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

BALH VALLEY, DISTRICT MANDI, HIMACHAL PRADESH

उत्तरी हिमालयी क्षेत्र, धर्मशाला

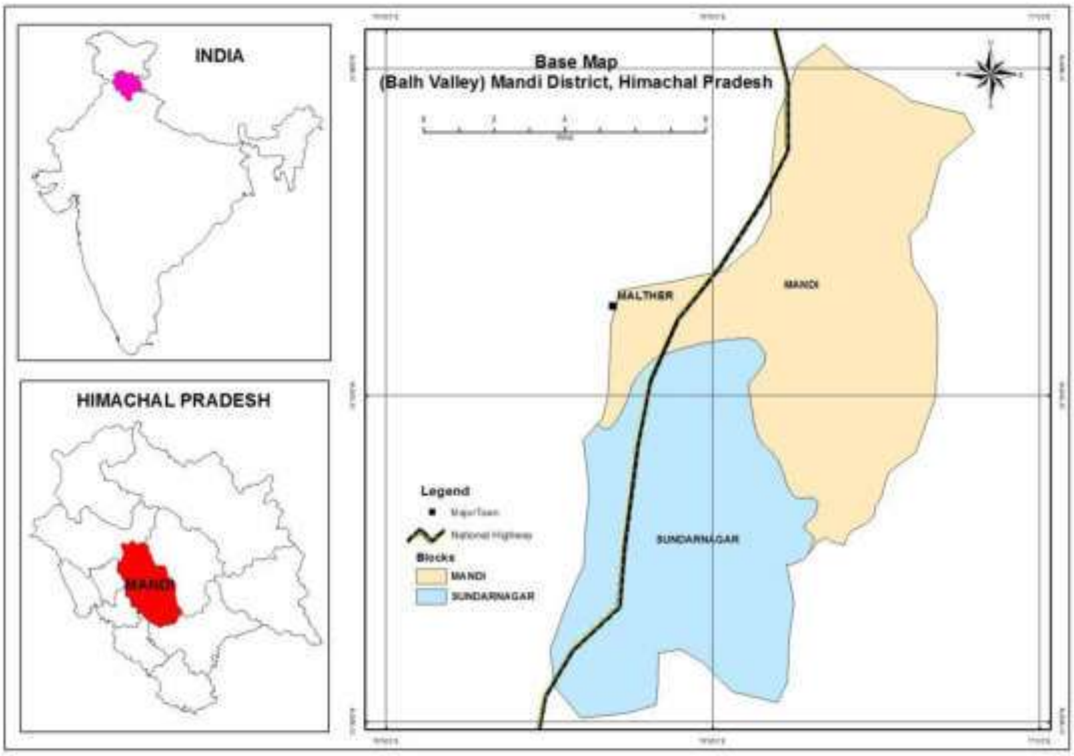
Northern Himalayan Region, Dharamshala

GOVERNMENT OF INDIA

MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

CENTRAL GROUND WATER BOARD

AQUIFER MAPPING AND MANAGEMENT PLAN OF BALH VALLEY, DISTRICT MANDI, HIMACHAL PRADESH



NORTHERN HIMALAYAN REGION

DHARAMSHALA

2019

AQUIFER MAPPING AND MANAGEMENT PLAN OF BALH VALLEY, DISTRICT MANDI, HIMACHAL PRADESH

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AQUIFER MAPPING AND MANAGEMENT PLAN OF BALH VALLEY, DISTRICT MANDI, HIMACHAL PRADESH

1. INTRODUCTION

Aquifer mapping is a process where in 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.

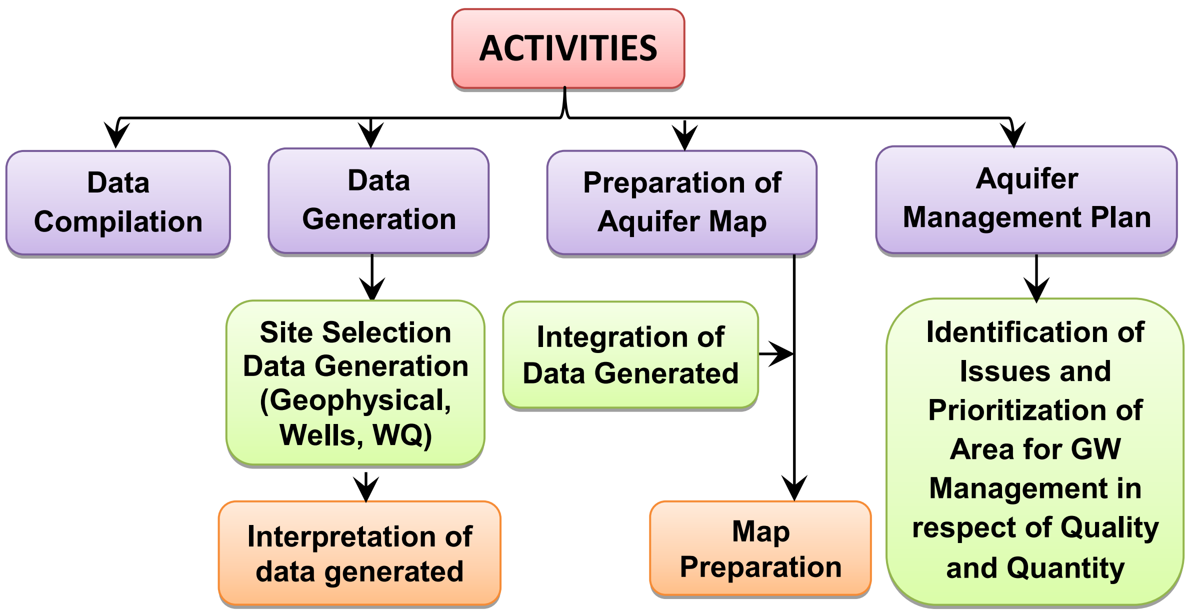
1.1 Objectives

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 asense 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 Balh valley of Mandi District of Himachal Pradesh under the Annual Action Programme 2014-15. 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, 8 key observation wells (Dugwells: 8 Nos.) were established. Subsequently, all the available data on ground water from the earlier studies are compiled 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 study area Balh valley forms few small intermontane valleys prominent among them is the Balh valley, located in the lesser Himalayan ranges, having an average altitude of about 790 m amsl and have a general slope towards NNE. The valley floor is undulating and is marked by low hillocks and terraces fringing the hills and intervening low alluvial plain. Balh valley are Alluvium, terrace deposits, fluvial deposits of Quaternary period occur in the intermontane valleys area of about 101 sq.km and extending SE-NW direction between northern latitudes of 31°30' to 31°41' and eastern longitudes of 76°53' to 77°58' which falls in the Survey of India Toposheet no. 53 A/14.

1.4 Administrative Divisions and Demographic Particulars

Administratively, Mandi town is the head quarter of the district. The study area comprises of 2 Blocks viz., Mandi, Sundernagar. Administrative divisions are shown in the Fig.1.1.

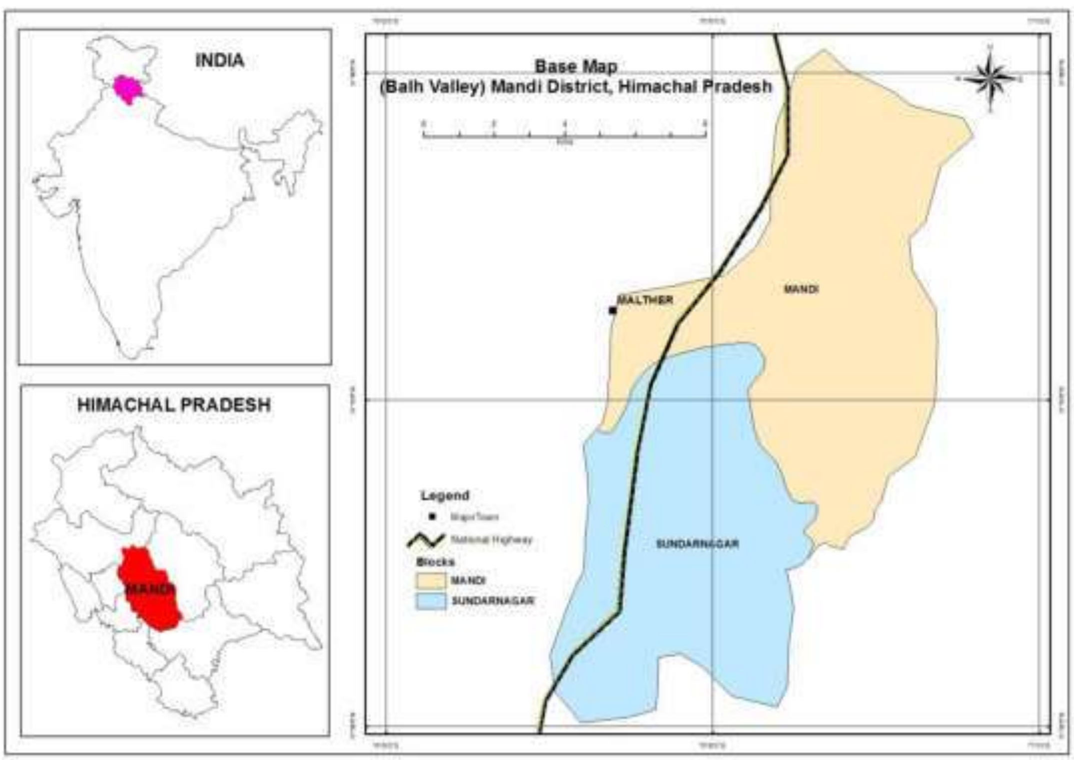


Fig 1.1: The Administrative Division of the Study Area

1.5 Data Gap Analysis

The Data gap analysis was done on the basis of NAQUIM & EFC guidelines in Aquifer Mapping Study area of 101 sq.kms in Balh Valley, District Mandi of Himachal Pradesh. The study area falls in Survey of India Toposheets No.53 A/14 covering full or partial area of 5 quadrants (Figure -1.2 Toposheet Index Map). The Data Gap analysis of all the attributes are given in Table 1.1.

