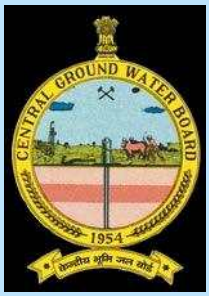


केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

HATHRAS DISTRICT, UTTAR PRADESH

उत्तरी क्षेत्र, लखनऊ

Northern Region, Lucknow

AQUIFER MAPPING AND MANAGEMENT OF HATHRAS DISTRICT, U.P.

(A.A.P.: 2017-2018)

By

Dr. Seraj Khan
Scientist 'D'

CONTENTS

HATHRAS DISTRICT AT A GLANCE

1.	**GENERAL INFORMATION**		
	i. Latitudes	:	$27^0$16'12" to $27^0$51'00" $77^0$52'30" to $78^0$31'54
	ii. Geographical Area	:	1840 Km^2
	iii. Administrative Divisions (As on 31.3.2016) Number of Tehsil/Block Number of Gram Sabha/Villages	:	 4/7 430/675
	iv. Population (as on 2011 census)	:	Total 15,64,708 Male 8,26,160, Female 7,38,547 Rural Population :79% Density of Population / Km^2 : 850 Population Growth (2001-2011): 15.5%
	v Average Annual Rainfall (mm)	:	781.6
2.	**GEOMORPHOLOGY**		
	Major Physiographic Units	:	Older & Younger Alluvium
	Major Drainages	:	• Drainage of the area is controlled by Ganga, Yamuna and their tributaries. • Nim and Kali nadi are major tributaries of Ganga. • Karwan ,Sengar Dehar and Kharia nalas are major tributaries of Yamuna. Both basins are separate by NNE-SSW water divide.
3.	**LAND USE (ha.) (2015-16)**		
	a) Forest area	:	1770
	b) Net area sown	:	149303
	c) Gross area sown	:	247342
4.	**MAJOR SOIL TYPES**	:	Sandy loamy

5.	**AREA UNDER PRINCIPAL CROPS (As on 2015-16) (ha.)**	:	Rabi 143102, Kharif 84636 & Zyad 19604
6.	**IRRIGATION BY DIFFERENT SOURCES (2015-16)** (Areas (ha)and Numbers of Structures)		138129 ha area through Tubewells/Borewells (Govt –/163 ; Pvt –37718)
		:	
	Canals	:	11154 ha area through canals which have length of 589 km.
	Ponds	:	0
	Other Sources	:	0
	Net Irrigated Area	:	149283ha
	Gross Irrigated Area	:	215547 ha
7.	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on 31-3-2017)**	:	
	No. of Dugwells	:	10
	No. of Piezometers	:	1
8.	**PREDOMINANT GEOLOGICAL FORMATIONS HYDROGEOLOGY AND AQUIFER GROUP**		Quaternary alluvium consisting of clay, sand of various grades kankar and gravel.
	I Aquifer Group from 0.00 to ~65-97 mbgl, II Aquifer group between ~107 -135 & ~300. mbgl		
9.	**MAJOR WATER BEARING FORMATION**	:	Sand, silt and gravel
	(Pre-monsoon Depth to water level during 2017)	:	305-29.13 mbgl
	(Post-monsoon Depth to water level during 2017)	:	2.9-30.60 mbgl
	Long term water level trend in 10 years (2004-13) Ground Water Resource estimation in 2013	:	**Pre-monsoon** Rise 44.97 cm/yr Fall 4.43 to 68.4 cm/yr **Post-monsoon** Rise 24.86 cm/yr Fall 16.18 to 56.78 cm/yr
10.	**GROUND WATER EXPLORATION BY CGWB**		
	No of wells drilled (EW, OW, PZ, SH, Total)	:	EW-6, Ow-2 Total – 8
	Depth range (m bgl)	:	188.9-367.5
	Discharge (litres per minutes)	:	400-2400
	Storativity (S)	:	2.65×10^{-4} to 6.5×10^{-3}
	Transmissivity (T= m^2/day)	:	131-1313
11.	**GROUND WATER QUALITY**		By and Large good. First Aquifer Group partly saline.

			Second Aquifer Group Brackish to Saline
12.	**DYNAMIC GROUND WATER RESOURCES (as on March 2013)- ham**	:	
	Net Annual Ground Water Availability	:	585.8 MCM
	Gross Annual Ground Water Draft	:	558.82 MCM
	Stage of Ground Water Development		95%
	Number of OE Block	:	3. Murasn, Sasni and Sahpau
	No Of Critical Blocks	:	1. Hathras
	No of Semi Critical Blocks	:	1. Sadabad
	No of Safe Blocks		2. Hasayan and Sikandra Rao
13.	**AWARENESS AND TRAINING ACTIVITY**		
	Tier II training Programme		Nil
14.	**MAJOR GROUND WATER ISSUES**	:	Dependency of Ground Water Irrigation in all blocks, Intensive Ground Water Development, Declining trend of water level and Ground Water Quality in few blocks.
15.	**MANAGEMENT PLAN**	:	Plan Prepared for three Over Exploited blocks; Murasn, Sasni and Sahpau, one critical: Hathras and one Semi Critical ; Sadabad

AQUIFER MAPPING AND MANAGEMENT PLAN
HATHRAS DISTRICT U.P.

(A.A.P.: 2017-2018)

By

Dr. Seraj Khan
Scientist 'D'

1.0 INTRODUCTION

Since the inception of life on the earth, water has been one the most essential and indispensible commodities for human civilization. The per capita consumption of water particularly ground water has increased a lot, specially where the population growth, industrial expansion and adoption of multi cropping are in vogue. Further practices of advanced agriculture have profoundly enhanced the need of water. The main source of fresh water is ground water resources which are being met out the major part of total useable water requirement. Thus dependency on ground water has increased for social-economic and agricultural development of a region to a great extent on easily availability with low capital cost. The scarcity of this vital resource can hamper the overall development of an area. The unplanned and unscientific development in various parts of the district as well as state has lead to stress on the availability of ground water resources which needs proper management.

Due to the phenomenal changes of "Ground water development" with "groundwater management", in the past two decades in the country, it is imperative to generate an accurate and comprehensive micro-level picture of ground water through aquifer mapping in different hydrogeological environment. It would enable robust groundwater management plans in an appropriate scale. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analysis are applied to characterize the quantity, quality and sustainability of ground water in aquifers. This would help achieving drinking water security, improved irrigation facility and sustainability in ground water resources development in Hathras District. Central Ground Water Board (CGWB) implemented the National Aquifer Mapping Programme in Hathras District, Uttar Pradesh with broad objective of preparing an aquifer wise and block wise management plan for the district. The present report is based upon the integration of existing data of CGWB & various Departments of State Government during A.A.P. 2017-18. The report prepared on "**Aquifer Mapping and Management Plan, Hathras District U.P**." will be very useful for the planners and various executive agencies engaged in the development and management of ground water for agricultural, industrial and drinking purposes.

1.1 OBJECTIVE

Hathras district has an agriculture based economy, about 83% of its total area is under cultivation and 70% population depends upon agriculture resources for their livelihood. Assured irrigation is one the most essential factor for obtaining the optimal agriculture yield. Presently about 88% of the gross cultivated area of the district is irrigated through its ground water resources. Since ground water is the most dynamic and dependable source of water supply, so it is also extensively used for domestic as well as industrial water supply. The exploitation of ground water in the district is increasing day by day to a extent that even at the some places is subjected to the over exploitation , causing depletion in water levels.

The broad objective of the study is to establish the geometry of the underlying aquifer systems in horizontal and vertical domain and characterize them, so as to work out the development potential and prepare block wise management plan. It is envisaged to assess the aquifer wise availability, utilization and water quality, especially in problematic/vulnerable area. Finally, the aim of this study is to prepare block wise management plan to facilitate the suitable development and management of ground water resources.

1.2 SCOPE OF STUDY

The scope of the present study is broadly outlined within the framework of National Aquifer Management programme (NAQUIM) being implemented by CGWB. In the present report an effort has been made to consider the four major activities viz (i) Data collection / compilation (ii) Data gap analysis (iii) Data generation and (vi) Preparation of aquifer maps and management plan to achieve the primary objective. Data compilation includes collection of data and maps from concerned Agencies, such as the Survey of India, Geological Survey of India, State Ground Water Department, U.P. Jal Nigam, Revenue Department., computerization and analyses of all acquired data and preparation of a data base. Identification of Data Gap included ascertaining requirement for further data generation in respect of hydrometeorological, hydrogeological, geophysical & chemical, studies. In continuity of data gap analysis. Data generation includes those of hydrometeorology, soil infiltration, and sub-surface geophysics, chemical quality of ground water, litho logs and aquifer parameters. Generation of ground water chemical quality data was accomplished by collection of water samples and their laboratory analyses for all major parameters, heavy metals, pesticides and bacteria. Sub-surface geophysical studies are incorporated borehole logging. The data pertaining to sub-surface lithology and aquifer parameters are obtained through studies of lithological logs of exiting exploratory wells, pumping tests and their analyses.

1.3 APPROACH AND METHODOLOGY

An approach and methodology adopted to achieve the major objective are Compilation of existing data collected from different sources and agencies and Identification of data gaps. Based on existing data various thematic layers and maps have been prepared in GIS environment and Aquifer maps incorporating the data and management plans are prepared.

1.4 STUDY AREA

The Hathras and Sikandra Rao tehsil of Aligarh district and Sadabad tehsil of Mathura District were carved out from their respective districts (Vide State Govt. Notification No. C.M. 70/1-85/97-R-5 dated 6th May 1997) and merged form the present district of Hathras. . The district situated in the western part of Uttar Pradesh occupies a small part of the Ganga-Yamuna doab which has been endowed with highly fertile soil. It lies between latitude $27^0$16'12" and $27^0$51'00" N and longitudes $77^0$52'30" and $78^0$31'54" E falling in the survey of India Toposheet nos. 54E and I. The district is bounded on north and north western by the district of Aligarh, north east by Kanshi Ram Nagar (Kasganj) , on the east and south east by the district Etah, on the south-west by district of Agra and on the west by district of Mathura. The district is of an elongated in shape and encompasses a geographical area of about 1840 sq.km. Hathras district is part the Aligarh division and for the administrative convenience the district has been divided into 04 (four) Tehsils and 07 (seven) Community Development Blocks (Fig. 1.1). It has 12 towns and 672 villages (665 inhabited and 17 uninhabited villages).The names of tehsils and blocks of the Hathras district with their respective geographical areas & numbers of villages are given in Table-1a. There are three Vidhan Sabha constituencies in this district: Hathras, Sadabad and Sikandra Rao. All of these are part of Hathras Lok Sabha constituency. The district head quarter, Hathras is well connected with Agra, Delhi, Lucknow and other important towns of the country through rail and road. Howrah-Kanpur-Delhi railways and Kanpur-Kasganj- Mathura railway lines serves the district passing through Hathras Road Junction. Three State Highways viz S.H. 33 (Mathura–Kasganj) S.H. No. 39 (Agra-Aligarh) and S.H. No. 22 (Etah-Aligarh) pass though district connection all its important towns. The rural area of the district has also a good network of all weathered roads connection almost each and every village with the district headquarters.

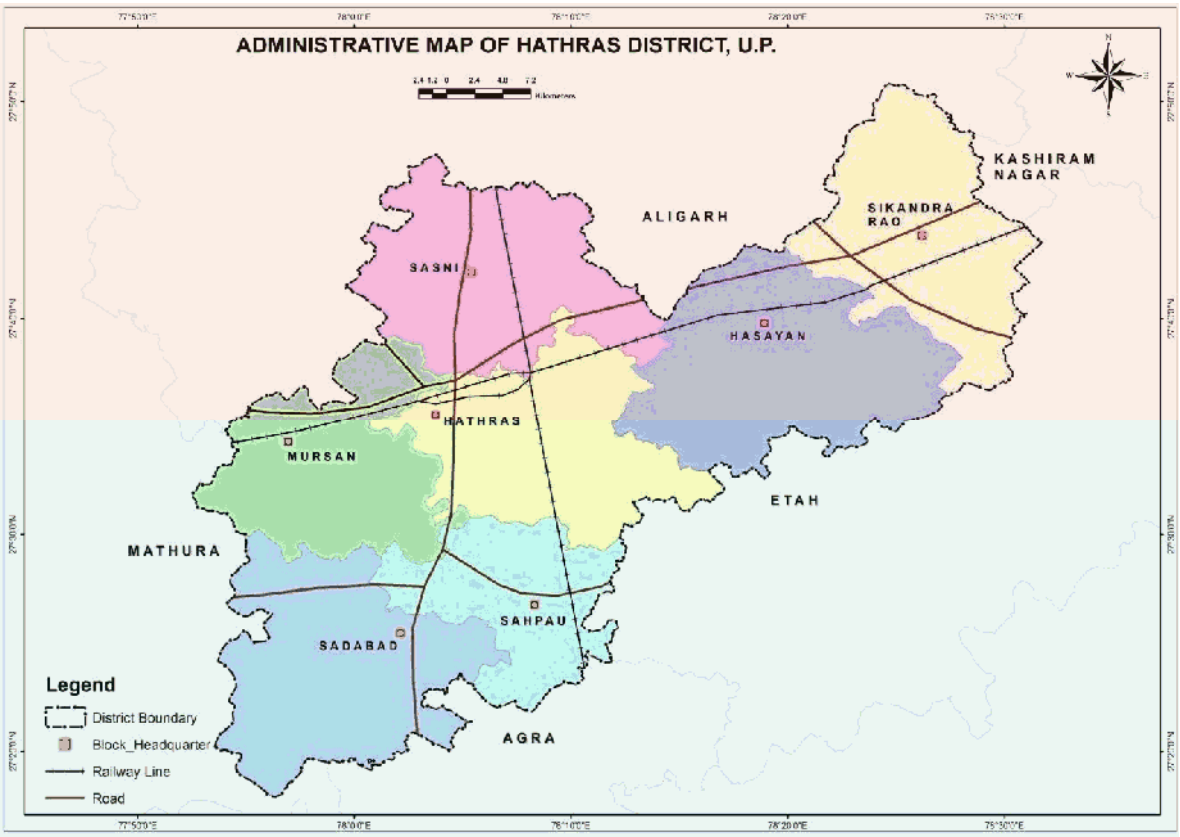


Fig. 1.1 Administrative Map of Hathras District, U.P.

Table-1a Block wise Number of Village, Hathras District as on 31.3.2016
(Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016)

Sl. No.	Blocks	Geographical area in sq.km.	Total No. of Villages		Total
			Inhabited	*Uninhabited*	
I	**SASNI TEHSIL**				
1.	SASNI	273.66	115	0	115
II	**HATHRAS TEHSIL**				
2.	HATHRAS	272.77	105	3	108
3.	MURSAN	234.79	143	10	153
III	**SADABAD TEHSIL**				
4.	SADABAD	290.56	71	0	71
5.	SAHPAU	176.31	63	0	63
IV	**SIKANDRA RAO TEHSIL**				
6.	SIKANRA RAO	265.18	65	2	67
7.	HASAYAN	327.40	93	2	95
	Total	**1840.67**	**665**	**17**	**672**

1.5 DEMOGRAPHY:

As per census 2011, the total population of the district is 15,64,708 in which males are 8,26,160 & female is 7,38,547. The rural population of the district is 12,32,015 comprising 6,59,814 males and 5,72201 females. About 79 % of total population is rural. The urban population of the district is 3,32,693. The schedule castes and schedule tribes population of the district is 7,55,254 and 629 respectively. The work force is approximately 28% of the total population & population density is 850 person/sq. km. The decadal variation in the population is 15.5 % and in rural areas it is 17.1%. The overall literacy percentage of the district is 73.0%. The demographic details are appended in Table-1b.

Table 1b Block wise population of Hathras District (Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016)

Block	People	Urban	Rural	Male	Female	Scheduled Caste Rural	Scheduled Tribe Rural	Decadal Growth % 2001-11	Population Density / sq km
Sasni	224282	13291	210991	119263	105018	62952	33	14.4	820
Hathras	349120	175106	174014	180487	168633	50687	40	12.7	1280
Mursan	202420	19906	182514	108036	94384	52713	85	16.8	862
Sadabad	248471	40926	207545	132140	116331	41708	36	14.7	855
Sahpau	135848	8920	126928	72533	63315	32555	6	17.4	771
Sikanra ra	204403	46038	158365	107490	96913	32891	1	17.1	771
Hasayan	200164	28506	171658	106211	93953	44729	32	19.0	611
Total	**1564708**	**332693**	**1232015**	**826160**	**738547**	**318235**	**233**	**15.5**	850

1.6 DATA AVAILABILITY & DATA GAP ANALYSIS GAP ANALYSIS.

The data pertaining to various attributes of ground water were collected from available literatures of Central Ground Water Board, State Departments and other agencies. The compiled data were plotted on 1:50,000 scale map and analysis of Data Gap was carried out for ascertaining additional requirement of Hydrogeological, Hydrological, Hydrochemical, and Geophysical Studies. Data Requirement, Data Availability and Data Gap Analysis are summarized in Table-1.2.

Table 1.2: Data Requirement, Data Availability and Data Gap Analysis for Aquifer Mapping

Sl No	Study Aspect	Data Requirement	Data Availability	Data Gap
1	Rainfall and Other Climatic data	IMD Meteorological Station & 3 rain gauge stations of revenue department in the area	Rainfall data of Study area Available	-
2	Soil	Soil Map and Soil infiltration rate	Soil Map	Soil Infiltration test requires for Infiltration rate.

Sl No	Study Aspect	Data Requirement	Data Availability	Data Gap
3	Land Use	Latest Land use Pattern in GIS Environment	Land Use available in Satellite data and UP Statistics Department-2015-16	No
4	Geomorphology	Digitized Geomorphological Map	Digitized Geomorphological Map Available	No
5	Geophysics	Geophysical Survey in all blocks	Not Available	35 VES Required & 2D Line Imaging
6	Exploration	Data of Exploratory well along with aquifer parameters	7 wells, 6 Exploratory wells and 1 ow exist tapping Aquifer Group –I only. Aquifer parameters not available	6 Exploratory, 6 observation wells required tapping different aquifer Groups vis a vis Aquifer Parameters
7	Recharge Parameters	Recharge parameters of different soil and aquifer types based on field studies	Recharge parameters are available in Ground Water Resource Estimation	No
8	Discharge Parameters	Discharge parameters for different Ground Water abstraction structure	Discharge parameters are available in Ground Water Resource Estimation	No

1.7 INDUSTRIES:

The district has not made much headway in industrial development. However small scale industries found in the district are engaged generally in manufacturing of handlooms, carpets , glass products, leather goods, paints , chemical , plastic products etc.

1.8 LAND USE, IRRIGATION AND CROPPING PATTERN

Land Use:

A major part of the land in the district is utilized for agriculture purpose. As per the latest statistical data available for the year 2015-16, following land utilization pattern has been observed in the district (Table 1.3). Land use distribution and map of Hathras district is shown in Fig. 1.2 and Fig. 1.3. A perusal of the Table-1.3 and Fig. 1.2 & 1.3 shows that 83% of land in the district is under active cultivation out of which in 54% of land, more than one crop is sown. The land under miscellaneous use is 1% and land other than agriculture use is 11% barren land is more than 1 %. The block wise land utilization pattern indicates that the total area sown is maximum in Hasayan block followed by, Sadabad, Sasni & Sikandra Rao while in remaining blocks, it is more or less evenly distributed where as in the Sahapau block it is minimum. The

cropping intensity of the district is 166 % with maximum of 185% in Hasayan block and minimum of 134 % in Sadabad block.

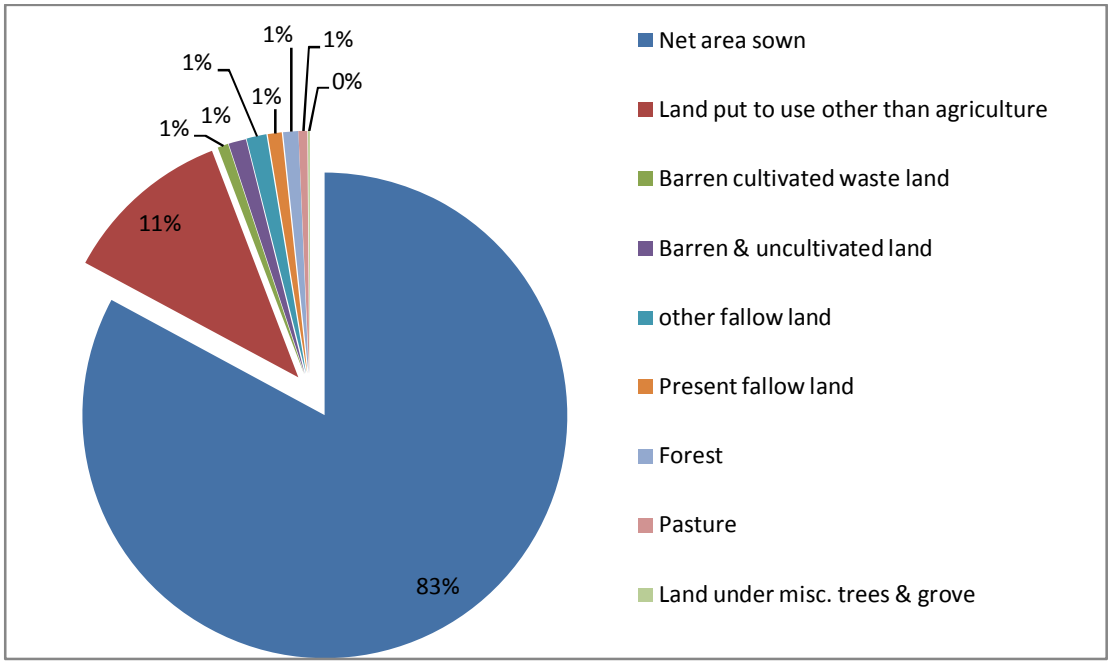


Fig.. 1.2 Land Use Pattern (2015-16) Hathras District,U.P.

Table 1.3 Block wise Land use pattern of Hathras District 2015-16
(Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016)

S No.	Block	Total area reported (ha)	forest	Barren cultivated waste land (ha)	Present fallow land (ha)	Other fallow land (ha)	Barren & uncultivated land (ha)	Land put to use other than agriculture (ha)
	1	2	3	4	5	6	7	8
1	Hasayan	3740	1266	328	384	435	469	3447
2	Hathras	2727	96	166	240	286	245	3658
3	Mursan	3447	126	57	247	115	156	2685
4	Sadabad	2905	17	148	127	550	124	3044
5	Sahapao	1763	20	32	68	141	107	1950
6	Sasni	2736	182	236	355	319	636	3124
7	Sikandra Rao	2651	63	282	315	495	365	2508
	Total District	18400	1770	1249	1736	2341	2102	20416

Table 1.3 (Continued) Block wise Land use pattern of Hathras District 2015-16
(Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016

S No.	Block	Pasture (ha)	Land under misc. trees & grove (ha)	net area sown (ha)	Area sown more than once (ha)	gross area sown (ha)	Cropping Intensity %
		9	10	11	12	13	14
1	Hasayan	244	63	24754	21135	45889	185
2	Hathras	88	5	21005	13541	34546	164
3	Mursan	67	16	5219701	13938	33639	171
4	Sadabad	144	11	24494	8346	32840	134
5	Sahapau	193	9	15055	8371	23426	156
6	Sasni	109	77	22299	15581	37880	170
7	Sikandra Rao	170	42	21995	17127	39122	178
	Total District	1015	223	149303	98039	247342	166

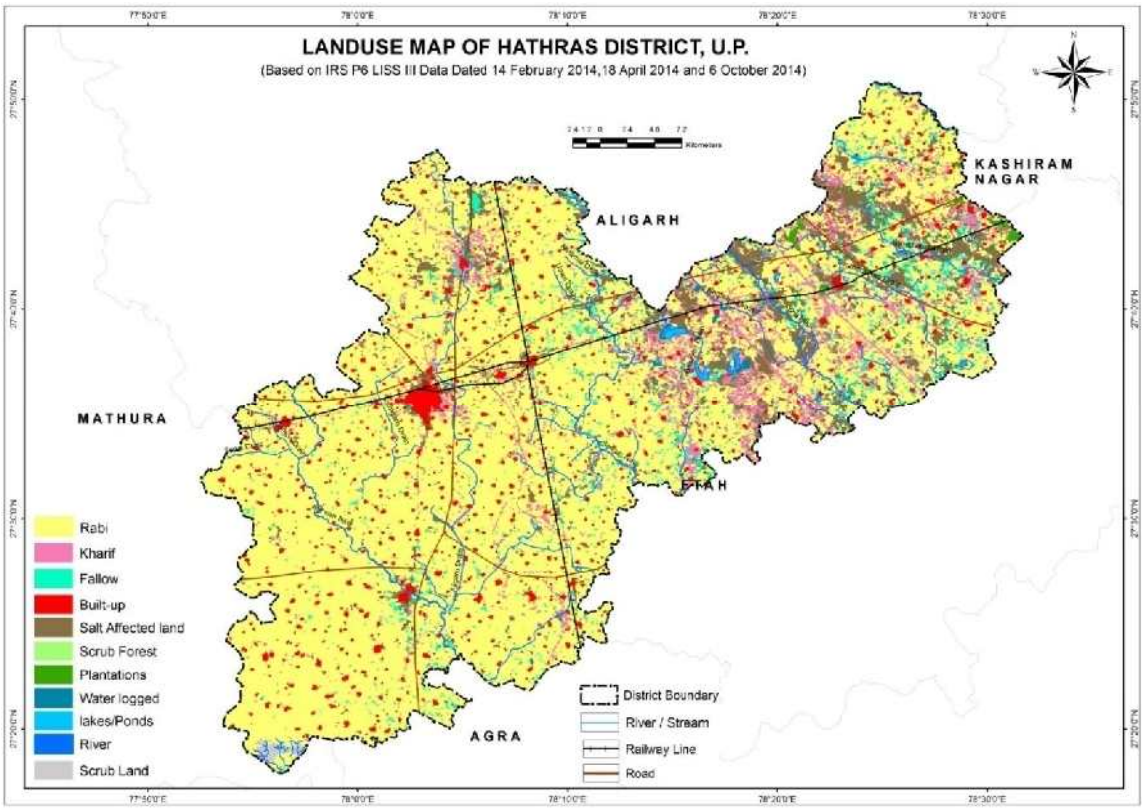


Fig.1.3 Land Use Pattern (2015-16) Hathras District,U.P.

Irrigation:

The development of irrigation potential in the district is remarkable. Block wise Irrigation facilities of district are presented in Table-1.4. The major source of irrigation in the district is ground water irrigating 1,38,129 ha contributing about

92.5% to the total irrigation potentials of the district. Surface water irrigation through the network of Upper Ganga canal passes through the north eastern parts of the district providing the irrigation facilities to the Sikadnra Rao and Hasayan block. The Mat branch canal and its distributaries irrigates the parts of Mursan, Sadadad and Sahpau blocks located in the western and south western parts of the distt. Total length of canal in the district is 589 kms. These canals provide irrigation facilities in 11154 hectare which is about 7.5 % of the total irrigation area of the district (Fig. 1.4a). The Fig. 1.4b shows block wise irrigated area by different sources.

Table 1.4 Block wise Area Irrigated by Different sources , Hathras District 2015-16
(Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016)

S. No.	Block	Canal (ha)	Tubewell (ha)		Well (ha)	Pond (ha)	Other (ha)	Net area irrigated(ha)	Area Irrigated by Surface water(ha)	Area Irrigated by Ground water(ha)	Contribution of GW	Gross area irrigated(ha)	Irrigation Intensity %
			Public	Private									
1	Sasni	90	20	22322	0	0	0	22432	90	22342	99.6	31784	142
2	Hathras	240	23	20820	0	0	0	21083	240	20843	98.8	29895	142
3	Mursan	74	0	19691	0	0	0	19765	74	19691	99.6	27512	139
4	Sadabad	0	0	24553	0	0	0	24553	0	24553	100	27493	112
5	Sahapao	239	0	14876	0	0	0	15115	239	14876	98.4	17620	117
6	Sikandra Rao	5458	21	16564	0	0	0	22043	5458	16585	75.2	38561	175
7	Hasayan	5053	63	19176	0	0	0	24292	5053	19239	79.2	42682	176
	Total	11154	127	138002	0	0	0	149283	11154	138129	92.5	215547	144

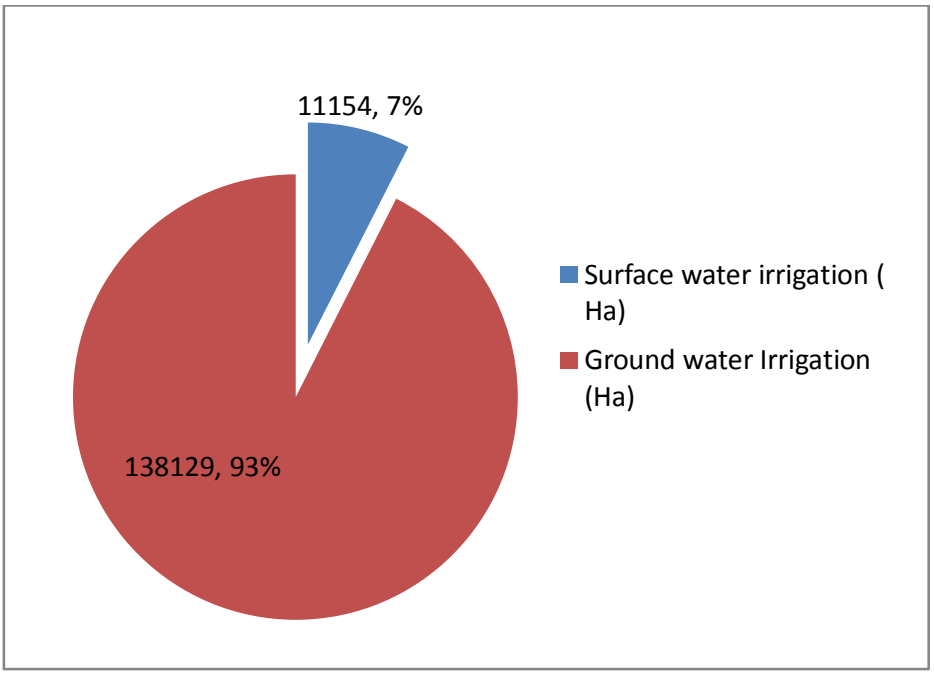


Fig. 1.4 a Area Irrigated by Ground Water and Surface Water in Hathras District-2015-16

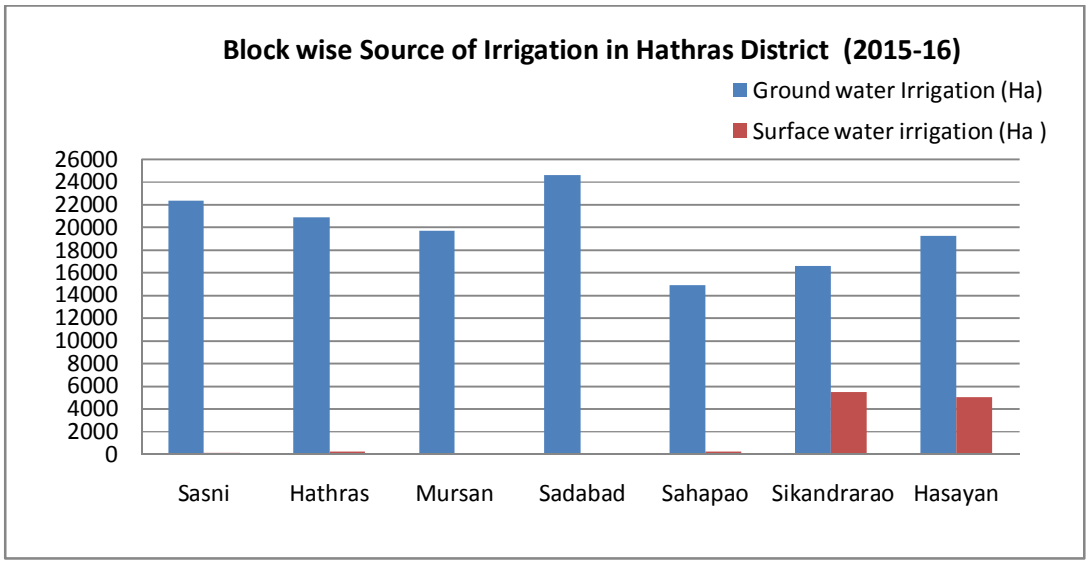


Fig. 1.4 b Block wise Area Irrigated by Ground Water and Surface Water in Hathras District-

The block wise irrigation system indicates that Sikandra Rao and Hasayan have the largest canal network system while remaining blocks have minimum length of canal network, consequently depend upon the ground water for irrigational. The highest number of state tubewells is in Sikandra Rao block followed by Sadabad, Hathras, Sahpau & Mursan blocks. The Hasayan has the minimum number of state tubewells. Large scale development of ground water through shallow private tube wells and boring can be seen in the entire district (Fig.. 1.5). Number of private tube wells is maximum in Sikandra rao followed by Sadabad and Mursan blocks and minimum in Sasni block. Irrigation through open wells and passion wheels in the entire district has become an out dated practice.

Table 1.5 Block wise Number of Ground water Structures of Hathras District 2015-16 (Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016)

S . No.	Block	Canal length km	Govt. tube well	Pakka wells	Rahat	Shallow Tubewell private				Ground pump set
						Electric	Diesel Run	Other	Total	
1	Sasni	5	30	0	0	516	2528	95	3139	3
2	Hathras	76	8	0	0	993	3543	60	4596	0
3	Mursan	58	20	0	0	1367	3752	85	5204	4
4	Sadabad	122	0	0	0	1567	3928	78	5573	0
5	Sahapau	60	30	0	0	2068	4039	87	6194	9
6	Sikandra Rao	250	43	0	0	2772	5154	97	8023	19
7	Hasayan	18	32	0	0	1468	3428	93	4989	9
8	Total	589	163	0	0	10751	26372	595	37718	44

Table-1.4 and Fig. 1.5 showing block wise irrigated area through different sources indicates that 11154 ha area of the district is through canal network. Maximum canal irrigation is being carried out in the Sikanrarao block (covering 24.8 % net irrigation of block) and zero in Sadabad block. State government tube

wells cover only about less than 1 % of the total irrigation area of the district. The private play the leading role in providing irrigation over the entire district & about 90 % of the net irrigation area i.e. 1,88,618 hectare is fed by ground water resources through these structures. All blocks except Sikandra Rao and Hasayan blocks utilize maximum ground water as a source of irrigation. The irrigation intensity of the district is 144% with maximum of 1765% in block Hasayan and minimum of 112% in Sadabad Block.

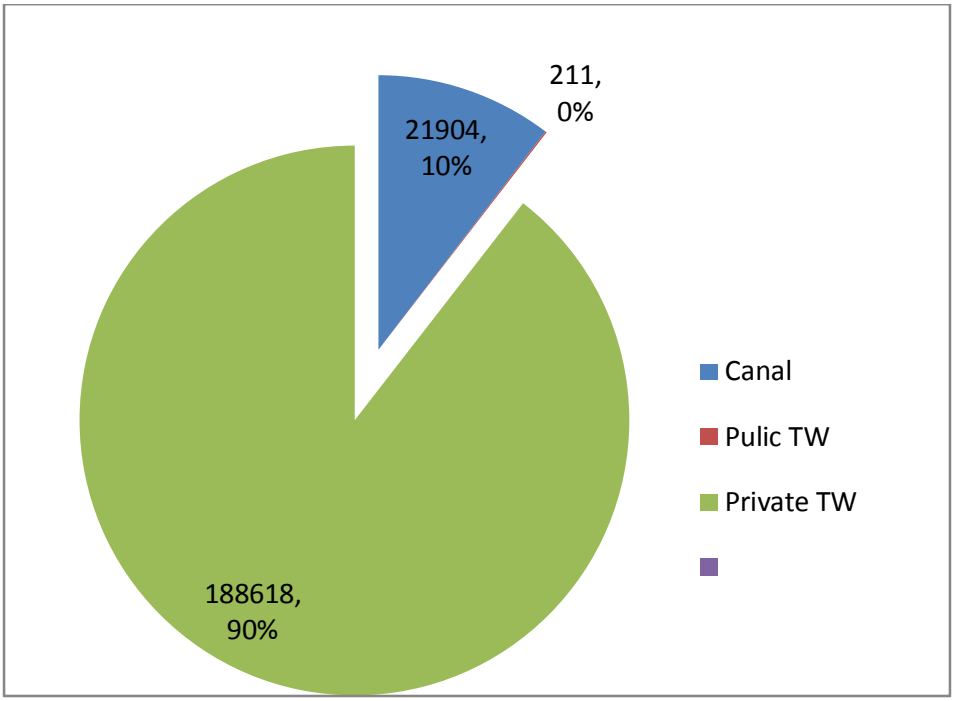


Fig. 1.5 Area Irrigated by Different Sources in Hathras District-2015-16

Cropping Pattern:

General cropping pattern of any area mainly depends upon its climate, topography, soil characteristics, drainage, irrigation facilities and socio-economic conditions. Block wise area under main crops is presented in Table-1.6 and Fig. 1.6 indicates that Pulses Wheat, Rice, Barley Millet and Maize are the principal crops of the area. In addition other crops such as Oil seed and Sugarcane are also grown in the district.

The area under different cultivated seasons in the district is as follows:

Rabi	-	143102 ha.
Kharif	-	84636 ha.
Zaid	-	19604 ha.

The cropping pattern over years from 1999 to 2016 is also analyzed and presented in Table 1.7 and shown in Fig.. 1.7. It is found that the cropping pattern has been changed and pulses are grown more since 2010 than other cereals.

Table 1.6 Block wise area under main crops of Hathras District 2015-16
(Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016)

S. No.	Block	Barley	Maize	Rice	Potato	Millet	Wheat	Pulses
			Area in ha					
1	Sasni	323	18	1889	7319	6562	10675	24927
2	Hathras	289	20	4507	5578	6009	12170	28398
3	Mursan	207	5	2255	9381	6179	8016	19006
4	Sadabad	102	8	171	13401	6895	7549	16267
5	Sahapao	95	6	363	7619	5750	6208	14043
6	Sikandra Rao	467	174	6541	1350	5916	17077	36708
7	Hasayan	474	24	10607	1469	7239	20162	45217
	District Total	1957	255	26333	46117	44550	81857	184566

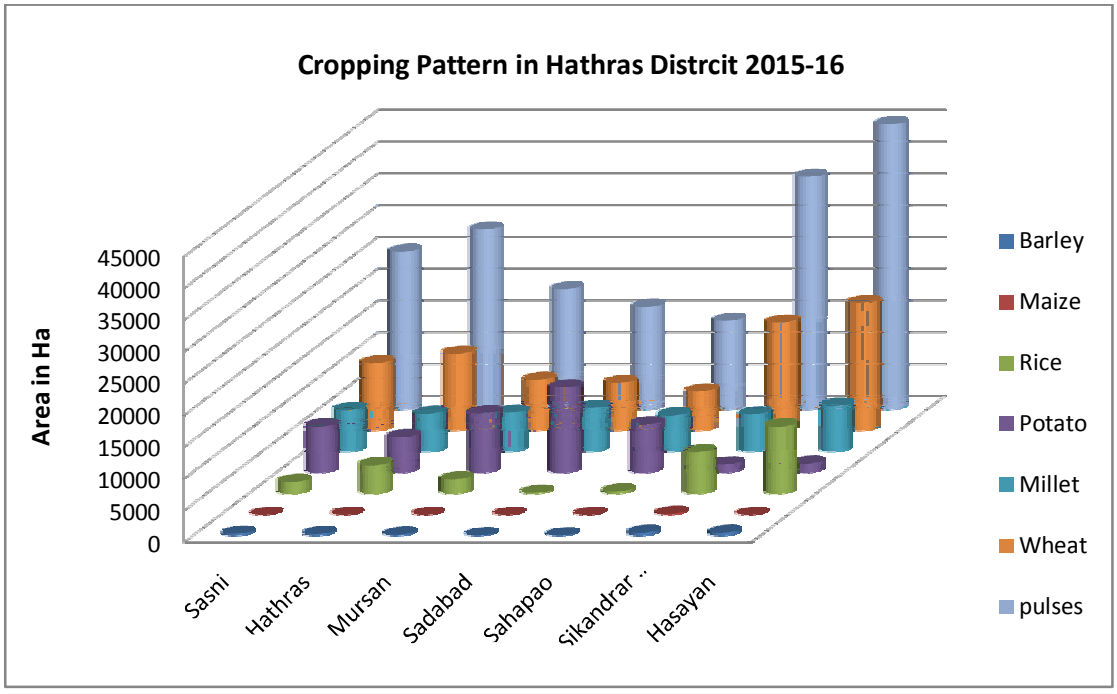


Fig. 1.6 Block wise Cropping pattern in Hathras District.

Table 1.7 Year wise area under main crops of Hathras District 2015-16 (Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P. -2016)

S. No.	Year	Barley	Maize	Rice	Potato	Millet	Wheat	pulses
		Area in ha						
1	1999/00	9153	8336	8394	10871	36744	82530	17613
2	2004/05	7768	4962	7129	20111	45512	92938	9020
3	2009/10	3401	211	14860	37647	46106	86674	183929
5	2015/16	1957	255	26330	46117	44550	81857	184566
5	1999/00	9153	8336	8394	10871	36744	82530	17613

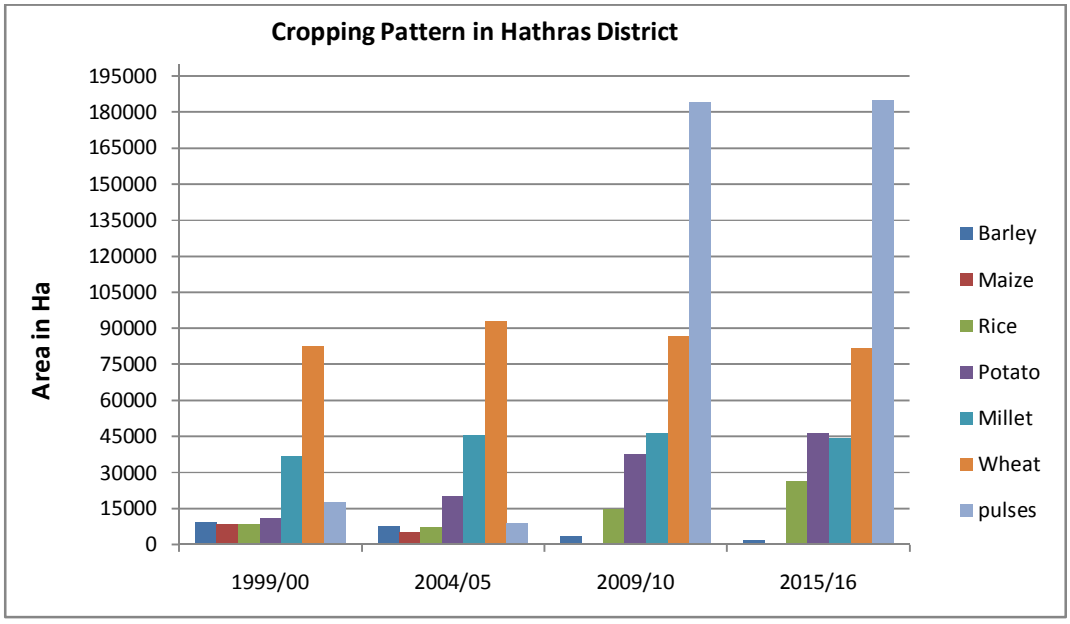


Fig. 1.7 Year wise Cropping pattern in Hathras District

1.9 CLIMATE

Temperature:

Since the district does not have any IMD observatory in its territory, hence to have an ideas of meteorological parameters, the records of Aligarh observatory have been considered . All Climatological variations are depicted in Table-1.8. The area experiences the sub-humid type of climate. The summers and winters are generally severe. The summer season starts from March and continues till late June when the monsoon sets in over the area. The hottest month is June with average mean temperature of 33.65. The coldest month temperature is 10.9^{0}C in December followed by January with 14.02^{0}C. The maximum & minimum temperature & Potential Evapotranspiration (P.E.T.) data are given in Table-1.8

Humidity:

The relative humidity remains high during the morning. Maximum relative humidity (85%) has been observed during the month of August and minimum (37%) in the month of May. The relative humidity falls to low during summer and increases during the active monsoon period. The average relative humidity at the morning is 64.25% and in the evening it is 50.25%. The relative humidity data of the district is given in Table-1.8.

Wind Velocity:

During the month of summer hot strong dust blows during the day time thunder storm with a velocity of 50 to 70 km/hr occurs during summers. In general

used velocity is generally low during the winter season and high during the summer. The mean of monthly the velocity over the district is 6.33 km/h (Table-1.8).

Table-1.8 : Climatological Variations of Aligarh (Average Monthly)

Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean/ Total
Temp. in ^{0}C Max	21	25	30.7	37.2	41	39.6	34	32.8	33.4	32.9	28.3	12.9	30.68
Temp. in ^{0}C Min	7.4	9.6	14.4	20.4	25	27.7	26	25.6	24.2	19.3	22.6	8.9	19.29
Temp. in ^{0}C Avg.	14	17	22.6	28.8	33	33.7	30	29.2	28.8	26.1	25.5	10.9	24.99
Relative Humidity (%) Morning	78	71	58	39	37	54	78	85	77	66	54	74	64.25
Relative Humidity (%) Evening	54	44	66	22	24	39	67	74	62	48	48	55	50.25
Avg.	66	58	62	30.5	31	45.5	73	79.5	69.5	57	51	64.5	57.25
Monthly Rainfall (mm)	15	14	7.4	5.2	14	48.6	230	245	144	48.2	2.2	7.6	781.6
Potential Evapotranspiration (mm)	54	76	130	175	222	215	151	127	136	119.4	72.9	51.5	1529.1
Wind speed K mph	5.3	6.2	6.9	7.5	8	8.5	7.9	6.4	6.3	4.4	4	4.6	6.33
No. of Rainy Days	1.5	1.2	1	0.6	1.3	3.6	11	11.4	5.5	1.9	0.2	0.7	39.6
P.E. Value	0.9	0.7	0.29	0.17	0.4	1.75	11	11.9	6.64	2.12	0.07	0.48	36.16

Potential Evapotranspiration:

The annual normal potential evapotranspiration of the district is 1529.1 mm. The maximum P.E.T occurs in the month of May & June with 222 and 215 mm. respectively whereas the minimum PET recorded in the month of December 51.5 mm. the average of monthly the P.E.T value the district is 1529.1 mm (Table-1.8).

Rainfall:

The Annual normal rainfall of the district is 781.6 mm. Normal monsoon rainfall is 667.6 mm for the period i.e. June to September. August is the wettest month having the normal rainfall of 217.08 mm. followed by July with normal rainfall of 210.24 mm. Normal non monsoon rainfall is 113.6 mm. The normal rainy day of the district is 39.6. The average of annual rainfall of Hathras raingauge stations of the year 1987 to 2016 is presented in the Table 1.9 and Fig. 1.8a& 1.8b. The annual rainfall for the year 2016 is 615.8 mm. The departure of the monsoon rainfall from normal is computed and is given in Table-1.9 & Fig. 1.9b. Monsoon rainfall within ± 19% of the normal monsoon rainfall is considered normal. Monsoon rainfall above 19% of the normal monsoon rainfall is considered excess and monsoon rainfall less than -19% and more than -59% of the normal monsoon rainfall is considered deficit and if the monsoon rainfall is less than -59% of the normal monsoon rainfall, it is considered scanty. Out of last 30 years, 21 years received deficient of rainfall, 7 years received normal and 2 years excess rainfall.

