

# ***DISTRICT GROUND WATER BROCHURE OF BAGESHWAR DISTRICT, UTTARAKHAND***

## ***BAGESHWAR DISTRICT AT A GLANCE***

### **1. GENERAL INFORMATION**

**1.1 Geographical area** 1687.8 km<sup>2</sup>

#### **1.2 Administrative Divisions**

District Headquarter Bageshwar

Number of Tehsil 4

Number of Blocks 3

Number of Villages 902

Number of Villages (Inhabited) 883

Number of Nyay Panchayats 35

#### **1.3 Population (Census, 2001)**

Total population 2,49,462

Male population 1,18,510

Female population 1,30,952

Population density 108 per km<sup>2</sup>

Population of Scheduled Caste 64524

Population of Scheduled Tribe 1943

#### **1.4 Rainfall**

Total Annual Rainfall at Bageshwar Town (Period: 2000-01) 1611 mm

Total Annual Rainfall at Kausani (Year: 2002) 1057 mm

Average number of Rainy Days (Daily Rainfall  $\geq$  2.5 mm) 87.6 days

### **2. GEOMORPHOLOGY**

Major physiographic units Central Himalayan Zone and Lesser Himalayan Zone

Major Drainage Saryu, Gomti and Pindar Rivers

### **3. LAND USE**

(a) Forest area 1101.60 km<sup>2</sup>

(b) Net Sown Area 240.24 km<sup>2</sup>

(c) Cultivable area 168.74 km<sup>2</sup>

#### 4. MAJOR SOIL TYPES:

1. Soils of Lesser Himalaya: (a) Soils of Summits and Ridge Tops, (b) Soils of Side Slopes, (c) Soils of Glacio-fluvial Valleys, (d) Soils of Fluvial Valleys and (e) Soils of Cliffs
2. Soils of Central Himalaya: (a) Soils of Summits, Ridge Tops and Mountain Glaciers, (b) Soils of Side Slopes, (c) Soils of Upper Glacio-fluvial Valleys and (d) Soils of Cliffs

#### 5. AREA UNDER PRINCIPAL CROPS

5.1 Rabi	19236 ha
5.2 Kharif	24024 ha
5.3 Total	43260 ha

#### 6. IRRIGATION BY DIFFERENT SOURCES

6.1 Dug Wells	Nil
6.2 Tube Wells/Bore Wells	Nil
6.3 Length of Canal	382 km
6.4 Hauj	927
6.5 Hydrum	87
6.6 Surface Pump Set	34
6.7 Area under Canal Irrigation	14 58 ha
6.8 Area irrigated by other sources	2635 ha
6.9 Net Irrigated Area	4093 ha
6.10 Gross Irrigated Area	8186 ha

#### 7. NUMBER OF GROUND WATER MONITORING WELLS OF CGWB

7.1 Number of Dug Wells	Nil
7.2 Number of Piezometers	Nil

**8. PREDOMINANT GEOLOGICAL FORMATIONS:** Central Crystallines, Jutogh Group – Nappe, Rautgara Formation, Tejam Formation, Berinag Formation and Granitoids of Almora-Ramgarh Group (after Geological Survey of India)

#### 9. HYDROGEOLOGY

**9.1 Fissured Formation of Lesser Himalaya** (comprising shale, quartzite, slate, phyllite, sandstone, dolomite, limestone) - **Local or Discontinuous Aquifers:**

Transmissivity – Not Available, Yield – Low (1 to 5 LPS)

**9.2 Fissured Formation of Central Himalaya** (Central Crystallines comprising gneiss, schist, migmatite, amphibolite, quartzite and granites of variable ages) – **Localised Aquifers:**  
Transmissivity – Not Available, Yield – Very Low (<1 LPS)

## 10. GROUND WATER QUALITY

10.1 Presence of Chemical Constituents more than the Maximum Permissible Limits of BIS: EC – not reported, Fluoride – 1.70 mg/L reported from a Hand Pump in Baijnath, Garur block (possibly of local nature), Arsenic – not reported, Iron – not analysed.

10.2 Type of ground water: Suitable for drinking and domestic use, almost all samples falling under C<sub>1</sub>S<sub>1</sub> Class except for three samples falling under C<sub>2</sub>S<sub>1</sub> Class (US Salinity Classification)

## 11. WATER AVAILABILITY AND GROUND WATER POTENTIAL

11.1 Number of Villages Covered by India Mark-II Hand Pumps	858
11.2 Number of India Mark-II Hand Pumps installed by Uttarakhand Jal Sansthan	75
11.3 Annual Ground water Resource by RIF Method	4723.1 ham

## 12. MASS AWARENESS AND TRAINING ACTIVITY

12.1 Number of Mass Awareness Programmes organized	Nil
12.1 Number of Water Management Training Programmes organized	Nil

## 13. EFFORTS OF ARTIFICIAL RECHARGE AND RAINWATER HARVESTING

13.1 Projects completed by CGWB	Nil
13.2 Projects under technical guidance of CGWB: One, undertaken by AVANI (an NGO), Tripuradevi, Berinag block, Pithoragarh district. Construction of one Storage Tank (Capacity: 40,000 litre) and Two Toilets at Remote Rural Government Schools were undertaken under the funding from the Ministry of Water Resources. The work was completed at Primary Schools in four villages viz. Saukura, Simayal, Chantola and Mahrori.	

