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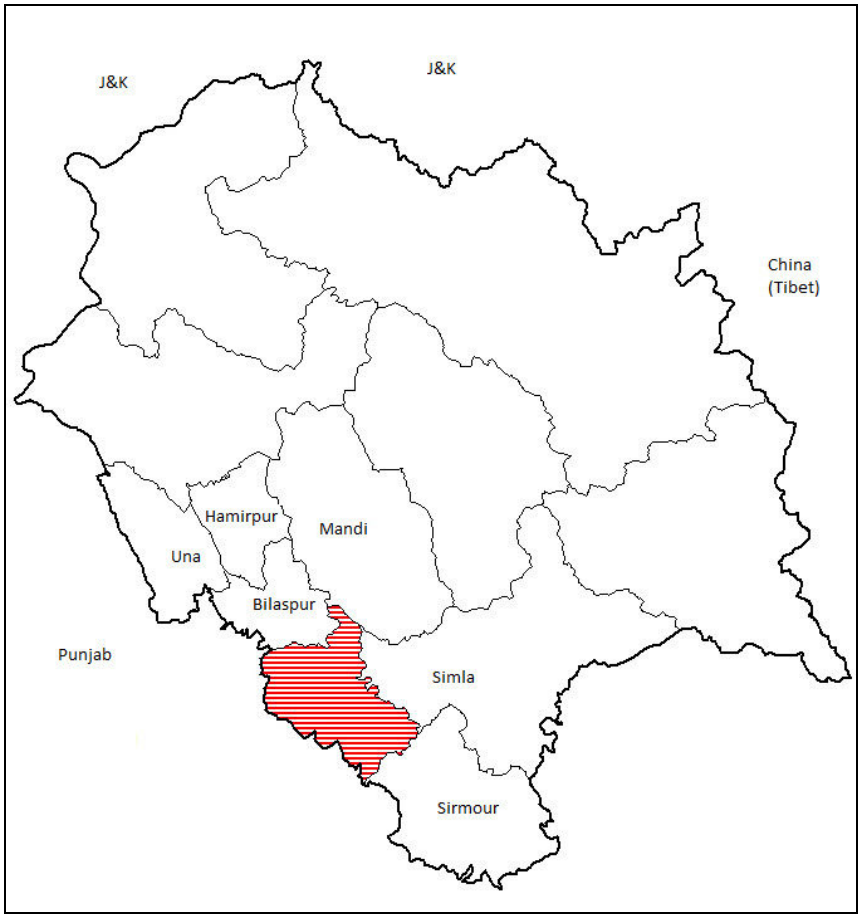
Government of India
Ministry of Water Resources
CENTRAL GROUND WATER BOARD

GROUND WATER INFORMATION BOOKLET
SOLAN DISTRICT, HIMACHAL PRADESH



NORTHERN HIMALAYAN REGION
DHARAMSALA
SEPTEMBER 2013

Contributors

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Under the guidance of

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Our Vision

Water security through sound groundwater management

Ground Water Information Booklet
Solan District, Himachal Pradesh

CONTENTS

SOLAN DISTRICT AT A GLANCE

Sl. No	Items	Statistics
1.	GENERAL INFORMATION	
	Geographical area (sq km)	1,936
	• Number of Tehsil & sub-tehsils	6 & 2
	• Number of CD Blocks	5
	• Number of Panchayats	198
	• Population (2011 Census) • Population Density (persons/km^2) • Rural & Urban Population (%) • Sex Ratio (F:M)	5,80,320 300 82.4 & 17.6 880: 1000
	i) Average Annual Rainfall (mm)	1140.86
2.	GEOMORPHOLOGY	
	Major Physiographic units	• High structural hills & mountains with intermontane valleys (elevation 1000-3000) • Denuded hills & upland (elevation 650–1041 amsl) • Valley/ alluvial plain/ terraces (elevation 360-550 m amsl)
	Major Drainages • Satluj basin (65%) • Yamuna basin	Gambhar River, Sirsa nadi Giri, Assan river
3.	LAND USE as on 2008-09 (ha)	
	• Forest area	20,300
	• Total cropped area	63,800
4.	MAJOR SOIL TYPES	
		• Mountainous Soil • Sub- Mountainous Soil
5.	AREA UNDER PRINCIPAL CROPS (2008-2009) in ha	
	• Rice	4,260
	• Wheat	25,346
	• Maize	22,733
	• Barley	1,836
	• Pulses	2,203
6.	IRRIGATION BY DIFFERENT SOURCES (2008-2009)	
	• Net Irrigated Area (ha)	12,615
7.	NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on 31.3.2013)	
	• Number of Dug Wells	12

