केंद्रीय भूमि जल बोर्ड

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

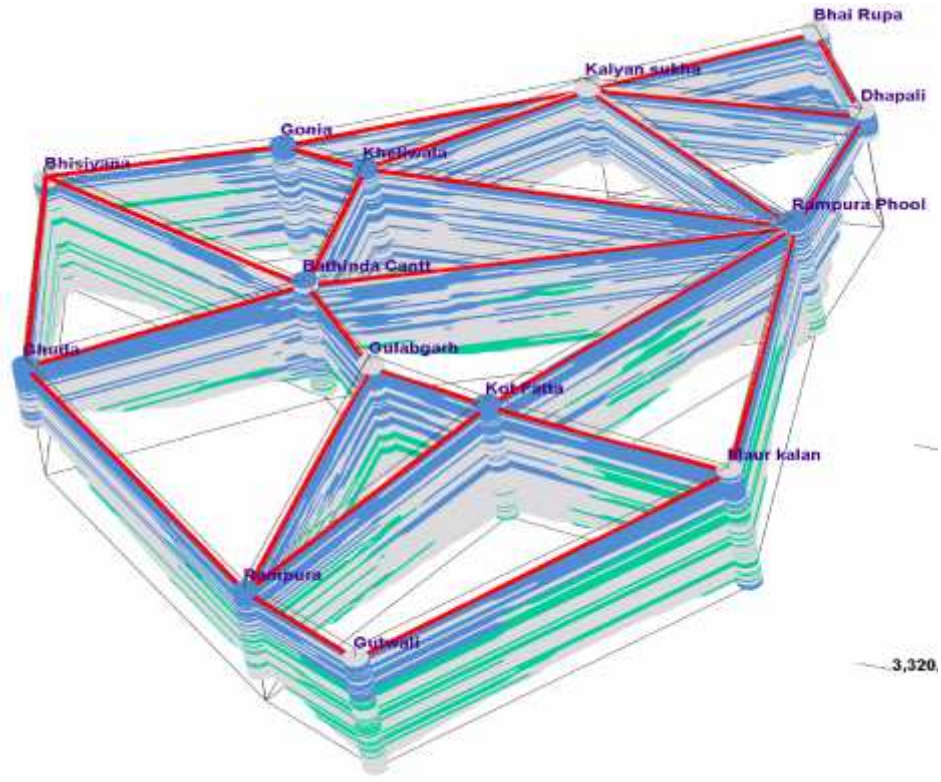
AQUIFER MAPPING AND MANAGEMENT PLAN

Bhatinda District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING & MANAGEMENT PLAN OF BATHINDA DISTRICT, PUNJAB



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2017

AQUIFER MAPPING AND MANAGEMENT PLAN
BATHINDA DISTRICT
(3547.20 Sq Km)

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Economic & statistical Organisation	Govt. of Punjab	www.esopb.gov.in

1.0 INTRODUCTION

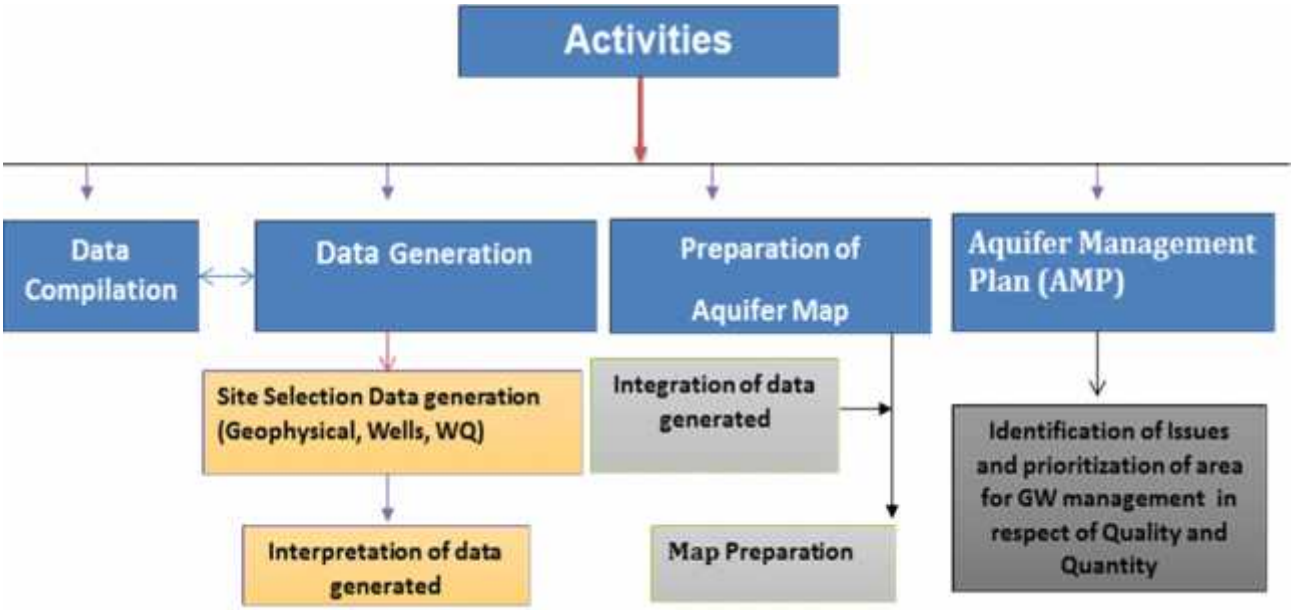
The primary objective of the Aquifer Mapping can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst 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.

1.2 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 manual attempts to evolve uniform protocols for these activities to facilitate their easy integration for the district as whole.

1.3 Approach and 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 flow chart below.



1.4 Location and Geographical Units

Bathinda district is located in the southern part of Punjab State in the heart of Malwa Region. The area lies between 29°-33' to 30°-36' North latitude and 74°-38' to 75°-46' East longitude and falls in Survey of India Toposheet nos. 44J, K, N, and O, covering a geographical area of 3547 sq km. It is surrounded by Sirsa district of Haryana state in the South, Barnala and Mansa districts in the East, Moga district in the North and Faridkot and Muktsar districts in the North-West.

The district has eight towns, namely Bathinda, Rampura, Phul, Maur, Raman, Bhuchu, Goniana, Kotfateh and Sangat. The district is sub-divided into seven development blocks namely Bathinda, Nathana, Sangat, Talwandi Sabo, Maur, Rampura, and Phul-Bhagta BhaiKa (Fig.1). The district comprises of a total of 272 villages (Inhabited 271 villages and Un-inhabited 1 village) and 307 Gram Panchayats. The headquarters of the district are located at Bathinda.

Total Population of the district, as per the 2011 Census, is 13, 88,525 out of which 7, 43,197 are males and 6,45,328 are females. The total rural population in the district is 8, 89,308 and the urban population is 4.99,217. The population density is 414 persons/ sq.km and the population growth is 17.34 %.

The area has a good network of canals for irrigation and domestic purposes. The main canals are Bathinda branch, Ghaggar branch and the Kotla branch of the Sirhind canal. The CGWB has carried out ground water exploration and hydrogeological studies in the study area.

1.5 Rainfall and climate

The climate of Bathinda district is classified as tropical, semi-arid and hot which is mainly dry except in rainy months and characterised by intensely hot summer and cold winter. The Normal Annual Rainfall is 408 mm in 20 days which is unevenly distributed over the district. Normal Monsoon Rainfall is 335 mm. The southwest monsoon sets in last week of June and withdrawn towards end of September and contributes about 82% of annual rainfall. July and August are the wettest months. The remaining of 18% of the annual rainfall occurs during non-monsoon months of the year in the form of thunder storm and western disturbances. Rainfall in the district increases from southwest to northeast.

1.6 Geomorphology and soils

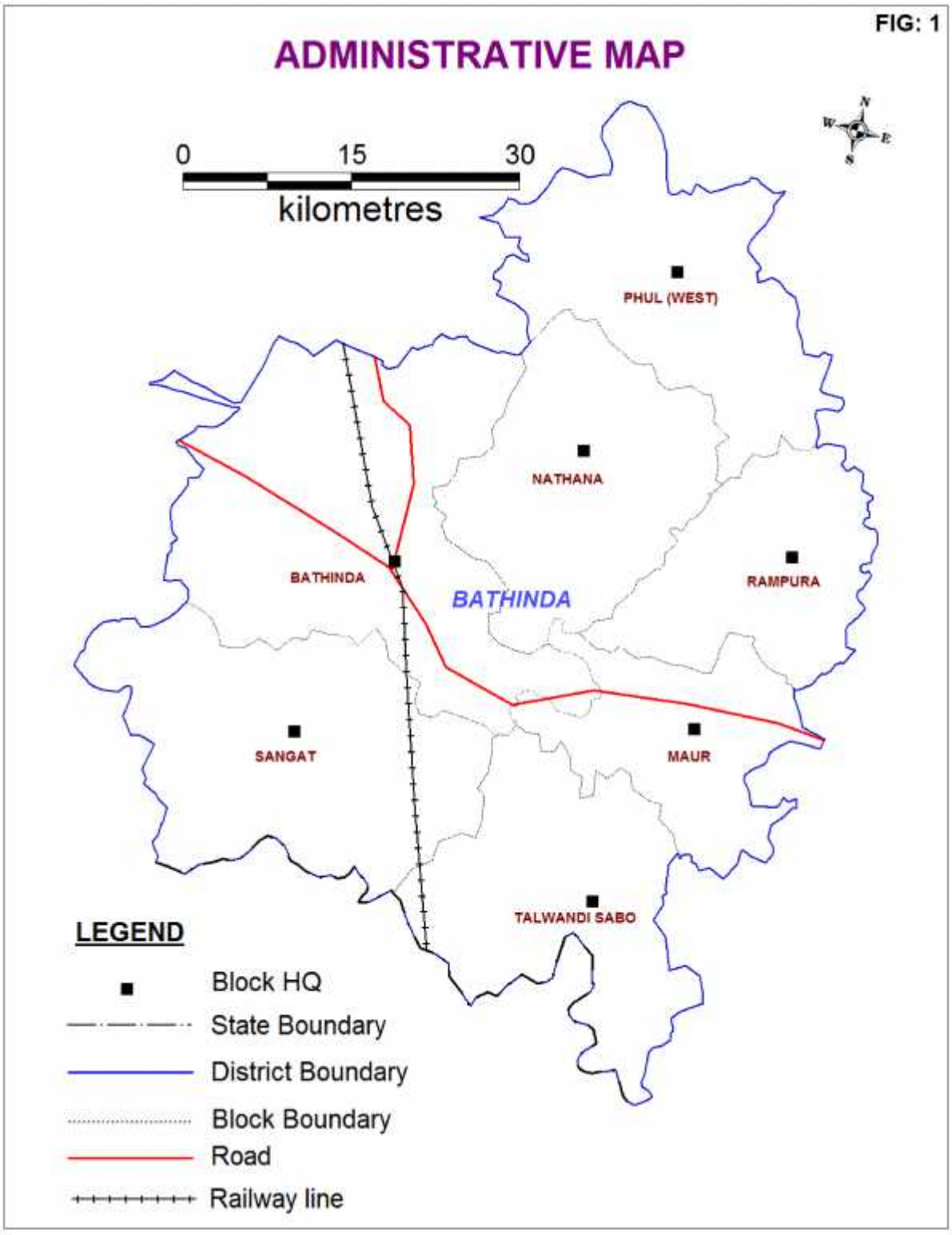
The study area forms a part of the Sutlej-Ghaggar plains and divided broadly into two major physical land forms, each having distinctive relief, lithology & slope. Expect for certain minor rolls, on the whole, it exhibits a low lying flat topography. In the absence of any significant drainage system, no major breaks in slopes are observed. The dune field and alluvial flat have (on micro and macro level) variations in relief. The relief classes are alluvial flats, sand dune and sheets.

The maximum elevation of the area is 220.6 m amsl and the minimum elevation is 197.5 m amsl. The master slope of the area is towards Southwest. The southern part contains isolated sand dunes of various dimensions.

The soil in the area is mostly sandy and has two types of soils, the arid brown soils and siezoram soils. The arid brown soils are calcareous in nature; these soils are imperfectly to moderately drain. Salinity and alkalinity are the principal problems of this soil. In siezoram soils the accumulation of calcium carbonate is in amorphous or

concretionary form (kankar). Presence of high amount of calcium carbonate and poor fertility is the main problem of this soil. The arid brown soils are found in mostly eastern parts and siezoram soils are found in the western part of the district.

Fig.1: Administrative map of Bathinda District



1.8 Land use Land cover

The main classes are Built Up land, Agricultural land, forestland, Land under non agriculture use, current fallows and water body. Out of total geographical area of 336725 hectares, an area of 280980 hectares is cultivable out of which an area of 280642 hectares is under cultivation which constitutes 83.35 %of the geographical area. The area under forest is 5862 ha. Area under agriculture crops is 251629 ha. (90%), fruit crops 4086 hectares (1.5%), vegetable crops 8814 hectare (3%) fodder crops 15046 hectares (5.5%).There is thus a need to bring more areas under forest cover and horticulture crops.

1.9 Hydrology and Drainage:

No river is flowing through the area, but there are some drains which flow during heavy rains and serve as natural drainage. The main drains are Chand Bhan Drain and Bassian out fall Drain (Fig.2). The main canals are Bathinda branch, Ghaggar branch and the Kotla branch of the Sirhind canal (Fig.3). The Bhakhra main canal runs along the southern part of the area. All the canals are unlined, except for Bhakhra main canal which is lined. These constitute the main canal network originate from the Ropar barrage on Satluj river at Ropar. The main canals in the area which feed the various distributaries and minor canals are the Bathinda branch and Kotla branch canal originated from Sirhind canal. The entire canals have south-westerly courses.

Surface water bodies exist in this area includes tanks, depressions/ponds and canals. Most of these tanks exist in and around villages are mostly used for domestic and cattle needs. On an average, these tanks are found to sustain only for a few months and most of them invariably become dry by summer. The absence of any viable permanent source for surface water in the area has led to an extensive development of canal network as compared to other district of Punjab.

1.10 Agriculture and Irrigation:

Wheat, paddy and cotton are the principal crops of the study area. The other crops grown in the area are oilseeds, gram, vegetables, etc. Main horticulture crops are viz., grapes, kinnow, ber, guava, etc. Cotton is an important kharif crop playing a key role in economic development of the district.

Canals are the main source of irrigation in the district, supplemented by the tubewells. The total irrigated area is 297,123 hectares, which constitutes 100 % of the Net sown area. The share of the canals is 217,000 hectares while 80,123 hectares is irrigated using tubewells & wells.

Nearly 83.2% of the net irrigated area of the area is exclusively irrigated by canals. Besides, due to presence of highly saline, brackish, fluoride rich subsurface water in the area, the canal water are largely exploited from domestic needs.

1.10 Industries:

Major industries in Bathinda include National Fertilizers Plant, Bathinda is home of two cement plants, Ambuja Cements and UltraTech Cement Limited. Two power plants (Guru Nanak Dev Thermal Plant and Guru Hargobind Thermal Plant) (Lehra Mohabbat), Petrochemical Plants, Yarn & Textiles Plants, Citrus Fruit Belts and Sugar Mills. HMEL is building a Grassroots oil refinery.

1.11 Water Conservation and Artificial recharge:

The Northern part of the area where water level decline exists, artificial recharge structures may help in arresting this water level decline. Generally Recharge Trench with injection well structure is the suitable for artificial recharge. 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 decline in the area.

Fig.2: Drainage and Water Bodies of Bathinda District

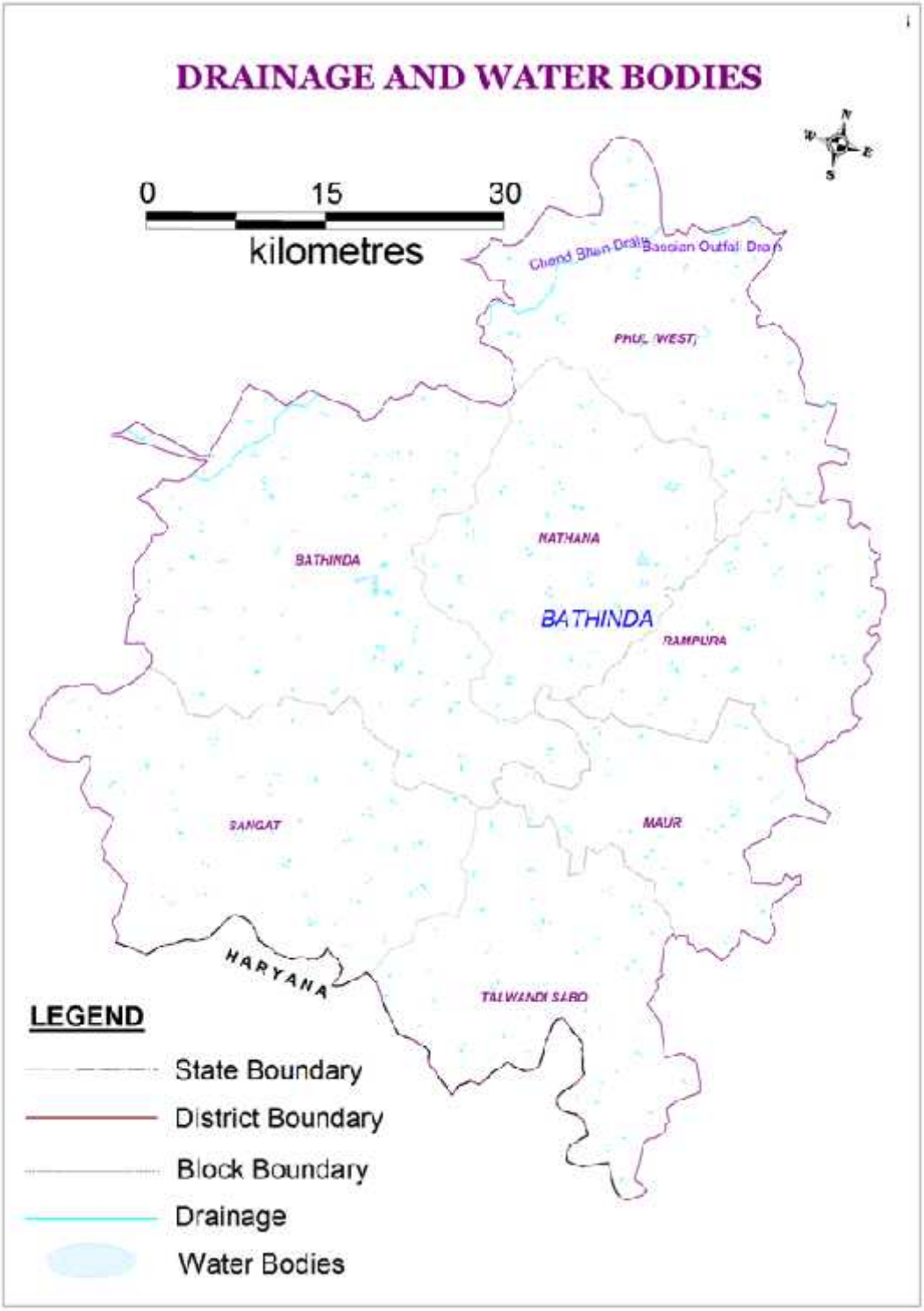
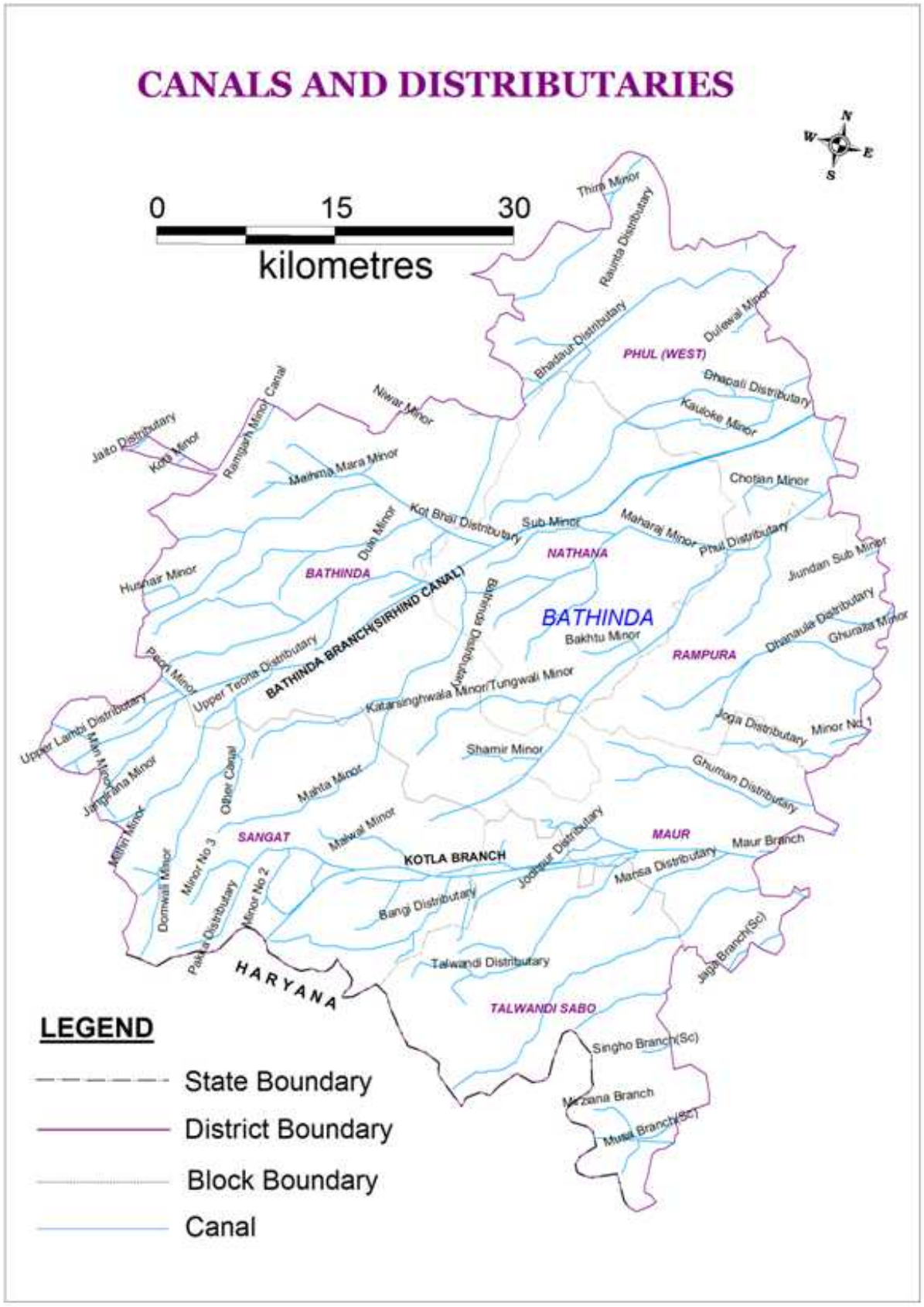


Fig.3: Canals and Distributaries of Bathinda District



2.0 DATA COLLECTION AND GENERATION

2.1 Geology and Hydrogeological data:

The area lies in the central part of Satluj basin of Indo-Gangetic Alluvial plain. Geologically, the area is occupied by a thick sequence of Quaternary deposits of Mid-Pleistocene to Recent age. These comprise alternate sequence of fluvial and arid phases (Singh, 1993).

The exposed Quaternary Sediments can be broadly classifies as- (i) Older Alluvium of Middle to Upper Pleistocene age overlain by (ii) Aeolian deposits of Holocene age. Alluvium comprises unconsolidated sand of various grades, silt, clay, Kankar and their intermixture in various proportions. The alluvium is overlain by windblown/sand in various places the wind-blown sand is composed mainly of fine grained quartz-sand with admixture of muscovite.

In this area, water-bearing formations mainly include fine to medium grained sand Kankar with admixture of little clay. The Ground water occurs in unconfined (water table) and confined conditions. The maximum thickness of alluvium encountered is 545 m at Kheliwala exploratory borehole site. The effective thickness of granular beds is more in the northern and north eastern parts than other parts of the area. The Principle Aquifer in the study area is Alluvium and the Major Aquifers are Older Alluvium and Aeolian Alluvium (Fig.4).

2.1.1 Water Level Behaviour

Thirty one monitoring stations of Central Ground Water Board (CGWB) (9 Piezometers and 22 Dugwells) and *Forty five* monitoring stations (45 Piezometers) of State government departments represent first aquifer. Second and third aquifer is represented by one monitoring station of CGWB. Depth to water level in the area ranges from 3.43 to 20.39 m bgl during pre-monsoon period (Fig.5) and 2.24 to 20.76 m bgl during post monsoon period (Fig.6). In the eastern part of the district water levels are > 20 m.bgl, in the central part water levels are in the range of 10 to 20 m bgl and in western part the water levels are shallower in the range of 5 to 10 m. Seasonal water level fluctuation shows a rise and fall in the range from 2.5 to (–) 0.03 meters during the year 2015.

Hydrograph of Different Observation Wells

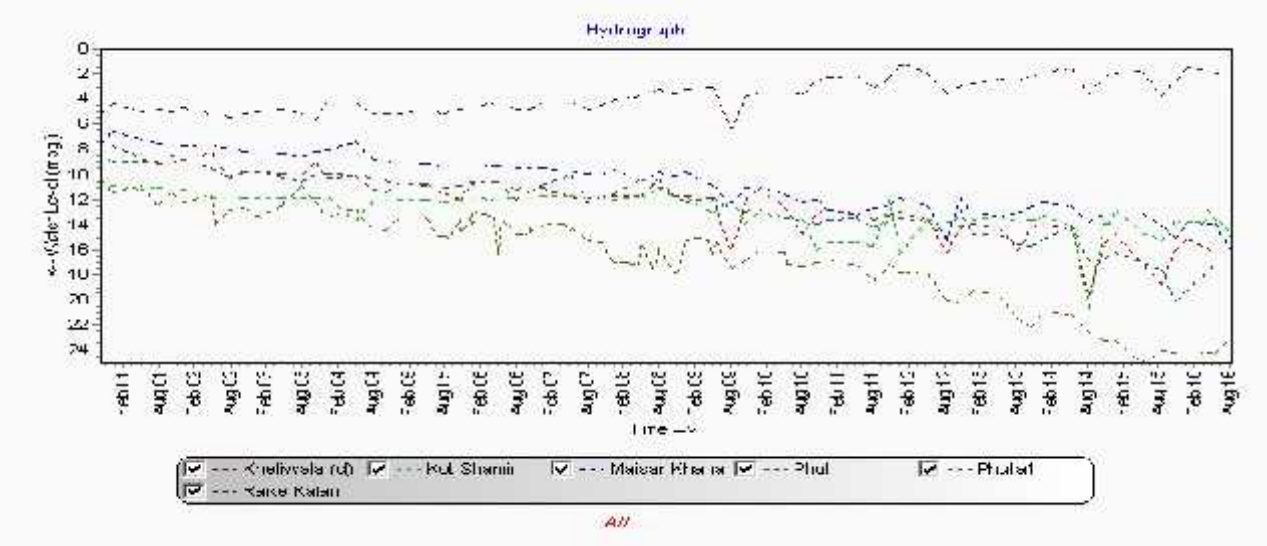


Fig.4: Major Aquifers

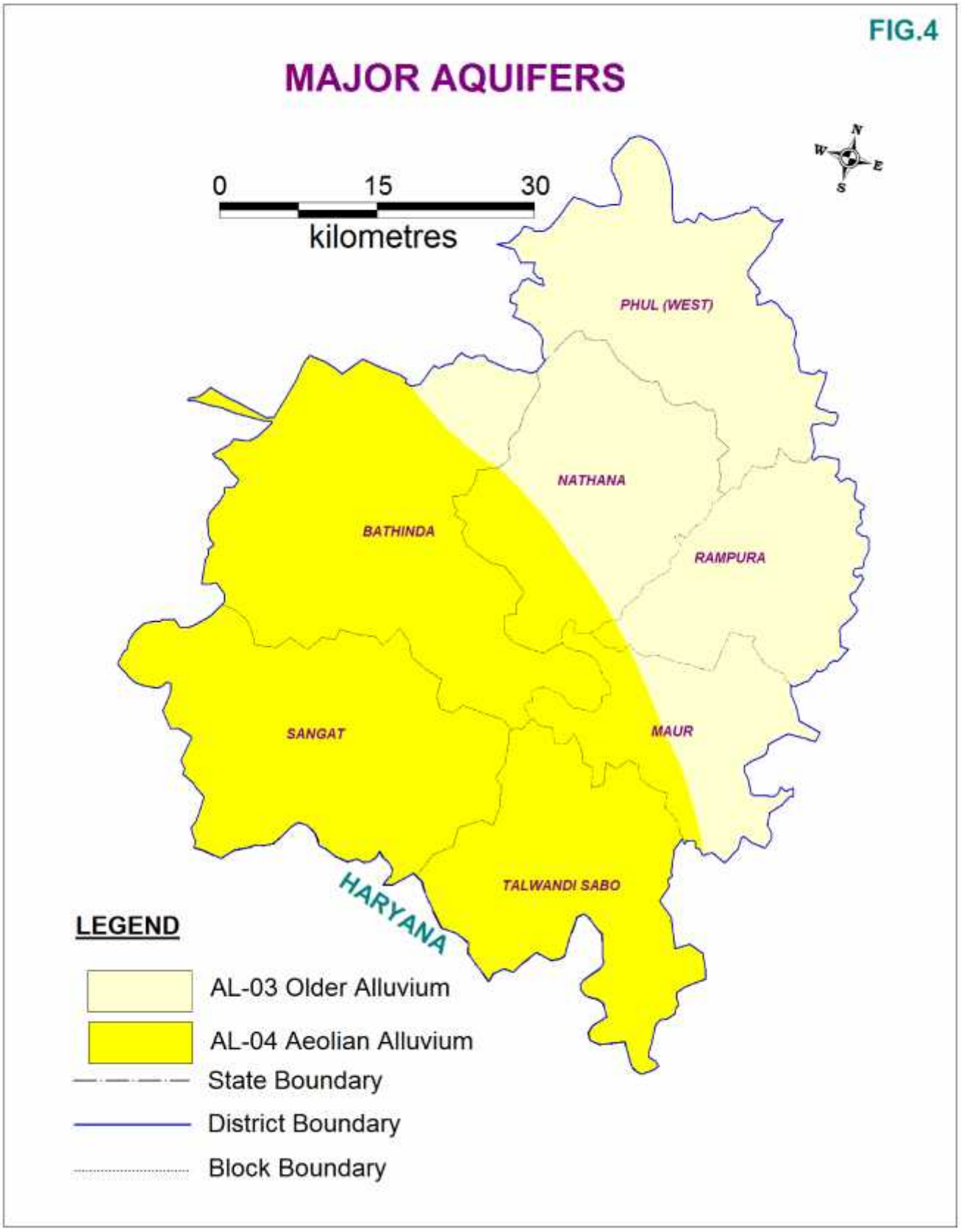


Fig.5: Depth to Water level Pre Monsoon, 2015

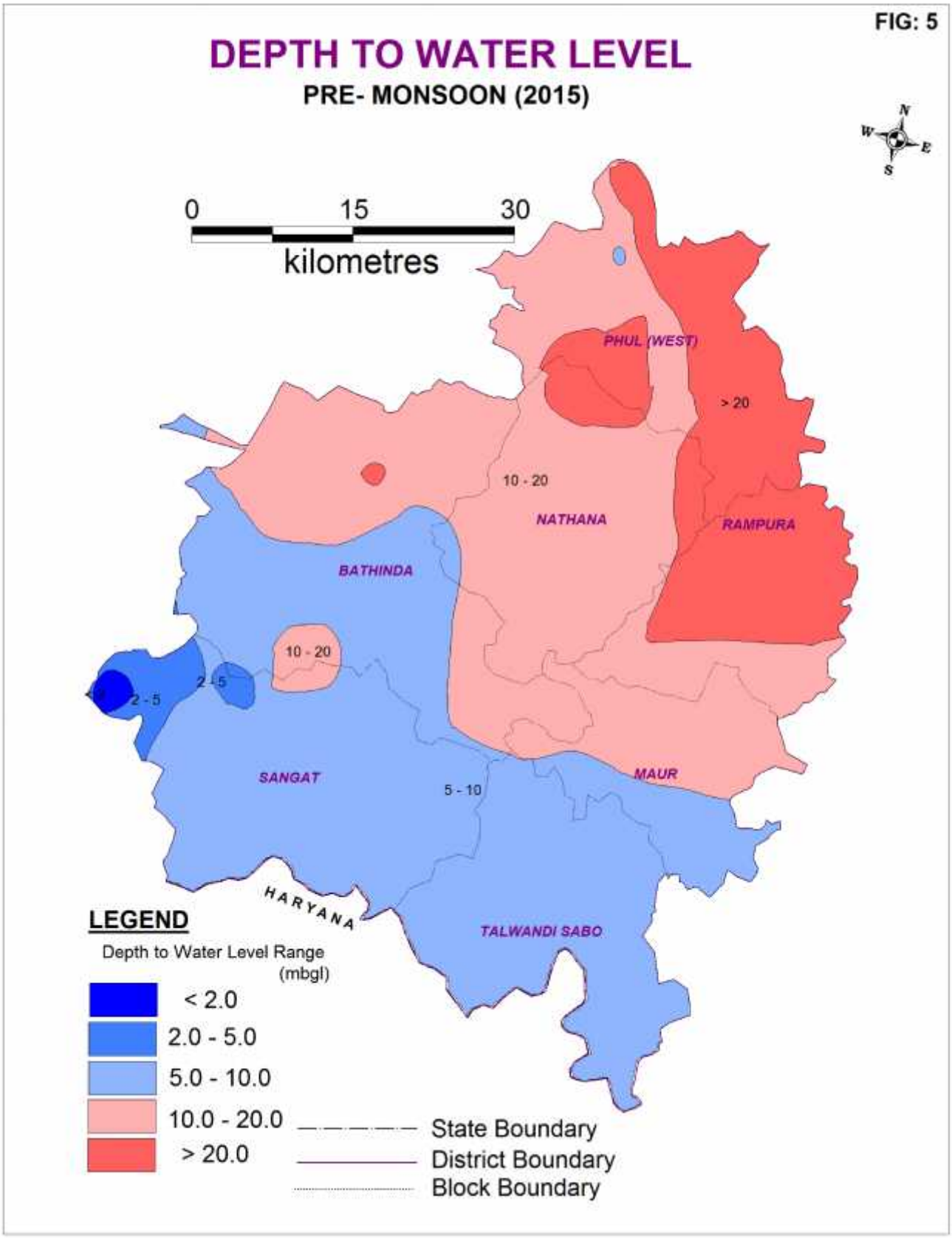
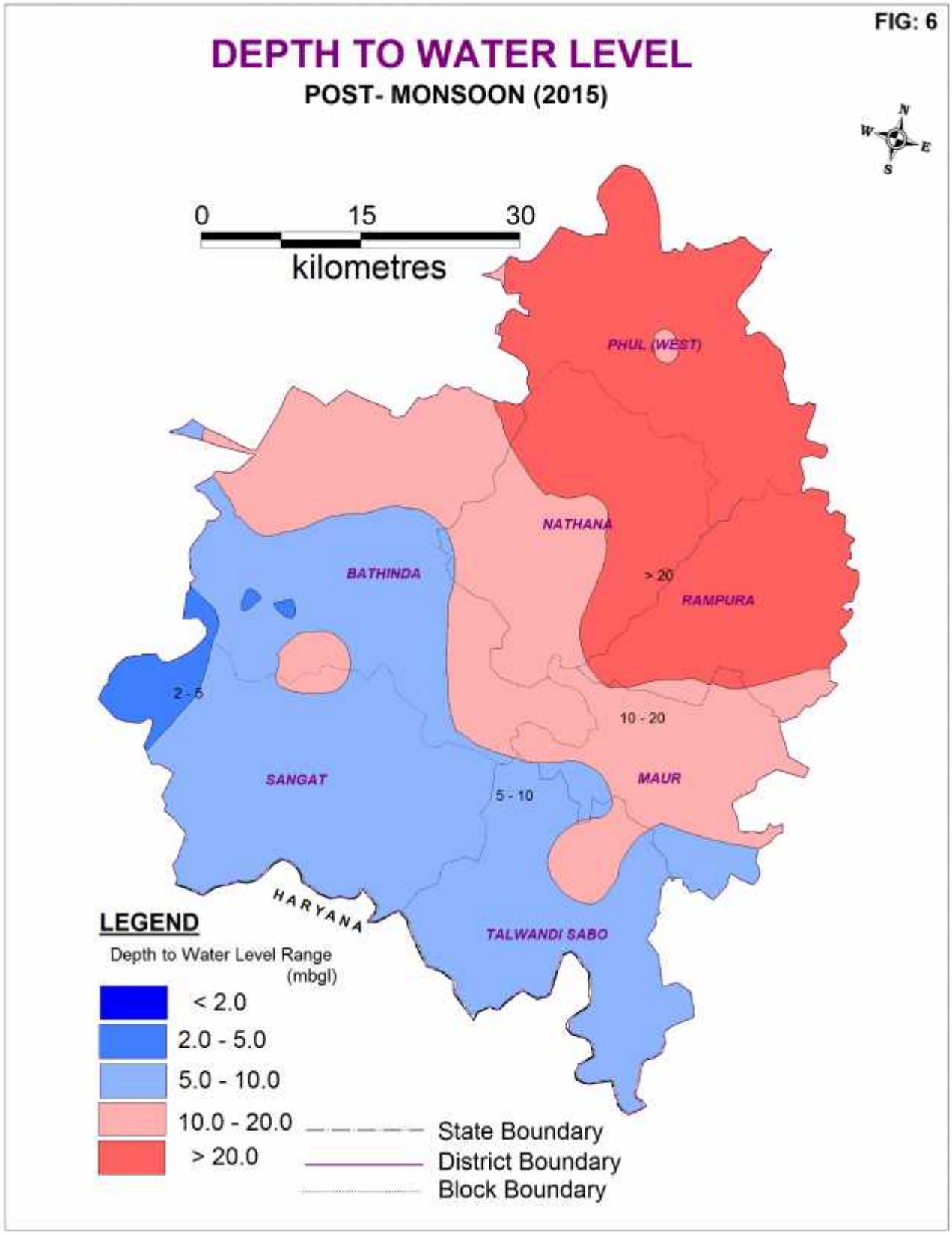


Fig.6: Depth to Water level Post Monsoon, 2015



2.2 Water Quality Data:

Ground water quality of shallow aquifer (Aquifer-I) is assessed on the basis of chemical data of National Hydrograph Network stations i.e. NHNS monitored during Pre monsoon period. Twenty six groundwater samples are collected and analyzed during NHNS, 2015, given in Annexure-I. The chemical quality of deeper aquifers has to be assessed during ongoing groundwater exploration programme under NAQUIM.