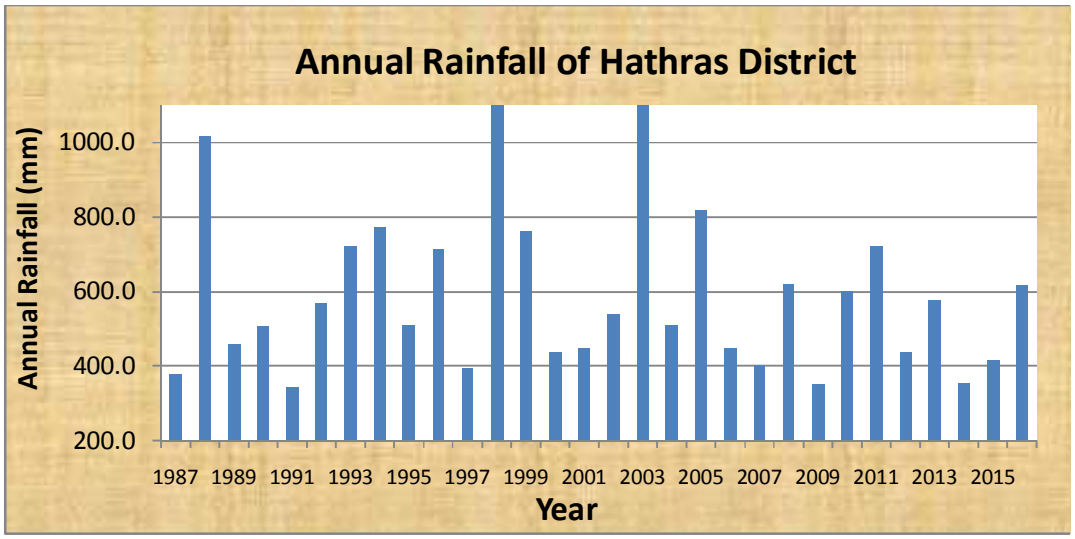


Fig. 1.8 a Annual rainfall of Hathras District

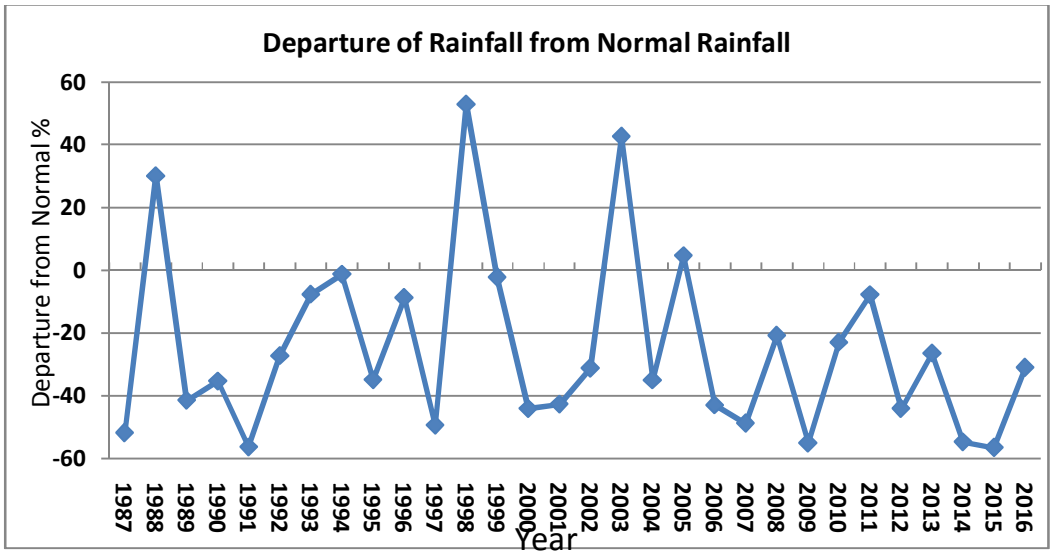


Fig. 1.8 b Departure of rainfall from normal rainfall, of Hathras District

Table 1.9 Annual rainfall of Hathras district (Hathras rain gauge station)																			
S . No .	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Monsoon	Non Monsoon	Departure from norma rainfall (mm	% Departure from normal rainfall	Status
1	1987	9.0	0.0	0.0	0.0	43.0	17.0	80.0	160.0	51.0	5.4	0.0	12.0	377.4	308.0	69.4	-403.8	-51.6641	Deficit
2	1988	2.0	0.0	18.0	4.0	0.0	0.0	537.8	375.8	28.0	35.0	0.0	16.0	1016.6	941.6	75.0	235.4	30.15873	Normal
3	1989	0.0	0.0	24.0	0.0	0.0	47.0	59.0	228.0	100.0	0.0	0.0	0.0	458.0	434.0	24.0	-323.2	-41.3466	Deficit
4	1990	0.0	51.0	0.0	0.0	8.0	34.0	133.0	105.0	174.0	0.2	0.0	0.9	506.1	446.0	60.1	-275.1	-35.1895	Deficit
5	1991	2.0	0.0	0.0	0.0	0.0	0.0	33.2	239.1	59.5	0.0	8.0	0.0	341.8	331.8	10.0	-439.4	-56.2212	Deficit
6	1992	15.2	5.2	5.0	0.0	0.1	3.0	156.0	229.5	72.0	73.0	10.0	0.0	569.0	460.5	108.5	-212.2	-27.1377	Deficit
7	1993	0.0	8.0	6.0	0.0	0.0	117.3	205.0	131.5	254.1	0.0	0.0	0.0	721.9	707.9	14.0	-59.3	-7.56528	Normal
8	1994	35.0	3.0	0.0	15.0	1.1	0.0	499.9	215.0	3.0	0.0	0.0	0.0	772.0	717.9	54.1	-9.2	-1.15207	Normal
9	1995	20.0	0.0	3.0	0.0	0.0	18.0	91.0	270.0	107.0	0.0	0.0	0.0	509.0	486.0	23.0	-272.2	-34.8182	Deficit
10	1996	5.0	49.0	0.0	0.0	16.0	128.0	159.0	210.1	125.0	21.0	0.0	0.0	713.1	622.1	91.0	-68.1	-8.69176	Normal
11	1997	0.0	0.0	2.0	25.0	0.0	39.9	175.9	153.0	0.0	0.0	0.0	0.0	395.8	368.8	27.0	-385.4	-49.3088	Deficit
12	1998	0.0	0.0	0.0	0.0	0.0	99.4	443.4	481.0	79.0	92.2	0.0	0.0	1195.	1102.8	92.2	413.8	52.99539	Excess
13	1999	45.0	0.0	0.0	0.0	0.0	38.0	160.0	370.0	151.3	0.0	0.0	0.0	764.3	719.3	45.0	-16.9	-2.13774	Normal
14	2000	0.0	0.0	0.0	0.0	0.0	89.0	207.0	82.6	59.0	0.0	0.0	0.0	437.6	437.6	0.0	-343.6	-43.958	Deficit
15	2001	0.0	0.0	0.0	0.0	0.0	67.5	236.0	69.0	29.0	47.0	0.0	0.0	448.5	401.5	47.0	-332.7	-42.5627	Deficit
16	2002	29.2	26.0	0.0	0.0	40.0	22.0	38.0	203.0	134.0	14.0	0.0	32.0	538.2	397.0	141.2	-243.0	-31.0804	Deficit
17	2003	22.0	26.0	0.0	4.0	23.0	71.0	347.0	320.0	298.0	0.0	0.0	4.0	1115.	1036.0	79.0	333.8	42.75474	Excess
18	2004	16.0	0.0	0.0	34.2	20.2	8.0	41.0	204.0	131.0	54.0	0.0	0.0	508.4	384.0	124.4	-272.8	-34.895	Deficit
19	2005	16.0	12.0	14.0	0.0	31.0	12.0	475.0	64.0	194.0	0.0	0.0	0.0	818.0	745.0	73.0	36.8	4.736303	Normal
20	2006	0.0	0.0	0.0	0.0	22.0	32.2	281.8	66.4	44.0	0.0	0.0	0.0	446.4	424.4	22.0	-334.8	-42.8315	Deficit
21	2007	0.0	59.0	35.0	0.0	0.0	37.4	122.4	95.4	52.0	0.0	0.0	0.0	401.2	307.2	94.0	-380.0	-48.6175	Deficit
22	2008	0.0	0.0	35.0	28.0	49.5	126.6	197.5	94.0	89.0	0.0	0.0	0.0	619.6	507.1	112.5	-161.6	-20.6605	Deficit
23	2009	0.0	0.0	0.0	13.0	8.2	1.0	25.0	186.0	46.0	53.0	20.0	0.0	352.2	258.0	94.2	-429.0	-54.8899	Deficit
24	2010	0.0	0.0	0.0	0.0	0.0	3.1	203.7	89.6	304.1	0.0	2.0	0.0	602.5	600.5	2.0	-178.7	-22.8495	Deficit
25	2011	8.0	11.0	0.0	0.0	23.0	0.0	297.0	212.0	120.0	0.0	50.0	0.0	721.0	629.0	92.0	-60.2	-7.68049	Normal
26	2012	29.0	0.0	0.0	1.5	0.0	11.9	116.7	239.7	37.8	1.5	0.0	0.0	438.1	406.1	32.0	-343.1	-43.894	Deficit
27	2013	9.7	29.3	0.0	2.0	0.0	51.0	110.0	278.0	36.0	48.5	0.0	11.0	575.5	475.0	100.5	-205.7	-26.3057	Deficit
28	2014	51.0	6.2	14.3	5.5	9.6	9.5	126.0	64.0	65.0	0.0	0.0	3.5	354.6	264.5	90.1	-426.6	-54.5827	Deficit
29	2015	42.3	0.0	53.5	27.5	4.0	68.5	80.5	90.3	31.0	12.5	0.0	6.5	416.6	270.3	146.3	-364.6	-46.6462	Deficit
30	2016	0.0	0.0	1.5	0.0	8.0	37.0	384.0	80.3	80.5	24.5	0.0	0.0	615.8	581.8	34.0	-165.4	-21.147	Deficit
31	**AVG.**	**11.9**	**9.5**	**7.0**	**5.3**	**10.2**	**39.6**	**200.7**	**186.9**	**98.5**	**16.1**	**3.0**	**2.9**	**591.6**	**525.7**	**65.9**	**-189.6**	**-24.2396**	**Deficit**

1.10 GEOMORPHOLOGY

Physiographically, Hathras district forms a part of Yamuna-Ganga doab in Cnenrtal Indo- Gangetic plain and except the Sikandra Rao and eastern parts of the Hasayan block the entire district area falls under Yamuna Basin. The Upper Ganga Canal (Etawah Branch) flows over the divide between two sub basins. Both parts of the area exhibit more or less a flat topography with gentle undulation. Topographically the area of both the parts of the district are almost an open plain, sloping gently from north to south in the Western side and south to east in the eastern side.

The general slope of the area is extremely regular from north-west direction except when the monotony of the terrain is broken either by elevation or some depressions such as rivers, to lakes, ponds paleo-channels etc . The highest elevation of 185 m amsl noted in the district and the minimum of 163 m amsl with the average elevation of the slope 178 m above mean sea level. The average gradient of slope is 0.24 m/km. (Fig. 1.9 a). Except the very small part (about 5-10%) in the south-western corner of the district. The entire district occupies geo-morphologically, the extensive tract of older Alluvium Plain or upland (Fig..1.9 b). Many paleo Channels tals, meander cut off and oxbow lakes exist in this plain. Badlands and minor ravines have also been observed at few places developed along the banks of the rivers. At places, the land surface is affected with salt encrustations. The sediments of the Older Alluvium plain comprises of yellow and grey coloured clay, silt sand with kamkars beds. Kankars are abundant in the district. Block kankars are available in Sadabad tehsil. In the south- western corner of the district , older alluvium plain is flanked by the terrace zones which in tune followed d by the recent flood plain of river Yamuna,. Relationship of geomorphic units' with lithology is as follows:

System	Lithology
1. Recent flood plains of the streams	Yellow coloured clay silt and sand of various grades.
2. Terrace zone	Yellow & grey coloured clay silt with kankar beds.
3. Older alluvial plains	Yellow grey coloured clay silt sand and kankar beds.

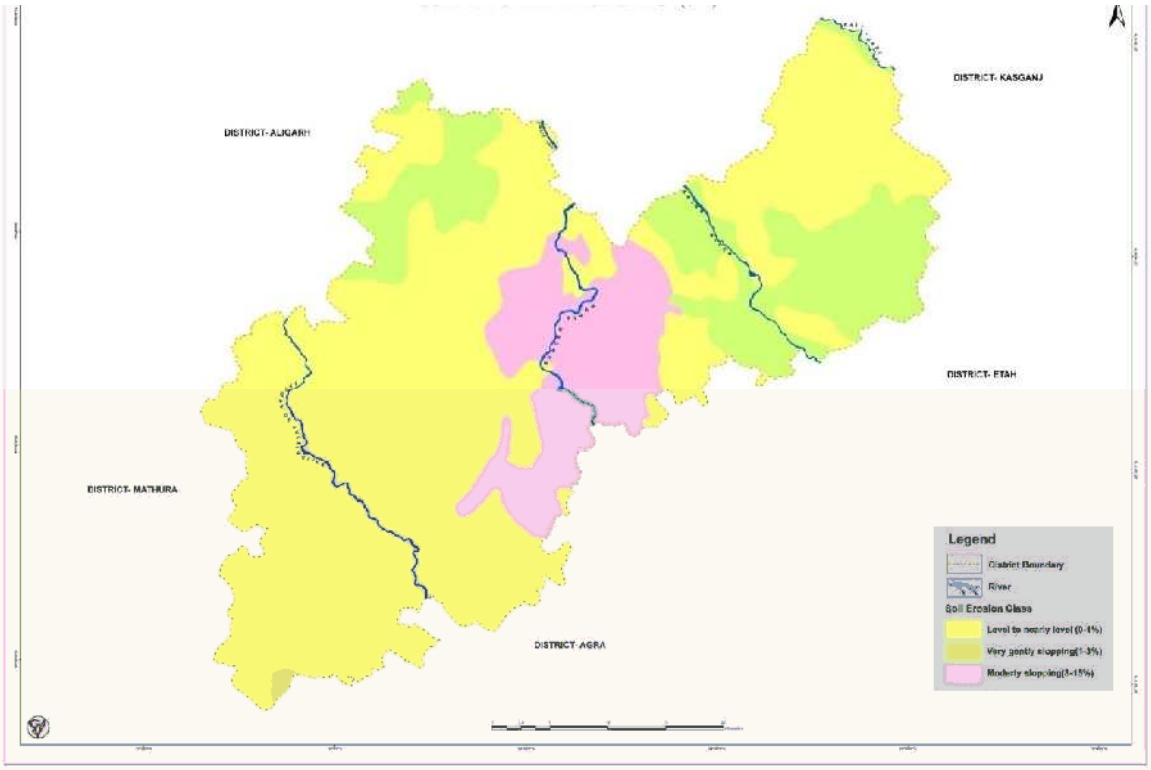


Fig. 1.9a Slope in Hathras District

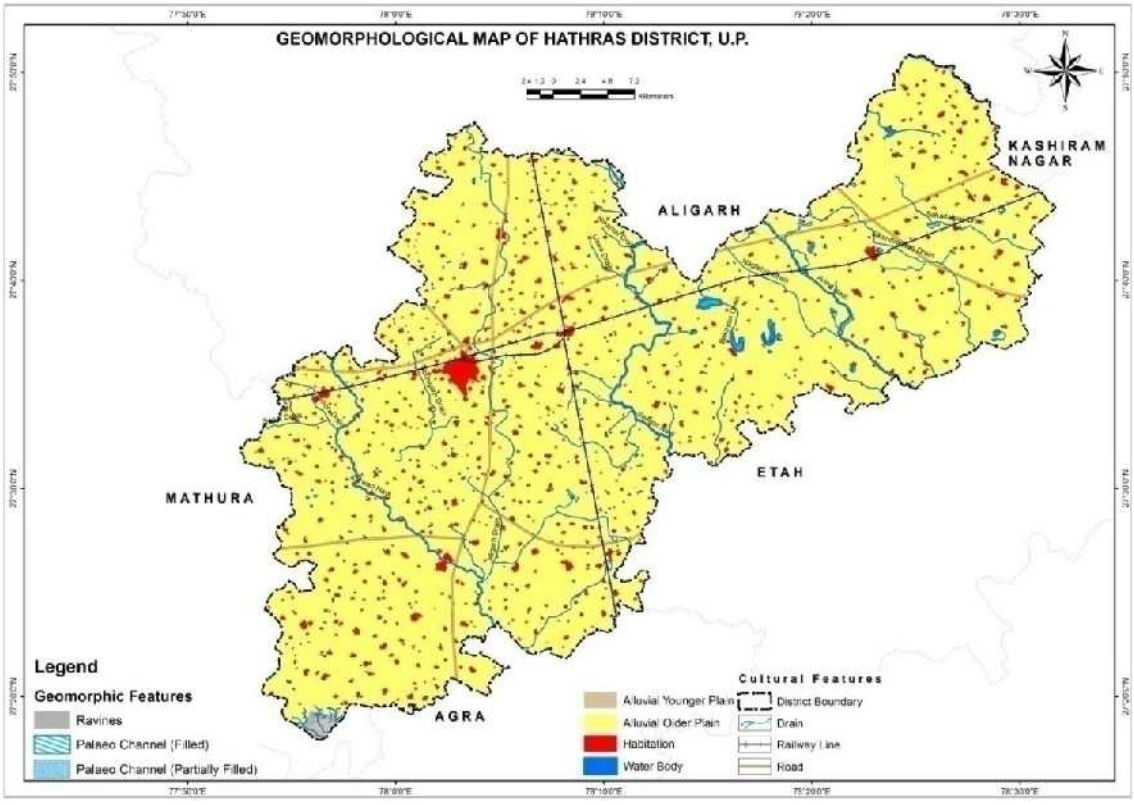


Fig. 1.9b Geomorphologic Features in Hathras District

1.11 HYDROLOGY:

As stated above the district occupies the inter fluvial areas of Ganga and Yamuna rivers. The drainage is controlled by tributaries of these two mighty rivers which flows toward south and south eastern direction (Fig. 1.10). The important tributaries of the Yamuna which cover larger part of the area are Karwan (Jhirna Sengar and Aligarh drain whereas Arind , Isan and Kali Nadi form the principal tributaries of The Ganaga River. All these tributaries are semi seasonal having very meager discharge during the lean period. Thus there are two basins in the district which are separated by NW-SE running water divide , roughly following the course of Upper Ganga Canal- Etawah Branch). The Yamuna sub Basin covers two third area of the district in the west and south and rest by Ganag basins in the east.

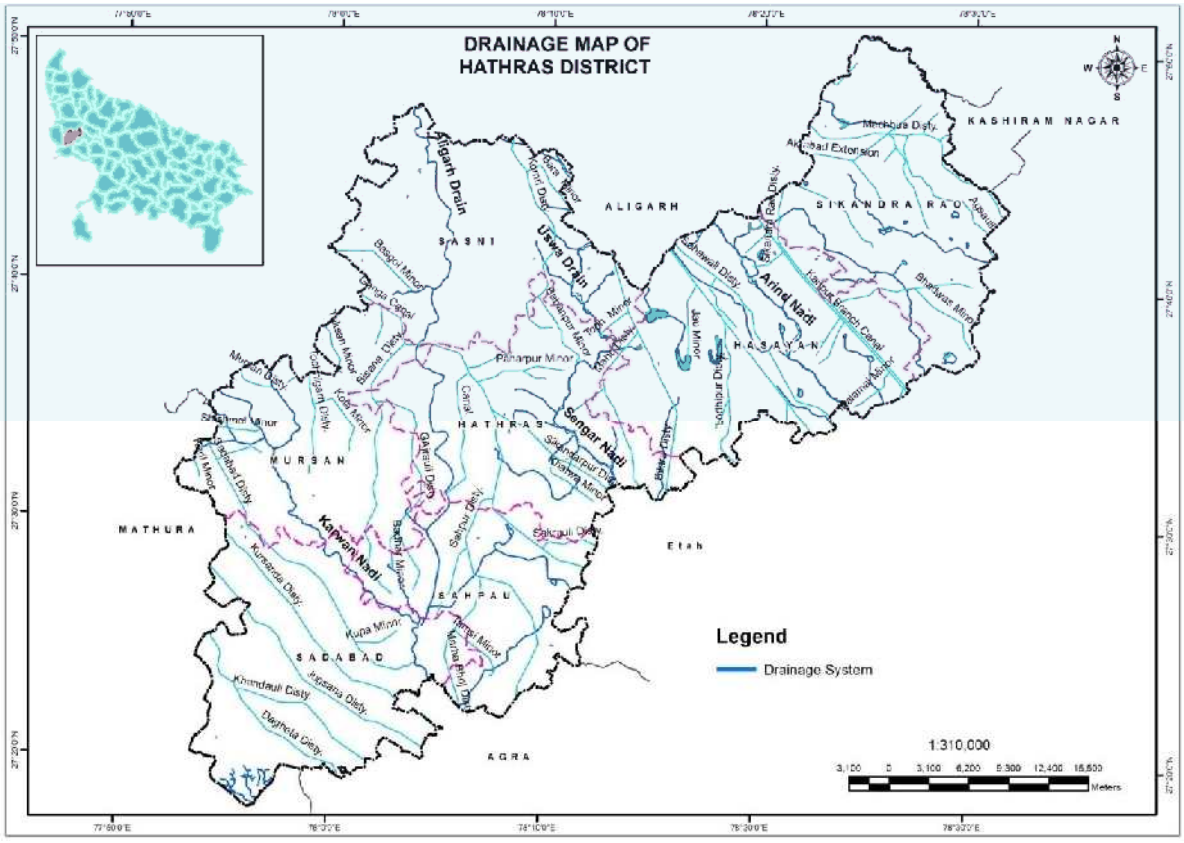


Fig. 1.10 Drainage and Canal Map of Hathras District

1.12 SOIL CHARACTERISTICS:

The development of soil in the entire district is controlled by the sedimentation pattern and landscape evolution during quaternary period. The major type of soils found in the district is loamy and coarse silty (Fig. 1.11). Further it is divided as Dumat (clay), Balui Dumat (sandy clay), Bhur (sandy), Reh (Alkaline) and loam soil. Rich Dumat soil is usually seen in the strength between the Ganga and

Yamuna. Kali nadi traverses the entire district in a north easterly direction. The surface water gets trapped without finding an escape. The tendency mass the fertility of the area giving rise to fragment stretches of alkaline soils (Usar). Once the district was largely covered with heavy "dhak" jungle which has now gradually turned into cultivated land . In the Khadar of Yamuna , there is narrow belt of 'Jhau' and is followed by the broad structures of waste covered with thatching grass. The district can be described as well as wooded mango groves. The babul trees which grow wild, is very common. The trees are neem ,pipla,bers,faras,shisham,gular and jamun.

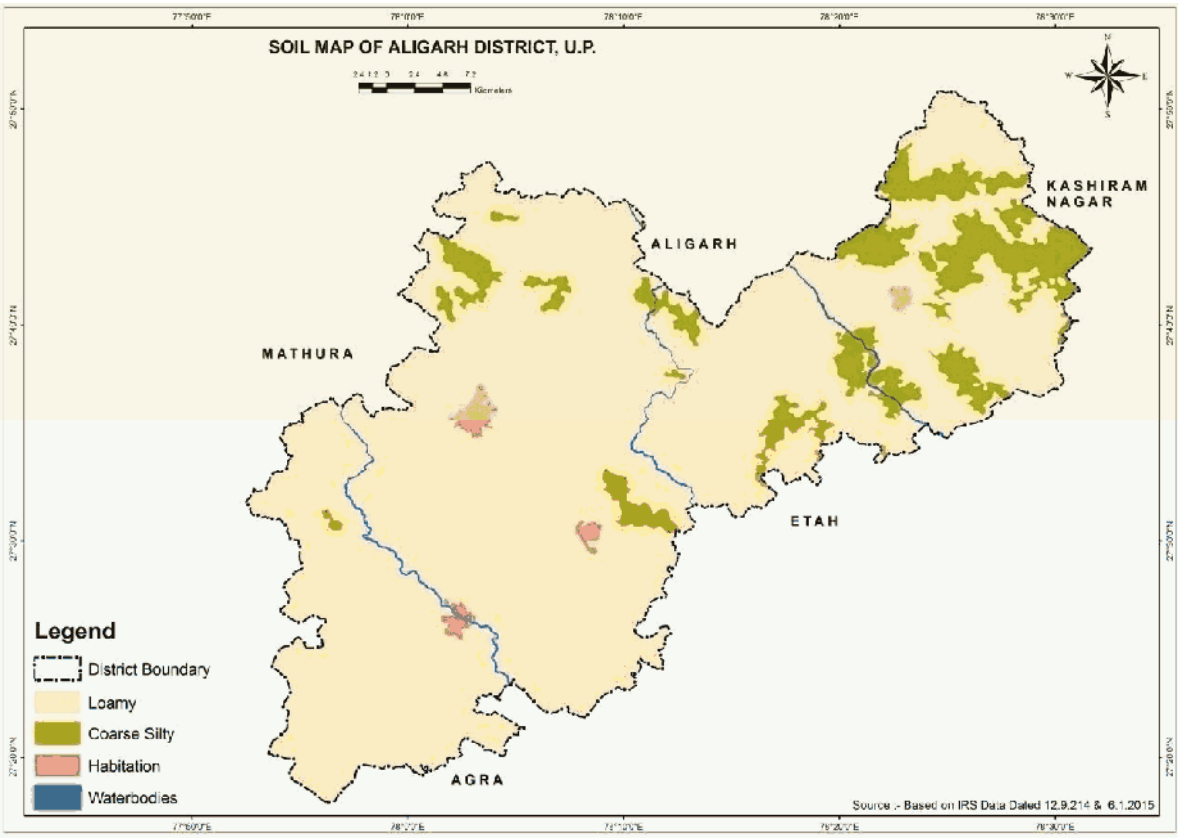


Fig. 1.11. Solis in Hathras District

2.0 DATA COLLECTION, GENERATION, INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

2.1 HYDROGEOLOGY

2.1.1 General Geology:

Hathras district constitutes a part of Central Indo-Gangetic plain and lies in the inter fluvial tract of the rivers Ganga and Yamuna. It is believed that the plain has been formed by the detritus brought down and deposited in the central depression by the rivers emanating from two different provenances, namely, the Himalayan Mountains in the north and the Vindhyan plateau in the south.

The available geological data indicate that the entire area of the district is underlain by moderately thick pile of Quaternary sediments (thickness vaies from 200 m to more than 450 m) comprising of silt, clay, sands of various grades graves and Kankars in varying proportion. Kankars are generally abundant in the entire district. The sediments are unconformable overlying the basement of the Vindhyan Super Group. The general stratigraphic sequence in the area is given in Table-below.

As discussed earlier under physiography, about 90% of the district occupies the upland and is underlain by the sediments of older alluvium. The Younger Alluvium occupies the lowland, in the very narrow strips along the course of river Yamuna and its tributaries which are prone to inundation during the annual floods. In addition, the newer alluvium is also found as land fills in thepaleo-cannels of Kali river in Ganga sub-basin.

Age	Group	Formation	Lithology
Recent to upper Pleistocene	Quaternary	Newer/Younger Alluvium	Fine sand and silt clay admixed with gravel
upper Pleistocene		Older Alluvium	Clay with kankar and sand of different grades
----------unconformity----------			
Proterozoic	Vindhyan Super Group	Upper Vindhyan system (Bhander series)	Red sandstone & shale.

The geological map of the district (Fig. 2.1) shows the area under Older and Younger Alluvium. Older Alluvium occupies the upland of the district while the Younger Alluvium occupies low land area along the courses of tributaries. Yamuna of Ganga

2.1.2 Occurrence of Ground Water

Ground water occurs in the pore space of the unconsolidated alluvium material in the zone of saturation. In Hathras district ground water occurs under water table condition at shallow depths while the deeper aquifers are under semi

confined to confined state of disposition. The confining layers are impermeable clay beds.

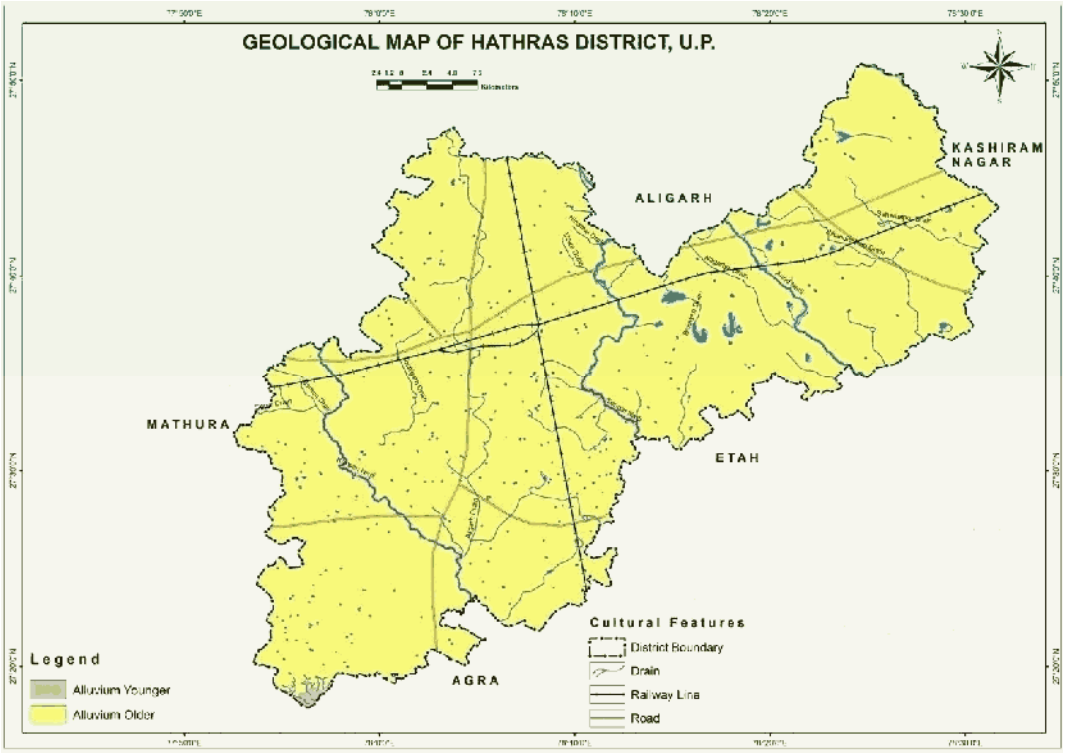


Fig. 2.1 Geological map of Hathras District

2.1.3 Water Levels:

In order to decipher the ground water regime, a total of 52 observation wells were established (Table 2.1 & Fig. 2.2). These ground water structures tap the phreatic aquifer up to 30 m. bgl under unconfined condition. On the basis of water level data collected during May 2017 & November 2017, maps have been prepared to represent the pre-monsoon and post-monsoon water level in the district respectively (Fig. 2.3 & 2.4). The study of pre-monsoon map reveals that the depth to water level in the district generally ranges between 3.05 and 29.13 mbgl with average of 15.47 m bgl . Shallow water level conditions i.e. within 6.00 mbgl, generally occurs along the upper Ganga canal in the Sikandra Rao, and Hasayan blocks. In major parts of Hathras, Sasni, Sadabad, Shahpau and Mursan blocks water level rests within the depth range of 15.0 to 25.0 mbgl. While in the 40% area of Hathras, Sahpau , Hasayan and Sikandra Rao blocks water level rest within the depth range of 5 to 15 mbgl. Deepest water level i.e. 29.00 mbgl have been observed at Mai in Sadabad block. Isolated patches of >25 mbgl are notices mainly in city area of Sadabad block. A perusal of post-monsoon map shows that water level in post-monsoon period generally ranges between 2.90 m. & 30.66 metres below ground level with average of 15.02 m bgl. Shallow water level within 3.00 mbgl and between

2 to 5 mbgl is noticed along the main canals and their distributaries. The shallowest water level of 2.90 metres was observed at Tekari Kalan in Sikandra rao block.

Seasonal Water Level Fluctuation May 17-Nov.17:

The water level data recorded from the observation wells during the pre & post monsoon periods for the year-2017, have been utilized for computing the water level fluctuations in the area and based on these seasonal water level map (Fig. 2.5) has been prepared. The water levels of the area chiefly influenced by the factors lie monsoon recharge, seepage from surface water bodies, recharge from applie irrigation , ground water draft and ground water movement. A perusal of Fig.. 2.5 indicates that the seasonal water level fluctuation in the district varies from -2.4m (Hanuman Chowki , Sasni Block) to 2.3 m (Sikandarpur , Hathras Block) with average of 0.45m. However the major part of the area has fluctuation of 0 to 2 m.

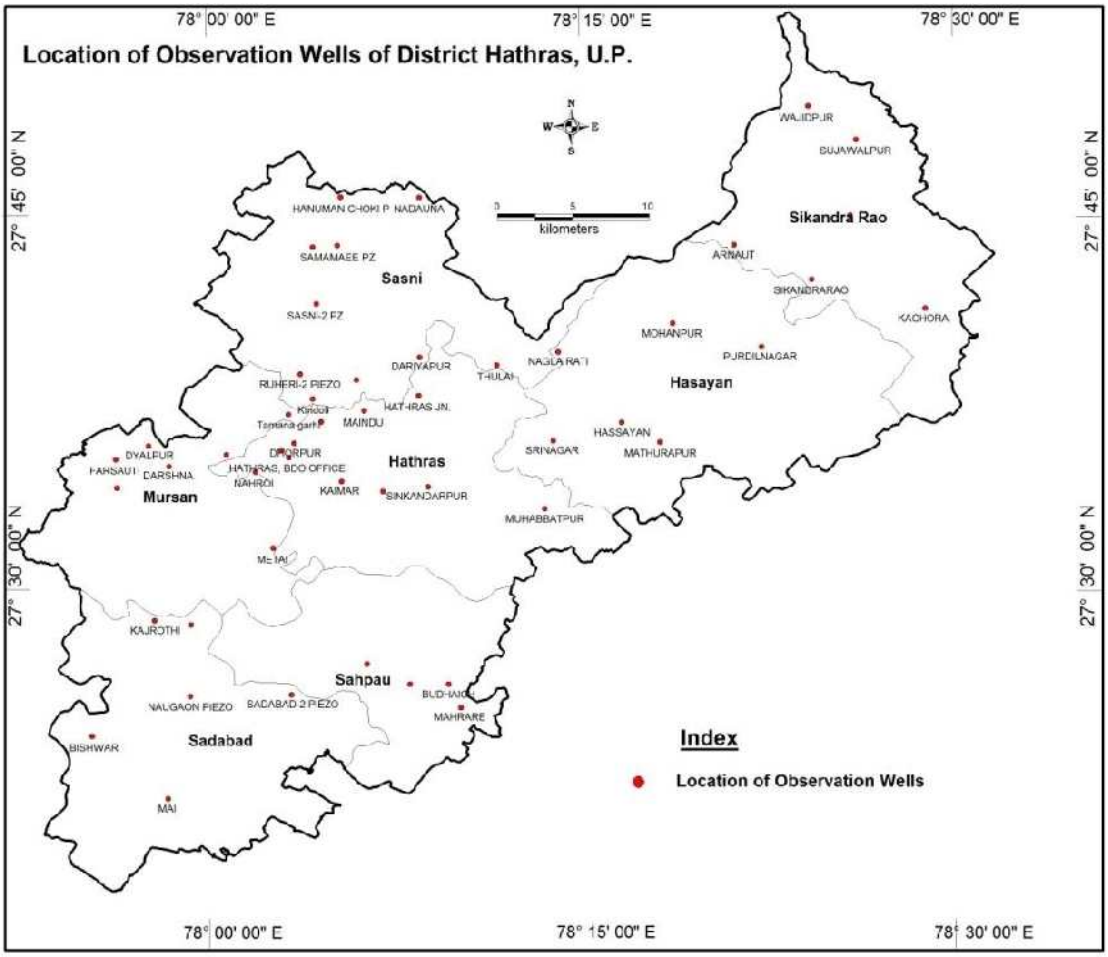


Fig. 2.2 Location map of observation wells in Hathras District

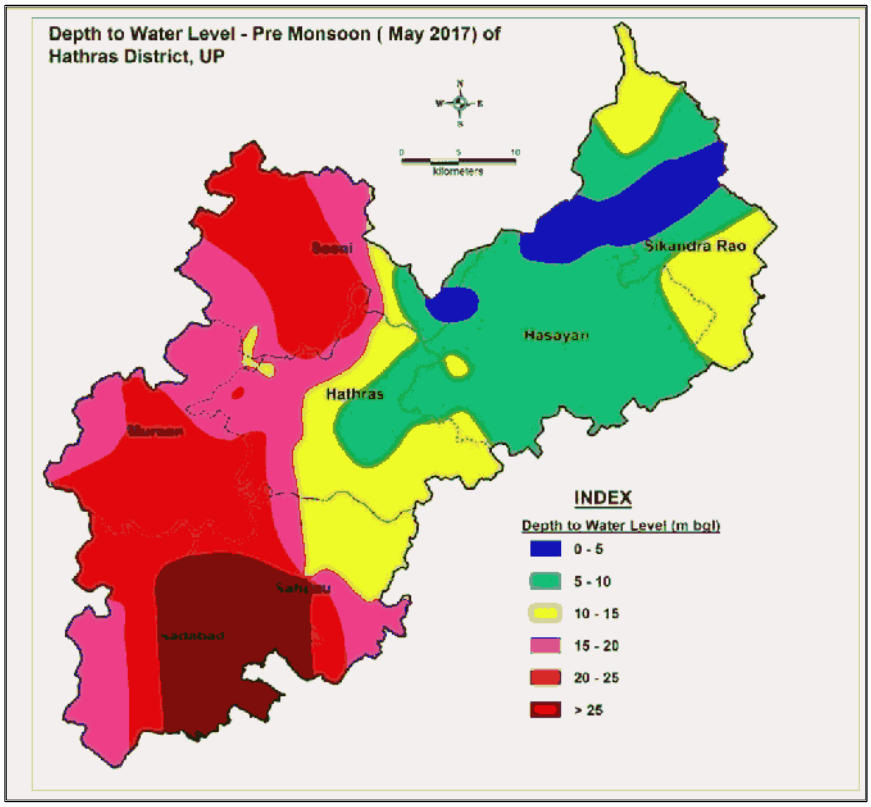


Fig. 2.3 Depth to water level (Premonsoon-17) map of Hathras District

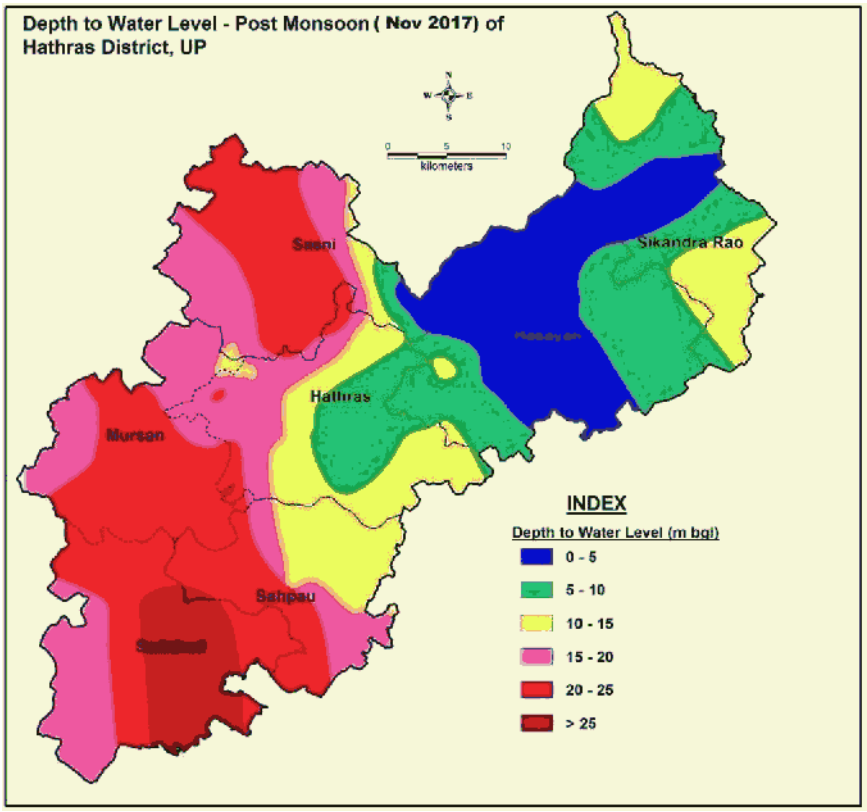


Fig. 2.4 Depth to water level (Post monsoon-17) map of Hathras District

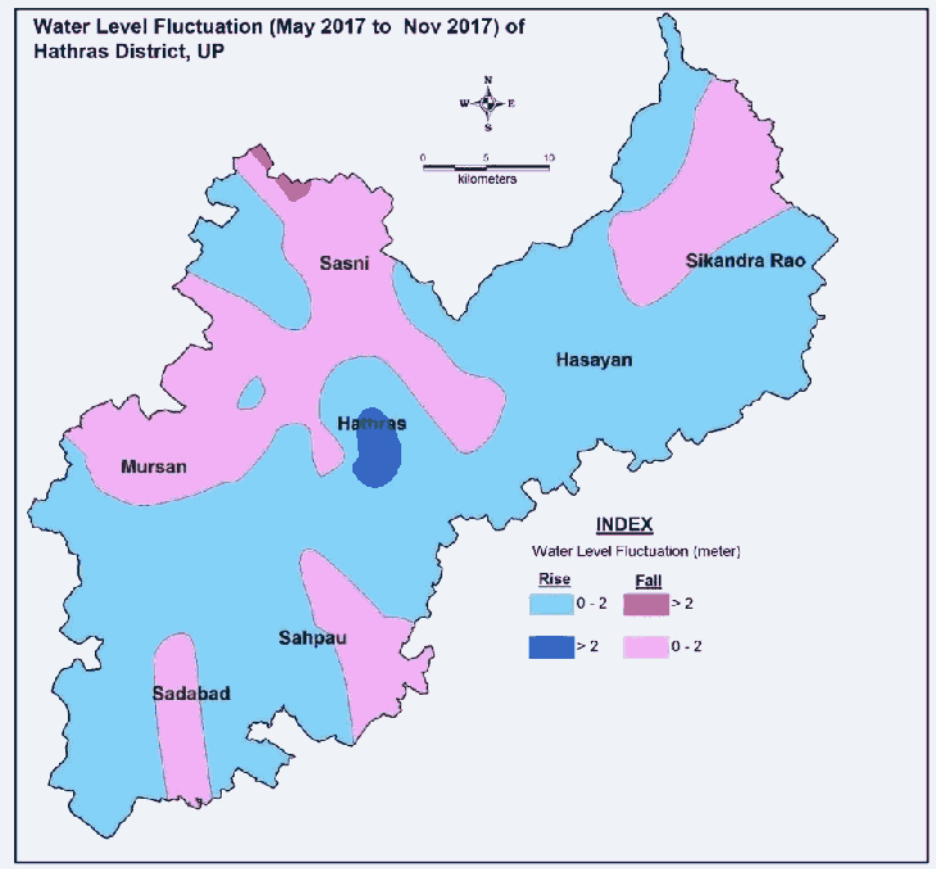


Fig. 2.5 Water level Fluctuation (Pre & Post monsoon-17) map of Hathras District

Table 2.1: Details Of Well Inventoried During Studies in Hathras District, U.P.

S.NO.	BLOCK	Place	Type	LATITUDE LONGITUDE	Location	Dia. mm	Total depth M bgl	DTW-Pre monsoon -17 mbgl	DTW-Post monsoon -17mbgl	Fluctuation	RL Ground surface m amsl
1	Hasayan	Mohanpur	W	27° 40' 41.4" 78° 18' 46.00"	In Village	2400	7.20	4.88	3.03	1.85	181.1
2		Purdilnagar	W	27°39' 43.44" 78° 22' 16.91"	In compound of Temple	1500	7.00	6.28	4.93	1.35	182.1
3		Mathurapur	P	27° 35' 56.00" 78° 18' 16.00"	In compound of Primary School	100	27.3	5.18	4.12	1.06	178.7
4		Nagla rati	W	27° 39' 36.5 78° 13'27.97"	Near post office	2000	6.10	4.02	2.75	1.27	181.3
5		Nagla rati	P	27° 39' 33.8 78° 14'1.23"	In compound of Primary School	100	30.0	5.05	2.62	2.43	181.3
6		Hasayan	W	27° 36' 43.38" 78° 16' 02.82"	In compound of School	1500	9.98	6.55	5.44	1.11	176.2
7		Srinagar	P	27° 35 58.91 78° 13' 25.51"	In compound of Primary School	100	45.85	4.65	4.93	-0.28	176.5
8	Hathras	Hathras jn.	W	27° 37' 47.9" 78° 8' 34.5"	Near College	1800	19.20	18.30	18.20	0.10	180.5

S.NO.	BLOCK	Place	Type	LATITUDE LONGITUDE	Location	Dia. mm	Total depth M bgl	DTW-Pre monsoon -17 mbgl	DTW-Post monsoon -17mbgl	Fluctuation	RL Ground surface m amsl
9	Hathras	Sinkandarpur	W	27° 34'7.91" 78° 8' 56.82"	In the village	3000	16.30	8.40	6.10	2.30	180.7
10		Ladpur	P	27° 33' 56.87" 78° 7' 8.49"	In compound of Primary School	100	35.26	11.69	11.61	0.08	178.9
11		Kaimar	P	27° 34' 21.00" 78° 5' 28.000"	In compound of Primary School	100	30.00	21.02	21.53	-0.51	180
12		Maindu	P	27° 37' 11.28" 78° 6' 21.07"	In compound of Primary School	100	25.00	13.45	13.91	-0.46	174.2
13		Dhorpur	P	27° 36' 36" 78° 8' 39.5"	In compound of Primary School	100	27.50	11.24	11.04	0.20	176.5
14		Rambag i.c.	P	27° 35' 59" 78° 3' 2.67"	In compound of the College	50	22.97	21.19	22.00	-0.81	187.8
15		Sokhana	P	27° 36' 44.3" 78° 4' 39.0"	In compound of Primary School	100	24.46	14.61	13.63	0.98	179.2
16		Hathras, bdo office	P	27° 35' 18.00" 78° 03' 20.58"	In compound of BDO office	100	30.00	19.36	20.61	-1.25	179.1
17		Muhabbatpur	P	27° 33' 16.00" 78° 13' 38.00"	In compound of Primary School	100	30.00	12.08	11.38	0.70	172.3
18	Mursan	Hatisha	P	27° 35' 25.19" 78° 0' 49.71"	In compound of Primary School	100	30.00	18.92	19.11	-0.19	177
19		Mursan-pizo	P	27° 34' 5.000" 77° 56' 26.49"	In compound of BDO office	50	22.50	19.86	19.90	-0.04	172.8
20		Dyalpur	P	27° 33' 59.05" 77° 54' 45.55"	In compound of Primary School	100	30.00	18.61	17.90	0.71	176.7
21		Farsauti	P	27° 35' 13.00" 77° 56' 23.00"	In compound of Primary School	100	40.91	20.04	20.14	-0.10	177.6
22		Darshna	P	27° 34' 56.9" 77° 58' 31.8"	In compound of Primary School	100	23.60	21.23	21.51	-0.28	183.3
23		Metai	P	27° 31' 40.7" 78° 2' 43.3"	In compound of Primary School	100	30.00	22.60	23.05	-0.45	179.6
24		Nahroi	P	27° 34' 43.8" 78° 2' 00.6"	In compound of Primary School	100	27.40	17.90	18.16	-0.26	177.6
25		Tamana garhi	P	27° 37' 02.16" 78° 3' 19.66"	In compound of Primary School	100	30.00	14.96	15.53	-0.57	182.6
26	Sasni	Hanuman choki p	P	27° 45' 36.27" 78° 05' 25.07"	In compound of police Chowki	50	24.30	20.27	19.73	0.54	185.1
27		Ruheri-2 piezo	P	27° 38' 39.16" 78° 3' 48.36"	In compound of Sahkari Beej Godam	100	40.10	14.99	15.33	-0.34	182.7

S.NO.	BLOCK	Place	Type	LATITUDE LONGITUDE	Location	Dia. mm	Total depth M bgl	DTW-Pre monsoon -17 mbgl	DTW-Post monsoon -17mbgl	Fluctuation	RL Ground surface m amsl
28	Sasni	Samamaee pz	P	27° 43' 49.10" 78° 5' 17.3"	In compound of Primary School	100	39.32	23.58	23.97	-0.39	187.9
29		Sasni-2 pz	P	27° 41' 27.99" 78° 04' 27.00"	In compound of BDO office	100	31.84	20.51	21.00	-0.49	187.7
30		Thulai	W	27° 39' 1.44"" 78° 11' 40.00"	Near College	3000	12.00	12.17	11.32	0.85	184.8
31		Susayatkala	P	27° 45' 15.00" 78° 5' 2.000"	In compound of Primary School	100	30.00	25.11	25.09	0.02	183.3
32 33		Dariyapur	P	27° 39' 20.00" 78° 8' 36.000"	In compound of Primary School	100	29.90	22.64	22.68	-0.04	178.7
33		Akhaipur	P	27° 38' 25.82" 78°6' 3.61"	In compound of Primary School	100	40.11	22.51	22.66	-0.15	185.3
34		Surajpur utra	P	27° 43' 45.00" 78° 4' 18.000"	In compound of Primary School	100	30.00	22.55	23.30	-0.75	180
35		Nadauna	P	27° 45' 44.23" 78° 8' 34.86"	In compound of Primary School	100	30.00	15.91	16.00	-0.09	183.1
36		Kindoli	P	27° 37' 40.83" 78° 4' 18.31"	In compound of Primary School	100	30.00	15.65	15.75	-0.10	180.1
37	Sadabad	Naugaon piezo	P	27° 25' 32.00" 77° 59' 19.48"	In compound of Primary School	100	30.00	25.46	25.61	-0.15	178.8
38		Sadabad-2 piezo	P	27° 25' 49.00" 78° 03' 28.30"	In compound of BDO office	100	30.00	27.13	26.78	0.35	174.1
39		Unchagaon	P	27° 28' 37.2" 77° 59' 24.11"	In compound of Primary School	100	30.00	20.94	21.02	-0.08	170.8
40		Mai	p	27° 21' 36.30" 77° 58' 29.35"	In compound of Primary School	100	30.00	29.13	30.41	-1.28	175.3
41		Bishwar	P	27° 24' 07.83" 77° 55' 26.88"	In compound of Primary School	100	30.00	16.43	16.42	0.01	170.9
42		Kajrothi	P	27° 28' 46.00" 77° 57' 57.00"	In compound of Primary School	100	30.00	24.09	24.51	-0.42	177.7
43	Sikandra-Rao	Sikandra Rao	P	27° 42' 28.8" 78° 24' 23.4"	In compound of B.D.O. Office	100	25.00	5.65	5.04	0.61	180.3
44		Sujawalpur	P	27° 48' 03.75" 78° 26' 9.07"	In compound of Primary School	100	23.40	8.95	8.96	-0.01	177.6
45		Arnaut	P	27° 43' 50.51" 78° 21' 14.4"	In compound of Primary School	100	30.00	3.61	3.35	0.26	181.2
46		Tekari kalan	P	27° 45' 46.15" 78° 25' 54.89"	In compound of Primary School	100	30.00	3.93	3.42	0.51	174.1

S.NO.	BLOCK	Place	Type	LATITUDE LONGITUDE	Location	Dia. mm	Total depth M bgl	DTW-Pre monsoon -17 mbgl	DTW-Post monsoon -17mbgl	Fluctuation	RL Ground surface m amsl
47		Wajidpur	P	27° 49' 25.49" 78° 24' 12.87"	In compound of Primary School	100	30.00	13.86	13.70	0.16	181
48		Kachora	P	27° 41' 18.14" 78° 28' 56.25"	In compound of Primary School	100	30.00	13.65	13.71	-0.06	177.1
49	Sahpau	Sahpau-	P	27° 26' 12.88" 78° 08' 12.92"	In compound of Primary School	100	40.44	18.40	18.60	-0.20	176.3
50		Khonda	P	27° 27' 01.5" 78° 6' 29.64"	In compound of Primary School	100	26.00	14.77	15.32	-0.55	172.7
51		Budhaich	P	27° 26' 13.00" 78° 9' 46.000"	In compound of Primary School	100	30.00	13.50	13.00	0.50	174.3
52		Mahrare	P	27° 25' 17.15" 78° 10' 16.22"	In compound of B.D.O. Office	100	30.00	16.20	16.55	-0.35	181.1

2.1.4 Change in Water Level over the Year

Water Level Trend

To study the behaviour of ground water regime in space and time long term water level data from the existing 10 nos. of National GW monitoring wells have been statistically analyzed for the period of 2005-15 (Table-2.2). Out of 10 existing National GW monitoring wells where the long term water level trends have been studied 7 (70 %) show a declining trend and the rest 3 (30 %) register a rising trend during pre monsoon period and 8 (80 %) show a declining trend and the rest 2 (20 %) register a rising trend during post monsoon period. Statistically analysis of data reveals that during pre monsoon period the minimum decline (0.009 m/year) has been observed at Rati Ka Nagla (NGWMW) of Hasayan block over a period of 10 years, whereas the maximum decline (0.71 m/year) is recorded at Mursan of Mursan block. During pre monsoon period the minimum rise (0.003m/year) has been observed at Thualai (NGWMW) of Sasni block over a period of 10 years, whereas the maximum rise (0.081 m/year) is recorded at village Hasayan of Hasayan block.

During post monsoon period, rise of 0.61 to 0.101- m/year is recorded at Hasayn of Hasayn Block and Thualai (NGWMW) of Sasni block respectively over a period of 10 years. Minimum fall of 0.06 m/year is recorded at at Rati ka nagla (NGWMW) of Hasayan block and the maximum fall has been recorded at Mursan (0.79 m/year) of Mursan block during post monsoon period. Generally rising trends showing the wells located in the canal command area. Long term water level trend are shown in the hydrographs (Fig. 2.6 to 2.11).

Table 2.2. Long term water level trends from 2005-2015 in Hathras District.

S. No	Location	Pre Monsoon			Post Monsoon		
		Data Points	Rise (m/year)	Fall (m/year)	Data Points	Rise (m/year)	Fall (m/year)
1	Mitai	7		0.4352	7		0.5669
2	Purdil Nagar	8	0.007		7		0.1295
3	Agsauli	7		0.3626	7		0.5856
4	Bhathikra	11		0.0598	7		0.1067
5	Hathras	9		0.0463	8		0.5479
6	Thulai	11	0.0030		11	0.1016	
7	Mursan	7		0.7110	7		0.7943
8	Hathras jn.	11		0.3858	11		0.3869
9	Rati ka Nagla	10		0.0094	9		0.0634
10	Hasayan	10	0.081		9	0.061	

Long term water level trend are also analyzed in Ground Water Resource estimation in 2013 considering data of monitoring wells of Ground Water Department for the period of 2004-2013 (Table 2.3). During pre monsoon, rise of 0.44 cm/year (Sadabad Block) and fall of 4.43 cm/year to 68.4 cm/year (Sikandra Rao and Mursan Blocks) are recoded. During post monsoon, rise of 24.86 cm/yea (Hasayan Block) and fall of 16.18 to 56.78 cm/year (Sasni and Mursan Blocks) are recoded.

