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

Ropar District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़
North Western Region, Chandigarh

AQUIFER MAPPING

&

MANAGEMENT PLAN

ROPAR DISTRICT

PUNJAB

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

CONTENTS

LIST OF FIGURES

LIST OF TABLES

AQUIFER MAPPING AND GROUND WATER MANAGEMENT IN ROPAR DISTRICT, PUNJAB

(1370 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 Ropar district of Punjab State (**Fig. 1**), covered under Phase-II.

Ropar district is located in the eastern part of the Punjab State and geographically lies between North latitudes of 76°19′00″ and 76°45′00″ and East longitudes of 30°44′00″ and 31°25′00″. The geographical extent of the area is 1440 sq.km. The area is bounded by Himachal Pradesh in the north and north east, Hoshiarpur, Nawanshahr and Ludhiana district in the west, Fatehgarh Sahib district in the South and Mohali district in the south east. Administratively the new Ropar district is divided into four tehsils – Rupnagar, Chamkaur Sahib, Anandpur Sahib and Nangal comprise of five development blocks.

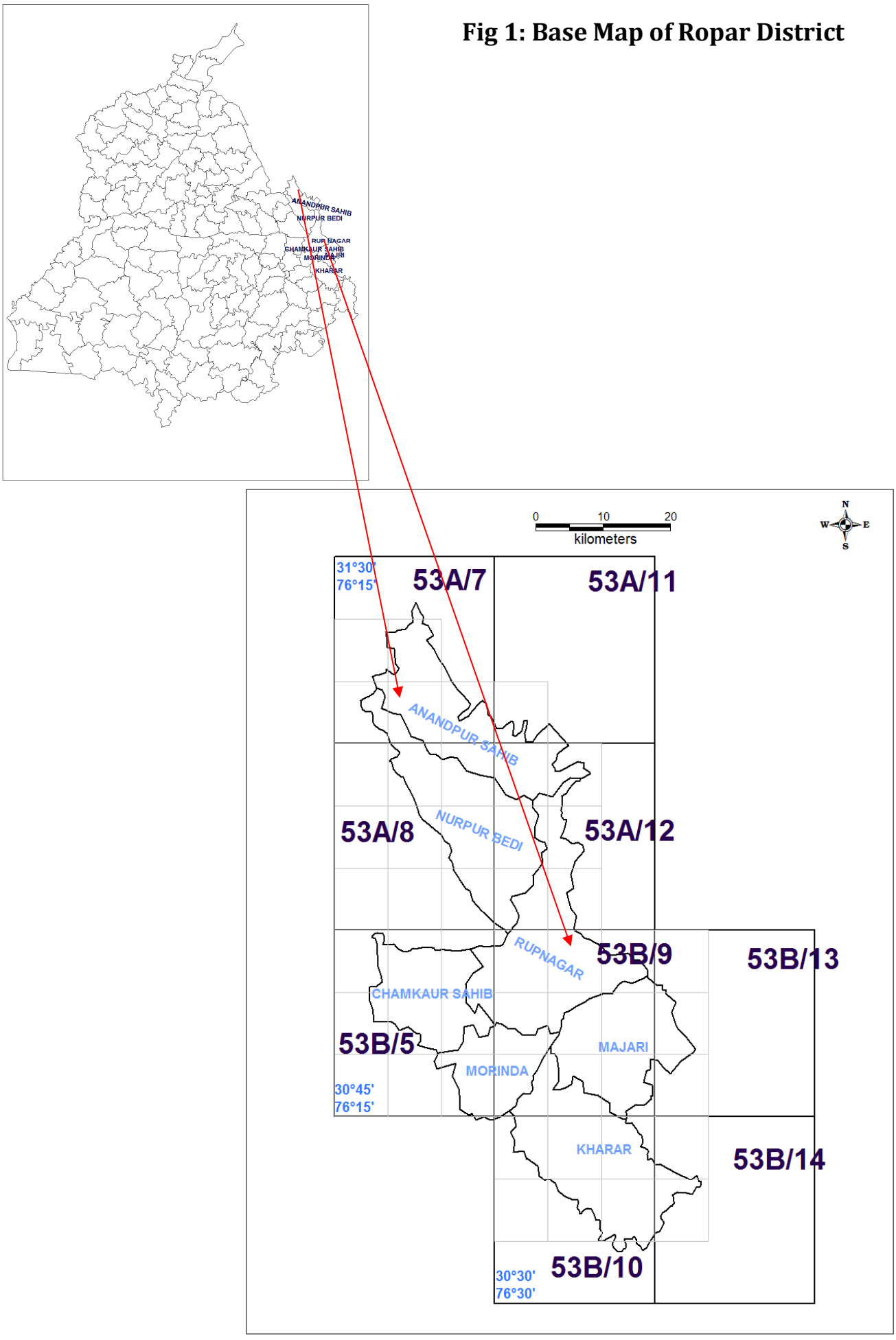
The total population of the district is 684627 (as per census 2011). The decennial growth of the population is 00.00%. Majority of the total population resides in rural area. The percentage of rural and urban population to total population is 72.71% and 27.29 % respectively. As per Ropar district data, there are 617 villages and 11 towns. The total number of uninhabited villages is 19.

Based on the physiography, the area can be divided into 4 units-Siwalik Hills, Intermontane valley of Sutlej, Kandi/Sirowal formations and alluvial plains-which run parallel to each other. The area is drained by Sutlej river basin. The Sutlej River enters the district near Nangal in north and flows in southeasterly direction and then meanders south and southwest across the outermost Siwalik Hills to debouch into plains. Budki Nadi and Siswa Nadi emerge from the hills drain the southeastern part of the district and finally confluence with Sutlej River.

Agriculture is the main source of economy. The land utilization pattern shows that net area sown is 780 sq.km while area under forest cover and land put to non-agricultural uses are 370 and 140 sq.km respectively. Total cropped area of the district is 1400 sq.km. Rice and maize constitute the main Kharif crops whereas wheat is the main Rabi crop.