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline and fresh to moderately saline. The Electrical Conductivity (EC) values ranges from 300 to 4880 µS/cm at 25^{o}C. The EC values less than 1000 µS/cm have observed at eight locations i.e. Dhapali, Ganga, Khialiwala, Dera tappa, Sangat Kalan, Bhagi Bandar, Ablu and Raike Kalan , where the EC value is 300, 305, 320, 375, 635, 690, 875 and 935 µS/cm at 25^{o}C respectively. The EC values more than 3000 µS/cm have observed at three locations i.e; Gurusar (4880), Gulabgarh (3950) and Kotha Guru (3100). The chloride concentration in ground water varies broadly between 7mg/l at three locations i.e. Khialiwala, Deratappa and Ganga and 386 mg/l at Gurusar. Ground water with fluoride above 1.5 mg/L are found mainly in Gurusar (4.50), Gulabgarh (2.16) and Kotha Guru (1.59) and Nitrate concentration in groundwater above permissible limit 1.5 mg/l are found in sixteen locations i.e. Jajjal (314), Jhanduke (220), Gurusar (183), Ghudda(138), Kot Shamir (129), Jassi Bhag wali (127), Balluana (125), Kala Bhander (124), Phulla (94) ,Kotha Guru (84), Rampura Phul (80), Maiser khana (77), Gulabgarh (64), Nahianwala (61), Phul (52) and Raike kalan(48). Iron concentration above permissible limit (1.5 mg/L) are observed in Ghudda(4.5), Ganga(2.99), Kot Shamir(1.65) and Maiser khana (1.64) . Type of water is Na-HCO_3 type and Mixed cation-HCO_3 type. Groundwater quality map is shown in Fig.7.

Salinity, chloride, fluoride and nitrate are the important parameters that are normally considered for evaluating the suitability of ground water for drinking uses. Based on recommendations made for these parameters by Bureau of Indian Standard (BIS,2012). It is found that ground water at quite a few places is not suitable for drinking uses because of either EC/Cl/F/NO3 or all of them. It is observed that unsuitable quality of ground water occurs in areas ground water is of suitable quality for drinking uses.

The USSL diagrams used for classification of irrigation water based on EC and SAR, observed that ground water occurring in southern and south western parts comprising of Bathinda district falls under C_3S_2, C_3S_3, C_4S_1, C_4S_2, C_4S_3 and C_4S_4 classes of irrigation classification. Such waters when used continuously for irrigation, they are likely to cause salinity hazards and lead to reduction in crop yields. Plot of USSL diagram indicates that ground waters fall under $C2S_1$ and $C3S_1$ classes of irrigation rating. Such waters are suitable for irrigating semi-salt tolerant crops on soils having adequate permeability.

Alkali hazards of irrigation ground waters are estimated through the computation of Residual Sodium Carbonate (RSC), also known as Eaton's Index. Classification based on RSC indicates that 14% of the waters are unsafe for irrigational use. 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. RSC of ground waters are found to vary from below zero (-10.08) to 21.88 meq/l. However, exceptionally high RSC values, 21.88, are also encountered at Khialiwala. The irrigation rating of well waters of the study area is given below.

Irrigation Rating of Well Waters of Bathinda District
(Based on Eaton's index and USSL Classification)

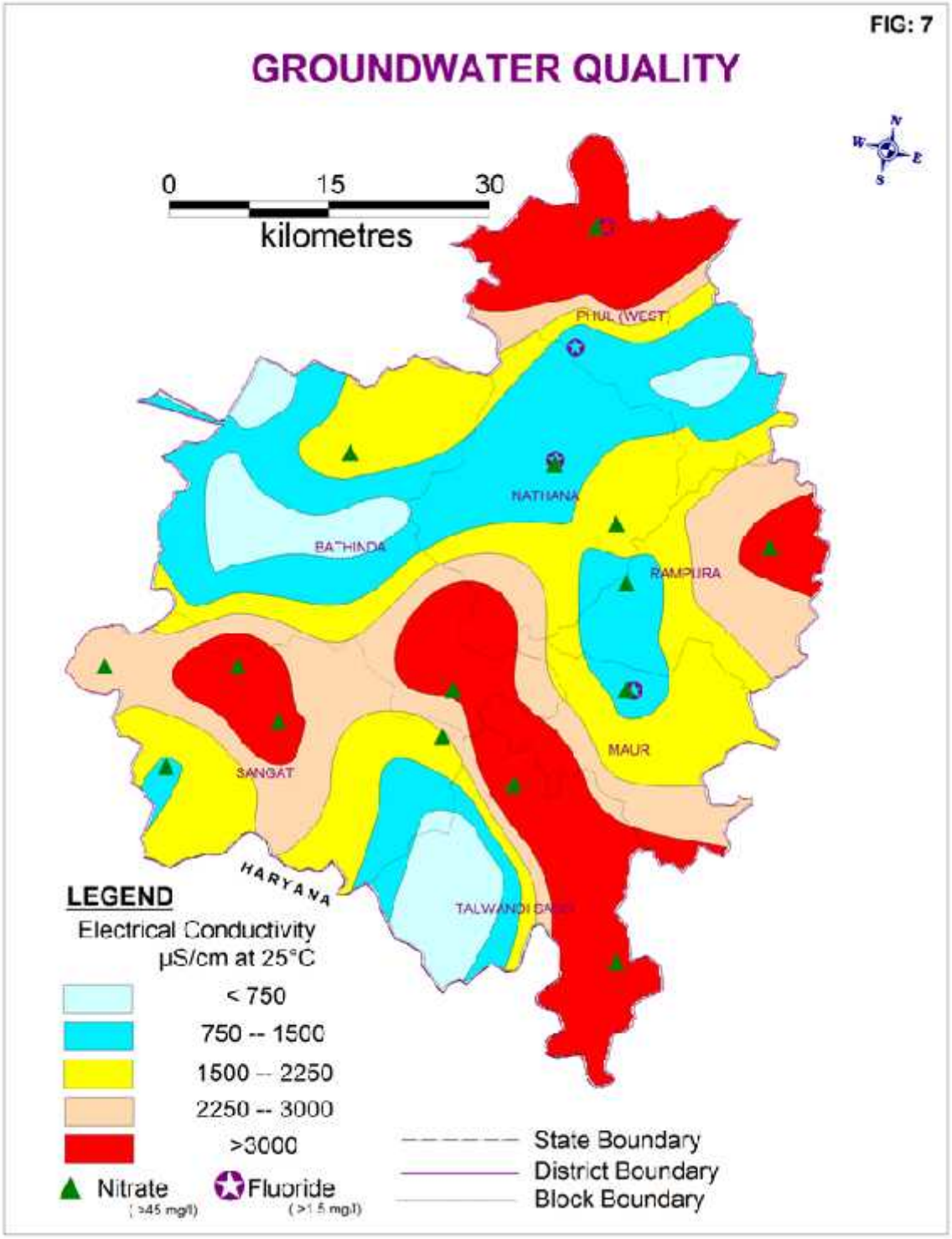
District	IRRIGATION SUITABILITY			
	EATON's INDEX (RSC in meq/L)			USSL Classification
	Safe <1.25	Marginal 1.25-2.5	Unsafe >2.5	
BHATHINDA	16	0	10	C1S1, C2S1, C3S1, C4S1, C3S2, C4S2 C4S4 C2S3, C3S3

Analysing mechanism and equipments used for chemical analysis are given in the below table-1.

Table-1: Analytical methods and equipments used for chemical analysis.

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

Fig.7: Groundwater Quality, 2015



2.3 Geophysical data:

To delineate fresh water - saline water interface laterally as well as vertically, surface geophysical investigations have been carried out in alluvial tracts over parts of the study area. Under surface geophysical investigations, total 40 VES in an area of 1800 sq km were conducted with current electrical separation of 600 to 1000 m.

2.4 Exploratory drilling State - Data Availability:

Exploratory drilling was conducted by CGWB at 13 locations in the district. The borehole at Bhatinda 447m deep was abandoned due to poor quality of formation water. The exploratory wells at Khaliwale and Gulabgarh were tested at discharge of 1006 and 1500 lpm. The transmissivity values were low in the order of 71 and 1300 m^2/day respectively in the district. The hydraulic conductivity value varies from 1.6 to 19.17m/day. The value of storage coefficient was computed as 2.8 x 10^{-2}.

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB, Punjab State Tubewell Corporation (PSTC) now as Punjab Water Resources Development and Management (PWRDM) , WRED (Water Resources and Environment Directorate), Water Supply and Sanitation (WSS) and Private Wells have been collected and those supported electrical logs have been validated for aquifer map preparation. The details are shown in Table-1.

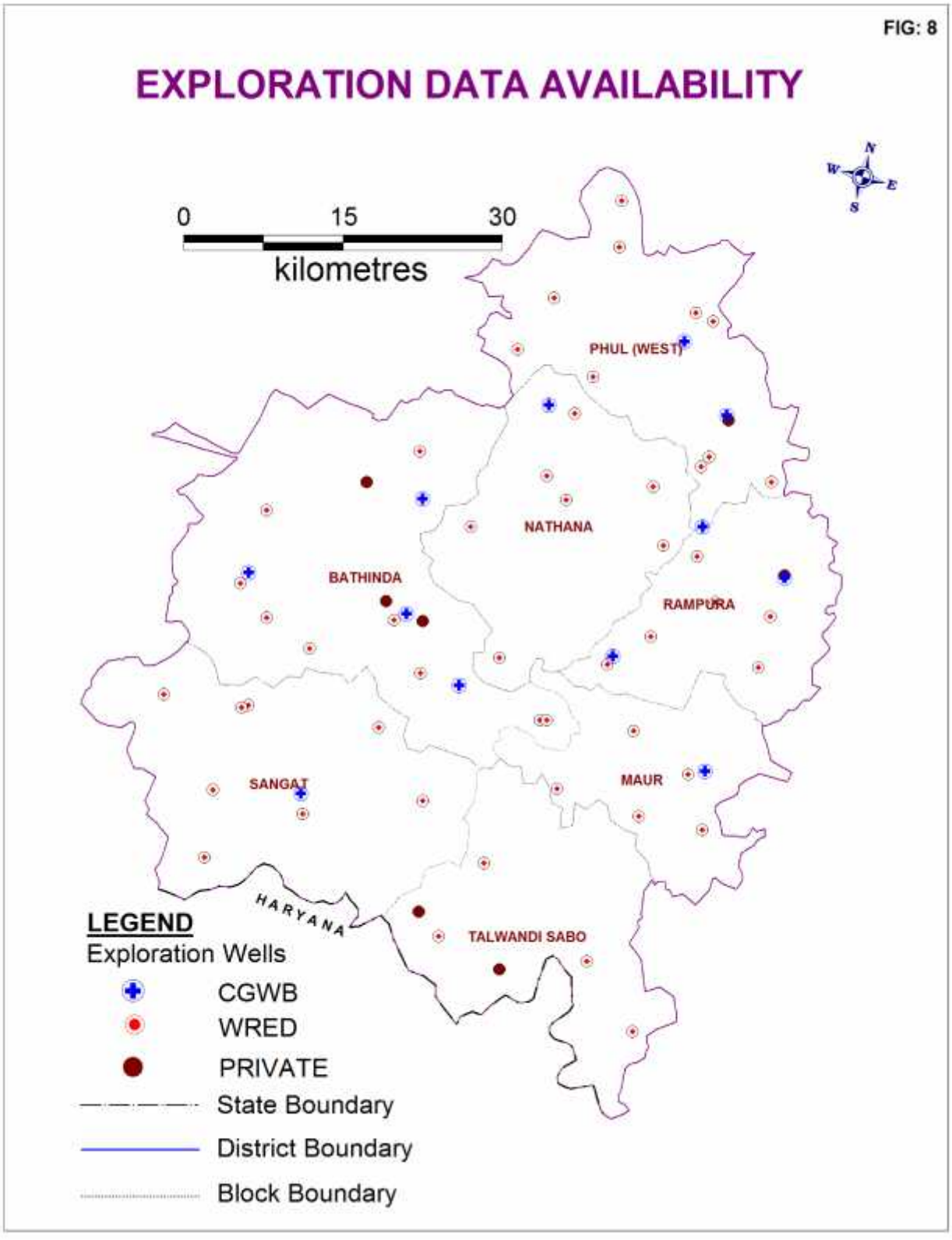
Table-2: Data Availability of Exploration Wells of Bathinda district

Sl.No	Source of data	Depth Range (m)				Total
		< 100	100-200	200-300	>300	
1	CGWB	7	0	3	6	16
2	WRED/PSTC/WSS	51	3	0	1	55
3	PRIVATE WELLS	2	2	2	2	8
Total		**60**	**5**	**5**	**9**	**79**

2.5 Spatial Data Distribution

The actual data of all the wells in the area are plotted on the map of 1:50000 scale with 5'X5'grid (9 x 9) km (Fig. 8). Perusal of table shows that majority of tube wells falls in the Aquifer-I and the depth more than 300m. The grids/ formations devoid of groundwater exploration are identified as data gaps and these are to be filled by data generation. The locations of availability of exploration data of respective blocks are shown in Annexure-II.

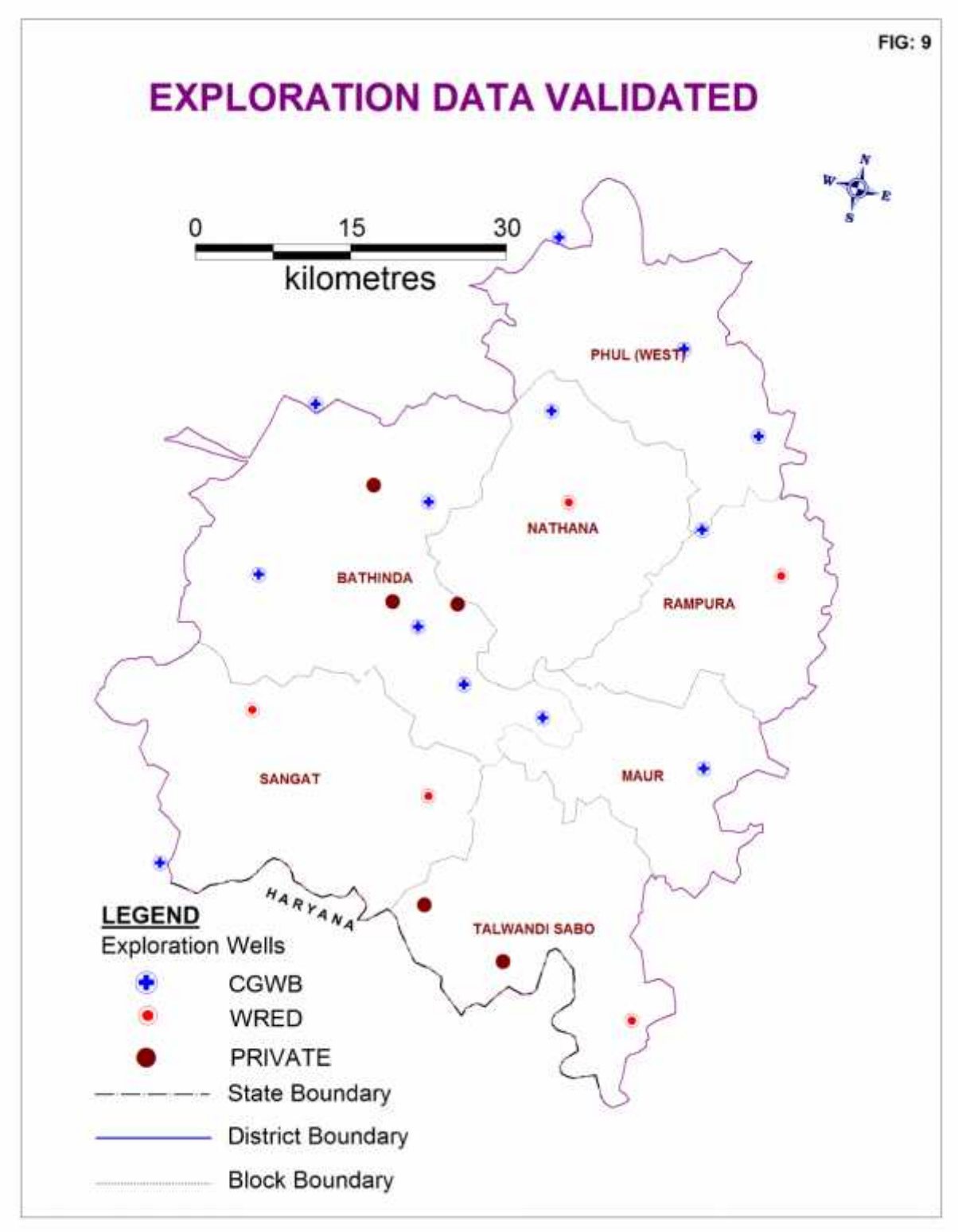
Fig.8: Locations of Exploration Data Availability



3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

All the available data have been validated to generate aquifer map. The deepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9) km (Fig.9).

Fig.9: Locations of validated exploration data



The optimized wells of CGWB, PSTC now as PWRDM, WRED, WSS and Private Wells have been used to prepare the elevation or collar elevation map to identify the topographic variations on ground surface so that it can give the synoptic picture of gradient variations in the water levels. The topographic elevation values have been plotted to prepare the elevation contour map (Fig.10).. Three exploratory wells from adjacent districts i.e: Killian wali and Kot Bhai from Muktsar district and Dal Singhwala from Faridkot district have been incorporated for the preparation of lithological fence and cross sections. The locations of validated wells in quadrant and toposheet wise distributions in respective blocks are given in Table-3. Locations of validated exploratory wells with litholog are shown in Fig.11.

Fig.10: Elevation contour map

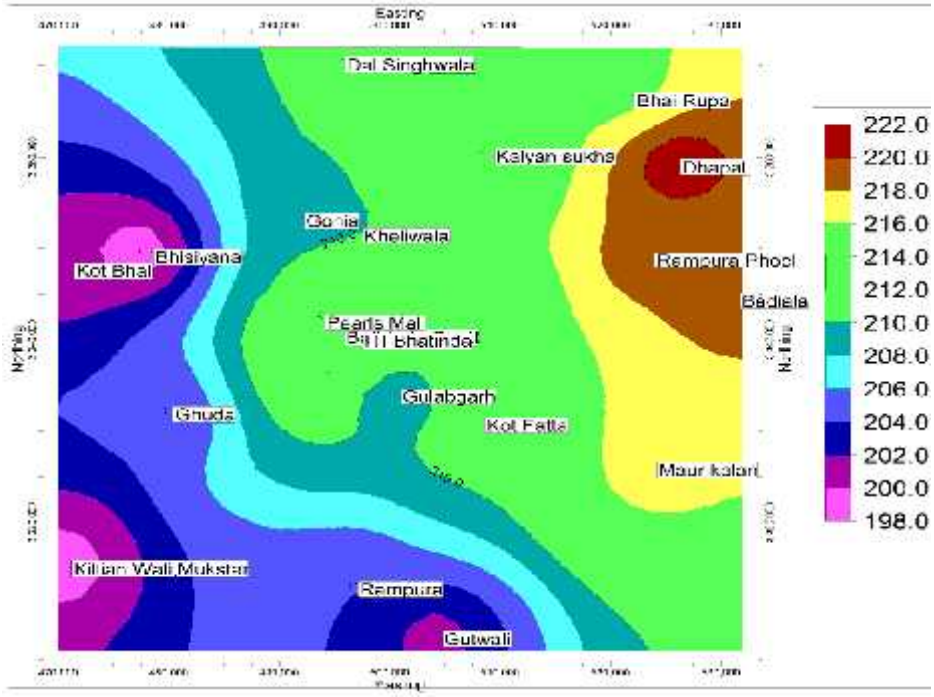


Fig.11: Locations of validated exploratory wells with Litholog

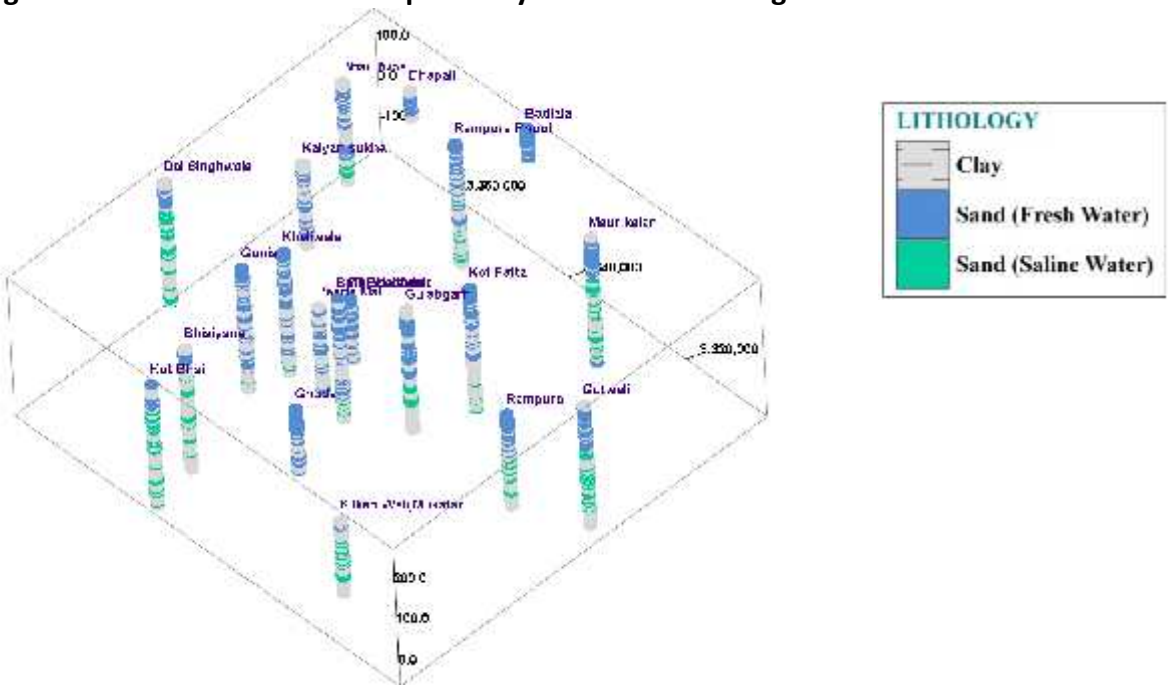


Table -3: Summary of optimized exploration wells

Validated Exploratory wells												
Sl. No	**Block**	**Toposheet/ Quadrant**	**Depth Range (m)**								**Elevation (m amsl)**	**Source of data**
			Location	**< 100**	**Location**	**100-200**	**Location**	**200-300**	**Location**	**>300**		
1	Rampura	1A 44N/8	Badiala	63.14							219	PRIVATE
2	Phul	1C 44N/3					BhaiRupa	250			215	CGWB
3	Sangat	2A 44J/16			Ghuda	156					204	PRIVATE
4	Phul	2A 44N/7	Dhapali	70.12							222	PRIVATE
5	Talwandi Sabo	2A 44O/1							Gutwali	300	201	PRIVATE
6	Bathinda	1A 44N/4			ITI Bhatinda	155					212	PRIVATE
7	Bathinda	2C 44N/4							Kot Fatta	300	211	CGWB
8	Maur	3C 44N/4							Maurkalan	300	218	CGWB
9	Talwandi Sabo	1C 44K/13					Rampura	227.1			204	PRIVATE
10	Bathinda	2B 44J/16					Pearls Mall	213			207	PRIVATE
11	Bathinda	3B 44J/15							Gonia	300	209	PRIVATE
12	Rampura	3B 44N/3							RampuraPhul	300	219	CGWB
13	Bathinda	3C 44N/3							Kheliwala	300	210	CGWB
14	Bathinda	2A 44N/4					Gulabgarh	297.9			207	CGWB
15	Bathinda	1C 44J/16							Bathinda Cantt	300	225	CGWB
16	Nathana	2B 44N/4					Kalyan sukha	205			212	CGWB
17	Talwandi Sabo	2A 44O/1	Nathea	60								WRED
18	Nathana	3B 44N/4	Nathana	60								WRED
19	Sangat	3C 44J/16	Kot Bhagtu	60								WRED
20	Bathinda	1A 44J/16							Brishiyana	300		WRED
21	*Faridkot*	2B 44J/15							Dal Singhwala	300	211	CGWB
22	*Muktsar*	1C 44J/11							KotBhai	300	200	CGWB
23	*Muktsar*	3C 44J/12			Killian Wali	182.92					199	PRIVATE

3.1 Sub Surface Disposition

3.1.1 Previous Work:

The area represents almost flat alluvial plain with sand dunes with maximum height of 5.5 m above general land surface. Ground water at shallow depth occurs under unconfined to semi confined and confined conditions in deeper aquifers.

Exploratory drilling was conducted by CGWB at 7 locations in the district includes 06 exploratory wells and 01 Piezometer from 1962 to 2015 through in-house activities and 6 piezometers through outsourced by M/s WAPCOS Ltd. from 2011 to 2012 (Fig.8); to delineate and determine the potential aquifer zones, evaluation of aquifer characteristics etc. The drilling has been carried out to a maximum depth of about 545 m (Kheliwala) and revealed the presence of 22 prominent permeable granular zones with aggregate thickness of 151 m. The granular zone consists of fine to medium sand. Delhi Quartzite is encountered at depth 533mbgl.

Further, the study of exploratory boreholes drilled in the district revealed the presence of multiple aquifer groups up to the maximum drilled depth of 545 m. The first aquifer group forms very shallow water table aquifer (IA) and occurs down to 71 m bgl. Below that clay layer starts getting thickened to about 8-10m separating Aquifer IB down to 139 m bgl. The second and third aquifer behaves as semi-confined to confined and consisting of thin sand layers alternating with thicker clay layers. Overall flow of ground water is towards south-west direction. The borehole at Bhatinda 447m deep was abandoned due to poor quality of formation water.

3.1.2 Present NAQUIM Study:

To understand the sub surface disposition in the study area, geological sections and fence diagram have been prepared by synthesizing the various sub-surface sections on the basis of study of the lithological logs and electrical logs of boreholes drilled by CGWB, WRED, WSS and Private Agencies using the RockWorks15 software and a 3D lithological model has been prepared (Fig.12). The 2D lithology sections and 3D lithological fence diagram has been prepared using lithology model and are shown in Fig.13a, b & 14 respectively. The aquifers are composed of fine to medium sand with clay intercalations. The granular zones are extensive. The aquifer occurring below 200m depth are composed of very fine to medium sand with silt.

Based on geophysical borehole logging and use of resistivity profiling followed by the depth soundings at few selected places, fresh-saline water zones are demarcated. This analysis is extremely important for the present study and will be referred from time to time as it is obviously the higher resistivity beds represents freshwater zone in contrast in low resistive beds indicating saline groundwater zone.

The top surface layer is mainly silty clay. The lithology along central part of the area i.e.m Kot Fatta to Dal singhwala shows the variation in lithological thickness i.e. thin clay layers inter bedded with sand except at Kot Fatta where thick clay layers were identified at 75mbgl. There is inter-layering of sand and clay with thick clay at Bathinda Cant and Dal Singhwala towards Eastern side at a depth between 100m to 175m bgl. The cross-section along NE-SW and shows thick pervious sand upto 50m depth and decreases towards the southwestern part, thin clay layers interbedded with sand and can be seen clearly at Kheliwala upto depth of 300m bgl. The interface is clearly demarcated to a depth of 254m at Kheliwala. Lithological data of wells are given in Annexure-III.

Fig.12: 3-Dimension Lithological Model

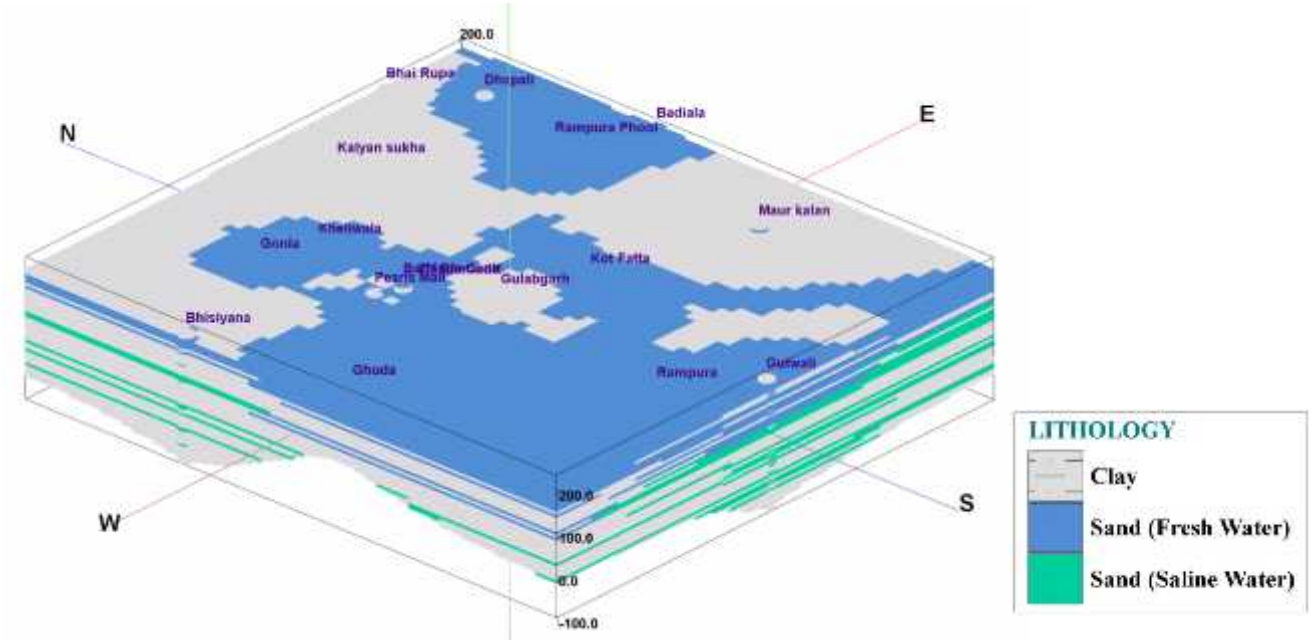


Fig.13a: 2D Lithological section along central part of Bathinda

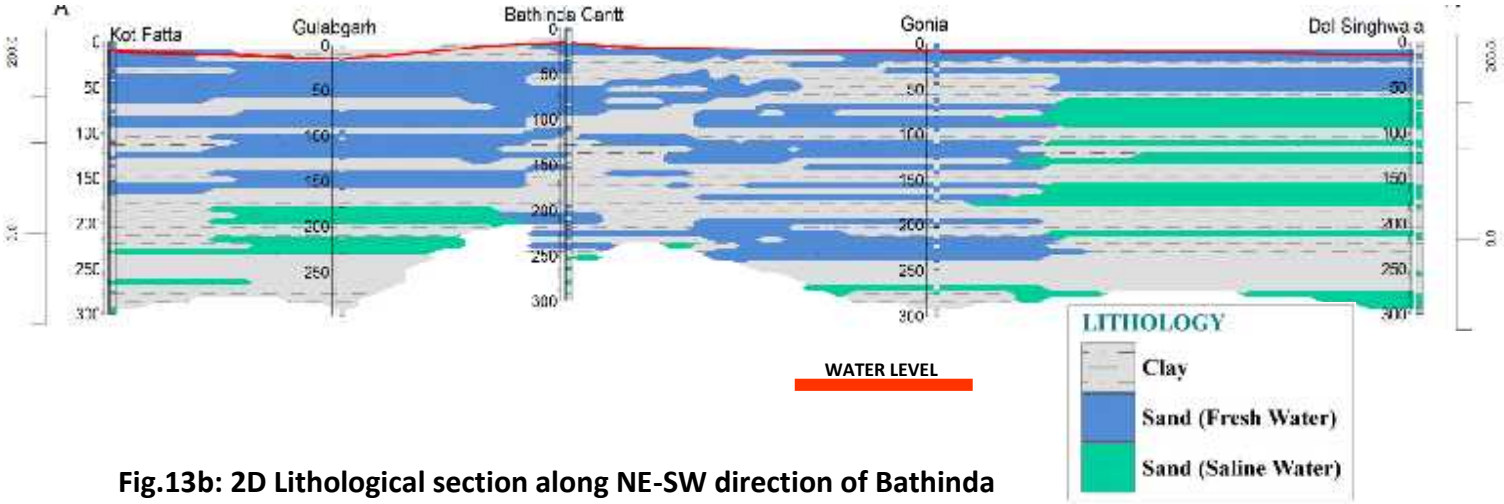


Fig.13b: 2D Lithological section along NE-SW direction of Bathinda

NE **SW**

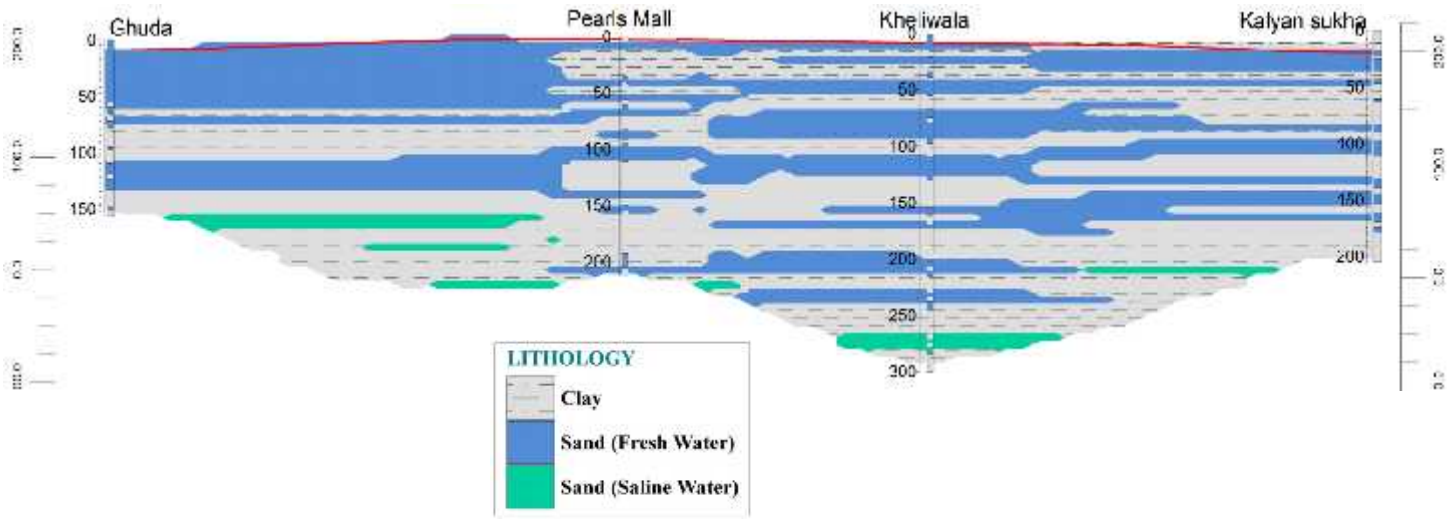
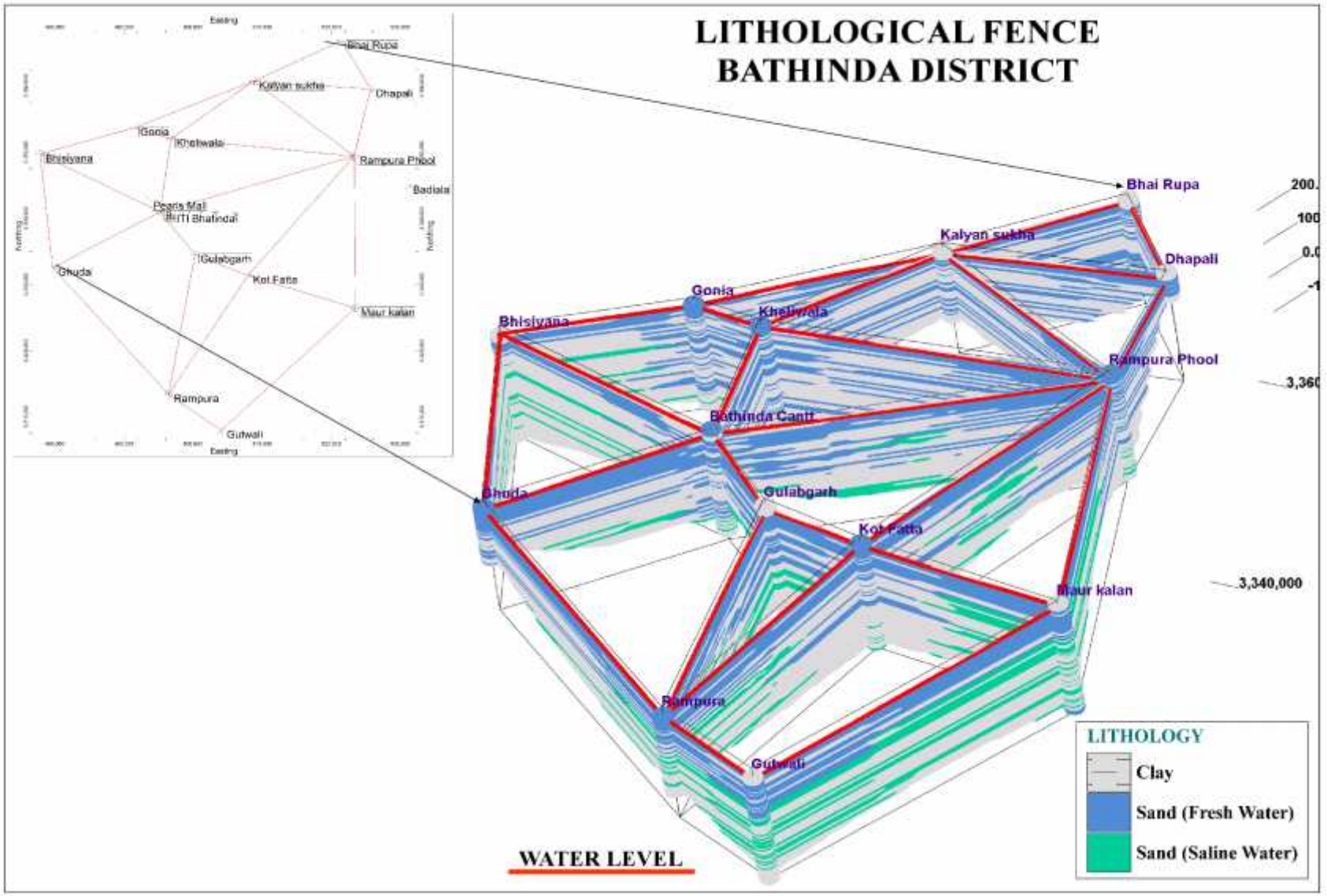


Fig.14: 3-Dimension Lithological Fence



3.2 Aquifer Geometry:

The aquifer group embodies a number of granular layers alternating with clay lenses. A few clay layers intervening these aquifer groups pinch out against the sand zones at few places. The marker horizons are traced all over the area by connecting their tops and bottoms. Sandy clay layer occurs at the surface covering the unconfined aquifer which is in turn underlain by prominent clay zone. It is composed of mainly of medium sand with thin beds of fine sand.