Table 2.3 Long term water level trend analyzed in Ground Water Resource estimation in 2013 for the period of 2004-2013

S. No.	**Block**	**Pre Monsoon**		**Post Monsoon**	
		Rise (cm/year)	**Fall (cm/year)**	**Rise (cm/year)**	**Fall (cm/year)**
1	Hasayan	-	4.78	24.86	-
2	Hathras	-	20.08	-	33.96
3	Mursan	-	68.40	-	56.78
4	Sadabad	44.97		-	45.42
5	Sahpau	-	33.01	-	19.47
6	Sasni	-	21.63	-	16.18
7	Sikandra Rao	-	4.43	-	

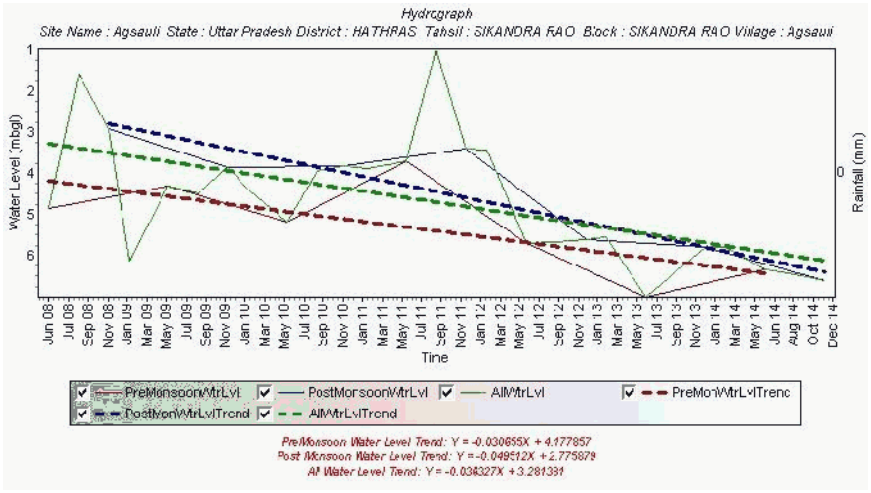


Fig. 2.6 Hydrograph of Agsauli GWMW of Hathras District

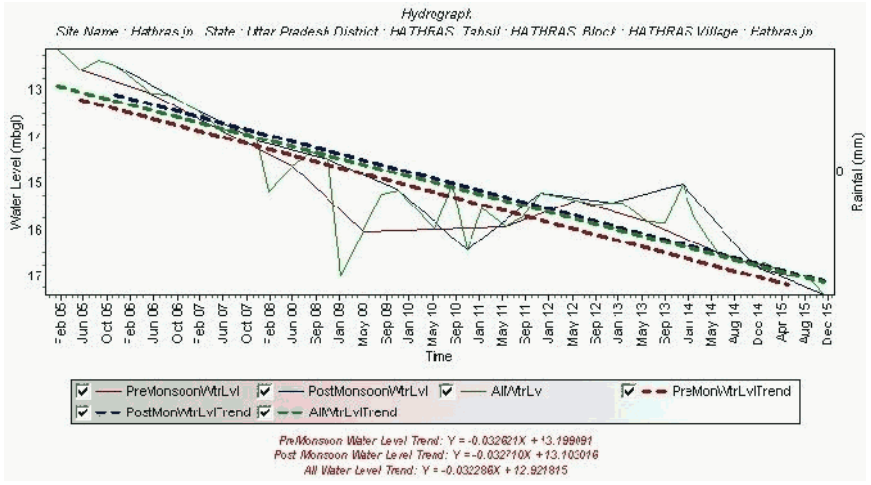


Fig. 2.7 Hydrograph of Hathras GWMW of Hathras District

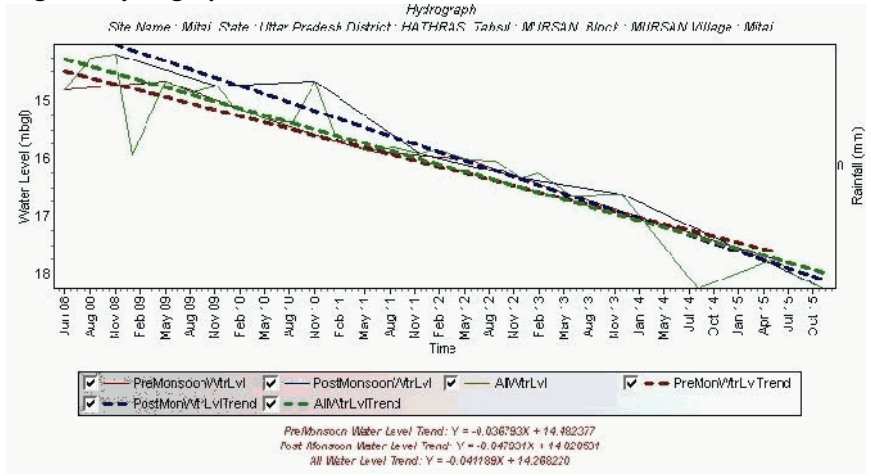


Fig. 2.8 Hydrograph of Mursan GWMW of Hathras District

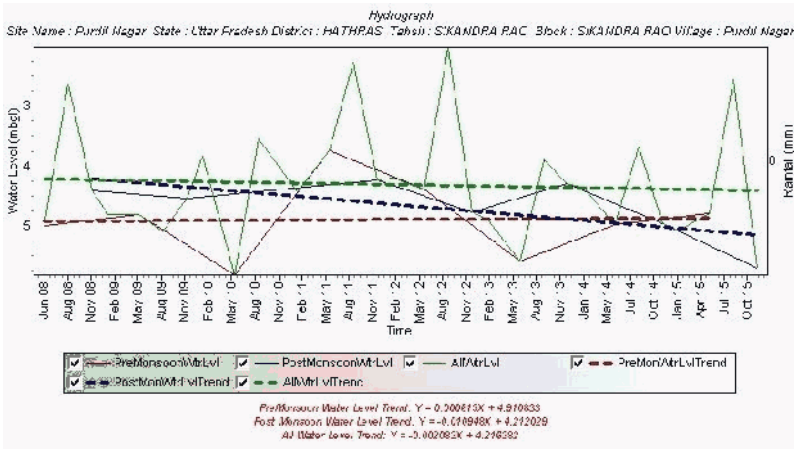


Fig. 2.9 Hydrograph of Purdil Nagar GWMW of Hathras District

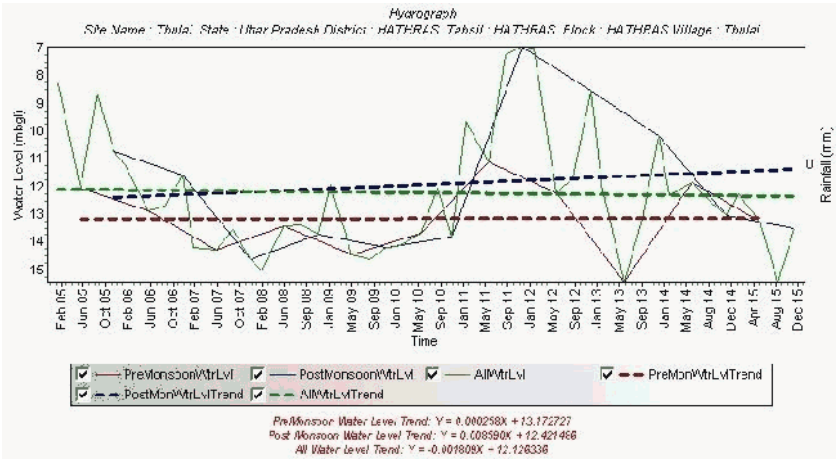


Fig. 2.10 Hydrograph of Thulai GWMW of Hathras District

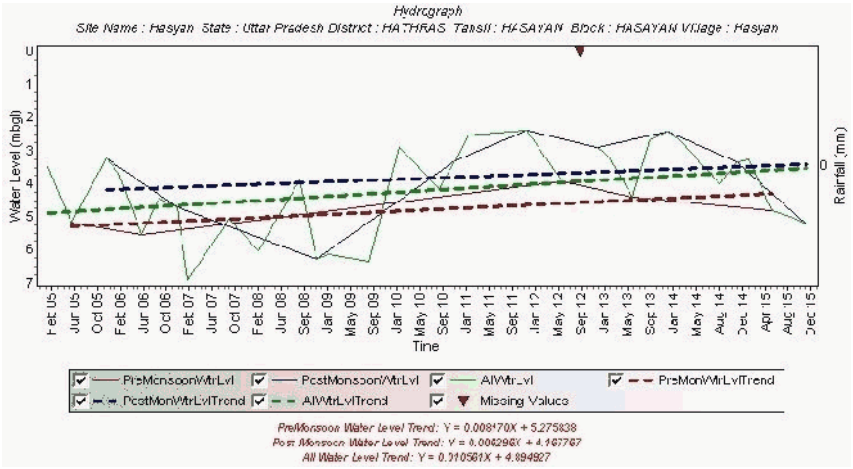


Fig. 2.11 Hydrograph of Hasayan GWMW of Hathras District

2.1.5 Water Table:

In order to decipher the form and slope of the phreatic water surface, direction of groundwater flow and also the hydrological behavior of rivers, a pre-monsoon water table elevation contour map for the year-2017 has been prepared (Fig.-2.12) with the help of altitude of water levels of observation wells. The R.L. values for each observation wells have been computed with the help of values of GPSVISUAL software. Study of the water table elevation map reveals the altitude of water table surface in the district ranges between 146 and 177 m amsl. The master slope of water table, in the district, is from northwest-southeast which corresponds with general topography of the area. However some local diversions have also been observed, especially in the area lying between Sengar and Karon rivers, due to local topographical conditions and impact of major branches of Ganga Canal over the shallow aquifers. The general gradient of the water table in the district varies from 0.34 to 0.80 m/km, the average being 0.57 m/km. By and large, the water table contours are moderately to widely spaced in the parts of the district lying between Sengar and Kali rivers and west of Karon river, inferring the very permeable nature of sediments, whereas, the area between Sengar and Karon river is exhibiting generally closely contours indicating steep surface of water table and dominance of argillaceous sediments. The shape of water table elevation contours and groundwater flow directions clearly indicate the effluent nature of rivers in the area.

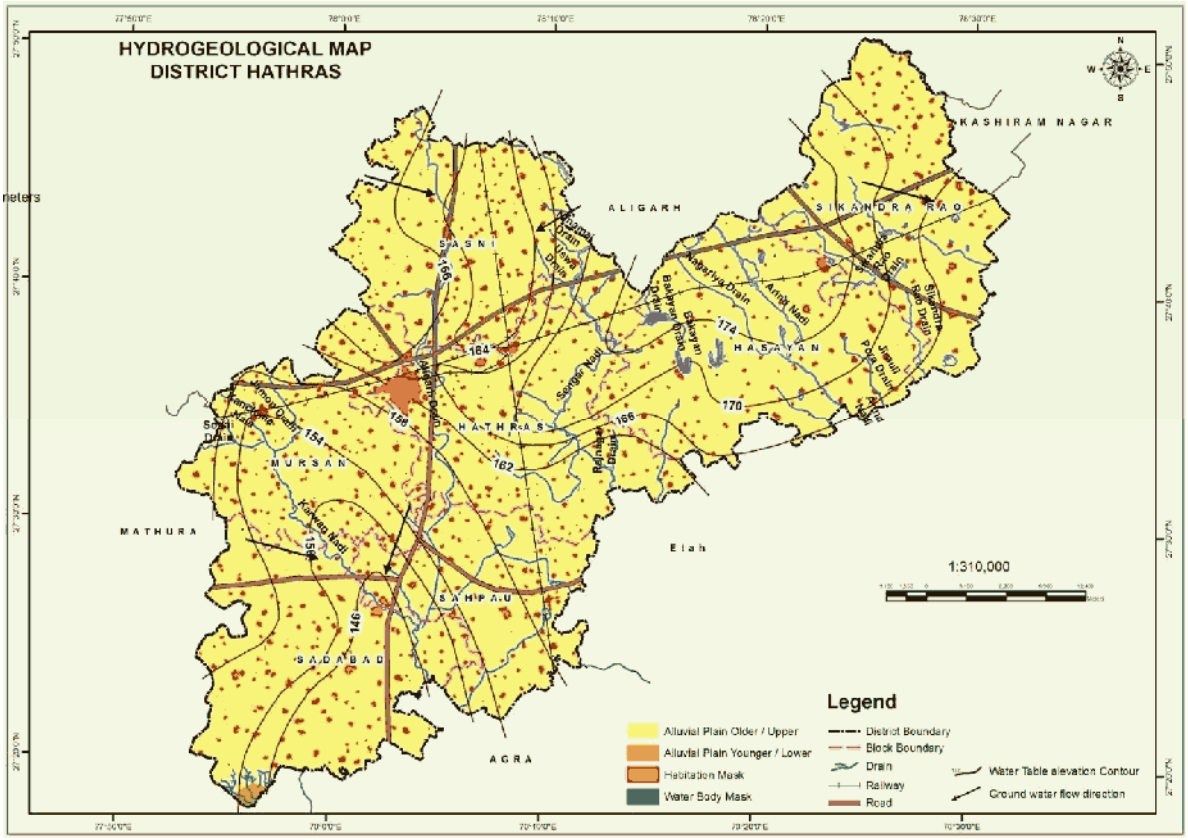


Fig. 2.12 Hydrogeological map of Hathras District

2.2 GROUND WATER QUALLIY

The quality of ground water is an important as its quantity and plays an important role in the development. The most extensive use of ground water is for irrigation of crops and a part of the potential is for domestic and industrial uses. With the advent of industrialization and inadequate attention paid to protect the environment degradation in water quality one of the challenges of modern time. Sometimes the excess mineralization exceeds the maximum permissible limit for human consumption followings are the factors affecting the chemical quality of ground water.

- Physiochemical characteristics of the rocks through which ground water is circulating.
- Geological environment of the area.
- Climate of the area.
- Role of micro organism.
- Chemical physical and mineralogical characteristic of the soil through which meteoric water percolate to the underground reservoir.
- Topography of the area.
- Effect of the area.
- Mixing of connate water.
- Manmade pollution due to excessive use of manure, pesticides, harmful disposal of industrial and sewerage of urban area etc.

To study the chemical quality of ground water for domestic, irrigation and industrial uses representative ground water samples from 31 locations (4 from each blocks) of shallow aquifer were collected. Samples were collected for physicochemical and trace metal analysis in polyethylene bottles along with their GPS coordinates during May-2016. All the groundwater samples were collected from Hand pumps IM-II, which are being used extensively. The details of groundwater samples collected for analysis of various parameters are provided in Table 2.4. All the samples were analysed as per standard methods (APHA 2005) for the determination of pH, EC, CO_3, HCO_3, Cl, F, NO_3, SO_4, PO_4, SiO_2, T.H., Ca, Mg, Na & K . The summarized result of basic constituents is given below.

S. No.	Constituents	Minimum	Maximum	Average
1.	pH	7.7	8.66	8.14
2.	EC µS/cm at 25 ºC	410	6030	1716.15
3.	CO_3 mg/l	Nil	48	38.04
4.	HCO_3 mg/l	171	872	506.88
5.	Cl mg/l	7	944	163.49
6.	F mg/l	0.09	4.15	1.19
7.	NO_3 mg/l	nd	700	58.66
8.	SO_4 mg/l	5.7	1100	131.85
9.	SiO_2 mg/l	18	33	25.97
10.	PO_4 mg/l	nd	nd	nd
11.	TH (as $CaCO_3$) mg/l	130	1150	330.65

S. No.	Constituents	Minimum	Maximum	Average
12.	Ca mg/l	16	212	51.48
13.	Mg mg/l	14	199	50.54
14.	Na mg/l	9.5	833	229.98
15.	K mg/l	3.2	54	12.54

Table-2.4: Results of Chemical analysis of water samples of Basics Constituents of Hathras District

Block	Location	Sample No.	Latitude N/ longitude E	pH	EC µS/cm at 25°C	CO_3^-	HCO_3^-	Cl^-	F^-	NO_3^-	SO_4^{2-}	TH
						mg/l						
Hasayan	Mohanpur	26	27° 40' 41.4" 78° 18' 46.00"	8.08	410	nil	183	14	0.09	nd	21	170
	Hasayain	25	27° 36' 43.38" 78° 16' 02.82"	7.70	1113	nil	354	163	0.4	93	31	220
	Purdilnagar	23	27°39' 43.44" 78° 22' 16.91"	7.95	1480	nil	561	71	0.92	19	130	350
	Rati Ka Nagla	27	27° 39' 36.5 78° 13'27.97"	8.53	883	12	366	43	0.33	15	25	230
Hathras	Hathras jn.	29	27° 37' 47.9" 78° 8' 34.5"	8.30	2480	nil	281	156	0.65	700	200	330
	Ladhpur	32	27° 33' 56.87" 78° 7' 8.49"	8.30	700	nil	305	21	0.5	24	29	220
	Hathras	12	27° 35' 18.00" 78° 03' 20.58"	7.80	1686	nil	695	149	1.61	9.3	26	230
	Muhabbat pur	33	27° 33' 16.00" 78° 13' 38.00"	8.15	820	nil	305	71	0.2	33	20	290
	Sikandrpur	34	27° 34' 7.91" 78° 08' 56.82"	8.48	562	36	171	14	1.56	4.2	38	140
	Sikandrpur	35	27° 34' 7.91" 78° 08' 56.82"	8.27	730	nil	354	14	1.88	4.9	30	190
Mursan	Hatisha	30	27° 35' 25.19" 78° 0' 49.71"	8.07	1540	nil	366	213	0.32	48	100	330
	Mursan	31	27° 34' 5.00" 77° 56' 26.49"	7.90	3165	nil	872	518	1.6	64	167	520
	Bisana	10	27° 29' 26.00" 78° 02' 46.4"	8.51	1530	36	610	64	3	42	48	230
	Metai	11	27° 31' 40.7" 78° 2' 43.3"	8.03	3050	nil	756	327	1.12	20	365	590
Sasni	Hanuman choki p	15	27° 45' 36.27" 78° 05' 25.07"	8.06	1030	nil	488	57	0.41	6.5	16	320
	Ruheri-	13	27° 38' 39.16" 78° 3' 48.36"	8.24	2100	nil	683	114	1.4	10	278	260
	Sasni	14	27° 41' 27.99" 78° 04' 27.00"	7.70	1750	nil	750	199	1	40	5.7	370
	Thulai	28	27° 39' 1.44" 78° 11' 40.00"	8.66	725	48	232	43	0.9	2.5	13	250
Sadabad	Naugaon	4	27° 25' 32.00" 77° 59' 19.48"	7.72	4500	nil	610	675	0.38	320	500	1150
	Sadabad	1	27° 26' 47.61" 78° 02' 25.90"	8.00	2682	nil	842	312	0.8	32	138	330
	Mai	2	27° 21' 37.30" 77° 58' 29.35"	8.15	2780	nil	647	398	0.74	40	202	400
	Bishwar	3	27° 24' 07.83" 77° 55' 26.88"	8.50	1800	60	549	99	4.15	7.5	150	300
	Kajrothi	5	27° 28' 46.00" 77° 57' 57.00"	7.88	6030	nil	500	944	0.7	16	1120	1130
Sikandra Rao	Sikandra Rao	24	27° 41' 32.32" 78° 22' 11.12"	8.00	457	nil	171	14	0.6	2.8	25	150

Block	Location	Sample No.	Latitude N/ longitude E	pH	EC µS/cm at 25°C	CO_3^-	HCO_3^-	Cl^-	F^-	NO_3^-	SO_4^{2-}	TH
						mg/l						
Sikandra Rao	Arnaut	22	27° 43' 50.51" 78° 20' 55.59"	8.05	1030	nil	427	28	0.83	7.8	106	320
	Wajidpur	20	27° 49' 25.49" 78° 24' 12.87"	8.02	880	nil	439	14	1.02	2.7	32	290
	Kachora	21	27° 41' 18.14" 78° 28' 56.25"	8.26	1840	nil	537	156	0.65	130	132	270
Sahpau	Sahpau-	7	27° 26' 12.88" 78° 08' 12.92"	8.10	1460	nil	683	43	1.01	28	67	220
	Khonda	8	27° 27' 01.5" 78° 6' 29.64"	8.26	1770	nil	866	64	3.55	16	33	130
	Nagla beru	9	27° 28' 28.07" 78° 5' 30.07"	8.57	1770	nil	866	64	3.55	16	33	130
	Mahrare	6	27° 25' 17.15" 78° 10' 16.22"	8.00	460	nil	244	7	0.9	5.7	6.6	190

Table-2.4: Continued Results of Chemical analysis of water samples of Basics Constituents of Hathras District

Block	Location	Sample no	Ca^{2+}	Mg^{2+}	Na^+	K^+	SiO2	PO4	SAR	Class	Na%
			mg/l								
Hasayan	Mohanpur	26	40	17	9.5	4.0	18	nd	0.32	C2S1	10.8
	Hasayan	25	96	43	93	6.3	33	nd	2.73	C3S1	32.5
	Purdilpur	23	64	46	170	8.3	30	nd	3.95	C3S1	51.2
	Rati ka Nagla	27	16	46	90	3.3	26	nd	2.58	C3S1	45.7
Hathras	Hathras jn.	29	80	32	406	6.3	29	nd	9.72	C4S2	72.7
	Ladhpur	32	48	24	50	4.9	23	nd	1.47	C2S1	32.9
	Hathras	12	24	41	267	5.3	28	nd	7.65	C3S2	71.5
	Muhabbatpur	33	52	39	49	5.3	27	nd	1.25	C3S1	26.7
	Sikandrpur	34	20	22	42	33	20	nd	1.54	C2S1	39.3
	Sikandrpur	35	48	17	74	4.7	21	nd	2.33	C2S1	45.7
Mursan	Hatisha	30	52	49	180	31	29	nd	4.31	C3S1	54.0
	Mursan	31	40	101	524	9	20	nd	9.99	C4S3	68.6
	Bisana	10	28	39	238	5.7	24	nd	6.82	C3S2	69.0
	Metai	11	52	112	410	28	32	nd	7.34	C4S2	59.9
Sasni	Hanuman choki	15	56	44	84	5.9	26	nd	2.04	C3S1	36.2
	Ruheri-	13	32	44	355	5.9	26	nd	9.57	C3S2	74.6
	Sasni	14	84	38	261	6.6	24	nd	5.90	C3S2	60.6
	Thulai	28	24	46	44	4.8	24	nd	1.21	C2S1	27.5
Sadabad	Naugaon	4	212	151	440	50	29	nd	5.64	C4S2	45.2
	Sadabad	1	32	60	444	5.3	31	nd	10.63	C4S3	74.5
	Mai	2	32	78	445	6.2	25	nd	9.67	C4S3	70.5
	Bishwar	3	36	51	267	3.2	23	nd	6.70	C3S1	65.7
	Kajrothi	5	124	199	833	52	24	nd	10.77	C4S3	61.3
Sikandra Rao	Sikandra Rao	24	36	14	34	4.94	32	nd	1.21	C2S1	33.3
	Arnaut	22	56	44	81	6.8	28	nd	1.97	C3S1	35.3
	Wajidpur	20	52	39	60	5.5	30	nd	1.53	C3S1	30.9
	Kachora	21	36	44	258	54.0	27	nd	6.83	C3S2	67.3
Sahpau	Sahpau-	7	36	32	225	10.0	27	nd	6.60	C3S2	68.8
	Khonda	8	24	17	340	4.4	25	nd	12.97	C3S3	85.0
	Nagla beru	9	24	17	340	4.4	25	nd	12.97	C3S3	85.0
	Mahrare	6	40	22	16	3.6	19	nd	0.50	C2S1	15.4

2.2.1 Results of Basic Constituents

pH Value:

pH is one of the most important parameter in water chemistry and is defined as log[H^+]. The pH concentration determines the alkaline/acidic nature of water on a scale ranges from 0-14. The pH concentration determines the alkaline/acidic nature of water. The BIS, (10500- 2012) has indicated a maximum range of 6.5 to 8.5 but allows a range of 6.5 to 9.2 for domestic uses. In the area, the pH range of 7.7 to 8.66 with average values of 8.14 which is quite safe and water is free from all corrosive & sealing action. In 87% of ground water samples the pH value ranges from 7.7 to 8.5 indicating the ground from water moderately alkaline.

Electrical Conductivity:

Electrical conductivity is a measure of the total mineralization in water and thus indicates its degree of salinity. A perusal of ISO-conductivity map (Fig..2.14) of the area indicates that conductivity in ground water generally varies from 410 to 6030 microsiemens/cm at 25^{0}C. E.C. < 750 noticed in isolated patches in Sikandra Rao, Hasayan, Hathras and Sahpau blocks E.C. is observed more than 750-1500 microsiemens/cm at 25^{0}C in Sikandra Rao, Hasayan Hathras and sasni blockcs. EC is observed more than 1500-2250 and more than 3000 microsiemens/cm at 25^{0}C in all seven blocks with continuous patches in Sasni Hathras, Sadabad, Mursan and Shapau, blocks. The maximum E.C. of 6030, 4500 (Kajrothi & Naugaon of Sadabad blocks) 3165& 3050 (Metai & Mursan of Mursan Blocks) microsiemens/cm at 25^{0}C have been observed respectively

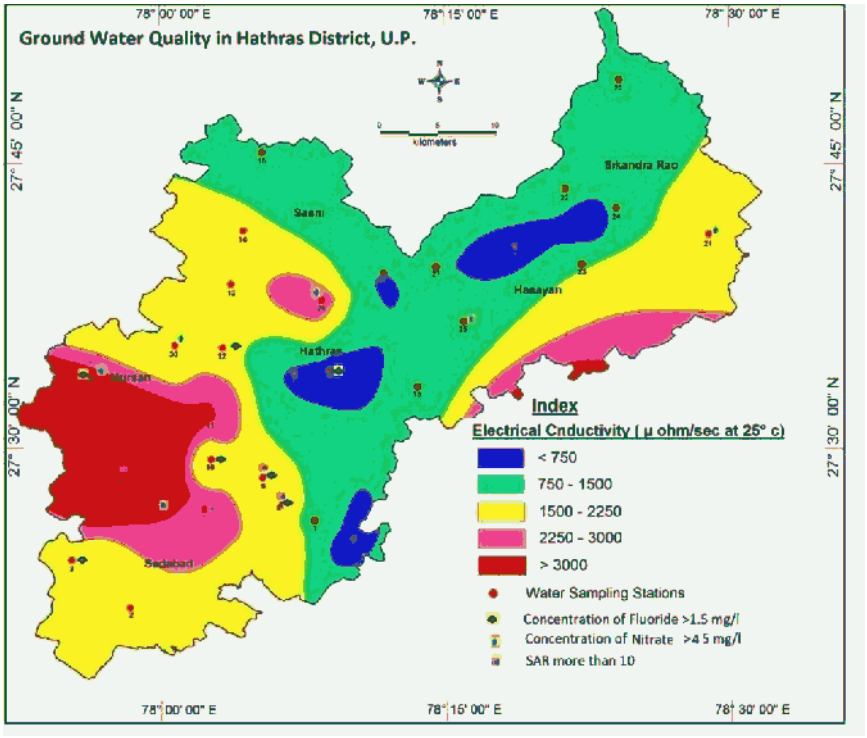


Fig. 2.13 :Ground Water Quality (Shallow Aquifer)-2016 in Hathras District

Total Hardness as $Caco_3$:

Hardness in water is caused by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations. It is usually expressed as milligrams of calcium carbonate per litre. The degree of hardness of drinking-water is important for aesthetic acceptability by consumers. Hardness is the property of water which prevents the lather (foam) formation with the soap and increased the boiling point of the water. Hardness is classified in four categories as soft water, hard water, moderately hard water and very hard water in table below.

Hardness Classification of water

Hardness (mg/l)	Water Class	% Sample
0-75	Soft	0 %
75-150	Moderately hard	13 %
150-300	Hard	48 %
>300	Very hard	39 %

The BIS, (10500- 2012) shows desirable limit upto 300 mg/l. maximum permissible limit of 600 mg/l. Higher concentration may cause urinary diseases of kidney, bladder and stomach disorder. Total hardness of the groundwater samples of Hathras district varies between 130 and 1150 mg/l. The average hardness of the analyzed samples was found as 330 mg/l. In general water is hard to very hard in nature as all the samples have hardness below 600 mg/l except two samples (1130 & 1150 mg/l in Kajaothi & Naugaon of Sadabad block).

Chloride:

The concentration of chloride (Cl) controls the taste of the water and its maximum permissible limit is 250 mg/l by BIS, (10500- 2012). However the permissible limit in the absence of alternate sources is relaxable upto 1000 mg/l. the chloride concentration in water samples varies between 7.0 and 944.0 mg/l (Avg. 163 mg/l). 81 % samples are below 250 mg/l however 19% samples collected from Sadabad, and Mursan blocks has been found maximum up to 944 mg/l. By and large the quality of ground in the area with reference to chloride concentration is fit for human consumption.

Carbonates and Bicarbonates:

In all water samples the concentration of carbonates (CO_3) is nil except Rati Ka Nagla (12mg/l) of Hasyan Blocks, Sikandarpur (36mg/l) of Hathras Block, Bisana (36mg/l) of Mursan blocks, Thulai (48 mg/l) of Sasni and Bishwar (48 mg/l) of Sadabad Block. Concentration of bicarbonate (HCO_3^-) varies from a minimum of 171.0 mg/l to a maximum value of 872.0 mg/l (Avg. 507.0). Bicarbonate below 600

mg/l is considered to be fairly safe and good for irrigation and domestic purposes. Bicarbonate in 12 samples from Sadabad, Mursan, Sahpau and Sasni blocks shows higher concentration between 610-827 mg/l, the rest of water samples are within permissible limit of drinking standard.

Nitrate:

Nitrate and nitrite are highly soluble in water. Nitrate ($NO3^-$) is found naturally in the environment and is an important plant nutrient. Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater disposal and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks. According to the Indian Standard for drinking water (BIS 10500:2012), the maximum allowable nitrate concentration in drinking water is 45 mg/L as NO_3 & WHO standards (1963) indicates the maximum permissible limit of (NO_3) nitrate is up to 45 mg/l. whereas 100 mg/l is the upper limit of concentration allowed by European drinking water standards (1970). The nitrate concentration in the district ranges between nd and 700 mg/l except at five(10%) samples of Kachora of Sikanrdarao block (130 mg/l,) Naugaon of Sadabad Block (320 mg/l) Hathras jn of Hathras Block (700mg/l) Mursan of Mursan Block (64 mg/l) Hasayan of Hasayan Block (63 mg/l) have been noticed in higher which may be due to mixing of sewerage into ground water. In city area due to above reason the higher nitrate concentration is more common. Overall the nitrate concentration is within permissible limit in the area.

Sulphate (SO_4^{2-}):

Sulphate in drinking-water can cause noticeable taste and very high levels might cause a laxative effect in unaccustomed consumers. Taste impairment varies with the nature of the associated cation; taste thresholds have been found to range from 250 mg/l for sodium sulphate to 1000 mg/l for calcium sulfate. High sulfate levels in drinking water results in gastro-intestinal disorders, and hence, it is recommended that health authorities be notified of sources of drinking water that contain sulfate concentrations in excess of 500 mg/l (WHO, 2011). BIS (2012) has prescribed 200 mg/l as acceptable limit and 400 mg/l as permissible limit for Sulphate in absence of alternate source for drinking and other domestic usage.

The Sulphate concentration in water samples are well within permissible limit of 400 mg/l. Generally the concentration of Sulphate in the district ranges from 5.7 to 1120mg/l with average values of 131 mg/l. Except two samples from Kajaothi & Naugaon of Sadabad block showing 500-1120 mg/l It shows that Sulphate concentration is well within permissible limit and is good for drinking as well as irrigational purposes.

Fluoride:

Fluoride is found in all natural waters at some concentration. Seawater typically contains about 1 mg/l while rivers and lakes generally exhibit concentrations of less than 0.5 mg/l. In groundwater, however, low or high concentrations of fluoride can occur, depending on the nature of the rocks and the occurrence of fluoride-bearing minerals. Fluoride occurs as fluorspar (fluorite), rock phosphate, triphite, phosphorite minerals etc in nature. The WHO (2011) and BIS (10500- 2012) estimates the maximum allowable limit for fluoride uptake to human's in drinking water as 1.5 mg/l. Excess fluoride intake causes different types of fluorosis, primarily dental and skeletal fluorosis. White line striations followed by brown patches and, in severe cases, brittling of the enamel are common symptoms of dental fluorosis. Skeletal fluorosis first causes pain in the different joints, then limits joint movement and finally causes skeletal deformities, which become particularly acute if fluoride uptake occurs during growth. Since these ailments are incurable, fluorosis can only be mitigated by preventing intake of excess fluoride. Fluoride concentration in the district ranges from 0.09 to 4.5 mg/l which is well within desirable limit. However, the fluoride concentration is slightly higher at Hathras (1.61 mg/l) Sikandarpur (1.8 mg/l), Of Hathras Block, Mursan of (1.6 mg/l) & Bisana ,(3.0 mg/l,) of Mursan block , Khonda & Naglaberu (3.55 mg/l) of Sahpau block and Biswar (4.15 mg/l) of Sadabad Block.

Calcium(Ca^{+}) **and Magnesium**(Mg^{2+})**:**

The dissolved solids like Calcium (Ca^{+}) and Magnesium (Mg^{2+}) in ground water are essential to human nutrition and beneficial to the heart and nervous system of human beings respectively. But the deficiency of calcium may cause adverse physiological effects. Excess of Magnesium contributes to hardness of water. BIS, (10500- 2012) have laid down the acceptable/maximum permissible limits for Calcium and Magnesium in drinking water as 75/200 mg/l. and 30/100 mg/l respectively. In the ground water samples the concentration of Calcium ranges between 16 and 124 mg/l. which is well within permissible limit. Only one sample Naugaon of Sdabad Block has 212 mg/l. The concentration of magnesium ranges from 17 to 101 mg/l. with exception a few samples showing higher concentration (Metai 112 mg/l of Mursan block and Kajaothi & Naugaon of Sadabad Block have 151 -199 mg/l respectively). Overall with some exception the concentration of Mg is within permissible limit.

Sodium (Na^{+}):

Sodium concentration in the distt. ranges between 9.5 and 833 mg/l. In general higher concentration of 524 & 833 mg/l has been found at Mursan of Mursan block and Kajaothi, Naugaon of Sadabad Block respectively. Higher drinking water is harmful to persons suffering from hypertension, cardiac and renal diseases.

Potassium (K^+):

No desirable limits for potassium concentration in the drinking water have been laid down however water with 10 to 20 mg/l potassium content is regarded as good outer ground water samples the concentration of 'K' ranges between 4 and 54 mg/l. except six samples Metai & Hatisha of Mursan block, Sikanarpur of Hathras block Kajaothi, Naugaon of Sadabad Block & Kachora of Sikanra Rao showing 28-54 mg/l. In general the water is good and potable drinking as well as irrigation purposes.

Quality of Ground Water for Irrigation Use:

Water quality, soil types and cropping practices play an important role in assessing the suitability of water for irrigation. Total salt concentration (EC), sodium adsorption ratio (SAR), sodium percentage (Na%), residual sodium) are the important parameters which are widely used in assessing the suitability of water for irrigation uses. These parameters, which affects the quality for irrigation purposes were also computed and results are furnished in Table 2.4.The Salinity and sodocity of the area are discussed below.

Sodacity of Ground Water*:*

The presence of sodium in irrigation water adversely affects the soil structure and its permeability by replacing calcium and Magnesium in the soil. To study the sodium hazards if any in ground water, the sodium percentage and the ratio of sodium, potassium ions to time the total of sodium, calcium, magnesium and potassium ions have been calculated. The sodium percentage ranges in ground water from 10.8 to 85 % with average value of 52 indicating serious sodium hazards. In 1954 the U.S. salinity laboratory proposed a classification based on the sodium adsorption ratio (SAR) replacing sodium percentage classification, because the farmer has direct relation with the adsorption of sodium by soils. It was recommended that water with SAR less than 10 be classified as excellent. The SAR values in the formation water generally ranges from 0.3 to 13.0 with average value of 5.4 indicating good to excellent class of water except at Mursan, (Mursan block) , Sadabad & Kajrothi and Khonda & Nagla Beru of Sahpau block where the SAR values have been detected as 10.0 and 13.0 Table-2.4 & Fig. 2.15

Alkali and Salinity Hazard (SAR)

The total concentration of soluble salts in irrigation water can be expressed as low (EC =<250 µS cm^{-1}), medium (250-750 µS cm^{-1}), high (750-2250 µS cm^{-1}) and very high (2250-5000 µS cm^{-1}) salinity zone. While a high salt concentration (high EC) in water leads to formation of saline soil, a high sodium concentration leads to development of an alkaline soil. Excessive solutes in irrigation water are a common problem in semi-arid areas where water loss through evaporation is maximal. Salinity problem encountered in irrigated agriculture are most likely to arise where

drainage is poor. This allows the water table to rise close to the root zone of plants, causing the accumulation of sodium salts in the soil solution through capillary rise following surface evaporation of water. The sodium or alkali hazard in the water for irrigation is determined by the absolute and relative concentration of cations and is expressed in terms of sodium adsorption ratio (SAR). It can be estimated by the formula:

$SAR = Na/[(Ca+Mg)/2]^{0.5}$

High saline water cannot be used on soils with restricted drainage and requires special management for salinity control. Plants with good salt tolerance should be selected for such areas. Very high saline water is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and salt tolerance crops/plants should be selected.

Low sodium (alkali) water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. Medium sodium water will present an appreciable sodium hazard in fine textured soils having high cation exchange capacity especially under low leaching conditions. This water can be used on coarse textured or organic soils with good permeability.

A perusal of ISO-conductivity map (Fig.. 2.14) of the area indicates that conductivity in ground water generally varies from 410 to 6030 microsiemens/cm at 25^0C. E.C. < 750 noticed in isolated patches in Sikandra Rao, Hasayan, Hathras and Sahpau blocks E.C. is observed more than 750-1500 microsiemens/cm at 25^0C in Sikandra Rao, Hasayan Hathras and sasni blockcs. EC is observed more than 1500-2250 and more than 3000 microsiemens/cm at 25^0C in all seven blocks with continuous patches in Sasni Hathras, Sadabad, Mursan and Shapau, blocks. The maximum E.C. of 6030, 4500 (Kajrothi & Naugaon of Sadabad blocks) 3165& 3050 (Metai & Mursan of Mursan Blocks) microsiemens/cm at 25^0C have been observed respectively. Irrigation waters classified into four categories on the basis of sodium adsorption ratio (SAR) and EC. The maximum water samples (52 %) falls under C2S1 and C3S1 low alkalinity and medium to high salinity classes. 29 % water samples falls under C3S2 and C4S2 medium alkalinity and higy to very high salinity classes Rest of the samples fall under C3S3, C4S3 and C4S4 classes. This water of C2S1 and C3S1 low and C3S2 and C4S2 can be used for plants with good salt tolerance. Thus by the above standard, indicating medium to high salinity and low medium alkali ground water in the district is in generally free from salinity hazards and is suitable for irrigation purposes.

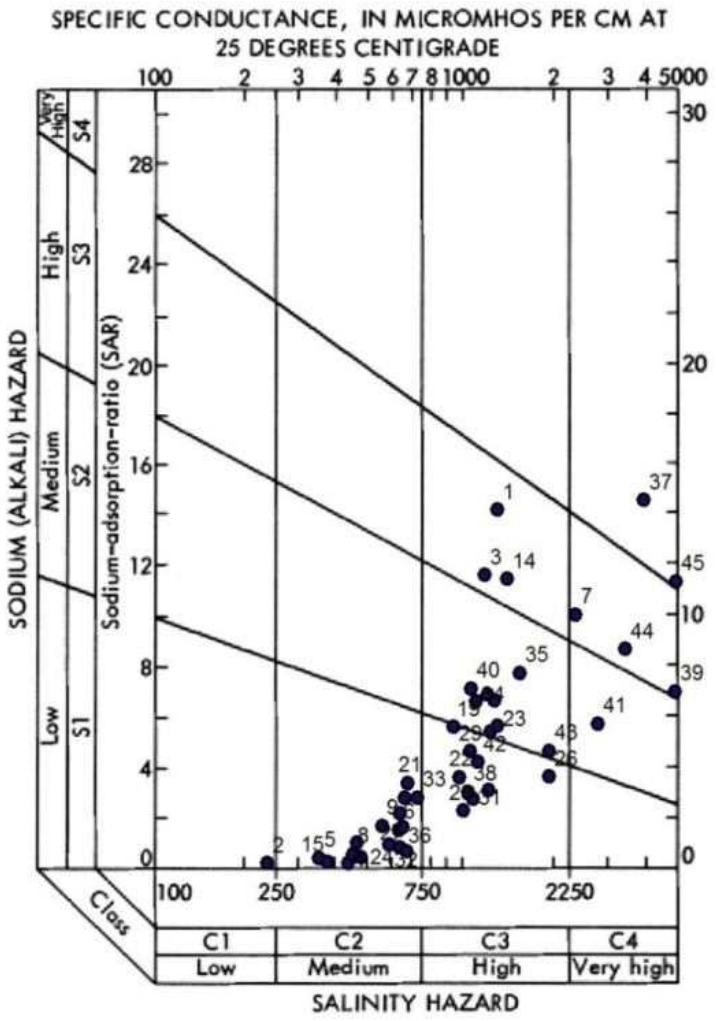


Fig. 2.14 Plot on US salinity Diagram for classification of water in Hathras District

2.2.2 Results of Heavy Metal

Heavy metals in ground water have a considerable significance due to their toxicity and adsorption behavior. Heavy metals are not biodegradable and enter the food chain through a number of pathways causing progressive toxicity due to the accumulation in human and animal organs during their life span on long term exposure to contaminated environments. Despite the presence of trace concentrations of Cr, Mn, Co, Cu and Zn in the aquatic environment, which is essential to a number of life processes, high concentrations of these metals become toxic. The major sources of heavy metals in ground water include weathering of rock minerals, discharge of sewage and other waste effluents on land and runoff water.

To evaluate the drinking water quality of ground water 31 water samples (4 from each blocks Table 2.5) were collected from Hand pumps IM-II during May 2016. The heavy metals are analysed and presented in Table 2.5. Arsenic was not detected in all the samples under study.

Copper (Cu):

Copper is both an essential nutrient and a drinking-water contaminant. It is used to make pipes, valves and fittings and is present in alloys and coatings. Beyond 0.05 mg/l the water imparts astringent taste and cause discoloration and corrosion of pipes, fittings and utensils. Recent studies have delineated the threshold for the effects of copper in drinking-water on the gastrointestinal tract but there is still some uncertainty regarding the long-term effects of copper on sensitive populations, such as carriers of the gene for Wilson disease and other metabolic disorders of copper homeostasis.

The concentrations of copper ranges from not detected (ND) to 0.095 mg/l. The Bureau of Indian Standards (BIS, 2012) has recommended 0.05 mg/l as the desirable limit and 1.5 mg/l as the permissible limit in the absence of alternate source. In the study area, 97 % of the analysed samples fall in the desirable limit of 0.05 mg/l except Sadabad of Sadabad Block (0.095 mg/l)

Iron (Fe):

It is a known fact that iron in trace amounts is essential for nutrition. High concentrations of iron generally cause inky flavor, bitter and astringent taste to water. Well water containing soluble iron remain clear while pumped out, but exposure to air causes precipitation of iron due to oxidation, with a consequence of rusty color and turbidity. The objection to iron in the distribution system is not due to health reason but to staining of laundry and plumbing fixtures and appearance. Taste and odor problems may be caused by filamentous organism that prey on iron compounds (frenothrix, gallionella and leptothrix are called iron bacteria), originating another consumer's objection (red water). The presence of iron bacteria may clog well screens or develop in the distribution system, particularly when sulfate compounds in addition to iron may be subjected to chemical reduction.

The concentration of iron in the ground water of the study area ranges from 0.026 to 4.39 mg/l with an average of 0.56 mg/l. The Bureau of Indian Standards (BIS, 2012) has recommended 0.3 mg/l as the maximum permissible limit for iron in drinking water. It is evident from the result that 39 % samples of the study area exceeded the maximum permissible limit.

Manganese (Mn):

Manganese is one of the most abundant metals in Earth's crust, usually occurring with iron. It is used principally in the manufacture of iron and steel alloys, as an oxidant for cleaning, bleaching and disinfection (as potassium permanganate) and as an ingredient in various products. More recently, it has been used in an organic compound, methylcyclopentadienyl manganese tricarbonyl, or MMT, as an octane enhancer in petrol. Manganese is naturally occurring in many surface water and groundwater sources, particularly in anaerobic or low oxidation conditions.

Manganese occurs naturally in many food sources, and the greatest exposure to manganese is usually from food. At levels exceeding 0.1 mg/l, manganese in water supplies causes an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking-water may lead to the accumulation of deposits in the distribution system. Manganese will often form a coating on pipes, which may slough off as a black precipitate.

The concentration of manganese in the ground water of the study area ranges from nd to 0.21 mg/l. The Bureau of Indian Standards (BIS, 2012), has recommended 0.1 mg/l as acceptable and 0.3 mg/l as the maximum permissible limit for Mn in drinking water. It is evident from the results that 100% are below permissible limit.

Zinc (Zn):

Zinc is an essential trace element found in virtually all food and potable water in the form of salts or organic complexes. The solubility of zinc in water is a function of pH and total inorganic carbon concentrations; the solubility of basic zinc carbonate decreases with increase in pH and concentrations of carbonate species. In general, concentration of zinc in surface water and groundwater normally do not exceed 0.01 and 0.05 mg/l, respectively

The concentration of Zinc in the ground water of the study area ranges from 0.009-1.18. The Bureau of Indian Standards (BIS, 2012), has recommended 5.0 mg/L as the desirable and 15.0 mg/L as the maximum permissible limit for drinking. It is evident from the results that zinc concentration in all the samples were well within the desirable limit.

Silver (Ag):

The concentration of Silver in the ground water of the study area ranges from nd-0.015 mg/l. The Bureau of Indian Standards (BIS, 2012), has recommended 0.1 mg/l as the acceptable limit without any relaxation for drinking. It is evident from the results that silver concentration in all the samples were well within the desirable limit exept Naugaon of Sadabad (0.015 mg/l).

Table-2.5: Results of Chemical analysis of water samples of Heavy Metal of Hathras District

S.No.	BLOCK	PLACE	LOCATION	Cu	Fe	Mn	Zn	Ag
				mg/l				
1	Hassayan	Mohanpur	In Village	nd	0.145	0.011	0.028	0.004
2		Hassayan	In compound of BDO office	nd	0.666	0.141	0.07	0.006
3		Purdilnagar	In compound of Temple	0.007	0.06	0.004	0.074	0.007
4		Nagla rati	In compound of Primary School	0.01	0.026	0.072	0.443	0.004

S.No.	BLOCK	PLACE	LOCATION	Cu	Fe	Mn	Zn	Ag
				mg/l				
5	Hathras	Hathras jn.	Near HS	0.01	0.094	0.059	0.057	0.006
6		Ladhpur	In compound of Primary School	0.01	0.29	0.004	0.191	0.009
7		Hathras,	In compound of BDO office	0.01	0.205	0.134	0.189	0.007
8		Muhabbatpu	In compound of Primary School	0.01	0.086	nd	0.414	0.006
9		Sikandrpur	In the campus of Temple	nd	0.99	nd	0.184	0.002
10		Sikandrpur	In the campus of Temple	nd	0.094	nd	0.046	0.004
11	Mursan	Hatisha	In compound of Primary School	nd	0.325	nd	0.082	0.01
12		Mursan	In compound of BDO office	nd	0.47	nd	0.433	0.01
13		Bisana	In compound of Primary School	nd	0.12	nd	0.151	0.007
14		Metai	In compound of Primary School	0.007	0.692	nd	0.181	0.01
15	Sasni	Hanuman choki p	In compound of police Chowki	nd	0.239	0.072	1.051	0.012
16		Ruheri-	In compound of Sahkari Beej Goda	0.012	0.487	0.155	0.201	0.009
17		Sasni	In compound of BDO office	0.004	0.367	0.079	0.521	0.007
18		Thulai	Near HS	nd	0.154	0.011	0.098	0.009
19	Sadabad	Naugaon	In compound of Primary School	0.059	3.636	0.1	0.708	0.015
20		Sadabad	In compound of Primary School	0.095	4.395	0.066	1.01	0.01
21		Mai	In compound of Primary School	0.048	0.188	0.21	0.507	nd
22		Bishwar	In compound of Primary School	0.007	0.137	0.018	0.745	0.002
23		Kajrothi	In compound of Primary School	nd	0.18	0.059	0.607	nd
24	Sikandra Rao	Sikandra Rao	B.D.O. OFFICE	nd	0.171	0.066	0.218	nd
25		Arnaut	In compound of Primary School	nd	0.692	0.127	1.058	nd
26		Wajidpur	In compound of Primary School	nd	1.383	0.018	0.463	nd
27		Kachora	In compound of Primary School	nd	0.162	0.169	0.528	nd
28	Sahpau	Sahpau-	In compound of Primary School	nd	0.205	0.045	0.067	nd
29		Khonda	In compound of Primary School	nd	0.128	0.072	0.179	nd
30		Nagla beru	In compound of Primary School	0.007	0.273	0.059	0.357	nd
31		Mahrare	B.D.O. Office	0.018	0.487	0.024	0.288	nd

nd-not detectable

2.3 AQUIFER MAPPING AND AQUIFER CHARACTERISTICS

The sub surface lithological variations and aquifer dispositions of the area are established through existing data of exploration and various geophysical data to meet the objectives of the study. The aquifers in the study area have been mapped through delineating lithological variations ascertained from lithologs of exploratory drilling of CGWB, tubewells of State Departments as well as borehole loggings using Self Potential (SP) and Electrical Resistivity Natural Gamma Radioactivity parameters.

The aquifer disposition maps have been prepared based on the lithological and geophysical log information obtained through existing exploratory well data of CGWB in conjunction with the tubewells of State department such as Minor Irrigation , Ground Water Department , U.P. Jal Nigam as summarized in Table 2.6 and details of tubewells considered for Aquifer Mapping are Tabulated in 2.7. The locations of these wells are shown in Fig. 2.15. Table 2.6 shows that out of 21 wells four wells drilled by CGWB are more than 300 m bgl depth in which Two wells taken from adjacent Aligarh & Etah districts. 13 numbers of tube wells are upto 127 m of depth, 5 numbers of tubewells are between 150-200 m of depth. No much information is gathered below 200 m bgl and adequate data is not available which is considered as data gap.

Central Ground Water Board (Northern Region), under its Exploratory Drilling/Accelerated Exploratory Drilling/Deposit Well programme, has drilled deep boreholes at Chandapa (367.50 m deep), Bhintar (331.60 m deep) and Sikandra Rao (196.60 m deep) in Hathras district and also in its environ at Aligarh Junction (383.26 m deep), Nera (86.20 m deep, Mathura district) and Pasia Begumpur (360 m deep Etah district). The main objective of the exploratory drilling programme was to delineate then aquifer system occurring in the area down to the maximum depth of upto bedrock whichever is met earlier and their hydrological characteristics with the quality of formation water therein.

Geophysical Electrical Logging of each exploratory/deposit borehole was conducted by the CGWB. The self-potential, short and long normal resistivity logs thus obtained were utilized for precise delineation of granular zones with quality of formation water therein, and also to demarcate the exact contacts of permeable and impermeable horizons. The available electrical logs of these boreholes are given in Fig. 2.16 to 2.20 and interpreted results are given in Table 2.7.

