CLIMATE CHANGE AND LANDSCAPE EVOLUTION IN UPPER BEAS BASIN, HIMACHAL PRADESH

Dissertation submitted in partial fulfillment of the requirement for the award of the degree of

MASTER OF PHILOSOPHY

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2003

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CERTIFICATE

I, **Ishwar Singh**, certify that the dissertation entitled **"CLIMATE CHANGE AND LANDSCAPE EVOLUTION IN UPPER BEAS BASIN, HIMACHAL PRADESH"** for the degree of **MASTER OF PHILOSOPHY** is my bonafide work and may be placed before the examiners for evaluation.

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ACKNOWLEDGEMENT

This academic endeavour of mine would not have become reality without the co-operation extended to me by a number of people at different stages of the work.

My first and foremost gratitude goes to my erudite and esteemed supervisor Dr. Milap Chand Sharma to whom I owe my entire effort, as without his keen supervision, able guidance, intellectual ingenuity, scholastic co-operation and avid suggestion this work would not have been possible. I am deeply indebted to him for his kind gesture.

I am also gratified to acknowledge the faculty members of the Centre for the Study of Regional Development who has helped me in inculcating the academic and research details during my course work. In this regard I am particularly thankful to Prof. Harjeet Singh, Prof. Sivasami and Dr. Anuradha Banerjee.

I am indebted to the staff members of different libraries, particularly JNU library our own Documentation Center to furnish all the required material for the preparation of the work. I am also grateful to SASE for providing me the weather data of few important places.

For the true appearance of data and to give it an appealing look maps and graphs are of immense help. And in this regard, I will be ever obliged to humble and cordial Mr. K. Varghese.

I am thankful Omvir Sir, Ram Kumar Tamang, Rajesh, Vivwk and all others who directly and indirectly have contributed their effort in the execution of this dissertation.

At last, I would like to dedicate my entire work to my parents whose blessings and untarnished faith in me has brought me up here at this stage and their constant inspiration and appreciation has helped in the wee hour of the completion of this work.

Ishwar Singh

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CHAPTER I

INTRODUCTION

Landscapes are that expressions of earth's surface which are composed of an assemblage of subjectively defined components. Each element of the landscape that can be observed in its entirety and has consistence of form (or regular change of form) is defined as a landform. Landform can be constructional such as fault scraps, volcanic cone, glacial moraine, coral reefs and river deltas. Due to peculiar intensity of weathering and erosion most of the landforms are destructional or erosional in their nature. The landscape can be expressed as an assemblage of residual landforms. Each landform is transformed in term by the process of erosion. Landforms should not be viewed as an assemblage of slope, ridges, and mountain peaks, but also of erosional valleys, gullies, and hollows, between which stand the residual hills and mountains.

Since the formation of Davis's trinity of structure, processes and time (stage) the genesis of landform has became the focus of the geomorphologist's attention. Each landform can be visualized as a conversion of rock mass that has specific physical and chemical property, imperfections and geometrically disposed discontinuities i.e. bedding plane, joints, faults etc. All these minerologic, lithologic and deformation factor are collected in geomorphic concept of structure. The most important factor among the trinity of Davis is the process. Therefore, each and every thing that initiates the process must be observed carefully. The famous glacial and interglacial phases have been the period of intensive variation. On account of the interaction of surface process with glacial structure does not completely explain the landforms unless we include the length of time during which the process has been operating. Relatively few landforms show purely constructional evolution, while some geomorphic processes, such as landslide or earthquakes are nearly instantaneous. Most geomorphic processes act much more slowly than anticipated.

Geomorphic processes also vary in intensity from one region to another, depending on the climate, vegetation and altitude above the oceans. The vital feature of geomorphic processes is that, like all chemical and physical process under the same set of environmental condition, they have acted in the past and will act in the future as they do now. Hutton's great principle of the uniformity of process, which is often called "Uniformitarianism" is a key stone of scientific investigation presently being carried out.

In the theoretical analysis of landscape evolution the time is a fundamental axiom. Time is typically measured in thousand and million of years in geomorphic evolution of landform. Traditionally, geomorphologist speaks of relative time and compares the development of landscape only in terms of relative stages of erosional evolution. The basis for this principle was that some landscapes are week or easily eroded terrains, having strong degradational process at work, and evolve rapidly. While other landscape, forming on resistance rock, experience week process and change very slowly. Little value was placed on specifying the rate of development of landscape in terms of actual time. Table 1.1

	Model 1		Model 2
	Static Equilibrium Steady time (1 day)		Static Equilibrium Steady time (1 day)
	Steady-State Equilibrium Graded Time (100 – 1000 years)		Steady-State Equilibrium Graded Time (100 – 1000 years)
	Dynamic Equilibrium Cyclic Time (1,000,000 years)		Dynamic Metastable Equilibrium Cyclic Time (1,000,000 years)
	Progressive Change Cyclic Time (10,000,000 years)		Progressive Change Cyclic Time. (10,000,000 years)

Altitude of Valley Floors

Table 1.1. Models of landscape evolution. Model 1: Equilibrium components of Davis model of progressive erosion. Model 2: Equilibrium components of model based on episodic erosion (after Schumm)

Adapted from Bloom (2000).

Climate change which includes extreme weather phenomenon poses a serious threat. Change in climate condition will have profound and possible harmful impact on life on the earth. In this context, climate change in mountainous area occupies a special place. Mountains present fragile ecosystem, which are globally very important. Mountains are considered as the water- tower of the earth. These are repositories of biological diversity, destination of recreation, tourism and area of cultural heritage. Mountain influence climate and related environmental features as a result of four basic factor namely altitude, continentality, latitude, and topography. Mountain present different climate types with in a small areal extent, primarily because of its varying height and topography.

The terrain characteristics of the basin is a function of exogenic and endogenic geomorphic processes. Exogenic processes are climatogenic, these are function of theprecipitation amount, atmospheric pressure, wind cloud cover etc. Frost action in cold moist climates results in physical weathering of rooks. In humid tropics, however, high temperature and plentiful supply of moisture lead to chemical weathering. Both chemical and physical weatherings are important agents of rock decay in the seasonally humid area of the basin. Ruggedness of terrain leads to local climatic variations, which determine the intensity of operation of various geomorphic processes. Beside the physical properties of parent rock and the waste mantle ,as well as the nature of vegetal cover and runoff characteristics also affect the type and character of landforms. Decomposed rock mantel, when charged with moisture, particularly in area of soluble rock, leads to frequent landslides

Climatic change over different time space and scale whether due to natural forcing or anthropogenic causes can be identified. The fluctuation from day to day or hour to hour can be studied with constant monitoring with modern gadgets..

Climatic changes have been noticed in different geological records with large fluctuation in global or regional climate over the past two million years (Quaternary). These fluctuations have been between ice ages which are periods of relatively large ice cover, extensive alpine glaciers, ice sheets and inter glacials with substantially high temperature. Temperatures were substantially lower in ice ages than in the inter glacial.

Short-term temperature fluctuation over land area differ considerably. Large-scale data show that the globe is warming at the rate of 0.5°C over the past 100 years. This temperature increase is common to both hamispheres. Science 1976 global temperature have increased rapidly with the 1980 being warmest year on record (WMO 1994).

Direct and indirect evidence of past climate change in mountain area of world suggests substantial changes over the last one hundred years or so. This is indicated most strikingly by glacier recisions. Recent model of global climate changes have stressed on significance of late Cenozoics tectonic upliftment of the Himalayas and Tibetan plateau. However there is a disagreement between uplift and climate, particularly with respect to forcing mechanisms timing of uplift and the timing and nature of environmental change (Owen, 1996).

For the optimal use of resources, specially land and water, there is a need for information from and about physical environment to meet the immediate need of present and growing demand of future generations, and therefore to ensure the conservation of natural environment. The study of a watershed or a basin is directly associated with the management of natural resources in terms of land, water and vegetation in the changing environment.

Drainage basin is the basic natural unit for studying changes in landscape and climatic because of its direct control on water yield, runoff volume, fluctuating quantum of sediment load and biological components. From this an assessment of contemporary processes can be maid easily.

The Upper Beas Basin has its own relevance in the landscape evolution and geomorphological studies because of its ability to influence downstream environs. The formation of landscape in the Himalayan region involves a number of different process domains at a number of time scale, to reflect changing environmental conditions . Many of these landforms reflect former prevailing climatic conditions and thus emphases the importance of climate as a major forcing mechanism of landforms genesis.

REVIEW of LITERATURE

Literature available reveals that extensive studies have been conducted on the global climate change and its impact on the overall environment. But very few studies are related directly to climate conditions and impact of climate variability on the mountain environments, especially in the Upper Beas Basin. Some of the works relevant to the present work are discussed below.

Critchfield (1983) has dealt in detail about the various concepts in climatology but has not done any areas specific study. Lal (1991) discussed various theories of climate change like astronomical theory, Co_2 theory etc. He gives a brief historical account of climate change. The causes of variability in climate conditions on earth have also been discussed.

Several relevant studies have been conducted with specific focus on the effect of climate change in mountain areas. Bary (1994) has made an overall review of the past and potential future changes in the movement of glaciers in the two hemispheres. Price and Haslett (1995) made a review of the different kinds of works done in the context of mountain ecosystem and climate change. They have also given an outline of the various approaches which can be adopted, for such areas. But the effects of climate change on mountain eco-systems have not been dealt with in detail. According to Anderson and Westterstad (1992), there are technological, economic and policy solutions that may be used to limit emission of greenhouse gases, and, therefore, likely rates of climate change can be reduced. Bary (1986) states that for mountain climates and the likely implications of climate change in mountain regions one should note that these climates are characterized by marked diurnal and seasonal cycles with high variability at all spatial scales. The temporal and spatial variability is further increased by the diverse relief, aspect and slope. Folland et al. (1990) pointed out that the lack of data in mountainous regions will impede the progress of scientific projects on global climate. Inadequate knowledge of the interaction between atmosphere and the earth's other systems, particularly with regard to the roles of clouds and vegetation influencing the earth's tradition balance and of oceans in absorbing heat has been pointed out by Cusbach and Cess (1990) and Gates et al. (1992). Broecker (1987) considered the possibility of sudden changes in climate change as a result of global warming. Ketz (1988) suggests that considerable re-conceptualization of the design use of Global Climate Models (GCMs) is required for many eco-systems where the extreme values are important. Giorgi (1990) analyzes the problems of GCM vis a vis the great variability of mountain climate over both space and time. He points out that computer models will remain only as exploratory tools for the time being. Smith (1979) has rightly said that meteorological research tended to focus on the upstream and downstream influences of barriers to flow and on orographic effects on weather systems rather than on conditions in the mountain environment. Brookfield and Allen (1989) have analyzed the frost occurrence and agro-climatic variability in New Guinea H highlands. Halpin (1994) has tried to predict the impact of variations in climatic conditions, through a conceptual model of the potential movement of species in different climate ranges along altitudinal gradients. In the Himalayan context, some notable contribution in the field of environment, resources and eco-development have been made by Shah (1986.) Sustainable development of any region, particularly mountainous region, may be achieved only through optimum use of available natural resources such as stream water, forests and soil.

The extreme events arising out of both natural and man-made causes are a major threat to the livelihood of the local community. Damage, loss of life, injury and disruption and economic activities caused by natural hazards such as landslides, snow avalanches, floods and debris flows have stimulated research into causes,and consequences characteristics, location and frequency of different phenomena. Debris flow and flash floods have created serious hazards in mountain environments like the Himalayas, Japan, Canada and Switzerland as observed by Caine and Mood (1982), Vuichard (1986) and Fort (1987). Ardner at al. (1992) analyzed the development of road network and tourism in the Southern ranges of the Himalayas where maintenance of traffic flow is a constant battle against debris flow and debris torrent blockage during the monsoons. Schuster (1978) has done a detailed study on mass wasting and forest ecology of a post glacial re-entrant valley and on landslides analysis and its control. Crozier (1984) has provided a landmark contribution in the field of slope instability, landslides, their causes and consequences.

Smith (1977) has highlighted the impact of the various types of climatic extreme events occurring in different parts of the world and the preventive measures to be adopted. Heathcote (1985) has given in brief the analysis of extreme events in terms of first order impacts and second order impacts.

Singh (1998) has highlighted in his paper the relation between extreme events resulting from unplanned and haphazard anthropogenic activities taking place in the Upper Beas Basin area.

Pirazizy, (1996) in his book 'Environmental Geography and Natural Hazards' has explained the physical structure, bio-physical system, hazards and risks and erosion of Kulu, Chamba and Simla district of Himachal Pradesh. This is a pioneering work in hazard assessment. Pandey (2002) in his work on the Upper Beas Basin, titled 'Geo-Environmental Hazards in Himalayas: Assessment and Mapping of the Upper Bias Basin'. Geo-environmental hazards and risks by geologically occurring physical processes in the environment, posing risks to people and causing calamities in the area. Poverty, population growth and environmental degradation are the main causes of natural disasters. The hazards have varying degree of intensity and severity. Any natural hazard becomes a disaster when it comes in contact with vulnerable social settings of large human population. Many natural hazards are not so natural but are triggered and indeed aggravated by man-made environmental degradation. Pandey(2002) lays great stress on hazards but he himself did not undertake a detailed study of lithology, rock structure, geology or hydrology of the region. He has used the weather data of only a single year, that of 1996. The source of this data is SASE, Manali. He describes the climatic condition and the nature of rainfall in the region. Dhar and Narayanan (1963) explained the nature of rainfall in the Upper Beas Basin. In their article, 'A Brief Study of Rainfall and Flood-Producing Rainstorms in the Beas Catchment', published in the Indian Journal of Meteorology and Geo-Physics, discuss the behaviour of the monsoon and western disturbances quite thoroughly. Eastern part of the catchment receives relatively sparse monsoonal rainfall than the western part. Being situated in the interior of the Himalayan ranges, the eastern part does not get as much rain as the western part because of topographic configuration. Thakur (2003) in his article 'Manu aur Himachal ka Mahnu' in *Vipasha*, correlates the mythic flood, mentioned in the Pauranic texts, in this region and highlights the formation of large lake around Bhunter.

Wadia (1981) and Krishnan (1956) presented a summary of structure, geology and tectonics of Himalayas. The manual of geology of India and Burma by Pascoe (1959) also contain some information about the region. Paterson (1939), provided a first comprehensive interpretation of t evolution of the western Himalayas in recent geological period.

The vegetation of different parts of western Himalayas has been treated by Sexena and Srivastava(1973), Puri and Maini (1957), and particularly for Himachal Pradesh by Raizada and Sexena (1978). The first modern quaternary study, on the Himalaya was undertaken by Porter (1970) in the Swat Kohistan. On the basis of mapping drift of glacial sediments he recognized evidence of Pleistocene glacial advances in the northern part of the Swat river drainage basin. Owen et. al. (1992) re-examined

Porter's chronology , using thermo luminescence dating technique. On the basis of landforms and thick accumulation of glacial, glacio-fluvial, mass-movement, aeolian and lacustrine sediments, glacial chronologies has been produced for the Karakoram mountain (Derbyshire et. al 1984), Swat Kohistan (Porter , 1970, Owen et al 1992), Nanga Parbat, Lahul (Owen et al 1995,96,97,2001) and Garhwal (Sharma . and Owen 1996)Himalayas . There have at least three major glaciations, which became progressively less extensive in dimension with time. The Upper Beas Basin has been identified to have undergone at least one major phase of glaciation which was followed by inter- glacial debris flows.

In addition to above literature other relevant references have been cited where necessary.

SELECTION OF THE STUDY AREA

The Beas river is very important as a water resources in Himachal Pradesh and neighboring states. It irrigates thousands of hectares of land in its periphery. This river is important both for horticulture and agriculture in Kullu Valley. Its paleoterraces are very important for the economy of Himachal Pradesh in the form of agriculture orchards.The Beas Valley contains various places of importance like Kullu, Naggar and Manali. Finally this valley is strategically very important because it provide a link to Ladakh. Besides the social and historical factors, the earth surface processes are very active and the region abounds treasure landforms.

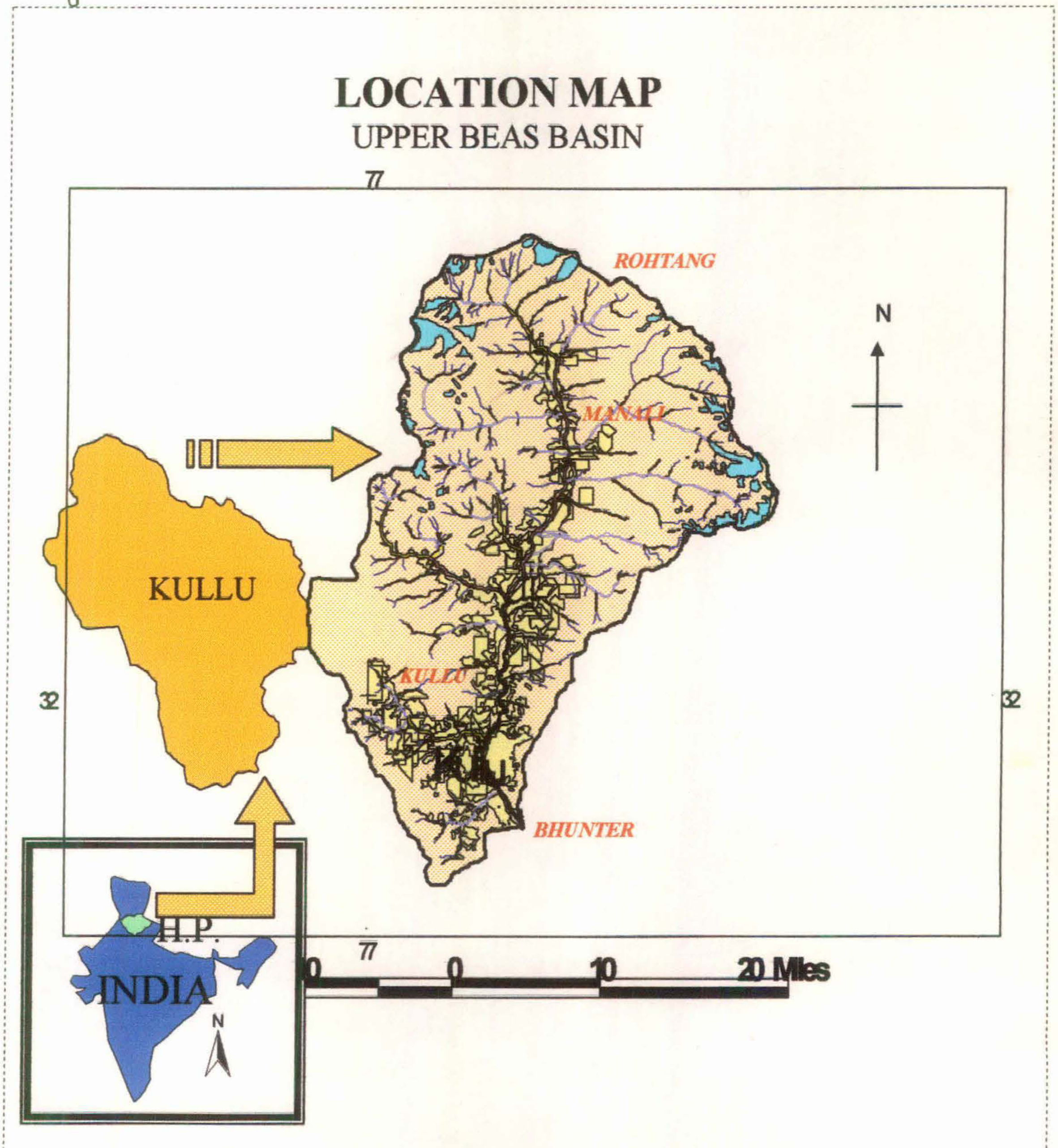
Study area as a drainage basin:

For a number of reasons, drainage basin is the fundamental unit of geomorphological investigation. It is a well-defined area, clearly separated from each other by drainage divide, within which surface or near surface flows of water and associated movements of sediments and solutes is contained. Since, it is the transfer of material that causes change in the elevation and form of the landforms over a period of time, a drainage basin constitutes the natural unit for the analysis of fluvial and other processes. Drainage basin as a unit of study in geomorphology is very famous since the days of Horton (1945). Another important property of drainage basin is its hierarchical nature. Each tributary in a drainage system has its own basin area contributing runoff, and so, large basin consists of many smaller ones. These features of drainage basins make it an important unit for analysis in geomorphology. Following the work of Horton and Strahler, many of its important properties can be expressed quantitatively, in a way, which allows one basin to be compared with other in terms of modification processes.

LOCATION

The Upper Beas Basin is situated in between 31°50'N to 32° 42' N and 76°56' E to77°39' E in Kullu district of Himachal Pradesh, India (Figure 1.1). The area is covered by toposheets Nos. 52 H/3, 52H/4, 52H/7, 52H/8, 53E/1, and 53A/13. Moreover, US Military Survey Map No. NI 43-16 on the scale of 1:250,000 is also used. Its catchment area is approximately 1681.54 sq. km. The general elevation of the Upper Beas Basin ranges from 1120 m at Bhunter to 5345 m at Beas Kund .The basin is demarcated by the Pir Panjal range in the north, whereas Bhunter makes the southern boundary. The water divide with the tributary of Beas- Parvati demarcates the boundary in the east, and on the west by Ravi river basin. Therefore, the study area remains the upper region of Beas river from Beas Kund to Bhunter, roughly 65 km. in length and 45 km in width.

Figure 1.1



LOCATION MAP
UPPER BEAS BASIN
77
ROHTANG
N
MANALI
KULLU
KULLU
32
32
BHUNTER
H.P.
INDIA
N
77
20 Miles

PHYSIOGRAPHY:

The Beas (vadic Arjikiya, Sanskrit Vipasa) rises from the Pir Panjal at Rohtang Pass (13050 ft) of the western Himalayas and river flows southward after origin. In the north and north western part of the basin is bounded by highest ranges with heights in excess of 4500 meters; i.e. Beas Kunde Ri Dhar (5345m), Hanuman Tibba (5932m), Goh Kincha (5085m) Shid Dhar (5209m), and Inder Kila (4941m), which divides the watershed of the Beas river and the Chandra river. In the eastern side, Gohru Peak rises above 4600m. Major passes in the basin are Rothang Pass (3998m), Taintu Ka Jot (4996m), Hamta Jot (4268m), Thanod Pass (4880m) and Haishin Jot (4942m).

The water resources of the region include rivers, streams, nalas,springs and glaciers. The major tributaries of Beas river include Solang Nala, Sarai Nala, Rawla Gohru Nala, Halindi Nala, Manalsu Nala, Sanjoin Nal, Phojal Nal, Sarbari Khad, and Chhaki Nala etc. Among the glaciers Dhundha (4200m), Rawla (4500m) and Ghoru and Chandar (4800m) are important.

The relief (Figure 1.2) shows the general elevation of the basin ranging between 1500 m in the valley side and 4800 m and above in the upper catchment areas. The Pir Panjal range which is also the head water of river Beas, contains the treasure of geomorphic, tectonic, climatic and vegetation records. The increasing altitude presents a spectacular zonation of vegetation type, geomorphic processes and associated landforms. The basin is very significant in the terms of tectonic and climatic change. The Chandrabhaga to the north of the Pir Panjal flows in a east-west direction where glaciers and drainage of Beas on the south has straight southern course.

Figure: 1.2

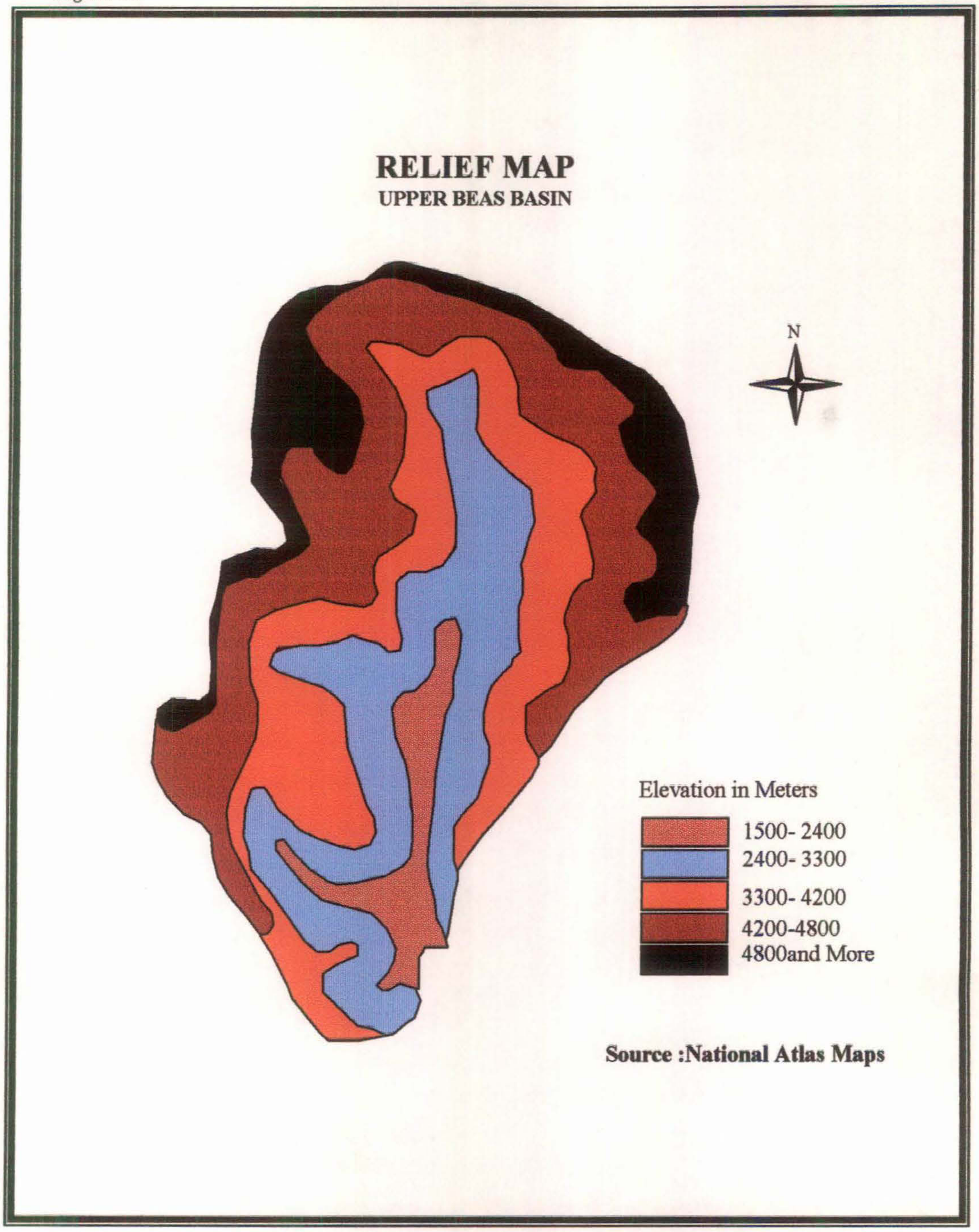

RELIEF MAP
UPPER BEAS BASIN
N
Elevation in Meters
1500- 2400
2400- 3300
3300- 4200
4200-4800
4800and More
Source :National Atlas Maps

Plate 1: High up erratics are common in the Upper Beas Basin. These border the highest terraces evolved out of lateral moraines almost 120 m higher than present valley floor.

Plate 2: A typical cirque (arrow) glacier with icefall in the Beas Kund area. Note the avalanche cones and impressive lateral moraines.

GEOLOGY:

In the study of any region, geology is an important factor because of endogenic nature of rocks. Various types of parental rocks behave differently in various climates andduring the process of land formation.

Geological structure of the region is mainly comprised of Middle Proterzoic Granite Group . It is the most complicated geological region of the northern mountains. Most of the area is composed of granite and other crystalline rocks of un-fossiliferous sediments. Therefore, in the geology of Upper Beas Basin , the underlying rocks are generally gneiss, schists, shales and quartzite. Granite rock is rare, but is generally found in bounds with gneiss, schists and shales. The rocks of Kullu formation particularly have been categorized into four members, namely: Green-bed Member, Schist Member, Carbonaceous Member and Granite/Gneiss and Schist Member. These members show, the activity of high metamorphism .The rocks exposed in the Upper Beas Basin belong to Pre Cambrian meta- sedimentary group (Ravinshankar and Dua, 1978).

SOILS:

The soils of the region are the result of climatic factors and geomorphic processes, aided by geo-lithology. On the whole, the soils are young and thin. Recently formed soils having shallow black, brown and alluvial characteristics are mainly found in the basin. Major soil groups found in the basin are Udolf, Udolf-Ochrepts, Ochrepts, and Glacial as given by ICAR. The organic matter content is also high . Available nitrogen varies from medium to high, whereas potash is medium . The soil reaction is acidic in nature . The soils between the heights of 2000-3000 m are shallower in depth as compared to the lower altitudinal soils (Pandey, 2002). Soils of valley and basin with medium texture and thick hydromoranic surface characteristics contribute comparatively less to the silt yield of the catchment. These soils are rich in organic matter and have well developed crumb structure that renders them less erosive both because of their characteristics in parts and partially by the density of vegetation (Pirazizy, 1992, Pandey, 2002).

GLACIER AND DRAINAGE

In its upper reaches the Beas has a north to south transverse flow through the Himalayan ranges. Till Marhi, below the Rohtang pass, Beas is a small stream, which is gradually feed by snowmelt . Manali onwards the path of river Beas become wide and gentle in gradient. The streams of the Beas basin show concurrent flow characteristics. Most of the streams are ice and snowfed and are a perennial source of freshwater for the local people . The major streams and glaciers are the Beas Kund Nala, Sarai Nala, Rawla Gohru Nala, Halindi Nala, Manalsu Nala, Sanjoin Nal, Phojal Nal, Sarbari Khad, and Chhaki Nal etc. Among the glaciers Dhundha (4200m), Rawla (4500m) and Ghoru and Chandar (4800m) are important.

Glacier are small in area but enough for perennial flow of water in the Beas River. Drainage is dendritic because the basin has a very steep valley sides in small area. With it, river basin receives rain fall both in summer as well as in winter seasons. This shows that the region has the high erosion possibilities, which can become a hazard with human intervention. The primary water sources for the Beas river are winter and spring snow melt, summer monsoon rainfall andglacial melt.

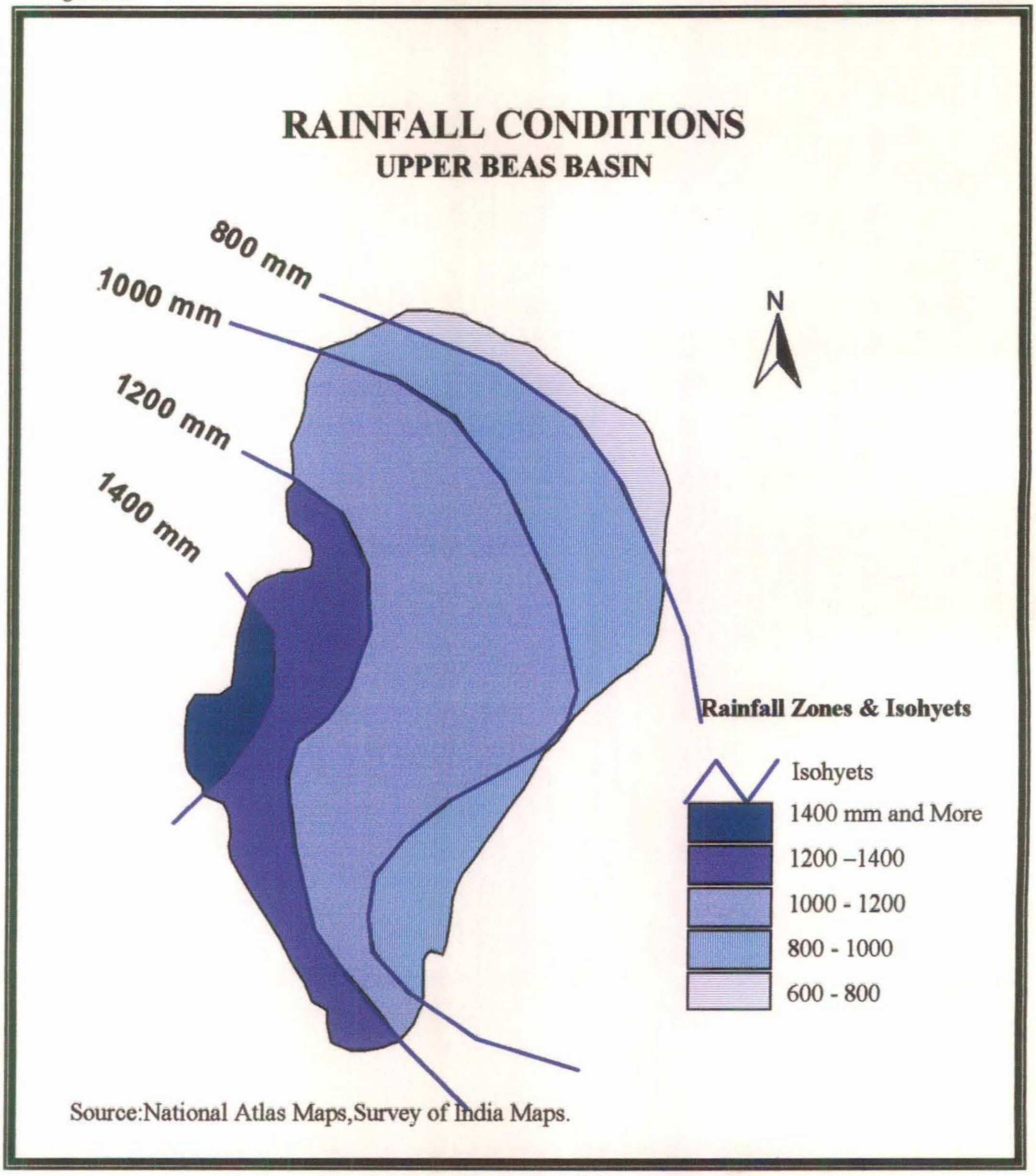
CLIMATE

Upper Beas Basin lies in a temperate zone. The variation in altitude from one end of the basin to the other is quite high. Hence, differences in temperature are marked. The climate of the low altitude area of the basin near the southern boundary is somewhat similar to the adjoining plain of Punjab, except for a milder summer season. From north to south of the basin, three distinct climatic zones have been identified on the basis of variation in relief. There is an alpine type climate near Rothang Pass which is devoid of any vegetation. Below Rohtang pass, is a zone of sub-alpine climate and further south is temperate zone. There are large annual variations in temperature with the maximum temperature in June and lowest temperature recorded in January.

The average relative humidity generally increases from the outer to the inner parts of the basin. Maximum relative humidity is recorded in July and August with the lowest in June. There is a general decrease in pressure gradient from north to south. The rainfall is during the month of July and August related to monsoons. The Upper Beas Basin also receives rainfall from the western disturbances in the winter during Nov- March. There is a general decrease in rainfall with altitudes and from west to north, and north-east (Figure 1.3). Precipitation is in the form of both rain and snowfall, with snowfall being more predominant in the upper part of the basin.

Generally the area of the Pir Panjal and Dhauladhar has been included in Mountain group of climate by Thornthwaite, Koeppen and also by R. L. Singh. The high altitudes of more than 2000m from mean sea level (MSL) as well as extra tropical latitudes 32^0 N shows a climate of temperate characteristics.

Figure :1.3


RAINFALL CONDITIONS
UPPER BEAS BASIN
800 mm
1000 mm
1200 mm
1400 mm
N
Rainfall Zones & Isohyets
Isohyets
1400 mm and More
1200 –1400
1000 - 1200
800 - 1000
600 - 800
Source:National Atlas Maps,Survey of India Maps.

NATURAL VEGETATION

Due to a very high variation in elevation, river basin contains deciduous forest in lower part to alpine vegetation in higher part of basin. The Alpine scrub forests are found above the limit of tree growth. Herbaceous flora is fairly rich and medicinal herbs such as Aconite, Dhoop and Karru occur in the basin . The moist Deodar forest are the most valuable timber forest of the basin. The mixed coniferous forest includes pure Spruce, pure Silver fir, Silver fir spruce and Spruce-Deodar formation. These occur above Deodar and Kail zone between 2000 m to 3000 m a.m.s.l. The moist temperate deciduous forest occurs between 2000-3000 m in moist depressions often along the Nalas. Chestnut, Walnut, Maple,Oak and Poplar are main species in quartzite rocks.

Devdar and Karsu are found mainly on the south facing slopes over most of these altitudinal range, while fir and spruce are particularly associated with north facing slopes. Forests also help in the holding of the soil on the steep slope and there by preventing not only soil erosion but also other catastrophic events. There is an over all reduction in the forest cover and the main causes of it can be attributed to over grazing, failure of continues afforestation and retarded regeneration measure, poor choice and handling of planting stock (Duffield, 1977). Climate, as an important component has been treated separately in the succeeding chapter.

LAND USE PATTERN

The basin extends over the valleys and high elevations. Cultivation is possible in small terraces of holding in the high hills and basins. Cultivation is mainly done in the low lying areas on fluvial terraces and alluvial fans . The cultivated area is found in pockets scattered in the basin. Kullu and Manali are located in the basin as major towns. Of the total area the Upper Beas basin 67.17 km^2 area is under glaciers and 184.55 km^2 and 562.53 km^2 under agriculture and forest respectively (Figures 1.4,1.5,1.6).

OBJECTIVES:

The main objective of the study is to examine geographic activity in the Upper Beas Basin. This study will ultimately lead to better understanding of present scenario and explain the relationship between past climatic processes and present landforms. The Huttonion theory of "Present as key to the past" is the basis for this investigation. This understanding, in turn, provides an insight into the impact of climate change on the physical landscape, vegetation and human activity which depend on them. Understanding is necessary of how catchments morphometrics and sediment yield in drainage basin evolves in response to changing climate. Glaciers are sensitive indicator of climate change, both in short term and for long term. Therefore, glacial landforms have been investigated here as an indicator of climate change.

A. To find out the previous glacial extent by examination of the moraine condition and terrace number with their height and width.

B. To analyse morphometry on the basis of toposheet for the better geomorphic understanding of the basin.

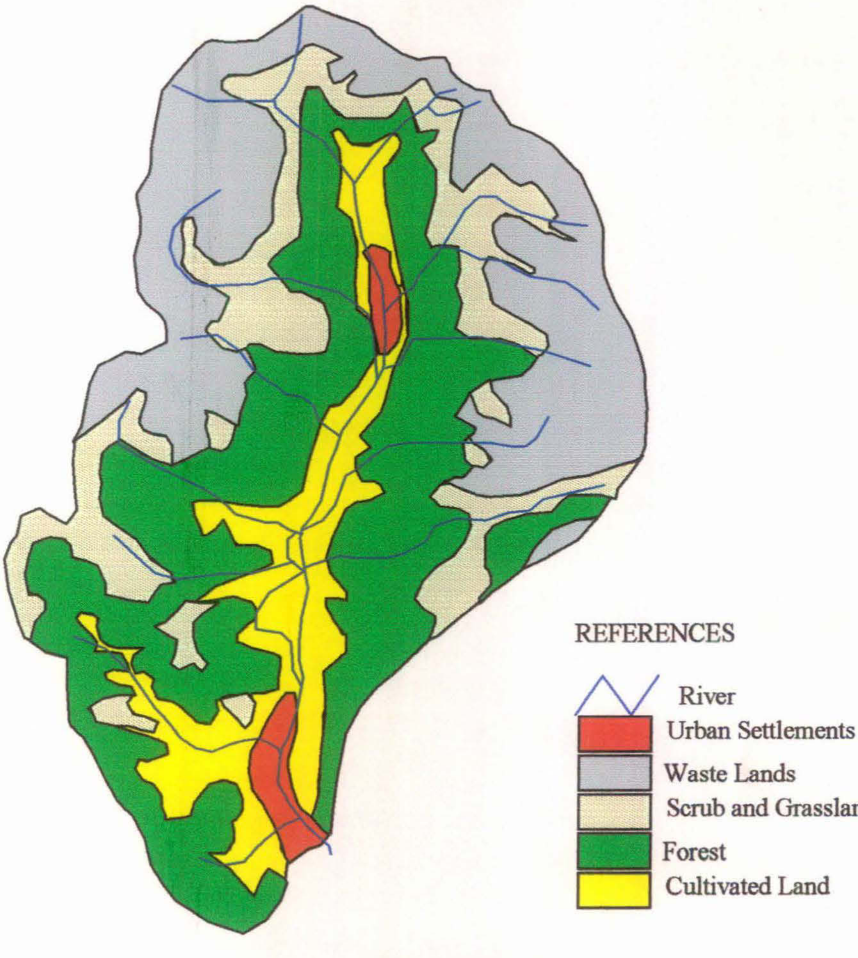
C. To analyse sediment from selected site to distinguish landforms and processes.

D. To find out present and past glacial extent through ELA (Equilibrium Line Altitude) of glaciers.

Figure 1.4

GENERAL LAND USE AND CROPING PATTERN

UPPER BEAS BASIN

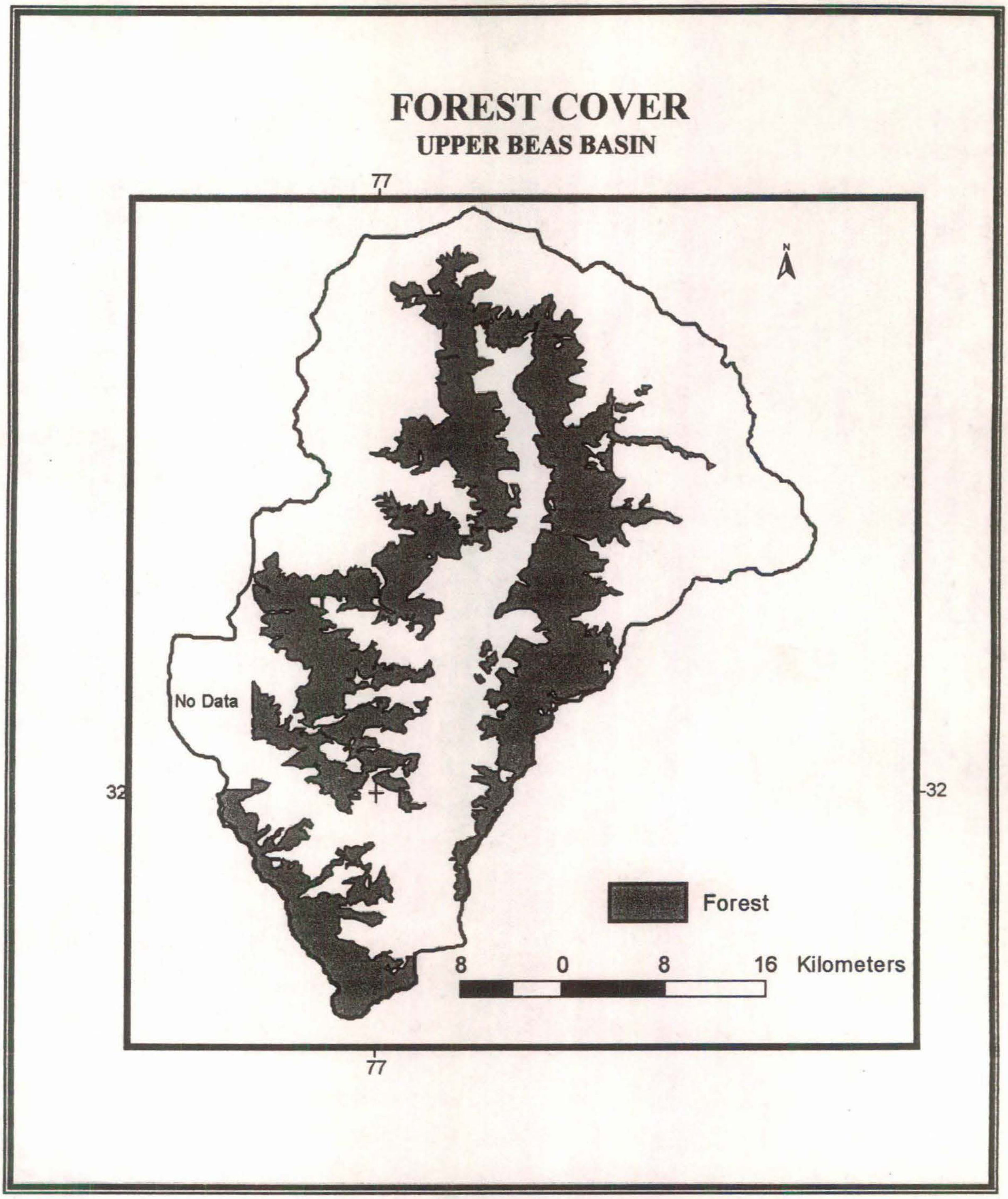


MAJOR CROPS: Wheat- Maize

MINOR CROPS :Small-Millets& Rice

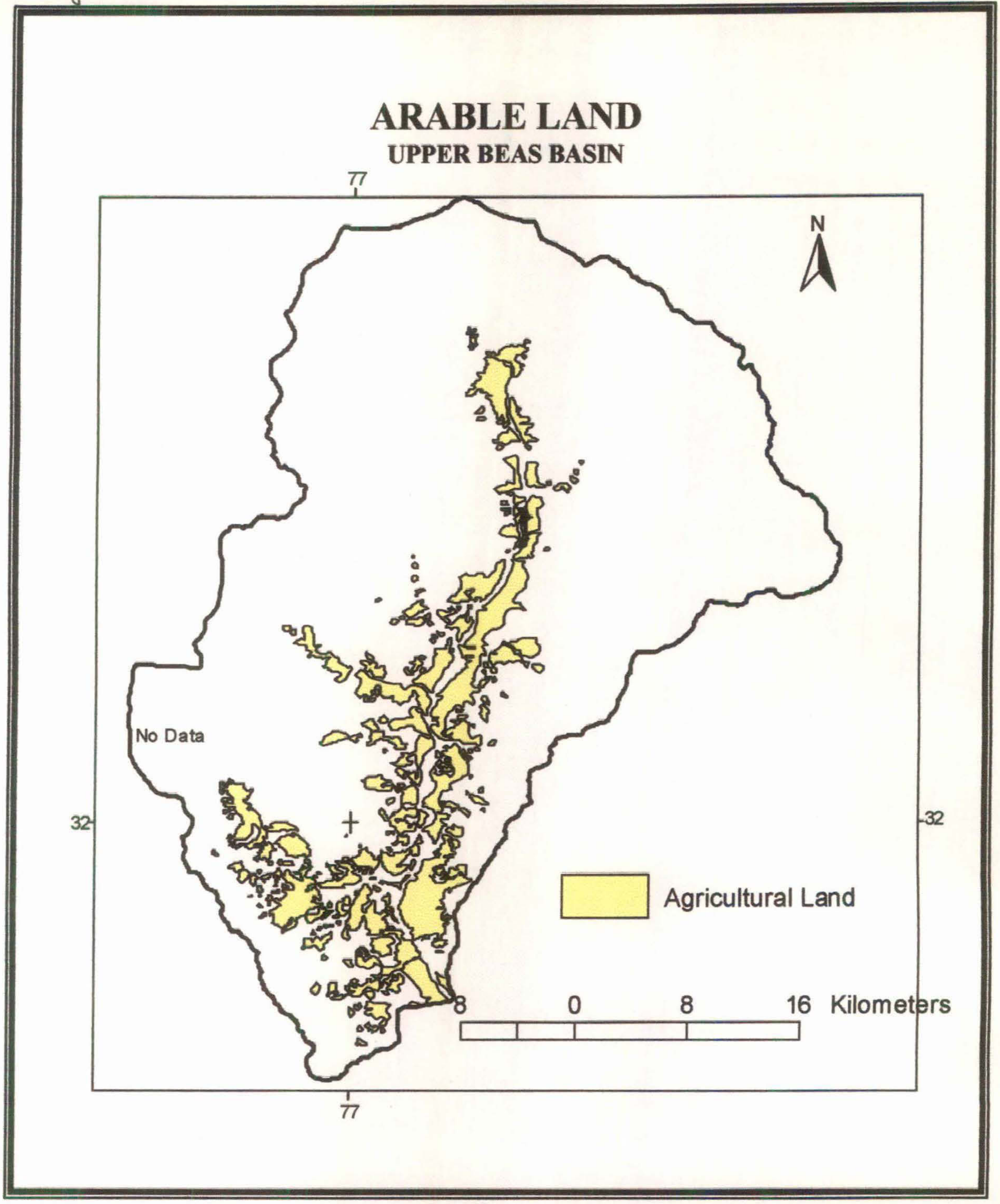
Source: Satellite Imagery, Remote Sensing Cell H.P.