This aquifer is overlain by a thin clay layer of about 0.5 to 2.5 m thick and is also underlain by clayey group which is about 3-6 m thick. In the southern part, there are 4-5 aquifers within 300 m depth and ranges in thickness from 15-50 m. These granular zones are laterally extensive in nature. Aquifer IA (Very Shallow Aquifer) extends maximum upto 71 m of depth and below that clay layer starts getting thickened about 8-10m separating Aquifer IB to a maximum depth of 139 m. Multi layer aquifers are existing in the area each aquifer is separated by thick clay zones of 23 to 67 m upto 300m depth. Aquifer grouping of wells is given in Annexure IV. 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 study area, the aquifer grouping has been carried out using the sub-surface lithology and a 3-Dimensional aquifer model (Fig.15) and aquifer disposition 3D fence diagram has also been prepared using the aquifer model (Fig.16). Various groups identified in the area are given in Table-3. It is very difficult to differentiate the aquifer groups after Aquifer Group I, so the whole lithology is considered to be a single aquifer group system. The first aquifer is water table aquifer and extends all over the area. The aquifer is mainly composed of fine to coarse grained sand.

Table 4: Aquifer Grouping in Bathinda District

Aquifer Group	Range		Thickness	
	From	To	Min	Max
Aquifer IA	7	71	27	63
Aquifer IB	56	139	44	69
Multiple Aquifers	131	300	74	164

Fig.15: 3D Aquifer Disposition Model

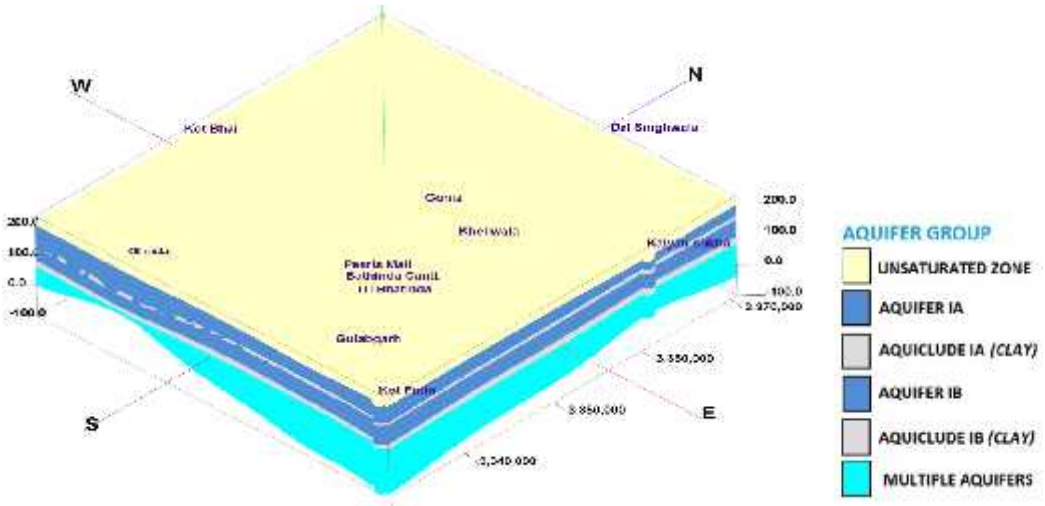
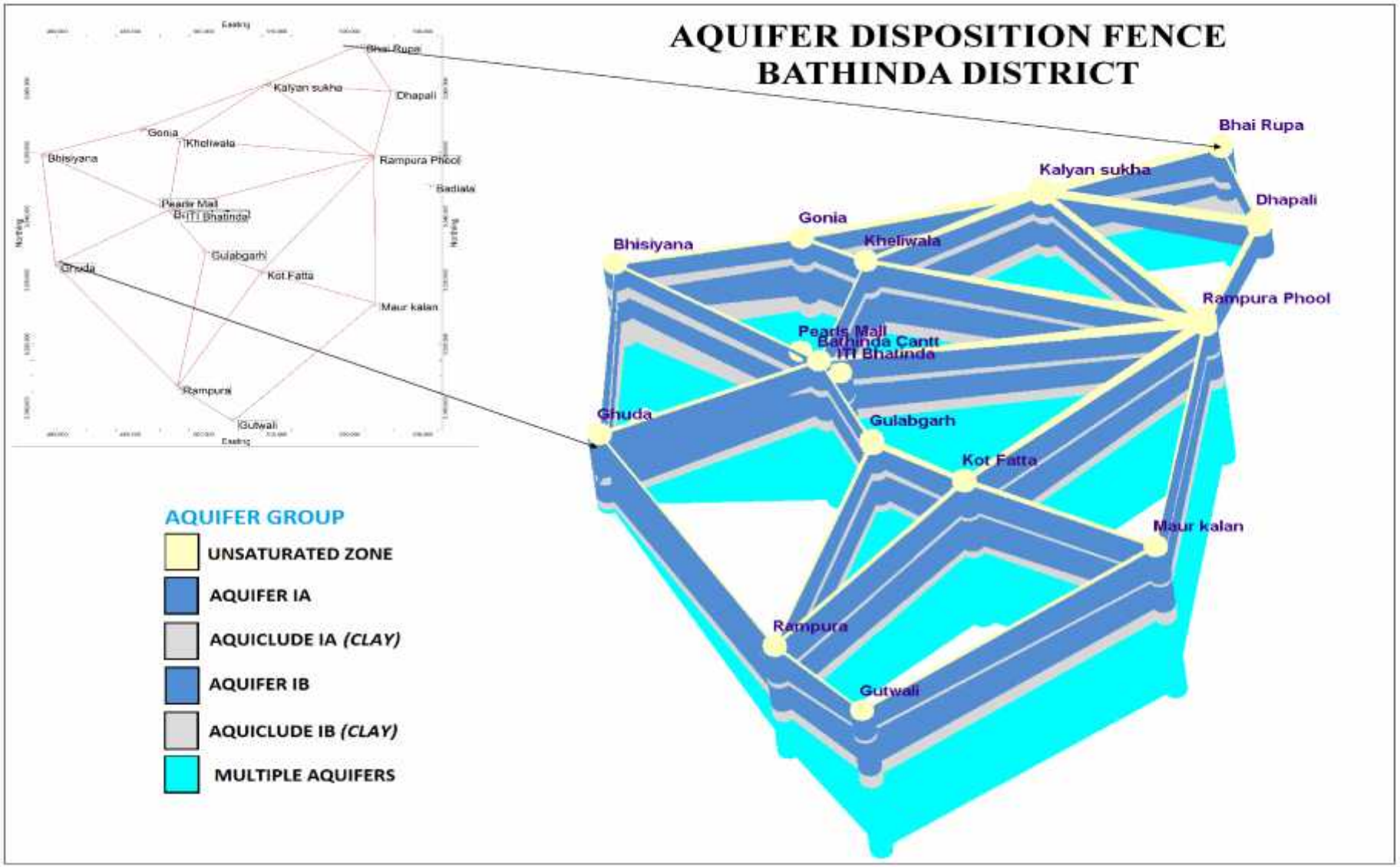


Fig.16: 3D Aquifer Disposition Fence



4.0 GROUND WATER RESOURCES

Ground water resource estimation of the area have been carried out by taking Dynamic and In-storage resources of unconfined aquifer and confined aquifer present upto 300m depth. The assessment of dynamic ground water Resources of the study area have been carried out jointly by CGWB and Water Resources and Environment Directorate (WRED), Department of Irrigation, Punjab on the basis of Ground Water Estimation Committee (1997) methodology.

The occurrence of potential aquifers (productive granular zones) upto 300 m depth has been demarcated on basis of aquifer wise subsurface 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 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, the 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 & WRED, Department of Irrigation, and Punjab.

4.1 Groundwater Resources up to depth of 300m

a. Dynamic Resources:

Block-wise ground water resource potential of the district has been assessed as per GEC-97 as on 31st March 2013. The primary source of recharge in the area is the rainfall. The other sources are from seepages from canals, tanks and ponds and return flows from the agricultural fields after applied irrigation. These recharges have been estimated for both monsoon and non-monsoon seasons. The primary source of ground water discharge (draft) is agricultural abstractions, apart from usages due to domestic and industrial needs. The ground water development in three blocks has exceeded the available recharge, thus the three blocks have been categorized as over exploited. Stage of ground water development is ranges from 56% (block-Sangat) to 169% (block-Phul). Net annual ground water availability in the district has been assessed as 1441.75 MCM.

The total ground water draft for all uses in the district is 1333.78 MCM out of which 1302.55 MCM (90%) is due ground water abstraction by irrigation wells and 31.23 MCM is the existing ground water usage for domestic and industrial needs.

The overall stage of ground water development in the Bathinda district has been assessed to be 93%. Thus, the region is currently using waters from the static ground water resources, which are generally reserved for the future generations. This is a very serious issue and needs immediate attention. The block wise details are given in below Table-5.

Table -5: Dynamic Ground Water Resource & Development Potential (31.03.2013) in mcm

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 (11+12)*	*Provision for domestic, and industrial requirement supply to 2025*	*Net Ground Water Availability for future irrigation development (10-11-14)*	*Stage of Ground Water Development {(13/10) * 100} (%)*	*Category*
Phul	187.56	314.23	2.47	316.70	3.51	-130.18	169	Over Exploited
Nathana	219.93	149.75	3.32	153.08	4.76	65.41	70	Safe
Maur	138.63	170.05	1.86	171.92	2.67	-34.10	124	Over Exploited
Bathinda	341.05	342.62	12.52	355.14	17.93	-19.50	104	Over Exploited
TalwandiSaboo	146.16	81.99	4.90	86.90	7.02	57.15	59	Safe
Sangat	155.61	83.83	2.83	86.66	4.05	67.73	56	Safe
Rampura	252.82	160.07	3.32	163.39	4.73	88.02	65	Safe
TOTAL	**1441.75**	**1302.55**	**31.23**	**1333.78**	**44.67**	**94.53**	**93**	

b. In-storage Ground Water Resources

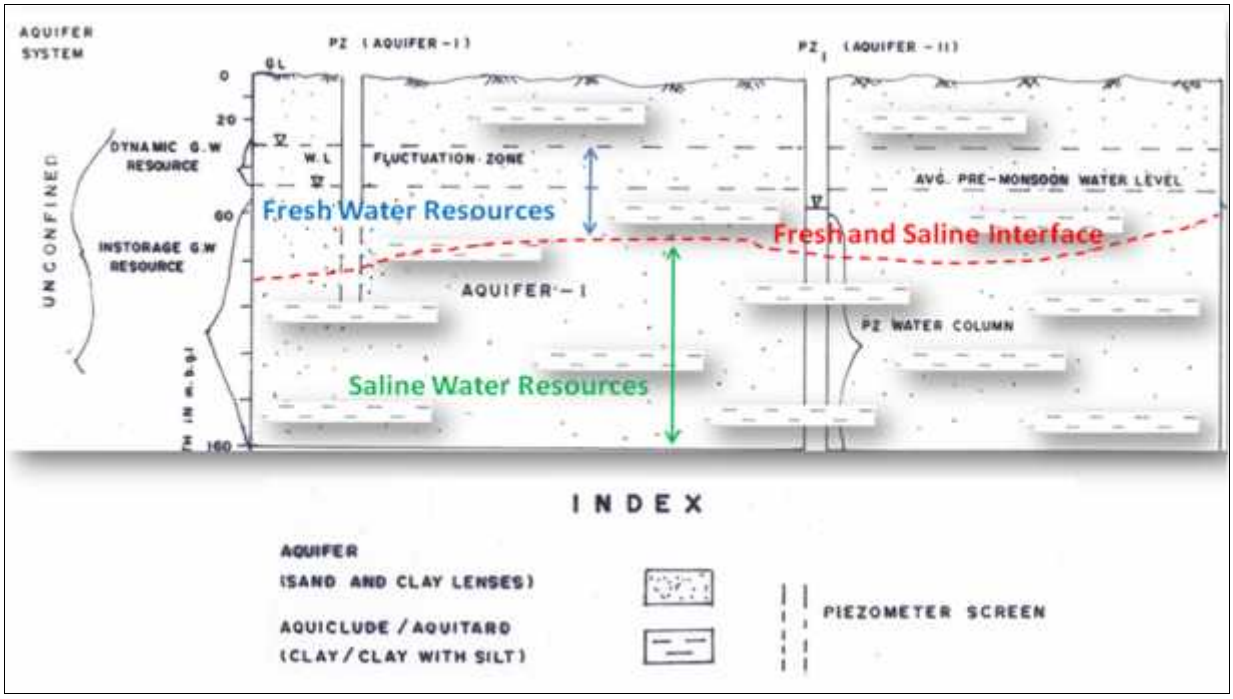
As per revised guidelines recommended by the Central Level Expert Group on groundwater resources assessment, the resources are separately considered as dynamic and in-storage unconfined. In case of alluvial area, in-storage resources of unconfined aquifer have been computed on the basis of specific yield of 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 resource estimations have been calculated for single aquifer group upto 300m of each block of Bathinda district. In-storage ground water resources are estimated for fresh water and saline water resources based on the geophysical interpretations of depth to fresh and saline water interface for each block. The fresh and saline calculations are made on the basis of the assumptions on aquifer that is considered as unconfined aquifer so that the specific yield concept is used for resources estimations (Fig.17). The detailed resources estimations are calculated in detailed table for fresh and saline water resources in the below Table-6, 7 & 8.

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

Fig.17: Conceptual figure to understand the fresh and saline water resources in the aquifer up to 300 m for Resource Estimation in Unconfined and Confined Aquifer System.



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

Table-6: Block wise In-Storage Ground Water Resources of Fresh Water Aquifer

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT BATHINDA, PUNJAB STATE (2013) in mcm												
Type of Ground Water Assessment Unit (Block): Bathinda Blocks												
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (sqkm)		Average Pre-monsoon Water Level (m bgl)	Depth to bottom of Aquifer based on Geophysical Interface &Boreloggi ng (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 (m)	Thickness of the unsaturate d granular Zones up to Pre-monsoon WL (m)	Thickness of the saturated granular Zones up to the depth of Fresh water aquifer below (m) (11-12)	Avera ge Specifi c Yield	In-Storage Ground Water Resources up to the depth of Fresh Water Aquifer (mcm) 5*13*14
			Total Geographical Area	Assessment Area Fresh Water								
1	*2*	*3*	*4*	*5*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
1	Phul	Alluvium	522.30	192.30	22.6	200	177.4	87	8	79	0.072	1094
2	Nathana	Alluvium	445.50	329.50	19.88	205	185.12	69	5	64	0.072	1518
3	Maur	Alluvium	356.10	26.10	11	85	74	62	7	55	0.072	103
4	Bathinda	Alluvium	739.50	272.50	7.95	250	242.05	100	3	97	0.072	1903
5	Talwandi Sabo	Alluvium	522.40	206.40	8.2	92	83.8	65	3	62	0.072	921
6	Sangat	Alluvium	630.40	24.40	8.3	150	141.7	95	5	90	0.072	158
7	Rampura	Alluvium	331.00	84.00	19.5	80	60.5	55	13	42	0.072	254
Dist. Total(MCM)			**3547.20**	**1135.20**								**5952**

mcm: million cubic metre

Table-7: Block Wise In-Storage Ground Water Resources of Saline Aquifers upto 300 m Depth

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT BATHINDA, PUNJAB STATE (2013) in mcm										
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (sqkm)		Depth to bottom of Fresh Water Aquifer based on Geophysical Interface &Borelogging (m bgl)	Depth to bottom of Saline Water Aquifer based on Geophysical Interface &Borelogging (m bgl)	Total thickness of the Saline Water up to the max depth (m)	Total thickness of the Granular Zones up to the depth ofSaline Water Zones (m)	Average Specific Yield	In-Storage Ground Water Resources up to the depth of Saline Water Aquifer (mcm) 5*13*14
			Total Geographical Area	Assessment Area Saline Water						
1	*2*	*3*	*4*	*5*	*9*	*10*	*11*	*12*	*14*	*15*
1	Phul	Alluvium	522.30	330.00	200	250	50	22	0.072	522.72
2	Nathana	Alluvium	445.50	116.00	205	230	25	11	0.072	91.87
3	Maur	Alluvium	356.10	330.00	85	300	215	61	0.072	1449.36
4	Bathinda	Alluvium	739.50	467.00	250	300	50	15	0.072	504.36
5	Talwandi Sabo	Alluvium	522.40	316.00	92	300	208	99	0.072	2252.45
6	Sangat	Alluvium	630.40	606.00	150	156	6	2	0.072	87.26
7	Rampura	Alluvium	331.00	247.00	80	300	220	59	0.072	1049.26
Dist. Total(MCM)			**3547**	**2412**						**5957**

mcm: million cubic metre

Table-8: Block Wise Total Availability of Fresh and Saline Groundwater Resources upto 300 m Depth and Volume of unsaturated granular zone after 3m upto water level.

BLOCK WISE AVAILABILITY OF TOTAL GROUNDWATER RESOURCES IN BATHINDA DISTRICT UP TO DEPTH OF 300M								
Sl.No	BLOCK	Volume of Unsaturated Granular Zone up to Pre-monsoon WL	Dynamic Groundwater Resources (2013) AQUIFER-I	In-storage Groundwater Resources UPTO FRESHWATER	Groundwater Resources upto FRESH WATER [(4)+(5)] (MCM)	Ground Water Resources UPTO SALINE WATER (MCM)	Total Availabilty of Groundwater Resources [(6)+(7)]	
							mcm	**bcm**
1	*2*	*3*	*4*	*5*	*6*	*7*	*9*	
1	Phul	**501.41**	187.56	*1093.80*	***1281.36***	***522.72***	*1804*	*1.804*
2	Nathana	**267.30**	219.93	*1518.34*	***1738.26***	***91.87***	*1830*	*1.830*
3	Maur	**299.12**	138.63	*103.36*	***241.99***	***1449.36***	*1691*	*1.691*
4	Bathinda	**266.22**	341.05	*1903.14*	***2244.19***	***504.36***	*2749*	*2.749*
5	Talwandi Sabo	**188.06**	146.16	*921.37*	***1067.53***	***2252.45***	*3320*	*3.320*
6	Sangat	**378.24**	155.61	*158.11*	***313.72***	***87.26***	*401*	*0.40*
7	Rampura	**516.36**	252.82	*254.02*	***506.84***	***1049.26***	*1556*	*1.556*
Dist.Total(mcm)		**2417**	**1442**	**5952**	**7394**	**5957**	**13351**	**13.351**
Dist.Total (bcm)		**2.417**	**1.442**	**5.952**	**7.394**	**5.957**		

bcm : billion cubic metre

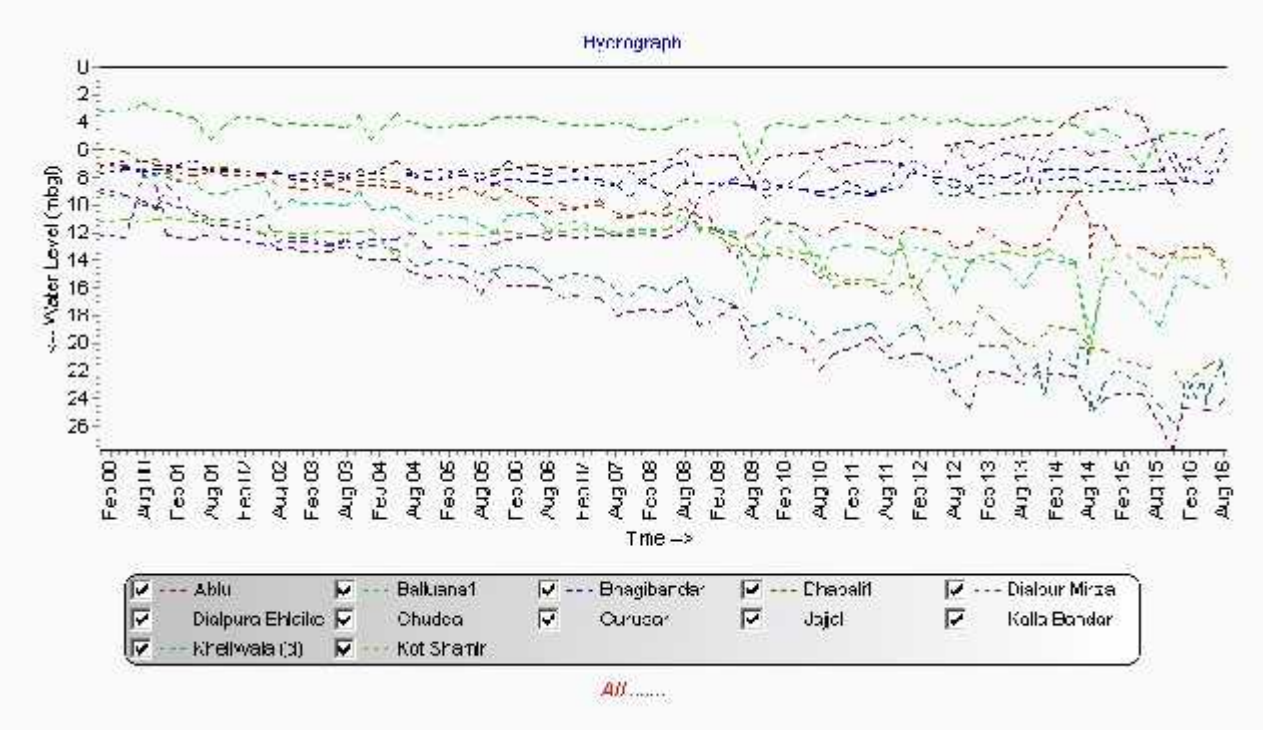
mcm: million cubic metre

5.0 GROUND WATER ISSUES

5.1 Ground Water Depletion

The main cause of ground water depletion is its excess withdrawal to meet the increasing demand of various sectors including Agriculture, Industry and Domestic. The quality of ground water in the area is suitable for 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. The hydrographs also shows the declining water level trend over the years in the district (Fig.18) Out of seven blocks, three blocks are overexploited, 2 blocks are critical and two blocks are under safe category. This will lead to its deepening of ground water levels in blocks of Bathinda district as the recharge of the groundwater through rainfall and other sources are less than the overall extraction. This declining water table trend, if not checked, would assume an alarming situation in the near future affecting agricultural production and thus economy. Ground Water Recharge and Conservation may be carried out in these areas to overcome the depletion. Other than the groundwater depletion, quality and rising water table are the other issues.

Fig.18: Long term ground water table variation



5.2 Rising Water table

In West to South west parts of the area water table is rising due to less withdrawal of ground water because of brackish / saline quality coupled with easy availability of canal water for domestic and irrigation purposes. As such, these areas are likely to get water logged in near future. There is an urgent need to arrest the rising water trend in western part and implement anti-water logging schemes.

5.3 Ground Water Quality

The ground water of the study area is alkaline in nature. Ground water in the area is generally fresh to marginally saline with fluoride concentration above permissible limit (1.5 mg/L) are found mainly in Gurusar (4.50) and Kotha Guru (1.59) and Nitrate concentration above permissible limit (45mg/l) are found in sixteen locations i.e. Jajjal (314), Jhanduke (220), Gurusar (183), Ghudda(138), Kot Shamir (129), Jassi Bhag wali (127), Balluana (125), Kala Bhander (124), Phulla (94) ,Kotha Guru (84), Rampura Phul (80), Maiser khana (77), Gulabgarh (64), Nahianwala (61), Phul (52) and Raike kalan(48) and iron concentration above permissible limit (1.5 mg/L)are observed in Ghudda(4.5), Ganga(2.99), Kot Shamir(1.65) and Maiser khana (1.64) . There is growing concern on deterioration of ground water quality due to geogenic and anthropogenic activities.

5.4 Ground Water Irrigation Scenario

As per the data available from minor irrigation census 2005-06, the detailed number of shallow, deep, tube wells, lined, unlined water distribution system, land holdings of wells are given in Table-9,10 &11 .

Table-9: Distribution of Tube wells According to Well Owner's land holding Size

Type of Tube well (TW)	***Marginal (0-1 ha)***	***Small (1-2 ha)***	***Semi-Medium (2-4 ha)***	***Medium (4-10ha)***	***Big (>10ha)***	***Total***
Shallow TW	757	5504	14796	17364	2790	**41219**
Deep TW	93	1125	2380	1595	360	**5553**
Total	**850**	**6629**	**17176**	**18959**	**3150**	**46772**

Table-10: Distribution of Tube wells According to Depth

Depth of Tubewells in metres							**Total depth Range 0-150m**
Depth range	0-20 m	20-40 m	40-60 m	60-70 m	70-90m	90-150m	
Tubewells	39679	909	493	138	1980	3573	**46772**
Tubewells (%)	85	2	1	0.3	4	7.7	

Table-11: System of Ground water distribution device

Open Water Channels				**Total**
Ground water distribution System	*Lined/ Pucca*	*Unlined/ Kutcha*	*Others*	
Tubewells	**19383**	**15647**	**11742**	**46772**

33.45 % wells have unlined system of water distribution resulting in inefficiency and wastage of ground water. There is scope to minimize unlined system.

6.0 MANAGEMENT STRATEGIES AND AQUIFER MANAGEMENT PLAN

Aquifer mapping is leads to groundwater management plans to be implemented by including demand side-management and Ground Water Use Efficiency.

An outline of the Aquifer Management Plan for each block is given in Part-II. 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.

Artificial recharge plan is less feasible in the Bathinda District due to very low availability of volume of surplus water (10.03 mcm). 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.

6.1 Scope of Implementation

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 govt. 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 Institution, 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 Punjab, particularly in overexploited blocks.

There are around 15647 (out of 46772) tube wells (33.45 %) operated by farmers for irrigation through unlined/Kutcha open channel system in study area (Table-11) where water from the tube well is discharge to the agricultural field. In this process, huge (around 25 %) (RKVY, 2015) quantity of ground water is wasted in soil moisture and evaporation losses.

Around 88 % of the tube wells are of shallow depth (20 to 70m) and remaining wells are deeper depth (70 to >150 m) existed in the area (Table-9). Thus, majority of wells are tapping shallow aquifer which is under stress.

Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation in the district is estimated at 1302.55 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 109 mcm (Table-12a) assuming that there is no crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks. The measure if implemented will bring down the ground water overdraft from 93 %

to 88%. The category of the blocks will also improve resulting in boosting of agriculture and industrial development otherwise not sustainable in over-exploited blocks (Table-12b).

The tube wells also consume enormous electricity which is subsidized and government incur 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. It is expected to save 1% of the agricultural land occupied by open channels which can be utilized for cultivation purpose. Heavy ground water overdraft can be reduced by these efforts. This will ensure ***more crops per drop.***

6.3 Water saving Potential from Crop Diversification-Change Paddy to Maize/Soya-bean:

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 soyabean planted in ***one sq km*** of land. In case of pulses even higher amount of ground water can be saved.

The block wise saving of water in mcm by applying various management strategies such as crop diversification, Under Ground Pipe lines (UGPL) in individual land and artificial recharge methods are given in tables 12.a, b.

Table-12a: Scope of Quantitative Impact on Stage of Development after applying various management strategies in mcm

Block	*Net Ground Water Availability (mcm)*	*Total Irrigation Draft (mcm)*	*Present Stage of draft (SOD) (%) (As per 2013)*	*Reduction in draft by different water saving method*				*SOD afterwards (%)*	*Change of paddy cultivation area (% of existing)*
				Replace water courses by UG Pipes (mcm)	*Adopt Artificial recharge (mcm)*	*Change Paddy to Maize (mcm)*	*Total (mcm) (2+3+4)*		
			1	2	3	4	5		
Phul	187.56	314.23	169	26.28	3.69	100.52	130.49	99	NR
Nathana	219.93	149.75	70	12.52	0.00	0.00	12.52	64	NR
Maur	138.63	170.05	124	14.22	2.41	16.50	33.13	100	NR
Bathinda	341.05	342.62	104	28.65	3.94	0.00	32.59	94	NR
Talwandi Sabo	146.16	81.99	59	6.86	0.00	0.00	6.86	54	NR
Sangat	155.61	83.83	56	7.01	0.00	0.00	7.01	52	NR
Rampura	252.82	160.07	65	13.39	0.00	0.00	13.39	60	NR
Total	**1441.75**	**1302.55**	**93**	**108.93**	**10.03**	**135.67**	**254.63**	**75**	

NR: Not Required

Table-12b: Impact on Stage of Development (SOD) after applying various management strategies in Bathinda District

Block	*Present SOD (%) as on 2013*	*Reduction in SOD (%) after unlined channel (%)*	*Resultant SOD (%) Col.(2 - 3)*	*Reduction in Stage of development after crop diversification by Maize/Soyabean (%)*	*Resultant SOD (%) Col.(2 - 5)*	*Reduction in Stage of development after Artificial recharge (%)*	*Resultant SOD (%) Col.(2 - 7)*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Phul	169	14.01	155	53.6	144	2	167
Nathana	70	5.69	64	0	70	0	70
Maur	124	10.26	114	11.9	124	2	122
Bathinda	104	8.40	96	0	104	1	103
Talwandi Sabo	59	4.69	55	0	59	0	59
Sangat	56	4.51	51	0	56	0	56
Rampura	65	5.29	59	0	65	0	65
Total	**93**	**7.56**	**85**	**9.4**	**83.6**	**1**	**92**

By adopting all the management strategies resulting in total reduction in stage of groundwater development is 17.7%. Hence overall stage of development afterwards is 75 % and is given in Table.12c.