Irrigation in the district is mainly by tubewells and canals. The Nangal Hydel canal. Anadpur Sahib hydel Canal and Sirhind canal passes through the district. The total area irrigated by canals is 66 sq.km, which forms 8.57% of the total irrigated area and rest 91% is irrigated by ground water.

Fig 1: Base Map of Ropar 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 Ropar district

ROPAR DISTRICT

Sl.No	Source of data	Depth Range (m)			
		< 100	100-200	200-300	>300
1	CGWB	0	3	6	3
2	WR&ED	0	0	0	3
3	PRIVATE	4	20	23	6
Total		**4**	**23**	**29**	**9**

2.2 Ground Water Quality

The ground water in the district is alkaline in nature with medium to high salinity. The chemical quality data from the shallow and deep aquifers indicate that all major cations (Ca, Mg, Na, K) and anions (CO3, HCO3, Cl, SO4) are within the permissible limits set by BIS, 2012. The physical parameter such as electrical conductivity shows a wide variation from 470µS/cm in southern and northern part to 1225µS/cm in the central part of the district particularly, in Ropar block. Nitrate and fluoride concentration is below the prescribed permissible limit in entire district 66.7% of the groundwater samples collected from the district show Ca-Mg-HCO3 type of water, which imparts temporary hardness. Rest 33.3% shows a mixed type of

chemical character. Since all the physical and chemical parameters are below the permissible limit prescribed by BIS the ground water in the area is suitable for drinking purposes. The suitability of groundwater for irrigation purpose is calculated by SAR and RSC values. The SAR value is below the permissible limit of 10.0 in entire district while the RSC value is slightly above the prescribed limit of 2.0 in two locations, viz., Chakdera and Kakrali. As per USSL diagram, ground water of the district falls in medium to high salinity hazard and low sodium hazard and hence it is suitable for irrigation in all types of soil.

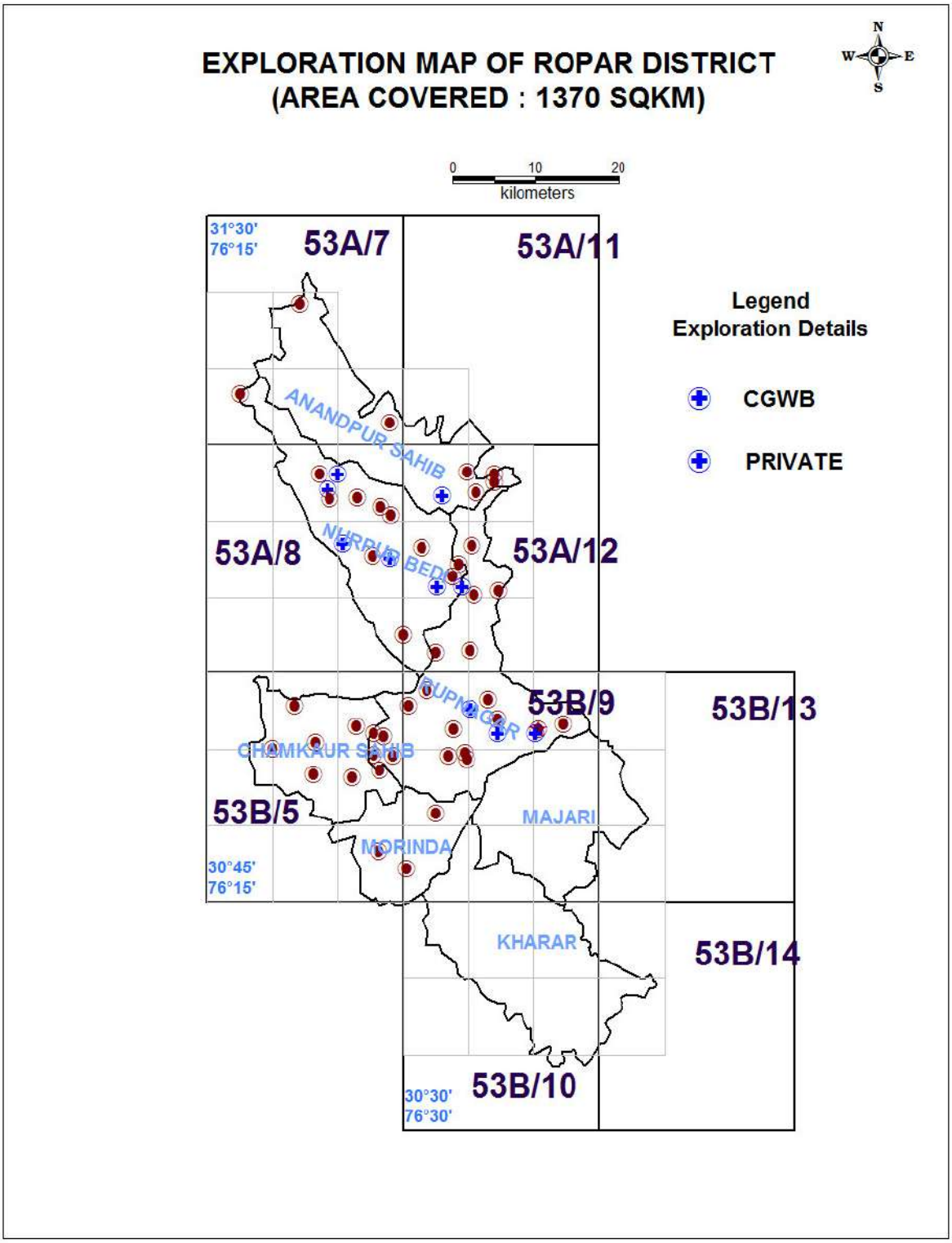
In the entire district Iron, which is an essential plant and animal nutrient, is found to be below the permissible limit with an exception in Ropar block. Majority of the samples in Ropar block show slightly higher values than the permissible limit of 1.0 mg/l. Arsenic above the prescribed BIS permissible limit of 0.05 mg/L is found in well waters located at Bara Chaunta (0.096 mg/l).

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.

