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कांगड़ा और पालमपुर घाटी की
जलभृत मानचित्रण और प्रबंधन योजना, हिमाचल प्रदेश

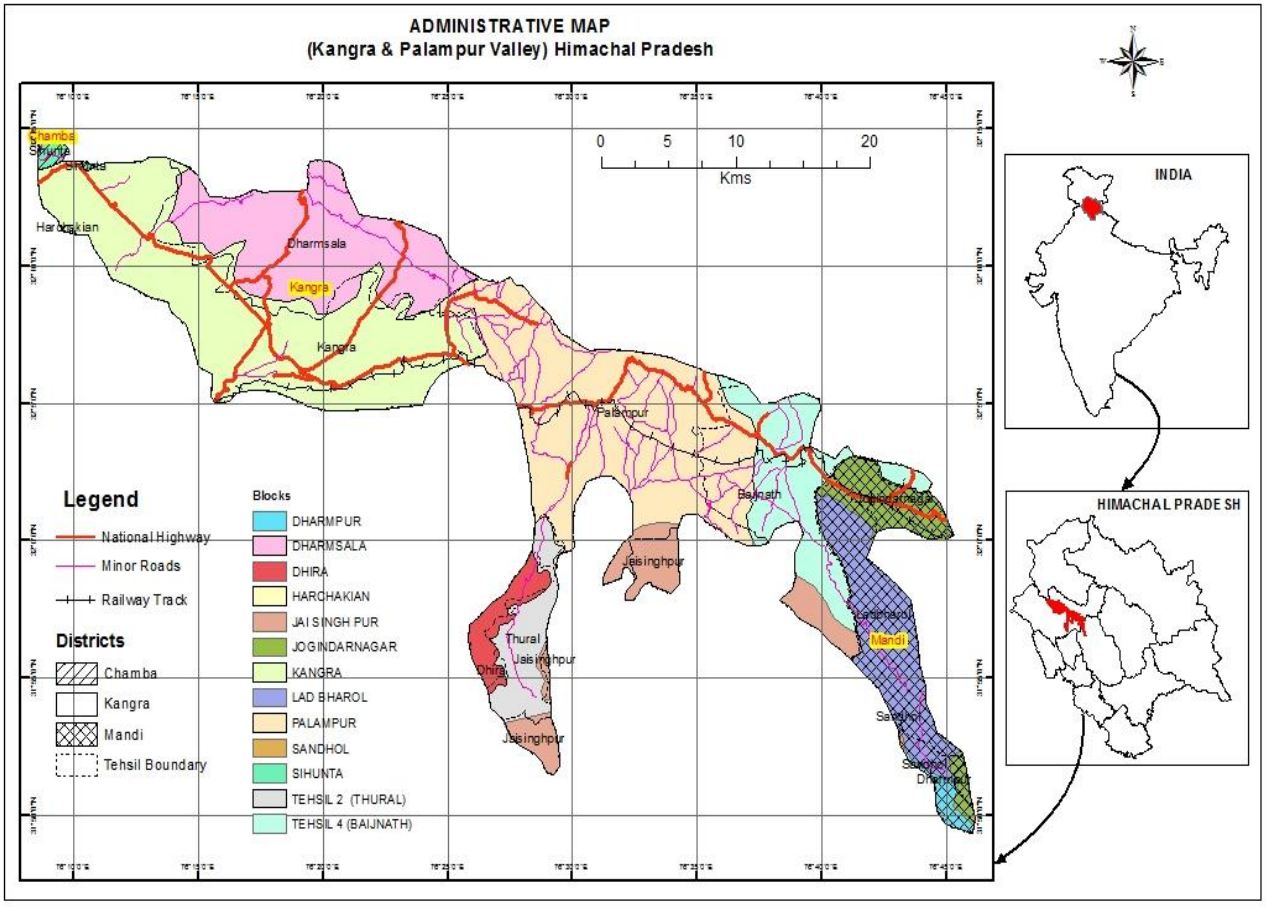
AQUIFER MAPPING AND MANAGEMENT PLAN OF KANGRA AND PALAMPUR VALLEY, HIMACHAL PRADESH

उत्तरी हिमालयन क्षेत्र, धर्मशाला

Northern Himalayan Region, Dharamshala

GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RD & GR
CENTRAL GROUND WATER BOARD,

AQUIFER MAPPING AND MANAGEMENT PLAN OF KANGRA AND PALAMPUR VALLEY, HIMACHAL PRADESH



Kangra palampur Valley at a Glance

Northern Himalayan Region, Dharamshala

2013-2014

AQUIFER MAPPING STUDIES IN KANGRA AND PALAMPUR VALLEY, HIMACHAL PRADESH

CONTENTS

AQUIFER MAPPING AND MANAGEMENT PLAN OF KANGRA AND PALAMPUR VALLEY, HIMACHAL PRADESH

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

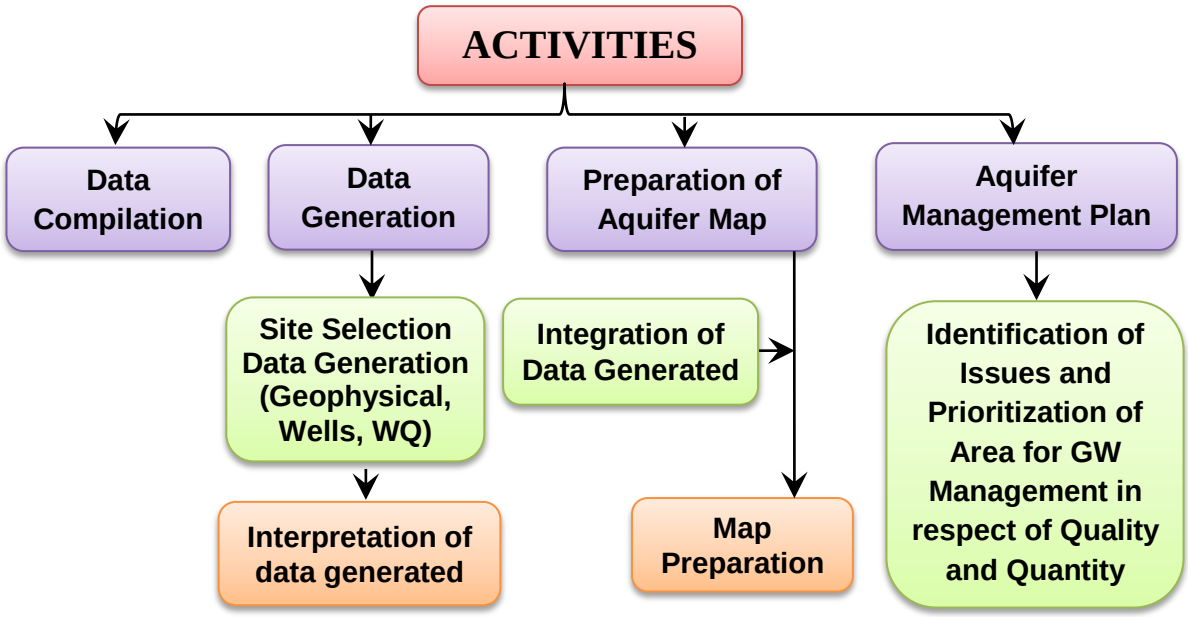
The primary objective of the Aquifer Mapping Exercise can be summed up as “Know your Aquifer, Manage your Aquifer”. Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership 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.

With these aims, Aquifer Mapping Study is carried out in Kangra and Palampur valley of Chamba, Kangra and Mandi Districts of Himachal Pradesh under the Annual Action Programme 2013-14. These 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, 51 key observation wells both dugwells and borewells (Dugwells: 4 Nos., springs: 27 Nos. and Hand Pump: 19 Nos.) were established. Subsequently, all the available data on ground water from the earlier studies are complied and integrated with these studies to bring out the ground water scenario, lateral and vertical characteristics of the aquifers and better management plan of ground water in a scientific manner.

1.2 Methodology

Various activities of NAQUIM are as follows:



1.3 Location, Extent and Accessibility

The Aquifer Mapping Study area is located in the western part of Himachal Pradesh which forms intermountain valley of Kangra district. The study area constitutes about 688 sq. km covering parts of inter-montain kangra – Palampur valley of Kangra, Chamba and Mandi district. The study area falls in Survey of India Toposheets No. 52 D/4, D/8, D/12, D/16, 53A/5, A/9& 53A/13 within the N Latitudes 31°50' & 32°16' and E Longitudes 78°08' & 78°47'. The area is bounded by all sides by District Kangra except on the South East by Mandi district and on western side by district Chamba of Himachal Pradesh. The Beas River and its tributaries cover the entire study area.

The study area is well connected by means of all-weather roads with the district headquarter at Dharamshala and also with other towns in the neighbouring districts. National Highway 20 passes through the entire study area.

1.4 Administrative divisions, Demographic particulars

The study area falls in three districts of Himachal Pradesh, namely Kangra, Chamba and Mandi district. Major part of the study area falls in Kangra district with Dharmashala as district headquarter. Administratively 11 blocks fall in the study area viz. Dharamspur, Dharamshala, Dhira, Harchakkian, Jaisinghpur, Jogindernagar, Kangra, Lad Bhadol, Palampur Sandhol and Sihunta (fig.1.1).

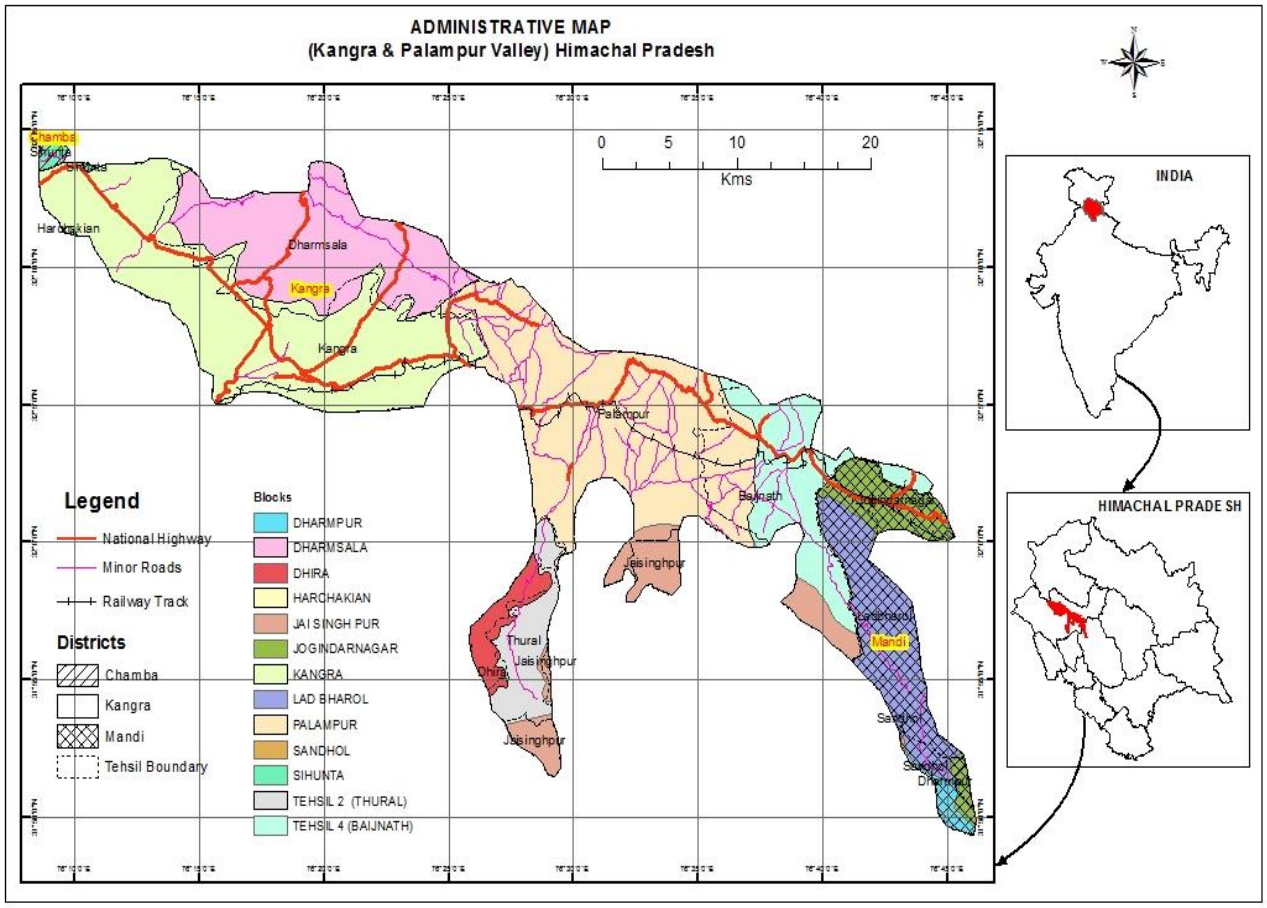


Fig 1.1: The administrative division of the study area

1.5 Data Gap Analysis

The Data gap analysis was done in Aquifer Mapping Study area of 688 sq.kms in Kangra and Palampur Valley of Himachal Pradesh. The study area falls in Survey of India Toposheets No. 52 D/4, D/8, D/12, D/16, 53A/5, A/9 & 53A/13 covering full or partial area of 18 quadrants (Fig.1.2). The Data Gap analysis of all the attributes are given in Table 1.1.

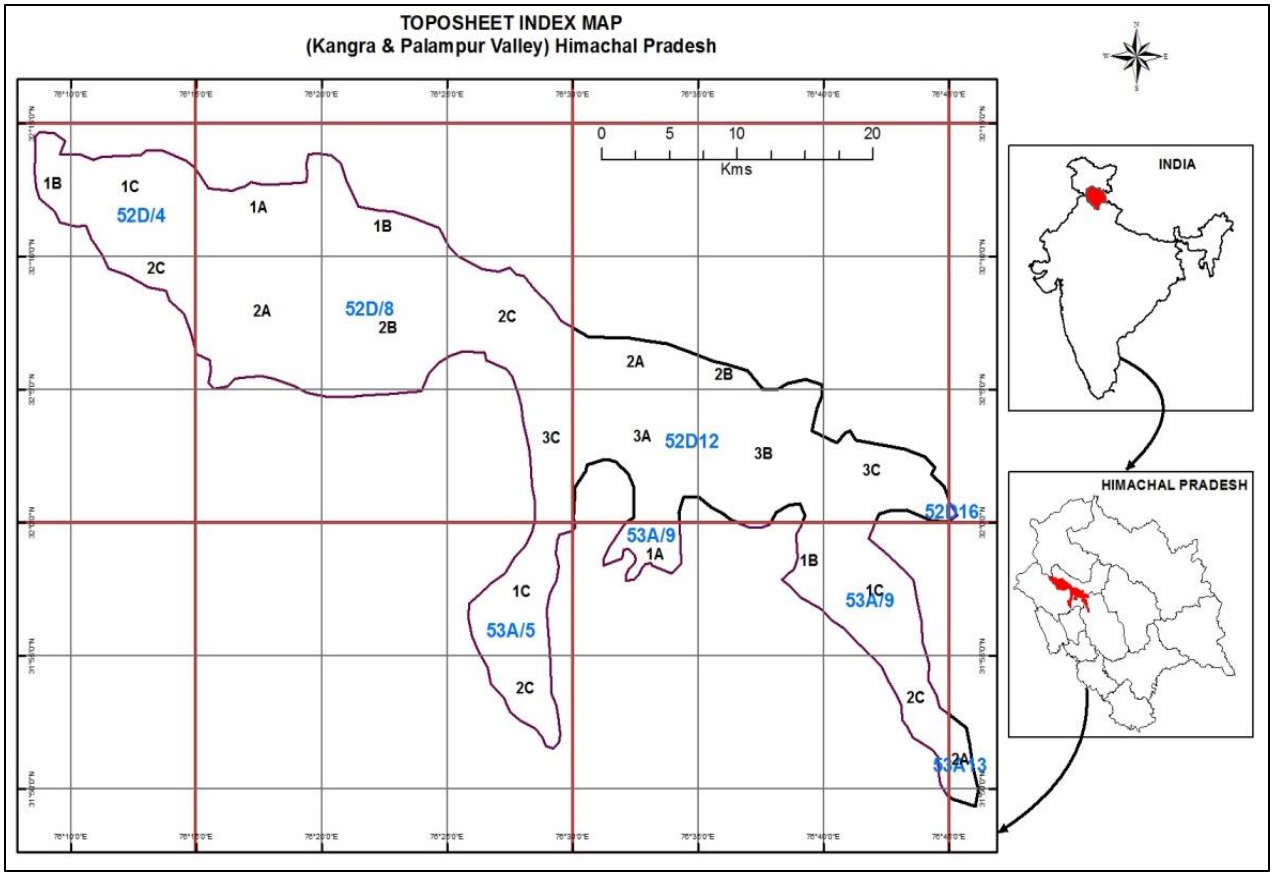


Fig.1.2 The Toposheet Index Map – Kangra & Palampur Valley, Himachal Pradesh

1.5.1 Exploratory Data

Ground water exploration by Central Ground Water Board was first initiated in the Kangra Palampur valley in the year 1988. Subsequently, the exploration was continued in different phases and was completed during the year 1997 upto a maximum depth of 90 m bgl. Later the exploration continued in the taluk in 2010-11 to the depth of 300 m bgl and under Aquifer Mapping Study in 2013-14.

The Central Ground Water Board has drilled 7 bore wells in the study area. This was done so as to facilitate the identification of aquifer systems, demarcation of their vertical and lateral extent, delineation of potential aquifers zones and to evaluate aquifer characteristics. The details of existing exploration data is given in Annexure-I and presented in Map (Fig.1.3 a & 13.b). Based on the available data, two aquifers are considered in the study area; 1st upto the depth of 100 - 150 m and 2nd between 150 to 300 m depth.