## 14. GROUND WATER CONTROL AND REGULATION

14.1 Number of Over Exploited Blocks	Nil
14.2 Number of Critical Blocks	Nil
14.3 Number of Blocks Notified	Nil

## 1. INTRODUCTION

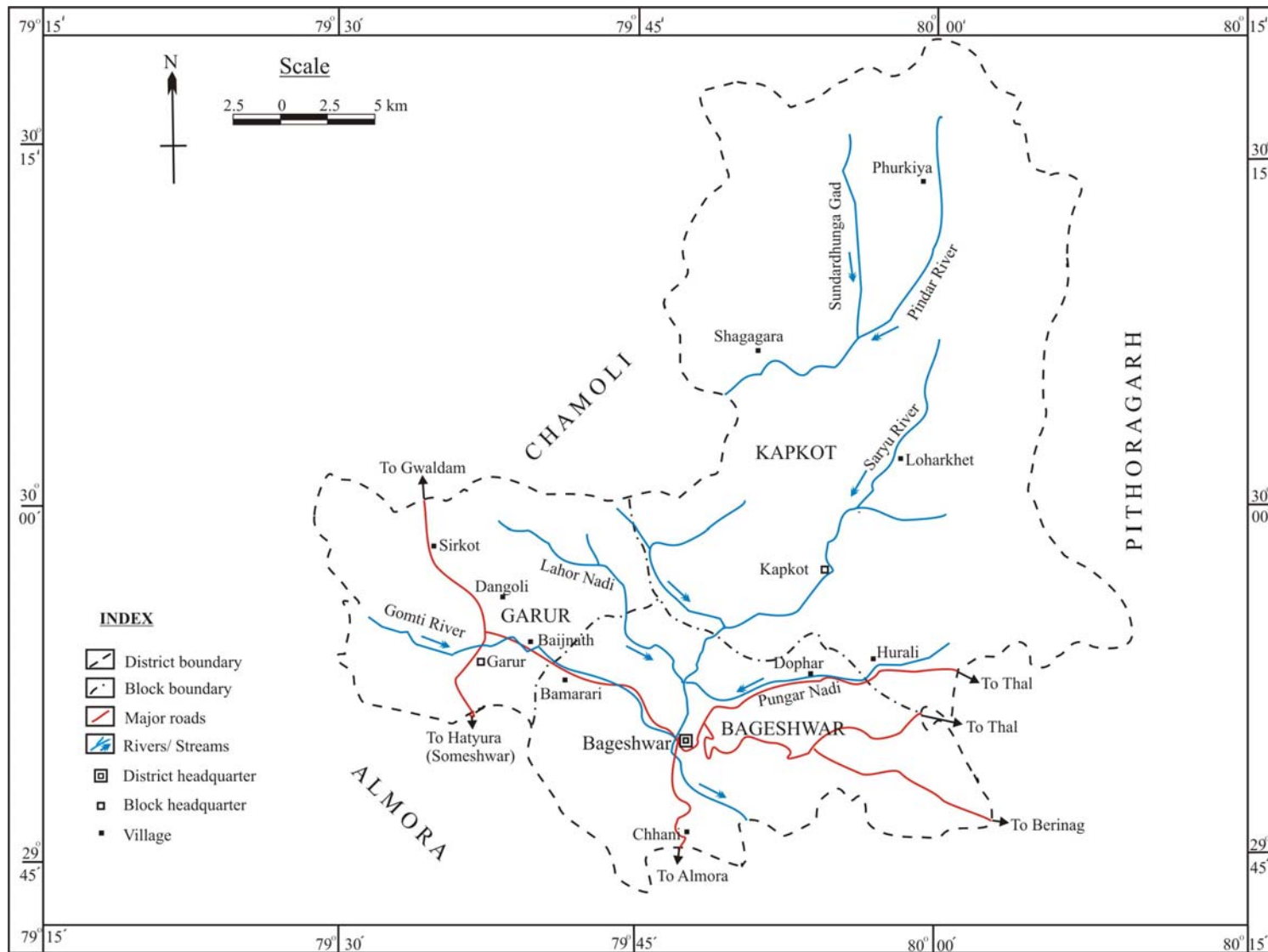
Bageshwar is one of the mountainous districts of Uttarakhand State. Prior to its formation as a separate district, Bageshwar constituted a part of Almora district. The district was included in Uttarakhand State after the state was carved out of Uttar Pradesh on 9<sup>th</sup> November 2000. The district lies between latitudes 29°40' and 30°20' N and longitudes 79°25' and 80°10' E (Survey of India Degree Sheet Nos. 53N and 53O). The district is bounded by Almora district in the south, Chamoli district in the north and northwest and Pithoragarh district in the east. The geographical area of the district is 1687.8 km<sup>2</sup> (Census, 2001).

**1.1 Accessibility:** The district is well connected with Dehradun, the capital of Uttarakhand State, by a network of metalled roads via Hardwar-Kashipur-Haldwani-Almora (NH-72, 74 and 87) and also via Rudraprayag-Gwaldam-Garur (NH-58). Bageshwar town is well connected by road with Almora (90 km), Nainital (137 km), Chaukori (47 km) and Baijnath (26 km). A number of motorable roads, unmetalled roads and cart tracks connect different villages with prominent places of the district. The total length of metalled roads in the district (Period 2002-03) was 488 km. The Uttarakhand Transport Corporation Limited provides bus facilities to most of the important routes. The nearest airport is at Pantnagar (206 km from Bageshwar) and the nearest railway station is at Kathgodam (180 km from Bageshwar).

**1.2 Administrative Details:** For the administrative convenience Bageshwar district, a part of Kumaon Division, has been divided into four tehsils viz. Bageshwar, Kapkot, Kanda (Sub-tehsil) and Garur and three blocks viz. Bageshwar, Garur and Kapkot. There are 902 villages on record, out of which 883 villages are inhabited and the rest are uninhabited. As per Census, 2001 there is one town (Bageshwar) whereas the number of Forest Habitation, Nyay Panchayats and Gram Panchayats are two, thirty five and three hundred and sixty three respectively during the year 2006. The Base Map of Bageshwar district is given in **Fig. 1**.

**1.3 Land Use:** The salient features of land use data for Bageshwar district is given below:

Forest Area	110160 ha
Land under Cultivation	42089 ha
Agriculturnable Barren Land	16874 ha
Total Fallow Land	2813 ha
Non-cultivable Land	6847 ha
Land under non-agricultural Use	4705 ha

