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

कांगड़ा-चंबा जिले के भागों का जलभृत मानचित्रण एवं प्रबंधन योजना हिमाचल प्रदेश

Aquifer Mapping and Management Plan in Parts of Kangra-Chamba Districts, Himachal Pradesh

उत्तरी हिमालयन क्षेत्र, धर्मशाला

Northern Himalayan Region, Dharamshala

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जल शक्ति विभाग/**Ministry of Jal Shakti**

जल संसाधन, नदी विकास और गंगा सरंक्षण विभाग

Department of Water Resources, River Development & Ganga Rejuvenation

March 2022

कार्यकारी सारांश / **Executive Summary**

हिमाचल प्रदेश उत्तर भारत के प्रमुख पहाड़ी राज्यों में से एक है और पश्चिमी हिमालय का हिस्सा है।जलभृत मान चत्रण अभ्यास का प्राथ मक उद्देश्य "अपने जलभृत को जानो, अपने जलभृत का प्रबंधनकरो" के रूप में अ भव्यक्त कया जा सकता है।वा षक कार्य कार्यक्रम 2012-13 के तहत हिमाचल प्रदेश के कांगड़ा-चंबा के कुछ हिस्सों में जलभृत मान चत्रण अध्ययन कया गया।ये सर्वेक्षण अन्वेषणात्मक ड्र लंग, गुणवत्ता के साथ जल स्तर की निगरानी, वसंत निगरानी (निर्वहन और गुणवत्ता), पं पंग परीक्षण, घुसपैठ परीक्षण के साथ-साथ गुणवत्ता और मात्रा के संदर्भ में भूजल घटना, उपलब्धता और उपयोग के परिदृश्य पर जानकारी को एकीकृत करने के लए कए जाते हैं। यह प्रतिवेदन अध्ययन क्षेत्र के झरनों, हैंडपंपों और सतही जल के भूजल परिदृश्य को सामने लाता है, जो पीने का मुख्य स्रोत है और वैज्ञानिक तरीके से भूजल के बेहतर प्रबंधन योजना का सुझाव देता है।

रिपोर्ट का कार्यकारी सारांश इस प्रकार है:

- पहले अध्ययन की शुरुआत में, AAP 2012-13 में, अध्ययन क्षेत्र का गठन 1400 वर्ग कमी था, जो इंटरमाउंटेन कांगड़ा - कांगड़ा की पालमपुर घाटी और चंबा जिलों के कुछ हिस्सों को कवर करता था। बाद में, अध्ययन क्षेत्र को NAQUIM के तहत लया गया, जिसमें केवल पहाड़ी भाग शा मल हैं, जिसे घटाकर 869 वर्ग कमी कर दिया गया था।
- कांगड़ा और चंबा जिलों में मेन बाउंड्री फॉल्ट के दोनों ओर टॉपोशीट में 10 कमी का सीमांकन करके अध्ययन के क्षेत्र का सीमांकन कया गया था।हिमाचल प्रदेश राज्य में इस अध्ययन क्षेत्र में सीजीडब्ल्यूबी द्वारा पहले कभी ऐसा कोई अध्ययन नहीं कया गया है
- नमूना संग्रह के स्थान की पहचान झरने और नदी के स्थानों की पहुंच और घनत्व के अनुसार की गई थी।
- अध्ययन क्षेत्र हिमाचल प्रदेश के दो जिलों कांगड़ा और चंबा जिले में आता है। अध्ययन क्षेत्र का अ धकांश भाग कांगड़ा जिले में आता है और धर्मशाला जिला मुख्यालय है। 8 ब्लॉक अध्ययन क्षेत्र में आते हैं। कांगड़ा जिले में धर्मशाला, कांगड़ा, रैत, नूरपुरं पालमपुर और चंबा जिले में भट्टियात, सहुंटा और हो ल।
- अध्ययन क्षेत्र में प्रतिनि धत्व की जाने वाली भू-आकृतिक इकाइयाँ संरचनात्मक पहा ड़याँ और बहुत कम नदी जलोढ़ हैं
- अध्ययन क्षेत्र पर्वत श्रृंखलाओं, पहा ड़यों और घाटियों का एक जटिल मोज़ेक प्रस्तुत करता है। यह मुख्य रूप से एक पहाड़ी जिला है, जिसकी ऊंचाई कांगड़ा जिले के धौलाधार की पहा ड़यों और चंबा जिले में पीर पंजाल रेंज में 350 मीटर से 4880 मीटर तक है।
- भू-आकृति वज्ञान की दृष्टि से, अ धकांश अध्ययन क्षेत्र कई संरचनात्मक पहा ड़यों और अनाच्छादित पहा ड़यों से आच्छादित है, दोनों उच्च और मध्यम रूप से वच्छेदित हैं
- जलन के प्रमुख स्रोत जिले के छोटे जल चैनल या कुहल हैं
- व वध भौगो लक, जलवायु, स्थलाकृतिक और भूग र्भक स्थितियों ने राज्य के व भन्न हिस्सों में व वध भूजल स्थिति को जन्म दिया है।
- खड़ी ढलानों वाले पहाड़ी और पहाड़ी हिस्से मुख्य रूप से अपवाह क्षेत्र बनाते हैं और इनमें भूजल की क्षमता कम होती है। घाटी और निचले इलाकों में, गैर-समे कत/अर्ध-समे कत संरचनाएं अच्छे संभा वत जलभृत बनाती हैं
- अध्ययन क्षेत्र में जायदातार प्रमुख जलापूर्ति योजनाएँ झरनों के स्रोत पर आधारित हैं

- चम्बा जिले में पड़ने वाले मेन बाउंड्री थ्रस्ट के साथ अध्ययन क्षेत्र पूरी तरह से अनछुया हुआ है,जिसमाइन भू जल को लेकर जानकारी उपलभ्ध नहीं है । चम्बा जिले में उत्खनन में खड़ी चढ़ाई वाली पहा ड़याँ और बीच-बीच में कटी हुई घाटियाँ,कठिन पहुँच और असहनीय जलवायु परिस्थितियों के कारण कार्य अव ध की सी मत उपलब्धता से बा धत है।
- कांगड़ा जिले में अन्वेषण घाटी के भराव क्षेत्रों तक ही सी मत है। अब तक ड्रल कए गए 13 खोजी कुओं में से 4 का निर्माण वैली फल में कया गया है, जब क 9 खोजपूर्ण कुओं का निर्माण मोरोनिक डपॉजिट में कया गया है। गहराई से ड्रल कए गए 23.50 से लेकर हैं। से 122.27mbgl जब क डस्चार्ज 7.2 से 1329 lpm तक भन्न होता है।
- स्ट ड एरिया मैं NAQUIMके तहत, 6 नये एक्सप्लोरटोरी वेल्स/ खोजपूर्ण कुओंका निर्माण कया गया, जिनकी गहराई लगभग 100 **m** तक है।
- निचली घाटी के क्षेत्र (नदियों के पास) नलकूपों के माध्यम से सतत भूजल वकास के लए व्यवहार्य हैं। नलकूपों को 100 मीटर की गहराई के भीतर डजाइन कया जा सकता है, जिससे दानेदार क्षेत्र की 20-30 मीटर मोटाई का सामना करने की उम्मीद है।
- ऊंची पहा ड़यों के बीच में स्क्री सामग्री, छोटे 6" ट्यूबवेल के लए भी संभव है, 40-100 मीटर गहराई तक, ट्रक/जीप माउंटेड रिग के साथ कया जा सकता है
- व भन्न जलभृतों से जल के नमूने व भन्न जलभृतों से एकत्र कए गए थे जैसे क फाइटिक एक्वीफर, उथले एक्वीफर और गहरे एक्वीफर। अध्ययन क्षेत्र में सतही जल की गुणवत्ता को देखने के लए झरनों और नदियों से भी नमूने लए गए। जांच से पता चला की सभी नमूनो मैं पनि की गुणवत्ता सही पायी गई है।
- WAPCOsके द्वारा भू- भोतिकी की जानकारी भी एकत्रीकृत की गई जो की 18 अलग अलग लोकतीओंस के बारे मैं बताई गई।
- NAQUIM अध्ययन के तहत जलभृत मान चत्रण क्षेत्र में 312 मीटर से 4800 मीटर amsl तक की ऊंचाई वाले पहाड़ी क्षेत्र शा मल हैं जिनमें 20% से अ धक ढलान हैं। इस लए GEC 1997 पद्धति के अनुसार, कोई भूजल संसाधन आकलन नहीं कया जा सकता है।
- अध्ययन के एरिया मैं, पहाड़ी एरिया जायदा है, इसी लए झरने/ स्प्रिंग्स/बावरी पायी जाती हैं। जिनमाइन से 16 श्प्रिंग्स/बावरी को अध्ययन के दोरान नापा गया, जो की बताते हैं की जायदातार का डस्चार्ज बहुत कम से लेकर 1 लटर प्रति सेकंड तक है।
- कुछ एक स्प्रिंग्स का डस्चार्ज 25 लटर प्रति सेकंड तक पाया गया, जिनको, स्थानीय लोग और जल शक्ति वभाग, दोनों ही, रोज़मर्रा की पानी की जरूरतों को पूरा करने के लए उपयाग मैं लाते हैं।
- घरेलू उपयोग के लए पहाड़ी की चोटी पर रहने वाले लोगों की मांग को पूरा करने के लए छत पर वर्षा जल संचयन को प्रभावी ढंग से अपनाया जा सकता है।
- स्प्रिंग शेड क्षेत्र ,पहाड़ी क्षेत्रों और शहरी क्षेत्रों में छत के ऊपर वर्षा जल संचयन प्रथाओं को अपनाया जा सकता है, क्यों क जिले में उ चत मात्रा में वर्षा होती है। सभी नए

निर्माणों में छत पर वर्षा जल संचयन संरचनाओं का निर्माण अनिवार्य कया जाए और ग्रामीण क्षेत्रों में वर्षा जल संचयन को बढ़ावा दिया जाए।

- पारंपरिक जल भंडारण प्रणा लयों को पुनर्जी वत करने की आवश्यकता है। पहाड़ी क्षेत्रों में संभा वत पुनर्भरण संरचनाएं चेक डैम और उपयुक्त स्थानों पर गेबियन संरचनाएं हैं।
- स्प्रिंग शेड प्रबंधन के लए क्षेत्र व शष्ट उपाय कए जा सकते हैं। कंटूर ट्रें चंग और वृक्षारोपण के लए स्प्रिंग्स के अपस्ट्रीम कंटूर को लया जा सकता है।
- अध्ययन क्षेत्रों के ढलानों के साथ-साथ कंटूर के साथ बंधन कया जा सकता है।
- संचाई और दैनिक कार्यों के लए छोटे-छोटे खेतों में वाटर हार्वेस्टिंग टैंक बनाए जा सकते हैं। इन संरचनाओं को छत के ऊपर वर्षा जल संचयन प्रणाली या लफ्ट संचाई तकनीक से संर क्षत पानी से भरा जा सकता है
- वर्षा जल संचयन और उथले जलभृतों के पुनर्भरण के लए इनका उपयोग करने के लए तालाबों, टैंकों, तालाबों जैसी पारंपरिक जल संचयन संरचनाओं की रक्षा करने की आवश्यकता है।
- झरनों का समु चत वकास आवश्यक है क्यों क यह देखा गया है क जिले के अ धकांश झरनों में संग्रह कक्ष या टैंक नहीं हैं जहां से गुरुत्वाकर्षण के तहत पानी वतरित कया जा सकता है। स्प्रिंग डेवलपमेंट का उद्देश्य भू मगत बहते पानी को इकट्ठा करना, सतही संदूषण से बचाना और आपूर्ति के लए सैनिटरी स्प्रिंग बॉक्स में स्टोर करना होना चाहिए।
- क्षेत्रों में, अप्रयुक्त और परित्यक्त खोदे गए कुओं का उपयोग वर्षा जल संचयन और भूजल पुनर्भरण के लए कृत्रिम पुनर्भरण संरचना के रूप में कया जा सकता है, जिसमें भूजल पुनर्भरण के लए सुरक्षा दिशानिर्देश शा मल हैं।
- कसी भी प्रकार की वकासात्मक गति व धयों के लए लोगों की भागीदारी अनिवार्य है। इस लए जल संसाधनों के उपयोग और संरक्षण के लए उ चत जागरूकता की आवश्यकता है।

AQUIFER MAPPING STUDIES IN PARTS OF KANGRA-CHAMBA DISTRICT, HIMACHAL PRADESH.

CONTENTS

Sr. No.	Description	Page Number
1.	**INTRODUCTION**	**5-37**
1.1	Introduction of Himachal Pradesh	
1.2	Introduction of Himachal Pradesh	
1.3	Objectives	
1.4	Methodology	
1.5	Purpose and scope	
1.6	Area, Extent and Methodology	
1.7	Previous Work	
1.8	Administrative divisions, Demographic Particulars	
1.9	Physiography & Drainage	
1.10	Aquifer Mapping-Goals & Objectives	
1.11	Climate &Rainfall	
1.12	Geomorphology	
1.13	Slope	
1.14	Land Use & Land Cover	
1.15	Geological Setup	
1.16	Main Structural Feature -Main Boundary Thrust	
1.17	Hydrogeological framework	
1.18	Springs	
1.19	Water Use and Water Demand in major cities of Study Area	
	1.19.1 History of Water Use in Dharamshala	
	1.19.2 Traditional source of water supply	
	1.19.3 Groundwater	
	1.19.4 Storage Reservoir	

	1.19.5 Current and Future demand of Dharamshala	
2.0	**DATA – GAP, ACQUISITION & METHODOLOGYN**	**38-45**
A	Administrative Boundaries	
B	Demography	
C	Agriculture & Irrigation	
D	Land use & Land cover	
E	Hydro-meteorological data	
F	Hydrological data	
G	Soil	
H	Geological data	
I	Hydrogeological Data	
J	Groundwater Exploration Data	
K	Pumping Test Data	
L	Geophysical Data	
M	Well Census Data	
N	Ground water Resource Estimation	
O	Hydro-geochemical data	
P	Data on Springs	
Q	Mining/Industries present in the area	
R	Data on Salinity Hazards	
2.1	**As Per EFC (Expenditure Finance Committee)**	
2.2	**As per guidelines of Hilly Area**	
	a. Exploratory Well	
	1.Data required	
	2.Data adequacy and Data gap analysis	
	b. Geophysical data	
	1.Data required	
	2.Data adequacy and Data gap analysis	
	c. Ground water monitoring data	
	1.Data required	
	2.Data adequacy and Data gap analysis	
	d. Ground water quality data	
	1.Data required	
	2.Data adequacy and Data gap analysis	

3	**DATA – GAP & ADEQUECY**	**46-58**
3.0	**Data gap analysis of Study Area**	
	Existing Data Base	
	1 Exploration	
	2 VES & Profiling	
	3 Hand Pump data	
	4 Water Level Monitoring	
	5. Sampling & water quality monitoring	
3.1	**Data Gap & Acquisition**	
3.2	Ground Water Exploration	
3.3	Rate of Infiltration	
3.4	Geophysical Data	
3.5	Ground Water Monitoring Stations	
3.6	Ground Water Quality Monitoring Stations	
3.7	Spring Discharge	
4.	**DATA GENERATION, INTEGRATION & DATA INTERPRETATION**	**59-77**
A	**Hydrogeology**	
4.1	Aquifer Disposition & Parameters Range	
4.2	Aquifer Geometry	
4.3	Fence Diagram Interpretation	
4.4	3-D Aquifer Disposition	
4.5	2-D Aquifer Disposition	
B	**Water Sampling & Water Quality**	
C	**Geophysical**	
4.6	Vertical Electrical Soundings(WAPCOS)	
4.7	District wise Findings	
4.8	Interpreted results of VES	
4.9	Conclusions of VES	
5.0	**MANAGEMENT PLAN**	**78-83**
5.1	Ground Water Resources	
5.2	Demand & Supply	
5.3	Supply Side Management	
5.4	Demand Side Management	
5.5	Hill Area Management	
6.0.	**CONCLUSIONS & RECOMMENDATIONS**	**84**

Maps & Figures

Map No	Description
1.	Map of Himachal Pradesh
2.	Bird Eye view ofStudy Area
3.	Administrative Map of Study Area
4.	Drainage Map
5.	Monsoon Rainfall
6.	Non Monsoon Rainfall
7.	DEM & Contour Map
8.	Geomorphology Map
9.	Slope Map
10.	Soil Map
11.	Land Use & Land Cover
12.	Forest Area
13.	Geology Map
14.	Lithology Map
15.	MBT
16.	Lineament Map
17.	Hydrogeology Map
18.	Series of Springs in Study Area
18-A.	Geophysical Survey layout map
19.	Decadal Fluctuations
20.	Administrative Map
21.	Topo- index Map
22.	Data Adequacy of Ground Water Exploration
23.	Data Adequacy of Soil Infiltration
24.	Data Adequacy of VES
25.	Data Adequacy of Water level Monitoring
26.	Data Adequacy of Water Quality Monitoring
27.	Locations of EWs in Study Area
28.	Locations of EWs with amsl
29.	Fence diagram
30.	3-Dimensional Lithological Model
31	2-Dimensional Lithological Model
32.	3-Dimensional Lithological Model
31-35	Water Quality(point values)
36	Sclumberger configuration for VES
37	Hydro-geological Interpretation with VES

List of Tables

Table No	Description
1.1	District & Blockwise area covered under study
1.2	Rainfall of Kangra and Chamba District
1.3	Geological Succession of Kangra and Chamba District
1.4	Hydrogeological unitas per yield potentials
1.5	Water Demand of Dharamshala
1.6	Use of types of pumps for abstracting ground water
1.7	Current and projected water demand from user agencies
2.0	Tentative norms of activities taken as per EFC
3.1	Location and draft details of EWs in nearby to study area
3.2	Geo-electrical parameters obtained from VES
3.3	NHS Locations and water levels
3.4	DGA of Study Area
4.1	EW details of the study area
4.2	Lithological distribution of Aquifer-I
4.3	Hydrogeological distribution with Yield Potentials
4.4	Sampling locations
4.5	Chemical Results
4.6	List of Distts and Blocks for VES

Plate No.	Description
I	A Geophysical Survey Layout map, Chamba district
II	General Geological setup of area indicating major faults & thrusts
III	MBT along with the earthquake epicentres with magnitude
IV	DEM & Contour Map
V	Geology Map
VI	Geomorphology Map
VII	Lithology Map
VIII	Location map of spring and surface water sampling points
IX	Monsoon Rainfall Map
X	Non Monsoon Map
XI	Satellite Imagery Showing Faults in Northern Himalayas

AQUIFER MAPPING STUDIES IN PARTS OF KANGRA-CHAMBA DISTRICT, HIMACHAL PRADESH.

(GROUND WATER AND SURFACE WATER STUDY IN SEISMIC BELT IN DISTRICTS KANGRA AND CHAMBA)

(2012– 2013)

1. INTRODUCTION

1.1 Introduction of Himachal Pradesh

Himachal Pradesh is one of prominent hilly State of north India and forms part of the western Himalayas. The State has an area of 55,673 sq km. and is located between North Latitude 30° 22’ to 33° 12’and East Longitudes 75° 45’ to 79° 04’. Administratively, the State comprise 12 districts, 76 Teshils, 75 Blocks, 2922 Gram Panchayats, 2623 Villages (Uninhabitated), 57 Towns and 28 Nagar Panchayat.

Himachal Pradesh presents an intricate mosaic of high mountain ranges, hills and valleys with altitude ranging from 350 m to 6500 m amsl. Physiographically, the State is divided from south to north into the *Outer Himalayas or Siwaliks* (350 to 1500 m amsl), the *Lesser Himalayan Range* (1500-5000 m amsl), the *Great Himalayan Range* (5000-6000 m amsl) and Spiti or Tethys Himalayan Range (>6000m amsl).

The major rivers draining the State are Chenab, Ravi, Beas, Sutluj and Yamuna. Most of the rivers are snow fed and perennial in nature. The climatic conditions vary from hot to sub–humid tropical (450-900m), warm to temperate (900-2400m) and cold alpine to glacial (2400 – 4800m). The climate in Lahaul & Spiti and Kinnaur area is of semi-arid, high land type. The state has an average annual temperature of 19°C. The state receives rainfall during southwest monsoon and also during northeast monsoon in winters. The average annual rainfall of the state is 1010 mm with 62 average rainy days. Dharamshala receive the highest rainfall with 3400 mm. Both porous and fissured formations are visualized in the State.

Most of the State is hilly except some intermountain valleys viz., Indora, Nurpur, Bath, Ponta, Kala Amb, Nalagarh, Una and Hum and numerous small valleys. In valley fill areas, ground water occurs under water table and semi confined conditions and extensive ground water development by open wells and tube wells is observed. In hilly areas, springs and *baories* form the major source of water supply, particularly for domestic purpose. State Government in such areas has installed large numbers of hand pumps. In general, ground water quality in the state is good and potable. Fast developing industrial and urban clusters are most vulnerable areas for ground water pollution and require scientific intervention.

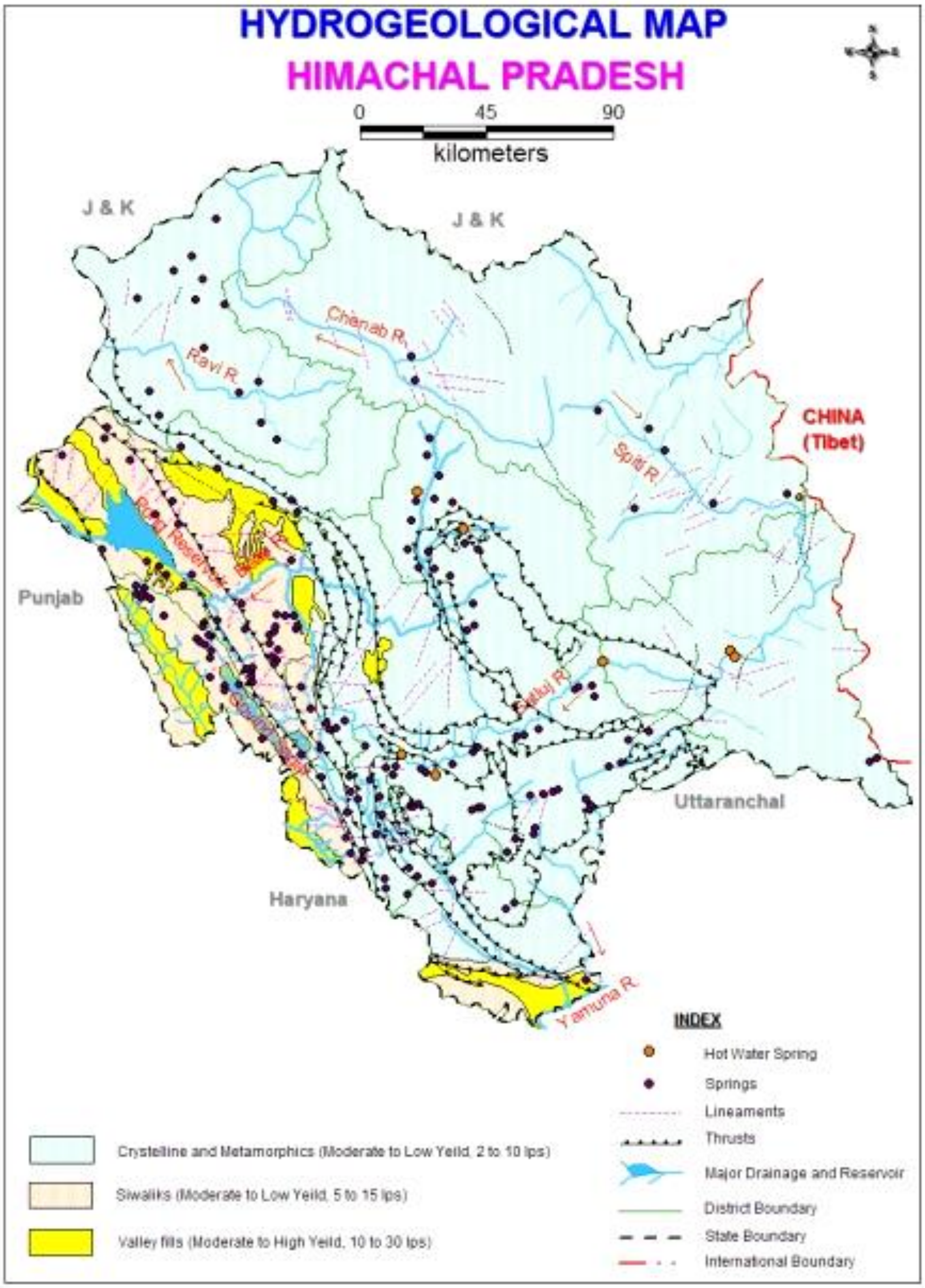


Figure 1: Map of Himachal Pradesh

1.2 Introduction to Aquifer Mapping

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.

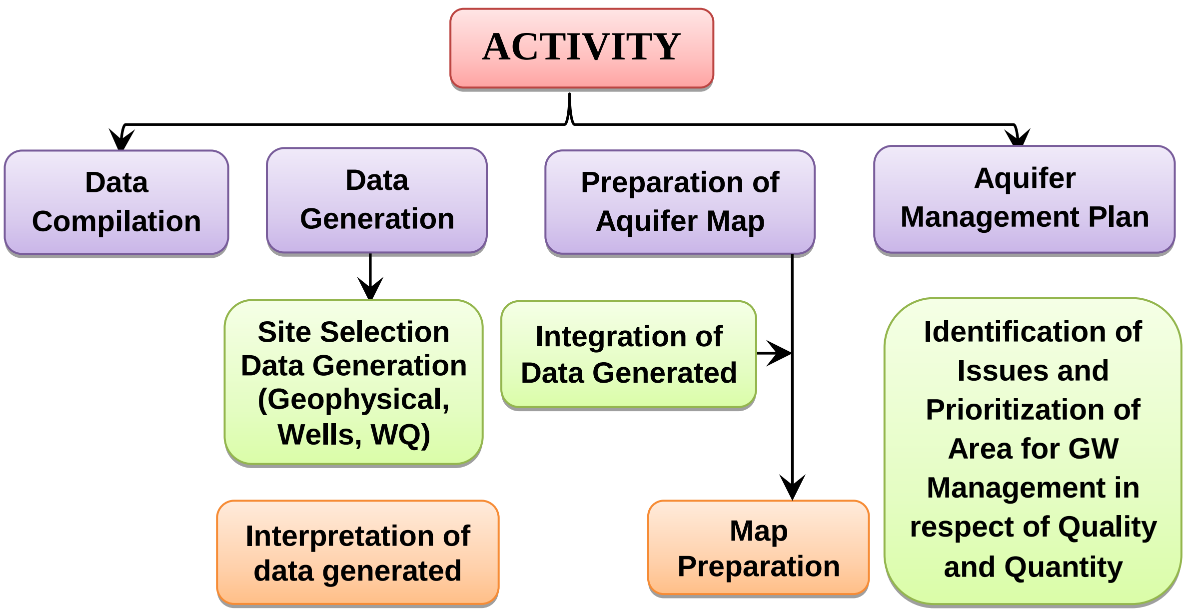
1.3 Objectives

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 participatorygroundwater management programme. The aquifer mapping approach can help integrate ground wateravailability with ground water accessibility and quality aspects.

With these aims, Aquifer Mapping Study was carried out in parts of Kangra- Chamba,of Himachal Pradesh under the Annual Action Programme 2012-13. 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, one key observation well (dugwell), 20 no of springs were established. Subsequently, all the available data on ground water from the earlier studies are compiled and integrated with these studies. This report brings out the ground water scenario, of springs, handpumps and surface water of the study area, which is the main source of drinking and suggests better management plan of ground water in a scientific manner.

1.4 Methodology

Various activities of NAQUIM are as follows:



1.5 Purpose and scope

Earlier, in AAP 2012-13, this study was taken as ground water and surface water study in seismic belt in district Kangra and Chamba. But later on the area was taken under aquifer mapping.

1.6 Area Extent &Methodology

The Aquifer Mapping Study area is located in the western part of Himachal Pradesh which forms hilly area of parts of Kangra and Chamba district. The present study area constitutes 864sq. km covering mainly hilly parts of Kangra and Chamba districts which comes under the

SOI toposheets 52 D/3; D/4; D/7 and D/8. The area is bounded by N 32°29’55”, 32°15’8”; 32°16’49”, 32°1’49” latitude and E 75°59’58”; 76°29’55” longitude. Being hilly area, approachability made it difficult to study. The study area is well connected by means of all weather small roads, with the district headquarter at Dharamshala and also with other towns in the neighbouring districts. National Highway 20 passes through the study area.

Preliminary monitoring studies conducted in the area include literature survey, collection of geologic and topographic data, spring inventory, rainfall data, hand pump data and geophysical data etc. Spring locations, discharge was measured, water temperature and samples were taken from the field. The location of sample collection was identified according to the approachability and density of the spring locations. Details of hand pumps in the area were obtained from the IPH department of respective area.

The area of study was demarcated by delineating 10 km in toposheet on either side of Main Boundary Fault in Kangra and Chamba districts. Approachability made it difficult to study the northern part of MBT where most the streams were originated. Spring and river location, discharge, water temperature and samples were collected from the field. The location of sample collection was identified according to the approachability and density of the spring and river locations. GIS maps and thematic layers were prepared from the collected data.

1.7 Previous work

No similar studies have undertaken ever before by CGWB in the state of Himachal Pradesh. Geophysical studies were conducted at few selected locations in the study area in 1987 by NWR, Chandigarh region. Explorations were done by CGWB in parts of Kangra district but Chamba district is yet to be explored.

Previously in starting of the study, in AAP 2012-13, the study area constituted1400 sq. km covering parts of intermontain kangra – Palampur valley of Kangra, and Chamba districts. Later on, the study area was taken under NAQUIM, which include hilly parts only, which was reduced to 859 sq km. The area under taken in the study included parts of Chamba and Kangra districts came under the SOI toposheets 52 D/3; D/4; D/7 and D/8. The area is bounded by N 32°29’55”, 32°15’8”; 32°16’49”, 32°1’49” latitude and E 75°59’58”; 76°29’55” longitude.

1.8 Administrative divisions, Demographic particulars

The study area falls in two districts of Himachal Pradesh, namely Kangra, and Chamba district. Major part of the study area falls in Kangra district with Dharmashala as district headquarters. 8 blocks fall in the study area wiz.,Dharamshala, Kangra, Rait, Nurpurand Palampur, in Kangra district and Bhattiyat,Sihuntaand Holi in Chamba district.

Table1.1 : District wise and Block wise area covered under study

Sn	District Name	Block Name	Area (Sq.Km)
1	**Parts of Chamba**	Bhattiyat	114
2		Sihunta	237
3		Holi Chamba	21 5
4	**Parts of Kangra**	Kangra	126
5		Dharmshala	244
6		Palampur	72
7		Nurpur	39
8		Dhira	1
		Total	**859 sq Km**

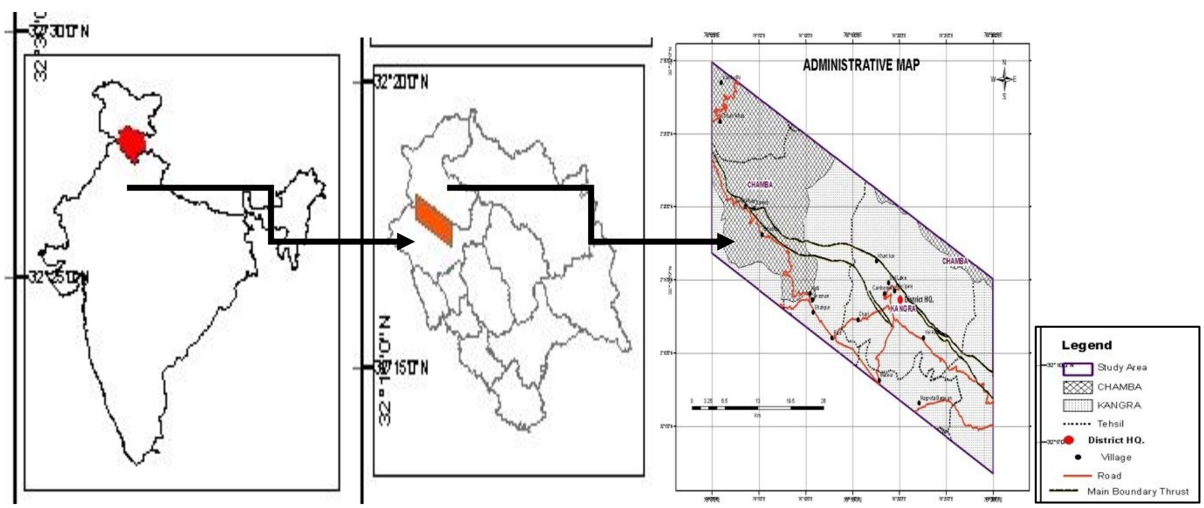


Figure 2: Bird Eye view of Study Area

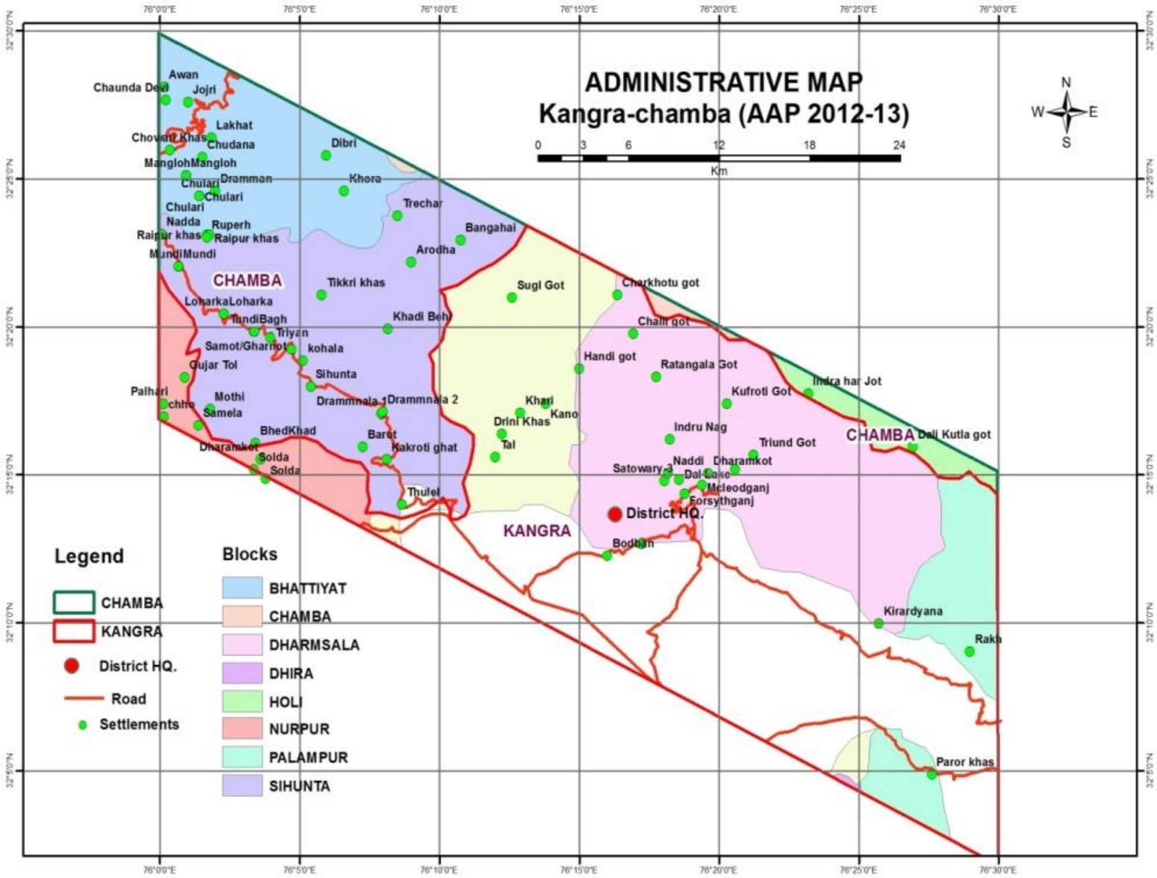


Figure 3: Administrative Map of Study Area

1.9 Physiography &Drainage

Physiographically, the area forms part of middle Himalayas with high peaks ranging in height from 3000 to 6000 m amsl. It is a region of complex folding, which has under gone many orogenesis. The topography of the area is rugged with high mountains and deep dissected by river Ravi and its tributaries.