Figure :1.5



FOREST COVER
UPPER BEAS BASIN
77
N
No Data
32
32
Forest
8 0 8 16 Kilometers
77

Figure 1.6


ARABLE LAND
UPPER BEAS BASIN
77
N
No Data
32
32
Agricultural Land
8 0 8 16 Kilometers
77

E. To identify main processes in operation and their relative roles in landscape evolution.

DATA BASE

A contiguous and detailed study of landscape and climate change is particularly not feasible without reliable data source. Hence several sources of information have been selected and acquired for the purpose of landscape evolution and climate change in the Upper Beas Basin. Survey of India Toposheets on 1:50,000 serves as the best map for field survey of area and the same has been fully utilized. A total seven toposheets, either fully or partially, is covered by the basin. Their number has been given in the section on location of the catchment earlier. Another major source of the data for the study is satellite imagery. FCC of three bands on the scale of 1:250,000 is produced with the standard colour, obtained from NRSA, Hyderabad.

Besides these, soil samples have been collected for particle size analysis. Other sporting database for amount and pattern of daily rainfall analysis is also acquired from four meteorological stations of Dhundi, Solang, Manali and Bhuntar all maintained by SASE, IMD for the period of 1989 to 2002, for Dhundi Solang and Bhang from SASE, and 1968 to1992 for Manali and Bhunter from IMD, respectively, to carry out the seasonal and annual rainfall and temperature analysis for the region. For the ground truth,3-week field work was carried out once during the study period to make the output more accurate. For this purpose, different part of the basin from Rohtang to Bhuntar from north to south, and Dhundi in the northwest have been traversed for the collection of soil sample, plant succession and boulder frequency etc. Terrestrial photographs of glacial extent and river terraces have been added where necessary. All these data, both primary and secondary, are properly analysed and

Plate 3: Three sets of terraces have been formed on the highest terrace of the Beas by its tributary. Note the levee and size of sediments.

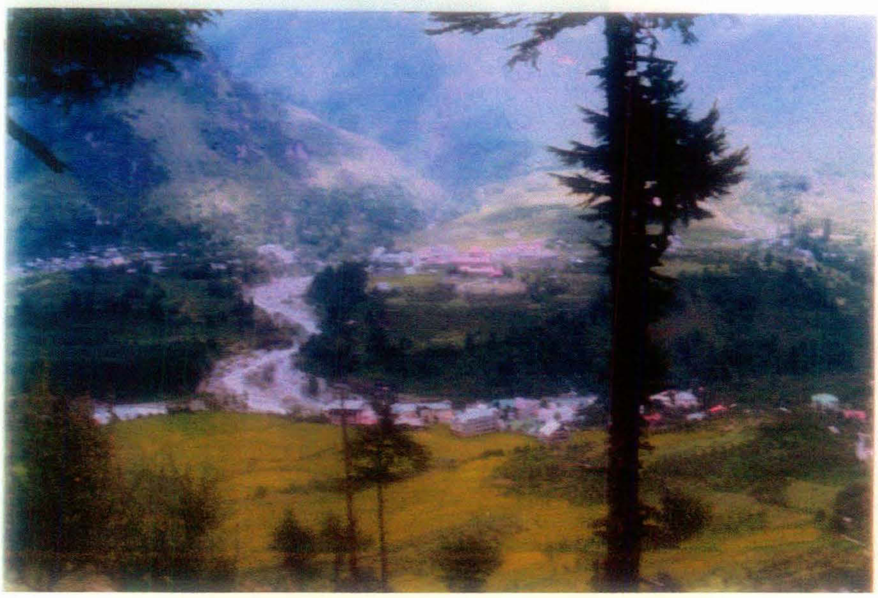


Plate 4: The bird-eye view of terraces of the Beas, its forest and agriculture/horticulture. The incision and fan formation by tributary streams in the Beas Valley are spectacular.

utilized to achieve the objective of the study of landscape evolution and climatic change in the Upper Beas Basin.

ORGANISATION OF MATERIAL

Present chapter is to build up objectives and introduce to the area of investigation.Chapter two describes the methods and techniques used in the study. This chapter is divided into three major parts, part one is based on the field survey methods, second part is on the morphometry methods, last deals with geologic history of landforms. Chapter three is devoted to morphometric analysis of the basin. Morphometric variables which have great significance in the landscape development have been analyzed in detail. The morphometic analysis done are relative relief, drainage density, dissection index, stream frequency, bifurcation ratio, etc. Thematic maps are prepared for each element in a GIS environment. The fourth examines the present and the past climatic behaviour ,and their resultant landscape. The final and last chapter is based on conclusion, summary and main contribution of the study undertaken.

LIMITATIONS

The Upper Beas Basin lies in the northern boundary of India. Due to the strategic reason detailed maps and other information are not available. In the western part of the Basin 72.52 sq. km area is incorporated from US military map on 1:250000 on a smaller scale. Due to this, some valuable information about drainage, vegetation, slope etc have been lost. A short field investigation carried out was not enough for a detailed collection of samples and mapping.

CHAPTER II

METHODS

A basin is the basic manageable geo-hydrologic unit in which rainfall occurring on the highest point of the area (ridgeline) drains at a common point (Tripathi and Singh, 1993, and Narayana et. al., 1997). For the purpose of the study the entire exercise has been divided into three distinct phases of enquiry namely;

-Pre-field Methods

-Field Methods and

-Post field Method.

Pre-field Methods

In this stage collection and consultation of available maps such as topographical sheets, satellite imagery, geological maps, soil maps, thematic maps etc. have been undertaken. To understand preliminary existing situation of the area under study, available literature and statistical information both published and unpublished have been used where necessary.

Various parameters like geomorphology, hydrology, climate, soil, vegetation, landuse etc. from the secondary source are analysed and interpreted for better understanding of the physical characteristics of the basin. Base map has been prepared with the help of available existing topographic and thematic maps.

A field inventory is also prepared for the collection of data for slope, vegetation, and moisture condition in the unconsolidated rocks and regoliths.

Field Methods

After preparing the base map and consulting the literature, the systematic methods followed are as under;

Field Mapping

Detailed and accurate mapping is difficult due to lack of large scale topographical maps and aerial photographs. The area was mapped using simple Plane Table techniques. Bearings were measured with a Silva inclinometer compass (Type 15T) and spot heights determined using a Thommen (TX 22) altimeter. In addition, Garmin Global Positioning system (GPS) has also been used for cross checking and accuracy. These were calibrated with bench marks and changes in atmospheric conditions where accounted for using a leap-frog method of survey. Slope gradients were determined using a Suunto (KB14/360B) hand-held inclinometer. Photographs were also used to help record field relationships similar to methods used by Owen (1988) and Sharma (1996).

Relative Dating Methods

There are numerous dating methods, which are being used in geomorphology. These methods can be grouped in two different ways. The first classification can be on the basis of whether a dating method provides an absolute date or just determines a relative chronology. The second classification is on the basis of the type of material used for dating purpose. It includes radiometric or radio-isotopic, chemical and biological methods. Absolute dating methods are those methods, which provide the age of the sample in number of years e.g. 20Ka BP or 6 Ma BP. The zero or the datum year is taken as 1950 AD.

The relative age comparisons are valid only when the landforms, from where samples have been collected, have the same geology, hydrology, climate and topography. The study focused primarily on the Beas Kund area, where the morainic deposits are found. The site is located on the bank of Solang Nala, at the height of 2500 m to 2900 m approximately. These moraine crusts, displaying the highest apparent density of erratic, boulders and cobbles were studied. This study has analysed the samples, taken from river and morainic terraces near Solang Nala. As discussed earlier, relative dating gives a general picture of relative age of differences. It does not require much sophisticated methods and instruments such as ^{14}C dating and Uranium dating.

A number of relative dating methods have been for the reconstruction of past climate and their resultant landforms in the upper Beas Basin (Dhundhi to Solang village). These are as follows;

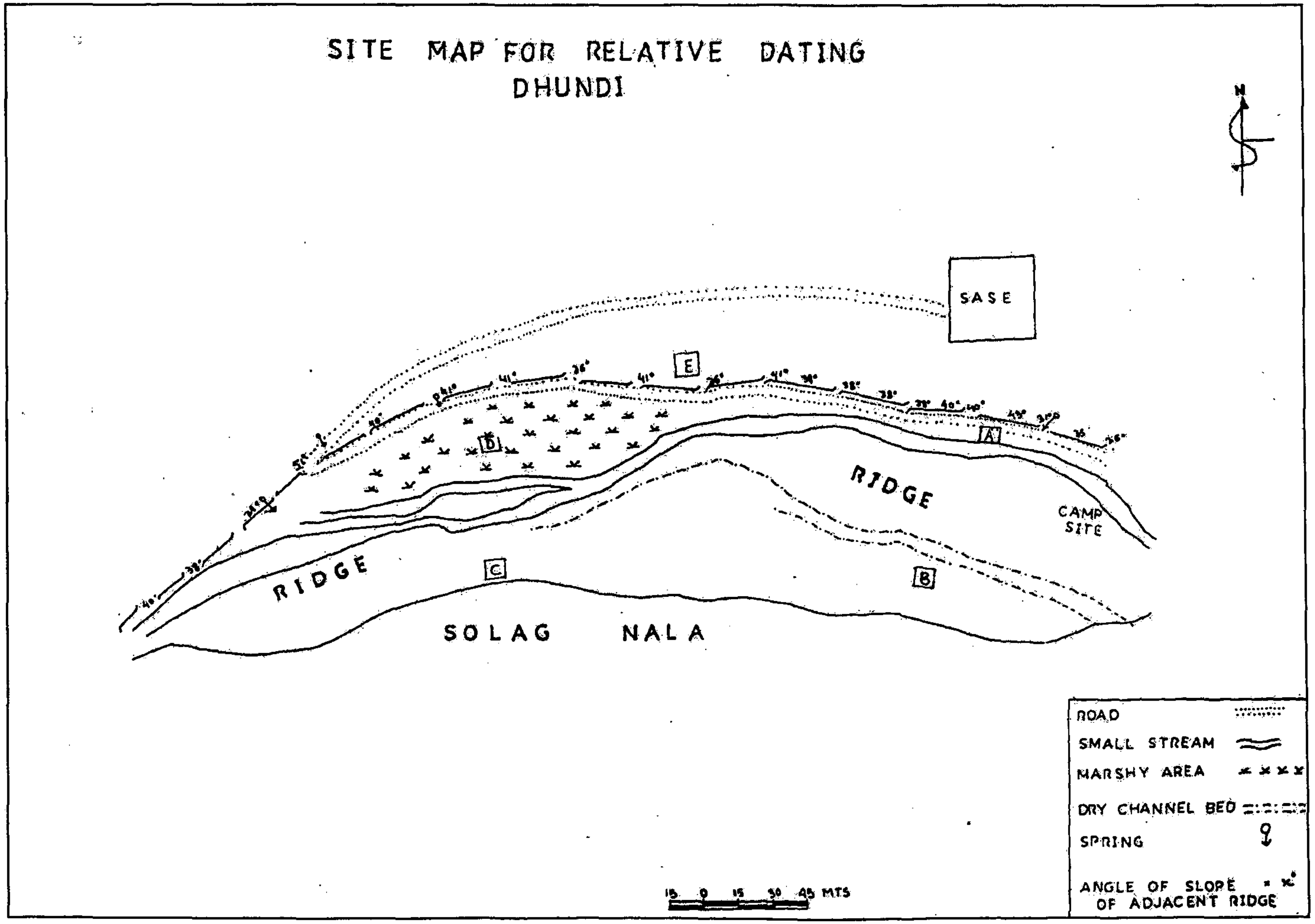
- Boulder frequency
- Bolder Varnish
- Sound Rebound
- Pits depth
- Plant succession

These methods were adopted only for Solang Nala and Dhundi because of suitability of site as given in figure 2.1.

These dating methods do not give absolute ages of samples rather they provide the relative order of antiquity i.e. it provides ages in terms of 'older than' or 'younger than'. The relative antiquity of materials can be established where superimposition exists which means that sediments which are at higher level are younger than those lying beneath them in most of the cases.

Methods used to define and differentiate the complex assemblage of landforms in the field included. Plants and lichens determine relative ages of river terraces, and terminal moraines etc. of the Upper Beas Basin. These analyses include the number of vascular plant species, the percentage plant cover (Briks (1980), Wardle (1980), Matthews (1978), and Matthews and Whittaker (1987) and the number of lichen species and their diameter (Ealkin and Ellis (1980), Procter (1983), Caseldine (1985), and Radbett (1992). The percentage plant cover and the number of species were recorded in transect of 10 m x 3 m which were aligned in a north west – south east direction along the Solang Nala of the basin. Biological Methods, these dating methods use the size of an individual plant species as an index of the age of the substrate on which it is growing. These methods include lichenometry and dendrochronology. These methods have a limitation that they have a short age range, limited only to Holocene used in the field.

Figure: 2.1


SITE MAP FOR RELATIVE DATING
DHUNDI
N
SASE
E
D
A
RIDGE
CAMP SITE
RIDGE
C
B
SOLAG NALA
ROAD
SMALL STREAM
MARSHY AREA
DRY CHANNEL BED
SPRING
ANGLE OF SLOPE OF ADJACENT RIDGE
15 0 15 30 45 MTS

The Solang Nala and Dhundi was the only region where climatic conditions were unfavourable for growth of lichen and vascular plant. Therefore, in this region relative dating techniques included boulder frequency, ratio of fresh to weathered boulders, and boulder relief. These were measured in transect of 10 m x 10 m using techniques of Perrott and Goudies (1984), Burkbank and Cheng (1991), Burke and Birkeland (1979), Corroll (1974) and Peck et. al (1990).

Sample Collection

Samples were collected from the field for laboratory analysis to understand the process involved and relative ages of this basin evolution. They include quartzite rocks for optically stimulated luminescence dating, sediments for particle size and shape analysis.

Post Field Methods

Laboratory analysis

The samples collected in the field were processed according to the set procedure for respective analysis, in order to evaluate definite criteria for each process and therefore resultant landforms. Major laboratory analyses are as follows;

Particle size analysis

Sediment samples were air-dried at room temperature for three weeks and the grain size distribution (ranging between 45µm-2mm) was determined by dry sieving using Lee's (1991) method. The dry analysis data has to provide a full range of grain size distribution between 2 mm and 45µm. The distribution has been plotted on semi-log arithmetic graphs for a visual representation of size classes..

Sediment Sieving or Particle size analysis

Attempts have been made for over half a century to use the particle size distribution by classifying sediments as a mean of establishing environment in which they were deposited. The processes of physical, chemical and biological weathering have two main effects on particle size distribution. First, they break down particles, reducing the overall size of materials and modifying the distribution of sizes. Second, they may redistribute particles with a sequence, either sorting particles or homogenizing the overall particle by size distribution.

The chemically weathered material contained significant amount of clay and silt, while the physically weathered material contained no material finer than 30µm. To possess a wider range of particle size than most other sediments, they are, therefore, normally very or extremely poorly sorted. Slope deposits, debris flows and alluvial fan deposits may all possess similar distribution. The decrease in particle size of tills has little or nothing to do with the progressive combination or abrasion of the glacial load with increasing distance of transport. The reduction in till particle size may reflect the presence of resistant igneous and metamorphic lithology in mountainous source areas and much less obdurate sedimentary rock type in the marginal zones.

Many approaches come through time for particle size distribution. In this work the method developed by Udden in 1898 and expanded by Wentworth in 1922 and latter modified by Krumbein (1976) is used. In this method scale for particle is a ratio scale in which grade boundaries differ by a factor of two. One grade coarser is twice the size of its predecessor and one grade finer is half the size.

The samples for present analysis have been collected from field and processed by the following steps. Their location and place name is given in the Table (2.1).

First sample were dried at room temperature in air. These dried samples were shorted by electric sieving machine for 15-20 minuets after that sediments were weighted care-fully for each sieve. Thus the data obtained for particle size analysis is given in appendix I.

These data has been plotted using logarithmic graph paper. For that phi ϕ values for each grain diameter have been used. The larger the phi number, the finer the particle and vice versa.

Equilibrium Line Altitude (ELA)

The equilibrium line altitude is the line on glacier surface, separating the accumulation area (the area where a glacier gains in mass) from the ablation area where a net loss of mass occurs. In order to find out equilibrium line altitude (ELA) for major glaciers in the Upper Beas Basin, three different methods have been used. These methods are as :

Area weighted mean (AWM) Sisson, (1974). In many methods of ELA determination this method has been considered as the best. For calculating the ELA, these following steps have been taken.

n

Sample No	Position	Place/Discription
1	32^{0}21' 247'' N 77^{0} 07' 501'' E	Highest lateral moraine at side ridge.
2	32^{0}21' 049'' N 77^{0} 05' 438'' E	Cirque glacier lateral moraine outside.
3	32^{0}21' 307'' N 77^{0} 07' 956'' E	River terrace, Dhundi.
4	32^{0}21' 313'' N 77^{0} 07' 857'' E	Dhundi large terrace (near water spring).
5	32^{0}21' 261'' N 77^{0} 07' 351'' E	River bend near Gujar hat (Dhundi).
6	32^{0}21' 149'' N 77^{0} 07' 766'' E	Terrace facing river
7	32^{0}19' 591'' N 77^{0} 09' 029'' E	Lower roadside.
8	32^{0}21' 272'' N 77^{0} 07' 509'' E	River side east terrace (Dhundi).
9	32^{0} 20' 510'' N 77^{0} 08'396'' E	River bank (Solang Nala)
10	32^{0}-18' 886'' N 77^{0} 09' 307'' E	Solang village side road.

Table 2.1

Relative Dating Methods																				
Sites	Boulder Size and Frequency				Boulder Varnish			Sound Rebound				Pits in Rocks				Mean Height in cm of Plant Species				
	Big	Mid	Sml	Total	Da	Li	Total	B	D	T	Total	H	M	L	N	Vh	H	M	L	Vl
A	2	12	28	42	8	6	14	4	9	2	15	6	5	2	0	0	1	7	3	4
B	1	8	68	77	4	9	13	8	2	3	13	5	6	2	0	0	1	9	4	3
C	12	31	88	131	46	68	114	27	66	23	116	72	30	10	0	0	1	5	9	4
D	0	5	30	35	12	14	26	3	14	10	27	8	12	0	5	0	2	1	6	5
E	5	38	10	53	15	31	46	15	27	7	49	18	28	2	0	2	1	5	2	3

Boulder Frequency:
Big
Medium
Small

Sound Varnish:
Da = Dark
Li = light

Sound Rebound:
B = Break
D = dhok
T = tng

Pits in Rocks:
H = high
M = medium
L = low
N = no

Mean Height of Plant Species (in cm.)
Vh = very high >100
H = high 20 - 100
M = medium 10 - 20
L = low 5 – 10
VL = very low <5

$$X = \frac{\sum_{i=0} A_i H_i}{\sum_{i=0}^{n} A_i}$$

Where X = Equilibrium line Altitude in meters;

Ai = the area of the glacier surface at contour interval i in $km,^2$

Hi = the altitude of the mid point contour interval i; and n +1 = the number of contour interval.

The second method is the calculation of accumulation area ratio (AAR) for the glacier, which is the ratio between the accumulation area and the total area of the glacier. It has been found that the AAR for present day glacier in a steady state commonly lies between 0.4 to 0.6 (Porter 1970). But generally 0.5 is taken as the standard value for the calculation of ELA. In other words we divide the glacier in to two equal parts, mid-point is taken as an ELA.

Toe- Headwall Area Ratio (THAR) Meirding, (1982) devised a very simple method, called ELA can be calculated by following simple formula.

ELA = H+ T / 2

Where, H = Head wall of the glacier (in meters) and T = Toe or lowest point of the glacier snout.

The shape of the former glacials can be traced by joining those points or area where clear ice-marginal evidence (e.g. terminal or lateral moraines, valley side –

limits or down valley terminal hummocky moraine is preserved). When the glacier outline has been determined, ice-surface contours can be estimated by analogy with typical contour patterns on present day glaciers. Ice surface contours are commonly perpendicular to valley walls near the middle altitude of a valley glacier, and they become progressively more convex toward the glacier terminus and more concave towards valley head wall. One the basis of contours it to possible to infer the volume of ice within the former glacier, and also to calculate the altitude of the equilibrium line.

Geographical distribution of the glacial landforms constitute a major source of evidence in the reconstructions of former ice sheets and glacials. By combining geomorphological data like drumlins, moraines glacial erratic etc.reconstruction becomes easier and analytical. Many scholars in Britain and other parts have used these indicators. Glacier modelling exercises have also been carried out in order to assess the rate at which ice sheets develop (Andrews and Mahiffey 1976). These glaciological reconstructions are a major recent development and have profound implication for many aspects of glacial studies. This may also help in explaining many of the observed morphological characteristics of glacial landscape.

The areal extent of glaciers and their ELAs are established from topographical sheets by survey of India for the Upper Beas Basin. For the purpose of ELAs calculation Sissons'(1974) area weighted mean method, Meierding's (1982) toe headwell altitude ratio (THAR) and Accumulation Area Ratio methods are taken into account.

Morphometic Analysis

Morphometary deals with the measurement and analysis of landform characteristics. Quantitative analysis of watershed is necessary for various drainage and land configuration characteristics, which need to be parameterised. Morphometic analysis based on Survey of India topographical sheets on 1:50000 are carried out for the morphological attributes like, the absolute relief, relative relief, slope, dissection index, ruggedness index, drainage frequency, drainage density, drainage texture, stream ordering, etc. Thematic maps for all these parameters have been prepared in a GIS environment.

a) Absolute Relief

Absolute relief gives the elevation of any area above the sea level in exact figure. It is useful in delineating the terrain morphology, including the existence of erosion surfaces. For the present study analysis of absolute relief has been made by dividing the contour map of the Upper Beas Basin into a square grid with unit area of 1 km^2 and noting the maximum height of each square with the help of contours and spot height, where available.

b) Relative Relief

Relative relief represents the difference in elevation between the highest and the lowest points falling in a unit area. The concept of relative relief was first introduced by Portsch in 1911. Nevertheless, the first scientific study of it was presented by Smith in 1935. There has been frequent application of the concept of relative relief since the time of Smith and its impact on landforms and general land use has been widely recognized. The relative relief of the Upper Beas Basin has been obtained by first dividing its contour map into a network of squares with unit area of 1 km^2 and then noting the difference between the maximum and minimum elevation for each unit.

c) Dissection Index

The dissection index, which is the ratio between relative relief and absolute relief gives a better understanding of the landscape Nir (1957) states that as a criterion of relief energy, the concept of relative altitude is not entirely satisfactory. He suggested that necessity of describing the relief in terms of the ratio between the two variables (absolute relief and relative relief). It can be obtained by the following methodology:

Dissection index (D.I.) = Relative relief/ Absolute Relief.

The value of dissection index varies from 0 (complete absence of dissection) to 1 (vertical cliff). Thus it is the index of the degree to which dissection has advanced. In other words, it expresses the relationship between the vertical distances to relative relief i.e. the dynamic potential state of the area.

d) Drainage Frequency

The Drainage Frequency is defined as the total number of stream segments per unit area. In general, the occurrence of stream segments depends on the nature and the structure of rocks, vegetation cover, nature and amount of rainfall, and infiltration capacity of the soil. It is an index of various stages in landscape evolution. The drainage frequency has been obtained by the following formula for the present analysis:

Drainage Frequency (D.F.) = $\Sigma N / A$

Where, ΣN is the total number of stream segments.

A is the areal unit which is 1 Km^2 in this study.

e) Drainage Density

Drainage Density is defined as the total length of stream segments per unit area. It is a function of the intensity of run-off, erosion proportionality factor, relief, density of absolute viscosity of the fluid and its acceleration due to gravity. Analysis of drainage density was first introduced by Horton in 1932. Drainage Density is calculated as:

Drainage Density (D.D.) = $\Sigma L/A$

Where, ΣL is the total stream length.

A is the areal unit.

f) Drainage Pattern

Drainage Pattern refers to the particular plan or design, which the stream courses collectively form. The design of the pattern is usually influenced by factors like initial slope, inequalities in rock hardness, structural control and the recent geologic and geomorphic history of drainage basin. It is of great help in the interpretation of geomorphic features. Drainage Pattern according to Thornbury (1969) provides a more practical approach to an understanding of structural and lithological control in landform evolution.

g) Stream Order

The first step in basin morphometry is designation of stream orders, following a system introduced in USA by Horton in 1945 and later slightly modified by Strahler (1952). Scheidegger (1965), Woldenberg (1966) and Shreve (1967) have put forward somewhat different stream ordering systems. According to Strahler (1964), the first order streams are those which have no tributaries. When two first order streams meet a second order stream is formed. Two second order segments or channels join to form a channel segment of third order. Similarly, when two third order channels join they give rise to a fourth order channel and so on. Thus, the trunk stream, through which all discharges of water and sediments pass is the segment of the highest order.

h) Stream Numbers

The number of stream segments in each order is known as 'stream number'. Horton's *law of stream numbers* states that the number of stream segments of each order form an inverse geometric series with the order number.

i) Stream Length

The total stream length of various orders of the Upper Beas Basin has been calculated with the help of G.I.S. by geo-referencing the topographical maps. Horton has stated that the total lengths of stream segments of each of the successive orders in a basin tend closely to approximate a direct geometric series in which the first term is the total length of the streams of the first order.

j) Bifurcation Ratio

The ratio between the total numbers of streams of one order to that of the next higher order in a drainage basin is known as the 'bifurcation ratio'. It shows the degree of integration prevailing between streams of various orders in a drainage basin. This can be analysed on the Horton's *law* which states that the number of streams of different orders in a given drainage basin tend closely to approximate an inverse geometric series in which the first term is unity and the ratio is bifurcation ratio. This Bifurcation Ratio is calculated by using the following formula:

Bifurcation Ratio (Rb) = Nu/ (Nu + 1)

Where, Nu is the number of segments of a given order

Nu + 1 is the number of segments of the next higher order

The value of bifurcation ratio ranges from 2 to 5. High value of the ratio indicates lower degree of drainage integration and vice versa. The ratio is generally influenced by variations in the physiographic, lithologic, and climatic conditions prevailing in individual basin. Thus, basin with similar rock group composition and tectonic history, uniform climatic condition and in similar stage of development are characterized by more or less similar values of bifurcation ratio.

k) Ruggedness Index

The ruggedness index is a measure of surface unevenness under a lithological basement complex. The technique expresses different degrees of surface resistance or submission top either manual or mechanical land use operations. It is a derivative of long-standing interaction between the available sharpness of the local relief and the amplitude of available drainage density. Moreover, other environmental parameters such as slope, precipitation, weathering, soil texture, natural vegetation etc. are partially responsible for ruggedness of a surface. Chorley (1972) devised the method of ruggedness index (number) for measuring the extent of dissection by taking in to account both relief and drainage. The method of ruggedness index is calculated as:

Ruggedness Index =relative relief and drainage density/1000(constant).

GIS As a Tool

The integrated approach of Geographical Information System (GIS) and Remote Sensing (RS) is now being recognised universally as unique, highly effective and extremely versatile technology for evaluation, management and monitoring of natural resources. It is a computer setup that makes it possible to view and analyse data in the form of digital maps. GIS technology is used in monitoring the changes in vegetation cover, erosion in land surface, and formation of new geomorphic landforms over a time period .Its utilization extends from risk assessment for calamities, natural resources and infrastructure development to various geological studies. In the present study GIS is used for the analysis of basin morphometry. Various types of geologic, thematic and topographic maps have been used in GIS environment. Remote sensing data from NRSA, Hyderabad is also used as GIS input for recent information.

Limitations

There are certain limitations to the study. Some of them are like the samples collected for Optically Stimulated Luminescence (OSL) dating technique could not be carried out due to non-availability of adequate facility. Non-availability of toposheet No. 52D/16 posed problems in the quantification of morphometric parameters. Area and length of first and second order streams could not be calculated while preparing maps in ArcView GIS.

CHAPTER III

BASIN MORPHOMETRY

Drainage basin being a fundamental geomorphic unit of study represents the area drained by its streams and its tributary. Therefore, fluvial processes may be understood in terms of law of drainage composition. The work done by Horton(1945) is termed as the Quantitative Geomorphology provides a systematic approach for analysis of a complex landscape of any size and origin. The analysis is based on the principle that a landscape can be resolved into its form elements, attributes and morphological laws governing the phenomena ,further quantified and formulated.

A handful of work on quantitative analysis of drainage basins have been done in India and abroad and a good correlation is established between the morphometric and the hydrologic character of and watershed [Singh and Gosh (1973), Singh Sharma (1979)]. These studies are found to be of great value for integrated development and planning of drainage basin. The use of geographical information system and remote sensing has made the task more speedy and reliable.

The purpose of the present study is to describe the geomorphic characteristics/parameters of the Upper Beas Basin up to Bhunter in terms of a few selected linear, areal and relief property of the basin. The linear aspect of drainage basin in this study are stream ordering, bifurcation ratio, stream number, and stream length. The areal aspect likewise includes drainage density, drainage texture and law of basin area. In the relief aspect of the basin, average relief, relative relief, dissection index, and ruggedness index are included.

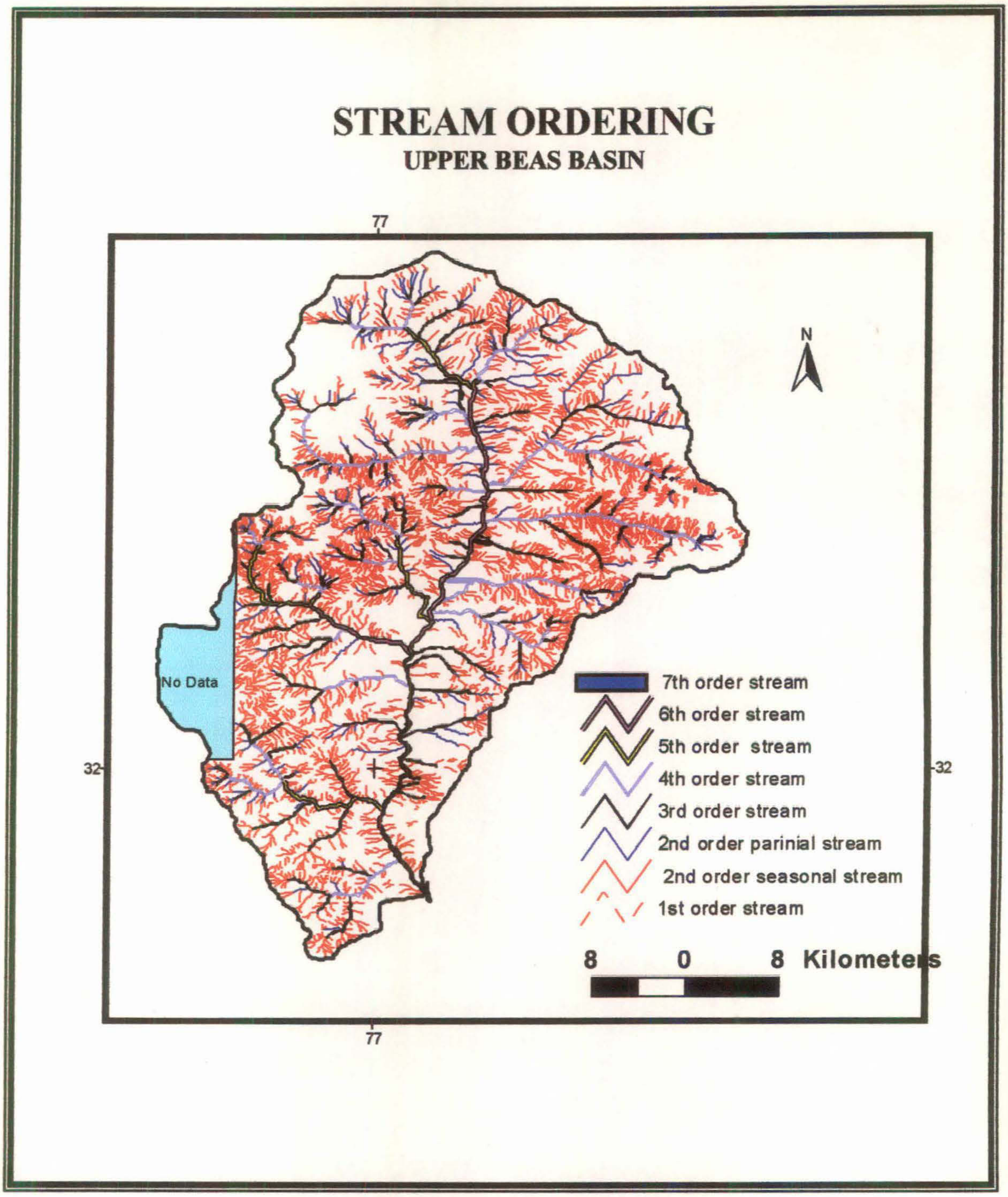
Drainage Characteristics

Drainage network analysis has been used not only for the purpose of identifying characteristics of network structure, but also as a basis for demonstrating the effect of environmental control on the fluvial system, for suggesting how network might evolve, and for indicating how basin output variables such stream discharge is related to network. Exercise has been carried out to associate the relationship of drainage network and other morphometric character with environment and their resultant landforms. For the purpose map digitized and the drainage line of the basin on map for the study area were ordered based on Strahler's system of stream number ordering (1957) upon digitization. Different morphometric parameters of the Upper Beas Basin up are briefly discussed as below;

Basin Size, Stream Number, Order and Length

. The purpose of stream ordering is to provide estimates of stream flows, provided data are available for correlation over a stable time. The present study shows that the Upper Beas Basin up to Bhuntar is a seventh order basin (Fig.3.1a).

Figure 3.1(a)



STREAM ORDERING
UPPER BEAS BASIN
77
N
No Data
32
32
7th order stream
6th order stream
5th order stream
4th order stream
3rd order stream
2nd order parinial stream
2nd order seasonal stream
1st order stream
8 0 8 Kilometers
77

Figure 3.1(b)

CONTOUR MAP
UPPER BEAS BASIN

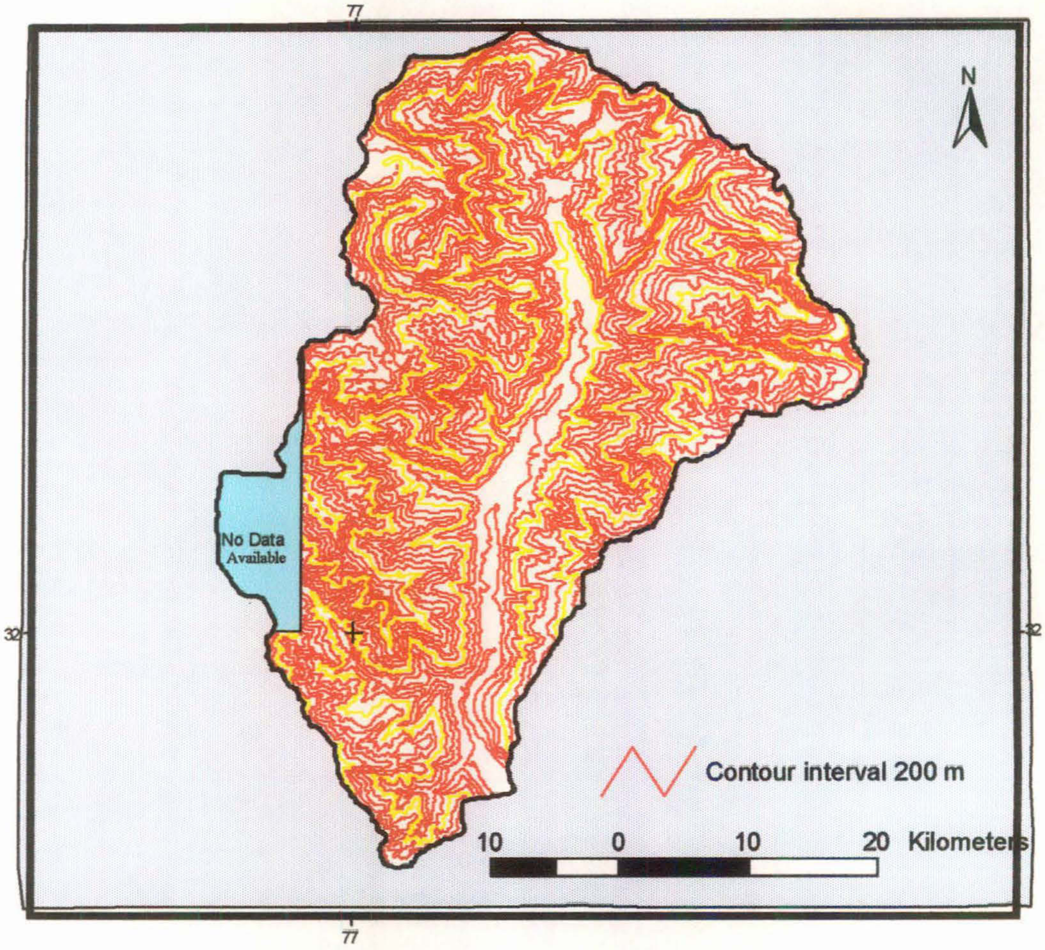


Plate 5: Recent floodplain of the Solang Nullah at Dhundi. Terrace in the foreground contains three sets of lateral moraine ridges in a recessional design. Erratic in the right foreground for scale.

Plate 6: Highest of the Pir Panjal range in the background with extensive erratic landscape in the foreground. Note the angular and sub-angular form of these erratics.

Mean length of channel segment of successive higher order of a drainage network form geometric series. This law of stream length holds true for drainage basin of all sizes, irrespective of their physiographic and climatic environments. The cumulative and mean stream length of different orders are presented in the Table 3.1.

The computed total stream length value is 511.33 km. Number of first order stream was found to be maximum at 3216. This indicates that the first order stream contribute maximum to the overall drainage and hydrologic behaviour of the watershed. The plot of logarithm of stream length along ordinate and stream order along abscissa for the watershed gave a straight-line fit and plot on a semi-logarithmic paper (Number of stream on the logarithm scale and the order on the linear scale) is also nearly a straight line [illegible].

