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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

Ludhiana District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING

&

MANAGEMENT PLAN

LUDHIANA DISTRICT

PUNJAB

Central Ground Water Board
Ministry of Water Resources, River Development and Ganga Rejuvenation
Government of India
2017

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AQUIFER MAPPING AND GROUND WATER MANAGEMENT IN LUDHIANA DISTRICT, PUNJAB
(3790 Sq. Km UNDER NAQUIFERUIM XII PLAN)

1.0 INTRODUCTION

There has been a paradigm shift from "groundwater development" to "groundwater management" in the past two decades in the country. An accurate and comprehensive micro-level picture of ground water through aquifer mapping in different hydrogeological settings would enable robust groundwater management plans in an appropriate scale. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. This would help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India.

Central Ground Water Board (CGWB) implemented the Aquifer Mapping Programme in Punjab in four phases (**Fig. 1**) with the broad objective of preparing an Aquifer-wise management plan for the region. Various multi–disciplinary geo-scientific activities were undertaken in the study partly through in-house capacity of CGWB, DWRS, PSCTC and Private agencies for generation of additional micro-level hydrogeological data. This report primarily deals with Ludhiana district of Punjab State (**Fig. 1**), covered under Phase-II.

Ludhiana district falls in central part of Punjab. The district is bounded between North latitude 30^0 33' and 31^0 01' and East longitude 75^0 25' and 76^0 27'. The River Sutlej forms the border of the district in the North with Jalandhar and Hoshiarpur districts. Ropar and Fatehgarh Sahib Districts marks the eastern and south eastern boundaries. The western border is adjoining Moga and Ferozpur districts. The geographical area of the district is 3790 sq.kms.

Administratively Ludhiana district falls under Patiala division. The district has four sub-divisions viz-Ludhiana, Khanna, Samrala and Jagraon and eleven development blocks viz.- Ludhiana, Mangat, Doraha, Khanna, Dehlon, Pokhwal , Samrala , Machiwara, Jagraon, Sidhwanbet and Sudhar.

The district area is occupied by Indo-Gangetic alluvium. And there are no surface

features worth to mention except that area is plain and major drains are Satluj and its tributaries and Budha nala.

Soil is the end product of the parent material resulting from the consistent influence of climate, topography and the natural vegetation over a long period of time. In the district soil characteristics are influenced to a very limited extent by the topography, vegetation and parent rock. The variations in soil profile characteristics are much more pronounced because of the regional climatic differences. The soil of this zone has developed under semi-arid condition. The soil is sandy loam to clayey with normal reaction (pH from 7.8 to 8.5).

The climate of Ludhiana district can be classified as tropical steppe, hot and semi-arid which is mainly dry with very hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrate into the district. There are four seasons in a year. The hot weather season starts from mid March to last week of the June followed by the south west monsoon which lasts upto September. The transition period from September to November forms the post-monsoon season. The winter season starts late in November and remains up to first week of March.

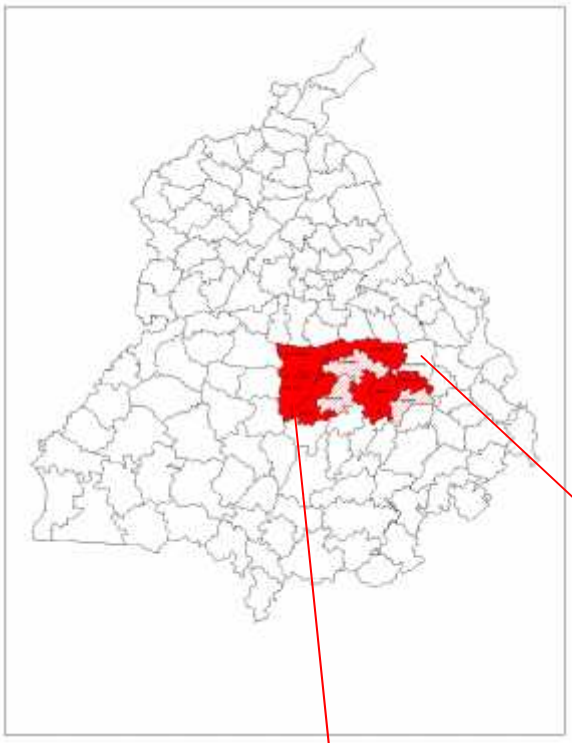
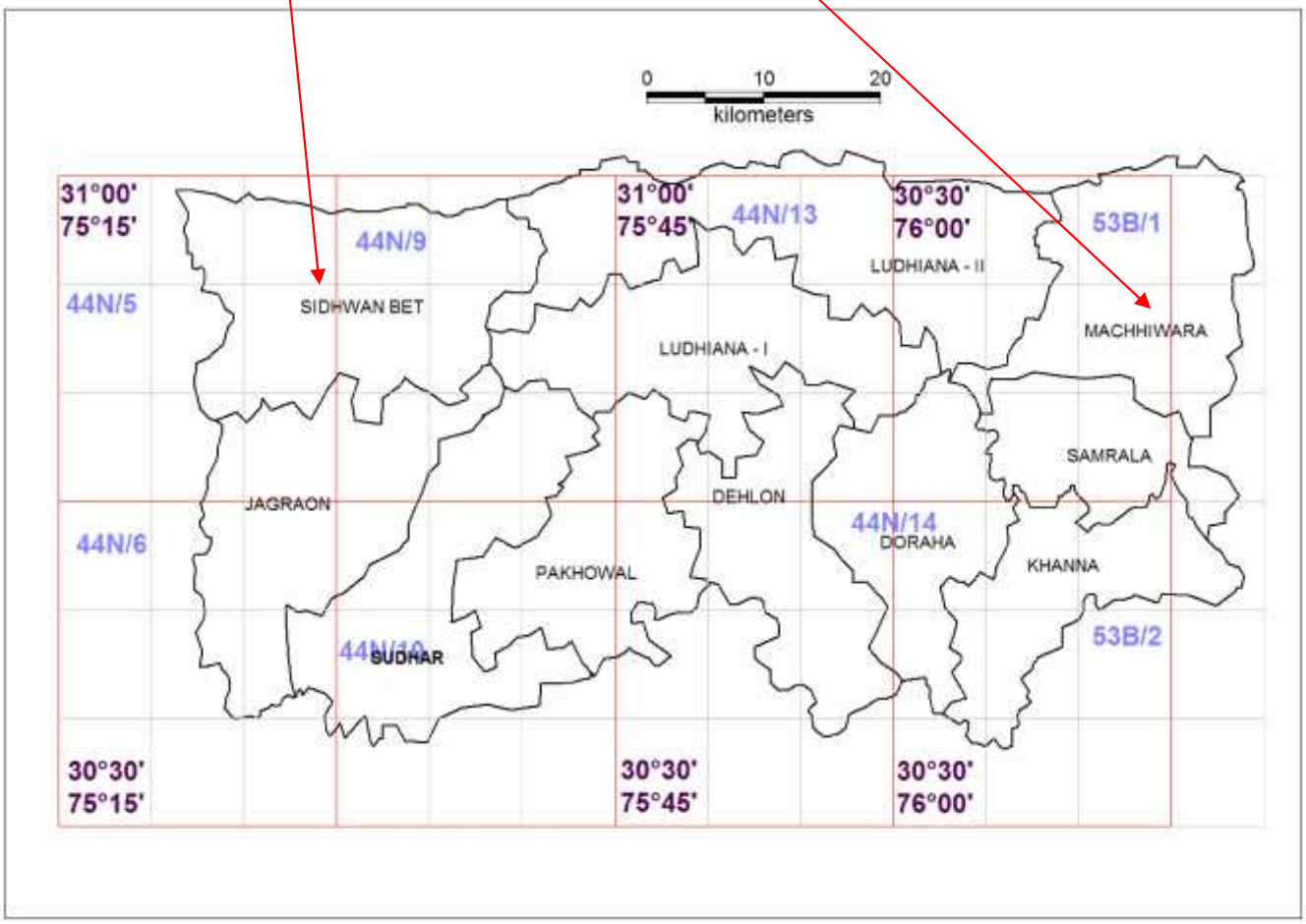


Fig 1: Base Map of Ludhiana District



2. DATA COLLECTION AND GENERATION

2.1 Tube well Logs

The Lithologs of Exploratory Well/ Observation well/ Peizometer/ productive wells of CGWB, and private wells have been collected and those supported electrical logs have been validate for aquifer map preparation. The details are shown below.

Table-I Data availability of exploration wells in Ludhiana district

LUDHIANA DISTRICT

Sl.No	Source of data	Depth Range (m)			
		< 100	**100-200**	**200-300**	**>300**
1	CGWB	6	3	2	7
2	WR&ED/ WSS	4	11	3	5
3	PRIVATE	0	23	6	1
Total		**10**	**37**	**11**	**13**

2.2 Ground Water Quality

Present data of chemical analysis of water samples collected from shallow aquifers (NHS-2006) indicates that ground water is slightly alkaline in nature (pH varies between 7.25-7.90). also ground water is fresh to moderate saline (Ec varies between 550-1320micromomhos/cm at 25^0C. All the chemical parameters are well with in the permissible limits for safe drinking water set by BIS 1991 revised in 2007 exfcept for NO_3 at Bhalolpur (52 mg/l), Muskabad (8 mg/l), Kohara (104 mg/l), Begowal (56mg/l) , and Serian (57 mg/l).

Bicarbonate is the dominant anion while calcium or calcium along with magnesium is the dominant cation in he waters. By and large , quality ground water is suitable for drinking except at few places mentioned above due to high value of NO_3 exceeding 45 mg/l.

The suitability of ground water for Irrigation is generally assessed by the factors of salinity (EC), Sodium absorption ratio (SAR) & Residual Sodium carbonate (RSC). These parameters range between 550-1320 microsiemens /cm at 25^0 C,

0.29-3.64 and (-) 1.68 to 4.08 respectively. Based upon the plot of EC Vs SAR on the USSL diagram for rating Irrigation Waters, C_{25} & C_3S_1, classes of waters have been observed, Such waters will cause problems of neither salinity nor sodium hazard when used for customary Irrigation.

The shallow ground water is getting polluting by heavy metals like copper, lead, manganese and iron. However, in deeper aquifer the concentration of these heavy metals is low as compare to shallow aquifer. The overall review of trace elements analysis

indicates that the presence of heavy metals in the ground water at shallow and deeper aquifers, which is due to industrial pollution.

Presence of chemical constituents more than the permissible limits:-

A.

Chemical Constituents	Total Wells	B15 Limit	Above Limits	Location with value in mg/l
NO3	**8**	**45**	**5**	**Bhalopur (52)** **Muskabad (58)** **Kohara (104)** **Begowal (56)** **Sherian (57)**
Fe	**5**	**1.0 mg/l**	**Nil**	
As	**5**	**0.01 mg/l**	**Nil**	

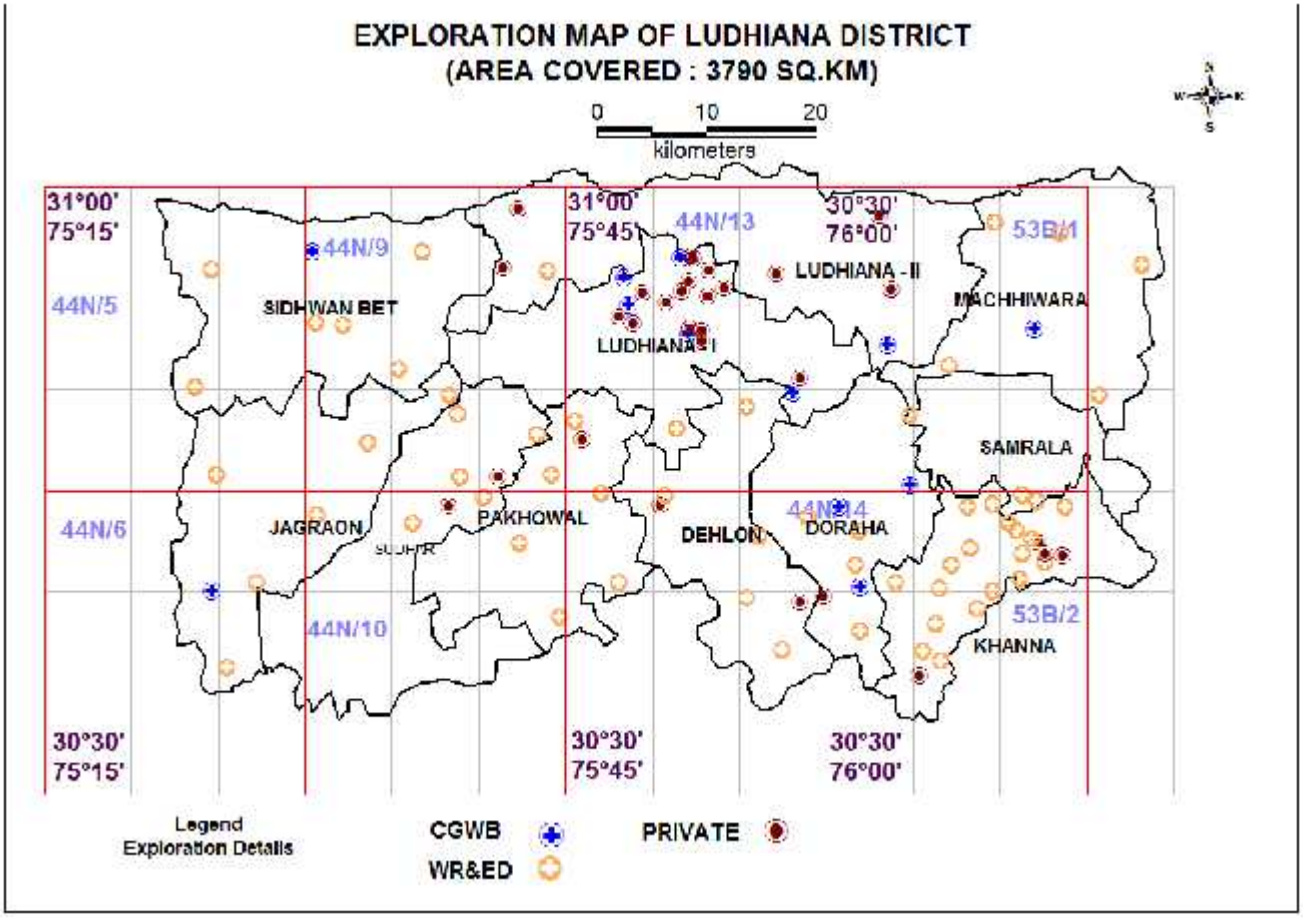
B. Type of water: - calcium bicarbonate

2.3 SPATIAL DATA DISTRIBUTION

Data Distribution

The actual data of all the wells in the area are plotted on the map of 1:50000 scale with 5 min x 5 min grid (9km x 9km) and is shown in Fig: 2.The exploration data shows that majority of tube wells falls in the IInd Aquifer. After data validation, only selected the deepest well in each quadrant is plotted on the map of 1.50000 scale with 5 min x 5 min grid (9km x 9km) and is shown in Fig: II. The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation.

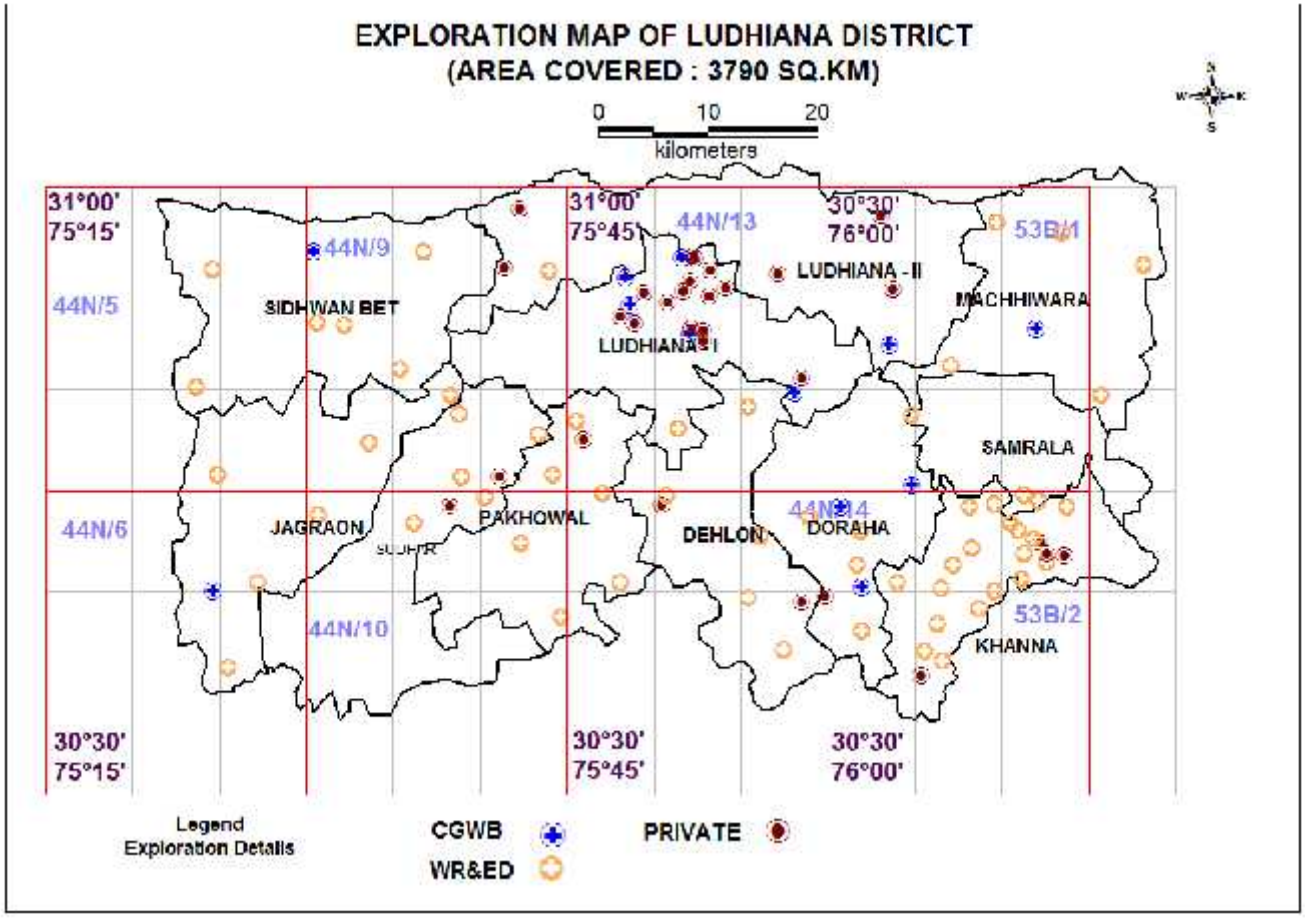
Fig-2 Location of Exploratory Bore Holes



2.4 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

All the available data have been validated for consideration 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 9km) and is shown in Fig -3.

Fig 3: Validated Exploration Data of Ludhiana District



The topographic elevation values have been plotted to prepare the elevation contour map and is in fig 4.

The data is validated by selecting the deepest well in each quadrant with those supported electrical logs for preparation of aquifer map and is shown below

Fig 4: Elevation Contour Map-Ludhiana District

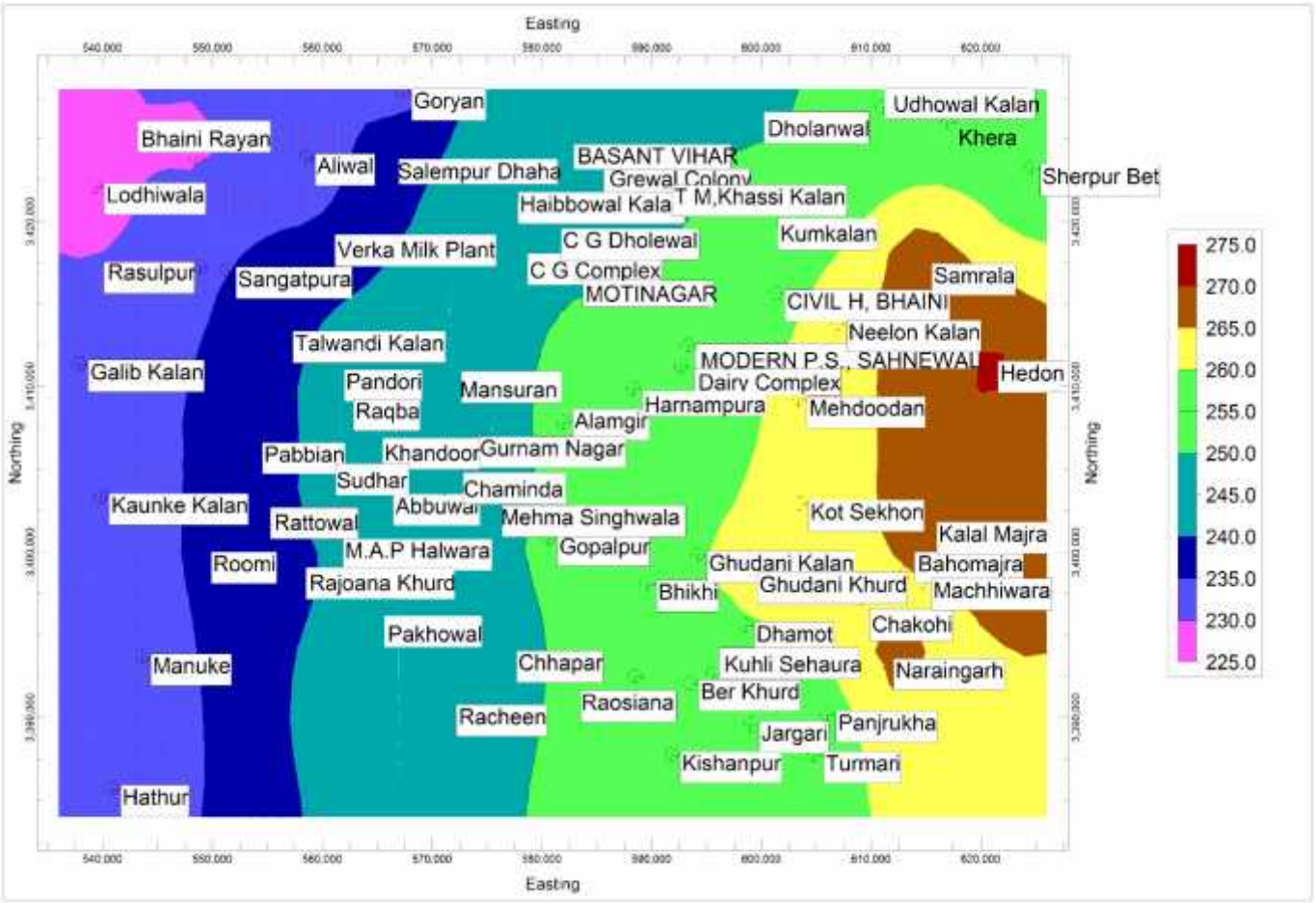


Table-3: Summery of Optimized Exploration Wells

Data Validated: The data is validated by selecting the deepest well in each quadrant with those supported electrical logs for preparation of aquifer map and is shown below;

Sl.No	Block	Toposheet and Grid number		Depth Range (m)								Elevation (m amsl)	Source of data
				Location	< 100	Location	100-200	Location	200-300	Location	>300		
1	**LUDHIANA-II**	44N/13, 53 B/1	2B						300	Janer		**191**	WR&ED
2	**JAGRAON**	44N/6, 44N/9	3A						285	Badni Khurd		**194**	CGWB
3	**SUDHAR**	44N/9,44N/10	3A						300	Nathuwala Jadid		**199**	CGWB
4	**RAIKOT**	44N/9, 44N/13, 53 B/1	2A						300	Rajoena		**192**	CGWB
5	**PAKHOWAL**	44N/9,44N/10, 44N/13	3A						247	Sosan		**192**	CGWB
6	**LUDHIANA-I**	44N/5	3A						300	Mehna		**195**	CGWB
7	**DEHLON**	44N/13, 44N/14											
8	**DORAH**												
9	**SAMRALA**												
10	**SIDWANBET**	44N/5, 44N/9											
11	**KHANNA**	44N/5	1A						300	Pandori Araen		**193**	WR&ED

3. HYDROGEOLOGY

3.1 PREVIOUS WORK

The district area is occupied by Indo-Gangatic alluvium of Quaternary age. The subsurface geological formations of the area comprise of sand, silt, clay and kankar in various proportions. In general the Ground water of the district is fresh except in and around Ludhiana city where the ground water is polluted due to industrial effluents. The aquifer disposition of the area is revealed by drilling data carried out down to 408 m by Central Ground Water Board and state govt. The lithological data of these boreholes indicate the presence of many sand beds forming the principal aquifers separated by clay beds at various depths.