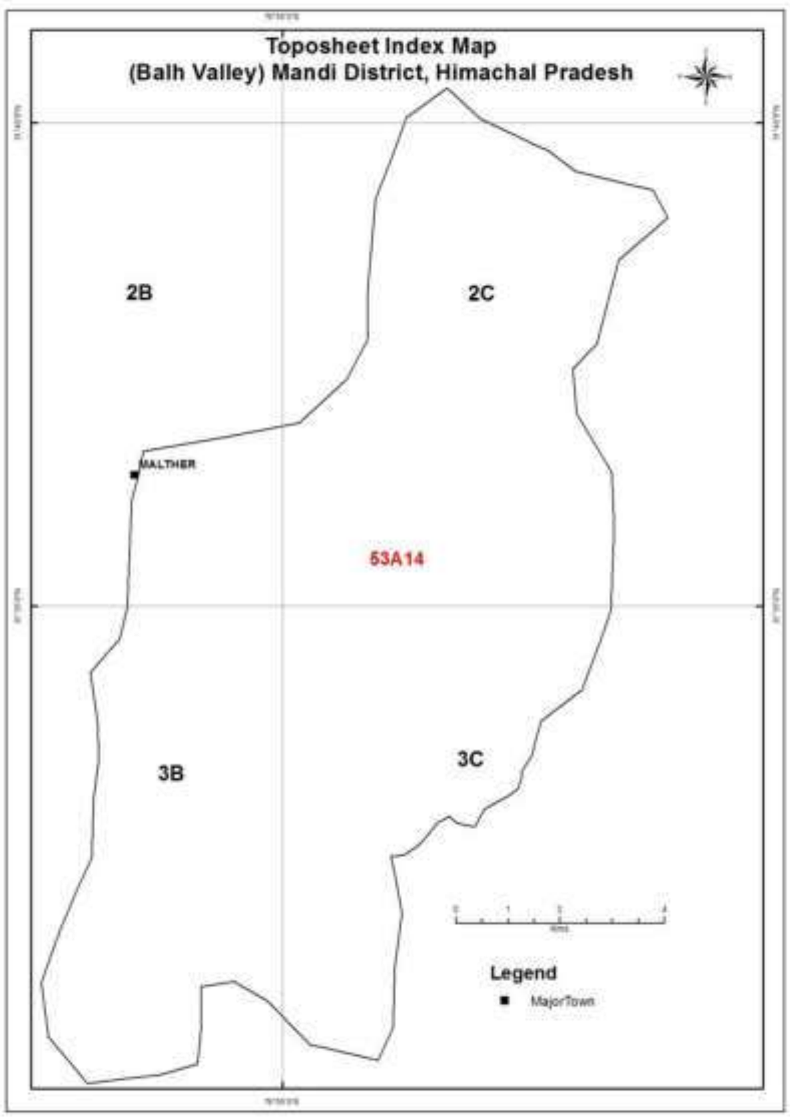


Fig.1.2 Toposheet Index Map - Balh Valley, Mandi District

1.5.1 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-1.3 and Table No.1.1

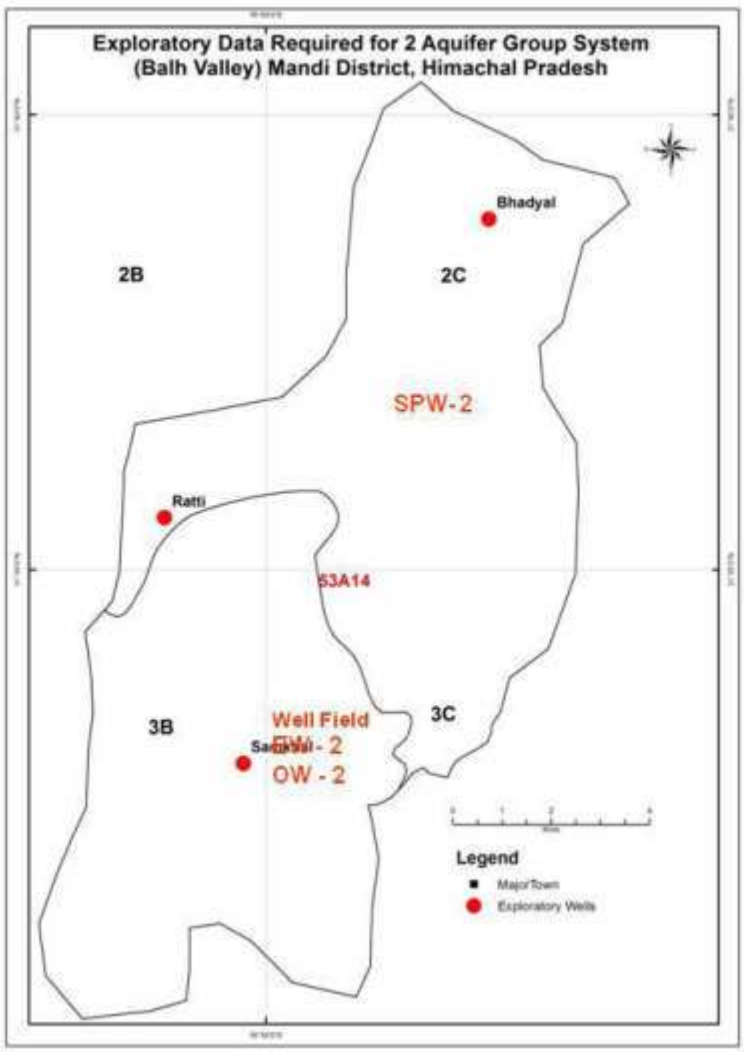


Fig.1.3 Exploratory Data Require Balh Valley, Mandi District

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 4 Nos. The quadrant-wise existing and recommended VES sites is presented and shown as square diagram in the figure -1.4.

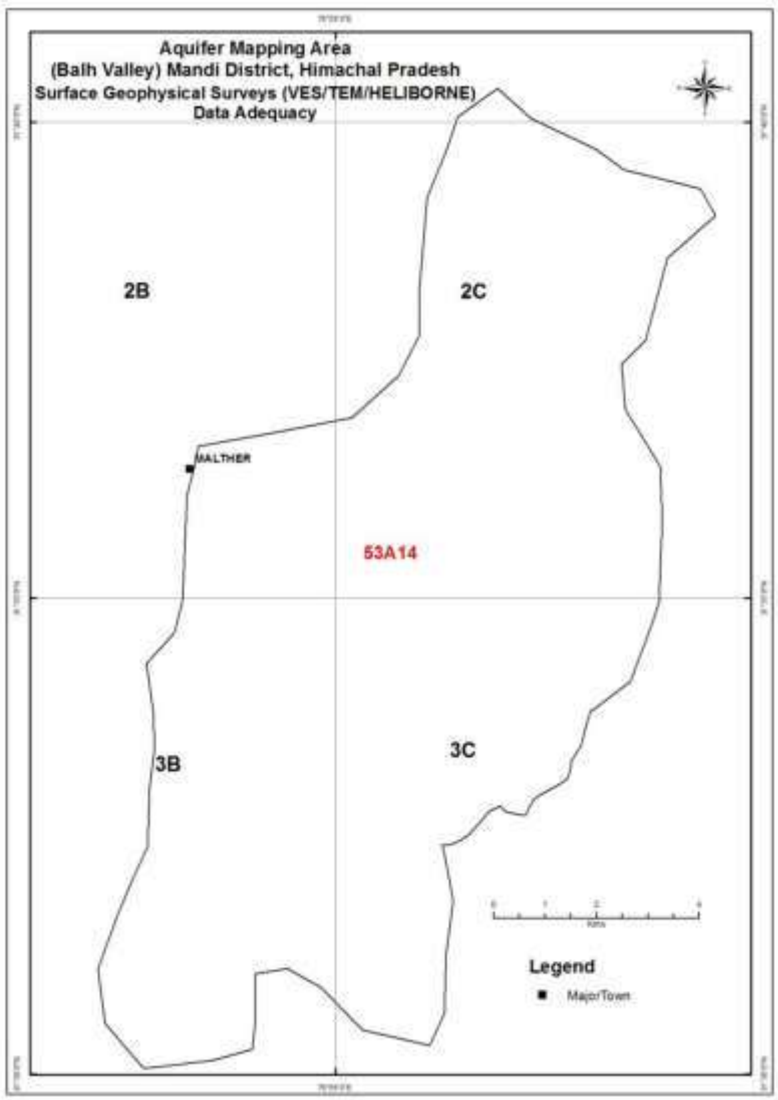


Fig.1.4 Data Gap Analysis of Surface Geophysical Surveys balh Valley, Mandi District

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.

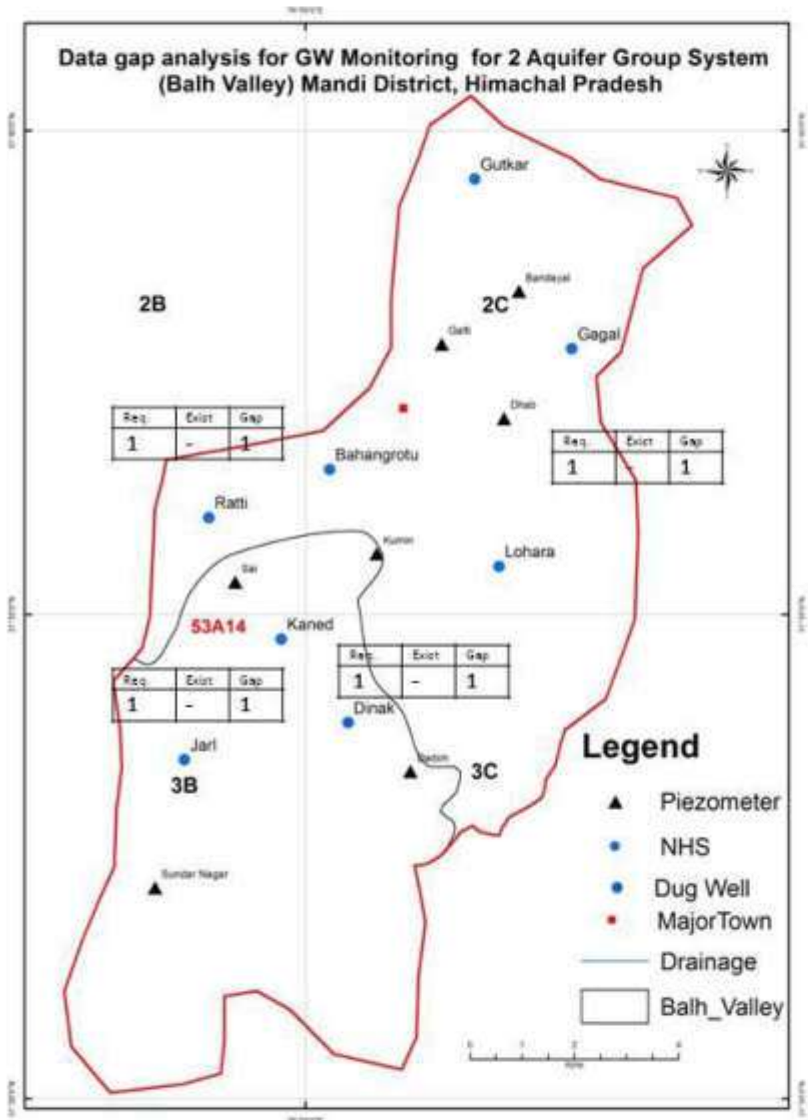


Fig.1.5 Data Gap Analysis for Ground Water Monitoring - balh Valley, Mandi District

1.5.4 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, 5 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.

