and 60% of AAF is excellent to outstanding habitat.

Table 2.1 Instream flow for fish, wildlife & recreation. Source: Tennant 1975.

Description of Survival conditions	**Recommended base flow regimes**	
	Oct-Mar	**Apr-Sep**
Flushing or Maximum	200% of AAF	
Optimum range	60% - 100% of AAF	
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or Degrading	10%	30%
Poor or Minimum	10%	10%
Severe degradation	10% of AAF to zero flow	

(ii) Hughes & Münster Method:

The computed of Environmental Water Requirements (EWR) values are based on the time series of monthly river flows. So, the computation of the long-term Annual Average Flow (AAF) is required. This methodology is based in the concept of aquatic ecosystem should be considered in the context of the natural variability of flow regime (Smakhtin, 2004).

In this methodology, the EWR is the summation of Low Flow Requirements (LFR) and High Flow Requirements (HFR). In equation form:

$$EWR = LFR + HFR \qquad \text{(eq. 2.1)}$$

LFR is believed to approximate the minimum requirement of water of the fish and other aquatic species throughout the year. HFR is important for river channel maintenance, as a stimulus for processes such as migration and spawning, for wetland flooding and recruitment of riparian vegetation.

LFR is assumed to be equal to the monthly flow which is exceeded 90% of the time (Q_{90}), value taken from Flow Duration Curve (FDC). The FDC is a plot of discharge vs. percent of time that a particular discharge was equaled or exceeded.

HFR is taken from table 2.2 which it is approximate by a set of thresholds linked to the different LFR levels. In reliable flowing rivers with high baseflow contribution (and consequently high LFR), HFR is low. In the other hand, in highly variable rivers, baseflow contributions are normally low (and consequently LFR is low) and the total environmental requirement is dominated by high HFR (Smakhtin, 2004).

Table 2.2 Estimation of environmental HFR. Source: Smakhtin, 2004.

Low Flow Req. (Q_{90})	**HFR**	**Comment**
If $Q_{90} < 10\%$ AAF	Then HFR = 20% AAF	Basins with very variable flow regimes. Most of the flow occurs as flood events during short wet season
If 10% AAF $\leq Q_{90} <$ 20% AAF	Then HFR = 15% AAF	
If 20% AAF $\leq Q_{90} <$ 30% AAF	Then HFR = 7% AAF	
If $Q_{90} \geq 30\%$ AAF	Then HFR = 0	Very stable flow regimes. Flow is consistent throughout the year. Low-flow requirement is the primary component.

(iii) Index Method:

This method defined the value of the Minimum Instream Flow (MIF) that must be maintained downstream of water diversion point in order to maintain vital conditions of ecosystem. This technique is based on Q_{355} (the flow not exceeded more than 355 days per year) this means on average, the natural flow is less than Q_{355} value only for 10 days in a year (Maran, 2007).

$$MIF = Ka*Kb*Kc*\ Q_{355} \qquad \text{(eq. 2.2)}$$

where:

Ka is corrective coefficient for different environmental sensitive of the interested river stretch [0.7 to 1.0].
Kb is an implementation factor. Range between 0.25 to 1.
Kc is a corrective coefficient to account different levels of protection due to special value of the interested area [1.0 to 1.5].

The concept of "environmental sensitive" is linkage with Flow Duration Curve (FDC). When the slope of the FDC is flat, for example when $Q_{90} \geq 30\%$ AAF, the flow in the river is very stable thought the year, and the ecosystem is getting used to have a constant rate of flow in the river most of the time. This type of ecosystem is more sensitive to any change in river flow regime and the value of Ka will be taken as 1. In the other hand, when the FDC slope is steep, say $Q_{90} < 10\%$ AAF, the river flow is very unstable and present high extreme values (floods and droughts). Under this conditions the ecosystem is getting used to water scarcity during some periods of the year, therefore this ecosystem is less sensitive to changes in flow regime, because the river naturally present a wide variability in flow regime. In this case, the value of Ka can be taken as 0.7.

The implementation factor refers to upgrade a degraded river condition, in which the quantity of water in the river is very low, due the abstractions made for different purposes (domestic, industrial, agriculture, etc.) The recovering of natural conditions of the river flow must to be done gradually, because another uses of water will be affected, in this case, the value of Kb could be 0.25. In the case of no significant abstractions, the value of Kb will be 1.

The Kc factor increases the value of MIF, for protection of special conditions in the river ecosystem like naturalistic and tourism values, fisheries development and medicinal or religious issues.

2. Hydraulic Rating Methods:

Hydraulic Rating Method (HRM) is combined desktop-field methods requiring limited hydrological, hydraulic modeling and ecological data and expertise. Like previous method, HRM also use the hydrological record and link this data to river geomorphology.

These methods are an improvement on hydrological index methods, since they require measurement of the river channel hence, are more sensitive than the desktop approaches to differences between rivers. The number of field visits and measurements taken will depend on the level of confidence required for the study and economic constraints.

Cross-sections are placed at a river site where maintenance of flow is most critical or where instream hydraulic habitat is most responsive to flow reduction, and thus potentially most limiting to the aquatic biota (e.g. riffles).

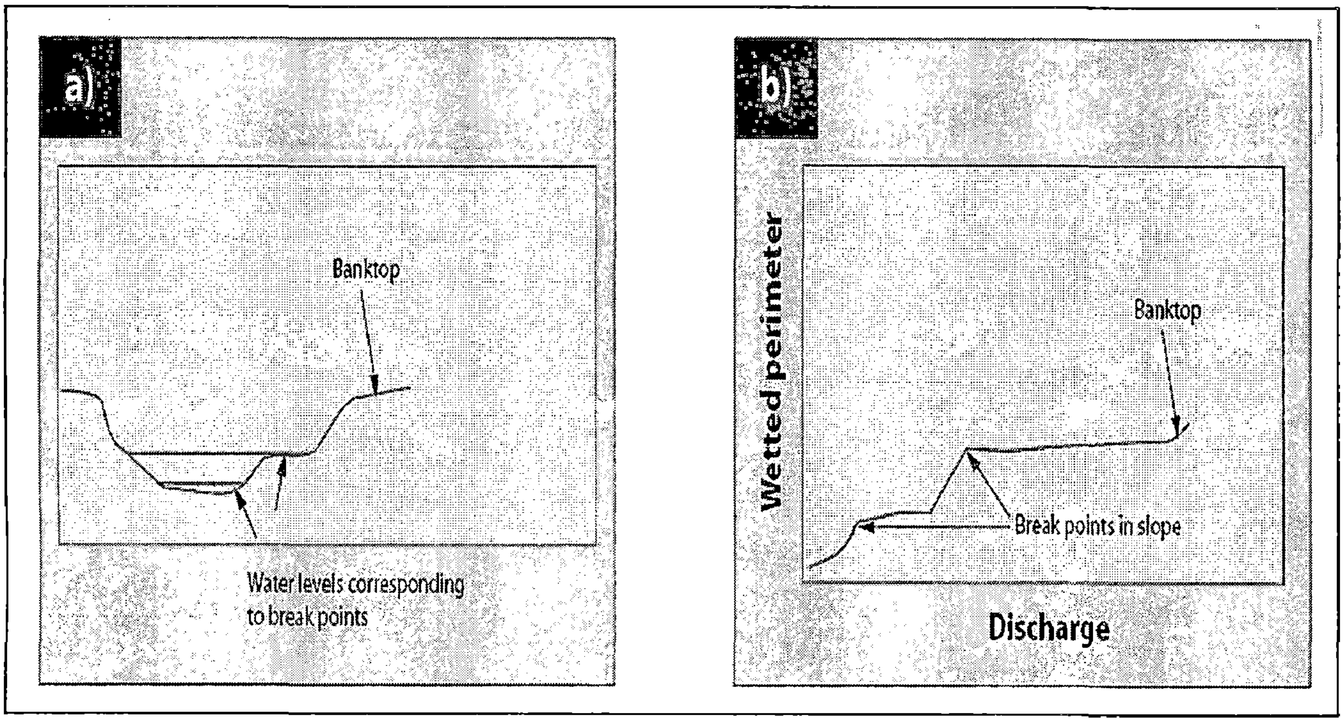
Due to their low-moderate field survey intensity and low complexity, this methodology is most appropriate for planning of water resources development where no limited negotiation of tradeoffs is required, or as a method within a habitat simulation or holistic type. The Wetted Perimeter Method is the most commonly applied hydraulic rating method.

(i) Wetted Perimeter Method:

The wetted perimeter is the length of stream bottom substrate that is wet along a cross section oriented perpendicular to the river. Cross section data are taken from several riffles along the stream length at several different flows to produce a curve between discharge and wetted perimeter that can be analyzed for the breakpoint or inflection point (Mann, 2006).

The resulting recommended discharges are based on inflection points on the wetted-perimeter-discharge curve. Breakpoints in slope indicate the maximum available fish habitat for the least amount of water, until the next breakpoint. Commonly, a breakpoint, interpreted as a threshold below which habitat quality becomes significantly degraded (Brown & King, 2003 & IMWI, 2007).

Figure 2.1 Wetted-Perimeter Discharge curve. Source: World Bank, 2006.



(A) Hypothetical channel cross-section.
(B) Graph of discharge (cumecs) versus wetted perimeter (meters).

3. Habitat Simulation Methodologies:

Methodologies under this category adopt a deterministic approach for simulating the fish response to water diversion considering the causal relationships that determines the influence of the flow diversion on aquatic life (Maran, 2007).

This metodology derive EWR through analysis of the quantity and suitability of instream physical habitat available to target species or assemblages (typically fish or invertebrates) under different flow regimes, on the basis of integrated hydrological, hydraulic and biological response data (IWMI, 2007).

Typically, the flow-related changes in physical microhabitat are modeled in various hydraulic programs, using data on hydraulic variables, most commonly depth, velocity, substratum composition, cover and, more recently, complex hydraulic indices (e.g. benthic shear stress), collected at multiple cross-sections within the river study reach.

Some habitat simulation programs consider ecosystem subcomponents in addition to instream biota (e.g. sediment transport, water quality, riparian vegetation, water dependent wildlife). Data requirements are moderate-high, and include historical flow records, hydraulic variables for multiple cross-sections, and habitat availability and suitability data for various biota. A high degree of expertise in advanced, dynamic hydrological and hydraulic habitat modeling, land surveying, and in physical habitat-flow is needed for target species.

The most frequently used methods under this category are: (i) Physical Habitat Simulation (PHABSIM) and (ii) Instream Flow Incremental Methodology (IFIM).

(i) PHABSIM:

The Physical Habitat Simulation (PHABSIM) is an integrated collection of hydraulic and microhabitat simulation models designed to quantify the amount of microhabitat available for a target species over a wide range of discharges (Bovee and others, 1998).

The purpose of PHABSIM is to simulate a relationship between streamflow and physical habitat for various life stages of a species of fish or a recreational activity. The basic objective of physical habitat simulation is to obtain a representation of the physical stream and linked, through biological considerations, to the social, political, and economic world.

PHABSIM uses a set of computer programs that combines empirical description of the structure features of the channel, simulated distribution of depth and velocity and habitat suitability criteria for the target species. This combination reveals a functional relationship between streamflow and the area of microhabitat available for the target species, per unit length of stream. PHABSIM consists of three main components described as follows:

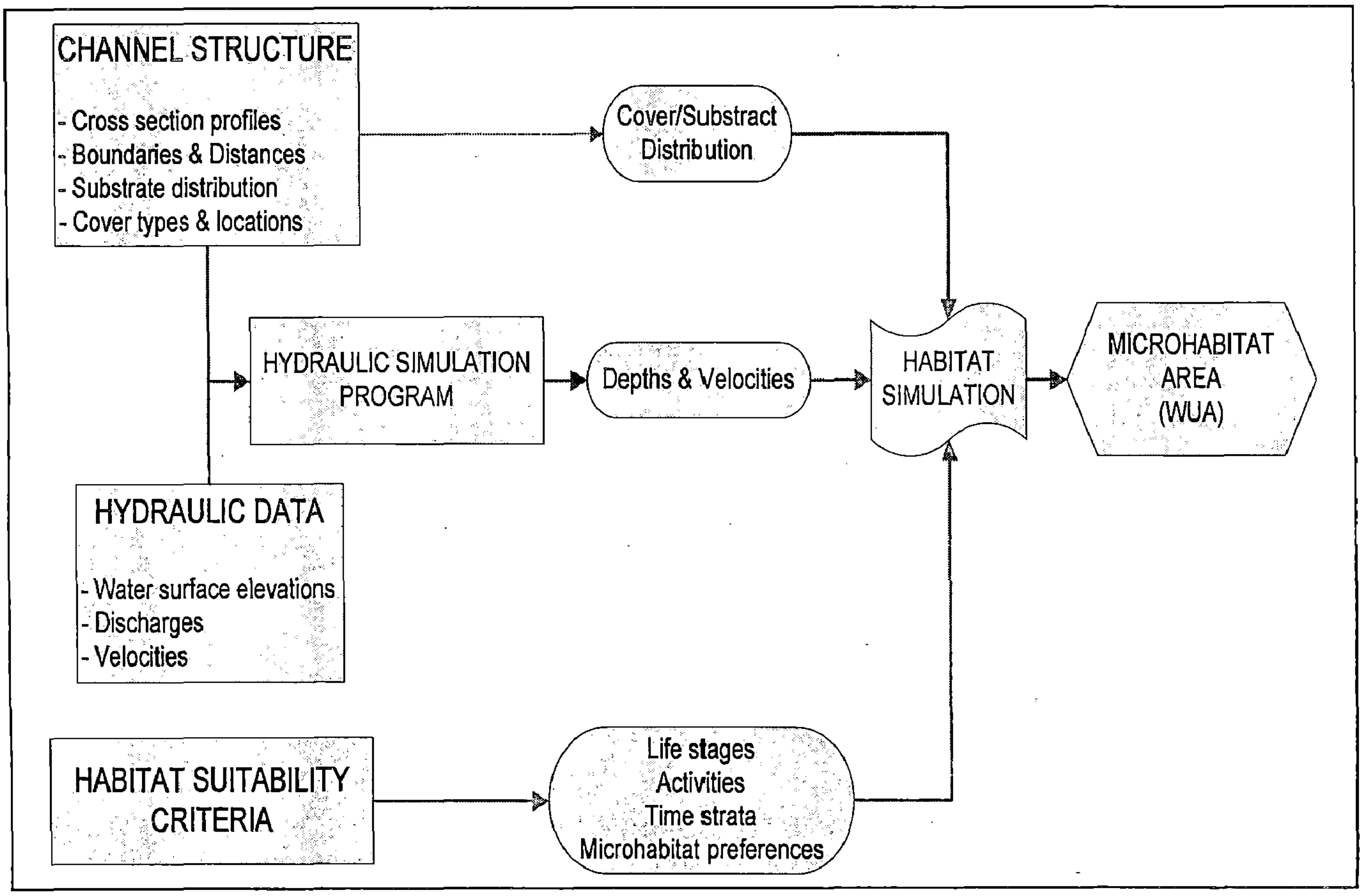
(i) Channel structure: it incorporates all of the fixed channel properties that do not change dynamically with flow (although they may change gradually over long period of time), for example, cross sectional configurations of the channel, substrate characteristics and distribution.

(ii) Hydraulic simulation: hydraulic variables are those that change dynamically as a function of discharge like water surface elevations, depths, velocities, wetted perimeters and surface areas. Hydraulic simulation programs are used to predict the values of these hydraulic variables at discharges that were not measured.

(iii) Habitat suitability criteria (HSC): HSC is used to define the ranges of depths and velocities, as well as what type of cover and which characteristics of the substrate are important to a species or life stage of a species.

Next figure shows the main components and their variables of PHABSIM software, used in the generation of Microhabitat Area, also called Weighted Usable Area (WUA). PHABSIM calculates WUA values as a function of discharge.

Figure 2.2 PHABSIM components. Source: Bovee & Others, 1998.



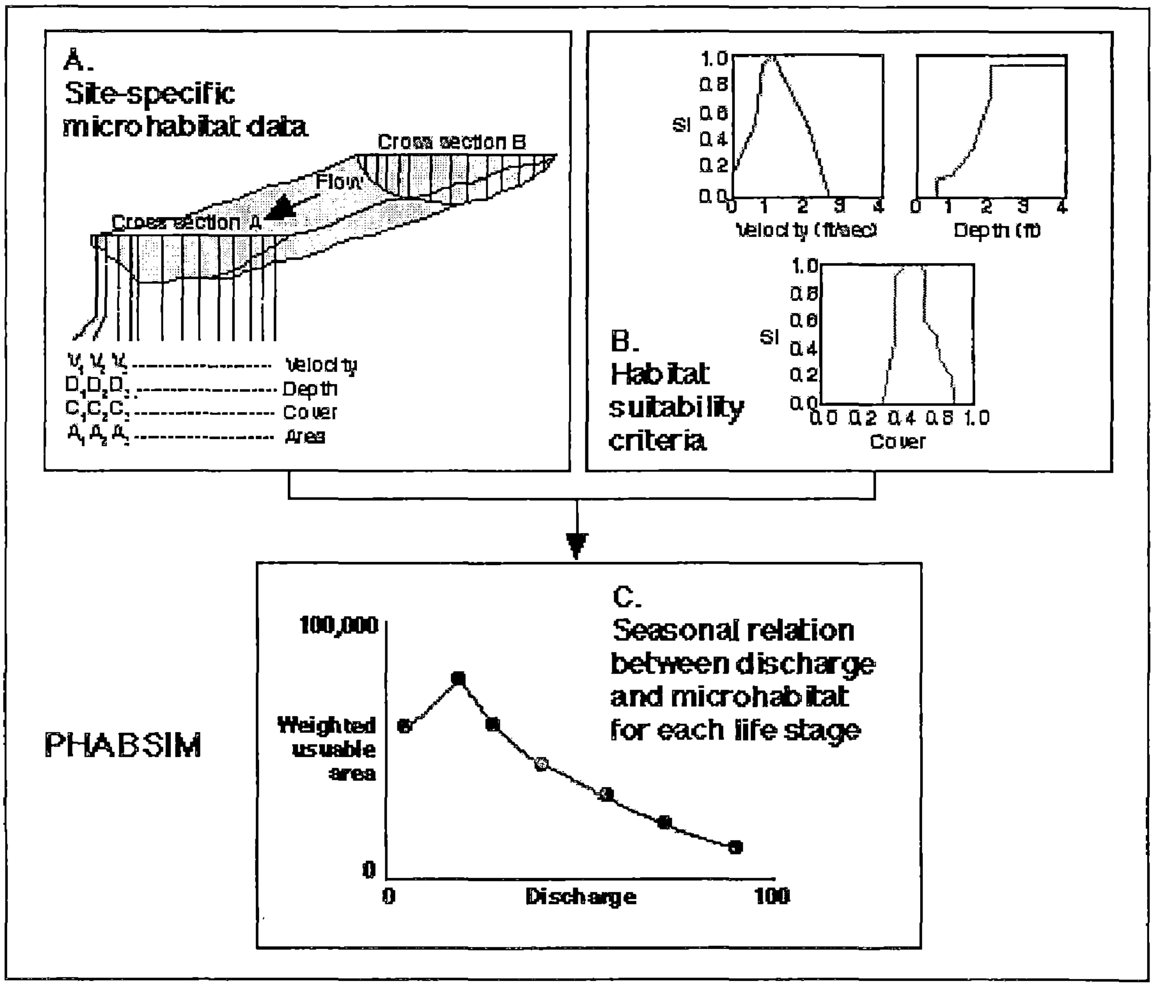
The procedure follows to obtain WUA curves is presented in schematic form, step by step, in figure 2.3.

(A) Site-specific microhabitat data.
Channel structure and hydraulic data are combined to predict depth (***Di***), velocity (*Vi*), cover conditions (*Ci*), and area (*A*i) for a given discharge using hydraulic simulation programs. Field measurements of depth, velocity, substrate material, and cover at specific sampling points on a cross section are taken at different flows. Hydraulic measurements, such as water surface elevations and water velocities are also collected during the field inventory to calibrate the hydraulic models and then predict depths and velocities at flows different from those measured.

(B) Suitability index (*SI*) criteria are used to weight the area of each cell for the discharge. The habitat values for all cells in the study reach are summed to obtain a single habitat value for the discharge.

(C) The procedure is repeated through a range of discharges to obtain the graph of Discharge vs. WUA.

Figure 2.3 Generation of PHABSIM Weighted Usable Area (WUA). Source: Bovee & Others, 1998.



The habitat component weights each stream cell using indices that assign a relative value between 0 and 1 for each habitat attribute indicating how suitable that attribute is for the life stage under consideration. These attribute indices are usually termed "habitat suitability indices" and are developed using direct observations of the attributes used most often by a life stage, by expert opinion about what the life requisites are, or by a combination. In the last step of the habitat component, the hydraulic estimates of depth and velocity at different flow levels are combined with the suitability values for those attributes to weight the area of each cell at the simulated flows. The weighted values for all cells are summed thus the term WUA is achieved.

There are many variations on the basic approach outlined above, with specific analyses tailored for different water management phenomena, or for special habitat needs. However, the fundamentals of hydraulic and habitat modeling remain the same, resulting in a WUA versus discharge function. This function should be combined with water availability to develop an idea of what life stages are impacted by a loss or gain of available habitat at what time of the year. Time series analysis plays this role, and also factors in any physical and institutional constraints on water management so that alternatives can be evaluated.

A limitation of this methodology is that modification of physical habitat by temperature and water quality is not included in primary PHABSIM analyzes therefore; these variables must be considered separately using water quality models such as EPA's QUAL-2 model for description of variations in water quality constituents.

(ii) IFIM:

Instream Flow Incremental Methodology (IFIM) is a decision-support system designed to help natural resources and their constituencies determine the benefits or consequences of different water management alternatives. It is used for solving water resources allocation problems that include concerns for riverine habitat resources (Bovee & Others, 1998).

IFIM is a process consisting of four interrelated activities or phases:

1. *Problem identification and diagnosis:* It consists of two main components: a legal and institutional analysis and identified concerns of the various stakeholders.
2. *Study planning:* It involves a comparison of information needs with information already available. Define appropriate models and data requirements.
3. *Study implementation:* It involves data collection, model calibration and verification of model input and output.
4. *Alternatives analysis/problem resolution:* All alternative solutions are examined for their effectiveness, physical feasibility, risk of failure and economic considerations. Problem resolution is accomplished through negotiation and compromise, based on the evaluation of competing alternatives.

One of the unique characteristics of IFIM is the simultaneous analysis of habitat variability over time and space. When IFIM is combined with PHABSIM, they produce a habitat time series that show how the fish habitat changes over time as a function of discharge. In the case of reservoir operation and water routing models; it is very useful because it allows numerous alternative water release schemes to be compared. Waddle (1992) demonstrated that releasing reservoir water as needed to provide fish habitat resulted in a more robust fish population than a constant minimum release of the same volume of water, due the natural water requirements of fish is not the same through out the year and is not the same at different stages of fish's life.

4. Holistic approach:

Holistic approach is actually frameworks that incorporate hydrological, hydraulic and habitat simulation models. They are the only Environmental Flow Methodologies (EFM) that explicitly adopts a holistic, ecosystem-based approach to environmental flow determinations.

These methods identify important flow events for all major components of river, model relationships between flow and ecological, geomorphologic and socioeconomic responses. It uses interdisciplinary team approach to establish recommended environmental-flow regime under different scenarios (De Freitas, 2008).

Holistic approach range from moderately to highly data intensive. It requires data from multiple river reaches/sites, historical flow records, numerous hydraulic variables across multiple cross-sections, and quantitative biophysical data/models of the flow and habitat requirements of all select biota and ecosystem components (IWMI, 2007).

EFM utilizes several tools from hydrological, hydraulic rating and habitat simulation methodologies, within a modular framework, for establishing EFR, and may also incorporate social (flow related ecosystem goods and services for dependent livelihoods) and economic data.

The most advanced holistic methodologies are applied in case of medium/large-scale; where water resources development is involving rivers with economically important fisheries or high conservation and/or strategic importance, and/or with complex, negotiated tradeoffs among water users (IWMI, 2007).

Some of these methodologies are:

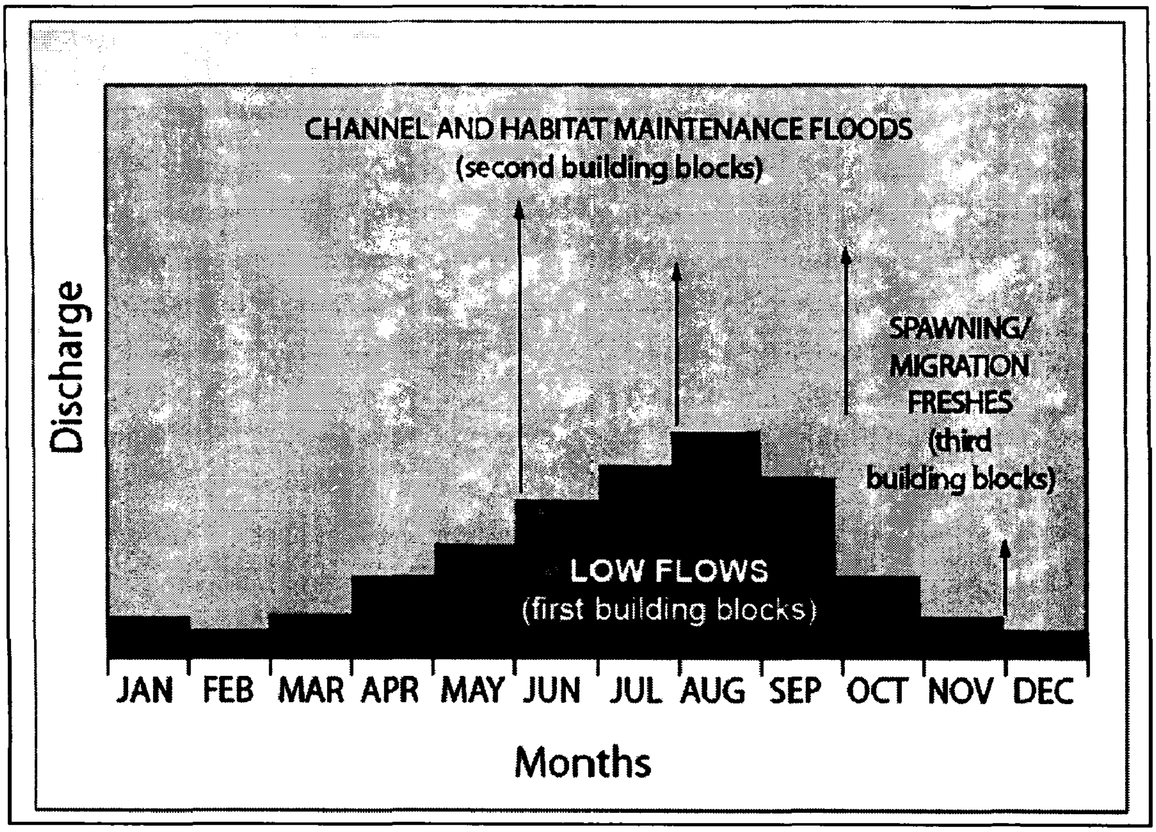
- Building Block Method (BBM).
- Experts Panel.
- Down Response to Imposed Flow Transformation (DRIFT).

(i) Building Block Method (BBM):

The objective of BBM is to determine ecologically acceptable, modified flow regimes for impounded rivers and other situations where flows are regulated (Arthington, 1998). An environmental flow regime is then constructed (month by month basis) through separate consideration of different components of the flow regime. Each component of flow being specified in terms of magnitude, time of year, duration and rate of rise and fall of flood flows. Each flow component is intended to achieve a particular ecological, geomorphological or water-quality objective (Brown & King, 2003).

In figure 3.4 is showing a hydrograph where different components of the natural flow were identified like: magnitude (amount of discharge), timing and duration (months of the year) and importance (relation of flow with river biota).

Figure 2.4 Modified flow regimen created by using BBM. Source: Brown & King, 2003.



In BBM, the major components of a river ecosystem, both physical (hydrology, physical habitat and chemical water quality) and biological (vegetation, fish and macro-invertebrates) are considered to achieve a particular "desire future state" also, considering the social and economic conditions of riparian people.

King & Louw (1998) summarized the assumptions of the methodology as follow:

- The biota associated with a river can cope with those low-flow conditions that naturally occur in it often, and may be reliant on higher flow conditions that naturally occur in it a certain time. This assumption reflects the thinking that the flows that are normal characteristics of a specific river, no matter how extreme, variable or unpredictable they may be, are ones to which the riverine species of a particular river are adapted and on which they may be reliant.
- Identification of what are felt to be the most important components of the natural flow regime and their incorporation as part of the modified flow regime will facilitate maintenance of the natural biota and natural functioning of the river.
- Certain kinds of flow influence channel geomorphology more than others. Identification of such flows and their incorporation into the modified flow regime will aid maintenance of natural channel structure and diversity of physical biotypes.

According with Tharme (2003) the strengths of the method are:

- It is relatively simple and rapid to apply, usually taking less than one year from initiation of background studies to provision or recommendations.
- The BBM involves a consistent, structured approach, employing a rigorous and explicit workshop process for development of flow recommendations based on the best scientific data available.
- It has the flexibility to incorporate all available physical and biological information about the river into the EFA.
- The BBM ensures that the modified flow regime of the regulated river will be characterized by the flow events having most influence on its fundamental character, even though part of the flow will be used for consumptive purposes (Arthintong, 1998).
- The BBM incorporates a monitoring program to assess the benefits of EF and make adjustments as more knowledge of the river's requirements becomes available from monitoring and research.

One of the main limitations of the methodology is that the concept of the desire future state is difficult and is not sufficient precise as a target for the construction of a modified flow regime.

The BBM is holistic, but issues such as water quality and the flow requirements of water-dependent wildlife require more development and stronger linkages into the methodology.

(ii) Expert Panels:

The family of expert-based methods described here has the common feature that they use an interdisciplinary team of experts to make judgment on the flow needs of different aquatic biota (Brown, 2006).

The composition of the panel will depend on the specific environmental and social features of the river in question, but typically includes a hydrologist, geologist, biologist and ecologist. In many cases, one or more community representatives will join the panel.

One objective of this method is to ensure direct communication of specialist knowledge from different fields and incorporated their judgments into river management recommendations (Arthington, 1998).

Its advantages are its rapidity, ability to effectively capture and integrate the knowledge of different experts and its flexibility. It does not rely on the existence of models, although models can be employed if available.

The main disadvantage is the results are site specific and non-reproducible, and therefore more open to challenge than traditional data-intensive/modeling approaches.

(iii) Down Response to Imposed Flow Transformation (DRIFT):

This is an interactive approach which describes in quantitative way a modified flow regime, the resulting condition of the river or species (whichever is being addressed), the effect on yield for offstream users and the direct economic cost and benefit of this issues (Brown & King, 2003).

DRIFT also uses data on cultural and subsistence use of the river to predict the socioeconomic implications of modifying river flows. It culminates in one or more multidisciplinary workshops that are designed to produce an agreed number of biophysical and socioeconomics scenarios.

DRIFT is essentially a system for managing data and knowledge in a structured way, following five main steps:

1. Identification and isolation of wet-season and dry-season low flows and small and large floods from the long-term hydrological records.
2. Description of the consequences for the river of partial or complete removal of each of these flow components.
3. Creation of a biophysical database detailing the consequences of flow alterations.
4. Use of the database to describe how river condition will change with any future combination of high and low flows.
5. Description of the socioeconomic implications of the change in river conditions. This, together with the previous steps, constitutes the creation of environment flow scenarios.

2.3 SELECTION OF APPROPIATE TECHNIQUE

The most important aspects to be considered in the selection of the appropriate technique are:

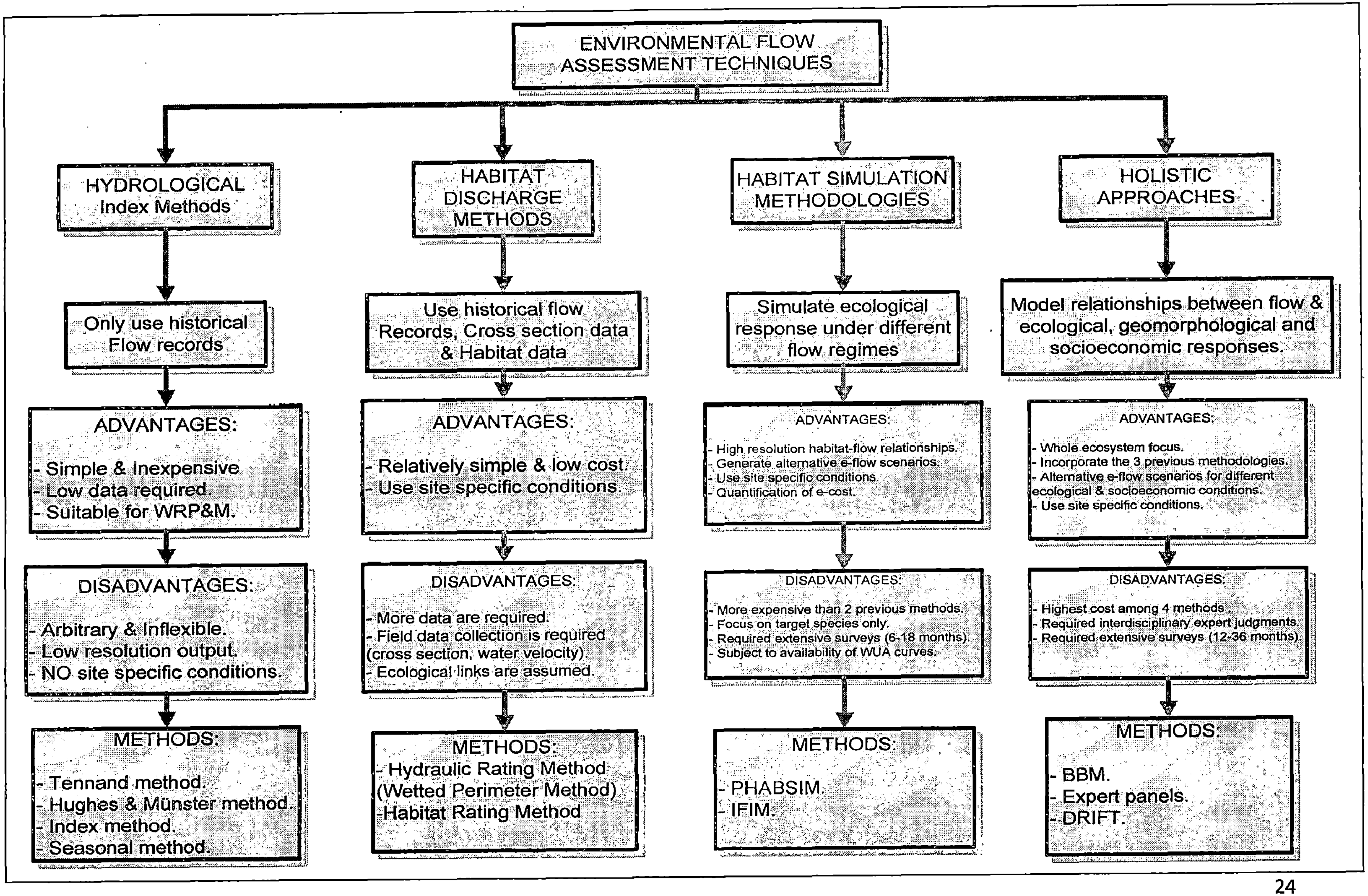
- Availability and quality of data.
- Location and extent of the study area.
- Prevailing time and financial constraints.
- Level of confidence required in the final output.

In general, a project-specific flow assessment for large or controversial projects, which are likely to call for considerable negotiation and tradeoffs between environment and development issues, require a more compressive approach than do flow assessment for coarse-scale planning, where a single number might suffice (Brown & King, 2003).

Most of the data and understanding required for interactive approaches (Habitat simulation and Holistic methodologies) have to be acquired on site by site basis, considerably adding to the time, funding and expertise required for a flow assessment. Probably because of this, most applications have used prescriptive approaches (Hydrological and Hydraulic methodologies).

Figure 2.5 shows a summary of different methodologies already explained with main advantages and disadvantages for each methodology.

Figure 2.5 Diagram of basic methodologies to Environmental Flow Assessment (EFA)



CHAPTER III

FISHERIES IN HIMALAYAN RIVERS AND ITS HYDROLOGYCAL REQUIREMENTS

3.1 RIVER ECOSYSTEM

The river ecosystem is formed by the interaction between river biota and their hydro-geochemical environment. The organisms living in the river are dependent on the transport of organic and inorganic matter from the land areas of the drainage basin to the river and from there, downstream with the flowing water. The vegetation, soil composition and topography of drainage basin influence the amount of water runoff and both, the composition and quantity of organic matter that enters streams and lakes. Nutrients transported to the river are essential for river biota, especially to macrophytes and to some extend to fungi and bacteria (NOREC, 2005).

Human pollution and modifications of the environment and climate are now so pervasive that no aquatic ecosystem of the biosphere is unaltered in some manner by these disturbances hence; one cannot study river ecosystems without consideration of human influences (Wetzel, 2001).

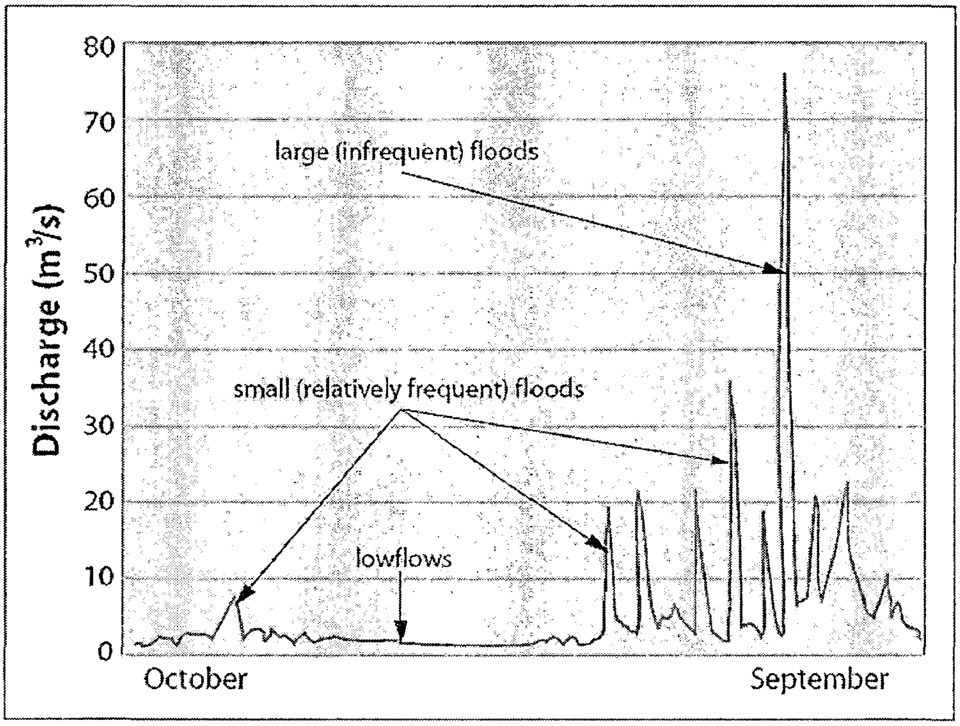
3.2 RIVER FLOWS

Flow consists of five components: magnitude, frequency, duration, timing and rate of change. The flow in rivers varies throughout a year and between years. This pattern of flow (termed flow regime) typically consist of low flows during the drier months, small flows when rains return and occasional large floods in unregulated rivers, like is shown if figure 3.1.

- *Low flows:* this occurs every year and move varied in the wet season than in the dry season and defines whether the river flows all year. The delayed flow that reaches a stream essentially as groundwater flow is also called base flow. In the annual hydrograph of a perennial stream the base flow is easily recognized as the slowly decreasing flow of the stream in rainless periods (Subramanya, 2008).

- *Small floods:* they are small in size, (as compared with high floods) a few number per year and they have a small period of time (days or weeks).
- *Large floods:* they are infrequently and the timing is very short (hours or days).

Figure 3.1 Typical Annual Hydrograph of daily flows in a river. Source: Brown & King, 2003.



Different types of flows with different amount of discharge are spread through dry and wet seasons. This fact plays a very important issue in the interaction of river flow with the surrounded ecosystem.

3.3 IMPORTANCE OF FLOWS

Nowadays, the flows of the world's river are increasing being modified through impoundments such as dams and weirs, abstractions for agriculture, industrial and domestic supply, hydropower, drainage return flows and structures for flood control (Brown & King, 2003).

These interventions have had significant impacts, reducing the total flow of many rivers and affecting both; the seasonality of flows and the size and frequency of floods. For example, not only the velocity and volume of flow are critical for fish, but that the timing of the flow events is equally important. In many cases, these modifications have adversely affected the river ecosystem, including the people living in the river banks (Brown & King, 2003 & Welcomme, 2001).

The river ecosystem includes both the channel and the floodplain. Regulations of river flows reduce or eliminate the linkage between the river and its floodplain margins.

It is important to recognize the importance of different flows in the river ecosystem. According with Brown; flows is needed for:

- Flows in general, are required to maintain river flow conditions like flow velocity, water depth and acceptable turbidity levels, making it possible for the river purify it self (dilution of effluents and waterwaste).
- Low flows supported livehoods (people which use the river for drinking water, wash clothes and dishes, take a bath, fishing, recreation and tourism, etc).
- Sustaining both terrestrial and aquatic ecosystem: for example, low flow provides water to wild animals and invertebrates. Small flows are required to maintain soil-moisture in the banks and support riparian vegetation. Small floods stimulate spawning in fish and allow passage for migratory fish and germination of seeds on river banks. Large floods deposits nutrients on the banks and distribute seeds.
- Large floods recharging groundwater and aquifers which maintain the perennial nature of rivers acting as source of water during dry season.
- Facility navigation: large floods that flush sediments and natural obstructions in the river course and maintain a sufficient deep channel for navigation.
- Preserving estuarine conditions: low flows maintain the required salt-freshwater balance and prevented the incursion of salinity. Large floods maintain links between river and ocean by scouring estuaries.
- From social point of view, flows enabling the river to play its role in the cultural and spiritual live of the people. This is very important in India context. Some religious festivals reduced flows in quality and quantity.

Identification of these flow components and the understanding the ecosystem consequences of their loss or modification are one of the main objectives of Environmental Flow Assessment (EFA).

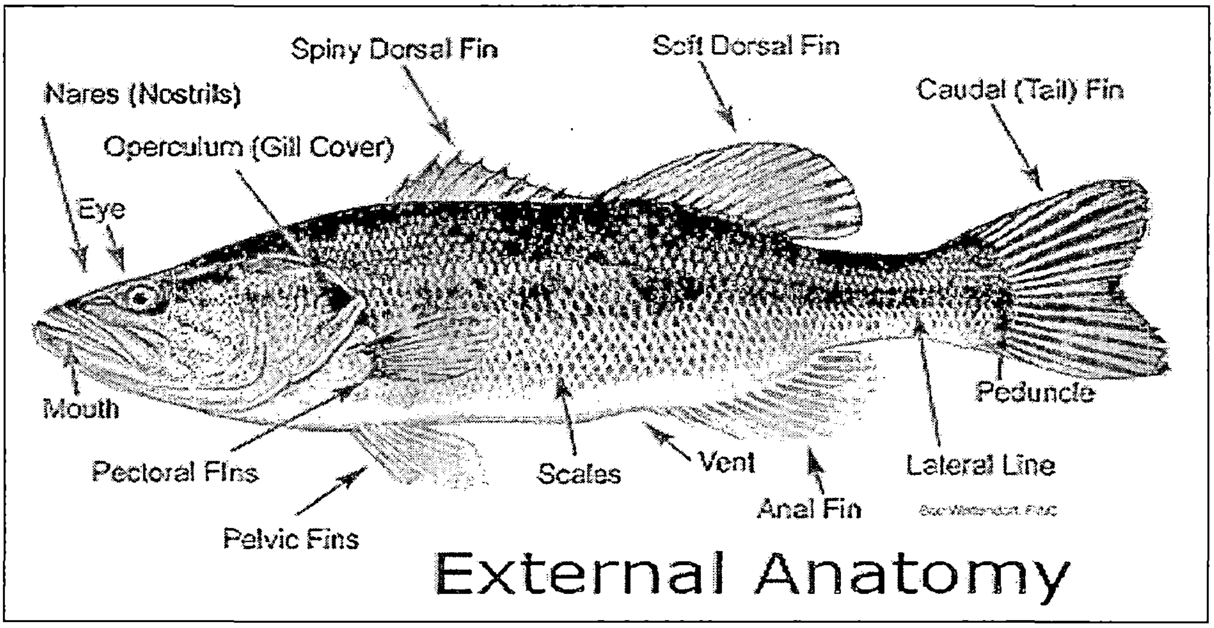
3.4 FRESHWATER FISHES

Ecology components in a river are huge and it is practically impossible to address the impact of flow modification on all the elements in the river ecosystem. Therefore, different techniques for assessing environmental flows are focused on a target species, commonly fish species.

Freshwater fishes are an extremely diverse group (41% of all known species of fish are found in freshwater) that occupies a wide range of habitat types. Freshwater fish are fish that spend some or all of their lives in freshwater, such as rivers and lakes, with a salinity less than 3000 mg/L. Many species of fish do reproduce in freshwater, but spend most of their adult lives in the sea. These are known as anadromous fish (salmon and trout) that have different tolerances in salinity in different stages of their lives and they become a migratory species (Wikipedia, 2009).

Most fish anatomy has similar characteristics: scales, fins and gills. In figure 3.2 is presented a general external anatomy of fish provided by Florida Fish & Wildlife Conservation Commission (FWC, 2009).

Figure 3.2 External Fish Anatomy. Source: FWC, 2009.



- *Scales:* A fish's outer body is normally covered by scales although there are fish that are called "naked fish" as they have no covering of scales, an example of this would be a catfish. Fish scales are composed of connective tissue covered with calcium. Most fishes also have a very important mucus layer covering the body that helps prevent infection.

- *Fins:* Fins are appendages used by the fish to maintain its position, move, steer and stop. The dorsal and anal fins primarily help fish to not roll over onto their sides. The caudal fin is the main fin for propulsion to move the fish forward. The paired fins assist with steering, stopping and hovering.
- *Gills:* The gills are a respiratory organ for extracting oxygen from water; fish use their gills to breathe. The gills are protected by a bony plate called an operculum water is "inhaled" via the fish's mouth, passed through the gills and "exhaled" through the operculum.
- *Vent:* An external opening, used by the fish to remove its digestive and urinary waste, as well as its reproductive tracts, usually found immediately in front of the anal fin.
- *Eyes and Nostrils:* Fish see through their eyes and can detect colour. The eyes are rounder in fish than mammals because of the refractive index of water and focus is achieved by moving the lens in and out, not distorting it as in mammals. Paired nostrils, or "nares", in fish are used to detect odors in water and can be quite sensitive. Eels and catfish have particularly well developed senses of smell.

Freshwater fish can be grouped roughly into cold and warm water species. Example of cold water species are: all members of *salmonidae* family (charr, trout, salmon), ide, dace, stone loach, river lamprey, brook lamprey, burbot, stickebacks and bullheads. The suitable range of water temperature for these species lies between 12 °C and 19 °C. In the case of warm water species, water temperature range lies between 19 °C and 28 °C and examples of these species are: cyprinids, bluegill, eel, pike-perch, perch, black crapie and ruff (NOREC, 2005).

3.5 WATER QUALITY REQUIREMENTS OF FISH

Water quality has physical, chemical and biological characteristics. Water quality shows spatial, seasonal and diurnal variations. There is also pronounced spatial and temporal variation in the water quality of rivers due to transport of substances downstream. Fish have adapted to these natural variations, but when human actions speed up these natural variations or bring foreign substances in the water, fish may not adapted and the first harmful effect can be seen in weakened of fish reproduction (NOREC, 2005).

Next table summarizes main water quality parameters and gives ranges and limits for those parameters related to fish survival.

Table 3.1 Summary of Water Quality Requirements for fishes. Source: CPCB, 2008; NLWRA, 2008; NRB state of Vermont, 2008; NRMMC, 2000.

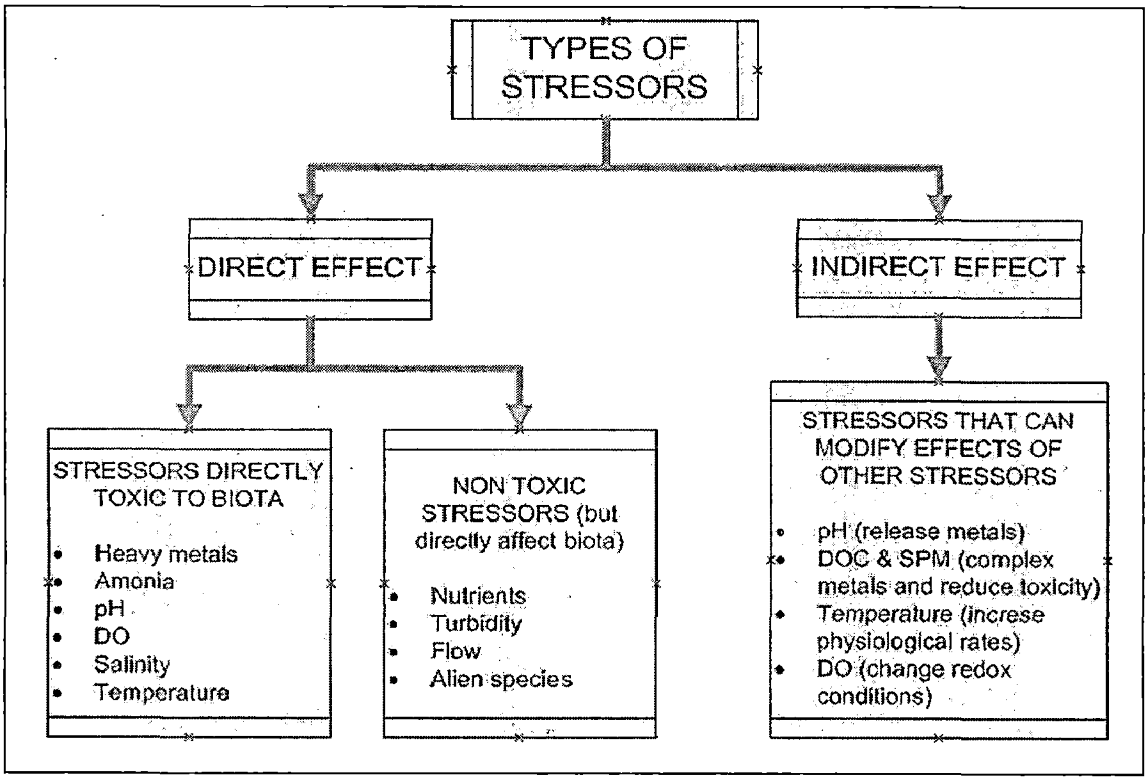
Water Quality Component	Parameters	Main Sources of Pollution	Acceptable values for fishes
PHYSICAL	Temperature	Exposure to sun, Industrial waste	Cold water species: ≥ 12 °C ≤ 19 °C
			Warm water species: ≥ 19 °C ≤ 28 °C
	Turbidity	Soil erosion, Eutrophication	≤ 10 NTU
	Suspend particulate matter (SPM)	Soil erosion, Agriculture, Construction & Urbanization	≤ 25 mg/L
CHEMICAL	Dissolved Oxygen (DO)	Photosynthesis, Dissolved from the air	≥ 3 mg/L
	Carbon Dioxide (CO_2)	Photosynthesis, Decomposition organic matter	≥ 1 mg/L & ≤ 20 mg/L
	pH	Sulphide soil runoff, High CO_2 concentration	≥ 6 and ≤ 9
	Salinity	Rock decomposition, wind, rain, groundwater	< 3000 mg/L
	Nitrates	Agriculture runoff, sewage, decomposition organic matter	≤ 0.2 mg/L
	Phosphates		≤ 0.01 mg/L
	Heavy Metals	Natural rock decomposition, mining	See Table 3.3
BIOLOGICAL	Bacteria, Viruses, Protozoa & Parasitic	Sewage and Animal waste	Cold water species: BOD ≤ 3 mg/L
			Warm water species: BOD ≤ 6 mg/L

Two types of physical and chemical stressors that directly affect aquatic ecosystems can be distinguished: those that are directly toxic to biota and those that, while not directly toxic, can result in adverse changes to the ecosystem. For example, organic matter decays process, which can significantly reduce the Dissolved Oxygen (DO) concentration and cause (indirectly) death of aquatic organisms, particularly fish (NRMMC, 2000).

- *Direct effects:* Toxic direct-effect stressors to biota are: salinity, pH and temperature, heavy metals and DO are naturally variable among and within ecosystem types and seasonally, natural biological communities are adapted to the site-specific conditions and non-toxic direct-effect stressors to biota are: nutrients, suspended particulate matter and water flow.

- *Indirect effects:* Indirect stressors are those that, while not directly affecting the biota, can affect other stressors making them more or less toxic. For example, DO can influence redox conditions and influence the uptake or release of nutrients by sediments. Equally, pH, dissolved organic carbon and suspended particulate matter (SPM) can have a major effect on the bioavailable concentrations of most heavy metals (NRMMC, 2000).

Figure 3.3 Types of physical and chemical stressors in water quality. Source: NRMMC, 2000.



Biological water stressors refer to a living organism in water such as bacteria, viruses, algae, protozoa and crustaceans. Bacteria and protozoa are the major groups of microorganisms which have a major role in carbon and nutrient cycling (Hammer, 2004).

Biochemical Oxygen Demand (BOD) is the most common used parameter to define quality in waters. BOD is by definition the quantity of oxygen utilized by a mixed population of microorganisms in the aerobic oxidation and standard values are given after 5 days incubation at 20°C in units of mg/L.

A coliform bacteria is an indicator of presence of pathogenic bacteria in water and is considered a feasible method for determining microbiological water quality, especially for drinking and recreational purposes. *Total coliforms* in laboratory testing refer to all coliform bacteria from feces, soil or other origin. The term *fecal coliforms* refer to coliform bacteria originating from human or warm-blooded animal feces and it is reported as the Most Probable Number (MPN) based on tabulated probability tables and expressed as MPN index/ 100 ml. (Hammer, 2004).

The organic pollution measured in terms of BOD and coliform count gives the indication of extent of water quality degradation. The water quality monitoring given by Central Pollution Control Board of India, indicates that organic pollution is predominant and almost all the surface water sources are contaminated to some extend by Coliform Group of Bacteria that make them unfit for human consumption unless disinfected. Some reference values are given in table 3.2 for different water uses (Bhardwaj, 2005).

Table 3.2 Biological water stressors for different water use. Source: Bhardwaj, 2005.

	WATER USE		
BIOLOGICAL WATER STRESSORS	**Drinking**	**Bathing and Swimming**	**Wild life and fisheries**
BOD at 5 days, 20°C (mg/L)	< 2	< 3	< 3
Total Coliform (MPN/100ml)	< 50	< 500	< 1000

The most important physical water stressors for fisheries survivor are water temperature, turbidity and SPM. A brief explanation of these stressors and their interaction with biota is explained as follow:

- *Water temperature*

  Water temperature has a direct effect in the amount of dissolved oxygen in water, the rate of photosynthesis by algae and aquatic plants and the metabolic rate of most stream organism. When the temperature rises, the rate of metabolism usually increases, therefore stream organisms need more food and oxygen, but when water temperature falls, the rate of metabolism decreases. Fish select habitats where the water temperature is suitable for them. In spring, fish may move to warmer littoral waters to feed. When the temperature increases further, they usually move to the middle of the lakes or into deeper, cooler waters (NOREC, 2005).

Rapid changes in water temperature are harmful to fish. They can paralyze both respiration and the heart and stop digestion. Juveniles are more vulnerable than adults, and to them, rapid changes of 1.5 °C to 3 °C are harmful. A sudden increase in temperature destroys the eggs. Changes in water temperature can affect spawning times and length of incubation.

- *Turbidity*

  Turbidity is a visual property of water. It is the measure of light scattering properties of water given in nephelometric turbidity units (NTU) and it depends on the amount, size and composition of the suspended material which include: sediments (particulate mineral matter like clays, carbonates and silicates), organic matter, inorganic components, algae, plankton and other microscope organisms like microbes and viruses (EPA, 2006; NLWRA, 2008 & Wetzel, 2001).

Transparency (or clarity) is a measure of how clear or transparent the water is and it is usually measured as Secchi depth and depends on both colour and light scattering (NLWRA, 2008).

Higher turbidity increases water temperatures because suspended particles absorb more heat. Higher turbidity also reduces the amount of light penetrating the water. Some fish are unable to survive without this light (ThinkQuest, 2005).

- *Suspended particulate matter (SPM)*

  SPM refer to the mass of the suspended matter and it's measured as mg/L. A soil surface removal, destroying the vegetation and natural soil cover, ditching, all those are actions that increase particulate matter concentrations in water systems. Also eutrophication increases the amount of organic particulate matter, consequently increasing siltation of the river bed.

Sedimentation of particulate mineral matter on riverbeds reduces the number of suitable feeding habitat, created abrasion on fish gills (leading to infection) and ultimately fills in the gravel areas needed for spawning. SPM concentrations also affect the amount and quality of food available to the fish and it can be extremely harmful to the eggs of fish that spawn and benthic macroinvertebrades.

According to the Europe Union Fish Water Directive, the recommended particulate matter concentration is less than 25 mg/l in inland waters. These concentrations are not detrimental to fish stocks or to fishing. A concentration of

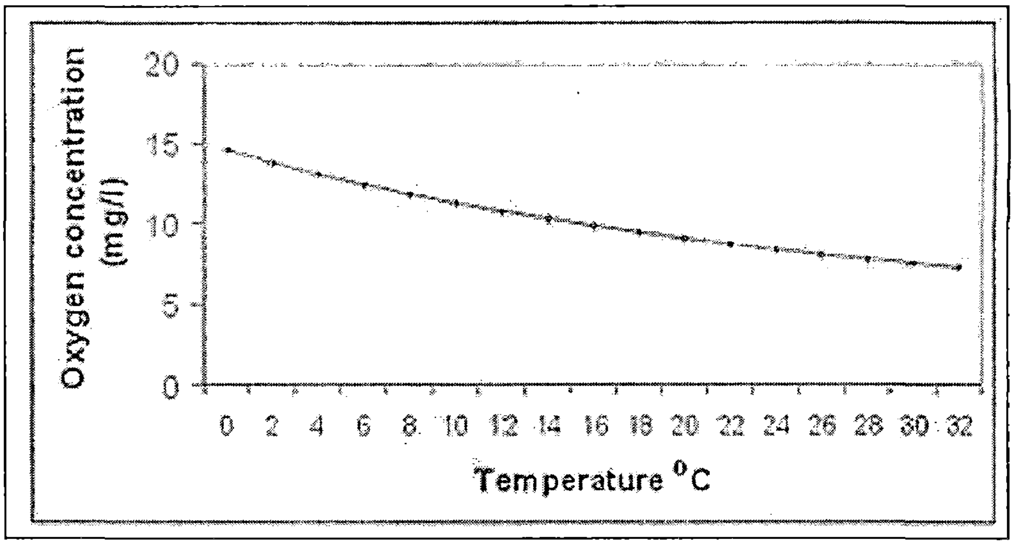
25–80 mg/l can affect fish stocks, and when the concentration is higher than 80 mg/l, changes occur in the stocks (NOREC, 2005).

The principal chemical water stressors are dissolved oxygen, carbon dioxide, acidity (pH), salinity, nutrients and heavy metals.

- *Dissolved Oxygen (DO)*

  Oxygen enters water through photosynthesis and by dissolving from the air. Oxygen is needed for respiration and the bacterial decomposition of organic matter. Oxygen is measured in its dissolved form as Dissolved Oxygen (DO) in units of mg/l. If more oxygen is consumed than is produced, DO levels decline and some sensitive animals may move away, weaken or die. DO levels fluctuate seasonally and over 24 hours. They vary with water temperature and altitude. DO concentrations decrease within increasing in water temperature, like is shown in figure 3.4. Cold water holds more oxygen than warm water and water hold less oxygen at higher altitudes (NOREC, 2005 & EPA, 2006).

Figure 3.4 Concentration of DO at different temperatures at 1 atmospheric pressure. Source: NOREC, 2005.



Fish species that favour cold waters also need high oxygen concentrations; for example, the optimal concentration of DO in *salmonidae*, minnow, stone loach and bullheads is 8–10 mg/l. The first symptoms of suffocation appear in concentrations of 3 mg/l. In the case of warm water species, they can survive in waters with lower concentrations of DO, like cyprinids, pike, lamprey, burbot, sticklebacks and perchids, which a sufficient oxygen concentration is 6–8 mg/l. The first symptoms of lack of oxygen appear in concentrations of 1.5–3 mg/l.

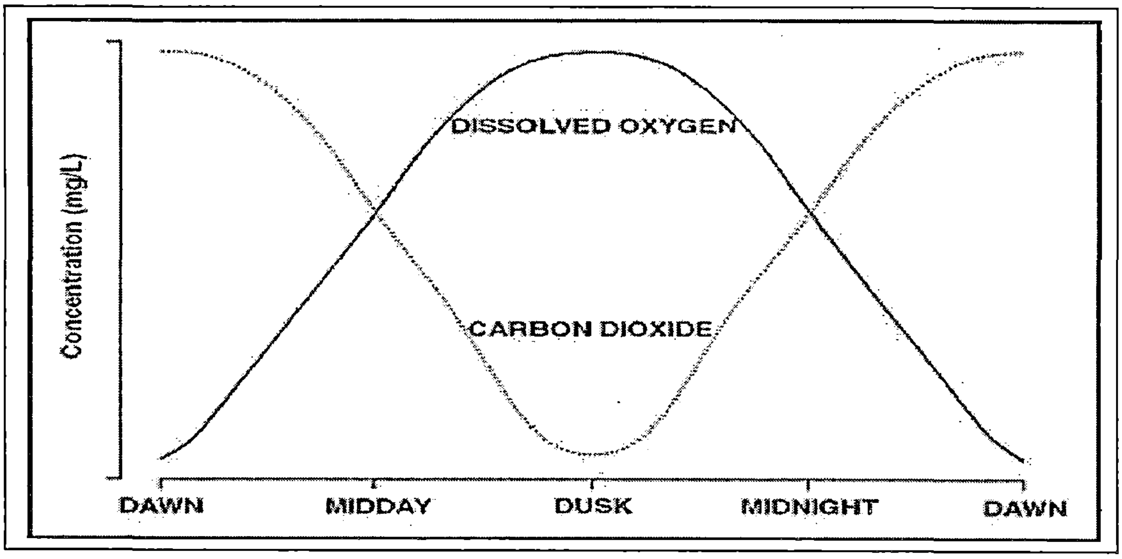
- *Carbon dioxide (CO_2)*

The toxicity of carbon dioxide affects fish either directly by hindering respiration or indirectly by regulating water acidity (pH). Carbon dioxide concentration affects fish respiration. A high concentration of carbon dioxide (20 mg/l) in water hinders the diffusion of carbon dioxide from blood into water through the gills. This may result in an increased carbon dioxide concentration in the blood, which can cause acidosis in fish. A too low carbon dioxide concentration (less than 1 mg/l) in water may increase the diffusion of carbon dioxide from fish into water, which increases the pH value of the blood and tissues of the fish (NOREC, 2005).

In fish ponds like a reservoirs or lakes, the primary sources of CO_2 are derived from respiration by fish, microscopic plants and animals that comprise the fish pond biota. Decomposition of organic matter is also a major source of CO_2 (Hargreaves & Brunson, 1996).

During the day, DO increases due the photosynthesis of algae and other aquatic plants which use sun light and CO_2 during this process. At night, photosynthesis ceases and the respiration of pond organisms consume DO and releases CO_2 therefore, CO_2 concentrations are highest when DO concentrations are lowest, producing the characteristic daily fluctuation of oxygen and carbon dioxide, like is represented in figure 3.5.

Figure 3.5 Daily cycles of oxygen and dioxide in a fish pond. Source: Hargreaves & Brunson, 1996.



- *Acidity (pH value)*

  The pH value is an indicator of the acid or alkaline condition of water. The pH scale ranges from 0-14 and this scale measures the logarithmic concentration of hydrogen (H+) and hydroxide (OH-) ions, which make up water (H+ + OH- = H_2O). When both types of ions are in equal concentration, the pH is 7.0 or neutral. Water with a pH value less than 7 indicates acidity (more hydrogen ions than hydroxide ions), while water with a value greater than 7 indicates alkalinity (more hydroxide ions than hydrogen ions) (EPA, 2006).

  Tolerance to acidity depends on the development stages of fishes; newly hatched juveniles are usually most sensitive to low pH values, while eggs and adults can tolerate acid environment better. Also, the tolerance to pH values depends on the calcium, aluminium and iron concentrations of water (NOREC, 2005).

  Measurement of pH can be used to estimate CO_2 concentrations because CO_2 is one of the principal causes of acidity in water. As CO_2 is added during the night pH will decline and conversely, when CO2 is removed during the day, pH increases (Hargreaves & Brunson, 1996).

  A low pH value (5 or lower) affects the reproduction of fish. For all fish species, a pH value of 4 is usually lethal. Acidity also has indirect effects on fish, for example acidity increases the toxicity of hydrogen sulphide, cyanide and heavy metals. The Europe Union Fish Water Directive recommends a pH value of 6–9 for both *cyprinid* and *salmonidae* waters.

  Alkalinity waters (high pH values) can occur in eutrophic waters, where photosynthesis consumes the free carbon dioxide of water. A pH value greater than 10.8 can be lethal.

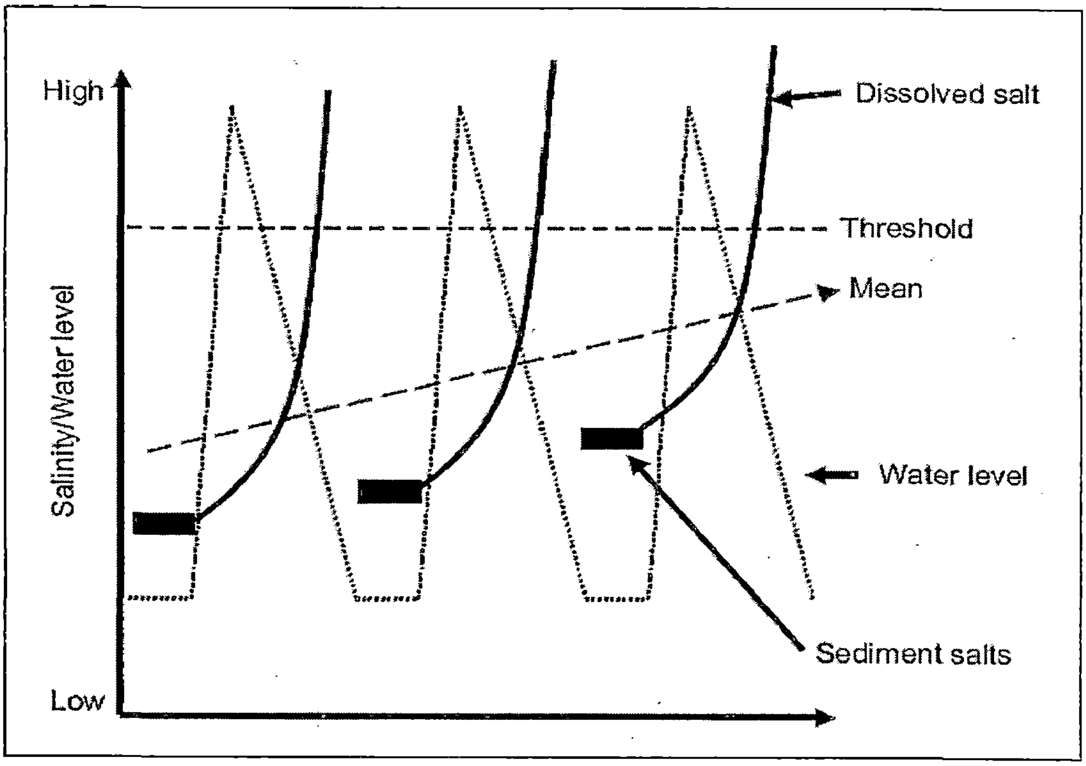
- *Salinity*

  Salt is a natural component of different type of soils. Salt enters aquatic system from groundwater, terrestrial material via weathering of rocks or from the atmosphere, transported by wind or rain. Under natural flow conditions in many wetlands and rivers, during low flow periods, evaporation combined with intrusion of groundwater often caused high natural salinity levels. During these periods of low flow-high salinity, biota that could not readily disperse managed to survive either with little or no reproduction and recruitment. Biota that is unable to tolerate these periods either perish or disperse to recolonise when more favourable conditions occur (Nielsen & others, 2003).

In regulated rivers where modification of temporal and spatial flows occurs, the reduction in the frequency of high-flows (flushing) events is causing an accumulation of salt in this river system and a gradual increase in the mean salt concentration over time. Most adult fish are tolerant of increasing salinity, but juveniles and eggs of some species are susceptible.

In figure 3.6 is showing the relation between flow regime and accumulation o salt in wetlands. Solid line indicates the variation in salinity over time. Dotted line indicates the variation in water level over time. Small-dashed line indicates biotic threshold level above which loss of taxa will occur, while large-dashed line indicates mean salinity over time. Solid rectangle indicates the accumulation of salt in the sediments as a consequence of reduced flushing.

Figure 3.6 Relation between flow regime and salt accumulation. Source: Nielsen and others, 2003).



- *Nutrients*

  Phosphorus and nitrogen are the most common nutrients. Sources of these nutrients include animal wastes, agricultural runoff, and sewage. A slight increase in nutrient concentrations usually enriches the species abundance of fish stocks and increases production, but as eutrophication intensifies, the number of species begins to diminish (ThinkQuest, 2005).

  Eutrophication occurs when large quantities of nutrients (mainly nitrates and phosphates) enter an aquatic environment. The ecosystem quickly experiences an increase in photosynthetic and blue-green algae, prohibiting light from penetrating deeper areas of lake or stream.

  Another problem related with Eutrophication is the incremental in Biochemical Oxygen Demand (BOD). This is important because it affects the amount of dissolved oxygen (DO) available to all species in an aquatic ecosystem. A higher BOD indicates a lower level of DO. This lower concentration of oxygen causes many fish to suffocate, and as they die.

- *Heavy metals*

  The toxic effect of several metals is based on their ability to attach to amino acids and to the SH-group of proteins in fish tissues, which results in their acting as enzyme toxicants. Metals also cause a toxic effect when the surface active free cations attach to the surface of the gills, hindering gas exchange and respiration. Metals are extremely toxic in the early life stages of fish (NOREC, 2005).

  Heavy metals include: Mercury (Hg), Arsenic (As), Chromium (Cr), Cadmium (Cd), Lead (Pb), Copper (Cu), Nickel (Ni), Zinc (Zn), and Iron (Fe). High pH values and high concentrations of calcium and electrolytes in water reduce the toxic effects of several metals on fish like is showed in table 3.3

Table 3.3 Safe concentrations of metal in waters. Source: NOREC, 2005.

METAL	MAX SAFE CONCENTRATIONS	REMARKS
Aluminium (Al)	< 0,04 mg/L, when pH is less than 6,5	Toxicity is reduced by the amount of dissolved organic carbon.
	< 0,1 mg/L, when pH is higher than 6,5	Toxicity is increased by sudden changes in pH.
Chrome III (Cr)	< 0,02 - 0,075 mg/L	
Chrome IV (Cr)	< 0,35 - 0,70 mg/L	
Iron II (Fe)	< 0,1 mg/L for salmonids	Toxicity is reduced by a high concentration of DO.
	< 0,2 mg/L for cyprinids	
Nickel (Ni)	< 0,025 mg/L	
Copper (Cu)	< 0,005 mg/L	
Zink (Zn)	< 0,03 mg/L for salmonids	
	< 0,3 mg/L for cyprinids	
Arsenic (As)	< 0,05 mg/L	
Cadmium (Cd)	< 0,0002 mg/L for salmonids	Toxicity is reduced by high concentrations of magnesium.
	< 0,001 mg/L for cyprinids	
Mercury (Hg), inorganic	< 0,001 mg/L for salmonids	
	< 0,002 mg/L for cyprinids	
Mercury (Hg), organic	< 0,0003 mg/L	
Lead (Pb)	< 0,001 - 0,008 mg/L for salmonids	Toxicity is reduced by high concentrations of magnesium.
	< 0,07 mg/L for cyprinids	

- *Other Pollutants*

  Water pollution can be defined as "any biological, chemical, or physical change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses (ThinkQuest, 2005).

  Other common pollutants in water not mentioned above are: solid waste (paper, plastic, textiles rubbers and garbage), radioactive material, pesticides (like Gama BHC known as Lindane, Carboril known as Carbamat and Malathion), herbicides, insecticides, fungicides, petroleum hydrocarbons, fats, grease and oils.

3.6 OTHER HABITAT REQUIREMENTS FOR FRESHWATER FISHES

Habitat quality affects health of individual fishes and fish populations. Changes in habitat will usually result in changes to the species composition of a fish community. In degraded habitats, only very tolerant species can survive, therefore, a river habitat with high fish diversity is a synonymous of "good" habitat quality.

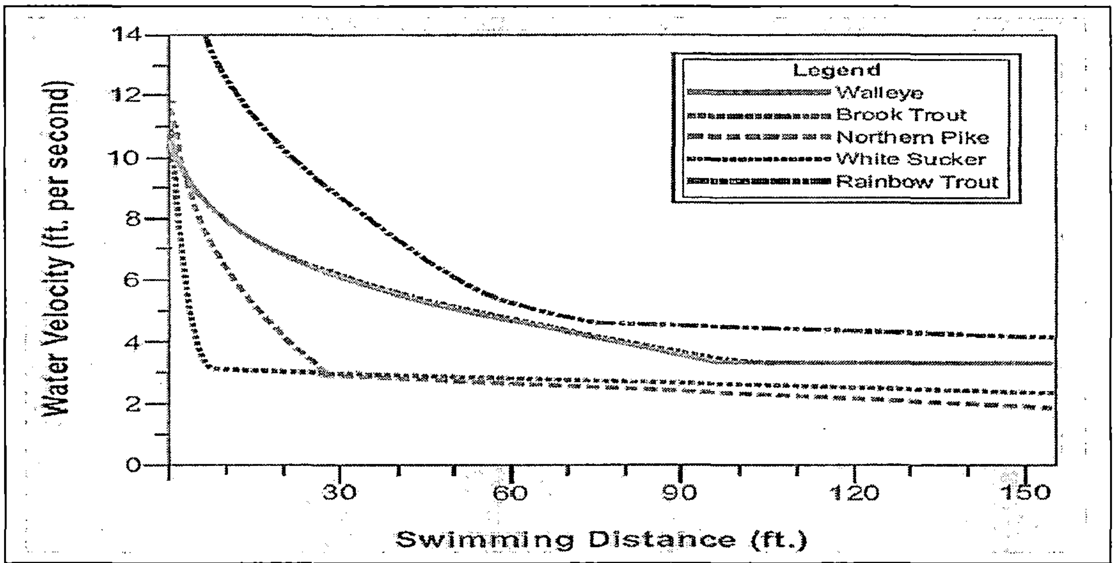
A "good" fish habitat must contain all the physical, chemical and biological features needed to complete its life cycle. This may include a variety of parameters such as water temperature, dissolved oxygen levels, pH, turbidity, depth, water velocity, inorganic nutrient levels, riparian vegetation and accessibility to migration routes and floodplain areas (Morrow & Fischenich, 2000).

- *Water Velocity*

  Fishes occupy habitats ranging from waterfalls to stagnant pools. Water velocity preferences vary among the species, thus a diversity of water velocity is generally desirable for fish habitat. Spatially uniform velocities characterized relatively poor fish habitat. In regulated rivers with flow velocities that vary from zero to very high on a daily or hourly basis can be extremely detrimental to fish communities.

  Fishes can swim with amazing bursts of speed, they maybe unable to sustain this speed in high velocity waters over long distances. Swimming speeds vary with the species, size and life stage of fish. In figure 3.7 is given a relationship between water velocity and swimming distances for different fish species (Haack, 2008).

Figure 3.7 Limiting flow velocities for different fish-species. Source: Haack, 2008.



- *Water depth*

  Optimal depth is varying at different life stages of fish species. Some species require shallow areas and some required deep areas thus, in a healthy fish habitat; a wide range of depth is required.

  A minimum water depth during low-flow dry periods is required. The depth must be adequate for fish to be completely immersed and no scrapping bottom. Haack, recommended a six-inch (15,2 cm) minimum water depth for fish passages like a culverts or fish ladders.

- *Instream cover*

  Instream cover, usually in the form of boulders or large debris, can provide habitat for invertebrates, velocity refuges, hiding places for predators and attachment sites for adhesive fish eggs. Because depth and velocity of flow are closely related to certain types of cover features, maximizing cover often increases diversity in depth and velocity.

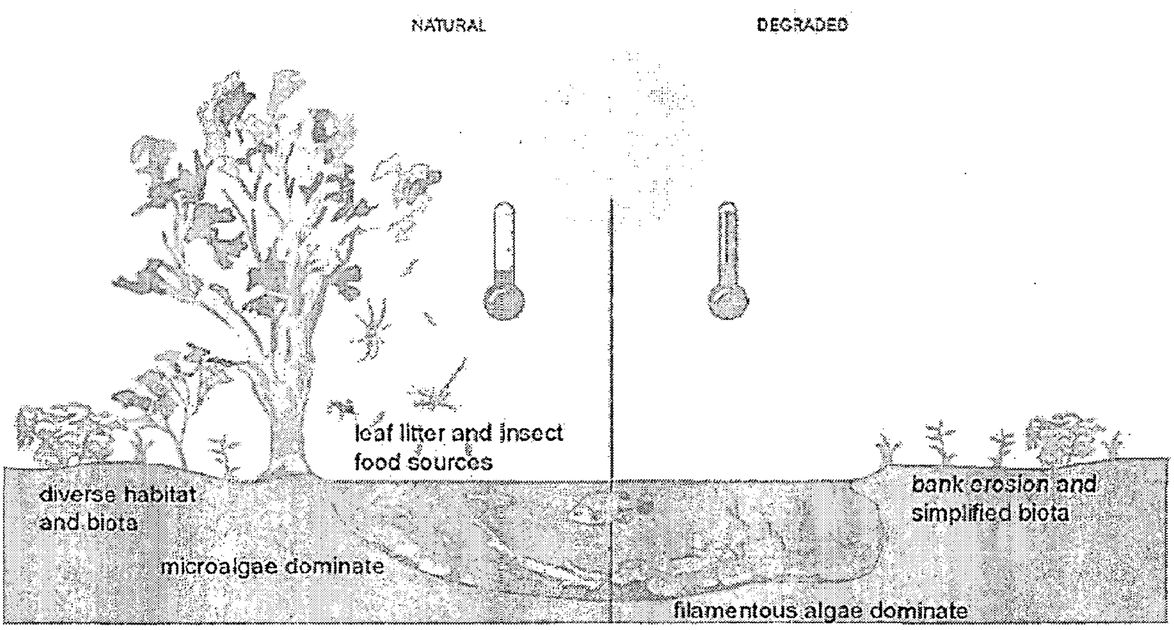
- *Substrate size*

  As a general rule, substrate size decreases with increasing stream order, with substrate in the largest river usually consisting of sand, silt and clays. Many fishes, including some culturally and economically important species, can not reproduce successfully unless gravel or large substrate is available. Thus, gravel and larger substrates are often very important habitat components.

- *Riparian vegetation*

  Riparian vegetation is very important for the health of many river ecosystems. Riparian vegetation increases bank stability, reduces sedimentation, reduces summer water temperatures and increased recruitment of large woody debris. Deposition of leaves and other organic matter from riparian vegetation is an important source of nutrients (Morrow & Fischenich, 2000). Figure 3.8 highlights the main consequences of loss of riparian vegetation.

Figure 3.8 Effects of riparian vegetation removal. Source: NLWRA, 2008.



- *Floodplain habitat*
  Many fish species require floodplains habitats for successful reproduction and some utilize floodplains during all phases of their life cycles. Healthy floodplains serve as nutrient and sediment sink resulting in improved water quality in the stream. Clearing floodplain habitat for agricultural or city's construction causes excessive sedimentation and turbidity, excessive nutrient inflows and these factors reduce water quality and habitat for fishes.

- *Accessibility for migration route*
  Migratory fish species are often among the most economic and culturally important species in lotic habitats. The most common structures that impede upstream fish migration are damns, weirs and culverts, however, anything that increases flow velocity, decreases depth or poses a physical barrier has the potential to impede fish migration.

3.7 FISHES IN THE HIMALAYAN RIVERS

The Himalayas, which run for about 2500 km from west to east, are drained by 19 major rivers. About 218 fish species are listed for the whole Himalayas. Subsistence and commercial fisheries exploit the larger fish, such as the cyprinids *Labeo dero, Tor putitora, Tor tor, Barilius bendelisis, Schizothorax richardsonii* and *Schizothoraichthys esocinus*, as well as *Garra gotyla* and *Crossocheilus diplochilus* (Sehgal, 1999).

The fish species distribution and fish life in the Himalayan streams depends mainly on following factors: (i) current velocity; (ii) fluctuation in water discharge; (iii) water temperature and dissolved oxygen level; (iv) substratum; (v) shelter from the current; and (vi) food availability represented mostly by organisms clinging to and growing on rock and stone surfaces in fast current.

In torrential streams, Sehgal (1988) determined three main zones in Himalayan Rivers, in which dominant fish species were identified and some habitat parameters are also given:

(i) *Greater Himalayan zone:* this zone lies between elevations of 4000 to 2000 m. Source of water is from snow-melt and glacier–fed. Characterized by very fast current (1.2-1.8 m/s) and turbulent waters. Common substrates are rocks and boulders. Range water temperature is 9°C to 13.4°C with a mean pH of 7.1 and high DO levels (11.2 mg/L). Major fish species are: *Salmo truta, Schizothorax richardsonii, Schizothoraichthys esocinus, Diptychus maculates and Glyptosternum reticulatum.*

(ii) *Lesser Himalayan zone:* between elevation of 2000 to 1000 m. It is a transitional zone with fast currents (0.7-1.2 m/s) and substratum composed by rocks and boulders with sand and silt patches and some pools. Mean water temperature is 17.3°C. Mean value of pH is 7.9 and DO of 8.7 mg/L. Major fish species are: *Salmo truta, Schizothorax richardsonii, Glyptosternum reticulatum, Tor puritora* (only in monsoon season) and *Labeo dero.*

(iii) *Siwalik zone:* elevation below 1000 m. Flow velocity ranges between 0.7 to 0.5 m/s and substrata mainly composed by pebbles, sand and gravel with large quantity of suspend sediments. Mean water temperature is 20°C with a pH value of 8.0 and DO of 7.6 mg/L. Major fish species are: *Schizothorax richardsonii* (only in winter season), *Tor puritora* and *Labeo dero.*

Next table summarize the major fish species in three Himalayan river zones.

Table 3.4 Major fish species in three Himalayan river zones. Source Sehgal, 1988.

Characteristic	**Greater Himalayan zone**	**Lesser Himalayan zone**	**Siwalik zone**
Elevation (m.a.s.l.)	4000-2000	2000-1000	< 1000
Substratum	Rock & boulders	Boulders/stones with sandy patches	Pebbles, sand, gravel
Water Temp. (°C)	9	17,3	20
pH	7,1	7,9	8,0
DO (mg/L)	11,2	8,7	7,6
Flow velocity (m/s)	1,8 - 1,2	1,2 - 0,7	0,7 - 0,5
Major fish species			
Salmo trutta	+	+	-
Schizothoraichthys esocinus	+	-	-
Schizothorax richardsonii	+	+	+ (winter)
Diptychus maculatus	+	-	-
Glyptosternum reticulatum	+	+	-
Tor putitora	-	+ (monsoon)	+
Labeo dero	-	+	+

Note: (+) means presence and (-) means absence.

The size of fishes is commonly given by length (cm) or weight (kg). For the same fish-species, the size of fish may vary between site to site or year to year, responding to specific conditions like scarcity or abundant of nutrients, water quality conditions or habitat conditions such as water depth or water velocity, instream cover and substrate size. In a review of literature, in Himalayan region, the common sizes of fishes are given in table 3.5 for different species (Sehgal, 1999; Raleigh & others, 1986; Nautiyal & others, 2008; Heok, 2005):

Table 3.5 Himalayan fishes and their sizes.

SPECIE	Total length (cm)	Max. Width (cm)	Weight (Kg)
Masheer (Tor putitora)	20 to 160	5 to 45	1 to 30
Schizothorax sps	20 to 45	5 to 15	0.3 to 2.5
Brown Trout	25 to 30	7 to 10	0.1 to 1.8
Raibown Trout	30 to 45	10 to 15	1 to 5
Glyptothorax	5 to 15	3 to 6	< 1.0

3.8 IMPACTS IN FISH DUE TO HYDROPOWER DEVELOPMENT

Hydropower developments used to construct a structure across the river to divert or storage water. These structures have generally resulted in negative impacts to native riverine fishes and the ecology in general. This has been attributed, in part, to disruption of seasonal flood cycles and to dams acting as barriers to fish movements (especially in migratory species) and blocking the transport of nutrients. Direct effects of dams in fish communities are: 1) Alteration of stream habitats upstream and downstream. 2) Fragmentation of fish populations and 3) Reduction of biodiversity and productivity of fishes (Hayes, Dodd & Lessard, 2006).

Dams can cause drastic changes in flow regimes, water temperature and water quality, subsequently influencing fish fauna in tailwaters. Blockage may influence fish movement and their escape from reservoirs. Dams are the principal factor constraining the distribution of fish in rivers by the process of disrupting natural fluvial regimes (Chang & others, 1999).

The impacts of dam are critical during construction phase, where the earth moving, transport of materials and water diversion cause a lot of negative changes in air, soil and water components of the environment. During operation phase, the impacts of a weir or dam can be analyzed from upstream and downstream effects.

UPSTREAM EFFECTS:

- *Creation a new habitat:*
  The most obvious effect from placing dams on rivers is the formation of new lentic or semi-lentic environment upstream from the dam by creating a reservoir.

