केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River
Development and Ganga Rejuvenation,
Ministry of Jal Shakti
Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

PAONTA SAHIB VALLEY, DISTRICT SIRMAUR, HIMACHAL PRADESH

उत्तरी हिमालयी क्षेत्र, धर्मशाला

Northern Himalayan Region, Dharamshala

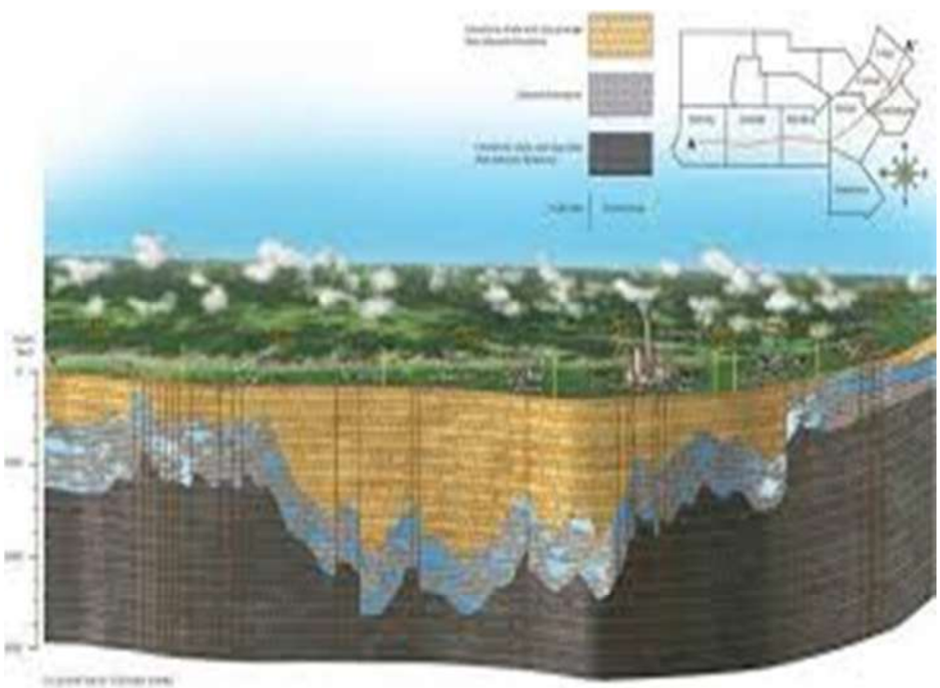
GOVERNMENT OF INDIA

MINISTRY OF WATER RESOURCES, RD & GR

CENTRAL GROUND WATER BOARD

AQUIFER MAPPING AND MANAGEMENT PLAN IN PAONTA SAHIB VALLEY, DISTRICT SIRMAUR, HIMACHAL PRADESH.

(2015-2016)



NORTHERN HIMALAYAN REGION

DHARAMSHALA

March 2019

AQUIFER MAPPING AND MANAGEMENT PLAN OF PAONTA VALLEY, DISTRICT SIRMAUR, HIMACHAL PRADESH

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXURE

REPORT ON AQUIFER MAPPING STUDIES AND MANAGEMENT PLAN IN PAONTA VALLEY OF DISTRICT SIRMAUR, HIMACHAL PRADESH.
AAP (2015-2016)

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. There has been a paradigm shift from "groundwater development" to "groundwater management". An accurate and comprehensive micro-level picture of groundwater in India through aquifer mapping in different hydrogeological settings will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India as well. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus the crux of NAQUIM is not merely mapping, but reaching the goal – that of ground water management through community participation.

1.1 Objectives

Aquifer Mapping objectives can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. This is an activity where the Government and the Community work in tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

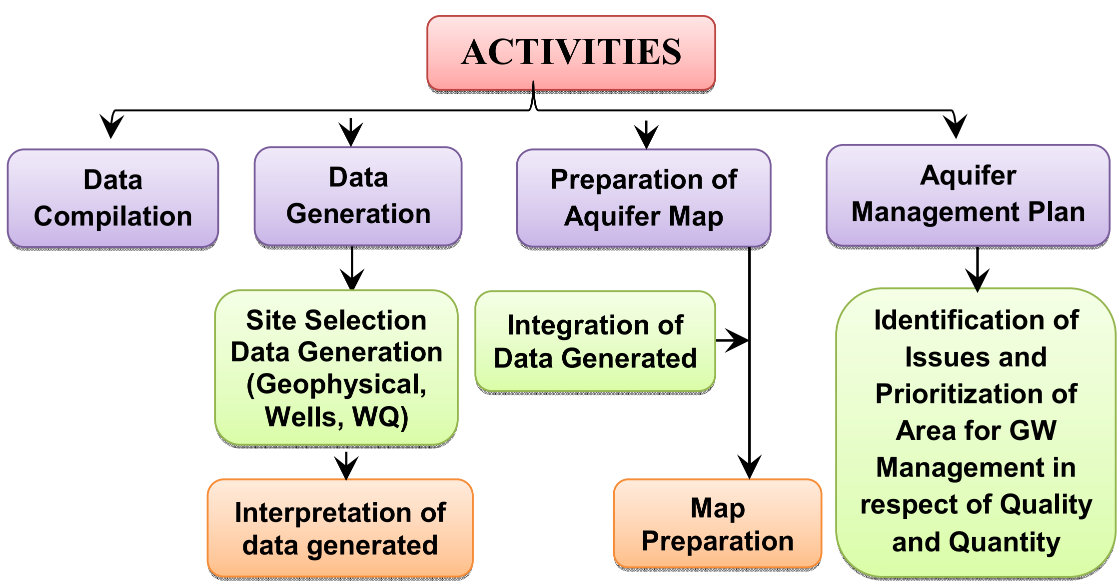
The primary objective of the Aquifer Mapping Project is to prepare micro-level aquifer information system with 1:50,000 or larger scale aquifer maps of 1:10,000 scale in identified stress areas and develop Aquifer Management Plans, which will allow institutions and stakeholders to effectively understand and manage groundwater resources at regional and local level. Secondary objectives are:

1. *Preparation of Aquifer Maps*
2. *Preparation of Aquifer Management Plans*
3. *Implementation of Aquifer management plan by Participatory ground water management*

With these aims, Aquifer Mapping Study was carried out in study area i.e. Kala Amb & Paonta valley in Sirmaur district. The surveys are carried out to integrate the information on the scenario of groundwater occurrence, availability and utilization in terms of quality and quantity along with exploratory drilling, monitoring of water levels with quality, spring monitoring (discharge and quality), pumping tests, infiltration tests, geophysical surveys etc. Development of aquifer mapping at the appropriate scale and formulation of sustainable management plan will help in achieving drinking water security, improving the sustainability of water resources development through springs. It will also result in better management of vulnerable areas. During this study, 21 key observation wells (dugwells), 33 water sampling points & 6 springs were established. Subsequently, all the available data on ground water from the earlier studies are compiled and integrated with these studies. This report brings out the ground water scenario, of springs, handpumps and surface water of the study area to suggest better management plan of ground water in a scientific manner.

1.2 Methodology

Various activities of NAQUIM are as follows:



1.3 EFC Norms by CGWB

CGWB, CHQ framed draft guidelines for different areas such as Alluvial, Hilly area, Hard Rock etc and also tentative norms of activities to be taken for Aquifer Mapping are given in EFC which are as under:

Table 1.1 As per EFC norms of activities to be taken for Aquifer Mapping

S.No	Activities	Unit	Per toposheet (700 Sq.km)
1	Micro level hydrogeological data including quality monitoring	Nos	174
2	GW monitoring (4 times in a year for 2 years)	Nos	70
3	Geophysical survey (VES)	Nos.	25
4	Borehole logging	Nos	Need based
5	2 D imaging	Line km	Need based
6	Ground TEM (Transient Electromagnetic)	Nos	Need based
7	Heliborn TEM	Line km	Need based
8	Water quality (Basic & heavy metals)	Nos.	105
9	Water quality (Pesticides, Bacteria, Arsenic & fluoride)	Nos	10
10	Carbon-14	Nos	1
11	Isotope study – stable & other isotopes	Nos	15
12	Soil infiltration rate	Nos	33
13	Core drilling in Arsenic & fluoride affected area with geochemical analysis	Nos	Need based
14	Slug test	Nos	6
15	Specific yield determination	Nos	6
16	GW exploration (EW & OWs)	Nos	6 – 12 , Avg-9

The study area is hilly except valley portion. Based on available data two aquifer system is considered in the area. The data gap is analysed following the EFC norms, guidelines of hilly area (**Annexure-1**), topography & other characteristics of the area.

1.4 Location, Extent & Accessibility

Sirmaur district is one of the densely populated districts, located in the southern part of Himachal Pradesh. The district lies between the North latitude $30^0$22'30" & $31^0$01"20"and East longitude 77°01'12" & $77^0$49'40" and falls in Survey of India degree sheet Nos. 53E and 53F covering an area of 2825 sq km. Sirmaur district with its head quarter at Nahan comprises of three-sub divisions, six tehsils and three sub-tehsils (Table-1 & Fig. 1). For developmental purposes, the district is divided into five community development blocks. There are 228 panchayats and 968 villages in the district.

Table 1.2 : Administrative Divisions, District Sirmaur

Sub division	Tehsil	Sub-tehsil	Towns
Nahan	Nahan		Nahan
Paonta Sahib	Paonta Sahib		Paonta Sahib
Rajgarh	Puchad	Nohra	
	Rajgarh	Ronhat	Rajgarh
	Renuka	Dadahu	
	Shalai		

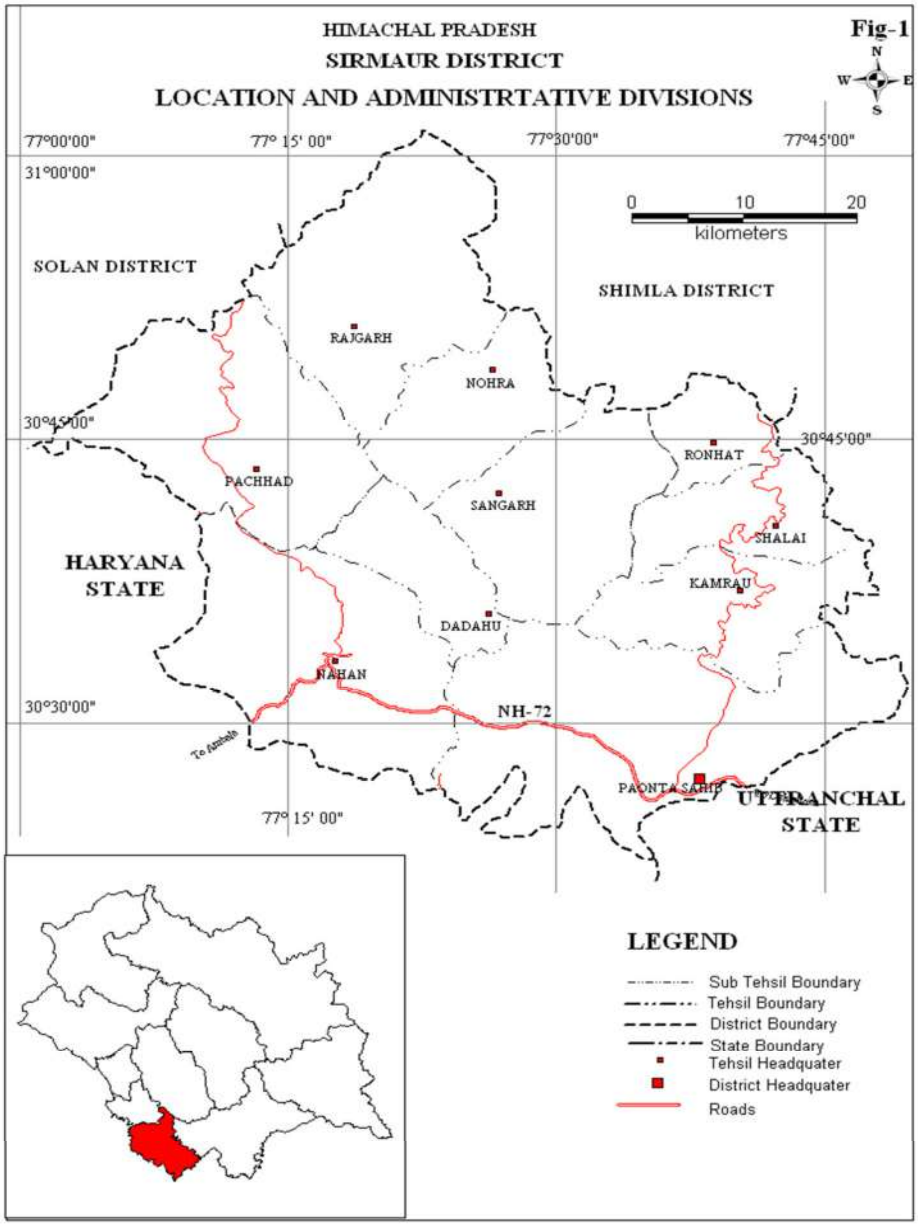


***Fig:1.** The Administrative map of District Sirmaur*

1.5 Administrative Divisions and Demography

The study area (Paonta Valley & Kala Amb valley, 793 Sq. Km) falls in Sirmaur district which is taken up for aquifer mapping study since AAP 2015-16. The Paonta valley having an area of 712 Sq. Km falls between latitude 30°22.5'N & 30°41.5'N and longitude 77°10'E & 77°48'E.

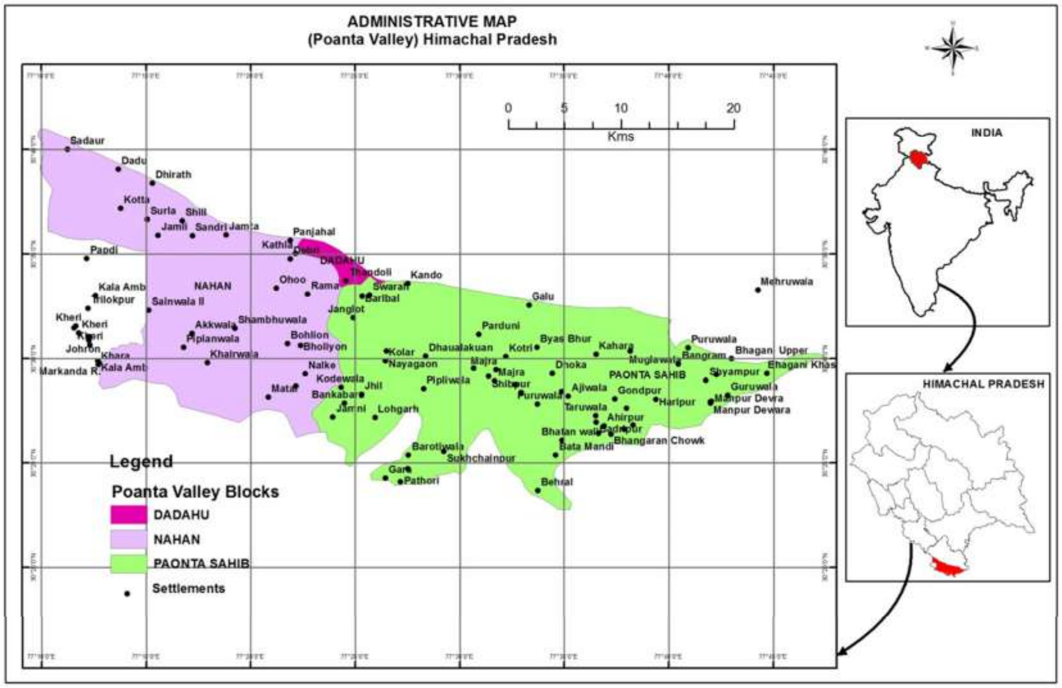


Fig:1.1 The Administrative Division of the Paonta Valley, District Sirmaur

1.6 Data Gap Analysis

The Data gap analysis was done on the basis of NAQUIM & EFC guidelines in Aquifer Mapping Study area of Paonta Valley (712 sq.kms),District Sirmaur of Himachal Pradesh. The study area falls in Survey of India Toposheets No.53 A/12, A/16, 53 B/9, B/13 and 53 F/1 covering full or partial area of 18 quadrants (Figure -1.2 -Toposheet Index Map). The Data Gap analysis of all the attributes are given in Table.

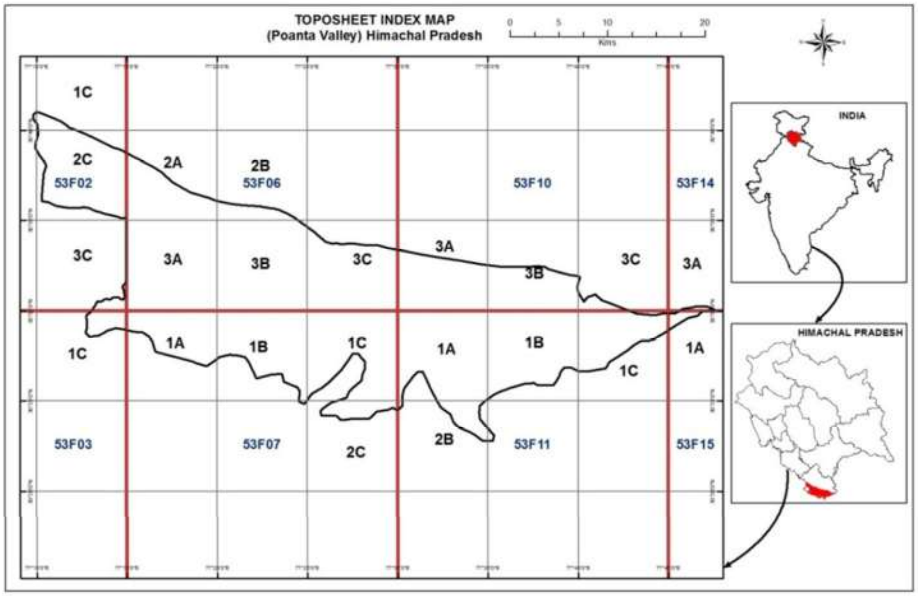


Fig:1.2. The Topo Index map of the Paonta Valley, District Sirmaur

1.6.1 Brief description: Data availability, Data Adequacy & Data Gap Analysis

Data gap is the required no. of structures – existing structures. Required no. of structures are worked out considering the above norms. The existing structures which fulfil the criteria is taken as available no of structures. Data generation is the creation of additional structure / data. The activity wise & aquifer wise data required, data available & data gap for both the study areas is given below;

Table 1.3 : Data Gap Analysis

Activity	Data required		Data available		Data Gap		Data Gap Filled		Data Gap To be Filled	
	1st Aq	2nd Aq	1st Aq	2nd Aq	1st Aq	2nd Aq	1st Aq	2nd Aq	1st Aq	2nd Aq
Exploration wells	4	1	0	0	4	1	3	0	1	1
Observation wells	4	1	1	0	3	1	3	1	1	1
Piezometers	0	0	0	0	0	0	0	0	0	0
WL monitoring Key wells	10	0	10	0	0	0	0	0	0	0
WQ monitoring wells	8	0	8	0	0	0	0	0	0	0
VES for Resistivity survey	0	30	0	0	0	30	0	0	0	30
Soil Infiltration test	34	0	0	0	34	0	0	0	34	0
Spring discharge monitoring	5 number of springs were identified and monitored in NAQUIM area									

1.6.1 Exploratory Data

The Data gap Analysis indicates the required Ground Water Exploration sites, sets of exploratory and observation wells to ascertain the aquifer parameters, in the area as per the EFC and the existing number of sites in the area and the Gap is indicated where ever the required number of sites is higher than the existing number of sites. If the number of existing exploratory wells is higher than the required exploration sites, the gap is considered as zero and the existing structures were taken as fulfilling the norms. On the basis of data gap analysis, quadrant-wise existing and recommended sites is presented and shown as square diagram in the figure-1.6.1

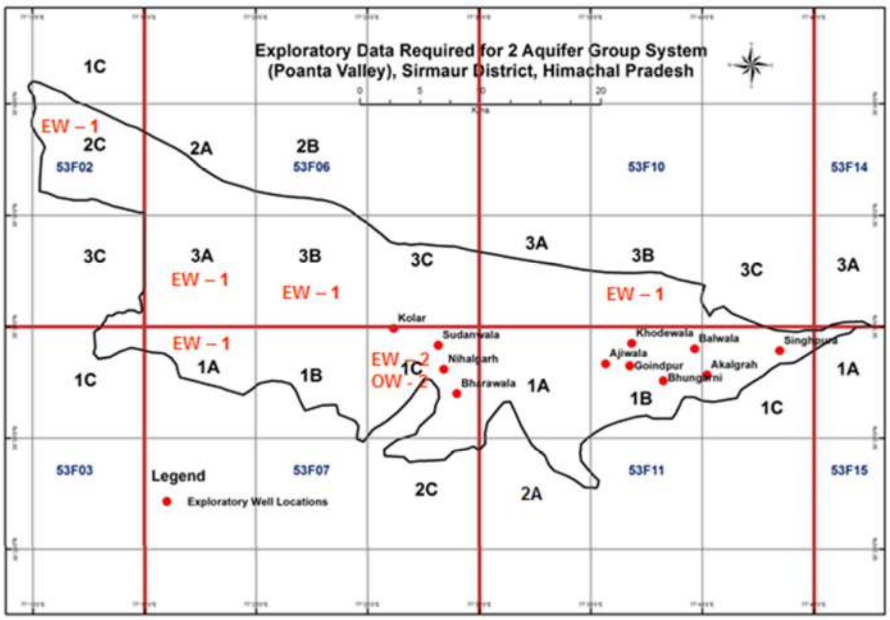


Fig.1.3 Exploratory Data Required Map – Paonta Valley, Sirmaur District

1.6.2 Geophysical Data

The Vertical Electrical Soundings (VES) is required for lithological interpretation to a depth of 300 m but due to hilly terrain the adequate spread may not be available, therefore, TEM is also recommended for lithological interpretation to a depth of about 100 m. But for the study area, no VES data is available with CGWB and state agencies. On the basis of data gap analysis, the required no. of 30 VES are proposed for Paonta valley. The quadrant-wise existing and recommended VES sites is presented and shown as square diagram in the following figures.

In Poanta Valley District Sirmaur, Himachal Pradesh surface geophysical data adequacy and data gap analysis aquifer mapping area is done for 712 sq.km. Geology of the area is fine to coarse grained sand admixed mixed clay of multiple sequence off sandstones, conglomerates, slates schist phyllites and & lime stones. The required depth for aquifer mapping depth is 200m.bgl. data adequacy is nil

And data gap analysis: 30/18nos. of (ves/tem).

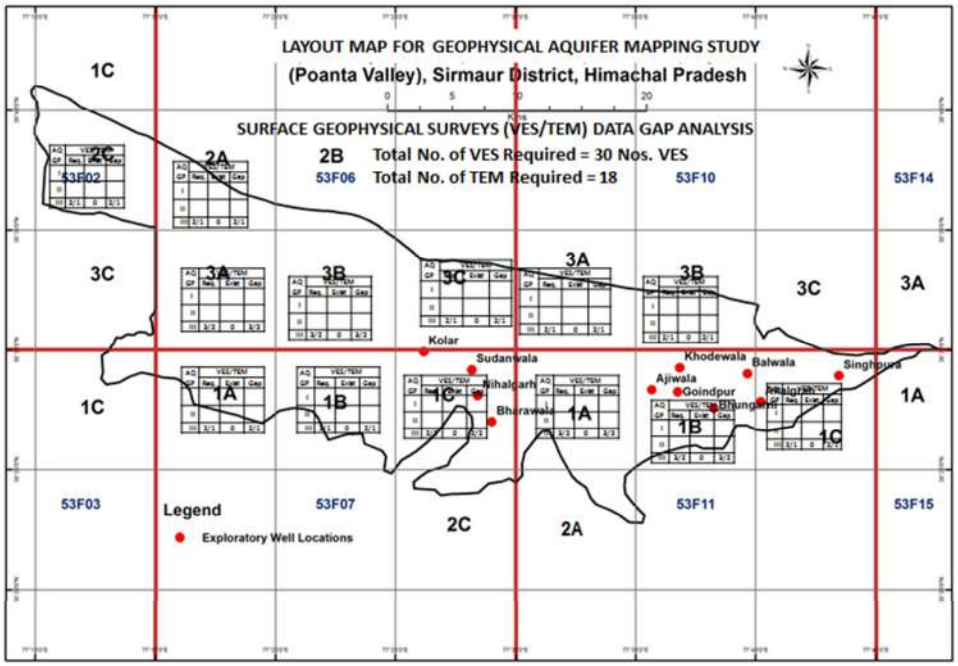


Fig. 1.4(A) Data Gap Analysis of Surface Geophysical Surveys
Paonta Valley, Sirmaur District

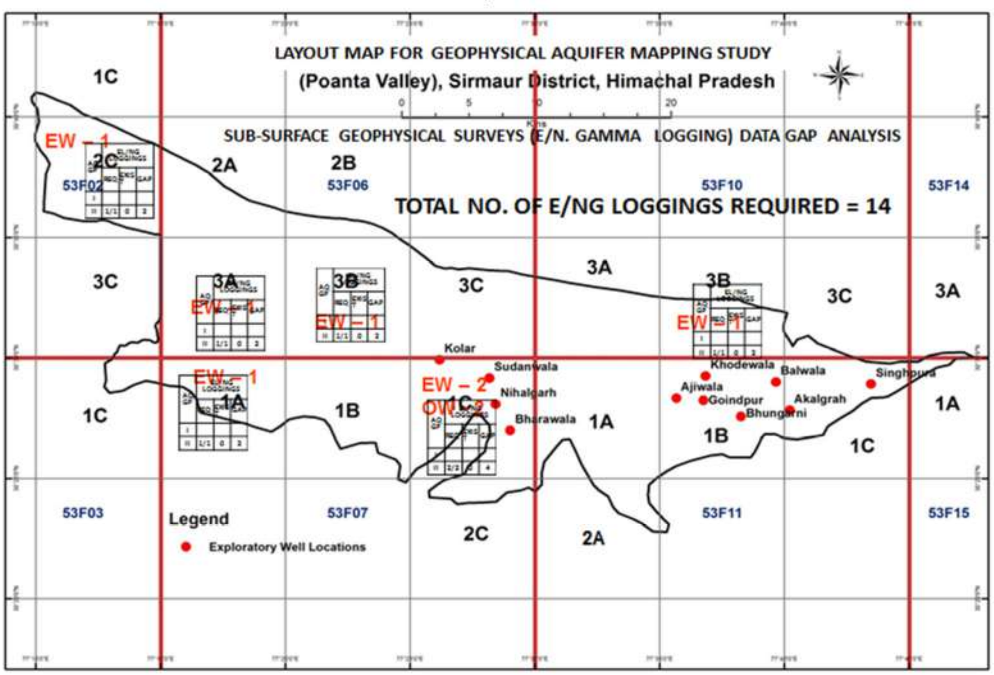


Fig. 1.4 (B) Data Gap Analysis of SURVEYS (E/N. GAMMA LOGGING)
Paonta Valley, Sirmaur District

1.6.3 Ground Water Monitoring Stations (GWMS)

The ground water monitoring NHS and Key well observation stations in the area tap the unconfined aquifer. Wells constructed by CGWB and hand pumps by State agencies which tap the deeper and shallow aquifers are utilised for drinking water supply instead of monitoring the piezometric head in the deeper and shallow aquifers. On the basis of data gap analysis, quadrant-wise and aquifer-wise existing and recommended ground water monitoring stations is presented and shown as square diagram in the figure -

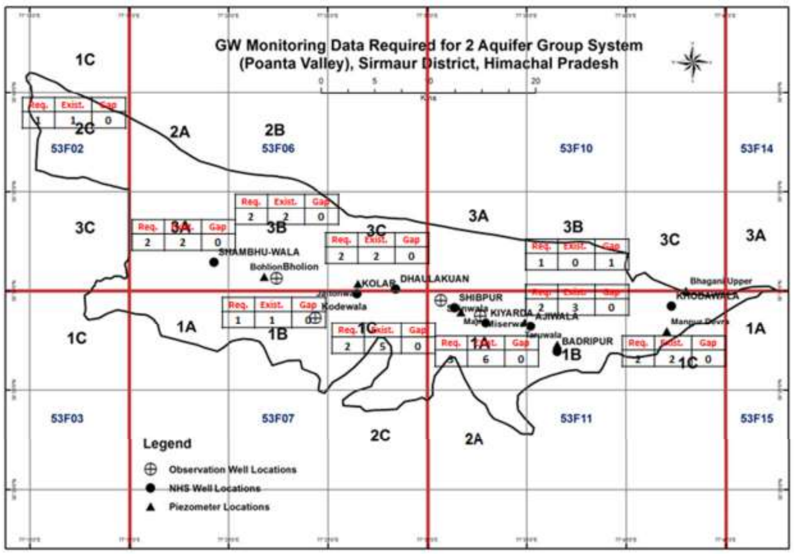


Fig. 1.5 Data Gap Analysis for Ground Water Monitoring - Paonta Valley, Sirmaur District

1.6.4 Ground Water Quality Monitoring Stations (GWQMS)

Most of the ground water quality monitoring NHS and Key well observation stations in the area tap the unconfined aquifer. Wells constructed by CGWB and hand pumps by the state agencies tapping the deeper and shallow aquifers are utilised to monitor the quality of ground water in the deeper and shallow aquifers. On the basis of data gap analysis, at few places, additional GWQMS are required; rest will be monitored through NHS, Key well observation stations, hand pumps, existing and proposed E/Ws, and Pzs. The quadrant-wise and aquifer-wise existing and recommended ground water quality monitoring stations are shown as square diagram in the figure -1.6.4

1.6.5 Rate of Infiltration

The amount of recharge to ground water depends on the infiltration rates of the soils. No infiltration tests have been conducted in previous surveys by CGWB and even this data is not available with state agencies. To know the infiltration characteristics of the soil in the study area, 39 nos. of infiltration tests are required. On the basis of data gap analysis, quadrant-wise existing and recommended infiltration tests are presented and shown as square diagram in the figure -1.6.5.