To establish the relationship between stream order and the cumulative stream length data were plotted against the stream order and a straight line was obtained . . The straight line fit included that the ratio between length and order was constant throughout the successive order of the watershed and suggested that geometrical similarity was preserved in the watershed of increasing order, which proves Horton's law of stream length. When the size of drainage basin (mean basin area) is plotted with increasing stream order it provides an increasing linear relation - and Basin of Third Order Streams Fig.3.3,

Figure 3.3

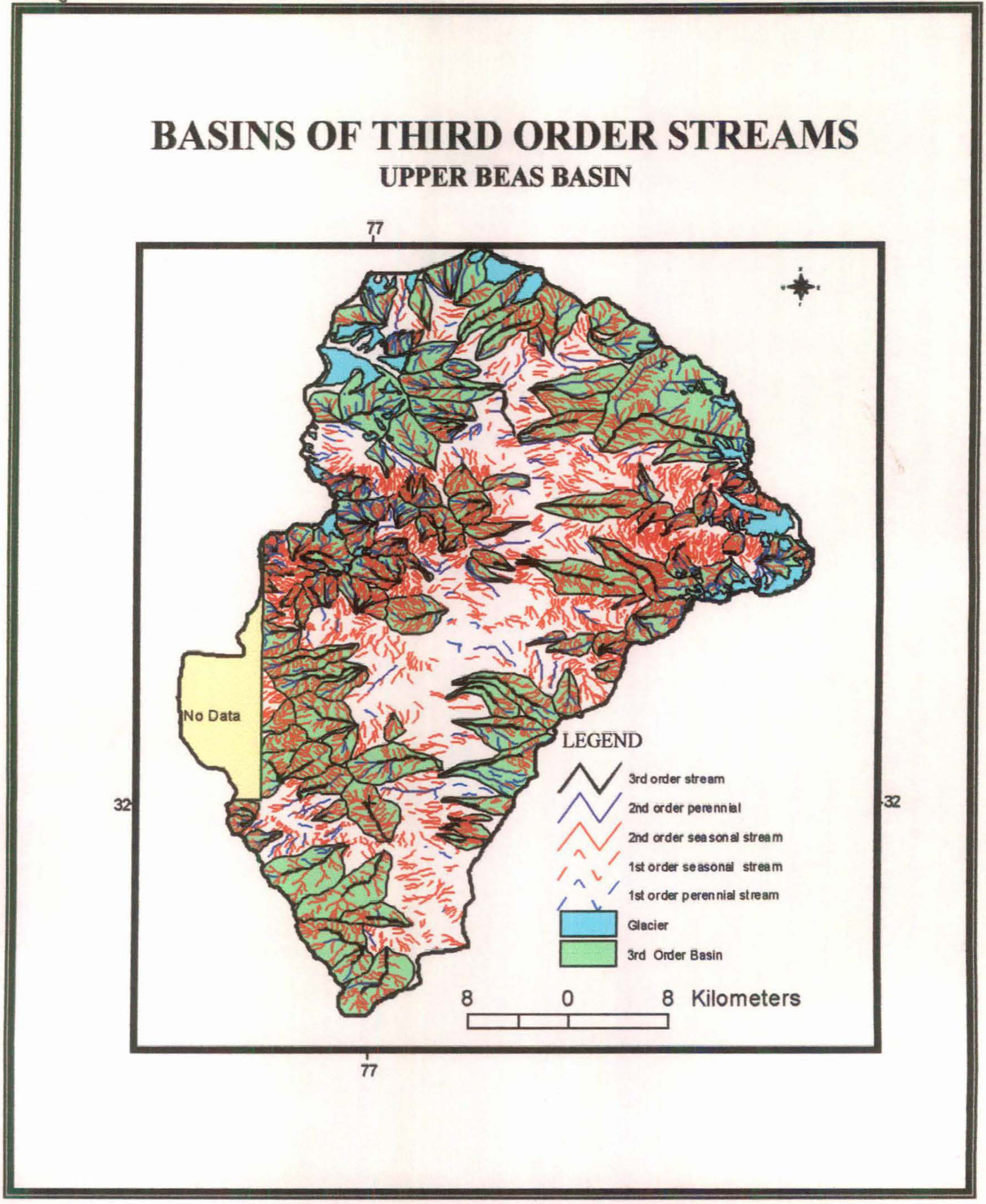
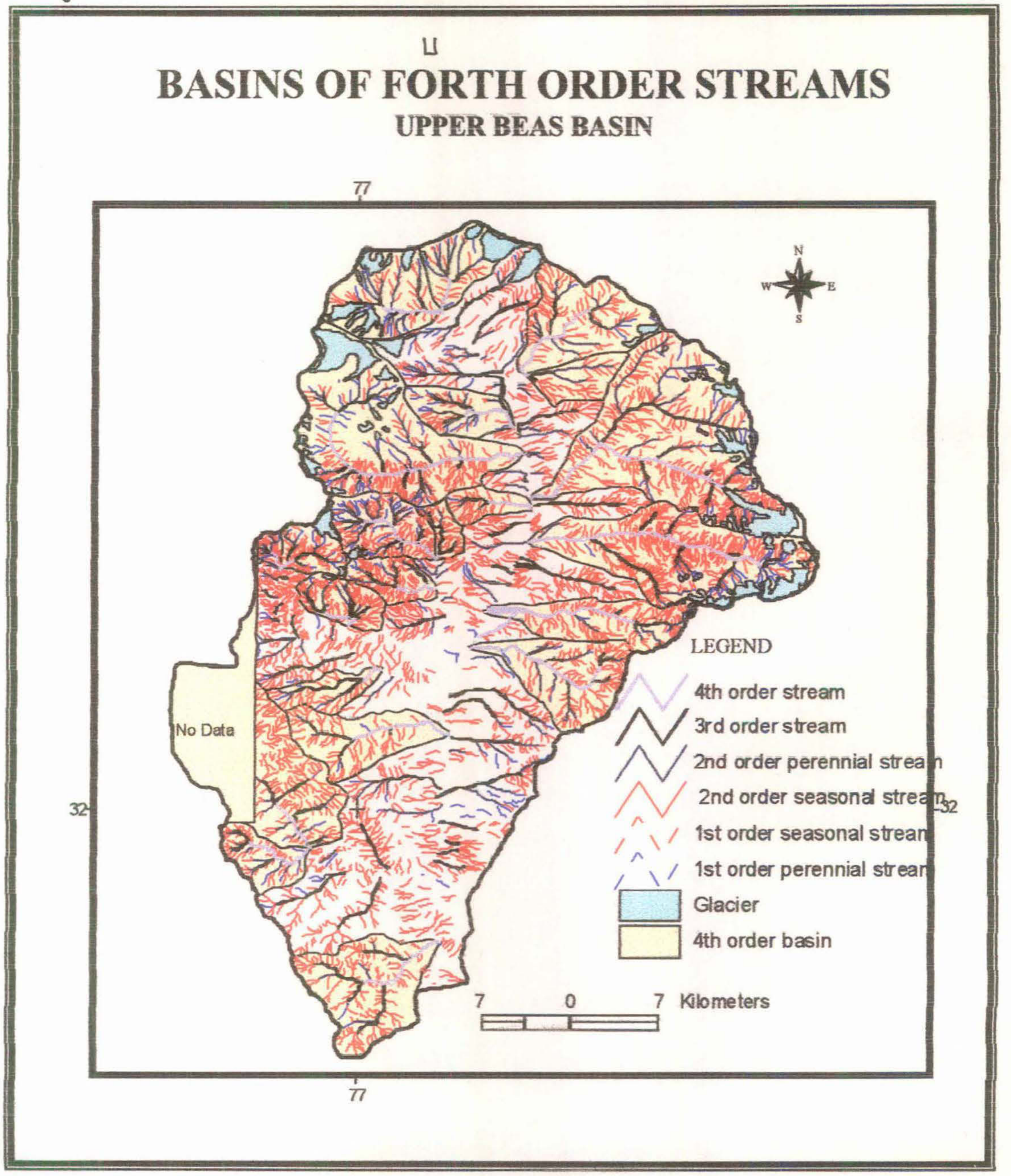
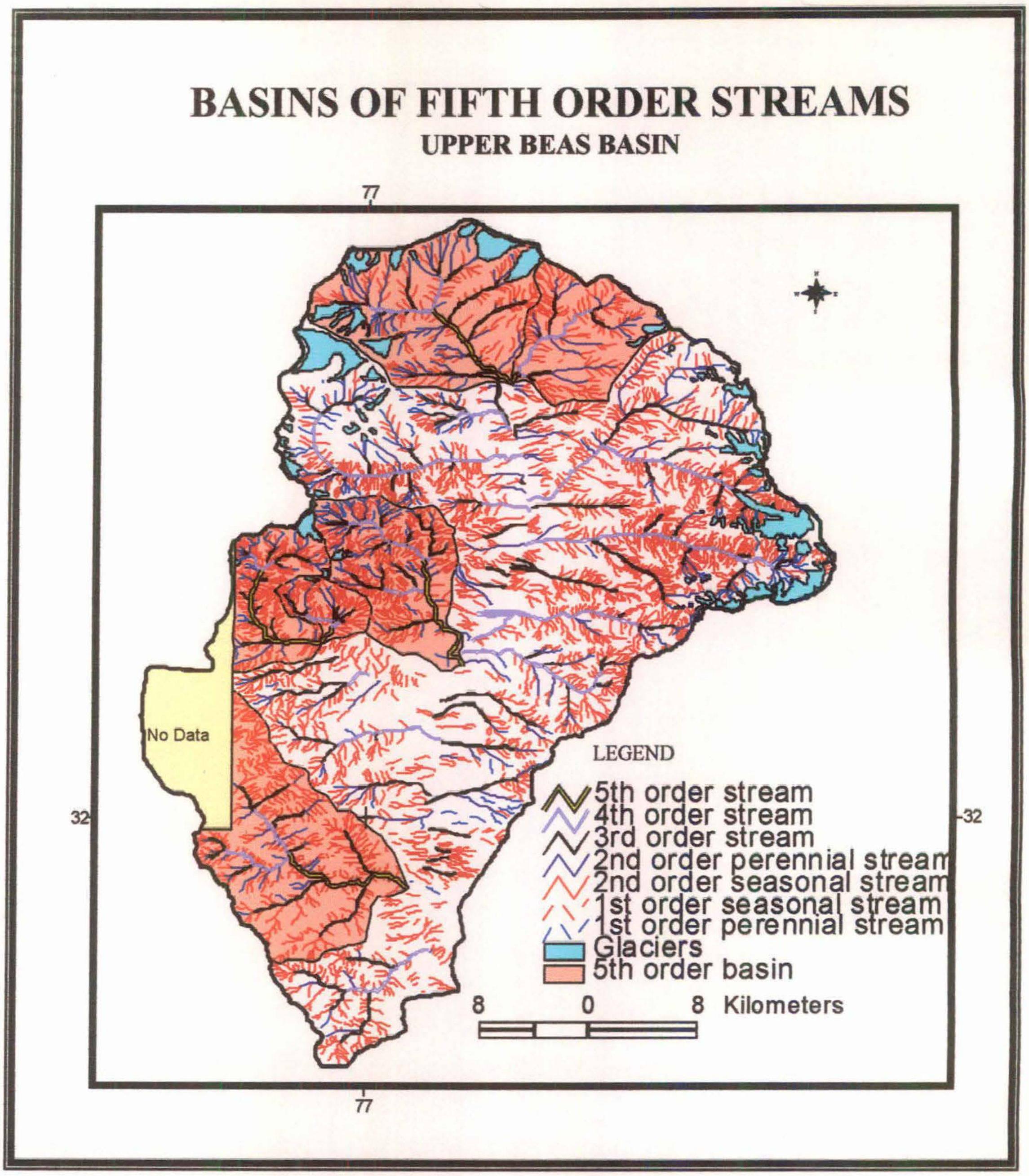

BASINS OF THIRD ORDER STREAMS
UPPER BEAS BASIN
77
No Data
LEGEND
3rd order stream
2nd order perennial
2nd order seasonal stream
1st order seasonal stream
1st order perennial stream
Glacier
3rd Order Basin
8 0 8 Kilometers
32
32
77

Figure 3.3(a)



BASINS OF FORTH ORDER STREAMS
UPPER BEAS BASIN
77
77
32
32
N
W
E
S
No Data
LEGEND
4th order stream
3rd order stream
2nd order perennial strea
2nd order seasonal strea
1st order seasonal strea
1st order perennial strea
Glacier
4th order basin
7
0
7 Kilometers

Figure : 3.3(b)


BASINS OF FIFTH ORDER STREAMS
UPPER BEAS BASIN
77
77
32
32
No Data
LEGEND
5th order stream
4th order stream
3rd order stream
2nd order perennial stream
2nd order seasonal stream
1st order seasonal stream
1st order perennial stream
Glaciers
5th order basin
8 0 8 Kilometers

STREAM LENGTH OF DIFFERENT ORDER			
Stream order	No of streams	Length of streams	Area
First	3216	-	-
Second	674	-	-
Third	136	261.70	860.19
Fourth	23	149.10	1046.75
Fifth	06	38.35	627.23
Sixth	02	36.55	1154.25
Seventh	01	25.63	1681.54
Total	4058	511.33	1681.54

Table 3.1

Basin of Fourth Order Stream Fig.3.3a, Basin of Fifth Order Fig.3.3b, and Basin of Sixth and Seventh Order.

The law of drainage basin composition as given by Horton (1945) is as follows;

1. There will be more first order streams than all other streams combined.
2. Stream length increases with increasing stream order.
3. Size of drainage area increases with increasing stream order.
4. Average gradient decreases with increasing stream order.
5. River discharge increases with increasing stream order.

In this exercise all the above said laws of the basin composition except the size of basin area increases with increasing stream order has been proved. The above mentioned third law is not proved because the Upper Beas River is flowing in a valley of high mountainous terrain and the number of fourth order streams directly merges with main river (Sixth or Seventh order streams). Thus we did not get the fifth order streams, and therefore the area under fifth order is less than the fourth order basin.

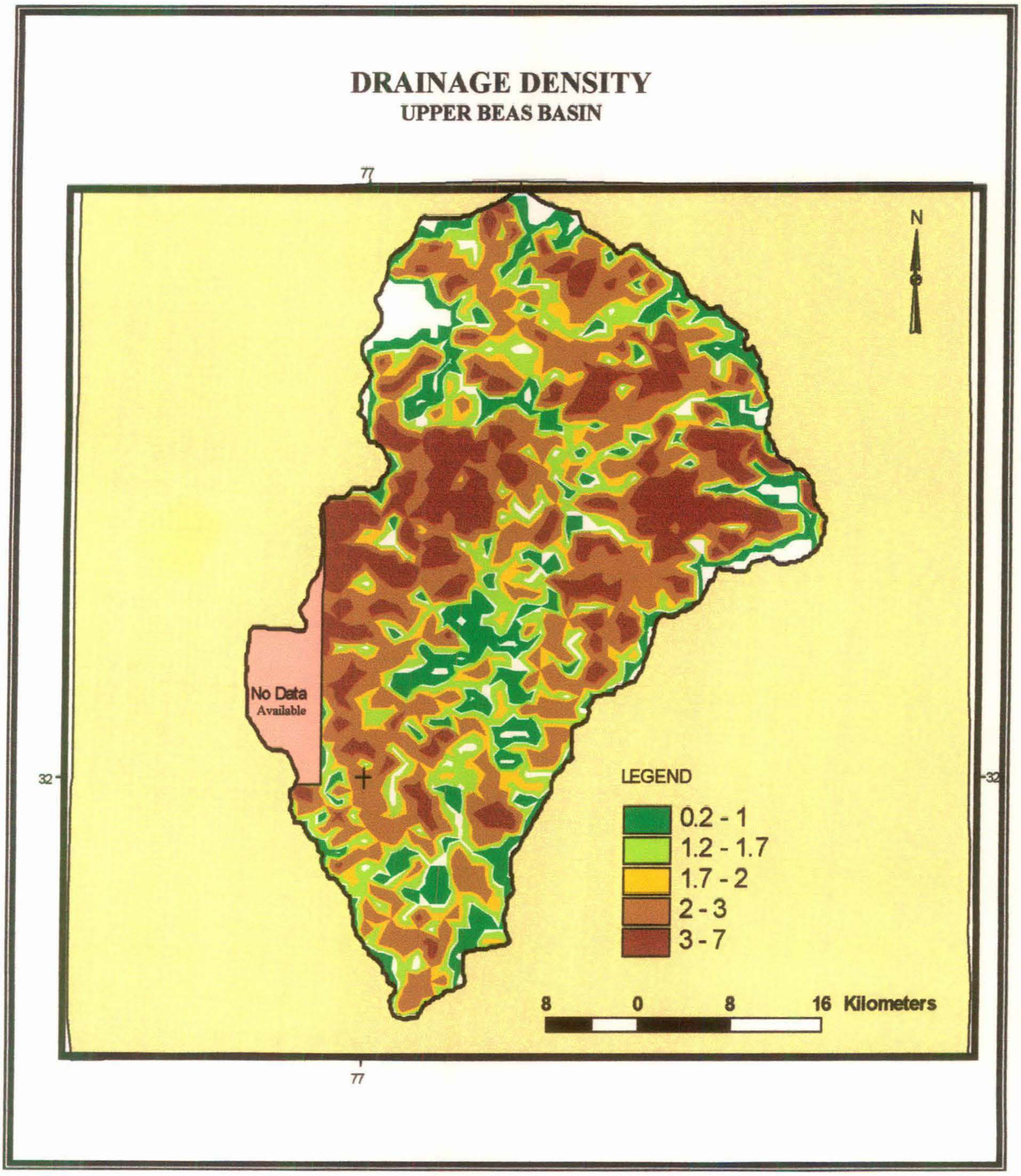
Bifurcation Ratio

The number of streams of various orders in the drainage basin is counted. Number decrease in a regular way with increasing order of streams forming geometrical series. The other aspect of bifurcation ratio expresses the ratio between the number of segments of any given order to the number of segments of the next higher order. The past studies suggest that the values of bifurcation ratio generally range from 2 to 5. The overall bifurcation ratio of the Upper Beas Basin is 4.07, which indicate an intermediate flood discharge. It also indicates greater number of first order channels,and streams flow on rocks of uniform resistance to erosion. The medium value of the basin also suggests that the basin has suffered less structural disturbance and the drainage has not been distorted (Strahler 1969). The bifurcation value is also an indicator of shape. The medium value indicate extended circular shape of the basin (Table 3.2)

Drainage Density

The drainage density is defined as the length of stream segment within a basin to the basin area. It is a dimension inverse of length. It is generally influenced by several factors like geology, climate, permeability of soil or rock etc (Morisawa, 1968). In the present study average drainage density of the basin is computed as 0.31 km./km^2. Figure 3.4 shows the drainage density of the Upper Beas Basin ranging between 0.2 and 7 km./km^2. which is grouped into five categories of very high (3-7), high(2-3), moderate(1.7-2), low(1-1.7) and very low(0.2-1). The lowest class of drainage density has very significant coverage of 377 km^2 which is 25.7 per cent of total catchment (Table 3.3). The area under this category is scattered throughout the basin but major portion lies on the margin and central part of the basin. The second class covers an area of 12.5 per cent. Maximum area of the basin is covered under 2-3 km./km^2 which amounts to 389 km^2 and covers a percentage of 26.6 of the total area in the Upper Beas Basin.

Figure: 3.4


DRAINAGE DENSITY
UPPER BEAS BASIN
77
N
No Data
Available
32
32
LEGEND
0.2 - 1
1.2 - 1.7
1.7 - 2
2 - 3
3 - 7
8
0
8
16 Kilometers
77

BIFURCATION RATIO OF UPPER BEAS BASIN		
Stream order	No of streams	Bifurcation ratio (N/N+1)
First	3216	4.77
Second	674	4.95
Third	136	5.91
Fourth	23	3.83
Fifth	06	3
Sixth	02	2
Seventh	01	-
Total	4058	24.46
Average bifurcation ratio		4.07

Table 3.2

Drainage Density of Upper Basin					
S.No	Class	Drainage Density	Frequency of grid	Percentage Area	Cumulative Percentage
1	Very High	3.00-7.00	215	16.4	16.4
2	High	2.00-3.00	349	26.6	43
3	Moderate	1.70-2.00	245	18.7	61.7
4	Low	1.20-1.70	164	12.5	74.3
5	Very Low	0.20-1.20	337	25.7	100
Total			1310	100	

Table 3.3

The area under this class lies in north-eastern and north -western part of the basin.

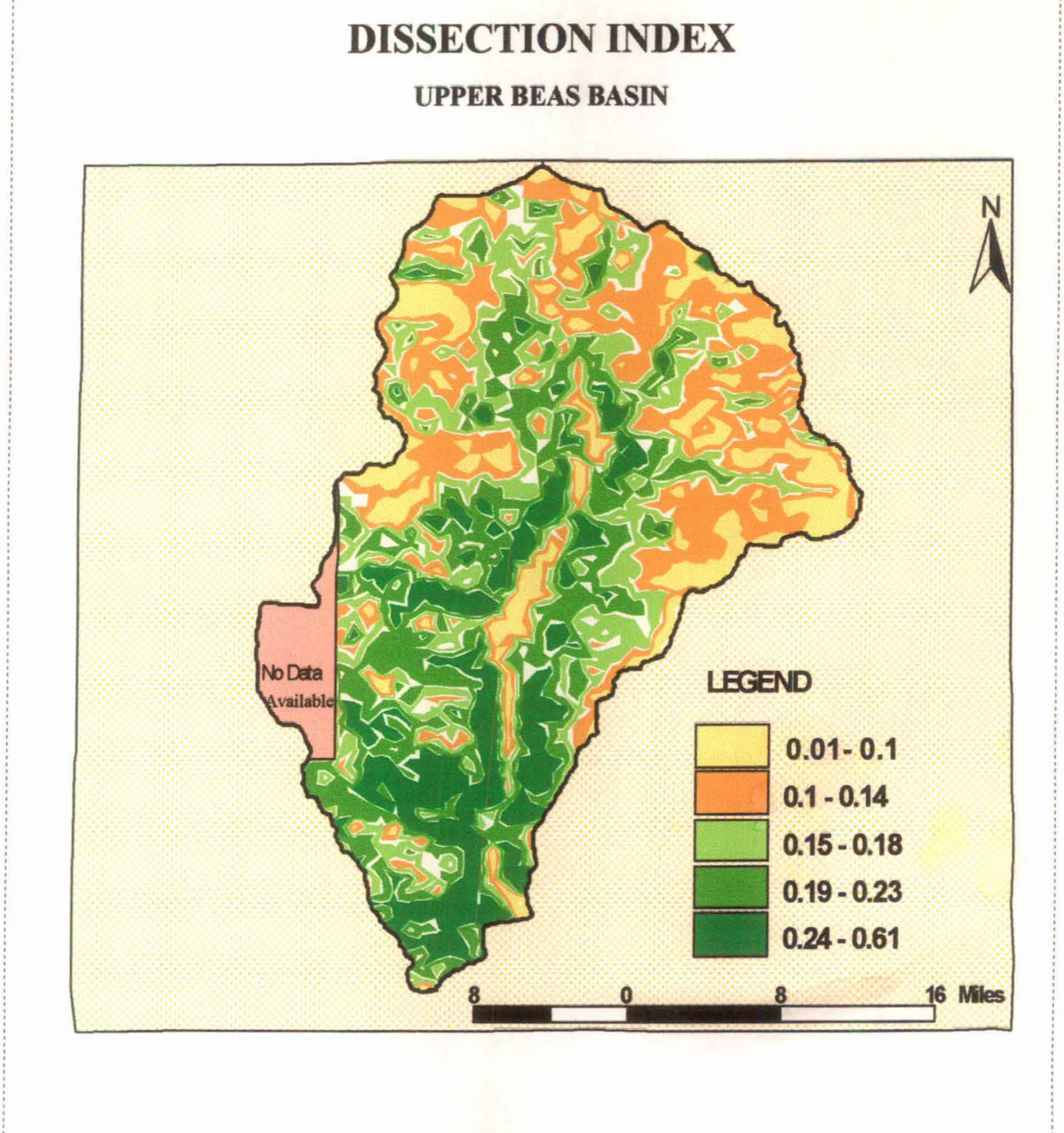
Dissection Index

From the geomorphological viewpoint, consideration of dissection index is very important in understanding the terrain characteristics of an area. It indicates the stages of evolution of the landforms. Dissection index is the ratio of two variables i.e, relative relief and absolute relief, within a well-defined unit area. The index of dissection indicates the intensity of effectiveness of relief. It is helpful in understanding the nature of relief better than either absolute relief or relative relief due to its manifold expositions of complex surface expressions. It is also helpful for classification and investigation of terrain unit. On the basis of dissection index, the study area has been divided into five major categories ranging between 0.01 and 0.61(Fig. 3.5, Table 3.4). Dissection index in the Upper Beas Basin is high to very high in the lower part of the basin.

Ruggedness Index

Ruggedness index is a measure of surface unevenness under a given lithological basement complex. It is a derivative of longstanding interaction between the available sharpness of the local relief and the amplitude of available drainage density. Physical environmental parameters such as slope, precipitation, weathering, soil texture, natural vegetation, etc. are partially responsible for the ruggedness of a surface (Patnaik, 1993). Chorley (1972) derived the method of ruggedness index for measuring the extent of dissection by taking into account

Figure:3.5



DISSECTION INDEX
UPPER BEAS BASIN
N
No Data Available
LEGEND
0.01 - 0.1
0.1 - 0.14
0.15 - 0.18
0.19 - 0.23
0.24 - 0.61
8
0
8
16 Miles

DISSECTION INDEX OF UPPER BEAS BASIN					
S.No	Class	Dissection index	Frequency of grid	Percentage Area	Cumulative Percentage
1	Very Low	0.01-0.10	297	20.5	20.5
2	Low	0.10-0.14	274	18.9	39.4
3	Moderate	0.15-0.18	290	20.0	59.5
4	High	0.19-0.23	321	22.2	81.6
5	Very High	0.24-0.61	266	18.4	100
Total			1448	100	

Table 3.4

both relief and drainage. Based on the ruggedness index the study area has been divided into five categories to assess the nature and magnitude of raggedness for practical purpose (Fig. 3.6, Table 3.5).

Stream Frequency

Stream frequency refers to the number of stream segments per unit area. Like drainage density stream frequency also depend upon the physical characteristics of the catchments and its climatic conditions Table 3.6.a gives the stream frequency in the Upper Beas Basin, which varies from 1 – 33. Zero value for stream frequency and area under glacier has not been considered in the study. The values of stream frequency are categorized in five groups as given in figure 3.7.

Drainage Texture

Drainage texture is the indicator of spacing of stream in a unit area. It refers to the relative spacing of total number of stream segments of a given length per unit area and represents various regional scales of texture fineness. The varying grades of drainage texture do not refer to steepness of slope, amount relief or stage in the geomorphic cycle. One may find a coarse drainage texture in regions of low or high relief, in region of gentle or steep slope or in young or old topography. The values of drainage texture are presented and depicted in Table 3.6.b and Figure 3.8.

Figure :3.6

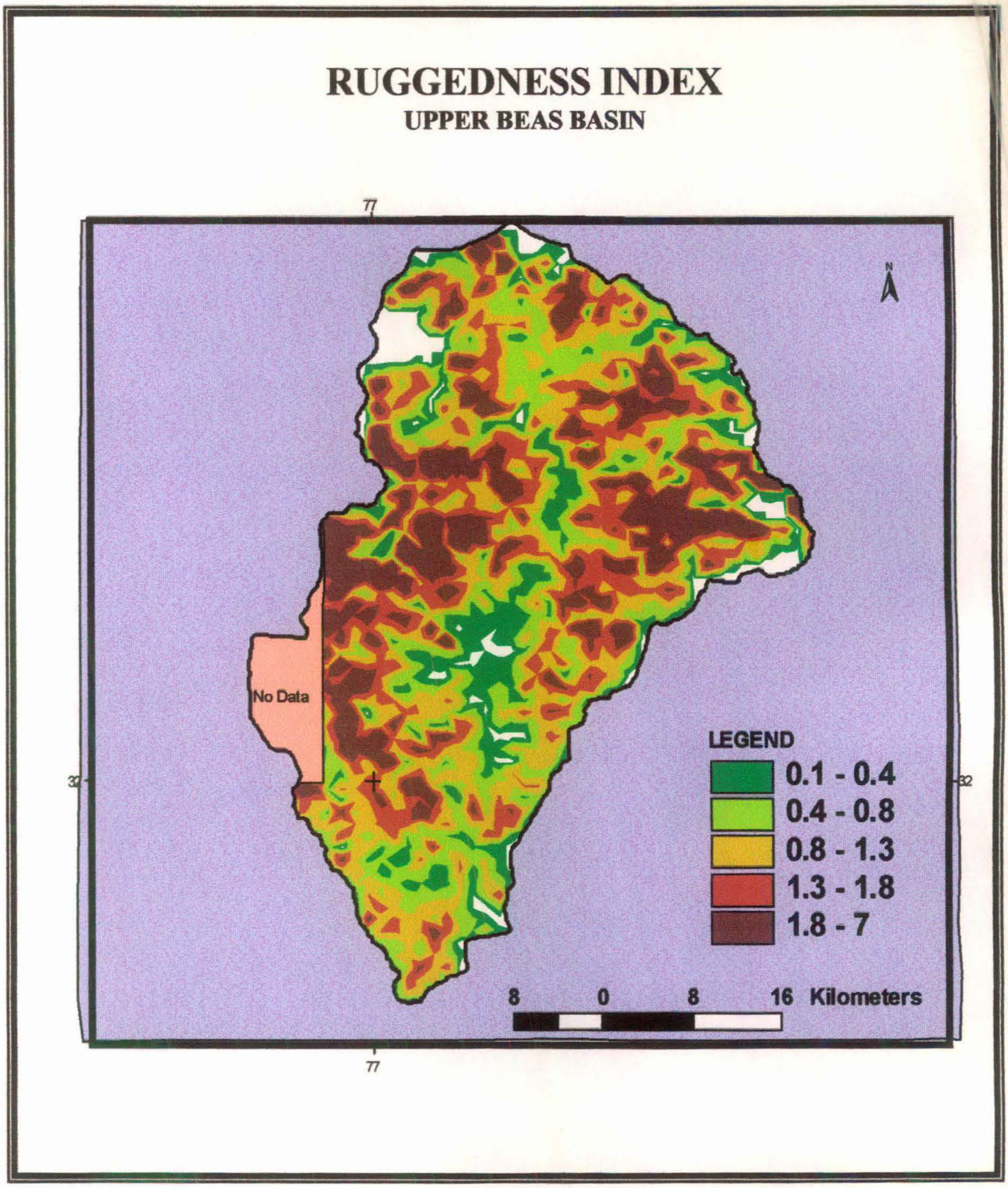

RUGGEDNESS INDEX
UPPER BEAS BASIN
77
N
No Data
LEGEND
0.1 - 0.4
0.4 - 0.8
0.8 - 1.3
1.3 - 1.8
1.8 - 7
32
32
8 0 8 16 Kilometers
77

Figure 3.7

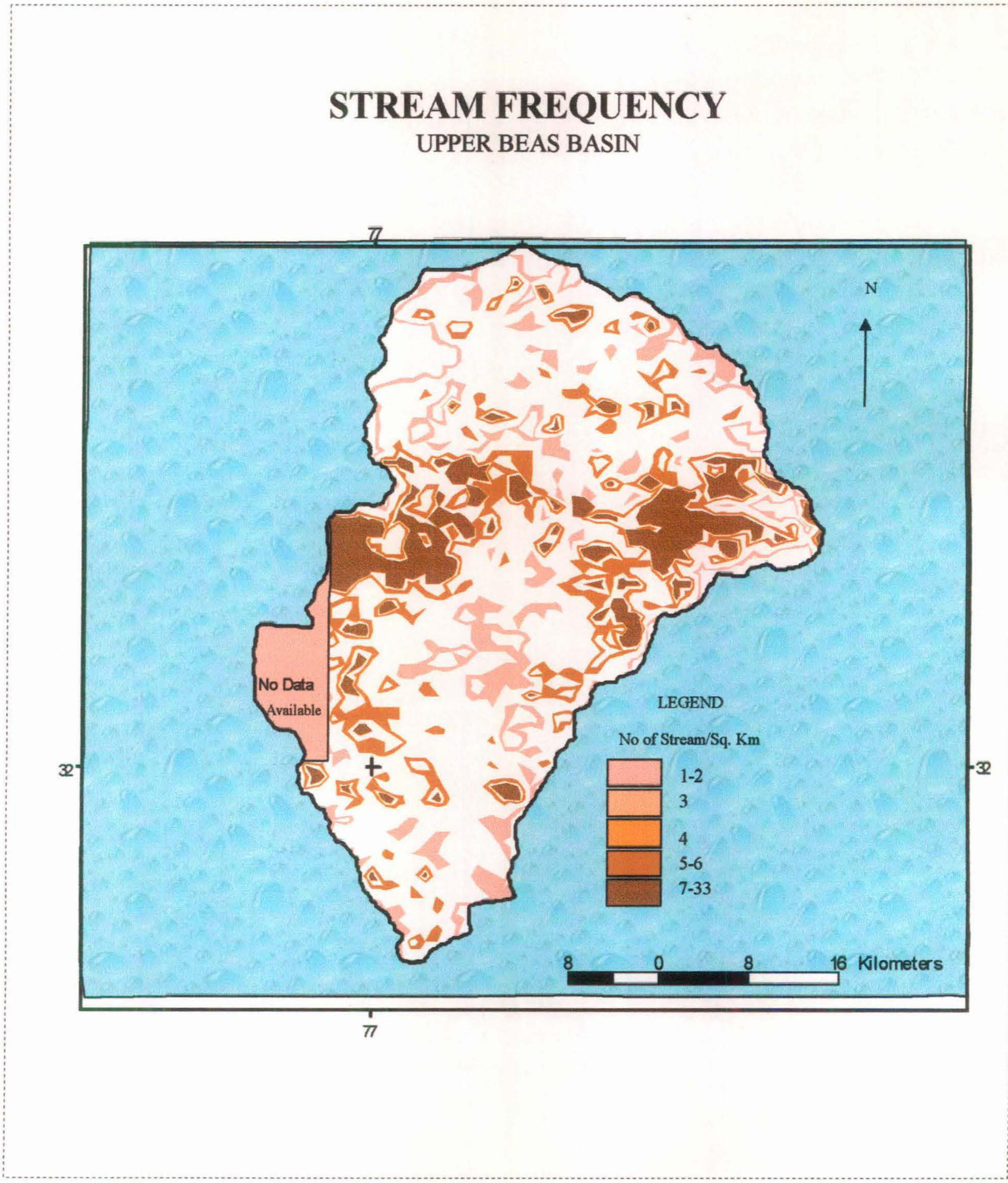

STREAM FREQUENCY
UPPER BEAS BASIN
77
N
No Data
Available
LEGEND
No of Stream/Sq. Km
1-2
3
4
5-6
7-33
32
32
8
0
8
16 Kilometers
77

Figure 3.8

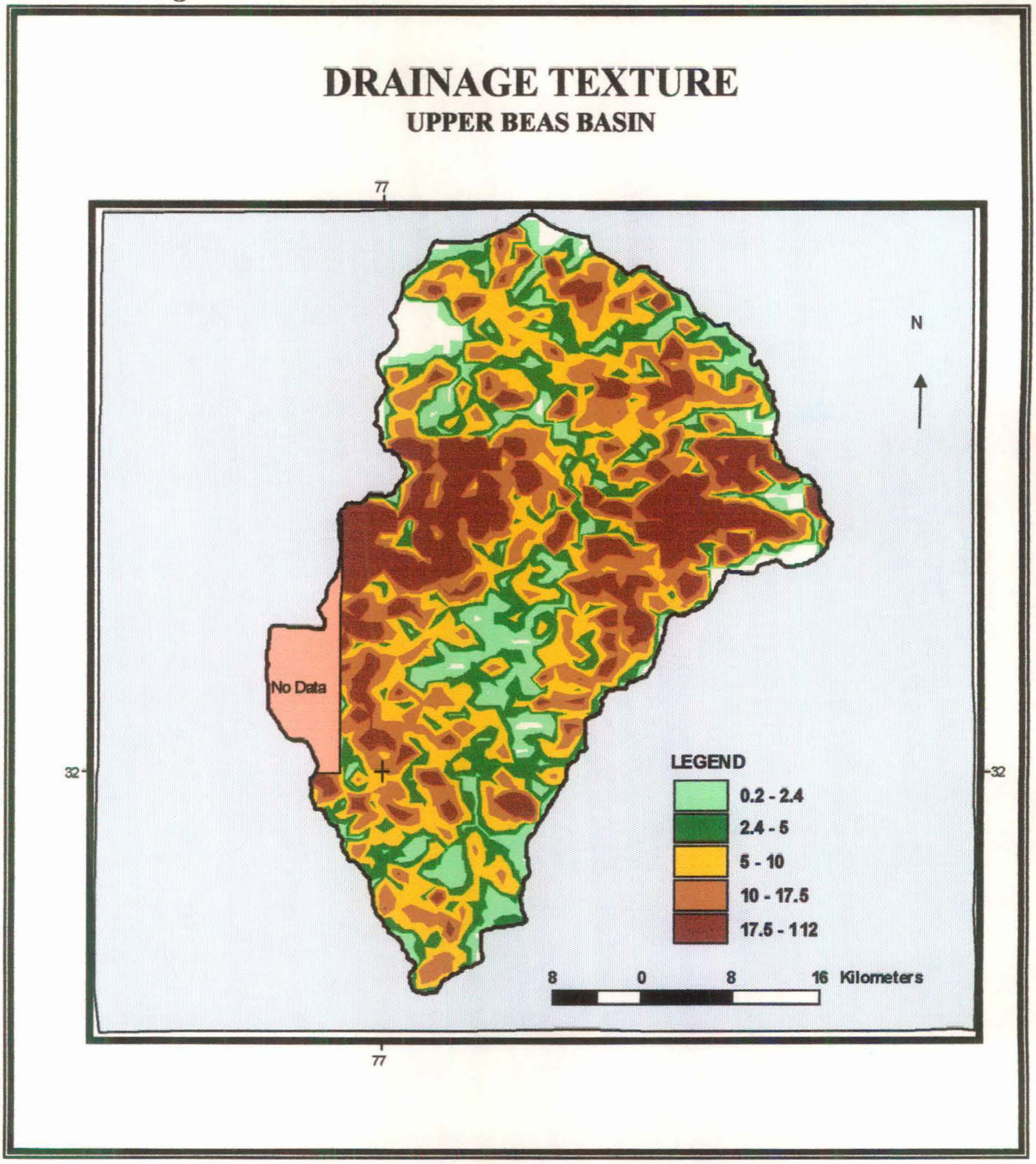

DRAINAGE TEXTURE
UPPER BEAS BASIN
77
N
No Data
32
LEGEND
0.2 - 2.4
2.4 - 5
5 - 10
10 - 17.5
17.5 - 112
8 0 8 16 Kilometers
77

Table 3.5

RUGGEDNESS INDEX

S.No	Class	Ruggedness Index Classes	Frequency	Valid Percent	Cumulative Percent
1	Very Low	0.1 – 0.4	244	18.7	18.7
2	Low	0.4 – 0.8	265	20.3	39.1
3	Moderate	0.8 – 1.3	288	22.1	61.2
4	High	1.3 – 1.8	237	18.2	79.4
5	Very High	1.8 – 7.0	269	20.6	100.0
Total			**1303**	**100.0**	

Table 3.6(a)
STREAM FREQUENCY

S.No	Class	Stream Frequency Classes	Frequency	Valid Percent	Cumulative Percent
1	Very Low	1 - 2	330	25.2	25.2
2	Low	3	243	18.5	43.7
3	Moderate	4	216	16.5	60.2
4	High	5 – 6	292	22.3	82.5
5	Very High	7 – 33	229	17.5	100.0
Total			**1310**	**100.0**	

Table 3.6(b)
DRANAGE TEXTURE

S.No.	Class	Drainage Texture Classes	Frequency	Valid Percent	Cumulative Percent
1	Very Low	0.2 – 2.4	253	19.3	19.3
2	Low	2.4 – 5.0	232	17.7	37.1
3	Moderate	5.0 – 10.0	306	23.4	60.4
4	High	10.0 – 17.5	236	18.0	78.5
5	Very High	17.5 – 112.0	282	21.5	100.0
Total			**1309**	**100.0**	

Table 3.6(c)
SLOPE

Slope Code	Class	Slope Classes	Frequency	Percent	Cumulative Percent
1	Very Low	51.52 – 83.52	306	20.2	20.2
2	Low	83.52 – 84.66	272	17.9	38.1
3	Moderate	84.66 – 85.34	336	22.1	60.2
4	High	85.34 – 85.96	314	20.7	80.9
5	Very High	85.96 – 88.65	290	19.1	100.0
Total			**1518**	**100.0**	

Average Slope

Regional slope characteristics are controlled by both endogenetic and exogenetic factors. The initial slope of a catchment is generally deformed by climatic conditions of a region through a series of activities of erosion and denudation. Average slope of the Upper Beas Basin has been calculated with the help of Wentworth (1930) method of slope analysis with the metric scale notation. Each terrain unit has both characteristics and limiting angles depending on the particular conditions of rock or climate.

Slope classification transforms the continuous variable of slope within certain discrete classes with conformity of the ground. The study area is in a high slope zone starting from approximately from 51^0 to 88^0. A general description of the average slope analysis is given in Figure 3.9[illegible] and Table 3.6.c. The maximum slope of an area as per grid arrangement is approximately near the margin of water divide .

Relative Relief

Relative relief is an important aspect of terrain analysis. From a relative relief map we may assume the nature of topography whether it is plain, plateau or hilly. It is also termed as relative energy, local relief or amplitude of relief. As cross association with slope, the relative relief is more expressive and useful in

Figure 3.9(a)

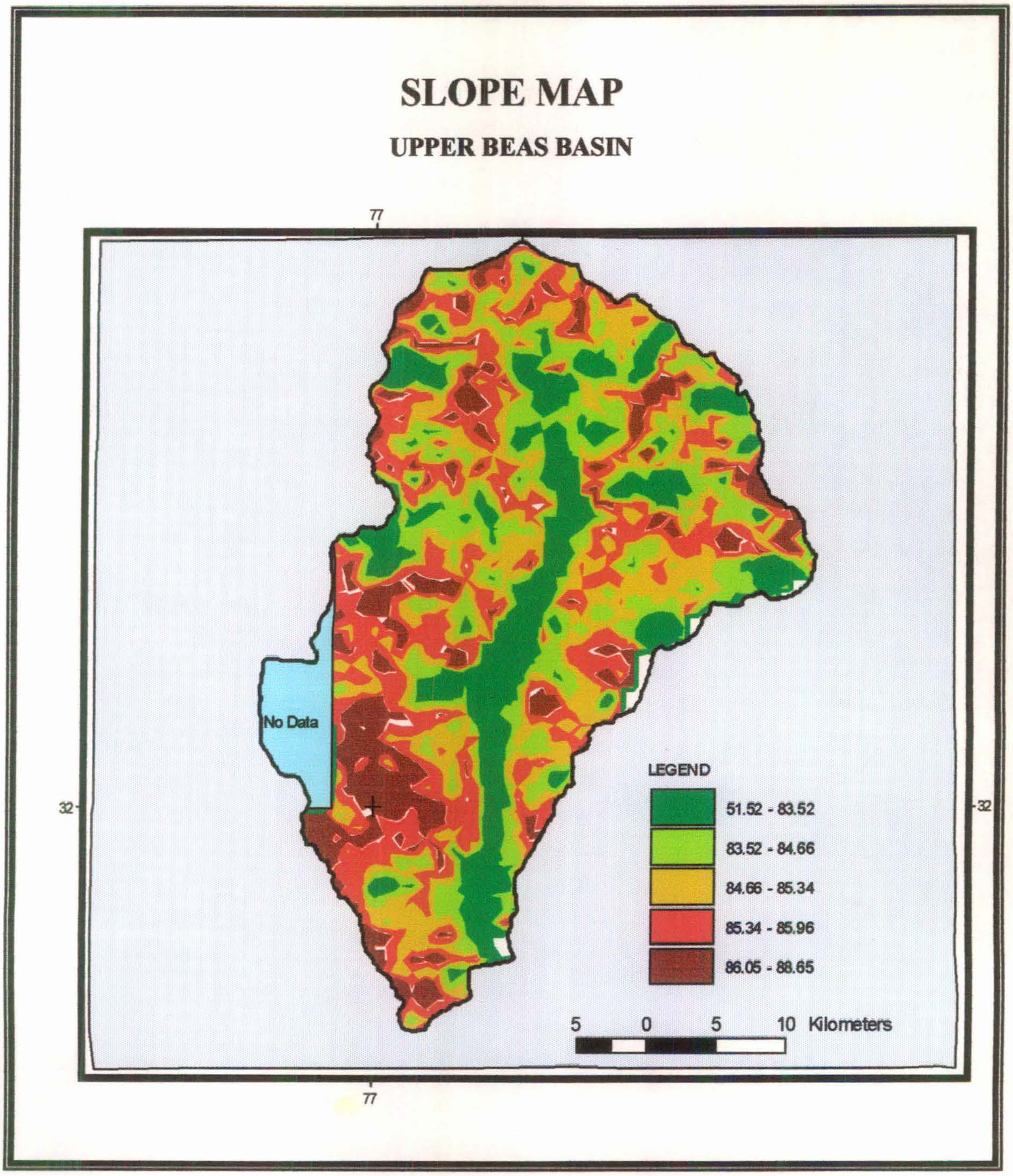
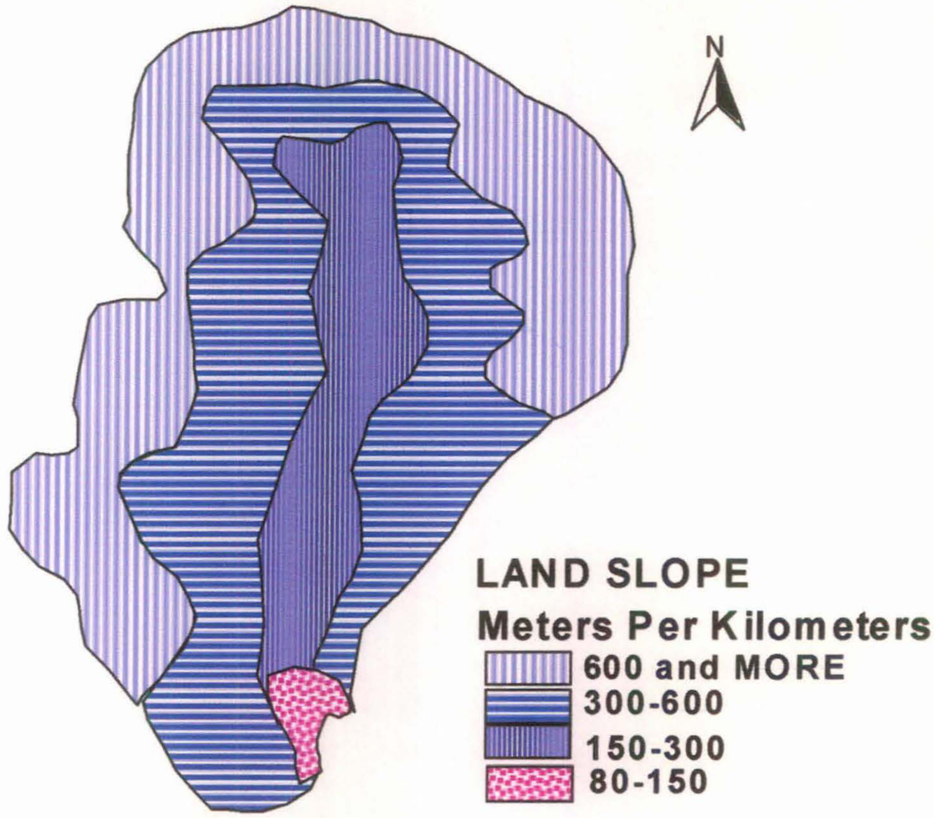

SLOPE MAP
UPPER BEAS BASIN
77
No Data
LEGEND
51.52 - 83.52
83.52 - 84.66
84.66 - 85.34
85.34 - 85.96
86.05 - 88.65
32
32
5 0 5 10 Kilometers
77

Figure: 3.9 (b)

SLOPE MAP

UPPER BEAS BASIN



Source: National Atlas Maps, Survey of India Maps

Table 3.7(a)
RELATIVE RELIEF

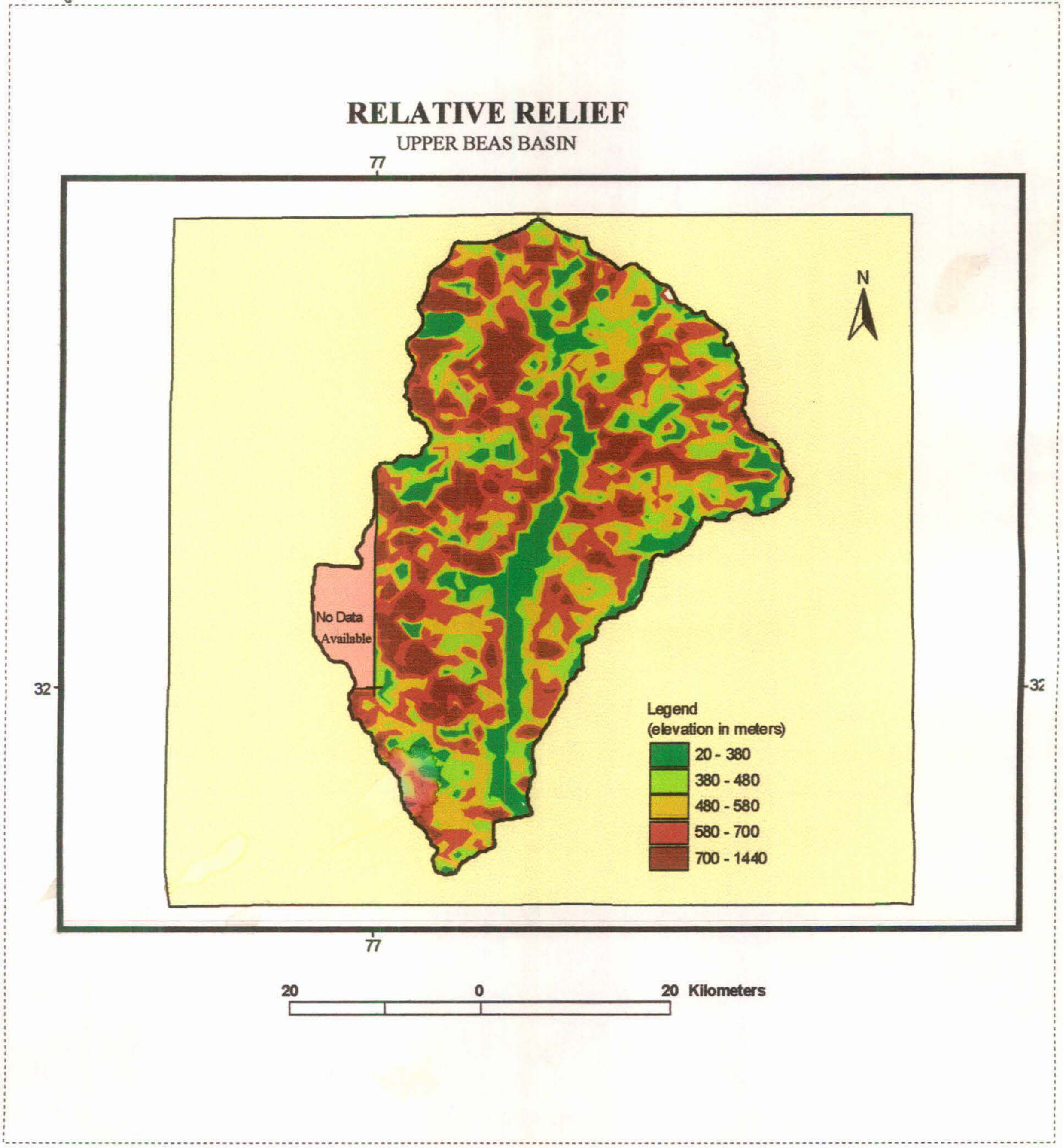
S.No	Class	Relative Relief Classes	Frequency	Valid Percent	Cumulative Percent
1	Very Low	20 – 380	269	18.6	18.6
2	Low	380 – 480	318	22.0	40.5
3	Moderate	480 – 580	223	15.4	55.9
4	High	580 – 700	334	23.1	79.0
5	Very High	700 -1440	304	21.0	100.0
Total			**1448**	**100.0**	

Table 3.7(b)

ABSOLUTE RELIEF

S.No	Class	Absolute Relief Classes	Frequency	Valid Percent	Cumulative Percent
1	Very Low	1120 – 2440	288	19.9	19.9
2	Low	2440 – 3080	292	20.1	40.0
3	Moderate	3080 – 3760	293	20.2	60.2
4	High	3760 – 4440	289	19.9	80.1
5	Very High	4440 – 5680	288	19.9	100.0
Total			**1450**	**100.0**	

Figure 3.10


RELATIVE RELIEF
UPPER BEAS BASIN
77
N
No Data Available
32
32
Legend
(elevation in meters)
20 - 380
380 - 480
480 - 580
580 - 700
700 - 1440
77
20
0
20 Kilometers

understanding classes of natural phenomena, including relief dissection and surface ruggedness (Patnaik, 1993).