	• Number of Piezometers	Nil
8.	PREDOMINANT GEOLOGICAL FORMATIONS	
		• Alluvium/valley-fill (Quaternary) • Siwalik, Sabathu Group (Tertiary) • Meta-sediments/ crystalline (Proterozoic)
9.	HYDROGEOLOGY	
	Major Water Bearing Formations	
	1. *Semi consolidated & consolidated (Tertiary & Older rocks)*	Covers major Hilly, Mountainous part (90%)
	• Yield prospects	Low (1-5 lps)
	• GW structures	Springs, shallow bore wells
	2. *Unconsolidated porous sediments (Alluvium)*	Occupies Nalagarh valley
	• Yield prospects	High (10-25 lps)
	• GW structures feasible	Open wells & tube wells
	Avg. Depth to water level -pre-monsoon	5.01 – 28.76 m
	-post-monsoon	3.02 – 27.57 m
	Long term water level trend	Decline in major part of valley area
10	GROUND WATER EXPLORATION BY CGWB (as on 31.3.2013)	
	• No of wells drilled	16
	• Depth Range (m)	65.00 – 300
	• Discharge (lpm)	1.44 - 1968
	• Static Water Level (mbgl)	2.20 - 43.20
	• Transmissivity (m^2/day)	10.68 – 1480
11.	GROUND WATER QUALITY	
	Presence of Chemical constituents more than permissible limits (eg. EC, F, As, Fe)	Nil
	Quality of Ground Water (EC Range in µS/cm)	Good (320 – 1100)
12.	DYNAMIC GROUND WATER RESOURCES (2011) (Nalagarh valley)	
	• Area	23,849 ha
	• Net Ground Water Availability	8331.66 ham
	• Annual Ground Water Draft	4332.31 ham
	• Stage of Ground Water Development	52%
13.	AWARENESS AND TRAINING ACTIVITY	
	• Mass Awareness Programmes	1

	• Date • Place • No of participants	11-1-2007 Sukedi Khalsa, Nalagarh 500
14.	EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING	
	Projects completed by CGWB	Nil
	Technical guidance to NGOs for roof top rain water harvesting structures.	15
15.	GROUND WATER CONTROL AND REGULATION	
	• Number of OE & Critical Blocks	Nil
	• No of blocks notified	Nil
16.	MAJOR GROUND WATER PROBLEMS AND ISSUES	
	• Hilly/Mountainous area	Forms runoff zone; Mostly hard rocks, low yield in favorable locations, Springs & natural sources vulnerable to pollution due to unchecked sewerage dumps.
	• Valley area (Nalagarh)	Declining trend discernible in recent years; Vulnerable to depletion and pollution due to rapid urbanization and industrialization. Needs immediate attention & monitoring.

