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जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report

on

AQUIFER MAPPING AND MANAGEMENT PLAN

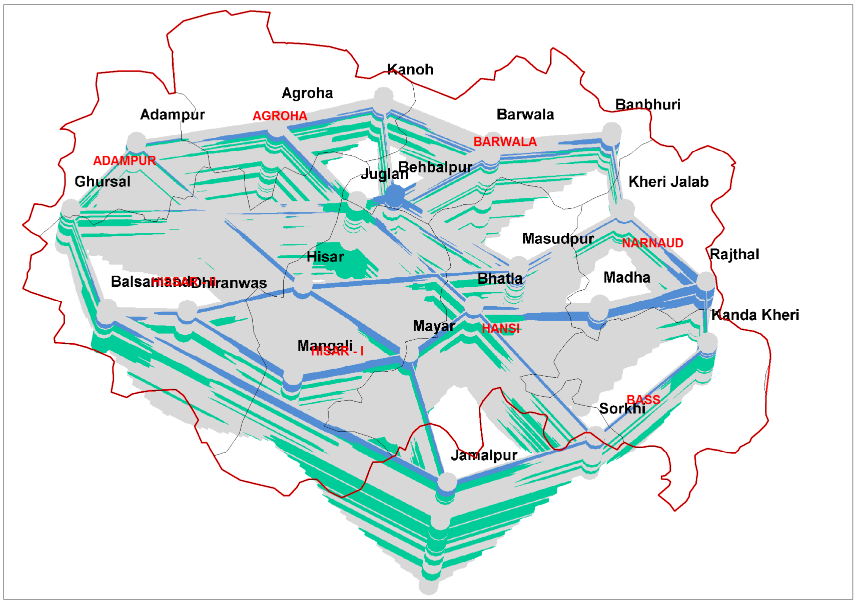
Hissar District, Haryana

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

राष्ट्रीय जलभृत मानचित्रण एवम प्रबंधन योजना

हिसार जिला, हरियाणा



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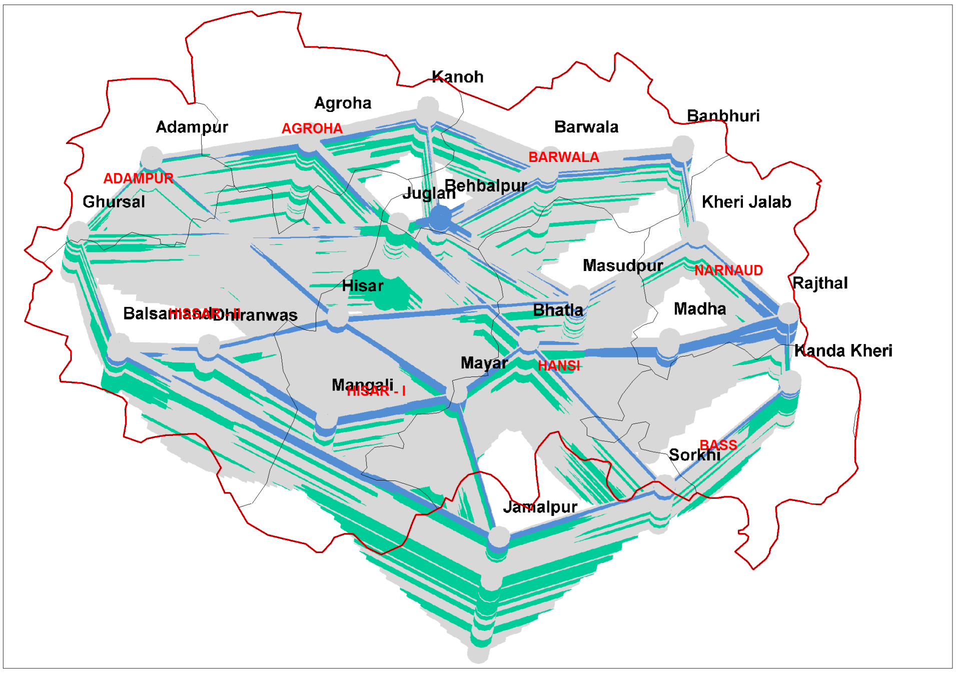
भारत सरकार

मार्च, 2017

AQUIFER MAPPING AND MANAGEMENT PLAN IN HISAR DISTRICT, HARYANA STATE



Central Ground Water Board
North Western Region, Chandigarh
Ministry of Water Resources, River Development & Ganga Rejuvenation
Government of India
March, 2017

AQUIFER MAPPING AND MANAGEMENT PLAN

HISAR DISTRICT

(3860 Sq. Km)

[PART-I: District Technical Report]

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1.0 INTRODUCTION

1.1 Introduction and Physiographic setup:

Hisar is the west central most district of Haryana State with a total geographical area of 3860 sq. km and it lies between the North latitudes 28° 56' 00" to 29° 38' 30" and East longitudes 75° 21' 12" to 76° 18' 12". Hisar district is one of the 21 districts of Haryana state, India. Hisar city serves as the district headquarters. Hisar is one of the five cities belonging to Indus Valley Civilization.

As of 2011 it is the second most populous of the 21 districts of Haryana, after Faridabad. Hisar is also known as the steel city because of the Jindal Stainless Steel Factories. It is also the largest producer of galvanized iron in India.

The 2011 census the district had a population of 1,742,815 and gave it a ranking of 276th in India out of a total of 640 districts. The district has a population density of 438 inhabitants per square kilometer. Its population growth rate over the decade 2001-2011 was 13.38%. Hisar has a sex ratio of 871 females for every 1000 males and a literacy rate of 73.2%. Haryanvi is the most spoken dialect in the district. Hisar is 98% Hindu, only about 40,000 are Muslims rests are mostly Jain and Sikhs.

The district is under control of Hisar division and administratively divided into nine community development blocks namely Agroha, Adampur, Barwala, Bass (Hansi-II), Hansi-I, Hisar-I, Hisar-II, Narnaund, and Uklana Mandi. The district has 05 towns namely Hisar, Hansi, Narnaund, Barwala and Uklana and 269 villages.

1.2 Hydrology and Drainage network:

The district falls in Ghaggar basin of Indo-Gangitic plains. The area is traversed by two artificial drains which are confined in Bass, Hansi-I, Narnaund and Barwala blocks. There are a total of 39 drains existing in the area, which run for a distance of 126.25 km. The satellite based interpretation drainage map of Haryana state and Hisar district drainage system are shown in below (Fig-1) (Source-Remote sensing Data).

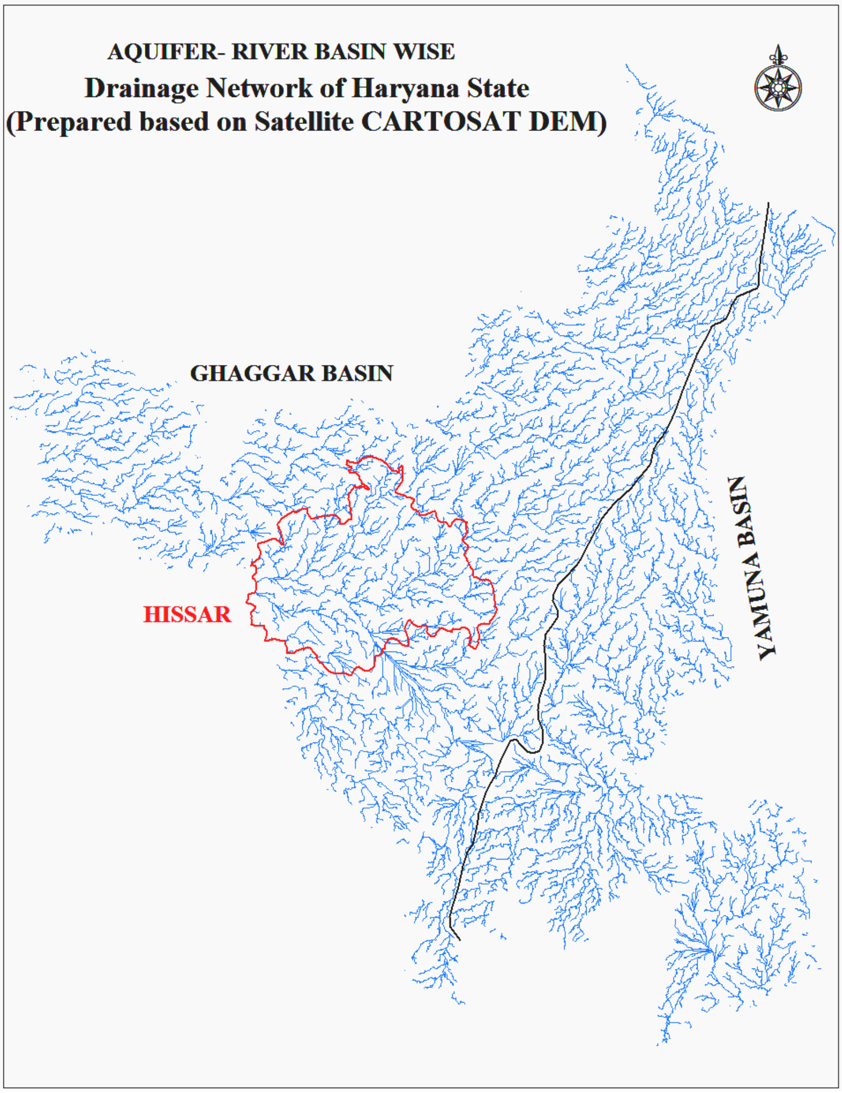


Fig-1: Drainage Network information in Hisar district & Haryana state

There is no major river in the district yet there is a good network of canal irrigation system. The district is located in the arid zone of the State. Rainfall is scanty and unreliable. The sub soil water is deep and unfit for irrigation in most parts of the district. This uncertainty of rainfall necessitated the development of irrigation through artificial sources of irrigation like canals and tube-wells. The area is irrigated by shallow tube wells and network of Bhakra Canal Systems and Western Yamuna Canal Systems. The main canals are the Fatehabad branch of Bhakra Canal, Barwala Branch, Balsamandh and Pabra Sub-branch of Barwala Link and Sirsa branch from Bhakra Main Line, Hisar major distributary and Deosar feeder of Western Yamuna canal System through Hansi branch. Canals are irrigating about 76.83 % (209000 ha) of the area, 23.17 % (63000 ha) is irrigated by ground water. There are sand dunes in canal command area, over which rain fed crops are grown. A total of 269 villages of the district come under Canal Irrigation System. The Irrigation Canal network map of the Hisar district is shown below map (Fig-2) (Source-Irrigation dept., Haryana).

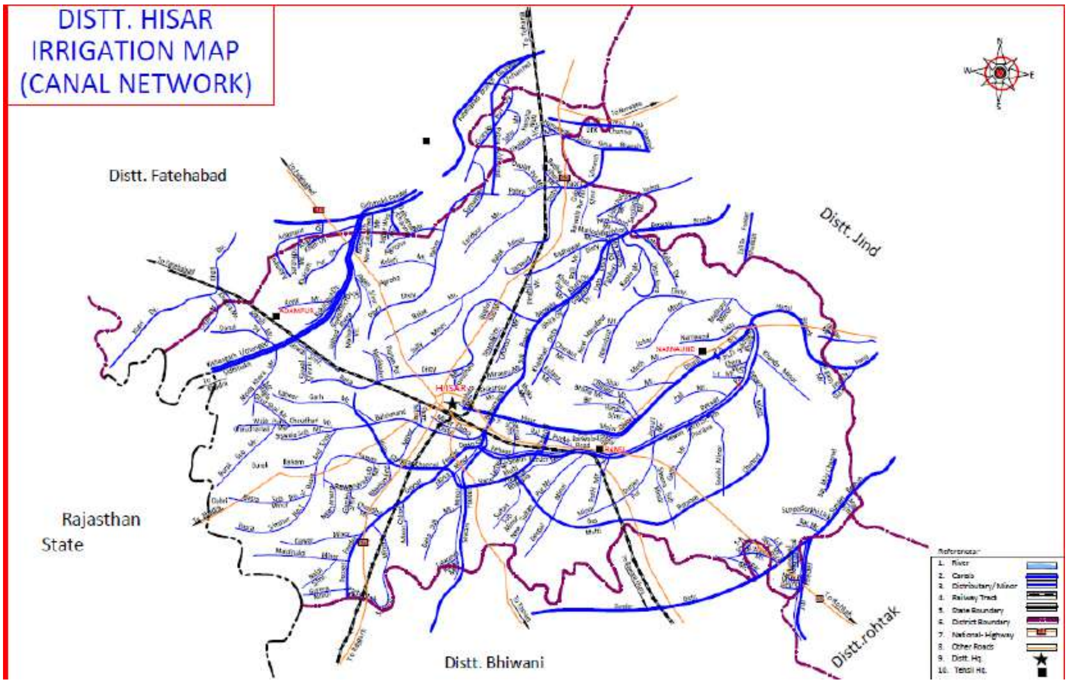


Fig-2: Canal Network of Hisar district

1.3 Agriculture and Cropping patterns:

The district area is irrigated by shallow tube wells and of Bhakra Canal network system. Crop rotation is the planting of different crops in recurring succession in the same field. Hisar district has the major crop rotations of Paddy/Other Crops Fallow/Other Crops-Fallow-Moong-Veg. and Cotton/ Wheat/ Other Crops-Fallow-Moong-Veg. occupy 22.33%, 20.04% areas respectively based on three seasons viz. Kharif, Rabi and Summer (table-1) (Source-HARSAC Publication).

S. No.	Crops	Area (00'h)	Area%
1.	Cotton	1167.52	30.22
2.	Bajra	629.84	16.30
3.	Paddy	293.67	7.60
4.	Other	1552	40.18
5.	Fallow	220	5.70
6.	**Total**	**3863.03**	**100.00**

Table-1: ***Kharif Season Cropping Pattern***

Crops	Area (00'h)	Area %
Moong	58.85	12.58
Vegetables	28.39	6.07
Other Crops	38.2	8.16
Fallow	342.49	73.19
Total	**467.93**	**100.00**

Table-2: Summer Season Cropping Pattern

1.4 Rainfall and Climate:

The climate of Hisar owes to its continental location on the outer margins of the south-west (SW) monsoon region. It has tropical monsoonal climate and is characterized as arid type of climate. The district has characteristically four seasons during the year viz., Summer (March to May), SW Monsoon (June to September), Post-Monsoon (October to November) and Winter (December to February) season. SW monsoon also known as summer monsoon brings rain during last week of June to mid-September. The period from October onward until next June remains almost dry except, few light showers received due to westerly depressions/western disturbances (WDs). The summers are generally quite hot and winters are fairly cool. The main characteristics of climate in the district are its dryness, extremes of temperature and scanty rainfall.

The normal annual rainfall of the district is 330 mm which is unevenly distributed over the area 22 days .Around 75 to 80 per cent of the annual rainfall is received during South West Monsoon season (June to September) with 50 per cent coefficient of variation (CV). The average annual rainfall is around 450 mm, of which the average monthly rainfall received during July and August months is 133.4 and 116.2 mm, respectively. The average monthly rainfall during September is 54.5 mm and June 49.8 mm. The average rainfall received during normal monsoon season is 283 mm. Generally rainfall in the district increases from southwest to northeast (table-2) (Source-IMD Data).

Normal Annual Rainfall	330 mm
Normal Monsoon Rainfall	283 mm
Temperature Mean Maximum Mean Minimum	 43°C (May & June) 5°C (January)
Normal Rainy days	22

Table-3: Meteorological data of Hisar district

1.5 Soils:

The soils of the district are of three types i.e. Arid brown solonized (in north eastern parts covering north eastern part of Narnaund and Uklana Mandi blocks.), Sierozem (in major parts covering Barwala, Hansi-I, Bass (Hansi-II), Hisar-I & Agroha blocks and parts of Uklana, Narnaund, Adampur & Hisar-II blocks) and desert soils (in southern western parts covering part of Adampur and Hisar-II blocks). 81% of the total district i.e 327000 ha area occupied and layered with Sandy loam soils, these are useful for macro and minor irrigations in this area.

1.6 Geomorphology:

The geomorphology of Hisar district is classified into two major categories they are fluvial origin and Aeolian origin landforms. The fluvial originated landforms existed in this district are older deep alluvial plains, palaeo-channels etc and the other landforms i.e dune complex, eolian plain deep, interdunal flat and sand dunes fall under eolian originated landforms. The details of landforms of the Hisar district are shown in the below map (Fig-3) (Source-NRSC-ISRO Thematic Data).

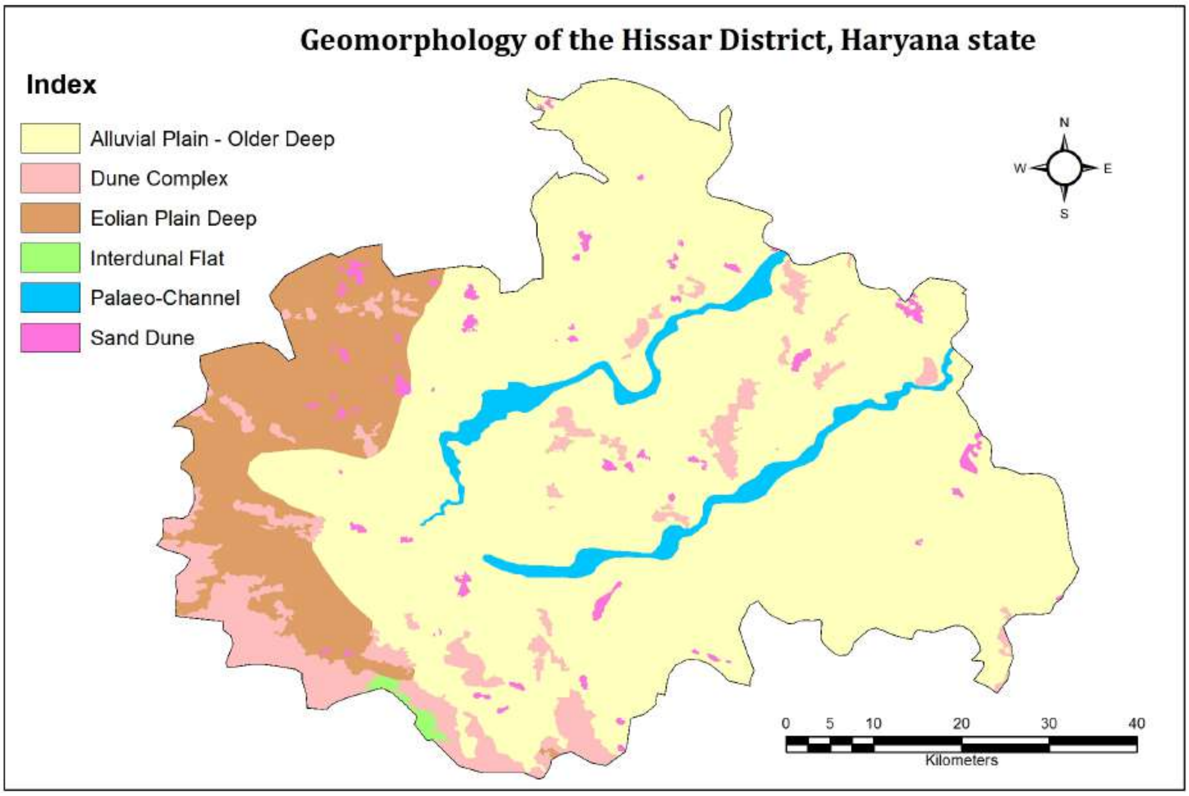
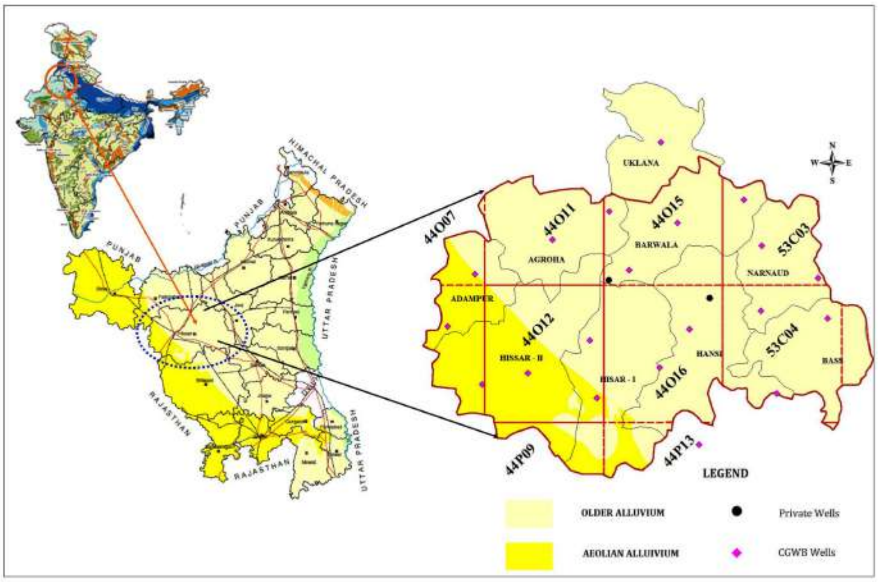


Fig-3: Geomorphology of Hisar district, Haryana state

1.7 Physiography/DEM:

The general altitude of the area varies from 203 to 225 m amsl and having a gentle slope towards south-westerly direction. The district covered survey of India toposheet information 44 O/7, O/8, O/11, O/12, O/14, O/15, O/16, 44 P/9, P/13, 53 C/3, C/4. Physiographically, the district is characterized by two distinct features i.e. upland plains and Sand dune clusters. Base map of the Hisar district that includes location accessibility, toposheet information, district, block head quarters information, road network and general geological, Hydrogeological information are shown in detailed below map (Fig-4) (Source-CGWB & NRSC-ISRO Thematic Data).



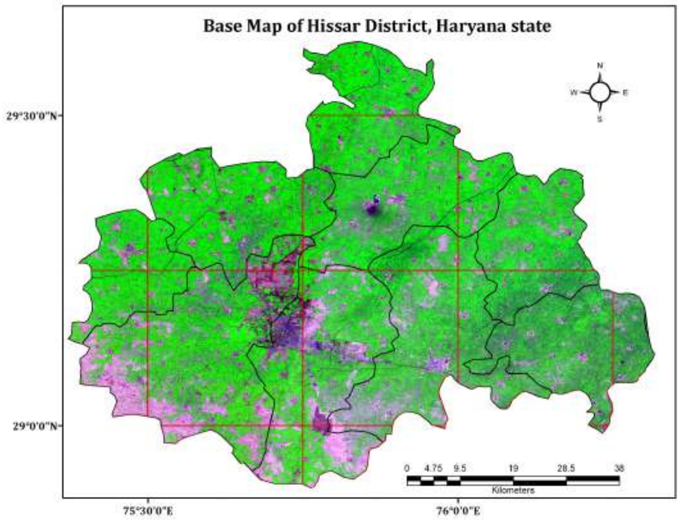


Fig-4: Base Map of the Hisar district, Haryana state (NCC Satellite image)

1.8 Land Use:

Land use and Land cover of the study area are prepared based on the visual interpretation of satellite data and toposheets. The major land use class in this district is agricultural crop land, plantation and fallow type agricultural type and other land use classes observed in this district are build up rural and rural areas, forest area, barren land classes. The detailed land use classes of Hisar district is shown in the below map (Fig-5) (Source-NRSC-ISRO Thematic Data).

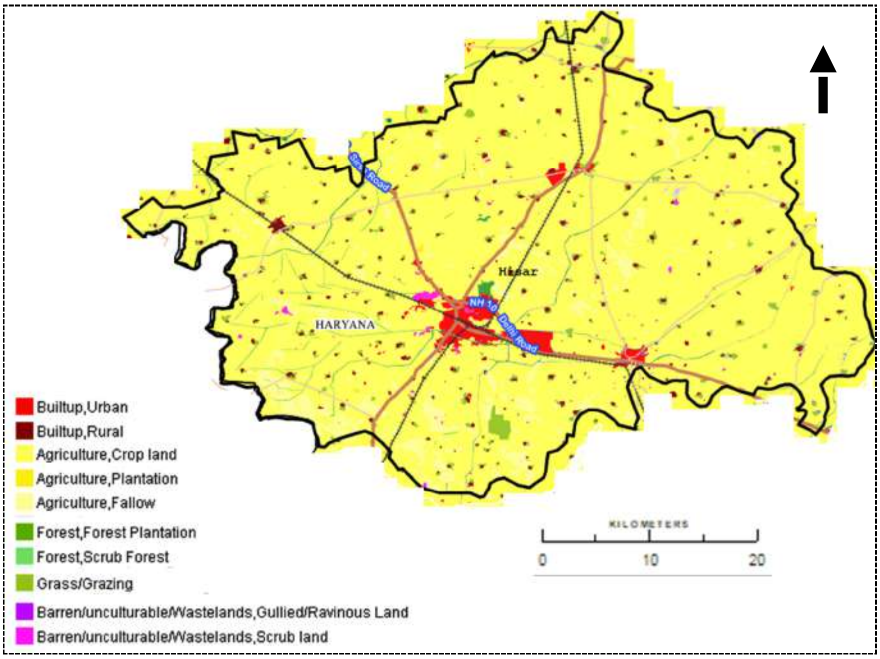


Fig-5: Land Use and Land Cover Map of Hisar district, Haryana state

1.9 Prevailing water conservation/recharge practices:

The district has 705 village ponds and those can be utilized for water conservation in each village. The State government had a few projects taken up for such conservation, management and utilization of waste water. Their block-wise distribution as follows and satellite based interpreted village ponds of the district of Haryana state are shown synoptically in the below figure (Fig-6). The three multipurpose irrigation projects namely Hisar – Ghaggar Multipurpose Channel, Bass. Multipurpose Channel & Hansi Multipurpose Channel are being taken up by the Irrigation Department. The main purpose of these multipurpose channels is to store rain water and flood water and seepage from the field in water logged areas and to irrigate the area of its command (Source-Remote Sensing Data).

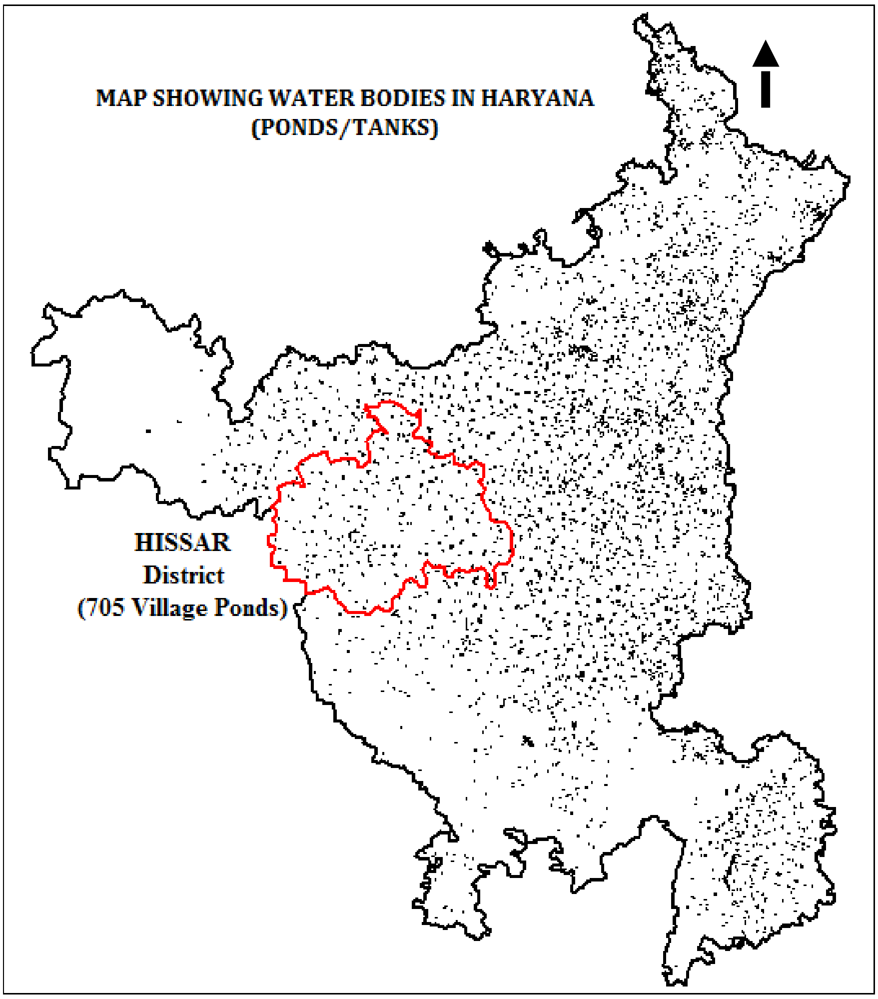


Fig-6: Scattering of Village ponds in Hisar district & Haryana state

Artificial recharge structures may help in balancing water levels at long term recharge. Recharge Trench with injection well structures are suitable artificial recharge structures at some areas. Water conservation methods like change in cropping pattern, change in Irrigation policy, lining of unlined channels, timely plantation of paddy, promotion of sprinkler and drip irrigation etc. may be adopted to overcome the ground water declining conditions in any area.

1.10 Objective:

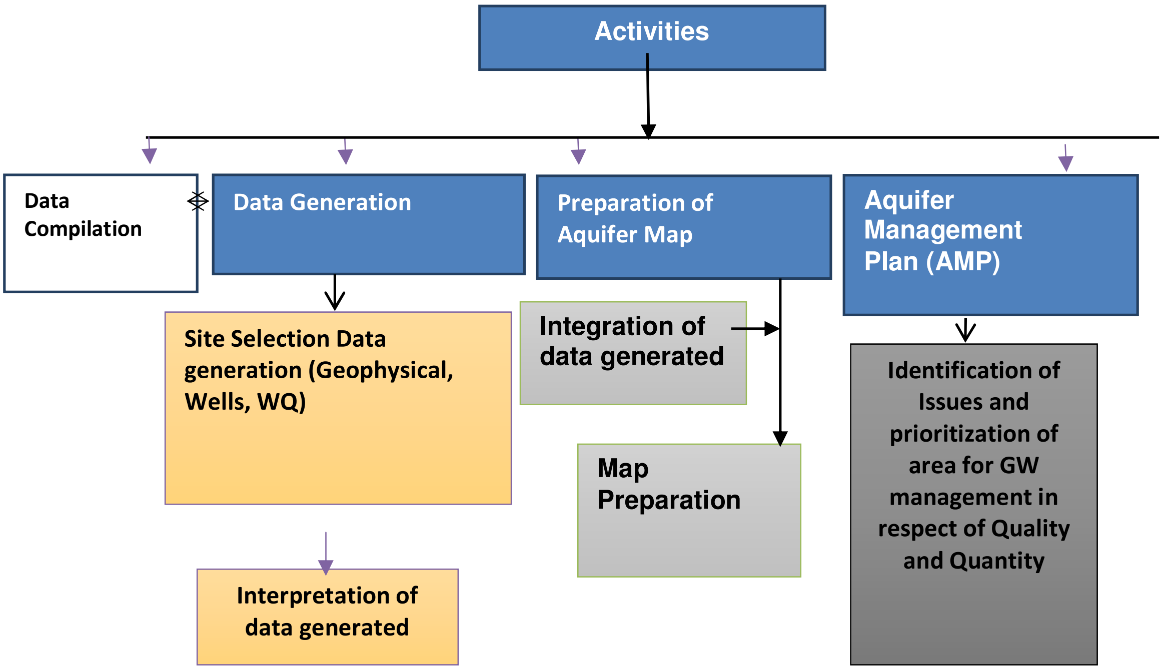
The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. This is an activity where the government and the community work in tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

1.11 Scope of the Study:

Systematic mapping of an aquifer encompasses a host of activities such as collection and compilation of available information on aquifer systems, demarcation of their extents and their characterization, analysis of data gaps, generation of additional data for filling the identified data gaps and finally, preparation of aquifer maps at the desired scale. This report attempts to evolve uniform protocols for these activities to facilitate their easy integration for the district as whole.

1.12 Methodology:

National Aquifer Mapping Programme basically aims at characterizing the geometry, parameters, behaviour of ground water levels and status of ground water development in various aquifer systems to facilitate planning of their sustainable management. The major activities involved in this process include compilation of existing data, identification of data gaps, and generation of data for filling data gaps and preparation of aquifer maps. The overall activities of aquifer mapping are presented in the flowchart below (Flowchart-1) (Source-NAQUIM manual).



Flowchart-1: Methodology of National Aquifer mapping project.

1.13 Data availability, Data adequacy and data gap analysis and data generation:

The district has been covered under Hydrogeological Studies and Geophysical Surveys (Hansi, Bass & Narnaund blocks) by the Central Ground Water Board. Besides, Ground Water Exploration has also been carried out at 11 sites exploratory wells including 02 slim holes and 15 piezometers. Under NAQUIM studies, Central Ground Water Board have carried out the ground exploration studies at village Thurana well site, (Hansi-II block) constructed to a depth of 100 m to know aquifer disposition system and also ground water quality issues in this district. The geophysical surveys also been conducted in two blocks of Hansi-I and Hansi-II (Bass) during 2004-05 under the project of conjunctive use of groundwater studies in Western Yamuna Canal command areas.

All datasets are sufficient to know the groundwater quality and aquifer delineation studies for district level itself but the information for block level aquifer delineation studies may not adequate so some more lithological datasets may be generated or acquired at 5*5 minute quadrant levels of each toposheet. At present consequently, the Private organization data was gathered from different agencies of Haryana, Chandigarh regions and PHED department of

Haryana state government. The litholog locations of CGWB wells and Private wells data are plotted together at block level 5*5 minutes quadrant interval on mapinfo software to see the datagap analysis at block level. Total 25 wells litholog information are collected from CGWB in-house and private agencies of Haryana, Chandigarh regions and lithologs of PHED, Govt. of Haryana data could not be accessed in this district. Under NAQUIM activity, additional three well-fields are proposed and will be constructed by outsourcing in the middle of 2B quadrant of each toposheet by constructing 3 sets of exploratory wells and observation wells in the depth range of 100 m to 300 m i.e (100 m, 200 m & 300 mts) for delineation of hydrogeological paraments and ground water quality in the area.

2.0 DATA COLLECTION AND GENERATION

2.1 Hydrogeological Data:

2.1.1 Geology of the area:

The district is occupied by geological formations of Quaternary age comprising of maximum area of older alluvium i.e Ambala formation belonging to the vast Indus alluvial plains and small part of western part of district is occupied with aeolian deposits. The shallow aquifers, which are unconfined in nature, are being tapped chiefly by shallow tubewells for irrigation. The deeper aquifers, which are underlained and over-lained by extensive impermeable clays with existence of saline groundwater. The geological formations of Hisar district is shown in below map (Fig-7) (Source-NRSC-ISRO Thematic Data).

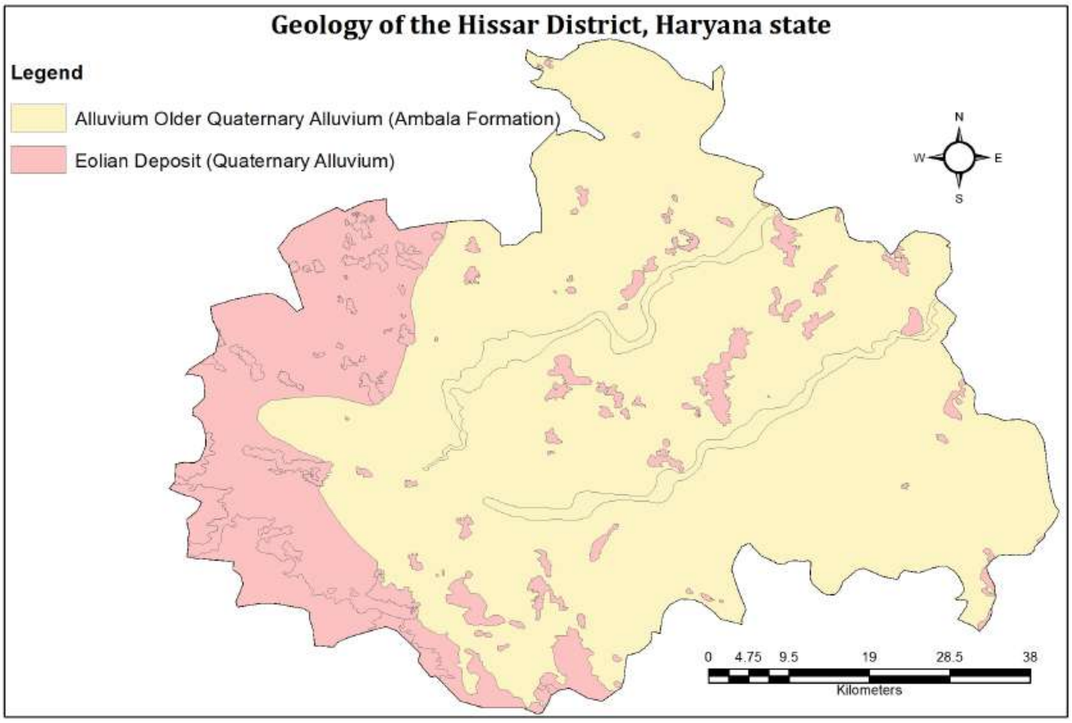


Fig-7: Geology of Hisar district, Haryana state.

2.1.2 Water Level Behaviour:

Depth to water level in the district ranges from 1.50 mbgl at Gurana (Hansi block) to 17.88 mbgl at Basra (Adampur block) during pre-monsoon 2016 and post-monsoon, 2016 water levels ranges from 2.10 to 16.76 mbgl in respective locations (Table-3). The depth to water level contour maps is generated for pre and post monsoon seasons for the entire district and water level fluctuations map are shown in following maps (Fig-8, Fig-9 and Fig-10) (Source-CGWB-RODC Data).

About 60% of the Ground Water Monitoring Wells are showing rising of water levels and remaining 40% shows declining in water levels. The water levels are declining seasonal fluctuation in south west part, north east part, south east and north western parts of the Hisar district. The water level data of pre and post-monsoon periods, 2016 and its seasonal fluctuations data for all Ground Water Monitoring Wells of Hisar district are given in Table-4.

Location	Longitude	Latitude	RL	Water level, 2016		Fluctuations
				May	Nov	
Adampur	75.479	29.271	208.0	4.11	3.97	**0.14**
Agroha	75.650	29.308	212.5	8.20	7.96	**0.24**
Balawas	75.822	28.958	216.0	14.52	13.34	**1.18**
Balsamand	75.492	29.075	209.3	13.52	14.32	**-0.80**
Barwala	75.921	29.371	220.7	9.42	8.93	**0.49**
Bas	76.200	29.108	224.0	3.87	3.80	**0.07**
Basra	75.525	29.217	208.7	17.88	16.76	**1.12**
Chanaut	75.921	29.208	214.9	5.13	3.84	**1.29**
Chaudhriwali	75.397	29.150	207.1	15.30	14.80	**0.50**
Chawdhariwas	75.600	29.008	210.1	9.19	9.30	**-0.11**
Dhansu	75.796	29.217	211.2	4.72	4.31	**0.41**
Gurana	75.967	29.300	226.0	1.50	2.10	**-0.60**
Hisar	75.717	29.154	268.0	7.42	7.47	**-0.05**
Juglan	75.794	29.257	217.0	3.40	3.26	**0.14**
Kheri jalab	76.071	29.325	220.0	8.46	8.34	**0.12**
Khot kalan	76.175	29.388	222.3	11.38	11.73	**-0.35**
Kirori	75.800	29.300	214.3	16.03	15.31	**0.72**
Kirtan	75.547	29.221	209.5	12.20	11.75	**0.45**
Mirka	75.758	29.075	193.0	3.34	3.66	**-0.32**
Mothmajri	76.096	29.208	217.0	10.81	11.08	**-0.27**
Narnaud	75.567	29.117	226.0	14.25	15.09	**-0.84**
Rajli cross	75.907	29.289	218.9	3.11	1.99	**1.12**
Rajthal	76.188	29.258	223.9	13.60	12.90	**0.70**
Samani	75.683	29.408	215.6	4.06	4.65	**-0.59**
Umra	75.913	29.053	213.4	6.22	6.47	**-0.25**

Table-4: Water level data (2016) CGWB-GWMS in Hisar district

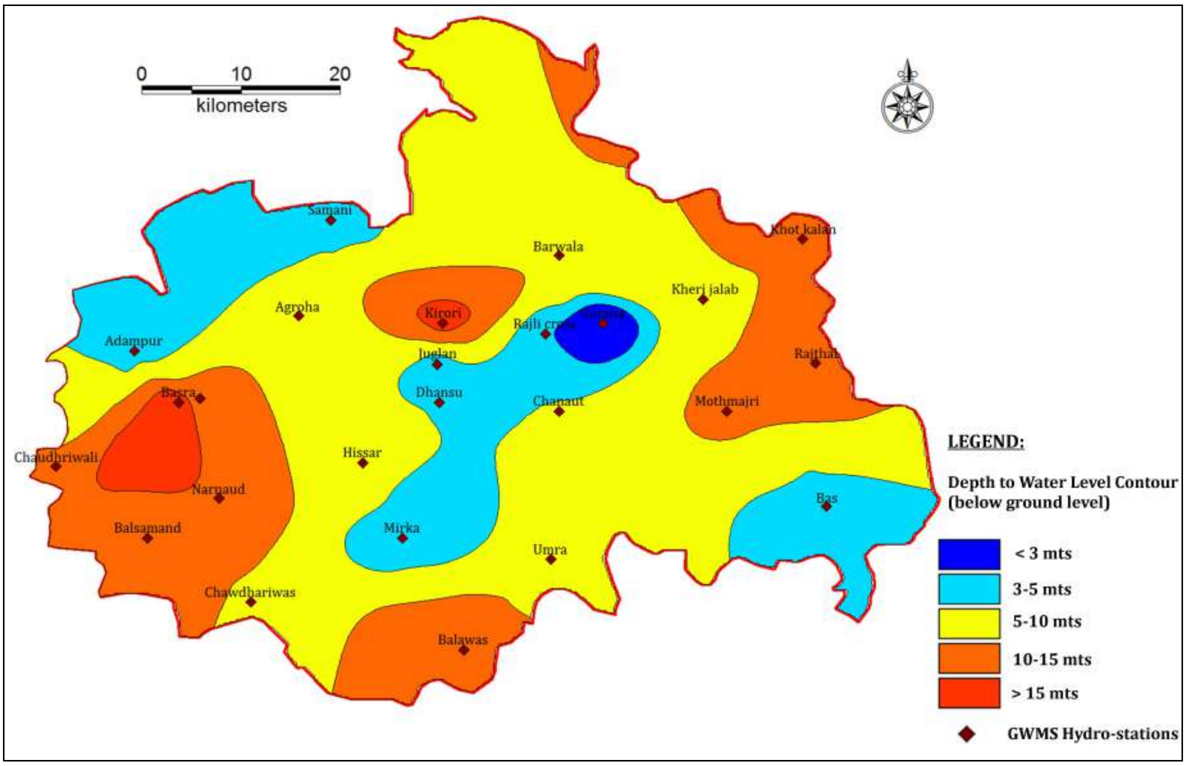


Fig-8: Depth to water level map of Hisar district, Pre-monsoon, 2016

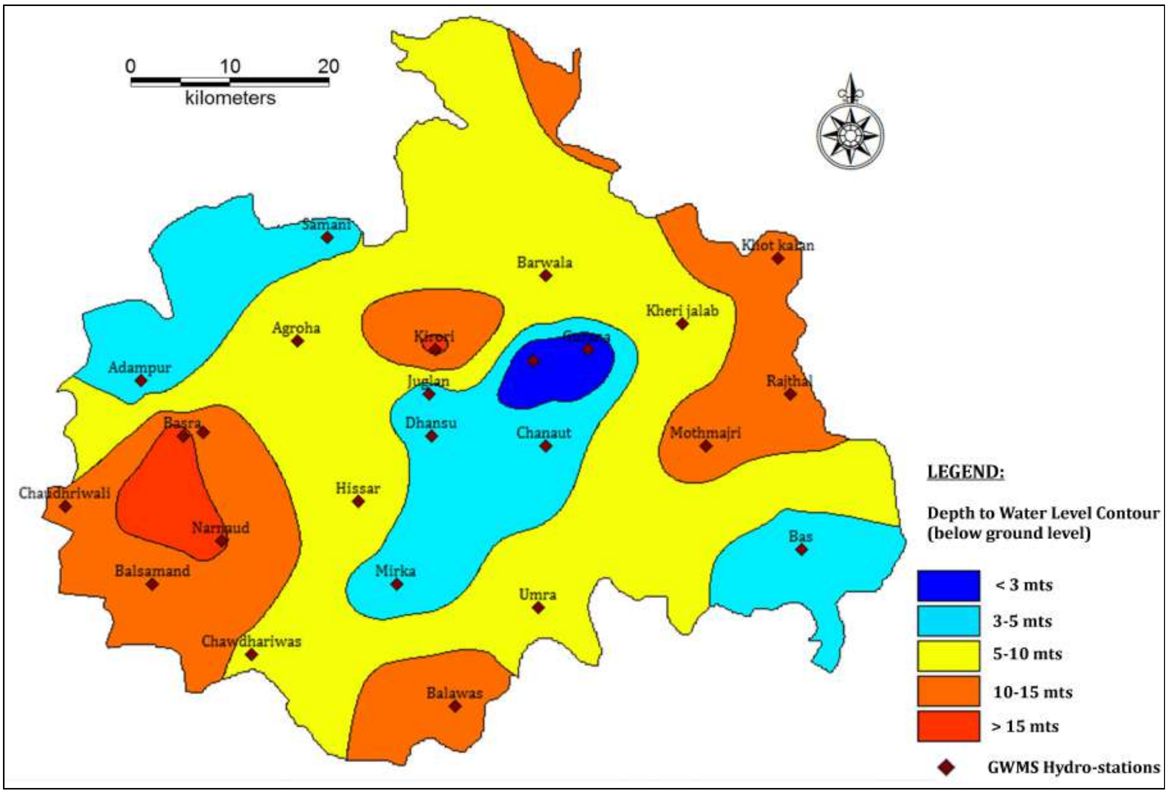


Fig-9: Depth to water level map of Hisar district, Post-monsoon, 2016

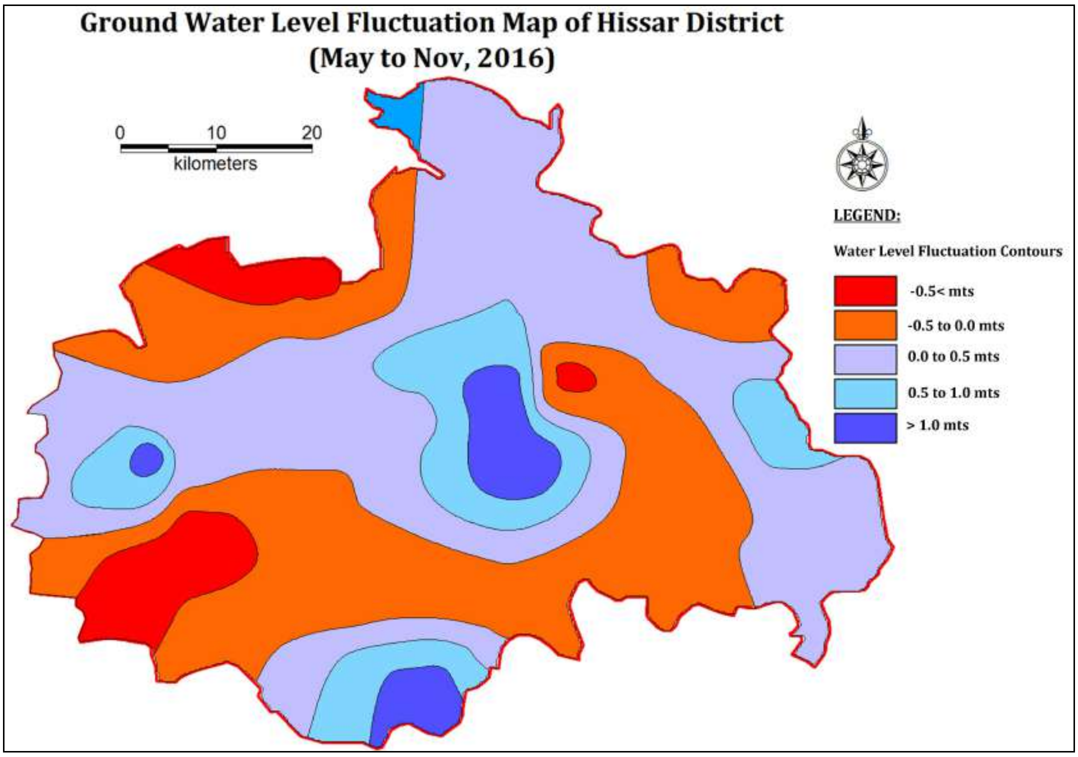


Fig-10: Ground Water level Fluctuation contour map of Hisar district

The long term trend in the water level reflected by water level hydrographs is indicative of the change in groundwater storage in phreatic zone with time. Maximum ground water monitoring stations show rising trend and this may be due to local hydrogeological conditions prevailing in the area. Whereas hydrographs of few GWMS show declining trend which may be due to over exploitation of ground water and these area require careful management of surface water and conjunctive use of surface water and ground water. For the rest of the stations, hydrograph neither indicate any substantial rise nor decline thus indicating that the storage (Dynamic) is being maintained at the normal level which is not disturbed by the present level of ground water development.