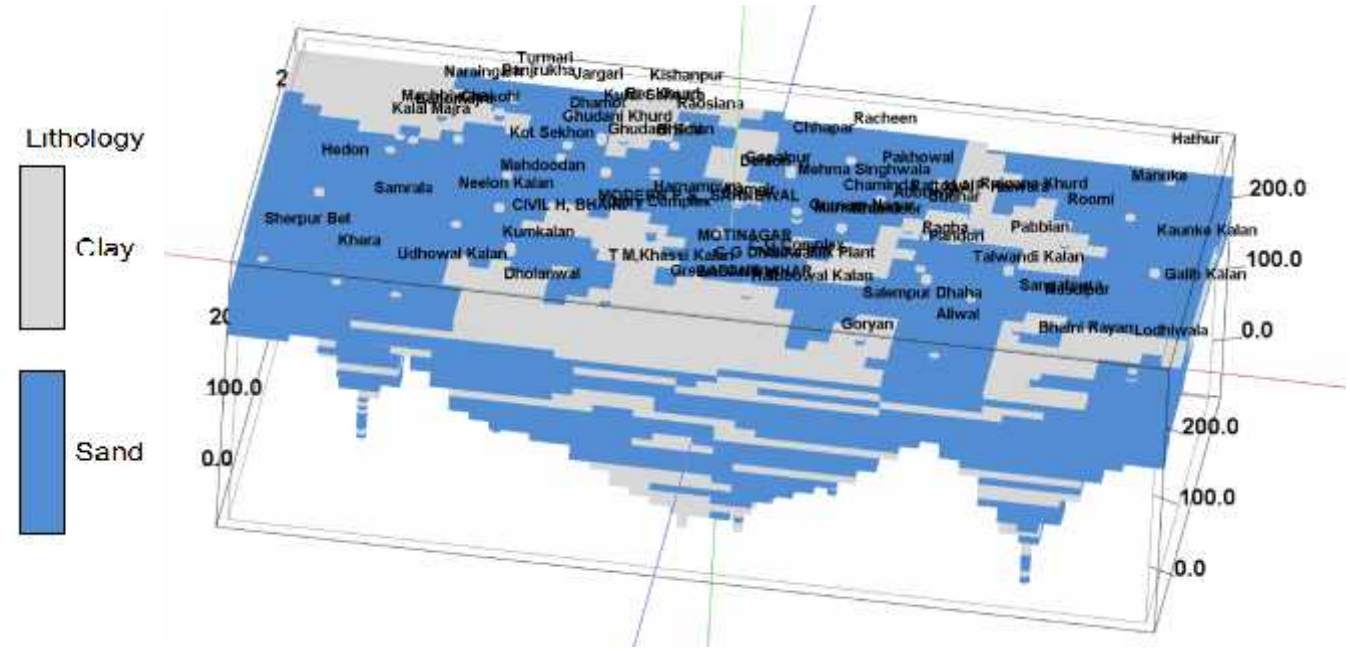
The data indicates presence of about 5 prominent sand horizons down to 400 m depth separated by thick clay horizons. The first aquifer generally occurs between 10 and 30m. The second is between 50 and 120m. Third between 150-175m. For the forth between 200-250m and the fifth between 300-400m. The aquifers are giving discharge from 3-52 lps with $4.3X10^{-4}$ - $6.98X10^{-4}$storativity and transvity is ranges between 628-1120 m^2/day. The sand content in the aquifer in the district varies from 50 to 80%. Clay beds though thick at places occur mostly as lens and pinches out laterally. The granular material becomes coarser with depth. The aquifer at deeper levels acts as semi-confined to con fined.

The depth to water level in the area ranges between 9-26 m bgl. In the north eastern part ‘Machhiwara’ block area it ranges between 5-10 m bgl and 10-20 m in north central part of the district in Ludhiana city aqnd Bhaini raian . In rest of the area of the district it ranges between 20-30 meters. During the pre monsoon period depth to water level varies between 4.32 to 31.22 m bgl and in post monsoon it ranges between 2.89-27.30 m bgl. The long term water trend indicates that the water level showing decline ranges from 0.11 m /y -1.34 m/year.

3.2 Present NAQUIFERUIM study

To understand the sub surface lithology and its disposition, the lithological data of the optimized wells drilled by CGWB, PHED and Private Agencies is plotted using the RockWorks15 software and a lithological model has been prepared and is shown in fig. The 2D lithology map and 3D lithological fence diagram has been prepared using the lithology model and are shown in fig 5 & 6 respectively.

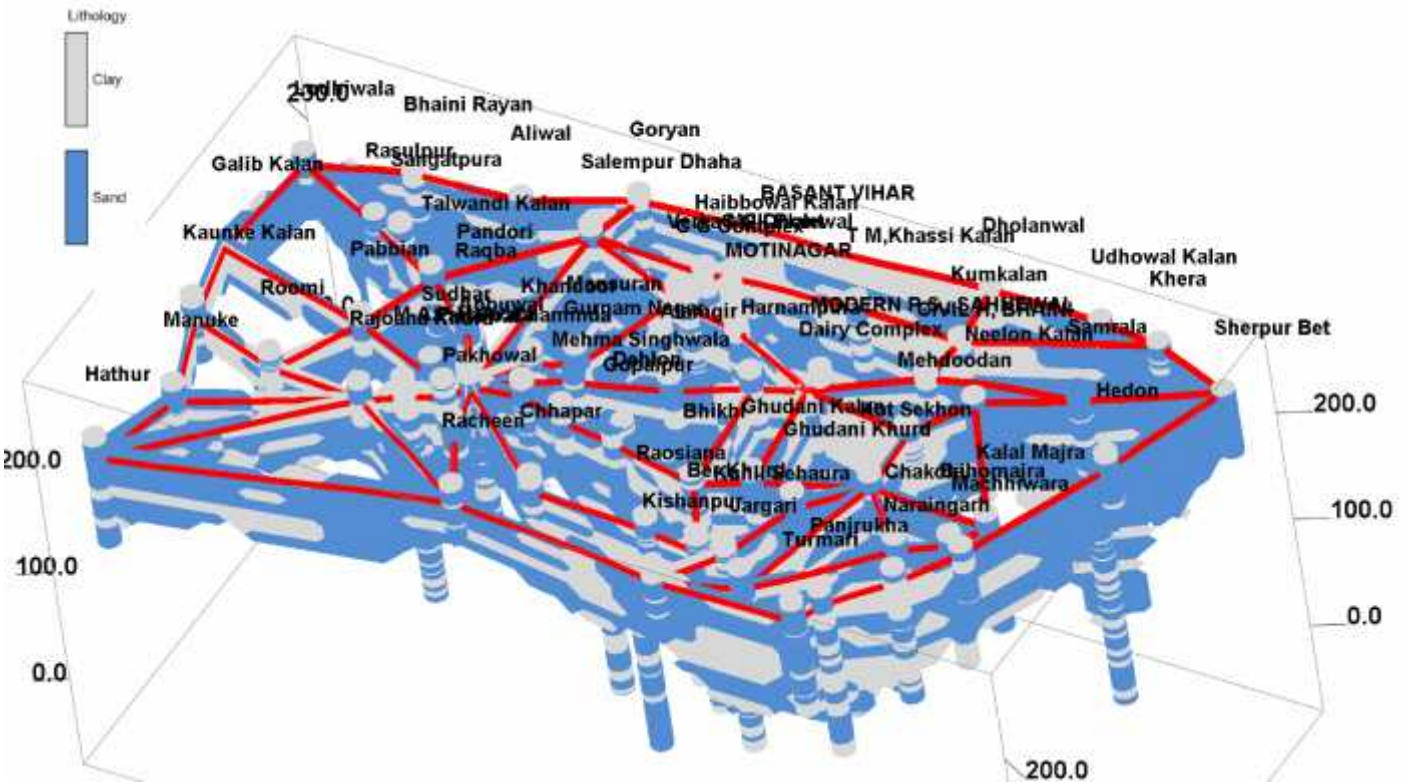
Fig 5: 3-Dimension Lithological Model of Ludhiana District



To present a three dimensional regional picture of the sub-surface conditions in the two districts a fence diagram was prepared by synthesizing the various sub-surface sections. The fence diagram thus drawn reveals broad picture of disposition, inter relationship of granular zones, nature, geometry and extension of aquifers of the entire district. The aquifer group embodies a number of granular layers alternating with thick or thin clay lenses. A few clay

layers intervening these aquifer groups pinch out against the sand zones at a few places. 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. The second and third aquifers are separated by a 8-10 m clay bed. Coarse sand beds occur as thin layers within medium sand. Fourth aquifer is again underlain by a clay zone of unknown thickness. Striplogs showing lithologs of exploration wells and various block diagrams based on Lithology and Aquifer Group .

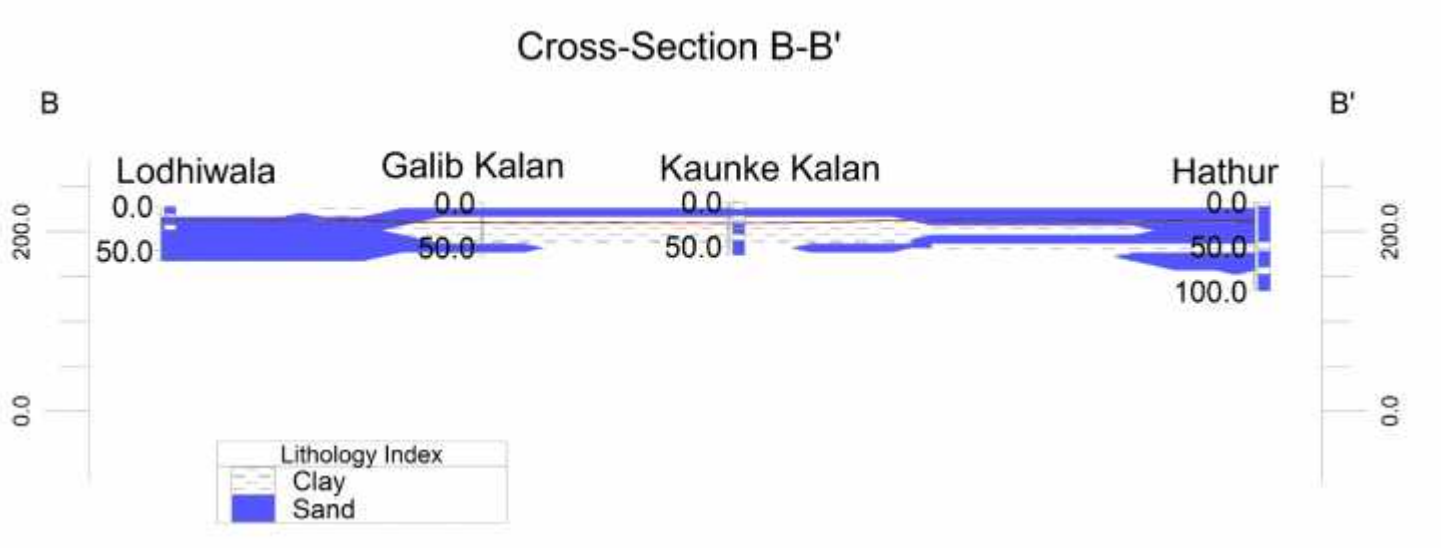
Fig 6: 3 Dimension Lithological Fence of Ludhiana District

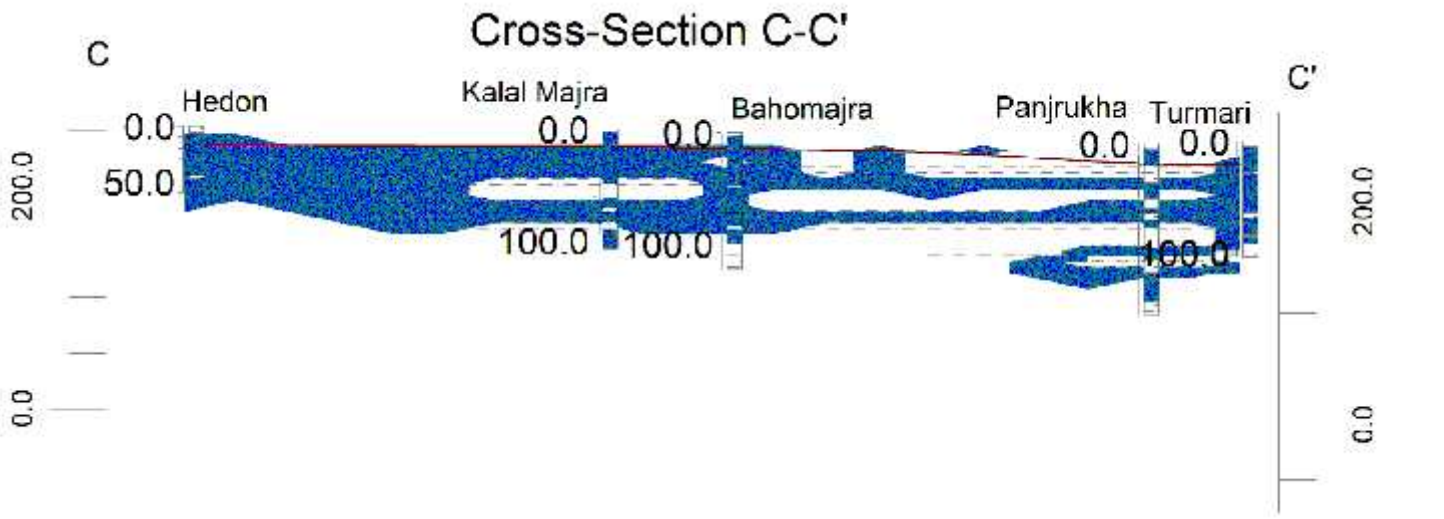


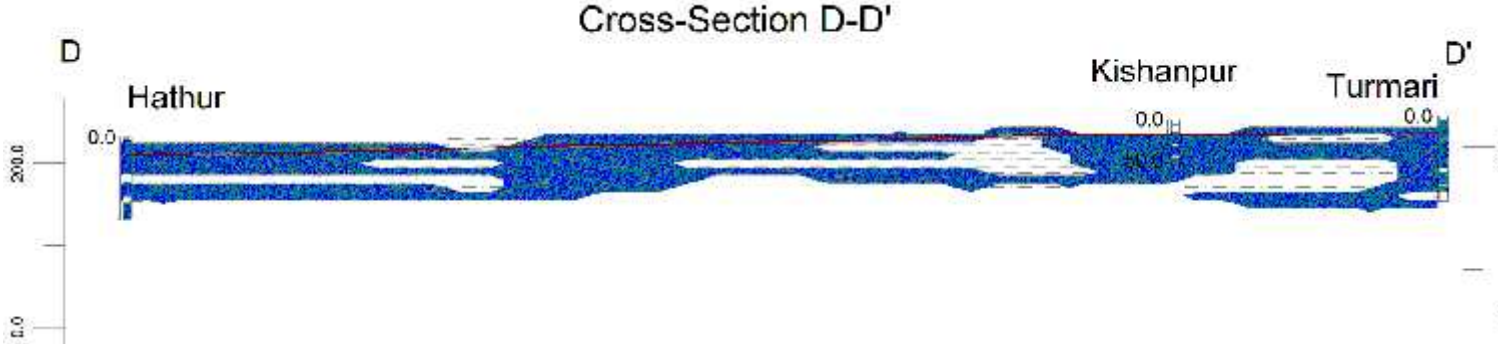
3.3 Aquifer Geometry

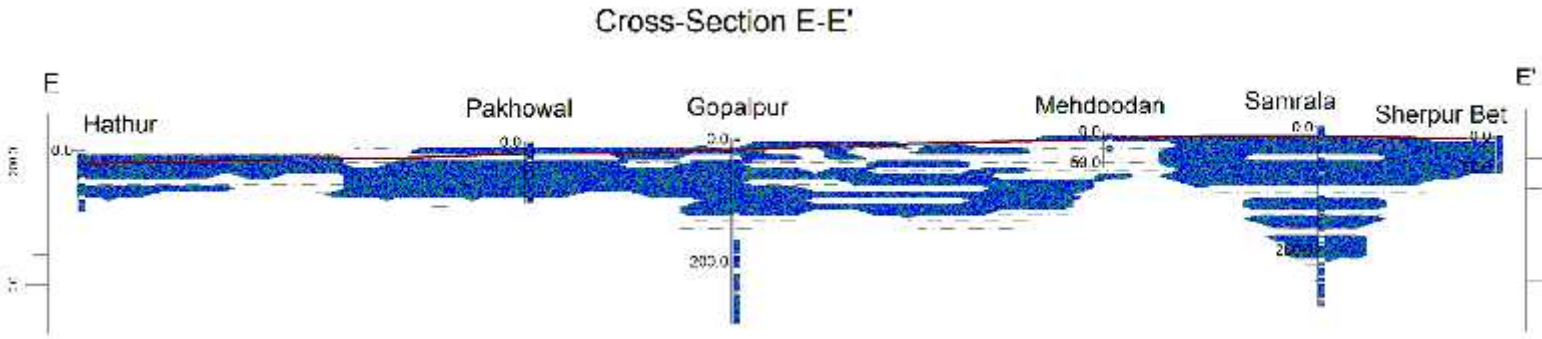
Ludhiana District forms central part of sate and is underlain by formations of Quaternary age comprising of alluvium deposits belonging to vast Indus alluvial plains; therefore it belongs to a multiple aquifer system up to 300m depth with alternate bands of medium to coarse sand and clay. To know the broad picture of the aquifer disposition, inter-relationship of granular zones, nature, geometry and extension of aquifers in the Ludhiana district, the aquifer grouping has been done using the sub-surface lithology and a three-dimensional aquifer model has been prepared. The 2D aquifer map was also prepared using the aquifer model. The aquifer grouping is done and given in Table. The first aquifer is water table aquifer and extends all over the area. The aquifer is mainly composed of fine to medium grained sand. The Aquifer grouping cannot be done in the district as fresh and saline water exist. The grouping of Aquifer is done as Fresh and Saline. The resources are calculated separately which are included in next chapter. The Lithological cross-section of Ludhiana district is given below:-

Fig 7: Cross Sections of Aquifer Map of Ludhiana District


Cross-Section B-B'
B
B'
Lodhiwala
Galib Kalan
Kaunke Kalan
Hathur
0.0
50.0
100.0
200.0
0.0
Lithology Index
Clay
Sand


Cross-Section C-C'
C
C'
Hedon
Kalal Majra
Bahomajra
Panjrukha
Turmari
0.0
50.0
100.0
200.0
0.0


Cross-Section D-D'
D
D'
Hathur
Kishanpur
Turmari
0.0
200.0
0.0



4. 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 aquifers present up to 300m depth. The assessment of Dynamic and in storage Ground Water Resources of the study area have been carried out jointly by CGWB, Water Resources & Environment Directorate, Department of Irrigation, on the basis of Groundwater Estimation Committee (GEC) (1997) methodology based on data available and as per the revised methodology for the year 2013.

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 ground water resource of this zone has been calculated considering 12% specific yield of the formation. The specific yield value for the unconfined aquifer has been taken as 60% of 0.12 which comes as 0.072 whereas for the confined aquifer, 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 fresh 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 Water Resources & Environment Directorate, Department of Agriculture, and Punjab Water Resource Management & Development Corporation, Punjab

4.1 Unconfined aquifers

Dynamic Resources

As per Groundwater Resources Estimation 2013, the ground water development in all 5 blocks has exceeded the available recharge, thus 5 blocks have been categorized as **over exploited**. Stage of ground water development in the Ludhiana district has been assessed to be 207%.

Table 4: Dynamic Ground Water Resource & Development Potential (as on 31.03.2013)

Assessment Unit/ Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground Water Draft for domestic and industrial water supply	Existing Gross Ground Water Draft for All uses	Provision for domestic, and industrial requirement supply to 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development (%)
DEHLON	18751	32868	538	33406	652	-14769	178
DORAHA	27298	29519	459	29978	568	-2789	110
JAGRAON	22502	30178	813	30991	1007	-8682	138
KHANNA	16238	32991	840	33831	1036	-17789	208
LUDHIANA	12503	26459	4520	30979	6060	-20016	248
MACHHIWARA	26440	27284	355	27639	423	-1267	105
MANGAT	23152	34533	1162	35695	1408	-12789	154
PAKHOWAL	12618	24034	268	24302	340	-11756	193
RAIKOT	11978	26459	287	26746	394	-14876	223
SAMRALA	10152	19879	540	20419	641	-10367	201
SIDHWAN BET	21205	35052	480	35533	538	-14385	168
SUDHAR	9837	13974	342	14316	447	-4583	146
Total (ham)	**212674**	**333230**	**10605**	**343835**	**13512**	**-134069**	**162**

Instorage Ground Water Resources

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

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

4.2 Confined Aquifer

The availability of ground water resources in confined aquifer have two components: Storage under pressure (using Storativity concept) and Storage under desaturated (gravity drainage) condition (using Specific Yield concept) (source: Assessment of Ground Water Resources; A Review of International Practices, 2014) and is shown in Fig 9. However, since ground water withdrawals from confined aquifer are known to have serious environmental degradation effects, the preliminary assessment of ground water resources in confined aquifer is restricted to the estimation of ground water storage under pressure conditions only but here the storage under de-saturation is also computed.