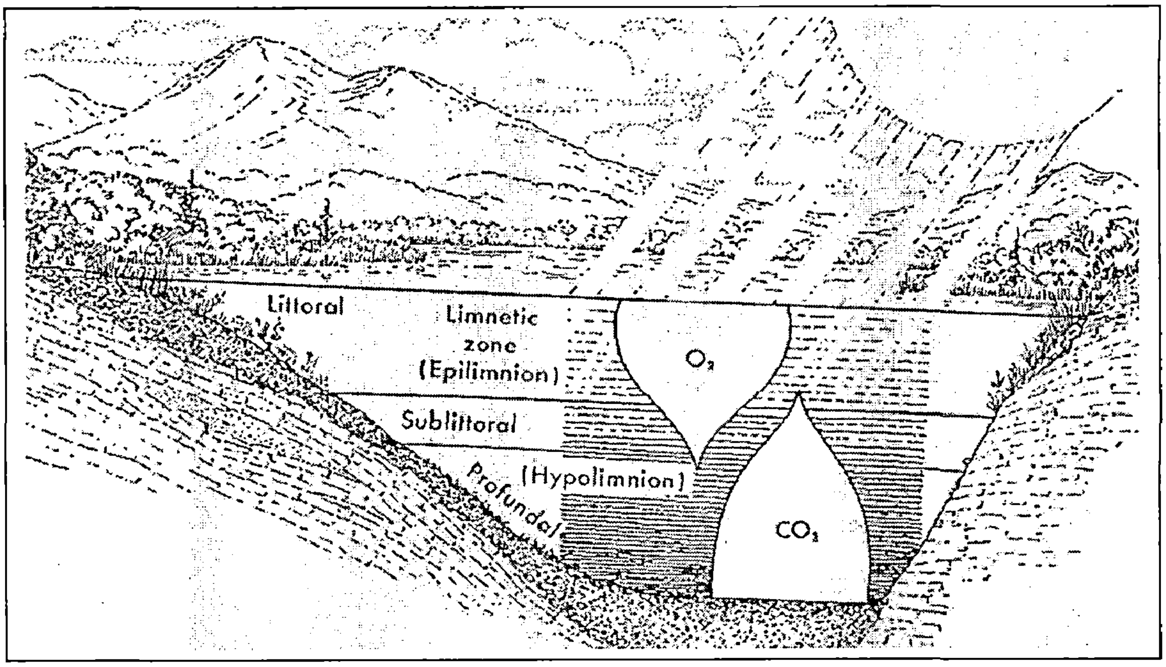
Reservoirs present special characteristics which differentiate from rivers and streams. The water in reservoirs is calm (lentic ecosystems) while in river the water flows (lotic ecosystems). Another one of these characteristics is the thermal stratification, which affects physical, chemical and biological process in lakes and reservoirs.

During stratification, the warm surface water, known as *epilimnion* layer, occupies the top zone. This layer is turbulently mixed throughout the day by wind and waves. The epilimnion can freely exchange dissolved gases such as O_2 and CO_2 with the atmosphere. This layer absorbs the heat mainly from solar radiation.

Below the epilimnion is the metalimnion, which is characterized by a rapid change in temperature with depth, usually accepted as a rate change equal or greater than 1°C per meter (Wetzel, 2001).

The bottom layer of a stratified reservoir is known as hypolimnion. It is typically the coldest layer in the summer and warmest in the winter. Sediments and organic matter settle in the bottom of this layer make deep-water layers denser and darker than water closer to the surface. The hypolimnion is often characterized by a stagnant, high level of CO_2 (due the decomposition of organic matter) and low DO levels.

Figure 3.9 Lakes and reservoir thermal stratification. Source: CH2M Hill, 2003.



Fishes are moving among these layers as their own needs, quantity of nutrients and water temperature.

- *Increasing in fish production:*
  Reservoirs can in some situations result in productive fisheries, particularly tailwater fisheries immediately below dams that result from discharge of seston (primarily plankton) and by stocking native or exotic species (Marmulla, 2001).

In regulated rivers, the river self-purification is significantly influenced by the amount of upstream reservoir releases; it is important and necessary to have integrated operations of the river and reservoir system, taking into account not only water quantity but also downstream water quality and ecosystem health (Chung & others, 2008).

The main problems associated to water releases from reservoirs are:

- Rapidly change in water temperature.
- Scour and river bed retrogression (Arora, 1996).
- Increasing in BOD and decreasing in DO concentrations, due to re-suspension of organic matter from the river bottom sediments (Chung & others, 2008).
- Releasing of sediments especially during reservoir scouring operations.
- Flushing of debris, which acts like a fish shelter and flushing of fish's eggs.

DOWNSTREAM EFFECTS:

- *Alteration of natural flow regimes:*
  The first impact of dam is the alteration of natural hydrograph often by reducing the absolute amount of water available to the river, by displacing the timing of peak discharges, or by suppressing (partially or completely) the river connection with their floodplains, which affect the abundance, species composition and viability of living aquatic resources (Welcomme, 2001). Once flooding occurs, invertebrates and fishes colonize the inundate areas and take advantages of resources and products on the floodplain. Floodplain thus serves as important spawning and nursery grounds, as well as important sources of food. In both tropical and temperate rives, fish yields per unit surface area are considerable greater in rivers with flood pulse and floodplains than in nearby impoundments where flood pulse are reduced or absent (Marmulla, 2001).

- *Dams acting as a barriers:*
  Dams in river can significantly block nutrients flow throughout the ecosystem, affecting fisheries production downstream in river channels and estuary and marine environments. Dams hold back not only sediment and nutrients, but also debris. The life of organisms (including fish) downstream depends on the constant feeding of the river with debris. This debris includes leaves, twigs, branches, and whole trees, as well as the organic remains of dead animals. Debris not only provides food, it provides hiding places for all sizes of animals and surfaces for phytoplankton and microorganisms to grow (Cave, 1998).

- *Fragmentation of fish populations:*
  Fragmented populations reduce gene flow, resulting in lower effective population sizes and eventually deleterious effects of inbreeding (Hayes, Dodd & Lessard, 2006). A general trend is the increasing species richness from upstream to downstream. For example in Tienluen Dam study, is show the reach composition of fishes is greater below dam, due the dam eliminates upstream movement. In other cases, fish density increases upstream where flows are higher and temperatures lower and fish communities are free of suddenly changes in habitat features, which often result in abrupt changes in community composition.

  The construction of fish passages or fish ladders is made to restoring the connectivity of migratory fishes. Many fishes must move upstream and downstream to complete their lifecycles. Dams are often built without fish ladders and when fish ladders are provided, they seldom work as needed, furthermore, these fish ladders becomes in a real tramp for fishes where predators find a optimal point to catch fishes (Caves, 1998).

- *Erosion and bed retrogression:*
  Hydropower plants has a common practice of running turbines during the day in order to provide electricity when demand and prices are highest and it releases large amounts of water during day hours and cutting down flow during the night in order to replenish reservoirs for the next day. The cyclic floods caused by this popular practice contribute to the extinction of fish species by flushing away their spawning gravels during the day and leaving them “high and dry” at night. Riverbeds become scoured, stripped of their organic materials, sediment, vegetation, and macroinvertebrades.

  The river downstream of a dam is usually degrading in which the bed level gradually decreases due to scouring of the bed material. This phenomenon is known as "bed retrogression" and it occurs because the silt load of the river is deposit in the reservoir upstream of the dam and the water flowing downstream is relatively free of silt. To replenish its silt load, the river scours the bed which affects the natural habitat of fishes for spawning, sheltering and reproducing (Arora, 1996).

- *Change in water temperatures:*
  When discharge is from the hypolimnion of the reservoir, lowered temperatures in the receiving tailwaters can curtail or eliminate warmwater river species, but if the dominant species in the river are coldwater species (like salmonids) it could be beneficial, especially during the summer, supposing well oxygenated hypolimnetic discharges (Marmulla, 2001).

  The thermal niche of coldwater game fishes (brook trout, brown trout, rainbow trout) show the increase in temperature below high impact dams was enough to reduce the abundance of one or more of the species. The large decline in overall trout abundance below high-impact dams demonstrates the large effect to which thermal habitat alteration can affect these species rather than habitat and population fragmentation (Hayes, Dodd & Lessard, 2006).

CHAPTER IV

CASE OF STUDY I: ENVIRONMENTAL FLOW ASSESSMENT FOR STORAGE BASED HYDROPOWER PROJECTS IN LOHIT RIVER BASIN

4.1 BACKGROUND OF THE PROJECT

The Lohit River basin development is designed under "Cascade Hydropower Scheme". A "cascade hydropower scheme" involves the construction of more than one hydropower plant located at different sites along the same river. In this type of scheme, the second plant uses the water discharged by the first one and so on.

In a cascade scheme; the total number of projects that can be allocated on the same river depends of multiple variables and must satisfy the total energy demand and minimizes the cost and minimizes the environment impact for each project. The main objective of this type of development is maximizing the utilization of river flow and river basin conditions like hydrology, topography, geology and ecology.

Lohit River basin is located in Arunachal Pradesh, India. The Lohit basin is the most eastern basin of India with its catchment spreading across international border covering part of Tibet and India. The basin is bounded by China and part of Dibang valley district of Arunachal Pradesh in the north, Changlang district (Burhi Dibang sub basin) in the south, China and hills of Myanmar in the east and Assam state in the west. The Lohit basin is situated between latitude 27° 34' 00" N and 29 36' 00" N and between longitude 95° 38' 00" E and 97° 44' 00" E.

It is mainly a hilly state among deep valleys, narrow gorges and deep green lush forest with great hydropower potential. The Lohit River is a major component of the Brahmaputra river system. It raises from the snow covered peaks in the eastern Tibet at elevation of 6190 m.a.s.l. Figure 4.1 shows the location of Lohit basin and the location of different proposed hydropower projects under cascade scheme.

The proposed hydropower development is the construction of 6 hydropower plants along Lohit River within multipurpose cascade scheme with low height lifting dams. In table 4.1, it is summarized the salient features for each proposed site.

Table 4.1 Salient Features at proposed sites in Lohit River basin.

Proposed Site	C.A. (Km^2)	Bed Elevat. (masl)	FRL (m)	Dam HT (m)	I.C. (MW)
Kalai I	16610	915.25	1065.25	186	1450
Kalai II	17846	779.8	904.8	161	1200
Hutong I	17968	755.8	779.8	24	750
Hutong II	18450	589.5	714.5	161	1250
Demwe Upper	20560	430	584	185	1800
Demwe Lower	22000	305	420	171	1630

Note: C.A. = Catchment Area. F.R.L. = Full Reservoir Level. I.C. = Install Capacity.

All the six (6) proposed projects are of storage type, in which the water is storage by construction of a dam across the river. The power house is located at the toe of the dam, where the length of the diversion structures (power tunnel & penstocks) ranges between 700 meters to 1200 meters among different project sites, therefore in this specific case a dry river "stretch" is not created, since the water is restore in the river in one point immediately downstream of the dam. For these types of hydropower developments, a further step consist in determine if the water which is passing through turbines is enough for maintain the aquatic life in the river or more water should be released from reservoir to fulfill environmental water requirements.

4.2 HYDROLOGY DATA AVAILABILITY

The long term G&D observations were collected from two stations: Hayuliang and Mompani. Hayuliang G&D station is located 67 Km downstream (D/S) of Kalai I and 18 Km D/S from Hutong II site. At this station, the observed ten daily flows are from 1984-85 up to 1994-95 (11 years). Mompani G&D station is located 98 Km D/S of Kalai I and 49 Km D/S form Hutong-II site and the observed ten daily flows are from 1984-85 up to 2002-03 (19 years). Figure 4.1 shows the localization of G&D stations.

In both G&D stations, data available is "Ten daily data", with some missing values in different years. The missing data were filled up by interpolation from the discharges of the adjacent 10-daily data for the same month. The consistency of data was checked based on double mass curve technique on annual basis. Correlation studies between these two sites and the data were found to be consistent (WAPCOS, 2005). Salient features of G&D stations and proposed projects are shown in Fig. 4.2.

Figure 4.1 Localization of Lohit River basin and location of different hydroelectric projects under cascade scheme.

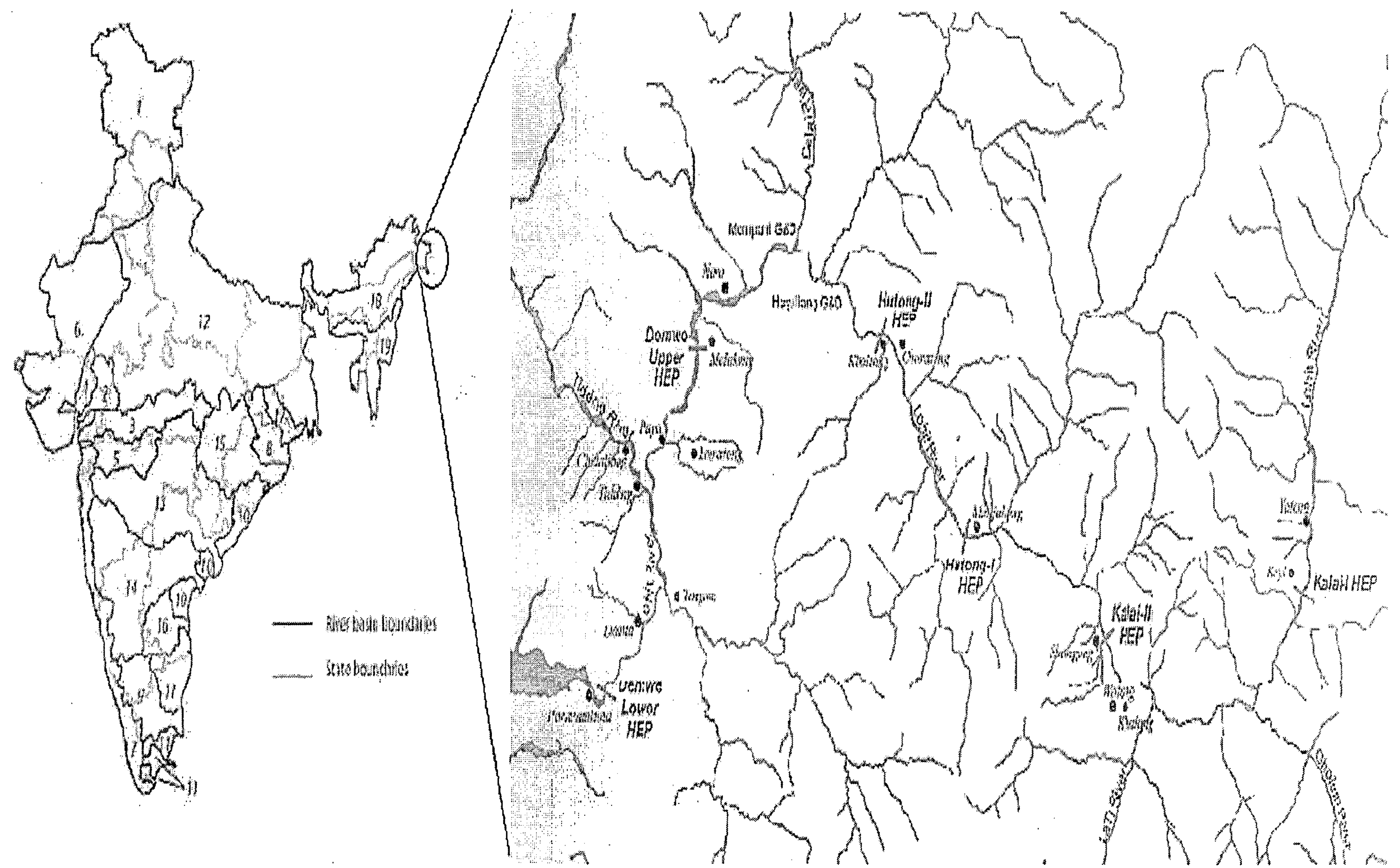
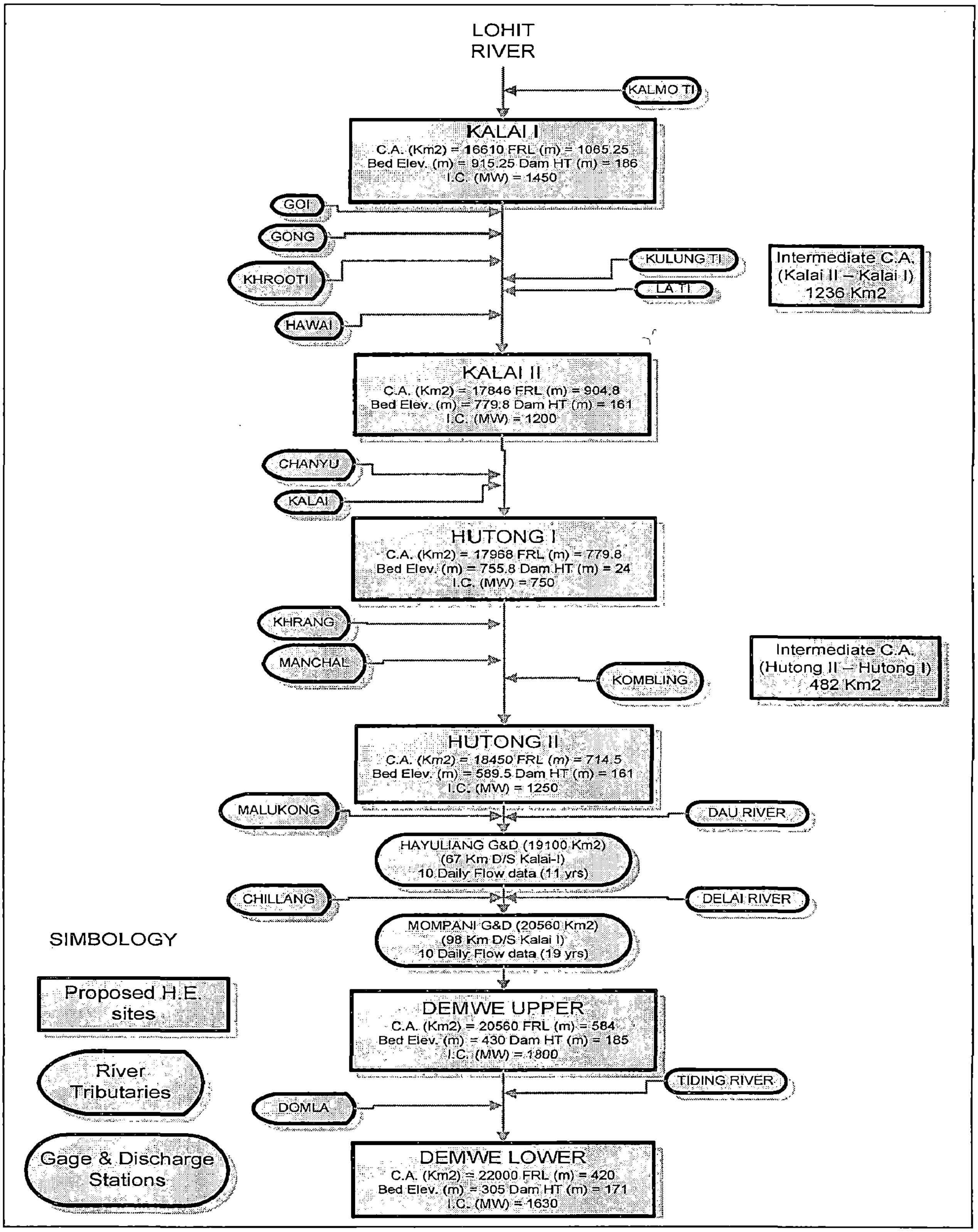


Figure 4.2 Salient features for cascade hydropower development at Lohit River basin.



4.3 HYDROLOGY DATA GENERATION

In order to have stage discharge data at all the sites for a uniform period of time, following interpolations were carried out:

For Discharge data at Kalai & Hutong Projects:

Hayuliang G&D station is nearest to Kalai & Hutong dam sites. However, it has only 11 years (1984-85 to 1994-95) of records. In order to have data for 19 years, a series having the observed data from Hayuliang G&D site and data derived from 1995-96 to 2002-03 using observed data at Mompani G&D site, is prepared. This integrated series is used for preparing series of discharges at Kalai and Hutong projects as shown in Fig. 4.3. The series of data for Kalai I, Kalai II, Hutong I and Hutong II are prepared using catchment area-proportion technique from May 1984 to April 2003.

For Discharge data at Demwe Projects:

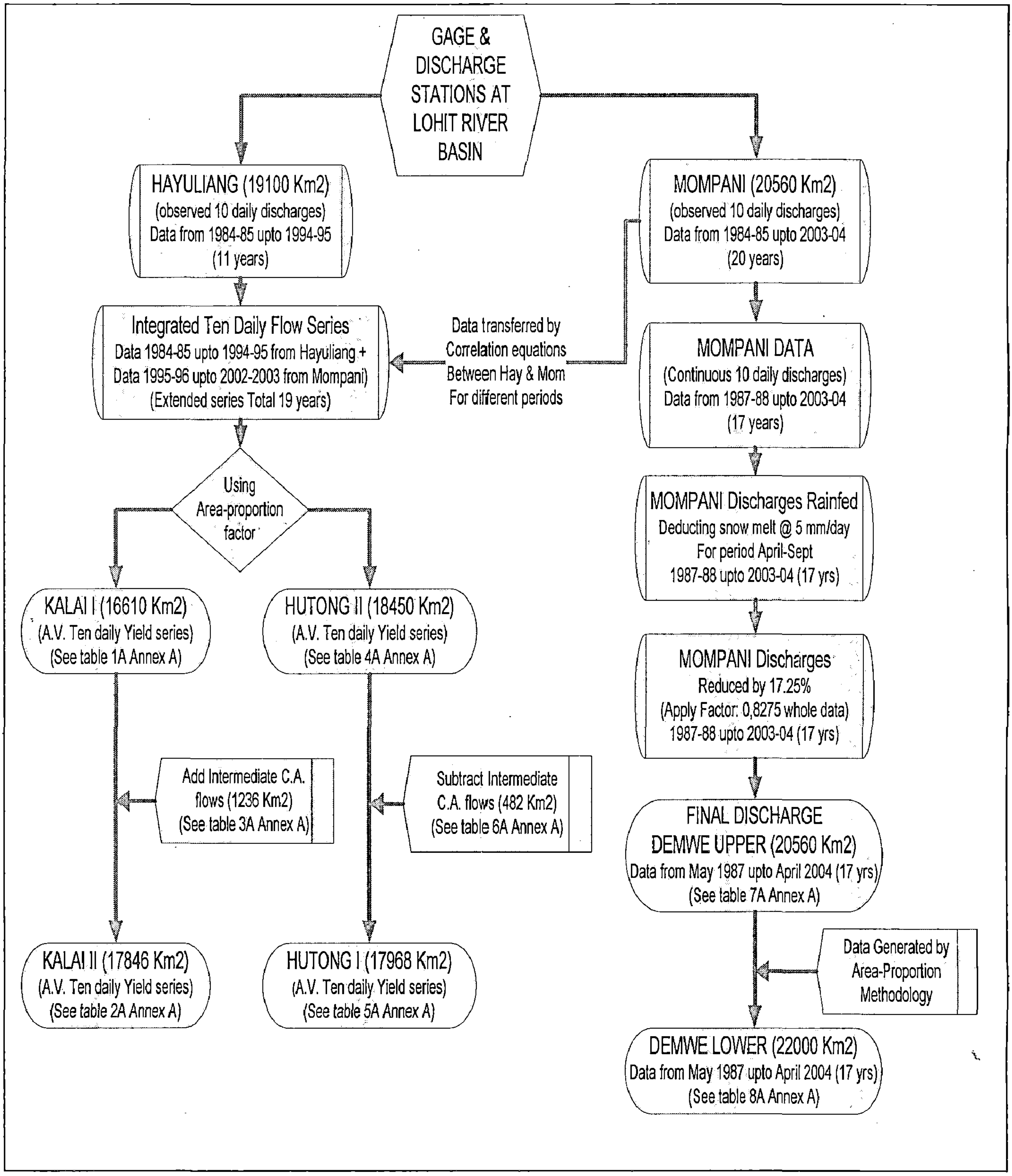
The observed discharge data of Mompani G&D site, which is available from 1984-85 to 2003-04 with some missing months, is used for these projects. For this site, the continuous data available is from 1987-88 to 2003-04 with some interpolated filled up data. In order to estimate the rainfall contribution in Mompani data, snow melt by a rate of 5 mm/day for the period of *April to September* is subtracted. After this, a new reduction is made to the entire series using a correction factor of 0.8275 in order to take care of the area proportion.

In order to obtain the discharge at Demwe upper project site, snow melt contribution is added to the previously calculated discharge data. Using area-proportion methodology, Demwe Lower data is obtained. Figure 4.3 shows in schematic form the process of data generation.

4.4 HYDROLOGY DATA ANALYSIS

In this case of study, two series of data derived from Hayuliang and Mompani are combined. One series (from Hayuliang) is covering 19 years; from May 1984 upto April 2003 and another series (from Mompani) is covering 17 years, from May 1987 upto April 2004. Using area-proportion method, these two series of ten-daily flows are extended to get a final series of 20 years data from 1984-1985 upto 2003-2004. Final extended flows series are shown in Annexure A for each proposed sites and intermediate catchment areas.

Figure 4.3 Data generation from different sites in Lohit River basin.



In all six proposed sites, using 10-daily extended flow series from 1984-1985 to 2003-2004, following is estimated:

- 10 daily average, maximum, minimum, and corresponding standard deviation values are estimated.
- Annual Average Flow (AAF) in cumec-day and Annual Average volume in MCM.
- Total Annual Average Flow in cumec.

Further, in order to know the dependability of flow, the following exercises were carried out:

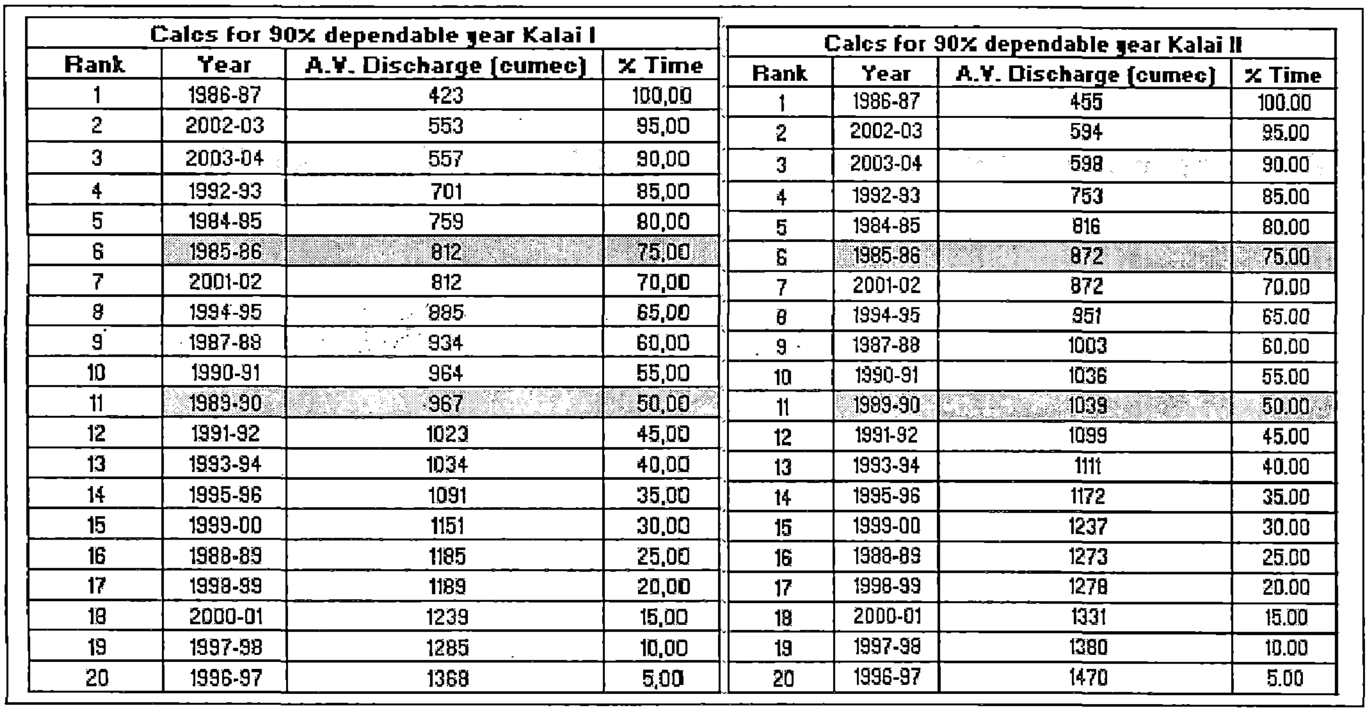
- 90% dependability year among corresponding years.
- 90% dependable flow from 90% dependable year.
- Flow Duration Curve (FDC) with whole data series (20 years) for each proposed site.

A summary of the results are shown in next tables:

Table 4.2 Annual Average Flow at proposed sites using extended series 1984-85 to 2003-04.

Proposed Dam Site	C.A. (Km^2)	AAF (1984-85 to 2003-04) (cumec)	Max (cumec)	Min (cumec)	Std. Dev (cumec)
Kalai I	16610	947	3603	156	363
Kalai II	17846	1017	3871	176	390
Hutong I	17968	1024	3897	169	393
Hutong II	18450	1051	4002	173	404
Demwe Upper	20560	1126	4070	239	425
Demwe Lower	22000	1185	4273	256	445

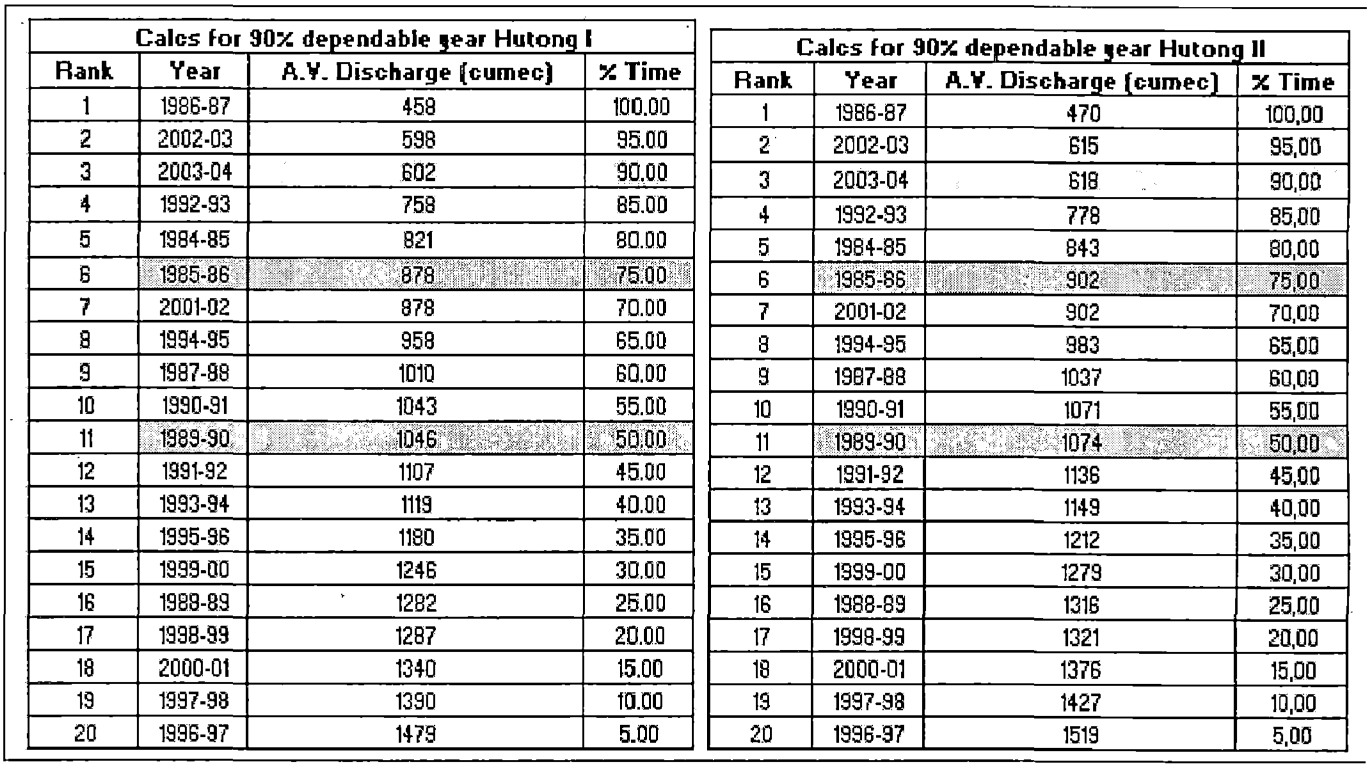
Table 4.3 Dependability year at Kalai sites.



Calcs for 90% dependable year Kalai I			
Rank	**Year**	**A.V. Discharge (cumec)**	**% Time**
1	1986-87	423	100,00
2	2002-03	553	95,00
3	2003-04	557	90,00
4	1992-93	701	85,00
5	1984-85	759	80,00
6	1985-86	812	75,00
7	2001-02	812	70,00
8	1994-95	885	65,00
9	1987-88	934	60,00
10	1990-91	964	55,00
11	1989-90	967	50,00
12	1991-92	1023	45,00
13	1993-94	1034	40,00
14	1995-96	1091	35,00
15	1999-00	1151	30,00
16	1988-89	1185	25,00
17	1998-99	1189	20,00
18	2000-01	1239	15,00
19	1997-98	1285	10,00
20	1996-97	1368	5,00

Calcs for 90% dependable year Kalai II			
Rank	**Year**	**A.V. Discharge (cumec)**	**% Time**
1	1986-87	455	100.00
2	2002-03	594	95.00
3	2003-04	598	90.00
4	1992-93	753	85.00
5	1984-85	816	80.00
6	1985-86	872	75.00
7	2001-02	872	70.00
8	1994-95	951	65.00
9	1987-88	1003	60.00
10	1990-91	1036	55.00
11	1989-90	1039	50.00
12	1991-92	1099	45.00
13	1993-94	1111	40.00
14	1995-96	1172	35.00
15	1999-00	1237	30.00
16	1988-89	1273	25.00
17	1998-99	1278	20.00
18	2000-01	1331	15.00
19	1997-98	1380	10.00
20	1996-97	1470	5.00

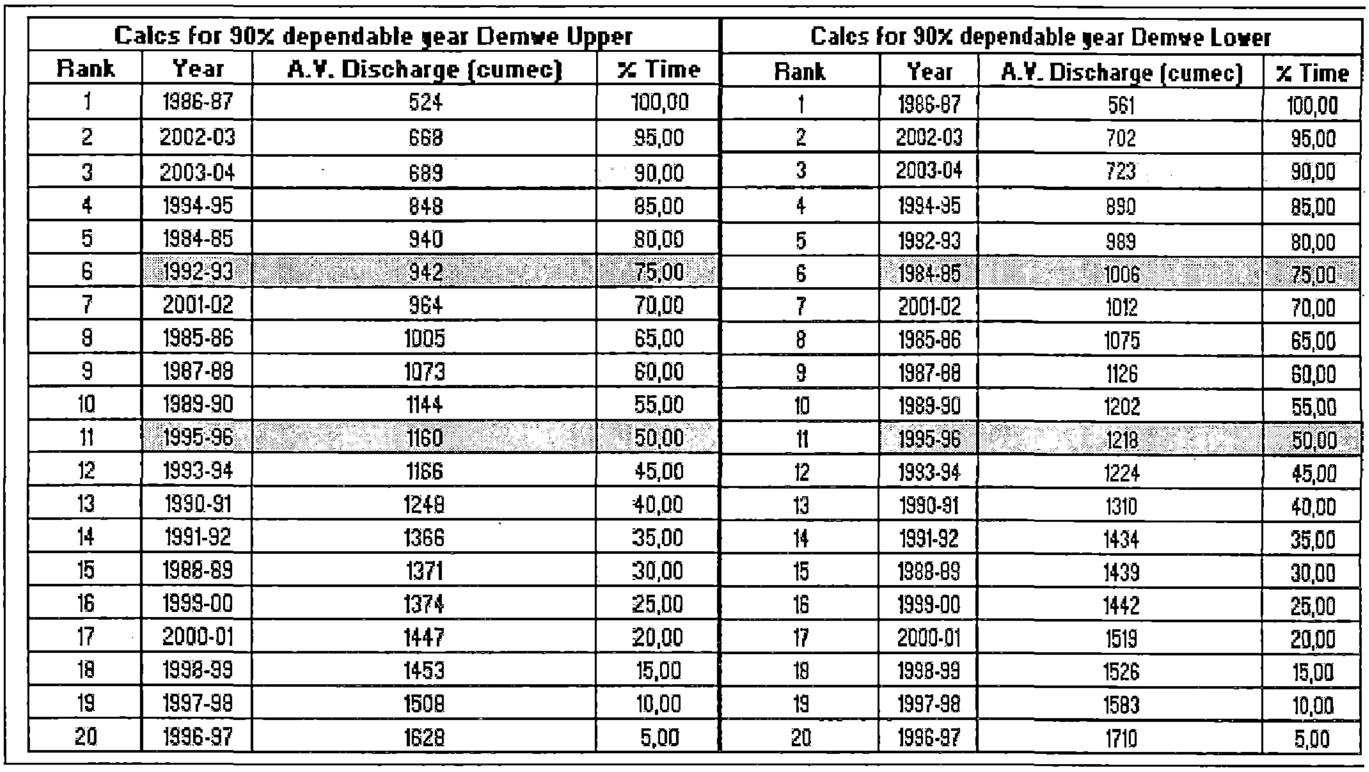
Table 4.4 Dependability year at Hutong sites.



Calcs for 90% dependable year Hutong I			
Rank	Year	A.Y. Discharge (cumec)	% Time
1	1986-87	458	100.00
2	2002-03	598	95.00
3	2003-04	602	90.00
4	1992-93	758	85.00
5	1984-85	821	80.00
6	1985-86	878	75.00
7	2001-02	878	70.00
8	1994-95	958	65.00
9	1987-88	1010	60.00
10	1990-91	1043	55.00
11	1989-90	1046	50.00
12	1991-92	1107	45.00
13	1993-94	1119	40.00
14	1995-96	1180	35.00
15	1999-00	1246	30.00
16	1988-89	1282	25.00
17	1998-99	1287	20.00
18	2000-01	1340	15.00
19	1997-98	1390	10.00
20	1996-97	1479	5.00

Calcs for 90% dependable year Hutong II			
Rank	Year	A.Y. Discharge (cumec)	% Time
1	1986-87	470	100,00
2	2002-03	615	95,00
3	2003-04	618	90,00
4	1992-93	778	85,00
5	1984-85	843	80,00
6	1985-86	902	75,00
7	2001-02	902	70,00
8	1994-95	983	65,00
9	1987-88	1037	60,00
10	1990-91	1071	55,00
11	1989-90	1074	50,00
12	1991-92	1136	45,00
13	1993-94	1149	40,00
14	1995-96	1212	35,00
15	1999-00	1279	30,00
16	1988-89	1316	25,00
17	1998-99	1321	20,00
18	2000-01	1376	15,00
19	1997-98	1427	10,00
20	1996-97	1519	5,00

Table 4.5 Dependability year at Demwe sites.



Calcs for 90% dependable year Demwe Upper			
Rank	Year	A.Y. Discharge (cumec)	% Time
1	1986-87	524	100,00
2	2002-03	668	95,00
3	2003-04	689	90,00
4	1994-95	848	85,00
5	1984-85	940	80,00
6	1992-93	942	75,00
7	2001-02	964	70,00
8	1985-86	1005	65,00
9	1987-88	1073	60,00
10	1989-90	1144	55,00
11	1995-96	1160	50,00
12	1993-94	1166	45,00
13	1990-91	1248	40,00
14	1991-92	1366	35,00
15	1988-89	1371	30,00
16	1999-00	1374	25,00
17	2000-01	1447	20,00
18	1998-99	1453	15,00
19	1997-98	1508	10,00
20	1996-97	1628	5,00

Calcs for 90% dependable year Demwe Lower			
Rank	Year	A.Y. Discharge (cumec)	% Time
1	1986-87	561	100,00
2	2002-03	702	95,00
3	2003-04	723	90,00
4	1994-95	890	85,00
5	1992-93	989	80,00
6	1984-85	1006	75,00
7	2001-02	1012	70,00
8	1985-86	1075	65,00
9	1987-88	1126	60,00
10	1989-90	1202	55,00
11	1995-96	1218	50,00
12	1993-94	1224	45,00
13	1990-91	1310	40,00
14	1991-92	1434	35,00
15	1988-89	1439	30,00
16	1999-00	1442	25,00
17	2000-01	1519	20,00
18	1998-99	1526	15,00
19	1997-98	1583	10,00
20	1996-97	1710	5,00

Table 4.6 Different flow dependability at each proposed site, considering all years (1984-85 to 2003-04).

Proposed Site	Flow for different dependability (cumec)		
	90 %	75 %	50 %
Kalai I	297	393	659
Kalai II	319	422	708
Hutong I	322	425	713
Hutong II	330	437	732
Demwe Upper	355	487	819
Demwe Lower	375	511	861

From hydropower development point of view, the availability of water for a given percentage of time is important. Generally, 90 % dependable flow of 90% dependable year is considered for reliable power production. According with dependability analysis, the 90% dependable year (one of the driest years) corresponds to 2003-04 in all proposed sites. The 5% dependable year (one of the wettest years) corresponds to 1996-97 in all proposed sites.

The Average Annual Flow (AAF) on the basis of all years flow, dependable year and corresponding 90 % dependable flow for 90 % dependable year for various sites and Av. Annual flow for 5% dependable year is shown in table 4.7.

Table 4.7 AAF, 90% dependable flow ($Q_{90\%}$) for 90% dependable year, and AAF for 90% and 5% dependable years.

Proposed Site	**Av. Annual Flow (1984-85 to 2003-04)**	**90 % dependable year**	**90 % dependable Flow ($Q_{90\%}$) (2003-04)**	**Av. Annual Flow for 90 % dependable year (2003-04)**	**Av. Annual Flow for 5% dependable year (1996-97)**
Kalai I	947	2003-04	258	557	1368
Kalai II	1017	2003-04	278	598	1470
Hutong I	1024	2003-04	279	602	1479
Hutong II	1051	2003-04	287	618	1519
Demwe Upper	1126	2003-04	320	689	1628
Demwe Lower	1185	2003-04	336	723	1710

4.5 ENVIRONMENTAL FLOW ASSESSMENT IN LOHIT BASIN

In this section; different Hydrological Index methods are applied to assess the environmental water requirements in Lohit River basin. These methodologies are based only in historical flow records and more details of each methodology are given in Chapter 2 Environmental Flow Assessment Techniques.

(i) Tennant Method:

Assume that fair and degrading conditions are prevailing in the basin. Hence EF is 10% of Annual Average Flow (AAF) for the period October to March and 30 % for the period April to September for the year 2003-04 which corresponds to 90% dependable year. Table 4.8 summarizes the results for each proposed site in Lohit River basin.

Table 4.8 Environmental Water Requirements using Tennant Method.

SITE	AAF 2003-04 (cumecs)	EWR (cumecs) (Oct.-Mar.) (0.1 * col. 2)	EWR (cumecs) (April-Sept.) (0.3 * col. 2)
(1)	(2)	(3)	(4)
Kalai I	557	56	167
Kalai II	598	60	179
Hutong I	602	60	181
Hutong II	618	62	185
Upper Demwe	689	69	207
Lower Demwe	723	72	217

(ii) Hughes & Münster Method (H&M):

The EWR = LFR + HFR (See eq. 2.1)

LFR = $Q_{90\%}$ dependable flow of year 2003-04.

HFR are taken following guidelines in table 2.2 (Chapter 2), since all $Q_{90\%} > 30\%$ of AAF the components of high flows are negligible. That means the flow in the river is very stable; the flow is consistent throughout the year and low-flow requirement is the primary component. This also means the river ecology is very sensitive to any change in river flow regimes. A summary of computations in H&M methodology is given in table 4.9.

Table 4.9 Environmental Water Requirements using Hughes & Münster method.

SITE	AAF 2003-04 (cumecs)	$Q_{90\%}$ 2003-04 (cumecs)	% Q90/AAF	HFR (cumecs)	EWR (cumecs)
Kalai I	557	258	46.32	0	258
Kalai II	598	278	46.49	0	278
Hutong I	602	279	46.35	0	279
Hutong II	618	287	46.44	0	287
Upper Demwe	689	320	46.44	0	320
Lower Demwe	723	336	46.47	0	336

(iii) Index Method:

The Minimum Instream Flow is given by equation:

$MIF = Q_{355}*Ka*Kb*Kc$ (See eq 2.2)

Assumptions taken in computations:

Ka = 1.0 River ecology is very sensitive.

Kb = 1.0 River flows are in natural state, therefore any implementation factor is required.

Kc = 1.5 considering high naturalistic values in Lohit river basin.

Q_{355} correspond to discharge equaled or exceeded 98% of the time. This value is taken from flow duration curve for the year 2003-04.

Table 4.10 Environmental Water Requirements using Index method.

SITE	Q_{355} for 2003-04 (cumecs)	EWR (cumecs)
Kalai I	254	381
Kalai II	272	408
Hutong I	274	411
Hutong II	282	423
Upper Demwe	314	471
Lower Demwe	330	495

(iv) Seasonal Methodology:

The seasonal methodology proposed in this study follows the principles given by Building Block Method (BBM), which is based on the identification of different natural flows regimes; their magnitudes, timing and duration as well as their interaction with surrounding biota. These flows are incorporated in a modified flow regime by a construction of synthetic hydrograph which must satisfy the water requirements of the river. The modified hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present through out the year. The identification and incorporation of these important flow characteristics will help to maintain the river's channel structure, diversity of the physical biotopes and processes. Four main seasons are identified along the year:

Season I: This season is considered as high flow season, influenced by monsoon. It covers the months from May to September in which the proposed minimum flow is taken as 30% of average flow for the corresponding period (10 daily or monthly).

Season II: This season is considering like average season and it corresponds to transition period between wet and dry period. It covers the month of October in which the proposed minimum flow is taken as 20% of average flow for corresponding period.

Season III: This season is considering as low flow, lean or dry season. It covers the months from November to March in which the proposed minimum flow is taken as 10% of average flow for corresponding period (10 daily or monthly).

Season IV: This season is considering like average season and it corresponds to transition period between dry and wet period. It covers the month of April in which the proposed minimum flow is taken as 20% of average flow for corresponding period.

The proposed minimum flows are estimated for two cases:

1. Using 20 years data (1984-85 upto 2003-04) on ten daily basis.
2. For 90% dependable year (2003-04) on ten daily basis.

In both cases, average flow values of each season are estimated and also, natural and modified hydrograph for each proposed site in Lohit basin are show for each case. The results are shown below.

Table 4.11 Proposed Minimum Flows Using Ten daily Average Flow for 20 Years Flow Data (1984-85 to 2003-04).

SEASONAL METHODOLOGY USING TENDAILY AVERAGE FLOW FOR 20 YEARS DATA (FROM 1984-85 TO 2003-04)															
				KALAI I		KALAI II		HUTONG I		HUTONG II		DEMVE UPPER		DEMVE LOVER	
Seasons	Month	Ten daily	Percentage	Average	Min.Flow	Average	Min.Flow	Average	Min.Flow	Average	Min.Flow	Average	Min.Flow	Average	Min.Flow
		I	0.3	1090	327	1171	351	1179	354	1211	363	1316	395	1385	415
	May	II	0.3	1212	364	1302	391	1311	393	1346	404	1458	438	1534	460
		III	0.3	1458	437	1566	470	1577	473	1619	486	1685	505	1773	532
S		I	0.3	1598	479	1717	515	1728	518	1774	532	1884	565	1983	595
E	June	II	0.3	1629	489	1750	525	1762	529	1809	543	1939	582	2041	612
A		III	0.3	1809	543	1943	583	1957	587	2009	603	2196	659	2311	693
S		I	0.3	1978	593	2126	638	2140	642	2197	659	2315	695	2437	731
O	July	II	0.3	1907	572	2049	615	2063	619	2119	636	2101	630	2211	663
N		III	0.3	1768	530	1899	570	1912	574	1963	589	1994	598	2098	630
		I	0.3	1621	486	1742	522	1753	526	1800	540	1823	547	1918	575
I	August	II	0.3	1576	473	1693	508	1705	511	1751	525	1823	547	1918	575
		III	0.3	1588	476	1706	512	1717	515	1763	529	1778	534	1871	561
		I	0.3	1476	443	1586	476	1597	479	1639	492	1632	490	1716	515
	September	II	0.3	1287	386	1383	415	1393	418	1430	429	1469	441	1546	464
		III	0.3	1204	361	1294	388	1303	391	1337	401	1435	431	1509	453
Season I Average values				**1547**	**464**	**1662**	**499**	**1673**	**502**	**1718**	**515**	**1790**	**537**	**1883**	**565**
		I	0.2	1084	217	1165	233	1173	235	1204	241	1181	236	1242	248
II	October	II	0.2	943	189	1013	203	1020	204	1048	210	1045	209	1099	220
		III	0.2	778	156	836	167	842	168	864	173	922	184	970	194
Season II Average values				**935**	**187**	**1005**	**201**	**1012**	**202**	**1039**	**208**	**1049**	**210**	**1103**	**221**
		I	0.1	558	56	599	60	603	60	619	62	750	75	789	79
	November	II	0.1	490	49	526	53	530	53	544	54	648	65	682	68
		III	0.1	448	45	481	48	484	48	497	50	585	59	616	62
S		I	0.1	381	38	410	41	413	41	423	42	535	53	562	56
E	December	II	0.1	345	35	372	37	373	37	383	38	490	49	516	52
A		III	0.1	370	37	395	40	400	40	411	41	450	45	474	47
S		I	0.1	347	35	373	37	375	38	385	39	396	40	417	42
O	January	II	0.1	341	34	366	37	368	37	378	38	381	38	401	40
N		III	0.1	326	33	350	35	353	35	362	36	369	37	388	39
		I	0.1	343	34	369	37	371	37	381	38	382	38	402	40
III	February	II	0.1	343	34	368	37	371	37	380	38	391	39	412	41
		III	0.1	354	35	381	38	383	38	393	39	421	42	443	44
		I	0.1	374	37	401	40	404	40	415	42	475	47	500	50
	March	II	0.1	421	42	452	45	455	45	467	47	571	57	602	60
		III	0.1	499	50	536	54	540	54	555	55	736	74	775	77
Season III Average values				**396**	**40**	**425**	**43**	**428**	**43**	**440**	**44**	**505**	**51**	**532**	**53**
		I	0.2	576	115	619	124	624	125	640	128	816	163	859	172
IV	April	II	0.2	689	138	741	148	746	149	766	153	962	192	1013	203
		III	0.2	746	149	801	160	807	161	828	166	1045	209	1100	220
Season IV Average values				**671**	**134**	**720**	**144**	**725**	**145**	**745**	**149**	**941**	**188**	**991**	**198**

Table 4.12 Proposed Minimum Flows Using Monthly Average Flow for 20 Years (1984-85 to 2003-04).

SEASONAL METHODOLOGY USING MONTHLY AVERAGE FLOW FOR 20 YEARS DATA (FROM 1984-85 TO 2003-04)														
			KALAI I		KALAI II		HUTONG I		HUTONG II		DEMWE UPPER		DEMWE LOWER	
Season	Month	Percentage	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow
	May	0.3	1253	376	1346	404	1356	407	1392	418	1486	446	1564	469
	June	0.3	1678	504	1803	541	1815	545	1864	559	2006	602	2112	633
I	July	0.3	1884	565	2025	607	2038	612	2093	628	2137	641	2249	675
	August	0.3	1595	478	1714	514	1725	518	1772	531	1808	542	1902	571
	September	0.3	1322	397	1421	426	1431	429	1469	441	1512	454	1591	477
Season I Average values			**1547**	**464**	**1662**	**499**	**1673**	**502**	**1718**	**515**	**1790**	**537**	**1883**	**565**
II	October	0.2	935	187	1005	201	1012	202	1039	208	1049	210	1103	221
	November	0.1	498	50	535	54	539	54	553	55	661	66	695	70
	December	0.1	365	37	393	39	395	40	406	41	492	49	517	52
III	January	0.1	338	34	363	36	366	37	375	38	382	38	402	40
	February	0.1	347	35	372	37	375	38	385	39	398	40	419	42
	March	0.1	431	43	463	46	466	47	479	48	594	59	625	63
Season III Average values			**396**	**40**	**425**	**43**	**428**	**43**	**440**	**44**	**505**	**51**	**532**	**53**
IV	April	0.2	671	134	720	144	725	145	745	149	941	188	991	198
Total Average			**947**	**239**	**1018**	**257**	**1025**	**258**	**1052**	**265**	**1126**	**280**	**1185**	**295**

Table 4.13 Proposed Minimum Flows Using Ten daily Flow for 90% Dependable Year 2003-04.

SEASONAL METHODOLOGY USING TENDAILY FLOW FOR 90% DEPENDABLE YEAR 2003-04															
				KALAI I		KALAI II		HUTONG I		HUTONG II		DEMWE UPPER		DEMWE LOWER	
Seasons	**Month**	**Ten daily**	**Percentage**	**2003-04**	**Flow**	**2003-04**	**Flow**	**2003-04**	**Flow**	**2003-04**	**Flow**	**2003-04**	**Flow**	**2003-04**	**Flow**
	May	I	0.3	631	189	677	203	682	205	700	210	780	234	820	246
		II	0.3	598	179	643	193	647	194	664	199	740	222	777	233
		III	0.3	689	207	740	222	745	223	765	229	852	256	895	268
S	June	I	0.3	866	260	930	279	937	281	962	289	1072	322	1126	338
E		II	0.3	1275	383	1370	411	1379	414	1416	425	1578	473	1657	497
A		III	0.3	1403	421	1508	452	1518	455	1559	468	1737	521	1824	547
S	July	I	0.3	1731	519	1860	558	1872	562	1923	577	2142	643	2249	675
O		II	0.3	1032	310	1109	333	1116	335	1146	344	1277	383	1341	402
N		III	0.3	742	223	797	239	803	241	824	247	918	276	964	289
	August	I	0.3	602	181	647	194	651	195	669	201	745	224	783	235
I		II	0.3	556	167	597	179	601	180	618	185	688	206	723	217
		III	0.3	586	176	630	189	634	190	651	195	726	218	762	229
	Septembe	I	0.3	588	176	631	189	636	191	653	196	727	218	764	229
		II	0.3	563	169	605	182	610	183	626	188	697	209	732	220
		III	0.3	486	146	522	156	525	158	539	162	601	180	631	189
Season I Average values				**823**	**247**	**884**	**265**	**890**	**267**	**914**	**274**	**1019**	**306**	**1070**	**321**
	October	I	0.2	449	90	482	96	486	97	499	100	556	111	584	117
II		II	0.2	425	85	457	91	460	92	473	95	527	105	553	111
		III	0.2	398	80	428	86	431	86	442	88	493	99	517	103
Season II Average values				**424**	**85**	**456**	**91**	**459**	**92**	**471**	**94**	**525**	**105**	**551**	**110**
	November	I	0.1	355	35	381	38	384	38	394	39	439	44	461	46
		II	0.1	337	34	362	36	365	36	375	37	418	42	438	44
		III	0.1	322	32	346	35	348	35	357	36	398	40	418	42
S	December	I	0.1	309	31	332	33	334	33	343	34	382	38	401	40
E		II	0.1	295	29	317	32	319	32	327	33	365	36	383	38
A		III	0.1	283	28	304	30	306	31	315	31	351	35	368	37
S	January	I	0.1	275	28	296	30	298	30	306	31	341	34	358	36
O		II	0.1	275	27	295	30	297	30	305	31	340	34	357	36
N		III	0.1	276	28	296	30	298	30	306	31	341	34	358	36
	February	I	0.1	254	25	273	27	275	28	282	28	315	31	330	33
III		II	0.1	250	25	269	27	271	27	278	28	310	31	325	33
		III	0.1	258	26	278	28	279	28	287	29	320	32	336	34
	March	I	0.1	285	29	307	31	309	31	317	32	353	35	371	37
		II	0.1	254	25	272	27	274	27	282	28	314	31	330	33
		III	0.1	488	49	524	52	527	53	542	54	603	60	634	63
Season III Average values				**301**	**30**	**323**	**32**	**326**	**33**	**334**	**33**	**373**	**37**	**391**	**39**
	April	I	0.2	484	97	520	104	524	105	538	108	600	120	630	126
IV		II	0.2	662	132	711	142	716	143	735	147	819	164	860	172
		III	0.2	768	154	825	165	831	166	853	171	951	190	998	200
Season IV Average values				**638**	**128**	**686**	**137**	**690**	**138**	**709**	**142**	**790**	**158**	**829**	**166**

Table 4.14 Proposed Minimum Flows Using Monthly Average Flow 90% Dependable Year 2003-04.

SEASONAL METHODOLOGY USING MONTHLY AVERAGE FLOW 90% DEPENDABLE YEAR 2003-04														
			KALAI I		KALAI II		HUTONG I		HUTONG II		DEMWE UPPER		DEMWE LOWER	
Season	Month	Percentage	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow	Average	Min. Flow
	May	0.3	639	192	687	206	691	207	710	213	791	237	831	249
	June	0.3	1181	354	1269	381	1278	383	1312	394	1462	439	1536	461
I	July	0.3	1168	350	1255	377	1264	379	1298	389	1446	434	1518	456
	August	0.3	581	174	625	187	629	189	646	194	720	216	756	227
	September	0.3	545	164	586	176	590	177	606	182	675	203	709	213
Season I Average values			**823**	**247**	**884**	**265**	**890**	**267**	**914**	**274**	**1019**	**306**	**1070**	**321**
II	October	0.2	424	85	456	91	459	92	471	94	525	105	551	110
	November	0.1	338	34	363	36	366	37	375	38	418	42	439	44
	December	0.1	296	30	318	32	320	32	328	33	366	37	384	38
III	January	0.1	275	28	296	30	298	30	306	31	341	34	358	36
	February	0.1	254	25	273	27	275	28	282	28	315	31	330	33
	March	0.1	342	34	368	37	370	37	380	38	424	42	445	44
Season III Average values			**301**	**30**	**323**	**32**	**326**	**33**	**334**	**33**	**373**	**37**	**391**	**39**
IV	April	0.2	638	128	686	137	690	138	709	142	790	158	829	166
Total Average			**558**	**134**	**599**	**144**	**603**	**145**	**619**	**149**	**690**	**166**	**725**	**174**

Figure 4.4 Ten daily hydrograph for Kalai I using flow series from 1984-85 to 2003-04.

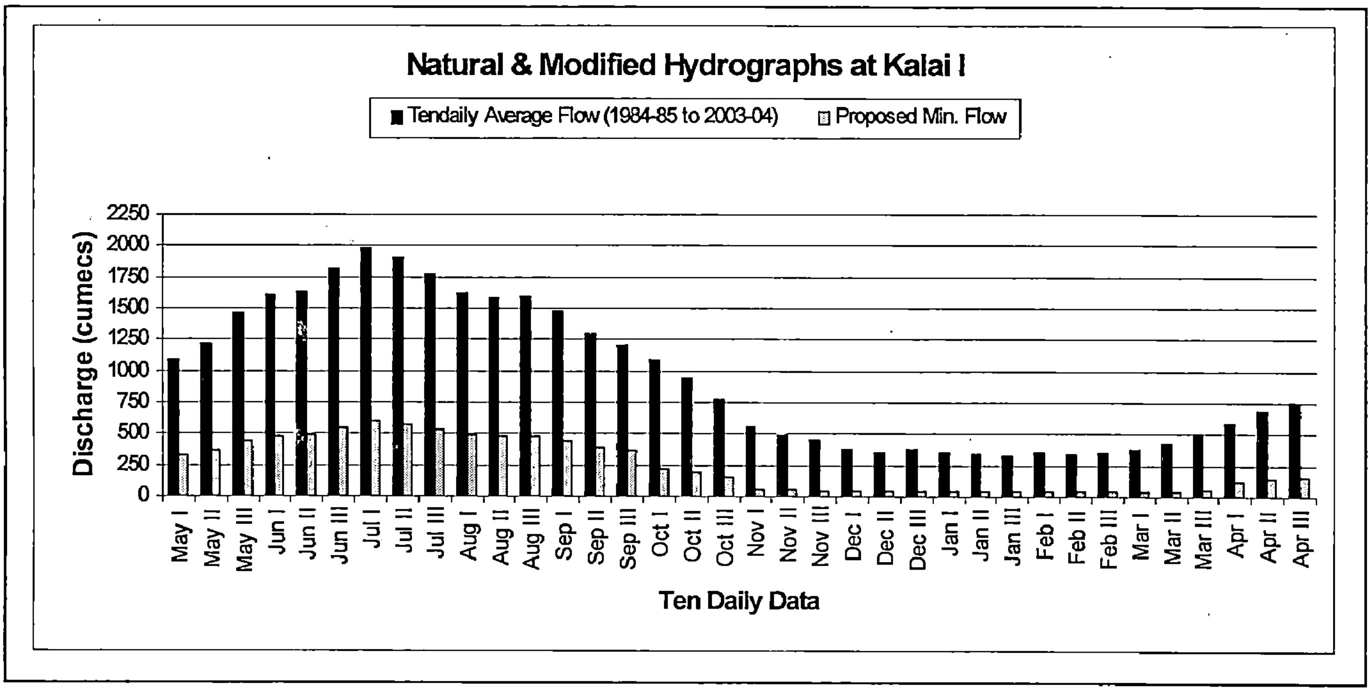


Figure 4.5 Ten daily hydrograph for Kalai II using series from 1984-85 to 2003-04.

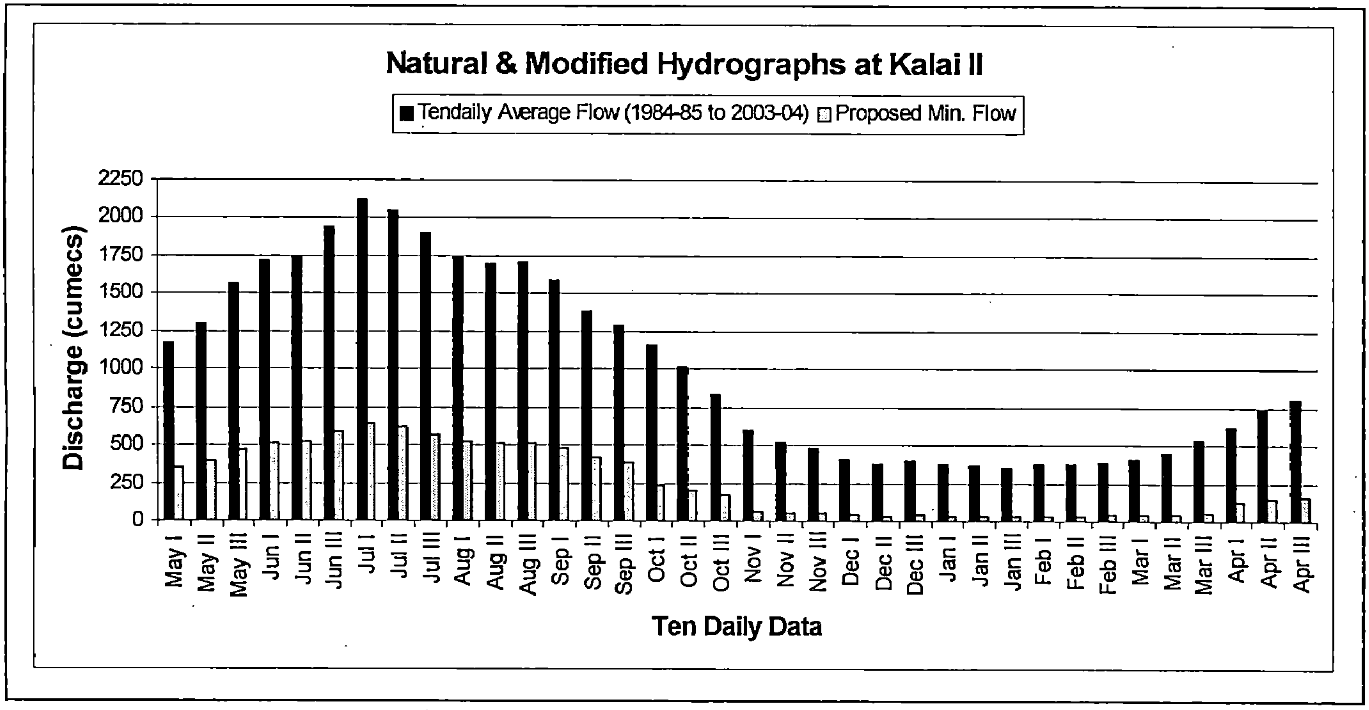


Figure 4.6 Ten daily hydrograph for Hutong I using flow series from 1984-85 to 2003-04.

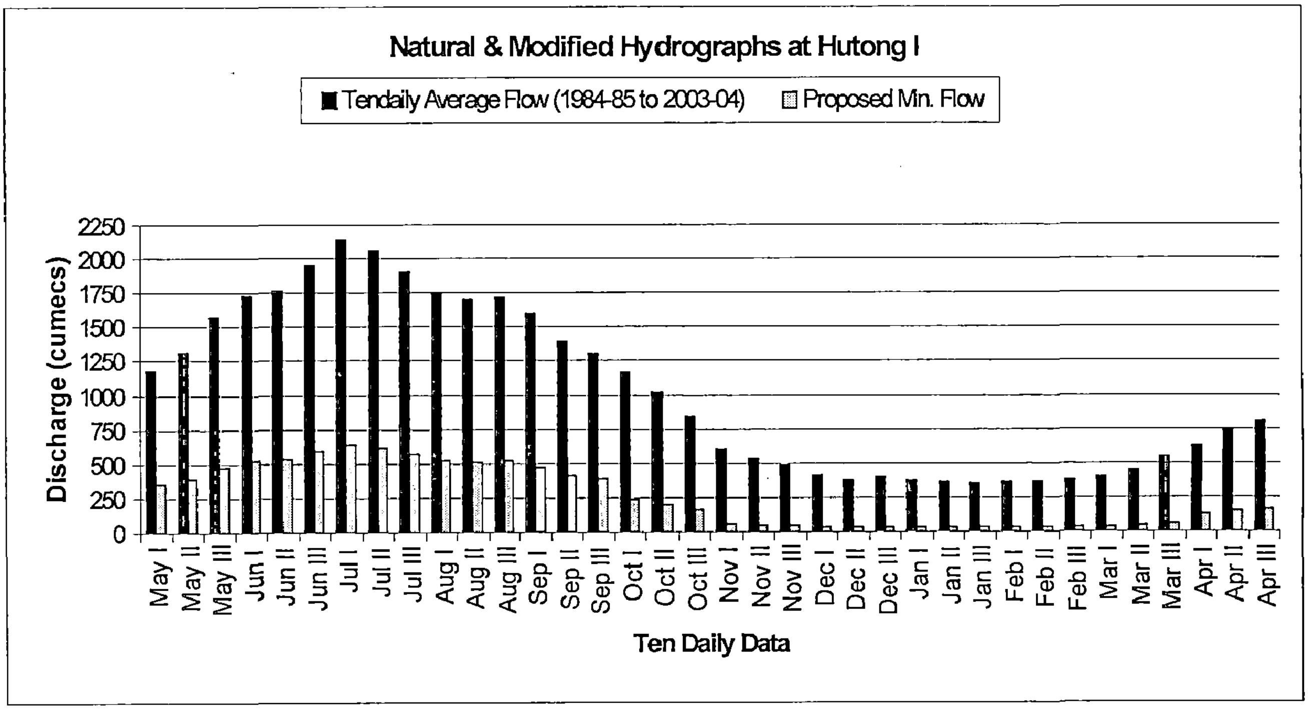


Figure 4.7 Ten daily hydrograph for Hutong II using flow series from 1984-85 to 2003-04.

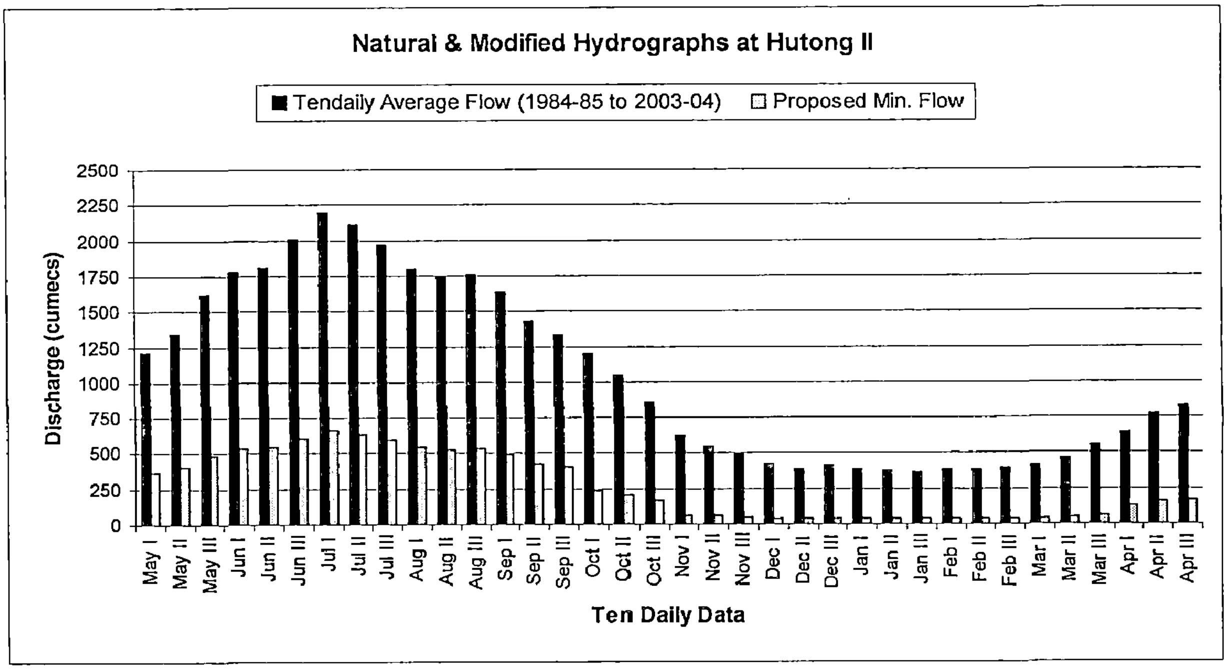


Figure 4.8 Ten daily hydrograph Demwe Upper using flow series from 1984-85 to 2003-04.

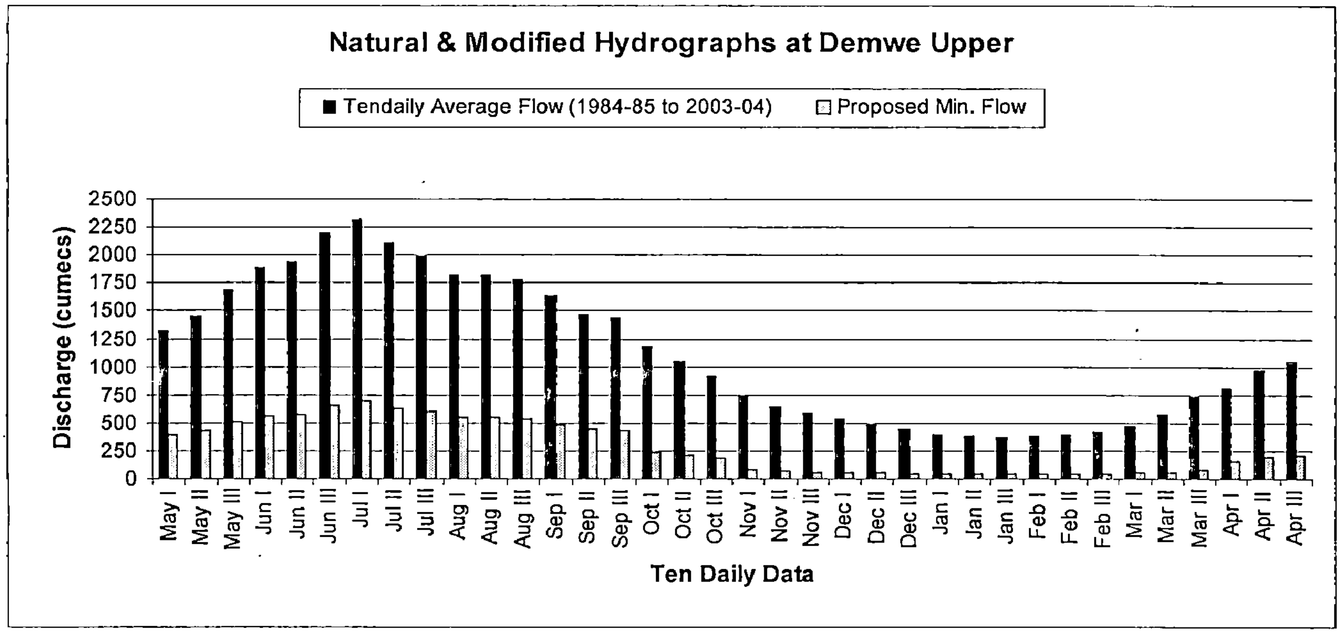


Figure 4.9 Ten daily hydrograph Demwe Lower using flow series from 1984-85 to 2003-04.

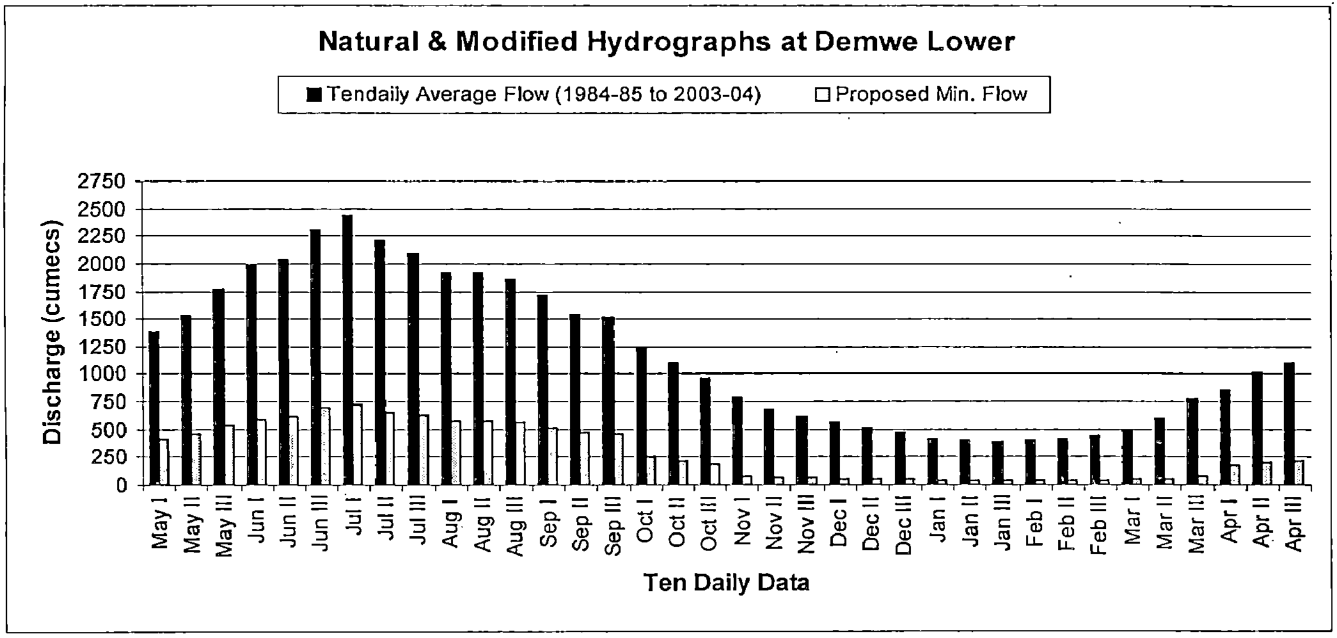


Figure 4.10 Ten daily hydrograph for 90% Dependable year 2003-04 for Kalai I.

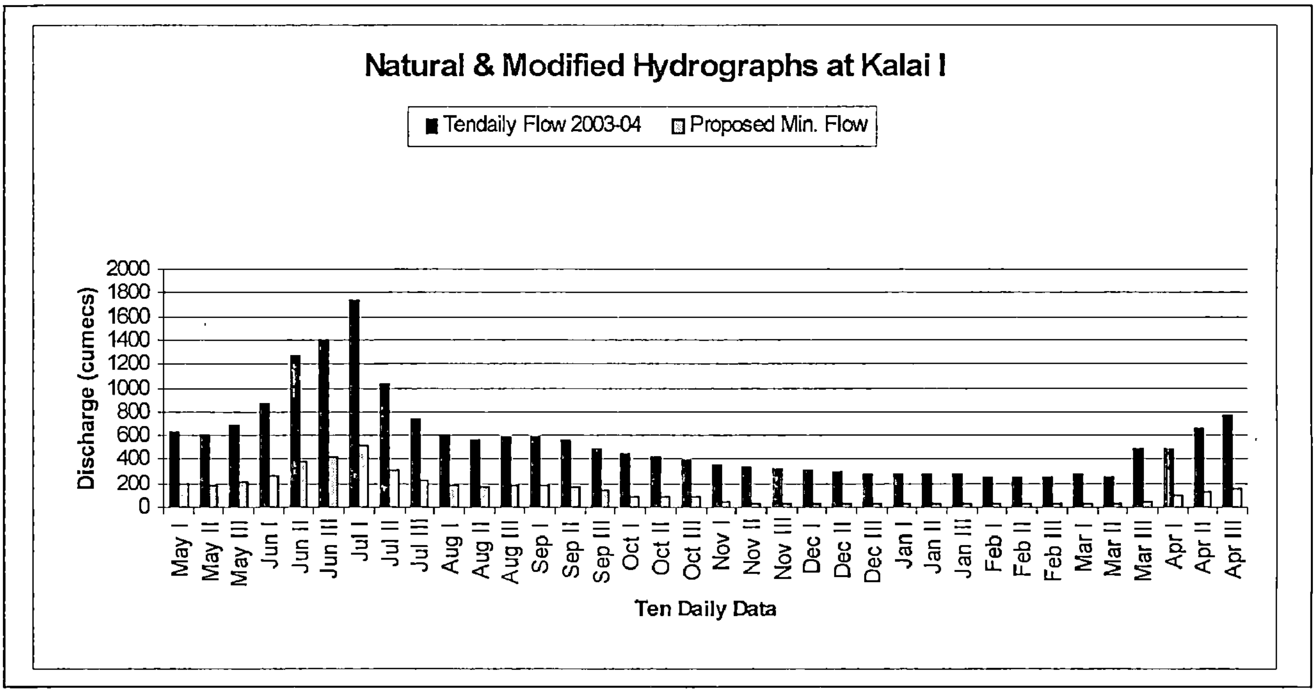


Figure 4.11 Ten daily hydrograph for 90% Dependable year 2003-04 for Kalai II.

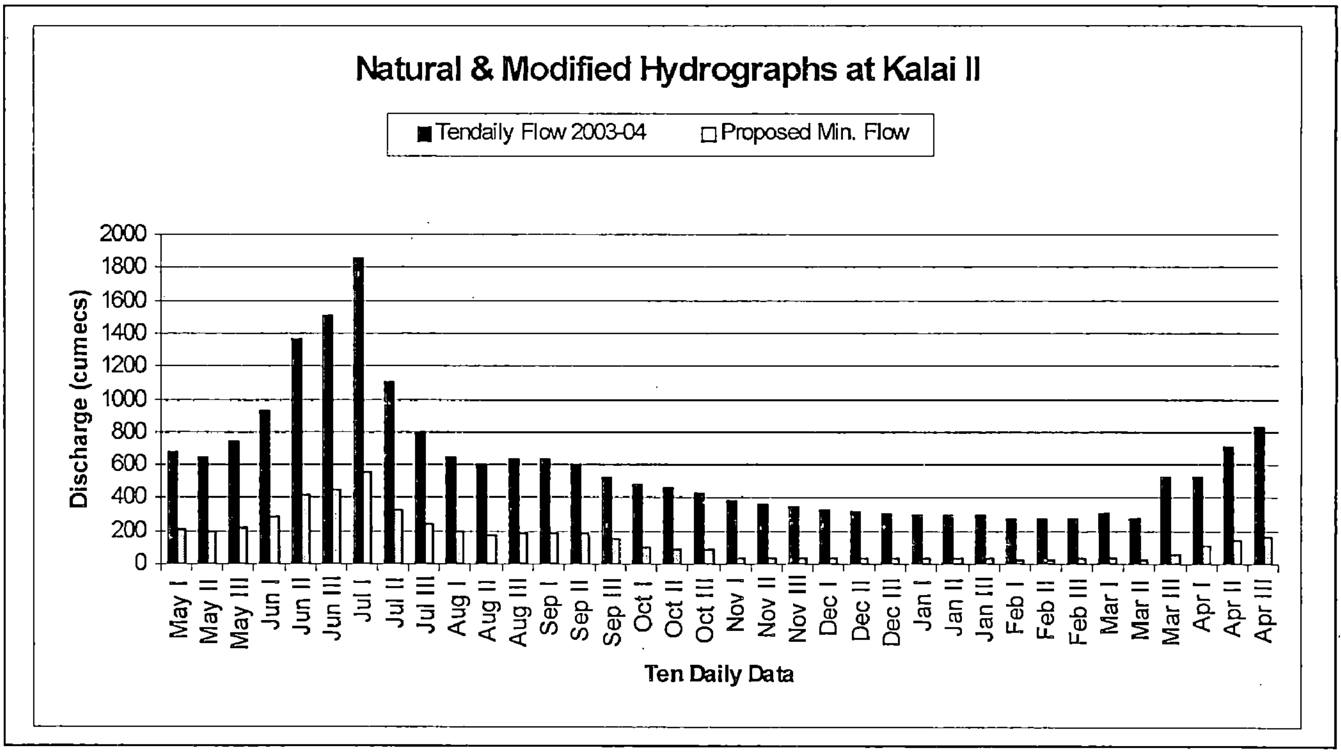


Figure 4.12 Ten daily hydrograph for 90% Dependable year 2003-04 for Hutong I.

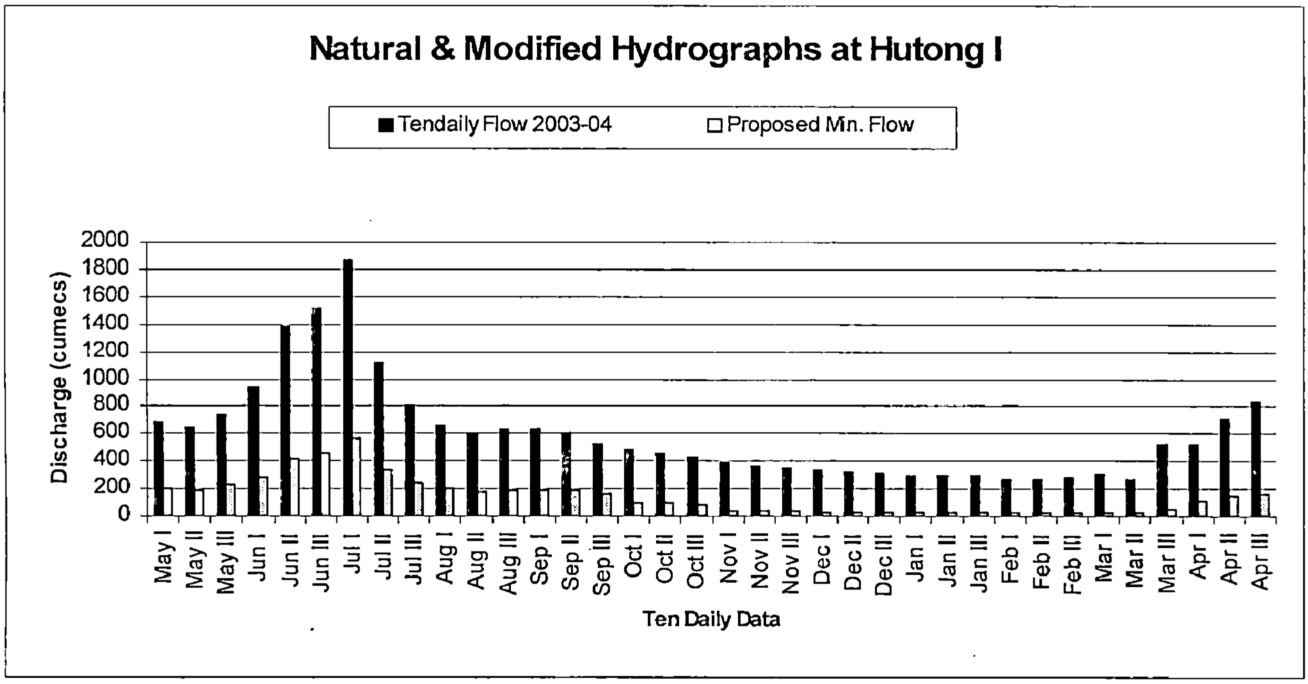


Figure 4.13 Ten daily hydrograph for 90% Dependable year 2003-04 for Hutong II.

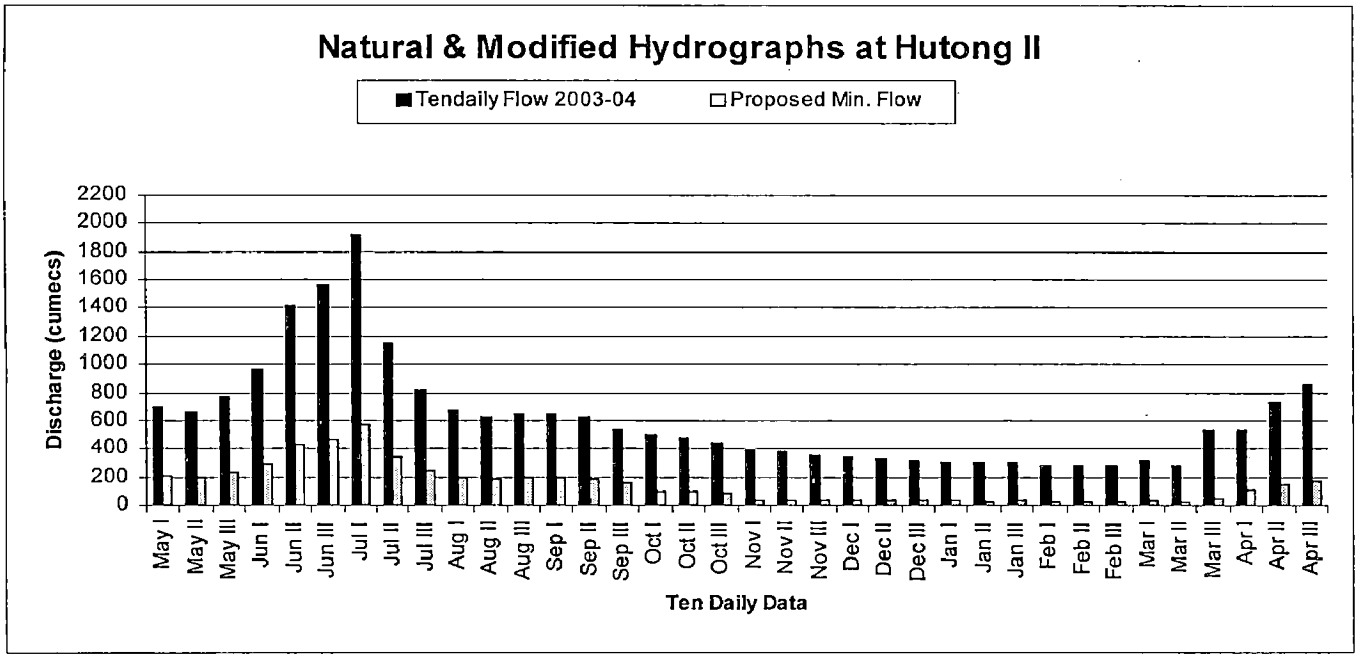


Figure 4.14 Ten daily hydrograph for 90% Dependable year 2003-04 for Demwe Upper.