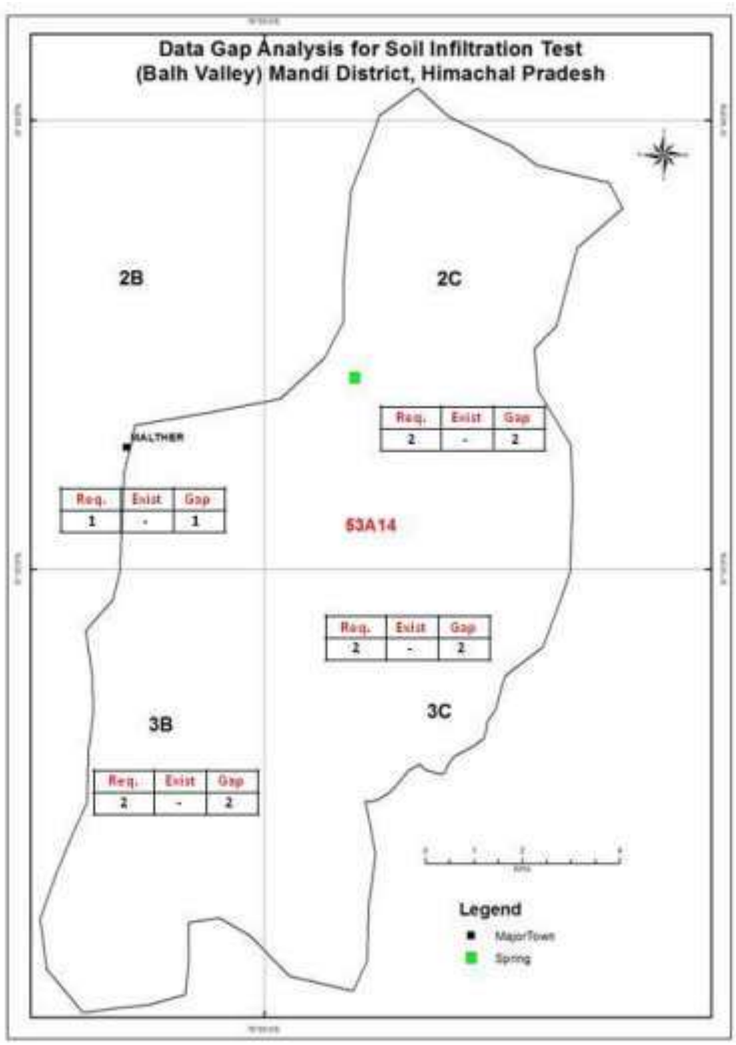


Fig.1.6 Data Gap Analysis for Soil Infiltration Studies - Balh Valley, Mandi District

Table 1.1 DATA GAP ANALYSIS, BALH VALLEY (2014-15)
Toposheet No: - 53A/14

AQUIFER MAPPING BALH VALLEY, MANDI DISTRICT, H.P. DATA GAP ANALYSIS (AAP 2014-15)													
Toposheet No.- 53 A/14													
Quadrant no.	No. of additional EW's Required		No. of additional OW's Required		No. of SPW's Required (EW /PZ)		No. of additional VES/TEM Required	No. of additional water Quality station reruired		No. of additional water level monitoring Stations(PZ's) Required		No. of Soil Infiltration test Required	Remarks
	Aq- I	Aq- II	Aq- I	Aq- II	Aq- I	Aq- II	Aq- II	Aq- I	Aq- II	Aq- I	Aq-II		
53 A/14 2B	1	0	1	0	0	0	0	0	0	0	0	1	
53 A/14 2C	1	0	1	0	0	1	2	0	1	0	0	2	
53 A/14 3B	1	0	0	0	0	0	1	1	0	0	0	1	
53 A/14 3C		1		1	0	1	1	0	1	0	0	1	
Total	**3**	**1**	**2**	**1**	**0**	**2**	**4**	**1**	**2**	0	0	**5**	

1.6 Physiography

Mandi district presents an intricate mosaic of mountain ranges, hills and valleys. It is primarily a hilly district with altitudes ranging from 550 m near Sandhol where the Beas river leaves the district, to about 3960 m amsl near Kullu border. There is a general increase in elevation from west to east and from south to north. Master slope is southwesterly. The south western part consists of Siwalik ranges having scarped slopes. There are few small intermontane valleys, prominent among them is the Balh valley, located in the lesser Himalayan ranges, having an average altitude of about 790 m amsl and have a general slope towards NNE. The valley floor is undulating and is marked by low hillocks and terraces fringing the hills and intervening low alluvial plain.

1.7 Drainage

The Beas and Satluj rivers form the major drainage system in the district. The river Beas and its tributaries drain about 70% of the district area in the northern part where as the area in the south is drained by the river Satluj. Suketi khad and its tributaries chiefly drain Balh valley. The Suketi khad maintains a perennial flow because of effluent seepage from groundwater. There are three important lakes in the district, namely Rewalsar, Prasher and Kamrunag. The Drainage Map of the study area was prepared on 1:50,000 scale the same was shown in Fig.1.7.

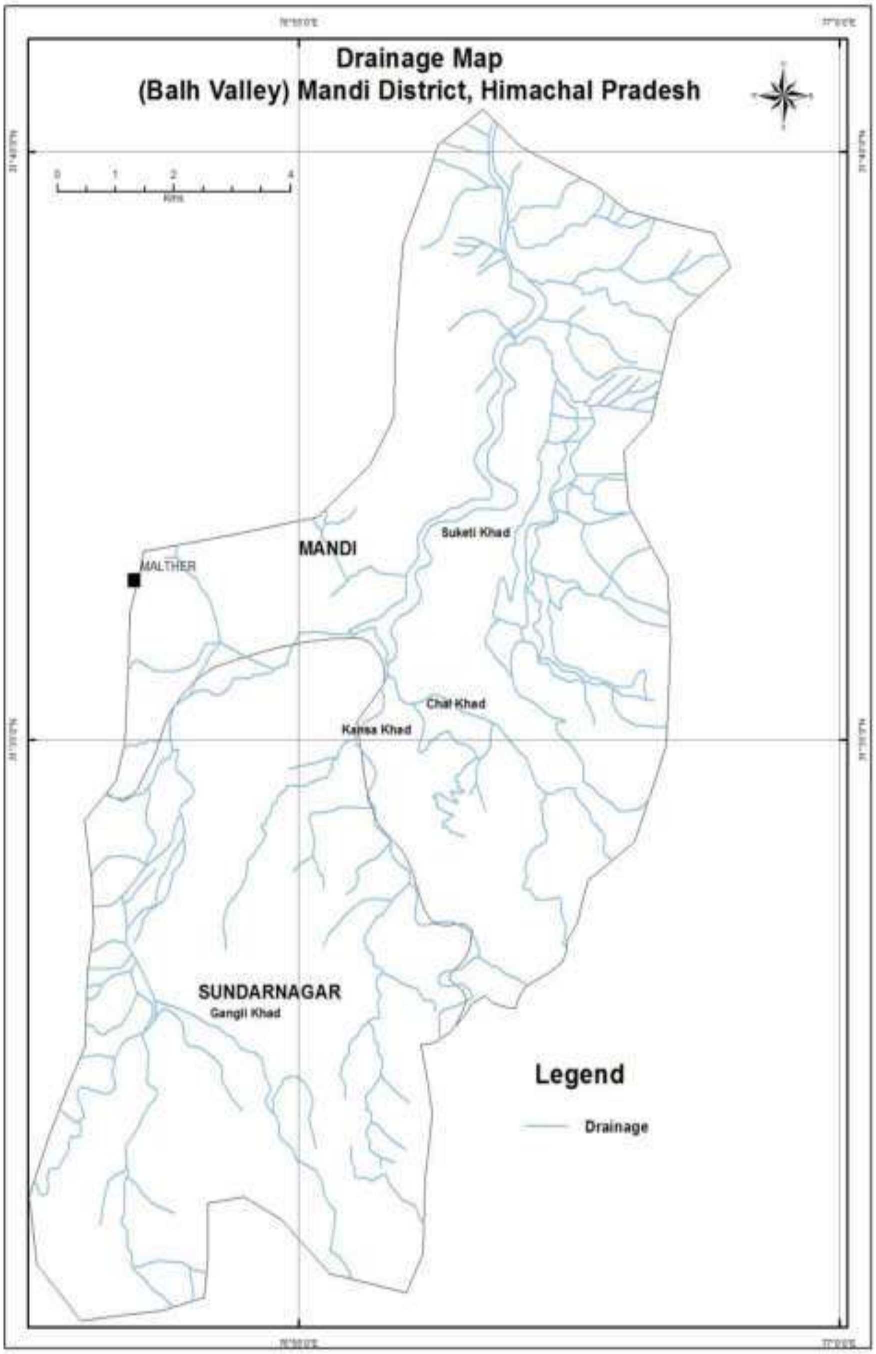


Fig 1.7 The Drainage Map - Balh Valley, Mandi District

1.8 Geology

The rock formations occupying the district range from pre-Cambrian to Quaternary period. The generalized geological succession in the district is given below in Table:1.2

<u>Age</u>	***Formation***	***Lithology***
Quaternary	Alluvium; Terrace & Fluvial deposits	Alluvium, clay, sands, gravels, pebbles, boulders and cobbles
Lower Pleistocene to Middle Miocene	Siwalik Group	Clay, siltstones, sandstones, and boulder beds
Oligocene to Lower Miocene	Dharamsala/ Kasauli Formation (Sabathu Group)	Grey/green sandstones, splintery shale, clay etc.
Permian	Basic Volcanic intrusives	
Proterozoic	Shimla Group	Phyllites, Quartzites, limestone, shale and dolomite
	Shali /Sundernagar /Kullu Formation	Phyllites, Quartzites, dolomite conglomerate and limestone
	Jutogh Group	Quartzites, Schists and phyllites
		Dalhousie / Kullu granites and gneisses

Source: Geological Survey of India

Hard formations, form hilly and mountainous terrain and mainly comprises of igneous and metamorphic rocks, belonging to the Jutogh, Shali/ Largi and Shimla group and occupy the major part of the area in the northern, central and eastern part. Granites and gneisses are intruded in the meta-sediments of Shali/Largi and Shimla group. In the western and southern parts sediments comprising of sandstone, shale, siltstone, conglomerate etc of Dharamshala/Sabathu group and Siwalik group of Tertiary age are observed. Alluvium, terrace deposits, fluvial deposits of Quaternary period occur in the intermontane valleys, viz., Balh valley, Sarkaghat valley etc., and constitute an important unit from ground water point of view.

1.9 Hydrogeology

Hydrogeologically, the district is divided into two distinct and well defined units viz. **porous formations** constituted by unconsolidated sediments and the **fissured formations** or hard rock formation constituted mainly by semi-consolidated to consolidated rocks.

The fissured formations includes the semi-consolidated to consolidated (hard) rocks exposed in the district and are of sedimentary, metamorphic and igneous origin. These form low and high hill ranges throughout the district. Fractured and jointed sandstone, siltstone forms low potential aquifers in the area. In general weathered and fractured hard rocks are favorable for groundwater aquifer. Fracture zones and contact zones form the important aquifers in the topographic low areas, with poor to moderate yields. These fracture or fault zones form potential ground water zones. Ground water in these hilly areas oozes in the form of seepages, springs and utilized for domestic and other uses. At places, shallow boreholes fitted with hand pumps have been constructed to develop ground water. The yield of the bore wells constructed along the fault/fracture/contact zones varies from less than 1 to 30 m^3/ hour. Weathered mantle in low topographic areas, also form poor aquifers. Bowris are constructed in oozing out spring/seepage zones for collecting water to fulfill the domestic water needs.