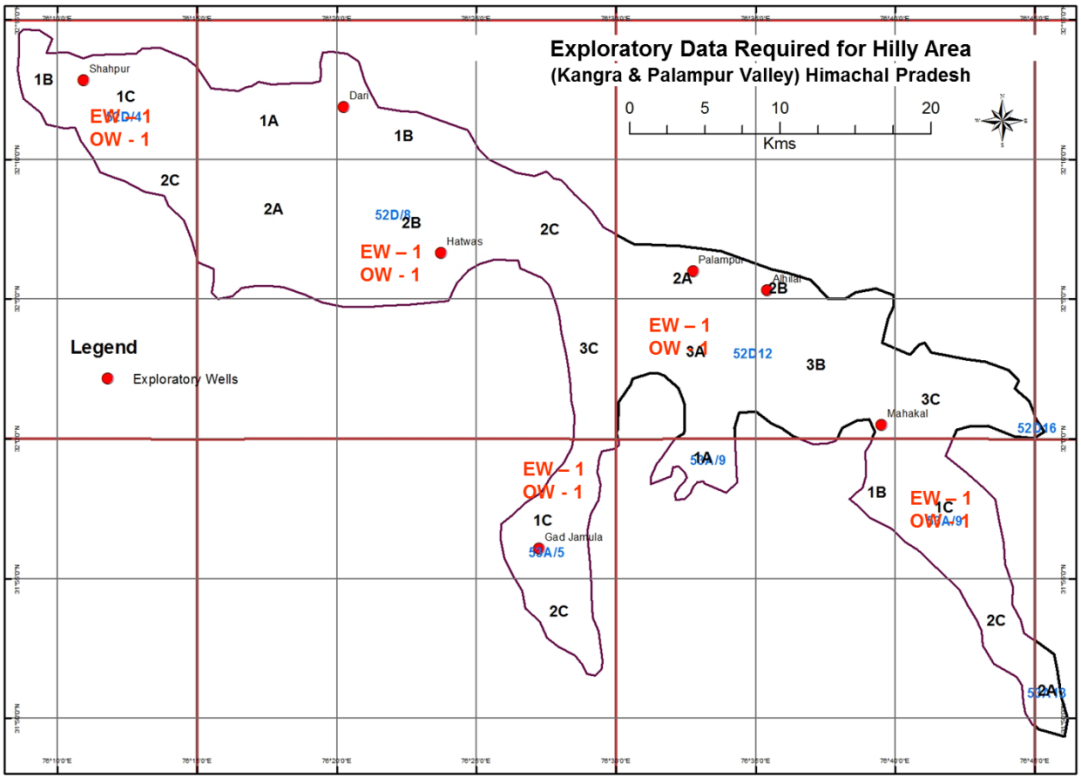


Fig.1.3 (a) Exploratory Data Required - Kangra & Palampur Valley, Himachal Pradesh

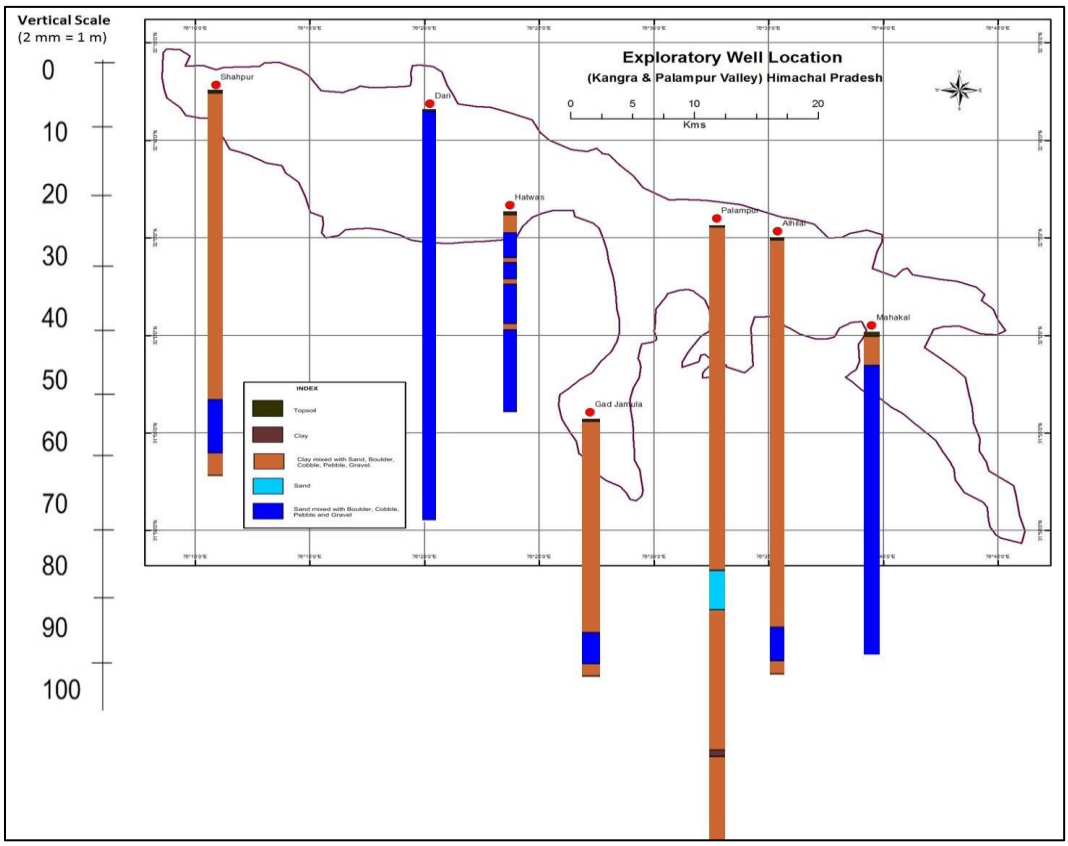


Fig.1.3 (b) The diagram showing disposition of aquifers

1.5.2 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 VES are 25 Nos. The quadrant-wise existing and recommended VES sites is presented as Annexure-II and shown as square diagram in the figure -1.4.

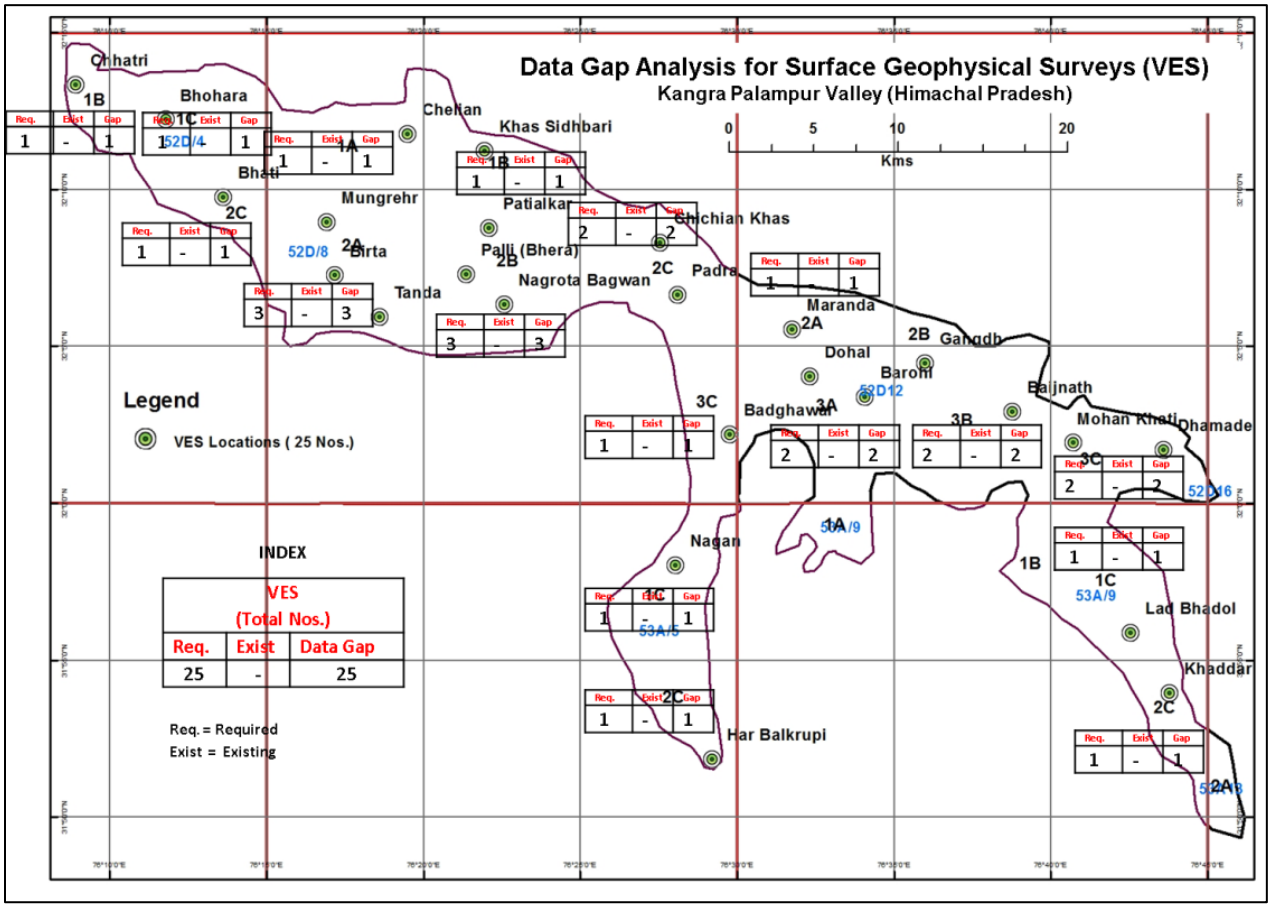


Fig.1.4 Data Gap Analysis of Surface Geophysical Surveys Kangra & Palampur Valley, Himachal Pradesh

1.5.3 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 -1.5.

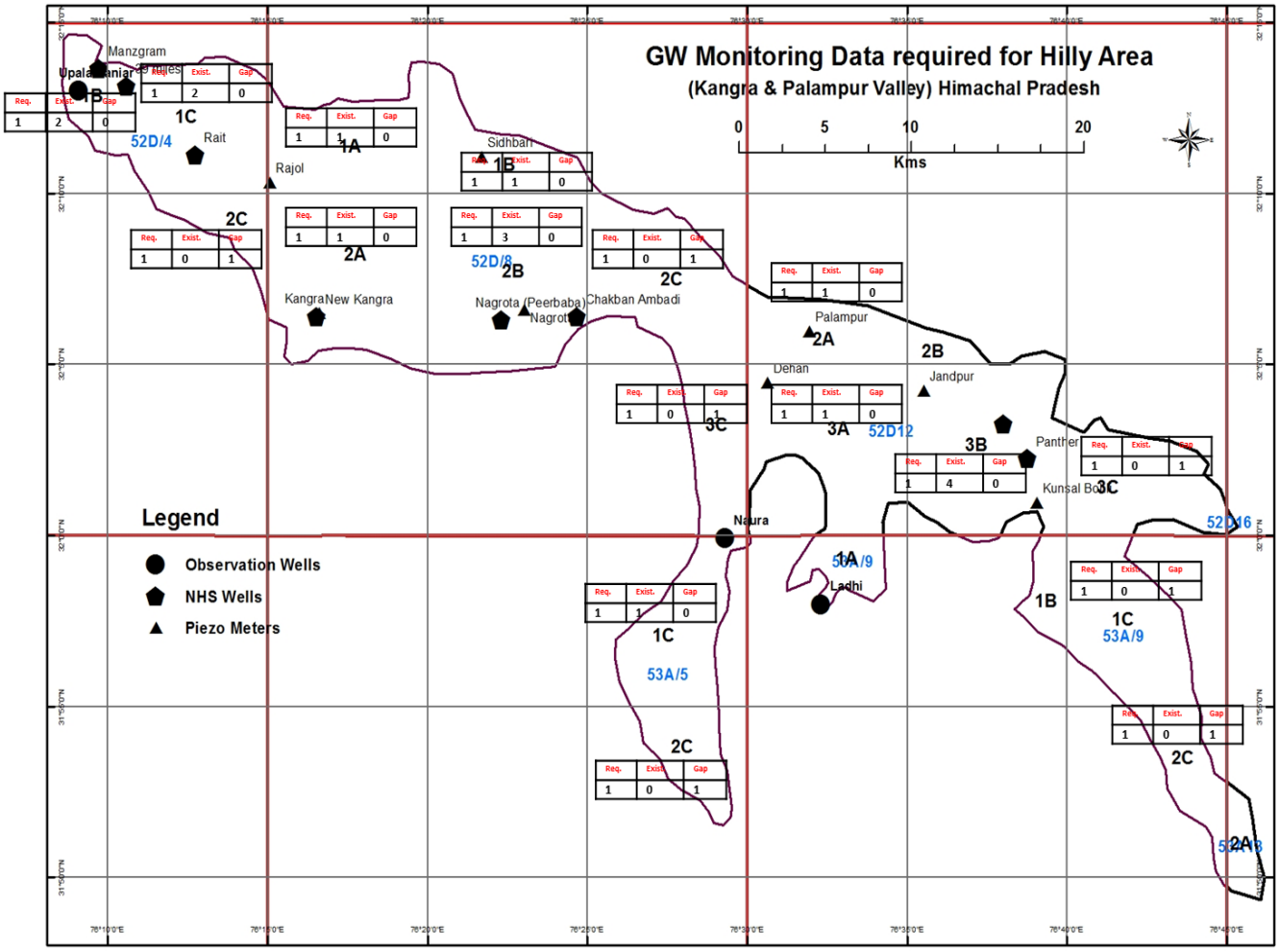


Fig.1.5 Ground Water Monitoring Data Required - Kangra & Palampur Valley, Himachal Pradesh

1.5.4 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, no additional GWQMS are required, it will be monitored through NHS, Key well observation stations, hand pumps, Spring, 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.

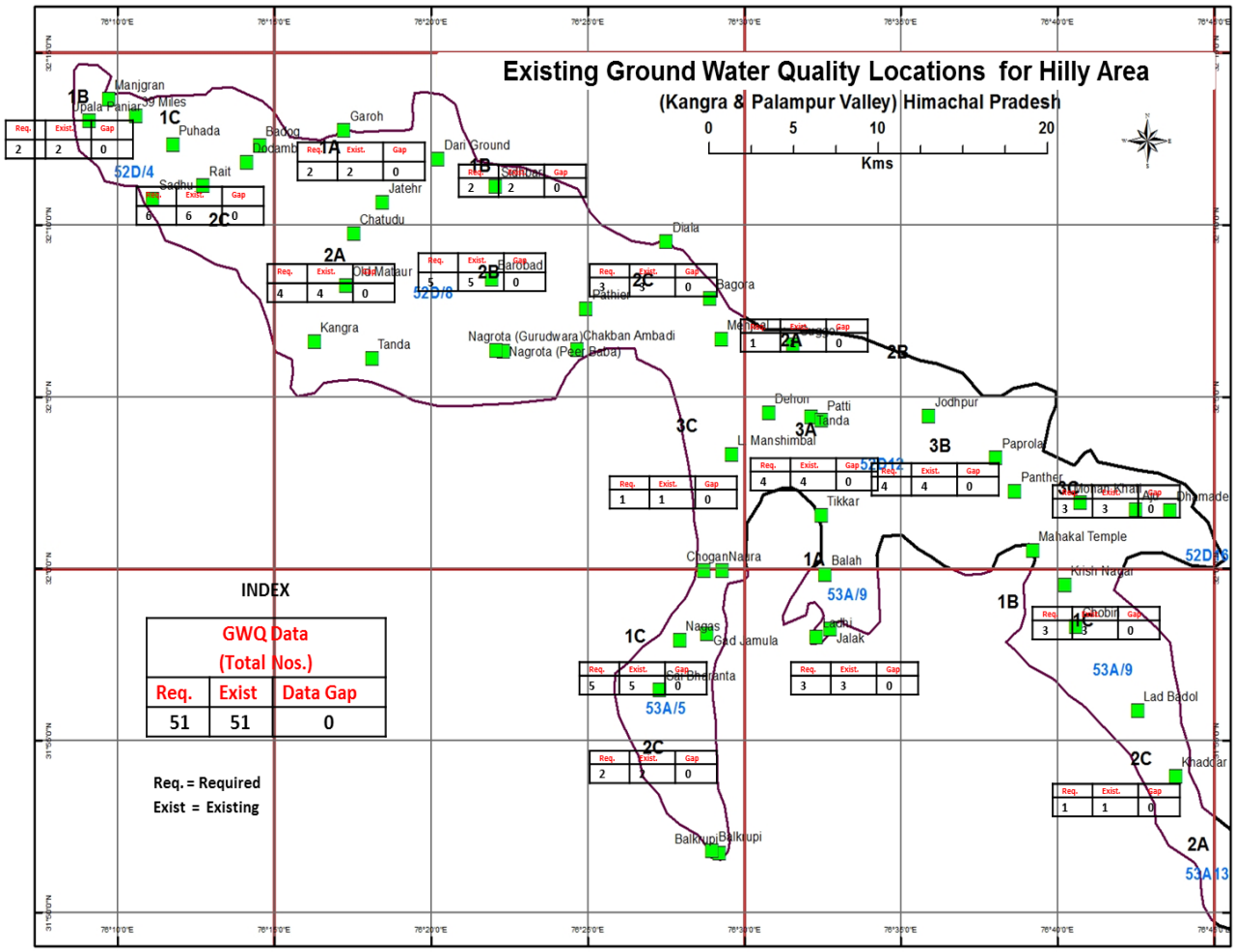


Fig.1.6 Existing Ground Water Quality Locations - Kangra & Palampur Valley, Himachal Pradesh

1.5.5 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 -1.7.