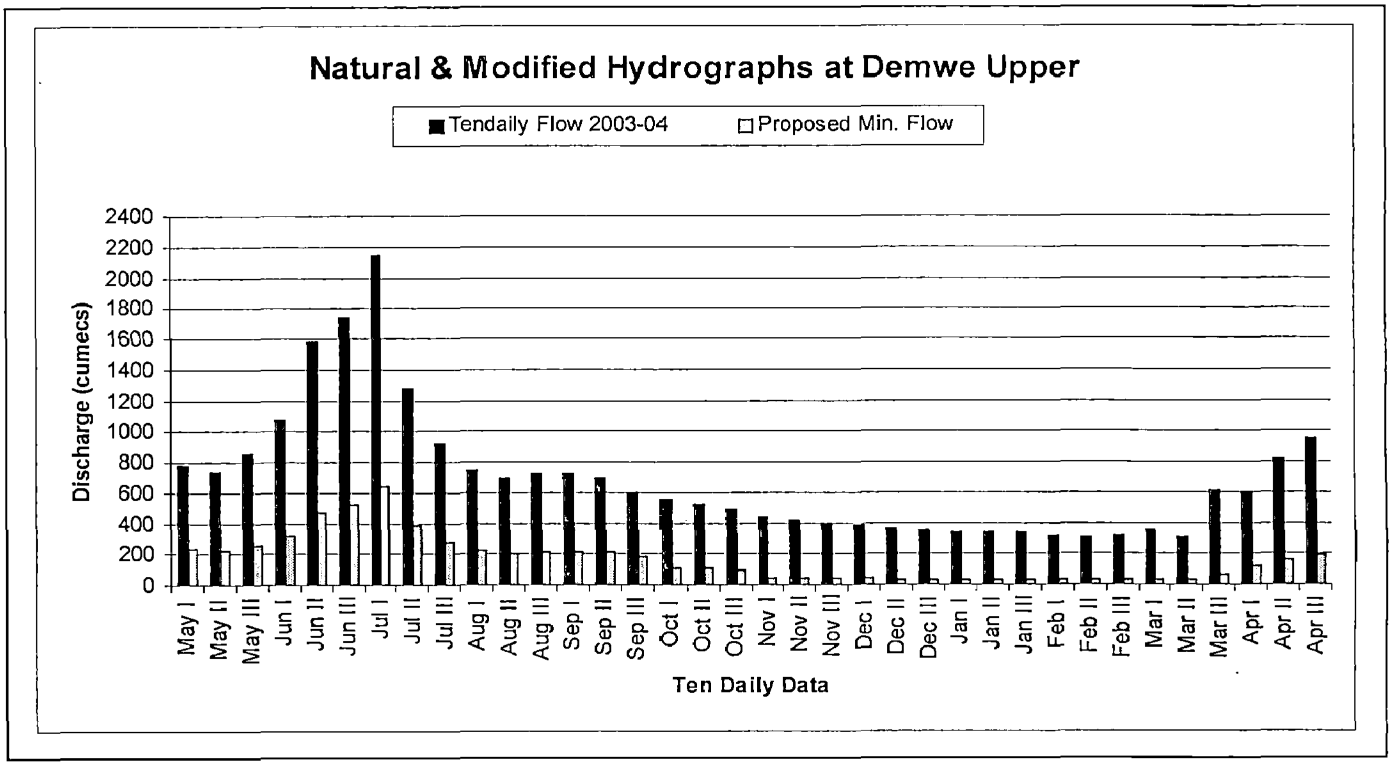
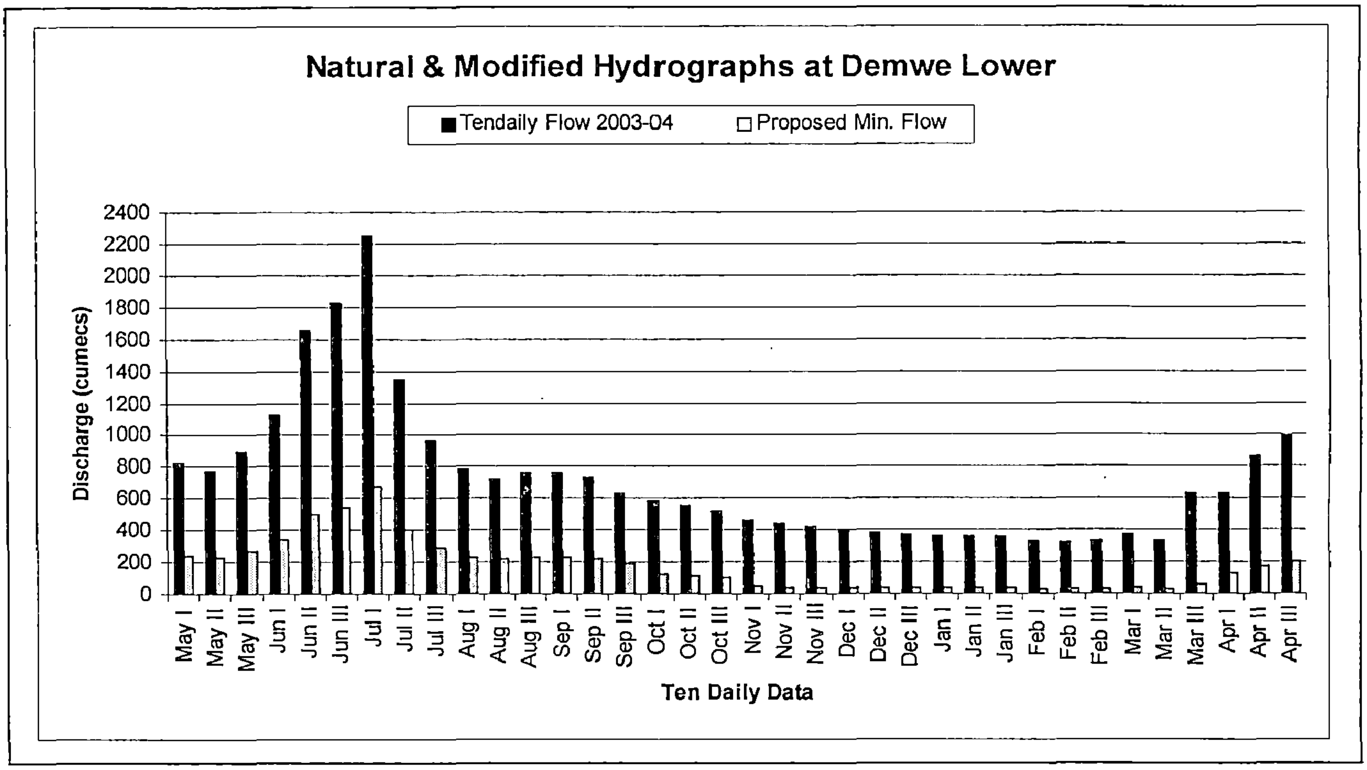


Figure 4.15 Ten daily hydrograph for 90% Dependable year 2003-04 for Demwe Lower.



4.6 ESTIMATION OF STAGE-DISCHARGE RELATIONSHIP

In Lohit River only cross section data was available at different locations downstream of three projects (Kalai I, Hutong II and Demwe Lower), and no stage discharge relationship was available. Therefore, the first step was to generate a synthetic form of normal depth discharge relationship. Since, only cross section area (A) and corresponding wetted perimeter (P) is available at different stages; the discharges were obtained using Manning's equation. The water depths were taken in the intervals of 0.5 m, ranging between 0.5 m to 3.0 meters. Therefore, a relation between normal depth and discharge is obtained at three different project sites, where the cross section of the river is available at different length along the river channel. Assumptions taken in Manning's equation are:

- *Steady flow condition.*
  The critical period of analysis in this project occurs during dry season, when rainfall is not expected and runoff can be taken as zero, therefore, additional discharge from lateral inflow for a selected reach is zero, seepage is negligible, and discharge is assumed to be steady.

- *One-dimensional analysis.*
  In one-dimensional analysis, the mean velocity is used as a representative velocity for the entire cross section and is defined on the basis of the longitudinal component. Hence, the velocities in the other than the main direction of flow are not considered.

Manning's equation can be written in terms of discharge as:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2} \qquad \text{(eq 4.1)}$$

where:

Q is the discharge (m3/s).
n is the roughness coefficient (dimensionless).
A is the area of the cross section perpendicular to flow (m2).
R is the hydraulic radius in meters (R=A/P).
S is the slope of the river bed (m/m)

The selection of *n* value was done by tables using a description of the river conditions "in situ". According with Chow (1959), the roughness coefficient for a natural minor stream (top width at flood stage < 100 ft), mountain river stream, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages. River bed conforms of boulders, cobbles and few boulders range from [0.03-0.05]. Therefore, the analysis has been carried out for Manning's *n* of 0.03, 0.04, and 0.05. Three different curves of Water Depth vs. Discharge were obtained for each dam site analyzed.

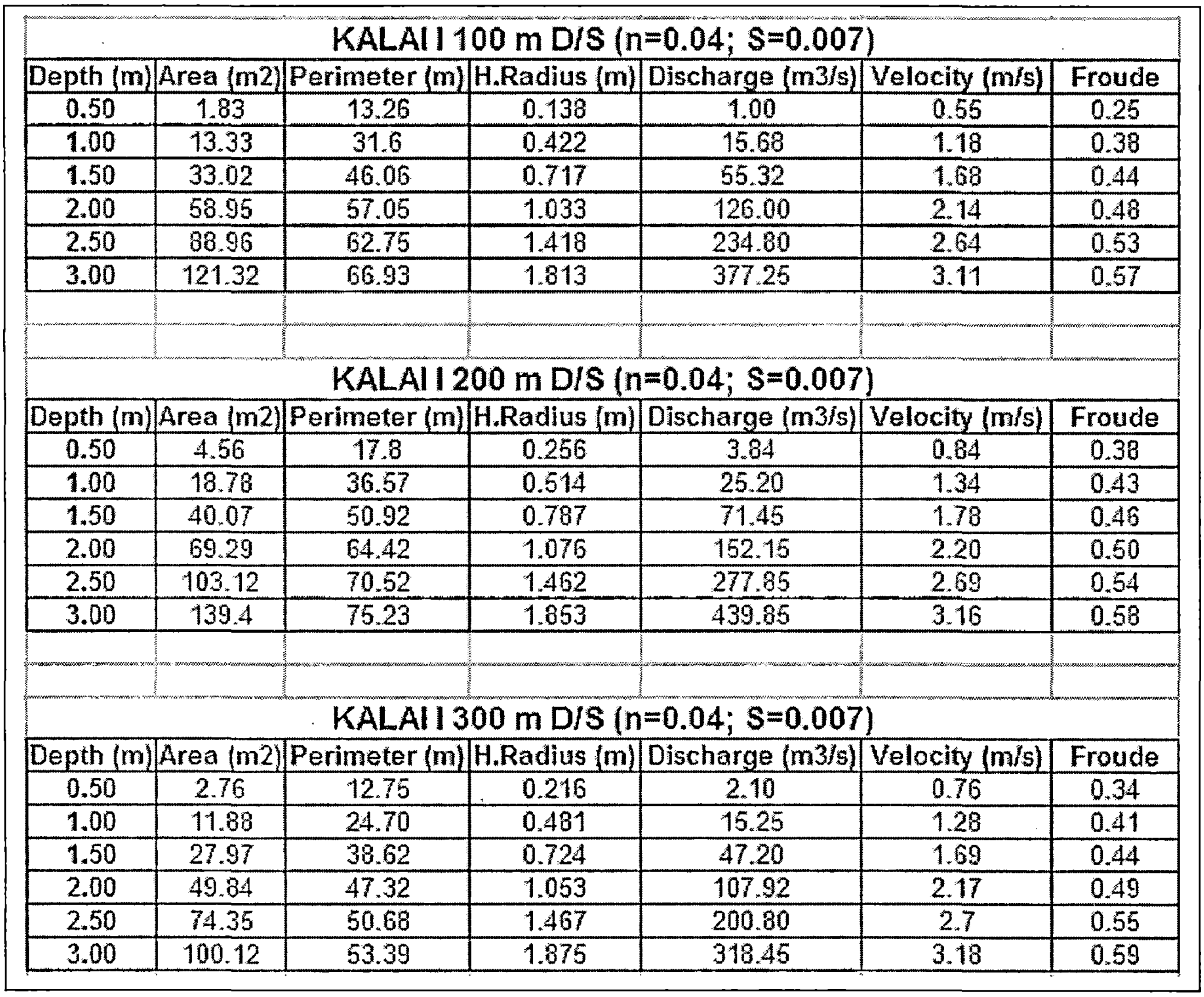
The river bed slope is taken as average value between two adjacent site projects, where the bed elevation and the distance is known. Hence, the slope is S = ΔH/ΔL, where ΔH is difference in bed elevation between two sites and ΔL is the distance between project sites.

Table 4.15 Average slope at different dam sites in Lohit River basin.

	COORDINATES		DISTANCE		SLOPE CALCS		
DAM SITE	LAT	LONG	Length (Km)	ΔL (Km)	BED LEVEL (msl)	ΔH (msl)	ΔH/ΔL
KL-I	27° 54' 55" N	96° 57' 30" E	0		915.25		
				19.5		135.45	0.007
KL-II	27° 54' 20" N	96° 47' 57" E	19.5		779.8		
				5.5		24	0.004
HTG-I	27° 57' 38" N	96° 43' 40" E	25		755.8		
				16.5		166.3	0.010
HTG-II	28° 00' 38" N	96° 37' 38" E	41.5		589.5		
				27		159.5	0.006
D.U	28° 02' 58" N	96° 27' 05" E	68.5		430		
				25.6		125	0.005
D.L	27° 52' 48" N	96° 22' 39" E	94.1		305		

Computations of average flow velocity using continuity equation and Froude number was also done. A summary of data generated is showing in table 4.16 for Kalai I, table 4.17 for Hutong II and table 4.18 for Demwe Lower.

Table 4.16 Normal depth-discharge relationship for Kalai I.



KALAI I 100 m D/S (n=0.04; S=0.007)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	1.83	13.26	0.138	1.00	0.55	0.25
1.00	13.33	31.6	0.422	15.68	1.18	0.38
1.50	33.02	46.06	0.717	55.32	1.68	0.44
2.00	58.95	57.05	1.033	126.00	2.14	0.48
2.50	88.96	62.75	1.418	234.80	2.64	0.53
3.00	121.32	66.93	1.813	377.25	3.11	0.57

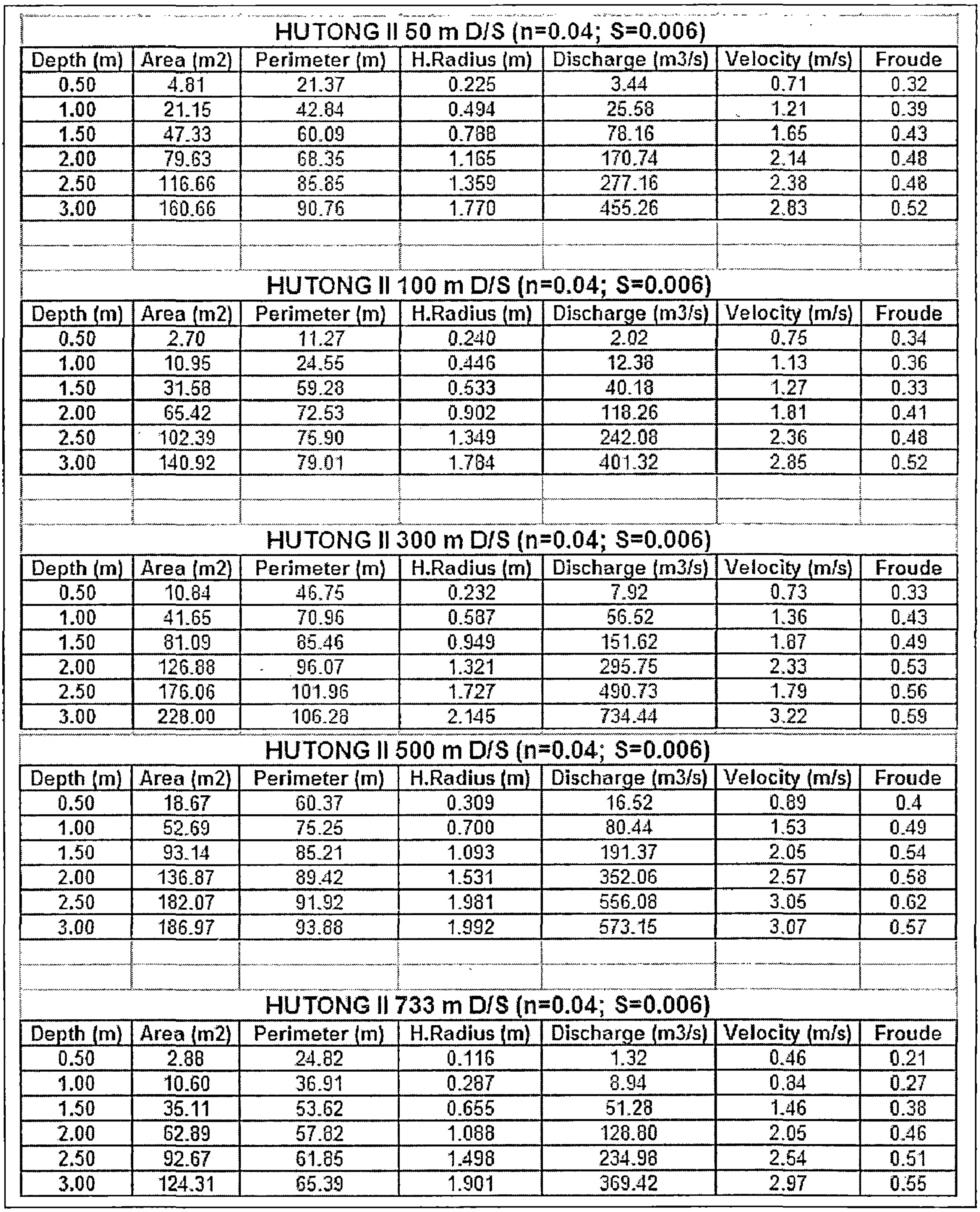
KALAI I 200 m D/S (n=0.04; S=0.007)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	4.56	17.8	0.256	3.84	0.84	0.38
1.00	18.78	36.57	0.514	25.20	1.34	0.43
1.50	40.07	50.92	0.787	71.45	1.78	0.46
2.00	69.29	64.42	1.076	152.15	2.20	0.50
2.50	103.12	70.52	1.462	277.85	2.69	0.54
3.00	139.4	75.23	1.853	439.85	3.16	0.58

KALAI I 300 m D/S (n=0.04; S=0.007)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	2.76	12.75	0.216	2.10	0.76	0.34
1.00	11.88	24.70	0.481	15.25	1.28	0.41
1.50	27.97	38.62	0.724	47.20	1.69	0.44
2.00	49.84	47.32	1.053	107.92	2.17	0.49
2.50	74.35	50.68	1.467	200.80	2.7	0.55
3.00	100.12	53.39	1.875	318.45	3.18	0.59

Table 4.17 Normal depth-discharge relation for Hutong II.



HUTONG II 50 m D/S (n=0.04; S=0.006)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	4.81	21.37	0.225	3.44	0.71	0.32
1.00	21.15	42.84	0.494	25.58	1.21	0.39
1.50	47.33	60.09	0.788	78.16	1.65	0.43
2.00	79.63	68.35	1.165	170.74	2.14	0.48
2.50	116.66	85.85	1.359	277.16	2.38	0.48
3.00	160.66	90.76	1.770	455.26	2.83	0.52

HUTONG II 100 m D/S (n=0.04; S=0.006)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	2.70	11.27	0.240	2.02	0.75	0.34
1.00	10.95	24.55	0.446	12.38	1.13	0.36
1.50	31.58	59.28	0.533	40.18	1.27	0.33
2.00	65.42	72.53	0.902	118.26	1.81	0.41
2.50	102.39	75.90	1.349	242.08	2.36	0.48
3.00	140.92	79.01	1.784	401.32	2.85	0.52

HUTONG II 300 m D/S (n=0.04; S=0.006)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	10.84	46.75	0.232	7.92	0.73	0.33
1.00	41.65	70.96	0.587	56.52	1.36	0.43
1.50	81.09	85.46	0.949	151.62	1.87	0.49
2.00	126.88	96.07	1.321	295.75	2.33	0.53
2.50	176.06	101.96	1.727	490.73	1.79	0.56
3.00	228.00	106.28	2.145	734.44	3.22	0.59

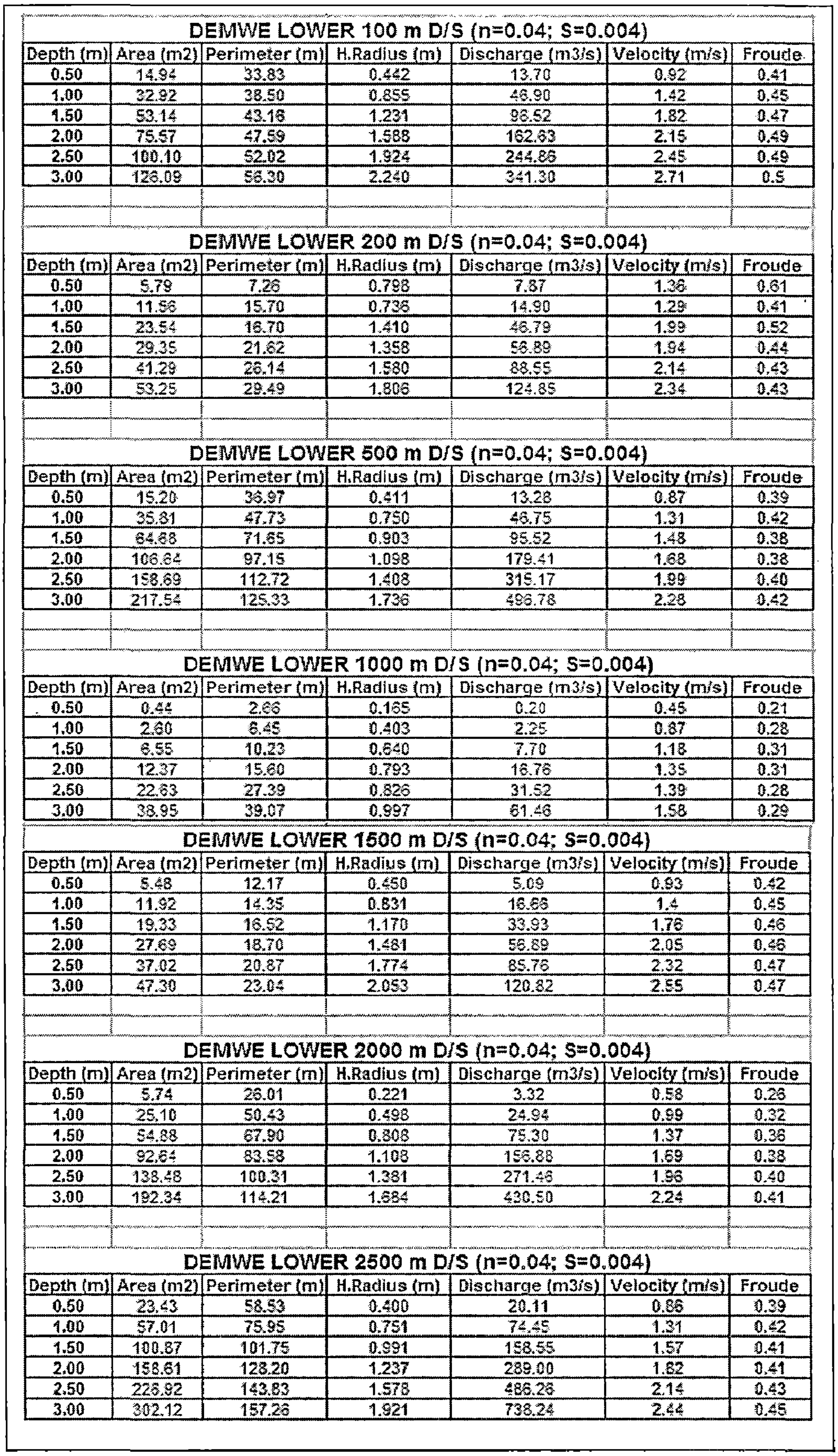
HUTONG II 500 m D/S (n=0.04; S=0.006)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	18.67	60.37	0.309	16.52	0.89	0.4
1.00	52.69	75.25	0.700	80.44	1.53	0.49
1.50	93.14	85.21	1.093	191.37	2.05	0.54
2.00	136.87	89.42	1.531	352.06	2.57	0.58
2.50	182.07	91.92	1.981	556.08	3.05	0.62
3.00	186.97	93.88	1.992	573.15	3.07	0.57

HUTONG II 733 m D/S (n=0.04; S=0.006)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	2.88	24.82	0.116	1.32	0.46	0.21
1.00	10.60	36.91	0.287	8.94	0.84	0.27
1.50	35.11	53.62	0.655	51.28	1.46	0.38
2.00	62.89	57.82	1.088	128.80	2.05	0.46
2.50	92.67	61.85	1.498	234.98	2.54	0.51
3.00	124.31	65.39	1.901	369.42	2.97	0.55

Table 4.18 Normal depth-discharge relation for Demwe Lower.



DEMWE LOWER 100 m D/S (n=0.04; S=0.004)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	14.94	33.83	0.442	13.70	0.92	0.41
1.00	32.92	38.50	0.855	46.90	1.42	0.45
1.50	53.14	43.16	1.231	96.52	1.82	0.47
2.00	75.57	47.59	1.588	162.63	2.15	0.49
2.50	100.10	52.02	1.924	244.86	2.45	0.49
3.00	126.09	56.30	2.240	341.30	2.71	0.5

DEMWE LOWER 200 m D/S (n=0.04; S=0.004)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	5.79	7.26	0.798	7.87	1.36	0.61
1.00	11.56	15.70	0.736	14.90	1.29	0.41
1.50	23.54	16.70	1.410	46.79	1.99	0.52
2.00	29.35	21.62	1.358	56.89	1.94	0.44
2.50	41.29	26.14	1.580	88.55	2.14	0.43
3.00	53.25	29.49	1.806	124.85	2.34	0.43

DEMWE LOWER 500 m D/S (n=0.04; S=0.004)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	15.20	36.97	0.411	13.28	0.87	0.39
1.00	35.81	47.73	0.750	46.75	1.31	0.42
1.50	64.68	71.65	0.903	95.52	1.48	0.38
2.00	106.64	97.15	1.098	179.41	1.68	0.38
2.50	158.69	112.72	1.408	315.17	1.99	0.40
3.00	217.54	125.33	1.736	496.78	2.28	0.42

DEMWE LOWER 1000 m D/S (n=0.04; S=0.004)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	0.44	2.66	0.165	0.20	0.45	0.21
1.00	2.60	6.45	0.403	2.25	0.87	0.28
1.50	6.55	10.23	0.640	7.70	1.18	0.31
2.00	12.37	15.60	0.793	16.76	1.35	0.31
2.50	22.63	27.39	0.826	31.52	1.39	0.28
3.00	38.95	39.07	0.997	61.46	1.58	0.29

DEMWE LOWER 1500 m D/S (n=0.04; S=0.004)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	5.48	12.17	0.450	5.09	0.93	0.42
1.00	11.92	14.35	0.831	16.66	1.4	0.45
1.50	19.33	16.52	1.170	33.93	1.76	0.46
2.00	27.69	18.70	1.481	56.89	2.05	0.46
2.50	37.02	20.87	1.774	85.76	2.32	0.47
3.00	47.30	23.04	2.053	120.82	2.55	0.47

DEMWE LOWER 2000 m D/S (n=0.04; S=0.004)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	5.74	26.01	0.221	3.32	0.58	0.26
1.00	25.10	50.43	0.498	24.94	0.99	0.32
1.50	54.88	67.90	0.808	75.30	1.37	0.36
2.00	92.64	83.58	1.108	156.88	1.69	0.38
2.50	138.48	100.31	1.381	271.46	1.96	0.40
3.00	192.34	114.21	1.684	430.50	2.24	0.41

DEMWE LOWER 2500 m D/S (n=0.04; S=0.004)

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude
0.50	23.43	58.53	0.400	20.11	0.86	0.39
1.00	57.01	75.95	0.751	74.45	1.31	0.42
1.50	100.87	101.75	0.991	158.55	1.57	0.41
2.00	158.61	128.20	1.237	289.00	1.82	0.41
2.50	226.92	143.83	1.578	486.26	2.14	0.43
3.00	302.12	157.26	1.921	738.24	2.44	0.45

Since Froude number is less than one in all cases, the flow is sub-critical. Normal depth vs. discharge relationship is prepared at a particular site considering the maximum discharge corresponding to a particular depth among various sections at a particular project site. That means, the maximum discharge which is capable of maintaining the required water depth (say 0.5, 1, 1.5, etc) in all the cross-sections in the respective reach is selected. These curves were prepared for n=0.03, 0.04 and 0.05. For example, at Kalai I, the maximum depth required for maintaining various depths are shown in Table 4.19; that means the respective depth will be maintained with corresponding flow.

Table 4.19 Relation between Normal depth and discharges at Kalai I.

Max Discharge among all sections of Kalai I			
Depth	**0.03**	**0.04**	**0.05**
0	0	0	0
0.5	5.14	3.84	3.1
1	33.57	25.2	20.14
1.5	95.27	71.45	57.16
2	202.85	152.15	121.71
2.5	370.5	277.85	222.3
3	586.48	439.85	351.88

Figure 4.16 Normal depth vs. discharge at Kalai I for different values of *n*.

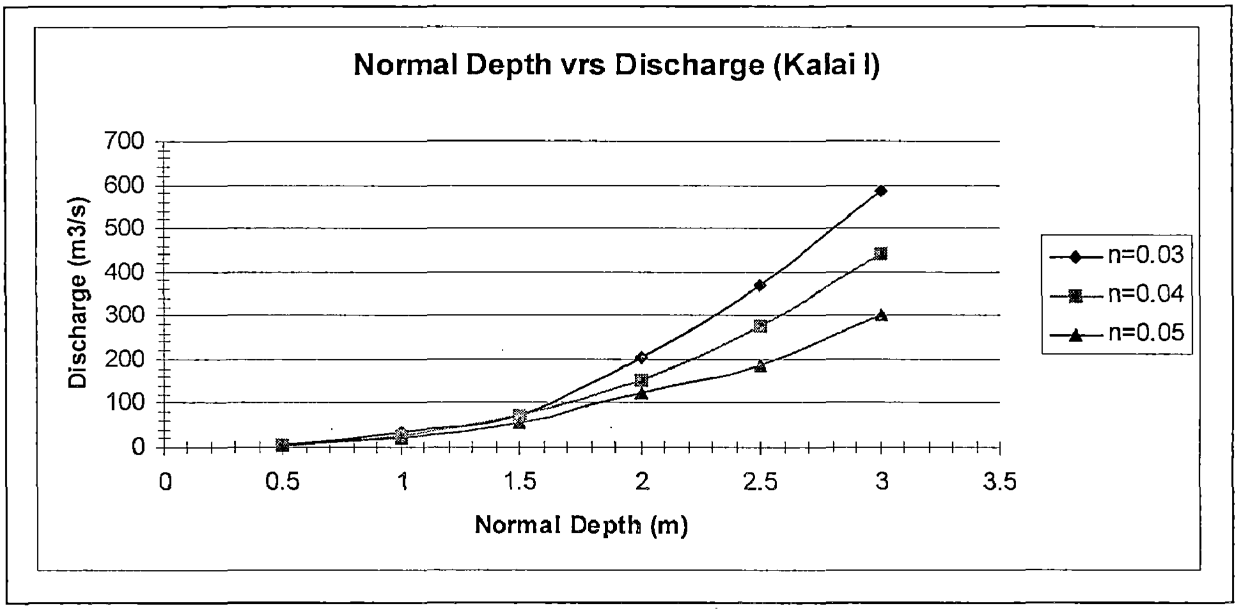


Table 4.20 Relation between Normal depth and discharges at Hutong II.

Max Discharge among all sections of H-II			
Depth	**0.03**	**0.04**	**0.05**
0	0	0	0
0.5	22.02	16.52	13.21
1	107.26	80.44	64.36
1.5	255.16	191.37	153.09
2	469.4	352.06	281.64
2.5	741.44	556.06	444.86
3	979.24	734.44	587.55

Figure 4.17 Normal depth vs. discharge at Hutong II for different values of *n*.

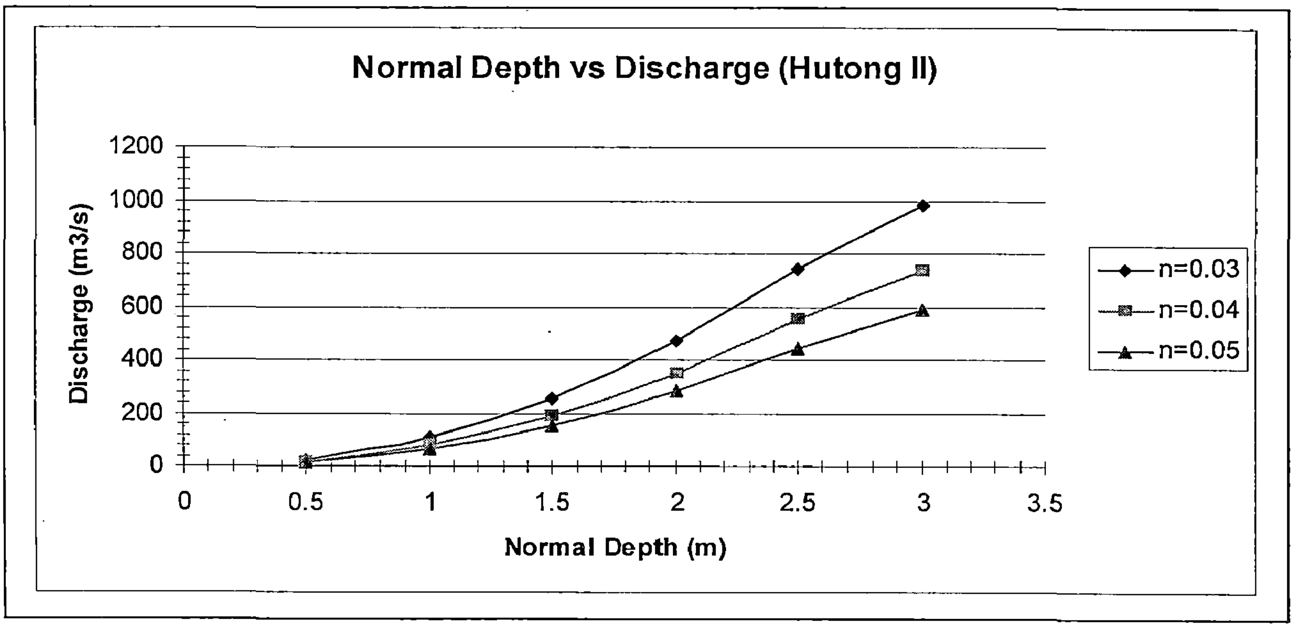
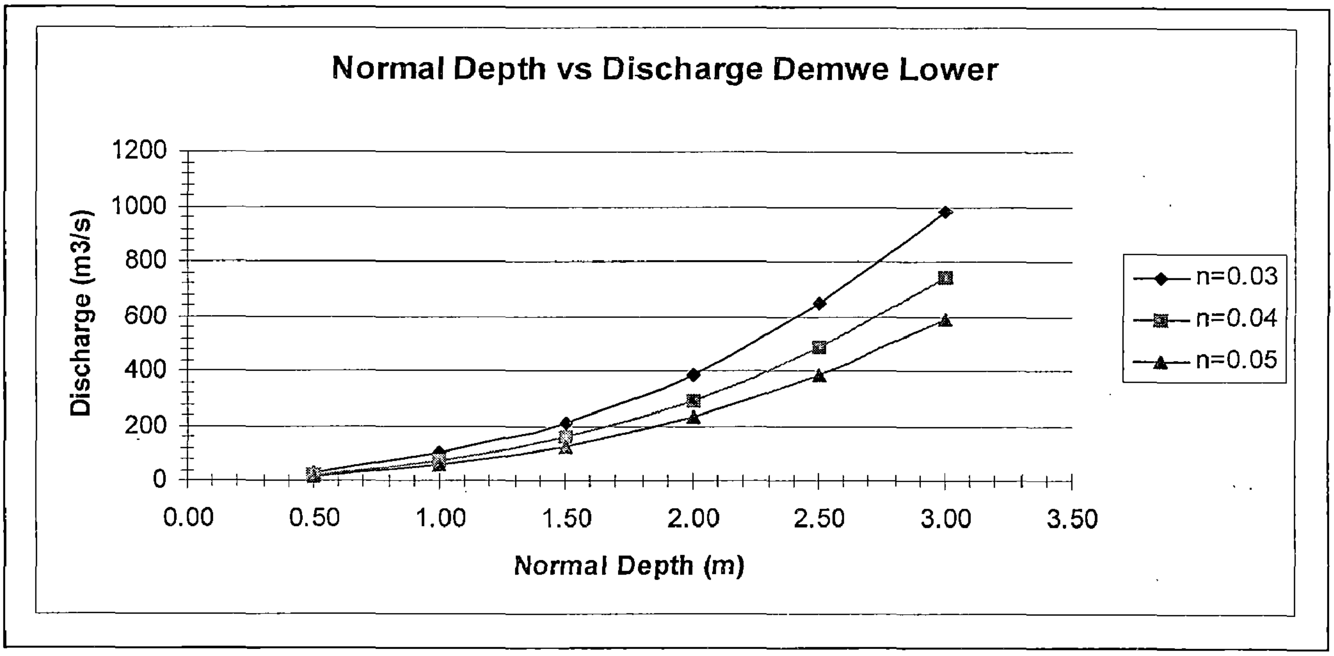


Table 4.21 Relation between Normal Depth and discharges at Demwe Lower.

Max Discharge among all sections of D. L.			
Depth	**0.03**	**0.04**	**0.05**
0	0	0	0
0.50	26.82	20.11	16.09
1.00	99.28	74.45	59.56
1.50	211.4	158.55	126.84
2.00	385.35	289	231.21
2.50	648.35	486.26	389
3.00	984.32	738.24	590.59

Figure 4.18 Normal Depth vs. discharge at Demwe Lower for different values of *n*.



Alternatively, numerical relationship can be derived between Normal depth and Discharge corresponding to different values of *n* as shown in Table 4.22.

Table 4.22 Numerical relations for Normal depth-discharge relationship.

n value	*n* = 0.03		*n* = 0.04		*n* = 0.05	
SITE	**Equation**	**R^2**	**Equation**	**R^2**	**Equation**	**R^2**
Kalai I	$Q=32.64Y^{2.6424}$	0.9999	$Q=24.45Y^{2.6442}$	0.9999	$Q=19.621Y^{2.6398}$	0.9999
HTG-II	$Q=102.52Y^{2.1384}$	0.9982	$Q=76.896Y^{2.1382}$	0.9982	$Q=61.508Y^{2.1384}$	0.9982
D.Lower	$Q=101.58Y^{1.9982}$	0.9979	$Q=76.175Y^{1.9983}$	0.9979	$Q=60.943Y^{1.9983}$	0.9979

4.7 WATER QUALITY IN LOHIT BASIN

(i) Time and frequency of the study

The total period of time covered by water quality study was six (6) months during 2009. The frequency of monitoring was done per month during six (6) consecutive months. The collection of samples and corresponding analysis were done by external source (WAPCOS, 2009) hence, the data presented in this section is a secondary data. The months in which monitoring was conducted are given as below:

- April 2009
- May 2009
- June 2009
- July 2009
- August 2009
- September 2009

(ii) Sampling sites

The water quality monitoring in Lohit basin was conducted at various locations in the study area, as mentioned earlier, six hydroelectric projects are proposed to be commissioned in the study area. Five sampling sites were monitored for each project. Thus, a total of thirty (30) sampling locations were covered as a part of the study. General sampling locations covered as a part of the study are listed below:

- Site 1 (S1): located at 5000 m upstream of dam site
- Site 2 (S2): located at 3000 upstream of dam site
- Site 3 (S3): located at dam site itself.
- Site 4 (S4): located at 3000 m downstream of dam site
- Site 5 (S5): located at 5000 m downstream of dam site

(iii) Water quality parameters

The main water quality parameters given in the study are:

- pH.
- Electrical conductivity.
- Total dissolved solids.
- Presence of heavy metals.
- BOD.
- COD.
- DO.
- Total coliforms.

A complete list of water quality parameters and values for each proposed site at different months are given in Annexure D.

4.8 FISHERIES SAMPLING IN LOHIT BASIN

The fisheries study was done in the same time and same locations of water quality studies, therefore both studies (water quality and fisheries survey) were carry on simultaneously. List of fishes available in Lohit River is given in next tables for each proposed site.

Table 4.23 Fish composition in Kalai I and II. Source: WAPCOS, 2009.

Family	Species	Kalai-I					Kalai-II				
		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×	×	×	×	×	×

Table 4.24 Fish composition in Hutong I and II. Source: WAPCOS, 2009.

Family	Species	Hutong-I					Hutong-II				
		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×		×	×		×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×	×	×	×	×	×

Table 4.25 Fish composition in Upper and Lower Demwe. Source: WAPCOS, 2009.

Family	Species	Upper Demwe					Lower Demwe				
		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×	×	×	×	×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×	×	×	×	×	×
Cyprinidae	*Labeo pangusia*						×	×	×	×	×
Cyprinidae	*Tor tor*						×	×	×	×	×
Cyprinidae	*Chagunius chagunio*						×	×	×	×	×
Cyprinidae	*Garra gotyla*						×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×	×	×	×	×	×
Siluridae	*Rita rita*						×	×	×	×	×

From fisheries sampling is may notice that three main species in Lohit river are:

- *Schizothorax richardsonii.*
- *Tor putitora.*
- *Acrossocheilus hexagonolepis.*

4.9 DISCUSSION OF RESULTS AND CONCLUSIONS

- From dependability analysis, the 90% dependable flow corresponds the year 2003-04, using ten-daily extended flow series of 20 years from 1984-1985 upto 2003-2004, it is considered as representative for further analysis.

- The Average Annual Flow (AAF) on the basis of all years flow (1984-85 to 2003-04), dependable year and corresponding 90 % dependable flow for 90 % dependable year for various sites and AAF for 5% dependable year are shown in table 4.26.

Copy Table 4.7 AAF for the whole series, 90% dependable flow ($Q_{90\%}$) for 90% dependable year, and AAF for 90% and 5% dependable years.7

Proposed Site	Av. Annual Flow (1984-85 to 2003-04)	90 % dependable year	90 % dependable Flow ($Q_{90\%}$) (2003-04)	Av. Annual Flow for 90 % dependable year (2003-04)	Av. Annual Flow for 5% dependable year (1996-97)
Kalai I	947	2003-04	258	557	1368
Kalai II	1017	2003-04	278	598	1470
Hutong I	1024	2003-04	279	602	1479
Hutong II	1051	2003-04	287	618	1519
Demwe Upper	1126	2003-04	320	689	1628
Demwe Lower	1185	2003-04	336	723	1710

It may be observed in table 4.26 that the total AAF is increasing within proposed site downstream of the river. That means the recorded data has a logic sequence, since the project is under cascade scheme and the catchment area of each proposed dam site is increasing downstream of the river.

- The environmental flow for Lohit basin has been estimated using the hydrologic Index methods. The various methods tried in hydrologic methods are: Tenant method, Hughes & Münster method, Index method, and seasonal method. The results are summarized as follows:

Table 4.26 Summary of Environmental Water Requirements using different techniques.

SITE	Tennant Method		H & M (cumec)	Index (cumec)
	Oct.-Mar. (cumec)	April-Sept. (cumec)		
Kalai I	56	167	258	381
Kalai II	60	179	278	408
Hutong I	60	181	279	411
Hutong II	62	185	287	423
Demwe Upper	69	207	320	471
Demwe Lower	72	217	336	495

Seasonal Methodology identifies four (4) main seasons along the year. For each season are proposed releases with different percentage of Annual Average Flow (AAF). The calculations were carried on using whole ten-daily flow records (1984-85 to 2003-04) and using the 90% dependable year (2003-04). A summary of proposed minimum flows for each dam site is given in next tables:

Table 4.27 Proposed Minimum Flow on the basis of average flow during 20 years data (1984-85 to 2003-04).

Season	Month	K-I	K-II	H-I	H-II	D.U.	D.L.
		Proposed Minimum Flow (cumecs)					
I	May	376	404	407	418	446	469
	June	504	541	545	559	602	633
	July	565	607	612	628	641	675
	August	478	514	518	531	542	571
	September	397	426	429	441	454	477
II	October	187	201	202	208	210	221
III	November	50	54	54	55	66	70
	December	37	39	40	41	49	52
	January	34	36	37	38	38	40
	February	35	37	38	39	40	42
	March	43	46	47	48	59	63
IV	April	134	144	145	149	188	198

Table 4.28 Proposed Minimum Flow on the basis of flow during the 90 % dependable year (2003-04).

Season	Month	K-I	K-II	H-I	H-II	D.U.	D.L.
		Proposed Minimum Flow (cumecs)					
I	May	192	206	207	213	237	249
	June	354	381	383	394	439	461
	July	350	377	379	389	434	456
	August	174	187	189	194	216	227
	September	164	176	177	182	203	213
II	October	85	91	92	94	105	110
III	November	34	36	37	38	42	44
	December	30	32	32	33	37	38
	January	28	30	30	31	34	36
	February	25	27	28	28	31	33
	March	34	37	37	38	42	44
IV	April	128	137	138	142	158	166

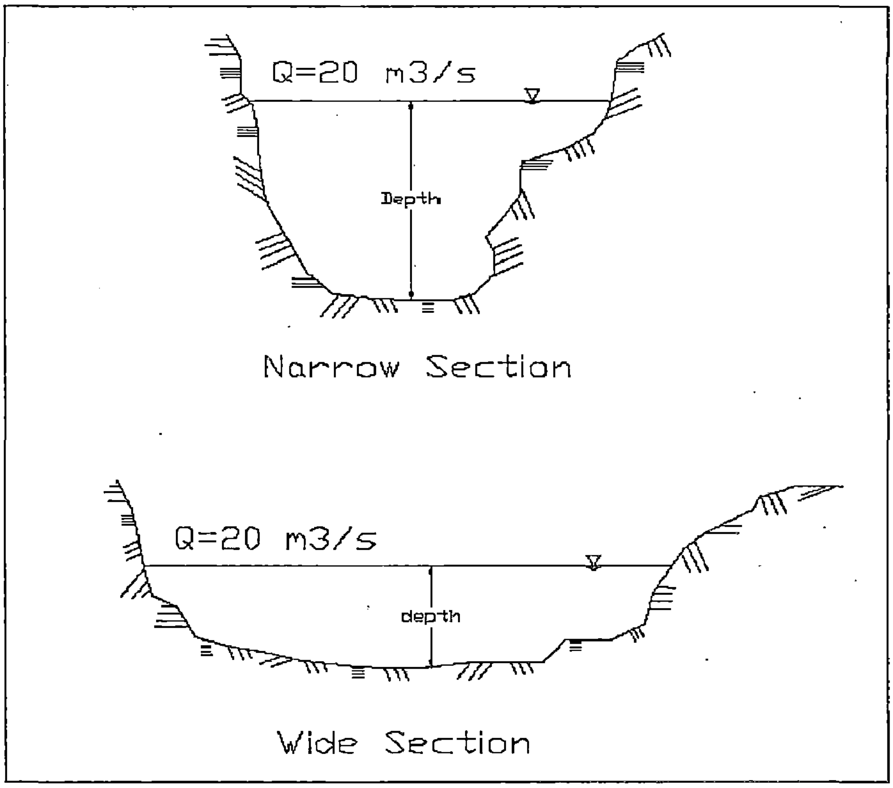
- Using the hydraulic rating method, flow required for maintaining the various normal depths at various sites will be computed by next equations:

Copy Table 4.22 Numerical relations for Normal depth-discharge relationship.

n value	$n = 0.03$		$n = 0.04$		$n = 0.05$	
SITE	**Equation**	**R²**	**Equation**	**R²**	**Equation**	**R²**
Kalai I	$Q=32.64Y^{2.6424}$	0.9999	$Q=24.45Y^{2.6442}$	0.9999	$Q=19.621Y^{2.6398}$	0.9999
HTG-II	$Q=102.52Y^{2.1384}$	0.9982	$Q=76.896Y^{2.1382}$	0.9982	$Q=61.508Y^{2.1384}$	0.9982
D.Lower	$Q=101.58Y^{1.9982}$	0.9979	$Q=76.175Y^{1.9983}$	0.9979	$Q=60.943Y^{1.9983}$	0.9979

The different relationships given in table 4.22 were obtained by plotting water depth vs. Maximum discharges required for maintained a specific water depth in all cross-sections available along the river. The correlation between water depth and discharge is very high, almost one (1) in all cases. The different cross-section in the river can be classified as narrow or wide. For the same discharge, the water depth will be higher in narrow cross-sections and lower in wide ones, like is shown in figure 4.19

Figure 4.19 Different Water Depth for same discharge in Narrow and Wide sections.



The numerical relationships developed in Case of Study I work with discharges at wide cross-sections, where for maintaining the same water depth, the discharge must be maximum at the respective cross-sections, therefore the above relationships give the minimum water depth among all cross-sections in the river, since the water depth will be more in narrow cross-sections.

- Validation of percentages of flow used in Seasonal Methodology.

From proposed minimum flows for Seasonal Method, it is identified that minimum flows among all the months occurs in February, these flows are critical flows since it represents the minimum quantity of water in the river. Using normal depth-discharge relationships given in table 4.22, the minimum water depths in the river were computed for different rugosity coefficients. The results are summarized in next table.

Table 4.29 Water Depth for critical Discharge form Seasonal Analysis.

Proposed Dam Sites	Kalai-I	Hutong-II	Demwe Lower
Discharge in February 2003-04 (cumecs)	25	28	33
Water Depth (n=0.03) in meters	0.90	0.52	0.57
Water Depth (n=0.04) in meters	1.00	0.62	0.66
Water Depth (n=0.05) in meters	1.10	0.69	0.74

In all three proposed dam sites where the cross-sections are available, the water depth (in meters) is increasing within the increasing of roughness coefficient for the same discharge.

The water depths at these three proposed dam sites are ranging between 0.5 meters to 1 meter for different minimum discharges. These are the lowest water depths among all cross-sections in the river downstream of each dam location during the lean flow month of February; therefore these values are critical for fish's survival.

From fisheries sampling in Lohit River basin is identified three main fish species: *Schizothorax richardsonii; Tor putitora; Acrossocheilus hexagonolepis.* The width of these fishes is ranging between 5 cm to 45 cm accordingly with table 3.5 in Chapter 3. The minimum proposed flows in Seasonal Method is considered acceptable from water depth point of view, since the minimum water depth in the river are higher than maximum fish width and water depth is higher than 50 cm, proposed as minimum water depth for Himalayan fish species.

Copy Table 3.5 Himalayan fishes and their sizes.

SPECIE	Total length (cm)	Max. Width (cm)	Weight (Kg)
Masheer (Tor putitora)	20 to 160	5 to 45	1 to 30
Schizothorax sps	20 to 45	5 to 15	0.3 to 2.5
Brown Trout	25 to 30	7 to 10	0.1 to 1.8
Raibown Trout	30 to 45	10 to 15	1 to 5
Glyptothorax	5 to 15	3 to 6	< 1.0

The highest water velocities are in Kalai I where the average slope (0.007 m/m) is more than Hutong II (0.006 m/m) and Demwe Lower (0.004 m/m). Also, the highest water velocities occur for a lowest roughness coefficient of 0.03. The velocities in this case are ranging between 0.75 m/s and 1.90 m/s for corresponding water depths. After checking suitable habitat for the fishes species present in Lohit River, it is established as maximum water velocity as 2.5 m/s therefore, the proposed minimum flows are considering acceptable from water velocity point of view and the percentages used in the methodology are satisfactory.

- From water quality sampling, it can be concluded that water quality is quite good in the area. This is expected in an area with no major sources of water pollution. The main reasons for low pollution loading are low population density, absence of industries, low cropping intensity with minimal or no use of agro-chemicals. The pollution loading observed is well below the carrying capacity available in the river taking into account of high discharges.

CHAPTER V

CASE OF STUDY II: ENVIRONMENTAL FLOW ASSESSMENT FOR RUN-OF THE RIVER SCHEME AT DHAMWARI SUNDA HYDROPOWER PROJECT

5.1 BACKGROUND OF THE PROJECT

Dhamwari Sunda hydro-electric project is a run-of-the-river scheme proposed on the Pabbar River in the Shimla district of Himachal Pradesh, which generates a total of 70 MW (2 turbines of 35 MW each).

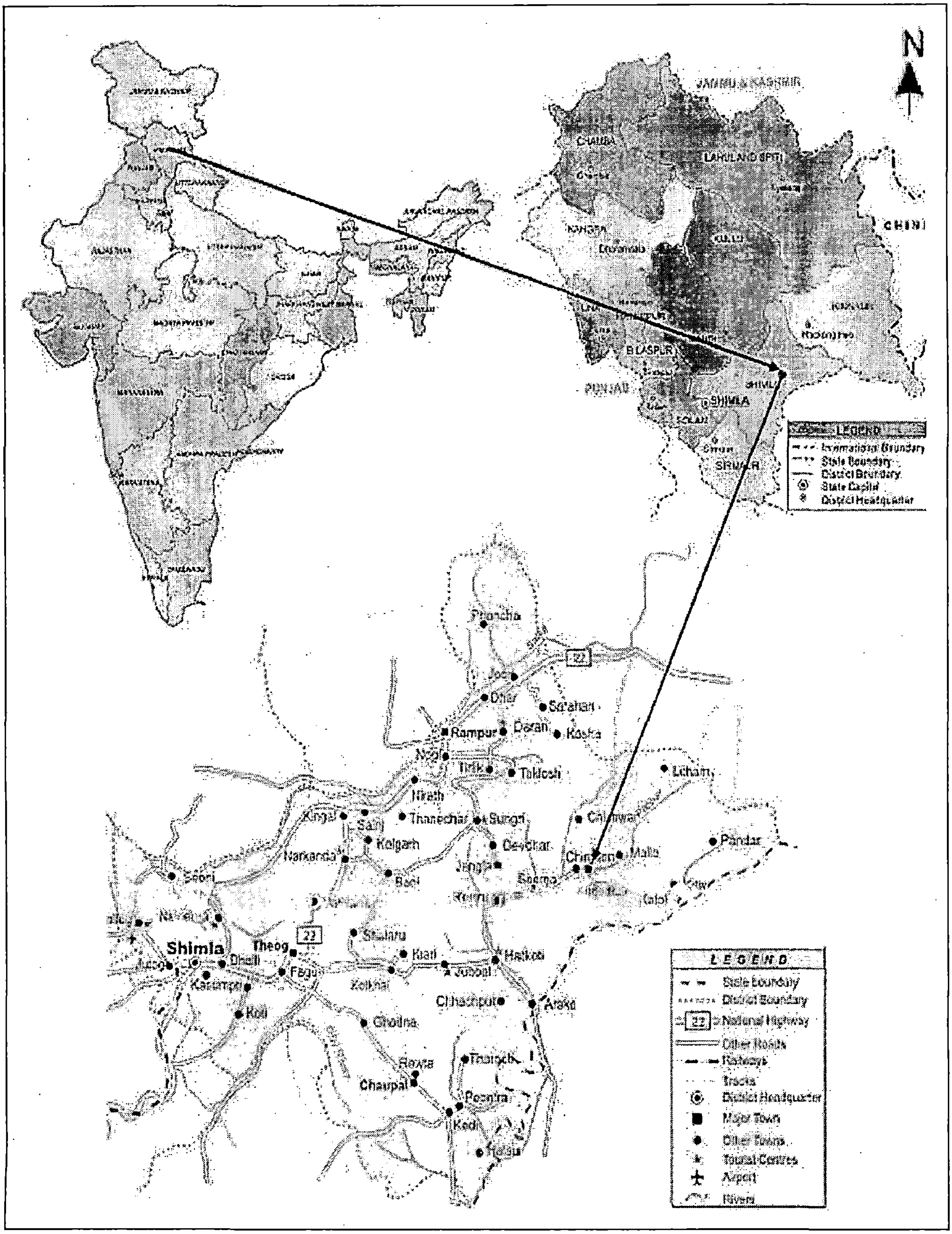
The total catchment area of the Pabbar River is about 1200 km^2 within the province of Himachal Pradesh and approximately 1060 km^2 at Sawra Bridge. The catchment area (C.A.) of the Pabbar River at the dam site lies between latitudes 31°15'0" N to 31°25'8" N and longitudes 77°57'10" E to 78°9'40" E and the area at the location of the proposed dam site is 212.48 km^2. In figure 5.1 is showed a detail of location of Dhamwari Hydro-Electric Project (HEP). The Pabbar River originates from the Gangdari Dhar ranges in the Western Himalayas at about 5 100 m.a.s.l. The upper-sub-basin, the major portion of the perennial discharge is from snow-melt, whereas, in the lower sub-basin, the major portion of the annual run-off comes from seasonal rainfall.

The project envisages construction of a diversion dam of concrete gravity type near Romari village. Dam height is 45 meters at overflow section and 47.4 meters at non-overflow section. A salient feature of the Dhamwari Sunda HEP is presented in table 5.1.

Table 5.1 Salient features of Dhamwari Sunda project.

Item	Description
State	Himachal Pradesh
District	Shimla
Location of Dam site	Near Romai village
Latitude at dam site	31°15'42" N
Longitude at dam site	77°59'20" E
River basin	Pabbar/Yamuna
River	Pabbar
Catchment area (CA)	212.48 km^2
River bed elevation	EL. 2159 m
Full Reservoir Level	EL.2180 m
Hydraulic structure for diversion	Concrete gravity dam
Gross storage at FRL (x10^6 m^3)	0.214 Mm^3

Figure 5.1 Location Map of Dhamwari Sunda HEP.



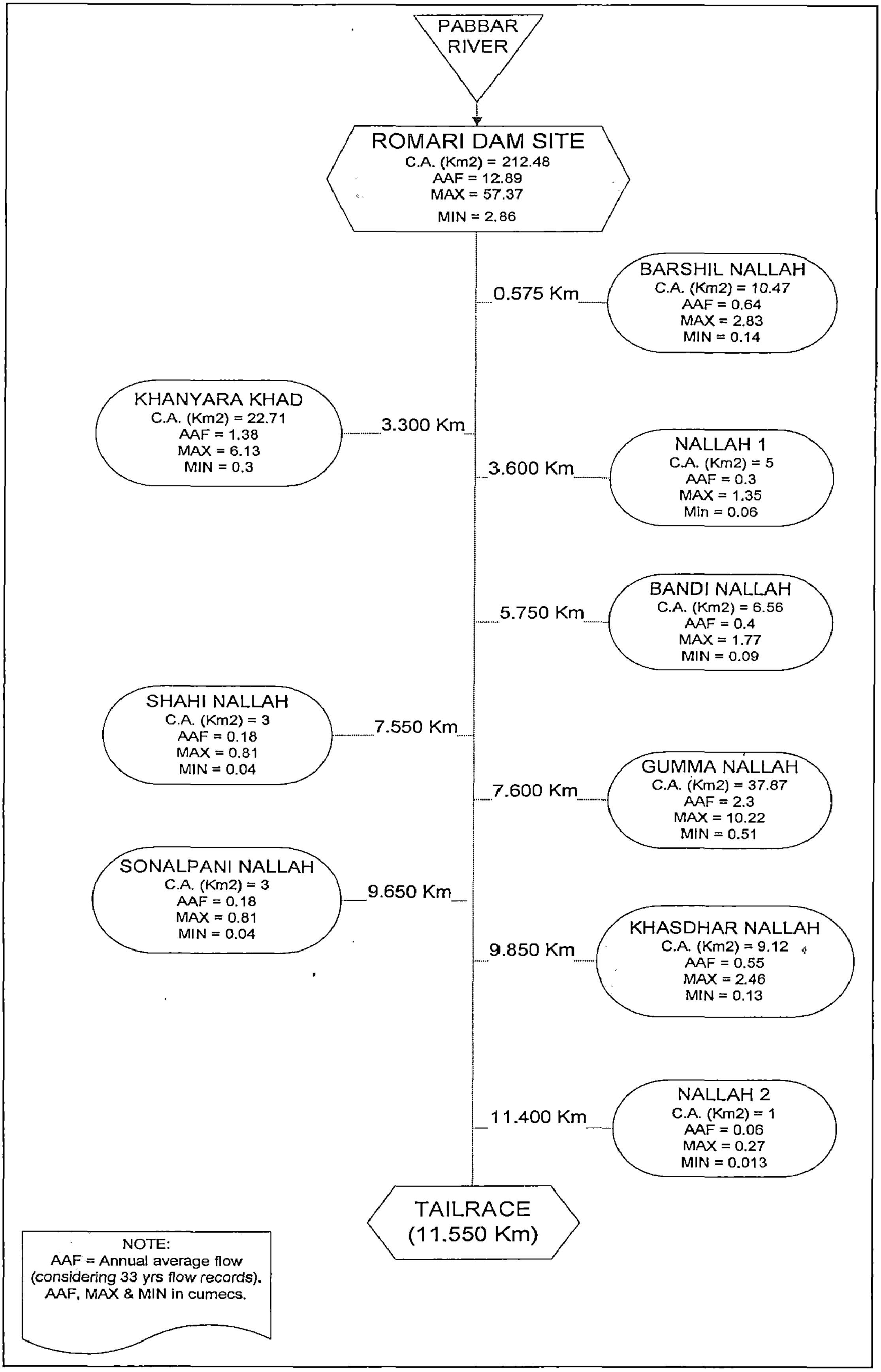
The length of the river between diversion point and tailrace is called river "stretch". In this case study the river stretch is about 11.55 km and this length along the river is critical from environmental point of view, since not all the inflow can be diverted for hydropower production, but some water must be released for sustain aquatic life in the river "stretch".

In this project nine (9) different Nallahs or tributaries are joining along the stretch length, and they contribute with some discharge thought out the year. The aim of EFA is determine the water requirements in the stretch of the project considering in one case, only the water released from reservoir and second case considering the contribution of different Nallahs. In table 5.2 are given the salient features of each Nallah with statistical values using data from 1975-76 upto 2007-08 for dam site and corresponding Nallahs and figure 5.2 shows this information in schematic form.

Table 5.2 Salient features of different Nallahs in Dhamwari Sunda HEP.

Location	RD (km)	Catchment Area (Km2)	AAF (cumec)	Max (cumec)	Min (cumec)	Std. Dev (cumec)
Diversion Dam	0.000	212.48	12.89	57.37	2.86	4.92
Barshil Nallah	0.575	10.47	0.64	2.83	0.14	0.22
Khanyara Khad	3.300	22.71	1.38	6.13	0.30	0.48
Nalla 1	3.600	5.00	0.30	1.35	0.06	0.10
Bandi Nallah	5.750	6.56	0.40	1.77	0.09	0.14
Shahi Nallah	7.550	3.00	0.18	0.81	0.04	0.06
Gumma Nallah	7.600	37.87	2.30	10.22	0.51	0.80
Sonalpani Nallah	9.650	3.00	0.18	0.81	0.04	0.06
Khasdhar Nallah	9.850	9.12	0.55	2.46	0.13	0.19
Nalla 2	11.400	1.00	0.06	0.27	0.013	0.02
Tailrace outfall	11.550	311.21				

Figure 5.2 Salient features of Dhamwari Sunda HEP.



5.2 HYDROLOGY DATA AVAILABILITY

The long term gauge & discharge (G&D) observations data were collected from three stations located at Tangnu, Dhamwari and Mandly, on the Pabbar River in Himachal Pradesh. In addition to the data from these three stations, flow data from a station at Tuini near the confluence of the Pabbar River with the Tons river, maintained by the Central Water Commission (CWC), were also used. In fig. 5.3 is shown a scheme of main G&D stations within available flow records and other salient features. Also in figure 5.4 is shown the location of rainfall and G&D stations along Pabbar River basin.

The observed precipitation (rainfall) and discharge records have been checked for internal and external consistencies. The consistency of data was checked based on double mass curve technique on annual basis. Correlation studies between different sites and the data was found to be consistent accordingly with Dhamwari Power Company Private Ltd; 2009.

Since Dhamwari Sunda HEP is an run-of-the-river (i.e. diversion) scheme having a provision of daily storage, a minimum of 10 years of observed flow data is required by the Ministry of Water Resources Govt. of India, therefore different nearby G&D sites have enough length of historical flow records for developing ten-diaily flow series at the project site. The ten-daily flow pattern of the Pabbar River at Dhamwari found to be consistent with the flows at Mandly and Tuini (Dhamwari Power Company Private Ltd, 2009).

5.3 HYDROLOGY DATA GENERATION

The observed ten-daily flow available at Dhamwari G&D station (June 1975 to August 1989 (14 years of records) is considered most representative of the flow at the proposed diversion dam site. Dhamwari G&D station is very close to the proposed diversion dam site and is hydrologically representative of the catchment characteristics of the project.

Following procedures have been adopted for intersparsing the observed flows at Dhamwari :

- The catchment area ratio of Dhamwari with respect to Mandly is 0.43. Ten-daily flows at Dhamwari (for the period from June 1978 to August 1989), which are higher than 0.7 times those at Mandly for the concurrent period, are eliminated from the analysis. The choice of 0.7 for assessing the acceptability of ten-daily flow data is made arbitrarily for remaining on the conservative side.
- Similarly, catchment area ratio of Dhamwari with respect to Tuini is 0.16. Ten-daily flows of Dhamwari (for the period January 1977 to May 1978), which are higher then 0.5 times those at Tuini for the concurrent period, are eliminated from the analysis. As indicated above, the choice of 0.5 for assessing the acceptability of ten-daily flow data is made arbitrarily for remaining on the conservative side.

Figure 5.3 Details of data available at G&D sites on the Pabbar River.

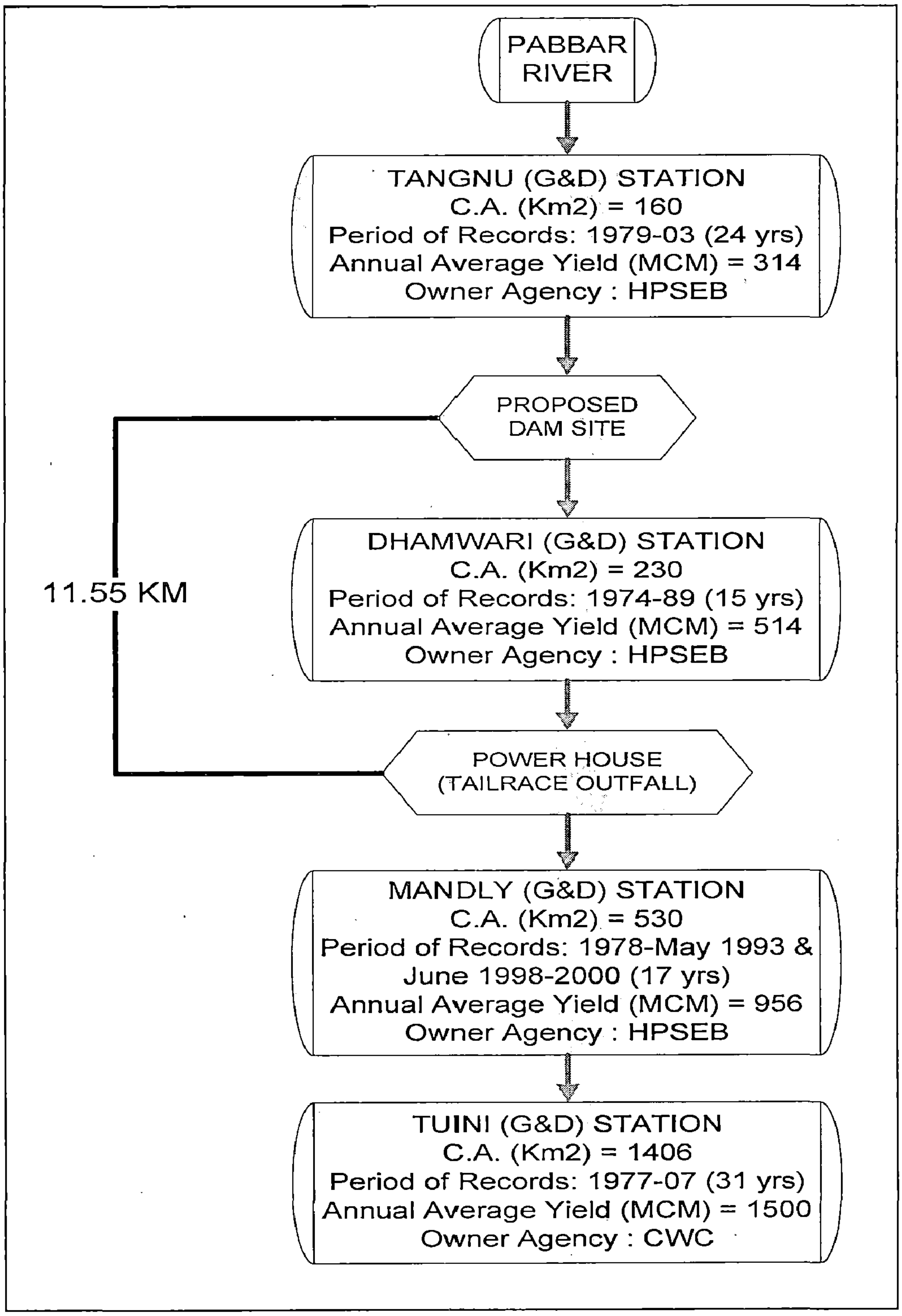
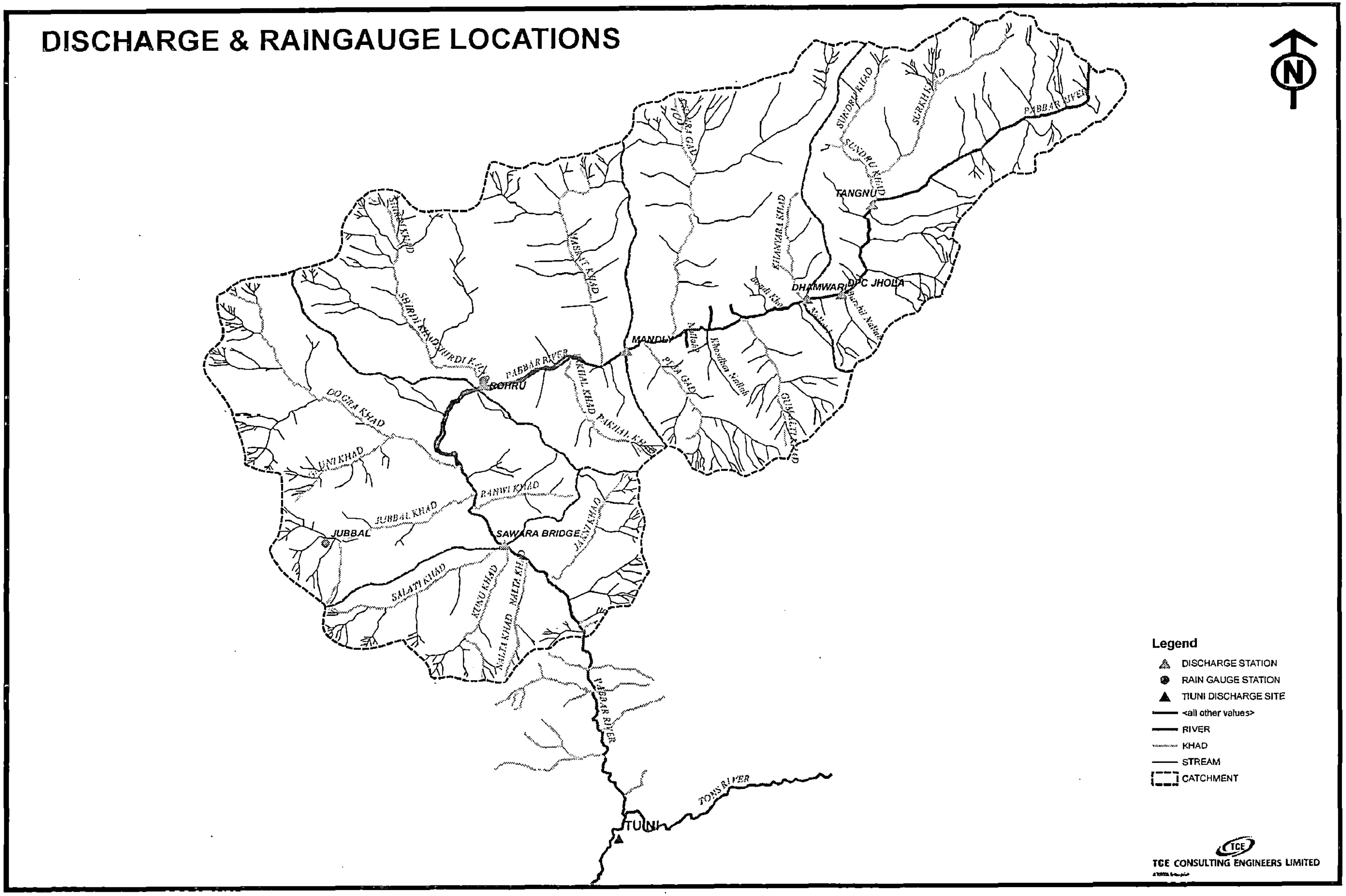


Figure 5.4 Location of rainfall and G&D stations in Pabbar River basin.



- The gaps in the ten-daily flow series of Dhamwari resulting from the elimination of higher flow values have been filled with the observed flow available either at Mandly or Tuini using seasonal correlations. Appropriate correlation equations established between the ten-daily flows of selected G&D stations on the Pabbar River have been used for filling data gaps. The runoff-runoff correlation equations are showed in table 5.3 for different periods.

The series of observed ten-daily flow of the Pabbar River at Tuini is the only longest and continuous data series available for extending the flow series at Dhamwari, but the runoff-runoff correlation for the monsoon period between Dhamwari and Tuini using ten-daily flows is considered as being inadequate transferring the flows at Tuini to Dhamwari (R=0.75), therefore an extended ten-daily flow series at Mandly is transferred to Dhamwari using monsoon period correlation between Mandly and Dhamwari.

The flow series at Dhamwari for the lean period for the month of October to February have been extended by transferring the Tuini flow (using the runoff-runoff correlation between Tuini and Dhamwari for the month of October to February). The flow series at Dhamwari for the snow melt period for the month of March to May have been extended by transferring the Tuini flow (using the runoff-runoff correlation between Tuini and Dhamwari for the month of March to May).

Table 5.3 Regression equations relating runoffs at selected pairs of G&D stations for different periods.

Period	Runoff-runoff correlation	Corr. coeff (R)
June to September	$Y_{MANDLY} = 0.5173X_{TUINI} + 11.09$	0.85
June to September	$Y_{DHAMWARI} = 3.4544 * (X_{TUINI})^{0.4885}$	0.75
June to September	$Y_{DHAMWARI} = 2.1794 * (X_{MAND})^{0.6336}$	0.81
October to February	$Y_{DHAMWARI} = 0.1733 X_{TUINI} + 2.997$	0.73
March to May	$Y_{DHAMWARI} = 0.2763 X_{TUINI} + 2.711$	0.81

5.4 HYDROLOGY DATA ANALYSIS

Along the river are identified nine (9) main Nallahs, using area-proportion methodology, the ten-daily extended flow series of the Pabbar River at Dhamwari site were used to transferred flow series in each corresponding Nallah and Romari Dam site. Ten-daily extended flow series (from 1975-76 to 2007-08) at each Nallah and Romari Dam site are given in Annexure E.

For all nine (9) Nallahs and Romari dam site, using ten-daily flow values (within whole series from 1975-76 to 2007-08), following is estimated and results are included in Annexure E.

- 10 daily average, maximum, minimum, and corresponding standard deviation values are estimated.
- Annual Average Flow (AAF) in cumec-day and Annual average volume in MCM.
- Total Annual Average Flow in cumec.

Further, in order to know the dependability of flow, the following exercises were carried out for entire flow series from 1975-76 to 2007-08 at Romari dam site and for each Nallah.

- 90%, 75% and 50% of dependability year among corresponding years.
- 90% dependable flow from 90% dependable year.
- Flow Duration Curve (FDC) with entire flow series from 1975-76 to 2007-08 (see Annexure F).

Similar dependability analysis was carried out considering four (4) seasons:

Season I (Jun-Sep): This season is considered as high flow season, influenced by monsoon. It covers the months from June to September.
Season II (Oct-Nov): This season is considering like average season and it corresponds to transition period between wet and dry period. It covers the month of October and November.
Season III (Dec-Feb): This season is considering as low flow, lean or dry season. It covers the months from December to February.
Season IV (Mar-May): This season is considering like average season and it corresponds to transition period between dry and wet period. It covers the month of March to May.

Dependability of flow was obtained for Romari dam site & for each Nallah in the river stretch in the basis of:

- 90, 75, and 50 % dependability years for annual flow, and for various seasons.
- 90, 75, and 50 % dependable flow from 90, 75, and 50 % dependable years.

Summary of these computations is shown in Table 5.4 below:

Table 5.4 Season Analysis and Summary of different Dependable flow in Cumecs at:

	Annual Flow			June to Sep			Oct to Nov			Dec to Feb			Mar to May		
Romari Dam Site	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %
Dependable Year	99-00	02-03	85-86	79-80	97-98	81-82	01-02	79-80	92-93	87-88	79-80	03-04	98-99	05-06	02-03
Average yearly flow	9.87	11.07	13.02	17.43	19.10	23.71	5.02	6.02	6.76	3.95	4.28	4.50	5.75	7.43	8.81
Flow of 90% Dependable year	4.71	5.54	8.68	9.05	13.21	21.80	4.43	4.53	4.99	2.96	3.51	3.97	5.08	5.17	5.27
Flow of 75% Dependable year	4.43	4.80	9.05	15.06	16.44	18.75	5.27	5.82	6.10	3.97	4.05	4.25	5.64	6.19	7.39
Flow of 50% Dependable year	4.53	5.73	12.93	11.92	18.01	19.68	4.99	5.45	6.65	4.25	4.34	4.43	5.64	6.65	9.15
Average Ten Daily flow	4.72	5.64	10.30	18.78	19.59	25.02	5.64	6.21	8.32	4.50	4.67	4.80	6.02	8.21	10.42
Whole Ten Daily Series	4.34	5.08	8.68	14.69	17.18	21.62	4.62	5.27	6.74	3.88	4.16	4.53	4.90	5.91	8.41
Barshil Nallah															
Average yearly flow	0.49	0.55	0.64	0.86	0.94	1.17	0.25	0.30	0.33	0.19	0.21	0.22	0.28	0.37	0.43
Flow of 90% Dependable year	0.23	0.27	0.43	0.45	0.65	1.07	0.22	0.22	0.25	0.15	0.17	0.20	0.25	0.25	0.26
Flow of 75% Dependable year	0.22	0.24	0.45	0.74	0.81	0.92	0.26	0.29	0.30	0.20	0.20	0.21	0.28	0.30	0.36
Flow of 50% Dependable year	0.22	0.28	0.64	0.59	0.89	0.97	0.25	0.27	0.33	0.21	0.21	0.22	0.28	0.33	0.45
Average Ten Daily flow	0.23	0.28	0.51	0.93	0.97	1.23	0.28	0.31	0.41	0.22	0.23	0.24	0.30	0.40	0.51
Whole Ten Daily Series	0.21	0.25	0.43	0.72	0.85	1.07	0.23	0.26	0.33	0.19	0.20	0.22	0.24	0.29	0.41
Khanyara Khad															
Average yearly flow	1.06	1.18	1.39	1.86	2.04	2.53	0.54	0.64	0.72	0.42	0.46	0.48	0.61	0.79	0.94
Flow of 90% Dependable year	0.50	0.59	0.93	0.97	1.41	2.33	0.47	0.48	0.53	0.32	0.38	0.42	0.54	0.55	0.56
Flow of 75% Dependable year	0.47	0.51	0.97	1.61	1.76	2.00	0.56	0.62	0.65	0.42	0.43	0.45	0.60	0.66	0.79
Flow of 50% Dependable year	0.48	0.61	1.38	1.27	1.93	2.10	0.53	0.58	0.71	0.45	0.46	0.47	0.60	0.71	0.98
Average Ten Daily flow	0.50	0.60	1.10	2.01	2.09	2.67	0.60	0.66	0.89	0.48	0.50	0.51	0.64	0.88	1.11
Whole Ten Daily Series	0.46	0.54	0.93	1.57	1.84	2.31	0.49	0.56	0.72	0.41	0.44	0.48	0.52	0.63	0.90

	Annual Flow			June to Sep			Oct to Nov			Dec to Feb			Mar to May		
Nalla 1	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %
Dependable Year	99-00	02-03	85-86	79-80	97-98	81-82	01-02	79-80	92-93	87-88	79-80	03-04	98-99	05-06	02-03
Average yearly flow	0.23	0.26	0.31	0.41	0.45	0.56	0.12	0.14	0.16	0.09	0.10	0.11	0.14	0.17	0.21
Flow of 90% Dependable year	0.11	0.13	0.20	0.21	0.31	0.51	0.10	0.11	0.12	0.07	0.08	0.09	0.12	0.12	0.12
Flow of 75% Dependable year	0.10	0.11	0.21	0.35	0.39	0.44	0.12	0.14	0.14	0.09	0.10	0.10	0.13	0.15	0.17
Flow of 50% Dependable year	0.11	0.13	0.30	0.28	0.42	0.46	0.12	0.13	0.16	0.10	0.10	0.10	0.13	0.16	0.22
Average Ten Daily flow	0.11	0.13	0.24	0.44	0.46	0.59	0.13	0.15	0.20	0.11	0.11	0.11	0.14	0.19	0.25
Whole Ten Daily Series	0.10	0.12	0.20	0.35	0.40	0.51	0.11	0.12	0.16	0.09	0.10	0.11	0.12	0.14	0.20
Bandi Nallah															
Average yearly flow	0.30	0.34	0.40	0.54	0.59	0.73	0.15	0.19	0.21	0.12	0.13	0.14	0.18	0.23	0.27
Flow of 90% Dependable year	0.15	0.17	0.27	0.28	0.41	0.67	0.14	0.14	0.15	0.09	0.11	0.12	0.16	0.16	0.16
Flow of 75% Dependable year	0.14	0.15	0.28	0.46	0.51	0.58	0.16	0.18	0.19	0.12	0.13	0.13	0.17	0.19	0.23
Flow of 50% Dependable year	0.14	0.18	0.40	0.37	0.56	0.61	0.15	0.17	0.21	0.13	0.13	0.14	0.17	0.21	0.28
Average Ten Daily flow	0.15	0.17	0.32	0.58	0.60	0.77	0.17	0.19	0.26	0.14	0.14	0.15	0.19	0.25	0.32
Whole Ten Daily Series	0.13	0.16	0.27	0.45	0.53	0.67	0.14	0.16	0.21	0.12	0.13	0.14	0.15	0.18	0.26
Shahi Nallah															
Average yearly flow	0.14	0.16	0.18	0.25	0.27	0.33	0.07	0.09	0.10	0.06	0.06	0.06	0.08	0.10	0.12
Flow of 90% Dependable year	0.07	0.08	0.12	0.13	0.19	0.31	0.06	0.06	0.07	0.04	0.05	0.06	0.07	0.07	0.07
Flow of 75% Dependable year	0.06	0.07	0.13	0.21	0.23	0.26	0.07	0.08	0.09	0.06	0.06	0.06	0.08	0.09	0.10
Flow of 50% Dependable year	0.06	0.08	0.18	0.17	0.25	0.28	0.07	0.08	0.09	0.06	0.06	0.06	0.08	0.09	0.13
Average Ten Daily flow	0.07	0.08	0.15	0.27	0.28	0.35	0.08	0.09	0.12	0.06	0.07	0.07	0.08	0.12	0.15
Whole Ten Daily Series	0.06	0.07	0.12	0.21	0.24	0.31	0.07	0.07	0.10	0.05	0.06	0.06	0.07	0.08	0.12

	Annual Flow			June to Sep			Oct to Nov			Dec to Feb			Mar to May		
Gumma Nallah	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %
Dependable Year	99-00	02-03	85-86	79-80	97-98	81-82	01-02	79-80	92-93	87-88	79-80	03-04	98-99	05-06	02-03
Average yearly flow	1.76	1.97	2.32	3.11	3.40	4.23	0.89	1.07	1.20	0.70	0.76	0.80	1.02	1.32	1.57
Flow of 90% Dependable year	0.84	0.99	1.55	1.61	2.35	3.89	0.79	0.81	0.89	0.53	0.63	0.71	0.91	0.92	0.94
Flow of 75% Dependable year	0.79	0.86	1.61	2.68	2.93	3.34	0.94	1.04	1.09	0.71	0.72	0.76	1.00	1.10	1.32
Flow of 50% Dependable year	0.81	1.02	2.31	2.12	3.21	3.51	0.89	0.97	1.19	0.76	0.77	0.79	1.00	1.19	1.63
Average Ten Daily flow	0.84	1.00	1.84	3.35	3.49	4.46	1.00	1.11	1.48	0.80	0.83	0.86	1.07	1.46	1.86
Whole Ten Daily Series	0.77	0.91	1.55	2.62	3.06	3.85	0.82	0.94	1.20	0.69	0.74	0.81	0.87	1.05	1.50
Sonalpani Nallah															
Average yearly flow	0.14	0.16	0.18	0.25	0.27	0.33	0.07	0.09	0.10	0.06	0.06	0.06	0.08	0.10	0.12
Flow of 90% Dependable year	0.07	0.08	0.12	0.13	0.19	0.31	0.06	0.06	0.07	0.04	0.05	0.06	0.07	0.07	0.07
Flow of 75% Dependable year	0.06	0.07	0.13	0.21	0.23	0.26	0.07	0.08	0.09	0.06	0.06	0.06	0.08	0.09	0.10
Flow of 50% Dependable year	0.06	0.08	0.18	0.17	0.25	0.28	0.07	0.08	0.09	0.06	0.06	0.06	0.08	0.09	0.13
Average Ten Daily flow	0.07	0.08	0.15	0.27	0.28	0.35	0.08	0.09	0.12	0.06	0.07	0.07	0.08	0.12	0.15
Whole Ten Daily Series	0.06	0.07	0.12	0.21	0.24	0.31	0.07	0.07	0.10	0.05	0.06	0.06	0.07	0.08	0.12
Khasdhar Nallah															
Average yearly flow	0.42	0.48	0.56	0.75	0.82	1.02	0.22	0.26	0.29	0.17	0.18	0.19	0.25	0.32	0.38
Flow of 90% Dependable year	0.20	0.24	0.37	0.39	0.57	0.94	0.19	0.19	0.21	0.13	0.15	0.17	0.22	0.22	0.23
Flow of 75% Dependable year	0.19	0.21	0.39	0.65	0.71	0.80	0.23	0.25	0.26	0.17	0.17	0.18	0.24	0.27	0.32
Flow of 50% Dependable year	0.19	0.25	0.56	0.51	0.77	0.84	0.21	0.23	0.29	0.18	0.19	0.19	0.24	0.29	0.39
Average Ten Daily flow	0.20	0.24	0.44	0.81	0.84	1.07	0.24	0.27	0.36	0.19	0.20	0.21	0.26	0.35	0.45
Whole Ten Daily Series	0.19	0.22	0.37	0.63	0.74	0.93	0.20	0.23	0.29	0.17	0.18	0.19	0.21	0.25	0.36

	Annual Flow			June to Sep			Oct to Nov			Dec to Feb			Mar to May		
Nalla 2	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %	Q90 %	Q75 %	Q50 %
Dependable Year	99-00	02-03	85-86	79-80	97-98	81-82	01-02	79-80	92-93	87-88	79-80	03-04	98-99	05-06	02-03
Average yearly flow	0.05	0.05	0.06	0.08	0.09	0.11	0.02	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.04
Flow of 90% Dependable year	0.02	0.03	0.04	0.04	0.06	0.10	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
Flow of 75% Dependable year	0.02	0.02	0.04	0.07	0.08	0.09	0.02	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.03
Flow of 50% Dependable year	0.02	0.03	0.06	0.06	0.08	0.09	0.02	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.04
Average Ten Daily flow	0.02	0.03	0.05	0.09	0.09	0.12	0.03	0.03	0.04	0.02	0.02	0.02	0.03	0.04	0.05
Whole Ten Daily Series	0.02	0.02	0.04	0.07	0.08	0.10	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.04

5.5 ENVIRONMENTAL FLOW ASSESSMENT FOR DHAMWARI SUNDA HEP

In this section; different Hydrological Index methods are applied to assess the environmental water requirements in Dhamwari Sunda HEP within Pabbar River Basin. These methodologies are based only in historical flow records and more details of each methodology are given in Chapter 2 Environmental Flow Assessment Techniques.