Table 2.6 Tubewells considered for Aquifer Mapping in Hathras District

S. No.	Source	No. of wells	Depth m bgl		
			50-127	150-200	300-383
1	CGWB	9	*1	4	*4
2	UP Jal Nigam	10	10	-	-
3	Minor Irrigation.	2	1	*1	
	Total	**21**	**13**	**5**	**4**
*Three wells taken from adjacent district (Aligarh , Etah & Mathura)					

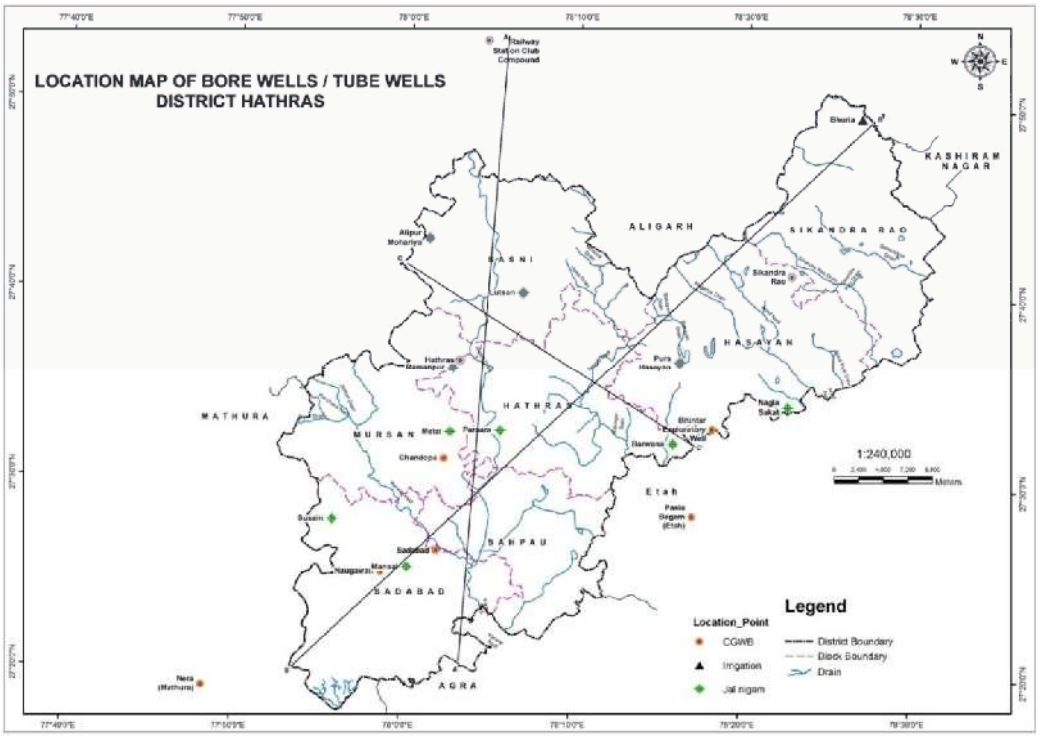


Fig. 2.15: Location of wells considered for preparation of Section , Fence and Aquifer models and maps

Table 2.7: Details of Tube Wells considered for Aquifer Mapping in Hathras District

S. No.	Location/ LatitudeLongitude	Year Of Construction/ Name of Agency	Depth Drilled / Depth of well (m.bgl)	Granular Zones Encountered (m. bgl)		Aquifer Tapped		Static Water Level (m.bgl) and date of Measurement	Discharge (lpm)	Drawdown (m)	Specific Capacity (lpm/m)	Transmissivity 'T' m^2/day	Storativity 'S'
1	Bhintar 78.30311 27.55077	1994/ CGWB	331.6/ 118	20	32	41	49	13.97 1994)	1200	7.71	156	-	-
				44	49	87	93						
				77	82	107	112						
				87	93								
				106	115								
				150	200								
				245	260								
				274	317								
2	Chandopa 78.03949 27.52083	1991/ CGWB	367.5 /95	7.54	36	55	59	12.49 1991)	1100	13.13	83.7	252.3	2.65x10^{-}4
				55	65	73	90						
				73	90								
				117	120								
				135.8	141.65								
				151	256								
				208.2	241.07								
				251.07	256.0								
				261.0	271								

S. No.	Location/ LatitudeLongitude	Year Of Construction/ Name of Agency	Depth Drilled / Depth of well (m.bgl)	Granular Zones Encountered (m. bgl)		Aquifer Tapped		Static Water Level (m.bgl) and date of Measurement	Discharge (lpm)	Drawdown (m)	Specific Capacity (lpm/m)	Transmissivity 'T' m^2/day	Storativity 'S'
				276	303								
3	Railway Station Club Compound Aligarh 78.07472 27.88861	1976/ CGWB	383/70	10	66	35	65	10.0 (1976)	2100	5.66	382	-	-
				99	110								
				131	176								
				179	201								
				342	368								
4	Pasia Begam, Etah 78.296 27.508	1991/ CGWB	360/100	22	36	46	58	13.97	1300	7.71	164	688	-
				45	58	68	74						
				67	75	91	97						
				90	97								
				109	119								
				122	125								
				130	141								
				159	173								
				189	196								
				218	223								
				226	234								
				236	252								
				268	271								
				275	295								
				297	305								
5	Sadabad/ Pragatipuram 78.03376 27.4398	2002/ CGWB	202.7/59	20	37	40.83	52.83	14.65 (2002)	800	6.2	129	-	-
				41	47								
				49	52								
				55	64								
				70	97								
				122	136								
				144	147								
				157	160								
				183	199								
6	Hathras 78.05369 27.60737	2002/ CGWB	178/70	16	27	43.07	51.07	13.37 (2002)	600	6.63	132	-	-
				29	34	57.17	65.17						
				42	51								
				37	40								
				56	66								
				81	86								
				93	108								
				118.87	161.54								

S. No.	Location/ LatitudeLongitude	Year Of Construction/ Name of Agency	Depth Drilled / Depth of well (m.bgl)	Granular Zones Encountered (m. bgl)		Aquifer Tapped		Static Water Level (m.bgl) and date of Measurement	Discharge (lpm)	Drawdown (m)	Specific Capacity (lpm/m)	Transmissivity 'T' m^2/day	Storativity 'S'
7	Naugawan 77.97953 27.42046	2002/ CGWB	188.97 /47	11.0	21.0	30.15	42.21	16.23 (2002)	700	3.15	339	-	-
				24.0	42.05								
				73.15	91.44								
				46	62								
				131.06	188.97								
8	Sikandra Rao 78.37839 27.68676	2002/ CGWB	196.6/ 149	18.0	30	52.27	70.27	6.24 (2002)	2000	3.4	798	-	-
				34	46	106.9	122.9						
				56	69	135.1	143.1						
				105	120								
				134	143								
				150	155								
9	Nera (Mathura District) 77.9225 27.2992	CGWB	86.2	19.76	43.85	30	42	17.07	810	4.55	176	-	-
			48	54.45	57.45								
			86.2	19.76	43.85								
10	Mansia 78.0053 27.42505	Jal Nigam 3.05.08	50	21.5	40	25.16	37.5	24.4 (30.05.08	600	6.1	96	-	-
				41	44								
				48	50								
11	Susain 77.93098 27.46555	Jal Nigam 4.08. 08	73	21.4	24.45	21.4	24.45	15.5 (18.05. 08	600	6.2	97	-	-
				30.44	36.55	30.49	36.55						
				39.43	42.49	39.43	42.49						
				53.05	59.12	53.35	59.42						
				60	70								
12	Ramanpur 78.04661 27.60086	Jal Nigam 23.04.08	105	3	21	30.28	42.28	21.3 1.06. 08)	1000	6.2	161	-	-
				27	67	52.66	64.74						
				73	80								
13	Alipur Mohariya 78.02099 27.71426	Jal Nigam 03.07. 09	113	18	52	44.75	50.85	21 22.07.09	400	4.5	89	-	-
				67	92	69.23	87.51						
14	Nagla Sakat 78.37709 27.57146	Jal Nigam 22.02. 10	72.25	9.2	31	24.85	31.35	5.5 30.03. 10	500	8.5	59	-	-
				42	49.1	43.01	49.01						
				60.8	65.85	61.28	65.78						
15	Metai 78.04515 27.54453	Jal Nigam/ 08.03. 10	127	11	30	40	51	7 16.04. 10	500	4.5	111	-	-
				33	38	59.86	64.86						
				46	51	74.45	93.61						
				60	65								
				75	104								
				120	127								

S. No.	Location/ LatitudeLongitude	Year Of Construction/ Name of Agency	Depth Drilled / Depth of well (m.bgl)	Granular Zones Encountered (m. bgl)		Aquifer Tapped		Static Water Level (m.bgl) and date of Measurement	Discharge (lpm)	Drawdown (m)	Specific Capacity (lpm/m)	Transmissivity 'T' m^2/day	Storativity 'S'
16	Parsara 78.09444 27.54635	Jal Nigam 19.04. 10	120	18	33	40	5154	22 20.05. 10	600	4.5	133	-	-
				40	52	62.55	68.73						
				61	69	82	91						
				82	92								
				103	112								
				39	54	64.95	68.95						
				66	70								
17	Pura Hasayan 78.26964 27.60912	Jal Nigam 19.06. 10	120	18	33	40	51.54	22 20.05.10	600	4.5	133	-	-
				40	52	62.55	68.73						
				61	69	82	91						
				82	92								
				103	112								
18	Barwana 78.26468 27.5373	Jal Nigam 18.06. 10	120 62	3	14	32	41.01	16 13.07. 10)	500	4.5	111		
				18	50	44.01	49.23						
				58	68								
				110	120								
19	Lutsan 78.1144 27.66803	Jal Nigam 22.09. 10	120	11	20	41.11	60.3	26 23.11. 10	600	4.45	135	-	-
				22	61	70.33	80.33						
				69	86	89.27	95.3						
20	Bhuria 78.44528 27.82586	Irrigation Deptt/ 1997	94.48 88	12.2	21.35	49.5	81.6	10.36 1997	2400	4.87	493	-	-
				26.82	30.5								
				35.5	41.46								
				48.17	82.92								
21	Sheora Bahadur pur	Irrigation Deptt/ 1980	204	18.3	30.48	18.3	30.4	7.16 (1998)	2000	0.84	184	1333	$6.5Xx10^{-3}$
				52.81	70.09	52.8	70.0						
				88.39	97.54	88.3	97.5						

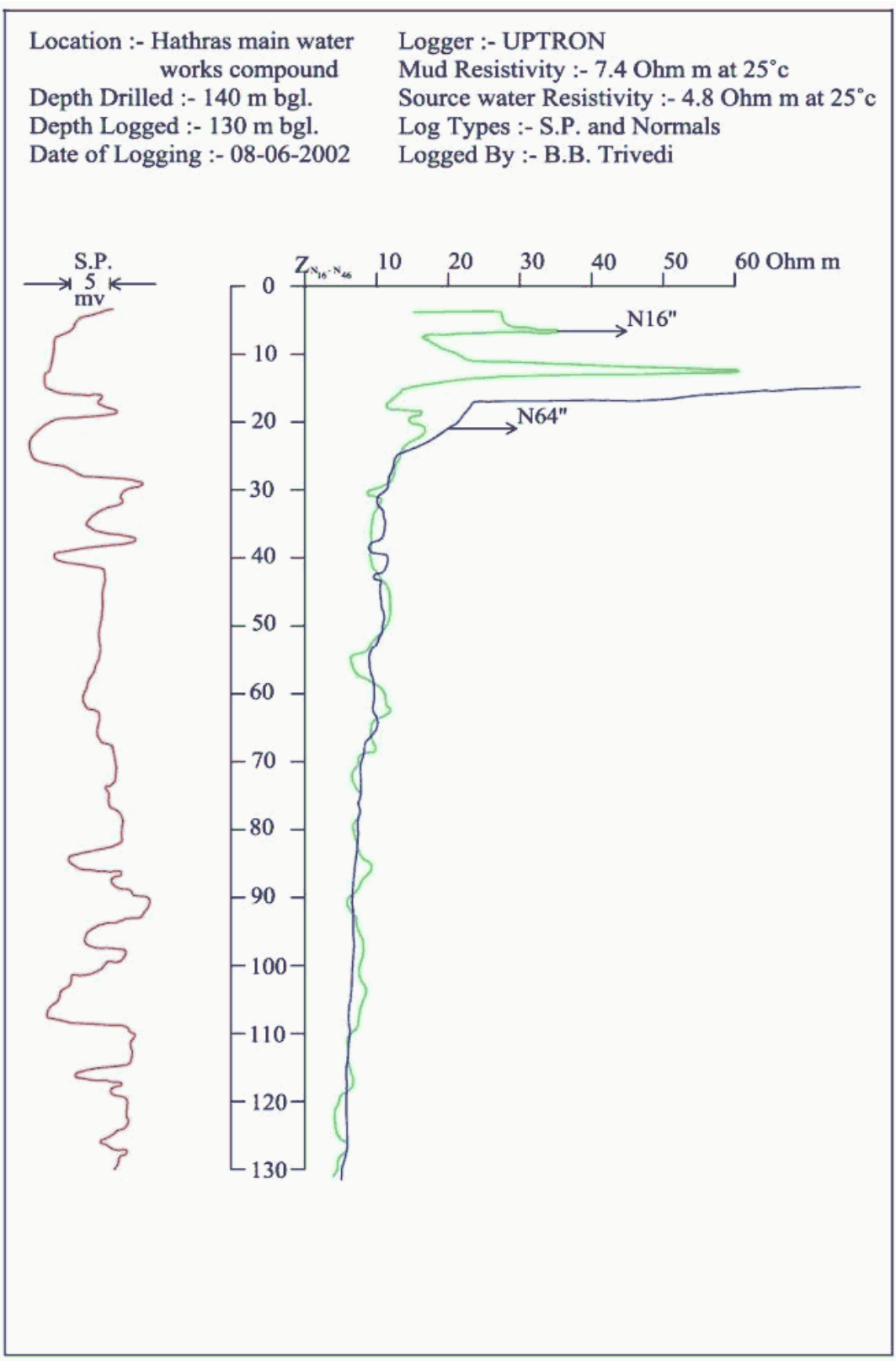


Fig.2.16 Electrical Logs of Exploratory borehole, Hathras , District Hathras

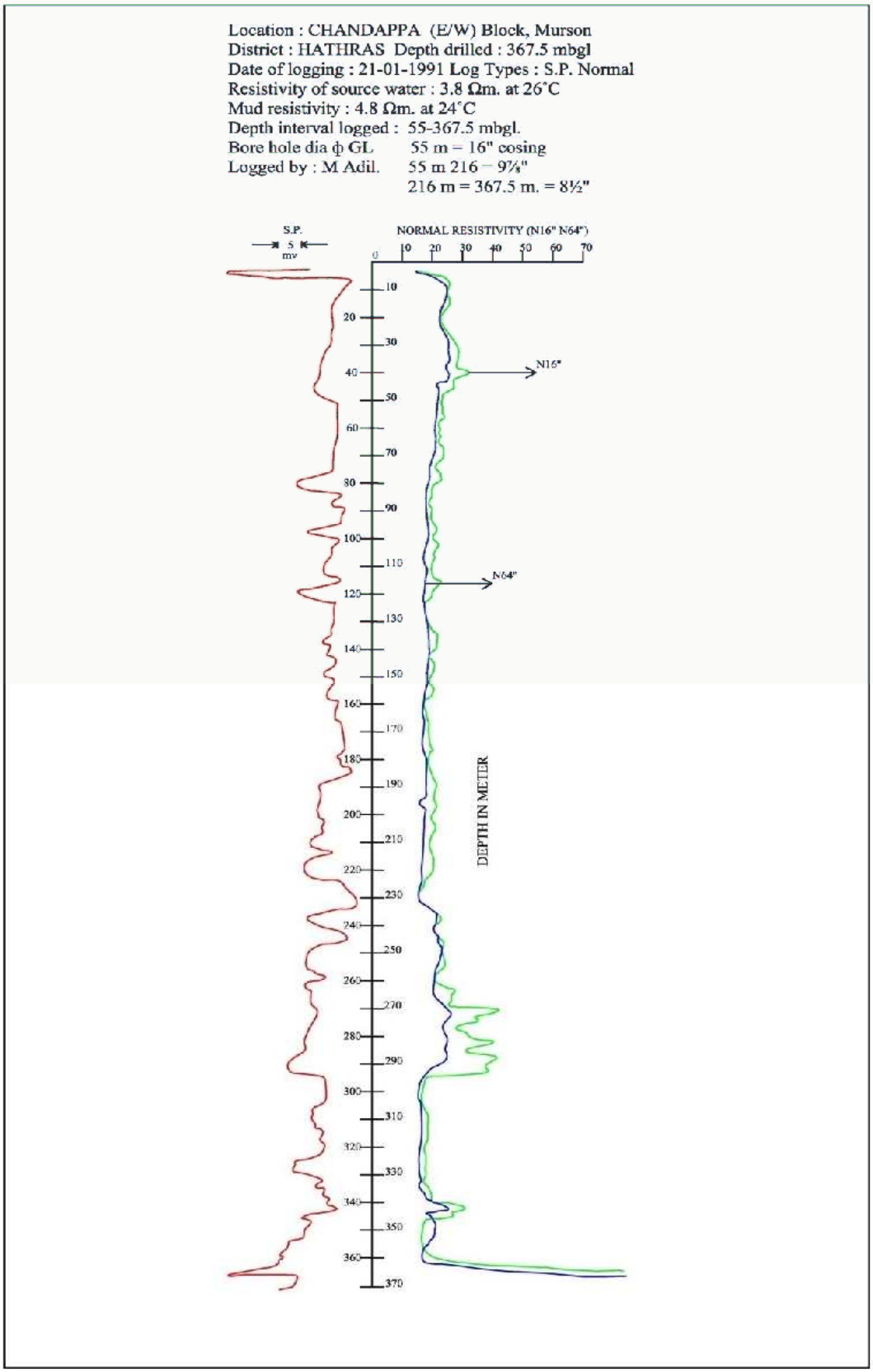


Fig.2.17 Electrical Logs of Exploratory borehole, Chandapa , District Hathras

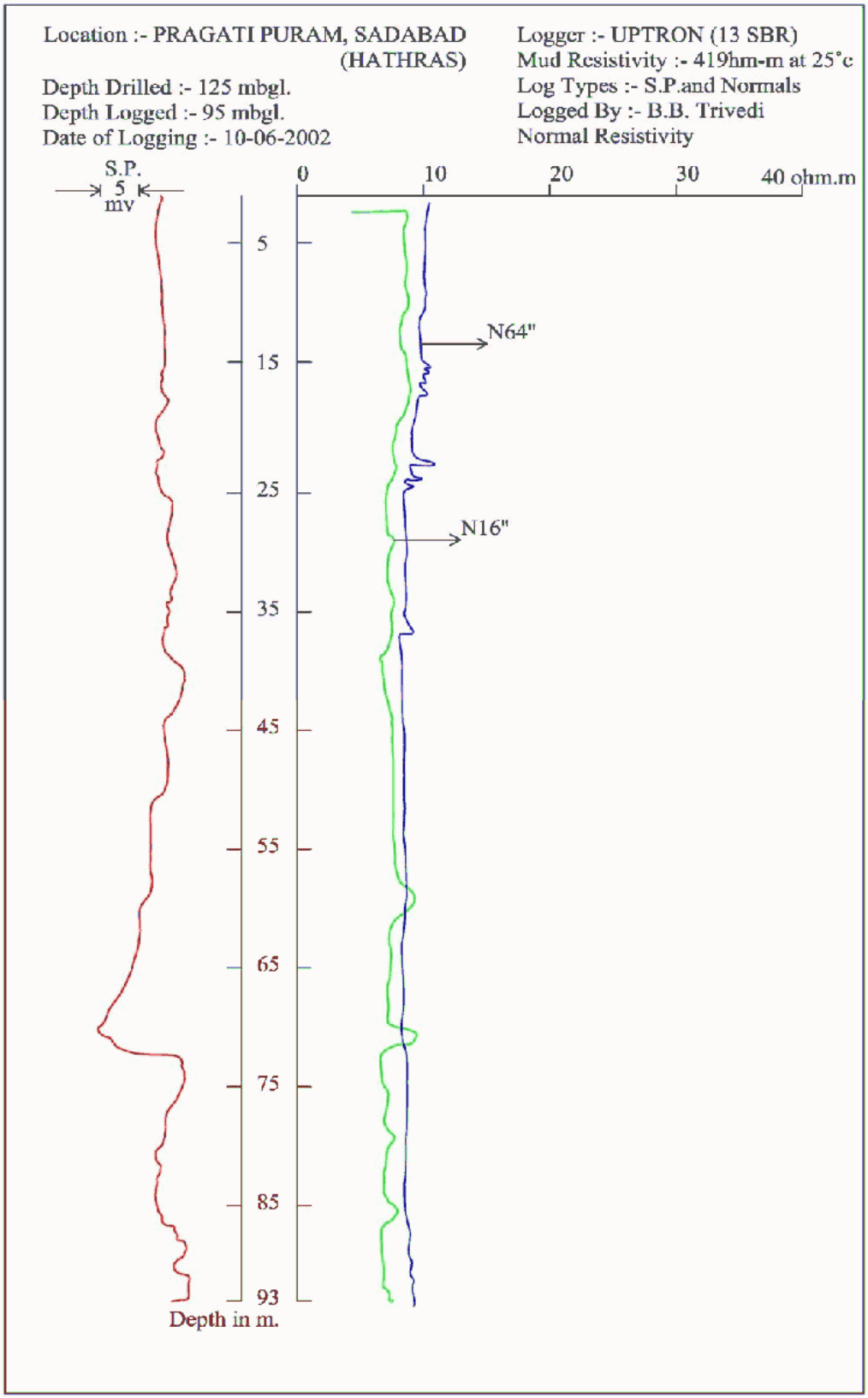


Fig..2.19 Electrical Logs of Exploratory borehole, Sadabad , District Hathras

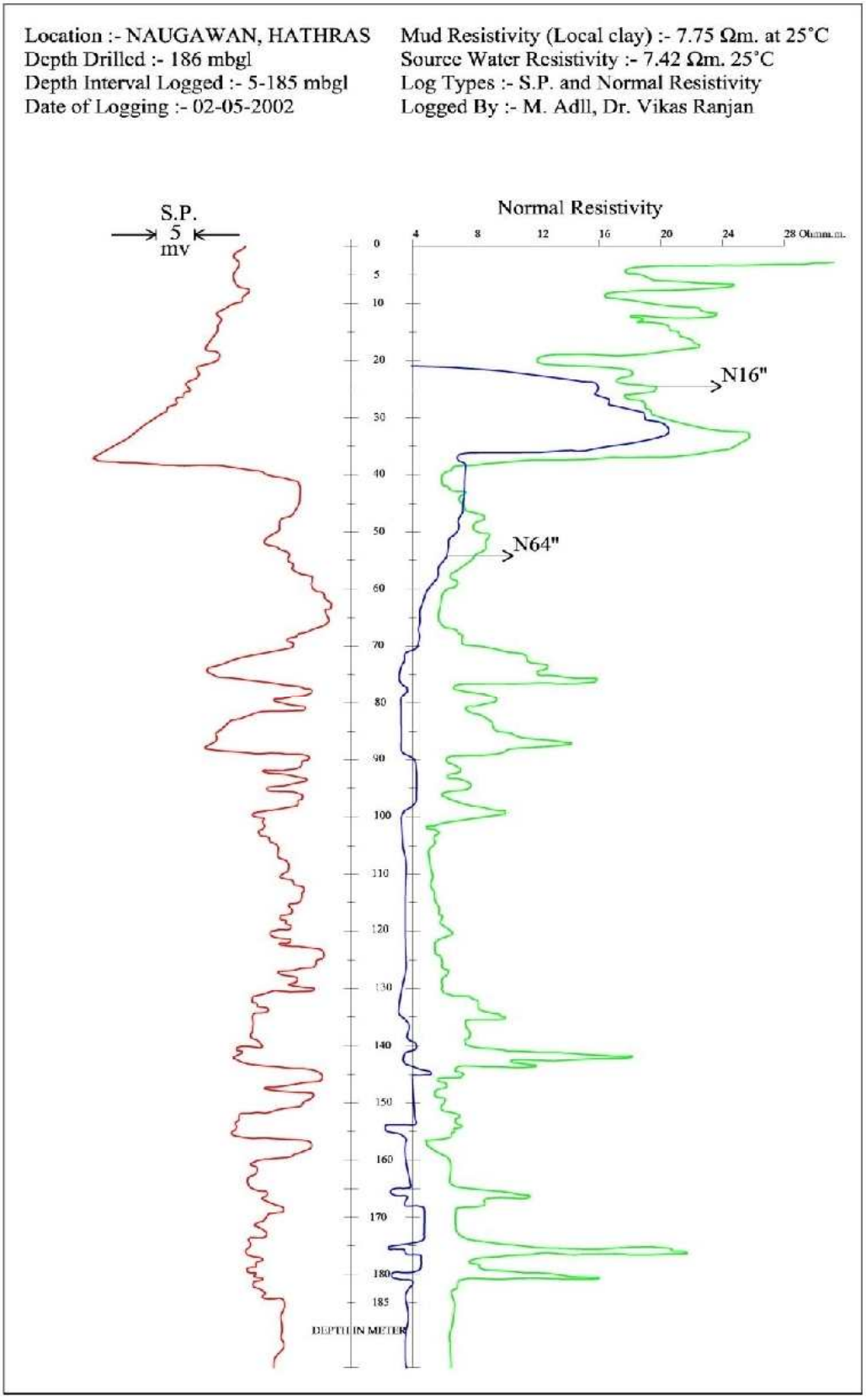


Fig.2.19 Electrical Logs of Exploratory borehole, Naugawn , District Hathras

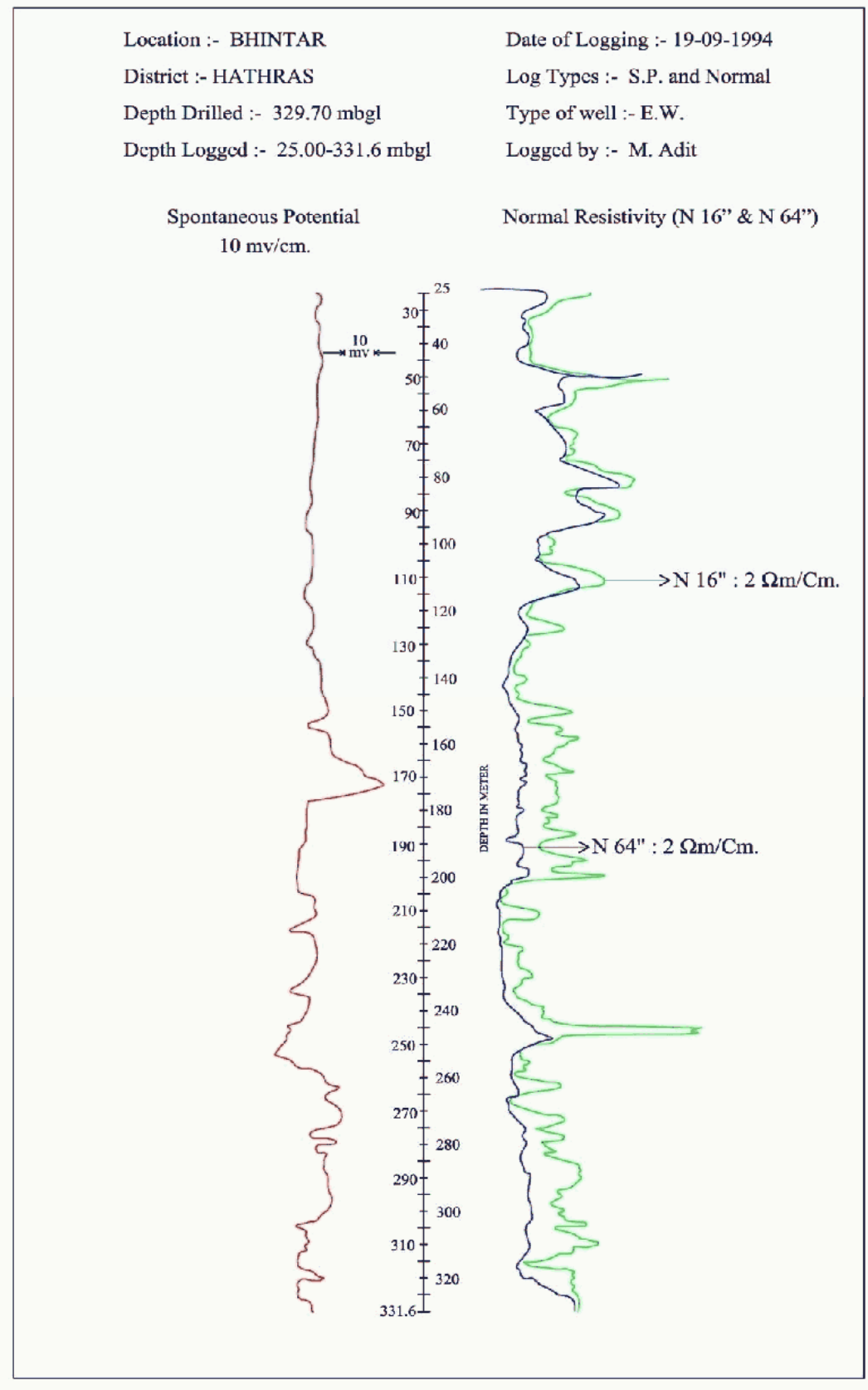


Fig. 2.20 Electrical Logs of Exploratory borehole, Bhintar , District Hathras

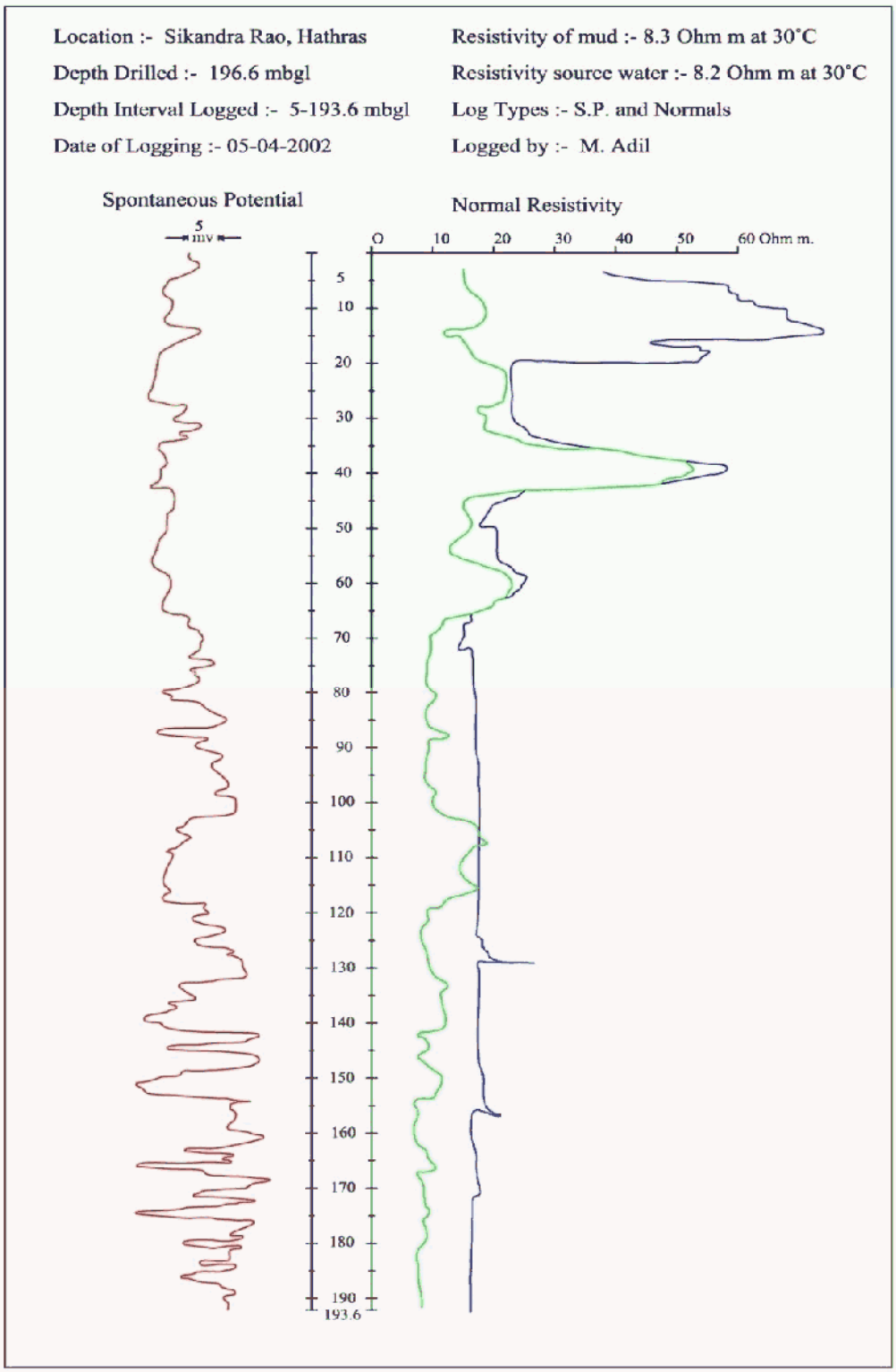


Fig.2.21 Electrical Logs of Exploratory borehole, Sikandrarao , District Hathras

Table 2.8: Details of electrical logs conducted in Hathras District

S.No.	Location	Depth drilled / E. logged Depth (m bgl)	Granular Zones encountered (m bgl)	Thickness (m)	Resistivity as per N 64 Ω m	Nature of *zone*	Quality of formation water
1	Hathras (Main Water Works Compound) – Block Hathras	178/	16-27	9	23	Medium to coarse grained granular materials	Formation quality is good up to 66 mbgl
		130	29-34	5	12	Medium grained granular materials	(Expected E.C. less than 2000 µS/cm
			37-40	3	10	Fine to Medium grained granular materials	
			42-51	9	12	Medium grained granular materials	
			56-66	10	10		
			81-86	5	7	Fine to Medium grained granular materials	Formation quality deteriorates below 70 m bgl (Expected E.C. more than 3000 µS/cm
			93-108	15	6		
			116-118	2	7		
2	Chandappa, Block Mursan	367.5 /367.5	55-65	10	10	Granular material mixed with clay and silt	Good
			73-90	17	12-15		
			117-120	3	5	Medium grained granula material with intercalation of clay	Brackish to saline
			151-154	3	5		EC 5140 3000 µS/cm as confirmed by zone test.
			208-241	33	8	Granular material mixed with clay	
			251-256	5	8		
			261-271	10	8		
			276-303	27	13		
3	Sadabad (Pragatipuram) Block- Sadabad	202/	20-37	17	16.5	-	Formation water quality good upto 64 m bgl (Expected E.C. less than 3000 µS/cm
		202	41-47	6	14	-	
			49-52	3	11	-	
			55-64	9	9	-	
			70-79	27	7.8		Very poor quality of formation water (Expected E.C. more than 3000 µS/cm
			122-136	14	8	-	
			144-147	3	8	-	
			157-160	3	8	-	
			183-199	16	8		
5	Bhintar , Block Hasayan	331.6/ 331.6	20-32	12	22	Coarse grained granular materials	
			44-49	5	35	Very Coarse grained granular materials	
			77-82	5	45		
			87-93	6	40		
			105-115	10	30		
			150-200	50	8-10	-	

S.No.	Location	Depth drilled / E. logged Depth (m bgl)	Granular Zones encountered (m bgl)	Thickness (m)	Resistivity as per N 64 Ω m	Nature of *zone*	Quality of formation water
5	Bhintar , Block Hasayan		245-260	15	20-25	Coarse to coarse grained granular materials with intercalation of clay.	Very poor quality of formation
			274-317	43	22		
6	Sikandra Rao, Block- Sikandra Rao	196.6/	18-30	12	55	Coarse grained granular materials	Formation water quality good upto 155 m bgl.
		193.6	34-46	12	55	Very Coarse grained granular materials	
			56-69	13	22	Coarse grained granular materials	
			105-120	15	16	Coarse to medium grained granular materials	
			134-143	9	15	Fine to medium grained granular materials with intercalation of clay.	
			150-155	5	15		

2.3.1 Sub surface Lithological Variation

To obtain a two-dimensional (2D) and three-dimensional (3D) generalized view of the sub surface lithological variation viz a viz aquifer dispositions in Hathras district, sub surface multi-logs 2D, 3D Sections and fence diagrams (lithological and aquifer groups) have been prepared on the basis of integrated lithologs using manual methods and Rockworks software. The data of available borewells are complied and analysed in the respect of lithological variations which are given in Table 2.9. Fig. 2.22 shows the strip logs of borewells of Hathras, Aligarh, Etah and Mathura Districts. The 2D lihtological sections are presented in Fig 2.23, 2.24, 2.25, 2.26 and 2.27. The lihtological 3-D sections and fence diagrams are presented in Fig 2.28, and 2.29.

A perusal of these figures reveals the presence of a thick pile of alluvial sediments with alternation of various grades of sand, clay and silt. The lithological variation in the district is fine to medium sand, kankar variably associated with clay formation. The basement Vindhyan sandstone/shale has been encountered down to the depth of 302-323 m bgl at Chandapa and Bhinthar in Hathras district.

The following observations are recorded after study of the Fig. 2.23 to 2.29.

❖ The entire area has capping of sandy-silty-clayey soil, varying in thickness from 3-20 metres.

❖ The unconsolidated alluvial sediments deposited over the undulatory surface of the basement rock show alternate beds of granular and clay horizons. The thickness of these sediments, over the district, varies from about 200 m (in NW corner of area) to more than 350 m (in NE parts). The alluvium comprises clay, silt, sand of various grades (fine to medium sand generally dominate), gravel and kankar. Indurated sand is also occasionally met with at places. Kankars are usually found intermixed with clay at shallow depth but have arenaceous sediment predominate over argillaceous ones in the northern and north-eastern parts of the district.

❖ A perusal of 2D sections (Fig 2.23 to 2.27) and fence diagrams (Fig 2.28 & 2.29.) reveals that lithological variation in the district is fine to medium sand, kankar variably occurs associated with clay formation. The thickness of clay increases in the from north to south and south western part of the district. The thickness of clays in deeper part increases 40 to 50 metres upto to depth of 300 mbgl in Sadabad, Mursan and Hathras blocks.

❖ Bedrock (Vindhyan sandstone/shales) has been encountered in a few exploratory boreholes drilled by CGWB in Hathras district & its environ at Nera (82.72 mbgl, SST), Chandappa (302 mbgl, shale), Aligarh Junction (368 mbgl, Shale). Bhintar (323 mbgl SST) and Pasia Begumpur (336 mbgl, Shales). The Vindhyan basin tends to deepen from south-west to north-east.

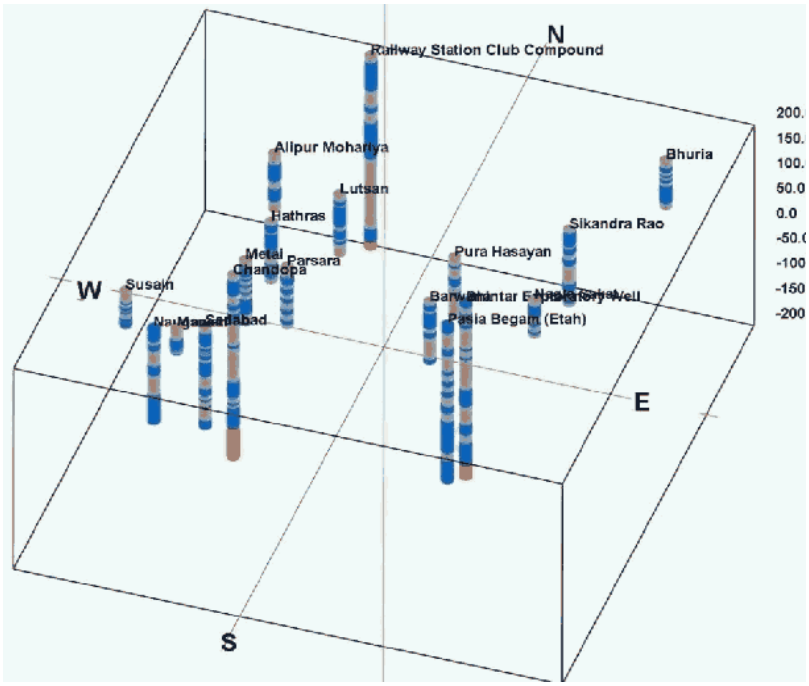


Fig. 2.22 Strip logs of borewells of Hathras , Aligarh , Etah and Mathura Districts U.P.

Table 2.9: Details of Lithological variation of borewells in Hathras district

S.No.	Borewell	Depth1	Depth2	Lithology	S.No.	Bore	Depth1	Depth2	Lithology
1	Alipur Mohariya	0	18	Clay	6	Hathras	0	3.05	Clay
		18	52	Medium Sand			3.05	18.29	Medium Sand
		52	67	Clay			18.29	21.34	Clay
		67	92	Medium Sand			21.34	53	Medium Sand
		92	113	Clay			53	56	Clay
2	Barwana	0	3	Clay			56	66	Medium Sand
		3	14	Medium Sand			66	81	Clay
		14	18	Clay			81	86	Medium Sand
		18	50	Medium Sand			86	93	Clay
		50	58	Clay			93	108	Medium Sand
		58	68	Medium Sand			108	118.87	Clay
		68	110	Clay			118.87	161	Medium Sand
		110	120	Medium Sand			161	178	Clay
3	Bhintar	0	7	Medium Sand	7	Lutsan	0	11	Clay
		7	20	Clay			11	20	Medium Sand
		20	32	Medium Sand			20	22	Clay
		32	41	Clay			22	61	Medium Sand
		41	49	Medium Sand			61	69	Clay
		49	89	Clay			69	86	Medium Sand
		89	93	Medium Sand			86	89	Clay
		93	107	Clay			89	96	Medium Sand
		107	112	Medium Sand			96	120	Clay
		112	171	Clay	8	Mansai	0	21.5	Clay
		171	205.2	Medium Sand			21.5	40	Medium Sand
		205.2	241	Clay			40	41	Clay
		241	261.7	Medium Sand			41	44	Medium Sand
		261.7	277.6	Clay			44	48	Clay
		277.6	323.2	Medium Sand			48	50	Medium Sand
		323.2	350	Vindhyan sandstone	9	Metai	0	11	Clay
4	Bhuria	0	12.2	Clay			11	30	Medium Sand
		12.2	21.35	Medium Sand			30	33	Clay
		21.35	26.82	Clay			33	38	Medium Sand
		26.82	30.5	Medium Sand			38	46	Clay
		30.5	35.5	Clay			46	51	Medium Sand
		35.5	41.46	Medium Sand			51	60	Clay
		41.46	48.17	Clay			60	65	Medium Sand
		48.17	82.92	Medium Sand			65	75	Clay
		82.92	94.48	Clay			75	104	Medium Sand
5	Chandopa	0	7.54	Clay			104	120	Clay
		7.54	36.93	Medium Sand			120	127	Medium Sand
		36.93	55	Clay	10	Nagla Sakat	0	9.2	Clay
		55	65.7	Medium Sand			9.2	31.5	Medium Sand
		65.7	73	Clay			31.5	42.6	Clay
		73	90.25	Medium Sand			42.6	49	Medium Sand
		90.25	135.8	Clay			49	60	Clay
		135.8	141.65	Medium Sand			60	65	Medium Sand
		141.65	208.22	Clay			65	72	Clay
		208.22	241.07	Medium Sand					
		241.07	251.07	Clay			9.2	31.5	Medium Sand
		251.07	256	Medium Sand			31.5	42.6	Clay
		256	261	Clay	11	Naugawa	0	24.38	Medium Sand
		261	302.04	Medium Sand			24.38	30.48	Clay
		302.04	365	Vindhyan sandstone			30.48	42.05	Medium Sand

S.No.	Borewell	Depth1	Depth2	Lithology	S.No.	Bore	Depth1	Depth2	Lithology
11	Naugawan	42.05	73.15	Clay	17	Raman pur	0	3	Clay
		73.15	91.44	Medium Sand			3	21	Medium Sand
		91.44	131.06	Clay			21	27	Clay
		131.06	188.9	Medium Sand			27	67	Medium Sand
12	Nera	0	19.65	Clay			67	73	Clay
		19.65	43.85	Medium Sand			73	80	Medium Sand
		43.85	54.45	Clay			80	91	Clay
		54.45	57.45	Medium Sand	18	Sadabad	0	12.19	Clay
		57.45	85	Clay			12.19	37	Medium Sand
13	Parsara	0	18	Clay			37	41	Clay
		33	40	Clay			41	47	Medium Sand
		40	52	Medium Sand			47	49	Clay
		52	61	Clay			49	52	Medium Sand
		61	69	Medium Sand			52	55	Clay
		69	82	Clay			55	64	Medium Sand
		82	92	Medium Sand			64	70	Clay
		92	103	Clay			70	97	Medium Sand
		103	112	Medium Sand			97	122	Clay
14	Pasia Begam (Etah)	0	13.7	Medium Sand			122	136	Medium Sand
		13.7	45	Clay			136	144	Clay
		45	58	Medium Sand			144	147	Medium Sand
		58	90	Clay			147	157	Clay
		90	97	Medium Sand			157	160	Medium Sand
		97	109	Clay			160	185	Clay
		109	119	Medium Sand			185	202.7	Medium Sand
		119	130	Clay	19	Sikandra Rao	0	3.05	Clay
		130	141	Medium Sand			3.05	30	Medium Sand
		141	159	Clay			30	34	Clay
		159	173	Medium Sand			34	46	Medium Sand
		173	189	Clay			46	56	Clay
		189	252	Medium Sand			56	69	Medium Sand
		252	268	Clay			69	105	Clay
		268	312.6	Medium Sand			105	120	Medium Sand
		312.6	336	Clay			120	134	Clay
		336	360	Vindhyan sandstone			134	143	Medium Sand
15	Pura Hasayan	0	14	Clay			143	196	Clay
		14	18	Medium Sand	20	Susain	0	21.4	Clay
		18	39	Clay			21.4	24.45	Medium Sand
		39	54	Medium Sand			24.45	30.44	Clay
		54	66	Clay			30.44	36.55	Medium Sand
		66	70	Medium Sand			36.55	39.43	Clay
		70	120	Clay			39.43	42.49	Medium Sand
16	Railway Station Club Compound	0	10	Clay			42.49	53.05	Clay
		10	66	Medium Sand			53.05	59.12	Medium Sand
		66	99.69	Clay			59.12	60	Clay
		99.69	110.02	Medium Sand			60	70	Medium Sand
		110.02	131	Clay			70	73	Clay
		131	201.85	Medium Sand					
		201.85	342.23	Clay					
		342.23	368.16	Medium Sand					
		368.16	383.26	Vindhyan sandstone					
17	Ramanpur	0	3	Clay					
		3	21	Medium Sand					
		21	27	Clay					
		27	67	Medium Sand					

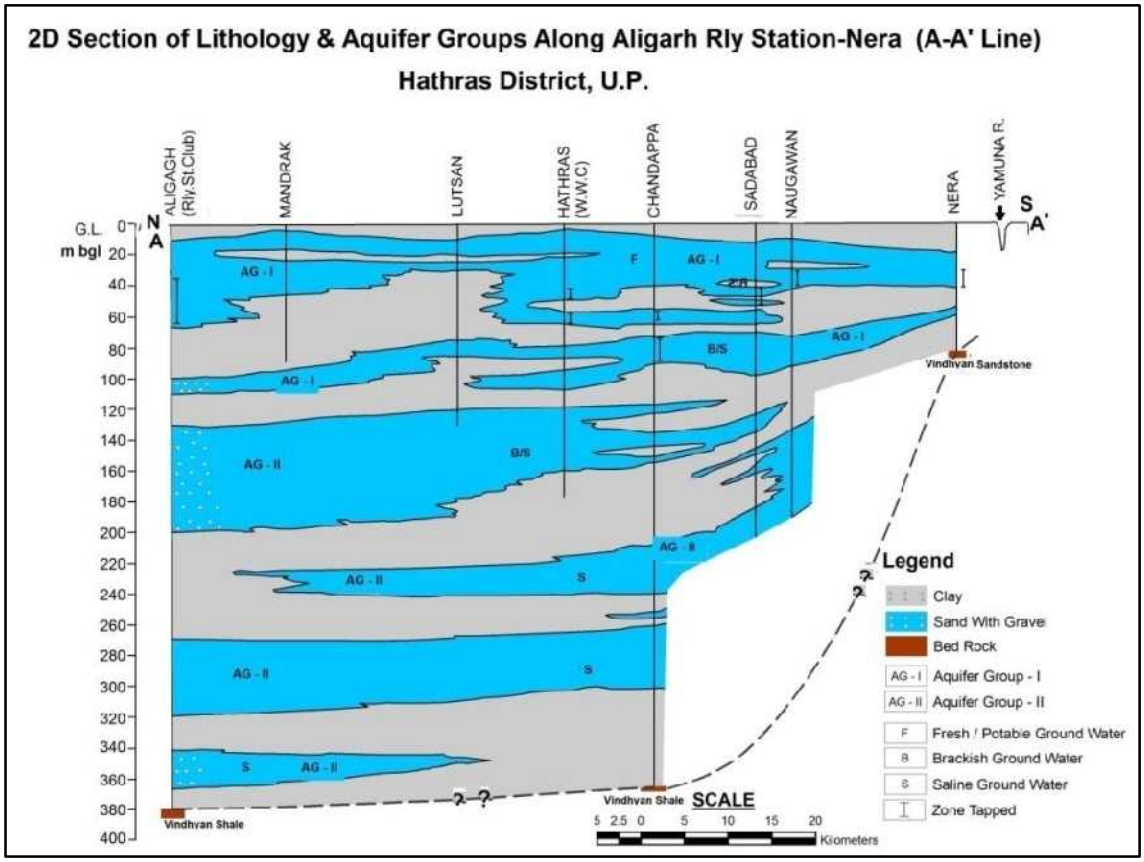


Fig. 2.23 2D section of Lithological variation and Aquifer Groups Along Aligarh Rly Station-Nera (A-A' Line) Hathras , District

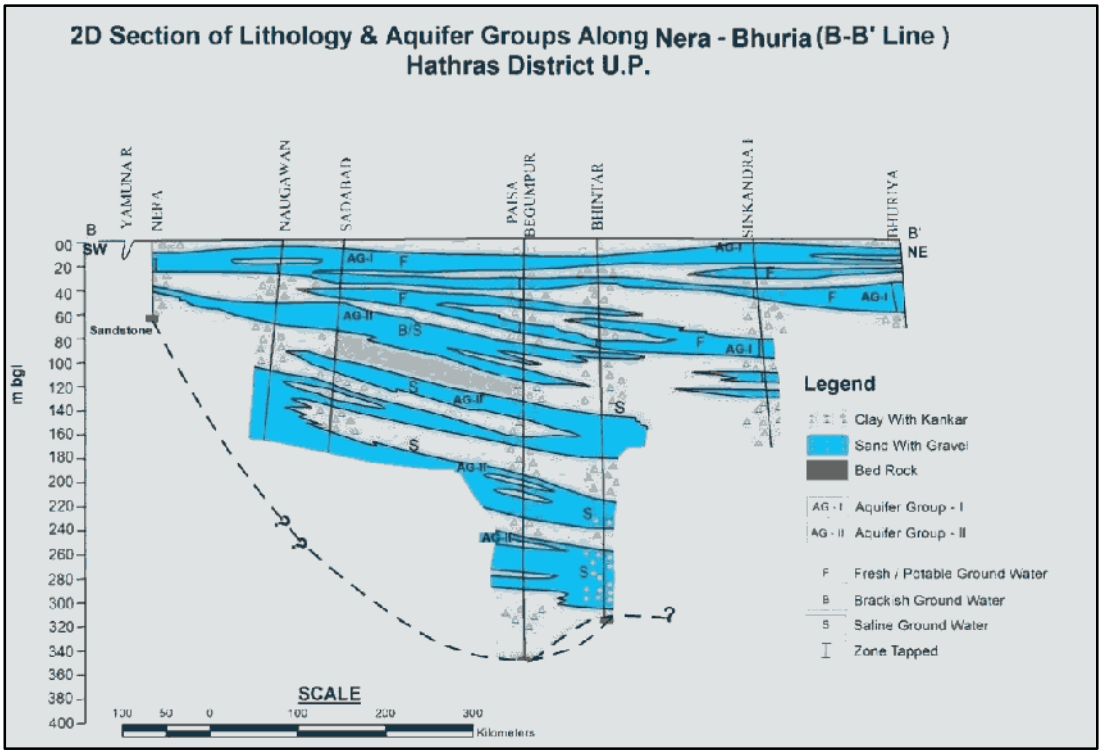


Fig. 2.24 2D section Lithological variation and Aquifer Groups Along Nera-Bhuria (B-B' Line) Hathras , District

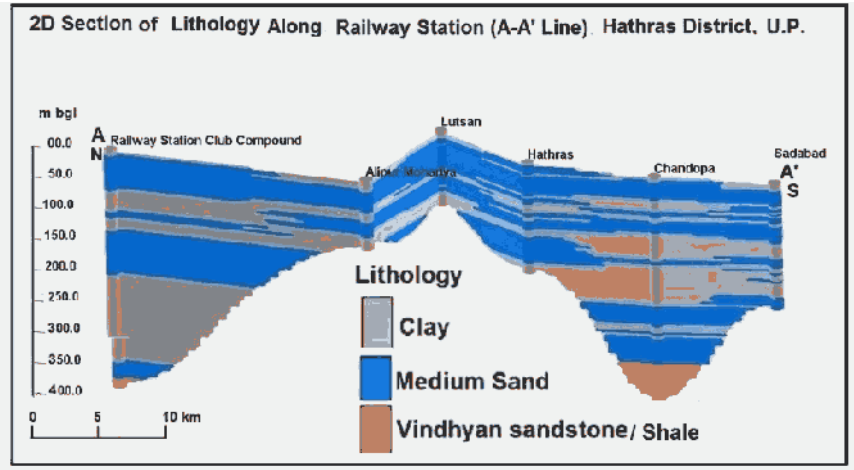


Fig. 2.25 2D section of Lithological variation along Aligarh Rly Station-Sadabab (A-A' Line)

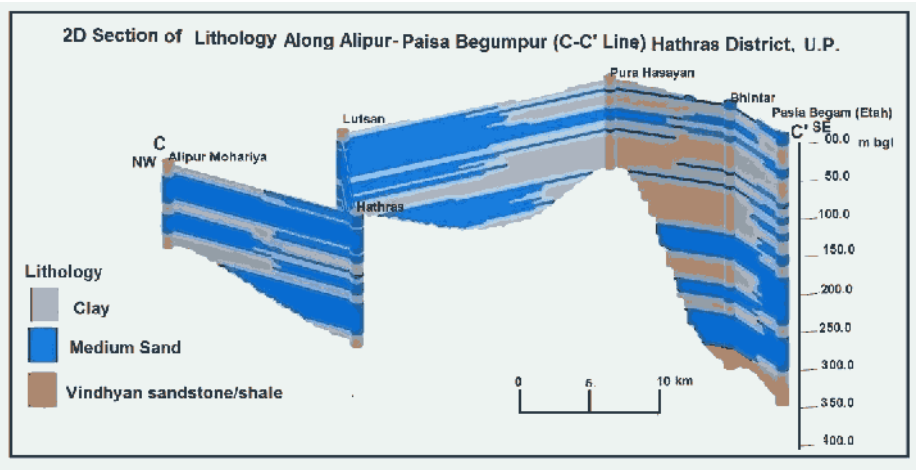


Fig 2.26 2D section of Lithological variation along Alipur-Paisa Begum (C-C' Line)