Physiographically, the area can be divided into six units-*viz.*

(i) high hills, which cover almost 80% of the district

(ii) Fluvio glacial outwash terraces, which is located in the north eastern part of the district

(iii) structural terraces, in the central part

(iv) valley fills

(v) piedmont plain and

(vi) flood plain.

The topography of the area is rugged with high mountains and deep dissected by river Ravi and its tributaries. Physiographically, the district can be divided in to two units-*viz.*

(i) high hills, which cover almost entire district
(ii) few valley fills.

The study area is drained by many hilly rivers shows dendratic pattern. In the study area of Kangra district, the Beas river, one of the perennial rivers, forms the southern border of the district. The Chakki River, tributary of Beas Rivers, forms the northwestern border of the district. In the study area, Beas river is fed by Gaj, Neogal, Manjhi, Ikka, Baner, Naker, Dehar khads. All these khads are perennial and snow fed. These khads have deep valleys in the hilly area. The valleys are wide in the Kangra valley region where the slope/gradient of the river is gentle. The courses of these rivers are structurally controlled. The gradient and flow are being utilized both of irrigation and power generations. A number of micro hydel projects are under construction on these khads. The water of these rivers are also being used for irrigation by diverting its flows through Kuhls/irrigational channels.

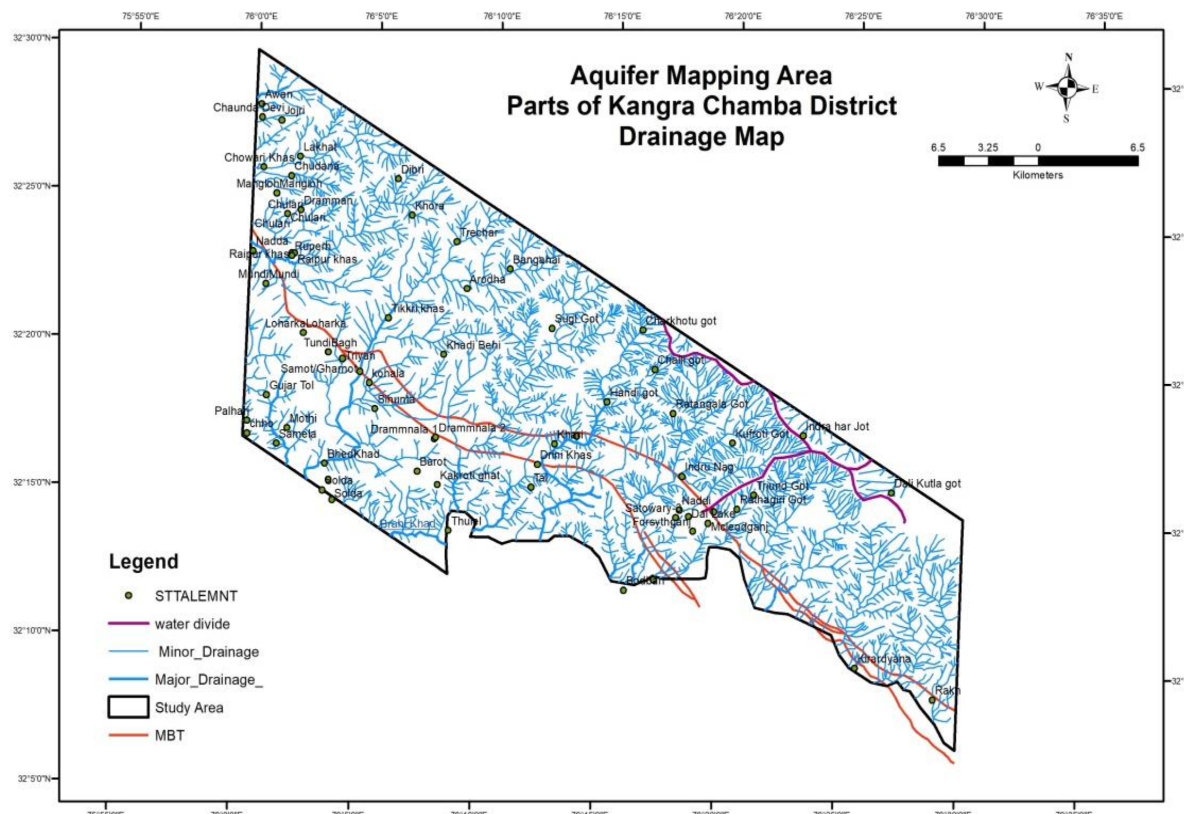
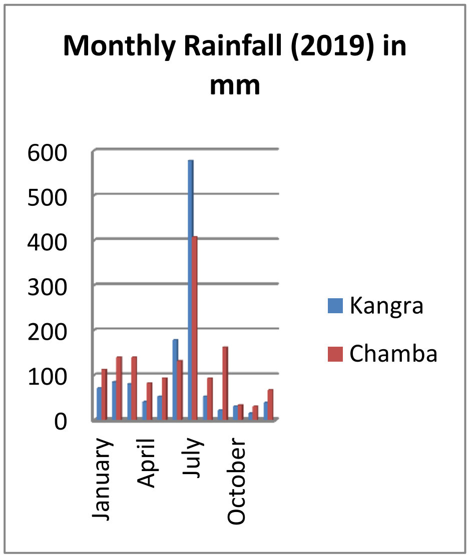


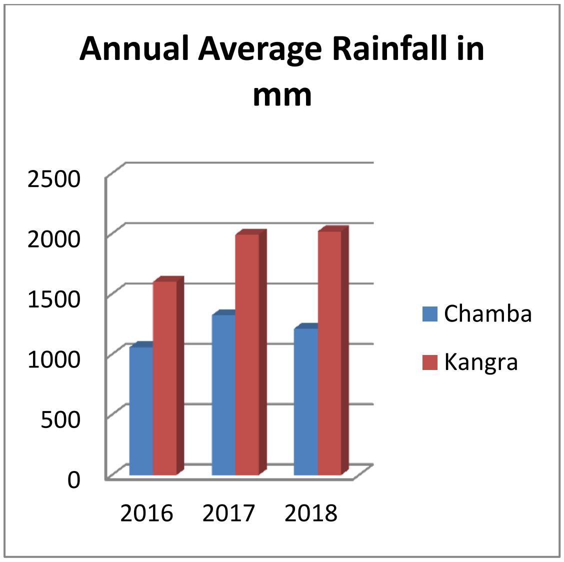
Figure 4: Drainage map of Study Area

1.10 Climate &Rainfall

The climate of the districts varies from sub-tropical to sub-humid. Winter extends from December to February and summer extends from March to June while July to September are the rainy months. The average annual rainfall of the district Kangra is 1870 mm, out of which 82% occurs during June to Sept. Snow fall is received in the higher reaches of Dhauladhar ranges. The minimum and maximum temperature at Dharamshala varies from 3.2°C in January to 35°C in June.The average annual rainfall in the district Kangra during 2009-2013 was 997.5 mm and 64% occurs during the month of monsoon. Snowfall is received in the higher reaches. The minimum and maximum temperature at Saloni in 2012 was -3.1°C and 34.5°C in January and June respectively.

Table1.2: Monthly & Annual Average Rainfall of Study Area





District : CHAMBA

The District Rainfall in millimeters (R/F) shown below are the arithmatic averages of Rainfall of Stations under the District.

Year	January	February	March	April	May	June	July	August	September	October	November	December
2009	81	81.1	5.4	0	26.3	10.9	78.4	22.8	115.3	0	65.8	7.3
2010	17.9	58.8	17.1	44	73.3	82.4	232.9	358.4	137.9	8.4	5.2	50.9
2011	21.6	125.6	83.7	53.2	17.2	129.9	210.7	275.9	120.4	9	0.6	5.1
2012	213.4	66.9	25.2	93.6	8	17.1	127.7	299.9	187.1	2.9	24	39.8
2013	56.7	228.4	68.3	19.4	45.9	175.4	185.1	386.5	44	19	34.2	47.6

District : KANGRA

The District Rainfall in millimeters (R/F) shown below are the arithmatic averages of Rainfall of Stations under the District.

Year	January	February	March	April	May	June	July	August	September	October	November	December
2009	30.1	35.1	29	55.6	33.9	52.3	402.8	329.4	162.1	13.5	65.7	0.4
2010	17.3	66	12.3	10.7	50.4	123.9	399.9	658.3	249.5	22.4	8.2	52.3
2011	51	93.1	36.6	69.1	45.8	213.6	357.8	756.6	218.6	28.8	0.2	4.6
2012	170.6	45.9	37.3	53.3	9.9	35.9	603.9	940.2	308.9	9.1	4	31.6
2013	52.2	121.3	72.3	28.9	26.5	370.4	666	739.6	169.4	89.4	19.8	47.5

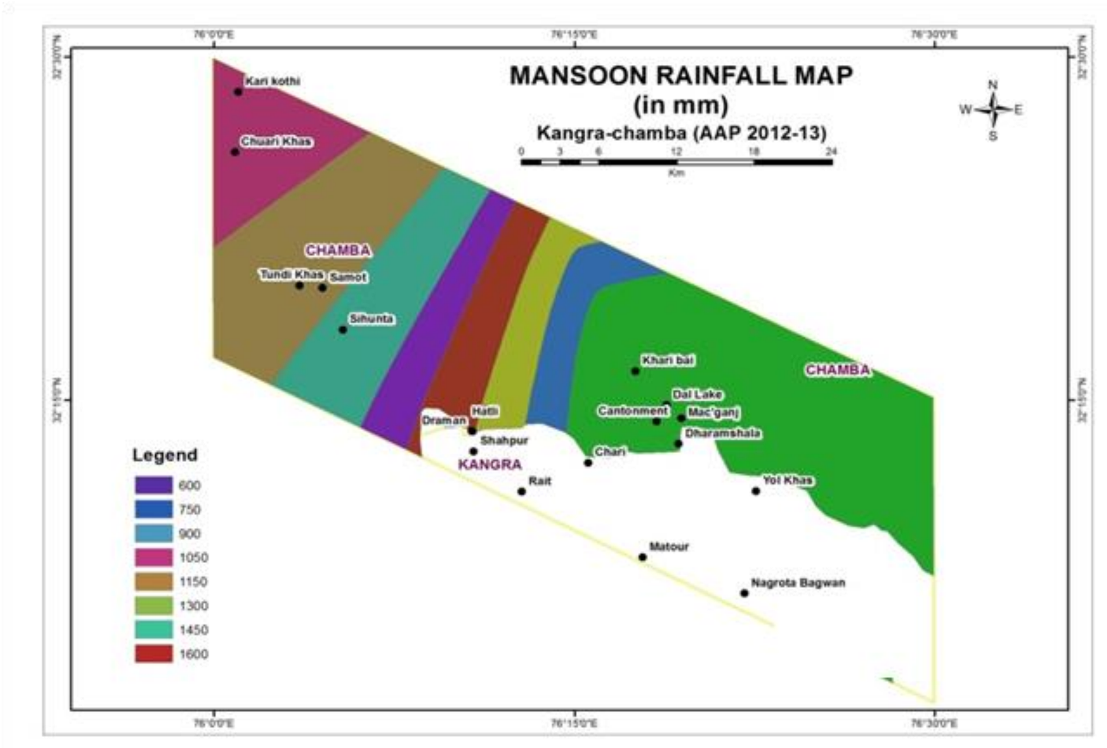


Figure 5: Monsoon Rainfall Map of Study Area

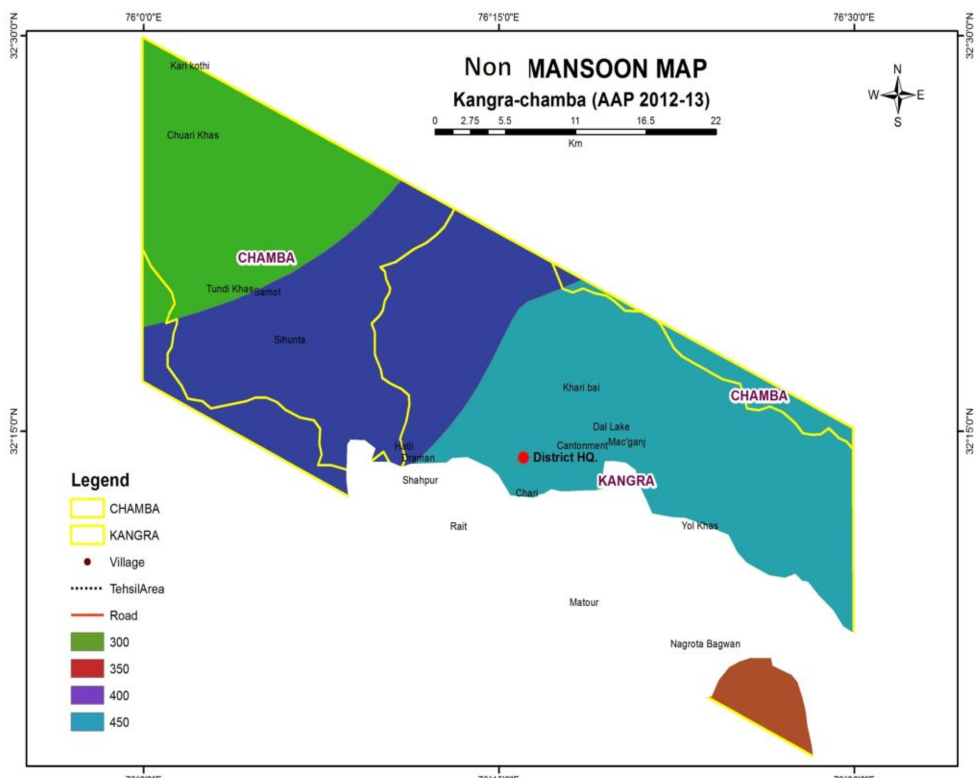


Figure 6: Non-Monsoon Rainfall Map of Study Area

1.11 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 Structural hills and very less river alluvium shown in fig.

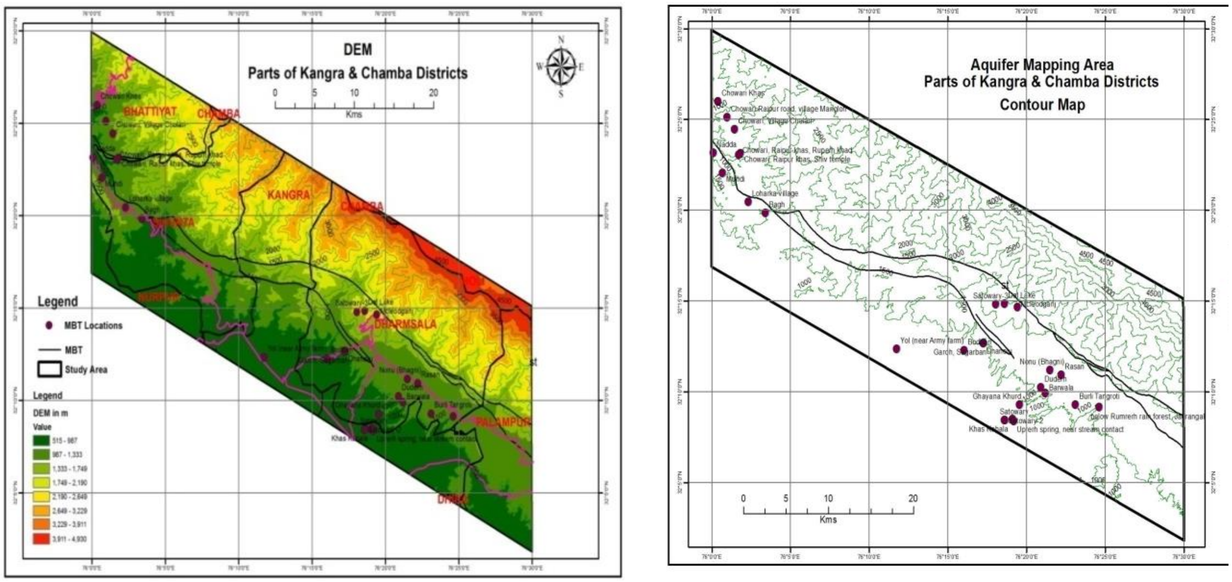


Figure 7: Digital Elevation& contour Map of Study Area

The study area presents an intricate mosaic of mountain ranges, hills and valleys. It is primarily a hilly district, with altitudes ranging from 350 m amsl to 4880 m amsl in the hills of Dhauladhar in Kangra district and Pir Panjal range in Chamba district.

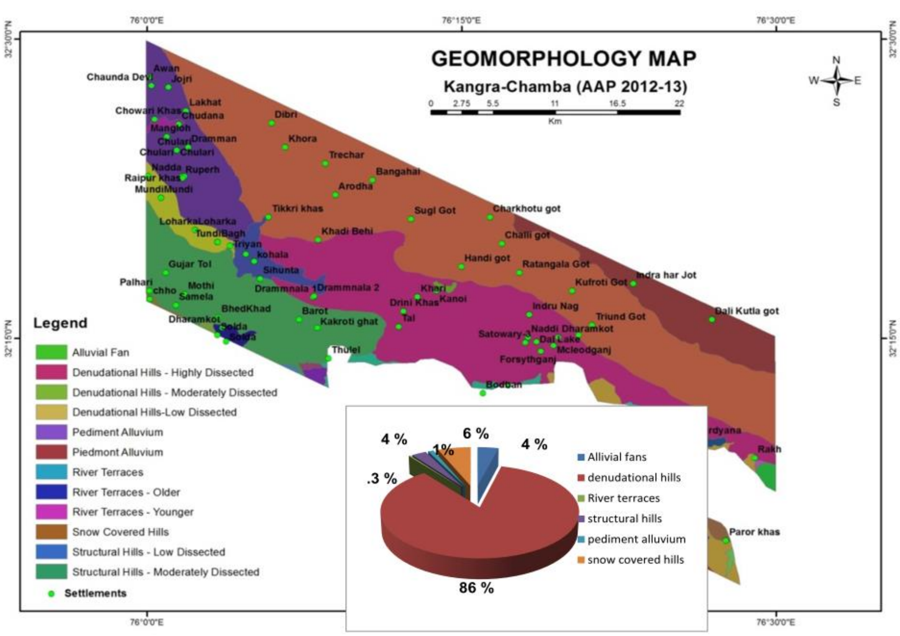


Figure 8: Geomorphology Map of Study Area

Geomorphologically, the most of the study area is covered with multiple structural hills and denudational hills, both highly and moderately dissected. North eastern part of the area, is snow covered hills. Piedmont alluvium is also found in the study area, with fewer river terraces.

1.12 Slope

The slope map was prepared using Survey of India topographic sheets and IRS P6 LISS – III satellite imagery. The slope features in the study area shows that most of the area falls in slope 40-60%. Very less area is showing slope less than 20%.

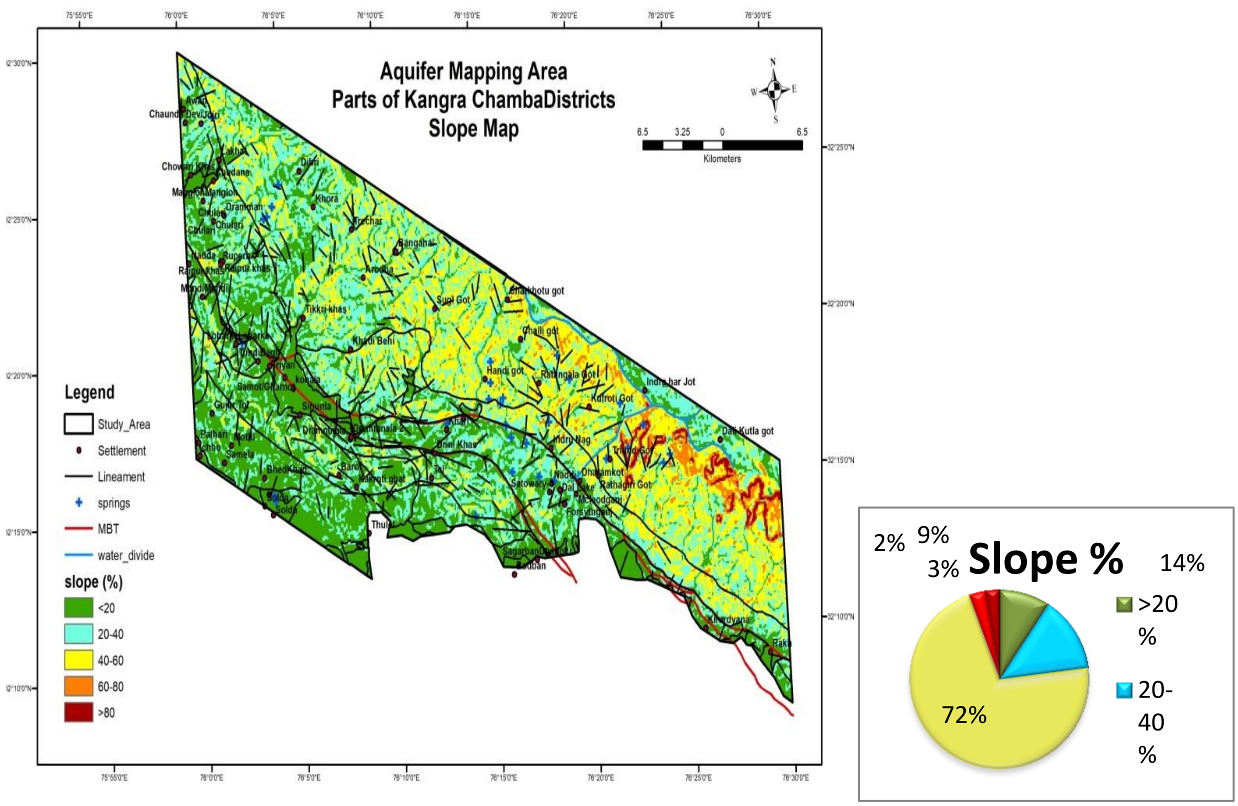


Figure 9: Slope Map of Study Area, along with chart representation

1.13 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.

Mostly, Six type of soils are observed in the district, they are :- 1. Histosols (Snow field, Peaty and Saline Peaty), 2.Ultisols (Brown red and yellow), 3. Alfisols (Sub Mountain), 4. Ardisols (Grey Brown), 5. Entisols (Younger alluvium).

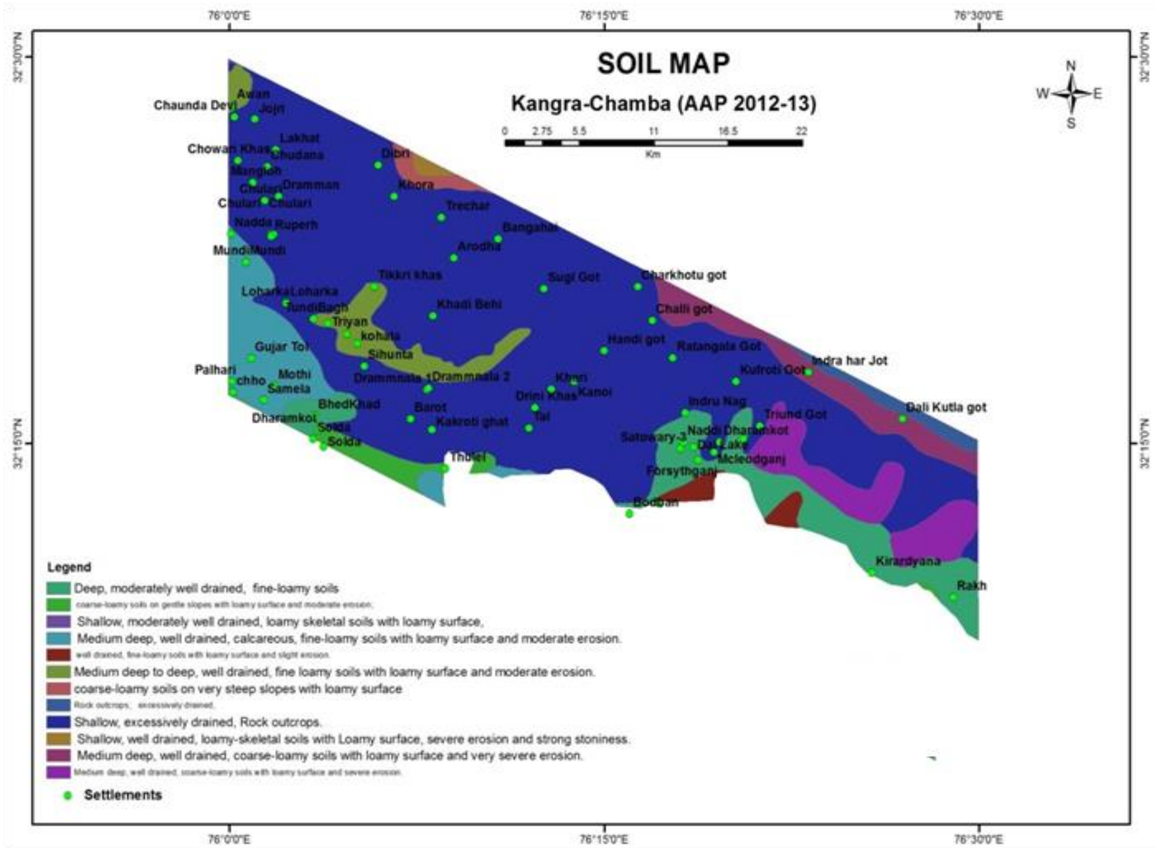


Figure 10: Soil Map of Study Area

1.14 Land Use & 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, Land with scrub, Plantation and River. Similarly Forest Area map was prepared with the help of processed satellite imagery, the same has been shown in fig.

The major sources of irritation are small water channels or the K*uhls* in the district and an area of 35,922 hectare is brought under irrigation by various sources like canals, tanks, wells and other sources. A sizeable part of the cultivated area of the district is not having the assured irrigation facilities and the agriculturists have to depend on the vagaries of weather. Under the various plans, the construction of *Kuhls*and lift irrigation schemes are being taken up in the district. Number of tubewells in Nurpur valley and Indora area has also been constructed by the State agencies. Besides tubewells, individual farmers have also constructed dugwells fitted with pumping sets for irrigation wherever feasible.

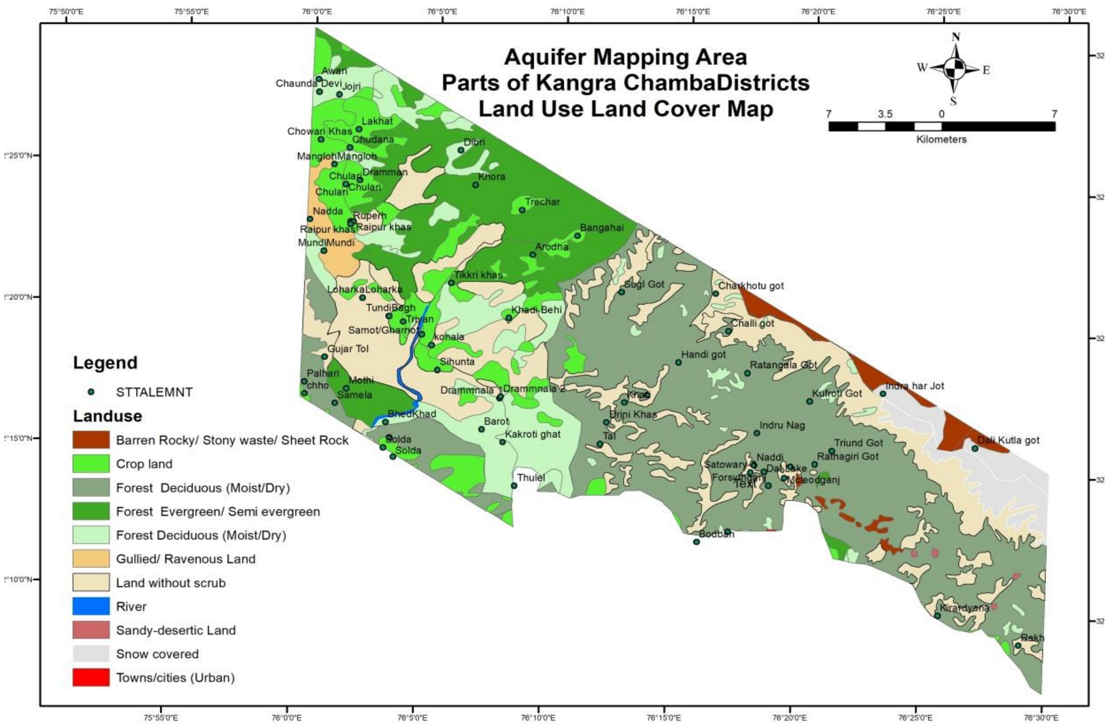


Figure 11: Land Use & Land Cover Map of Study Area

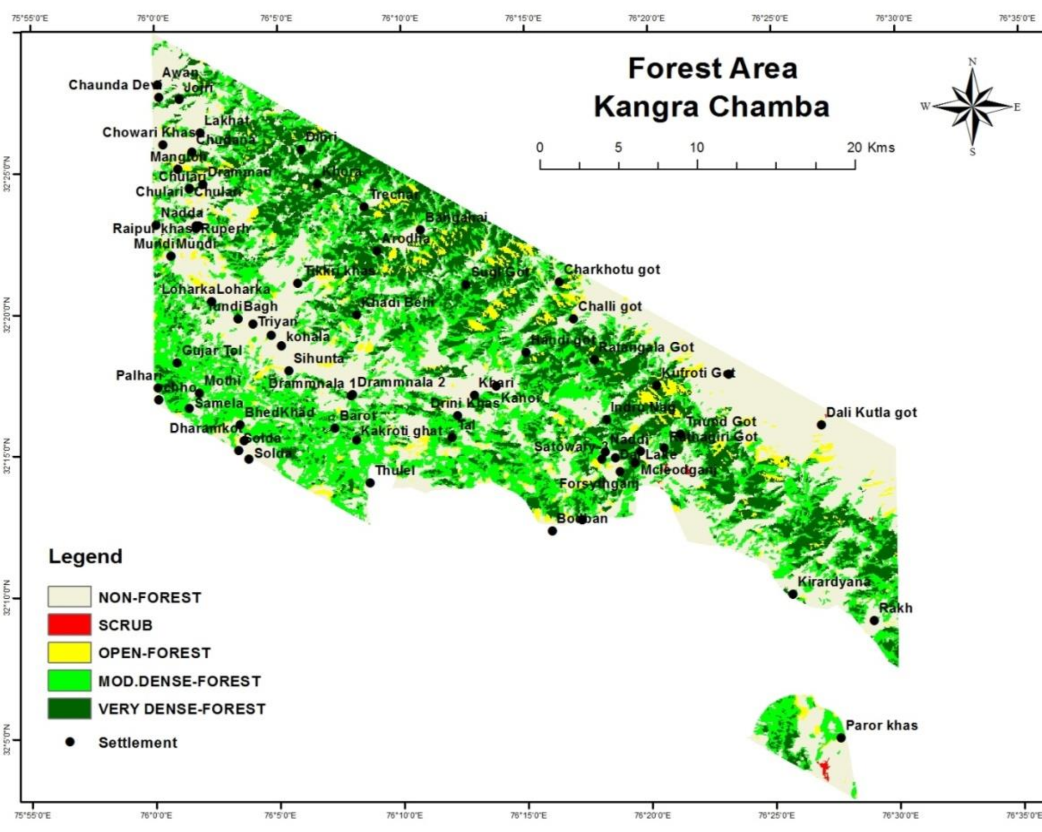


Figure 12: Forest Area Map of Study Area

1.15 Geological Setup

The area exhibits very complex geological disposition and can be sub divided into following Groups.

The Outer Himalayan Zone or Siwalik hill range predominantly of low lying hills extends from NW to SE. The Siwaliks are separated from Eocene by main Boundary Thrust. The Lower Himalayan Zone lies between MBT and Central Himalayan Thrust and composed of granites, gneisses, quartzites and other sediments of Krol belt. In addition to above zones, valley fills are more common in western and southern parts. Major moraine deposits are occurring in Kangra district. The recent moraine formations are occurring in higher altitude areas.

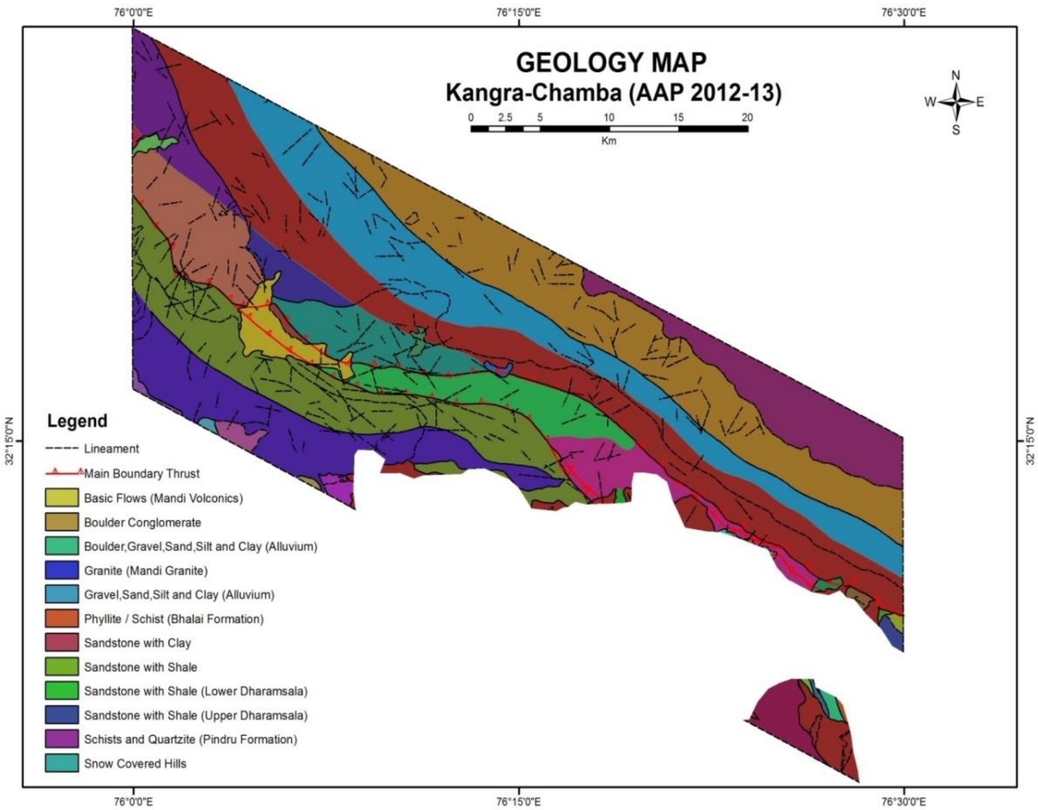


Figure 13: Geology Map of Study Area

Table.1.3: Geological succession in Kangra and Chamba districts of Himachal Pradesh.