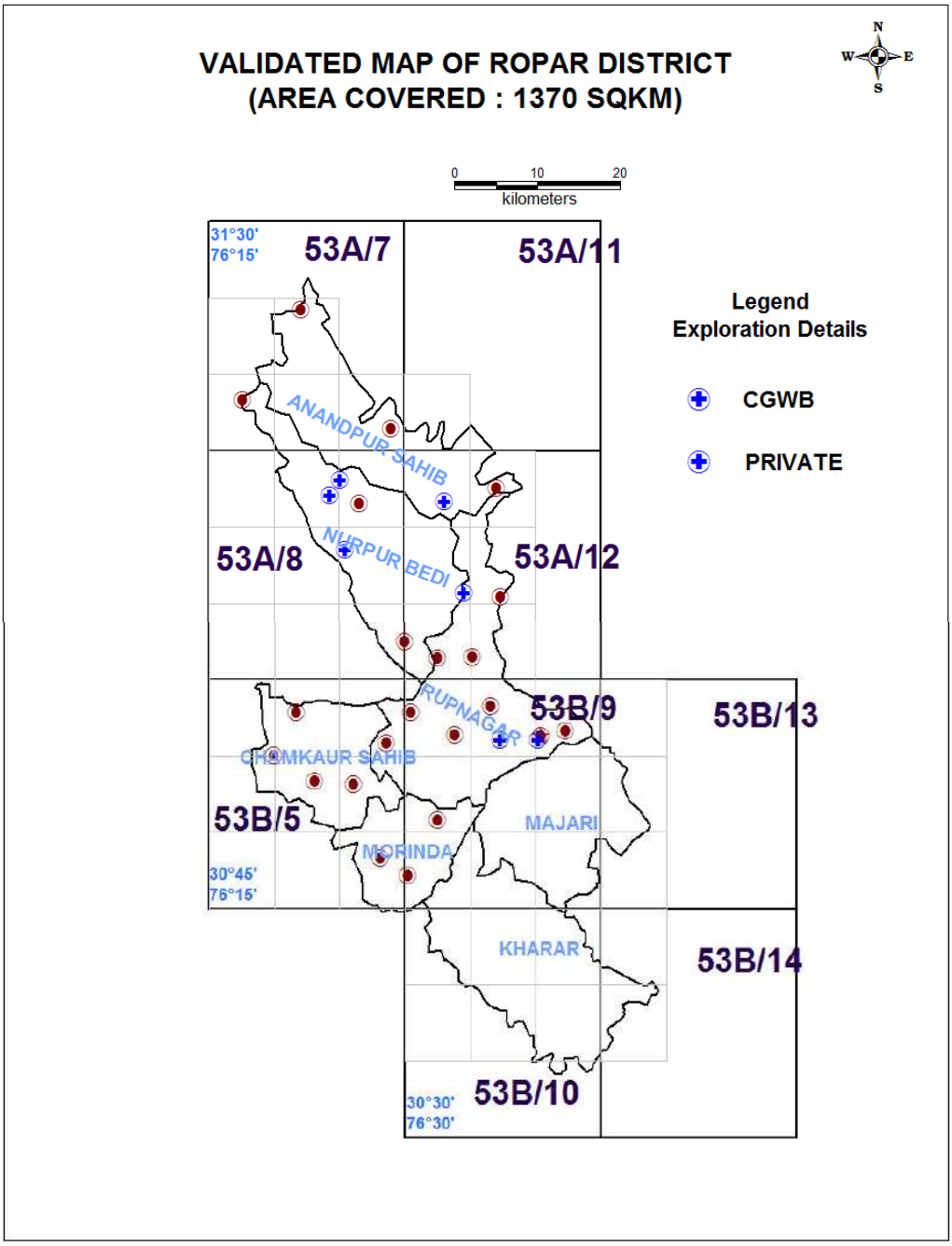
Fig-2 Location of Exploratory Bore Holes



2.4 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

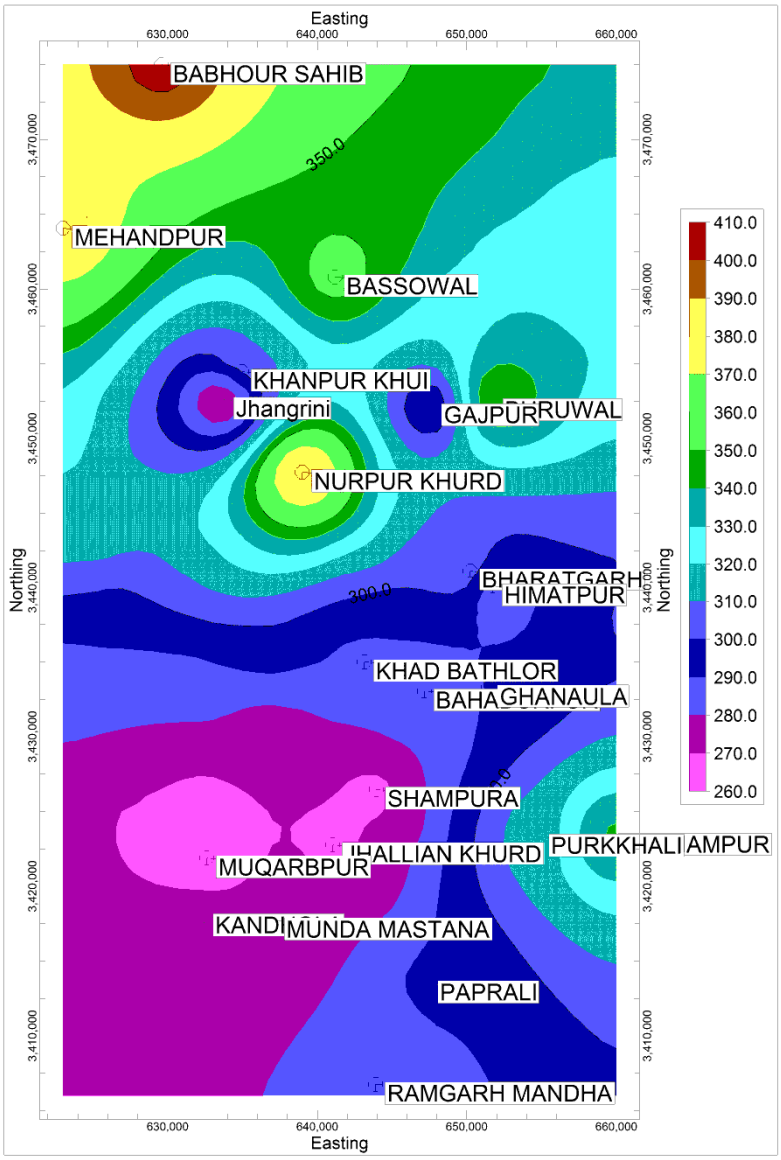
All the available data have been validated for consideration to generate aquifer map. The deepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig -3.