DISTRICT GROUND WATER BOOKLET
SOLAN DISTRICT, HIMACHAL PRADESH

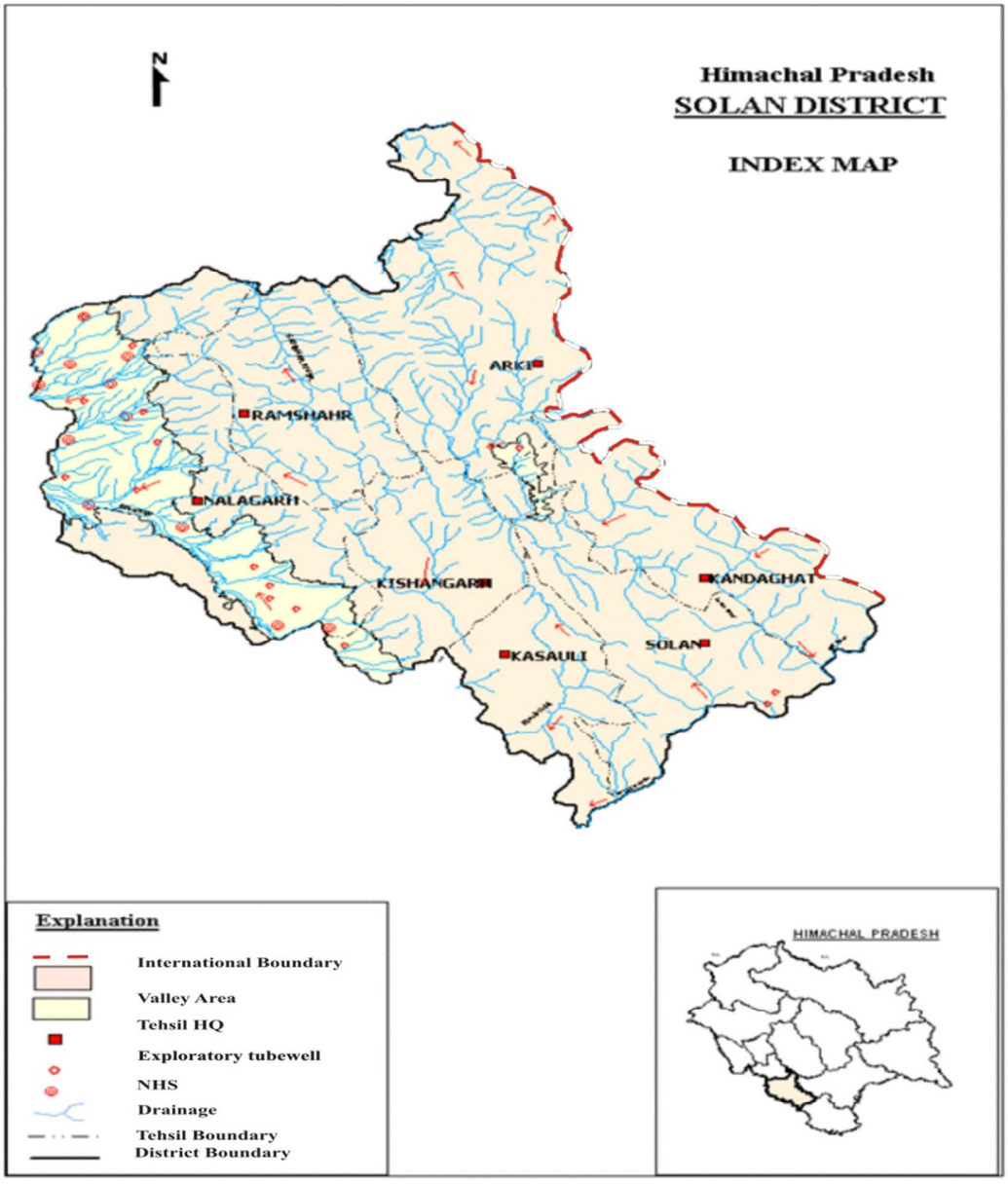
1.0 INTRODUCTION

Solan is one of the south-western districts of Himachal Pradesh having geographical area of 1,936 sq km. The district lies between north latitude 30°44'53" to 31°22'01" and east longitude 76°36'10" to 77°15'14" and is covered by Survey of India degree-sheets 53A, 53B, 53E and 53F. The district is bounded by Bilaspur district in north-west and Mandi district in the north, Shimla and Sirmaur districts in east and south-east respectively. District has inter-state boundary in the south and west with State of Haryana and Punjab respectively. The district is well connected by rail and road network. The nearest airports are at Shimla (Jubbal Hatti) and Chandigarh. Administratively, Solan town is the Head Quarter of the district. The district comprises of 4 sub-divisions viz., Arki, Kandaghat, Nalagarh and Solan and has 6 Tehsils (Arki, Baddi, Kandaghat, Kasauli, Nalagarh and Solan) and 2 sub-tehsils (Krishangarh and Ramshahar). For development purpose, the district has been divided into five community development blocks viz., Dharampur, Kandaghat, Kunihar, Nalagarh and Solan, 198 Gram Panchayats. Important towns in the district are Solan, Nalagarh, Kasauli, Subathu, Dagshai, Arki, Kandaghat, Parwanoo etc.

The population of the district is 5,80,320 (2011 census),out of which 3,08,754 (53 %) are males, and the rest 2,71,566 (47 %) are female. Sex ratio (F:M) is 880:1000 and density of population is 300 per sq km. The rural and urban population is 82.40 % and 17.60 % respectively