(i) Tennant Method:

Assume that fair and degrading conditions are prevailing in the basin. Hence EF is 10% of Annual Average Flow (AAF) for the period October to March and 30 % for the period April to September for the year 1999-00 which represents the 90% dependable year of entire series at Romari dam site (1975-76 to 2007-08). Table 5.5 shows the result:

Table 5.5 Environmental Water Requirements using Tennant Method.

SITE	AAF 1999-00 (cumecs)	EWR (cumecs) (Oct.-Mar.) (0.1 * col. 2)	EWR (cumecs) (April-Sept.) (0.3 * col. 2)
(1)	(2)	(3)	(4)
Romari	9.87	0.987	2.961

(ii) Hughes & Münster Method (H&M):

The EWR = LFR + HFR (See eq. 2.1)

LFR = $Q_{90\%}$ dependable flow of year 1999-00 (90% dependable year).

HFR are taken following guidelines in table 2.2 (Chapter 2), The flows at Romari dam site used to be constant throughout the year. The ratio between $Q_{90\%}$ and AAF are greater than 30%. For the year 1999-00, the AAF is 9.87 cumecs and corresponding $Q_{90\%}$ is 4.71 cumecs, the ratio $Q_{90\%}$ / AAF is 4.71/9.87 = 0.48 or 48% greater than 30%. Therefore, in this case the river ecology is classified like very sensitive according with Hughes & Münster method. A summary of computations in H&M methodology is given in table 5.6.

Table 5.6 Environmental Water Requirements using Hughes & Münster method.

SITE	AAF 1999-00 (cumecs)	$Q_{90\%}$ 1999-00 (cumecs)	% Q90/AAF	HFR (cumecs)	EWR (cumecs)
Romari	9.87	4.71	47.72	0	4.71

(iii) Index Method:

The Minimum Instream Flow is given by equation:

$MIF = Q_{355}*Ka*Kb*Kc$ (See eq. 2.2)

Assumptions taken in computations:

Ka = 1 River ecology is very sensitive.

Kb = 1 River flows are in natural state, therefore any implementation factor is required.

Kc = 1.5 considering high naturalistic values in Lohit river basin.

Q_{355} correspond to discharge equaled or exceeded 98% of the time. This value is taken from FDC for the year 1999-00 and corresponds to 4.43 cumecs.

Table 5.7 Environmental Water Requirements using Index method.

SITE	Q_{355} for 1999-00 (cumecs)	EWR (cumecs)
Romari	4.43	6.65

(iv) Seasonal Methodology:

The seasons methodology proposed in this study follows the principles given by Building Block Method (BBM), which is based on the identification of different natural flows regimes; their magnitudes, timing and duration as well as their interaction with surrounding biota. These flows are incorporated in a modified flow regime by a construction of synthetic hydrograph which must satisfy the water requirements in the river. The hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present through out the year. The identification and incorporation of these important flow characteristics will help to maintain the river's channel structure, diversity of the physical biotopes and processes. Four main seasons are identified along the year and they were already explained above:

The proposed minimum flows are estimated for two cases:

1. Using 33 years data (1975-76 upto 2007-08) on ten daily basis.
2. For 90% dependable year (1999-00) on ten daily basis.

In both cases, average flow values of each season are estimated. The results are shown below.

Table 5.8 Proposed Minimum Flows using Seasonal Method.

BBM USING TEN-DAILY AVERAGE FLOW FROM 33 YRS (1975-76 TO 2007-08)					
Romari Dam Site					
Seasons	**Month**	**Ten daily**	**Percentage**	**Average**	**Min. Flow**
SEASON I	June	I	40	18.45	7.38
		II	40	18.78	7.51
		III	40	19.59	7.84
	July	I	40	22.00	8.80
		II	40	25.16	10.06
		III	40	29.40	11.76
	August	I	40	28.08	11.23
		II	40	27.73	11.09
		III	40	25.63	10.25
	September	I	40	25.02	10.01
		II	40	21.32	8.53
		III	40	18.80	7.52
Season I Average values				**23.33**	**9.33**
II	October	I	30	10.30	3.09
		II	30	9.14	2.74
		III	30	8.32	2.50
	November	I	30	6.84	2.05
		II	30	6.21	1.86
		III	30	5.64	1.69
Season II Average values				**7.74**	**2.32**
SEASON III	December	I	20	5.33	1.07
		II	20	5.13	1.03
		III	20	4.92	0.98
	January	I	20	4.80	0.96
		II	20	4.67	0.93
		III	20	4.62	0.92
	February	I	20	4.50	0.90
		II	20	4.72	0.94
		III	20	4.83	0.97
Season III Average values				**4.84**	**0.97**
IV	March	I	30	6.02	1.80
		II	30	6.35	1.91
		III	30	8.21	2.46
	April	I	30	8.73	2.62
		II	30	10.42	3.13
		III	30	11.89	3.57
	May	I	30	12.93	3.88
		II	30	13.90	4.17
		III	30	14.00	4.20
Season IV Average values				**10.27**	**3.08**

Table 5.9 Proposed Minimum Flows using Seasonal Method.

BBM USING TEN-DAILY AVERAGE FLOW FOR YEAR 1999-00					
Romari Dam Site					
Seasons	**Month**	**Ten daily**	**Percentage**	**Average**	**Min.Flow**
SEASON I	June	I	40	11.82	4.73
		II	40	11.09	4.43
		III	40	11.46	4.58
	July	I	40	12.01	4.80
		II	40	15.43	6.17
		III	40	23.56	9.42
	August	I	40	24.76	9.90
		II	40	22.54	9.02
		III	40	21.25	8.50
	September	I	40	14.50	5.80
		II	40	13.95	5.58
		III	40	13.67	5.47
Season I Average values				**16.34**	**6.53**
II	October	I	30	6.93	2.08
		II	30	6.84	2.05
		III	30	6.56	1.97
	November	I	30	6.37	1.91
		II	30	6.47	1.94
		III	30	6.19	1.86
Season II Average values				**6.56**	**1.97**
SEASON III	December	I	20	5.82	1.16
		II	20	5.54	1.11
		III	20	4.80	0.96
	January	I	20	4.71	0.94
		II	20	4.80	0.96
		III	20	4.53	0.91
	February	I	20	4.71	0.94
		II	20	4.62	0.92
		III	20	4.99	1.00
Season III Average values				**4.95**	**0.99**
IV	March	I	30	4.99	1.50
		II	30	5.54	1.66
		III	30	6.56	1.97
	April	I	30	8.68	2.61
		II	30	9.52	2.85
		III	30	9.70	2.91
	May	I	30	9.79	2.94
		II	30	10.62	3.19
		III	30	9.42	2.83
Season IV Average values				**8.31**	**2.49**

5.6 RIVER ANALYSIS SYSTEM

The HEC-RAS software was developed at the Hydrology Engineering Center (HEC), which is a division of the U.S. Army Corps of Engineers. This software is able to perform a River Analysis System (RAS) in one-dimensional steady and unsteady flow. The version used in this study is version 4.0 releases in March 2008 (Brunner, 2008).

The HEC-RAS system contains four one-dimensional river analysis components for: (1) steady water surface profile computations; (2) unsteady flow simulation; (3) movable boundary sediment transport computations and (4) water quality analysis. In the present study is carried out steady flow water surface profiles for a single river reach. The steady flow component is capable of modeling subcritical, supercritical and mixed flow regime water surface profiles.

The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head).

5.7 HYDRAULIC MODELLING

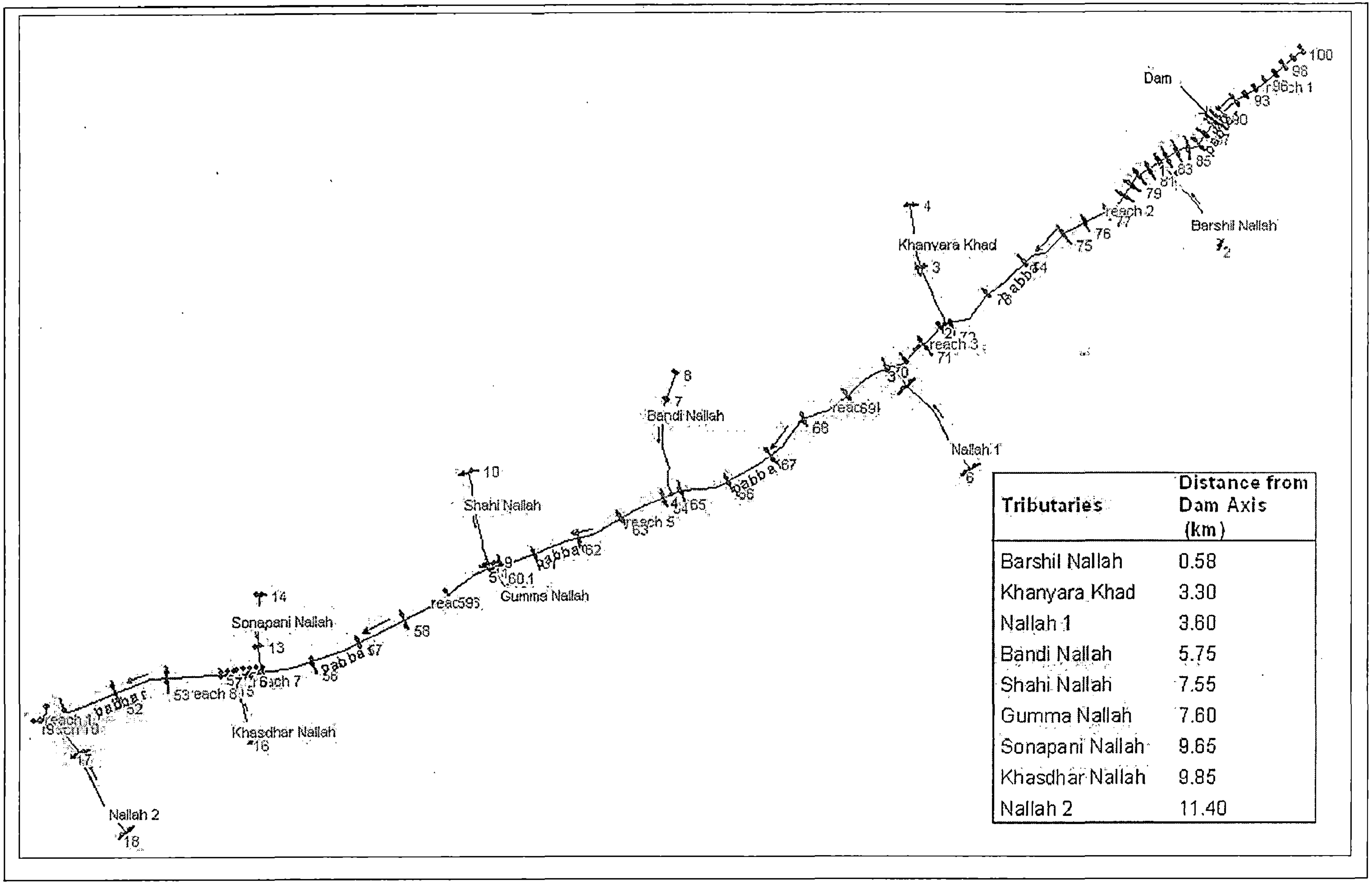
The objective of the hydraulic modeling is to compute steady flow water surface profile in the "stretch" of Pabbar River considering different scenarios which can come in the life of hydro-power plant.

Several assumptions are made like one dimensional open channel flow for developing model of steady flow water surface profile. In the boundary condition, it is assumed that normal depth occurs at upstream and downstream end of every individual reach and computation has been done using energy slope equal to the average bed slope. One of the main assumptions is that the mixed flow regime occurs in the reach as it contains a weir in between and the river is having very steep slope. Energy losses are computed by using Manning's equation considering constant roughness coefficient "n" value of 0.03 for main stream as well as for flood plane.

In figure 5.5 is showed the location of different cross section and different Nallahs along the river "stretch". These cross sections were used in the HEC-RAS modeling to compute water surface elevations. Table 5.10 summarized the name, reaches and distances from Romari dam site for each cross section along the "stretch" in Pabbar River.

In the computations average bed slope was used and it was calculated between two extreme points. One point correspond to Dam (River bed elevation of 2 161.63 m) and Cross Section named 50.05* in reach 9 (River bed elevation of 1 747.35 m), divided by the total length of main channel among this two points (Total length 11 055 m). The final Average Bed Slope was computed like: [(2161.63-1747.35) / 11055] = 0.038.

Figure 5.5 General layout of Pabbar River Cross Sections and Nallahs.



Tributaries	Distance from Dam Axis (km)
Barshil Nallah	0.58
Khanyara Khad	3.30
Nallah 1	3.60
Bandi Nallah	5.75
Shahi Nallah	7.55
Gumma Nallah	7.60
Sonapani Nallah	9.65
Khasdhar Nallah	9.85
Nallah 2	11.40

Table 5.10 Different Cross Sections at stretch in Pabbar River.

No. Sections	Reach	Cross Section	Channel Point (m)	Bed Level (m)	No. Sections	Reach	Cross Section	Channel Point (m)	Bed Level (m)
1	reach 1	88.5	0	2161.63	27	reach 4	65	5600	1921.4
2	reach 1	88	100	2157.58	28	reach 5	64	6000	1901
3	reach 1	87	200	2152.45	29	reach 5	63	6400	1885.5
4	reach 1	86	300	2148.86	30	reach 5	62	6800	1873.8
5	reach 1	85	400	2144.2	31	reach 5	61	7100	1861.1
6	reach 1	84	500	2139.8	32	reach 5	60.1	7195	1849.2
7	reach 1	83	575	2136.55	33	reach 6	60	7595	1849.2
8	reach 2	82	675	2133.42	34	reach 6	59	7995	1838.6
9	reach 2	81	775	2130	35	reach 6	58	8395	1826.5
10	reach 2	80	875	2124.8	36	reach 6	57	8795	1817.2
11	reach 2	79	975	2119.2	37	reach 6	56	9195	1806
12	reach 2	78	1175	2112.3	38	reach 6	55	9245	1795.9
13	reach 2	77	1375	2104.1	39	reach 7	54.75*	9295	1794.18
14	reach 2	76	1575	2093.6	40	reach 7	54.625*	9345	1793.31
15	reach 2	75	1975	2088	41	reach 7	54.5*	9395	1792.45
16	reach 2	74	2375	2069	42	reach 7	54.375*	9420	1791.59
17	reach 2	73	2775	2045	43	reach 8	54.25*	9470	1790.73
18	reach 2	72	2875	2028.1	44	reach 8	54.125*	9520	1789.86
19	reach 3	71.5	3075	2028.1	45	reach 8	54	9920	1789
20	reach 3	71	3275	2012.2	46	reach 8	53	10320	1776
21	reach 3	70.5	3450	1990	47	reach 8	52	10720	1765.9
22	reach 4	70	3850	1990	48	reach 8	51	10870	1756.8
23	reach 4	69	4250	1974.2	49	reach 9	50.5*	10880	1751.4
24	reach 4	68	4650	1961.6	50	reach 9	50.2	10930	1751.4
25	reach 4	67	5050	1951.2	51	reach 9	50.15*	10980	1750.05
26	reach 4	66	5450	1940	52	reach 9	50.1*	11030	1748.7
					53	reach 9	50.05*	11055	1747.35

(*) These cross sections were interpolated between adjacent cross section.

5.8 HEC-RAS SIMULATIONS USING DIFFERENT SCENARIOS

In HEC-RAS computations, the water surface elevations were simulated under different discharges, considering water releases from reservoir only, as well as considering Nallah contributions.

According with Himachal Pradesh State Government, the minimum water releases from reservoir must be 15% of average flow during lean season. The lean season corresponds to December and February and during this period the average ten-daily flow is 4.84 cumecs at Romari dam site, therefore the proposed minimum flow will be 4.84*0.15 = 0.726 cumecs (say 1 cumec).

Different combinations are represented as "Scenarios" and they are described as follow:

- *Scenario 1*: In this scenario is simulated the water surface profiles in the river "stretch" within a minimum water releases of 1 cumec from reservoir, without considering any contribution of the different Nallahs joining along the river "stretch".
- *Scenario 2*: In this scenario is simulated the water surface profiles in the river "stretch" within a minimum water releases of 1 cumec from reservoir, considering the contribution of the different Nallahs joining along the river "stretch". The amount of water inflow in each Nallah is taken from 90% dependable flow (Q90) of 90% dependable year for the Ten-Daily flow series at each corresponding Nallah.
- *Scenario 3*: In this case, the simulation is done considering the amount of water releases from reservoir taken as 90% dependable flow (Q90) of 90% dependable year from the whole Ten-Daily flow series at Romari Dam site (1975-76 to 2007-08). The amount of this flow corresponds to 4.71 cumec without considering any contribution of the different Nallahs joining along the river "stretch".
- *Scenario 4*: In this case, the simulation is done considering the amount of water releases from reservoir taken as 90% dependable flow (Q90) of 90% dependable year from the whole Ten-Daily flow series at Romari Dam site (1975-76 to 2007-08) which corresponds to 4.71 cumec and considering the contribution of the different Nallahs joining along the river "stretch". The amount of water inflow in each Nallah is taken from 90% dependable flow (Q90) of 90% dependable year for the Ten-Daily flow series at each corresponding Nallah.

Next table summarize the different 90% dependable flow of 90% dependable year for each Nallah used in the simulation of HEC-RAS Modeling. Also, cumulative values of flows are used in every reach section after junction point in the confluence of Pabbar River and different Nallahs.

Table 5.11 The 90% Dependable flow of 90% dependable year at different Nallahs used in HEC-RAS simulation.

NALLAH	90% Dep. Year	90% Dep. Flow	Cumulative Flow for 1 cumec	Cumulative Flow for 4.71 cumec
Barshil Nallah	1999-00	0.23	1.23	4.94
Khanyara Khad	1999-00	0.50	1.73	5.44
Nalla 1	1999-00	0.11	1.84	5.55
Bandi Nallah	1999-00	0.15	1.99	5.70
Shahi Nallah	1999-00	0.07	2.06	5.77
Gumma Nallah	1999-00	0.84	2.90	6.61
Sonalpani Nallah	1999-00	0.07	2.97	6.68
Khasdhar Nallah	1999-00	0.20	3.17	6.88
Nalla 2	1999-00	0.02	3.19	6.90

The main hydraulic variables of the cross sections like: area, wetted perimeter, hydraulic radius and water surface elevations, water depth and water velocity are shown in next tables:

5.9 HEC-RAS SIMULATIONS USING SEASONAL METHODOLOGY

Same exercises of computation water surface elevation under different discharges were done in seasonal bases. Four main seasons are identified along the year:

Season I (Jun-Sep): This season is considered as high flow season, influenced by monsoon. It covers the months from June to September.

Season II (Oct-Nov): This season is considering like average season and it corresponds to transition period between wet and dry period. It covers the month of October and November.

Season III (Dec-Feb): This season is considering as low flow, lean or dry season. It covers the months from December to February.

Season IV (Mar-May): This season is considering like average season and it corresponds to transition period between dry and wet period. It covers the month of March to May.

Table 5.12 Mixed Flow Regime in Pabbar River for 1 cumec for Scenario 1

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	1	2157.58	2158.1	2158.1	0.52	0.62	2.64	0.23	1.62	1.02
reach 1	87	1	2152.45	2152.93	2152.73	0.28	0.22	1.71	0.13	4.61	3.97
reach 1	86	1	2148.86	2149.03	2149.03	0.17	1.07	12.29	0.09	0.94	1.02
reach 1	85	1	2144.2	2144.7	2144.55	0.35	0.31	1.92	0.16	3.21	2.44
reach 1	84	1	2139.8	2140.09	2140.07	0.27	0.69	5.15	0.13	1.44	1.25
reach 1	83	1	2136.55	2136.81	2136.77	0.22	0.65	5.98	0.11	1.53	1.47
reach 2	82	1	2133.42	2133.68	2133.64	0.22	0.63	5.82	0.11	1.58	1.52
reach 2	81	1	2130	2130.36	2130.33	0.33	0.63	3.98	0.16	1.58	1.24
reach 2	80	1	2124.8	2125.05	2124.97	0.17	0.41	4.92	0.08	2.44	2.69
reach 2	79	1	2119.2	2119.65	2119.61	0.41	0.54	2.81	0.19	1.86	1.32
reach 2	78	1	2112.3	2112.66	2112.52	0.22	0.27	2.51	0.11	3.74	3.6
reach 2	77	1	2104.1	2104.33	2104.3	0.2	0.67	5.28	0.13	1.5	1.34
reach 2	76	1	2093.6	2094.09	2093.96	0.36	0.34	2.04	0.16	2.98	2.25
reach 2	75	1	2088	2088.24	2088.24	0.24	0.91	7.58	0.12	1.1	1
reach 2	74	1	2069	2069.33	2069.19	0.19	0.28	2.94	0.09	3.61	3.71
reach 2	73	1	2045	2045.17	2045.16	0.16	0.99	12.15	0.08	1.01	1.13
reach 2	72	1	2028.1	2028.29	2028.49	0.39	4.15	21.7	0.19	0.24	0.17
reach 3	71.5	1	2028.1	2028.29	2028.29	0.19	1.02	10.74	0.09	0.98	1.01
reach 3	71	1	2012.2	2012.61	2012.4	0.2	0.14	1.92	0.07	7.23	8.25
reach 3	70.5	1	1990	1990.27	1990.56	0.55	3.53	12.62	0.28	0.28	0.17
reach 4	70	1	1990	1990.27	1990.27	0.27	0.86	6.56	0.13	1.16	1.01
reach 4	69	1	1974.2	1974.48	1974.38	0.18	0.37	4.09	0.09	2.72	2.88
reach 4	68	1	1961.6	1961.77	1961.77	0.17	1.09	12.74	0.09	0.92	1
reach 4	67	1	1951.2	1951.44	1951.42	0.22	0.77	7.11	0.11	1.3	1.26
reach 4	66	1	1940	1940.24	1940.22	0.22	0.81	7.4	0.11	1.24	1.19
reach 4	65	1	1921.4	1921.45	1921.41	0.01	0.23	25.04	0.01	4.26	14.06
reach 5	64	1	1901	1901.1	1901.08	0.08	0.92	24.44	0.04	1.09	1.79
reach 5	63	1	1885.5	1885.67	1885.67	0.17	1.04	12.13	0.09	0.96	1.05
reach 5	62	1	1873.8	1873.97	1873.96	0.16	0.95	11.83	0.08	1.05	1.18
reach 5	61	1	1861.1	1861.29	1861.28	0.18	0.94	10.49	0.09	1.06	1.13
reach 5	60.1	1	1849.2	1849.43	1849.65	0.45	3.41	15.11	0.23	0.29	0.2
reach 6	60	1	1849.2	1849.43	1849.43	0.23	0.91	7.8	0.12	1.1	1.03
reach 6	59	1	1838.6	1838.78	1838.76	0.16	0.9	11.3	0.08	1.11	1.24

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 6	58	1	1826.5	1826.82	1826.79	0.29	0.66	4.57	0.14	1.53	1.28
reach 6	57	1	1817.2	1817.38	1817.38	0.18	1.05	11.99	0.09	0.95	1.02
reach 6	56	1	1806	1806.35	1806.3	0.3	0.55	3.84	0.14	1.81	1.5
reach 6	55	1	1795.9	1796.13	1796.13	0.23	0.93	8.07	0.12	1.08	1.01
reach 7	54.75*	1	1794.18	1794.41	1794.35	0.18	0.55	6.19	0.09	1.82	1.94
reach 7	54.625*	1	1793.31	1793.54	1793.54	0.23	0.93	8.08	0.12	1.07	1.01
reach 7	54.5*	1	1792.45	1792.68	1792.69	0.24	0.99	8.38	0.12	1.01	0.94
reach 7	54.375*	1	1791.59	1791.81	1791.81	0.23	0.93	8.28	0.11	1.07	1.02
reach 8	54.25*	1	1790.73	1790.95	1790.9	0.17	0.58	6.73	0.09	1.72	1.86
reach 8	54.125*	1	1789.86	1790.07	1790.08	0.22	1.04	9.56	0.11	0.96	0.93
reach 8	54	1	1789	1789.19	1789.19	0.19	1.03	10.98	0.09	0.97	1.01
reach 8	53	1	1776	1776.05	1776.05	0.05	1.45	29.77	0.05	0.69	1
reach 8	52	1	1765.9	1766.24	1766.21	0.31	0.65	4.2	0.15	1.55	1.25
reach 8	51	1	1756.8	1756.91	1756.91	0.11	1.08	11.93	0.09	0.93	0.98
reach 9	50.5*	1	1751.4	1751.56	1751.67	0.27	1.76	9.18	0.19	0.57	0.41
reach 9	50.2	1	1751.4	1751.56	1751.56	0.16	0.89	7.1	0.13	1.12	1.01
reach 9	50.15*	1	1750.05	1750.24	1750.2	0.15	0.64	5.65	0.11	1.56	1.48
reach 9	50.1*	1	1748.7	1748.92	1748.91	0.21	0.8	5.58	0.14	1.25	1.04
reach 9	50.05*	1	1747.35	1747.61	1747.57	0.22	0.6	4.5	0.13	1.67	1.45

Table 5.13 Mixed Flow Regime in Pabbar River for 1 cumec for Scenario 2

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	1	2157.58	2158.1	2158.1	0.52	0.62	2.64	0.23	1.62	1.02
reach 1	87	1	2152.45	2152.93	2152.73	0.28	0.22	1.71	0.13	4.61	3.97
reach 1	86	1	2148.86	2149.03	2149.03	0.17	1.07	12.29	0.09	0.94	1.02
reach 1	85	1	2144.2	2144.7	2144.55	0.35	0.31	1.92	0.16	3.21	2.44
reach 1	84	1	2139.8	2140.09	2140.07	0.27	0.69	5.15	0.13	1.44	1.25
reach 1	83	1	2136.55	2136.81	2136.77	0.22	0.65	5.98	0.11	1.53	1.47
reach 2	82	1.23	2133.42	2133.7	2133.66	0.24	0.75	6.32	0.12	1.64	1.52
reach 2	81	1.23	2130	2130.39	2130.36	0.36	0.74	4.29	0.17	1.67	1.26
reach 2	80	1.23	2124.8	2125.07	2124.98	0.18	0.49	5.35	0.09	2.54	2.68
reach 2	79	1.23	2119.2	2119.69	2119.64	0.44	0.63	3.03	0.21	1.97	1.34
reach 2	78	1.23	2112.3	2112.7	2112.54	0.23	0.31	2.7	0.11	3.99	3.72
reach 2	77	1.23	2104.1	2104.35	2104.35	0.25	0.95	5.86	0.16	1.3	1.02
reach 2	76	1.23	2093.6	2094.13	2093.9	0.3	0.24	1.73	0.14	5.1	4.19
reach 2	75	1.23	2088	2088.26	2088.26	0.26	1.07	8.22	0.13	1.14	1.01
reach 2	74	1.23	2069	2069.35	2069.21	0.21	0.32	3.14	0.1	3.89	3.86
reach 2	73	1.23	2045	2045.19	2045.16	0.16	0.97	12.05	0.08	1.27	1.42
reach 2	72	1.23	2028.1	2028.31	2028.54	0.44	5.32	22.67	0.23	0.23	0.15
reach 3	71.5	1.73	2028.1	2028.34	2028.34	0.24	1.57	13.33	0.12	1.1	1.02
reach 3	71	1.73	2012.2	2012.69	2012.44	0.24	0.21	2.43	0.09	8.07	8.34
reach 3	70.5	1.73	1990	1990.34	1990.67	0.67	4.97	13.88	0.36	0.35	0.18
reach 4	70	1.84	1990	1990.35	1990.35	0.35	1.41	8.39	0.17	1.31	1
reach 4	69	1.84	1974.2	1974.55	1974.43	0.23	0.61	5.24	0.12	3.04	2.84
reach 4	68	1.84	1961.6	1961.82	1961.82	0.22	1.75	16.11	0.11	1.05	1.02
reach 4	67	1.84	1951.2	1951.5	1951.47	0.27	1.13	8.64	0.13	1.62	1.42
reach 4	66	1.84	1940	1940.3	1940.29	0.29	1.4	9.74	0.14	1.32	1.11
reach 4	65	1.84	1921.4	1921.48	1921.43	0.03	0.77	25.13	0.03	2.39	4.37
reach 5	64	1.99	1901	1901.12	1901.12	0.12	2.36	33.42	0.07	0.84	1.01
reach 5	63	1.99	1885.5	1885.73	1885.67	0.17	0.98	11.75	0.08	2.04	2.26
reach 5	62	1.99	1873.8	1874.03	1874.03	0.23	1.88	16.64	0.11	1.06	1
reach 5	61	1.99	1861.1	1861.35	1861.29	0.19	1.03	10.99	0.09	1.92	2
reach 5	60.1	1.99	1849.2	1849.51	1849.82	0.62	6.32	20.46	0.31	0.32	0.18
reach 6	60	2.9	1849.2	1849.56	1849.56	0.36	2.16	12.03	0.18	1.34	1.01

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 6	59	2.9	1838.6	1838.87	1838.82	0.22	1.72	15.56	0.11	1.69	1.62
reach 6	58	2.9	1826.5	1826.99	1826.97	0.47	1.7	7.35	0.23	1.71	1.13
reach 6	57	2.9	1817.2	1817.47	1817.45	0.25	2.05	16.75	0.12	1.41	1.28
reach 6	56	2.9	1806	1806.53	1806.49	0.49	1.47	6.27	0.23	1.97	1.28
reach 6	55	2.9	1795.9	1796.26	1796.22	0.32	1.78	11.17	0.16	1.63	1.3
reach 7	54.75*	2.97	1794.18	1794.53	1794.47	0.3	1.55	10.38	0.15	1.92	1.58
reach 7	54.625*	2.97	1793.31	1793.67	1793.67	0.36	2.26	12.59	0.18	1.31	0.99
reach 7	54.5*	2.97	1792.45	1792.81	1792.79	0.34	2.07	12.12	0.17	1.44	1.11
reach 7	54.375*	2.97	1791.59	1791.94	1791.92	0.33	2.02	12.16	0.17	1.47	1.15
reach 8	54.25*	3.17	1790.73	1791.07	1791.01	0.28	1.55	10.98	0.14	2.04	1.74
reach 8	54.125*	3.17	1789.86	1790.2	1790.2	0.33	2.43	14.63	0.17	1.3	1.02
reach 8	54	3.17	1789	1789.3	1789.29	0.29	2.44	16.86	0.14	1.3	1.09
reach 8	53	3.17	1776	1776.11	1776.08	0.08	2.44	30.29	0.08	1.3	1.46
reach 8	52	3.17	1765.9	1766.44	1766.44	0.54	1.91	7.23	0.26	1.66	1.02
reach 8	51	3.17	1756.8	1757.01	1756.96	0.16	1.78	13.9	0.13	1.78	1.59
reach 9	50.5*	3.19	1751.4	1751.71	1751.85	0.45	3.76	12.74	0.3	0.85	0.49
reach 9	50.2	3.19	1751.4	1751.71	1751.71	0.31	2.16	9.99	0.22	1.48	1.01
reach 9	50.15*	3.19	1750.05	1750.4	1750.31	0.26	1.39	7.68	0.18	2.29	1.71
reach 9	50.1*	3.19	1748.7	1749.09	1749.08	0.38	1.94	8.34	0.23	1.65	1.08
reach 9	50.05*	3.19	1747.35	1747.8	1747.72	0.37	1.41	6.81	0.21	2.27	1.58

Table 5.14 Mixed Flow Regime in Pabbar River for 4.71 cumec for Scenario 3

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	4.71	2157.58	2158.55	2158.55	0.97	2.14	4.91	0.44	2.2	1.01
reach 1	87	4.71	2152.45	2153.33	2152.96	0.5	0.73	3.14	0.23	6.45	4.1
reach 1	86	4.71	2148.86	2149.18	2149.17	0.31	3.45	22.13	0.16	1.36	1.1
reach 1	85	4.71	2144.2	2145.13	2144.87	0.67	1.14	3.66	0.31	4.14	2.28
reach 1	84	4.71	2139.8	2140.35	2140.26	0.46	1.99	8.82	0.23	2.36	1.57
reach 1	83	4.71	2136.55	2137.02	2136.96	0.41	2.32	11.26	0.21	2.03	1.43
reach 2	82	4.71	2133.42	2133.9	2133.79	0.37	1.84	9.92	0.19	2.56	1.89
reach 2	81	4.71	2130	2130.67	2130.62	0.62	2.19	7.41	0.3	2.15	1.24
reach 2	80	4.71	2124.8	2125.26	2125.08	0.28	1.15	8.25	0.14	4.09	3.48
reach 2	79	4.71	2119.2	2120.12	2119.94	0.74	1.8	5.14	0.35	2.61	1.37
reach 2	78	4.71	2112.3	2112.98	2112.69	0.39	0.83	4.43	0.19	5.66	4.11
reach 2	77	4.71	2104.1	2104.59	2104.56	0.46	2.42	8.25	0.29	1.94	1.13
reach 2	76	4.71	2093.6	2094.51	2094.14	0.54	0.76	3.08	0.25	6.18	3.81
reach 2	75	4.71	2088	2088.45	2088.45	0.45	3.14	14.05	0.22	1.5	1.01
reach 2	74	4.71	2069	2069.61	2069.32	0.32	0.76	4.88	0.16	6.17	4.92
reach 2	73	4.71	2045	2045.31	2045.28	0.28	2.91	20.86	0.14	1.62	1.38
reach 2	72	4.71	2028.1	2028.46	2028.73	0.63	9.76	23.71	0.41	0.48	0.24
reach 3	71.5	4.71	2028.1	2028.46	2028.46	0.36	3.51	19.96	0.18	1.34	1.02
reach 3	71	4.71	2012.2	2012.91	2012.54	0.34	0.5	3.76	0.13	9.45	7.99
reach 3	70.5	4.71	1990	1990.5	1990.93	0.93	8.78	16.78	0.52	0.54	0.23
reach 4	70	4.71	1990	1990.5	1990.5	0.5	2.93	12.06	0.24	1.61	1.02
reach 4	69	4.71	1974.2	1974.71	1974.51	0.31	1.06	6.93	0.15	4.46	3.62
reach 4	68	4.71	1961.6	1961.92	1961.92	0.32	3.71	23.49	0.16	1.27	1.02
reach 4	67	4.71	1951.2	1951.64	1951.57	0.37	2.19	12.03	0.18	2.15	1.59
reach 4	66	4.71	1940	1940.44	1940.41	0.41	2.77	13.71	0.2	1.7	1.21
reach 4	65	4.71	1921.4	1921.55	1921.48	0.08	2.05	25.36	0.08	2.3	2.58
reach 5	64	4.71	1901	1901.18	1901.14	0.14	3.07	34.22	0.09	1.53	1.64
reach 5	63	4.71	1885.5	1885.82	1885.8	0.3	3.07	20.84	0.15	1.53	1.27
reach 5	62	4.71	1873.8	1874.12	1874.08	0.28	2.86	20.5	0.14	1.65	1.41
reach 5	61	4.71	1861.1	1861.45	1861.41	0.3	2.7	17.76	0.15	1.74	1.43
reach 5	60.1	4.71	1849.2	1849.64	1849.95	0.75	9.29	24	0.39	0.51	0.26
reach 6	60	4.71	1849.2	1849.64	1849.64	0.44	3.19	14.62	0.22	1.48	1.01

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 6	59	4.71	1838.6	1838.93	1838.86	0.26	2.33	18.11	0.13	2.02	1.8
reach 6	58	4.71	1826.5	1827.1	1827.07	0.57	2.56	9.75	0.26	1.84	1.14
reach 6	57	4.71	1817.2	1817.53	1817.48	0.28	2.73	19.3	0.14	1.73	1.46
reach 6	56	4.71	1806	1806.65	1806.6	0.6	2.22	7.69	0.29	2.13	1.24
reach 6	55	4.71	1795.9	1796.33	1796.27	0.37	2.37	12.89	0.18	1.99	1.47
reach 7	54.75*	4.71	1794.18	1794.6	1794.54	0.37	2.34	12.77	0.18	2.01	1.5
reach 7	54.625*	4.71	1793.31	1793.74	1793.74	0.43	3.19	14.95	0.21	1.48	1.02
reach 7	54.5*	4.71	1792.45	1792.88	1792.86	0.41	2.93	14.44	0.2	1.61	1.14
reach 7	54.375*	4.71	1791.59	1792.01	1792.01	0.42	3.22	15.35	0.21	1.46	1.02
reach 8	54.25*	4.71	1790.73	1791.14	1791.03	0.31	1.83	11.94	0.15	2.57	2.09
reach 8	54.125*	4.71	1789.86	1790.25	1790.25	0.39	3.35	17.18	0.19	1.41	1.02
reach 8	54	4.71	1789	1789.35	1789.33	0.33	3.21	19.35	0.17	1.47	1.15
reach 8	53	4.71	1776	1776.14	1776.11	0.11	3.24	30.69	0.11	1.46	1.43
reach 8	52	4.71	1765.9	1766.53	1766.51	0.61	2.47	8.23	0.3	1.9	1.1
reach 8	51	4.71	1756.8	1757.07	1757.01	0.21	2.4	15.44	0.16	1.96	1.59
reach 9	50.5*	4.71	1751.4	1751.79	1751.94	0.54	4.91	14.39	0.34	0.96	0.52
reach 9	50.2	4.71	1751.4	1751.79	1751.79	0.38	2.93	11.4	0.26	1.61	1
reach 9	50.15*	4.71	1750.05	1750.47	1750.37	0.32	1.82	8.64	0.21	2.58	1.78
reach 9	50.1*	4.71	1748.7	1749.17	1749.16	0.45	2.59	9.59	0.27	1.82	1.11
reach 9	50.05*	4.71	1747.35	1747.88	1747.79	0.44	1.9	7.89	0.24	2.48	1.6

Table 5.15 Mixed Flow Regime in Pabbar River for 4.71 cumec for Scenario 4

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. No.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	4.71	2157.58	2158.55	2158.55	0.97	2.14	4.91	0.44	2.2	1.01
reach 1	87	4.71	2152.45	2153.33	2152.96	0.5	0.73	3.14	0.23	6.45	4.1
reach 1	86	4.71	2148.86	2149.18	2149.17	0.31	3.45	22.13	0.16	1.36	1.1
reach 1	85	4.71	2144.2	2145.13	2144.87	0.67	1.14	3.66	0.31	4.14	2.28
reach 1	84	4.71	2139.8	2140.35	2140.26	0.46	1.99	8.82	0.23	2.36	1.57
reach 1	83	4.71	2136.55	2137.02	2136.96	0.41	2.32	11.26	0.21	2.03	1.43
reach 2	82	4.94	2133.42	2133.91	2133.8	0.38	1.92	10.15	0.19	2.57	1.88
reach 2	81	4.94	2130	2130.69	2130.63	0.63	2.26	7.53	0.3	2.19	1.25
reach 2	80	4.94	2124.8	2125.27	2125.09	0.29	1.21	8.45	0.14	4.09	3.44
reach 2	79	4.94	2119.2	2120.13	2120.01	0.81	2.15	6.8	0.32	2.29	1.27
reach 2	78	4.94	2112.3	2112.99	2112.68	0.38	0.81	4.36	0.18	6.13	4.49
reach 2	77	4.94	2104.1	2104.6	2104.57	0.47	2.49	8.35	0.3	1.98	1.15
reach 2	76	4.94	2093.6	2094.53	2094.15	0.55	0.8	3.16	0.25	6.14	3.74
reach 2	75	4.94	2088	2088.46	2088.46	0.46	3.25	14.3	0.23	1.52	1.01
reach 2	74	4.94	2069	2069.62	2069.32	0.32	0.78	4.92	0.16	6.36	5.05
reach 2	73	4.94	2045	2045.32	2045.3	0.3	3.25	22.06	0.15	1.52	1.26
reach 2	72	4.94	2028.1	2028.46	2028.76	0.66	10.32	23.84	0.43	0.48	0.23
reach 3	71.5	5.44	2028.1	2028.48	2028.48	0.38	3.97	21.22	0.19	1.37	1.01
reach 3	71	5.44	2012.2	2012.94	2012.55	0.35	0.54	3.9	0.14	10.14	8.42
reach 3	70.5	5.44	1990	1990.53	1990.98	0.98	9.62	17.35	0.55	0.57	0.24
reach 4	70	5.55	1990	1990.54	1990.54	0.54	3.32	12.42	0.27	1.67	1.01
reach 4	69	5.55	1974.2	1974.75	1974.53	0.33	1.18	7.31	0.16	4.72	3.73
reach 4	68	5.55	1961.6	1961.94	1961.94	0.34	4.26	25.15	0.17	1.3	1.01
reach 4	67	5.55	1951.2	1951.67	1951.59	0.38	2.38	12.53	0.19	2.33	1.69
reach 4	66	5.55	1940	1940.46	1940.44	0.44	3.29	14.94	0.22	1.69	1.15
reach 4	65	5.55	1921.4	1921.57	1921.48	0.08	1.92	25.33	0.08	2.9	3.36
reach 5	64	5.7	1901	1901.2	1901.13	0.12	2.44	33.51	0.07	2.33	2.76
reach 5	63	5.7	1885.5	1885.85	1885.85	0.35	4.3	24.66	0.17	1.33	1.01
reach 5	62	5.7	1873.8	1874.15	1874.07	0.27	2.68	19.83	0.13	2.13	1.85
reach 5	61	5.7	1861.1	1861.48	1861.47	0.37	3.96	21.51	0.18	1.44	1.07
reach 5	60.1	5.7	1849.2	1849.67	1850.02	0.82	11.13	25.38	0.44	0.51	0.25
reach 6	60	6.61	1849.2	1849.7	1849.7	0.5	4.16	16.69	0.25	1.59	1.01

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. No.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 6	59	6.61	1838.6	1838.97	1838.89	0.29	2.87	20.1	0.14	2.31	1.94
reach 6	58	6.61	1826.5	1827.18	1827.15	0.65	3.44	11.9	0.29	1.92	1.14
reach 6	57	6.61	1817.2	1817.58	1817.53	0.33	3.63	22.26	0.16	1.82	1.44
reach 6	56	6.61	1806	1806.74	1806.67	0.67	2.83	8.69	0.33	2.34	1.29
reach 6	55	6.61	1795.9	1796.4	1796.33	0.43	3.16	14.87	0.21	2.09	1.44
reach 7	54.75*	6.68	1794.18	1794.67	1794.59	0.41	2.97	14.39	0.21	2.25	1.57
reach 7	54.625*	6.68	1793.31	1793.8	1793.8	0.49	4.21	17.18	0.25	1.58	1.02
reach 7	54.5*	6.68	1792.45	1792.94	1792.91	0.46	3.76	16.34	0.23	1.78	1.18
reach 7	54.375*	6.68	1791.59	1792.08	1792.07	0.48	4.23	17.61	0.24	1.58	1.03
reach 8	54.25*	6.88	1790.73	1791.2	1791.08	0.36	2.5	13.94	0.18	2.75	2.07
reach 8	54.125*	6.88	1789.86	1790.32	1790.32	0.45	4.55	20.02	0.23	1.51	1.01
reach 8	54	6.88	1789	1789.41	1789.38	0.38	4.14	21.97	0.19	1.66	1.22
reach 8	53	6.88	1776	1776.17	1776.11	0.11	3.4	30.78	0.11	2.02	1.94
reach 8	52	6.88	1765.9	1766.64	1766.64	0.73	3.57	9.89	0.36	1.93	1.01
reach 8	51	6.88	1756.8	1757.13	1757.03	0.23	2.75	16.24	0.17	2.5	1.94
reach 9	50.5*	6.9	1751.4	1751.87	1752.04	0.64	6.39	16.28	0.39	1.08	0.55
reach 9	50.2	6.9	1751.4	1751.87	1751.87	0.47	3.94	13	0.3	1.75	1.01
reach 9	50.15*	6.9	1750.05	1750.57	1750.43	0.38	2.42	9.81	0.25	2.85	1.82
reach 9	50.1*	6.9	1748.7	1749.27	1749.24	0.54	3.42	10.97	0.31	2.02	1.14
reach 9	50.05*	6.9	1747.35	1747.98	1747.87	0.52	2.57	9.17	0.28	2.68	1.6

The discharge input in the HEC-RAS simulation corresponds to the 90% dependable flow of 90% dependable year at Romari dam site and different Nallahs for the above mentioned season. Similarly, in this seasonal analysis is made for two cases: the first case is only considering a constant discharge along the river which corresponds to the 90% dependable flow of 90% dependable year without any contribution from Nallahs. The second case is considering the contribution of 90% Dependable flow of 90% dependable year from different Nallahs. The cumulative values of discharge for different season are shown in table 5.16:

Table 5.16 Shows 90% dependable flow and cumulative flows for different seasons:

SEASONS	SEASON I (Jun-Sep)		SEASON II (Oct-Nov)		SEASON III (Dec-Feb)		SEASON IV (Mar-May)	
90% Dep Year	**1979-80**		**2001-02**		**1987-88**		**1998-99**	
NALLAH	**90% Dep Flow**	**Cum. Flow Season I**	**90% Dep Flow**	**Cum. Flow Season II**	**90% Dep Flow**	**Cum. Flow Season III**	**90% Dep Flow**	**Cum. Flow Season IV**
Romari Dam site	9.05	9.05	4.43	4.43	2.96	2.96	5.08	5.08
Barshil Nallah	0.45	9.50	0.22	4.65	0.15	3.11	0.25	5.33
Khanyara Khad	1.41	10.91	0.69	5.34	0.46	3.57	0.79	6.12
Nalla 1	1.63	12.54	0.80	6.14	0.53	4.10	0.91	7.03
Bandi Nallah	1.91	14.45	0.93	7.07	0.62	4.72	1.07	8.10
Shahi Nallah	2.03	16.48	1.00	8.07	0.66	5.38	1.14	9.24
Gumma Nallah	3.65	20.13	1.79	9.86	1.19	6.57	2.05	11.29
Sonalpani Nallah	3.78	23.91	1.85	11.71	1.23	7.80	2.12	13.41
Khasdhar Nallah	4.16	28.07	2.04	13.75	1.36	9.16	2.34	15.75
Nalla 2	4.21	32.28	2.06	15.81	1.37	10.53	2.36	18.11

The main hydraulic variables of the cross sections like: area, wetted perimeter, hydraulic radius and water surface elevations, water depth and water velocity are shown in next tables:

Table 5.17 Mixed Flow Regime in Pabbar River for Season I

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	9.05	657.63	658.63	658.63	1.00	4.41	11.1	0.4	2.05	1
reach 1	87	9.05	656.07	657.18	656.86	0.79	1.95	5.33	0.37	4.64	2.38
reach 1	86	9.05	654.97	655.52	655.35	0.37	2.71	9.39	0.29	3.34	1.97
reach 1	85	9.05	653.55	654.58	654.49	0.94	3.11	6.56	0.47	2.91	1.26
reach 1	84	9.05	652.21	652.84	652.61	0.4	2.11	10.54	0.2	4.29	3.01
reach 1	83	9.05	651.22	651.8	651.74	0.52	3.89	11.74	0.33	2.32	1.27
reach 2	82	9.05	650.27	650.9	650.74	0.48	2.8	9.91	0.28	3.23	1.93
reach 2	81	9.05	649.22	650.09	650.03	0.81	3.76	9.71	0.39	2.41	1.21
reach 2	80	9.05	647.64	648.3	648.04	0.4	1.99	7.99	0.25	4.55	2.88
reach 2	79	9.05	645.93	646.67	646.53	0.6	2.93	9.06	0.32	3.09	1.7
reach 2	78	9.05	643.83	644.72	644.45	0.62	2.1	6.31	0.33	4.31	2.34
reach 2	77	9.05	641.33	642.13	641.99	0.66	2.93	7.73	0.38	3.09	1.58
reach 2	76	9.05	638.13	639.31	639.02	0.89	2.11	5.11	0.41	4.3	2.05
reach 2	75	9.05	636.42	637.07	636.94	0.52	3.06	8.46	0.36	2.96	1.54
reach 2	74	9.05	630.63	631.41	631.2	0.57	2.39	8.64	0.28	3.78	2.26
reach 2	73	9.05	623.32	623.86	623.7	0.38	2.75	10.09	0.27	3.3	1.99
reach 2	72	9.05	618.16	618.77	619.08	0.92	7.28	11.11	0.66	1.24	0.48
reach 3	71.5	9.05	618.16	618.77	618.77	0.6	4.2	9.41	0.45	2.16	1.01
reach 3	71	9.05	613.32	614.06	613.75	0.43	1.24	8.52	0.15	7.29	5.96
reach 3	70.5	9.05	606.55	607.3	607.69	1.14	8.27	12.3	0.67	1.09	0.41
reach 4	70	9.05	606.55	607.3	607.3	0.74	4.23	10.04	0.42	2.14	1.01
reach 4	69	9.05	601.74	602.45	602.14	0.41	1.74	7.29	0.24	5.21	3.38
reach 4	68	9.05	597.9	598.34	598.32	0.42	4.52	14.15	0.32	2	1.12
reach 4	67	9.05	594.73	595.3	595.2	0.47	3.58	15.36	0.23	2.53	1.66
reach 4	66	9.05	591.31	591.91	591.84	0.53	3.79	10.61	0.36	2.39	1.26
reach 4	65	9.05	585.64	586.14	585.89	0.25	1.99	8.7	0.23	4.55	3.02
reach 5	64	9.05	579.42	579.79	579.63	0.21	2.48	16.7	0.15	3.65	3.02
reach 5	63	9.05	574.7	575.19	575.15	0.45	4.18	12.23	0.34	2.16	1.17
reach 5	62	9.05	571.13	571.54	571.45	0.32	3.75	23.46	0.16	2.42	1.93
reach 5	61	9.05	567.26	567.71	567.66	0.4	3.8	13.51	0.19	1.73	1.2

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	60.1	9.05	563.64	564.27	564.59	0.95	6.71	9.42	0.71	1.35	0.49
reach 6	60	9.05	563.64	564.27	564.27	0.63	4.06	8.66	0.47	2.23	1.01
reach 6	59	9.05	560.41	560.83	560.7	0.29	2.85	17.38	0.16	3.17	2.49
reach 6	58	9.05	556.72	557.35	557.35	0.64	5.76	23.21	0.25	1.57	1
reach 6	57	9.05	553.88	554.32	554.22	0.34	3.54	16.97	0.21	2.56	1.78
reach 6	56	9.05	550.47	551.29	551.27	0.8	4.19	10.94	0.38	2.16	1.1
reach 6	55	9.05	547.39	547.95	547.82	0.43	3.14	14.83	0.21	2.88	1.99
reach 7	54.75*	9.05	546.86	547.42	547.36	0.49	4.2	17.11	0.25	2.15	1.38
reach 7	54.625*	9.05	546.6	547.16	547.14	0.53	4.95	18.41	0.27	1.83	1.12
reach 7	54.5*	9.05	546.34	546.88	546.87	0.53	4.83	16.82	0.28	1.87	1.11
reach 7	54.375*	9.05	546.08	546.62	546.59	0.52	4.59	14.71	0.3	1.96	1.12
reach 8	54.25*	9.05	545.81	546.36	546.26	0.44	3.48	12.61	0.26	2.58	1.58
reach 8	54.125*	9.05	545.55	546.1	546.09	0.54	4.32	10.51	0.36	1.97	1.01
reach 8	54	9.05	545.29	545.86	545.8	0.52	3.65	8.44	0.36	2.25	1.14
reach 8	53	9.05	541.32	541.74	541.56	0.24	2.54	12.55	0.2	3.56	2.52
reach 8	52	9.05	538.25	539.07	539.07	0.82	4.45	11.04	0.4	2.03	1.01
reach 8	51	9.05	535.47	535.96	535.82	0.34	2.93	13.48	0.2	3.06	2.11
reach 9	50.5*	9.05	533.83	534.43	534.54	0.71	6.53	15.68	0.42	1.39	0.68
reach 9	50.2	9.05	533.83	534.44	534.44	0.61	5.01	15.35	0.33	1.81	1
reach 9	50.15*	9.05	533.42	534.06	533.97	0.56	3.7	15.53	0.24	2.45	1.59
reach 9	50.1*	9.05	533	533.68	533.65	0.65	4.56	16.18	0.28	1.99	1.18
reach 9	50.05*	9.05	532.59	533.31	533.25	0.65	4.11	16.58	0.25	2.2	1.4

Table 5.18 Mixed Flow Regime in Pabbar River for Season I + Nallahs

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	9.05	657.63	658.64	658.64	1.01	4.43	11.11	0.4	2.04	1
reach 1	87	9.05	656.07	657.18	656.86	0.79	1.95	5.33	0.37	4.63	2.37
reach 1	86	9.05	654.97	655.52	655.35	0.37	2.71	9.39	0.29	3.34	1.97
reach 1	85	9.05	653.55	654.58	654.49	0.94	3.11	6.56	0.47	2.91	1.26
reach 1	84	9.05	652.21	652.84	652.61	0.4	2.11	10.54	0.2	4.29	3.01
reach 1	83	9.05	651.22	651.8	651.74	0.52	3.89	11.74	0.33	2.32	1.27
reach 2	82	9.5	650.27	650.92	650.76	0.49	2.96	10.04	0.29	3.21	1.88
reach 2	81	9.5	649.22	650.11	650.04	0.82	3.86	9.84	0.39	2.46	1.23
reach 2	80	9.5	647.64	648.31	648.05	0.41	2.08	8.1	0.26	4.56	2.84
reach 2	79	9.5	645.93	646.69	646.54	0.6	3.01	9.09	0.33	3.16	1.71
reach 2	78	9.5	643.83	644.74	644.46	0.63	2.18	6.36	0.34	4.35	2.33
reach 2	77	9.5	641.33	642.15	642	0.67	3.01	7.77	0.39	3.16	1.59
reach 2	76	9.5	638.13	639.34	639.04	0.91	2.2	5.22	0.42	4.32	2.05
reach 2	75	9.5	636.42	637.08	636.95	0.53	3.14	8.5	0.37	3.02	1.56
reach 2	74	9.5	630.63	631.42	631.21	0.58	2.5	8.83	0.28	3.8	2.25
reach 2	73	9.5	623.32	623.87	623.7	0.39	2.82	10.13	0.28	3.37	2.01
reach 2	72	9.5	618.16	618.78	619.17	1.01	8.21	11.33	0.71	1.16	0.42
reach 3	71.5	10.91	618.16	618.83	618.83	0.67	4.81	9.77	0.49	2.27	1.01
reach 3	71	10.91	613.32	614.1	613.77	0.45	1.46	9.48	0.15	7.46	5.93
reach 3	70.5	10.91	606.55	607.36	607.84	1.29	9.99	12.83	0.77	1.09	0.37
reach 4	70	12.54	606.55	607.41	607.41	0.86	5.36	10.72	0.5	2.34	1.01
reach 4	69	12.54	601.74	602.57	602.2	0.47	2.19	7.57	0.29	5.73	3.37
reach 4	68	12.54	597.9	598.43	598.38	0.49	5.42	14.32	0.38	2.31	1.19
reach 4	67	12.54	594.73	595.38	595.27	0.54	4.7	17.66	0.27	2.67	1.64
reach 4	66	12.54	591.31	592.01	591.92	0.61	4.64	11.03	0.42	2.7	1.32
reach 4	65	12.54	585.64	586.26	585.95	0.31	2.55	8.98	0.28	4.92	2.93
reach 5	64	14.45	579.42	579.89	579.68	0.25	3.32	18.55	0.18	4.35	3.28
reach 5	63	14.45	574.7	575.33	575.27	0.57	5.67	12.84	0.44	2.55	1.21
reach 5	62	14.45	571.13	571.63	571.51	0.37	5.01	25.04	0.19	2.87	2.06
reach 5	61	14.45	567.26	567.8	567.73	0.47	4.79	13.51	0.23	1.94	1.24

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	60.1	14.45	563.64	564.46	565.09	1.45	11.16	10.36	1	1.29	0.37
reach 6	60	20.13	563.64	564.63	564.63	0.99	7.08	9.52	0.74	2.84	1
reach 6	59	20.13	560.41	561.04	560.78	0.38	4.41	17.98	0.25	4.57	2.93
reach 6	58	20.13	556.72	557.53	557.51	0.79	9.71	25.84	0.37	2.07	1.07
reach 6	57	20.13	553.88	554.54	554.36	0.48	6.01	17.35	0.33	3.33	1.81
reach 6	56	20.13	550.47	551.6	551.52	1.05	6.95	12.05	0.58	2.9	1.19
reach 6	55	20.13	547.39	548.15	547.97	0.58	5.74	20.06	0.29	3.51	2.08
reach 7	54.75*	23.91	546.86	547.68	547.56	0.7	8.31	21.05	0.38	2.86	1.46
reach 7	54.625*	23.91	546.6	547.42	547.4	0.79	9.87	18.93	0.47	2.34	1.06
reach 7	54.5*	23.91	546.34	547.17	547.1	0.76	8.7	16.82	0.46	2.64	1.2
reach 7	54.375*	23.91	546.08	546.93	546.85	0.77	8.38	14.71	0.49	2.67	1.17
reach 8	54.25*	28.07	545.81	546.76	546.67	0.86	8.69	12.61	0.56	2.85	1.16
reach 8	54.125*	28.07	545.55	546.54	546.44	0.89	8.02	10.51	0.59	2.89	1.15
reach 8	54	28.07	545.29	546.33	546.22	0.94	7.17	8.44	0.61	2.92	1.14
reach 8	53	28.07	541.32	542.12	541.75	0.43	5.2	15.52	0.33	5.4	2.97
reach 8	52	28.07	538.25	539.44	539.44	1.19	12.94	27.69	0.47	2.17	1.01
reach 8	51	28.07	535.47	536.29	536.03	0.56	5.78	13.48	0.3	3.96	2.14
reach 9	50.5*	32.28	533.83	534.88	534.71	0.88	9.2	16.25	0.57	3.51	1.47
reach 9	50.2	32.28	533.83	534.88	534.88	1.05	11.92	16.79	0.71	2.71	1.01
reach 9	50.15*	32.28	533.42	534.5	534.3	0.88	8.86	16.57	0.53	3.64	1.57
reach 9	50.1*	32.28	533	534.11	533.94	0.93	9.23	17.06	0.54	3.5	1.5
reach 9	50.05*	32.28	532.59	533.73	533.56	0.96	9.24	17.5	0.53	3.49	1.51

Table 5.19 Mixed Flow Regime in Pabbar River for Season II

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	4.43	657.63	658.45	658.45	0.82	2.56	9.44	0.27	1.73	1.03
reach 1	87	4.43	656.07	656.9	656.65	0.58	1.04	3.89	0.27	4.27	2.55
reach 1	86	4.43	654.97	655.34	655.25	0.28	1.86	8.94	0.21	2.39	1.66
reach 1	85	4.43	653.55	654.33	654.25	0.7	1.81	5.82	0.31	2.45	1.34
reach 1	84	4.43	652.21	652.67	652.53	0.32	1.36	8.94	0.15	3.27	2.64
reach 1	83	4.43	651.22	651.63	651.61	0.39	2.51	10.63	0.24	1.77	1.15
reach 2	82	4.43	650.27	650.73	650.62	0.35	1.61	8.92	0.18	2.75	2.06
reach 2	81	4.43	649.22	649.88	649.86	0.63	2.3	7.59	0.3	1.93	1.09
reach 2	80	4.43	647.64	648.11	647.91	0.27	1.07	6.84	0.16	4.15	3.33
reach 2	79	4.43	645.93	646.48	646.42	0.49	2	8.74	0.23	2.22	1.46
reach 2	78	4.43	643.83	644.48	644.28	0.45	1.15	5.21	0.22	3.85	2.58
reach 2	77	4.43	641.33	641.92	641.84	0.52	1.91	6.73	0.28	2.32	1.37
reach 2	76	4.43	638.13	639.02	638.78	0.65	1.11	3.71	0.3	4	2.25
reach 2	75	4.43	636.42	636.87	636.82	0.4	2.1	8.08	0.26	2.11	1.31
reach 2	74	4.43	630.63	631.22	631.04	0.41	1.23	6.2	0.2	3.59	2.54
reach 2	73	4.43	623.32	623.69	623.6	0.29	1.86	9.25	0.2	2.38	1.68
reach 2	72	4.43	618.16	618.57	618.83	0.66	4.73	9.73	0.49	0.94	0.42
reach 3	71.5	4.43	618.16	618.57	618.57	0.4	2.51	8.36	0.3	1.76	1.01
reach 3	71	4.43	613.32	613.91	613.66	0.34	0.66	5.15	0.13	6.71	5.81
reach 3	70.5	4.43	606.55	607.1	607.42	0.87	5.42	10.75	0.5	0.82	0.35
reach 4	70	4.43	606.55	607.1	607.1	0.55	2.54	8.95	0.28	1.74	1.01
reach 4	69	4.43	601.74	602.24	602.05	0.31	1.09	6.88	0.16	4.07	3.25
reach 4	68	4.43	597.9	598.21	598.21	0.31	2.99	13.86	0.22	1.48	1.01
reach 4	67	4.43	594.73	595.16	595.08	0.35	2	11.48	0.17	2.21	1.68
reach 4	66	4.43	591.31	591.74	591.71	0.4	2.44	9.91	0.25	1.81	1.16
reach 4	65	4.43	585.64	585.96	585.79	0.15	1.16	8.27	0.14	3.81	3.23
reach 5	64	4.43	579.42	579.68	579.58	0.15	1.67	14.7	0.11	2.65	2.51
reach 5	63	4.43	574.7	575.03	575.01	0.31	2.6	11.56	0.22	1.71	1.14
reach 5	62	4.43	571.13	571.45	571.39	0.25	2.34	18.54	0.13	1.89	1.7
reach 5	61	4.43	567.26	567.61	567.57	0.31	2.6	13.51	0.13	1.5	1.19

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	60.1	4.43	563.64	564.07	564.32	0.69	4.5	8.79	0.51	0.98	0.42
reach 6	60	4.43	563.64	564.08	564.08	0.44	2.5	8.19	0.31	1.77	1.01
reach 6	59	4.43	560.41	560.72	560.64	0.24	1.98	16.7	0.12	2.24	2.07
reach 6	58	4.43	556.72	557.24	557.24	0.52	3.3	19.3	0.17	1.34	1.03
reach 6	57	4.43	553.88	554.2	554.15	0.27	2.44	16.69	0.15	1.82	1.51
reach 6	56	4.43	550.47	551.1	551.07	0.6	2.28	7.8	0.29	1.95	1.13
reach 6	55	4.43	547.39	547.81	547.73	0.34	2.02	11.89	0.17	2.2	1.69
reach 7	54.75*	4.43	546.86	547.28	547.24	0.37	2.41	12.94	0.19	1.84	1.36
reach 7	54.625*	4.43	546.6	547.02	547.02	0.42	3.05	14.62	0.21	1.45	1.01
reach 7	54.5*	4.43	546.34	546.76	546.74	0.4	2.8	14.03	0.2	1.58	1.13
reach 7	54.375*	4.43	546.08	546.49	546.48	0.41	2.97	14.06	0.21	1.49	1.04
reach 8	54.25*	4.43	545.81	546.21	546.14	0.32	1.99	11.51	0.17	2.23	1.71
reach 8	54.125*	4.43	545.55	545.94	545.94	0.39	2.76	10.51	0.25	1.58	0.99
reach 8	54	4.43	545.29	545.68	545.64	0.35	2.3	8.44	0.25	1.88	1.16
reach 8	53	4.43	541.32	541.6	541.5	0.17	1.74	11.51	0.15	2.55	2.09
reach 8	52	4.43	538.25	538.86	538.86	0.62	2.51	8.29	0.3	1.76	1.01
reach 8	51	4.43	535.47	535.82	535.74	0.27	1.91	12.06	0.16	2.32	1.85
reach 9	50.5*	4.43	533.83	534.3	534.39	0.56	4.28	15.19	0.28	1.04	0.62
reach 9	50.2	4.43	533.83	534.31	534.31	0.48	3.12	14.93	0.21	1.42	0.99
reach 9	50.15*	4.43	533.42	533.93	533.86	0.45	2.16	10.07	0.21	2.05	1.4
reach 9	50.1*	4.43	533	533.56	533.54	0.54	2.82	15.84	0.18	1.57	1.18
reach 9	50.05*	4.43	532.59	533.19	533.1	0.51	2.18	8.4	0.26	2.04	1.26

Table 5.20 Mixed Flow Regime in Pabbar River for Season II + Nallahs

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	4.43	657.63	658.45	658.45	0.82	2.56	9.44	0.27	1.73	1.03
reach 1	87	4.43	656.07	656.9	656.65	0.58	1.04	3.89	0.27	4.27	2.56
reach 1	86	4.43	654.97	655.34	655.25	0.28	1.85	8.94	0.21	2.39	1.67
reach 1	85	4.43	653.55	654.33	654.25	0.7	1.81	5.82	0.31	2.45	1.33
reach 1	84	4.43	652.21	652.67	652.53	0.32	1.36	8.94	0.15	3.27	2.64
reach 1	83	4.43	651.22	651.63	651.61	0.39	2.51	10.63	0.24	1.77	1.15
reach 2	82	4.65	650.27	650.74	650.62	0.36	1.69	9	0.19	2.74	2.01
reach 2	81	4.65	649.22	649.89	649.87	0.64	2.37	7.7	0.31	1.97	1.11
reach 2	80	4.65	647.64	648.12	647.92	0.28	1.12	6.9	0.16	4.16	3.28
reach 2	79	4.65	645.93	646.49	646.43	0.49	2.05	8.76	0.23	2.27	1.47
reach 2	78	4.65	643.83	644.49	644.29	0.46	1.2	5.33	0.23	3.86	2.56
reach 2	77	4.65	641.33	641.93	641.85	0.52	1.97	6.83	0.29	2.36	1.38
reach 2	76	4.65	638.13	639.04	638.79	0.66	1.16	3.79	0.31	4.02	2.23
reach 2	75	4.65	636.42	636.88	636.83	0.4	2.15	8.1	0.27	2.16	1.32
reach 2	74	4.65	630.63	631.23	631.05	0.42	1.29	6.34	0.2	3.6	2.52
reach 2	73	4.65	623.32	623.7	623.61	0.29	1.91	9.32	0.2	2.43	1.7
reach 2	72	4.65	618.16	618.58	618.88	0.72	5.26	10.03	0.52	0.88	0.38
reach 3	71.5	5.34	618.16	618.61	618.61	0.45	2.87	8.59	0.33	1.86	1.01
reach 3	71	5.34	613.32	613.94	613.68	0.36	0.78	6	0.13	6.85	5.91
reach 3	70.5	5.34	606.55	607.15	607.52	0.97	6.47	11.35	0.57	0.82	0.33
reach 4	70	6.14	606.55	607.18	607.18	0.63	3.2	9.39	0.34	1.92	1.01
reach 4	69	6.14	601.74	602.32	602.09	0.35	1.34	7.04	0.19	4.59	3.33
reach 4	68	6.14	597.9	598.26	598.26	0.36	3.63	13.98	0.26	1.69	1.05
reach 4	67	6.14	594.73	595.22	595.13	0.4	2.59	13.06	0.2	2.37	1.69
reach 4	66	6.14	591.31	591.81	591.77	0.45	3	10.2	0.29	2.05	1.2
reach 4	65	6.14	585.64	586.03	585.83	0.18	1.47	8.43	0.17	4.17	3.16
reach 5	64	7.07	579.42	579.75	579.61	0.19	2.22	16.09	0.14	3.18	2.73
reach 5	63	7.07	574.7	575.13	575.09	0.39	3.52	11.95	0.29	2.01	1.17
reach 5	62	7.07	571.13	571.51	571.43	0.3	3.23	21.77	0.15	2.19	1.81
reach 5	61	7.07	567.26	567.67	567.63	0.36	3.33	13.51	0.16	1.65	1.21

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	60.1	7.07	563.64	564.19	564.64	1	7.16	9.55	0.75	0.99	0.35
reach 6	60	9.86	563.64	564.3	564.3	0.66	4.31	8.73	0.49	2.29	1.01
reach 6	59	9.86	560.41	560.85	560.7	0.3	2.98	17.43	0.17	3.31	2.54
reach 6	58	9.86	556.72	557.37	557.34	0.62	5.5	22.84	0.24	1.79	1.16
reach 6	57	9.86	553.88	554.33	554.26	0.38	4.23	17.14	0.25	2.33	1.49
reach 6	56	9.86	550.47	551.32	551.26	0.79	4.08	10.89	0.37	2.42	1.24
reach 6	55	9.86	547.39	547.97	547.86	0.47	3.81	16.35	0.23	2.59	1.7
reach 7	54.75*	11.71	546.86	547.48	547.41	0.54	5.07	18.75	0.27	2.31	1.42
reach 7	54.625*	11.71	546.6	547.21	547.2	0.59	6.1	18.93	0.31	1.92	1.08
reach 7	54.5*	11.71	546.34	546.94	546.91	0.57	5.56	16.82	0.32	2.09	1.17
reach 7	54.375*	11.71	546.08	546.68	546.65	0.57	5.44	14.71	0.34	2.11	1.12
reach 8	54.25*	13.75	545.81	546.48	546.39	0.58	5.18	12.61	0.37	2.55	1.3
reach 8	54.125*	13.75	545.55	546.23	546.2	0.65	5.47	10.51	0.43	2.27	1.06
reach 8	54	13.75	545.29	546	545.93	0.65	4.74	8.44	0.44	2.47	1.13
reach 8	53	13.75	541.32	541.86	541.62	0.29	3.22	13.38	0.24	4.26	2.77
reach 8	52	13.75	538.25	539.25	539.25	1	7.9	26.56	0.3	1.74	1.02
reach 8	51	13.75	535.47	536.07	535.9	0.42	4	13.48	0.23	3.2	1.96
reach 9	50.5*	15.81	533.83	534.59	534.71	0.88	9.21	16.26	0.57	1.72	0.72
reach 9	50.2	15.81	533.83	534.58	534.58	0.76	7.26	15.84	0.46	2.18	1.01
reach 9	50.15*	15.81	533.42	534.21	534.08	0.66	5.38	15.88	0.34	2.94	1.6
reach 9	50.1*	15.81	533	533.83	533.75	0.75	6.19	16.49	0.38	2.55	1.31
reach 9	50.05*	15.81	532.59	533.45	533.36	0.76	5.91	16.91	0.35	2.67	1.43

Table 5.21 Mixed Flow Regime in Pabbar River for Season III

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	2.96	657.63	658.37	658.37	0.74	1.9	8.24	0.23	1.56	1.01
reach 1	87	2.96	656.07	656.78	656.56	0.49	0.72	3.23	0.22	4.11	2.69
reach 1	86	2.96	654.97	655.27	655.21	0.24	1.5	8.76	0.17	1.97	1.51
reach 1	85	2.96	653.55	654.22	654.16	0.61	1.34	5.53	0.24	2.21	1.38
reach 1	84	2.96	652.21	652.61	652.5	0.29	1.1	8.81	0.12	2.69	2.4
reach 1	83	2.96	651.22	651.57	651.56	0.34	1.98	10.49	0.19	1.5	1.09
reach 2	82	2.96	650.27	650.66	650.56	0.3	1.16	7.89	0.15	2.54	2.11
reach 2	81	2.96	649.22	649.78	649.77	0.55	1.71	6.55	0.26	1.73	1.06
reach 2	80	2.96	647.64	648.03	647.87	0.23	0.76	6.41	0.12	3.88	3.58
reach 2	79	2.96	645.93	646.41	646.37	0.44	1.61	8.6	0.19	1.84	1.34
reach 2	78	2.96	643.83	644.39	644.21	0.38	0.79	4.33	0.18	3.73	2.74
reach 2	77	2.96	641.33	641.82	641.77	0.44	1.46	5.9	0.25	2.03	1.28
reach 2	76	2.96	638.13	638.89	638.67	0.54	0.77	3.08	0.25	3.87	2.38
reach 2	75	2.96	636.42	636.8	636.77	0.35	1.7	7.92	0.21	1.75	1.19
reach 2	74	2.96	630.63	631.13	630.97	0.33	0.83	5.09	0.16	3.57	2.78
reach 2	73	2.96	623.32	623.62	623.56	0.24	1.49	8.73	0.17	1.99	1.52
reach 2	72	2.96	618.16	618.49	618.72	0.55	3.75	9.14	0.41	0.79	0.39
reach 3	71.5	2.96	618.16	618.49	618.49	0.33	1.89	7.94	0.24	1.57	1.01
reach 3	71	2.96	613.32	613.84	613.61	0.29	0.46	3.64	0.13	6.42	5.57
reach 3	70.5	2.96	606.55	607.01	607.3	0.75	4.29	10.08	0.43	0.69	0.32
reach 4	70	2.96	606.55	607.01	607.01	0.46	1.8	7.02	0.26	1.65	1.01
reach 4	69	2.96	601.74	602.16	602.01	0.27	0.81	6.05	0.13	3.67	3.19
reach 4	68	2.96	597.9	598.16	598.16	0.26	2.27	13.72	0.17	1.3	1.02
reach 4	67	2.96	594.73	595.09	595.04	0.31	1.55	10.1	0.15	1.91	1.55
reach 4	66	2.96	591.31	591.67	591.65	0.34	1.85	9.59	0.19	1.6	1.16
reach 4	65	2.96	585.64	585.89	585.76	0.12	0.94	8.15	0.12	3.16	2.96
reach 5	64	2.96	579.42	579.63	579.55	0.12	1.25	13.54	0.09	2.38	2.5
reach 5	63	2.96	574.7	574.97	574.96	0.26	2.04	11.31	0.18	1.45	1.09
reach 5	62	2.96	571.13	571.4	571.35	0.22	1.72	15.87	0.11	1.73	1.67
reach 5	61	2.96	567.26	567.56	567.53	0.27	2.1	13.51	0.14	1.38	1.13

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	60.1	2.96	563.64	564	564.22	0.58	3.63	8.53	0.43	0.82	0.39
reach 6	60	2.96	563.64	564	564	0.36	1.9	8	0.24	1.56	1.01
reach 6	59	2.96	560.41	560.67	560.62	0.21	1.57	14.89	0.11	1.88	1.84
reach 6	58	2.96	556.72	557.19	557.19	0.47	2.43	16.43	0.15	1.22	1.01
reach 6	57	2.96	553.88	554.15	554.12	0.24	1.88	16.01	0.12	1.58	1.47
reach 6	56	2.96	550.47	551.01	550.99	0.52	1.67	6.69	0.25	1.77	1.11
reach 6	55	2.96	547.39	547.75	547.69	0.3	1.51	10.3	0.15	1.96	1.62
reach 7	54.75*	2.96	546.86	547.22	547.19	0.32	1.78	11.12	0.16	1.67	1.33
reach 7	54.625*	2.96	546.6	546.96	546.96	0.36	2.2	12.42	0.18	1.34	1.02
reach 7	54.5*	2.96	546.34	546.69	546.68	0.35	2.11	12.24	0.17	1.4	1.08
reach 7	54.375*	2.96	546.08	546.43	546.42	0.35	2.19	12.43	0.18	1.35	1.02
reach 8	54.25*	2.96	545.81	546.15	546.09	0.27	1.45	10.32	0.14	2.04	1.73
reach 8	54.125*	2.96	545.55	545.88	545.88	0.33	2.09	10.51	0.2	1.42	1.01
reach 8	54	2.96	545.29	545.6	545.58	0.3	1.81	8.44	0.2	1.62	1.12
reach 8	53	2.96	541.32	541.54	541.46	0.14	1.34	10.95	0.12	2.21	2.02
reach 8	52	2.96	538.25	538.77	538.77	0.52	1.82	7.05	0.26	1.63	1.01
reach 8	51	2.96	535.47	535.77	535.7	0.23	1.48	10.67	0.14	2	1.71
reach 9	50.5*	2.96	533.83	534.24	534.33	0.5	3.39	14.99	0.23	0.87	0.58
reach 9	50.2	2.96	533.83	534.24	534.24	0.42	2.19	11.94	0.18	1.35	1
reach 9	50.15*	2.96	533.42	533.83	533.77	0.36	1.44	7.28	0.2	2.05	1.46
reach 9	50.1*	2.96	533	533.45	533.42	0.42	1.69	7.62	0.22	1.75	1.17
reach 9	50.05*	2.96	532.59	533.07	533.01	0.42	1.49	6.96	0.21	1.99	1.35

Table 5.22 Mixed Flow Regime in Pabbar River for Season III + Nallahs

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	2.96	657.63	658.37	658.37	0.74	1.9	8.24	0.23	1.56	1.01
reach 1	87	2.96	656.07	656.78	656.56	0.49	0.72	3.23	0.22	4.11	2.69
reach 1	86	2.96	654.97	655.27	655.21	0.24	1.5	8.76	0.17	1.97	1.51
reach 1	85	2.96	653.55	654.22	654.16	0.61	1.34	5.53	0.24	2.21	1.38
reach 1	84	2.96	652.21	652.61	652.5	0.29	1.1	8.81	0.12	2.69	2.4
reach 1	83	2.96	651.22	651.57	651.56	0.34	1.98	10.49	0.19	1.5	1.09
reach 2	82	3.11	650.27	650.67	650.57	0.3	1.23	8.12	0.15	2.52	2.06
reach 2	81	3.11	649.22	649.79	649.78	0.56	1.77	6.66	0.27	1.76	1.07
reach 2	80	3.11	647.64	648.04	647.87	0.23	0.8	6.47	0.12	3.89	3.52
reach 2	79	3.11	645.93	646.42	646.38	0.45	1.65	8.62	0.19	1.89	1.36
reach 2	78	3.11	643.83	644.4	644.22	0.39	0.83	4.43	0.19	3.74	2.72
reach 2	77	3.11	641.33	641.83	641.78	0.45	1.51	5.99	0.25	2.06	1.29
reach 2	76	3.11	638.13	638.9	638.68	0.55	0.8	3.15	0.25	3.88	2.36
reach 2	75	3.11	636.42	636.8	636.77	0.35	1.74	7.94	0.22	1.79	1.2
reach 2	74	3.11	630.63	631.14	630.97	0.34	0.87	5.21	0.17	3.57	2.75
reach 2	73	3.11	623.32	623.63	623.57	0.25	1.53	8.79	0.17	2.03	1.54
reach 2	72	3.11	618.16	618.5	618.76	0.59	4.13	9.38	0.44	0.75	0.35
reach 3	71.5	3.57	618.16	618.53	618.53	0.36	2.16	8.12	0.27	1.65	1.01
reach 3	71	3.57	613.32	613.87	613.63	0.31	0.54	4.12	0.13	6.6	5.62
reach 3	70.5	3.57	606.55	607.06	607.39	0.84	5.1	10.57	0.48	0.7	0.31
reach 4	70	4.1	606.55	607.09	607.09	0.54	2.4	8.85	0.27	1.71	1.02
reach 4	69	4.1	601.74	602.22	602.04	0.31	1.05	6.85	0.15	3.91	3.18
reach 4	68	4.1	597.9	598.2	598.2	0.3	2.84	13.83	0.21	1.45	1.01
reach 4	67	4.1	594.73	595.14	595.07	0.34	1.9	11.2	0.17	2.15	1.66
reach 4	66	4.1	591.31	591.72	591.7	0.39	2.32	9.84	0.24	1.77	1.16
reach 4	65	4.1	585.64	585.94	585.78	0.14	1.11	8.24	0.14	3.68	3.18
reach 5	64	4.72	579.42	579.69	579.58	0.16	1.73	14.86	0.12	2.73	2.55
reach 5	63	4.72	574.7	575.04	575.02	0.32	2.71	11.61	0.23	1.74	1.15
reach 5	62	4.72	571.13	571.45	571.39	0.26	2.44	18.94	0.13	1.93	1.72
reach 5	61	4.72	567.26	567.62	567.58	0.32	2.69	13.51	0.13	1.52	1.19

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	60.1	4.72	563.64	564.09	564.46	0.82	5.62	9.11	0.62	0.84	0.33
reach 6	60	6.57	563.64	564.17	564.17	0.53	3.26	8.42	0.39	2.01	1.01
reach 6	59	6.57	560.41	560.77	560.67	0.27	2.43	17.2	0.14	2.71	2.29
reach 6	58	6.57	556.72	557.29	557.29	0.58	4.44	21.21	0.21	1.48	1.03
reach 6	57	6.57	553.88	554.26	554.19	0.3	3.02	16.84	0.18	2.17	1.63
reach 6	56	6.57	550.47	551.21	551.19	0.72	3.33	10.56	0.31	1.97	1.11
reach 6	55	6.57	547.39	547.88	547.78	0.39	2.6	13.5	0.19	2.53	1.83
reach 7	54.75*	7.8	546.86	547.39	547.34	0.47	3.84	16.35	0.23	2.03	1.34
reach 7	54.625*	7.8	546.6	547.13	547.11	0.5	4.43	17.47	0.25	1.76	1.11
reach 7	54.5*	7.8	546.34	546.85	546.84	0.5	4.38	16.82	0.26	1.78	1.11
reach 7	54.375*	7.8	546.08	546.59	546.57	0.49	4.2	14.71	0.28	1.85	1.11
reach 8	54.25*	9.16	545.81	546.36	546.28	0.47	3.82	12.61	0.28	2.37	1.38
reach 8	54.125*	9.16	545.55	546.11	546.1	0.55	4.46	10.51	0.37	1.93	0.98
reach 8	54	9.16	545.29	545.86	545.8	0.51	3.63	8.44	0.36	2.29	1.17
reach 8	53	9.16	541.32	541.75	541.57	0.25	2.63	12.66	0.21	3.48	2.43
reach 8	52	9.16	538.25	539.07	539.07	0.82	4.5	11.09	0.41	2.04	1.01
reach 8	51	9.16	535.47	535.97	535.82	0.34	2.95	13.48	0.2	3.07	2.11
reach 9	50.5*	10.53	533.83	534.47	534.58	0.75	7.15	15.82	0.45	1.47	0.69
reach 9	50.2	10.53	533.83	534.47	534.47	0.65	5.55	15.47	0.36	1.9	1
reach 9	50.15*	10.53	533.42	534.09	534	0.58	4.08	15.61	0.26	2.58	1.6
reach 9	50.1*	10.53	533	533.72	533.67	0.67	4.95	16.26	0.3	2.13	1.22
reach 9	50.05*	10.53	532.59	533.34	533.27	0.68	4.53	16.66	0.27	2.32	1.41

Table 5.23 Mixed Flow Regime in Pabbar River for Season IV

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	5.08	657.63	658.48	658.48	0.85	2.91	10.01	0.29	1.75	1
reach 1	87	5.08	656.07	656.96	656.68	0.62	1.17	4.12	0.28	4.35	2.53
reach 1	86	5.08	654.97	655.37	655.27	0.29	2	9.02	0.22	2.55	1.72
reach 1	85	5.08	653.55	654.37	654.29	0.74	2	5.94	0.34	2.54	1.32
reach 1	84	5.08	652.21	652.7	652.55	0.34	1.46	8.99	0.16	3.47	2.7
reach 1	83	5.08	651.22	651.66	651.63	0.41	2.72	10.81	0.25	1.86	1.17
reach 2	82	5.08	650.27	650.76	650.64	0.37	1.79	9.08	0.2	2.84	2.03
reach 2	81	5.08	649.22	649.91	649.89	0.66	2.53	7.96	0.32	2.01	1.11
reach 2	80	5.08	647.64	648.14	647.93	0.29	1.2	7.02	0.17	4.23	3.24
reach 2	79	5.08	645.93	646.51	646.44	0.51	2.15	8.79	0.24	2.36	1.5
reach 2	78	5.08	643.83	644.52	644.31	0.48	1.3	5.55	0.23	3.9	2.53
reach 2	77	5.08	641.33	641.95	641.87	0.54	2.09	7.03	0.3	2.43	1.4
reach 2	76	5.08	638.13	639.07	638.82	0.69	1.25	3.94	0.32	4.06	2.21
reach 2	75	5.08	636.42	636.9	636.84	0.42	2.26	8.15	0.28	2.25	1.35
reach 2	74	5.08	630.63	631.25	631.07	0.44	1.4	6.62	0.21	3.62	2.48
reach 2	73	5.08	623.32	623.72	623.62	0.3	2.01	9.45	0.21	2.53	1.73
reach 2	72	5.08	618.16	618.6	618.87	0.7	5.13	9.95	0.52	0.99	0.43
reach 3	71.5	5.08	618.16	618.6	618.6	0.44	2.77	8.53	0.33	1.83	1.01
reach 3	71	5.08	613.32	613.93	613.67	0.36	0.75	5.77	0.13	6.82	5.89
reach 3	70.5	5.08	606.55	607.13	607.47	0.91	5.87	11.01	0.53	0.87	0.36
reach 4	70	5.08	606.55	607.13	607.13	0.58	2.8	9.12	0.31	1.82	1.01
reach 4	69	5.08	601.74	602.27	602.06	0.33	1.19	6.94	0.17	4.28	3.28
reach 4	68	5.08	597.9	598.23	598.23	0.33	3.26	13.91	0.23	1.56	1.02
reach 4	67	5.08	594.73	595.18	595.1	0.37	2.21	12.07	0.18	2.3	1.7
reach 4	66	5.08	591.31	591.76	591.73	0.42	2.67	10.03	0.27	1.9	1.17
reach 4	65	5.08	585.64	585.99	585.8	0.16	1.27	8.33	0.15	3.99	3.24
reach 5	64	5.08	579.42	579.7	579.59	0.16	1.82	15.09	0.12	2.79	2.56
reach 5	63	5.08	574.7	575.06	575.03	0.33	2.84	11.66	0.24	1.79	1.15

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	62	5.08	571.13	571.46	571.4	0.27	2.58	19.45	0.13	1.97	1.73
reach 5	61	5.08	567.26	567.62	567.59	0.32	2.8	13.51	0.14	1.54	1.19
reach 5	60.1	5.08	563.64	564.11	564.37	0.73	4.86	8.89	0.55	1.05	0.44
reach 6	60	5.08	563.64	564.11	564.11	0.47	2.74	8.26	0.33	1.85	1.01
reach 6	59	5.08	560.41	560.74	560.65	0.25	2.13	17.09	0.12	2.38	2.15
reach 6	58	5.08	556.72	557.26	557.26	0.54	3.73	20.04	0.19	1.36	1
reach 6	57	5.08	553.88	554.22	554.16	0.28	2.56	16.72	0.15	1.98	1.61
reach 6	56	5.08	550.47	551.15	551.11	0.64	2.6	8.33	0.31	1.96	1.1
reach 6	55	5.08	547.39	547.83	547.74	0.35	2.14	12.24	0.17	2.38	1.81
reach 7	54.75*	5.08	546.86	547.31	547.26	0.4	2.72	13.76	0.2	1.87	1.34
reach 7	54.625*	5.08	546.6	547.04	547.04	0.44	3.39	15.41	0.22	1.5	1.02
reach 7	54.5*	5.08	546.34	546.78	546.76	0.42	3.09	14.65	0.21	1.64	1.14
reach 7	54.375*	5.08	546.08	546.51	546.5	0.43	3.28	14.67	0.22	1.55	1.04
reach 8	54.25*	5.08	545.81	546.23	546.16	0.34	2.22	12	0.19	2.29	1.7
reach 8	54.125*	5.08	545.55	545.97	545.97	0.42	3.04	10.51	0.27	1.64	0.98
reach 8	54	5.08	545.29	545.71	545.67	0.38	2.51	8.44	0.26	1.95	1.16
reach 8	53	5.08	541.32	541.62	541.51	0.18	1.88	11.69	0.16	2.71	2.16
reach 8	52	5.08	538.25	538.9	538.9	0.65	2.8	8.75	0.32	1.81	1.02
reach 8	51	5.08	535.47	535.85	535.75	0.28	2.09	12.6	0.17	2.43	1.89
reach 9	50.5*	5.08	533.83	534.32	534.41	0.59	4.67	15.28	0.31	1.09	0.62
reach 9	50.2	5.08	533.83	534.32	534.32	0.5	3.33	14.97	0.22	1.53	1.03
reach 9	50.15*	5.08	533.42	533.95	533.9	0.48	2.58	14.52	0.18	1.97	1.48
reach 9	50.1*	5.08	533	533.57	533.57	0.56	3.23	15.92	0.2	1.57	1.1
reach 9	50.05*	5.08	532.59	533.21	533.15	0.56	2.59	12.12	0.21	1.96	1.34

Table 5.24 Mixed Flow Regime in Pabbar River for Season IV + Nallahs

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 1	88.5	Dam									
reach 1	88	5.08	657.63	658.48	658.48	0.85	2.87	9.95	0.29	1.77	1.02
reach 1	87	5.08	656.07	656.96	656.68	0.62	1.17	4.12	0.28	4.35	2.53
reach 1	86	5.08	654.97	655.37	655.27	0.29	2	9.02	0.22	2.55	1.72
reach 1	85	5.08	653.55	654.37	654.29	0.74	2	5.94	0.34	2.54	1.32
reach 1	84	5.08	652.21	652.7	652.55	0.34	1.46	8.99	0.16	3.47	2.7
reach 1	83	5.08	651.22	651.66	651.63	0.41	2.72	10.81	0.25	1.87	1.18
reach 2	82	5.33	650.27	650.77	650.65	0.38	1.89	9.16	0.21	2.83	1.98
reach 2	81	5.33	649.22	649.93	649.9	0.67	2.6	8.08	0.32	2.05	1.13
reach 2	80	5.33	647.64	648.15	647.94	0.30	1.26	7.09	0.18	4.23	3.19
reach 2	79	5.33	645.93	646.52	646.44	0.51	2.2	8.81	0.25	2.42	1.52
reach 2	78	5.33	643.83	644.54	644.32	0.49	1.36	5.67	0.24	3.92	2.52
reach 2	77	5.33	641.33	641.96	641.88	0.55	2.16	7.15	0.3	2.47	1.41
reach 2	76	5.33	638.13	639.09	638.83	0.70	1.31	4.03	0.32	4.08	2.2
reach 2	75	5.33	636.42	636.91	636.85	0.42	2.31	8.17	0.28	2.3	1.36
reach 2	74	5.33	630.63	631.26	631.08	0.45	1.47	6.77	0.22	3.63	2.45
reach 2	73	5.33	623.32	623.73	623.62	0.31	2.06	9.52	0.22	2.59	1.75
reach 2	72	5.33	618.16	618.61	618.93	0.76	5.72	10.28	0.56	0.93	0.39
reach 3	71.5	6.12	618.16	618.65	618.65	0.48	3.17	8.79	0.36	1.93	1
reach 3	71	6.12	613.32	613.97	613.7	0.38	0.88	6.61	0.13	6.98	5.96
reach 3	70.5	6.12	606.55	607.18	607.58	1.02	7.02	11.65	0.6	0.87	0.34
reach 4	70	7.03	606.55	607.22	607.22	0.67	3.52	9.6	0.37	2	1.01
reach 4	69	7.03	601.74	602.36	602.1	0.37	1.46	7.12	0.21	4.8	3.36
reach 4	68	7.03	597.9	598.29	598.28	0.38	3.92	14.04	0.28	1.79	1.07
reach 4	67	7.03	594.73	595.25	595.15	0.42	2.9	13.81	0.21	2.43	1.68
reach 4	66	7.03	591.31	591.84	591.79	0.48	3.25	10.33	0.31	2.16	1.22
reach 4	65	7.03	585.64	586.07	585.85	0.20	1.64	8.52	0.19	4.3	3.11
reach 5	64	8.1	579.42	579.77	579.63	0.20	2.4	16.5	0.15	3.38	2.83
reach 5	63	8.1	574.7	575.16	575.12	0.42	3.86	12.09	0.32	2.1	1.18

Reach	River Sta	Total Q	Min Ch El	Crit W.S.	W.S. Elev	W. Depth	Area	W.P.	H. Radius	Vel.	Fr. NO.
		(m3/s)	(m)	(m)	(m)	(m)	(m2)	(m)	(m)	(m/s)	
reach 5	62	8.1	571.13	571.53	571.44	0.31	3.53	22.77	0.16	2.29	1.86
reach 5	61	8.1	567.26	567.69	567.64	0.38	3.57	13.51	0.18	1.7	1.21
reach 5	60.1	8.1	563.64	564.23	564.71	1.07	7.78	9.72	0.8	1.04	0.35
reach 6	60	11.29	563.64	564.35	564.35	0.71	4.73	8.85	0.53	2.39	1.01
reach 6	59	11.29	560.41	560.88	560.72	0.31	3.21	17.52	0.18	3.52	2.61
reach 6	58	11.29	556.72	557.39	557.39	0.68	6.72	24.58	0.27	1.68	1.02
reach 6	57	11.29	553.88	554.37	554.25	0.37	4.1	17.11	0.24	2.76	1.79
reach 6	56	11.29	550.47	551.37	551.33	0.86	4.81	11.2	0.43	2.35	1.12
reach 6	55	11.29	547.39	548	547.86	0.46	3.72	16.14	0.23	3.04	2.01
reach 7	54.75*	13.41	546.86	547.51	547.44	0.58	5.74	19.91	0.29	2.34	1.39
reach 7	54.625*	13.41	546.6	547.24	547.24	0.64	7	18.93	0.35	1.9	1
reach 7	54.5*	13.41	546.34	546.98	546.93	0.59	5.85	16.82	0.33	2.27	1.24
reach 7	54.375*	13.41	546.08	546.72	546.69	0.62	6.06	14.71	0.38	2.15	1.09
reach 8	54.25*	15.75	545.81	546.52	546.43	0.62	5.72	12.61	0.4	2.61	1.28
reach 8	54.125*	15.75	545.55	546.28	546.23	0.68	5.85	10.51	0.46	2.4	1.09
reach 8	54	15.75	545.29	546.06	545.98	0.7	5.16	8.44	0.47	2.54	1.13
reach 8	53	15.75	541.32	541.9	541.64	0.31	3.49	13.69	0.26	4.51	2.84
reach 8	52	15.75	538.25	539.28	539.28	1.03	8.63	26.73	0.32	1.82	1.02
reach 8	51	15.75	535.47	536.11	535.92	0.44	4.27	13.48	0.24	3.38	2.02
reach 9	50.5*	18.11	533.83	534.63	534.52	0.70	6.35	15.64	0.41	2.85	1.41
reach 9	50.2	18.11	533.83	534.63	534.63	0.80	7.98	16	0.5	2.27	1.01
reach 9	50.15*	18.11	533.42	534.25	534.11	0.70	5.9	15.98	0.37	3.07	1.59
reach 9	50.1*	18.11	533	533.87	533.78	0.78	6.66	16.58	0.4	2.72	1.35
reach 9	50.05*	18.11	532.59	533.5	533.39	0.80	6.46	17.01	0.38	2.81	1.44

5.10 WATER QUALITY IN DHAMWARI SUNDA HEP

Surface water quality was monitored during winter, pre-monsoon, and during monsoon seasons of the year 2009. The sampling locations are shown in Figure 5.6 and are listed in Table 5.25. The collection of samples and corresponding analysis were done by external source (International Testing Centre Panchkula, 2009) hence, the data presented in this section is a secondary data. Some of the important water quality parameters which are measured and reported in Annexure G are pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Heavy metals, Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), and Total Coliforms.