Fig 3: Validated Exploration Data of Ropar District



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

Fig 4: Elevation Contour Map-Ropar District



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

3. HYDROGEOLOGY

3.1 PREVIOUS WORK

The Quaternary alluvial deposits belonging to the vast Indo-Gangetic Alluvium occurring in the southern blocks of the district forms the main aquifer system. The aquifers in the northern part are mainly Siwalik formation, Intermontane Valleys and Kandi/Sirowal formation.

The Central Ground Water Board has drilled 12 Exploratory wells in the district in the depth range of 50-459 m to determine various aquifer systems and its properties. Exploratory drilling has revealed the presence of 5 to 27 saturated granular zones comprising fine to coarse sand, silt, gravel and kankar upto the depth of 460 m. Shallow aquifers up to the depth of 75 m are either in the form of isolated lenses of sand embedded in clay beds or well connected granular zones that have pinching and swelling disposition and are quite extensive in nature. These aquifers comprising fine to coarse sand are often intercepted with kankar horizons. Deeper aquifers in the range of 50-460 m are composed of fine to coarse sand, silt, gravel and kankar. From west to east the granular zones thin out and clay horizons with gravel or kankar become predominant.

Two Piezometers were drilled at Rurkee Heeran, Chamkaur Sahib block and Chutamali, Morinda block. At Rurkee Heeran Pz is drilled upto the depth of 100 meters with SWL 17.77 m bgl and at Chutamli, Pz is drilled upto the depth of 88.34 meters with SWL 41.34 m. The Pz were drilled in the phreatic aquifer occurring in the depth range of 60 – 100 m.

Groundwater occurs under phreatic condition in the shallow aquifers of Quaternary alluvium deposits, Intermontane valley and Kandi formation while groundwater occurs under leaky confined to confined conditions in the deeper aquifers of alluvium.

In the case of unconfined aquifers, the depth to water level varies from 3.55 to 9.08 meters during pre-monsoon and 3.61 to 10.14 meters during post-monsoon. Seasonal fluctuation shows that in general there is an overall fall in water level except few isolated patches. The long-term trend of water level (10 years) shows a general decline in the entire district. The maximum fall is observed along the intermontane valley and the decline is at the rate of 1.05 m/year. Near the Siwalik hill, groundwater occurs at greater depth when compared to alluvial plains where it occurs at shallow depth. Generally, the water level is

deep in intermontane valley and slope towards central part of the valley. North Western Region, Chandigarh have 12 Ground water monitoring stations (10 Dug well & 2 Pz) at Ropar district.

In the northern part, especially in the intermontane valley, groundwater flow is towards south and southeastern direction whereas in the southeastern part of the district, the groundwater flow is in the south and southwestern direction. The water table elevation is highest near the hills and lowest in the southeastern part, which in turns reflects the topographic gradient. The hydraulic gradient is steeper near the hills and gentles near the plains.

The aquifer parameters show marked difference depending upon the subsurface lithology. The wells drilled in the intermontane valley shows more yield in the range of 1098-1500 lpm for 6.2 to 13.3 m drawdown. While the yield of wells tapping alluvial aquifers are in the range of 731 to 946 lpm for 4.4 to 8.2 m drawdown. This high discharge may be attributed to induced recharge from antecedent Sutlej River passing through the valley. The transmissivity value ranges from 123 to 1180 m^2/day in Nupur Bedi and Ropar Block respectively. Similarly, the lateral hydraulic conductivity ranges from 3 to 21.6 m/day. The storativity value is between 7.8 $*10^{-4}$ and 1.7* 10^{-3} indicating semi-confined to confined conditions.

Out of 12 exploratory wells, 2 exploratory wells have been constructed in Kandi area. In these locations - Harnampur and Bhagwati- Aquifer performance test were conducted for more than 10,000 min. The specific capacity is 49.76 lpm/m at Harnampur and 115.09 lpm/m at Bhagwati.