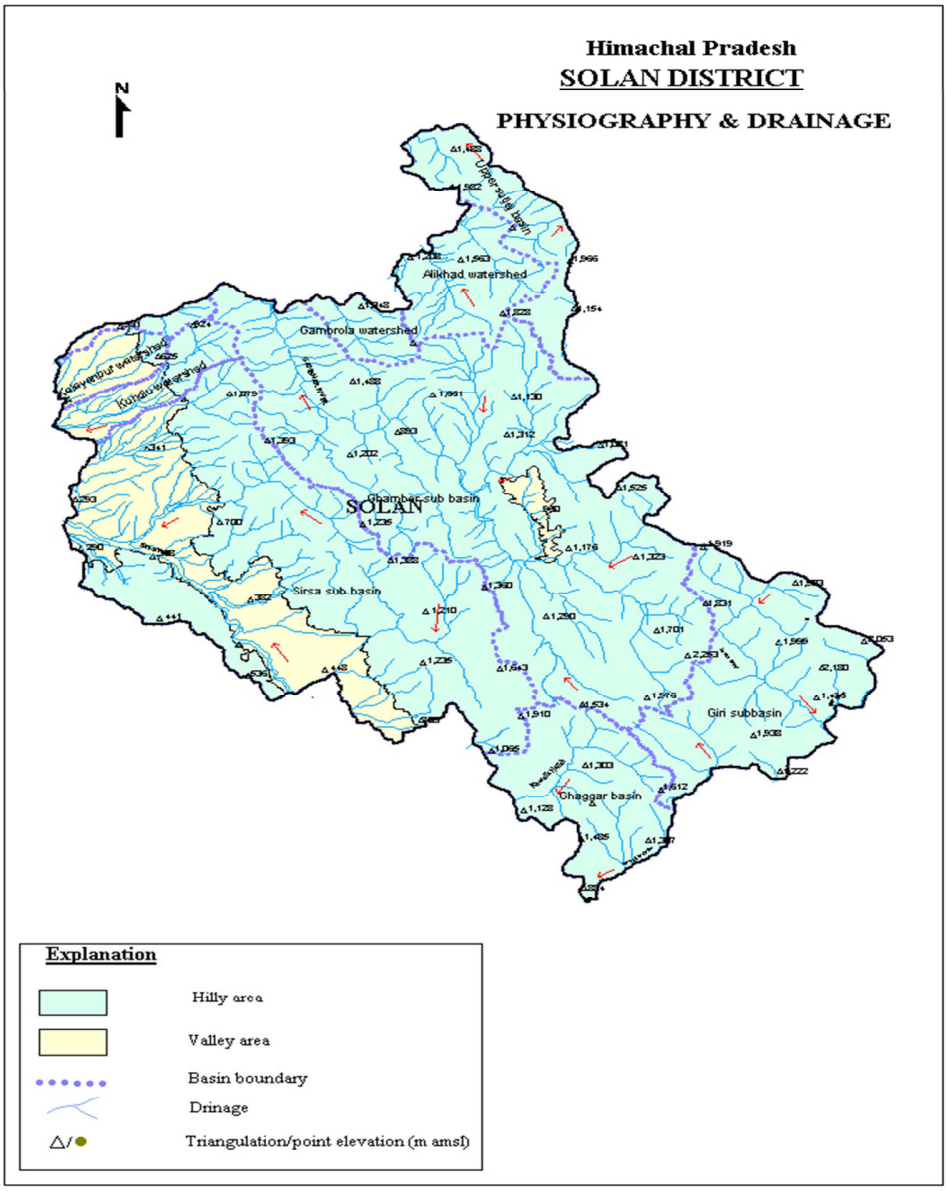
The local inhabitants mainly depend on agriculture for their subsistence and adopt several traditional practices conducive for farming in sloping terrain. Large and small scale industrial development however has taken place randomly all over the district, especially rapid industrial development is taking place in areas adjoining Punjab plains viz., at Nalagarh valley within the Nagar Panchayat of Baddi and Gram Panchayats of Barotiwala, Gulurawala, Sandholi, Thana, Bhud areas.

Central Ground Water Board (CGWB) has carried out extensive hydro-geological studies and ground water exploration in the district. Hydrogeological studies and exploration commenced in sixties, and under exploratory drilling programme 16 exploratory wells ranging in depth from 65 to 300 m have been drilled. Further, CGWB under its national network maintains 12 stations for ground water regime monitoring, where water level and ground water quality is monitored on regular basis.



2.0 CLIMATE AND RAINFALL

The climate of the district is sub-tropical in the valley and tends to be temperate on the hilltops. There are four major seasons. The winter season commences from November to February and ends in March; summer season extends from March to June, followed by the monsoon period extending from July to September. Maximum precipitation occurs during July to September. Average annual rainfall in the district is about 1140.86 mm, out of which 85% rainfall occurs during June to September. In the winter season, precipitation as snowfall also occurs in the higher reaches up to 1000 m elevation and as rainfall in low hills and valleys of the district. Mean maximum and minimum temperature ranges between 32.2°C (May) and 0.6°C (January).



3.0 GEOMORPHOLOGY AND SOILS

Solan district presents an intricate mosaic of high mountain ranges, hills and valleys with altitude ranging from 300 to 3000 m above msl. The altitude of the hill ranges is higher in northern parts, whereas south-western part of the district is represented by low denuded hill ranges of Siwalik. In the areas underlain by high hill ranges of Himalayas, the valleys are narrow and deep with steep slopes trending in NW-SE direction. The terrain is moderate to highly dissected with steep slopes.

Solan district is drained by streams/rivers forming part of the drainage basins of the Sutlej, the Yamuna and the Ghaggar rivers. However, major part of the district is drained by tributaries of Sutlej river viz., Ghambar River and Sirsa nadi. Ghambar River flows almost from the central part of the district towards north-east to join the Sutlej River in Gobind Sagar Lake. Another important-tributary of the Sutlej River is the Sirsa Nadi, flowing towards north-west in the Nalagarh valley. The Giri River and its tributary, Assan flows towards south in the eastern part over a small area and are part of Yamuna river basin. Ghaggar River flows towards south-west and marks the south-eastern boundary of the district. Most of the rivers/streams/*khads* maintain base flow for major part of the year. In hilly terrain, the drainage density is high and fine, but it become coarse in foothills, kandi areas and valleys.