Storativity Concept:

ii)	In-storage Ground Water resources (within the Peizometer)	=	Thickness of the water column in Peizometer of particular confined aquifer up to the top layer of same confined aquifer	×	Storativity of the confined aquifer	×	Areal extent of the confined aquifer group

Specific Yield Concept:

ii)	In-storage Ground Water	=	Thickness of the confined aquifer	×	Sp. Yield	×	Areal extent of

resources (within the aquifer thickness)	(granular/ productive zone) down to the bottom layer of confined aquifer or exploitable depth of 300 m	of the aquifer	the confined aquifer group

Preliminary assessment of the ground water resources in confined aquifer does not imply that the assessed resource is available for exploitation. The objective of this exercise is to have an overview of the ground water regime in the particular confined aquifer. It should be kept in mind that any significant ground water withdrawal from confined aquifer may invoke serious environmental degradation problem. Therefore, in case the preliminary assessment reveals that ground water is being withdrawn in significant quantity for any confined aquifer, that particular aquifer should be identified for detailed assessment using numerical modelling approach.

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

Fig 8: Concept for Resource Estimation in Unconfined and Confined Aquifer System

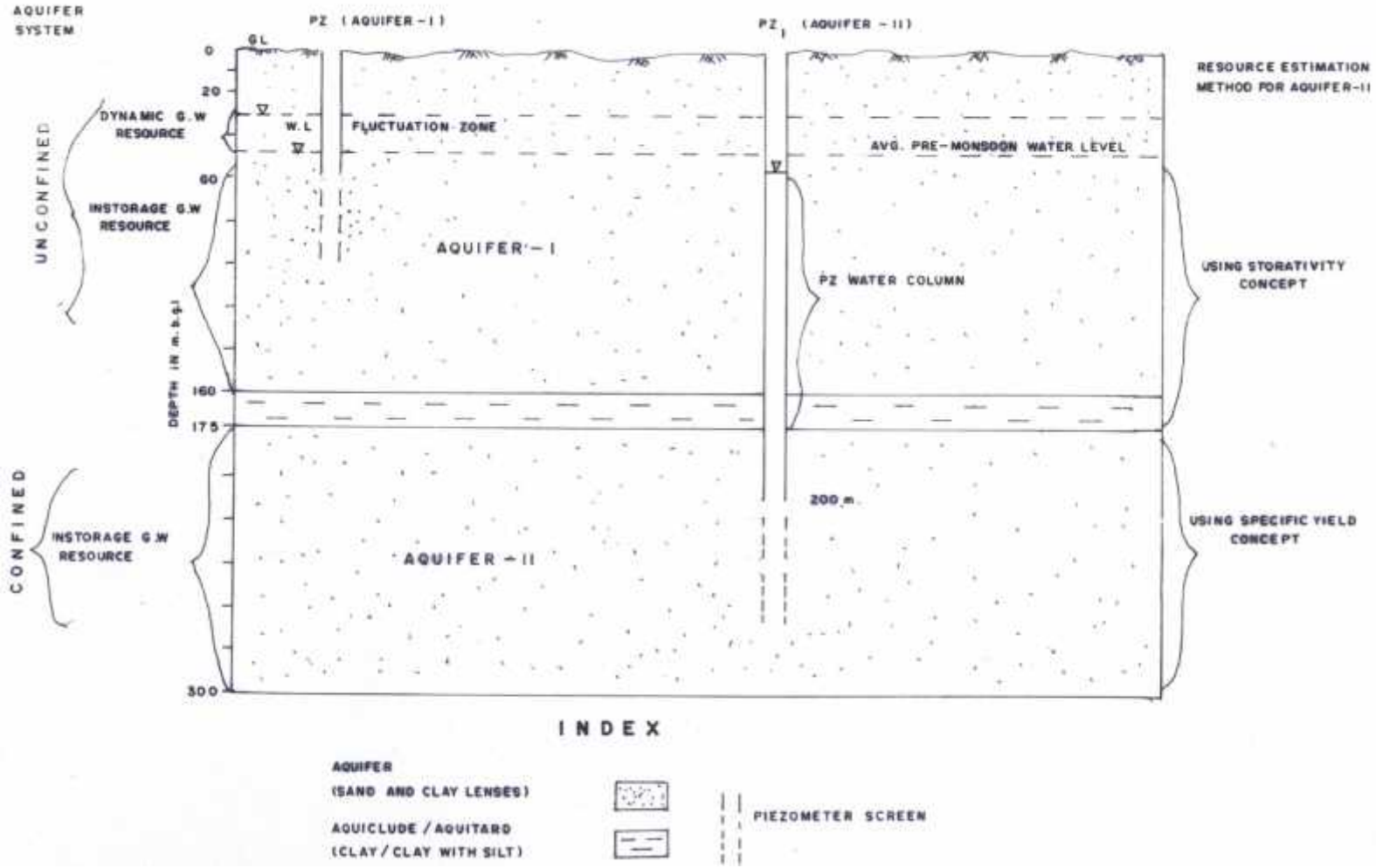


Table 5: BLOCK WISE AVAILABILITY OF TOTAL GROUNDWATER RESOURCES IN LUDHIANA DISTRICT UP TO DEPTH OF 300M

BLOCK WISE INSTORAGE GROUND WATER RESOURCES IN UNCONFINED AQUIFER –I (ALLUVIUM)											
Sr. No.	Name of Assessment Unit	Areal extent (ha)				Average Pre-monsoon Water Level (m bgl)	Depth to bottom of Aquifer Group I (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) (9-8)	Thickness of the Granular Zone in AQUIFER GROUP-I below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Ground Water Resources (ham) [(6)*(11)*(12)]
		Total Geographical Area (ha)	Assessment Area								
			Total	Fresh Water	Brackish/Saline Water						
1	2	4	5	6	7	8	9	10	11	12	13
1	DEHLON	28560	28560	28560	0	16.51	72.21	55.70	33.75	0.072	69401
2	DORAHA	22480	22480	22480	0	16.28	94.24	77.96	51.91	0.072	84019
3	JAGRAON	34430	34430	34430	0	20.96	63	42.04	23.42	0.072	58057
4	KHANNA	36570	36570	36570	0	18.68	88	69.32	48.92	0.072	128808
5	LUDHIANA	31680	31680	31680	0	30.90	119.81	88.91	61.18	0.072	139549
6	MACHHIWARA	36570	36570	36570	0	5.26	60	54.74	37.57	0.072	98923
7	MANGAT	50730	50730	50730	0	9.49	105.87	96.38	67.36	0.072	246036
8	PAKHOWAL	21083	21083	21083	0	16.35	75.62	59.27	34.62	0.072	52552
9	RAIKOT	26620	26620	26620	0	22.24	60	37.76	24.5	0.072	46958
10	SAMRALA	15350	15350	15350	0	12.80	71.34	58.54	31.6	0.072	34924
11	SIDHWAN BET	40170	40170	40170	0	13.60	72.5	58.90	39	0.072	112797
12	SUDHAR	14447	14447	14447	0	18.09	71.56	53.47	31.82	0.072	33099
Dist. Total (ham)		**358690**	**358690**	**358690**							**1105125**
Dist. Total (mcm)		**3586.9**	**3586.9**	**3586.9**							**11051**

ham: hectare metre,
mcm: million cubic metre

BLOCK WISE INSTORAGE GROUND WATER RESOURCES – CONFINED (AQUIFER II)															
Sr. No.	Name of Assessment Unit	Total Geogra-phical Area	Areal extent (ha)		Top Aquifer II (m bgl)	Depth to bottom of Aquifer II (m bgl)	Peizometer head value for Confined Aquifer-II (m bgl)	Thickness of piezometric level(m bgl)	Total Thickness of confined aquifer down to explored depth (m) (7-6)	Thickness of the Granular Zone in confined aquifer down to explored depth (m)	Average Specific Yield	Average value of Storati-vity	In-Storage Ground Water Resources (ham) (Specific yield concept) [(5)*(11)*(12)] FRESH	In-Storage Ground Water Resources (Storativity concept) [(5)*(9)*(13)]	Total in-Storage Ground Water Resources (ham) (15+16)
			Total	Fresh Water											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	DEHLON	28560	28560	28560	110	158	30	80	48	33	0.072	0.00195	67859	4455	72314
2	DORAHA	22480	22480	22480	124	169	30	94	45	29	0.072	0.00195	46938	4121	51059
3	JAGRAON	34430	34430	34430	0	0	0	0	0	0	0.072	0.00195	0	0	0
4	KHANNA	36570	36570	36570	110	162	30	80	52	37	0.072	0.00195	97422	5705	103127
	LUDHIANA	31680	31680	31680	147	194	30	117	47	30	0.072	0.00195	68429	7228	75657
	MACHHIWARA	36570	36570	36570	0	0	0	0	0	0	0.072	0.00195	0	0	0
	MANGAT	50730	50730	50730	114	164	30	84	50	40	0.072	0.00195	146102	8310	154412
	PAKHOWAL	21083	21083	21083	166	244	30	136	78	38	0.072	0.00195	57683	5591	63274
5	RAIKOT	26620	26620	26620	0	0	0	0	0	0	0.072	0.00195	0	0	0
6	SAMRALA	15350	15350	15350	112	169	30	82	57	48	0.072	0.00195	53050	2454	55504
7	SIDHWAN BET	40170	40170	40170	155	210	30	125	55	42	0.072	0.00195	121474	9791	131266
8	SUDHAR	14447	14447	14447	135	168	30	105	33	21	0.072	0.00043	21844	652	22496
Dist. Total (ham)		**358690**	**358690**	**358690**									**680801**	**48308**	**729109**
Dist. Total (mcm)		**3586.9**	**3586.9**	**3586.9**									**6808**	**483**	**7291**

BLOCK WISE INSTORAGE GROUND WATER RESOURCES – CONFINED (AQUIFER III)													
Sr. No.	Name of Assessment Unit	Total Geographical Area	Areal extent (ha)		Top Aquifer III (m bgl)	Depth to bottom of Aquifer III (m bgl)	Thickness of piezometric level(m bgl)	Total Thickness of confined aquifer down to explored depth (m) (9-8)	Thickness of the Granular Zone in confined aquifer down to explored depth (m)	Average Specific Yield	Average value of Storativity	In-Storage Ground Water Resources (ham) (Specific yield concept) [(6)*(12)*(13)] FRESH	In-Storage Ground Water Resources (Storativity concept) [(6)*(10)*(14)]
			Total	Fresh Water									
1	2	4	5	6	8	9	10	11	12	13	14	15	16
1	DEHLON	28560	28560	28560	220	300	0	80	30	0.072	0.00195	61690	0
2	DORAHA	22480	22480	22480	0	0	0	0	0	0.072	0.00195	0	0
3	JAGRAON	34430	34430	34430	0	0	0	0	0	0.072	0.0038	0	0
4	KHANNA	36570	36570	36570	0	0	0	0	0	0.072	0.00195	0	0
	LUDHIANA	31680	31680	31680	207	258	0	51	27	0.072	0.00195	61586	0
	MACHHIWARA	36570	36570	36570	0		0	0		0.072	0.00195	0	0
	MANGAT	50730	50730	50730	0		0	0		0.072	0.00195	0	0
	PAKHOWAL	21083	21083	21083	255	300	0	45	25	0.072	0.00195	37949	0
5	RAIKOT	26620	26620	26620	0	0	0	0	0	0.072	0.00195	0	0
6	SAMRALA	15350	15350	15350	186	279	0	93	71	0.072	0.00195	78469	0
7	SIDHWAN BET	40170	40170	40170	235	300	0	65	51	0.072	0.00195	147504	0
8	SUDHAR	14447	14447	14447	193	220	0	27	9	0.072	0.00195	9362	0
Dist. Total (ham)		**358690**	**358690**	**358690**								**396560**	**0**
Dist. Total (mcm)		**3586.9**	**3586.9**	**3586.9**								**3966**	**0**

Table 6: BLOCK WISE TOTAL AVAILABLE GROUND WATER RESOURCES IN AQUIFERS UP TO 300m DEPTH

AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN LUDHIANA DISTRICT									
Sl.No	Block	*Volume of Unsaturated Zone up to Pre-monsoon WL (ham)*	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*In-storage Groundwater Resources AQUIFER-I*	Fresh Groundwater Resources AQUIFER-I [(4)+(5)]	Fresh In-storage Groundwater Resources AQUIFER-II	Fresh In-storage Groundwater Resources AQUIFER-III	**Total Availabilty of Fresh Groundwater Resources [(6)+(7)+(8)]**	
								ham	mcm
1	2	*3*	*4*	5	6	7	8	9	10
1	DEHLON	44554	18751	69401	88151	72314	61690	222155	2222
2	DORAHA	24278	27298	84019	111317	51059	0	162376	1624
3	JAGRAON	61974	22502	58057	80559	0	0	80559	806
4	KHANNA	35107	16238	128808	145046	103127	0	248174	2482
5	LUDHIANA	41818	12503	139549	152052	75657	61586	289294	2893
6	MACHHIWARA	57049	26440	98923	125364	0	0	125364	1254
7	MANGAT	36526	23152	246036	269189	154412	0	423601	4236
8	PAKHOWAL	27830	12618	52552	65170	63274	37949	166394	1664
9	RAIKOT	31944	11978	46958	58935	0	0	58935	589
10	SAMRALA	18420	10152	34924	45077	55504	78469	179050	1790
11	SIDHWAN BET	81947	21205	112797	134003	131266	147504	412772	4128
12	SUDHAR	20804	9837	33099	42936	22496	9362	74793	748
Dist. Total (ham)		**482250**	**212674**	**1105125**	**1317799**	**729109**	**396560**	**2443468**	**24435**
Dist. Total (mcm)		**4822**	**2127**	**11051**	**13178**	**7291**	**3966**		

5. GROUND WATER RELATED ISSUES

Ludhiana is famous for its paddy cultivation and is also known as 'Rice Bowl' of Punjab. The quality of ground water in the district is potable for both the drinking and irrigation purposes therefore, the ground water is constantly being pumped for the irrigation due to its easy access through tube wells and they are the main source of irrigation.

This will lead to its major ground water issue which is deepening of ground water level as the recharge of the groundwater through rainfall and other sources are less than the overall extraction.

5.1 GROUND WATER IRRIGATION SCENARIO

As per the data available from minor irrigation census 2006-07, the number of shallow and deep, tube wells, lined, unlined water distribution system, land holdings of wells are given in Table 7,8 and 9

Fig 9: Irrigation tube wells as per depth.

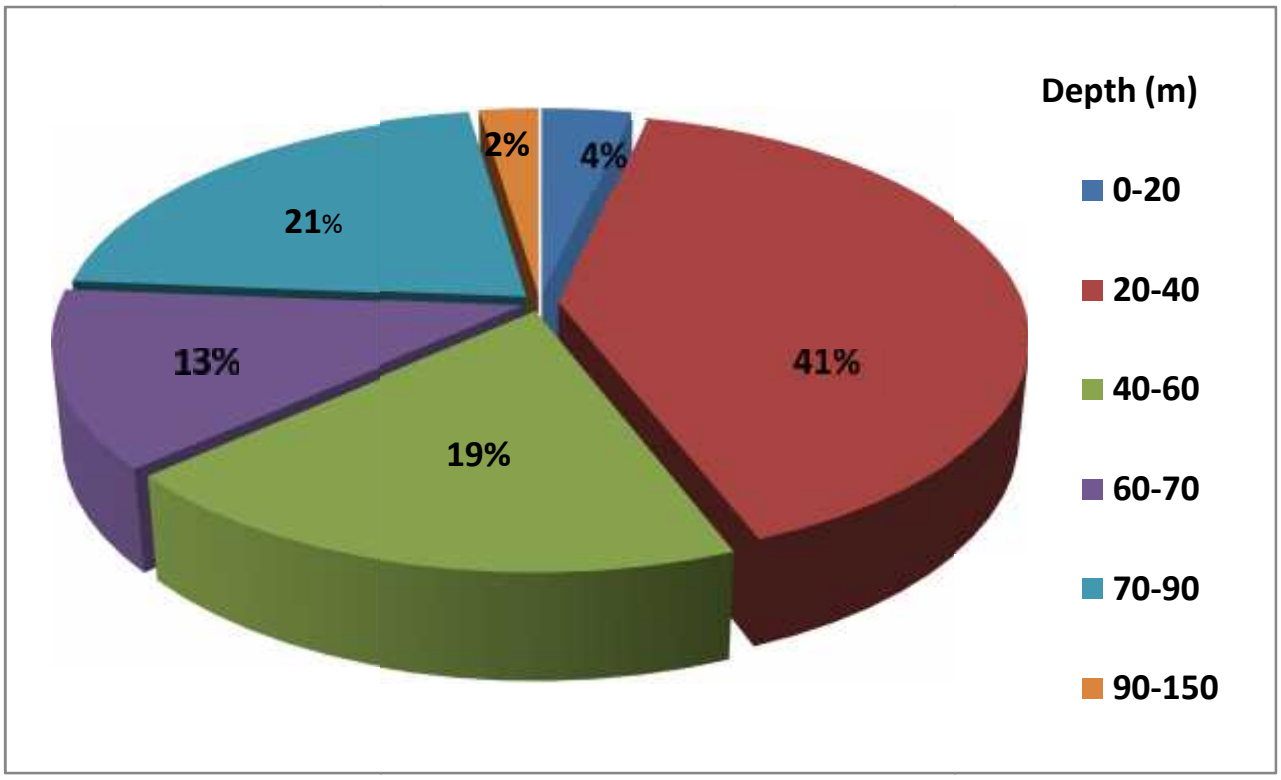


Table 7-Distribution of Tube wells According to Owner's holding Size

No. of shallow tube wells by size class of individual owner							
Sr.no	district	Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10ha)	Big (>=10 ha)	Total
1	**Ludhiana**	**5474**	**12162**	**14761**	**15994**	**4135**	**52526**

Table 8 -Distribution of Shallow Tube wells According to Depth of tube well

No. by the depth of shallow Tube well							
Sr.no	district	(0-20 mts)	(20-40 mts)	(40-60 mts)	(60-70 mts)	(>70 mts)	Total
1	**Ludhiana**	**4271**	**48433**	**23011**	**15485**	**28319**	**119519**

Table 9- Type of Ground water distribution device

Open Water Channel		
Lined/pucca	**Unlined/kutcha**	Total
615	**118905**	**119520**

6. AQUIFER MANAGEMENT PLAN

A summery outline of the artificial recharge plan for the entire district of each OE block is given at the beginning in tabular forms. This is followed by the salient features of each block along with the detailed structure-wise recharge plan and cost estimates. Details of the block wise type of suitable recharge structures and volume of water assured for annual recharge for each block in rural area, urban area and artificial recharge in agricultural farm are given in table and design of recharge structures are annexed at annexure I, II. More than 5 meter Mean decadal water level with falling trend is considered for block wise artificial recharge calculation.

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 in the whole 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 and NGO may also take up the pilot or demonstrative projects in the blocks suitable to them to plan at local level as per local conditions.

6.2 POTENTIAL OF ENHANCING THE GROUND WATER USE EFFICIENCY

The micro level transformation in the ground water management have vast impact potential to counter extensive ground water depletion faced by the state of Punjab, particularly in overexploited blocks. There are around 119520 tubewells operated by farmers for irrigation through unlined/Katcha (99.48%) open channel system in Ludhiana district where water from the tube-well is discharge to the agricultural field. In this process huge quantity of ground water is wasted in soil moisture and evaporation losses.

Dynamic ground water resources (2011) indicate that Gross ground water draft for irrigation in Ludhiana district is estimated at 3332.30 MCM. It is expected that around 43.27% of over draft can be brought down by switching over to underground/surface pipeline based distribution from the prevailing unlined open channels. Thereby gross draft will be reduced to the tune of 2525.24 MCM assuming there is no crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks of Ludhiana Districts. The measure if implemented will bring down the ground water overdraft from 162% to 118.73 %. The category of the blocks will also improve drastically resulting in

boosting of agriculture and industrial development otherwise not sustainable in majority of the blocks in the state.