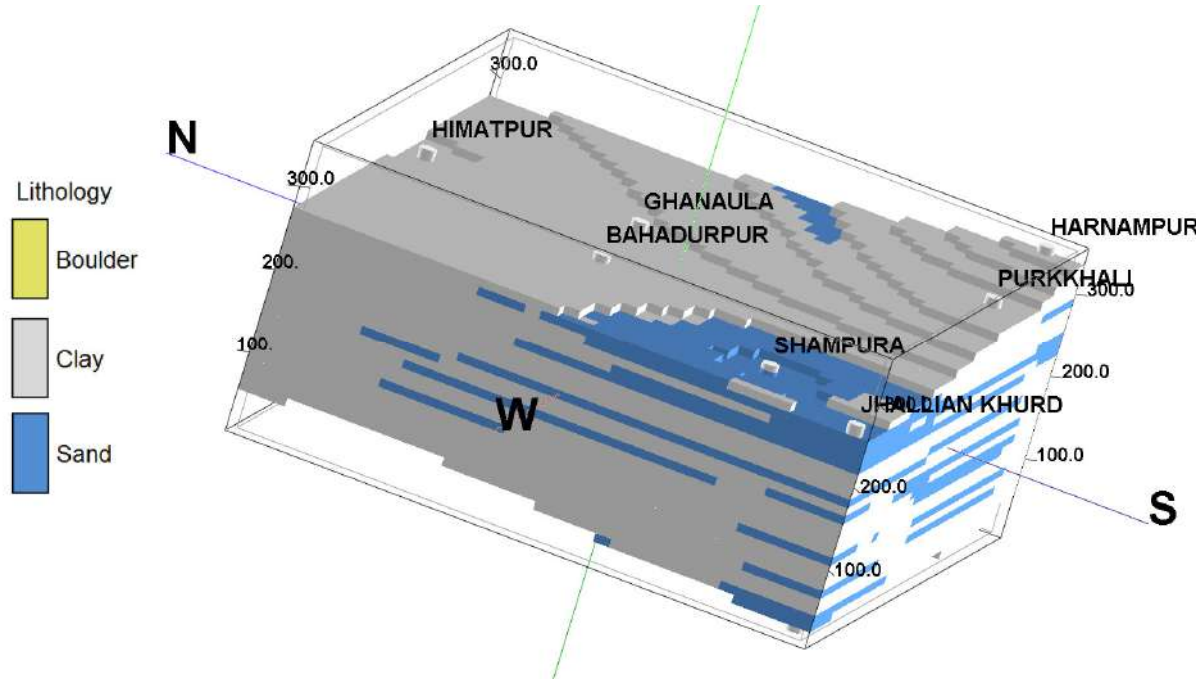
3.2 Present NAQUIFERUIM study

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 Ropar 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 Ropar District



3.3 Aquifer Geometry

Ropar 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 Ropar 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 resources are calculated separately which are included in next chapter. The Lithological cross-section of Ropar district is given below:-