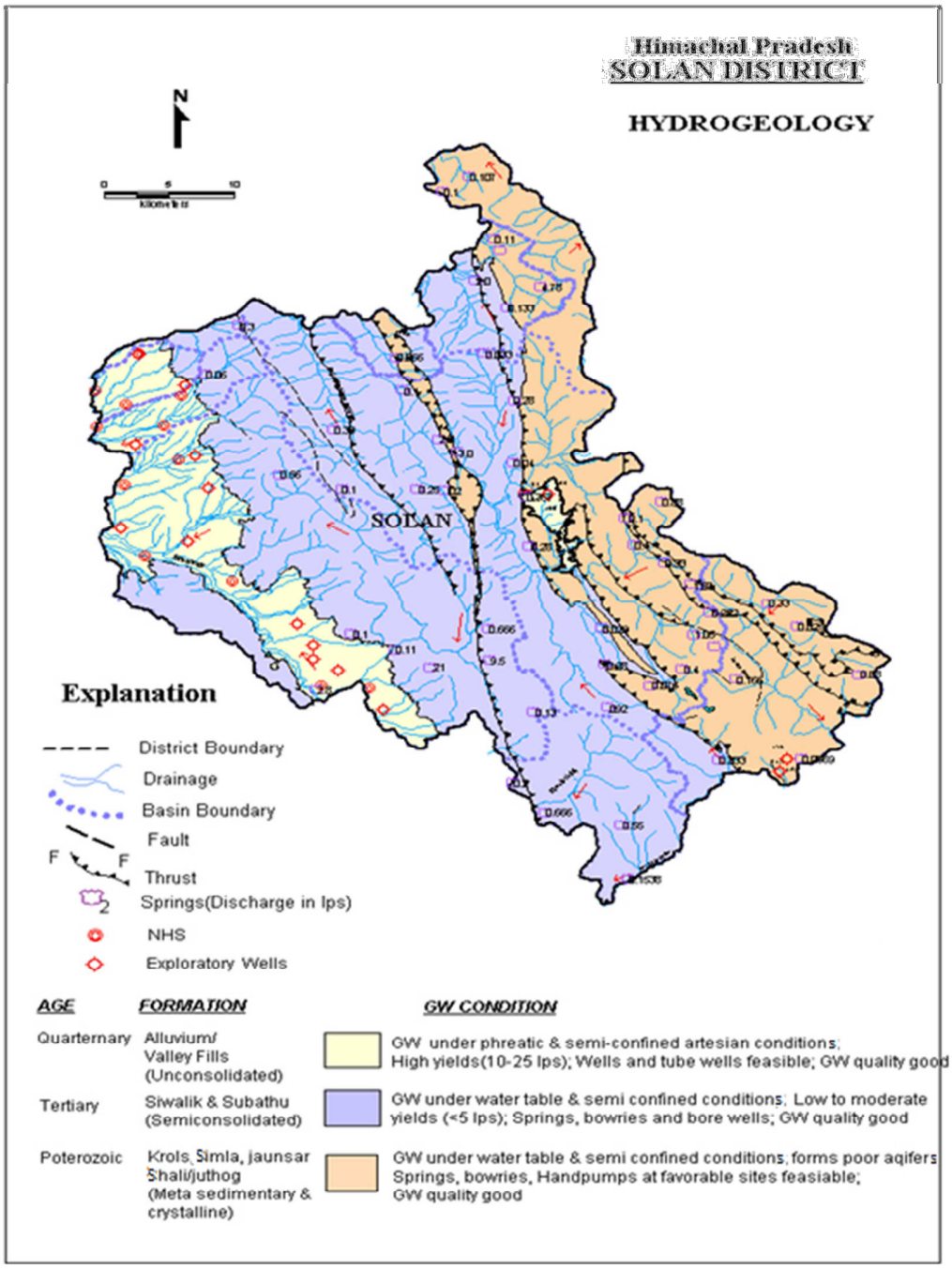
Soil is generally sandy loam in valley areas of the district and in rest of the hilly and mountainous areas, soil is skeletal. Soil depth is generally shallow, except in areas having good vegetative cover. It is generally dry, shallow and deficient in organic matter. Landslides are the common features in mountainous terrain. Soils are rich in nutrients and thus are fertile

4.0 GROUND WATER SCENARIO

4.1 Hydrogeology

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

Era	*Period*	*Formation*	*Lithology*
Quaternary	Recent to Pleistocene	Alluvium /valley fills/ Older alluvium	Sand with pebble and clay, medium to coarse grained sand with pebble of sandstone and lenses of clay
Tertiary	Pliocene – M-Miocene	Siwalik Group	Sand stone, conglomerate, clay, gravel beds, shale, mudstone
	L-Miocene - Oligocene	Subathu	Sand stone, shale, nodular clay, limestone.
Proterozoic	Upper-III	Krols	Red Sandstone, Carbonaceous shale, slate, greywacke, dolomitic limestone.
	Lower-III	Simla / Jaunsar	Siltstone, greywacke, sandstone, quartzite, conglomerate, Shale, slate, phyllite, dolomite and meta-volcanics
	Proterozoic-II	Shali/ Sundernagar	Cherty dolomite, quartzite, limestone, shale, slate, phylitised/ sporadic shale, meta-volcanics etc.,
	Un-differentiated	Jutogh Group	Shale, phyllite, schist, staurolite quartzite, dolomite, Limestone, and amphibolite