The relative relief map (Fig. 3.10) shows that there are abrupt changes in relative relief of the study area. Five major categories of relative relief have been identified in present context for analytical interpretation as given in table 3.7.a. This illustrates that the study region covers maximum area (23%) under high relative relief.

Absolute Relief

Absolute relief gives the elevation of any area above the sea level. It is quite helpful in the determination of morphology and existence of erosional surfaces. The absolute relief of the Upper Beas Basin varies between 1120 m - 5680 m. The distribution and extent of absolute relief has been presented in table 3.7.b and Figure 3.11.

Digital Terrain Model (DTM)

Morphometric analysis given above shows that the Upper Beas Basin produces peak and extended flow of runoff . In order to get detail about the watershed behaviour terrain analysis is a prerequisite. To generate precise physiographic analysis, flow direction and stream network Digital Terrain Model(DTM) is required. It is a representation of relief over space in raster format. Both the contours and spot heights are used with the existing drainage line to generate the DTM of the Upper Beas Basin (Fig. 3.12). DTM is the first step of

Figure: 3.11

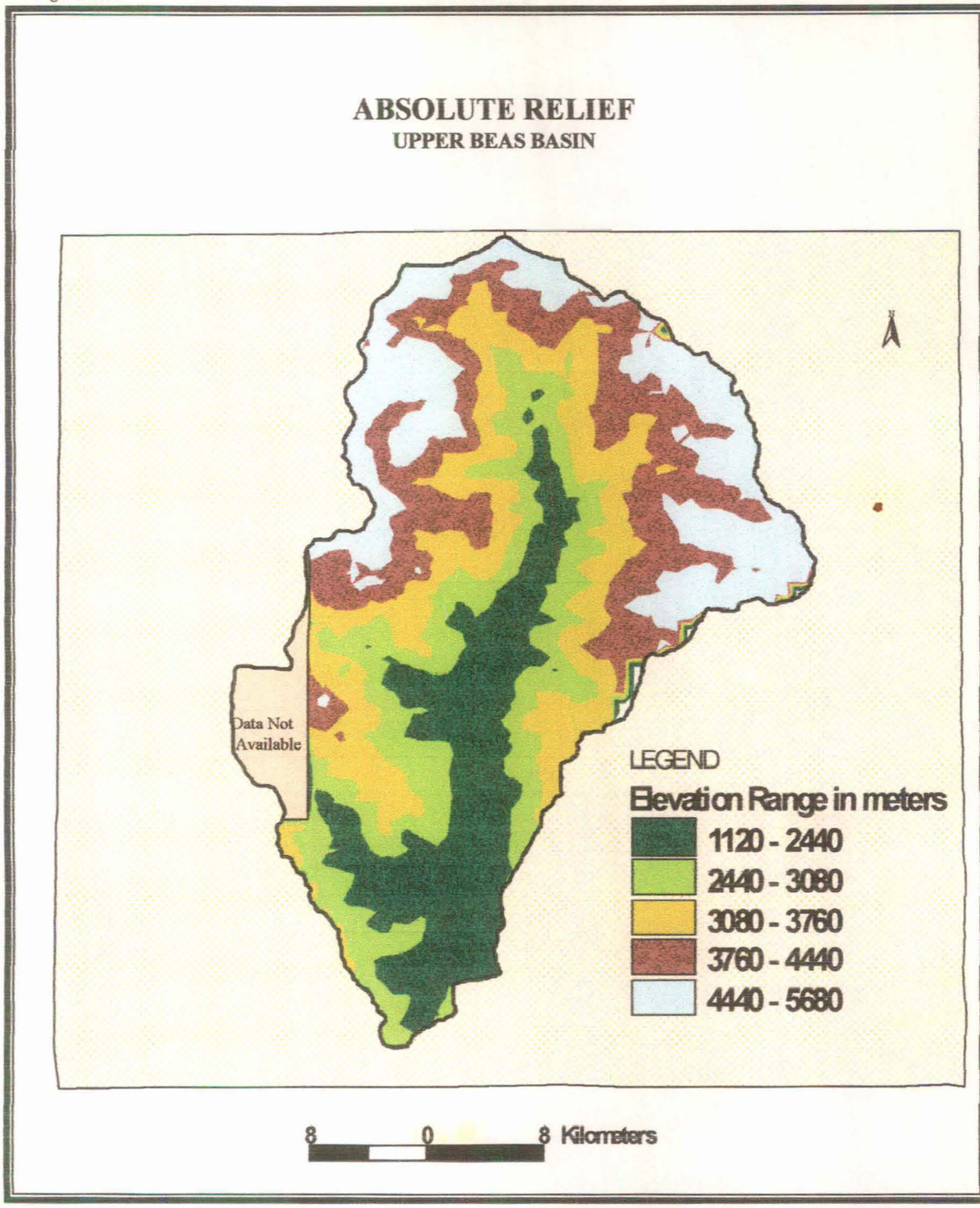
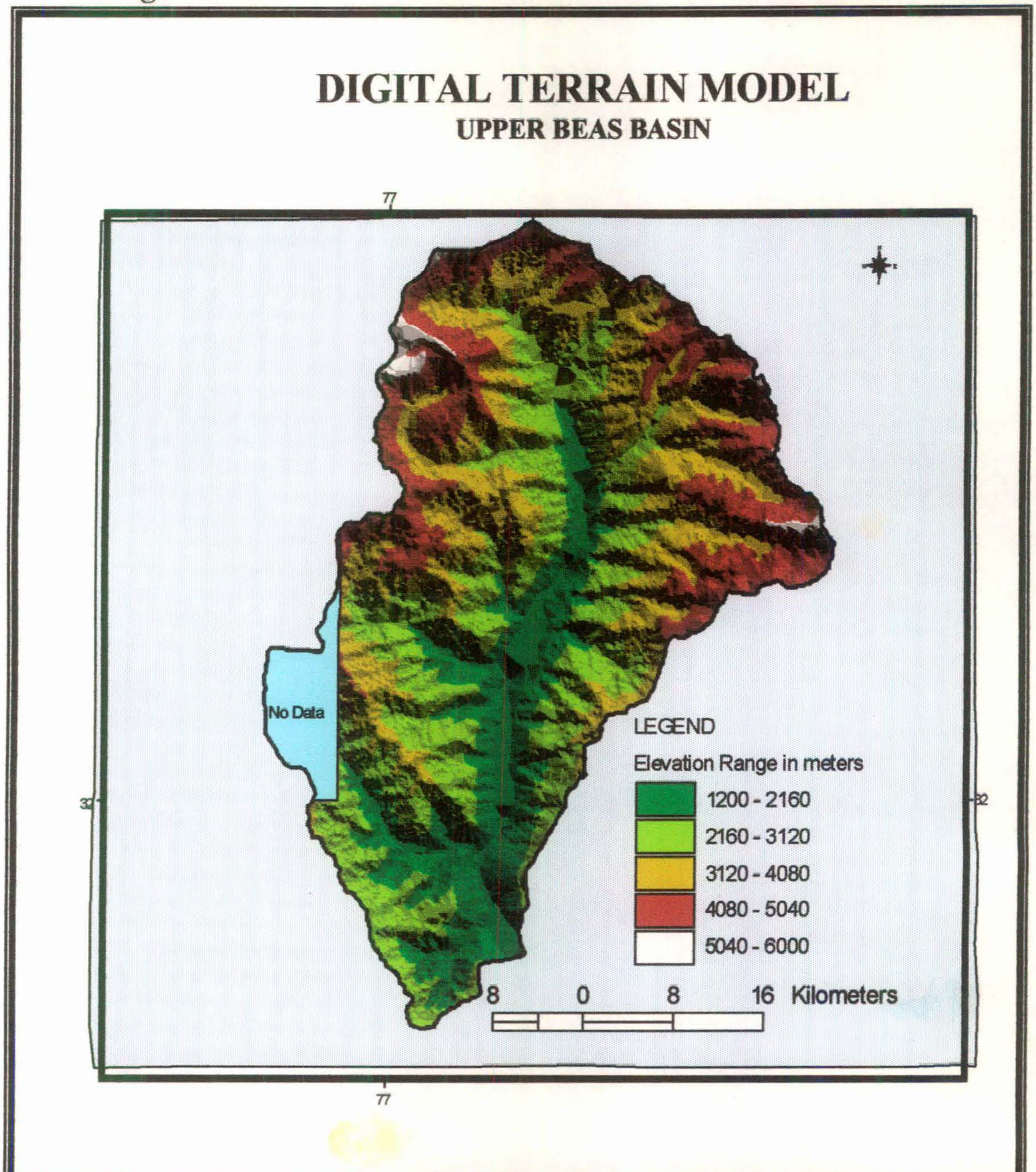
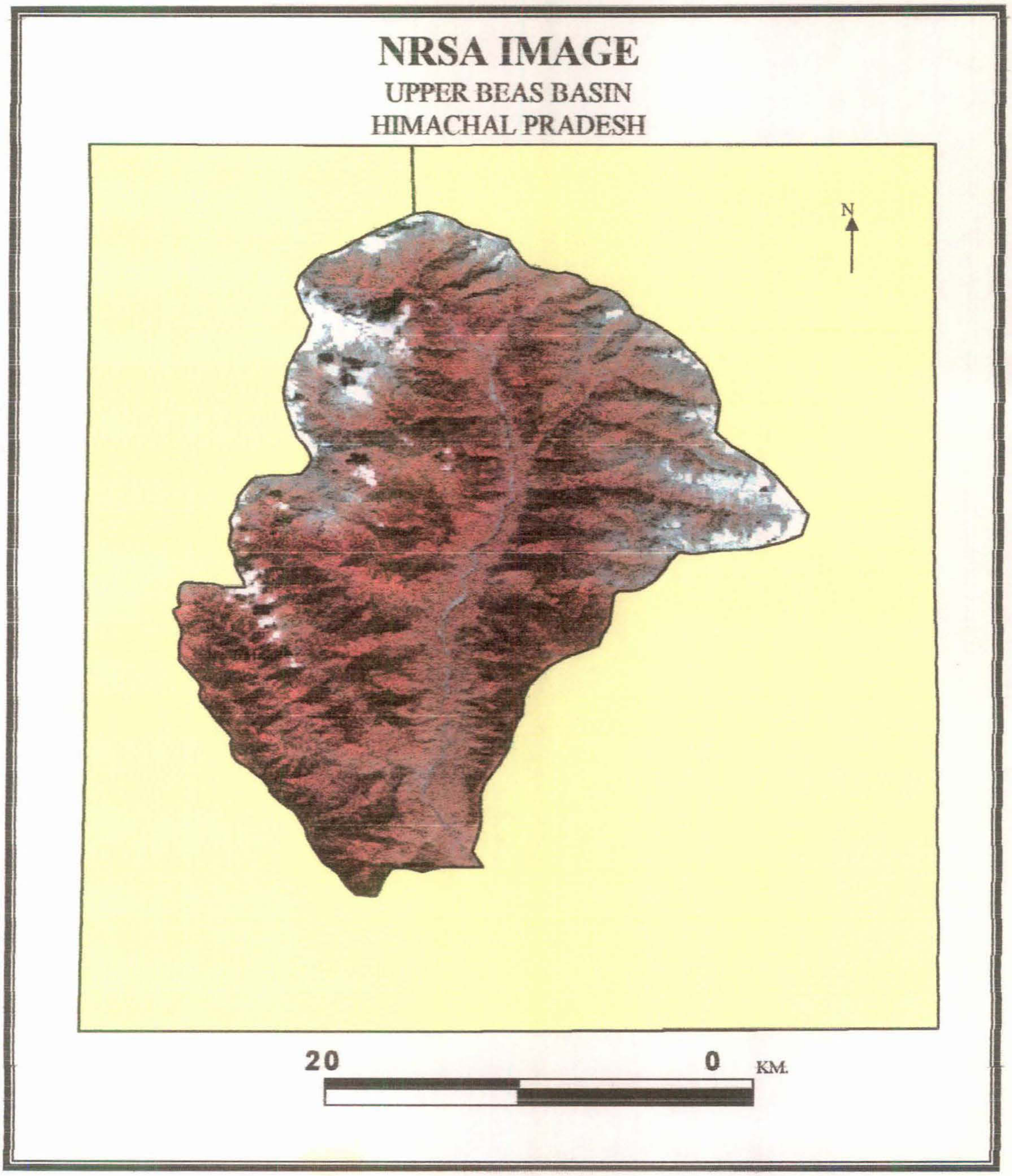

ABSOLUTE RELIEF
UPPER BEAS BASIN
Data Not Available
LEGEND
Elevation Range in meters
1120 - 2440
2440 - 3080
3080 - 3760
3760 - 4440
4440 - 5680
8
0
8 Kilometers

Figure 3.12


DIGITAL TERRAIN MODEL
UPPER BEAS BASIN
77
No Data
LEGEND
Elevation Range in meters
1200 - 2160
2160 - 3120
3120 - 4080
4080 - 5040
5040 - 6000
8 0 8 16 Kilometers
77

deriving the hydrologic information about the surface of the watershed. DTM can provide information about rainfall estimates, runoff analysis and erosional processes of a basin. The DTM shows that there are peaks in the north-western as well as in north-eastern parts of the basin. The rest of the basin is represented by more regular physiographic patterns. The terrain pattern is very nicely matched with the drainage characteristics of the basin and National Remote Sensing Agency (NRSA) image (Fig. 3.15).

Figure 3.16



CHAPTER 4

CLIMATIC CHANGE AND LANDFORMS

The Himalayas have evolved through a series of land forming processes, operating over a long geological time; the outcome of these processes is the present environment. There are now definite indications of permanent and near permanent changes in the climate in several parts of Himalayas, tending towards desert conditions, advancing and retreating glaciers, dried up springs, erratic precipitation, rising temperatures and higher temperature regime. The tropical glaciers are considered repositories of environmental change indicators.

The formation of landforms in the Himalayas requires addressing a number of different process domains at a number of time scales to represent changing environmental conditions. Many of these landforms reflect former climatic conditions and emphasize the importance of climate as a major forcing mechanism on landform genesis in geomorphology. Despite these important issues little research has been undertaken on the nature of climate change and landform evolution within the high mountains of the Himalayas due to various reasons.

The Himalayan region, endowed with a staggering geomorphological diversity, offers an exceptionally rich field for the study of glacial, glacio-fluvial, slope and fluvial landscapes. Therefore, active glaciers and associated landscapes provide an ideal laboratory for the investigation of fluvial, glacial, and slope processes and their resultant landforms.

Glacial landforms

The advance and retreat of body of ice generates the glacial process, which creates erosional and depositional features in a geomorphic landscape. Glacial features, both erosional and depositional are present almost everywhere in the high Himalayas, confined to the steep slope and in the present broad river valleys

The depositional features are created directly by the advance and retreat of glaciers. These landforms, therefore, provide much of the information regarding the history of the Pleistocene glacier fluctuations, and thus the environmental episode in which these usually evolve. The advance produces distinctive depositional features, which epitomize the changing times of landform formation. The retreat of the glaciers produces distinctive interwoven morainic features linked with the sub-stages of glacier retreat. The volume of deposition is closely correlated with the intensity of weathering and erosion in a glacial environment. The major glacial landforms in different environmental conditions in the Himalayas are-

Moraine

The distribution of moraines reveals a close relationship between the landform orientation and ice flow direction. This, in turn, may be used as a yardstick to look into environmental change, locally and regionally. The different types of moraines can be attributed as under:

Plate 7: Heap of sediments of all sizes near Beas Kund. Note the exposed lateral moraine of recent age in the top right background.

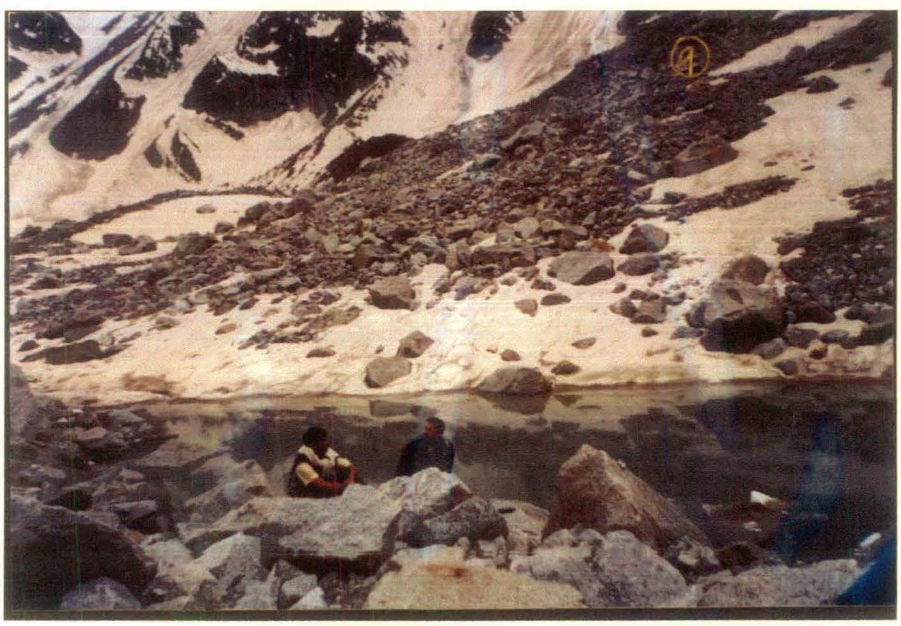


Plate 8: Proglacial lake at Beas Kund. Note the talus fan and avalanche snow accumulated in the left background.

Lateral moraines

This type of moraines form through the accumulation of valley side material on either side of the glacier. Examples of lateral moraines formed through sub glacial processes can be rare, because the slope processes in a dynamic environment such as in the Himalayas rapidly modify these.

Owen and Derbyshire (1989) recognized two main types of lateral moraines, which are dependent on supra-glacial debris formation. Lateral moraine aggradations may result from fluctuation in the position of the ice front.

Sharma (1996) identified that well developed lateral moraines are present 50-120 m above the present glacier surfaces in a terrace form. The older lateral moraine landforms complexes have been found to resemble fluvial terraces in the upper parts of the Garhwal Himalayas.

In the Upper Beas basin lateral moraines form both sharp- crested and terrace forms down to Palchan near the confluence of the Beas and Solang nallah.

End or terminal moraines

The end moraines are one of the important geomorphic features formed by the movement of the glacier snout. The form and size are mainly related to the ice movement, the rate of surface ablation and volume of sediments contained in the ice. In the western Himalayas the majority of the end moraines are partly destroyed by the river, through widening of its flood plains and fluctuations in snout positions and melt water volume. End moraines are present at various site in the upper Beas Basin. These are Palchan, Solang ki slopes, Dhundi, Bakearthal and Beas kund. Push moraines are composed of large boulders, embedded in sand

and silt matrix. Push moraines though few in numbers are prominent at Beas kund. These indicate minor fluctuations in the snout position.

Ablation valleys

Ablation valleys are prominent landforms that exist in two different forms. Ablation valleys are highly variable in character depending on ice marginal processes, with lateral moraines and kame terrace development being important component (Owen, 1988; Owen and Derbyshire, 1989; Hewitt, 1989). Hewitt (1988) suggests that the formation of ablation valleys is dependent to varying degrees upon slope, snowmelt, lacustrine debris flow and glacial processes.

Sharma, (1996) identified two types of ablation valleys in the N.W. Garhwal Himalayas based on their size and form. He describes that ablation valleys are formed by sedimentation involving glacial, mass movement, periglacial and paraglacial processes. A single lateral moraine forms the first type. These are fairly long and narrow with associated lacustrine deposited with in the valley. The second type is produced when the lateral moraines of two glaciers converge, forming relatively large ablation valley lakes. Both these types are found in the upper region, above Solang village.

Cirque

The cirques are universal in occurrence in the glaciated mountain regions and the most recurrent worldwide feature in the glaciated landscapes. These are confined to the areas of the present or former glaciations. On the basis of cirque level two to three Pleistocene advances of the Himalayan glaciers have been

Plate 9: A typical landform in the Upper Beas Basin near Beas Kund. Note the pile of sediment accumulation in the middle related to bulldozing effect of glacier. Chutes in the background are impressive.

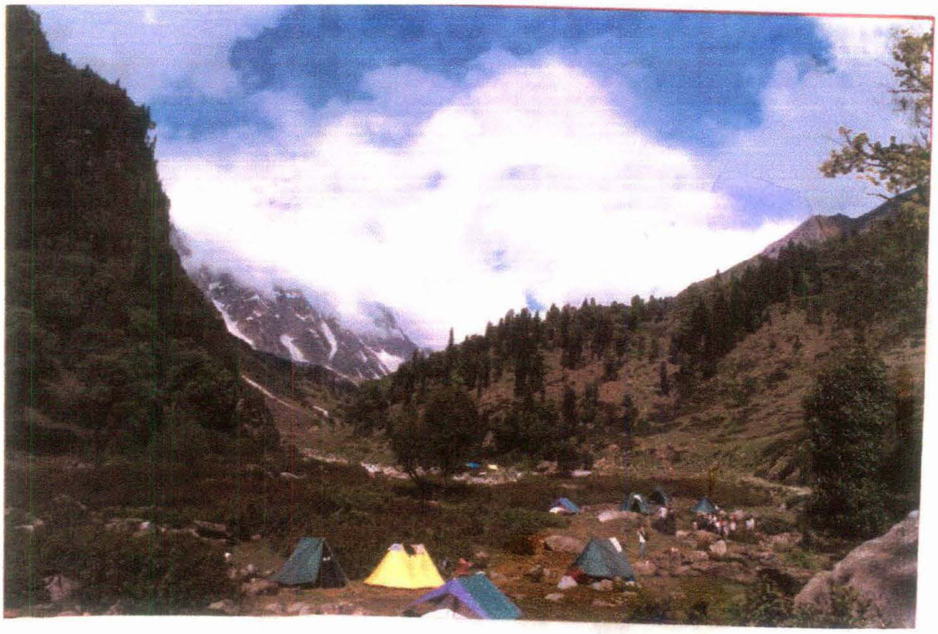


Plate 10: Open pine and oak forest mixed with hedges at Dhundi. Aspect has a great control on density and tree-line altitude.

proposed (Krenek and Bhawan,1945; Vohra,1981; Ahmed and Mayewaski, 1981).

Cirques that still have snow and ice filled have developed at different levels in different parts of the Himalayas. The highest cirque level is recorded from Sikkim and the lowest from the Kashmir valley.

Cirques in the upper Beas basin are at 4200-4800 m above sea level. Both paleo and present active cirques of small dimension are abundant.

Fluvial Landforms

River terraces

Terraces are flat or gently inclined land surfaces produced by fluvial action. They have been classified into erosional and depositional ones on the basis of their genesis. Lot of work has been conducted on the terraces of Himalayan Rivers and it has been reported that they comprise of five to seven levels (Khan and Srivastava, 1981; Vohra, 1970).

The high level terraces have been identified in the Kashmir Himalayas. The terraces in the river valleys in the lesser Himalayas are more common. Downstream of Manali to the gorge point south of Bajoura, the Beas river has eroded 5 levels of fluvial terrace. Each of these terraces are 5-30 m high above the flood plain.

The environmental relationship of the landforms can be established looking at their morphogenitic characteristics, extent, shape and locations. The varied phases of glaciations due to cold climate conditions in the Pleistocene might have evolved the deep and broad valleys in the Himalayas. Subsequent warming up of climate seems to have resulted in the evolution of incision of valley through increased melt waters from the glaciers. This increase in the volume of the river discharge in turn may have been responsible for the formation of paired terraces that exists 10s of meters high and kilometers long from the present day river course; although the role of uplift in their evolution can not be ruled out. This also might have affected the rate of denudation. The continued retreat of glaciers position in response to warming up of climate has given rise to sediment fans in the higher Himalayas where paraglacial processes dominate present day landscape.

Alluvial fans

These are depositional landforms whose surface forms a segment of a cone that radiated down slope from the point where the stream leaves the surface area normally 2°-5° in gradient with apex and toe. They vary greatly in size from less than 10 m in length to more than 20 km, and many large fans are thicker than 300m. The debris that makes up the fan decreases in size but is frequently coarse, and much of it has been transported by mudflow activity. Deposition is caused by decrease in depth and velocity where stream flow spreads out on a fan and by infiltration of water into permeable superficial deposited. There is every possibility that alluvial fan development started after the formation of river terraces. Their toe-head truncation and incision is the evidence of its time of evolutionary initiation.

Plate 11: Modification of lateral moraine terrace by slope and paraglacial process at Bakarthatch. A palaeo-cirque is visible in the centre background.

Plate 12: Interlocking spurs of sediment origin. Trees in the centre background indicate the upper tree-line in this region.

Alluvial fans are widespread throughout the arid, mountainous and periglacial areas, but are especially notable in particular tectonic environment, where there is a marked contrast between mountain front and depositional areas.

During July 1993 intense monsoonal rainstorms occurred along the southern slopes of the Pir Panjal, causing extensive flooding in the Upper Beas basin. The floods resulted in major channel changes, large-scale erosion and deposition and serious damage to roads and property. Major landforms of fluvial and glaciofluvial deposition include large braided plains and alluvial fans. Large braided plains in low- gradient valley bottoms, which tend to develop where moraines or debris cones or where valley have been over deepened by glacial erosion blocks drainage along with slope failures. Large alluvial fans are best developed throughout the upper Beas basin with gradients ranging between 2°-10° (Figure 4.1). These comprise three main units formed by major debris flow and fluvial sedimentation. These fans reflect high rates of sedimentation from glacier-fed rivers or streams laden with paraglacial debris. There is a gradation between alluvial fans and fans dominated by debris flow activity. The sediment sections commonly expose interbedded sands, gravels, diamictons and boulder layers. Fan surfaces are frequently terraced, reflecting repeated episodes of aggradations and incision. Some of the largest fans in the Upper Beas basin form rich agricultural land such as those between Prini and Naggar.

There are evidences of slight mass-movement activity in the Upper Beas basin. The dominant mass movement processes are debris flow, rock fall and snow avalanching, slumping, rotational failure, catastrophic flow slides and soil

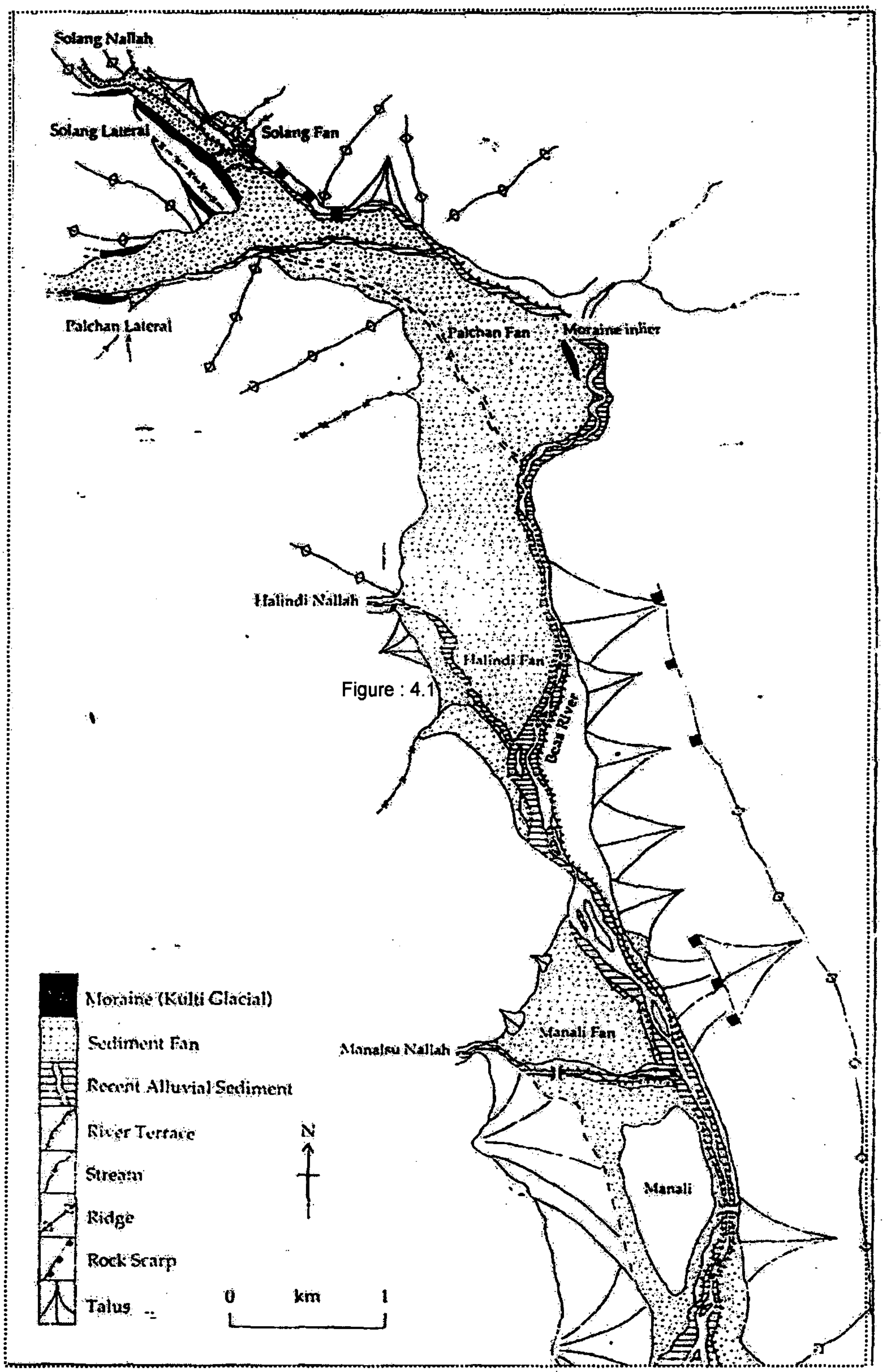


Figure : 4.1 Moraine and Sediment Fan in Upper Beas Basin (Adapted from Owen et. al, 1996).

Plate 13: A view of anthropogenic development in an area which is dynamic in earth-surface processes.

Plate 14: The highway construction and related slope failures are common. Tourism and supply to Ladakh on NH 21 brings in uncontrollable traffic in to fragile Himalayas.

creep. The distribution of particular failure types reflects the nature of the parent materials and local topography. For example, debris flows are frequent where moderate to steep slopes are underlain by

Unconsolidated sediment, mudstones or other week bedrock, particularly where gullies focus the flow of ephemeral streams or snowmelt. Debris transport by snow avalanches is concentrated below shallow concavities in long and steep slopes. High magnitude slope failures are locally impressive, but are fairly uncommon. Many slopes in the region have been modified by combinations of mass movement processes. Some debris mantled slopes record a complex history of development, including several episodes of stability and reactivation.

The widespread distribution of alluvial fans in the Upper Beas basin is notable and suggests that mass movement is probably intensified due to deglaciation and large areas of unconsolidated debris are exposed on steep slopes. Episodes of landscape change were probably sporadic and very rapid soon after deglaciation. The role of fluvial/ glaciofluvial sedimentation during paraglacial modifications has still to be fully assessed but, clearly, the erosion of moraines and the resedimentation of sediments on outwash plains in association with moraines and alluvial fans is dramatic. The thick and extensive fans in the Upper Beas basin, which are the result of postglacial sedimentation, dominated by debris flow and glacio-fluvial processes (Figure 4.1.)

Palaeoclimatic Changes

Palaeoclimatic changes refer to all climatic changes occurring before and during the historical period. Since there was no direct instrumental measurement of climate in the distant past, and without surviving eyewitness accounts, climatologists must make use of indirect ‘proxy’ evidence to establish a chronology of climate changes. About six or seven ice ages can be identified at roughly 100000 years intervals, with warm interglacial in between a continental scene and unidentified number in the Himalayas.

Relative Dating Methods

Boulder Frequency

Bolder frequency was done in a transect area of 10X3 $m^{2.}$ Boulder frequency is high close to stream and which further decreases away from stream Table (2.1). For site A number of large boulder is very low and the number of small boulder is high. The presences of small boulder indicate weathering effect and its resultant size. The site C has the highest number of small boulders. This shows that it is newer than the site A.

In **Bolder Varnish** colour of rocks has been analysed. The darker colour indicates that they are of older age and lighter colour boulder indicates that they are of latter age (Newer). Site A and D are relatively old than B and E.

In **Sound Rebound** sound has been classified in three categories 1. Break or Dhom, 2. Dhak 3. Tong or Tang. Thus old weather rock when hit by hammer will either breaks or give the sound of very faded Dhom and the newer rocks give Tang sound and total repletion or rebound. with increasing distance from the river, rocks show older age on the terraces of similar lithology.

Plate 15: Nature of slope and valley width with uncosolidated sediments in the Upper Beas Basin. Note the change in river channel within a small distance.

Plate 16: The man-made structure such as the one in the left foreground have increased the sites with potential slope failures.

In **Pits depth** the number and depth of pits is observed on the rock surface indicating the degree of weathering effect on the rocks. More the depth and number of pits in rocks more will be the age and Vice versa.

In **Plant Succession** Number of plants species and their density is affected by soil formation and topographic configuration. Therefore, more the density of plants and number of species older is the age and vice versa. In the Upper Beas basin area closer to the river show less number of species as well as density.

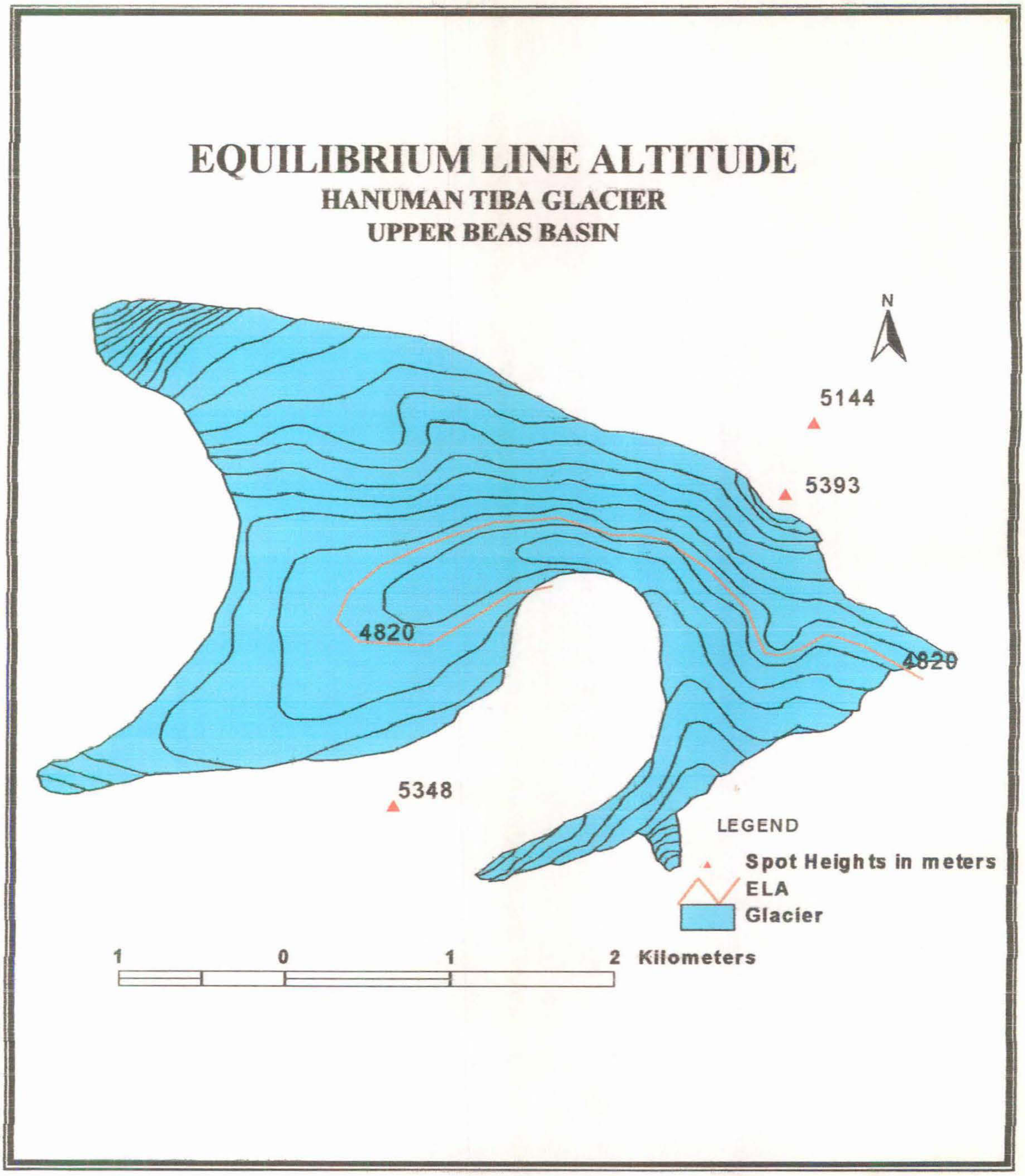
Equilibrium Line Altitude (ELA)

ELA for East Chander glacier by AWM is 4554 meters, THAR 4560 and AAR 4700 meters. Mean of these ELAs is 4604. By landform and contour lines a former ELA of this glacier is calculated using AWM method and the value is 4458.42 meters, and 100 meter below the present ELA. This indicates the rate of glacier retreat in the recent past (Fig 4.3). The Glacial features both erosional and depositional are present almost everywhere in the high Himalayas, confined to the steep slope or in the now broad river valleys. Most reliable ELA value for glacier at Patalsu is 4420 m because this is proved by two methods, i.e. AWM and AAR. The value far Hanuman Tibba glacier is 4890 meter and for Dhundha glacier is 4078 meter.

Particle Size Analysis

Shape processes in the basin have been evaluated using detailed inventory (appendix II) prepared during fieldwork. The shear steep nature of slopes with no or little vegetation close to the valley bottom have been found to be susceptible to

Figure 4.2 (a)



EQUILIBRIUM LINE ALTITUDE
HANUMAN TIBA GLACIER
UPPER BEAS BASIN
N
5144
5393
4820
4820
5348
LEGEND
Spot Heights in meters
ELA
Glacier
1
0
1
2 Kilometers

Figure 4.2b

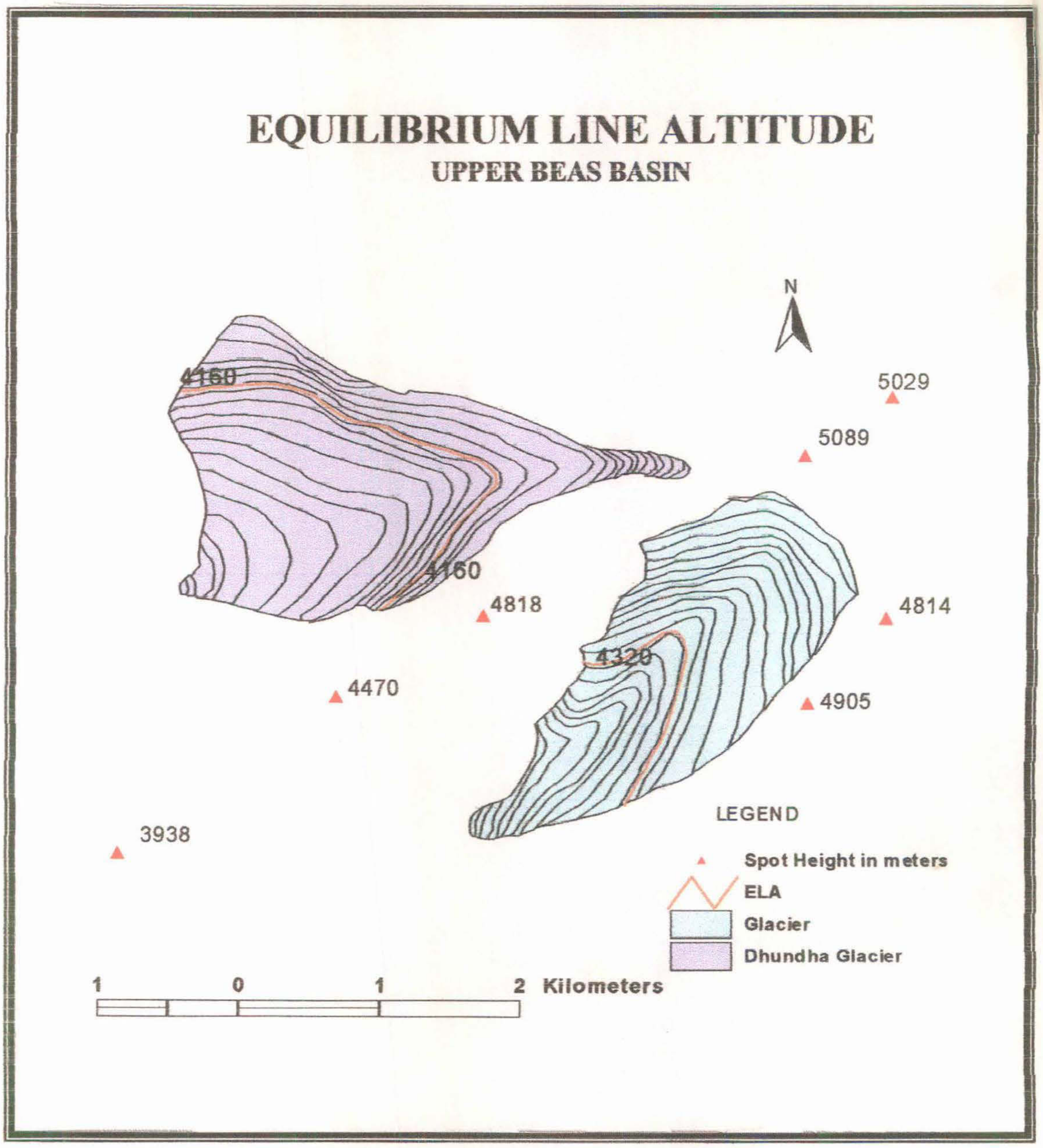

EQUILIBRIUM LINE ALTITUDE
UPPER BEAS BASIN
N
4160
4160
4320
5029
5089
4818
4814
4470
4905
3938
LEGEND
Spot Height in meters
ELA
Glacier
Dhundha Glacier
1 0 1 2 Kilometers

Plate 17 : The villages on the river bank such as Solang are potentially at risk due to river under-cutting and incision. Note the fissures in the middle between the fields.