Age	Group/Formation	Rock Types
Recent To Sub Recent	Alluvium, Fluvio-Glacial Deposit	Sand, Clay, Boulder
Lower Miocene To Middle Pleistocene	Upper Siwalik	Boulder Conglomerate, Sandstone
	Middle Siwalik	Sandstone, Clay
	Lower Siwalik	Clay, Sandstone
Lower Miocene to Middle Miocene	Murree, Kasauli, Daghsai, Dharamsala	Shale, Sandstone, Clay
Eocene	Susbathu, Kakra	Shale, Limestone, Sandstone
Cretaceous	Giumal, Chikkim	Quartzite, Limestone, Sandstone
Jurassic	Krol, Kiota, Laptal, Tal, Spiti	Quartzite, Shale, Limestone
Permian to Triassic	Kuling, Salooni	Shale, Slate, Limestone, Schist
Permo-Carboniferous	Infra Krol	Shale, Quartzite, Slate
Carboniferous	Lipak, Po, Manjir, Blaini	Conglomerate, Quartzite, Limestone, Slate, Boulder bed, Limestone
Devonian	Nagthat, Muth Quartzite	Quartzite
Pre Cambrian to Devonian	Haimanta, Jaunsar, Simla, Rampur, Shali,Larji	Quartzite, Slate, Shale, Dolomite, Limestone, Siltstone, Sandstone, conglomerate
Pre Cambrian	Jutogh, Vaikrita, Central Gneiss, Chamba, Chail	Slate, Phyllite, Quartzite, Sandstone, Schist, Granite and Gneiss

Lithologicaly, the study area composed of Granites, schists/Quartzites, Limestones, shales, sandstones & Gneisses ranging age from pre-cambrian to recent.. Granites covered major part of the study area.

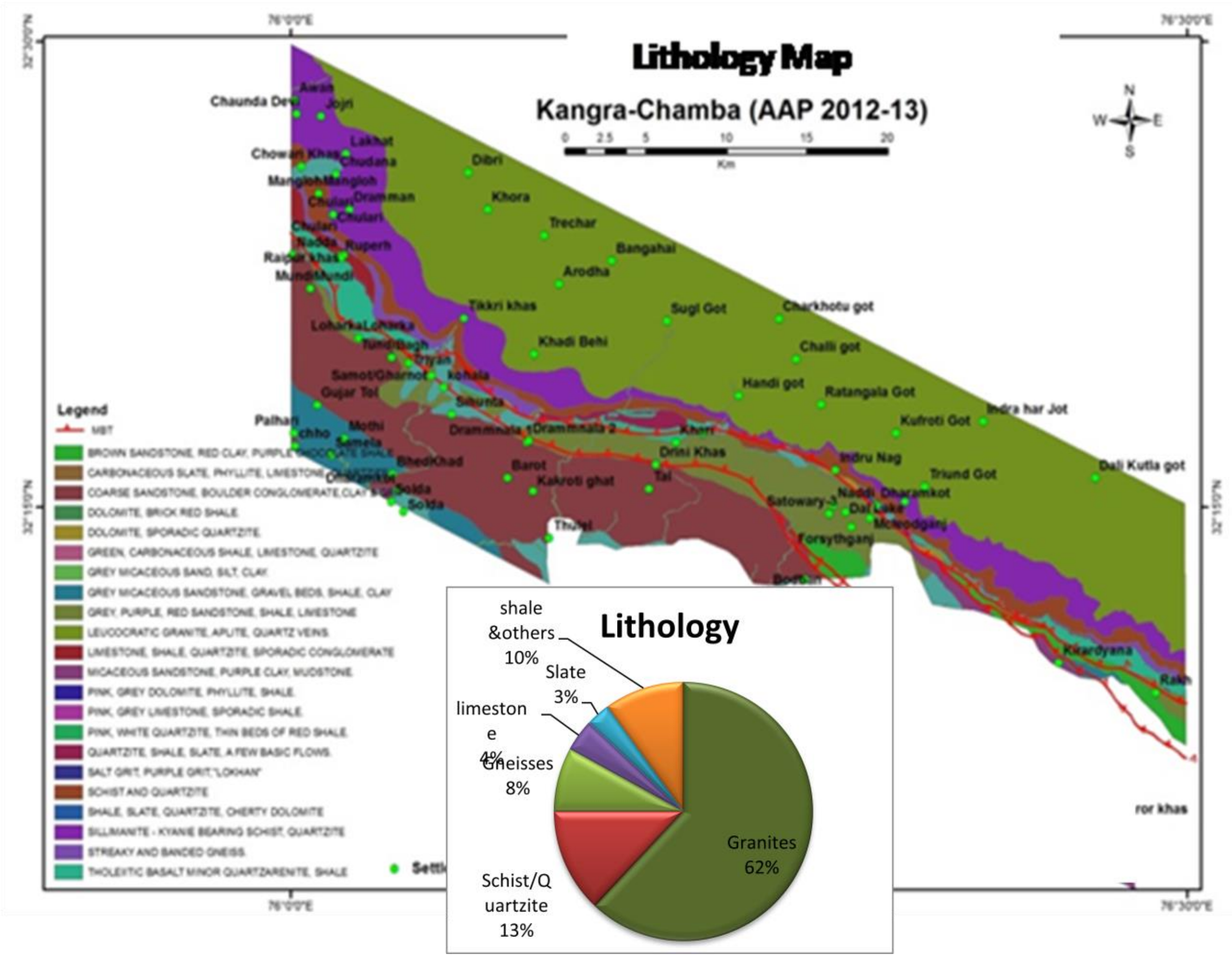


Figure 14: Lithology Map of Study Area

1.16 Main Boundary Thrust (MBT)

The Himalayas uphold a complex episodic tectonic history. It is formed as a result of collision between Indian sub-continent to Asia ~ 45-50 Ma (Thakur et al., 1995). The Dauladhar ranges which is a part of Great Himalayan ranges extends from north of Dalhousie in Chamba districts and extends through Kangra district. The Dharamsala- Kangra area is one of the most active earthquake zone in the Himalayan seismic belt due to the existence of MBT and experienced several destructive earthquakes in previous years. The Siwalik group of rocks of the lesser Himalayas consists of huge thickness of fresh water deposits bordering the Himalayas. An important feature of the Siwalik Group is its northern contact with the pre-Siwalik rocks which is faulted all along the length of the Himalayas, Medlicot(1864) introduced the concept of the main boundary fault , considering that the boundary between the Siwalik group and pre-Siwalik rocks, represents the northerner limit of the Siwalik basin , later faulted .

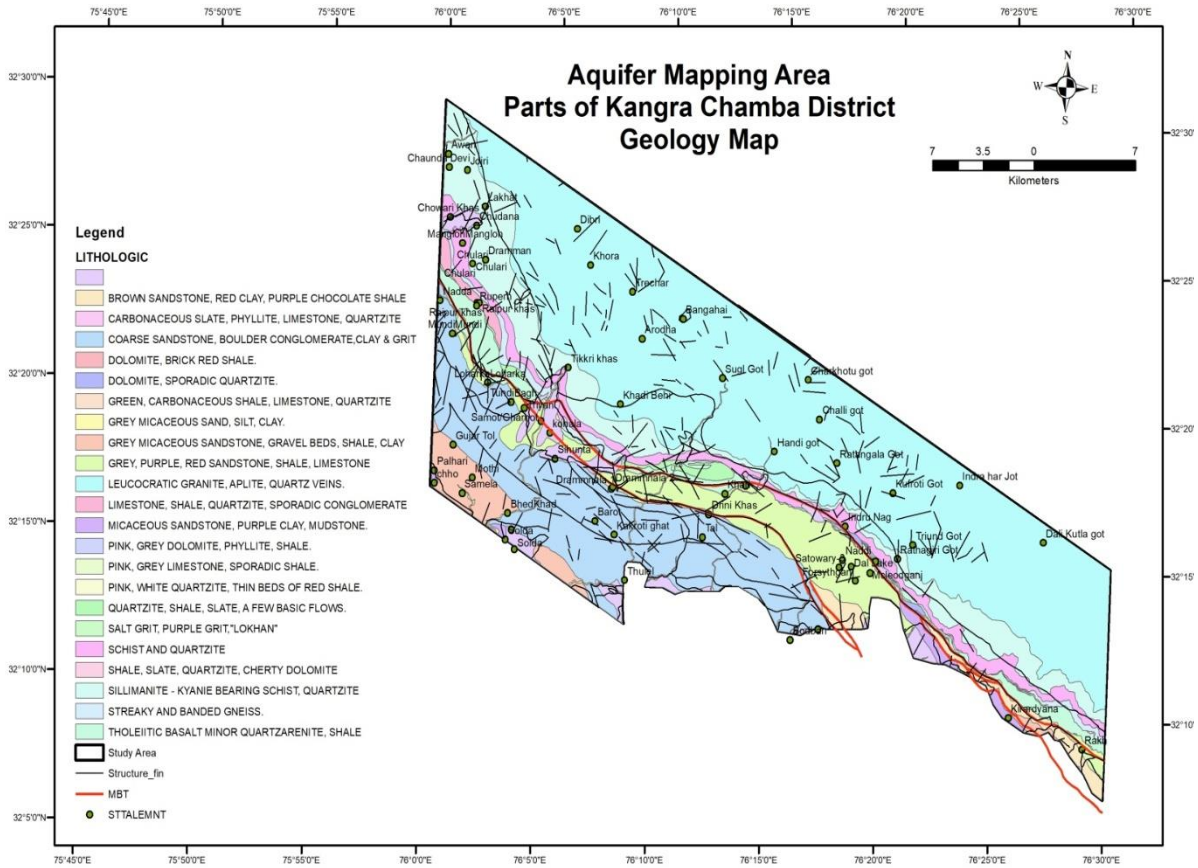
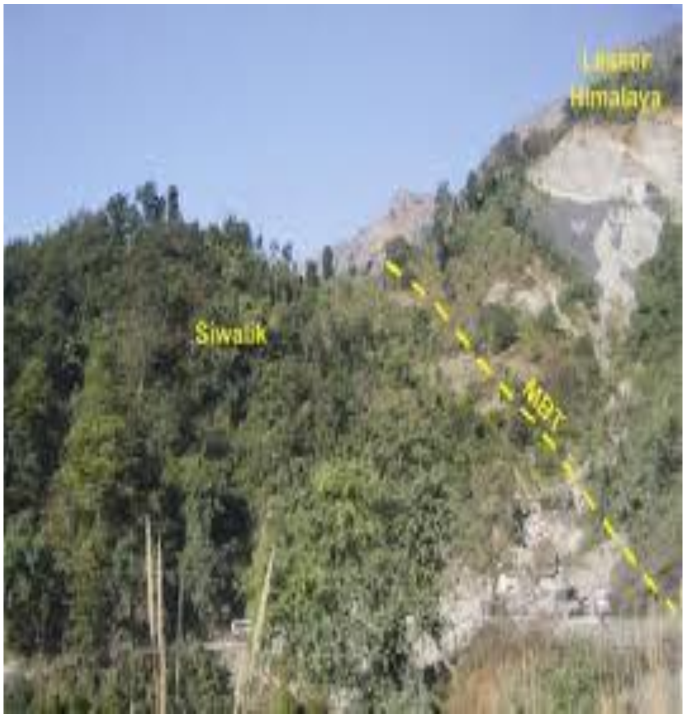


Figure 15: MBT & Lesser Himalayas and Siwalik hills separated by MBT

This steep thrust flattens with depth, developed during the Pliocene time and has been shown as active through the Pleistocene (Ni and Barazangi, 1984). The Main Boundary Thrust (MBT) is one of the major Himalayan thrusts and it is presently incorporated within the Himalayan thrust wedge (Lesser and Outer Himalayas) displaced above the Indian lithosphere (Mugnier et al., 1994).



The Siwalik belt is divisible into a number of broad structural units separated by low to moderately dipping thrust, namely Kotla, Jawalamukhi thrust. Considerations of the vertical displacements along these thrusts indicate that they are steepening in depth and are essentially vertical to sub-vertical in nature, developed along the pre-existing weak planes. The Siwalik basin formed as a foredeep in front of the newly risen Himalayas, continued with sedimentation as indicated by their huge thickness of shallow water sediments. As the subsidence proceeded, fracturing of the basement rocks controlled by the pre existing weak planes, the physical character and original structure of the rocks, occurred in the border zone and within the basin. These thrust trends in NNW-SSE to NW-SE direction and get successfully truncated towards NW by the main boundary fault.

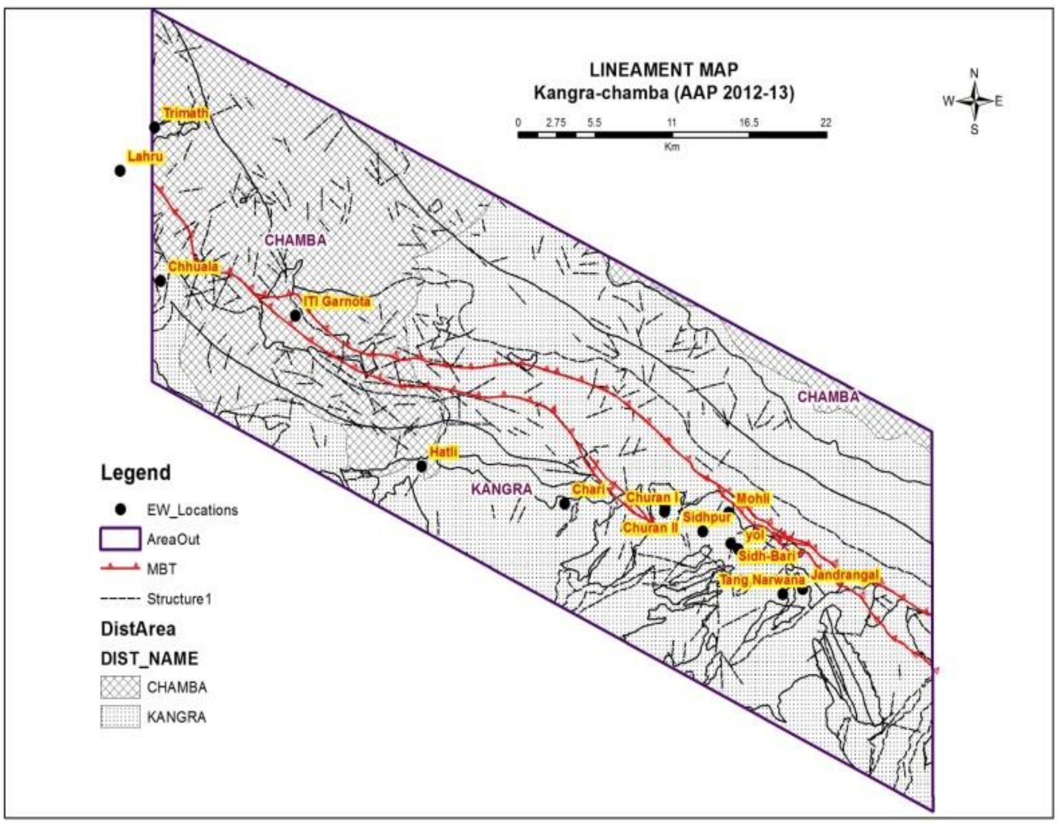


Figure 16: Lineament Map of Study Area

1.17 Hydrogeological Framework

The diverse physiographic, climatic, topographic and geologic conditions have given rise to diversified ground water situation in different parts of the state. The rock formation ranges in age from Archean to Recent occupy the area and control the occurrence and movement of ground water depending upon aquifer composition, structure and deposition. Hilly and mountainous parts with steep slopes mainly constitute the run off areas and have low ground water potential. In valley and low-lying areas, unconsolidated / semi-consolidated formations form good potential aquifers.

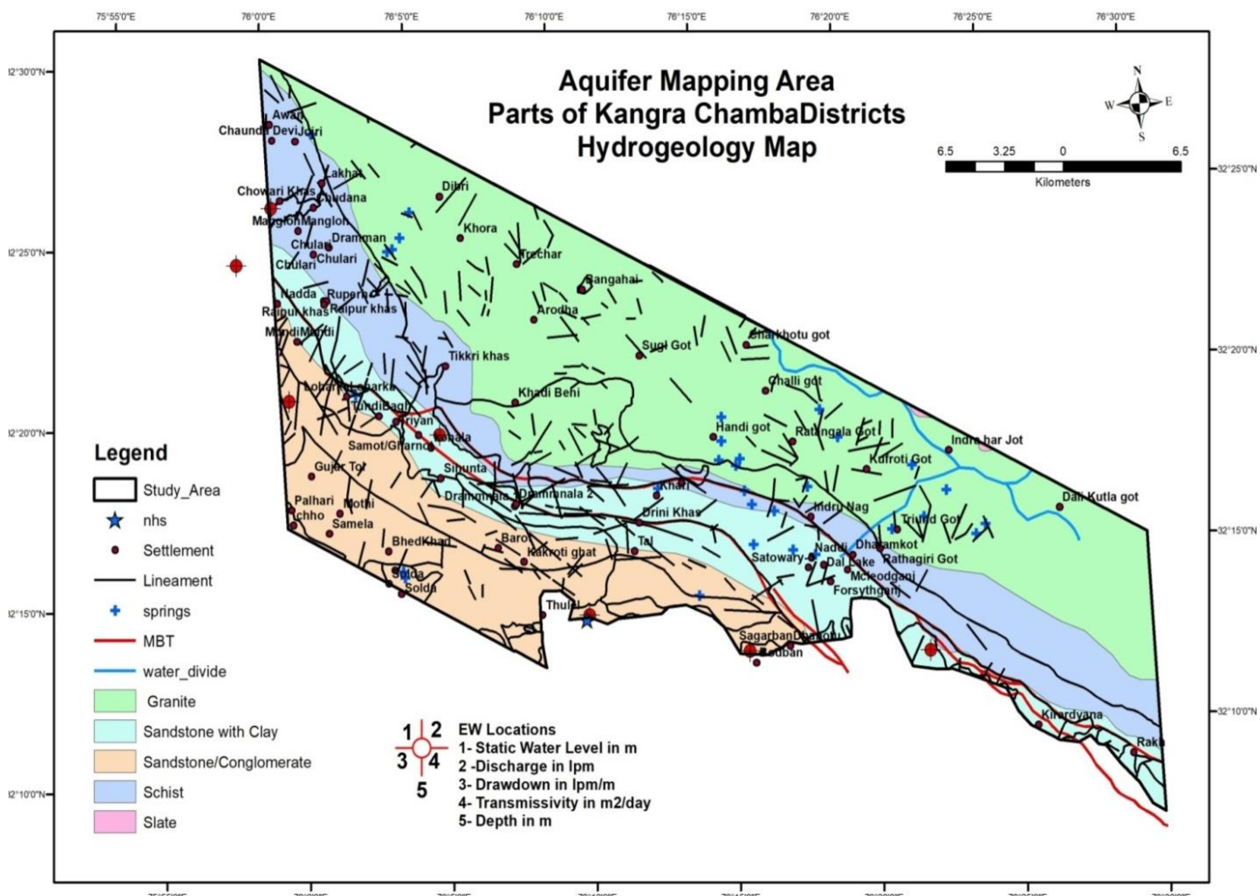


Figure 17: Hydrogeology Map of Study Area

Hydrogeology of the study area can be depicted by unconsolidated material in the form of Scree material/riverine deposits, which occurs in the north western part, with a depth from 1-20 meter below ground level. Uncnsolidated material (shiwalik) is found at a depth from 20 to 100 m (approximately) in the form of moraines, shales, in the central part of study area.

Consolidated material in the form of slate is found at one location at depth ranging from 20 m to 100m, overburdened with scree material, in north-western part. The discharge varies from 18 lpm to 720 lpm, which is considered as good aquifer.

Table.1.4 :Hydrogeology in study area of Himachal Pradesh.

Aquifer	**Type**	**Lithology**	**Distribution**	**Depth**	**Discharge lpm**	**Suitability**	**T (m3/day**
Aq-I	Unconsolidated	Scree/reverine	North-west	1-20 m	355	Yes	647
	Unconsolidated	Moranic/sst, shale	central part	20-100	18-72	Yes	
	Unconsolidated	Siwalik	central part	15-100	29	Yes/No	1.4
	Consolidated	Slate	North-west	20-101	720	Yes/No	

1.18 Springs

In the study area, 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.A 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. Other important springs are located at the intersection of Jawalamukhi- Kotla thrust and north-south trending faults.

Figure 18: A series of springs in the study area

Two major springs are Trilokpur(30 lps) and Jangle(28 lps). All these springs are oozing out within the contact of conglomerates and alluviums. These springs are used for water supply schemes in the surrounding areas

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 Neoglepul near Palampur oozing out from the conglomeratic formation,which are highly fractured along the bedding planes giving a discharge of more than 60 lpm.

1.19 Water Use and Demand

1.19.1 History of Water Use in Dharamshala, Kangra District:

The management structure of water resources and the trends of water use in Dharamshala have seen many changes since the town was first inhabited. It is estimated that the first piped water-supply system in Dharamshala was laid during British rule in the mid to late 1800s (the precise date is not known). This system has been expanded in stages since then, but even today, not all parts of the town have access to piped water supply (Malhotra 2009). Senior residents of Dharamshala recall that prior to the 1960s, there used to be equilibrium in the supply and demand of water in the town. There are two primary explanations for this equilibrium: firstly, the population of Dharamshala was much smaller during this period (less than 10,000 people), which indicates that the total demand for water was lower. Secondly, limited household access to convenient and piped water kept the per capita demand in check. Water supply infrastructure in Dharamshala during this period was poorly developed, and therefore, residents would often fetch water on their own from natural springs (known as baulis) and streams that flowed through Dharamshala. As a result, water was used frugally. For example, people would not bathe or wash clothes every day, and used pit latrinesfor sanitary purposes (Tandon 2009). With the introduction and expansion of the piped water network, new uses of water that were previously not feasible became possible. For example, as awareness about hygiene and sanitation increased, residents adopted the water-intensive western model of water supply and sanitation, which included the use of septic tanks. Additionally, a growing tourist industry and rapid urbanization resulted in a greater increase in the demand for water since the 1960s (Tandon 2009).

1.19.2 Traditional Sources of Water Supply:

Traditionally, Dharamshala has relied mostly on surface water for its needs. Examples of surface water sources include small streams (*nullahs*), medium-sized streams (k*hads*), and rivers. Water from stream sources is collected via pipes, and diverted to one of two water treatment plants in Dharamshala. The method of diversion depends on the relative location of the water source and the treatment plants. Most streams that supply water to Dharamshala originate at higher elevations in the Dhauladhar Mountains and therefore, the water from these streams is carried to the treatment plants via gravity (Tandon 2009). In addition to surface water, Dharamshala also relies to some extent on spring sources. These spring sources are considered to be generally pristine, and therefore water from springs is only chlorinated before it reaches the point of use. After treatment, the water is distributed either to individual households or public taps via a centralized water supply system, also by gravity. At the point of use, water is generally stored in overhead storage tanks by consumers who have individual household connections. Generally, the pressure of the piped water supply is high enough to transport it to these tanks, which are typically installed on terraces. Those without access to individual connections collect water from public taps and store it in buckets (Tandon 2009).

On average, water is supplied for two hours per day, at various times of the day in different parts of the town. During lean periods, however, IPH adjusts its water supply by providing water for only one hour per day, or half hour per day, and at times of acute scarcity, on alternative days (Tandon 2009). Thus, water rationing has been a regularly employed strategy to deal with limited water supply, necessitating some form of storage at the household level, either in tanks, or buckets (Tandon2009).

As far as water quality is concerned, IPH maintains that water sources in Dharamshala are relatively pristine, and so far, no health concerns have emerged. Moreover, past studies indicate that many households in Dharamshala either filter[11] or boil their drinking water, and therefore, water quality does not seem to be a major issue of concern for the town (Sterkele, et al. 2003). In some locations, residents still have the option of getting water directly from streams or springs on their own (using buckets), and as a rule, do, given that not all parts of the city have access to piped water (Tandon 2009).

[11] This information was taken from a report on the water management in Dharamshala by Sterkele, et al. (2003), and the type of filtration was not specified in the report.

Overall, it is estimated that 86% of households in Dharamshala have individual connections, and 12% have access to public water taps (Sterkele, et al. 2003).

Based on increased demand, additional water sources have been added to Dharamshala's water supply on an incremental basis in the last ten years (Department of Irrigation and Public Health 2009). Currently, there are six main sources that supply water to the town. Table below lists these sources, along with the quantity of lean period discharge available in these sources and the quantity of water drawn from these sources during wet as well as dry periods.

Table:1.5 Water Demand of Dharamshala Area

Source	Available Discharge in 2006 during Lean Period (LPD[1])	Water Drawn in 2009 during Wet Period (LPD)	Water Drawn in 2009 during Lean Period (LPD)
Churan *Khad*	2,710,000	900,000	700,000
Glenmore Spring	106,670	100,000	60,000
Bhagsu Spring	325,000	300,000	260,000
Dhoop *Nullah* (Dharamkot)	400,000	300,000	100,000
Bathed *Khad*	5,284,800	4,200,000	3,000,000
Additional Water from Bhagsu Spring	-	-	700,000
Total:	8,826,470 LPD	5,800,000 LPD	4,820,000 LPD
[1]LPD = Liters per day			

Source: Department of Irrigation and Public Health (2009)

According to this table, if the average available discharge in Dharamshala during the dry season is assumed to be 8.8 MLD, and water drawn during the lean period is assumed to be 4.8 MLD, this means that approximately 54%[12] of the available discharge in the supply sources of Dharamshala was withdrawn for consumption in 2009. This gives an estimate of the extent of water stress in Dharamshala per international standards. For example, IPCC and the United Nations Environment Programme (UNEP) use an index developed by Falkenmark and Lindh (1976) which categorizes water stress based on the amount of water withdrawn in a region as a percentage of available water resources in that region (IPCC 2001).

12 This calculation of 54% is derived by dividing the water drawn during the lean period (4.8 MLD) by the average available discharge during the lean period (8.8 MLD

In this categorization, the regions in which over 40% of total available water resources is withdrawn are denoted as regions facing the highest magnitude of stress (IPCC 2001). Thus, the data on surface-water discharge indicates that Dharamshala faces significant water stress during the dry season.

1.19.3 Groundwater:

It was mentioned earlier that Dharamshala has primarily relied on surface sources for its water supply, along with some spring sources that emanate naturally from the sub-surface. Until the last decade, the town had not considered extracting groundwater via pumping wells to augment its supply. However, since the beginning of the new century, IPH has installed numerous hand-pumps and motorized pumps in various parts of Dharamshala in order to extract groundwater (Tandon 2009). Records indicate that these pumps are used by government institutions such as police stations, municipal schools, and the Government College (Department of Irrigation and Public Health, Himachal Pradesh 2009). Table 6 gives a summary of the number of pumps installed by IPH in the town, along with the average daily extraction rate of each pump. The total daily extraction of water from these pumps amounts to 837,000 LPD, which is roughly 17% of the daily water supply of Dharamshala as shown in Table 5. The rates of extraction given in Table 6 are based on estimates made by senior officials in the Dharamshala Zone office, and are not accounted for in the overall water supply-demand calculations derived by IPH for the town (Tandon 2009). Additionally, the data in Table 6 does not include the numerous individual motorized and manual pumping wells that have been installed by various users in Dharamshala without registering them with IPH.

Table1.6 : Types of pumps used for extraction of ground water in Dharamsala,KangraDistt(Sudhalkar, 2010).

Type of Pump	Number of Pumps	Daily Rate of Extraction Per Pump (LPD[1])	Total Daily Extraction (LPD)
Manual Hand Pumps	21	9,000	189,000
Motorized Hand pumps	18	36,000	648,000
		Total:	837,000 LPD
[1]LPD = Liters per day			

Source: Department of Irrigation and Public Health, Himachal Pradesh (2009)

There is no reliable estimate on the number of private pumping wells being operated by users in the town and the amount of groundwater extracted from these wells. However, it can be assumed that given the upfront investment required to install private wells, it is probably only the wealthier households and commercial users like hotels that are currently able to avail of the benefits of private wells (Sterkele, et al. 2009, Sudhalkar, 2010).

1.19.4 Storage Reservoirs:

Dharamshala currently has ten municipal storage tanks located at various sites within the town. The combined storage capacity of these tanks is 3.33 million liters (Department of Irrigation and Public Health, Himachal Pradesh 2009). This storage capacity is less than the quantity of water supplied on a daily basis to Dharamshala, which, according to Table 5, is 5.80 MLD during normal wet conditions. This lower storage capacity is partially due to the fact that a portion of the water supply is piped directly from sources to the end users. However, even after accounting for this direct supply, there is still a deficit in the town's storage capacity, implying that storage tanks are able to hold less than a day's worth of water supply. This means that the town cannot store water to be prepared for unanticipated problems that could arise in 77 the various components of the water supply system (i.e. extraction, treatment and distribution). For example, natural hazards like landslides or floods could cause damage to water infrastructure, thereby disrupting supply, and during such times, the presence of adequate storage systems is highly desirable. Additionally, limited storage capacity prevents the town from being able to store large quantities of water for use during the dry season, which is when there are limited reliable sources of water available to the town (Sudhalkar, 2010).

1.19.5 Current and Future Demand for Water in Dharamshala:

In light of the expected population growth and urbanization trends projected for the town, IPH has documented the current and projected demand for water up to the year 2015 in Dharamshala. Table 7 provides details on the distribution of users of water in the town, along with present and future demand for water (Department of Irrigation and Public Health, Himachal Pradesh 2009). These projections of water demand are based on minimum acceptable rates of consumption for each of the user categories listed in the table, as determined by the Himachal Pradesh Department of Irrigation and Public Health. From the table, it is clear that the population of Dharamshala is going to increase by approximately 58% of its current population by 2015. As a result, the demand for water will increase by approximately the same magnitude. Similarly, there is an expected increase in the number of students, employees, and visitors as well as commercial user categories (Sudhalkar, 2010).

Table 1.7: Current and projected water demand by user category (Sudhalkar, 2010).

	2009			2015		
	Number of Units	Unit Rate of Consumption in Liters/Day	Water Demand in MLD[1]	Number of Units	Unit Rate of Consumption in Liters/Day	Water Demand in MLD
Persons	34,036	120	4.08	53,948	120	6.47
Students & Employees	11,661	45	0.52	18,483	45	0.83
Hotel Beds	592	180	0.11	940	180	0.17
Visitors	4,498	45	0.20	7,129	45	0.32
Rest Houses	385	135	0.05	610	135	0.08
Hostel Beds	633	135	0.09	1,004	135	0.14
Hospital Beds	415	455	0.19	658	455	0.30
Cinema Seats	434	15	0.01	688	15	0.01
Fire Hydrant	-	-	-	-	-	0.70
		Total	5.25		Total	9.02

[1]MLD = Million Liters per Day

Source: Department of Irrigation and Public Health (2009)

2. DATA ACQUISITION & METHODOLOGY

The different data to be collected for aquifer mapping are:

A. Administrative Boundaries.
B. Demography.
C. Agriculture and irrigation.
D. Land use and land cover.
E. Hydrometeorological data.
F. Hydrological data.
G. Soil.
H. Geological data.
I. Hydrogeological data.
J. Ground Water Exploration data.
K. Pumping Test data.
L. Geophysical data.
M. Well census data.
N. Ground Water Resources Estimation.
O. Hydro-geochemical Data.
P. Data on springs.
Q. Mining/ Industry present in the area.
R. Data on salinity hazard in coastal areas.

A. Administrative Boundaries

First different maps of the study area such as district, taluka / block and village boundary has to be collected from concerned state government department. This will be helpful in delineation of the aquifer boundary and collection of other relevant data.

B. Demography

Demographic data from population census and district agencies can be collected. From population data one can know the present water utilization pattern of the area and future demand can also be worked out.

C. **Agriculture and irrigation**

Agriculture and irrigation data has to be collected from concerned state government department. Whether it is ground water or surface water agriculture is the largest user. Data on cropping pattern and irrigation has to be collected from state government agencies. These data can be collected from irrigation, minor irrigation department etc.

D. Land use and land cover

Land use and land cover data can be collected from district statistical hand book and from the concerned block/taluka. This data shall be useful to know the detailed land utilization pattern of the area such as forest, barren and uncultivable land etc.

E. Hydrometeorological data

Data on rainfall, temperature, humidity, wind velocity and potential evapo-transpiration of the study area has to be collected. Monthly rainfall data can be collected from Indian Meteorological Department (IMD) as well as state government agencies. This shall be helpful to estimate the surface run off and the recharge by rainfall into the aquifer system. Drought analysis of rainfall data can be done to know the frequency of droughts. If data on infiltration rate of the soil is available, it can also be collected.

F. Hydrological data

Data on measurement of flow in streams/ water bodies has to be collected. If available data on drainage patterns/ order of streams such as length and breadth of 1^{st}, 2^{nd} and 3^{rd} order streams would be collected. Data on water bodies Tanks/Ponds and other water conservation structures are to be collected from different agencies.

G. Soil

Soil is the thin layer on the surface of the earth where living beings survive. It is the weathered product of bed rocks occurring in the area. The data on different types of soil their geochemical characteristics occurring in the area has to be collected. The type of soil controls the rate of infiltration of rainfall and runoff.

H. Geological data

Lithology and structure controls the occurrence and movement of ground water in crystalline rocks. In alluvial formation, occurrence of porous material like sand, gravel forms very good aquifers. Geological map can be collected from Geological Survey of India. It gives detailed information on lithology of the area. Detailed information on structure like lineament, fault, fold is available in the geological map. Detailed report on geology is also available with different state geological department which can also be collected.

I. Hydrogeological data

Different state agencies like state ground water department etc. used to do hydrogeological survey of the state. Data like pre and post-monsoon depth to water level and detailed hydrogeological report can be collected. Data available with Central Ground Water Board on Systematic Hydrogeological Survey, Ground Water Management studies can also be collected. Data on well yield, areal extent and aquifer disposition has also to be collected.

J. Ground Water Exploration data

State ground water department & Public Health and Engineering Department is engaged in drilling activities for different purposes. Data on depth of weathered zone, detailed borehole lithology, depth of occurrence of fracture zones, well yield of individual fractures can also be collected. Ground water exploration data available with Central Ground Water Board can be collected and compiled.

K. Pumping Test data

A pumping test is performed to find out the behaviour of aquifer as well as the well in response to the stress applied in the form of pumping. The pumping tests are generally conducted to determine:

a. Yield and sustainability of well (Yield Tests).
b. Performance and efficiency of the well (Well Performance Tests).
c. Hydraulic properties of the aquifer (Aquifer Performance Tests).

The aquifer parameters are required for planning ground water development and management. These are required for planning the type and nature of wells to be constructed for various purposes. These are also required for developing a mathematical model for any area, which in turn helps in designing ground water management strategies. The different parameters to be collected are Hydraulic Conductivity or Permeability (K), Transmissivity (T or KD), Specific Yield (Sy), Storativity or Storage Coefficient (S), Hydraulic Resistance (C), Leakage Factor (L) etc.

L. Geophysical data

By geophysical investigation one can know the anomalies or signatures of the physical properties of material beneath the earth surface. Geophysical measurements made remotely or insitu, characterize subsurface geology, geological structures based on lateral and vertical mapping of physical property variations. Geophysical data of the aquifer available with state department has to be collected to know the lateral as well as vertical extent of the aquifer. A variety of methods exists for collection of geophysical data of the aquifer, viz., Schlumberger, Wenner, dipole-dipole etc. By geophysical studies one can get the depth of weathered zone thickness, occurrence of fracture zone etc.

All available Vertical Electrical Sounding (VES) data has to be compiled and analysed from which different geo-electric layers can be deciphered. Available sub-surface logging data has to be interpreted. 2-D imaging data, and Heliborne survey data can be acquired from NGRI. From these studies vertical and lateral extent of different layers such as clay can be determined.

M. **Well Census data**

Well census data regarding total number of ground water structures such as dug wells, bore wells has to be collected. Data on well yield, depth and diameter has to be collected. Ground water draft data of all the ground water structures available has to be collected.