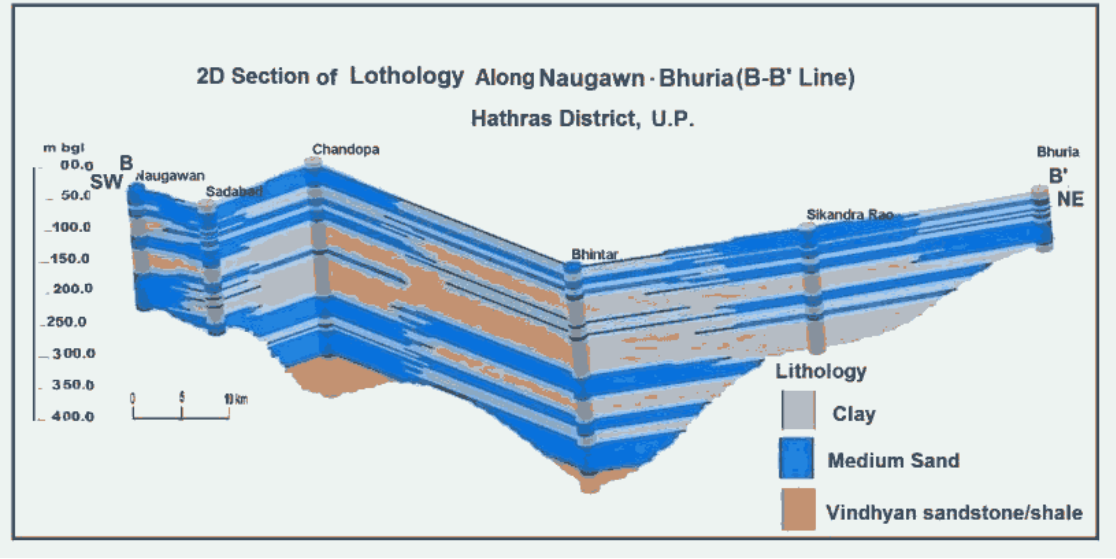


Fig 2.27 2D section of Lithological variation along Naugawn-Bhuria (B-B' Line) in Hathras , District

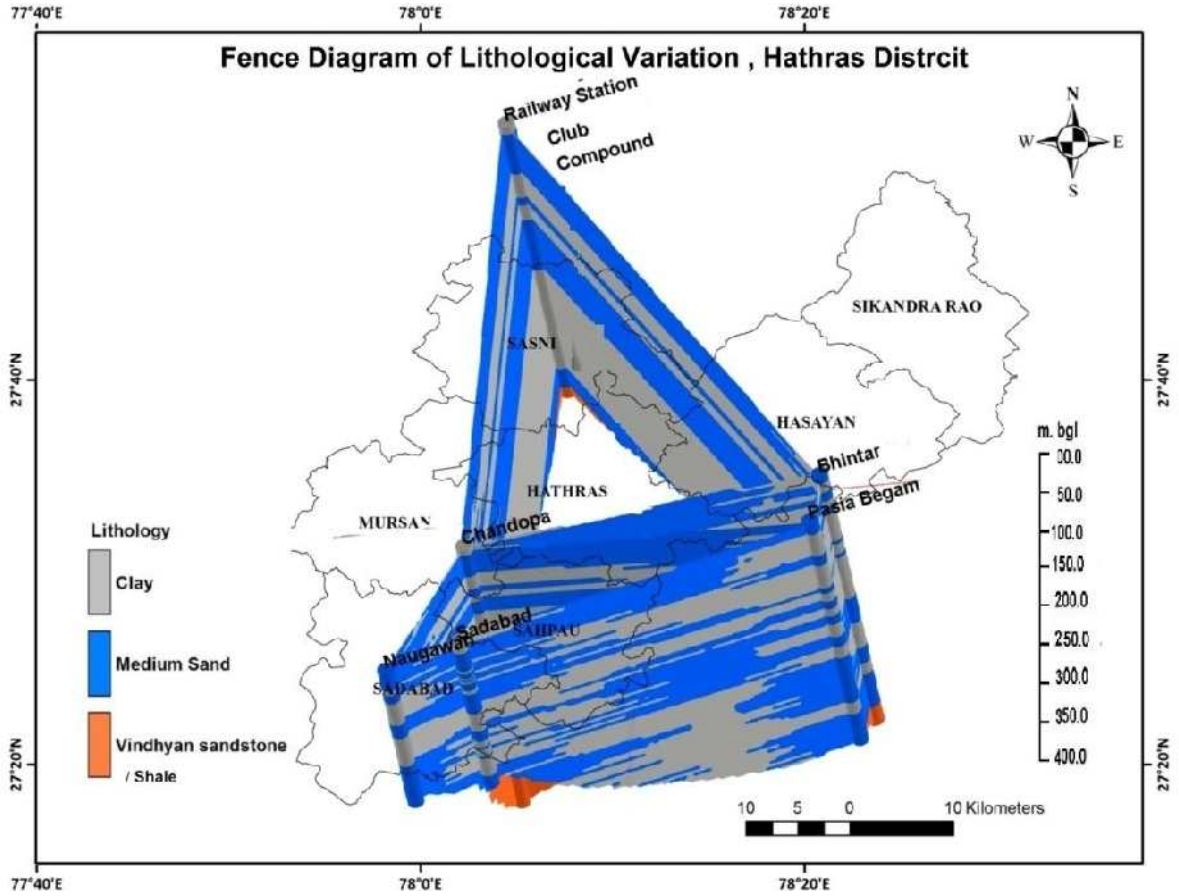


Fig. 2.28 Fence Diagram showing lithological variation in Hathras , District

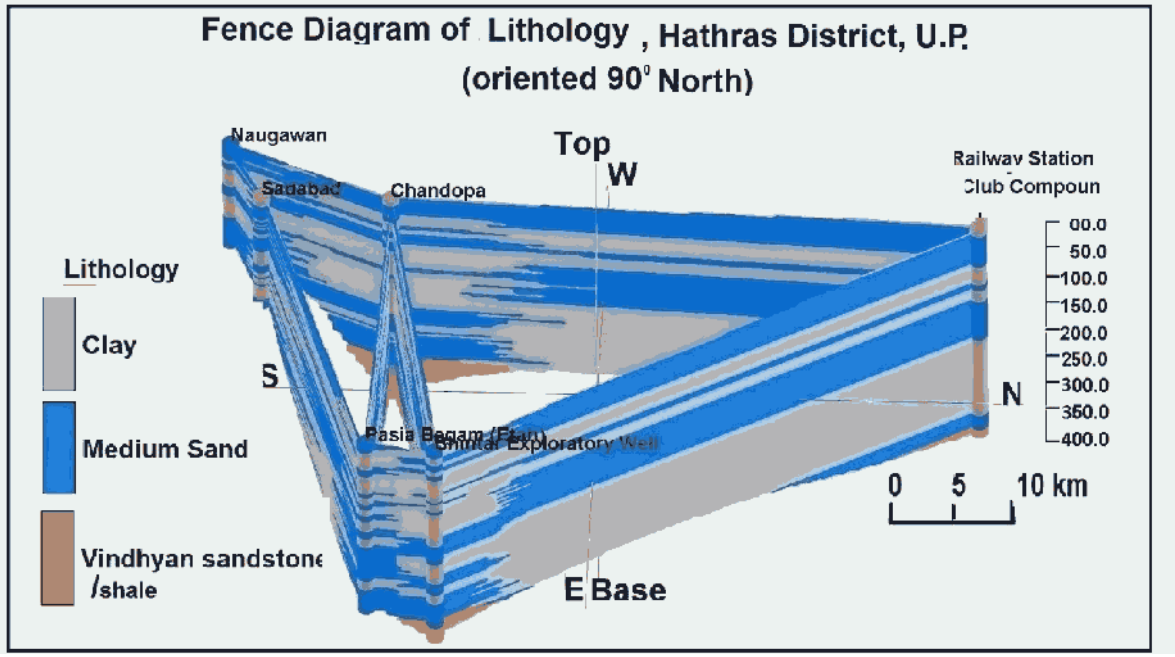


Fig. 2.29 Fence Diagram showing lithological variation oriented to 90^0 North in Hathras , District

2.3.2 Aquifer Disposition

To establish the sub-surface configuration of the aquifer dispositions over the district, 2D sections and 3D fence diagrams (Fig. 2.30 to 2.34) are prepared after grouping the aquifer based on the aquifer materials which is given in Table 2.10. Demarcation of different aquifer groups has been done on the basis of lithological character, hydraulic properties and quality ascertained though exploratory drilling, geophysical logging. The granular zones with varied resistivities were picked up from the combined interpretations of electrical resistivity (16 & 64 inches Normal) S.P. logs of the boreholes drilled in the area. The optimum thickness of the granular zones are obtained by apportioning 70 % of the total thickness and percentage of granular zone (sand percentage) is also determined. To view the areal extent of aquifer groups, isopach maps of Aquifer group I & II are prepared (Fig. 2.34 &2.35). Similarly, areal extent of variation of aquifer materials (Sand %) within aquifers are also demonstrated (Fig. 2.36 & 2.37). Fig. 2.30 to 2.34 depicts the detailed aquifer geometry on regional scale established in the study area. The principal aquifers in the area have been delineated by grouping the fine to medium sand, coarse sand and gravelly sand as aquifers. The thick pile of the sediments constituting alternate clay and sand beds may be divided into two major groups down to the depth of 300 m bgl. A careful study of the lithological logs and perusal of 2D sections & fence diagrams (Fig. 2.30 to 2.37 and Table 2.11) show the occurrence of a two aquifer groups in the area. The aquifers have been grouped as Aquifer Group-I and Aquifer Group-II on the basis of variations in their physical characteristics and the quality of formation water. These aquifer groups are separated by confining clay layers of thickness more than 10 m which maintain their identity in almost entire district. Also these groups consist of several thin aquifers separated by clays and silts. The resistivity of these aquifer groups in general decreases with depth.

There is variation in thickness of aquifer group but in regional scale they are making different groups on the basis of aquifer characteristics grade of sand and clay. The fence and 2D sections reveal the presence of a thick pile of alluvial sediments with alternation of various grades of sand with clay and silt. The area is characterized by occurrence of fairly thick sands of various grades forming prolific aquifers. The variations in aquifer thicknesses and the trend in their occurrences are indicative of variations in the depositional palaeo-environment and the influences of structural controls at different geological times. The Aquifer groups with their characteristics are described below and 3D Aquifer disposition is shown in Fig. 2.39.

A) First Aquifer Group (Aquifer Group- I):

It is the most potential aquifer group covering almost the entire area below the soil capping, occurring and continues down to generally 97 mbgl (Bottom between 65 and 97 mbgl) with the average depths of 78.00 mbgl. Figure-2.35 shows Isopachs of Aquifer Group- I where thickness or depth of Aquifer group ranges

between 70-90 m bgl in the entire area however isolated patches of > 90 mbgl are seen in the Sasni block. The aquifer material is fine to medium sand and kankar variably associated with clay formation. The thickness of granular zone varies between 16-50 m with an average of 34 m. Figure-2.37 shows that sand percentage in the first aquifer group ranging between 30-50% in all blocks, However an small area of 20-30% are seen in Sadabad & Hasayan blocks and 50-60% in Sasni, Mursan & Sikanrarao blocks. Ground water occurs under water table condition & depth to water level varies between 3.88 and 29.13 metres. The quality of the formation water of this aquifer group is generally fresh. However EC of more than 3000 microsiemens/cm is observed in 30-40 % area of Sadabad block.

The First aquifer group forms the main source of water supply to hand pumps & shallow tube wells. About 90% of the state tube wells of 50-100 metres depth are parts of this aquifer group. The discharge of tube wells varies from 400 to 2400 lpm at moderate draw-downs of about 3-8 meters. Transmissivity 'T' is 256-1333 m^2/day. Storativity 'S' is to the order of 2.65×10^{-4} -6.5×10^{-3} showing semi confined to confined state of aquifer as per available data which are needed for refinement. Being the only fresh water aquifer in the area it holds almost the entire ground water developmental activities and thus is overstressed.

B) Second Aquifer Group (Aquifer Group-II):

This aquifer group is separated with the overlying shallow aquifer group by a thick clay and occurs between the depth range of 103 (Top between 103 and 136 mbgl) m bgl and 302 mbgl (Bottom between 261 and 302 mbgl) is separated by 10-15 m thick clay layer from the first aquifer. The aquifer material is generally medium sand but at place it is an admixture of fine and coarse grained sand. Figure-2.36 shows Isopach of Aquifer Group- II where thickness of Aquifer group ranges between 164-197 m bgl with the average depths of 169 mbgl. Generally the thickness ranges between 170-190 m in the entire area however the thickness increases from west to east. The thickness of granular zones varies upto 58 metres and total clay content in this aquifer group is 65 to 70%. Figure-2.38 shows that sand percentage in the second aquifer group ranging between 29-35 % in all blocks. However a small area of >32% is also noticed in Sadabad, Mursan and Sasni blocks.

Since the depth of all the existing groundwater structures dugwells/tubewells) are limited to Aquifer Group-1, the aquifer parameter for aquifer group-2 & 3 could not be determined. These deeper aquifers, in spite of having good thickness of granular zones and apparently good potentiality, contain very poor quality (Brackish to highly saline) formation water hence have not been exploited in the area for any purpose.

As all wells constructed in Aquifer Group-I and only two wells tested, some more wells are proposed to be constructed for refinement of Aquifer mapping and Aquifer

demarcation in the area in terms of quantity and quality aspect. Fig. 2.39 shows the 3D Aquifer disposition with all details in the Hathras District.

Table 2.10: Details of Aquifer Group in Hathras district

S.No.	Location	Elevation m amsl	Depth1	Depth2	Lithology
1	Bhintar	172.8	0	93	Aquifer Group I
			93	107	Clay Horizon I
			107	261	Aquifer Group II
			261	323	Clay Horizon II
			323	331.6	Vindhyan Sandstone
2	Chandopa	175.8	0	65	Aquifer Group I
			65	73	Clay Horizon I
			73	302	Aquifer Group II
			302	367	Vindhyan Shale
3	Railway Station Club Compound	190.0	0	110	Aquifer Group I
			110	150	Clay Horizon I
			150	176	Aquifer Group II
			176	342	Clay Horizon II
			342	383.26	Vindhyan Shale
4	Pasia Begam (Etah)	176.3	0	97	Aquifer Group I
			97	109	Clay Horizon I
			109	252	Aquifer Group II
			252	312.6	Clay Horizon II
			312.6	360	Vindhyan Shale
5	Sadabad	169.6	0	97	Aquifer Group I
			97	122	Clay Horizon I
			122	160	Aquifer Group II
			160	202.7	Clay Horizon II
6	Hathras	185.8	0	86	Aquifer Group I
			86	93	Clay Horizon I
			93	161	Aquifer Group II
			161	178	Clay Horizon II
7	Naugawan	177.6	0	91.44	Aquifer Group I
			91.44	131.06	Clay Horizon I
			131.06	188.97	Aquifer Group II
8	Sikandra Rao	180.4	0	69	Aquifer Group I
			69	105	Clay Horizon I
			105	143	Aquifer Group II
			143	196	Clay Horizon II
9	Nera	176.7	0	57.45	Aquifer Group I
			57.45	85	Clay Horizon I
10	Mansai	174.6	0	50	Aquifer Group I
11	Susain	176	0	70	Aquifer Group I
	Susain		70	73	Clay Horizon I
12	Ramanpur	177.9	0	80	Aquifer Group I
			80	91	Clay Horizon I
13	Alipur		0	92	Aquifer Group I

S.No.	Location	Elevation m amsl	Depth1	Depth2	Lithology
	Mohariya		92	113	Clay Horizon I
14	Nagla Sakat	177.6	0	65.85	Aquifer Group I
			65.85	72.25	Clay Horizon I
15	Metai	180.1	0	65	Aquifer Group I
			65	75	Clay Horizon I
			75	120	Aquifer Group II
			120	127	Clay Horizon II
16	Parsara	181.7	0	92	Aquifer Group I
			92	120	Clay Horizon I
17	Pura Hasayan	183.1	0	70	Aquifer Group I
			70	120	Clay Horizon I
18	Barwana	177.2	0	68	Aquifer Group I
			68	120	Clay Horizon I
19	Lutsan	188	0	96	Aquifer Group I
			96	120	Clay Horizon I
20	Bhuria	175.7	0	82.92	Aquifer Group I
			82.92	94.48	Clay Horizon I

Table 2.11: Details of Geophysical Logged Boreholes in Hathras District

S. No.	*Location*	*Drilling Depth/ E. logging m bgl*	*Remarks Aquifer group/ Resistivity m bgl/ Ωm*	*Quality of formation water*	
				Based on testing EC µS/cm	***Based on E log***
1.	Hathras Main Water Works Compound	170/130	2 Aquifer groups : WT - 67 10-23 (F) 83 - 130 06-7 (S)	2840-	Formation quality is good up to 66 mbgl (Expected E.C. less than 2000 µS/cm and deteriorate below 81mbgl (Expected E.C. more than 3000 µS/cm
2.	Chandappa	367.5/367	2 Aquifer group : WT – 90 (F) 10-15 95 – 242 (S) 5-8 253- 364 (S) Bedrock (shale) encountered 302.0 m bgl.	2436	Good upto 90 mbgl. deteriorate below 95- mbgl . Brackish to saline. EC 5140 µS/cm (as confirmed by zone test)
3.	Sadabad Pragati Puram	202/200	2 Aquifer groups : WT - 68 11-16.5 (F) 71 - 200 08 (S)	3240	Formation quality is good up to 64 mbgl (Expected E.C. less than 2000 µS/cm and deteriorate below 70 mbgl (Expected E.C. more than 3000 µS/cm
4.	Naugawan	188.97/186	2 Aquifer groups: WT - 41 16 (F) 74 - 185 04 (S)	2690	Formation quality is good up to 47 mbgl

S. No.	*Location*	*Drilling Depth/ E. logging m bgl*	*Remarks Aquifer group/ Resistivity m bgl/ Ωm*	*Quality of formation water*	
				Based on testing EC µS/cm	***Based on E log***
5.	Bhinter	331.6/330	2 Aquifer groups : WT -115 (F) 22-24 122– 238 (S) 8-10 245 - 328 (F) 22 Bedrock (sst.) at 323.0		Formation quality is good up to 115 mbgl. And deteriorate below 115 m bgl.
6.	Sikandara Rao	196.6/193	2 Aquifer groups : WT - 67 20 (F) 81 - 193 05 (S)	1540	Formation quality is good up to 155 mbgl

Table 2.12a Block wise Details of Aquifer Group-I (Unconfined) and Aquifer-II (confined) in Hathras District

Block	Borewells	Aquifer Group-I			Aquifer Group-II			
		Thickness (m bgl)	Thickness of Granular zone (m)	% of Granular Zone (Sand %)	Bottom of Top conf. bed m bgl	Thickness (m)	Thickness of Granular zone (m)	% of Granular Zone (Sand %)
Hasayan	Bhintar	93	22	23	107	193	57.61	30
	Nagla Sakat	66	24	36				
	Pura Hasayan	70	16	23	120	180	57.61	32
Hathras	Barwana	68	37	54	110	190	57.61	30
	Hathras	86	43	50	108	192	57.61	30
	Parsara	92	32	34	103	197	57.61	29
Mursan	Metai	65	24	37	120	180	57.61	32
	Ramanpur	80	46	57	120	180	57.61	32
	Chandopa	65	41	63	136	164	57.84	35
Sadabad	Mansai	50	16	33				
	Naugawan	91	38	42	131	169	57.84	34
	Sadabad	97	49	50	122	178	57.84	32
	Susain	70	20	28				
Sasni	Alipur Mohariya	92	41	45	113	187	57.84	31
	Lutsan	96	50	53	120	180	57.84	32
Sikandra Rao	Sikandra Rao	69	36	53	105	195	57.84	30
	Bhuria	83	37	45				
	Pasia Begam (Etah)	97	24	24	109	191	91	48
	Railway Station Club Compound-Aligarh	110	46	42	131	169	49	29

Table 2.12 b Block wise Details of Aquifer Group-I (Unconfined) and Aquifer-II (confined in Hathras District

Block	Aquifer Group-I			Aquifer Group-II			
	Thickness (m bgl)	Thickness of Granular zone (m)	% of Granular Zone (Sand %)	Bottom of Top conf. bed m bgl	Thickness (m)	Thickness of Granular zone (m)	% of Granular Zone (Sand %)
	Average						
Hasayan	76	20	27	114	187	58	31
Hathras	82	37	46	107	193	58	30
Mursan	70	37	52	125	175	58	33
Sadabad	77	31	38	127	174	58	33
Sahpau	77	31	38	115	185	58	31
Sasni	94	46	49	117	184	59	32
Sikandra Rao	76	37	49	105	195	58	30
District	78	34	43	114	187	58	31

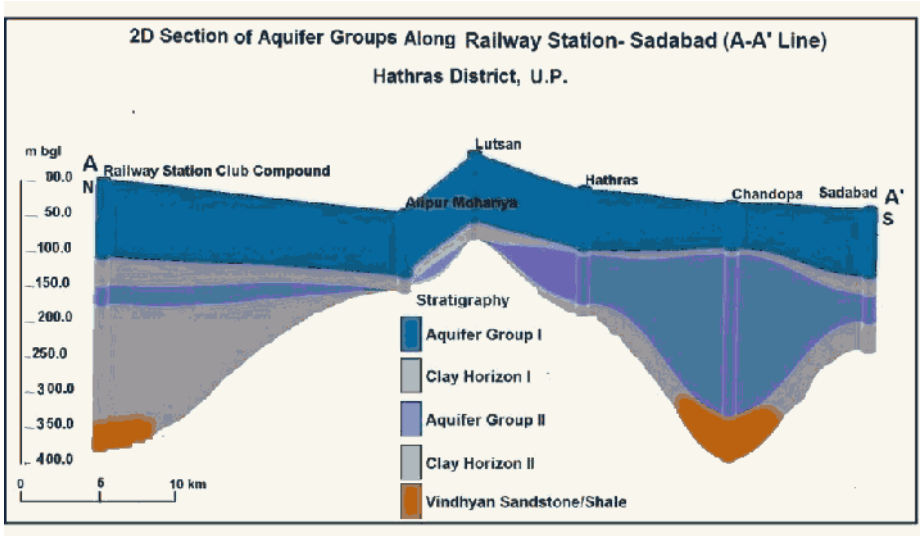


Fig 2.30 2D Section of Aquifer disposition along Railway Station-Sadabad (A-A' Line)

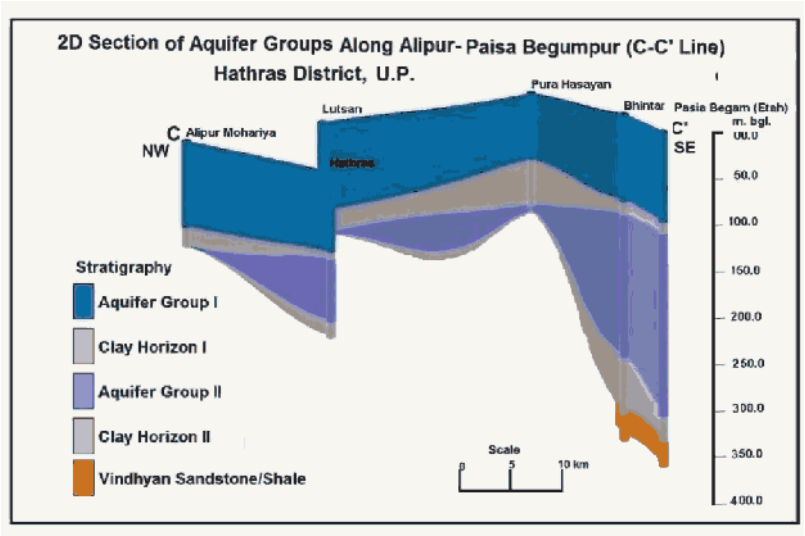


Fig 2.31 2D Section of Aquifer disposition Along Alipur-Paisa Begumpur (C-C' Line)

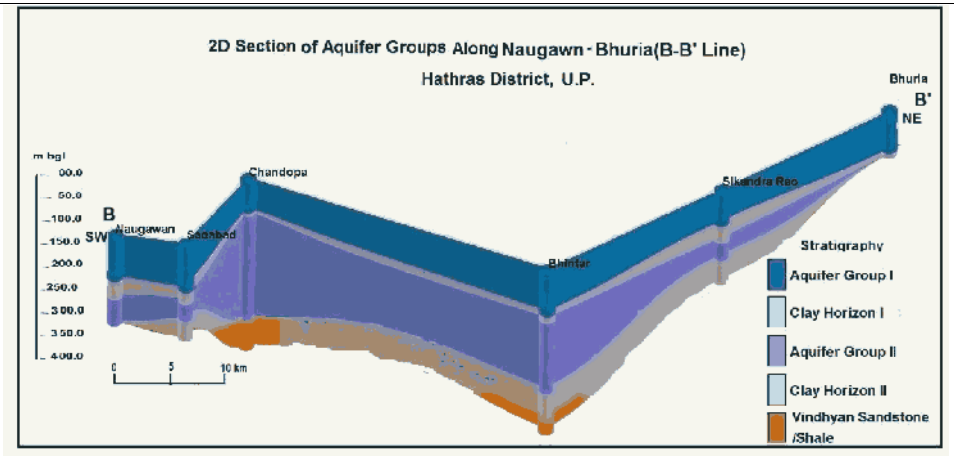


Fig 2.32 Section of Aquifer disposition along Naugawn-Bhuria (B-B' Line)

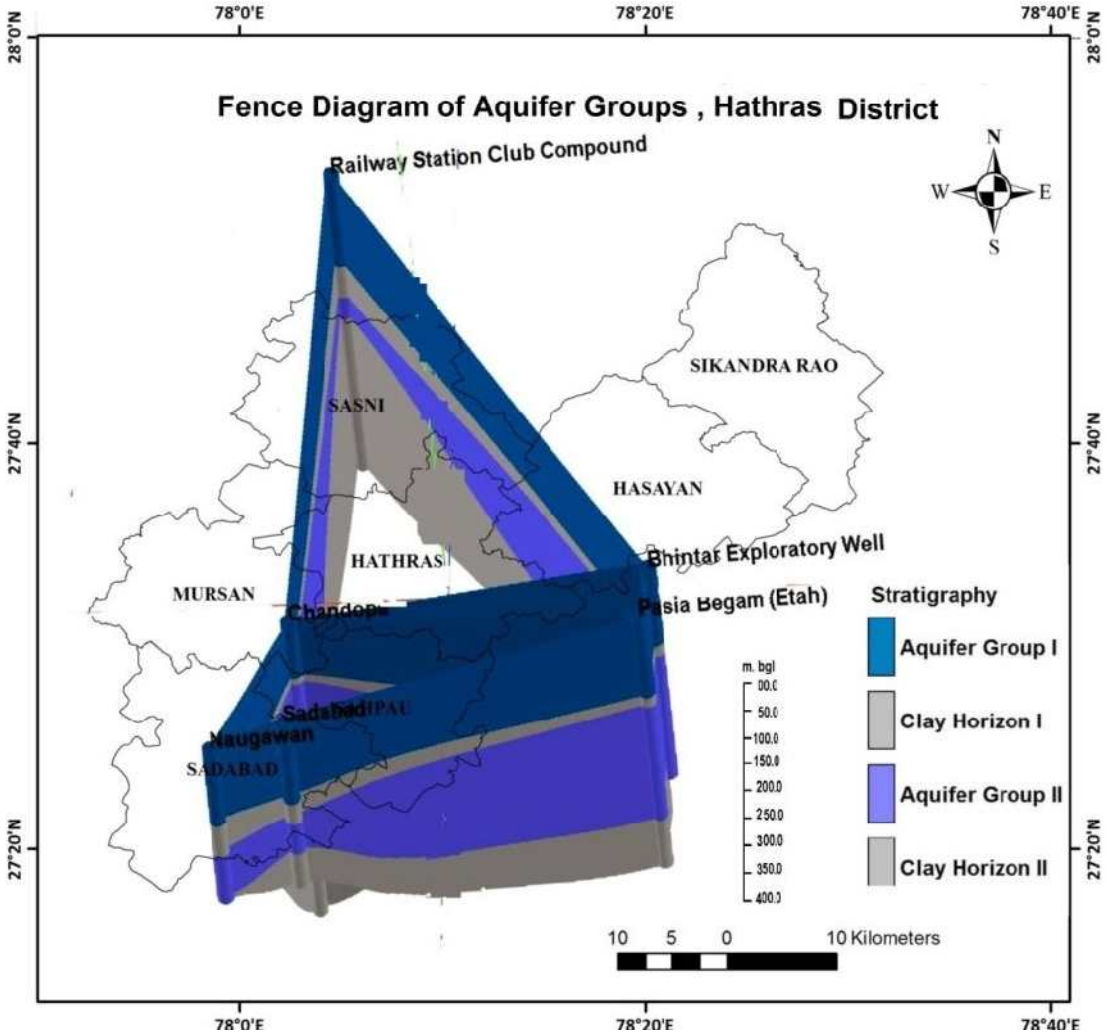


Fig. 2.33 Fence Diagram showing Aquifer Disposition in Hathras District,

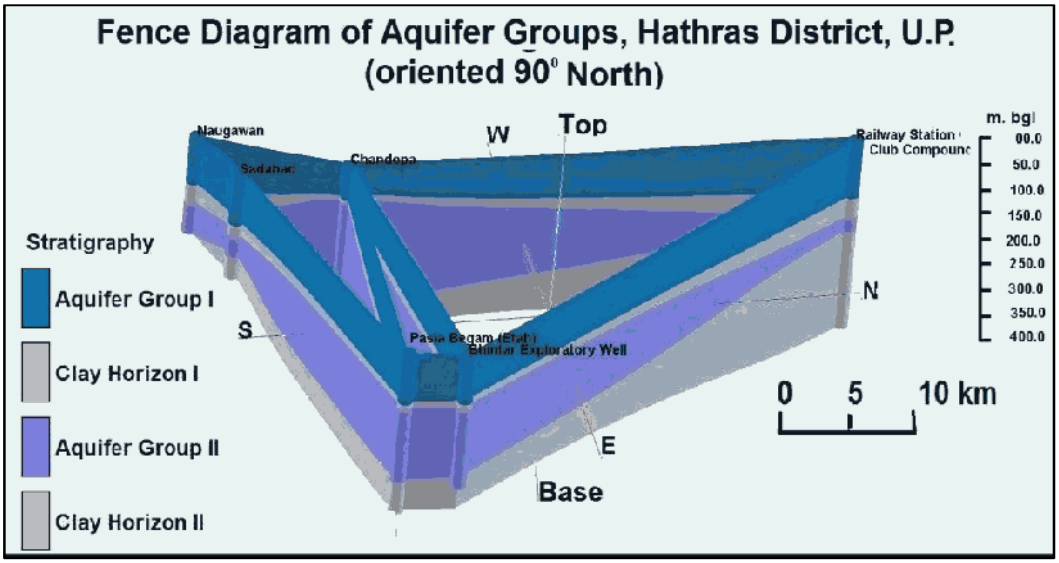


Fig. 2.34 Fence Diagram showing Aquifer Disposition oriented to 90^0 North in Hathras District

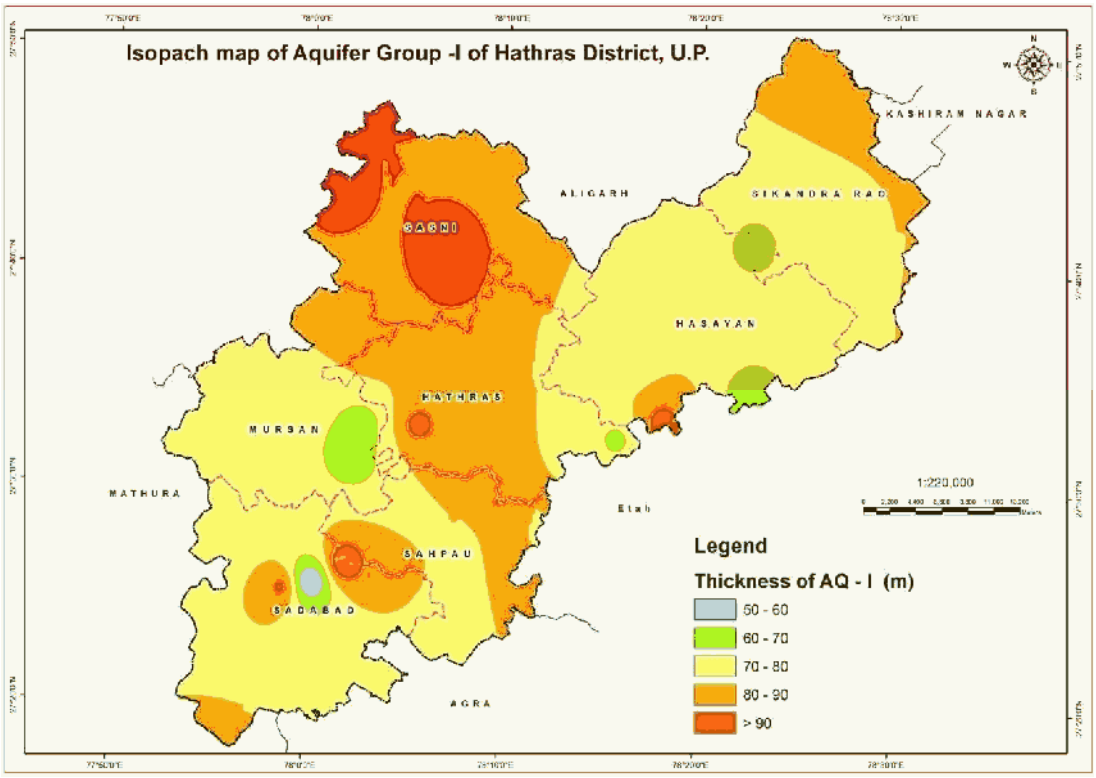


Fig. 2.35 Isopach of Aquifer Group-I in Hathras Distict

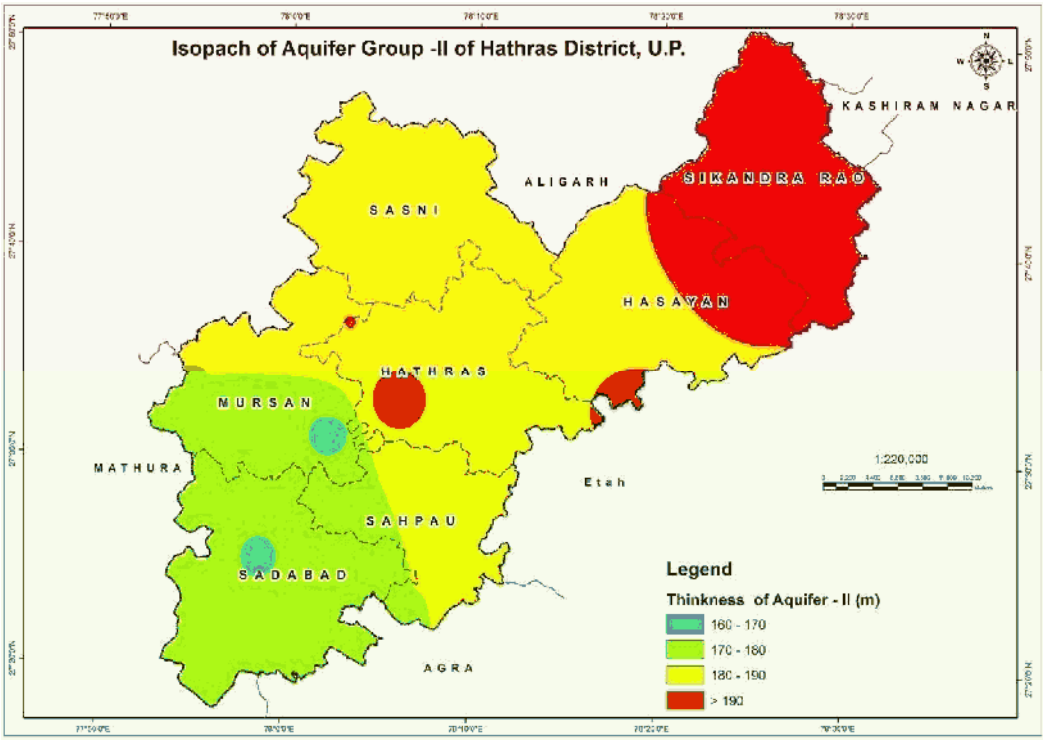


Fig. 2.36 Isopach of Aquifer Group-II in Hathras Distict

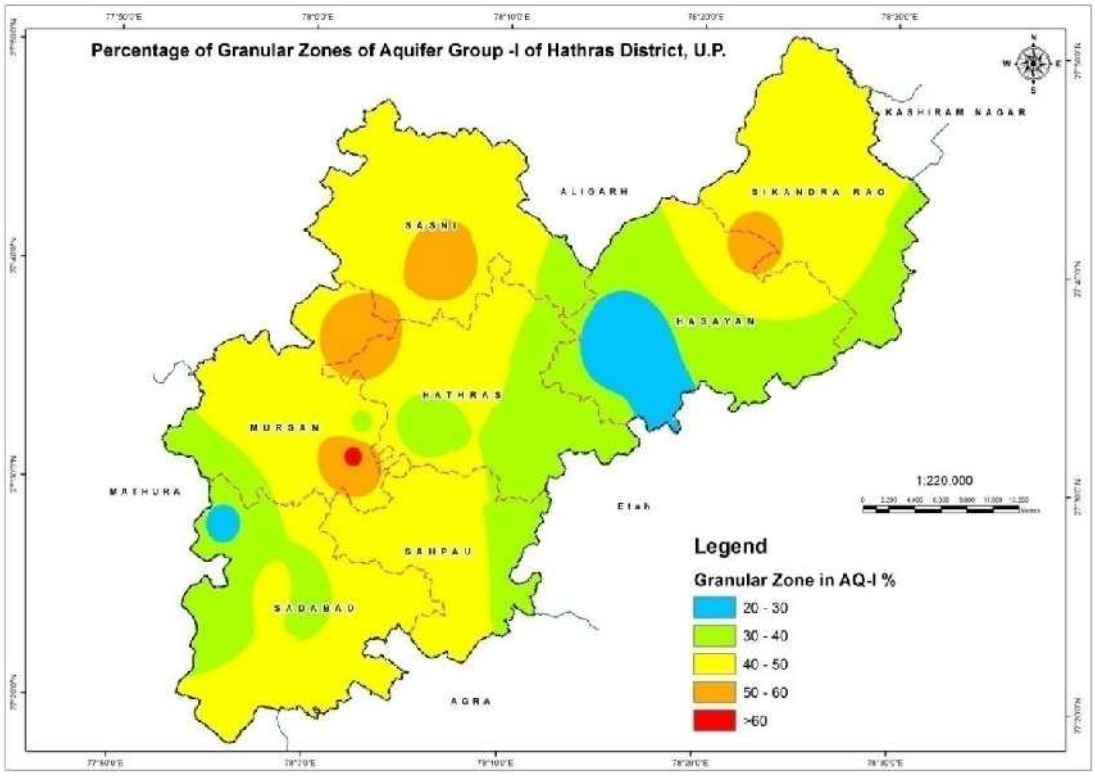


Fig. 2.37 Variation of aquifer materials (Sand %) in Aquifer Group-I, Hathras Distict

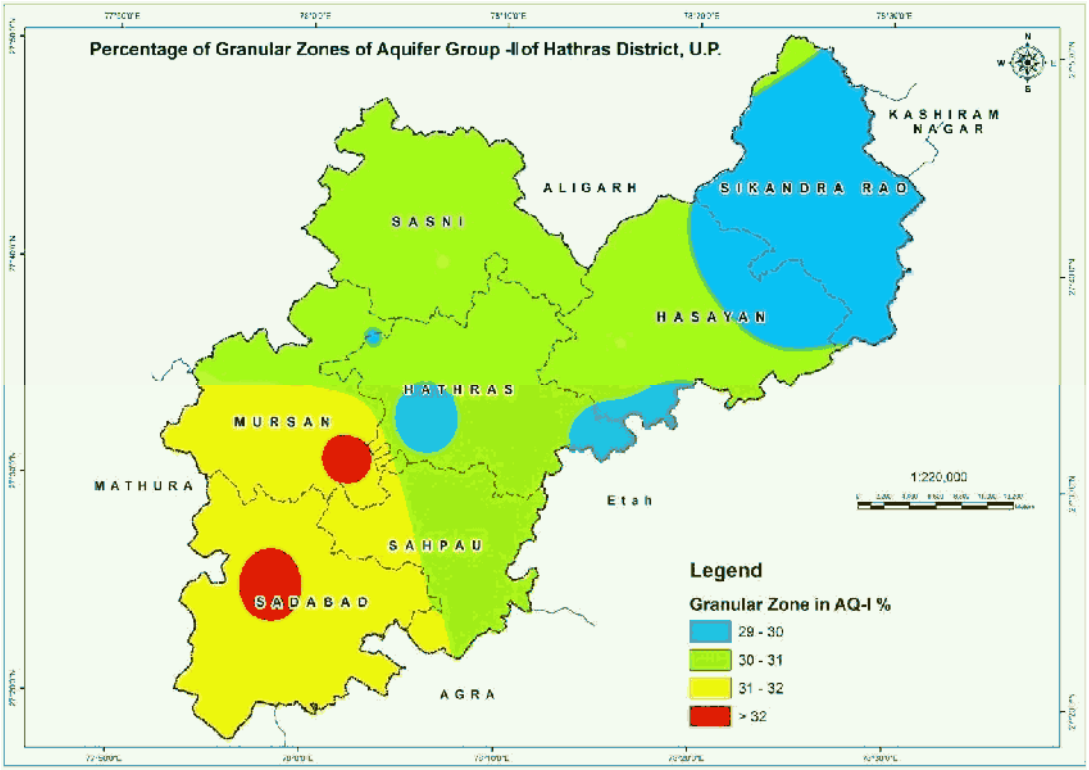
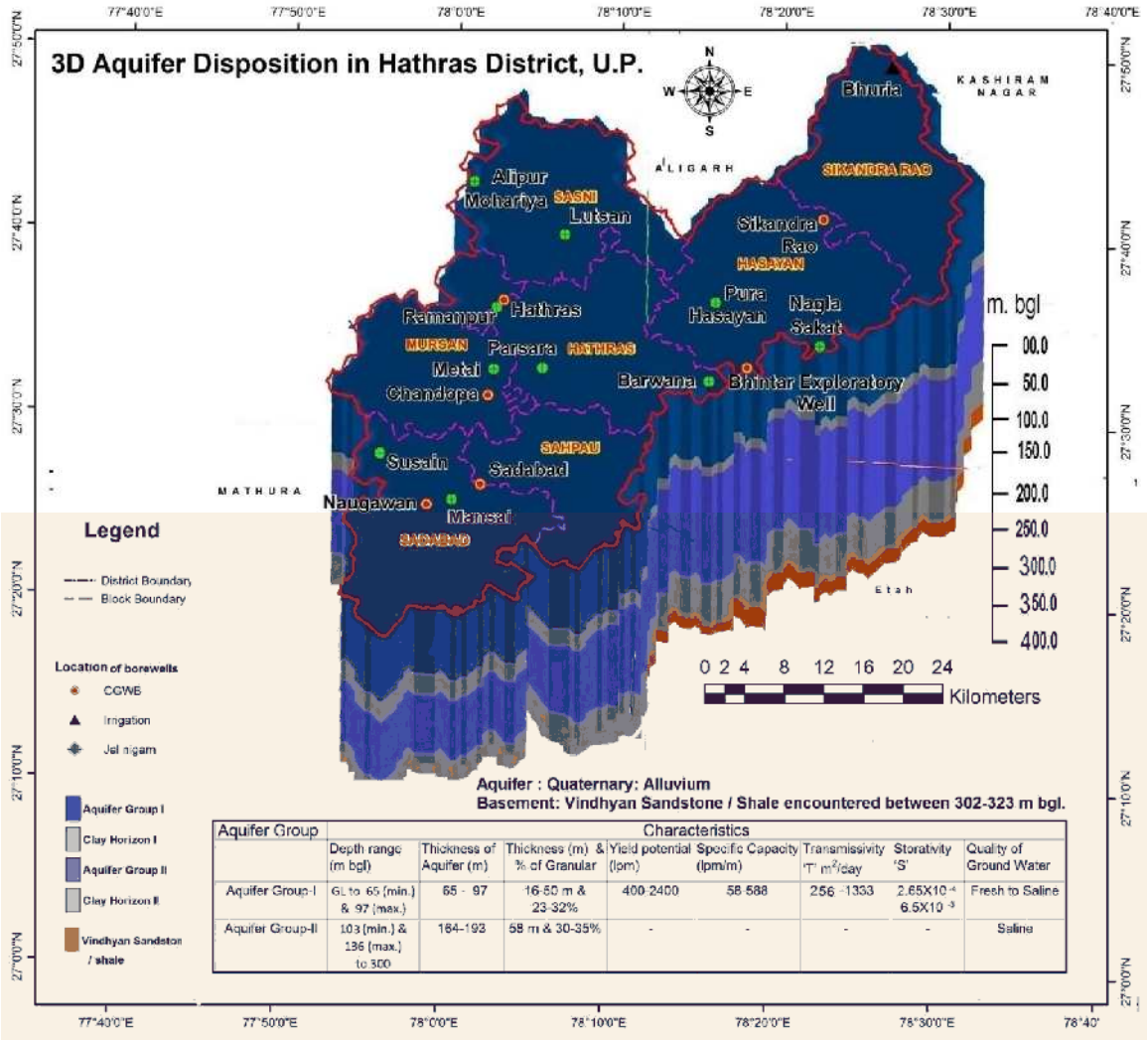


Fig. 2.38 Variation of aquifer materials (Sand %) in Aquifer Group-II, Hathras Distict



Aquifer Group	Characteristics							
	Depth range (m bgl)	Thickness of Aquifer (m)	Thickness (m) & % of Granular	Yield potential (lpm)	Specific Capacity (lpm/m)	Transmissivity 'T' m^2/day	Storativity 'S'	Quality of Ground Water
Aquifer Group-I	GL to 65 (min.) & 97 (max.)	65 - 97	16-50 m & 23-32%	400-2400	58-588	256 -1333	$2.65X10^{-4}$ $6.5X10^{-3}$	Fresh to Saline
Aquifer Group-II	103 (min.) & 136 (max.) to 300	164-193	58 m & 30-35%	-	-	-	-	Saline

Fig. 2.39 3D Aquifer Disposition in Hathras District, U.P.

2.3.3 Well Design:

Since the quality of formation water in the district is generally deteriorating below the depth of 70 m. bgl which becomes saline further below the depth of 100 mbgl. The total depth tube wells, for irrigation of water supply, are generally down 40-140 mbgl. The prevailing hydrogeological conditions in the area favour the construction of tubewells with 50 meters housing length, 1.58 mm size slot opening and 3.14 mm to 4.34 mm size of gravels. Depending upon the water requirement, 356×203 mm and 305×152 mm integrated well assemblies are generally found suitable for irrigation as well domestic water supply tube wells respectively. A number of cavity borings/strainer (30-40 m deep) has also been constructed by the farmers.

2.0 GROUND WATER RESOURCES ESTIMATION (As on March 2013)

Ground Water Resource estimation of Hathras District has been carried out by Ground Water Department U.P. in coordination with CGWB according to the methodology recommended by the Ground Water Estimation Committee constituted by Government of India (GEC 1997).

3.1 DYNAMIC GROUND WATER RESOURCES

Dynamic Ground Water Resource Estimation as on 31.3.2013 has been carried out with administrative blocks as ground water assessment units. Due to lack of data on command, non-command and poor ground water quality areas, the resources could not be estimated separately and the administrative unit (block) as a whole without sub-dividing it into sub-units has been considered. The precise estimation of ground water reserves and irrigation potential is prerequisite for proper planning and execution for socio-economic development in the area. The ground water recharge has been estimated on the basis of water level fluctuation & Rainfall Infiltration Factor methods adopting Percent Deviation. Since the area is alluvium, the specific yield has been considered 16 % and of rainfall infiltration is 25 % for all blocks.

Recharge from Rainfall

Precipitation is the principal source of recharge to ground water in the district. The quantity of recharge depends upon the intensity and duration of rainfall, nature and texture of soil, vegetation cover and land use pattern of the area. Recharge from rainfall has been computed separately for monsoon and non-monsoon periods. Recharge from rainfall is mainly a function of geographical area of the district, normal monsoon rainfall and lithology of the area. The recharge from rainfall during monsoon season has been computed using mainly Water Level Fluctuation Method & Rainfall Infiltration Factor Method, whereas recharge from rainfall during non-monsoon period has been computed using Rainfall Infiltration Factor Method. Block-wise recharge from rainfall is given in Table-3.1.Total recharge from rainfall in the Hathras district is of the order of 28648.90 ham, with Sikandra Rao Block having the highest recharge of 5099.78 ham and Sahpau Block has minimum recharge of the order of 2495.95 ham .

Recharge from Other Sources:

Total Recharge to ground water has several components, rainfall being the major one. The other component include seepage from canals, return flow from surface water irrigation, return flow from ground water irrigation, seepage from

Tanks and Ponds etc. for command area. Block wise recharge from other sources is given Table-3.1. Component of recharge from other sources is highest in Sikandraroa block (5618.07ham) ham) followed by Hasayan block (5174.00 ham) and Sdabad block (3448.0 ham). Lowest value of recharge from other source is recorded in Sasni (1810.0 ham).

Recharge from All Sources:

Total replenishable ground water resources including rainfall recharge and recharge from other sources have been computed on block- wise which is presented Table-3.1 respectively. Total annual recharge from all sources in the district is of the order 64604.96 ham with Sikandra Rao block having the highest recharge of 13803.38 ham and Sahpau block has minimum recharge of the order of 5683.66ham. The annual replenishable ground water resources in metre per unit area is maximum at Sikandra Rao block (0.50 m/ area) followed Hasayan block (0.46 m/ area) with minimum of 0.27 metre per unit area in Sadabad block. The average annual replenishable ground water resource of the District is 0.36 m/ area.

Table- 3.1: Block- wise Dynamic Ground Water Resource of Hathras District as on March 2013

S. No.	Block	Recharge From Rainfall during Monsoon Season (ham)	Recharge From Rainfall during Non Monsoon Season (ham)	Recharge From Other Sources during Monsoon Season (ham)	Recharge From Other Sources during Non Monsoon Season (ham)	Total Annual ground water Recharge (ham)	Natural Discharge (ham)	Net Ground Water Availability (ham)	Annual replenishable Groun water resources (m/unit area)
1	Hasayan	4748.51	747.09	2722.29	5174.24	13392.13	1339.21	12052.92	0.46
2	Hathras	3750.99	546.59	1610.43	2801.04	8709.05	435.45	8273.60	0.34
3	Mursan	3330.21	485.81	1302.72	2286.79	7405.53	740.55	6664.98	0.32
4	Sadabad	2365.95	576.11	1760.73	3448.97	8151.76	815.18	7336.59	0.27
5	Sahpau	2152.98	342.96	1114.06	2073.66	5683.66	568.37	5115.30	0.32
6	Sasni	3928.78	573.13	1147.31	1810.23	7459.45	745.95	6713.51	0.28
7	Sikandra rao	4406.50	693.28	3085.53	5618.07	13803.38	1380.34	12423.04	0.50
	Total	**24683.92**	**3964.99**	**12743.07**	**23212.99**	**64604.96**	**6025.04**	**58579.92**	**0.36**

Unaccounted Natural Discharge and Net Ground Water Availability

The total annual ground water recharge of the area is the sum of monsoon and non-monsoon recharge. An allowance of 5-10 % of total annual ground water recharge has been kept for natural discharge in the non-monsoon season because WLF/RIF method respectively is employed to compute rainfall recharge during monsoon season. The balance of ground water available accounts for existing net ground water availability for various uses and potential for future development.

Block wise unaccounted natural discharge and net ground water availability is given in Table -3.1. Total unaccounted natural discharge in the district is of the order of 6025.04 ham, with Sikandra Rao block having the highest discharge of 1380.34 ham and Hathras block with lowest of 435.45 ham. The net annual ground water availability in the District is 55882 ham with Sikandraroa block having the highest annual net ground water availability of 12423.04 ham and Sahpau block with lowest of 5115.30ham.

Ground Water Draft:

The ground water draft is the quantity of water withdrawn from ground water reservoirs. The principal ground water development structures for utilization of ground water in the district are open wells, dug cum borewells, private tubewells / government tubewells/government tubewells constructed under minor irrigation works and by other state government departments. On the basis of statistical data available on the number of various ground water structures, the block wise annual gross draft has been computed by multiplying its average discharge and annual working hours. The existing annual gross ground water draft for all uses the district is 53080 ham. From the Table-3.2, it is seen that maximum ground water drawl for all uses is 10999 ham in Sikandra Rao block and minimum draft of ground water for all uses is 5290 ham in Sahpau block. Comparison of ground water draft for various uses reveals that draft for irrigation accounts for more than 95% of total ground water draft, where as draft for domestic & industrial supply accounts for merely 5 % of the total ground water draft in the district.