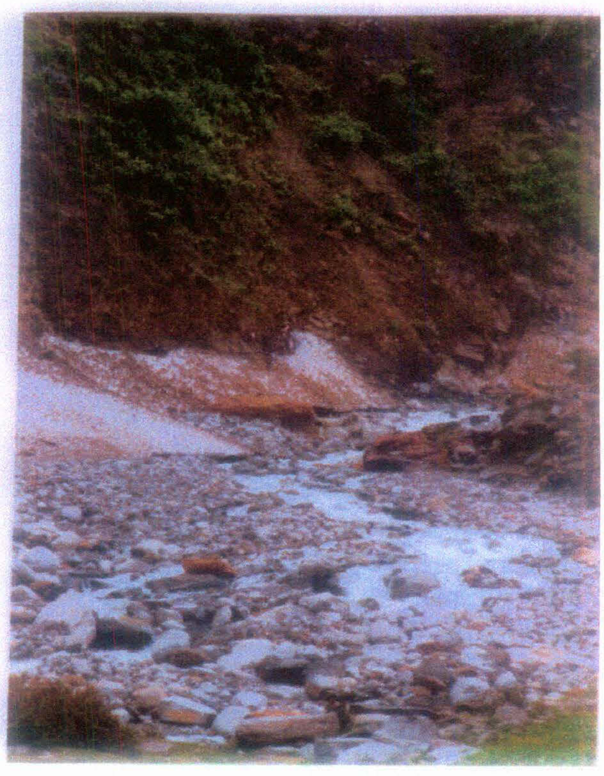


Plate 18: Polycyclic nature of processes at work in the Upper Beas Basin.

major slope failures. The nature of regolith also is equally responsible in such cases where open spaces and poor texture lead to such events. Shah and Mazari (1998) suggest that river terraces with thick sediments are also prone to failures where anthropogenic activity is intense.

Plate 19: Road excavation exposing the glacigenic sediments in the Upper Beas Basin. Note that huge pine trees have grown on these deposits.

Plate 20: Erratics and boulder such as these have been displaced, reworked and reoriented by the debris flows near Solang.

CHAPTER V

SUMMARY AND CONCLUSION

The conclusion resulting form present investigation provides a scope for the understanding of the climate change and landscape evolution in the Upper Beas Basin. The evolution is the result of dynamic interactions between progressive upliftment produced by tectonics and isostatistically induced by denudational unloding, climate change and the dynamics of geomorphological processes. This study has laid to the identification of important geomorphological agents and the relative role of earth surface processes in shaping the landscape.

The interaction between tectonic, climate and geomorphological process has resulted in the evolution of landform in the Upper Beas Basin. Tectonic activity and various phases of glaciations have played a vital role in denudation and shaping of these landforms. Various altitudinal processes have a strong control on the form and extent of landforms in the study area. Extensive sediments are stored in the form of river terraces, alluvial fans, moraines, debris flows etc. These sediments may be mobilized or transported out of the basin due to climatic fluctuation.

Present day landforms in the basin are dominated by extensive debris flow and glacio-fluvial processes. Snow avalanching is another important process in the higher altitudes in sediment transfer and resedimentation in the basin. Recent extensive floods and their frequency have totally changed the landscape formation along the river channel in the study area.

ELA reconstructions in the Upper Beas Basin clearly indicate the control of topography, as glacier retreat does not vary considerably over a short temporal scale. The ELA values of various glaciers by different methods show substantial variation in snout position.

The fluvial regimes of the basin are dominated by glacial and snow melt water dynamics, which provide large daily and seasonal variation in discharge. The general assumption of very high sediment load in the Himalayan river system is valid for the Upper Beas Basin also. Sediment transfer is an episodic process associated with seasonal cycle, high magnitude monsoon storms events and the dynamics of highly active hill slope process. Estimates of the magnitude of fluvial processes are extremely difficult for large river basin to be quantified in absolute terms.

Analysis of sediments is important in identifying process involved in the evolution of particular landform. This should be extensively and judiciously used in all geomorphological enquries. The fragile mountain landscape of the basin makes it vulnerable to varied geomorphic hazards. The episodic snow avalanching, landslides, debris and mudflow, subsidence, fissures, rock fall, slope instability, cloud burst and soil erosion are the common geomorpholigical hazards. These hazards are the outcome of changing biophysical environment and great socio-economic interaction in the basin.

Recent research has shown that the Himalayan uplift has a profound effect on global climate and atmospheric circulation. This uplift was important in stimulating the climatic changes over the Himalayan territory. Rapid uplift of the Pir Panjal produced by tectonic isostacy has reduced the moisture supply to the northern slopes of the Pir Panjal leading to a strong climatic gradient. On the southern slope of the Pir Panjal deep weathering and fluvial processes dominate. Most slopes show major modification by mass movement, Landforms within the Upper Beas Basin constitute great thickness of sediments. A substantial amount of this sediment has been transported out of the mountains via the Beas River. Therefore, present landforms probably have a relatively short life, therefore, a temporary storage. Due to the paucity of dating facilities available locally, it is difficult to obtain any absolute rate of change and landscape modification in this basin. Absence of organic material in glacigenic sediments it is difficult to have time constraint. Paraglacial processes, following in reshaping the landscape soon after the major glaciation played and still plays a strong role. This has resulted in large mass movement and slope modification both surficial sediment and bedrock. For further studies, dynamics of contemporary processes need to be addressed in more detail, in order to characterize their variability and comparison with paleo landform in order to estimate the rates of landscape change within the Upper Beas Basin.

The altitudinal organization of landform has produced a distinctive landform association which is important for understanding landscape evolution and changes through time, and for hazard assessment. Most of the landforms of the Upper Beas Basin are polygenetic in evolution.

The process of floods in the Upper Beas Basin is episodic in occurrence, and is responsible for abrupt changes in landscape. However, processes like mass movement and glacio-fluvial may be important in landscape evolution. A change in climate, and associated rapid retreat in glaciers has exposed the Upper Beas Basin for potential geomorphic hazard like soil erosion, debris flows, mudflows, mass wasting, rock fall, etc.

The evolution of landscape in the Upper Beas Basin is a result of interaction between tectonism, climate and earth surfaces. An understanding of the interacting surface and environmental processes as presented in fig. 5.1 may help in assessing the relative significance of each in landscape evolution, and the hazard mitigation; therefore for a safer human habitat.

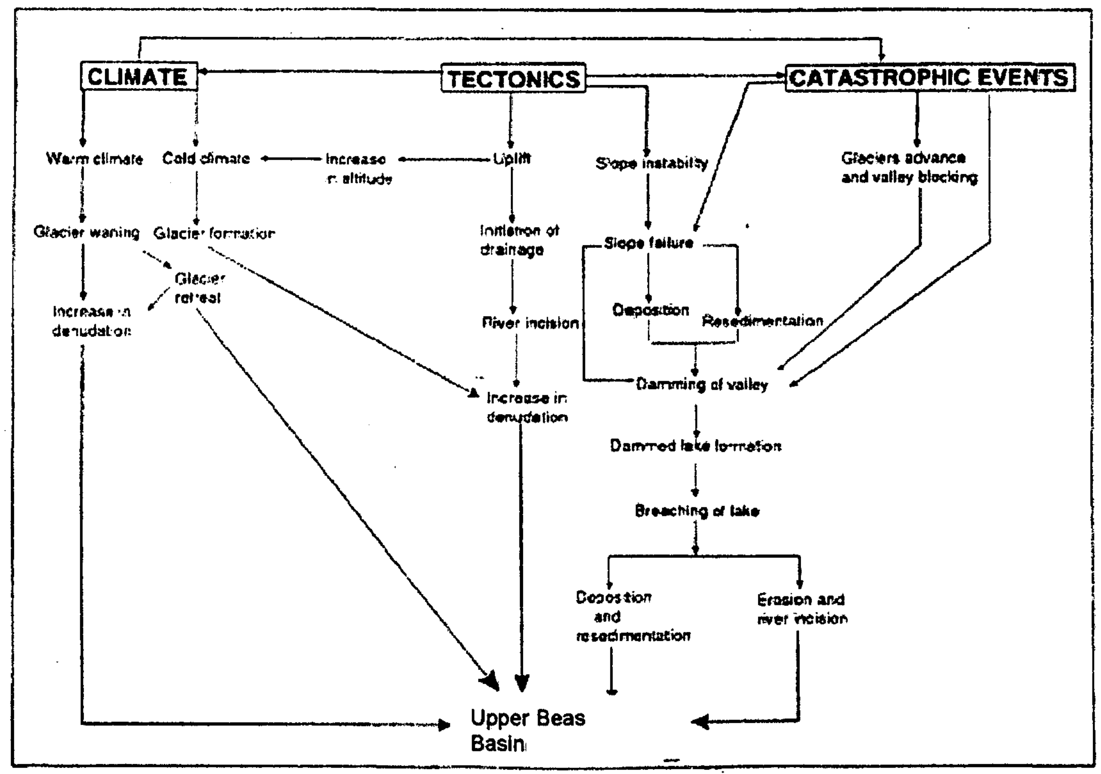

CLIMATE
TECTONICS
CATASTROPHIC EVENTS
Warm climate
Cold climate
Increase in altitude
Uplift
Slope instability
Glaciers advance and valley blocking
Glacier waning
Glacier formation
Initiation of drainage
Slope failure
Glacier retreat
Increase in denudation
Deposition
Resedimentation
River incision
Damming of valley
Increase in denudation
Dammed lake formation
Breaching of lake
Deposition and resedimentation
Erosion and river incision
Upper Beas Basin

Figure 5.1

REFERENCES

Anderson, S., and Wetterstad, J., (1992) "International resource cooperation and greenhouse problem" in global environmental change: human and policy dimensions 2, pp. 277 – 291.

Bary, R. G. (1984) "Mountain climate data for long term ecological research" in proceeding International Symposium on the Quinghai – Xizang Plateau and Mountain Meteorology; pp. 170 – 187.

Bary, R. G. (1994) Past and potential future changes in Mountain environment : A review un changing climates; Routledge, London

Bloom, A.L., (1979) Geomorphology: A systematic analysis of Late Cenozoic landforms, Prentice hall of India, Pvt. Ltd., New Delhi.

Brocker, W. S. (1987), "Unpleasent surprises in the Greenhouse" in Nature, 326: pp. 123-126.

Bryan, P.W., (1958) Geography and Landscape; Geography, London, 43, pp.1-29.

Bucknell, J., (1964), Climatology: An introduction, Macmillan and Co. Ltd., New York, pp.138-296.

Burbank, D.W. and Cheng, K.J. (1991), Relative Dating of Quaternary moraines, Rongbuk valley, mount Everest, Tibet: Implications for an ice sheet on the Tibetan Plateau. Quaternary research, 19, pp. 1-18.

Burke, R.M. and Birkland, P.W.(1979), Reevaluation of muliparameter relative dating techniques and their application to the glacial sequence along the eastern escarpment of Sierra, Nevada, Quaternary Research ,11, pp. 21-51.

Caine, T.N. and Mool, P.K. (1982), "Landslide Hazard in Kopula Khola drainage, Middle Mountain, Nepal", Mountain Research and Development, Vol 2., pp. 157-175.

Chorley, R. J. (ed) (1971) Introduction to Physical Hydrology, Methuen and Co. Ltd., Britain, pp. 153-161.

Chorley, R.J and Morgan, M.A., (1962), Comparison of morphometric features of Unaka Mountains, Tennessee North Carolina and Dartmoor, England; Geol. Soc. Amer. Bull, 73, pp.17-34.

Chorley, R.J. (1969), The drainage basin as an fundamental geomorphic unit, In R.J. Chorley (ed.), Introduction to fluvial Processes, Methuen and Co. Ltd., pp30-52.

Critchfield, H.J.(1983), General Climatology, Prentice Hall, India.

Cusbach, U. and Cessa, R. (1990), "Processes and Modeling" in Climate change: The IPCC Scientific Assessment edt. By J.T. Houghton et. al., Cambridge University Press, Cambridge, pp. 75-98.

David Knighton (1998) Fluvial Forms &Processes: A New Perspective; Arnold, London, pp9-20.

Davis, W.M., (1899) The geographical cycle; Geog. J. I., 14, pp.481-504.

Dhar, O.N. and Narayanan, J. (1965) "A brief study of Rainfall and Flood producing Rainstorms in Beas catchment (up to Pong)" Indian Journal of Meteorology and Geophysics, vol. 16 No 1 pp. 1-11.

Doornkamp, J.C. and C.A.M. King, (1971) Drainage basin and stream networks, In J.C. Doorkamp and C.A.M. (ed.), Numerical analysis in Geomorphology, London, Arnold, pp.3-20.

Dowdeswell, J. A. and Sharp, M. J., (1986) Characterization of pebble fabric in modern terrestrial glaciogenic sediments, Sedimentology. 699 – 710.

Dury G.H., (1967). Climatic changes as a geographical backdrop; Aust. Geogr., 10, pp.231-42

Dury G.H., (1969), Relation of morphometry to run-off frequency. In R. J. Chorley (ed.) Water Earth and Man, London, p. 419-30.

Dury G.H., (1970), River and River Terraces, London. p.283.

Easterbrook, D. J. (1969) Principles of Geomorphology; McGraw-Hill. New York. pp 111-145.

Folland, C.K. et. al. (1990), "Observed climate variations and change" in Climate Change: The IPCC Scientific Assessment edt. By J.T. Houghton et. al., Cambridge University Press, Cambridge.

Fort, M. (1987),"Geomorphic and hazard mapping in the dry continental Himalayas, 1:50,000 map and Mustang district, Nepal", Mountain Research and Development, Vol. 7, No. 3, pp. 222-238.

Gansser, A., (1967) Geology of Himalayas, John Wiley and sons, p289.

Gates, W.L. (1992), "Climate modeling, Climate Prediction and Model Validation" in IPCC 1992, Climate Change, 1992:The supplementary report to the IPCC Scientific assessment edt J.T. Houghton, L.G. Meira Filho et. al. Cambridge University Press, Cambridge.

Giorgi, F. (1990), Simulation of Regional Climate Choosing a Limited Area Nested in General Circulation Model", journal of climate, 3: pp. 941-963.

Golding, B. L. and Elow, D. (1960), Physical characteristic of drainage basins. Proce. Amer. Soc. Civil. Eng., Jl. Hydr. Divi., 86, pp.47-61.

Gregory, K.J. and Walling, D.E. (1973), Drainage Basin Forms and Processes: A Geomorphological Approach; Edward Arnold, London. p.456.

Hagget. P. and R. J. Chorley, (1969), Network analysis in Geography; Methuen and Co. Ltd., London, p. 348.

Halpin, P. N. (1994), Latitudinal variation in the potential responses of mountain ecosystem to climate change", M. Beniston (ed.) Mountain Environments in changing Climates, Routledge, London.

Hewitt, K. (1993), Altitudinal organization of Karakoram geomorphic processes and depositional environment. In Shroder, J. F. Jr. (ed.) Himalayas to the Sea, Routledge, London, 159-183.

Holmes, A., (1959), Principles of Physical Geography; London.

Horton, R. E., (1932), Drainage basin characteristics: Trans. Amer. Geophys. Union, 13, pp.350-61.

Horton, R. E., (1945), Erosional development of streams and there drainage basins: Hydro physical approach to quantitative morphology; Geol. Soc. Amer.Bull., 56 pp. 275 – 370.

Janartha, T. C. (2000) Himachal Pradesh district gazetteers: Kullu

Katz, R.W. (1988) "Statistics of climate change: implications for scenario development" in M.H. Glantz (ed.) Societal Responses to regional climate change. Boulder. West View, pp. 95-112.

Kaushic, S.D. (1965), Geomorphology of rejuvenation of Garhwal Himalayas, Ind. Geog. Jl., 40 (1,2).

Kenneth, Hewitt (1981) "The altitudinal organization of Karakoram geomorphic processes and depositional environment" Z. *Geomorphologic N.F.* Bd. pp. 102 – 112.

Khan, A.A. and Srivastava, M.C. (1981), An evaluation of texual parameters of quarternary terraces, Dhauli Ganga. Garwal Himalaya, UP, Symposium on tree, Decade development in petrology, mineralogy and petrochemistry in India.

King L.C., (1962), The morphology of the Earth; Olivers and Oyd, Edinburgh.

King, C.A.M., (1967), Techniques of Geomorphology; Edward Arnold (Pub.), Ltd. London.

Krenek, L. and Bhawan V. (1945) Recent and Past Glaciation of Lahaul, Indian Geographical Journal, Vol. 20. pp. 930102.

Krishnan, M.S., (1960). Geology of India and Burma Higginbothams, Madras.

Kulhe, M., (1988) Topography as the fundamental element of glacial systems: a new approach to ELA calculation and typological classification of paleo and recent glaciations; Geo Journal, 17.4, pp. 545-568

Lal, D.S. (1991) Climatology, Chaitanya Publishing House, Allahabad.

Langbein, W.B., (1947), Topographical characteristics of drainage basins, U.S. Geol. Survey water supply paper, 968C, pp.125-57.

Lee, J. (1991). Particle size analysis of less than 2 mm (-1.1phi) traction. Centre for Environmental Analysis and Management, Royal Holloway. University of London. 7.

Leopold, L.B., Wolman, M.G. and Miller, J.P. (1964). Fluvial Processes in Geomorphology; Eurasia Publishing House (Pvt.) Ltd., New Delhi, p. 522.

Marisawa, M.E. (1957), Accuracy of determination of stream length from topographic map, Trans Amer. Geophy. Jr., 38, pp. 86-88.

Matthews, J.A. (1978), Planned colonization pattern on a Gletschervorfeld, Southern Norway: a meso scale geographical approach to vegetation change and phytometric dating. Boreas, 7, 155-178.

Medicott, H.B., (1864), On the Geological Structure and relation on the southern portion of Himalayan ranges between the rivers Ganga and Rivac; Mem.G.S.I. 3 (2), pp. 73 - 77.

Middlewiss, C.S., (1885), A fossixiferous series in the lower Himalaya; Rec.G.S.I., 18(2), pp 73-77.

Mieirding, P.C. (1980). Grain size determination and interpretation. In Tucker, M. (ed.) Techniques in sedimentology, Oxford, 229-273.

Miller, A.A., (1964) The skin of the Earth ; Methuen and Co. Ltd . London.

Miller, J.P., (1958) High Mountain systems: effects of geology on channel characteristics and bed material; New Maxico Bur. Mines and mineral resources. Mem., 4.

Miller, V.C., (1953), A quantitative geomorphic study of Drainage basin characteristics in the clinch mountain area: Va and Tenn. Project NR 389-042 Tech. Rept; Columbia University.

Owen L. A., Derbyshire, E., Evans, D. J. A.. Mitchell, Thompson, D., (1995) The geomorphology and landscape evolution of Lahul Himalayas, northern India; Z. Geomorphologic N.F., pp.

Owen, L.A (1996) "Style and timing of Glaciation in Lahul Himalayas, Northern India: a framework for reconstructing late quaternary palaeoclimatic change in western Himalayas" *Journal of Quaternary Science,* 12 (2), pp. 83- 109.

Owen, L.A and Lehmkuhl, F. (2000) Late Quaternary Glaciation and Paleoclimate of the Tibetan Plateau and Bordering mountains; *Quaternary International,* vol. 65 /66 pp.23-34

Owen, L.A and Sharma, M.C. (1998) " Rates and magnitudes of Paraglacial fan formation in Garhwal Himalayas: implication for landscape evolution" Geomorphology, 26, pp. 171-184.

Owen, L.A. (1988), Terraces Uplift and Climate, Karakoram mountains, Northern Pakistan. Ph.D Thesis, University of Leicester, pp.399.

Owen, L.A. (1991) "Mass Movement deposit in Karakoram mountains: their sedimentary characteristics, recognition and role of Karakoram landform evolution" *Z. fur Geomorphologie* pp. 45 – 62.

Owen, L.A. and Derbyshire, E. (1989) The Karakoram Glacial Depositional System. Zeithch fur Geomorph., suppl. Bd, 76, 33-73.

Pal, S.K. (1972), A classification of morphometric methods of analysis: An appraisal, Geog. Rev. Ind . 34(1), pp. 61-87.

Pascoe, E.H., (1959), A manual of geology of India and Burma: Government of India Press, Calcutta, p. 1343.

Perroot, F.A. and Goudie, A.S. (1984), Techniques for the study of glacial fluctuations in Miler, K. (ed) International Karakoram project, Cambridge University Press, 95-100.

Porter, S.C. (1970), The quaternary glacial record in Swat Kohistan, North West Pakistan, Geol. Soc. Amer. Bull., 81, pp.447-456.

Price, M.F. and Haslett, J.R. (1995), "Climate change and mountain ecosystem" in NJR Allan edt. Mountains in risk: current issues in environmental studies, Manohar Publishers, New Delhi.

Procter, M.C.F. (1983), Sizes and Growth Rate of Thallis of Lichen, Rhizocarpon geographicum on moraines of the Glacier de Valsorey, Valais, Switzerland. The Lichonologist, 15, 249-261.

Puri, G. S. and Maini, J.S. (1957), Succession of forest communities in Chakarata Himalayas, Proc. India, S.C. Cong., Assam, Pt 3 Abst. P. 287.

Sah, M. P. and Srivastava, R. A. K. (1992) Norphological facies of the alluvial-fan sedimentation in the Kangra valley, Himachal Himalaya; Sedimentary Geology, 76, pp. 23 – 42.

Sah, M. P., (1991) Some geomorphic observations on Badrinath-Satopanth area, Chamoli district, Garhwal Himalaya; Journal of Himalayan Geology. 2(2), pp. 185 – 195

Sah, M.P. and Mazari. R.K. (1998), Anthropogenically accelerated mass movement, Kullu Valley, Himachal Pradesh, Geomorphology, Vol. 26, pp. 123-138

Scheideger, A.E. (1967), The algebra of stream order numbers. Us geological survey professional paper. 525B, pp. 187-189.

Schuster, R.L. (1978), "Introduction to landslides analysis and control" in R. L. Schuster and R.J. Kirzek edt. Transport Research Board, Special report. No. 176., National Academy of Sciences, Washington, pp. 106-117.

Shah, S.L. (1986), Planning and Management of Natural Human Resources in the Mountains: A Mocro-Level Approach with Special References to Central Himalayas, VPKAS, Almora.

Shreve, R.L. (1966), Infinite topologically random channel network. Jl Geol, 75, pp.178-86.

Singh, R.B. (1998), "Landuse cover changes, extreme events and ecohydrological responses in the Himalayan region" in R. B. Singh (ed.) Sustainable Development of Mountain Environment in India and Canada (CIDA-SICI Project Experience), New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd. pp. 53-67.

Singh, R.L.(ed) (1971), India: A Regional Geography, National Geographical Society of India, Varanasi, pp.

Sissons, J. B. (1974) A Late-glacial icecap in the central Grampians, Scotland. Transactions of the Institute of British Geographers, 62, 95-113.

Smith, Keith (1997), "Climatic extremes as a hazard to human" in Russel D. Thompson and L. N. Perry (ed.) Applied Climatology: Principles and Practice. Routledge. New York, New York, pp. 304-316.

Smith, R.B. (1979), Climatic extremes as a hazard to humans" Advances in Geophysics, 21: pp. 87-230.

Strahler (1964), Quantitative geomorphology of drainage basin and channel networks in V.T. Chow (ed.) Handbook of Applied Hydrology, pp.439-76.

Strahler (1969), Physical Geography: quantitative analysis of erosional landforms, John Wiley and sons, (3rd edition), 481-497.

Strahler, A.N. (1952), Hypsometric (area altitude) analysis of erosional topography, Geol Soc of Amer Bull, 63, pp. 1117-42.

Thronbury, W.D. (1969), Principles of Geomoprphology. John Wiliey, 594 pp.

Vuichard, D. (1986) "Geological and petrographical investigation of the mountain hazards mapping projects Khumbhu Himal. Nepal" Mountain Resource and Development, Vol. 6, pp.41-52.

Wardle, P. (1980), Primary succession in National Park and its vicinity, New Zealand of Botany, 80. 221-232.

Appendix 1

Morphometry Table

S.No.	Highest Contour	Lowest Contour	No. of Stream (per Sq. Km)	Stream Length	No. of Contr Crossing	Relative Relief	Stream Frequency	Absolute Relief	Dissection Index	Drainage Density	Ruggedness Index	Slope	Drainage Texture
1	5000	4680	0	0	54	320	0	5000	0.06	0.00	0.0	86.63	0.0
2	5000	4600	0	0	50	400	0	5000	0.08	0.00	0.0	86.36	0.0
3	5000	4560	0	0	46	440	0	5000	0.09	0.00	0.0	86.05	0.0
4	5200	4760	0	0	67	440	0	5200	0.08	0.00	0.0	87.28	0.0
5	5000	4320	5	3	64	680	5	5000	0.14	3.00	2.0	87.16	15.0
6	4900	4200	5	5	46	700	5	4900	0.14	4.50	3.2	86.05	22.5
7	4600	4120	2	1	29	480	2	4600	0.10	1.00	0.5	83.74	2.0
8	4680	4160	0	0	31	520	0	4680	0.11	0.00	0.0	84.14	0.0
9	4840	4240	0	0	37	600	0	4840	0.12	0.00	0.0	85.09	0.0
10	4600	4400	0	0	37	200	0	4600	0.04	0.00	0.0	85.09	0.0
11	5000	4520	0	0	36	480	0	5000	0.10	0.00	0.0	84.95	0.0
12	5440	4920	0	0	42	520	0	5440	0.10	0.00	0.0	85.67	0.0
13	5240	4800	0	0	30	440	0	5240	0.08	0.00	0.0	83.95	0.0
14	5240	4800	1	0	35	440	1	5240	0.08	0.30	0.1	84.81	0.3
15	5280	4720	0	0	36	560	0	5280	0.11	0.00	0.0	84.95	0.0
16	5200	3920	2	2	52	1280	2	5200	0.25	1.50	1.9	86.50	3.0
17	4680	3760	5	5	42	920	5	4680	0.20	4.50	4.1	85.67	22.5
18	4200	3600	2	2	44	600	2	4200	0.14	2.00	1.2	85.87	4.0
19	4200	3680	2	2	33	520	2	4200	0.12	1.70	0.9	84.50	3.4
20	4200	3800	0	0	25	400	0	4200	0.10	0.00	0.0	82.75	0.0
21	4800	4120	0	0	39	680	0	4800	0.14	0.00	0.0	85.34	0.0
22	4800	4400	4	1	46	400	4	4800	0.08	1.00	0.4	86.05	4.0
23	5000	4440	1	0	37	560	1	5000	0.11	0.30	0.2	85.09	0.3
24	4760	4400	0	0	32	360	0	4760	0.08	0.00	0.0	84.32	0.0
25	5280	4600	0	0	55	680	0	5280	0.13	0.00	0.0	86.69	0.0
26	5240	4600	1	1	34	640	1	5240	0.12	0.50	0.3	84.66	0.5
27	4880	4360	2	0	31	520	2	4880	0.11	0.20	0.1	84.14	0.4
28	4840	4360	2	2	27	480	2	4840	0.10	1.50	0.7	83.28	3.0
29	4640	4120	3	2	33	520	3	4640	0.11	1.50	0.8	84.50	4.5
30	4120	3860	2	2	64	260	2	3860	0.06	1.50	0.4	87.16	3.0
31	3800	3240	4	4	38	560	4	3800	0.15	3.50	2.0	85.22	14.0
32	3760	3240	2	1	48	520	2	3760	0.14	1.20	0.6	86.21	2.4
33	4440	3280	8	4	33	1160	8	4440	0.26	3.50	4.1	84.50	28.0
34	4800	3760	2	1	37	1040	2	4800	0.22	0.50	0.5	85.09	1.0
35	4800	4320	4	2	50	480	4	4800	0.10	2.00	1.0	86.36	8.0
36	4800	4000	3	2	40	800	3	4800	0.17	2.00	1.6	85.45	6.0
37	4840	4240	0	0	34	600	0	4840	0.12	0.00	0.0	84.66	0.0
38	4640	4400	3	2	52	240	3	4640	0.05	1.50	0.4	86.50	4.5
39	5200	4000	2	1	43	1200	2	5200	0.23	1.00	1.2	85.77	2.0
40	5040	4440	0	0	59	600	0	5040	0.12	0.00	0.0	86.91	0.0
41	5040	4400	0	0	60	640	0	5040	0.13	0.00	0.0	86.97	0.0
42	4640	4160	2	3	44	480	2	4640	0.10	2.50	1.2	85.87	5.0
43	4600	3960	4	4	40	640	4	4600	0.14	3.50	2.2	85.45	14.0
44	4600	3920	5	3	45	680	5	4600	0.15	2.50	1.7	85.96	12.5
45	4600	3760	2	1	50	840	2	4600	0.18	1.00	0.8	86.36	2.0
46	4200	3760	1	1	35	440	1	4200	0.10	1.00	0.4	84.81	1.0
47	3640	3080	4	3	29	560	4	3640	0.15	2.50	1.4	83.74	10.0
48	3600	3080	5	3	38	520	5	3600	0.14	2.50	1.3	85.22	12.5
49	4000	3400	4	1	34	600	4	4000	0.15	1.00	0.6	84.66	4.0
50	4300	3640	0	0	46	660	0	4300	0.15	0.00	0.0	86.05	0.0
51	4300	3680	10	4	43	620	10	4300	0.14	4.00	2.5	85.77	40.0
52	4400	3960	2	1	47	440	2	4400	0.10	0.50	0.2	86.13	1.0
53	4840	4720	4	1	40	120	4	4840	0.02	1.00	0.1	85.45	4.0
54	4640	3800	5	3	46	840	5	4640	0.18	3.00	2.5	86.05	15.0
55	4400	3800	5	3	33	600	5	4400	0.14	2.50	1.5	84.50	12.5
56	4400	3880	3	2	60	520	3	4400	0.12	1.50	0.8	86.97	4.5
57	4600	4120	1	1	52	480	1	4600	0.10	0.50	0.2	86.50	0.5
58	4600	4000	0	0	32	600	0	4600	0.13	0.00	0.0	84.32	0.0
59	4960	4440	0	0	64	520	0	4960	0.10	0.00	0.0	87.16	0.0
60	5200	4440	1	1	62	760	1	5200	0.15	0.50	0.4	87.06	0.5
61	4880	3920	4	3	50	960	4	4880	0.20	2.50	2.4	86.36	10.0
62	4600	3720	4	3	37	880	4	4600	0.19	2.50	2.2	85.09	10.0
63	4200	3600	3	2	41	600	3	4200	0.14	2.00	1.2	85.56	6.0
64	4280	3560	5	2	45	720	5	4280	0.17	2.00	1.4	85.96	10.0
65	4280	3400	3	2	50	880	3	4280	0.21	2.00	1.8	86.36	6.0
66	3840	3360	1	1	32	480	1	3840	0.13	1.00	0.5	84.32	1.0
67	3720	3000	7	3	42	720	7	3720	0.19	3.00	2.2	85.67	21.0
68	3640	3080	3	3	31	560	3	3640	0.15	2.50	1.4	84.14	7.5
69	3960	3200	1	1	40	760	1	3960	0.19	0.50	0.4	85.45	0.5
70	3920	3200	3	3	50	720	3	3920	0.18	2.50	1.8	86.36	7.5
71	4240	4040	5	3	38	200	5	4240	0.05	2.50	0.5	85.22	12.5
72	4440	4140	3	3	36	300	3	4440	0.07	2.50	0.8	84.95	7.5
73	4680	4080	5	4	34	600	5	4680	0.13	3.50	2.1	84.66	17.5
74	4360	3400	5	3	63	960	5	4360	0.22	2.50	2.4	87.11	12.5
75	3840	3360	4	3	32	480	4	3840	0.13	3.00	1.4	84.32	12.0
76	4520	3800	3	1	40	720	3	4520	0.16	0.50	0.4	85.45	1.5
77	4520	3840	3	2	39	680	3	4520	0.15	2.00	1.4	85.34	6.0
78	4400	3960	4	3	37	440	4	4400	0.10	2.50	1.1	85.09	10.0
79	4360	4000	2	1	36	360	2	4360	0.08	0.50	0.2	84.95	1.0
80	5080	4720	0	0	41	360	0	5080	0.07	0.00	0.0	85.56	0.0

Morphometry Table

81	4840	4200	3	3	38	640	3	4840	0.13	3.00	1.9	85.22	9.0
82	4200	3800	5	3	35	400	5	4200	0.10	2.50	1.0	84.81	12.5
83	3840	3520	7	4	22	320	7	3840	0.08	3.50	1.1	81.78	24.5
84	3640	3320	4	2	29	320	4	3640	0.09	2.00	0.6	83.74	8.0
85	3840	3120	4	2	44	720	4	3840	0.19	2.00	1.4	85.87	8.0
86	3840	3000	3	3	43	840	3	3840	0.22	2.50	2.1	85.77	7.5
87	3400	2840	3	2	32	560	3	3400	0.16	2.00	1.1	84.32	6.0
88	3280	2800	3	2	31	480	3	3280	0.15	2.00	1.0	84.14	6.0
89	3600	2840	2	1	48	760	2	3600	0.21	0.50	0.4	86.21	1.0
90	3600	3120	3	2	45	480	3	3600	0.13	1.50	0.7	85.96	4.5
91	3960	3340	1	1	37	620	1	3960	0.16	0.50	0.3	85.09	0.5
92	4040	3720	4	3	34	320	4	4040	0.08	3.00	1.0	84.66	12.0
93	4200	3760	8	4	36	440	8	4200	0.10	3.50	1.5	84.95	28.0
94	4280	3800	8	3	41	480	8	4280	0.11	3.00	1.4	85.56	24.0
95	3860	3080	9	4	50	780	9	3860	0.20	4.00	3.1	86.36	36.0
96	3760	3120	4	3	34	640	4	3760	0.17	3.00	1.9	84.66	12.0
97	3840	3120	3	2	34	720	3	3840	0.19	2.00	1.4	84.66	6.0
98	3840	3280	4	3	37	560	4	3840	0.15	2.50	1.4	85.09	10.0
99	4000	3600	6	4	40	400	6	4000	0.10	4.00	1.6	85.45	24.0
100	4280	3720	5	2	40	560	5	4280	0.13	2.00	1.1	85.45	10.0
101	4640	4280	2	1	34	360	2	4640	0.08	1.00	0.4	84.66	2.0
102	4600	4200	1	1	33	400	1	4600	0.09	0.50	0.2	84.50	0.5
103	5680	4720	0	0	65	960	0	5680	0.17	0.00	0.0	87.20	0.0
104	4920	4200	0	0	52	720	0	4920	0.15	0.00	0.0	86.50	0.0
105	4720	3880	0	0	45	840	0	4720	0.18	0.00	0.0	85.96	0.0
106	4200	3600	0	0	31	600	0	4200	0.14	0.00	0.0	84.14	0.0
107	3760	3400	3	2	25	360	3	3760	0.10	1.50	0.5	82.75	4.5
108	3680	3120	7	4	35	560	7	3680	0.15	4.00	2.2	84.81	28.0
109	3760	3000	7	4	34	760	7	3760	0.20	3.50	2.7	84.66	24.5
110	3400	2880	3	2	45	520	3	3400	0.15	2.00	1.0	85.96	6.0
111	3320	2760	3	3	37	560	3	3320	0.17	2.50	1.4	85.09	7.5
112	3080	2680	2	2	29	400	2	3080	0.13	1.50	0.6	83.74	3.0
113	3520	2800	1	1	34	720	1	3520	0.20	1.00	0.7	84.66	1.0
114	3720	3200	1	1	29	520	1	3720	0.14	1.00	0.5	83.74	1.0
115	3880	3400	2	1	26	480	2	3880	0.12	1.00	0.5	83.03	2.0
116	4200	3520	2	2	42	680	2	4200	0.16	1.50	1.0	85.67	3.0
117	4240	3320	6	4	48	920	6	4240	0.22	3.50	3.2	86.21	21.0
118	3840	3120	5	4	48	720	5	3840	0.19	3.50	2.5	86.21	17.5
119	3400	3380	3	3	29	20	3	3400	0.01	2.50	0.1	83.74	7.5
120	3680	3080	7	4	37	600	7	3680	0.16	3.50	2.1	85.09	24.5
121	3680	3200	3	2	34	480	3	3680	0.13	2.00	1.0	84.66	6.0
122	4160	3600	1	1	38	560	1	4160	0.13	0.50	0.3	85.22	0.5
123	4400	3820	9	4	32	580	9	4400	0.13	4.00	2.3	84.32	36.0
124	4440	4080	3	2	19	360	3	4440	0.08	2.00	0.7	80.50	6.0
125	4400	1720	1	1	26	2680	1	1720	0.61	0.50	1.3	83.03	0.5
126	4200	3320	0	0	41	880	0	4200	0.21	0.00	0.0	85.56	0.0
127	4800	3440	0	0	30	1360	0	4800	0.28	0.00	0.0	83.95	0.0
128	4160	3120	0	0	52	1040	0	4160	0.25	0.00	0.0	86.50	0.0
129	4880	3760	0	0	52	1120	0	4880	0.23	0.00	0.0	86.50	0.0
130	4800	3720	2	1	52	1080	2	4800	0.23	1.00	1.1	86.50	2.0
131	4520	3720	5	3	49	800	5	4520	0.18	3.00	2.4	86.29	15.0
132	4200	3760	5	1	48	440	5	4200	0.10	1.00	0.4	86.21	5.0
133	4000	3280	3	2	44	720	3	4000	0.18	2.00	1.4	85.87	6.0
134	3400	2760	4	2	44	640	4	3400	0.19	2.00	1.3	85.87	8.0
135	3080	2600	5	3	34	480	5	3080	0.16	3.00	1.4	84.66	15.0
136	3240	2600	4	2	42	640	4	3240	0.20	2.00	1.3	85.67	8.0
137	3360	2840	4	3	37	520	4	3360	0.15	3.00	1.6	85.09	12.0
138	3520	3280	3	2	25	240	3	3520	0.07	1.50	0.4	82.75	4.5
139	3840	3440	3	2	32	400	3	3840	0.10	1.50	0.6	84.32	4.5
140	4040	2800	4	3	34	1240	4	4040	0.31	3.00	3.7	84.66	12.0
141	3200	2680	5	3	32	520	5	3200	0.16	3.00	1.6	84.32	15.0
142	3200	2680	3	2	39	520	3	3200	0.16	2.00	1.0	85.34	6.0
143	3680	3120	3	3	30	560	3	3680	0.15	2.50	1.4	83.95	7.5
144	4080	3560	4	2	36	520	4	4080	0.13	2.00	1.0	84.95	8.0
145	4200	3600	4	3	40	600	4	4200	0.14	2.50	1.5	85.45	10.0
146	4560	3840	2	2	25	720	2	4560	0.16	2.00	1.4	82.75	4.0
147	4400	4040	1	1	28	360	1	4400	0.08	0.50	0.2	83.52	0.5
148	4840	4400	0	0	40	440	0	4840	0.09	0.00	0.0	85.45	0.0
149	4600	4400	2	1	46	200	2	4600	0.04	1.00	0.2	86.05	2.0
150	4800	4200	0	0	48	600	0	4800	0.13	0.00	0.0	86.21	0.0
151	5320	4880	0	0	42	440	0	5320	0.08	0.00	0.0	85.67	0.0
152	5280	5040	0	0	15	240	0	5280	0.05	0.00	0.0	78.03	0.0
153	5280	5000	0	0	21	280	0	5280	0.05	0.00	0.0	81.39	0.0
154	5200	5040	0	0	32	160	0	5200	0.03	0.00	0.0	84.32	0.0
155	5240	4640	0	0	35	600	0	5240	0.11	0.00	0.0	84.81	0.0
156	4800	4240	0	0	29	560	0	4800	0.12	0.00	0.0	83.74	0.0
157	4440	4000	3	2	31	440	3	4440	0.10	2.00	0.9	84.14	6.0
158	4080	3440	2	1	42	640	2	4080	0.16	0.50	0.3	85.67	1.0
159	4000	3400	4	2	40	600	4	4000	0.15	2.00	1.2	85.45	8.0
160	3360	2680	3	2	34	680	3	3360	0.20	2.00	1.4	84.66	6.0
161	2760	2540	3	2	24	220	3	2760	0.08	1.50	0.3	82.45	4.5
162	3040	2800	1	1	26	240	1	2800	0.08	0.50	0.1	83.03	0.5

Morphometry Table

163	3280	2800	2	2	28	480	2	3280	0.15	1.50	0.7	83.52	3.0
164	3600	3120	2	2	31	480	2	3600	0.13	2.00	1.0	84.14	4.0
165	3400	2600	3	2	33	800	3	3400	0.24	2.00	1.6	84.50	6.0
166	3000	2600	4	3	21	400	4	3000	0.13	3.00	1.2	81.39	12.0
167	3240	2760	3	2	25	480	3	3240	0.15	2.00	1.0	82.75	6.0
168	3680	3120	1	1	30	560	1	3680	0.15	1.00	0.6	83.95	1.0
169	4040	3520	3	2	40	520	3	4040	0.13	1.50	0.8	85.45	4.5
170	4440	3960	2	2	28	480	2	4440	0.11	1.50	0.7	83.52	3.0
171	4520	4320	1	1	16	200	1	4520	0.04	0.50	0.1	78.76	0.5
172	4760	4140	2	1	48	620	2	4760	0.13	0.50	0.3	86.21	1.0
173	4760	4140	5	4	42	620	5	4760	0.13	3.50	2.2	85.67	17.5
174	4640	4200	3	2	31	440	3	4640	0.09	2.00	0.9	84.14	6.0
175	4800	4560	1	1	28	240	1	4800	0.05	0.50	0.1	83.52	0.5
176	4920	4600	1	1	40	320	1	4920	0.07	0.50	0.2	85.45	0.5
177	5240	4800	0	0	30	440	0	5240	0.08	0.00	0.0	83.95	0.0
178	5040	5000	0	0	4	40	0	5040	0.01	0.00	0.0	51.52	0.0
179	5160	4920	0	0	15	240	0	5160	0.05	0.00	0.0	78.03	0.0
180	5200	4920	0	0	19	280	0	5200	0.05	0.00	0.0	80.50	0.0
181	5280	4800	0	0	26	480	0	5280	0.09	0.00	0.0	83.03	0.0
182	5080	4520	0	0	35	560	0	5080	0.11	0.00	0.0	84.81	0.0
183	5000	4320	3	1	60	680	3	5000	0.14	1.00	0.7	86.97	3.0
184	4560	4080	5	1	46	480	5	4560	0.11	1.00	0.5	86.05	5.0
185	4240	3320	4	1	53	920	4	4240	0.22	1.00	0.9	86.57	4.0
186	3480	2760	5	3	36	720	5	3480	0.21	2.50	1.8	84.95	12.5
187	2880	2480	4	2	24	400	4	2880	0.14	2.00	0.8	82.45	8.0
188	2760	2440	4	3	24	320	4	2760	0.12	2.50	0.8	82.45	10.0
189	3200	2560	1	1	40	640	1	3200	0.20	1.00	0.6	85.45	1.0
190	3200	2600	2	2	51	600	2	3200	0.19	1.50	0.9	86.43	3.0
191	3200	2880	3	2	32	320	3	3200	0.10	2.00	0.6	84.32	6.0
192	3040	2640	3	2	22	400	3	3040	0.13	2.00	0.8	81.78	6.0
193	3440	3080	2	1	21	360	2	3440	0.10	0.50	0.2	81.39	1.0
194	3680	3240	2	2	23	440	2	3680	0.12	1.50	0.7	82.13	3.0
195	4080	3640	2	2	33	440	2	4080	0.11	1.50	0.7	84.50	3.0
196	4600	4080	2	1	28	520	2	4600	0.11	1.00	0.5	83.52	2.0
197	4680	4200	2	1	20	480	2	4680	0.10	1.00	0.5	80.97	2.0
198	4520	3880	6	4	43	640	6	4520	0.14	3.50	2.2	85.77	21.0
199	4560	4000	2	2	28	560	2	4560	0.12	1.50	0.8	83.52	3.0
200	4680	4080	2	1	37	600	2	4680	0.13	1.00	0.6	85.09	2.0
201	4680	4040	2	2	39	640	2	4680	0.14	1.50	1.0	85.34	3.0
202	4760	4160	2	2	27	600	2	4760	0.13	1.50	0.9	83.28	3.0
203	4760	4200	1	1	46	560	1	4760	0.12	0.50	0.3	86.05	0.5
204	4760	4000	0	0	48	760	0	4760	0.16	0.00	0.0	86.21	0.0
205	5520	5000	0	0	33	520	0	5520	0.09	0.00	0.0	84.50	0.0
206	5320	5080	0	0	19	240	0	5320	0.05	0.00	0.0	80.50	0.0
207	5360	5040	0	0	18	320	0	5360	0.06	0.00	0.0	79.98	0.0
208	5280	4920	0	0	31	360	0	5280	0.07	0.00	0.0	84.14	0.0
209	5040	4560	1	1	25	480	1	5040	0.10	0.50	0.2	82.75	0.5
210	5040	4640	0	0	22	400	0	5040	0.08	0.00	0.0	81.78	0.0
211	5160	4720	3	1	36	440	3	5160	0.09	1.00	0.4	84.95	3.0
212	4680	3880	5	4	47	800	5	4680	0.17	3.50	2.8	86.13	17.5
213	4200	3480	5	4	37	720	5	4200	0.17	3.50	2.5	85.09	17.5
214	3800	3000	3	2	40	800	3	3800	0.21	2.00	1.6	85.45	6.0
215	3400	2720	4	2	48	680	4	3400	0.20	2.00	1.4	86.21	8.0
216	2960	2560	2	2	28	400	2	2960	0.14	1.50	0.6	83.52	3.0
217	2560	2400	3	3	21	160	3	2560	0.06	2.50	0.4	81.39	7.5
218	2680	2320	6	4	20	360	6	2680	0.13	3.50	1.3	80.97	21.0
219	2680	2320	2	2	18	360	2	2680	0.13	2.00	0.7	79.98	4.0
220	2600	2280	3	2	20	320	3	2600	0.12	1.50	0.5	80.97	4.5
221	3080	2480	1	1	37	600	1	3080	0.19	1.00	0.6	85.09	1.0
222	3400	2880	3	2	32	520	3	3400	0.15	1.50	0.8	84.32	4.5
223	3680	3200	2	2	33	480	2	3680	0.13	1.50	0.7	84.50	3.0
224	4080	3520	5	3	33	560	5	4080	0.14	2.50	1.4	84.50	12.5
225	4240	3840	5	4	25	400	5	4240	0.09	3.50	1.4	82.75	17.5
226	4560	3640	4	1	40	920	4	4560	0.20	1.00	0.9	85.45	4.0
227	4240	3720	7	5	49	520	7	4240	0.12	5.00	2.6	86.29	35.0
228	4520	4160	5	3	47	360	5	4520	0.08	2.50	0.9	86.13	12.5
229	4680	3800	5	3	59	880	5	4680	0.19	3.00	2.6	86.91	15.0
230	4640	3960	6	3	36	680	6	4640	0.15	3.00	2.0	84.95	18.0
231	4800	4120	2	2	35	680	2	4800	0.14	2.00	1.4	84.81	4.0
232	4800	4200	2	2	38	600	2	4800	0.13	1.50	0.9	85.22	3.0
233	4920	4520	0	0	50	400	0	4920	0.08	0.00	0.0	86.36	0.0
234	5400	4680	0	0	45	720	0	5400	0.13	0.00	0.0	85.96	0.0
235	5600	4480	1	1	52	1120	1	5600	0.20	0.50	0.6	86.50	0.5
236	5480	4560	2	1	48	920	2	5480	0.17	1.00	0.9	86.21	2.0
237	5200	4320	2	1	44	880	2	5200	0.17	1.00	0.9	85.87	2.0
238	4760	4080	4	3	43	680	4	4760	0.14	2.50	1.7	85.77	10.0
239	4640	4160	3	2	33	480	3	4640	0.10	1.50	0.7	84.50	4.5
240	4600	4240	1	1	45	360	1	4600	0.08	0.50	0.2	85.96	0.5
241	4880	3880	2	1	65	1000	2	4880	0.20	1.00	1.0	87.20	2.0
242	4280	3440	2	2	46	840	2	4280	0.20	1.50	1.3	86.05	3.0
243	3880	3120	2	1	42	760	2	3880	0.20	1.00	0.8	85.67	2.0
244	3560	2560	2	2	36	1000	2	3560	0.28	1.50	1.5	84.95	3.0