2.1.3 Ground water flow:

In general the ground water table varies from 203 to 225 m a.m.s.l. and the regional ground water flow direction is towards western side or southwestern of the district and it may be due to water divide or local hydrological conditions existence in the area (Fig-1 and Fig-11) (Source-CGWB-RODC Data).

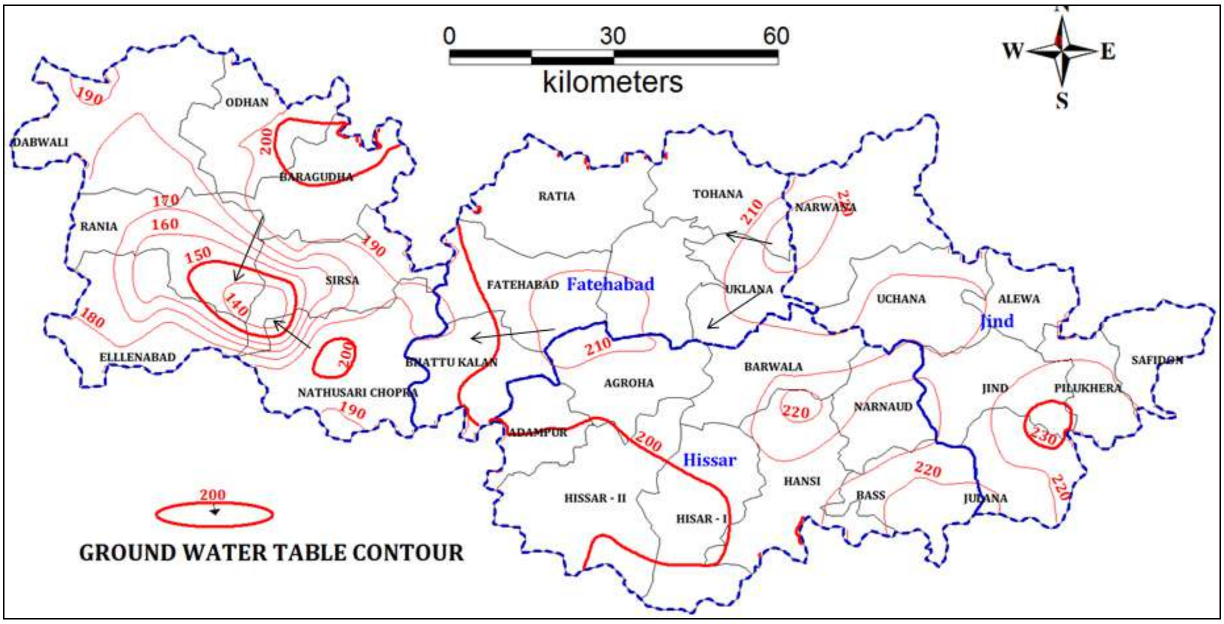


Fig-11: Ground Water Flow map of Hisar district (also neighboring districts)

2.1.4 Hydrograph/Trend:

The available hydrographs of long term monitoring stations in district are shown in below Fig-12 and found that there are no major fluctuations in the district (Source-CGWB-RODC Data).

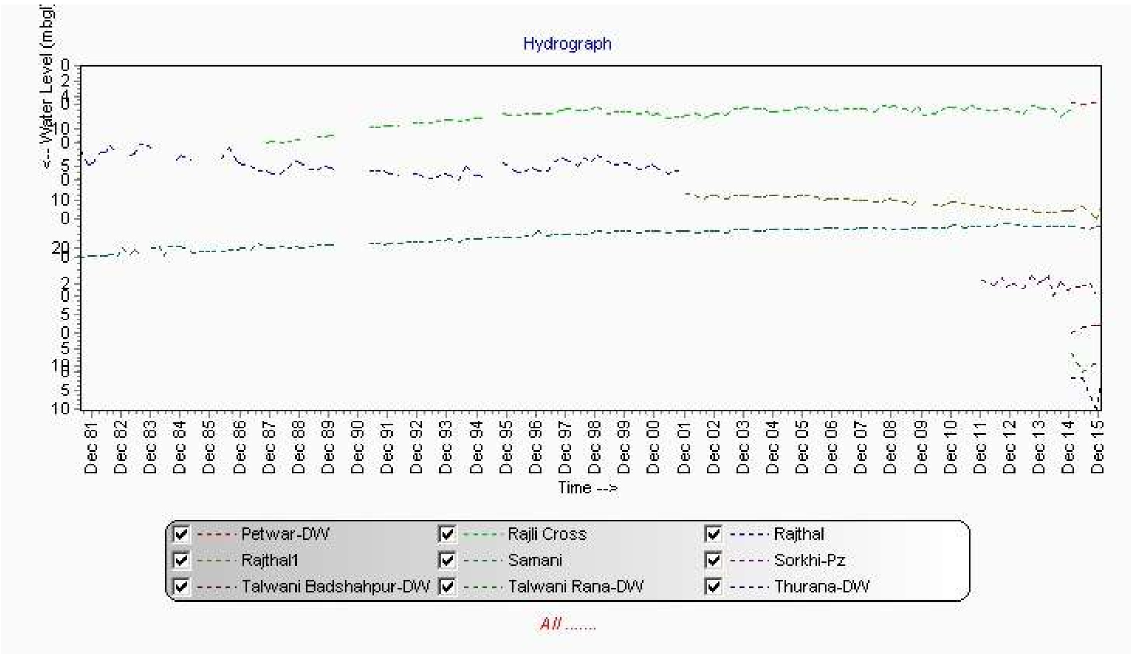


Fig-12: Long term Hydrograph chart of Hisar district

2.1.5 Pumping test data:

Under ground water exploration studies, 24 exploratory wells were constructed to indentifies granular zones disposition, its aquifer parameters like Transitivity (T), Storativity (S), Hydraulic conductivity (K) and also discharge/drawdown of wells (as per GWER-Haryana, 2004). Maximum 45% of the exploratory wells show the success in ground water exploration and remaining wells are abandoned due to salinity or bad quality issues encountering at different depths and hydrogeological conditions in the Hisar district. The available aquifer parameters are given in below table-5 (Source-CGWB Data).

District	Location of Exploratory wells	Depth drilled (mts)	Transmisivity (T) (m^2/day)	Storativity (S)	Discharge (Q) (lpm)	Lithology Type
Hisar	Madha	311	2440	--	1905	Sand. Clay Kankar
	Hayanpur	306	1500	$1.8*10^{-2}$	2090	Clay, Kankar, Sand
	Zalanla	344	350	$1.47*10^{-3}$	2336	Sand, Clay & Gravel
	Tibbi	366	1770	--	1852	Sand, Clay & Gravel
	Akhanwali	305	--	$7.7*10^{-3}$	1817	Sand, Clay
	Jamalpur	305	1930	--	2121	Sand, Kankar & Gravel
Average		***323***	***1332***	***$4.5*10^{-3}$***	***2020***	

Table-5: Ground Water Exploration data in Hisar district

2.1.6 Exploratory drilling-CGWB, State and private wells:

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB and private wells have been collected and those supported electrical logs have been used to validation for preparation of aquifer maps. Deeper well data of CGWB is available and considered for validation of other agencies data. The validated wells available with different agencies and depth wise validated wells are given detailed in Table-6. The compromised logs derived from lithologs and geophysical well loggings have been taken as reliable data base.

CGWB and other private agencies well data of the Hisar district are plotted on 1:50000 scale with 5'X5'grid (9km x 9km) interval to know the spatial distribution of the and also to find out the datagap analysis in the entire area. The validated and optimised wells of different agencies and its well location details are shown in map (Fig-13).

The Validated and Optimized wells in Hisar district (Total 21 wells)				
Agency	Well Depth (Mt)			
	<100	100-200	200-300	>300
CGWB	0	11	5	3
PRIVATE	0	0	2	0
PHED	0	0	0	0
Total	**0**	**11**	**7**	**3**

Table-6: Data availability of exploration wells in Hisar district

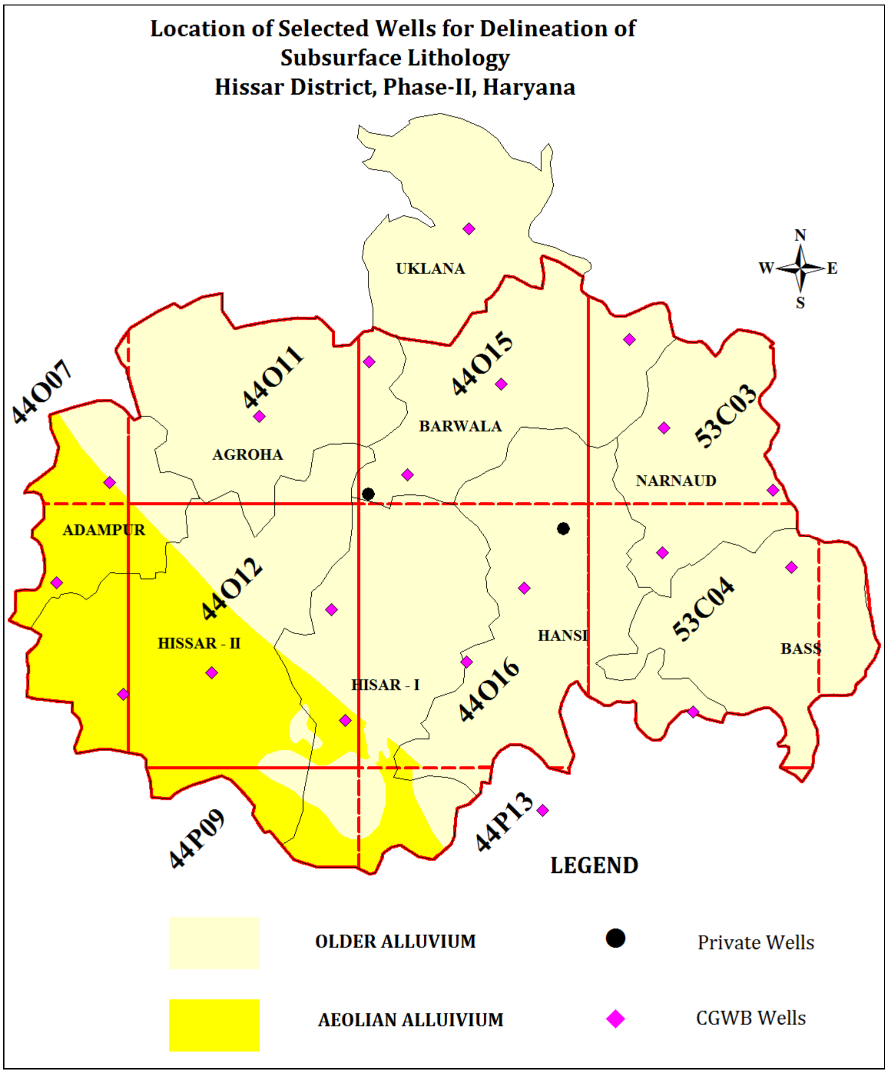


Fig 13: Distribution of validated and optimized well locations in Hisar district.

2.2 Geophysical Studies:

The surface geophysical studies are carried out in Hansi and Bass blocks of Hisar district under Western Yamuna Command area by Central Ground Water Board, NWR, Chandigarh in FSP 2004-05. Hansi and Bass blocks cover eastern and south east parts of the Hisar district and surrounded by Jind and Bhiwani districts. The area covered for geophysical survey is 700 sq. km and has more or less flat topography. The location map of the area studied and Vertical Electrical Soundings (VES) conducted locations map are given below Fig-14 & 15 (Source-CGWB-NWR Data).

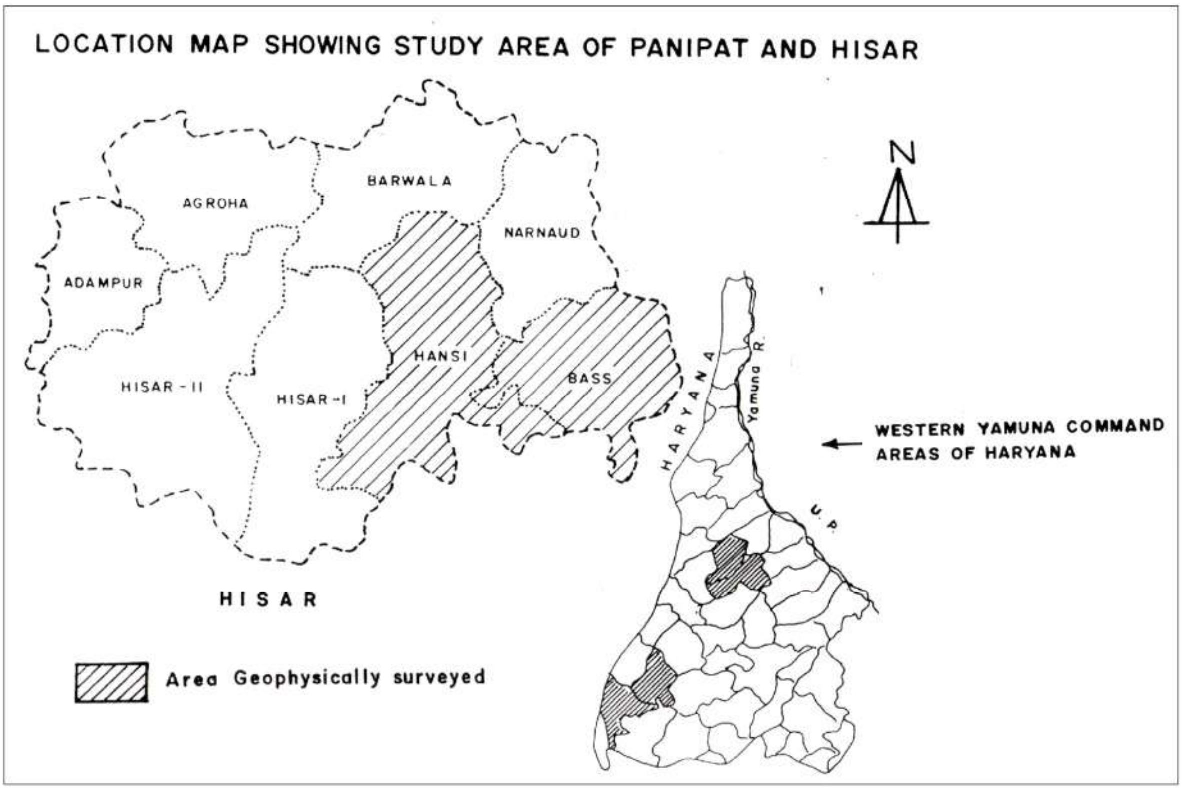


Fig 14: Area of Geophysical Surveys conducted in blocks of Hisar district.

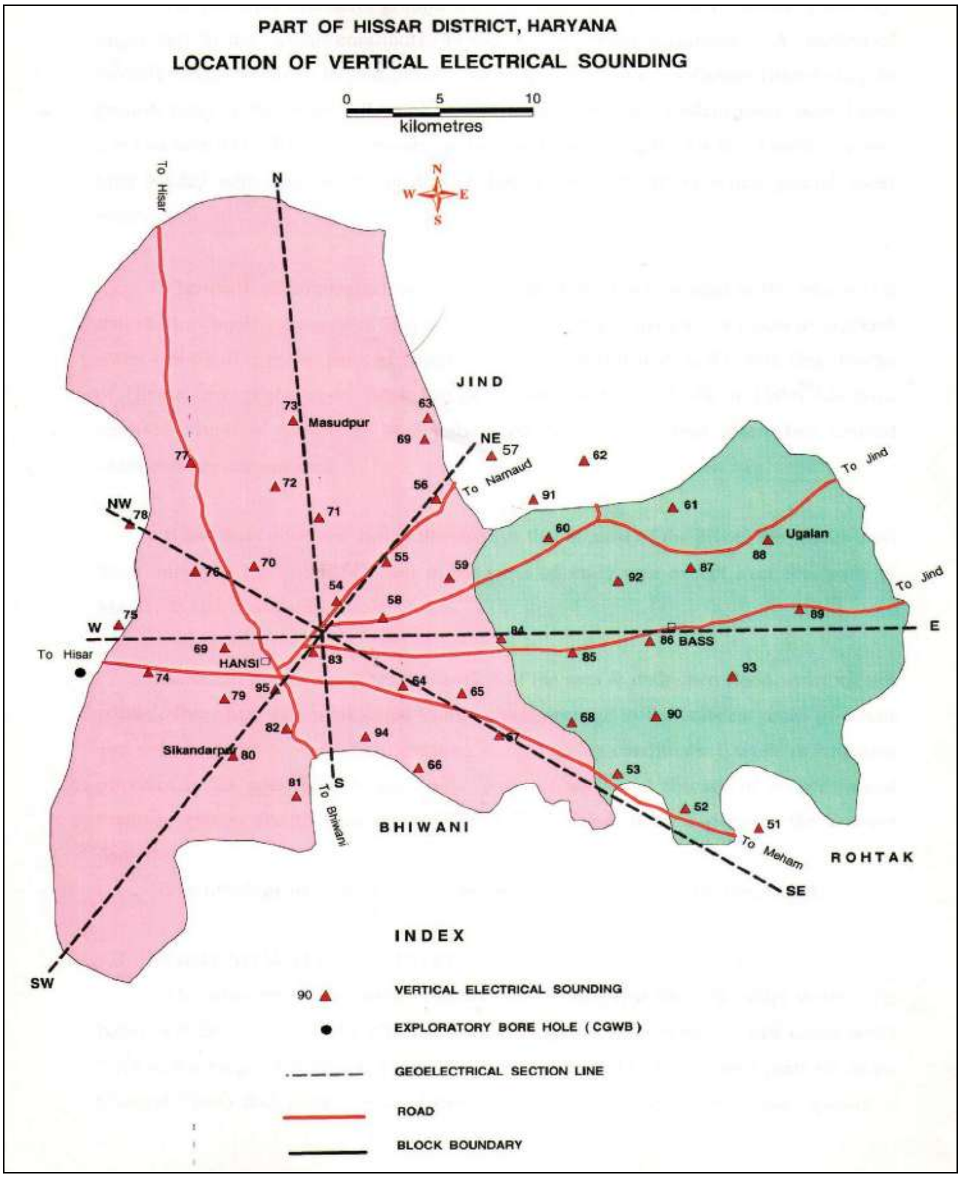


Fig 14: Locations of VES in blocks of Hisar district.

The most common and economical method of geophysical surveys for ground water investigation i.e electrical resistivity method was adopted to look into the sub-surface aquifer systems and ground water quality issues in the district. The instrument was used for this purpose Sweden made ABEM Terrameter. The total 46 Vertical Electrical Soundings (VES) were conducted with current electrodes separation in the range of 200 m and 600 m using Schlumberger configuration of electrode array. The generated VES resistivity database are interpreted for lithology and quality. Generally VES curves are recorded as Q, K and KQ type multilayered system in this area. Q type VES curves represent consequent fall of resistivities and K type curves represent initial rise and consequent fall of resistivities in the little part of the curves. H type of curves also found in the area and it represents fall in the initial part and rise in the little part of the curves. The interpretation of selected curves and type of VES curves observed from the field are given in the given figure-15.

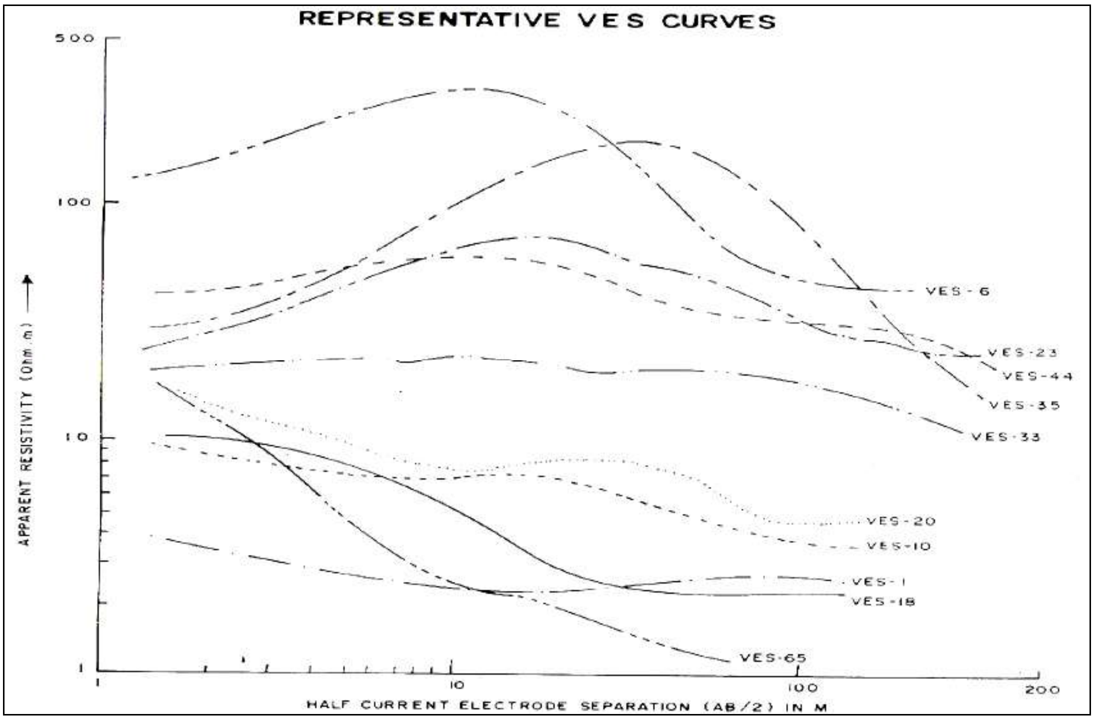


Fig-15: The interpreted VES curves in parts of Hisar district.

2.3 Ground Water Quality:

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline, fresh or moderately saline. The ground water sampling is carried out through Ground Water Observation Wells each year in pre-monsoon period by CGWB. The chemical quality data of pre-monsoon, 2015 is used in this report and the main observations are given as follows. The Electrical Conductivity (EC) values in 71% samples is <3000 µS/cm (EC range minimum 299 to maximum 2830 µS/cm at 25oC), and remaining 29% samples depict saline water conditions (EC ranges minimum 3120 to maximum 4910 µS/cm at 25^{o} C). The Nitrate (NO_3) values in 62% groundwater samples show nitrate content less than permissible limits i.e. <45mg/l and 18% samples show high nitrate groundwater conditions i.e more than permissible limits (>45mg/l) Nitrate concentration range from below detection limit at Bass to a maximum of 609mg/l at Uklana). The Fluoride (F) values observed from groundwater analysis depict that 71% samples have fluoride content less than permissible limits i.e. <1.5mg/l while 29% samples depict fluoride rich groundwater conditions i.e more than BIS permissible limits of >1.5mg/l for drinking water. Fluoride concentration ranges from minimum 0.19mg/l at Samani to a maximum 4.04mg /l at Ghursal village. The groundwater quality map (Fig-16) has been prepared wherein Electrical conductivity contours are integrated with nitrate and fluoride point source values more 45 mg/l and 1.50 mg/l, respectively (BIS permissible limits) The results of GWMS chemical analysis for pre-monsoon, 2015 are attached in Annexure I and II and constituents above permissible limits of Bureau of Indian Standards (BIS), 2012 are highlighted in red colour (Source-CGWB-RODC Data).

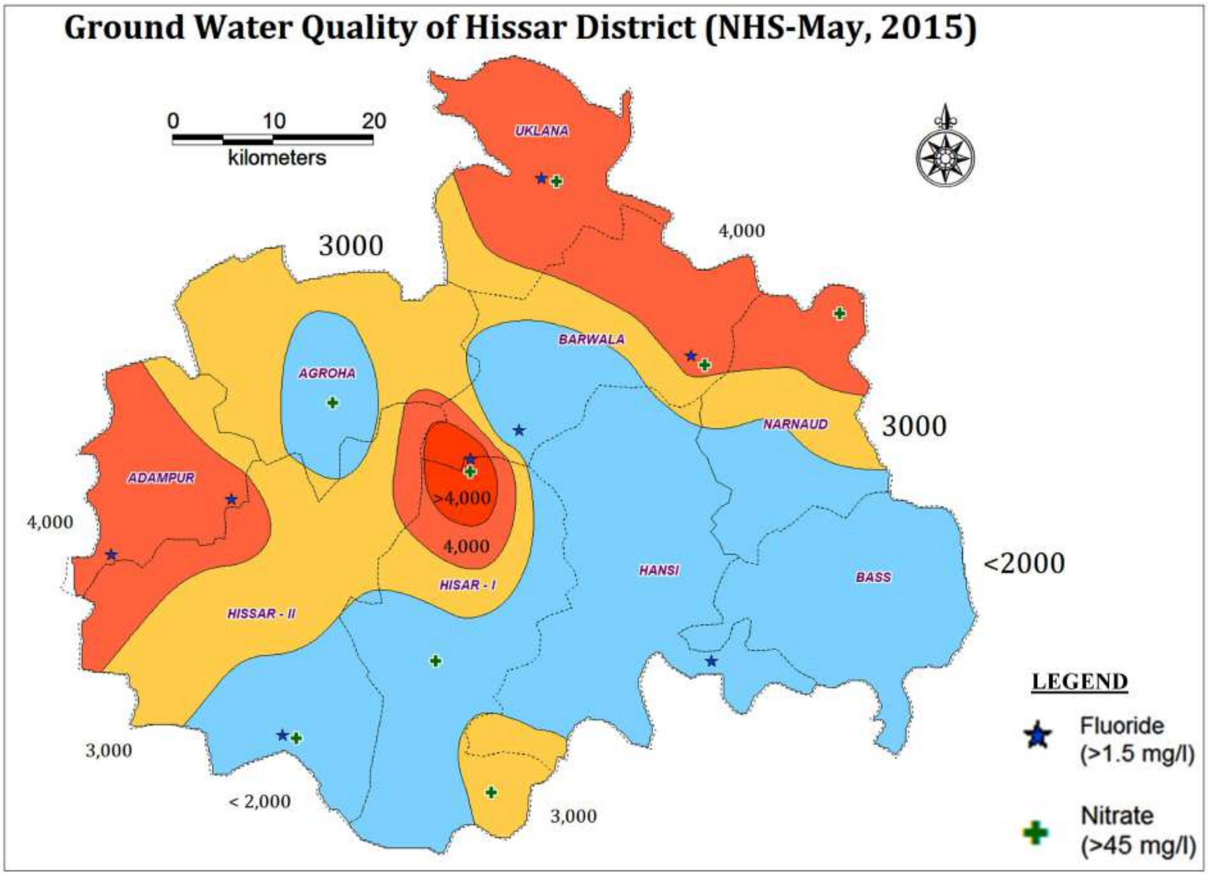


Fig-16: Ground Water Quality Map of the Hisar district (May, 2015).

As per the analytical data generated, it is observed that Arsenic concentration is within BIS desirable limit of >0.01mg/l in entire district. The concentration of iron (total) in ground water of the study area ranges from below detection limit to 1.0063 mg/l at Kirtan village.

Alkali hazards of irrigation ground waters are estimated through the computation of Residual Sodium Carbonate (RSC), also known as Eaton's Index. Waters with RSC value <1.25 meq/L are safe for irrigational uses, RSC between 1.25 and 2.5 are marginal and waters with RSC value >2.5 meq/L are unsafe for irrigation. Classification based on RSC indicates that area groundwater is useful for irrigational use and RSC of ground waters ranges from -23.75 to 0.57 meq/l. The groundwater samples analyzing mechanism and used equipments for chemical analysis are given in table-7.

S. No.	Parameters	Analytical Methods
A.	**Physico-chemical analysis**	
	pH	Electrometric method
	Conductivity (EC)	Electrical conductivity method
	Carbonate & bicarbonate (CO_3,HCO_3)	Titrimetric method
	Chloride (Cl)	Argenotometric method
	Sulphate (SO_4)	Nephloturbidity method
	Nitrate (NO_3)	Spectro-photometric method
	Fluoride (F)	Ion metric method
	Total hardness (T.H)	EDTA-Titri metric method
	Calcium (Ca)	EDTA-Titri metric method
	Magnesium (Mg)	By difference
	Sodium (Na)	Flame photometric method
	Potassium (K)	Flame photometric method
	Total Dissolved Solids (TDS)	Gravimetric
B.	***Trace elements/Heavy metals***	
	Copper (Cu), Cadmium (Cd), Chromium (Cr), Lead (Pb), Manganese (Mn), Nickel (Ni), Cyanide (Cn)	Digestion followed by Atomic Absorption Spectrophotometer (AAS)
	Iron (Fe)	Spectrophotometer method

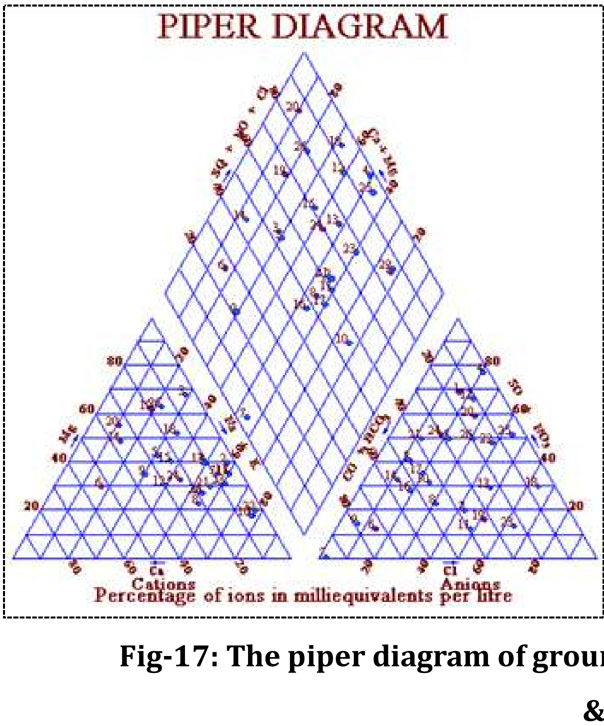
Table-7: Analytical methods and equipments used for chemical analysis.

The Basic chemical quality data of GWMS of Hisar district are used to interpret with Piper and USSL diagrams. As per the piper diagram (Fig-17)the groundwater is saline in 37% samples, mixed type in 33% samples while 24% samples have permanent or temporary hardness and remaining 6% samples are sodium alkaline water.

As per USSL salinity diagram (Fig-18), 70% samples are medium to high salinity and low sodicity, 20% samples have high salinity and medium sodicity while remaining 10% of the samples have very high salinity and very high sodicity. Such water when used for customary irrigation may cause both salinity and sodium hazards. However, these waters can be used for irrigating salt tolerant crops grown on soils with adequate permeability and only after addition of appropriate amounts of gypsum.

Based upon EC, Cl, NO3 & F contents 43% water samples are having potable quality as per BIS 2012 standards in the Hisar district. Overall 70% ground water in the Hisar district is suitable for irrigation purposes.

(Fig-17)



(Fig-18)

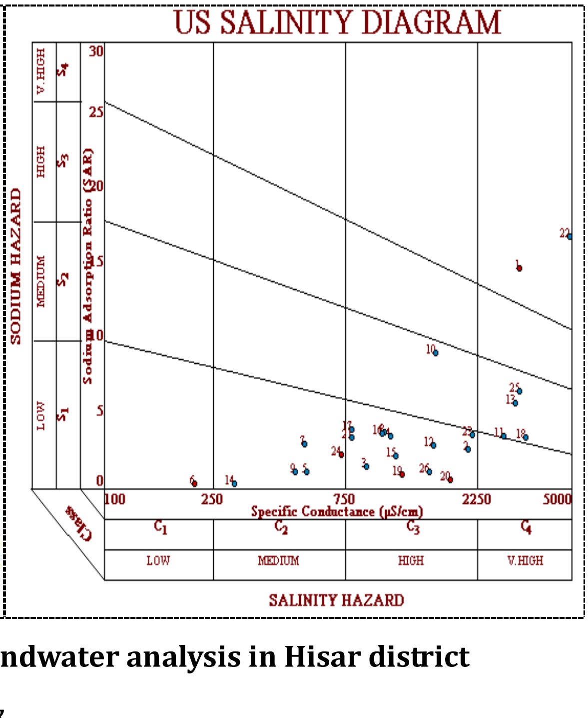


Fig-17: The piper diagram of groundwater analysis in Hisar district

&

Fig-18: The USSL diagram of groundwater analysis in Hisar district

3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. There has been a paradigm shift from "groundwater development" to "groundwater management". An accurate and comprehensive micro-level picture of groundwater in India through aquifer mapping in different hydrogeological settings will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India as well. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus the crux of NAQUIM is not merely mapping, but reaching the goal – that of ground water management through community participation.

The area of Hisar district occupied in Ghaggar basin and geological formations belongs to Quaternary age comprising of Aeolian deposits and older alluvial deposits of major Indus plains. Ground water at shallow depth occurs under unconfined to semi confined condition and deeper water levels under semi confined to confined conditions with huge clay dominance at deeper depths. The combined studies on fluvial geomorphology and Remote sensing studies in north western region are carried out by IITs and Delhi University. It has been observed that the huge flood depositions by river Ghaggar, Saraswati and other minor rivers at different time interval and channel migrations in different ages and also Aeolian depositions caused sand dunes in different time interval leads to difficulty in aquifer grouping. The studies are also conformed through sedimentological, core sampling analysis during the project. The observations are understood by regional geomorphology and channels migrations which shown in the below Fig-19:

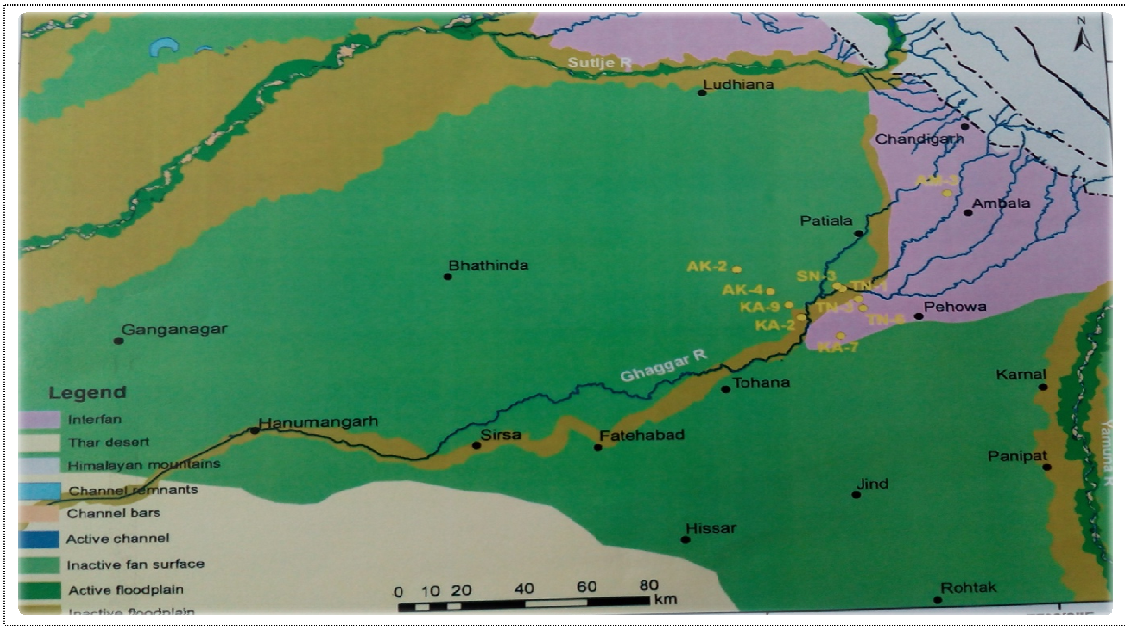


Fig-19: Fluvial geomorphological studies carried out by different researchers to understanding the subsurface aquifer system in north western region.

Central Ground Water Board has drilled 11 exploratory wells and 10 piezometers through in-house and 2 slim holes to delineate the aquifer zones and determine the potential evaluation of aquifer characteristics, aquifer water quality etc. The maximum drilling carried out at Madha (depth of 311 m) and other remaining wells of 10 locations with average depth of 269 m and also the shallow piezometers up to maximum depth of 110 m at 10 locations, all location are shown in the figure-13. The presence of potential granular zones with aggregate thickness varying from 17 to 153 m within the maximum considered depth of 275 to 311 m. The potential granular zones are existed average thickness i.e Isopach is 68 m within the exploratory wells of average depth of 272 m in the Hisar district and also the average thickness of granular zones 46 m at shallow aquifers presented in average depth of 105 m, these observations are estimated through Piezometers existed in the Hisar district. The exploratory well wise and piezometers wise locations, depth of the wells and thickness of potential granular zones thickness details are given below table-8. The granular zones consist of fine to medium sand, occasional kankar and clay presence in the major aquifers. The huge clay is dominantly presented in the major aquifers and this may be deposited during the different palaeo-floods and meandering of different channels of major ghaggar river at different geological cycles.

Locations of EW	Granular Zones Thickness (m)	Total Depth (m)	Locations of Pz	Granular Zones Thickness (m)	Total Depth (m)
Adampur	20	246	Balsamand	71	108
Agroha	84	277	Banbhuri	54	102
Barwala	60	306	Behbalpur	39	109
Bhatla	45	214	Ghursal	44	108
Danoda	51	308	Kanda Kheri	55	102
Dhiranwas	65	229	Kanoh	51	108
Hisar	17	275	Kheri Jalab	24	100
Jamalpur	140	304	Mangali	49	109
Madha	24	311	Sorkhi	15	105
Mayar	94	295	Uklana Mandi	58	103
Paoli	153	309	**Avg. Hisar**	**46**	**105**
Rajthal	67	152			
Uchana	66	307			
Avg. Hisar	**68**	**272**			

Table-8: Isopach details in CGWB wells of Exploratory, Piezometers in Hisar District

3.1 Hydrogeological Interpretations and results:

In the area all exploratory boreholes (EW-Pz & SH wells of CGWB, private and PHED-HR state govt.) are used to optimise, validate and also considered for generation of aquifer map at district level and also at block level. The selections of optimised wells are based on the maximum depth availability and composite lithologs. The deepest well in each quadrant wise selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig-13. Based on the interpretations of the optimized well lithologs, the single aquifer system is observed up to the maximum depth of 300 m (up to depth of 300 m only considered for alluvial aquifers per NAQUIM methodology). The available potential aquifers thickness details within the depth of 300 m single aquifer system of Hisar district are given below table-9. The block wise distributions of well details are given in table-10.

Aquifer system Type	Agency	Maximum depth ranges available (m bgl)		Thickness of Aquifer (m)	
		From	**To**	**Min**	**Max**
Single Aquifer system up to 300m depth	CGWB	**102**	**311**	**15**	**153**
	Private	**244**	**300**	**60**	**119**

Table-9: Aquifers thickness at different depths data of different agencies in Hisar.

Block	Toposheet and grid Number		No of Well & Depth range (m)				Location with depth (m)
			>300	200-300	100-200	<100	
Ukhlana	44 O/14	2B	-	-	1	-	Uklana Mandi (103 m)
Barwala	44 O/14	3A	-	1	-	-	Juglan (244m)
			-	-	1	-	Behbalpur (109m)
		2B	1	-	-	-	Barwala (306m)
	53 C/3	2A	-	-	1	-	Banbhuri (102m)
Agroha	44 O/11	3B	-	1	-	-	Agroha (277m)
	44 O/15	2A	-	-	1	-	Kanoh (108m)
Adampur	44 O/7	3C	-	1	-	-	Adampur (246m)
	44 O/8	1C	-	-	1	-	Ghursal (108m)
Hisar-II	44 O/8	3C	-	-	1	-	Balsamand (108m)
	44 O/12	2B	-	1	-	-	Dhiranwas (229m)
Hisar-I	44 O/12	3C	-	-	1	-	Mangali (109m)
		2C	-	1	-	-	Hisar (275m)
Hansi-I	44 O/16	2B	-	1	-	-	Mayar (295m)
		1C	-	1	-	-	Bhatla (214m)
		1C	1	-	-	-	Masudpur (350m)
	53 C/4	3B	-	-	1	-	Sokri (105m)
Narnaud	53 C/3	3A	-	-	1	-	Kheri Jalab (100m)
		3C	-	-	1	-	Rajthal (152m)
	53 C/4	1A	1	-	-	-	Madha (310m)
Bass (Hansi-II)	53 C/4	1C	-	-	1	-	Kanda Kheri (102m)

Table-10: Summary of block wise optimized exploration wells.

The optimized wells of CGWB, state PHED and private data are used to compute the elevation or collar elevation map to know the topographic variations in the area, so that it can give the synoptic picture of gradient variations in the water levels in the aquifers. The topographic elevation values have been plotted to prepare the elevation contours and map is shown in Figure-20. The locations of validated wells are toposheet wise and grid wise distribution in respective blocks is shown Table-10 and the groundwater exploration and aquifer parameters wise details are also explained in sub-chapter 2.1.5 and Table-5.

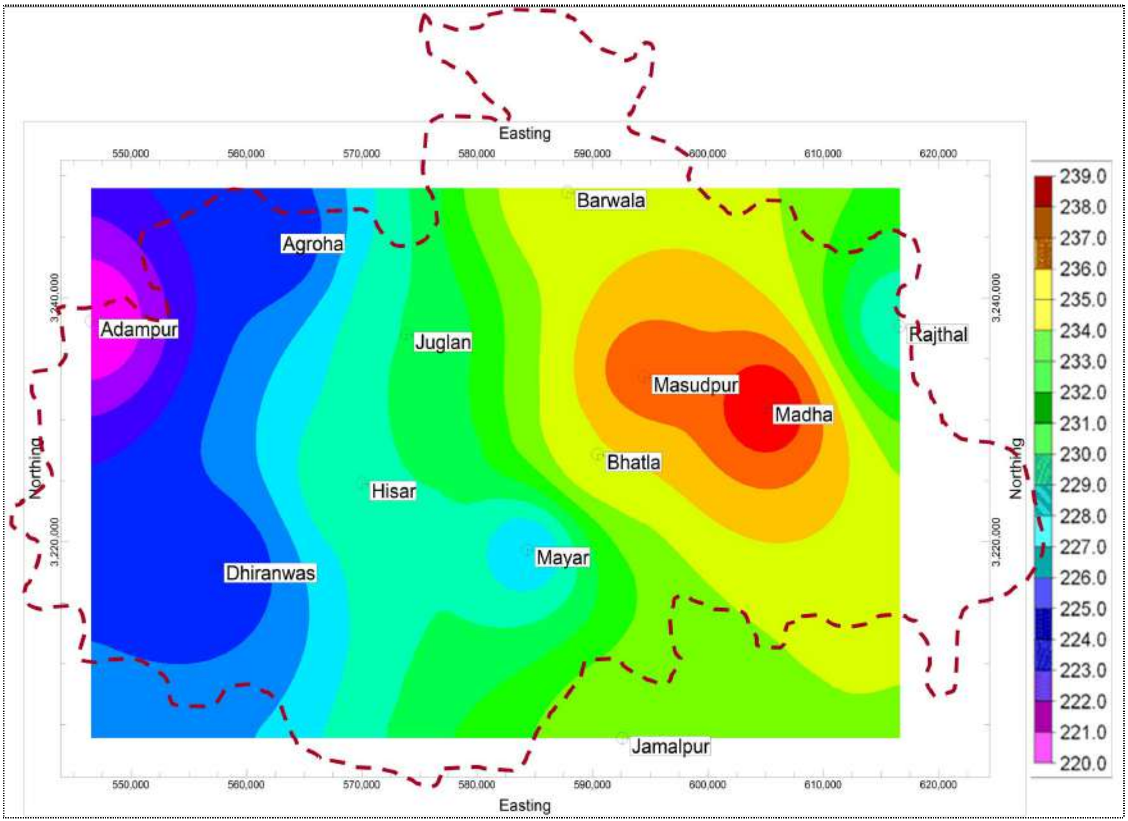


Fig-20: Elevation Contour Map-Hisar District

3.1.1 Aquifer Geometry and Disposition:

To understand the lithological frame work and aquifer disposition in the sub surface aquifers, the litholog data of wells drilled by CGWB, PHED and Private agencies are used to compile, optimized and modeled into 3D, 2D systems by using the RockWorks16 software. The lithological model has been prepared along with distribution of wells are shown in Fig-21 and each location wise lithologs are given in Annexure-3 & 4. The 3D geometrical lithological fence diagram has been also prepared on the basis of distribution of wells in different blocks and the 3D lithological fence diagram is shown in Fig-22. The lithology model elucidates that the variations in lithology from surface to sub-surface disposition in whole district can be synoptically identified from this model (Fig-21), whereas lithological fence diagram (3D geometry) explains that how the each Lithologies are deposited at different directions at different depth intervals at blocks level/village level.

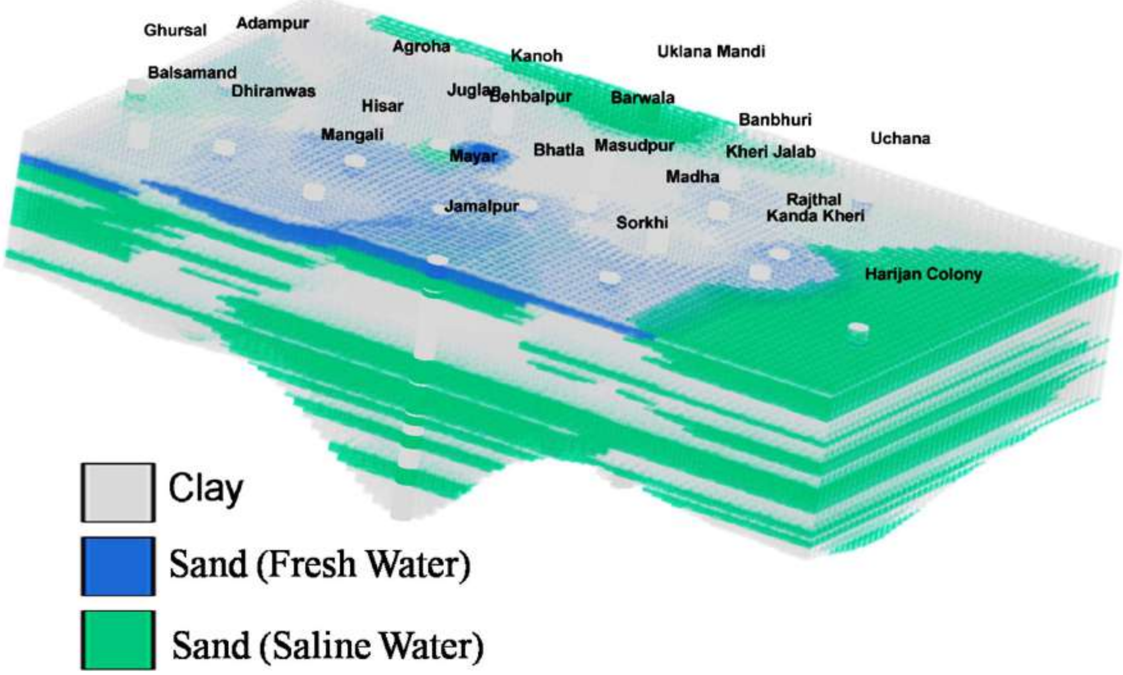


Fig-21: 3D Lithological Model of Hisar District

The major aquifer system of the Hisar district is composed of older alluvium in maximum area and aeolian deposits at minor part in western direction. The alluvium in major single aquifer group category mainly comprised of sand, clay, kankar and sand/clay with kankar lithology. In lithology model concept, the concised lithological formations are made in to two major lithological groups that are sand and clay only. Thick layering of clay with sand at many places and can be observed at deeper depths and also thin inter-layered of sand with saline water bearing zones in the thick clay beds at deeper levels observed in middle areas and its surroundings. The saline water is dominant resources below after 20-60 m to up to the depth of 300 m at relatively all places in Hisar district. The fresh water resources are limited in aquifer up to maximum depth of 60m in north and northeast, south east etc but towards west and southwestern side of the district salinity started from 3 m to 10 m depth range, the detailed explanations are below given sub-chapter. The fresh and saline water interfaces are explained in briefly in geophysical chapter. The 3D lithological fence will represent the much more clear representation about sub-surface lithology in space and dimension wise are shown in Fig-22.