N.Ground Water Resources Estimation

Ground water resources are estimated assessment unit wise. The assessment unit is watershed in the states occupied predominantly with hard rocks. This is because the ground water balance equations recommended in GEC-1997 can be better applied in the assessment units with hydrologic/ hydrogeologic boundaries. The ground water recharge is estimated season-wise both for monsoon and non-monsoon season. The following recharge and discharge components are assessed in the resource estimation. Recharge from rainfall, recharge from canal seepage, return flow from irrigation, recharge from water tanks & ponds and recharge from water conservations structures and discharge through ground water draft. Ground Water Resource Estimation data available should also be collected.

O. Hydro-geochemical Data

There are two major objectives of water quality studies:

1. To ensure safe water for various types of uses
2. As a tool for understanding, characterization and quantification for various natural processes and parameters. The different chemical data available with the organisation, state ground water department and other agencies can be collected which will be helpful in delineation of chemical quality problem areas like fluoride, arsenic, nitrate. On the basis of the data future sampling in the entire aquifer can be done.

P. Data on springs.

A spring is a localized natural discharge of ground water issuing on the land surface through well-defined outlets. The discharge may vary from a trickle to a stream. Data on springs, auto-flow wells present in the area has to be collected.

Q. Mining/ Industry present in the area.

All data regarding mines both open cast and underground of the area has to be collected. Any mining activities like coal etc affect the aquifer. By mining activities the ground water of the surrounding aquifer is affected. So data on mine dewatering are to be collected.

R. Data on salinity hazard in coastal areas.

Salinity hazard is mostly common in coastal areas and in some inland areas. So data on areas affected with salinity hazard has to be collected. All the collected data has to be compiled and various thematic maps will be prepared. On the basis of these thematic maps further studies will be carried out.

2.1 METHODOLOGY AS PER EFC

Table 2.1: Tentative norms of activities to be taken for Aquifer Mapping as per EFC

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

2.2. AS PER GUIDELINES FOR HILLY AREAS

a. Exploratory data 1.

Data Required

i. Desirable spatial scale should be 5" x 5" grids and 100 m depth depending upon the area attributes.

ii. In hilly areas 10*EWs* and 10 OW"s should be constructed (wherever possible) at suitable locations, preferably one in central quadrant and one each in the four corner quadrants for establishing aquifer geometry and determining aquifer parameters. (Fig-Dl)

iii. For the first aquifer 3-4 pumping test are be carried out in dug wells/ if possible in shallow bore wells.

iv. Aquifer performance test shall be conducted at all the ten EWs tapping different aquifers to estimate the aquifer parameters/ hydraulic characteristics and water quality.

2. Data adequacy and Data gap analysis

1. Assessment of Data Adequacy (Adequacy of available sub-surface information for deciphering aquifer geometry at the desired vertical&horizontal scale) is to be done based on recommended and available information.
2. Aquifer parameter availability upto the desired depth should be presented in form of square diagram for each quadrant. (Fig-D2)

3. Quadrant wise recommended and existing EW/OW/PZ/SH should be depicted using square diagram and the additional EW/OW/PZ/SH etc. required for aquifer geometry delineation should be assessed (Fig-D3).

b. Geophysical Data

1. Data Required

i. Desirable spatial scale should be 5" x 5" grids and 100 m depth depending upon the site attributes.(wherever possible)

ii. It is recommended that 2 Profiling/VES/TEM soundings having 100 meter interpretation depth should be carried out in each of the nine quadrants of the toposheettotaling to 18 nos. in each sheet to decipher aquifer geometry (Fig-D4).

iii. It is recommended that all the Exploratory Wells should be e-logged and the data should be tabulated.

Sample-Geophysical data required for aquifer in Hilly areas (Quadrant wise)		
2 Profiling/ VES/TEM	2Profiling/ VES/TEM	2 Profiling/ VES/TEM
2 Profiling/ VES/TEM	2 Profiling/ VES/TEM	2 Profiling/ VES/TEM
2Profiling/ VES/TEM	2 Profiling/ VES/TEM	2 Profiling/ VES/TEM

2.Data adequacy and Data gap analysis

1. Assessment of Data Adequacy is to be done based on recommended and available information.(Fig-D5)
2. Quadrant wise recommended and existing VES/TEM profiling data should be depicted using square diagram and the additional Profiling/ VES/TEM required for aquifer
3.

c. Ground Water Monitoring Data

1.*Data Required*

i. Desirable spatial scale should be 5"x 5" grids and 100 m depth.

ii. One open/dug well is recommended for each quadrant of a toposheet. (Fig-12)

iii. All the spring sheds in a toposheet should be demarcated and only sustainable spring sheds are to be taken for discharge and quality monitoring.

iv. Minimum four times monitoring annually is recommended as per the state specific schedule of monitoring.

Sample-GW monitoring data required for the aquifer in hilly area		
1stAq - 1	1stAq - 1	IslAq - 1
1stAq - 1	1stAq - 1	1stAq - 1
1stAq - 1	1stAq - 1	1stAq - 1

4. geometry delineation should be assessed (Fig-D6)

d. Ground Water Quality Data

i. Assessment of Data Adequacy is to be done based on recommended and available information.(Fig-08)

ii. Quadrant wise recommended and existing DW/PZ should be depicted using square diagram and the additional DW/PZ required for ground water monitoring should be assessed (Fig-D9).

1.Data Required

i. Desirable spatial scale should l be 5".x 5"grids and 200 m depth.

ii. For I[5]'aquifer (un-confined/Phreatic) one .sample from open/dug wells isrecommended for each quadrant of a toposheet. (Fig-DIO)

iii. Quality of available springs should be monitored.

iv. Minimum two times monitoring initially is recommended for qualitymonitoring.

2.Data adequacy and Data gap analysis

i. Assessment of Data Adequacy is to be done based on recommended and available information and depicted as in Fig-D 11.

ii. Quadrant wise recommended and existing quality monitoring stations should be depicted using square diagram and the additional quality monitoring stations required should be assessed (Fig-012)

Sample- GW quality data required for the aquifer in hilly area		
IstAq- 1	1stAq - 1	1stAq – 1
1stAq - 1	1stAq - 1	1stAq – 1
1stAq - 1	1stAq - 1	1stAq – 1

3. DATA - GAP ANALYSIS, ADEQUECY

3.0 Existing Data Base

1 Exploration

The study area along Main boundary Thrust which falls in Chamba district is completely unexplored. The exploration in Chamba district is obstructed by steep rising hills and intervening highly dissected valleys, hard accessibility and limited availability of working period due to intolerable climatic conditions.

The exploration in the Kangra district has been confined to valley fill areas as well as moranic deposits. Out of 13 exploratory wells drilled so far 4 have been constructed in valley fills where as 9 exploratory well are constructed in moronic deposit. The Depth drilled ranges from 23.50 to 122.27mbglwhereas the discharge varies from 7.2 to 1329 lpm.

Table 3.1: Location and draft details of exploratory wells in the nearby study area, District Kangra.

Sl_No	Location	Latitude	Longitude	Formation	Depth (m)	Discharge (lpm)	Transmissivity (m^3/day)
1	Sidhpur	32°11’ 37”	76°21’ 08”	Morainic	86.40	1026	673.00
2	Sidhwari	32°11’ 12”	76°22’ 13”	Morainic	62.40	757	47.56
3	Yol	32°11’00”	76 22’ 30”	Morainic	86.00	190	222.80
4	Dari	32°12’ 00”	76°20’ 15”	Morainic	71.00	1329	270
5	Pathiar	32°07’42”	76°24’15”	Morainic	100.00	300	-
6	Churan-I	32°08’12”	76°20’05”	Morainic	86.17	-	-
7	Churan-II	32°07’42”	76°24’15”	Morainic	122.27	7.2	7.27
8	Khabbal	32°07’42”	76°24’15”	Valley fill	70.00	1105	216.09
9	Bajhera-I	32°07’42”	76°24’15”	Valley fill	45.50	105	61.60
10	Bajhera-II	32°08’05”	76°22’24”	Valley fill	23.50	-	-
11	Shahpur	32°12’50”	76°10’55”	Valley fill	75.00	632	-
12	Massal	32°05’39”	76°23’24”	Morainic	84.00	16.8	-
13	Tang Narvana	32°09’26”	76°24’15”	Morainic	72.50	120	-

2.Geophysical - VES and Profiling

VES were already conducted in 9 selected locations in the study area by NWR Chandigarh region in 1987. The study was done by Schlumberger method to identify the possibility of constructing tube wells in the area. Even though the ground water potential of Siwaliks and Chamba Formations are meager, the moderately high resistivity layers indicating boulders with clay and sand stones. From the data obtained from 2 test boreholes, K, KQ, KH, Q and H types of VES curves were found. Resistivity of aquifer zones varied from 2700 to 23Ohm-m. The depth and thickness of the aquifer varied from 1.6 to 74 mbgl. Test drilling was recommended at one or two locations up to a depth of 70 m.

Schlumberger VES has been implied using Aqua meter AC resistivity meter. Maximum current electrode separation was 240m. Partial and complete curve matching techniques were used to analyze the sounding data with the help of Auxiliary Master Curves of CGG, 1963.

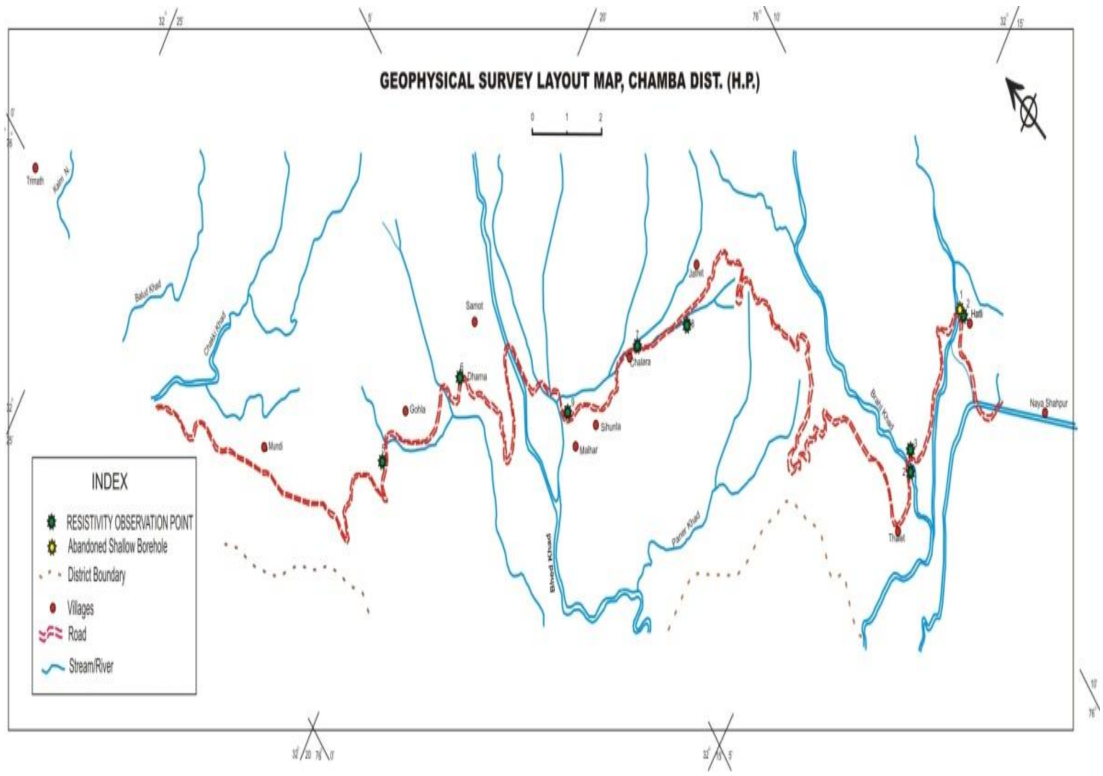


Figure 14: Geophysical Survey Location map of study area

Table 3.2: Geo-electrical parameters obtained from VES in the study area.

INTERPRETED RESULTS OF RESISTIVITY SOUNDING DATA

VES No.	locations	Geo- electric parameters							
		Resistivity (ρ) in Ohm-m				Thickness (h) in meters			
		1st layer	2nd layer	3rd layer	4th layer	1st layer	2nd layer	3rd layer	4th layer
1	North of Hatli	180	2700	1170		1.75	2.3		
2	Thelel (Govt. Middle school	390	585	35	V.L	1.75	2.1	25	
3	Thalel (Near Km stone No. 59)	180	360	51		2.1	12.6		
4	Hatli (Near Dramman Khad)	120	240			2.0			
5	Chhowala Nallah	160	400	105	160	1.9	1.9	9.5	
6	Dharan (culvert No.35/2)	115	23			1.6			
7	Chalara (in Sri Sardar Singh's land	83	290			2.4			
8	Military base point	Not interpretable							
9	Laherahar (in agriculture land of Sh. Raj Kumar sharma)	97	340	46		3.1	7.1		
10	Thrimuth	1900	95	1650		1.7	8.5		

3.Water Level Monitoring

The area is mostly hilly and devoid of dug wells. Only one NHS well is present in the study area. The water level monitoring was mainly carried out from NHS wells of surroundings area under study. The water level data obtained from the NHS wells in the surrounding area are as given below.

Table 3.3: NHS locations and water level (mbgl) in surrounding area of study area.

Sl. No.	Location	Depth to the Water Level. (mbgl)		
		May-12	Nov-12	Jan-13
1	Manjgram	1.56	1.00	1.96
2	Rait	9.90	6.97	9.10
3	Mao	4.78	1.09	4.53
4	NagrotaBagwan	Dry	Dry	Dry

4 Hydrographs

The decadal groundwater level trend for both pre monsoon (in the month of May) & post monsoon (in the month of November) of nearby dug wells are shown in the form of Hydrograph, which has been prepared with the help of water level monitoring data since 1999.During pre-monsoon period trend is showing falling behaviour of ground water level and during post monsoon, groundwater level trend is showing rising or stable water level behaviour.

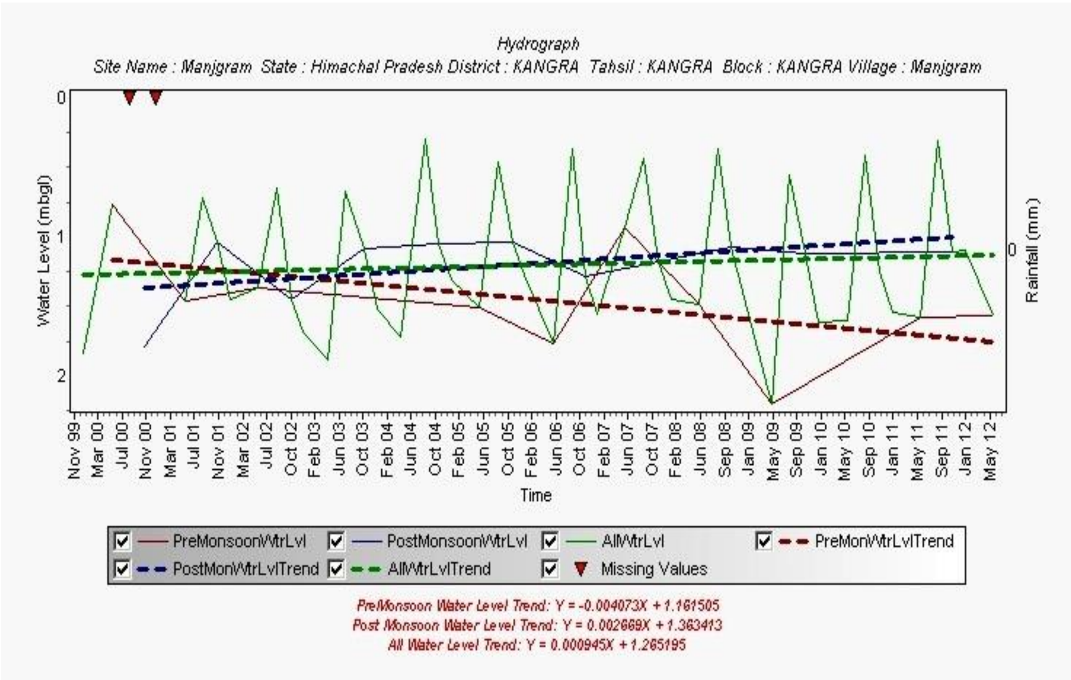


Figure 19(a): Decadal fluctuation trend in the water level at Manjgram

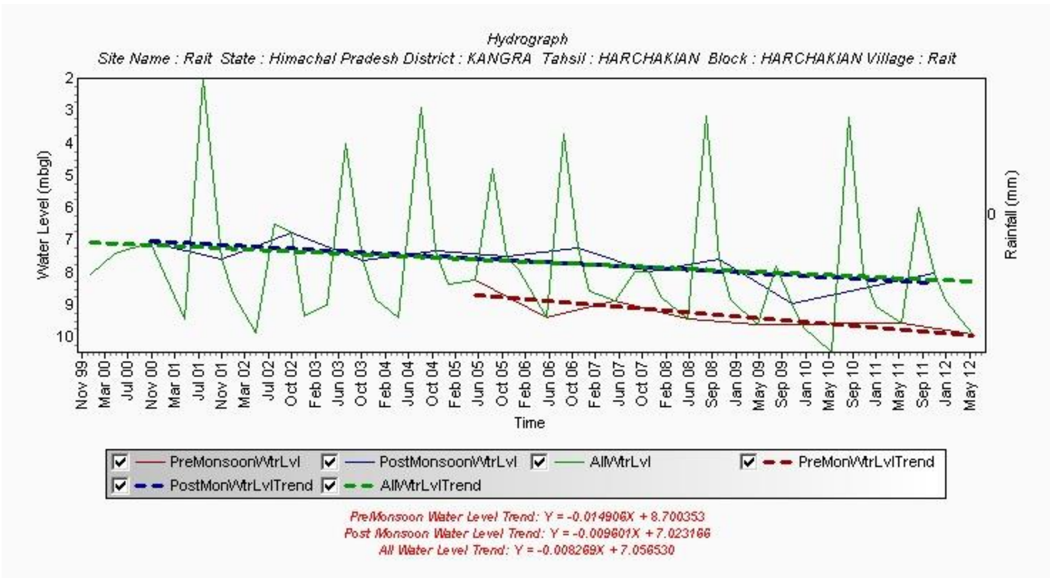


Figure 19(b): Decadal fluctuation trend in the water level at Rait

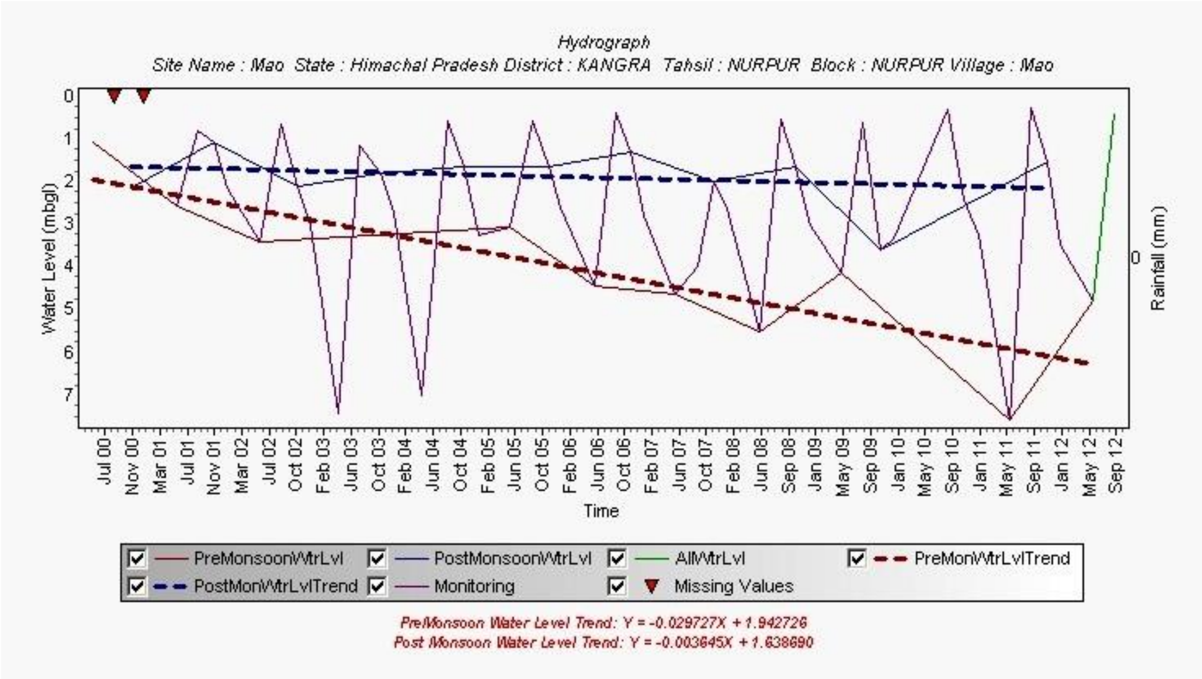


Figure 19©: Decadal fluctuation trend in the water level at Mao

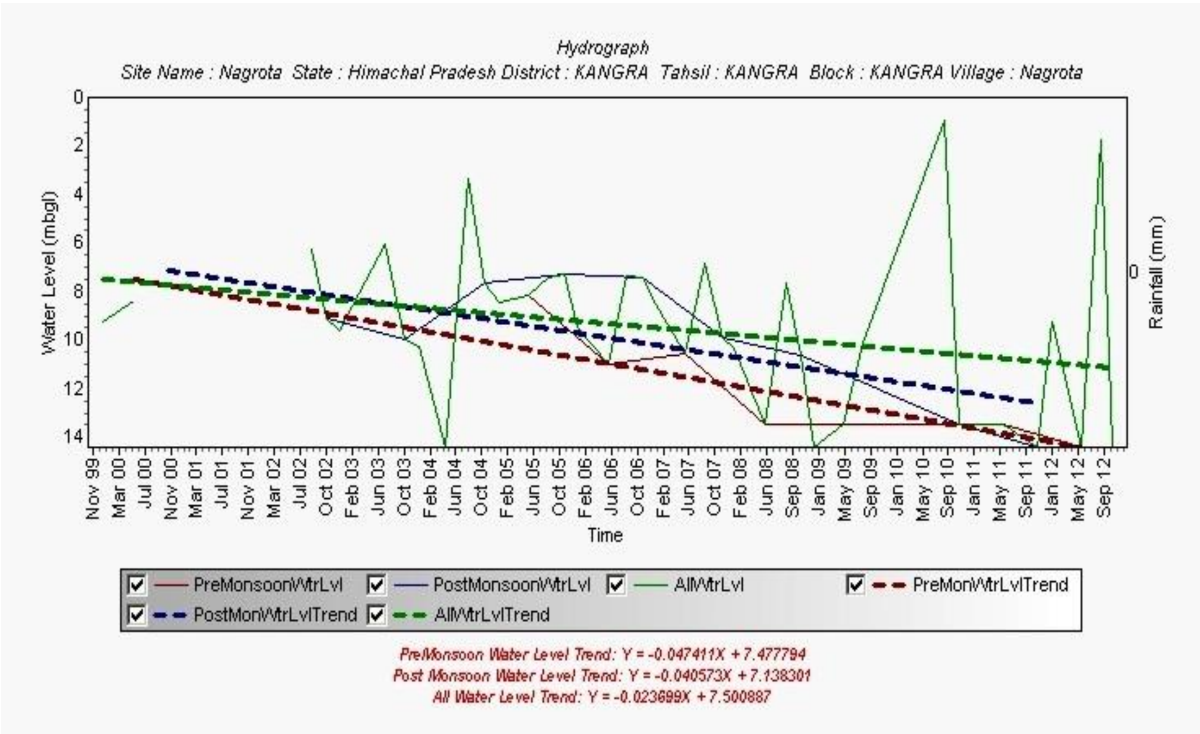


Figure 19(d): Decadal fluctuation trend in the water level at Nagrota

3.1 Data Gap & Data Acquisition

The Data gap analysis was done in Aquifer Mapping Study area of about 869 sq.kms in parts of Kangra-Chamba districts of Himachal Pradesh. The study area falls in Survey of India Toposheets No. 52 D/3, D/4, D/7, &D/8, covering full or partial area of 21 quadrants (Figure -3.2 -Toposheet Index Map).

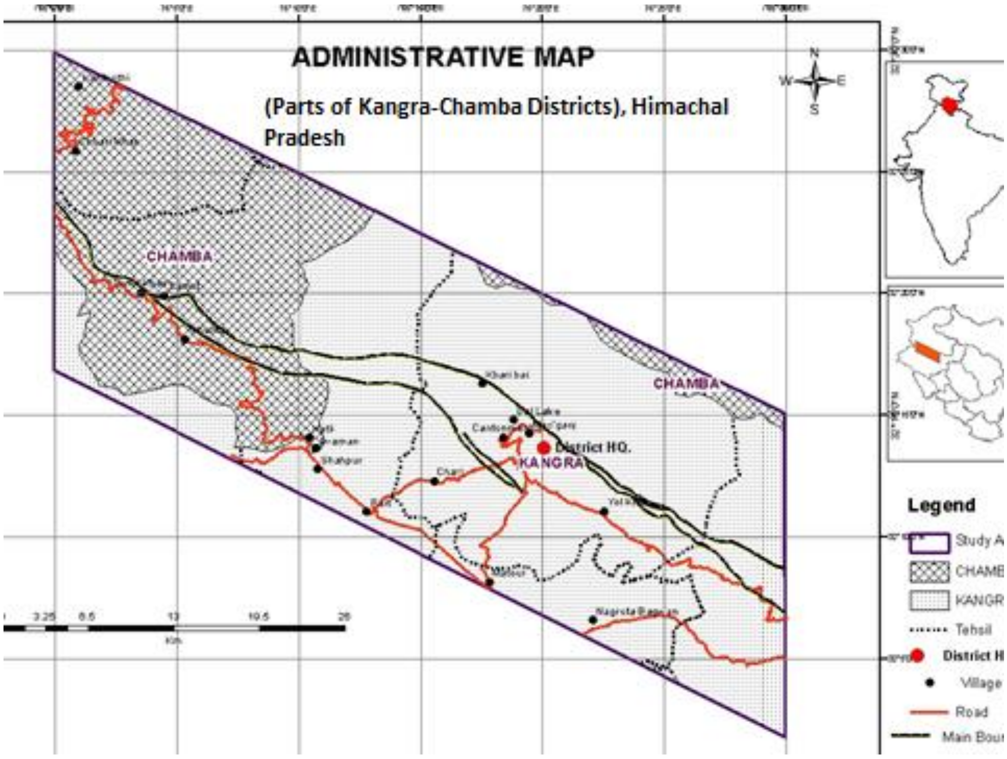


Fig: 20 Administrative Map

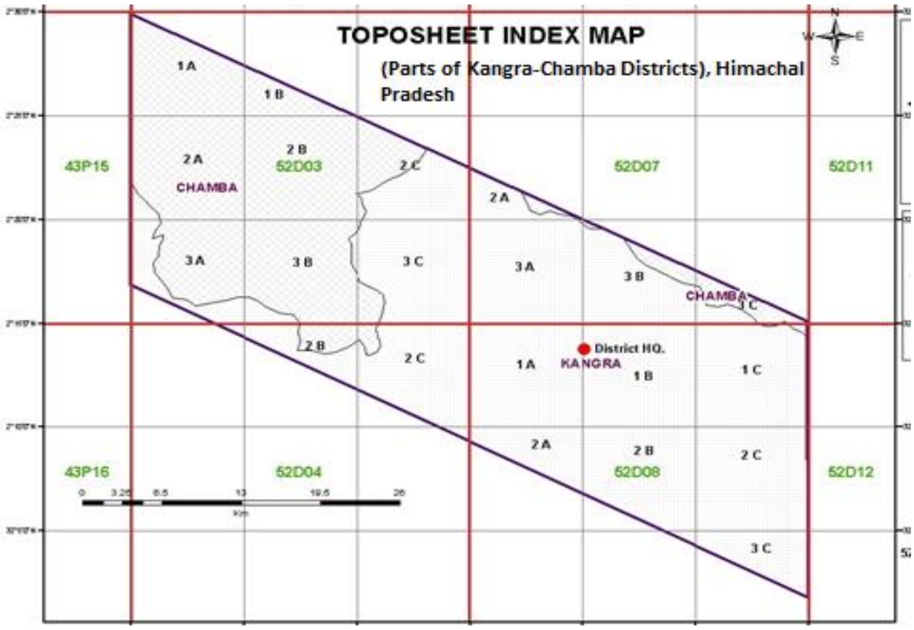
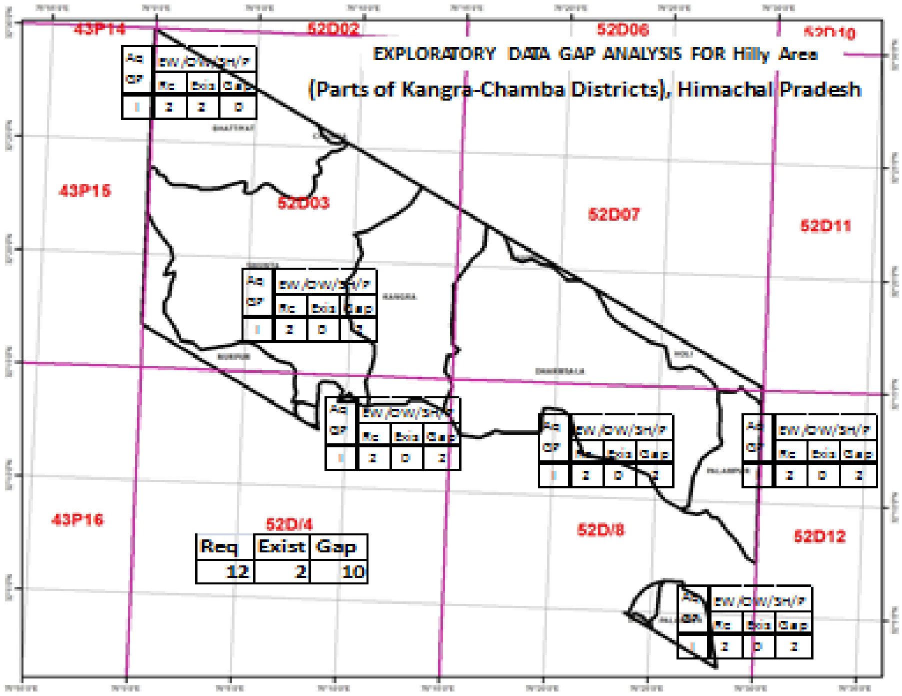


Fig 21 : The Toposheet and quadrantgrid is shown as Basemap

3.2 Ground Water Exploration

The Data gap Analysis indicates the required Ground Water Exploration sites,sets of exploratory and observation wells to ascertain the aquifer parametersin the area as per the guide lines.and the existing number of sites in the areaand the Gap is indicated where ever the required number of sites is higher thanthe existing number of sites.



If the number of existing exploratory wells ishigher than the required exploration sites, the gap is considered as zero and theexisting structures were taken as fulfilling the norms.

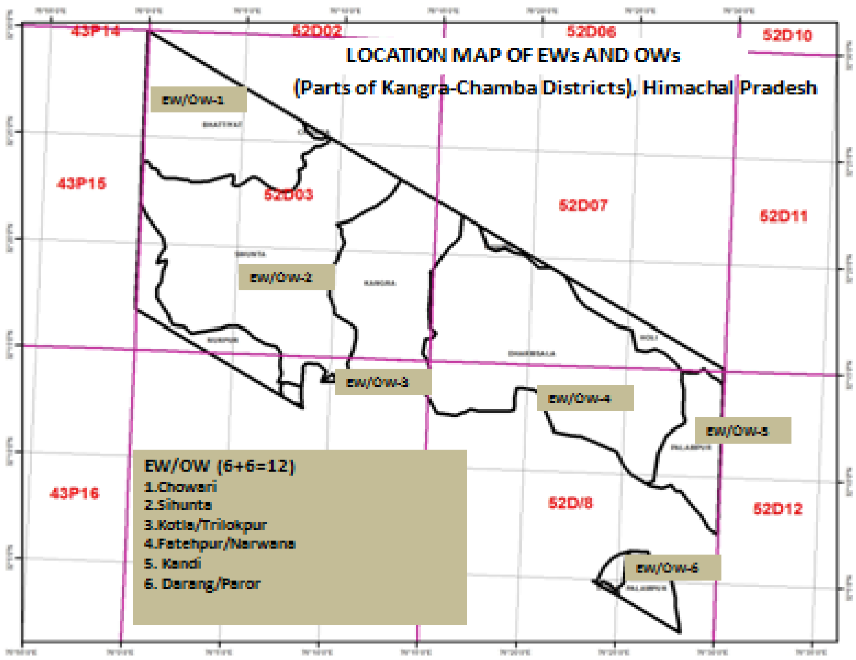


Figure 22: Data Gap &adequacy map for GW exploration prepared on the basis of guidelines

On the basis of data gap analysis, quadrant-wise existing and recommended sites is presented as Annexure-I and shown as square diagram in the figure-3.3. The details of existing exploration data is given in Annexure-I and presented in Map (Figure-3.3). Based on the available data, one aquifer is considered in the study area upto the depth of 100 m.

3.3 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, 40 nos. of infiltration tests are required. On the basis of data gap analysis, quadrant-wise existing and recommended infiltration tests are presented in table and shown as square diagram in the figure -4.4.