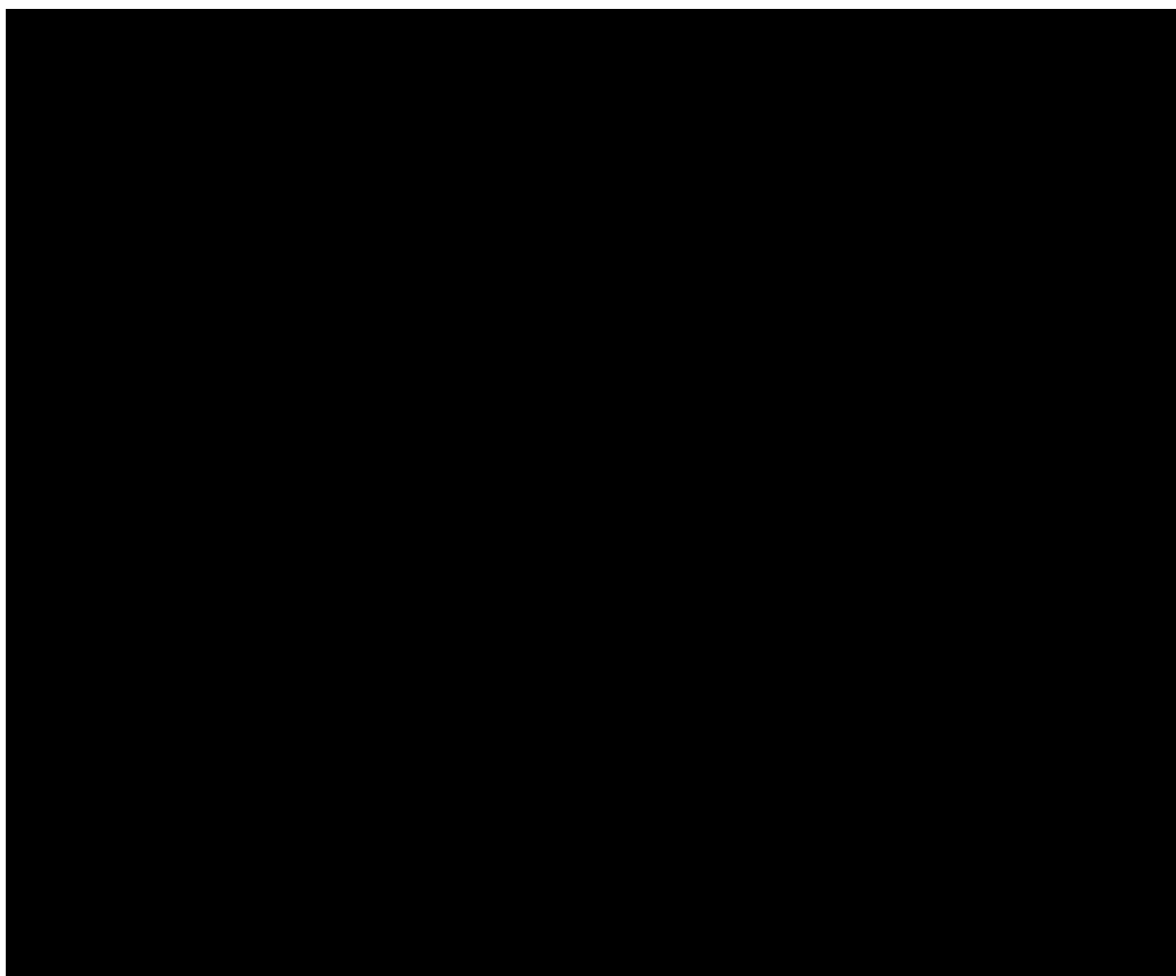


**Fig. 1. Base Map of Bageshwar district, Uttarakhand**

### Land Use Data of Bageshwar district (contd.)

Pasture Land	27504 ha
Area under Gardens, Bushes, Groves etc.	20706 ha

The area wise break up of land use pattern is represented as a pie chart (**Fig. 2**). A study of the figure reveals that majority of the district (58%) is under forest cover followed by pasture land (15%) and area under gardens, bushes and groves (11%). The total fallow land (current fallow and other fallow) accounts for only 1%, which indicates that maximum area is utilised for agricultural use or for some other purpose.



**Fig. 2. Land Use pattern in Bageshwar district**

#### **1.4 Agriculture**

Agriculture is the main occupation of the people. However, intensive cultivation is not possible as major part of the district is mountainous. Agricultural activities are common on gentle hill slopes and in relatively plain, broad river valleys of Gomti and Saryu Rivers. Rice, wheat, mandua, barley,

maize and sawan are the principal crops grown in the district. Garur valley has the maximum cultivated area. Due to high production of rice, the area is known as "Rice Bowl of Kumaun". The salient features of agricultural statistics in the district are given below:

Gross Sown Area	43260 ha
Net Sown Area	24024 ha
Percentage of Gross Sown Area against Net Sown Area (Cropping Intensity)	180.07%
Gross Sown Area under Rabi Crops	19236 ha
Gross Sown Area under Kharif Crops	24024 ha
Production of Food Grains	63851 Mt

Rice is the major crop grown in 38% of the net sown area closely followed by wheat, which is grown in 35% of the area. Apart from this, other major crops are mandua (18%), barley (6%), sawan (2%) and maize (1%).

### **1.5 Irrigation**

Major sources to develop irrigation potential are Gomti, Saryu and Pindar Rivers and some of their tributaries like Pungar Nadi and Lahor Nadi. These rivers are main source for Bimola Canal, Mandalseera Canal and Kathayatbara Canal. The salient features of agricultural statistics in the district are as under:

Gross Irrigated Area	5429 ha
Net Irrigated Area	4093 ha
Net Irrigated Area through Canals	1458 ha
Net Irrigated Area through Other sources	2635 ha
Total Number of Canals (Irrigational)	127
Total length of Canals (Irrigational)	382 km
Percentage of Gross Irrigated Area against Net Irrigated Area (Irrigation Intensity)	132.64 %
Total Number of Surface Pump Sets	34
Total Number of Hauj	927
Total Number of Hydrum	87
Total Number of Surface Lift Schemes	47
Total area irrigated under Surface Water Irrigation	8111.568 ha

Canal irrigation is utilised for growing both Rabi and Kharif crops. Besides the conventional methods of irrigation, a total of 47 surface lift

schemes are constructed (Minor Irrigation Census, 2001) out of which 37 are operational. The total irrigation potential created through the lift schemes is 816 ha while the irrigation potential actually used by them is 610 ha (74.75% of the total potential). The absence of dedicated ground water irrigation schemes (comprising dug wells, dug-cum-bore wells, borings, private shallow tubewells, filter points and deep tubewells) in Bageshwar district is a major handicap for developing ground water resource for irrigational purposes. Hence only surface irrigation schemes (surface flow schemes like guls and surface lift schemes like hydrams) mainly cater to the irrigational needs of the local populace.

### **1.6 Drainage**

Drainage of the area is mainly controlled by Saryu, Gomti and Pindar Rivers and their tributaries (locally called Nadi, Gad or Gadhera) viz. Pungar Nadi, Khir Ganga Nadi, Bhadrapati Nadi, Revti Ganga, Kanal Gad, Lahor Nadi, Jagtana Gad, Kulur Gad, Sukunda Gad etc. Sub-trellis, sub-rectangular and sub-dendritic are the most common drainage patterns in the area. The Central and North-Central parts of the district are drained by Saryu River. Gomti River drains the western and south eastern parts whereas Pindar River drains the northern part. These rivers are primarily fed by snowmelt with relatively smaller contribution from ground water. However, during the lean period, the rivers are fed by ground water occurring as base flow. The drainage map of the district is given as **Fig. 3**.

### **1.7 Previous Work**

Since the district was a part of Almora district before its inception, a number of hydrogeological investigations were carried out by the officers of Central Ground Water Board from time to time. Among these, systematic hydrogeological surveys were undertaken by Venkatesan and Bhattacharya during the AAP 1975-76 and 1976-77 covering an area of 145 km<sup>2</sup> and 1180 km<sup>2</sup> respectively. A total of 110 springs were studied during the course of investigation. Later, an area of 1400 km<sup>2</sup> was covered by Bhattacharya during the AAP 1977-78 and 1978-79 when one hundred cold water springs and two groups of warm water sulphur springs were studied in Almora district (Zaidi, 1995). Apart from this, state government departments like Uttarakhand Jal Sansthan, Uttarakhand Peyjal Sansadhan Vikas Evam Nirman Nigam (Jal Nigam) and Minor Irrigation Department have also constructed a number of water supply and ground water abstraction structures (e. g. hand pump, guls, hydrams etc.) for domestic and irrigational purpose.

## **2. RAINFALL AND CLIMATE**

The climate in Bageshwar district is temperate to sub-humid. The northern part of the district experiences sub-zero temperature almost throughout the year whereas the central and southern parts are comparatively warm and humid. Severe winter is the chief climatic feature in the district. In



general, the district experiences a tropical to sub-tropical and sub-humid climate except for the northern part where a cold temperate climate prevails.