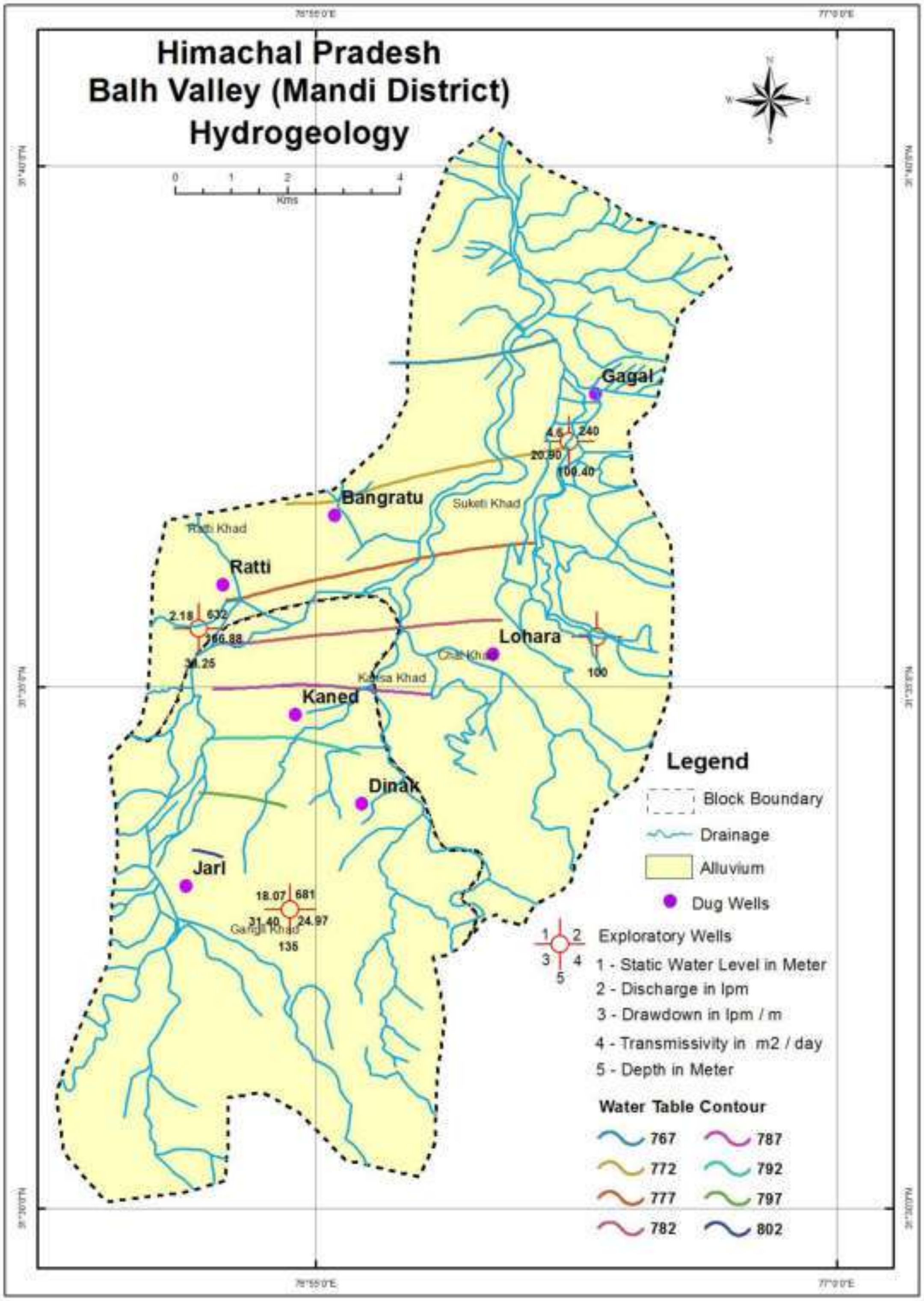


Fig 1.8 Hydrogeology Map of BalhValley, Mandi District

1.10 Land use Map

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 Open Forest, Land with scrub, Plantation and River (fig.1.9). Similarly Forest Area map was prepared with the help of processed satellite imagery.

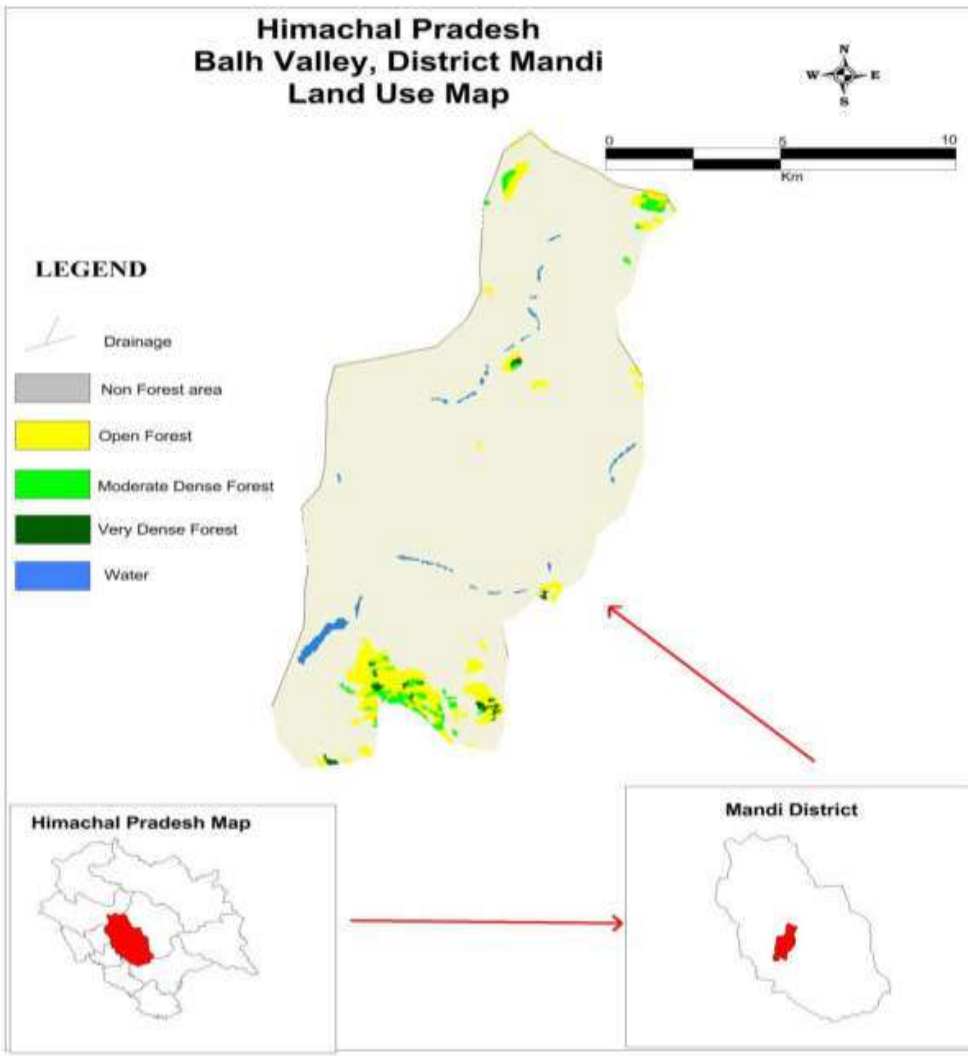


Fig. 1.9 Land Use Map

1.11 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. 1.10

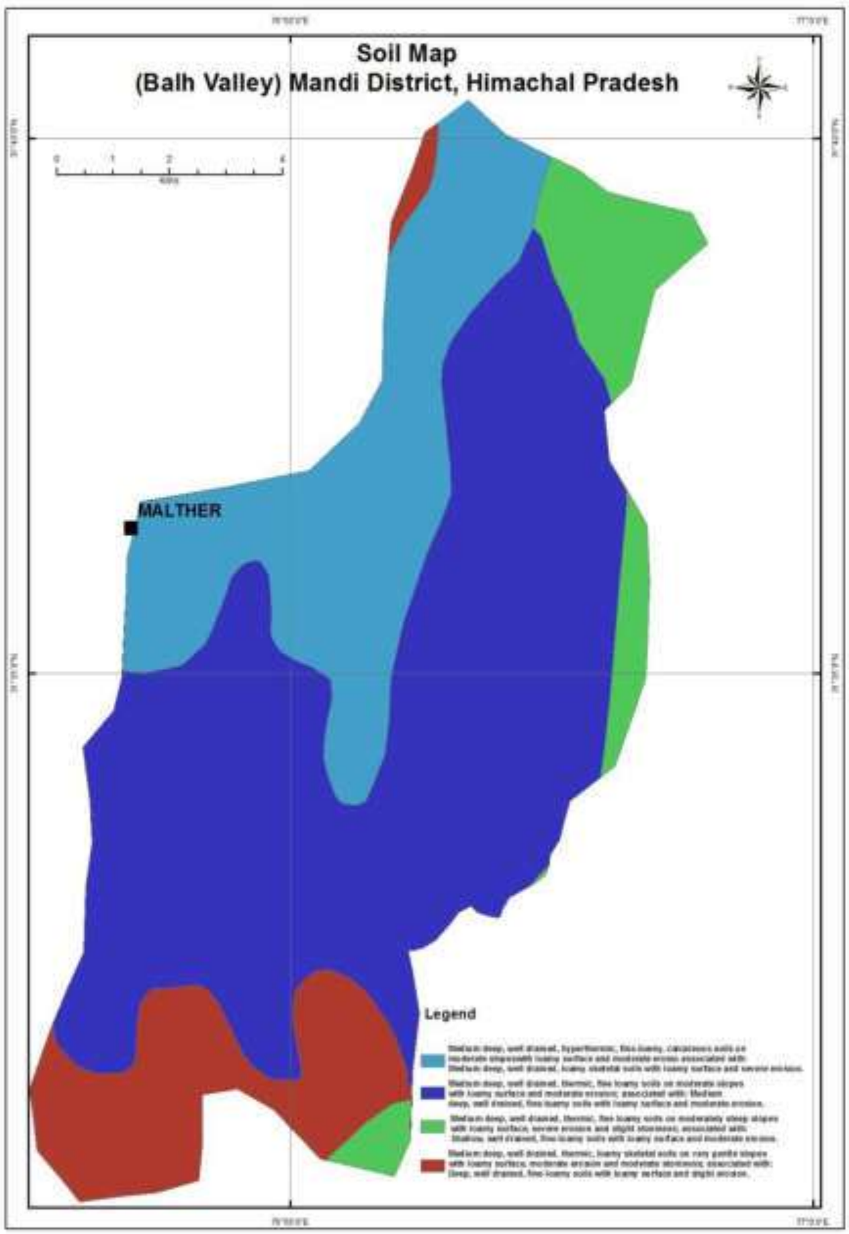


Fig. 1.10 Soil Map of Balh Valley, Mandi District

1.12 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 Mandi district during various field seasons.

CGWB NHR, Dharamshala is monitoring ground water levels from National Hydrograph Network observations and aquifer mapping wells (Table 1.3) 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 1.3 National Hydrograph Network observations and aquifer mapping wells of Balh Valley, Mandi District, Himachal Pradesh

Sl.No	Name of Village/site	Latitude	Longitude	Estt. Date	RL (mamsl)	Type (DW/)	Measuring Point (magl)
1	JHIRI	31.834694	77.171556	6/11/2014	1174.45	DW	0.39
2	GUTKAR	31.657278	76.944361	5/11/2014	766.48	DW	0.35
3	BANGROTU	31.610778	76.919722	6/11/2014	777.81	DW	0.28
4	KANED	31.578917	76.913417	6/11/2014	790.70	DW	0.59
5	LOHARA	31.588611	76.945083	6/11/2014	788.14	DW	0.50
6	JARL	31.551528	76.895917	6/11/2014	805.57	DW	0.25
7	GAAGAL	31.630222	76.961444	6/11/2014	771.72	DW	0.32
8	RATI	31.599722	76.901806	6/11/2014	778.47	DW	0.80
9	Dinak	31.564788	76.924061	6/11/2014	801	DW	0.70

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, 9 dug wells have been inventoried for Ground Water Management Studies all over the area. The dug wells are located in and around Balh 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 Balh valley area. The hydrogeological data of the inventoried dug wells are given in Table 2.1.