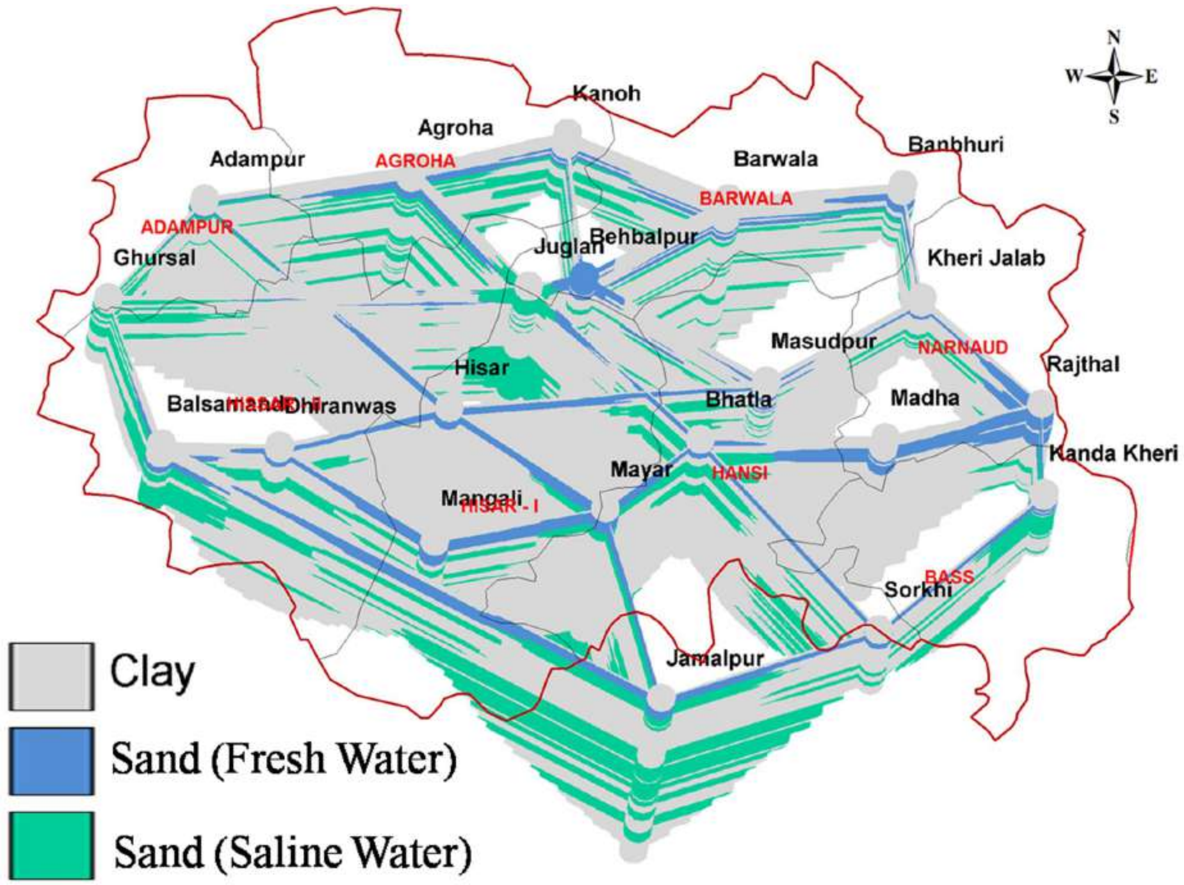


Fig-22: 3D Geometry of lithological fence diagram of Hisar District

In major part of district Hisar, sand content decreases and aquifers become thinner and quality of ground water also deteriorates to marginal and saline category below average 30 m depth, clay invariably forms the major portion of alluvium. Aquifers in these saline areas are mostly thin and pinch out at short distances, thus restricting the movement of ground water. In the clay predominant region Kankar (nodules of $CaCo3$ of secondary origin) is mixed with clay and also occasionally present in the sand layers. Kankar layers are distinctly present at different depth ranges. This is considered to be a characteristic of older alluvium and is mostly associated with saline ground water regime.

Hisar District falls under the Ghaggar river basin and also the area is confined to major single aquifer system up to the depth of 300m below ground level. The thin inter-layering of sand, clay and clay layers are thicker with increase in depth (Ghaggar River Project Report). The findings from litholog study in Ghaggar basin, the lithologs of each bore hole are not correlating with in another borehole Lithology at depth wise, therefore the lithologies are cannot be combined and it also presumes that each Lithology is existed at some extent i.e pinched (annexure-4). Based on the same criteria, to know the broad picture of the aquifer disposition, inter-relationship of granular zones, nature, geometry and extension of aquifers in the Hisar district, the Lithology grouping have been done and shown in three-dimensional aquifer model (Fig-22).

3.2 Geophysical Interpretations and Ground Water Quality Issue studies:

A total 41 numbers of VES were conducted in Hansi, Bass and parts of Narnaund blocks of Hisar district to delineate sub-surface lithology and also to identify the fresh and saline ground water interfaces. The ABEB Terrameter was used for surface geophysical field investigations in parts of Hisar district. The analysis of resistivity data was done to assess the depth wise variation in groundwater quality with the help of apparent resistivity data at different current electrode separations and interpreted results of VES. Such analysis of data has yielded lateral and vertical distribution of ground water quality maps in the study area. Different geo-electrical sections in different directions (W-E, SW-NE, NW-SE and N-S) were prepared to study the vertical and lateral extent of fresh and saline ground water after interpretations of VES curves. Based on the analysis of data, portability of groundwater map showing depth wise and lateral variations in ground water quality has been prepared.

3.2.1 Quantitative Interpretation of Geophysical data for Quality in Hansi and Bass Blocks:

As part of qualitative interpretation data, apparent resistivity contours or Iso-resistivity maps and orthogonal patterns were prepared for qualitative interpretation of resistivity data. The inference were drawn on the basis of distribution of apparent resistivity contours at half current electrode separation AB/2 = 10m, 30m & 60m, 80m. The apparent resistivity contours though do not completely represent actual aerial and vertical extent of a particular parameter at a particular half current electrode separation, but the correlation with the existing borehole data helps in making important inference. After the detailed study of apparent resistivity data and interpreted results of VES it has been established that the contours with apparent resistivity value more than 15 ohm m represent the area available with fresh quality of ground water whereas contours with apparent resistivity less than 15 ohm m represent area available with saline ground water. The field based VES data (Figure-15) used to prepare the different iso-resistivity maps which are describe in the following section (Source-CGWB-NWR Data):

The iso-resistivity map at half current electrode separation 10 m indicates app. resistivity contour of less than 15 ohm m value are distributed over approx. 90% area affected with shallow ground water salinity at the surface level (Fig-23). Remaining area is dominated by contours of apparent resistivity values more than 15 ohm m. representing ground water within 10m depth. Such localities are Rajpura, Sorkhi, Rampura, Premnagar and Samain villages.

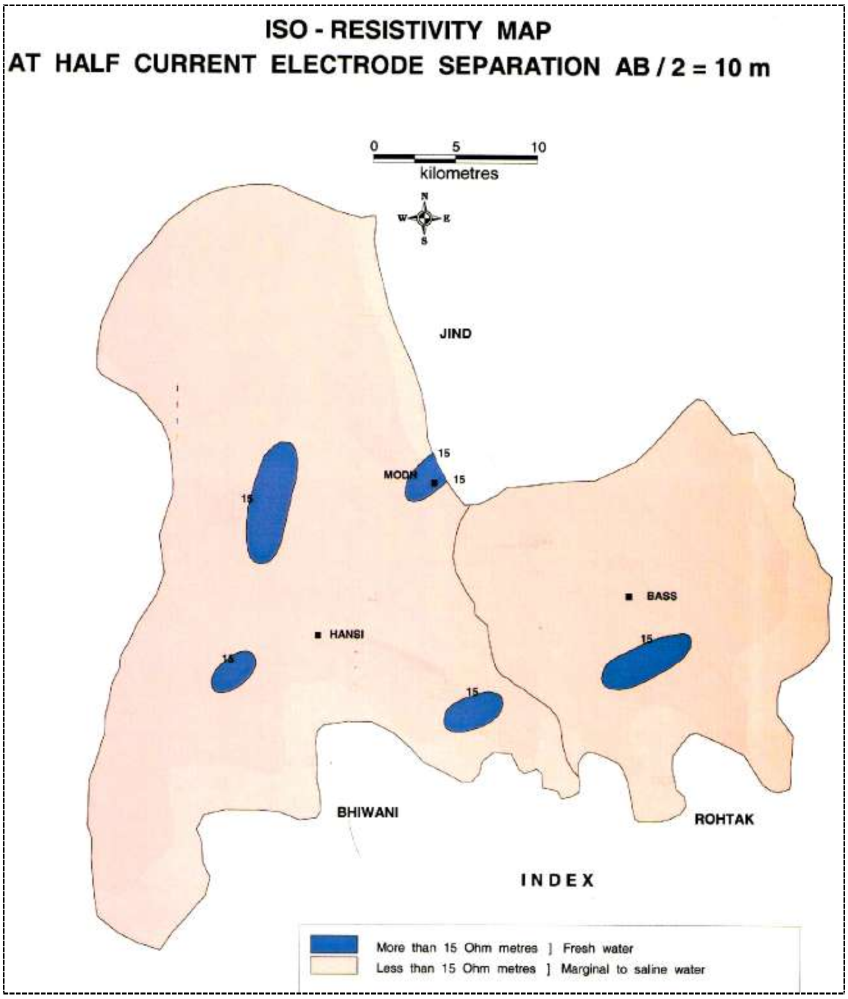


Fig-23: Iso-Resistivity map at 10 m depth in Hansi-Bass blocks

The iso-resistivity map at half current electrode separation 30m and 60 shows only one or two villages of entire study area are distributed by apparent resistivity contours of values more than 15 ohm m representing area with fresh water within 60m, these villages are Rajpura, Narnaud. The iso-resistivity maps at depth of 30m and 60m are shown in below figures-24 and 25. The remaining 97 to 98 % study area dominated mainly by apparent resistivity contours of values less than 15 ohm m bears saline water b/w 30-60m depth. This means major portion of study area in Hansi and Bass block is affected adversely with shallow ground water saline within a depth of mere 30-60m.

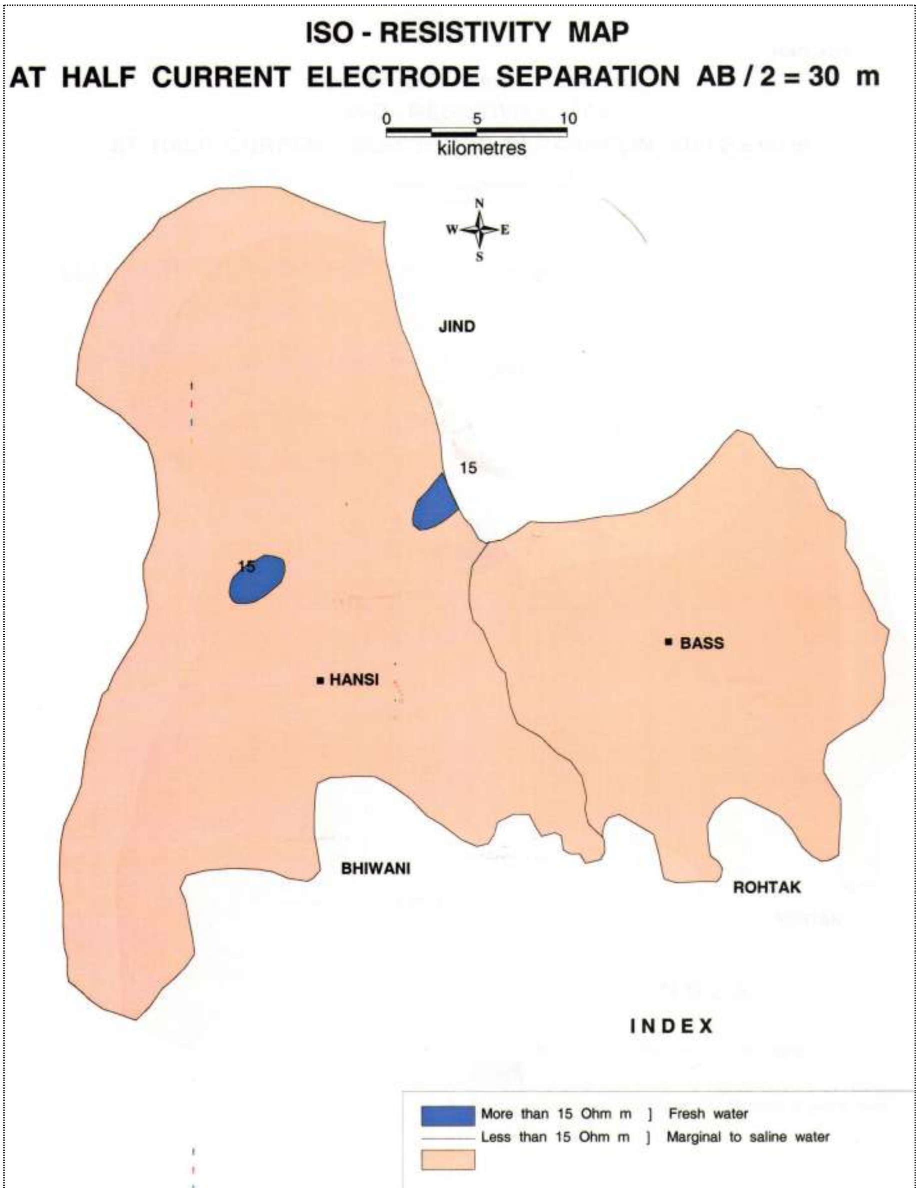


Fig-24: Iso-Resistivity map at 30 m depth in Hansi-Bass blocks.

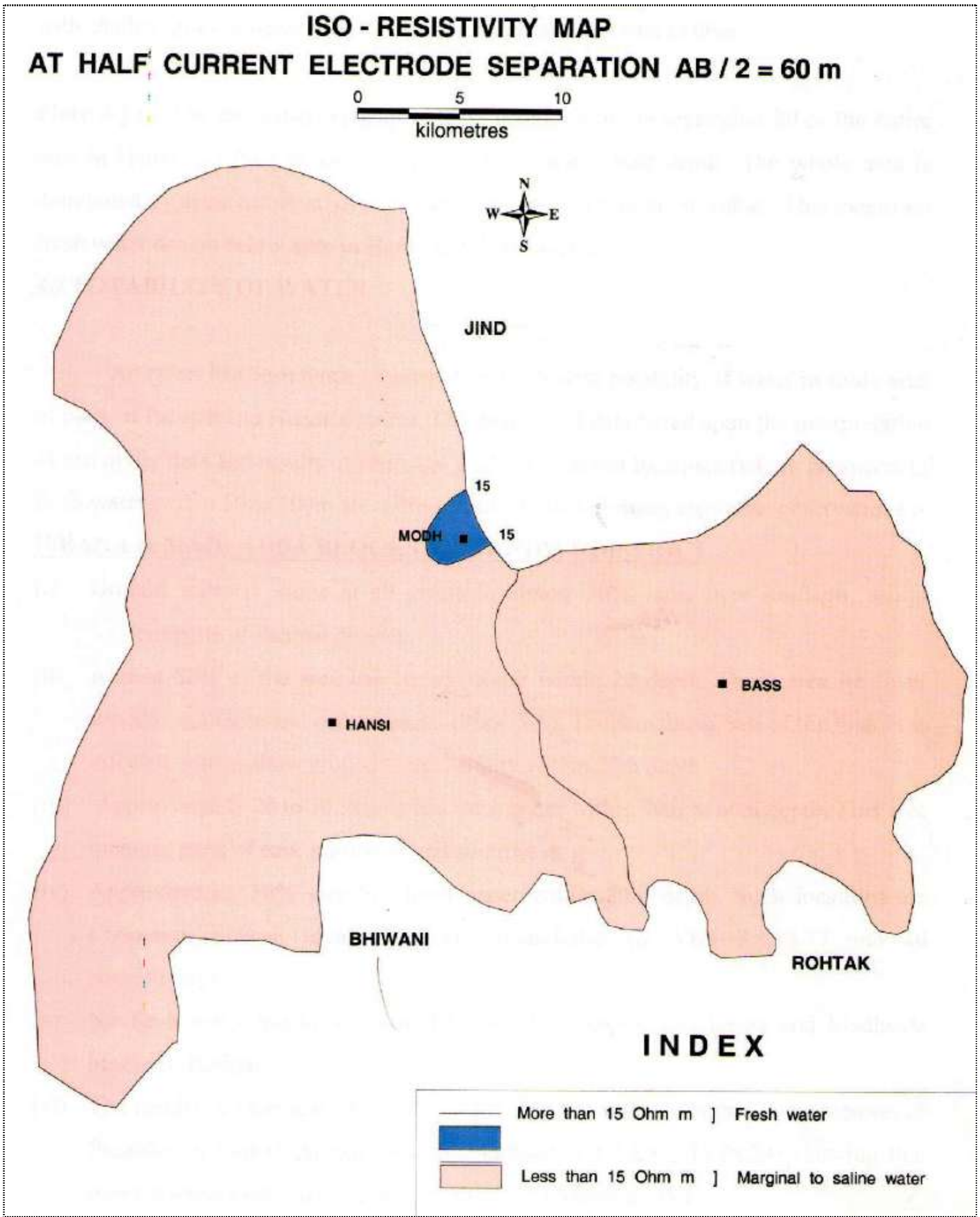


Fig-25: Iso-Resistivity map at 60 m depth in Hansi-Bass blocks

The iso-resistivity map at half current electrode separation 80m the entire area in Hansi and Bass blocks has saline water below 80m depth. The whole area is dominated by apparent resistivity contours of less than 15 ohm m value. This means no fresh water occurs below 80m in Hansi and Bass blocks and the map is shown in figure-26.

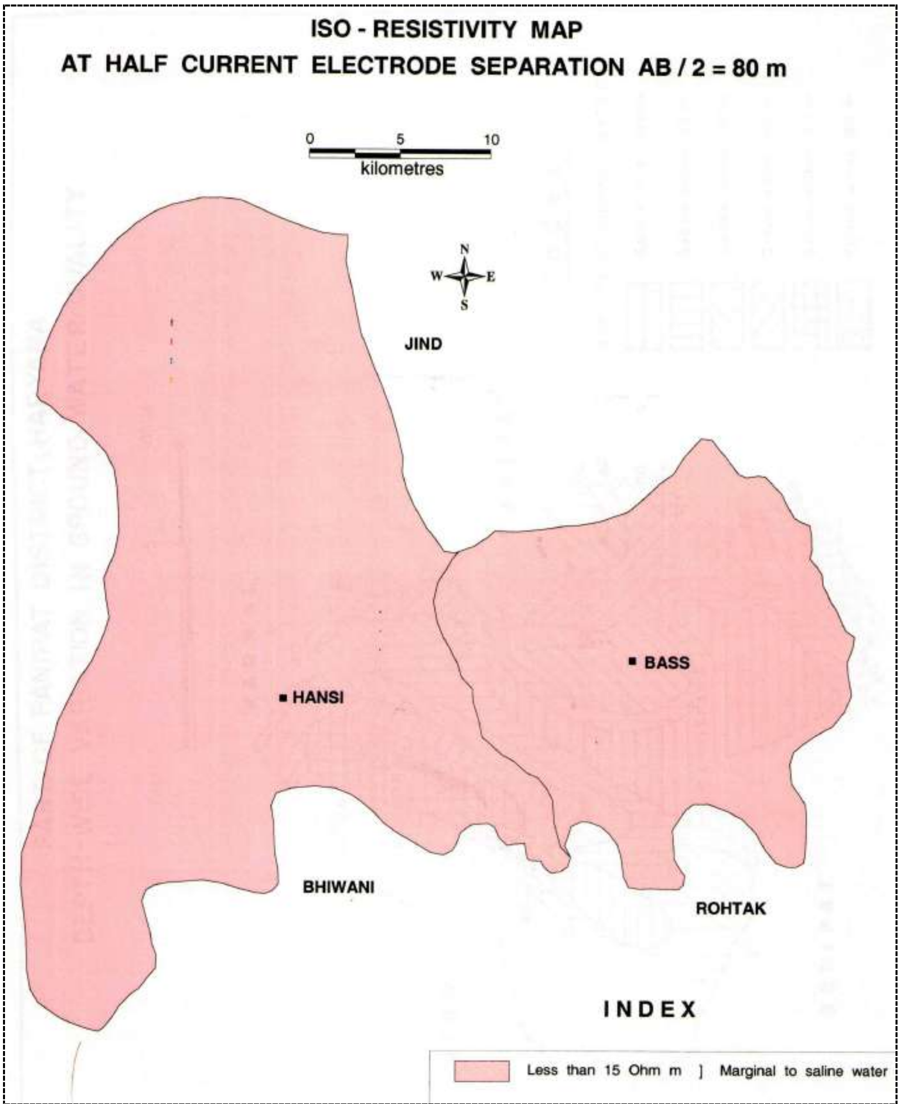


Fig-26: Iso-Resistivity map at 80 m depth in Hansi-Bass blocks

3.2.1.1 Integration of geophysical data for delineation of quality issues:

The integrated map has been prepared using iso-resistivity data for depth wise information data for delineation of quality issues in respective blocks of Hisar district. The map is shown in below figure-27. Ground water is saline at all level in almost 90% area. Only 10% of the area distributed in small patches has fresh water within 20-60m depth .These area lie over western, southern and central parts. No fresh water has been inferred below 60m depth over Hansi block of Hisar district. The results of chemical analysis of water samples indicate higher concentrations of fluorides in Narnaund showing that water at these places not suitable for drinking. Ground water is saline at almost all levels in almost entire Bass block.

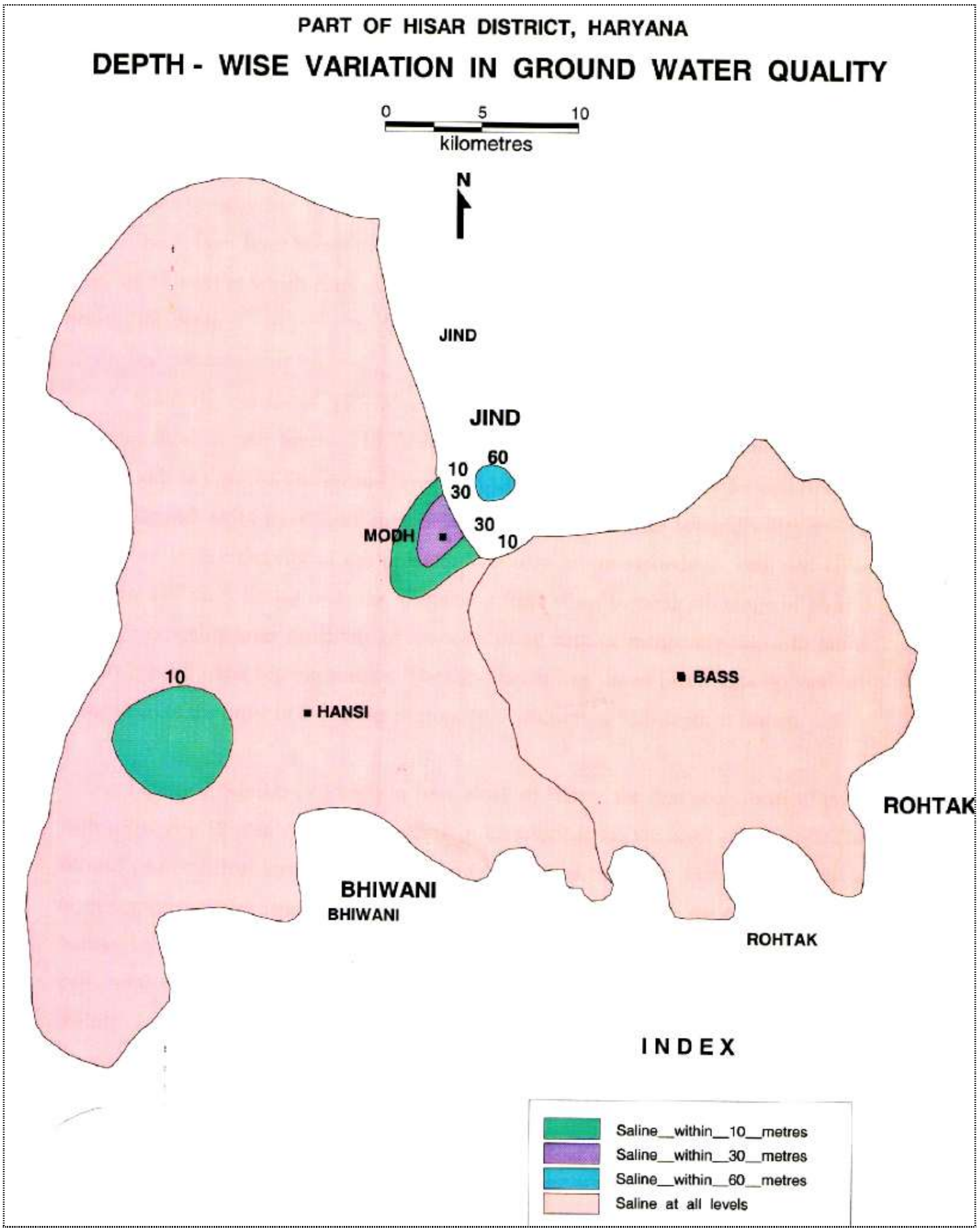


Fig-26: Depth wise resistivity contours for salinity identification in Hansi-Bass blocks

The quantitative interpretation of surface resistivity data was done to infer the extent of fresh and saline water interface. The interpreted results obtained by curve matching method were correlated with existing bore hole data and electrical conductivity of ground water in vicinity of VES .The interpreted results of VES were utilize to estimate the thickness of granular zones and expected quality of ground water at location of particular VES. To correlate the interpreted results of geo-electrical layers within lithology (Samain village) were conducted near the CGWB exploratory borehole location at these places. At Samain in Bass block of Hisar, the first geo-electrical layer with resistivity 12 ohm m and thickness 1m corresponds to the layer of top soil. The second geo-electrical layer of 24ohm m resistivity and thickness 13m corresponds to layer comprising clay sand and kankar containing saline water within the depth 14m. The bottom layer with decreased resistivity of the order of mere 7ohm m indicates vertical deterioration of ground water quality below 14 m depth at Samain. This layer comprises mainly clay, kankar lithology.

In order to prevent deterioration of ground water quality in affected areas due to water logging some preventive measures are to be taken , such as lining of unlined canals & repairs of broken linings to avoid seepage of water to the adjacent areas and installation of proper subsurface & surface drainage system to stop accumulation of flood water. Proper management of water resources by the users especially the ground water & canal water is essential.

3.2.2 Geophysical data for delineation of Lithology:

The general classification of resistivities with respect to Lithology using VES interpreted data for the area as described as <40 ohm values for top soil with clay content, >15 ohm resistivity value for Lithology of sand with kankar, clay containing fresh water and <15 ohm indicates that lithology clay, kankar with sand containing saline water in the total district of Haryana. The VES interpreted resistivity data of each lithology in sub-surface layers of this district are used to prepare the cross-sections in each direction to observe the lithology disposition at sub-surface level. The prepared cross-section details are explained below:

3.2.2.1 Geo-electrical section E1, E2 between Depal, Manikpur and Bar Chappar (W-E):

VES 74,69,83,54,58,59,84,85,92,86,87,93 and VES 89 (Fig:14) lie along this section covering localities of Depalmanikpur in the west, Hansi 2, Kundanpur, Shahpura in the central part and Jamuri, Khumba, Bhataul –Jattan, Badala, Petwar, Bass-Akbarpur, Bass, Samain and Bar-Chappar in the east respectively. The section is shown through figure-27 and the interpreted results show three geo-electrical layers in general. The section in corroboration with litholog of the exploratory borehole near Samain (VES 93) reveals that:

(1) The top layer with thickness 5m has resistivity within 12 ohm m in general. This layer comprises top soil & clay.

(2) The second underlying thin layer of fresh water is seen only at few places which are Hansi 2, Bass, Samain, and Bar Chappar (VES 69,87,93,89 respectively) having thickness in the range of 6 and 13 m respectively and resistivity varying from 19 to 24 ohm m

(3) The layer of fresh water is not seen in Depalmanikpur in the west, Kundanpur, Shahpura in the central part and Jamuri, Khamba, Bhataul-Jattan, Badala, Petwar, Bass-Akbarpur in the east (VES 74,83,54,58,59,84,85,92,86 respectively). Ground water is saline at all levels at these places.

(4) The third or bottom layer is present all over the section with resiastivity less than 10 ohm m in general indicating saline horizon. This saline water horizon is seen immediately below top soil layer or fresh water layer all over the section. No improvement in ground water quality has been inferred at deeper depth. Thickness of the order of 47 to 62m has been computed for saline horizon at Depalmanikpur, Hansi-2 and Shahpura (VES 74, 69 and 54). The ground water salinity increases vertically due to decreasing resistivity of the bottom horizon. The layer is comprised of clay and kankar.

(5) The fresh and saline water interface as per interpreted results along this section is at shallow depth of 10m and 17m at places where fresh water layer is present. No thick layer of fresh water is present all over this section along W-E. At other places along this section ground water is saline at all levels.

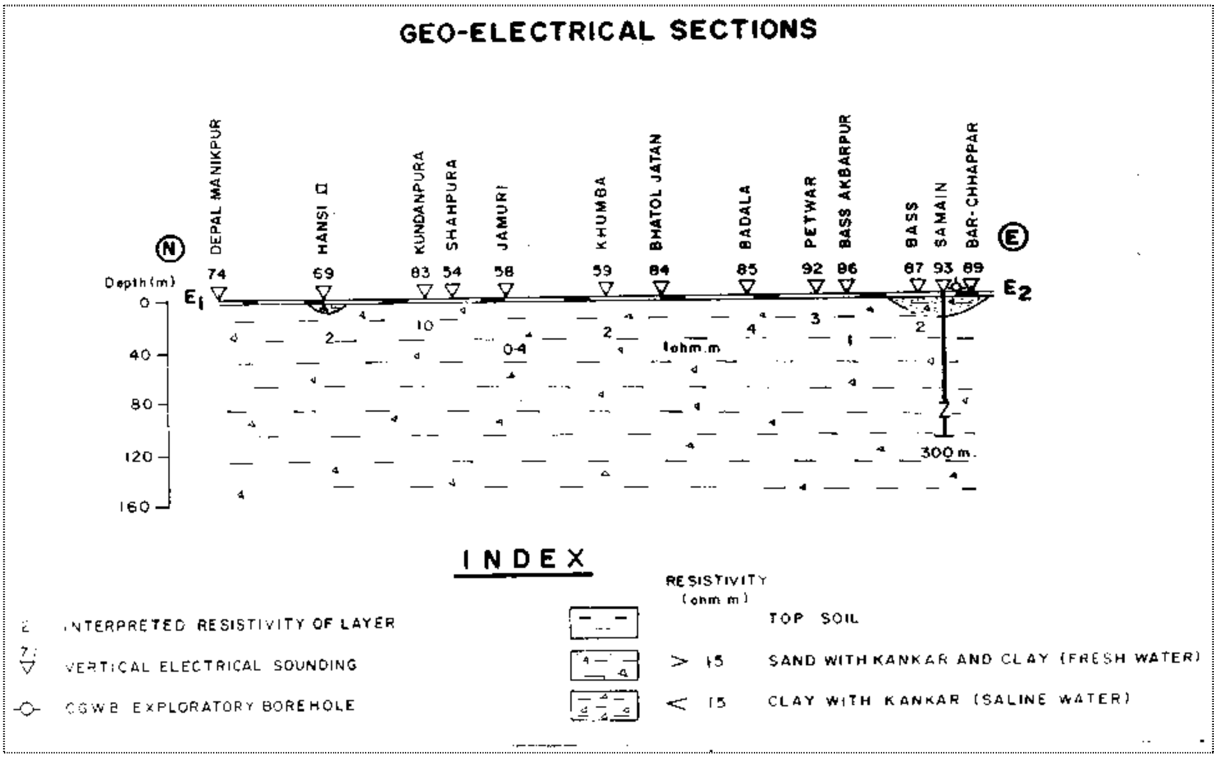


Fig-27: Geo-electrical cross-section along the West to East direction of area

3.2.2.2 Geo-electrical section F1-F2 b/w Masudpur and Azampur along North-South:

VES-73,72,71,54,83,95,82,94 and VES 81 at Masudpur, Sisai in the north, Shahpura, kundanpura, Dhani-raju, Sikandarpur in the central part and Dhana-Khurd, Azampur in the southern direction respectively are located on this geo electrical section (Figure-28) between Masudpur and Azampur along North-South. The study of this section follows that:

(1) The top layer withn resistivity within 26 ohm m and thickness within 3m in general is comprised of topsoil & clay.

(2) Ground water is saline at all levels over this entire section along North-South which includes the localitiesa of Masudpur, Dhani-raju, Sikandarpur in the central part and Dhana-Khurd, Azampur in the south (VES-73,72,71,54,83,95,82,94 and VES 81 respectively) as the second geo electrical layer of fresh water is totally absent all over the section along north-south. This saline water layer with resistivity in t5he range of 0.1 and 4 ohm m comprises clay and kankar.

(3) The resistivity of the bottom layer has been inferred to be less than 4 ohm m in general which indicates serious vertical determination in the quality of ground water with increasing depth. This layer is comprised of clay, kankar.

3.2.2.3 Geo-electrical section H1-H2 b/w Narnaud and Sikandarpur along NE-SW:

VES 57, 55, 63, 56, 58, 54, 83, 95, 79 and 80 lie along on the section (Figure-28) covering the locations of narnaud, Modha, Rajpura in northwest, Dhani-brahman, jamuri, Shahpura, Kundanpura, Dhani raju in the centra part, Premnagar, srikandarpura in southwestern parts respectively. After the study of this section following observations have been made in respect of different geo-electrical layers.

1. Thickness of the top layer has been inferred within 8 m and its resistivity is within 16 ohm in general. The layer is comprised of topsoil and clay.
2. The second layer of fresh water is seen only at Premnagar, Rajpura, Narnaud (VES 19, 56, 57) over northwest having thickness of the order of 18, 48, 64 m respectively. The resistivity of this fresh water layer has been inferred in the range of 22 and 28 ohm. This layer is comprised of sand, kankar with clay.
3. Over the areas where fresh water layer is present, the depth to fresh and saline water interface has been inferred between 31 and 72 m bgl, where it becomes shallow at other two places viz. Rajpura and Premnagar being within 30m.

In Modha, Dhani Brahman, Jamuri, Shahpura, Kundanpura, Dhani raju, Sikandarpur (VES 63, 55, 58, 54, 83, 95 and 80), the groundwater is saline at all levels and the salinity increases with depth as evident from the low resistivity of the order of 0.1 to 3 ohm for the bottom layer.

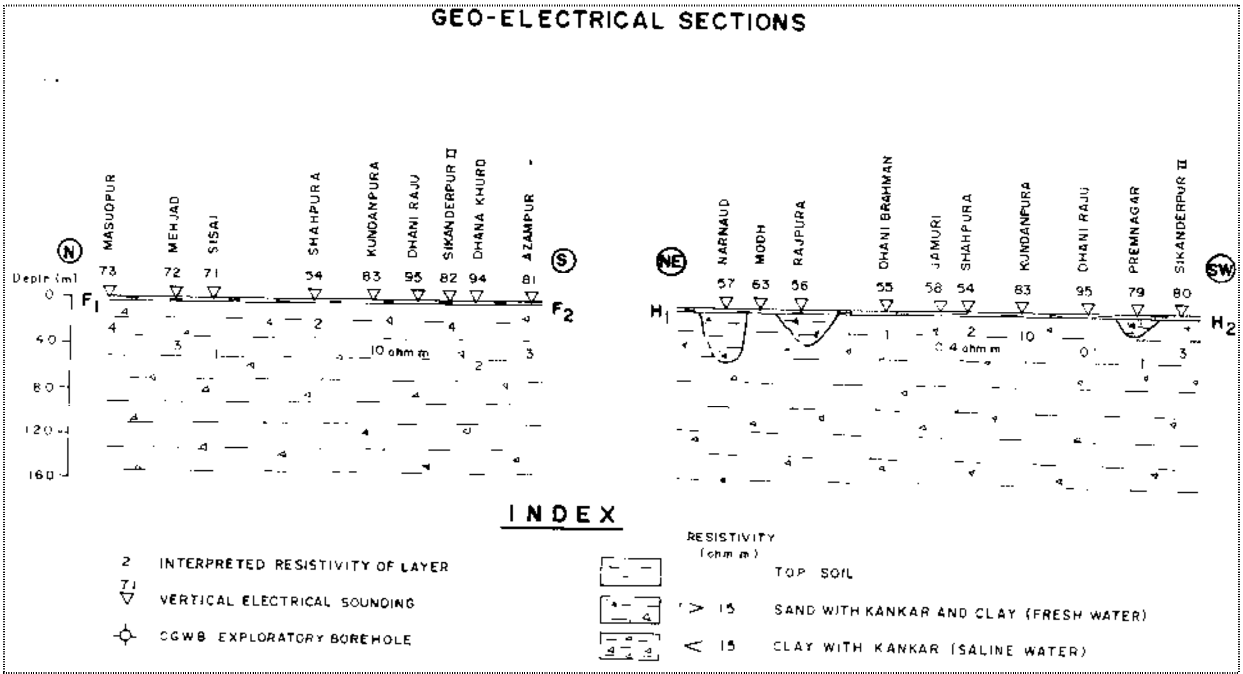


Fig-28: Geo-electrical cross-section along the North-South & NE-SW directions of area

3.2.2.4 Geo-electrical section G1-G2 b/w Khokha and Singhwa-Khurd along NW-SE:

VES 78,76,70,54,83,58,64,65,67,68,53 and VES 52 covering the localities viz. Khokha, Kulana, Rampura in the northwest, Shahpura, Kundanpura, Jamuri, Rampura Kharkhauda in the central part,Sorkhi, Sisar, Mundhal-khurd and Sulakhani in the southeast respectively lie over this section. Following observations have been drawn after the study of this geo-electrical section shown in Figure-29.

(1) The top layer comprised of topsoil has thickness within 4m in general with resistivity less than 17ohm m.

(2) The thin layer of fresh water below the top llayer has been inferred only at one place over this section i.e. VES 70 Rampura in central part having thickness of mere 7m.This layer is comprised of clay and kankar.

(3) Ground water is saline at all levels over this section except at Rampura in Kahni ,as the fresh water layer is totaly absent at these places .This is evident from EC value of ground water in these areas. Very low resistivity of the order of 0.4 to 5 ohm was inferred for the bottom layers indicating thereby the vertical deterioration of groundwater quality at these locations all over this section.

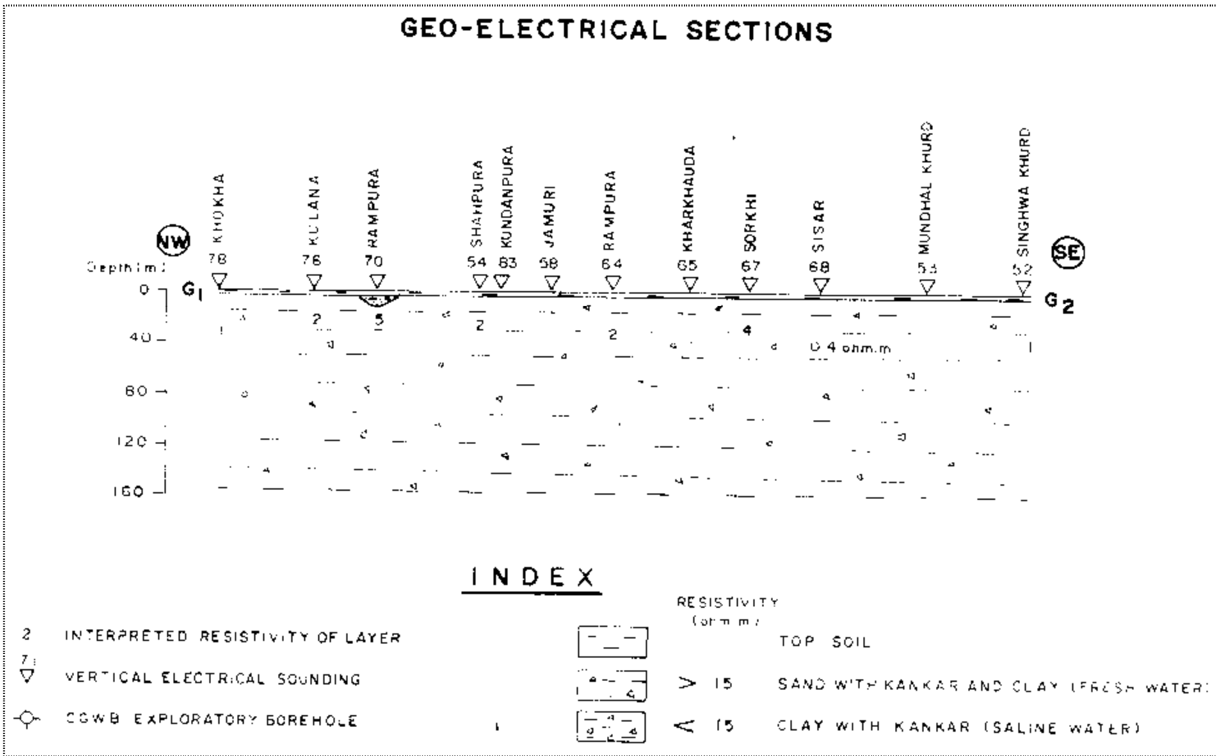


Fig-29: Geo-electrical cross-section along the NW-SE direction of area

3.2.3 Surface and Sub-surface Geophysical data for delineation of fresh and saline Interfaces in the aquifer system:

On the basis of existing geophysical electrical logs of CGWB exploratory wells and VES data are used to interpret the fresh and saline water interfaces in the aquifers at all wells of the district. The interpretations are made by using electrical resistivity surveys and VES sounding for saline and fresh water interface as <10 Ωm for saline water and above 40-60 Ωm represents sand lithology with fresh water content in the aquifers. The prepared interface 3D fence diagram for fresh and saline waters in the aquifers of Hisar district is shown in below Fig-30.

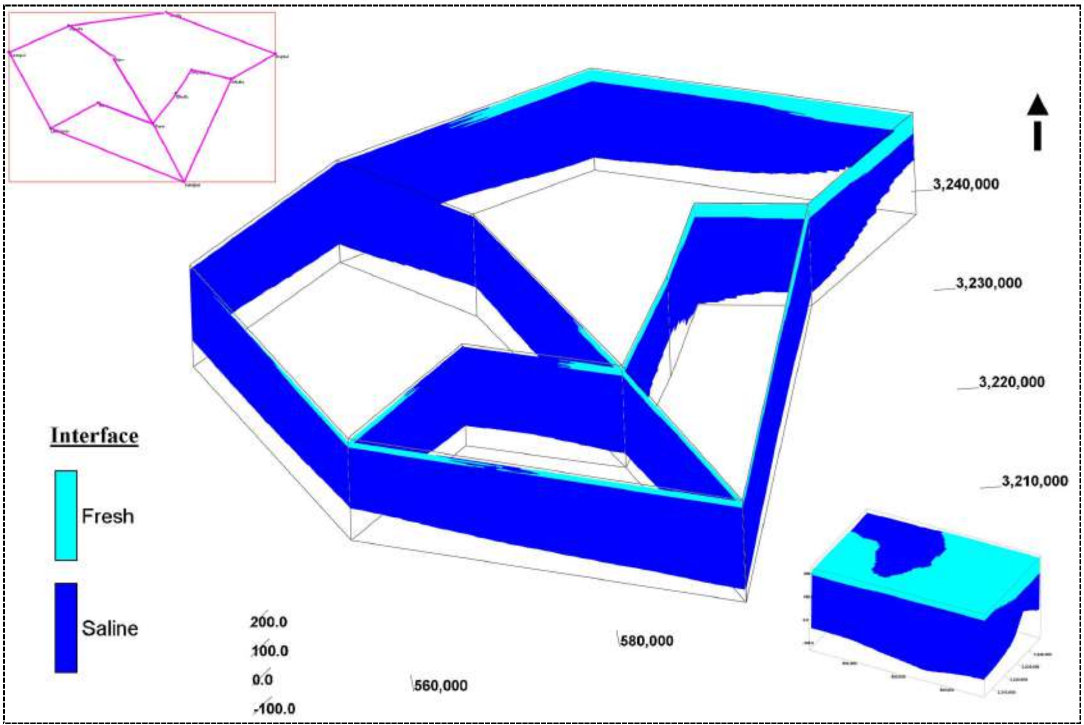


Fig-30: The geophysical resistivity based interpretation for fresh and saline water interfaces in 3D model aquifer system.

4.0 GROUND WATER RESOURCES

Ground water resource estimations have been calculated for both Dynamic and Static/In-storage resources of aquifer presented up to the depth of 300m in alluvial plains of the Hisar district. The assessment of dynamic ground water resources of the Hisar has been carried out jointly by CGWB and Ground Water Cell, Department of Agriculture, Haryana on the basis of available data using Ground Water Estimation Committee (1997) methodology and also revised methodology as on 31st March 2013.

The occurrence of potential granular zones in the single major aquifer up to 300 m depth has been counted on basis of aquifer mapping. The total saturated thickness of granular zones was derived from the exploratory borehole data of a particular block. The granular zones occurring below the zone of water level fluctuation up to the first confining layer has been considered as static unconfined zone. The ground water resource of this zone has been calculated considering 12% specific yield of the formation. The specific yield value for the unconfined aquifer has been taken as 60% of 0.12 which comes as 0.072 whereas for the confined aquifer, Storativity value has been considered. Since the specific yield is likely to reduce with increase in depth due to compaction of overlying sediments.

Hence, the major data elements considered in this estimation are thickness of granular zones, specific yield/storativity, and area of both fresh water and saline/brackish water. It has been observed that in some of the blocks sufficient data on probable occurrence of granular zones was not available. In those cases, the existing exploratory data of adjoining block/district has been either extrapolated or interpolated to derive such parameters required for estimation. This assessment of total groundwater resources has been computed based on the available data with CGWB & Ground Water Cell, Department of Agriculture, Haryana.

4.1 Resources in Single Aquifer group up to the depth of 300 m:

4.1.1 Dynamic Groundwater Resources:

The Stage of ground water development in the Hisar district has been assessed to be 112%. The details are explained in below Table-11. Out of nine blocks of Hisar district, 2 blocks are Over-exploited, 2 critical, 1 Semi-critical and 1 Safe blocks.