### **2.1 Temperature, Relative Humidity and Wind**

January is the coldest month with mean maximum temperature of 10°C, the mean minimum temperature being about 2°C. Temperature drops down to – 6°C during January and February in the northern part of the district. June is the warmest month with the mean maximum and the mean minimum temperatures of 25°C and 15°C respectively. The maximum temperature recorded in the district was 43°C (May 2003) whereas the minimum temperature recorded was 4°C (January 2003).

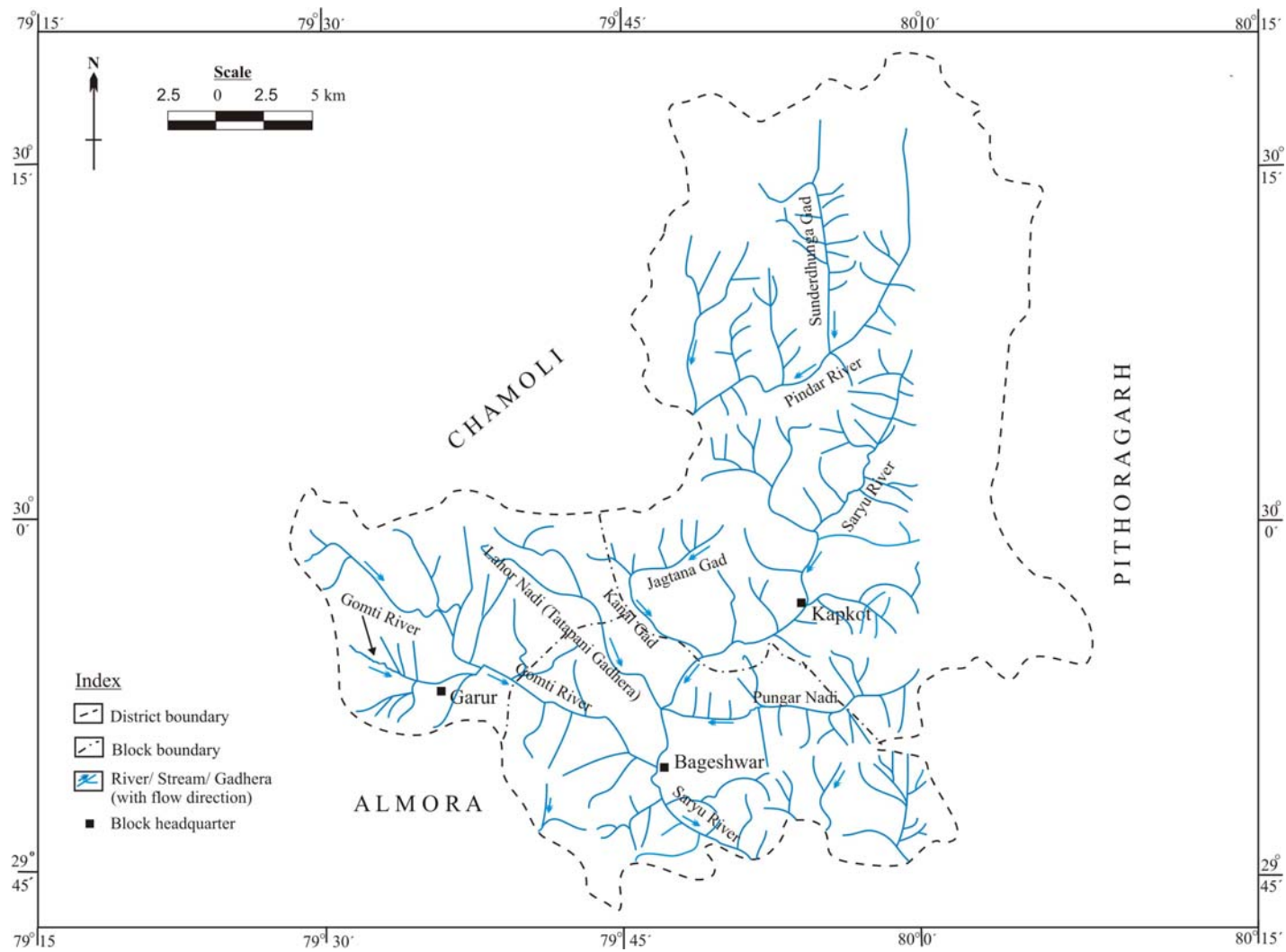
The Relative Humidity increases rapidly with the onset of monsoon and reaches at about 80% during July to September. The driest part of the year is the pre-monsoon period, when the humidity is as low as 30% in the afternoons. Skies are heavily clouded during the monsoon months and for short spells when the district is affected by Western Disturbances. Two broad wind patterns are observed in the district viz. north easterly to easterly (May to September) and south easterly to westerly (October to March).

### **2.2 Rainfall**

Most of the rainfall, about 75% of the annual value, occurs during monsoon months of June to September. July is the rainiest month followed by August. In September, depressions from Bay of Bengal occasionally reach Uttarakhand and affect the weather of Bageshwar district also. This phenomenon may cause heavy rains. With the withdrawal of monsoon in September, the intensity of rainfall rapidly decreases. The decrease continues till November, which is a practically rainless month. Winter precipitation is associated with the passage of the Western Disturbances and is in the form of snowfall over higher elevations. The monthly and annual normal rainfall data of Kausani Rain Gauge Station for the period 1997-2002 shows that the annual rainfall ranges from 1051 to 1705 mm and the Annual Average Rainfall is 1331.4 mm. The monthly rainfall data from the rain gauge station also reveals that the maximum rainfall (460.4 mm) was received in July 2001 whereas the minimum rainfall (355.8 mm) was observed in June 2000.

## **3. GEOMORPHOLOGY AND SOIL TYPES**

Bageshwar district comprises two broad physiographic divisions from north to south viz. Central Himalayan Zone (north of the Main Central Thrust) and Lesser Himalayan Zone (south of the Main Central Thrust). The area shows an extremely rugged topography characterised by precipitous hills and deep gorges with sharp variation of high magnitude in surface relief. The general slope is towards south. In the northern parts the elevation of the land surface ranges from about 3000 m to 6861 m above mean sea level whereas in the valleys of southern part, the altitude is as low as 795 m. The soils of Bageshwar district can be broadly classified into two types, viz. Soils of



**Fig. 3. Drainage network in Bageshwar district, Uttarakhand**

Lesser Himalaya and Soils of Greater or Central Himalaya. Majority of the area is covered by the first type. The soils in this area are exposed in massive mountainous tracts and tangled mass of series of ridges divided from each other by deep, narrow valleys. The soils of Lesser Himalaya are further subdivided into a) Soils of Summits and Ridge tops, b) Soils of Side Slopes, c) Soils of Glacio-Fluvial Valleys, d) Soils of Fluvial Valleys and e) Soils of Cliffs. The soils of Greater Himalaya have been broadly classified under a) Soils of Summits, Ridge Tops and Mountain Glaciers, b) Soils of Side Slopes, c) Soils of Upper Glacio-Fluvial Valleys and d) Soils of Cliffs.