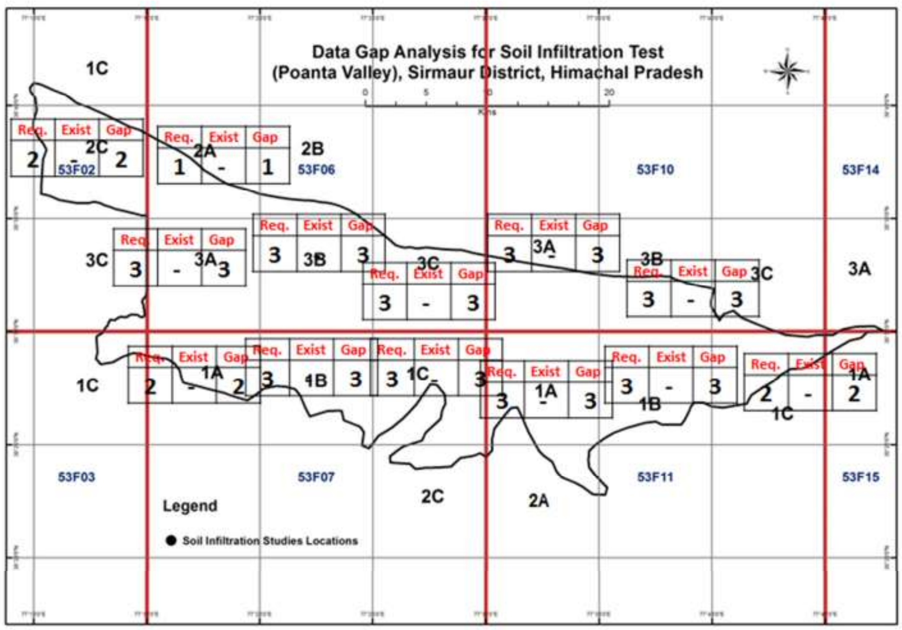


Fig.1.6 Data Gap Analysis for Soil Infiltration Studies - Paonta Valley, Sirmaur District

1.6.6 spring monitoring

The spring monitoring (discharge and quality) is essential to know the inflow and outflow of the water in the study area and its quality for domestic and other use. In the study area, a total of 5 springs in Ponta area, have been located. The location-wise existing springs and discharge data available are presented as below:

Table 1.4 Showing Sping Locations

Sr. No	Lattitude	Longitude	Altitude	Name of spring	Discharge
1	30.63624	77.26532	1302 m	Bhaneti/Dhaneti	Meagre-.03 lps. Most of springs are unable to measure, because of no pipe as outlet
2	30.60321	77.33736	1130	Kyartu	
3	30.59193	77.36449	1275	Panjahal	
4	30.57683	77.26736	606	Devka Purla	
5	30.57683	77.30979	750	serta	

1.6.7. Data Gap Analysis

The data gap analysis has been calculated on the basis of EFC norms of CGWB, as follows:

Table 1.5 Data Gap Analysis, Paonta Valley, Sirmaur District (2014-15)

DATA GAP ANALYSIS (Poanta Valley), Sirmaur District, Himachal Pradesh
Toposheet No: - 53 F/2, 53 F/3, 53 F/6, 53 F/7, 53 F/10 & 53 F/11

Quadrant no.	No. of additional EWs Required		No. of additional OWs Required		No. of VES /TEM Required		No. of E/G Logging Required		No. of additional water level monitoring stations Required		No. of Soil infiltration test Required
	Aq-I	Aq-II	Aq-I	Aq-II	Aq-I	Aq-II	Aq-I	Aq-II	Aq-I	Aq-II	
53F/2-1C	0	0	0	0	0	0	0	0	0	0	0
53F/2-2C	0	1	0	0	0	2/1	0	1/1	0	0	2
53F/2-3C	0	0	0	0	0	0	0	0	0	0	0
53F/3-1C	0	0	0	0	0	0	0	0	0	0	0
53F/6-2A	0	0	0	0	0	2/1	0	0	0	0	1
53F/6-2B	0	0	0	0	0	0	0	0	0	0	0
53F/6-3A	0	1	0	0	0	3/2	0	1/1	0	0	3
53F/6-3B	0	1	0	0	0	3/2	0	1/1	0	0	3
53F/6-3C	0	0	0	0	0	2/1	0	0	0	0	3
53F/7-1A	0	1	0	0	0	2/1	0	1/1	0	0	2
53F/7-1B	0	0	0	0	0	2/1	0	0	0	0	3
53F/7-1C	1	1	1	1	0	2/2	0	2/2	0	0	3
53F/7-2C	0	0	0	0	0	0	0	0	0	0	0
53F/10-3A	0	0	0	0	0	2/1	0	0	0	0	3
53F/10-3B	0	1	0	0	0	2/1	0	1/1	1	0	3
53F/11-1A	0	0	0	0	0	3/2	0	0	0	0	3
53F/11-1B	0	0	0	0	0	3/2	0	0	0	0	3
53F/11–1C	0	0	0	0	0	2/1	0	0	0	0	2
53F/11–2A	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	6	1	1	0	30/18	0	7/7	1	0	34

1.7 Geomorphology

The geomorphological map was interpreted from survey of India topographic sheets and IRS P6 LISS - IV satellite imagery. The geomorphic units as below

The area shows mainly 3 types of geomorphology:

- Denudational Hills
- Pediplains
- Structural Hills

The area is equally divided in all the three types of geomorphology. The Paonta valley portion of the area comes under Pedi plains. Kala Amb valley is covered under denudational hills. Major forest area is under structural hills.

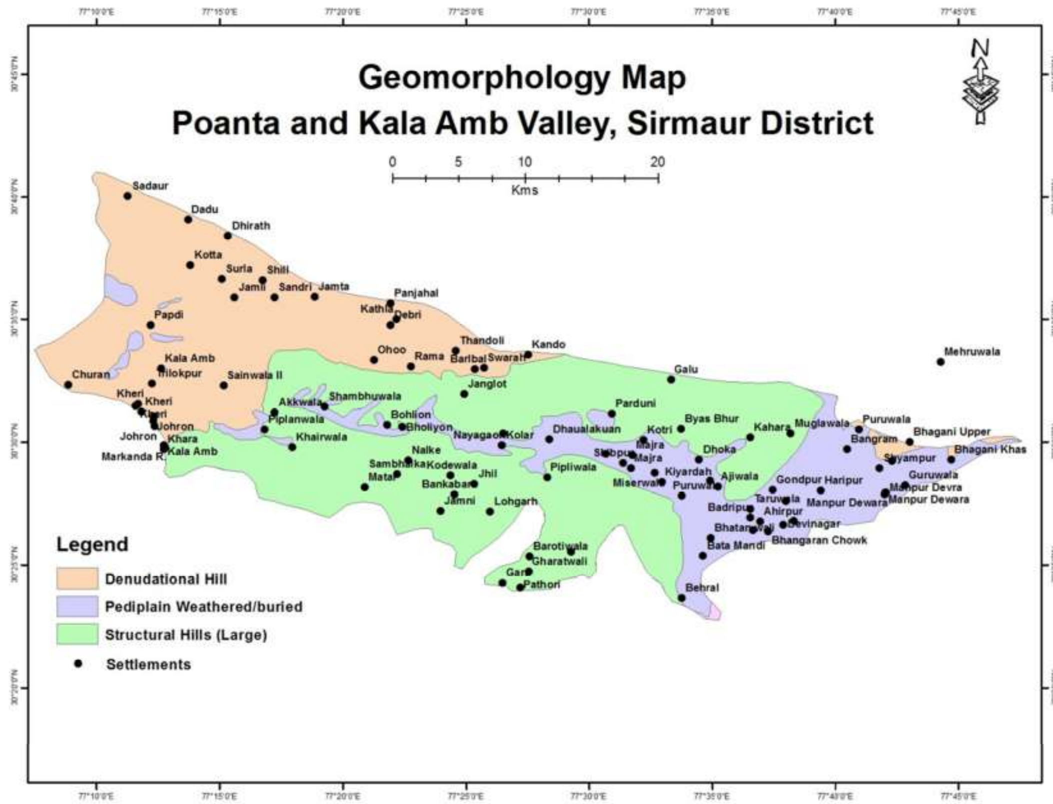


Fig 1.7 The Geomorphology Map of Paonta-Kala Amb Valley, Sirmaur District

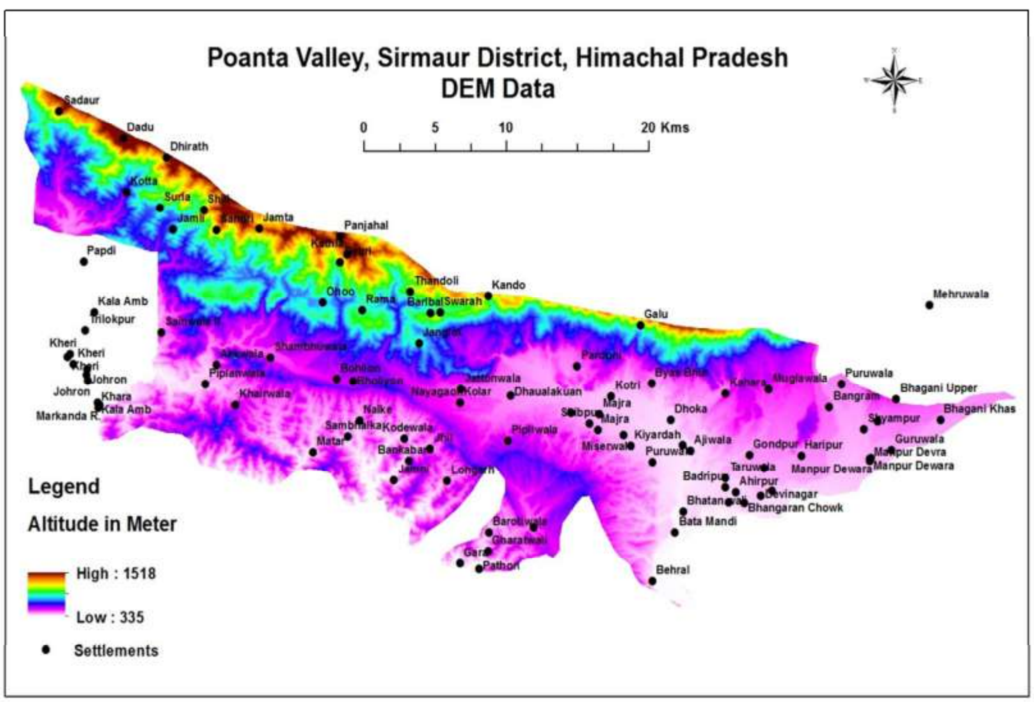
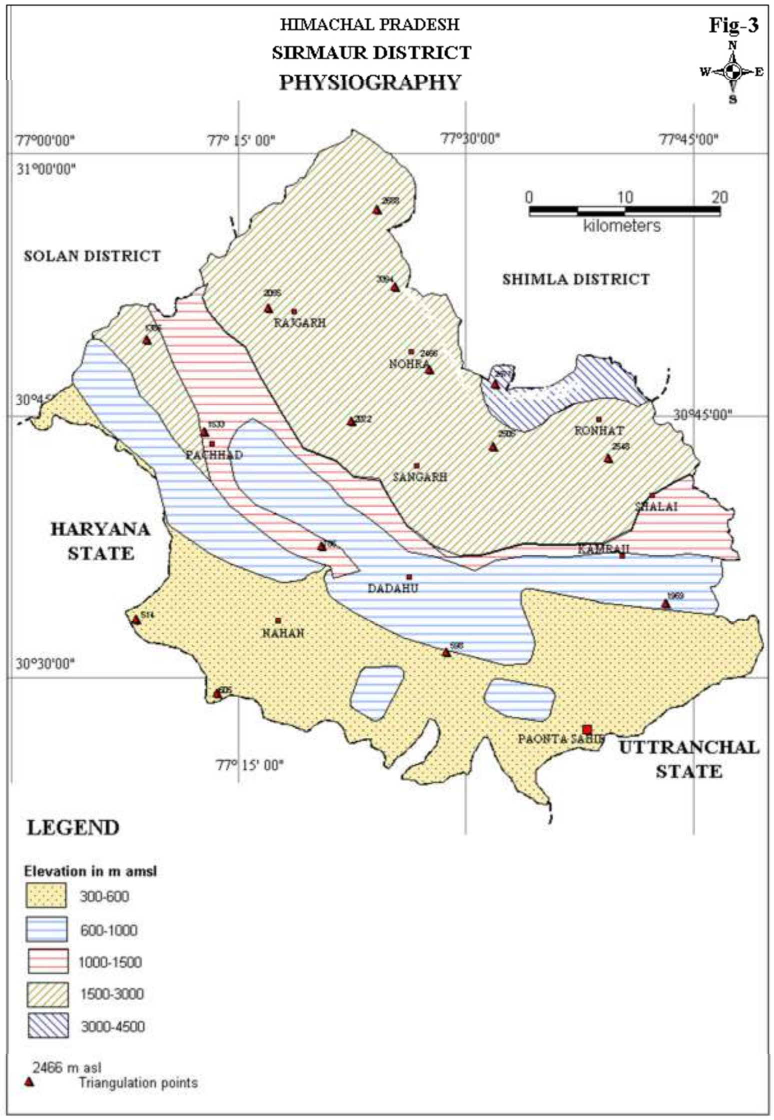


Fig 1.8 The DEM Map of Paonta-Kala Amb Valley, Sirmaur District

1.7.Pysiography

The detailed study area, Paonta valley is located in the outer part of lesser Himalayas, which has been formed in the last phase of upheaval of the Himalayas. The entire territory is mountainous with the exception of the valley, in the Paonta tehsil commonly called Paonta Valley (Kayarda -Dun valley) (Fig. 3). This valley is roughly 40 km long and 10 km to 21 km broad, is mostly flat and plan. Apart from the lie of the land, and the hill ranges called ***dhars***, the rivers determine the natural divisions. This valley is situated in the South – Eastern corner of the state It is also known as 'Paonta valley' after the town which lies in the valley. This is located in the Markanda and Dharti ranges. Jamuna river separates it from Dehra-Dun. A greater part of Kiarda-dun valley which is plain falls within the Cis-Giri division and a very small part in a corner spreading across the Giri falls in to the trans-Giri division. The Giri river enters the district and flows length wise from one end to other, dividing the whole territory into two almost equal parts, the Cis-Giri (Giri- war), and the trans (Giri-par). Trans Giri division are more widely and more highly mountainous than the Cis-Giri division.



1.8 Drainage of District

The entire district is very well drained with major rivers, with its tributaries, as shown :

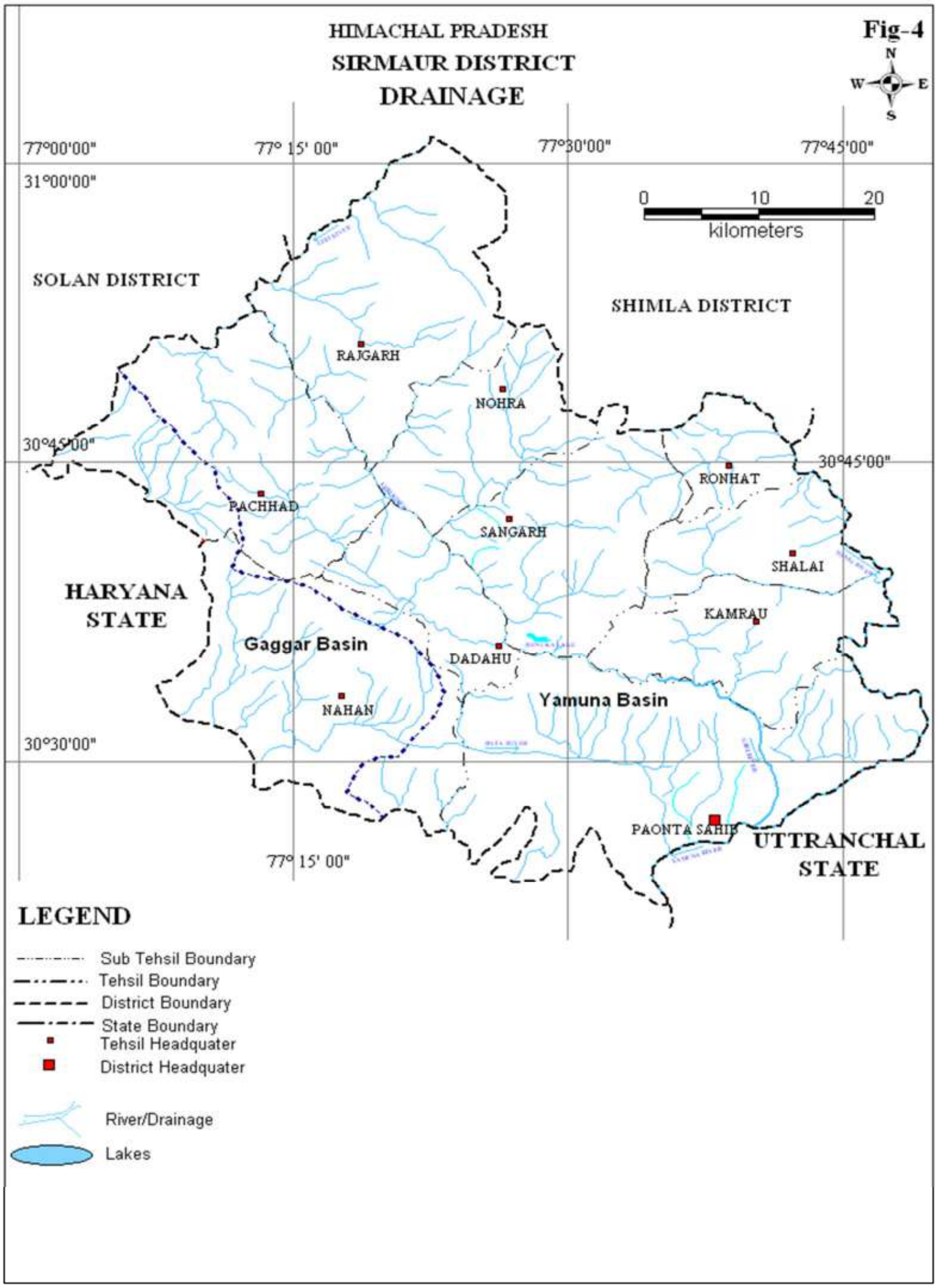


Fig 1.9 The Basin wise drainage Map of Sirmaur District

1.8.1 (A)Drainage of Paonta Valley

Leaving apart the multitude of small and insignificant streamlets that flows in the district, the major rivers flowing in the district are described below

The Yamuna

The river originates from Jamnotri Mountain in Uttranchal and flows on the eastern boundary of the district enters at village Khodar Majri and leaves at Kaunch and continues in Uttranchal. It separates Kayarda Dun from the Dehra Dun and forms the boundary between the district Sirmaur and Uttranchal. The tributaries are Tones river joining at Khodar Majri, the Giri river joining it near Rampur Ghat and Bata river joining at Bata Mandi. The water cannot be used for irrigating the area. Since this river flows at a lower level than of the plateau of the Kayarda Dun.

The Giri

Major portion of the district is drained by Giri and its tributaries. It takes its rise in the hills of Jubbal, district Simla. At village Mandoplasa this takes on east-southerly direction, dividing district into two parts namely Trans Giri area and Cis-Giri area in between the Siwalik range on the south and the main Himalayan range on the north lies the Paonta valley trending in north west-south east direction following the strike of the Himalayan ranges.

The Bata

The river rises from Siori spring in the Dharthi range, located in village Bagna, tehsil Nahan, and takes easterly direction in reverse to the course of Markanda river. Dividing Kayarda Dun into two parts, it joins Yamuna river at Bata Mandi. It is a perennial stream, subject to heavy floods in rainy season.

1.8.2 Drainage of Kala Amb Area

The Markanda

It rises at Baraban in the hill of Katasan pass below a temple of Keratins Devi. After flowing from southeast to southwest for a distance of about 24 km within the district, irrigating Bajora area it passes on to the Ambala district of Haryana at Kala Amb.

The Ghaggar

The river originates from village Lawasa in this district. It flows in the westerly direction and whole of the southern slope of Dharthi dhar up to Lawasa drains into this river. It flows for about 12.8 km in Pachhad tehsil of this district before it enters the Haryana near Prit Nagar.

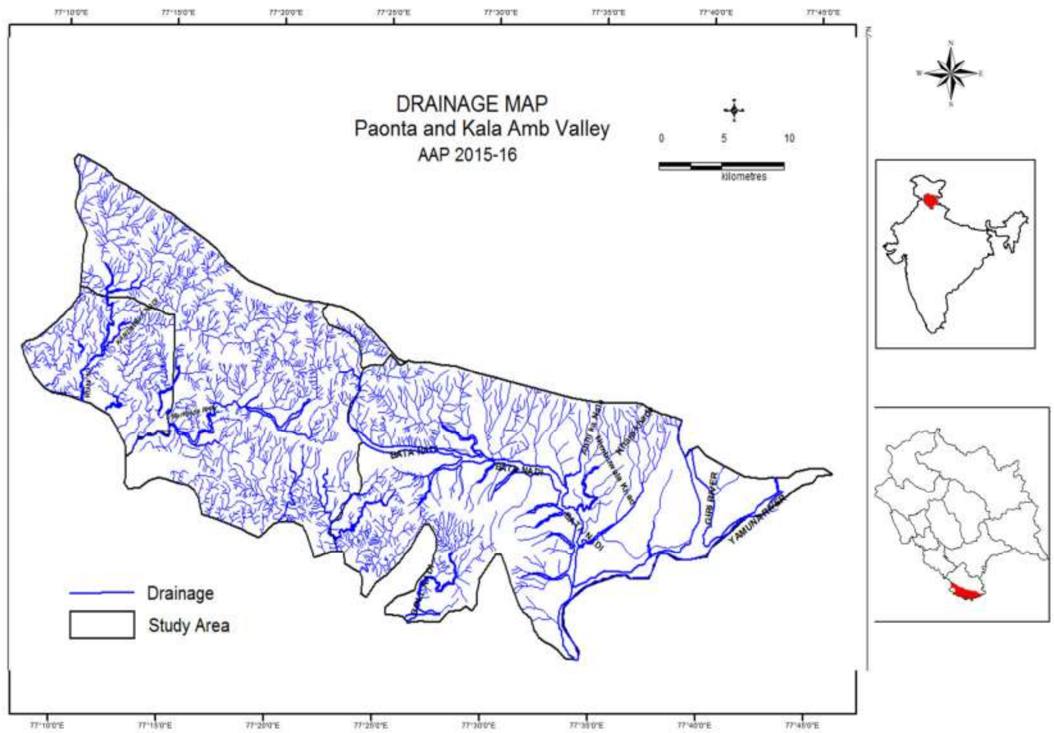


Fig 1.10(A) The Drainage Map (1:50000) of Paonta-Kala Amb Valley, Sirmaur District

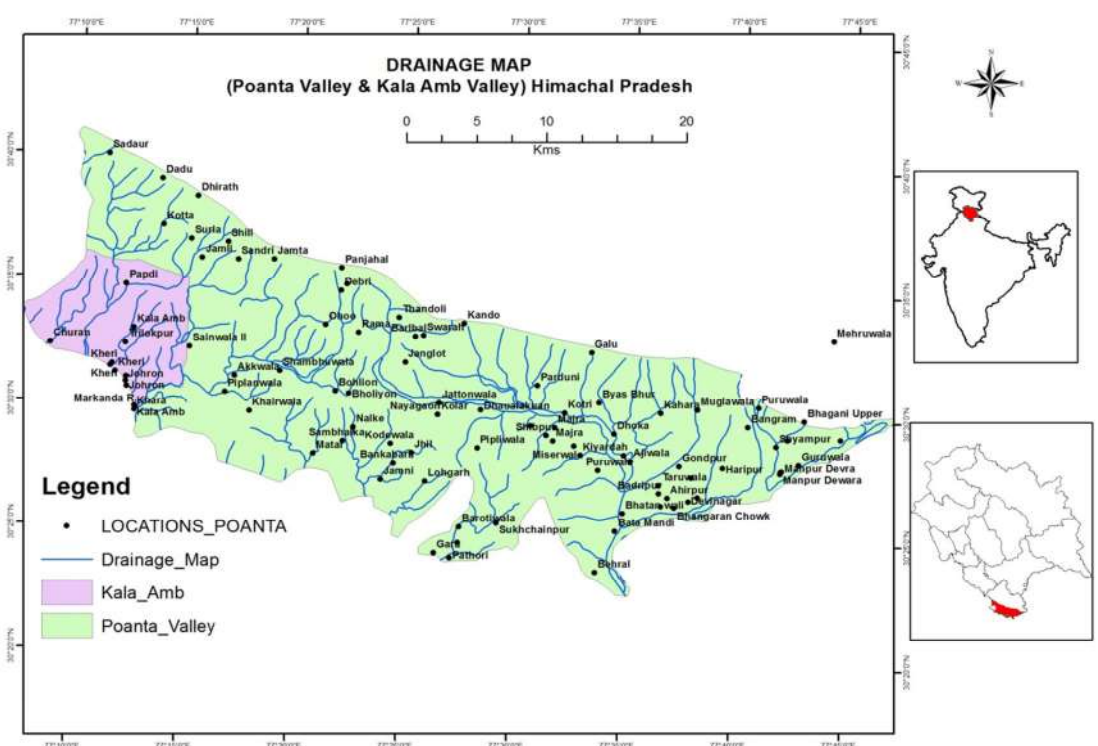


Fig 1.10(B) The Drainage Map of Paonta-Kala Amb Valley, with settlements, Sirmaur District

1.9 Geological Setup

Geologically, the rock formations occupying the district range in age from pre-Cambrian to Quaternary period. The generalized geological succession in the district is given below in

Table 1.6 Geological Succession

Era	***Period***	***Formation***	***Lithology***
Quaternary	Recent to Pleistocene	Alluvium /valley fills/ Older alluvium	Sand with pebble and clay & multiple cyclic sequence of medium to coarse grained sand with pebble of sandstone and lenses of clay
Tertiary	Pliocene – Middle Miocene	Siwalik Group	Sandstone, shale, conglomerate, mudstone, clay, gravel & boulder beds beds
	Lower Miocene to Eocene	Kasauli/Dagshai/ Subathu	Grey, purple sandstone, Shale, nodular clay, Shale, Limestone etc.
Pre-Tertiary Group	Pemo Carboniferous	Karol/ Infra-Karol, Blainis boulder beds	Limestone, shale, red shale Carbonaceous shale, slate, greywacke, dolomitic limestone.
	Devonian	Jaunsar series	Slates schist phyllite,
	Pre-Cambrian	Chail series	Slates called Shimla slates
	Achaean	Jutogh series	Quartzites, schist and limestone.

(Source: Geological Survey of India)

Outer Himalayan Zone: This zone is also known as Shiwalik or the foothill zone, which consists mainly of Tertiary formations extending from northwest to southeast. This system comprises of great thickness of cobbles, pebbles, detrial rocks, clays and conglomerates. The Nahans are separated from the Eocene beds of the lesser Himalayas by the main boundary thrust, which probably measures the whole length of the Himalaya from Assam to the Beas demarcating the northern boundary of the Shiwalik series. On paleontological grounds the Shiwalik can be subdivided into three groups; upper, middle and the lower. Thickness in the lower section of the Shiwalik varies between 1,800 m to 2,700 m. The Sirmour group has also three formations namely Kasauli, Dagshai and Subathu and is separated by a fault from the Shiwalik. The Subathu formations have greenish grey shale with bands of limestone and sandstone. The Sirmour group is perfectly continuous and formations lying conformably over each other. In study area generally formation is Alluvium, Fluvio glacial deposits of Recent to Sub-Recent age group comprising of sand caly & boulders and Siwalik formation of Boulder, Conglomerate & Sandstone.