Assessment Unit/ Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground Water Draft for domestic and industrial water supply	Existing Gross Ground Water Draft for All uses	Provision for domestic, and industrial requirement supply to 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development (%)	
Adampur	**4521**	4969	0	4969	41	-489	110	OE
Agroha	**6432**	5194	0	5194	28	1210	81	SAFE
Barwala	**12970**	10963	32	10995	69	1938	85	SAFE
Hansi-I	**8765**	11566	23	11589	85	-2886	132	CRIT
Hansi-II/ Bass	**6022**	9199	0	9199	28	-3205	153	CRIT
Hisar-I	**8866**	6589	211	6800	163	2114	77	SAFE
Hisar-II	**8272**	6321	0	6321	129	1822	76	SAFE
Narnaund	**9198**	18555	21	18576	21	-9378	202	OE
Uklana	**5132**	4634	23	4657	46	452	91	S.CRIT
Total (ham)	**70178**	**77990**	**310**	**78300**	**610**	**-8422**	**112**	

Table-11: Dynamic Ground Water Resources estimation & Development Potential (As on 31.03.2013) of Hisar district

4.1.2 In-storage Ground Water Resources:

As per revised guidelines recommended by the Central Level Expert Group on ground water resources assessment, the resources are separately considered as dynamic and in-storage unconfined. In case of alluvial area, the in-storage resources of unconfined aquifer have been computed based on specific yield of the aquifer as detailed below:

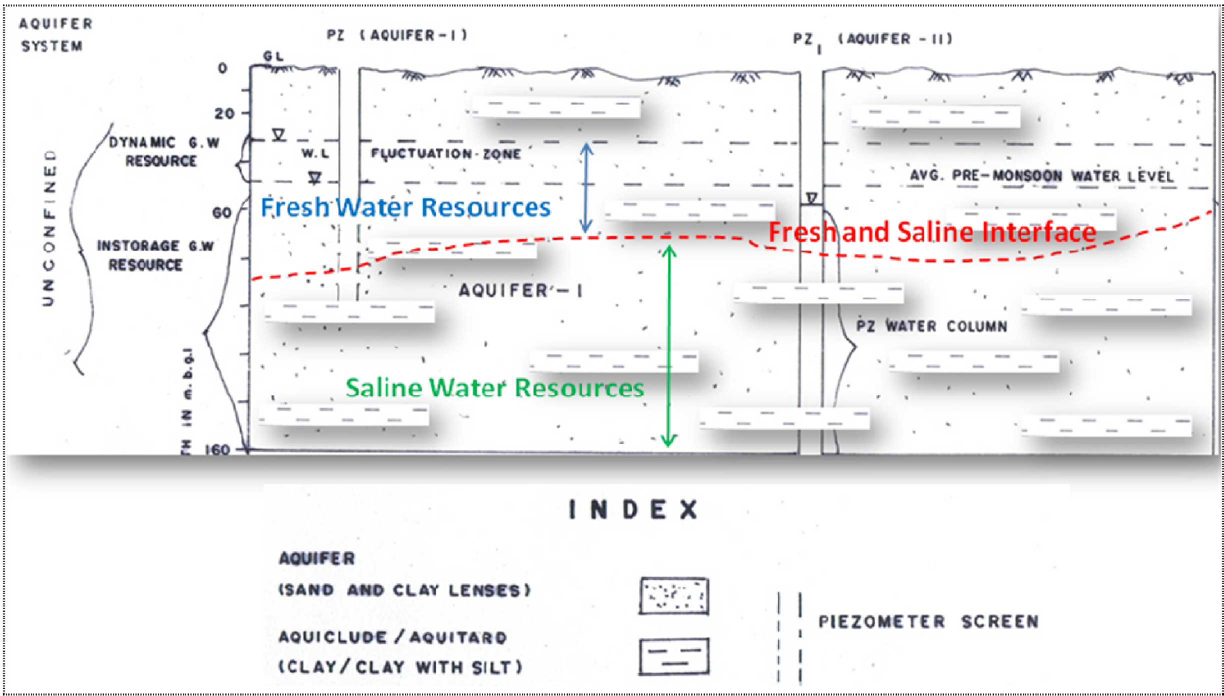
In-storage Ground Water resources (unconfined Aquifer)	=	Thickness of the aquifer (granular/productive zone) below the zone of water level fluctuation down to the bottom layer of unconfined aquifer	x	Sp. Yield of the aquifer	x	Areal extent of the aquifer

The dynamic and in-storage ground water resources estimations have been calculated for single aquifer group of each block of Hisar district. In-storage ground water resources are estimated for fresh water and saline water resources based on the geophysical interpretations of depth of fresh and saline water interface for each block wise. The fresh and saline calculations are made based on the assumptions on aquifer is considered as unconfined aquifer so that the specific yield concept is used for resources estimations (Fig-31). The detailed resources estimations are calculated in detailed table for fresh and saline water resources in the below Table-12, 13 and Table-14.

"Total Availability of Ground Water Resources = Dynamic Resources + In-storage Resources"

The existing dynamic groundwater resources are 623 mcm and in-storage groundwater resources (both fresh and saline water resources) are 18493 mcm for total Hisar district. The fresh water resources are 3692 mcm existed upto the average depth of 30m bgl and saline water resources are 14801 mcm existed in depth of 30 m to 300m bgl.

Fig-31: Conceptual figure for understand the fresh and saline water resource estimations in the single aquifer system up to 300 m depth (*Figure Not to Scale*).



(The clay lances are more dominant in the aquifer and sometimes huge thickness of clay deposits are also observed in the lithologs

Table-12: BLOCK WISE IN-STORAGE GROUND WATER RESOURCES OF FRESH WATER IN AQUIFER UPTO AVERAGE DEPTH OF 30 M (i.e SURFACE TO 30 M)

Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)			Average Pre-monsoon Water Level (m bgl)	Bottom Depth of Fresh water Aquifer (based on Geophysical Interface) (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) (9-8)	Total thickness of the Granular Zones up to the depth of Fresh Water Zones available (m)	Thickness of the unsaturated granular Zones up to Pre-monsoon WL (m)	Thickness of the saturated granular Zones up to the depth of Fresh water aquifer below (m) (12-11)	Average Specific Yield	In-Storage Ground Water Resources up to the depth of Fresh Water Aquifer (ham) = 6*13*14
			Total Geographical Area	Area of Fresh Water	Area of Saline Water								
1	2	3	4	6	7	8	9	10	11	12	13	14	15
1	Adampur	Alluvium	28228	26262	1966	8.3	**15**	6.7	6	1	5	0.072	**9454**
2	Agroha	Alluvium	42110	36958	5152	7.5	**40**	32.5	14	1	13	0.072	**34593**
3	Barwala	Alluvium	47682	46887	795	10	**40**	30	20	6	14	0.072	**47262**
4	Hansi-I	Alluvium	52361	49537	2824	6.5	**32**	25.5	17	3	14	0.072	**49933**
5	Hansi-II (Bass)	Alluvium	30140	28780	1360	4	**20**	16	11	1	10	0.072	**20722**
6	Hisar-I	Alluvium	49587	44585	5002	6.5	**35**	28.5	18	1	17	0.072	**54572**
7	Hisar-II	Alluvium	73773	67605	6168	10.5	**27**	16.5	12	1	11	0.072	**53543**
8	Narnaud	Alluvium	35261	34096	1165	7.5	**45**	37.5	20	5	15	0.072	**36824**
9	Uklana	Alluvium	26910	26239	671	8.3	**15**	6.7	5	5	0	0.072	**0**
District Total (ham)			**386052**	**360949**	**25103**	**7.68**	**30**	**22.2**	**123**	**3**	**11**	**0.072**	**306903**
Total Fresh Water Resources available up to the average depth of 30m (in MCM)													**3069**
Total Fresh Water Resources available up to the average depth of 30m (in BCM)													**3.1**

Table-13: BLOCK WISE IN-STORAGE GROUND WATER RESOURCES OF SALINE WATER IN AQUIFER UPTO DEPTH OF 300 M (i.e between 30 m to 300 m)

Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)			Average Specific Yield	Depth to bottom of Saline water Aquifer based on Geophysical Interface (m bgl) (Up to available drilled depth)	Total thickness of the Granular Zones up to the depth of Saline Water Zones available (m)	In-Storage Ground Water Resources up to the depth of Saline Water Aquifer (ham) 4*8*10
			Total Geographical Area.	Area of Fresh Water	Area of Saline Water				
1	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**10**	**11**
1	Adampur	Alluvium	28228	26262	1966	0.072	**177**	30	**60972.5**
2	Agroha	Alluvium	42110	36958	5152	0.072	**163**	50	**151596.0**
3	Barwala	Alluvium	47682	46887	795	0.072	**182**	51	**175088.3**
4	Hansi-I	Alluvium	52361	49537	2824	0.072	**286**	55	**207349.6**
5	Hansi-II (Bass)	Alluvium	30140	28780	1360	0.072	**104**	30	**65102.4**
6	Hisar-I	Alluvium	49587	44585	5002	0.072	**209**	54	**192794.3**
7	Hisar-II	Alluvium	73773	67605	6168	0.072	**182**	76	**403685.9**
8	Narnaud	Alluvium	35261	34096	1165	0.072	**126**	43	**109168.1**
9	Uklana	Alluvium	26910	26239	671	0.072	**103**	59	**114313.7**
District Total (ham)			**386052**	**360949**	**25103**	**0.072**	**170**	**50**	**1480071**
Total Saline Water Resources available after the average depth of 30m to 300 m (in MCM)									**14801**
Total Saline Water Resources available after the average depth of 30m to 300 m (in BCM)									**14.80**

Table-14: BLOCK WISE TOTAL AVAILABILITY OF TOTAL FRESH AND SALINE GROUNDWATER RESOURCES IN HISAR DISTRICT UPTO MAX. 300 M DEPTH (BASED ON THE DRILLED DATA AVAILABLE IN EACH BLOCK INFROMATION)

Sl. No	BLOCK	*Dynamic Ground water Resources (2013) (HAM)*	*In-storage Groundwater Resources UP TO FRESH WATER ZONES*	Total Groundwater Resources up to Avg. 30 m Depth Fresh Water [(3)+(4)] (HAM)	Fresh Water Total		Total Saline Groundwater Resources up to the Depth of wells available in each block (HAM)	Saline Water Total		Total Availability of Fresh and Saline Groundwater Resources up to 300 m depth [(5)+(7)]		Volume of Unsaturated Granular Zones (above Water Level) for Natural Recharge (Considered below 3m bgl to WL)	Unsaturated Zone Block wise	
					Block wise MCM	Block wise BCM		Block wise MCM	Block wise BCM	HAM	BCM		Block wise MCM	Block wise BCM
1	*2*	*3*	*4*	*5*	*6*		*7*	*8*		*9*	*10*	11	12	
1	Adampur	4809	9454	**14263**	142.6	0.14	**60972**	609.7	0.61	**75236**	**0.75**	**3387.36**	33.9	0.03
2	Agroha	5601	34593	**40194**	401.9	0.40	**151596**	1516.0	1.52	**191790**	**1.92**	**5053.2**	50.5	0.05
3	Barwala	8626	47262	**55888**	558.9	0.56	**175088**	1750.9	1.75	**230976**	**2.31**	**34331.0**	343.3	0.34
4	Hansi-I	9320	49933	**59253**	592.5	0.59	**207350**	2073.5	2.07	**266603**	**2.67**	**18850.0**	188.5	0.19
5	Hansi-II (Bass)	6032	20722	**26754**	267.5	0.27	**65102**	651.0	0.65	**91856**	**0.92**	**3616.8**	36.2	0.04
6	Hisar-I	7286	54572	**61858**	618.6	0.62	**192794**	1927.9	1.93	**254652**	**2.55**	**5950.4**	59.5	0.06
7	Hisar-II	7736	53543	**61279**	612.8	0.61	**403686**	4036.9	4.04	**464965**	**4.65**	**8852.8**	88.5	0.09
8	Narnaud	8762	36824	**45586**	455.9	0.46	**109168**	1091.7	1.09	**154754**	**1.55**	**21156.6**	211.6	0.21
9	Uklana	4148	0	**4148**	41.5	0.04	**114314**	1143.1	1.14	**118462**	**1.18**	**16146.0**	161.5	0.16
	Total (HAM)	**62320**	**306903**	**369223**			**1480071**			**1849293**	**18.49**	**117344**		
	Total (MCM)	**623**	**3069**	**3692**			**14801**			**18493**		**1173**		
	Total (BCM)	**0.62**	**3.07**	**3.69**			**14.80**			**18.49**		**1.17**		

5.0 GROUND WATER RELATED ISSUES

Hisar is famous for its non-paddy and paddy cultivations. The quality of ground water in the district is potable for both the irrigation and drinking purposes therefore, the ground water is constantly being pumped for the irrigation due to its easy access through tube wells at shallow depths and they are the main source of irrigation.

This will lead to its major ground water issue which is deepening of ground water levels in parts of Uklana, Narnaud, Adampur, Agroha, Hisar-I blocks of Hisar district as the recharge of the groundwater through rainfall and other sources are less than the overall extraction. The hydrographs also indicates that some areas show the constant declining water level trend and the district is categorized as over-exploited (SOD=112%) based on GEC 1997 methodology. Other than this the main ground water issue is quality i.e saline water increases with depths and those resources are available more than fresh water resources. The Aquifers in these saline areas are mostly in thin sand beds and pinch out at short distances, thus restricting the movement of ground water and causes to water logging. In the clay predominant region Kankar is mixed with clay distinctly and also occasionally present in the sand layers at different depth ranges. This is considered to be a characteristic of older alluvium and is mostly associated with saline ground water regime in this district at an average depth of 30 m below ground level. The over-exploitation of groundwater levels are explained in sub-chapter-2.1.4.

The projected demand for domestic and industrial water supply is kept based on projected population for the year 2025 and present dependency on ground water. The ground water available for future irrigation is obtained by deducting the sum of projected demand for Domestic and Industrial use and existing gross irrigation draft from the Net Annual Ground Water Availability. Net Ground Water Availability for future irrigation development in the Hisar district is -84.22 mcm of water.

5.1 Ground Water Irrigation Scenario:

As per the data available from minor irrigation census 2006-07, the detailed number of shallow, deep, tube wells, lined, unlined water distribution system, land holdings of wells are given in Table 15, 16 and 17 and shown in Fig-32.

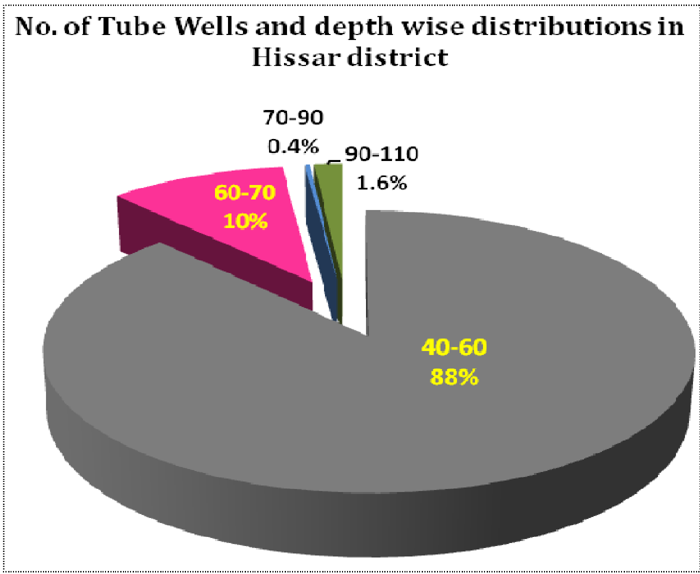


Fig-32: Irrigation tube wells as per depth wise distributions in Hisar district.

Table-15: Distribution of Tube wells According to Owner's holding Size

Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10ha)	Public	Group of Farmers/ Private	Total
374	4023	12750	435	136	5486	23204

Table-16: Distribution of Shallow Tube wells According to Depth of tube well

District	**Depth of Tube Wells (m)**			
	40-60	**60-70**	**70-90**	**90-110**
Hisar	20407	2360	69	368

Table-17: Type of Ground water distribution device

Open Water Channels		
Lined/pucca	**Unlined/kutcha**	**Total**
15765	7439	23204

6.0 AQUIFER MANAGEMENT PLAN

An outline of the Aquifer mapping and management plan for each block is given in Part-II (Chapter-7). This includes details regarding population, rainfall, average annual rainfall, agriculture and irrigation, water bodies, ground water resource availability, ground water extraction and water level behavior. Aquifer disposition and various cross sections have also been given. Ground water resources, extraction and other issues including ground water resource enhancement and demand side innervations have been given.

Another focus has been given to minimize the gross draft by enhancing ground water use efficiency in irrigation system after replacing the water distribution system from unlined/kutcha channel to Under Ground Pipeline System (UGPS) in over exploited blocks of the district and recharge through artificial recharge structures, village ponds, drains/nallas and crop diversification process. The scopes of quantitative impact on stage of ground water development after applying various management strategies are mentioned for block wise and whole district in Table-22.

6.1 Scope of Implementation Plans:

This plan is focusing on the technical aspects of the ground water recharge through various means so that various implementing agencies may get the appropriate technical guidelines. The existing/ongoing schemes of the central or state government like MANERGA, IWSP, PMKSY (Prime Minister Krishi Sinchai Yojna), NABARD funded schemes, Urban Development schemes, departmentally funded projects etc may be benefitted from the recharge plan by incorporating the input in the operational guidelines/ design and for locating the specific sites.

Agriculture University, Engineering collages, academic and research institutions, and NGO may also take up the pilot or demonstrative projects in the blocks suitable to them to plan at local level as per local conditions.

6.2 Potential of Enhancing the Ground Water Use Efficiency:

The micro level transformation in the ground water management have vast impact potential to counter extensive ground water depletion faced in the state of Haryana, particularly in overexploited blocks.

There are around 7439 tube wells (out of 23204) i.e 32% operated by farmers for irrigation through unlined/Katcha open channel system in Hisar district where water from the tube well is discharge to the agricultural field. In this process, huge (around 25%) quantity of ground water is wasted in soil moisture and evaporation losses. The wastage of water through unlined channels is estimated 55 mcm and 62.4 mcm for assessment years 2011 and 2013 respectively and datasheet is shown in table-18.

Around 88% of the tube wells are of shallow depth (40 to 60m) and remaining 12% of the wells are existed at deeper depth >60 to 110 m in the district. Thus majority of wells are tapping at shallow Aquifers.

Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation, domestic and industrial users in Hisar district is estimated at 783 mcm. It is expected that around 25% of over draft can be brought down by switching over to underground/surface pipeline based distribution from the prevailing unlined open channels. Thereby gross draft will be reduced to the tune of 62.4 mcm assuming there is no crop diversification by the farmers (Table-18 & 22).

The benefit will lead to saving of precious ground water resources in over-exploited blocks. If implemented above adapted techniques in the areas then it will bring down the ground water overdraft from 112% to 102.7% at district level. The category of the blocks will also improve resulting in boosting of agriculture and industrial development otherwise not sustainable in over-exploited blocks.

The tubewells also consume enormous electricity which is subsidized and government incurs significant revenue on this account. The measures therefore will result in saving of energy and money. Pollution impact will be reduced whenever diesel engines are used by the farmers. The environmental and ecological condition in the irrigated land will improve. Unwanted weed growth will also be controlled inside the farm land. This will also be useful in the waterlogged/ shallow water table areas as the seepage losses in these areas also aggravate the water logging. Government should make/launch a mission mode program for installing the underground pipe lines instead of having katcha channel in the entire Haryana. Heavy ground water overdraft can be reduced by these efforts. This will ensure more crops per drop. Reduction in stage of development after construction of Pacca channels in irrigated land is given in table-18.

Assessment Year	Assessment Unit	Net Annual Ground Water Availability (mcm)	Total Draft (present) (mcm)	Gross Irrigation Draft (present) (mcm)	Gross Ground Water Draft for Domestic and industrial supply (mcm)	Percentage of unlined channel	Wastage through unlined channel, (mcm) (Col 3 X Col5 X 0.25#)	Potential of Reduced irrigation overdraft (Col3-col6) (mcm)	Gross draft after saving of water (mcm) (Col 7+Col4)	Present Stage of development (%)	Stage of development afterwards ((Col8/Col11)X100) %	Reduction in stage of development after constructing pucca channel (Col9-Col 10) (%)
		1	2	3	4	5	6	7	8	9	10	11
2013	Adampur	45.21	49.69	49.69	0	**32%**	3.50	46.19	46.19	110	102	**7.7**
	Agroha	64.32	51.94	51.94	0	**32%**	3.66	48.28	48.28	81	75	**5.7**
	Barwala	129.7	109.95	109.63	0.32	**32%**	7.73	101.90	102.22	85	79	**6.0**
	Hansi-I	87.65	115.89	115.66	0.23	**32%**	8.15	107.51	107.74	132	123	**9.3**
	Hansi-II	60.22	91.99	91.99	0	**32%**	6.49	85.50	85.50	153	142	**10.8**
	Hisar-I	88.66	68.00	65.89	2.11	**32%**	4.65	61.24	63.35	77	71	**5.2**
	Hisar-II	82.72	63.21	63.21	0	**32%**	4.46	58.75	58.75	76	71	**5.4**
	Narnaund	91.98	185.76	185.55	0.21	**32%**	13.08	172.47	172.68	202	188	**14.2**
	Uklana	51.32	46.57	46.34	0.23	**32%**	3.27	43.07	43.30	91	84	**6.4**
2013	**Hisar Dist Total**	**701.78**	**783**	**779.9**	**3.1**	**32%**	**62.4**	**717.5**	**720.6**	**112**	**102.7**	**9.3**
2011		**623.2**	**582.93**	**578.41**	**4.52**	**32%**	**55.5**	**523.41**	**518.89**	**94**	**83**	**11**

(Note: # 25% of losses from open kuchha channels)

Table-18: Potential for reduction in overdraft by enhancing the groundwater use efficiency in irrigation tube wells, Hisar district (Assessment year-2013).

6.3 Artificial Recharge rural, urban and also through recharge pits in farm:

Artificial recharge structures are to be constructed in rural and urban houses to conserve the rainwater harvesting to groundwater recharge in over-exploited blocks. The suitable methodology is adopted and estimations are made for rural village households, urban households and explained in block wise recharge in over-exploited blocks in mcm and reductions in stage of development are mentioned in below table-19 & 22.

Assessment Unit	Net Annual Ground Water Availability (mcm)	Total Draft (present) (mcm)	Present SOD %	AR in Rural & Urban (mcm)	Draft reduced in mcm	Draft reduced in %	Change in SOD% by AR
	1	*2*	*3*	*4*	*5*	*6*	*7*
Adampur	45.21	49.69	110	0.73	49.0	108.3	1.6
Agroha	64.32	51.94	81	0.00	51.9	80.8	0.0
Barwala	129.7	109.95	85	0.00	110.0	84.8	0.0
Hansi-I	87.65	115.89	132	0.00	115.9	132.2	0.0
Hansi-II	60.22	91.99	153	0.00	92.0	152.8	0.0
Hisar-I	88.66	68.00	77	0.00	68.0	76.7	0.0
Hisar-II	82.72	63.21	76	0.00	63.2	76.4	0.0
Narnaund	91.98	185.76	202	1.25	184.5	200.6	1.4
Uklana	51.32	46.57	91	0.00	46.6	90.7	0.0

Table-19: Potential recharge through Artificial Recharge structures in rural and urban areas of Hisar district

6.4 Recharge through village ponds and utility for irrigation:

The disposal of waste water in rural/villages is a major problem. The stagnant waste water smells bad and also acts as breading place for mosquitoes resulting in spread diseases like Denguem, Malaria, Filaria etc. Therefore proper disposal and reuse of waste water wherever possible will help in controlling diseases as well as meting out scarcity of water. The waste water of households called the grey water collected from bathroom, washing of cloths and kitchen requires less treatment than black water and generally contains fewer pathogens. The treated water can be used for gardening, fodder raising and kitchen gardening.

Under water management for rural areas is that it is revealed that more than 90% of waste water generated in rural areas is grey water. For the treatment of waste water at village level by natural way, a system has been evolved called 3/5 pond system. The grey water of the village collected through the drains/nallas collected at a common point and passed through the iron mesh of different sizes and then allowed to pass through large shallow basins or ponds. Its pathogenicity is reduced and stabilized water becomes reusable. The field photographs of this three and five pond systems adopted in different villages of Karnal district are given in Fig-33.

There are 705 village ponds existed in Hisar district and recharge to groundwater from few of village ponds are explained in sub-chapter-1.9. In addition to this Industrial sectors may also initiated to adopt the surrounding village ponds with a prime objective of artificial recharge to groundwater through rainwater runoff. Periodically desiltation and cleaning of ponds and plantation of trees along the pond banks improve the quality of water in the ponds and ultimately this water is used for irrigation and recharge to ground water.

Figure-33: A view of village tanks of five pond / three pond system of water treatment under natural process.

The above mentioned techniques can be adopted in every village ponds for ground water development. The utilization of waste water though ponds in Hisar district is given in table-19. The domestic demand is taken as person is 70 lpcd and out of this 80% will be domestic effluent. The 80% of water i.e waste can be saved in the ponds; the pond water can be treated and can be used for irrigation purpose. These are ultimately reflected to reduce in the draft of groundwater from tube well and reductions in change of present stage of development. The details are explained in block wise given in table-20 (Source is Census data, 2011).

Name of CD block	Total number of inhabited villages in the C. D. block	Total population of C.D. block	Domestic demand in litre per day@70 lpcd	Domestic demand in litre per day@70 lpcd/Annum	Domestic effluent @ 80% of after use (lpcd/annum)	Saving of water through waste water of pond (ham)		Net Availability (ham)	Total draft (ham)	Modified draft (ham)	Existing stage of Development (%)	SOD* after wards	Reduce the % change in present SOD
						cubic meter	In Ham						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Adampur	19	86011	6020770	2197581050	1758064840	1758065	176	4521	4969	4793	110	106	4
Agroha	23	101193	7083510	2585481150	2068384920	2068385	207	6432	5194	4987	81	78	3
Barwala	38	157981	11058670	4036414550	3229131640	3229132	323	12970	10995	10672	85	82	3
Hisar II	40	174733	12231310	4464428150	3571542520	3571543	357	8272	6321	5964	76	72	4
Hisar I	40	144128	10088960	3682470400	2945976320	2945976	295	8866	6800	6505	77	73	4
Uklana	12	92473	6473110	2362685150	1890148120	1890148	189	5132	4657	4468	91	87	4
Narnaund	30	123638	8654660	3158950900	2527160720	2527161	253	9198	18576	18323	202	199	3
Hansi I	40	207569	14529830	5303387950	4242710360	4242710	424	8765	11589	11165	132	127	5
Hansi II	22	92451	6471570	2362123050	1889698440	1889698	189	6022	9199	9010	153	150	3

(SOD = Stage of Ground Water Development)*

Table-20: Utilization of waste water from village ponds and reduction in stage of development estimations (2013).

6.5 Water saving Potential from Crop Diversification-Change Paddy to Maize/Soya-bean or Pulses:

As the requirement of water for paddy is much high therefore by changing paddy to maize/soya-bean will help in saving of water. For estimating the water saving by crop diversification it is assumed that ***one mcm*** of water will be saved in case of maize or soybean planted in ***one sq km*** of land. In case of pulses even higher amount of ground water can be saved.

The water saving through crop diversification is major challenge and it will give major impact on groundwater resources extraction. The paddy cultivation replaces by maise/soyabean or pulses are showing impact on groundwater draft. The calculations for block wise saving of water in mcm and reduction in draft after crop diversification technique like paddy replaced with maise/soyabean and paddy replaced with pulses are explained in detailed table-21.

In Hisar district, there are 2 Over-exploited (OE) blocks and remaining 7 blocks are Safe, Semi-critical & Critical blocks with less percentage of land for paddy cultivations. After adaptation of all methods of management plans like crop diversification paddy with maise/soyabeans or with pulses, AR (Artificial Recharge in rural, urban), UGPL and Ponds water usage/recharge are caused to reduce in the groundwater draft and also saving of water for different users. After adaptation of above methods of techniques in OE and Critical blocks are reduced 14 to 35% in their stage of development and ultimately these blocks fall in safe to semi-critical category. Adampur, Hansi-I & II blocks are reduced in stage of development to 96%, 92% & 97% after adaptation of all techniques like crop diversification paddy with maise/soyabeans or with pulses, AR (Artificial Recharge in rural, urban), UGPL and Ponds water usage/recharge, whereas Narnaund block is reached to 150-170% after included all management plans. The block wise saving of water in mcm by crop diversification, UGPL artificial recharge in rural, urban areas and pond recharge methods details are given in below table-22. The table shows that how much reduction of stage of development presents to after adaptation of all these management practices are explained in detail in this table-22.

Sr. No.	Block	Net Annual Ground Water Availability (mcm)	Total Draft (present) (mcm)	Overdraft (mcm)	Stage of development (present %)	Total paddy area in sq. km	Water saving (mcm) replacement of paddy by Maize/Soybean @0.13 mcm/sq.km	Draft Reduced due to replacement of paddy by Maize/Soybean	Water saving replacement of paddy by Pulses @0.3 mcm/sq.km (mcm)	Draft Reduced due to replacement of paddy by Pulses	SOD % (Maize/Soyabean)	SOD % (Pulses)	Reduced SOD % by Maize	Reduced SOD % by Pulses
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Adampur	45.21	49.69	4.48	110	0.00	0.00	49.69	0.00	49.69	109.91	109.91	0.1	0.1
2	Agroha	64.32	51.94	-12.38	81	0.47	0.06	51.88	0.14	51.80	80.66	80.53	0.1	0.2
3	Barwala	129.7	109.95	-19.75	85	30.56	3.97	105.98	9.17	100.78	81.71	77.70	3.1	7.1
4	Hansi-I	87.65	115.89	28.24	132	77.31	10.05	105.84	23.19	92.70	120.75	105.76	11.5	26.5
5	Hansi-II (Bass)	60.22	91.99	31.77	153	82.68	10.75	81.24	24.80	67.19	134.91	111.57	17.8	41.2
6	Hisar-I	88.66	68	-20.66	77	30.35	3.95	64.05	9.11	58.90	72.25	66.43	4.5	10.3
7	Hisar-II	82.72	63.21	-19.51	76	0.64	0.08	63.13	0.19	63.02	76.31	76.18	0.1	0.2
8	Narnaund	91.98	185.76	93.78	202	103.36	13.44	172.32	31.01	154.75	187.35	168.25	14.6	33.7
9	Uklana	51.32	46.57	-4.75	91	14.53	1.89	44.68	4.36	42.21	87.06	82.25	3.7	8.5

Table-21: Water saving Potential from Crop Diversification-Change Paddy to Maize/Soya-bean or Pulses

Block	Category	Stage of development (%) as per GWR 2013	Net Annual Ground Water Availability (mcm)	Total Draft (present) (mcm)	Water Saving Methods											SOD % afterwards without pulses	SOD % afterwards without Maize
					UG (mcm)	Reduction in % through UG	AR (mcm)	Reduction in % through AR	Saving by replce. Maize (mcm)	Reduction in % through paddy to Maize	Ponds (mcm)	Reduction in % through Ponds	Total Savings in % by all	Saving by replce. Pulses (mcm)	Reduction in % through paddy to Pulses		
Adampur	OVER EXPLOITED	**110**	45.21	49.7	3.5	7.7	0.73	1.6	0.0	0.1	1.8	4	**13**	0.0	**0.1**	**96**	**96**
Agroha	SAFE	**81**	64.32	51.9	3.7	5.7	0.00	0.0	0.1	0.1	2.1	3	**9**	0.1	**0.2**	**Safe**	
Barwala	SAFE	**85**	129.7	110.0	7.7	6.0	0.00	0.0	4.0	3.1	3.2	3	**12**	9.2	**7.1**		
Hansi-I	CRITICAL	**132**	87.65	115.9	8.2	9.3	0.00	0.0	10.1	11.5	3.6	4	**25**	23.2	**26.5**	**107**	**92**
Hansi-II (Bass)	CRITICAL	**153**	60.22	92.0	6.5	10.8	0.00	0.0	10.7	17.8	3.0	4	**33**	24.8	**41.2**	**120**	**97**
Hisar-I	SAFE	**77**	88.66	68.0	4.6	5.2	0.00	0.0	3.9	4.5	1.9	4	**14**	9.1	**10.3**	**Safe**	
Hisar-II	SAFE	**76**	82.72	63.2	4.5	5.4	0.00	0.0	0.1	0.1	2.5	3	**8**	0.2	**0.2**		
Narnaund	OVER EXPLOITED	**202**	91.98	185.8	13.1	14.2	1.25	1.4	13.4	14.6	4.2	5	**35**	31.0	**33.7**	**167**	**148**
Uklana	SEMI CRITICAL	**91**	51.32	46.6	3.3	6.4	0.00	0.0	1.9	3.7	1.9	3	**13**	4.4	**8.5**	**Safe**	

Table-22: Scope of Quantitative Impact on Stage of Development after applying various management strategies.

[PART-II]

7. BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

I. ADAMPUR BLOCK (282.28 SQ. KM)

Population (2011)	Rural-86,011
	Urban-25,531
	Total- 111,542
Rainfall	Monsoon: 130 mm
	Non Monsoon: 43 mm
Average Annual Rainfall	173 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

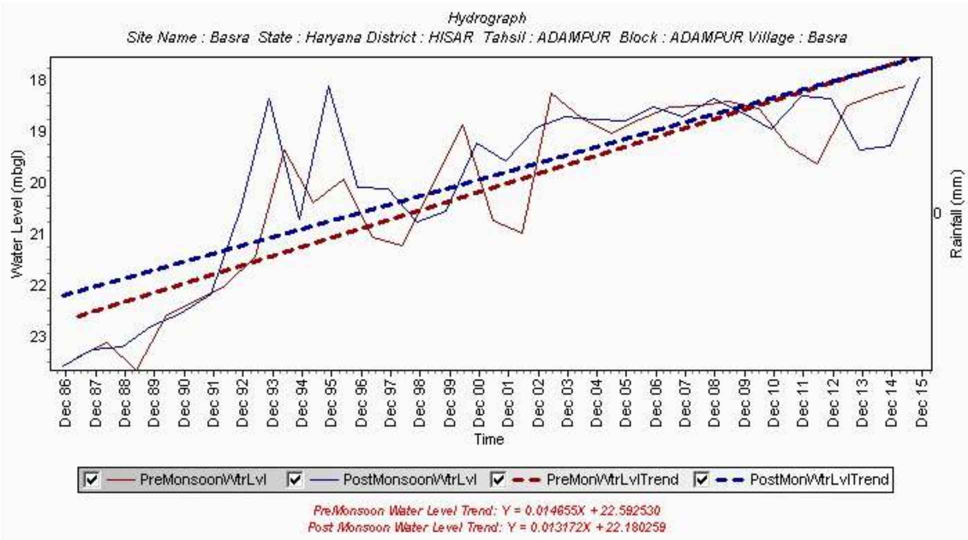
Net Area Sown:	25405 ha
Total Irrigated Area:	Monsoon= 27489 ha
	Non-monsoon= 52174 ha

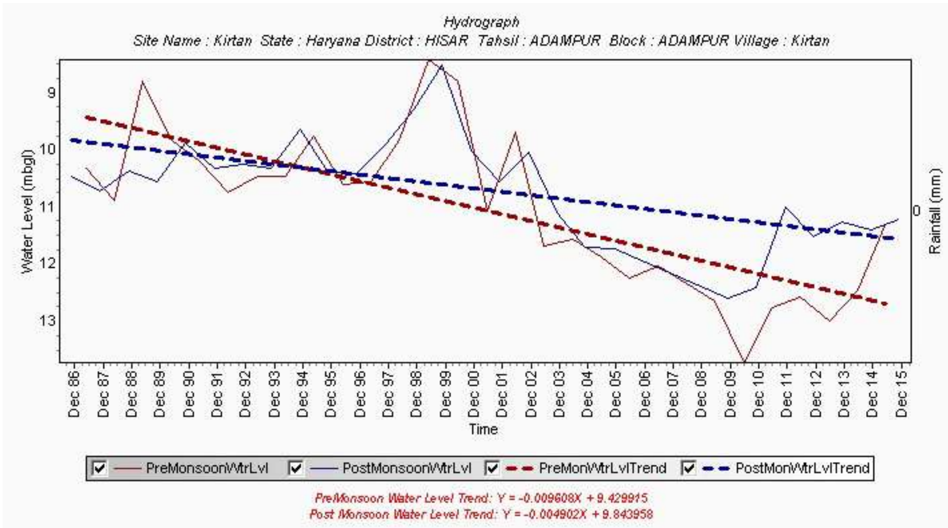
Canal Irrigation 4 lined canals & 13 unlined canals

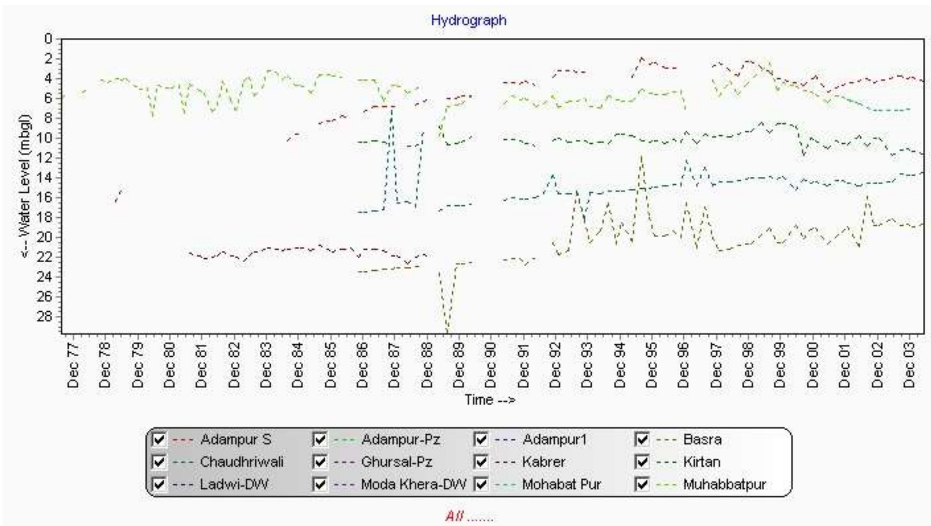
Ground Water Resource Availability: Ground Water Resources are available 0.75 bcm (0.14 bcm fresh and 0.61 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 15 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 6 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 162 m and the granular zones are counted after the depth of 30 m and available zones are 15 m. This Block is categorized as Over-Exploited as per 2013 assessment and present stage of development SOD is 110%.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~12.4 m bgl.


Hydrograph
Site Name : Basra State : Haryana District : HISAR Tahsil : ADAMPUR Block : ADAMPUR Village : Basra
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.014655X + 22.592530
Post Monsoon Water Level Trend: Y = 0.013172X + 22.180259


Hydrograph
Site Name : Kirtan State : Haryana District : HISAR Tahsil : ADAMPUR Block : ADAMPUR Village : Kirtan
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.009608X + 9.429915
Post Monsoon Water Level Trend: Y = -0.004802X + 9.843958

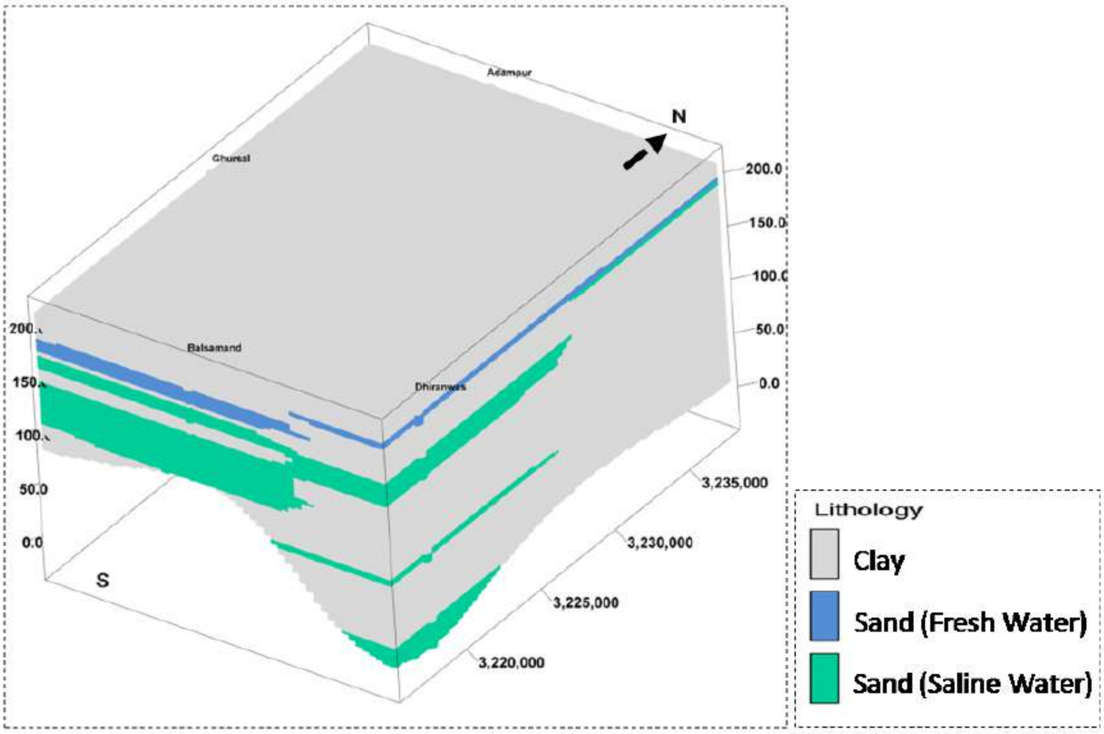

Hydrograph
<-- Water Level (mbgl)
Time -->
Adampur S
Adampur-Pz
Adampur1
Basra
Chaudhriwali
Ghursal-Pz
Kabrer
Kirtan
Ladwi-DW
Moda Khera-DW
Mohabat Pur
Muhabbatpur
All ....