Table-12c: Overall Stage of Development (SOD) after total reduction potential in Bathinda

Block	*Present Stage of development (%) as on 2013*	*Reduction in stage of development after unlined channel (%)*	*Reduction in Stage of development after crop diversification by Maize/Soyabean (%)*	*Reduction in Stage of development after Artificial recharge (%)*	*Total Reduction in Stage of development (%) (3 +4+5)*	*Stage of development afterwards (%) (2-6)*
1	**2**	**3**	**4**	**5**	**6**	**7**
Phul	169	14.01	53.6	1.97	69.6	99
Nathana	70	5.69	0	0	5.7	64
Maur	124	10.26	11.9	1.74	23.9	100
Bathinda	104	8.40	0	1.16	9.6	94
Talwandi Sabo	59	4.69	0	0	4.69	54
Sangat	56	4.51	0	0	4.51	52
Rampura	65	5.29	0	0	5.29	60
Total	**93**	**7.56**	**9.4**	**0.70**	**17.7**	**75**

BLOCK WISE

AQUIFER MAPS

AND

MANAGEMENT PLAN

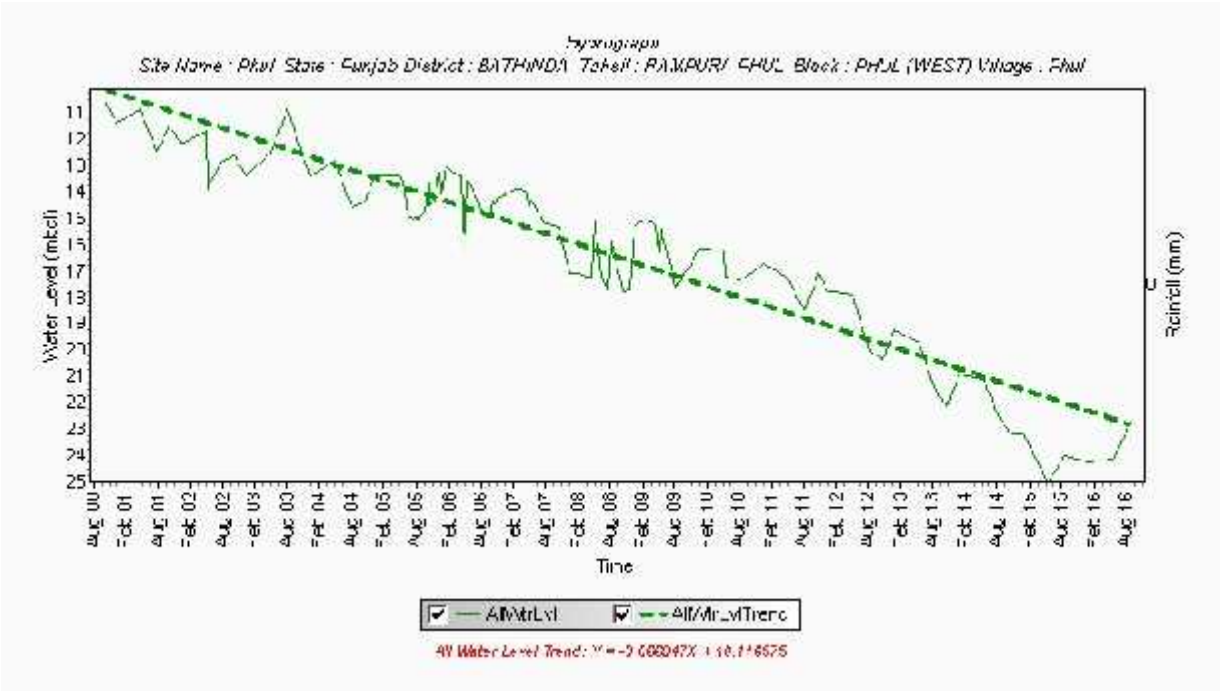
(PART-II)

I. Salient Information of Phul & Bhagta Bhaike Blocks

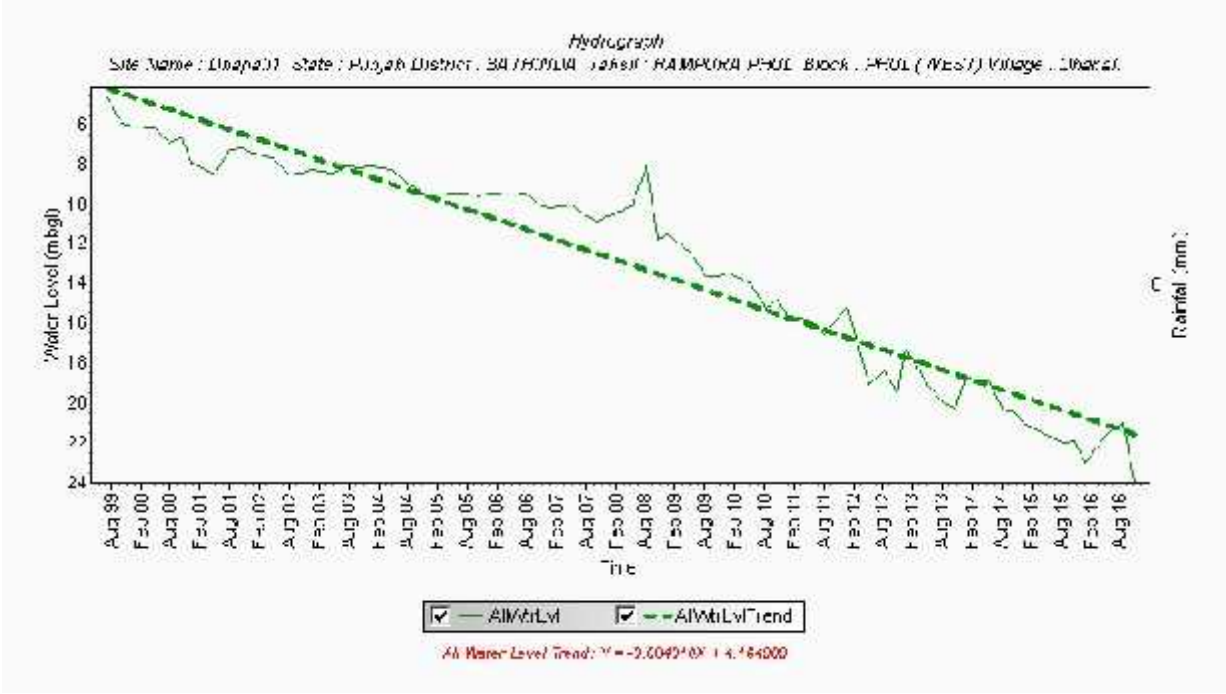
Block Area (in Km^2)	**522.3 sq km.**
District/ State	Bathinda, Punjab
Population	Urban Population: 1400 Rural Population: 148815 Total population: 150215
Rainfall	Normal Monsoon: 296 mm Non-monsoon Rainfall : 59 mm Annual Average Rainfall: 355 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 560.73 sq km Net sown area: 293.06 sq km Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 191% *Area under* Ground water Irrigation: 179.74 sq km Surface water irrigation: 274.89 sq km Number and types of abstraction structures: 12079, Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Total Ground Water Resources available is 1617 mcm (fresh and saline water) up to the depth of 250 m. The fresh water resources (1094 mcm) are estimated up to the depth of 200 m on the basis of geophysical interpretations. The potential granular zones available for fresh water are 87 m. Saline water resources (523 mcm) are estimated on the basis of well (up to 250 m) and the granular zones are counted after depth of 200 m and available zones are 22 m. Block is categorized as Over-Exploited as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and not suitable for irrigation purpose as such all users are tapping shallow aquifers. Drinking water supply wells of State Government tapping shallow aquifers Therefore, the ground water draft could not be assessed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 314.23 mcm Domestic and industrial water supply: 2.47 mcm *Future water demands* Irrigation development potential : (-)130.18 mcm Domestic and industrial water supply up to 2025 years : 3.51 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 8.85 – 27.64 m bgl Post Monsoon: 9.36 – 31.00 m bgl Mean (10 yrs) : 3.97 – (-)0.19 m/yr *Trends* Pre Monsoon: (-)0.92 – (-)1.42 m/yr Post Monsoon: (-)0.99 – (-)1.41 m/yr **Aquifer-II /III:** No Monitoring Stations

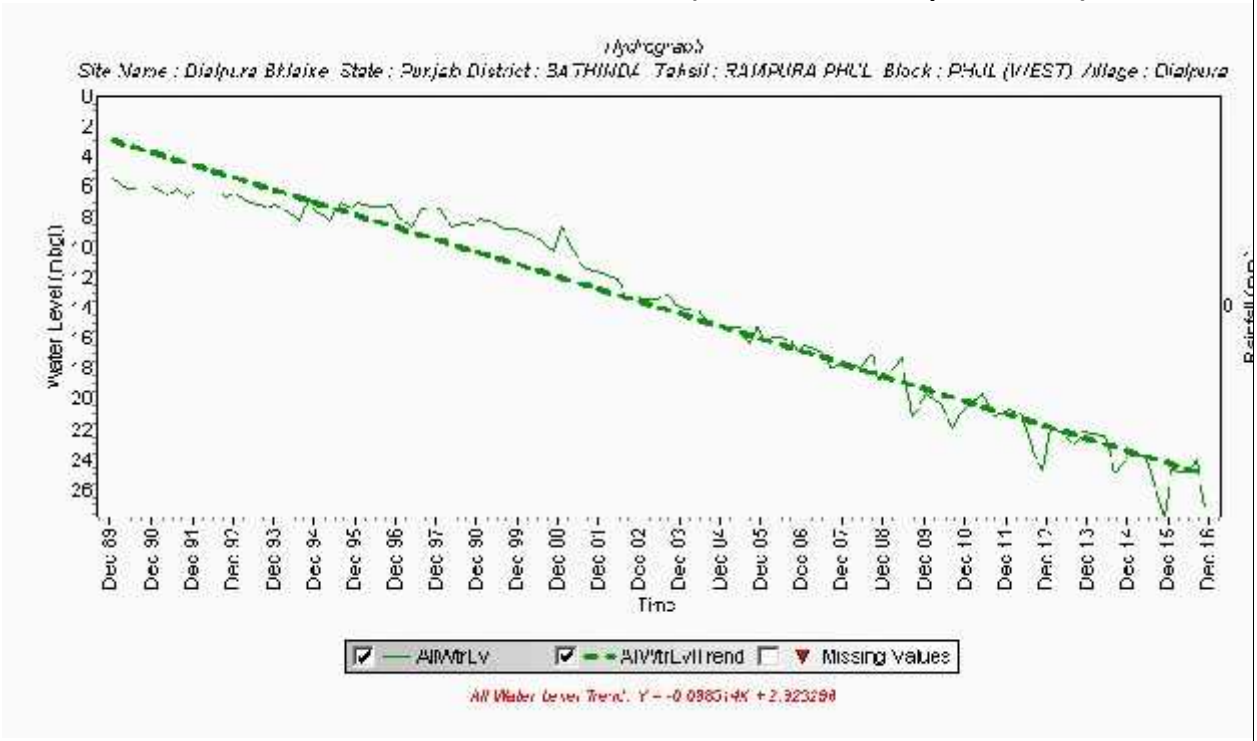
HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Phul)



HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Dhapali)



HYDROGRAPH SHOWING DECLINING WATER TABLE (LOCATION: Dhialpur Bhlaike)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	3	0	1	0	**4**
WRED	12	2	0	0	**14**
PRIVATE	1	0	0	0	**1**
TOTAL	**16**	**2**	**1**	**0**	**19**

Aquifer wise Characteristics

Aquifer Group *	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)#	Yield (m^3/day) #	Specific Yield	Storativity #
Aquifer -I	Quarter-nary Alluvial deposits	Unconfined to confined	109	Not Available (NA)	Not Available (NA)	12 % *(0.072)*	Not Available (NA)

* Well field proposed in adjacent block

CGWB, 2015, Ground Water Exploration Report, Punjab state

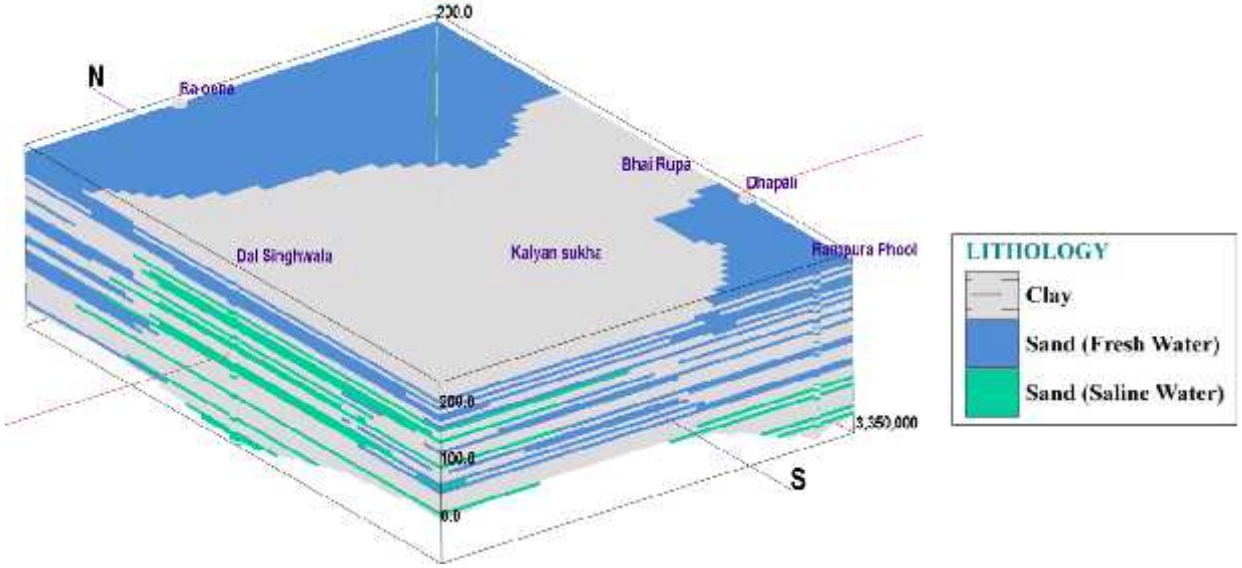
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	1	0	**1**
WRED	0	0	0	0	**0**
PRIVATE	1	0	0	0	**1**
TOTAL	**1**	**0**	**1**	**0**	**2**

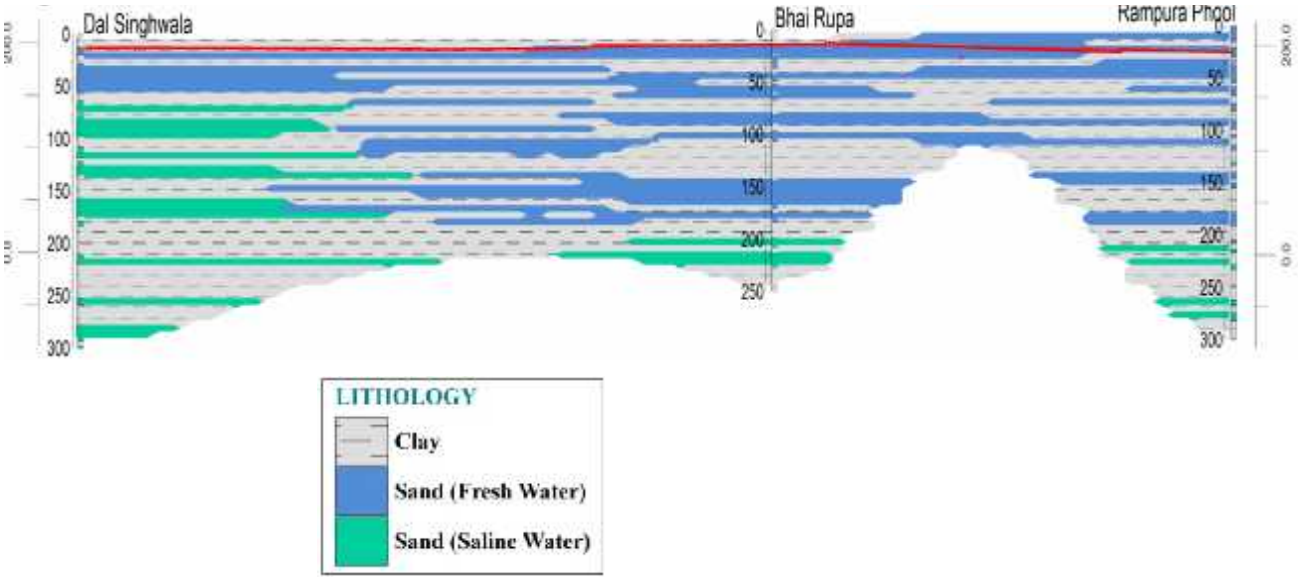
The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

3-D Lithological model of Phul Block

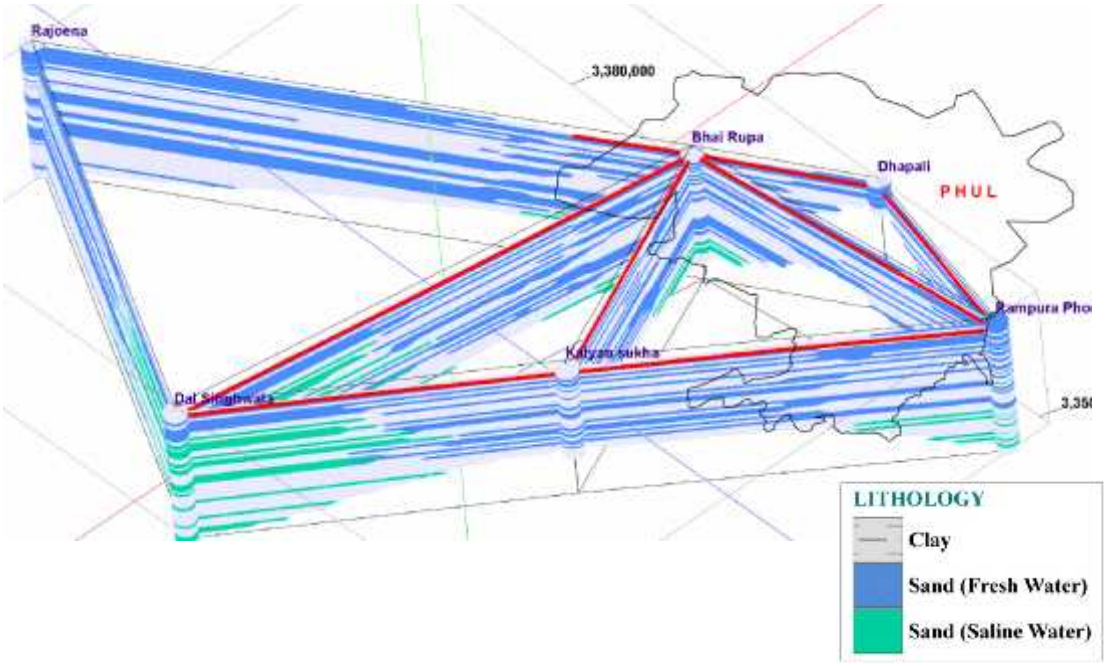


Lithological Cross section from Rampura Phul to Rajeona

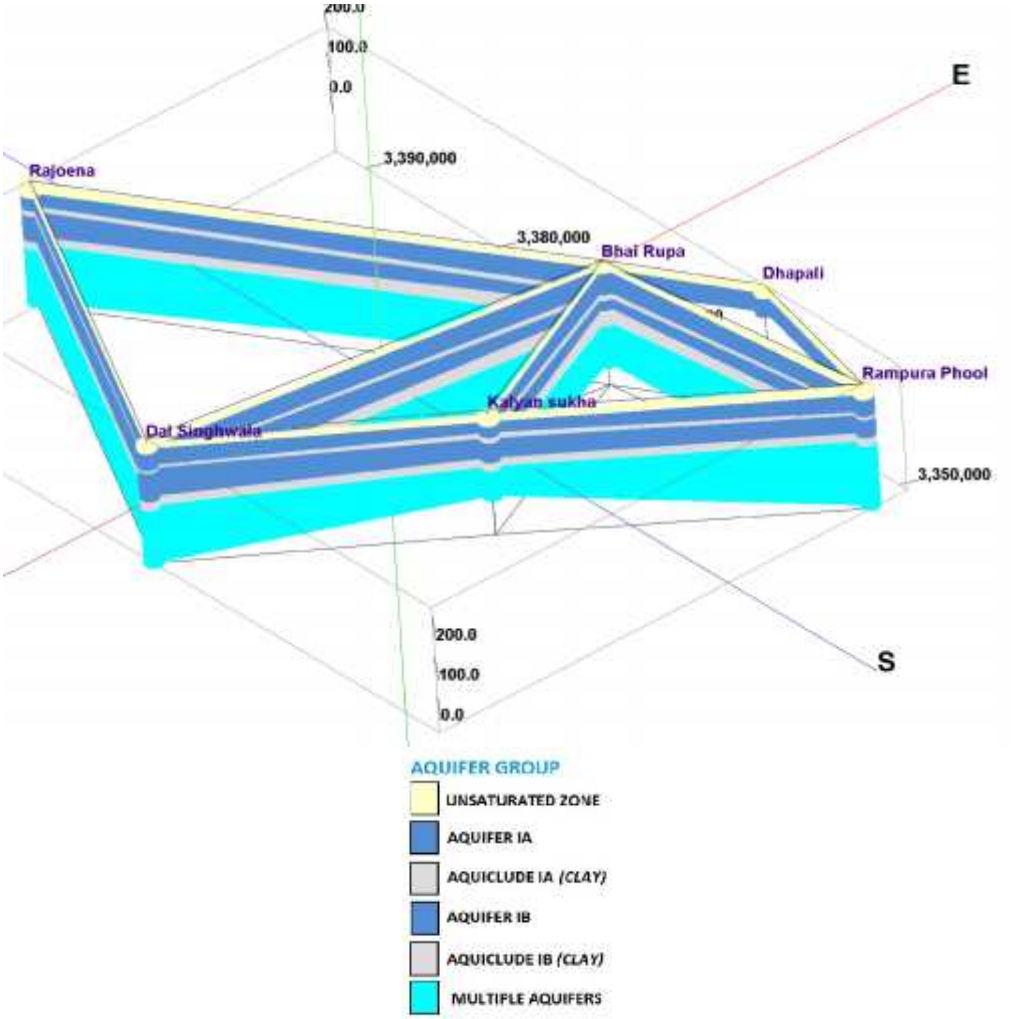
Lithological Cross section from Dal Singhwala to Rampura Phul



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Phul & Bhagta Bhaike Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	187.56 mcm
	In-storage Fresh water resources	1094 mcm
	In-storage Saline water resources	523 mcm
	Total	1804 mcm
Ground Water Extraction (as per 2013)	Irrigation	314.23 mcm
	Domestic & Industrial	2.47 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		3.51 mcm
Stage of Groundwater Development		169 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.43 and 9.44. Ground water in the area is slightly fresh to marginal saline. EC value of the ground water show wide variations and ranges from 300 μS/cm to 4880 μS/cm at 25^0C. RSC values are varies from -2.43 to 21.21 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		***Fluoride (mg/l):*** Gurusar (4.50) ***Nitrate (mg/l):*** Phul (52), Rampura Phul (80), Gurusar (183)
Other issues		Water level decline has been observed in all parts of the block due to in discriminate development of ground water resources.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 501.41 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will conserve 3.69 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Phul Block (522.30 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 26.28 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean .*
The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop
Area coverage: *28 % of the total rice area needs to change i.e.* 100.52 sq km
Anticipated volume of water to be saved: 100.52 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
187.56	314.23	316.70	359	100.52	100.52	213.71	169	53.6	28

Alternate Water sources

Surface water sources: *Tanks, Ponds*
Location, details and availability from such sources outside the area: Not Available
Regulation and Control:

Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Cotton, Sunflower, Maize

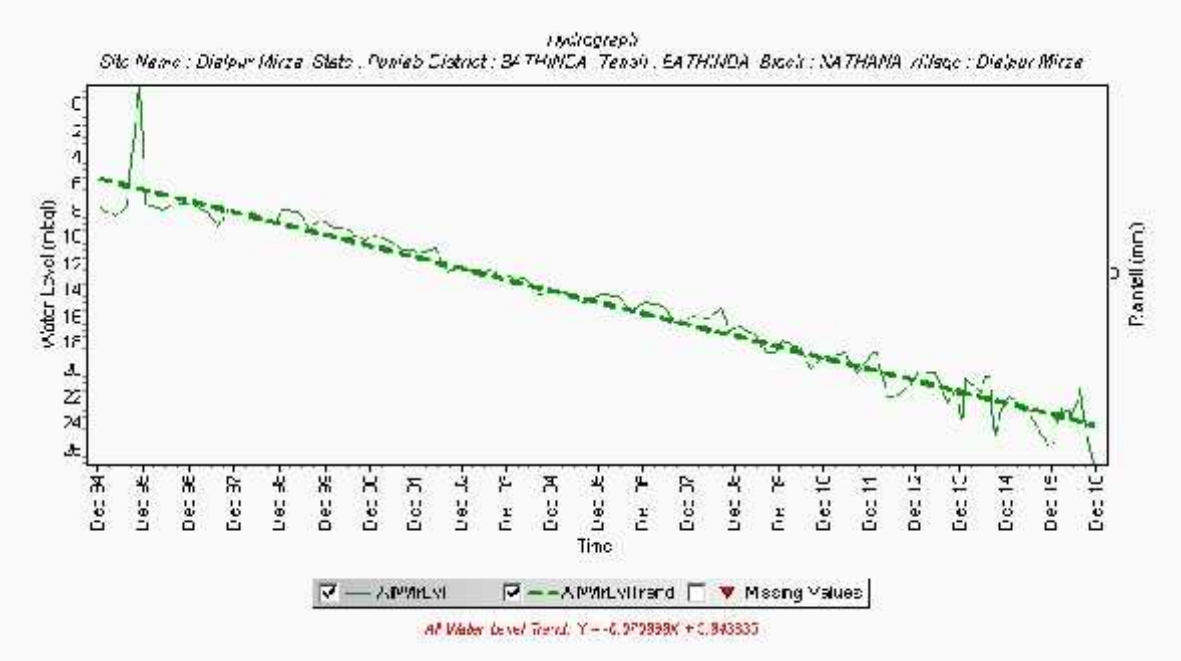
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

II. Salient Information of Nathana Block

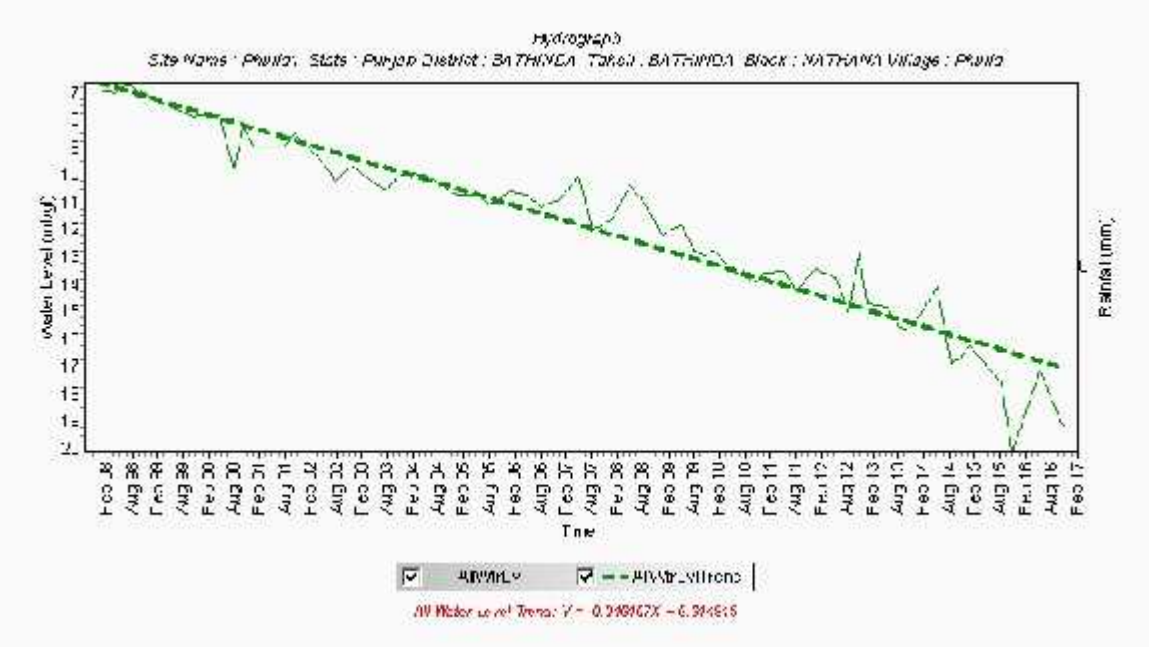
Block Area (in Km^2)	**445.5 sq km.**
District/ State	Bathinda, Punjab
Population	Urban Population: 27733 Rural Population: 114476 Total population: 142209
Rainfall	Normal Monsoon: 286 mm Non-monsoon Rainfall : 96 mm Annual Average Rainfall: 362 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 530.24 sq km Net sown area: 277.19 sq km Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 191% *Area under* Ground water Irrigation: 93.9 sq km Surface water irrigation: 204.66 sq km Number and types of abstraction structures: 5177, Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Total Ground Water Resources available is 1610 mcm (fresh and saline water) up to the depth of 300 m. The fresh water resources (1518mcm) are estimated up to the depth of 205 m on the basis of geophysical interpretations. The potential granular zones available for fresh water are 69 m. Saline water resources (92 mcm) are estimated on the basis of well (up to 230 m) and the granular zones are counted after depth of 205 m and available zones are 11 m. Block is categorized as Safe as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and not suitable for irrigation purpose as such all users are tapping shallow aquifers. Drinking water supply wells of State Government tapping shallow aquifers Therefore, the ground water draft could not be assessed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 149.75 mcm Domestic and industrial water supply: 3.32 mcm *Future water demands* Irrigation development potential : 65.41 mcm Domestic and industrial water supply up to 2025 years : 4.76 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 15.08 – 22.92 m bgl Post Monsoon: 16.28 – 25.72 m bgl Mean (10 yrs) : 0.48 – 3.92 m/yr *Trends* Pre Monsoon: (-)0.60 – (-)0.96 m/yr Post Monsoon: (-)0.80 – (-)1.01 m/yr **Aquifer-II (169 m)** Pre Monsoon: m bgl Post Monsoon: m bgl **Aquifer-III (300 m)** Pre Monsoon: NA Post Monsoon: 8.20 m bgl

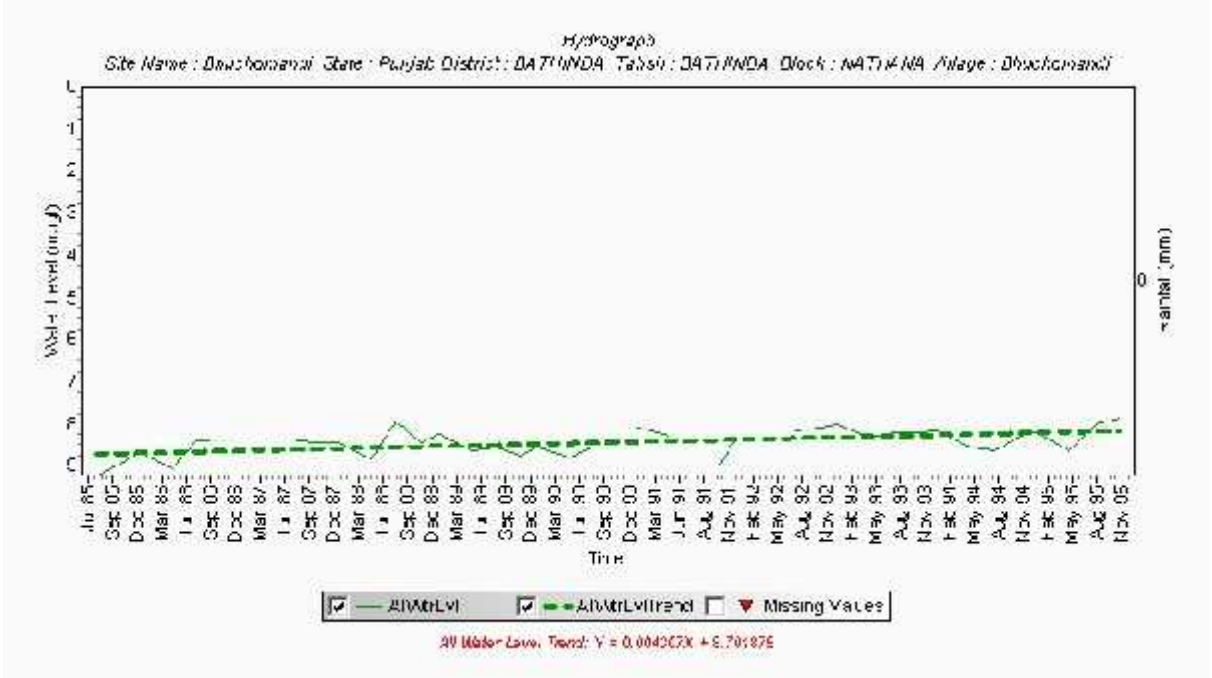
HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Dialpur Mirza)



HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Phulla)



HYDROGRAPH SHOWING RISING WATER TABLE (Location: Bucho Mandi)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Aeolian Alluvium

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	*100-200*	*200-300*	*>300*	
CGWB	0	0	1	0	**1**
WRED	8	0	0	0	**8**
PRIVATE	0	0	0	0	**0**
TOTAL	**8**	**0**	**1**	**0**	**9**

Aquifer wise Characteristics

Aquifer Group *	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmis-sivity (m^2/day)#	Yield (m^3/day) #	Specific Yield	Storativity #
Aquifer -I	Quarter-nary Alluvial deposits	Unconfined to confined	80	Not Available (NA)	Not Available (NA)	12 % (0.072)	Not Available (NA)

* Well field proposed in this block, Site: Kalyan Sukha

CGWB, 2015, Ground Water Exploration Report, Punjab state

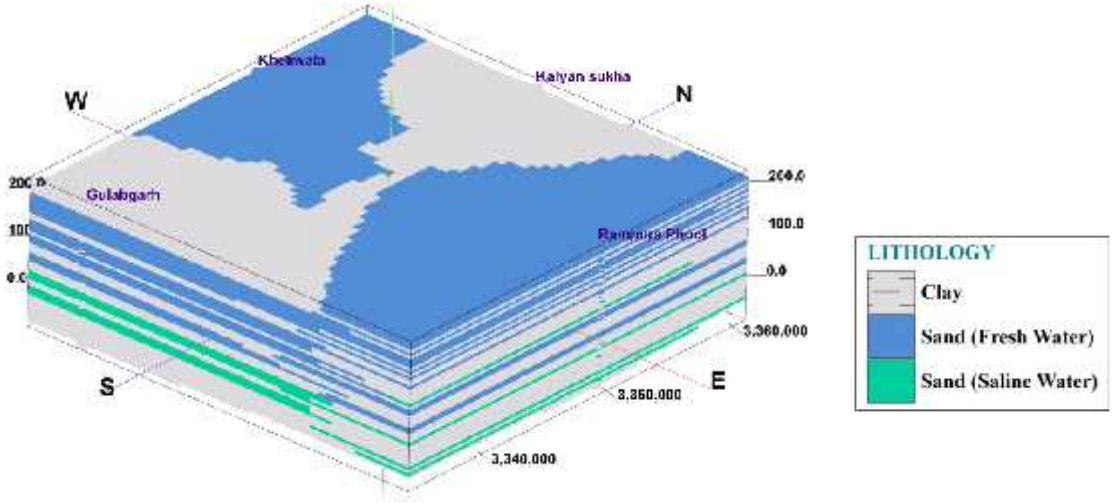
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

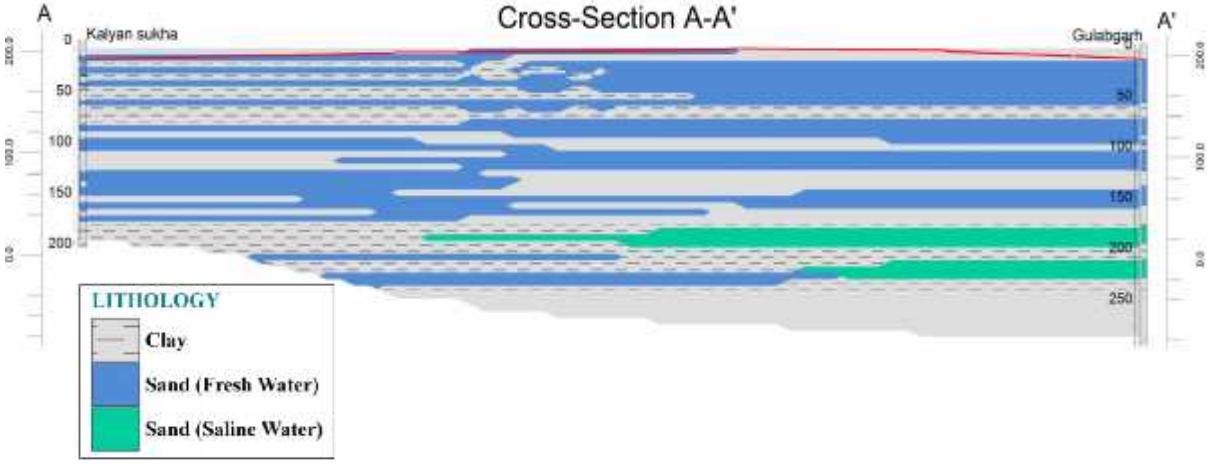
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	1	0	**1**
WRED	1	0	0	0	**1**
PRIVATE	0	0	0	0	**0**
TOTAL	**1**	**0**	**1**	**0**	**2**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

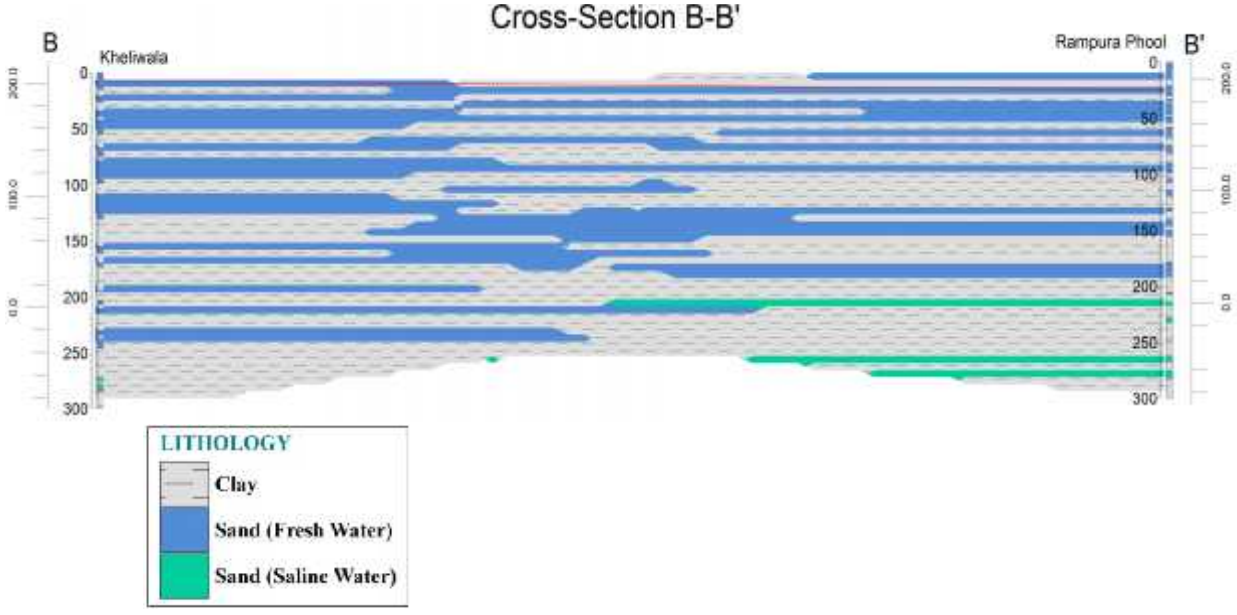
3-D Lithological model of Nathana Block



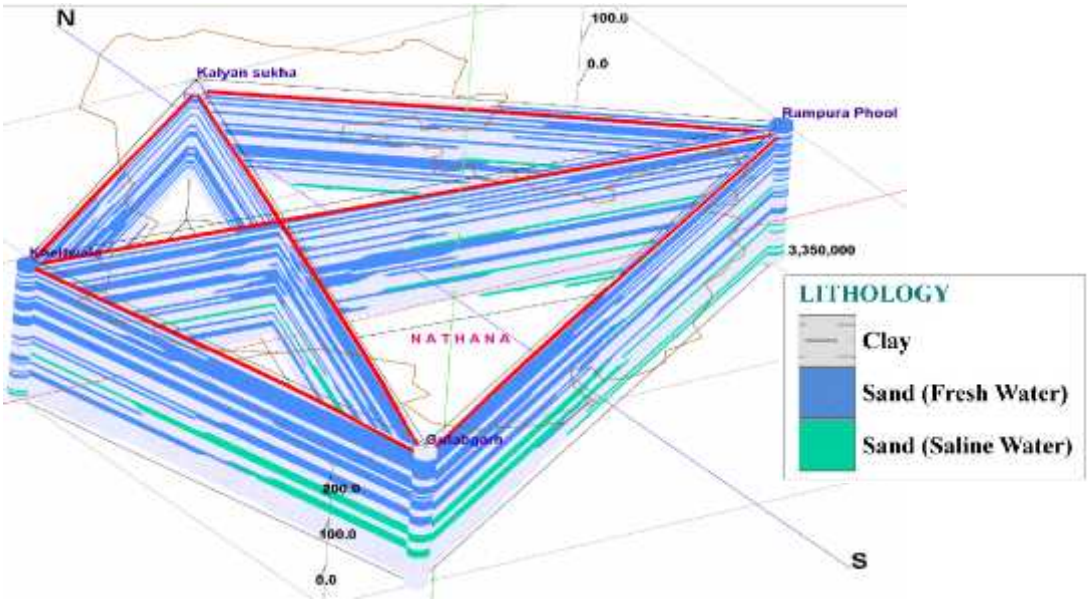
Lithological Cross section from Kalyan Sukha to Gulabgarh