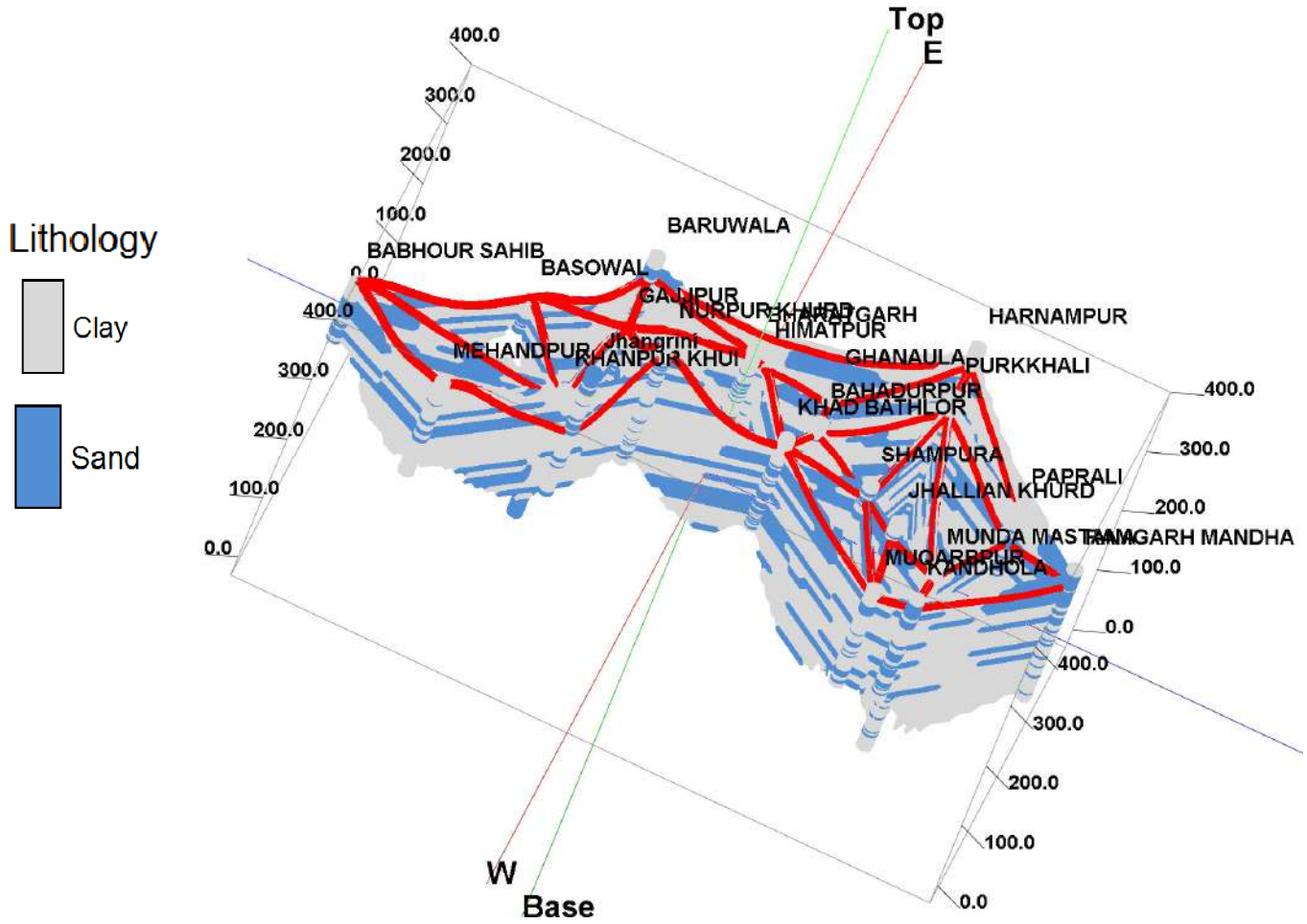
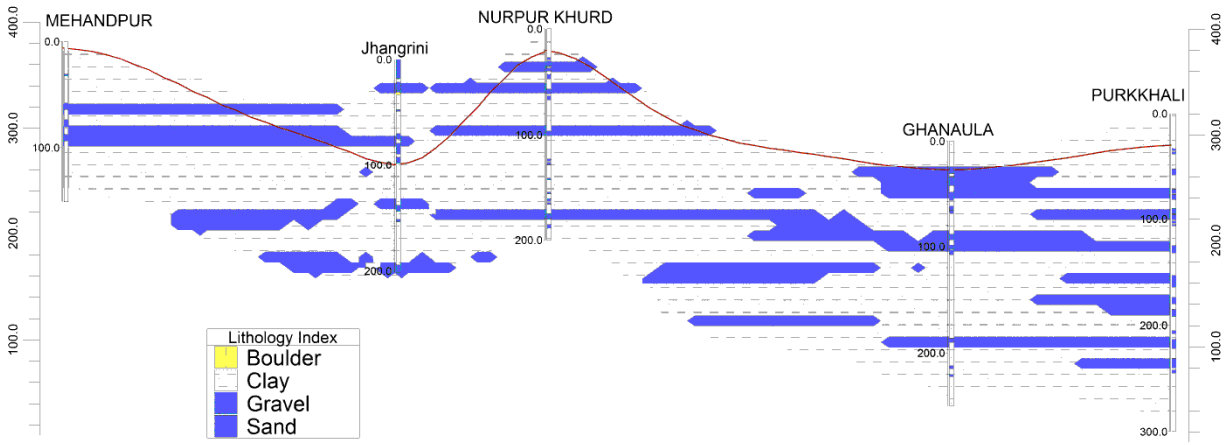
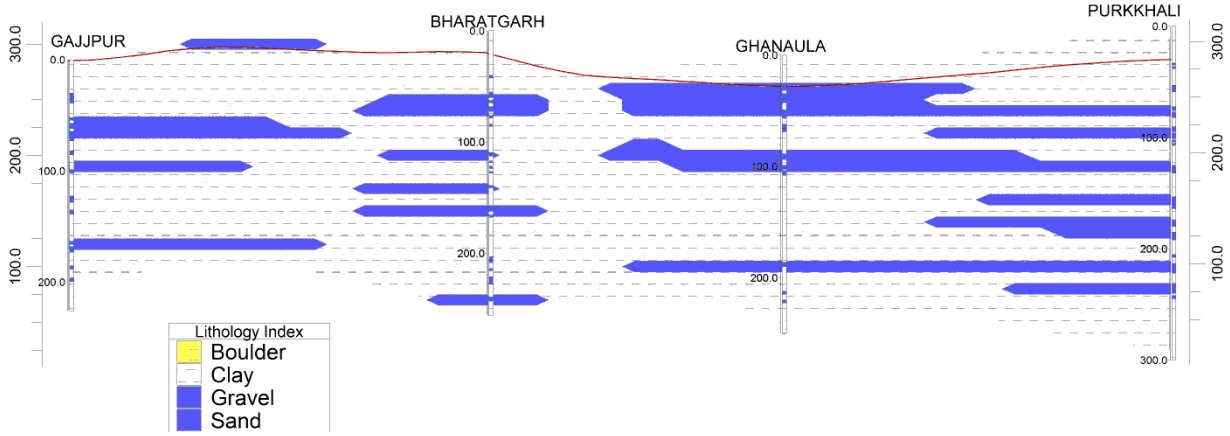
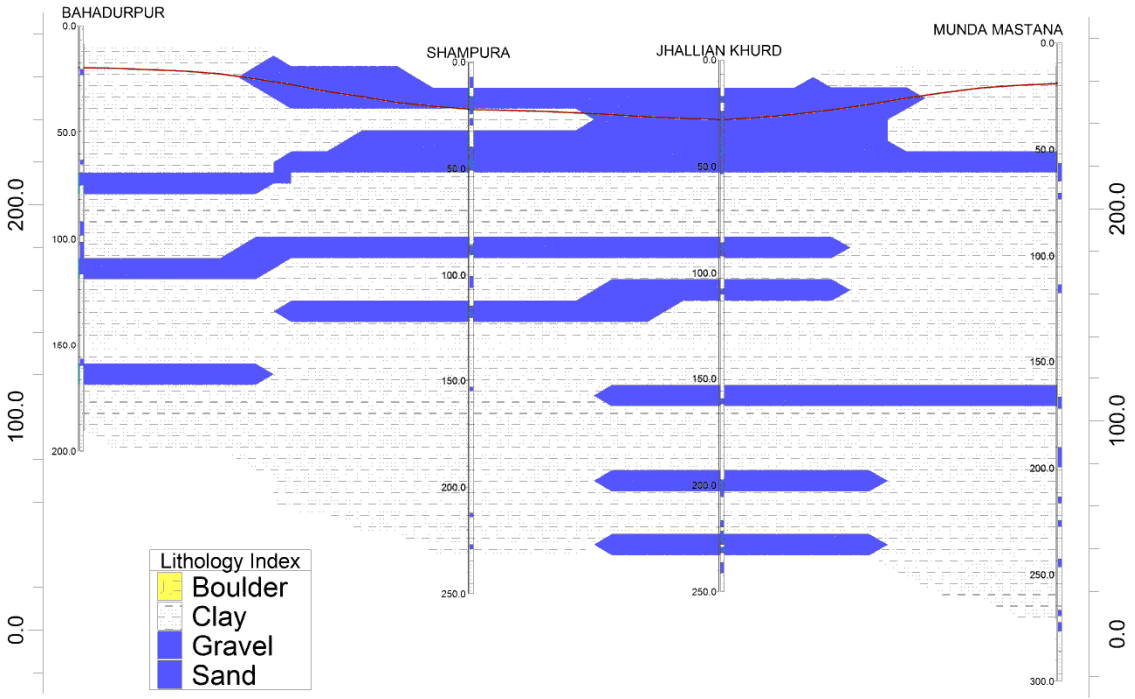


Fig 7: Cross Sections of Aquifer Map of Ropar District






BAHADURPUR
SHAMPURA
JHALLIAN KHURD
MUNDA MASTANA
0.0
50.0
100.0
150.0
200.0
250.0
300.0
200.0
100.0
0.0
Lithology Index
Boulder
Clay
Gravel
Sand

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 2 blocks has exceeded the available recharge, thus 2 blocks have been categorized as **over exploited**. 2 Blocks are safe and 1block is semi critical Stage of ground water development in the Ropar district has been assessed to be 109 %.