Aquifer Disposition: There is single Aquifer System (up to 300 m)

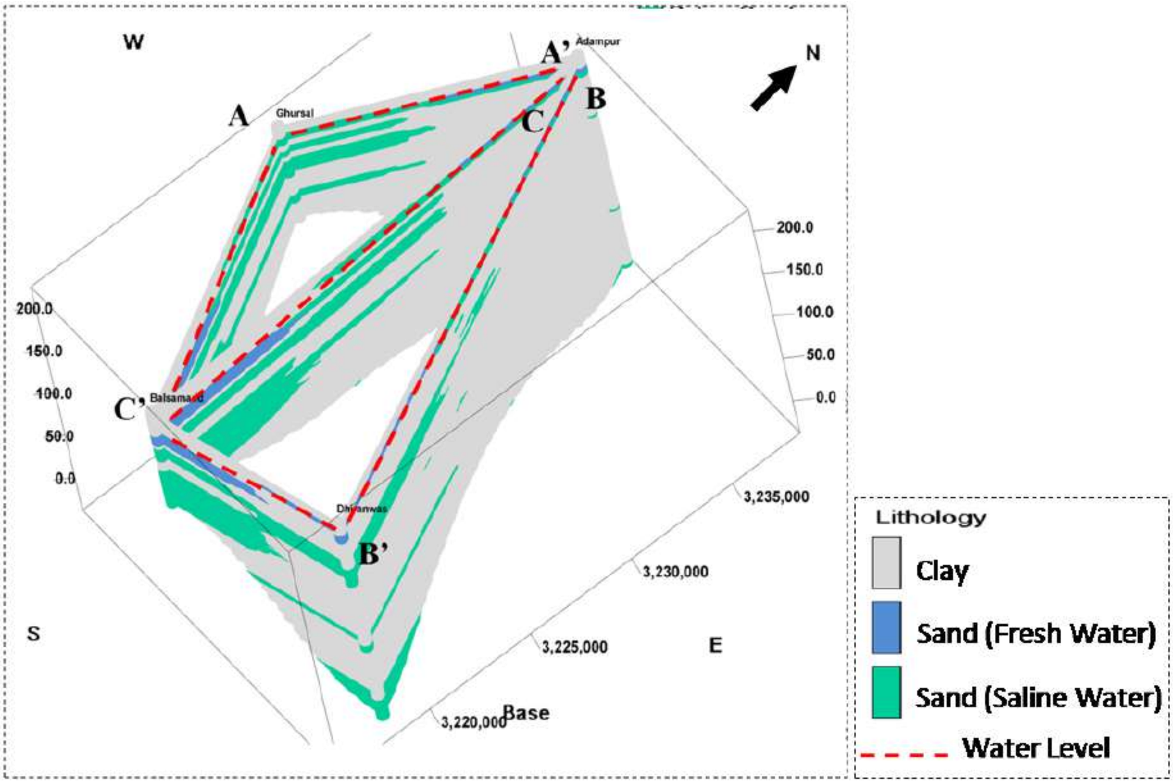
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	36	--	12	--
			Wells abandoned due to bad quality of water			

The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

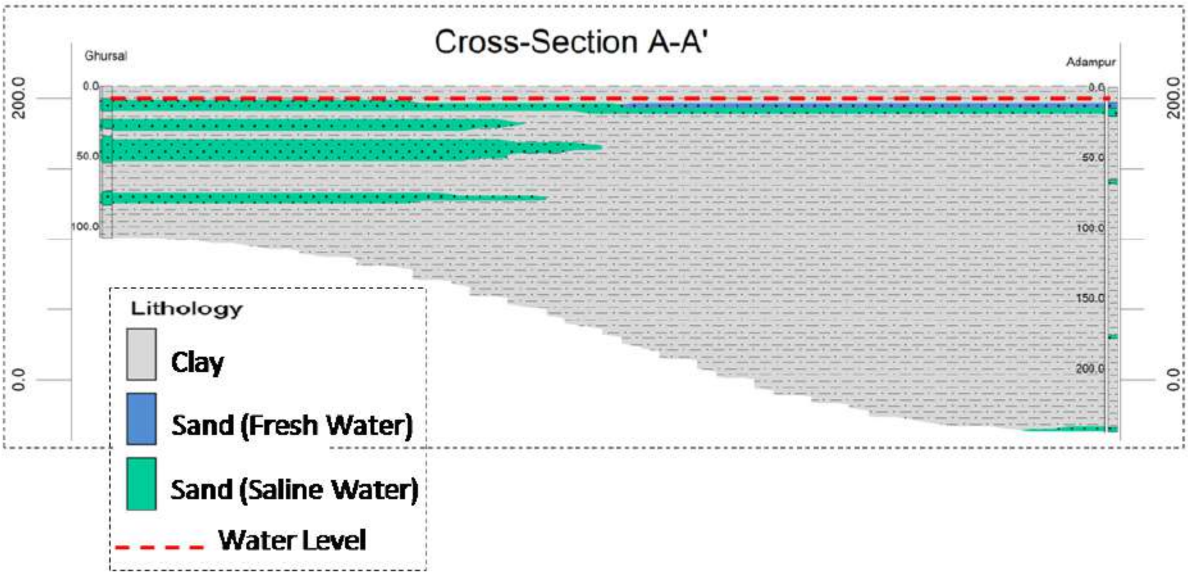
3D Lithology model

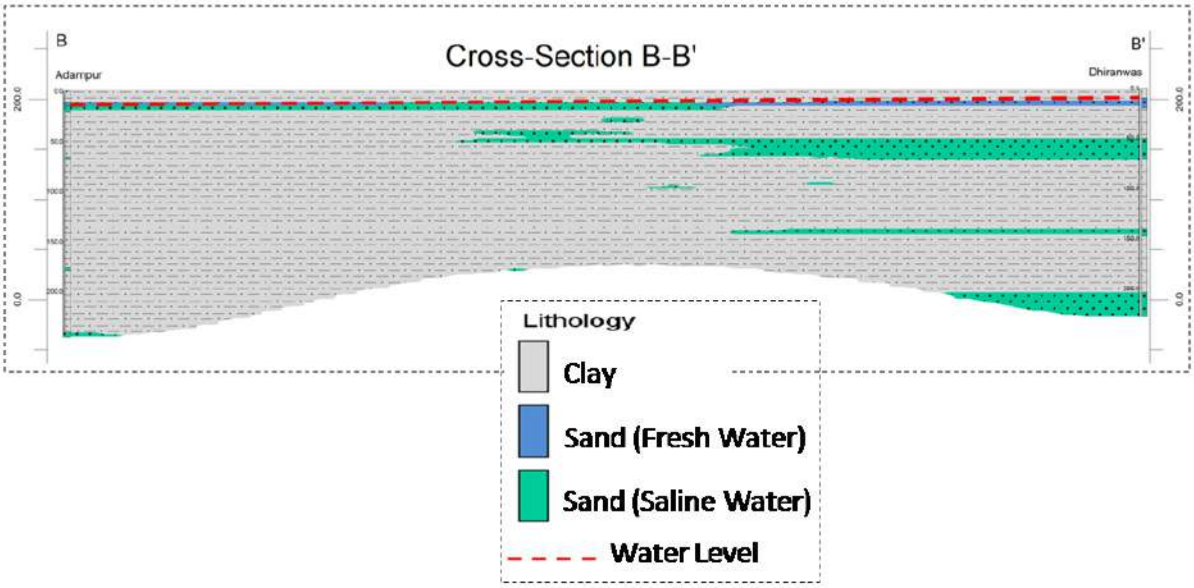


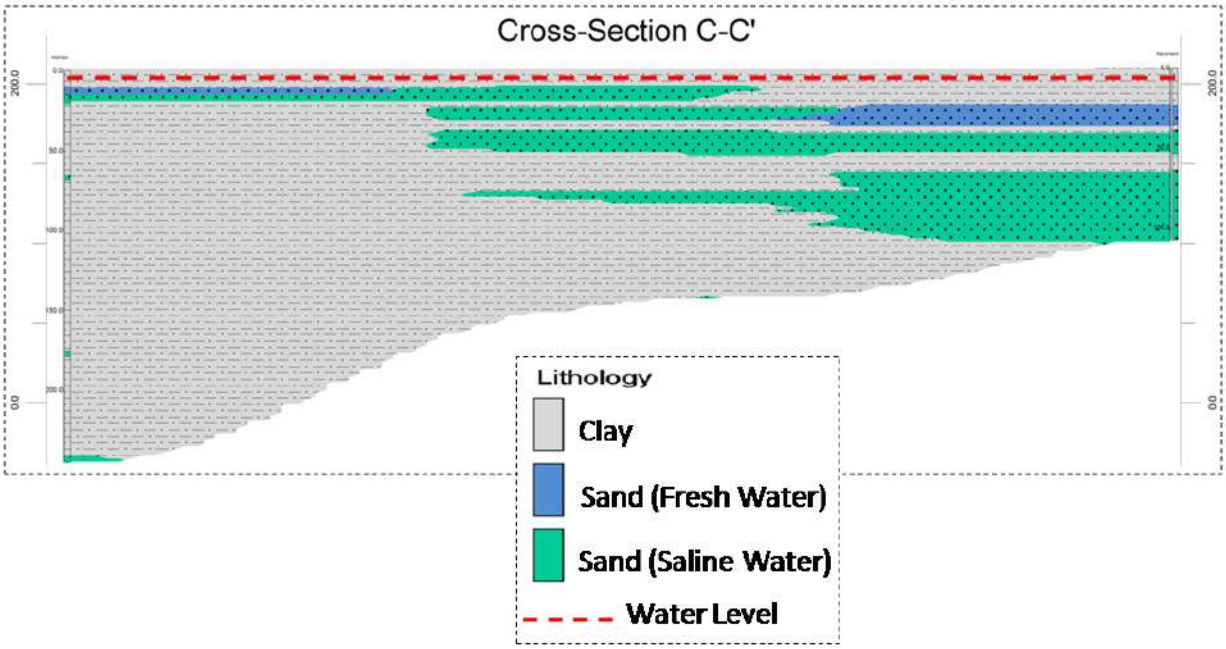
3D Lithology Fence



Cross-Sections




Cross-Section B-B'
B
B'
Adampur
Dhiranwas
200.0
0.0
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section C-C'
200.0
0.0
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	48.09
	In-storage Fresh water resources	94.54
	In-storage Saline water resources	609.7
	Total	752.33
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	49.69
	Domestic & Industrial	0
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		0.41
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 3000 to 4000 µS/cm at 25^{0}c)
Other issues		Water levels are declining and rising trend in some areas. Present stage of development 110%.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level is 33.9 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 6.03 mcm.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 3.50 mcm volume of water wastage
Change in cropping pattern	Proposed for change in cropping pattern from Paddy to maize/soyabean in total area. Anticipated volume of water to be saved by maize/soyabean is 49.69 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

II. AGROHA BLOCK (421.10 SQ. KM)

Population (2011) Rural- 101,193
Urban- 0
Total- 101,193

Rainfall Monsoon: 220 mm
Non Monsoon: 50 mm

Average Annual Rainfall 270 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

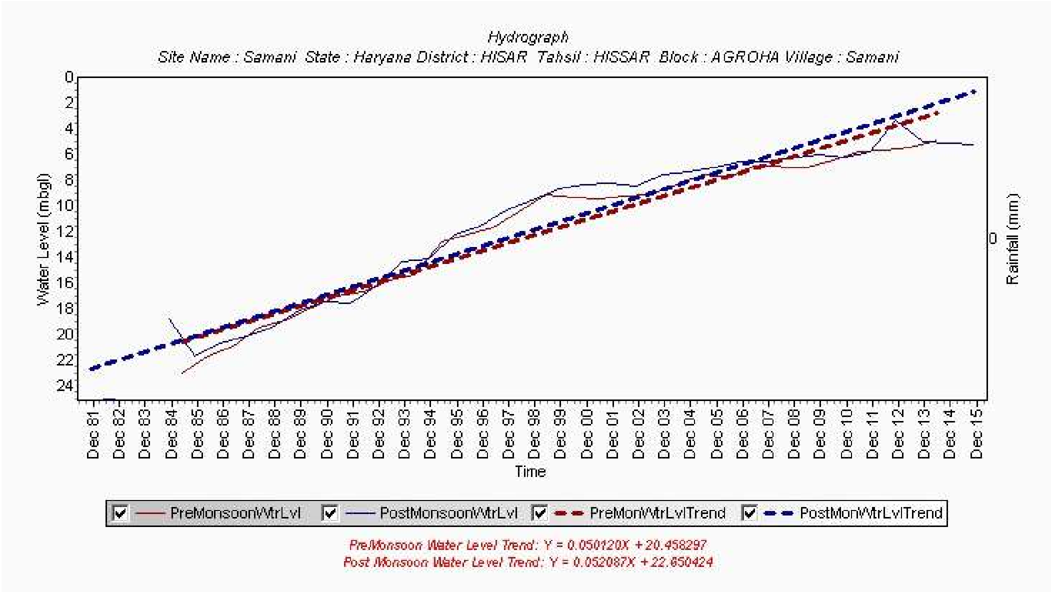
Net Area Sown: 37899 ha
Total Irrigated Area: Monsoon= 24818 ha
Non-monsoon= 26948 ha

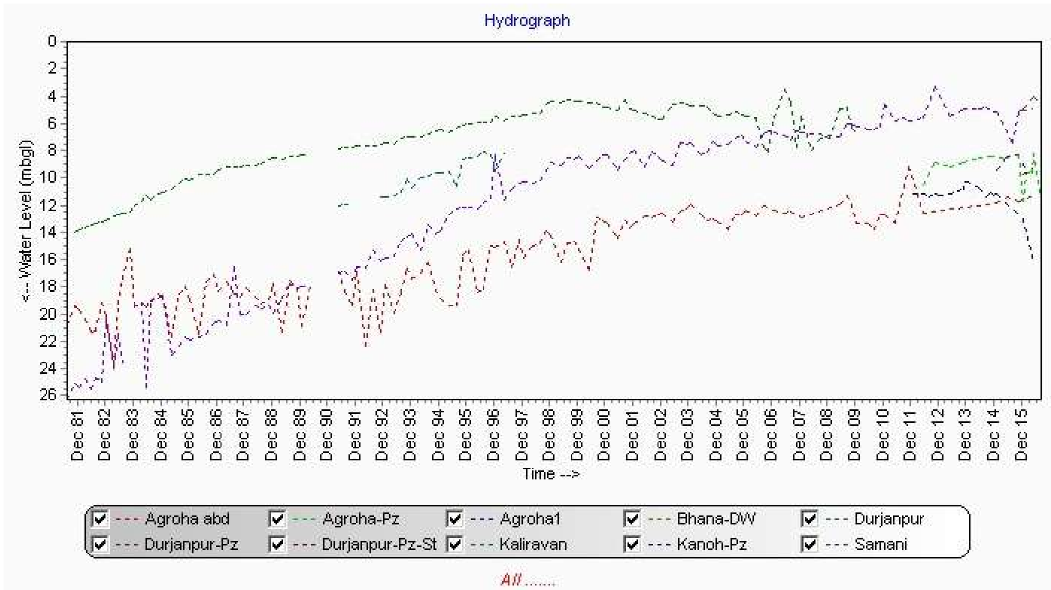
Canal Irrigation 23 lined canals

Ground Water Resource Availability: Ground Water Resources are available 1.92 bcm (0.40 bcm fresh and 1.52 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 40 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 14 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 123 m and the granular zones are counted after the depth of 40 m and available zones are 50 m. This Block is categorized as safe as per 2013 assessment and SOD % is 81%.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~6.13 m bgl.



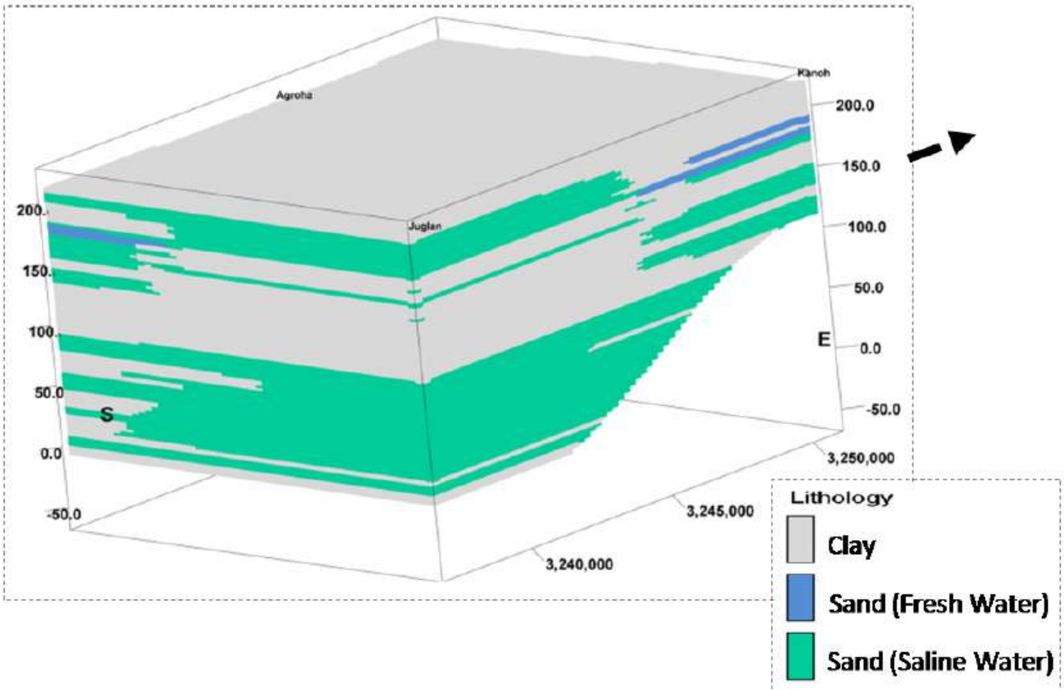


Aquifer Disposition: There is single Aquifer System (up to 300 m)

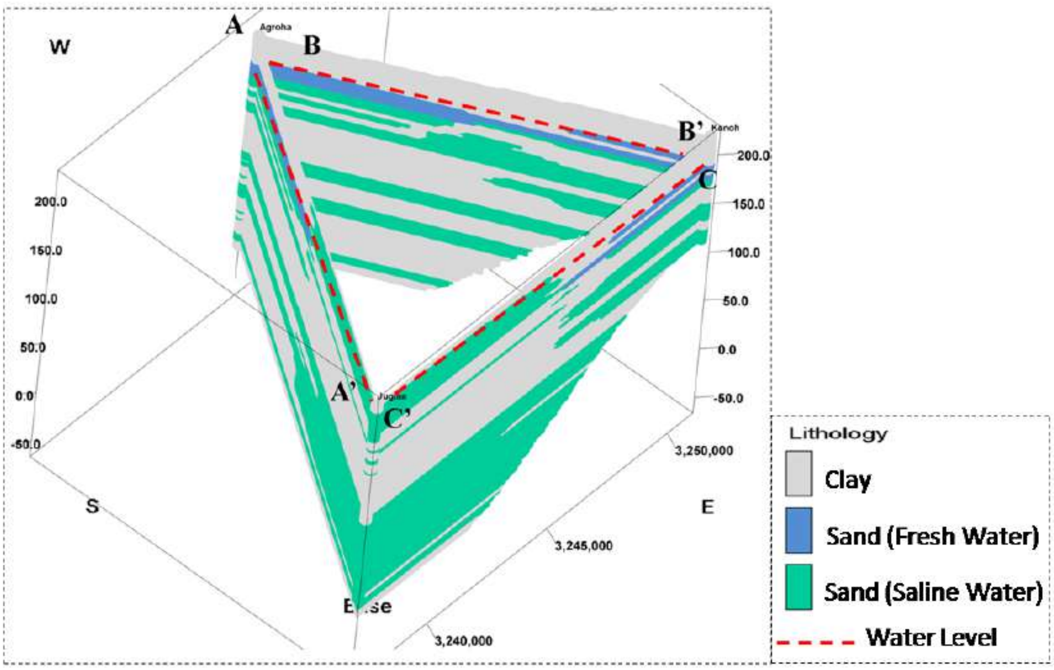
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	64	--	12	--
			Wells abandoned due to bad quality of water			

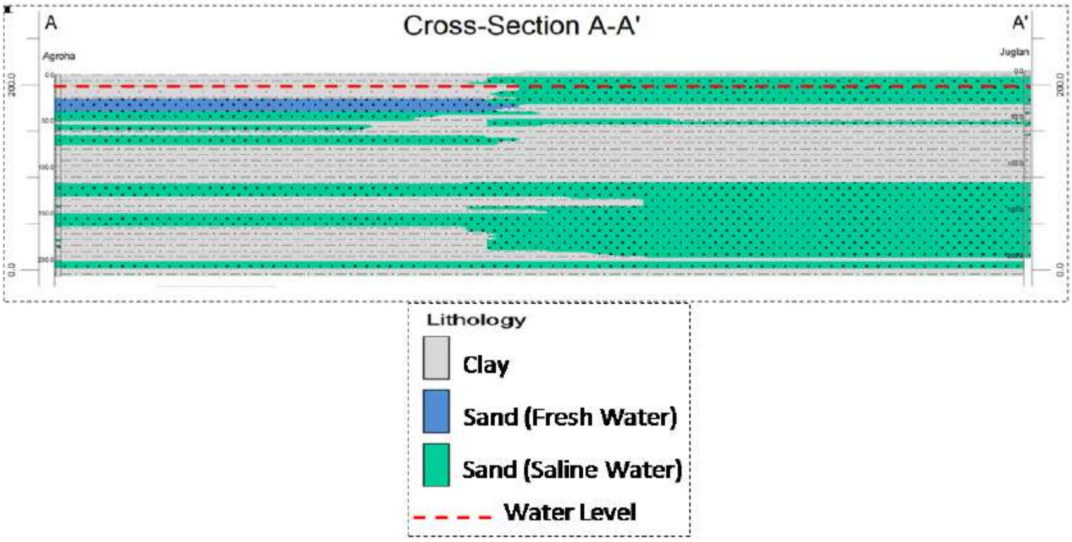
The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

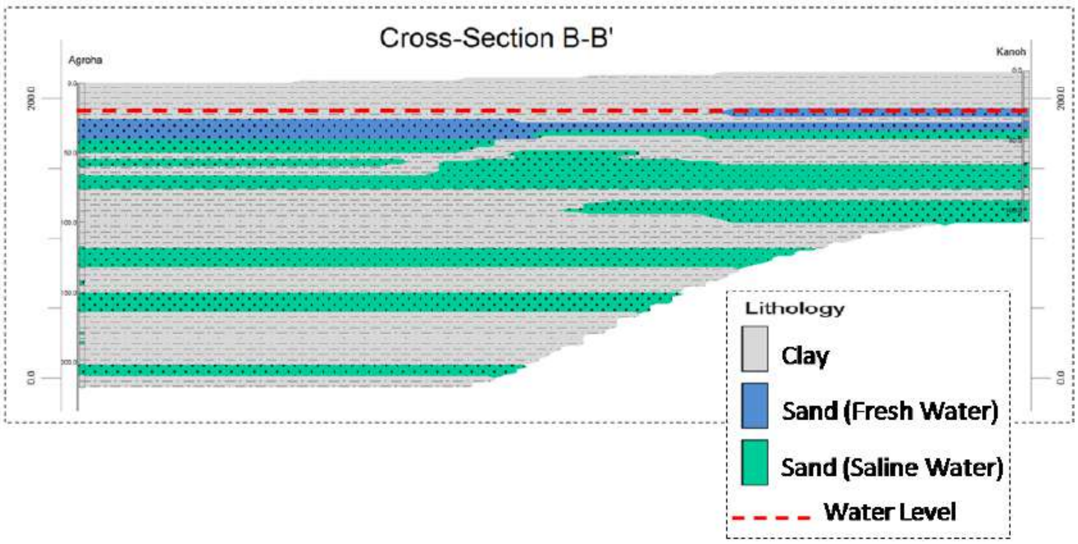
3D Lithology model

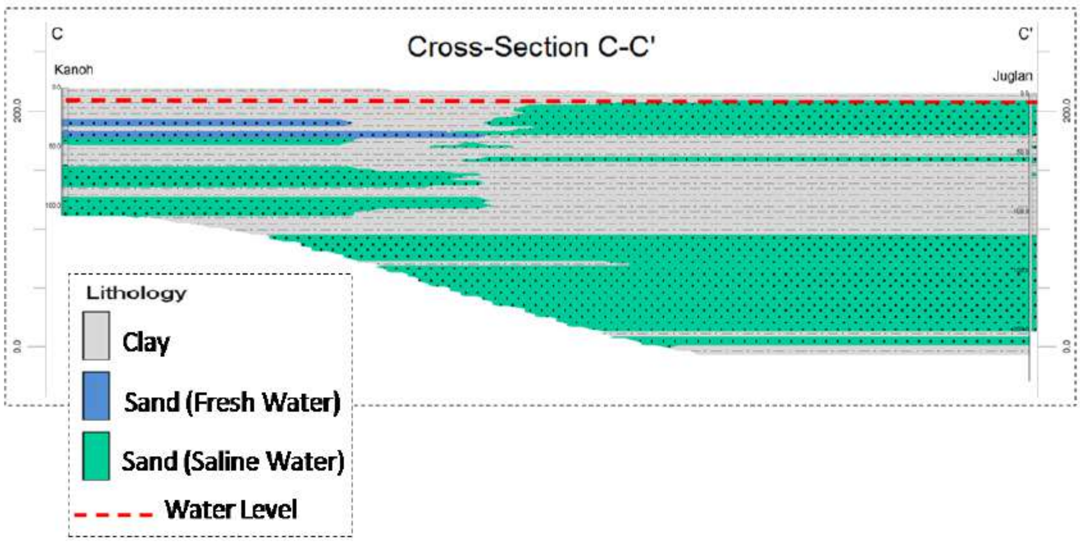


3D Lithology Fence




A
Cross-Section A-A'
A'
Agroha
Juglan
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section B-B'
Agroha
Kanoh
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


C
Cross-Section C-C'
C'
Kanoh
Juglan
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	56.01
	In-storage Fresh water resources	345.93
	In-storage Saline water resources	1516.00
	Total	1917.90
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	51.94
	Domestic & Industrial	0
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		0.28
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 901 to <3000 µS/cm at 25^0c)
Other issues		Water levels are raising trend in some areas. Present stage of development 81%.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level is 50.5 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 5.9 mcm. The block falls under Safe category not required to adopt these interventions.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 3.66 mcm volume of water wastage
Change in cropping pattern	If adapted these crop diversification method in this area, the anticipated volume of water to be saved by maize/soyabean is 51.88 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

III. BARWALA BLOCK (476.82 SQ. KM)

Population (2011) Rural- 157,981

Urban- 43,384

Total- 201,365

Rainfall Monsoon: 306 mm

Non Monsoon: 62 mm

Average Annual Rainfall 368 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

Net Area Sown: 42914 ha

Total Irrigated Area: Monsoon= 39185 ha

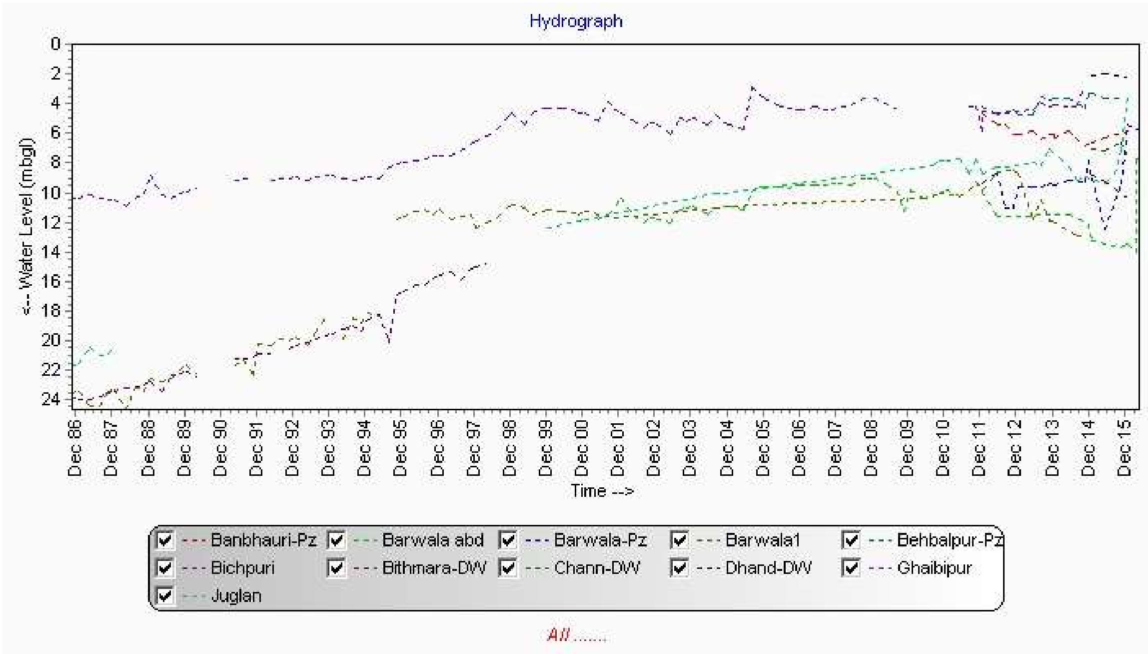
Non-monsoon= 42863 ha

Canal Irrigation 22 lined canals

Ground Water Resource Availability: Ground Water Resources are available 2.31 bcm (0.56 bcm fresh and 1.75 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 40 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 20 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 142 m and the granular zones are counted after the depth of 40 m and available zones are 51 m. The block is safe category and present stage of development 85% as per 2013 assessment.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~8.00 m bgl.

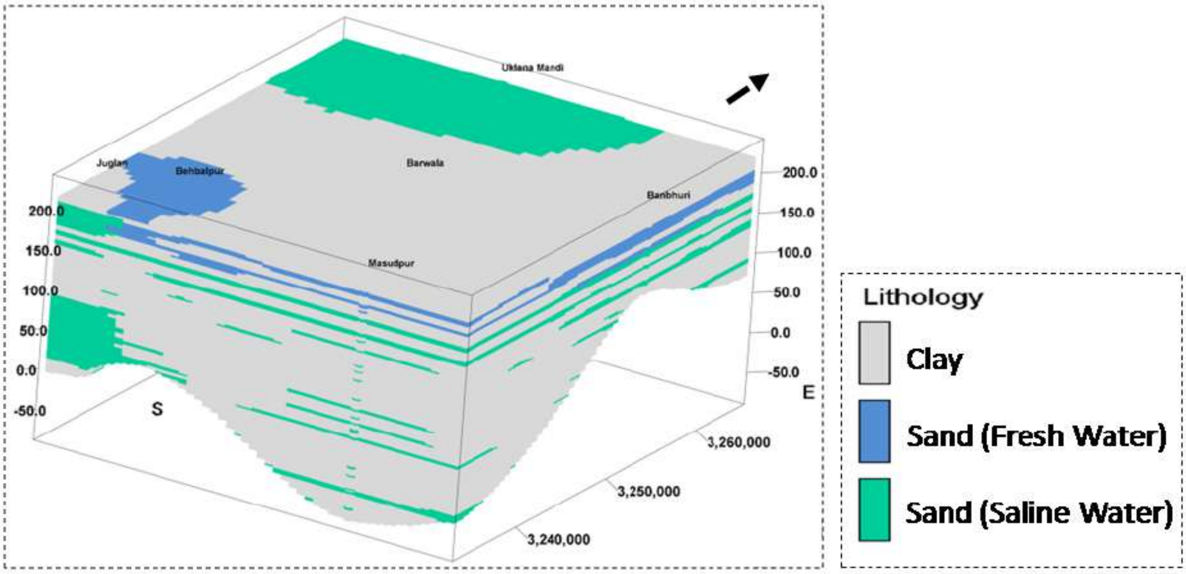


Aquifer Disposition: There is single Aquifer System (up to 300 m)

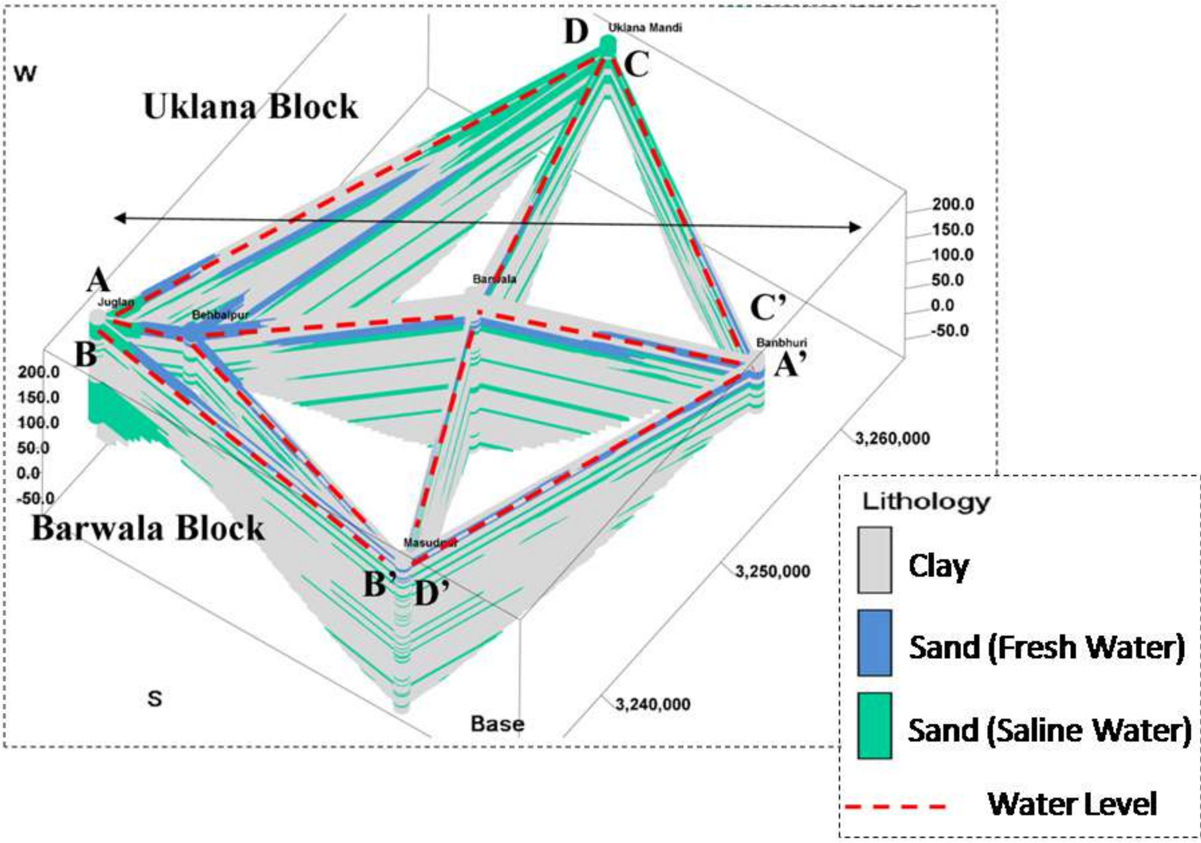
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	71	--	12	--
			Wells abandoned due to bad quality of water			

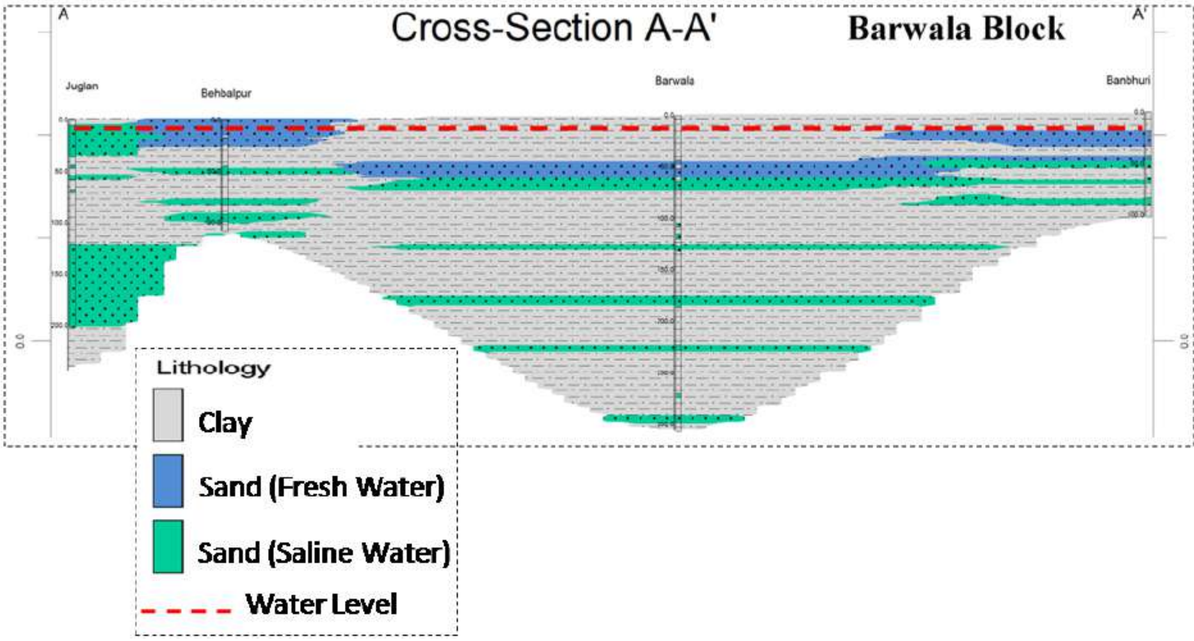
The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

3D Lithology model

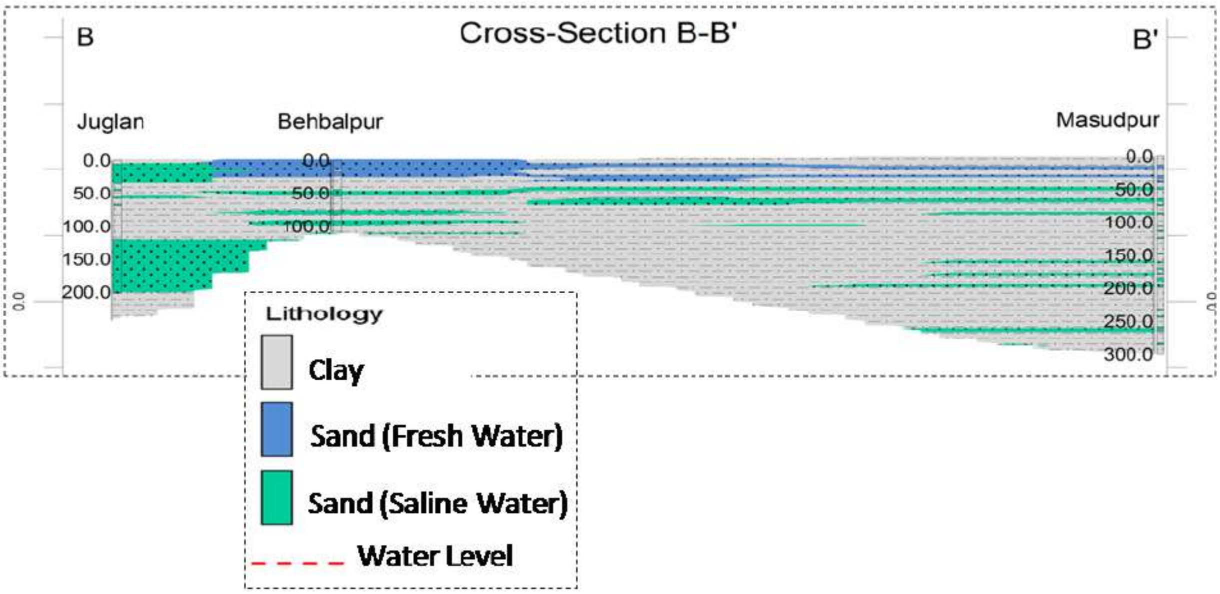


3D Lithology Fence





A
Cross-Section A-A'
Barwala Block
A'
Juglan
Behbalpur
Barwala
Banbhuri
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level



B
Cross-Section B-B'
B'
Juglan
Behbalpur
Masudpur
0.0
50.0
100.0
150.0
200.0
250.0
300.0
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	86.26
	In-storage Fresh water resources	472.62
	In-storage Saline water resources	1750.9
	Total	2309.76
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	109.63
	Domestic & Industrial	0.32
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		0.69
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 732 to <4000 µS/cm at 25^0c)
Other issues		Water levels are declining and rising trend in some areas. Present stage of development 85% and Safe category.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level is 343.3 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 14.93 mcm. But this block is Safe category not required to adopt these techniques.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 7.73 mcm volume of water wastage
Change in cropping pattern	Proposed for change in cropping pattern from Paddy to maize/soyabean in total area. Anticipated volume of water to be saved by maize/soyabean is 105.98 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

IV. HANSI-I BLOCK (523.61 SQ. KM)

Population (2011) Rural- 207,569

Urban- 0

Total- 207,569

Rainfall Monsoon: 139 mm

Non Monsoon: 50 mm

Average Annual Rainfall 189 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

Net Area Sown: 47125 ha

Total Irrigated Area: Monsoon= 46407 ha

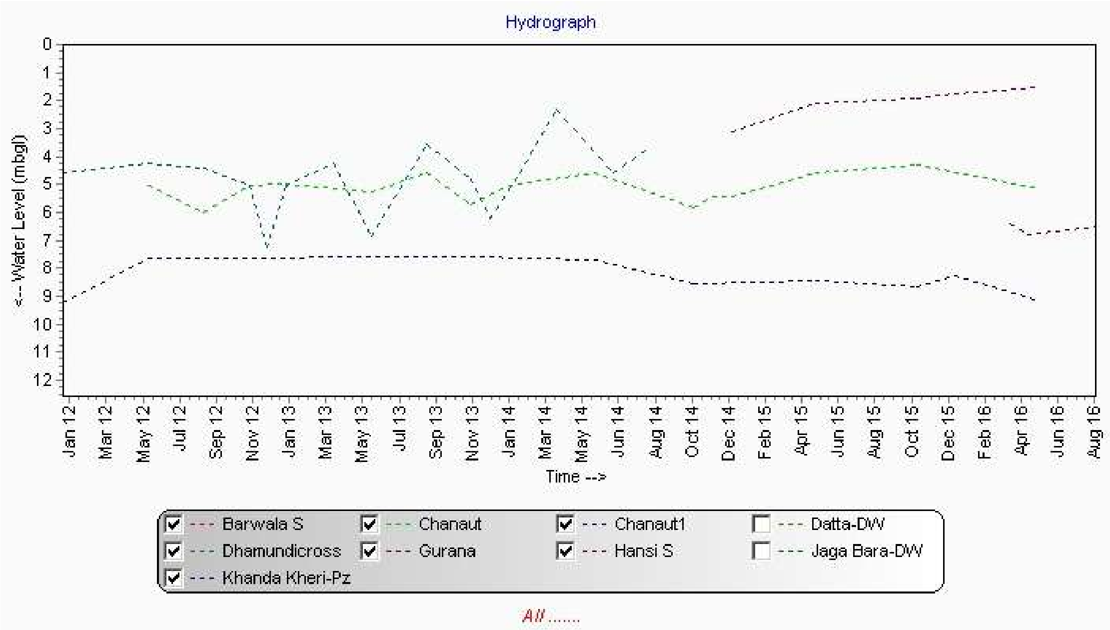
Non-monsoon= 49791 ha

Canal Irrigation 28 lined canals

Ground Water Resource Availability: Ground Water Resources are available 2.66 bcm (0.59 bcm fresh and 2.07 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 32 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 17 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 254 m and the granular zones are counted after the depth of 32 m and available zones are 55 m. This Block is categorized as Critical as per 2013 assessment and present SOD is 132%.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~4.00 m bgl

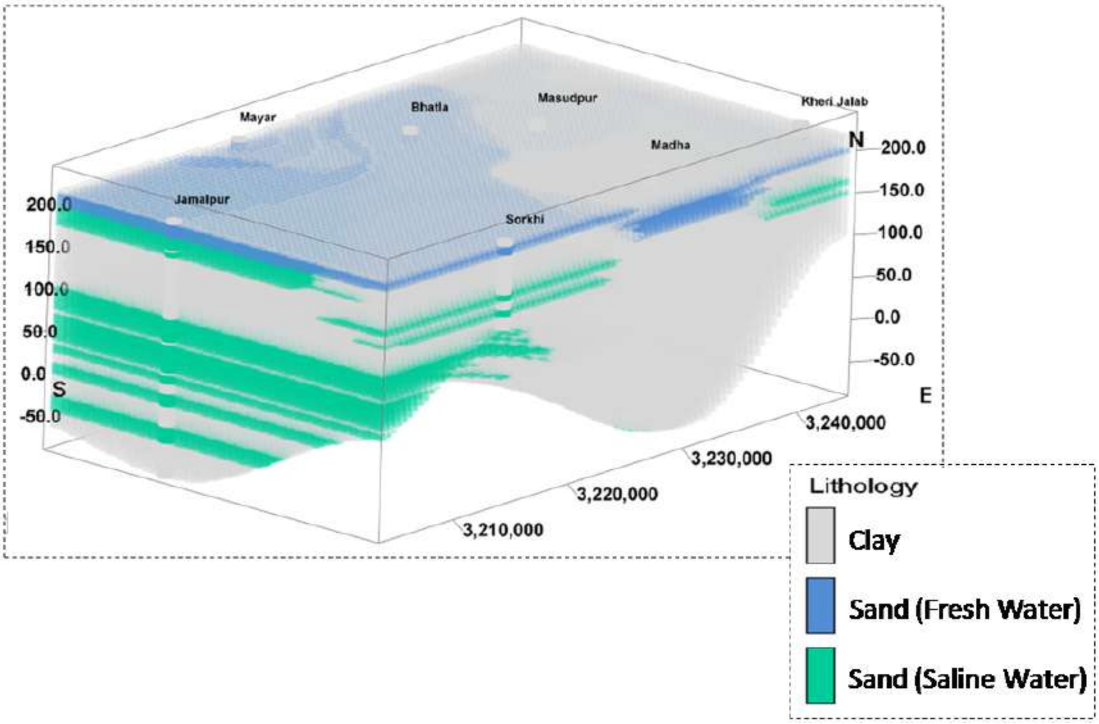


Aquifer Disposition: There is single Aquifer System (up to 300 m)

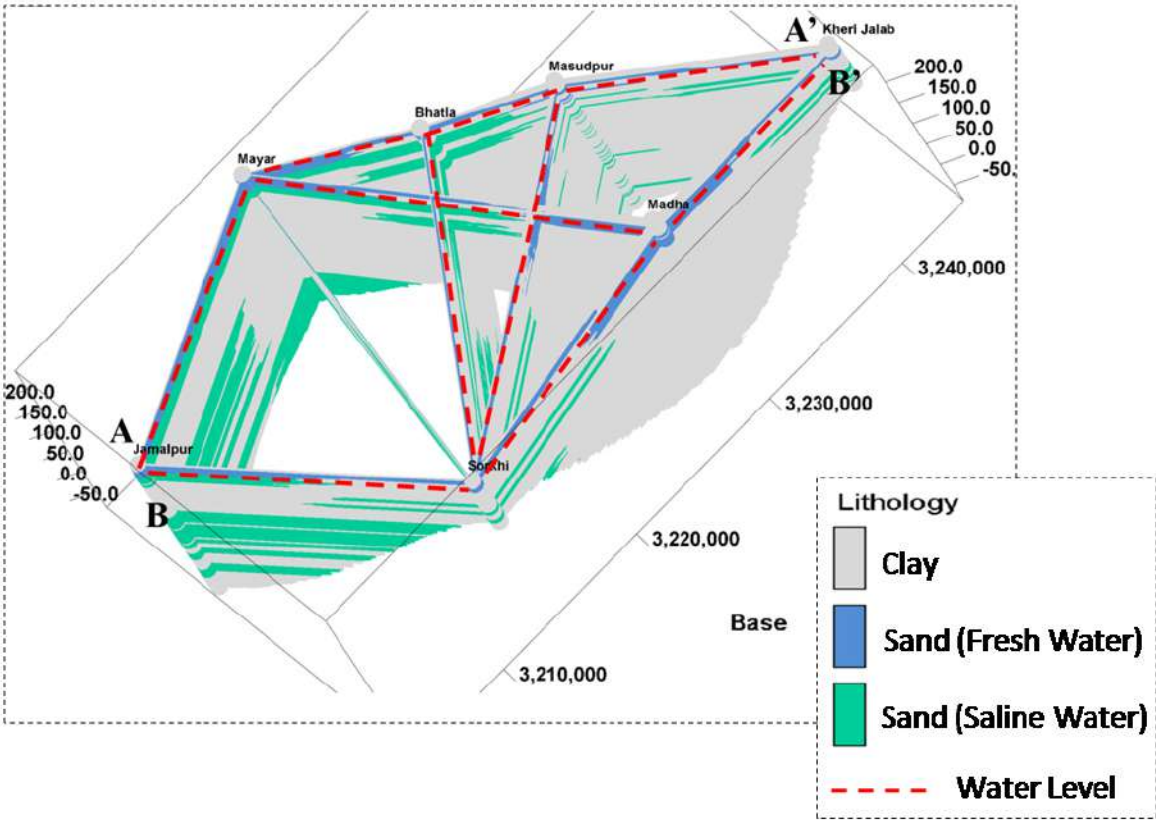
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	72	--	12	--
			Wells abandoned due to bad quality of water			

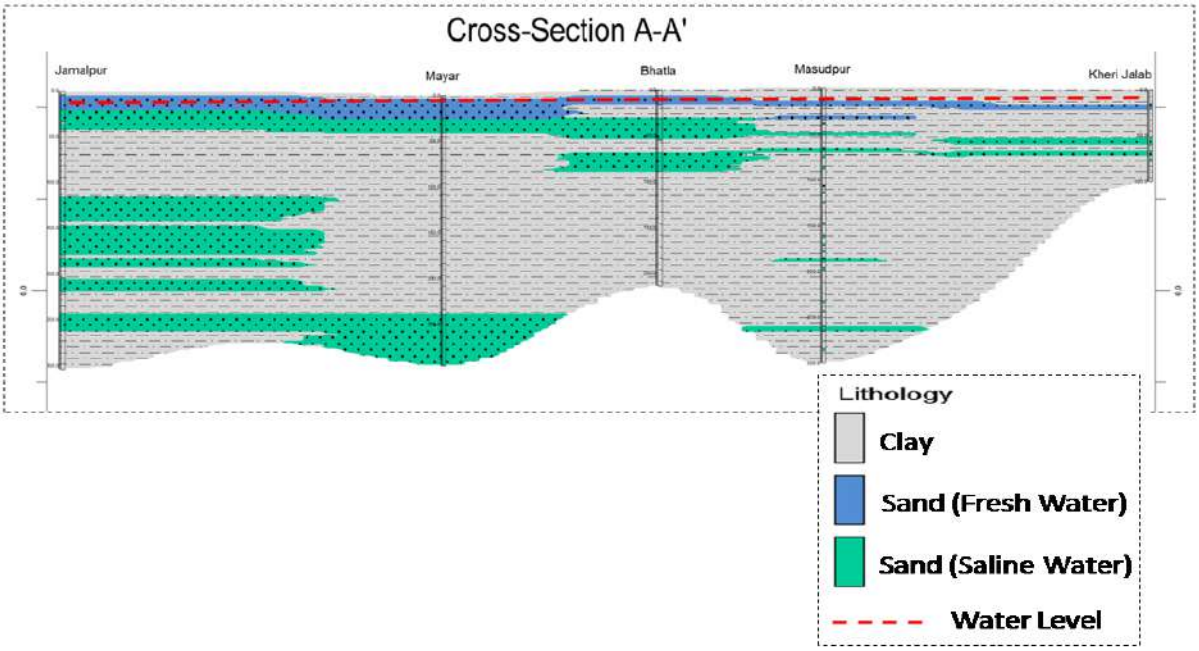
The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

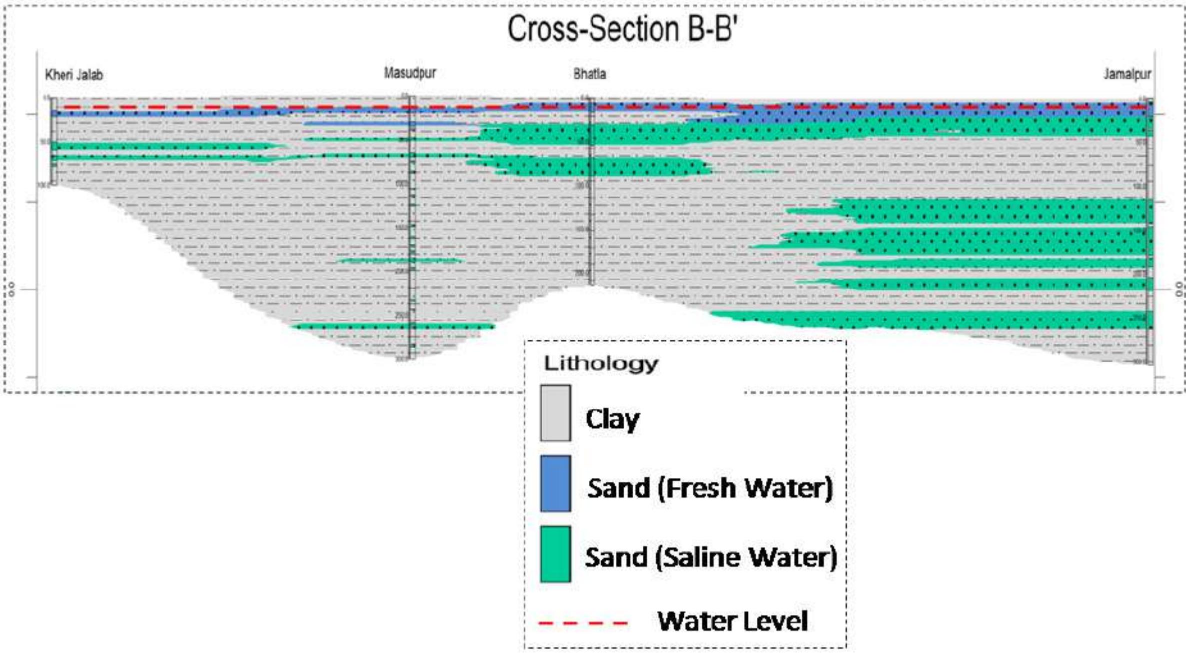
3D Lithology model



3D Lithology Fence




Cross-Section A-A'
Jamalpur
Mayar
Bhatla
Masudpur
Kheri Jalab
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section B-B'
Kheri Jalab
Masudpur
Bhatla
Jamalpur
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	93.20
	In-storage Fresh water resources	499.33
	In-storage Saline water resources	2073.5
	Total	2666.03
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	115.66
	Domestic & Industrial	0.23
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		0.85
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 299 to 1217 µS/cm at 25^{0}c)
Other issues		Water levels are declining and rising trend in some areas. Present stage of development 132%.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level is 188.5 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 21.77 mcm.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 8.2 mcm volume of water wastage
Change in cropping pattern	Proposed for change in cropping pattern from Paddy to maize/soyabean in total area. Anticipated volume of water to be saved by maize/soyabean is 105.84 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

V. HANSI-II BLOCK (301.40 SQ. KM)

Population (2011)	Rural- 92,451
	Urban- 0
	Total- 92,451
Rainfall	Monsoon: 245 mm
	Non Monsoon: 50 mm
Average Annual Rainfall	295 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

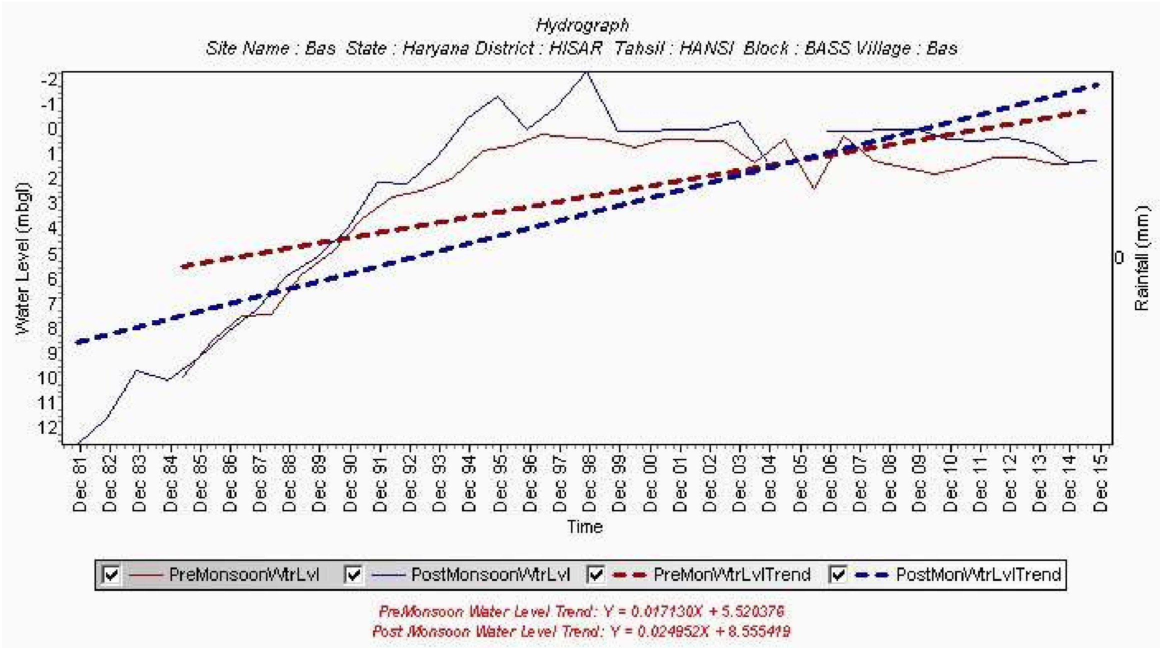
Net Area Sown:	27126 ha
Total Irrigated Area:	Monsoon= 19889 ha
	Non-monsoon= 22952 ha

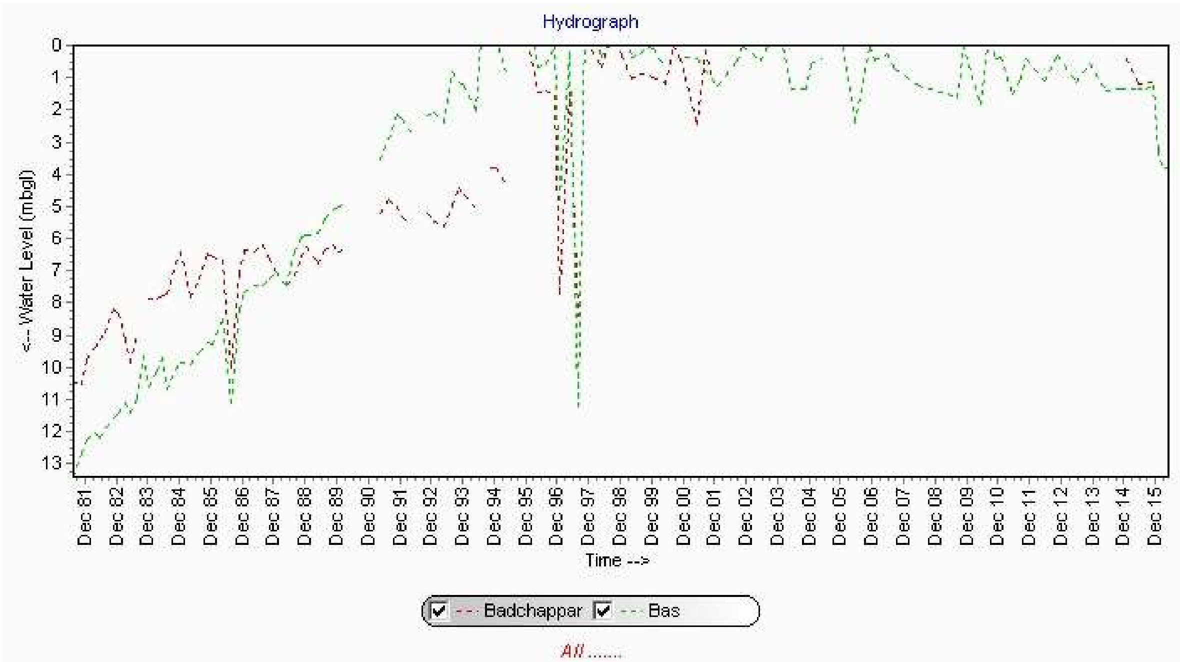
Canal Irrigation 17 lined canals

Ground Water Resource Availability: Ground Water Resources are available 0.92 bcm (0.27 bcm fresh and 0.65 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 20 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 11 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 84 m and the granular zones are counted after the depth of 20 m and available zones are 30 m. this block is Critical and present SOD is 153% (2013 assessment).