Morphometry Table

245	3240	2520	1	1	41	720	1	3240	0.22	1.00	0.7	85.56	1.0
246	2960	2400	2	1	32	560	2	2960	0.19	1.00	0.6	84.32	2.0
247	2480	2240	3	2	14	240	3	2480	0.10	2.00	0.5	77.20	6.0
248	2320	2200	4	2	12	120	4	2320	0.05	2.00	0.2	75.16	8.0
249	2800	2520	4	3	28	280	4	2800	0.10	2.50	0.7	83.52	10.0
250	2800	2520	5	3	34	280	5	2800	0.10	3.00	0.8	84.66	15.0
251	3320	2920	4	3	34	400	4	3320	0.12	2.50	1.0	84.66	10.0
252	3720	3200	3	3	42	520	3	3720	0.14	2.50	1.3	85.67	7.5
253	4080	3600	4	4	41	480	4	4080	0.12	3.50	1.7	85.56	14.0
254	4280	3880	2	1	39	400	2	4280	0.09	0.50	0.2	85.34	1.0
255	4240	3520	6	3	59	720	6	4240	0.17	3.00	2.2	86.91	18.0
256	4480	3760	4	2	47	720	4	4480	0.16	2.00	1.4	86.13	8.0
257	4480	3720	4	3	53	760	4	4480	0.17	3.00	2.3	86.57	12.0
258	4320	3720	2	2	32	600	2	4320	0.14	1.50	0.9	84.32	3.0
259	4680	4240	2	1	24	440	2	4680	0.09	0.50	0.2	82.45	1.0
260	4840	4400	0	0	26	440	0	4840	0.09	0.00	0.0	83.03	0.0
261	5040	4720	1	1	23	320	1	5040	0.06	0.50	0.2	82.13	0.5
262	5200	4800	0	0	32	400	0	5200	0.08	0.00	0.0	84.32	0.0
263	5040	4800	0	0	48	240	0	5040	0.05	0.00	0.0	86.21	0.0
264	5120	4760	2	1	36	360	2	5120	0.07	0.50	0.2	84.95	1.0
265	4840	4080	5	4	42	760	5	4840	0.16	3.50	2.7	85.67	17.5
266	4840	3880	2	2	42	960	2	4840	0.20	1.50	1.4	85.67	3.0
267	4120	3760	3	2	37	360	3	4120	0.09	2.00	0.7	85.09	6.0
268	4200	3760	6	4	35	440	6	4200	0.10	4.00	1.8	84.81	24.0
269	4280	3920	4	4	35	360	4	4280	0.08	3.50	1.3	84.81	14.0
270	4880	4200	0	0	43	680	0	4880	0.14	0.00	0.0	85.77	0.0
271	4880	3960	3	2	59	920	3	4880	0.19	2.00	1.8	86.91	6.0
272	4160	3320	6	3	49	840	6	4160	0.20	3.00	2.5	86.29	18.0
273	3800	3120	4	2	45	680	4	3800	0.18	2.00	1.4	85.96	8.0
274	3520	2760	4	2	38	760	4	3520	0.22	2.00	1.5	85.22	8.0
275	3240	2760	3	2	30	480	3	3240	0.15	1.50	0.7	83.95	4.5
276	2880	2360	3	2	28	520	3	2880	0.18	1.50	0.8	83.52	4.5
277	2480	2120	3	2	20	360	3	2480	0.15	2.00	0.7	80.97	6.0
278	2600	2080	4	3	25	520	4	2600	0.20	2.50	1.3	82.75	10.0
279	3000	2400	6	3	31	600	6	3000	0.20	3.00	1.8	84.14	18.0
280	3320	2800	6	3	34	520	6	3320	0.16	3.00	1.6	84.66	18.0
281	3680	3000	3	2	36	680	3	3680	0.18	2.00	1.4	84.95	6.0
282	3840	3320	2	1	32	520	2	3840	0.14	1.00	0.5	84.32	2.0
283	4120	3600	3	2	30	520	3	4120	0.13	2.00	1.0	83.95	6.0
284	4280	3720	3	1	48	560	3	4280	0.13	1.00	0.6	86.21	3.0
285	4240	3200	2	2	47	1040	2	4240	0.25	1.50	1.6	86.13	3.0
286	4280	3400	5	5	45	880	5	4280	0.21	4.50	4.0	85.96	22.5
287	4000	3400	5	5	34	600	5	4000	0.15	4.50	2.7	84.66	22.5
288	4200	3560	3	2	32	640	3	4200	0.15	2.00	1.3	84.32	6.0
289	4360	3920	4	3	22	440	4	4360	0.10	3.00	1.3	81.78	12.0
290	4680	4200	2	1	25	480	2	4680	0.10	1.00	0.5	82.75	2.0
291	4840	4520	3	2	22	320	3	4840	0.07	2.00	0.6	81.78	6.0
292	4920	4600	3	1	17	320	3	4920	0.07	1.00	0.3	79.40	3.0
293	5080	4640	0	0	42	440	0	5080	0.09	0.00	0.0	85.67	0.0
294	5280	4760	0	0	43	520	0	5280	0.10	0.00	0.0	85.77	0.0
295	4800	4000	3	2	44	800	3	4800	0.17	2.00	1.6	85.87	6.0
296	4120	3680	5	2	47	440	5	4120	0.11	2.00	0.9	86.13	10.0
297	4200	3720	4	4	34	480	4	4200	0.11	3.50	1.7	84.66	14.0
298	4680	3800	2	1	40	880	2	4680	0.19	1.00	0.9	85.45	2.0
299	4800	4040	0	0	46	760	0	4800	0.16	0.00	0.0	86.05	0.0
300	4680	4280	9	2	50	400	9	4680	0.09	1.50	0.6	86.36	13.5
301	4840	4080	3	1	42	760	3	4840	0.16	1.00	0.8	85.67	3.0
302	4560	3480	5	4	44	1080	5	4560	0.24	4.00	4.3	85.87	20.0
303	3640	2920	4	3	39	720	4	3640	0.20	3.00	2.2	85.34	12.0
304	3120	2640	3	3	34	480	3	3120	0.15	2.50	1.2	84.66	7.5
305	2840	2560	4	2	30	280	4	2840	0.10	2.00	0.6	83.95	8.0
306	2800	2160	2	2	33	640	2	2800	0.23	1.50	1.0	84.50	3.0
307	2280	2000	2	2	29	280	2	2280	0.12	2.00	0.6	83.74	4.0
308	2600	2000	2	1	33	600	2	2600	0.23	1.00	0.6	84.50	2.0
309	3040	2560	3	2	35	480	3	3040	0.16	2.00	1.0	84.81	6.0
310	3360	2800	2	2	26	560	2	3360	0.17	1.50	0.8	83.03	3.0
311	3600	3000	7	4	32	600	7	3600	0.17	4.00	2.4	84.32	28.0
312	3800	3240	10	5	34	560	10	3800	0.15	5.00	2.8	84.66	50.0
313	4040	3520	4	4	28	520	4	4040	0.13	3.50	1.8	83.52	14.0
314	4240	3200	6	3	52	1040	6	4240	0.25	3.00	3.1	86.50	18.0
315	3400	2960	8	4	43	440	8	3400	0.13	4.00	1.8	85.77	32.0
316	3480	3040	5	4	31	440	5	3480	0.13	3.50	1.5	84.14	17.5
317	3920	3320	8	3	35	600	8	3920	0.15	3.00	1.8	84.81	24.0
318	3880	3440	5	3	40	440	5	3880	0.11	3.00	1.3	85.45	15.0
319	4200	3600	4	3	29	600	4	4200	0.14	2.50	1.5	83.74	10.0
320	4560	3760	2	1	43	800	2	4560	0.18	1.00	0.8	85.77	2.0
321	4600	4000	3	2	39	600	3	4600	0.13	2.00	1.2	85.34	6.0
322	4720	4160	5	4	32	560	5	4720	0.12	4.00	2.2	84.32	20.0
323	4880	4440	3	1	32	440	3	4880	0.09	1.00	0.4	84.32	3.0
324	5280	4480	0	0	62	800	0	5280	0.15	0.00	0.0	87.06	0.0
325	4440	3760	4	4	40	680	4	4440	0.15	3.50	2.4	85.45	14.0
326	4040	3680	5	4	42	360	5	4040	0.09	3.50	1.3	85.67	17.5

Morphometry Table

327	4560	4000	2	2	30	560	2	4560	0.12	2.00	1.1	83.95	4.0
328	4800	4240	2	1	27	560	2	4800	0.12	1.00	0.6	83.28	2.0
329	4940	4440	0	0	28	500	0	4940	0.10	0.00	0.0	83.52	0.0
330	4600	3800	4	2	36	800	4	4600	0.17	2.00	1.6	84.95	8.0
331	4760	4000	2	1	40	760	2	4760	0.16	1.00	0.8	85.45	2.0
332	4760	3720	6	1	52	1040	6	4760	0.22	1.00	1.0	86.50	6.0
333	4040	3120	9	4	41	920	9	4040	0.23	4.00	3.7	85.56	36.0
334	3280	2680	7	4	35	600	7	3280	0.18	4.00	2.4	84.81	28.0
335	2920	2360	5	3	27	560	5	2920	0.19	3.00	1.7	83.28	15.0
336	2880	2400	0	0	26	480	0	2880	0.17	0.00	0.0	83.03	0.0
337	2560	2000	2	2	28	560	2	2560	0.22	1.50	0.8	83.52	3.0
338	2280	2000	7	4	20	280	7	2280	0.12	4.00	1.1	80.97	28.0
339	2680	2040	3	2	33	640	3	2680	0.24	2.00	1.3	84.50	6.0
340	3080	2600	5	3	27	480	5	3080	0.16	3.00	1.4	83.28	15.0
341	3400	3080	4	4	21	320	4	3400	0.09	3.50	1.1	81.39	14.0
342	3760	3320	5	3	25	440	5	3760	0.12	3.00	1.3	82.75	15.0
343	4080	3640	4	1	28	440	4	4080	0.11	1.00	0.4	83.52	4.0
344	4120	2820	3	2	60	1300	3	4120	0.32	2.00	2.6	86.97	6.0
345	3440	2840	8	5	43	600	8	3440	0.17	4.50	2.7	85.77	36.0
346	3800	3200	5	4	34	600	5	3800	0.16	3.50	2.1	84.66	17.5
347	4000	3480	3	4	27	520	3	4000	0.13	3.50	1.8	83.28	10.5
348	4760	3600	5	3	39	1160	5	4760	0.24	2.50	2.9	85.34	12.5
349	4400	3680	5	2	45	720	5	4400	0.16	2.00	1.4	85.96	10.0
350	4200	3640	4	4	40	560	4	4200	0.13	3.50	2.0	85.45	14.0
351	4200	3800	6	3	31	400	6	4200	0.10	2.50	1.0	84.14	15.0
352	4400	3880	4	3	30	520	4	4400	0.12	3.00	1.6	83.95	12.0
353	4680	4040	3	2	33	640	3	4680	0.14	2.00	1.3	84.50	6.0
354	4680	3800	0	0	48	880	0	4680	0.19	0.00	0.0	86.21	0.0
355	5200	4600	0	0	43	600	0	5200	0.12	0.00	0.0	85.77	0.0
356	4440	3760	3	2	38	680	3	4440	0.15	1.50	1.0	85.22	4.5
357	4040	3600	4	2	29	440	4	4040	0.11	2.00	0.9	83.74	8.0
358	4600	4040	1	1	26	560	1	4600	0.12	0.50	0.3	83.03	0.5
359	4920	4560	0	0	34	360	0	4920	0.07	0.00	0.0	84.66	0.0
360	4920	4160	3	1	48	760	3	4920	0.15	0.50	0.4	86.21	1.5
361	4160	3680	3	2	36	480	3	4160	0.12	1.50	0.7	84.95	4.5
362	4120	3400	6	3	38	720	6	4120	0.17	2.50	1.8	85.22	15.0
363	4080	3320	2	2	40	760	2	4080	0.19	1.50	1.1	85.45	3.0
364	4080	3360	3	1	48	720	3	4080	0.18	0.50	0.4	86.21	1.5
365	3400	3200	2	1	35	200	2	3400	0.06	0.50	0.1	84.81	1.0
366	3400	3000	1	1	21	400	1	3400	0.12	0.50	0.2	81.39	0.5
367	3200	2600	0	0	29	600	0	3200	0.19	0.00	0.0	83.74	0.0
368	2680	2080	6	3	30	600	6	2680	0.22	3.00	1.8	83.95	18.0
369	2200	1960	8	4	13	240	8	2200	0.11	3.50	0.8	76.25	28.0
370	2560	2000	3	2	31	560	3	2560	0.22	2.00	1.1	84.14	6.0
371	3040	2400	4	4	34	640	4	3040	0.21	4.00	2.6	84.66	16.0
372	3400	3000	5	3	26	400	5	3400	0.12	3.00	1.2	83.03	15.0
373	3800	3400	6	3	32	400	6	3800	0.11	3.00	1.2	84.32	18.0
374	3880	3200	4	2	33	680	4	3880	0.18	2.00	1.4	84.50	8.0
375	3640	2760	5	3	48	880	5	3640	0.24	3.00	2.6	86.21	15.0
376	3520	2880	3	2	31	640	3	3520	0.18	2.00	1.3	84.14	6.0
377	3880	3440	5	3	23	440	5	3880	0.11	2.50	1.1	82.13	12.5
378	4240	3760	4	2	32	480	4	4240	0.11	2.00	1.0	84.32	8.0
379	4400	4040	2	1	40	360	2	4400	0.08	1.00	0.4	85.45	2.0
380	4600	4180	2	1	41	420	2	4600	0.09	1.00	0.4	85.56	2.0
381	4680	4160	3	1	43	520	3	4680	0.11	0.50	0.3	85.77	1.5
382	4720	4000	1	1	54	720	1	4720	0.15	0.50	0.4	86.63	0.5
383	4600	3920	0	0	34	680	0	4600	0.15	0.00	0.0	84.66	0.0
384	4440	4040	3	3	19	400	3	4440	0.09	3.00	1.2	80.50	9.0
385	4440	4200	2	1	30	240	2	4440	0.05	0.50	0.1	83.95	1.0
386	5080	4360	0	0	50	720	0	5080	0.14	0.00	0.0	86.36	0.0
387	5000	3720	4	3	42	1280	4	5000	0.26	3.00	3.8	85.67	12.0
388	4000	3560	5	3	37	440	5	4000	0.11	2.50	1.1	85.09	12.5
389	4520	3720	1	1	45	800	1	4520	0.18	0.50	0.4	85.96	0.5
390	4720	4200	2	1	30	520	2	4720	0.11	1.00	0.5	83.95	2.0
391	4400	3960	3	3	27	440	3	4400	0.10	2.50	1.1	83.28	7.5
392	4080	3400	2	2	35	680	2	4080	0.17	1.50	1.0	84.81	3.0
393	3600	3020	4	2	30	580	4	3600	0.16	2.00	1.2	83.95	8.0
394	3600	2760	5	2	37	840	5	3600	0.23	1.50	1.3	85.09	7.5
395	3600	2920	1	1	38	680	1	3600	0.19	0.50	0.3	85.22	0.5
396	3240	2600	3	3	34	640	3	3240	0.20	2.50	1.6	84.66	7.5
397	3120	2560	3	3	32	560	3	3120	0.18	2.50	1.4	84.32	7.5
398	3080	2320	1	1	38	760	1	3080	0.25	0.50	0.4	85.22	0.5
399	2680	2000	2	1	38	680	2	2680	0.25	1.00	0.7	85.22	2.0
400	2200	1920	1	1	12	280	1	2200	0.13	0.50	0.1	75.16	0.5
401	2560	1920	4	4	26	640	4	2560	0.25	3.50	2.2	83.03	14.0
402	3000	2220	3	3	38	780	3	3000	0.26	3.00	2.3	85.22	9.0
403	3480	2820	4	3	34	660	4	3480	0.19	3.00	2.0	84.66	12.0
404	3680	3000	4	2	39	680	4	3680	0.18	2.00	1.4	85.34	8.0
405	3400	2600	3	2	47	800	3	3400	0.24	2.00	1.6	86.13	6.0
406	3040	2600	5	3	33	440	5	3040	0.14	3.00	1.3	84.50	15.0
407	3520	2920	4	3	135	600	4	3520	0.17	2.50	1.5	88.65	10.0
408	3680	3280	3	2	28	400	3	3680	0.11	1.50	0.6	83.52	4.5

Morphometry Table

409	4000	3440	1	1	35	560	1	4000	0.14	1.00	0.6	84.81	1.0
410	4160	3520	2	1	44	640	2	4160	0.15	1.00	0.6	85.87	2.0
411	4160	3760	5	5	31	400	5	4160	0.10	4.50	1.8	84.14	22.5
412	4600	4080	5	3	35	520	5	4600	0.11	3.00	1.6	84.81	15.0
413	4960	4360	2	1	35	600	2	4960	0.12	0.50	0.3	84.81	1.0
414	5020	4680	0	0	28	340	0	5020	0.07	0.00	0.0	83.52	0.0
415	4960	4240	0	0	29	720	0	4960	0.15	0.00	0.0	83.74	0.0
416	5000	4200	0	0	50	800	0	5000	0.16	0.00	0.0	86.36	0.0
417	5280	4640	0	1	40	640	0	5280	0.12	0.50	0.3	85.45	0.0
418	4800	3820	2	5	48	980	2	4800	0.20	4.50	4.4	86.21	9.0
419	4280	3560	6	3	42	720	6	4280	0.17	2.50	1.8	85.67	15.0
420	4360	3560	4	2	50	800	4	4360	0.18	1.50	1.2	86.36	6.0
421	4320	3560	3	1	44	760	3	4320	0.18	1.00	0.8	85.87	3.0
422	4020	3600	1	2	42	420	1	4020	0.10	1.50	0.6	85.67	1.5
423	4080	3120	4	2	56	960	4	4080	0.24	1.50	1.4	86.75	6.0
424	3400	2820	2	2	33	580	2	3400	0.17	1.50	0.9	84.50	3.0
425	3200	2720	1	1	52	480	1	3200	0.15	1.00	0.5	86.50	1.0
426	2600	2120	5	3	37	480	5	2600	0.18	3.00	1.4	85.09	15.0
427	2760	2120	5	3	43	640	5	2760	0.23	3.00	1.9	85.77	15.0
428	2680	2080	5	3	40	600	5	2680	0.22	2.50	1.5	85.45	12.5
429	2640	2040	5	3	35	600	5	2640	0.23	3.00	1.8	84.81	15.0
430	2280	2000	1	1	28	280	1	2280	0.12	0.50	0.1	83.52	0.5
431	2080	1920	1	1	10	160	1	2080	0.08	0.50	0.1	72.36	0.5
432	2280	1920	2	2	16	360	2	2280	0.16	1.50	0.5	78.76	3.0
433	2840	2040	3	2	42	800	3	2840	0.28	1.50	1.2	85.67	4.5
434	3640	3120	1	1	52	520	1	3640	0.14	0.50	0.3	86.50	0.5
435	3400	2720	4	2	46	680	4	3400	0.20	2.00	1.4	86.05	8.0
436	3280	2760	4	2	35	520	4	3280	0.16	2.00	1.0	84.81	8.0
437	3320	2760	2	2	35	560	2	3320	0.17	2.00	1.1	84.81	4.0
438	3800	3200	4	2	36	600	4	3800	0.16	1.50	0.9	84.95	6.0
439	3840	3360	6	5	41	480	6	3840	0.13	5.00	2.4	85.56	30.0
440	3600	3280	4	2	32	320	4	3600	0.09	2.00	0.6	84.32	8.0
441	3720	3360	3	2	32	360	3	3720	0.10	2.00	0.7	84.32	6.0
442	4360	3520	3	2	32	840	3	4360	0.19	2.00	1.7	84.32	6.0
443	4680	3720	4	1	53	960	4	4680	0.21	0.50	0.5	86.57	2.0
444	4960	3960	4	1	49	1000	4	4960	0.20	1.00	1.0	86.29	4.0
445	5000	4320	3	1	46	680	3	5000	0.14	1.00	0.7	86.05	3.0
446	5000	4600	0	0	41	400	0	5000	0.08	0.00	0.0	85.56	0.0
447	5000	4200	0	0	53	800	0	5000	0.16	0.00	0.0	86.57	0.0
448	5040	4800	0	0	20	240	0	5040	0.05	0.00	0.0	80.97	0.0
449	4880	4400	8	4	32	480	8	4880	0.10	4.00	1.9	84.32	32.0
450	4440	3720	8	6	41	720	8	4440	0.16	6.00	4.3	85.56	48.0
451	4000	3560	7	4	25	440	7	4000	0.11	3.50	1.5	82.75	24.5
452	3840	3280	5	3	50	560	5	3840	0.15	3.00	1.7	86.36	15.0
453	3600	3040	8	6	39	560	8	3600	0.16	6.00	3.4	85.34	48.0
454	3560	2880	7	4	48	680	7	3560	0.19	4.00	2.7	86.21	28.0
455	3240	2080	11	6	38	1160	11	3240	0.36	6.00	7.0	85.22	66.0
456	3400	2760	4	2	36	640	4	3400	0.19	2.00	1.3	84.95	8.0
457	3240	2600	6	3	43	640	6	3240	0.20	3.00	1.9	85.77	18.0
458	3280	2600	7	4	41	680	7	3280	0.21	4.00	2.7	85.56	28.0
459	3120	2680	5	3	27	440	5	3120	0.14	3.00	1.3	83.28	15.0
460	3120	2560	5	3	34	560	5	3120	0.18	2.50	1.4	84.66	12.5
461	2600	1960	3	2	26	640	3	2600	0.25	2.00	1.3	83.03	6.0
462	2440	1920	3	3	20	520	3	2440	0.21	2.50	1.3	80.97	7.5
463	2000	1840	2	2	12	160	2	2000	0.08	1.50	0.2	75.16	3.0
464	2820	1920	4	2	36	900	4	2820	0.32	2.00	1.8	84.95	8.0
465	3200	2240	7	3	40	960	7	3200	0.30	3.00	2.9	85.45	21.0
466	2920	2360	6	3	35	560	6	2920	0.19	3.00	1.7	84.81	18.0
467	3040	2740	2	2	28	300	2	3040	0.10	2.00	0.6	83.52	4.0
468	3240	2800	1	1	24	440	1	3240	0.14	0.50	0.2	82.45	0.5
469	3940	3440	4	1	29	500	4	3940	0.13	1.00	0.5	83.74	4.0
470	3920	3600	7	3	20	320	7	3920	0.08	3.00	1.0	80.97	21.0
471	4000	3600	1	1	22	400	1	4000	0.10	0.50	0.2	81.78	0.5
472	4200	3640	6	5	28	560	6	4200	0.13	4.50	2.5	83.52	27.0
473	4200	3600	7	5	33	600	7	4200	0.14	5.00	3.0	84.50	35.0
474	4200	3760	9	5	31	440	9	4200	0.10	5.00	2.2	84.14	45.0
475	4240	3760	8	4	26	480	8	4240	0.11	4.00	1.9	83.03	32.0
476	4760	4120	8	4	52	640	8	4760	0.13	4.00	2.6	86.50	32.0
477	5040	4200	8	3	48	840	8	5040	0.17	3.00	2.5	86.21	24.0
478	5240	4600	0	0	54	640	0	5240	0.12	0.00	0.0	86.63	0.0
479	4840	4560	0	0	16	280	0	4840	0.06	0.00	0.0	78.76	0.0
480	4800	4200	5	2	38	600	5	4800	0.13	1.50	0.9	85.22	7.5
481	4520	3600	7	3	43	920	7	4520	0.20	3.00	2.8	85.77	21.0
482	4280	3680	7	3	38	600	7	4280	0.14	2.50	1.5	85.22	17.5
483	4320	3600	6	4	31	720	6	4320	0.17	4.00	2.9	84.14	24.0
484	4200	3320	8	5	44	880	8	4200	0.21	5.00	4.4	85.87	40.0
485	3800	3200	8	4	36	600	8	3800	0.16	3.50	2.1	84.95	28.0
486	3600	3040	10	6	27	560	10	3600	0.16	6.00	3.4	83.28	60.0
487	3840	3280	3	2	38	560	3	3840	0.15	2.00	1.1	85.22	6.0
488	3880	3040	5	3	47	840	5	3880	0.22	3.00	2.5	86.13	15.0
489	3440	3080	6	2	32	360	6	3440	0.10	2.00	0.7	84.32	12.0
490	3240	2640	5	1	40	600	5	3240	0.19	1.00	0.6	85.45	5.0

Appendix 1

Morphometry Table

491	2640	2000	4	3	34	640	4	2640	0.24	3.00	1.9	84.66	12.0
492	2160	1960	1	1	28	200	1	2160	0.09	1.00	0.2	83.52	1.0
493	1880	1800	3	2	11	80	3	1880	0.04	1.50	0.1	73.88	4.5
494	2600	1880	2	1	44	720	2	2600	0.28	0.50	0.4	85.87	1.0
495	2600	2000	6	2	53	600	6	2600	0.23	2.00	1.2	86.57	12.0
496	3000	2600	3	1	27	400	3	3000	0.13	1.00	0.4	83.28	3.0
497	3320	3000	1	1	20	320	1	3320	0.10	0.50	0.2	80.97	0.5
498	3800	3320	2	2	26	480	2	3800	0.13	1.50	0.7	83.03	3.0
499	4000	3760	5	4	23	240	5	4000	0.06	3.50	0.8	82.13	17.5
500	4200	3800	6	2	28	400	6	4200	0.10	2.00	0.8	83.52	12.0
501	4480	3800	5	3	27	680	5	4480	0.15	3.00	2.0	83.28	15.0
502	4320	4000	3	2	24	320	3	4320	0.07	2.00	0.6	82.45	6.0
503	4280	3800	7	3	32	480	7	4280	0.11	3.00	1.4	84.32	21.0
504	4320	3620	4	3	35	700	4	4320	0.16	3.00	2.1	84.81	12.0
505	3880	3600	8	4	31	280	8	3880	0.07	4.00	1.1	84.14	32.0
506	3880	3640	5	3	36	240	5	3880	0.06	2.50	0.6	84.95	12.5
507	4640	4000	7	4	54	640	7	4640	0.14	4.00	2.6	86.63	28.0
508	4920	4400	0	0	49	520	0	4920	0.11	0.00	0.0	86.29	0.0
509	4800	4400	2	1	30	400	2	4800	0.08	0.50	0.2	83.95	1.0
510	4600	4160	7	3	44	440	7	4600	0.10	2.50	1.1	85.87	17.5
511	4440	4000	6	3	27	440	6	4440	0.10	2.50	1.1	83.28	15.0
512	4240	3800	6	3	27	440	6	4240	0.10	3.00	1.3	83.28	18.0
513	4160	3800	7	3	31	360	7	4160	0.09	3.00	1.1	84.14	21.0
514	4160	3600	7	3	36	560	7	4160	0.13	3.00	1.7	84.95	21.0
515	4000	3560	5	3	25	440	5	4000	0.11	2.50	1.1	82.75	12.5
516	4000	3620	6	2	31	380	6	4000	0.10	2.00	0.8	84.14	12.0
517	3880	3080	5	4	45	800	5	3880	0.21	4.00	3.2	85.96	20.0
518	3200	2600	11	6	42	600	11	3200	0.19	6.00	3.6	85.67	66.0
519	2920	2360	5	3	45	560	5	2920	0.19	3.00	1.7	85.96	15.0
520	2800	2040	4	2	46	760	4	2800	0.27	2.00	1.5	86.05	8.0
521	2520	1880	2	2	37	640	2	2520	0.25	1.50	1.0	85.09	3.0
522	1880	1760	5	2	11	120	5	1880	0.06	2.00	0.2	73.88	10.0
523	2040	1880	2	2	19	160	2	2040	0.08	2.00	0.3	80.50	4.0
524	2800	1960	4	2	51	840	4	2800	0.30	1.50	1.3	86.43	6.0
525	2960	2240	8	3	52	720	8	2960	0.24	3.00	2.2	86.50	24.0
526	3280	2480	5	3	40	800	5	3280	0.24	3.00	2.4	85.45	15.0
527	3600	2880	6	3	42	720	6	3600	0.20	3.00	2.2	85.67	18.0
528	4000	3280	11	5	42	720	11	4000	0.18	5.00	3.6	85.67	55.0
529	4200	3760	6	3	26	440	6	4200	0.10	2.50	1.1	83.03	15.0
530	4480	4200	5	2	25	280	5	4480	0.06	1.50	0.4	82.75	7.5
531	4480	4240	2	1	35	240	2	4480	0.05	0.50	0.1	84.81	1.0
532	4800	4080	5	3	34	720	5	4800	0.15	2.50	1.8	84.66	12.5
533	4400	3800	9	3	46	600	9	4400	0.14	2.50	1.5	86.05	22.5
534	4400	3840	13	6	35	560	13	4400	0.13	6.00	3.4	84.81	78.0
535	4320	3760	5	3	30	560	5	4320	0.13	2.50	1.4	83.95	12.5
536	3960	3600	2	1	32	360	2	3960	0.09	0.50	0.2	84.32	1.0
537	4000	3280	10	5	48	720	10	4000	0.18	5.00	3.6	86.21	50.0
538	5200	4080	7	4	52	1120	7	5200	0.22	4.00	4.5	86.50	28.0
539	5280	4800	0	0	46	480	0	5280	0.09	0.00	0.0	86.05	0.0
540	4840	4600	0	0	11	240	0	4840	0.05	0.00	0.0	73.88	0.0
541	4840	4240	5	3	40	600	5	4840	0.12	3.00	1.8	85.45	15.0
542	4280	3680	8	4	24	600	8	4280	0.14	4.00	2.4	82.45	32.0
543	4160	3640	3	3	28	520	3	4160	0.13	2.50	1.3	83.52	7.5
544	4000	3440	8	4	34	560	8	4000	0.14	4.00	2.2	84.66	32.0
545	3840	3440	6	4	30	400	6	3840	0.10	4.00	1.6	83.95	24.0
546	4040	3640	4	2	26	400	4	4040	0.10	1.50	0.6	83.03	6.0
547	4000	3640	11	4	31	360	11	4000	0.09	4.00	1.4	84.14	44.0
548	3920	3560	5	3	22	360	5	3920	0.09	3.00	1.1	81.78	15.0
549	3840	3240	5	2	37	600	5	3840	0.16	2.00	1.2	85.09	10.0
550	3560	2880	10	5	34	680	10	3560	0.19	5.00	3.4	84.66	50.0
551	3360	2640	7	3	44	720	7	3360	0.21	2.50	1.8	85.87	17.5
552	2840	2360	6	3	28	480	6	2840	0.17	2.50	1.2	83.52	15.0
553	2520	2000	1	1	28	520	1	2520	0.21	1.00	0.5	83.52	1.0
554	1880	1760	5	3	8	120	5	1880	0.06	2.50	0.3	68.32	12.5
555	2240	1880	1	1	20	360	1	2240	0.16	0.50	0.2	80.97	0.5
556	2480	1920	2	1	27	560	2	2480	0.23	1.00	0.6	83.28	2.0
557	2800	2000	3	2	34	800	3	2800	0.29	2.00	1.6	84.66	6.0
558	3120	2400	3	2	40	720	3	3120	0.23	2.00	1.4	85.45	6.0
559	3640	2920	1	1	35	720	1	3640	0.20	1.00	0.7	84.81	1.0
560	4000	3340	4	3	40	660	4	4000	0.17	3.00	2.0	85.45	12.0
561	4280	3800	9	3	54	480	9	4280	0.11	3.00	1.4	86.63	27.0
562	4320	3640	16	7	44	680	16	4320	0.16	7.00	4.8	85.87	112.0
563	4520	3800	8	4	33	720	8	4520	0.16	4.00	2.9	84.50	32.0
564	5000	4600	6	3	35	400	6	5000	0.08	2.50	1.0	84.81	15.0
565	5000	4520	8	3	40	480	8	5000	0.10	2.50	1.2	85.45	20.0
566	4820	4440	7	2	28	380	7	4820	0.08	2.00	0.8	83.52	14.0
567	4640	4200	10	5	31	440	10	4640	0.09	5.00	2.2	84.14	50.0
568	4400	4000	6	3	30	400	6	4400	0.09	3.00	1.2	83.95	18.0
569	4200	3960	2	1	22	240	2	4200	0.06	0.50	0.1	81.78	1.0
570	4400	4040	6	1	40	360	6	4400	0.08	1.00	0.4	85.45	6.0
571	5000	4440	2	1	42	560	2	5000	0.11	0.50	0.3	85.67	1.0
572	5000	4800	0	0	58	200	0	5000	0.04	0.00	0.0	86.86	0.0

Appendix 1

Morphometry Table

573	5200	4880	0	0	25	320	0	5200	0.06	0.00	0.0	82.75	0.0
574	5200	4840	0	0	28	360	0	5200	0.07	0.00	0.0	83.52	0.0
575	5120	4800	3	1	23	320	3	5120	0.06	1.00	0.3	82.13	3.0
576	4800	4640	2	1	26	160	2	4800	0.03	1.00	0.2	83.03	2.0
577	4880	4640	1	1	17	240	1	4880	0.05	0.50	0.1	79.40	0.5
578	4920	4640	7	3	30	280	7	4920	0.06	2.50	0.7	83.95	17.5
579	4480	3880	5	4	32	600	5	4480	0.13	4.00	2.4	84.32	20.0
580	3880	3360	4	2	36	520	4	3880	0.13	2.00	1.0	84.95	8.0
581	3600	3240	7	4	33	360	7	3600	0.10	3.50	1.3	84.50	24.5
582	3800	3560	5	3	32	240	5	3800	0.06	3.00	0.7	84.32	15.0
583	3680	3280	6	3	30	400	6	3680	0.11	3.00	1.2	83.95	18.0
584	3720	3360	7	4	36	360	7	3720	0.10	4.00	1.4	84.95	28.0
585	3880	3560	5	3	27	320	5	3880	0.08	3.00	1.0	83.28	15.0
586	3800	3280	3	1	30	520	3	3800	0.14	1.00	0.5	83.95	3.0
587	3440	2800	4	2	33	640	4	3440	0.19	2.00	1.3	84.50	8.0
588	3000	2560	6	3	32	440	6	3000	0.15	2.50	1.1	84.32	15.0
589	2600	1800	2	2	39	800	2	2600	0.31	1.50	1.2	85.34	3.0
590	1840	1780	9	3	14	60	9	1840	0.03	3.00	0.2	77.20	27.0
591	2280	1840	3	1	19	440	3	2280	0.19	0.50	0.2	80.50	1.5
592	2600	2160	33	2	28	440	33	2600	0.17	1.50	0.7	83.52	49.5
593	3040	2040	3	2	43	1000	3	3040	0.33	1.50	1.5	85.77	4.5
594	3400	2560	3	2	47	840	3	3400	0.25	1.50	1.3	86.13	4.5
595	3600	2760	2	2	44	840	2	3600	0.23	1.50	1.3	85.87	3.0
596	3400	2840	6	3	40	560	6	3400	0.16	3.00	1.7	85.45	18.0
597	3840	2960	9	4	47	880	9	3840	0.23	4.00	3.5	86.13	36.0
598	4000	3120	8	4	44	880	8	4000	0.22	4.00	3.5	85.87	32.0
599	4200	3320	10	5	56	880	10	4200	0.21	5.00	4.4	86.75	50.0
600	4440	3800	5	4	32	640	5	4440	0.14	3.50	2.2	84.32	17.5
601	4880	4400	5	1	42	480	5	4880	0.10	1.00	0.5	85.67	5.0
602	4840	4440	2	1	39	400	2	4840	0.08	0.50	0.2	85.34	1.0
603	4880	4440	1	0	46	440	1	4880	0.09	0.20	0.1	86.05	0.2
604	5120	4360	3	1	43	760	3	5120	0.15	1.00	0.8	85.77	3.0
605	5000	4320	0	0	37	680	0	5000	0.14	0.00	0.0	85.09	0.0
606	5040	4360	0	0	45	680	0	5040	0.13	0.00	0.0	85.96	0.0
607	5000	4720	0	0	31	280	0	5000	0.06	0.00	0.0	84.14	0.0
608	5280	4960	0	0	57	320	0	5280	0.06	0.00	0.0	86.81	0.0
609	5080	4200	9	6	55	880	9	5080	0.17	6.00	5.3	86.69	54.0
610	4960	4200	9	3	44	760	9	4960	0.15	3.00	2.3	85.87	27.0
611	4600	4160	7	4	25	440	7	4600	0.10	4.00	1.8	82.75	28.0
612	4480	4160	8	4	29	320	8	4480	0.07	4.00	1.3	83.74	32.0
613	4480	4080	6	4	25	400	6	4480	0.09	3.50	1.4	82.75	21.0
614	4720	4400	4	1	20	320	4	4720	0.07	1.00	0.3	80.97	4.0
615	4700	4000	8	5	32	700	8	4700	0.15	4.50	3.2	84.32	36.0
616	4320	3960	7	3	30	360	7	4320	0.08	2.50	0.9	83.95	17.5
617	4200	3440	6	3	42	760	6	4200	0.18	3.00	2.3	85.67	18.0
618	3560	3020	12	5	35	540	12	3560	0.15	5.00	2.7	84.81	60.0
619	3400	2920	8	4	34	480	8	3400	0.14	4.00	1.9	84.66	32.0
620	3600	2920	7	3	38	680	7	3600	0.19	3.00	2.0	85.22	21.0
621	3600	3080	6	4	36	520	6	3600	0.14	4.00	2.1	84.95	24.0
622	3840	3280	7	4	26	560	7	3840	0.15	3.50	2.0	83.03	24.5
623	3760	3040	4	3	39	720	4	3760	0.19	2.50	1.8	85.34	10.0
624	3200	2600	4	1	35	600	4	3200	0.19	1.00	0.6	84.81	4.0
625	2840	2120	6	3	36	720	6	2840	0.25	3.00	2.2	84.95	18.0
626	2400	1760	1	1	36	640	1	2400	0.27	1.00	0.6	84.95	1.0
627	1760	1720	3	2	10	40	3	1760	0.02	2.00	0.1	72.36	6.0
628	2200	1760	2	2	32	440	2	2200	0.20	1.50	0.7	84.32	3.0
629	2480	1820	6	3	29	660	6	2480	0.27	3.00	2.0	83.74	18.0
630	2520	2020	8	4	42	500	8	2520	0.20	4.00	2.0	85.67	32.0
631	2600	2240	8	4	34	360	8	2600	0.14	4.00	1.4	84.66	32.0
632	3120	2520	6	3	44	600	6	3120	0.19	2.50	1.5	85.87	15.0
633	3560	2800	7	4	40	760	7	3560	0.21	3.50	2.7	85.45	24.5
634	3600	2960	10	6	33	640	10	3600	0.18	6.00	3.8	84.50	60.0
635	3800	3200	13	6	34	600	13	3800	0.16	6.00	3.6	84.66	78.0
636	3760	3280	12	5	43	480	12	3760	0.13	5.00	2.4	85.77	60.0
637	4400	3440	9	4	42	960	9	4400	0.22	4.00	3.8	85.67	36.0
638	4440	3600	9	5	40	840	9	4440	0.19	5.00	4.2	85.45	45.0
639	4640	3800	7	3	44	840	7	4640	0.18	3.00	2.5	85.87	21.0
640	4800	3880	7	4	52	920	7	4800	0.19	4.00	3.7	86.50	28.0
641	5200	4320	7	3	47	880	7	5200	0.17	3.00	2.6	86.13	21.0
642	5120	4440	5	2	45	680	5	5120	0.13	2.00	1.4	85.96	10.0
643	5060	4720	2	1	34	340	2	5060	0.07	0.50	0.2	84.66	1.0
644	5080	4840	0	0	52	240	0	5080	0.05	0.00	0.0	86.50	0.0
645	5080	4880	0	0	54	200	0	5080	0.04	0.00	0.0	86.63	0.0
646	4400	4080	11	6	28	320	11	4400	0.07	6.00	1.9	83.52	66.0
647	4400	3800	13	6	38	600	13	4400	0.14	6.00	3.6	85.22	78.0
648	4280	3680	12	4	40	600	12	4280	0.14	4.00	2.4	85.45	48.0
649	4280	3680	12	4	40	600	12	4280	0.14	4.00	2.4	85.45	48.0
650	4450	3960	13	5	27	490	13	4450	0.11	5.00	2.5	83.28	65.0
651	4480	3960	6	3	25	520	6	4480	0.12	3.00	1.6	82.75	18.0
652	4600	4280	2	1	23	320	2	4600	0.07	0.50	0.2	82.13	1.0
653	4440	4120	8	3	27	320	8	4440	0.07	3.00	1.0	83.28	24.0
654	4280	3520	8	3	43	760	8	4280	0.18	3.00	2.3	85.77	24.0