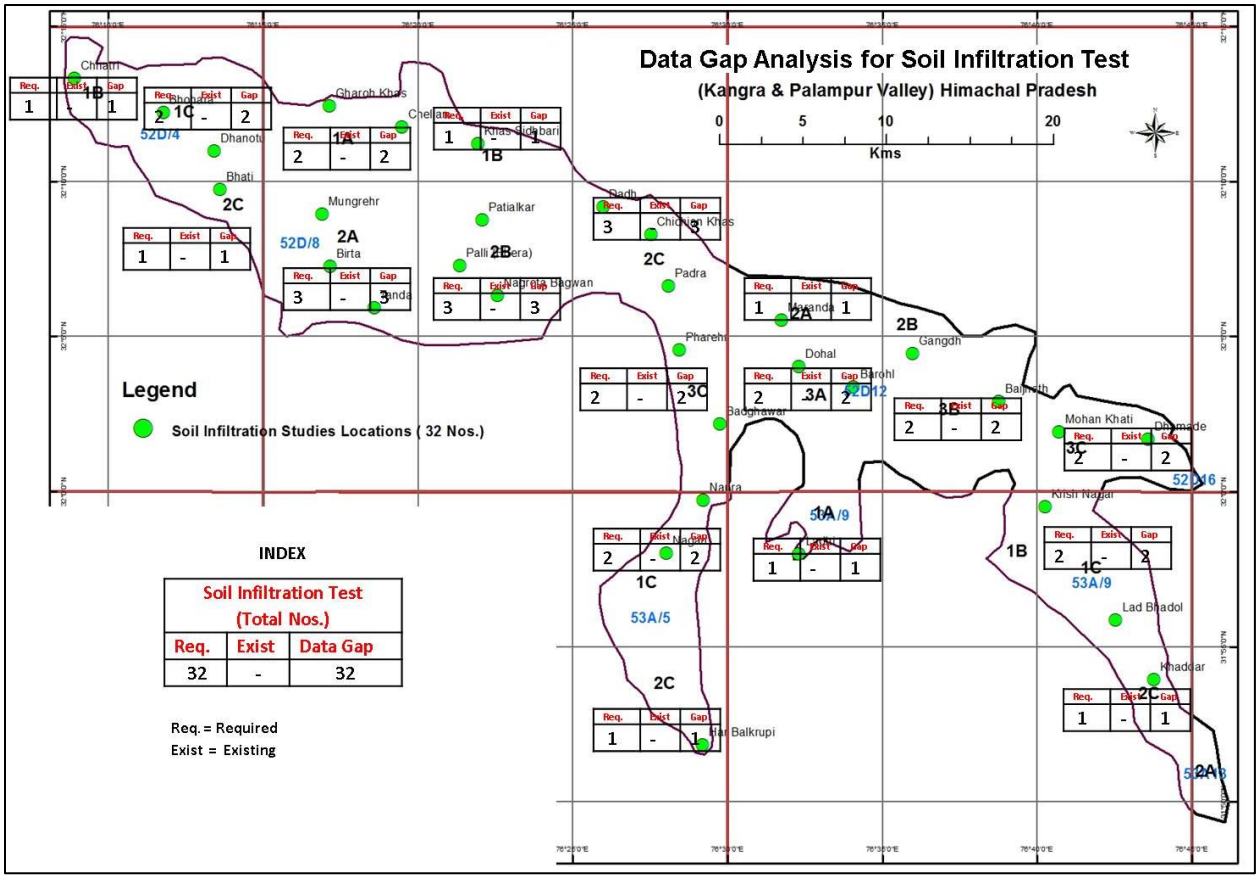


Fig.1.7 Data Gap Analysis for Soil Infiltration Studies - Kangra & Palampur Valley, Himachal Pradesh

1.5.6 Spring discharge

The major water supply schemes are based on the springs in Dharamsala and Palampur area. The ground water in these areas is discharged through the springs in the topographically favorable areas. Springs, located all along the thrust in Dharamsala and Palampur area are having discharge of less than 1 lps to more than 40 lps. Discharge is indicative of their higher potential. In Siwalik formations, the contact zones of various formations and fault zones form the potential ground water horizons. In the study area, 27 springs have been located. 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. The quadrant-wise existing springs and discharge data available are presented in Annexure-III and shown as square diagram in the figure -1.8

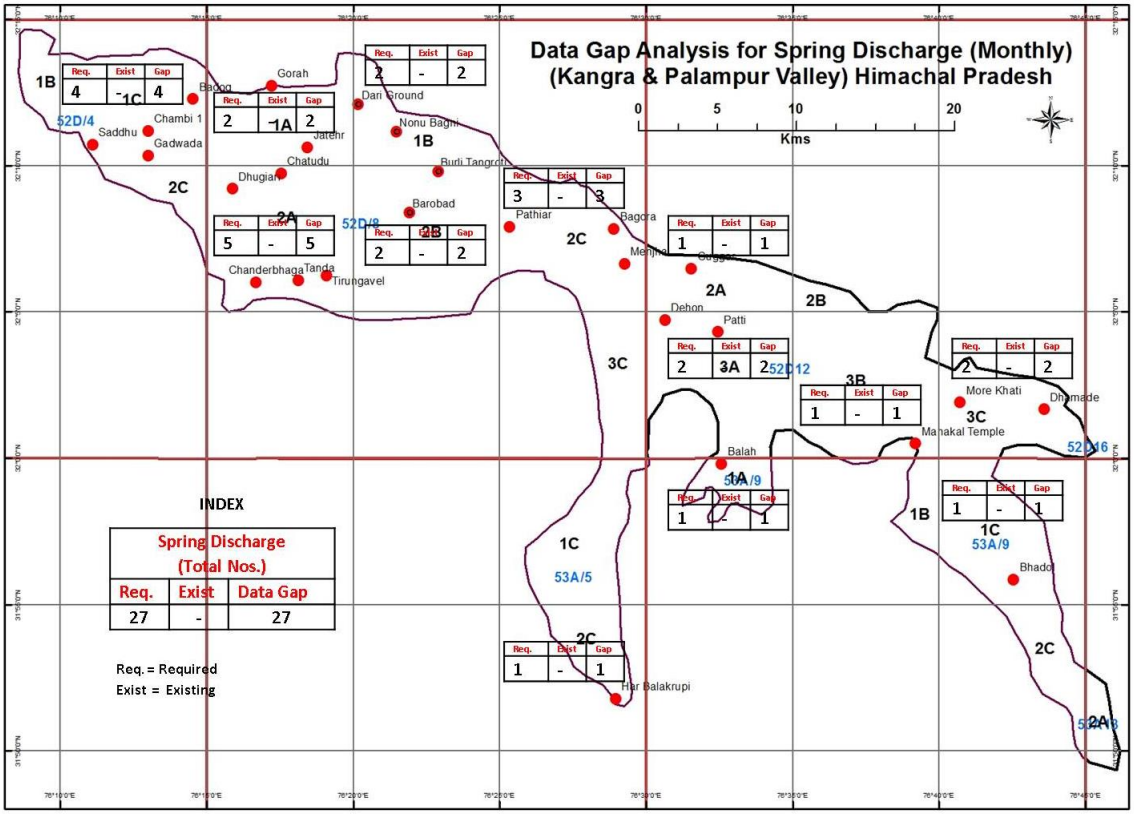


Fig.1.8 Data Gap Analysis for Spring Discharge - Kangra & Palampur Valley, Himachal Pradesh

Table 1.1 DATA GAP ANALYSIS, KANGRA & PALAMPUR VALLEY

Toposheet No: - 52D/4, 52D/8, 52D/12, 53A/5, 53A/9, 53A/13

Quadrant no.	No. of additional EWs Required	No. of additional OWs Required	No. of additional VES Required	No. of additional water level monitoring stations Required	Monthly Discharge of Existing Springs Required	No. of Soil infiltration test Required
	100 m Depth	100 m Depth	100 m Depth	100 m Depth	100 m Depth	100 m Depth
52D/4-1B			1		0	1
52D/4-1C	1	1	1		4	2
52D/4-2C			1	1	0	1
52D/8-1A			1		2	2
52D/8-1B			1		2	1
52D/8-2A			3		5	3
52D/8-2B	1	1	3		2	3
52D/8-2C			2	1	3	3
52D/8-3C			1		0	2
52D/12-2A			1		1	1
52D/12-2B			0		0	0
52D/12-3A	1	1	2		2	2
52D/12-3B			2		1	2
52D/12-3C			2	1	2	2
53A/5-1C	1	1	1		0	2
53A/5-2C			1		1	1
53A/9-1A			0		1	1
53A/9-1B					0	0
53A/9-1C	1	1	1		1	2
53A/9-2C			1	1	0	1
53A/13-2A			0		0	0
TOTAL	**5**	**5**	**25**	**4**	**27**	**32**

1.6 Physiography

Dharamsala and Palampur area is covered by mighty Dhauladhar ranges (4500m and 6000m above mean sea level). Thick ice valley glaciers cover these ranges. These glaciers got snow during winters and known as permafrost zone, followed by higher mountain zones ranging in height below 3500m. The study area falls in lower mountain zone stretching in between 1500m to 3000 m above mean sea level. Closely associated ridges and valleys covered by former valley glaciers and flowing channel creeps characterize this area and small solid slips are common. Below this is a piedmont zone which is narrow zone occurring all along the base of Dhauladhar ranges which roughly coincides with the main boundary fault at altitude between 1500 and 1200m above mean sea level. Piedmont zone is followed by fan zone which forms the important valley of Kangra and Palampur. These deposits exits between the foot of Dhauladhar ranges in the north and Siwalik in the south. The fan deposits exist all along the main khads like gaj, bunner, neogal, binwa. They are deposited by the major channels and former glaciers coming down from the Dhauladhar range.

1.7 Drainage

Kangra drainage system is chained by the Beas river flowing from east to towards west in the district (Fig.1.9). Beas river is fetched by southern flowing tributaries neogal, awa, binwa, baner, gaj, dehar khad. All these khads are perennial. The various khads / streams and their catchments area are tabulated below: -

Sr. no.	Name of river / khad	Catchment area (sq. km.)
1.	Dehar	477
2.	Gaj	616
3.	Buner	782
4.	Neogal	-
5.	Binwa	-

Being hilly, Dharamsala and Palampur area is irrigated is by kuhls which gets water from these perennial khads. Kuhls are drawn from the perennial khads / river by taking the advantage of variable slopes / gradient of the channels. The major kuhls are tabulated below: -

Sr. no.	Name of kuhl	Source	Approximate area under irrigation (hectares)	Approximate length of kuhl km.
1	Kirpal chand	Neogal	2670	12.86
2	Dewan chand	Neogal	2024	12.86
3	Fateh chand	Neogal	1234	9.65
4	Rani	Neogal	809	4.80

5	Pathri	Neogal	870	9.65
6	Dai	Neogal	600	12.86
7	Awa	Awa	1655	12.86
8	Binnu	Binwa	445	6.40
9	Maul	Maul	300	6.40
10	Kharuhal	Banoj	60	3.20
11	Committee	Gaj	2225	9.65
12	Gaj	Gaj	1417	8.00
13	Gaj	Gaj	445	8.00
14	Chambi	Gaj	850	6.40
15	Pakki dandi	Kohli	445	9.65
16	Jhikli	Kohli	325	3.20
17	Harnai	Baner	162	6.40
18	Chari	Chari	930	12.86
19	Ranai	Gaj	1620	14.50
20	Shahnagar	Beas	40	3.20
21	Denar	Denar	202	6.40
22	Bohal	Bohal	81	3.20

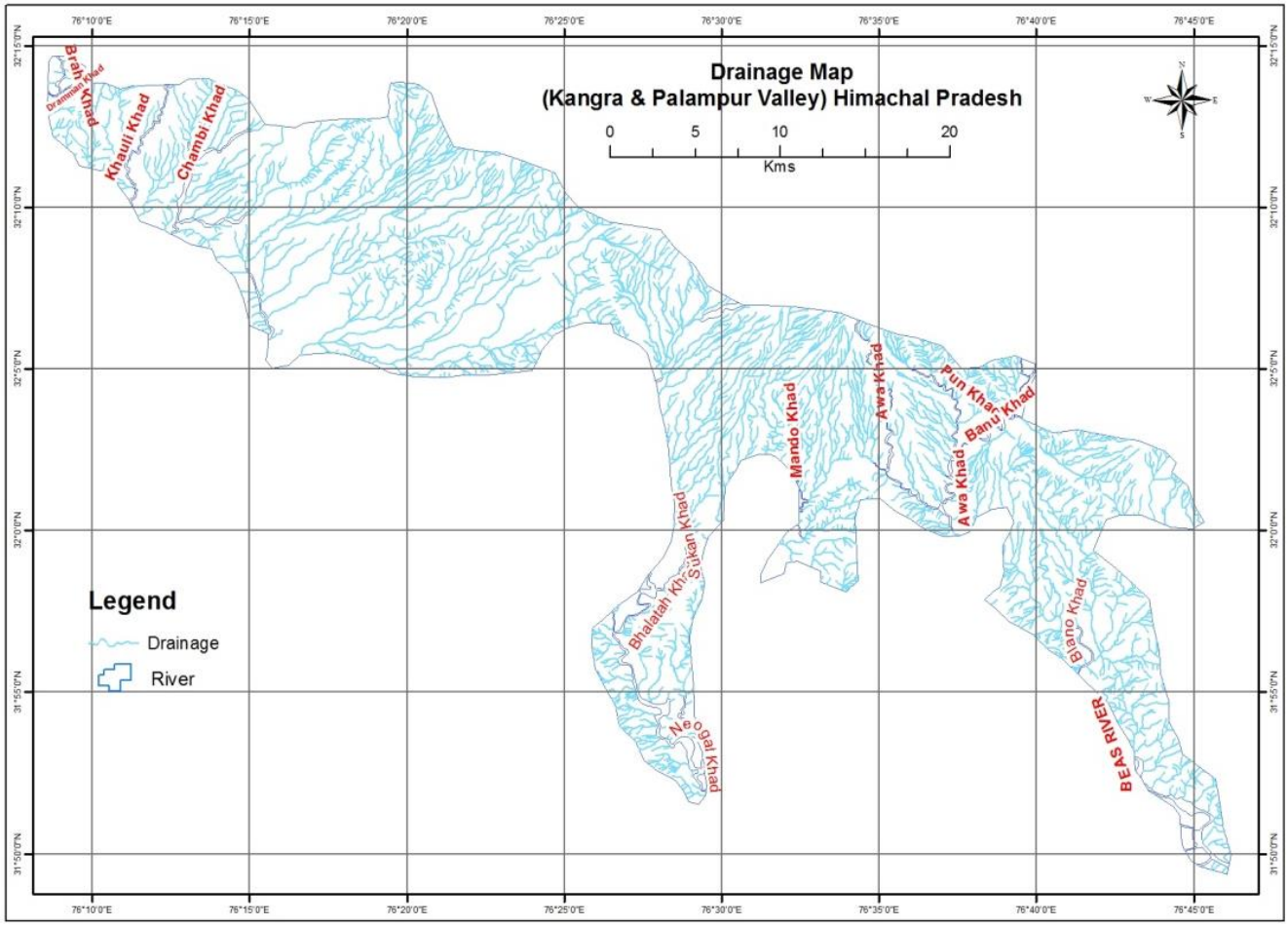


Fig 1.9: The Drainage Map – Kangra & Palampur Valley, Himachal Pradesh

1.8 Geology

The Geological Map of the study area has been prepared with the help of G.S.I. Digital Geological Map (Fig.1.10).

The details of formation as given below: -

Table: 1 Geological sequence of study area

AGE	SUPER GROUP	GROUP NAME	FORMATION	LITHOLOGICAL UNIT
EOCENE-MIOCENE		SIRMUR	DAGSHAI	BROWN SANDSTONE, RED CLAY, PURPLE CHOCOLATE SHALE
EOCENE-MIOCENE		SIRMUR	KASAULI	GREY, PURPLE, RED SANDSTONE, SHALE, LIMESTONE
HOLOCENE		NEWER ALLUVIUM	CHANNEL ALLUVIUM	GREY MICACEOUS SAND, SILT, CLAY.
MIO-PLIOCENE	SIWALIK	MIDDLE SIWALIK		GREY MICACEOUS SANDSTONE, GRAVEL BEDS, SHALE, CLAY
MIOCENE	SIWALIK	LOWER SIWALIK		MICACEOUS SANDSTONE, PURPLE CLAY, MUDSTONE.
PLIO-PLEISTOCENE	SIWALIK	UPPER SIWALIK		COARSE SANDSTONE, BOULDER CONGLOMERATE,CLAY & GRIT
QUATERNARY			UNDIFFERENTIATED QUATERNARY	

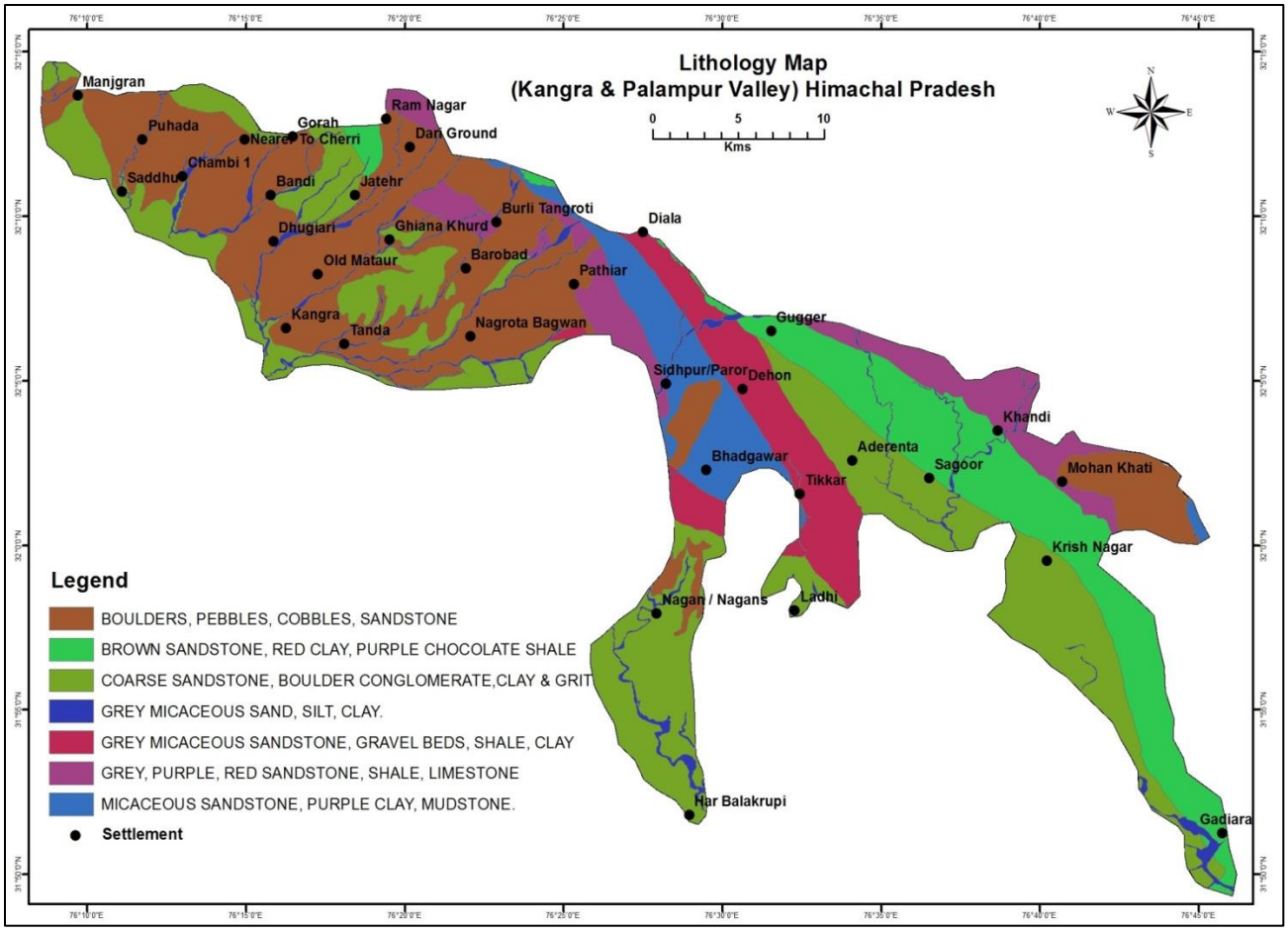


Fig 1.10 Lithology Map of Kangra & Palampur Valley, Himachal Pradesh

1.9 Hydrogeology

Based on the geological diversities and relative ground water potentiality of different geological formation, the area can broadly be divided into two hydro geological units (Fig.1.11).