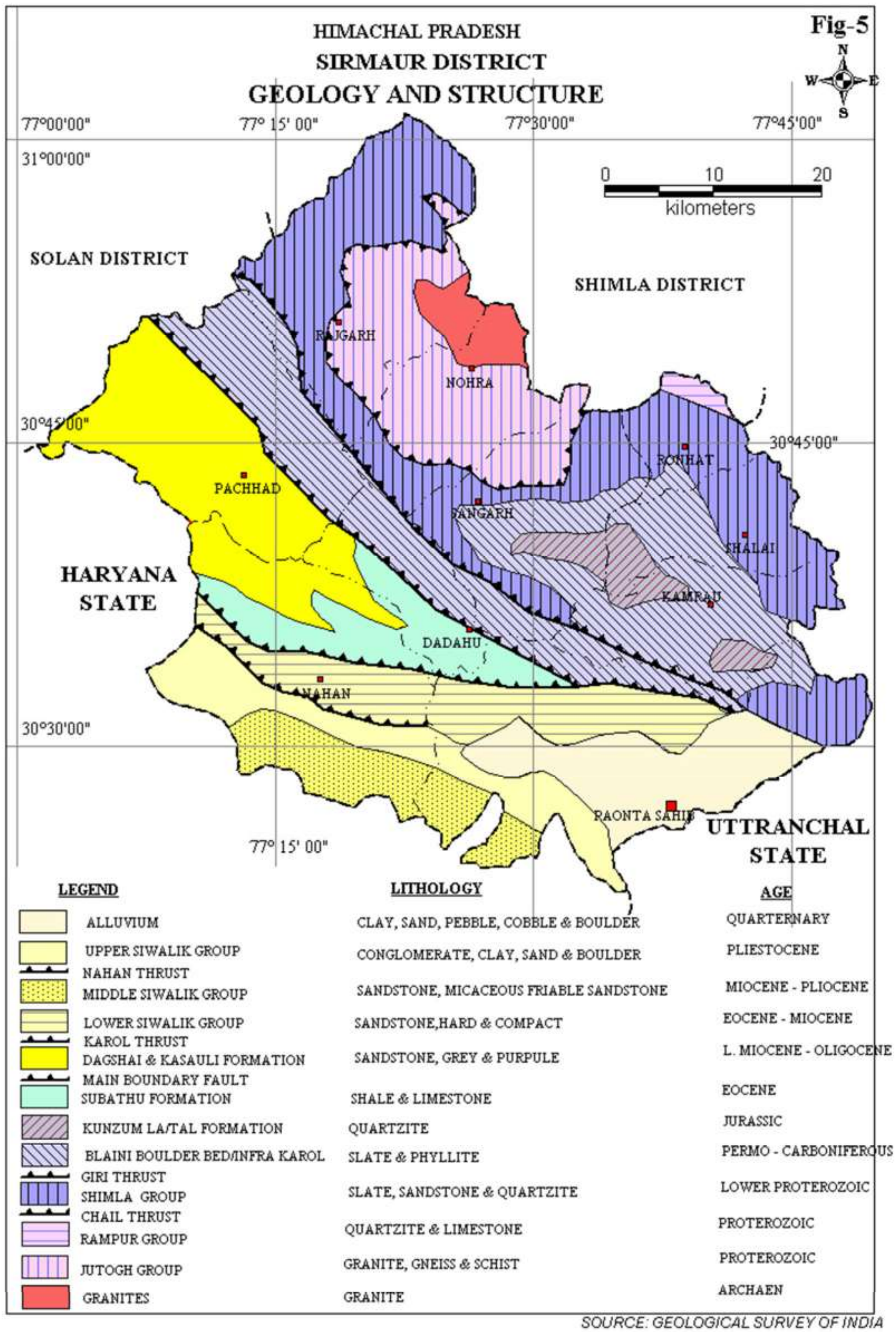


Fig 1.11 The Geology Map of Sirmaur District

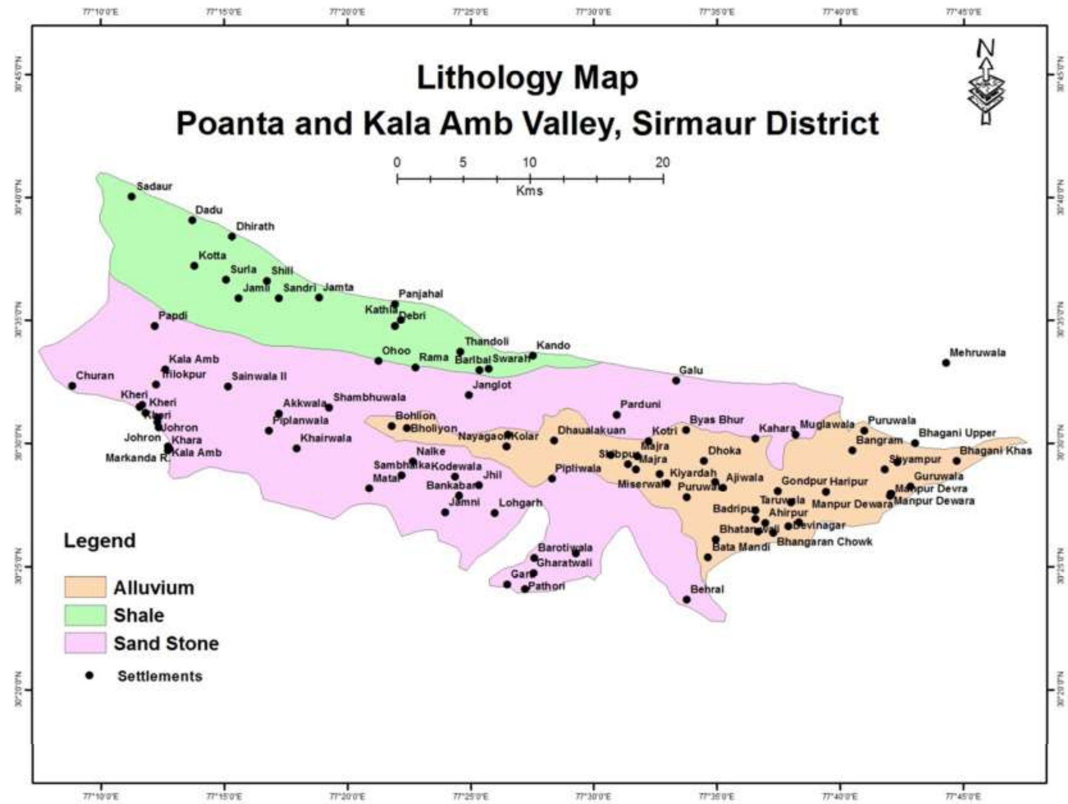


Fig 1.12 The Lithology Map of Paonta-Kala Amb Valley, Sirmaur District

1.10 Hydrogeological Framework

Hilly and mountainous parts with steep slopes mainly constitute the run off areas and have low ground water potential. In valley and low-lying areas, unconsolidated / semi-consolidated formations form good potential aquifers.

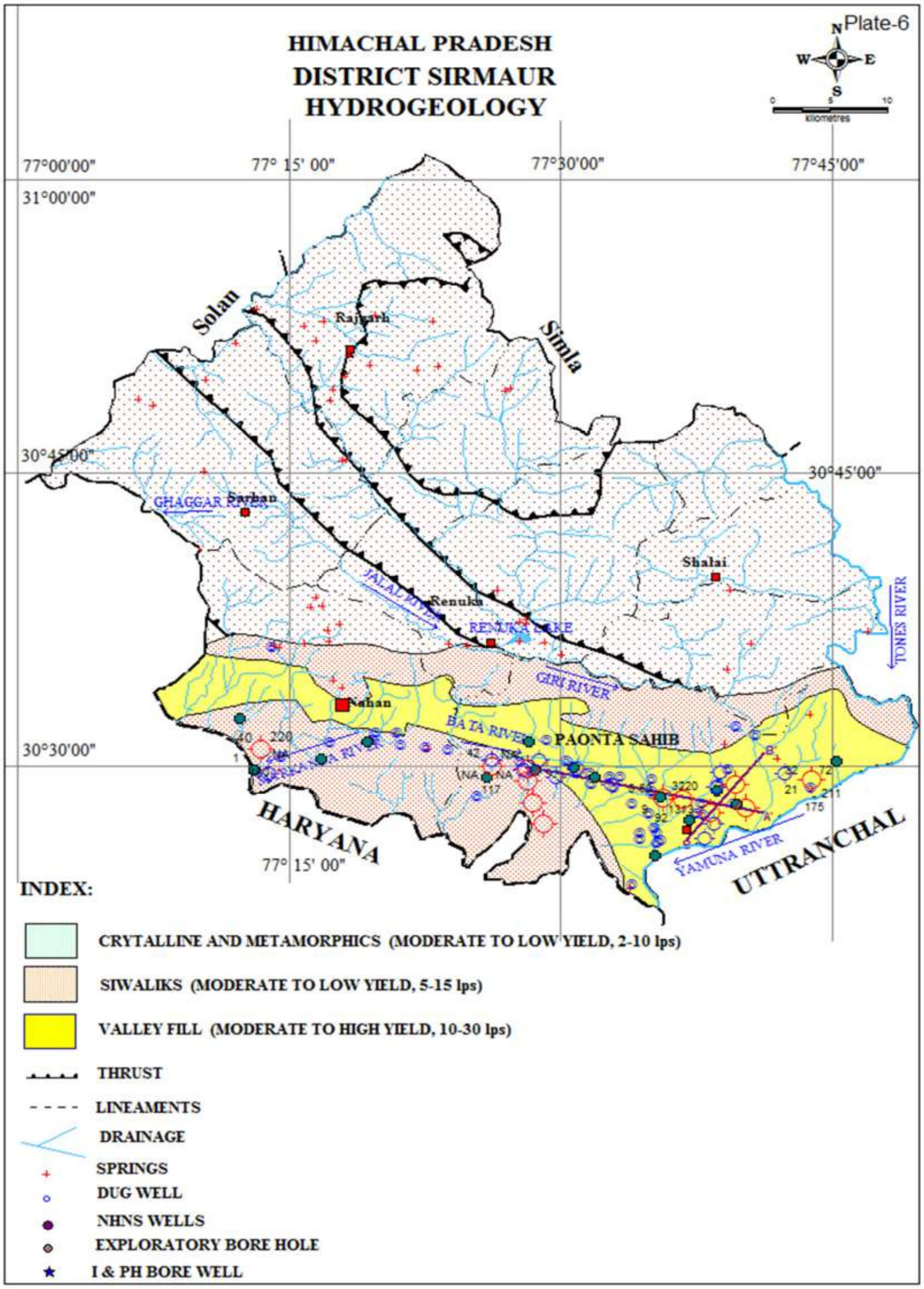


Fig 1.13 The Hydrogeology Map of Sirmaur District

1.11 Aquifer System

Hydro geologically the entire area of Sirmaur district is divided into two aquifer systems i.e. Consolidated and Unconsolidated. The hilly area comprises of consolidated formation with sandstone and limestone exposed in the central part around Nahan, western and northwestern part of the district (Fig. 1.12) Metamorphic and igneous rocks are exposed in northwestern and northern parts are represented by quartzites, phyllites, slates, schists and dolomites. The fissured formations are represented in the district by sedimentary, metamorphic and igneous rock units and forms as high hill ranges throughout the district. Springs exist in the low topographic areas along the lineaments and contact of various formations. The weathering is more prominent in schistose rocks. Ground Water in these formations is poorly developed by constructing shallow dugwells along the drainage lines in low topography. Depth to water varies from less than a metre to about 15 m and yield varies up to about 8 lps. Most of these structures dried up during peak summers.

Unconsolidated formations include fluvial channel deposits, valley fill deposits and alluvial-fans, (Piedmont zone) acts as potential aquifers. The Paonta valley is underlain by unconsolidated to semi-consolidated sediments. Ground water in the valley fill deposits occurs both under unconfined and confined conditions. The zone of saturation is formed chiefly by boulders, pebbles, gravels, sand and variegated clays. The near surface ground water, which is exploited by means of open wells, is in un-confined condition. The depth to water shows a wide variation ranging from less than metre to more than 40 m bgl. The general direction of movement of ground water in the valley fills is towards the streams.

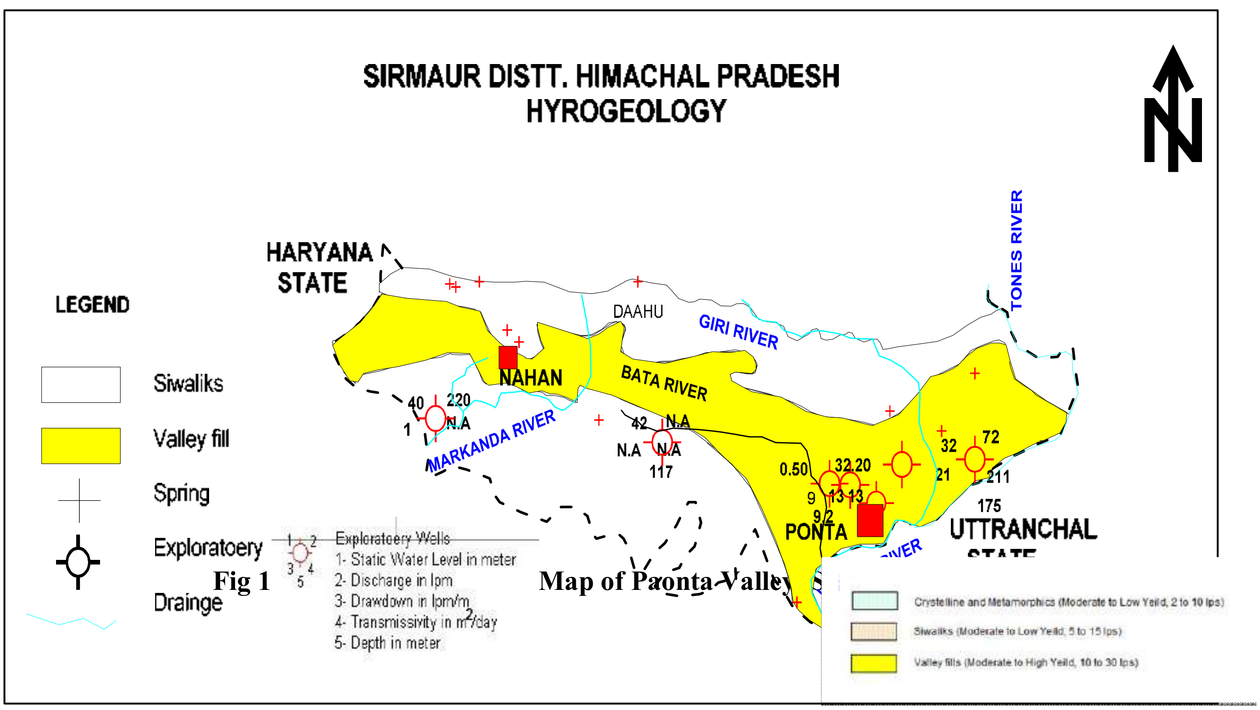


Fig 1.14 The Hydrogeology Map of Paonta Valley, Sirmaur District

1.7 Formation &their yield potentials

Formation	Yield Potential
Unconsolidated (Alluvium / valley fills of Quarternary age group)	GW under water table & confined artesian condition Moderate to High yield (10 to 25 lps)
Semi consolidated (Siwaliks, Subathu, Dagshai of Tertiary age group)	GW under water table & confined condition Moderate to low yield (2 to 15 lps)

District	EW Drilled	Formation	Depth Range (m)	Discharge (lpm)	Trans- missivity (m2/day)
Sirmaur	17	Valley Fill	90-139	72-3220	1098-3336

1.12 Irrigation and Cropping Pattern of the District

Sirmour district is spread in three agro-ecological zones. Majority of farmers (87 %) in this district are marginal and small farmers and average size of land holding is 2.28 ha. Agriculture is the primary occupation of the people in the district. . Irrigated facilities are available on 35.32% of net sown area.

In valley plains - Maize, paddy & wheat are main crops grown on large area, pulses & oilseeds are grown as sole /mixed on neglected /marginal lands. Vegetable and cash crops are grown on limited scale. Horticulture is done as back yard enterprise.- Mango, kinnow, lime, litchi, guava are main fruits. Livestock- Cows, buffalos, goat are common live stock. Fodder crops grown are- Oats, barseem sorghum, charry and bajra. Grass lands has local grasses. Cropping patterns is cereal based. Irrigation is limited and mostly done through tube wells & springs i.e ground water and also utilizing the water available in streams.

In the district, agriculture is done mainly in valley areas of the district. The major source of irrigation in the district is the "*kuhls*" (artificially made water channel). Only 12 % of the net cropped area of the district is irrigated and sizeable part of the cultivated area of the district is not having the assured irrigation facilities and the farmers have to depend on the rainfall. Under various plans, the construction of Kuhls and lift irrigation schemes are being carried out in the district. The lift irrigation has been introduced and shallow wells have been dug by Irrigation and Public Health (I&PH) department. CGWB and other State agencies have installed tube wells in the district which are being used for irrigation. The land utilization particulars in Sirmaur district are given in Table below.

Table1.8 : Land Utilization Pattern in Sirmaur District

Land Use	Area(Hectares)	Percentage of total area
Total geographic area of the district	282500	
Total Reported area	224752	
Total forest area	48704	22
Barren and uncultivated area	8781	4
Land put to non agricultural use	10401	5
Net area sown	42488	19
Area sown more than once	35794	16
Cultivable waste land	14264	6
Current fallows	9045	20
Other fallows	1666	0.7
Total cropped area	78282	35
Total irrigated area	26363	12
Total orchards area	61200	27

The Kharif and the Rabi are the two principal crops. The kharif crops largely depend on the rainfall. Very limited area is irrigated by the assured irrigation water supply. The area covered under food grain crops is given in table below:

Table 1.9 Cropping Pattern, District Sirmaur

Crops	Area (Hectares)	Crop Production (Tones)
Wheat	25834	31594
Maize	22563	65866
Rice	5383	8729
Barley	2716	2314
Sugar	800	790
Pulses	3983	1764
Ragi	348	317
Common Millets	122	123
Chillies	307	69
Ginger	1187	9170
Oil seeds	1189	270

Source: Department of Agriculture

1.13 (A) Land Use & Land Cover of Study Area

The landuse / land cover map was prepared using Survey of India topographic sheets and IRS P6 LISS – III satellite imagery. The Landuse and land cover features in the study area Dense Forest, Land with scrub, Plantation and River (fig.1.13 (a)).

Similarly Forest Area map was prepared with the help of processed satellite imagery, the same has been shown

In the study area, the map shows that the study area is mostly forest cover, having barren rocky type of topography and land without scrub at few places. The urban part is restricted to the eastern and western side of the study area. The crop land which is mainly found near rivers and in major part of the valley portion of Paonta valley.

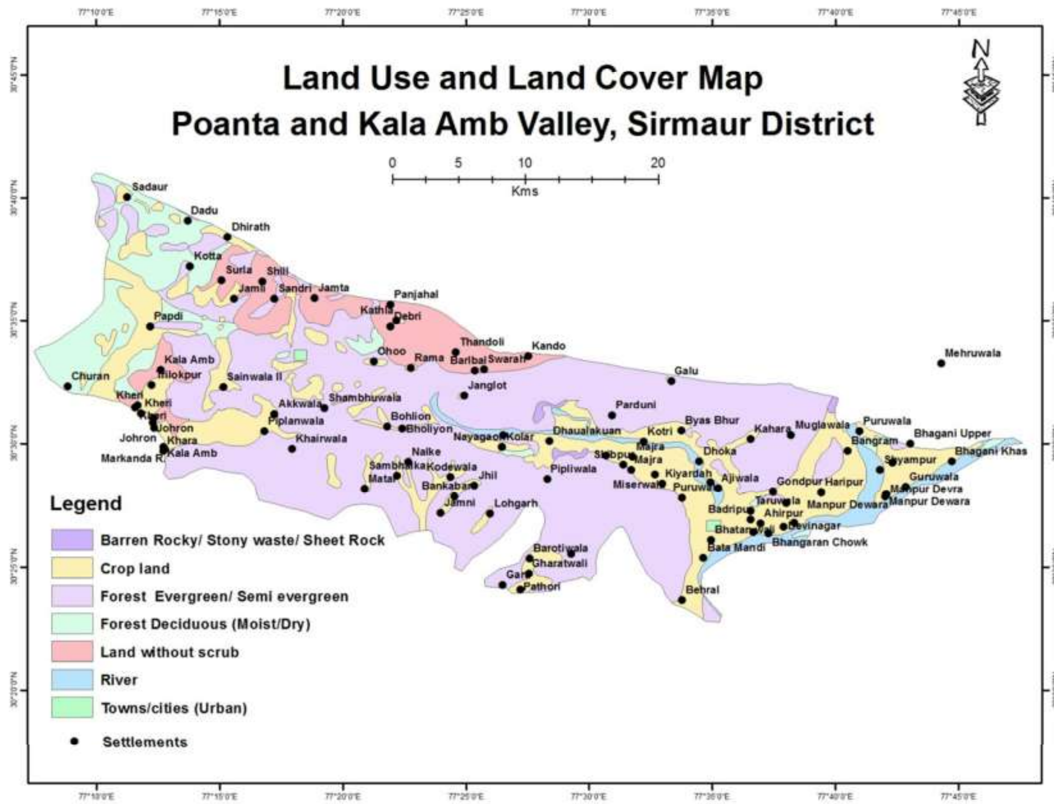


Fig 1.15 The Land Use, Map of Paonta-Kala Amb Valley, Sirmaur District

(B) Forest cover of the Study area

Most of the area under study shows, moderately dense and open forest. Densely forest area are also shown in some places. Non forest cover area is the main valley part of Sirmaur district.

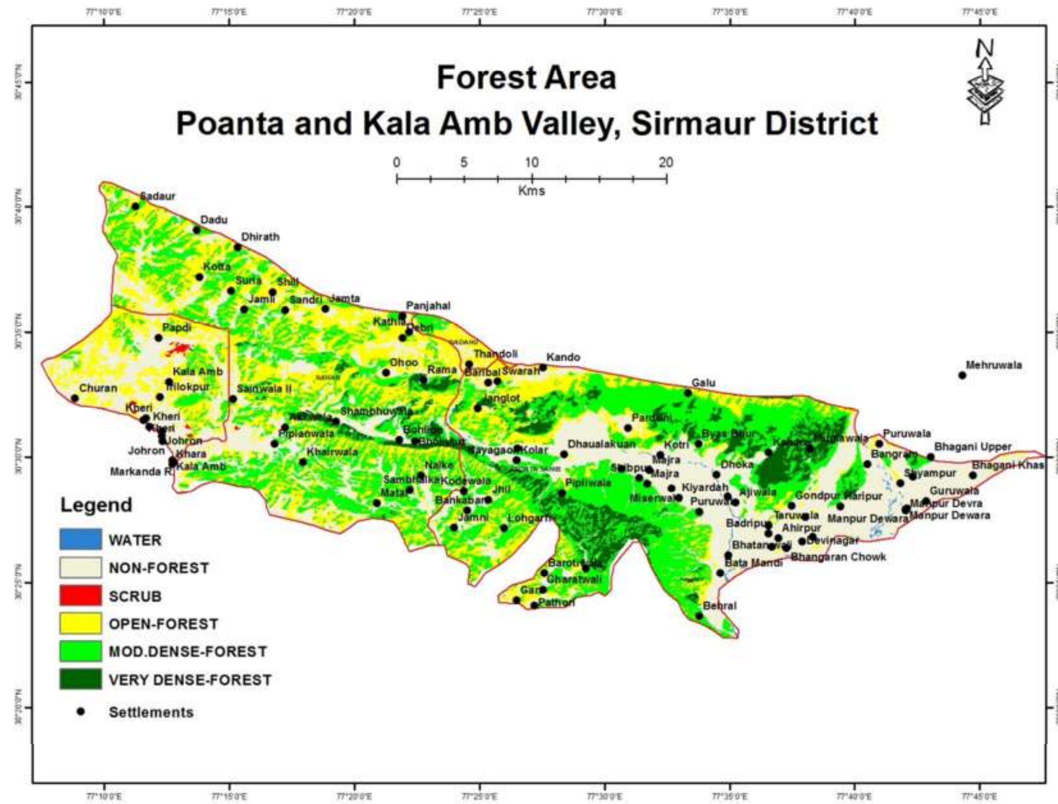


Fig 1.16 The Forest cover Map of Paonta-Kala Amb Valley, Sirmaur District

1.14 Industries and Mining activities

There is not much industrial development in the district. However, industries which are situated near Paonta town, are: Daulakuan: Lime industry on Giri Nagar road, Patlian: Malwa cotton mills, Gondpur Industrial: Lime industry, Rajban CCI: Lime industry, Ranbaxy: Pharmaceutical industry, Bangran road: Gill chemicals, lime industry, Rampur Ghat road: Milk plant, Jattanwali on Trilokpur Road: Ruchila paper,Paper mill, Khairi on Trilokpur Road: Pashupati Textile dying industry.

1.15 Climate & Rainfall

The climate of the district is sub-tropical to temperate depending upon the elevation. Four major seasons that is the winter season extends from Nov to February; summer season from March to June followed by the monsoon period extending from July to September end. Maximum precipitation in the form of rain occurs during July to September. Average annual rainfall in the district is about 1356.4 mm, out of which 83.2% occurs during monsoon season. In the non monsoon season precipitation as snowfall also occurs in the higher reaches above 1500 m amsl, the peaks of Choor dhar remains covered by snow. During winter period rainfall also occurs in lower hills and valleys parts. Mean maximum and minimum temperature of 30°C and -0°C respectively. The district wise monthly rainfall is as under.

Table 1.10 : **Monthly Rainfall (mm)** , District Sirmaur

Year	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov.	Dec,	Total
2004	98.5	6	0	31.7	55.5	147.7	150.2	542.9	77.6	97.5	2.7	3.7	1214.0
2005	63.5	96.9	87.7	3.3	29.4	105.6	477	127.5	323	0	0	0	1313.9
2006	42.7	1.3	125.4	6.4	104.6	123.4	538.4	322	64.4	20	10.8	18.8	1378.2
2007	0	179.7	166	15.2	24.8	186.9	199.6	399	80.8	13.3	0	11	1276.3
2008	29.4	33.1	0	41.9	64	320.6	305.7	366	255.1	5.3	1	0	1422.1
2009	1.3	24.1	24.9	16.6	37.1	40.7	313.3	112.7	365.1	26.3	12.8	0	974.9
2010	8.1	31.4	1.2	4.4	24.6	90.3	566.7	509.5	597.1	13.4	12.3	44.9	1903.9
2011	11.4	32.7	15.2	17.7	61.4	415.4	456.2	399.3	196.7	7	0	11.9	1624.9
2012	49.9	12.2	8.3	26.6	0.7	41.3	375.9	396.6	169	0.2	2.2	16.7	1099.6
Avg.	**33.9**	**46.4**	**47.6**	**18.2**	**44.7**	**163.5**	**375.9**	**352.8**	**236.5**	**20.3**	**4.6**	**11.9**	**1356.4**

Source: IMD data

1.16 Soil Types

For the preparation of the soil map, the soil atlas of the Himachal Pradesh, prepared by C.G.W.B. Northern Himalayan Region is used as the primary source and then updated with satellite imagery. The different soil types are shown in fig. 1.14

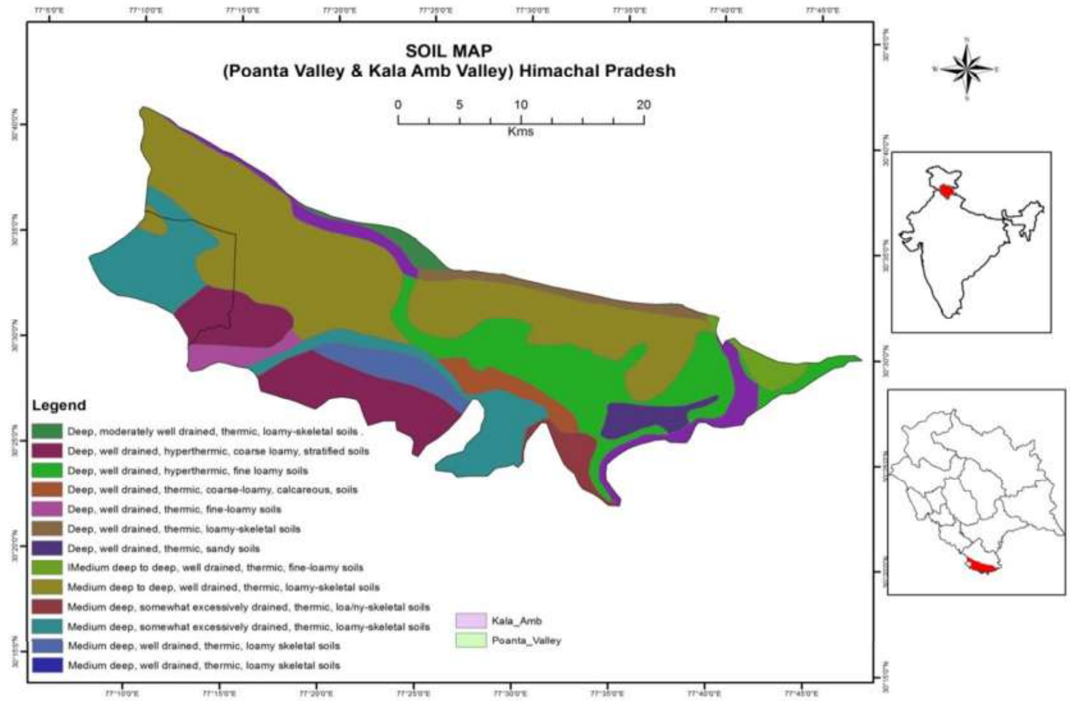
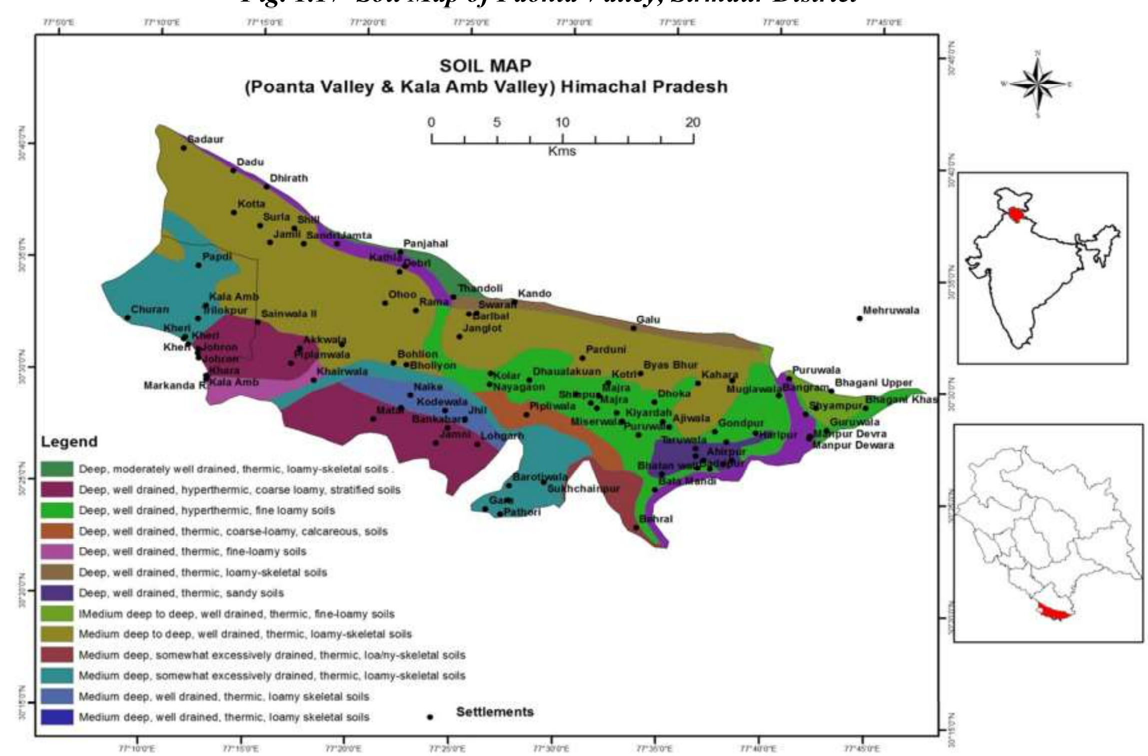


Fig. 1.17 Soil Map of Paonta Valley, Sirmaur District



1.13 Previous Work and Present Status of Data

Central Ground Water Board, NHR, Dharamshala has brought out district reports, ground water management studies reports, ground water exploration reports periodically on all districts of Himachal Pradesh. The systematic surveys and reappraisal hydro geological surveys were carried out by CGWB in Sirmaur district during various field seasons.