Figure 5.6 Surface water sampling locations in the study area.

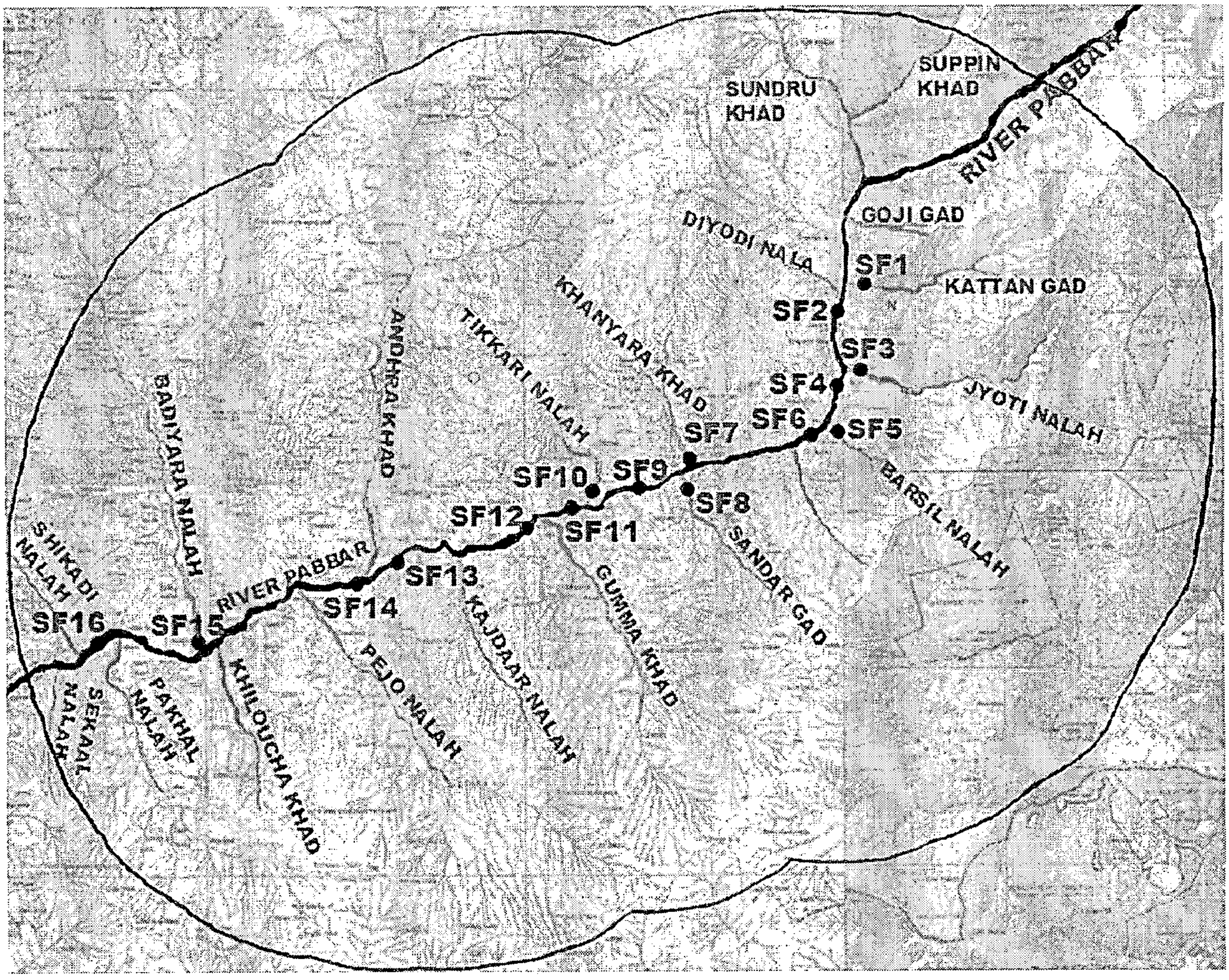


Table 5.25 Surface Water Sampling Locations.

Code	Location
SF1	50 mt upstream of Katan Khad
SF2	50 mt downstream of Confluence of Diudi Nala & River Pabbar from River Pabbar.
SF3	50 mt upstream of Jyoti Khad
SF4	75 mt downstream of confluence of Jyoti Khad & River Pabbar from River Pabbar
SF5	50 mt upstream from Barsheel Khad
SF6	From River Pabbar at Romai Diversion Weir Site
SF7	From Khanyara Khad at Village Dhamwari
SF8	75 mt upstream of Sandhar Khad
SF9	150 mt downstream after Village Dhamwari
SF10	50 mt upstream of Tikkari Khad
SF 11	From Pabbar at Village Tikkari
SF 12	50 mt downstream of Gumma HEP
SF13	150 mt upstream of Confluence of Andhra Khad and River Pabbar from river Pabbar
SF14	50 mt downstream of Confluence of Andhra Khad and River Pabbar from river Pabbar at Village Chirgaon
SF15	50 mt upstream of Badiyara Nala
SF16	From Pabbar at Village Sima

The results of analysis of collected surface waters (Annexure G) show that pH values are varying from 6.92 to 8.0. Low Calcium and Magnesium contents indicate water to be soft and suitable for drinking, construction & other purposes. However, necessary bacteriological treatment would be required to make the water safe for drinking. Total hardness (<90 mg/l) is much below the permissible limit of 200 mg/l). TDS values ranged from 87 to 170 mg/l which is again well below the permissible limit as specified in drinking water standards. BOD and COD values are very low indicating absence of organic pollution load in the area. Dissolved Oxygen values indicate that water is suitable to sustain aquatic life.

The above results are attributable mainly to low population density and absence of industries generating effluents with high pollutants in the area. Thus, physio-chemical parameters of the surface water are within the desirable limits of Drinking Water Standards (IS: 10500:1991) and tolerance limits for inland surface water quality indicates the surface water is as per CPCB under *Category A : Drinking Water Source without conventional treatment but after disinfections.* Higher conductance of the samples collected during monsoon season indicates more dissolution of cations / anions from the rocks, mountains and water run-off, around the river. The monsoon samples were a little muddy as compared to those in pre-monsoon or winter collection.

5.11 FISHERIES SAMPLING IN DHAMWARI SUNDA HEP

All fishes in Pabbar river and its tributaries are Potamodromous migratory fishes. The size of fishes is commonly given by length (cm) or by weight (kg). For the same species, the size of fish may vary between site to site or year to year, responding to specific conditions like scarcity or abundant of nutrients, water quality conditions or habitat conditions such as water depth or water velocity, instream cover and substrate size. Table 5.26 summarizes the location and population of fishes in the project area.

Table 5.26 Type of fishes and their population in Pabbar River. Source: Directorate of Fisheries. Himachal Pradesh, 2009.

Remarks	**Type of fish**	**Location**
Type of fish, their population and locations along the river Pabbar upto Rohru	Masher (*Tor-Putitora*)	Near the confluence of river Pabbar with that of river Tons.
	Schizothorax sps.	Hatkoti, Patsari, Rohru & downstream Hatkoti.
	Trout (Brown & Rainbow)	
	Salmo trutta fario	Downstream Rohru: Hatkoti, Patsari, Rohru.
	Salmo gairdneri gairdneri	Upstream Rohru: Chirgaon, Seema, Sandhasu, Gumma, Dhamwari.
	Glyptothorax	Upstream Dhamwari near village Janglie.
Population	Fish caught by fisherman in Pabbar river during the year:	
	i) 2008-09 = 88.428 MT	
	ii) 2009-10 = 23.894 MT (upto 8/2009)	

5.12 DISCUSSION OF RESULTS AND CONCLUSIONS

- From dependability analysis, the 90% dependable year corresponds to 1999-00, using extended data ten daily flow series of 33 years from 1975-1976 upto 2007-2008, it is considered as representative for further analysis.

- The Average Annual Flow (AAF) on the basis of all years flow (1975-76 to 2007-08), dependable year and corresponding 90 % dependable flow for 90 % dependable year for various sites and AAF for 5% dependable year are shown in table 5.26.

Table 5.26 AAF for the whole series, 90% dependable flow ($Q_{90\%}$) for 90% dependable year, and AAF for 90% and 5% dependable years.

Proposed Site	Av. Annual Flow (1975-76 to 2007-08)	90 % Dependable year	90 % Dependable Flow ($Q_{90\%}$) (1999-00)	Av. Annual Flow for 90% dependable year (1999-00)	Av. Annual Flow for 5% dependable year (1975-76)
Romari	12.89	1999-00	4.71	9.87	17.82
Barshil Nallah	0.64	1999-00	0.23	0.49	0.88
Khanyara Khad	1.38	1999-00	0.5	1.06	1.91
Nalla 1	0.3	1999-00	0.11	0.23	0.42
Bandi Nallah	0.4	1999-00	0.15	0.3	0.55
Shahi Nallah	0.18	1999-00	0.07	0.14	0.25
Gumma Nallah	2.3	1999-00	0.84	1.76	3.18
Sonalpani Nallah	0.18	1999-00	0.07	0.14	0.25
Khasdhar Nallah	0.55	1999-00	0.2	0.42	0.77
Nalla 2	0.06	1999-00	0.02	0.05	0.08

- The environmental flow for Dhamwari Sunda HEP has been estimated using the hydrologic Index methods. The various methods tried in hydrologic methods are: Tenant method, Hughes & Münster method, Index method, and Seasonal Method. The results are summarized as follows:

Table 5.27 Summary of Environmental Water Requirements using different techniques.

SITE	Tennant Method		H & M (cumec)	Index (cumec)
	Oct.-Mar. (cumec)	April-Sept. (cumec)		
Romari	0.987	2.961	4.71	6.65

Seasonal Methodology identifies four (4) main seasons along the year. For each season is proposed releases a different percentage of Annual Average Flow (AAF) for whole ten-daily flow records (1975-76 to 2007-08) and for the 90% dependable year (1999-00). A summary of proposed minimum flows for Romari dam site is given in next table:

Table 5.28 Summary of Environmental Water Requirements using Seasonal Method.

Using Flow Series (1975-76 to 2007-08)	
Season	**Proposed Min. Flow**
I	9.33 (say 9)
II	2.32 (say 2.5)
III	0.97 (say 1)
IV	3.08 (say 3)
Using 90% Dependable Year 1999-00	
Season	**Proposed Min. Flow**
I	6.53 (say 6.5)
II	1.97 (say 2)
III	0.99 (say 1)
IV	2.49 (say 2.5)

- HEC-RAS Simulations

River analysis was done with the help of software HEC-RAS version 4.0. It shows three cross-sections which are the most critical ones from water depth point of view. A detail of these cross-sections are given in next table and figures:

Table 5.29 Critical Cross-Sections in river stretch at Pabbar River.

Reach	River station	Min. Channel Elevation (m)
4	65	1921.40
5	64	1901.00
8	53	1776.00

Figure 5.7 Cross-Section No. 65 at Reach 4.

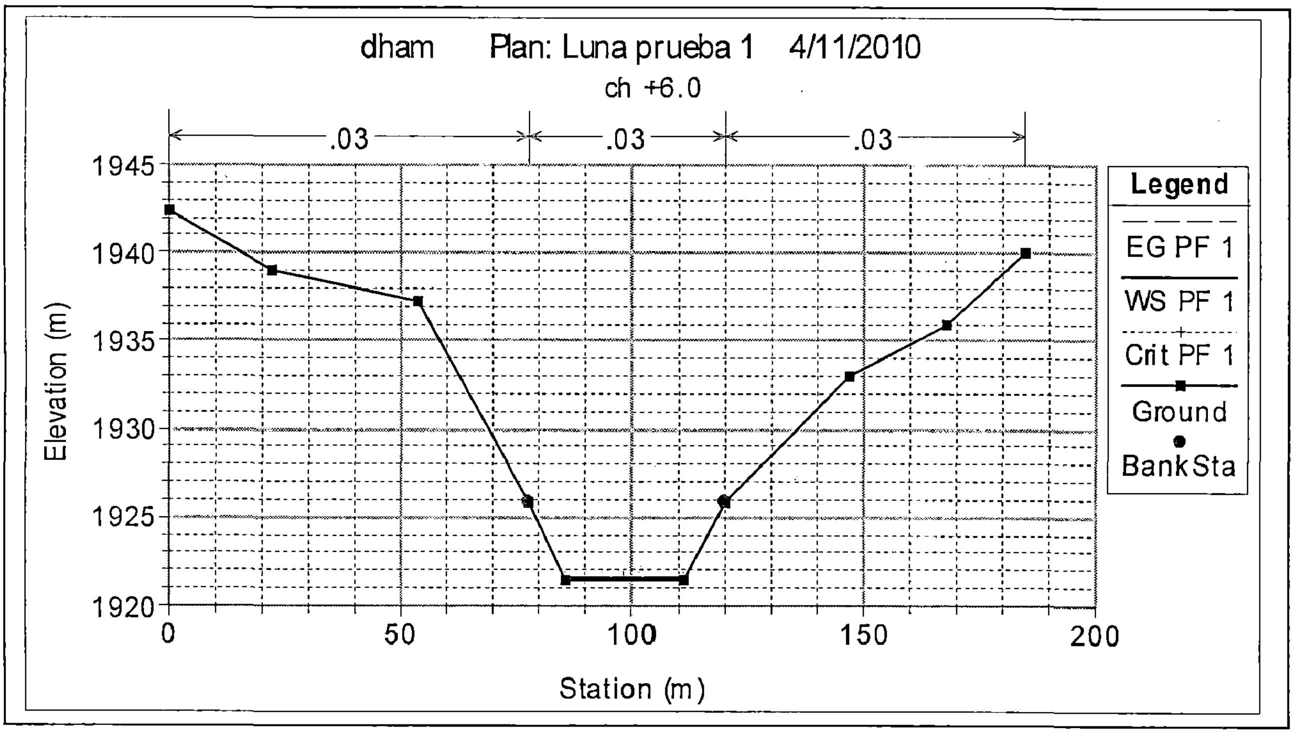


Figure 5.8 Cross-Section No. 64 at Reach 5.

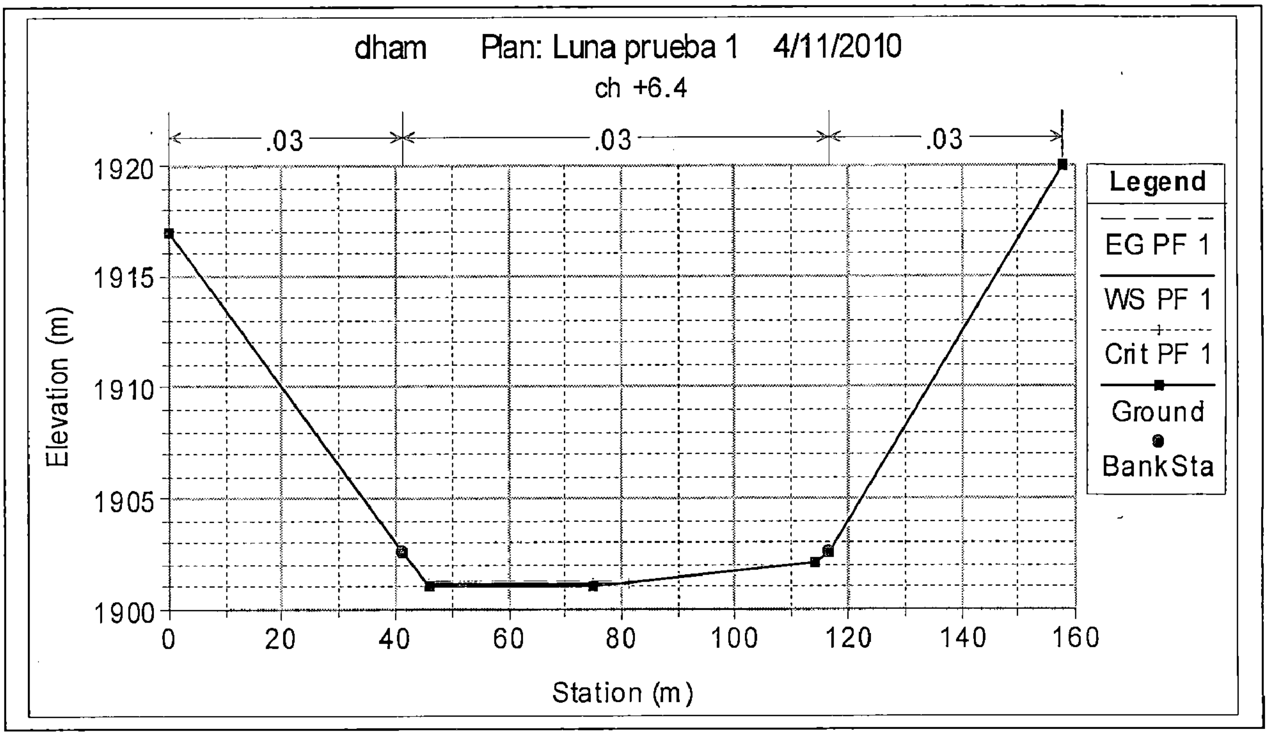
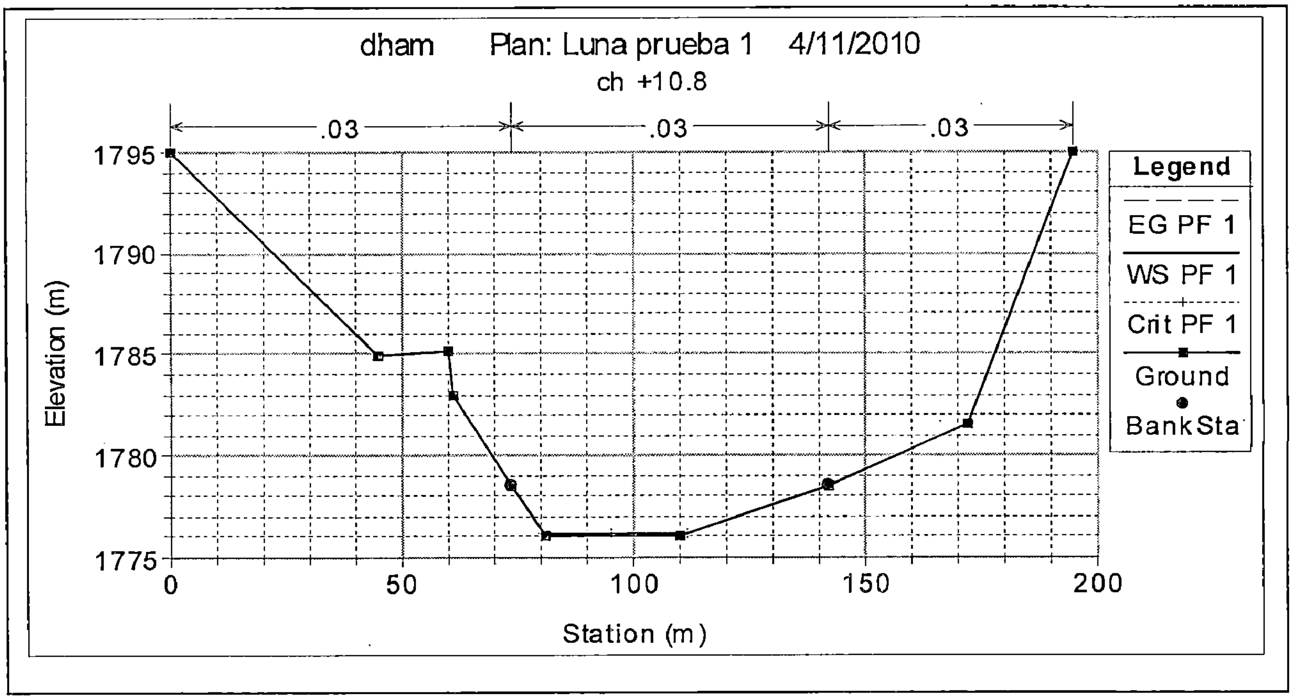


Figure 5.9 Cross-Section No. 53 at Reach 8.



The most critical condition from fisheries survival is when the flow contribution from Nallahs is not taken into account; therefore, conclusion will be based on flow releases from reservoir only. The HEC-RAS simulations were done for two cases.

The first case is for different scenarios, using the proposed minimum flow of 1 cumec suggested by Himachal Pradesh Government and using the 90% dependable flow of 90% dependable year, which corresponds to 4.71 cumecs. The results of these computations are summarized in table 5.30.

Table 5.30 Water Depth and Velocity at critical Cross-Sections for different scenarios.

SCENARIO	REACH	RIVER STA	TOTAL Q (cumecs)	W. DEPTH (m)	VEL (m/s)	Fr. No.
1	4	65	1.00	0.01	4.26	14.06
	5	64	1.00	0.08	1.09	1.79
	8	53	1.00	0.05	0.69	1.00
3	4	65	4.71	0.08	2.30	2.58
	5	64	4.71	0.14	1.53	1.64
	8	53	4.71	0.11	1.46	1.43

The water depth at these critical cross-sections is very low, less than 15 cm for discharge of 1 cumec and 4.71 cumec. The minimum water depth is taken as 50 cm for Himalayan fish species; therefore, the proposed minimum flows given by Himachal Pradesh Government of 1 cumec is not enough for maintaining migratory fish species in the river, since in critical cross-section, the access to migration routes will be interrupted by a very low water depth.

The second case is for different seasons along the year, in which is identified the 90% dependable flow of 90% dependable year for each season. Table 5.31 highlights the main hydraulic features for these three critical cross-sections with different flows corresponding to different seasons.

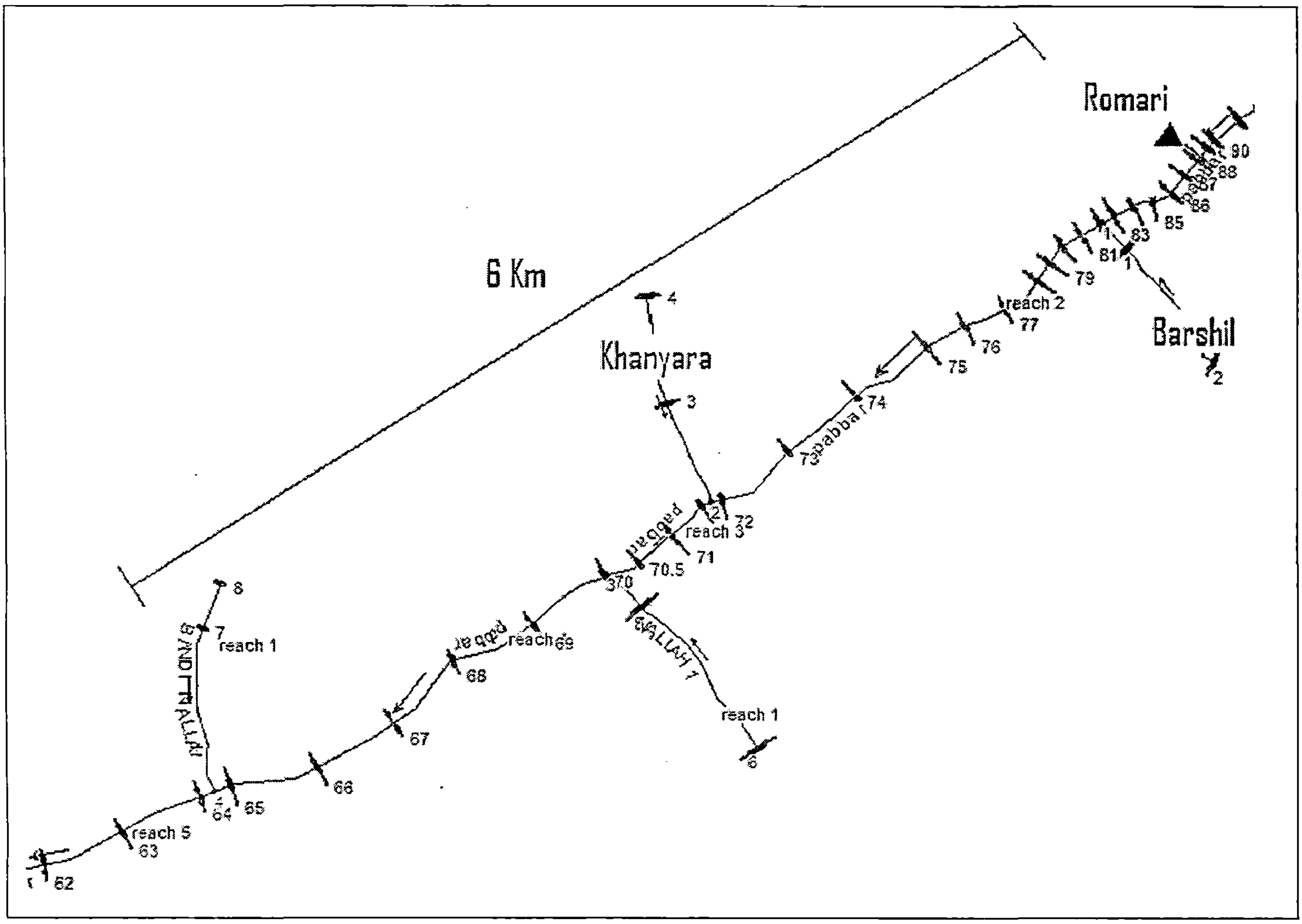
Table 5.31 Water Depth and Velocity at critical Cross-Sections for different seasons.

SEASONS	REACH	RIVER STA	TOTAL Q (cumecs)	W. DEPTH (m)	VEL (m/s)	Fr. No.
I	4	65	9.05	0.25	4.55	3.02
	5	64	9.05	0.21	3.65	3.02
	8	53	9.05	0.24	3.56	2.52
II	4	65	4.43	0.15	3.81	3.23
	5	64	4.43	0.15	2.65	2.51
	8	53	4.43	0.17	2.55	2.09
III	4	65	2.96	0.12	3.16	2.96
	5	64	2.96	0.12	2.38	2.50
	8	53	2.96	0.14	2.21	2.02
IV	4	65	5.08	0.16	3.99	3.24
	5	64	5.08	0.16	2.79	2.56
	8	53	5.08	0.18	2.71	2.16

In this case, the water depth in all seasons is less than proposed minimum water depth of 50 cm for Himalayan fishes, therefore discharges for each season are not acceptable from water depth point of view. Another problem in these critical sections is related with water velocity. The maximum average flow velocity that a fishes can swim continuously for a short distance of 10 meters; ranges between 2-2.5 m/s (see figure 3.7 Chapter 3). The maximum water velocity permissible for Himalayan fishes is assumed as 2.5 m/s hence, higher water velocity will be constrained for most of migratory fish species.

From water depth and water velocity point of view, along the river stretch of 11.5 km exists different sections where the survival of fishes is not guaranteed. Due to low water depth (less than 50 cm) or high water velocity (more than 2.5 m/s) the migratory routes of fishes will be locked or not suitable for fish migration. Accordingly with HEC-RAS simulations, the unsuitable values of water depth and water velocity from fish's survival point of view are in the first portion of the river stretch (around 6 Km), this portion is from Romari dam site to the confluence of Bandi Nallah and Pabbar River at Reach No.5 and River Station No. 64. Figure 5.10 shows a scheme of this portion of the river, where the fishes are not allow surviving.

Figure 5.10 Unsuitable Section of River Stretch for Fishes Survival.



CHAPTER VI

CONCLUSIONS

Environmental Flow (EF) is the water that is left in a river ecosystem, or released into it, for the specific purpose of managing the ecosystem. EF refers to quality, quantity and timing of water flows required to maintain the components, functions, processes and resilience of aquatic ecosystem that provides goods and services to people.

EF is concerned with the equitable sharing and sustainable use of water resources and these concepts should be extended beyond rivers to groundwater, lakes, estuaries and even coastal areas. In the specific case of hydropower development, the aim of EF is to enhance the management of river flows to ensure the sustainability of river ecosystem and provide a reliable tool for water allocation decisions between hydropower production and ecology needs.

Environmental Flow Assessment (EFA) must be done within preliminary studies of hydropower projects. The availability of water for hydropower production defines the size and capacity of hydropower plants. In the case of run-of-river plants, the Environmental Water Requirements (EWR) defines how much water can be diverted from river; hence, EWR influences the design and dimension of different structures like power channels, penstock and number and sizes of turbines. Similarly, in the case of storage hydropower plants, the EWR influences reservoir operations and total power production.

A common practice in reservoir operations is releasing a minimum fixed amount of water throughout the year, commonly 10% or 15% of 90% dependable flow. This amount of water may or may not sufficient for maintaining aquatic life downstream of dam. EFA techniques are beyond of this old practice and studies have demonstrated that keeping modified flow regime in the river, rather than a fixed amount of water is more beneficial for downstream ecosystem (Waddle, 1992).

EFA is an essential part of integrated water resources management. EFA must be incorporated in water resources policy, basin and catchment plans, new infrastructure projects and the rehabilitation and reoperation of existing infrastructure. India must clarify their environmental water policy and adopt EFA technique for assess EF in a river basins where there are competing water use and where flows are regulated.

Different EFA techniques were applied in two cases of study located in India. The first case study is located in Lohit river basin in Arunachal Pradesh. The river basin development is under cascade scheme with six proposed storage dams and power houses at toe of the dam. The second case study is located in Pabbar River basin in Himachal Pradesh. The project is run-off the river scheme which creates a dry river stretch of 11.55 km between diversion point and power house.

Under category of Hydrological Index methods, four techniques were applied: (1) Tennant method, (2) Hughes & Münster Method, (3) Index method and (4) Seasonal Method. These techniques are based in historical flow records only, using Annual Average Flows (AAF) and 90% dependable flow in their computations. They provide a relatively rapid, non-resource intensive, but low resolution estimate of Environmental Flows (EF). Hydrological Index methods are suitable only as preliminary estimation of EF or in low controversy situations where a simple discharge value can be used at the planning level of water resources development.

For case study I, tables 4.26 and 4.27 summarize EWR using different techniques at each proposed dam site in Lohit Basin.

Copy Table 4.26 Summary of Environmental Water Requirements using different techniques.

SITE	Tennant Method		H & M (cumec)	Index (cumec)
	Oct.-Mar. (cumec)	April-Sept. (cumec)		
Kalai I	56	167	258	381
Kalai II	60	179	278	408
Hutong I	60	181	279	411
Hutong II	62	185	287	423
Demwe Upper	69	207	320	471
Demwe Lower	72	217	336	495

Copy Table 4.27 Proposed Minimum Flow on the basis of average flow during 20 years data (1984-85 to 2003-04).

Season	Month	K-I	K-II	H-I	H-II	D.U.	D.L.
		Proposed Minimum Flow (cumecs)					
I	May	376	404	407	418	446	469
	June	504	541	545	559	602	633
	July	565	607	612	628	641	675
	August	478	514	518	531	542	571
	September	397	426	429	441	454	477
II	October	187	201	202	208	210	221
III	November	50	54	54	55	66	70
	December	37	39	40	41	49	52
	January	34	36	37	38	38	40
	February	35	37	38	39	40	42
	March	43	46	47	48	59	63
IV	April	134	144	145	149	188	198

For case study II, tables 5.27 and 5.28 summarize EWR using different techniques at Romari dam site in Pabbar River basin.

Copy Table 5.27 Summary of Environmental Water Requirements using different techniques.

SITE	Tennant Method		H & M (cumec)	Index (cumec)
	Oct.-Mar. (cumec)	April-Sept. (cumec)		
Romari	0.987	2.961	4.71	6.65

Copy Table 5.28 Summary of Environmental Water Requirements using Seasonal Method.

Using Flow Series (1975-76 to 2007-08)	
Season	Proposed Min. Flow
I (Jun-Sep)	9.33 (say 9)
II (Oct-Nov)	2.32 (say 2.5)
III (Dec-Feb)	0.97 (say 1)
IV (Mar-May)	3.08 (say 3)

Among all those techniques, Tennant Method and Seasonal method is recommended. These two techniques are based on the identification of different natural flows regimes; their magnitudes, timing and duration. These flows are incorporated in a modified flow hydrograph which must satisfy the water requirements of the river. The modified hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present through out the year and it recognizes the importance of high flows as well as low flows in the river processes.

The values of EF obtained by using 90% dependable flow of 90% dependable year must be taken as limiting values, since these flows are the minimum flows in the river during stress period along historical flow records and they represent extreme values. The final values of EF must be derived using 90% dependable flow of the whole hydrology data series which take in account wet years as well as dry years.

Hydraulic model uses energy equation and steady flow condition to compute water profiles at different cross-sections in the river. Input data required are: area and wetted perimeter for different cross-sections of the river, average river slope and roughness coefficient. The main hydraulic parameters related with fish habitat health are water depth and water velocity. For these two parameters; limiting values were established as minimum water depth of 50 cm and maximum water velocity of 2.5 m/s accordingly with literature review of Himalayan fish species.

For different discharges obtained from Hydrological Index methods, water depth and water velocity was computed at different cross-sections and then compared with suitable habitat parameter for different fish species available in Himalayan Rivers to identify which discharge fulfills water fish requirements. In this way is possible to make a link among hydrology, hydraulic and biology of the river, in this case focused in a target fish species.

Both cases of study are located in hilly areas, where narrow cross-section, steep slopes and fast flows are expected. In case study I the average river bed slope is 0.006 m/m and the computations of water depth and water velocity were done using Manning's equations in which flow regime is expected as subcritical flow. Since all values of Froude Number obtained were less than 1, Manning's equation is valid and it gives the normal depth of flow for different discharges and different roughness coefficients. In case of study II, the average river bed slope is 0.038 m/m and the expected flow is mixed flow, in which is possible to find cross-sections within subcritical or supercritical flow. In this case, HEC-RAS software version 4.0 is suitable to make the computations.

In case of study I, the environmental flows and proposed minimum flows are under subcritical flow regime; with water depth and water velocities suitable for maintain aquatic life in the river. In case of study II, the environmental flows and proposed minimum flows are under supercritical flow, with low water depth (less than 50 cm) and high water velocity (more than 2.5 m/s) especially in the first portion of the river "stretch" covering a distance of 6 km between Romari dam site and Bandi Nallah; where these conditions are unsuitable for fish's survival. This theoretical result is validated in the field; with absence of most of the common Himalayan fish species near of the proposed dam site, where only the presence of *Glyptothorax* fish specie is reported under pristine conditions.

In both cases of study, the water quality sampling shows the water flowing in the river is suitable for human and wildlife consumption and it is under Category A according with Central Pollution Control Board (CPCB) of India.

SCOPE FOR FURTHER WORK:

A further step in Environmental Flow Assessment Techniques is towards use software PHABSIM/IFIM which incorporates in hydraulic modeling additional variables like substrate material and instream cover as well as suitable microhabitat criteria at different stage life of fish species. The most complete panorama is given by Holistic Approach technique, which takes in consideration hydrology, hydraulic and biology parameters of the river, as well as economic and social parameters of the people which are directly influenced by a river flow regulations.

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Table 1A. Average Ten Daily Flow Extended Series at Kalai I (1984-85 upto 2003-04).

			Average Ten Daily Flows Series at Kalai I H.E Project site as Derived from Hayuliang (20 years) in cumecs																							
			Catchment Area of Kalai I site = 16610 Km2																							
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
Tot Days	Month	Ten Daily	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	A.V. (cumec)	Max	Min	SD
30	June	I	1351	2406	491	1406	1733	1566	1964	2369	1046	1515	1296	1896	1896	1951	1605	1260	2624	1956	763	866	1598	2624	491	560
		II	1466	1723	570	1304	1743	1901	1627	2606	1229	1440	1386	1960	1958	2077	1653	1230	2608	1961	855	1275	1629	2608	570	509
		III	1492	1788	843	1553	1529	1723	1655	2082	1763	1454	1368	2311	2997	1995	2004	2012	3443	1920	841	1403	1809	3443	841	614
31	July	I	1624	2081	595	1646	2645	2763	2106	2082	1486	2498	1224	1750	2628	3005	2798	1832	2288	1627	1156	1731	1978	3005	595	629
		II	1752	1966	609	1364	1577	1910	2603	2149	1319	2522	1357	1574	3603	3212	2374	2181	2167	1694	1182	1032	1907	3603	609	728
		III	1630	1908	525	1817	2012	1809	2165	1650	1349	1879	1674	1349	2756	2832	2192	2061	2197	1935	873	742	1768	2832	525	591
31	August	I	1039	1608	479	1794	1249	1591	1568	1628	1221	1683	1555	1328	2665	3062	2092	1915	2712	1707	921	602	1621	3062	479	660
		II	1039	1388	433	1956	1400	1571	1544	1602	1077	1622	1431	1293	2572	3087	2306	2390	2241	1094	918	556	1576	3087	433	680
		III	1033	1351	442	1781	3280	1379	1654	1419	1041	1497	1365	1175	2287	2641	2303	2621	2065	1170	662	586	1588	3280	442	748
30	September	I	957	627	423	1643	1925	1522	1466	1255	776	1222	1316	1354	2161	2727	3395	2635	1999	1035	494	588	1476	3395	423	803
		II	1381	454	625	1372	1209	1344	1351	1168	693	1102	1301	1165	1838	2820	1791	2414	1986	714	456	563	1287	2820	454	640
		III	933	696	249	1818	1457	1245	1140	1092	589	1127	1165	1125	1739	3031	1439	1647	1474	636	995	486	1204	3031	249	604
31	October	I	659	647	331	1120	2106	1381	1321	911	429	1113	1058	2105	1907	1441	1044	1269	824	811	756	449	1084	2106	331	519
		II	575	522	330	892	2013	1145	907	951	530	886	1016	1846	1566	946	1158	1534	586	590	445	425	943	2013	330	483
		III	407	507	259	744	1399	784	626	847	457	724	851	1449	1404	664	1554	1135	499	446	410	398	778	1554	259	401
30	November	I	446	480	302	641	976	611	495	390	286	622	783	910	948	487	592	632	405	403	387	355	558	976	286	210
		II	367	420	300	460	810	528	432	341	251	622	750	794	821	462	473	489	391	383	363	337	490	821	251	176
		III	276	385	269	401	728	412	386	310	234	532	730	762	706	449	527	455	375	359	338	322	448	762	234	165
31	December	I	259	364	235	348	676	340	348	684	217	496	161	205	567	418	463	508	347	342	325	309	381	684	161	147
		II	255	337	225	321	574	305	256	518	199	470	156	196	513	438	403	468	333	328	314	295	345	574	156	119
		III	246	322	267	281	502	283	250	412	183	449	513	780	498	406	376	413	326	310	301	283	370	780	183	135
31	January	I	236	294	315	478	478	263	302	354	177	533	342	400	472	382	347	386	320	297	289	275	347	533	177	91
		II	232	270	305	459	459	248	298	298	187	544	350	411	439	438	338	381	309	299	271	275	341	544	187	92
		III	231	258	283	439	439	271	304	274	170	537	303	352	420	362	326	384	308	305	282	276	326	537	170	85
28/29	February	I	203	271	275	414	414	282	298	271	407	542	385	386	417	378	335	397	328	309	301	254	343	542	203	79
		II	193	264	268	405	405	282	304	272	397	522	393	394	445	387	333	392	324	316	303	250	343	522	193	79
		III	202	266	287	421	421	261	328	271	402	533	493	451	439	387	333	380	331	315	304	258	354	533	202	88
31	March	I	339	244	294	421	421	268	381	295	430	566	487	380	475	441	361	425	335	327	297	285	374	566	244	84
		II	588	372	335	418	418	263	409	323	496	669	554	428	584	465	407	447	333	317	331	254	421	669	254	113
		III	549	342	406	524	517	403	461	328	664	1001	601	462	564	590	405	504	504	351	322	488	499	1001	322	153
30	April	I	509	412	820	471	471	512	716	699	717	804	576	805	401	543	508	803	549	362	366	484	576	820	362	156
		II	566	633	827	757	757	937	808	793	745	816	673	951	416	739	461	664	655	541	387	662	689	951	387	157
		III	732	378	755	1010	1010	1079	611	515	909	895	713	1010	418	777	834	862	728	522	390	768	746	1079	378	216
31	May	I	976	976	356	706	982	1035	1117	1311	943	1221	1116	1670	1616	648	1428	1238	2280	949	603	631	1090	2280	356	438
		II	1131	795	437	943	1406	990	1084	2079	1153	1302	1120	1878	2043	656	1339	949	2500	1002	831	598	1212	2500	437	537
		III	1331	1328	482	1022	2162	1486	1284	2193	991	1165	1200	1913	1857	800	2247	1959	2721	1470	852	689	1458	2721	482	600
																								3603	156	363
Leap Year	A. Flow (cumec-day)		277093	296292	154547	341678	432499	352843	351781	374293	255683	377413	323142	399211	499240	468956	434162	421438	452110	296373	201924	203699				
Syntetic years	Annual Flow (cumec)		759	812	423	934	1185	967	964	1023	701	1034	885	1091	1368	1285	1189	1151	1239	812	553	557	947			
	Annual Volume (MCM)		23941	25600	13353	29521	37368	30486	30394	32339	22091	32609	27919	34492	43134	40518	37512	36412	39062	25607	17446	17600	29870			
	A.V. basin (cumec)		947																							

Table 2A. Average Ten Daily Flow Extended Series at Kalai II (1984-85 upto 2003-04).

			Average Ten Daily Flow Series at Kalai II H.E Project site as Derived from Hayuliang (20 years) in cumecs																							
			Catchment Area of Kalai II site = 17846 Km2																							
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
Tot Days	**Month**	**Ten Daily**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**A.V. (cumec)**	**Max**	**Min**	**SD**
30	June	I	1451	2585	527	1510	1862	1683	2110	2546	1124	1627	1392	2037	2036	2096	1725	1354	2819	2101	819	930	1717	2819	527	602
		II	1575	1851	612	1401	1873	2043	1748	2800	1321	1547	1489	2106	2103	2231	1776	1322	2802	2107	919	1370	1750	2802	612	547
		III	1603	1921	906	1668	1643	1851	1778	2237	1894	1562	1469	2483	3220	2143	2153	2162	3699	2063	903	1508	1943	3699	903	660
31	July	I	1745	2236	640	1769	2842	2969	2263	2237	1596	2684	1315	1880	2824	3228	3006	1969	2459	1748	1242	1860	2126	3228	640	675
		II	1882	2112	654	1466	1694	2052	2796	2309	1417	2709	1457	1691	3871	3451	2551	2343	2328	1820	1270	1109	2049	3871	654	782
		III	1752	2050	564	1952	2162	1944	2326	1773	1449	2018	1799	1449	2961	3043	2355	2214	2360	2079	938	737	1899	3043	564	635
31	August	I	1116	1728	514	1927	1342	1710	1685	1749	1312	1808	1671	1427	2863	3290	2248	2058	2913	1834	990	647	1742	3290	514	709
		II	1116	1492	465	2101	1504	1688	1659	1722	1157	1743	1537	1389	2764	3317	2477	2568	2408	1175	987	597	1693	3317	465	730
		III	1110	1452	475	1914	3524	1481	1777	1525	1118	1609	1466	1262	2457	2837	2474	2816	2219	1257	711	630	1706	3524	475	803
30	September	I	1028	673	454	1766	2068	1635	1575	1348	833	1313	1414	1455	2321	2930	3648	2831	2148	1112	530	631	1586	3648	454	863
		II	1484	488	672	1474	1299	1444	1452	1255	744	1184	1398	1252	1974	3030	1925	2594	2133	767	490	605	1383	3030	488	688
		III	1003	748	268	1953	1565	1338	1225	1173	633	1210	1252	1208	1869	3257	1546	1770	1583	683	1069	522	1294	3257	268	649
31	October	I	708	695	355	1203	2262	1484	1419	979	461	1195	1136	2261	2049	1549	1121	1364	885	871	812	482	1165	2262	355	558
		II	618	561	354	958	2162	1231	974	1021	570	952	1092	1984	1683	1016	1244	1649	629	633	478	457	1013	2162	354	519
		III	437	545	278	799	1503	842	673	910	491	778	914	1557	1508	714	1670	1220	536	479	441	428	836	1670	278	431
30	November	I	479	515	325	688	1049	657	532	419	307	668	841	978	1018	524	636	679	436	432	416	381	599	1049	307	225
		II	394	451	322	494	870	567	464	367	270	668	805	853	882	496	508	525	420	412	390	362	526	882	270	190
		III	297	414	289	430	783	442	415	333	251	572	784	818	759	482	566	489	403	386	363	346	481	818	251	177
31	December	I	278	391	252	374	727	365	374	735	233	533	184	237	609	449	497	546	373	367	349	332	410	735	184	156
		II	274	362	242	344	617	328	275	556	214	505	176	225	551	471	433	503	358	352	337	317	372	617	176	126
		III	265	346	287	302	539	304	268	443	197	483	534	809	535	436	404	443	350	333	324	304	395	809	197	139
31	January	I	254	316	339	514	514	282	324	380	190	573	367	430	507	410	373	415	344	319	310	296	373	573	190	97
		II	249	290	328	493	493	266	320	320	201	585	376	441	471	471	363	409	332	322	291	295	366	585	201	99
		III	248	277	304	471	471	291	327	294	183	577	325	378	451	389	351	413	331	328	303	296	350	577	183	91
28/29	February	I	218	291	295	445	445	303	320	291	437	582	414	415	448	406	360	427	352	332	323	273	369	582	218	85
		II	207	284	288	435	435	303	327	292	426	561	422	423	479	416	358	422	349	340	326	269	368	561	207	85
		III	218	286	308	453	453	280	353	291	432	573	530	484	471	416	357	408	356	338	327	278	381	573	218	94
31	March	I	364	262	316	452	452	288	410	317	463	608	524	408	510	474	387	457	360	352	319	307	401	608	262	90
		II	632	400	360	449	449	283	440	347	533	719	596	460	628	500	437	480	358	340	355	272	452	719	272	121
		III	590	368	437	562	555	433	495	353	714	1075	646	497	606	634	435	541	542	378	346	524	536	1075	346	164
30	April	I	546	443	881	506	506	550	769	751	770	864	618	865	431	583	545	863	590	389	393	520	619	881	389	168
		II	608	680	888	814	814	1007	869	852	800	876	723	1021	447	794	495	713	704	582	416	711	741	1021	416	168
		III	786	406	811	1085	1085	1159	656	554	977	961	766	1085	449	835	896	926	783	560	419	825	801	1159	406	232
31	May	I	1049	1049	383	759	1055	1112	1200	1409	1013	1312	1199	1794	1736	697	1534	1330	2449	1020	648	677	1171	2449	383	470
		II	1215	854	470	1013	1511	1064	1165	2234	1239	1399	1204	2018	2195	704	1438	1020	2686	1077	893	643	1302	2686	470	577
		III	1430	1426	518	1098	2323	1597	1380	2356	1065	1252	1290	2055	1995	859	2415	2105	2923	1579	915	740	1566	2923	518	645
																								3871	**176**	**390**
Leap Year	A. Flow (cumec-day)		297713	318340	166047	367103	464682	379099	377958	402145	274709	405498	347188	428918	536382	503852	466469	452799	485753	318427	216950	218858				
Syntetic years	Annual Flow (cumec)		816	872	455	1003	1273	1039	1036	1099	753	1111	951	1172	1470	1380	1278	1237	1331	872	594	598	**1017**			
	Annual Volume (MCM)		25722	27505	14346	31718	40149	32754	32656	34745	23735	35035	29997	37058	46343	43533	40303	39122	41969	27512	18744	18909	**32093**			
	A.V. basin (cumec)		1017																							

Table 3A. Intermediate Ten Daily Flow Extended Series between Kalai II & Kalai I (1984-85 upto 2003-04).

			Intermediate Tendaily Flow Series between KL-2 & KL-1																			
			Intermediate Catchment Area = 1236 Km2																			
Tot Days	Month	Ten Daily	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
30	June	I	101	179	37	105	129	117	146	176	78	113	96	141	140	145	119	94	195	146	57	123
		II	109	128	42	97	130	141	121	194	91	107	103	146	146	155	123	92	194	146	64	128
		III	111	133	63	116	114	128	123	155	131	108	102	172	223	148	149	150	256	143	63	151
31	July	I	121	155	44	123	197	206	157	155	111	186	91	130	196	224	208	136	170	121	86	234
		II	130	146	45	102	117	142	194	160	98	188	101	117	268	239	177	162	161	126	88	210
		III	121	142	39	135	150	135	161	123	100	140	125	100	205	211	163	153	163	144	65	180
31	August	I	77	120	36	133	93	118	117	121	91	125	116	99	198	228	156	143	202	127	69	176
		II	77	103	32	146	104	117	115	119	80	121	106	96	191	230	172	178	167	81	68	171
		III	77	101	33	133	244	103	123	106	77	111	102	87	170	197	171	195	154	87	49	156
30	September	I	71	47	31	122	143	113	109	93	58	91	98	101	161	203	253	196	149	77	37	169
		II	103	34	47	102	90	100	101	87	52	82	97	87	137	210	133	180	148	53	34	148
		III	69	52	19	135	108	93	85	81	44	84	87	84	129	226	107	123	110	47	74	143
31	October	I	49	48	25	83	157	103	98	68	32	83	79	157	142	107	78	94	61	60	56	70
		II	43	39	25	66	150	85	67	71	39	66	76	137	117	70	86	114	44	44	33	62
		III	30	38	19	55	104	58	47	63	34	54	63	108	104	49	116	84	37	33	31	49
30	November	I	33	36	22	48	73	46	37	29	21	46	58	68	71	36	44	47	30	30	29	39
		II	27	31	22	34	60	39	32	25	19	46	56	59	61	34	35	36	29	29	27	34
		III	21	29	20	30	54	31	29	23	17	40	54	57	53	33	39	34	28	27	25	32
31	December	I	19	27	17	26	50	25	26	51	16	37	22	32	42	31	34	38	26	25	24	29
		II	19	25	17	24	43	23	19	39	15	35	20	29	38	33	30	35	25	24	23	27
		III	18	24	20	21	37	21	19	31	14	33	21	30	37	30	28	31	24	23	22	27
31	January	I	18	22	23	36	36	20	22	26	13	40	25	30	35	28	26	29	24	22	22	33
		II	17	20	23	34	34	18	22	22	14	40	26	31	33	33	25	28	23	22	20	35
		III	17	19	21	33	33	20	23	20	13	40	23	26	31	27	24	29	23	23	21	28
28/29	February	I	15	20	20	31	31	21	22	20	30	40	29	29	31	28	25	30	24	23	22	24
		II	14	20	20	30	30	21	23	20	30	39	29	29	33	29	25	29	24	24	23	25
		III	15	20	21	31	31	19	24	20	30	40	37	34	33	29	25	28	25	23	23	33
31	March	I	25	18	22	31	31	20	28	22	32	42	36	28	35	33	27	32	25	24	22	22
		II	44	28	25	31	31	20	30	24	37	50	41	32	43	35	30	33	25	24	25	26
		III	41	25	30	39	38	30	34	24	49	74	45	34	42	44	30	37	38	26	24	28
30	April	I	38	31	61	35	35	38	53	52	53	60	43	60	30	40	38	60	41	27	27	51
		II	42	47	62	56	56	70	60	59	55	61	50	71	31	55	34	49	49	40	29	62
		III	54	28	56	75	75	80	45	38	68	67	53	75	31	58	62	64	54	39	29	66
31	May	I	73	73	26	53	73	77	83	98	70	91	83	124	120	48	106	92	170	71	45	50
		II	84	59	33	70	105	74	81	155	86	97	83	140	152	49	100	71	186	75	62	57
		III	99	99	36	76	161	111	96	163	74	87	89	142	138	60	167	146	202	109	63	58

Table 4A. Average Ten Daily Flow Extended Series at Hutong I (1984-85 upto 2003-04).

Average Ten Daily Flow Series at Hutong I H.E. Project site as Derived from Hutong II (20 years) in cumecs

Catchment Area of Hutong I site = 17968 Km2

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
Tot Days	**Month**	**Ten Daily**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**A.V. (cumec)**	**Max**	**Min**	**SD**
30	June	I	1461	2602	531	1520	1875	1634	2124	2563	1132	1639	1401	2051	2039	2110	1737	1363	2839	2116	825	337	1728	2839	531	605
		II	1586	1864	617	1411	1886	2057	1760	2819	1330	1558	1499	2121	2118	2246	1789	1331	2822	2121	925	1379	1762	2822	617	551
		III	1614	1935	912	1680	1654	1864	1791	2252	1907	1573	1480	2500	3242	2158	2167	2177	3725	2077	909	1518	1957	3725	909	664
31	July	I	1757	2251	644	1781	2862	2369	2279	2252	1607	2702	1324	1893	2843	3250	3027	1982	2475	1759	1250	1372	2140	3250	644	680
		II	1895	2126	659	1476	1706	2066	2815	2325	1427	2728	1467	1703	3897	3475	2568	2359	2344	1832	1279	1116	2063	3897	659	788
		III	1764	2064	567	1966	2177	1957	2342	1785	1459	2032	1811	1459	2981	3063	2371	2229	2376	2093	944	803	1912	3063	567	639
31	August	I	1124	1739	518	1940	1351	1722	1696	1761	1321	1820	1682	1437	2882	3312	2263	2072	2933	1847	997	651	1753	3312	518	714
		II	1123	1502	468	2116	1514	1700	1671	1733	1165	1755	1548	1398	2783	3340	2494	2585	2424	1183	993	601	1705	3340	468	735
		III	1118	1461	478	1927	3548	1491	1789	1535	1126	1620	1476	1271	2474	2857	2491	2835	2234	1266	716	634	1717	3548	478	809
30	September	I	1036	678	458	1778	2082	1646	1586	1357	839	1322	1424	1465	2337	2950	3673	2851	2162	1119	534	636	1597	3673	458	869
		II	1494	491	677	1484	1308	1454	1462	1264	750	1192	1408	1260	1988	3050	1938	2612	2148	773	494	610	1393	3050	491	692
		III	1009	753	270	1966	1576	1347	1233	1181	637	1219	1261	1217	1882	3279	1556	1782	1594	688	1076	525	1303	3279	270	653
31	October	I	713	700	358	1211	2278	1494	1428	985	465	1204	1144	2277	2063	1559	1129	1373	891	877	818	486	1173	2278	358	562
		II	622	564	357	965	2177	1239	981	1028	573	959	1100	1997	1694	1023	1253	1660	633	638	481	460	1020	2177	357	522
		III	440	548	280	805	1513	848	677	917	494	783	921	1567	1518	719	1681	1228	539	482	444	431	842	1681	280	434
30	November	I	482	519	327	693	1056	661	536	422	309	673	847	985	1025	527	640	683	439	435	419	384	603	1056	309	227
		II	397	454	324	497	876	571	467	369	271	673	811	959	888	500	511	529	423	414	393	365	530	888	271	191
		III	299	417	291	433	788	445	418	336	253	575	789	824	764	485	570	493	405	389	365	348	484	824	253	178
31	December	I	280	393	254	377	732	368	376	767	235	537	175	222	614	452	501	549	376	370	351	334	413	757	175	161
		II	276	364	244	347	621	330	277	560	215	509	169	212	555	474	436	506	361	355	340	319	373	621	169	129
		III	267	348	289	304	543	306	270	446	198	486	555	843	538	439	406	446	352	336	326	306	400	843	198	146
31	January	I	256	318	341	517	517	284	327	383	191	577	370	433	510	413	376	417	347	321	313	298	375	577	191	98
		II	250	292	330	496	496	268	323	323	202	588	379	444	475	474	366	412	334	324	293	297	368	588	202	100
		III	250	279	306	475	475	293	329	296	184	581	327	381	454	331	353	416	333	330	305	298	353	581	184	91
28/29	February	I	219	293	297	448	448	305	322	293	440	586	417	418	451	409	362	430	354	334	325	275	371	586	219	85
		II	209	285	290	438	438	305	329	294	429	564	425	426	482	419	360	424	351	342	328	271	371	564	209	85
		III	219	288	311	456	456	282	355	293	435	577	533	488	475	419	360	411	358	341	329	279	383	577	219	95
31	March	I	367	263	318	455	455	290	412	319	466	613	527	411	514	477	390	460	362	354	322	309	404	613	263	91
		II	636	403	362	452	452	285	443	349	537	724	600	463	632	503	440	483	361	343	358	274	455	724	274	122
		III	594	370	440	566	559	436	498	355	719	1082	651	500	610	638	438	545	545	380	348	527	540	1082	348	165
30	April	I	550	446	887	509	509	554	774	756	775	869	623	871	434	587	549	869	594	392	396	524	624	887	392	169
		II	612	685	894	819	819	1014	874	858	806	882	728	1028	450	800	498	718	709	585	419	716	746	1028	419	169
		III	792	408	817	1093	1093	1167	660	557	984	968	772	1093	452	841	902	933	788	564	422	831	807	1167	408	234
31	May	I	1056	1056	385	764	1063	1119	1208	1419	1020	1321	1207	1806	1748	701	1545	1339	2466	1027	652	682	1179	2466	385	474
		II	1224	860	473	1020	1521	1071	1173	2249	1248	1409	1212	2032	2210	703	1448	1027	2704	1084	899	647	1311	2704	473	581
		III	1440	1436	521	1106	2339	1608	1389	2372	1072	1260	1299	2069	2009	865	2431	2119	2943	1590	921	745	1577	2943	521	649
																								3897	169	393
Leap Year	A. Flow (cumec-day)		299748	320517	167183	369612	467859	381690	380542	405063	276587	408270	349561	431850	539940	507297	469658	455894	489073	320604	218433	220353				
Syntetic years	Annual Flow (cumec)		821	878	458	1010	1282	1046	1043	1107	758	1119	958	1180	1479	1330	1287	1246	1340	878	598	602	1024			
	Annual Volume (MCM)		25898	27693	14445	31935	40423	32978	32879	34997	23897	35275	30202	37312	46651	43830	40578	39389	42256	27700	18873	19038	32312			
	A.V. basin (cumec)		1024																							

Table 5A. Average Ten Daily Flow Extended Series at Hutong II (1984-85 upto 2003-04).

Average Ten Daily Flow Series at Hutong II H.E. Project site as Derived from Hayuliang (20 years) in cumecs

Catchment Area of Hutong II Site = 18450 Km2

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
Tot Days	**Month**	**Ten Daily**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**A.V. (cumec)**	**Max**	**Min**	**SD**
30	June	I	1500	2672	545	1561	1925	1740	2181	2632	1162	1682	1439	2106	2094	2167	1783	1400	2915	2172	847	962	1774	2915	545	622
		II	1629	1914	633	1449	1936	2112	1807	2835	1365	1600	1539	2178	2174	2307	1837	1367	2897	2178	950	1416	1809	2897	633	566
		III	1658	1987	937	1725	1698	1914	1839	2312	1958	1615	1519	2567	3329	2216	2226	2235	3825	2133	934	1559	2009	3825	934	682
31	July	I	1804	2312	661	1829	2938	3069	2340	2313	1650	2775	1360	1944	2919	3337	3108	2035	2542	1807	1284	1923	2197	3337	661	698
		II	1946	2183	677	1515	1751	2121	2891	2387	1465	2801	1507	1749	4002	3568	2637	2422	2407	1882	1313	1146	2119	4002	677	809
		III	1811	2119	583	2018	2235	2010	2405	1833	1498	2087	1860	1498	3061	3146	2435	2289	2440	2149	970	824	1963	3146	583	656
31	August	I	1154	1786	532	1993	1388	1768	1742	1808	1357	1869	1727	1475	2960	3401	2324	2127	3012	1836	1023	669	1800	3401	532	733
		II	1154	1542	481	2173	1555	1745	1716	1780	1196	1802	1589	1436	2857	3429	2581	2655	2490	1215	1020	618	1751	3429	481	755
		III	1148	1501	491	1979	3644	1531	1837	1577	1156	1663	1516	1305	2540	2933	2558	2911	2294	1300	735	651	1763	3644	491	831
30	September	I	1063	696	470	1825	2138	1690	1628	1394	862	1357	1462	1504	2400	3029	3771	2927	2220	1149	548	653	1639	3771	470	892
		II	1534	504	695	1524	1343	1493	1501	1298	770	1224	1445	1294	2041	3132	1990	2682	2206	793	507	626	1430	3132	504	711
		III	1036	773	277	2019	1618	1383	1266	1213	654	1251	1295	1249	1932	3367	1598	1830	1637	706	1105	539	1337	3367	277	671
31	October	I	732	719	367	1244	2339	1534	1467	1012	477	1236	1175	2338	2118	1601	1159	1410	915	901	840	499	1204	2339	367	577
		II	639	579	366	990	2235	1272	1007	1056	599	984	1129	2051	1740	1050	1287	1704	650	655	494	473	1048	2235	366	536
		III	452	563	288	826	1553	871	695	941	507	804	945	1609	1559	738	1726	1261	554	495	456	442	864	1726	288	446
30	November	I	495	533	336	712	1084	679	550	434	317	691	870	1011	1053	541	658	702	450	447	430	394	619	1084	317	233
		II	408	466	333	511	899	586	479	379	279	691	833	882	912	513	525	543	435	426	403	375	544	912	279	196
		III	307	428	299	445	809	457	429	345	260	591	810	846	784	498	585	506	416	399	375	357	497	846	260	183
31	December	I	288	404	261	387	751	378	386	760	241	551	179	228	630	464	514	564	386	380	361	343	423	760	179	163
		II	283	374	250	356	637	333	285	575	221	522	173	218	670	487	447	520	370	364	349	327	383	637	173	132
		III	274	358	296	313	557	315	277	458	203	499	570	866	553	451	417	458	362	345	335	315	411	866	203	149
31	January	I	262	326	350	531	531	292	335	393	196	592	380	445	524	424	386	429	356	330	321	306	385	592	196	101
		II	257	300	339	510	510	275	331	331	208	604	389	456	487	487	376	423	343	332	301	305	378	604	208	102
		III	257	287	314	487	487	301	338	304	189	596	336	391	467	402	363	427	342	339	313	306	362	596	189	94
28/29	February	I	225	301	305	460	460	313	331	301	452	602	428	429	464	420	372	441	364	343	334	282	381	602	225	88
		II	214	293	297	450	450	313	338	302	441	580	437	438	495	430	370	436	360	351	337	278	380	580	214	88
		III	225	296	319	468	468	290	365	301	446	592	547	501	487	430	370	422	368	350	338	287	393	592	225	98
31	March	I	376	271	327	467	467	297	423	327	478	629	541	422	527	490	401	472	372	363	330	317	415	629	271	93
		II	653	414	372	464	464	293	455	359	551	743	616	476	649	517	452	496	370	352	367	282	467	743	282	125
		III	610	380	451	582	574	447	512	365	738	1111	668	513	626	655	450	560	560	390	357	542	555	1111	357	169
30	April	I	565	458	911	523	523	569	785	777	796	893	639	895	446	603	564	892	610	403	406	538	640	911	403	173
		II	629	703	918	841	841	1041	838	881	827	906	748	1056	462	821	512	737	728	601	430	735	766	1056	430	174
		III	813	419	839	1122	1122	1199	678	572	1010	994	792	1122	464	863	927	958	809	579	433	853	828	1199	419	240
31	May	I	1084	1084	395	785	1091	1149	1240	1457	1048	1356	1239	1855	1794	720	1586	1375	2532	1055	670	700	1211	2532	395	486
		II	1256	883	486	1047	1562	1100	1204	2309	1281	1447	1245	2086	2269	728	1487	1054	2777	1113	923	664	1346	2777	486	597
		III	1479	1475	535	1135	2401	1651	1427	2435	1101	1234	1333	2125	2062	888	2496	2176	3022	1633	946	765	1619	3022	535	666
																								4002	173	404
Leap Year	A.Flow (cumec-day)		307789	329115	171668	379528	480410	391929	390750	415756	284007	413222	358938	443434	554424	520905	482257	468124	502133	323204	224233	226264				
Syntetic year	Annual Flow (cumec)		843	902	470	1037	1316	1074	1071	1136	778	1149	983	1212	1519	1427	1321	1279	1376	902	615	618	1051			
	Annual Volume (MCM)		26593	28436	14832	32791	41507	33863	33761	35921	24538	36221	31012	38313	47902	45006	41667	40446	43389	28443	19379	19549	33178			
	A.V. basin (cumec)		1051																							

Table 6A. Intermediate Ten Daily Flow Extended Series between Hutong II & Hutong I (1984-85 upto 2003-04).

Intermediate Tendaily Flow Series between HTG-2 & HTG-1

Intermediate Catchment Area = 482 Km2

Tot Days	Month	Ten Daily	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
	June	I	39	70	14	41	50	45	57	69	30	44	38	55	55	57	47	37	76	57	22	48
30		II	43	50	17	38	51	55	47	76	36	42	40	57	57	60	48	36	76	57	25	50
		III	43	52	24	45	44	50	48	60	51	42	40	67	87	58	58	58	100	56	24	59
	July	I	47	60	17	48	77	80	61	60	43	72	36	51	76	87	81	53	66	47	34	91
31		II	51	57	18	40	46	55	76	62	38	73	39	46	105	93	69	63	63	49	34	82
		III	47	55	15	53	58	53	63	48	39	55	49	39	80	82	64	60	64	56	25	70
	August	I	30	47	14	52	36	46	46	47	35	49	45	39	77	89	61	56	79	50	27	69
31		II	30	40	13	57	41	46	45	46	31	47	42	38	75	90	67	69	65	32	27	67
		III	30	39	13	52	95	40	48	41	30	43	40	34	66	77	67	76	60	34	19	61
	September	I	28	18	12	48	56	44	43	36	23	35	38	39	63	79	99	76	58	30	14	66
30		II	40	13	18	40	35	39	39	34	20	32	38	34	53	82	52	70	58	21	13	58
		III	27	20	7	53	42	36	33	32	17	33	34	33	50	88	42	48	43	18	29	56
	October	I	19	19	10	32	61	40	38	26	12	32	31	61	55	42	30	37	24	24	22	27
31		II	17	15	10	26	58	33	26	28	15	26	29	54	45	27	34	45	17	17	13	24
		III	12	15	8	22	41	23	18	25	13	21	25	42	41	19	45	33	14	13	12	19
	November	I	13	14	9	19	28	18	14	11	8	18	23	26	28	14	17	18	12	12	11	15
30		II	11	12	9	13	23	15	13	10	7	18	22	23	24	13	14	14	11	11	11	13
		III	8	11	8	12	21	12	11	9	7	15	21	22	20	13	15	13	11	10	10	13
	December	I	8	11	7	10	20	10	10	3	6	14	5	6	16	12	13	15	10	10	9	11
31		II	7	10	7	9	17	9	7	15	6	14	5	6	15	13	12	14	10	10	9	10
		III	7	9	8	8	15	8	7	12	5	13	15	23	14	12	11	12	9	9	9	11
	January	I	7	9	9	14	14	8	9	10	5	15	10	12	14	11	10	11	9	9	8	13
31		II	7	8	9	13	13	7	9	9	5	16	10	12	13	13	10	11	9	9	8	13
		III	7	7	8	13	13	8	9	8	5	16	9	10	12	10	9	11	9	9	8	11
	February	I	6	8	8	12	12	8	9	8	12	16	11	11	12	11	10	12	10	9	9	9
28/29		II	6	8	8	12	12	8	9	8	12	15	11	11	13	11	10	11	9	9	9	10
		III	6	8	8	12	12	8	10	8	12	15	14	13	13	11	10	11	10	9	9	13
	March	I	10	7	9	12	12	8	11	9	12	16	14	11	14	13	10	12	10	9	9	9
31		II	17	11	10	12	12	8	12	9	14	19	16	12	17	13	12	13	10	9	10	10
		III	16	10	12	15	15	12	13	10	19	29	17	13	16	17	12	15	15	10	9	11
	April	I	15	12	24	14	14	15	21	20	21	23	17	23	12	16	15	23	16	11	11	20
30		II	16	18	24	22	22	27	23	23	22	24	20	28	12	21	13	19	19	16	11	24
		III	21	11	22	29	29	31	18	15	26	26	21	29	12	23	24	25	21	15	11	26
	May	I	28	28	10	20	29	30	32	38	27	35	32	48	47	19	41	36	66	28	17	20
31		II	33	23	13	27	41	29	31	60	33	38	33	55	59	19	39	28	73	29	24	22
		III	39	39	14	30	63	43	37	64	29	34	35	56	54	23	65	57	79	43	25	23

Table 7A. Average Ten Daily Flow Extended Series at Demwe Upper (1984-85 upto 2003-04).

Average Ten Daily Flow Series at Demve Upper H.E. Project site as Derived from Mompani (20 years) in cumecs

Catchment Area of DEMVE UPPER site = 20560 Km2

						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17				
Tot Days	**Month**	**Ten Daily**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**A.V. (cumec)**	**Max**	**Min**	**SD**
30	June	I	1672	2978	607	1665	1880	1839	2660	1518	1551	2168	1794	2174	2145	2220	2197	1446	2974	2225	888	1072	1884	2978	607	623
		II	1815	2133	706	1473	1877	2125	2097	2092	1595	2102	2160	2008	2227	2360	2846	1413	2956	2231	992	1578	1939	2956	706	542
		III	1847	2214	1044	1797	1716	1997	2139	2369	2982	2188	1848	2035	3391	2269	3002	2289	3891	2185	976	1737	2136	3891	976	701
31	July	I	2010	2576	737	1867	2840	3009	1975	3387	1787	3062	1407	2426	2978	3400	3168	2087	2598	1856	996	2142	2315	3400	737	761
		II	2169	2433	754	1442	1600	1902	2468	2252	1753	2279	1290	1729	4070	3633	2693	2560	2457	1932	1329	1277	2101	4070	754	794
		III	2018	2362	649	1837	2050	1825	2285	2037	1678	2214	1447	1215	3121	3203	2492	2418	2495	2201	1407	918	1994	3203	649	653
31	August	I	1286	1990	592	1983	1288	1629	1942	2211	1481	1976	1278	990	3015	3423	2378	2180	3072	1946	1061	745	1823	3423	592	768
		II	1286	1718	536	2378	1456	1595	1594	2095	1383	1838	1176	2033	2916	3492	2700	2711	2545	1260	1063	688	1823	3492	536	777
		III	1279	1672	547	2074	3241	1415	1539	1883	1236	1803	1174	1332	2596	2392	2618	2970	2347	1345	776	726	1778	3241	547	793
30	September	I	1185	776	524	1731	1935	1647	1392	1810	1125	1369	1151	1175	2399	2980	3667	2887	2233	1242	686	727	1632	3667	524	842
		II	1709	562	774	1515	1272	1390	1526	1696	1057	1220	1093	1268	2067	3077	2024	2659	2219	913	648	697	1469	3077	562	676
		III	1155	862	309	2093	1480	1324	1798	1667	842	1239	981	1837	1966	3298	1657	1871	1693	832	1201	601	1435	3298	309	659
31	October	I	816	801	409	1269	2212	1459	1993	1427	548	1258	821	823	2094	1617	1207	1439	981	968	912	556	1181	2212	409	515
		II	712	646	408	981	2089	1357	1481	1444	919	956	713	730	1744	1030	1323	1711	736	740	692	527	1045	2089	408	466
		III	504	628	320	784	2130	1027	1218	1279	630	875	667	687	1577	817	1731	1301	647	593	556	493	922	2130	320	475
30	November	I	552	594	374	698	1362	778	997	1136	483	803	586	586	1494	690	873	942	547	546	516	439	750	1494	374	305
		II	454	519	371	533	1188	649	828	971	401	760	543	543	1272	646	664	693	522	508	473	418	648	1272	371	249
		III	342	477	333	466	1106	522	717	820	350	728	484	484	1072	622	759	634	493	466	429	398	585	1106	333	223
31	December	I	321	450	291	386	1006	424	658	743	320	678	466	466	829	614	647	726	446	436	406	382	535	1006	291	192
		II	316	417	279	362	899	383	565	600	287	645	453	453	759	605	543	657	421	412	388	365	490	899	279	164
		III	305	399	330	315	713	368	472	535	261	612	445	445	708	548	480	560	408	381	365	351	450	713	261	129
31	January	I	292	364	390	289	513	353	418	405	281	283	368	405	663	506	446	512	398	357	344	341	396	663	281	95
		II	287	334	378	286	489	341	393	373	306	280	338	389	605	491	429	504	378	362	312	340	381	605	280	85
		III	286	319	350	271	463	357	371	332	257	302	309	378	573	470	409	510	376	374	331	341	369	573	257	81
28/29	February	I	251	335	340	251	513	381	379	355	455	300	284	490	539	472	397	504	384	353	338	315	382	539	251	87
		II	239	327	331	277	489	373	391	342	569	286	323	519	588	487	394	496	378	365	342	310	391	588	239	100
		III	251	330	355	489	522	349	494	361	665	304	379	566	576	487	393	474	390	362	345	320	421	665	251	107
31	March	I	419	301	364	742	532	387	651	453	645	315	399	607	638	581	442	553	397	384	333	353	475	742	301	132
		II	728	461	415	1168	538	358	567	605	671	520	407	968	828	622	517	591	395	366	390	314	571	1168	314	218
		III	680	424	503	1084	626	650	743	1362	733	1275	471	1254	793	837	512	689	690	426	375	603	736	1362	375	293
30	April	I	630	510	1015	926	715	807	1279	1250	792	630	556	1254	715	800	740	1250	812	489	494	600	816	1279	489	265
		II	701	784	1023	1043	1064	1402	1272	1842	837	683	765	1361	582	1139	658	960	994	798	619	819	962	1842	519	324
		III	906	467	935	983	1644	1461	1059	1100	1037	769	1088	1685	585	1205	1303	1310	1121	764	537	951	1045	1685	467	334
31	May	I	1208	1208	441	864	1239	1683	1277	2567	1116	1244	870	1768	1844	761	1634	1421	2589	1098	710	780	1316	2589	441	570
		II	1400	984	541	1075	1781	1595	1512	2203	1583	2176	758	2164	2323	769	1534	1098	2809	1157	965	740	1458	2809	541	626
		III	1648	1643	597	1160	2499	1921	1668	1611	1293	1555	1166	2504	2114	930	2552	2229	3082	1681	989	852	1685	3082	597	658
																								4070	239	425
Leap Year	A. Flow (cumec-day)		342988	366753	191300	392603	500356	417695	455495	500023	343825	425576	309509	424528	594373	550356	530331	602728	528015	351789	243928	252140				
Sintetiques	Annual Flow (cumec)		940	1005	524	1073	1371	1144	1248	1366	942	1166	848	1160	1628	1508	1453	1374	1447	964	668	689	1126			
	Annual Volume (MCM)		29634	31687	16528	33921	43231	36089	39355	43202	29706	36770	26742	36679	51354	47551	45821	43436	45620	30395	21075	21785	35529			
	A.V. basin (cumec)		1126																							

Table 8A. Average Ten Daily Flow Extended Series at Demwe Lower (1984-85 upto 2003-04).