(i) Fissured Formation

(ii) Porous Formation

(i) Fissured Formation

Fissured formation are constituted by hard rock formation belonging to Jutogh and Shali limestone, Chandpurs, volcanics, Dharamsala and Siwaliks. These formations consist of schists, quartzites, slates, phyllites, limestones, granites, gneisses, sandstones, conglomerates and shales. These rocks are devoid of primary porosity but secondary porosity has been developed due to the tectonic activities along the fracture, joint and fault zones. In these hard rocks, ground water is distributed either along structurally weak zones, fractured zones, faults, joints and land slide zones or along the contact of different formation. The ground water in these areas are discharged through the springs in the topographically favorable areas. Springs located all along the thrust in Dharamsala and Palampur areas are having discharge of less than 1 lps to more than 40 lps, are indicative of their higher potential. In Siwalik formations, the contact zones of various formations and fault zones form the potential ground water horizons. Important springs at Trilokpur (30 lps) and Nagni (25 lps) are located at the intersection of Jawalamukhi thrust and NS trending faults.

(ii) Porous Formation

Quaternary sediments as fluvio-glacial and fluvetile deposits occurs as valley fill deposits overlying the older rocks. Moronic and fluvio-glacial deposits are distributed in Kangra-Palampur valley while fluviotile deposits occurs either along Beas River or its tributaries.

Fluvio-glacial deposits are widely distributed in the upper catchments of Neogal, Binwa, Baner, Manjhi, Gaj, Dehar,Uhl and Bir khads. These sediments are unconsolidated and are comprises of sand, gravels, pebbles, cobbles, boulders etc. These sediments has been deposited by the glacial activities in different phases and reworked by fluvial activities in various catchments. Large numbers of springs are also found in these deposits either along the contact with the older rocks or different phases of deposition. These springs form the traditional sources of water supply. The yield of these springs ranges between less than 1 lps to 10 lps. This water is used both for drinking and irrigation purposes.

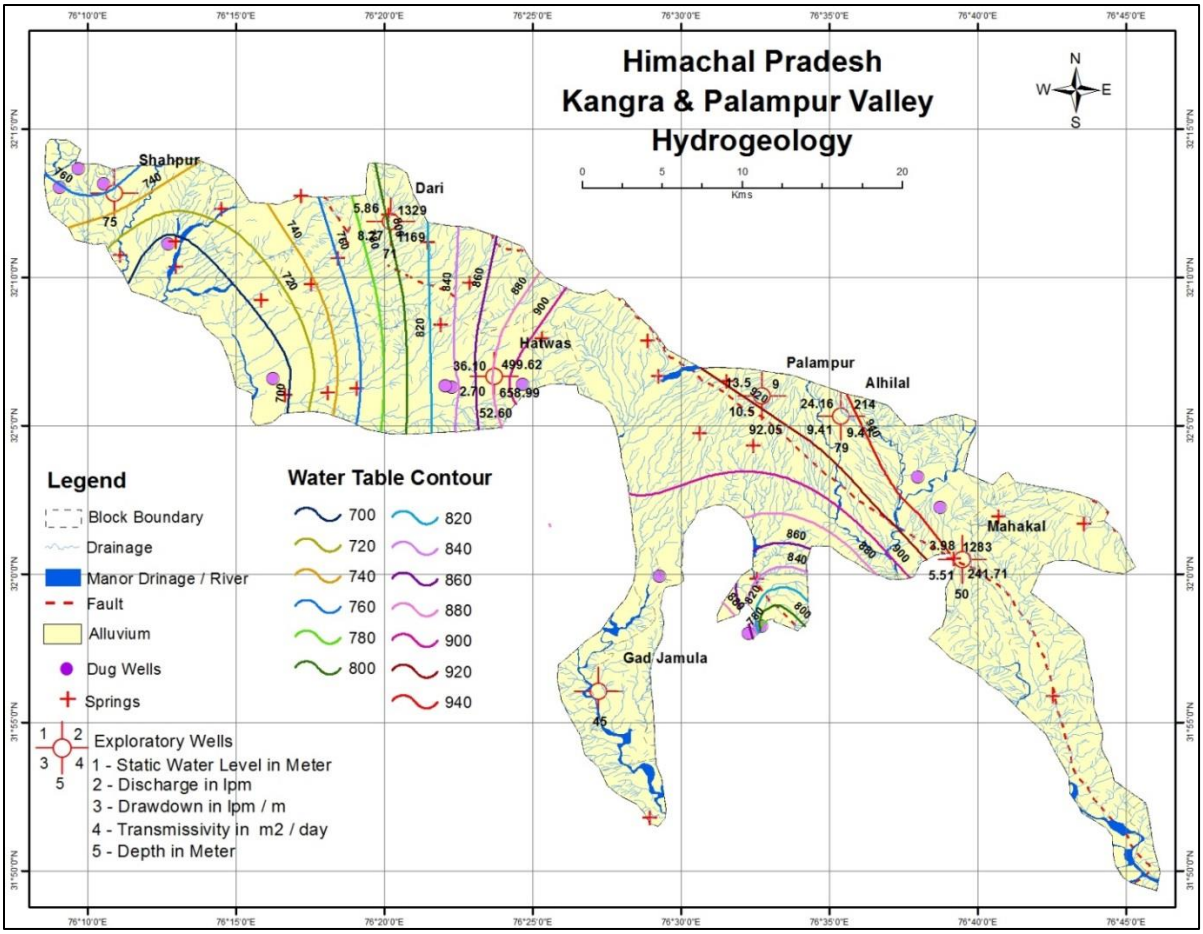


Fig 1.11 Hydrogeology Map of Kangra & Palampur Valley, Himachal Pradesh

(iii) Springs

The major water supply schemes are based on the source of springs in Dharamsala and Palampur area. The discharge of the springs varies from 0.5 lps to 25 lps. Majority of the springs are gravity springs, which results from water flowing under hydrostatic pressure. In the gravity springs, the most commonly are the contact springs, which are formed by permeable water bearing formations overlying less permeable formations, which intersects the ground surface.

The weathered mantle of the rocks in this area normally acts as permeable formations through which rainwater seeps. The underlying less permeable or impermeable rocks from the lower confining layer.

Another spring at Bhagsunag having a discharge of more than 40 lps, is of great importance to Dharamsala town and nearby areas. The spring is oozing out from the Pre-Tertiary formations. In this area faulting of the formations resulted in the oozing of the springs, which might be recharged at higher altitude. Such high discharges might be due to solution channels of Dharamkot Limestone's, which are conformably lies over the formation. In

Dharamsala to Palampur area major springs are oozing out between the contacts of the formations or different lineaments and fractures. The spring oozing out at Neogle pul near Palampur oozing out from the conglomeratic formation, which is highly fractured along the bedding planes giving a discharge of more than 60 lpm.

1.10 Geomorphology

The geomorphological map was interpreted from survey of India topographic sheets and IRS P6 LISS - IV satellite imagery. The geomorphic units represented in the study area are Denudational Hill, Alluvial Fan, River Alluvium and River shown in fig.1.11.

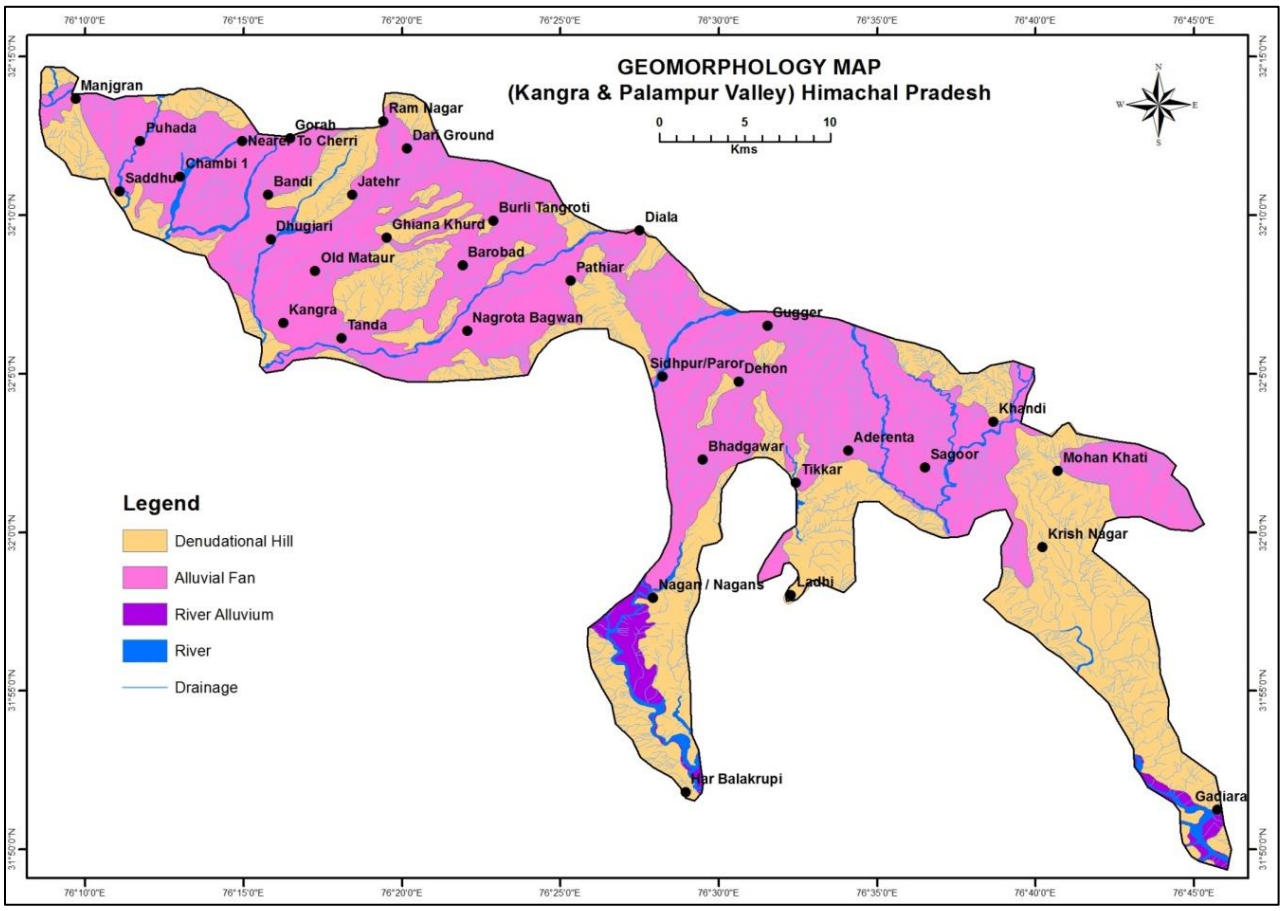
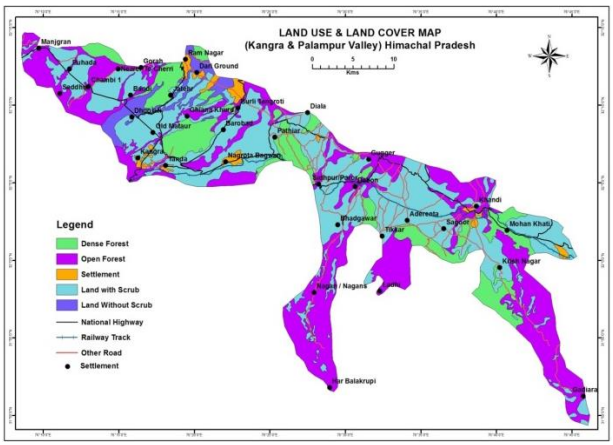


Fig 1.11 Geomorphology Map of Kangra & Palampur Valley, Himachal Pradesh

1.11 Land use and Land Cover

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, Open Forest, Settlement, Land with scrub and Land without scrub. (fig.1.12 (a)). Similarly Forest Area map was prepared with the help of processed satellite imagery, the same has been shown in fig. 1.12 (b).



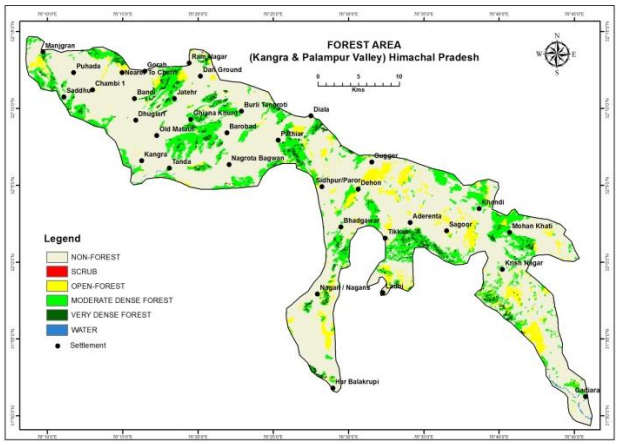


Fig. 1.12 (a) Land Use & Land Cover (b) Forest Area

1.12 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. 1.13.

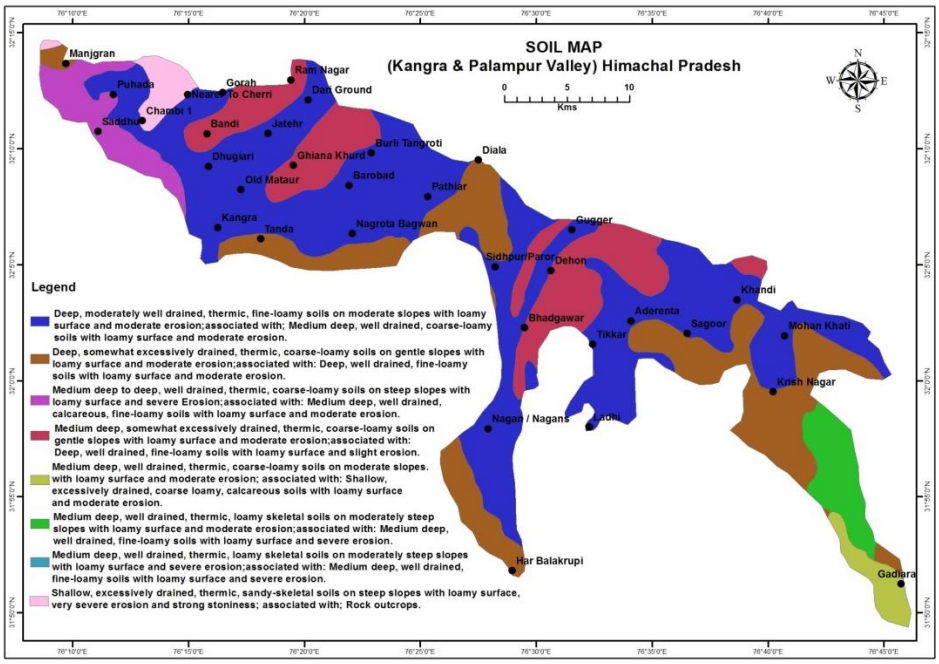


Fig. 1.13 Soil Map of Kangra Palampur Valley, Himachal Pradesh

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 Kangra and Mandi district during various field seasons. Central Ground Water Board, NHR, Dharamshala has also carried out preliminary Pollution studies in

Urban clusters of Dharmshala and Palampur area and ground water exploration studies in the area.

CGWB NHR, Dharamshala is monitoring ground water levels from National Hydrograph Network observations wells 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.

Also, the Irrigation and Public Health Department of Himachal Pradesh also measures ground water quality on monthly basis in some of water supply abstraction structures.

Name of Village/site	Latitude in degrees decimal	Longitude in degrees decimal	Establishment date (dd/mm/yyyy)	RL (mamsl)	Total Depth of DW (mbgl)	Type (DW)	Measuring point (magl)
Ladhi	31.9667	76.5382	6/19/2013		20	DW	0.25
Naura	31.9989	76.4883	6/20/2013		28	DW	0.35
New Kangra	32.1099	76.2712	5/29/2013	697.47	14.85	DW	0.50
Upala Paniar	32.2171	76.1512	7/12/2013		3.6	DW	0.5
Nagrota Bagwan (Peerbaba)	32.1052	76.3716	5/28/2013	843.78	14.4	DW	0.45
Jalak	31.9707	76.5455	1/8/2015		3.95	DW	0.45
Manzgram	32.2277	76.1617	5/26/2013	784.01	4.86	DW	0.35
Rait	32.1856	76.2120	5/29/2013	701	11.1	DW	0
39 miles	32.2193	76.1761	8/29/2013		10	DW	0.60
Chakban Ambadi	32.1068	76.4111	8/26/2013		7	DW	0.30
Panther	32.0375	76.6460	6/20/2013		3.68	DW	0.60
Paprola	32.0544	76.6333	6/20/2013	967.85	1.08	DW	1.10
Nagrota Bagwan (Gurudwara)	32.1057	76.3679	7/19/2013		11.4	DW	0.2

2.0 DATA COLLECTION AND GENERATION

2.1 Hydrogeological Data

Water Level Behavior: To know the water level and its behavior 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 Kangra and Palampur valley. The water levels were taken during the month of May and November, 2014 & 2015 and on the basis of these data, pre-monsoon, post monsoon and seasonal fluctuation map have been prepared for the Kangra and Palampur valley area. The hydrogeological data of the inventoried dug wells are given in Table 2.1.

In Kangra and Palampur valley depth to water level shows wide variation. During pre-monsoon period (May 2014) it ranges from 0 to 12.65 m bgl (Fig. 2.0) and post monsoon period (Nov.2014) ranges from 0 to 9.97 m bgl. (Fig. 2.1). In major parts of Kangra and Palampur Valley, Seasonal Water Level Fluctuation ranges between less than -0.19 to 4.15 m bgl

(Fig.2.2). Whereas in pre-monsoon period of (May 2015) it ranges from 0.6 to 12.45 m bgl (Fig.2.3) and post monsoon period (Nov.2015) ranges from 0.55 to 8.74 m bgl (Fig.2.4) and Seasonal Water Level Fluctuation ranges between 0.05 to 5.1 m bgl (Fig. 2.5).