Central Ground Water Board, NHR, Dharamshala has also carried out preliminary Pollution studies in Urban clusters of Kala Amb and Paonta Sahib of Sirmaur District and ground water exploration studies in the area.

CGWB NHR, Dharamshala is monitoring ground water levels from National Hydrograph Network observations and aquifer mapping wells (Table 1.13) since 1977 in all valleys of Himachal Pradesh four times a year in the months of, May, August, November and January. The ground water quality is being studied by CGWB once in a year from the samples collected from those observation wells during the month of May.

Table 1.11 National Hydrograph Network observations and aquifer mapping wells of Kala Amb & Paonta Valley, Sirmaur District, Himachal Pradesh

S.No	Location details	Block	Lat	Long	type of well	Depth	Estt date	MP	RL
1	TIRLOKPUR	Nahan	30.54	77.204	Dug well	16.5	1981	0.89	366.01
2	KALA AMB	Nahan	30.498	77.212	Dug well	14.5	1974	0.72	340.18
3	SHAMBHU-WALA	Nahan	30.524	77.321	Dug well	13	1975	0.42	482.42
4	KIYARDA	Paonta sahib	30.473	77.549	Dug well	14.55	1975	0.56	408.49
5	KOLAR	Paonta sahib	30.498	77.441	Dug well	29.95	1974	0.85	501.77
6	NAYAGAON	Paonta sahib	30.498	77.441	Dug well	20	1974	0.6	422.5
7	SHIBPUR	Paonta sahib	30.486	77.523	Dug well	30.5	1975	0.36	450.72
8	DHAULAKUAN	Paonta sahib	30.502	77.473	Dug well	13	1974	0.38	442.08
9	BADRIPUR	Paonta sahib	30.449	77.609	Dug well	13.5	1990	0.38	394.81
10	NARIWALA	Paonta sahib			abandoned	45	1981	0.38	469.41
11	AJIWALA	Paonta sahib	30.47	77.587	Dug well	8.65	1981	0.56	391.62
12	KHODAWALA	Paonta sahib	30.487	77.705	Dug well	20.5	1990	0.2	445.09
13	AKKWALA	Paonta sahib	30.52	77.287	Dug well				

2.0 DATA COLLECTION & GENERATION

2.1 Exploratory Drilling Data

The existing structures which fulfil the criteria is taken as available no of structures and their data is collected for further studies. Data generation is the creation of additional structure / data. The activity wise & aquifer wise data gap, data generation during the study period & balance to be generated is given below;

Table 1.12 **DGA** , District Sirmaur

Activity	**Data Gap**		**Data Generated**		**To be Generated**	
	1st Aq	**2nd Aq**	**1st Aq**	**2nd Aq**	**1st Aq**	**2nd Aq**
Exploration wells	3	1	2	0	1	1
Observation wells	2	1	0	0	2	1
Piezometers	0	0	0	0	0	0
WL monitoring Key wells	17	0			17	0
WQ monitoring wells	0	0			0	0
VES for Resistivity survey	0	25	0	0	0	25
Soil Infiltration test	34		0		34	
Spring discharge monitoring	0				0	

Table 1.13 EWs of Paonta valley, drilled by CGWB

Location	**LONGITUDE**	**LATITUDE**	**ELEVATION**	**COLLAR ELEVATION**	**TOTAL DEPTH**
Akalgarh	77.670	30.464	442	442	137
Bhungarni	77.638	30.460	424	424	91
Singhpura	77.724	30.482	448	448	175
Paunta	77.621	30.441	400	400	75
Jawalapur	77.639	30.486	467	467	76.83
Nariwala	77.638	30.477	450	450	82.35
Khaddar	77.436	30.508	472	472	97.56
Dhaulakuan 1	77.458	30.505	417	417	93.6
Sudanwala	77.469	30.486	473	473	139
Kiyardah	77.550	30.475	410	410	110
Paunta Sahib II	77.620	30.449	405	405	95
Matak Majri	77.538	30.493	400	400	127
Kala Amb	77.205	30.500	405	405	134.72
Jattowala	77.439	30.506	470	470	121.92
Dhaulakuan	77.488	30.525	420	420	123.13

Location	LONGITUDE	LATITUDE	ELEVATION	COLLAR ELEVATION	TOTAL DEPTH
Bhattanwali	77.589	30.440	418	418	125
Mnpur deora	77.697	30.463	430	430	100
Moginand	77.239	30.514	380	380	100
Bhurridiyon	77.200	30.536	368	368	100
Rajban Road	77.643	30.482	480	480	101
Bherewala	77.483	30.450	544	544	106
Paunta Sahib I	77.621	30.441	400 m	400	75
Dholakuna 2	77.458	30.485	406 m	406	123.13
Dhandwala gurudwara	77.194	30.602	449	449	120
Johron	77.224	30.514	405	405	100
Goindpur	77.613	30.471	442	442	123
Nihalgarh	77.483	30.468	593	593	101.5
Bharawala	77.483	30.450	544	544	106
Kolar	77.436	30.499	504	504	116.5
Balwala	77.474	30.483	495	495	90
Nihalgarh	77.483	30.468	593	593	101.5

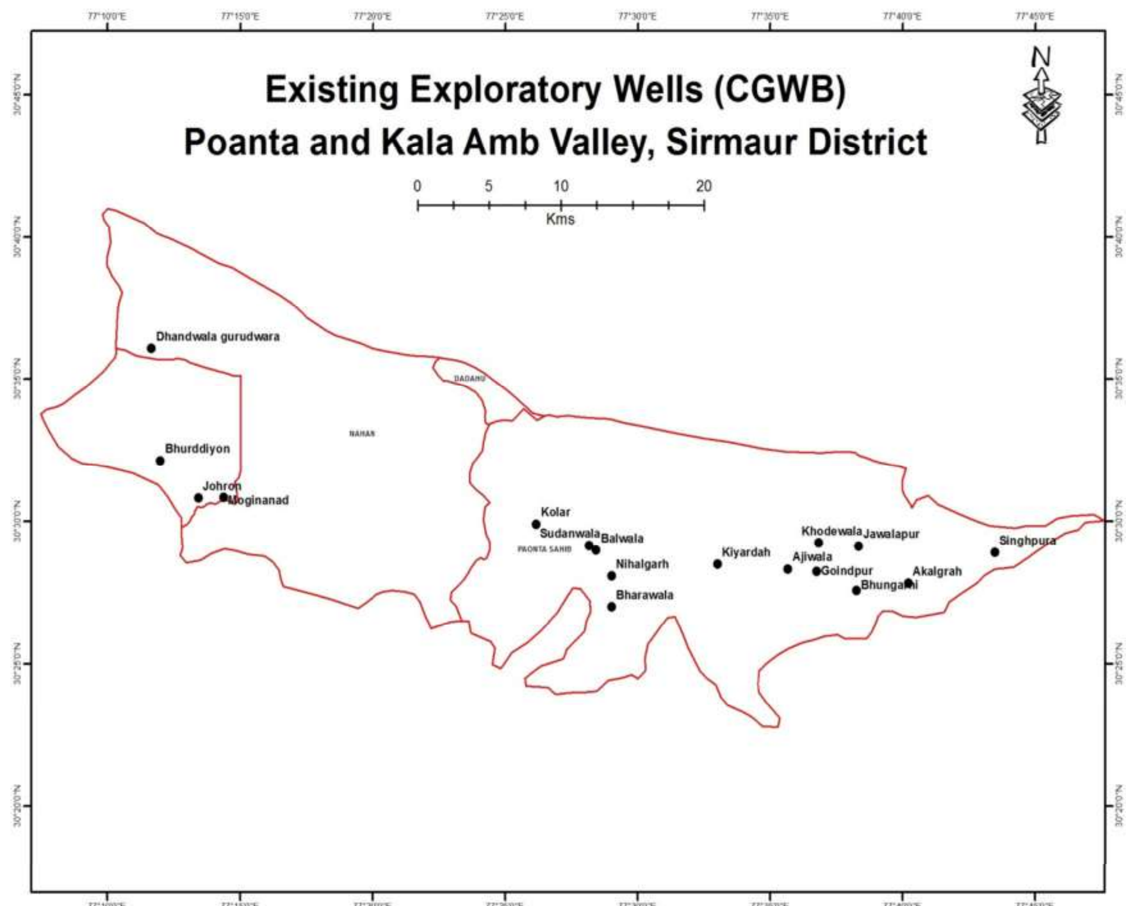


Fig. 2.0 Existing EW Map of Paonta Valley, Sirmaur District

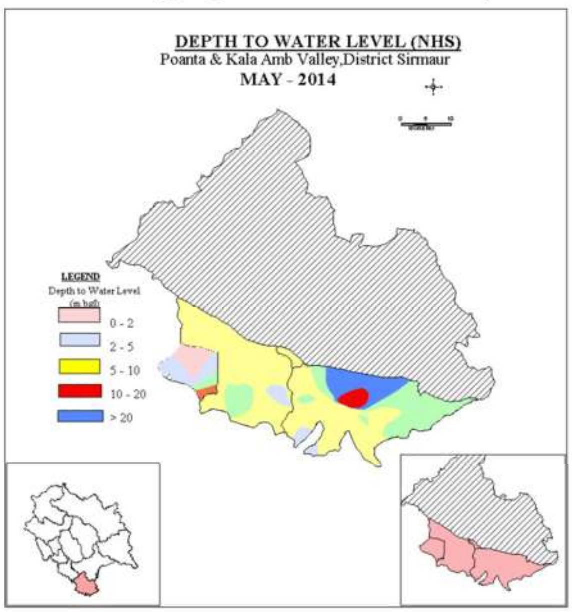
2.2 Hydrogeological Data

2.2.1 Water Level Behaviour (NHS)

To know the water level and its behaviour with respect to time and space, 13 dug wells have been inventoried for Ground Water Management Studies all over the area. The dug wells are located in and around Kala amb and Paonta valley. The water levels were taken during the month of May and November, 2015 & 2016 and on the basis of these data, pre-monsoon, post monsoon and seasonal fluctuation map have been prepared for the Nalagarh valley area. The hydrogeological data of the inventoried dug wells are given in Table 2.1.

In Paonta valley depth to water level shows wide variation. During pre-monsoon period (May 2014) it ranges from 5.06 to 31.00 m bgl (Fig. 2.1) and post monsoon period (Aug.2015) & Nov 2015, ranges from 4.53 to 27.00 m bgl. (Fig. 2.2& 2.3).

Table 2.4 Water level data (May & Nov.2016 and May & Nov.2016) GWMS and Aquifer Mapping Wells of Paonta Valley, Sirmaour District, Himachal Pradesh



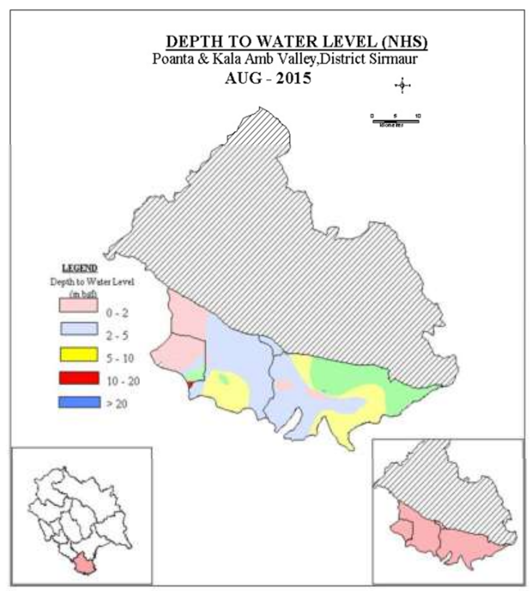
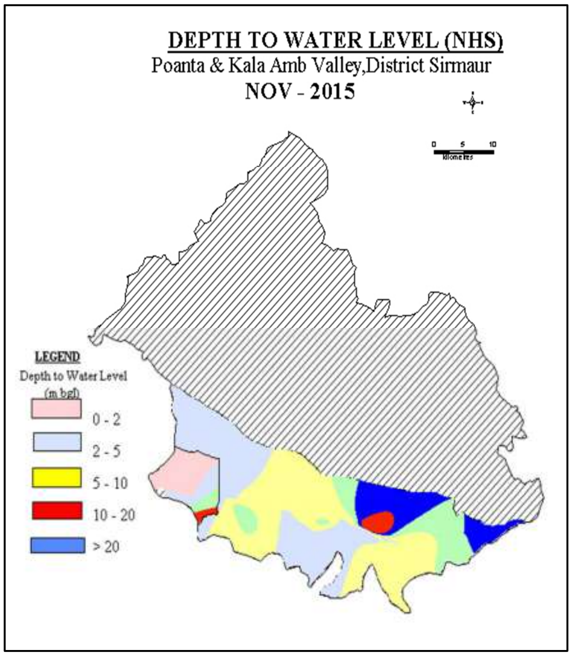


Fig:2.1 Map showing DTW from NHS (May 2014)	Fig:2.2 Map showing DTW from NHS (Aug 2015)

In the year 2017, Water level monitoring shows that, pre monsoon water level ranged from 2.07 to 28.83 m bgl & post monsoon water level ranged from 1.11 to 26.78m bgl. Monsoonal fluctuation varies from 0.69 to 14.13m, showing rise in all wells. Annual pre-monsoon fluctuation shows rise in 7 wells, ranging from 0.16m to 6.96m and fall in 4 wells, ranging from 0.39m to 3.42m. Decadal fluctuation of water level monitoring in Paonta valley of Sirmour district, showsrise in 4 wells, ranging from 0.42m to 12.64m and fall in 8 wells, ranging from 0.02m to 9.01m.



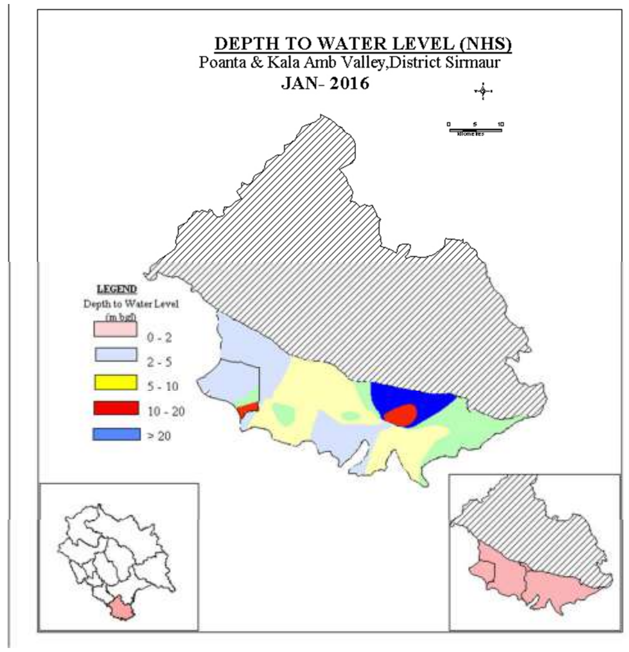


Fig:2.3 Map showing DTW from NHS (Nov 2015)

Fig:2.4 Map showing DTW from NHS (Jan 2016)

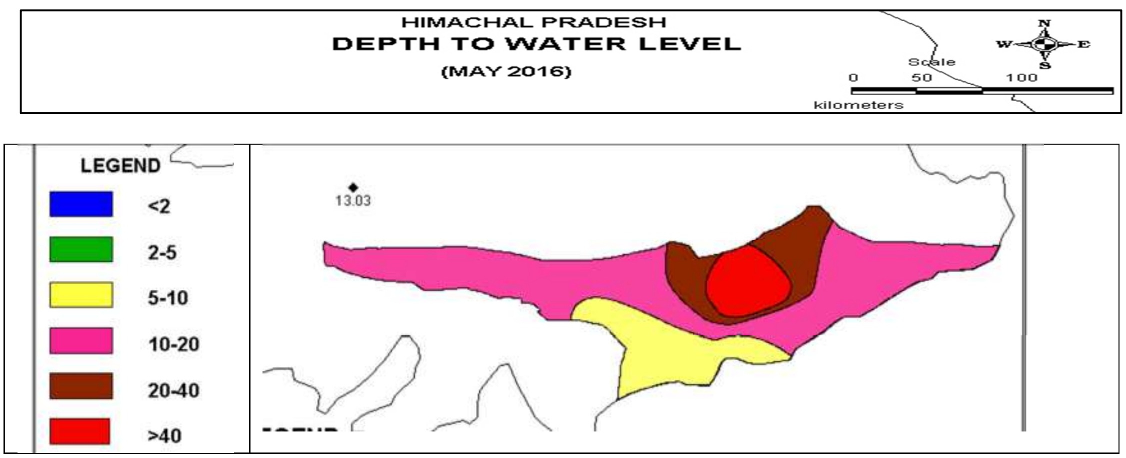


Fig:2.5 Map showing DTW from NHS (May 2016)

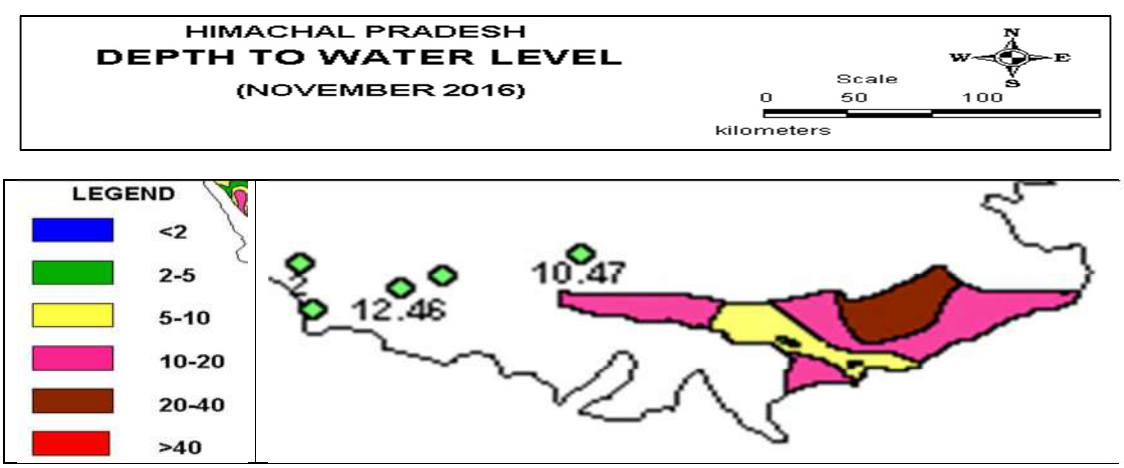


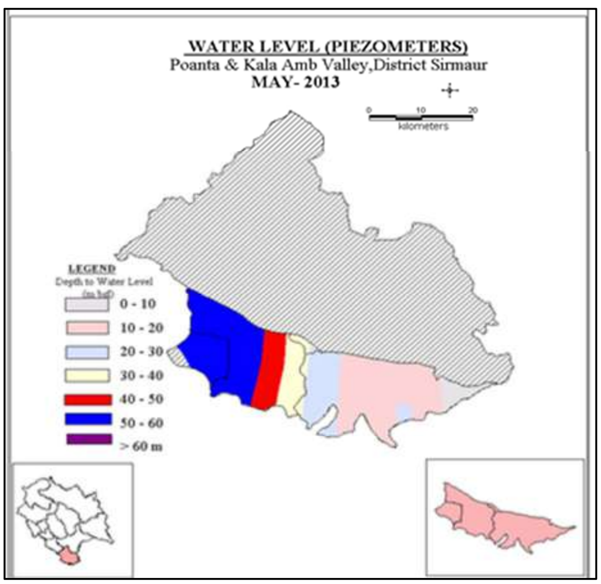
Fig:2.6 Map showing DTW from NHS (Nov 2016)

2.2.2 Water Level Behaviour (PIEZOMETERS):

To know the water level and its behaviour with respect to time and space, of deep aquifer water level of piezometers was analysed. This data have been received from Irrigation & Public Health Department, Govt of Himachal Pradesh. A total of 10 piezometers have been monitored from automatic water level recorders. The detail peruse of maps are shown below:

Table 2.1 : Location of Piezometers (I&PH Deptt), District Sirmaur

Unique ID	Name of village/site	Latitude	Longitude	Type (DW/PZ/Spring)	Source/Agency
sPz-1	Majra	30.4822	77.5281	Pz	IPH
spz-2	Manpur Devra	30.466	77.7009	Pz	IPH
spz-3	Bhagani Upper	30.5001	77.7169	Pz	IPH
spz-4	Gulabgarh	30.4736	77.5818	Pz	IPH
spz-5	Taruwala	30.4545	77.6089	Pz	IPH
spz-6	Jattonwala	30.5058	77.4417	Pz	IPH
spz-7	Johron	30.5143	77.2049	Pz	IPH
spz-8	Kheri	30.5205	77.1967	Pz	IPH
spz-9	Churan	30.539	77.1474	Pz	IPH
spz-10	Bohlion	30.5117	77.3631	Pz	IPH



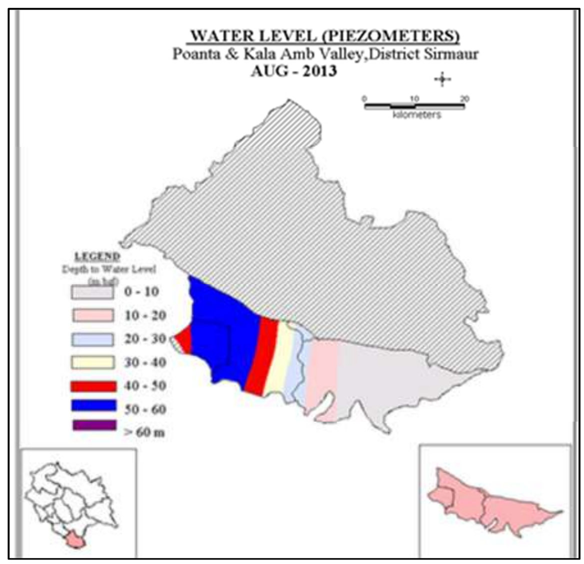


Fig:2.7 Pre monsoon Map showing DTW from Piezometers (May 2013)	Fig:2.8 Map showing DTW from Piezometers (Aug 2013)

The water level behavior from piezometers of the State, shows that water level ranges from 2m to a range of 20-40m. Eastern part of the valley shows shallower water level behavior. As we go from western side, the deep water levels are shown, shown in figures.

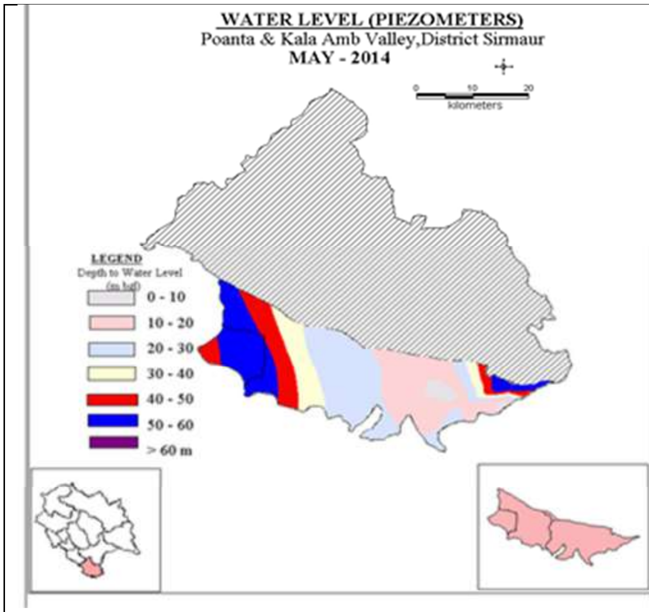


Fig:2.9 Pre monsoon Map showing DTW from Piezometers (May 2014)

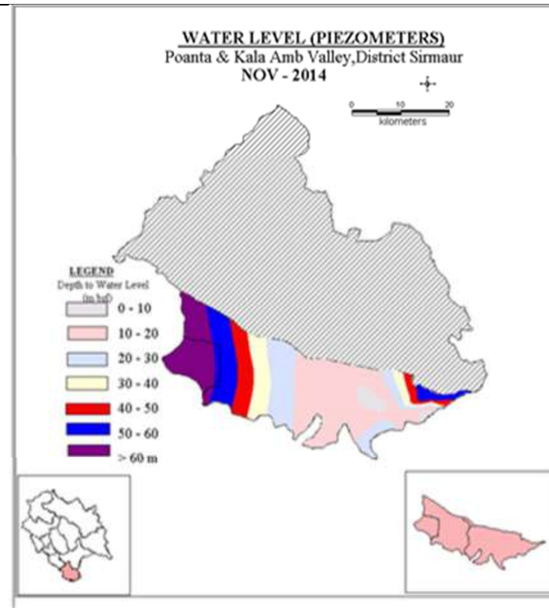


Fig:2.10 Post Monsoon Map showing DTW from Piezometers (Nov 2014)

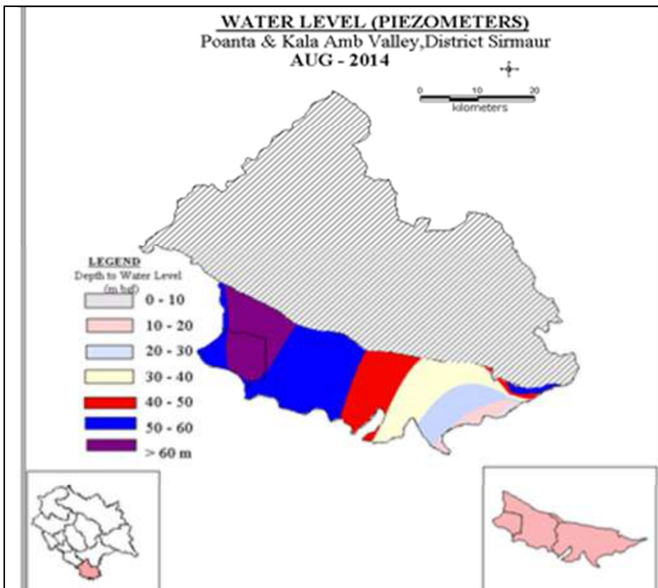


Fig:2.11 Map showing DTW from Piezometers (August 2014)

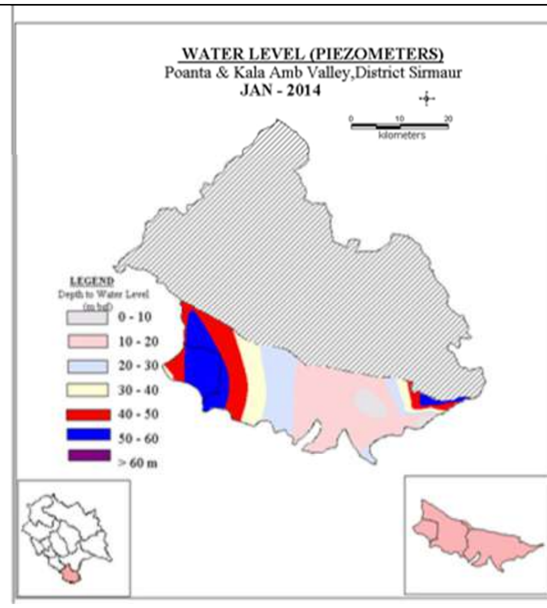


Fig:2.12 Map showing DTW from Piezometers (Jan 2014)

2.3 Ground Water Quality

The water quality standards are laid down to evaluate suitability of water for intended uses and to safeguard water from degradation. These recommended limits form the basis of treatment needed for improvement in quality of water before use. In the formulation of water quality standards, the selection of parameters is considered depending upon its end use. Two types of standards are referred in India decipher the quality of water suitable for drinking purposes, namely Bureau of Indian Standards (BIS) and World Health Organisation (WHO) Standards.

2.3.1 Drinking Water

The BIS has laid down the standard specification for drinking water during 1983, which have been revised and updated from time to time. In order to enable the users to exercise their discretion, the maximum permissible limit has been prescribed especially where no alternative sources are available. It is medically established fact that water with concentration beyond permissible limits cause short term or permanent adverse health effects.

2.3.2 Standards for Chemical Parameters

The water quality standards as laid down in BIS standard (IS-10500, 1991), First Revision, 2003-2009 and WHO (2008) standards are summarized in Table 2.7 and Table 2.8 respectively. In addition separate standards for the use of Surface water i.e. lakes and rivers for drinking purposes have been laid down by BIS and have been given in table.