Hydro-geologically, the unconsolidated valley fill or alluvial formation occurring in the valley area, semi-consolidated formations belonging to Siwalik Group and older consolidated hard

rocks forms the aquifer in the district. Intergarnular pore spaces in the sedimentary formations and secondary fissured porosity in hard rocks, topographical set up coupled with precipitation in the form of rain and snow, mainly govern the occurrence and movement of ground water. Porous alluvial formation occurring in the valley area, forms the most prolific aquifer system, where as the sedimentary semi-consolidated formations and hard rocks, form aquifer of low yield prospect.

Major parts of the district are hilly and mountainous with highly dissected and undulating terrain. These areas are underlain by semi-consolidated and consolidated hard rocks of Tertiary and Proterozoic age. Ground water potential in such areas is very low, due to its hydro-geomorphic set up. Springs are the main ground water structures that provide water for domestic and irrigation in major rural and urban centers.

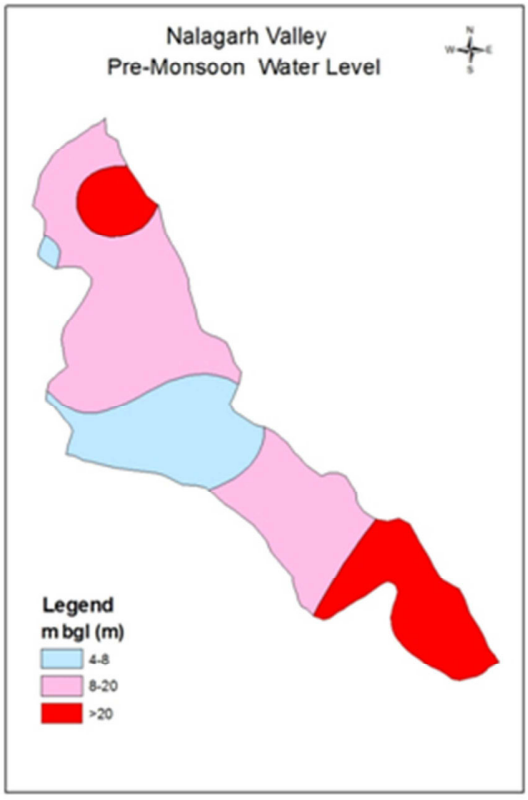
Springs in the district are mainly gravity, contact or fracture type and springs located along major thrust/faults or structurally weak planes are high yielding. The springs are locally called as C*hasma* and the discharge varies from seepages to as high as nine litres per second. *Bowries*, a type of dug well, are another structure constructed on the hill slopes to tap the seepages. Such *Bowries* are very common and found all over the district. Recently, state department have drilled shallow bore wells fitted with hand-pumps to provide domestic water. The hand pumps have an average depth of 50-60m with low discharges upto 1 lps.

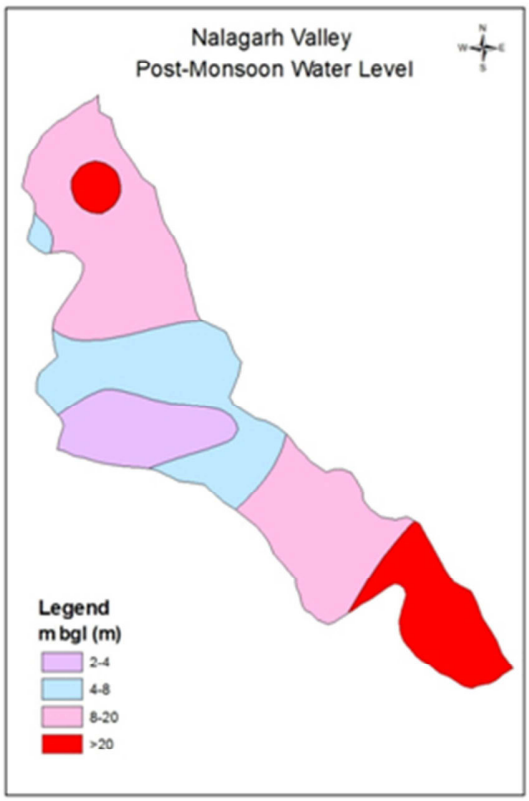
In valley area of Nalagarh, the ground water occurs in porous unconsolidated alluvial formation (valley fills), comprising of sand, silt, gravel, cobbles/pebbles etc. Ground water occurs under phreatic and confined conditions. Wells and tube wells are the main ground water abstraction structures. Ground water is being developed in the area by medium to deep tube wells, dug wells, dug-cum bored wells. Depth of open dug wells and dug-cum bored well in the area ranges from 4.00 to 60.00 m bgl, wherein depth to water level varies from near ground surface to more than 35 m bgl. Yield of shallow aquifer is moderate, with well discharges upto 10 lps.