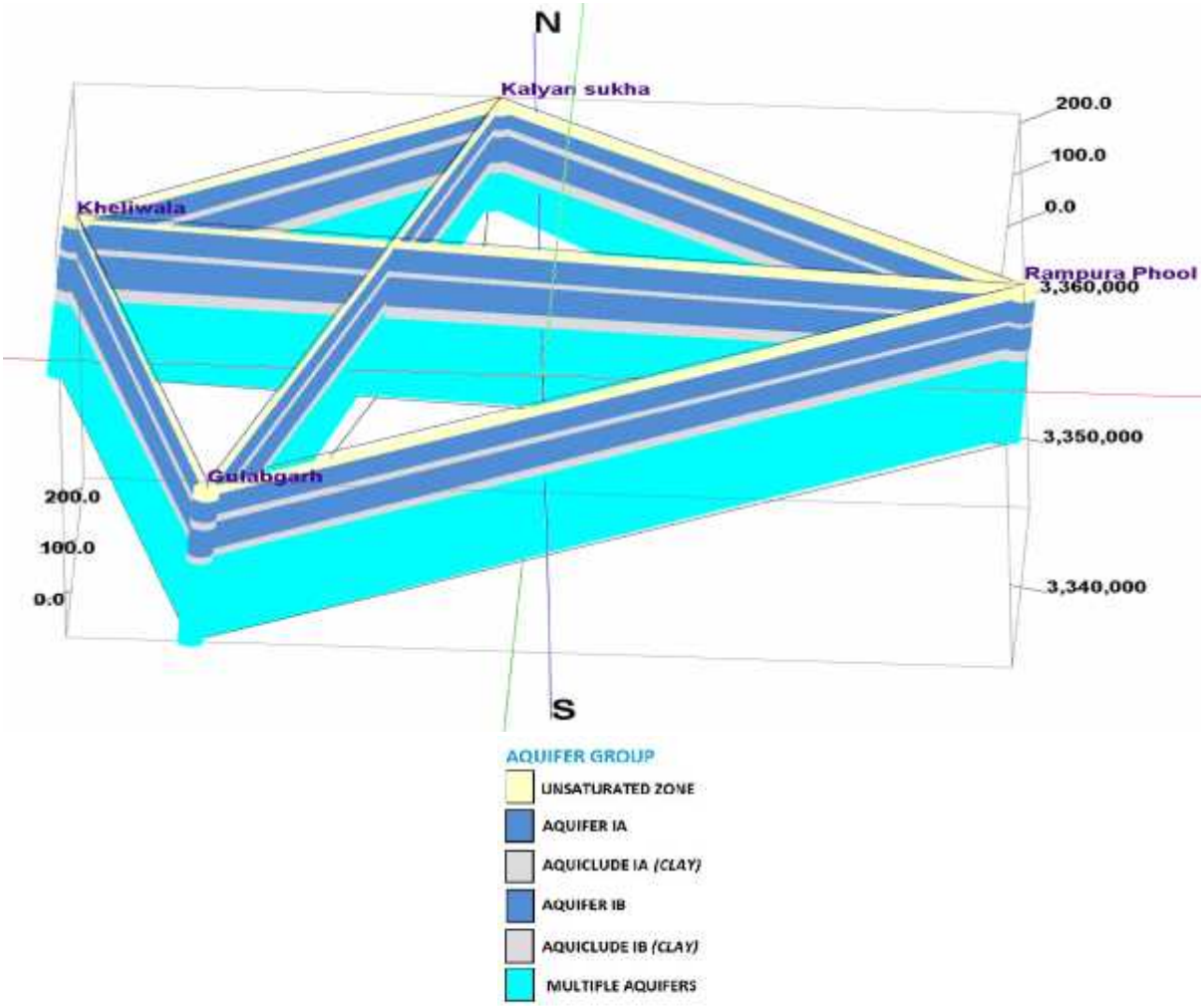
Lithological Cross section from Kheliwala to Rampura phul



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Nathana Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	219.93 mcm
	In-storage Fresh water resources	1518 mcm
	In-storage Saline water resources	92 mcm
	Total	1830 mcm
Ground Water Extraction (as per 2013)	Irrigation	149.75 mcm
	Domestic & Industrial	3.32 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		4.76 mcm
Stage of Groundwater Development		70 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.56 and 8.91. Ground water in the area is fresh to brackish. EC value of the ground water show wide variations and ranges from 1130 μS/cm to 1845 μS/cm at 25^0C. RSC values are varies from 4.19 to 8.52 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		***Nitrate (mg/l):*** Phulla (94)
Other issues		Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 267.30 mcm

Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*

Types and number of structures: NA

Other interventions proposed*:* NA

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Nathana Block (445.5 sq km)

Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 12.52 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: Not Required

Alternate Water sources

Surface water sources: *Tanks, Ponds*

Location, details and availability from such sources outside the area: Not Available

Regulation and Control:

Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Cotton, Sunflower, Maize

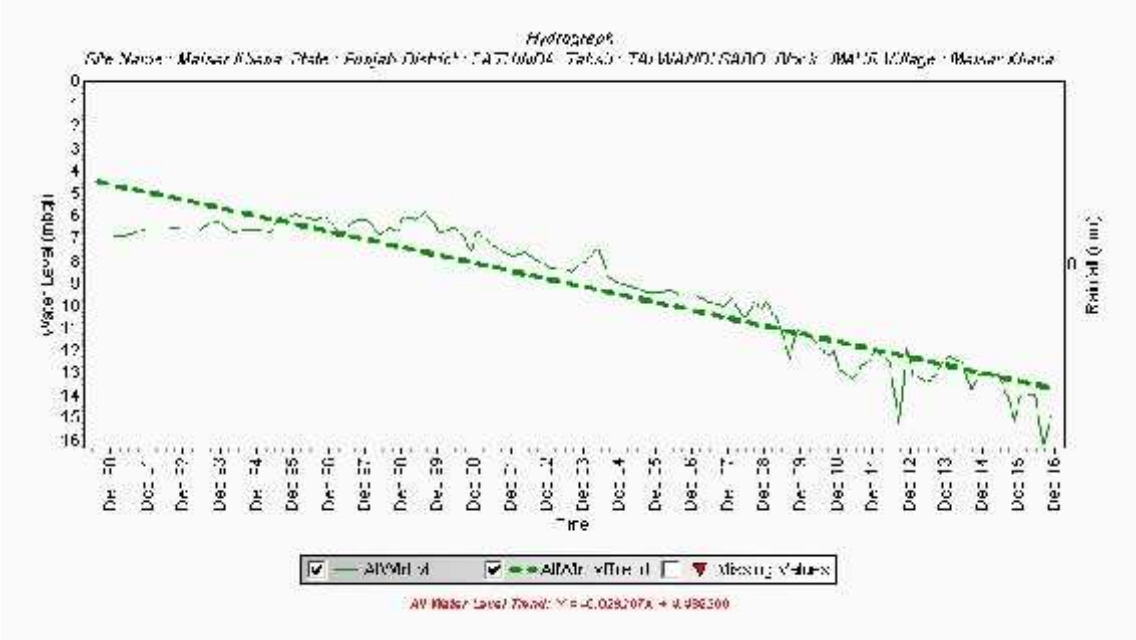
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

III. Salient Information of Maur Block

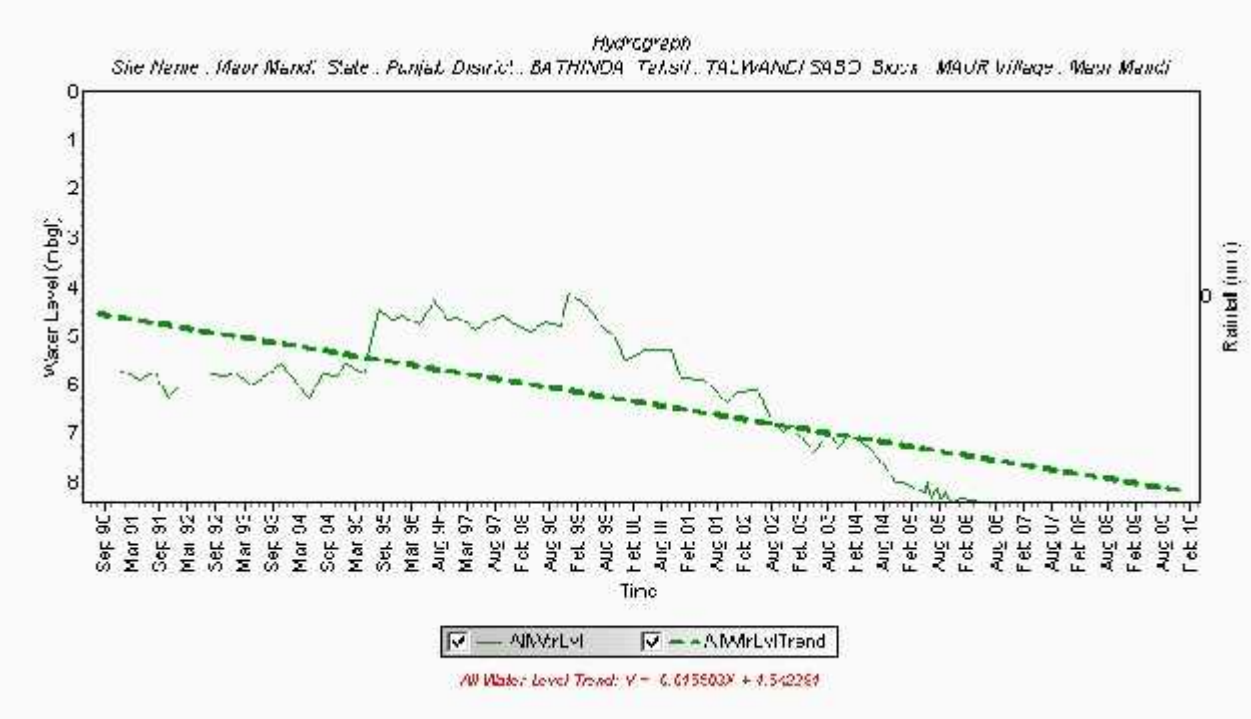
Block Area (in Km^2)	**356.10 sq km.**
District/ State	Bathinda, Punjab
Population	Urban Population: 0 Rural Population: 77656 Total population: 77656
Rainfall	Normal Monsoon: 332 mm Non-monsoon Rainfall : 63 mm Annual Average Rainfall: 395 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 521.64 sq km Net sown area: 266.86 sq km Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 195 % *Area under* Ground water Irrigation: 36.25 sq km Surface water irrigation: 211.82 sq km Number and types of abstraction structures: 4752, Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Total Ground Water Resources available is 1552 mcm (fresh and saline water) up to the depth of 300 m. The fresh water resources (103 mcm) are estimated up to the depth of 85 m on the basis of geophysical interpretations. The potential granular zones available for fresh water are 62 m. Saline water resources (1449 mcm) are estimated on the basis of well (up to 300 m) and the granular zones are counted after depth of 85 m and available zones are 61 m. Block is categorized as Over-Exploited as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and not suitable for irrigation purpose as such all users are tapping shallow aquifers. Drinking water supply wells of State Government tapping shallow aquifers Therefore, the ground water draft could not be assessed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 170.05 mcm Domestic and industrial water supply: 1.86 mcm *Future water demands* Irrigation development potential : (-)34.10 mcm Domestic and industrial water supply up to 2025 years : 2.67 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 7.85 – 13.65 m bgl Post Monsoon: 9.00 – 15.10 m bgl Mean (10 yrs) : 1.16 – (-)0.99 m/yr *Trends* Pre Monsoon: (-)0.41 m/yr Post Monsoon: (-)0.52 m/yr **Aquifer-II / III :** No Monitoring Stations

HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Maisar khana)



HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Maur Mandi)



Well is dried after 2007

Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Aeolian Alluvium

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED	6	0	0	0	**6**
PRIVATE	0	0	0	0	**0**
TOTAL	**6**	**0**	**0**	**1**	**7**

Aquifer wise Characteristics

Aquifer Group *	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)#	Yield (m^3/day) #	Specific Yield	Storativity #
Aquifer -I	Quatern ary Alluvial deposits	Unconfine d to confined	123	Not Available (NA)	Not Available (NA)	12 % *(0.072)*	Not Available (NA)

* Well field proposed in adjacent block

CGWB, 2015, Ground Water Exploration Report, Punjab state

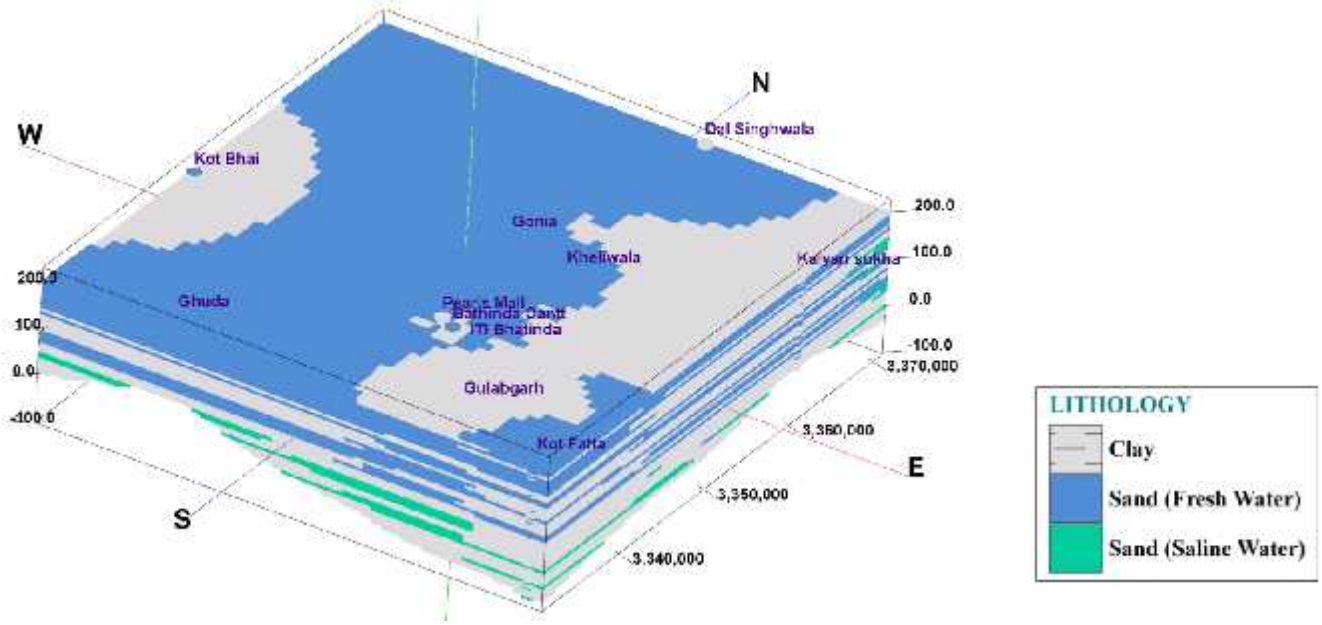
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

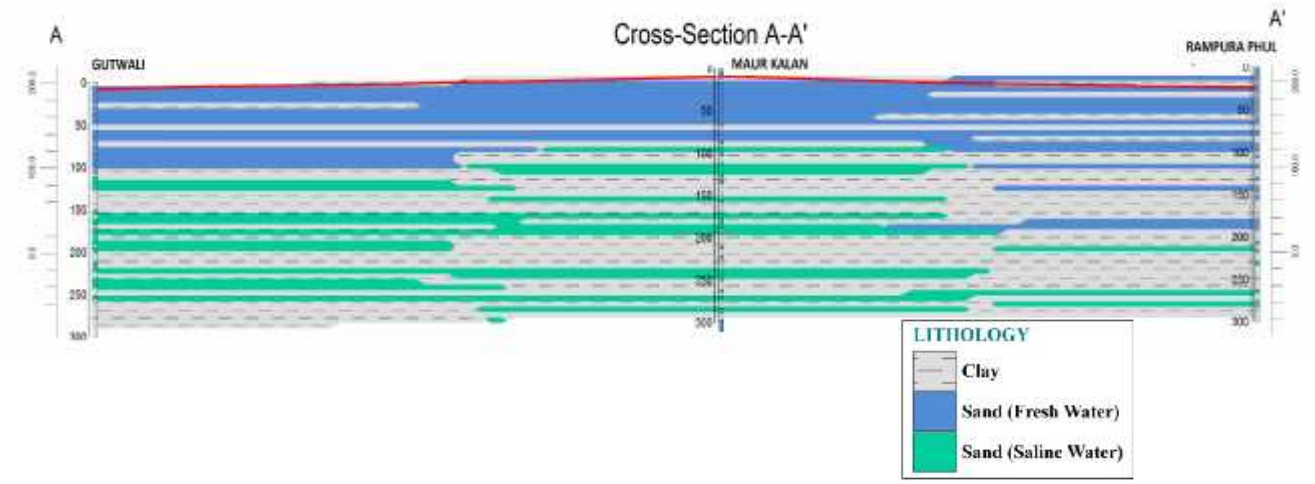
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED	0	0	0	0	**0**
PRIVATE	0	0	0	0	**0**
TOTAL	**0**	**0**	**0**	**1**	**1**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

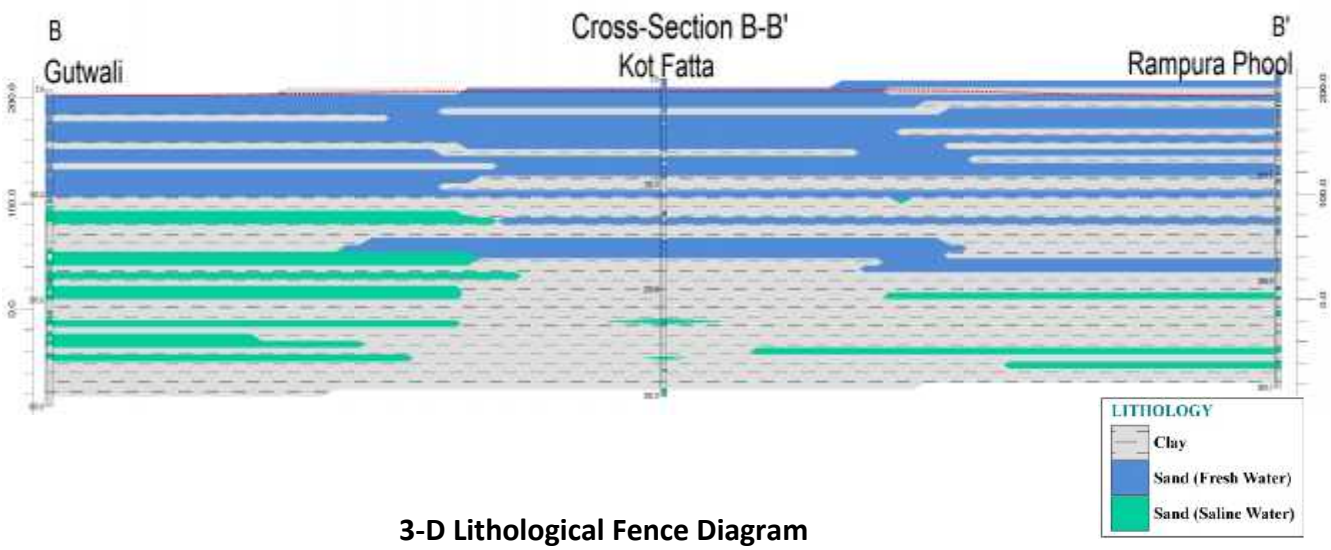
3-D Lithological model of Maur Block



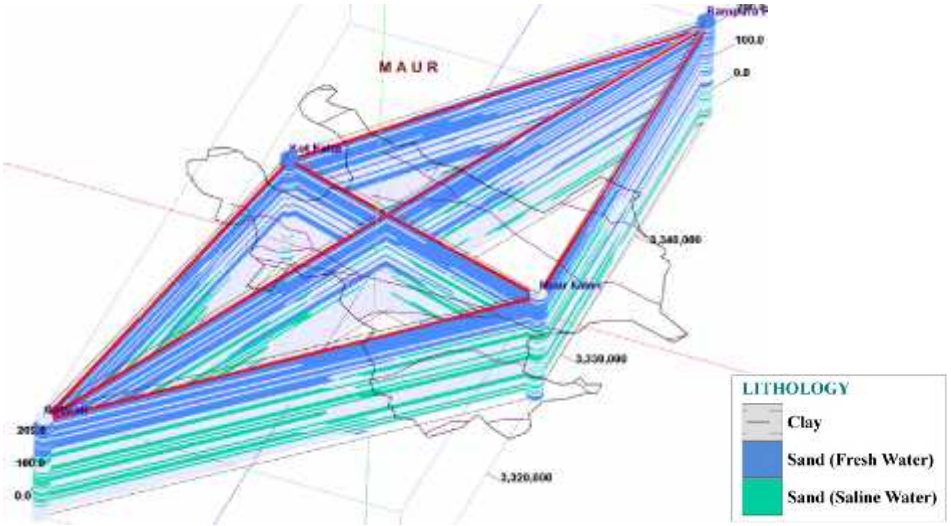
Lithological Cross section from Gutwali to Rampura Phul



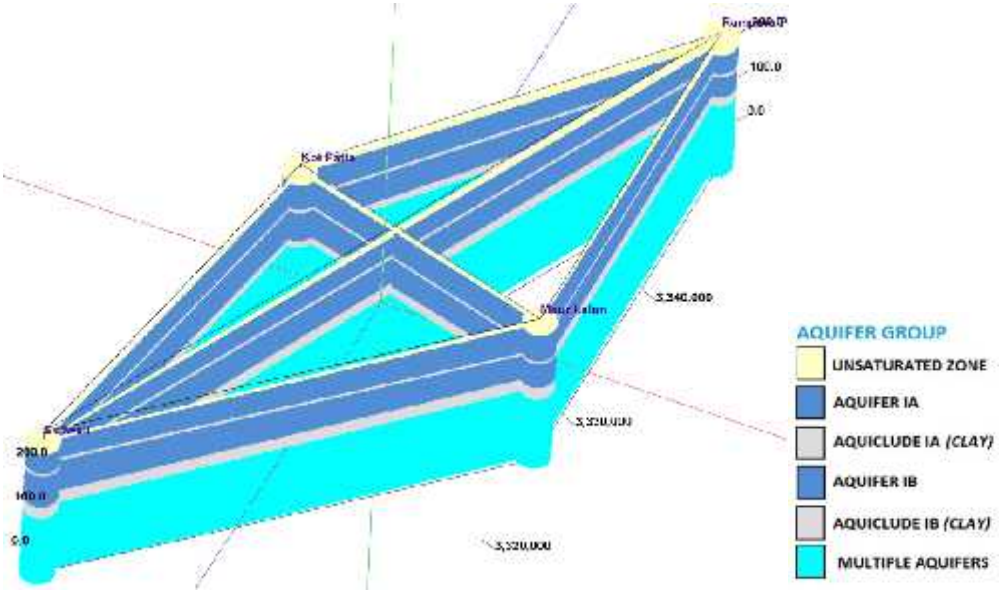
Lithological Cross section Gutwali – Kot Fatta- Rampura Phul



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Maur Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	138.63 mcm
	In-storage Fresh water resources	103 mcm
	In-storage Saline water resources	1449 mcm
	Total	1691 mcm
Ground Water Extraction (as per 2013)	Irrigation	170.05 mcm
	Domestic & Industrial	1.86 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		2.67 mcm
Stage of Groundwater Development		124 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.12 and 9.44. Ground water in the area is slightly fresh to marginal saline. EC value of the ground water show wide variations and ranges from 300 µS/cm to 2420 µS/cm at 25^0C. RSC values are varies from -7.39 to 2.74 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		NA
Other issues		Water level decline has been observed in major part of the block due to in

	discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 299.12 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will conserve 2.41 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Maur Block (356.10 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 14.22 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean .The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop*
Area coverage: *25 % of the total rice area needs to change i.e.* 16.50 sq km
Anticipated volume of water to be saved: 16.50 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
138.63	170.05	171.92	66	16.50	16.50	153.55	124	11.9	25

Alternate Water sources

Surface water sources: *Tanks, Ponds*
Location, details and availability from such sources outside the area: Not Available

Regulation and Control:

Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Cotton, Sunflower, Maize

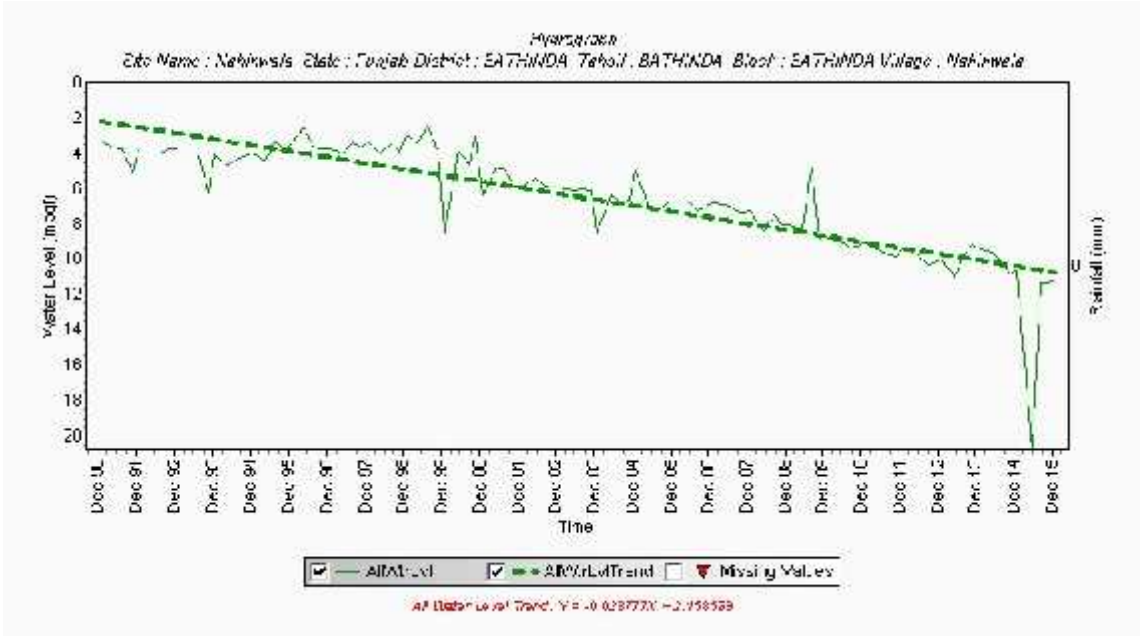
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

IV. Salient Information of Bathinda Block

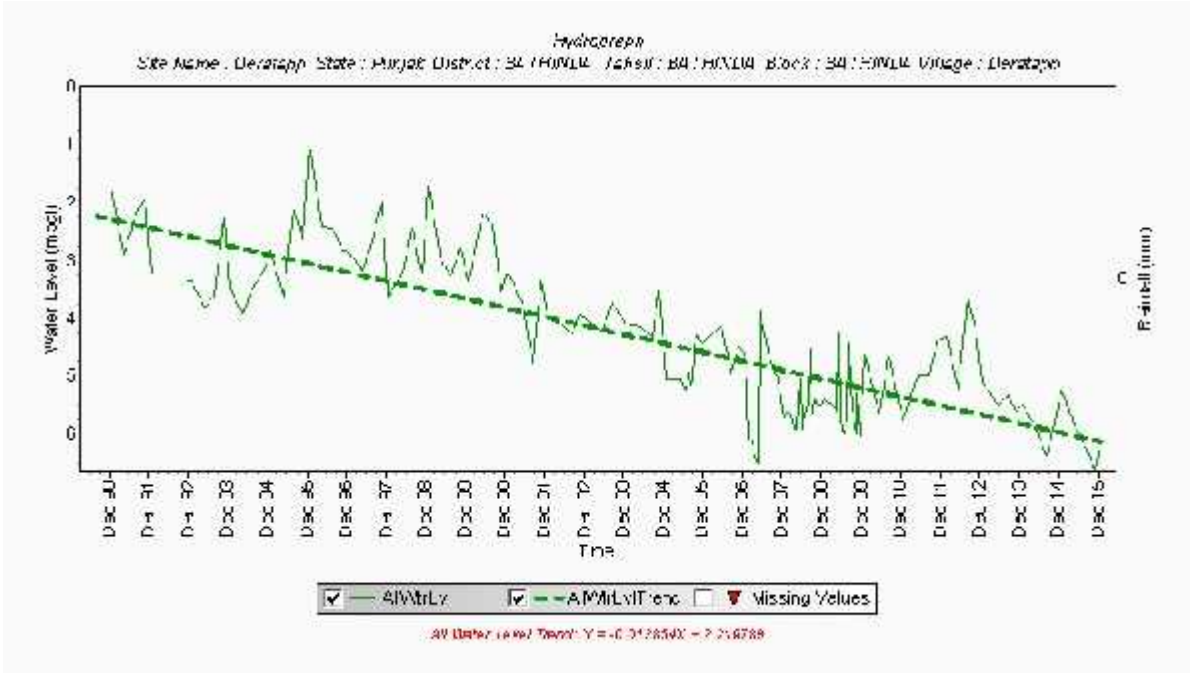
Block Area (in Km^2)	**739.5 sq km.**
District/ State	Bathinda, Punjab
Population	Urban Population: 4890 Rural Population: 188916 Total population: 193806
Rainfall	Normal Monsoon: 321 mm Non-monsoon Rainfall : 58 mm Annual Average Rainfall: 379 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 951.37 sq km Net sown area: 504.55sq km Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 189% *Area under* Ground water Irrigation: 60.14 sq km Surface water irrigation: 426.05 sq km Number and types of abstraction structures: 9724, Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Total Ground Water Resources available is 2407 mcm (fresh and saline water) up to the depth of 300 m. The fresh water resources (1903 mcm) are estimated up to the depth of 250 m on the basis of geophysical interpretations. The potential granular zones available for fresh water are 97 m. Saline water resources (504 mcm) are estimated on the basis of well (up to 300 m) and the granular zones are counted after depth of 250 m and available zones are 15 m. Block is categorized as Over-Exploited as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and not suitable for irrigation purpose as such all users are tapping shallow aquifers. Drinking water supply wells of State Government tapping shallow aquifers Therefore, the ground water draft could not be assessed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 342.62 mcm Domestic and industrial water supply: 12.52 mcm *Future water demands* Irrigation development potential : (-)19.50 mcm Domestic and industrial water supply up to 2025 years : 17.93 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 6.04 – 16.80 m bgl Post Monsoon: 4.36 – 17.52 m bgl Mean (10 yrs) : 3.80 – (-)0.29 m/yr *Trends* Pre Monsoon: 0.09 – (-)0.48 m/yr Post Monsoon: (-)0.11 – (-)0.52 m/yr **Aquifer-II / III :** No Monitoring stations

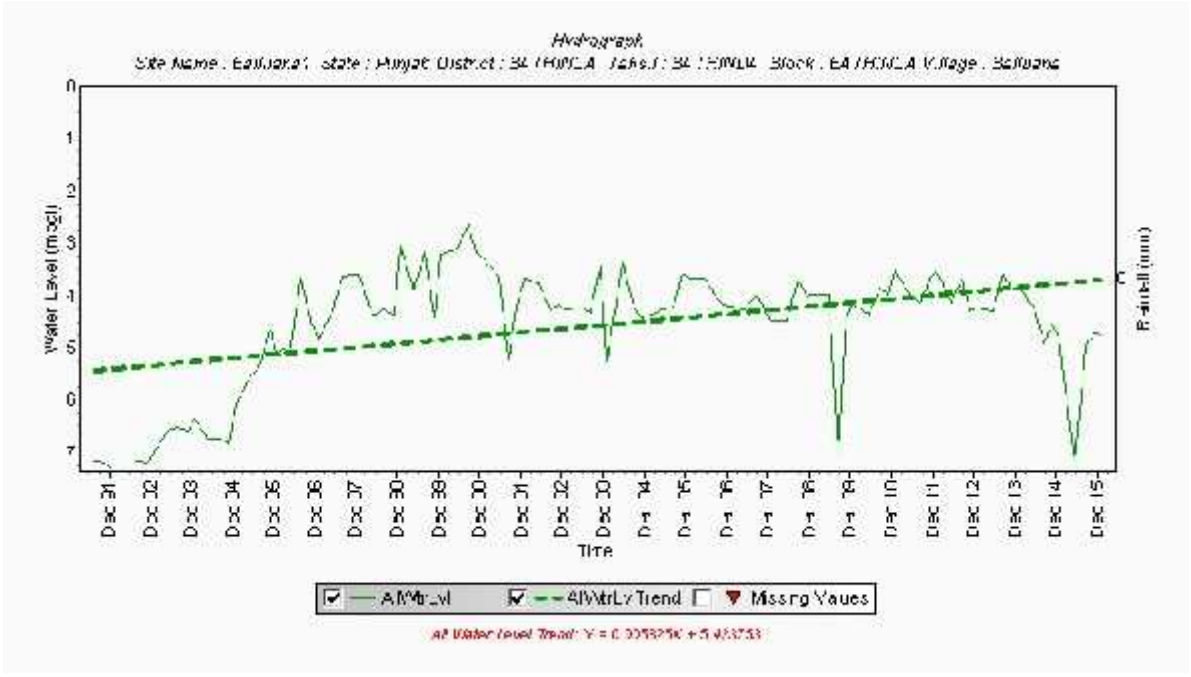
HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Nahin Wala)



HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Deratapp)



HYDROGRAPH SHOWING RISING WATER TABLE (Location: Balluana)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Aeolian Alluvium , Older Alluvium

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	1	0	1	4	**6**
WRED	6	1	0	1	**8**
PRIVATE	0	1	1	1	**3**
TOTAL	**7**	**2**	**2**	**6**	**17**

Aquifer wise Characteristics

Aquifer Group *	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmissivity (m^2/day)#	Yield (m^3/day) #	Specific Yield	Storativity #
Aquifer -I	Quarternary Alluvial deposits	Unconfined to confined	115	$7.1*10^{-1}$ to $1.3*10^{3}$	1000 to 1500	12 % *(0.072)*	$2.8*10^{-2}$