Morphometry Table

655	4200	3320	7	4	43	880	7	4200	0.21	4.00	3.5	85.77	28.0
656	3680	3080	5	2	30	600	5	3680	0.16	2.00	1.2	83.95	10.0
657	3280	2600	11	4	42	680	11	3280	0.21	4.00	2.7	85.67	44.0
658	3320	2600	5	4	45	720	5	3320	0.22	3.50	2.5	85.96	17.5
659	3560	3000	8	4	35	560	8	3560	0.16	4.00	2.2	84.81	32.0
660	3560	3040	4	1	38	520	4	3560	0.15	1.00	0.5	85.22	4.0
661	3120	2640	4	2	35	480	4	3120	0.15	1.50	0.7	84.81	6.0
662	2800	1920	4	1	41	880	4	2800	0.31	1.00	0.9	85.56	4.0
663	2240	1720	4	2	35	520	4	2240	0.23	2.00	1.0	84.81	8.0
664	1820	1720	8	4	8	100	8	1820	0.05	4.00	0.4	68.32	32.0
665	2240	1800	3	1	23	440	3	2240	0.20	1.00	0.4	82.13	3.0
666	2840	2240	2	1	37	600	2	2840	0.21	1.00	0.6	85.09	2.0
667	3040	2320	3	2	45	720	3	3040	0.24	1.50	1.1	85.96	4.5
668	3160	2560	3	2	39	600	3	3160	0.19	2.00	1.2	85.34	6.0
669	3400	2640	6	3	42	760	6	3400	0.22	2.50	1.9	85.67	15.0
670	3680	3200	6	3	28	480	6	3680	0.13	2.50	1.2	83.52	15.0
671	3800	3560	5	3	30	240	5	3800	0.06	3.00	0.7	83.95	15.0
672	4200	3600	7	4	34	600	7	4200	0.14	4.00	2.4	84.66	28.0
673	4200	3680	10	4	38	520	10	4200	0.12	4.00	2.1	85.22	40.0
674	4200	3520	14	7	43	680	14	4200	0.16	7.00	4.8	85.77	98.0
675	4240	3600	7	4	40	640	7	4240	0.15	4.00	2.6	85.45	28.0
676	4280	3760	11	6	36	520	11	4280	0.12	6.00	3.1	84.95	66.0
677	4240	3840	11	5	46	400	11	4240	0.09	5.00	2.0	86.05	55.0
678	4440	3880	9	5	47	560	9	4440	0.13	5.00	2.8	86.13	45.0
679	4800	3960	9	5	42	840	9	4800	0.18	5.00	4.2	85.67	45.0
680	5000	4160	6	4	48	840	6	5000	0.17	4.00	3.4	86.21	24.0
681	4920	4200	4	2	36	720	4	4920	0.15	2.00	1.4	84.95	8.0
682	5280	4440	7	2	48	840	7	5280	0.16	2.00	1.7	86.21	14.0
683	5280	4920	0	0	47	360	0	5280	0.07	0.00	0.0	86.13	0.0
684	4600	3840	6	2	26	760	6	4600	0.17	2.00	1.5	83.03	12.0
685	4200	3360	12	5	42	840	12	4200	0.20	5.00	4.2	85.67	60.0
686	3960	3400	11	5	51	560	11	3960	0.14	5.00	2.8	86.43	55.0
687	4400	3800	10	4	35	600	10	4400	0.14	4.00	2.4	84.81	40.0
688	4480	4160	4	2	21	320	4	4480	0.07	1.50	0.5	81.39	6.0
689	4400	4200	4	2	15	200	4	4400	0.05	2.00	0.4	78.03	8.0
690	4400	3960	2	1	38	440	2	4400	0.10	1.00	0.4	85.22	2.0
691	4400	3680	13	5	44	720	13	4400	0.16	5.00	3.6	85.87	65.0
692	4240	3520	5	2	40	720	5	4240	0.17	1.50	1.1	85.45	7.5
693	4560	3200	10	3	40	1360	10	4560	0.30	2.50	3.4	85.45	25.0
694	3520	2880	6	2	33	640	6	3520	0.18	2.00	1.3	84.50	12.0
695	3280	2360	7	4	47	920	7	3280	0.28	4.00	3.7	86.13	28.0
696	2960	2320	5	3	34	640	5	2960	0.22	3.00	1.9	84.66	15.0
697	3320	2600	5	3	40	720	5	3320	0.22	3.00	2.2	85.45	15.0
698	3360	2640	4	2	36	720	4	3360	0.21	2.00	1.4	84.95	8.0
699	3000	2200	5	3	41	800	5	3000	0.27	3.00	2.4	85.56	15.0
700	2600	1720	4	2	50	880	4	2600	0.34	2.00	1.8	86.36	8.0
701	2080	1600	6	3	28	480	6	2080	0.23	3.00	1.4	83.52	18.0
702	2000	1760	6	3	15	240	6	2000	0.12	3.00	0.7	78.03	18.0
703	2440	1880	1	1	36	560	1	2440	0.23	0.50	0.3	84.95	0.5
704	2880	2240	2	1	40	640	2	2880	0.22	1.00	0.6	85.45	2.0
705	3200	2560	5	1	35	640	5	3200	0.20	1.00	0.6	84.81	5.0
706	3440	2920	4	1	40	520	4	3440	0.15	1.00	0.5	85.45	4.0
707	3680	3200	4	2	29	480	4	3680	0.13	1.50	0.7	83.74	6.0
708	3800	3400	12	3	27	400	12	3800	0.11	3.00	1.2	83.28	36.0
709	4120	3560	13	5	39	560	13	4120	0.14	5.00	2.8	85.34	65.0
710	4320	3720	9	4	41	600	9	4320	0.14	4.00	2.4	85.56	36.0
711	4440	4000	10	2	33	440	10	4440	0.10	2.00	0.9	84.50	20.0
712	4400	3980	15	6	35	420	15	4400	0.10	6.00	2.5	84.81	90.0
713	4560	4080	7	3	34	480	7	4560	0.11	3.00	1.4	84.66	21.0
714	4600	4160	5	2	35	440	5	4600	0.10	2.00	0.9	84.81	10.0
715	4440	3920	5	1	31	520	5	4440	0.12	1.00	0.5	84.14	5.0
716	4400	3880	3	1	30	520	3	4400	0.12	1.00	0.5	83.95	3.0
717	4480	4120	8	4	25	360	8	4480	0.08	4.00	1.4	82.75	32.0
718	4400	4160	6	4	18	240	6	4400	0.05	4.00	1.0	79.98	24.0
719	4520	4360	8	3	15	160	8	4520	0.04	3.00	0.5	78.03	24.0
720	4840	4560	6	2	25	280	6	4840	0.06	2.00	0.6	82.75	12.0
721	5280	4800	3	1	33	480	3	5280	0.09	0.50	0.2	84.50	1.5
722	4240	3560	10	3	44	680	10	4240	0.16	2.50	1.7	85.87	25.0
723	3800	3200	9	3	42	600	9	3800	0.16	3.00	1.8	85.67	27.0
724	4360	3400	8	3	48	960	8	4360	0.22	3.00	2.9	86.21	24.0
725	4040	3680	11	2	33	360	11	4040	0.09	2.00	0.7	84.50	22.0
726	4440	4200	7	2	33	240	7	4440	0.05	2.00	0.5	84.50	14.0
727	4520	4280	4	1	40	240	4	4520	0.05	1.00	0.2	85.45	4.0
728	4480	3880	4	1	45	600	4	4480	0.13	1.00	0.6	85.96	4.0
729	4000	2920	12	4	49	1080	12	4000	0.27	4.00	4.3	86.29	48.0
730	3720	2760	8	3	46	960	8	3720	0.26	3.00	2.9	86.05	24.0
731	3360	2600	9	4	45	760	9	3360	0.23	3.50	2.7	85.96	31.5
732	3280	2400	5	4	46	880	5	3280	0.27	3.50	3.1	86.05	17.5
733	2840	2280	2	1	40	560	2	2840	0.20	1.00	0.6	85.45	2.0
734	2600	2000	4	2	32	600	4	2600	0.23	2.00	1.2	84.32	8.0
735	2960	2600	1	1	27	360	1	2960	0.12	0.50	0.2	83.28	0.5
736	2880	2200	5	3	36	680	5	2880	0.24	3.00	2.0	84.95	15.0

Morphometry Table

737	2600	1820	3	2	34	780	3	2600	0.30	2.00	1.6	84.66	6.0
738	2200	1600	2	2	30	600	2	2200	0.27	2.00	1.2	83.95	4.0
739	1960	1600	9	4	15	360	9	1960	0.18	4.00	1.4	78.03	36.0
740	2360	1680	3	2	28	680	3	2360	0.29	2.00	1.4	83.52	6.0
741	2440	2000	2	1	34	440	2	2440	0.18	1.00	0.4	84.66	2.0
742	2520	2080	8	4	39	440	8	2520	0.17	4.00	1.8	85.34	32.0
743	2640	2280	9	4	42	360	9	2640	0.14	3.50	1.3	85.67	31.5
744	3200	2680	8	4	45	520	8	3200	0.16	3.50	1.8	85.96	28.0
745	3760	3000	3	1	40	760	3	3760	0.20	1.00	0.8	85.45	3.0
746	4080	3480	3	2	35	600	3	4080	0.15	1.50	0.9	84.81	4.5
747	4240	3680	7	2	37	560	7	4240	0.13	1.50	0.8	85.09	10.5
748	4360	3780	17	6	44	580	17	4360	0.13	6.00	3.5	85.87	102.0
749	4640	4000	10	4	36	640	10	4640	0.14	4.00	2.6	84.95	40.0
750	4800	4320	3	1	36	480	3	4800	0.10	1.00	0.5	84.95	3.0
751	4800	4440	3	1	35	360	3	4800	0.08	1.00	0.4	84.81	3.0
752	4800	4160	4	3	34	640	4	4800	0.13	2.50	1.6	84.66	10.0
753	4400	4040	14	5	28	360	14	4400	0.08	5.00	1.8	83.52	70.0
754	4680	4120	4	3	30	560	4	4680	0.12	3.00	1.7	83.95	12.0
755	4680	4200	2	2	33	480	2	4680	0.10	1.50	0.7	84.50	3.0
756	4800	4200	4	2	20	600	4	4800	0.13	2.00	1.2	80.97	8.0
757	4520	4200	1	1	18	320	1	4520	0.07	0.50	0.2	79.98	0.5
758	4800	4360	0	0	24	440	0	4800	0.09	0.00	0.0	82.45	0.0
759	5080	4600	0	0	24	480	0	5080	0.09	0.00	0.0	82.45	0.0
760	3680	3120	5	2	38	560	5	3680	0.15	2.00	1.1	85.22	10.0
761	3600	2920	12	5	45	680	12	3600	0.19	5.00	3.4	85.96	60.0
762	4240	3320	10	4	46	920	10	4240	0.22	4.00	3.7	86.05	40.0
763	4120	3400	13	5	45	720	13	4120	0.17	5.00	3.6	85.96	65.0
764	4360	3360	12	4	54	1000	12	4360	0.23	4.00	4.0	86.63	48.0
765	3880	3280	8	3	53	600	8	3880	0.15	3.00	1.8	86.57	24.0
766	4240	3200	7	3	50	1040	7	4240	0.25	3.00	3.1	86.36	21.0
767	3800	3320	8	1	44	480	8	3800	0.13	1.00	0.5	85.87	8.0
768	3680	2800	9	3	64	880	9	3680	0.24	2.50	2.2	87.16	22.5
769	3240	2600	10	5	49	640	10	3240	0.20	5.00	3.2	86.29	50.0
770	2960	2240	9	4	58	720	9	2960	0.24	4.00	2.9	86.86	36.0
771	2680	2080	4	3	33	600	4	2680	0.22	3.00	1.8	84.50	12.0
772	2560	1880	3	2	42	680	3	2560	0.27	1.50	1.0	85.67	4.5
773	2840	2200	2	1	40	640	2	2840	0.23	1.00	0.6	85.45	2.0
774	2880	2040	6	3	35	840	6	2880	0.29	3.00	2.5	84.81	18.0
775	2160	1680	3	2	24	480	3	2160	0.22	1.50	0.7	82.45	4.5
776	1880	1600	1	1	20	280	1	1880	0.15	0.50	0.1	80.97	0.5
777	1800	1600	3	1	14	200	3	1800	0.11	1.00	0.2	77.20	3.0
778	2240	1720	3	1	27	520	3	2240	0.23	1.00	0.5	83.28	3.0
779	2800	1920	5	2	39	880	5	2800	0.31	2.00	1.8	85.34	10.0
780	3040	2360	6	4	39	680	6	3040	0.22	4.00	2.7	85.34	24.0
781	3280	2560	7	2	38	720	7	3280	0.22	2.00	1.4	85.22	14.0
782	3440	2840	5	3	30	600	5	3440	0.17	3.00	1.8	83.95	15.0
783	3840	3000	6	3	38	840	6	3840	0.22	3.00	2.5	85.22	18.0
784	4200	2920	6	3	38	1280	6	4200	0.30	2.50	3.2	85.22	15.0
785	4400	4000	6	1	35	400	6	4400	0.09	1.00	0.4	84.81	6.0
786	4440	3840	14	6	36	600	14	4440	0.14	6.00	3.6	84.95	84.0
787	4480	3960	5	3	35	520	5	4480	0.12	3.00	1.6	84.81	15.0
788	4680	4320	7	3	33	360	7	4680	0.08	3.00	1.1	84.50	21.0
789	4680	4400	2	1	27	280	2	4680	0.06	1.00	0.3	83.28	2.0
790	4760	4200	7	4	38	560	7	4760	0.12	4.00	2.2	85.22	28.0
791	4840	4200	5	3	34	640	5	4840	0.13	2.50	1.6	84.66	12.5
792	5040	4440	2	1	31	600	2	5040	0.12	0.50	0.3	84.14	1.0
793	5080	4400	0	0	34	680	0	5080	0.13	0.00	0.0	84.66	0.0
794	4880	4400	0	0	26	480	0	4880	0.10	0.00	0.0	83.03	0.0
795	5000	4640	0	0	27	360	0	5000	0.07	0.00	0.0	83.28	0.0
796	5040	4560	0	0	32	480	0	5040	0.10	0.00	0.0	84.32	0.0
797	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
798	3680	3000	5	2	36	680	5	3680	0.18	2.00	1.4	84.95	10.0
799	3320	2960	11	4	39	360	11	3320	0.11	3.50	1.3	85.34	38.5
800	3600	3000	12	4	40	600	12	3600	0.17	4.00	2.4	85.45	48.0
801	3800	3000	11	4	51	800	11	3800	0.21	4.00	3.2	86.43	44.0
802	3760	2840	6	2	57	920	6	3760	0.24	2.00	1.8	86.81	12.0
803	3680	2800	7	5	47	880	7	3680	0.24	5.00	4.4	86.13	35.0
804	3280	2640	8	4	36	640	8	3280	0.20	4.00	2.6	84.95	32.0
805	3400	2800	9	5	29	600	9	3400	0.18	5.00	3.0	83.74	45.0
806	3600	3200	7	3	28	400	7	3600	0.11	3.00	1.2	83.52	21.0
807	3480	2800	8	3	35	680	8	3480	0.20	3.00	2.0	84.81	24.0
808	3040	2520	8	3	37	520	8	3040	0.17	2.50	1.3	85.09	20.0
809	2680	2200	3	3	28	480	3	2680	0.18	2.50	1.2	83.52	7.5
810	2280	1800	4	2	42	480	4	2280	0.21	2.00	1.0	85.67	8.0
811	2520	2000	4	2	39	520	4	2520	0.21	1.50	0.8	85.34	6.0
812	2440	1640	2	2	44	800	2	2440	0.33	1.50	1.2	85.87	3.0
813	2000	1560	3	2	27	440	3	2000	0.22	2.00	0.9	83.28	6.0
814	1720	1560	3	3	15	160	3	1720	0.09	2.50	0.4	78.03	7.5
815	2000	1720	1	1	18	280	1	2000	0.14	1.00	0.3	79.98	1.0
816	2520	1840	2	1	39	680	2	2520	0.27	0.50	0.3	85.34	1.0
817	2960	2200	4	2	49	760	4	2960	0.26	1.50	1.1	86.29	6.0
818	3160	2400	5	3	45	760	5	3160	0.24	2.50	1.9	85.96	12.5

Appendix 1

Morphometry Table

819	3360	2680	4	2	35	680	4	3360	0.20	2.00	1.4	84.81	8.0
820	3560	2920	5	2	35	640	5	3560	0.18	2.00	1.3	84.81	10.0
821	3960	3240	6	2	40	720	6	3960	0.18	2.00	1.4	85.45	12.0
822	4440	3720	4	2	30	720	4	4440	0.16	2.00	1.4	83.95	8.0
823	4680	4320	4	2	33	360	4	4680	0.08	2.00	0.7	84.50	8.0
824	4520	4080	8	2	37	440	8	4520	0.10	2.00	0.9	85.09	16.0
825	4600	4120	6	2	32	480	6	4600	0.10	2.00	1.0	84.32	12.0
826	4840	4200	3	1	38	640	3	4840	0.13	1.00	0.6	85.22	3.0
827	4840	4460	0	0	39	380	0	4840	0.08	0.00	0.0	85.34	0.0
828	4920	4440	0	0	29	480	0	4920	0.10	0.00	0.0	83.74	0.0
829	4800	4440	0	0	34	360	0	4800	0.08	0.00	0.0	84.66	0.0
830	5000	4840	0	0	24	160	0	5000	0.03	0.00	0.0	82.45	0.0
831	4960	4560	0	0	24	400	0	4960	0.08	0.00	0.0	82.45	0.0
832	4880	4480	0	0	28	400	0	4880	0.08	0.00	0.0	83.52	0.0
833	4800	4680	0	0	30	120	0	4800	0.03	0.00	0.0	83.95	0.0
834	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
835	3440	2800	5	3	31	640	5	3440	0.19	3.00	1.9	84.14	15.0
836	3000	2520	9	4	54	480	9	3000	0.16	4.00	1.9	86.63	36.0
837	3120	2520	10	6	42	600	10	3120	0.19	6.00	3.6	85.67	60.0
838	3400	2920	3	2	45	480	3	3400	0.14	1.50	0.7	85.96	4.5
839	3160	2800	3	1	45	360	3	3160	0.11	1.00	0.4	85.96	3.0
840	3120	2560	7	3	46	560	7	3120	0.18	2.50	1.4	86.05	17.5
841	2680	2400	8	4	38	280	8	2680	0.10	4.00	1.1	85.22	32.0
842	3160	2600	5	4	36	560	5	3160	0.18	4.00	2.2	84.95	20.0
843	3440	2880	7	3	43	560	7	3440	0.16	2.50	1.4	85.77	17.5
844	3400	2640	7	2	44	760	7	3400	0.22	2.00	1.5	85.87	14.0
845	2840	1920	3	3	32	920	3	2840	0.32	3.00	2.8	84.32	9.0
846	2400	1920	6	4	28	480	6	2400	0.20	4.00	1.9	83.52	24.0
847	2200	1800	4	2	37	400	4	2200	0.18	2.00	0.8	85.09	8.0
848	2400	1720	2	1	49	680	2	2400	0.28	0.50	0.3	86.29	1.0
849	2200	1560	4	2	34	640	4	2200	0.29	2.00	1.3	84.66	8.0
850	1640	1520	3	2	7	120	3	1640	0.07	1.50	0.2	65.57	4.5
851	1720	1640	1	1	6	80	1	1720	0.05	1.00	0.1	62.08	1.0
852	2240	1720	2	2	31	520	2	2240	0.23	1.50	0.8	84.14	3.0
853	2280	1840	5	4	28	440	5	2280	0.19	3.50	1.5	83.52	17.5
854	2440	2000	6	3	34	440	6	2440	0.18	3.00	1.3	84.66	18.0
855	2800	2200	7	3	40	600	7	2800	0.21	3.00	1.8	85.45	21.0
856	3000	2480	8	4	30	520	8	3000	0.17	4.00	2.1	83.95	32.0
857	3440	2960	5	2	29	480	5	3440	0.14	2.00	1.0	83.74	10.0
858	3660	3240	8	3	37	420	8	3660	0.11	3.00	1.3	85.09	24.0
859	4080	3540	8	3	38	540	8	4080	0.13	3.00	1.6	85.22	24.0
860	4280	3720	4	3	29	560	4	4280	0.13	2.50	1.4	83.74	10.0
861	4400	3920	4	3	27	480	4	4400	0.11	3.00	1.4	83.28	12.0
862	4680	4120	8	4	28	560	8	4680	0.12	3.50	2.0	83.52	28.0
863	4760	4200	8	3	42	560	8	4760	0.12	3.00	1.7	85.67	24.0
864	4680	4400	0	0	30	280	0	4680	0.06	0.00	0.0	83.95	0.0
865	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
866	3800	3000	5	3	45	800	5	3800	0.21	2.50	2.0	85.96	12.5
867	3200	2600	3	2	39	600	3	3200	0.19	2.00	1.2	85.34	6.0
868	2880	2320	5	3	37	560	5	2880	0.19	2.50	1.4	85.09	12.5
869	3160	2200	5	3	45	960	5	3160	0.30	2.50	2.4	85.96	12.5
870	2880	2080	2	2	37	800	2	2880	0.28	2.00	1.6	85.09	4.0
871	2800	2080	4	3	47	720	4	2800	0.26	2.50	1.8	86.13	10.0
872	2880	2200	4	2	54	680	4	2880	0.24	2.00	1.4	86.63	8.0
873	3080	2680	4	2	39	400	4	3080	0.13	2.00	0.8	85.34	8.0
874	3520	3240	5	1	41	280	5	3520	0.08	0.50	0.1	85.56	2.5
875	3080	2480	6	3	42	600	6	3080	0.19	3.00	1.8	85.67	18.0
876	2600	2160	5	4	38	440	5	2600	0.17	4.00	1.8	85.22	20.0
877	2520	2080	4	3	24	440	4	2520	0.17	3.00	1.3	82.45	12.0
878	2440	1800	2	1	35	640	2	2440	0.26	0.50	0.3	84.81	1.0
879	2360	1600	3	2	42	760	3	2360	0.32	1.50	1.1	85.67	4.5
880	1680	1520	3	2	20	160	3	1680	0.10	1.50	0.2	80.97	4.5
881	1600	1500	5	3	7	100	5	1600	0.06	2.50	0.3	65.57	12.5
882	1960	1640	4	3	18	320	4	1960	0.16	2.50	0.8	79.98	10.0
883	2440	1720	4	2	39	720	4	2440	0.30	2.00	1.4	85.34	8.0
884	2680	2280	3	1	24	400	3	2680	0.15	0.50	0.2	82.45	1.5
885	2960	2360	5	4	34	600	5	2960	0.20	3.50	2.1	84.66	17.5
886	3480	2840	5	4	30	640	5	3480	0.18	4.00	2.6	83.95	20.0
887	3440	2880	5	3	37	560	5	3440	0.16	3.00	1.7	85.09	15.0
888	3680	3000	6	4	39	680	6	3680	0.18	4.00	2.7	85.34	24.0
889	4000	3520	6	3	29	480	6	4000	0.12	3.00	1.4	83.74	18.0
890	4320	3800	4	2	31	520	4	4320	0.12	2.00	1.0	84.14	8.0
891	4120	3800	3	3	22	320	3	4120	0.08	2.50	0.8	81.78	7.5
892	4280	3880	2	2	21	400	2	4280	0.09	1.50	0.6	81.39	3.0
893	4320	3920	8	3	16	400	8	4320	0.09	3.00	1.2	78.76	24.0
894	4400	4160	5	3	31	240	5	4400	0.05	3.00	0.7	84.14	15.0
895	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
896	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
897	3440	2760	5	3	47	680	5	3440	0.20	2.50	1.7	86.13	12.5
898	3320	2320	6	3	58	1000	6	3320	0.30	2.50	2.5	86.86	15.0
899	2800	2320	7	4	38	480	7	2800	0.17	4.00	1.9	85.22	28.0
900	2880	2280	5	3	43	600	5	2880	0.21	3.00	1.8	85.77	15.0

Appendix 1

Morphometry Table

901	2800	2040	4	3	40	760	4	2800	0.27	3.00	2.3	85.45	12.0
902	2400	2000	10	4	34	400	10	2400	0.17	4.00	1.6	84.66	40.0
903	2520	1920	6	4	56	600	6	2520	0.24	3.50	2.1	86.75	21.0
904	3000	2200	3	3	40	800	3	3000	0.27	2.50	2.0	85.45	7.5
905	3200	2400	5	2	45	800	5	3200	0.25	2.00	1.6	85.96	10.0
906	3240	2680	3	2	44	560	3	3240	0.17	1.50	0.8	85.87	4.5
907	3040	2600	3	1	34	440	3	3040	0.14	1.00	0.4	84.66	3.0
908	2960	2360	1	1	41	600	1	2960	0.20	0.50	0.3	85.56	0.5
909	2600	1840	1	1	46	760	1	2600	0.29	0.50	0.4	86.05	0.5
910	2200	1520	1	1	39	680	1	2200	0.31	0.50	0.3	85.34	0.5
911	1600	1520	2	2	15	80	2	1600	0.05	1.50	0.1	78.03	3.0
912	1640	1520	3	2	9	120	3	1640	0.07	1.50	0.2	70.54	4.5
913	2000	1640	1	1	21	360	1	2000	0.18	0.50	0.2	81.39	0.5
914	2400	1760	1	1	42	640	1	2400	0.27	1.00	0.6	85.67	1.0
915	2600	2000	1	1	32	600	1	2600	0.23	0.50	0.3	84.32	0.5
916	3000	2320	4	3	36	680	4	3000	0.23	3.00	2.0	84.95	12 0
917	3400	2840	3	1	36	560	3	3400	0.16	1.00	0.6	84.95	3.0
918	3800	3160	5	1	42	640	5	3800	0.17	1.00	0.6	85.67	5.0
919	4080	3520	7	2	44	560	7	4080	0.14	1.50	0.8	85.87	10.5
920	4166	3760	9	3	42	406	9	4166	0.10	2.50	1.0	85.67	22.5
921	4280	3920	4	2	36	360	4	4280	0.08	1.50	0.5	84.95	6.0
922	4320	4040	6	3	17	280	6	4320	0.06	3.00	0.8	79.40	18.0
923	4320	4080	5	2	14	240	5	4320	0.06	1.50	0.4	77.20	7.5
924	4520	4280	6	2	26	240	6	4520	0.05	2.00	0.5	83.03	12.0
925	4400	4280	1	1	36	120	1	4400	0.03	0.50	0.1	84.95	0.5
926	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
927	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
928	3840	3360	5	3	28	480	5	3840	0.13	3.00	1.4	83.52	15.0
929	3640	2800	6	4	45	840	6	3640	0.23	4.00	3.4	85.96	24.0
930	3440	2800	6	3	48	640	6	3440	0.19	3.00	1.9	86.21	18.0
931	3240	2680	5	2	40	560	5	3240	0.17	2.00	1.1	85.45	10.0
932	3080	2400	4	3	49	680	4	3080	0.22	2.50	1.7	86.29	10.0
933	2640	2080	3	2	39	560	3	2640	0.21	1.50	0.8	85.34	4.5
934	2440	1840	4	2	43	600	4	2440	0.25	2.00	1.2	85.77	8.0
935	2400	1800	6	3	31	600	6	2400	0.25	3.00	1.8	84.14	18.0
936	2640	1840	2	2	40	800	2	2640	0.30	1.50	1.2	85.45	3.0
937	3000	2000	3	3	45	1000	3	3000	0.33	2.50	2.5	85.96	7.5
938	3040	2240	2	1	48	800	2	3040	0.26	0.50	0.4	86.21	1.0
939	3000	2200	0	0	46	800	0	3000	0.27	0.00	0.0	86.05	0.0
940	2320	1800	1	1	40	520	1	2320	0.22	0.50	0.3	85.45	0.5
941	1800	1520	3	2	16	280	3	1800	0.16	1.50	0.4	78.76	4.5
942	1520	1480	3	2	9	40	3	1520	0.03	2.00	0.1	70.54	6.0
943	1720	1600	1	1	8	120	1	1720	0.07	1.00	0.1	68.32	1.0
944	2040	1800	3	2	17	240	3	2040	0.12	1.50	0.4	79.40	4.5
945	2240	1800	2	2	31	440	2	2240	0.20	1.50	0.7	84.14	3.0
946	2240	1800	5	3	28	440	5	2240	0.20	3.00	1.3	83.52	15.0
947	2600	2000	3	2	42	600	3	2600	0.23	2.00	1.2	85.67	6.0
948	3200	2400	4	3	44	800	4	3200	0.25	3.00	2.4	85.87	12.0
949	3480	2680	8	5	46	800	8	3480	0.23	4.50	3.6	86.05	36.0
950	3800	3200	6	2	50	600	6	3800	0.16	2.00	1.2	86.36	12.0
951	3800	3160	9	4	46	640	9	3800	0.17	3.50	2.2	86.05	31.5
952	4400	3600	9	3	48	800	9	4400	0.18	3.00	2.4	86.21	27.0
953	4400	3920	3	1	31	480	3	4400	0.11	0.50	0.2	84.14	1.5
954	4400	3680	1	1	30	720	1	4400	0.16	0.50	0.4	83.95	0.5
955	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
956	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
957	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
958	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
959	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
960	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
961	4280	3680	2	2	36	600	2	4280	0.14	1.50	0.9	84.95	3.0
962	3680	3280	5	4	35	400	5	3680	0.11	3.50	1.4	84.81	17.5
963	3480	2960	8	5	39	520	8	3480	0.15	4.50	2.3	85.34	36.0
964	2920	2760	10	5	34	160	10	2920	0.05	4.50	0.7	84.66	45.0
965	3200	2560	5	4	53	640	5	3200	0.20	3.50	2.2	86.57	17.5
966	3120	2320	4	3	50	800	4	3120	0.26	2.50	2.0	86.36	10.0
967	2560	1920	2	1	35	640	2	2560	0.25	0.50	0.3	84.81	1.0
968	2160	1760	4	2	29	400	4	2160	0.19	1.50	0.6	83.74	6.0
969	2000	1600	4	2	33	400	4	2000	0.20	2.00	0.8	84.50	8.0
970	2200	1600	4	2	33	600	4	2200	0.27	2.00	1.2	84.50	8.0
971	2600	1720	4	4	59	880	4	2600	0.34	3.50	3.1	86.91	14.0
972	2520	1640	3	1	46	880	3	2520	0.35	0.50	0.4	86.05	1.5
973	2080	1480	1	1	33	600	1	2080	0.29	0.50	0.3	84.50	0.5
974	1560	1480	1	1	6	80	1	1560	0.05	0.50	0.0	62.08	0.5
975	1600	1480	2	2	9	120	2	1600	0.08	1.50	0.2	70.54	3.0
976	1960	1560	2	1	26	400	2	1960	0.20	0.50	0.2	83.03	1.0
977	2200	1760	3	3	27	440	3	2200	0.20	2.50	1.1	83.28	7.5
978	2560	2080	2	1	30	480	2	2560	0.19	1.00	0.5	83.95	2.0
979	2520	2000	4	3	29	520	4	2520	0.21	3.00	1.6	83.74	12.0
980	2400	2000	5	2	39	400	5	2400	0.17	1.50	0.6	85.34	7.5
981	2800	2160	4	1	43	640	4	2800	0.23	1.00	0.6	85.77	4.0
982	3280	2620	5	3	43	660	5	3280	0.20	3.00	2.0	85.77	15.0

Morphometry Table

983	3480	2760	5	2	42	720	5	3480	0.21	2.00	1.4	85.67	10.0
984	3560	2920	4	3	43	640	4	3560	0.18	3.00	1.9	85.77	12.0
985	4200	3560	12	4	49	640	12	4200	0.15	4.00	2.6	86.29	48.0
986	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
987	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
988	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
989	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
990	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
991	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
992	4240	3800	5	3	44	440	5	4240	0.10	2.50	1.1	85.87	12.5
993	4080	3400	7	4	44	680	7	4080	0.17	4.00	2.7	85.87	28.0
994	3640	2960	3	1	42	680	3	3640	0.19	1.00	0.7	85.67	3.0
995	3440	3040	4	2	42	400	4	3440	0.12	1.50	0.6	85.67	6.0
996	3440	2840	4	1	38	600	4	3440	0.17	1.00	0.6	85.22	4.0
997	3000	2200	3	2	43	800	3	3000	0.27	2.00	1.6	85.77	6.0
998	2440	2000	3	2	43	440	3	2440	0.18	2.00	0.9	85.77	6.0
999	2240	2120	5	3	34	120	5	2240	0.05	2.50	0.3	84.66	12.5
1000	2120	1640	1	1	30	480	1	2120	0.23	0.50	0.2	83.95	0.5
1001	1800	1560	3	2	27	240	3	1800	0.13	2.00	0.5	83.28	6.0
1002	1840	1540	4	2	18	300	4	1840	0.16	2.00	0.6	79.98	8.0
1003	1840	1520	3	2	23	320	3	1840	0.17	2.00	0.6	82.13	6.0
1004	1600	1440	1	1	14	160	1	1600	0.10	0.50	0.1	77.20	0.5
1005	1560	1440	1	1	8	120	1	1560	0.08	1.00	0.1	68.32	1.0
1006	1640	1480	0	0	10	160	0	1640	0.10	0.00	0.0	72.36	0.0
1007	2000	1640	0	0	22	360	0	2000	0.18	0.00	0.0	81.78	0.0
1008	2540	1960	2	1	37	580	2	2540	0.23	0.50	0.3	85.09	1.0
1009	2840	2200	3	2	36	640	3	2840	0.23	2.00	1.3	84.95	6.0
1010	2880	2440	4	3	27	440	4	2880	0.15	3.00	1.3	83.28	12.0
1011	2800	2400	2	1	31	400	2	2800	0.14	1.00	0.4	84.14	2.0
1012	2680	2240	3	2	38	440	3	2680	0.16	2.00	0.9	85.22	6.0
1013	2800	2320	7	4	46	480	7	2800	0.17	4.00	1.9	86.05	28.0
1014	3080	2520	4	2	57	560	4	3080	0.18	2.00	1.1	86.81	8.0
1015	3400	2800	8	3	37	600	8	3400	0.18	3.00	1.8	85.09	24.0
1016	4040	3480	9	2	53	560	9	4040	0.14	1.50	0.8	86.57	13.5
1017	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1018	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1019	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1020	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1221	3400	2680	6	3	63	720	6	3400	0.21	2.50	1.8	87.11	15.0
1022	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1023	4240	3580	4	2	40	660	4	4240	0.16	2.00	1.3	85.45	8.0
1024	4200	3760	3	3	29	440	3	4200	0.10	2.50	1.1	83.74	7.5
1025	4880	3440	4	3	34	1440	4	4880	0.30	3.00	4.3	84.66	12.0
1026	3760	3200	7	3	37	560	7	3760	0.15	3.00	1.7	85.09	21.0
1027	3560	2840	6	2	36	720	6	3560	0.20	2.00	1.4	84.95	12.0
1028	3000	2400	4	3	41	600	4	3000	0.20	2.50	1.5	85.56	10.0
1029	2800	2200	5	3	42	600	5	2800	0.21	3.00	1.8	85.67	15.0
1030	2680	2000	3	2	33	680	3	2680	0.25	1.50	1.0	84.50	4.5
1031	2160	1800	3	2	16	360	3	2160	0.17	1.50	0.5	78.76	4.5
1032	2160	1800	1	1	16	360	1	2160	0.17	0.50	0.2	78.76	0.5
1033	2200	1760	1	1	23	440	1	2200	0.20	0.50	0.2	82.13	0.5
1034	2040	1560	0	0	30	480	0	2040	0.24	0.00	0.0	83.95	0.0
1035	1480	1400	2	1	8	80	2	1480	0.05	0.50	0.0	68.32	1.0
1036	1560	1400	2	2	12	160	2	1560	0.10	2.00	0.3	75.16	4.0
1037	1680	1560	2	2	11	120	2	1680	0.07	2.00	0.2	73.88	4.0
1038	2120	1680	1	1	31	440	1	2120	0.21	1.00	0.4	84.14	1.0
1039	2440	1800	4	2	44	640	4	2440	0.26	2.00	1.3	85.87	8.0
1040	2880	2080	4	2	46	800	4	2880	0.28	2.00	1.6	86.05	8.0
1041	3200	2600	5	2	40	600	5	3200	0.19	1.50	0.9	85.45	7.5
1042	3200	2680	5	3	29	520	5	3200	0.16	3.00	1.6	83.74	15.0
1043	3080	2480	3	1	35	600	3	3080	0.19	1.00	0.6	84.81	3.0
1044	2920	2480	4	3	36	440	4	2920	0.15	2.50	1.1	84.95	10.0
1045	3000	2520	7	2	42	480	7	3000	0.16	2.00	1.0	85.67	14.0
1046	3600	2920	6	2	49	680	6	3600	0.19	1.50	1.0	86.29	9.0
1047	3680	3400	5	2	60	280	5	3680	0.08	2.00	0.6	86.97	10.0
1048	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1049	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1050	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1051	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1052	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1053	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1054	4080	3200	4	2	50	880	4	4080	0.22	2.00	1.8	86.36	8.0
1055	4200	3600	7	3	44	600	7	4200	0.14	3.00	1.8	85.87	21.0
1056	4240	3680	5	3	43	560	5	4240	0.13	2.50	1.4	85.77	12.5
1057	4000	3240	8	4	50	760	8	4000	0.19	3.50	2.7	86.36	28.0
1058	3640	2800	4	3	55	840	4	3640	0.23	3.00	2.5	86.69	12.0
1059	3400	2680	4	2	42	720	4	3400	0.21	2.00	1.4	85.67	8.0
1060	3080	2480	2	1	37	600	2	3080	0.19	1.00	0.6	85.09	2.0
1061	2640	2160	2	1	28	480	2	2640	0.18	1.00	0.5	83.52	2.0
1062	2520	2160	1	1	31	360	1	2520	0.14	0.50	0.2	84.14	0.5
1063	2520	2160	0	0	30	360	0	2520	0.14	0.00	0.0	83.95	0.0
1064	2400	1920	0	0	30	480	0	2400	0.20	0.00	0.0	83.95	0.0

Appendix 1

Morphometry Table

1065	2000	1480	2	2	32	520	2	2000	0.26	2.00	1.0	84.32	4.0
1066	1560	1400	5	3	11	160	5	1560	0.10	2.50	0.4	73.88	12.5
1067	1560	1400	4	3	14	160	4	1560	0.10	2.50	0.4	77.20	10.0
1068	2040	1560	2	1	26	480	2	2040	0.24	0.50	0.2	83.03	1.0
1069	2120	1680	2	1	29	440	2	2120	0.21	1.00	0.4	83.74	2.0
1070	2680	2000	2	1	47	680	2	2680	0.25	1.00	0.7	86.13	2.0
1071	2720	2080	5	2	49	640	5	2720	0.24	2.00	1.3	86.29	10.0
1072	3200	2400	4	3	50	800	4	3200	0.25	3.00	2.4	86.36	12.0
1073	3480	3040	4	1	34	440	4	3480	0.13	0.50	0.2	84.66	2.0
1074	3160	2720	2	2	35	440	2	3160	0.14	1.50	0.7	84.81	3.0
1075	3200	2720	7	4	37	480	7	3200	0.15	4.00	1.9	85.09	28.0
1076	3280	2800	4	3	22	480	4	3280	0.15	3.00	1.4	81.78	12.0
1077	3680	3040	3	2	40	640	3	3680	0.17	1.50	1.0	85.45	4.5
1078	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1079	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1080	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1081	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1082	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1083	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1084	3640	3000	4	3	45	640	4	3640	0.18	2.50	1.6	85.96	10.0
1085	4080	3400	4	3	43	680	4	4080	0.17	3.00	2.0	85.77	12.0
1086	4160	3520	7	4	53	640	7	4160	0.15	3.50	2.2	86.57	24.5
1087	3600	2800	5	3	63	800	5	3600	0.22	3.00	2.4	87.11	15.0
1088	3480	2680	4	3	57	800	4	3480	0.23	2.50	2.0	86.81	10.0
1089	3400	2680	5	2	47	720	5	3400	0.21	2.00	1.4	86.13	10.0
1090	3080	2480	1	1	47	600	1	3080	0.19	0.50	0.3	86.13	0.5
1091	2800	2120	1	1	40	680	1	2800	0.24	0.50	0.3	85.45	0.5
1092	2480	1800	2	1	42	680	2	2480	0.27	1.00	0.7	85.67	2.0
1093	2280	1680	3	1	47	600	3	2280	0.26	1.00	0.6	86.13	3.0
1094	2200	1560	3	2	44	640	3	2200	0.29	1.50	1.0	85.87	4.5
1095	1840	1480	2	2	39	360	2	1840	0.20	1.50	0.5	85.34	3.0
1096	1480	1360	2	2	10	120	2	1480	0.08	1.50	0.2	72.36	3.0
1097	1720	1360	1	1	23	360	1	1720	0.21	1.00	0.4	82.13	1.0
1098	2120	1640	2	2	34	480	2	2120	0.23	1.50	0.7	84.66	3.0
1099	2520	2000	1	1	32	520	1	2520	0.21	0.50	0.3	84.32	0.5
1100	2640	2040	7	3	47	600	7	2640	0.23	3.00	1.8	86.13	21.0
1101	3760	3160	6	2	49	600	6	3760	0.16	1.50	0.9	86.29	9.0
1102	3160	2560	5	3	44	600	5	3160	0.19	2.50	1.5	85.87	12.5
1103	3520	2860	6	3	42	660	6	3520	0.19	3.00	2.0	85.67	18.0
1104	3600	3000	5	3	36	600	5	3600	0.17	2.50	1.5	84.95	12.5
1105	3560	3000	5	3	35	560	5	3560	0.16	3.00	1.7	84.81	15.0
1106	3520	3200	2	2	35	320	2	3520	0.09	1.50	0.5	84.81	3.0
1107	3520	3320	3	1	47	200	3	3520	0.06	1.00	0.2	86.13	3.0
1108	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1109	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1110	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1111	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1112	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1113	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1114	3400	2600	4	2	43	800	4	3400	0.24	2.00	1.6	85.77	8.0
1115	3600	2840	9	4	48	760	9	3600	0.21	3.50	2.7	86.21	31.5
1116	3880	3480	4	2	45	400	4	3880	0.10	2.00	0.8	85.96	8.0
1117	3480	2760	2	2	52	720	2	3480	0.21	1.50	1.1	86.50	3.0
1118	2960	2480	7	3	44	480	7	2960	0.16	3.00	1.4	85.87	21.0
1119	2800	2240	5	3	45	560	5	2800	0.20	2.50	1.4	85.96	12.5
1120	2760	2120	3	1	45	640	3	2760	0.23	1.00	0.6	85.96	3.0
1121	2400	1920	6	3	42	480	6	2400	0.20	2.50	1.2	85.67	15.0
1122	2280	1800	3	2	37	480	3	2280	0.21	2.00	1.0	85.09	6.0
1123	2280	1720	3	3	30	560	3	2280	0.25	2.50	1.4	83.95	7.5
1124	2280	1680	2	2	37	600	2	2280	0.26	2.00	1.2	85.09	4.0
1125	2120	1440	0	0	28	680	0	2120	0.32	0.00	0.0	83.52	0.0
1126	1480	1360	2	1	9	120	2	1480	0.08	1.00	0.1	70.54	2.0
1127	1760	1360	2	2	24	400	2	1760	0.23	2.00	0.8	82.45	4.0
1128	2200	1680	1	1	32	520	1	2200	0.24	0.50	0.3	84.32	0.5
1129	2600	1960	1	1	38	640	1	2600	0.25	0.50	0.3	85.22	0.5
1130	2640	2200	5	2	36	440	5	2640	0.17	2.00	0.9	84.95	10.0
1131	3200	2480	4	2	39	720	4	3200	0.23	1.50	1.1	85.34	6.0
1132	3360	2960	4	1	35	400	4	3360	0.12	1.00	0.4	84.81	4.0
1133	3520	3000	5	2	40	520	5	3520	0.15	2.00	1.0	85.45	10.0
1134	3800	3400	1	1	39	400	1	3800	0.11	0.50	0.2	85.34	0.5
1135	3640	3440	2	1	41	200	2	3640	0.05	0.50	0.1	85.56	1.0
1136	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1137	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1138	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1139	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1140	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1141	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1142	3080	2400	2	1	40	680	2	3080	0.22	1.00	0.7	85.45	2.0
1143	3600	2800	6	3	52	800	6	3600	0.22	2.50	2.0	86.50	15.0
1144	3680	2920	7	3	50	760	7	3680	0.21	3.00	2.3	86.36	21.0
1145	3600	3600	4	2	49	0	4	3600	0.00	1.50	0.0	86.29	6.0
1146	3400	2720	3	2	36	680	3	3400	0.20	1.50	1.0	84.95	4.5