Table 2.1 Water level data (May & Nov.2014 and May & Nov.2015) GWMS and Aquifer Mapping Wells of Kangra and Palampur Valley, Himachal Pradesh

Location	Latitude	Longitude	Water Level, 2014		2014 Fluctuation	Water Level, 2015		2015 Fluctuation
			May 2014	Nov. 2014		May 2015	Nov. 2015	
Ladhi	31.9667	76.5382	2.74	1.8	0.94	2.1	1.85	0.25
Naura	31.9989	76.4883	1.75	1.3	0.45	1.85	1.2	0.65
New Kangra	32.1099	76.2712	12.65	8.5	4.15	12.05	7.4	4.65
Upala Paniar	32.2171	76.1512	1.86	1.8	0.06	2.44	0.6	1.84
Nagrota Bagwan (Peerbaba)	32.1052	76.3716	0	0	0	12.45	7.35	5.1
Jalak	31.9707	76.5455	0	0	0	2.6	2.15	0.45
Manzgram	32.2277	76.1617	1.75	0.75	1	1.35	0.85	0.5
Rait	32.1856	76.2120	9.3	8.35	0.95	9.45	8.74	0.71
39 miles	32.2193	76.1761	9.1	6.5	2.6	8.6	7.2	1.4
Chakban Ambadi	32.1068	76.4111	4.21	4.4	-0.19	4.6	4.55	0.05
Panther	32.0375	76.6460	1.4	0.6	0.8	0.6	0.55	0.05
Paprola	32.0544	76.6333	11.91	9.97	1.94	10.05	5.7	4.35
Nagrota Bagwan (Gurudwara)	32.1057	76.3679	11.25	9	2.25	11.4	8.4	3

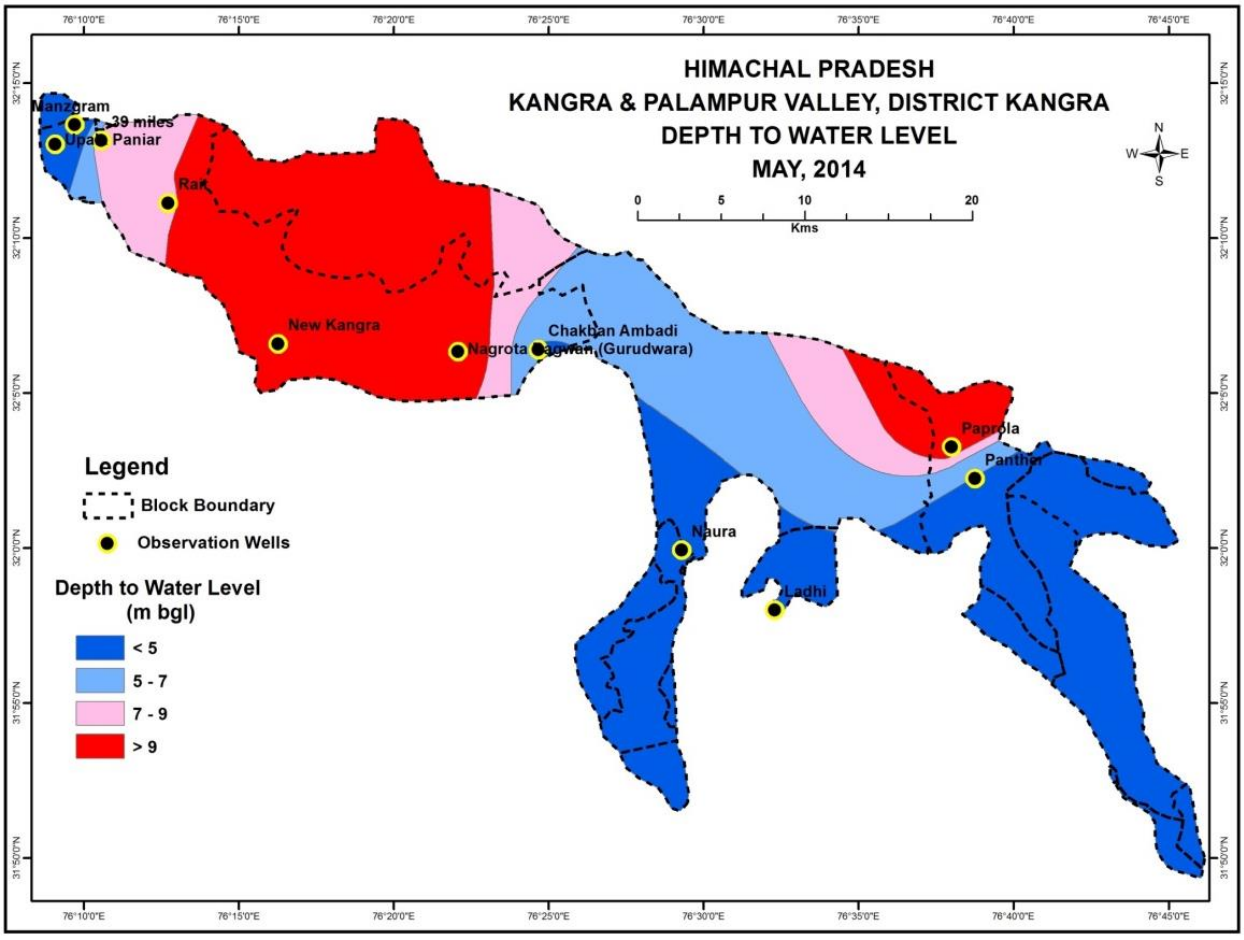


Fig. 2.0 Depth Water Level – May 2014, Kangra & Palampur Valley, Himachal Pradesh

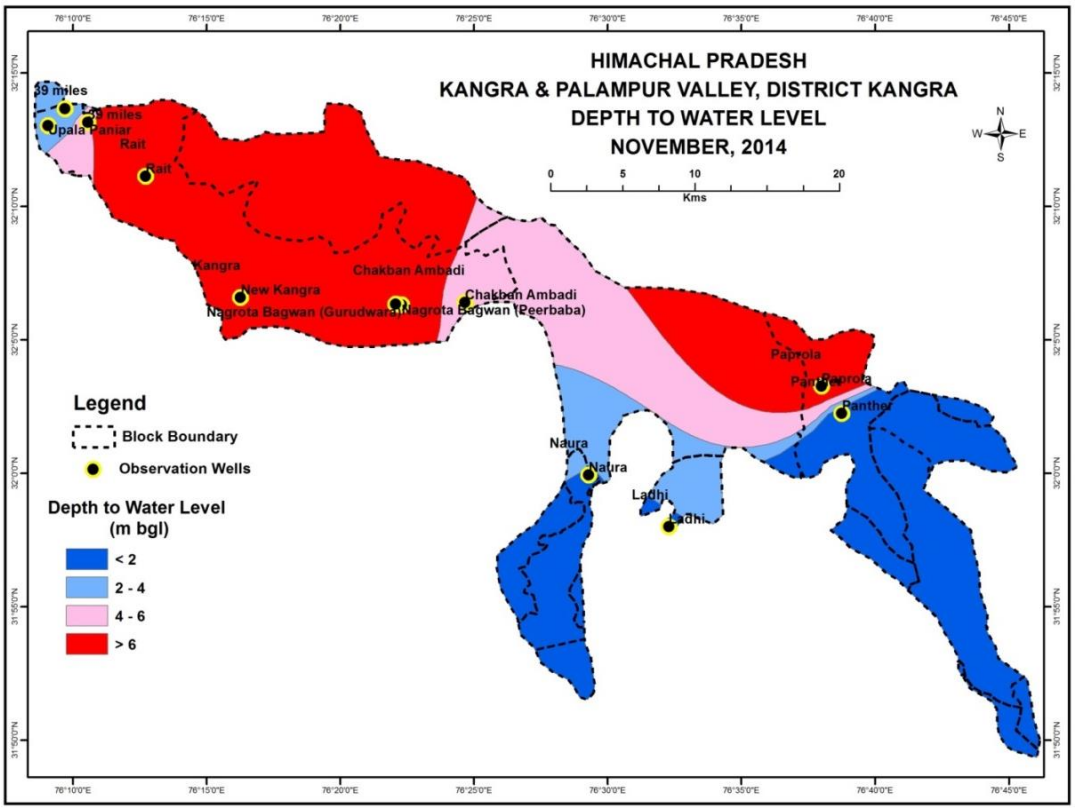


Fig. 2.1 Depth Water Level – Nov. 2014, Kangra & Palampur Valley, Himachal Pradesh

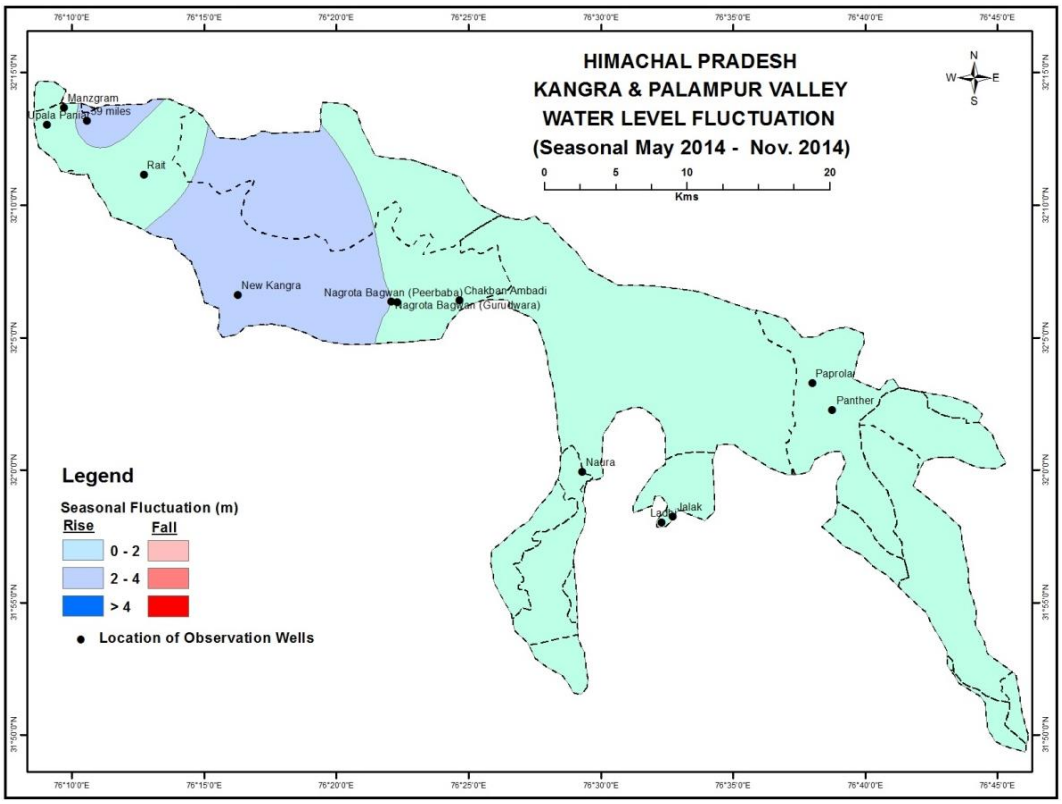


Fig. 2.2 Seasonal Water Level Fluctuation – May 2014 & November 2014, Kangra & Palampur Valley, Himachal Pradesh

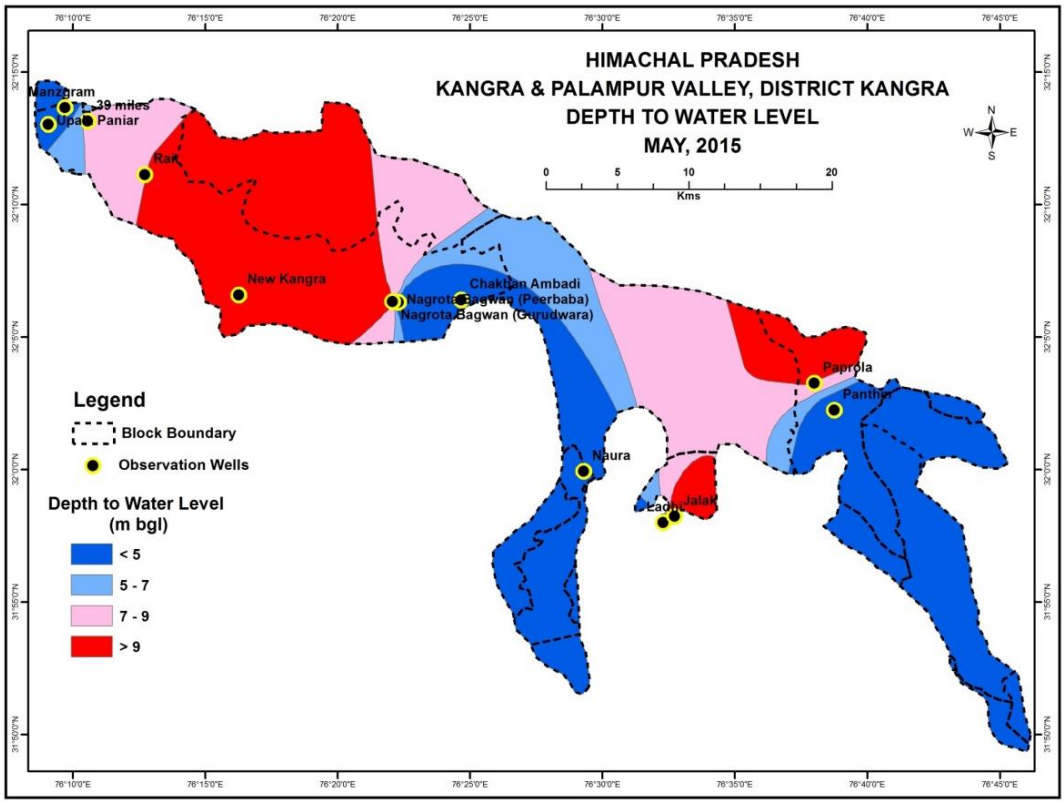


Fig. 2.3 Depth Water Level – May, 2015, Kangra & Palampur Valley, Himachal Pradesh

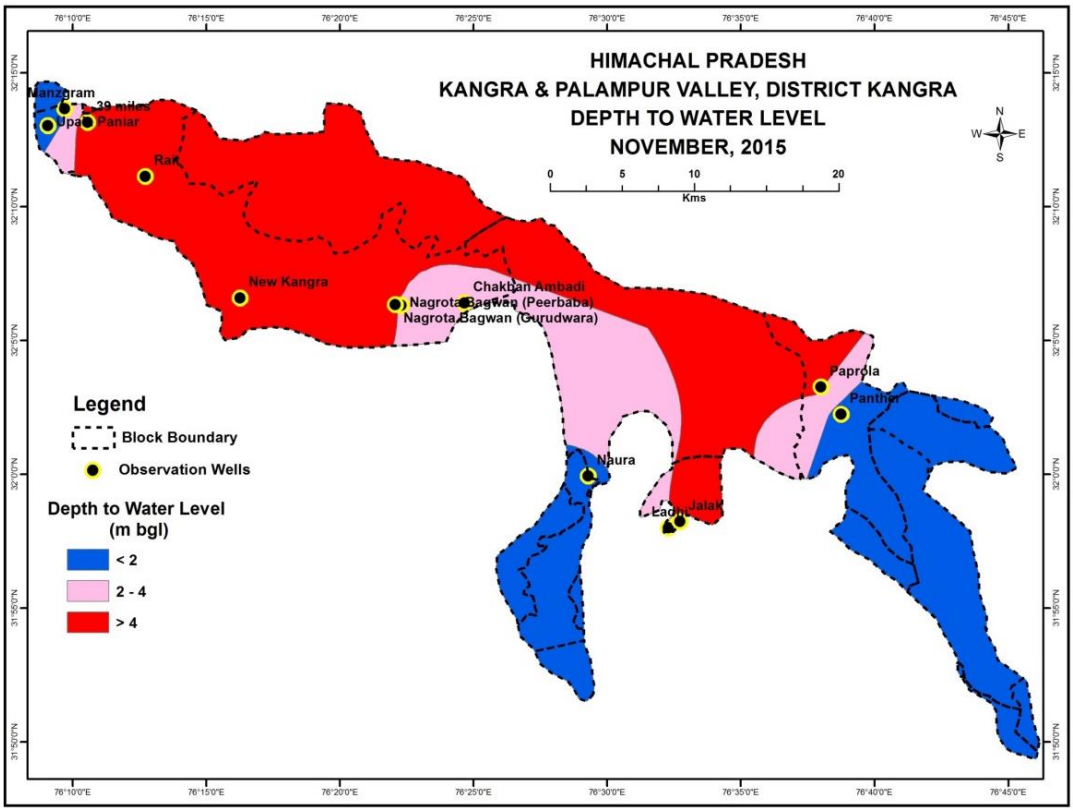


Fig. 2.4 Depth Water Level – November, 2015, Kangra & Palampur Valley, Himachal Pradesh

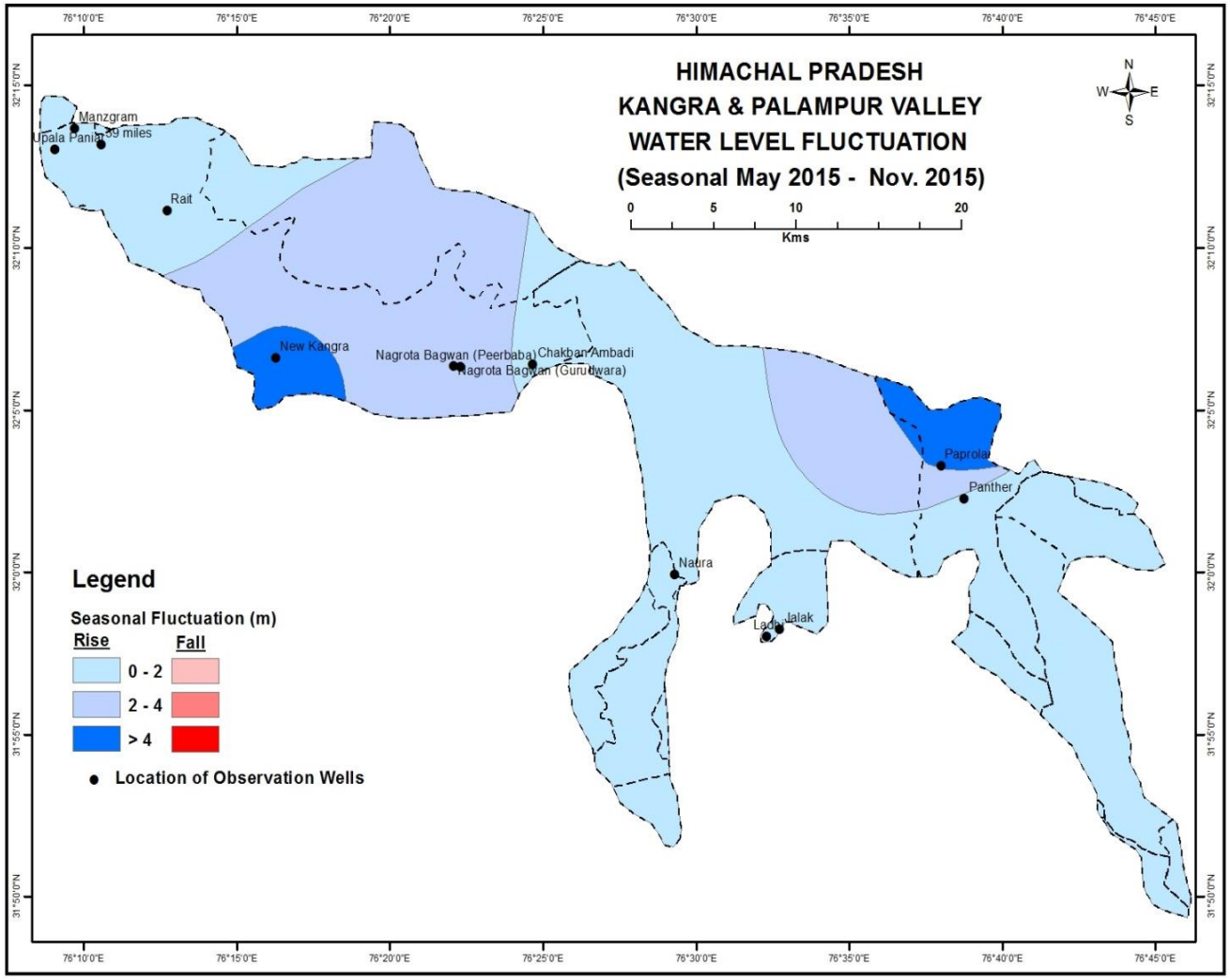


Fig. 2.5 Seasonal Water Level Fluctuation – May 2015 & November 2015, Kangra & Palampur Valley, Himachal Pradesh

Annual fluctuation in water level of GWMS and Aquifer Mapping Wells during different monitoring periods were analysed and discussed below.