Average Ten Daily Flow Series at Demwe Lower H.E. Project site as Derived from Mompani (20 years) in cumecs

Catchment Area of DEMWE LOWER site = 22000 Km2

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
Tot Days	**Month**	**Ten Daily**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**A.V. (cumec)**	**Max**	**Min**	**SD**
30	June	I	1789	3186	650	1749	1974	1931	2793	1594	1628	2277	1883	2283	2252	2331	2307	1518	3122	2336	933	1126	1983	3186	650	658
		II	1942	2282	755	1546	1971	2232	2202	2197	1675	2207	2268	2108	2338	2478	2988	1483	3104	2342	1042	1657	2041	3104	755	568
		III	1977	2369	1117	1887	1802	2097	2246	2488	3131	2298	1940	2136	3560	2382	3152	2403	4086	2234	1025	1824	2311	4086	1025	734
31	July	I	2151	2757	789	1961	2982	3159	2074	3557	1876	3215	1477	2548	3127	3570	3327	2191	2727	1949	1045	2249	2437	3570	789	798
		II	2320	2604	807	1514	1680	1997	2592	2364	1840	2393	1355	1815	4273	3814	2828	2688	2580	2028	1396	1341	2211	4273	807	834
		III	2159	2527	695	1929	2153	1916	2400	2139	1762	2325	1520	1276	3277	3363	2617	2539	2620	2311	1477	964	2098	3363	695	686
31	August	I	1376	2130	634	2082	1352	1710	2039	2322	1555	2074	1341	1039	3166	3594	2496	2289	3225	2043	1114	783	1918	3594	634	805
		II	1376	1839	573	2497	1529	1675	1674	2200	1452	1929	1235	2134	3061	3667	2835	2847	2672	1323	1116	723	1918	3667	573	814
		III	1368	1789	585	2178	3403	1486	1616	1977	1297	1893	1233	1393	2726	3142	2749	3119	2465	1412	814	762	1871	3403	585	831
30	September	I	1268	830	560	1817	2032	1729	1461	1901	1181	1438	1209	1234	2519	3129	3851	3031	2345	1304	720	764	1716	3851	560	882
		II	1829	601	828	1591	1336	1460	1603	1781	1110	1281	1148	1331	2170	3231	2125	2792	2330	958	680	732	1546	3231	601	709
		III	1236	922	330	2198	1554	1391	1888	1750	884	1301	1030	1929	2064	3463	1740	1965	1778	874	1261	631	1509	3463	330	690
31	October	I	873	857	438	1333	2323	1532	2093	1499	576	1321	862	864	2199	1698	1267	1511	1030	1016	957	584	1242	2323	438	539
		II	761	691	437	1030	2193	1425	1556	1516	965	1004	749	766	1831	1144	1389	1797	773	778	622	553	1099	2193	437	488
		III	539	672	343	823	2237	1079	1279	1343	662	919	700	700	1656	858	1818	1366	679	622	584	517	970	2237	343	497
30	November	I	530	635	400	733	1430	817	1047	1193	508	843	615	615	1569	725	917	989	574	573	541	461	789	1569	400	319
		II	486	556	397	559	1248	682	870	1020	421	798	570	570	1336	678	698	728	548	533	497	438	682	1336	397	261
		III	366	510	356	489	1161	648	753	861	368	764	508	508	1126	654	797	666	518	490	450	418	616	1161	356	233
31	December	I	343	482	311	405	1057	445	690	780	336	712	489	489	871	645	680	762	468	458	426	401	562	1057	311	201
		II	338	446	298	380	943	402	593	630	302	677	475	475	797	635	570	689	442	432	407	383	516	943	298	172
		III	326	426	354	331	748	386	496	562	274	643	467	467	743	575	504	588	429	400	383	368	474	748	274	134
31	January	I	313	389	417	304	538	371	438	425	295	298	387	425	696	531	468	538	418	375	361	358	417	696	295	100
		II	307	358	404	300	514	358	413	392	321	294	355	408	635	516	451	529	397	380	327	357	401	635	294	89
		III	306	342	375	284	486	375	389	349	270	317	324	397	601	493	429	536	394	393	348	358	388	601	270	85
28/29	February	I	269	359	364	263	538	400	398	372	478	315	298	515	566	495	417	530	404	370	355	330	402	566	263	91
		II	256	350	355	291	513	391	411	359	598	300	339	544	617	511	414	521	397	383	359	325	412	617	256	104
		III	268	353	380	514	548	367	518	379	698	319	398	595	605	511	413	498	410	381	362	336	443	698	268	112
31	March	I	449	323	389	779	558	406	683	476	677	331	419	637	670	610	464	580	417	403	349	371	500	779	323	138
		II	779	493	444	1227	565	376	596	635	704	546	428	1016	869	653	543	620	414	384	409	330	602	1227	330	229
		III	728	453	538	1139	658	683	780	1430	770	1339	494	1317	832	879	537	723	724	447	394	634	775	1430	394	307
30	April	I	674	546	1086	972	751	848	1343	1313	831	724	584	1316	750	840	777	1312	852	513	519	630	859	1343	513	278
		II	760	839	1095	1095	1117	1472	1336	1934	878	717	803	1429	611	1196	691	1008	1044	838	545	860	1013	1934	545	339
		III	969	500	1000	1032	1726	1534	1112	1155	1089	807	1143	1769	614	1265	1369	1376	1177	802	564	998	1100	1769	500	349
31	May	I	1293	1293	472	907	1301	1767	1341	2696	1172	1306	914	1856	1936	799	1716	1492	2718	1153	745	820	1385	2718	472	597
		II	1498	1053	579	1129	1870	1675	1588	2313	1662	2285	796	2272	2439	807	1611	1152	2950	1215	1013	777	1534	2950	579	656
		III	1763	1758	638	1218	2624	2017	1751	1692	1357	1633	1224	2629	2220	977	2680	2340	3236	1765	1038	895	1773	3236	638	690
																								4273	256	445
Leap Year	A.Flow (cumec-day)		367011	392440	204699	412233	525374	438580	478270	525024	361016	446855	324985	445755	624092	577873	556848	527864	554415	369378	256125	264747				
Syntetic year	Annual Flow (cumec)		1006	1075	561	1126	1439	1202	1310	1434	989	1224	890	1218	1710	1583	1526	1442	1519	1012	702	723	1185			
	Annual Volume (MCM)		31710	33907	17686	35617	45392	37693	41323	45362	31132	38608	28079	38513	53922	49928	48112	45607	47901	31914	22129	22874	37383			
	A.V. basin (cumec)		1185																							

ANNEXURE - B

Flow Duration Curves using total data (1984-85 upto 2003-04) and for 90% dependable year (2003-04) for all the six proposed sites in Lohit river basin.

Figure B1 Flow Duration Curve at Kalai I with Total Data and 90% Dependable yr.

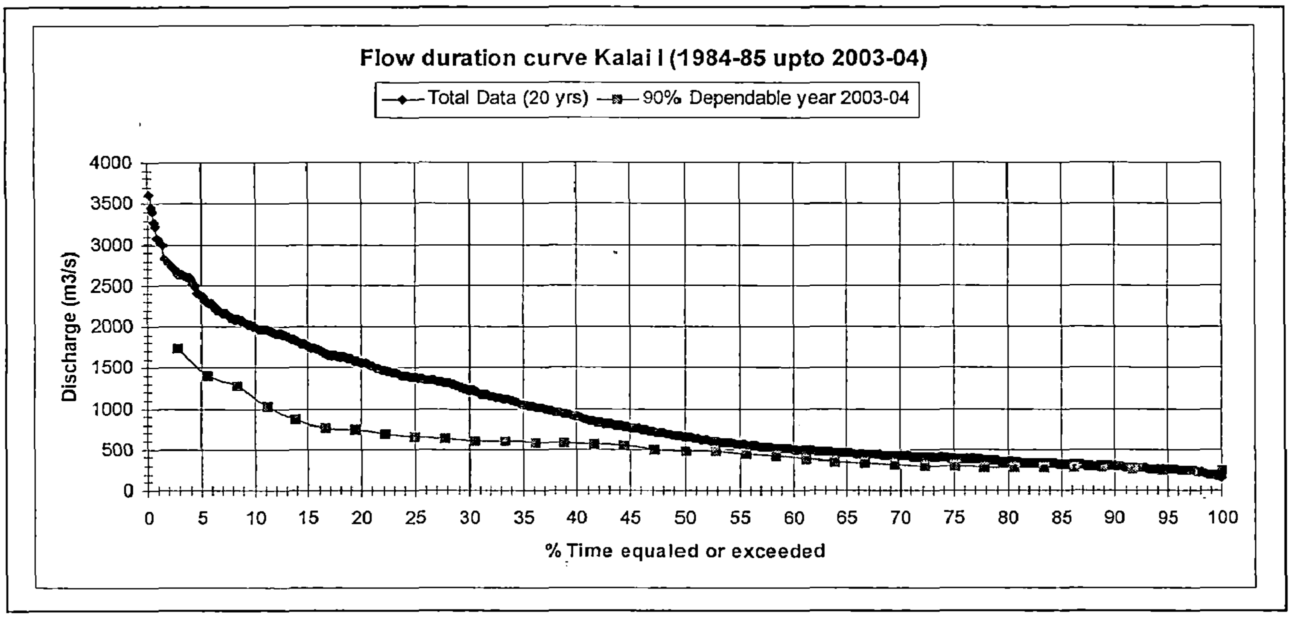


Figure B2 Flow Duration Curve at Kalai II with Total Data and 90% Dependable yr.

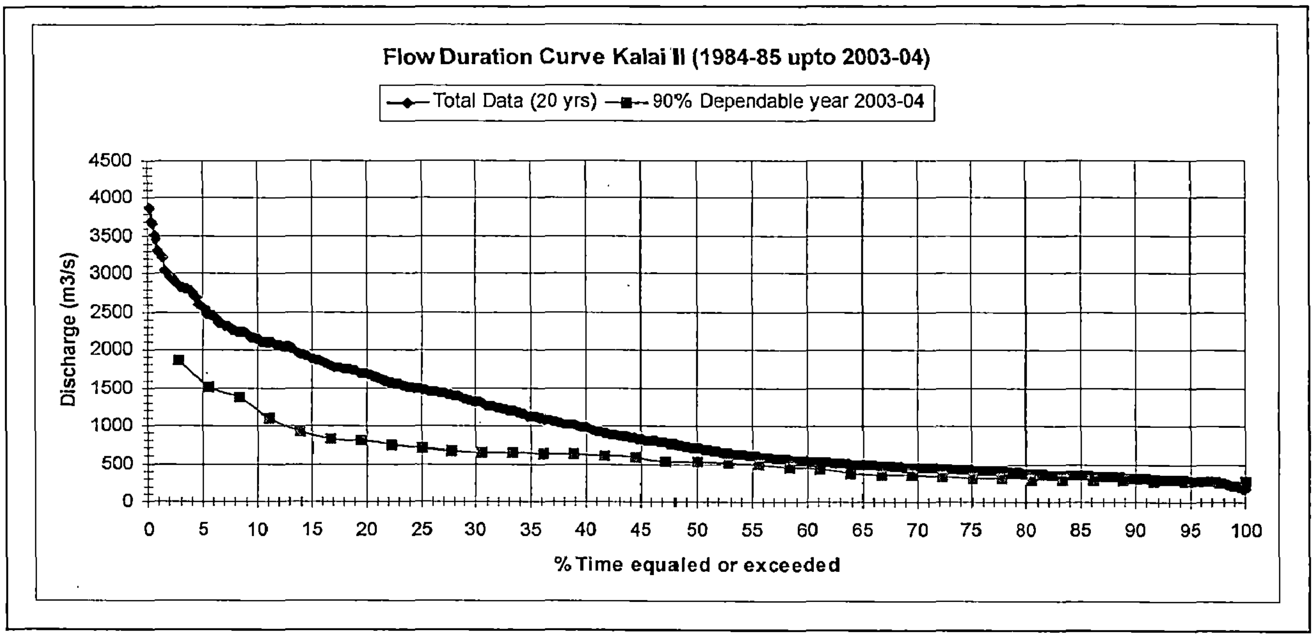


Figure B3 Flow Duration Curve at Hutong I with Total Data and 90% Dependable yr.

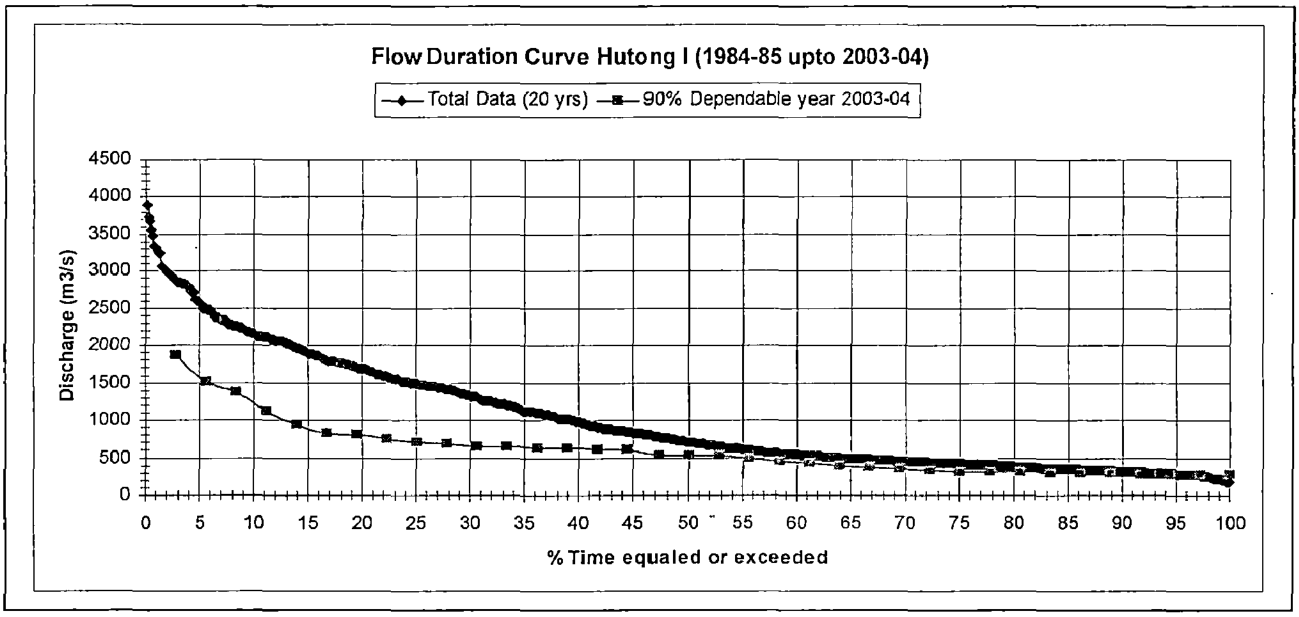


Figure B4 Flow Duration Curve at Hutong II with Total Data and 90% Dependable yr.

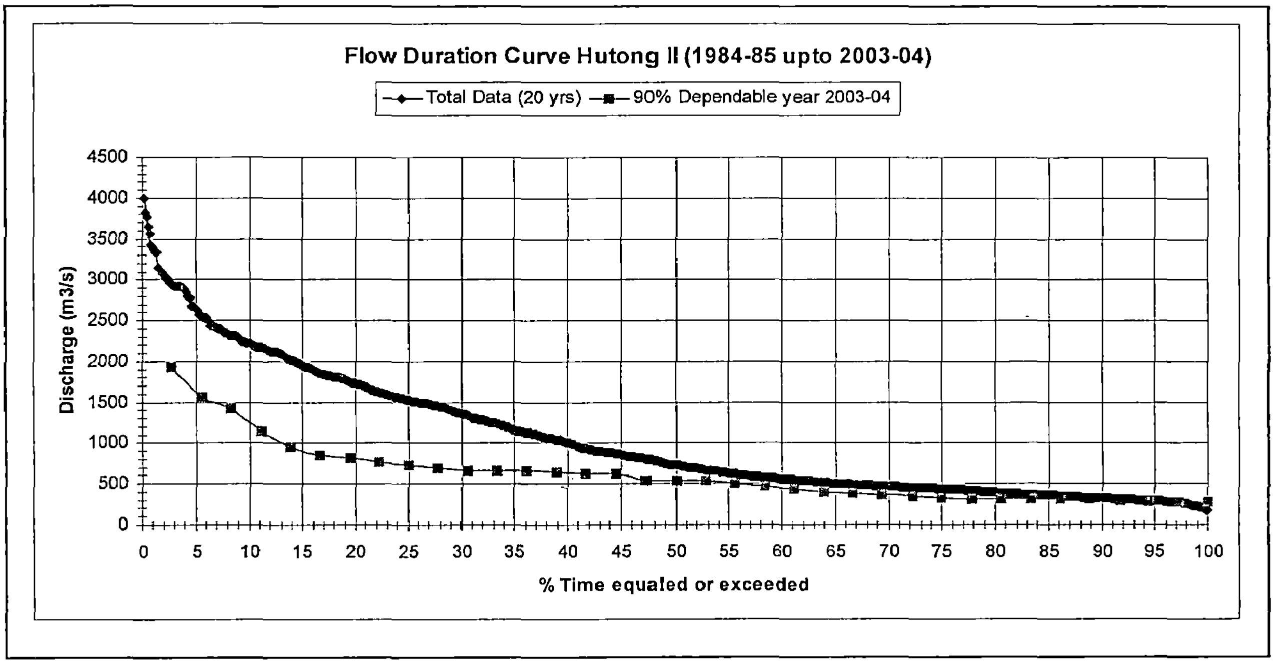


Figure B5 Flow Duration Curve at Demwe Upper Total Data and 90% Dependable yr.

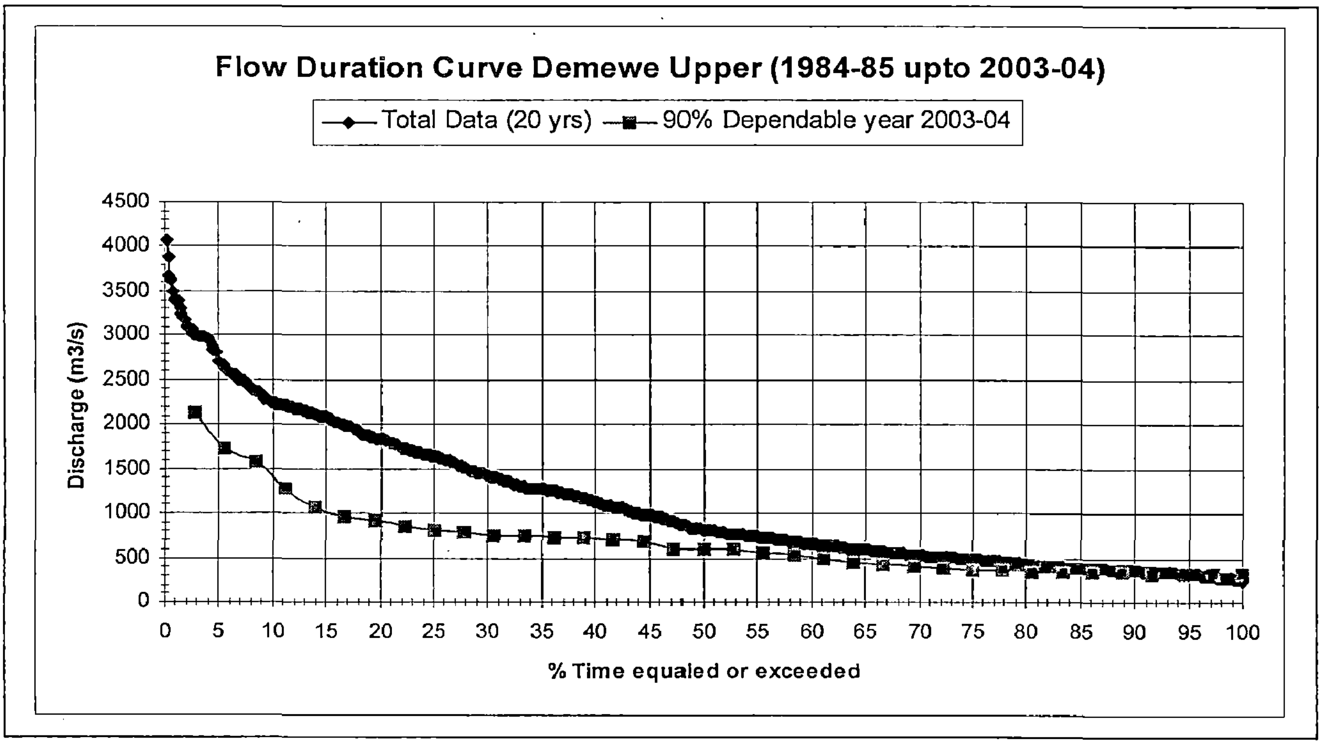


Figure B6 Flow Duration Curve at Demwe Lower with Total Data and 90% Dependable yr.

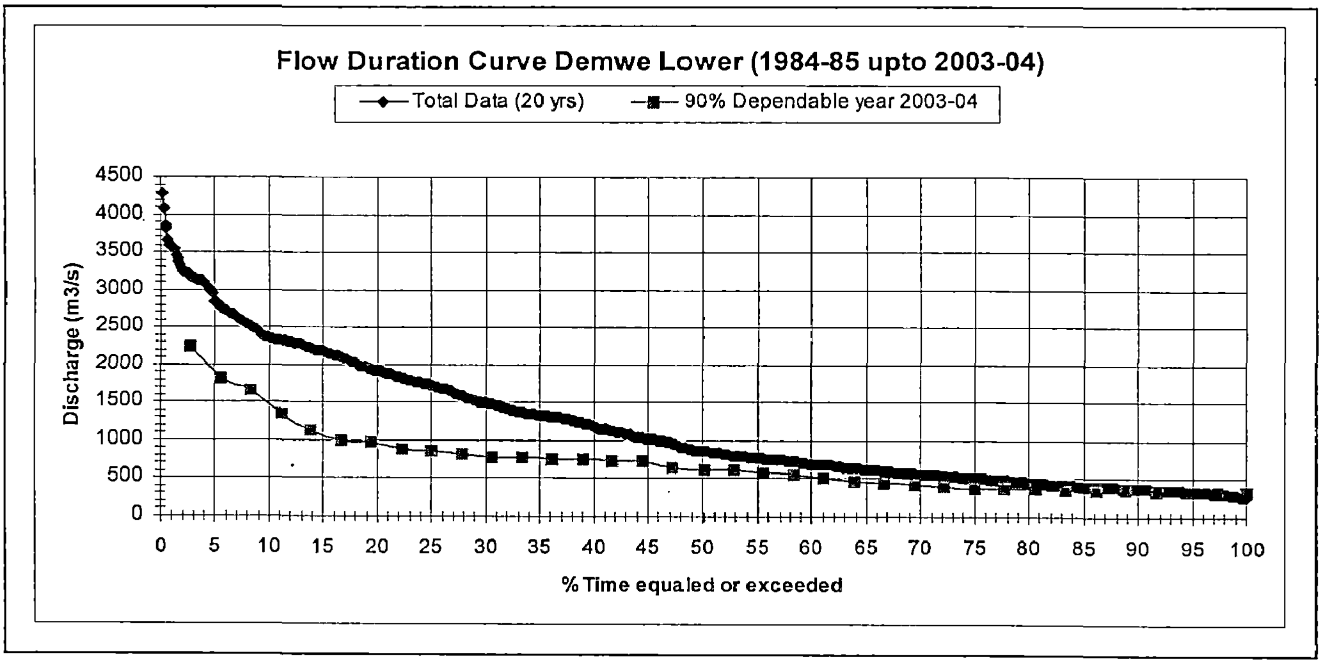


Table B7 Summary Flow Duration Curve data for all six proposed sites in Lohit river basin.

	KALAI I		**KALAI II**		**HUTONG I**		**HUTONG II**		**DEMWE UPPER**		**DEMWE LOWER**	
% Depend	**All Data**	**2003-04**	**All Data**	**2003-04**	**All Data**	**2003-04**	**All Data**	**2003-04**	**All Data**	**2003-04**	**All Data**	**2003-04**
Q50	659	486	714	522	711	525	732	539	819	601	861	631
Q75	393	295	422	317	424	319	437	327	487	365	511	383
Q90	297	258	320	278	322	279	330	287	355	320	375	336
Q95	263	254	283	273	285	275	293	282	319	315	336	330
Q98	231	254	248	272	250	274	257	282	286	314	300	330
Q100	156	250	176	269	169	271	173	278	239	310	256	325

Note: All Data means whole extended flow series from 1984-85 upto 2003-04.

ANNEXURE-C

In this Annexure C is showing an example of calculations for the estimation of synthetic stage-discharge relationship at Kalai I for Manning's roughness coefficient n=0.03.

For n=0.03 at 100 m cross-section (Kalai I)

Cross-sections 100 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	1,38	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	0,49
KALAI I (100 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	0,50
901,00	901,25	0,03	1,48	0,018	0,00	Cross-sectional area =	1,83
901,25	901,50	1,83	13,26	0,138	0,49	Velocity of flow =	0,75
901,50	901,75	6,49	23,19	0,280	2,78	Froude's Number =	0,34
901,75	902,00	13,33	31,60	0,422	7,50		

Cross-sections 100 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	20,92	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	7,50
KALAI I (100 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	1,00
901,00	901,25	0,03	1,48	0,018	0,00	Cross-sectional area =	13,33
901,25	901,50	1,83	13,26	0,138	0,49	Velocity of flow =	1,57
901,50	901,75	6,49	23,19	0,280	2,78	Froude's Number =	0,50
901,75	902,00	13,33	31,60	0,422	7,50		
902,00	902,25	22,27	40,16	0,555	15,03		

Cross-sections 100 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	73,76	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	26,45
KALAI I (100 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	1,50
901,00	901,25	0,03	1,48	0,018	0,00	Cross-sectional area =	33,02
901,25	901,50	1,83	13,26	0,138	0,49	Velocity of flow =	2,23
901,50	901,75	6,49	23,19	0,280	2,78	Froude's Number =	0,58
901,75	902,00	13,33	31,60	0,422	7,50		
902,00	902,25	22,27	40,16	0,555	15,03		
902,25	902,50	33,02	46,06	0,717	26,45		
902,50	902,75	45,26	52,11	0,869	41,20		

Cross-sections 100 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250.00	
Discharge (Q)=	168,00	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	60,24
KALAI I (100 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	2,00
901,00	901,25	0,03	1,48	0,018	0,00	**Cross-sectional area =**	58,95
901,25	901,50	1,83	13,26	0,138	0,49	**Velocity of flow =**	2,85
901,50	901,75	6,49	23,19	0,280	2,78	**Froude's Number =**	0,64
901,75	902,00	13,33	31,60	0,422	7,50		
902,00	902,25	22,27	40,16	0,555	15,03		
902,25	902,50	33,02	46,06	0,717	26,45		
902,50	902,75	45,26	52,11	0,869	41,20		
902,75	903,00	58,95	57,05	1,033	60,25		
903,00	903,25	73,62	60,39	1,219	84,02		

Cross-sections 100 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	313,12	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	112,27
KALAI I (100 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	2,50
901,00	901,25	0,03	1,48	0,018	0,00	**Cross-sectional area =**	88,96
901,25	901,50	1,83	13,26	0,138	0,49	**Velocity of flow =**	3,52
901,50	901,75	6,49	23,19	0,280	2,78	**Froude's Number =**	0,71
901,75	902,00	13,33	31,60	0,422	7,50		
902,00	902,25	22,27	40,16	0,555	15,03		
902,25	902,50	33,02	46,06	0,717	26,45		
902,50	902,75	45,26	52,11	0,869	41,20		
902,75	903,00	58,95	57,05	1,033	60,25		
903,00	903,25	73,62	60,39	1,219	84,02		
903,25	903,50	88,96	62,75	1,418	112,27		
903,50	903,75	104,88	64,12	1,636	145,60		

Cross-sections 100 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	503,00	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	180,36
KALAI I (100 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	3,00
901,00	901,25	0,03	1,48	0,018	0,00	**Cross-sectional area =**	121,32
901,25	901,50	1,83	13,26	0,138	0,49	**Velocity of flow =**	4,15
901,50	901,75	6,49	23,19	0,280	2,78	**Froude's Number =**	0,76
901,75	902,00	13,33	31,60	0,422	7,50		
902,00	902,25	22,27	40,16	0,555	15,03		
902,25	902,50	33,02	46,06	0,717	26,45		
902,50	902,75	45,26	52,11	0,869	41,20		
902,75	903,00	58,95	57,05	1,033	60,25		
903,00	903,25	73,62	60,39	1,219	84,02		
903,25	903,50	88,96	62,75	1,418	112,27		
903,50	903,75	104,88	64,12	1,636	145,60		
903,75	904,00	121,32	66,93	1,813	180,36		
904,00	904,25	138,14	68,48	2,017	220,54		

For n=0.03 at 200 m cross-section (Kalai I)

Cross-sections 200 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	5,14	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	1,84
KALAI I (200 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	0,50
899,75	900,00	0,95	3,71	0,256	0,38	Cross-sectional area =	4,56
900,00	900,25	4,56	17,80	0,256	1,84	Velocity of flow =	1,13
900,25	900,50	10,47	29,59	0,354	5,24	Froude's Number =	0,51
900.50	900,75	18,78	36,57	0,514	12,04		

Cross-sections 200 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	33,57	Manning's n =	0,03	Bed Slope =	0.007	Qn/(S**1/2)=	12,04
KALAI I (200 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	1,00
899,75	900,00	0.95	3,71	0,256	0,38	Cross-sectional area =	18,78
900,00	900,25	4.56	17,80	0.256	1.84	Velocity of flow =	1,79
900,25	900,50	10,47	29,59	0,354	5,24	Froude's Number =	0,57
900,50	900,75	18,78	36,57	0,514	12,04		
900,75	901,00	28,61	41,86	0,683	22,19		

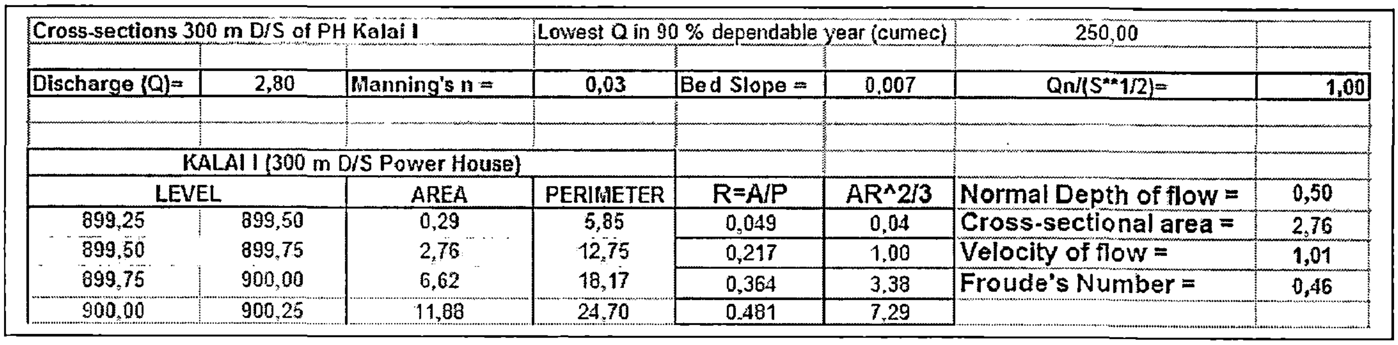
Cross-sections 200 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	95,27	Manning's n =	0,03	Bed Slope =	0.007	Qn/(S**1/2)=	34,16
KALAI I (200 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	1,50
899,75	900,00	0,95	3.71	0,256	0,38	Cross-sectional area =	40,07
900,00	900,25	4,56	17,80	0.256	1.84	Velocity of flow =	2,38
900,25	900,50	10,47	29,59	0,354	5,24	Froude's Number =	0,62
900.50	900,75	18,78	36,57	0,514	12,04		
900,75	901,00	28,61	41,86	0,683	22.19		
901,00	901,25	40,07	50,92	0,787	34,16		
901,25	901,50	53,19	59,12	0,900	49,57		

Cross-sections 200 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	202,85	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	72,74
KALAI I (200 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	2,00
899,75	900,00	0,95	3,71	0,256	0,38	**Cross-sectional area =**	69,29
900,00	900,25	4,56	17,80	0,256	1,84	**Velocity of flow =**	2,93
900,25	900,50	10,47	29,59	0,354	5,24	**Froude's Number =**	0,66
900,50	900,75	18,78	36,57	0,514	12,04		
900,75	901,00	28,61	41,86	0,683	22,19		
901,00	901,25	40,07	50,92	0,787	34,16		
901,25	901,50	53,19	59,12	0,900	49,57		
901,50	901,75	69,29	64,42	1,076	72,74		
901,75	902,00	85,84	68,03	1,262	100,24		

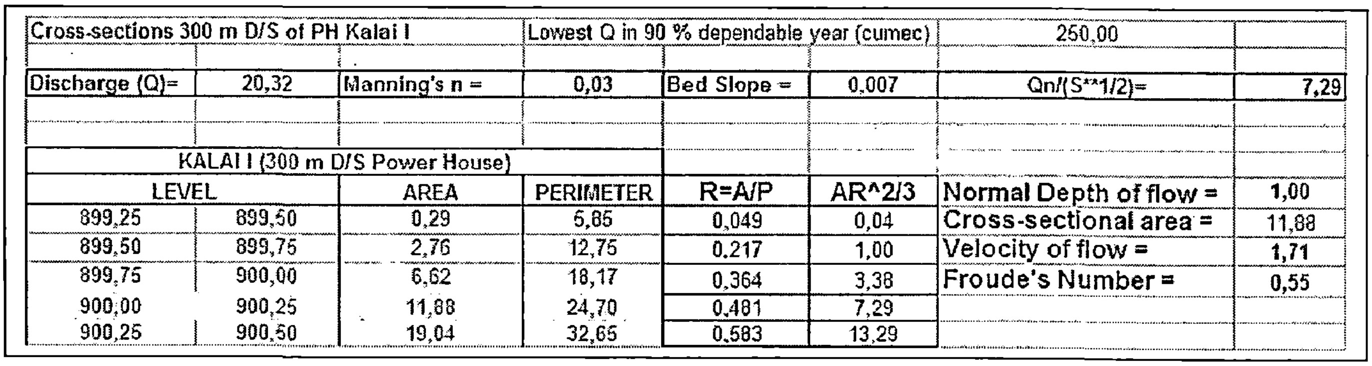
Cross-sections 200 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	370,50	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	132,85
KALAI I (200 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	2,50
899,75	900,00	0,95	3,71	0,256	0,38	**Cross-sectional area =**	103,12
900,00	900,25	4,56	17,80	0,256	1,84	**Velocity of flow =**	3,59
900,25	900,50	10,47	29,59	0,354	5,24	**Froude's Number =**	0,73
900,50	900,75	18,78	36,57	0,514	12,04		
900,75	901,00	28,61	41,86	0,683	22,19		
901,00	901,25	40,07	50,92	0,787	34,16		
901,25	901,50	53,19	59,12	0,900	49,57		
901,50	901,75	69,29	64,42	1,076	72,74		
901,75	902,00	85,84	68,03	1,262	100,24		
902,00	902,25	103,12	70,52	1,462	132,85		
902,25	902,50	120,97	72,87	1,660	169,59		

Cross-sections 200 m D/S of PH Kalai I		Lowest Q in 90 % dependable year (cumec)				250,00	
Discharge (Q)=	586,48	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	210,29
KALAI I (200 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	3,00
899,75	900,00	0,95	3,71	0,256	0,38	**Cross-sectional area =**	139,40
900,00	900,25	4,56	17,80	0,256	1,84	**Velocity of flow =**	4,21
900,25	900,50	10,47	29,59	0,354	5,24	**Froude's Number =**	0,78
900,50	900,75	18,78	36,57	0,514	12,04		
900,75	901,00	28,61	41,86	0,683	22,19		
901,00	901,25	40,07	50,92	0,787	34,16		
901,25	901,50	53,19	59,12	0,900	49,57		
901,50	901,75	69,29	64,42	1,076	72,74		
901,75	902,00	85,84	68,03	1,262	100,24		
902,00	902,25	103,12	70,52	1,462	132,85		
902,25	902,50	120,97	72,87	1,660	169,59		
902,50	902,75	139,40	75,23	1,853	210,29		
902,75	903,00	158,37	77,16	2,052	255,77		

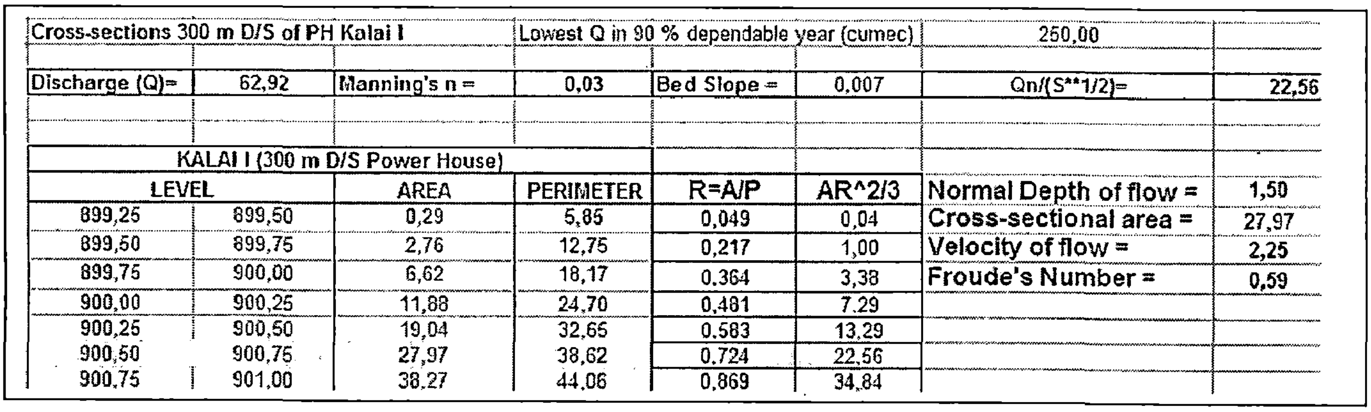
For n=0.03 at 300 m croos-section (Kalai I)



Cross-sections 300 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	2,80	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	1,00
KALAI I (300 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	0,50
899,25	899,50	0,29	5,85	0,049	0,04	Cross-sectional area =	2,76
899,50	899,75	2,76	12,75	0,217	1,00	Velocity of flow =	1,01
899,75	900,00	6,62	18,17	0,364	3,38	Froude's Number =	0,46
900,00	900,25	11,88	24,70	0,481	7,29		



Cross-sections 300 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	20,32	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	7,29
KALAI I (300 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	1,00
899,25	899,50	0,29	5,85	0,049	0,04	Cross-sectional area =	11,88
899,50	899,75	2,76	12,75	0,217	1,00	Velocity of flow =	1,71
899,75	900,00	6,62	18,17	0,364	3,38	Froude's Number =	0,55
900,00	900,25	11,88	24,70	0,481	7,29		
900,25	900,50	19,04	32,65	0,583	13,29		



Cross-sections 300 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	62,92	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	22,56
KALAI I (300 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	Normal Depth of flow =	1,50
899,25	899,50	0,29	5,85	0,049	0,04	Cross-sectional area =	27,97
899,50	899,75	2,76	12,75	0,217	1,00	Velocity of flow =	2,25
899,75	900,00	6,62	18,17	0,364	3,38	Froude's Number =	0,59
900,00	900,25	11,88	24,70	0,481	7,29		
900,25	900,50	19,04	32,65	0,583	13,29		
900,50	900,75	27,97	38,62	0,724	22,56		
900,75	901,00	38,27	44,06	0,869	34,84		

Cross-sections 300 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	143,90	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	51,60
KALAI I (300 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	2,00
899,25	899,50	0,29	5,85	0,049	0,04	**Cross-sectional area =**	49,84
899,50	899,75	2,76	12,75	0,217	1,00	**Velocity of flow =**	2,89
899,75	900,00	6,62	18,17	0,364	3,38	**Froude's Number =**	0,65
900,00	900,25	11,88	24,70	0,481	7,29		
900,25	900,50	19,04	32,65	0,583	13,29		
900,50	900,75	27,97	38,62	0,724	22,56		
900,75	901,00	38,27	44,06	0,869	34,84		
901,00	901,25	49,84	47,32	1,053	51,60		
901,25	901,50	61,94	49,32	1,256	72,10		

Cross-sections 300 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	267,74	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	96,00
KALAI I (300 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	2,50
899,25	899,50	0,29	5,85	0,049	0,04	**Cross-sectional area =**	74,35
899,50	899,75	2,76	12,75	0,217	1,00	**Velocity of flow =**	3,60
899,75	900,00	6,62	18,17	0,364	3,38	**Froude's Number =**	0,73
900,00	900,25	11,88	24,70	0,481	7,29		
900,25	900,50	19,04	32,65	0,583	13,29		
900,50	900,75	27,97	38,62	0,724	22,56		
900,75	901,00	38,27	44,06	0,869	34,84		
901,00	901,25	49,84	47,32	1,053	51,60		
901,25	901,50	61,94	49,32	1,256	72,10		
901,50	901,75	74,35	50,68	1,467	96,00		
901,75	902,00	87,08	52,03	1,673	122,74		

Cross-sections 300 m D/S of PH Kalai I			Lowest Q in 90 % dependable year (cumec)			250,00	
Discharge (Q)=	424,58	Manning's n =	0,03	Bed Slope =	0,007	Qn/(S**1/2)=	152,24
KALAI I (300 m D/S Power House)							
LEVEL		AREA	PERIMETER	R=A/P	AR^2/3	**Normal Depth of flow =**	3,00
899,25	899,50	0,29	5,85	0,049	0,04	**Cross-sectional area =**	100,12
899,50	899,75	2,76	12,75	0,217	1,00	**Velocity of flow =**	4,24
899,75	900,00	6,62	18,17	0,364	3,38	**Froude's Number =**	0,78
900,00	900,25	11,88	24,70	0,481	7,29		
900,25	900,50	19,04	32,65	0,583	13,29		
900,50	900,75	27,97	38,62	0,724	22,56		
900,75	901,00	38,27	44,06	0,869	34,84		
901,00	901,25	49,84	47,32	1,053	51,60		
901,25	901,50	61,94	49,32	1,256	72,10		
901,50	901,75	74,35	50,68	1,467	96,00		
901,75	902,00	87,08	52,03	1,673	122,74		
902,00	902,25	100,12	53,39	1,875	152,24		
902,25	902,50	113,81	54,75	2,079	185,36		

ANNEXURE-D

Water Quality monitoring in Lohit River for different months during 2009 at Kalai I and Demwe Lower proposed dam sites.

Table 1D Results of water quality monitoring for Kalai I hydroelectric project: April 2009.

Parameter	**W1**	**W2**	**W3**	**W4**	**W5**
pH	7.6	7.5	7.5	7.5	7.8
Electrical Conductivity, micromhos/cm	77	78	81	79	74
Total Dissolved Solids, mg/l	56	57	59	58	54
Hardness, mg/l	43	38	41	39	41
Chlorides, mg/l	7	11	8	9	12
Sulphates, mg/l	6	5	7	7	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.5	2.8	3.0	2.8	4.2
Potassium, mg/l	0.8	1.0	0.8	1.0	0.9
Calcium, mg/l	13.1	11.8	12.5	12.1	12.1
Magnesium, mg/l	2.9	2.1	2.4	2.2	2.4
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.7	1.5	1.3	1.2	1.3
COD, mg/l	3.2	2.9	2.5	2.4	2.5
DO, mg/l	9.8	9.7	9.7	9.8	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 2D Results of water quality monitoring for Kalai I hydroelectric project: May 2009.

Parameter	**W1**	**W2**	**W3**	**W4**	**W5**
pH	7.7	7.5	7.6	7.6	7.8
Electrical Conductivity, micromhos/cm	78	78	80	82	89
Total Dissolved Solids, mg/l	57	57	58	60	65
Hardness, mg/l	45.2	39.1	41.6	40.0	40.1
Chlorides, mg/l	7	10	10	9	12
Sulphates, mg/l	6	6	7	8	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	**W1**	**W2**	**W3**	**W4**	**W5**
Sodium, mg/l	3.6	2.9	3.2	3.1	4.1
Potassium, mg/l	1.0	1.0	1.0	1.0	1.0
Calcium, mg/l	13.3	12.0	12.5	12.2	12.1
Magnesium, mg/l	2.9	2.2	2.5	2.3	2.4
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.8	1.6	1.3	1.3	1.3
COD, mg/l	3.4	3.0	2.5	2.4	2.5
DO, mg/l	9.8	9.8	9.7	9.8	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 3D Results of water quality monitoring for Kalai I hydroelectric project: June 2009.

Parameter	**W1**	**W2**	**W3**	**W4**	**W5**
pH	7.8	7.7	7.7	7.6	7.8
Electrical Conductivity, micromhos/cm	79	81	78	71	90
Total Dissolved Solids, mg/l	58	59	57	52	66
Hardness, mg/l	43.5	40.0	41.3	40.6	42.8
Chlorides, mg/l	8	11	10	10	14
Sulphates, mg/l	6	7	7	8	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.7	3.0	3.3	3.3	4.0
Potassium, mg/l	1.0	1.0	0.9	0.9	1.0
Calcium, mg/l	12.8	12.2	12.4	12.3	12.5
Magnesium, mg/l	2.8	2.3	2.5	2.4	2.8
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.8	1.6	1.4	1.4	1.3
COD, mg/l	3.5	3.0	2.8	2.8	2.5
DO, mg/l	9.8	9.7	9.7	9.8	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 4D Results of water quality monitoring for Kalai-I hydroelectric project: July 2009.

Parameter	W1	W2	W3	W4	W5
pH	7.6	7.6	7.6	7.5	7.6
Electrical Conductivity, micromhos/cm	73	68	66	75	79
Total Dissolved Solids, mg/l	53	50	48	55	58
Hardness, mg/l	34.6	34.4	32.7	34.2	34.6
Chlorides, mg/l	6	8	9	8	7
Sulphates, mg/l	5	5	5	5	5
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	2.8	2.4	2.6	2.8	3.4
Potassium, mg/l	0.8	0.8	0.7	0.8	0.8
Calcium, mg/l	10.2	10.3	9.8	10.2	11.0
Magnesium, mg/l	2.2	2.1	2.0	2.1	2.2
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.4	1.2	1.2	1.2	1.2
COD, mg/l	2.6	2.2	2.3	2.2	2.2
DO, mg/l	9.9	9.8	9.8	9.9	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 5D Results of water quality monitoring for Kalai I hydroelectric project: August 2009.

Parameter	W1	W2	W3	W4	W5
pH	7.5	7.5	7.6	7.5	7.6
Electrical Conductivity, micromhos/cm	71	68	68	71	77
Total Dissolved Solids, mg/l	52	50	50	52	56
Hardness, mg/l	33.4	31.5	32.0	33.0	35.0
Chlorides, mg/l	6	6	7	8	7
Sulphates, mg/l	5	5	5	5	5
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	2.4	2.3	2.6	2.6	3.0
Potassium, mg/l	0.7	0.7	0.7	0.8	0.8
Calcium, mg/l	9.9	9.3	9.5	9.9	10.7
Magnesium, mg/l	2.1	2.0	2.0	2.0	2.0
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W1	W2	W3	W4	W5
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.3	1.3	1.3	1.2	1.2
COD, mg/l	2.5	2.3	2.4	2.2	2.3
DO, mg/l	9.8	9.9	9.9	9.8	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 6D Results of water quality monitoring for Kalai I hydroelectric project: September 2009.

Parameter	W1	W2	W3	W4	W5
pH	7.5	7.6	7.6	7.7	7.5
Electrical Conductivity, micromhos/cm	73	71	64	66	78
Total Dissolved Solids, mg/l	53	52	47	48	57
Hardness, mg/l	35.0	33.6	34.0	36.3	37.0
Chlorides, mg/l	8	7	10	8	8
Sulphates, mg/l	6	6	5	8	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	2.5	2.4	2.5	2.6	3.2
Potassium, mg/l	0.8	0.8	0.7	0.9	0.8
Calcium, mg/l	10.2	9.8	9.8	10.4	11.0
Magnesium, mg/l	2.3	2.2	2.2	2.5	2.3
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.4	1.2	1.2	1.2	1.4
COD, mg/l	2.8	2.3	2.3	2.2	2.7
DO, mg/l	9.9	9.7	9.8	9.9	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 7D Results of water quality monitoring for Demwe Lower hydroelectric project: April 2009.

Parameter	**W26**	**W27**	**W28**	**W29**	**W30**
pH	7.9	7.8	7.9	7.6	7.8
Electrical Conductivity, micromhos/cm	89	92	90	82	81
Total Dissolved Solids, mg/l	65	67	66	60	59
Hardness, mg/l	59	60	59	57	55
Chlorides, mg/l	10	10	10	13	11
Sulphates, mg/l	10	9	9	8	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	6.0	5.6	4.8	5.1	5.1
Potassium, mg/l	2.7	2.9	2.6	3.2	3.4
Calcium, mg/l	19.1	18.6	17.2	16.7	17.0
Magnesium, mg/l	2.8	3.4	3.8	3.6	3.1
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.2	2.0	1.8	1.9	1.8
COD, mg/l	4.2	3.7	3.6	3.7	3.5
DO, mg/l	9.6	9.5	9.7	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 8D Results of water quality monitoring for Demwe Lower hydroelectric project: May 2009.

Parameter	**W26**	**W27**	**W28**	**W29**	**W30**
pH	7.9	7.9	7.9	7.7	7.8
Electrical Conductivity, micromhos/cm	90	89	93	84	79
Total Dissolved Solids, mg/l	66	65	68	61	58
Hardness, mg/l	62	61	60	56	56
Chlorides, mg/l	11	10	12	12	11
Sulphates, mg/l	9	10	10	9	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	6.2	5.6	4.7	5.2	5.2
Potassium, mg/l	2.8	2.9	2.8	3.5	3.5
Calcium, mg/l	19.5	19.1	17.5	16.2	17.1
Magnesium, mg/l	3.1	3.2	3.6	3.8	3.2
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W26	W27	W28	W29	W30
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.1	2.0	1.8	1.8	1.8
COD, mg/l	4.1	3.9	3.6	3.4	3.5
DO, mg/l	9.6	9.6	9.6	9.6	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 9D Results of water quality monitoring for Demwe Lower hydroelectric project: June 2009.

Parameter	W26	W27	W28	W29	W30
pH	7.8	7.8	7.9	7.8	7.9
Electrical Conductivity, micromhos/cm	89	92	92	86	81
Total Dissolved Solids, mg/l	63	61	59	57	58
Hardness, mg/l	62	61	60	56	56
Chlorides, mg/l	10	10	10	11	10
Sulphates, mg/l	8	9	10	8	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	6.1	5.8	4.9	5.1	5.5
Potassium, mg/l	3.1	3.0	2.8	3.3	3.9
Calcium, mg/l	19.7	19.0	17.7	16.5	16.9
Magnesium, mg/l	3.3	3.2	3.5	3.8	3.6
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.0	2.0	1.9	2.1	2.0
COD, mg/l	4.0	3.9	3.8	4.1	3.9
DO, mg/l	9.6	9.5	9.5	9.6	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 10D Results of water quality monitoring for Demwe Lower hydroelectric project: July 2009.

Parameter	W26	W27	W28	W29	W30
pH	7.7	7.7	7.7	7.7	7.7
Electrical Conductivity, micromhos/cm	77	75	75	71	70
Total Dissolved Solids, mg/l	56	55	55	52	51
Hardness, mg/l	51	54	54	54	55
Chlorides, mg/l	8	8	9	7	9
Sulphates, mg/l	6	6	7	6	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.6	5.1	4.3	4.8	5.0
Potassium, mg/l	2.7	2.6	2.2	2.9	3.2
Calcium, mg/l	15.9	17.0	16.8	16.5	16.9
Magnesium, mg/l	2.6	2.8	2.9	3.1	3.0
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.7	1.7	1.5	1.8	1.5
COD, mg/l	3.3	3.2	3.0	3.5	2.9
DO, mg/l	9.7	9.7	9.6	9.6	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 11D Results of water quality monitoring for Demwe Lower hydroelectric project: August 2009.

Parameter	W26	W27	W28	W29	W30
pH	7.6	7.6	7.7	7.6	7.5
Electrical Conductivity, micromhos/cm	77	73	70	71	74
Total Dissolved Solids, mg/l	56	53	52	51	54
Hardness, mg/l	51	51	51	53	52
Chlorides, mg/l	8	7	9	7	7
Sulphates, mg/l	6	6	6	6	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.1	5.0	4.2	4.5	4.7
Potassium, mg/l	2.8	2.5	2.1	2.5	2.8
Calcium, mg/l	16.2	16.5	16.2	16.1	16.3
Magnesium, mg/l	2.6	2.5	2.6	3.0	2.8
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					

Parameter	**W26**	**W27**	**W28**	**W29**	**W30**
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.5	1.4	1.6	1.4
COD, mg/l	3.0	2.9	2.8	3.1	2.6
DO, mg/l	9.8	9.7	9.7	9.7	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 12D Results of water quality monitoring for Demwe Lower hydroelectric project: September 2009.

Parameter	**W26**	**W27**	**W28**	**W29**	**W30**
pH	7.5	7.6	7.5	7.5	7.5
Electrical Conductivity, micromhos/cm	71	66	68	69	71
Total Dissolved Solids, mg/l	52	48	50	50	52
Hardness, mg/l	52	50	52	50	51
Chlorides, mg/l	6	7	8	6	6
Sulphates, mg/l	6	6	5	5	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.6	4.5	4.0	4.3	4.3
Potassium, mg/l	2.6	2.3	2.0	2.2	2.5
Calcium, mg/l	16.1	16.2	16.1	15.7	16.0
Magnesium, mg/l	2.5	2.5	2.5	2.7	2.6
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l					
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.4	1.5	1.4	1.5	1.4
COD, mg/l	2.7	2.8	2.6	3.0	2.7
DO, mg/l	9.8	9.8	9.7	9.7	9.7
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

Table 1E Ten-daily extended flow (m^3s^{-1}) of the Pabbar River at Romai dam site.

Month		1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83
JUN	I	23.5	30.9	16.9	17.4	13.3	10.9	18.0	29.1
	II	20.2	28.3	15.2	15.0	16.8	13.7	19.7	36.8
	III	24.9	30.8	22.4	24.6	23.2	15.8	22.6	22.2
JUL	I	32.9	28.8	30.6	31.5	21.8	19.9	19.0	28.1
	II	38.0	31.9	39.5	38.4	23.8	23.6	28.0	27.5
	III	45.6	29.3	43.1	34.7	23.2	35.2	38.4	32.9
AUG	I	28.9	44.0	36.4	37.1	22.8	33.8	43.2	28.8
	II	36.6	38.6	21.6	30.2	23.4	16.2	37.4	39.7
	III	48.6	39.7	20.8	21.2	13.2	11.6	18.5	35.4
SEP	I	36.3	44.2	20.9	42.4	10.1	9.5	14.9	21.5
	II	35.0	27.0	26.9	20.1	9.1	11.4	11.8	19.2
	III	29.8	18.3	19.9	17.8	8.4	10.9	11.9	17.4
OCT	I	19.5	13.3	14.6	13.6	6.8	8.5	9.3	12.7
	II	15.5	11.2	12.6	12.2	6.0	7.2	6.8	9.2
	III	17.8	13.5	12.2	11.5	6.1	6.9	6.2	6.2
NOV	I	12.3	8.0	10.0	7.7	6.1	5.5	5.4	6.4
	II	10.5	7.1	7.7	8.0	5.8	5.0	4.8	5.6
	III	7.5	6.4	4.8	5.7	5.3	4.7	4.6	4.8
DEC	I	5.5	5.9	6.7	5.0	4.6	4.5	4.4	4.3
	II	5.0	5.5	5.9	5.5	4.2	4.5	4.2	4.1
	III	4.2	4.1	6.7	4.7	4.6	4.5	4.1	4.5
JAN	I	4.3	4.2	5.5	4.5	4.1	4.9	5.4	4.0
	II	4.2	4.2	4.8	4.3	4.0	4.5	3.4	3.7
	III	4.2	5.2	4.3	4.2	4.5	4.6	3.3	3.7
FEB	I	4.4	4.6	4.2	4.1	4.3	4.1	3.4	3.0
	II	5.2	4.2	5.3	4.2	4.0	4.1	3.7	2.7
	III	4.8	4.2	4.6	3.0	3.6	4.6	4.2	2.9
MAR	I	4.8	4.3	9.4	4.2	6.3	4.4	5.7	3.7
	II	4.9	5.2	8.7	4.3	4.2	4.7	6.7	4.4
	III	6.6	5.7	7.4	6.1	4.9	7.2	11.2	12.7
APR	I	6.8	6.2	10.1	7.0	5.2	8.7	14.4	13.7
	II	12.5	7.0	20.7	7.0	6.4	18.7	19.2	19.0
	III	19.8	8.6	13.0	8.6	9.7	18.7	30.5	24.5
MAY	I	18.4	7.9	13.4	10.5	10.3	21.8	32.1	27.1
	II	18.1	10.5	20.7	10.5	9.9	18.7	23.9	25.6
	III	20.8	14.4	21.2	14.6	12.6	20.7	24.1	25.9

Table contd...

Table 1E Ten-daily extended flow (m^3s^{-1}) of the Pabbar River at Romai dam site.

Month		1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
JUN	I	22.4	19.2	13.5	17.2	21.0	19.9	23.4	22.2
	II	18.1	18.2	12.9	18.8	22.4	16.7	17.7	19.7
	III	23.1	17.3	13.9	22.2	19.9	19.8	18.5	23.9
JUL	I	33.7	23.5	14.1	30.3	24.4	29.0	17.9	29.7
	II	27.0	24.3	17.8	31.5	26.8	37.4	22.4	32.4
	III	28.9	34.6	25.8	34.6	32.5	44.9	32.4	26.4
AUG	I	27.1	28.5	24.1	44.8	18.9	35.8	27.1	27.7
	II	31.9	34.5	25.7	43.5	20.4	28.0	29.7	30.7
	III	34.5	34.6	33.8	30.8	15.5	22.3	35.8	24.6
SEP	I	24.9	32.1	27.4	22.5	13.4	16.0	35.6	26.6
	II	20.1	30.9	22.0	16.5	11.6	14.8	19.2	24.3
	III	16.4	19.9	17.1	14.1	10.0	38.1	16.3	20.2
OCT	I	13.5	6.3	22.1	12.7	7.7	18.6	12.3	16.7
	II	14.9	5.8	24.4	11.5	6.6	15.2	11.3	10.6
	III	14.5	5.5	16.2	10.5	5.5	13.1	10.3	9.6
NOV	I	3.8	8.6	11.3	5.6	5.3	9.5	9.8	9.0
	II	5.2	5.1	8.5	5.1	5.0	8.1	9.4	8.7
	III	4.6	5.9	7.4	5.1	4.6	6.7	9.6	8.4
DEC	I	5.0	5.2	5.8	5.4	4.2	5.9	9.2	8.2
	II	4.3	4.4	5.7	7.9	4.0	4.9	8.3	7.9
	III	4.2	4.5	5.3	4.9	3.5	4.5	9.2	7.9
JAN	I	3.6	4.5	5.2	4.7	3.2	4.3	9.3	8.0
	II	3.4	4.2	4.5	4.8	3.0	5.7	9.1	7.9
	III	3.5	4.3	4.4	4.7	4.7	4.1	7.6	8.8
FEB	I	3.1	4.0	3.7	4.4	4.0	4.9	7.4	8.8
	II	3.3	4.0	6.4	4.7	4.1	4.8	8.3	9.8
	III	3.4	3.3	5.3	5.1	4.5	4.2	8.6	10.3
MAR	I	5.1	4.0	4.3	7.4	5.3	5.1	12.1	16.4
	II	7.2	4.6	4.8	6.5	8.1	5.5	14.7	15.2
	III	10.3	5.0	5.6	6.0	8.5	6.8	30.8	16.8
APR	I	11.1	5.5	5.8	7.4	8.8	8.9	17.8	15.9
	II	11.9	7.3	7.6	9.5	9.9	10.5	27.9	15.9
	III	13.6	7.7	9.5	10.4	11.9	15.0	31.8	16.9
MAY	I	16.3	7.8	13.8	16.8	14.1	17.0	27.4	20.1
	II	17.8	7.8	17.2	19.2	16.7	24.3	32.3	20.5
	III	12.3	9.3	12.9	13.5	20.0	24.9	27.5	18.8

Table contd...

Table 1E Ten-daily extended flow (m^3s^{-1}) of the Pabbar River at Romai dam site.

Month		1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
JUN	I	22.7	14.5	15.9	17.0	19.6	16.1	14.4	21.7
	II	21.7	16.4	16.0	17.4	23.1	16.3	15.1	41.2
	III	19.6	18.1	15.6	19.4	23.1	20.6	16.0	24.9
JUL	I	18.8	20.6	16.5	20.0	21.1	22.4	16.4	25.3
	II	19.1	21.4	32.1	28.5	25.5	22.8	17.1	25.5
	III	20.1	32.7	30.1	51.5	33.3	27.2	21.0	22.5
AUG	I	21.2	29.8	23.6	35.8	36.9	22.4	24.1	23.5
	II	21.8	31.2	21.7	33.8	36.1	29.5	23.6	26.3
	III	34.6	27.6	18.7	30.7	29.1	24.0	22.3	26.4
SEP	I	30.9	27.6	23.8	37.6	57.4	27.8	22.6	25.4
	II	26.1	27.2	26.7	32.8	37.7	23.0	18.8	26.1
	III	20.8	20.4	18.2	21.2	22.3	18.3	17.5	49.1
OCT	I	9.8	10.7	8.0	8.0	7.5	7.9	8.0	10.1
	II	9.2	6.9	5.7	6.7	6.5	6.9	7.5	14.8
	III	7.9	6.7	5.4	5.5	6.2	9.0	7.6	9.3
NOV	I	7.3	5.8	5.5	5.2	6.0	8.3	7.5	7.2
	II	7.0	5.0	5.4	4.6	5.8	7.3	7.1	6.4
	III	6.6	5.5	4.9	4.2	5.7	5.1	6.9	6.4
DEC	I	6.0	5.3	4.7	4.0	5.7	4.8	7.0	6.3
	II	5.7	4.8	4.2	4.3	5.5	4.7	7.2	5.6
	III	6.3	4.2	4.0	4.4	5.5	4.8	7.0	5.4
JAN	I	5.8	4.2	4.0	4.3	5.5	4.6	7.2	5.0
	II	5.8	4.4	4.0	4.0	5.6	4.6	6.5	4.9
	III	5.9	4.3	4.0	3.9	4.9	4.6	6.1	4.8
FEB	I	5.9	4.2	3.9	3.7	4.6	4.4	6.3	4.6
	II	5.8	4.5	3.9	4.0	4.6	4.3	5.9	4.6
	III	5.5	4.9	4.2	4.0	4.5	4.2	6.9	4.5
MAR	I	7.0	5.7	5.2	4.4	5.1	4.3	10.6	5.2
	II	7.4	6.0	6.2	4.5	5.4	4.4	8.3	5.1
	III	8.8	13.8	7.0	5.0	5.5	4.4	9.5	5.3
APR	I	9.6	13.7	8.9	5.3	6.4	4.7	16.0	5.3
	II	10.7	12.1	7.4	5.4	7.1	5.4	12.3	5.2
	III	13.9	17.0	7.3	5.6	7.1	4.9	11.7	5.5
MAY	I	15.7	19.3	8.1	5.9	7.5	7.1	9.3	6.2
	II	21.3	14.5	11.6	7.1	7.8	7.0	8.3	6.7
	III	23.7	14.2	11.5	7.8	7.9	7.3	8.1	7.3

Table contd...

Table 1E Ten-daily extended flow (m^3s^{-1}) of the Pabbar River at Romai dam site.

Month		1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
JUN	I	11.8	23.7	14.0	17.7	17.5	16.2	17.0	15.8	14.6
	II	11.1	17.7	14.2	17.4	17.5	17.3	17.6	14.7	15.2
	III	11.5	16.6	16.0	16.5	17.2	17.0	18.2	16.1	15.1
JUL	I	12.0	14.4	17.1	17.1	17.3	16.7	21.5	16.4	17.0
	II	15.4	22.7	21.9	16.1	17.7	13.9	25.2	19.1	15.5
	III	23.6	36.3	21.2	15.3	19.5	14.1	22.0	21.4	15.8
AUG	I	24.8	38.2	17.2	17.1	24.6	17.5	20.0	21.5	19.5
	II	22.5	34.6	22.0	24.9	21.9	19.6	19.0	19.7	18.9
	III	21.2	32.6	20.7	23.4	21.2	19.3	16.8	19.3	17.2
SEP	I	14.5	27.6	17.6	26.2	21.1	16.5	15.2	17.5	18.0
	II	13.9	27.2	15.4	26.7	19.2	15.5	16.8	15.2	15.5
	III	13.7	16.1	13.9	21.5	18.3	14.4	18.9	14.4	15.0
OCT	I	6.9	6.3	6.1	9.1	8.2	5.5	8.9	5.1	5.9
	II	6.8	5.5	5.5	7.8	7.6	5.3	8.1	4.6	5.1
	III	6.6	5.0	5.0	6.3	6.9	5.0	7.6	4.5	4.7
NOV	I	6.4	5.2	4.6	5.3	6.5	4.8	7.2	4.4	4.5
	II	6.5	4.8	4.4	5.0	5.9	4.5	6.8	4.4	4.4
	III	6.2	4.5	4.5	4.8	5.3	4.3	6.2	4.4	4.3
DEC	I	5.8	4.2	4.5	4.6	4.6	4.2	5.4	4.4	4.3
	II	5.5	4.2	4.5	4.4	4.3	4.2	5.0	4.4	4.3
	III	4.8	4.0	4.4	4.3	4.3	4.1	4.7	4.3	4.3
JAN	I	4.7	4.2	4.2	4.4	4.2	4.4	4.6	4.3	2.8
	II	4.8	4.5	4.2	4.5	4.4	4.4	4.6	4.2	2.8
	III	4.5	4.2	4.3	4.5	4.4	4.3	4.4	4.2	2.8
FEB	I	4.7	4.1	4.5	4.5	4.8	4.3	4.4	4.2	2.8
	II	4.6	4.4	4.7	4.4	4.5	4.8	4.8	4.4	2.8
	III	4.4	4.5	4.4	4.6	4.3	4.9	4.8	4.3	2.8
MAR	I	5.0	5.4	7.1	5.6	5.5	6.6	5.6	5.2	2.5
	II	5.5	5.5	6.5	5.6	5.9	8.9	5.8	6.4	2.5
	III	6.6	5.8	7.0	6.7	6.5	8.7	6.2	10.2	2.5
APR	I	8.7	5.7	8.7	8.6	6.5	7.6	6.7	10.3	2.5
	II	9.5	5.5	10.1	9.1	6.1	7.4	7.4	9.8	2.5
	III	9.7	5.4	10.6	10.0	6.6	7.4	8.1	9.1	2.5
MAY	I	9.8	5.4	10.3	10.4	7.5	8.7	8.4	9.6	2.5
	II	10.6	6.7	11.3	11.3	9.2	11.1	9.0	9.0	2.5
	III	9.4	7.8	11.1	11.8	10.1	11.2	9.5	7.2	2.5

Table 2E Ten-daily extended flow series in cumec-day at Barshil Nallah.

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	11.563	15.204	8.330	8.558	6.555	5.372	8.877	14.339	11.062	9.463	6.646	8.467	10.333	9.787	11.517	10.925	11.198	7.147
	II	10	9.969	13.930	7.466	7.375	8.285	6.737	9.696	18.118	8.922	8.968	6.373	9.241	11.062	8.239	8.740	9.696	10.698	8.057
	III	10	12.291	15.159	11.062	12.109	11.426	7.784	11.153	10.925	11.330	8.513	6.874	10.925	9.787	9.742	9.104	11.790	9.651	8.922
JUL	I	10	16.206	14.203	15.068	15.523	10.743	9.787	9.377	13.839	16.615	11.563	6.965	14.931	12.018	14.294	8.831	14.658	9.241	10.151
	II	10	18.709	15.705	19.483	18.937	11.745	11.608	13.793	13.565	13.292	11.972	8.786	15.523	13.201	18.436	11.062	15.978	9.423	10.561
	III	11	24.737	15.873	23.334	18.828	12.569	19.078	20.831	17.826	15.673	18.728	13.971	18.778	17.626	24.336	17.576	14.321	10.916	17.726
AUG	I	10	14.248	21.668	17.936	18.300	11.244	16.661	21.304	14.203	13.338	14.066	11.881	22.078	9.332	17.617	13.338	13.657	10.424	14.704
	II	10	18.027	19.028	10.652	14.886	11.517	7.966	18.436	19.574	15.705	16.980	12.655	21.441	10.060	13.793	14.612	15.113	10.743	15.386
	III	11	26.339	21.532	11.267	11.467	7.161	6.309	10.015	19.178	18.678	18.778	18.327	16.675	8.412	12.068	19.429	13.320	18.778	14.972
SEP	I	10	17.890	21.759	10.288	20.834	4.962	4.689	7.329	10.807	12.291	15.798	13.520	11.107	6.601	7.875	17.526	13.110	15.204	13.611
	II	10	17.253	13.292	13.247	9.924	4.461	5.599	5.827	9.469	9.924	15.250	10.834	8.148	5.736	7.283	9.469	11.972	12.837	13.383
	III	10	14.704	9.013	9.787	8.786	4.142	5.372	5.872	8.558	8.057	9.787	8.422	6.965	4.916	18.755	8.012	9.969	10.242	10.060
OCT	I	10	9.605	6.555	7.192	6.692	3.369	4.188	4.598	6.236	6.646	3.095	10.880	6.282	3.778	9.150	6.054	8.239	4.825	5.281
	II	10	7.648	5.508	6.191	6.009	2.959	3.551	3.369	4.552	7.329	2.868	12.018	5.690	3.232	7.466	5.554	5.235	4.552	3.414
	III	11	9.664	7.311	6.610	6.259	3.305	3.766	3.355	3.355	7.862	2.954	8.763	5.708	3.004	7.110	5.558	5.208	4.256	3.605
NOV	I	10	6.054	3.960	4.916	3.778	3.004	2.686	2.640	3.141	1.866	4.234	5.554	2.777	2.595	4.689	4.825	4.416	3.596	2.868
	II	10	5.189	3.505	3.778	3.960	2.868	2.458	2.367	2.777	2.549	2.504	4.188	2.504	2.458	4.006	4.643	4.279	3.460	2.458
	III	10	3.687	3.141	2.367	2.822	2.595	2.322	2.276	2.367	2.276	2.913	3.642	2.504	2.276	3.323	4.734	4.142	3.232	2.686
DEC	I	10	2.731	2.913	3.323	2.458	2.276	2.231	2.185	2.140	2.458	2.549	2.868	2.640	2.094	2.913	4.552	4.051	2.959	2.595
	II	10	2.458	2.686	2.913	2.731	2.094	2.231	2.048	2.003	2.140	2.185	2.822	3.869	1.957	2.413	4.097	3.869	2.822	2.367
	III	11	2.303	2.203	3.605	2.554	2.504	2.454	2.203	2.454	2.253	2.454	2.854	2.654	1.903	2.454	5.007	4.306	3.405	2.303
JAN	I	10	2.140	2.048	2.731	2.231	2.003	2.413	2.640	1.957	1.775	2.231	2.549	2.322	1.593	2.140	4.598	3.960	2.868	2.094
	II	10	2.094	2.094	2.367	2.140	1.957	2.231	1.684	1.821	1.684	2.048	2.231	2.367	1.457	2.822	4.461	3.869	2.868	2.185
	III	11	2.253	2.804	2.353	2.303	2.454	2.504	1.803	2.003	1.903	2.353	2.404	2.554	2.554	2.203	4.106	4.757	3.205	2.353
FEB	I	10	2.185	2.276	2.048	2.003	2.140	2.003	1.684	1.502	1.548	1.957	1.821	2.185	1.957	2.413	3.642	4.325	2.913	2.094
	II	10	2.549	2.094	2.595	2.048	1.957	2.003	1.821	1.320	1.639	1.957	3.141	2.322	2.003	2.367	4.097	4.825	2.868	2.231
	III	8	2.130	1.639	1.821	1.202	1.598	1.821	1.675	1.129	1.516	1.311	2.076	2.003	2.008	1.639	3.387	4.079	2.417	1.930
MAR	I	10	2.367	2.140	4.643	2.048	3.095	2.185	2.822	1.821	2.504	1.957	2.140	3.642	2.595	2.504	5.963	8.103	3.460	2.822
	II	10	2.413	2.549	4.279	2.140	2.094	2.322	3.278	2.185	3.551	2.276	2.367	3.187	4.006	2.731	7.238	7.511	3.642	2.959
	III	11	3.555	3.105	4.006	3.305	2.654	3.906	6.059	6.860	5.608	2.704	3.055	3.255	4.607	3.705	16.675	9.113	4.757	7.461
APR	I	10	3.369	3.050	4.962	3.460	2.549	4.279	7.101	6.737	5.463	2.686	2.868	3.642	4.325	4.370	8.786	7.830	4.734	6.737
	II	10	6.145	3.460	10.197	3.460	3.141	9.195	9.469	9.377	5.872	3.596	3.733	4.689	4.871	5.189	13.748	7.830	5.281	5.963
	III	10	9.742	4.234	6.419	4.234	4.780	9.195	15.022	12.063	6.692	3.778	4.689	5.144	5.872	7.375	15.659	8.330	6.828	8.376
MAY	I	10	9.059	3.915	6.601	5.189	5.098	10.743	15.796	13.338	8.012	3.824	6.783	8.285	6.965	8.376	13.520	9.924	7.739	9.514
	II	10	8.922	5.189	10.197	5.189	4.871	9.195	11.790	12.610	8.786	3.824	8.467	9.469	8.239	11.972	15.933	10.106	10.516	7.147
	III	11	11.267	7.812	11.517	7.912	6.810	11.217	13.069	14.021	6.660	5.057	7.010	7.311	10.816	13.470	14.922	10.215	12.869	7.711
Leap Year																				
A.Flow (Cumec-Day)			321.465	282.558	275.552	251.712	176.984	208.048	263.266	287.971	253.529	227.185	234.173	261.281	206.250	279.026	330.975	303.034	249.427	243.837
Annual Flow (Cumec)			0.878	0.774	0.755	0.690	0.484	0.570	0.721	0.789	0.693	0.622	0.642	0.716	0.564	0.764	0.907	0.830	0.681	0.668
Annual Volume (MCM)			27.775	24.413	23.808	21.748	15.291	17.975	22.746	24.881	21.905	19.629	20.233	22.575	17.820	24.108	28.596	26.182	21.551	21.068
A.V. Basin (Cumec)			0.640																	

Table 2E Ten-daily extended flow series in cumec-day at Barshil Nallah (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	7.830	8.376	9.651	7.921	7.101	10.698	5.827	11.693	6.919	8.740	8.604	7.966	8.376	7.784	7.192	9.092	15.204	5.372	2.250
	II	10	7.875	8.558	11.380	8.012	7.420	20.303	5.463	8.740	7.010	8.558	8.604	8.513	8.695	7.238	7.456	9.255	20.303	5.463	3.034
	III	10	7.693	9.560	11.380	10.151	7.875	12.291	5.645	8.194	7.876	8.148	8.467	8.376	8.968	7.921	7.420	9.653	15.159	5.645	1.993
JUL	I	10	8.148	9.878	10.379	11.016	8.103	12.473	5.918	7.101	8.422	8.422	8.513	8.239	10.607	8.103	8.376	10.840	16.615	5.918	2.995
	II	10	15.842	14.066	12.564	11.244	8.422	12.564	7.602	11.198	10.789	7.921	8.740	6.874	12.427	9.423	7.648	12.397	19.483	6.874	3.491
	III	11	16.324	27.891	18.027	14.722	11.367	12.218	12.769	19.679	11.517	8.312	10.566	7.661	11.918	11.617	8.563	15.936	27.891	7.661	4.962
AUG	I	10	11.608	17.617	18.163	11.062	11.881	11.563	12.200	18.800	8.467	8.422	12.109	9.604	9.878	10.607	9.605	13.836	22.078	8.422	3.963
	II	10	10.698	16.661	17.799	14.521	11.608	12.974	11.107	17.025	10.834	12.245	10.789	9.651	9.377	9.696	9.332	13.663	21.441	7.966	3.548
	III	11	10.115	16.625	15.773	13.019	12.068	14.321	11.517	17.676	11.217	12.669	11.467	10.465	9.113	10.465	9.314	13.895	26.339	6.309	4.565
SEP	I	10	11.745	18.527	28.269	13.702	11.153	12.518	7.147	19.611	8.649	12.928	10.379	8.148	7.466	8.604	8.877	12.327	28.269	4.689	5.161
	II	10	13.156	16.160	18.573	11.335	9.241	12.837	6.874	13.383	7.602	13.156	9.469	7.648	8.285	7.466	7.648	10.507	18.573	4.461	3.551
	III	10	8.968	10.470	10.971	9.013	8.604	24.218	6.737	7.921	6.828	10.607	9.013	7.101	9.332	7.101	7.375	9.263	24.218	4.142	3.797
OCT	I	10	3.960	3.960	3.687	3.869	3.960	4.962	3.414	3.095	3.004	4.461	4.051	2.686	4.370	2.504	2.913	5.078	10.880	2.504	2.114
	II	10	2.822	3.323	3.187	3.414	3.687	7.283	3.369	2.731	2.686	3.824	3.733	2.595	4.006	2.276	2.504	4.503	12.018	2.276	2.088
	III	11	2.904	3.004	3.355	4.857	4.106	5.057	3.555	2.704	2.704	3.405	3.756	2.704	4.106	2.454	2.554	4.511	9.664	2.454	1.926
NOV	I	10	2.686	2.549	2.959	4.097	3.687	3.551	3.141	2.549	2.276	2.595	3.187	2.367	3.551	2.185	2.231	3.370	6.054	1.866	1.024
	II	10	2.640	2.276	2.868	3.596	3.505	3.141	3.187	2.367	2.185	2.458	2.913	2.231	3.369	2.185	2.185	3.062	5.189	2.185	0.795
	III	10	2.413	2.094	2.822	2.504	3.414	3.141	3.050	2.231	2.231	2.367	2.595	2.140	3.050	2.185	2.140	2.778	4.734	2.094	0.623
DEC	I	10	2.322	1.957	2.822	2.367	3.460	3.095	2.868	2.048	2.231	2.276	2.276	2.094	2.640	2.185	2.140	2.628	4.552	1.957	0.578
	II	10	2.094	2.140	2.731	2.322	3.551	2.777	2.731	2.048	2.231	2.185	2.140	2.048	2.458	2.185	2.140	2.530	4.097	1.957	0.574
	III	11	2.153	2.404	3.004	2.604	3.806	2.904	2.604	2.153	2.404	2.353	2.353	2.203	2.554	2.353	2.353	2.669	5.007	1.903	0.663
JAN	I	10	1.957	2.140	2.686	2.276	3.551	2.458	2.322	2.094	2.094	2.185	2.094	2.185	2.276	2.140	1.366	2.367	4.598	1.366	0.629
	II	10	1.957	1.957	2.777	2.276	3.187	2.413	2.367	2.231	2.048	2.231	2.185	2.185	2.276	2.094	1.366	2.301	4.461	1.366	0.613
	III	11	2.153	2.103	2.654	2.504	3.305	2.604	2.454	2.303	2.353	2.454	2.404	2.353	2.404	2.253	1.502	2.505	4.757	1.502	0.606
FEB	I	10	1.912	1.821	2.276	2.185	3.095	2.276	2.322	2.003	2.231	2.231	2.367	2.140	2.185	2.048	1.366	2.217	4.325	1.366	0.574
	II	10	1.912	1.957	2.276	2.140	2.913	2.276	2.276	2.185	2.322	2.185	2.231	2.367	2.367	2.185	1.366	2.327	4.825	1.320	0.673
	III	8	1.639	1.566	2.008	1.675	2.731	1.784	1.967	1.784	1.748	1.821	1.926	1.930	1.894	1.712	1.229	1.903	4.079	1.129	0.578
MAR	I	10	2.549	2.185	2.504	2.140	5.235	2.549	2.458	2.640	3.505	2.777	2.686	3.232	2.777	2.549	1.229	2.964	8.103	1.229	1.324
	II	10	3.050	2.231	2.640	2.185	4.097	2.504	2.731	2.686	3.187	2.777	2.913	4.370	2.868	3.141	1.229	3.131	7.511	1.229	1.294
	III	11	3.806	2.704	2.954	2.404	5.158	2.854	3.555	3.155	3.806	3.605	3.505	4.707	3.355	5.508	1.352	4.449	16.675	1.352	2.705
APR	I	10	4.370	2.595	3.141	2.322	7.875	2.595	4.279	2.822	4.279	4.234	3.187	3.733	3.323	5.098	1.229	4.304	8.786	1.229	1.805
	II	10	3.642	2.640	3.505	2.640	6.054	2.549	4.689	2.731	4.962	4.507	3.004	3.642	3.642	4.825	1.229	5.136	13.748	1.229	2.695
	III	10	3.595	2.777	3.505	2.413	5.781	2.731	4.780	2.640	5.235	4.916	3.232	3.642	4.006	4.507	1.229	5.861	15.659	1.229	3.387
MAY	I	10	4.006	2.913	3.687	3.505	4.598	3.050	4.825	2.640	5.098	5.144	3.687	4.279	4.142	4.734	1.229	6.370	15.796	1.229	3.437
	II	10	5.736	3.505	3.824	3.460	4.097	3.278	5.235	3.323	5.554	5.554	4.552	5.463	4.416	4.416	1.229	6.850	15.933	1.229	3.390
	III	11	6.259	4.206	4.256	3.956	4.407	3.956	5.108	4.206	6.009	6.409	5.458	6.059	5.158	3.906	1.352	7.587	14.922	1.352	3.549
Leap Year																					
A.Flow (Cumec-Day)			202.540	235.397	255.058	203.428	214.102	244.766	178.090	216.401	182.510	199.080	189.152	172.600	191.633	177.653	139.474	232.065			
Annual Flow (Cumec)			0.555	0.645	0.697	0.557	0.587	0.671	0.487	0.593	0.500	0.545	0.517	0.473	0.525	0.487	0.381	0.635			
Annual Volume (MCM)			17.499	20.338	22.037	17.576	18.498	21.148	15.387	18.697	15.769	17.201	16.343	14.913	16.557	15.349	12.051	20.050			
A.V. Basin (Cumec)			0.640																		

Table 3E Ten-daily extended flow series in cumec-day at Khanyara Nallah.