Deeper semi-confined aquifers are being developed by tube wells, ranging in depth from 65 to 120 m, tapping 25-35 m granular zones. The well discharges vary from about 10 to 30 lps. Out of the 16 exploratory wells, CGWB has drilled/constructed 14 exploratory wells in the valley area, in the depth range of 65.00 to 300.00 m bgl. Static water level ranges from 2.2 to 43.20 mbgl, discharge ranges from 1.44 to 1968 lpm, for a draw-down of 2.48 to 24.10 m.

In Nalagarh valley area, there are 12-hydrograph network stations, where depth to water level is monitored four times a year and ground water quality once, during pre-monsoon period. Depth to water table shows wide variation. During pre-monsoon period (May 2012), it ranged between 5.01 and 28.76 m bgl, while during the post-monsoon period (November 2012), depth to water level ranged from 3.02 to 27.57 m bgl. Deeper water levels are observed mainly in northwestern part and along the foothills. In major parts of the valley, the depth to water level is less than 15.00 m bgl.

Fast pace of ground water development is observed in recent years in valley areas and this has resulted in declining water levels. There is thus a need to initiate water conservation and artificial recharge measures in such areas.





4.2 Ground Water Resources

Rainfall is the major source of recharge to the groundwater body, apart from the influent seepage from the rivers, irrigated fields and inflow from upland areas. The discharge from ground water, mainly takes place from wells and tube wells; effluent seepages of ground water in the form of springs and base flow in streams. Ground water resources and irrigation potential for Nalagarh valley area of the district, have been computed as per the GEC-97 methodology and the resources for the year 2011 are presented below.

1.	Area of Nalagarh valley considered for GW Assessment (ha)	23,849
2.	Net Annual Ground Water Availability (ha)	8,331.6
3.	Annual Ground Water Draft (ha)	4,332.31
4.	*Stage of Ground Water Development* (%)	52

The stage of ground water development is 52%, as on March 2011 in Nalagarh valley area and falls under "*safe category"*. This suggests, that further ground water development can take place.

4.3 Ground Water Quality

Chemical quality data of ground water from shallow as well as deep aquifers in the district, indicates that ground water is generally alkaline in nature and suitable for both domestic and irrigation use. All the parameters analyzed are well within the permissible limits of safe drinking water, as per Bureau of Indian Standard (BIS). The range of chemical parameters, as per samples collected from hydrograph network stations of CGWB in the district are summarized below

Range	pH	EC µS/cm	HCO_3	Cl	NO_3	F	Ca	Mg	Na	K	TH as $CaCO_3$
			mg/l								
Min	7.50	320	81	14	5.40	0.11	16	9.5	25	1	20
Max	8.10	1100	228	264	107	0.33	55	29	138	6	208

Quality of ground water in shallow aquifer, is thus good for domestic and irrigation purpose in the district. Though, contamination of ground water have not been reported in the district so far, however, the fast developing industrial area particularly in Nalagarh block, is highly vulnerable to pollution from industrial effluents. There is thus, a need to have proper ETPs and waste disposal system, with all the industries and major towns. Proper monitoring is very much required.

4.4 Status of Ground Water Development

Ground water development particularly in valley areas in the district, underlain by alluvium/valley fills, is on moderate scale. In these areas, all the major irrigation, industrial and domestic water supplies depend on ground water viz., open wells and tube wells. In rest of the district area, due to poor potentialities in hilly hard rock areas and hilly slopy terrain, groundwater development is low. However, in these areas also, major water supply and sources of water are ground water based viz., perennial springs, *bowries* and hand pumps. Springs are tapped at the source, so that the water can be supplied under gravity. All major towns and villages are supplied water from ground water sources. Large-scale ground water development is mainly restricted to Nalagarh valley only, where wells and tube wells are feasible. In these areas, ground water is developed by large number of dug wells and shallow tube wells. All the major

irrigation, drinking and industrial water supplies depend on these structures, in addition to various water supply schemes based on base flow in rivers and streams or *nallas*.

5.0 GROUND WATER MANAGEMENT STRATEGY

5.1 Ground Water Development

In hilly and mountainous area of the district, ground water development through the traditional ground water sources viz. Springs *(chasmas*), *Bowries* and perennial streams, are only possible, apart from the shallow bores or hand pumps in favorable locations. Proper development of springs is essential, as it is observed that most of the springs do not have collection chambers 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 be developed for harnessing ground water, in such areas.

In the last decade number of shallow bore wells fitted with hand pumps has been constructed in these areas, which serve as a source of water supply for domestic uses in the district. In the hilly areas, shallow bore wells in favorable locations are feasible. However, looking at the fragile eco-system, drilling activity should be minimum.