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

6.3 Water Saving Potential from Crop Diversification-Change Paddy to Maize/Pulses:

As the requirement of water for paddy is much high therefore by changing paddy to maize/Pulses 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 pulses planted in one sq km of land. In case of pulses even higher amount of ground water can be saved

Table 10: Scope of Quantitative Impact on Stage of Development after applying various management strategies

Block	Net Ground Water Availability (mcm)	Total Draft (mcm)	esent Stage of aft (SOD) (%) As per 2013	Reduction in draft by different water saving method				SOD afterwards (%)	Change of paddy ltivation area (% of existing)
			1	eplace water ourses by UG Pipes (mcm) 2	t Artificial echarge (mcm) 3	ge Paddy to Maize (mcm) 4	Total (mcm) (2+3+4) 5		
DEHLON	187.5	334.1	178	83.5	2.92	60.1	146.52	100	30
DORAHA	273.0	299.8	110	74.9	2.73	0.0	77.63	81	
JAGRAON	225.0	309.9	138	77.5	3.42	4.0	84.92	100	1
KHANNA	162.4	338.3	208	84.6	3.36	88.0	175.96	100	46
LUDHIANA	125.0	309.8	248	77.4	12.94	94.4	184.74	100	70
MACHHIWARA	264.4	276.4	105	69.1	0.00	0.0	69.1	78	
MANGAT	231.5	357.0	154	89.2	3.70	32.5	125.4	100	10
PAKHOWAL	126.2	243.0	193	60.8	2.59	53.5	116.89	100	24
RAIKOT	119.8	267.5	223	66.9	2.54	78.3	147.74	100	37
SAMRALA	101.5	204.2	201	51.0	2.05	49.6	102.65	100	36
SIDHWAN BET	212.1	355.3	168	88.8	4.28	50.2	143.28	100	16
SUDHAR	98.4	143.2	146	35.8	1.31	7.7	44.81	100	3
Total	2126.7	3438.4	162	859.6	41.83	410.2	1311.63	119	

7. BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

(I) LUDHIANA-II BLOCK (MANGAT) (507.3 SQ KM)

1. Salient Information

Population (2011)	Rural-218267 Urban-24017 Total-242284
Rainfall 2014 (Ludhiana District)	Average annual rainfall -681 mm
Average Annual Rainfall (Ludhiana-II block)	645 mm
Agriculture and Irrigation	Major Crops- Rice, Wheat Other crops-Sugarcane, Potatoes, Pulses, Net Area Sown- - Total Irrigated Area--

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Ludhiana-II block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-*~10.00—40.00 (mbgl)* &Post Monsoon-*~9.50—38.75(mbgl)*

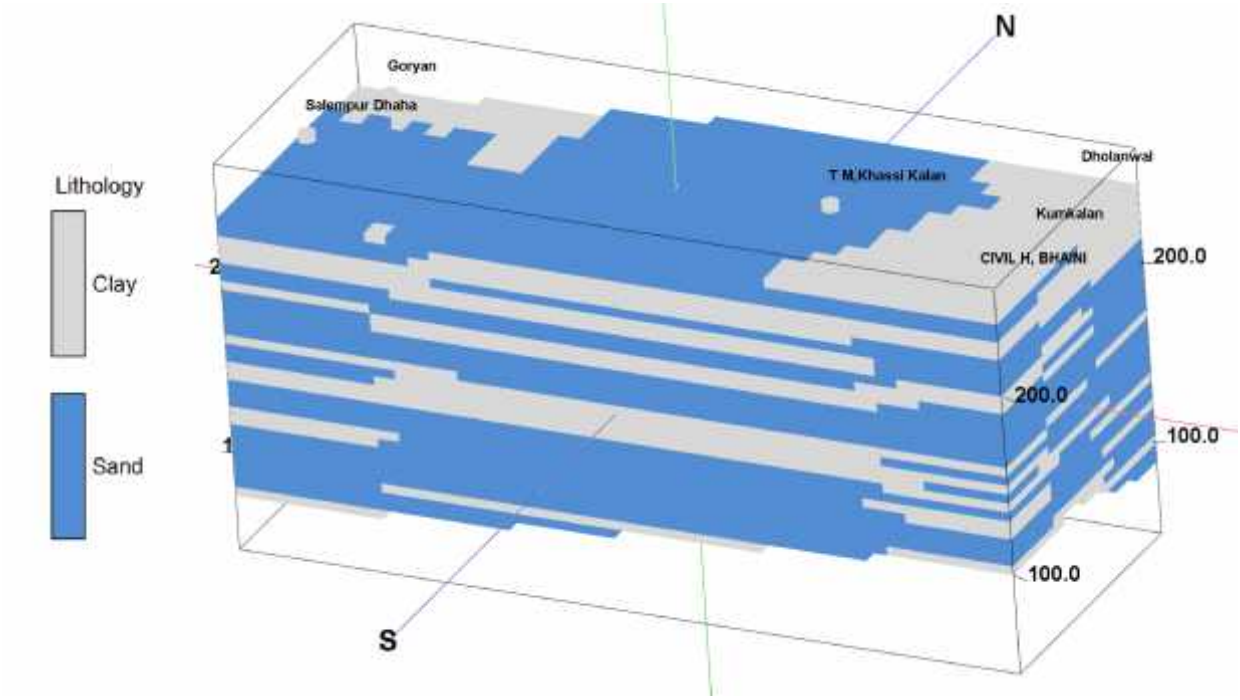
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (10-106m)	Quaternary Alluvial deposits	Unconfined	67	1120	0.072	4.3*10-3
Aquifer-II (113-164m)		Unconfined to Confined	40	-	NA	-

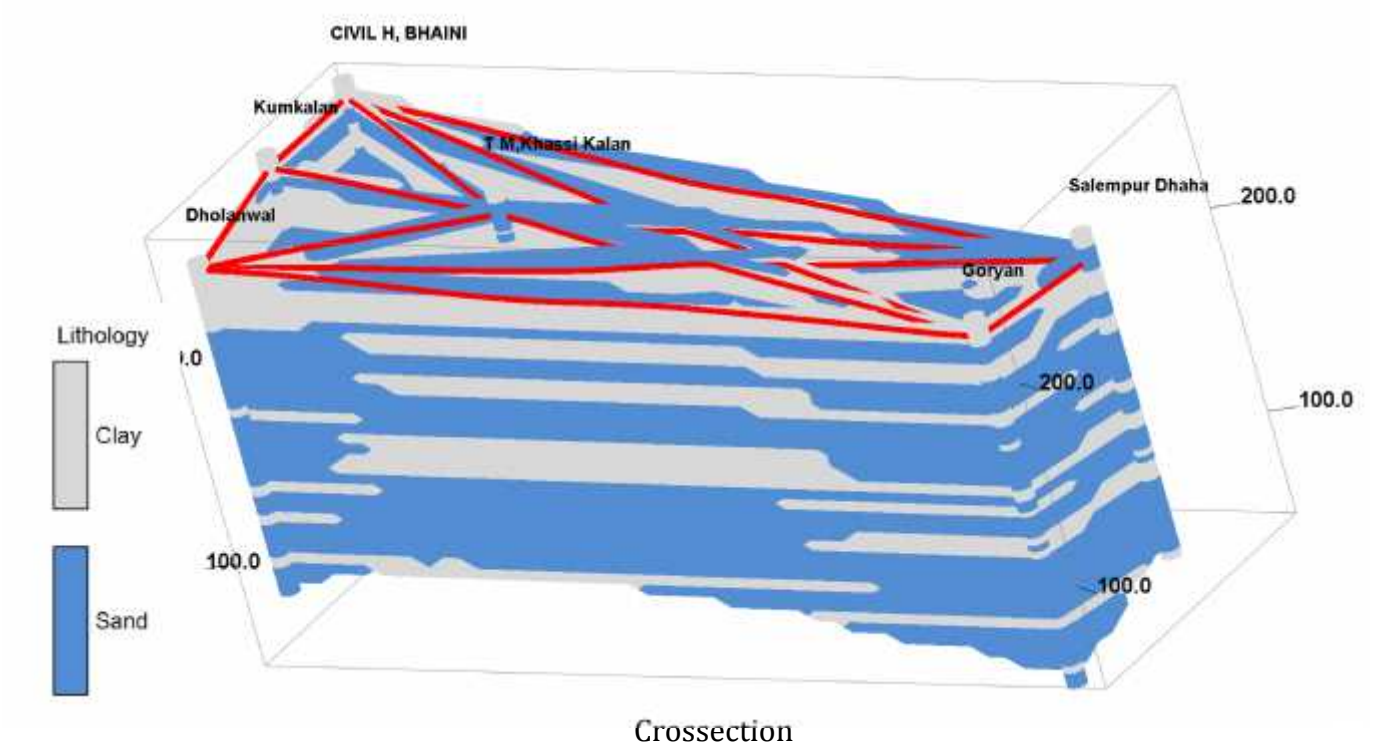
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

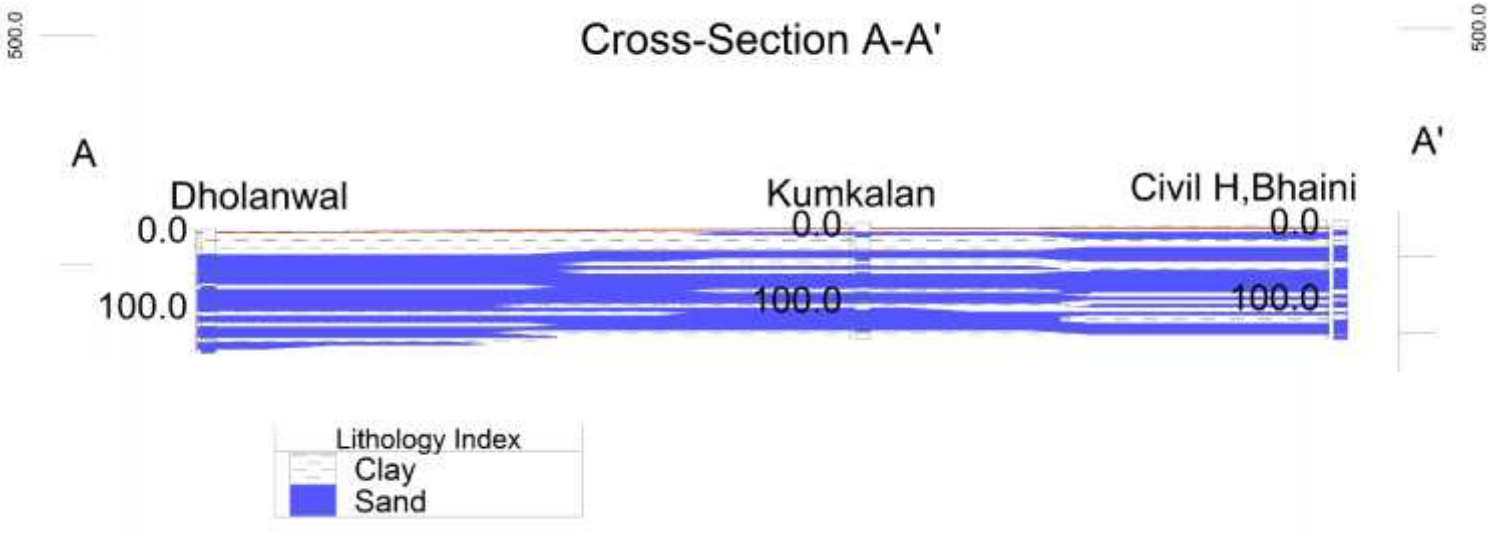
3D Lithology model



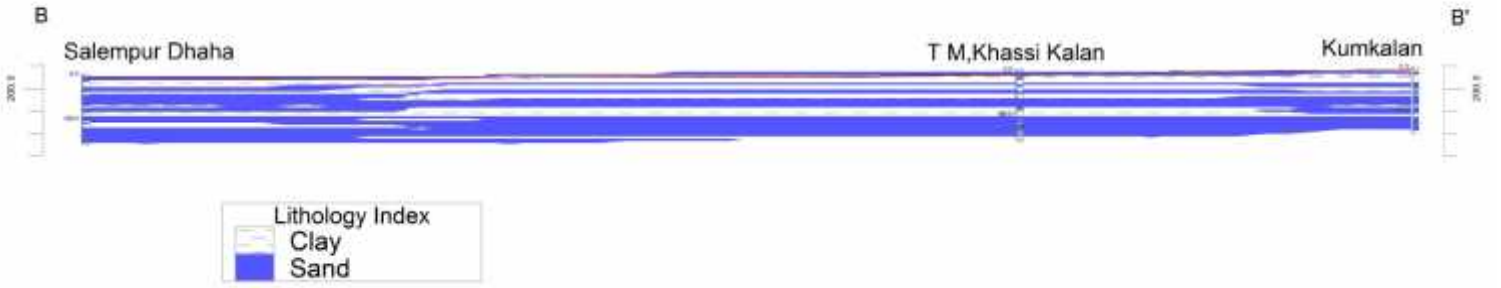
3D Lithology Fence



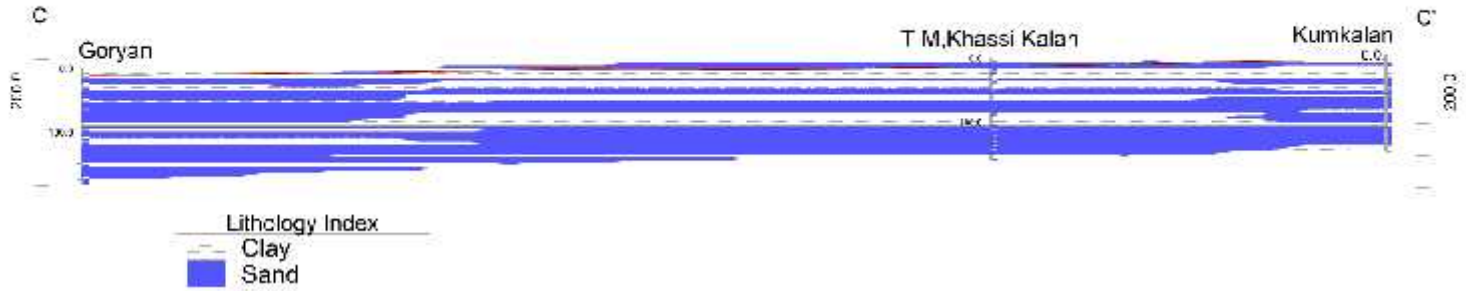
Crossection



Cross-Section B-B'



Cross-Section C-C'



2. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*187.51*
	In-storage Ground Water Resources	4048.49
	Total	4236
Ground Water Extraction (in mcm)	Irrigation	345.33
	Domestic & Industrial	11.62
Provision for domestic & Industrial requirement upto 2025 (in mcm)		14.08
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

3. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (6m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 7.945 mcm volume of water

4. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 103.06 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 10 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 32.50 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

(II) DEHLON BLOCK (285.60 SQ KM)

1. Salient Information

Population (2011) Rural-129706
Urban- -
Total-1,29,706

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Dehlon block) 664 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 262.35 sq.km
Total Irrigated Area- 537.26 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Dehlon block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~6.75 – 25.30 (mbgl) Post Monsoon – 6.49 – 26.32(mbgl)

Aquifer Disposition: Combined Aquifer System

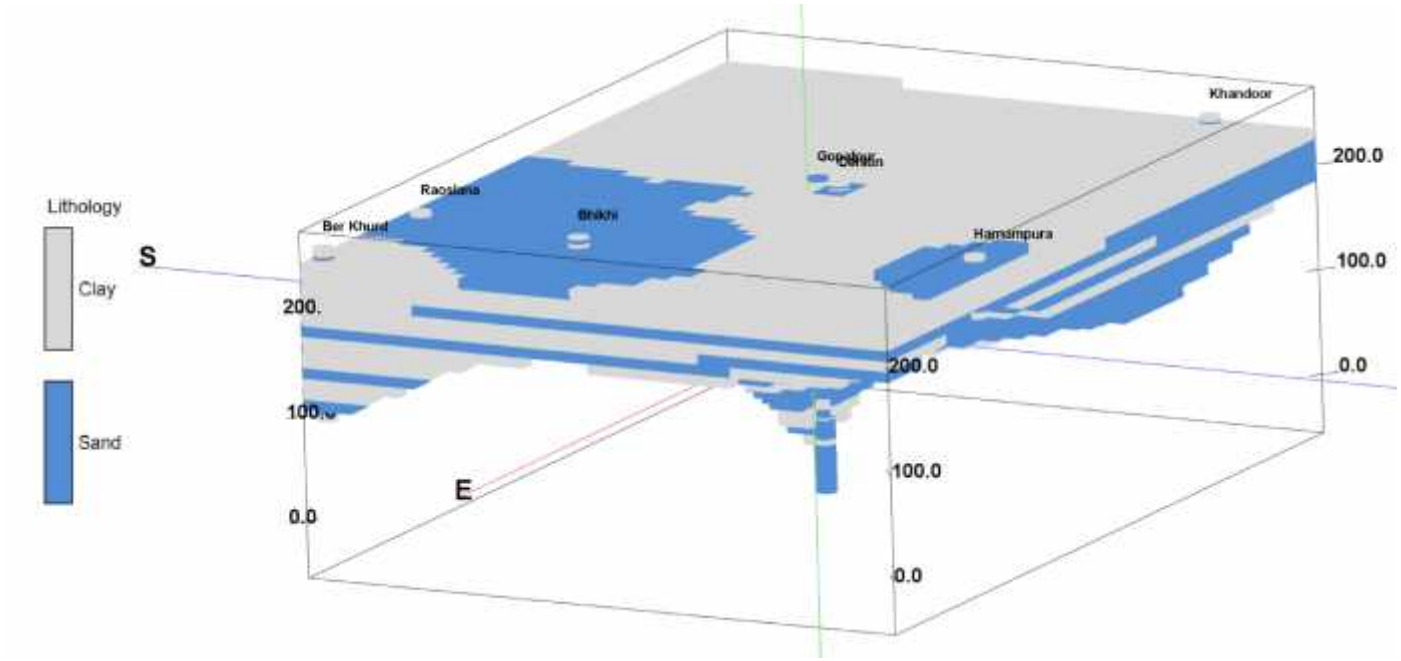
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (17-72m)	Quaternary Alluvial deposits	Unconfined	34	1120	0.072	4.3*10-3
Aquifer-II (109-160m)		Unconfined to Confined	33	-	NA	-
Aquifer-III (240-300m)		Unconfined to Confined	30	-	NA	-

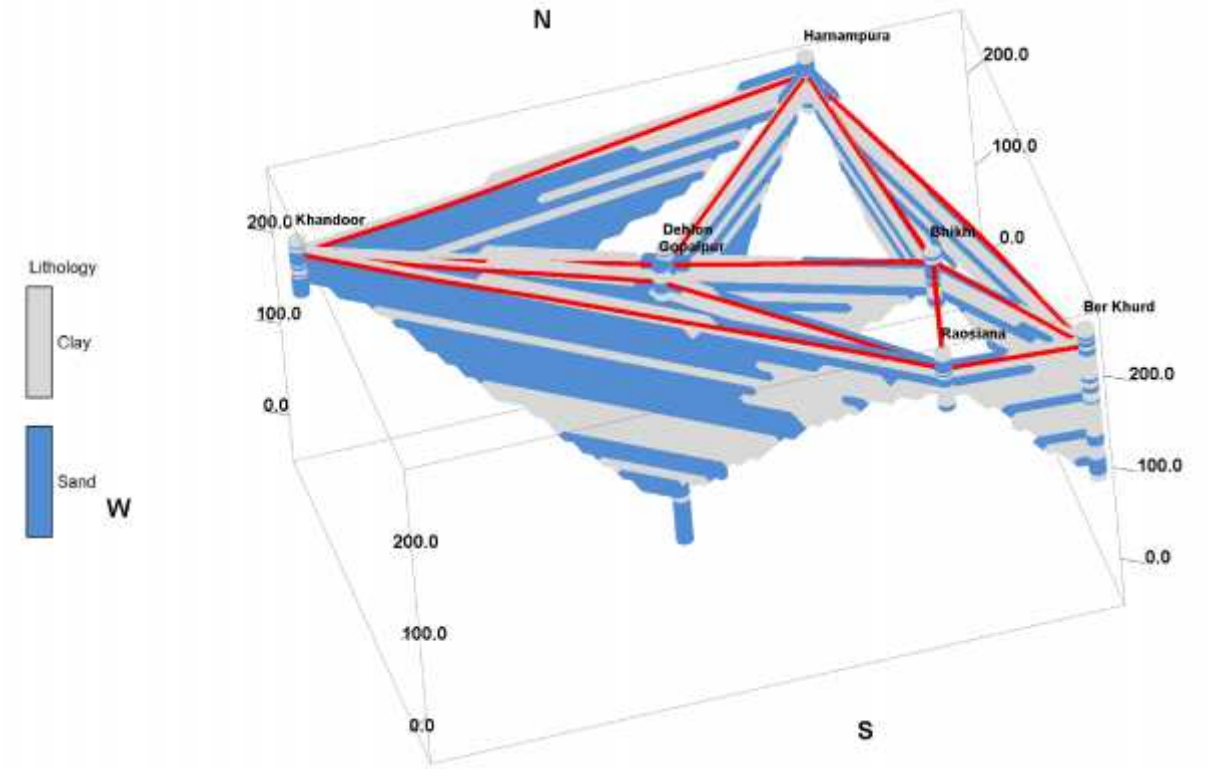
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

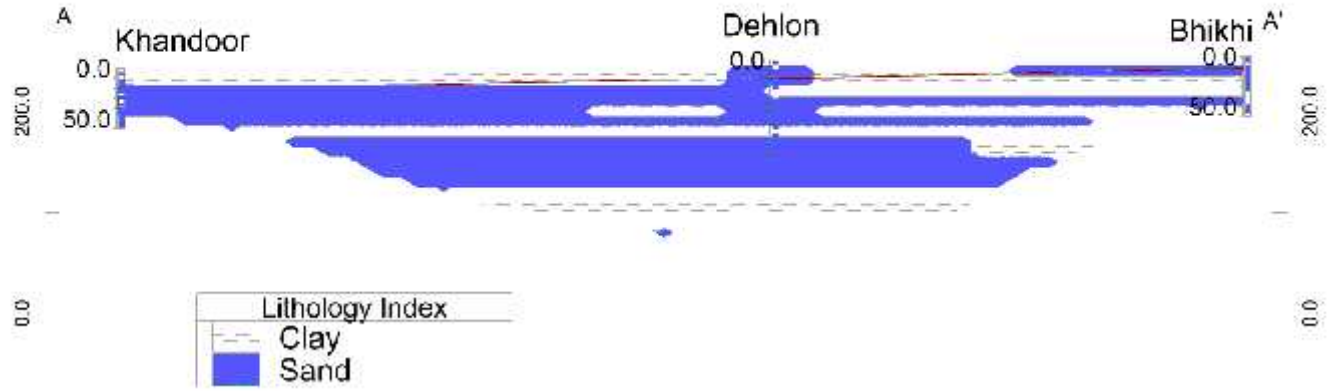
3D Lithology model

3D Lithology Fence

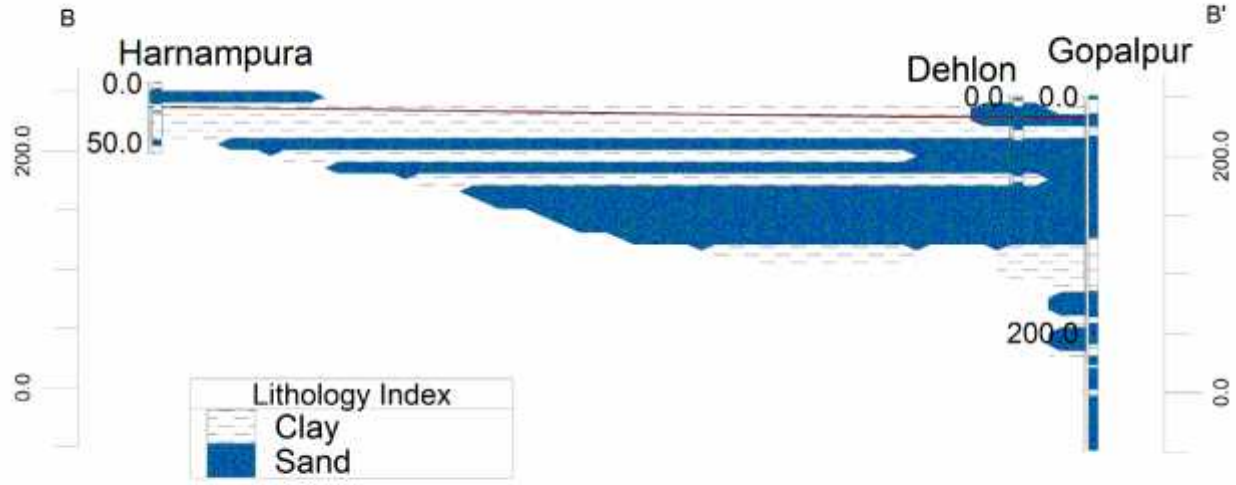




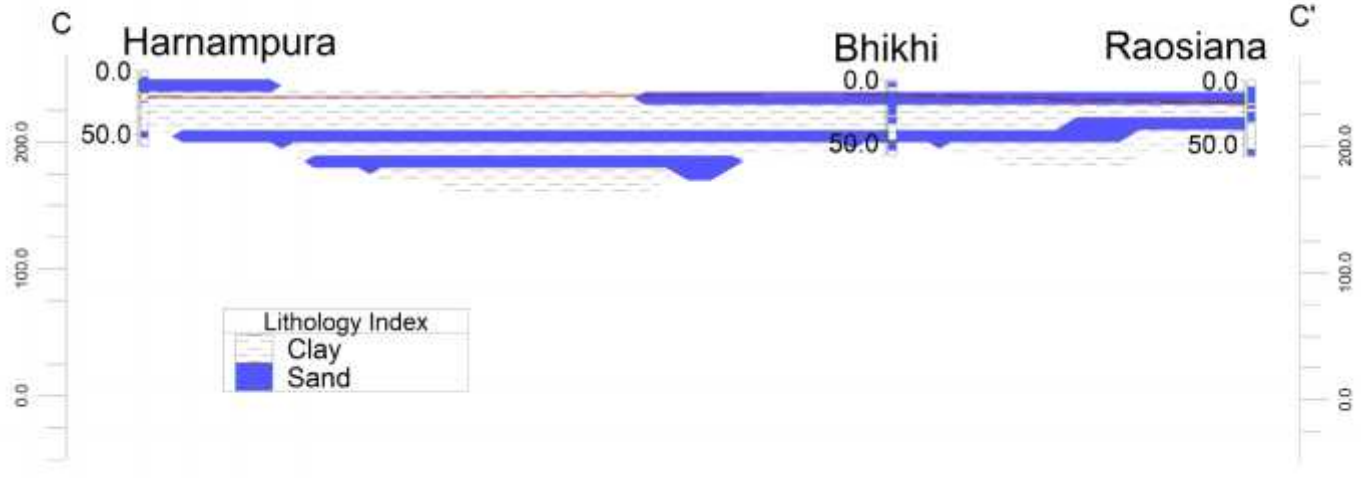
Cross-Section A-A'