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	25.080	32.979	18.069	18.563	14.218	11.651	19.254	31.103	23.994	20.538	14.416	18.365	22.414	21.229	24.981	23.697	24.290	15.502
	II	10	21.624	30.214	16.193	15.996	17.971	14.613	21.031	39.298	19.353	19.452	13.823	20.044	23.994	17.872	18.958	21.031	23.204	17.477
	III	10	26.660	32.880	23.994	26.265	24.784	16.884	24.191	23.697	24.685	18.464	14.910	23.697	21.229	21.130	19.748	25.573	20.933	19.353
JUL	I	10	35.151	30.807	32.683	33.670	23.302	21.229	20.340	30.017	36.040	25.080	15.107	32.386	26.067	31.004	19.155	31.794	20.044	22.019
	II	10	40.582	34.065	42.260	41.075	25.475	25.178	29.918	29.424	28.832	25.968	19.057	33.670	28.634	39.989	23.994	34.657	20.439	22.907
	III	11	53.655	34.430	50.614	40.839	27.262	41.382	45.183	38.686	33.996	40.621	30.303	40.730	38.232	52.786	38.123	31.063	23.678	38.449
AUG	I	10	30.905	47.000	38.903	39.693	24.389	36.139	46.210	30.807	28.931	30.510	25.771	47.888	20.242	38.212	28.931	29.622	22.611	31.893
	II	10	39.101	41.273	23.105	32.288	24.981	17.279	39.989	42.458	34.065	36.830	27.449	46.506	21.821	29.918	31.695	32.781	23.302	33.374
	III	11	57.130	46.704	24.438	24.872	15.532	13.685	21.723	41.599	40.513	40.730	39.752	36.168	18.247	26.176	42.142	28.891	40.730	32.475
SEP	I	10	38.804	47.197	22.315	45.321	10.763	10.170	15.897	23.006	26.660	34.262	29.326	24.092	14.317	17.082	38.015	28.437	32.979	29.523
	II	10	37.422	28.832	28.733	21.525	9.676	12.145	12.639	20.638	21.525	33.078	23.500	17.674	12.441	15.798	20.538	25.968	27.844	29.029
	III	10	31.893	19.550	21.229	19.057	8.985	11.651	12.737	18.563	17.477	21.229	18.267	15.107	10.664	40.681	17.378	21.624	22.216	21.821
OCT	I	10	20.834	14.218	15.601	14.515	7.307	9.084	9.973	13.527	14.416	6.714	23.599	13.626	8.195	19.847	13.132	17.872	10.466	11.454
	II	10	16.588	11.947	13.429	13.034	6.418	7.702	7.307	9.874	15.897	6.221	26.067	12.342	7.010	16.193	12.046	11.355	9.874	7.405
	III	11	20.962	15.858	14.337	13.577	7.168	8.146	7.277	7.277	17.052	6.408	19.007	12.382	6.517	15.423	12.056	11.296	9.232	7.820
NOV	I	10	13.132	8.590	10.664	8.195	6.517	5.826	5.727	6.813	4.048	9.183	12.046	6.023	5.628	10.170	10.466	9.578	7.800	6.221
	II	10	11.256	7.603	8.195	8.590	6.221	5.332	5.134	6.023	5.529	5.431	9.084	5.431	5.332	8.689	10.071	9.281	7.504	5.332
	III	10	7.998	6.813	5.134	6.122	5.628	5.036	4.937	5.134	4.937	6.319	7.899	5.431	4.937	7.208	10.269	8.985	7.010	5.826
DEC	I	10	5.924	6.319	7.208	5.332	4.937	4.838	4.739	4.641	5.332	5.529	6.221	5.727	4.542	6.319	9.874	8.788	6.418	5.628
	II	10	5.332	5.826	6.319	5.924	4.542	4.838	4.443	4.345	4.641	4.739	6.122	8.393	4.246	5.233	8.887	8.393	6.122	5.134
	III	11	4.996	4.779	7.820	5.539	5.431	5.322	4.779	5.322	4.888	5.322	6.191	5.756	4.127	5.322	10.861	9.341	7.386	4.996
JAN	I	10	4.641	4.443	5.924	4.838	4.345	5.233	5.727	4.246	3.851	4.838	5.529	5.036	3.456	4.641	9.973	8.590	6.221	4.542
	II	10	4.542	4.542	5.134	4.641	4.246	4.838	3.653	3.950	3.653	4.443	4.838	5.134	3.160	6.122	9.676	8.393	6.221	4.739
	III	11	4.888	6.082	5.105	4.996	5.322	5.431	3.910	4.345	4.127	5.105	5.213	5.539	5.539	4.779	8.906	10.318	6.951	5.105
FEB	I	10	4.739	4.937	4.443	4.345	4.641	4.345	3.653	3.258	3.357	4.246	3.950	4.739	4.246	5.233	7.899	9.380	6.319	4.542
	II	10	5.529	4.542	5.628	4.443	4.246	4.345	3.950	2.863	3.555	4.246	6.813	5.036	4.345	5.134	8.887	10.466	6.221	4.838
	III	8	4.621	3.555	3.950	2.607	3.466	3.950	3.634	2.449	3.288	2.844	4.503	4.345	4.354	3.555	7.346	8.847	5.243	4.187
MAR	I	10	5.134	4.641	10.071	4.443	6.714	4.739	6.122	3.950	5.431	4.246	4.641	7.899	5.628	5.431	12.935	17.576	7.504	6.122
	II	10	5.233	5.529	9.281	4.641	4.542	5.036	7.109	4.739	7.702	4.937	5.134	6.912	8.689	5.924	15.700	16.292	7.899	6.418
	III	11	7.712	6.734	8.689	7.168	5.756	8.472	13.142	14.880	12.165	5.865	6.625	7.060	9.992	8.037	36.168	19.768	10.318	16.183
APR	I	10	7.307	6.616	10.763	7.504	5.529	9.281	15.403	14.613	11.849	5.826	6.221	7.899	9.380	9.479	19.057	16.983	10.269	14.613
	II	10	13.330	7.504	22.118	7.504	6.813	19.945	20.538	20.340	12.737	7.800	8.097	10.170	10.565	11.256	29.819	16.983	11.454	12.935
	III	10	21.130	9.183	13.922	9.183	10.368	19.945	32.584	26.166	14.515	8.195	10.170	11.158	12.737	15.996	33.966	18.069	14.811	18.168
MAY	I	10	19.649	8.492	14.317	11.256	11.059	23.302	34.262	28.931	17.378	8.294	14.712	17.971	15.107	18.168	29.326	21.625	16.786	20.636
	II	10	19.353	11.256	22.118	11.256	10.565	19.945	25.573	27.351	19.057	8.294	18.365	20.538	17.872	25.968	34.559	21.920	22.809	15.502
	III	11	24.438	16.944	24.981	17.161	14.771	24.329	28.348	30.412	14.446	10.970	15.206	15.858	23.460	29.217	32.367	22.157	27.914	16.726
Leap Year																				
A.Flow (Cumec-Day)			697.276	612.884	597.688	545.978	383.888	451.267	571.038	624.624	549.918	492.777	507.934	566.733	447.367	605.222	717.903	657.297	541.021	528.896
Annual Flow (Cumec)			1.905	1.679	1.638	1.496	1.049	1.236	1.564	1.711	1.503	1.350	1.392	1.653	1.222	1.658	1.967	1.801	1.478	1.449
Annual Volume (MCM)			60.245	52.953	51.640	47.173	33.168	38.990	49.338	53.967	47.513	42.576	43.885	48.966	38.653	52.291	62.027.	56.790	46.744	45.697
A.V. Basin (Cumec)			1.380																	

Table 3E Ten-daily extended flow series in cumec-day at Khanyara Nallah (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	16.983	18.168	20.933	17.181	15.403	23.204	12.639	25.376	15.008	18.958	18.662	17.279	18.168	16.884	15.601	19.721	32.979	11.651	4.881
	II	10	17.082	18.563	24.685	17.378	16.094	44.038	11.849	18.958	15.206	18.563	18.662	18.464	18.859	15.700	16.193	20.074	44.038	11.849	6.580
	III	10	16.687	20.735	24.685	22.019	17.082	26.660	12.244	17.773	17.082	17.674	18.365	18.168	19.452	17.181	16.094	20.939	32.880	12.244	4.324
JUL	I	10	17.674	21.426	22.513	23.895	17.576	27.055	12.836	15.403	18.267	18.267	18.464	17.872	23.006	17.576	18.168	23.512	36.040	12.836	6.496
	II	10	34.361	30.510	27.252	24.389	18.267	27.252	16.489	24.290	23.401	17.181	18.958	14.910	26.956	20.439	16.588	26.890	42.260	14.910	7.573
	III	11	35.408	60.497	39.101	31.932	24.655	26.502	27.696	42.685	24.981	18.030	22.917	16.618	25.850	25.198	18.573	34.565	60.497	16.618	10.764
AUG	I	10	25.178	38.212	39.397	23.994	25.771	25.080	26.462	40.779	18.365	18.267	26.265	18.662	21.426	23.006	20.834	30.011	47.888	18.267	8.597
	II	10	23.204	36.139	38.607	31.498	25.178	28.141	24.092	36.928	23.500	26.561	23.401	20.933	20.340	21.031	20.242	29.637	46.506	17.279	7.695
	III	11	21.940	36.060	34.213	28.239	26.176	31.063	24.981	38.340	24.329	27.479	24.872	22.700	19.768	22.700	20.202	30.138	57.130	13.685	9.901
SEP	I	10	25.475	40.187	61.317	29.720	24.191	27.153	15.502	29.523	18.760	28.042	22.513	17.674	16.193	18.662	19.254	26.737	61.317	10.170	11.195
	II	10	28.536	35.052	40.286	24.586	20.044	27.844	14.910	29.029	16.489	28.536	20.538	16.588	17.971	16.193	16.588	22.791	40.286	9.676	7.703
	III	10	19.452	22.710	23.796	19.550	18.662	52.529	14.613	17.181	14.811	23.006	19.550	15.403	20.242	15.403	15.996	20.092	52.529	8.985	8.236
OCT	I	10	8.590	8.590	7.998	8.393	8.590	10.763	7.405	6.714	6.517	9.676	8.788	5.826	9.479	5.431	6.319	11.014	23.599	5.431	4.585
	II	10	6.122	7.208	6.912	7.405	7.998	15.798	7.307	5.924	5.826	8.294	8.097	5.628	8.689	4.937	5.431	9.766	26.067	4.937	4.529
	III	11	6.300	6.517	7.277	10.535	8.906	10.970	7.712	5.865	5.865	7.386	8.146	5.865	8.906	5.322	5.539	9.785	20.962	5.322	4.178
NOV	I	10	5.826	5.529	6.418	8.887	7.998	7.702	6.813	5.529	4.937	5.628	6.912	5.134	7.702	4.739	4.838	7.310	13.132	4.048	2.221
	II	10	5.727	4.937	6.221	7.800	7.603	6.813	6.312	5.134	4.739	5.332	6.319	4.838	7.307	4.739	4.739	6.642	11.256	4.739	1.724
	III	10	5.233	4.542	6.122	5.431	7.405	6.813	6.616	4.838	4.838	5.134	5.628	4.641	6.616	4.739	4.641	6.026	10.269	4.542	1.365
DEC	I	10	5.036	4.246	6.122	5.134	7.504	6.714	6.221	4.443	4.838	4.937	4.937	4.542	5.727	4.739	4.641	5.700	9.874	4.246	1.254
	II	10	4.542	4.641	5.924	5.036	7.702	6.023	5.924	4.443	4.838	4.739	4.641	4.443	5.332	4.739	4.641	5.488	8.887	4.246	1.244
	III	11	4.670	5.213	6.517	5.648	8.255	6.300	5.648	4.670	5.213	5.105	5.105	4.779	5.539	5.105	5.105	5.789	10.861	4.127	1.438
JAN	I	10	4.246	4.641	5.826	4.937	7.702	5.332	5.036	4.542	4.542	4.739	4.542	4.739	4.937	4.641	2.962	5.134	9.973	2.962	1.365
	II	10	4.246	4.246	6.023	4.937	6.912	5.233	5.134	4.838	4.443	4.838	4.739	4.739	4.937	4.542	2.962	4.991	9.676	2.962	1.330
	III	11	4.670	4.562	5.756	5.431	7.168	5.648	5.322	4.996	5.105	5.322	5.213	5.105	5.213	4.888	3.258	5.434	10.318	3.258	1.314
FEB	I	10	4.147	3.950	4.937	4.739	6.714	4.937	5.036	4.345	4.838	4.838	5.134	4.641	4.739	4.443	2.962	4.808	9.380	2.962	1.245
	II	10	4.147	4.246	4.937	4.641	6.319	4.937	4.937	4.739	5.036	4.739	4.838	5.134	5.134	4.739	2.962	5.048	10.466	2.863	1.461
	III	8	3.555	3.397	4.354	3.634	5.924	3.871	4.266	3.871	3.792	3.950	4.177	4.187	4.108	3.713	2.666	4.127	8.847	2.449	1.253
MAR	I	10	5.529	4.739	5.431	4.641	11.355	5.529	5.332	5.727	7.603	6.023	5.826	7.010	6.023	5.529	2.666	6.430	17.576	2.666	2.871
	II	10	6.616	4.838	5.727	4.739	8.887	5.431	5.924	5.826	6.912	6.023	6.319	9.479	6.221	6.813	2.666	6.792	16.292	2.666	2.807
	III	11	8.255	5.865	6.408	5.213	11.187	6.191	7.712	6.843	8.255	7.820	7.603	10.210	7.277	11.947	2.933	9.650	36.168	2.933	5.867
APR	I	10	9.479	5.628	6.813	5.036	17.082	5.628	9.281	6.122	9.281	9.183	6.912	8.097	7.208	11.059	2.666	9.335	19.057	2.666	3.914
	II	10	7.899	5.727	7.603	5.727	13.132	5.529	10.170	5.924	10.763	9.775	6.517	7.899	7.899	10.466	2.666	11.140	29.819	2.666	5.846
	III	10	7.800	6.023	7.603	5.233	12.540	5.924	10.368	5.727	11.355	10.664	7.010	7.899	8.689	9.775	2.666	12.713	33.966	2.666	7.348
MAY	I	10	8.689	6.319	7.998	7.603	9.973	6.616	10.466	5.727	11.059	11.158	7.938	9.281	8.985	10.269	2.666	13.817	34.262	2.666	7.454
	II	10	12.441	7.603	8.294	7.504	8.887	7.109	11.355	7.208	12.046	12.046	9.874	11.849	9.578	9.578	2.666	14.859	34.559	2.666	7.352
	III	11	13.577	9.123	9.232	8.580	9.558	8.580	11.079	9.123	13.034	13.902	11.839	13.142	11.187	8.472	2.933	16.457	32.367	2.933	7.699
Leap Year																					
A.Flow (Cumec-Day)			439.32	510.5899	553.2353	441.2454	464.3998	530.9104	386.2872	469.3861	395.8748	431.8158	410.2808	374.3783	415.6621	385.3393	302.5268	503.3625123			
Annual Flow (Cumec)			1.203616	1.398876	1.511572	1.208892	1.272328	1.454549	1.05543	1.285989	1.084588	1.183057	1.120986	1.025697	1.1388	1.055724	0.826576	1.378106378			
Annual Volume (MCM)			37.95725	44.11497	47.79953	38.1236	40.12414	45.87066	33.37522	40.55496	34.20358	37.30889	35.44826	32.34637	35.91321	33.29332	28.13832	43.49052106			
A.V. Basin (Cumec)			1.380																		

Table 4E Ten-daily extended flow series in cumec-day at Nallah 1

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	5.522	7.261	3.978	4.087	3.130	2.565	4.239	6.848	5.283	4.522	3.174	4.043	4.935	4.674	5.500	5.217	5.348	3.413
	II	10	4.761	6.652	3.565	3.522	3.957	3.217	4.630	8.652	4.261	4.283	3.043	4.413	5.283	3.935	4.174	4.630	5.109	3.848
	III	10	5.870	7.239	5.283	5.783	5.457	3.717	5.326	5.217	5.435	4.065	3.283	5.217	4.674	4.652	4.348	5.630	4.609	4.261
JUL	I	10	7.739	6.783	7.196	7.413	5.130	4.674	4.478	6.609	7.935	5.522	3.326	7.130	5.739	6.826	4.217	7.000	4.413	4.848
	II	10	8.335	7.500	9.304	9.043	5.609	5.543	6.587	6.478	6.348	5.717	4.196	7.413	6.304	8.804	5.283	7.630	4.500	5.043
	III	11	11.813	7.590	11.143	8.991	6.002	9.111	9.948	8.513	7.485	8.943	6.672	8.967	8.417	11.622	8.393	6.839	5.213	8.465
AUG	I	10	6.804	10.348	8.565	8.739	5.370	7.957	10.174	6.783	6.370	6.717	5.674	10.543	4.457	8.413	6.370	6.522	4.978	7.022
	II	10	8.609	9.087	5.087	7.109	5.500	3.804	8.804	9.348	7.500	8.109	6.043	10.239	4.804	6.587	6.978	7.217	5.130	7.348
	III	11	12.578	10.283	5.380	5.476	3.420	3.013	4.783	9.159	8.920	8.967	8.752	7.963	4.017	5.763	9.278	6.361	8.967	7.150
SEP	I	10	8.543	10.391	4.913	9.978	2.370	2.239	3.500	5.065	5.870	7.543	6.457	5.304	3.152	3.761	8.370	6.261	7.261	6.500
	II	10	8.239	6.348	6.326	4.739	2.130	2.674	2.783	4.522	4.739	7.283	5.174	3.891	2.739	3.478	4.522	5.717	6.130	6.391
	III	10	7.022	4.304	4.674	4.196	1.978	2.565	2.804	4.087	3.848	4.674	4.022	3.326	2.348	8.957	3.826	4.761	4.891	4.804
OCT	I	10	4.587	3.130	3.435	3.196	1.609	2.000	2.196	2.978	3.174	1.478	5.196	3.000	1.804	4.370	2.891	3.935	2.304	2.522
	II	10	3.652	2.630	2.957	2.870	1.413	1.696	1.609	2.174	3.500	1.370	5.739	2.717	1.543	3.565	2.652	2.500	2.174	1.630
	III	11	4.615	3.491	3.157	2.989	1.578	1.793	1.602	1.602	3.754	1.411	4.185	2.726	1.435	3.396	2.654	2.487	2.033	1.722
NOV	I	10	2.891	1.891	2.348	1.804	1.435	1.283	1.261	1.500	0.891	2.022	2.652	1.326	1.239	2.239	2.304	2.109	1.717	1.370
	II	10	2.478	1.674	1.804	1.891	1.370	1.174	1.130	1.326	1.217	1.196	2.000	1.196	1.174	1.913	2.217	2.043	1.652	1.174
	III	10	1.761	1.500	1.130	1.348	1.239	1.109	1.087	1.130	1.087	1.391	1.739	1.196	1.087	1.587	2.261	1.978	1.543	1.283
DEC	I	10	1.304	1.391	1.587	1.174	1.087	1.065	1.043	1.022	1.174	1.217	1.370	1.261	1.000	1.391	2.174	1.935	1.413	1.239
	II	10	1.174	1.283	1.391	1.304	1.000	1.065	0.978	0.957	1.022	1.043	1.348	1.848	0.935	1.152	1.957	1.848	1.348	1.130
	III	11	1.100	1.052	1.722	1.220	1.196	1.172	1.052	1.172	1.076	1.172	1.363	1.267	0.909	1.172	2.391	2.057	1.626	1.100
JAN	I	10	1.022	0.978	1.304	1.065	0.957	1.152	1.261	0.935	0.848	1.065	1.217	1.109	0.761	1.022	2.196	1.891	1.370	1.000
	II	10	1.000	1.000	1.130	1.022	0.935	1.065	0.804	0.870	0.804	0.978	1.065	1.130	0.696	1.348	2.130	1.848	1.370	1.043
	III	11	1.076	1.339	1.124	1.100	1.172	1.196	0.861	0.957	0.909	1.124	1.148	1.220	1.220	1.052	1.961	2.272	1.530	1.124
FEB	I	10	1.043	1.087	0.978	0.957	1.022	0.957	0.804	0.717	0.739	0.935	0.870	1.043	0.935	1.152	1.739	2.065	1.391	1.000
	II	10	1.217	1.000	1.239	0.978	0.935	0.957	0.870	0.630	0.783	0.935	1.500	1.109	0.957	1.130	1.957	2.304	1.370	1.065
	III	8	1.017	0.783	0.870	0.574	0.763	0.870	0.800	0.539	0.724	0.626	0.991	0.957	0.959	0.783	1.617	1.948	1.154	0.922
MAR	I	10	1.130	1.022	2.217	0.978	1.478	1.043	1.348	0.870	1.196	0.935	1.022	1.739	1.239	1.196	2.848	3.870	1.652	1.348
	II	10	1.152	1.217	2.043	1.022	1.000	1.109	1.565	1.043	1.696	1.087	1.130	1.522	1.913	1.304	3.457	3.587	1.739	1.413
	III	11	1.698	1.483	1.913	1.578	1.267	1.865	2.893	3.276	2.678	1.291	1.459	1.554	2.200	1.770	7.963	4.352	2.272	3.563
APR	I	10	1.609	1.457	2.370	1.652	1.217	2.043	3.391	3.217	2.609	1.283	1.370	1.739	2.065	2.087	4.196	3.739	2.261	3.217
	II	10	2.935	1.652	4.870	1.652	1.500	4.391	4.522	4.478	2.804	1.717	1.783	2.239	2.326	2.478	6.565	3.739	2.522	2.848
	III	10	4.652	2.022	3.065	2.022	2.283	4.391	7.174	5.761	3.196	1.804	2.239	2.457	2.804	3.522	7.478	3.978	3.261	4.000
MAY	I	10	4.328	1.870	3.152	2.478	2.435	5.130	7.543	6.370	3.826	1.826	3.239	3.957	3.326	4.000	6.457	4.739	3.696	4.543
	II	10	4.261	2.478	4.870	2.478	2.326	4.391	5.630	6.022	4.196	1.826	4.043	4.522	3.935	5.717	7.609	4.826	5.022	3.413
	III	11	5.380	3.730	5.500	3.778	3.252	5.357	6.241	6.696	3.180	2.415	3.348	3.491	5.165	6.433	7.126	4.878	6.146	3.683
Leap Year																				
A.Flow (Cumec-Day)			153.517	134.937	131.591	120.207	84.520	99.354	125.724	137.522	121.074	108.493	111.830	124.776	98.496	133.250	158.059	144.715	119.115	116.446
Annual Flow (Cumec)			0.419	0.370	0.361	0.329	0.231	0.272	0.344	0.377	0.331	0.297	0.306	0.342	0.269	0.365	0.433	0.396	0.325	0.319
Annual Volume (MCM)			13.264	11.659	11.369	10.386	7.302	8.584	10.863	11.882	10.461	9.374	9.662	10.781	8.510	11.513	13.656	12.503	10.292	10.061
A.V. Basin (Cumec)			0.303																	

Table 4E Ten-daily extended flow series in cumec-day at Nallah 1 (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	3.739	4.000	4.609	3.783	3.391	5.109	2.783	5.587	3.304	4.174	4.109	3.804	4.000	3.717	3.435	4.342	7.261	2.565	1.075
	II	10	3.761	4.087	5.435	3.826	3.543	9.696	2.609	4.174	3.348	4.087	4.109	4.065	4.152	3.457	3.565	4.420	9.696	2.609	1.449
	III	10	3.674	4.565	5.435	4.848	3.761	5.870	2.696	3.913	3.761	3.891	4.043	4.000	4.283	3.783	3.543	4.610	7.239	2.696	0.952
JUL	I	10	3.891	4.717	4.957	5.261	3.870	5.957	2.826	3.391	4.022	4.022	4.065	3.935	5.065	3.870	4.000	5.177	7.935	2.826	1.430
	II	10	7.565	6.717	6.000	5.370	4.022	6.000	3.630	5.348	5.152	3.783	4.174	3.283	5.935	4.500	3.652	5.920	9.304	3.283	1.667
	III	11	7.796	13.320	8.609	7.030	5.428	5.835	6.098	9.398	5.500	3.970	5.046	3.659	5.691	5.548	4.089	7.610	13.320	3.659	2.370
AUG	I	10	5.543	8.413	8.674	5.283	5.674	5.522	5.826	8.978	4.043	4.022	5.783	4.109	4.717	5.065	4.587	6.607	10.543	4.022	1.893
	II	10	5.109	7.957	8.500	6.935	5.543	6.196	5.304	8.130	5.174	5.848	5.152	4.609	4.478	4.630	4.457	6.525	10.239	3.804	1.694
	III	11	4.830	7.939	7.533	6.217	5.763	6.839	5.500	8.441	5.357	6.050	5.476	4.998	4.352	4.998	4.448	6.636	12.578	3.013	2.160
SEP	I	10	5.609	8.848	13.500	6.543	5.326	5.978	3.413	6.500	4.130	6.174	4.957	3.891	3.565	4.109	4.239	5.887	13.500	2.239	2.465
	II	10	6.283	7.717	8.870	5.413	4.413	6.130	3.283	6.391	3.630	6.283	4.522	3.652	3.957	3.565	3.652	5.018	8.870	2.130	1.696
	III	10	4.283	5.000	5.239	4.304	4.109	11.565	3.217	3.783	3.261	5.065	4.304	3.391	4.457	3.391	3.522	4.424	11.565	1.978	1.813
OCT	I	10	1.891	1.891	1.761	1.848	1.891	2.370	1.630	1.478	1.435	2.130	1.935	1.283	2.087	1.196	1.391	2.425	5.196	1.196	1.009
	II	10	1.348	1.587	1.522	1.630	1.761	3.478	1.609	1.304	1.283	1.826	1.783	1.239	1.913	1.087	1.196	2.150	5.739	1.087	0.997
	III	11	1.387	1.435	1.602	2.320	1.961	2.415	1.698	1.291	1.291	1.626	1.793	1.291	1.961	1.172	1.220	2.154	4.615	1.172	0.920
NOV	I	10	1.283	1.217	1.413	1.957	1.761	1.696	1.500	1.217	1.087	1.239	1.522	1.130	1.696	1.043	1.065	1.609	2.891	0.891	0.489
	II	10	1.261	1.087	1.370	1.717	1.674	1.500	1.522	1.130	1.043	1.174	1.391	1.065	1.609	1.043	1.043	1.462	2.478	1.043	0.380
	III	10	1.152	1.000	1.348	1.196	1.630	1.500	1.457	1.065	1.065	1.130	1.239	1.022	1.457	1.043	1.022	1.327	2.261	1.000	0.300
DEC	I	10	1.109	0.935	1.348	1.130	1.652	1.478	1.370	0.978	1.065	1.087	1.087	1.000	1.261	1.043	1.022	1.255	2.174	0.935	0.276
	II	10	1.000	1.022	1.304	1.109	1.696	1.326	1.304	0.978	1.065	1.043	1.022	0.978	1.174	1.043	1.022	1.208	1.957	0.935	0.274
	III	11	1.028	1.148	1.435	1.243	1.817	1.387	1.243	1.028	1.148	1.124	1.124	1.052	1.220	1.124	1.124	1.275	2.391	0.909	0.317
JAN	I	10	0.935	1.022	1.283	1.087	1.696	1.174	1.109	1.000	1.000	1.043	1.000	1.043	1.087	1.022	0.652	1.130	2.196	0.652	0.300
	II	10	0.935	0.935	1.326	1.087	1.522	1.152	1.130	1.065	0.978	1.065	1.043	1.043	1.087	1.000	0.652	1.099	2.130	0.652	0.293
	III	11	1.028	1.004	1.267	1.196	1.578	1.243	1.172	1.100	1.124	1.172	1.148	1.124	1.148	1.076	0.717	1.196	2.272	0.717	0.289
FEB	I	10	0.913	0.870	1.087	1.043	1.478	1.087	1.109	0.957	1.065	1.065	1.130	1.022	1.043	0.978	0.652	1.059	2.065	0.652	0.274
	II	10	0.913	0.935	1.087	1.022	1.391	1.087	1.087	1.043	1.109	1.043	1.065	1.130	1.130	1.043	0.652	1.111	2.304	0.630	0.322
	III	8	0.783	0.748	0.959	0.800	1.304	0.852	0.939	0.852	0.835	0.870	0.920	0.922	0.904	0.817	0.587	0.909	1.948	0.539	0.276
MAR	I	10	1.217	1.043	1.196	1.022	2.500	1.217	1.174	1.261	1.674	1.326	1.283	1.543	1.326	1.217	0.587	1.416	3.870	0.587	0.632
	II	10	1.457	1.065	1.261	1.043	1.957	1.196	1.304	1.283	1.522	1.326	1.391	2.087	1.370	1.500	0.587	1.495	3.587	0.587	0.618
	III	11	1.817	1.291	1.411	1.148	2.463	1.363	1.698	1.507	1.817	1.722	1.674	2.248	1.602	2.630	0.646	2.125	7.963	0.646	1.292
APR	I	10	2.087	1.239	1.500	1.109	3.761	1.239	2.043	1.348	2.043	2.022	1.522	1.783	1.587	2.435	0.587	2.055	4.196	0.587	0.862
	II	10	1.739	1.261	1.674	1.261	2.891	1.217	2.239	1.304	2.370	2.152	1.435	1.739	1.739	2.304	0.587	2.453	6.565	0.587	1.287
	III	10	1.717	1.326	1.674	1.152	2.761	1.304	2.283	1.261	2.500	2.348	1.543	1.739	1.913	2.152	0.587	2.799	7.478	0.587	1.618
MAY	I	10	1.913	1.391	1.761	1.674	2.196	1.457	2.304	1.261	2.435	2.457	1.761	2.043	1.978	2.261	0.587	3.042	7.543	0.587	1.641
	II	10	2.739	1.674	1.826	1.652	1.957	1.565	2.500	1.587	2.652	2.652	2.174	2.609	2.109	2.109	0.587	3.271	7.609	0.587	1.619
	III	11	2.989	2.009	2.033	1.889	2.104	1.889	2.439	2.009	2.870	3.061	2.607	2.893	2.463	1.865	0.646	3.623	7.126	0.646	1.695
Leap Year																					
A.Flow (Cumec-Day)			96.724	112.415	121.804	97.148	102.246	116.889	85.048	103.343	87.159	95.072	90.330	82.426	91.515	84.839	66.607	110.824			
Annual Flow (Cumec)			0.265	0.308	0.333	0.266	0.280	0.320	0.232	0.283	0.239	0.260	0.247	0.226	0.251	0.232	0.182	0.303			
Annual Volume (MCM)			8.357	9.713	10.524	8.394	8.834	10.099	7.348	8.929	7.531	8.214	7.805	7.122	7.907	7.330	5.755	9.575			
A.V. Basin (Cumec)			0.303																		

Table 5E Ten-daily extended flow series in cumec-day at Bandi Nallah

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	7.245	9.526	5.219	5.362	4.107	3.366	5.562	8.984	6.931	5.933	4.164	5.305	6.474	6.132	7.216	6.845	7.016	4.478
	II	10	6.246	8.728	4.678	4.621	5.191	4.221	6.075	11.352	5.590	5.619	3.993	5.790	6.931	5.162	5.476	6.075	6.703	5.048
	III	10	7.701	9.498	6.931	7.587	7.159	4.877	6.988	6.845	7.130	5.334	4.307	6.845	6.132	6.104	5.704	7.387	6.047	5.590
JUL	I	10	10.154	8.893	9.441	9.726	6.731	6.132	5.875	8.671	10.410	7.245	4.364	9.355	7.530	8.956	5.533	9.184	5.790	6.360
	II	10	11.722	9.840	12.207	11.865	7.359	7.273	8.642	8.499	8.328	7.501	5.505	9.726	8.271	11.551	6.931	10.011	5.904	6.617
	III	11	15.499	9.946	14.620	11.797	7.875	11.953	13.052	11.169	9.820	11.734	8.753	11.765	11.044	15.248	11.012	8.973	6.840	11.106
AUG	I	10	8.927	13.576	11.238	11.466	7.045	10.439	13.348	8.899	8.357	8.813	7.444	13.833	5.847	11.038	8.357	8.557	6.531	9.213
	II	10	11.295	11.922	6.674	9.327	7.216	4.931	11.551	12.264	9.840	10.639	7.929	13.434	6.303	8.642	9.155	9.469	6.731	9.640
	III	11	16.503	13.491	7.059	7.185	4.486	3.953	6.275	12.016	11.702	11.765	11.483	10.448	5.271	7.561	12.173	8.345	11.765	9.381
SEP	I	10	11.209	13.633	6.446	13.091	3.109	2.938	4.592	6.646	7.701	9.897	8.471	6.959	4.136	4.934	10.981	8.214	9.526	8.528
	II	10	10.810	8.328	8.300	6.218	2.795	3.508	3.651	5.933	6.218	9.555	6.788	5.105	3.594	4.563	5.933	7.501	8.043	8.385
	III	10	9.213	5.647	6.132	5.505	2.595	3.366	3.679	5.362	5.048	6.132	5.277	4.364	3.080	11.751	5.020	6.246	6.417	6.303
OCT	I	10	6.018	4.107	4.506	4.193	2.111	2.624	2.881	3.907	4.164	1.939	6.817	3.936	2.367	5.733	3.793	5.162	3.023	3.309
	II	10	4.792	3.451	3.879	3.765	1.854	2.225	2.111	2.852	4.592	1.797	7.530	3.565	2.025	4.678	3.480	3.280	2.852	2.139
	III	11	6.055	4.581	4.141	3.922	2.071	2.353	2.102	2.102	4.926	1.851	5.490	3.677	1.882	4.455	3.483	3.263	2.667	2.259
NOV	I	10	3.793	2.481	3.080	2.367	1.882	1.683	1.654	1.968	1.169	2.653	3.480	1.740	1.626	2.938	3.023	2.767	2.253	1.797
	II	10	3.251	2.196	2.367	2.481	1.797	1.540	1.483	1.740	1.597	1.569	2.624	1.569	1.540	2.510	2.909	2.681	2.168	1.540
	III	10	2.310	1.968	1.483	1.768	1.626	1.455	1.426	1.483	1.426	1.825	2.282	1.569	1.426	2.082	2.966	2.595	2.025	1.683
DEC	I	10	1.711	1.825	2.082	1.540	1.426	1.398	1.369	1.341	1.540	1.597	1.797	1.654	1.312	1.825	2.852	2.538	1.854	1.626
	II	10	1.540	1.683	1.825	1.711	1.312	1.398	1.283	1.256	1.341	1.369	1.768	2.424	1.226	1.512	2.567	2.424	1.768	1.483
	III	11	1.443	1.380	2.259	1.600	1.569	1.537	1.380	1.537	1.412	1.537	1.788	1.663	1.192	1.537	3.137	2.698	2.133	1.443
JAN	I	10	1.341	1.283	1.711	1.398	1.255	1.512	1.654	1.226	1.112	1.398	1.597	1.455	0.998	1.341	2.881	2.481	1.797	1.312
	II	10	1.312	1.312	1.483	1.341	1.226	1.398	1.055	1.141	1.056	1.283	1.398	1.483	0.913	1.768	2.795	2.424	1.797	1.369
	III	11	1.412	1.757	1.475	1.443	1.537	1.569	1.129	1.255	1.192	1.475	1.506	1.600	1.600	1.380	2.573	2.981	2.008	1.475
FEB	I	10	1.369	1.426	1.283	1.255	1.341	1.265	1.055	0.941	0.970	1.226	1.141	1.369	1.226	1.512	2.282	2.710	1.825	1.312
	II	10	1.597	1.312	1.626	1.283	1.226	1.255	1.141	0.827	1.027	1.226	1.968	1.455	1.255	1.483	2.567	3.023	1.797	1.398
	III	8	1.335	1.027	1.141	0.753	1.001	1.141	1.050	0.707	0.950	0.821	1.301	1.255	1.258	1.027	2.122	2.556	1.515	1.209
MAR	I	10	1.483	1.341	2.909	1.283	1.939	1.369	1.768	1.141	1.569	1.226	1.341	2.282	1.626	1.569	3.736	5.077	2.168	1.768
	II	10	1.512	1.597	2.681	1.341	1.312	1.455	2.054	1.369	2.225	1.426	1.483	1.997	2.510	1.711	4.535	4.706	2.282	1.854
	III	11	2.228	1.945	2.510	2.071	1.663	2.447	3.796	4.298	3.514	1.694	1.914	2.039	2.886	2.322	10.448	5.710	2.981	4.675
APR	I	10	2.111	1.911	3.109	2.168	1.597	2.681	4.449	4.221	3.423	1.683	1.797	2.282	2.710	2.738	5.505	4.906	2.966	4.221
	II	10	3.850	2.168	6.389	2.168	1.968	5.761	5.933	5.875	3.679	2.253	2.339	2.938	3.052	3.251	8.614	4.906	3.309	3.736
	III	10	6.104	2.653	4.022	2.653	2.995	5.761	9.412	7.558	4.193	2.367	2.938	3.223	3.679	4.621	9.811	5.219	4.278	5.248
MAY	I	10	5.676	2.453	4.136	3.251	3.194	6.731	9.897	8.357	5.020	2.396	4.250	5.191	4.364	5.248	8.471	6.218	4.849	5.961
	II	10	5.590	3.251	6.389	3.251	3.052	5.761	7.387	7.901	5.505	2.396	5.305	5.933	5.162	7.501	9.983	6.332	6.589	4.478
	III	11	7.059	4.894	7.216	4.957	4.267	7.028	8.189	8.785	4.173	3.169	4.392	4.581	6.777	8.440	9.349	6.400	8.063	4.832
Leap Year																				
A.Flow (Cumec-Day)			201.415	177.037	172.648	157.711	110.890	130.353	164.950	180.429	158.849	142.343	146.722	163.706	129.226	174.824	207.373	189.866	156.279	152.777
Annual Flow (Cumec)			0.550	0.485	0.473	0.432	0.303	0.357	0.452	0.494	0.434	0.390	0.402	0.449	0.353	0.479	0.568	0.520	0.427	0.419
Annual Volume (MCM)			17.402	15.296	14.917	13.626	9.581	11.262	14.252	15.589	13.725	12.298	12.677	14.144	11.165	15.105	17.917	16.404	13.503	13.200
A.V. Basin (Cumec)			0.398																	

Table 5E Ten-daily extended flow series in cumec-day at Bandi Nallah (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	4.906	5.248	6.047	4.963	4.449	6.703	3.651	7.330	4.335	5.476	5.391	4.991	5.248	4.877	4.506	5.697	9.526	3.366	1.410
	II	10	4.934	5.362	7.130	5.020	4.649	12.721	3.423	5.476	4.392	5.362	5.391	5.334	5.448	4.535	4.678	5.799	12.721	3.423	1.901
	III	10	4.820	5.990	7.130	6.360	4.934	7.701	3.537	5.134	4.934	5.105	5.305	5.248	5.619	4.363	4.649	6.048	9.498	3.537	1.249
JUL	I	10	5.105	6.189	6.503	6.902	5.077	7.815	3.708	4.449	5.277	5.277	5.334	5.162	6.646	5.077	5.248	6.792	10.410	3.708	1.876
	II	10	9.926	8.813	7.872	7.045	5.277	7.872	4.763	7.016	6.760	4.963	6.476	4.307	7.786	5.904	4.792	7.767	12.207	4.307	2.187
	III	11	10.228	17.475	11.295	9.224	7.122	7.655	8.000	12.330	7.216	5.208	6.620	4.800	7.467	7.279	5.365	9.985	17.475	4.800	3.109
AUG	I	10	7.273	11.038	11.380	6.931	7.444	7.245	7.644	11.779	5.305	5.277	7.587	5.391	6.189	6.646	6.018	8.669	13.833	5.277	2.483
	II	10	6.703	10.439	11.152	9.098	7.273	8.129	6.959	10.667	6.788	7.672	6.760	6.047	5.875	6.075	5.847	8.561	13.434	4.991	2.223
	III	11	6.338	10.416	9.883	8.157	7.561	8.973	7.216	11.075	7.028	7.938	7.185	6.557	5.710	6.557	5.836	8.706	16.503	3.953	2.860
SEP	I	10	7.359	11.608	17.712	8.585	6.988	7.843	4.478	8.528	5.419	8.100	6.503	5.105	4.678	5.391	5.562	7.723	17.712	2.938	3.234
	II	10	8.243	10.125	11.637	7.102	5.790	8.043	4.307	8.365	4.763	8.243	5.933	4.792	5.191	4.678	4.792	6.583	11.637	2.795	2.225
	III	10	5.619	6.560	6.874	5.647	5.391	15.174	4.221	4.963	4.278	6.646	5.647	4.449	5.847	4.449	4.621	5.804	15.174	2.595	2.379
OCT	I	10	2.481	2.481	2.310	2.424	2.481	3.109	2.139	1.939	1.882	2.795	2.538	1.683	2.738	1.569	1.825	3.181	6.817	1.569	1.324
	II	10	1.768	2.082	1.997	2.139	2.310	4.563	2.111	1.711	1.683	2.396	2.339	1.626	2.510	1.426	1.569	2.821	7.530	1.426	1.308
	III	11	1.820	1.882	2.102	3.043	2.573	3.169	2.228	1.694	1.694	2.133	2.353	1.694	2.573	1.537	1.600	2.827	6.055	1.537	1.207
NOV	I	10	1.683	1.597	1.654	2.567	2.310	2.225	1.968	1.537	1.426	1.626	1.997	1.483	2.225	1.369	1.398	2.111	3.793	1.169	0.642
	II	10	1.654	1.426	1.797	2.253	2.196	1.968	1.997	1.483	1.369	1.540	1.825	1.398	2.111	1.369	1.369	1.919	3.251	1.369	0.498
	III	10	1.512	1.312	1.768	1.569	2.139	1.968	1.911	1.398	1.398	1.483	1.626	1.341	1.911	1.369	1.341	1.741	2.966	1.312	0.394
DEC	I	10	1.455	1.226	1.768	1.483	2.168	1.939	1.797	1.283	1.398	1.426	1.426	1.312	1.654	1.369	1.341	1.646	2.852	1.226	0.362
	II	10	1.312	1.341	1.711	1.455	2.225	1.740	1.711	1.283	1.398	1.369	1.341	1.283	1.540	1.369	1.341	1.585	2.567	1.226	0.359
	III	11	1.349	1.506	1.882	1.631	2.384	1.820	1.631	1.349	1.506	1.475	1.475	1.380	1.600	1.475	1.475	1.672	3.137	1.192	0.415
JAN	I	10	1.226	1.341	1.683	1.426	2.225	1.540	1.455	1.312	1.312	1.369	1.312	1.369	1.426	1.341	0.856	1.483	2.881	0.856	0.394
	II	10	1.226	1.226	1.740	1.426	1.997	1.512	1.483	1.398	1.283	1.398	1.369	1.369	1.426	1.312	0.856	1.442	2.795	0.856	0.384
	III	11	1.349	1.318	1.663	1.569	2.071	1.631	1.537	1.443	1.475	1.537	1.506	1.475	1.506	1.412	0.941	1.570	2.981	0.941	0.380
FEB	I	10	1.198	1.141	1.426	1.369	1.939	1.426	1.455	1.255	1.398	1.398	1.483	1.341	1.369	1.283	0.856	1.389	2.710	0.856	0.360
	II	10	1.198	1.226	1.426	1.341	1.825	1.426	1.426	1.369	1.455	1.369	1.398	1.483	1.483	1.369	0.856	1.458	3.023	0.827	0.422
	III	8	1.027	0.981	1.258	1.050	1.711	1.118	1.232	1.118	1.095	1.141	1.206	1.209	1.187	1.072	0.770	1.192	2.556	0.707	0.362
MAR	I	10	1.597	1.369	1.569	1.341	3.280	1.597	1.540	1.654	2.136	1.740	1.683	2.025	1.740	1.597	0.770	1.857	5.077	0.770	0.929
	II	10	1.911	1.398	1.654	1.369	2.567	1.569	1.711	1.683	1.937	1.740	1.825	2.738	1.797	1.968	0.770	1.962	4.706	0.770	0.811
	III	11	2.384	1.694	1.851	1.506	3.232	1.788	2.228	1.977	2.384	2.259	2.196	2.949	2.102	3.451	0.847	2.788	10.449	0.847	1.695
APR	I	10	2.738	1.626	1.968	1.455	4.934	1.626	2.681	1.768	2.681	2.653	1.997	2.339	2.082	3.194	0.770	2.697	5.505	0.770	1.131
	II	10	2.282	1.654	2.196	1.654	3.793	1.597	2.938	1.711	3.109	2.824	1.882	2.282	2.282	3.023	0.770	3.218	8.614	0.770	1.689
	III	10	2.253	1.740	2.196	1.512	3.622	1.711	2.995	1.654	3.280	3.060	2.025	2.282	2.510	2.824	0.770	3.672	9.811	0.770	2.122
MAY	I	10	2.510	1.825	2.310	2.196	2.881	1.911	3.023	1.654	3.134	3.223	2.310	2.681	2.595	2.966	0.770	3.991	9.897	0.770	2.153
	II	10	3.594	2.196	2.396	2.168	2.567	2.054	3.280	2.082	3.480	3.480	2.852	3.423	2.767	2.767	0.770	4.292	9.983	0.770	2.124
	III	11	3.922	2.635	2.667	2.479	2.761	2.479	3.200	2.635	3.765	4.016	3.420	3.796	3.232	2.447	0.847	4.754	3.349	0.847	2.224
Leap Year																					
A.Flow (Cumec-Day)			126.902	147.489	159.807	127.458	134.146	153.359	111.583	135.587	114.352	124.734	118.514	108.143	120.068	111.309	87.388	145.401			
Annual Flow (Cumec)			0.348	0.404	0.437	0.349	0.368	0.420	0.305	0.371	0.313	0.342	0.324	0.296	0.329	0.305	0.239	0.398			
Annual Volume (MCM)			10.964	12.743	13.807	11.012	11.590	13.250	9.641	11.715	9.880	10.777	10.240	9.344	10.374	9.617	7.550	12.563			
A.V. Basin (Cumec)			0.398																		

Table 6E Ten-daily extended flow series in cumec-day at Shahi Nallah

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	3.313	4.357	2.387	2.452	1.878	1.539	2.543	4.109	3.170	2.713	1.904	2.426	2.961	2.804	3.300	3.130	3.209	2.048
	II	10	2.857	3.991	2.139	2.113	2.374	1.930	2.778	5.191	2.557	2.670	1.826	2.648	3.170	2.361	2.504	2.778	3.065	2.309
	III	10	3.522	4.343	3.170	3.470	3.274	2.230	3.196	3.130	3.261	2.439	1.970	3.130	2.804	2.791	2.609	3.378	2.765	2.557
JUL	I	10	4.643	4.070	4.317	4.448	3.078	2.804	2.687	3.965	4.761	3.313	1.996	4.278	3.443	4.096	2.530	4.200	2.648	2.909
	II	10	5.361	4.500	5.583	5.426	3.365	3.326	3.952	3.887	3.809	3.430	2.517	4.448	3.783	5.283	3.170	4.578	2.700	3.026
	III	11	7.088	4.548	6.686	5.395	3.601	5.467	5.969	5.108	4.491	5.366	4.003	5.380	5.050	6.973	6.036	4.103	3.128	5.079
AUG	I	10	4.083	6.209	5.139	5.243	3.222	4.774	6.104	4.070	3.822	4.030	3.404	6.326	2.674	5.048	3.822	3.913	2.987	4.213
	II	10	5.165	5.452	3.052	4.265	3.300	2.283	5.283	5.609	4.500	4.865	3.626	6.143	2.883	3.952	4.187	4.330	3.078	4.409
	III	11	7.547	6.170	3.228	3.286	2.052	1.808	2.870	5.495	5.352	5.380	5.251	4.778	2.410	3.458	5.567	3.817	5.380	4.290
SEP	I	10	5.126	6.235	2.948	5.987	1.422	1.343	2.100	3.039	3.522	4.526	3.874	3.183	1.891	2.257	5.022	3.757	4.357	3.900
	II	10	4.943	3.809	3.796	2.843	1.278	1.604	1.670	2.713	2.843	4.370	3.104	2.335	1.643	2.087	2.713	3.430	3.678	3.835
	III	10	4.213	2.583	2.804	2.517	1.187	1.539	1.683	2.452	2.309	2.804	2.413	1.996	1.409	5.374	2.296	2.857	2.935	2.883
OCT	I	10	2.752	1.878	2.061	1.917	0.965	1.200	1.317	1.787	1.904	0.887	3.117	1.800	1.083	2.622	1.735	2.361	1.383	1.513
	II	10	2.191	1.578	1.774	1.722	0.848	1.017	0.965	1.304	2.100	0.822	3.443	1.630	0.926	2.139	1.591	1.500	1.304	0.978
	III	11	2.769	2.095	1.894	1.793	0.947	1.076	0.961	0.961	2.253	0.847	2.511	1.636	0.861	2.037	1.593	1.492	1.220	1.033
NOV	I	10	1.735	1.135	1.409	1.083	0.861	0.770	0.757	0.900	0.535	1.213	1.591	0.796	0.743	1.343	1.383	1.265	1.030	0.822
	II	10	1.487	1.004	1.083	1.135	0.822	0.704	0.678	0.796	0.730	0.717	1.200	0.717	0.704	1.148	1.330	1.226	0.991	0.704
	III	10	1.057	0.900	0.678	0.809	0.743	0.665	0.652	0.678	0.652	0.835	1.043	0.717	0.652	0.952	1.357	1.187	0.926	0.770
DEC	I	10	0.783	0.835	0.952	0.704	0.652	0.639	0.626	0.613	0.704	0.730	0.822	0.757	0.600	0.835	1.304	1.161	0.848	0.743
	II	10	0.704	0.770	0.835	0.783	0.600	0.639	0.587	0.574	0.613	0.626	0.809	1.109	0.561	0.691	1.174	1.109	0.809	0.678
	III	11	0.660	0.631	1.033	0.732	0.717	0.703	0.631	0.703	0.646	0.703	0.818	0.760	0.545	0.703	1.435	1.234	0.976	0.660
JAN	I	10	0.613	0.587	0.783	0.639	0.574	0.691	0.757	0.561	0.509	0.639	0.730	0.665	0.457	0.613	1.317	1.135	0.822	0.600
	II	10	0.600	0.600	0.678	0.613	0.561	0.639	0.483	0.522	0.483	0.587	0.639	0.678	0.417	0.809	1.278	1.109	0.822	0.626
	III	11	0.646	0.803	0.674	0.660	0.703	0.717	0.517	0.574	0.545	0.674	0.689	0.732	0.732	0.631	1.177	1.363	0.918	0.674
FEB	I	10	0.626	0.652	0.587	0.574	0.613	0.574	0.483	0.430	0.443	0.561	0.522	0.626	0.561	0.691	1.043	1.239	0.835	0.600
	II	10	0.730	0.600	0.743	0.587	0.561	0.574	0.522	0.378	0.470	0.561	0.900	0.665	0.574	0.678	1.174	1.383	0.822	0.639
	III	8	0.610	0.470	0.522	0.344	0.458	0.522	0.480	0.323	0.434	0.376	0.595	0.574	0.575	0.470	0.970	1.169	0.693	0.553
MAR	I	10	0.678	0.613	1.330	0.587	0.887	0.626	0.809	0.522	0.717	0.561	0.613	1.043	0.743	0.717	1.709	2.322	0.991	0.809
	II	10	0.691	0.730	1.226	0.613	0.600	0.665	0.939	0.626	1.017	0.652	0.678	0.913	1.148	0.783	2.074	2.152	1.043	0.848
	III	11	1.019	0.830	1.148	0.947	0.760	1.119	1.736	1.966	1.607	0.775	0.875	0.933	1.320	1.062	4.778	2.611	1.363	2.138
APR	I	10	0.965	0.874	1.422	0.991	0.730	1.226	2.035	1.930	1.565	0.770	0.822	1.043	1.239	1.252	2.517	2.243	1.357	1.930
	II	10	1.761	0.991	2.922	0.991	0.900	2.635	2.713	2.687	1.683	1.030	1.070	1.343	1.396	1.487	3.939	2.243	1.513	1.709
	III	10	2.791	1.213	1.839	1.213	1.370	2.635	4.304	3.457	1.917	1.083	1.343	1.474	1.683	2.113	4.487	2.387	1.957	2.400
MAY	I	10	2.536	1.122	1.891	1.487	1.461	3.078	4.526	3.822	2.296	1.096	1.943	2.374	1.996	2.400	3.874	2.843	2.217	2.726
	II	10	2.557	1.487	2.922	1.487	1.396	2.635	3.378	3.613	2.517	1.096	2.426	2.713	2.361	3.430	4.565	2.896	3.013	2.048
	III	11	3.228	2.238	3.300	2.267	1.951	3.214	3.745	4.017	1.908	1.449	2.009	2.095	3.099	3.860	4.276	2.927	3.687	2.210
Leap Year																				
A.Flow (Cumec-Day)			92.110	80.962	78.955	72.124	50.712	59.613	75.434	82.513	72.644	65.096	67.098	74.866	59.097	79.950	94.835	86.829	71.469	69.867
Annual Flow (Cumec)			0.252	0.222	0.216	0.198	0.139	0.163	0.207	0.226	0.198	0.178	0.184	0.205	0.161	0.219	0.260	0.238	0.195	0.191
Annual Volume (MCM)			7.958	6.995	6.822	6.232	4.381	5.151	6.518	7.129	6.276	5.624	5.797	6.468	5.106	6.908	8.194	7.502	6.175	6.037
A.V. Basin (Cumec)			0.182																	

Table 6E Ten-daily extended flow series in cumec-day at Shahi Nallah (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	2.243	2.400	2.765	2.270	2.035	3.065	1.670	3.352	1.983	2.504	2.465	2.283	2.400	2.230	2.061	2.605	4.357	1.539	0.645
	II	10	2.257	2.452	3.261	2.296	2.126	5.817	1.565	2.504	2.009	2.452	2.465	2.439	2.491	2.074	2.139	2.652	5.817	1.565	0.863
	III	10	2.204	2.739	3.261	2.909	2.257	3.522	1.617	2.348	2.257	2.335	2.426	2.400	2.570	2.270	2.126	2.766	4.343	1.617	0.571
JUL	I	10	2.335	2.830	2.974	3.157	2.322	3.574	1.696	2.035	2.413	2.413	2.439	2.361	3.039	2.322	2.400	3.106	4.761	1.696	0.858
	II	10	4.539	4.030	3.600	3.222	2.413	3.600	2.178	3.209	3.091	2.270	2.504	1.970	3.561	2.700	2.191	3.552	5.583	1.970	1.000
	III	11	4.677	7.992	5.165	4.218	3.257	3.501	3.659	5.633	3.300	2.382	3.027	2.195	3.415	3.329	2.453	4.566	7.992	2.195	1.422
AUG	I	10	3.326	5.048	5.204	3.170	3.404	3.313	3.496	5.387	2.426	2.413	3.470	2.465	2.830	3.039	2.752	3.364	6.326	2.413	1.136
	II	10	3.065	4.774	5.100	4.161	3.326	3.717	3.183	4.878	3.104	3.509	3.091	2.765	2.687	2.778	2.674	3.915	6.143	2.283	1.017
	III	11	2.898	4.763	4.520	3.730	3.458	4.103	3.300	5.065	3.214	3.630	3.286	2.999	2.611	2.999	2.669	3.981	7.547	1.808	1.308
SEP	I	10	3.365	5.309	8.100	3.926	3.196	3.587	2.048	3.900	2.478	3.704	2.974	2.335	2.139	2.465	2.543	3.532	8.100	1.343	1.479
	II	10	3.770	4.630	5.322	3.248	2.648	3.678	1.970	3.835	2.178	3.770	2.713	2.191	2.374	2.139	2.191	3.011	5.322	1.278	1.018
	III	10	2.570	3.000	3.143	2.583	2.465	6.939	1.930	2.270	1.957	3.039	2.583	2.035	2.674	2.035	2.113	2.654	6.939	1.187	1.088
OCT	I	10	1.135	1.135	1.057	1.109	1.135	1.422	0.978	0.887	0.861	1.278	1.161	0.770	1.252	0.717	0.835	1.455	3.117	0.717	0.606
	II	10	0.809	0.952	0.913	0.978	1.057	2.087	0.965	0.783	0.770	1.096	1.070	0.743	1.148	0.652	0.717	1.290	3.443	0.652	0.598
	III	11	0.832	0.861	0.961	1.392	1.177	1.449	1.019	0.775	0.775	0.976	1.076	0.775	1.177	0.703	0.732	1.293	2.769	0.703	0.552
NOV	I	10	0.770	0.730	0.848	1.174	1.057	1.017	0.900	0.730	0.652	0.743	0.913	0.678	1.017	0.626	0.639	0.966	1.735	0.535	0.293
	II	10	0.757	0.652	0.822	1.030	1.004	0.900	0.913	0.678	0.626	0.704	0.835	0.639	0.965	0.626	0.626	0.877	1.487	0.626	0.228
	III	10	0.691	0.600	0.809	0.717	0.978	0.900	0.874	0.639	0.639	0.678	0.743	0.613	0.874	0.626	0.613	0.796	1.357	0.600	0.180
DEC	I	10	0.665	0.561	0.809	0.678	0.991	0.887	0.822	0.587	0.639	0.652	0.652	0.600	0.757	0.626	0.613	0.753	1.304	0.561	0.166
	II	10	0.600	0.613	0.783	0.665	1.017	0.796	0.783	0.587	0.639	0.626	0.613	0.587	0.704	0.626	0.613	0.725	1.174	0.561	0.164
	III	11	0.617	0.689	0.861	0.746	1.090	0.832	0.746	0.617	0.689	0.674	0.674	0.631	0.732	0.674	0.674	0.765	1.435	0.545	0.190
JAN	I	10	0.561	0.613	0.770	0.652	1.017	0.704	0.665	0.600	0.600	0.626	0.600	0.626	0.652	0.613	0.391	0.678	1.317	0.391	0.180
	II	10	0.561	0.561	0.796	0.652	0.913	0.691	0.678	0.639	0.587	0.639	0.626	0.626	0.652	0.600	0.391	0.659	1.278	0.391	0.176
	III	11	0.617	0.603	0.760	0.717	0.947	0.746	0.703	0.660	0.674	0.703	0.689	0.674	0.689	0.646	0.430	0.718	1.363	0.430	0.174
FEB	I	10	0.548	0.522	0.652	0.626	0.887	0.652	0.665	0.574	0.639	0.639	0.678	0.613	0.626	0.587	0.391	0.635	1.239	0.391	0.164
	II	10	0.548	0.561	0.652	0.613	0.835	0.652	0.652	0.626	0.665	0.626	0.639	0.678	0.678	0.626	0.391	0.667	1.383	0.378	0.193
	III	8	0.470	0.449	0.575	0.480	0.783	0.511	0.563	0.511	0.501	0.522	0.552	0.553	0.543	0.490	0.352	0.545	1.169	0.323	0.166
MAR	I	10	0.730	0.626	0.717	0.613	1.500	0.730	0.704	0.757	1.004	0.796	0.770	0.926	0.796	0.730	0.352	0.849	2.322	0.352	0.379
	II	10	0.874	0.639	0.757	0.626	1.174	0.717	0.783	0.770	0.913	0.796	0.835	1.252	0.822	0.900	0.352	0.897	2.152	0.352	0.371
	III	11	1.090	0.775	0.847	0.689	1.478	0.818	1.019	0.904	1.090	1.033	1.004	1.349	0.961	1.578	0.387	1.275	4.778	0.387	0.775
APR	I	10	1.252	0.743	0.900	0.665	2.257	0.743	1.226	0.809	1.226	1.213	0.913	1.070	0.952	1.461	0.352	1.233	2.517	0.352	0.517
	II	10	1.043	0.757	1.004	0.757	1.735	0.730	1.343	0.783	1.422	1.291	0.861	1.043	1.043	1.383	0.352	1.472	3.939	0.352	0.772
	III	10	1.030	0.796	1.004	0.691	1.657	0.783	1.370	0.757	1.500	1.409	0.926	1.043	1.148	1.291	0.352	1.679	4.487	0.352	0.971
MAY	I	10	1.148	0.835	1.057	1.004	1.317	0.874	1.383	0.757	1.461	1.474	1.057	1.226	1.187	1.357	0.352	1.825	4.526	0.352	0.985
	II	10	1.643	1.004	1.096	0.991	1.174	0.939	1.500	0.952	1.591	1.591	1.304	1.565	1.265	1.265	0.352	1.963	4.565	0.352	0.971
	III	11	1.793	1.205	1.220	1.133	1.263	1.133	1.463	1.205	1.722	1.837	1.564	1.736	1.478	1.119	0.387	2.174	4.276	0.387	1.017
Leap Year																					
A.Flow (Cumec-Day)			58.034	67.449	73.083	58.289	61.347	70.133	51.028	62.006	52.295	57.043	54.198	49.456	54.909	50.903	39.964	66.494			
Annual Flow (Cumec)			0.159	0.185	0.200	0.160	0.168	0.192	0.139	0.170	0.143	0.156	0.148	0.135	0.150	0.139	0.109	0.182			
Annual Volume (MCM)			5.014	5.828	6.314	5.036	5.300	6.060	4.409	5.357	4.518	4.929	4.683	4.273	4.744	4.398	3.453	5.745			
A.V. Basin (Cumec)			0.182																		

Table 7E Ten-daily extended flow series in cumec-day at Gumma Nallah

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	41.822	54.994	30.131	30.955	23.710	19.429	32.107	51.865	40.010	34.248	24.039	30.625	37.376	35.400	41.657	39.517	40.504	25.850
	II	10	36.059	50.384	27.003	26.674	29.967	24.369	35.071	65.532	32.272	32.436	23.051	33.424	40.010	29.802	31.613	35.071	38.693	29.143
	III	10	44.456	54.829	40.010	43.797	41.328	28.156	40.340	39.517	41.163	30.790	24.862	39.517	35.400	35.236	32.930	42.645	34.906	32.272
JUL	I	10	58.616	51.371	54.500	56.146	38.858	35.400	33.918	50.054	60.098	41.822	25.192	54.006	43.468	51.701	31.943	53.018	33.424	36.717
	II	10	67.672	56.805	70.471	68.495	42.480	41.986	49.890	49.066	48.078	43.304	31.778	56.146	47.749	66.684	40.010	57.793	34.083	38.199
	III	11	89.472	57.414	84.401	68.100	45.460	69.008	75.345	64.478	56.690	67.738	50.532	67.919	63.753	88.023	63.572	51.800	39.484	64.116
AUG	I	10	51.536	78.374	64.873	66.190	40.669	60.263	77.057	51.371	48.243	50.878	42.974	79.856	33.754	63.720	48.243	49.396	37.705	53.183
	II	10	65.202	68.825	38.529	53.841	41.657	28.814	66.684	70.800	56.805	61.415	45.773	77.551	36.388	49.830	52.853	54.665	38.858	55.652
	III	11	95.268	77.880	40.751	41.476	25.900	22.821	36.223	69.368	67.557	67.919	66.289	60.312	30.428	43.649	70.274	48.177	67.919	54.154
SEP	I	10	64.708	78.704	37.211	75.575	17.347	16.959	26.509	38.364	44.456	57.134	48.902	40.175	23.875	28.485	63.391	47.420	54.994	49.231
	II	10	62.403	48.078	47.914	35.894	16.136	20.252	21.075	34.248	35.894	55.158	39.187	29.473	20.746	26.344	34.248	43.304	46.432	48.408
	III	10	53.183	32.601	35.400	31.778	14.983	19.429	21.240	30.955	29.143	35.400	30.461	25.192	17.782	67.837	28.979	36.059	37.047	36.388
OCT	I	10	34.742	23.710	26.015	24.204	12.184	15.148	16.630	22.557	24.039	11.196	39.352	22.722	13.666	33.095	21.899	29.802	17.453	19.100
	II	10	27.662	19.923	22.393	21.734	10.702	12.843	12.184	16.465	26.509	10.373	43.468	20.582	11.690	27.003	20.088	18.935	16.465	12.349
	III	11	34.956	26.443	23.907	22.640	11.954	13.584	12.135	12.135	28.435	10.686	31.696	20.647	10.867	25.719	20.104	18.836	15.395	13.040
NOV	I	10	21.899	14.325	17.782	13.666	10.867	9.714	9.550	11.361	6.761	15.313	20.088	10.044	9.385	16.959	17.453	15.971	13.008	10.373
	II	10	18.770	12.678	13.666	14.325	10.373	8.891	8.562	10.044	9.221	9.056	15.148	9.056	8.891	14.489	16.795	15.477	12.514	8.891
	III	10	13.337	11.361	8.562	10.208	9.385	8.397	8.233	8.562	8.233	10.538	13.172	9.056	8.233	12.020	17.124	14.983	11.690	9.714
DEC	I	10	9.879	10.538	12.020	8.891	8.233	8.068	7.903	7.739	8.891	9.221	10.373	9.550	7.574	10.538	16.465	14.654	10.702	9.385
	II	10	8.891	9.714	10.538	9.879	7.574	8.068	7.409	7.245	7.739	7.903	10.208	13.995	7.080	8.727	14.819	13.995	10.208	8.562
	III	11	8.331	7.969	13.040	9.237	9.056	8.875	7.969	8.875	8.150	8.876	10.324	9.593	6.882	8.875	18.112	15.576	12.316	8.331
JAN	I	10	7.739	7.409	9.879	8.068	7.245	8.727	9.550	7.080	6.421	8.068	9.221	8.397	5.763	7.739	16.630	14.325	10.373	7.574
	II	10	7.574	7.574	8.562	7.739	7.080	8.068	6.092	6.586	6.092	7.409	8.068	8.562	5.269	10.208	16.136	13.995	10.373	7.903
	III	11	8.150	10.143	8.513	8.331	8.875	9.056	6.520	7.245	6.882	8.513	8.694	9.237	9.237	7.969	14.852	17.206	11.692	8.513
FEB	I	10	7.903	8.233	7.409	7.245	7.739	7.245	6.092	5.434	5.598	7.080	6.586	7.903	7.080	8.727	13.172	15.642	10.538	7.574
	II	10	9.221	7.574	9.385	7.409	7.080	7.245	6.586	4.775	5.927	7.080	11.361	8.397	7.245	8.562	14.819	17.453	10.373	8.068
	III	8	7.706	5.927	6.586	4.347	5.779	6.586	6.059	4.083	5.483	4.742	7.508	7.245	7.261	5.927	12.250	14.753	8.743	6.981
MAR	I	10	8.562	7.739	16.795	7.409	11.196	7.903	10.208	6.586	9.056	7.080	7.739	13.172	9.385	9.056	21.569	29.308	12.514	10.208
	II	10	8.727	9.221	15.477	7.739	7.574	9.397	11.855	7.903	12.843	8.233	8.562	11.526	14.489	9.879	26.180	27.168	13.172	10.702
	III	11	12.859	11.229	14.489	11.954	9.599	14.127	21.915	24.813	20.285	9.780	11.048	11.773	16.663	13.403	60.312	32.963	17.206	26.986
APR	I	10	12.184	11.032	17.947	12.514	9.221	15.477	25.686	24.369	19.758	9.714	10.373	13.172	15.642	15.807	31.778	28.320	17.124	24.369
	II	10	22.228	12.514	36.882	12.514	11.361	33.260	34.248	33.918	21.240	13.008	13.501	16.959	17.618	18.770	49.725	28.320	19.100	21.569
	III	10	35.236	15.313	23.216	15.313	17.288	33.260	54.335	43.633	24.204	13.666	16.959	18.606	21.240	26.674	56.640	30.131	24.698	30.296
MAY	I	10	32.766	14.160	23.875	18.770	18.441	38.858	57.134	48.243	28.379	13.831	24.533	29.967	25.192	30.296	48.902	35.894	27.991	34.412
	II	10	32.272	18.770	36.882	18.770	17.618	33.260	42.645	45.609	31.778	13.831	30.625	34.248	29.802	43.304	57.628	36.553	38.035	25.850
	III	11	40.751	28.254	41.657	28.617	24.632	40.570	47.272	50.713	24.089	18.293	25.356	26.443	39.121	48.721	53.973	36.948	46.547	27.892
Leap Year																				
A.Flow (Cumec-Day)			1162.741	1022.013	996.673	910.444	640.151	752.510	952.233	1041.590	917.014	821.730	847.004	945.054	746.006	1009.236	1197.137	1096.073	902.179	881.959
Annual Flow (Cumec)			3.177	2.800	2.731	2.494	1.749	2.062	2.609	2.854	2.506	2.251	2.321	2.589	2.038	2.765	3.280	3.003	2.465	2.416
Annual Volume (MCM)			100.461	88.302	86.113	78.662	55.309	65.017	82.273	89.993	79.230	70.997	73.181	81.653	64.455	87.198	103.433	94.701	77.948	76.201
A.V. Basin (Cumec)			2.298																	

Table 7E Ten-daily extended flow series in cumec-day at Gumma Nallah (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	28.320	30.296	34.906	28.649	25.686	38.693	21.076	42.316	25.027	31.613	31.119	28.814	30.296	28.156	26.015	32.886	54.934	19.429	8.139
	II	10	28.485	30.955	41.163	28.979	26.838	73.435	19.758	31.613	25.356	30.955	31.119	30.790	31.449	26.180	27.003	33.474	73.435	19.758	10.973
	III	10	27.826	34.577	41.163	36.717	28.485	44.456	20.417	29.637	28.485	29.473	30.625	30.296	32.436	28.649	26.838	34.916	54.829	20.417	7.210
JUL	I	10	29.473	35.730	37.541	39.846	29.308	45.115	21.405	25.686	30.461	30.461	30.790	29.802	38.364	29.308	30.296	39.207	60.098	21.405	10.832
	II	10	57.299	50.878	45.444	40.669	30.461	45.444	27.497	40.504	39.023	28.649	31.613	24.862	44.950	34.083	27.662	44.840	70.471	24.862	12.628
	III	11	69.044	100.882	65.202	53.249	41.114	44.193	46.185	71.179	41.667	30.065	38.216	27.711	43.106	42.019	30.971	57.639	100.882	27.711	17.943
AUG	I	10	41.986	63.720	65.696	40.010	42.974	41.822	44.127	68.001	30.625	30.461	43.797	31.119	35.730	38.364	34.742	50.044	79.856	30.461	14.335
	II	10	38.693	60.263	64.379	52.524	41.986	46.926	40.175	61.580	39.187	44.291	39.023	34.906	33.918	35.071	33.754	49.421	77.551	28.814	12.832
	III	11	36.586	60.131	57.052	47.091	43.649	51.800	41.657	63.934	40.570	45.823	41.476	37.854	32.963	37.854	33.688	50.257	95.268	22.821	16.510
SEP	I	10	42.480	67.013	102.249	49.560	40.340	45.279	25.850	49.231	31.284	46.761	37.541	29.473	27.003	31.119	32.107	44.586	102.249	16.959	18.668
	II	10	47.584	58.452	67.178	40.998	33.424	46.432	24.862	48.408	27.497	47.584	34.248	27.662	29.967	27.003	27.662	38.005	67.178	16.136	12.846
	III	10	32.436	37.870	39.681	32.601	31.119	87.595	24.369	28.649	24.698	38.364	32.601	25.686	33.754	25.686	26.674	33.504	87.595	14.983	13.734
OCT	I	10	14.325	14.325	13.337	13.995	14.325	17.947	12.349	11.196	10.867	16.136	14.654	9.714	15.807	9.056	10.538	18.366	39.352	9.056	7.646
	II	10	10.208	12.020	11.526	12.349	13.337	26.344	12.184	9.879	9.714	13.831	13.501	9.385	14.489	8.233	9.056	16.286	43.468	8.233	7.552
	III	11	10.505	10.867	12.135	17.568	14.852	18.293	12.859	9.780	9.780	12.316	13.584	9.780	14.852	8.875	9.237	16.317	34.956	8.875	6.967
NOV	I	10	9.714	9.221	10.702	14.819	13.337	12.843	11.361	9.221	8.233	9.385	11.526	8.562	12.843	7.903	8.068	12.189	21.899	6.751	3.704
	II	10	9.550	8.233	10.373	13.008	12.678	11.361	11.526	8.562	7.903	8.891	10.538	8.068	12.184	7.903	7.903	11.077	18.770	7.903	2.875
	III	10	8.727	7.574	10.208	9.056	12.349	11.361	11.032	8.068	8.068	8.562	9.385	7.739	11.032	7.903	7.739	10.049	17.124	7.574	2.276
DEC	I	10	8.397	7.080	10.208	8.562	12.514	11.196	10.373	7.409	8.068	8.233	8.233	7.574	9.550	7.903	7.739	9.505	16.465	7.080	2.091
	II	10	7.574	7.739	9.879	8.397	12.843	10.044	9.879	7.409	8.068	7.903	7.739	7.409	8.891	7.903	7.739	9.151	14.819	7.080	2.075
	III	11	7.788	8.694	10.867	9.418	13.765	10.505	9.418	7.788	8.694	8.513	8.513	7.969	9.237	8.513	8.513	9.654	18.112	6.882	2.397
JAN	I	10	7.080	7.739	9.714	8.233	12.843	8.891	8.397	7.574	7.574	7.903	7.574	7.903	8.233	7.739	4.940	8.562	16.630	4.940	2.276
	II	10	7.080	7.080	10.044	8.233	11.526	8.727	8.562	8.068	7.409	8.068	7.903	7.903	8.233	7.574	4.940	8.322	16.136	4.940	2.218
	III	11	7.788	7.607	9.599	9.056	11.954	9.418	8.875	8.331	8.513	8.875	8.694	8.513	8.694	8.150	5.434	9.061	17.206	5.434	2.191
FEB	I	10	6.915	6.586	8.233	7.903	11.196	8.233	8.397	7.245	8.068	8.068	8.562	7.739	7.903	7.409	4.940	8.018	15.642	4.940	2.076
	II	10	6.315	7.080	8.233	7.739	10.538	8.233	8.233	7.903	8.397	7.903	8.068	8.562	8.562	7.903	4.940	8.417	17.453	4.775	2.436
	III	8	5.927	6.664	7.261	6.059	9.879	6.454	7.113	6.454	6.323	6.586	6.965	6.981	6.850	6.191	4.446	6.882	14.753	4.083	2.090
MAR	I	10	9.221	7.903	9.056	7.739	18.935	9.221	8.891	9.550	12.678	10.044	9.714	11.690	10.044	9.221	4.446	10.722	29.308	4.446	4.788
	II	10	11.032	8.068	9.550	7.903	14.819	9.056	9.879	9.714	11.526	10.044	10.538	15.807	10.373	11.361	4.446	11.326	27.168	4.446	4.681
	III	11	13.765	9.780	10.686	8.694	18.655	10.324	12.859	11.410	13.765	13.040	12.678	17.025	12.135	19.923	4.890	16.092	60.312	4.890	9.784
APR	I	10	15.807	9.385	11.361	8.397	28.485	9.385	15.477	10.208	15.477	15.313	11.526	13.501	12.020	18.441	4.446	15.567	31.778	4.446	6.527
	II	10	13.172	9.550	12.678	9.550	21.899	9.221	16.959	9.879	17.947	16.301	10.867	13.172	13.172	17.453	4.446	18.576	49.725	4.446	9.748
	III	10	13.008	10.044	12.678	8.727	20.911	9.879	17.288	9.550	18.935	17.782	11.690	13.172	14.489	16.301	4.446	21.200	56.640	4.446	12.253
MAY	I	10	14.489	10.538	13.337	12.678	16.630	11.032	17.453	9.550	18.441	18.606	13.337	15.477	14.983	17.124	4.446	23.041	57.134	4.446	12.430
	II	10	20.746	12.678	13.831	12.514	14.819	11.855	18.935	12.020	20.088	20.088	16.465	19.758	15.971	15.971	4.446	24.778	57.628	4.446	12.260
	III	11	22.640	15.214	15.395	14.308	15.938	14.308	18.474	15.214	21.734	23.183	19.742	21.915	18.655	14.127	4.890	27.442	53.973	4.890	12.838
Leap Year																					
A.Flow (Cumec-Day)			732.587	851.433	922.546	735.798	774.409	885.318	644.152	782.724	660.140	720.073	684.163	624.295	693.136	642.572	504.478	839.381			
Annual Flow (Cumec)			2.007	2.333	2.521	2.016	2.122	2.426	1.760	2.144	1.809	1.973	1.869	1.710	1.899	1.760	1.378	2.298			
Annual Volume (MCM)			63.296	73.564	79.708	63.573	66.909	76.491	55.655	67.627	57.036	62.214	59.112	53.939	59.887	55.518	43.587	72.523			
A.V. Basin (Cumec)			2.298																		

Table 9E Ten-daily extended flow series in cumec-day at Khasdhar Nallah (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	V. (Cume	Max	Min	SD
JUN	I	10	6.820	7.296	8.406	6.899	6.186	9.318	5.075	10.191	6.027	7.613	7.494	6.939	7.296	6.781	6.265	7.920	13.244	4.679	1.960
	II	10	6.860	7.455	9.913	6.979	6.463	17.685	4.758	7.613	6.106	7.455	7.494	7.415	7.574	6.305	6.503	8.061	17.685	4.758	2.642
	III	10	6.701	8.327	9.913	8.842	6.860	10.706	4.917	7.137	6.860	7.098	7.375	7.296	7.811	6.899	6.463	8.409	13.204	4.917	1.736
JUL	I	10	7.098	8.605	9.041	9.596	7.058	10.865	5.155	6.186	7.336	7.336	7.415	7.177	9.239	7.058	7.296	9.442	14.473	5.155	2.609
	II	10	13.793	12.253	10.344	9.794	7.336	10.344	6.622	9.754	9.398	6.899	7.613	5.987	10.825	8.208	6.662	10.799	16.971	5.987	3.041
	III	11	14.219	24.295	15.702	12.824	9.901	10.643	11.122	17.142	10.032	7.240	9.203	6.673	10.381	10.119	7.459	13.881	24.295	6.673	4.323
AUG	I	10	10.111	15.345	15.621	9.635	10.349	10.072	10.627	16.376	7.375	7.336	10.547	7.494	8.605	9.239	8.367	12.052	19.231	7.336	3.452
	II	10	9.318	14.513	15.504	12.649	10.111	11.301	9.675	14.830	9.437	10.666	9.398	8.406	9.168	8.446	8.129	11.902	18.676	6.939	3.090
	III	11	8.811	14.481	13.739	11.341	10.512	12.475	10.032	15.397	9.770	11.035	9.988	9.116	7.938	9.116	8.113	12.103	22.943	5.496	3.976
SEP	I	10	10.230	16.138	24.624	11.935	9.715	10.904	6.225	11.856	7.534	11.261	9.041	7.098	6.503	7.494	7.732	10.737	24.624	4.084	4.496
	II	10	11.459	14.077	16.178	9.873	8.049	11.182	5.987	11.658	6.622	11.459	8.248	6.662	7.217	6.503	6.662	9.152	16.178	3.886	3.094
	III	10	7.811	9.120	9.556	7.851	7.494	21.095	5.869	6.899	5.948	9.239	7.851	6.186	8.129	6.186	6.424	8.069	21.095	3.608	3.308
OCT	I	10	3.450	3.450	3.212	3.370	3.450	4.322	2.974	2.896	2.617	3.886	3.529	2.339	3.807	2.181	2.539	4.423	9.477	2.181	1.841
	II	10	2.458	2.895	2.776	2.974	3.212	6.344	2.934	2.379	2.339	3.331	3.251	2.260	3.489	1.983	2.181	3.922	10.468	1.983	1.819
	III	11	2.530	2.617	2.922	4.231	3.577	4.405	3.097	2.355	2.355	2.966	3.271	2.355	3.577	2.137	2.224	3.930	8.418	2.137	1.678
NOV	I	10	2.339	2.221	2.577	3.569	3.212	3.093	2.736	2.221	1.983	2.260	2.776	2.062	3.093	1.903	1.943	2.935	5.274	1.626	0.892
	II	10	2.300	1.983	2.498	3.133	3.053	2.736	2.776	2.062	1.903	2.141	2.538	1.943	2.934	1.903	1.903	2.668	4.520	1.903	0.692
	III	10	2.102	1.824	2.458	2.181	2.974	2.736	2.657	1.943	1.943	2.062	2.260	1.864	2.657	1.903	1.864	2.420	4.124	1.824	0.548
DEC	I	10	2.022	1.705	2.458	2.062	3.014	2.696	2.498	1.784	1.943	1.983	1.983	1.824	2.300	1.903	1.864	2.289	3.365	1.705	0.504
	II	10	1.824	1.864	2.379	2.022	3.093	2.419	2.379	1.784	1.943	1.903	1.864	1.784	2.141	1.903	1.864	2.204	3.569	1.705	0.500
	III	11	1.876	2.094	2.617	2.268	3.315	2.530	2.268	1.876	2.094	2.050	2.050	1.919	2.224	2.050	2.050	2.325	4.362	1.657	0.577
JAN	I	10	1.705	1.864	2.339	1.983	3.093	2.141	2.022	1.824	1.824	1.903	1.824	1.903	1.983	1.864	1.190	2.062	4.005	1.190	0.548
	II	10	1.705	1.705	2.419	1.983	2.776	2.102	2.062	1.943	1.784	1.943	1.903	1.903	1.983	1.824	1.190	2.004	3.886	1.190	0.534
	III	11	1.876	1.832	2.312	2.181	2.879	2.268	2.137	2.006	2.050	2.137	2.094	2.050	2.094	1.963	1.309	2.182	4.144	1.303	0.528
FEB	I	10	1.665	1.586	1.983	1.903	2.696	1.983	2.022	1.745	1.943	1.943	2.062	1.864	1.903	1.784	1.130	1.931	3.767	1.130	0.500
	II	10	1.665	1.705	1.983	1.864	2.538	1.983	1.983	1.903	2.022	1.903	1.943	2.062	2.062	1.903	1.190	2.027	4.203	1.150	0.587
	III	8	1.427	1.364	1.749	1.459	2.379	1.554	1.713	1.554	1.523	1.586	1.677	1.681	1.650	1.491	1.071	1.657	3.553	0.983	0.503
MAR	I	10	2.221	1.903	2.181	1.864	4.560	2.221	2.141	2.300	3.053	2.419	2.339	2.815	2.419	2.221	1.071	2.582	7.058	1.071	1.153
	II	10	2.657	1.943	2.300	1.903	3.569	2.181	2.379	2.339	2.776	2.419	2.538	3.807	2.498	2.736	1.071	2.728	6.543	1.071	1.127
	III	11	3.315	2.355	2.573	2.094	4.493	2.486	3.097	2.748	3.315	3.140	3.053	4.100	2.922	4.798	1.178	3.875	14.525	1.178	2.356
APR	I	10	3.807	2.260	2.736	2.022	6.860	2.260	3.727	2.458	3.727	3.688	2.776	3.251	2.895	4.441	1.071	3.749	7.653	1.071	1.572
	II	10	3.172	2.300	3.053	2.300	5.274	2.221	4.084	2.379	4.322	3.926	2.617	3.172	3.172	4.203	1.071	4.473	11.975	1.071	2.347
	III	10	3.133	2.419	3.053	2.102	5.036	2.379	4.163	2.300	4.560	4.282	2.815	3.172	3.489	3.926	1.071	5.106	13.640	1.071	2.951
MAY	I	10	3.489	2.538	3.212	3.053	4.005	2.657	4.203	2.300	4.441	4.481	3.212	3.727	3.608	4.124	1.071	5.549	13.759	1.071	2.993
	II	10	4.996	3.053	3.331	3.014	3.569	2.855	4.560	2.895	4.838	4.838	3.965	4.758	3.846	3.846	1.071	5.967	13.878	1.071	2.953
	III	11	5.452	3.664	3.707	3.446	3.838	3.446	4.449	3.664	5.234	5.583	4.754	5.278	4.493	3.402	1.178	6.609	12.998	1.178	3.092
Leap Year																					
A.Flow (Cumec-Day)			176.424	205.045	222.171	177.198	186.496	213.208	155.127	188.499	158.977	173.411	164.763	150.345	166.924	154.747	121.490	202.143			
Annual Flow (Cumec)			0.483	0.562	0.607	0.485	0.511	0.584	0.424	0.516	0.436	0.475	0.450	0.412	0.457	0.424	0.332	0.553			
Annual Volume (MCM)			15.243	17.716	19.196	15.310	16.113	18.421	13.403	16.286	13.736	14.983	14.235	12.990	14.422	13.370	10.497	17.465			
A.V. Basin (Cumec)			0.553																		

Table 9E Ten-daily extended flow series in cumec-day at Khasdhar Nallah

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	10.072	13.244	7.256	7.455	5.710	4.679	7.732	12.490	9.635	8.248	5.789	7.375	9.001	8.525	10.032	9.517	9.754	6.225
	II	10	8.684	12.134	6.503	6.424	7.217	5.869	8.446	15.782	7.772	7.811	5.551	8.049	9.635	7.177	7.613	8.446	9.318	7.018
	III	10	10.706	13.204	9.635	10.547	9.953	6.781	9.715	9.517	9.913	7.415	5.987	9.517	8.525	8.486	7.930	10.270	8.406	7.772
JUL	I	10	14.116	12.371	13.125	13.521	9.358	8.525	8.169	12.054	14.473	10.072	6.067	13.006	10.468	12.451	7.693	12.768	8.049	8.842
	II	10	16.297	13.680	16.971	16.495	10.230	10.111	12.015	11.816	11.578	10.429	7.653	13.521	11.499	16.059	9.635	13.918	8.208	9.199
	III	11	21.547	13.827	20.326	16.400	10.948	16.618	18.145	15.528	13.652	16.313	12.169	16.357	15.353	21.198	15.310	12.475	9.509	15.441
AUG	I	10	12.411	18.874	15.623	15.940	9.794	14.513	18.557	12.371	11.618	12.253	10.349	19.231	8.129	15.345	11.618	11.896	9.080	12.808
	II	10	15.702	16.575	9.279	12.966	10.032	6.939	16.059	17.050	13.680	14.790	11.023	18.676	8.763	12.015	12.728	13.165	9.358	13.402
	III	11	22.943	18.755	9.814	9.988	6.237	5.496	8.723	16.705	16.269	16.357	15.964	14.525	7.328	10.512	16.924	11.602	16.357	13.042
SEP	I	10	15.583	18.954	8.961	18.200	4.322	4.084	6.384	9.239	10.706	13.759	11.777	9.675	5.750	6.860	15.266	11.420	13.244	11.856
	II	10	15.028	11.578	11.539	8.644	3.886	4.877	5.075	8.248	8.644	13.283	9.437	7.098	4.996	6.344	8.248	10.429	11.182	11.658
	III	10	12.808	7.851	8.525	7.653	3.608	4.679	5.115	7.455	7.018	8.525	7.336	6.067	4.282	16.337	6.979	8.684	8.922	8.763
OCT	I	10	8.367	5.710	6.265	5.829	2.934	3.648	4.005	5.432	5.789	2.696	9.477	5.472	3.291	7.970	5.274	7.177	4.203	4.600
	II	10	6.662	4.798	5.393	5.234	2.577	3.093	2.934	3.965	6.384	2.498	10.468	4.957	2.815	6.503	4.838	4.560	3.965	2.974
	III	11	8.418	6.368	5.757	5.452	2.879	3.271	2.922	2.922	6.848	2.573	7.633	4.972	2.617	6.194	4.842	4.536	3.707	3.140
NOV	I	10	5.274	3.450	4.282	3.291	2.617	2.339	2.300	2.736	1.626	3.688	4.838	2.419	2.260	4.084	4.203	3.846	3.133	2.498
	II	10	4.520	3.053	3.291	3.450	2.498	2.141	2.062	2.419	2.221	2.181	3.648	2.181	2.141	3.489	4.045	3.727	3.014	2.141
	III	10	3.212	2.736	2.062	2.458	2.260	2.022	1.983	2.062	1.983	2.538	3.172	2.181	1.983	2.895	4.124	3.608	2.815	2.339
DEC	I	10	2.379	2.538	2.895	2.141	1.983	1.943	1.903	1.864	2.141	2.221	2.498	2.300	1.824	2.538	3.965	3.529	2.577	2.260
	II	10	2.141	2.339	2.538	2.379	1.824	1.943	1.784	1.745	1.864	1.903	2.458	3.370	1.705	2.102	3.569	3.370	2.458	2.062
	III	11	2.006	1.919	3.140	2.224	2.181	2.137	1.919	2.137	1.963	2.137	2.486	2.312	1.657	2.137	4.362	3.751	2.966	2.006
JAN	I	10	1.864	1.784	2.379	1.943	1.745	2.102	2.300	1.705	1.546	1.943	2.221	2.022	1.386	1.864	4.005	3.450	2.498	1.824
	II	10	1.824	1.824	2.062	1.864	1.705	1.943	1.467	1.586	1.467	1.784	1.943	2.062	1.269	2.459	3.886	3.370	2.498	1.903
	III	11	1.963	2.443	2.050	2.006	2.137	2.181	1.570	1.745	1.657	2.050	2.094	2.224	2.224	1.919	3.577	4.144	2.792	2.050
FEB	I	10	1.903	1.983	1.784	1.745	1.864	1.745	1.467	1.309	1.348	1.705	1.586	1.903	1.705	2.102	3.172	3.767	2.538	1.824
	II	10	2.221	1.824	2.260	1.784	1.705	1.745	1.586	1.150	1.427	1.705	2.736	2.022	1.745	2.062	3.569	4.203	2.498	1.943
	III	8	1.856	1.427	1.586	1.047	1.392	1.586	1.459	0.983	1.320	1.142	1.809	1.745	1.749	1.427	2.950	3.553	2.106	1.681
MAR	I	10	2.062	1.864	4.045	1.784	2.696	1.903	2.458	1.586	2.181	1.705	1.864	3.172	2.260	2.181	5.194	7.058	3.014	2.458
	II	10	2.102	2.221	3.727	1.864	1.824	2.022	2.855	1.903	3.093	1.983	2.062	2.776	3.489	2.379	6.305	6.543	3.172	2.577
	III	11	3.097	2.704	3.489	2.879	2.312	3.402	5.278	5.976	4.885	2.355	2.661	2.835	4.013	3.228	14.525	7.938	4.144	6.499
APR	I	10	2.934	2.657	4.322	3.014	2.221	3.727	6.186	5.869	4.758	2.339	2.498	3.172	3.767	3.807	7.653	6.820	4.124	5.869
	II	10	5.353	3.014	8.882	3.014	2.736	8.010	8.248	8.168	5.115	3.133	3.251	4.084	4.243	4.520	11.975	6.820	4.600	5.194
	III	10	8.486	3.688	5.591	3.688	4.163	8.010	13.085	10.508	5.829	3.291	4.084	4.481	5.115	6.424	13.640	7.256	5.948	7.296
MAY	I	10	7.891	3.410	5.750	4.520	4.441	9.358	13.759	11.618	6.979	3.331	5.908	7.217	8.067	7.296	11.777	8.644	6.741	8.287
	II	10	7.772	4.520	8.882	4.520	4.243	8.010	10.270	10.984	7.653	3.331	7.375	8.248	7.177	10.429	13.878	8.803	9.160	6.225
	III	11	9.814	6.804	10.032	6.892	5.932	9.770	11.384	12.213	5.801	4.405	6.106	6.368	9.421	11.733	12.998	8.898	11.210	6.717
Leap Year																				
A.Flow (Cumec-Day)			280.016	246.125	240.023	219.257	154.164	181.222	229.320	250.840	220.839	197.892	203.979	227.592	179.656	243.048	288.299	263.961	217.266	212.397
Annual Flow (Cumec)			0.765	0.674	0.658	0.601	0.421	0.496	0.628	0.687	0.603	0.542	0.559	0.624	0.491	0.666	0.790	0.723	0.594	0.582
Annual Volume (MCM)			24.193	21.265	20.738	18.944	13.320	15.658	19.813	21.673	19.080	17.098	17.624	19.664	15.522	20.999	24.909	22.806	18.772	18.351
A.V. Basin (Cumec)			0.553																	