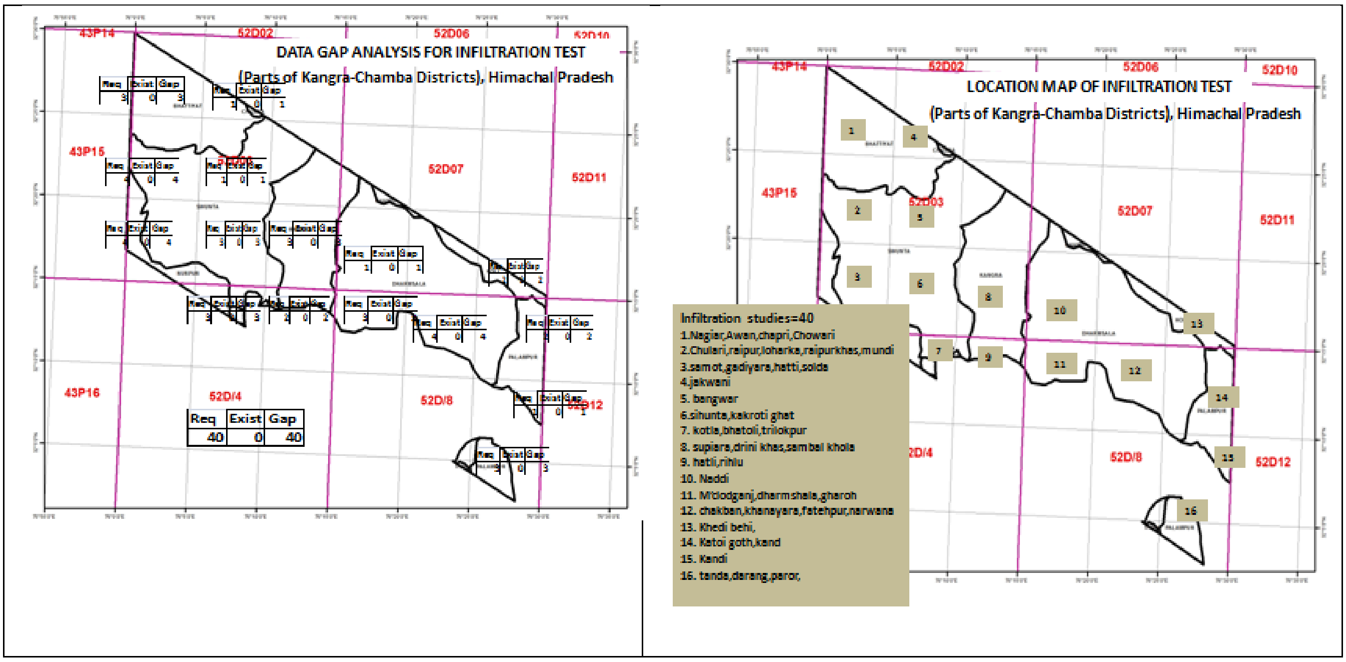
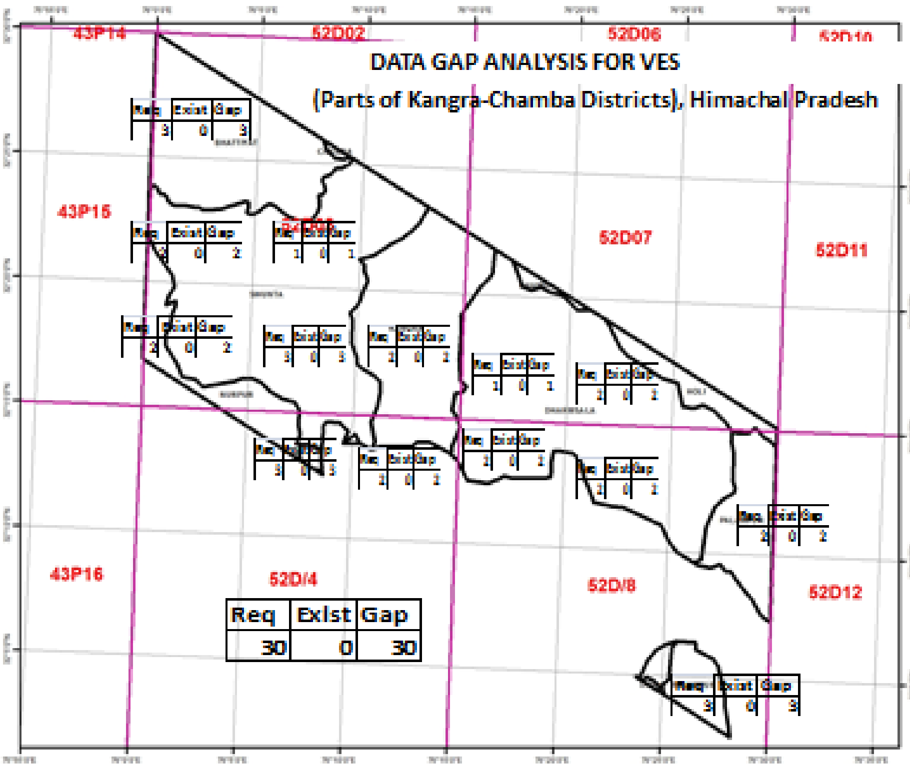


Figure 23: The data adequacy map for Soil Infiltration prepared on the basis of guidelines

3.4 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/TEM data is available with CGWB and state agencies. On the basis of data gap analysis, the required no. of VES/TEM are 30. The quadrant-wise existing and recommended VES/TEM sites is presented as Table and shown as square diagram. The data adequacy map for geophysical data prepared on the basis of guidelines is given in Figure-3.5.



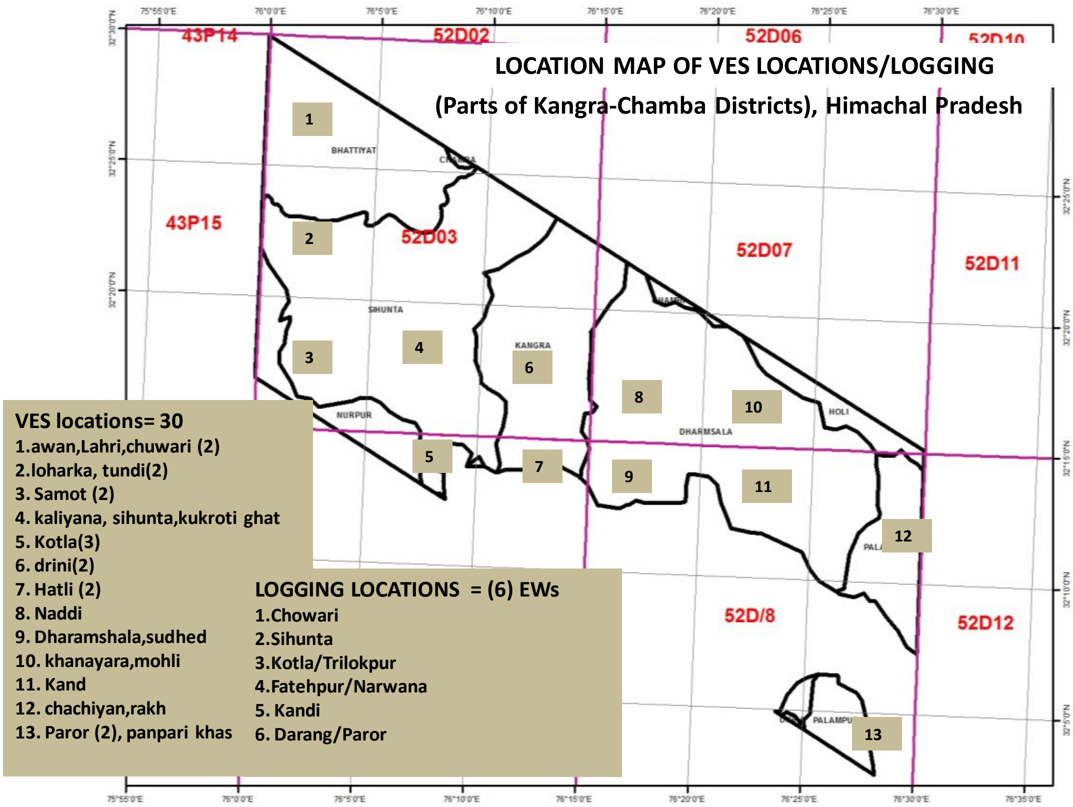


Figure 24: The data adequacy map for VES

3.5 Ground Water Monitoring Stations

The ground water monitoring NHS and Key well observation stations in the area tap the unconfined aquifer. Wells constructed by CGWB 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 are 20, (6 Ews/ Ows +1 NHS+13 Pzs) and and is presented as Table and shown as square diagram in the figure -4.6.

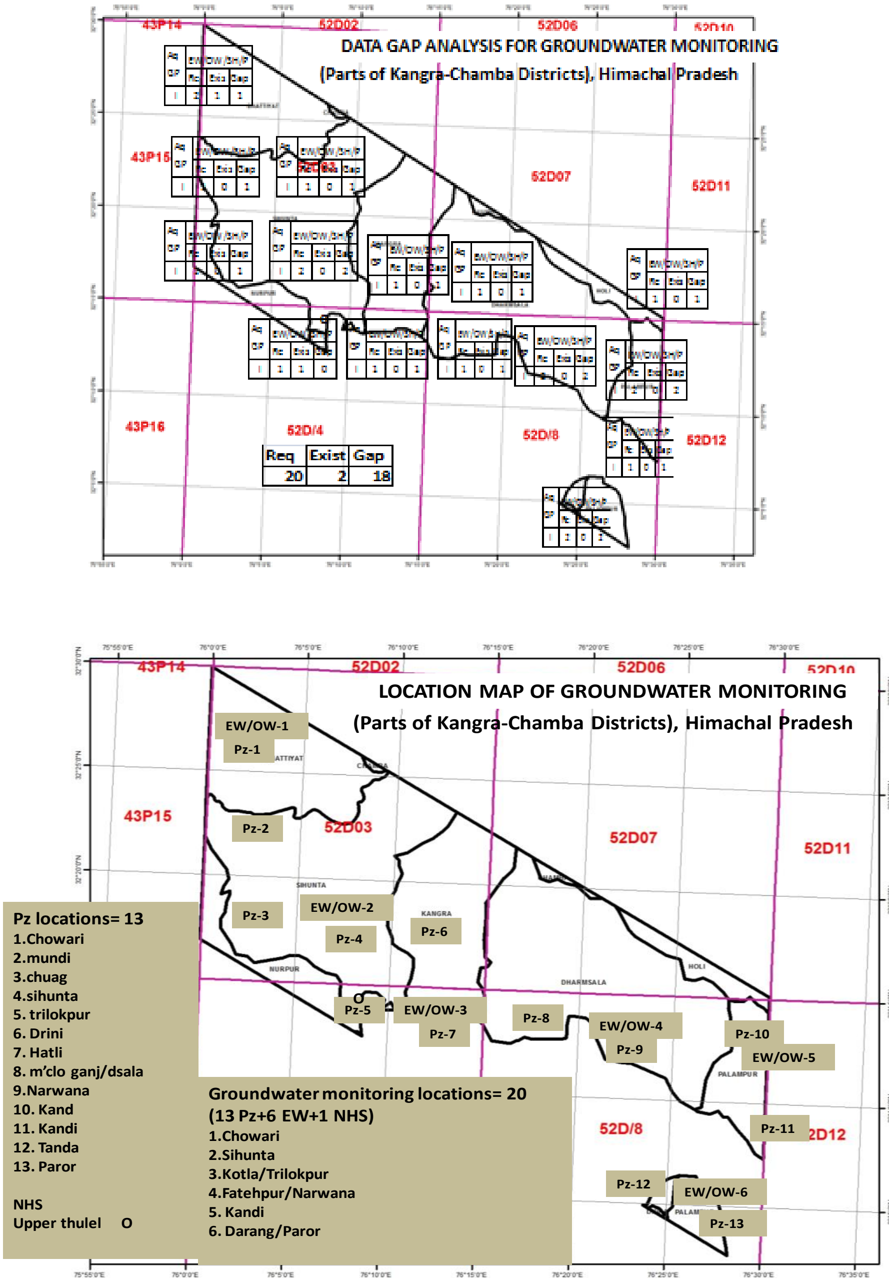
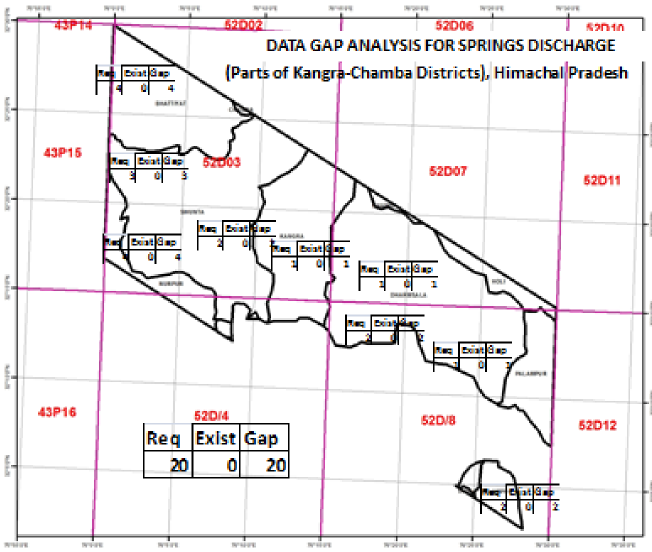


Figure 25: The data adequacy map for WL Monitoring

3.6 Ground Water Quality Monitoring Stations

Most of the ground water quality is being done by sampling the spring water in the area. Wells constructed by CGWB, 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, spring water and proposed Exploratory wells will be taken for water quality sampling. Proposed E/Ws,. The quadrant-wise and aquifer-wise existing and recommended ground water quality monitoring stations are shown.



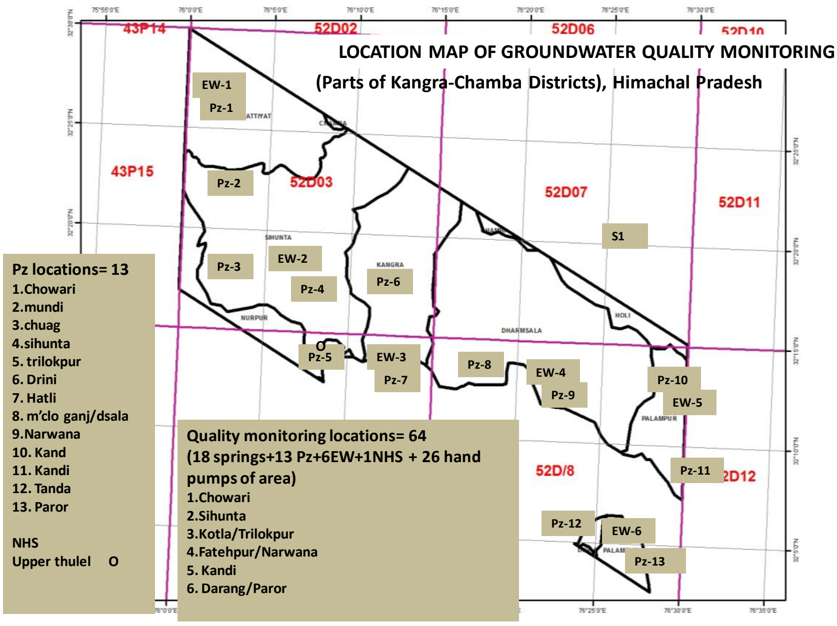


Figure 26: The data adequacy map for Water Quality Monitoring

3.7 Spring discharge

The major water supply schemes are based on the source of springs in study area. The ground water in these areas are discharged through the springs in the topographically favorable areas. Springs located along the thrust in study area are having discharge of less than 1 lps to more than 25 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. 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 -4.8

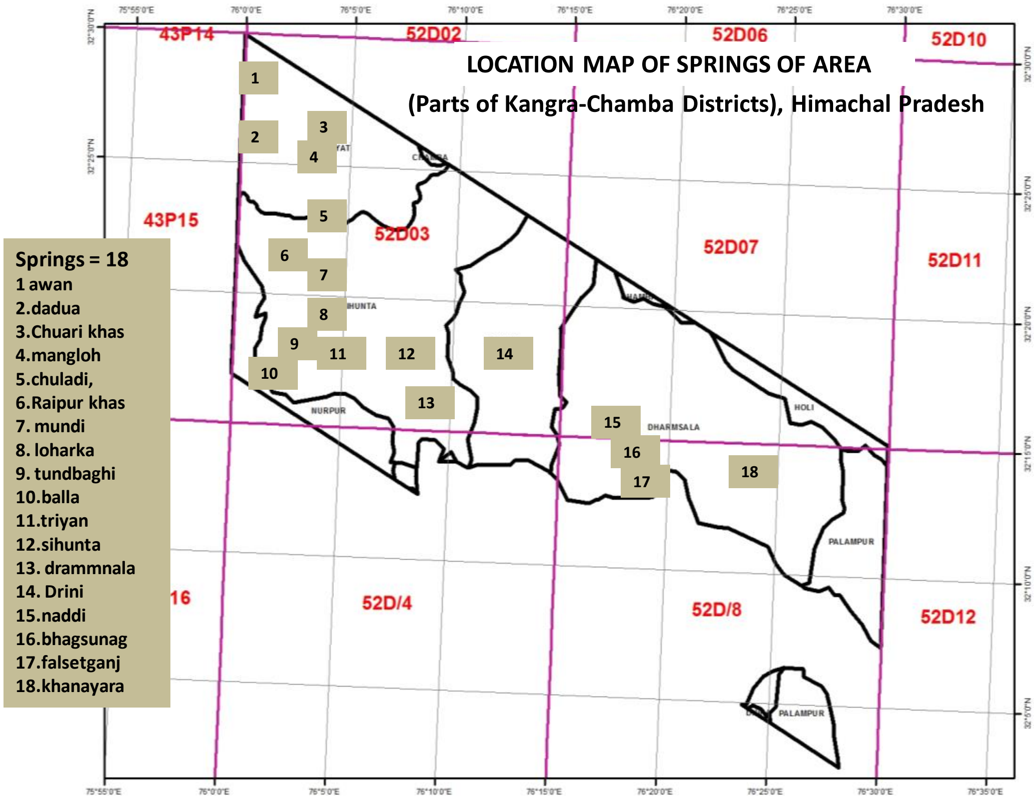


Figure 27: The data adequacy map for Spring Monitoring

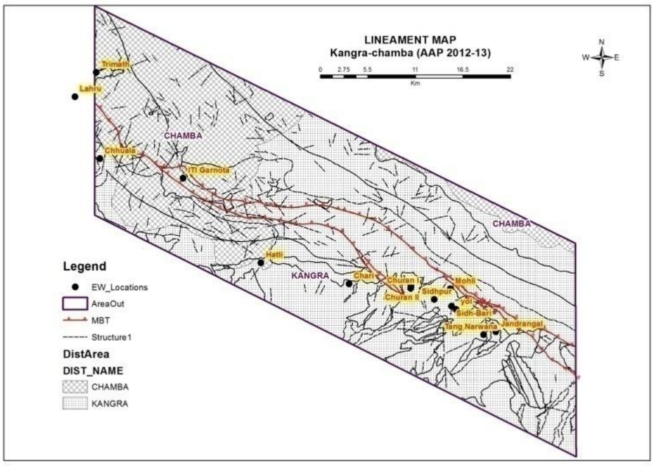
Table 3.4: Data Gap Analysis of the study area

DATA GAP ANALYSIS
Aquifer Mapping Area – Parts of Kangra-Chamba Districts(MBT)
Toposheet No: 52D/3, 52D/7, 52D/4 and 52D/8

Quadrant No.	No. of additional EWs Required	No. of additional OWs Required	No. of additional VES/TEM Required	No. of additional water level monitoring stations Required	No. of Infiltrations	Monthly spring discharge required
	Aq-I	Aq-I	Aq-I	Aq-I	Aq-I	
52D/3 -1A			3	1	3	4
52D/3 -2A			2	1	4	3
52D/3 -3A			2	1	4	4
52D/3 -1B					1	
52D/3 -2B			1	1	1	
52D/3 -3B	1	1	3	2	3	2
52D/3 -2C						
52D/3 -3C			2	1	3	1
52D/4-1A						
52D/4 -1B			3		3	
52D/4 -1C	1	1	2	1	2	
52D/7-2A						
52D/7-3A			1	1	1	1
52D/7 -3B			2			
52D/7 -3C				1	2	
52D/8-1A			2	1	3	2
52D/8-1B	1	1	2	2	4	1
52D/8-2B						
52D/8-1C	1	1	2	2	2	
52D/8-2C				1	1	
52D/8-3C	1	1	3	2	3	2
Total	5	5	30	18	40	20

4. DATA GENERATION, INTEGRATION & INTERPRETATION

A. Hydrogeology:



In order to fulfil the data gap six number of exploratory wells has been constructed at locations Trimath, Garnota,. Lahru, Hatli, Chadi, Mohli and Jadrangal Data so generated have been validated and optimised to generate the aquifer map in Parts of Kangra-Chamba district. The wells in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown below:

Table 4.1: Exploratory Wells details in the study area

Sr.	Location	Latitude	Longitude	Formation	SWL	Depth (m)	Dis (lpm)	T (m^3/day
1	Sidhpur	32.193	76.352	Morainic/ dharamshala	9.15	86.4	1026	673
2	Sidhwari	32.186	76.370	Morainic/ dharamshala	1.88	62.4	757	47.56
3	Yol	32.183	76.375	Morainic/ dharamshala	15.5	86	190	222.8
4	Dari	32.122	76.261	Morainic/ dharamshala	5.86	71	1329	270
5	Churan-II	32.207	76.328	Morainic/ dharamshala	17.59	122.27	7.2	7.27
6	Narvana	32.157	76.403	Morainic/ dharamshala	9	72.5	120	-
7	Hatli	32.231	76.171	Morainic/Siwalik	86	99	abandon	
8	Mohli	32.204	76.369	Morainic/Siwalik	35	100	18	
9	Jadrangal	32.159	76.416	Morainic/Siwalik	33.15	101	60	
10	Garnota	32.319	76.091	Morainic/	14	95	72	
11	Chadi	32.210	76.263	Morainic/	-	186	abandon	
12	Trimath	32.429	76.00	Scree/Slates	9.24	86	355	647.03
13	Lahru	32.404	75.978	Siwalik	2.8	301	29	1.406

4.1 Aquifer Disposition &Parameter Ranges

The diverse physiographic, climatic, topographic and geologic conditions have given rise to diversified ground water situation in different parts of the study area. Even The rock formation ranges in age from Pre-Cambrian to Recent occupy the area and control the occurrence and movement of ground water depending upon aquifer composition, structure and deposition. Hilly and mountainous parts with steep slopes mainly constitute the run off areas and have low ground water potential. In low-lying areas, unconsolidated / semi-consolidated formations form good potential aquifers.

Table 4.2 Lithological distribution of Aquifer-1

Aquifer	Type	Lithology	Distribution	Depth	Discharge lpm	Suitability	T (m3/day
Aq-I	Unconsolidated	Scree/reverine	North-west	1-20 m	355	Yes	647
	Unconsolidated	Moranic/sst, shale	central part	20-100	18-72	Yes	
	Unconsolidated	Siwalik	central part	15-100	29	Yes/No	1.4
	Consolidated	Slate	North-west	20-101	720	Yes/No	

4.2 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. 3.2 & 3.3) &3D synoptic picture by using the Arc GIS and RockWorks16 software. The lithological model has been prepared along with distribution of wells are shown in figure below. The 3D lithological fence diagram has been prepared along with distribution of wells are shown.

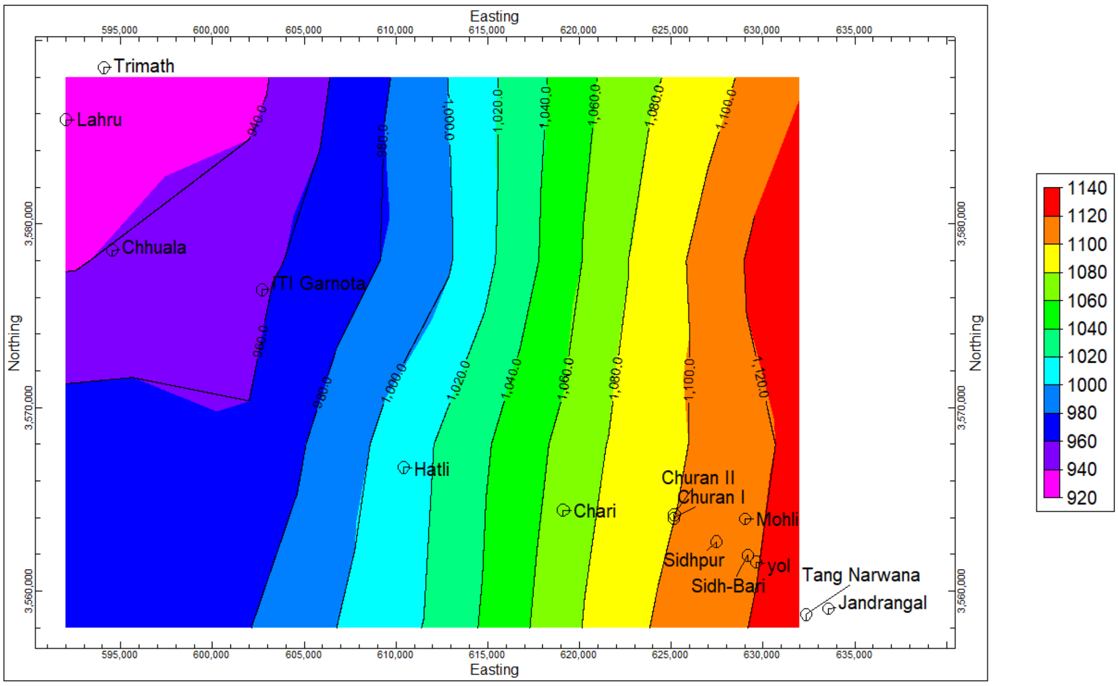
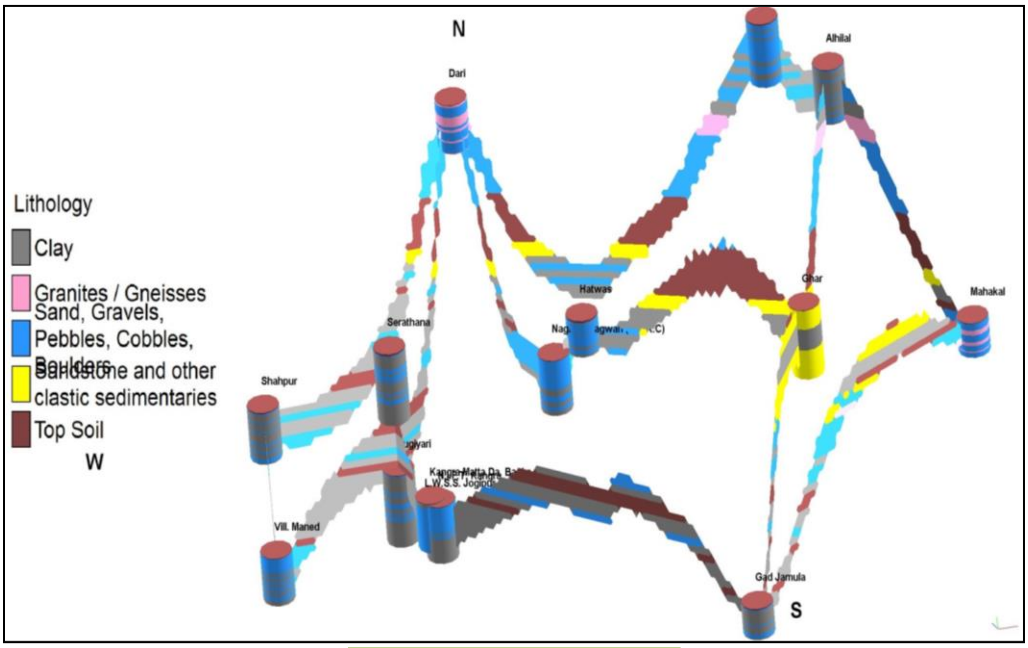


Fig 28: Location of Exploratory wells in the study area

4.3 Fence Diagram

Data has been compiled by using Rockworks software, to generate fence diagram.



Fence

4.4 3-D Lithology of Study area

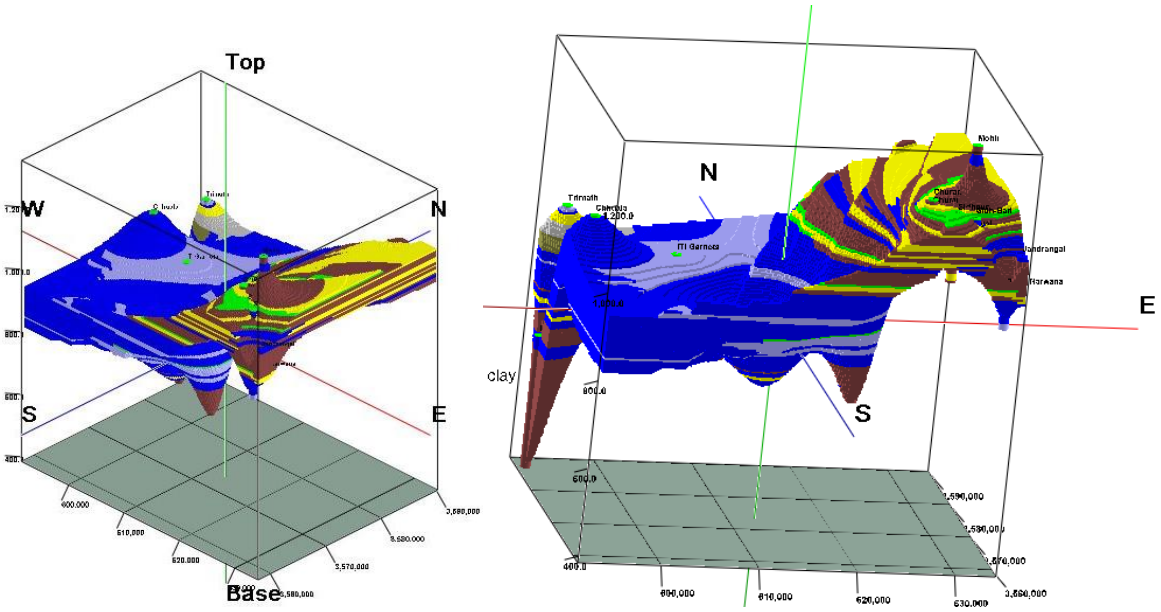


Fig.30 3-Dimension Lithological Model of Study Area

4.5 2-D Aquifer Disposition

The study area can be divided in to three types of hydrogeological units, with yield potential of aquifer. The distribution is shown in the table below:

Table 4.3 : Hydro-geological distribution with yield potentials

Hydrogeological Unit	Distribution	Yield Potential
Unconsolidated (Alluvium / valley fills)	Valley fill/Fluvial/ fluvio-glacial deposits in district Kangra, and in patches in district Chamba	Moderate
Semi consolidated (Siwaliks)	covering areas in Kangra,	Moderate to low yield
Consolidated (Crystalline and Metamorphics)	In parts of District Chamba	low yield

2-D Geological section along A-A'

In the study area falling under district Kangra, cross-section of exploratory wells at locations Churan, Sidhpur, Sidhbari and Yol has been prepared along A-A'. Lithology of exploratory well at Chran shows alternate bands of sand and clay, with boulder and pebbles. Significant thickness of sand, boulder has been found in Sidhbari and Yol. Alternate bands of clay and sand are shown from Sidhbari to Churan.

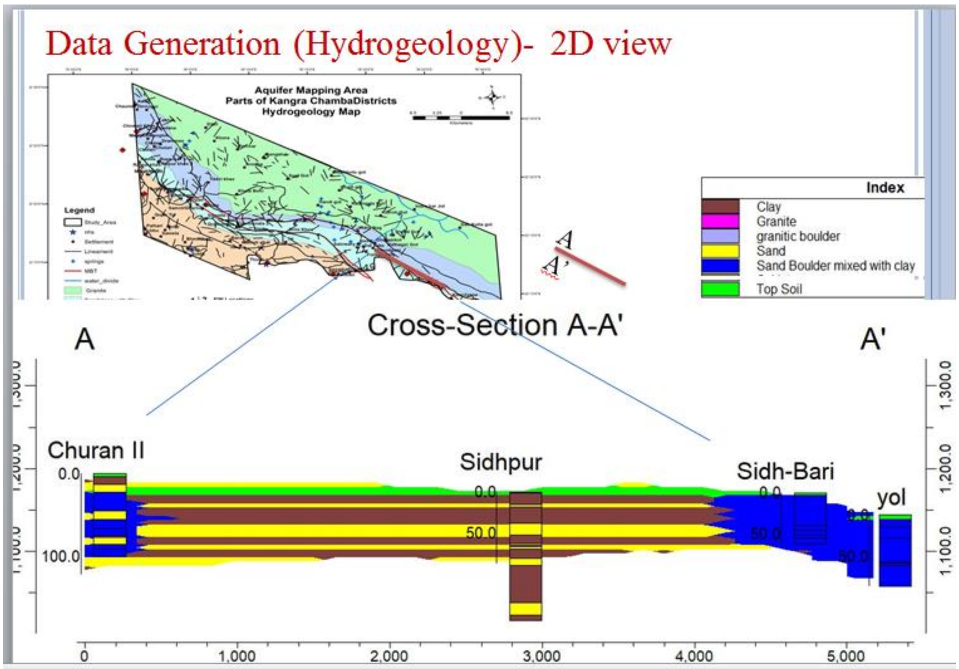


Fig.31 (A) 2-Dimension Lithological cross section along A-A’

2-D Geological Section along B-B’’

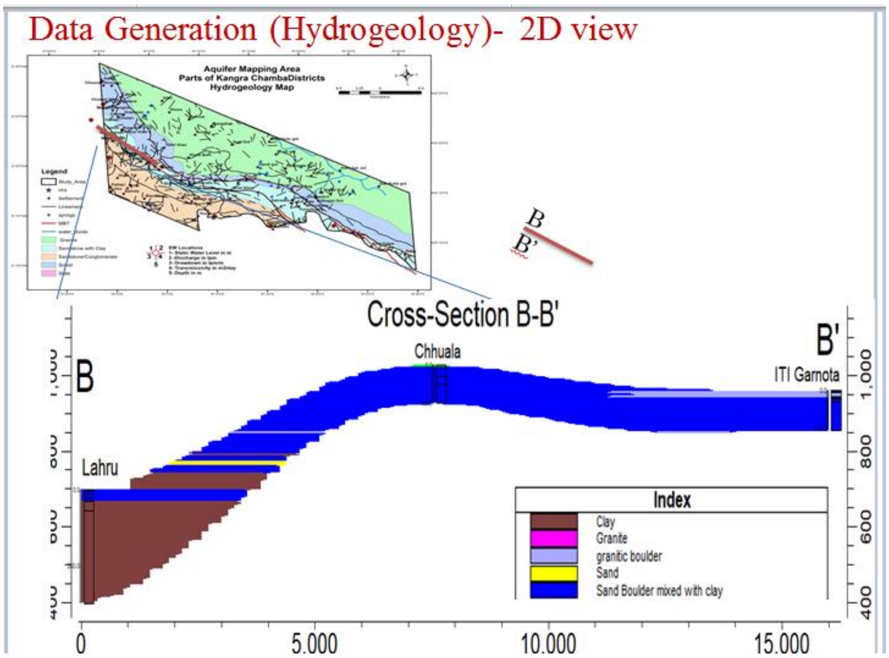


Fig.31 (B) 2-Dimension Lithological cross section along B-B’

A cross-section has been prepared for locations Lahru, Chuuala and ITI Garnota in district Chamba, the cross section shows predominance of sand boulders mixed with clay in EW ITI Garnota to Chhuala. The lithology is extending up to EW Lahru, where as EW Lahru is showing predominance of clay.