## **4. GEOLOGY**

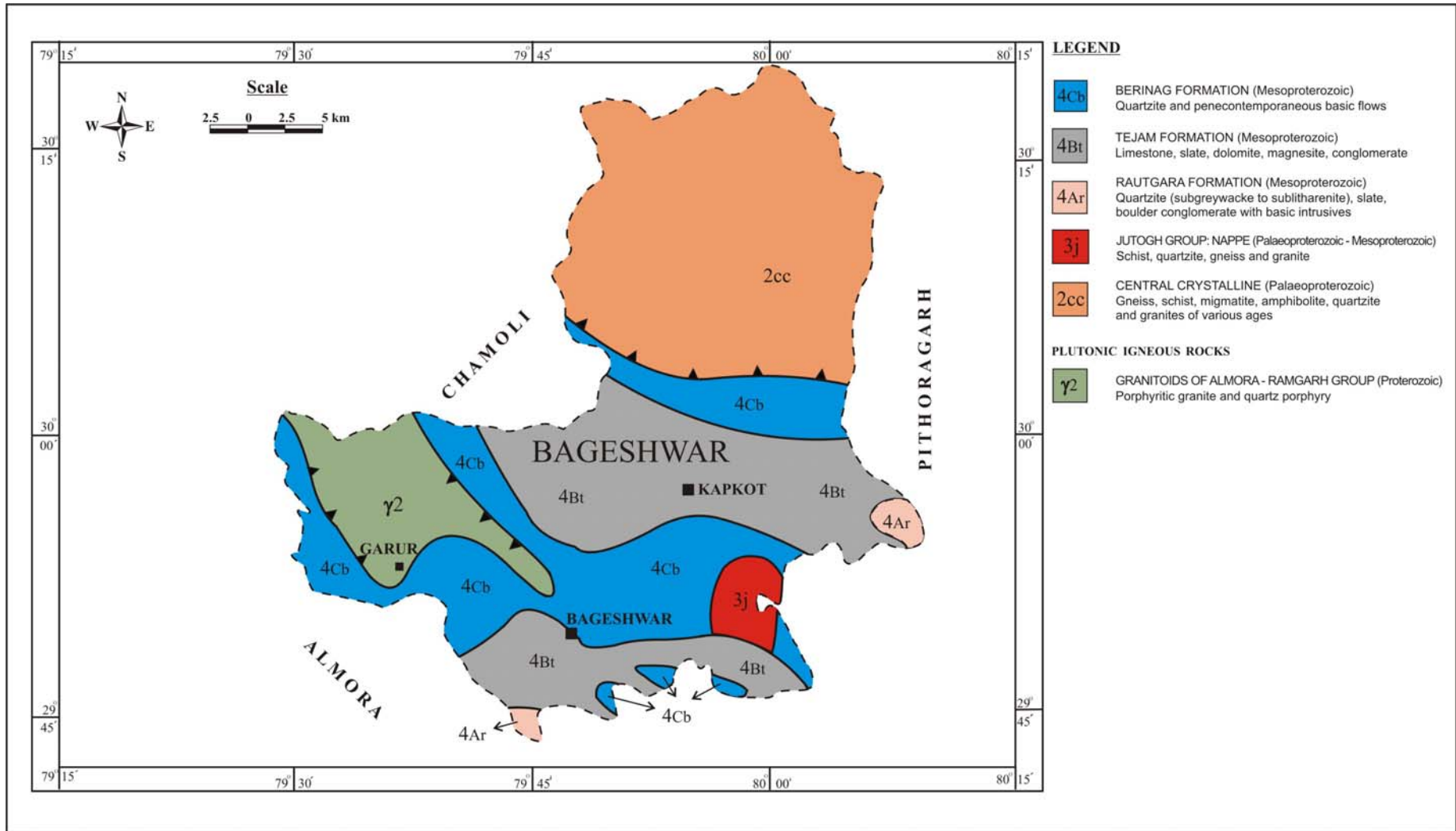
District Bageshwar is mainly represented by the rocks of Lesser Himalaya and Central Himalaya. The geological set up is very complex due to the repeated tectonic disturbances caused by different orogenic cycles. Valdiya (1980) carried out extensive geological and structural mapping in the area. The salient features of geology are depicted in the geological map of Bageshwar district (**Fig. 4**). The map is based on Geological Survey of India, 2002.

The rock units exposed in various parts of Bageshwar district comprise current-bedded quartzite with associated volcanics, mica-talc schist, limestone, conglomerate, slate, quartzite, granodiorite, augen gneiss, migmatite and granite gneiss. Many areas in the northern part of the district are yet to be mapped by conventional field methods due to inaccessibility and permanent snow cover. However, a group of regionally metamorphosed rocks known as the Central Crystallines are exposed in this area. The Central Crystallines of the Central Himalayan Zone occur as thrust sheets over the metasedimentary and sedimentary rocks of Lesser Himalayan Zone in varied tectonic settings. Major rock types of Central Crystallines are migmatites, psammitic and mica gneiss, calc gneiss, quartzite, marble, mica schist and amphibolite. Granites of different ages ranging from Paleoproterozoic to Mesozoic-Tertiary intrude the Central Crystallines. Major parts of Bageshwar district falls under the geotectonic zone known as the Lesser Himalaya. Rock types in the Lesser Himalayan Zone include sedimentaries, metasedimentaries and plutonic igneous rocks. The various rock units have suffered multiple phases of deformation and metamorphism in major parts of the district.

## **5. GROUND WATER SCENARIO**

### **5.1 HYDROGEOLOGY**

Ground water, in general, occurs locally within disconnected bodies under favourable geohydrological conditions such as in channel and alluvial terraces of river valleys, joints, fractures and fissures of crystalline and metasedimentary rocks, well vegetated and relatively plain areas of valley regions and in subterranean caverns of limestone and dolomitic limestone



**Fig. 4. Geological map of Bageshwar district, Uttarakhand**

country rocks. The occurrence and movement of ground water depend not only on the nature of the litho units and the nature of the interspaces/interstices, but also on the degree of interconnection between them, the vertical and aerial extension of joints, faults and/or shear zones and the local and regional geomorphology. Ground water emerges as springs and seepage (locally called Srots and Naolas) under favourable physiographic conditions such as in gently sloping areas, broad valleys of rivers and along the lithological contacts.