Stage of Ground Water Development and Categorization of Blocks

The level of ground water development in Aligarh district has been worked out for each block as the ratio of gross annual draft to net ground water availability.

$$\text{Level of Ground Water Development} = \frac{\text{Gross Annual Draft for all uses} \times 100}{\text{Net Annual Ground Water}}$$

The distributions of various categorized blocks are shown in the Figure-3.1. Three blocks namely Mursan Sasni and Sahpau of the district are categorized as over-exploited, Hathras as Critical, Sadabad as Semi critical. Remaining two namely Hasayan and Sikanrarao blocks in the district fall under 'safe' category. Overall level of ground water development in Hathras district is 95.0 %. The summarized block wise estimate of ground water resources position in the district are given in Table-3.2.

Table-3.2: Block wise Ground Water Draft and Stage of GW development as on March 2013

S. No.	Block	Net Annual Ground water Availability (ham)	Existing Gross Ground water Draft for Irrigation (ham)	Existing Gross Ground water Draft for Domestic & Industrial water Supply (ham)	Existing Gross Ground water Draf for All uses (ham)	Provision for domestic, and industrial requirement supply To next 25 year (ham)	Net Ground water Availability for future irrigation Developm -ent (ham)	Stage of Ground water Develop-ment (%)	Category
1	Hasayan	12053	6702	383	7085	576	4775	59	Safe
2	Hathras	8274	7764	415	8179	864	0	99	Critical
3	Mursan	6665	8990	409	9398	728	0	141	Over-exploited
4	Sadabad	7337	5442	484	5926	747	1147	81	Semi-critical
5	Sahpau	5115	5009	282	5290	873	0	103	Over-exploited
6	Sasni	6714	8532	473	9005	702	0	134	Over-exploited
7	Sikandra rao	12423	10642	357	10999	980	801	89	*Safe
	TOTAL	**58580**	**53080**	**2802**	**55882**	**5471**	**6723**	**95**	
	*Safe blocks are categorized as safe since no significant water level trend is observed.								

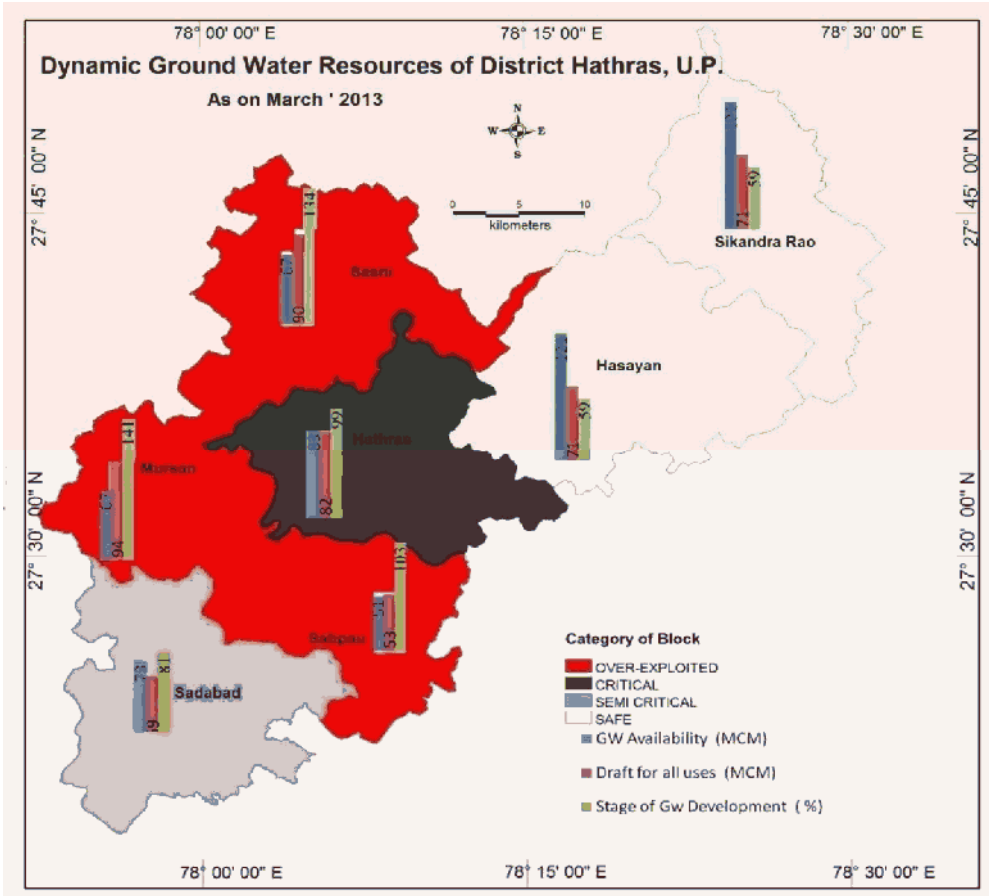


Fig. 3.1: Block-wise category of ground water development in Hathras District as on March, 2013

3.2 STATIC/IN STORAGE GROUND WATER RESOURCES

The In-storage availability of groundwater resources in the unconfined aquifers below the zone of fluctuation is computed based on groundwater storage concept using specific yield of the rock formations, which is as follows: -

In-storage Ground Water Resources= **Thickness of the granular zone** (in the aquifer below the zone of water level fluctuation of the aquifer Down to exploitable limit) **X Areal extent of the aquifer X Specific Yield**

In the process of computing the In-storage (static) ground water resources the volume of granular zones in the aquifer has been worked out on the basis of ground water exploration carried out by CGWB. Estimations have been done blockwise on pro-rata basis because of occurrence of multilayered unconfined aquifer. Specific yield values which have been considered for estimating Dynamic Ground Water Resource of unconfined aquifers have been taken the same as that of values used . Apportioning the specific yield of 9.6% (60% of 16) and considering 70% of total thickness of Granular Zones in Un-Confined Aquifer as average due to increase in silt and clay content as depth increases. The ground water resources for fresh and brackish/saline water have been computed separately as far as possible in some blocks by apportioning ~40% of resources as given in Table 3.3. The Electrical conductivity values considered for classifying saline/ brackish aquifers have been adopted and the same EC values as considered while computing Dynamic Ground Water Resource as on 31.3.2013, while computing ground water resource for unconfined and confined aquifers.

3.3 IN-STORAGE GROUND WATER RESOURCES OF UNCONFINED AND CONFINED AQUIFERS

The computations have been carried out block-wise. The aquifers have been broadly classified in two groups viz. Aquifer Group-I unconfined and Aquifer-II confined down to a depth of 300 m. The maximum depth of 300 m of exploration has been considered for extrapolation of confined aquifers and has been used for computation of ground water resource of confined aquifers. The average depth of predominant pre-monsoon water level (for last 5 years) of unconfined aquifers of each block has been considered as top of Unconfined Aquifer. The depth of bottom of Un-confined aquifers varies to some extent in the same block. In order to overcome such problem, an average depth of bottom of Un-confined aquifers of the each block has been considered for In-Storage ground water resource estimation of

Un-confined Aquifers. Block wise thickness of unconfined aquifers considered for computations was thus arrived at by subtracting average bottom depth of unconfined aquifer from predominant pre-monsoon water levels. Block wise thickness of granular zones in unconfined aquifers was estimated based on the interpretations of lithological logs, electrical logs of the exploratory wells drilled by CGWB for the purpose. The inter-layering of clay in Unconfined and Confined aquifers have been subsumed and assumed as single unit for computation purpose. In this exercise Ground water resources have been attempted utilising only storage concept have been taken into consideration since adequate information regarding ground water flow across various boundaries was not available. But it is suggested that ground water resource for development purposes should be determined by simulating various scenarios through ground water modeling techniques. Based on the Block wise area considered, Specific yield and thickness of granular zones the in-storage ground water resource of unconfined aquifers have been computed and presented in table 3.3 and confined aquifer in Table 3.4 and 3.5.

Table 3.3: Block wise in-storage Ground water Potential of unconfined aquifers in Hathras District

Sr. No.	Block	Area In Sq.Km.	Average Pre Monsoon water level Mbgl	Average Bottom Depth of Un-Confined Aquifer In mbgl	Average Thickness Of Un-Confined Aquifer Below water level in M	Average Thickness Of Granular Zones In Un-Confined Aquifer In below water pre monsoon water level M	Specific Yield % As Taken For Estimating Dynamic Resource	Resource In MCM (Area x Granular Zone Thickness Sp. Yield x 0.60)	Fresh & Potable Ground Water In MCM	Saline/ Brackish Ground Water (EC > 3000 µ S) IN MCM
1	Hasayan	327.40	4.53	76	71	17	16	538	538	
2	Hathras	272.77	13.49	82	69	28	16	724	724	
3	Mursan	234.79	17.08	70	53	25	16	567	340	227
4	Sadabad	290.56	23.70	77	53	14	16	396	159	238
5	Sahpau	176.31	13.10	77	64	22	16	366	293	73
6	Sasni	273.66	18.44	94	76	33	16	875	875	
7	Sikandra rao	265.18	7.01	76	69	32	16	820	820	
	Total	**1840.67**	**13**	**78**	**65**	**24**	**16**	4323	**3785**	**538**

Table 3.4 Block wise in-storage Ground water Potential of confined aquifers in Hathras District

Block	Area (A) (sq. km.)	Avg. Piezometric head (P) Considered (mbgl)	Avg Top Conf Aq (TII) (mbgl)	Storativity (S) Considered	Thickness of granular zones (Gr) down to 300	Specific Yield (Sy) Considered 60% of 16	Storage under Pressure in MCM Ax(TII – P) x S	Storage in Aquifer MCM (AxGrxSy)	Total Storage in Deeper Aquifer	FRESH	SALINE
Hasayan	327.40	20	114	0.000265	58	0.096	7.55	1823	1831	0	1831
Hathras	272.77	20	107	0.000265	58	0.096	6.22	1519	1525	0	1525
Mursan	234.79	20	125	0.000265	58	0.096	6.91	1307	1314	0	1314
Sadabad	290.56	20	127	0.000265	58	0.096	8.16	1618	1626	0	1626
Sahpau	176.31	20	115	0.000265	58	0.096	4.95	982	987	0	987
Sasni	273.66	20	117	0.000265	58	0.096	6.96	1524	1531	0	1531
Sikandra Rao	265.18	20	105	0.000265	58	0.096	5.97	1477	1482	0	1482
Total	1840.67						47	10249	10296	0	10296

Table 3.5 Total Ground Water Resources Up to 300 m bgl in Hathras district.

S. No.	Block	Aquifer Group-I (Unconfined)						Aquifer Group -II (confined)		Aquifer Group -I+II	
		Dynamic GW Resources (MCM)		Static GW Resources (MCM)		Total GW Resources (MCM)		Static GW Resources (MCM)		Total GW Resources (MCM)	
		Fresh	saline	Fresh	saline	Fresh	saline	Fresh	saline	Fresh	saline
1	Hasayan	121	0	538	0	659	0	0	1831	659	1831
2	Hathras	83	0	724	0	807	0	0	1525	807	1525
3	Mursan	67	0	340	227	407	227	0	1314	407	1541
4	Sadabad	73	0	159	238	232	238	0	1626	232	1864
5	Sahpau	51	0	293	73	344	73	0	987	344	1060
6	Sasni	67	0	875	0	942	0	0	1531	942	1531
7	Sikandra Rao	124	0	820	0	944	0	0	1482	944	1482
	Total	**586**	**0**	**3748**	**538**	**4334**	**538**	**0**	**10296**	**4334**	**10833**

4.0 GROUND WATER RELATED ISSUES

The major source of irrigation in the district is ground water irrigating 149283 ha contributing about 93% to the total irrigation potentials of the district. The contribution of ground water irrigation is minimum in Sikandra Rao Block with 75.2% whereas maximum in Sdabad block with 100 %. Because of its being less susceptible to the influences of the changes in the weather phenomenon, which often cause drought and scarcity conditions, the reliance of the users on these resources is progressively increasing and new challenges are threatening the sustainability of the ground water resources. Negative impacts on replenishable ground water resources can be minimized by its proper and planned development and management. The major emerging issues in ground water resources in the district are discussed below.

4.1 GROUND WATER RESOURCES

Ground water potential at any area mainly depends on the topography, rainfall and geology. The occurrence and movement of ground water depends in the hydrogeological characteristics of the sub surface geological formations. The salient feature of ground water resources of Aligarh District, as on March 2013, is given in Table 4.1.

Table 4.1: Ground Water Resources of Hathras District (As on March 2013)

1	**Parameters**	**Ground Water in MCM**
2	Total annual replenishable ground water resources	**646.04**
3	Natural Losses	**60.25**
4	**Net Annual Dynamic Ground Water Availability**	**585.80**
5	Existing Gross Ground Water Draft for Irrigation	**530.80**
6	Existing Gross Ground Water Draft for Domestic & Industrial water Supply	**28.02**
7	Existing Gross Ground Water Draft for all uses	**558.82**
8	Provision for domestic, and industrial requirement supply to next 25 year	**54.71**
9	Net Ground water availability for future irrigation development	**67.23**
10	Stage of Ground water Development	**95**
11	Number of Safe Blocks	2
12	Number of Semi-Critical Blocks	1
13	Number of Critical Blocks	1
14	Number of Over Exploited Blocks	3
15	**Fresh Static/in-storage Ground water Availability (only in alluvial area)**	**3748.3**
16	**Total Ground Water Availability (4+15)**	**4334.1**

As on March 2013, the Dynamic annual replenishable ground water resource is 646.04 MCM; net ground water availability (fresh) is 585.8 MCM in Aquifer group-I. Total annual recharge from all sources in the district is of the order 646.04.96 MCM with Sikandra Rao block having the highest recharge of 138.03 MCM and Sahpau block has minimum recharge of the order of 56.83.66 MCM The annual replenishable ground water resources in metre per unit area is maximum at Sikandra Rao block (0.50 m/ area) followed Hasayan block (0.46 m/ area) with minimum of 0.27 metre per unit area in Sadabad block. The average annual replenishable ground water resource of the District is 0.36 m/ area.

In Aquifer Group I, Dynamic net ground water availability (fresh) is 585.8 MCM and static/in-storage (fresh) ground water resources are assessed to the tune of 3748.3 MCM. Thus the total ground water resources (fresh) available are estimated to be 4334.1 MCM in Aquifer Group I. The static/in-storage (saline) ground water resources in Aquifer Group I is 538 MCM and in Aquifer Group II 10296 MCM. The total static/in-storage (saline) is 10833 MCM in Aquifer Group I&II.

4.2 AREA OF INTENSIVE GROUND WATER DEVELOPMENT:

The stage of ground water development of the district is 95 %. Out of 7 blocks Three blocks namely Mursan Sasni and Sahpau of the district are categorized as over-exploited, Hathras as Critical, Sadaba as Semi critical whereas 2 blocks are in safe category. The block wise areas under agriculture activities vary from 79-85% with average of 83 % of area of the district. The over exploited blocks where ground water draft has increased many folds during past decades, is a biggest challenge because these are the blocks where in storage ground water resources is depleting very fast. There is a probability for adjacent block which may also be comes in water stressed category in future if proper effective intervention is not taken by stack holder. The change in climatic pattern is also exerting withdrawal pressure on groundwater resource creating imbalance in groundwater resources.

4.3 WATER LEVEL DEPLETED AREAS:

Long term water level trend are also analyzed in Ground Water Resource estimation in 2013 considering data of monitoring wells of Ground Water Department for the period of 2004-2013 (Table 2.3). During pre monsoon, rise of 0.44 cm/year (Sadabad Block) and fall of 4.43 cm/year to 68.4 cm/year (Sikandra Rao and Mursan Blocks) are recoded. During post monsoon rise of 24.86 cm/year (Hasayan Block) and fall of 16.18 to 56.78 cm/year (Sasni and Mursan Blocks).

4.4 DEPENDENCY OF GROUND WATER IRRIGATION:

The contribution of ground water for irrigation is 93% where as surface water is only 7%. The block wise contribution of ground water irrigation is minimum in Sikandra Rao Block with 75.2% whereas maximum in Sadabad block with 100

%Moreover, it envisaged from Fig. 4.1 the gap between the irrigation by ground water and surface water is being widened over period from 1994-95 to 2013-14 leaving adverse impact on ground water resources. There is urgent need to increase the surface water irrigating to reduce the stressed on the ground water along with intervention practices.

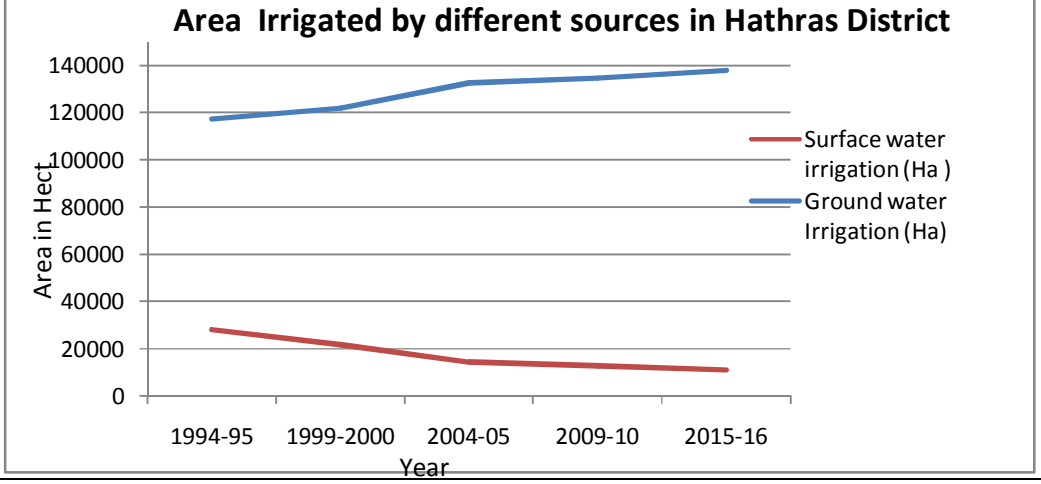


Fig. 4.1 Area irrigated by Different sources in Hathras District

4.5 GROUND WATER QUALITY ISSUES:

The Quality of Ground water in shallow Aquifer of Aquifer Group I, is good. However in Sadabad block, salinity starts from water table itself with lateral extent of poor quality groundwater zones. The deeper part of Aquifer Group I, below ~ 70 are infested with inland salinity problem of this aquifer group in Sadabad. It is manifested in construction of tube well which are constructed within 100 m depth.

Fluoride concentration in the district ranges from 0.09 to 1.5 mg/l which is well within desirable limit. However, the fluoride concentration is slightly higher at Hathras (1.61 mg/l) Sikandarpur (1.8 mg/l), of Hathras Block, Mursan of (1.6 mg/l) & Bisana, (3.0 mg/l,) of Mursan block , Khonda & Naglaberu (3.55 mg/l) of Sahpau block and Biswar (4.15 mg/l) at Sadabad Block.

The nitrate concentration in the district ranges between nd and 700 mg/l except at three (10%) samples of Kachora of Sikanrdarao block (130 mg/l,) Naugaon of Sadabad Block (320 mg/l) Hathras in of Hathras Block (700mg/l) Mursan of Mursan Block (64 mg/l) Hasayan of Hasayan Block (63 mg/l) have been noticed in higher which may be due to mixing of sewerage into ground water. In city area due to above reason the higher nitrate concentration is more common. Overall the nitrate concentration is within permissible limit in the area.

In 39 % samples of the study area concentration of iron exceeded the maximum permissible limit.

4.6 EFFICIENT IRRIGATION PRACTICES:

The flooding irrigation practices are in vogue. As per the prevailing flooding irrigation practices the actual water applied is more than the optimum crop water requirement. As per the prevailing flood irrigation practices the actual water applied is 100 to 200% more than the optimum crop water requirement. Proper and efficient irrigation practices and water saving techniques are not being adopted by the majority of farmers in the district for a variety of reasons. By adoption of micro irrigation practices such as sprinkler and drip irrigation method water can be saved between 30 to 40%. When properly maintained, application of water by drip irrigation can be as much as 60 percent efficient, which means there is very little loss due to evaporation, surface runoff or from percolation. Drip irrigation, wherever it has been implemented has dramatically increased crop yield by 20 to 40% higher than flood irrigation method. Consumption of fertilizers also gets reduced in such irrigation practices.

4.7 ISSUES IN PARTICIPATORY MANAGEMENT

The numbers of land holding farmers and area hold by individual farmers are given Table 4.2. The majority of farmers were small or marginal. Average size of land holding in the district was 1.03 hectare in 2015-16 as against the State of 0.83 ha. Total number of holdings in the district is 1,53,797 which cover an area of 1,48,199 hectares. The distribution is given in Fig. 4.2 and Table 4.2 which shows that marginal and small farmers account for more than two third (87%) and hold one & half (54%) of total area. The small size of holding is one of the major constraints in increasing irrigation potential viz a viz agricultural productivity. As the land hold by small and marginal farmers is less therefore the financial status of these farmers is not good. The electricity supply has still not reached in all of the villages and where it is reached the supply of electricity is erratic. The problem of low voltage and its non availability during agriculture activities are the major problem faced by cultivators

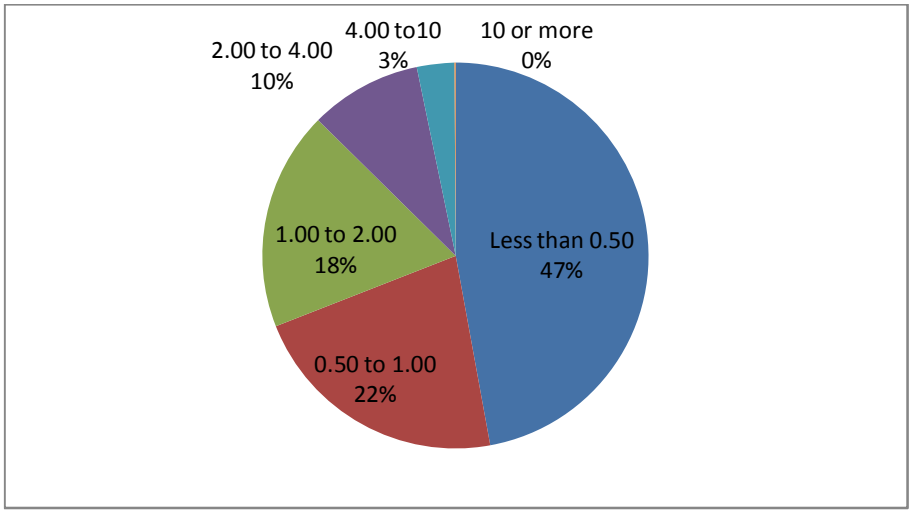


Fig. 4.2 Distribution of Land Holding in Hathras District - 2015-16

Table 4.2: Land Holding and Area in Hathras District. Source: Statistical Diary, Directorate of Economics and Statistics, Govt. U.P. -2016

Block	Unit in hectare													
	Less than 0.50		0.50 to 1.00		1.00 to 2.00		2.00 to 4.00		4.00 to10		10 or more		Total Number	
	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Sasni	8283	1816	2966	2275	3449	4881	2354	6613	1081	6067	50	602	18183	22254
Hathras	11575	2237	5972	3868	4076	5698	2017	5452	593	3375	15	254	24248	20884
Mursan	11315	2318	5978	3658	4895	5696	1926	5395	678	3385	16	244	24808	20696
Sadabad	11495	2245	3989	2932	4597	5689	1916	5375	625	3365	12	252	22634	19858
Sahapao	11597	2148	3950	3015	2738	5690	1810	5190	547	3376	19	231	20661	19650
Sikandra Rao	8465	2471	5047	3425	3968	5642	2012	5261	572	3166	20	240	20084	20205
Hasayan	9701	3659	5815	3968	4520	6092	2390	6550	721	4006	32	377	23179	24652
Total	**72431**	**16894**	**33717**	**23141**	**28243**	**39388**	**14425**	**39836**	**4817**	**26740**	**164**	**2200**	**153797**	**148199**

5.0 GROUND WATER DEVELOPMENT AND MANAGEMENT STRATEGIES

5.1 GROUND WATER DEVELOPMENT

The development of groundwater resources is increasing over the years in order to meet drinking water, industrial and irrigation requirements. The stage of ground water development had been changed to 99.89 % in 2004, 89.24 % in 2009, 84.52% in 2011 and 95.39 in 2013. As on 31.03.2013, it shows that block wise level of development of ground water potential in Hathras district varies from 59 % in Hasayan to 141% in Mursan block. This increase in ground water utilization, for agriculture activity through adaptation of bore wells/tube wells, has increased the ground water draft. The area irrigated by Ground water is seen in Fig. 5.1 since 1994-95. It is observed that it was 2,41,253 ha in 1994-95 and steadily increase to 2,78,196 ha in 2013-14. Fig. 5.2 shows block wise irrigation from 1994-95 to 2013-14. It is observed that it is has been steadily increased over the period. The number of ground water structures are 25,681 in 1994-45, 28,421 in 1999-2000, 32,973 in 2004-5, 35,735 in 2009-10 and 37,925 in 2013-14. It is seen from Fig. 5.3, in recent years the number of ground water structures is increased at slower rate. Keeping in view the level of ground water development, growing needs, there is an urgent need for scientific approach for proper management of the available ground water resources for sustainability of this precious natural resource without having any adverse effect on the environment. At those places where water level is gradually going down we should restrict or minimized the ground water for irrigation needs. Planned ground water development is possible only when the availability of the ground water potential is precisely quantified and also the demand for various uses is properly estimated for the projected development scenario of urban as well as rural area for next 25 years.

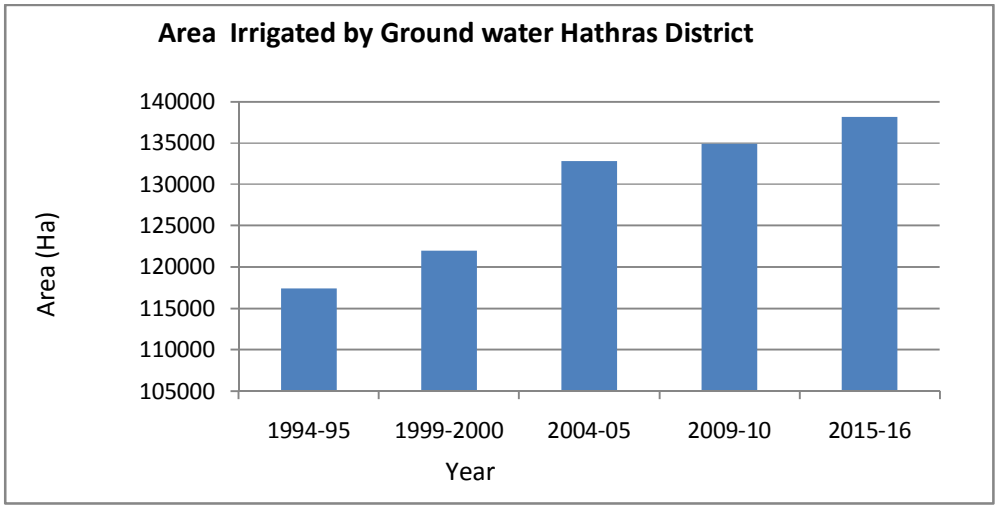


Fig. 5.1 Area irrigated by ground water in Hathras District

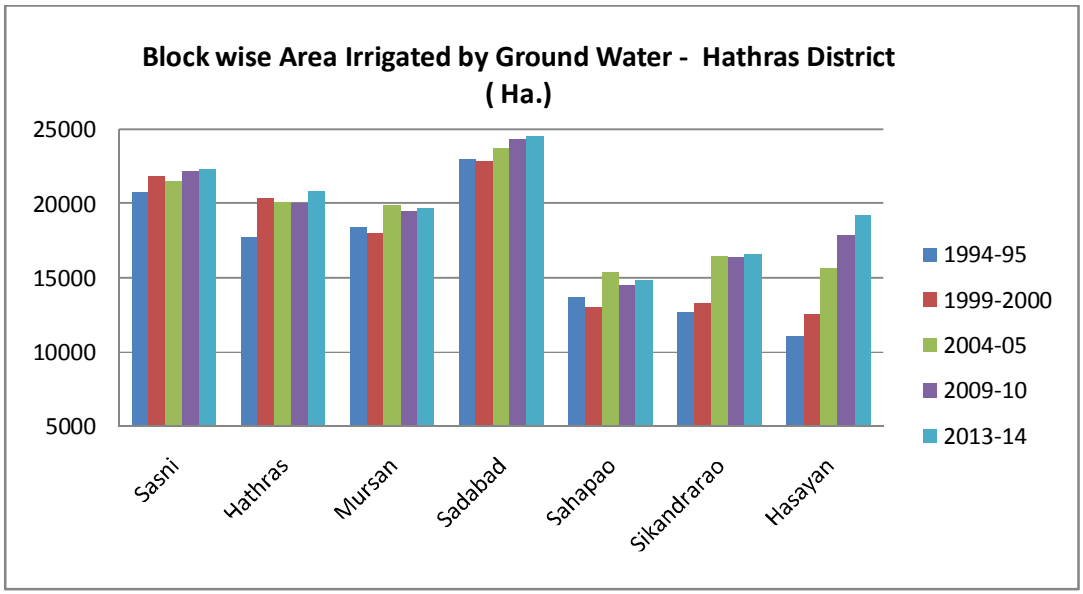


Fig. 5.2 Block wise Area irrigated by Ground water in Hathras District

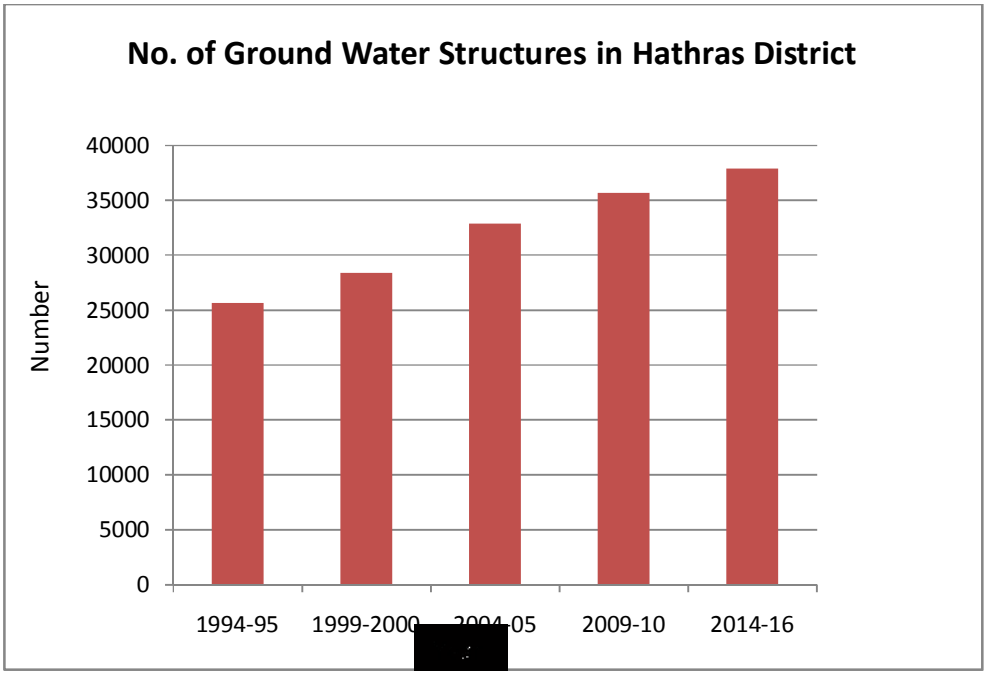


Fig. 5.3 Number of ground water structures in Hathras District

5.2 GROUND WATER MANAGEMENT STRATEGIES

Block wise management plan is prepared considering the present water level, water level trend category of the block and further prioritized the blocks for interventions (Table 5.1). Three blocks namely Mursan Sasni and Sahpau of the district are categorized as over-exploited, Hathras as Critical, Sadaba as Semi critical

and declining trend of water level is recoded over the last ten years. Thus there is urgent need for taking up suitable water management interventions based on integrated approach, which on one hand includes augmentation of ground water resources through appropriate techniques, and on the other hand requires the adoption of suitable water conservation measures, such as ensuring water use efficiency through creation of additional water storage facility, maintenance/ renovation of existing water bodies etc. Water awareness and capacity building of the stakeholders are also the important attributes of water management interventions as envisaged in the National Water Policy.

Table 5.1Prioritization of Block for Management Plan, Hathras District

Block	Category	Water level trend (cm/year) 2004-2013		Average post monsoon m bgl	Unsaturated thickness below 5 m	Volume of sub surface potential MCM	Net area sown (ha)	Net irrigated area (ha)	Management plan
		Pre	Post						
Mursan	Over Exploited	Declining 68.40	Declining 56.78	19.4	14.4	540.96	19701	19765	Intervention required – artificial Recharge and water conservation
Sasni	Over Exploited	Declining 21.63	Declining 16.18	19.71	14.71	644.09	22299	22432	Do
Sahpau	Over Exploited	Declining 33.01	Declining 19.47	15.85	10.85	306.07	15055	15115	Do
Hathras	Critical	Declining 20.08	Declining 33.96	15	10	436.43	21005	21083	Do
Sadabad	Semi critical	Rising 44.97	Declining 45.42	24.13	19.13	890.57	24494	24553	Do
Sikandra rRao	Safe	Declining 4.43	Declining 17.39	7.55	2.55	108.19	21995	22043	Since net sown and net irrigated area is nearly equal. Hence intervention & ground water development not required
Hasayan	Safe	Declining 4.78	Rising 24.86	3.97	-1.03	-53.96	24754	24292	Do

5.3 GROUND WATER MANAGEMENT OPTIONS

Ground water issues can be addressed mainly by focussing on measures to increase recharge and reducing the draft. It can be managed by a mix of measures such as supply side and demand side management: Five blocks are prioritized for interventions. Remaining two blocks are safe with rising or static trend of water level no interventions are required. As the net sown area and net irrigated area are same in theses ten block, no further ground water development is also required.

5.3.1 SUPPLY SIDE MANAGEMENT:

It includes Artificial Recharge to ground water, Water conservation and On Farm Activities to Increasing storage capacity and conservation of rainfall**.** Based on available information about the area such as ground water scenario, hydrogeology, hydrology, topography, rainfall pattern, drainage, soil cover, utilizable rainfall, etc., scope for various interventions has been studied and assessment of suitable areas, tentative design and costs of structures has been worked out. By and large the methodology such as estimation of sub surface storage potential and availability of surface water for harvesting used for ground water conservation in Master Plan 2011 is kept same in this plan. However, the specific yield taken in GWRE-13 in individual block is considered for surface storage potential. Since all blocks comes under as flat, partly cultivated-various soils hence runoff coefficient is taken as 15%. The non committed run off is considered 90% of total run off (Table . 5.2)

Table 5.2 Details of Recharge plan, Area suitable, Normal rainfall, Run off , sub surface storage space

S. No.	Block	Stage of GW Dev (%)	Total Geo-graphical Area (Sq.km)	Area suitable/ feasible for AR (Sq Km)	Normal Rainfall (mm)	Run off factor (%)	Committed Run off (%)	Non-committed Run-off (%)	Surplus surface runoff (MCM)	Storage Space (MCM)	Unit Draft ham/ha
1	Mursan	141	232	232	667	15	10	90	20.86	540.96	0.48
2	Sasni	134	273	273	667	15	10	90	24.62	644.09	0.35
3	Sahpau	103	176	176	667	15	10	90	15.83	306.07	0.40
4	Hathras	99	258	258	667	15	10	90	23.22	436.43	0.39
5	Sadabad	81	287	287	667	15	10	90	25.81	890.57	0.24

Artificial Recharge to ground water Recharge / Water Conservation

- Water conservation structures such as check dams, farm ponds, nala bunds etc result in ground water recharge to the tune of about 50% of the storage capacity considering 4 annual fillings. Further construction of recharge trenches in the upstream side of the check dams is also proposed to enhance rate of infiltration by about 30 to 40%.
- The existing ponds and tanks lose their storage capacity as well as the natural ground water recharge due to siltation and encroachment by farmers for agriculture purposes. Through desilting, coupled with providing proper waste weir, the village tanks can be converted into recharge structure. The numbers of ponds are available for each block surveyed by Fisheries Department Table 5.3. Only 70% of total ponds are taken for management plan in blocks selected for intervention.

On Farm Practices

- Leveling of crop field is essential for uniform distribution of water. Laser leveling has been found very effective ensuring saving of 10 to 30% of applied irrigation.
- The in situ farm activities such as contour bunding, land leveling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

Artificial Recharge to ground water Recharge / Water Conservation

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Table 5.3 Details of Ponds in Hathras District

S.no.	BLOCK	NO. OF TANKS	AREA RANGE (Ha)		
			LOWER	UPPER	AVERAGE
1	Hasayan	141	0.15	34.409	0.979082
2	Hathras	69	0.023	1.252	0.396209
3	Mursan	221	0.081	2.811	0.417534
4	Sadabad	277	0.004	2.213	0.299264
5	Sasni	290	0.006	2.212	0.228044
6	Sahpau	211	0.008	1.882	0.300778
7	Sikandra Rao	99	0.139	4.76	0.913368

On Farm Practices

- Leveling of crop field is essential for uniform distribution of water. Laser leveling has been found very effective ensuring saving of 10 to 30% of applied irrigation.
- The in situ farm activities such as contour bunding, land leveling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

5.3.2 DEMAND SIDE MANAGEMENT

It mainly includes adoption of techniques to enhance water Use Efficiency for reducing draft of ground water.

Efficient irrigation

In flood/furrow irrigation method more than 50% of applied water is wasted through seepage to deeper level, localized inundation causes loss through evaporation and it leaches out the nutrients from the plant. While through drip & sprinkler irrigation wastage of irrigational water could be minimized. The conveyance losses (mainly seepage & evaporation) can be saved upto 25 to 40% through utilization of HDPE pipes.

Aquifer Management Plan for Hathras district has been prepared as block wise and shown in Table 5.4 and Tentative locations are shown in Fig. in 5.4. Tentative financial out-lay plan is also shown in Table 5.5. Each Plan discusses the tentative framework of ground water situation in the block, status of water availability (both surface and ground water), identification of feasible areas for interventions, feasibility of artificial recharge and other water conservation structures, their design considerations, numbers and cost estimates. The expected outcomes of the proposed interventions have also been elucidated and given in Table 5.6.

Table 5.4 Proposed Interventions in Hathras District							
Block	**No. Of Structures /Cost**	**Check Dams of 1 ham Capacity**	**Drain/stream development (Length in km 10 to15m x 1.5m)**	**Nala Bunds of 0.75 ham Capacity**	**Revival of Ponds with RW Average area 0.23-0.98 ha x3m); deepening by 0.5m**	**On-farm Activities (Area in ha)**	**Water Use Efficiency (WUE) Measures (Area in ha)**
Mursan	**No. Of Structures**	**5**	**10**	**30**	**154**	**3700**	**3776**
	Cost Rs	**50**	**78.75**	**60**	**539**	**518**	**2265.6**
Sasni	**No. Of Structures**	6	10	15	203	4077	4498
	Cost Rs	60	**78.75**	30	710.5	570.78	2698.8
Sahpau	**No. Of Structures**	4	10	30	148	3300	2773
	Cost Rs	40	**78.75**	60	518	462	1663.8
Hathras	**No. Of Structures**	6	**10**	**30**	**48**	**4310**	**4405**
	Cost Rs	60	**78.75**	**60**	**168**	**603.4**	**2643**
Sadabad	**No. Of Structures**	0	0	5	193	4141	4075
	Cost Rs			10	675.5	579.74	2445
Total	**No. Of Structures**	21	40	110	746	19528	19527
	Cost Rs	210	315	220	2611	2733.92	11716.2

Block	**Total cost (Rs in Lak)**	**5% Provision for O & M (Rs in Lakh)**	**5% Provision for Impact assessment (Rs in Lakh)**	**Grand Total (Rs in Lakh)**
Mursan	3511.35	175.57	175.57	3862.49
Sasni	4148.83	207.44	207.44	4563.71
Sahpau	2822.55	141.13	141.13	3104.81
Hathras	3613.15	180.66	180.66	3974.47
Sadabad	3710.24	185.51	185.51	4081.26
District G Total	17806.12	890.31	890.31	19586.73

Table 5.5 Summarized Expected Benefits						
Summarised Expected Benefits	Mursan Block	Sasni Block	Sahpau Block	Hathras Block	Sadabad Block	District Total (MCM)
Total Expected Annual Recharge (MCM)	**7.49**	**6.83**	**6.11**	**5.94**	**6.99**	**33.35**
Total Saving from On-farm Activities & WUE Measures (MCM)	**12.65**	**12.43**	**7.18**	**11.99**	**6.87**	**51.12**
Total Saving from Recharge/ Conservation (MCM)	**20.14**	**19.26**	**13.29**	**17.93**	**13.86**	**84.47**
Provision for supplemental irrigation (MCM)	**3.79**	**2.75**	**2.81**	**1.63**	**2.84**	**13.82**
Saving of Ground water through projects (MCM)	**16.44**	**15.18**	**9.99**	**13.62**	**9.71**	**64.94**
Total Recharge/ Saving (MCM)	**23.93**	**22.01**	**16.10**	**19.56**	**16.70**	**98.29**

5.6 Projected Impact on Status Of Groundwater Resource & Development in Hathras District								
Block	**Net G.W. Availability (Ham)**	**Additional Recharge from RWH & Recharge (ham)**	**Total Net G.W. Availability afte intervention (ham)**	**Existing G.W Draft for all purpose (ham)**	**Saving of Ground Water through projects (ham)**	**Net GW draft after interventions (ham)**	**Present stage of G.W. development (%)**	**Projected stage of G.W. development (%)**
MURSAN	8273.60	593.80	8867.40	8179.16	1361.66	6817.50	98.86	76.88
SASNI	6664.98	749.20	7414.18	9398.37	1644.29	7754.08	141.01	104.58
SAHPAU	7336.59	698.50	8035.09	5926.01	970.58	4955.43	80.77	61.67
HATHRAS	5115.30	610.80	5726.10	5290.38	998.57	4291.81	103.42	74.95
SADABAD	6713.5	682.90	7396.40	9004.8	1517.8	7487.00	134.13	101.22
Total	34103.97	3335.20	37439.17	37798.72	6492.90	31305.82	110.83	**83.6178**
	Estimates based upon Resource Estimation as on 31.03.2013							

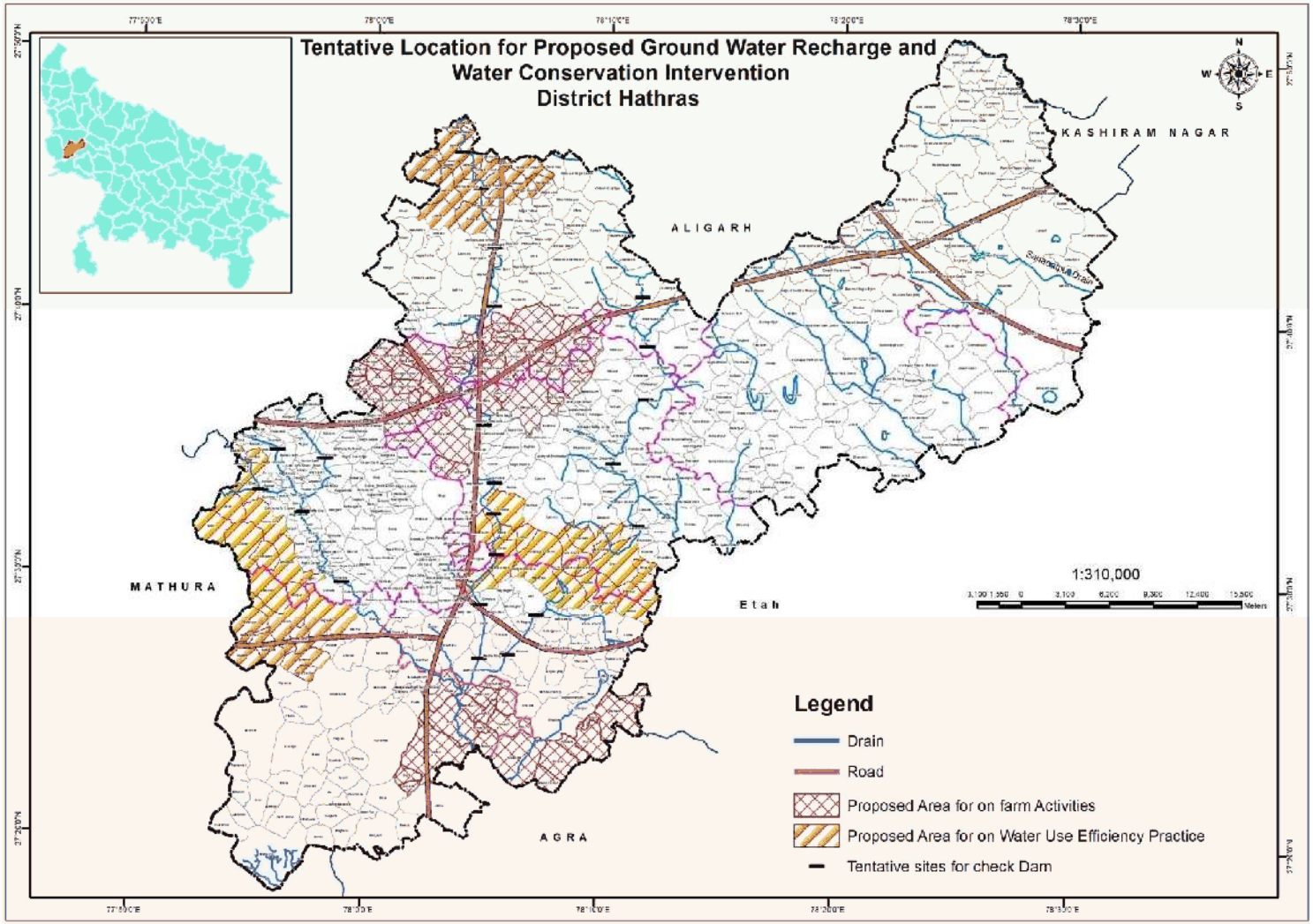

Fig. 5.4 Locations for proposed ground water recharge and water conservation intervention in Hathras District

6.0 CONCLUSION & RECOMMENDATION

6.1 CONCLUSION

Hathras situated in the western part of Uttar Pradesh occupies a small part of the Ganga-Yamuna doab. It lies between latitude $27^0$16'12" and $27^0$51'00" N and longitudes $77^0$52'30" and $78^0$31'54" E falling in the survey of India Toposheet nos. 54E and I. The district is of an elongated in shape and encompasses a geographical area of about 1840 sq.km. Hathras district is part the Aligarh division and for the administrative convenience the district has been divided into 04 (four) Tehsils and 07 (seven) Community Development Blocks. It has 12 towns and 672 villages (665 inhabited and 17 uninhabited villages).

As per census 2011, the total population of the district is 15,64,708 in which males are 8,26,160 & female is 7,38,547. The rural population of the district is 12,32,015 comprising 6,59,814 males and 5,72201 females. About 79 % of total population is rural. The urban population of the district is 3,32,693. The schedule castes and schedule tribes population of the district is 7,55,254 and 629 respectively. The work force is approximately 28% of the total population & population density is 850 person/sq. km. The decadal variation in the population is 15.5 % and in rural areas it is 17.1%. The normal annual rainfall of Hathas district is 781.6 mm. The minimum temperature recorded in Aligarh district i.e. 7.4^0C in the month of January and maximum temperature recorded i.e. 41^0C in the month of May.

A major part of the land in the district is utilized for agriculture purpose. 83% of land in the district is under active cultivation out of which in 54% of land, more than one crop is sown. The land under miscellaneous use is 1% and land other than agriculture use is 11% barren land is more than 1 %. The block wise land utilization pattern indicates that the total area sown is maximum in Hasayan block followed by, Sadabad, Sasni & Sikandra Roa while in remaining blocks it is more or less evenly distributed where as in the Sahapau block it is minimum.

The major source of irrigation in the district is ground water irrigating 1,38,129 ha contributing about 92.5% to the total irrigation potentials of the district. Total length of canal in the district is 589 kms. These canals provide irrigation facilities in 11154 hectare which is about 7.5 % of the total irrigation area of the district . Maximum canal irrigation is being carried out in the Sikanra Rao block (covering 24.8 % net irrigation of block) and zero in Sadabad block. State government tubewells cover only about less than 1 % of the total irrigation area of the district. The private play the leading role in providing irrigation over the entire district & about 90 % of the net irrigation area i.e. 1,88,618 hectare is fed by ground water resources through these structures. All blocks except Sikandra Rao and Hasayan blocks utilize maximum ground water as a source of irrigation. The irrigation intensity of the district is 144% with maximum of 175% in block Hasayan and minimum of 112% in Sadabad Block.

Pulses, Wheat, Rice, Barley, Millet and Maize are the principal crops of the area. In addition other crops such as Oil seed and Sugarcane are also grown in the district. The area under different cultivated season in the district is Rabi 1,43,102ha Kharif 84,636ha and Zaid 19,604 ha. The cropping pattern over years from 1994 to 2014 is also analyzed it is found that the cropping pattern has been changed and pulses are grown more in since 2010. The cropping intensity of the district is 166 % with maximum of 185% in Hasayan block and minimum of 134 % in Sadabad block.

Physiographically, the Hathras forms a part of Yamuna-Ganga doab in Central Indo- Gangetic plain and except the Sikandra Rao and eastern parts of the Hasayan block the entire district area falls under Yamuna Basin. The general slope of the area is extremely regular from north-west direction . The highest elevation of 185 m amsl noted in the district and the minimum of 163 m amsl with The average elevation of the slope 178 m above mean sea level. The average gradient of slope is 0.24 m/km. The district occupies the inter fluvial areas of Ganga and Yamuna rivers. The drainage is controlled by tributaries of these two mighty rivers which flows toward south and south eastern direction. The important tributaries of the Yamuna which cover larger part of the area are Karwan (Jhirna Sengar and Aligarh drain whereas Arind , Isan and Kali Nadi form the principal tributaries of the Ganaga River. All these tributaries are semi seasonal having very meager discharge during the lean period.

The major type of soils found in the district is loamy and course silty. Further it is divided as Dumat (clay), Balui Dumat (sandy clay), Bhur (sandy), Reh (Alkaline) and loam soil.

The geologically the area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar of older and newer alluvium. Older alluvium occupies the upland of the district while the newer alluvium occupies low land area along the courses of Ganga, Yamuna and their tributaries and palaeo channels of Ganga and Kali rivers. The quaternary sediments with alternation of various grades of sand, clay and silt overlay the pre existing Vindhyan basement. The lithological variation in the district is fine to medium sand, kankar variably associated with clay formation. The entire area has capping of sandy-silty-clayey soil, varying in thickness from 3-20 metres. lithological variation in the district is fine to medium sand, kankar variably occurs associated with clay formation. The thickness of clay increases in the from north to south and south western part of the district. The thickness of clays in deeper part increases 40 to 50 metres upto to depth of 300 mbgl in Sadabad, Mursan and Hathras blocks. Bedrock (Vindhyan sandstone/shales) has been encountered in a few exploratory boreholes drilled by CGWB in Hathras district & its environ at Nera (82.72 mbgl, SST), Chandappa (302 mbgl, shale), Aligarh Junction (368 mbgl, Shale). Bhintar (323 mbgl

SST) and Pasia Begumpur (336 mbgl, Shales). The Vindhyan basin tends to deepen from south-west to north-east.

Ground water occurs under water table condition at shallow depths while the deeper aquifer is under semi confined to confined state of disposition where confining layers are impermeable clay beds. The pre-monsoon depth to water level in the district generally ranges between 3.05 and 29.13 mbgl with average of 15.47 m bgl . Shallow water level conditions i.e. within 6.00 mbgl, generally occurs along the upper Ganga canal in the Sikandra Rao, and Hasayan blocks . In major parts of Hathras, Sasni, Sadabad, Shahpau, and Mursan blocks water level rests within the depth range of 15.0 to 25.0 mbgl. While in the 40% area of Hathras, Sahpau , Hasayan and Sikandra Rao blocks water level rest within the depth range of 5 to 15 mbgl. Deepest water level i.e. 29.00 mbgl have been observed at Mai in Sadabad block. Isolated patches of >25 mbgl are notices mainly in city area of Sadabad block. The water level in post-monsoon period generally ranges between 2.90 m. & 30.66 metres below ground level with average of 15.02 m bgl. Shallow water level within 3.00 mbgl and between 2 to 5 mbgl is noticed along the main canals and their distributaries. The shallowest water level of 2.90 metres was observed at Tekari Kalan in Sikandra Rao block. The seasonal water level fluctuation in the district varies from -2.4m (Hanuman Chowki, Sasni Block) to 2.3 m (Sikanarpur, Hathras Block) with average of 0.45m. However the major part of the area has fluctuation of 0 to 2 m.