Cross-Section B -B'



Cross-Section C-C'



5. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*187.51*
	In-storage Ground Water Resources	*2034.49*
	Total	2222
Ground Water Extraction (in mcm)	Irrigation	328.68
	Domestic & Industrial	5.38
Provision for domestic & Industrial requirement upto 2025 (in mcm)		6.52
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

6. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (13m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 0.26 mcm volume of water

7. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 98.09 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 30 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 60.10 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

3. DORAHA BLOCK (224.80 SQ KM)

1. Salient Information

Population (2011) Rural-96668
Urban--
Total-96668

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Doraha -I block) 681 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 204.55 sq.km
Total Irrigated Area-387.43 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Doraha block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~8.43 – 16.60 (mbgl) &Post Monsoon-~2.32 -16.40 (mbgl)

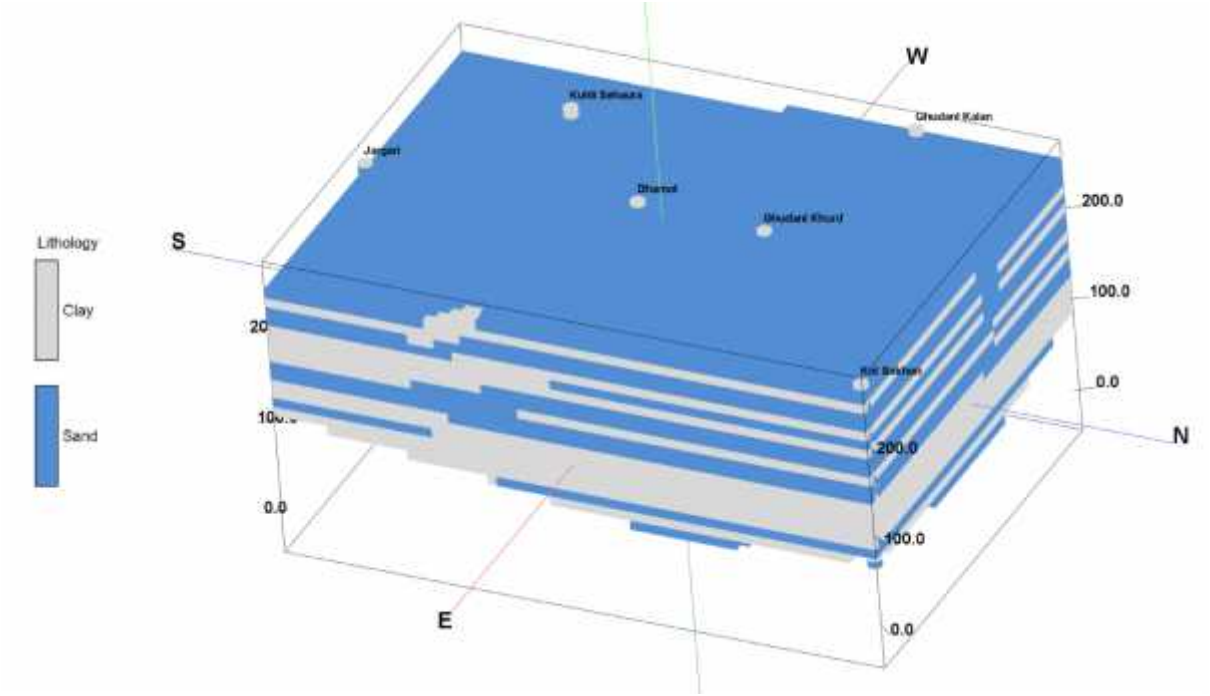
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (14-94m)	Quaternary Alluvial deposits	Unconfined	52	1120	0.072	4.3*10-3
Aquifer-II (124-170m)		Unconfined to Confined	29	-	NA	-

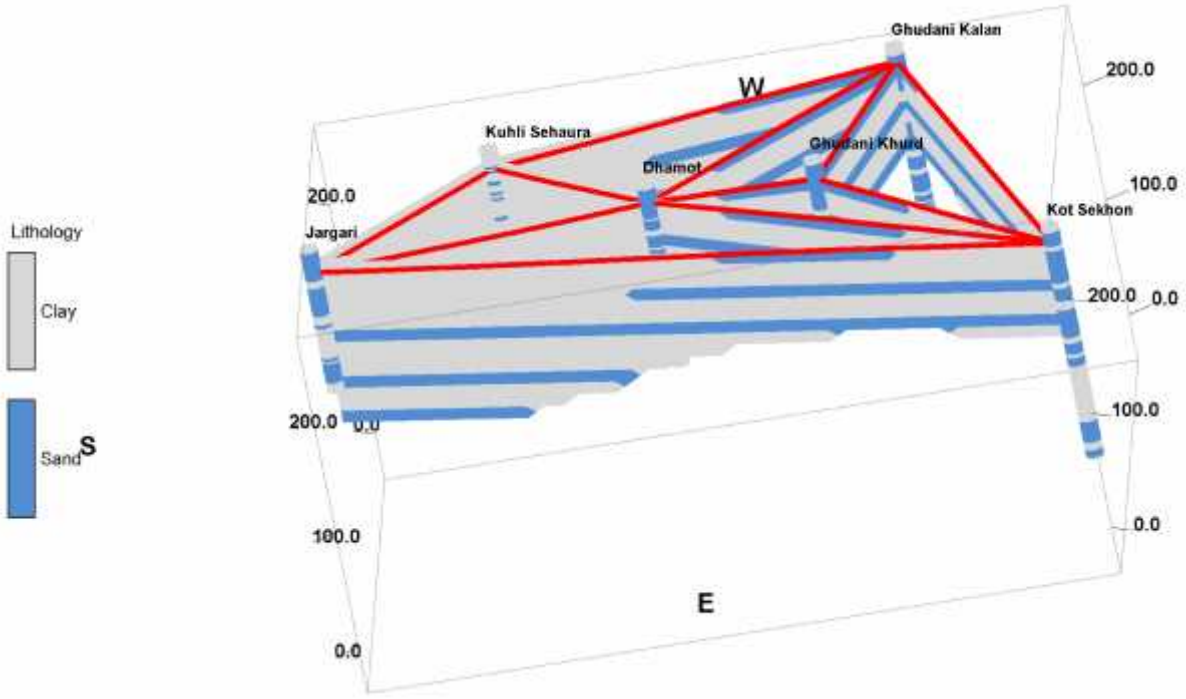
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

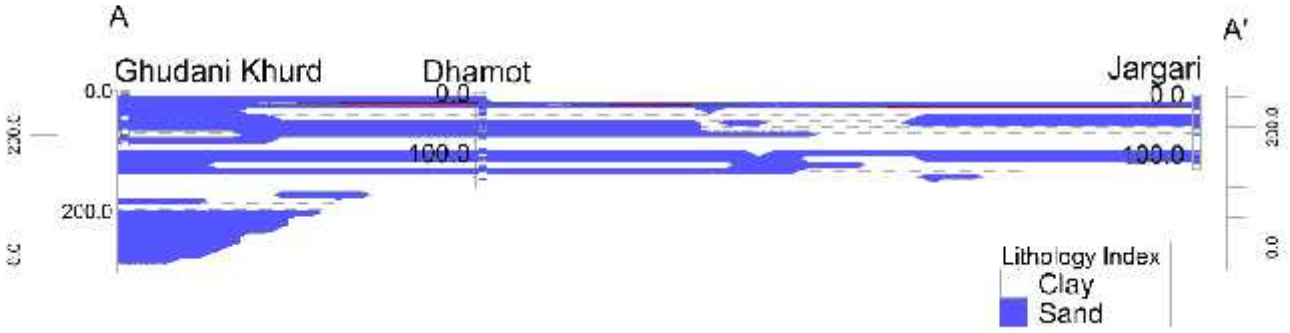
3D Lithology model



3D Lithology Fence

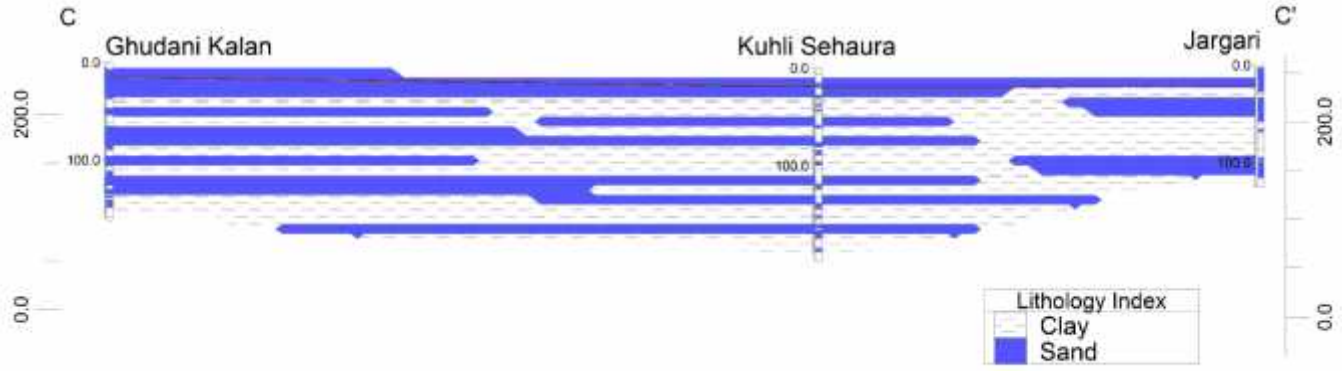


Cross-Section A-A'



Cross-Section B-B'

Cross-Section C-C'



2. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*272.98*
	In-storage Ground Water Resources	*1351*
	Total	1624
Ground Water Extraction (in mcm)	Irrigation	295.19
	Domestic & Industrial	4.59
Provision for domestic & Industrial requirement upto 2025 (in mcm)		5.68
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

3. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (9m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 0.208 mcm volume of water

4. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 88.1mcm volume of water wastage
Change in cropping pattern	No change in crop pattern
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

4. JAGRAON BLOCK (344.30 SQ KM)

1. Salient Information

Population (2011) Rural-146566
Urban--
Total-146566

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Jagraon block) 553 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 412.16 sq.km
Total Irrigated Area- 667 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Ludhiana - II block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~16.12 – 25.90 (mbgl) & Post Monsoon-~15.65 – 26.60 (mbgl)

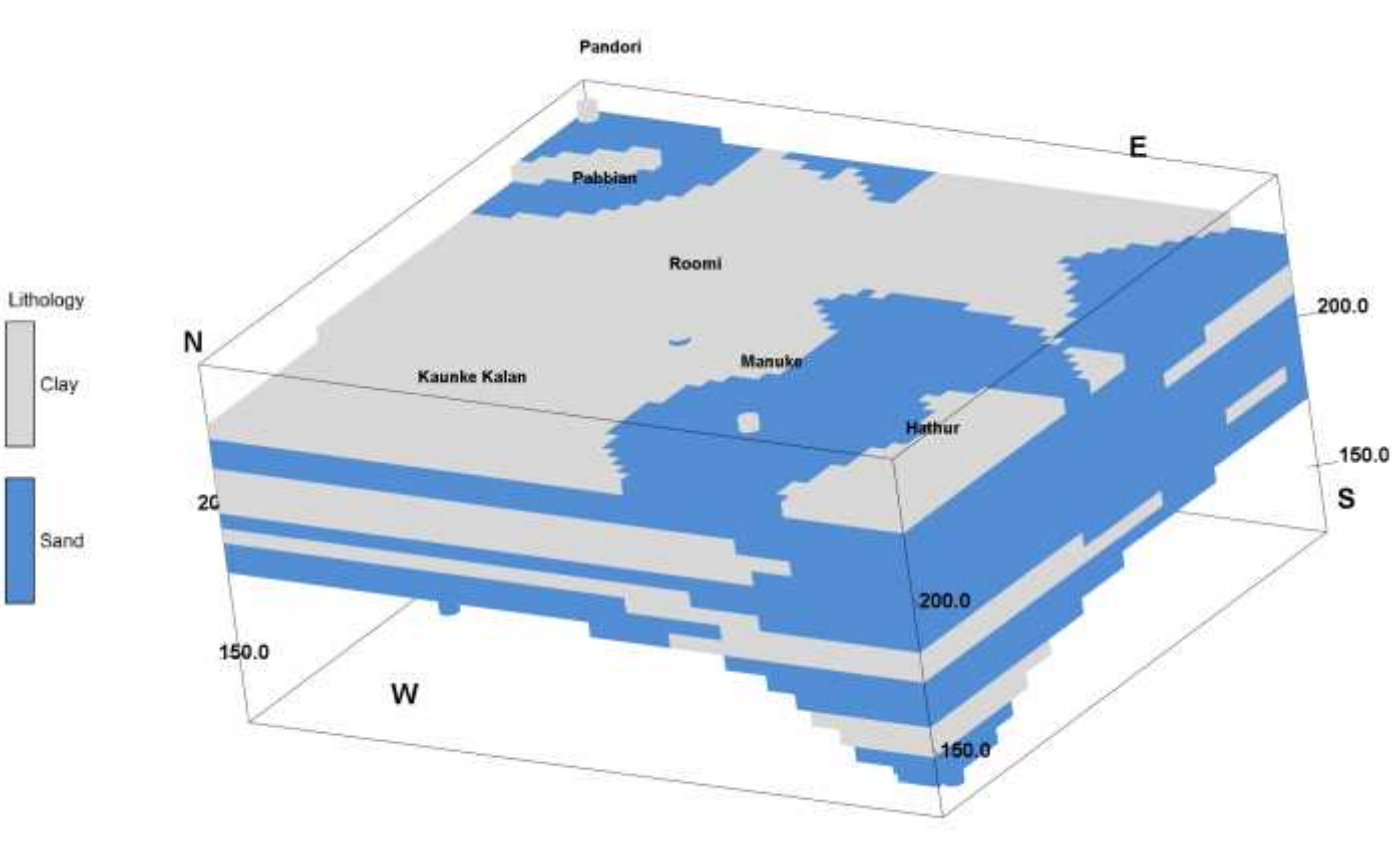
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (21-90m)	Quaternary Alluvial deposits	Unconfined	57	1120	0.072	4.3*10-3
Aquifer-II (101-182m)		Unconfined to Confined	60	-	NA	-
Aquifer-III (200-300m)		Unconfined to Confined	47.5	-	NA	-

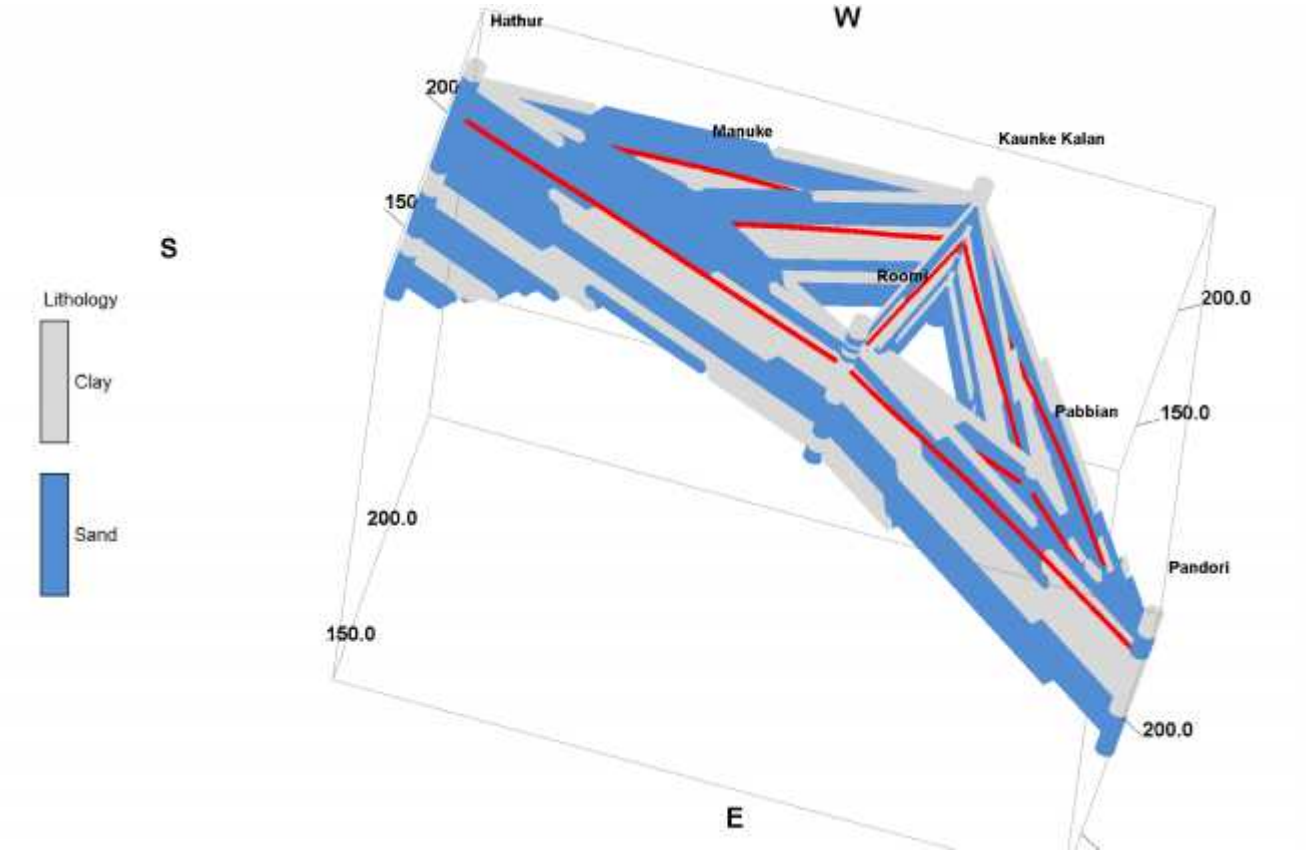
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

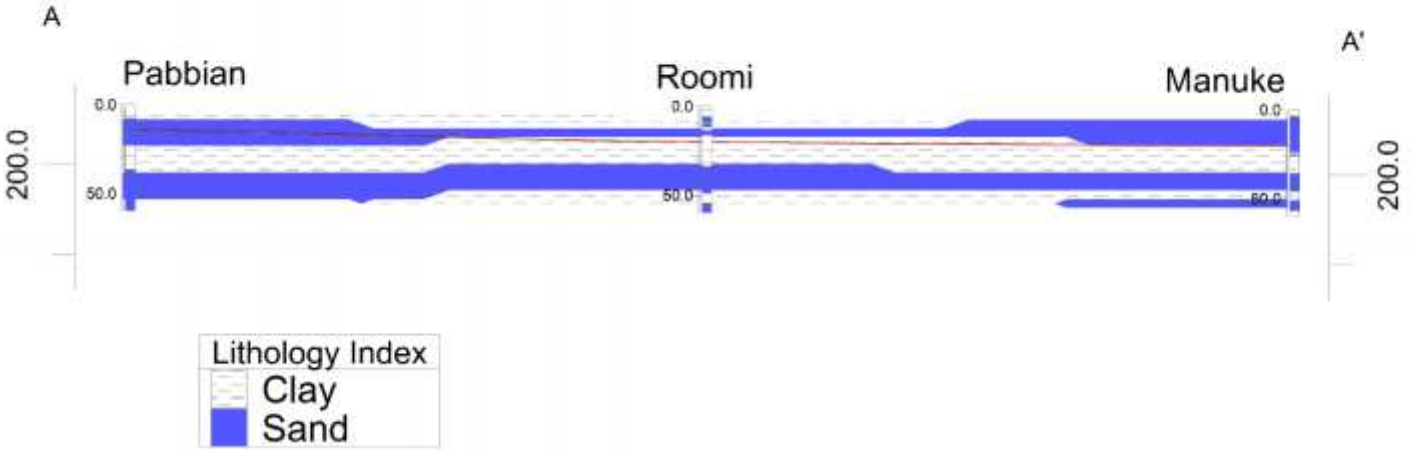
3D Lithology model



3D Stratigraphical Fence



Cross-Section A-A'



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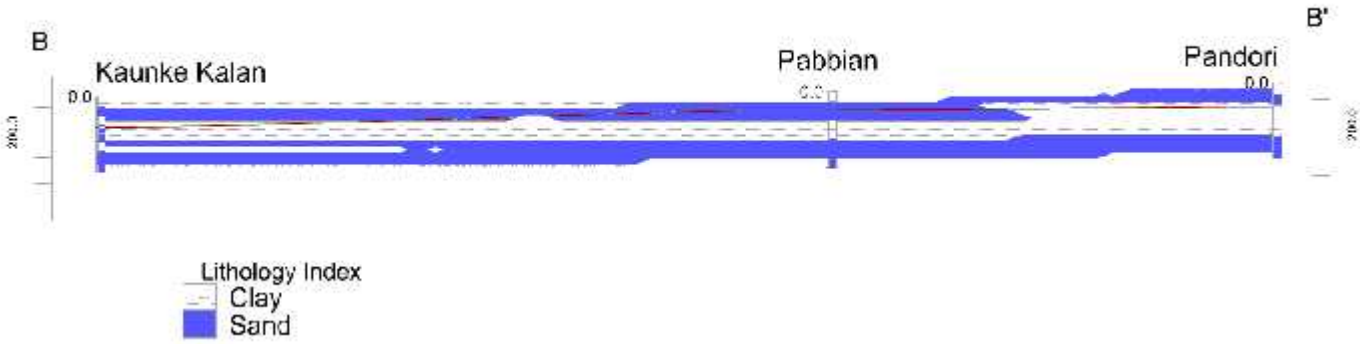

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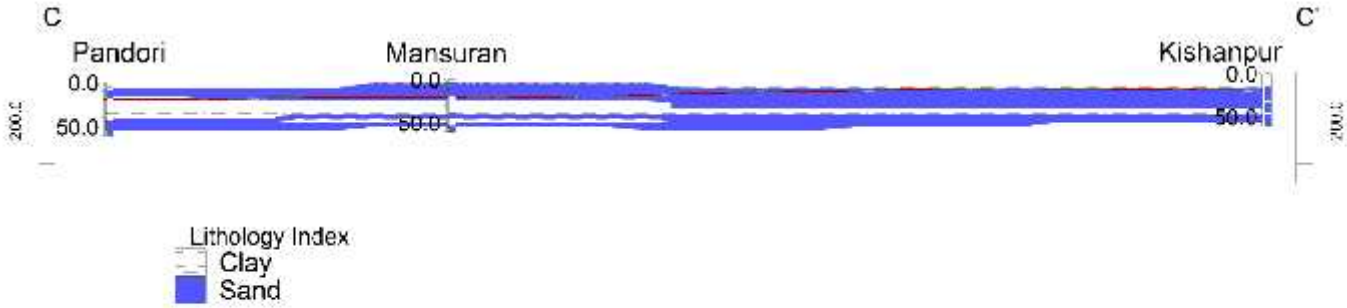


2. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*225.02*
	In-storage Ground Water Resources	*4125.98*
	Total	4351
Ground Water Extraction (in mcm)	Irrigation	301.78
	Domestic & Industrial	8.13
Provision for domestic & Industrial requirement upto 2025 (in mcm)		10.07
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

3. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (21 m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 7.945 mcm volume of water

4. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 90.06 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 1 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 4 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

5. KHANNA BLOCK (365.70 SQ KM)

1. Salient Information

Population (2011) Rural-114322
Urban-0
Total-114322

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Khanna block) 654 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 216.54 sq.km
Total Irrigated Area- 411.24 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Nihal Singh Wala block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~10.33-23.15 (mbgl) &Post Monsoon-~10.37 – 22.30 (mbgl)

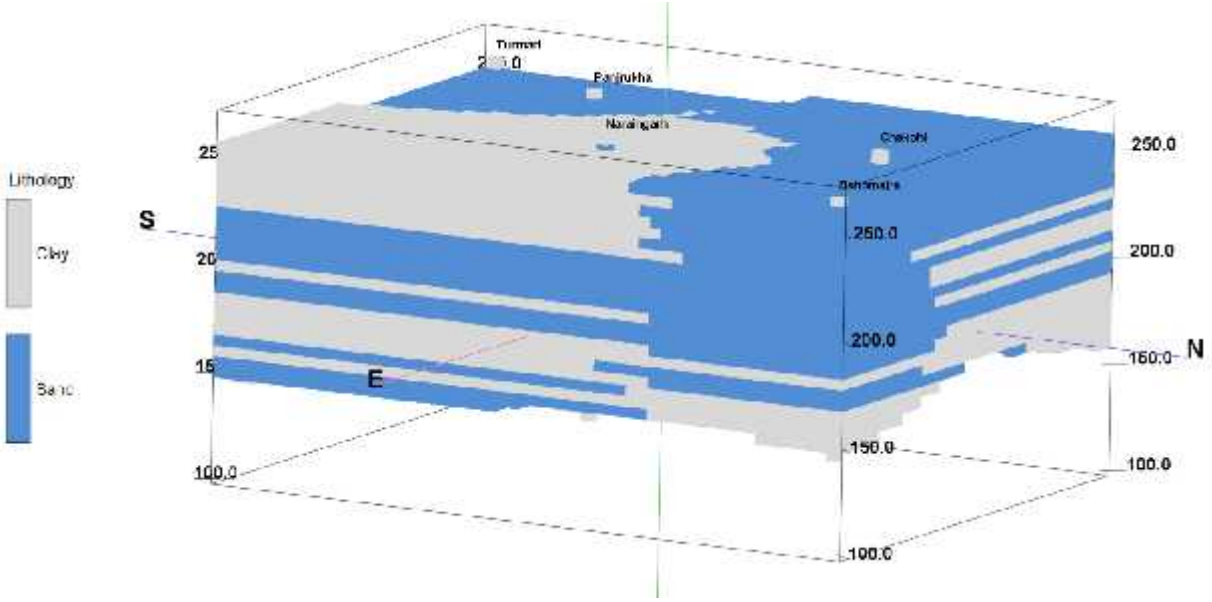
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (15-88m)	Quaternary Alluvial deposits	Unconfined	49	1120	0.072	4.3*10-3
Aquifer-II (110-163m)		Unconfined to Confined	37	-	NA	-

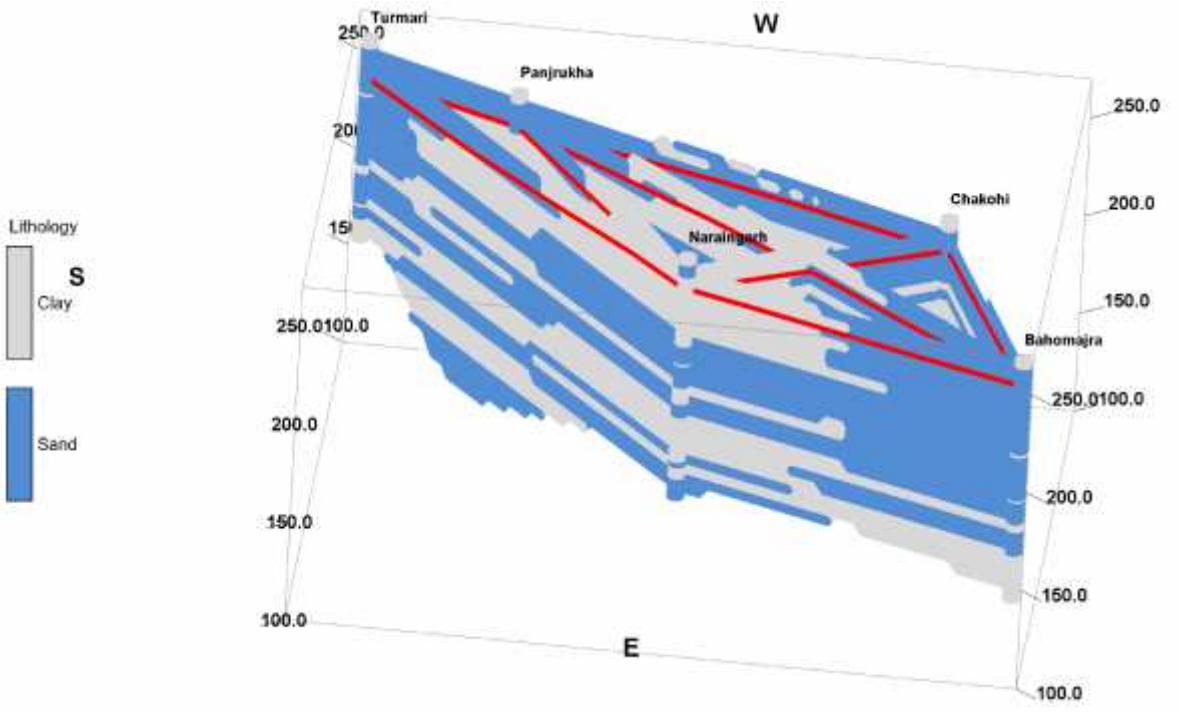
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

3D Lithology model

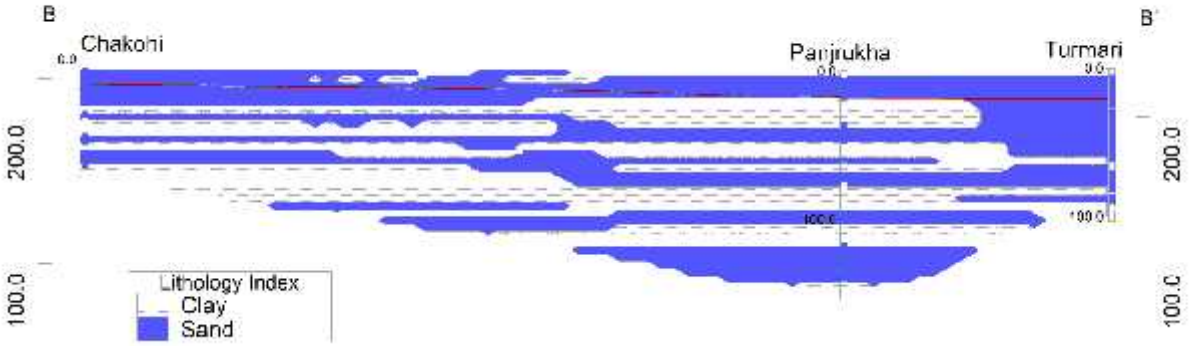


3D Stratigraphy Fence

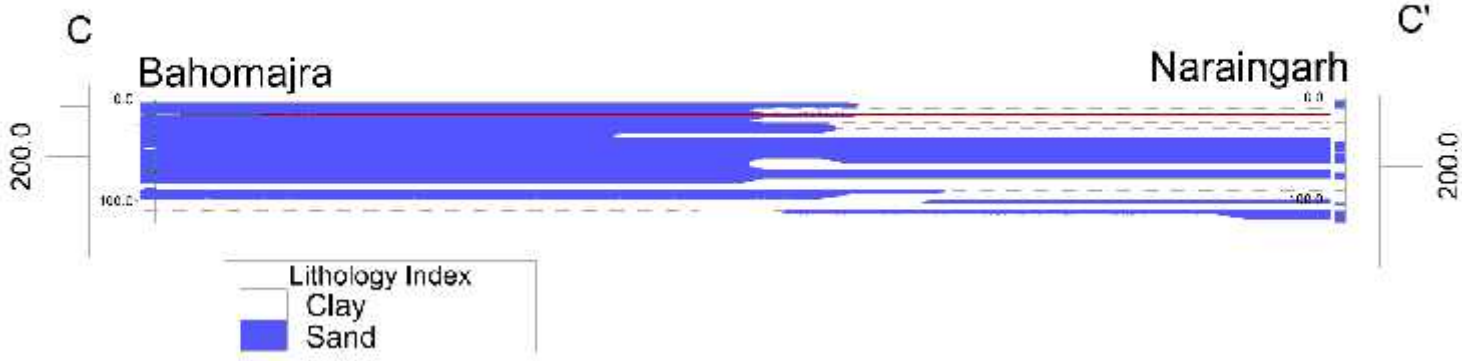


Cross-Section A-A'

Cross-Section B-B'



Cross-Section C-C'



2. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*162.38*
	In-storage Ground Water Resources	*2319.62*
	Total	2482
Ground Water Extraction (in mcm)	Irrigation	329.91
	Domestic & Industrial	8.40
Provision for domestic & Industrial requirement upto 2025 (in mcm)		10.36
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

3. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (15 m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 0.889 mcm volume of water

4. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 98.46 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 46 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 88.00 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

6. LUDHIANA BLOCK (316.80 SQ KM)

Salient Information

Population (2011) Rural-158821
Urban-59069
Total-217890

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Ludhiana block) 666 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 188.70 sq.km
Total Irrigated Area- 312.37 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Nihal Singh Wala block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~21.75-28.80 (mbgl) &Post Monsoon-~21.15 – 27.90 (mbgl)

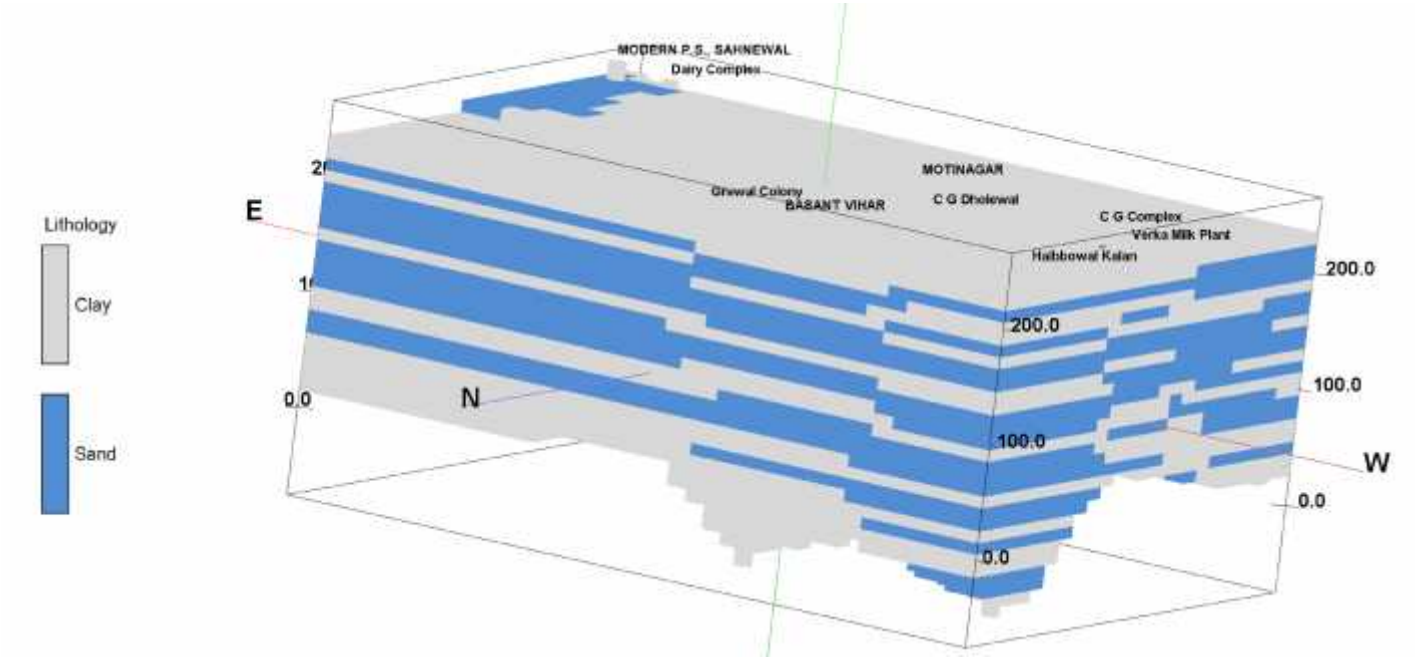
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (24-120m)	Quaternary Alluvial deposits	Unconfined	61	1120	0.072	4.3*10-3
Aquifer-II (148-195m)		Unconfined to Confined	30	-	NA	-
Aquifer-III (207-258m)		Unconfined to Confined	27	-	NA	-

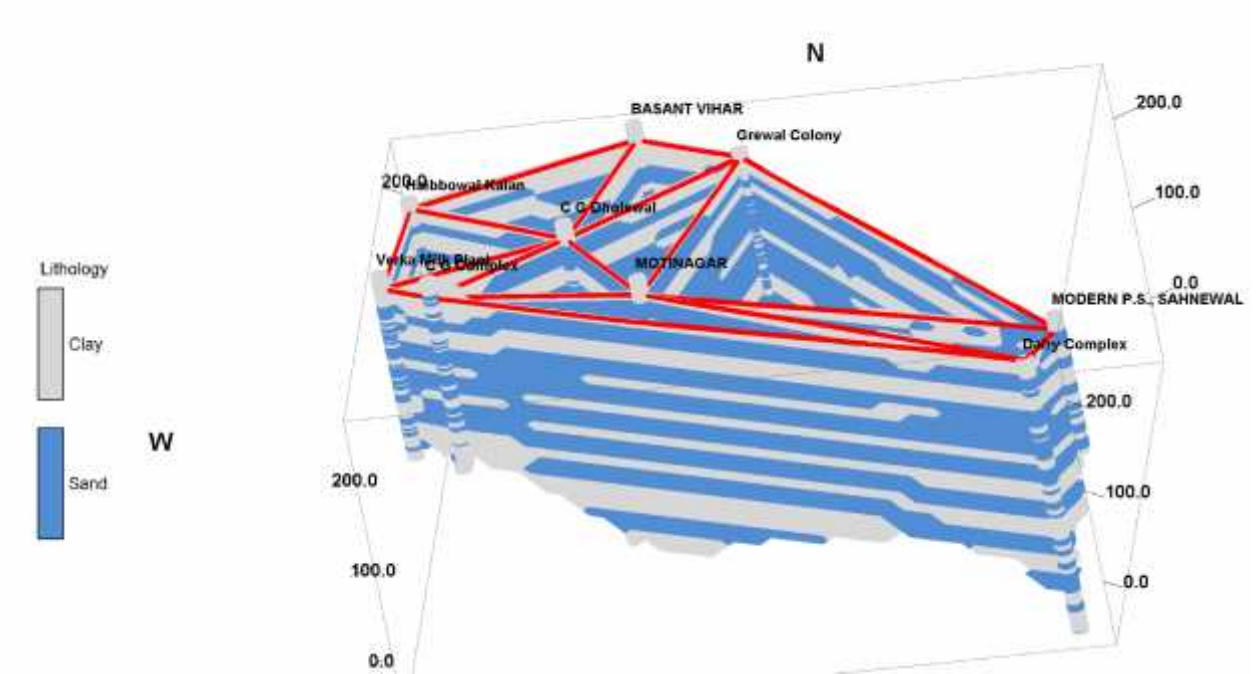
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

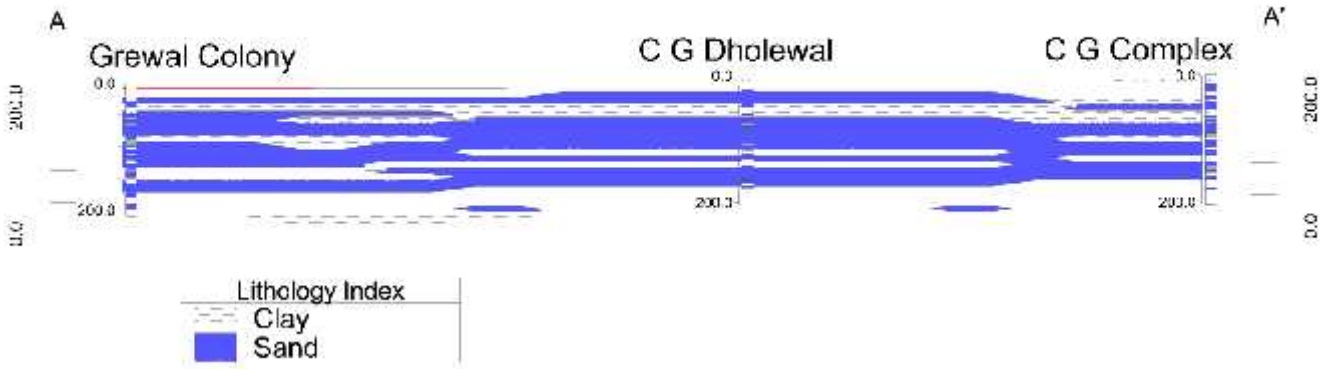
3D Lithology model



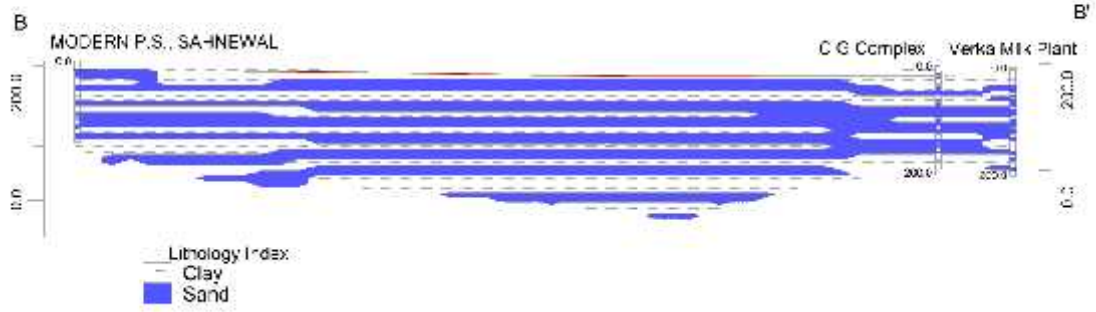
3D Stratigraphy Fence



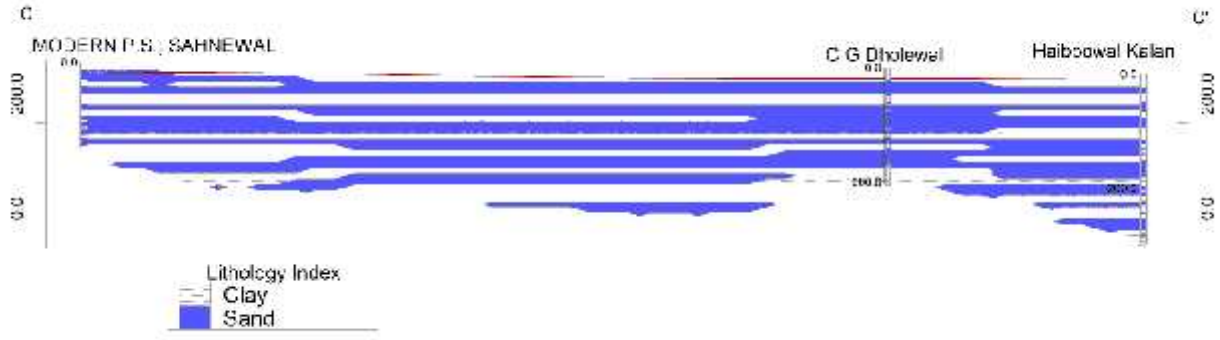
Cross-Section A-A'



Cross-Section B-B'



Cross-Section C-C'



5. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*125.03*
	In-storage Ground Water Resources	*2767.97*
	Total	2893
Ground Water Extraction (in mcm)	Irrigation	264.59
	Domestic & Industrial	45.20
Provision for domestic & Industrial requirement upto 2025 (in mcm)		60.60
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

6. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (24m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 1.512 mcm volume of water

7. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 78.96 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 70 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 94.40 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

7. MACHIWARA BLOCK (365.70 SQ KM)

Salient Information

Population (2011) Rural-94057
Urban-0
Total-94057

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Machiwara block) 765mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 271.11 sq.km
Total Irrigated Area- 525.79 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Ludhiana block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~10.33-23.15 (mbgl) &Post Monsoon-~10.37 – 22.30 (mbgl)

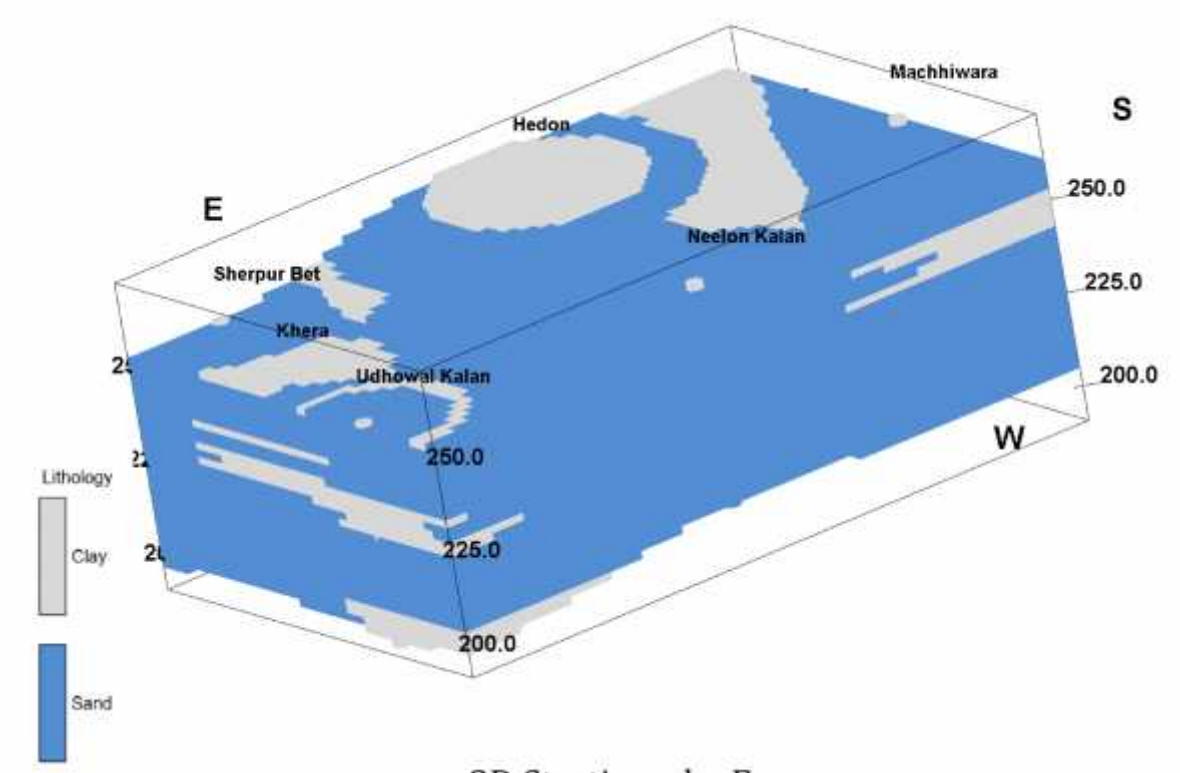
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (14-60m)	Quaternary	Unconfined	37	1120	0.072	4.3*10-3