In valley areas of the district, Nalagarh area, resource estimation shows only 52% stage of ground water development (as on March 2011). This area falls in *safe category*. Thus there is a scope for further ground water development by constructing additional wells, shallow and medium depth tube-wells. However, in view of mild decline in water levels, cautious development approach along with proper monitoring of development is required.

5.2 Water Conservation and Artificial Recharge

Ground water is the major source for irrigation and domestic water supply, in both rural and urban areas. Water level monitoring data has revealed declining trend in water levels, in some parts of the district. Though the stage of ground water development in valley is still in *safe category*, however, declining water levels in recent years suggest a need for cautious and well-planned ground water development. Further, there is an urgent need to monitor development pattern by the implementing agencies.

In many parts, the availability of water during summer is limited, particularly in hilly areas during drought/ low rain fall years. There is thus, immediate need to conserve and augment water resources. Based upon the climatic conditions, topography, hydro-geology of the area, suitable structures for rain water harvesting and artificial recharge to ground water, need to be planned and implemented. Roof top rainwater harvesting in urban/rural areas and water harvesting in

rural area, need to be adopted and proper scientific intervention for spring development and revival of traditional water storage is required, in water scarce hilly upland areas.

The hilly areas receive fair amount of rainfall and ample scope exists for implementing roof top rain water harvesting by constructing appropriate harvesting structures. An NGO named SUTRA working in the district, has constructed such roof top rain water harvesting structures in number of schools and thus demonstrated its efficacy. Such structures should be replicated to conserve and augment water resources. There should be mandatory provision under law, to construct roof top rainwater harvesting structures in all schools, colleges, offices and *pucca* buildings. In similar way, the defence establishments can also have such water harvesting provisions.

6.0 GROUND WATER RELATED ISSUES AND PROBLEMS

Most of the ground water issues and problems in the district are localized and need to be treated independently, by taking the micro level studies in a particular area. In hilly and mountainous parts, the most common issues relate to scarcity of water, particularly during low precipitation year and during non-monsoon period, when dwindling levels of spring discharges are seen. Rainwater harvesting and awareness for water conservation, protection and water harvesting are measures that need to be taken up.

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

7.0 AWARENESS AND TRAINING ACTIVITY

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

Under the aegis of Central Ground Water Authority, Northern Himalayan Region, and in association with Department of Agriculture, HP, one mass awareness programme on *rainwater harvesting for artificial recharge and water management* was conducted at Sukedi Khalsa village in Nalagarh tehsil. About 500 persons, mostly local people, farmers, NGO's, government officials and students from local Senior Secondary School, attended the function.

An exhibition displaying models, maps and displays of rainwater harvesting, artificial recharge and other displays were arranged during the function. Lectures were delivered by the scientific officers and staff of CGWB and State Govt. Departments like Agriculture, Forest etc., for the benefit of local farmers and NGO's wherein, the focus was on the need to conserve water and on rain water harvesting and artificial recharge to ground water, for future use.

7.1 Participation in Exhibition, Mela, Fair etc

To create the awareness about ground water resources, need for rain water harvesting and artificial recharge models, posters, displays etc. were exhibited during mass awareness programme conducted in the district.

7.2 Presentation and Lectures delivered in public forum / Radio/TV/Institution of repute/Grassroots association /NGO/Academic institutions etc

So far, presentations and lectures are delivered amongst the gathering, during the MAP and WMTP only.

8.0 AREAS NOTIFIED BY CGWA / SGWA

The stage of ground water development in Nalagarh valley of the district (as on March 2011), is only 52%. No area or block has been notified from groundwater development point of view.

9.0 RECOMMENDATIONS

- In alluvial areas of Nalagarh valley, though there is scope for ground water development, as stage of ground water development is only 52%, however, there is need to adopt cautious approach and phased manner development of ground water in view of depleting water levels in some parts. This decline can be attributed to fast pace of development in recent years, both in agriculture sector and industrial sector.
- This industrial area, is highly prone and vulnerable to surface and ground water pollution, thus close network of water quality monitoring is essential.
- Proper waste/effluent disposal measures are required to be adopted by industrial units and state authorities need to check this.
- There is a need to protect traditional water harvesting structures like ponds, tanks, talavs etc and to utilize these for rain water harvesting and recharging shallow aquifers.
- In hilly and mountainous terrain, traditional ground water sources viz., springs, *bowries* etc, need to be developed and protected for better health and hygiene, with proper scientific intervention.
- Springs need to be inventoried and studied for optimum utilization of their discharge, either by fracturing, horizontal drilling or by constructing galleries etc.
- Roof top rainwater harvesting practices, may be adopted in hilly and urban areas, since the district receives fair amount of rainfall.
- Rain water harvesting in rural areas should be promoted. Traditional water storage systems need to be revived.
- People's participation is a must for any type of developmental activity. So, proper awareness for utilization and conservation of water resources is required.

For Technical Assistance Relating to
Rainwater Harvesting
&
Artificial Recharge to Ground Water

Contact:

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SAVE WATER-SERVE HUMANITY