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~8.7 m bgl



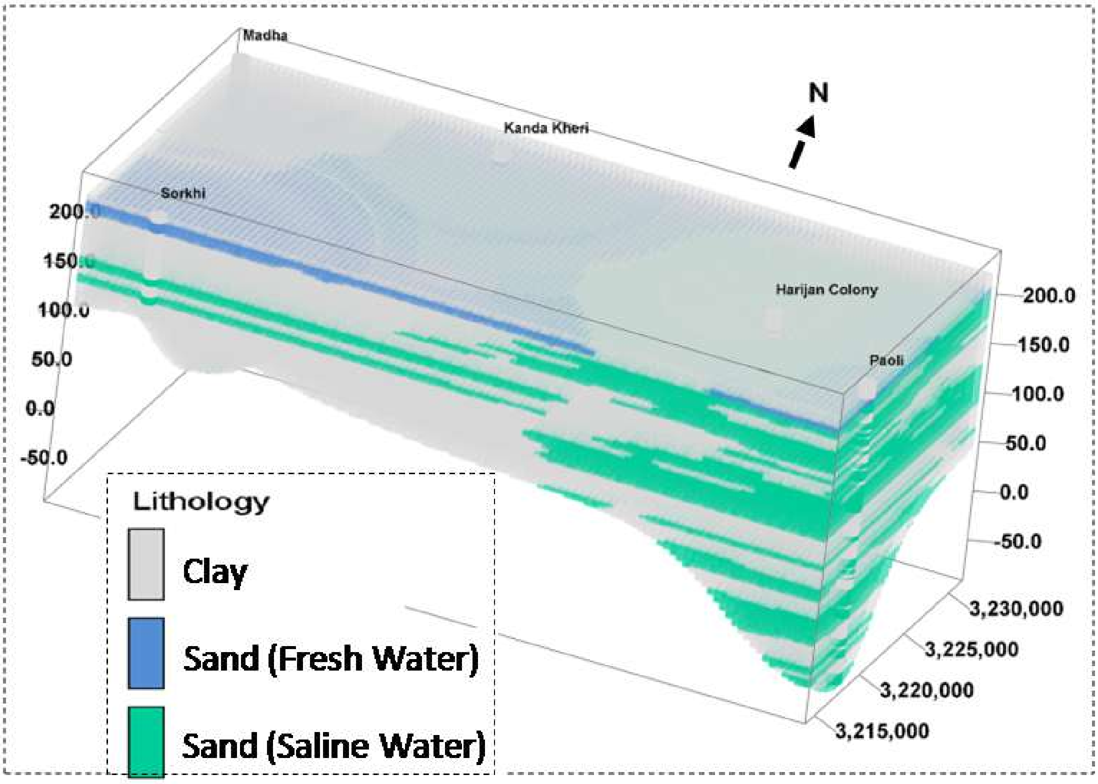


Aquifer Disposition: There is single Aquifer System (up to 300 m)

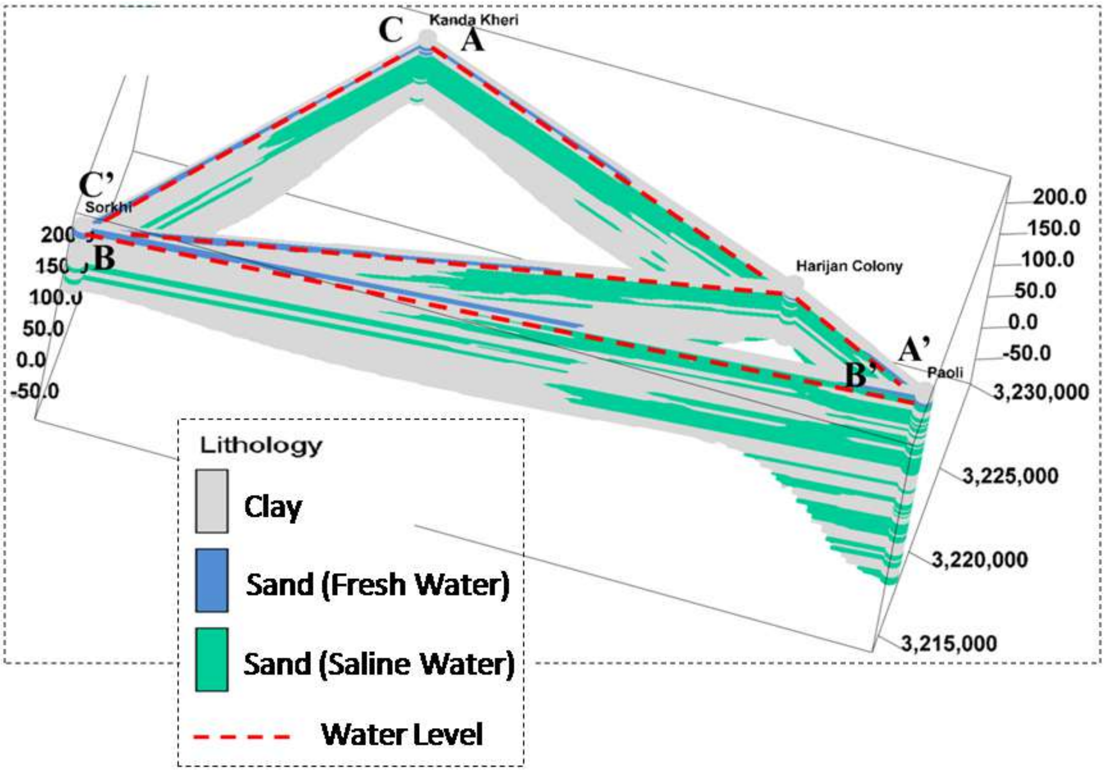
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmis sivity (m²/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	41	--	12	--
			Wells abandoned due to bad quality of water			

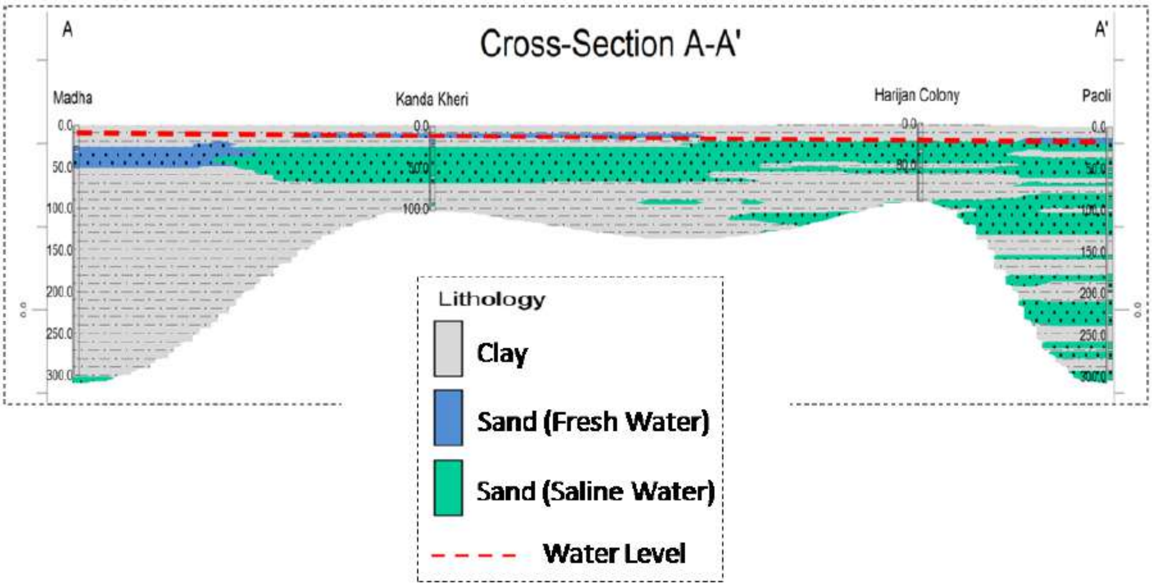
The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

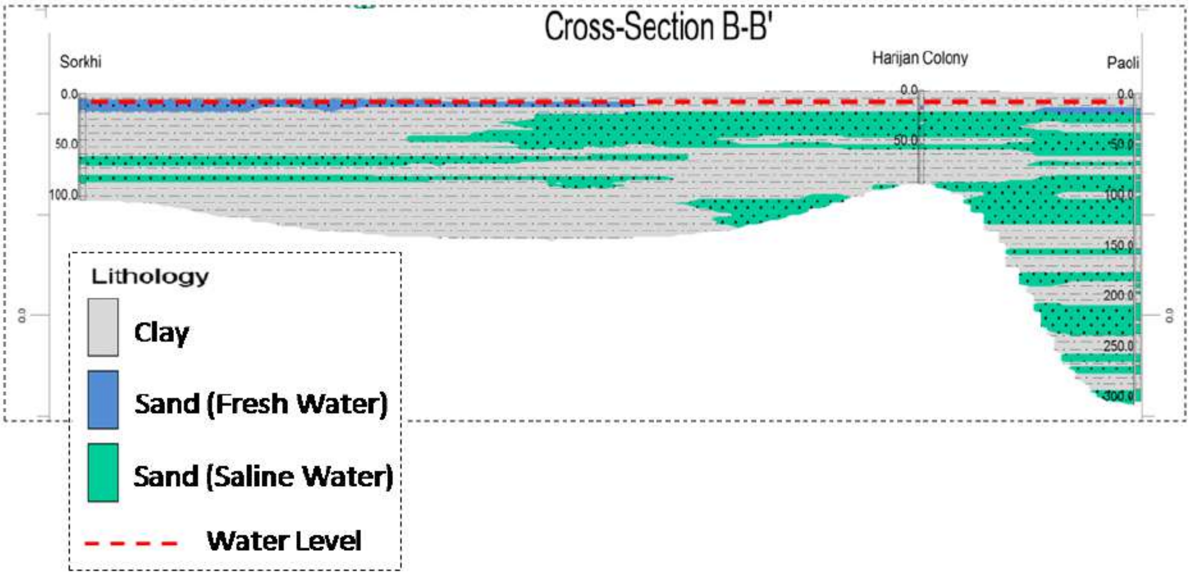
3D Lithology model

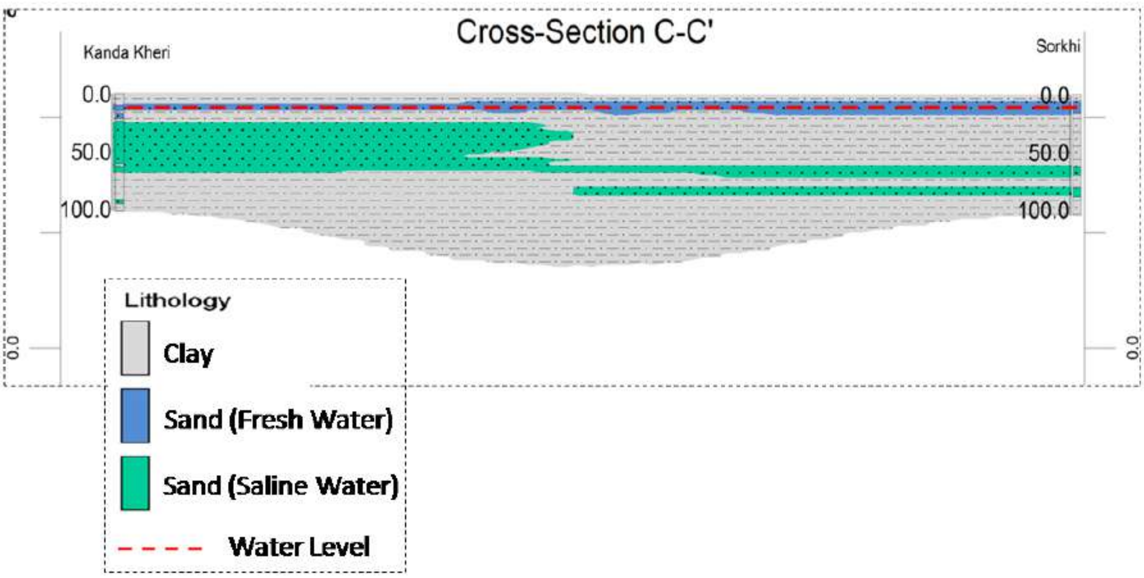


3D Lithology Fence




A
A'
Cross-Section A-A'
Madha
Kanda Kheri
Harijan Colony
Paoli
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section B-B'
Sorkhi
Harijan Colony
Paoli
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section C-C'
Kanda Kheri
Sorkhi
0.0
50.0
100.0
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	60.32
	In-storage Fresh water resources	207.22
	In-storage Saline water resources	651.00
	Total	918.56
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	91.99
	Domestic & Industrial	0
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		0.28
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 797 to <2000 µS/cm at 25^{0}c)
Other issues		Water levels are raising trend in some areas. Present stage of development 153%.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level is 36.2 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 20.18 mcm.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 6.49 mcm volume of water wastage
Change in cropping pattern	Proposed for change in cropping pattern from Paddy to maize/soyabean in total area. Anticipated volume of water to be saved by maize/soyabean is 81.24 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

VI. HISAR-I BLOCK (495.87 SQ. KM)

Population (2011) Rural- 144,128

Urban- 120,636

Total- 264,764

Rainfall Monsoon: 306 mm

Non Monsoon: 62 mm

Average Annual Rainfall 368 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

Net Area Sown: 44628 ha

Total Irrigated Area: Monsoon= 41261 ha

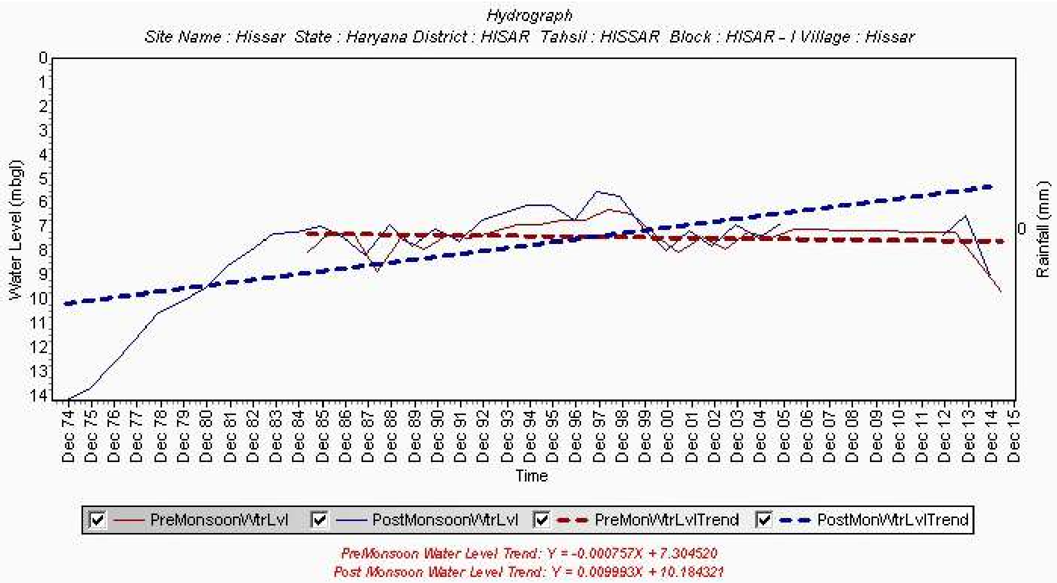
Non-monsoon= 41943 ha

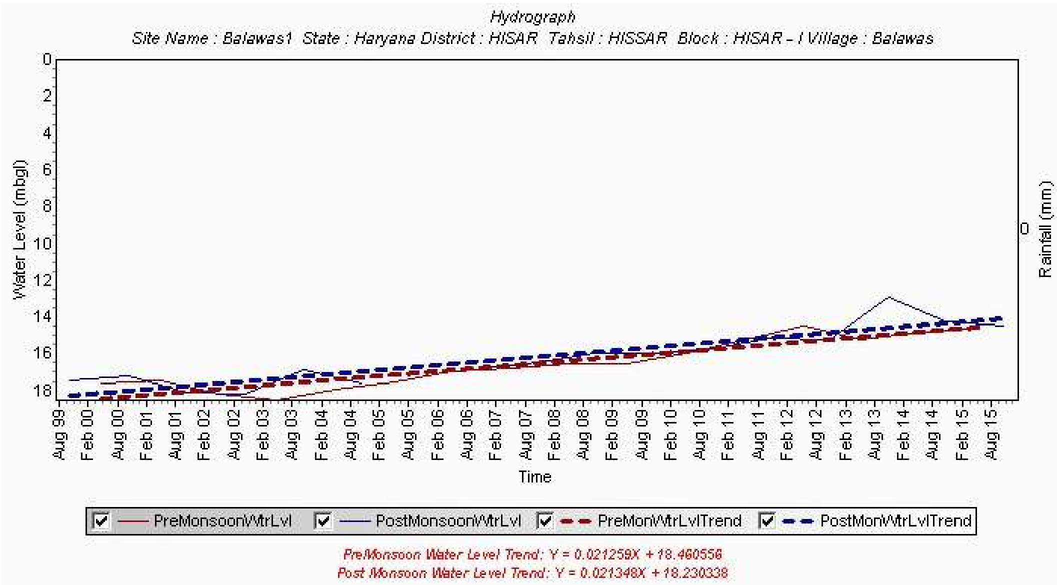
Canal Irrigation 22 lined canals

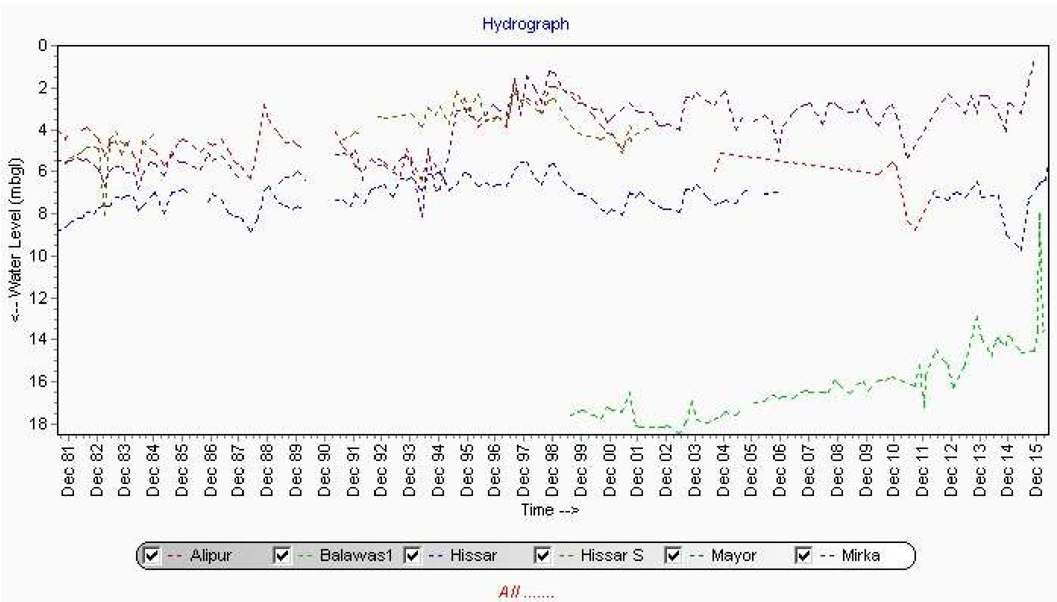
Ground Water Resource Availability: Ground Water Resources are available 2.55 bcm (0.62 bcm fresh and 1.93 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 35 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 18 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 174 m and the granular zones are counted after the depth of 35 m and available zones are 54 m. Block is categorized as Safe and SOD is 77% as per 2013 assessment.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~6.7 m bgl


Hydrograph
Site Name : Hissar State : Haryana District : HISAR Tahsil : HISSAR Block : HISAR - I Village : Hissar
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000757X + 7.304520
Post Monsoon Water Level Trend: Y = 0.009993X + 10.184321


Hydrograph
Site Name : Balawas1 State : Haryana District : HISAR Tahsil : HISSAR Block : HISAR - I Village : Balawas
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.021259X + 18.460556
Post Monsoon Water Level Trend: Y = 0.021348X + 18.230338

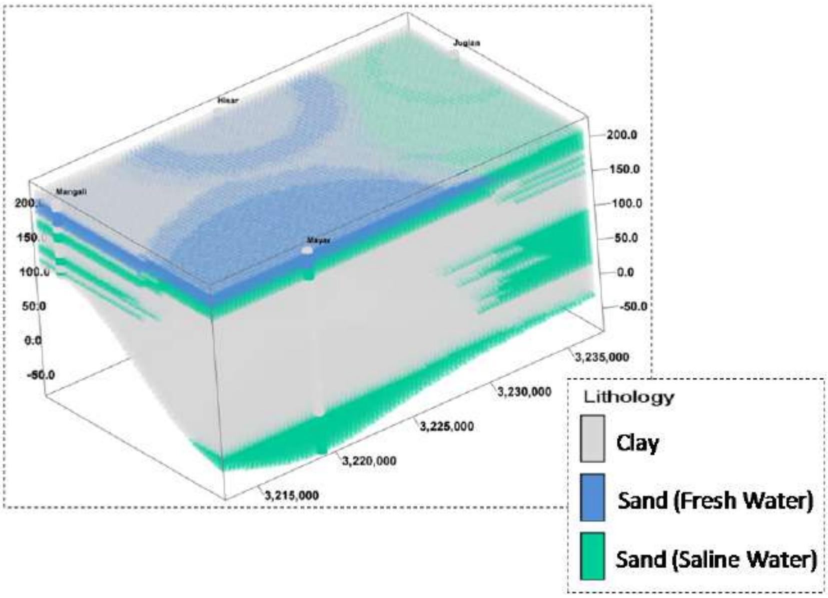

Hydrograph
<-- Water Level (mbgl)
Time -->
Alipur
Balawas1
Hissar
Hissar S
Mayor
Mirka
All ....

Aquifer Disposition: There is single Aquifer System (up to 300 m)

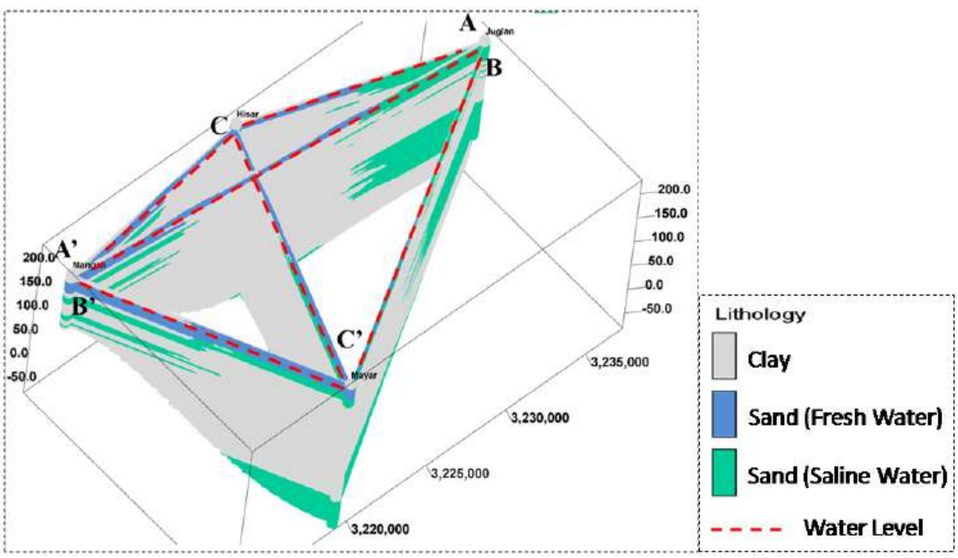
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	72	--	12	--
			Wells abandoned due to absence of granular zones and bad quality of water			

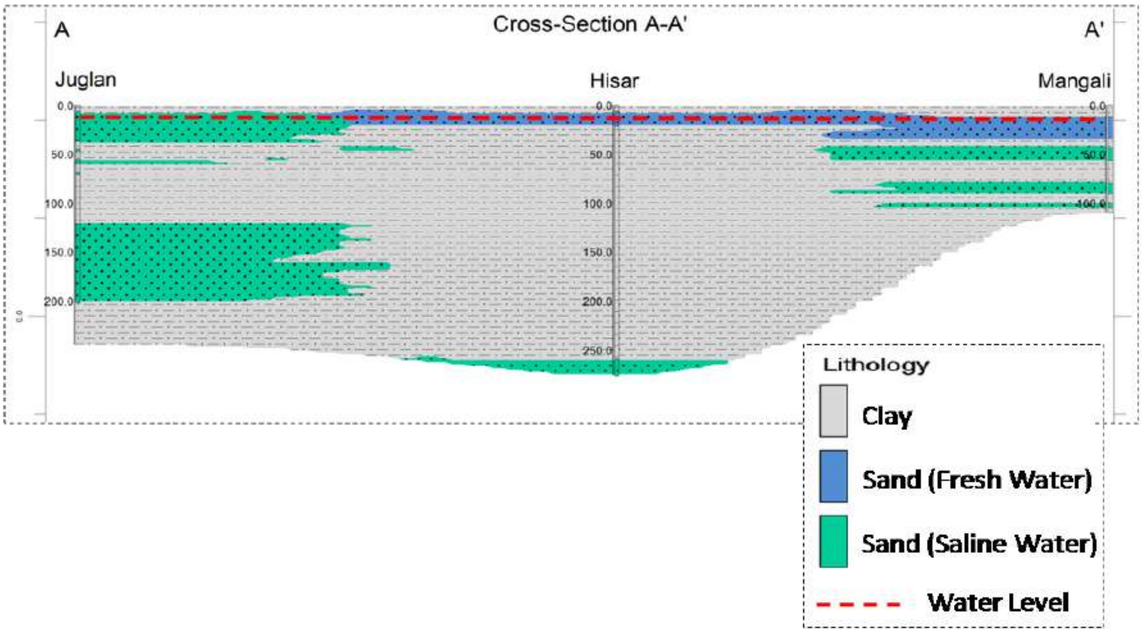
The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

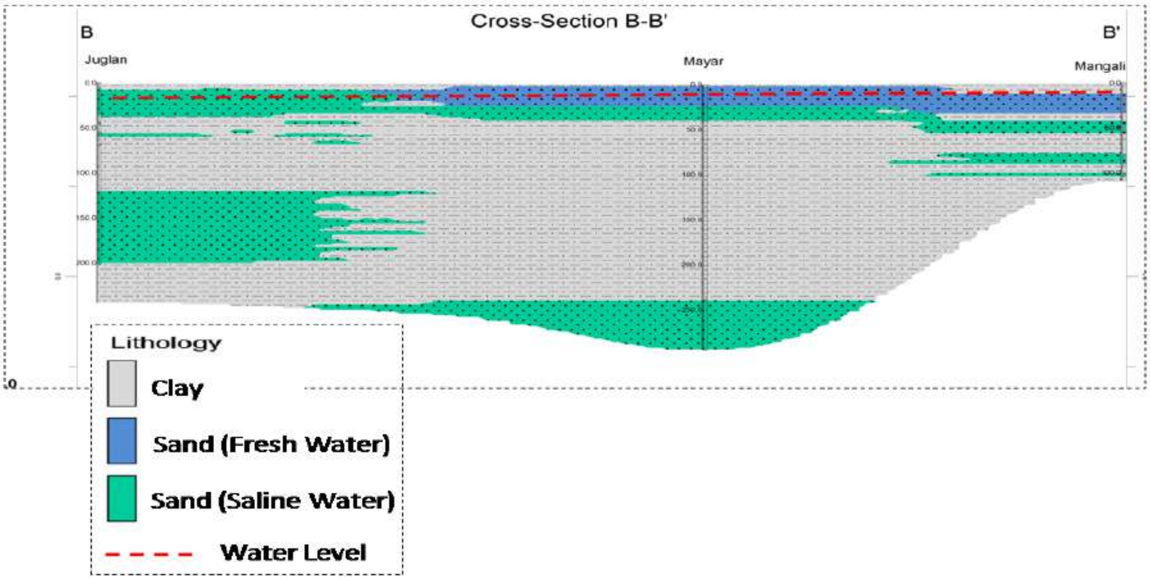
3D Lithology model

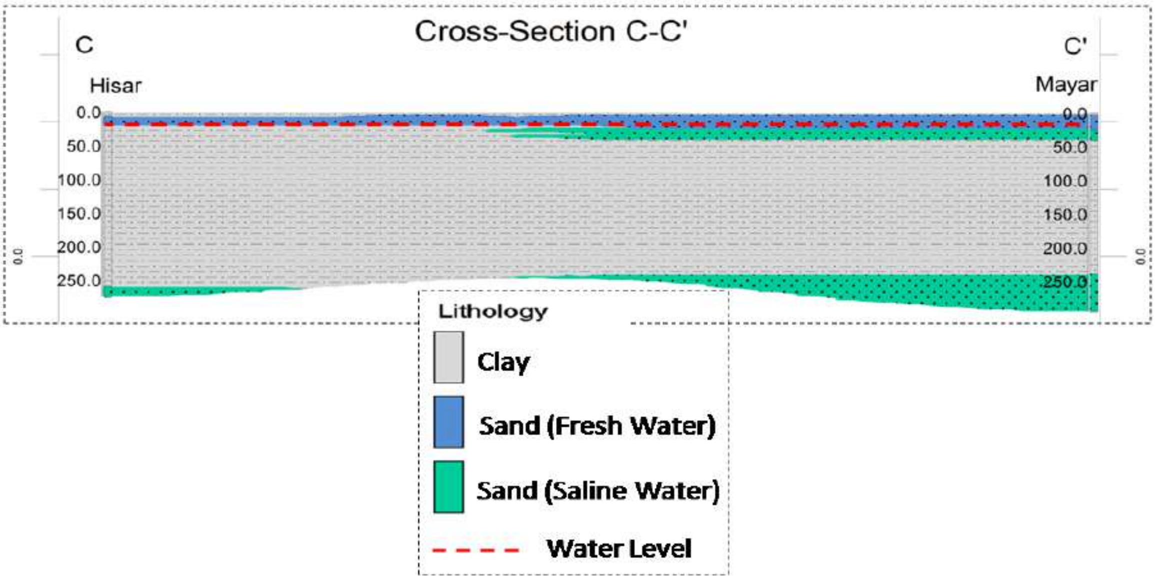


3D Lithology Fence




Cross-Section A-A'
A
A'
Juglan
Hisar
Mangali
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section B-B'
B
B'
Juglan
Mayar
Mangali
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section C-C'
C
C'
Hisar
Mayar
0.0
50.0
100.0
150.0
200.0
250.0
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	72.86
	In-storage Fresh water resources	545.72
	In-storage Saline water resources	1927.90
	Total	2546.52
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	65.89
	Domestic & Industrial	2.11
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		1.63
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 1570 to >4000 µS/cm at 25^0c)
Other issues		Water levels are raising trend in some areas. Present stage of development 77% and safe category.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level is 59.5 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 10.48 mcm. Not required to adopt these techniques in this block due to being as Safe.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 4.65 mcm volume of water wastage
Change in cropping pattern	If adapted these crop diversification method in this area, the anticipated volume of water to be saved by maize/soyabean is 64.05 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

VII. HISAR-II BLOCK (737.73 SQ. KM)

Population (2011)		Rural- 174,733
		Urban- 5,641
		Total- 180,374
Rainfall		Monsoon: 306 mm
		Non Monsoon: 62 mm
Average Annual Rainfall		368 mm

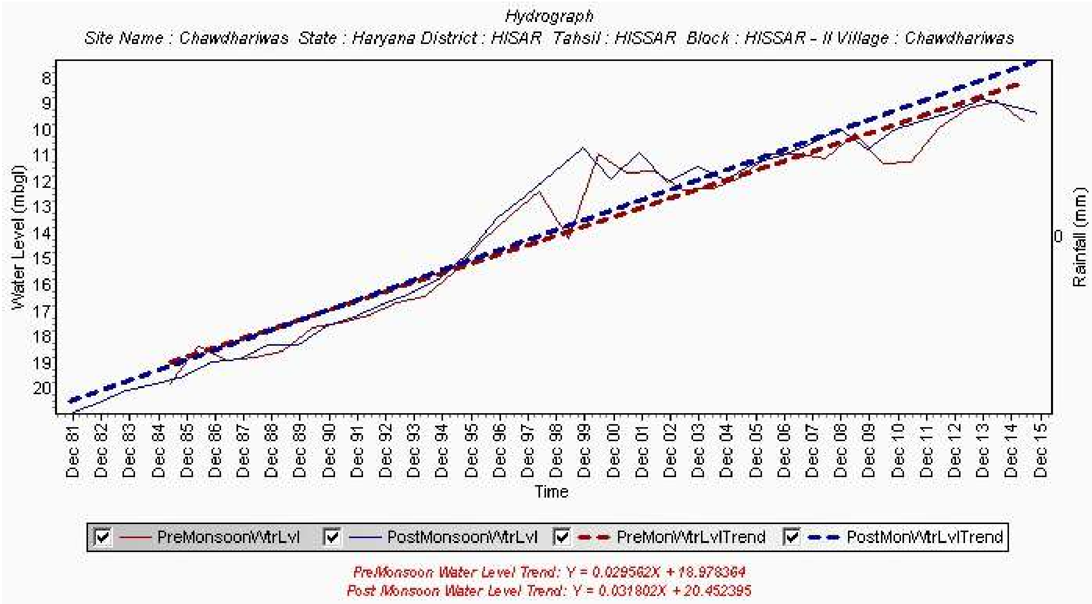
Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

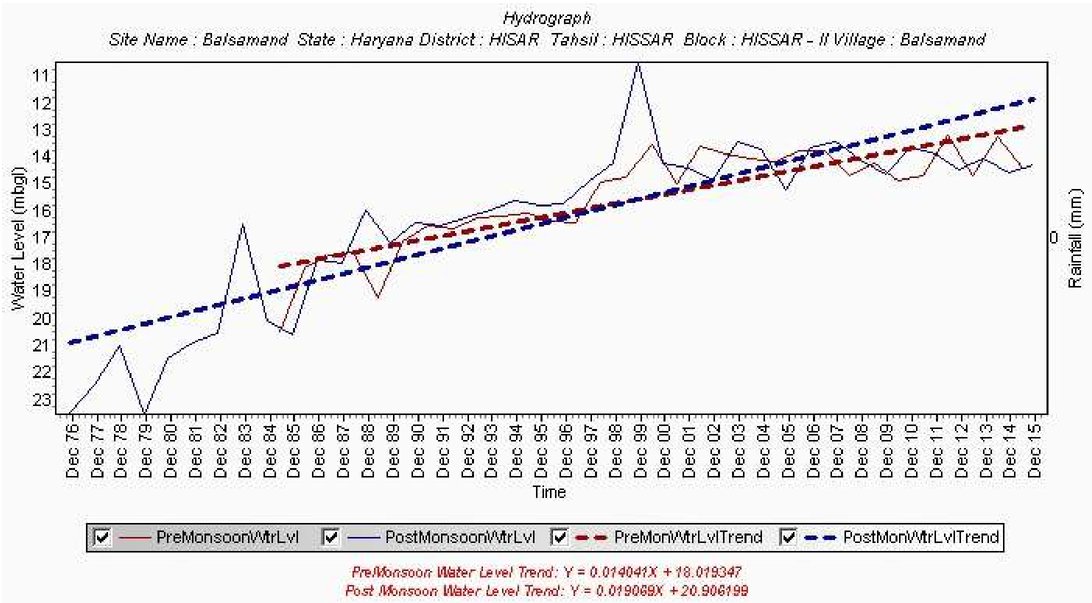
	Net Area Sown:	66396 ha
	Total Irrigated Area:	Monsoon= 51456 ha
		Non-monsoon= 51216 ha
Canal Irrigation		26 lined canals

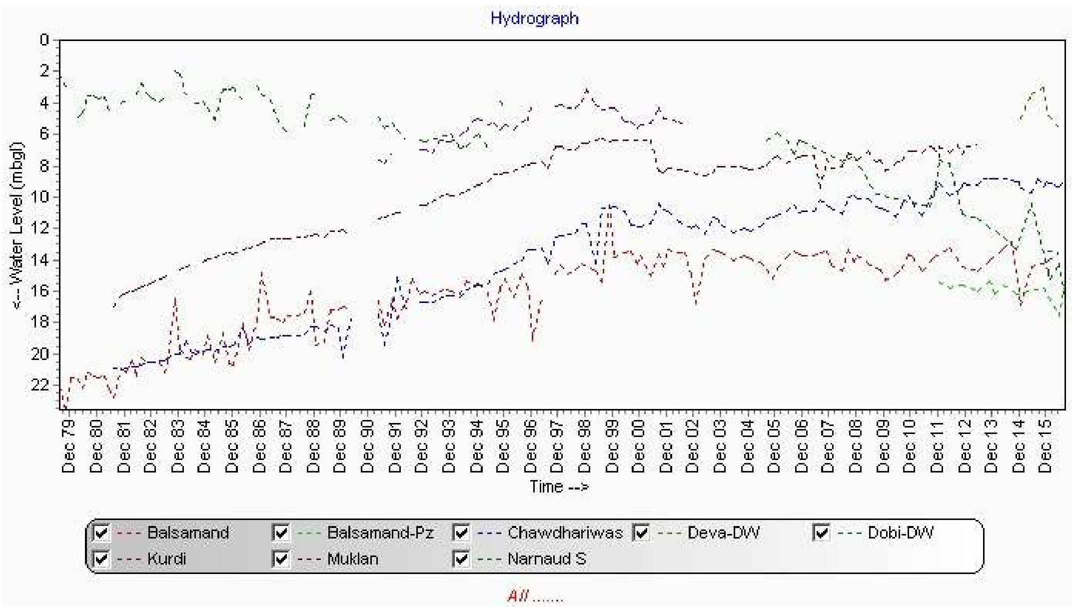
Ground Water Resource Availability: Ground Water Resources are available 4.65 bcm (0.61 bcm fresh and 4.04 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 27 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 12 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 137 m and the granular zones are counted after the depth of 27 m and available zones are 76 m. this block is falls under Safe category and SOD is 76% as per 2013 assessment.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~12.3 m bgl


Hydrograph
Site Name : Chawdhariwas State : Haryana District : HISAR Tahsil : HISSAR Block : HISSAR - II Village : Chawdhariwas
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.029562X + 18.978364
Post Monsoon Water Level Trend: Y = 0.031802X + 20.452395


Hydrograph
Site Name : Balsamand State : Haryana District : HISAR Tahsil : HISSAR Block : HISSAR - II Village : Balsamand
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.014041X + 18.019347
Post Monsoon Water Level Trend: Y = 0.019069X + 20.906199

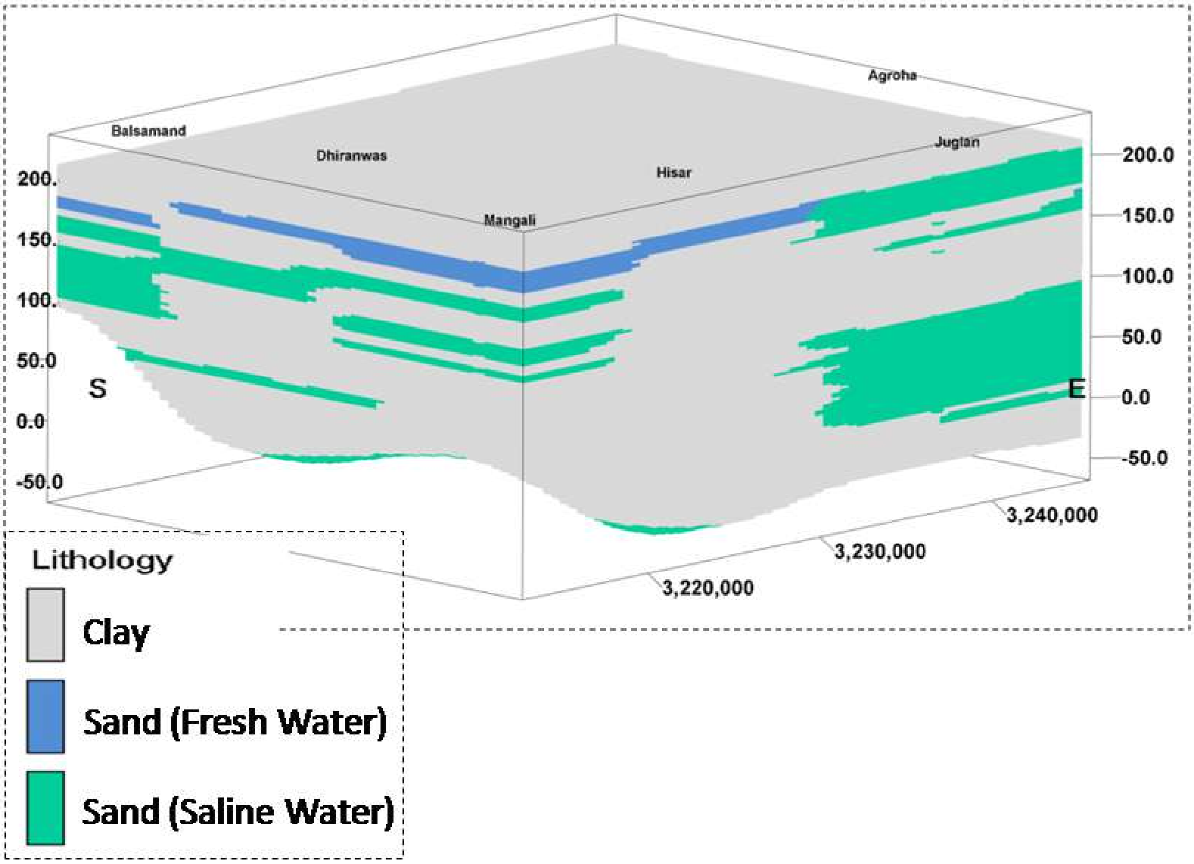

Hydrograph
<-- Water Level (mbgl)
Time -->
Balsamand
Balsamand-Pz
Chawdhariwas
Deva-DW
Dobi-DW
Kurdi
Muklan
Narnaud S
All ....