Rainfall is the principal source of ground water replenishment. Out of the total annual rainfall (1611 mm), the southern and central parts of the district receive considerable amount of precipitation. A part of the precipitation is lost into the atmosphere as evaporation and evapotranspiration from soils and plants, another considerable part flows as surface run off due to extremely rugged and undulating topography with steep slope and the remaining part directly infiltrates through the soil profile to form the ground water storage in joints, fractures, fissures etc. In hilly areas, ground water flows out as springs and seepage where the water table intersects the ground surface. Based on the observations of various workers of Central Ground Water Board over the last couple of decades, a hydrogeological map of Bageshwar district is prepared (**Fig. 5**). A study of this map indicates the general hydrogeological scenario of the district and reveals that two main types of aquifers are present in the district viz. a) Local or Discontinuous Aquifers and b) Localised Aquifers. Ground water in the district occurs in fissured formations characterised by secondary porosity. A brief description of the main types of aquifers is given below:

**5.1.1 Local or Discontinuous Aquifers:** These aquifers occur within the Lesser Himalayan Zone and are seen as a wide patch in the central part and small, isolated areas in the western part and the southern tip of the district. Ground water in these areas occurs generally under unconfined to semi-confined conditions in the sedimentary rocks (sandstone, shale and limestone), metasedimentary and low-grade metamorphic rocks like dolomite, slate, phyllite, quartzite etc. Calcareous rocks like limestone and dolomite host ground water in solution cavities and subsurface channels of limited areal extent. Aquifer characteristics are not available in this area, as no pumping test has been carried out so far. However, a study of the springs and naolas indicates that in general, the yield is low and varies from 1 to 5 litre per second (lps).

**5.1.2 Localised Aquifers:** A study of the hydrogeological map of the district reveals that the localised aquifers are mainly restricted to the Central Himalayan Zone north of the Main Central Thrust. Localised aquifers are also seen in parts of the Lesser Himalayan Zone in the south western part of the district (parts of Garur and Bageshwar blocks). Occurrence of ground water in localised aquifers is very restricted because of the nature of hard, crystalline rocks. Compact and massive crystalline igneous rocks (granite, granodiorite etc.) and medium to high-grade metamorphic rocks (gneiss, amphibolite,

quartzite etc) contain very little ground water in the secondary porosity of fractures, joints and fissures of limited vertical and areal extent. Study of a few spring shows that, as expected, yield of localised aquifers are very low, i.e. even less than 1 lps.

### **5.1.3 Study on Springs**

The hydrogeology of different formations in Bageshwar district, based on hydrogeological behaviour of springs and seepage areas/naolas occurring in different rock types is given below:

**a) Quartzites of Outer and Inner Sedimentary Belt:** Four cold-water springs were studied. The springs are located on road side slopes and their discharge during the Pre-monsoon period varies from 0.07 lps at Harsila to 0.09 lps at a place about 3 km NE of Harsila on Bageshwar-Kapkot road. The temperature of spring water during Pre-monsoon period varies from 18.0°C at Harsila to 20.2°C about 1 km south of Gwaldam on Baijnath-Gwaldam road.

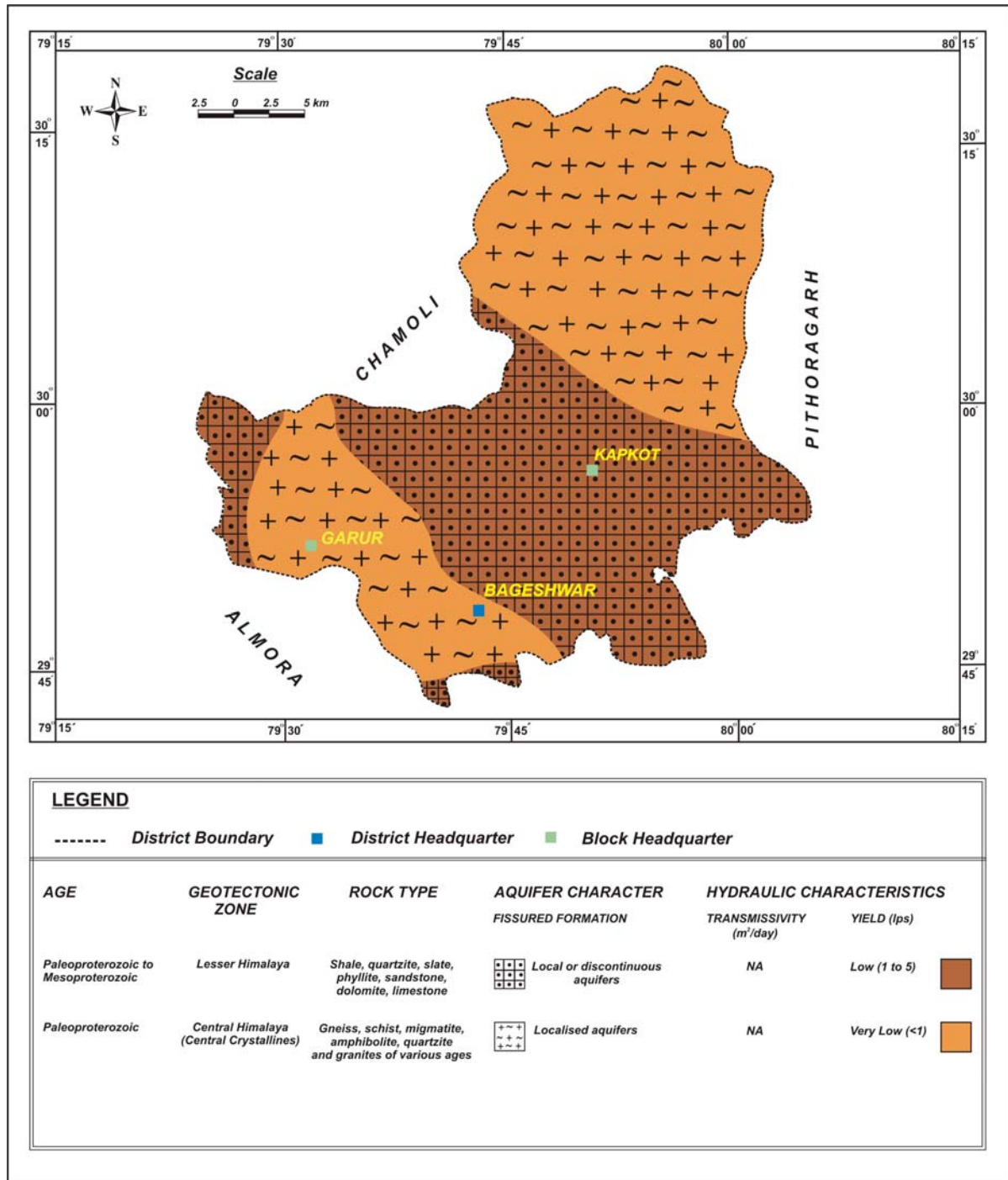
**b) Schist:** Fourteen cold-water springs and naolas were studied. The naolas are located in relatively plain areas such as valley floors and agricultural land. The discharge of the springs/naolas during Pre-monsoon period varies from negligible in naolas (i.e. <0.001 lps) at several villages like Chhani, Jhalamali, Kapkot and Titatappar to a maximum of 0.13 lps at Dharkhola. The Pre-monsoon water temperature of springs and naolas ranges between 18.0 and 25.5°C whereas the Post-monsoon temperature ranges from 18.0 to 20.0°C.