In Balh valley depth to water level shows wide variation. During pre-monsoon period (May 2014) it ranges from 0.65 to 7.15 bgl (Fig. 2.0) and post monsoon period (Nov.2014) ranges from 0.27 to 5.56 m bgl.(Fig. 2.1).In major parts of Balh valley, Seasonal Water Level Fluctuation ranges between less than 0.14 to 2.96 m bgl (Fig.2.2).Whereas in pre-monsoon period of (May 2015)it ranges from 0.70 to 5.43 m bgl(Fig.2.3) and post monsoon period (Nov.2015) ranges from 0.69 to 5.60 m bgl(Fig.2.4) and Seasonal Water Level Fluctuation ranges between 0.01 to 0.90 m bgl (Fig. 2.5).

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

Location	Latitude	Longitude	Water Level, 2014		2014 Fluctuation	Water Level, 2015		2015 Fluctuation
			May 2014	Nov. 2014		May 2015	Nov. 2015	
GUTKAR	31.6572	76.9443	7.15	4.19	2.96	5.00	5.14	0.14
BANGROTU	31.6107	76.9197	6.62	5.56	1.06	5.43	5.60	0.13
KANED	31.5789	76.9134	1.06	1.49	0.43	1.06	1.62	0.56
LOHARA	31.5886	76.945	3.6	3.46	0.14	4.25	3.41	0.84
JARL	31.5515	76.8959	0.65	0.27	0.38	0.70	0.69	0.01
GAAGAL	31.6302	76.9614	2.5	1.86	0.64	2.31	2.00	0.31
RATI	31.5997	76.9018	3.98	4.16	0.18	4.00	4.90	0.90

2.2. Exploratory Drilling– CGWB & I& PH Wells

The Lithologs 12 Nos. of Exploratory Well productive wells of CGWB, 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 Balh Valley, Mandi District.

Table of Wells, Balh Valley			
Agency	**Well Depth (meters)**		
	<100	**100-150**	**>150**
CGWB	10	2	0
Total	**10**	**2**	**0**

2.3Ground 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.

2.4 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.

2.4.1 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 2.8respectively. 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 2.9.

Table 2.7 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 2.8 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

Table 2.9 Surface Water Quality Standards -BIS

Characteristic	**Tolerance Limit**				
	Class A	**Class B**	**Class C**	**Class D**	**Class E**
pH value	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Dissolved Oxygen (mg/l), min.	6	5	4	4	--
BOD (5-days at 20° C, mg/l, min.	2	3	3	--	--
Total Coliform Organism, MPN/100ml, max	50	500	5000	--	--
Colour, Hazen units, max.	10	300	300	--	--
Odour	10	300	300	--	--
Taste	Tasteless	--	--	--	--
Total dissolved solids, mg/l, max.	500	--	1500	--	2100

Total hardness(as $CaCo_3$), mg/l, max.	300	--	--	--	--
Calcium hardness (as $CaCO_3$), mg/l, max.	200	--	--	--	--
Magnesium hardness (as $CaCO_3$), mg/l, max.	100	--	--	--	--
Copper (as Cu), mg/l, max.	1.5	--	1.5	--	--
Iron (as Fe), Mg/l, max.	0.3	--	0.5	--	--
Manganese (as Mn), mg/l, max.	0.5	--	--	--	--
Chlorides (as Cl), mg/l, max.	250	--	600	--	600
Sulphates (as SO_4), mg/l, max.	400	--	400	--	1000
Nitrates (as NO_3), mg/l, max.	20	--	50	--	--
Fluorides (as F), mg/l, max.	1.5	1.5	1.5	--	--
Phenolic compounds (as C_6H_5 OH), mg/l, max.	0.002	0.005	0.005	--	--
Mercury (as Hg), mg/l, max.	0.001	--	--	--	--
Cadmium (as Cd), mg/l, max.	0.01	--	0.01	--	--
Salenium (as Se), mg/l, max.	0.01	--	0.05	--	--
Arsenic (as As), mg/l, max.	0.05	0.2	0.2	--	--
Cyanide (as CN), mg/l, max.	0.05	0.05	0.05	--	--
Lead (as Pb), mg/l, max.	0.1	--	0.1	--	--
Zinc (as Zn), mg/l, max.	15	--	15	--	--
Chromium (as Cr^{6+}), mg/l, max.	0.05	--	0.05	--	--
Anionic detergents (as MBAS) mg/l, max.	0.2	1	1	--	--
Polynucleararomatic hydrocarbons, (as PAH)	0.2	--	--	--	--
Mineral oil, mg/l, max.	0.01	--	0.1	0.1	--
Barium (as Ba), mg/l, max.	1	--	--	--	--
Silver (as Ag), mg/l, max.	0.05	--	--	--	--
Pesticides	Absent	--	Absent	--	--
Alpha emitters, uC/ml, max.	10^{-9}	10^{-9}	10^{-9}		
Beta emitters, uC/ml, max.	10^{-8}	10^{-8}	10^{-8}	10^{-8}	10^{-8}
Free ammonia (as N), mg/l, max.	--	--	--	1.2	--
Electrical conductance at 25° C, mhos, max.	--	--	--	1000×10^{-6}	2250×10^{-6}
Free carbon dioxide (as CO), mg/l, max.	--	--	--	61	--
Sodium absorption ratio	--	--	--	--	26
Boron (as B), mg/l, max.	--	--	--	--	--
Percent sodium, max.	--	--	--	--	--

*Explanation for Symbols:

A: Drinking water sources without conventional treatment but after disinfection.

B: Organized outdoor Bathing.

C: Drinking water sources with conventional treatment followed by disinfection.

D: Propogation of wild life and Fisheries.

E: Irrigation, industrial cooling and controlled water disposal.

2.4.2 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 2.10 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.

The detrimental effect of various pesticides/ organic compounds cannot be ignored.

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline, fresh or moderately saline. The ground water samplings are carried out through Ground Water Observation Wells in every year pre-monsoon period by CGWB. The chemical quality data of pre-monsoon, 2014 is used in this report and the main observations are given as follows in Table 2.11. The same has shown in Figure No. 2.18.

Table 2.11 Ground Water Quality Results (2016) in Balh Valley, Mandi District.

Location	PH	EC (us/cm)	PO_4	CO_3	TH	Ca	Mg	Na	K	HCO_3	CL	SO_4	NO_3	F
	(mg/l)													
BANGROTU	8.31	1157	<0.1	25	369	58	55	112	27	77	220	188	39	0
KANED	8.37	414	<0.1	25	175	37	27	23	12	128	57	0	6.82	0.10
LOHARA	8.19	526	<0.1	0	277	45	45	24	2.50	243	71	0	25	0.08
JARL	8.47	329	<0.1	38	154	33	18	23	2.80	90	43	0	1.51	0.14
GAAGAL	8.43	244	<0.1	38	134	45	4.99	11	6.60	64	28	0	3.88	0.95
RATI	8.34	363	<0.1	25	164	41	15	24	4.10	90	57	0	29	0.04
DINAK	8.45	335	<0.1	25	175	37	20	19	1.40	115	43	0	17	0.16
JHIRI	8.39	342	<0.1	38	175	58	10	12	4.10	77	35	0	28	0.08

To assess the impact of ground water quality, 8 numbers of water samples were collected from the study area of Balh Valley of district Mandi in 2016, as per the list below:

Sr.No	Type of Source	Total Nos.
1	Dug Well	8 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 2.12 General ranges of water quality parameters of study area

Sr.No	Water Quality Parameters	Minimum	Maximum
1.	PH	8.19	8.47
2.	E.C Sp. Cond. µmhos/cm at 25°C	244	1157
3.	CO_3 (mg/l)	0	38
4.	HCO_3 (mg/l)	77	243
5.	CL (mg/l)	28	220
6.	NO3(mg/l)	3.88	39
7.	F (mg/l)	0	0.95
8.	Ca (mg/l)	33	58
9.	Mg (mg/l)	4.99	55
10.	Na (mg/l)	11	112
11.	K (mg/l)	1.40	27
12.	TH (mg/l)	134	369

pH

The pH is a numerical scale which express the degree of acidity or alkalinity of solution and represented by the equation pH= log1/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 8.19 (Lohara) to 8.47 (Jarl). Ground water of the area is alkaline in nature (Fig-1.11).

Electrical conductivity

Electrical Conductivity can be defined as the ability of a solution to conduct an electric current and measured in micromhos /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 1157 micromhos /cm is determined in the sample collected from Bangrotu, Mandi District (Fig-1.12).

Bicarbonate

Overall value of Bicarbonate varies from 77 (Bangrotu) to 243(Lohara) mg/l. (Fig-1.13).

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 28 mg/l (Gagal) to 220 mg/l (Bangrotu)(Fig-1.14).

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, over all nitrate concentration is less than 45 mg/l. It varies from minimum 3.88 to a maximum concentration of Nitrate 39mg/l (Fig-1.15).

High concentration of nitrate causes infant methaemoglobinaemia (Blue baby disease).Very high concentration of Nitrate causes gastric cancer and affects central nervous and cardiovascular system.

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 to 0.95mg/l Fig-1.16).

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(Fig-1.17).

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 8th 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. (Fig-1.18).

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 (Fig-1.18).

Sodium

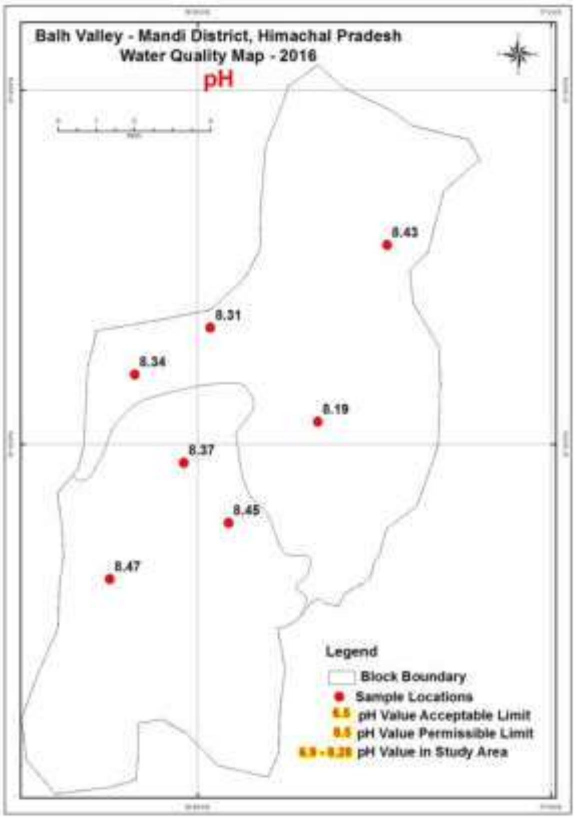
Sodium is the abundant of the alkali element in the earth's crust. Most of the Sodium occurs in the Feldspars, Mica, amphiboles and Pyroxenes. In study area, Sodium concentration ranges from 11 to 112mg/l .(Fig-1.19).

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 1.40 and 27 mg/l .(Fig-1.20).

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 134 mg/l to 369mg/l .(Fig-2.0).