* Well field proposed in adjacent block

CGWB, 2015, Ground Water Exploration Report, Punjab state

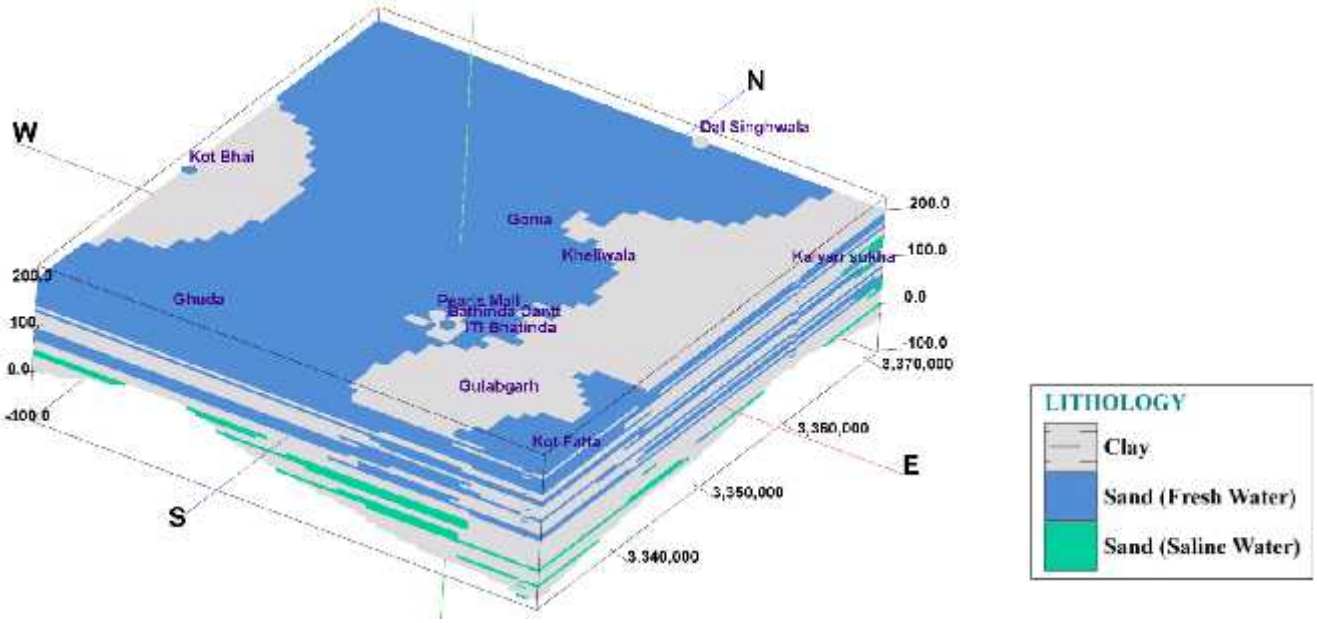
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	1	3	**4**
WRED	0	0	0	1	**1**
PRIVATE	0	1	1	1	**3**
TOTAL	**0**	**1**	**2**	**5**	**8**

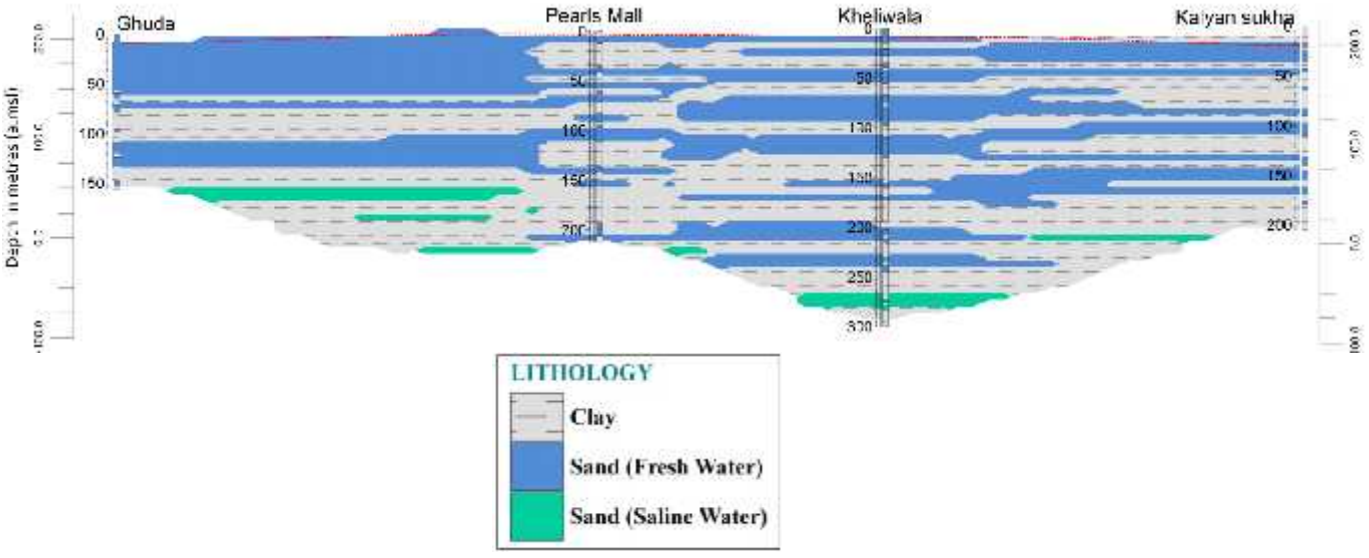
The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

3-D Lithological model of Bathinda Block

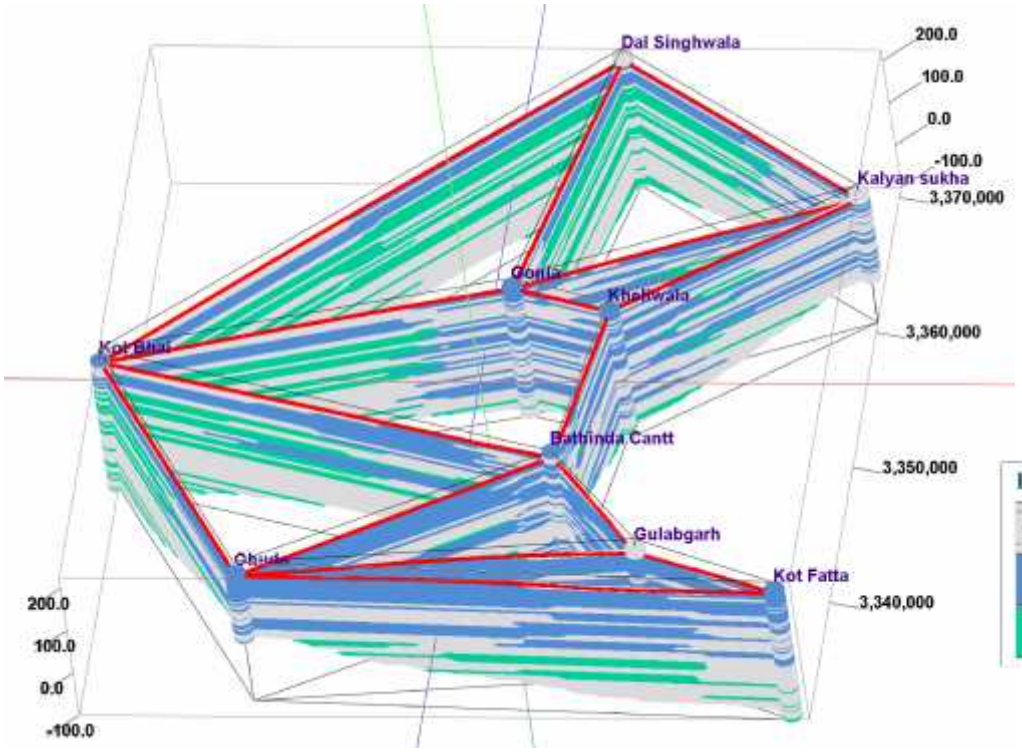


Lithological Cross section from Kot Fatta to Dal singhwala

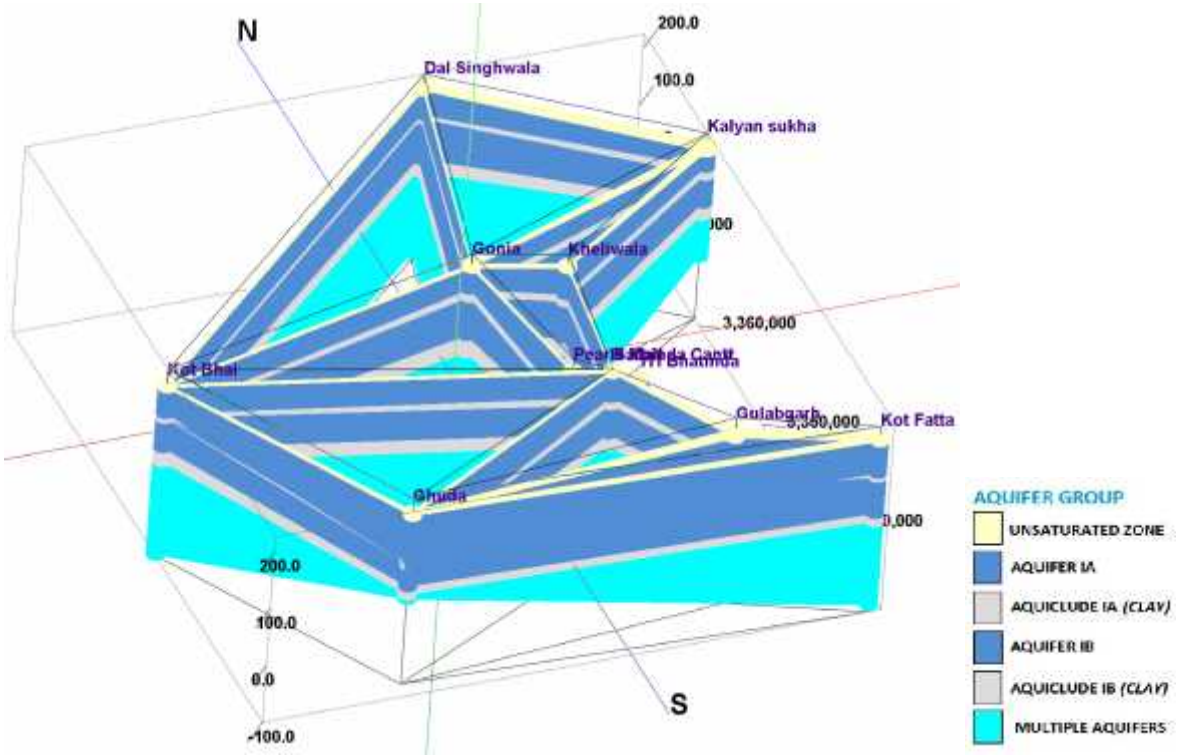
Lithological Cross section from Ghuda to Kalyan Sukha



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Bathinda Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	341.05 mcm
	In-storage Fresh water resources	1903 mcm
	In-storage Saline water resources	504.36 mcm
	Total	2749 mcm
Ground Water Extraction (as per 2013)	Irrigation	342.62 mcm
	Domestic & Industrial	12.52 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		17.93mcm
Stage of Groundwater Development		104 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 7.92 and 9.46. Ground water in the area is slightly fresh to marginal saline. EC value of the ground water show wide variations and ranges from 305 μS/cm to 3950 μS/cm at 25^0C. RSC values are varies from -1.10 to 21.88 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		***Fluoride (mg/l):*** Gulabgarh (2.16) ***Nitrate (mg/l):*** Kot Shamir (129), Balluana (125), Gulabgarh (64) and Nahian wala (61) ***Iron (mg/l):*** Ganga (2.99) and Kot Shamir (1.65)
Other issues		Water level decline has been observed in major part of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 266.22 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will conserve 3.94 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices
Area proposed to be covered: Entire Bathinda Block (739.50 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 28.65 mcm

Required Change in cropping pattern: Not Required

Alternate Water sources
Surface water sources: *Tanks, Ponds*
Location, details and availability from such sources outside the area: Not Available
Regulation and Control:
Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any
Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Cotton, Sunflower, Maize

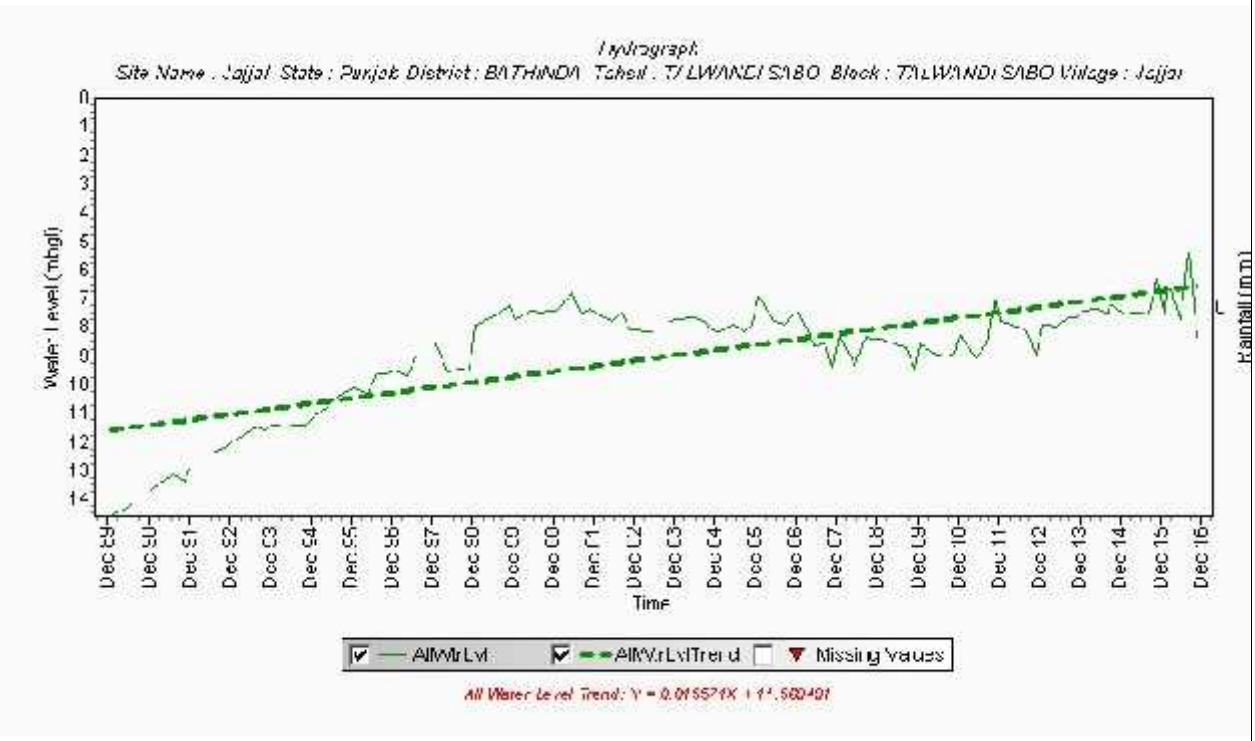
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

V. Salient Information of Talwandi Saboo Block

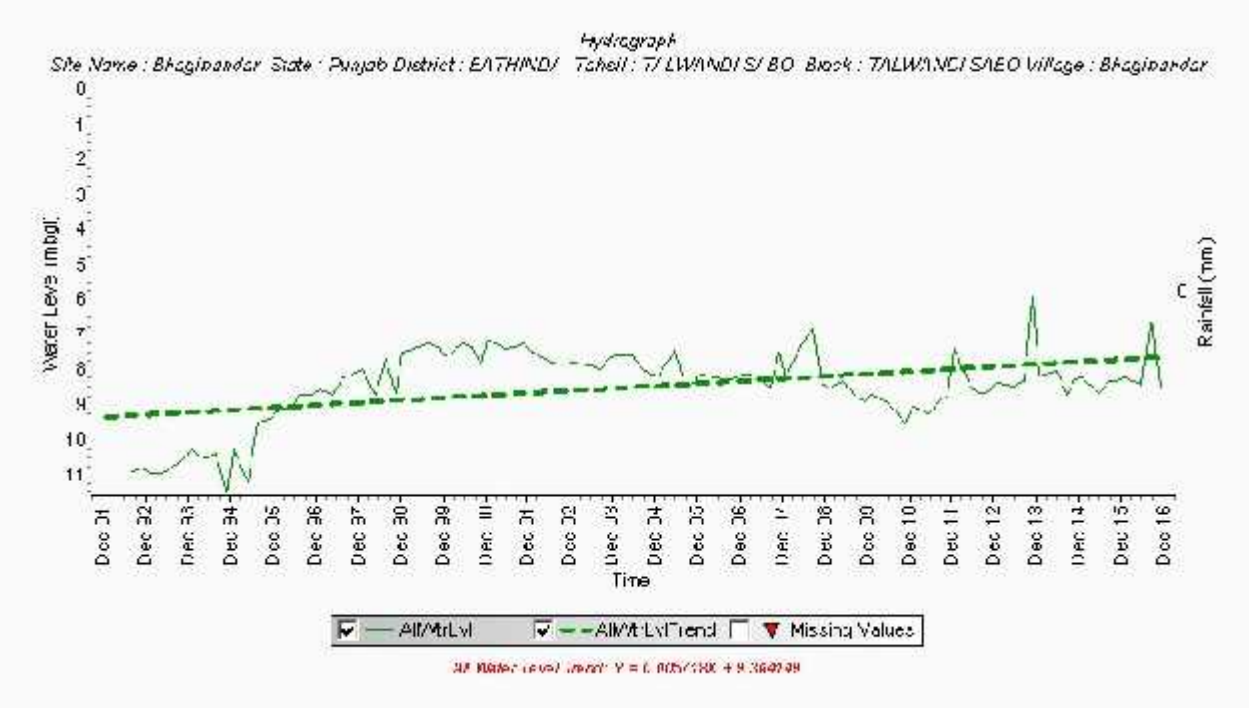
Block Area (in Km^2)	**522.40 sq km.**
District/ State	Bathinda, Punjab
Population	Urban Population: 0 Rural Population: 137035 Total population: 137035
Rainfall	Normal Monsoon: 315 mm Non-monsoon Rainfall : 78 mm Annual Average Rainfall: 393 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 852.88 sq km Net sown area: 453.34 sq km Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 188% *Area under* Ground water Irrigation: 8.11 sq km Surface water irrigation: 435.19 sq km Number and types of abstraction structures: 6170, Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Total Ground Water Resources available is 3173 mcm (fresh and saline water) up to the depth of 300 m. The fresh water resources (921 mcm) are estimated up to the depth of 92 m on the basis of geophysical interpretations. The potential granular zones available for fresh water are 65 m. Saline water resources (2252 mcm) are estimated on the basis of well (up to 300 m) and the granular zones are counted after depth of 92 m and available zones are 99 m. Block is categorized as Safe as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and not suitable for irrigation purpose as such all users are tapping shallow aquifers. Drinking water supply wells of State Government tapping shallow aquifers Therefore, the ground water draft could not be assessed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 81.99 mcm Domestic and industrial water supply: 4.90 mcm *Future water demands* Irrigation development potential : 57.15 mcm Domestic and industrial water supply up to 2025 years : 7.02 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 5.25 – 9.65 m bgl Post Monsoon: 5.85 – 11.12 m bgl Mean (10 yrs) : 0.29 – (-)0.78 m/yr *Trends* Pre Monsoon: 0.17 – (-)0.06 m/yr Post Monsoon: 0.20 – (-)0.14 m/yr **Aquifer-II /III** No Monitoring Stations

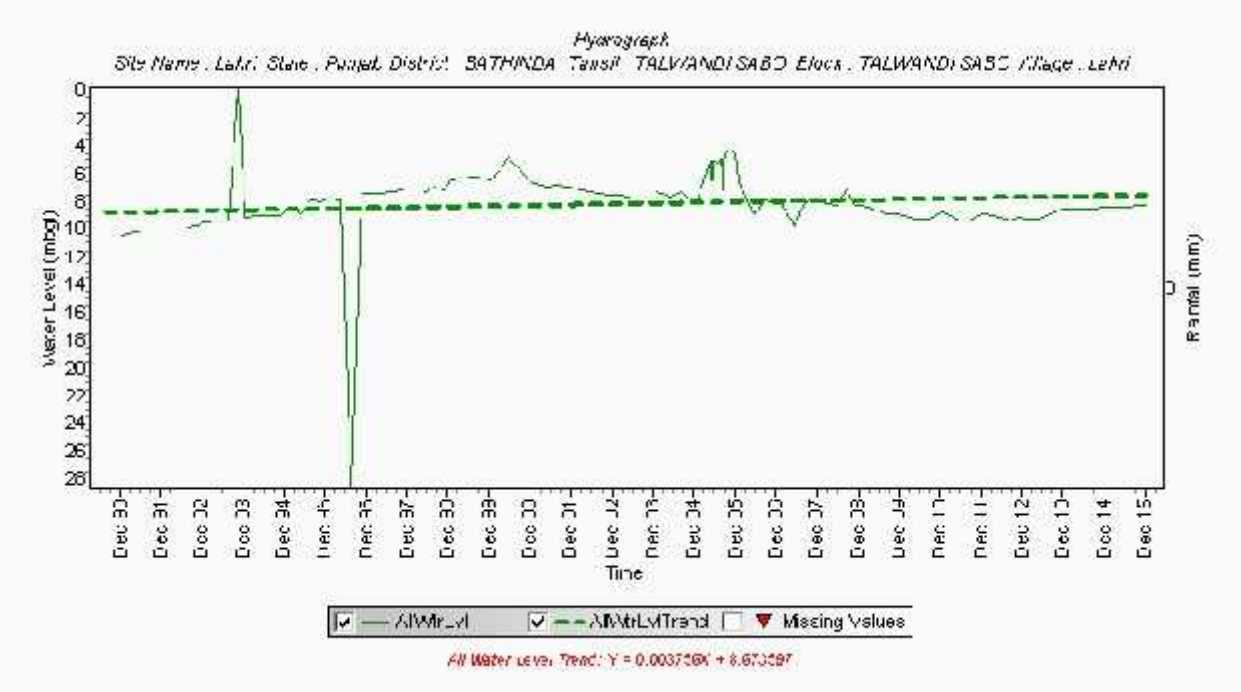
HYDROGRAPH SHOWING RISING WATER TABLE (Location: Jajjal)



HYDROGRAPH SHOWING RISING WATER TABLE (LOCATION: Bhagi Bandhar)



HYDROGRAPH SHOWING RISING WATER TABLE (Location: Lahri)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Aeolian Alluvium

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	0	**0**
WRED	6	0	0	0	**6**
PRIVATE	0	0	1	1	**2**
TOTAL	**6**	**0**	**1**	**1**	**8**

Aquifer wise Characteristics

Aquifer Group *	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)#	Yield (m^3/day) #	Specific Yield	Storativity #
Aquifer -I	Quarter-nary Alluvial deposits	Unconfined to confined	164	Not Available (NA)	Not Available (NA)	12 % *(0.072)*	Not Available (NA)

* Well field proposed in adjacent block

CGWB, 2015, Ground Water Exploration Report, Punjab state

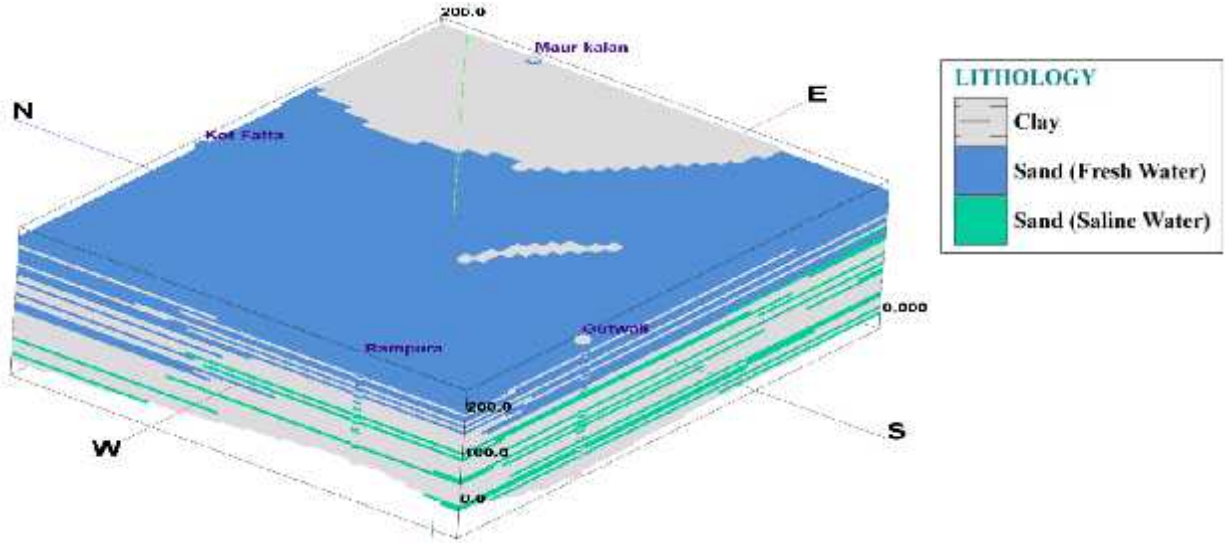
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

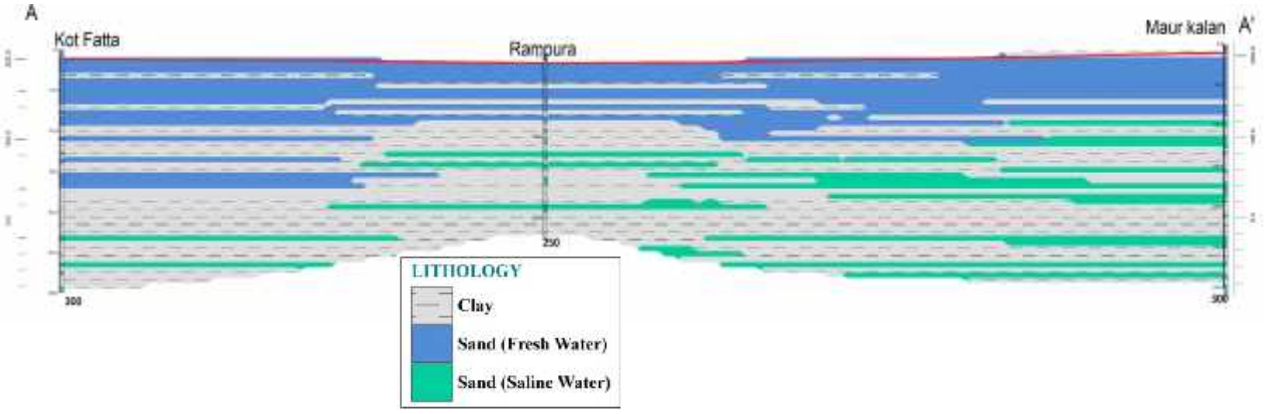
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	0	**0**
WRED	1	0	0	0	**1**
PRIVATE	0	0	1	1	**2**
TOTAL	**1**	**0**	**1**	**1**	**3**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

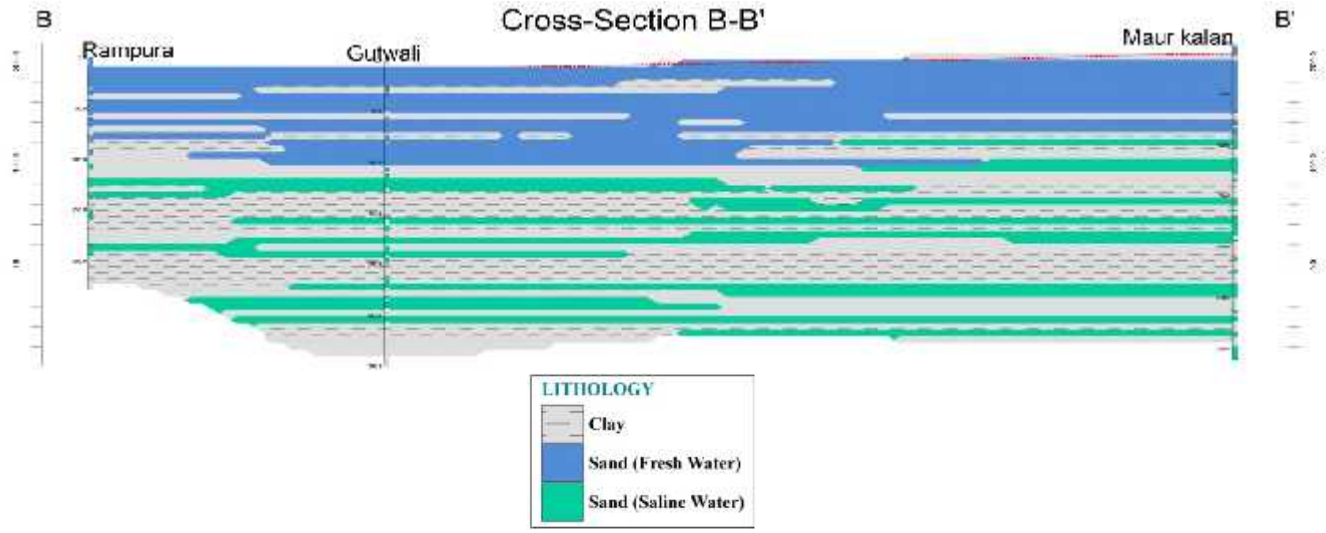
3-D Lithological model of Talwandi Saboo Block



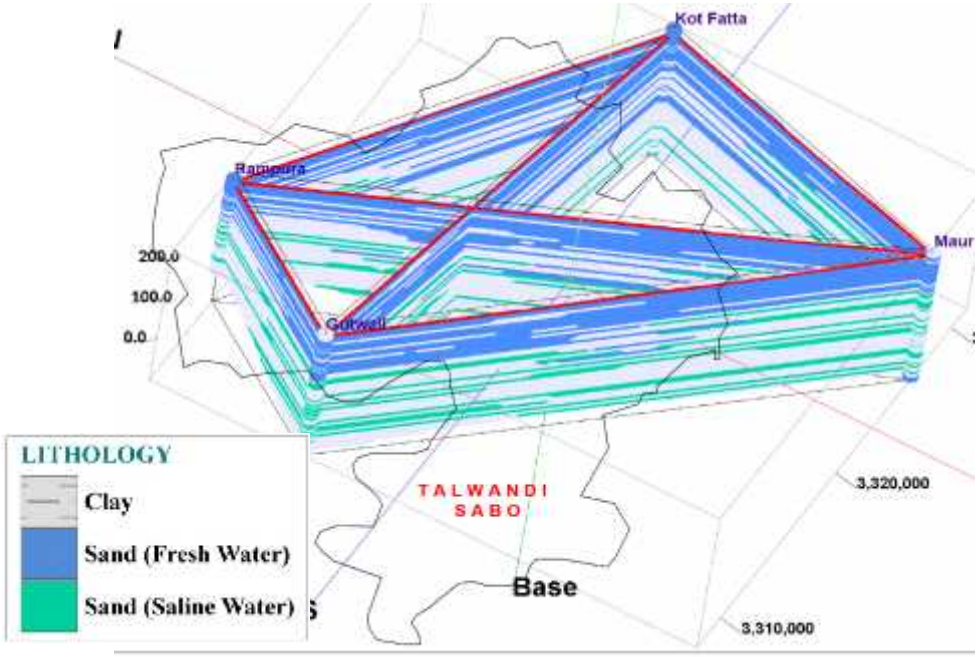
Lithological Cross section from Kot Fatta to Maur kalan



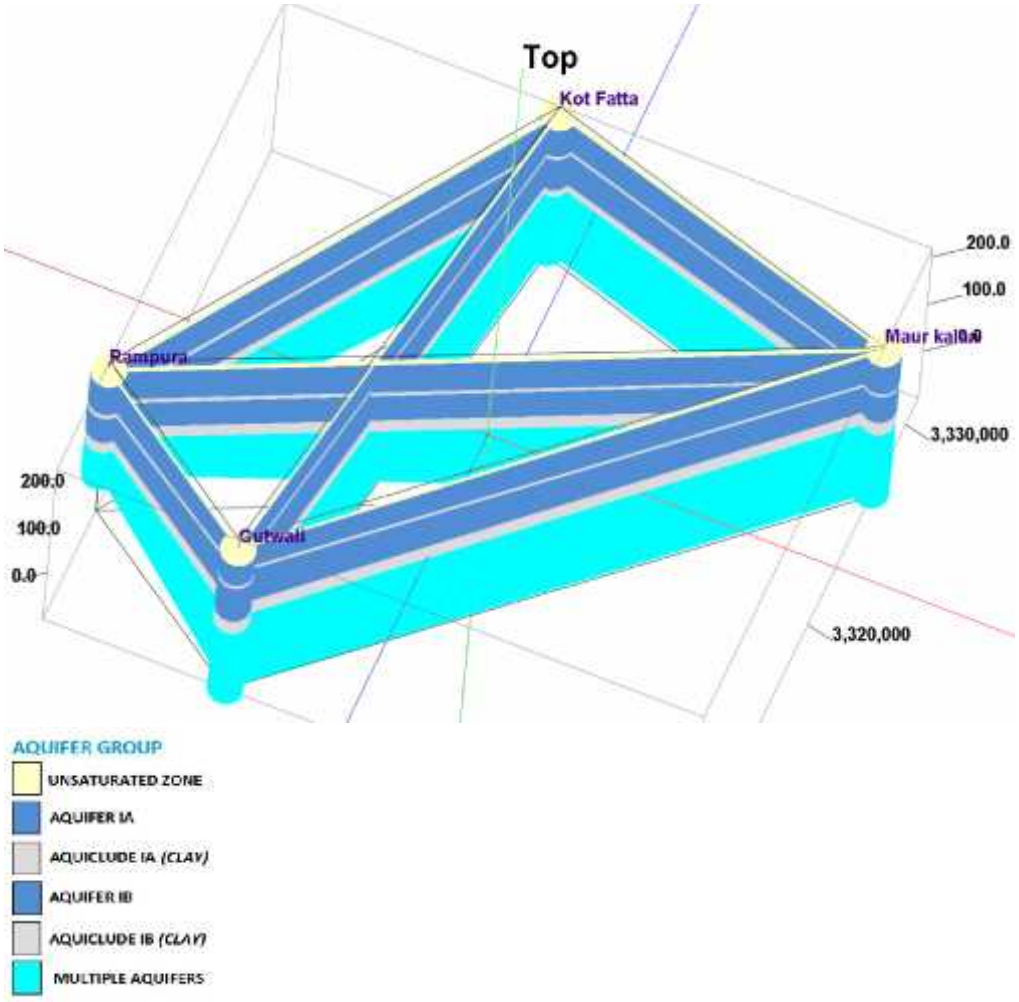
Lithological Cross section from Ghuda to Kalyan Sukha



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Talwandi Saboo Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	146.16 mcm
	In-storage Fresh water resources	921 mcm
	In-storage Saline water resources	2252 mcm
	Total	3320 mcm
Ground Water Extraction (as per 2013)	Irrigation	81.99 mcm
	Domestic & Industrial	4.90 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		7.02 mcm
Stage of Groundwater Development		59 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.52 and 8.67. Ground water in the area is slightly fresh to marginal saline. EC value of the ground water show wide variations and ranges from 690 μS/cm to 2255 μS/cm at 25^0C. RSC values are varies from -4.58 to 3.11 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		***Nitrate (mg/l):*** Jajjal (314)and Maiser Khanna (77) ***Iron (mg/l):*** Maiser Khanna (1.642)
Other issues		Water level decline has been observed in north eastern part of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 188.06 mcm

Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA
Other interventions proposed*:* NA

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Bathinda Block (522.40 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 6.86 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: Not required
Area coverage: Not required
Anticipated volume of water to be saved: Not required

Alternate Water sources

Surface water sources: *Tanks, Ponds*
Location, details and availability from such sources outside the area: Not Available

Regulation and Control:

Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

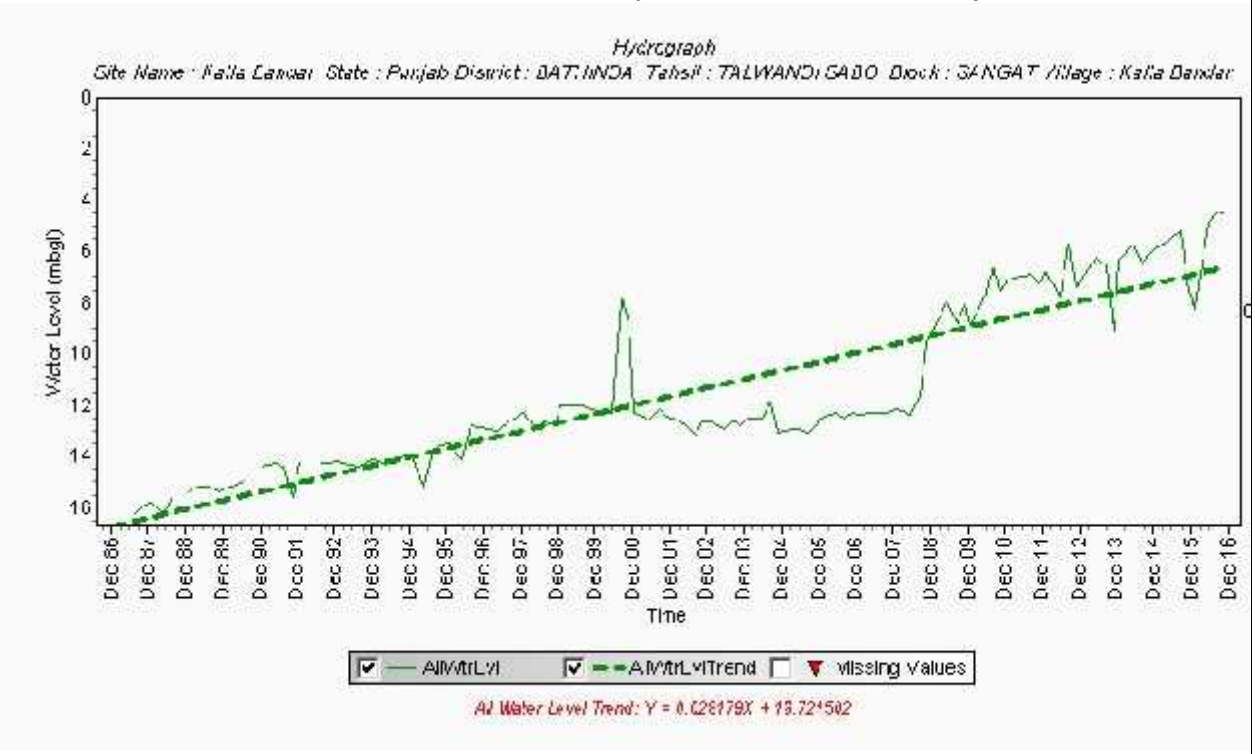
Sl.No	Techniques	Water Saving (%)	Crops
1	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Cotton, Sunflower, Maize

VI. Salient Information of Sangat Block

Block Area (in Km^2)	**630.4 sq km.**
District/ State	Bathinda, Punjab
Population	Urban Population: 0 Rural Population: 120046 Total population: 120046
Rainfall	Normal Monsoon: 349 mm Non-monsoon Rainfall : 41 mm Annual Average Rainfall: 390 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 696.20 sq km Net sown area: 389.10 sq km Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 179% *Area under* Ground water Irrigation: 11.50 sq km Surface water irrigation: 344.42 sq km Number and types of abstraction structures: 3272, Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Total Ground Water Resources available is 245 mcm (fresh and saline water) up to the depth of 156 m. The fresh water resources (158 mcm) are estimated up to the depth of 150 m on the basis of geophysical interpretations. The potential granular zones available for fresh water are 95 m. Saline water resources (87 mcm) are estimated on the basis of well (up to 156 m) and the granular zones are counted after depth of 150 m and available zones are 2 m. Block is categorized as Safe as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and not suitable for irrigation purpose as such all users are tapping shallow aquifers. Drinking water supply wells of State Government tapping shallow aquifers Therefore, the ground water draft could not be assessed for deeper aquifer.