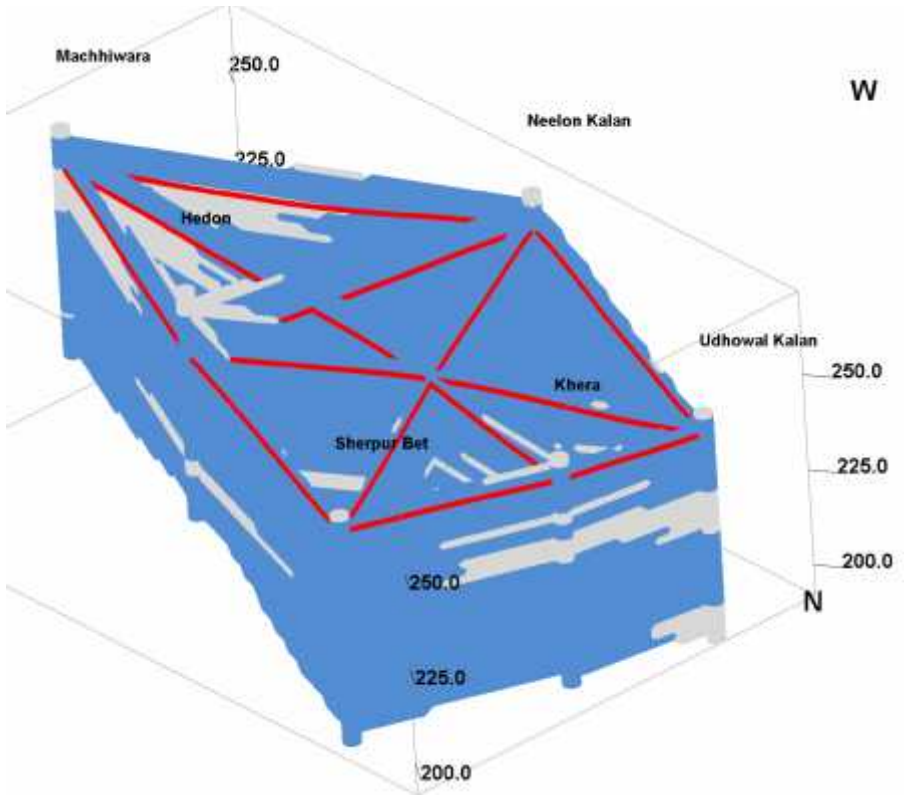
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

3D Lithology model



3D Stratigraphy Fence



8. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*264.40*
	In-storage Ground Water Resources	*989.60*
	Total	1254
Ground Water Extraction (in mcm)	Irrigation	272.84
	Domestic & Industrial	3.55
Provision for domestic & Industrial requirement upto 2025 (in mcm)		4.33
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

9. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (14 m).
Other interventions proposed	Not required

10.Demand Side Interventions

Advanced Irrigation Practices	Not required
Change in cropping pattern	Not required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

8. PAKHOWAL BLOCK (210.83 SQ KM)

Salient Information

Population (2011) Rural-105356
Urban-3845
Total-109201

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Pakhowal block) 612 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 183.97 sq.km
Total Irrigated Area- 362.08 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Pakhowal block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~13.33-25.25 (mbgl) &Post Monsoon-~13.05 – 25.68 (mbgl)

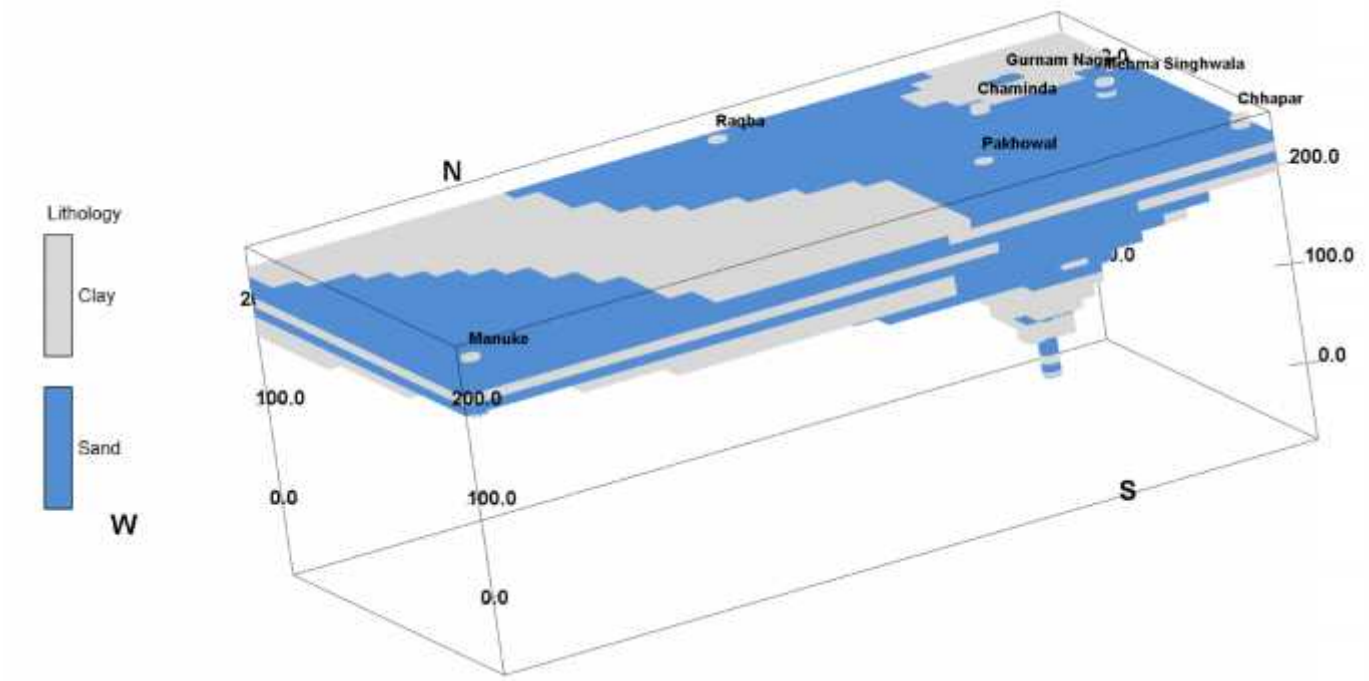
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (16-75m)	Quaternary Alluvial deposits	Unconfined	34	1120	0.072	4.3*10-3
Aquifer-II (120-212m)		Unconfined to Confined	38	-	NA	-
Aquifer-III (225-300m)		Unconfined to Confined	25	-	NA	-

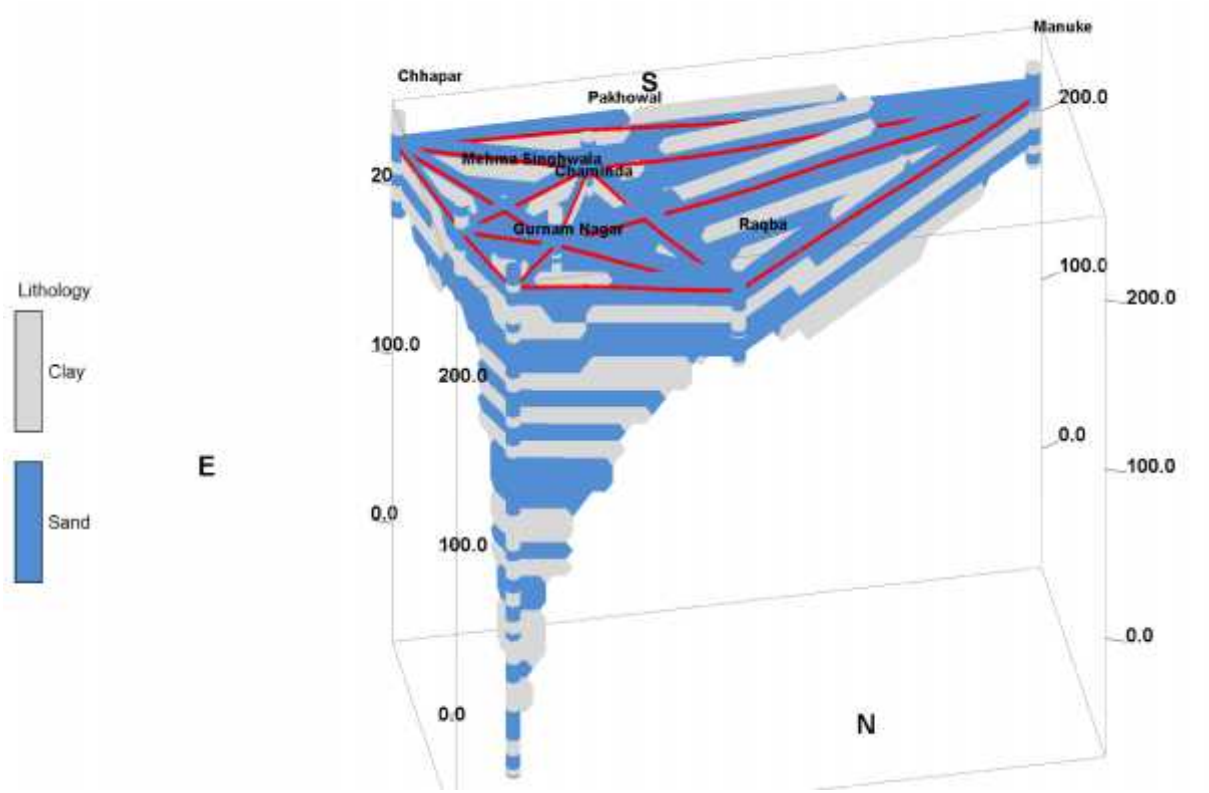
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

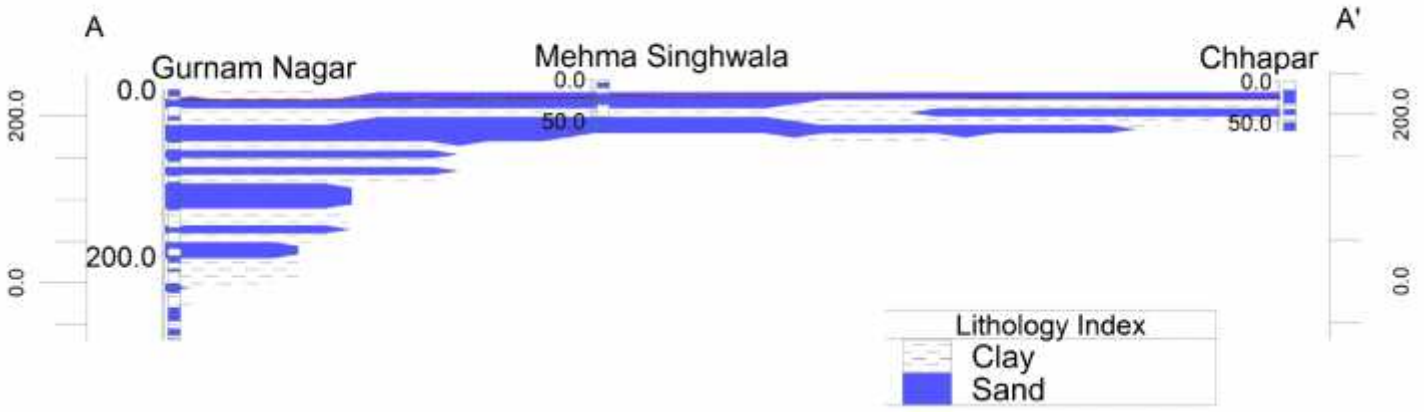
3D Lithology model



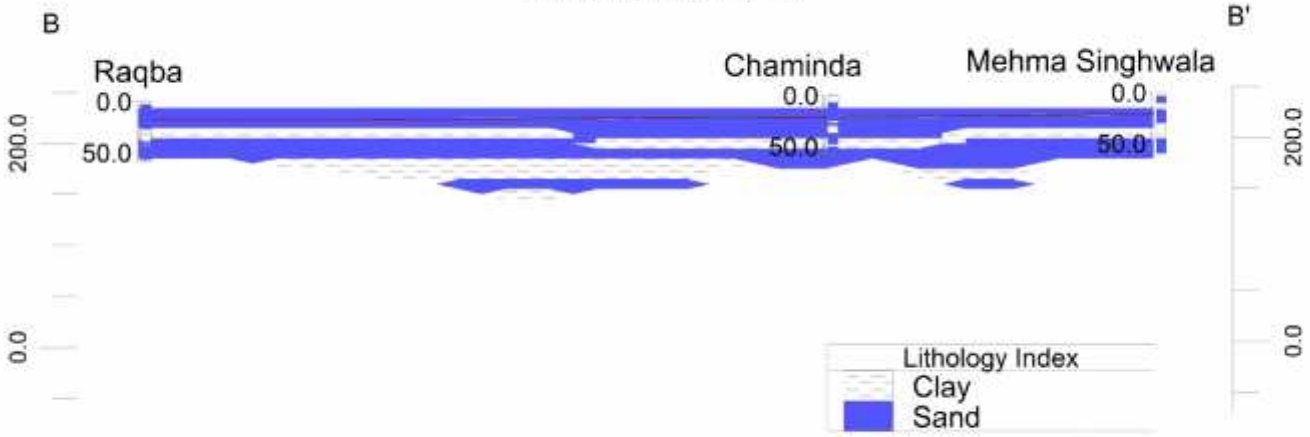
3D Stratigraphy Fence



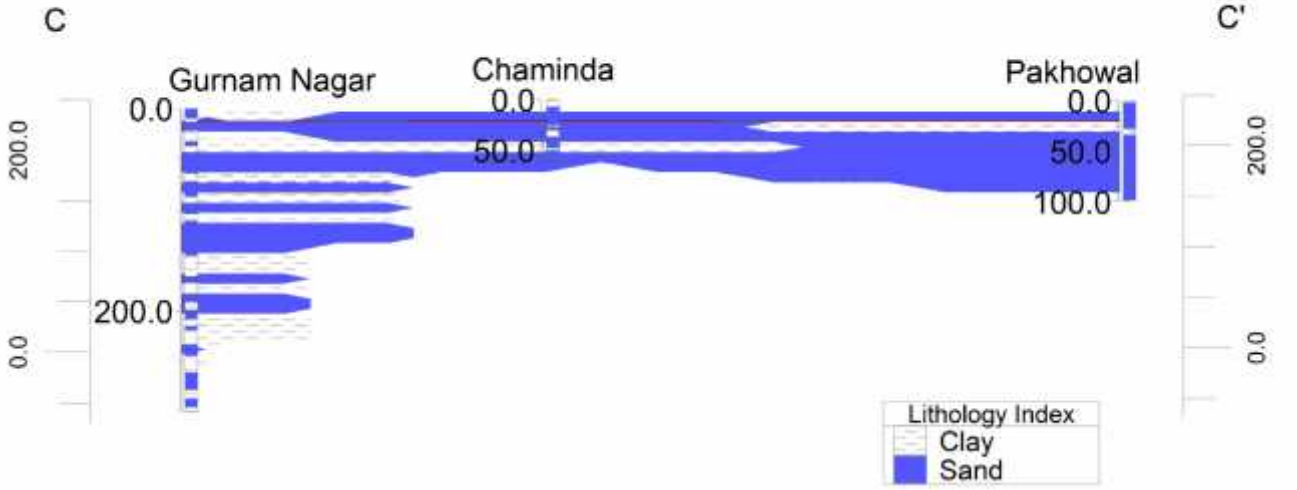
Cross-Section A-A'



Cross-Section B-B'



Cross-Section C-C'



Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*126.18*
	In-storage Ground Water Resources	*1537.82*
	Total	1664
Ground Water Extraction (in mcm)	Irrigation	240.34
	Domestic & Industrial	2.68
Provision for domestic & Industrial requirement upto 2025 (in mcm)		3.40
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

11. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (16 m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 0.13 mcm volume of water

12. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 71.73 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 24% of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 53.5 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

9. SAMRALA BLOCK (153.50 SQ KM)

Salient Information

Population (2011) Rural-84205
Urban-0
Total-84205

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Samrala block) 721 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 150.52 sq.km
Total Irrigated Area- 293.79 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Samrala block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~8.80-20.62 (mbgl) &Post Monsoon-~10.00 – 20.18 (mbgl)

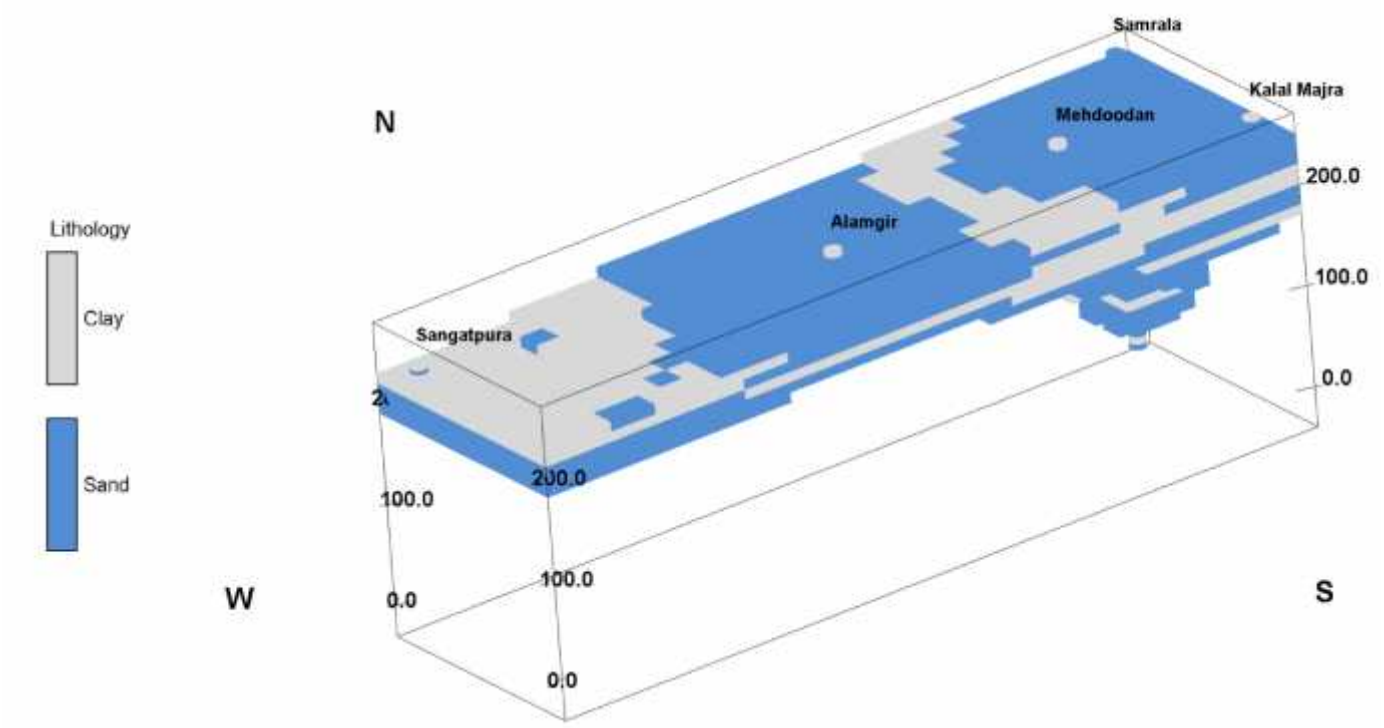
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (18-72m)	Quaternary Alluvial deposits	Unconfined	32	1120	0.072	4.3*10-3
Aquifer-II (100-169m)		Unconfined to Confined	48	-	NA	-
Aquifer-III (186-279m)		Unconfined to Confined	71	-	NA	-

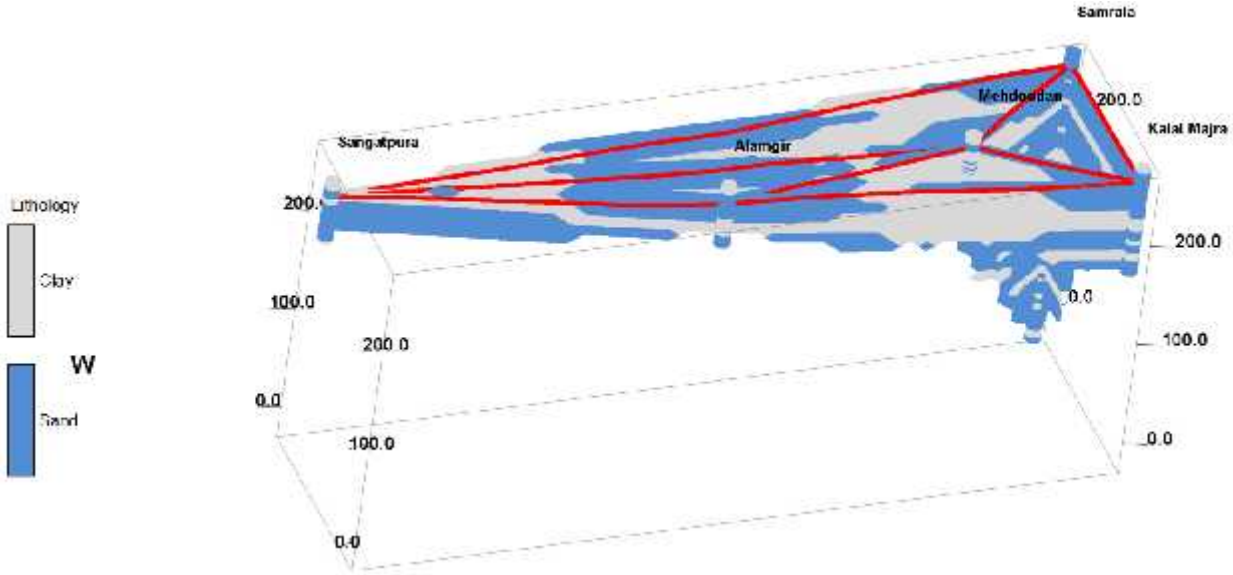
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