November 2013 & November 2014

To know the annual water level fluctuation and its behavior with respect to time and space, 13 dug wells have been inventoried for Ground Water Management Studies all over the Kangra and Palampur Valley area. The water levels were taken during the month of November, 2013 & November 2014 and on the basis of these data, annual fluctuation map have been prepared for the Kangra and Palampur valley area. The hydrogeological data of the inventoried dug wells are given in Table 2.2.

Table 2.2 Water level data (Nov. 2013 and Nov. 2014) GWMS and Aquifer Mapping Wells of Kangra & Palampur Valley, Himachal Pradesh

Location	Latitude	Longitude	November 2013	November 2014	Annual Fluctuation
Ladhi	31.9667	76.5382	2.73	1.8	0.93
Naura	31.9989	76.4883	6.8	1.3	5.5
New Kangra	32.1099	76.2712	9.6	8.5	1.1
Upala Paniar	32.2171	76.1512	1.7	1.8	-0.1
Nagrota Bagwan (Peerbaba)	32.1052	76.3716	0	0	0
Jalak	31.9707	76.5455	0	0	0
Manzgram	32.2277	76.1617	1	0.75	0.25
Rait	32.1856	76.2120	6.99	8.35	-1.36
39 miles	32.2193	76.1761	0	0	0
Chakban Ambadi	32.1068	76.4111	3.88	4.4	-0.52
Panther	32.0375	76.6460	1.04	0.6	0.44
Paprola	32.0544	76.6333	7	9.97	-2.97
Nagrota Bagwan (Gurudwara)	32.1057	76.3679	8.5	9	-0.5

During the period of November 2013 water level ranges from 0 to 9.6 m bgl (Fig.2.6) and November 2014 water level ranges from 0 to 9.97 m bgl. (Fig.2.7) and Annual Water Level Fluctuation ranges between -1.36 to 5.5 m bgl (Fig. 2.8).

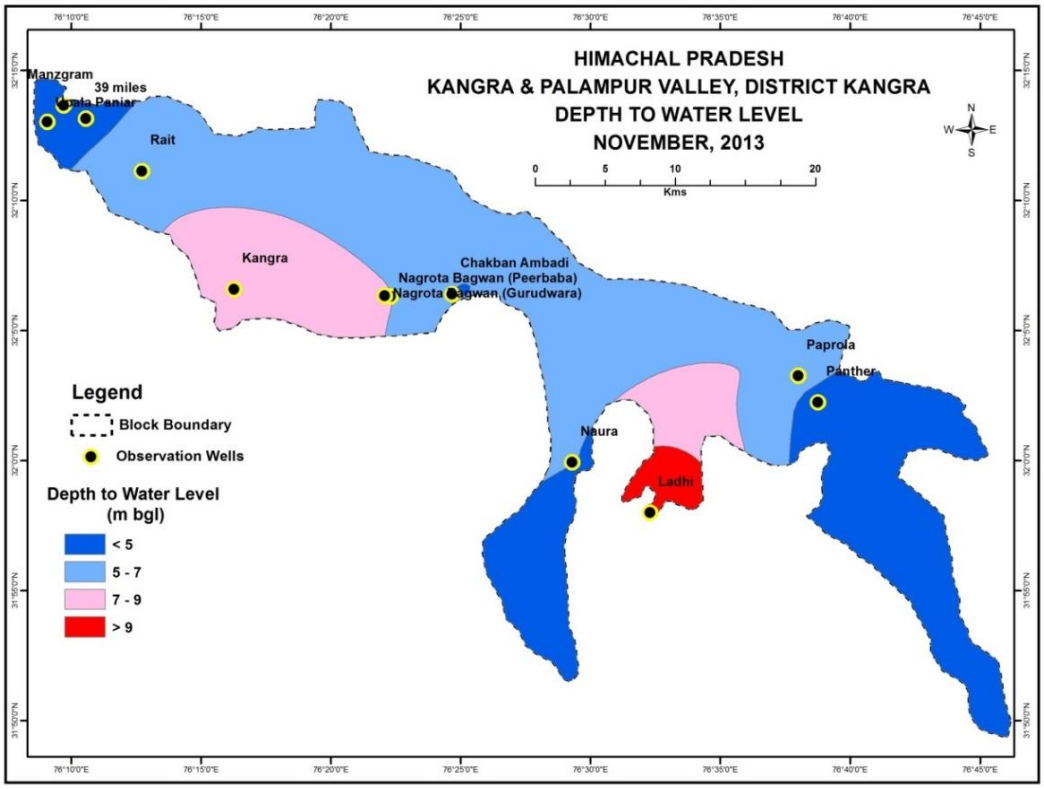


Fig. 2.6 Depth Water Level – November 2013, Kangra & Palampur Valley, Himachal Pradesh

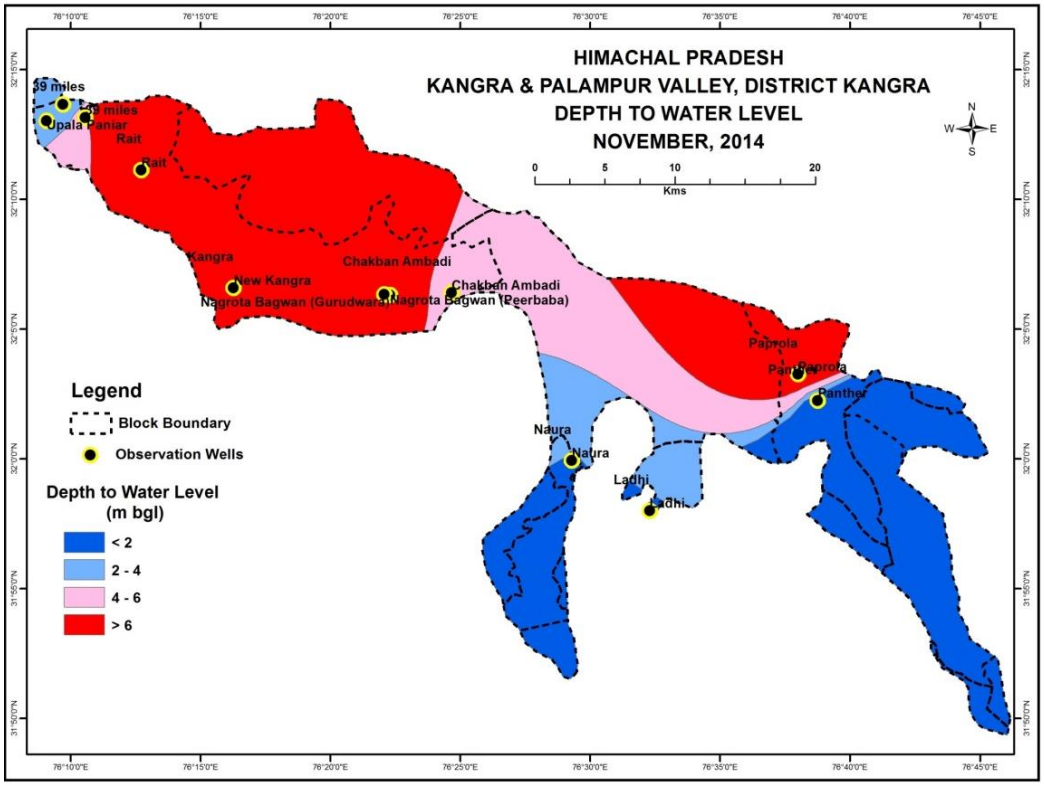


Fig. 2.7 Depth Water Level – November 2014, Kangra & Palampur Valley, Himachal Pradesh

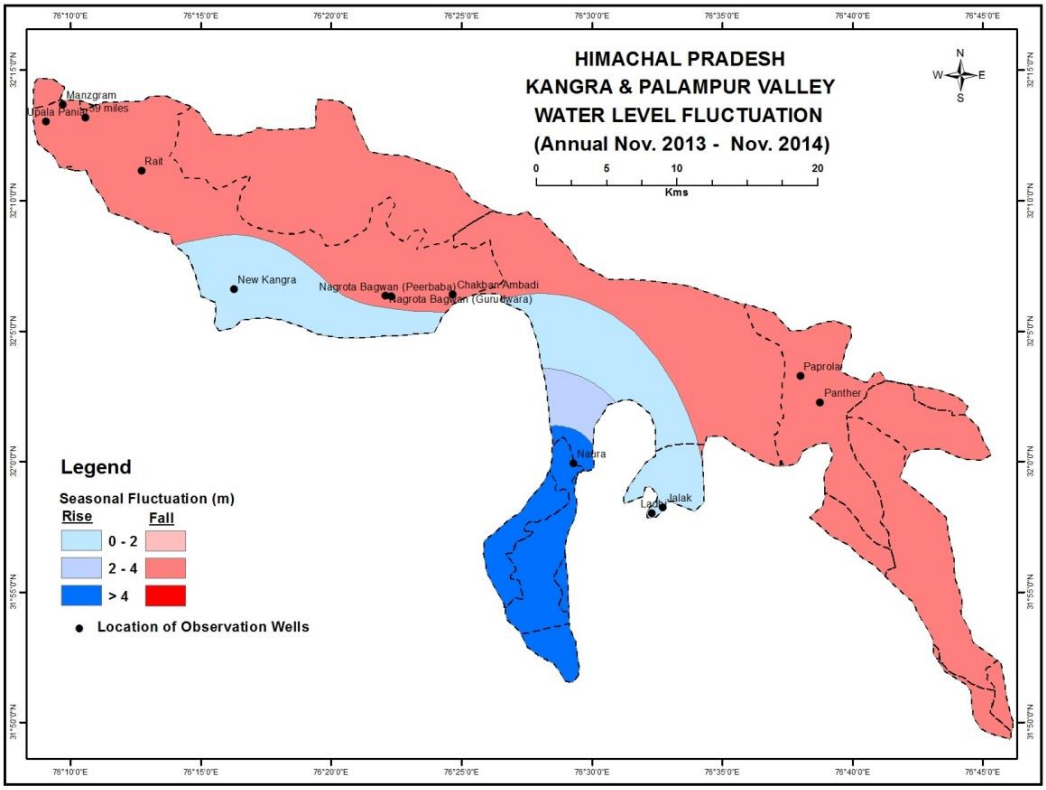


Fig. 2.8 Annual Water Level Fluctuation – November 2013 & November 2014, Kangra & Palampur Valley, Himachal Pradesh

January 2014 & January 2015

8 Nos. dug well water levels were taken during the month of January, 2014 & January 2015 on the basis of these data, annual fluctuation map have been prepared for the Kangra and Palampur Valley area. The hydrogeological data of the inventoried dug wells are given in Table 2.3. During the period of January 2014 water level ranges from 0.58 to 11.71 m bgl (Fig.2.9) and January 2015 water level ranges from 1.45 to 10.95 m bgl. (Fig.2.10) and Annual Water Level Fluctuation ranges between – 2.7 to 3.75 m bgl (Fig. 2.11).

Table 2.3 Water level data (Jan. 2014 and Jan. 2015) GWMS and Aquifer Mapping Wells of Kangra & Palampur Valley, Himachal Pradesh

Location	Latitude	Longitude	January 2014	January 2015	Annual Fluctuation
Ladhi	31.9667	76.5382	1.78	1.7	0.08
Naura	31.9989	76.4883	1.5	1.45	0.05
New Kangra	32.1099	76.2712	11.71	10.95	0.76
Upala Paniar	32.2171	76.1512	1.4	2.15	-0.75
Nagrota Bagwan (Peerbaba)	32.1052	76.3716	14.2	10.45	3.75
Manzgram	32.2277	76.1617	0.58	1.45	-0.87
Rait	32.1856	76.212	8.35	9.4	-1.05
Nagrota Bagwan (Gurudwara)	32.1057	76.3679	8.2	10.9	-2.7

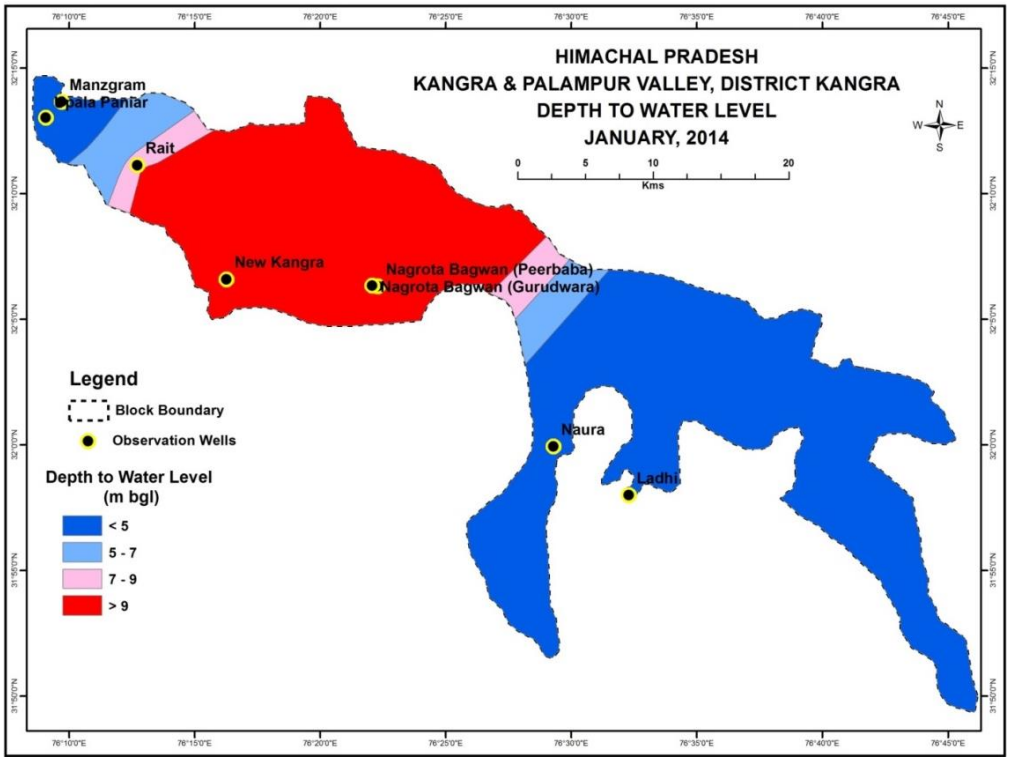


Fig. 2.9 Depth Water Level – January 2014, Kangra & Palampur Valley, Himachal Pradesh

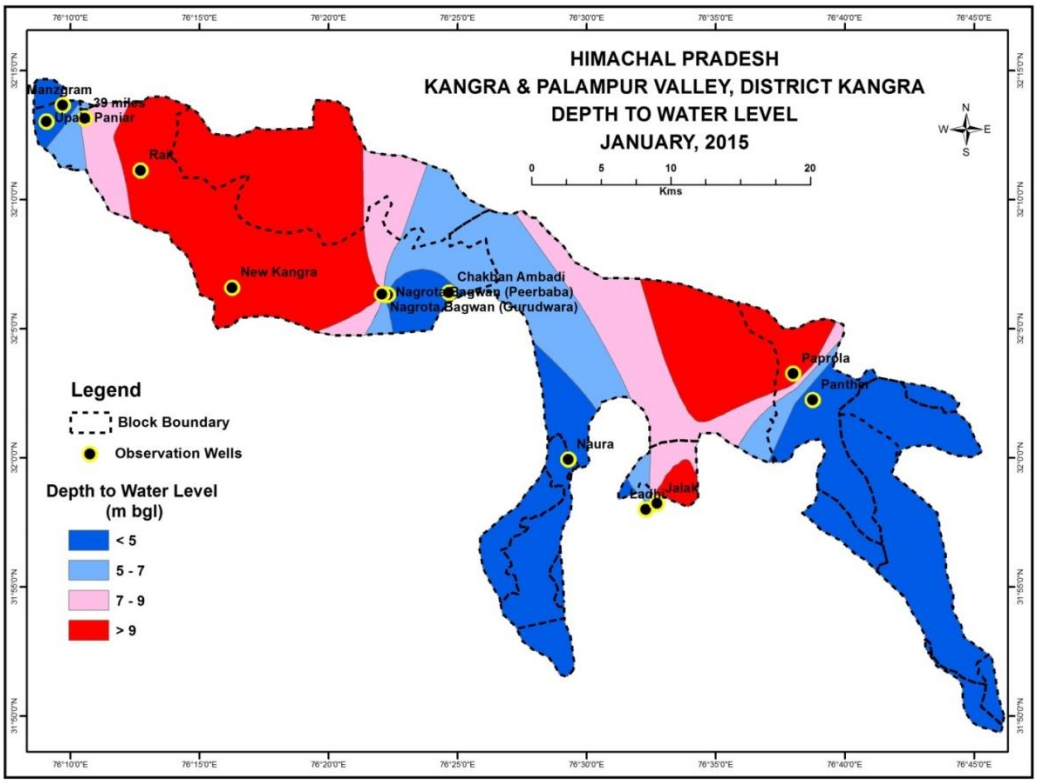


Fig. 2.10 Depth Water Level – January 2015, Kangra & Palampur Valley, Himachal Pradesh