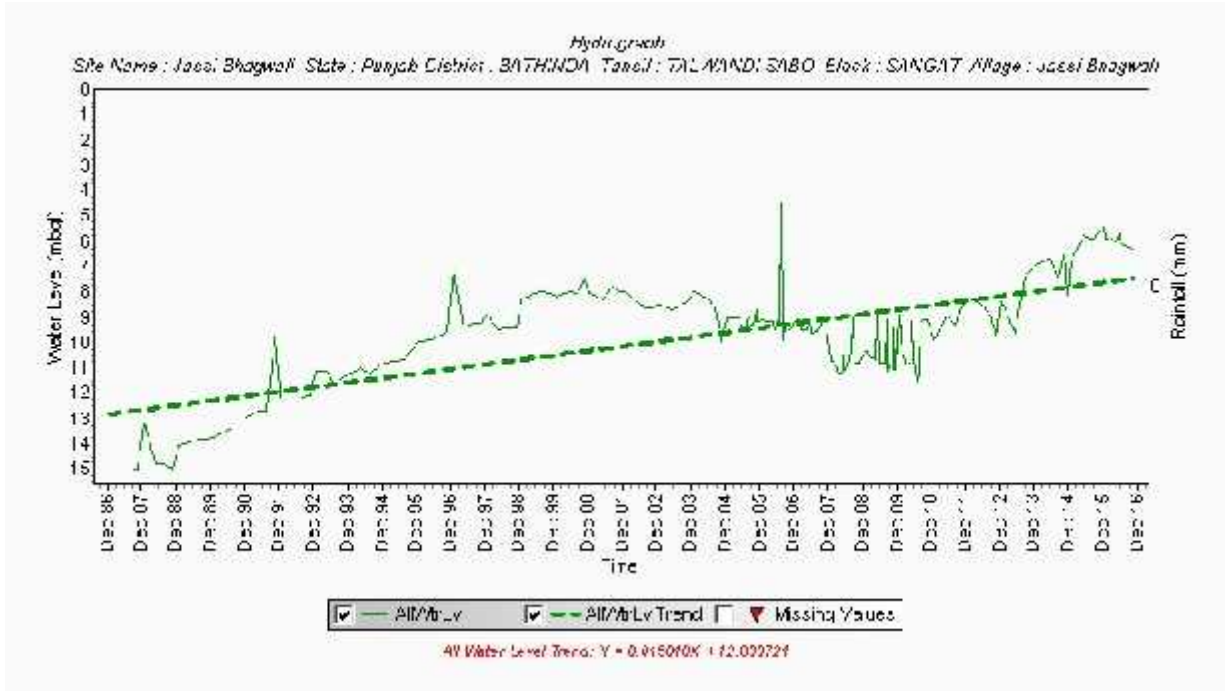
Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 83.83 mcm Domestic and industrial water supply: 2.83 mcm *Future water demands* Irrigation development potential : 67.73 mcm Domestic and industrial water supply up to 2025 years : 4.05 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 1.76 – 9.60 m bgl Post Monsoon: 3.98 – 9.30 m bgl Mean (10 yrs) : 0.21 – (-)3.40 m/yr *Trends* Pre Monsoon: 0.84 – (-)0.02 m/yr Post Monsoon: 0.56 – (-)0.01 m/yr **Aquifer-II & Aquifer-III** No Monitoring Stations

HYDROGRAPH SHOWING RISING WATER TABLE (Location: Kalla Bandhar)



HYDROGRAPH SHOWING RISING WATER TABLE (Location: Raike Kalan)

HYDROGRAPH SHOWING RISING WATER TABLE (Location: Jassi Bhagwali)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Aeolian Alluvium

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	1	0	0	0	**1**
WRED	7	0	0	0	**7**
PRIVATE	0	1	0	0	**1**
TOTAL	**8**	**1**	**0**	**0**	**9**

Aquifer wise Characteristics

Aquifer Group *	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)#	Yield (m^3/day) #	Specific Yield	Storativity #
Aquifer -I	Quatern ary Alluvial deposits	Unconfine d to confined	97	Not Available (NA)	Not Available (NA)	12 % (0.072)	Not Available (NA)

* Well field proposed in adjacent block

CGWB, 2015, Ground Water Exploration Report, Punjab state

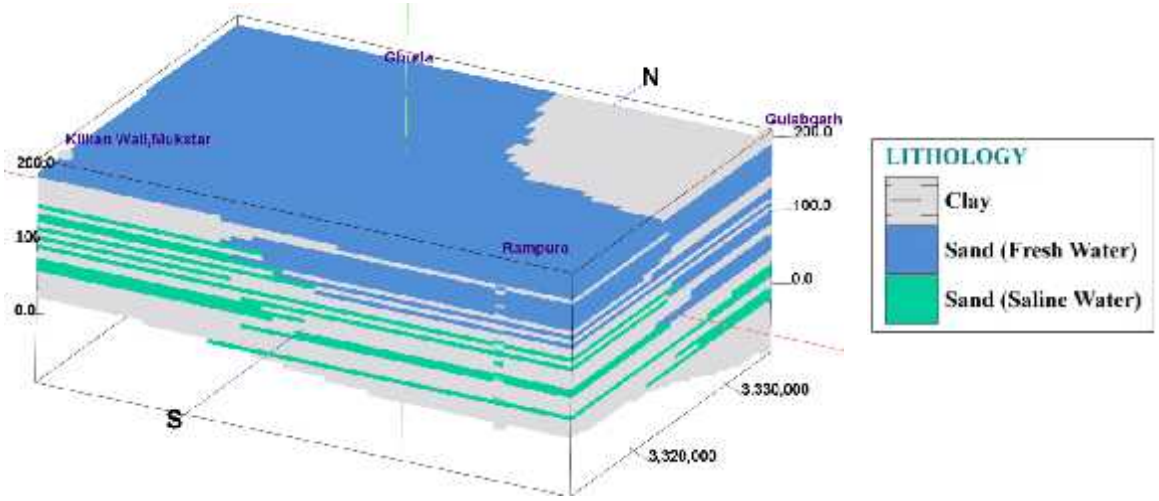
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

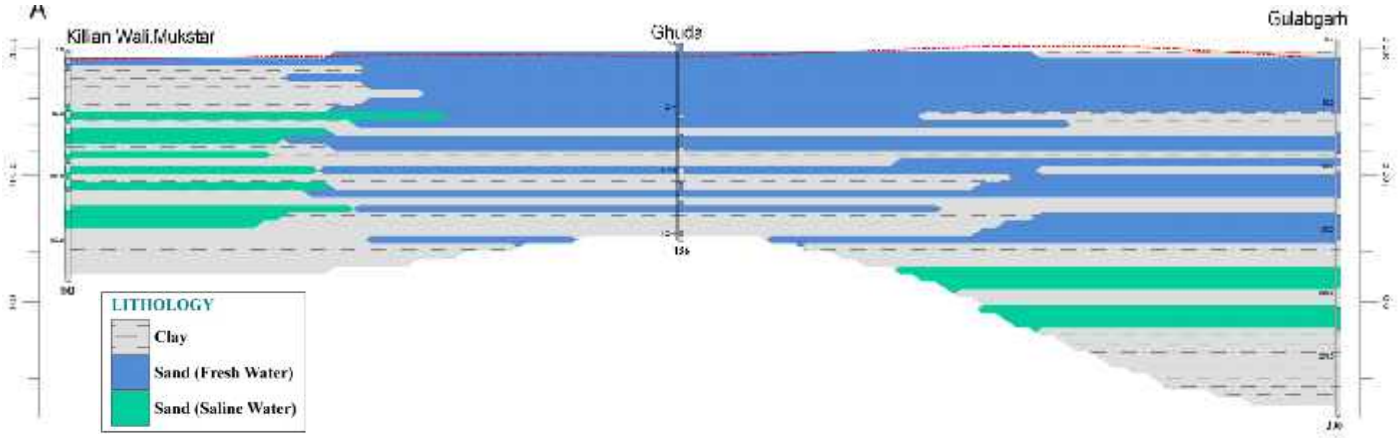
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	0	**0**
WRED	1	0	0	0	**1**
PRIVATE	0	1	0	0	**1**
TOTAL	**1**	**1**	**0**	**0**	**2**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

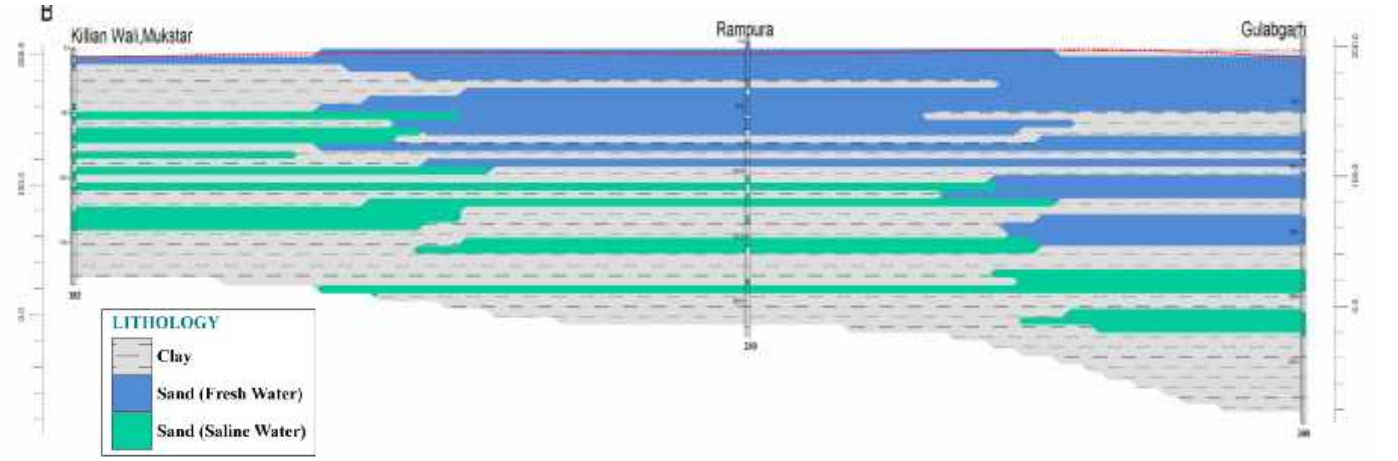
3-D Lithological model of Sangat Block



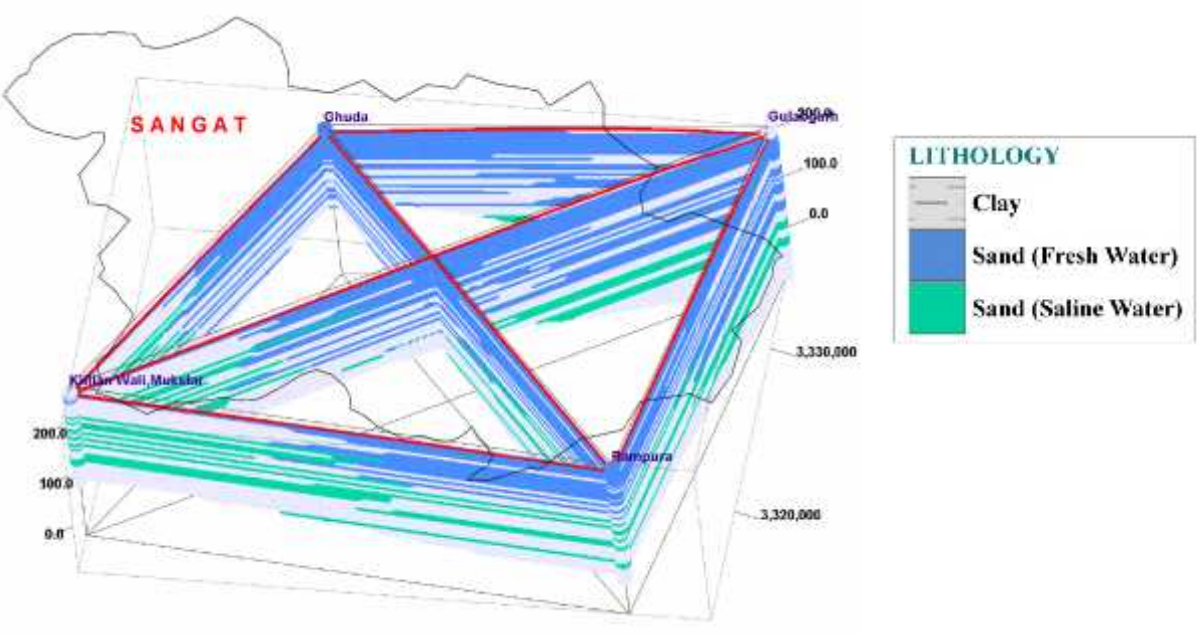
Lithological Cross section Killian wali – Ghuda- Gulabgarh



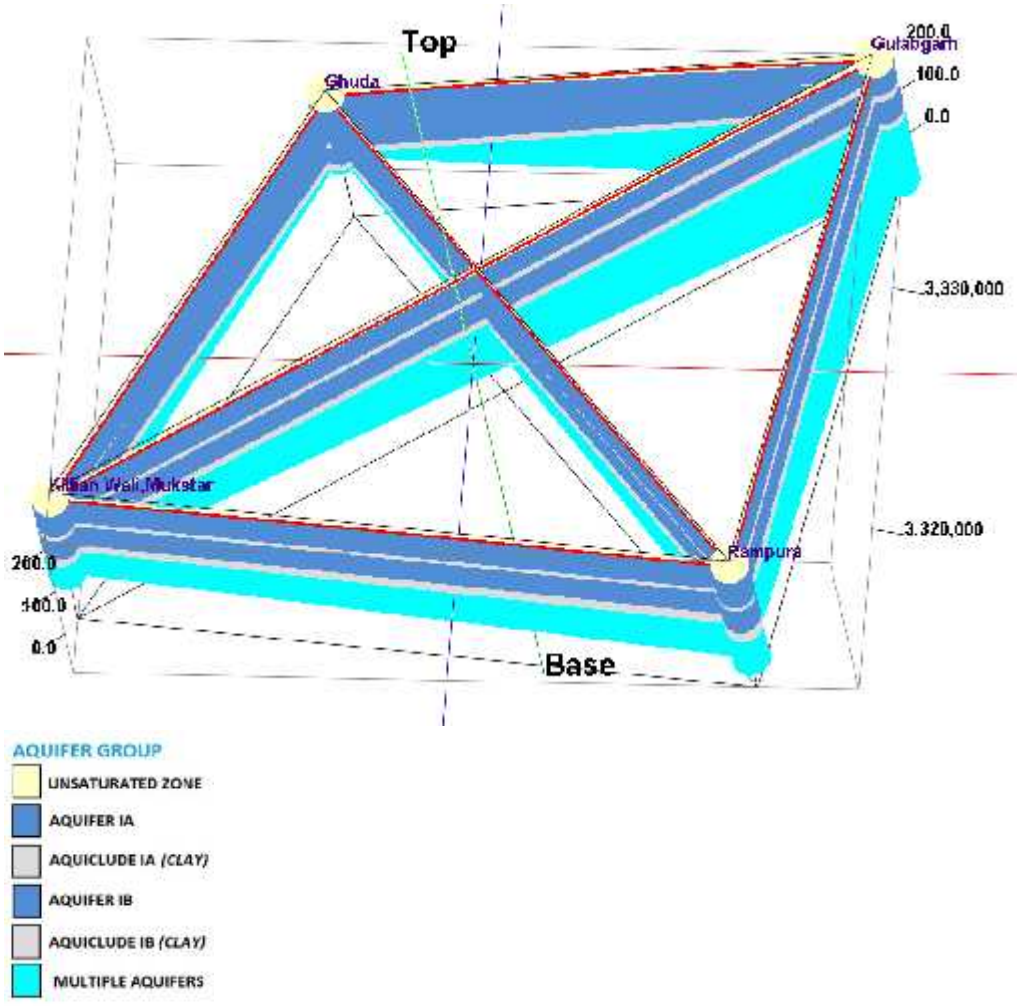
Lithological Cross section Killian wali – Rampura- Gulabgarh



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Sangat Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	155.61 mcm
	In-storage Fresh water resources	158 mcm
	In-storage Saline water resources	87 mcm
	Total	401 mcm
Ground Water Extraction (as per 2013)	Irrigation	83.83 mcm
	Domestic & Industrial	2.83 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		4.05 mcm
Stage of Groundwater Development		56 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 7.95 and 9.04. Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and ranges from 635 μS/cm to 2512 μS/cm at 25^0C. RSC values are varies from -10.08 to -0.45 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		***Nitrate (mg/l):*** Ghudda (138), Jassi Bhagwali (127), and Raike kalan (48) ***Iron (mg/l):*** Ghudda (4.5)
Other issues		In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 378.24 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA

Other interventions proposed*:* NA

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Sangat Block (630.4 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 7.01 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: Not Required
Area coverage: Not Required
Anticipated volume of water to be saved: Not Required

Alternate Water sources

Surface water sources: *Tanks, Ponds*
Location, details and availability from such sources outside the area: Not Available

Regulation and Control:

Punjab Subsoil Act, 2009 for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

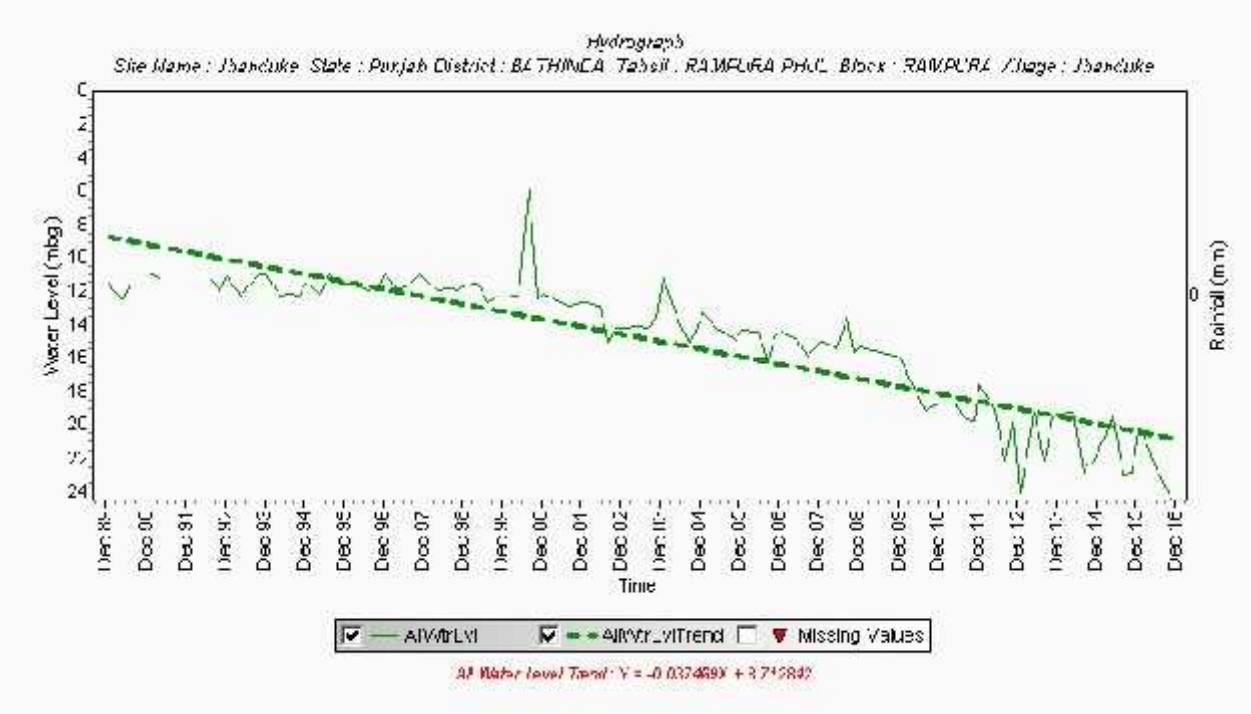
Sl.No	Techniques	Water Saving (%)	Crops
1	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Cotton, Sunflower, Maize

VII. Salient Information of Rampura Block

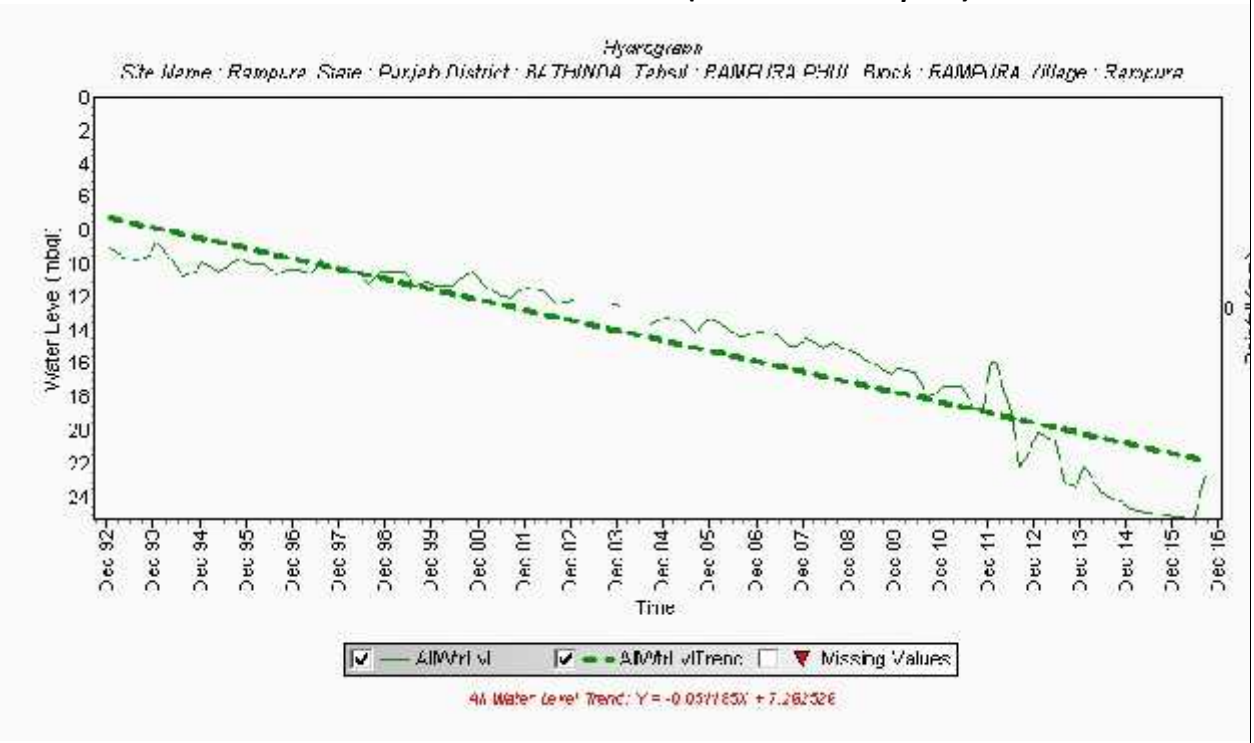
Block Area (in Km^2)	**331 sq km.**
District/ State	Bathinda, Punjab
Population	Urban Population: 1173 Rural Population: 102364 Total population: 103537
Rainfall	Normal Monsoon: 287 mm Non-monsoon Rainfall : 96 mm Annual Average Rainfall: 383 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 434.31 sq km Net sown area: 222.10 sq km Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 196% *Area under* Ground water Irrigation: 96.91 sq km Surface water irrigation: 202.51 sq km Number and types of abstraction structures: 5598, Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Total Ground Water Resources available is 1303mcm (fresh and saline water) up to the depth of 300 m. The fresh water resources (254 mcm) are estimated up to the depth of 80 m on the basis of geophysical interpretations. The potential granular zones available for fresh water are 55 m. Saline water resources (1049 mcm) are estimated on the basis of well (up to 300 m) and the granular zones are counted after depth of 80 m and available zones are 59 m. Block is categorized as Safe as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and not suitable for irrigation purpose as such all users are tapping shallow aquifers. Drinking water supply wells of State Government tapping shallow aquifers Therefore, the ground water draft could not be assessed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 160.07 mcm Domestic and industrial water supply: 3.32 mcm *Future water demands* Irrigation development potential : 88.02 mcm Domestic and industrial water supply up to 2025 years : 4.73 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 18.99 – 26.65 m bgl Post Monsoon: 21.76 – 28.48 m bgl Mean (10 yrs) : 0.99 – 1.93 m/yr *Trends* Pre Monsoon: (-)0.62 – (-)1.10 m/yr Post Monsoon: (-)0.88 – (-)1.33 m/yr **Aquifer-II & Aquifer-III** No Monitoring Stations

HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Jhanduke)



HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Rampura)



HYDROGRAPH SHOWING DECLINING WATER TABLE (Location: Dadde)

Well Location, Dadde dried after2009.

Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Aeolian Alluvium

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	2	0	0	1	**3**
WRED	6	0	0	0	**6**
PRIVATE	1	0	0	0	**1**
TOTAL	**9**	**0**	**0**	**1**	**10**

Aquifer wise Characteristics

Aquifer Group *	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)#	Yield (m^3/day) #	Specific Yield	Storativity #
Aquifer -I	Quarter-nary Alluvial deposits	Unconfined to confined	114	260	1874	12 % (0.072)	$10.35 * 10^{-5}$

* Well field proposed in adjacent block

CGWB, 2015, Ground Water Exploration Report, Punjab state

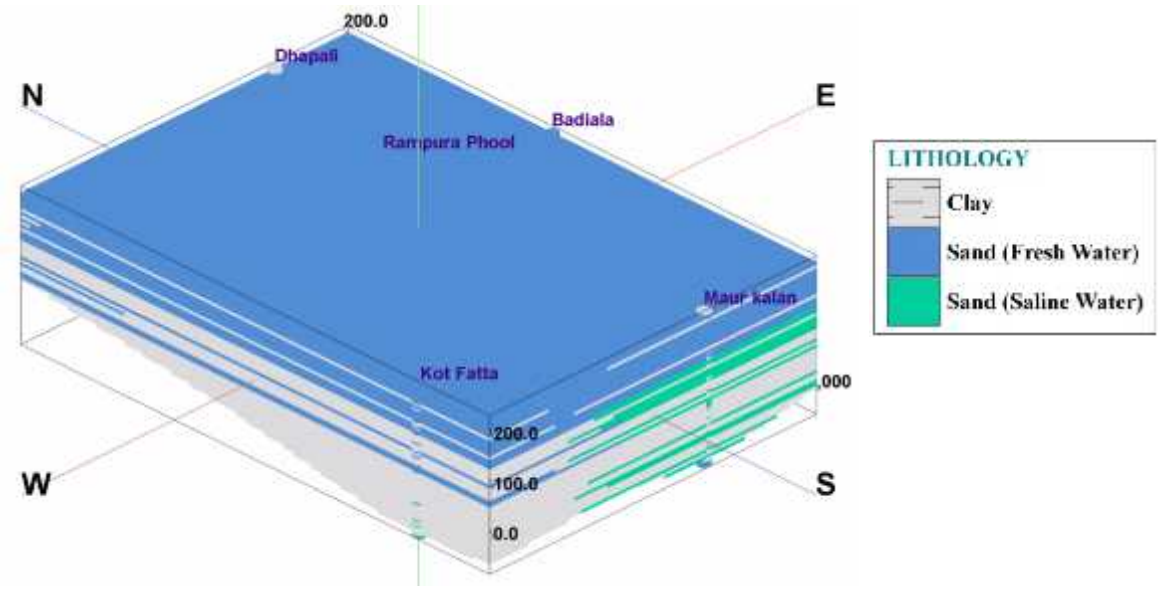
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

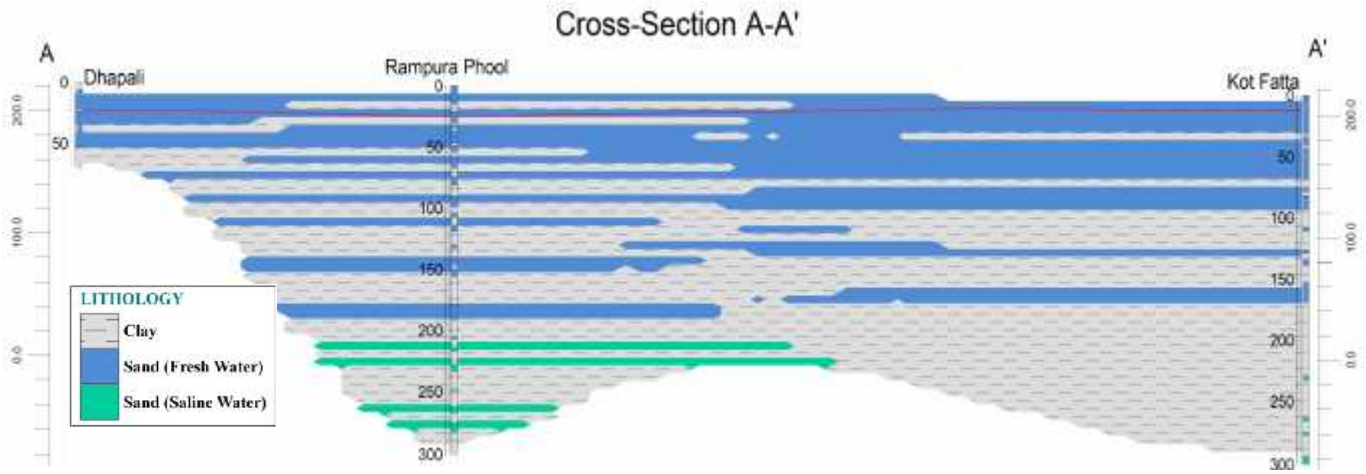
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED	0	0	0	0	**0**
PRIVATE	1	0	0	0	**1**
TOTAL	**1**	**0**	**0**	**1**	**2**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

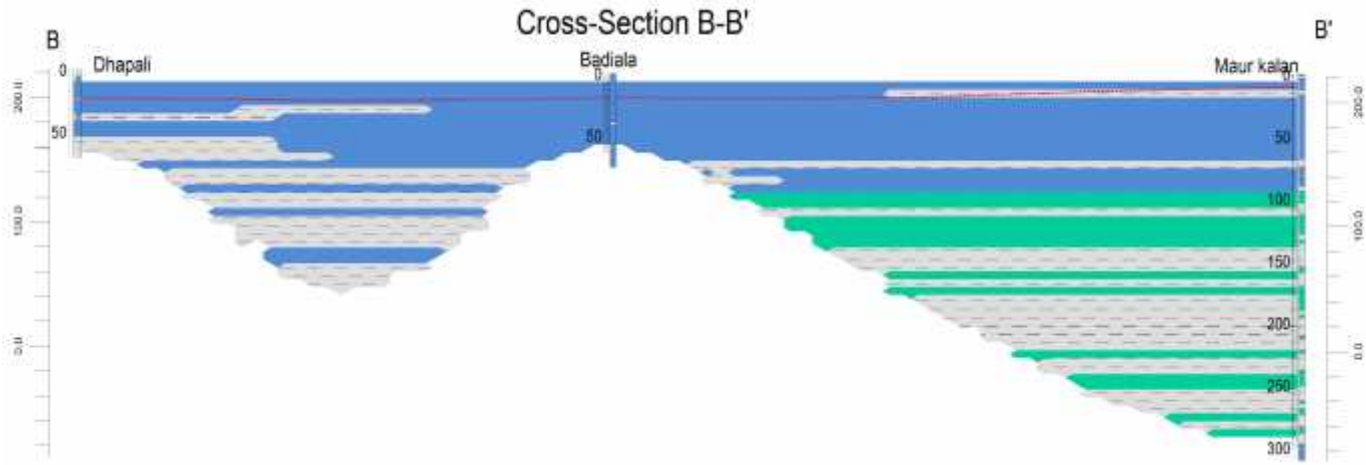
3-D Lithological model of Sangat Block



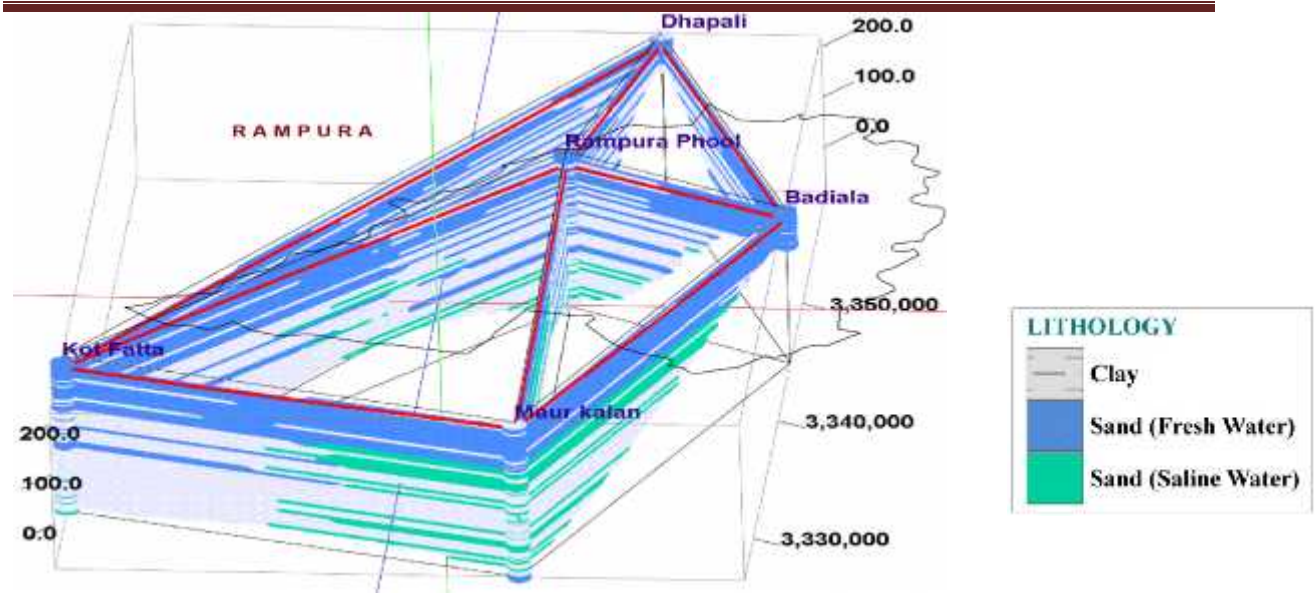
Lithological Cross section Dhapali – Rampuraphul- Kot Fatta