Table 2.2 Drinking water Standards - BIS (IS-10500, 1991)

S. No.	Parameters	Desirable limits (mg/l)	Permissible limits (mg/l)
Essential Characteristics			
1	Colour Hazen unit	5	25
2	Odour	Unobjectionable	-
3	Taste	Agreeable	-
4	Turbidity (NTU)	5	10
5	pH	6.5 - 8.5	No relaxation
6	Total Hardness, $CaCO_3$	300	600
7	Iron (Fe)	0.3	1
8	Chloride (Cl)	250	1000
9	Residual Free Chlorine	0.2	-
10	Fluoride (F)	1	1.5
Desirable Characteristics			
11	Dissolved Solids	500	2000
12	Calcium (Ca)	75	200
13	Magnesium (Mg)	30	100
14	Copper (Cu)	0.05	1.5
15	Manganese (Mn)	0.1	0.3
16	Sulphate (SO_4)	200	400
17	Nitrate (NO_3)	45	100
18	Phenolic Compounds	0.001	0.002
19	Mercury (Hg)	0.001	No relaxation
20	Cadmium (Cd)	0.01	No relaxation
21	Selenium (Se)	0.01	No relaxation
22	Arsenic (As)	0.01	No relaxation
23	Cyanide (CN)	0.05	No relaxation
24	Lead (Pb)	0.05	No relaxation

25	Zinc (Zn)	5	15
26	Anionic Detergents (as MBAS)	0.2	1
27	Hexavelant Chromium	0.05	no relaxation
28	Poly Nuclear Hydrocarbons (as PAH)	-	-
29	Alkalinity	200	600
30	Aluminium (Al)	0.03	0.2
31	Boron (B)	1	5
32	Pesticides	Absent	0.001
33	Mineral Oil	0.01	0.03
34	Radioactive Material		
	Alpha Emmiters, Bq/l	-	.0.1
	Beta Emmiters, pci/l	-	1

NTU = Nephelometric Turbidity Unit

Table 2.3 Drinking Water Standards, WHO (2008)

S. No.	Parameters	Guideline value (mg/l)	Remarks
1	Aluminium	0.2	
2	Ammonia	-	NAD
3	Antimony	0.005	
4	Arsenic	0.01	For excess skin cancer risk of 6×10^{-4}
5	Asbestos	-	NAD
6	Barium	0.3	
7	Beryllium	-	NAD
8	Boron	0.3	
9	Cadmium	0.003	
10	Chloride	250	
11	Chromium	0.05	
12	Color	-	Not Mentioned
13	Copper	2	ATO
14	Cyanide	0.07	
15	Dissolved Oxygen		NAD
16	Fluoride	1.5	Climatic conditions, volume of water consumed, and intake from other sources should be considered when setting national standards.
17	Hardness		NAD
18	Hydrogen Sulfide		NAD
19	Iron		NAD
20	Lead	0.01	It is recognized that not all water will meet the guideline value immediately; meanwhile, all other recommended measures to reduce the total exposure to lead should be implemented.
21	Manganese	0.5 (P)	ATO
22	Mercury (total)	0.001	-
23	Molybdenum	0.07	-
24	Nickel	0.02	-
25	Nitrate (as NO_3) Nitrite (as NO_2)	50	The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1.
26	Turbidity		Not Mentioned
27	pH		NAD
28	Selenium	0.01	-
29	Silver		NAD
30	Sodium	200	
31	Sulfate	500	
32	Inorganic Tin		NAD

33	TDS		NAD
34	Uranium	1.4	
35	Zinc	3	

NAD - No adequate data to permit recommendation
ATO - Appearance, taste or odour of the water

2.3.3 Standards for Bacteriological Parameters

Faecal contamination is widespread in most of the Rural Areas. The major bacteriological contamination and their limits are given below:

E. Coli is the more precise indicator of faecal pollution. The count of thermo-tolerant, coliform bacteria is an acceptable method however, if necessary, proper confirmatory tests of the sample should be carried out. As per Indian standard for drinking water - specification (First Revision) IS-10500:1991 BIS, ideally, all samples taken from the distribution system including consumers' premises should be free from coliform organisms. In practice, this is not always attainable. The following standard of water collected in the distribution system is therefore recommended when tested in accordance with IS 1622:1981.

a) 95 percent of samples should not contain any coliform organisms in 100 ml;
b) No sample should contain E. coli in 100 ml;
c) No sample should contain more than 10 coliform organism per 100 ml; and
d) Coliform organism should not be detectable in 100 ml of any two consecutive samples.

WHO has also suggested guidelines for bacteriological parameters are as follows (Table 2.10)

Table 2.4 Bacteriological quality of drinking water (WHO, 2008)

Organisms	Guideline Value
All water intended for drinking	
E. Coli or thermo-tolerant coliform bacteria	Must not be detectable in any 100/ml sample.
Treated water entering the distribution system	
E. Coli or thermo-tolerant coliform bacteria	Must not be detectable in any 100/ml sample.
Total coliform bacteria	Must not be detectable in any 100/ml sample.
Treated water in the distribution system	
E. Coli or thermo-tolerant coliform bacteria	Must not be detectable in any 100/ml sample.
Total coliform bacteria	Must not be detectable in any 100/ml sample. In the case of large supplies, where sufficient samples are examined must not be present in 95% of sample taken throughout any 12 month period.

Table 2.5 Water Quality results of Sampling of Paonta Valley, District Sirmaur

Location	**Sp Cond ms/cm 25°C**	**HCO_3**	**Alkalinity**	**Cl** (mg/l)	**SO_4** (mg/l)	**NO_3** (mg/l)	**F** (mg/l)	**Ca** (mg/l)	**Mg** (mg/l)	**Na** (mg/l)	**K** (mg/l)	**TH** (mg/l)	**TDS**	**As** (mg/l)
Kala amb	580	214	175	43.0	94	2.0	0.24	56	20	50	6	220	302	BDL
Trilokpur	1050	275	225	152.0	89	15.0	0.35	30	12	186.0	12	125	546	BDL
Shambuwala	210	98	80	11.0	12	2.0	0.18	26	9	4.2	1	100	109	BDL
Kolar	550	201	165	14.0	78	28.0	0.07	68	22	12.0	2	260	286	BDL
Dhaula Kuan	450	153	125	18.0	81	0.0	0.12	54	18	12.0	3.2	205	234	BDL
Naya Goan	250	110	90	11.0	36	1.0	0.07	26	16	6.0	1	130	130	BDL
Kiyarda	330	147	120	25.0	12	5.0	0.05	22	23	9.5	1.3	150	172	BDL
Badripur	390	116	95	25.0	63	28.0	0.04	36	24	12.0	2	190	203	BDL
Shibpur	190	85	70	11.0	21	0.0	0.15	18	12	5.1	0.8	95	99	BDL
Khodewala	560	305	250	11.0	8	13.0	0.03	36	44	5.6	1.3	270	291	BDL
Ajjwala	430	153	125	18.0	54	35.0	0.02	40	24	12.0	7.2	200	224	BDL
Akkwala	350	195	160	14.0	32	0.0	0.10	30	15	33.0	4.5	135	182	BDL

2.4 Spatial Distribution of Quality Data

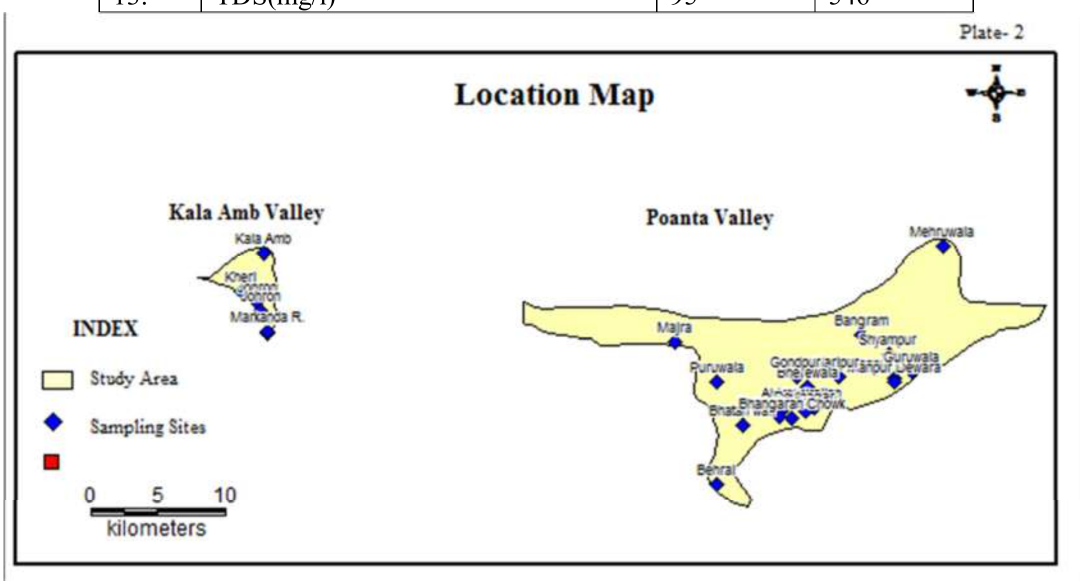
To assess the impact of ground water quality, 12 numbers of water samples were collected from the study area of Poanta Valley of district Sirmour in 2015, as per the list below:

Sr.No	Type of Source	Total Nos.
1	Dug Well	12 Nos.
2	Spring	5 Nos.

All the collected samples were analyzed at chemical laboratory of CGWB, North Western Himalayan Region, Jammu, (J&K), by adopting Standard methods of analysis (APHA) and ranges are given below Table 2.12.

Table 2.6 General ranges of water quality parameters of study area

Sr.No	Water Quality Parameters	Minimum	Maximum
1.	PH	6.50	8.00
2.	E.C Sp. Cond. µmhos/cm at 25°C	190	1050
3.	CO_3 (mg/l)	0	
4.	HCO_3 (mg/l)	85	305
5.	CL (mg/l)	11	152
6.	NO3(mg/l)	1.0	35
7.	F (mg/l)	0.04	6.35
8.	Ca (mg/l)	18	68
9.	Mg (mg/l)	9	44
10.	Na (mg/l)	4.2	186
11.	K (mg/l)	0.8	12
12.	TH (mg/l)	95	270
13.	TDS(mg/l)	95	546



pH

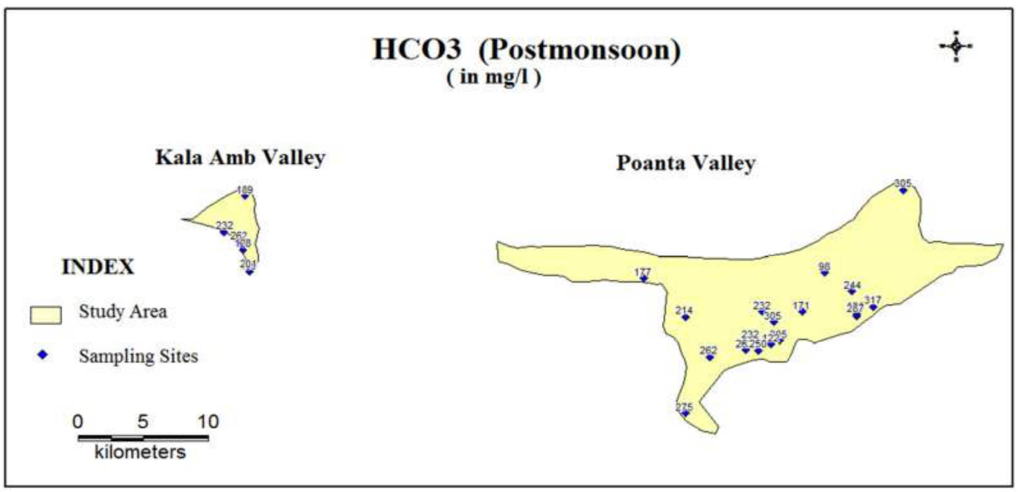
The pH is a numerical scale which express the degree of acidity or alkalinity of solution and represented by the equation pH= $\log 1/aH^{+} = -\log aH^{+}$ or in other words pH may be defined as negative logarithmic of Hydrogen ion concentration. In study area, the overall range of pH in ground water varies from 6.50 to 8.00. Ground water of the area is alkaline in nature varying from 70 to 250.

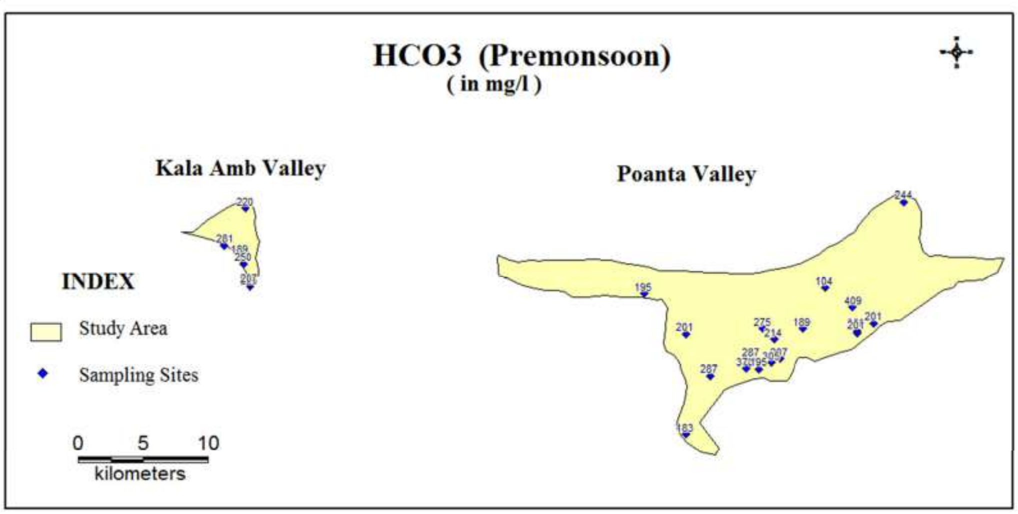
Electrical conductivity

Electrical Conductivity can be defined as the ability of a solution to conduct an electric current and measured in micro mhos /cm and reported at 25°C. Electrical Conductivity is a function of concentration of ions, charge and ionic mobility Electrical Conductivity is approximately indicative of ionic strength. In study area spring water is least mineralised. Maximum value of EC 1050 micro mhos /cm is determined in the sample collected from Trilokpur, Sirmour District.

Bicarbonate

Overall value of Bicarbonate varies from 85 to 305(Khodewala) mg/l. Maximum concentration of Bicarbonate is noticed in all samples collected from Shallow depth :



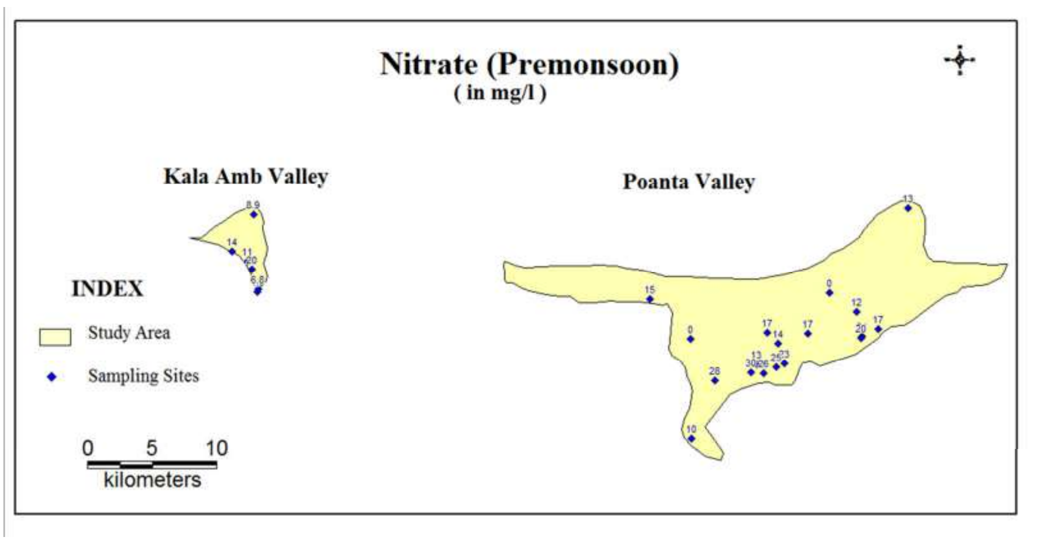


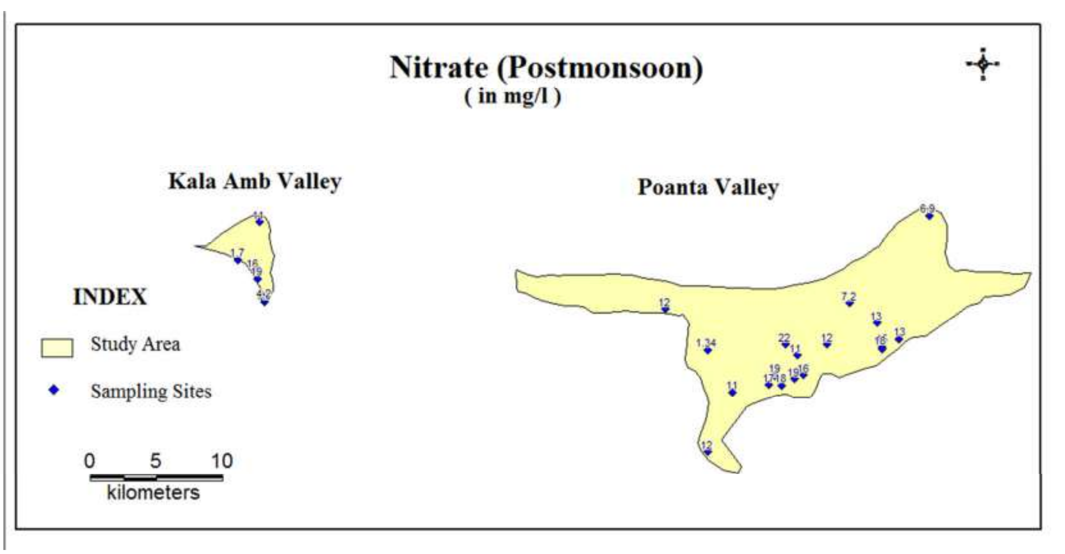
Chloride

Chloride is one of the most common constituent in groundwater and very stable as compared to other ions like SO_4, HCO_3, NO_3 etc. It is noticed from the chemical data that, varies from 7 mg/l (Nayagaon) to 167 mg/l (Trilokpur)

Nitrate

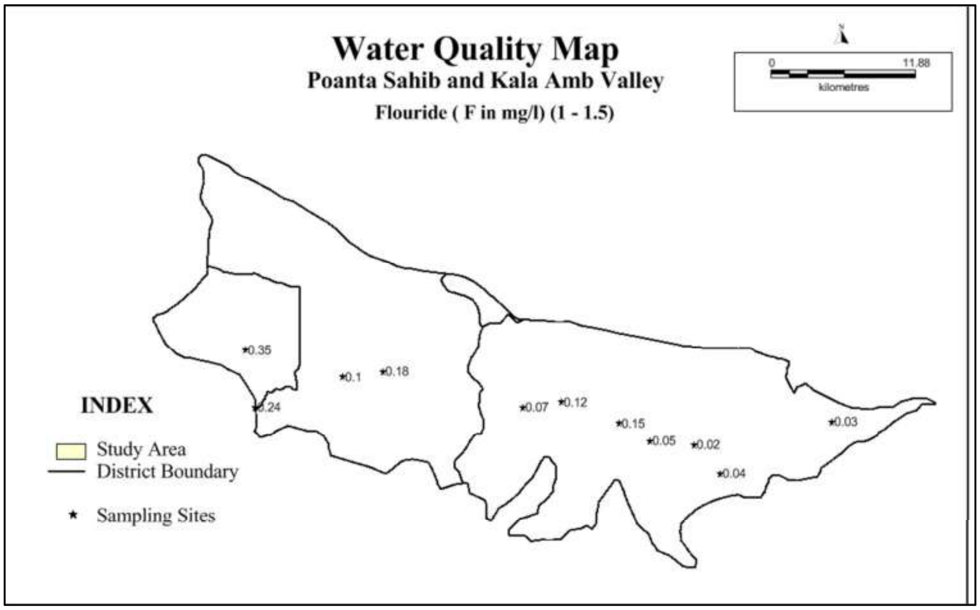
Nitrate is one of the important pollution related parameter. Nitrate is the end product of the aerobic oxidation of nitrogen compounds. Mainly it is contributed by nitrogenous fertilizers, decomposition of organic matter in the soil, fixation of nitrogen by bacteria etc. Human and animal excreta may also add nitrate to water by bacterial decomposition. For drinking water maximum permissible limit of nitrate is 45 mg/l as per BIS 1991-Rev-2007. In the study area, Nitrate concentration varies from minimum 1.0 (Nayagaon) to a maximum concentration of 35 (Ajiwala) mg/. The concentrations are all with in the permissible limit.





Fluoride

Fluoride is an important water quality parameter for accessing the water quality for drinking purpose. Fluoride is more abundant than chloride in the igneous and as well as sedimentary rocks. Fluoride differs from other halogen members due to high electronegative character. In study area, Fluoride concentration ranges from 0.03 to 0.72.



Calcium

The calcium is a major constituent of various rocks. The precipitates (limestone) contain about 27.2% of calcium ions. It is one of the most common constituent present in natural water. Calcium minerals associated with sodium, aluminium, silica, sulphate, carbonate and Fluoride. Maximum permissible limit for calcium is 200 mg/l.

It is observed that all collected samples, are found to have concentration of Calcium, within the maximum permissible limit of BIS for drinking water.

Magnesium

Magnesium is the 8^{th} most abundant element in the solar system. It is available in various rocks .The maximum concentration of Magnesium, 4.53 % is found in the evaporates of sedimentary rocks. The concentration of Magnesium in natural water is mainly controlled by dissolved CO_2.

The concentration of Magnesium in springs, Ground Water Aquifers (Shallow & Deep) are within the maximum permissible of BIS (100 mg/l) for drinking water.

It is observed that all collected samples, are found to have concentration of Magnesium, within the maximum permissible limit of BIS for drinking water.

Sodium

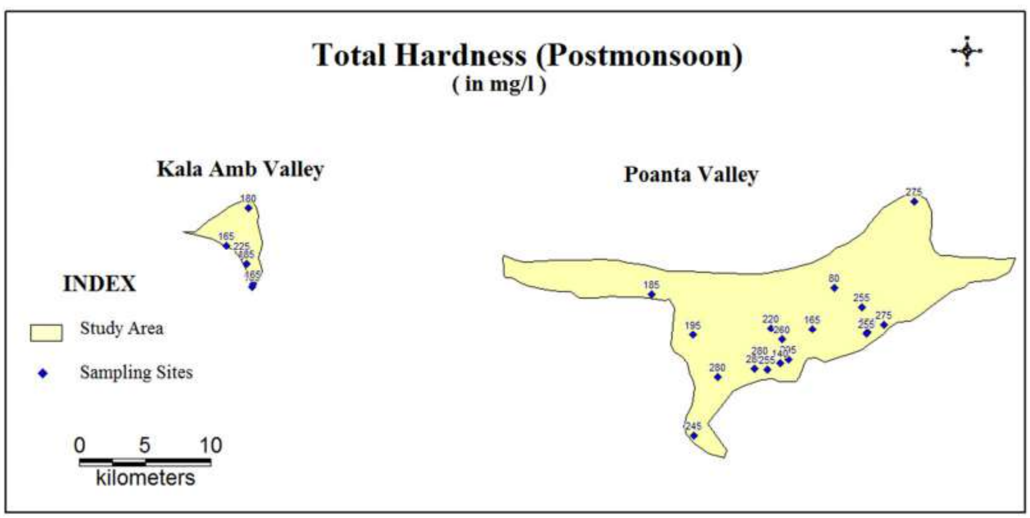
Sodium is the abundant of the alkali element in the earth's crust. Most of the Sodium occurs in the Feldspars, Mica, amphiboles and Pyroxenes. In study area, Sodium concentration ranges from 0.03 to 0.72 mg/l.

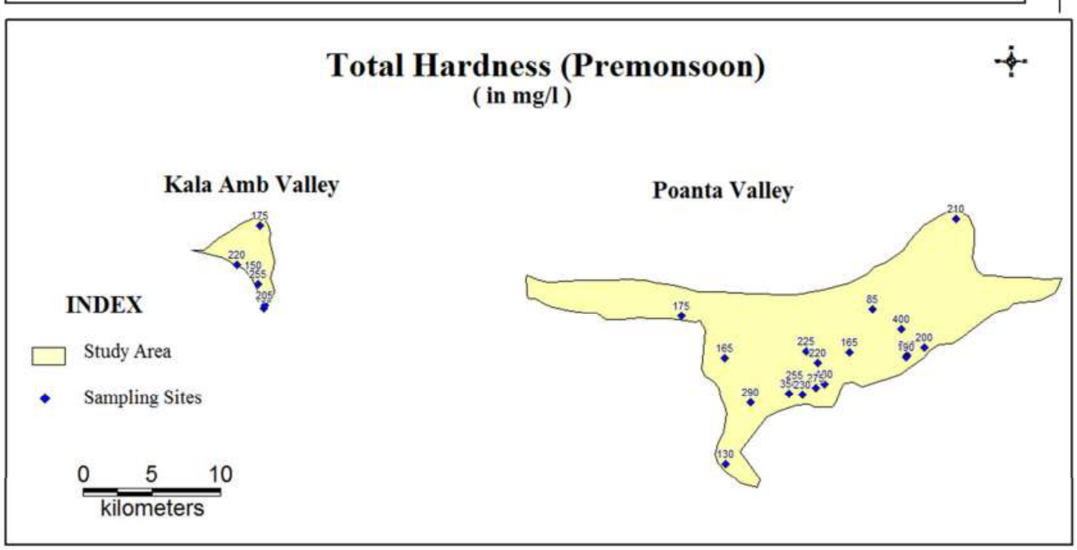
Potassium

Potassium in sedimentary rock is more abundant than Sodium. The main potassium minerals containing silicates are Orthoclase, micas. Evaporate beds may contain potassium salts. In study area, Potasium concentration ranges from 0.03 to 0.72 mg/l

Total Hardness (TH)

High concentration of carbonates, bicarbonates of calcium and magnesium, in ground water causes hardness. It causes scaling in water supply lines. High concentration of hardness in ground water is social economic problem; hence it is also an important water quality parameter. Hardness of water is the capacity to neutralize soap and is mainly caused by carbonates and bicarbonates of calcium, magnesium. In study area the overall value of total hardness varies from 105 mg/l to 390mg/l

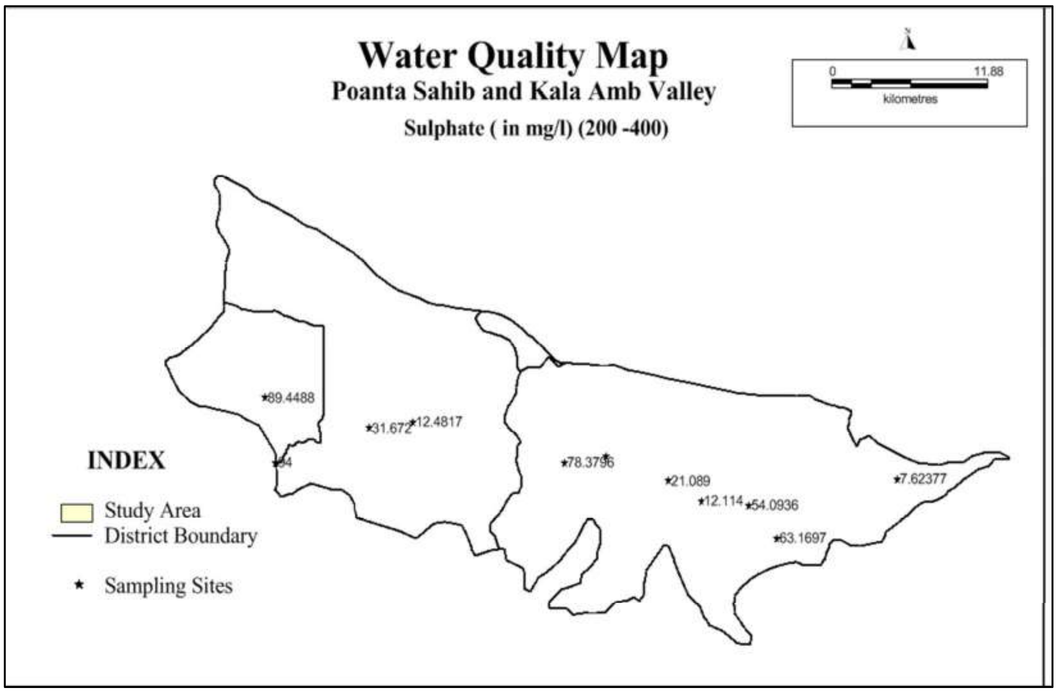




Sulphate

Sulphur and its compounds are widely distributed in nature. In rocks it occurs mostly as the metallic sulphides which on oxidation yield sulphate ions. Sulphate ions occur mostly as anhydrite and as Gypsum.

The concentrations of Sulphate, in all the samples collected from the study area are within the permissible limit of BIS for drinking water.