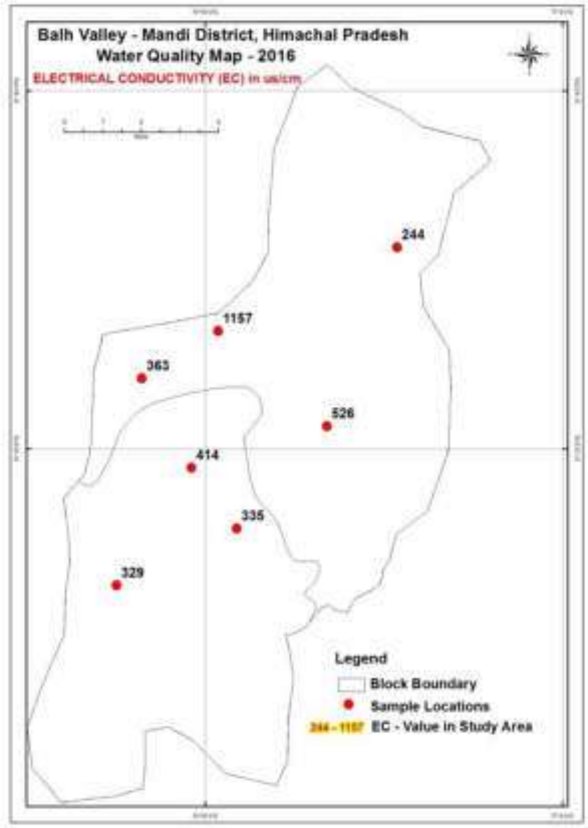
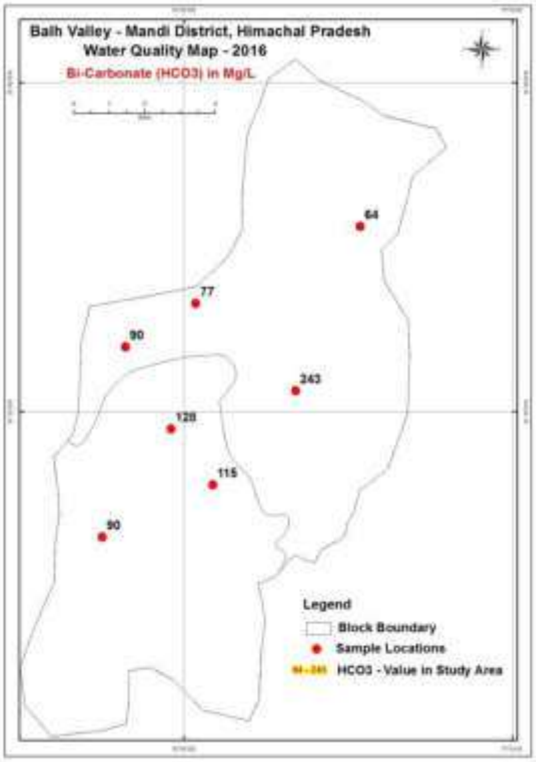
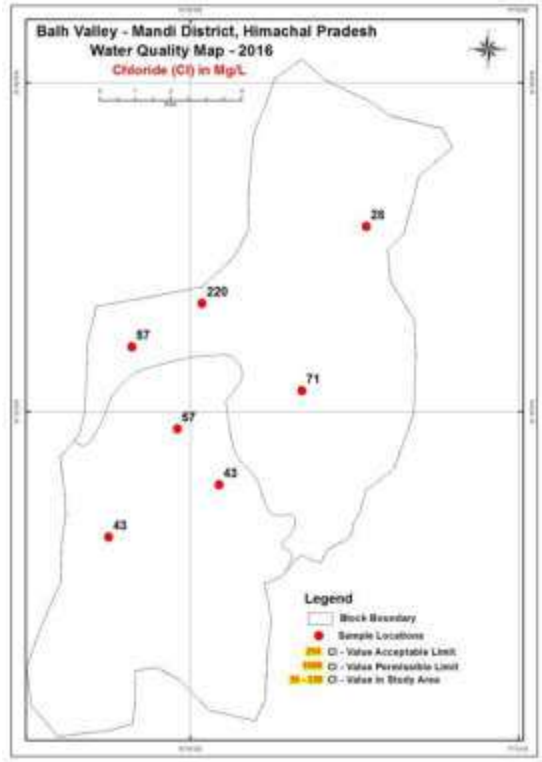


Fig-1.11 pH (2016) Balh Valley, Mandi District

Fig-1.12 Electrical Conductivity (2016) Balh Valley, Mandi District





1.13 Bi-Carbonate (2016) Balh Valley Mandi District

Fig1.14 Chloride (2016) Balh Valley, Mandi District

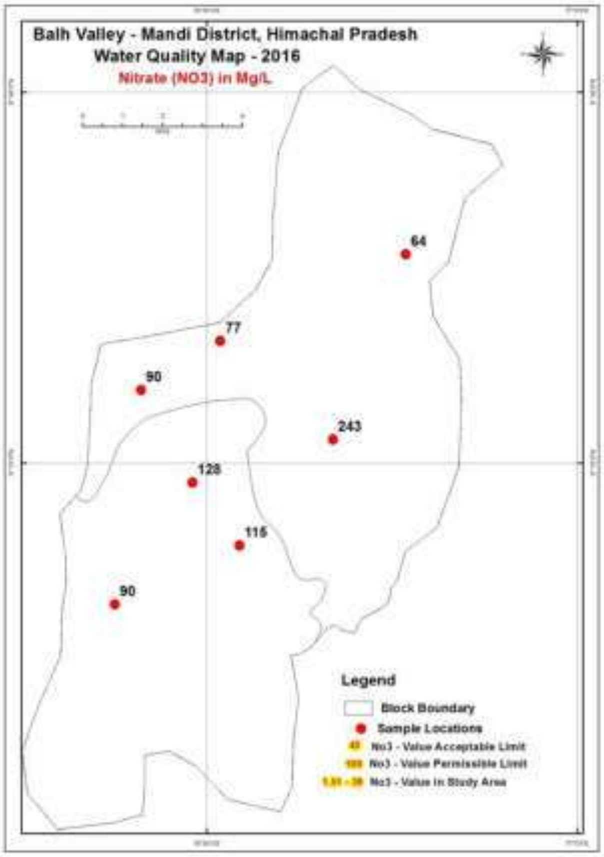


Fig-1.15 Nitrate (2016) Balh Valley Mandi District

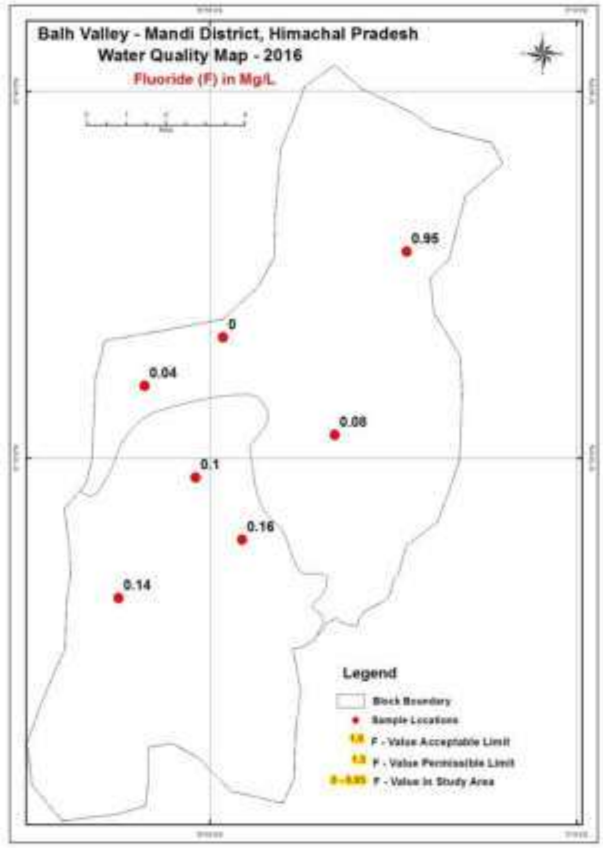


Fig-1.16 Fluoride (2016) Balh Valley, Mandi District

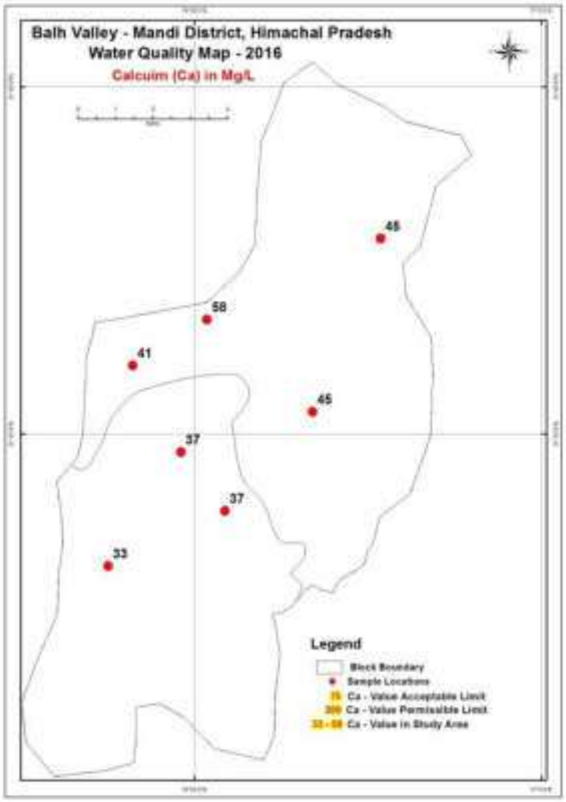


Fig-1.17 Calcium (2016) Balh Valley,

Mandi District

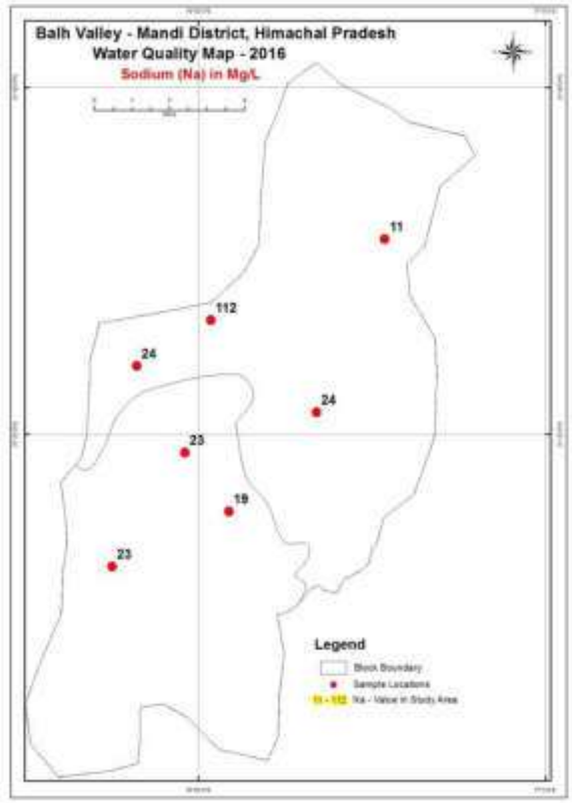
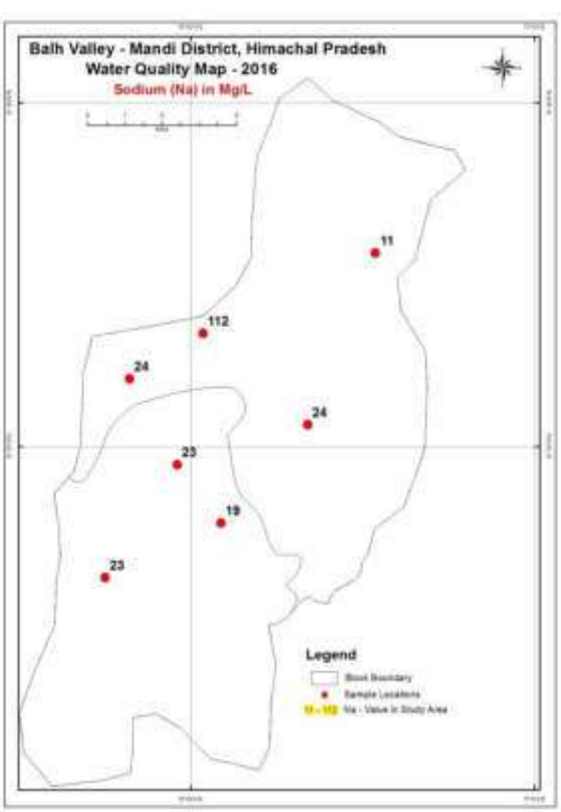