Aquifer Disposition: There is single Aquifer System (up to 300 m)

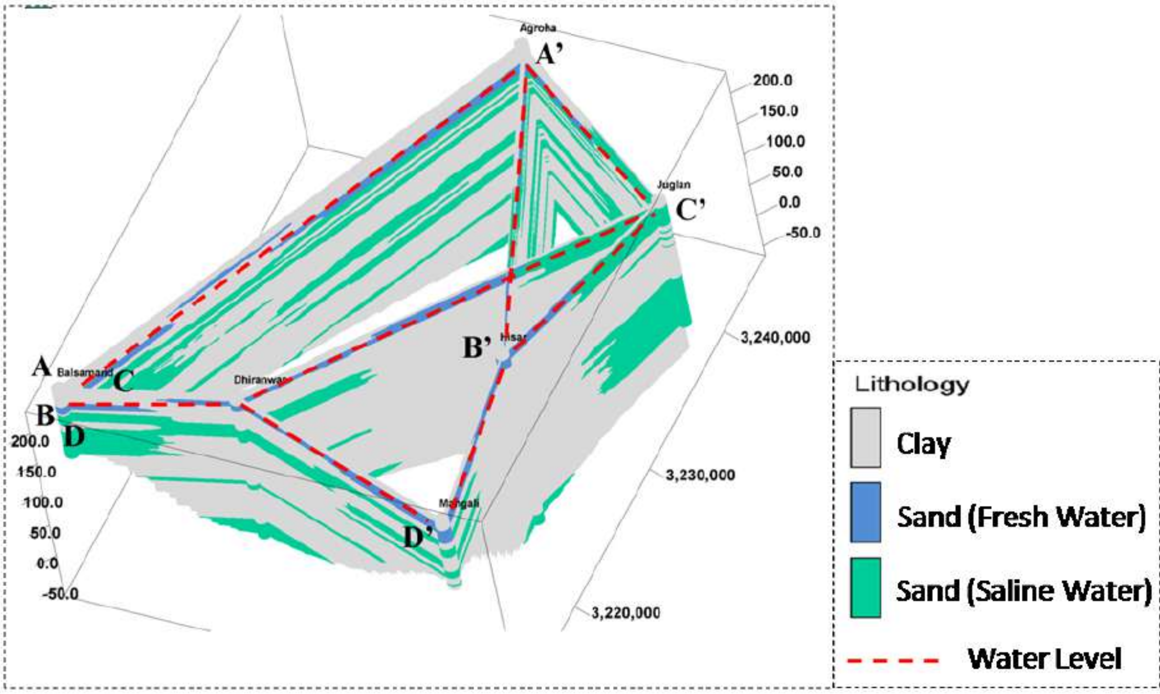
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	88	--	12	--
			Wells abandoned due to bad quality of water			

The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

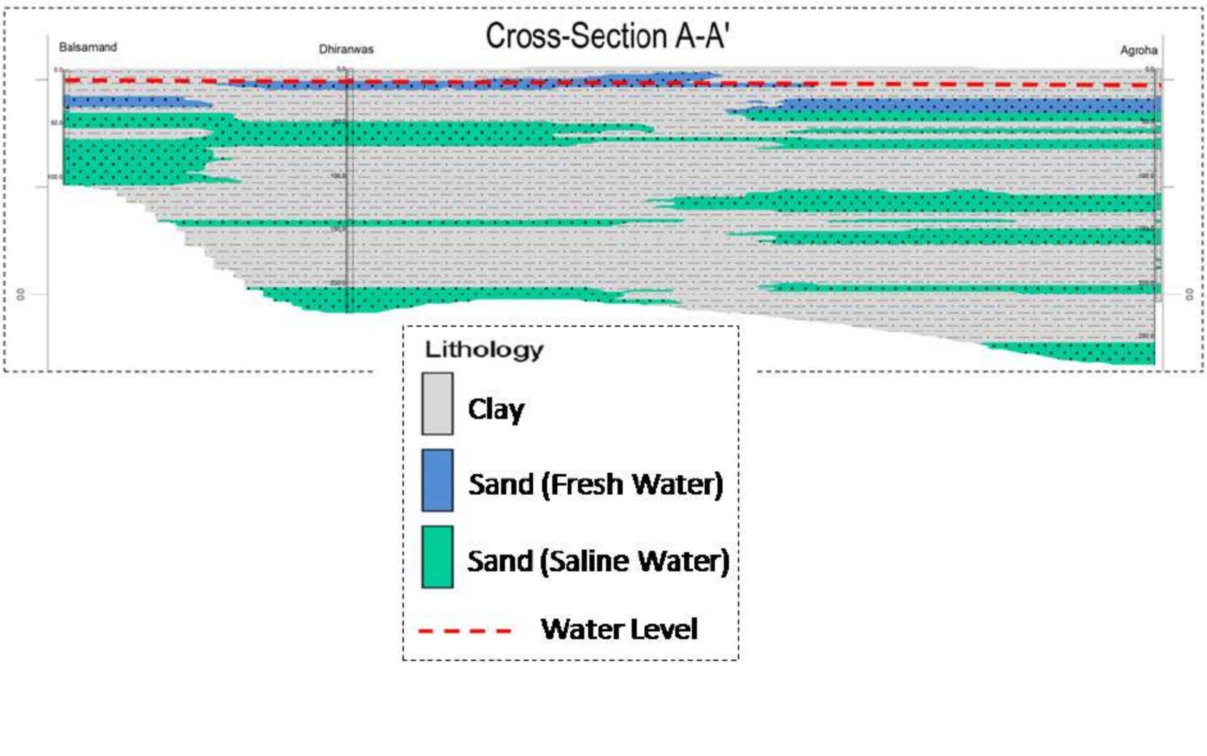
3D Lithology model

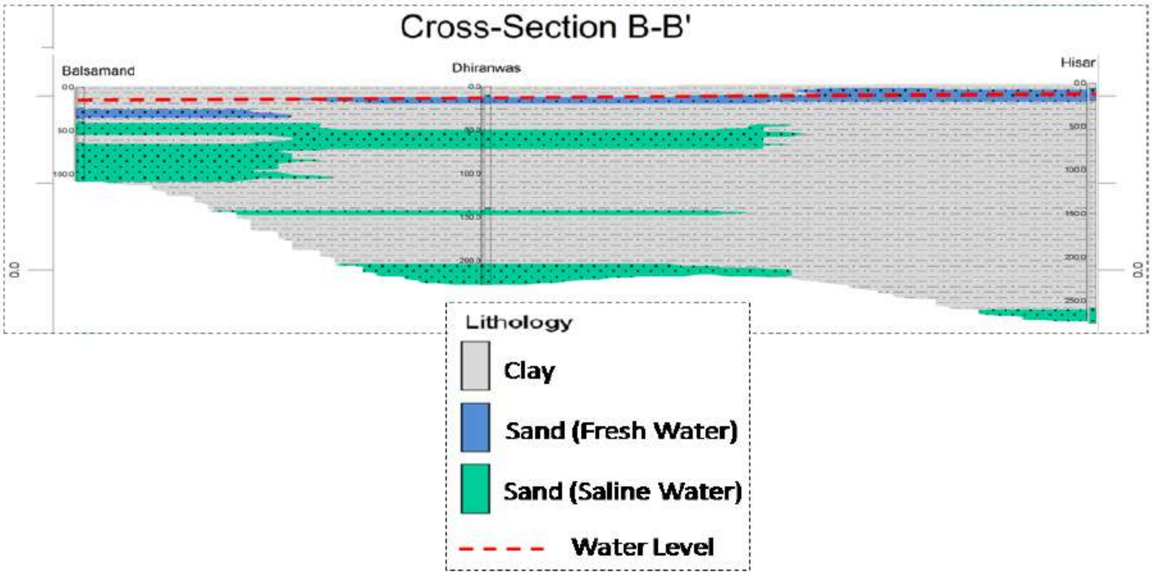


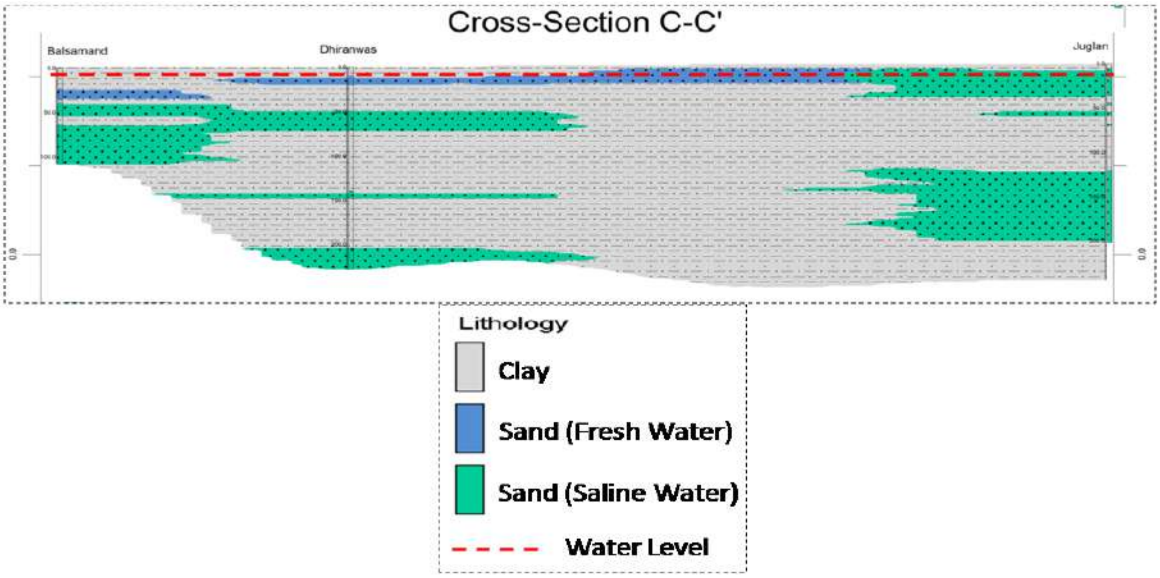
3D Lithology Fence

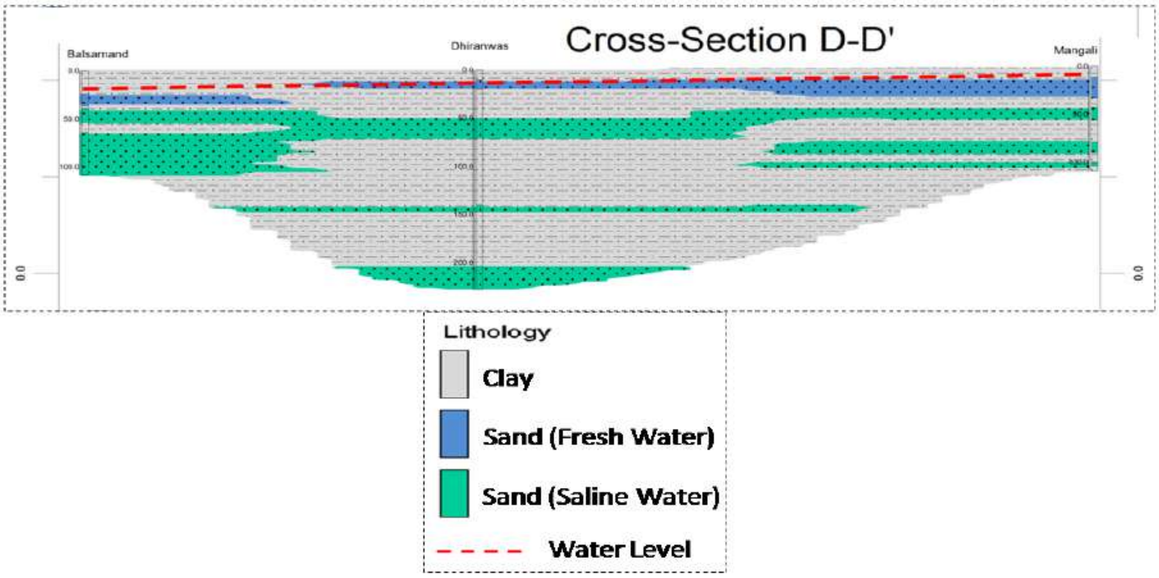


Cross-Sections




Cross-Section B-B'
Balsamand
Dhiranwas
Hisar
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section C-C'
Balsamand
Dhiranwas
Juglan
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section D-D'
Balsamand
Dhiranwas
Mangali
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	77.36
	In-storage Fresh water resources	535.43
	In-storage Saline water resources	4036.9
	Total	4649.65
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	63.21
	Domestic & Industrial	0
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		1.29
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 1517 to <4000 µS/cm at 25^0c)
Other issues		Water levels are raising trend in some areas. Present stage of development 76% and it is safe category.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level is 88.5 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 7.07 mcm. Not required to adopt these techniques in this block due to being as Safe.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 4.46 mcm volume of water wastage
Change in cropping pattern	If adapted these crop diversification method in this area, the anticipated volume of water to be saved by maize/soyabean is 63.13 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

VIII. NARNAUND BLOCK (352.61 SQ. KM)

Population (2011)	Rural- 123,638
	Urban- 0
	Total- 123,638
Rainfall	Monsoon: 245 mm
	Non Monsoon: 50 mm
Average Annual Rainfall	295 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

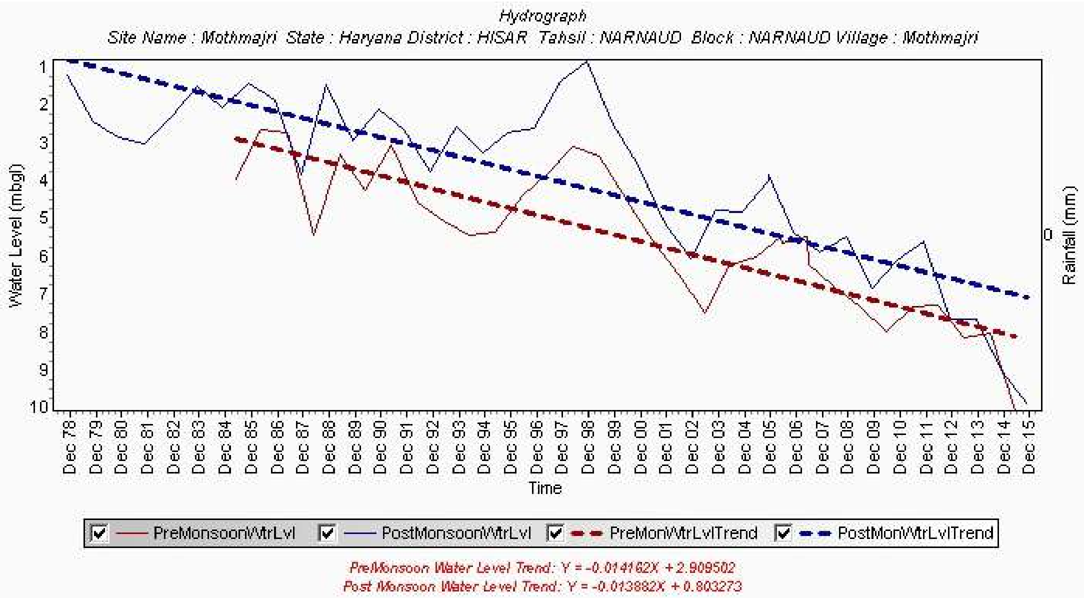
Net Area Sown:	31735 ha
Total Irrigated Area:	Monsoon= 33359 ha
	Non-monsoon= 35754 ha

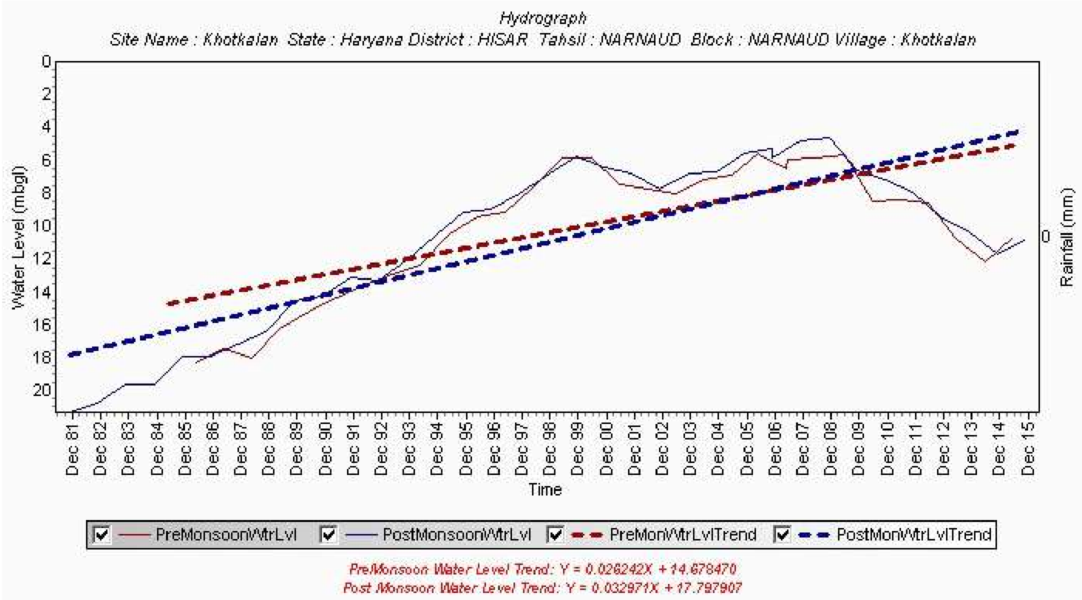
Canal Irrigation 16 lined canals

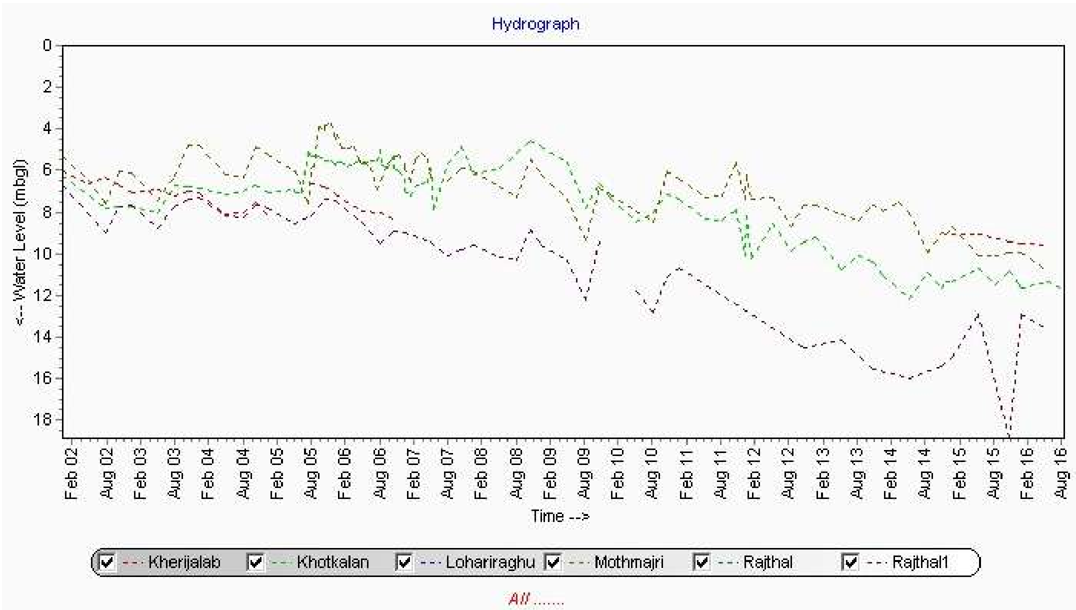
Ground Water Resource Availability: Ground Water Resources are available 1.55 bcm (0.46 bcm fresh and 1.09 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 45 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 20 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 111 m and the granular zones are counted after the depth of 45 m and available zones are 43 m. this block is falling over-exploited category and present SOD is 202% as per 2013 assessment.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~11.2 m bgl.


Hydrograph
Site Name : Mothmajri State : Haryana District : HISAR Tahsil : NARNAUD Block : NARNAUD Village : Mothmajri
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.014162X + 2.909502
Post Monsoon Water Level Trend: Y = -0.013882X + 0.803273


Hydrograph
Site Name : Khotkalan State : Haryana District : HISAR Tahsil : NARNAUD Block : NARNAUD Village : Khotkalan
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.026242X + 14.678470
Post Monsoon Water Level Trend: Y = 0.032971X + 17.797907

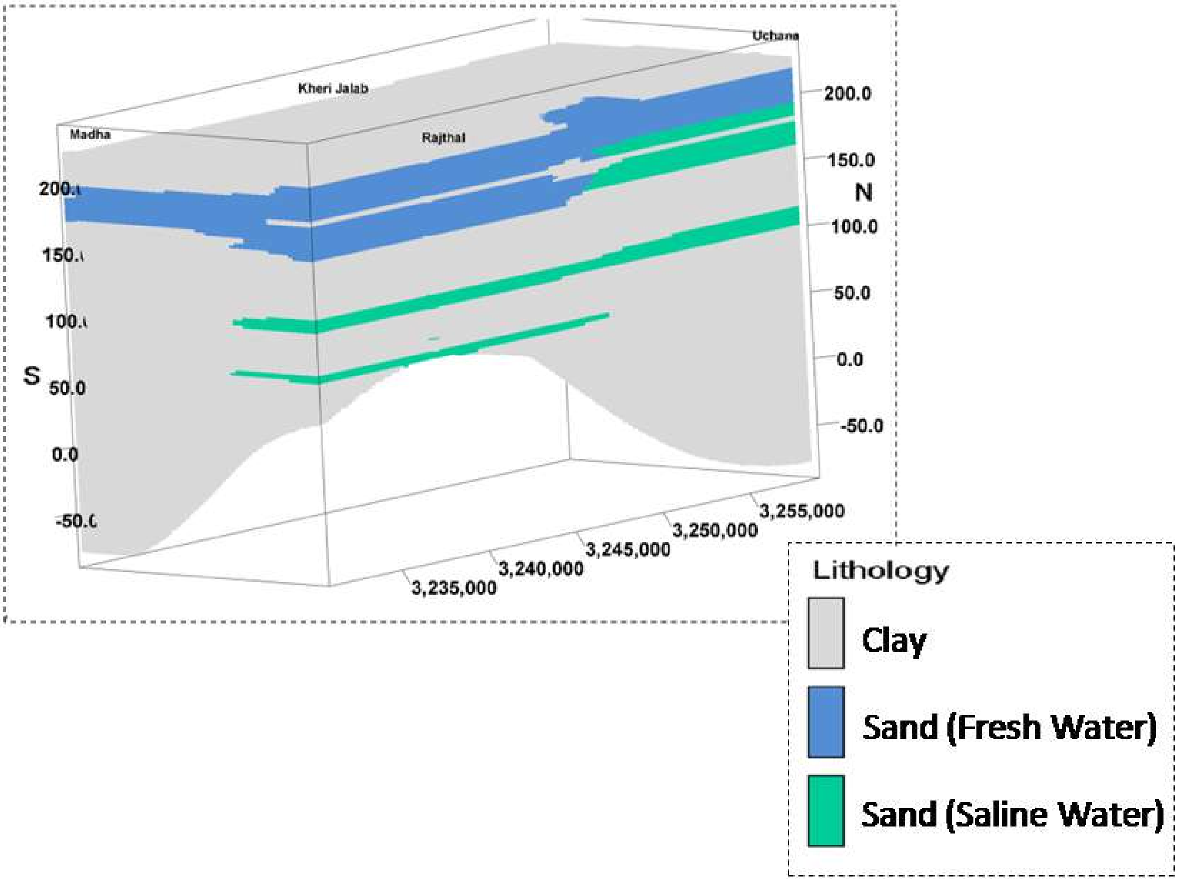

Hydrograph
<-- Water Level (mbgl)
Time -->
Kherijalab
Khotkalan
Lohariraghu
Mothmajri
Rajthal
Rajthal1
All ....

Aquifer Disposition: There is single Aquifer System (up to 300 m)

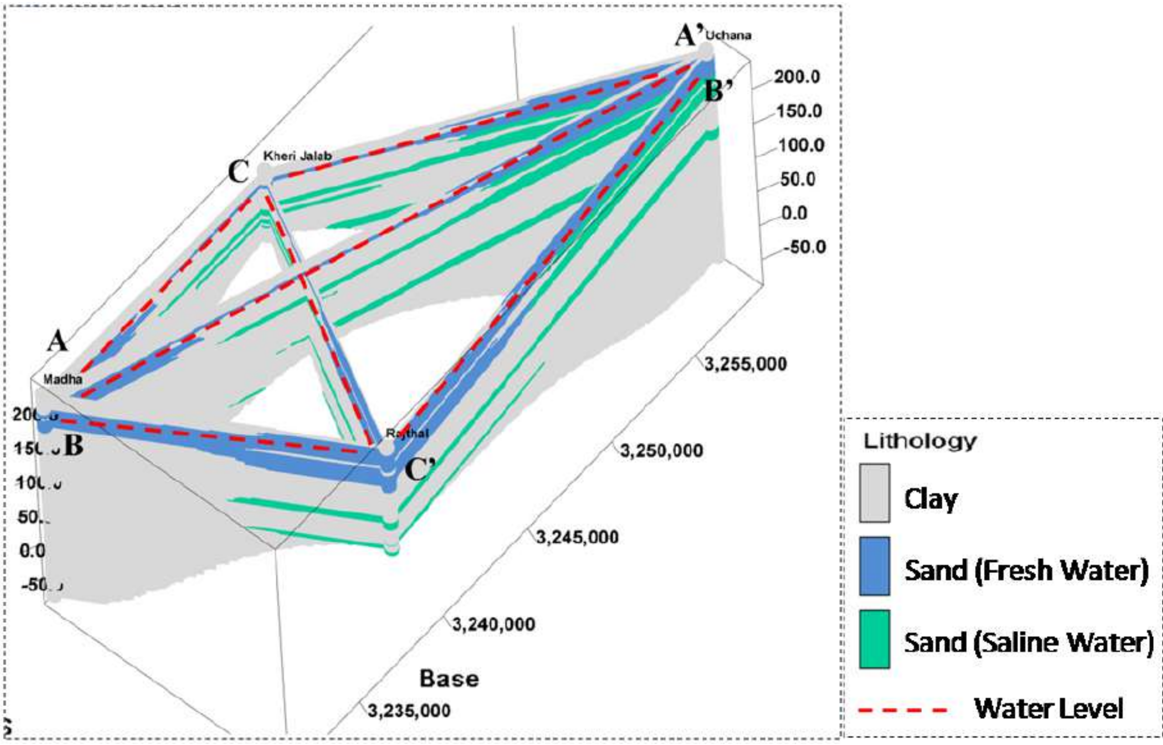
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	63	2240	12	--

The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

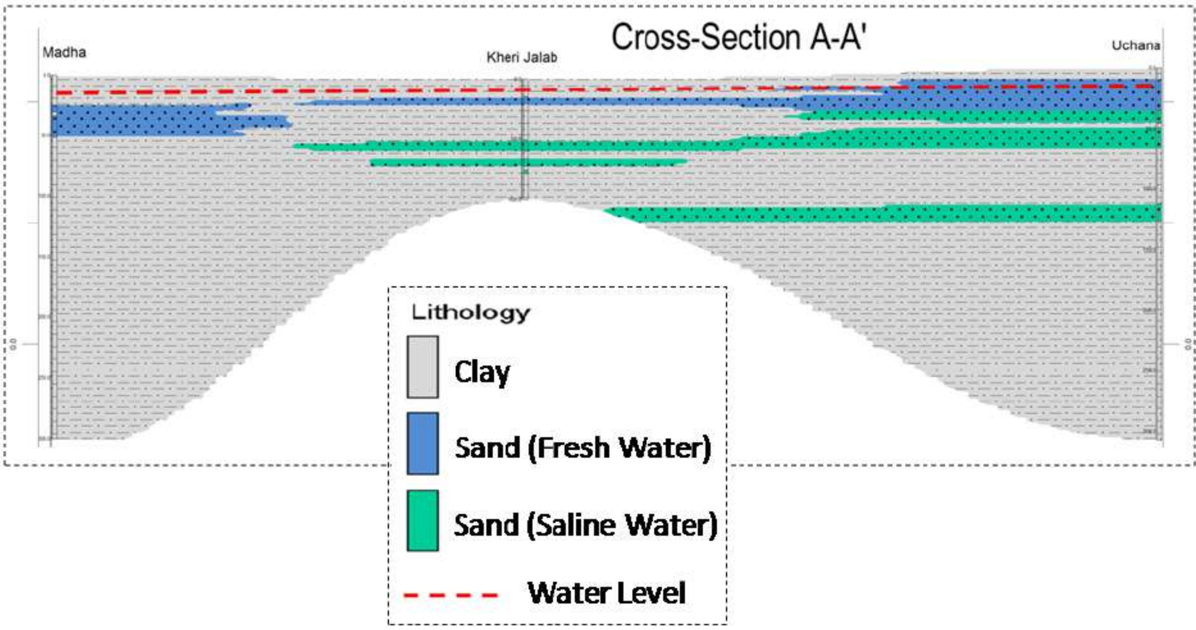
3D Lithology model

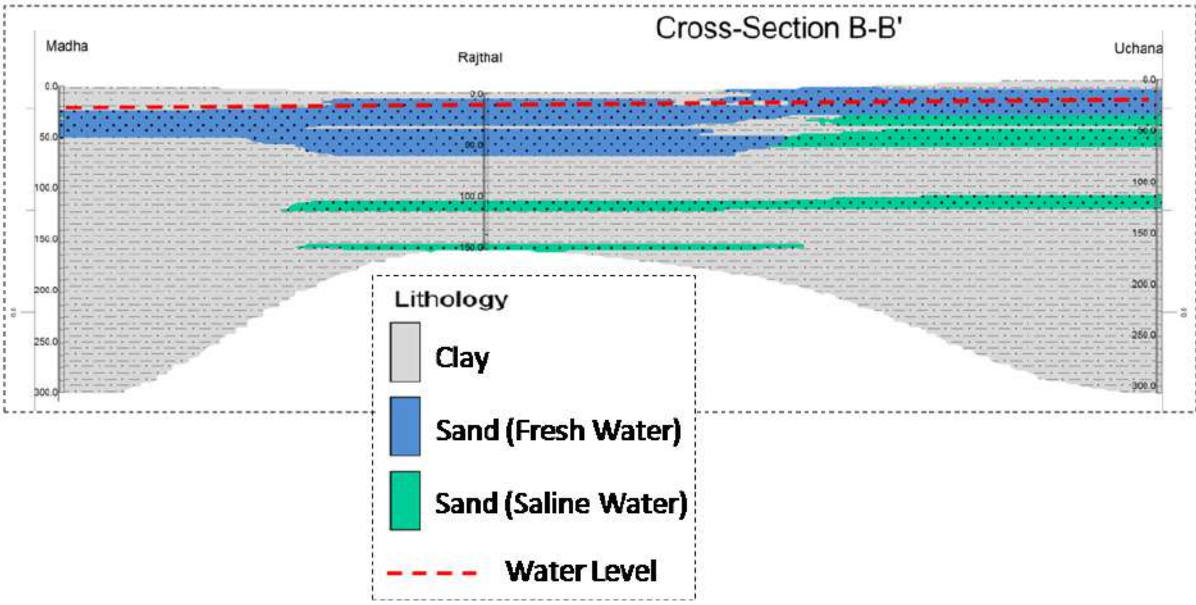


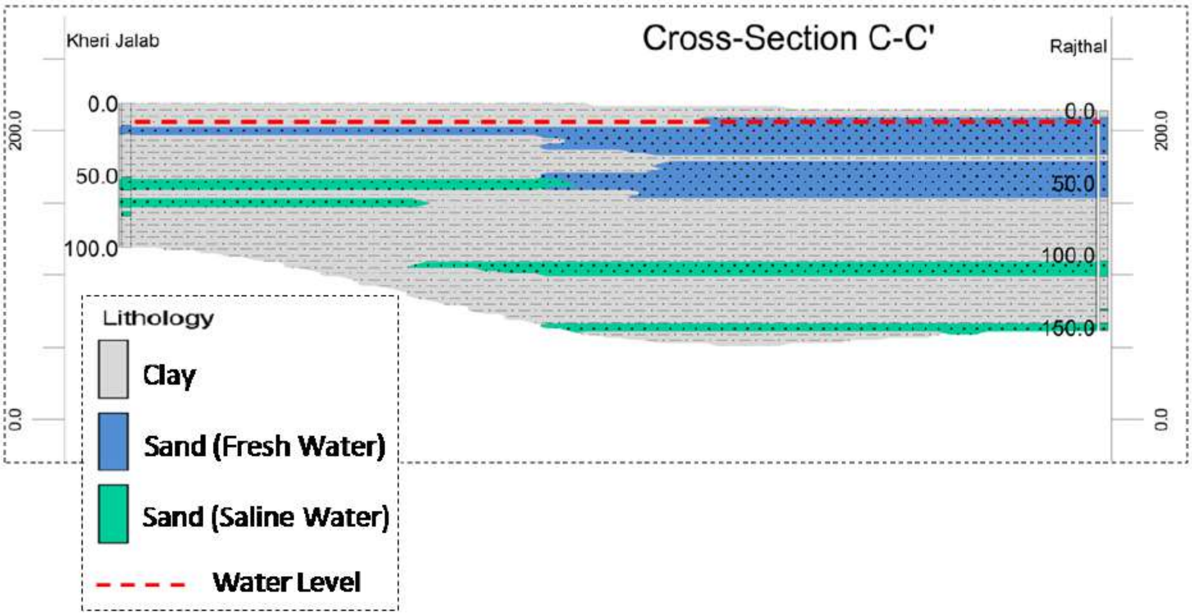
3D Lithology Fence



Cross-sections




Cross-Section B-B'
Madha
Rajthal
Uchana
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Cross-Section C-C'
Kheri Jalab
Rajthal
0.0
50.0
100.0
150.0
200.0
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	87.62
	In-storage Fresh water resources	368.24
	In-storage Saline water resources	1091.7
	Total	1547.54
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	185.55
	Domestic & Industrial	0.21
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		185.76
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 1026 to <4000 µS/cm at 25^{0}c)
Other issues		Water levels are declining trend in some areas. Present stage of development 202% and Over-exploited.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level is 211.6 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 32.01 mcm.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 13.08 mcm volume of water wastage
Change in cropping pattern	Proposed for change in cropping pattern from Paddy to maize/soyabean in total area. Anticipated volume of water to be saved by maize/soyabean is 172.32 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

IX. UKLANA BLOCK (269.10 SQ. KM)

Population (2011)	Rural- 92,473
	Urban- 13,219
	Total- 105,692
Rainfall	Monsoon: 259 mm
	Non Monsoon: 82 mm
Average Annual Rainfall	341 mm

Agriculture and Irrigation Major Crops-Cotton, Sugarcane, Bajra, Wheat, Paddy, Pulses, Other crops-Rapeseed, Mustard, Potatoes, Onions, Ber, Mangoes, Citrus fruits, Pomegranate, Peach, Guava, Grapes & Papaya.

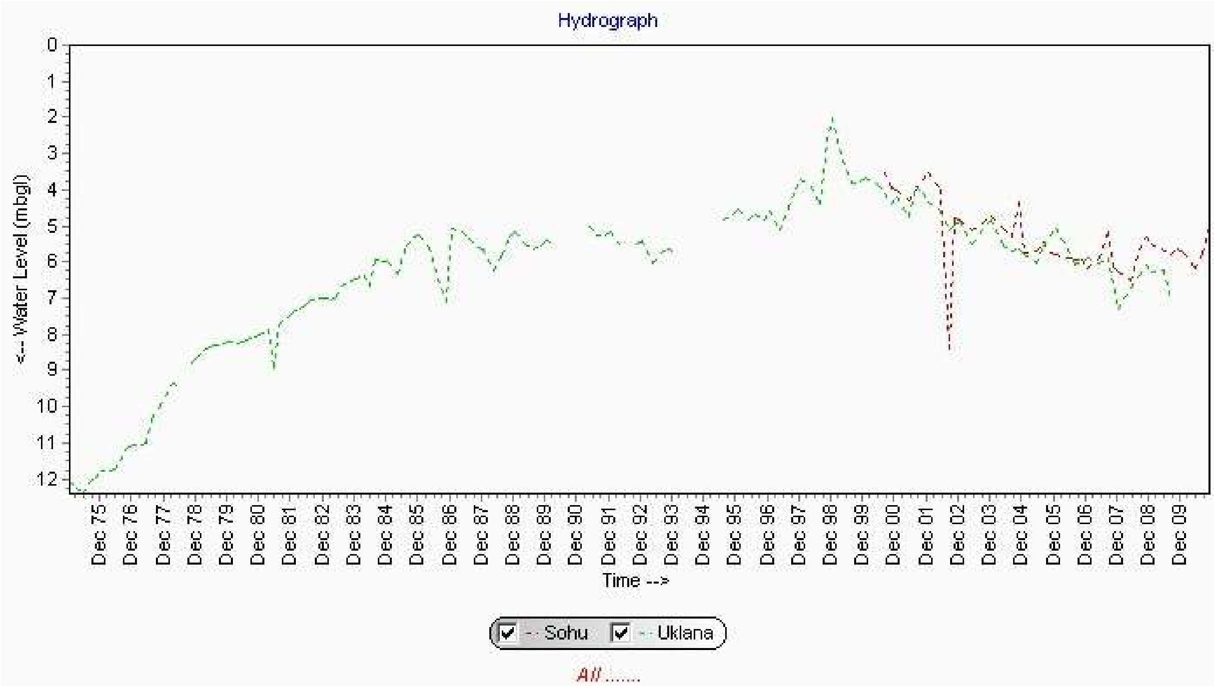
Net Area Sown:	24219 ha
Total Irrigated Area:	Monsoon= 18012 ha
	Non-monsoon= 19208 ha

Canal Irrigation 2 lined canals & 16 unlined canals

Ground Water Resource Availability: Ground Water Resources are available 1.18 bcm (0.04 bcm fresh and 1.14 bcm saline water resources) in the single aquifer group up to the depth of 300m. The fresh water resources are estimated up to the depth of 15 m based on geophysical interpretations interface. The potential granular zones are available for fresh water in this block as 5 m. Saline water resources are estimated based on the available depth of wells existed in this block i.e average depth of 73 m and the granular zones are counted after the depth of 15 m and available zones are 59 m. this block is falling in Semi-critical category and present SOD is 91% as per 2013 assessment.

Ground water Extraction: Deeper aquifer is totally saline and it is not suitable for irrigation purpose and all users are tapping at shallow aquifers i.e Domestic water supply, agricultural wells and industrial supply. It causes over exploitation in those demand areas, so that the proper ground water management techniques to be adapted.

Water level Behavior (2016): Pre Monsoon ~10.00 m bgl

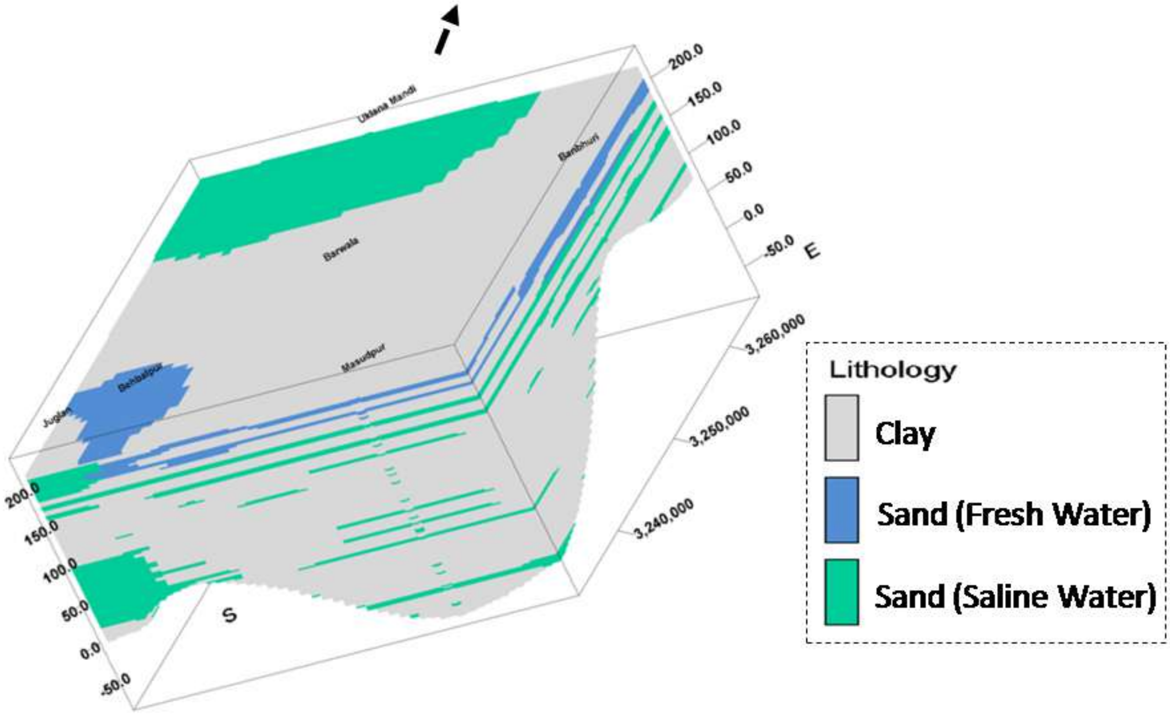


Aquifer Disposition: There is single Aquifer System (up to 300 m)

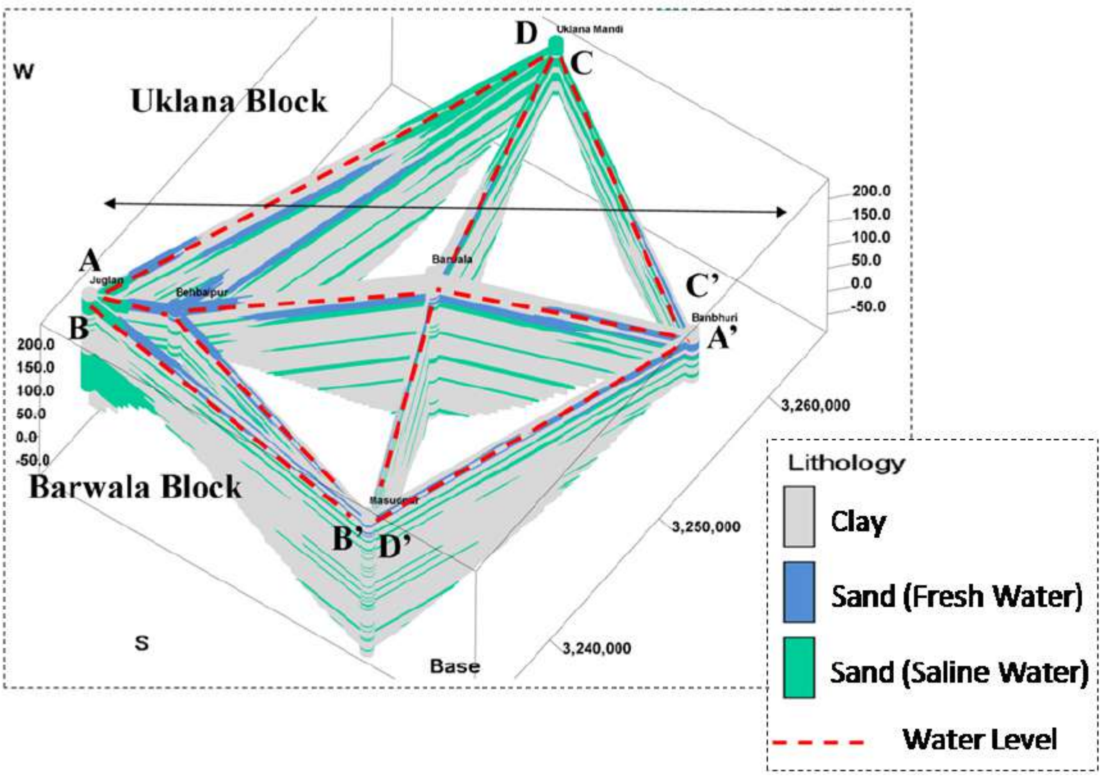
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Single aquifer system	Quaternary Alluvial deposits	Unconfined to Semi Confined	64	--	12	--
			Wells abandoned due to bad quality of water			

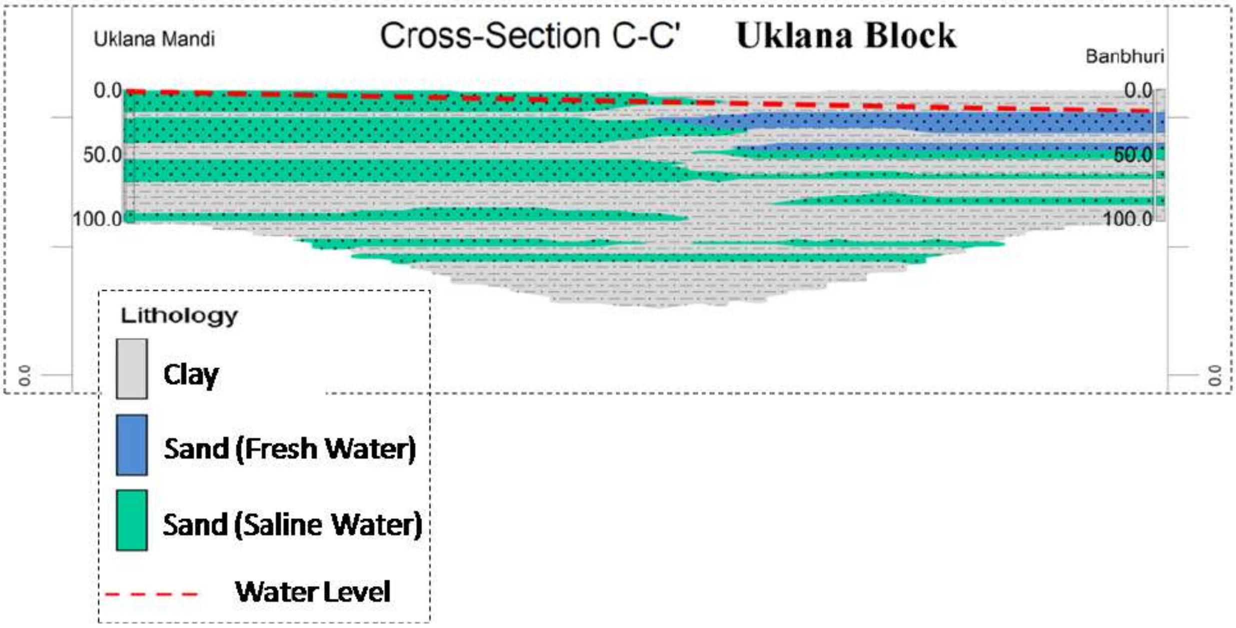
The Aquifer comprises of both fresh and saline water and the main aquifer formation is sand, sand with kankar. The non-aquifer material comprise of clay, clay with silt.

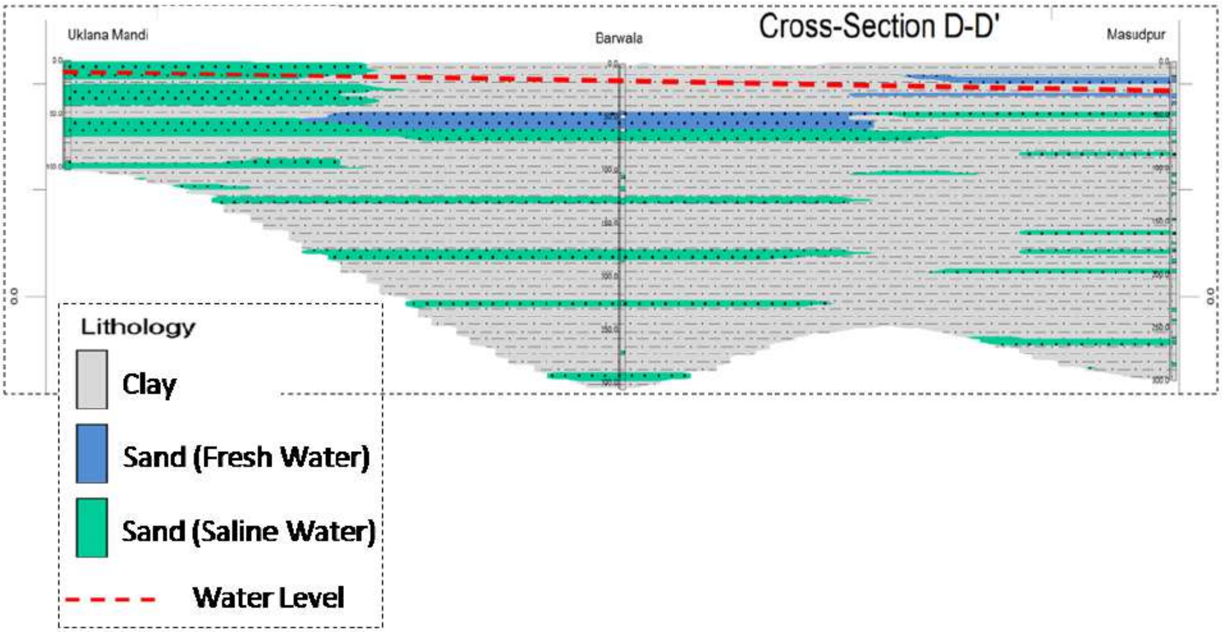
3D Lithology model



3D Lithology Fence




Uklana Mandi
Cross-Section C-C'
Uklana Block
Banbhuri
0.0
50.0
100.0
0.0
50.0
100.0
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level


Uklana Mandi
Barwala
Cross-Section D-D'
Masudpur
Lithology
Clay
Sand (Fresh Water)
Sand (Saline Water)
Water Level

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources in Single aquifer system upto the depth of 300m (in mcm)	Dynamic Fresh water resources	41.48
	In-storage Fresh water resources	0 (*total saline area*)
	In-storage Saline water resources	1143.1
	Total	1184.62
Ground Water Extraction (in mcm) (as per 2013)	Irrigation	46.34
	Domestic & Industrial	0.23
Future Demand for domestic & Industrial sector (2025) (in mcm) (as per 2013)		46.57
Chemical Quality of ground water		Maximum Saline water and it suits irrigation (EC is ranges between 3530 to <4000 µS/cm at 25^0c)
Other issues		Water levels are raising trend in some areas. Present stage of development 91% and semi-critical category.