Morphometry Table

1147	2920	2400	2	2	38	520	2	2920	0.18	1.50	0.8	85.22	3.0
1148	2680	2160	4	3	38	520	4	2680	0.19	3.00	1.6	85.22	12.0
1149	2720	2200	5	3	33	520	5	2720	0.19	2.50	1.3	84.50	12.5
1150	2640	2120	5	3	34	520	5	2640	0.20	2.50	1.3	84.66	12.5
1151	2640	2080	4	2	35	560	4	2640	0.21	1.50	0.8	84.81	6.0
1152	2520	1960	2	1	39	560	2	2520	0.22	0.50	0.3	85.34	1.0
1153	2080	1440	1	1	40	640	1	2080	0.31	1.00	0.6	85.45	1.0
1154	1440	1360	1	1	5	80	1	1440	0.06	0.50	0.0	57.54	0.5
1155	1800	1360	3	2	24	440	3	1800	0.24	2.00	0.9	82.45	6.0
1156	2320	1680	4	2	39	640	4	2320	0.28	1.50	1.0	85.34	6.0
1157	2480	1960	8	3	34	520	8	2480	0.21	3.00	1.6	34.66	24.0
1158	2600	2160	6	3	29	440	6	2600	0.17	2.50	1.1	83.74	15.0
1159	3040	2400	6	3	43	640	6	3040	0.21	3.00	1.9	85.77	18.0
1160	3400	2800	7	3	41	600	7	3400	0.18	3.00	1.8	85.56	21.0
1161	3640	3160	3	1	36	480	3	3640	0.13	1.00	0.5	84.95	3.0
1162	3640	3000	1	1	52	640	1	3640	0.18	1.00	0.6	86.50	1.0
1163	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1164	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1165	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1166	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1167	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1168	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1169	2880	2200	5	2	50	680	5	2880	0.24	2.00	1.4	86.36	10.0
1170	3000	2320	7	4	53	680	7	3000	0.23	4.00	2.7	86.57	28.0
1171	3400	2680	6	3	58	720	6	3400	0.21	3.00	2.2	86.86	18.0
1172	3680	3000	5	2	55	680	5	3680	0.18	1.50	1.0	86.69	7.5
1173	3600	2960	5	2	52	640	5	3600	0.18	1.50	1.0	86.50	7.5
1174	3200	2480	5	4	43	720	5	3200	0.23	3.50	2.5	85.77	17.5
1175	2880	2480	4	1	37	400	4	2880	0.14	1.00	0.4	85.09	4.0
1176	3040	2640	4	2	30	400	4	3040	0.13	2.00	0.8	83.95	8.0
1177	3040	2640	3	1	41	400	3	3040	0.13	0.50	0.2	85.56	1.5
1178	2880	2480	3	1	37	400	3	2880	0.14	0.50	0.2	85.09	1.5
1179	2640	1960	3	3	40	680	3	2640	0.26	2.50	1.7	85.45	7.5
1180	1960	1440	4	3	30	520	4	1960	0.27	2.50	1.3	83.95	10.0
1181	1440	1360	2	2	7	80	2	1440	0.06	1.50	0.1	65.57	3.0
1182	1800	1360	2	2	28	440	2	1800	0.24	1.50	0.7	83.52	3.0
1183	2400	1800	1	1	34	600	1	2400	0.25	0.50	0.3	84.66	0.5
1184	2860	2280	2	1	29	580	2	2860	0.20	0.50	0.3	83.74	1.0
1185	2960	2440	2	2	31	520	2	2960	0.18	1.50	0.8	84.14	3.0
1186	3240	2600	3	2	35	640	3	3240	0.20	1.50	1.0	84.81	4.5
1187	3400	3080	4	2	37	320	4	3400	0.09	1.50	0.5	85.09	6.0
1188	3400	3160	2	2	48	240	2	3400	0.07	1.50	0.4	86.21	3.0
1189	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1190	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1191	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1192	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1193	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1194	2600	2160	7	3	43	440	7	2600	0.17	2.50	1.1	85.77	17.5
1195	3040	2200	5	3	54	840	5	3040	0.28	2.50	2.1	86.63	12.5
1196	3320	2680	6	3	39	640	6	3320	0.19	3.00	1.9	85.34	18.0
1197	3200	2440	6	3	53	760	6	3200	0.24	2.50	1.9	86.57	15.0
1198	3480	2560	5	3	34	920	5	3480	0.26	3.00	2.8	84.66	15.0
1199	3560	3040	5	3	58	520	5	3560	0.15	2.50	1.3	86.86	12.5
1200	3480	3000	5	3	47	480	5	3480	0.14	2.50	1.2	86.13	12.5
1201	3000	2520	3	1	41	480	3	3000	0.16	0.50	0.2	85.56	1.5
1202	2880	2160	3	3	36	720	3	2880	0.25	3.00	2.2	84.95	9.0
1203	2560	2040	4	5	34	520	4	2560	0.20	4.50	2.3	84.66	18.0
1204	2440	1640	5	2	47	800	5	2440	0.33	2.00	1.6	86.13	10.0
1205	2000	1440	3	2	34	560	3	2000	0.28	1.50	0.8	84.66	4.5
1206	1400	1320	3	2	9	80	3	1400	0.06	2.00	0.2	70.54	6.0
1207	1880	1320	2	0	33	560	2	1880	0.30	0.00	0.0	84.50	0.0
1208	2400	1800	0	0	41	600	0	2400	0.25	0.00	0.0	85.56	0.0
1209	2880	1680	0	0	42	1200	0	2880	0.42	0.00	0.0	85.67	0.0
1210	3000	2200	2	1	46	800	2	3000	0.27	1.00	0.8	86.05	2.0
1211	3120	2600	7	3	39	520	7	3120	0.17	3.00	1.6	85.34	21.0
1212	3400	2920	7	3	38	480	7	3400	0.14	2.50	1.2	85.22	17.5
1213	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1214	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1215	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1216	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1217	2520	2000	3	1	34	520	3	2520	0.21	1.00	0.5	84.66	3.0
1218	2680	1960	6	3	49	720	6	2680	0.27	3.00	2.2	86.29	18.0
1219	2800	2120	8	4	51	680	8	2800	0.24	3.50	2.4	86.43	28.0
1220	2920	2200	7	4	53	720	7	2920	0.25	4.00	2.9	86.57	28.0
1221	3400	2680	6	3	63	720	6	3400	0.21	2.50	1.8	87.11	15.0
1222	3480	2600	3	1	49	880	3	3480	0.25	1.00	0.9	86.29	3.0
1223	3480	2800	3	3	56	680	3	3480	0.20	2.50	1.7	86.75	7.5
1224	3120	2400	5	3	47	720	5	3120	0.23	3.00	2.2	86.13	15.0
1225	2640	2200	6	4	42	440	6	2640	0.17	4.00	1.8	85.67	24.0
1226	2600	2040	4	2	33	560	4	2600	0.22	2.00	1.1	84.50	8.0
1227	2480	1640	2	1	47	840	2	2480	0.34	1.00	0.8	86.13	2.0
1228	2000	1400	2	1	31	600	2	2000	0.30	1.00	0.6	84.14	2.0

Morphometry Table

1229	1400	1280	4	2	13	120	4	1400	0.09	2.00	0.2	76.25	8.0
1230	1760	1320	1	1	36	440	1	1760	0.25	1.00	0.4	84.95	1.0
1231	2040	1560	2	2	41	480	2	2040	0.24	2.00	1.0	85.56	4.0
1232	2200	1720	3	2	39	480	3	2200	0.22	2.00	1.0	85.34	6.0
1233	2680	2120	2	2	33	560	2	2680	0.21	1.50	0.8	84.50	3.0
1234	3080	2680	6	3	25	400	6	3080	0.13	2.50	1.0	82.75	15.0
1235	3320	2960	4	2	26	360	4	3320	0.11	1.50	0.5	83.03	6.0
1236	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1237	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1238	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1239	2480	2000	3	1	42	480	3	2480	0.19	1.00	0.5	85.67	3.0
1240	2200	1880	3	2	50	320	3	2200	0.15	2.00	0.6	86.36	6.0
1241	2600	1880	6	3	50	720	6	2600	0.28	2.50	1.8	86.36	15.0
1242	3080	2360	5	1	57	720	5	3080	0.23	1.00	0.7	86.81	5.0
1243	3240	2360	6	3	65	880	6	3240	0.27	2.50	2.2	87.20	15.0
1244	3160	2480	7	4	53	680	7	3160	0.22	3.50	2.4	86.57	24.5
1245	3480	3160	4	1	44	320	4	3480	0.09	1.00	0.3	85.87	4.0
1246	3320	2880	3	2	38	440	3	3320	0.13	2.00	0.9	85.22	6.0
1247	3080	2600	3	3	42	480	3	3080	0.16	2.50	1.2	85.67	7.5
1248	2920	2600	3	1	31	320	3	2920	0.11	1.00	0.3	84.14	3.0
1249	2600	1920	2	2	41	680	2	2600	0.26	1.50	1.0	85.56	3.0
1250	2000	1400	3	2	40	600	3	2000	0.30	2.00	1.2	85.45	6.0
1251	1400	1280	6	3	19	120	6	1400	0.09	2.50	0.3	80.50	15.0
1252	1760	1280	0	0	27	480	0	1760	0.27	0.00	0.0	83.28	0.0
1253	2200	1600	0	0	39	600	0	2200	0.27	0.00	0.0	85.34	0.0
1254	2280	1760	3	2	32	520	3	2280	0.23	1.50	0.8	84.32	4.5
1255	2720	2280	3	3	31	440	3	2720	0.16	3.00	1.3	84.14	9.0
1256	3120	2720	3	3	27	400	3	3120	0.13	2.50	1.0	83.28	7.5
1257	3400	3120	3	1	36	280	3	3400	0.08	0.50	0.1	84.95	1.5
1258	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1259	0	0	0	0	0	0	0	0		0.00	0.0	0.00	0.0
1260	2600	2120	2	2	38	480	2	2600	0.18	1.50	0.7	85.22	3.0
1261	2200	1880	1	1	43	320	1	2200	0.15	0.50	0.2	85.77	0.5
1262	2280	1760	5	3	49	520	5	2280	0.23	2.50	1.3	86.29	12.5
1263	2400	1920	5	3	47	480	5	2400	0.20	2.50	1.2	86.13	12.5
1264	2600	2120	6	3	46	480	6	2600	0.18	3.00	1.4	86.05	18.0
1265	3280	2560	4	1	56	720	4	3280	0.22	1.00	0.7	86.75	4.0
1266	3400	2560	3	2	53	840	3	3400	0.25	1.50	1.3	86.57	4.5
1267	3160	2520	3	3	46	640	3	3160	0.20	2.50	1.6	86.05	7.5
1268	3160	2760	3	2	44	400	3	3160	0.13	1.50	0.6	85.87	4.5
1269	2880	2280	4	2	39	600	4	2880	0.21	2.00	1.2	85.34	8.0
1270	2520	1880	2	2	46	640	2	2520	0.25	1.50	1.0	86.05	3.0
1271	1960	1400	3	2	42	560	3	1960	0.29	1.50	0.8	85.67	4.5
1272	1400	1280	2	2	20	120	2	1400	0.09	2.00	0.2	80.97	4.0
1273	1600	1280	2	2	22	320	2	1600	0.20	2.00	0.6	81.78	4.0
1274	2200	1560	2	2	46	640	2	2200	0.29	2.00	1.3	86.05	4.0
1275	2600	2080	1	1	31	520	1	2600	0.20	1.00	0.5	84.14	1.0
1276	3000	2360	2	1	37	640	2	3000	0.21	1.00	0.6	85.09	2.0
1277	3160	2760	3	1	41	400	3	3160	0.13	1.00	0.4	85.56	3.0
1278	3160	2600	0	0	41	560	0	3160	0.18	0.00	0.0	85.56	0.0
1279	3480	2920	0	0	50	560	0	3480	0.16	0.00	0.0	86.36	0.0
1280	3440	2640	7	4	50	800	7	3440	0.23	4.00	3.2	86.36	28.0
1281	3280	2520	6	3	53	760	6	3280	0.23	3.00	2.3	86.57	18.0
1282	2800	2440	2	1	33	360	2	2800	0.13	1.00	0.4	84.50	2.0
1283	2480	2000	4	3	34	480	4	2480	0.19	3.00	1.4	84.66	12.0
1284	2200	1600	3	2	45	600	3	2200	0.27	2.00	1.2	85.96	6.0
1285	2280	1600	3	3	46	680	3	2280	0.30	2.50	1.7	86.05	7.5
1286	2600	2000	3	2	54	600	3	2600	0.23	2.00	1.2	86.63	6.0
1287	3280	2460	2	1	49	820	2	3280	0.25	1.00	0.8	86.29	2.0
1288	3000	2240	7	4	42	760	7	3000	0.25	3.50	2.7	85.67	24.5
1289	2680	1920	7	4	60	760	7	2680	0.28	3.50	2.7	86.97	24.5
1290	3000	2080	3	1	58	920	3	3000	0.31	1.00	0.9	86.86	3.0
1291	2960	2520	3	1	39	440	3	2960	0.15	0.50	0.2	85.34	1.5
1292	2480	1920	2	1	40	560	2	2480	0.23	1.00	0.6	85.45	2.0
1293	2000	1400	2	2	41	600	2	2000	0.30	1.50	0.9	85.56	3.0
1294	1480	1240	6	3	21	240	6	1480	0.16	3.00	0.7	81.39	18.0
1295	1720	1280	2	2	30	440	2	1720	0.26	2.00	0.9	83.95	4.0
1296	2200	1600	2	2	40	600	2	2200	0.27	1.50	0.9	85.45	3.0
1297	2600	1880	3	2	40	720	3	2600	0.28	2.00	1.4	85.45	6.0
1298	3000	2280	6	2	43	720	6	3000	0.24	2.00	1.4	85.77	12.0
1299	3200	2800	4	1	46	400	4	3200	0.13	1.00	0.4	86.05	4.0
1300	3480	3000	0	0	48	480	0	3480	0.14	0.00	0.0	86.21	0.0
1301	3480	2680	5	2	56	800	5	3480	0.23	2.00	1.6	86.75	10.0
1302	2840	2440	9	3	61	400	9	2840	0.14	3.00	1.2	87.02	27.0
1303	2800	2200	4	2	51	600	4	2800	0.21	2.00	1.2	86.43	8.0
1304	2560	2200	3	1	39	360	3	2560	0.14	0.50	0.2	85.34	1.5
1305	2320	1680	5	2	38	640	5	2320	0.28	2.00	1.3	85.22	10.0
1306	2120	1600	5	3	50	520	5	2120	0.25	2.50	1.3	86.36	12.5
1307	2560	1840	6	3	40	720	6	2560	0.28	3.00	2.2	85.45	18.0
1308	3040	2360	3	1	43	680	3	3040	0.22	1.00	0.7	85.77	3.0
1309	3040	2280	4	2	39	760	4	3040	0.25	2.00	1.5	85.34	8.0
1310	2120	1600	5	3	55	520	5	2120	0.25	3.00	1.6	86.69	15.0

Appendix 1

Morphometry Table

1311	2480	1600	5	3	52	880	5	2480	0.35	3.00	2.6	86.50	15.0
1312	2680	2000	2	1	41	680	2	2680	0.25	1.00	0.7	85.56	2.0
1313	2440	1960	3	1	39	480	3	2440	0.20	0.50	0.2	85.34	1.5
1314	1960	1400	4	3	43	560	4	1960	0.29	3.00	1.7	85.77	12.0
1315	1400	1200	3	2	18	200	3	1400	0.14	2.00	0.4	79.98	6.0
1316	1720	1240	4	3	28	480	4	1720	0.28	3.00	1.4	83.52	12.0
1317	2200	1600	3	1	33	600	3	2200	0.27	1.00	0.6	84.50	3.0
1318	2600	1960	1	1	52	640	1	2600	0.25	0.50	0.3	86.50	0.5
1319	2840	2280	3	1	42	560	3	2840	0.20	1.00	0.6	85.67	3.0
1320	2880	2800	0	0	46	80	0	2880	0.03	0.00	0.0	86.05	0.0
1321	3400	2760	0	0	50	640	0	3400	0.19	0.00	0.0	86.36	0.0
1322	3440	2680	6	2	56	760	6	3440	0.22	2.00	1.5	86.75	12.0
1323	3120	2440	4	2	62	680	4	3120	0.22	1.50	1.0	87.06	6.0
1324	2680	2120	3	1	43	560	3	2680	0.21	0.50	0.3	85.77	1.5
1325	2480	1880	8	4	50	600	8	2480	0.24	3.50	2.1	86.36	28.0
1326	2440	1720	4	1	52	720	4	2440	0.30	1.00	0.7	86.50	4.0
1327	1920	1560	6	3	46	360	6	1920	0.19	3.00	1.1	86.05	18.0
1328	2360	1560	4	2	44	800	4	2360	0.34	2.00	1.6	85.87	8.0
1329	2800	1840	3	2	48	960	3	2800	0.34	1.50	1.4	86.21	4.5
1330	2800	2080	2	2	41	720	2	2800	0.26	2.00	1.4	85.56	4.0
1331	2520	1560	4	3	46	960	4	2520	0.38	3.00	2.9	86.05	12.0
1332	2000	1400	6	3	35	600	6	2000	0.30	3.00	1.8	84.81	18.0
1333	2400	1800	3	2	37	600	3	2400	0.25	1.50	0.9	85.09	4.5
1334	2400	1720	2	1	44	680	2	2400	0.28	1.00	0.7	85.87	2.0
1335	1960	1240	4	3	43	720	4	1960	0.37	3.00	2.2	85.77	12.0
1336	1360	1200	7	4	16	160	7	1360	0.12	4.00	0.6	78.76	28.0
1337	1680	1280	8	4	28	400	8	1680	0.24	4.00	1.6	83.52	32.0
1338	2200	1560	7	3	38	640	7	2200	0.29	3.00	1.9	85.22	21.0
1339	2720	2040	2	2	48	680	2	2720	0.25	1.50	1.0	86.21	3.0
1340	3000	2680	0	0	48	320	0	3000	0.11	0.00	0.0	86.21	0.0
1341	3400	2800	0	0	55	600	0	3400	0.18	0.00	0.0	86.69	0.0
1342	3280	2520	3	2	66	760	3	3280	0.23	1.50	1.1	87.24	4.5
1343	2600	2080	3	3	51	520	3	2600	0.20	2.50	1.3	86.43	7.5
1344	2360	1920	3	2	38	440	3	2360	0.19	1.50	0.7	85.22	4.5
1345	2240	1720	6	3	45	520	6	2240	0.23	2.50	1.3	85.96	15.0
1346	2180	1560	3	2	40	620	3	2180	0.28	2.00	1.2	85.45	6.0
1347	2000	1520	9	3	43	480	9	2000	0.24	3.00	1.4	85.77	27.0
1348	2080	1480	6	3	45	600	6	2080	0.29	3.00	1.8	85.96	18.0
1349	2200	1480	3	2	48	720	3	2200	0.33	2.00	1.4	86.21	6.0
1350	2080	1480	6	1	35	600	6	2080	0.29	1.00	0.6	84.81	6.0
1351	1720	1380	8	4	48	340	8	1720	0.20	3.50	1.2	86.21	28.0
1352	1840	1280	4	3	27	560	4	1840	0.30	2.50	1.4	83.28	10.0
1353	1880	1280	2	1	44	600	2	1880	0.32	1.00	0.6	85.87	2.0
1354	1680	1200	5	2	32	480	5	1680	0.29	2.00	1.0	84.32	10.0
1355	1520	1200	4	3	20	320	4	1520	0.21	3.00	1.0	80.97	12.0
1356	1800	1280	7	3	35	520	7	1800	0.29	3.00	1.6	84.81	21.0
1357	2240	1760	9	4	32	480	9	2240	0.21	3.50	1.7	84.32	31.5
1358	2680	2200	2	1	41	480	2	2680	0.18	0.50	0.2	85.56	1.0
1359	2920	2600	2	1	61	320	2	2920	0.11	0.50	0.2	87.02	1.0
1360	2880	2280	1	1	47	600	1	2880	0.21	1.00	0.6	86.13	1.0
1361	2840	2200	5	3	43	640	5	2840	0.23	3.00	1.9	85.77	15.0
1362	2680	2080	4	2	45	600	4	2680	0.22	1.50	0.9	85.96	6.0
1363	2480	2000	2	1	40	480	2	2480	0.19	1.00	0.5	85.45	2.0
1364	2080	1600	3	2	42	480	3	2080	0.23	2.00	1.0	85.67	6.0
1365	2080	1480	4	3	29	600	4	2080	0.29	2.50	1.5	83.74	10.0
1366	1640	1400	4	2	32	240	4	1640	0.15	1.50	0.4	84.32	6.0
1367	1680	1400	4	3	29	280	4	1680	0.17	2.50	0.7	83.74	10.0
1368	1680	1360	4	2	49	320	4	1680	0.19	2.00	0.6	86.29	8.0
1369	2120	1320	3	1	42	800	3	2120	0.38	0.50	0.4	85.67	1.5
1370	1520	1240	2	1	25	280	2	1520	0.18	1.00	0.3	82.75	2.0
1371	1440	1200	3	2	19	240	3	1440	0.17	2.00	0.5	80.50	6.0
1372	1720	1200	3	3	26	520	3	1720	0.30	3.00	1.6	83.03	9.0
1373	2040	1280	4	2	30	760	4	2040	0.37	2.00	1.5	83.95	8.0
1374	2400	1520	2	1	29	880	2	2400	0.37	0.50	0.4	83.74	1.0
1375	2480	1840	0	0	45	640	0	2480	0.26	0.00	0.0	85.96	0.0
1376	3240	2280	1	1	41	960	1	3240	0.30	0.50	0.5	85.56	0.5
1377	2880	2680	0	0	42	200	0	2880	0.07	0.00	0.0	85.67	0.0
1378	2680	2240	3	2	41	440	3	2680	0.16	2.00	0.9	85.56	6.0
1379	2400	2000	3	3	33	400	3	2400	0.17	2.50	1.0	84.50	7.5
1380	2000	1880	4	3	31	120	4	2000	0.06	2.50	0.3	84.14	10.0
1381	2240	1680	3	1	35	560	3	2240	0.25	1.00	0.6	84.81	3.0
1382	2240	1600	1	1	39	640	1	2240	0.29	0.50	0.3	85.34	0.5
1383	2120	1520	3	1	42	600	3	2120	0.28	1.00	0.6	85.67	3.0
1384	2200	1400	5	3	45	800	5	2200	0.36	2.50	2.0	85.96	12.5
1385	2000	1440	3	1	42	560	3	2000	0.28	1.00	0.6	85.67	3.0
1386	1440	1200	3	3	25	240	3	1440	0.17	2.50	0.6	82.75	7.5
1387	1480	1200	2	1	28	280	2	1480	0.19	1.00	0.3	83.52	2.0
1388	1880	1440	1	1	25	440	1	1880	0.23	0.50	0.2	82.75	0.5
1389	2200	1760	2	1	26	440	2	2200	0.20	0.50	0.2	83.03	1.0
1390	2440	2080	0	0	38	360	0	2440	0.15	0.00	0.0	85.22	0.0
1391	3200	2600	2	1	57	600	2	3200	0.19	1.00	0.6	86.81	2.0
1392	2800	2200	5	4	43	600	5	2800	0.21	3.50	2.1	85.77	17.5

Morphometry Table

1393	2520	2000	2	2	41	520	2	2520	0.21	2.00	1.0	85.56	4.0
1394	2240	1920	2	1	22	320	2	2240	0.14	1.00	0.3	81.78	2.0
1395	2240	1920	2	2	23	320	2	2240	0.14	1.50	0.5	82.13	3.0
1396	2360	2000	1	1	28	360	1	2360	0.15	0.50	0.2	83.52	0.5
1397	2360	2120	2	1	27	240	2	2360	0.10	0.50	0.1	83.28	1.0
1398	2120	1560	4	3	42	560	4	2120	0.26	2.50	1.4	85.67	10.0
1399	2160	1560	2	1	33	600	2	2160	0.28	1.00	0.6	84.50	2.0
1400	2080	1480	2	1	34	600	2	2080	0.29	1.00	0.6	84.66	2.0
1401	1600	1160	4	3	26	440	4	1600	0.28	3.00	1.3	83.03	12.0
1402	1480	1160	2	2	17	320	2	1480	0.22	2.00	0.6	79.40	4.0
1403	1880	1440	2	2	24	440	2	1880	0.23	2.00	0.9	82.45	4.0
1404	2240	1840	2	1	22	400	2	2240	0.18	0.50	0.2	81.78	1.0
1405	2400	2240	0	0	34	160	0	2400	0.07	0.00	0.0	84.66	0.0
1406	3200	2800	0	0	47	400	0	3200	0.13	0.00	0.0	86.13	0.0
1407	3200	2560	4	2	40	640	4	3200	0.20	1.50	1.0	85.45	6.0
1408	2840	2200	3	2	42	640	3	2840	0.23	2.00	1.3	85.67	6.0
1409	2640	2160	2	2	29	480	2	2640	0.18	1.50	0.7	83.74	3.0
1410	2520	2120	4	1	34	400	4	2520	0.16	0.50	0.2	84.66	2.0
1411	2400	1920	2	1	36	480	2	2400	0.20	1.00	0.5	84.95	2.0
1412	2200	1800	3	2	41	400	3	2200	0.18	2.00	0.8	85.56	6.0
1413	2200	1760	2	2	40	440	2	2200	0.20	1.50	0.7	85.45	3.0
1414	2360	1920	1	1	31	440	1	2360	0.19	0.50	0.2	84.14	0.5
1415	2160	1640	4	1	30	520	4	2160	0.24	0.50	0.3	83.95	2.0
1416	1680	1200	3	3	28	480	3	1680	0.29	3.00	1.4	83.52	9.0
1417	1460	1400	2	2	15	60	2	1400	0.04	2.00	0.1	78.03	4.0
1418	1800	1280	3	2	28	520	3	1800	0.29	2.00	1.0	83.52	6.0
1419	2200	1640	1	1	31	560	1	2200	0.25	0.50	0.3	84.14	0.5
1420	2440	2160	0	0	37	280	0	2440	0.11	0.00	0.0	85.09	0.0
1421	3000	2200	0	0	60	800	0	3000	0.27	0.00	0.0	86.97	0.0
1422	3160	2600	3	2	42	560	3	3160	0.18	1.50	0.8	85.67	4.5
1423	2800	2160	2	2	36	640	2	2800	0.23	1.50	1.0	84.95	3.0
1424	2400	2120	6	3	37	280	6	2400	0.12	3.00	0.8	85.09	18.0
1425	2240	1960	4	2	38	280	4	2240	0.13	2.00	0.6	85.22	8.0
1426	2480	2000	2	1	34	480	2	2480	0.19	0.50	0.2	84.66	1.0
1427	2440	2000	1	1	42	440	1	2440	0.18	1.00	0.4	85.67	1.0
1428	2560	2200	2	1	31	360	2	2560	0.14	0.50	0.2	84.14	1.0
1429	2240	1680	2	1	32	560	2	2240	0.25	0.50	0.3	84.32	1.0
1430	1760	1280	3	2	25	480	3	1760	0.27	2.00	1.0	82.75	6.0
1431	1240	1160	4	2	9	80	4	1240	0.06	2.00	0.2	70.54	8.0
1432	1600	1160	5	3	16	440	5	1600	0.28	2.50	1.1	78.76	12.5
1433	2080	1600	2	2	30	480	2	2080	0.23	1.50	0.7	83.95	3.0
1434	2440	2120	0	0	27	320	0	2440	0.13	0.00	0.0	83.28	0.0
1435	3200	2800	1	1	45	400	1	3200	0.13	0.50	0.2	85.96	0.5
1436	2920	2360	5	3	36	560	5	2920	0.19	2.50	1.4	84.95	12.5
1437	2800	2080	3	1	33	720	3	2800	0.26	1.00	0.7	84.50	3.0
1438	2560	1960	4	2	36	600	4	2560	0.23	2.00	1.2	84.95	8.0
1439	2560	2260	5	2	36	300	5	2560	0.12	2.00	0.6	84.95	10.0
1440	2640	2160	5	1	36	480	5	2640	0.18	1.00	0.5	84.95	5.0
1441	2480	1960	1	1	35	520	1	2480	0.21	1.00	0.5	84.81	1.0
1442	2200	1640	2	1	38	560	2	2200	0.25	1.00	0.6	85.22	2.0
1443	1720	1280	3	2	28	440	3	1720	0.26	2.00	0.9	83.52	6.0
1444	1240	1120	2	1	7	120	2	1240	0.10	1.00	0.1	65.57	2.0
1445	1560	1120	5	2	29	440	5	1560	0.28	2.00	0.9	83.74	10.0
1446	2080	1200	4	2	47	880	4	2080	0.42	2.00	1.8	86.13	8.0
1447	2280	1400	0	0	53	880	0	2280	0.39	0.00	0.0	86.57	0.0
1448	3280	2860	3	1	57	420	3	3280	0.13	0.50	0.2	86.81	1.5
1449	2920	2400	8	2	60	520	8	2920	0.18	2.00	1.0	86.97	16.0
1450	2880	2200	4	3	49	680	4	2880	0.24	2.50	1.7	86.29	10.0
1451	2760	2280	4	2	42	480	4	2760	0.17	2.00	1.0	85.67	8.0
1452	2660	2120	4	1	35	540	4	2660	0.20	1.00	0.5	84.81	4.0
1453	2440	2160	8	4	38	280	8	2440	0.11	3.50	1.0	85.22	28.0
1454	2360	1720	3	2	48	640	3	2360	0.27	2.00	1.3	86.21	6.0
1455	1880	1320	3	2	47	560	3	1880	0.30	2.00	1.1	86.13	6.0
1456	1600	1240	3	2	32	360	3	1600	0.23	2.00	0.7	84.32	6.0
1457	1440	1160	1	1	17	280	1	1440	0.19	0.50	0.1	79.40	0.5
1458	1200	1120	1	1	7	80	1	1200	0.07	0.50	0.0	65.57	0.5
1459	1560	1120	3	2	24	440	3	1560	0.28	1.50	0.7	82.45	4.5
1460	3240	2400	0	0	57	840	0	3240	0.26	0.00	0.0	86.81	0.0
1461	3120	2360	6	3	45	760	6	3120	0.24	3.00	2.3	85.96	18.0
1462	2640	1960	6	2	45	680	6	2640	0.26	1.50	1.0	85.96	9.0
1463	2280	1720	5	3	37	560	5	2280	0.25	2.50	1.4	85.09	12.5
1464	2280	1720	5	2	36	560	5	2280	0.25	2.00	1.1	84.95	10.0
1465	2160	1600	4	2	37	560	4	2160	0.26	2.00	1.1	85.09	8.0
1466	2200	1640	3	1	38	560	3	2200	0.25	1.00	0.6	85.22	3.0
1467	1880	1320	4	3	35	560	4	1880	0.30	3.00	1.7	84.81	12.0
1468	1720	1320	3	1	28	400	3	1720	0.23	1.00	0.4	83.52	3.0
1469	1720	1200	2	1	29	520	2	1720	0.30	1.00	0.5	83.74	2.0
1470	1320	1120	1	1	12	200	1	1320	0.15	1.00	0.2	75.16	1.0
1471	1120	1120	1	1	0	0	1	1120	0.00	1.00	0.0	0.00	1.0
1472	3160	2640	2	1	51	520	2	3160	0.16	1.00	0.5	86.43	2.0
1473	2680	2000	3	2	45	680	3	2680	0.25	2.00	1.4	85.96	6.0
1474	2240	1680	4	3	37	560	4	2240	0.25	2.50	1.4	85.09	10.0

Morphometry Table

1475	2120	1560	5	2	50	560	5	2120	0.26	2.00	1.1	86.36	10.0
1476	2000	1520	5	3	48	480	5	2000	0.24	2.50	1.2	86.21	12.5
1477	2000	1400	5	4	55	600	5	2000	0.30	3.50	2.1	86.69	17.5
1478	2000	1360	4	3	44	640	4	2000	0.32	2.50	1.6	85.87	10.0
1479	2200	1440	4	1	42	760	4	2200	0.35	1.00	0.8	85.67	4.0
1480	2200	1400	3	1	46	800	3	2200	0.36	0.50	0.4	86.05	1.5
1481	1640	1120	2	2	28	520	2	1640	0.32	2.00	1.0	83.52	4.0
1482	1200	1120	2	2	6	80	2	1200	0.07	2.00	0.2	62.08	4.0
1483	1200	1120	2	2	6	80	2	1200	0.07	1.50	0.1	62.08	3.0
1484	3120	2200	0	0	67	920	0	3120	0.29	0.00	0.0	87.28	0.0
1485	2840	2080	2	1	40	760	2	2840	0.27	0.50	0.4	85.45	1.0
1486	2600	2160	1	1	35	440	1	2600	0.17	1.00	0.4	84.81	1.0
1487	2160	1680	4	2	39	480	4	2160	0.22	2.00	1.0	85.34	8.0
1488	2140	1640	3	1	34	500	3	2140	0.23	1.00	0.5	84.66	3.0
1489	2000	1480	6	4	38	520	6	2000	0.26	3.50	1.8	85.22	21.0
1490	2000	1600	3	2	26	400	3	2000	0.20	2.00	0.8	83.03	6.0
1491	2440	2000	0	0	27	440	0	2440	0.18	0.00	0.0	83.28	0.0
1492	2400	1680	0	0	29	720	0	2400	0.30	0.00	0.0	83.74	0.0
1493	2880	2640	0	0	51	240	0	2880	0.08	0.00	0.0	86.43	0.0
1494	2880	2040	2	1	50	840	2	2880	0.29	1.00	0.8	86.36	2.0
1495	2600	1920	3	2	44	680	3	2600	0.26	1.50	1.0	85.87	4.5
1496	2600	1920	4	1	57	680	4	2600	0.26	1.00	0.7	86.81	4.0
1497	2120	1480	4	2	43	640	4	2120	0.30	2.00	1.3	85.77	8.0
1498	2160	1640	2	2	28	520	2	2160	0.24	1.50	0.8	83.52	3.0
1499	2520	2040	1	1	34	480	1	2520	0.19	0.50	0.2	84.66	0.5
1500	2840	2240	1	1	64	600	1	2840	0.21	0.50	0.3	87.16	0.5
1501	2680	2200	2	2	46	480	2	2680	0.18	1.50	0.7	86.05	3.0
1502	2440	1760	4	3	59	680	4	2440	0.28	3.00	2.0	86.91	12.0
1503	2160	1640	6	2	50	520	6	2160	0.24	2.00	1.0	86.36	12.0
1504	2400	1760	3	3	39	640	3	2400	0.27	2.50	1.6	85.34	7.5
1505	2600	2160	0	0	34	440	0	2600	0.17	0.00	0.0	84.66	0.0
1506	2840	2280	1	1	51	560	1	2840	0.20	0.50	0.3	86.43	0.5
1507	2680	2040	7	3	40	640	7	2680	0.24	2.50	1.6	85.45	17.5
1508	2160	1840	5	3	47	320	5	2160	0.15	3.00	1.0	86.13	15.0
1509	2240	1800	5	3	39	440	5	2240	0.20	2.50	1.1	85.34	12.5
1510	2480	2040	2	1	40	440	2	2480	0.18	1.00	0.4	85.45	2.0
1511	2520	1800	0	0	61	720	0	2520	0.29	0.00	0.0	87.02	0.0
1512	2800	2400	1	1	50	400	1	2800	0.14	0.50	0.2	86.36	0.5
1513	2560	2160	4	3	29	400	4	2560	0.16	3.00	1.2	83.74	12.0
1514	2800	2260	4	2	38	540	4	2800	0.19	2.00	1.1	85.22	8.0
1515	2400	1800	0	0	39	600	0	2400	0.25	0.00	0.0	85.34	0.0
1516	2720	2200	0	0	43	520	0	2720	0.19	0.00	0.0	85.77	0.0
1517	2600	2520	1	1	43	80	1	2600	0.03	0.50	0.0	85.77	0.5
1518	2640	2200	1	1	49	440	1	2640	0.17	0.50	0.2	86.29	0.5

Appendix II

S.No.	GPS Reading	Bedrock lithology	Bedrock Structure	Regolith Type	Regolith Thickness	Vegetation Type	Vegetation Cover in Percentage	Stream Type	Stream Density	Fissures
1	E-77° 09' 016" N-32° 19' 790" A-2536 m	Obscure	Obscure	Fragmented	1.5 m	Bushes Grasses	70-75	Nil	Nil	Nil
2	E-77° 08' 889" N-32° 19' 737" A-2713 m	Obscure Schist Phyllite	Obscured	Fragmented dry	2.3 m	Deciduous oak walnut and grasses	100	Perennial Sub surface	1	Nil
3	E-77° 09' 053" N-32° 19' 751" A-2532 m	Obscure	Obscure	Glacial type	1 m	Bushes and grasses	20	Nil	Nil	Nil
4	E-77° 08' 937" N-32° 19' 946" A-2540 m	Phyllite	Obscure &Dipping Toward river	Fine and small size sediments	2 m	Bushes and grasses	20	Nil	Nil	T – scars creaks L- 1 m W – 5cm D – 15 cm
5	E-77° 08' 907" N-32° 19' 917" A-2543 m	Phyllite Schist and shale	Fragmented	Fragmented	2 m	Willow and bushes	20	Nil	Nil	T- shallow fissures L-20cm W – 2cm D – 10cm
6	E-77° 09' 113" N-32° 19' 589" A-2514 m	Shale & Phyllite	Fine soil over large fragmented rock	Fine soil over large fragmented rock	2 m	Poplar trees And bushes	65	Nil	Nil	Nil
7	E-77° 09' 162" N-32° 19' 460" A-2515 m	Shale	Dipping towards river	Fragmented	2 m	Bushes and grasses Poplar &pine	95	Rill	Nil	Nil

8	E-77° 09' 072" N-32° 19' 663" A-2515 m	Phyllite	Dipping towards river	Glacial	1.2 m	Bushes and grasses	30-40	Dry Channel	Nil	T- shallow fissures L-50 cm W - 2.5cm D - 20cm
9	E-77° 09' 159" N-32° 19' 438" A-2521 m	Obscure	Nil	Medium and large size boulder	2.5 m	Grass Poplar &pine	75	Nil	Nil	Nil
10	E-77° 09' 208" N-32° 19' 378" A-2485 m	Obscure	Nil	Glacial & fluvial	2 m	Bushes and grasses Poplar &pine	85	Narrow perennial surface stream	Nil	Nil
11	E-77° 09' 280" N-32° 19' 280" A-2482 m	Phyllite	Dipping towards river	Glacial & fluvial	Obscure	Bushes and grasses & trees	90	Dry Channel	Nil	Obscure

Source: Field survey done by the author himself.

Abbreviation used:-V- volume, W – width, L – length, H – height, T – type, D – depth, R – river, S – settlement, H/T- Highway & track, m – metre, cm – centimetre.

Appendix III

		Dhunda Glacier				
Sl.No.	Contour Interval	Mid point (Hi)	Area sq. km (Ai)	cumulative	Ai*Hi	
1	4760-4720	4740	0.01	0.01	47.40	
2	4720-4680	4700	0.01	0.02	47.00	
3	4680-4640	4660	0.01	0.03	46.60	
4	4640-4600	4620	0.01	0.04	46.20	
5	4600-4560	4580	0.01	0.05	45.80	
6	4560-4520	4540	0.01	0.06	45.40	
7	4520-4480	4500	0.01	0.07	45.00	
8	4480-4440	4460	0.01	0.08	44.60	
9	4440-4400	4420	0.10	0.18	442.00	
10	4400-4360	4380	0.08	0.26	350.40	
11	4360-4320	4340	0.31	0.57	1345.40	
12	4320-4280	4300	0.43	1	1849.00	
13	4280-4240	4260	0.31	1.31	1320.60	
14	4240-4200	4220	0.30	1.61	1266.00	
15	4200-4160	4180	0.22	1.83	919.60	
16	4160-4120	4140	0.26	2.09	1076.40	
17	4120-4080	4100	0.30	2.39	1230.00	
18	4080-4040	4060	0.35	2.47	1421.00	
19	4040-4000	4020	0.41	3.15	1648.20	
20	4000-3960	3980	0.38	3.53	1512.40	
21	3960-3920	3940	0.37	3.9	1457.80	
22	3920-3880	3900	0.32	4.22	1248.00	
23	3880-3840	3860	0.25	4.5	965.00	
24	3840--3800	3820	0.13	4.63	496.60	
25	3800-3760	3780	0.04	4.67	151.20	
26	3760-3720	3740	0.04	4.71	149.60	
27	3720-3680	3700	0.01	2.72	37.00	
28	3680-3640	3660	0.01	4.73	36.60	
			4.73		19290.80	
		ELA AWM	4078.393235			
		ELA AAR	2.365	4120-4080		
		ELA THAR	4200			

	Glacier Near Rohtang					
Sl.No.	Contour Interval	Mid point (Hi)	Area sq. km (Ai)	cumulative	Ai*Hi	
1	4840-4800	4820	0.02	0.02	96.40	
2	4800-4760	4780	0.15	0.17	717.00	
3	4760-4720	4740	0.21	0.38	995.40	
4	4720-4680	4700	0.1	0.48	470.00	
5	4680-4640	4660	0.15	0.63	699.00	
6	4640-4600	4620	0.17	0.8	785.40	
7	4600-4560	4580	0.15	0.95	687.00	
8	4560-4520	4540	0.22	1.17	998.80	
9	4520-4480	4500	0.22	1.39	990.00	
10	4480-4440	4460	0.29	1.68	1293.40	
11	4440-4400	4420	0.3	1.98	1326.00	
12	4400-4360	4380	0.2	2.18	876.00	
13	4360-4320	4340	0.22	2.4	954.80	
14	4320-4280	4300	0.22	2.62	946.00	
15	4280-4240	4260	0.2	2.82	852.00	
16	4240-4200	4220	0.17	2.99	717.40	
17	4200-4160	4180	0.13	3.12	543.40	
18	4160-4120	4140	0.14	3.26	579.60	
19	4120-4080	4100	0.15	3.41	615.00	
20	4080-4040	4060	0.08	3.49	324.80	
21	4040-4000	4020	0.05	3.54	201.00	
22	4000-3960	3980	0.02	3.56	79.60	
23	3960-3920	3940	0.01	3.57	39.40	
24	3920-3880	3900	0.01	3.58	39.00	
			3.58		15826.40	
		ELA AWM	4420.782123			
		ELA AAR	1.79	4440-4400		
		ELA THAR	4360			

		Hnuman Tibba Glacier				
Sl.No.	Contour Interval	Mid point (Hi)	Area sq. km (Ai)	cumulative	Ai*Hi	
1	5640-5600	5620	0.01	0.01	56.20	
2	5600-5560	5580	0.02	0.03	111.60	
3	5560-5520	5540	0.02	0.05	110.80	
4	5520-5480	5500	0.02	0.07	110.00	
5	5480-5440	5460	0.03	0.1	163.80	
6	5440-5400	5420	0.03	0.13	162.60	
7	5400-5360	5380	0.04	0.17	215.20	
8	5360-5320	5340	0.05	0.22	267.00	
9	5320-5280	5300	0.03	0.25	159.00	
10	5280-5240	5260	0.04	0.29	210.40	
11	5240-5200	5220	0.04	0.33	208.80	
12	5200-5160	5180	0.07	0.4	362.60	
13	5160-5120	5140	0.04	0.44	205.60	
14	5120-5080	5100	0.49	0.93	2499.00	
15	5080-5040	5060	0.53	1.46	2681.80	
16	5040-5000	5020	0.66	2.12	3313.20	
17	5000-4960	4980	0.54	2.66	2689.20	
18	4960-4920	4940	0.51	3.17	2519.40	
19	4920-4880	4900	1.01	4.18	4949.00	
20	4880-4840	4860	1.76	5.94	8553.60	
21	4840-4800	4820	0.59	6.53	2843.80	
22	4800-4760	4780	0.05	6.58	239.00	
23	4760-4720	4740	0.73	7.31	3460.20	
24	4720-4680	4700	0.5	7.81	2350.00	
25	4680-4640	4660	0.27	8.08	1258.20	
26	4640-4600	4620	0.32	8.4	1478.40	
27	4600-4560	4580	0.17	8.57	778.60	
28	4560-4520	4540	0.07	8.64	317.80	
29	4520-4480	4500	0.01	8.65	45.00	
30	4480-4440	4460	0.01	8.66	44.60	
31	4440-4400	4420	0.01	8.67	44.20	
32	4400-4360	4380	0.01	8.68	43.80	
33	4360-4320	4340	0.01	8.69	43.40	
			8.69		42495.80	
			ELA AWM	4890.196		
			ELA AAR	4.345	4880-4840	
			ELA THAR	4980		

	Jobri Glacier (Eastern Cander)					
Sl.No.	Contour Interval	Mid point (Hi)	Area sq. km (Ai)	cumulative	Ai*Hi	
1	5400-5360	5380	0.02	0.02	107.60	
2	5360-5320	5340	0.03	0.05	160.20	
3	5320-5280	5300	0.03	0.08	159.00	
4	5280-5240	5260	0.03	0.11	157.80	
5	5240-5200	5220	0.08	0.19	417.60	
6	5200-5160	5180	0.09	0.28	466.20	
7	5160-5120	5140	0.14	0.42	719.60	
8	5120-5080	5100	0.15	0.57	765.00	
9	5080-5040	5060	0.19	0.76	961.40	
10	5040-5000	5020	0.22	0.98	1104.40	
11	5000-4960	4980	0.30	1.28	1494.00	
12	4960-4920	4940	0.64	1.92	3161.60	
13	4920-4880	4900	0.68	2.60	3332.00	
14	4880-4840	4860	0.61	3.21	2964.60	
15	4840-4800	4820	0.44	3.65	2120.80	
16	4800-4760	4780	0.42	4.07	2007.60	
17	4760-4720	4740	0.26	4.33	1232.40	
18	4720-4680	4700	0.22	4.55	1034.00	
19	4680-4640	4660	0.22	4.77	1025.20	
20	4640-4600	4620	0.23	5.00	1062.60	
21	4600-4560	4580	0.21	5.21	961.80	
22	4560-4520	4540	0.24	5.45	1089.60	
23	4520-4480	4500	0.11	5.56	495.00	
24	4480-4440	4460	0.19	5.75	847.40	
25	4440-4400	4420	0.21	5.96	928.20	
26	4400-4360	4380	0.13	6.09	569.40	
27	4360-4320	4340	0.11	6.20	477.40	
28	4320-4280	4300	0.02	6.22	86.00	
29	4280-4240	4260	0.09	6.31	383.40	
30	4240-4200	4220	0.03	6.34	126.60	
31	4200-4160	4180	0.09	6.43	376.20	
32	4160-4120	4140	0.13	6.56	538.20	
33	4120-4080	4100	0.12	6.68	492.00	
34	4080-4040	4060	0.27	6.95	1096.20	
35	4040-4000	4020	0.26	7.21	1045.20	
36	4000-3960	3980	0.39	7.60	1552.20	
37	3960-3920	3940	0.26	7.86	1024.40	
38	3920-3880	3900	0.33	8.19	1287.00	
39	3880-3840	3860	0.22	8.41	849.20	
40	3840-3800	3820	0.18	8.59	687.60	
41	3800-3760	3780	0.19	8.78	718.20	
42	3760-3720	3740	0.12	8.90	448.80	
			8.90		40533.60	
			ELA AWM	4554.337		
			ELA AAR	4.45	4720-4680	
		Advance	ELA THAR	4560		
	3720-3680	3700	0.04		148.0	
	3680-3640	3660	0.26		951.6	
	3640-3600	3620	0.25		905.0	
	3600-3560	3580	0.21		751.8	
	3560-3520	3540	0.21		743.4	
	3520-3480	3500	0.03		105.0	
			9.90		44138.4	
				ELA AWM	4458.424	