B**. Groundwater Sampling & Water quality**

Water samples were collected from various sites from different aquifers as phreatic aquifer, shallow aquifer and deep aquifers. Samples were also collected from springs and rivers to see the water quality of surface water in the study area. Sampling was done in set of two, one for the analysis of basic parameters and other one for heavy metal determination (with preservation with HNO_3). The samples were collected mainly from public water supplies in the study area. Temperature was measured with a thermometer, pH with a pH meter, electrical conductivity with an EC meter and these measurements were done in situ. Collected water samples were analyzed in the laboratory to determine the concentration of some physico-chemical parameters. Factors to be defined in the sampling design include:

- Selection of site locations
- Determining the types of samples to be collected
- Quantity and frequency of sampling
- Water Quality Sampling Procedures
- Analytical and field parameters to be measured
- Representative Sampling

Table 4.4 (a) Sampling locations identified in May 2012

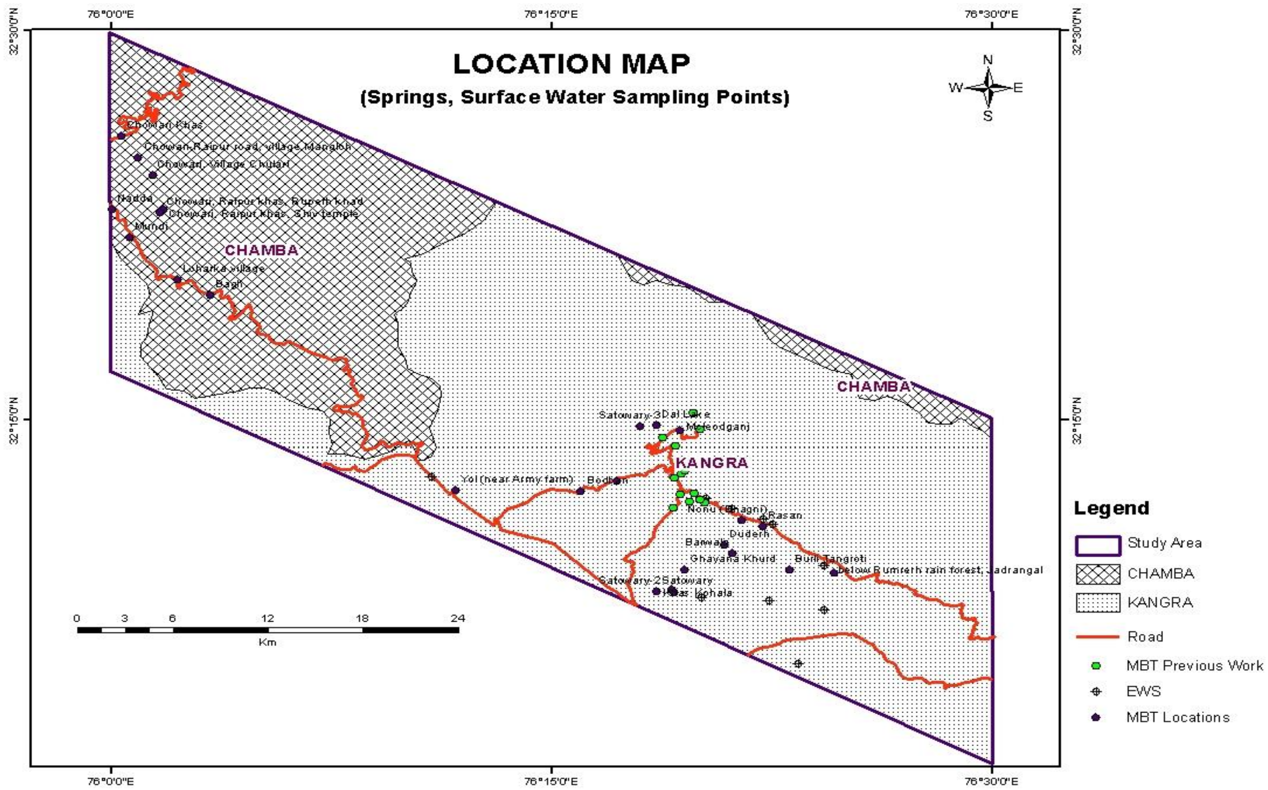
Sr. No.	Location	Lattitude	Longitude
1	Uprerh spring, paddy field	32.141563	76.318162
2	Uprerh spring, near stream contact	32.139583	76.319383
3	Khas Kohala	32.140628	76.310025
4	Forsythganj	0.000000	0.000000
5	Satowary	32.140457	76.309695
6	Satowary-2	32.140437	76.309767
7	Satowary-3	32.246667	76.300668
8	Dal Lake	32.247458	76.309670
9	Mcleodganj	32.244230	76.323280
10	Garoh, Sagarban	32.211215	76.287170
11	Bodban	32.204508	76.266897
12	Dhanotu	32.211192	76.287173
13	Nonu (Bhagni)	32.186153	76.358130
14	Duderh	32.170550	76.348008
15	Rasan	32.182067	76.369918
16	Barwala	32.165123	76.353082
17	Ghayana Khurd	32.154555	76.325655
18	Yol (near Army farm)	32.205588	76.195673
19	Burli Tangroti	32.154773	76.385018
20	below Rumrerh rain forest, Jadrangal	32.152383	76.410208

21	Chowari-Raipur road, village Mangloh	32.418760	76.015730
22	Chowari, Village Chulari	32.407425	76.023765
23	Chowari, Raipur khas, Shiv temple	32.385482	76.029852
24	Jot Khas	0.000000	0.000000
25	Chowari, Raipur khas, Ruperh khad	32.384012	76.028090
26	Kaman-Chowari-Bharadi road	0.000000	0.000000
27	Awan	0.000000	0.000000
28	Chowari Khas	32.433083	76.005995
29	Nadda	32.385783	76.001115
30	Mundi	32.367552	76.011090
31	Loharka village	32.340832	76.038182
32	Bagh	32.330662	76.056343

River Samples

Sr.	Sample	Sample name	Water t(^oC)	Atm.t (^oC)	Remarks
1	SR1	Manuni Khad			
2	SR2	Churan+Manji Khad			
3	SR3	Gaj Khad	18	33	
4	SR4	Khauli Khad	32	40	
5	SR5	Nod Khad	27	35	
6	SR6	Ikku Khad	18	28	
7	SR7	Hubarad Khad	18	20	

4.Sampling and water quality monitoring



In nut shell, for the current study, following methodology was adopted to see the water quality of the study area. Samples from NHS also were analyzed from the study area. The details of samples are as given below.

Table 4.4(b): Spring and river sampling locations in the study area

Sr. no.	Sample no.	Sample name	Water temperature (^oC)	Atmospheric temperature (^oC)	Date of sample collection
1	S3	Sagarban	18	33	21/06/12
2	S4	NonuBhagni	20	40	22/06/12
3	S5	ChowariKhas	20	29	27/06/12
4	S6	Mundi	20	31	27/06/12

Sr. no.	Sample no.	Sample name	Water temperature (^oC)	Atmospheric temperature (^oC)	Date of sample collection
1	SR1	ManuniKhad	-	-	19/06/12
2	SR2	Churan+ManjiKhad	-	-	19/06/12
3	SR3	GajKhad	18	33	21/06/12
4	SR4	KhauliKhad	32	40	21/06/12
5	SR5	Nod Khad	27	35	22/06/12
6	SR6	IkkuKhad	18	28	22/06/12
7	SR7	HubaradKhad	-	-	27/06/12

6.Water Quality

Table 4.5(a): Chemical analysis result of spring and river sample from the study area (12-13)

S. No.	Location	Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO_3	HCO_3	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	Fe	TH
38E/1	Sagarban	Spring	21/06/2012	18	8.26	360	Nil	183	10.7	Tr	3.61	Tr	60	2.4	6.2	1.3	N D	160
2	Nonu Bhagni	Spring	22/06/2012	20	7.66	80	Nil	31	7.1	Tr	1.88	0.30	8	1.2	4.6	0.9	N D	25
3	Chowri Khas	Spring	27/06/2012	20	7.20	140	Nil	37	11	Tr	6.28	Tr	12	4.9	9.5	1.2	N D	50
4	Mundi	Spring	27/06/2012	20	7.33	300	Nil	183	7.1	Tr	6.28	Tr	34	17	6.1	1.0	N D	155
5	Manuni Khad	River	19/06/2012	NM	7.51	200	Nil	116	10.7	Tr	3.45	0.15	26	7.3	6.8	1.2	N D	95
6	Churan + Manji Kahad	River	19/06/2012	NM	7.102	220	Nil	122	7.1	Tr	3.14	0.18	28	6.08	7.3	2.2	N D	95
7	Gaj Khad	River	21/06/2012	18	7.45	70	Nil	37	3.6	Tr	1.88	0.59	12	1.22	3.2	1	N D	35
8	Khauli Khad	River	21/06/2012	32	7.53	140	Nil	73	7.1	Tr	1.1	Tr	22	2.43	3.1	1	N D	65
9	Nod Khad	River	22/06/2012	27	7.36	210	Nil	110	10.7	Tr	5.97	Tr	32	2.43	6.5	1.6	N D	90
10	Ikku Kahad	River	22/06/2012	18	7.43	60	Nil	25	7.1	Tr	4.08	0.14	8	1.2	2.5	Tr	N D	25
11	Hubarad Khad	River	27/06/2012	NM	7.3	90	Nil	43	7.1	Tr	1.41	0.54	8	2.43	6.3	Tr	N D	30

Table 4.5(b): Chemical analysis result of the NHS samples from the study area.(2014)

Sl. No.	Location	Temp °C	pH	Sp. Cond. ms/cm 25°C	CO_3	HCO_3	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	Fe	TH
1	Manjgram	20	7.70	260	0	134	18	12	2	Tr	30	12	11	1.7	ND	125
2	Rait	20	8.35	120	12	37	14	7	2	Tr	12	3.7	8.1	1.2	ND	60
3	Mao	19	7.79	240	0	116	28	8	Tr	0.12	26	11	14	3.1	ND	110
4	NagrotaBagwan*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* *Well is dry for the last few years.*

Table 4.5(c): Water Quality of EWs under NAQUIM

Name of EW	Trimath	Lahru	Mohli
Date of collection	20.5.2015	21.5.2015	Dec-17
Temperature	21	22	Jan-00
pH	8.14	8.35	7.23
EC (mS/cm) at 25^0C	130	480	92
CO_3 mg/l	0	6	0
HCO_3 mg/l	35	177	25
Cl mg/l	18	46	12
NO_3 mg/l	0.3	20	10
F mg/l	0.67	0.64	0.2
Ca mg/l	14	18	11
Mg mg/l	1	30	5.2
Na mg/l	4.8	31	6
K mg/l	2.34	5.08	2.53
TH as $CaCO_3$ mg/l	85	170	120
TDS	50	312	
Fe	50.16	5.11	

Table 4.5(c): Chemical analysis result of samples from the study area. (Premonsoon-2015)

S. No.	Location	Source	Temp °C	pH	Sp Cond ms/cm 25°C	CO_3	HCO_3	Alkalinity	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	TH	TDS
1	Kakroti Ghat	Spring	20	8.23	210	0	55	45	18.0	57	3.0	0.11	22	13	**9**	**1.7**	110	109
2	Balu	Spring	20	8.29	110	0	43	35	18.0	6	3.0	0.20	5	7	5.5	2.1	55	57
3	Loharka	Spring	18	8.25	290	0	171	140	11.0	5	1.0	0.04	20	24	4.9	0.9	150	151
4	Raipur Khas	Spring	18	7.96	170	0	96	79	11.0	0	1.0	0.15	24	5	6.4	0.9	80	88
5	Raipur Khas	H.P	19	7.83	210	0	110	90	7.0	18	0.0	0.13	26	10	6.0	0.4	105	109
6	Jonta	H.P	19	7.75	210	0	97	80	14.0	9	3.0	0.16	14	15	6.2	1.6	95	109
7	Upper Thulel	D.W	19	7.66	250	0	152	125	11.0	1	0.0	0.16	26	14	9.3	0.5	120	130

Table 4.5(d): Chemical analysis result of samples from the study area. (Post monsoon-2015)

S. No.	Location	Source	Temp °C	pH	Sp Cond ms/cm 25°C	CO_3	HCO_3	Alkalinity	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	TH	TDS
1	Upper Thulel	NHS	20	6.99	350	0	264	216	10.7	0.6	1.0	**0.1**	58	1.3	**10.1**	**0.7**	210	182
2	Drammnala 1	HP	NM	6.74	800	0	592	485	17.8	3	0.0	0.16	96	4.3	21.6	8.21	455	416
3	Loharka	Spring	18	7.53	330	0	214	175	7.1	3	0.0	0.15	24	2.3	5.4	0.98	175	172
4	Chowari Khas	Spring	18	7.6	120	0	55	45	10.7	4	0.0	0.29	22	0.1	1.2	1.4	60	62
5	Raipur Khas	Spring	19	7.82	300	0	207	170	3.6	19	2.0	0.06	58	0.7	6.9	1.2	180	156
6	Jonta (HP)	HP	19	6.8	2100	0	897	735	298.2	225	1.0	0.48	136	9.0	253.0	39	790	1092

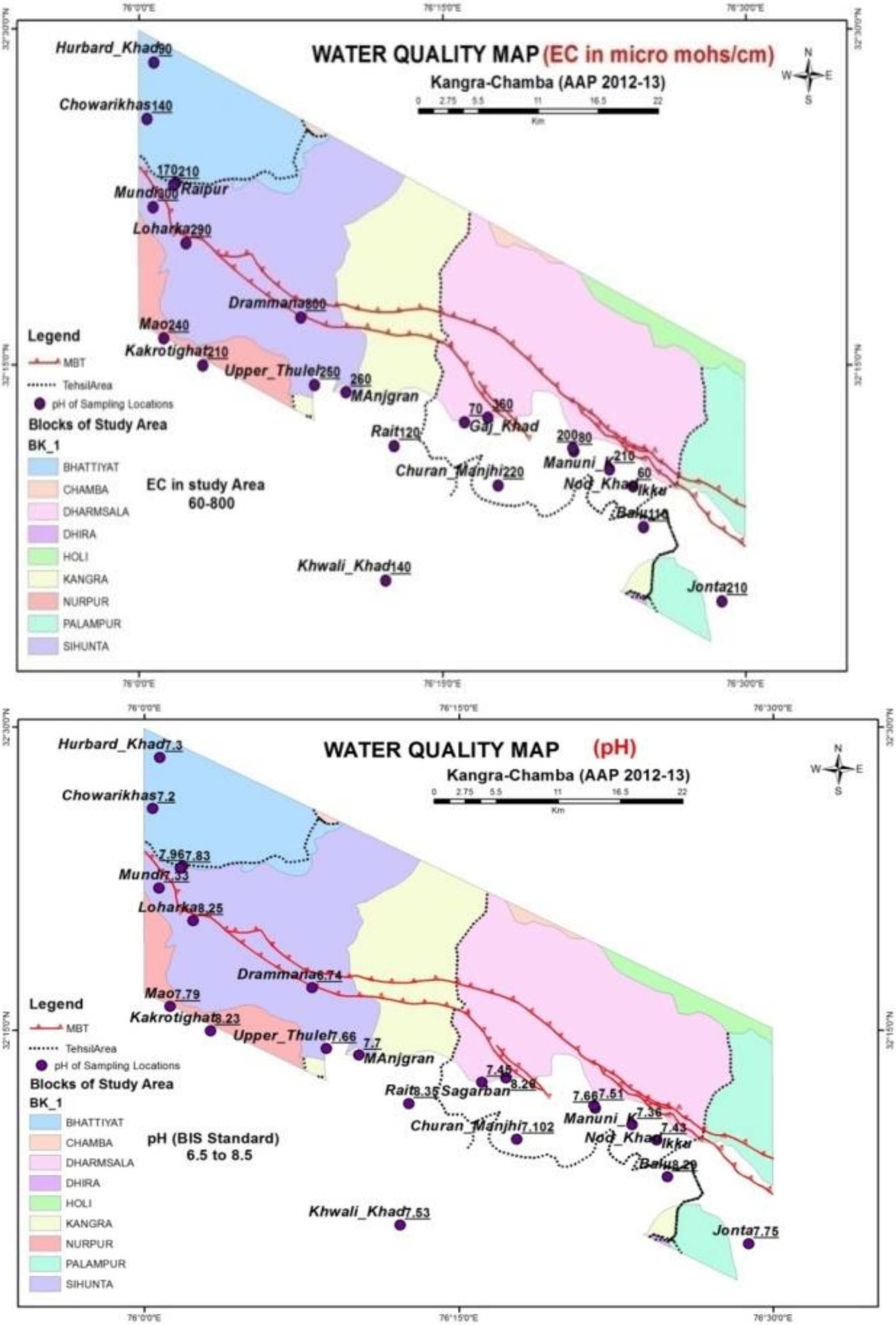


Fig 32 : Showing point values of EC & pH shown in table 3.4

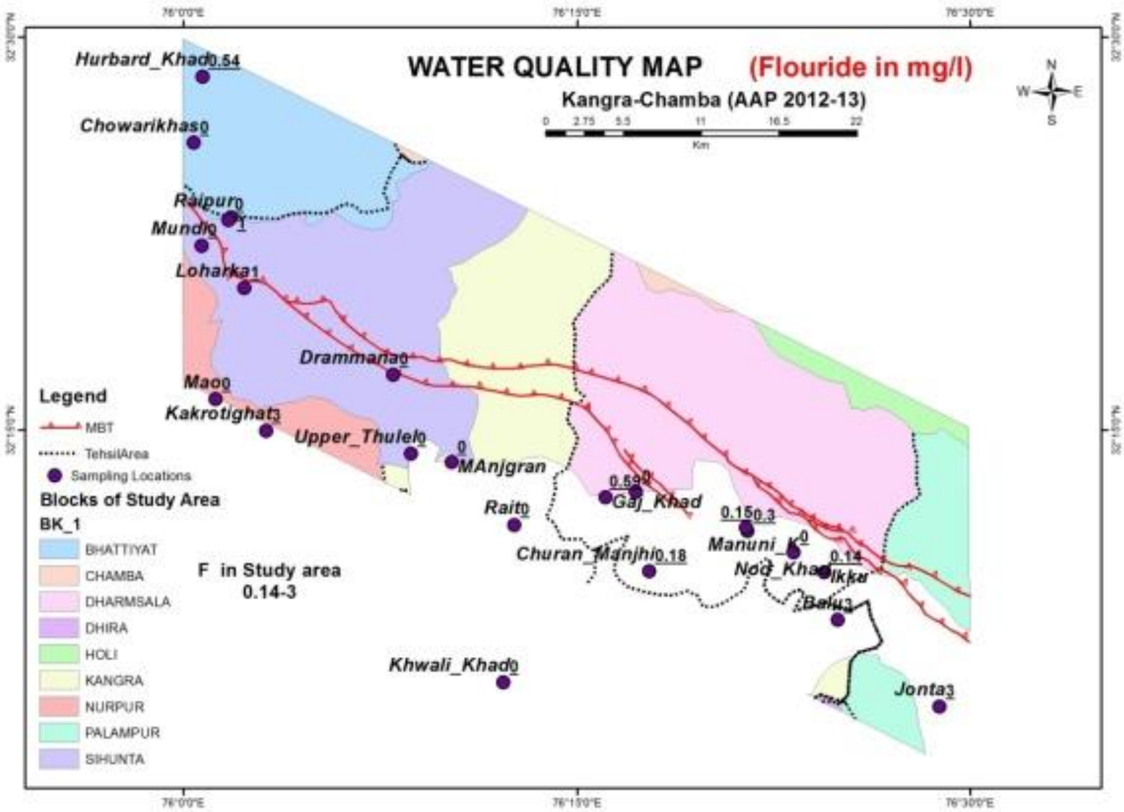


Fig 33: Showing point values Nitrate and Fluoride shown in table 3.4

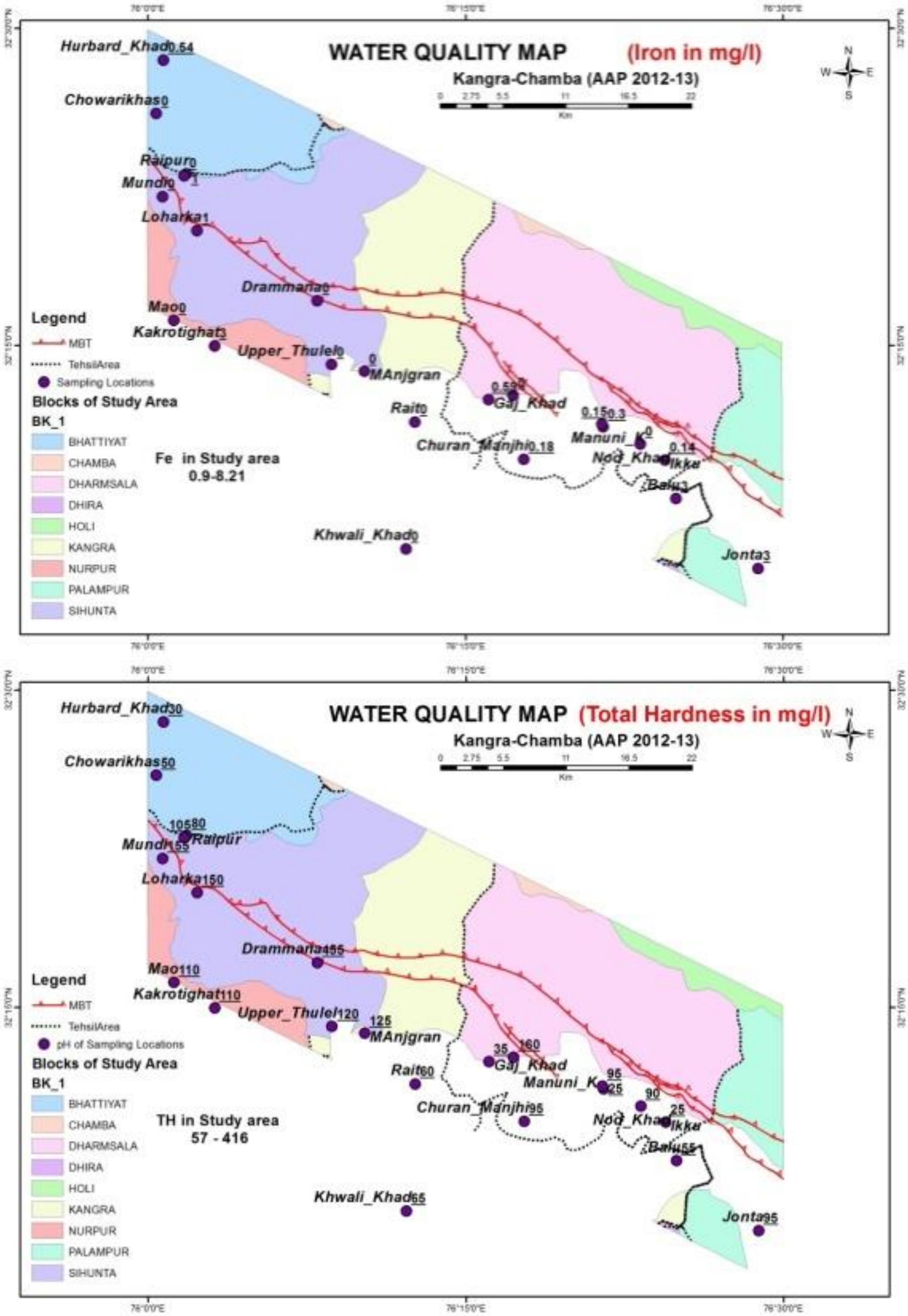


Fig 20: Showing point values Iron and Total Hardness shown in table 3.4

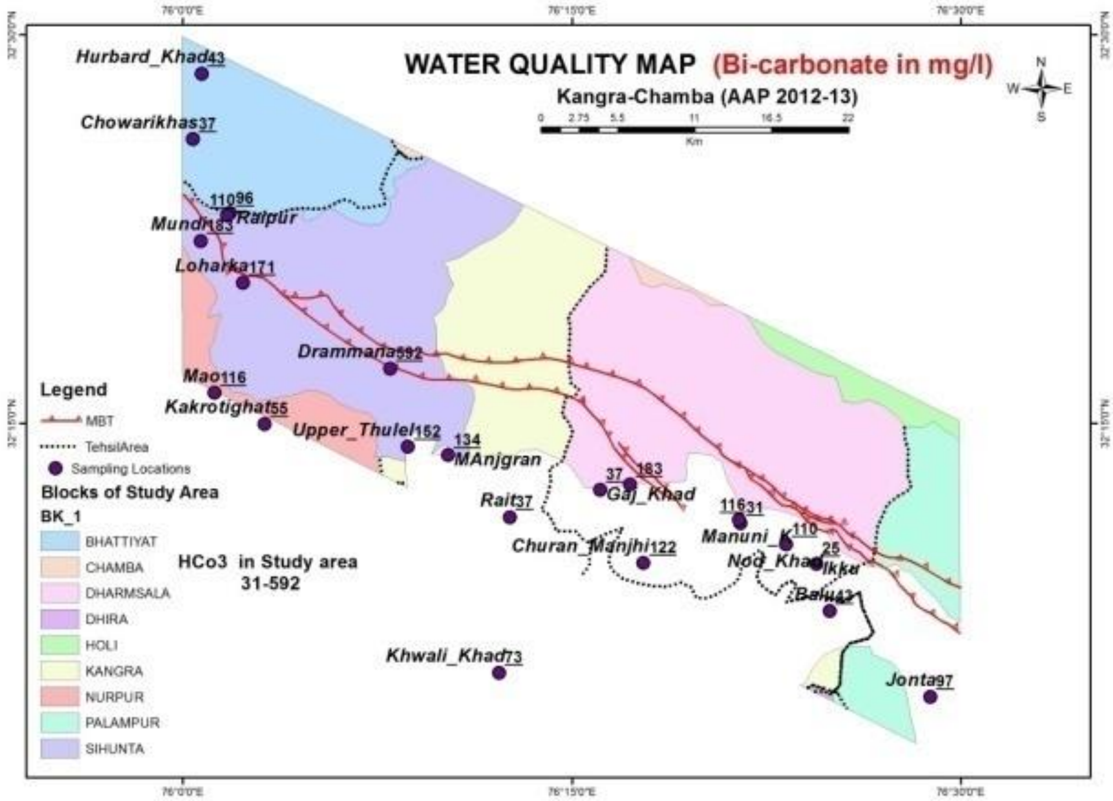


Fig 35: Showing point values Bicarbonate and Sulphate shown in table 3.4

C Vertical Electrical Sounding-WAPCOS

Under National Aquifer Mapping Programme, the geophysical primary data generation in 10 districts of Himachal Pradesh was entrusted to WAPCOS Ltd. by the Central Ground Water Board, Ministry of Jal Shakti, and Govt. of India. The details of the blocks and the number of Vertical Electrical Soundings (VES) proposed and conducted in district under this study area are given in Table 6.4

Table 4.6: List of districts and blocks in Himachal Pradesh for geophysical surveys

District	Block	No. of VES Proposed by CGWB	No. of VES Conducted by WAPCOS
Chamba	Bhattiyat, Sihunta	(11-14) 4	4
Kangra	Nurpur, Kangra, Dharamshala, Palampur, Baijnath, Indora, Fatehpur, Jaswan, Jawali	(18-57) 40	40

The geophysical exploration method of electrical resistivity, having direct bearing on the presence of groundwater, has been used widely in hard rock, to identify the weathered zone and their thicknesses and aquifer characteristics, depth to compact formation, saturated fractured zones, their lateral extension and orientation and other structures like basic dyke and quartz reef controlling the groundwater conditions and delineation of granular zones and claysThe hard rocks are hydrogeologically heterogeneous. Aquifer mapping in these hard rocks demands mapping of aquifers in the weathered zone, and in the underlying saturated fractured zones.

The objectives of geophysical surveys were

- To ascertain sub-surface information and aquifer deposition up to 300m depth in soft rock and 200m depth in hard rock,
- To provide detailed site-specific recommendations based on survey results for drilling or not-drilling the boreholes at the sites proposed and given for the survey, and also,
- To provide tentative aquifer water quality inferred from VES interpretation.

4.6 Vertical Electrical Sounding (VES)

The Vertical Electrical Soundings (VES) were carried out using Schlumberger configuration (Figure 6.5). The only modification made in sounding data collection was to increase the current electrode spacing at a smaller increment of 5 m up to AB/2:100 m, increment of 10 m up to AB/2 : 200 m and there after it was 20 m and the potential electrode spacing was increased at the minimum to avoid static shifts. In general where there is no space constraint, the VES were spread in strike direction of the formation or structure. The curves were interpreted for the layered-earth model as well as for fracture depth determination using empirical methods of ‘current increase’, ‘curve –break’ and ‘factor-method’ wherever required.

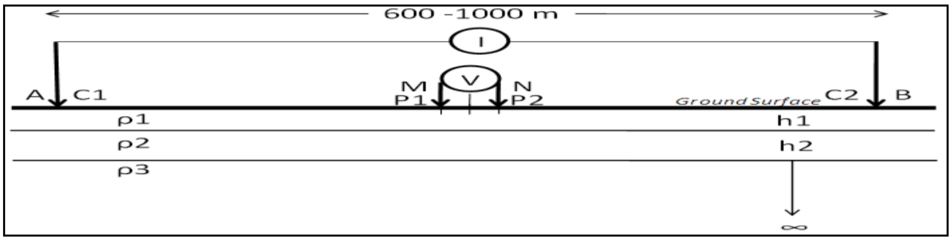
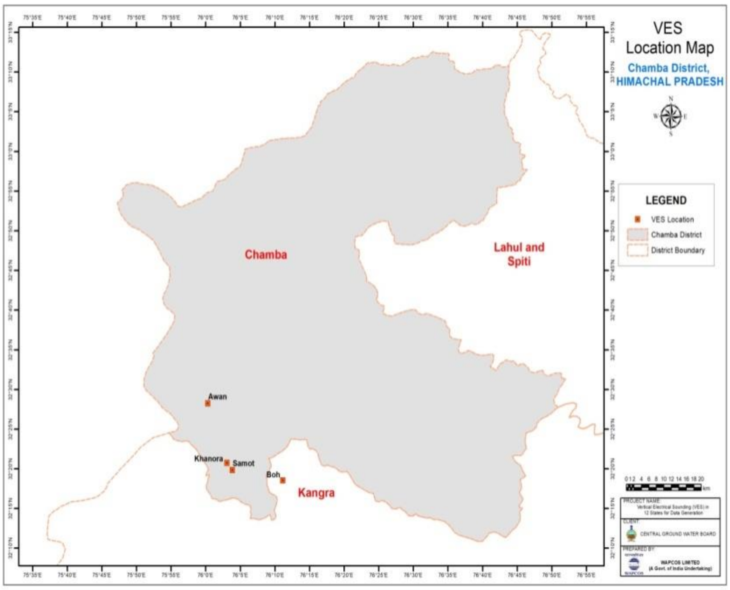


Figure 36 : The Schlumberger configuration of collinear electrodes used for conducting vertical electrical sounding (VES). AB separation is increased in a sequence of close increments up to 600 to 1000 m. MN collinear with AB is kept fixed at the centre of the configuration at a maximum spacing of AB/5. MN is changed when the potential values measured are too low for the instrument.

- **4.7 DISTRICT-WISE FINDINGS**
- **4.7.1 Chamba District**
- **Study Area, Geology and Hydrogeological Conditions**



The resistivity surveys comprising 4 VES were carried out in about 75 sq km area of Bhattiyat and Sihunta blocks lying between North latitudes 32^{o} 18’ 35” and 32^{o} 28’ 20” and East Longitudes 76^{o} 00’ 11” and 76^{o} 11’ 07” (Fig.3.1.1). These two blocks are adjacent and in the extreme southwestern part of the district. Towards north and west are the interstate boundaries of Jammu & Kashmir and Punjab respectively. Towards south lies the district of Kangra The western part of the blocks is occupied by Siwaliks. As moved towards east, Siwaliks are underlain by Dagshai, Kasauli and Dharamshala formations and then the phyllite, quartzite, schist and granite gneiss. The lithologs of two boreholes – Trimath and Garnota are available. The borehole at Trimath is 104 m deep. The boulders with sand and clay are encountered up to 16 m depth followed by fine to medium sand in the depth range 16-40 m. Slates occur in the depth range 40-68 m and then schists from 68 to 104 m depth. At Garnota borehole (drilled depth: 105 m) the entire depth drilled is in boulder mixed with sand and clay. It indicates that the VES 12 and 13 located towards west of Garnota are in Siwaliks and Lower Tertiaries, while VES 11 located towards north of Trimath is in the contact zone of Lower Tertiaries and Precambrian formation. Similarly, VES 14 is also expected to be in the contact zone of Lower Tertiaries and the Precambrian metasediments. The locations of these 2 boreholes are far away from VES locations and therefore no VES-BH correlation has been attempted.

4.8. Interpreted Results of VES

4.8.1 . Interpreted Results of VES-Chamba District

The interpreted results of VES are given in Annexure-I. The VES 11 is located at 1310 m amsl. It is in the contact zone of Lower Tertiaries and the meta sediments. The VES reveals very high resistivity values. Fractured zones may be encountered in 60-100m depth range. The VES 12 is expected to be in Siwalik sediments. At this site a layer (the bottom most layer delineated) with relatively less resistivity (278 ohm.m) commences at 36 m depth. The resistivity value though does not support the presence of groundwater, but this is the only layer at depth with lesser resistivity. The VES 13, however, shows the presence of low resistivity layers (15-35 ohm.m) up to 76 m depth. The layer with 35 ohm.m resistivity in the depth range 34-76 m may form aquifer. It is likely that fractured zones are encountered in the depth range 110-140 m. The VES 14 is in meta sediments. The resistivitys are high. The layer with resistivity 193 ohm.m up to 20 m depth may be tapped through dug well.

4.9. Conclusions and Recommendations.

On the basis of the interpreted results of only 4 VES, it is not possible to make any generalized conclusions. The VES site specific recommendations are given in the Interpretation Table.

4.9.1 Interpreted Results of VES-Kangra District.

Study Area, Geology and Hydrogeological Conditions

In Kangra district 40 VES were conducted in 9 blocks. In the study area The third group of 18 VES (Nos 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28,29, 30, 31,32, 33, 34 and 35) is in the extreme eastern part close to Dhauladhar range in the contact zone of Siwaliks with Lower Tertiaries (Dharamshala formation) and the Lesser Himalaya Metasediments.

VES 18, the borehole Hatli (DD: 100 m) is near VES 19(Fig. 6.6(A)). It encountered sand and boulder up to 30 m depth; sand boulder and clay in 30-51 m; sand and boulder in 51-63 m; sand clay and boulder in 63-78 m and sand and boulder in 78-100m depth range. The interpreted results of VES 19 indicated the presence of a layer of resistivity 81 ohm.m in the depth range 16-64 m and a layer of very high resistivity beyond 64 m depth. It indicates that the resistivity of 81 ohm.m may be assigned to sand mixed with clay and boulder.
The borehole at Mohli (DD: 101 m) is located near VES 21(Fig. 3.2.6). It

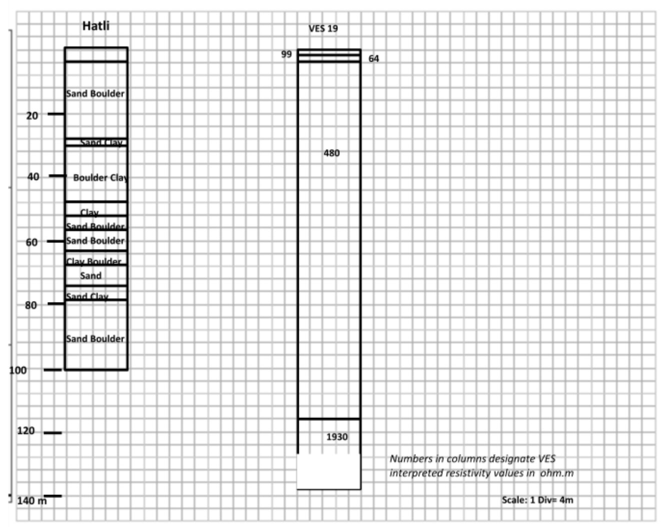


Figure 36(A): VES-Borehole Litholog Correlation,Hatli

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<td>encountered sand cobble, pebble and boulder up to 50 m depth and fine to medium grained sand and silt in the depth range 50-101m. The VES 21 delineates very high resistivity layer up to 19 m depth and then a layer of 120 ohm.m.</td>
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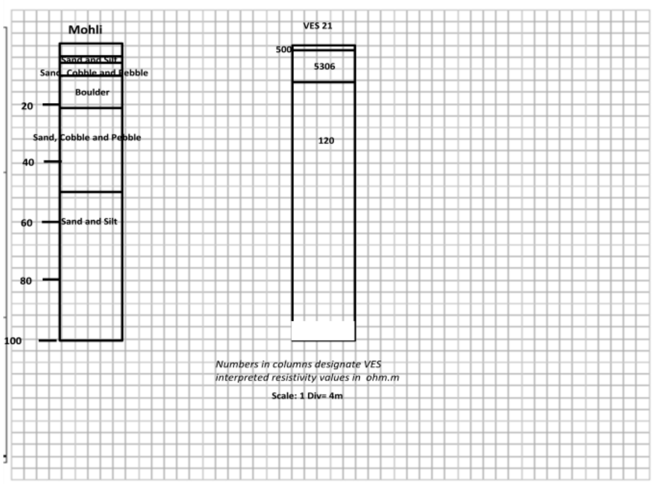

Figure 36(B): VES-Borehole Litholog Correlation,Mohli
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<td>The borehole at Jadrangal (DD: 101 m) is located near VES 22(Fig. 3.2.7). The BH encountered clay up to 86 m depth and then sand and sandstone in the depth rang 86-101m. The VES 22 infers a layer of 40 ohm.m up to 19 m depth and then a layer of 100 ohm.m.</td>
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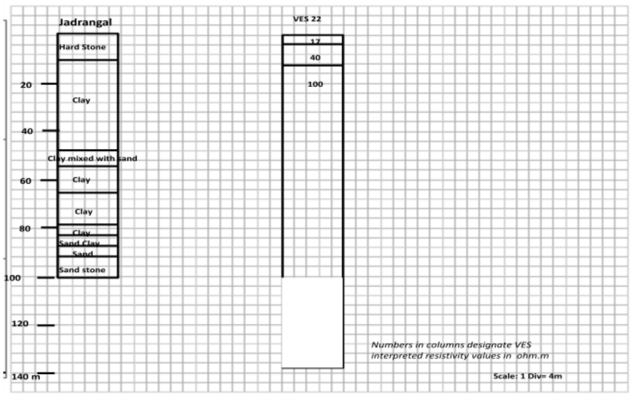

Figure 36©:VES-Borehole Litholog Correlation,Jadrangal
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All these VES-BH correlations reveal that the layer resistivities in the range of 30-80 ohm.m are likely to be associated with sand mixed with clay and boulders and may form aquifers. Another important aspect to be considered is that the area has suffered thrusting, folding and faulting and is overlain by sediments brought down by numerous Himalayan rivers and streams. All these have made the subsurface highly heterogeneous and rapid variations in lithologic and hydrogeological conditions are the characteristics of the area. Therefore, it is essential that borehole drilling in the area is always preceded by spot VES measurement.