Fig-1.18 Magnesium (2016) Balh Valley, Mandi District



1.19 Sodium (2016) Balh Valley Mandi District

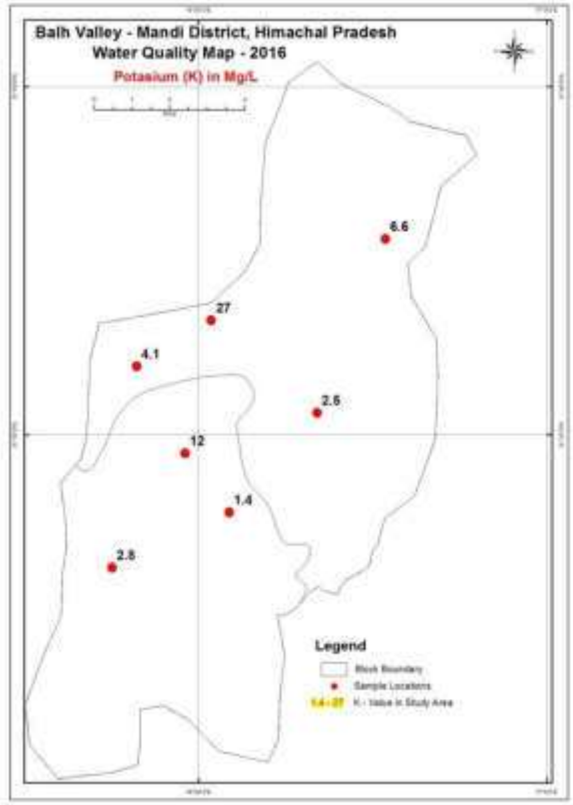


Fig-1.20 Potasium (2016),Balh Valley Mandi District

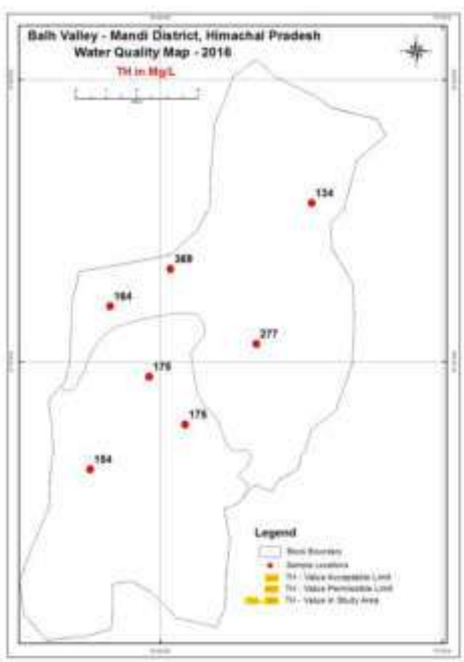


Fig-2.0 TH (2016) Balh Valley, Mandi District

2.5 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-2.10 respectively. The exploration data shows that majority of tube wells falls in the Ist Aquifer and II nd Aquifer. The grids/ formations devoid of EW/ DW and PZ are identified as data gaps and these are to be filled by data generation.

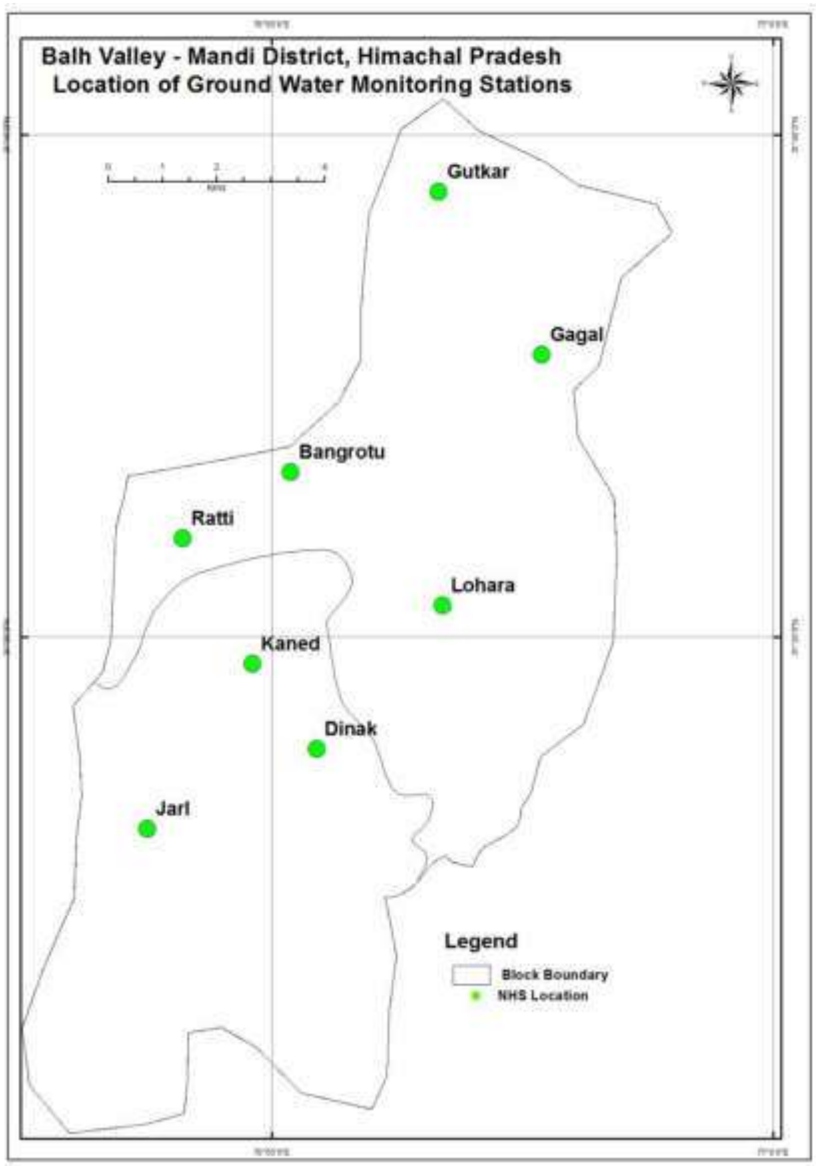


Fig. 2.1 Locations of GWMS in Balh Valley, Mandi District

3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

All the available data have been validated and optimized for consideration to generate the aquifer map in Balh Valley, Mandi District. The wells optimization 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- 2.20.

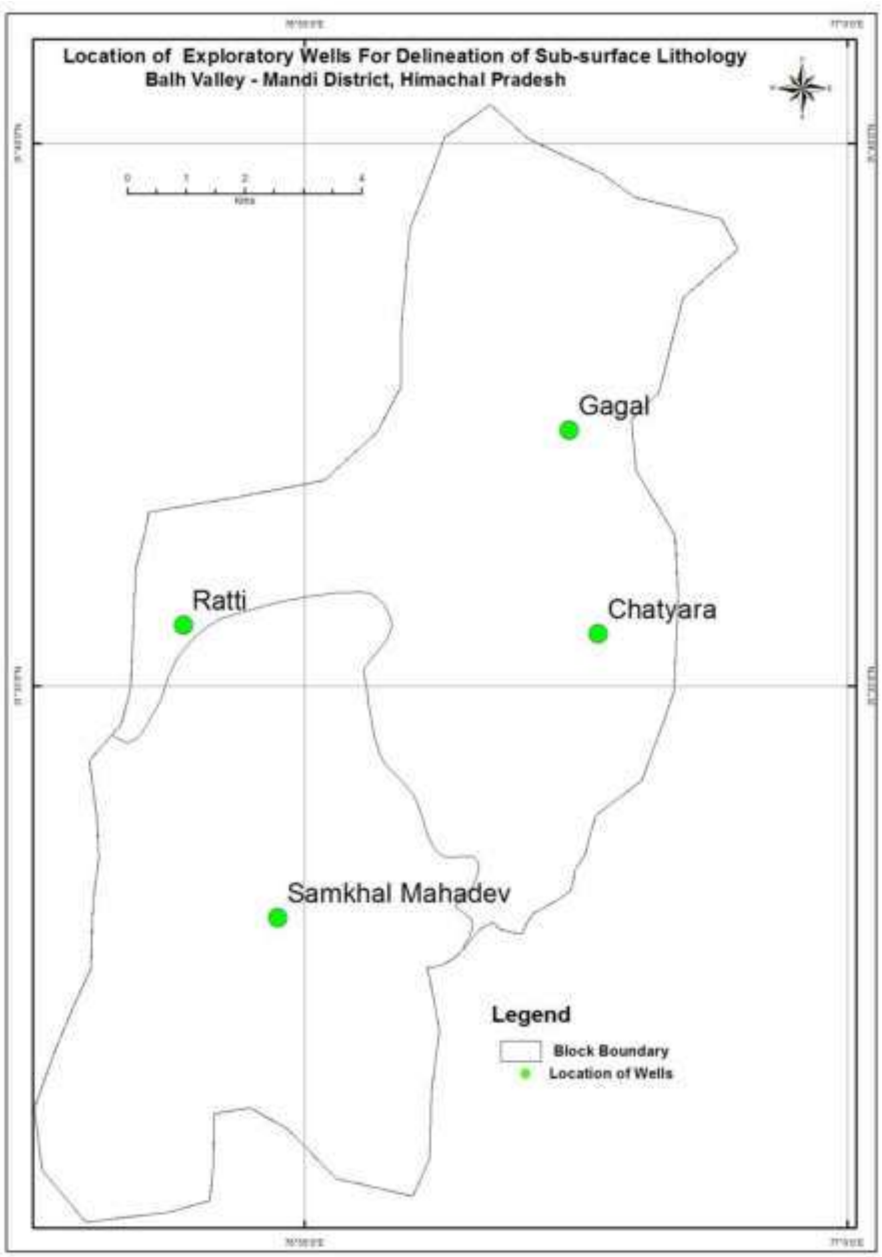


Fig. 2.2 Locations of Exploratory Wells for delineation of Sub-Surface Lithology Balh Valley, Mandi District.