**c) Granite:** Seven cold-water springs, emerging from granite, through joints and fractures, were studied. The discharge during Pre-monsoon period in these springs varies from negligible to a maximum of 0.22 lps. Two naolas showed negligible discharge, one is located up slope of Baijnath-Gwaldam road within weathered granite in association with schistose rocks (phyllites and mica schist) and the other down slope of road and about 200 m east of the previous naola. The water temperature in the springs and naolas varies between 19.7 and 26.6°C.

**d) Granite gneiss:** Twelve cold-water springs and naolas were studied. Out of these, one naola, located about 3 km SW of Garur on Baijanth-Kausani road, was found completely dry during both during Pre-monsoon and Post-monsoon periods. During the Pre-monsoon period, the discharge of the springs and naolas generally varies from 0.06 to 0.22 lps. The post-monsoon discharge varies from negligible at several villages like Darsani, Ratamatiya, Kaulag, Dangoli and Laubanj to a maximum of 0.02 lps at Baijnath. The water temperature of springs and naolas ranges from 21.2 to 26.0°C during Pre-monsoon period. The Post-monsoon water temperature ranges from 16.5 to 20.0°C.

**e) Weathered schist and phyllite:** Twelve cold water springs and naolas were studied in Bageshwar district. The discharge of naolas was negligible even during the Post-monsoon period at villages Darsani and Jiltoli. Three naolas studied in village Gale (Galo) on Baijnath-Gwaldam road also showed negligible discharge. The maximum discharge recorded in this formation is 0.08 lps at Ghanghali followed by 0.05 lps at Gagarigol during Post-monsoon period. The water temperature ranges from 14.0 to 20.0°C. The temperature

of water samples revealed all naolas/springs are cold water. No thermal spring is reported in Bageshwar district.



**Fig. 5. Hydrogeological Map of Bageshwar district, Uttarakhand**

#### 5.1.4 Study on Hand Pumps

Apart from the development of springs for drinking water supply, Uttarakhand Jal Sansthan, Kumaun Division, has installed a number of India Mark-II hand pumps. As on 31<sup>st</sup> March 2001, a total of 860 villages and one town (Bageshwar) were covered under water supply scheme by the India

Mark-II hand pumps. The Uttarakhand Pey Jal Sansadhan, Vikas Evam Nirman Nigam (popularly known as Jal Nigam) looks after the supply, distribution and maintenance of water for drinking, domestic and industrial uses.

Hand pumps are extensively used by the local people for drinking and domestic works and are preferred over springs and naolas, which sometimes become the places of solid and liquid waste disposal thereby making ground water contaminated. It is further observed that most of the hand pumps are located close to the places where the nalas intersect the roads/mule tracks, which are sometimes damaged during the flash floods when torrential flow of surface water from the hills gushes down slope.

Out of 75 hand pumps installed by Uttarakhand Jal Sansthan in the district from March 2003 to June 2004, 38 are located in Bageshwar block, 17 in Kapkot block and 20 in Garur block. The drilled depth of the hand pumps varies from 32.22 to 121.95 m and their discharge varies from 15 to 30 LPM. The strata charts of three hand pumps installed in village Darsani, Dharamghar and Kathpuriya Chhina show the presence of bouldary formation at shallow depth and hard, massive formations at deeper levels. The static water levels observed in the hand pumps during January 2002 are 57.90 m bgl at Darsani, 18.30 m bgl at Dharamghar and 53.35 m bgl at Kathpuriya Chhina.

## **5.2 GROUND WATER RESOURCES**

Ground water is an important component of total water supply in an area. However, due to hilly tracts, its utilisation in a major part of Bageshwar district is much less than the desired level. Besides, the complex hydrogeological set-up coupled with lack of hydrogeological database hampers precise estimation of ground water resource potential and its development in the district. Estimation of annual ground water recharge as per the standard norms of Ground water Estimation Committee (GEC, 1997) is not possible. However, considering rainfall as the principal source of recharge, estimation of annual ground water recharge has been done on ad hoc norms by Rainfall Infiltration Factor (RIF) method. The rates of infiltration for variety of rock formations exposed in the district are unknown. Considering the general geology, geomorphology and intensity of development of secondary porosity, the infiltration co-efficient of 0.03 (i.e. 3%) has been used. The estimation has been done block wise considering the normal annual rainfall and geographical area of the blocks. The estimated ground water resource is 4723.1 ham (as on 31-03-2005) for the entire district.

## **5.3 GROUND WATER QUALITY**

To assess the chemical quality of ground water in Bageshwar district, 63 water samples were collected from the springs, naolas and India Mark-II hand pumps. Out of these 30 samples were collected in Pre-monsoon period and the rest in Post-monsoon period. A perusal of hydrochemical data shows that ground water in Bageshwar district is mildly alkaline having pH varying



from 7.75 to 8.1. The pH values are within permissible limit as per the guidelines of the Bureau of Indian Standards (BIS, 1991).

The electrical conductivity varies from 50  $\mu\text{S}/\text{cm}$  (at 25°C) to 670  $\mu\text{S}/\text{cm}$ . Concentration of bicarbonate varies from 18 to 232 mg/L. Concentration of chloride varies between 3.6 and 64 mg/L. Groundwater is free from anthropogenic sources of pollution/contamination indicated by the concentration of nitrate except for a few places where the concentration is above the desirable limit but below the maximum permissible limit. Concentration of sulphate varies from 4 to 15 mg/L. Concentration of calcium varies from 2 to 40 mg/L while magnesium varies from 12 to 97 mg/L. Concentration of sodium and potassium vary from 0.11 to 38 mg/L and 0.1 to 16 mg/L respectively. The Total Hardness of ground water (as  $\text{CaCO}_3$ ) in Bageshwar district varies from 10 to 290 mg/L. The low value of total hardness indicates that ground water is suitable for domestic use.

Concentration of fluoride in ground water of Bageshwar district is generally well below the desirable limit of 1.0 mg/L. It varies from 0.01 mg/L in Kausani Market to as high as 1.7 mg/L near Tourist Reception Centre, Baijnath, which is slightly above the maximum permissible limit of 1.5 mg/L. High concentration of fluoride (1.5 mg/L) is also found in a hand pump at village Jhalamali, Garur block. It is interesting to mention here that samples collected from hand pumps at Jhalamali and Baijanth show high fluoride concentration but samples from nearby naolas are free from fluoride. The marginally high concentration is probably due to the local lithology.