4.9.2 .Interpreted Results of VES-Kangra District (study area)

The interpreted results are given in Annexure-I. The VES 36, 37, 38, 39, and 40 are located southwest of Himalayan Frontal Thrust (HFT). The VES, 41, 43, 44, 45 and 47 are also located southwest of HFT but they are located much closer to HFT and therefore variations in subsurface lithological conditions are observed. Most of these VES fall either on the axis of a NNW-SSE trending anticline in the Upper Siwaliks or immediate southwest of it.

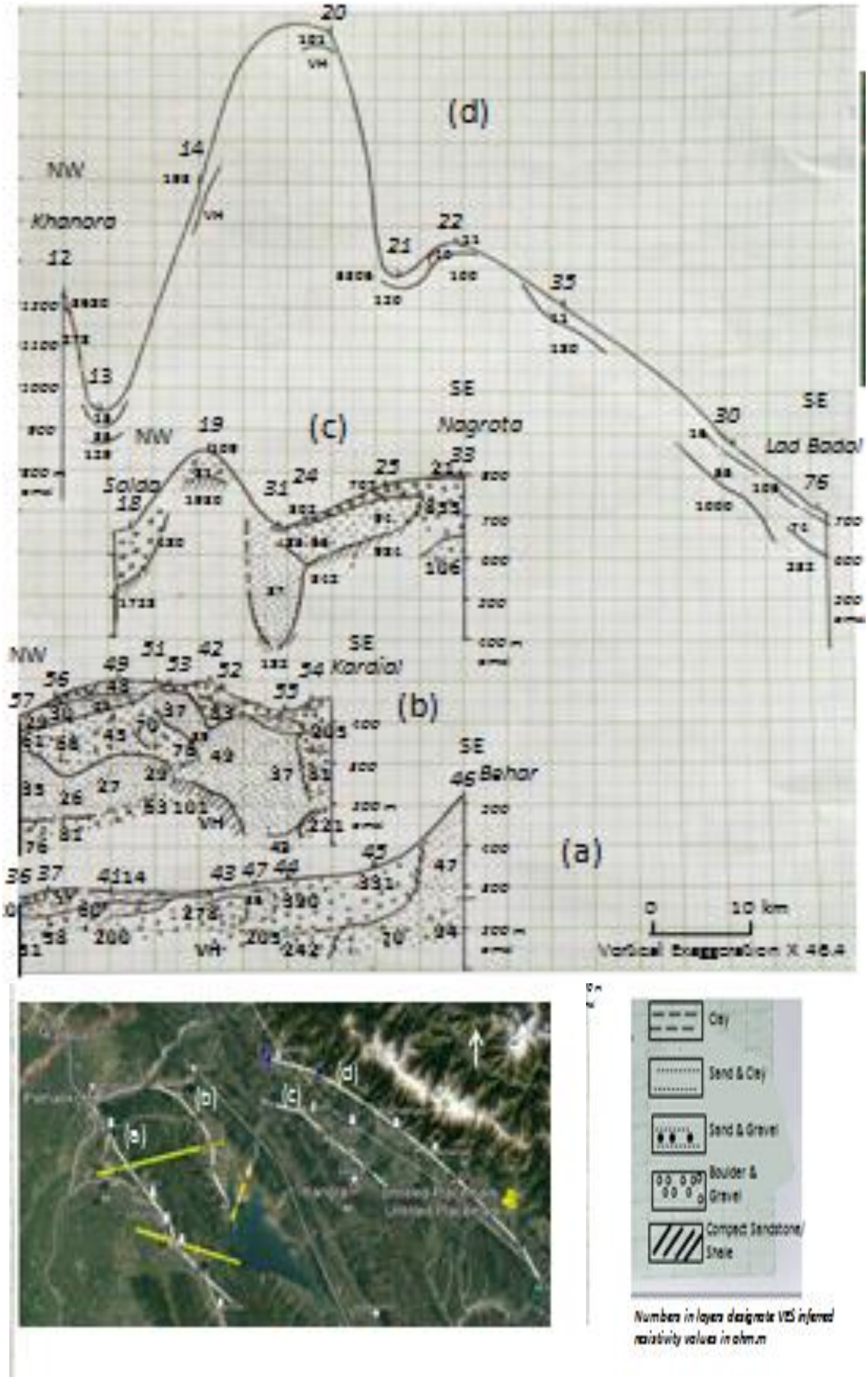

Figure 37: Hydrogeophysical Cross-Sections , Kangra District, Himachal Pradesh

At first a lateral correlation of VES 36, 37, 41, 43 and 47 was attempted (Fig 3.2.8 a). It shows thickening of near surface clay layer towards NW, i.e., from VES 41 to VES 36. While the depth to the bottom of clay layer with 14 to 20 ohm.m resistivity is 16 m at VES 41, it attains a depth of 50 m at VES 36. Immediately underlying the clay there exist a layer of 51 to 60 ohm.m resistivity which could be sand predominating. It is about 31 m thick at VES 41 and thickens towards NW. At VES 36 and 37, its bottom depth could not be estimated. This layer could form the aquifer with a northward thickening clay layer overlying it. The geoelectrical layer underlying the aquifer is associated with higher order resistivity and indicates the presence of gravel and boulder bed. As moved SE towards VES 43, 47, 44 and 45, the near-surface clay layer disappears and the sand bed (aquifer) becomes thin. At VES 44 and 45, the entire depth sequence becomes highly resistive indicative of boulder bed / compaction which may not form aquifer. Further SE the VES 46 located at 522 m amsl in Siwaliks reveals the presence of a very thick (233 m) layer of resistivity around 47 ohm.m. Its bottom is at 245 m depth. As far as resistivity is concerned, it may hold aquifers. It is not confirmed through any borehole drilling.

As moved towards SW, from VES 41 to 38 and then 39, a depression in geoelectrical layering is inferred at VES 38. The depression holds a thick layer of resistivity around 46 ohm.m up to 149 m depth, and is expected to hold sands of varied granularity forming potential aquifer zone. Compared to VES 38 the depth to the bottom of this layer is 48 m at VES 41 and 58 m at VES 39. However, as moved from VES 41 to 39, the resistivity of the aquifer forming geoelectrical layer reduces from 60 to 31 ohm.m. It indicates either fineness in granularity or presence of clay interbeds. Besides, VES 40 located about 4 km north of VES 38, reveals the presence of thick clay bed up to about 105 m depth. Overall it indicates subsurface heterogeneities and manifests localized development aquifers in the area. The area around VES 36, 37, 38, 39 and 41 excluding VES 40 appears suitable for shallow and deep borehole drilling,

5. MANAGEMENT PLAN FOR STUDY AREA

An outline of the Aquifer Management Plan includes details regarding population, rainfall, average annual rainfall, agriculture and irrigation, water bodies, ground water resource availability, ground water extraction and water level behaviour. Aquifer disposition and various cross sections have also been given.

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5.1GROUND 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 springs, wells/hand pumps and tube wells; effluent seepages of ground water in the form of springs and base flow in streams.

Aquifer mapping area under NAQUIM study consists of hilly area with altitude ranging from 312 m to 4800 m amsl having slopes of more than 20%.Hence as per GEC 1997 methodology, no ground water resource estimation can be carried out.

5.2 Demand and Supply

Existing water supply is surface water source (rivers) with cumulative collection of water from springs. The spring discharge is irrespective of the season, except monsoon season. In most of springs, discharge can not be measured, and springs are not in use. This water is being wasted. Conservation measures may be taken up as spring shed restoration and revival of springs. Site specific recharge Measures are to be taken to increase sustainability**.**

Data have been collected from Irrigation &Public Health Department, who is responsible for drinking and irrigation water supply in the state. Springs are major source of water supply. Following table is showing the demand and supply gap in the study area of district Chamba. The gap of demand & supply is being filled by treated surface water.

Table5.1: Demand & supply in study area of district Chamba

Sr.No	Scheme	Name of villages/spring sources	Source of Water	Demand (liters)	Supply (liters)	Gap (liters)
1	WSS Jogindra Kaman Trimth	Kut, Bhagotta, Sail, Tornu -I & II.	Spring	192150	154730	37420
2	WSS to PC Habitation Kutt	Kutt Nallah	Spring	17500	12470	5030
3	WSS Sailla Lanoh	Saila Source	Spring	8400	7640	760

Sr.No	Scheme	Name of villages/spring sources	Source of Water	Demand (liters)	Supply (liters)	Gap (liters)
4	WSS to PC Hab.Satkab in GP Banet	Bhabled	Spring	3080	2270	810
5	WSS Kuthed in GP Kudnu	Sapnalu, Lahar, Marcheed	Spring	102760	78970	23790
6	WSS Saila Bhabled	Jajdo Source	Spring	15540	12430	3110
7	WSS Bhabled in GP Malunda	Babled	Spring	17500	19750	2750
8	WSS Chamb in GP Banet	Chatooli	Spring	6230	5470	760
9	WSS Lohani in GP Malunda	Matooni, Bhagutta Nallah, Thathiyali, Dhamshalla	Spring	19880	15740	4140
10	WSS to LOH Saila Banet in GP Banet	Saila	Spring	1890	1440	450
11	WSS Malunda in GP Malunda	Ghatnallah, Bhagatta Nallah		20300	16740	3560
12	WSS Laprah Satkab in GP Gahar	Bhabled	Spring	68600	50710	17890
13	WSS Banuni Awan in GP Awan	Kahari Ghrat- I, II, Sail, Daddi, Seail	Spring	37380	34780	2600
14	WSS Barla Trimble in GP Parchore	Paniala, Bhatti, Prainal, Bain Da Nalu, Ghai Da Ghar	Spring	30870	26430	4440
15	WSS Naddal Purwai Gulad in GP Parchore	Naddle- I, II, Thatroon, Parwat	Spring	75950	70412	5536
16	WSS Fallahad in GP Khadet	Chatreel- I, II, Kula Dabu, Dramani, Mundi	Spring	3010	2476	540
17	WSS Bainska Raipur Khas in GP Raipur	Cheli	Spring	396900	380470	16430
18	WSS Chalari Raipur Fagot Phase-I & II	Nag Bintru, Kalmnallah, Hadwani, Bhuri Nallah	Spring	2170	1670	500
19	WSS Theru Kaimbli in GP Turkara	Kaimbly	Spring	1200	940	320

Sr.No	Scheme	Name of villages/spring sources	Source of Water	Demand (liters)	Supply (liters)	Gap (liters)
20	WSS Appru in GP Turkara	Apru Nallah	Spring	49980	46470	3510
21	WSS Khabbar Banet in GP Banet	Bankwalu	Spring	2450	1990	460
			Total	**1073740**	**943998**	**134806**

Source: IPH

5.3The Supply side Management

- Low-lying valley areas (near rivers) are feasible for sustainable ground water development through tube wells. Tube wells can be designed within a depth of 100 m, expected to encounter 20 – 30 m thickness of granular zone.
- Scree material, in between high hills, is also feasible for small 6'' tubewells, up to 40-100m depth, can be done with truck/jeep mounted rigs
- The supply is mainly through surface water, but ground water is also being used.
- In addition, roof top rainwater harvesting may be adopted effectively to meet the demand of the people residing on hilltops for domestic use.

❖ Augmentation of GW through Artificial Recharge structures.

❖ Ground Water Recharge Practices should be adopted in spring shed area

5.4 Hill Area Management Plan

❖ In present study area proper development of springs is essential as it is observed that most of the spring in the area does not have collection chamber or tanks from where water can be distributed under gravity. The objective of spring development should be to collect the flowing water underground, to protect it from surface contamination and store it for supply. Similarly, seepage springs along hill sides also need to develop for harnessing ground water in such areas.

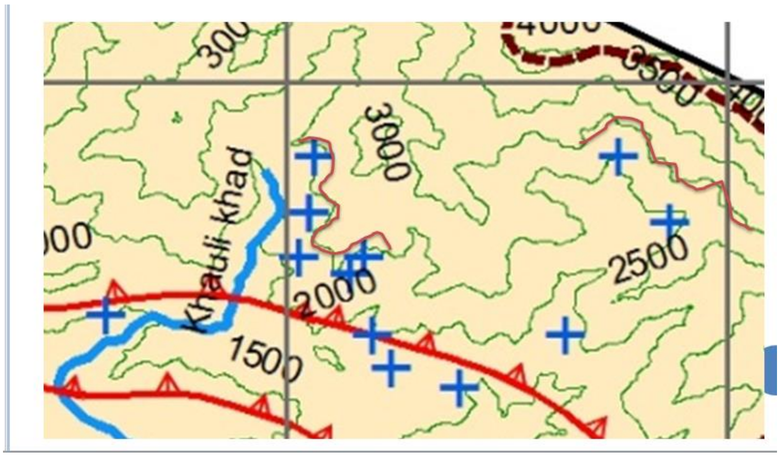
❖ Roof top rainwater harvesting practices can be adopted in hilly areas and urban areas, since the district receives fair amount of rainfall. Construction of roof top rain water harvesting structures should be made mandatory in all new construction and rain water harvesting in rural areas should be promoted.

❖ Traditional water storage systems need to be revived. Recharge structures feasible in hilly areas are check dams and Gabion structures at suitable locations.

❖ Ground Water Recharge Practices should be adopted in spring shed area.

5.4.1Spring shed Management-contour trenching/bunding

- Area specific measures can be taken up for spring shed management. Upstream contours of the springs can be taken for contour trenching and plantation.
- Bunding can be done along the contours, along slopes of the study areas.



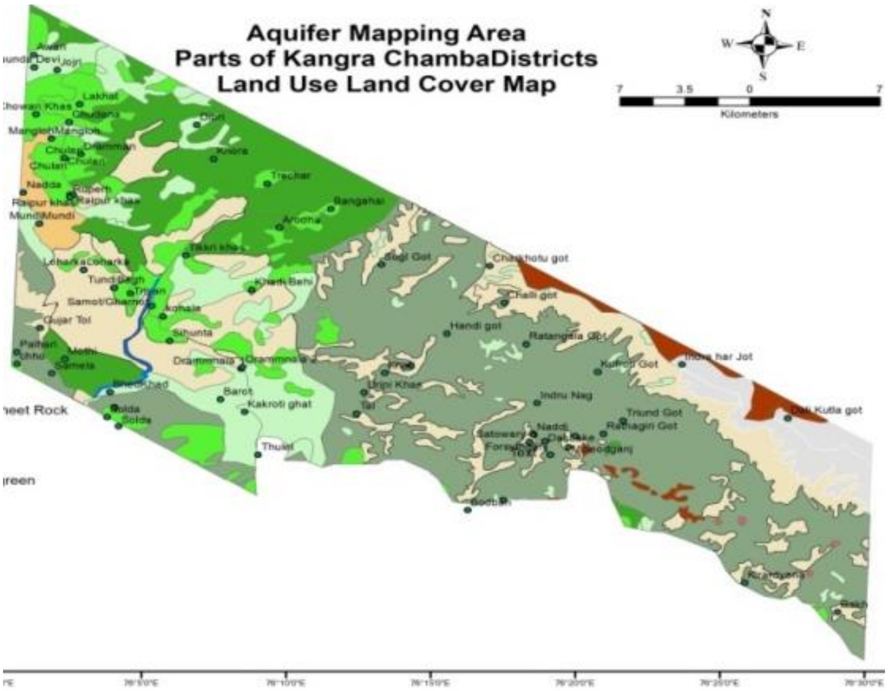
Cost Estimate

Table7.2: Cost estimate of one contour trench

contour trenching	Item of work	L rate (2009)	T rate	total cost(2020)
Cost Estimate	1m*1m*1m	167.5	180.5	375

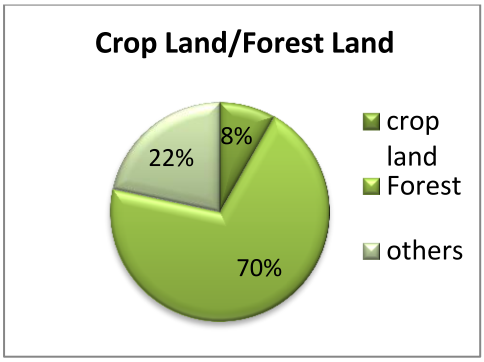
Areas identified(on the basis of landuse-landcover

- All Got areas (Forest area –deciduous, evergreen, semi green)
- Springshed areas of Dibbri, Trecher, Bangai, Kareri, Dal, Kand Kardiyana, Drini, Guna Mata, Kareri, Triund, Kand Krdiyana)



5.4.2Water Harvesting Tanks

Water Harvesting Tanks can be made in small fields, for irrigation & daily work. These structures can be filled with the water conserved from roof top rain water harvesting system or lift irrigation technique. Following table shows the crop land/forest land area blocks under study area, with number of persons living.



Bhattiyat	114 sq km	42967 persons
Sihunta	237 sq km	39871 persons
Nurpur	39 sq km	8000 persons
	Total	90838

Table7.3: Cost estimate of one water harvesting tank

Cost Estimate per tank

Water Harvesting Tank (stone work, single use)=4m*4m*2m= **@1.50lakh**

Water Harvesting Tank (RCC work, community use)=4m*4m*2m= **@2.50 lakh**

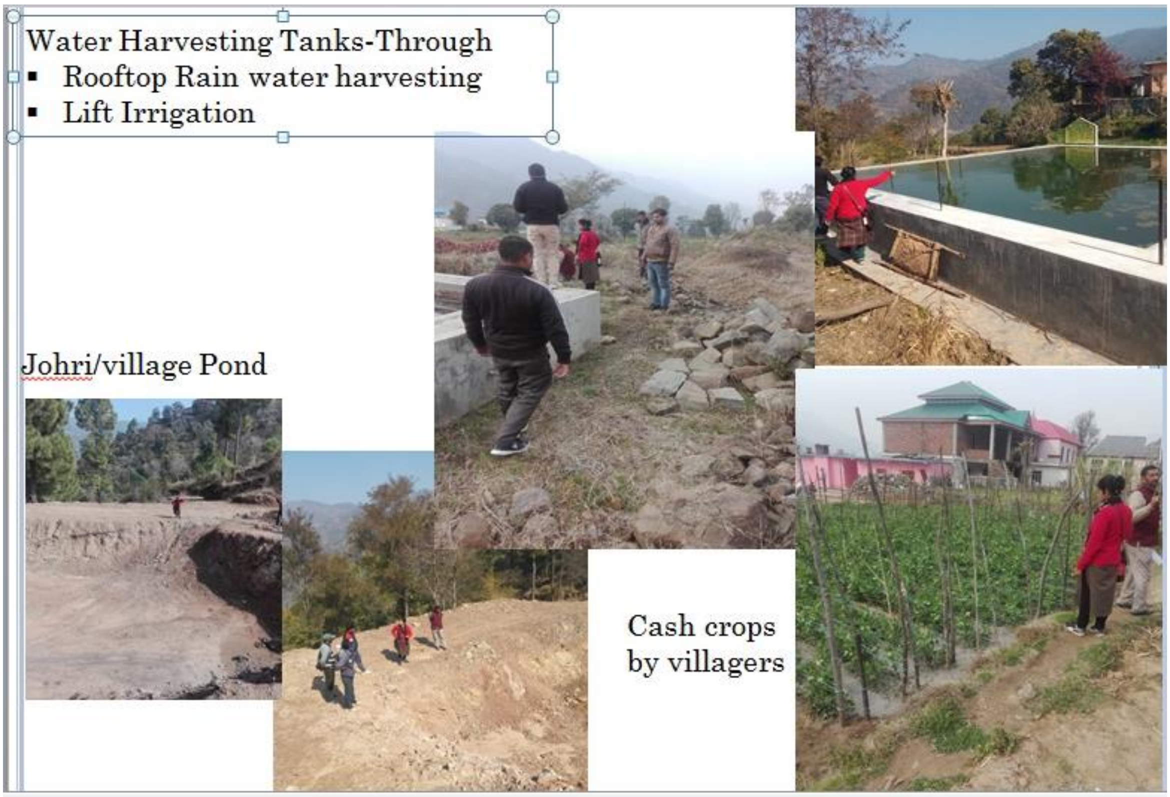
Source-Gram Panchayat-Sor, Nallagarh, solan

Total Cost of Intervention

1.50 lakh*2,00 house holds= **3 Cr.**

Areas identified(on the basis of landuse-landcover

- Gullied/Ravenous land
- Bhattiyat, Chowari, Solda, Drini valley



8. CONCLUSIONS & RECOMMENDATIONS

For sustainable ground water management in area, following additional suggestion should also be considered:

- 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.
- Proper development of springs is essential as it is observed that most of the spring in the district does not have collection chamber or tanks from where water can be distributed under gravity. The objective of spring development should be to collect the flowing water underground, to protect it from surface contamination and store it in sanitary spring box for supply. Similarly, seepage springs along hill sides also need to develop for harnessing ground water in such areas.
- Roof top rainwater harvesting practices can be adopted in hilly areas and urban areas, since the district receives fair amount of rainfall. Construction of roof top rain water harvesting structures should be made mandatory in all new construction and rain water harvesting in rural areas should be promoted. Traditional water storage systems need to be revived.
- In areas, unused and abandoned dug wells can be used as rainwater harvesting and artificial recharge structure to recharge ground water, with safety guidelines for recharging 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.

Annexure-IV

Year-wise Sampling Details in the Study Area

1. November 2014.

(For Basic Analysis)

Sr. No	Sample No	Location	Field parameters		
			EC	pH	Temp
1	S1	Upper Thulel (NHS)	400	7.5	20
2	S2	Drammnala 1 (HP)			
3	S3	Loharka (spring)	500	7.5	18
4	S4	Chowari khas (spring)	400	7.4	18
5	S5	Raipur khas (spring)	600	7.4	19
6	S6	Jonta (HP)	600	7.5	19

(For Trace Elements Analysis)

Sr. No	Sample No	Location	Field parameters		
			EC	pH	Temp
1	TS1	Upper Thulel (NHS)	400	7.5	20
2	TS2	Drammnala 1 (HP)	350	7.2	18
3	TS3	Loharka (spring)	500	7.5	18
4	TS4	Chowari khas (spring)	400	7.4	18
5	TS5	Raipur khas (spring)	600	7.4	19
6	TS6	Jonta (HP)	600	7.5	19

2. May 2014

Sr. No.		Location	Lattitude	Longitude	Water temp. (°C)	EC/pH
1	S1	Kakroti Ghat,(spring) (2samples)	32°17’8.6’’	76°07’58.3’’	20	
2	S2	Balu,(spring) (2samples)	32°18’52.2’’	76°05’7.2’’		
3	S3	Loharka,(spring) (2samples)	32.340832	76.038182	20	
4	S4	Raipur khas,(spring) (2samples)	32.385482	76.029852	18	
5	S4 (A)	Raipur khas,(HP) (2samples)	32.385482	76.029852	18	
6.	S5	Jonta (HP) (2samples)			19	
7.	S5(A)	Jonta A (HP) (2samples)			19	
8.	S6	Upper Thulel NHS (1samples)			19	
	Total	**15 samples**				

3. Sampling (May 2012)

Table 3.3: Spring sampling locations in the study area

Sr. no.	Sample no.	Sample name	Water temperature(^oC)	Atmospheric temperature (^oC)	Date of sample collection
1	S3	Sagarban	18	33	21/06/12

2	S4	NonuBhagni	20	40	22/06/12
3	S5	ChowariKhas	20	29	27/06/12
4	S6	Mundi	20	31	27/06/12

Table 3.4: River sampling locations in the study area

Sr. no.	**Sample no.**	**Sample name**	**Water temperature (^oC)**	**Atmospheric temperature (^oC)**	**Date of sample collection**
1	SR1	ManuniKhad	-	-	19/06/12
2	SR2	Churan+ManjiKhad	-	-	19/06/12
3	SR3	GajKhad	18	33	21/06/12
4	SR4	KhauliKhad	32	40	21/06/12
5	SR5	Nod Khad	27	35	22/06/12
6	SR6	IkkuKhad	18	28	22/06/12
7	SR7	HubaradKhad	-	-	27/06/12

Annexure-V

In January 2013

In November 2012

Sr. No.	**Location**	**Lattitude**	**Longitude**
1	Uprerh spring, paddy field	32.141563	76.318162
2	Uprerh spring, near stream contact	32.139583	76.319383
3	Khas Kohala	32.140628	76.310025
4	Forsythganj	0.000000	0.000000
5	Satowary	32.140457	76.309695
6	Satowary-2	32.140437	76.309767
7	Satowary-3	32.246667	76.300668
8	Dal Lake	32.247458	76.309670
9	Mcleodganj	32.244230	76.323280
10	Garoh, Sagarban	32.211215	76.287170
11	Bodban	32.204508	76.266897
12	Dhanotu	32.211192	76.287173
13	Nonu (Bhagni)	32.186153	76.358130
14	Duderh	32.170550	76.348008
15	Rasan	32.182067	76.369918
16	Barwala	32.165123	76.353082
17	Ghayana Khurd	32.154555	76.325655
18	Yol (near Army farm)	32.205588	76.195673
19	Burli Tangroti	32.154773	76.385018
20	below Rumrerh rain forest, Jadrangal	32.152383	76.410208
21	Chowari-Raipur road, village Mangloh	32.418760	76.015730

22	Chowari, Village Chulari	32.407425	76.023765
23	Chowari, Raipur khas, Shiv temple	32.385482	76.029852
24	Jot Khas	0.000000	0.000000
25	Chowari, Raipur khas, Ruperh khad	32.384012	76.028090
26	Kaman-Chowari-Bharadi road	0.000000	0.000000
27	Awan	0.000000	0.000000
28	Chowari Khas	32.433083	76.005995
29	Nadda	32.385783	76.001115
30	Mundi	32.367552	76.011090
31	Loharka village	32.340832	76.038182
32	Bagh	32.330662	76.056343

River Samples

Sr.	**Sample**	**Sample name**	**Water t(^{o}C)**	**Atm.t (^{o}C)**	**Remarks**
1	SR1	Manuni Khad	19		
2	SR2	Churan+Manji Khad	20		
3	SR3	Gaj Khad	18	33	
4	SR4	Khauli Khad	32	40	
5	SR5	Nod Khad	27	35	
6	SR6	Ikku Khad	18	28	
7	SR7	Hubarad Khad	18	20	

SPRING SAMPLE DATA
Kangra-Chamba Area (AAP-2012/13)

Name	District/ Tehsil	Sample	Date of sampling	Toposheet no.	Latitude	Longitude	Discharge	Temperature (Water/Atmos.)
Uprerh 1	Kangra		19/06/2012	52 D/8	32.14156	76.31816	Meager	16/
Uprerh 2	Kangra		19/06/2013	52 D/8	32.13958	76.31938	Meager	
Khas Kohala	Kangra		19/06/2014	52 D/8	32.14063	76.31003		20/40
Forsythganj	Kangra		20/06/2014	52 D/8	32.24203	76.3173	Meager	20/35
Satowary-1	Kangra		20/06/2015	52 D/8	32.14046	76.3097	Meager	20/40
Satowary-2	Kangra		20/06/2016	52 D/8	32.14044	76.30977	dry	20/35
Satowary-3	Kangra		20/06/2017	52 D/8	32.24667	76.30067	0.04 lps	18/35
Dal Lake	Kangra		20/06/2017	52 D/8	32.24746	76.30967	Meager	18/35
Mcleodganj	Kangra		20/06/2018	52 D/8	32.24423	76.32328	0.03 lps	18/35
Garoh, Sagarban	Kangra	S3	21/06/2019	52 D/8	32.21122	76.28717	Meager	18/33
Bodban	Kangra		21/06/2020	52 D/8	32.20451	76.2669	0.27 lps	19/35
Dhanotu, dudhamb	Kangra		21/06/2021	52 D/4	32.21119	76.28717	0.15 lps	25/40
Nonu (Bhagni)	Kangra	S4	22/06/2022	52 D/8	32.18615	76.35813	0.12 lps	20/40
Duderh	Kangra		22/06/2023	52 D/8	32.17055	76.34801	Meager	23/27
Rasan	Kangra		22/06/2024	52 D/8	32.18207	76.36992	0.25 lps	20/39
Barwala	Kangra		22/06/2025	52 D/8	32.16512	76.35308	Meager	20/36
Ghayana Khurd	Kangra		22/06/2026	52 D/8	32.15456	76.32566	Meager	21/35
Yol (near Army farm)	Kangra		25/06/2027	52 D/8	32.20559	76.19567	0.08 lps	19/33
Burli Tangroti	Kangra		25/06/2028	52 D/8	32.15477	76.38502	Meager	21/
below Rumrerh rain forest, Jadrangal	Kangra		25/06/2029	52 D/8	32.15238	76.41021	0.16 lps	18/28
Chowari-Raipur road, village Mangloh	Chamba		26/06/2030	52 D/3	32.41876	76.01573	Meager	23/35
Chowari, Village Chulari	Chamba		26/06/2031	52 D/3	32.40743	76.02377	0.05 lps	21/

Chowari, Raipur khas, Shiv temple	Chamba		26/06/2032	52 D/3	32.38548	76.02985	0.16 lps	22/35
Jot Khas	Chamba		26/06/2033	52 D/3	32.488	76.0599	Meager	15/20
Chowari, Raipur khas, Rupnerh khad, gufa	Chamba		26/06/2034	52 D/3	32.38401	76.02809	0.04 lps	22/36
Kaman-Chowari-Bharadi road	Chamba		27/06/2035	52 D/3			Meager	24/30
Awan	Chamba		27/06/2036	52 D/3	32.47209	76.00843	Meager	21/30
Chowari Khas	Chamba	S5	27/06/2037	52 D/3	32.43308	76.00600	Meager	20/29
Nadda	Chamba		27/06/2038	52 D/3	32.38578	76.00112	Meager	
Mundi	Chamba	S6	27/06/2039	52 D/3	32.36755	76.01109	Meager	20/31
Loharka village	Chamba		27/06/2040	52 D/3	32.34083	76.03818	0.018 lps	22/31
Bagh	Chamba		27/06/2041	52 D/3	32.33066	76.05634	Meager	23

Table 3.8: Surface water sampling locations and details in the study area

SURFACE WATER SAMPLE DATA
Kangra-Chamba Area (AAP-2012/13)

Sl. No.	Name	District/Tehsil	Sample	Date of sampling	Toposheet no.	Latitude	Longitude	Discharge	Temperature (water/Atmos.)
1	Manuni Khad	Kangra	SR1	19/06/2013	52 D/8	32.14067	76.30982	0.15 m^3/sec	
2	Chetru	Kangra	SR2	19/06/2013	52 D/8			0.24 m^3/sec	
3	Gaj Khad, Chadi	Kangra	SR3	21/06/2012	52 D/8			6 m^3/sec	
4	Khauli Khad	Kangra	SR4	22/06/2012	52 D/8			0.42 m^3/sec	32/40
5	Nod Khad, Yol	Kangra	SR5	25/06/2027	52 D/8	32.17112	76.38443	0.171 m^3/sec	27/35
6	Ikku kHad	Kangra	SR6	25/06/2027	52 D/8	32.15474	76.38501	4.91 m^3/sec	18/28
7	Hubard Khad	Chamba	SR7	25/06/2027	52 D/3	32.46353	76.99544	0.2 m^3/sec	

5.0 CONCLUSIONS AND RECOMMENDATIONS

Ground Water Related Issues

- ❖ Augmentation of GW through Artificial Recharge structures
- ❖ Roof top rainwater harvesting practices can be adopted in the study area and urban areas, since the district receives fair amount of rainfall. Construction of roof top rain water harvesting structures should be made mandatory in all new construction and rain water harvesting in rural areas should be promoted.
- ❖ Traditional water storage systems need to be revived. Recharge structures feasible in hilly areas are check dams and Gabion structures at suitable locations.
- ❖ Ground Water Recharge Practices should be adopted in spring shed area.

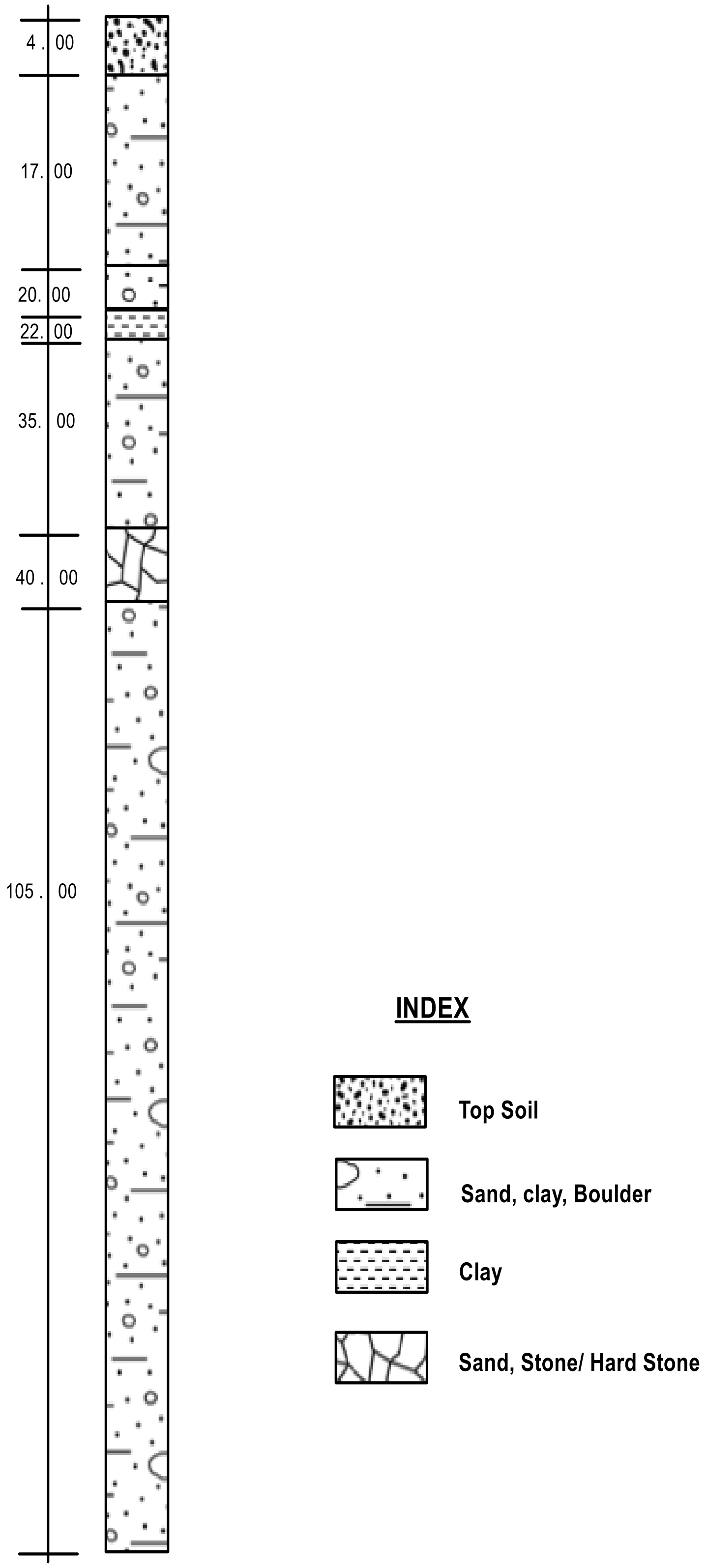
Conclusion and recommendations

- There is an inadequate data available with CGWB and state agencies and existing exploratory wells are not upto the desired depth.
- The ODEX / rotary drilling capacity of KLR rigs is 100 m which is not adequate for aquifer mapping.
- Due to hilly area and limited road network, there is difficulty in transportation of heavy machinery i.e. drilling rigs. Truck mounted drilling rigs capable of manoeuvring need to be deployed.
- As per the data gap analysis, the data is to be generated.
- The state agencies should collect the data on scientific lines.
- Close coordination is required with the state agencies for collecting and sharing the data.
- There is a need for generation of data especially for construction of EWs, Pzs, SPWs, VES, monitoring of water levels, spring discharge, infiltration test, Surveying of NHS, Pzs and other OWs and Impact assessment studies of AR projectsetc.
- Dedicated software is required to be developed for storing & compilation of data and preparation of maps etc.