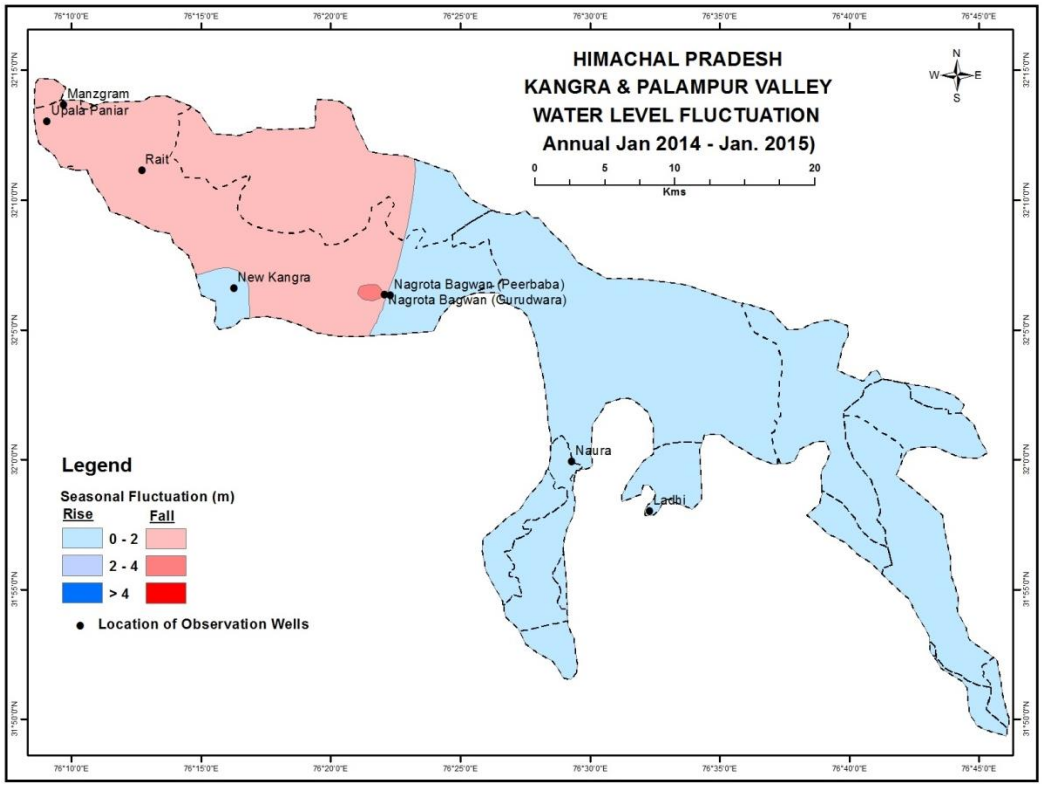


Fig. 2.11 Annual Water Level Fluctuation January 2014 & January 2015, Kangra & Palampur Valley, Himachal Pradesh

May 2014 & May 2015

11 Nos. dug well water levels were taken during the month of May, 2014 & May 2015 on the basis of these data, annual fluctuation map have been prepared for the Kangra & Palampur valley area. The hydrogeological data of the inventoried dug wells are given in Table 2.4. During the period of May 2014 water level ranges from 1.4 to 12.65 m bgl (Fig.2.12.) and May 2015 water level ranges from 0.6 to 12.05 m bgl. (Fig.2.13.) and Annual Water Level Fluctuation ranges between – 0.58 to 1.86 m bgl (Fig. 2.14).

Table 2.4 Water level data (May 2014 and May 2015) GWMS and Aquifer Mapping Wells of Kangra & Palampur Valley, Himachal Pradesh

Location	Latitude	Longitude	May 2014	May 2015	Annual Fluctuation
Ladhi	31.9667	76.5382	2.74	2.1	0.64
Naura	31.9989	76.4883	1.75	1.85	-0.1
New Kangra	32.1099	76.2712	12.65	12.05	0.6
Upala Paniar	32.2171	76.1512	1.86	2.44	-0.58
Manzgram	32.2277	76.1617	1.75	1.35	0.4
Rait	32.1856	76.212	9.3	9.45	-0.15
39 miles	32.2193	76.1761	9.1	8.6	0.5
Chakban Ambadi	32.1068	76.4111	4.21	4.6	-0.39
Panther	32.0375	76.646	1.4	0.6	0.8
Paprola	32.0544	76.6333	11.91	10.05	1.86
Nagrota Bagwan (Gurudwara)	32.1057	76.3679	11.25	11.4	-0.15

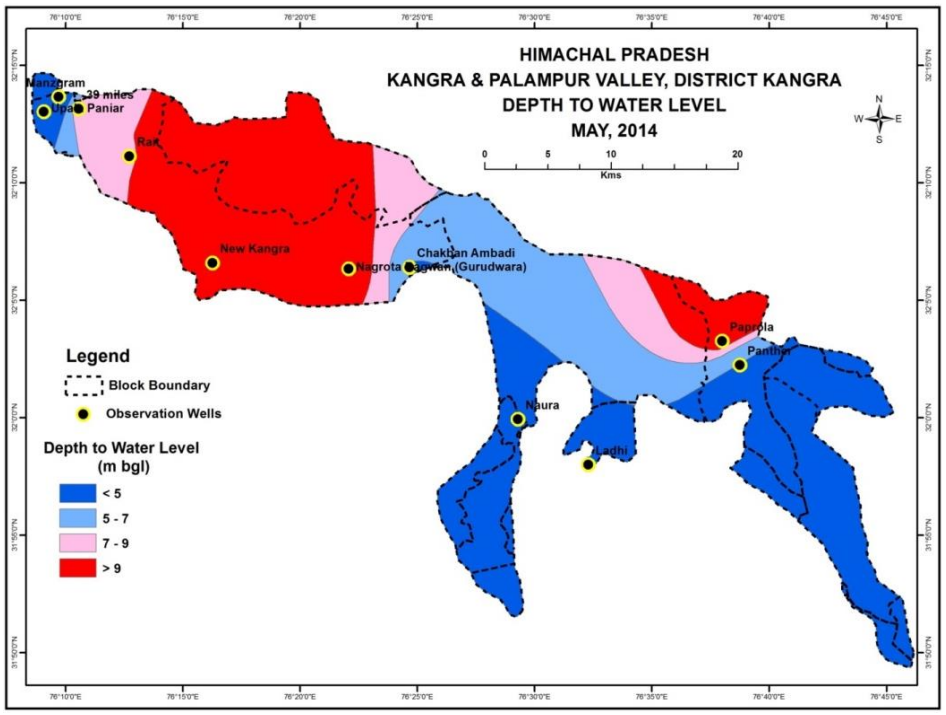


Fig. 2.12 Depth Water Level – May, 2014, Kangra & Palampur Valley, Himachal Pradesh

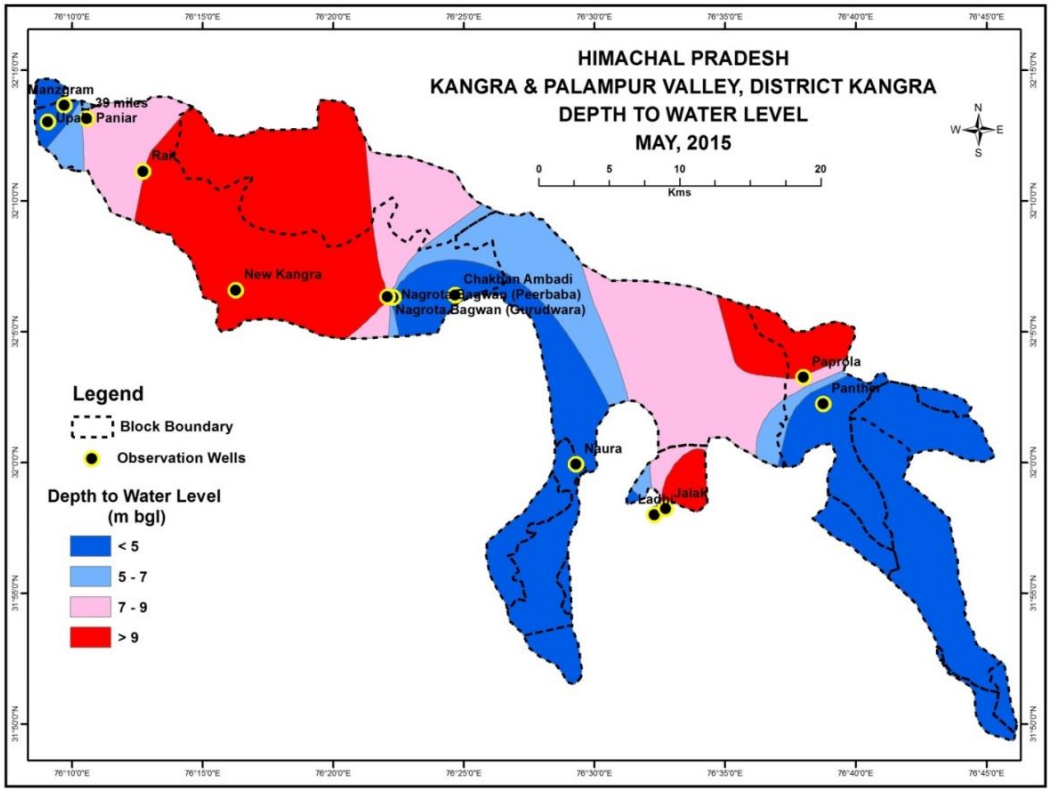


Fig. 2.13 Depth Water Level – May, 2015, Kangra & Palampur Valley, Himachal Pradesh

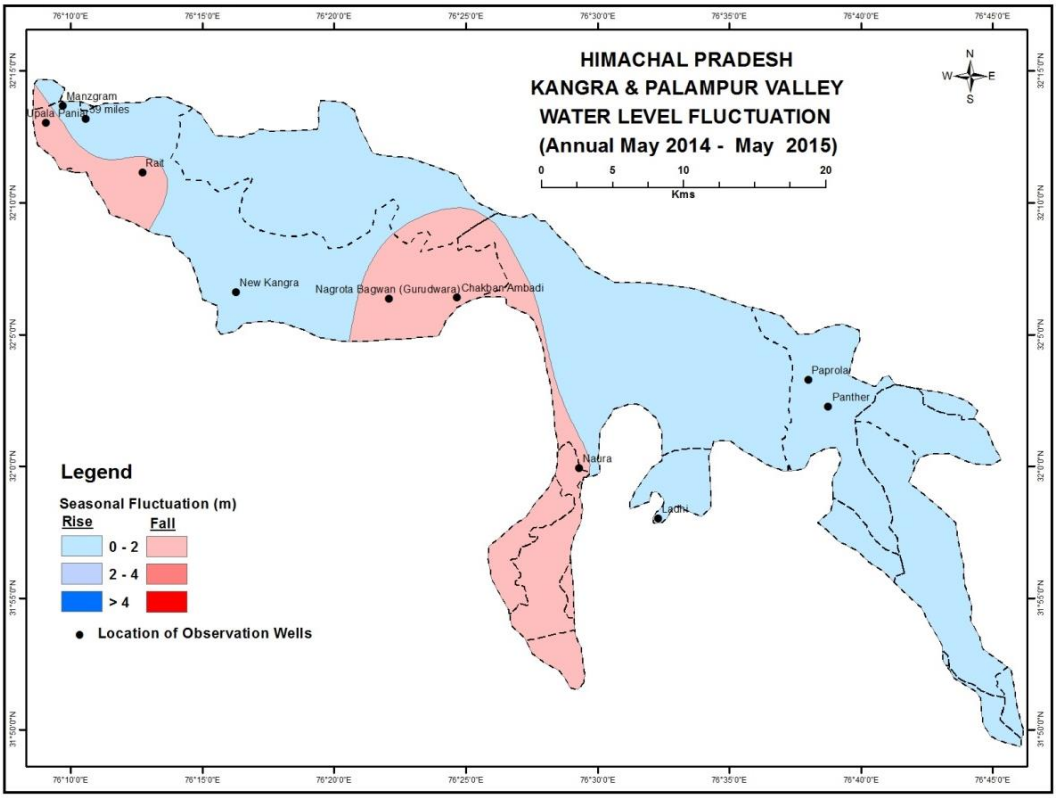


Fig. 2.14 Annual Water Level Fluctuation May 2014 & May 2015, Kangra & Palampur Valley, Himachal Pradesh

August 2014 & August 2015

12 Nos. dug well water levels were taken during the month of August, 2014 & August 2015 on the basis of these data, annual fluctuation map have been prepared for the Kangra and Palampur valley area. The hydrogeological data of the inventoried dug wells are given in Table 2.5. During the period of August 2015 water level ranges from 1.00 to 24.05 m bgl (Fig.2.15.) and August 2016 water level ranges from 0.00 to 27.40 m bgl. (Fig.2.16.) and Annual Water Level Fluctuation ranges between – 15.85 to 19.30m bgl (Fig. 2.17).

Table 2.4 Water level data (August 2014 and August 2015) GWMS and Aquifer Mapping Wells of Kangra & Palampur Valley, Himachal Pradesh

Location	Latitude	Longitude	Aug. 2014	Aug. 2015	Annual Fluctuation
Ladhi	31.9667	76.5382	0.2	0.35	-0.15
Naura	31.9989	76.4883	0.5	0.55	-0.05
New Kangra	32.1099	76.2712	6.45	2.9	3.55
Upala Paniar	32.2171	76.1512	1.4	1.45	-0.05
Nagrota Bagwan (Peerbaba)	32.1052	76.3716	6.75	2.35	4.4
Manzgram	32.2277	76.1617	0.45	0.25	0.2
Rait	32.1856	76.212	4.9	1.9	3
39 miles	32.2193	76.1761	4.35	2.9	1.45
Chakban Ambadi	32.1068	76.4111	4.1	2.6	1.5
Panther	32.0375	76.646	0.5	0.43	0.07
Paprola	32.0544	76.6333	5.5	4.3	1.2
Nagrota Bagwan (Gurudwara)	32.1057	76.3679	5.7	1.6	4.1

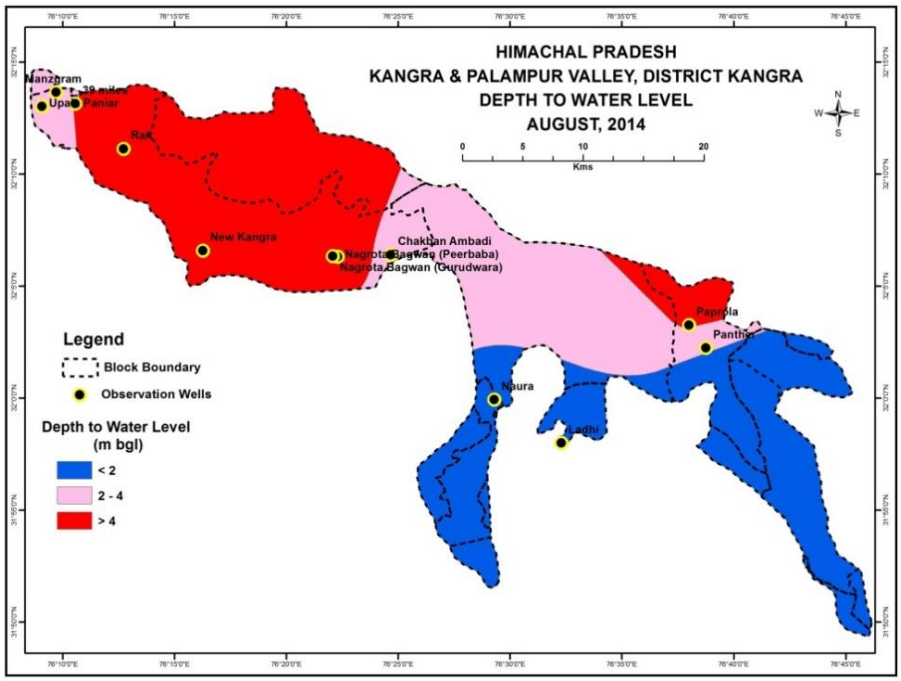


Fig. 2.15 Depth Water Level – August, 2014, Kangra & Palampur Valley, Himachal Pradesh

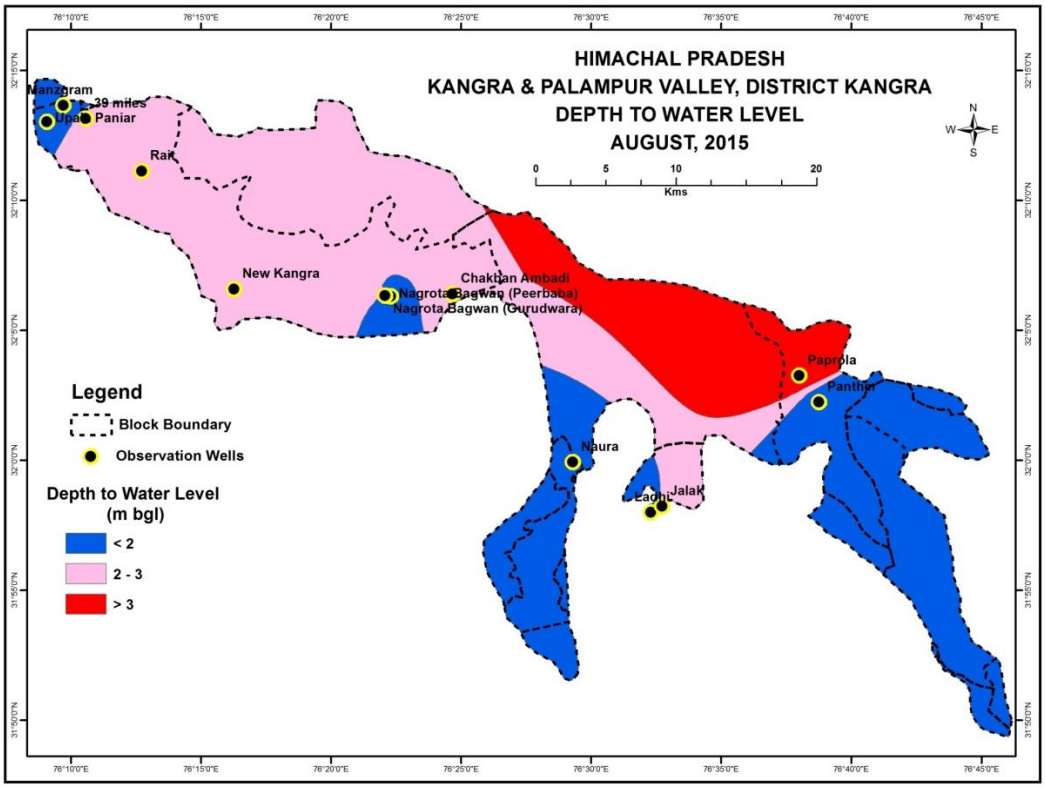


Fig. 2.16 Depth Water Level – August, 2015, Kangra & Palampur Valley, Himachal Pradesh