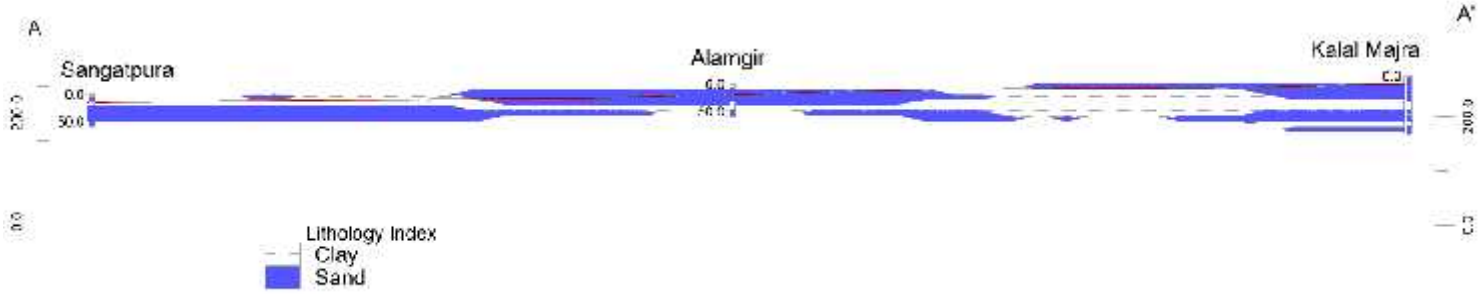
3D Lithology model



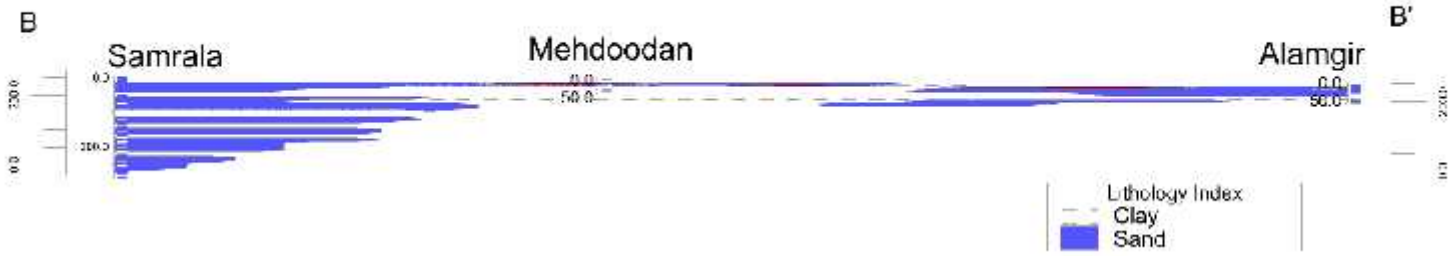
3D Stratigraphy Fence



Cross-Section A-A'



Cross-Section B-B'



Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*101.52*
	In-storage Ground Water Resources	*1688.48*
	Total	3033.31
Ground Water Extraction (in mcm)	Irrigation	198.79
	Domestic & Industrial	5.40
Provision for domestic & Industrial requirement upto 2025 (in mcm)		6.41
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

13. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (18m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 0.152 mcm volume of water

14. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 59.33 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 36 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 49.60 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

10. SIDWANBET BLOCK (401.70 SQ KM)

Salient Information

Population (2011) Rural-127065
Urban-0
Total-127065

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Sidwanbet block) 605 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 234.41 sq.km
Total Irrigated Area- 610.34 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Sidwanbet block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~8.05-21.79 (mbgl) &Post Monsoon-~7.26 – 23.30 (mbgl)

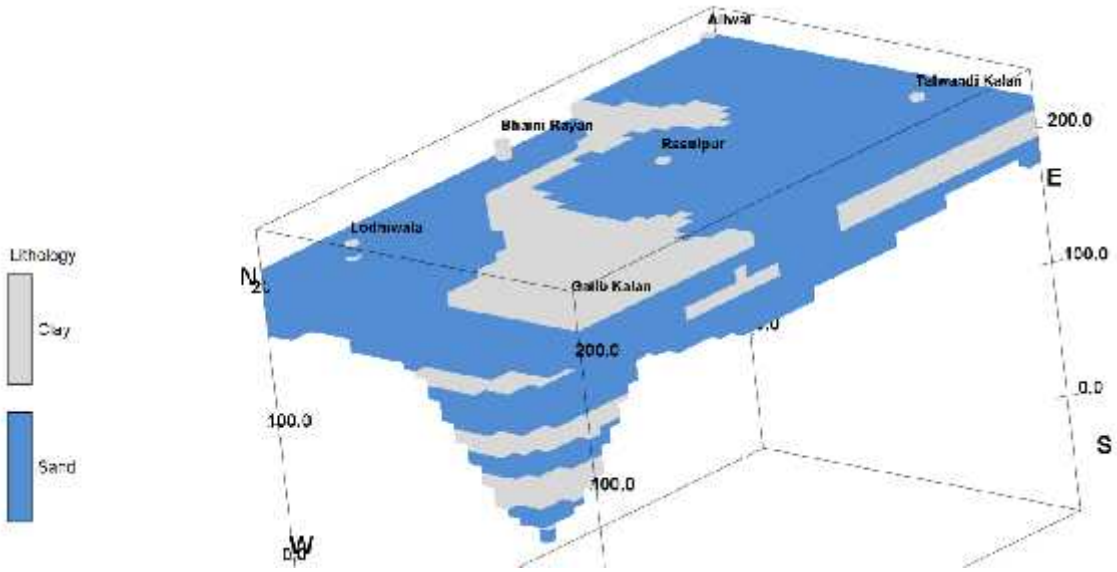
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (20-120m)	Quaternary Alluvial deposits	Unconfined	39	1120	0.072	4.3*10-3
Aquifer-II (155-210m)		Unconfined to Confined	42	-	NA	-
Aquifer-III (235-300m)		Unconfined to Confined	51	-	NA	-

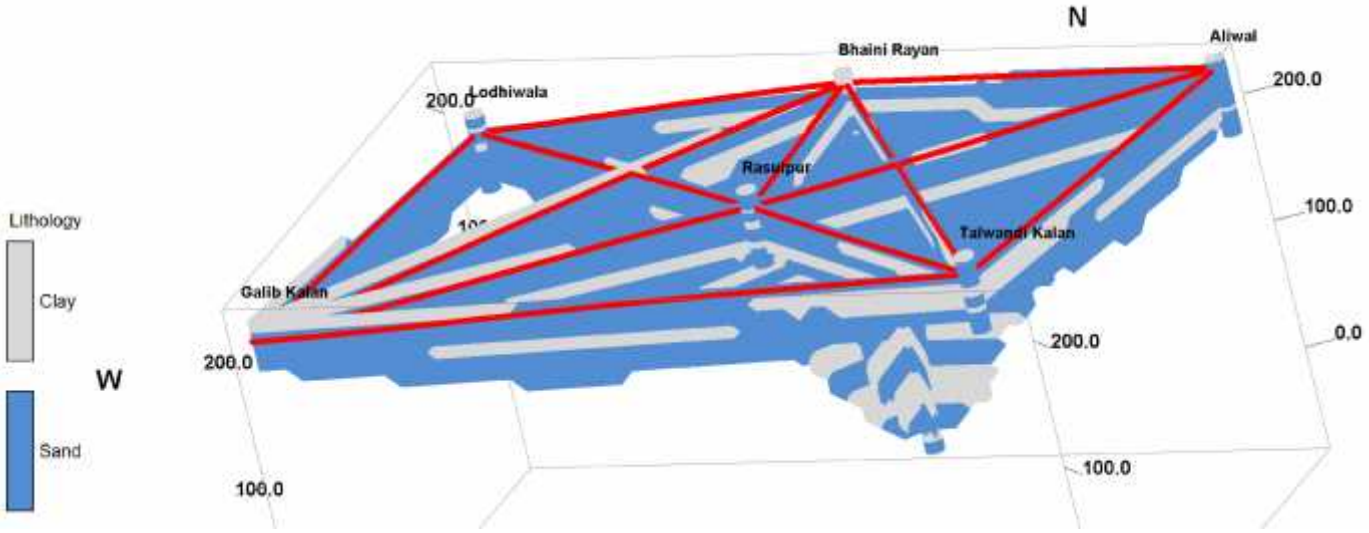
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

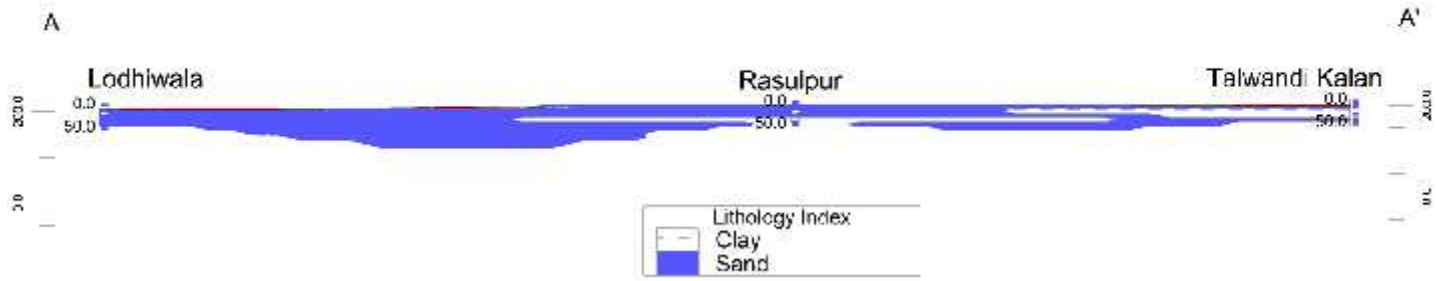
3D Lithology model



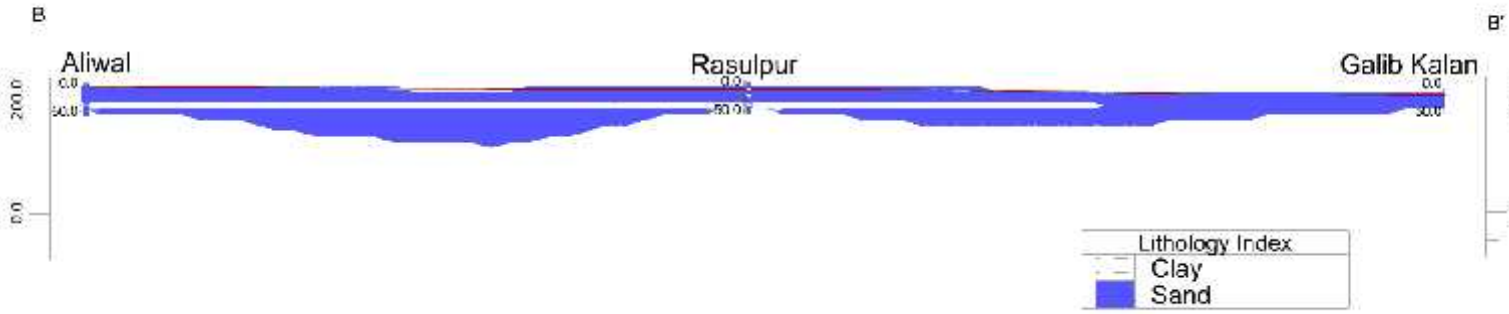
3D Stratigraphy Fence



Cross-Section A-A'



Cross-Section B-B'



Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*212.05*
	In-storage Ground Water Resources	*3915.95*
	Total	4128
Ground Water Extraction (in mcm)	Irrigation	350.52
	Domestic & Industrial	4.80
Provision for domestic & Industrial requirement upto 2025 (in mcm)		5.38
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

15. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (20 m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 0.14 mcm volume of water

16. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 104.61 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 16 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 50.20 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

11.SUDHAR BLOCK (144.70 SQ KM)

Salient Information

Population (2011) Rural-53647
Urban-17439
Total-71086

Rainfall 2014 (Ludhiana District) Average annual rainfall -681 mm

Average Annual Rainfall (Sudhar block) 557 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 228.09 sq.km
Total Irrigated Area- 382.99 sq.km

Water Bodies & Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Sudhar block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over- Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~19.50-27.10 (mbgl) &Post Monsoon-~18.85 – 27.35 (mbgl)

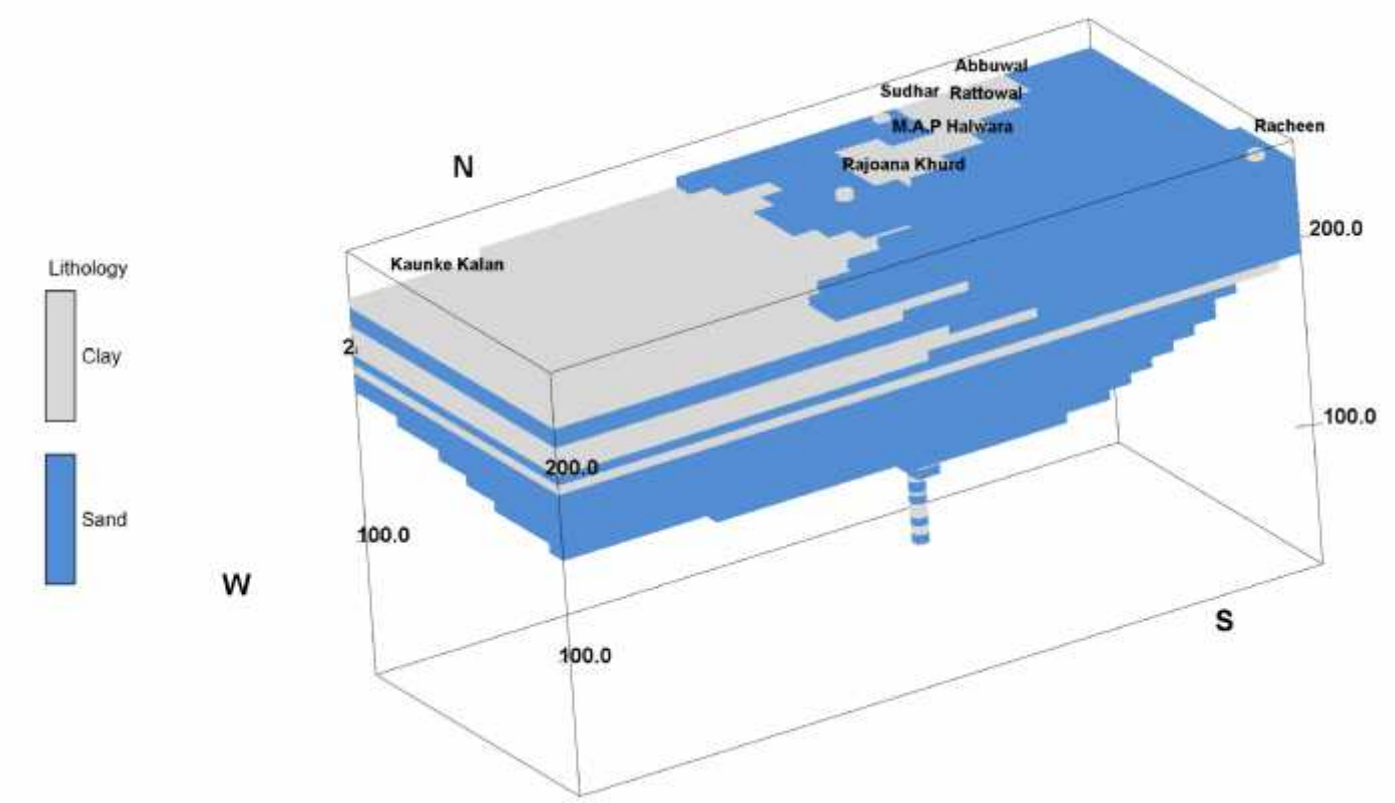
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (18-100m)	Quaternary Alluvial deposits	Unconfined	32	1120	0.072	4.3*10-3
Aquifer-II (115-175m)		Unconfined to Confined	22	-	NA	-
Aquifer-III (190-210m)		Unconfined to Confined	9	-	NA	-

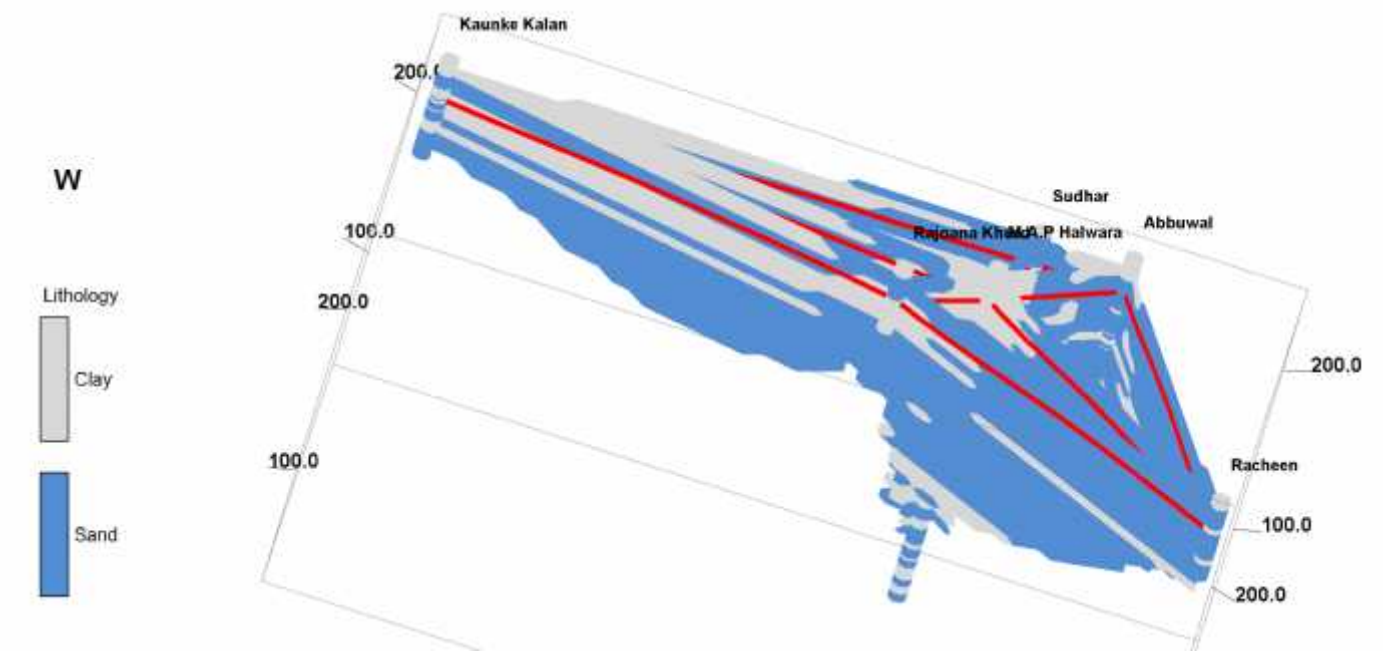
Aquifer comprises of freshwater only and the main aquifer material is sand.

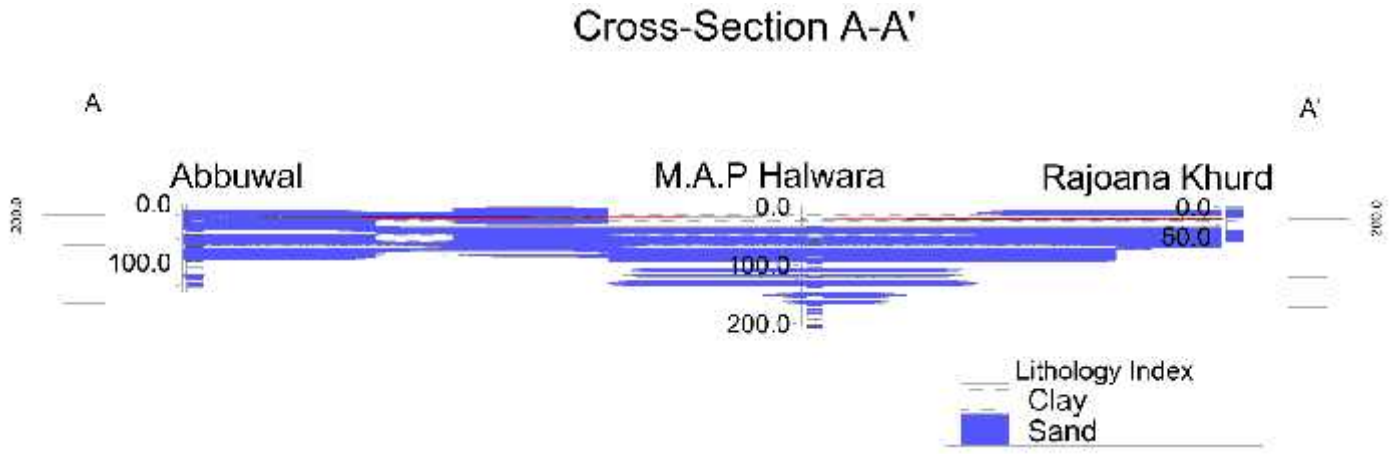
The non-aquifer material comprise of clay.

3D Lithology model

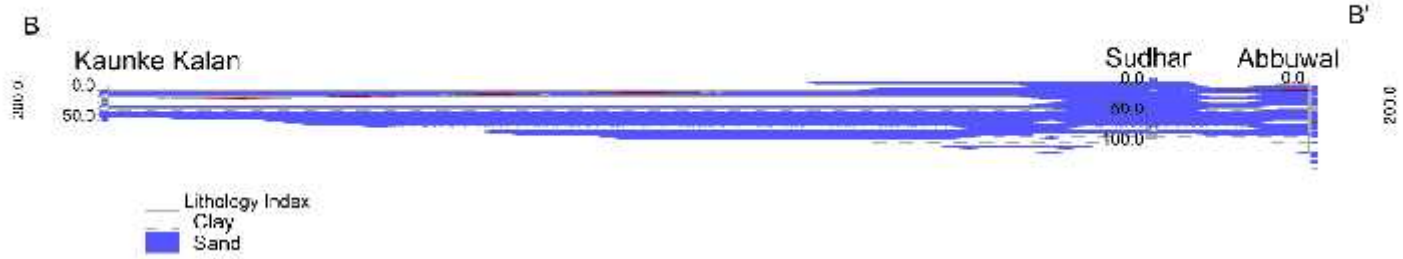


3D Stratigraphy Fence





Cross-Section B-B'



Cross-Section C-C'

17. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*98.37*
	In-storage Ground Water Resources	*659.63*
	Total	758
Ground Water Extraction (in mcm)	Irrigation	139.74
	Domestic & Industrial	3.42
Provision for domestic & Industrial requirement upto 2025 (in mcm)		4.47
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

18. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (18 m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 0.189 mcm volume of water

19. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 41.70 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 3 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 7.7.00 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-