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 (%)
ANANDPUR SAHIB	7615	5374	385	5759	467	1773	76
CHAMKAUR SAHIB	9441	18822	267	19089	324	-9705	202
MORINDA	5976	10259	294	10553	325	-4608	177
NURPUR BEDI	4728	4595	225	4820	273	-140	102
ROPAR	14188	4260	1254	5514	1363	8565	39
Total (ham)	**41947**	**43310**	**2425**	**45735**	**2752**	**-4115**	**109**

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 resources (within the aquifer thickness)	=	Thickness of the confined aquifer (granular/ productive zone) down to the bottom layer of confined aquifer or exploitable depth of 300 m	×	Sp. Yield of the aquifer	×	Areal extent of 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

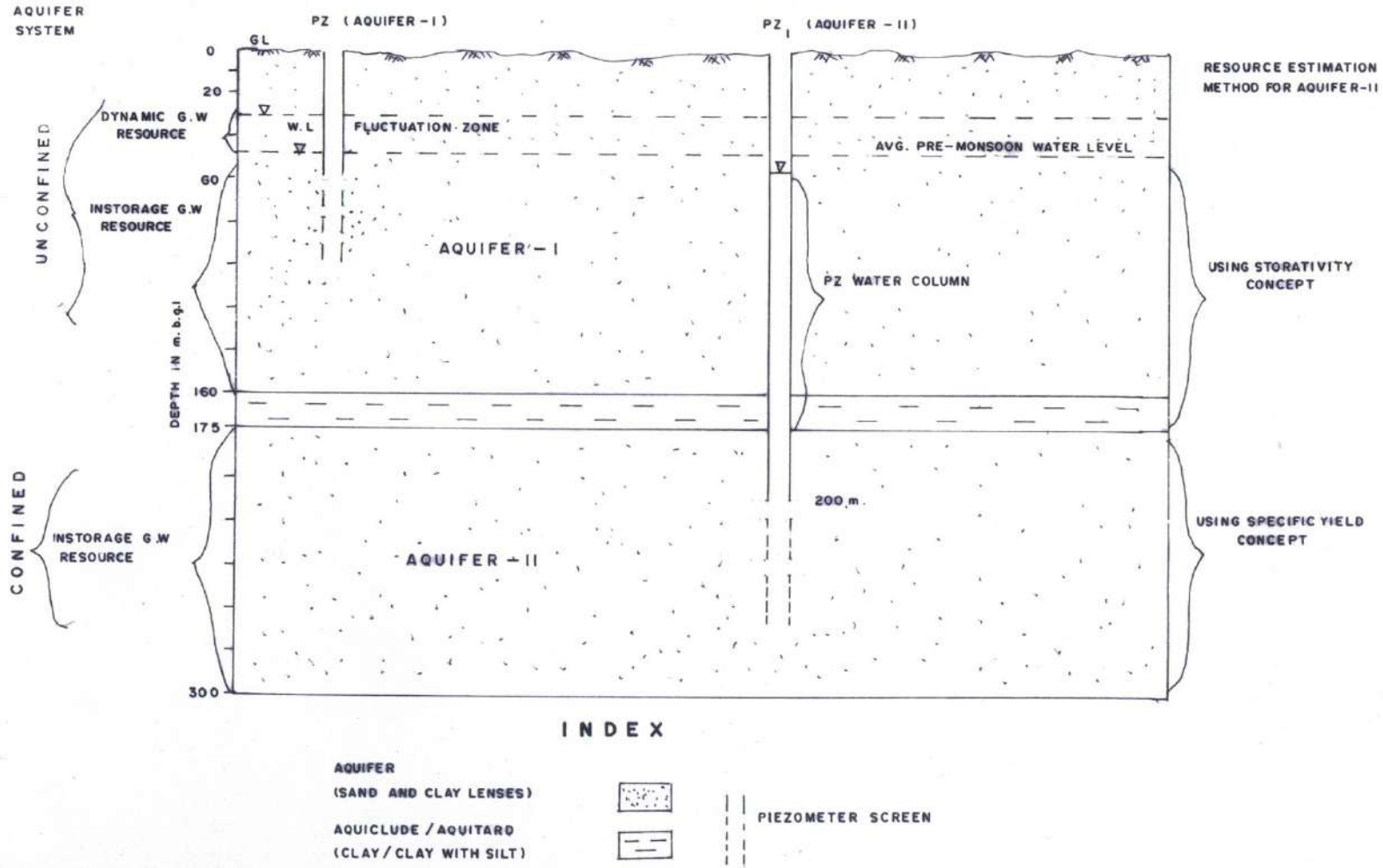


Table 5: BLOCK WISE AVAILABILITY OF TOTAL GROUNDWATER RESOURCES IN ROPAR DISTRICT

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	ANANDPUR SAHIB	31140	31140	31140	0	6.8	94.17	87.28	26.65	0.072	59751
2	CHAMKAUR SAHIB	15160	15160	15160	0	6.5	107.17	100.64	36.06	0.072	39360
3	MORINDA	16950	16950	16950	0	8.8	108.67	99.85	34	0.072	41494
4	NURPUR BEDI	31980	31980	31980	0	8.2	116.14	107.87	41	0.072	94405
5	ROPAR	41810	41810	41810	0	6.1	115.31	109.15	36.33	0.072	109365
Dist. Total (ham)		**137040**	**137040**	**137040**							**344375**
Dist. Total (mcm)			**1370.4**	**1370.4**							**3444**

ham: hectare metre

mcm: million cubic metre

BLOCK WISE INSTORAGE GROUND WATER RESOURCES – CONFINED (AQUIFER II)

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											
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ANANDPUR SAHIB	31140	31140	31140	121	185.25	0	121	64.25	26.41	0.072	0	59213	0	59213
CHAMKAUR SAHIB	15160	15160	15160	128.33	180.67	0	128.33	52.34	21.27	0.072	0	23217	0	23217
MORINDA	16950	16950	16950	131.34	197.67	0	131.34	66.33	23.55	0.072	0	28740	0	28740
NURPUR BEDI	31980	31980	31980	134	193	0	134	59	26	0.072	0	59867	0	59867
ROPAR	41810	41810	41810	146.26	198.6	0	146.26	52.34	18.26	0.072	0	54968	0	54968
Dist. Total (ham)	**137040**	**137040**	**137040**									**226005**	**0**	**226005**
Dist. Total (mcm)	**1370**	**1370**	**1370**									**2260**	**0**	**2260**