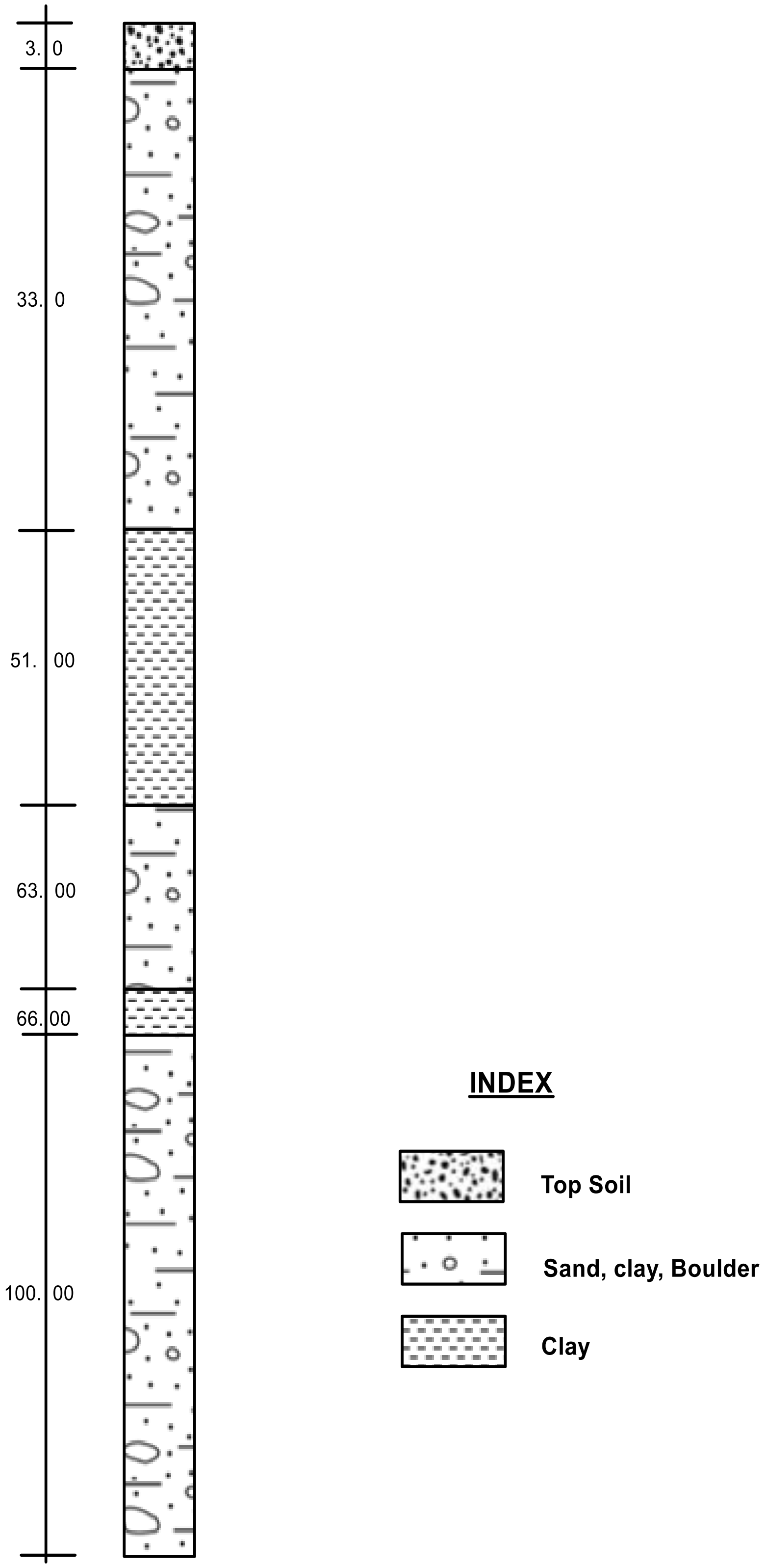
➢ In hard rock area all the weak zones, like thrust, faults, fractures, lineaments, and contact of different formation are to be studied in detail for demarcating the aerial extent and vertical distribution of ground water potential zones by micro level hydrogeological/geophysical studies followed by 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.
- Springs needs to be inventoried & studied for optimum utilisation and development of their discharge either by fracturing, horizontal drilling or by constructing galleries etc.
- 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 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.
- Abandoned handpumps can be used as 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.

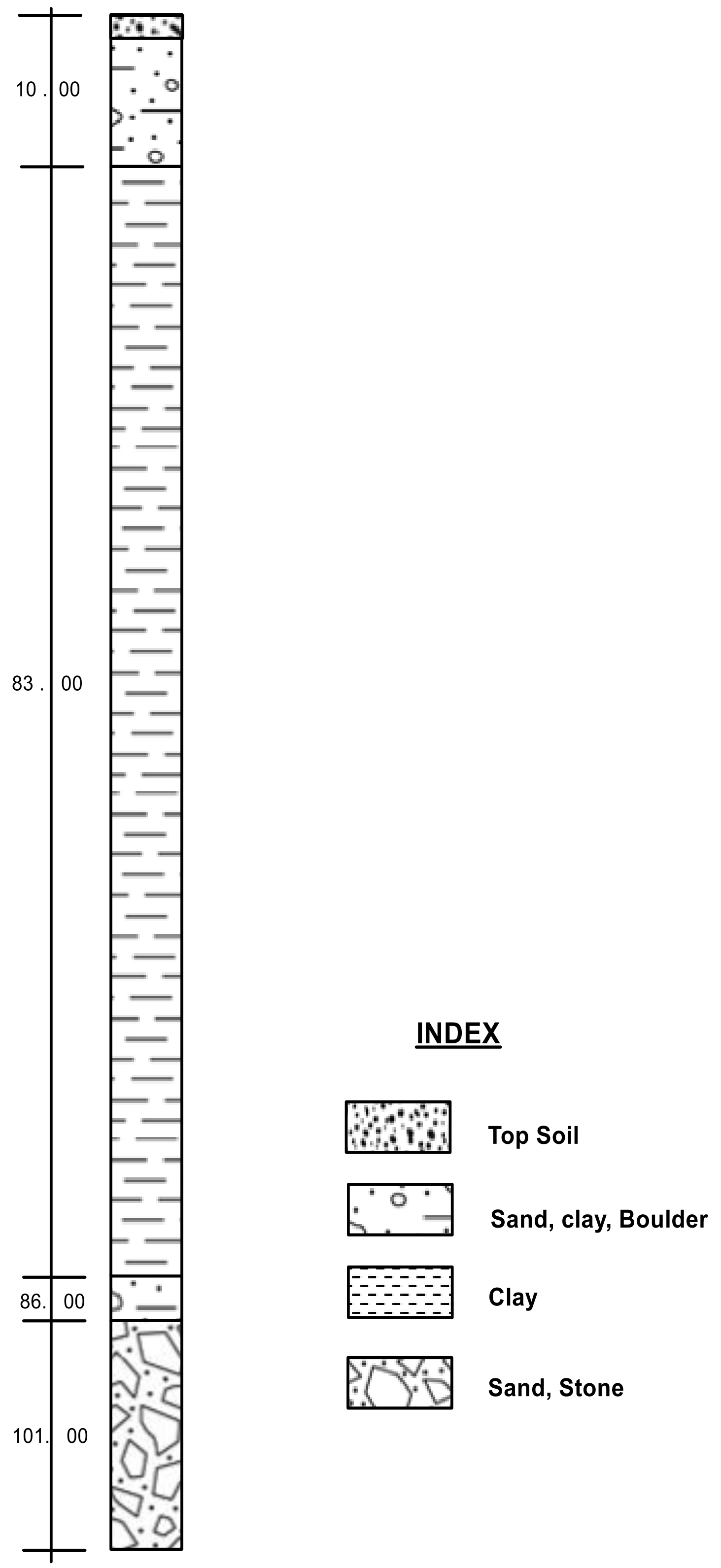
LITHOLOG OF E.W. AT I.T.I GARNOTA
DISTT. KANGRA



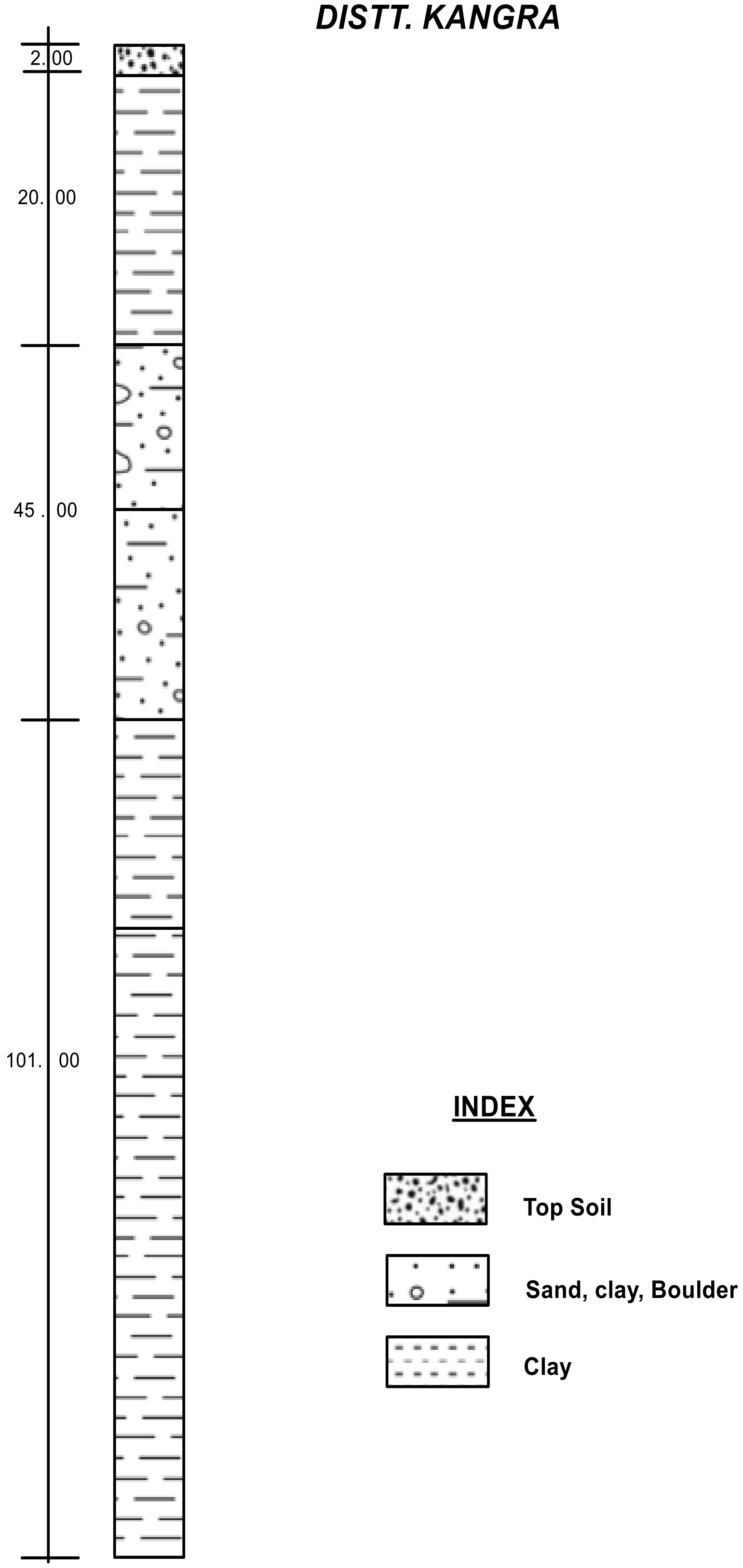
LITHOLOG OF E.W. AT HATLI
DISTT. KANGRA

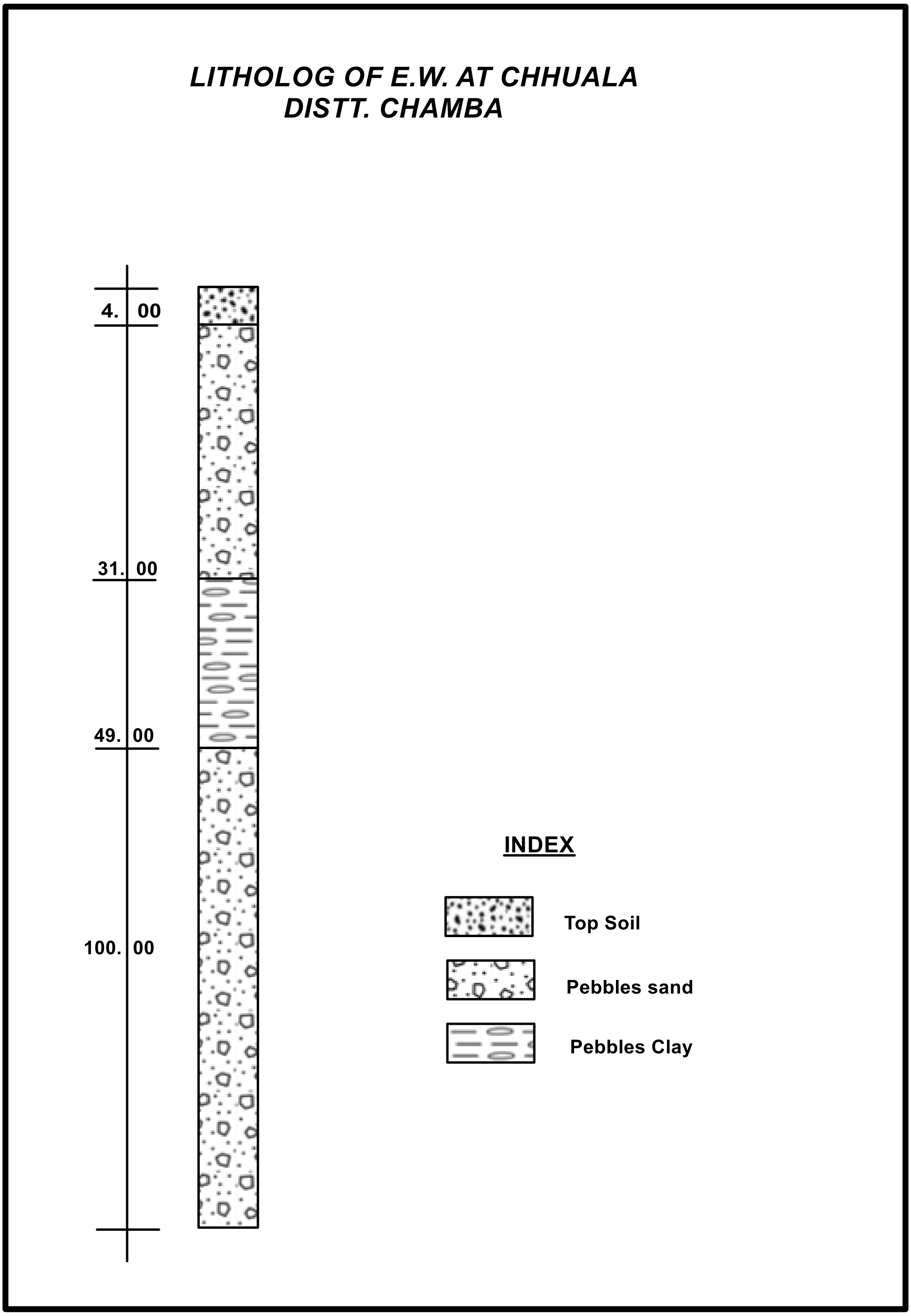


LITHOLOG OF E.W. AT JANDRANGAL DISTT. KANGRA



LITHOLOG OF E.W. AT MOHLI
DISTT. KANGRA





LITHOLOG OF E.W. AT CHHUALA
DISTT. CHAMBA
4. 00
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49. 00
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INDEX
Top Soil
Pebbles sand
Pebbles Clay

Annexure:

Hand pump location data (from State Departments)

Table 3.4 : Location And Coordinates Of Hand Pumps In Respect of IPH Sub-Division Banikhet

SR. NO.	***LOCATION***	***COORDINATES***	
		LONGITUDE	***LATITUDE***
1	***2***	***3***	*4*
1	*Ghared Near Primary School*	*32° 35' 04 0"*	*75° 59' 12.2"*
2	*Ghared Near Bus stop*	*32° 34' 58.3"*	*75° 59' 19.7"*
3	*Gandhiar Lower rain shutter*	*32° 35' 17.6"*	*75° 58' 54.9"*
4	*Chhana near Bus Stop*	*32° 35' 23.2"*	*75° 59' 11.9"*
5	*Chhana near lower Bus Stop*	*32° 35' 32.9"*	*75° 59' 13.4"*
6	*Chowrah Dam site Bus stop*	*32° 35' 48.2"*	*75° 59' 01.7"*
7	*Chowrah Lower near Rain shutter*	*32° 35' 54.4"*	*75° 58' 51.0"*
8	*Sherpur Lower near Mango house*	*32° 35' 21.5"*	*75° 57' 18.5"*
9	*Sherpur near crusher*	*32° 35' 05.5"*	*75° 57' 08.6"*
10	*Sherpur Govt. School Complex*	*32° 34' 53.0"*	*75° 57' 15.9"*
11	*Sherpur Bus Stop*	*32° 35' 09.6"*	*75 °57' 34.5"*
12	*Sanjip Near Barrier*	*32° 36' 51.8"*	*75° 55' 27.6"*
13	*Kheri near bridge & Rain Shutter*	*32° 36' 53.6"*	*75° 55' 17.5"*
14	*Samleo Near Penchant Ghar*	*32° 36' 40.7"*	*75° 54' 50.8"*
15	*Samleo Near Peepal tree*	*32° 36' 27.4"*	*75° 54' 40.2"*
16	*Samleo near Pump House*	*32° 36' 13.5"*	*75° 54' 32.7"*
17	*Samleo near new basti & Gurudwara*	*32° 36' 17.9"*	*75° 54' 40.7"*
18	*Samleo near Kandai Check post Barrier*	*32° 36' 03.2"*	*75° 54' 34.8"*
19	*Kandaie near Pry. School*	*32° 34' 29.4"*	*75° 53' 58.7"*
20	*Kandaie Ghato near Bus Stop*	*32° 34' 09.8"*	*75° 53' 46.2"*

21	*Tarwar Near village foot path*	*32° 33' 51.9"*	*75° 54' 05.0"*
22	*Tarwar Near Bridge*	*32° 33' 47.8"*	*75° 54' 06.8"*
23	*Garh near Tample gate*	*32° 33' 46.2"*	*75° 53' 43.7"*
24	*Garh near Govt. High School*	*32° 33' 48.7"*	*75° 53' 23.0"*
25	*Garh near Bus Stop*	*32° 33' 38.1"*	*75° 53' 20.1"*
26	*Garh near Ravi Shop*	*32° 33' 35.2"*	*75° 53' 20.5"*
27	*Dall near Bus Stop*	*32° 33' 03.4"*	*75° 53' 12.3"*
28	*Siharoo near Bus stop*	*32° 32' 33.5"*	*75° 53' 00.2"*
29	*Chambi near Gargesh Master house*	*32° 32' 01.4"*	*75° 53' 03.8"*
30	*Chambi near Bus Stop*	*32° 31' 46.6"*	*75° 52' 56.7"*
31	*Chambi near Sukardeen house*	*32° 31' 36.0"*	*75° 53' 01.8"*
32	*Mariyada Bus Stop*	*32° 31' 27.5"*	*75° 53' 13.5"*
33	*Kail Near pry. School*	*32° 31' 25.5"*	*75° 53' 30.7"*
34	*Kail Near Bus Stop*	*32° 31' 21.8"*	*75° 53' 36.8"*
35	*Mornoo Near Bus Stop*	*32° 31' 37.1"*	*75° 53' 59.9"*
36	*Nekka Near Bus Stop*	*32° 31' 06.1"*	*75° 53' 49.4"*
37	*Dukka Near Bus Stop*	*32° 30' 37.3"*	*75° 54' 44.1"*
38	*Annan near Temple gate*	*32° 30' 39.8"*	*75° 54' 29.6"*
39	*Mail near High School*	*32° 30' 31.5"*	*75° 53'18.2"*
40	*Draman near culvert*	*32° 30' 45.8"*	*75° 53' 47.6"*
41	*Dev Nagar Near Tank*	*32° 31' 44.7"*	*75° 53' 09.4"*
42	*Chambi Near Mela Ground*	*32° 31' 42.3"*	*75° 53' 20.6"*
43	*Sudli Near Govt. School*	*32° 32' 35.1"*	*75° 53' 26.6"*
44	*Sudli near Bus stop*	*32° 32' 33.6"*	*75° 53' 32.8"*
45	*Sudli Tample gate*	*32° 32' 33.2"*	*75° 53' 35.8"*
46	*Bhathi Near Harizan Basti*	*32° 32' 37.4"*	*75° 53' 56.3"*
47	*Bathi near u-curve*	*32° 32' 44.2"*	*75° 53' 57.6"*

48	*Bassa near Miyan Avadi*	*32° 32' 50.1"*	*75° 54' 07.0"*
49	*Gurdal near Culvert*	*32° 32' 50.2"*	*75° 54' 13.7"*
50	*Bassa near culvert*	*32° 32' 41.9"*	*75° 54' 28.8"*
51	*Bassa near Shop*	*32° 32' 48.3"*	*75° 54' 35.1"*
52	*Bassa Near primary School*	*32° 32' 40.2"*	*75° 55' 04.6"*
53	*Dhalog Near Bus stop*	*32° 32' 40.2"*	*75° 55' 04.6"*
54	*Dhalog Dharti Lahar near Culvert*	*32° 32' 39.2"*	*75° 55' 18.9"*
55	*Dharti Lahar Near Bus stop*	*32° 32' 43.8"*	*75° 55' 22.8"*
56	*Bagdhar near Shamshanghat*	*32° 33' 03.7"*	*75° 55' 48.2"*
57	*karda Near bus stop*	*32° 33' 12.9"*	*75° 55' 38.9"*
58	*Bagdhar near Bus stop*	*32° 33' 22.6"*	*75° 55' 30.7"*
59	*Bagdhar near Bus stop*	*32° 33' 26.3"*	*75° 55' 24.0"*
60	*Bagdhar near school*	*32° 33' 31.0"*	*75° 55' 22.2"*
61	*Bhadhar Mugatta*	*32° 33' 35.0"*	*75° 55' 22.4"*
62	*Khirdi near Dharmkanta*	*32° 33' 53.3"*	*75° 55' 04.6"*
63	*Khirdi near Rain shulter*	*32° 34' 28.3"*	*75° 54' 27.6"*
64	*Chakra below Govt. School*	*32° 34' 43.8"*	*75° 58' 04.7"*
65	*Garani near bus stop*	*32° 34' 36.6"*	*75° 58' 00.7"*
66	*Samma near Tample*	*32° 34' 33.7"*	*75° 57' 48.2"*
67	*Chowrah near Sabo Ram House*	*32° 34' 21.3"*	*75° 57' 25.3"*
68	*Drabed near Jagro House*	*32° 34' 24.2"*	*75° 57' 13.5"*
69	*Ghat Near Amro Ram House*	*32° 34' 23.9"*	*75° 57' 03.3"*
70	*Kaniyarka near vill. Parking*	*32° 34' 11.8"*	*75° 56' 36.3"*
71	*Rangar near bus stop*	*32° 35' 00.2"*	*75° 55' 21.4"*
72	*Manjdhar near bus stop*	*32° 35' 22.4"*	*75° 55' 25.1"*
73	*Dhalog near Culvert*	*32° 32' 34.8"*	*75° 55' 08.0"*
74	*Baderu Nallah Near Shamshan Ghat*	*32° 32' 33.4"*	*75° 55' 38.4"*

75	*Baderu near Tample*	*32° 32' 21.4"*	*75° 55' 48.7"*
76	*Bader near bus stop*	*32° 32' 57.9"*	*75° 55' 12.5"*
77	*Baderu Bar near vill. Path*	*32° 32' 12.5"*	*75° 56' 12.8"*
78	*Belly near bus stop*	*32° 30' 52.2"*	*75° 56' 58.7"*
79	*Belly below lakh data temple*	*32° 30' 43.8"*	*75° 56' 00.9"*
80	*Dhundiara near upper bus stop*	*32° 30' 32.9"*	*75° 56' 02.7"*
81	*Dhundiara lower near ram shelter*	*32° 30' 34.9"*	*75° 56' 15.4"*
82	*Panjpulla near bus stop*	*32° 30' 28.1"*	*75° 56' 40.6"*
83	*Dhundiara near café*	*32° 30' 12.2"*	*75° 55' 39.9"*
84	*Nainikhad near shiv temple & bus stop*	*32° 29' 22.4"*	*75° 55' 50.3"*
85	*Nainikhad near HPSC Bank*	*32° 29' 27.5"*	*75° 55' 41.6"*
86	*Nanikhad near culvert*	*32° 29' 32.8"*	*75° 55' 34.7"*
87	*Nanikhad near shiv temple*	*32° 29' 42.8"*	*75° 55' 26.9"*
88	*Hatli near atul petrol pump*	*32° 29' 34.2"*	*75° 55' 04.9"*
89	*Tunnahatti near excise colony*	*32° 29' 18.5"*	*75° 55' 04.9"*
90	*Tunnahatti near culvert no. 56/9*	*32° 29' 10.4"*	*75° 54' 49.7"*
91	*Tunnuhatti near sood petrol pump*	*32° 29' 63.0"*	*75° 54' 39.6"*
92	*Tunnuhatti near check post*	*32° 28' 55.1"*	*75° 54' 38 .2"*
93	*Dhakog near rohni WSS source*	*32° 28' 39.8"*	*75° 54' 38.4"*
94	*Dhakog near culvert*	*32° 28' 27.8"*	*75° 54' 36.5"*
95	*Gandhiarview point near Chamera*	*32° 35' 16.6"*	*75° 59' 08.6"*
96	*Golli zero point rain shelter*	*32° 34' 51.6"*	*75° 59' 28.2"*
97	*Tikroo near sachin Dhaba*	*32° 34' 46.5"*	*75° 59' 50.7"*
98	*Thandapani village near Hans Raj house*	*32° 34' 28 .0"*	*75° 00' 11.8"*
99	*Golli near middle school*	*32° 34' 39.3"*	*75° 59' 48.1"*
100	*Bhatkara near babu ram house*	*32° 34' 34.9"*	*75° 59' 55.4"*

101	*Goli near bus stop*	*32° 34' 37.8"*	*75° 59' 49.6"*
102	*Goli near pollution center*	*32° 34' 31.8"*	*75° 59' 41.5"*
103	*Loharka near village path*	*32° 34' 31.4"*	*75° 59' 36.5"*
104	*Devidehra near lovely sweet shop*	*32° 34' 06.4"*	*75° 59' 15.3"*
105	*Devidehra near bal ashram*	*32°34' 06.4"*	*75° 59' 15.3"*
106	*Bainska near bus stop*	*32° 34' 13.0"*	*75° 59' 04.4"*
107	*Bathri near rain shelter*	*32° 34' 14.0"*	*75° 58' 56.3"*
108	*Bathri near mahajan medical shop*	*32° 34' 15.2"*	*75° 58' 54.6"*
109	*Bathri PHC Complex*	*32° 34' 17.5"*	*75° 58' 50.3"*
110	*Patna morh bus stop*	*32° 34' 08.6"*	*75° 58' 43.6"*
111	*Samra near bus stop*	*32° 34' 20.4"*	*75° 58' 39.0"*
112	*Kafla near bus stop*	*32° 34' 32.0"*	*75° 58' 45.3"*
113	*Bounkrimorh Bus stop*	*32° 34' 39.1 "*	*75° 58' 51.7"*
114	*Phatti Near Bus Stand*	*32° 34' 23.8"*	*75° 58' 29.9"*
115	*Maluda Bus Stop*	*32° 34' 15.9"*	*75° 58' 24.0"*
116	*Allan Nali near Ram Shelter*	*32° 34' 00.9"*	*75° 58' 11.8"*
117	*Allan Nali near Village Path*	*32° 33' 58.0 "*	*75° 58' 08.3"*
118	*Sukrain bian lower near Sharma house*	*32° 33' 56.3"*	*75° 57' 47.1"*
119	*Gaggi dhar Near Bus Stop*	*32° 33' 56.3"*	*75° 57' 47.1"*
120	*Sukrain bian Near Shiv Temple*	*32° 33' 54 .5"*	*75° 57' 42.5"*
121	*Ugral near madan house*	*32° 33' 48.7"*	*75° 57' 30.5"*
122	*Ugral near tyre shop & bus stand*	*32° 33' 37.2"*	*75° 57' 20.8"*
123	*Vekunth nagar near bus stop*	*32° 33' 13.9"*	*75° 57' 05.2"*
124	*Vekunth nagar near Sashtri niwas*	*32° 33' 12.1"*	*75° 57' 04.2"*
125	*Banikhet Pukhri Galu*	*32° 33' 04.9"*	*75° 56' 57.5"*
126	*Surkhigala near forest rest house*	*32° 32' 57.7"*	*75° 57' 30.7"*
127	*Surkhigala near vatika resturant*	*32° 32' 52.9"*	*75° 57' 18.4"*

128	*Banikhet Near Pine wood*	*32° 32' 57.9"*	*75° 57' 13.2"*
129	*Banikhet near sahara Inn*	*32° 32' 57.3"*	*75° 57' 08.6"*
130	*Banikhet Bus stand*	*32° 32' 54.9"*	*75° 57' 04.9"*
131	*Banikhet hotel sun beam*	*32° 32' 55.1"*	*75° 56' 56.4"*
132	*Banikhet amar Dhaba*	*32° 32' 57.3"*	*75° 56' 55.0"*
133	*Banikhet near HIM Bunkar*	*32° 32' 54.5"*	*75° 56' 51.9"*
134	*Banikhet near check post*	*32° 32' 49.4"*	*75° 56' 45.8"*
135	*Banikhet near helli pad road*	*32° 32' 40.5"*	*75° 56' 44.5"*
136	*Banikhet near Samshan ghat*	*32° 32' 29.3"*	*75° 56' 27.5"*
137	*Banikhet near khairi rain shelter*	*32° 32' 28.5"*	*75° 56' 23.1"*
138	*Banikhet near civil supply godown*	*32° 32' 34.4"*	*75° 56' 28.0"*
139	*Banikhet padder near navneet traders Telephone exchange*	*32° 32' 37.2"*	*75° 56' 29.6"*
140	*Banikhet near nag temple*	*32° 32' 38.9"*	*75° 56' 33.3"*
141	*Banikhet near IPH A.E. residence*	*32° 32' 46.2"*	*75° 56' 38.4"*
142	*Banikhet near central school gate*	*32° 32' 44.9"*	*75° 56' 32.2"*
143	*Banikhet near gas godown*	*32° 32' 50.4"*	*75° 56' 32.6"*
144	*Banikhet chamera colony upper quarter*	*32° 32' 48.6"*	*75° 56' 32.7"*
145	*Banikhet chamera colony middle quarter*	*32° 32' 45.8"*	*75° 56' 43.2"*
146	*Banikhet chamera colony lower quarter*	*32° 32' 46.9"*	*75° 56' 31.2"*
147	*Banikhet power grid complex*	*32° 32' 46.9"*	*75° 56' 31.2"*
148	*Banikhet chelli colony upper*	*32° 32' 42.0"*	*75° 56' 13.7"*
149	*Banikhet PH Store Complex*	*32° 32' 33.9"*	*75° 56' 24.6"*
150	*Banikhet near P.H.C.*	*32° 32' 41.4"*	*75° 56' 38.3"*
151	*Banikhet paddar near little angle school*	*32° 32' 44.7"*	*75° 56' 42.9"*
152	*Banikhet padder near jai amby vastralaya*	*32° 32' 48.2"*	*75° 56' 43.9"*

153	*Banikhet near nirankari bus stand*	*32° 32' 53.1"*	*75° 56' 58.2"*
154	*Banikhet lower near kuldeep sharma house*	*32° 32' 51.0"*	*75° 57' 50.5"*
155	*Banikhet Senior Sec. School*	*32° 32' 53.3"*	*75° 57' 00.0"*
156	*Banikhet Near Yog manav Trust*	*32° 32' 06.8"*	*75° 57' 00.1"*
157	*Bathiyaan M.E.S. Pump*	*32° 32' 36.0"*	*75° 57' 36.6"*
158	*Dalhousie Near Durdwara*	*32° 32' 47.7"*	*75° 57 ' 58.3"*
159	*Dalhousie Tagore Chowk*	*32° 32' 38.7"*	*75° 57' 56.0"*
160	*Dalhousie police station*	*32° 32' 59.0"*	*75° 57' 57.1"*
161	*Dalhousie Subhash chowk*	*32° 32' 09.4"*	*75° 58' 05.6"*
162	*Khol pukhar near primary school*	*32° 32' 06.5"*	*76° 00' 13.5"*
163	*Khol pukhar near bus stop*	*32° 32' 22.6"*	*75° 59' 55.3"*
164	*Dhuda sappar near bus stop*	*32° 30' 35 .8"*	*75° 58' 11.3"*
165	*Balera near bus stop*	*32° 29' 58.8"*	*75° 57' 14.4"*
166	*Lakar Mandi Ground*	---------	---------
167	*Gadana near bus stop*	*32° 29' 18.7"*	*75° 57' 57.9"*
168	*Banikhet Talkoot near Petrol Pump*	*32° 32' 17.7"*	*75° 56' 24.4"*
169	*Lahad near Temple*	*32° 31' 36.0"*	*75° 56' 31.0"*
170	*Lahad near Kunah road*	*32° 31' 24.6"*	*75° 56' 28.5"*
171	*Bhatolli near bus stop*	*32° 31' 11.0"*	*75° 56' 25.8"*
172	*Bhatolli upper near village path*	*32° 31' 11.8"*	*75° 56' 32.9"*
173	*Kunah near village*	*32° 31' 03.4"*	*75° 56' 39.8"*
174	*Belly near Khandi junction*	*32° 30' 53.8"*	*75° 56' 07.3"*

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