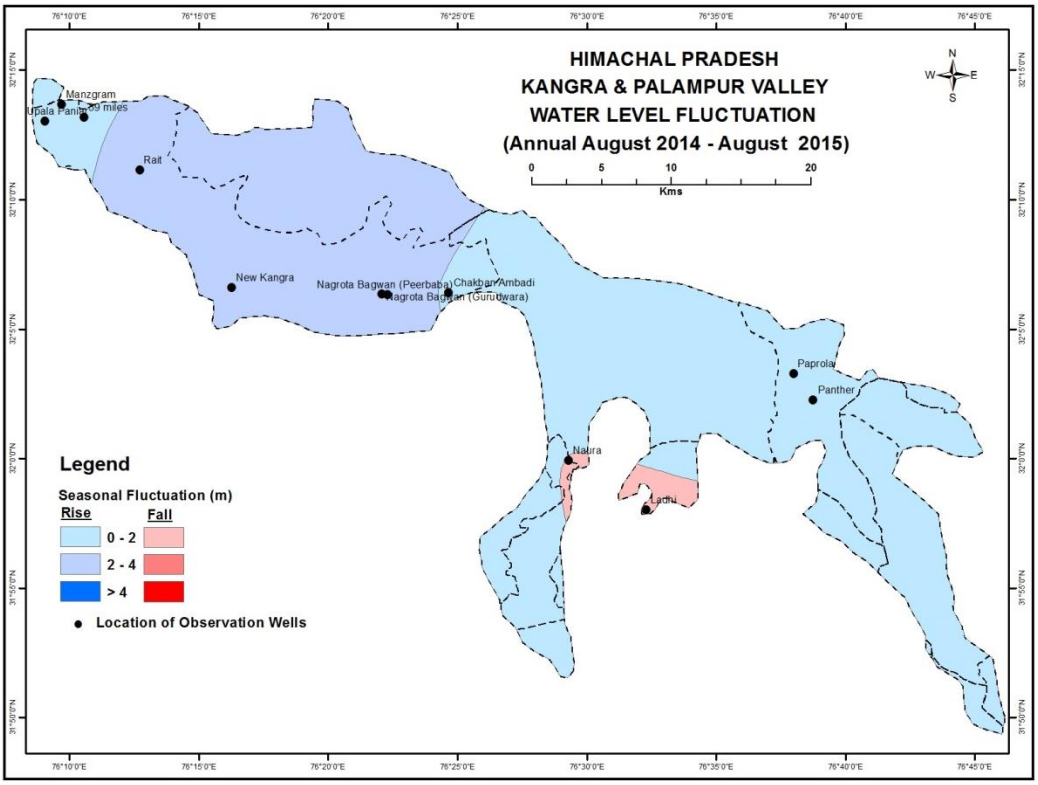


Fig. 2.17 Annual Water Level Fluctuation August 2014 & August 2015, Kangra & Palampur Valley, Himachal Pradesh

2.2. Exploratory Drilling – CGWB & I& PH Wells

The Lithologs 12 Nos. of Exploratory Well productive wells of CGWB, Irrigation and Public Health Department (I &PH) have been collected and those supported electrical logs have been used to validation for preparation of aquifer maps. Deeper well data of CGWB is available. The details are shown in Table-2.6. The compromised logs derived from lithologs and geophysical well loggings have been taken as reliable data base.

Table 2.6 Data availability of exploration wells in Kangra & Palampur Valley

Table of Wells, Kangra and Palampur valley			
Agency	**Well Depth (meters)**		
	<100	**100-150**	**>150**
CGWB	7	2	0
I & PH	3	0	0
Total	**10**	**2**	**0**

2.3 Spatial Data Distribution

The data of CGWB wells in the area are plotted on the map of 1:50000 scale with 5'X5'grid (9km x 9km) and is shown in Fig-2.30 respectively. The exploration data shows that majority of tube wells falls in the Ist Aquifer and IInd Aquifer. The grids/ formations devoid of EW/ DW and PZ are identified as data gaps and these are to be filled by data generation.

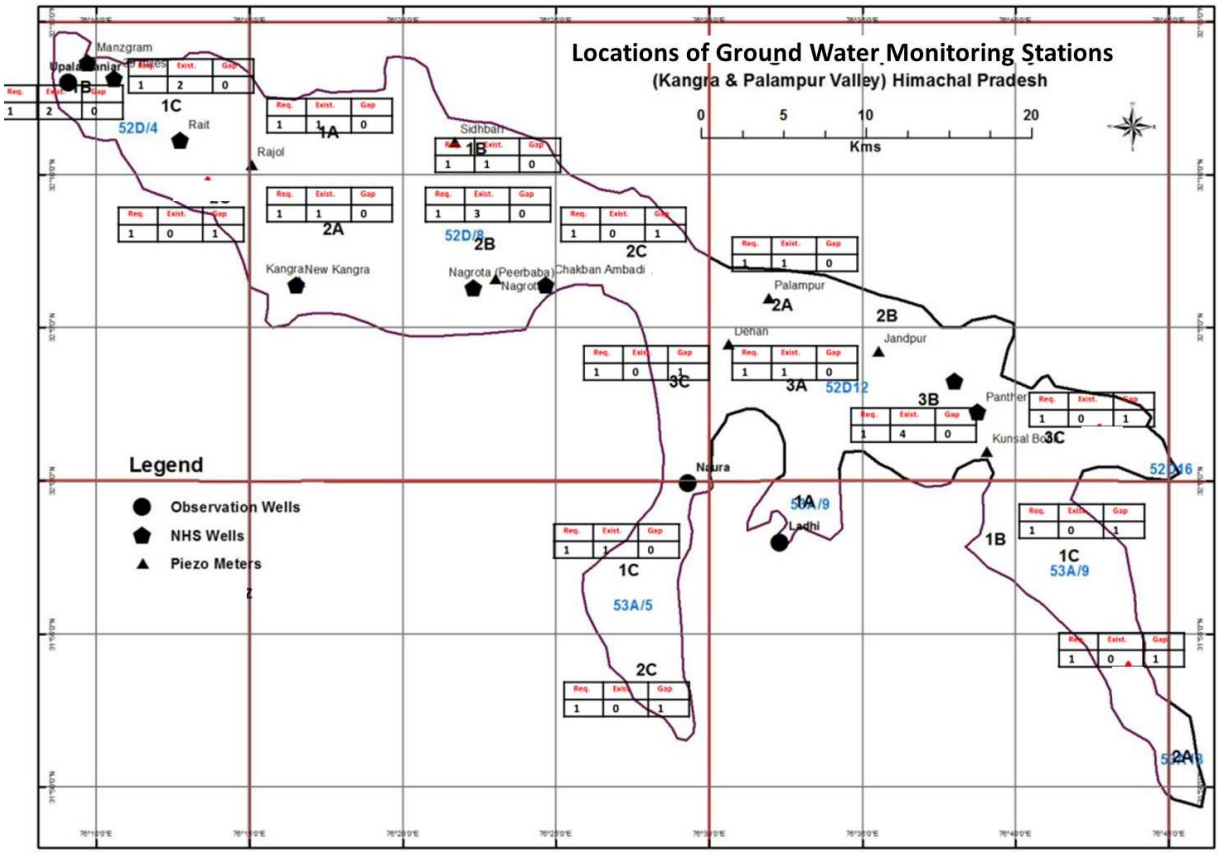


Fig. 2.18 Locations of GWMS in Kangra & Palampur Valley

3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

All the available data have been validated and optimised for consideration to generate the aquifer map in Kangra & Palampur Valley. The wells optimisation part is done based on the maximum depth & litholog. The deepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig-3.0.

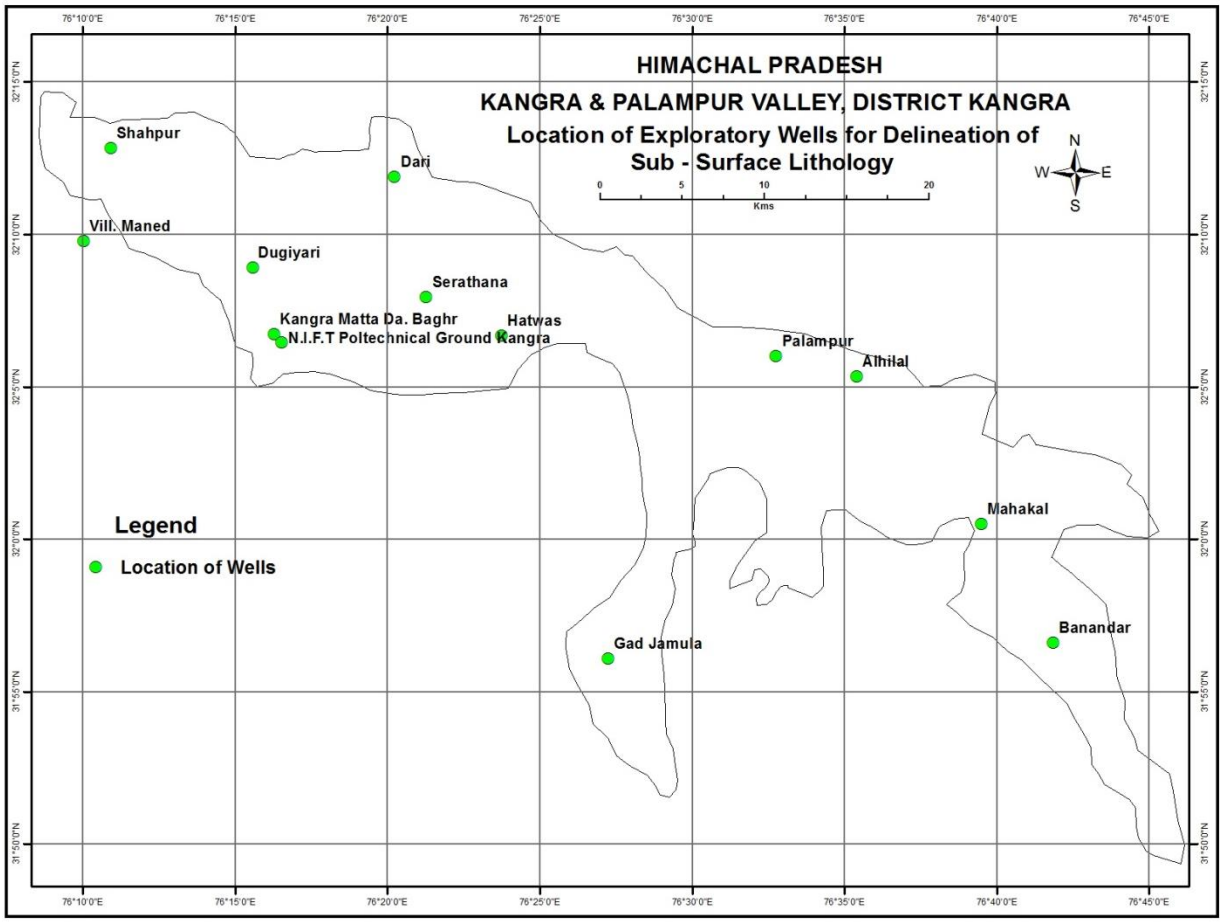


Fig. 3.0 Locations of Exploratory Wells for delineation of Sub-Surface Lithology Kangra & Palampur Valley

3.1 Aquifer Parameter Ranges

In Kangra & Palampur Valley, H.P the exploration drilling was carried out by CGWB, the aquifer parameters range extracted and given in below Table-2.13.

Table 2.13 Summary of exploration and hydraulic details in Kangra & Palampur Valley

Exploratory Well	T (m2/day)	Specific Capacity (lpm/m)	Discharge (lpm)	Well Depth
Alhilal	9.41	-	214	79
Hatwas	658.99	178.43	499.62	52
Palampur	149.90	-	851	92.05
Dari	270	160.70	1329	71
Mahakal	271	205.93	1283	50

3.2 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 are used to compile, optimized and modeled into 3D synoptic picture by using the 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.

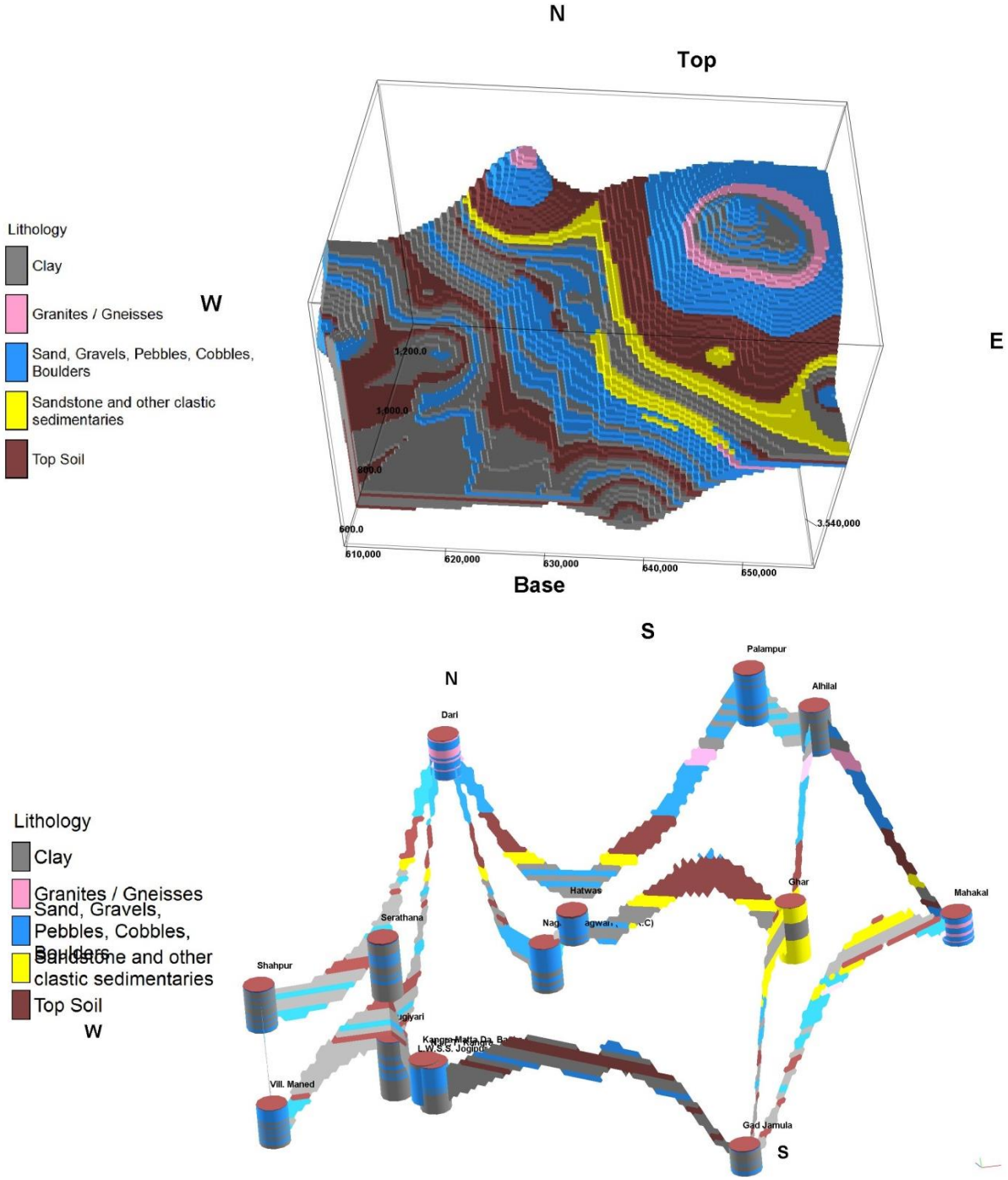


Fig.3.1 3-Dimension Lithological Model of Kangra & Palampur Valley

4.0 GROUND WATER RELATED ISSUES

In Kangra & Palampur valley major cultivation is Rice, Wheat & Maize. The quality of ground water in the area is potable for both the drinking and irrigation purposes. Therefore, ground in valley area is constantly being pumped for the irrigation due to its easy occurs through tube wells, kuhl which are the main source of irrigation.

This will lead to its major ground water issues which is deepening of ground water level if the recharge of ground water through rainfall and other sources are less than overall extraction.

In the hilly areas i.e. at the marginal areas of Kangra & Palampur Valley, ground water extractions are done through shallow bore wells fitted with hand pumps and spring water is being used as a source of water supply for domestic uses. The discharge of the spring water is also decreasing with the passage of time or during the non – monsoon period.

5.0 AQUIFER MANAGEMENT PLAN

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 behavior. Aquifer disposition and various cross sections have also been given.

5.1 Plan for Sustainable Management of the Resource

- The major aquifer system of the Kangra & Palampur valley is alluvial deposits.
- Valley fill deposits and terraces are to be fully explored by constructing test wells for studying the precise distribution of ground water horizons and scope for development.
- In hard rock area all the weak zones, like thrust, faults, fractures, lineaments, and contact of different formation are to be studied in detail for demarcating the aerial extent and vertical distribution of ground water potential zones by micro level hydrogeological/geophysical studies followed by exploratory drilling based on which suitable ground water structures can be constructed for the development of ground water resources.
- There is need to protect traditional water harvesting structures like ponds, tanks, talavs to utilized these for rain water harvesting and recharging shallow aquifers.
- In hilly and mountainous terrain, traditional ground water sources viz., springs, *bowries* etc needs to be developed and protected for better health and hygiene with proper scientific intervention.
- 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.

- In Kangra & Palampur valley for most of the households, IPH department supplies water, so the people put their dugwells abandoned without using it. These unused and abandoned dugwells can be used as rainwater harvesting and artificial recharge structure to recharge ground water.
- People's participation is a must for any type of developmental activities. So proper awareness for utilization and conservation of water resources is required.
- Constrictions of bore well near to spring source in hilly area should be avoided as this could lead to drying of the natural water sources.
- Recharge structures feasible in hilly areas are check dams, Gabion structures and staggered contour trends at suitable locations.

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