Keeping in mind the potential of ground water irrigation in the area, emphasis is given on the suitability of water for irrigation. Geochemical parameters like Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC), Kelly's Salt Ratio (KSR) and Puri Salt Index (PSI) were determined. Calculations of SAR, SSP and KSR were done for ten representative samples. The analysis reveals that the SAR values vary from 0.21 to a maximum of 0.85; which can be considered good. By and large, the SAR values in all the samples are within the permissible limit ( $<3.0$ ). Accordingly, most of the water samples fall under  $C_1S_1$  class of the US Salinity Classification. Only three water samples collected from Garur market, Tourist Reception Centre and near Iron Bridge at Baijnath fall under the  $C_2S_1$  class. The value of SSP in the naolas ranges between 7.88 and 38.0%. Corresponding values obtained from water of hand pumps show a variation from 11.89 to 28.84%. The SSP values indicate suitability of ground water for irrigational use. The KSR values for naolas range between 0.09 and 0.63 whereas those from hand pumps vary from 0.14 to 0.43. Again, the values fall under good to permissible class indicating that ground water is suitable for irrigational use.

## **6. GROUND WATER MANAGEMENT STRATEGY**

### **6.1 GROUND WATER DEVELOPMENT**

Taking into consideration the extremely rugged topography in major parts of the area, it is not feasible to go for a large-scale ground water development in Bageshwar district. However, small to medium scale

development may be planned and materialised in a systematic manner. The promising areas for the development of ground water resources are the relatively broad river valleys such as Garur and Bageshwar Valleys where tubewell construction can be taken up to augment supply of drinking water after locating the site scientifically.

In the northern part of the district, which is covered with snow almost throughout the year, the possibility of ground water development is nil. However, remaining areas of the district show moderate to good scope for ground water development. Springs emerging along the roadside slopes can be developed depending upon the local conditions. Hand pumps may be installed along roads by locating sites on prominent lineaments and structurally weak zones as ground water in such terrain occurs in joints and fractures. Joint planes, which are developed systematically with specific spatial orientations can be identified by systematic investigations and earmarked for limited development. The broad, U-shaped valleys with glacial and fluvio-glacial deposits (Garur Valley and Bageshwar Valley) may be promising areas having moderate scope of development. Ground water exploration and more detailed hydrogeological studies may indicate whether there is any feasibility for constructing tubewells in these valleys. There is no dedicated ground water irrigation scheme in the district and irrigation potential created by man-made ground water abstraction structures (hand pumps) is negligible.

## **6.2 WATER CONSERVATION AND ARTIFICIAL RECHARGE**

Due to the high Average Annual Rainfall in Bageshwar district, there is good scope of water conservation through Roof Top Rainwater Harvesting. However, artificial recharge of aquifers in the area is really a challenging task due to the overall complex hydrogeological condition. Due to high land slope in major part of the district, a significant amount of rainfall goes waste as immediate surface run off or overland flow, resulting in very less percolation to shallow aquifers. In such areas construction of suitable water conservation structures is required. Gully plugs and contour bunds are quite suitable for this purpose as they arrest surface run off, increase soil moisture, recharge the shallow aquifers, help in preventing soil erosion and increase the discharge of nearby springs and naolas. Construction of small check dams, nala bunds and continuous contour trenches depending on the local topographic and hydrologic conditions can be taken up in project mode. Continuous contour trenches would cover the entire slopes uniformly whereas nala bunds constructed in a series would cover the entire stretch of drainage in the hilly tracts.

AVANI, a Non Government Organisation based at Tripuradevi, Pithoragarh district has completed roof top rainwater harvesting structures in four villages of Bageshwar district. Among these, construction of a storage tank (30,000 litre capacity) for surface storage by roof top rainwater harvesting and an overflow recharge pit was undertaken at many locations like Primary Schools at Saukura, Simayal, Chantola and Mahrori. The project was funded by the Ministry of Water Resources, New Delhi.

## **7. GROUND WATER RELATED ISSUES AND PROBLEMS**

As far as the overall hydrogeological scenario of Bagehswar district is concerned, there are no significant problems. However, some local problems encountered in the district and their possible remedies are listed below:

1. Poor quality of ground water in some naolas. This may be due to misuse and/or disuse of the structures. This problem may be tackled by development and renovation of the structures, cleaning of dirt and other garbage (frequently dumped in and around naolas) and periodic maintenance, either by the gram panchayat or by the state agencies and non-government organizations under self help programmes e.g. the Swajal Pariyojana. The local people needs to be properly educated and trained by the district authorities and state/central government departments so that they can understand the value of fresh drinking water they are supposed to get from the naolas.

2. Poor quality of water coming out of some India Mark-II hand pumps installed recently by Uttarakhand Jal Sansthan. The quality problem is mainly because of the colour (yellowish brown) and bitter taste, indicating that the water has very high iron content. Putting an iron filter unit with the outlet of the hand pump can solve the problem. The filter unit consists of a filter plant and valve for flushing out the residue/precipitate. The iron content in ground water is in ferrous form, which in contact with air gets converted into ferric state and subsequently precipitated.

3. There is scarcity of safe drinking water in some villages in the district. This is mainly due to unavailability of hand pumps and naolas/springs nearby. The problem can be mitigated either by installing hand pumps in the areas where accessibility is not a problem or by storing rainwater in storage tanks (surface or underground) and harnessing surplus monsoon runoff through small check dams and/or gully plugs in suitable areas. The latter solution is more attractive as the system of rainwater harvesting in hilly areas has proved cost-effective and sustainable.

## **8. AWARENESS AND TRAINING ACTIVITY**

### ***8.1 Mass Awareness Programme (MAP) and Water Management Training Programme (WMTP) by CGWB***

Nil.

### ***8.2 Participation in Exhibition, Mela, Fair etc.***

Nil.

### ***8.3 Presentation and Lectures Delivered in Public Forum/Radio/T.V./Institution of Repute/ Grassroots Association/ NGO/Academic Institutions etc.***

Nil.

## **9. AREAS NOTIFIED BY CGWA/SGWA**

Nil.

## 10. RECOMMENDATIONS

The following recommendations are made to augment and develop the ground water resources of Bageshwar district:

- Integrated hydrogeological, geophysical and hydrochemical approach should be taken in promising areas such as Garur and Bageshwar Valleys.

- The hand pumps should be installed at feasible sites.

- The springs and naolas should be properly maintained by the local people and/or gram panchayat in active collaboration with Non Government and Voluntary Organisations and state government departments.

- Local incidence of higher nitrate and fluoride concentrations in ground water needs to be closely monitored. Hand pumps operating in such areas should be specifically identified and unhygienic practices by the local populace near hand pumps should be controlled as these structures act as point sources of pollution.

- The villagers are to be properly educated and advised through mass awareness programmes. A concerted effort by the user and service provider, be it the rural community, Gram Panchayat and Non Government Organisation can really make a significant difference in improving the ground water quality.

- The villagers should be encouraged to tap roof top rain water as the system of roof top rain water harvesting in hilly areas with high amount of monsoon rainfall has been found useful and cost-effective.

- Unnecessary wastage of ground water should be stopped by putting valves or water taps in storage-cum-supply tanks constructed at the outlets of springs.