3.1 Aquifer Parameter Ranges

In Balh Valley, District Mandi (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 Balh Valley, Mandi District

Exploratory Well	T (m2/day)	Specific Capacity (lpm/m)	Discharge (lpm)	Well Depth(m)
Gaggal	21.851	11.48	240	100.00
Chatyara	70.40	52.06	240	100.00
Dinak	NA	NA	NA	98.00
Dhangu	4.526	3.69	60	85.00

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 2D (Fig. 2.4) & 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-2.3 .The 3D lithological fence diagram has been prepared along with distribution of wells are shown in Fig-2.3

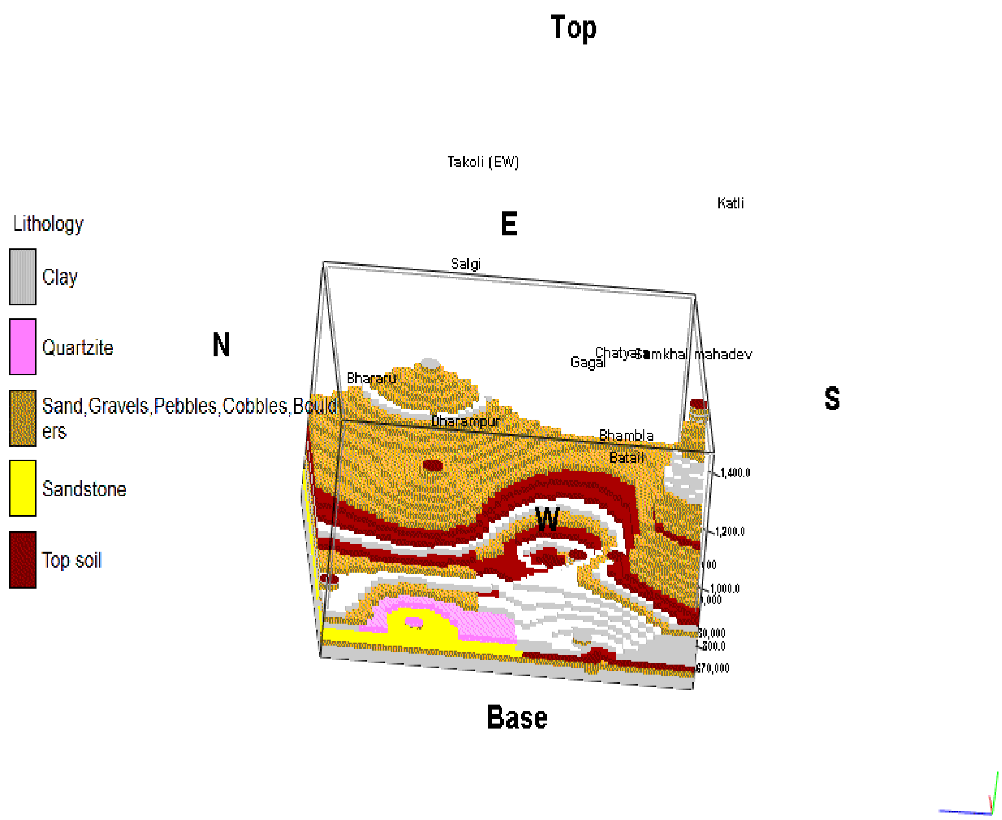


Fig-2.3 3-Dimension Lithological Model of Balh Valley, Mandi District

BALH VALLEY, DISTRICT MANDI (H.P)
FENCE DIAGRAM

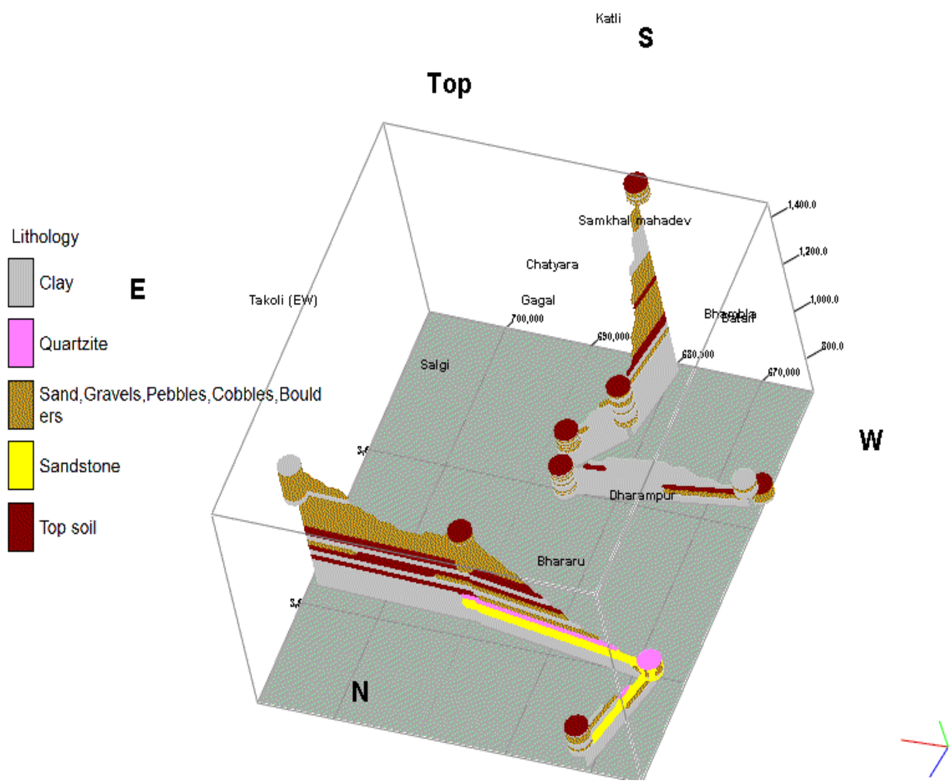


Fig-2.3 3-Dimension Lithological Fence Diagram of Balh Valley, Mandi District

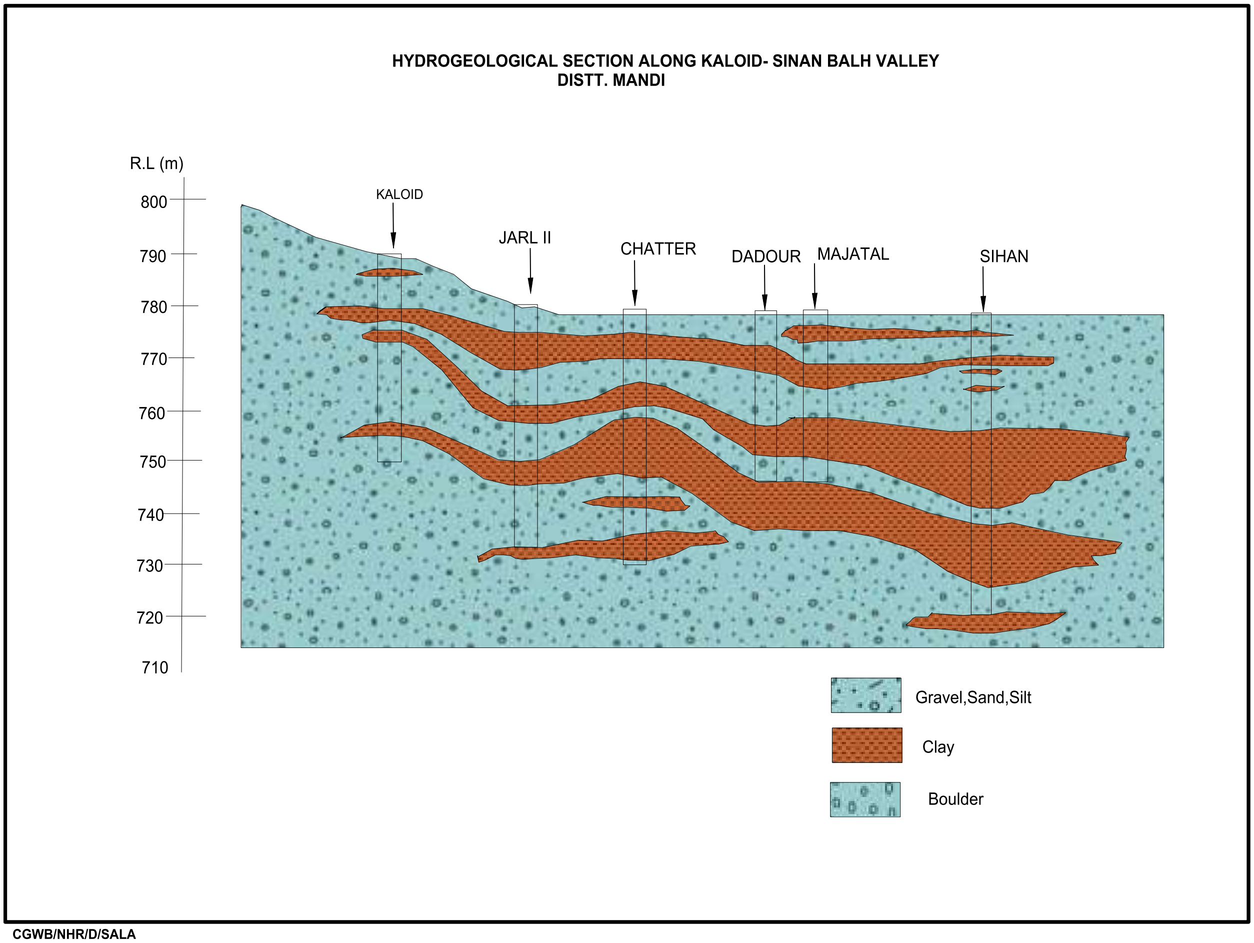


Fig.2.4 Hydrogeological Section along Balh Valley, Mandi District.

4.0 GROUND WATER RESOURCES

Rainfall is the major source 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.

Aquifer mapping area of Balh valley consists of valley areas with an area of 101sq.km. Which have slopes of more than 20%. Hence as per GEC 1997 methodology, no ground water resource estimation can be carried out only for valley areas by neglecting hilly areas. Ground water resources and irrigation potential for Balh valley area of the Mandi district have been computed and details of the Dynamic ground water resource of Balh valley are as given below:

1.	Area of Balh valley considered for GW Assessment	101	Sq. km.
2.	Net Ground water Availability	2605.08	Ham
3.	Existing Gross Ground Water Draft for Irrigation	113.89	-do-
4.	Existing Gross Ground Water Draft for Domestic & Industrial Supply	784.89	-do-
5.	Existing Gross Ground Water Draft	898.87	-do-
6.	Demand for Domestic and Industrial uses (Projected up to 2025)	933.85	-do-
7.	Net Ground Water Development for future Irrigation Development	1557.34	-do-
8.	Stage of Ground Water Development	34.50	**%**

The stage of ground water development of Balh valley is 34.50 % as on March, 2013 and falls under **"Safe Category".** This suggests that further ground water development can take place in the valley area.

5.0 GROUND WATER RELATED ISSUES

In Balh valley major cultivation is Wheat, paddy, maize, onion, garlic, vegetables and fruits like Plum, Mango, litchi. 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 which are the main source of irrigation.

This will lead to its major ground water issues which are 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 Balh 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.

6.0 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.

6.1 Plan for Sustainable Management of the Resource

- The major aquifer system of the Balh valley is alluvial deposits.

- As per GEC 1997 methodology, ground water resources for Balh Valley was estimated and observed that there is a scope for ground water development as stage of ground water development is **34.50 %, as on March, 2013** and falls under **"Safe Category"** however, there is need to adopt cautious and phased manner ground water development approach in view of depleting water levels in some parts. This decline can be attributed to fast pace of development in recent years, both in agriculture sector and industrial sector.
- Since the Balh valley area falls in **Safe Category** as per Ground Water Resource Estimation. The Mandi district receives good rainfall (1700 mm), intensity and also having good recharge. So, in the present valley area the construction of shallow tube wells also suggested for extracting the ground water.
- 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.
- People's participation is a must for any type of developmental activities. So proper awareness for utilization and conservation of water resources is required.
- Construction 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.