Table 8E Ten-daily extended flow series in cumec-day at Sonalpani Nallah (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	2.243	2.400	2.765	2.270	2.035	3.065	1.670	3.352	1.983	2.504	2.465	2.283	2.400	2.230	2.061	2.605	4.357	1.539	0.845
	II	10	2.257	2.452	3.261	2.296	2.126	5.817	1.565	2.504	2.009	2.452	2.465	2.439	2.491	2.074	2.139	2.652	5.817	1.565	0.869
	III	10	2.204	2.739	3.261	2.909	2.257	3.522	1.617	2.348	2.257	2.335	2.426	2.400	2.570	2.270	2.126	2.766	4.343	1.617	0.571
JUL	I	10	2.335	2.830	2.974	3.157	2.322	3.574	1.696	2.035	2.413	2.413	2.439	2.361	3.039	2.322	2.400	3.106	4.761	1.696	0.858
	II	10	4.539	4.030	3.600	3.222	2.413	3.600	2.178	3.209	3.091	2.270	2.504	1.970	3.561	2.700	2.191	3.552	5.583	1.970	1.000
	III	11	4.677	7.992	5.165	4.218	3.257	3.501	3.659	5.639	3.300	2.382	3.027	2.195	3.415	3.329	2.453	4.566	7.992	2.195	1.422
AUG	I	10	3.326	5.048	5.204	3.170	3.404	3.313	3.496	5.387	2.426	2.413	3.470	2.465	2.830	3.039	2.752	3.964	6.326	2.413	1.136
	II	10	3.065	4.774	5.100	4.161	3.326	3.717	3.183	4.878	3.104	3.509	3.091	2.765	2.687	2.778	2.674	3.915	6.143	2.283	1.017
	III	11	2.898	4.763	4.520	3.730	3.458	4.103	3.300	5.065	3.214	3.630	3.286	2.999	2.611	2.999	2.669	3.981	7.547	1.808	1.308
SEP	I	10	3.365	5.309	8.100	3.926	3.136	3.587	2.048	3.900	2.478	3.704	2.974	2.335	2.139	2.465	2.543	3.532	8.100	1.343	1.479
	II	10	3.770	4.630	5.322	3.248	2.648	3.678	1.970	3.835	2.178	3.770	2.713	2.191	2.374	2.139	2.191	3.011	5.322	1.278	1.018
	III	10	2.570	3.000	3.143	2.583	2.465	6.939	1.930	2.270	1.957	3.039	2.583	2.035	2.674	2.035	2.113	2.654	6.939	1.187	1.088
OCT	I	10	1.135	1.135	1.057	1.109	1.135	1.422	0.978	0.887	0.861	1.278	1.161	0.770	1.252	0.717	0.835	1.455	3.117	0.717	0.606
	II	10	0.809	0.952	0.913	0.978	1.057	2.087	0.965	0.783	0.770	1.096	1.070	0.743	1.148	0.652	0.717	1.290	3.443	0.652	0.598
	III	11	0.832	0.861	0.961	1.392	1.177	1.449	1.013	0.775	0.775	0.976	1.078	0.775	1.177	0.703	0.732	1.293	2.769	0.703	0.552
NOV	I	10	0.770	0.730	0.848	1.174	1.057	1.017	0.900	0.730	0.652	0.743	0.913	0.678	1.017	0.626	0.639	0.966	1.735	0.535	0.293
	II	10	0.757	0.652	0.822	1.030	1.004	0.900	0.913	0.678	0.626	0.704	0.835	0.639	0.965	0.626	0.626	0.877	1.487	0.626	0.228
	III	10	0.691	0.600	0.809	0.717	0.978	0.900	0.874	0.639	0.639	0.678	0.743	0.613	0.874	0.626	0.613	0.796	1.357	0.600	0.180
DEC	I	10	0.665	0.561	0.809	0.678	0.991	0.887	0.822	0.587	0.639	0.652	0.652	0.600	0.757	0.626	0.613	0.753	1.304	0.561	0.166
	II	10	0.600	0.613	0.783	0.665	1.017	0.796	0.783	0.587	0.639	0.626	0.613	0.587	0.704	0.626	0.613	0.725	1.174	0.561	0.164
	III	11	0.617	0.689	0.861	0.746	1.090	0.832	0.746	0.617	0.689	0.674	0.674	0.631	0.732	0.674	0.674	0.765	1.435	0.545	0.130
JAN	I	10	0.561	0.613	0.770	0.652	1.017	0.704	0.665	0.600	0.600	0.626	0.600	0.626	0.652	0.613	0.391	0.678	1.317	0.391	0.180
	II	10	0.561	0.561	0.796	0.652	0.913	0.691	0.678	0.639	0.587	0.639	0.626	0.626	0.652	0.600	0.391	0.659	1.278	0.391	0.176
	III	11	0.617	0.603	0.760	0.717	0.947	0.746	0.703	0.660	0.674	0.703	0.689	0.674	0.689	0.646	0.430	0.718	1.363	0.430	0.174
FEB	I	10	0.548	0.522	0.652	0.626	0.887	0.652	0.665	0.574	0.639	0.639	0.678	0.613	0.626	0.587	0.391	0.635	1.239	0.391	0.164
	II	10	0.548	0.561	0.652	0.613	0.835	0.652	0.652	0.626	0.665	0.626	0.639	0.678	0.678	0.626	0.391	0.667	1.383	0.378	0.193
	III	8	0.470	0.449	0.575	0.480	0.783	0.511	0.563	0.511	0.501	0.522	0.552	0.553	0.543	0.490	0.352	0.545	1.169	0.323	0.166
MAR	I	10	0.730	0.626	0.717	0.613	1.500	0.730	0.704	0.757	1.004	0.796	0.770	0.926	0.796	0.730	0.352	0.849	2.322	0.352	0.379
	II	10	0.874	0.639	0.757	0.626	1.174	0.717	0.783	0.770	0.913	0.796	0.835	1.252	0.822	0.900	0.352	0.897	2.152	0.352	0.371
	III	11	1.090	0.775	0.847	0.689	1.478	0.818	1.019	0.904	1.090	1.033	1.004	1.349	0.961	1.578	0.387	1.276	4.778	0.387	0.775
APR	I	10	1.252	0.743	0.900	0.665	2.257	0.743	1.226	0.809	1.226	1.213	0.913	1.070	0.952	1.461	0.352	1.233	2.517	0.352	0.517
	II	10	1.043	0.757	1.004	0.757	1.735	0.730	1.343	0.783	1.422	1.291	0.861	1.043	1.043	1.383	0.352	1.472	3.939	0.352	0.772
	III	10	1.030	0.796	1.004	0.691	1.657	0.783	1.370	0.757	1.500	1.409	0.926	1.043	1.148	1.291	0.352	1.679	4.487	0.352	0.971
MAY	I	10	1.148	0.835	1.057	1.004	1.317	0.874	1.383	0.757	1.461	1.474	1.057	1.226	1.187	1.357	0.352	1.825	4.526	0.352	0.985
	II	10	1.643	1.004	1.096	0.991	1.174	0.939	1.500	0.952	1.591	1.591	1.304	1.565	1.265	1.285	0.352	1.963	4.565	0.352	0.971
	III	11	1.783	1.205	1.220	1.133	1.263	1.133	1.463	1.205	1.722	1.837	1.564	1.736	1.478	1.119	0.387	2.174	4.276	0.387	1.017
Leap Year																					
A.Flow (Cumec-Day)			58.034	67.449	73.083	58.289	61.347	70.133	51.029	62.006	52.295	57.043	54.198	49.456	54.909	50.903	39.964	66.494			
Annual Flow (Cumec)			0.159	0.185	0.200	0.160	0.168	0.192	0.139	0.170	0.143	0.156	0.148	0.135	0.150	0.139	0.109	0.182			
Annual Volume (MCM)			5.014	5.828	6.314	5.036	5.300	6.060	4.409	5.357	4.518	4.929	4.683	4.273	4.744	4.398	3.453	5.745			
A.V. Basin (Cumec)			0.182																		

Table 8E Ten-daily extended flow series in cumec-day at Sonalpani Nallah

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	3.313	4.357	2.387	2.452	1.878	1.539	2.543	4.109	3.170	2.713	1.904	2.426	2.961	2.804	3.300	3.130	3.209	2.048
	II	10	2.857	3.991	2.139	2.113	2.374	1.930	2.778	5.191	2.557	2.570	1.826	2.648	3.170	2.361	2.504	2.778	3.065	2.309
	III	10	3.522	4.343	3.170	3.470	3.274	2.230	3.196	3.130	3.261	2.439	1.970	3.130	2.804	2.791	2.609	3.378	2.765	2.557
JUL	I	10	4.643	4.070	4.317	4.448	3.078	2.804	2.687	3.965	4.761	3.313	1.936	4.278	3.443	4.096	2.530	4.200	2.648	2.909
	II	10	5.361	4.500	5.583	5.426	3.365	3.326	3.952	3.887	3.809	3.430	2.517	4.448	3.783	5.283	3.170	4.578	2.700	3.026
	III	11	7.088	4.548	6.686	5.395	3.601	5.467	5.969	5.108	4.491	5.366	4.003	5.380	5.050	6.973	5.036	4.103	3.128	5.079
AUG	I	10	4.083	6.209	5.139	5.243	3.222	4.774	6.104	4.070	3.822	4.030	3.404	6.326	2.674	5.048	3.822	3.913	2.987	4.213
	II	10	5.165	5.452	3.052	4.265	3.300	2.283	5.283	5.609	4.500	4.865	3.626	6.143	2.883	3.952	4.187	4.330	3.078	4.409
	III	11	7.547	6.170	3.228	3.286	2.052	1.808	2.870	5.495	5.352	5.380	5.251	4.778	2.410	3.458	5.567	3.817	5.380	4.290
SEP	I	10	5.126	6.235	2.948	5.987	1.422	1.343	2.100	3.039	3.522	4.526	3.874	3.183	1.891	2.257	5.022	3.757	4.357	3.900
	II	10	4.943	3.809	3.796	2.843	1.278	1.604	1.670	2.713	2.843	4.370	3.104	2.335	1.643	2.087	2.713	3.430	3.678	3.835
	III	10	4.213	2.583	2.804	2.517	1.187	1.539	1.683	2.452	2.309	2.804	2.413	1.996	1.409	5.374	2.296	2.857	2.935	2.883
OCT	I	10	2.752	1.878	2.061	1.917	0.965	1.200	1.317	1.787	1.904	0.887	3.117	1.800	1.083	2.622	1.735	2.361	1.383	1.513
	II	10	2.191	1.578	1.774	1.722	0.848	1.017	0.965	1.304	2.100	0.822	3.443	1.630	0.926	2.139	1.591	1.500	1.304	0.978
	III	11	2.769	2.095	1.894	1.793	0.947	1.076	0.961	0.961	2.253	0.847	2.511	1.636	0.861	2.037	1.593	1.492	1.220	1.033
NOV	I	10	1.735	1.135	1.409	1.083	0.861	0.770	0.757	0.900	0.535	1.213	1.591	0.796	0.743	1.343	1.383	1.265	1.030	0.822
	II	10	1.487	1.004	1.083	1.135	0.822	0.704	0.678	0.796	0.730	0.717	1.200	0.717	0.704	1.148	1.330	1.226	0.991	0.704
	III	10	1.057	0.900	0.678	0.809	0.743	0.665	0.652	0.678	0.652	0.835	1.043	0.717	0.652	0.952	1.357	1.187	0.926	0.770
DEC	I	10	0.783	0.835	0.952	0.704	0.652	0.639	0.626	0.613	0.704	0.730	0.822	0.757	0.600	0.835	1.304	1.161	0.848	0.743
	II	10	0.704	0.770	0.835	0.783	0.600	0.639	0.587	0.574	0.613	0.626	0.809	1.109	0.561	0.691	1.174	1.109	0.809	0.678
	III	11	0.660	0.631	1.033	0.732	0.717	0.703	0.631	0.703	0.646	0.703	0.818	0.760	0.545	0.703	1.435	1.234	0.976	0.660
JAN	I	10	0.613	0.587	0.783	0.639	0.574	0.691	0.757	0.561	0.509	0.639	0.730	0.565	0.457	0.613	1.317	1.135	0.822	0.600
	II	10	0.600	0.600	0.678	0.613	0.561	0.639	0.483	0.522	0.483	0.587	0.639	0.678	0.417	0.809	1.278	1.109	0.822	0.626
	III	11	0.646	0.803	0.674	0.660	0.703	0.717	0.517	0.574	0.545	0.674	0.689	0.732	0.732	0.631	1.177	1.363	0.918	0.674
FEB	I	10	0.626	0.652	0.587	0.574	0.613	0.574	0.483	0.430	0.443	0.561	0.522	0.626	0.561	0.691	1.043	1.239	0.835	0.600
	II	10	0.730	0.600	0.743	0.587	0.561	0.574	0.522	0.378	0.470	0.561	0.900	0.665	0.574	0.678	1.174	1.383	0.822	0.639
	III	8	0.610	0.470	0.522	0.344	0.458	0.522	0.480	0.323	0.434	0.376	0.535	0.574	0.575	0.470	0.970	1.169	0.693	0.553
MAR	I	10	0.678	0.613	1.330	0.587	0.887	0.626	0.809	0.522	0.717	0.561	0.613	1.043	0.743	0.717	1.709	2.322	0.991	0.809
	II	10	0.691	0.730	1.226	0.613	0.600	0.665	0.939	0.626	1.017	0.652	0.678	0.913	1.148	0.783	2.074	2.152	1.043	0.848
	III	11	1.019	0.890	1.148	0.947	0.760	1.119	1.736	1.966	1.607	0.775	0.875	0.933	1.320	1.062	4.778	2.611	1.363	2.138
APR	I	10	0.965	0.874	1.422	0.991	0.730	1.226	2.035	1.930	1.565	0.770	0.822	1.043	1.239	1.252	2.517	2.243	1.357	1.930
	II	10	1.761	0.991	2.922	0.991	0.900	2.635	2.713	2.687	1.683	1.030	1.070	1.343	1.396	1.487	3.939	2.243	1.513	1.709
	III	10	2.791	1.213	1.839	1.213	1.370	2.635	4.304	3.457	1.917	1.083	1.343	1.474	1.683	2.113	4.487	2.387	1.957	2.400
MAY	I	10	2.596	1.122	1.891	1.487	1.461	3.078	4.526	3.822	2.296	1.096	1.943	2.374	1.996	2.400	3.874	2.843	2.217	2.726
	II	10	2.557	1.487	2.922	1.487	1.396	2.635	3.378	3.613	2.517	1.096	2.426	2.713	2.361	3.430	4.565	2.896	3.013	2.048
	III	11	3.228	2.238	3.300	2.267	1.951	3.214	3.745	4.017	1.908	1.449	2.009	2.095	3.099	3.860	4.276	2.927	3.687	2.210
Leap Year																				
A.Flow (Cumec-Day)			92.110	80.962	78.955	72.124	50.712	59.613	75.434	82.513	72.644	65.096	67.098	74.866	59.097	79.850	94.835	86.829	71.469	69.867
Annual Flow (Cumec)			0.252	0.222	0.216	0.198	0.139	0.163	0.207	0.226	0.198	0.178	0.184	0.205	0.161	0.219	0.260	0.238	0.195	0.191
Annual Volume (MCM)			7.958	6.995	6.822	6.232	4.381	5.151	6.518	7.129	6.276	5.624	5.797	6.468	5.106	6.908	8.194	7.502	6.175	6.037
A.V. Basin (Cumec)			0.182																	

(Cond...) CHEMICAL COMPOSITION OF SURFACE WATER SAMPLES OF RIVER PABBAR AND ITS TRIBUTARIES (MONSOON COLLECTIONS)

Locations → Parameters ↓	SF9	SF10	SF11	SF12	SF13	SF14	SF15	SF16
pH	7.90	7.50	7.80	7.20	6.96	7.12	7.05	7.08
Colour	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	<1 Hazen
Turbidity	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU
Temp. of Water (° C)	12.60	11.90	12.20	11.50	12.70	12.40	11.9	12.10
TS (mg/l)	155	160	159	131	167	156	176	178
TDS (mg/l)	148	147	149	125	159	148	167	170
TSS (mg/l)	7	13	10	6	8	8	9	8
Conductance (µmhos/cm)	164.71	168.90	168.29	152.06	175.80	174.12	191.95	189.50
Alkalinity as HCO_3^- (mg/l)	83.52	76.55	85.00	86.36	90.22	110	85.69	105.00
Calcium as Ca (mg/l)	25.30	27.80	33	28	28.80	26	24.30	24.0
Total Hardness as $CaCO_3$ (mg/l)	73	80	88	76.60	80.60	74	82	78
Magnesium as Mg (mg/l)	2.36	2.55	1.29	1.55	2.02	2.11	4.90	4.60
Chloride (mg/l)	18.90	20.40	22	19	14.90	11.60	10.80	9.80
DO (mg/l)	8	8.70	7.20	9.50	8.40	8.50	7.40	7.20
COD (mg/l)	5.20	5.80	2.50	4.60	3.90	2.80	N.D.	3.50
BOD (mg/l)	1.30	1.40	N.D.	1.20	3.60	1.60	N.D.	1.10
O&G (mg/l)	N.D.	N.D.	N.D.	N.D.	1.10	N.D.	N.D.	N.D
Sulphate as SO_4^{-2} (mg/l)	6	5.80	4.90	7.40	9.40	5.40	5.78	4.68
Nitrate as NO_3^- (mg/l)	0.12	0.02	0.19	0.02	0.09	0.09	0.08	0.03
Flouride as F (mg/l)	N.D (0.1)	N.D (0.1)	N.D (0.1)	N.D (0.1)	N.D (0.1)	N.D (0.1)	N.D (0.1)	N.D (0.1)
Phosphate as PO_4(mg/l)	0.13	0.09	0.15	0.14	0.16	0.15	0.20	0.18
Residual Chlorine	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D.(0.01)	N.D.(0.01)
Ammonical Nitrogen	0.005	0.004	0.004	0.005.	0.007	0.004	0.002	0.003
Arsenic as As (mg/l)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D.(0.01)	N.D.(0.01)
Sodium as Na (mg/l)	9.20	6.58	9.92	8.22	10.15	8.14	9.01	8.55
Lead as Pb (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Zinc as Zn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Copper as Cu (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Iron as Fe (ppm)	0.08	0.06	0.03	0.04	0.06	0.08	0.03	0.04
Hexavalent Cromium as Cr6+ (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
MPN Count	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Potassium as K(mg/l)	1.50	1.60	0.30	1.20	0.90	1.30	1.02	0.90
Manganese as Mn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Mercury as Hg (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Cadmium as Cd (mg/l)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)
Selenium as Se (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
PAH (mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Pesticide Residues(mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
(Source: ITC Study)	Legend: N.D.(Value): Not detected (Minimum Detection Limit)							

CHEMICAL COMPOSITION OF SURFACE WATER SAMPLES OF RIVER PABBAR AND ITS TRIBUTARIES (MONSOON COLLECTIONS)

Locations Parameters ↓	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8
pH	7.15	7.20	6.98	7.20	7.24	7.80	7.90	8.00
Colour	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen
Turbidity	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU
Temp. of Water (° C)	12.10	11.80	12	11.40	11.6	11.20	11.70	13
TS (mg/l)	111	132	130	148	157	149	160	156
TDS (mg/l)	105	123	120	138	149	141	152	144
TSS (mg/l)	6	9	10	10	8	8	8	12
Conductance (µmhos/cm)	156.47	161.63	161.18	162.35	159.41	152.07	168.80	167.44
Alkalinity as HCO_3^- (mg/l)	55.00	56.00	58.00	69.08	56.50	68.00	85.36	70.32
Calcium as Ca (mg/l)	30	32.60	28	26	28.60	24	26	27.20
Total Hardness as $CaCO_3$ (mg/l)	80	91	79	73	77	72	84	77
Magnesium as Mg (mg/l)	1.20	2.30	2.10	1.94	1.33	2.9	4.60	2.10
Chloride (mg/l)	20.90	20.60	11.60	19.60	19.3	23	21.40	20.70
DO (mg/l)	8.80	8.60	8.20	8.50	9.10	8.80	7.60	8.70
COD (mg/l)	3.80	4.20	1.20	3.60	4.50	5	2.80	2.80
BOD (mg/l)	0.90	1.80	N.D.	1.10	1.65	1.20	<1	N.D.
O&G (mg/l)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sulphate as SO_4^{-2} (mg/l)	9.10	5.20	3.60	6	7.27	8.60	11.30	5.30
Nitrate as NO_3^- (mg/l)	0.39	0.20	0.11	0.10	0.14	0.09	0.09	0.08
Flouride as F (mg/l)	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1
Phosphate as PO_4(mg/l)	0.15	0.11	1.14	0.13	0.15	0.14	0.16	0.12
Residual Chlorine	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)
Ammonical Nitrogen	0.003	0.002	0.005	0.003	0.003	0.003	0.002	0.004
Arsenic as As (mg/l)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)	N.D. (0.01)
Sodium as Na (mg/l)	14.10	15	13.30	5.90	10	7.60	6.10	7.52
Lead as Pb (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Zinc as Zn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Copper as Cu (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Iron as Fe (ppm)	0.09	0.07	0.05	0.04	0.09	0.04	0.04	0.04
Hexavalent Cromium as Cr6+ (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
MPN Count	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

(Cond...) CHEMICAL COMPOSITION OF SURFACE WATER SAMPLES OF RIVER PABBAR AND ITS TRIBUTARIES (PRE-MONSOON COLLECTION)

Locations → Parameters ↓	SF9	SF10	SF11	SF12	SF13	SF14	SF15	SF16
pH	7.24	7.21	7.13	7.30	7.60	7.12	7.05	7.10
Colour	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	<1 Hazen
Temp. of Water (° C)	12.60	14	13.30	14.20	13.80	13.20	13.6	13.70
Turbidity	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU
TS (mg/l)	147	158	136	148	162	163	149	146
TDS (mg/l)	143	154	132	143	156	158	147	141
TSS (mg/l)	4	4	4	5	6	5	2	5
Conductance (µmhos/cm)	151.66	162.53	140.12	150.69	163.20	161.45	153.87	160.30
Alkalinity as HCO_3^- (mg/l)	80.50	85.23	90.50	92.00	98.65	98.33	85.00	95.69
Calcium as Ca (mg/l)	17.60	16	25.60	80	90	16	14	17.80
Total Hardness as $CaCO_3$ (mg/l)	52	47	72	2.05	2.50	47	42	54
Magnesium as Mg (mg/l)	1.94	1.70	1.94	20	21	1.70	1.70	2.00
Chloride (mg/l)	12.90	12.40	13.50	8.70	9	11.60	10.80	12.70
DO (mg/l)	8.50	7.50	8	6	8	8.40	7.40	8.20
COD (mg/l)	3.90	4	3	1.40	2.80	3.90	N.D.	4.00
BOD (mg/l)	N.D.	1.70	N.D.	N.D.	N.D.	N.D.	N.D.	1.60
O&G (mg/l)	N.D.	N.D.	N.D.	14	14.70	N.D.	N.D.	N.D
Sulphate as SO_4^{-2} (mg/l)	5	5.80	4.90	0.07	0.09	5.40	5.78	4.80
Nitrate as NO_3^- (mg/l)	0.12	0.02	0.19	N.D.	N.D.	0.09	0.08	0.18
Flouride as F (mg/l)	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1
Phosphate as PO_4(mg/l)	0.13	0.096	0.15	N.D.	N.D.	0.15	0.20	0.12
Residual Chlorine	N.D.	N.D.	N.D.	0.007	0.009	N.D.	N.D.	0.007
Ammonical Nitrogen	0.005	0.004	0.004	N.D.(0.01)	N.D.(0.01)	0.004	0.002	0.004
Arsenic as As (mg/l)	N.D.	N.D.	N.D.	12	7	N.D.	N.D.	N.D
Sodium as Na (mg/l)	9.20	9.54	9.45	10.02	10.45	11.75	9.01	9.15
Lead as Pb (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Zinc as Zn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Copper as Cu (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	0.05	0.04	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Iron as Fe (ppm)	0.08	0.06	0.03	0.04	0.02	0.08	0.03	0.02
Hexavalent Cromium as Cr6+ (mg/l)	N.D.(0.01)	N.D.	N.D.	Nil	Nil	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
MPN Count	Nil	Nil	Nil	1.80	2.10	Nil	Nil	Nil
Potassium as K(mg/l)	1.50	1.60	0.30	0.32	0.25	1.32	1.02	1.04
Manganese as Mn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Mercury as Hg (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)
Cadmium as Cd (mg/l)	N.D.(0.03)	N.D.(0.03)	N.D.	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Selenium as Se (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.	N.D.(0.05)	N.D.(0.05)	N.D.(0.05)	N.D.(0.05)	N.D.(0.05)
PAH (mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Pesticide Residues(mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

(Source: ITC Study)

Legend : N.D (Value): Not Detected (Minimum Detection Limit)

CHEMICAL COMPOSITION OF SURFACE WATER SAMPLES OF RIVER PABBAR AND ITS TRIBUTARIES (PRE-MONSOON COLLECTION)

Locations → Parameters ↓	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8
pH	7.22	7.03	6.98	7.05	7.22	7.05	7.08	6.92
Colour	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen
Temp. of Water (° C)	14.50	11.60	12.5	13.20	11.9	12.80	13.2	13.90
Turbidity	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU
TS (mg/l)	151	155	149	156	147	154	157	142
TDS (mg/l)	148	150	146	153	145	148	152	139
TSS (mg/l)	3	5	3	3	2	6	5	7
Conductance (µmhos/cm)	155.60	156.12	151.86	158.65	152.36	160.29	160.05	145.47
Alkalinity as HCO_3^- (mg/l)	40.23	42.00	45.22	60.88	50.88	65.88	80.42	75.30
Calcium as Ca (mg/l)	17.60	22.80	20.80	26	17.20	22.40	14.80	21.20
Total Hardness as $CaCO_3$ (mg/l)	51	65	59	73	51	63	45	60
Magnesium as Mg (mg/l)	1.70	1.94	1.70	2.2	1.94	1.70	1.94	1.70
Chloride (mg/l)	12.10	10.90	11.60	13	12.10	11.90	12.40	11.50
DO (mg/l)	7.90	7.30	7.90	7.30	7.70	7.60	7.60	8.10
COD (mg/l)	N.D.	3.50	3.60	N.D.	N.D.	4	N.D.	3
BOD (mg/l)	N.D.	0.80	N.D.	0.50	N.D.	N.D.	N.D.	N.D.
O&G (mg/l)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sulphate as SO_4^{-2} (mg/l)	7.27	5.20	3.60	6	7.27	4.90	4.92	5.30
Nitrate as NO_3^- (mg/l)	0.14	0.20	0.11	0.10	0.14	0.09	0.09	0.08
Flouride as F (mg/l)	N.D (0.1)	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1
Phosphate as PO_4(mg/l)	0.15	0.11	1.14	0.13	0.15	0.14	0.16	0.12
Residual Chlorine	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Ammonical Nitrogen	0.003	0.002	0.005	0.003	0.003	0.003	0.002	0.004
Arsenic as As (mg/l)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sodium as Na (mg/l)	10.50	7.75	7.15	8.92	10.20	7.64	6.17	7.15
Lead as Pb (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Zinc as Zn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Copper as Cu (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Iron as Fe (ppm)	0.09	0.07	0.05	0.04	0.09	0.04	0.04	0.04
Hexavalent Cromium as Cr6+ (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
MPN Count	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Potassium as K(mg/l)	1.80	1.40	0.60	0.70	3.60	1.30	1.10	1.30
Manganese as Mn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Mercury as Hg (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Cadmium as Cd (mg/l)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)
Selenium as Se (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
PAH (mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Pesticide Residues(mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

(Contd.....) CHEMICAL COMPOSITION OFSURFACE WATER SAMPLES OF RIVER PABBAR AND ITS TRIBUTARIES (WINTER COLLECTION)

Locations → Parameters ↓	SF9	SF10	SF11	SF12	SF13	SF14	SF15	SF 16
pH	7.13	7.40	7.60	7.7	7.3	7.09	7.35	7.38
Colour	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1	< 1 Hazen	<1 Hazen
Turbidity	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	<1 NTU
Temp. of Water (° C)	5.90	4.80	5.70	6.3	4.5	4.8	5	5
TS (mg/l)	98	110	117	116	116	122	125	130
TDS (mg/l)	89	105	110	114	112	116	118	124
TSS (mg/l)	9	5	7	6	4	6	7	6
Conductance (μmhos/cm)	101.14	123.53	127.91	128.9	128.4	8.82	130.13	128.8
Alkalinity as HCO_3^- (mg/l)	76.40	79.00	84.30	85.30	76.32	80.12	60.20	85.23
Calcium as Ca (mg/l)	23.60	28.16	27.60	21	24.5	24.4	23.6	22.4
Total Hardness as $CaCO_3$ (mg/l)	69	77.40	78	65	69	68	68	67
Magnesium as Mg (mg/l)	2.45	1.7	2.18	2.9	1.82	1.7	2.18	1.8
Chloride (mg/l)	20.20	12.40	13.10	18.5	19.7	11.8	10.9	11.2
DO (mg/l)	7.50	8.10	7.90	7.4	7.0	8.3	8	7.8
COD (mg/l)	2.80	3.90	4.50	3.8	2.7	7.8	6	5.4
BOD (mg/l)	N.D.	N.D.	1.50	1.2	1.2	2.6	1.8	1.2
O&G (mg/l)	N.D.	N.D	N.D.	N.D	N.D	N.D.	N.D.	N.D
Sulphate as SO_4^{-2} (mg/l)	8.80	8.80	9.40	8.5	8.2	4.9	6.4	6.5
Nitrate as NO_3^- (mg/l)	0.20	0.06	0.04	0.05	0.03	0.05	0.06	0.04
Flouride as F (mg/l)	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1
Phosphate as PO_4(mg/l)	0.16	0.13	0.14	0.12	0.19	0.019	0.164	0.112
Residual Chlorine	N.D. (0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D (0.01)
Ammonical Nitrogen	0.08	0.004	0.004	0.005	0.007	0.005	0.009	0.01
Arsenic as As (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D (0.01)
Sodium as Na (mg/l)	11.75	9.85	6.45	8.28	9.25	8.74	10.05	9.30
Lead as Pb (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D (0.01)
Zinc as Zn (mg/l)	N.D.(0.01)	0.05	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.05	0.04
Copper as Cu (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D (0.01)
Iron as Fe (ppm)	0.05	0.04	0.009	0.01	0.02	0.007	0.07	0.06
Hexavalent Cromium as Cr6+ (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D (0.01)
MPN Count	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Potassium as K(mg/l)	1.80	1.20	1.30	1.4	1.6	1.7	1.8	1.6
Manganese as Mn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D(0.01)
Mercury as Hg (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D(0.01)
Cadmium as Cd (mg/l)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03	N.D(0.03)	N.D(0.03)
Selenium as Se (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01	N.D(0.01)	N.D(0.01)
PAH (mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Pesticide Residues(mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

(SOURCE: ITC Study)

Legend : N.D (Value): Not Detected (Minimum Detection Limit)

Table G1 Chemical Composition of Surface Water Samples in Pabbar River for different periods of collection during 2009.

CHEMICAL COMPOSITION OF SURFACE WATER SAMPLES OF RIVER PABBAR AND ITS TRIBUTARIES (WINTER COLLECTION)								
Locations → Parameters ↓	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8
pH	7.14	7.10	7.24	7.14	7	6.98	7.20	7.10
Colour	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen	< 1 Hazen
Turbidity	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU	< 1 NTU
Temp. of Water (° C)	6.20	7.10	5.80	5.90	5.20	4.90	6	4.50
TS (mg/l)	102	107	111	101	103	113	94	106
TDS (mg/l)	96	97	103	91	99	102	87	94
TSS (mg/l)	6	10	8	10	4	11	7	12
Conductance (µmhos/cm)	112.94	114.12	121.18	105.81	116.47	120.00	100.00	109.30
Alkalinity as HCO_3^- (mg/l)	32.50	34	34.77	50.50	52.32	50.56	48.40	75.50
Calcium as Ca (mg/l)	24.40	26	29.6	24.40	24.50	21.20	24.4 0	23.20
Total Hardness as $CaCO_3$(mg/l)	69	74	81	68	70.30	62	69	65
Magnesium as Mg (mg/l)	1.94	2.18	1.70	1.70	2.20	2.18	1.90	1.70
Chloride (mg/l)	11	22	23	17	10.30	24	19.8	20
DO (mg/l)	8.20	7.30	7.80	7.6 0	7.20	7.70	7.60	7.70
COD (mg/l)	5	2	5	<4	4	<2	2.60	8
BOD (mg/l)	1.90	N.D	1.2	N.D	N.D	N.D.	N.D.	1.30
O&G (mg/l)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sulphate as SO_4^{-2} (mg/l)	5.50	14.50	13	11.10	7.20	12.20	7.70	6.30
Nitrate as NO_3^- (mg/l)	0.07	0.09	0.08	0.18	0.07	0.13	0.20	0.30
Flouride as F (mg/l)	N.D (0.1)	N.D (0.1)	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1	N.D (0.1
Phosphate as PO_4(mg/l)	0.15	1.31	1.35	1.42	0.15	1.20	0.17	1.13
Residual Chlorine	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Ammonical Nitrogen	0.007	0.007	0.008	0.017	0.006	0.048	0.008	0.009
Arsenic as As (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Sodium as Na (mg/l)	11.40	9.85	10.14	13.50	10.70	8.75	10.25	12.50
Lead as Pb (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Zinc as Zn (mg/l)	0.04	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	0.09	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Copper as Cu (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Iron as Fe (ppm)	0.05	0.04	0.03	0.03	0.02	0.05	0.04	0.02
Hexavalent Cromium as Cr6+ (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
MPN Count	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Potassium as K(mg/l)	1.90	1.80	2.20	2.50	1.40	1.40	1.90	1.50
Manganese as Mn (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Mercury as Hg (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
Cadmium as Cd (mg/l)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)	N.D.(0.03)
Selenium as Se (mg/l)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)	N.D.(0.01)
PAH (mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Pesticide Residues(mg/l)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Table 10E Ten-daily extended flow series in cumec-day at Nallah 2

Month	Ten-Daily	No. Days	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
JUN	I	10	1.104	1.452	0.796	0.817	0.626	0.513	0.848	1.370	1.057	0.904	0.635	0.809	0.987	0.935	1.100	1.043	1.070	0.683
	II	10	0.952	1.330	0.713	0.704	0.791	0.643	0.926	1.730	0.852	0.857	0.609	0.883	1.057	0.787	0.835	0.926	1.022	0.770
	III	10	1.174	1.448	1.057	1.157	1.091	0.743	1.065	1.043	1.087	0.813	0.657	1.043	0.935	0.930	0.870	1.126	0.922	0.852
JUL	I	10	1.548	1.357	1.439	1.483	1.026	0.935	0.896	1.322	1.587	1.104	0.665	1.426	1.148	1.365	0.843	1.400	0.883	0.970
	II	10	1.787	1.500	1.661	1.809	1.122	1.109	1.317	1.296	1.270	1.143	0.839	1.483	1.261	1.761	1.057	1.526	0.900	1.009
	III	11	2.363	1.516	2.229	1.798	1.200	1.822	1.990	1.703	1.497	1.789	1.334	1.793	1.683	2.324	1.679	1.368	1.043	1.693
AUG	I	10	1.361	2.070	1.713	1.748	1.074	1.591	2.035	1.357	1.274	1.343	1.135	2.109	0.891	1.683	1.274	1.304	0.996	1.404
	II	10	1.722	1.817	1.017	1.422	1.100	0.761	1.761	1.870	1.500	1.622	1.209	2.048	0.961	1.317	1.396	1.443	1.026	1.470
	III	11	2.516	2.057	1.076	1.095	0.684	0.603	0.957	1.832	1.784	1.793	1.750	1.593	0.803	1.153	1.856	1.272	1.793	1.430
SEP	I	10	1.709	2.078	0.983	1.996	0.474	0.448	0.700	1.013	1.174	1.509	1.291	1.061	0.630	0.752	1.674	1.252	1.452	1.300
	II	10	1.648	1.270	1.265	0.948	0.426	0.535	0.557	0.904	0.948	1.457	1.035	0.778	0.548	0.696	0.904	1.143	1.226	1.278
	III	10	1.404	0.861	0.935	0.839	0.396	0.513	0.561	0.817	0.770	0.935	0.804	0.665	0.470	1.791	0.765	0.952	0.978	0.961
OCT	I	10	0.917	0.626	0.687	0.639	0.322	0.400	0.439	0.596	0.635	0.296	1.039	0.600	0.361	0.874	0.578	0.787	0.461	0.504
	II	10	0.730	0.526	0.591	0.574	0.283	0.339	0.322	0.435	0.700	0.274	1.148	0.543	0.309	0.713	0.530	0.500	0.435	0.326
	III	11	0.923	0.698	0.631	0.598	0.316	0.359	0.320	0.320	0.751	0.282	0.837	0.545	0.287	0.679	0.531	0.497	0.407	0.344
NOV	I	10	0.578	0.378	0.470	0.361	0.287	0.257	0.252	0.300	0.178	0.404	0.530	0.265	0.248	0.448	0.461	0.422	0.343	0.274
	II	10	0.496	0.335	0.361	0.378	0.274	0.235	0.226	0.265	0.243	0.239	0.400	0.239	0.235	0.383	0.443	0.409	0.330	0.235
	III	10	0.352	0.300	0.226	0.270	0.248	0.222	0.217	0.226	0.217	0.278	0.348	0.239	0.217	0.317	0.452	0.396	0.309	0.257
DEC	I	10	0.261	0.278	0.317	0.235	0.217	0.213	0.209	0.204	0.235	0.243	0.274	0.252	0.200	0.278	0.435	0.387	0.283	0.248
	II	10	0.235	0.257	0.278	0.261	0.200	0.213	0.196	0.191	0.204	0.209	0.270	0.370	0.187	0.230	0.391	0.370	0.270	0.226
	III	11	0.220	0.210	0.344	0.244	0.239	0.234	0.210	0.234	0.215	0.234	0.273	0.253	0.182	0.234	0.478	0.411	0.325	0.220
JAN	I	10	0.204	0.196	0.261	0.213	0.191	0.230	0.252	0.187	0.170	0.213	0.243	0.222	0.152	0.204	0.439	0.378	0.274	0.200
	II	10	0.200	0.200	0.226	0.204	0.187	0.213	0.161	0.174	0.161	0.196	0.213	0.226	0.139	0.270	0.426	0.370	0.274	0.209
	III	11	0.215	0.268	0.225	0.220	0.234	0.239	0.172	0.191	0.182	0.225	0.230	0.244	0.244	0.210	0.392	0.454	0.306	0.225
FEB	I	10	0.209	0.217	0.196	0.191	0.204	0.191	0.161	0.143	0.148	0.187	0.174	0.209	0.187	0.230	0.348	0.413	0.278	0.200
	II	10	0.243	0.200	0.248	0.196	0.187	0.191	0.174	0.126	0.157	0.187	0.300	0.222	0.191	0.226	0.391	0.461	0.274	0.213
	III	8	0.203	0.157	0.174	0.115	0.153	0.174	0.160	0.108	0.145	0.125	0.198	0.191	0.192	0.157	0.323	0.390	0.231	0.184
MAR	I	10	0.226	0.204	0.443	0.196	0.296	0.209	0.270	0.174	0.239	0.187	0.204	0.348	0.248	0.239	0.570	0.774	0.330	0.270
	II	10	0.230	0.243	0.409	0.204	0.200	0.222	0.313	0.209	0.339	0.217	0.226	0.304	0.383	0.261	0.691	0.717	0.348	0.283
	III	11	0.340	0.297	0.383	0.316	0.253	0.373	0.579	0.655	0.536	0.258	0.292	0.311	0.440	0.354	1.593	0.870	0.454	0.713
APR	I	10	0.322	0.291	0.474	0.330	0.243	0.409	0.678	0.643	0.522	0.257	0.274	0.348	0.413	0.417	0.839	0.748	0.452	0.643
	II	10	0.587	0.330	0.974	0.330	0.300	0.878	0.904	0.896	0.561	0.343	0.357	0.448	0.465	0.496	1.313	0.748	0.504	0.570
	III	10	0.930	0.404	0.613	0.404	0.457	0.878	1.435	1.152	0.639	0.361	0.448	0.491	0.561	0.704	1.496	0.796	0.652	0.800
MAY	I	10	0.865	0.374	0.630	0.496	0.487	1.026	1.509	1.274	0.765	0.365	0.648	0.791	0.665	0.800	1.291	0.948	0.739	0.909
	II	10	0.852	0.496	0.974	0.496	0.465	0.978	1.126	1.204	0.839	0.365	0.809	0.904	0.787	1.143	1.522	0.965	1.004	0.683
	III	11	1.076	0.746	1.100	0.756	0.650	1.071	1.248	1.339	0.636	0.483	0.670	0.698	1.033	1.287	1.425	0.976	1.229	0.737
Leap Year																				
A.Flow (Cumec-Day)			30.703	26.987	26.318	24.041	16.904	19.871	25.145	27.504	24.215	21.699	22.366	24.955	19.699	26.650	31.612	28.943	23.823	23.289
Annual Flow (Cumec)			0.084	0.074	0.072	0.066	0.046	0.054	0.069	0.075	0.066	0.059	0.061	0.068	0.054	0.073	0.087	0.079	0.065	0.064
Annual Volume (MCM)			2.653	2.332	2.274	2.077	1.460	1.717	2.173	2.376	2.092	1.875	1.932	2.156	1.702	2.303	2.731	2.501	2.058	2.012
A.V. Basin (Cumec)			0.061																	

Table 10E Ten-daily extended flow series in cumec-day at Nallah 2 (continued)

Month	Ten-Daily	No. Days	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	A.V. (Cumec)	Max	Min	SD
JUN	I	10	0.748	0.800	0.922	0.757	0.678	1.022	0.557	1.117	0.661	0.835	0.822	0.761	0.800	0.743	0.687	0.868	1.452	0.513	0.215
	II	10	0.752	0.817	1.087	0.765	0.709	1.939	0.522	0.835	0.670	0.817	0.822	0.813	0.830	0.691	0.713	0.884	1.939	0.522	0.290
	III	10	0.735	0.913	1.087	0.970	0.752	1.174	0.539	0.783	0.752	0.778	0.809	0.800	0.857	0.757	0.709	0.922	1.448	0.539	0.190
JUL	I	10	0.778	0.943	0.991	1.052	0.774	1.191	0.565	0.678	0.804	0.804	0.813	0.787	1.013	0.774	0.800	1.035	1.587	0.565	0.286
	II	10	1.513	1.343	1.200	1.074	0.804	1.200	0.726	1.070	1.030	0.757	0.835	0.657	1.187	0.900	0.730	1.184	1.661	0.657	0.333
	III	11	1.559	2.664	1.722	1.406	1.036	1.167	1.220	1.880	1.100	0.794	1.009	0.732	1.138	1.110	0.818	1.522	2.664	0.732	0.474
AUG	I	10	1.109	1.683	1.735	1.057	1.135	1.104	1.165	1.796	0.809	0.804	1.157	0.822	0.943	1.013	0.917	1.321	2.109	0.804	0.379
	II	10	1.022	1.591	1.700	1.387	1.109	1.239	1.061	1.626	1.035	1.170	1.030	0.922	0.896	0.926	0.891	1.305	2.048	0.761	0.339
	III	11	0.966	1.588	1.507	1.243	1.153	1.368	1.100	1.688	1.071	1.210	1.035	1.000	0.870	1.000	0.890	1.327	2.516	0.603	0.436
SEP	I	10	1.122	1.770	2.700	1.309	1.065	1.196	0.683	1.300	0.826	1.235	0.991	0.778	0.713	0.822	0.848	1.177	2.700	0.448	0.493
	II	10	1.257	1.543	1.774	1.083	0.883	1.226	0.657	1.278	0.726	1.257	0.904	0.730	0.791	0.713	0.730	1.004	1.774	0.426	0.339
	III	10	0.857	1.000	1.048	0.861	0.822	2.313	0.643	0.757	0.652	1.013	0.861	0.678	0.891	0.678	0.704	0.885	2.313	0.396	0.363
OCT	I	10	0.378	0.378	0.352	0.370	0.378	0.474	0.326	0.296	0.287	0.426	0.387	0.257	0.417	0.239	0.278	0.485	1.039	0.239	0.202
	II	10	0.270	0.317	0.304	0.326	0.352	0.696	0.322	0.261	0.257	0.365	0.357	0.248	0.383	0.217	0.239	0.430	1.148	0.217	0.199
	III	11	0.277	0.287	0.320	0.464	0.392	0.483	0.340	0.258	0.258	0.325	0.359	0.258	0.392	0.234	0.244	0.431	0.923	0.234	0.184
NOV	I	10	0.257	0.243	0.283	0.391	0.352	0.339	0.300	0.243	0.217	0.249	0.304	0.226	0.339	0.209	0.213	0.322	0.578	0.178	0.098
	II	10	0.252	0.217	0.274	0.343	0.335	0.300	0.304	0.226	0.209	0.235	0.278	0.213	0.322	0.209	0.209	0.292	0.496	0.209	0.076
	III	10	0.230	0.200	0.270	0.239	0.326	0.300	0.291	0.213	0.213	0.226	0.248	0.204	0.291	0.209	0.204	0.265	0.452	0.200	0.060
DEC	I	10	0.222	0.187	0.270	0.226	0.330	0.296	0.274	0.196	0.213	0.217	0.217	0.200	0.252	0.209	0.204	0.251	0.435	0.187	0.055
	II	10	0.200	0.204	0.261	0.222	0.339	0.265	0.261	0.196	0.213	0.209	0.204	0.196	0.235	0.209	0.204	0.242	0.391	0.187	0.055
	III	11	0.206	0.230	0.287	0.249	0.363	0.277	0.249	0.206	0.230	0.225	0.225	0.210	0.244	0.225	0.225	0.255	0.478	0.182	0.063
JAN	I	10	0.187	0.204	0.257	0.217	0.339	0.235	0.222	0.200	0.200	0.209	0.200	0.209	0.217	0.204	0.130	0.226	0.439	0.130	0.060
	II	10	0.187	0.187	0.265	0.217	0.304	0.230	0.226	0.213	0.196	0.213	0.209	0.209	0.217	0.200	0.130	0.220	0.426	0.130	0.059
	III	11	0.206	0.201	0.253	0.239	0.316	0.249	0.234	0.220	0.225	0.234	0.230	0.225	0.230	0.215	0.143	0.239	0.454	0.143	0.058
FEB	I	10	0.183	0.174	0.217	0.209	0.296	0.217	0.222	0.191	0.213	0.213	0.226	0.204	0.209	0.196	0.130	0.212	0.413	0.130	0.055
	II	10	0.183	0.187	0.217	0.204	0.278	0.217	0.217	0.209	0.222	0.209	0.213	0.226	0.226	0.209	0.130	0.222	0.461	0.126	0.064
	III	8	0.157	0.150	0.192	0.160	0.261	0.170	0.188	0.170	0.167	0.174	0.184	0.184	0.181	0.163	0.117	0.182	0.390	0.108	0.055
MAR	I	10	0.243	0.209	0.239	0.204	0.500	0.243	0.235	0.252	0.335	0.265	0.257	0.309	0.265	0.243	0.117	0.283	0.774	0.117	0.126
	II	10	0.291	0.213	0.252	0.209	0.391	0.239	0.261	0.257	0.304	0.265	0.278	0.417	0.274	0.300	0.117	0.299	0.717	0.117	0.124
	III	11	0.363	0.258	0.282	0.230	0.493	0.273	0.340	0.301	0.363	0.344	0.335	0.450	0.320	0.526	0.129	0.425	1.593	0.129	0.258
APR	I	10	0.417	0.248	0.300	0.222	0.752	0.248	0.409	0.270	0.409	0.404	0.304	0.357	0.317	0.487	0.117	0.411	0.839	0.117	0.172
	II	10	0.348	0.252	0.335	0.252	0.578	0.243	0.448	0.261	0.474	0.430	0.287	0.348	0.348	0.461	0.117	0.491	1.313	0.117	0.257
	III	10	0.343	0.265	0.335	0.230	0.552	0.261	0.457	0.252	0.500	0.470	0.309	0.348	0.383	0.430	0.117	0.560	1.496	0.117	0.324
MAY	I	10	0.383	0.278	0.352	0.335	0.439	0.291	0.461	0.252	0.487	0.491	0.352	0.409	0.396	0.452	0.117	0.608	1.509	0.117	0.328
	II	10	0.548	0.335	0.365	0.330	0.391	0.313	0.500	0.317	0.530	0.530	0.435	0.522	0.422	0.422	0.117	0.654	1.522	0.117	0.324
	III	11	0.598	0.402	0.407	0.378	0.421	0.378	0.488	0.402	0.674	0.612	0.521	0.579	0.493	0.373	0.129	0.725	1.425	0.129	0.339
Leap Year																					
A.Flow (Cumec-Day)			19.345	22.483	24.361	19.430	20.449	23.378	17.010	20.669	17.432	19.014	18.066	16.485	18.303	16.968	13.321	22.165			
Annual Flow (Cumec)			0.053	0.062	0.067	0.053	0.056	0.064	0.046	0.057	0.048	0.052	0.049	0.045	0.050	0.046	0.036	0.061			
Annual Volume (MCM)			1.671	1.943	2.105	1.679	1.767	2.020	1.470	1.786	1.506	1.643	1.561	1.424	1.581	1.466	1.151	1.915			
A.V. Basin (Cumec)			0.061																		

Flow dependability analysis at Romari dam site and different Nallahs and Flow Duration Curves.

Table 1F Summary of different dependable flow for Romari Dam Site.

Dam Site	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	9.87	11.07	13.02
Various Depend. Flow of 90% Dependable year	4.71	5.54	8.68
Various Depend. Flow of 75% Dependable year	4.43	4.80	9.05
Various Depend. Flow of 50% Dependable year	4.53	5.73	12.93
Various dep. Flows based on Av. Ten Daily flow	4.72	5.64	10.30

Figure 1F Flow Duration Curve for different dependable years at Romari Dam Site.

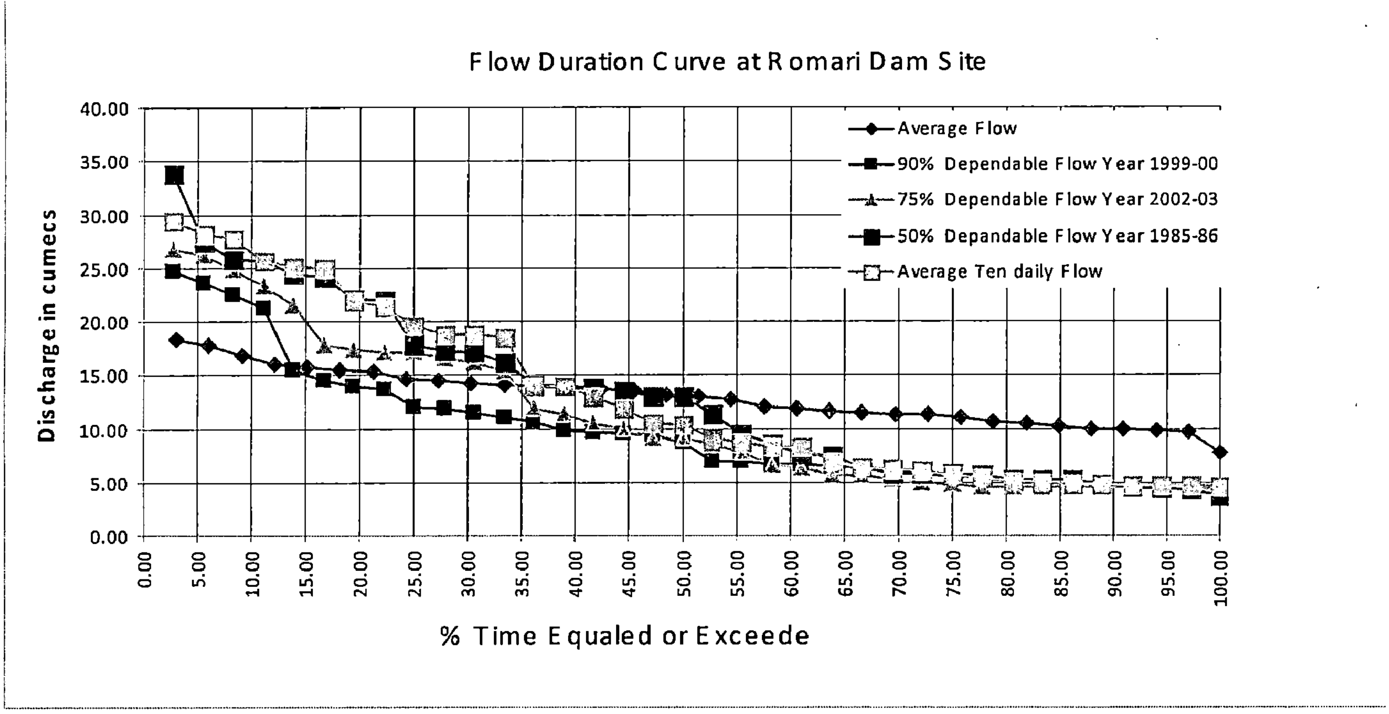


Table 2F Summary of different dependable flow for Barshil Nallah.

Barshil Nallah	Q90%	Q75%	Q50%
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	0.49	0.55	0.64
Various Depend. Flow of 90% Dependable year	0.23	0.27	0.43
Various Depend. Flow of 75% Dependable year	0.22	0.24	0.45
Various Depend. Flow of 50% Dependable year	0.22	0.28	0.64
Various dep. Flows based on Av. Ten Daily flow	0.23	0.28	0.51

Figure 2F Flow Duration Curve for different dependable years at Barshil Nallah.

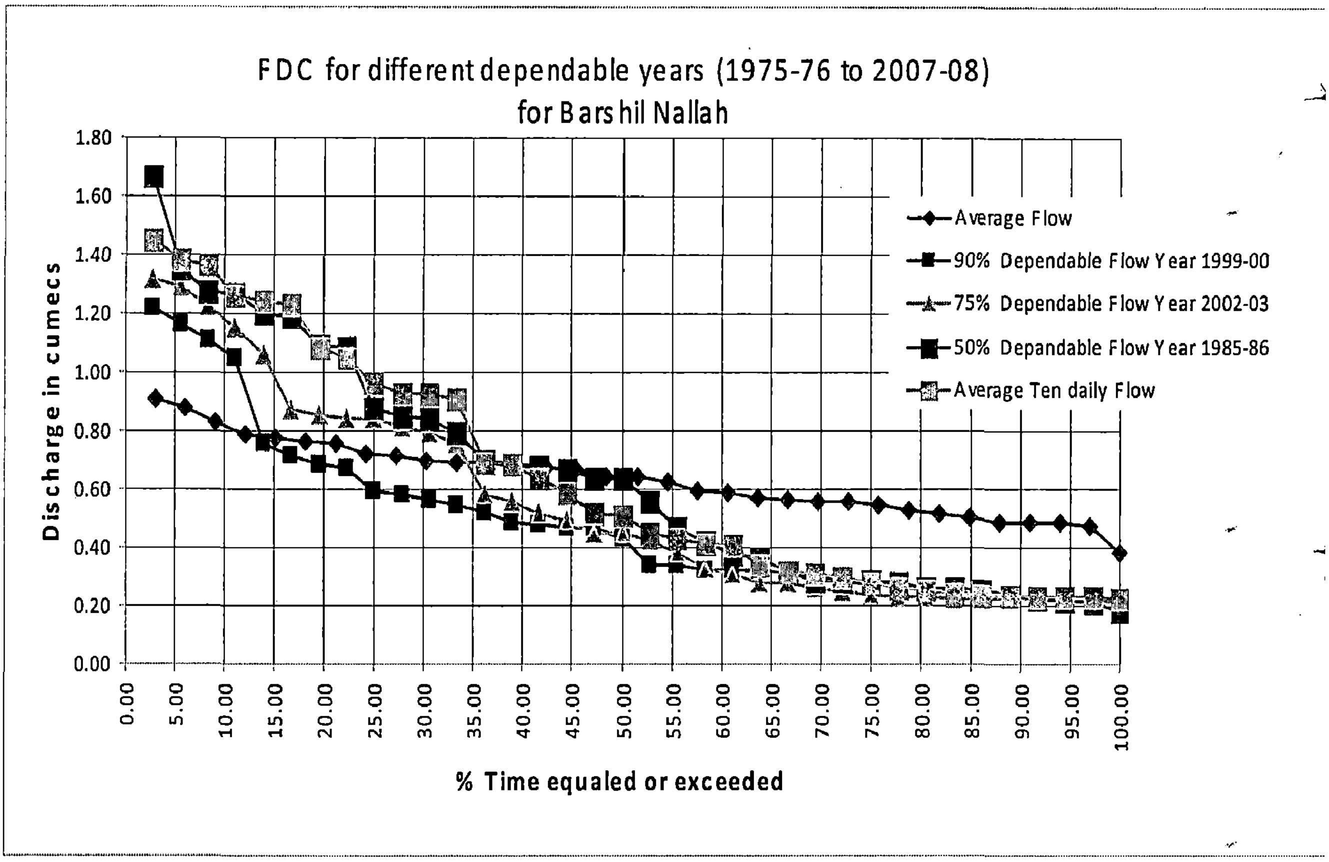


Table 3F Summary of different dependable flow for Khanyara Nallah.

Khanyara Nallah	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	1.06	1.18	1.39
Various Depend. Flow of 90% Dependable year	0.50	0.59	0.93
Various Depend. Flow of 75% Dependable year	0.47	0.51	0.97
Various Depend. Flow of 50% Dependable year	0.48	0.61	1.38
Various dep. Flows based on Av. Ten Daily flow	0.50	0.60	1.10

Figure 3F Flow Duration Curve for different dependable years at Khanyara Nallah.

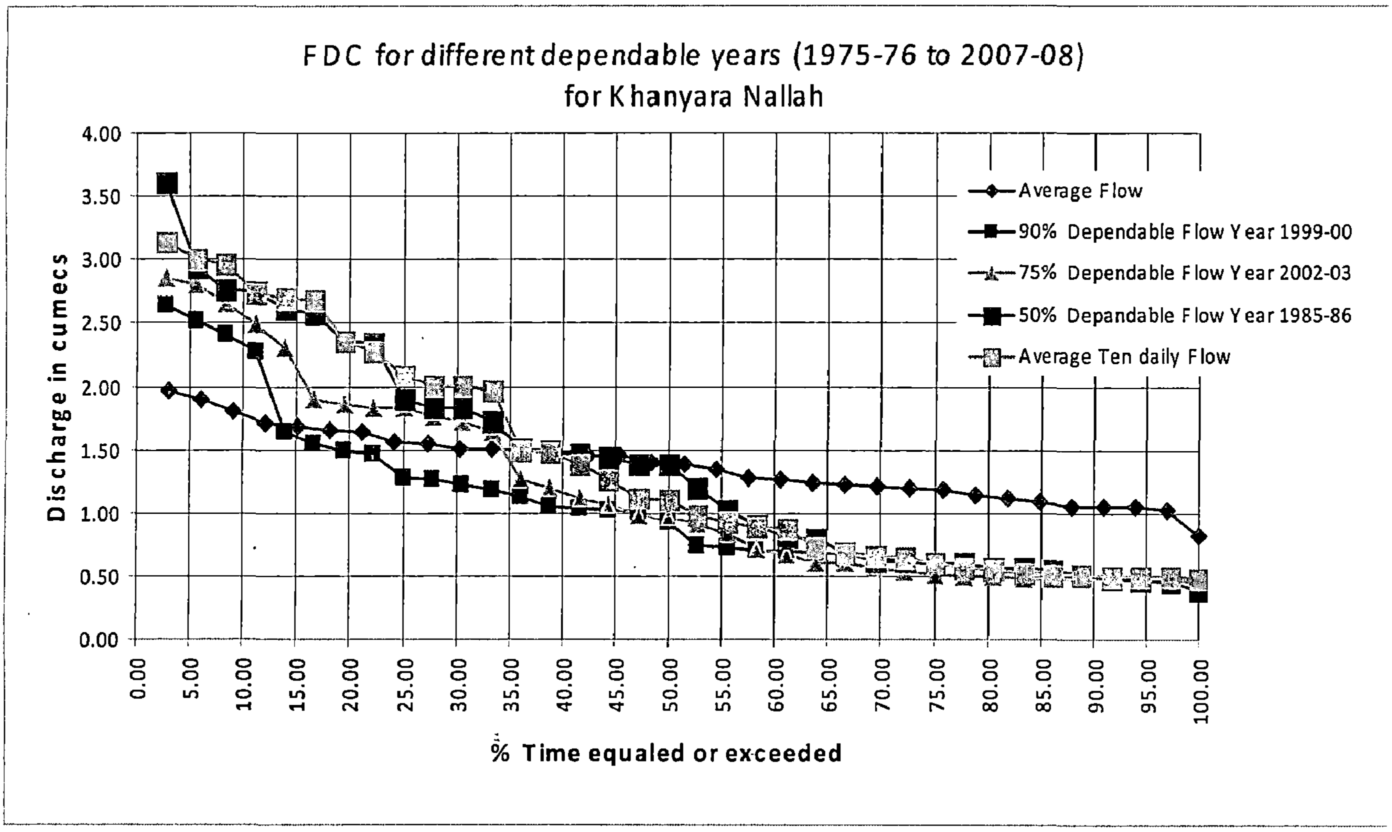


Table 4F Summary of different dependable flow for Nallah 1.

Nallah 1	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	0.23	0.26	0.31
Various Depend. Flow of 90% Dependable year	0.11	0.13	0.20
Various Depend. Flow of 75% Dependable year	0.10	0.11	0.21
Various Depend. Flow of 50% Dependable year	0.11	0.13	0.30
Various dep. Flows based on Av. Ten Daily flow	0.11	0.13	0.24

Figure 4F Flow Duration Curve for different dependable years at Nallah 1.

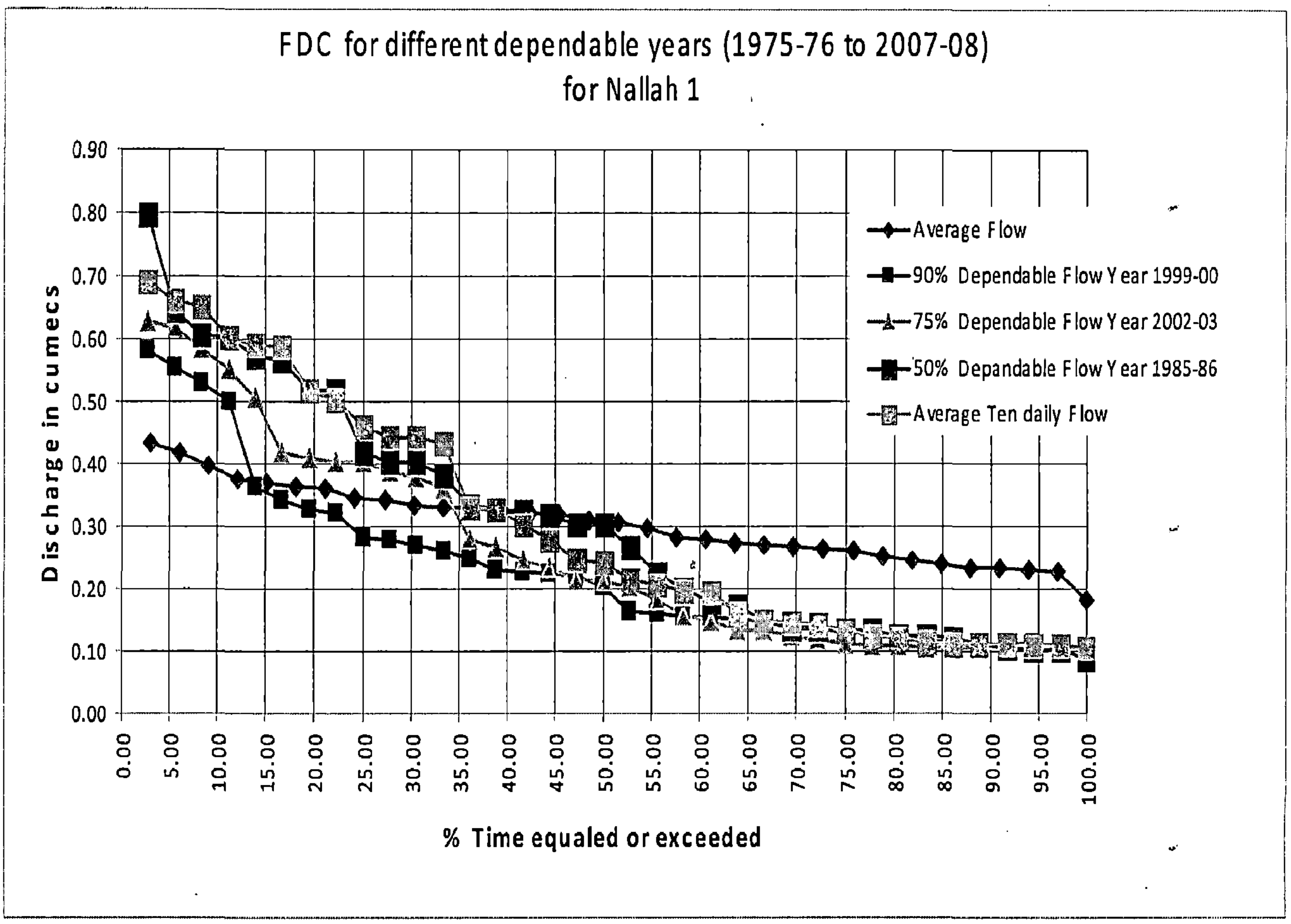


Table 5F Summary of different dependable flow for Bandhi Nallah.

Bandhi Nallah	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	0.30	0.34	0.40
Various Depend. Flow of 90% Dependable year	0.15	0.17	0.27
Various Depend. Flow of 75% Dependable year	0.14	0.15	0.28
Various Depend. Flow of 50% Dependable year	0.14	0.18	0.40
Various dep. Flows based on Av. Ten Daily flow	0.15	0.17	0.32

Figure 5F Flow Duration Curve for different dependable years at Bandi Nallah.

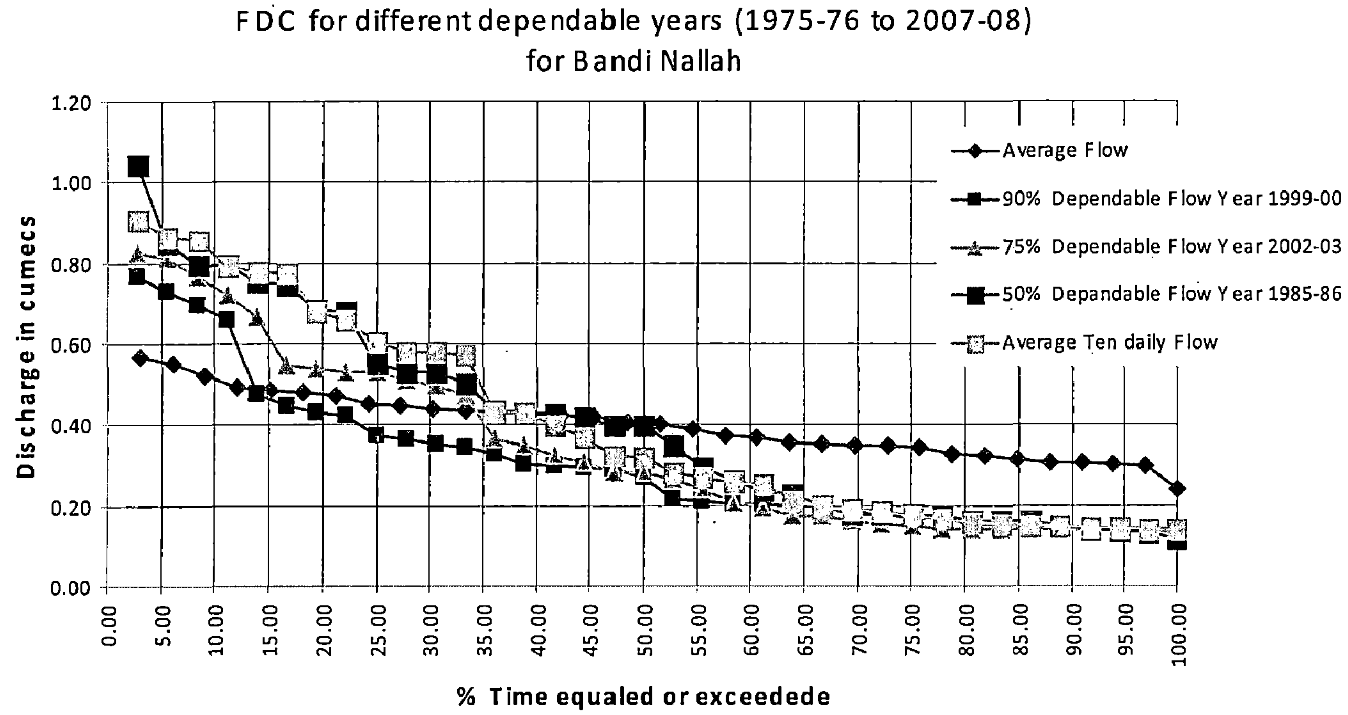


Table 6F Summary of different dependable flow for Shahi Nallah.

Shahi Nallah	Q90%	Q75%	Q50%
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	0.14	0.16	0.18
Various Depend. Flow of 90% Dependable year	0.07	0.08	0.12
Various Depend. Flow of 75% Dependable year	0.06	0.07	0.13
Various Depend. Flow of 50% Dependable year	0.06	0.08	0.18
Various dep. Flows based on Av. Ten Daily flow	0.07	0.08	0.15

Figure 6F Flow Duration Curve for different dependable years at Shahi Nallah.

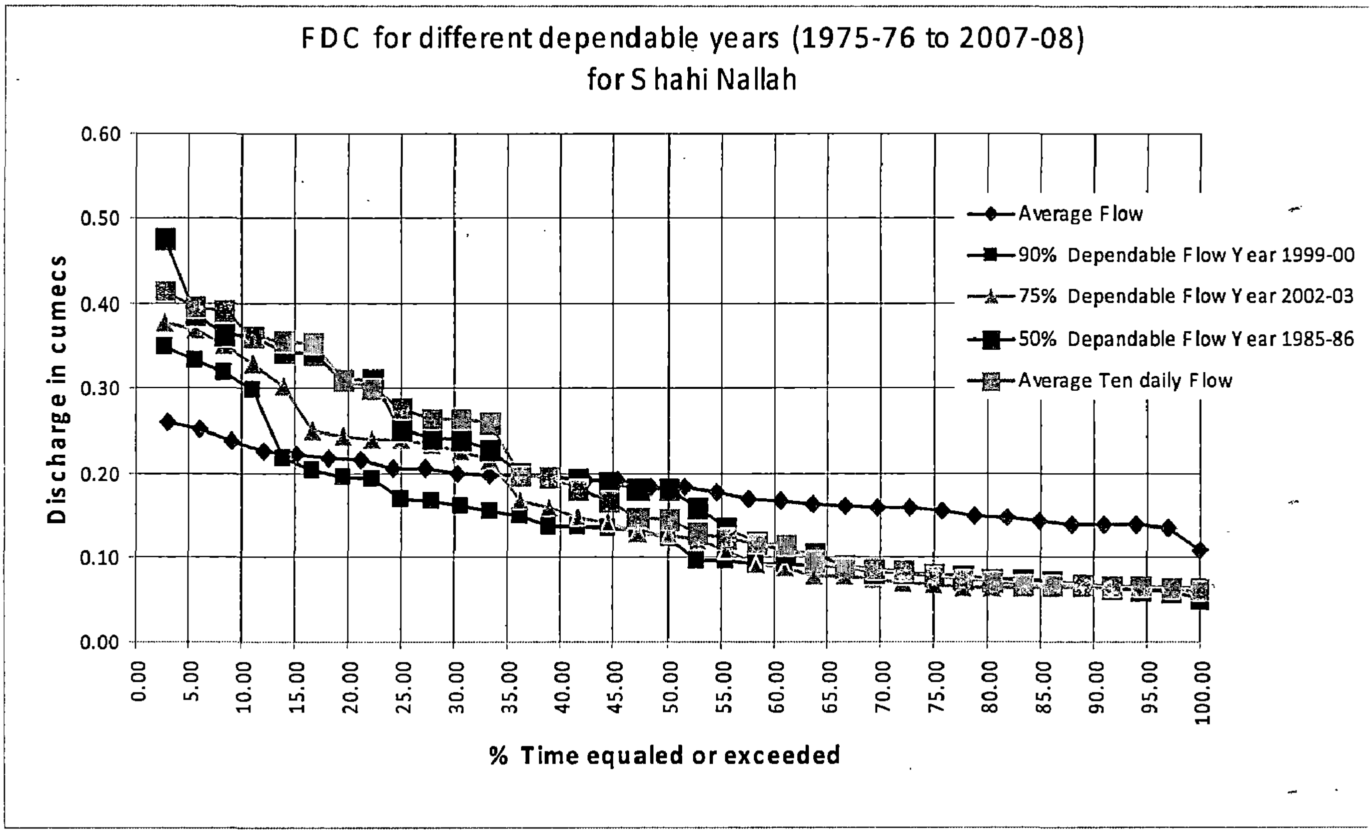


Table 7F Summary of different dependable flow for Gumma Nallah.

Gumma Nallah	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	1.76	1.97	2.32
Various Depend. Flow of 90% Dependable year	0.84	0.99	1.55
Various Depend. Flow of 75% Dependable year	0.79	0.86	1.61
Various Depend. Flow of 50% Dependable year	0.81	1.02	2.31
Various dep. Flows based on Av. Ten Daily flow	0.84	1.00	1.84

Figure 7F Flow Duration Curve for different dependable years at Gumma Nallah.

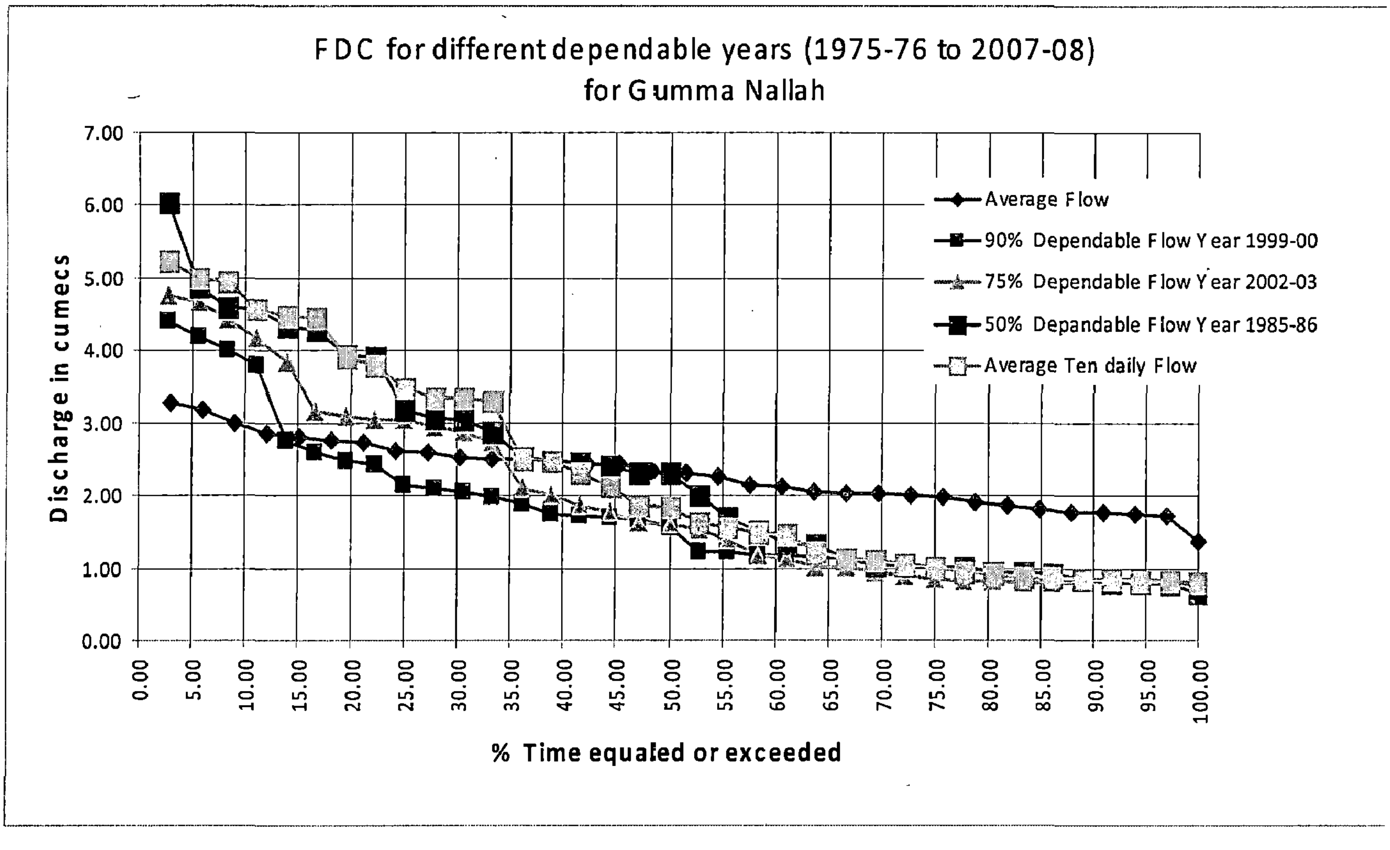


Table 8F Summary of different dependable flow for Sonalpani Nallah.

Sonalpani Nallah	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	0.14	0.16	0.18
Various Depend. Flow of 90% Dependable year	0.07	0.08	0.12
Various Depend. Flow of 75% Dependable year	0.06	0.07	0.13
Various Depend. Flow of 50% Dependable year	0.06	0.08	0.18
Various dep. Flows based on Av. Ten Daily flow	0.07	0.08	0.15

Figure 8F Flow Duration Curve for different dependable years at Sonalpani Nallah.

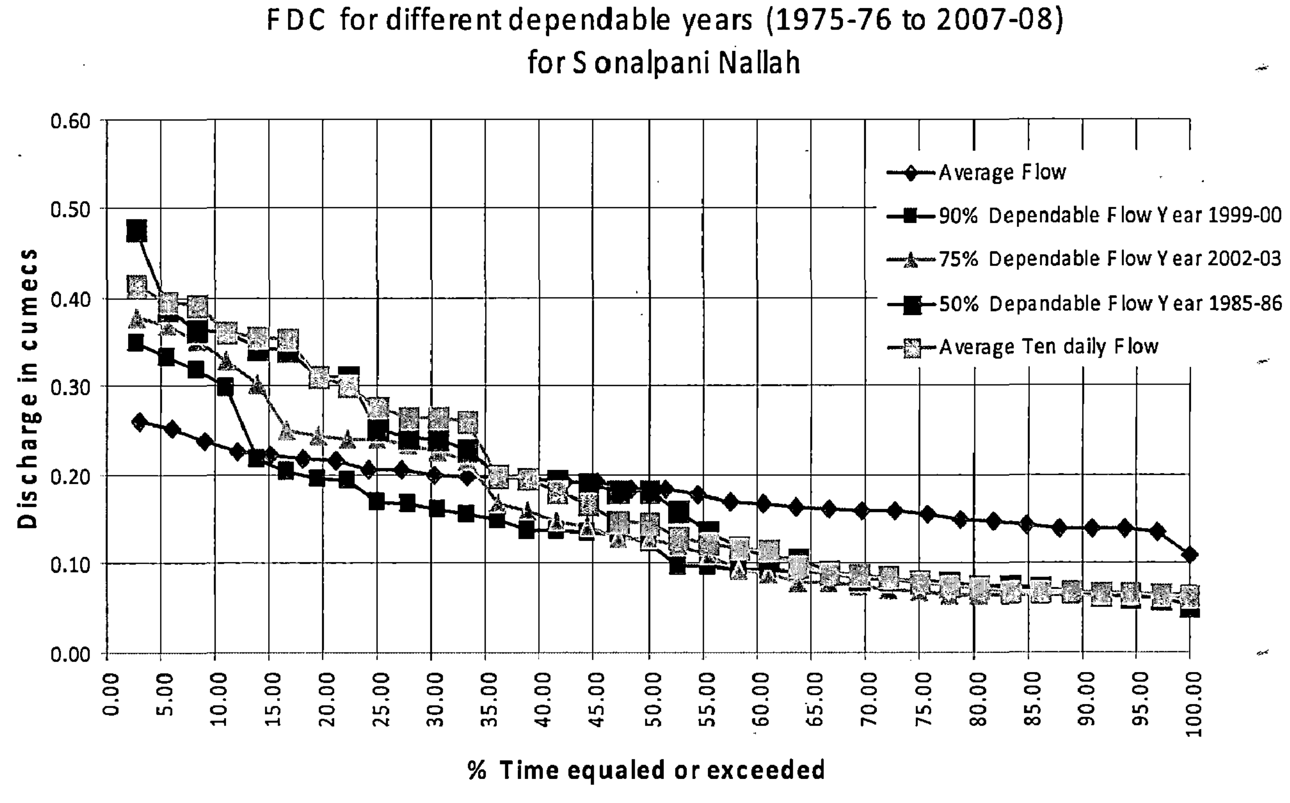


Table 9F Summary of different dependable flow for Khasdhar Nallah.

Khasdhar Nallah	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	0.42	0.48	0.56
Various Depend. Flow of 90% Dependable year	0.20	0.24	0.37
Various Depend. Flow of 75% Dependable year	0.19	0.21	0.39
Various Depend. Flow of 50% Dependable year	0.19	0.25	0.56
Various dep. Flows based on Av. Ten Daily flow	0.20	0.24	0.44

Figure 9F Flow Duration Curve for different dependable years at Khasdhar Nallah.

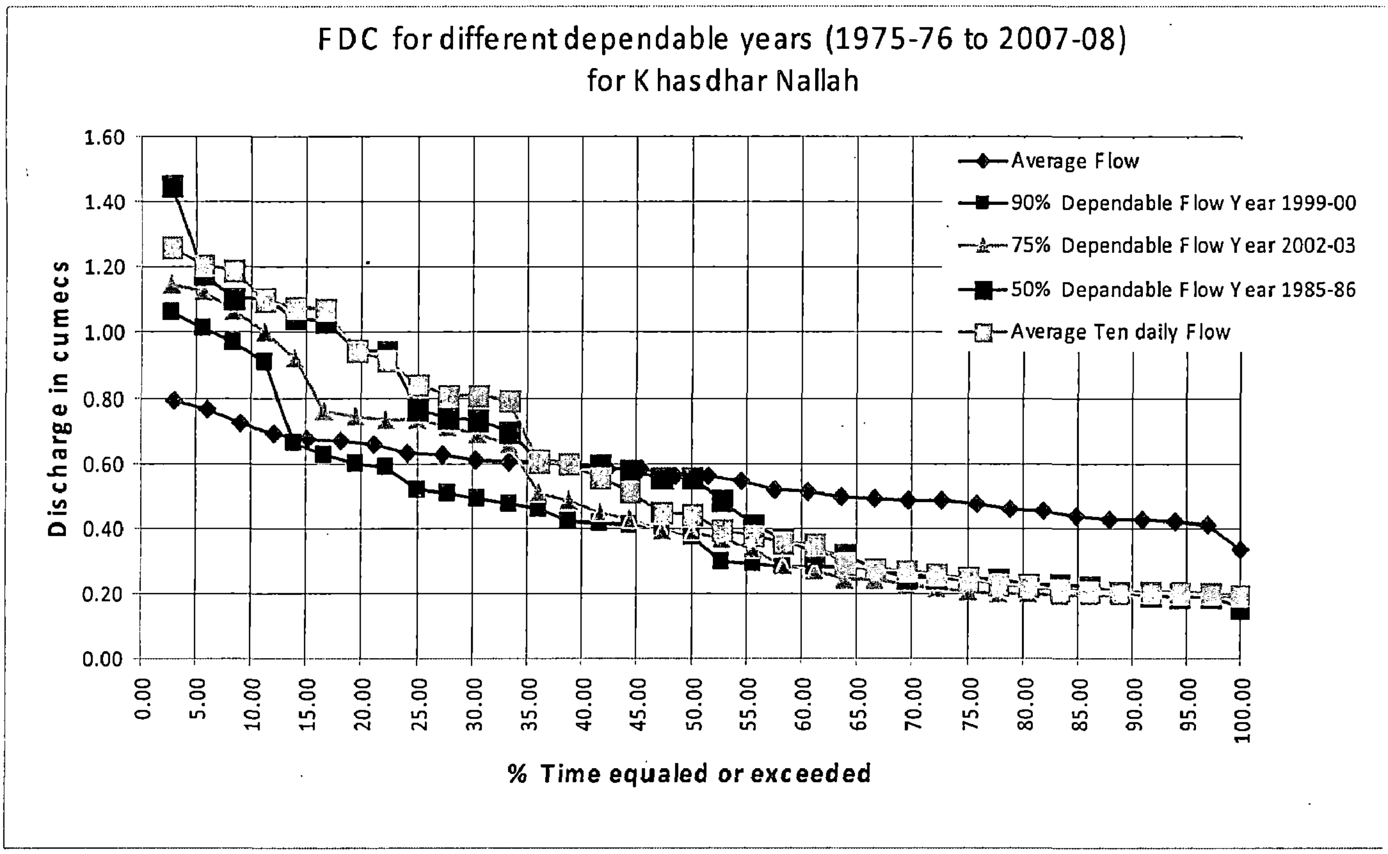


Table 10F Summary of different dependable flow for Nallah 2.

Nallah 2	Q90%	Q75%	Q50%
Dependable year	1999-00	2002-03	1985-86
Average yearly flow	0.05	0.05	0.06
Various Depend. Flow of 90% Dependable year	0.02	0.03	0.04
Various Depend. Flow of 75% Dependable year	0.02	0.02	0.04
Various Depend. Flow of 50% Dependable year	0.02	0.03	0.06
Various dep. Flows based on Av. Ten Daily flow	0.02	0.03	0.05

Figure 10F Flow Duration Curve for different dependable years at Nallah 2.