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level is 161.5 mcm.
Other interventions proposed	Pond recharge system, Artificial Recharge, UGPL and crop diversified from paddy to maize. Adaptation of all these practices will be saved water up to 7.07 mcm.

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 3.27 mcm volume of water wastage
Change in cropping pattern	If adapted these crop diversification method in this area, the anticipated volume of water to be saved by maize/soyabean is 44.68 mcm from total draft.
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	Adopt a technique of 3 / 5 pond system in every village for utilization of waste water.

SUMMARY AND CONCLUSIONS:

- ✓ The area of Hisar district falls in Ghaggar basin and occupied by geological formations of older alluvial deposits and Aeolian deposits of Quaternary age and holding of single aquifer system up to the depth of 300 m bgl.
- ✓ The major lithological formations are Sand, Kankar and clay & silt and all are admixed with sand and clay formations.
- ✓ Thick layering of clay with sand at many places can be observed centre part and also towards south of the district at deeper depths.
- ✓ There is thin inter-layering of sand with saline water bearing zones in thick clay beds at deeper levels.
- ✓ The fresh water resources are limited in aquifer up to maximum average depth of 30m, whereas saline water is dominant resources below 30 m depth up to 300 m.
- ✓ The ground water development in two the blocks has exceeded the available recharge, thus two blocks have been categorized as over exploited. Stage of Ground Water Development of the district is 112% and it categorized as Over-exploitation.
- ✓ Dynamic & In- storage ground water resources has also been carried out to a depth of 300 meters for single aquifer group.
- ✓ Dynamic ground water resources of the district are 0.62 BCM, whereas In-storage ground water resources up to fresh water zones (about 30 m) are 3.07 BCM. Thus total fresh ground water resources up to average depth of 30 m are 3.69 BCM.
- ✓ Total saline water resources up to depth of 300 m are 14.80 BCM. Hence the total saline water resources are more than fresh water resources.
- ✓ Considering the high ground water abstraction (783 mcm) and overdraft (-81.22 mcm), it is suggested that proposed artificial recharge measures (1.97 mcm), crop diversification measures (44 to 102 mcm by paddy to maize and paddy to pulses) and conserving ground water through laying of pipe line (55.5 mcm) will be useful and also 24.13 mcm of waste water can be utilized through 3/5 pond system, this water can be used for irrigation, ultimately it reduce the ground water draft of tube wells.
- ✓ In case, the water table is <2 mt in some areas, the fish ponds/lotus type of crops

can be grown.

- ✓ However, long-term sustainability remains a serious issue as the major part of the area is under saline ground water.
- ✓ Other techniques of water saving and modern irrigation technology to be enforced to maximize per drop of water use in the district.

Annexure-1

Location	Block	pH*	EC* in µS/cm at 25⁰ C	CO3	HCO3	Cl*	SO4	NO3*	F*	PO4	Ca*	Mg*	Na	K	SiO2	T.H *as CaCO3	SAR	RSC
				<------mg/l------>														
Agroha	Agroha	8.7	901	14.0	302.0	57.0	171.0	75.0	1.4	0.1	8.0	94.5	70.0	11.0	17.0	409.0	1.5	-2.8
Balawas- 1	Hisar-I	9.0	2830	58.6	622.0	540.6	140.0	61.0	0.3	0.0	28.0	141.0	208.0	410.0	12.0	650.5	3.5	-0.8
Barwala-2	Barwala	7.8	1802	0.0	158.6	182.5	138.0	521.9	2.7	0.0	124.0	124.0	42.0	8.0	16.0	821.0	0.6	-13.8
Bass	Bass	8.7	797	6.5	212.0	60.0	141.0	0.0	0.6	0.2	8.0	37.0	119.0	2.6	17.0	170.1	3.9	0.2
Behbalpur	Barwala	8.5	732	6.5	132.0	55.0	198.0	0.2	2.5	0.0	37.0	32.0	78.0	4.4	12.0	223.0	2.3	-2.1
Chaudhariw	Hisar-II	8.6	1517	13.0	178.0	195.3	389.0	45.0	4.0	0.0	52.0	136.0	67.0	20.0	22.0	691.0	1.1	-10.4
Dhamundi	Hansi	8.4	1150	6.5	212.0	105.0	295.0	24.0	2.9	0.0	60.1	66.0	105.0	13.0	15.0	420.3	2.2	-4.7
Gainpura	Barwala	8.8	3120	32.4	423.4	596.6	457.0	53.0	2.1	0.0	80.2	178.0	400.0	17.0	15.0	931.0	5.7	-10.6
Ghursal	Adampur	8.5	3230	27.0	330.0	261.0	1440.0	27.0	4.0	0.2	40.0	93.6	750.0	29.0	17.0	485.0	14.8	-3.4
Jugian	Barwala	8.6	793	6.5	191.0	40.0	213.0	2.6	0.5	0.0	25.0	33.0	112.0	5.8	16.0	197.0	3.5	-0.6
Juglan	Barwala	8.5	4910	26.0	383.0	781.3	1029.0	358.0	2.6	0.0	29.0	133.0	965.0	25.0	9.5	621.0	16.9	-5.2
Khotkalan	Narnaud	8.2	3400	0.0	139.0	926.6	488.0	123.1	0.7	0.0	116.2	246.0	285.0	28.0	22.0	1301.0	3.4	-23.8
Kirtan	Adampur	8.2	3210	0.0	95.0	606.2	936.0	6.4	1.5	0.0	137.0	122.0	438.0	43.0	24.0	846.0	6.6	-15.3
Mirka	Hisar-I	8.1	1570	0.0	106.0	140.0	494.0	62.0	0.9	0.0	100.0	63.0	153.0	5.6	22.0	510.0	3.0	-8.4
Mothmajri	Narnaud	8.8	1026	13.0	311.2	74.0	139.0	8.8	0.7	0.0	40.0	36.0	135.0	7.0	16.0	250.0	3.7	0.6
Rajli Cross	Hansi	8.1	299	0.0	106.0	14.0	48.0	1.6	0.8	0.0	24.0	19.0	10.0	1.8	13.0	140.0	0.4	-1.0
Samani	Agroha	8.5	2180	13.0	273.0	498.4	114.0	36.0	0.2	0.0	33.0	81.0	170.0	215.0	25.0	414.0	3.6	-3.4
Uklana	Uklana	8.1	3530	0.0	82.0	552.0	746.0	608.7	1.5	0.0	83.0	232.0	402.0	24.0	20.0	1160.0	5.1	-21.9
Umra	Hansi	8.2	1217	0.0	157.0	94.0	462.0	5.5	0.7	0.1	44.0	69.5	149.0	3.2	15.0	396.0	3.3	-5.3
Min.		**7.8**	**299**	**0.0**	**82.0**	**14.0**	**48.0**	**0.0**	**0.2**	**0.0**	**8.0**	**19.0**	**10.0**	**1.8**	**9.5**	**140.0**	**0.4**	**-23.8**
Max.		**9.0**	**4910**	**58.6**	**622.0**	**926.6**	**1440.0**	**608.7**	**4.0**	**0.2**	**137.0**	**246.0**	**965.0**	**410.0**	**25.0**	**1301.0**	**16.9**	**0.6**

Annexure-1: Analytical results of Basic parameters of ground water samples of Hisar district (GWMS-NHS-2015)

Annexure-2

Location	Longitude	Latitude	As (mg/lt)	Fe (mg/lt)
Agroha	75.6228	29.3250	0.001	0.0078
Balawas1	75.8222	28.9583	0.001	BDL
Banbahuri	76.0500	29.4000	0.001	0.0087
Barwala2	75.9208	29.3708	BDL	0.0974
Bas	76.2000	29.1083	0.001	BDL
Behbalpur-Pz	75.7894	29.2833	Leaked	Leaked
Chaudhariwas	75.6000	29.0083	0.001	0.0397
Dhamundi Rampur	76.0417	29.0750	0.001	0.0096
Gain Pura	75.9292	29.4250	0.001	BDL
Ghursal-Pz	75.4228	29.1708	0.001	BDL
Juglan	75.9956	29.4250	0.001	BDL
Kaliravan	75.5708	29.2972	0.001	BDL
Kanoh-Pz	75.7569	29.3728	0.005	0.0069
Khotkalan	76.1750	29.3875	0.007	0.3465
Kirtan	75.5472	29.2208	BDL	1.0063
Mirka	75.7583	29.0750	0.001	BDL
Mothmajri	75.5667	29.1167	0.001	0.9079
Rajli Cross	75.9069	29.2889	0.001	0.1656
Samani	75.6833	29.4083	0.003	BDL
Sohu	75.8333	29.4986	0.001	Leaked
Uklana	75.8583	29.5083	BDL	BDL
Umra	75.9125	29.0528	0.001	0.3962

Annexure-2: Analytical results of Arsenic and Iron parameters of groundwater samples of Hisar district (GWMS-NHS-2015)

Annexure-3

Location	Longitude	Latitude	Depth (m)	Elevation (m)	Collar Elevation (m)	Agency
Adampur	75.479	29.271	246	208	208	CGWB
Agroha	75.642	29.333	277	211	211	CGWB
Juglan	75.760	29.260	244	215	215	PRIVATE
Mayar	75.867	29.100	295	213	213	CGWB
Barwala	75.905	29.364	306	219	219	CGWB
Masudpur	75.972	29.227	350	221	221	PRIVATE
Rajthal	76.200	29.263	152	214	214	CGWB
Madha	76.080	29.204	310	222	222	CGWB
Hisar	75.720	29.150	275	215	215	CGWB
Jamalpur	75.950	28.960	304	218	218	CGWB
Bhatla	75.930	29.170	214	219	219	CGWB
Dhiranwas	75.590	29.090	229	211	211	CGWB
Banbhuri	76.044	29.406	102	222	222	CGWB-Pz
Kanoh	75.761	29.385	108	220	220	CGWB-Pz
Kanda Kheri	76.220	29.190	102	221	221	CGWB-Pz
Balsamand	75.494	29.070	108	210	210	CGWB-Pz
Ghursal	75.421	29.175	108	209	209	CGWB-Pz
Uklana Mandi	75.870	29.511	103	222	222	CGWB-Pz
Kheri Jalab	76.082	29.322	100	219	219	CGWB-Pz
Sorkhi	76.113	29.053	105	220	220	CGWB-Pz
Behbalpur	75.803	29.278	109	215	215	CGWB-Pz
Mangali	75.735	29.045	109	215	215	CGWB-Pz
Thurana	76.112	29.149	112	218	218	CGWB-AQM

Annexure-3: Borehole location details of Hisar district drilled by different agencies

Annexure-4

Name of Borehole	Depth-1 (m)	Depth-2 (m)	Lithology	Thickness (m)
Adampur	0	6.7	Top Soil	6.70
Adampur	6.7	10.66	Clay	3.96
Adampur	10.6	20.47	Kankar	9.87
Adampur	20.47	65.6	Clay	45.13
Adampur	65.6	68.45	Sand with Kankar	2.85
Adampur	68.45	176.04	Clay	107.59
Adampur	176.04	178.96	Kankar	2.92
Adampur	178.96	209.67	Clay	30.71
Adampur	209.67	224.15	Clay with Kankar	14.48
Adampur	224.15	241.35	Clay	17.20
Adampur	241.35	245.31	Sand with Kankar	3.96
Agroha	0	6	Top Soil	6.00
Agroha	6	26	Clay	20.00
Agroha	26	50	Sand	24.00
Agroha	50	54	Clay	4.00
Agroha	54	60	Sand	6.00
Agroha	60	65	Clay	5.00
Agroha	65	76	Sand	11.00
Agroha	76	117	Clay	41.00
Agroha	117	126	Sand	9.00
Agroha	126	127	Clay	1.00
Agroha	127	132	Sand	5.00
Agroha	132	141	Clay	9.00
Agroha	141	144	Sand	3.00
Agroha	144	150	Clay	6.00
Agroha	150	164	Sand	14.00
Agroha	164	178	Clay	14.00
Agroha	178	180	Sand	2.00
Agroha	180	185	Clay	5.00
Agroha	185	187	Sand	2.00
Agroha	187	201	Clay	14.00
Agroha	201	209	Sand	8.00
Agroha	209	218	Clay	9.00

Name of Borehole	Depth-1 (m)	Depth-2 (m)	Lithology	Thickness (m)
Juglan	0	6	Top Soil	6.00
Juglan	6	36	Sand	30.00
Juglan	36	44.2	Clay	8.21
Juglan	44.2	46.6	Sand	2.44
Juglan	46.6	54.9	Clay	8.23
Juglan	54.9	58.8	Sand	3.96
Juglan	58.8	68.0	Clay	9.15
Juglan	68.0	69.8	Sand	1.83
Juglan	69.8	120.7	Clay	50.91
Juglan	120.7	201.8	Sand	81.10
Mayar	0	3	Top Soil	3.00
Mayar	3	6.1	Sand	3.10
Mayar	6.1	20.01	Kankar	13.91
Mayar	20.01	41.1	Sand	21.09
Mayar	41.1	85.9	Clay with Kankar	44.80
Mayar	85.9	89.7	Clay	3.80
Mayar	89.7	92.7	Clay with Kankar	3.00
Mayar	92.7	138.3	Clay	45.60
Mayar	138.3	144.8	Clay with Kankar	6.50
Mayar	144.8	238.8	Clay	94.00
Mayar	238.8	294.8	Sand	56.00
Barwala	0	6	Top Soil	6.00
Barwala	6	44	Clay	38.00
Barwala	44	48	Sand	4.00
Barwala	48	52	Clay	4.00
Barwala	52	60	Sand	8.00
Barwala	60	64.5	Clay	4.50
Barwala	64.5	72	Sand	7.50
Barwala	72	105	Clay	33.00
Barwala	105	108	Sand	3.00
Barwala	108	115.5	Clay	7.50
Barwala	115.5	120	Sand	4.50
Barwala	120	126.5	Clay	6.50

Barwala	126.5	132	Sand	5.50
Barwala	132	175	Clay	43.00
Barwala	175	186.5	Sand	11.50
Barwala	186.5	223	Clay	36.50
Barwala	223	228	Sand	5.00
Barwala	228	270	Clay	42.00
Barwala	270	274	Sand	4.00
Barwala	274	291	Clay	17.00
Barwala	291	298	Sand	7.00
Barwala	298	306.63	Clay	8.63
Masudpur	0	3	Top Soil	3.00
Masudpur	3	13.4	Clay	10.40
Masudpur	13.4	19.4	Sand	6.00
Masudpur	19.4	29.8	Clay	10.40
Masudpur	29.8	34.2	Sand	4.40
Masudpur	34.2	37.4	Clay	3.20
Masudpur	37.4	40	Sand	2.60
Masudpur	40	47.2	Clay	7.20
Masudpur	47.2	51	Sand	3.80
Masudpur	51	65	Clay	14.00
Masudpur	65	69.4	Sand	4.40
Masudpur	69.4	74.2	Clay	4.80
Masudpur	74.2	76.2	Sand	2.00
Masudpur	76.2	86.3	Clay	10.10
Masudpur	86.3	88.4	Sand	2.10
Masudpur	88.4	105.6	Clay	17.20
Masudpur	105.6	107.6	Sand	2.00
Masudpur	107.6	113	Clay	5.40
Masudpur	113	114.6	Sand	1.60
Masudpur	114.6	123.4	Clay	8.80
Masudpur	123.4	125.4	Sand	2.00
Masudpur	125.4	147	Clay	21.60
Masudpur	147	149	Sand	2.00
Masudpur	149	160.2	Clay	11.20
Masudpur	160.2	162.6	Sand	2.40
Masudpur	162.6	169.8	Clay	7.20
Masudpur	169.8	171.8	Sand	2.00
Masudpur	171.8	177	Clay	5.20
Masudpur	177	179	Sand	2.00
Masudpur	179	185	Clay	6.00
Masudpur	185	189.8	Sand	4.80
Masudpur	189.8	195.4	Clay	5.60
Masudpur	195.4	198.6	Sand	3.20
Masudpur	198.6	231.8	Clay	33.20
Masudpur	231.8	234.6	Sand	2.80
Masudpur	234.6	242.6	Clay	8.00
Masudpur	242.6	244.6	Sand	2.00
Masudpur	244.6	259	Clay	14.40
Masudpur	259	261	Sand	2.00
Masudpur	261	262.6	Clay	1.60
Masudpur	262.6	265.6	Sand	3.00
Masudpur	265.6	283.4	Clay	17.80
Masudpur	283.4	286.4	Sand	3.00
Rajthal	0	2	Top Soil	2.00
Rajthal	2	5	Clay	3.00
Rajthal	5	30	Sand	25.00
Rajthal	30	35	Clay	5.00
Rajthal	35	60	Sand	25.00
Rajthal	60	104	Clay	44.00
Rajthal	104	115	Sand	11.00
Rajthal	115	137	Clay	22.00
Rajthal	137	138	Sand	1.00
Rajthal	138	147	Clay	9.00
Rajthal	147	152	Sand	5.00
Rajthal	152	152.4	Clay	0.40
Madha	0	3.96	Top Soil	3.96
Madha	3.96	24.9	Clay	20.94
Madha	24.9	30.48	Sand	5.58
Madha	30.48	33.52	Clay	3.04
Madha	33.52	48.5	Sand	14.98
Madha	48.5	51.51	Sand with Kankar	3.01
Madha	51.51	116.51	Clay	65.00

Madha	116.51	310.59	Clay with Kankar	194.08
Hisar	0	6	Top Soil	6.00
Hisar	6	20.72	Clay	14.72
Hisar	20.72	59.74	Clay with Kankar	39.02
Hisar	59.74	199.94	Clay	140.20
Hisar	199.94	220.18	Clay with Kankar	20.24
Hisar	220.18	252	Clay	31.82
Hisar	252	259	Clay with Kankar	7.00
Hisar	259	275.84	Sand	16.84
Jamalpur	0	4	Top Soil	4.00
Jamalpur	4	33.52	Sand	29.52
Jamalpur	33.52	36.57	Clay	3.05
Jamalpur	36.57	42.67	Sand with Kankar	6.10
Jamalpur	42.67	115.82	Clay with Kankar	73.15
Jamalpur	115.82	124	Sand	8.18
Jamalpur	124	143	Sand with Kankar	19.00
Jamalpur	143	146	Clay	3.00
Jamalpur	146	164	Sand	18.00
Jamalpur	164	179	Sand with Kankar	15.00
Jamalpur	179	182	Clay with Kankar	3.00
Jamalpur	182	192	Sand with Kankar	10.00
Jamalpur	192	204	Clay with Kankar	12.00
Jamalpur	204	219	Sand with Kankar	15.00
Jamalpur	219	225	Clay with Kankar	6.00
Jamalpur	225	243	Clay	18.00
Jamalpur	243	252	Sand	9.00
Jamalpur	252	262	Sand with Kankar	10.00
Jamalpur	262	304	Clay with Kankar	42.00
Bhatla	0	6	Top Soil	6.00
Bhatla	6	16.5	Clay	10.50
Bhatla	16.5	30.5	Clay with Kankar	14.00
Bhatla	30.5	50.91	Sand with Kankar	20.41
Bhatla	50.91	54.9	Sand	3.99
Bhatla	54.9	68	Clay	13.10
Bhatla	68	89	Kankar	21.00
Bhatla	89	102	Clay	13.00

Bhatla	102	116	Clay with Kankar	14.00
Bhatla	116	130	Clay	14.00
Bhatla	130	157	Clay with Kankar	27.00
Bhatla	157	186	Clay	29.00
Bhatla	186	214	Clay with Kankar	28.00
Dhiranwas	0	4	Top Soil	4.00
Dhiranwas	4	10	Clay	6.00
Dhiranwas	10	19.8	Kankar	9.80
Dhiranwas	19.8	50.2	Clay with Kankar	30.40
Dhiranwas	50.2	71	Kankar	20.80
Dhiranwas	71	123	Clay	52.00
Dhiranwas	123	136.9	Clay with Kankar	13.90
Dhiranwas	136.9	147.5	Kankar	10.60
Dhiranwas	147.5	198	Clay with Kankar	50.50
Dhiranwas	198	204	Clay	6.00
Dhiranwas	204	226	Kankar	22.00
Dhiranwas	226	228	Sand	2.00
Banbhuri	0	9	Top Soil	9.00
Banbhuri	9	18	Clay	9.00
Banbhuri	18	33	Sand with Kankar	15.00
Banbhuri	33	36	Clay	3.00
Banbhuri	36	42	Clay with Kankar	6.00
Banbhuri	42	48	Sand with Kankar	6.00
Banbhuri	48	54	Sand	6.00
Banbhuri	54	58	Clay	4.00
Banbhuri	58	64	Clay with Kankar	6.00
Banbhuri	64	69	Sand with Kankar	5.00
Banbhuri	69	83	Clay	14.00
Banbhuri	83	90	Sand with Kankar	7.00
Banbhuri	90	102	Clay with Kankar	12.00
Kanoh	0	5	Top Soil	5
Kanoh	5	15	Clay	10
Kanoh	15	27	Clay with Kankar	12
Kanoh	27	33	Sand	6
Kanoh	33	36	Clay	3
Kanoh	36	42	Sand	6

Kanoh	42	48	Sand with Kankar	6
Kanoh	48	60	Clay	12
Kanoh	60	66	Clay with Kankar	6
Kanoh	66	84	Sand with Kankar	18
Kanoh	84	93	Clay	9
Kanoh	93	108	Sand with Kankar	15
Kanda Kheri	0	10	Top Soil	10
Kanda Kheri	10	15	Sand	5
Kanda Kheri	15	17	Clay	2
Kanda Kheri	17	22	Sand with Kankar	5
Kanda Kheri	22	24	Clay	2
Kanda Kheri	24	41	Sand with Kankar	17
Kanda Kheri	41	53	Sand	12
Kanda Kheri	53	61	Sand with Kankar	8
Kanda Kheri	61	64	Clay with Kankar	3
Kanda Kheri	64	68	Sand with Kankar	4
Kanda Kheri	68	92	Clay with Kankar	24
Kanda Kheri	92	96	Sand	4
Kanda Kheri	96	102	Clay with Kankar	6
Balsamand	0	6	Top Soil	6
Balsamand	6	24	Clay with Kankar	18
Balsamand	24	30	Sand with Kankar	6
Balsamand	30	36	Sand	6
Balsamand	36	39	Clay with Kankar	3
Balsamand	39	45	Sand	6
Balsamand	45	54	Sand with Kankar	9
Balsamand	54	64	Clay with Kankar	10
Balsamand	64	108	Sand	44
Ghursal	0	6	Top Soil	6
Ghursal	6	9	Clay with Kankar	3
Ghursal	9	12	Sand with Kankar	3
Ghursal	12	18	Sand	6
Ghursal	18	24	Clay with Kankar	6
Ghursal	24	30	Sand	6
Ghursal	30	36	Clay with Kankar	6
Ghursal	36	40	Sand	4

Ghursal	40	50	Sand with Kankar	10
Ghursal	50	55	Sand	5
Ghursal	55	75	Clay with Kankar	20
Ghursal	75	81	Sand	6
Ghursal	81	85	Sand with Kankar	4
Ghursal	85	108	Clay with Kankar	23
Uklana Mandi	0	6	Top Soil	6
Uklana Mandi	6	18	Sand	12
Uklana Mandi	18	23	Clay	5
Uklana Mandi	23	33	Sand	10
Uklana Mandi	33	42	Sand with Kankar	9
Uklana Mandi	42	48	Clay	6
Uklana Mandi	48	54	Clay with Kankar	6
Uklana Mandi	54	60	Sand with Kankar	6
Uklana Mandi	60	72	Sand	12
Uklana Mandi	72	94	Clay	22
Uklana Mandi	94	98	Sand with Kankar	4
Uklana Mandi	98	103	Sand	5
Kheri Jalab	0	6	Top Soil	6
Kheri Jalab	6	15	Clay	9
Kheri Jalab	15	21	Sand with Kankar	6
Kheri Jalab	21	51	Clay with Kankar	30
Kheri Jalab	51	60	Sand with Kankar	9
Kheri Jalab	60	66	Clay with Kankar	6
Kheri Jalab	66	72	Sand with Kankar	6
Kheri Jalab	72	75	Clay	3
Kheri Jalab	75	78	Sand with Kankar	3
Kheri Jalab	78	100	Clay with Kankar	22
Sorkhi	0	6	Top Soil	6
Sorkhi	6	21	Clay	15
Sorkhi	21	34	Clay with Kankar	13
Sorkhi	34	63	Clay	29
Sorkhi	63	70	Sand	7
Sorkhi	70	81	Clay with Kankar	11
Sorkhi	81	86	Sand	5
Sorkhi	86	89	Sand with Kankar	3

Sorkhi	89	96	Clay	7
Sorkhi	96	105	Clay with Kankar	9
Behbalpur	0	5	Top Soil	5
Behbalpur	5	15	Sand	10
Behbalpur	15	18	Clay	3
Behbalpur	18	25	Sand	7
Behbalpur	25	45	Clay with Kankar	20
Behbalpur	45	54	Sand	9
Behbalpur	54	63	Clay with Kankar	9
Behbalpur	63	77	Clay	14
Behbalpur	77	83	Sand	6
Behbalpur	83	92	Clay with Kankar	9
Behbalpur	92	99	Sand with Kankar	7
Behbalpur	99	109	Clay with Kankar	10
Mangali	0	6	Top Soil	6
Mangali	6	12	Clay	6
Mangali	12	24	Sand	12
Mangali	24	33	Sand with Kankar	9
Mangali	33	43	Clay	10
Mangali	43	56	Sand	13

Mangali	56	63	Clay with Kankar	7
Mangali	63	74	Clay	11
Mangali	74	79	Clay with Kankar	5
Mangali	79	84	Sand with Kankar	5
Mangali	84	90	Sand	6
Mangali	90	100	Clay with Kankar	10
Mangali	100	104	Sand with Kankar	4
Mangali	104	109	Clay with Kankar	5
Thurna (NAQM)	0	3	Top Soil	3
Thurna	3	16	Clay	13
Thurna	16	20	Sand	4
Thurna	20	36	Clay	16
Thurna	36	42	Sand	6
Thurna	42	51	Clay	9
Thurna	51	54	Sand	3
Thurna	54	68	Clay	14
Thurna	68	77	Sand	9
Thurna	77	90	Clay	13
Thurna	90	94	Sand	4
Thurna	94	112	Clay	18

Annexure-4: Litholog data each boreholes drilled by different agencies in Hisar district.

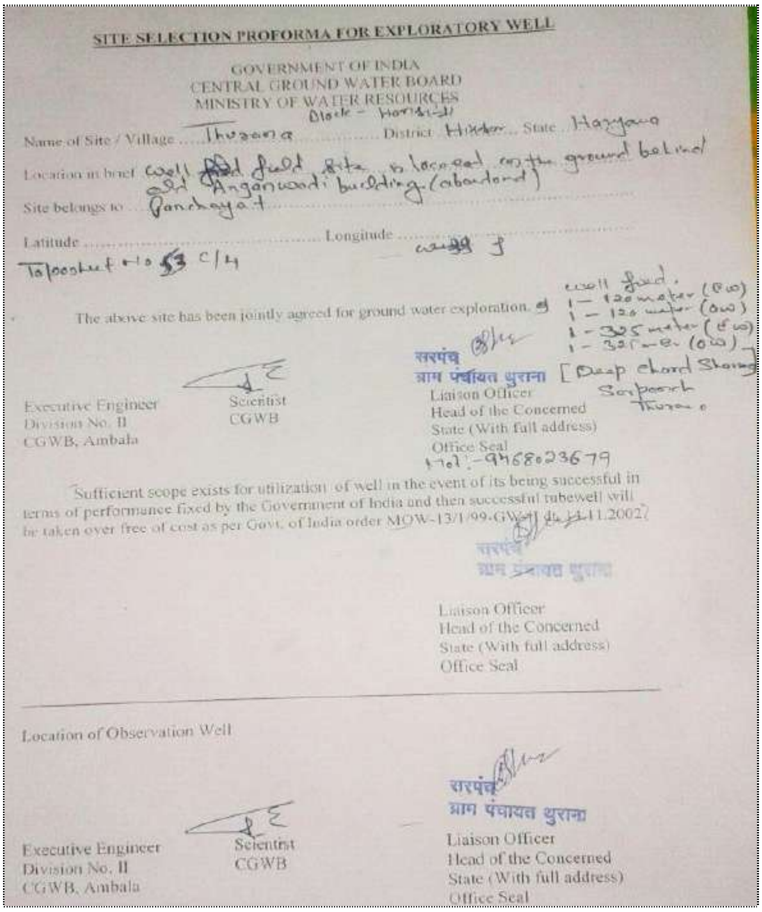
PHOTOGRAPHS:

1. HYDROGEOLOGY AND ENGINEERING DOMAIN

Site selection for exploratory well drilling and rig deployment and pin-pointing at site Thurana in Hisar district.

Litholog preparation at site Thurana

Discussions for depth wise in quality variations in the area and collection of well inventory data.



SITE SELECTION PROFORMA FOR EXPLORATORY WELL

GOVERNMENT OF INDIA
CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES

Name of Site / Village Thurana District Hisar State Haryana

Location in brief Well field site is located on the ground behind old Anganwadi building (abandoned)

Site belongs to Panchayat

Latitude .... Longitude ....

The above site has been jointly agreed for ground water exploration.

Executive Engineer
Division No. II
CGWB, Ambala

Scientist
CGWB

सरपंच
ग्राम पंचायत थुराना

Liaison Officer
Head of the Concerned
State (With full address)
Office Seal

Sufficient scope exists for utilization of well in the event of its being successful in terms of performance fixed by the Government of India and then successful tubewell will be taken over free of cost as per Govt. of India order MOW-13/1/99-GW-II dt. 11.11.2002.

Liaison Officer
Head of the Concerned
State (With full address)
Office Seal

Location of Observation Well

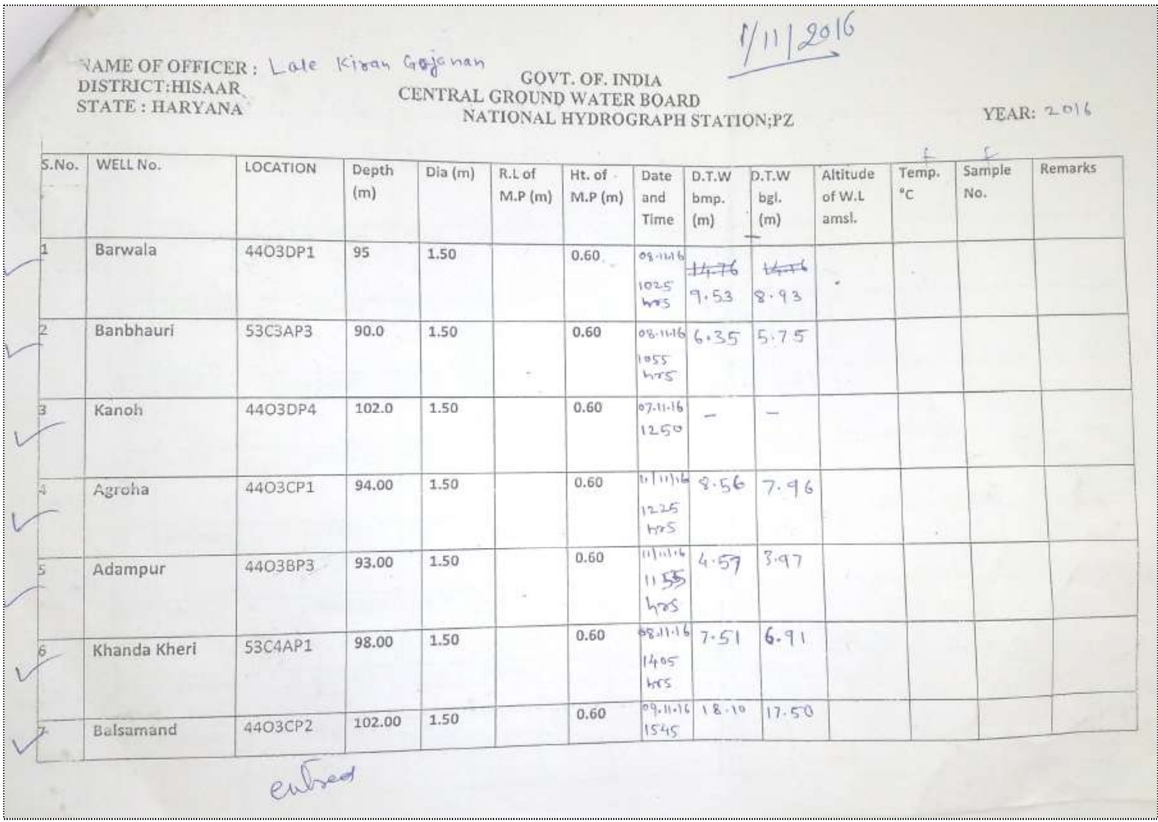
Executive Engineer
Division No. II
CGWB, Ambala

Scientist
CGWB

सरपंच
ग्राम पंचायत थुराना

Liaison Officer
Head of the Concerned
State (With full address)
Office Seal

Site Selection Proforma for Exploratory well constructed at Thurana site



NAME OF OFFICER : Lale Kiran Gajanan
DISTRICT:HISAAR
STATE : HARYANA

1/11/2016

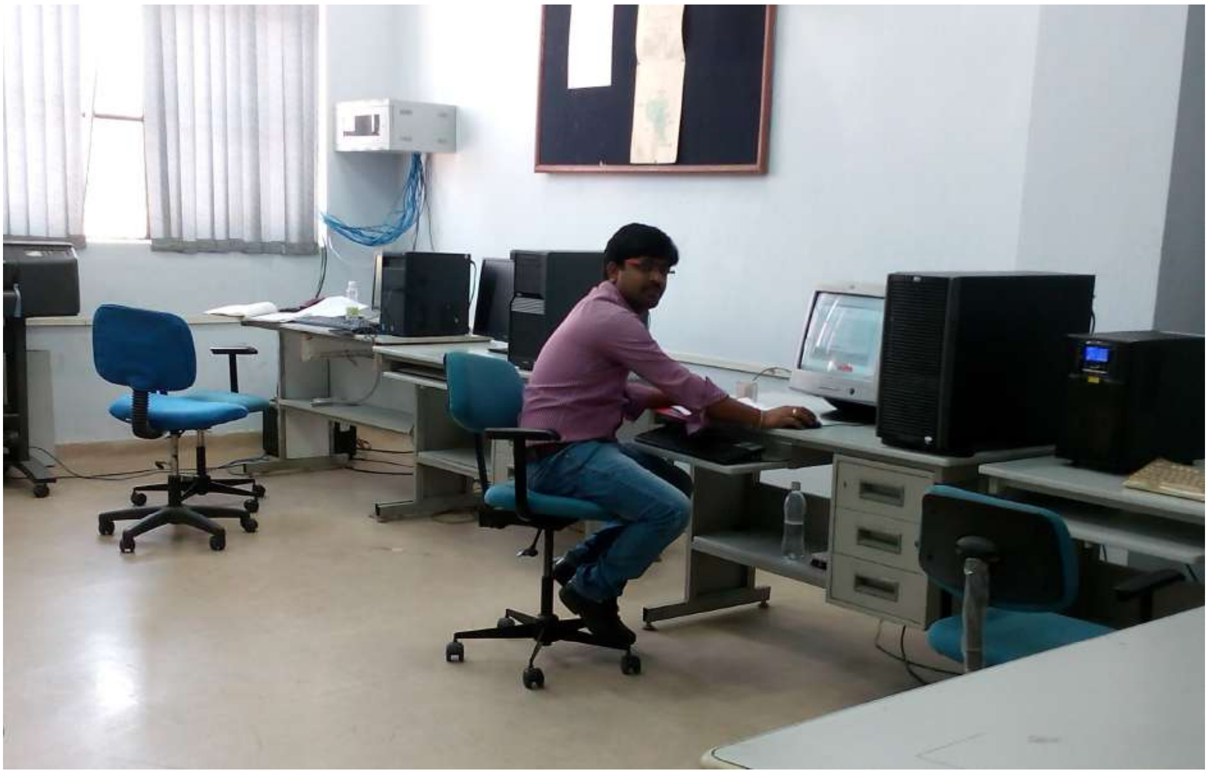
GOVT. OF. INDIA
CENTRAL GROUND WATER BOARD
NATIONAL HYDROGRAPH STATION;PZ

YEAR: 2016

S.No.	WELL No.	LOCATION	Depth (m)	Dia (m)	R.L of M.P (m)	Ht. of M.P (m)	Date and Time	D.T.W bmp. (m)	D.T.W bgl. (m)	Altitude of W.L amsl.	Temp. °C	Sample No.	Remarks
1	Barwala	44O3DP1	95	1.50		0.60	08.11.16 1025 hrs	~~14.76~~ 9.53	~~14.16~~ 8.93				
2	Banbhauri	53C3AP3	90.0	1.50		0.60	08.11.16 1055 hrs	6.35	5.75				
3	Kanoh	44O3DP4	102.0	1.50		0.60	07.11.16 1250	–	–				
4	Agroha	44O3CP1	94.00	1.50		0.60	11/11/16 1225 hrs	8.56	7.96				
5	Adampur	44O3BP3	93.00	1.50		0.60	11/11/16 1155 hrs	4.57	3.97				
6	Khanda Kheri	53C4AP1	98.00	1.50		0.60	08.11.16 1405 hrs	7.51	6.91				
7	Balsamand	44O3CP2	102.00	1.50		0.60	09.11.16 1545	18.10	17.50				

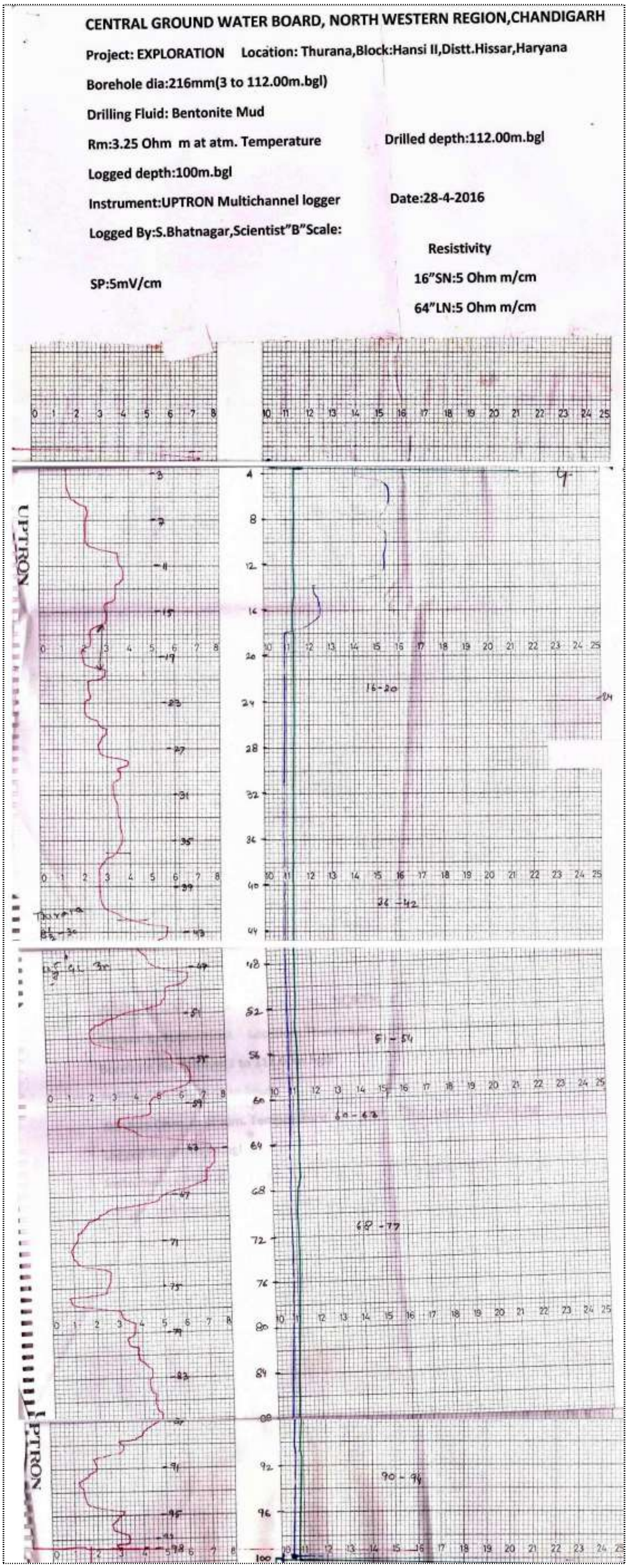
entered

Datasheet for Water Level monitoring data collection during NHS filed.



Data collection for making of NAQUIM report from CGWB-Data Centre (RODC).

2. GEOPHYSICAL DOMAIN



76 07 08
29 08 46

(1)

Dated:29.4.2016

To
Regional Director
Central Ground Water Board
North Western Region
Chandigarh

Sub: Borehole Logging Results of Exploratory/Peizometer borehole at Thurana ,Block:Hansi II , Distt. Hissar, Haryana

Sir,

The Geophysical logging (Electrical logging) of above mentioned borehole is conducted on 28-04-2016 down to depth of 100m.bgl respectively by UPTRON Multichannel logger. Drilled depth of the borehole was 112.00m.bgl. The resistivity of the drilling fluid Rm:3.25 Ohm m.

On the basis of geophysical log interpretation, following granular zones are deciphered:

Sl.No	Depth Ranges		Thickness(m)	Remarks
1.	16.00	20.00	4.00	1. Quality of ground water interpreted to be saline.
2.	36.00	42.00	6.00	
3.	51.00	54.00	3.00	
4.	68.00	77.00	9.00	
5.	90.00	94.00	4.00	

Yours faithfully

/

(S. Bhatnagar)
Junior Geophysicist

Copy to:
1. Dr. P.K.Nayak, Scientist "D" and OIC, Aquifer mapping, for information please.
2. Shri Sunil Kumar Saigal, Scientist "D" and OIC (Aq. Mapping Haryana) for Information please.
3. Site hydrogeologist for information and necessary action please.
4. File No. SB/GLR/2016-17/No.1.

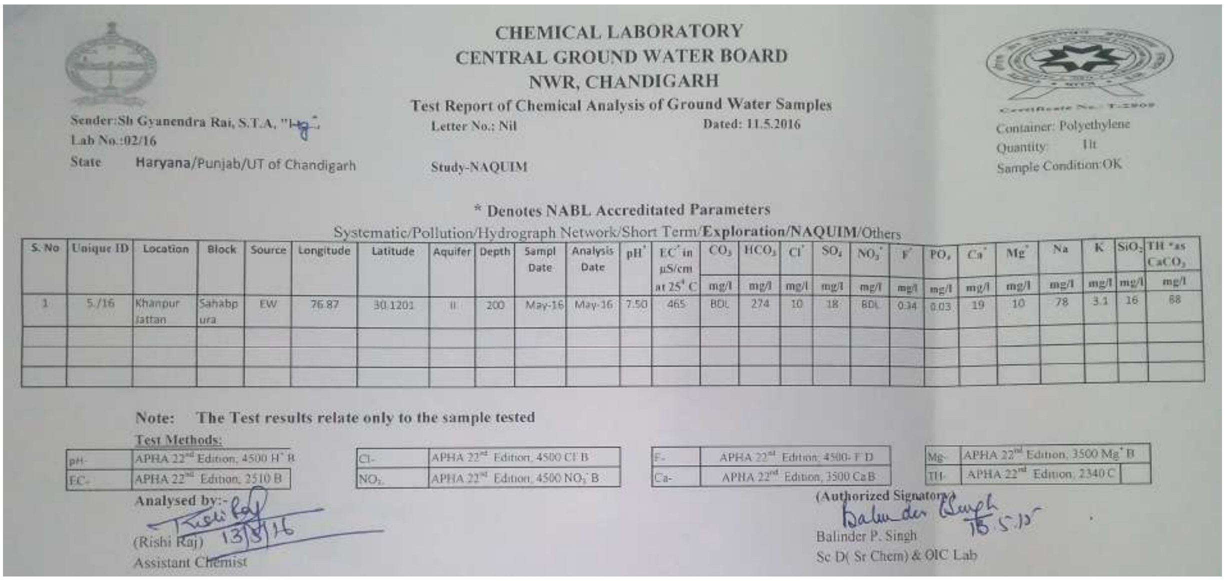
29.4.2016
(S. Bhatnagar)

1) Subsurface Geophysical log analysis of Thurana site, Hansi-II block, Hisar district constructed under NAQUIM (AAP: 2016-17) &

2. Format for distribution of subsurface geophysical results for CGWB, NWR, Chandigarh

3. CHEMICAL DOMAIN

Photograph of NABL Chemical laboratory for Groundwater Analysis at CGWB-NWR, Chandigarh.



CHEMICAL LABORATORY
CENTRAL GROUND WATER BOARD
NWR, CHANDIGARH
Test Report of Chemical Analysis of Ground Water Samples

Sender: Sh Gyanendra Rai, S.T.A, "Hg"
Lab No.: 02/16
State Haryana/Punjab/UT of Chandigarh

Letter No.: Nil
Dated: 11.5.2016
Study-NAQUIM

Container: Polyethylene
Quantity: 1lt
Sample Condition: OK

* Denotes NABL Accreditated Parameters

Systematic/Pollution/Hydrograph Network/Short Term/**Exploration/NAQUIM**/Others

S. No	Unique ID	Location	Block	Source	Longitude	Latitude	Aquifer	Depth	Sampl Date	Analysis Date	pH*	EC* in µS/cm at 25° C	CO_3	HCO_3	Cl^*	SO_4	NO_3^*	F^*	PO_4	Ca^*	Mg^*	Na	K	SiO_2	TH *as $CaCO_3$
													mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	5./16	Khanpur Jattan	Sahabpura	EW	76.87	30.1201	II	200	May-16	May-16	7.50	465	BDL	274	10	18	BDL	0.34	0.03	19	10	78	3.1	16	68

Note: The Test results relate only to the sample tested

Test Methods:

pH-	APHA 22nd Edition; 4500 H⁺ B
EC-	APHA 22nd Edition; 2510 B
Cl-	APHA 22nd Edition, 4500 Cl⁻ B
NO_3-	APHA 22nd Edition, 4500 NO_3^- B
F-	APHA 22nd Edition; 4500- F⁻ D
Ca-	APHA 22nd Edition; 3500 Ca B
Mg-	APHA 22nd Edition; 3500 Mg⁺ B
TH-	APHA 22nd Edition; 2340 C

Analysed by:-
(Rishi Raj) 13/5/16
Assistant Chemist

(Authorized Signatory)
Balinder P. Singh
Sc D(Sr Chem) & OIC Lab

Chemical Analysis results proforma for individual distribution at CGWB-NWR, Chandigarh.

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