Long term water level data from the existing 10 nos. of National Ground Water monitoring wells were statistically analyzed to study the behaviour of ground water regime in space and time. Out of 10 existing National GW monitoring wells where the long term water level trends have been studied 7 (70 %) show a declining trend and the rest 3 (30 %) register a rising trend during pre monsoon period and 8 (80 %) show a declining trend and the rest 2 (20 %) register a rising trend during post monsoon period. Statistically analysis of data reveals that during pre monsoon period the minimum decline (0.009 m/year) has been observed at Rati ka nagla (NGWMW) of Hasayan block over a period of 10 years, whereas the maximum decline (0.71 m/year) is recorded at Mursan of Mursan block. During pre monsoon period the minimum rise (0.007m/year) has been observed at Thualai (NGWMW) of Sasni block over a period of 10 years, whereas the maximum rise (0.081 m/year) is recorded at village Hasayan of Hasayan block. During post monsoon period, rise of 0.61 to 0.101- m/year is recorded at Hasayn of Hasayn Block and Thualai (NGWMW) of Sasni block respecivly over a period of 10 years. Minimum fall of 0.06 m/year is recorded at at Rati ka nagla (NGWMW) of Hasayan block and the maximum fall has been recorded at Mursan (0.79 m/year) of Mursan block during post monsoon period. Generally rising trends showing the wells located in the canal command area.

Long term water level trend are also analyzed in Ground Water Resource estimation in 2013 considering data of monitoring wells of Ground Water Department for the period of 2004-2013 (Table 2.3). During pre monsoon, rise of 0.44 cm/year (Sadabad Block) and fall of 4.43 cm/year to 68.4 cm/year (Sikandra Rao and Mursan Blocks) are recoded. During post monsoon rise of 24.86 cm/year (Hasayan Block) and fall of 16.18 to 56.78 cm/year (Sasni and Mursan Blocks).

The altitude of water table surface in the district ranges between 146 and 177 m amsl. The master slope of water table, in the district, is from northwest- southeast which corresponds with general topography of the area. However some local diversions have also been observed, especially in the area lying between Sengar and Karon rivers, due to local topographical conditions and impact of major branches of Ganga Canal over the shallow aquifers. The general gradient of the water table in the district varies from 0.34 to 0.80 m/km, the average being 0.57 m/km.

Out of 21 wells four wells drilled by CGWB are more than 350 m bgl depth in which Two wells taken from adjacent district (Aligarh & Etah). 13 numbers of tube wells are upto 127 m of depth, 5 numbers of tube wells are between 150-200 m of depth. Hence no much information is gathered below 200 m bgl. Central Ground Water Board (Northern Region), has drilled deep boreholes at Chandappa (367.50 m deep), Bhintar (331.6 m deep) and Sikandra Rao (196.60 m deep) in Hathras district and also in its environ at Aligarh Junction (383.26 m deep), Nera (86.20 m deep, Mathura district) and Pasia Begumpur (360 m deep Etah district).

The aquifers have been grouped as Aquifer Group-I and Aquifer Group-II on the basis of variations in their physical characteristics and the quality of formation water. These aquifer groups are separated by confining clay layers of thickness more than 10 m which maintain their identity in almost entire district. Also these groups consist of several thin aquifers separated by clays and silts. The resistivity of these aquifer groups in general decreases with depth.

First Aquifer Group (Aquifer Group- I) is the most potential aquifer group covering almost the entire area below the soil capping, occurring and continues down to generally 97 mbgl (Bottom between 65 and 97 mbgl) with the average depths of 78.00 mbgl. The thickness or depth of Aquifer group I ranges between 70-90 m bgl in the entire area however isolated patches of > 90 mbgl are seen in the Sasni block. The aquifer material is fine to medium sand and kankar variably associated with clay formation. The thickness of granular zone varies between 16-50 m with an average of 34 m. The sand percentage in the first aquifer group ranging between 30-50% in all blocks, However an small area of 20-30% are seen in Sadabad & Hasayn blocks and and 50-60% in Sasni, Mursan & Sikanrarao blocks. Ground water occurs under water table condition & depth to water level varies between 3.88 and 29.13 metres. The quality of the formation water of this aquifer group is generally fresh. However EC of more than 3000 microsiemens/cm is observed in 30-

40 % area of Sadabad block. This aquifer group forms the main source of water supply to hand pumps & shallow tube wells. About 90% of the state tube wells of 50-100 metres depth are parts of this aquifer group. The discharge of tube wells varies from 400 to 2400 lpm at moderate draw-downs of about 3-8 meters. Transmissivity 'T' is 256-1333 m^2/day. Storativity 'S' is to the order of 2.65×10^{-4} -6.5×10^{-3} showing semi confined to confined state of aquifer as per available data which are needed for refinement. Being the only fresh water aquifer in the area it holds almost the entire ground water developmental activities and thus is overstressed.

Second Aquifer Group (Aquifer Group-II) is separated with the overlying shallow aquifer group by a thick clay and occurs between the depth range of 103 m bgl (Top between 103 and 136 mbgl) and 302 mbgl (Bottom between 261 and 302 mbgl) is separated by 10-15 m thick clay layer from the first aquifer. The aquifer material is generally medium sand but at place it is an admixture of fine and coarse grained sand. Figure-2.36 shows Isopachs of Aquifer Group- II where thickness of Aquifer group ranges between 164-197 m bgl with the average depths of 169 m bgl. Generally the thickness ranges between 170-190 m in the entire area however the thickness increases from west to east. The sand percentage in the second aquifer group ranges between 29-35 % in all blocks. However a small area of >32% is also noticed in Sadabad, Mursan and Sasni blocks.

Since the depth of all the existing groundwater structures dugwells/tubewells) are limited to Aquifer Group-1, the aquifer parameter for aquifer group-2 & 3 could not be determined. These deeper aquifers, in spite of having good thickness of granular zones and apparently good potentiality, contain very poor quality (Brackish to highly saline) formation water hence have not been exploited in the area for any purpose.

As all wells constructed in Aquifer Group-I and only two wells tested, some more wells are proposed to be constructed for refinement of Aquifer mapping and Aquifer demarcation in the area in terms of quantity and quality aspect.

As on March 2013, the Dynamic annual replenishable ground water resource is 646.04 MCM; net ground water availability (fresh) is 585.8 MCM in Aquifer group-I. Total annual recharge from all sources in the district is of the order 646.04.96 MCM with Sikandra Rao block having the highest recharge of 138.03 MCM and Sahpau block has minimum recharge of the order of 56.83.66 MCM The annual replenishable ground water resources in metre per unit area is maximum at Sikandra Rao block (0.50 m/ area) followed Hasayan block (0.46 m/ area) with minimum of 0.27 metre per unit area in Sadabad block. The average annual replenishable ground water resource of the District is 0.36 m/ area. Total unaccounted natural discharge in the district is of the order of 6025.04 ham, with Sikandra Rao block having the highest discharge of 1380.34 ham and Hathras block with lowest of 435.45 ham. The net annual ground water availability in the District is 55882 ham with Sikandraroa block

having the highest annual net ground water availability of 12423.04 ham and Sahpau block with lowest of 5115.30ham. The existing annual gross ground water draft from the district is 53080 ham. The maximum ground water drawl for all uses is 10999 ham in Sikandra Rao block and minimum draft of ground water for all uses is 5290 ham in Sahpau block. Comparison of ground water draft for various uses reveals that draft for irrigation accounts for more than 95% of total ground water draft, where as draft for domestic & industrial supply accounts for merely 5 % of the total ground water draft in the district. Three blocks namely Mursan Sasni and Sahpau of the district are categorized as "Over-exploited", Hathras as "Critical", Sadabad as Semi critical. Remaining two namely Hasayan and Sikanrarao blocks in the district fall under 'Safe' category. Overall level of ground water development in Hathras district is 95.0 %.

In Aquifer Group I, Dynamic net ground water availability (fresh) is 585.8 MCM and static/in-storage (fresh) ground water resources are assessed to the tune of 3748.3 MCM. Thus the total ground water resources (fresh) available are estimated to be 4334.1 MCM in Aquifer Group I. The static/in-storage (saline) ground water resources in Aquifer Group I is 538 MCM and in Aquifer Group II 10296 MCM. The total static/in-storage (saline) is 10833 MCM in Aquifer Group I&II.

The analytical results show that E.C. values ranges between 410 & 6030 micro siemens/cm at 25^0C. E.C. < 750 noticed in isolated patches in Sikandra Rao, Hasayan, Hathras and Sahpau blocks E.C. is observed more than 750-1500 micro siemens/cm at 25^0C in Sikandra Rao, Hasayan Hathras and Sasni blockcs. EC is observed more than 1500-2250 and more than 3000 micro siemens/cm at 25^0C in all seven blocks with continuous patches in Sasni Hathras, Sadabad, Mursan and Shapau, blocks. The maximum E.C. of 6030, 4500 (Kajrothi & Naugaon of Sadabad blocks) 3165& 3050 (Metai & Mursan of Mursan Blocks) micro siemens/cm at 25^0C have been observed respectively. The SAR values in the formation water generally ranges from 0.3 to 13.0 with average value of 5.4 indicating good to excellent class of water except at Mursan, (Mursan block), Sadabad & Kajrothi and Khonda & Nagla Beru of Sahpau block where the SAR values have been detected as 10.0 and 13.0.The maximum water samples (52 %) falls under C2S1 and C3S1 low alkalinity and medium to high salinity classes. 29 % water samples falls under C3S2 and C4S2 medium alkalinity and high to very high salinity classes Rest of the samples fall under C3S3, C4S3 and C4S4 classes. This water can be used for plants with good salt tolerance. Thus by the above standard, indicating medium to high salinity and low medium alkali ground water in the district is in generally free from salinity hazards and is suitable for irrigation purposes.

Fluoride concentration in the district ranges from 0.09 to 1.5 mg/l which is well within desirable limit. However, the fluoride concentration is slightly higher at Hathras (1.61 mg/l) Sikandarpur (1.8 mg/l), Of Hathras Block, Mursan of (1.6 mg/l) & Bisana ,(3.0 mg/l,) of Mursan block , Khonda & Naglaberu (3.55 mg/l) of Sahpau

block and Biswar (4.15 mg/l) at Sadabad Block. The nitrate concentration in the district ranges between nd and 700 mg/l except at three (10%) samples of Kachora of Sikanrdarao block (130 mg/l,) Naugaon of Sadabad Block (320 mg/l) Hathras in of Hathras Block (700mg/l) Mursan of Mursan Block (64 mg/l) Hasayan of Hasayan Block (63 mg/l) have been noticed in higher which may be due to mixing of sewerage into ground water. In city area due to above reason the higher nitrate concentration is more common. Overall the nitrate concentration is within permissible limit in the area.

In the study area, 97 % samples analysed for copper fall in the desirable limit of 0.05 mg/l except Sadabad of Sadabad Block (0.095 mg/l). 39 % samples of the study area exceeded the maximum permissible limit of Iron. The results shows that 100% are below permissible limit of Mn . Zinc concentration in all the samples were well within the desirable limit. Silver concentration in all the samples were well within the desirable limit except Naugaon of Sadabad (0.015 mg/l).

The Quality of Ground water in shallow Aquifer of Aquifer Group I, are good however in Sadabad and Mursan block, salinity starts from water table itself with lateral extent of poor quality groundwater zones is about 78 m. The deeper part of Aquifer Group I, below ~80 is infested with inland salinity problem of this aquifer group in all blocks. It is manifested in construction of tube well which are constructed within 100 m depth. The occurrence of saline quality groundwater (> 2000 μ S/cm) has been established on the basis of geophysical logs of more than 6 exploratory /deposit wells and slim holes/ piezometers upto a depth ranging from 78 to 360 m. The Second Aquifer has inferior water quality in terms of salinity in entire district. Thus the scenario leaves little scope for ground water development in Aquifer Group I in the district. To ensure the quality of Aquifer Group II, five deep exploratory wells have been proposed.

The development of groundwater resources is increasing over the years in order to meet drinking water, industrial and irrigation requirements. The stage of ground water development had been changed to 99.89 % in 2004, 89.24 % in 2009, 84.52% in 2011 and 95.39 in 2013. As on 31.03.2013, it shows that block wise level of development of ground water potential in Hathras district varies from 59 % in Hasayan to 141% in Mursan block. This increase in ground water utilization, for agriculture activity through adaptation of bore wells/tube wells, has increased the ground water draft. The area irrigated by Ground water is seen steadily increased from 1994-95 to 2015-16

The number ground water structures are 25,681 in 1994-45, 28,421 in 1999-2000, 32973 in 2004-5, 35,735 in 2009-10 and 37,925 2015-16. It is observed that in recent years the number of ground water structures is increased at slower rate.

Block wise management plan is prepared considering the present water level, water level trend category of the block and further prioritized the blocks for

interventions. Three blocks namely Mursan, Sasni and Sahpau of the district are categorized as “Over-exploited”, Hathras as “Critical”, Sadabad as “Semi critical” and declining trend of water level is recoded over the last ten years. Thus there is urgent need for taking up suitable water management interventions based on integrated approach, which on one hand includes augmentation of ground water resources through appropriate techniques, and on the other hand requires the adoption of suitable water conservation measures, such as ensuring water use efficiency through creation of additional water storage facility, maintenance/ renovation of existing water bodies etc.

6.2 RECOMMENDATION

On the basis of the present study of the area the following recommendations have been made.

1. Ground water issues can be addressed mainly by focussing on measures to increase recharge and reducing the draft. It can be managed by a mixing of measures such as supply side and demand side management. In view of it, the management plan is prepared and recommended for implementation in five blocks which are prioritized as three blocks namely Mursan, Sasni and Sahpau of the district are categorized as “Over-exploited”, Hathras as “Critical”, Sadabad as “Semi critical”. In remaining two blocks such intervention is not required for increasing the ground water availability and reducing draft except we need be little more vigilant. On farm activities and Water Use Efficiency practices may be recommended in the blocks of higher stage of ground water development.
2. Artificial Ground Water recharge should be not taken where polluted surface water is available
3. It is observed that the contribution of ground water for irrigation in this district is more than surface water which is from 75 % (Sikandra Rao block) to 100 % (Sadabad block). So surface water irrigation system should be planned and effectively be implemented in all blocks by increasing the canal network, which will help in reducing the stress on Ground Water withdraw directly as well as increase the recharge of ground water.
4. Blending with First and /or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline ground water may be put in canal to enhance supply in canal so water can reach upto tail ends. It will just cause blending without affecting EC of water beyond usable limit.
5. Additional ground water development should have under taken by supply side considering slippage factors only and in areas of water divides between two major canals and the tail end areas of the canal.
6. The present aquifer mapping is done based on the existing data of CGWB in conjunction with the tubewells of State department such as Minor Irrigation, Ground Water Department, U.P. Jal Nigam. As only two wells drilled by CGWB

are 300 m bgl. Hence, three numbers of exploratory wells are proposed for refinement of the Aquifer groups, aquifer geometry, and aquifer parameters, ground water resources and to ascertain the quality of each aquifer.

7. Further for refinement of aquifer disposition, the proposed 35 VES required & 2D Line Imaging should be taken up.

8. The data gap for soil infiltration is also observed and soil infiltration rate study should be carried out.

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BLOCK WISE AQUIFER MAPS

AND MANAGEMENT PLAN

HATHRAS DISTRICT, U.P.

Aquifer Map and Management plan of Mursan Block Hathras District U.P.

1. Salient Information **Area :** 234.79 sq km

Population

Total: 202420, Male: 108036, Female: 94384 Decadal Growth rate: 16.8%,

Density: 862/sq km

Rainfall (2016)

The normal annual rainfall: 781.6 mm, Normal monsoon: 667.6 mm,

Normal non monsoon rainfall: 113.6 mm.

Annual Rainfall (2016): 615.8 mm

Monsoon rainfall (2016):581 mm Non-monsoon Rainfall (2016): 34.0 mm.

Agriculture and Irrigation 2015-16

The area of Rabi is 19027 ha, Kharif 10449 ha and Zaid 4163 ha. Total Cropped area is 33639 ha.

The principal crops of the area is Pulses -19006ha, Wheat-8016 ha, Rice-2255 ha, Barley -207 ha, Millet-6179 ha and Maize-5 ha.

Net sown area is 19701 ha and Gross cropped area is 33639 ha with cropping intensity of 171%.

Net Irrigated area is 19765 ha and Gross Area Irrigated is 27512 ha with Irrigation Intensity-139 %.

Net Irrigated area by ground water is 19651 ha and net Irrigated area under surface water is 74ha.

The Canal length is 58 km. Govt. Deep tube wells are 20 number and private Shallow Tube wells are 5204.

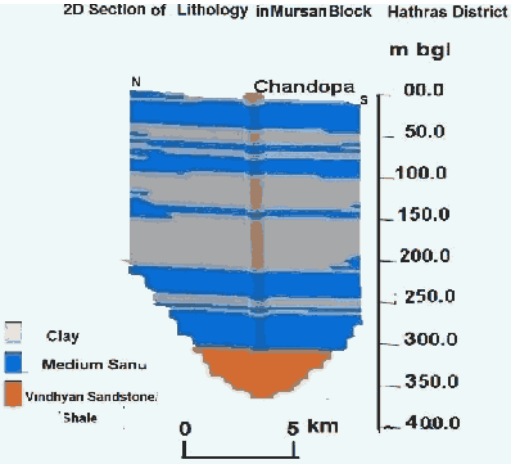
Water level behavior

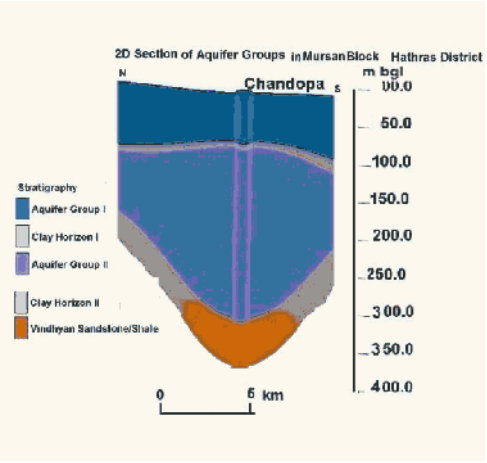
Eight observation wells have been monitored. Depth to water level ranges between 14.96 to 22.60 mbgl during Pre monsoon-2017 and between 15.53 to 23.05 mbgl during Post monsoon 2016 with fluctuation of -0.57 to 0.71 m. For the period of2004-13, Pre monsoon Declining trend is 68.40 cm/year and post monsoon declining trend of 56.78 cm/year. Due to lack of data piezomteric head is not available. However from few wells of district, it is continued to be 20 m bgl.

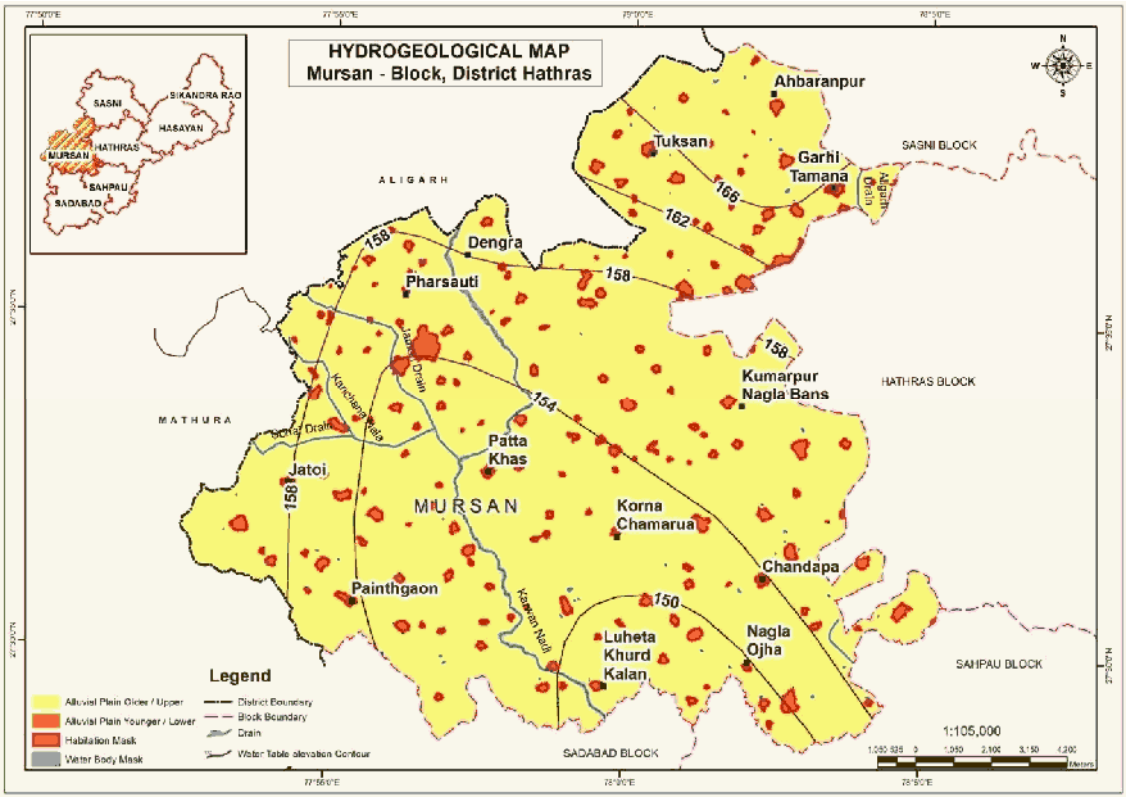
2. Aquifer Disposition, Number of aquifers:

First Aquifer Group Second Aquifer Group

The area falls in interfluvial tract of Central Ganga plain. The area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar. Ground water occurs under water table condition at shallow depths while the deeper aquifer is under confined state of disposition where the confining layers are impermeable clay beds. Average thickness of Aquifers Group-I is 70 m bgl with thickness of granular zone of 37 m and percentage of granular is 52. Limited data of aquifer group- II is available. Aquifer group- II exists between 120&136-300 mbgl with average thickness of aquifer is 175 m. The granular of zone in this group is 58 m thick with percentage of granular materials is 33. 2D lithological section and aquifer disposition and hydrogeological maps are shown in Figures below.







3. Ground water resource, extraction, contamination and other issues

Aquifer wise Ground Water availability and extraction

A	**FIRST AQUIFER**	
1	**Dynamic Resources (Fresh)**	**67.0 MCM**
2	**GW Draft ; Irrigation : 89.90 MCM** **Drinking &Industries: 4.09 MCM**	**94.0 MCM**
3	**Stage of Ground Water Development**	**: 141 %**
4	**Category**	**:Over exploited**
5	**Static Resources**	**567.0 MCM**
6	**Static Resources (Fresh)**	**340.0 MCM**
7	**Static Resources (Saline)**	**227.0 MCM**
8	**Total Resources Dynamic+ Static - (Fresh, 1+6)**	**407 .0 MCM**
9	**Grand total Dynamic+ Static - (Fresh+ Saline, 7+8)**	**634.0 MCM**
B	**SECOND AQUIFER**	
10	**Static Resources (Fresh)**	**0**
11	**Static Resources (Saline)**	**1314.0 MCM**
9	**Grand Total GW Resources (First Aquifer+ Second Aquifer, 9+10+11)**	**1948.0 MCM**

Issues: Dependency on Ground Water Irrigation, Intensive Ground Water Development and declining trend of water level. Second Aquifer Group & part of First Aquifer Group has inferior ground water quality in terms of salinity.

4.0 Chemical quality of ground water and contamination

S. No.	Constituents	Minimum	Maximum
1.	pH	7.90	8.51
2.	EC µS/cm at 25 ºC	1530	3165
3.	CO_3 mg/l	nil	36
4.	HCO_3 mg/l	366	872
5.	Cl mg/l	64	518
6.	F mg/l	0.32	3.0
7.	NO_3 mg/l	20	64
8.	SO_4 mg/l	48	367
9.	SiO_2 mg/l	20	32
10.	PO_4 mg/l	nd	nd
11.	TH (as $CaCO_3$) mg/l	230	590
12.	Ca mg/l	28	52
13.	Mg mg/l	39	112
14.	Na mg/l	180	524
15.	K mg/l	5.7	31

Heavy metals: Cu nd-.007, Zn 0.082-0.433 Fe0.12-0.692 and Mn nd . SAR 4.3-9.99 C3 S1, C3S2, C4 S3 and C4 S31. **All the chemical constituents are within permissible limit.**

Ground water is suitable for Drinking and irrigation. However F is higher (1.6-3.0 mg/l at Bisana & Mursan respectively).

First Aquifer Group is partly saline and Second Aquifer Group is Saline.

5. Ground water resource enhancement & Demand side interventions:

Surface water available for harvesting Runoff

Area Sq.km	Average Monsoon. Rainfall (mm)	Runoff coefficient % (utilizable rainfall)	Utilizable runoff Water (MCM)	Runoff used for storage / Recharge/ other interventions after excluding committed component MCM
a	b	c	d (axbxc/10^5)	50% of d
234. 79	667	15	20.86 (2086 ham)	10.43

Volume of unsaturated aquifer zone available for recharge: 540 MCM

- Ground water resource enhancement & Demand side interventions are tabulated below and tentative proposed Plan shown in Figure below**.**
- In addition, blending of water with First and/or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline ground water may be put in canal to enhance supply in canal so water can reach upto tail ends.

Feasible Artificial Recharge & Water Conservation structures/ activities	**Tentative Design**	**Quantity (nos. or area in ha)**	**Total runoff available (ham)**	**Total volume considering 4 times filling annually (ham)**	**Tentative unit cost (in Rs lakh)**	**Total tentative cost (in Rs lakh)**	**Expected benefits through implementation of plan (considering 80% of total storage)**		
							Expected Annual GW recharge (ham)	**Provision for supplemental irrigation, saving of GW draft (ham)**	**Expected conservation of ground water through efficiency enhancement measures (ham)**
	a	**b**	**c**	**d**	**e**	**f**	**40% of d**	**d**	**e**
Recharge structures/ activities									
Masonry Check dams (~ 1 ham capacity)	Crest- 10 -15 m; Height- 1 to 2 m	5		20	10	50.00	8	8	
Drain/stream development (Length in km x 10 to 15m x 1.5m)	Widening of channel upto 10-15m (Avg 12m) and 1.5m deepening	10		63	0.5/1000 m^3	79	25.2	25.2	
Nala bunds/ Gabion (~0.75 ham capacity)	Width: 5 to 15 m and 1 to 1.5 m height	30		90.00	2	60.00	36	36	
Revival, repair of water bodies with Recharg well	Average area 0.42 ha x 3m); deepening by 0.5m	154		775	3.5	539.0	310	310	
Total				**948**		**727.7**	**379.2**	**379.2**	**0**
Water Conservation Activities									
On farm activities (proposed in 15% of total catchment area) (in ha)		3700			0.14/ha	518.00	370.00		177.60
Sprinkler/ drip/ HDPE pipes for 3500 ha select area		3776			0.60/ha	2265.6			1087.49
Total						**2783.6**	**370**	**0**	**1265.088**
Grand Total						**3511.35**	**749.2**	**379.2**	**1265.088**
								379.2+1265.08=1644.24	
5% Provision for O & M						**175.56**			
5% provision for Impact Assessment						**175.56**			
Grand Total						**3862.48**			

Projected Impact on Status of Groundwater Resource & Development

Net G.W. Availability (Ham)	Additional Recharge from RWH & Recharge (ham)	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventio ns (ham)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. (in %)
MURSAN	**6664.98**	**749.20**	**7414.18**	**9398.37**	**1644.29**	**7754.08**	**141.01**

1. Aquifer Map and Management plan of Sasni Block Hathras District U.P.

1.0 Salient Information **Area: 273.66 sq km**

Population

Total: 2,24,282, Male: 1,1,9263, Female: 1,05,018 Decadal Growth rate: 14.4 %, Density: 820/sq km

Rainfall (2016)

The normal annual rainfall: 781.6 mm, Normal monsoon: 667.6 mm,

Normal non monsoon rainfall: 113.6 mm.

Annual Rainfall (2016): 615.8 mm

Monsoon rainfall (2016):581 mm Non-monsoon Rainfall (2016): 34.0 mm.

Agriculture and Irrigation 2015-16

The area of Rabi is 21212 ha, Kharif 11718 ha and Zaid 4950 ha . Total Cropped area is 37880 ha. The principal crops of the areas are Pulses -24927ha, Wheat-10675 ha, Rice-1889 ha, Barley -323 ha and Millet- 6562 ha .

Net sown area is 22299 ha and Gross cropped area 37880 ha with cropping intensity of 170%.

Net Irrigated area is 22432 ha and Gross Area Irrigated -31784 ha with Irrigation Intensity-142%.

Net Irrigated area under groundwater is 22,342 ha and net Irrigated area under surface water - 90 ha .

The Canal length is 5 km. Govt. Deep tube wells are -30 number and private Shallow Tube well - 3139.

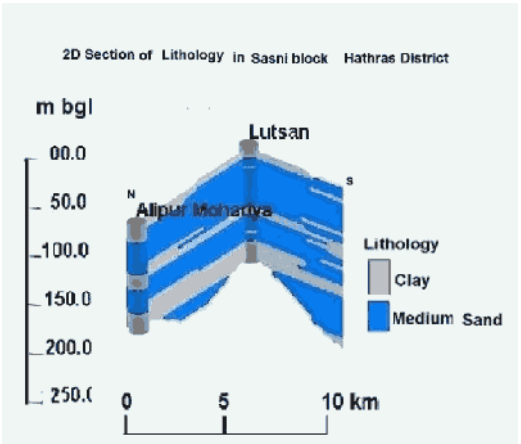
Water level behavior

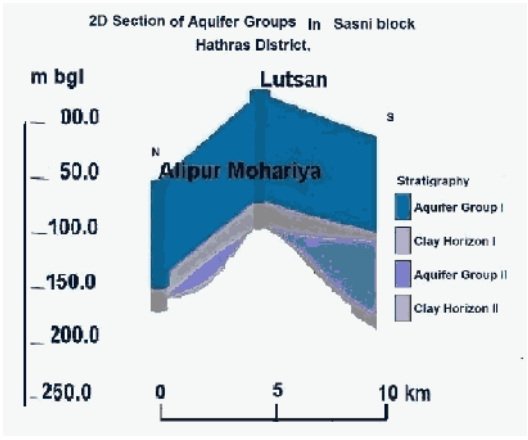
Eleven observation wells have been monitored. Depth to water level ranges between 12.17 to 25.11 mbgl during Pre monsoon-2017 and between 11.32 to 25.09 mbgl during Post monsoon 2017 with fluctuation of -0.75 to 0.85 m. For the period of 2004-13, Pre monsoon declining trend is 21.63 cm/year and post monsoon declining trend of 16.18 cm/year. Due to lack of data piezomteric head is not available. However from few wells of district, it is 20 m bgl.

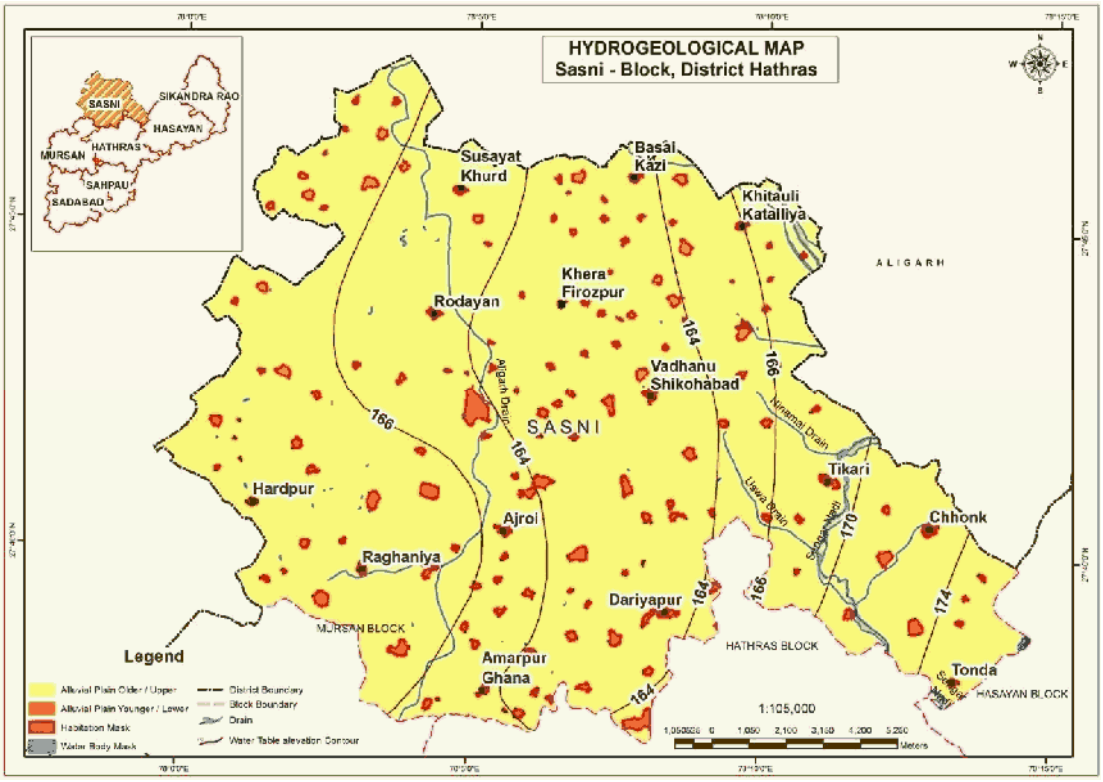
2.0 Aquifer Disposition, Number of aquifers

First Aquifer Group Second Aquifer Group

The area falls in interfluvial tract of Central Ganga plain. The area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar. Ground water occurs under water table condition at shallow depths while the deeper aquifer is under confined state of disposition where the confining layers are impermeable clay beds. Average Thickness of aquifers group-I is 94 m bgl with thickness of granular zone of 46 m and percentage of granular is 49. Limited data of aquifer group- II is available. Aquifer group- II exists between 105&120-300 mbgl with average thickness of aquifer is 193 m. The granular of zone in this group is 58 m thick wit percentage of granular is 32. 2D lithological section and aquifer disposition and hydrogeological maps are shown in Figures below.







3. Ground water resource, extraction, contamination and other issues

Aquifer wise Ground Water availability and extraction

A	FIRST AQUIFER	
1	Dynamic Resources (Fresh)	67.0 MCM
2	GW Draft ; Irrigation : 85.32 MCM Drinking &Industries: 4.73 MCM	90.0 MCM
3	Stage of Ground Water Development	: 134 %
4	Category	:Over exploited
5	Static Resources	875.0 MCM
6	Static Resources (Fresh)	875.0 MCM
7	Static Resources (Saline)	0 MCM
8	Total Resources Dynamic+ Static - (Fresh, 1+6)	942.0 MCM
9	Grand total Dynamic+ Static - (Fresh+ Saline, 7+8)	942.0MCM
B	SECOND AQUIFER	
10	Static Resources (Fresh)	0
11	Static Resources (Saline)	1531 MCM
9	Grand Total GW Resources (First Aquifer+ Second Aquifer, 9+10+11)	2473.0 MCM

Issues: Dependency of Ground Water Irrigation, Intensive Ground Water Development, Declining trend of water level. Second Aquifer Group has inferior ground water quality in terms of salinity.

4. Chemical quality of ground water and contamination

S. No.	Constituents	Minimum	Maximum
1.	pH	7.70	8.66
2.	EC µS/cm at 25 ºC	725	2100
3.	CO_3 mg/l	Nil	48
4.	HCO_3 mg/l	232	750
5.	Cl mg/l	43	199
6.	F mg/l	0.41	1.4
7.	NO_3 mg/l	2.5	40
8.	SO_4 mg/l	5.7	278
9.	SiO_2 mg/l	24	26
10.	PO_4 mg/l	nd	nd
11.	TH (as $CaCO_3$) mg/l	250	370
12.	Ca mg/l	24	84
13.	Mg mg/l	38	46
14.	Na mg/l	44	355
15.	K mg/l	4.8	6.6

Heavy metals: Cu nd-.012, Zn 0.098-1.051 Fe0. 1.54-0.487 and Mn 0.011-0.155mg/l SAR 1.21-9.57 C2S1,C3S1 and, C3S2.

All the chemical constituents are within permissible limit .

In general Ground water is suitable for Drinking and irrigation. EC 2100 µS/cm at 25 ºC is higher at Ruheri. First Aquifer Group is fresh and Second Aquifer Group is Saline.

5. Ground water resource enhancement & Demand side interventions:

Surface water available for harvesting Runoff

Area Sq.km	Average Monsoon Rainfall (mm)	Runoff coefficient % (utilizable rainfall)	Utilizable runoff Water (MCM)	Runoff used for storage/ Recharge/ other interventions after excluding committed component(MCM
a	b	c	d (axbxc/10^5)	50% of d
273.66	667	15	24.62 (2462 ham)	12.31

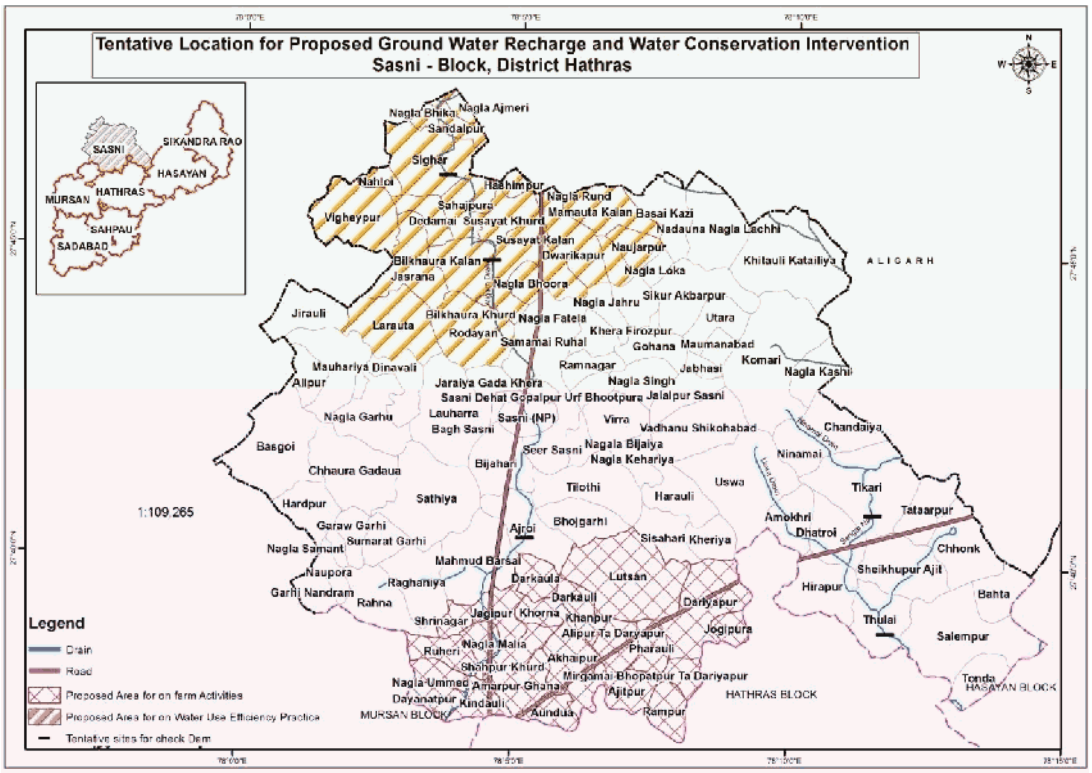
Volume of unsaturated aquifer zone available for recharge: 644 MCM

- Ground water resource enhancement & Demand side interventions are tabulated below and tentative proposed Plan shown in Figure below**.**
- In addition, blending of water with First and /or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline ground water may be put in canal to enhance supply in canal so water can reach upto tail ends.

Feasible Artificial Recharge & Water Conservation structures/ activities	Tentative Design	Quantity (nos. or area in ha)	Total runoff available (ham)	Total volume considering 4 times filling annually (ham)	Tentative unit cost (in Rs lakh)	Total tentative cost (in Rs lakh)	Expected benefits through implementation of plan (considering 80% of total storage)		
							Expected Annual GW recharge (ham)	Provision for supplemental irrigation, saving of GW draft (ham)	Expected conservation of ground water through efficiency enhancement measures (ham
	a	b	c	d	e	f	40% of d	d	e
Recharge structures/ activities									
Masonry Check dams (~ 1ham capacity)	Crest-10 -15 m; Height- 1 to 2 m	6		24	10	60.00	9.6	9.6	
Drain/stream development (Length in km x 10 to15m x 1.5m)	Widening of channel upto 10-15 m (Avg 12m) and 1.5m deepening	10		63	0.5/1000 m^3	78.75	25.2	25.2	
Nala bunds/ Gabion (~0.75ham capacity)	Width: 5 to 1 m and 1 to 1.5 m height	15		45	2	30.00	18	18	
Revival, repair of water bodies with Recharge well	Average area 0.0.23ha x3m); deepening by 0.5m	203		556	3.5	710.5	222.4	222.4	
Total				**688**	**15.5**	**879.2**	**275.2**	**275.2**	**0**
Water Conservation Activities									
On farm activities (proposed in 15% of total catchment area) (in ha)		4077			0.14/ha	570.78	407.70		163.08
Sprinkler/ drip/ HDPE pipes for 3500 ha select ar		4498			0.60/ha	2698.80			1079.52
Total						**3269.58**	**407.7**	**0**	**1242.6**
Grand Total						**4148.83**	**682.9**	**275.2**	**1242.6**
5% Provision for O & M						**207.44**		**275.2+1242.6==1517.8**	
5% provision for Impact Assessment						**207.44**			
Grand Total						**4563.71**			

Projected Impact on Status Of Groundwater Resource & Development Impact

Net G.W. Availability (Ham)	Additional Recharge from RWH & Recharge (ham)	Total Net G.W. Availability after intervention (ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. (in %)
6713.5	682.90	7396.40	9004.8	1517.8	7487.00	134.13	101.22



3. Aquifer Map and Management plan of Sahpau Block, Hathras District U.P.

1.0 Salient Information **Area** 176.31 sq km

Population

Total: 1,35,848, Male: 72,533, Female: 63,315, Decadal Growth rate: 17.4 %,

Density :771/sq km

Rainfall (2016)

The normal annual rainfall: 781.6 mm, Normal monsoon: 667.6 mm,

Normal non monsoon rainfall: 113.6 mm.

Annual Rainfall (2016): 615.8 mm

Monsoon rainfall (2016):581 mm Non-monsoon Rainfall (2016): 34.0 mm.

Agriculture and Irrigation 2015-16

The area of is Rabi 14901ha Kharif, 7597 ha and Zaid 928 ha. Total Cropped area is 23426 ha.

The principal crops of the area is Pulses -14043 ha, Wheat-6208 ha, Rice-363 ha, Barley -95 ha Millet-5750 ha and Maize 6.

Net sown area is 15055 ha and Gross cropped area 23426 ha with cropping intensity of 156 %.

Net Irrigated area is 15115 ha and Gross Area Irrigated -17620 ha with Irrigation Intensity-117%.

Net Irrigated area under groundwater is 14,876 ha and net Irrigated area under surface water is 239 ha.

The Canal length is 60 km. Govt. Deep tube wells are 30 number and private-Shallow Tube wells are 6194.

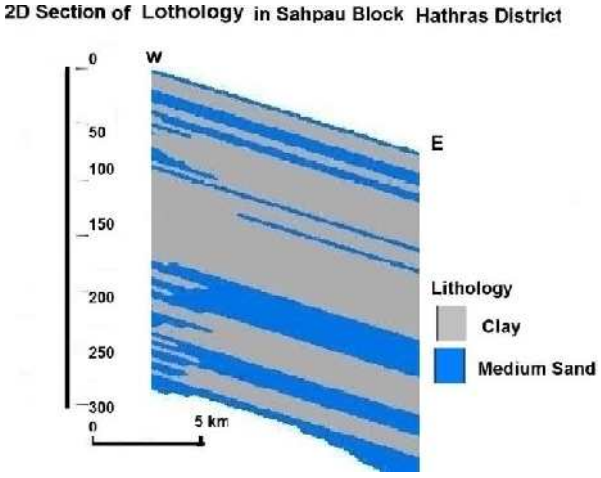
Water level behavior

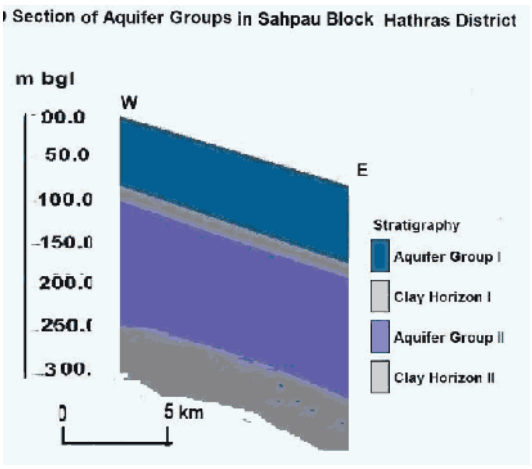
Four observation wells have been monitored. Depth to water level ranges between 13.50 to 18.40 mbgl during Pre monsoon-2017 and between 13.00 to 18.60 mbgl during Post monsoon 2017 with fluctuation of -0.55 to 0.50 m. For the period of2004-13, Pre monsoon declining trend 33.06 cm/year and post monsoon declining trend of 16.18 cm/year. Due to lack of data piezomteric head is not available. However from few wells of district, it is 20 m bgl.

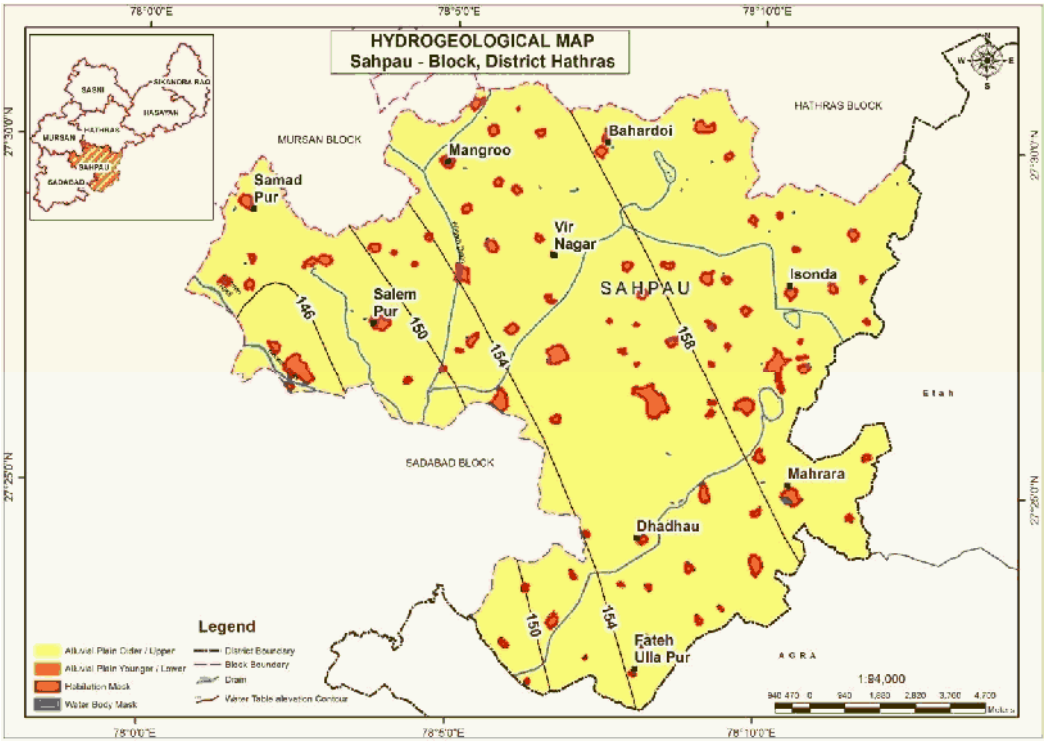
2. Aquifer Disposition, Number of aquifers

First Aquifer Group Second Aquifer Group

The area falls in interfluvial tract of Central Ganga plain. The area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar. Ground water occurs under water table condition at shallow depths while the deeper aquifer is under confined state of disposition where the confining layers are impermeable clay beds. Average Thickness of aquifers group-I is 77 m bgl with thickness of granular zone of 31 m and percentage of granular is 38. Limited data of aquifer group- II is available. Aquifer group- II exists between 115-300 mbgl with average thickness of aquifer is 184 m. The granular of zone in this group is 58 m thick with percentage of granular materials is 31. 2D lithological section and 3D aquifer disposition and hydrogeological maps are shown in Figures below.







3. Ground water resource, extraction, contamination and other issues

Aquifer wise Ground Water availability and extraction

A	**FIRST AQUIFER**	
1	**Dynamic Resources (Fresh)**	**51.0 MCM**
2	**GW Draft ; Irrigation : 50.09 MCM** **Drinking &Industries: 2.82 MCM**	**52.9 MCM**
3	**Stage of Ground Water Development**	**: 103 %**
4	**Category**	**:Over exploited**
5	**Static Resources**	**366.0 MCM**
6	**Static Resources (Fresh)**	**293.0 MCM**
7	**Static Resources (Saline)**	**73.0 MCM**
8	**Total Resources Dynamic+ Static - (Fresh, 1+6)**	**344 MCM**
9	**Grand total Dynamic+ Static - (Fresh+ Saline, 7+8)**	**417.0 MCM**
B	**SECOND AQUIFER**	
10	**Static Resources (Fresh)**	**0**
11	**Static Resources (Saline)**	**987 MCM**
9	**Grand Total GW Resources (First Aquifer+ Second Aquifer, 9+10+11)**	**1404.0 MCM**

Issues: Dependency of Ground Water Irrigation, Second Aquifer Group & part of First Aquifer Group has inferior ground water quality in terms of salinity.

4. Chemical quality of ground water and contamination.

S. No.	Constituents	Minimum	Maximum
1.	pH	8.00	8.57
2.	EC µS/cm at 25 ºC	460	1770
3.	CO_3 mg/l	Nil	Nil
4.	HCO_3 mg/l	224	866
5.	Cl mg/l	7	64
6.	F mg/l	0.9	3.55
7.	NO_3 mg/l	5.7	28
8.	SO_4 mg/l	6.6	67
9.	SiO_2 mg/l	19	27
10.	PO_4 mg/l	nd	nd
11.	TH (as $CaCO_3$) mg/l	130	220
12.	Ca mg/l	24	40
13.	Mg mg/l	17	32
14.	Na mg/l	16	340
15.	K mg/l	3.6	10.0

Heavy metals: Cu n-.018, Zn 0.067-0.357 Fe 0.128 -0.487 and Mn 0.024-0.072 mg/l

SAR 0.50-12.97, C2 S1, C3S2, and C3S3

All the chemical constituents are within permissible limit .

Ground water is suitable for Drinking and irrigation. However F is higher (3.55 mg/l) at Khonda and Naglaberu.

First Aquifer Group is Partly saline and Second Aquifer Group is Saline.