3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Due to limited data availability the aquifer and other related maps could not be generated. However, whatever the data is available; it is compiled & interpreted as given below;

Table 3.1 Table showing Activites & their Need

Activities	Why Needed	Paonta Valley	Remarks
Exploration wells	To know the lithology & aquifer parameters	Total EWs are in the depth range of 100m - 150m. Lithologs & other details are given in Annexure	**Annexure-I Table 1.13 Fig. 2.0**
Observation wells	OW is required for pumping test of main well.	Total OWs are in the same range	
Piezometers	Required for monitoring water level & collecting water samples	Already 10 Pzs of state govt exist for monitoring water level	**Table-2.1 Fig. 2.7-2.12**
Water Level monitoring Key wells	For water level monitoring	Water level data of 13- wells monitored 4 times in a year and WL varies from 1.20 to 28mbgl, The water level maps are prepared .	**Table-1.11 Fig 2.1 – 2.6**
Water Quality monitoring wells	To know the ground water quality	Water samples at 13 locations are taken 2 times in a year and results shown	**Table 2.5**
VES for Resistivity survey	to know the depth of weathered & fractures zone and Lineaments	Due to non availability of instrument the VES could not be conducted	
Electrical Logging	To identify the aquifers properly	Due to non availability of instrument the VES could not be conducted	
Soil Infiltration test	To know the infiltration rate of the soil for assessing the rainfall recharge & runoff component	Due to non availability of instrument the soil infiltration test could not be conducted	
Spring discharge monitoring	To know the availability of water for direct use and ground water withdrawal	Monitored discharge of 5 springs 4 times in a year and discharge varies from meager to 1 lpm during may	**Table 1.4**
Pumping test analysis	conducted pumping test to know the aquifer parameters i.e discharge of well, draw down of Water Level, Transmisivity, Specific Yield of well, Storativity etc	Conducted pumping test of - Dhangwala well at a discharge of 870lpm, with drawdown 1.42m. Transmisiivity 1399.75 m3/day/m. and Specifiec Yield 635.43lpm/m	**Table 3.2**

3.1. Aquifer Parameters

Central Ground Water Board has constructed 19 exploratory tubewells in the Paonta valley varying in depth from 90 m to 163 m. The depth to water varies from 2 m bgl at Nihalgarh to 42 m at Kolar and discharges ranged from 2 lpm (Akalgarh) to 3220 lpm (Ajiwala). Transmissivity range from 211 m^2/day to 3336 m^2/day. The lithologs of exploratory wells of CGWB and I&PH Deptt.are summarized in Annexure I .

In Paonta Valley, District Sirmaur, the exploration drilling was carried out by CGWB under NAQUIM. Tthe aquifer parameters range of the wells which are tested, and given in below Table-3.2.

Table 3.2 Summary of exploration and hydraulic details in Paonta Valley, Sirmour District

Exploratory Well	T (m2/day)	Specific Capacity (lpm/m)	Discharge (lpm)	Well Depth
Dhangwala Gurudwara	1399.75	635.43	870.55	120
Mogi Nand	22.075	11.58	210	100
Bhurridiyon	16.8535	1.7	210	100

3.2 Subsurface Geology

The nature and character of sediments, their lateral and vertical extent and aquifer system have been studied with the help of sub-surface geological sections prepared from the litho logs of the boreholes drilled in the Paonta valley are as below:

3.2.1 Section along AA'

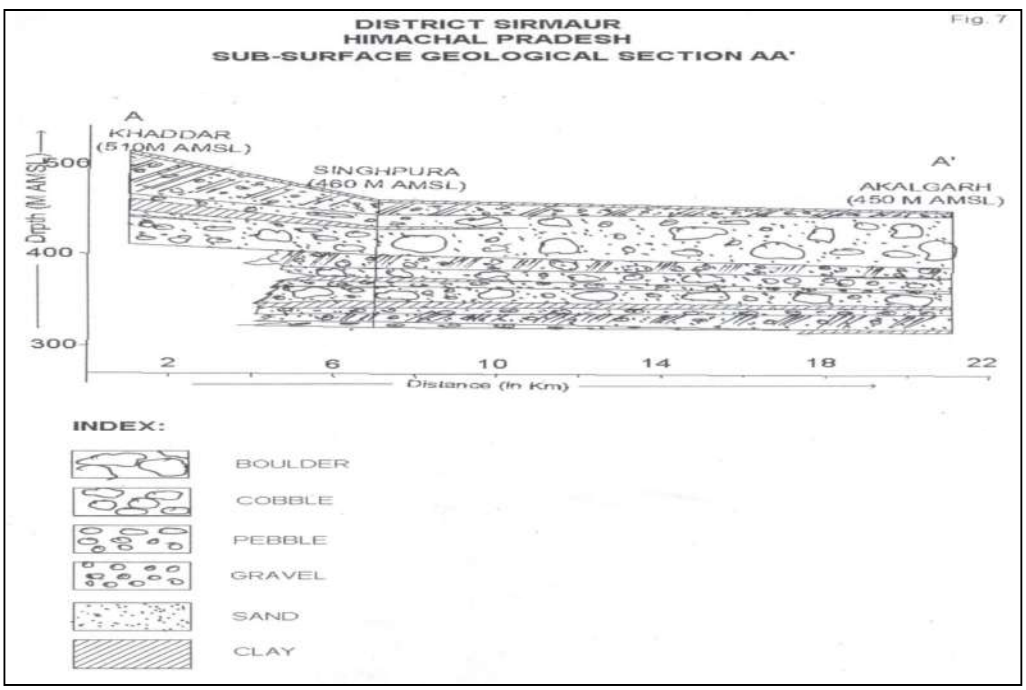


Fig 3.1 The cross section along AA' Paonta- Valley, Sirmaur District

The section runs along the NW-SE direction in Paonta valley and incorporates borehole at Khaddar, Singhpura and Akalgarh. It reveals the presence of 4-5 thick permeable granular zones down to the depth of 150 m bgl. The top soil cover is thin and varies from 0-3 m in the area.

The first aquifer forms the water table aquifer and occurs up to 15-25m bgl. It consists of sand, gravel, pebble and cobbles. At Singhpura second and third aquifer consists of sand, gravel, pebble and cobbles.

3.2.2 Section along BB'

The section runs along the NE-SW direction in Paonta valley and incorporates borehole at Paunta Sahib, Bhungarni and Nariwala (Fig. 8).This section reveals the prominent two aquifers. Both the aquifers consists of fine to coarse grained sand with gravels and pebbles at all places.

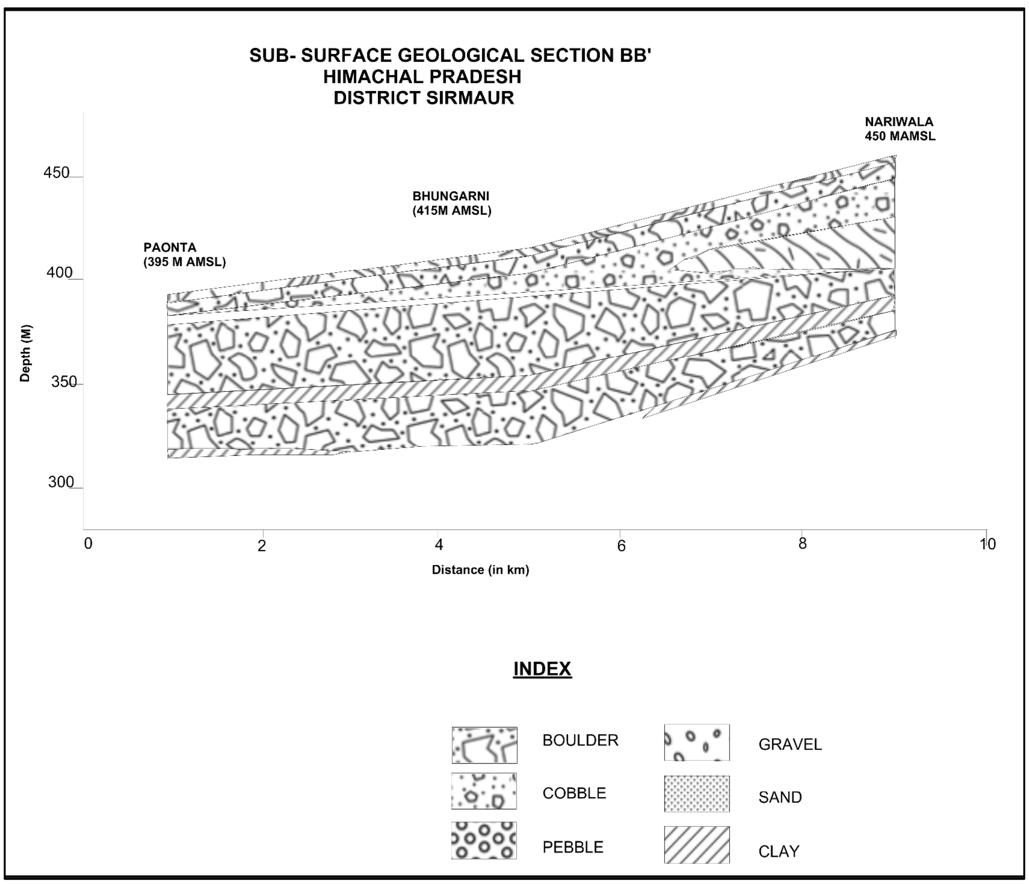


Fig3.2The cross section along BB' Paonta- Valley, Sirmaur District

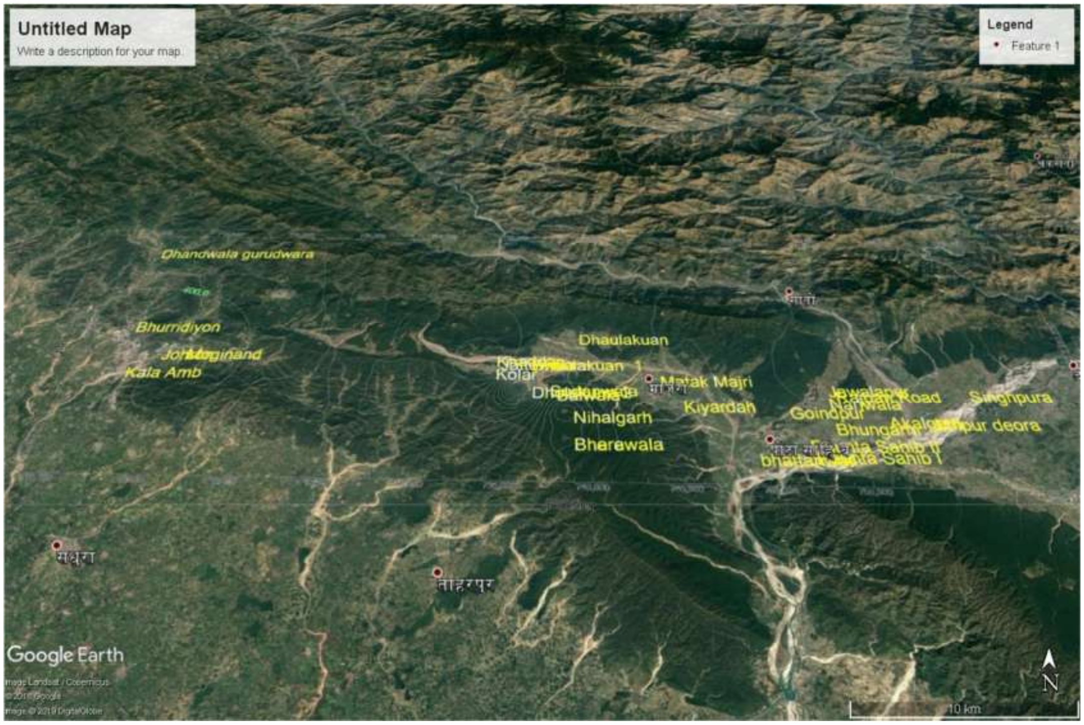
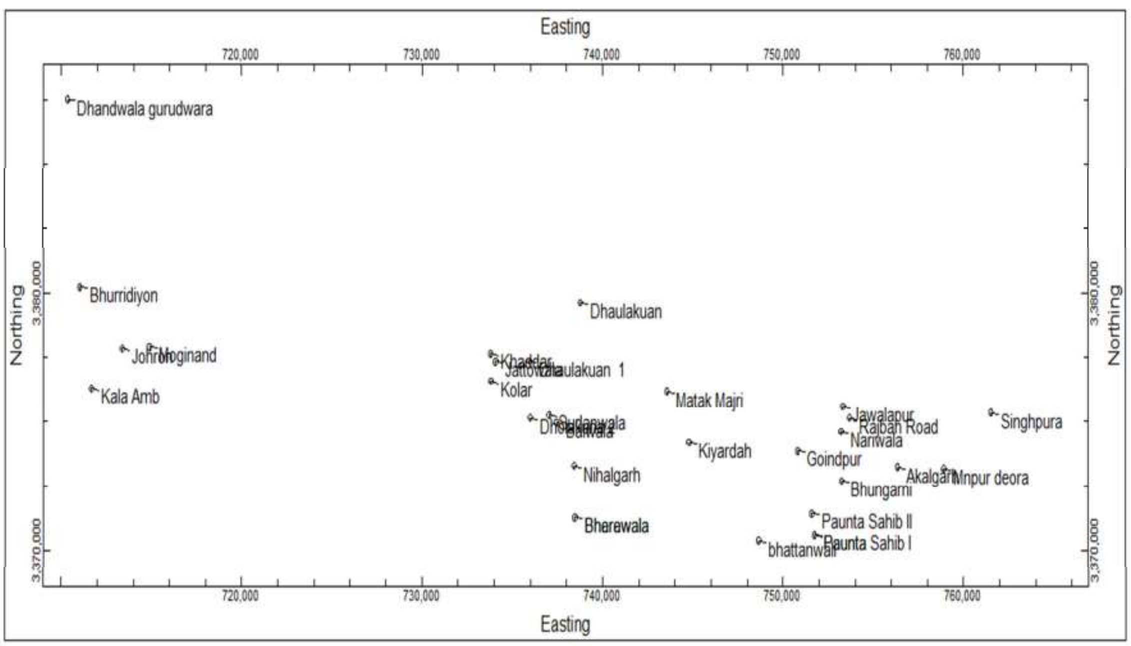


Fig Google Map distribution of Exploratory wells



3.3 Aquifer Geometry and Disposition

To understand the lithological frame work and aquifer disposition in the sub surface aquifers, the litholog data of wells drilled by CGWB & I&PH deptt are used to compile, optimized and modeled into 2D (Fig. 3.2 & 3.3) & 3D synoptic picture by using the Arc GIS and RockWorks16 software. The lithological model has been prepared along with distribution of wells are shown in Fig-3.1. The 3D lithological fence diagram has been prepared along with distribution of wells are shown in Fig-3.1.

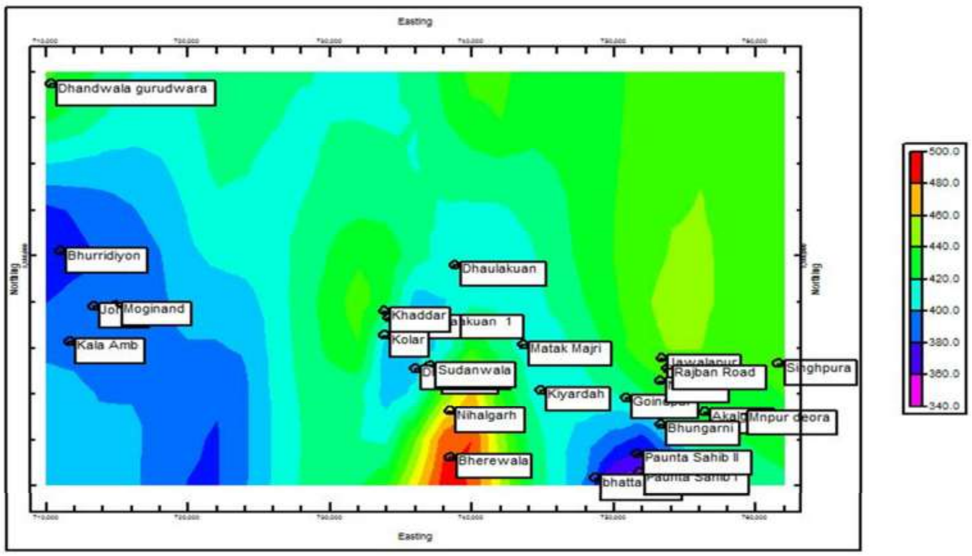
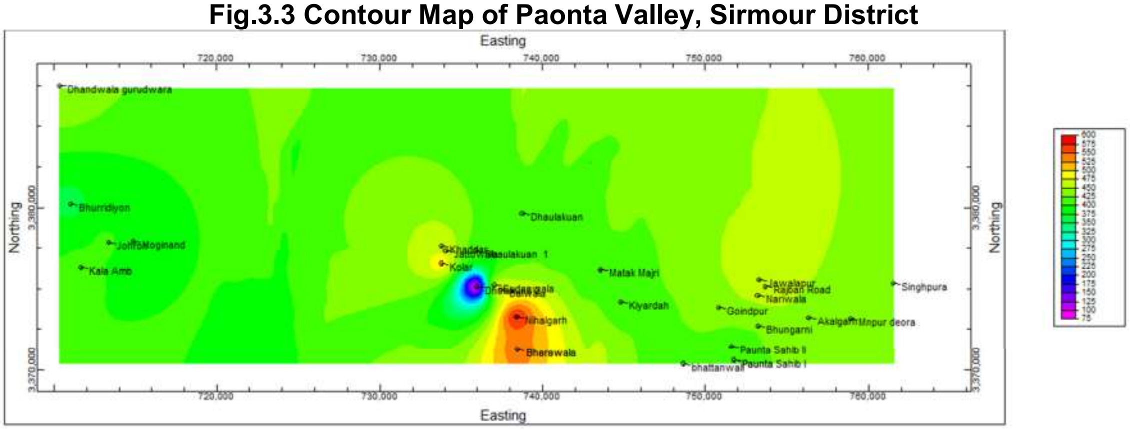


Fig.3.3 Contour Map of Paonta Valley, Sirmour District



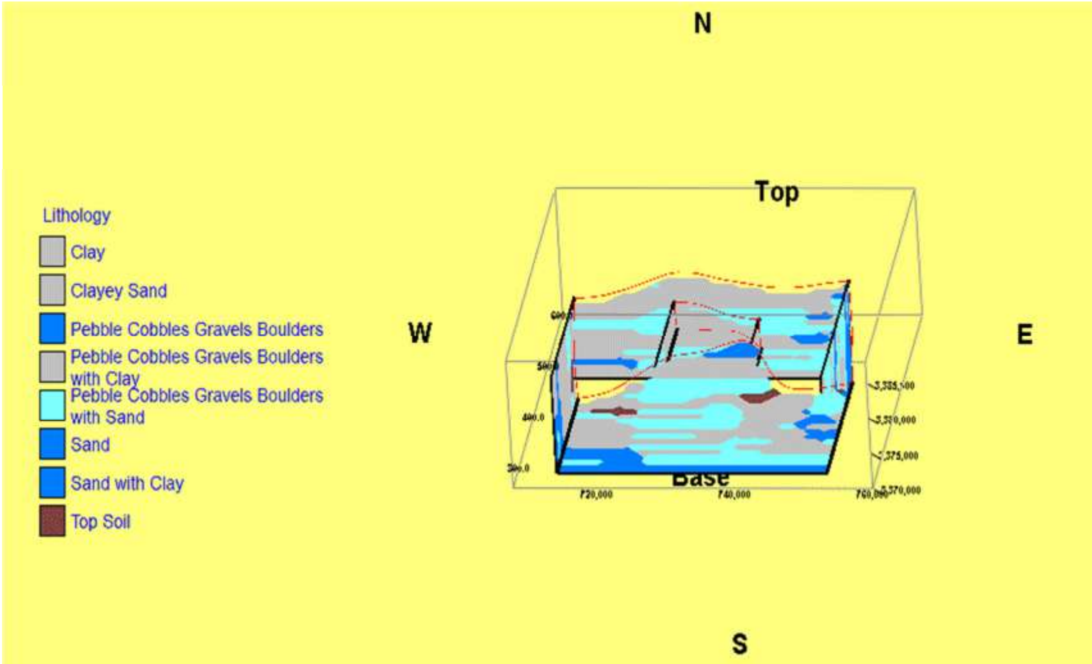


Fig.3.4 Fence Diagram of Paonta Valley, Sirmour District

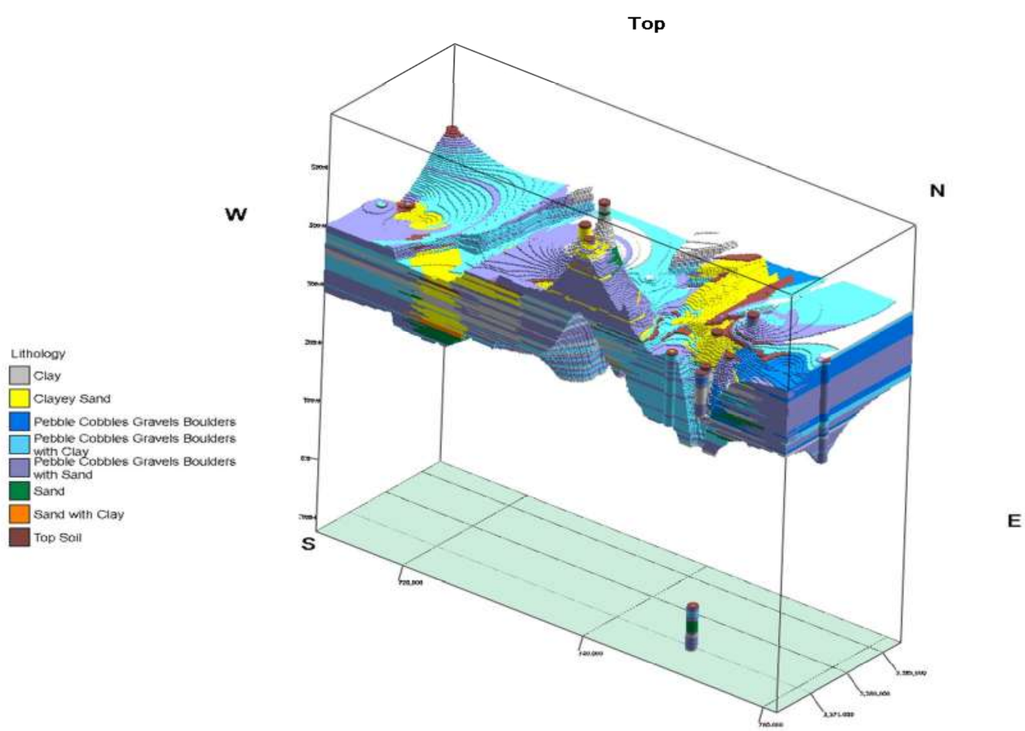


Fig.3.5 3-Dimension Lithological Model of Paonta Valley, Sirmour District

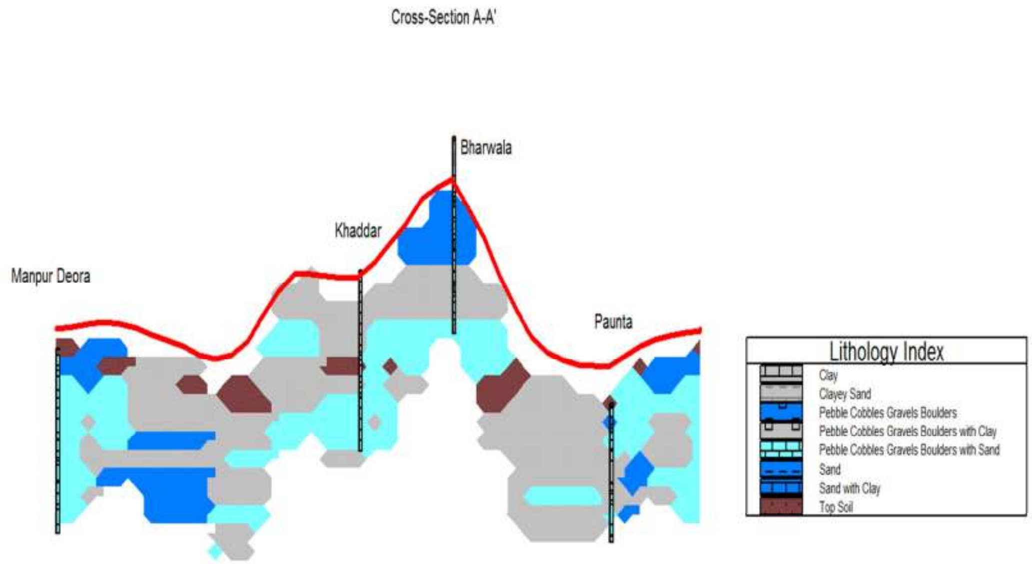


Fig.3.6 Cross-Section along A-A', Paonta Valley, Sirmour District

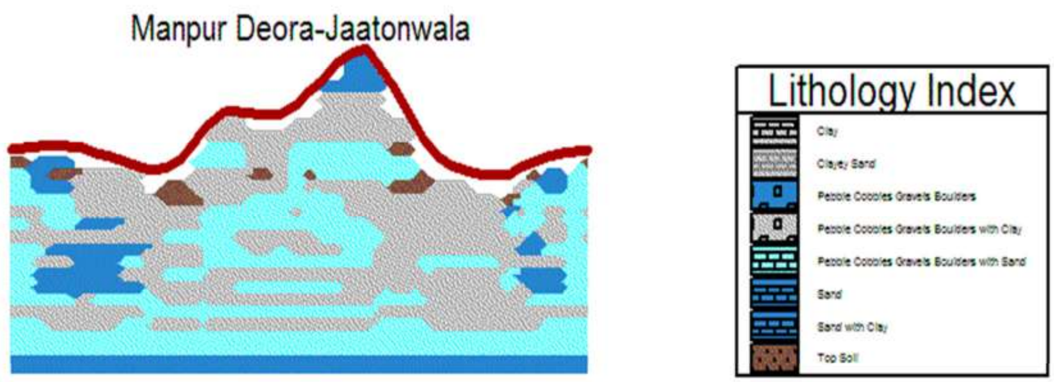
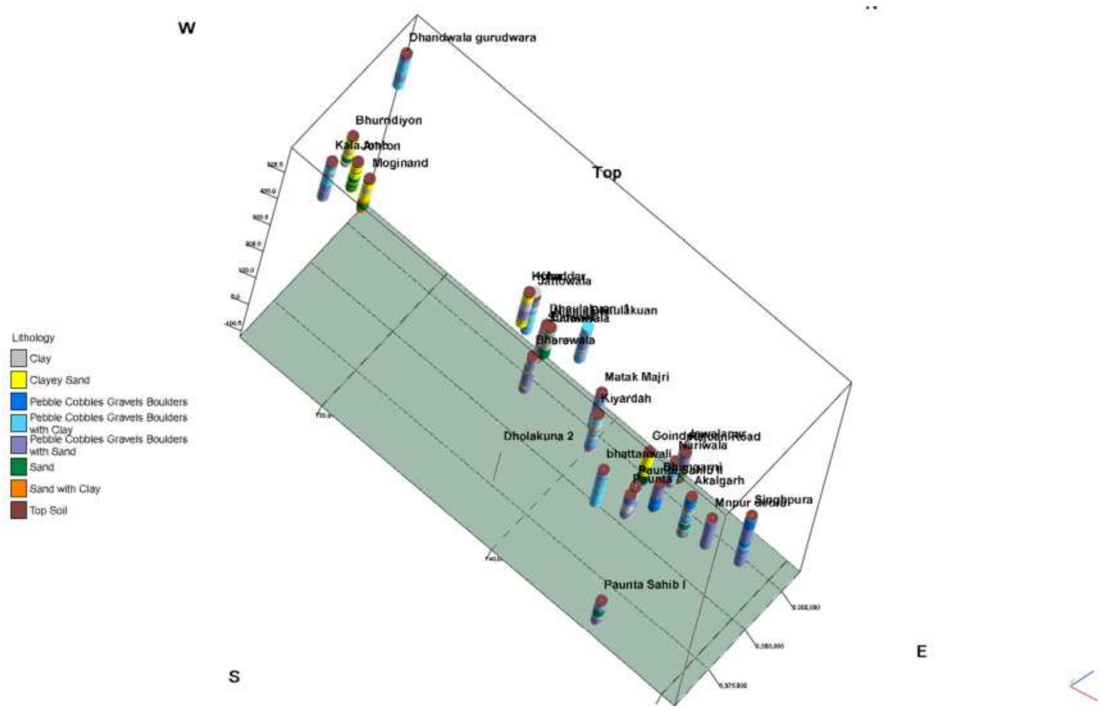


Fig.3.7 Cross-Section Manpur Deora-Jattonwala, Paonta Valley, Sirmour District



4.0 GROUND WATER RESOURCES

Rainfall is the major source of recharge to the groundwater body apart from the influent seepage from the rivers, irrigated fields and inflow from upland areas. The discharge from ground water mainly takes place from wells and tube wells; effluent seepages of ground water in the form of springs and base flow in streams.

Ground water resources and irrigation potential for Poanta valley of Sirmaur district computed utilising GEC-97 methodology as on March 2011 & March 2013 is as below

Table 4.1 Dynamic Ground Water Resource 2011-2013

S.no	Particulars	Unit	**Paonta valley**	
			2011	2013
1	Area of Assessment Unit	Sq. km	156.27	156.27
2	Ground water draft for all uses	Hect.m	2174.46	887.14
3	Annual Ground water recharge	Hect. m	8108.39	5646.60
4	Net ground water availability for future irrigation development	Hect. m	5980.7	4691.10
5	Stage of ground water development	%age	**26.66**	**14.26**
6	Categorization of the Assessment Unit	Safe/ unsafe	Safe	Safe

5.0 GROUND WATER RELATED ISSUES

Most of the ground water issues and problems in the district are localized requiring independent treatment by taking the micro level studies. In hilly and mountainous parts, the most common issues relate to scarcity of water particularly in low precipitation year during non-monsoon period when dwindling water levels and spring discharges are seen. Rainwater harvesting and awareness for water conservation, protection & scientific development of traditional sources and water harvesting are measures that need to be adopted.

Presently large development of ground water is observed in industrial belts of Poanta valley wherein fall of water level down to six meters have been observed in parts. Thus, ground water level depletion and also vulnerability to ground water pollution is major issues in this industrial belt.

In valley area there are large number of khads and most of them are seasonal flowing. High elevated hills adjacent to the valleys don't contribute much to arrest surface run off during monsoon periods and due to over exploitation of ground water, the depth to ground water level is depleting.

In hilly region, there is a tradition to divert stream flow by making full use of slope for irrigating the fields by short approach channels locally called Kulhs (khul irrigation). In high hill areas, spring water is being utilized for irrigation. Potentiality of spring sources has been diminishing due to deforestation and in consequent upon global warming.