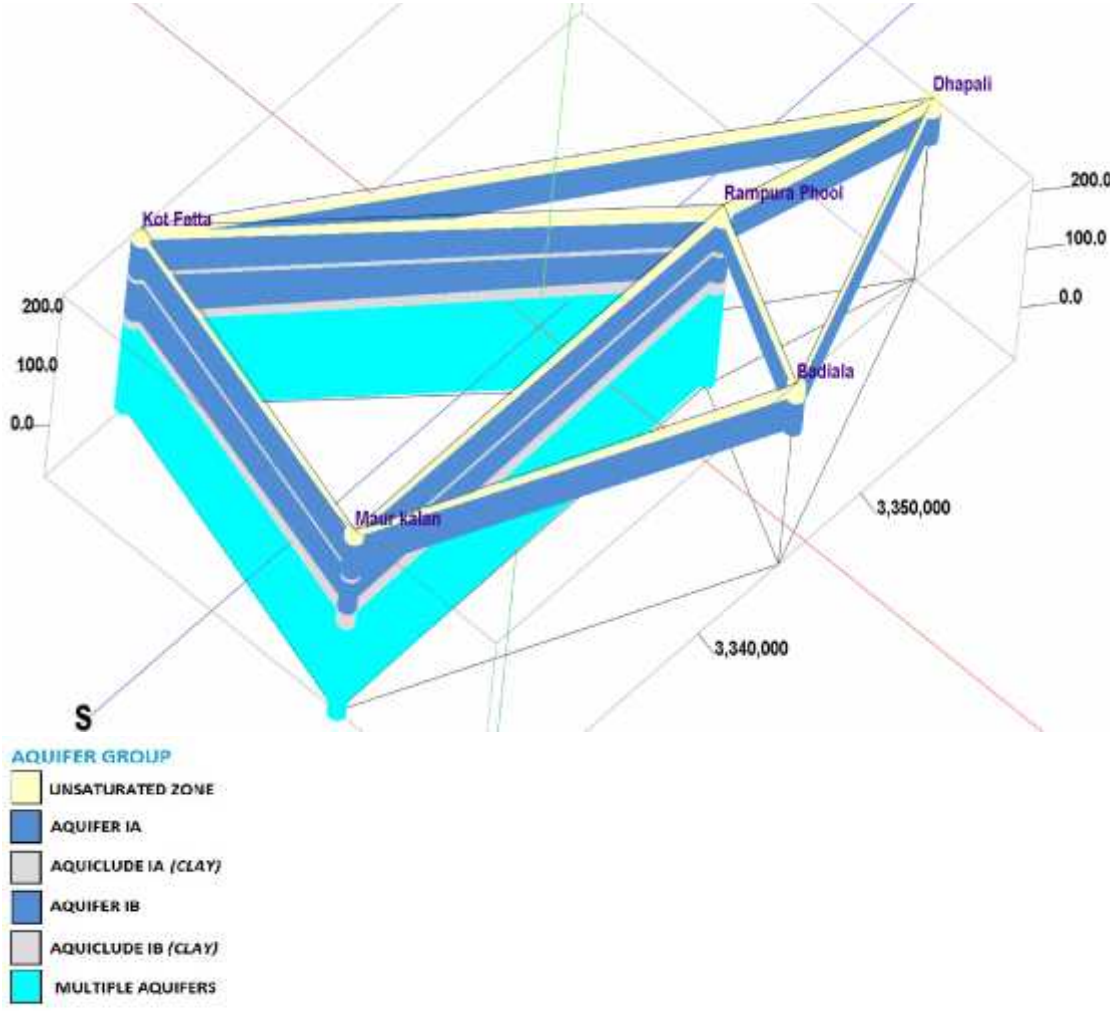
Lithological Cross section Dhapali – Badiala- Maur Kalan



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Rampura Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	252.82 mcm
	In-storage Fresh water resources	254 mcm
	In-storage Saline water resources	1049 mcm
	Total	1556 mcm
Ground Water Extraction (as per 2013)	Irrigation	160.07 mcm
	Domestic & Industrial	3.32 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		4.73 mcm
Stage of Groundwater Development		65 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.12 and 9.38. Ground water in the area is slightly fresh to marginal saline. EC value of the ground water show wide variations and ranges from 2150 μS/cm to 3100 μS/cm at 25^0C. RSC values are varies from -7.39 to 9.82 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		***Fluoride(mg/l):*** Kothaguru (1.59) ***Nitrate (mg/l):*** Jhanduke (220), Kaila Bhandar (124), and Kothaguru (84)
Other issues		Water level decline has been observed in major part of the block due to in discriminate development of ground water resources.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 516.36 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA
Other interventions proposed*:* NA

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Rampura Block (331 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 13.39 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: Not Required
Area coverage: Not Required
Anticipated volume of water to be saved: Not Required

Alternate Water sources

Surface water sources: *Tanks, Ponds*
Location, details and availability from such sources outside the area: Not Available

Regulation and Control:

Punjab Subsoil Act, 2009 for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Cotton, Sunflower, Maize

Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

Annexure- I

Results of chemical analysis of water samples from NHS in Bathinda District (2015)

S. No	Block	Location	pH	EC in µS/cm at 25^{0}C	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	Ca	Mg	Na	K	SiO_2	Arsenic (As)	Iron (Fe)	RSC
					(----------mg/l----------)														
1	Bathinda	Nahianwala	7.98	1370	nil	568	112	62	61	0.48	BDL	74	60	87	92	23	0.001	1.382	0.61
2	Bathinda	Dera Tappa	8.64	375	36	109	7.01	110	BDL	0.52	0.008	49	30	10	6.4	21	BDL	0.186	-1.96
3	Bathinda	Ablu	8.12	875	nil	266	91	174	28	0.14	BDL	82	40	66	32	23	BDL	0.703	-3.07
4	Bathinda	Balluana	7.92	2315	nil	640	309	214	125	0.72	BDL	91	115	115	265	25	0.001	0.903	-3.64
5	Bathinda	Kot Shamir	8.22	2770	nil	386	344	680	129	0.101	BDL	49	105	459	54	34	BDL	1.656	-4.87
6	Bathinda	Khialiwala	8.75	320	24	109	7	66	11	0.37	BDL	74	4.9	4.1	2.7	6.8	0.001	0.391	-1.52
7	Bathinda	Gulabgarh	9.46	3950	202	1244	190	560	64	2.16	0.091	25	48	918	13	17	0.001	0.05	21.88
8	Bathinda	Ganga	9.02	305	12	121	7.0	58	1.7	0.14	BDL	8.2	38	5.1	4.7	6.6	BDL	2.995	-1.19
9	Nathana	Phulla	8.56	1130	36	386	77	122	94	1.28	BDL	25	25	159	144	11	BDL	BDL	4.19
10	Nathana	Dial Pur Mirja	8.91	1845	71	592	105	354	44	1.12	BDL	16	33	450	8	21	BDL	0.002	8.52
11	Phul	Dial Pur Bhlaike	8.92	1023	59	459	28	55	18	0.52	BDL	21	7.5	230	6.5	18	BDL	0.083	7.82
12	Phul	Rampura Phull	8.77	1897	59	592	154	280	80	0.46	BDL	21	60	391	11.5	21	BDL	0.021	5.62
13	Phul	Phul	8.43	1594	36	411	218	150	52	0.42	BDL	33	70	242	11	24	BDL	BDL	0.45
14	Phul	Gurusar	9.44	4880	190	1352	386	667	183	4.50	0.123	4.1	85	1126	18	21	0.002	0.013	21.21
15	Phul	Dhapali	9.27	300	12	97	14	102	7.1	0.30	BDL	25	38	5.8	3.1	13	0.004	0.038	-2.43
16	Rampura	Kaila Bander	8.12	2150	nil	374	267	400	124	ND	BDL	62	125	183	110	28	BDL	0.014	-7.39
17	Rampura	Jhanduke	9.13	2490	95	350	175	510	220	1.21	0.015	16	55	518	15	21	0.002	0.013	3.52
18	Rampura	Badiala	9.24	2420	48	411	225	570	22	0.73	BDL	62	30	491	8.2	18	BDL	0.109	2.74
19	Rampura	Kotho Guru	9.38	3100	107	737	246	576	84	1.59	0.024	25	55	695	5.1	20	0.002	0.003	9.82
20	Sangat	Rai Ke Kalan	7.95	935	nil	278	77	184	48	0.85	BDL	99	48	52	12	128	0.001	0.065	-4.39
21	Sangat	Jassi Bhag Wali	8.24	1574	nil	531	112	144	127	1.03	BDL	78	63	172	19	22	0.001	0.066	-0.45
22	Sangat	Ghudda	8.05	2512	nil	399	232	660	138	0.94	BDL	49	170	156	230	25	BDL	4.5	-10.08
23	Sangat	Sangat Kalan	9.04	635	24	218	14	165	13	0.55	BDL	45	57	30	7	16	BDL	0.396	-2.63
24	Talwandi Sabo	Maiser Khanna	8.55	1186	36	350	98	122	77	0.364	BDL	29	75	122	16	22	BDL	1.642	-0.76
25	Talwandi Sabo	Bhagi Bandar	8.67	690	36	374	21	70	0.85	0.98	BDL	21	38	63	98	18	BDL	0.117	3.11

26	Talwandi Sabo	Jajjal	8.52	2255	24	181	260	350	314	0.18	BDL	62	63	304	80	23	0.001	0.039	-4.58

Annexure-II

Physical record of Exploration data of Bathinda district						
Sl.no	**Village**	**Longitude**	**Latitude**	**Depth**	**Dept.**	**BLOCK**
1	Dulewal	75.252	30.451	60	WRED	Phul
2	Burj Gill	75.235	30.458	60	WRED	Phul
3	Raiya	75.308	30.201	60	WRED	Phul
4	Mehraj Patti Sohal	75.193	30.311	60	WRED	Phul
5	Bugran	75.309	30.315	60	WRED	Phul
6	Koir Singh Wala	75.162	30.553	60	WRED	BhagtaBhaike
7	Aklia Jalal	75.160	30.514	60	WRED	BhagtaBhaike
8	Maulka	75.060	30.427	60	WRED	BhagtaBhaike
9	SalabatPur	75.248	30.336	60	WRED	BhagtaBhaike
10	DyalPurMirza	75.134	30.404	60	WRED	BhagtaBhaike
11	MehmaBhagwana	74.814	30.291	60	WRED	Bhatinda
12	Harraipur	74.964	30.341	60	WRED	Bhatinda
13	Balluana	74.788	30.229	60	WRED	Bhatinda
14	Multania	74.856	30.174	60	WRED	Bhatinda
15	JassiPaowali	74.965	30.153	60	WRED	Bhatinda
16	KalyanSukha	75.116	30.373	60	WRED	Nathana
17	Nathana	75.089	30.320	60	WRED	Nathana
18	GobindPura	75.014	30.277	60	WRED	Nathana
19	LehraDhulkot	75.203	30.261	60	WRED	Nathana
20	Tungwali	75.042	30.166	60	WRED	Nathana
21	Rampura	75.236	30.252	60	WRED	Rampura
22	MandiKalan	75.254	30.213	60	WRED	Rampura
23	Ballaianwali	75.191	30.184	60	WRED	Rampura
24	JhanduKe	75.148	30.160	60	WRED	Rampura
25	Sooch	75.296	30.158	60	WRED	Rampura
26	KotPhatta	75.089	30.113	60	WRED	Maur
27	BhagerMohbat	75.099	30.055	60	WRED	Maur
28	MaisarKhana	75.174	30.104	60	WRED	Maur
29	MaurMandi	75.227	30.067	60	WRED	Maur
30	RajgarhKube	75.241	30.020	60	WRED	Maur
31	Burj Mansa	75.179	30.032	60	WRED	Maur
32	Bambiha	74.713	30.135	60	WRED	Sangat
33	Ghudda	74.796	30.126	60	WRED	Sangat
34	Mehta	74.924	30.107	60	WRED	Sangat
35	Bandi	74.761	30.054	60	WRED	Sangat
36	Pathrala	74.753	29.997	60	WRED	Sangat
37	PakkaKalan	74.849	30.034	60	WRED	Sangat
38	KotBagtu	74.967	30.045	60	WRED	Talwandi Sabo
39	Laleana	75.027	29.992	60	WRED	Talwandi Sabo
40	PhuloKhari	74.983	29.930	60	WRED	Talwandi Sabo
41	BehmanKaur	75.128	29.909	60	WRED	Talwandi Sabo

42	Natheha	75.173	29.849	60	WRED	Talwandi Sabo
43	Bathinda	74.943	30.201	100	WRED	Bathinda
44	BhagtaBhaika	75.096	30.471	100	WRED	BhagtaBhaika
45	Phul	75.240	30.328	100	WRED	Phul
46	Badiala	75.322	30.236	63.14	PRIVATE	Rampura
47	BhaiRupa	75.224	30.433	250	CGWB	Phul
48	Ghuda	74.789	30.124	156	PRIVATE	Sangat
49	Dhapali	75.267	30.367	70.12	PRIVATE	Phul
50	Gutwali	75.042	29.902	300	PRIVATE	Talwandi Sabo
51	ITI Bhatinda	74.967	30.197	155	PRIVATE	Bathinda
52	KotFatta	75.082	30.113	300	CGWB	Bathinda
53	Maur kalan	75.244	30.069	300	CGWB	Maur
54	DialpurMirza	75.134	30.404	58	CGWB	BhagtaBhaike
55	Teona	74.816	30.200	60	WRED	Bathinda
56	Brishiyana	74.800	30.240	300	CGWB	Bathinda
57	Dhapali	75.267	30.367	70.12	CGWB	Phul
58	Phulla	75.108	30.30	60	WRED	Phul
59	Rampura	74.963	29.951	227.13	PRIVATE	Talwandi Sabo
60	Pearls Mall	74.931	30.214	213	PRIVATE	Bathinda
61	Gonia	74.912	30.315	300	PRIVATE	Bathinda
62	RampuraPhool	75.242	30.276	300	CGWB	Rampura
63	Kheliwala	74.967	30.300	300	CGWB	Bathinda
64	Gulabgarh	75.003	30.142	297.9	CGWB	Bathinda
65	Bathinda Cantt	74.950	30.200	300	CGWB	Bathinda
66	Kalyansukha	75.091	30.379	205	CGWB	Nathana
67	Sidhana	75.240	30.318	50	WRED	Phul
68	Kot Guru	75.144	30.410	50	WRED	BhagtaBhaike
69	Gumti	74.684	30.104	50	WRED	Sangat
70	Seema	75.114	30.201	50	WRED	Nathana
71	Kahan Singh Wala	75.050	30.164	50	WRED	Nathana
72	Puhla	75.136	30.157	50	WRED	Nathana
73	Jajjal	74.953	29.941	50	WRED	Talwandi Sabo
74	Brishiyana	74.796	30.237	300	CGWB	Bathinda
75	Sangat Kalan	74.842	30.084	65	CGWB	Sangat
76	Gurusar	75.103	30.496	65	CGWB	Phul
77	Dhapali	75.229	30.358	65	CGWB	Phul
78	Ganga	74.821	30.364	65	CGWB	Bathinda
79	Badiala	75.320	30.230	62	CGWB	Rampura
80	Kotho guru	74.856	30.021	60	CGWB	Rampura

Annexure-III

Lithological Data of Wells in Bathinda District

Location	*Depth from (m)*	*Depth to (m)*	*Lithology*	*Thickness*
Badiala	0	24.6	Fresh Sand	24.6
	24.6	25.2	Clay	0.6
	25.2	39.2	Fresh Sand	14
	39.2	41.6	Clay	2.4
	41.6	59.2	Fresh Sand	17.6
	59.2	60.4	Clay	1.2
	60.4	75	Fresh Sand	14.6
Bhai Rupa	0	15	Clay	15
	15	23	Fresh Sand	8
	23	25	Clay	2
	25	31	Fresh Sand	6
	31	33	Clay	2
	33	37	Fresh Sand	4
	37	43	Clay	6
	43	49	Fresh Sand	6
	49	52	Clay	3
	52	58	Fresh Sand	6
	58	62	Clay	4
	62	67	Fresh Sand	5
	67	81	Clay	14
	81	89	Fresh Sand	8
	89	97	Clay	8
	97	106	Fresh Sand	9
	106	145	Clay	39
	145	171	Fresh Sand	26
	171	175	Clay	4
	175	184	Fresh Sand	9
	184	199	Clay	15
	199	208	Saline Sand	9
	208	214	Clay	6
	214	227	Saline Sand	13
	227	250	Clay	23
Ghuda	0	56	Fresh Sand	56
	56	59.5	Clay	3.5
	59.5	65.5	Fresh Sand	6
	65.5	72	Clay	6.5
	72	79.6	Fresh Sand	7.6

	79.6	96	Clay	16.4
	96	98.2	Fresh Sand	2.2
	98.2	110	Clay	11.8
	110	120	Fresh Sand	10
	120	123.5	Clay	3.5
	123.5	133.5	Fresh Sand	10
	133.5	148	Clay	14.5
	148	152	Fresh Sand	4
	152	156	Clay	4
Dhapali	0	5.8	Clay	5.8
	5.8	22.4	Fresh Sand	16.6
	22.4	24.2	Clay	1.8
	24.2	37.2	Fresh Sand	13
	37.2	38.4	Clay	1.2
	38.4	53	Fresh Sand	14.6
	53	70.12	Clay	17.12
Gutwali	0	5.8	Clay	5.8
	5.8	25	Fresh Sand	19.2
	25	27	Clay	2
	27	33.4	Fresh Sand	6.4
	33.4	35	Clay	1.6
	35	49	Fresh Sand	14
	49	56	Clay	7
	56	71	Fresh Sand	15
	71	73.4	Clay	2.4
	73.4	79.8	Fresh Sand	6.4
	79.8	82.6	Clay	2.8
	82.6	103	Fresh Sand	20.4
	103	105	Clay	2
	105	107.8	Saline Sand	2.8
	107.8	111	Clay	3.2
	111	125.4	Saline Sand	14.4
	125.4	151	Clay	25.6
	151	155.8	Saline Sand	4.8
	155.8	161.8	Clay	6
	161.8	167.8	Saline Sand	6
	167.8	171	Clay	3.2
	171	179.8	Saline Sand	8.8
	179.8	181.8	Clay	2
	181.8	191	Saline Sand	9.2
	191	194.2	Clay	3.2
	194.2	199.8	Saline Sand	5.6
	199.8	210.2	Clay	10.4

	210.2	213	Saline Sand	2.8
	213	215	Clay	2
	215	222.6	Saline Sand	7.6
	222.6	230	Clay	7.4
	230	235	Saline Sand	5
	235	237.8	Clay	2.8
	237.8	241.8	Saline Sand	4
	241.8	251	Clay	9.2
	251	255	Saline Sand	4
	255	300	Clay	45
ITI Bhatinda	0	15	Fresh Sand	15
	15	24	Clay	9
	24	33	Fresh Sand	9
	33	37	Clay	4
	37	50	Fresh Sand	13
	50	56	Clay	6
	56	71	Fresh Sand	15
	71	78	Clay	7
	78	91	Fresh Sand	13
	91	106	Clay	15
	106	108.2	Fresh Sand	2.2
	108.2	112	Clay	3.8
	112	115	Fresh Sand	3
	115	126	Clay	11
	126	130.1	Fresh Sand	4.1
	130.1	145	Clay	14.9
	145	148	Fresh Sand	3
	148	149.4	Clay	1.4
	149.4	151	Fresh Sand	1.6
	151	155	Clay	4
Kot Fatta	0	31	Fresh Sand	31
	31	34	Clay	3
	34	40.8	Fresh Sand	6.8
	40.8	44	Clay	3.2
	44	68	Fresh Sand	24
	68	75	Clay	7
	75	79	Fresh Sand	4
	79	82	Clay	3
	82	93	Fresh Sand	11
	93	108	Clay	15
	108	111.2	Fresh Sand	3.2
	111.2	126	Clay	14.8

	126	129	Fresh Sand	3
	129	134.5	Clay	5.5
	134.5	139	Fresh Sand	4.5
	139	153	Clay	14
	153	169	Fresh Sand	16
	169	229	Clay	60
	229	233	Saline Sand	4
	233	263	Clay	30
	263	266	Saline Sand	3
	266	274.6	Clay	8.6
	274.6	277	Saline Sand	2.4
	277	293.5	Clay	16.5
	293.5	300	Saline Sand	6.5
Maur Kalan	0	3	Clay	3
	3	12.25	Fresh Sand	9.25
	12.25	16.8	Clay	4.55
	16.8	68	Fresh Sand	51.2
	68	74	Clay	6
	74	80	Fresh Sand	6
	80	82	Clay	2
	82	89	Fresh Sand	7
	89	93.5	Clay	4.5
	93.5	103	Saline Sand	9.5
	103	112	Clay	9
	112	128	Saline Sand	16
	128	133	Clay	5
	133	135.5	Saline Sand	2.5
	135.5	154	Clay	18.5
	154	159	Saline Sand	5
	159	170	Clay	11
	170	175.5	Saline Sand	5.5
	175.5	186	Clay	10.5
	175.5	189	Saline Sand	13.5
	189	193	Clay	4
	193	195	Saline Sand	2
	195	210	Clay	15
	210	212	Saline Sand	2
	212	222	Clay	10
	222	224	Saline Sand	2
	224	237	Clay	13
	237	250	Saline Sand	13
	250	262	Clay	12
	262	264	Saline Sand	2

	264	268	Clay	4
	268	273	Saline Sand	5
	273	283	Clay	10
	283	288	Saline Sand	5
	288	297	Clay	9
	297	310	Fresh Sand	13
Rampura	0	29.6	Fresh Sand	29.6
	29.6	31	Clay	1.4
	31	36.6	Fresh Sand	5.6
	36.6	41.4	Clay	4.8
	41.4	57	Fresh Sand	15.6
	57	59.4	Clay	2.4
	59.4	68.2	Fresh Sand	8.8
	68.2	76.6	Clay	8.4
	76.6	83	Fresh Sand	6.4
	83	91	Clay	8
	91	95.4	Fresh Sand	4.4
	95.4	104.2	Clay	8.8
	104.2	109.8	Saline Sand	5.6
	109.8	117.8	Clay	8
	117.8	127	Saline Sand	9.2
	127	134.2	Clay	7.2
	134.2	139.4	Saline Sand	5.2
	139.4	149	Clay	9.6
	149	153.8	Saline Sand	4.8
	153.8	155.4	Clay	1.6
	155.4	158.2	Saline Sand	2.8
	158.2	183.4	Clay	25.2
	183.4	185.8	Saline Sand	2.4
	185.8	186.5	Clay	0.7
	186.5	193.4	Saline Sand	6.9
	193.4	227.13	Clay	33.73
Pearls Mall	0	5	Clay	5
	5	13	Fresh Sand	8
	13	35	Clay	22
	35	41	Fresh Sand	6
	41	51	Clay	10
	51	56.5	Fresh Sand	5.5
	56.5	61	Clay	4.5
	61	71	Fresh Sand	10
	71	83	Clay	12
	83	91	Fresh Sand	8
	91	94	Clay	3

	94	111	Fresh Sand	17
	111	137	Clay	26
	137	143	Fresh Sand	6
	143	149.5	Clay	6.5
	149.5	155	Fresh Sand	5.5
	155	193	Clay	38
	193	198	Fresh Sand	5
	198	200	Clay	2
	200	206	Fresh Sand	6
	206	213	Clay	7
Gonia	0	25.1	Fresh Sand	25.1
	25.1	30.6	Clay	5.5
	30.6	37.6	Fresh Sand	7
	37.6	42.6	Clay	5
	42.6	45.6	Fresh Sand	3
	45.6	60	Clay	14.4
	60	64.6	Fresh Sand	4.6
	64.6	68.4	Clay	3.8
	68.4	74.8	Fresh Sand	6.4
	74.8	80.8	Clay	6
	80.8	97.6	Fresh Sand	16.8
	97.6	111.2	Clay	13.6
	111.2	126.8	Fresh Sand	15.6
	126.8	139.2	Clay	12.4
	139.2	144.4	Fresh Sand	5.2
	144.4	157.6	Clay	13.2
	157.6	163.6	Fresh Sand	6
	163.6	172	Clay	8.4
	172	174.8	Fresh Sand	2.8
	174.8	196.8	Clay	22
	196.8	202	Fresh Sand	5.2
	202	214	Clay	12
	214	221.6	Fresh Sand	7.6
	221.6	225.6	Clay	4
	225.6	240	Fresh Sand	14.4
	240	247.6	Clay	7.6
	247.6	249.6	Fresh Sand	2
	249.6	272	Clay	22.4
	272	276.4	Saline Sand	4.4
	276.4	300	Clay	23.6
Rampura Phool	0	15	Fresh Sand	15
	15	21	Clay	6
	21	30	Fresh Sand	9

	30	33	Clay	3
	33	34.5	Fresh Sand	1.5
	34.5	37	Clay	2.5
	37	47	Fresh Sand	10
	47	49	Clay	2
	49	54	Fresh Sand	5
	54	58.5	Clay	4.5
	58.5	67	Fresh Sand	8.5
	67	74.5	Clay	7.5
	74.5	81	Fresh Sand	6.5
	81	90	Clay	9
	90	99	Fresh Sand	9
	99	104	Clay	5
	104	107	Fresh Sand	3
	107	114	Clay	7
	114	119	Fresh Sand	5
	119	130	Clay	11
	130	132.8	Saline Sand	2.8
	132.8	140	Clay	7.2
	140	146	Fresh Sand	6
	146	150	Clay	4
	150	155.5	Fresh Sand	5.5
	155.5	178	Clay	22.5
	178	191.3	Fresh Sand	13.3
	191.3	205	Clay	13.7
	205	207	Saline Sand	2
	207	214	Clay	7
	214	217	Saline Sand	3
	217	228	Clay	11
	228	233	Saline Sand	5
	233	248	Clay	15
	248	249	Saline Sand	1
	249	262	Clay	13
	262	267	Saline Sand	5
	267	275	Clay	8
	275	282.5	Saline Sand	7.5
	282.5	300	Clay	17.5
Kheliwala	0	15	Fresh Sand	15
	15	21	Clay	6
	21.5	27	Fresh Sand	5.5
	27	34	Clay	7
	34	39	Fresh Sand	5
	39	42	Clay	3

	42	55	Fresh Sand	13
	55	67	Clay	12
	67	74.5	Fresh Sand	7.5
	74.5	78.5	Clay	4
	78.5	98	Fresh Sand	19.5
	98	109	Clay	11
	109	130.5	Fresh Sand	21.5
	130.5	155	Clay	24.5
	155	161	Fresh Sand	6
	161	170	Clay	9
	170	173	Fresh Sand	3
	173	195	Clay	22
	203	207	Fresh Sand	4
	207	211	Clay	4
	211	215	Fresh Sand	4
	215	230	Clay	15
	230	234	Fresh Sand	4
	234	238	Clay	4
	238	245.5	Fresh Sand	7.5
	245.5	272	Clay	26.5
	272	275	Saline Sand	3
	275	278	Clay	3
	278	284	Saline Sand	6
	284	300	Clay	16
Gulabgarh	0	15	Clay	15
	15	58	Fresh Sand	43
	58	73	Clay	15
	73	90	Fresh Sand	17
	90	94	Clay	4
	94	100	Fresh Sand	6
	100	104	Clay	4
	104	125	Fresh Sand	21
	125	139	Clay	14
	139	159	Fresh Sand	20
	159	179	Clay	20
	179	196	Saline Sand	17
	196	212	Clay	16
	212	230	Saline Sand	18
	230	297.9	Clay	67.9
Bathinda Cantt	0	3	Fresh Sand	3
	3	16	Clay	13
	16	32	Fresh Sand	16
	32	35	Clay	3
	35	50	Fresh Sand	15
	50	63	Clay	13

	63	82	Fresh Sand	19
	82	86	Clay	4
	86	96	Fresh Sand	10
	96	108	Clay	12
	108	114	Fresh Sand	6
	114	136	Clay	22
	136	140	Fresh Sand	4
	140	147	Clay	7
	147	148	Fresh Sand	1
	148	151	Clay	3
	151	154	Fresh Sand	3
	154	193	Clay	39
	193	198	Fresh Sand	5
	198	200	Clay	2
	200	206	Fresh Sand	6
	206	212	Clay	6
	212	216	Fresh Sand	4
	216	221	Clay	5
	221	231	Fresh Sand	10
	231	237	Clay	6
	237	243	Fresh Sand	6
	243	251	Clay	8
	251	254	Saline Sand	3
	254	263	Clay	9
	263	266	Saline Sand	3
	266	277	Clay	11
	277	282	Saline Sand	5
	282	300	Clay	18
Kalyan sukha	0	17	Clay	17
	17	23	Fresh Sand	6
	23	26	Clay	3
	26	36	Fresh Sand	10
	36	43	Clay	7
	43	47	Fresh Sand	4
	47	61	Clay	14
	61	64	Fresh Sand	3
	64	83	Clay	19
	83	90	Fresh Sand	7
	90	98	Clay	8
	98	110	Fresh Sand	12
	110	131	Clay	21
	131	139	Fresh Sand	8
	139	145	Clay	6
	145	153	Fresh Sand	8
	153	161	Clay	8

	161	170	Fresh Sand	9
	170	175	Clay	5
	175	179	Fresh Sand	4
	179	205	Clay	26
Dal Singhwala	0	13	Clay	13
	13	20	Fresh Sand	7
	20	28	Clay	8
	28	57	Fresh Sand	29
	57	64	Clay	7
	64	75	Saline Sand	11
	75	78	Clay	3
	78	97	Saline Sand	19
	97	108	Clay	11
	108	117	Saline Sand	9
	117	122	Clay	5
	122	134	Saline Sand	12
	134	157	Clay	23
	157	173	Saline Sand	16
	173	179	Clay	6
	179	184	Saline Sand	5
	184	211	Clay	27
	211	219	Saline Sand	8
	219	253	Clay	34
	253	259	Saline Sand	6
	259	278	Clay	19
	278	293	Saline Sand	15
	293	298	Clay	5
	298	300	Saline Sand	2
Kot Bhai	0	0.5	Fresh Sand	0.5
	0.5	25	Clay	24.5
	25	34	Fresh Sand	9
	34	37	Clay	3
	37	43	Fresh Sand	6
	43	46	Clay	3
	46	52	Fresh Sand	6
	52	60	Clay	8
	60	67	Saline Sand	7
	67	73	Clay	6
	73	82	Saline Sand	9
	82	90	Clay	8
	90	101	Saline Sand	11
	101	103	Clay	2
	103	112	Saline Sand	9
	112	130.5	Clay	18.5
	130.5	134.5	Saline Sand	4

	134.5	137	Clay	2.5
	137	145	Saline Sand	8
	145	152	Clay	7
	152	161	Saline Sand	9
	161	194	Clay	33
	194	199	Saline Sand	5
	199	227	Clay	28
	227	237	Saline Sand	10
	237	251	Clay	14
	251	257	Saline Sand	6
	257	263	Clay	6
	263	268	Saline Sand	5
	268	287.5	Clay	19.5
	287.5	291.5	Saline Sand	4
	291.5	300	Clay	8.5
Killian Wali,Mukstar	0	6	Clay	6
	6	8	Fresh Sand	2
	8	11	Clay	3
	11	15.8	Fresh Sand	4.8
	15.8	43.4	Clay	27.6
	43.4	47.8	Saline Sand	4.4
	47.8	53	Clay	5.2
	53	57.8	Saline Sand	4.8
	57.8	66.6	Clay	8.8
	66.6	73	Saline Sand	6.4
	73	75	Clay	2
	75	77	Saline Sand	2
	77	82	Clay	5
	82	89	Saline Sand	7
	89	96	Clay	7
	96	103	Saline Sand	7
	103	107	Clay	4
	107	111	Saline Sand	4
	111	127	Clay	16
	127	141	Saline Sand	14
	141	182.92	Clay	41.92

Annexure-IV

Aquifer Grouping of Well Locations in Bathinda District

Location	*Depth from (m)*	*Depth to (m)*	*Aquifer Grouping*	*Thickness*	*Fresh Granular Zones*	*Saline Granular Zones*
Badiala	0	20	Unsaturated Zone	20	19	
	20	75	Aquifer Group-IA	55	51.2	
Bhai Rupa	0	14	Unsaturated Zone	14	2	
	14	67	Aquifer Group-IA	53	17	
	67	81	Aquiclude-IA	14		
	81	106	Aquifer Group-IB	25	36	
	106	145	Aquiclude-IB	39		
	145	250	Multiple Aquifers	105	35	22
Ghuda	0	10	Unsaturated Zone	10	9	
	10	80	Aquifer Group-IA	70	22	
	80	96	Aquiclude-IA	16		
	10	133.5	Aquifer Group-IB	124	59.8	
	133.5	148	Aquiclude-IB	15		
	148	156	Multiple Aquifers	8	4	
Dhapali	0	23	Unsaturated Zone	23	17	
	23	70.12	Aquifer Group-I	47	27.6	
Gutwali	0	7	Unsaturated Zone	7	1	
	7	49	Aquifer Group-IA	42	38	
	49	56	Aquiclude-IA	7		
	56	125	Aquifer Group-IB	69	41	17.2
	125	151	Aquiclude-IB	26		
	151	300	Multiple Aquifers	149		57.8
ITI Bhatinda	0	8	Unsaturated Zone	8	7	
	8	50	Aquifer Group-IA	42	29	
	50	56	Aquiclude-IA	6		
	56	115	Aquifer Group-IB	59	33.2	
	115	145	Aquiclude-IB	30		
	145	155	Multiple Aquifers	10	4.6	
Kot Fatta	0	13	Unsaturated Zone	13	12	
	13	68	Aquifer Group-IA	55	58	
	68	75	Aquiclude-IA	7		
	75	139	Aquifer Group-IB	64	41	
	139	153	Aquiclude-IB	14		
	153	300	Multiple Aquifers	147	16	15.9
Maur Kalan	0	10	Unsaturated Zone	10	7	
	10	68	Aquifer Group-IA	58	52	
	68	74	Aquiclude-IA	6		
	74	128	Aquifer Group-IB	54	13	25.5
	128	154	Aquiclude-IB	26		
	154	310	Multiple Aquifers	156	13	55

Rampura	0	10	Unsaturated Zone	10	9	
	10	68	Aquifer Group-IA	58	50	
	68	77	Aquiclude-IA	9		
	77	127	Aquifer Group-IB	50	11	15
	127	149	Aquiclude-IB	22		
	149	227.13	Multiple Aquifers	78		16.9
Pearls Mall	0	8	Unsaturated Zone	8	3	
	8	71	Aquifer Group-IA	63	26.5	
	71	83	Aquiclude-IA	12		
	83	111	Aquifer Group-IB	28	25	
	111	137	Aquiclude-IB	26		
	137	213	Multiple Aquifers	76	22.5	
Gonia	0	9	Unsaturated Zone	9	8	
	9	46	Aquifer Group-IA	37	26	
	46	60	Aquiclude-IA	14		
	60	127	Aquifer Group-IB	67	43.4	
	127	157	Aquiclude-IB	30		
	157	300	Multiple Aquifers	143	38	4.4
Rampura Phool	0	25	Unsaturated Zone	25	19	
	25	67	Aquifer Group-IA	42	30	
	67	75	Aquiclude-IA	8		
	75	119	Aquifer Group-IB	44	24	
	119	140	Aquiclude-IB	21		
	140	300	Multiple Aquifers	160	24.8	23.5
Kheliwala	0	9	Unsaturated Zone	9	8	
	9	55	Aquifer Group-IA	46	30	
	55	67	Aquiclude-IA	12		
	67	130.5	Aquifer Group-IB	64	48	
	130.5	155	Aquiclude-IB	25		
	155	300	Multiple Aquifers	145	25.5	9
Gulabgarh	0	18	Unsaturated Zone	18	3	
	18	58	Aquifer Group-IA	40	40	
	58	73	Aquiclude-IA	15		
	73	125	Aquifer Group-IB	52	44	
	125	139	Aquiclude-IB	14		
	139	297.9	Multiple Aquifers	159	20	35
Bathinda Cantt	0	8	Unsaturated Zone	8	3	
	8	50	Aquifer Group-IA	42	31	
	50	63	Aquiclude-IA	13		
	63	114	Aquifer Group-IB	51	34	
	114	136	Aquiclude-IB	22		
	136	300	Multiple Aquifers	164	39	11
Kalyan sukha	0	20	Unsaturated Zone	20	3	
	20	47	Aquifer Group-IA	27	17	
	47	61	Aquiclude-IA	14		

	61	110	Aquifer Group-IB	49	22	
	110	131	Aquiclude-IB	21		
	131	205	Multiple Aquifers	74	29	
Dal Singhwala	0	15	Unsaturated Zone	15	2	
	15	57	Aquifer Group-IA	42	34	
	57	64	Aquiclude-IA	7		
	64	134	Aquifer Group-IB	70		51
	134	157	Aquiclude-IB	23		
	157	300	Multiple Aquifers	143		52
Kot Bhai	0	7	Unsaturated Zone	7	1	
	7	52	Aquifer Group-IA	45	21	
	52	60	Aquiclude-IA	8		
	60	112	Aquifer Group-IB	52		36
	112	137	Aquiclude-IB	25		
	137	300	Multiple Aquifers	163		47
Killian Wali, Mukstar	0	8	Unsaturated Zone	8	2	
	8	58	Aquifer Group-IA	50	5	9
	58	67	Aquiclude-IA	9		
	67	111	Aquifer Group-IB	44		27
	111	127	Aquiclude-IB	16		
	127	182.92	Multiple Aquifers	56		14