5. Ground water resource enhancement & Demand side interventions:

Surface water available for harvesting Runoff

Sahpau block Area Sq.km	Average Monsoon Rainfall (mm)	Runoff coefficient % (utilizable rainfall)	Utilizable runoff Water (MCM)	Runoff used for storage/ Recharge/ other interventions after excluding committed component(MCM
a	b	c	d (axbxc/10^5)	50% of d
176.31	667	15	15.83 (1583 ham)	7.91

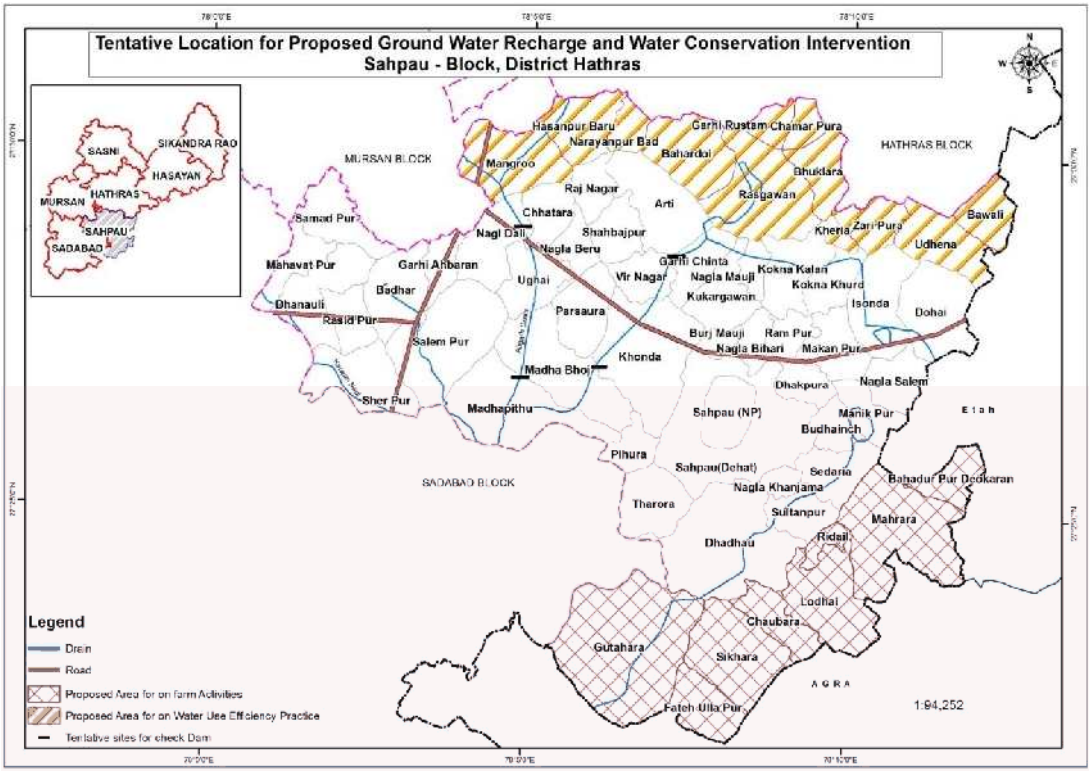
Volume of unsaturated aquifer zone available for recharge: 306 MCM

- Ground water resource enhancement & Demand side interventions are tabulated below and tentative proposed Plan shown in Figure below**.**
- In addition, blending of water with First and /or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline ground water may be put in canal to enhance supply in canal so water can reach upto tail ends.

Feasible Artificial Recharge & Water Conservation structures/ activities	**Tentative Design**	**Quantity (nos. or area in ha)**	**Total runoff available (ham)**	**Total volume considering 4 times filling annually (ham)**	**Tentative unit cost (in Rs lakh)**	**Total tentative cost (in Rs lakh)**	**Expected benefits through implementation of plan (considering 80% of total storage)**		
							Expected Annual GW recharge (ham)	**Provision for supplemental irrigation, saving of GW draft (ham)**	**Expected conservation of ground water through efficiency enhancement measures (ham)**
	a	**b**	**c**	**d**	**e**	**f**	**40% of d**	**d**	**e**
Recharge structures/ activities									
Masonry Check dams (~ 1ham capacity)	Crest- 10 -15 m; Height- 1 to 2 m	4		16	10	40.00	6.4	6.4	
Drain/stream development (Length in km x 10 to15m x 1.5m)	Widening of channel upto 10-15m (Avg 12m) and 1.5m deepening	10		63	0.5/1000 m3	78.75	25.2	25.2	
Nala bunds/ Gabion (~7500 m3 capacity)	Width: 5 to 15 m and 1 to 1.5 m height	30		90	2	60.00	36	36	
Revival, repair of water bodies with Recharge well	Average area 0.0.30 ha x3m); deepening by 0.5m	148		533	3.5	518.00	213.2	213.2	
Total				**702**	**15.5**	**696.75**	**280.8**	**280.8**	**0**
Water Conservation Activities									
On farm activities (proposed in 15% of total catchment area) (in ha)		3300			0.14/ha	462.00	330.00		118.80
Sprinkler/ drip/ HDPE pipes for 3500 ha select area		2773			0.60/ha	1663.80			598.97
Total						**2125.8**	**330**	**0**	**717.77**
Grand Total						**2822.55**	**610.8**	**280.8**	**717.77**
5% Provision for O & M						141.13		**280.8+717.77=998.7**	
5% provision for Impact Assessment						141.13			
Grand Total						3104.8			

Projected Impact on Status Of Groundwater Resource & Development Impact

Net G.W. Availability (Ham)	Additional Recharge from RWH & Recharge (ham)	Total Net G.W. Availability after intervention (ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. (in %)
5115.30	610.80	5726.10	5290.38	998.57	4291.81	103.42	74.95



4. Aquifer Map and Management plan of Hathras Block Hathras District U.P.

1.0 Salient Information **Area: 272.77 sq km**

Population

Total: 3,49,120, Male: 1,8,0487, Female: 1,68,633 Decadal Growth rate: 12.7 %,

Density: 1280/sq km

Rainfall (2016)

The normal annual rainfall: 781.6 mm, Normal monsoon: 667.6 mm,

Normal non monsoon rainfall: 113.6 mm.

Annual Rainfall (2016): 615.8 mm

Monsoon rainfall (2016):581 mm Non-monsoon Rainfall (2016): 34.0 mm.

Agriculture and Irrigation 2015-16

The area of Rabi is 20726 ha, Kharif 10736 ha and Zaid 3084 ha . Total Cropped area is 34546 ha. The principal crops of the areas are Pulses -28398ha, Wheat-12170 ha, Rice-4507 ha, Barley -289ha and Millet- 6562 ha.

Net sown area is 21005 ha and Gross cropped area 34546 ha with cropping intensity of 164%.

Net Irrigated area is 21083 ha and Gross Area Irrigated -29895 ha with Irrigation Intensity-142%.

Net Irrigated area under groundwater is 20843 ha and net Irrigated area under surface water – 240 ha .

The Canal length is 76 km. Govt. Deep tube wells are -8 number and private Shallow Tube well - 4596.

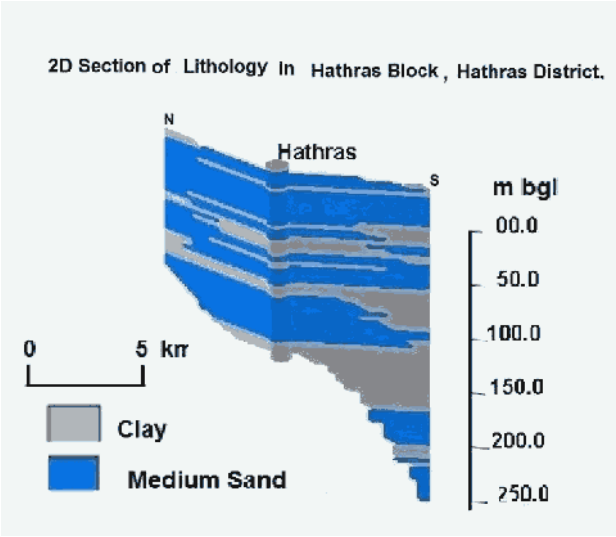
Water level behavior

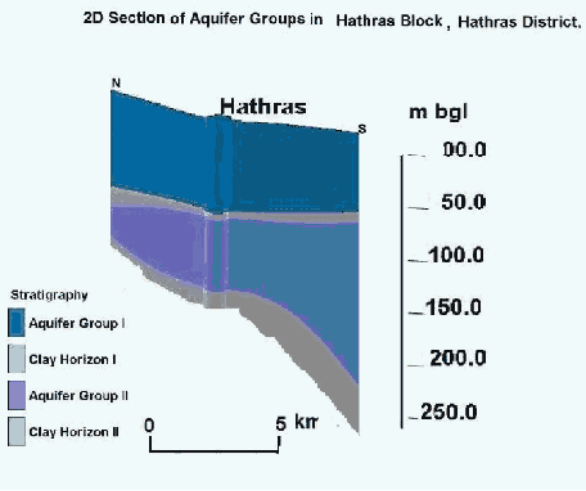
Ten observation wells have been monitored. Depth to water level ranges between 8.40 to 21.19 mbgl during Pre monsoon-2017 and between 6.10 to 22.0 mbgl during Post monsoon 2017 with fluctuation of-1.25 to 2.30 m. For the period of 2004-13, Pre monsoon declining trend is 20.08 cm/year and post monsoon declining trend of 33.96 cm/year. Due to lack of data piezomteric head is not available. However from few wells of district, it is 20 m bgl.

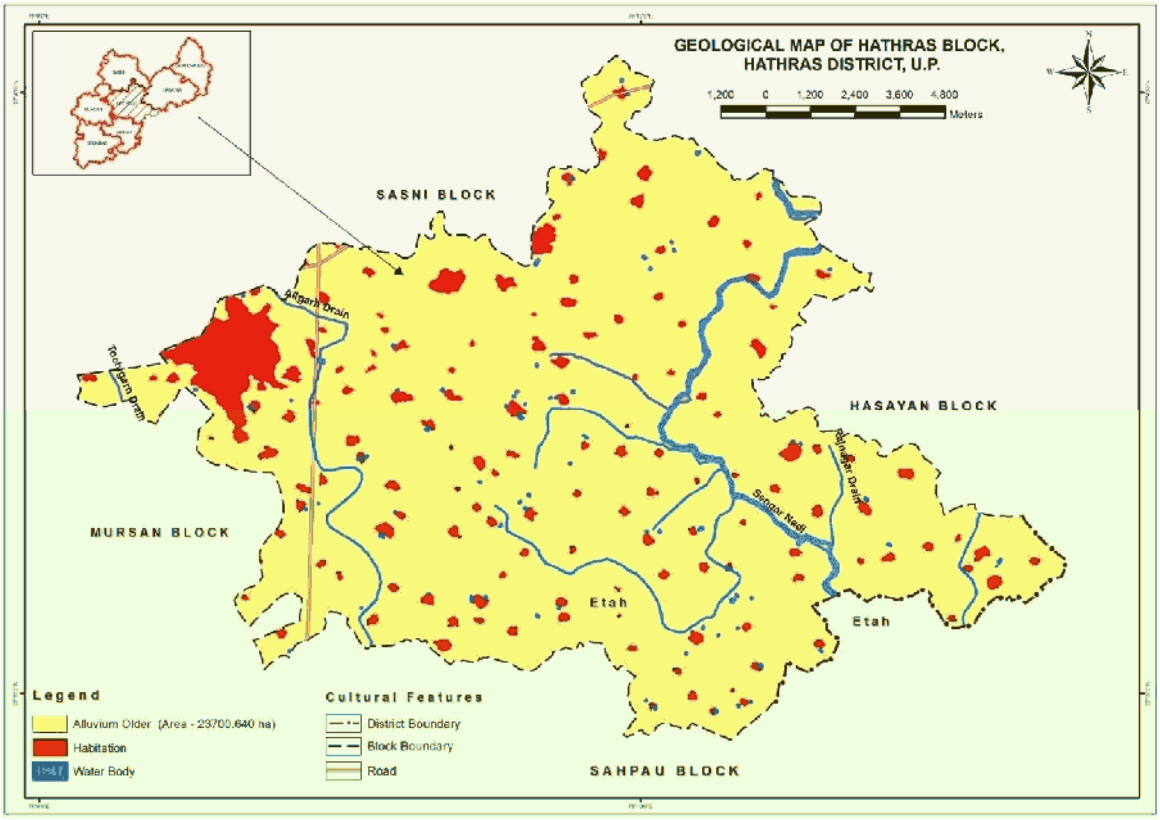
2. Aquifer Disposition, Number of aquifers

First Aquifer Group Second Aquifer Group

The area falls in interfluvial tract of Central Ganga plain. The area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar. Ground water occurs under water table condition at shallow depths while the deeper aquifer is under confined state of disposition where the confining layers are impermeable clay beds. Average Thickness of aquifers group-I is 82 m bgl with thickness of granular zone of 37 m and percentage of granular is 46. Limited data of aquifer group- II is available. Aquifer group- II exists between 103&120-300 mbgl with average thickness of aquifer is 193 m. The granular of zone in this group is 58 m thick with percentage of granular materials is 33. 2D lithological section and aquifer disposition and hydrogeological maps are shown in Figures below.







3. Ground water resource, extraction, contamination and other issues

Aquifer wise Ground Water availability and extraction

A	**FIRST AQUIFER**	
1	**Dynamic Resources (Fresh)**	**83.0 MCM**
2	**GW Draft ; Irrigation : 78.0 MCM** **Drinking &Industries: 4.0 MCM**	**82.0 MCM**
3	**Stage of Ground Water Development**	**: 99 %**
4	**Category**	**:Critical**
5	**Static Resources**	**724.0 MCM**
6	**Static Resources (Fresh)**	**724.00 MCM**
7	**Static Resources (Saline)**	**0 MCM**
8	**Total Resources Dynamic+ Static - (Fresh, 1+6)**	**807.0 MCM**
9	**Grand total Dynamic+ Static - (Fresh+ Saline, 7+8)**	**807.0 MCM**
B	**SECOND AQUIFER**	
10	**Static Resources (Fresh)**	**0**
11	**Static Resources (Saline)**	**1525 MCM**
9	**Grand Total GW Resources (First Aquifer+ Second Aquifer, 9+10+11)**	**2332.0 MCM**

Issues: Dependency of Ground Water Irrigation, Intensive Ground Water Development, Declining trend of water level. Second Aquifer Group has inferior ground water quality in terms of salinity.

4. Chemical quality of ground water and contamination

S. No.	Constituents	Minimum	Maximum
1.	pH	7.8	8.48
2.	EC µS/cm at 25 ºC	700	2480
3.	CO_3 mg/l	Nil	Nil
4.	HCO_3 mg/l	171	695
5.	Cl mg/l	14	156
6.0	F mg/l	0.2	1.88
7.	NO_3 mg/l	4.2	700
8.	SO_4 mg/l	20	200
9.	SiO_2 mg/l	20	29
10.	PO_4 mg/l	Nd	Nd
11.	TH (as $CaCO_3$) mg/l	140	330
12.	Ca mg/l	20	80
13.	Mg mg/l	17	32
14.	Na mg/l	42	406
15.	K mg/l	3.3	33

Heavy metals: Cu.01, Zn 0.046-0.414 Fe0. 0.86-0.99 and Mn nd-0.134mg/l SAR 1.25-9.72 C2S1,C3S1 and, C3S2, C4S2.

All the chemical constituents are within permissible limit .

In general Ground water is suitable for Drinking and irrigation. EC 2100 µS/cm at 25 ºC is higher at Hathras Jn. However, F is higher (1.61 & 1.88 mg/l in Hathras & Sikandarpur). First Aquifer is fresh and Second Aquifer Group is Saline.

5. Ground water resource enhancement & Demand side interventions:

Surface water available for harvesting Runoff

Area Sq.km	Average Monsoon Rainfall (mm)	Runoff coefficient % (utilizable rainfall)	Utilizable runoff Water (MCM)	Runoff used for storage/ Recharge/ other interventions after excluding committed component(MCM
a	b	c	d (axbxc/10^5)	50% of d
272.77	667	15	23.22 (2322 ham)	11.61

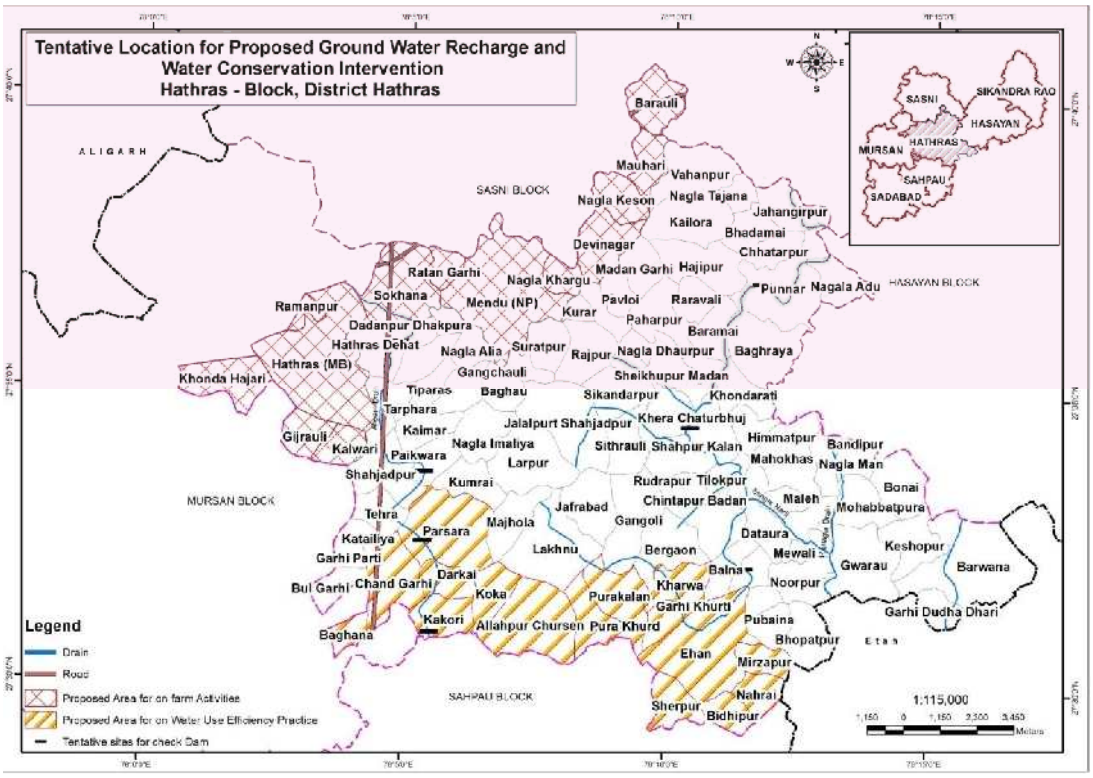
Volume of unsaturated aquifer zone available for recharge: 436 MCM

- Ground water resource enhancement & Demand side interventions are tabulated below and tentative proposed Plan shown in Figure below**.**
- In addition, blending of water with First and /or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline ground water may be put in canal to enhance supply in canal so water can reach upto tail ends.

Feasible Artificial Recharge & Water Conservation structures/ activities	**Tentative Design**	**Quantity (nos. or area in ha)**	**Total runoff available (ham)**	**Total volume consideri ng 4 times filling annually (ham)**	**Tentative unit cost (in Rs lakh**	**Total tentative cost (in Rs lakh)**	**Expected benefits through implementation of plan (considering 80% of total storage)**		
							Expected Annual GW recharge (ham)	**Provision for supplemental irrigation, saving of GW draft (ham)**	**Expected conservation of ground water through efficiency enhancement measures (ham)**
	a	**b**	**c**	**d**	**e**	**f**	**40% of d**	**d**	**e**
Recharge structures/ activities									
Masonry Check dams (~ 1ham capacity)	Crest- 10 -15 m; Height- 1 to 2 m	6		24.00	10	60.00	9.6	9.6	6
Drain/stream development (Length in km x 10 to15m x 1.5m)	Widening of channel upto 10-15m (Avg 12m) and 1.5m deepening	10		63	0.5/1000 m^3	78.75	25.2	25.2	10
Nala bunds/ Gabion (~0.75 ham capacity)	Width: 5 to 15 m and 1 to 1.5 m height	30		90.00	2	60.00	36.0	36.0	30
Revival, repair of water bodies with Recharge well	Average area 0.40 ha x3m); deepening by 0.5m	48		230.00	3.5	168.00	92.0	92.0	48
Total				**407**		**366.7**	**162.8**	**162.8**	
Water Conservation Activities									
On farm activities (proposed in 15% of total catchment area) (in ha)		4310			0.14/ha	603.40	431.00		168.09
Sprinkler/ drip/ HDPE pipes for 3500 ha select area		4405			0.60/ha	2643.0			1030.77
Total						**3246.4**	**431.0**	**0**	**1198.9**
Grand Total						**3613.15**	**593.8**	**162.8**	**1198.9**
5% Provision for O & M						**180.66**		**162.8+1198.9=1361.66**	
5% provision for Impact Assessment						**180.66**			
Grand Total						**3974**			

Projected Impact on Status Of Groundwater Resource & Development Impact

Net G.W. Availability (Ham)	Additional Recharge from RWH & Recharge (ham)	Total Net G.W. Availability after intervention (ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. (in %)
8273.60	593.80	8867.40	8179.16	1361.66	6817.50	98.86	76.88



5.0 Aquifer Map and Management plan of Sadabad Block Hathras District U.P.

1.0 Salient Information **Area: 290.56 sq km**

Population

Total: 2,48,471, Male: 1,32,140, Female: 1,16,331 Decadal Growth rate: 14.7 %,

Density: 855/sq km

Rainfall (2016)

The normal annual rainfall: 781.6 mm, Normal monsoon: 667.6 mm,

Normal non monsoon rainfall: 113.6 mm.

Annual Rainfall (2016): 615.8 mm

Monsoon rainfall (2016):581 mm Non-monsoon Rainfall (2016): 34.0 mm.

Agriculture and Irrigation 2015-16

The area of Rabi is 22178 ha, Kharif 9099 ha and Zaid 1563ha . Total Cropped area is 32840 ha. The principal crops of the areas are Pulses -16267 ha, Wheat-7549ha, Rice-171 ha, Barley -102ha and Millet- 6895 ha .

Net sown area is 24494 ha and Gross cropped area 32840 ha with cropping intensity of 134%.

Net Irrigated area is 24553 ha and Gross Area Irrigated -27493 ha with Irrigation Intensity-112%.

Net Irrigated area under groundwater is 24553 ha and net Irrigated area under surface water – 0 ha .

The Canal length is 0 km. Govt. Deep tube wells are -122 number and private Shallow Tube well - 5573.

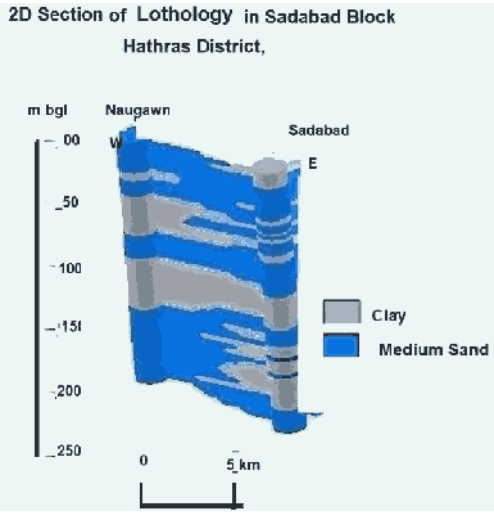
Water level behavior

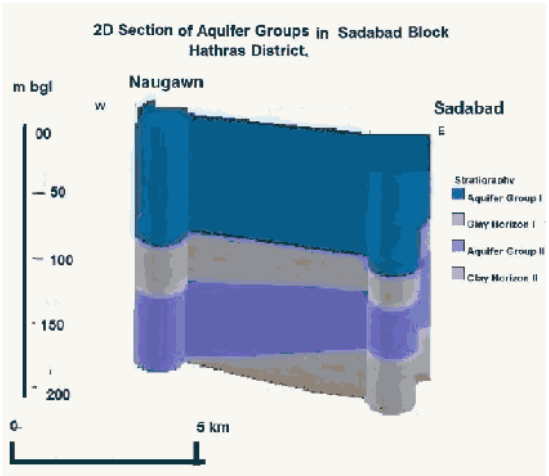
Six observation wells have been monitored. Depth to water level ranges between 16.43 to 29.13 mbgl during Pre monsoon-2017 and between 16.42 to 30.41 mbgl during Post monsoon 2017 with fluctuation of-1.28 to 0.35 m. For the period of 2004-13, Pre monsoon declining trend is 44.97 cm/year and post monsoon rising trend of 45.42 cm/year. Due to lack of data piezomteric head is not available. However from few wells of district, it is 20 m bgl.

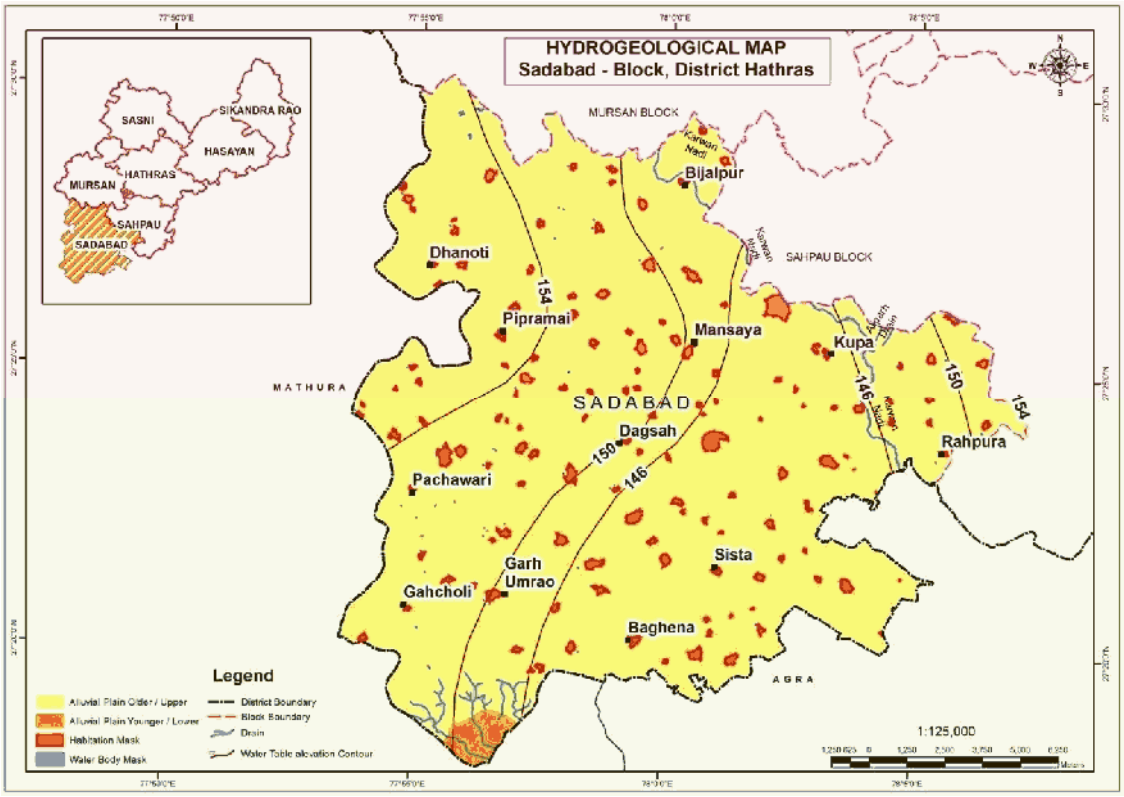
2 Aquifer Disposition, Number of aquifers

First Aquifer Group Second Aquifer Group

The area falls in interfluvial tract of Central Ganga plain. The area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar. Ground water occurs under water table condition at shallow depths while the deeper aquifer is under confined state of disposition where the confining layers are impermeable clay beds. Average Thickness of aquifers group-I is 77 m bgl with thickness of granular zone of 31 m and percentage of granular is 38. Limited data of aquifer group- II is available. Aquifer group- II exists between 122&131-300 mbgl with average thickness of aquifer is 174 m. The granular of zone in this group is 58 m thick with percentage of granular materials is 33. 2D lithological section and aquifer disposition and hydrogeological maps are shown in Figures below.







3. Ground water resource, extraction, contamination and other issues

Aquifer wise Ground Water availability and extraction

A	**FIRST AQUIFER**	
1	**Dynamic Resources (Fresh)**	**73.0 MCM**
2	**GW Draft ; Irrigation : 54.0 MCM** **Drinking &Industries: 5.0 MCM**	**59.0 MCM**
3	**Stage of Ground Water Development**	**: 81 %**
4	**Category**	**: Semi Critical**
5	**Static Resources**	**397.0 MCM**
6	**Static Resources (Fresh)**	**159.0 MCM**
7	**Static Resources (Saline)**	**238.0 MCM**
8	**Total Resources Dynamic+ Static - (Fresh, 1+6)**	**232.0 MCM**
9	**Grand total Dynamic+ Static - (Fresh+ Saline, 7+8)**	**470.0 MCM**
B	**SECOND AQUIFER**	
10	**Static Resources (Fresh)**	**0**
11	**Static Resources (Saline)**	**1626MCM**
9	**Grand Total GW Resources (First Aquifer+ Second Aquifer, 9+10+11)**	**2096 MCM**

Issues: Dependency of Ground Water Irrigation, Intensive Ground Water Development, Declining trend of water level. Second Aquifer Group & part of First Aquifer Group has inferior ground water quality in terms of salinity.

4. Chemical quality of ground water and contamination

S. No.	Constituents	Minimum	Maximum
1.	pH	7.72	8.50
2.	EC µS/cm at 25 ºC	1800	4500
3.	CO_3 mg/l	nil	60
4.	HCO_3 mg/l	500	842
5.	Cl mg/l	99	675
6.0	F mg/l	0.38	4.15
7.	NO_3 mg/l	7.5	320
8.	SO_4 mg/l	150	1120
9.	SiO_2 mg/l	23	31
10.	PO_4 mg/l	nd	nd
11.	TH (as $CaCO_3$) mg/l	300	1150
12.	Ca mg/l	32	212
13.	Mg mg/l	51	199
14.	Na mg/l	267	833
15.	K mg/l	3.2	52

Heavy metals: Cu.nd-0.095, Zn 0.607-1.01 Fe0. 0.18-4.39 and Mn 0.066-0.21mg/l SAR 5.64-10.63 C3S1, C4S2, , C4S3.

All the chemical constituents are within permissible limit .

EC is higher in the entire block and F is higher (4.15 mg/l) at Biswan. First Aquifer is partly fresh and Second Aquifer Group is Saline.

5. Ground water resource enhancement & Demand side interventions:

Surface water available for harvesting Runoff

Area Sq.km	Average Monsoon Rainfall (mm)	Runoff coefficient % (utilizable rainfall)	Utilizable runoff Water (MCM)	Runoff used for storage/ Recharge/ other interventions after excluding committed component(MCM
a	b	c	d (axbxc/10^5)	50% of d
290.56	667	15	25.81 (2581 ham)	12.90

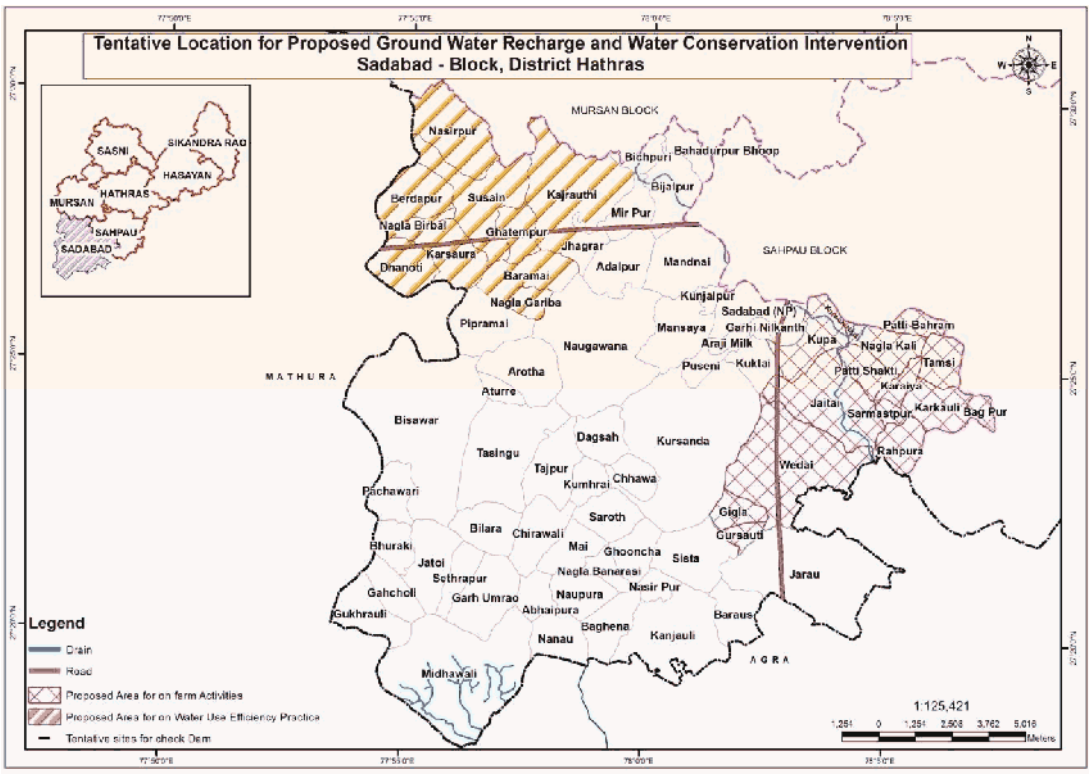
Volume of unsaturated aquifer zone available for recharge: 890 MCM

- Ground water resource enhancement & Demand side interventions are tabulated below and tentative proposed Plan shown in Figure below**.**
- In addition, blending of water with First and /or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline ground water may be put in canal to enhance supply in canal so water can reach upto tail ends.

Feasible Artificial Recharge & Water Conservation structures/ activities	Tentative Design	Quantity (nos. or area in ha)	Total runoff available (ham)	Total volume considering 4 times filling annually (ham)	Tentative unit cost (in Rs lakh)	Total tentative cost (in Rs lakh)	Expected benefits through implementation of plan (considering 80% of total storage)		
							Expected Annual GW recharge (ham)	Provision for supplemental irrigation, saving of GW draft (ham)	Expected conservation of ground water through efficiency enhancement measures (ham)
	a	b	c	d	e	f	40% of d	d	e
Recharge structures/ activities									
Masonry Check dams (~ 1ham capacity)	Crest-10 -15 m; Height- 1 to 2 m	0		0	10	0.00	0	0	
Drain/stream development (Length in km x 10 to15m x 1.5m)	Widening of channel upto 10-15m (Avg 12m) and 1.5m deepening	0		0	0.5/1000 m3	0	0	0	
Nala bunds/ Gabion (~0.75ham capacity)	Width: 5 to 15 m and 1 to 1.5 m height	5		15	2	10.00	6	6	
Revival, repair of water bodie with Recharge well	Average area 0.30 ha x3m); deepening by 0.5m	193		696	3.5	675.50	278.4	278.4	
Total				**711**	**15.5**	**685.5**	**284.4**	**284.4**	**0**
Water Conservation Activitie									
On farm activities (proposed in 15% of total catchment area) (in ha)		4141			0.14/ha	579.74	414.10		99.38
Sprinkler/ drip/ HDPE pipes for 3500 ha select area		4075			0.60/ha	2445.0			586.80
Total						**3024.74**	**414.1**	**0**	**686.184**
Grand Total							**698.5**	**284.4**	**686.2**
5% Provision for O & M						185.51		284.4+686.2= 970.58	
5% provision for Impact Assessment						185.51			
Grand Total						4081.26			

Projected Impact on Status of Groundwater Resource & Development Impact

Net G.W. Availability (Ham)	Additional Recharge from RWH & Recharge (ham)	Total Net G.W. Availability after intervention (ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. (in %)
7336.59	698.50	8035.09	5926.01	970.58	4955.43	80.77	61.67



6.0 Aquifer Map and Management plan of Sikandra Rao Block Hathras District U.P.

1.0 Salient Information **Area: 265.18 sq km**

Population

Total: 2,04,403, Male: 1,07,490, Female: 9,6913 Decadal Growth rate: 17.1 %, Density: 771/sq km

Rainfall (2016)

The normal annual rainfall: 781.6 mm, Normal monsoon: 667.6 mm,

Normal non monsoon rainfall: 113.6 mm.

Annual Rainfall (2016): 615.8 mm

Monsoon rainfall (2016):581 mm Non-monsoon Rainfall (2016): 34.0 mm.

Agriculture and Irrigation 2015-16

The area of Rabi is 20766 ha, Kharif 15983 ha and Zaid 2373ha . Total Cropped area is 39122 ha. The principal crops of the areas are Pulses -36708ha, Wheat-17077 ha, Rice-6541ha, Barley -467 ha Millet- and 5916 ha .

Net sown area is 21995 ha and Gross cropped area 39122 ha with cropping intensity of 178%.

Net Irrigated area is 22043 ha and Gross Area Irrigated -38561ha with Irrigation Intensity-175%.

Net Irrigated area under groundwater is 16585 ha and net Irrigated area under surface water – 5458 ha .

The Canal length is 250 km. Govt. Deep tube wells are -43 number and private Shallow Tube well 8023.

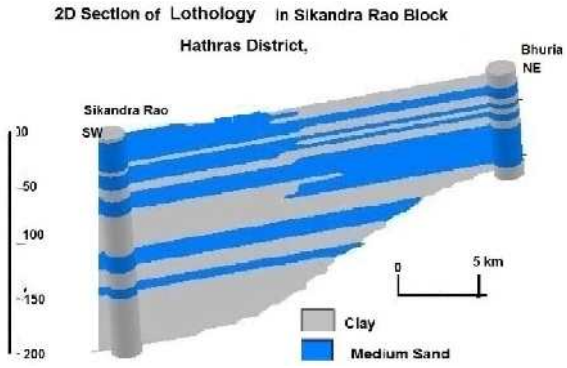
Water level behavior

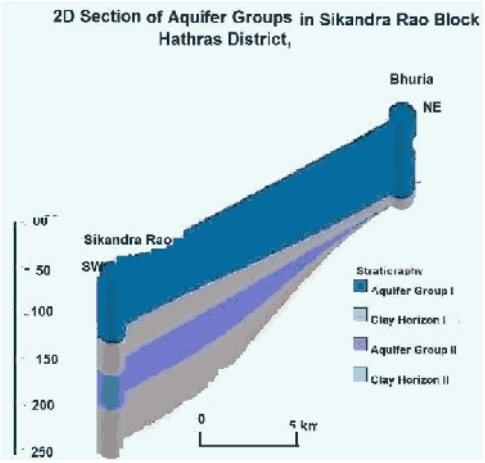
Six observation wells have been monitored. Depth to water level ranges between 3.61 to 13.86 mbgl during Pre monsoon-2017 and between 3.35 to 13.71 mbgl during Post monsoon 2017 with fluctuation of-0.01to 0.61 m. For the period of 2004-13, Pre monsoon declining trend is 4.43 cm/year. Due to lack of data piezomteric head is not available. However from few wells of district, it is 20 m bgl.

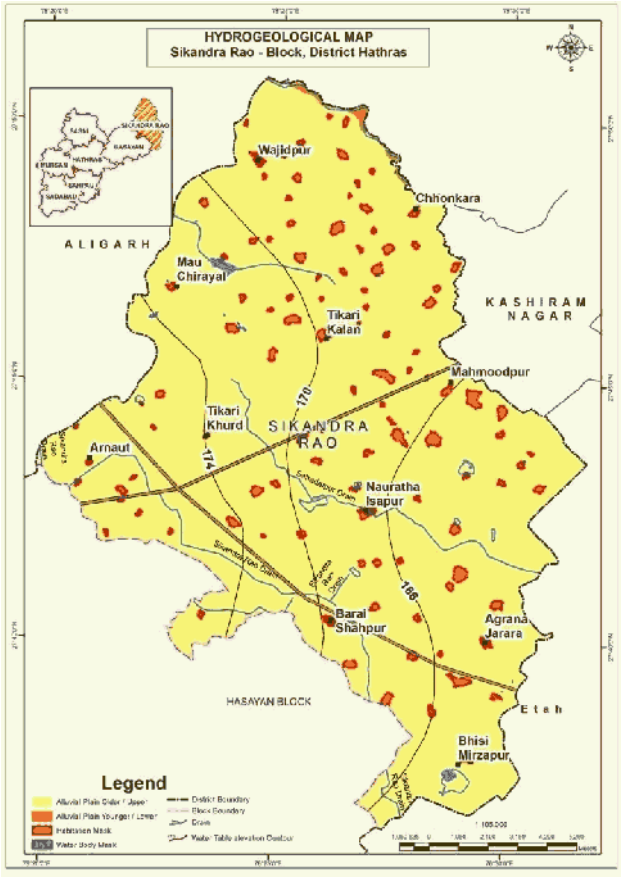
2 Aquifer Disposition, Number of aquifers

First Aquifer Group Second Aquifer Group

The area falls in interfluvial tract of Central Ganga plain. The area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar. Ground water occurs under water table condition at shallow depths while the deeper aquifer is under confined state of disposition where the confining layers are impermeable clay beds. Average Thickness of aquifers group-I is 76 m bgl with thickness of granular zone of 37 m and percentage of granular is 49. Limited data of aquifer group- II is available. Aquifer group- II exists between 105-300 mbgl with average thickness of aquifer is 195 m. The granular of zone in this group is 58 m thick with percentage of granular materials is 30. 2D lithological section and aquifer disposition and hydrogeological maps are shown in Figures below.







3. Ground water resource, extraction, contamination and other issues

Aquifer wise Ground Water availability and extraction

A	**FIRST AQUIFER**	
1	**Dynamic Resources (Fresh)**	**124.0MCM**
2	**GW Draft ; Irrigation : 106.42 MCM** **Drinking &Industries: 3.57 MCM**	**109.99 MCM**
3	**Stage of Ground Water Development**	**: 89 %**
4	**Category**	**:Safe**
5	**Static Resources**	**820.0 MCM**
6	**Static Resources (Fresh)**	**82.0 MCM**
7	**Static Resources (Saline)**	**0 MCM**
8	**Total Resources Dynamic+ Static - (Fresh, 1+6)**	**944.0 MCM**
9	**Grand total Dynamic+ Static - (Fresh+ Saline, 7+8)**	**944.0MCM**
B	**SECOND AQUIFER**	
10	**Static Resources (Fresh)**	**0**
11	**Static Resources (Saline)**	**1482 MCM**
9	**Grand Total GW Resources (First Aquifer+ Second Aquifer, 9+10+11)**	**2426.0 MCM**

Issues: Dependency of Ground Water Irrigation, Intensive Ground Water Development. Second Aquifer Group has inferior ground water quality in terms of salinity.

4. Chemical quality of ground water and contamination

S. No.	Constituents	Minimum	Maximum
1.	pH	8.00	8.26
2.	EC µS/cm at 25 ºC	457	1840
3.	CO_3 mg/l	Nil	Nil
4.	HCO_3 mg/l	171	537
5.	Cl mg/l	14	156
6.	F mg/l	0.6	1.06
7.	NO_3 mg/l	2.7	130
8.	SO_4 mg/l	25	132
9.	SiO_2 mg/l	27	32
10.	PO_4 mg/l	nd	nd
11.	TH (as $CaCO_3$) mg/l	150	320
12.	Ca mg/l	36	56
13.	Mg mg/l	14	44
14.	Na mg/l	34	258
15.	K mg/l	4.9	54

Heavy metals: Cu nd-0.01, Zn 0.218-1.058 Fe 0.0.162-1.383 and Mn 0.018-0.169mg/l SAR 1.21-6.83 C2S1,C3S1 and, C3S2.

All the chemical constituents are within permissible limit .

In general Ground water is suitable for Drinking and irrigation. Second Aquifer Group is Saline.

5. Ground water resource enhancement & Demand side interventions:
Surface water available for harvesting Runoff

5.0 Ground water resource enhancement & Demand side interventions:

Block is safe showing no significant declining trend of water level hence no intervention is required. However, on farm activities and Water Use Efficiency practices are recommended. Since net sown area and net irrigated area is nearly equal, no further ground water development is required. The contribution of ground water for irrigation in this block is 75.2%. So surface water irrigation system should be planned and effectively be implemented by increasing the canal network, which will help in reducing the stress on Ground Water withdraw directly as well as recharge of ground water . In addition blending with First and /or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline

ground water may be put in canal to enhance supply in canal so water can reach upto tail ends

7. Aquifer Map and Management plan of Hasayan Block Hathras District U.P.

1.0 Salient Information **Area: 327.40 sq km**

Population

Total: 200164, Male: 106211, Female: 93953 Decadal Growth rate: 19.0 %, Density: 611

/sq km

Rainfall (2016)

The normal annual rainfall: 781.6 mm, Normal monsoon: 667.6 mm,

Normal non monsoon rainfall: 113.6 mm.

Annual Rainfall (2016): 615.8 mm

Monsoon rainfall (2016):581 mm Non-monsoon Rainfall (2016): 34.0 mm.

Agriculture and Irrigation 2015-16

The area of Rabi is 24292 ha, Kharif 19054 ha and Zaid 12543 ha . Total Cropped area is 45889 ha.

The principal crops of the areas are Pulses -45217ha, Wheat-20162 ha, Rice-10607 ha, Barley -474 ha and Millet- 7239 ha .

Net sown area is 24754 ha and Gross cropped area 45889 ha with cropping intensity of 185%.

Net Irrigated area is 24292 ha and Gross Area Irrigated -42682ha with Irrigation Intensity-176%.

Net Irrigated area under groundwater is 19239 ha and net Irrigated area under surface water – 5053 ha .

The Canal length is 18 km. Govt. Deep tube wells are -32 number and private Shallow Tube well 4989.

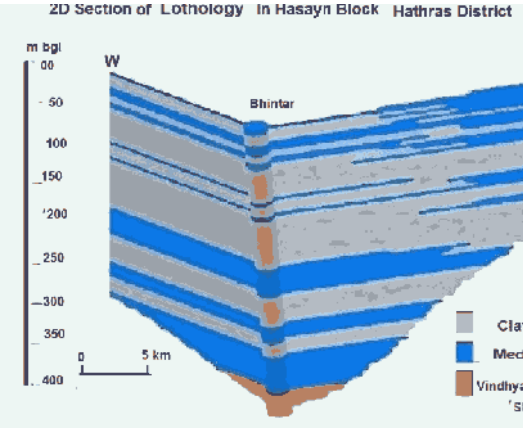
Water level behavior

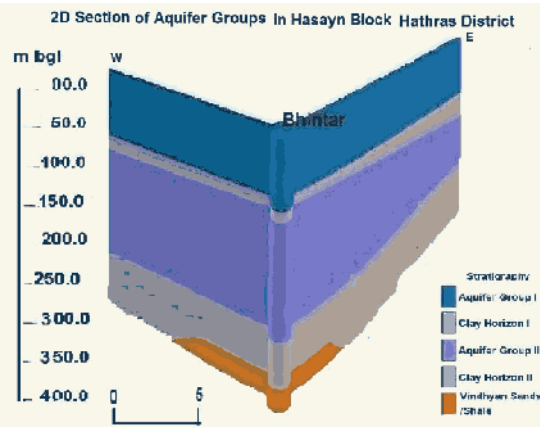
Seven observation wells have been monitored. Depth to water level ranges between 4.02 to 6.55 mbgl during Pre monsoon-2017 and between 2.62 to 5.4 mbgl during Post monsoon 2017 with fluctuation of-0.28to 2.43 m. For the period of 2004-13, Pre monsoon declining trend is 4.78 cm/year and post monsoon rising trend of 24.86 cm/year. Due to lack of data piezomteric head is not available. However from few wells of district, it is 20 m bgl.

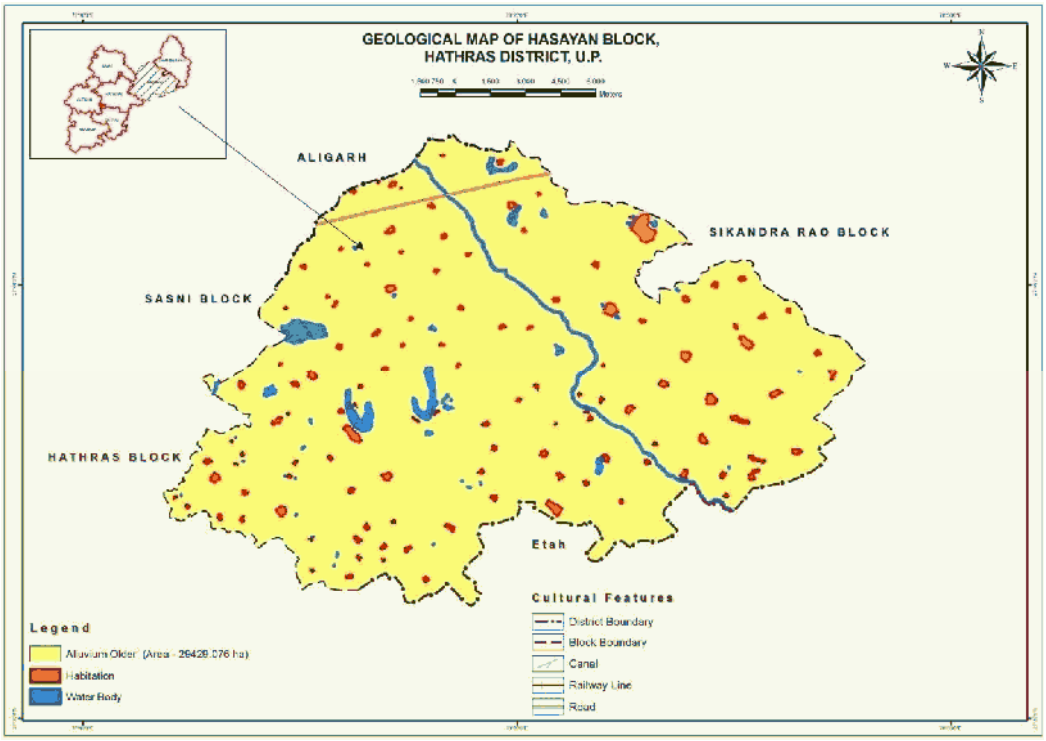
2 Aquifer Disposition, Number of aquifers

First Aquifer Group Second Aquifer Group

The area falls in interfluvial tract of Central Ganga plain. The area is underlain by moderately thick pile of quaternary sediments which comprises sands of various grades, clays and kankar. Ground water occurs under water table condition at shallow depths while the deeper aquifer is under confined state of disposition where the confining layers are impermeable clay beds. Average Thickness of aquifers group-I is 76 m bgl with thickness of granular zone of 20 m and percentage of granular is 27. Limited data of aquifer group- II is available. Aquifer group- II exists between 107&120-300 mbgl with average thickness of aquifer is 187 m. The granular of zone in this group is 58 m thick with percentage of granular material is 31. 2D lithological section and aquifer disposition and hydrogeological maps are shown in Figures below.







3. Ground water resource, extraction, contamination and other issues

Aquifer wise Ground Water availability and extraction

A	**FIRST AQUIFER**	
1	**Dynamic Resources (Fresh)**	**121 MCM**
2	**GW Draft ; Irrigation : 67.0 MCM** **Drinking &Industries: 4.0 MCM**	**71.0 MCM**
3	**Stage of Ground Water Development**	**: 59 %**
4	**Category**	**:Safe**
5	**Static Resources**	**538.0 MCM**
6	**Static Resources (Fresh)**	**538.0 MCM**
7	**Static Resources (Saline)**	**0 MCM**
8	**Total Resources Dynamic+ Static - (Fresh, 1+6)**	**538.0 MCM**
9	**Grand total Dynamic+ Static - (Fresh+ Saline, 7+8)**	**659.0 MCM**
B	**SECOND AQUIFER**	
10	**Static Resources (Fresh)**	**0**
11	**Static Resources (Saline)**	**1831.0MCM**
9	**Grand Total GW Resources (First Aquifer+ Second Aquifer, 9+10+11)**	**2426.0 MCM**

Issues: Dependency of Ground Water Irrigation, Intensive Ground Water Development, Declining trend of water level. Second Aquifer Group has inferior ground water quality in terms of salinity.

4. Chemical quality of ground water and contamination

S. No.	Constituents	Minimum	Maximum
1.	pH	7.7	8.53
2.	EC µS/cm at 25 ºC	410	1480
3.	CO_3 mg/l	nil	12
4.	HCO_3 mg/l	183	561
5.	Cl mg/l	14	163
6.	F mg/l	0.09	0.92
7.	NO_3 mg/l	nd	9321
8.	SO_4 mg/l	21	130
9.	SiO_2 mg/l	18	33
10.	PO_4 mg/l	nd	nd
11.	TH (as $CaCO_3$) mg/l	170	350
12.	Ca mg/l	16	96
13.	Mg mg/l	17	46
14.	Na mg/l	9.5	70
15.	K mg/l	3.3	8.3

Heavy metals: Cu nd-0.01, Zn 0.028-0.443, Fe 0.026-0.666 and Mn 0.004-0.14mg/l SAR 0.32-3.95 C2S1, and,C3S1 .

All the chemical constituents are within permissible limit .

In general Ground water is suitable for Drinking and irrigation. First Aquifer group is fresh and Second Aquifer Group is Saline.

5. Ground water resource enhancement & Demand side interventions:
Surface water available for harvesting Runoff

5.0 Ground water resource enhancement & Demand side interventions:

Block is safe showing no significant declining trend of water level hence no intervention is required. However, on farm activities and Water Use Efficiency practices are recommended. Since net sown area and net irrigated area is nearly equal, no further ground water development is required. The contribution of ground water for irrigation in this block is 79.2%. So surface water irrigation system should be planned and effectively be implemented by increasing the canal network, which will help in reducing the stress on Ground Water withdraw directly as well as recharge of ground water . In addition blending with First and /or second aquifer water is proposed for irrigation. Limited and controlled quantity of Saline ground water may be put in canal to enhance supply in canal so water can reach upto tail ends.