Fertile agricultural soils in valleys need prevention of erosion during monsoon period which washes out natural organic top soil contents and affect crops. Thus, there is a need for conservation and augmentation of ground water resource through wide spectrum of techniques which are in vogue. These recharge techniques are decided based on geomorphological, geological and hydrogeological frame work.

6.0 MANAGEMENT STRATEGIES

Ground water is the major source for irrigation & domestic water supply in both rural and urban areas. Water level observation data has revealed declining trend in water level in some parts of the district. Though the stage of ground water development in valley is still in safe category, however, in many parts the availability of water during summer is limited particularly in hilly areas in drought/ low rain/snow years. There is thus a general need to conserve and augment water resource. Based upon the climatic conditions, topography, hydro-geology of the area, suitable structure for rain water harvesting and artificial recharge to ground water need to be planned and implemented. Roof top rainwater harvesting is one such solution both for urban & rural areas. Rainwater harvesting in rural area and proper scientific intervention for spring development and revival of traditional water storage is required in water scarce hilly upland areas

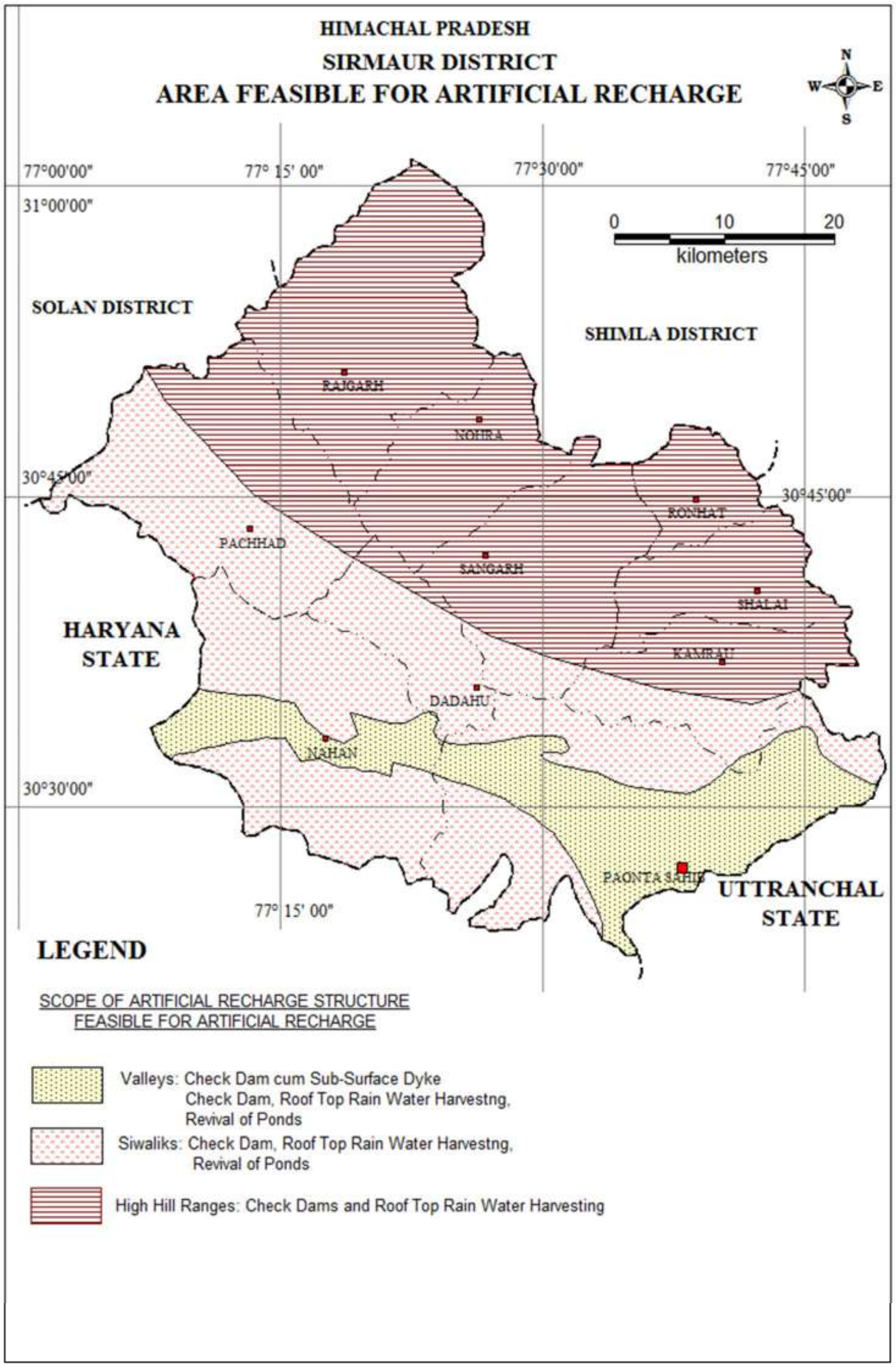


Fig.3.7Areas Feasible for Artificial Recharge, Sirmour District

6.1 Aquifer Management Plan – Paonta Valley

In Paonta valley, the stage of GW development is 14.26% (2013) and it is safe for further GW development .An outline of the Aquifer Management Plan includes details regarding population, rainfall, average annual rainfall, agriculture and irrigation, water bodies, ground water resource availability, ground water extraction and water level behaviour. Aquifer disposition and various cross sections have also been given.

6.2 Surplus Runoff

Surplus runoff is assessed considering the drainage area, rainfall & runoff coefficient (0.3) of the area and is about 290 mcm. As data is not available with the state govt. for the availability of surplus runoff in the area.

In Paonta valley, the stage of GW development is 14.26% as on March 2013 and is safe for further GW development. The Annual Ground water recharge is 81.08 MCM & 70% (56.76 MCM) of the total recharge is required to keep the valley in safe category, while the total draft is only 21.74 mcm which is within the safe category.

The stage of ground water development will increase with time. Therefore to stop the increasing ground water development some of the recharge structures may be implemented to harness the part of available runoff i.e 290 mcm. The details of the identified structures are given below:

6.3 Proposed Strategy

- Artificial recharge structures identified for 23 sites which can recharge about 0.73 mcm water.

6.3.1 Details of Proposed sites for Recharge Structures

These sites were jointly visited and identified by the officers of Central Ground Water Board and Irrigation & Public Health Department, Govt. of Himachal Pradesh. Sites are identified considering the geology of the area, depth to water level and other criteria's. All the parameters recorded during field visit are compiled and tabulated below. The locations of the proposed recharge sites in and around the Poanta valley area are marked on map.

By implementation of these structures, it will not only contribute to meet the growing water demand but also contribute to the base flow to the streams to some extent especially in the lean period which will be beneficial from pollution point of view as well. Generally, the proposed structures are check dams except at sr. no.4 which is a water body. These structures are identified for Recharge to ground water, creating irrigation potential & meeting the drinking water requirement for cattles.

By construction of these structures, about 0.73 MCM water is expected to recharge to ground water, annually in the area. As shown below:

Table 6.1 Feasible artificial recharge sites selected in & around the Paonta Valley, Sirmaur district

Sr. No	Location	Latitude	Longitude	Tehsil	Approx. Length in (m)	Approx. Height (m.abl)	Geology	Approx. Storage in (m^3)	Remarks
1	Bheron- I	N $30^0$29'03"	E $77^0$19'29"	Nahan	15	2	Alluvium deposit, sand stone, clay boulder	2000	Nil
2	Bheron-II	N $30^0$28'31"	E$77^0$19'29"	Nahan	45	3	Alluvium deposit, sand stone, clay boulder	12000	Nil
3	Hardan wale and Seesamwale	N $30^0$28'22"	E$77^0$19'35"	Nahan	30	1.5	Alluvium deposit, sand stone, clay boulder	3000	Nil
4	East Bheron	N $30^0$29'36"	E$77^0$19'38"	Nahan	30	3	Alluvium deposit, sand stone, boulder	2700	Nil
5	Kolar SunkarGhat near Govt.SSS.	N $30^0$30'26"	E$77^0$24'53"	Paonta-Sahib	50	1.5	Alluvium deposit, sand stone, clay boulder	35000	Nil
6	Sukh chainpur on the river bed of Sunkar Ghat.	N $30^0$30'23"	E$77^0$26'26"	Paonta Sahib	35	1.5	Alluvium deposit, sand stone, clay boulder	30000	Nil

Site-1

Site-3

Site-5

Site-2

Site-4

Site-6

Fig.3.8 Sites (1 to 6) Feasible for Artificial Recharge, Sirmour District

Table 6.2 Feasible artificial recharge sites selected in & around the Paonta Valley, Sirmaur district

Sr.No	Location	Latitude	Longitude+	Tehsil	Approx. Length in (m)	Approx. Height (m.agl)	Geology	Approx. Storage in (m^3)	Remarks
7	Chille wale khad	N 30^{0}28'38"	E77^{0}24'15"	Paonta Sahib	15	1.5	Alluvium deposit, sand stone, clay boulder	2200	NIL
8	Kode wala khad	N 30^{0}29'05"	E77^{0}24'26"	Paonta Sahib	55	2.5	Alluvium deposit, sand stone, clay boulder	10000	Nil
9	Kode wala khad-II	N 30^{0}28'43"	E77^{0}24'40"	Paonta Sahib	35	2.5	Alluvium deposit, sand stone, clay boulder	5000	Nil
10	Charanwala	N 30^{0}28'53"	E77^{0}23'26"	Poanta Sahib	60	2.5	Alluvium deposit, sand stone, clay boulder	10000	Nil
11	Haripur khad	N 30^{0}26'53"	E77^{0}23'08"	Paonta Sahib	45	2.5	Alluvium deposit, sand stone, clay & boulder	9000	Nil
12	Palodi khad (khairni)	N 30^{0}23'58"	E77^{0}26'39"	PaontaSahib	82	1.5	Alluvium deposit, sand stone, clay boulder	6000	Nil

Site-7

Site-9

Site-11

Site-8

Site-10

Site-12

Fig.3.9 Sites (7 to 12) Feasible for Artificial Recharge, Sirmour District

Sr.No	Location	Latitude	Longitude+	Tehsil	Approx. Length in (m)	Approx. Height (m.agl)	Geology	Approx. Storage in (m^3)	Remarks
13	Confluence of Gharat and Palhorighat Near GHS Palhori	N $30^0$24’16”	E$77^0$27’19”	Paonta Sahib	40	1.5	Alluvium deposit, sand stone, clay boulder	4000	Discharge is 1 lpsl
14	Gharat ghat near GHS Palhori	N $30^0$24’16”	E$77^0$27’19”	Paonta Sahib	22	2	Alluvium deposit, sand stone, clay boulder	2500	Nil
15	Palhori ki khad near masjid	N $30^0$25’30”	E$77^0$27’31”	Paonta Sahib	57	1.5	Alluvium deposit, sand stone, clay boulder	4000	Discharge of the khad is 1 lps
16	Palhori near house of Mohd. Yashian	N $30^0$25’16”	E$77^0$28’28”	Paonta-Sahib	19	1.5	Sand stone, conglomeratebed & clay	8000	Nil
17	Palhori Simbal wale near forest rest house	N $30^0$25’29”	E$77^0$29’01”	Paonta Sahib	45	1.5	Alluvium deposit, sand stone, conglomerates	3000	Khad is having discharge of 1 lps
18	Bata khad Banjar Gungalo	N $30^0$30’31”	E$77^0$29’43”	PaontaSahib	40	2.5	Alluvium deposit, sand stone, conglomerates	4000	Flow of water is very less and is almost stagnant

Site-13

Site-15

Site-17

Site-14

Site-16

Site-18

Fig.3.10 Sites (13 to 18) Feasible for Artificial Recharge, Sirmour District

Table 6.4 Feasible artificial recharge sites selected in & around the Paonta Valley, Sirmaur district

Sr.No	Location	Latitude	Longitude+	Tehsil	Approx. Length in (m)	Approx. Height (m.agl)	Geology	Approx. Storage in (m^3)	Remarks
19	Simbal wale forest sanctuary	N 30^{0}27'34"	E76^{0}31'26"	Paonta Sahib	65	1.5	Alluvium deposit, sand stone, conglomerates	19000	Forest use
20	Sankhi khala 300 m towards south of the nallah	N 30^{0}28'46"	E77^{0}21'48"	Paonta-Sahib	30	2.5	Alluvium deposit, sand stone, conglomerates	11000	Forest use
21	Swarandasi khara near IPH Pump house	N 30^{0}33'55"	E77^{0}26'21"	Paonta Sahib	52	2	Alluvium deposit, sand stone, conglomerates, quartzite	6000	Nil
22	Swarandasi khara 1 km western side from site No. 21.	N 30^{0}35'00"	E77^{0}26'23"	Paonta Sahib	30	3	Alluvium deposit, sand stone, conglomerates, quartzite	7200	Nil
23	Kawal Khad below Mariog Village	N 30^{0}52'18"	E77^{0}12'48"	Pachhad	30	5	Slates, shale & boulders	15000	Nil

Site-19

Site-21

Site-23

Site-20

Site -22

Fig.3.11 Sites (19 to 23) Feasible for Artificial Recharge, Sirmour District

6.4 General Recommendations for Planning Sustainable Management of the Resource

6.4.1 Supply Management

- Since the Paonta valley area falls in **Safe Category** as per Ground Water Resource Estimation 2013. The Sirmaur district receives good rainfall (1405 mm), intensity and also having good recharge. So, in the present valley area the construction of **1424** Nos. shallow tube wells also suggested for extracting the ground water.
- Landfills should be designed scientifically so that no leachate percolates to reach and contaminate ground water. There should be strict monitoring of waste disposal in industrial belts. Industrial effluents should be discharged only after proper treatment.
- Agriculture oriented Management Plan - Aberrant erratic behaviour of monsoon and prolonged dry spells during the crop period cause crop failure/low productivity besides drinking water crisis during summers.
- Augmentation of GW through Artificial Recharge structures.
- Ground Water Recharge Practices should be adopted in spring shed area

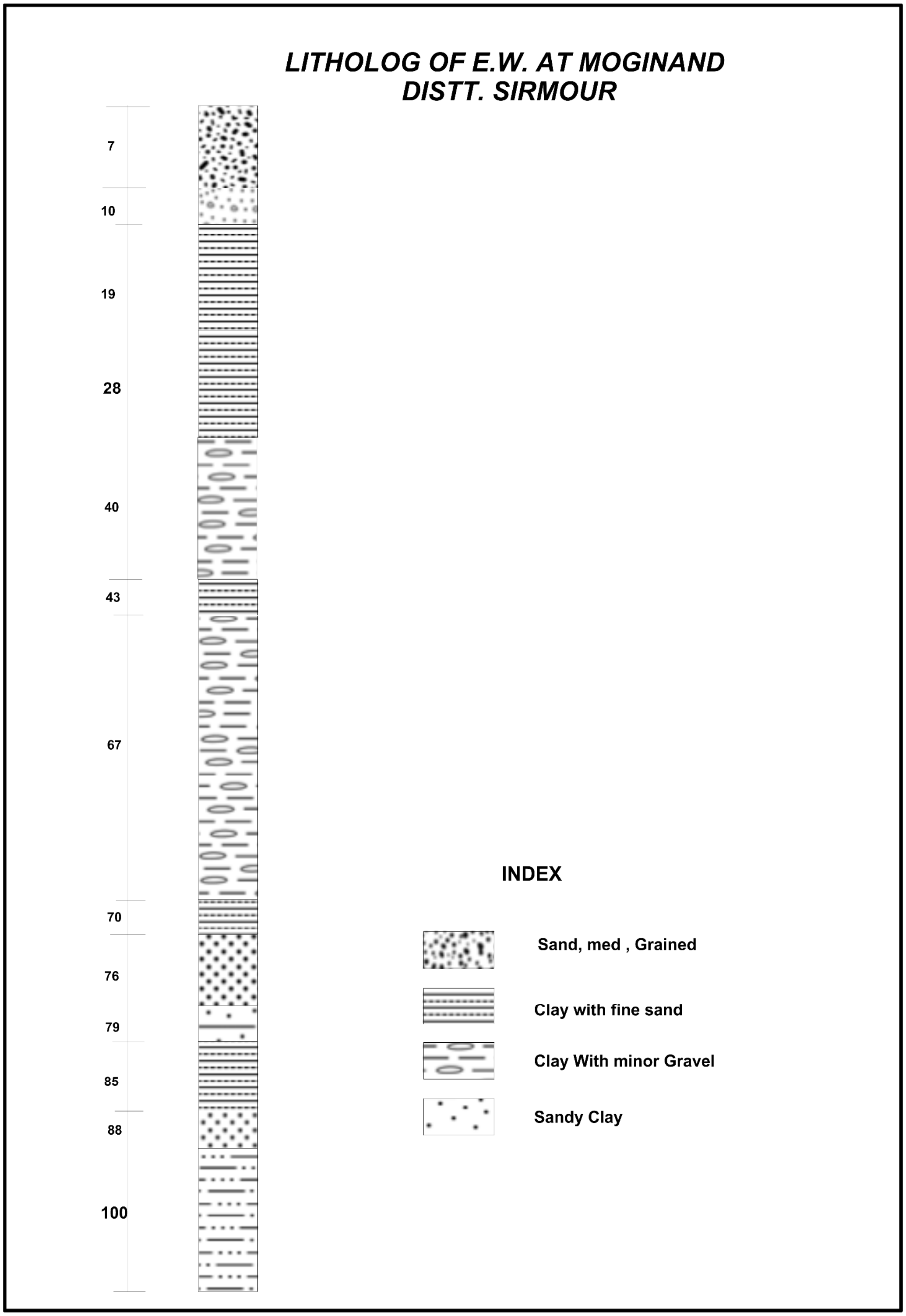
6.4.2 Hill Area oriented Management Plan

- In present study area proper development of springs is essential as it is observed that most of the spring in the district does not have collection chamber or tanks from where water can be distributed under gravity. The objective of spring development should be to collect the flowing water underground, to protect it from surface contamination and store it for supply. Similarly, seepage springs along hill sides also need to develop for harnessing ground water in such areas.
- Roof top rainwater harvesting practices can be adopted in hilly areas and urban areas, since the district receives fair amount of rainfall. Construction of roof top rain water harvesting structures should be made mandatory in all new construction and rain water harvesting in rural areas should be promoted.
- Traditional water storage systems need to be revived. Recharge structures feasible in hilly areas are check dams and Gabion structures at suitable locations.
- Ground Water Recharge Practices should be adopted in spring shed area.

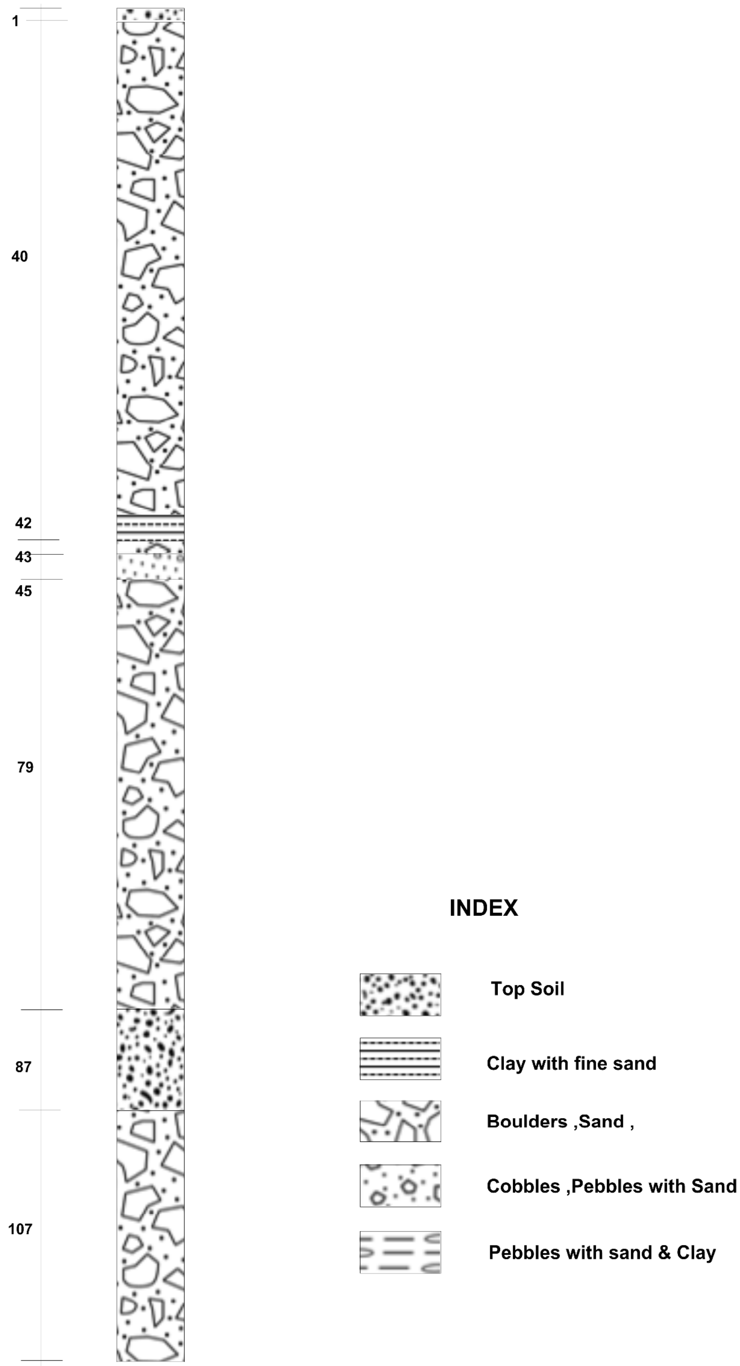
6.4.3 Demand Management

Water Use Efficiency method

- To minimize transmission losses, evaporation losses constructing shallow tube wells, shallow dug wells, percolation wells etc. in the farmers field/community.
- Irrigation Practices: Sprinkler / Drip method has higher application and distribution efficiency, saves considerable water and provides complete control on timing and quality of irrigation water to be applied. The Water use efficiency can be much higher as compared to surface method of irrigation.

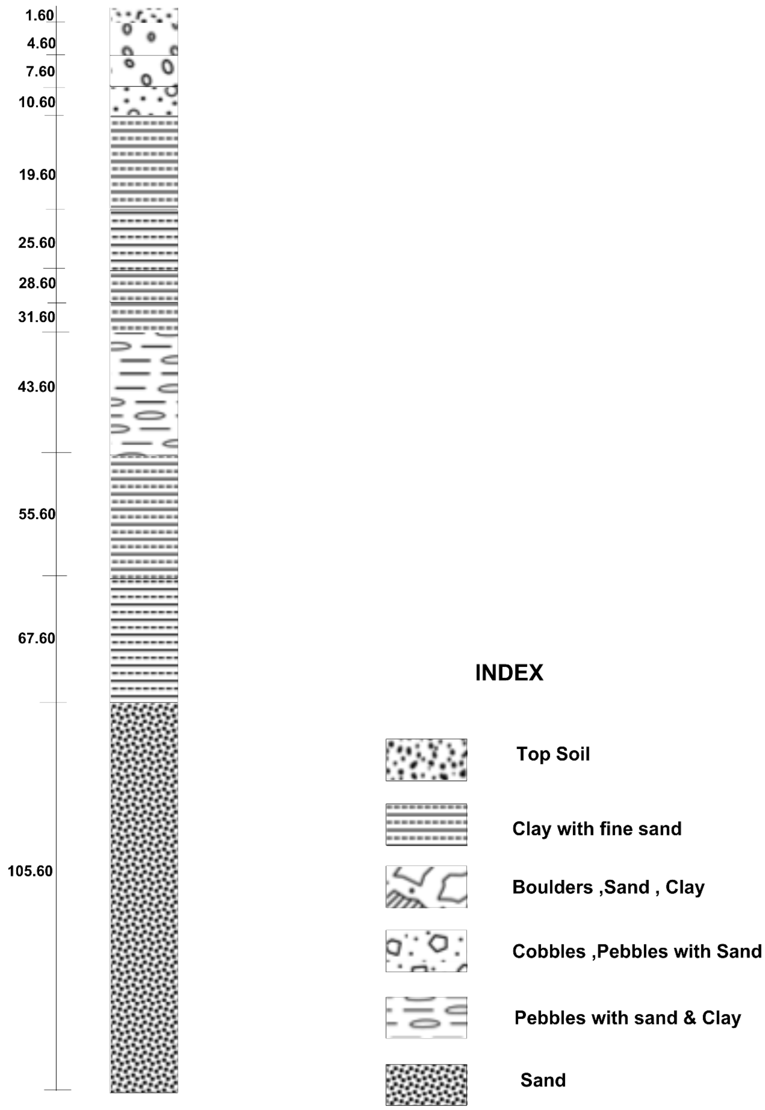

LITHOLOG OF E.W. AT MOGINAND
DISTT. SIRMOUR
7
10
19
28
40
43
67
70
76
79
85
88
100
INDEX
Sand, med , Grained
Clay with fine sand
Clay With minor Gravel
Sandy Clay

LITHOLOG OF E.W. AT JAWALAPUR
DISTT. SIRMOUR



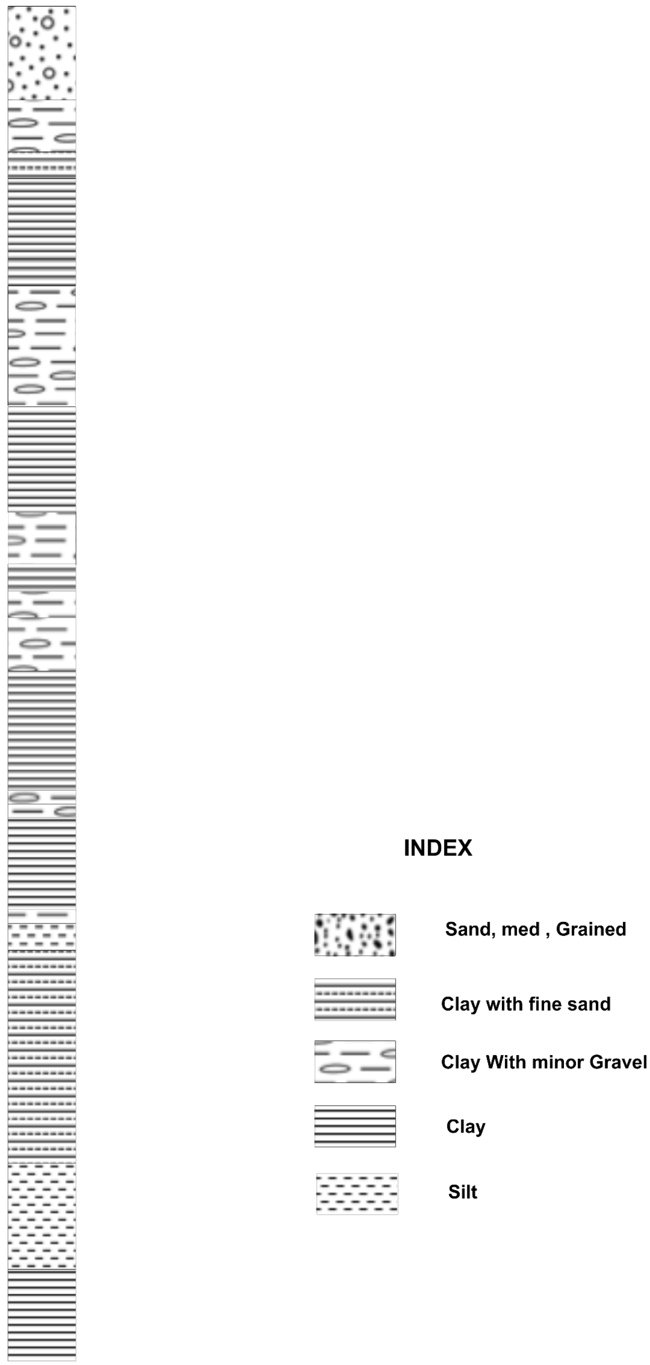
CGWB/NHR/D/SHALA

LITHOLOG OF E.W. AT DHAWGWALA GURUDWARA DISTT. SIRMOUR

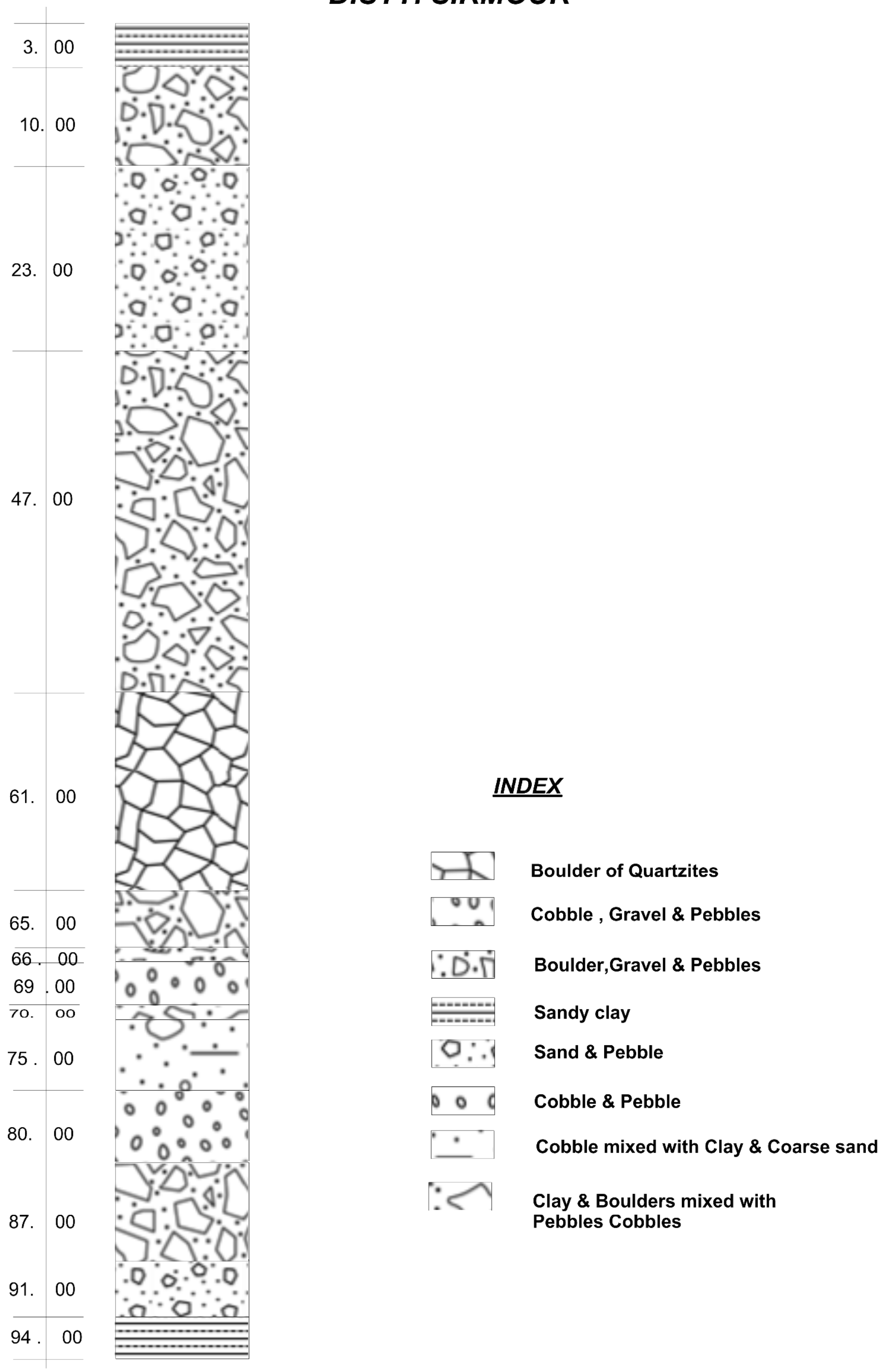


CGWB/NHR/D/SHALA

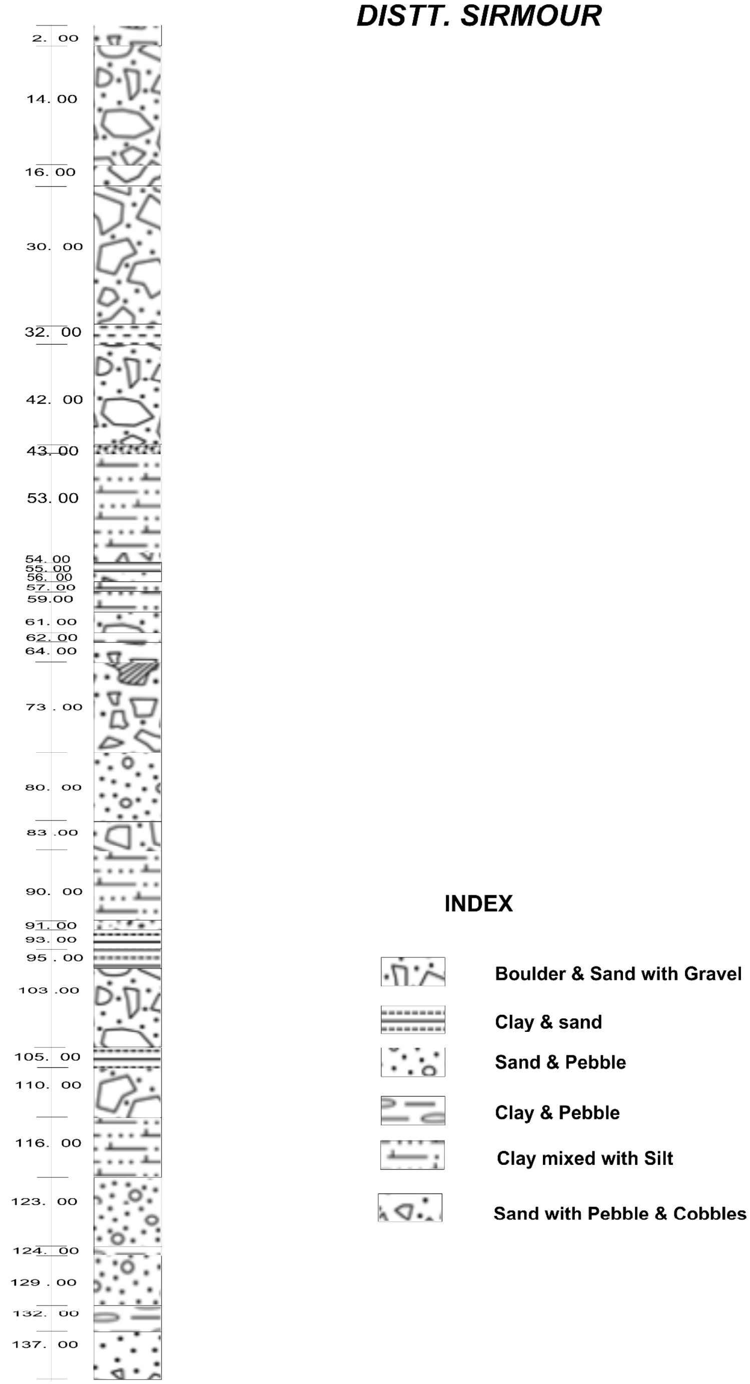
LITHOLOG OF E.W. AT BHURDDIYON DISTT. SIRMOUR



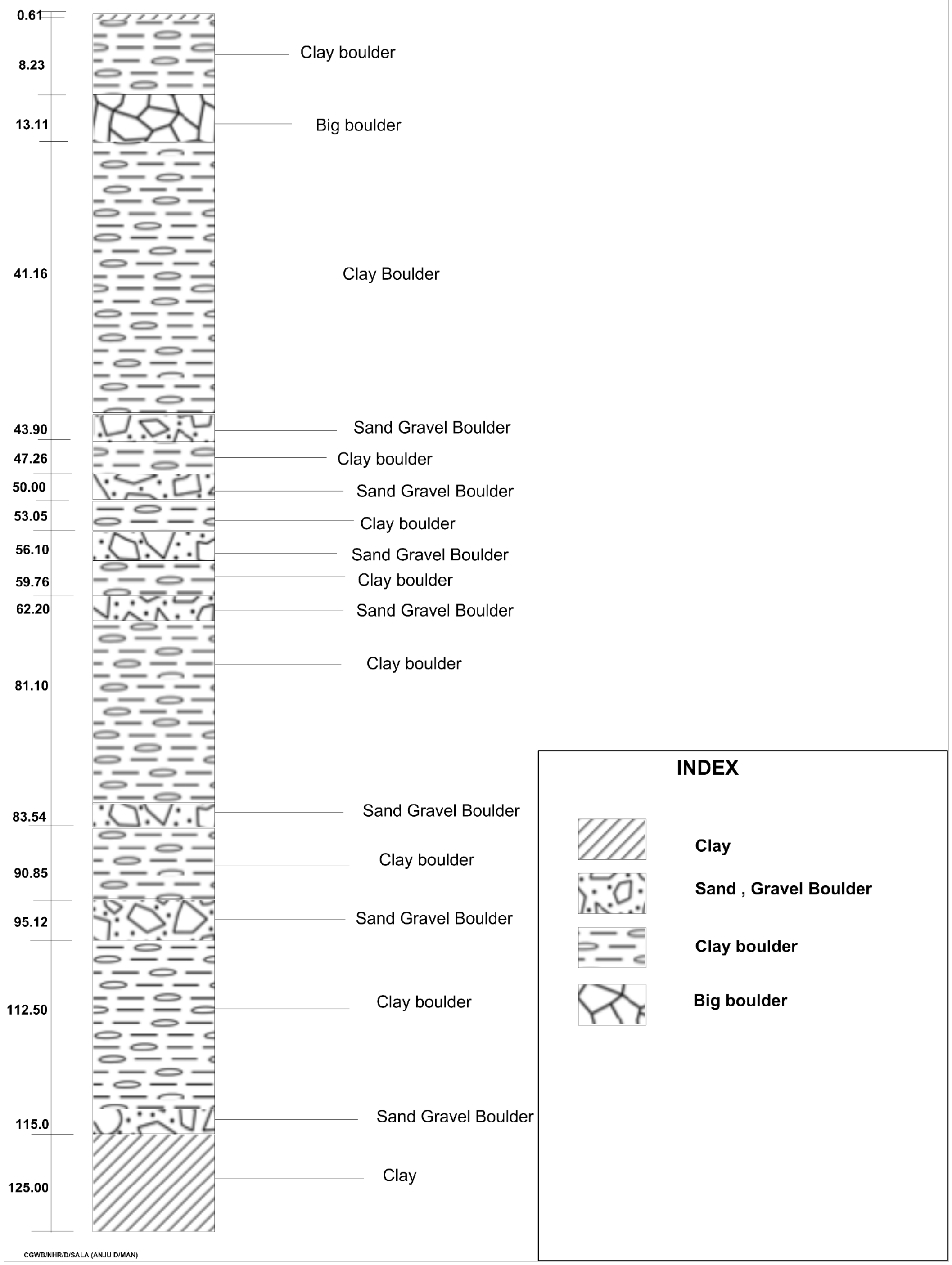
LITHOLOG OF E.W. AT BHUNGARNI DISTT. SIRMOUR



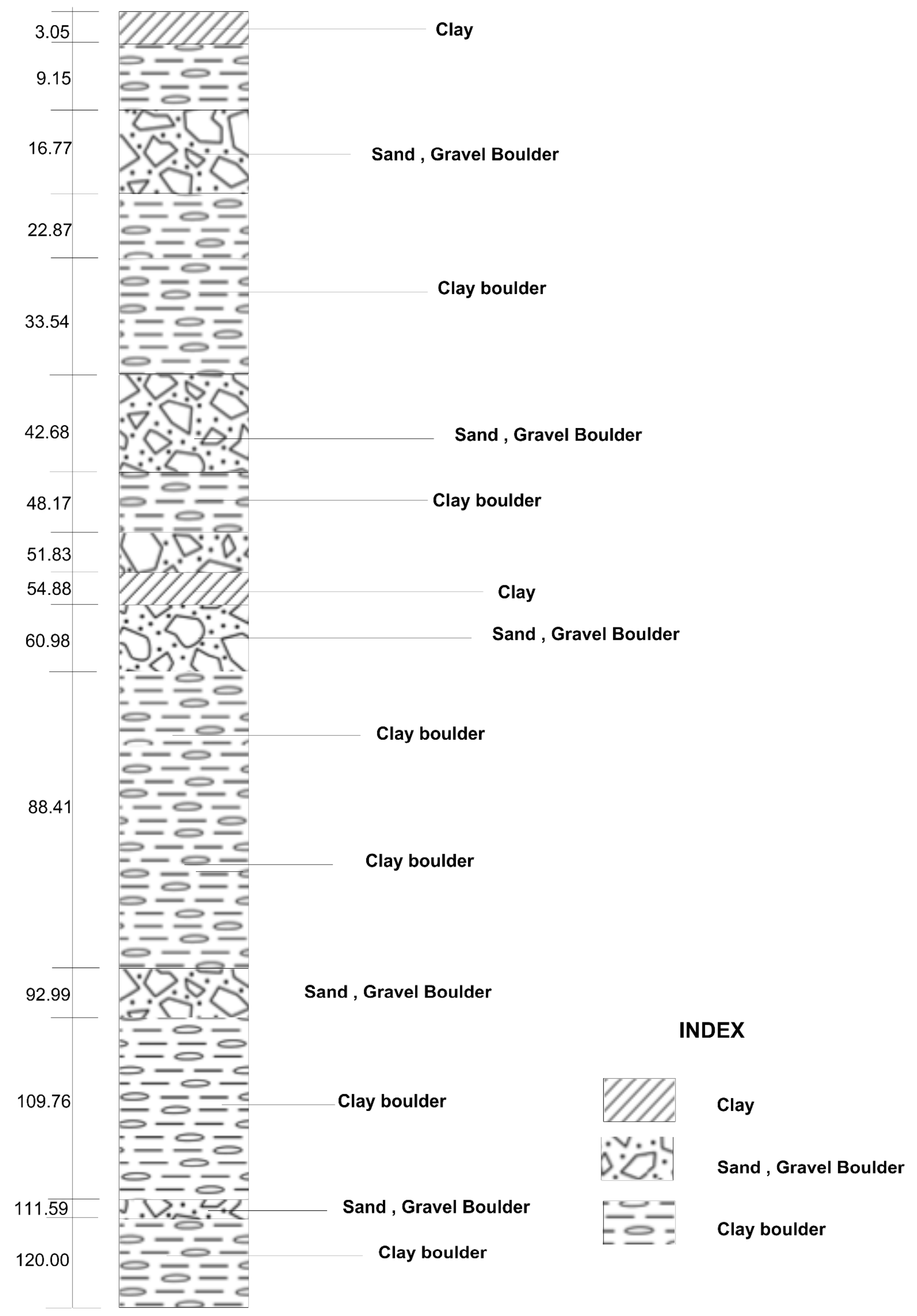
LITHOLOG OF E.W. AT AKALGARH
DISTT. SIRMOUR



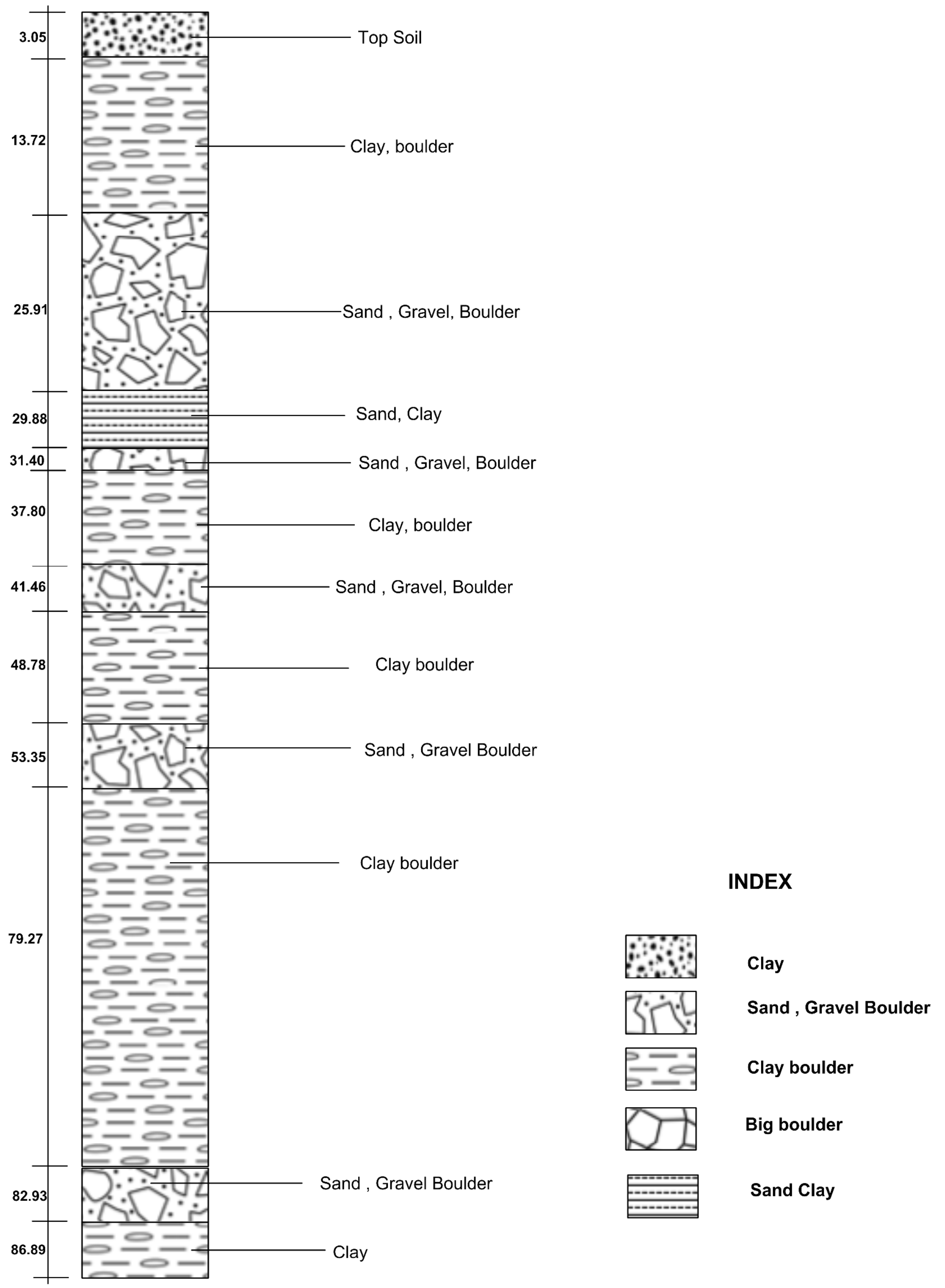
LITHOLOG OF T/WELL AT AMBIWALA G.P.SALWALA TEH. PAONTA SAHIB DISTT. SIRMOUR



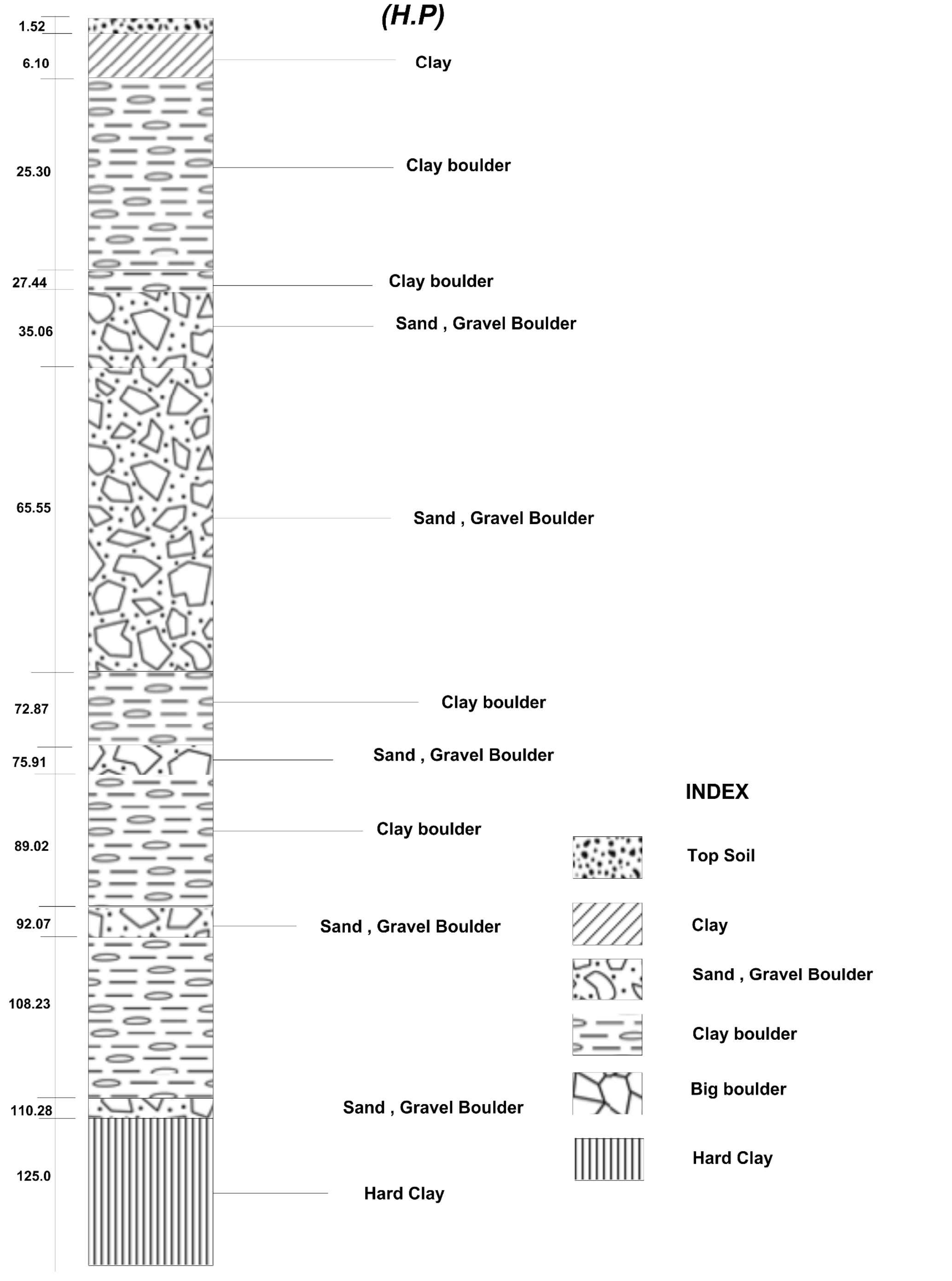
LITHOLOG OF T/WELL AT VILL. LWSS PATION TEH. PAONTA SAHIB DISTT. SIRMOUR



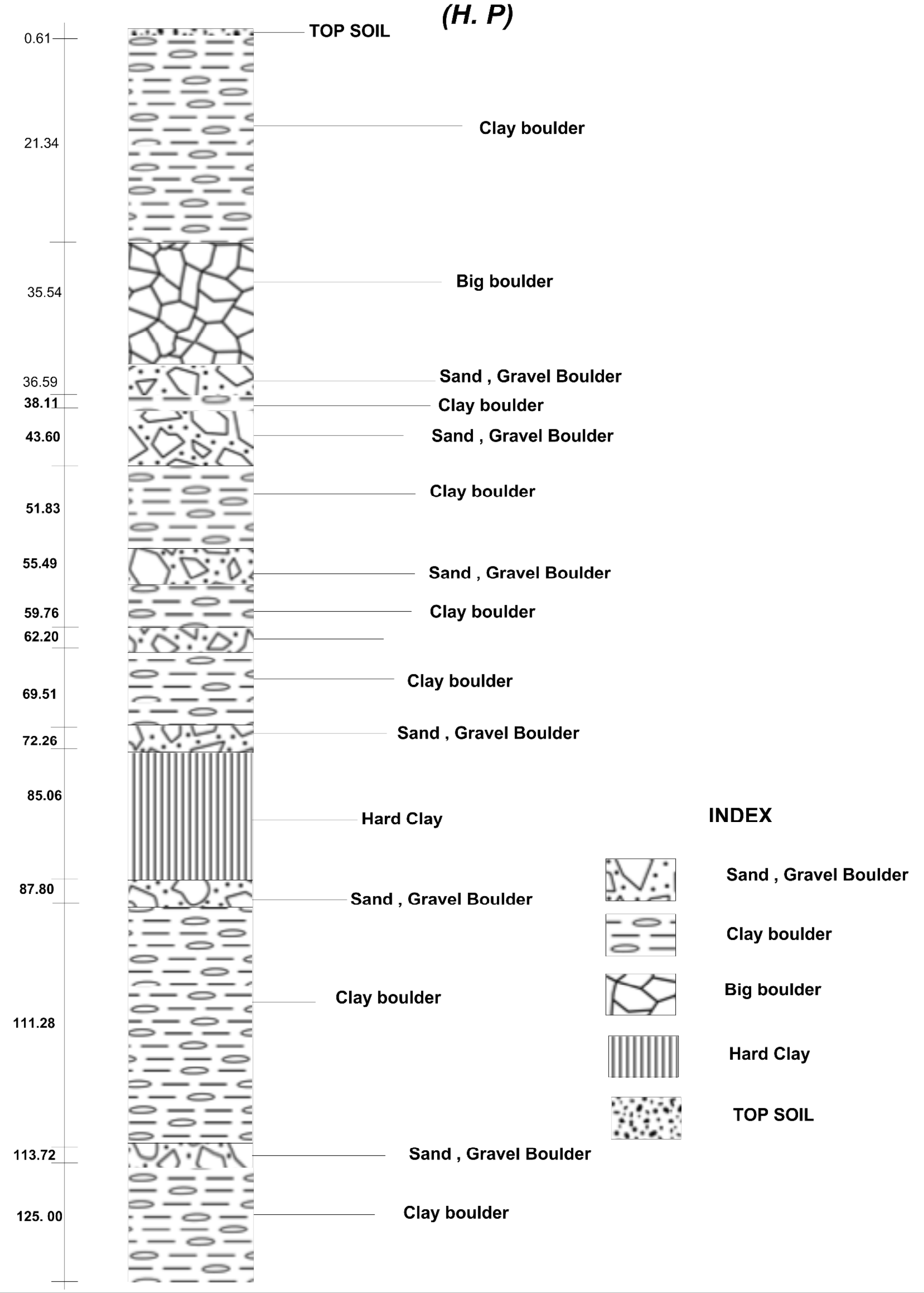
LITHOLOG OF T/WELL AT BHATTANWALI G.P.KISHAPURA
TEH. PAONTA SAHIB DISTT. SIRMOUR



LITHOLOG OF T/WELL AT VILL. BHUNGARNI TEH. PAONTA SAHIB DISTT. SIRMOUR (H.P)



LITHOLOG OF T/WELL AT VILL. BHERWALA TEH. PAONTA SAHIB DISTT. SIRMOUR (H. P)



CGWB/NHR/D/SALA (ANJU D/MAN)

LITHOLOG OF T/WELL AT LIS AJOLOI, NARIWALA,, JAWALAPUR TEH. PAONTA SAHIB DISTT. SIRMOUR

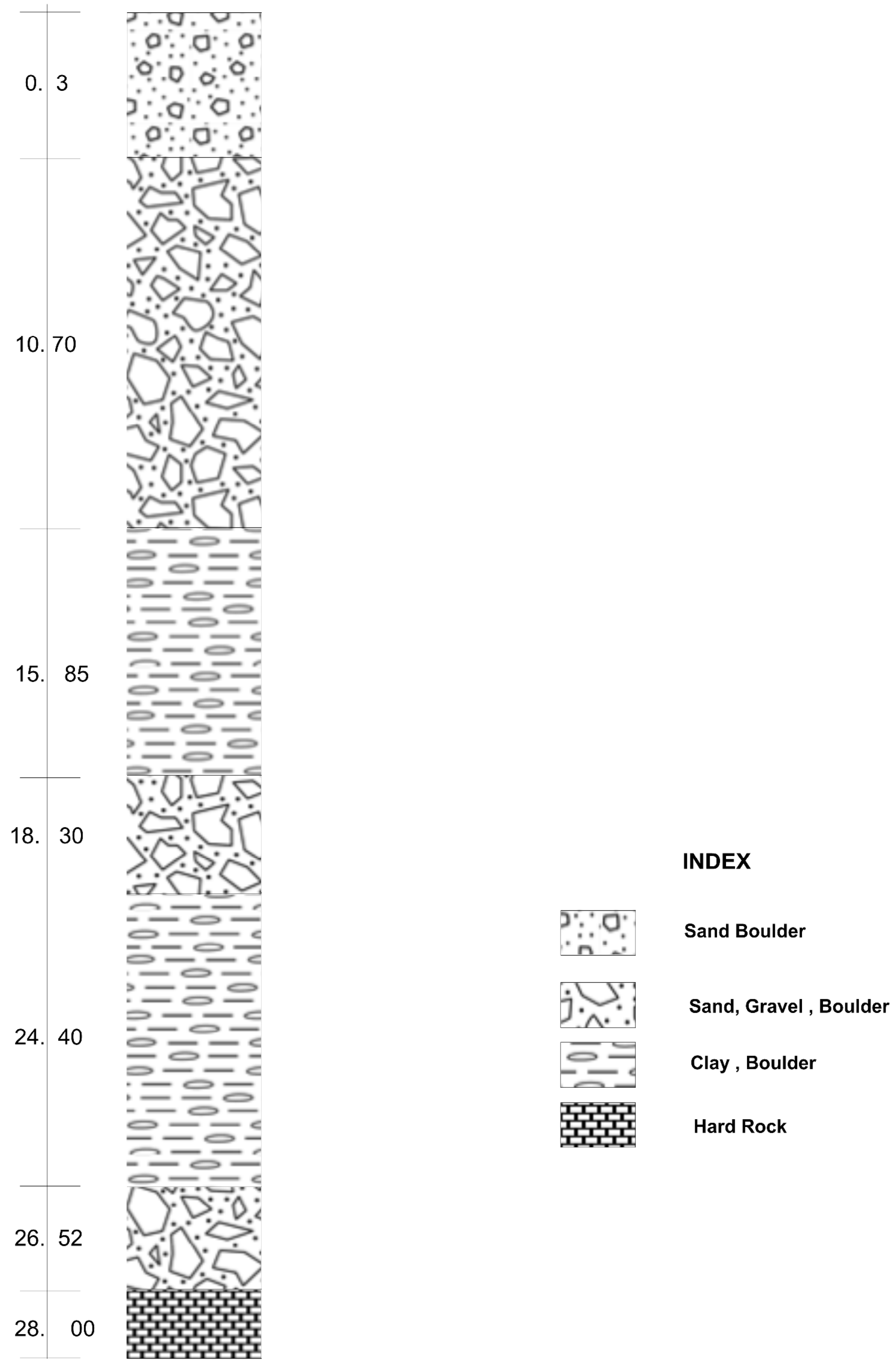


Table: Showing No. of TW can be constructed till 70% Stage of GW development, in Paonta Valley (on the basis of Resource Estimation 2013)

Name of Valley	Net GW availability	70%	Total draft	Net available till 70%	Dom Tw No.	Irri No.	Industrial No.	Total No. of TW	Dom draft	Irri draft	Industrial draft	Total Draft	Draft ham per well	No. of TW can be constructed till 70% Stage of GW development
Poanta Valley	6219.27	4353.489	887.19	3466.299	42	292	22	356	482.67	288.31	95.68	866.66	2.43	**1424**