ham: hectare metre

mcm: million cubic metre

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 in-Storage Ground Water Resources (ham) (15+16)
			Total	Fresh Water										
1	2	4	5	6	8	9	10	11	12	13	14	15	16	17
1	ANANDPUR SAHIB	31140	31140	31140	0	0	0	0	0	0.072	0	0	0	0
2	CHAMKAUR SAHIB	15160	15160	15160	242	300	0	58	14.8	0.072	0	16154	0	16154
3	MORINDA	16950	16950	16950	219.5	250	0	5.4	23	0.072	0	28069	0	28069
4	NURPUR BEDI	31980	31980	31980	194	210	0	16	7.4	0.072	0	17039	0	17039
5	ROPAR	41810	41810	41810	208.5	247.5	0	39	17.44	0.072	0	52500	0	52500
Dist. Total (ham)		**137040**	**137040**	**137040**								**113763**	**0**	**113763**
Dist. Total (mcm)		**1370**	**1370**	**1370**								**1138**	**0**	**1138**

The Average Peizometer head value for confined Aquifer - III is 34.40 m.bgl

ham: hectare metre

mcm: million cubic metre

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

AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN ROPAR 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	ANANDPUR SAHIB	43496	7615	59751	67366	59213	0	126580	1266
2	CHAMKAUR SAHIB	11898	9441	39360	48801	23217	16154	88172	882
3	MORINDA	43751	5976	41494	47470	28740	28069	104279	1043
4	NURPUR BEDI	23409	4748	94405	99153	59867	17039	176058	1761
5	ROPAR	30906	14188	109365	123553	54968	52500	231021	2310
Dist. Total (ham)		**153461**	**41968**	**344375**	**386343**	**226005**	**113763**	**726111**	**7261**
Dist. Total (mcm)		**1535**	**420**	**3444**	**3863**	**2260**	**1138**		

ham: hectare metre

mcm: million cubic metre

5. GROUND WATER RELATED ISSUES

Ropar 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.

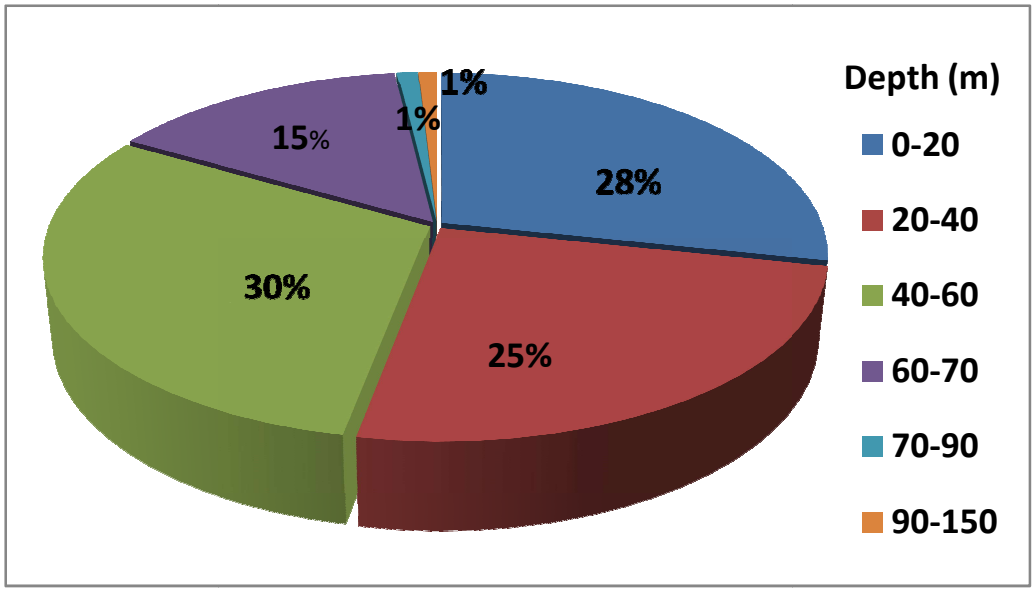


Table 7-Distribution of Tube wells According to Owner's holding Size

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	**Ropar**	**96**	**143**	**266**	**119**	**15**	**639**

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	**Ropar**	**7081**	**6161**	**7595**	**3684**	**477**	**24998**

Table 9- Type of Ground water distribution device

Open Water Channel		
Lined/pucca	**Unlined/kutcha**	Total
956	**23751**	**24707**

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 64232 tubewells operated by farmers for irrigation through unlined/Katcha (63.67%) open channel system in Ropar 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 Ropar district is estimated at 858.40 MCM. It is expected that around 23.64% 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 786.88 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 Ropar Districts. The measure if implemented will bring down the ground water overdraft from 110% to 86.36 %. 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)
				eplace water urses by UG Pipes (mcm)	t Artificial echarge (mcm)	ge Paddy to Maize (mcm)	Total (mcm) (2+3+4)		
			1	2	3	4	5		
ANANDPUR SAHIB	76.1	57.6	76	14.4	0.00	0	14.4	57	Not Required
CHAMKAUR SAHIB	94.4	190.9	202	47.7	2.95	45.847	96.497	100	36
MORINDA	59.8	105.5	177	26.4	2.77	16.653	45.823	100	18
NURPUR BEDI	47.3	48.2	102	12.1	4.56	0	16.66	67	Not Required
ROPAR	141.9	55.1	39	13.8	0.00	0	13.8	29	Not Required
Total	419.5	457.3	109	114.3	10.27	62.50	187.07	79	

7. BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

(I) ANANDPUR SAHIB BLOCK (311.40 SQ KM)

1. Salient Information

Population (2011)	Rural-150467 Urban-7325 Total-157792
Rainfall 2014 (Ropar District)	Average annual rainfall -776 mm
Average Annual Rainfall (Anandpur Sahib block)	918 mm
Agriculture and Irrigation	Major Crops- Rice, Wheat Other crops-Sugarcane, Potatoes, Pulses, Net Area Sown- 172.58 sq.km Total Irrigated Area-178.61 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 Anandpur Sahib 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 **Semi Critical** 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-~*4.45-8.19 (mbgl)* &Post Monsoon-~*4.00-7.54(mbgl)*

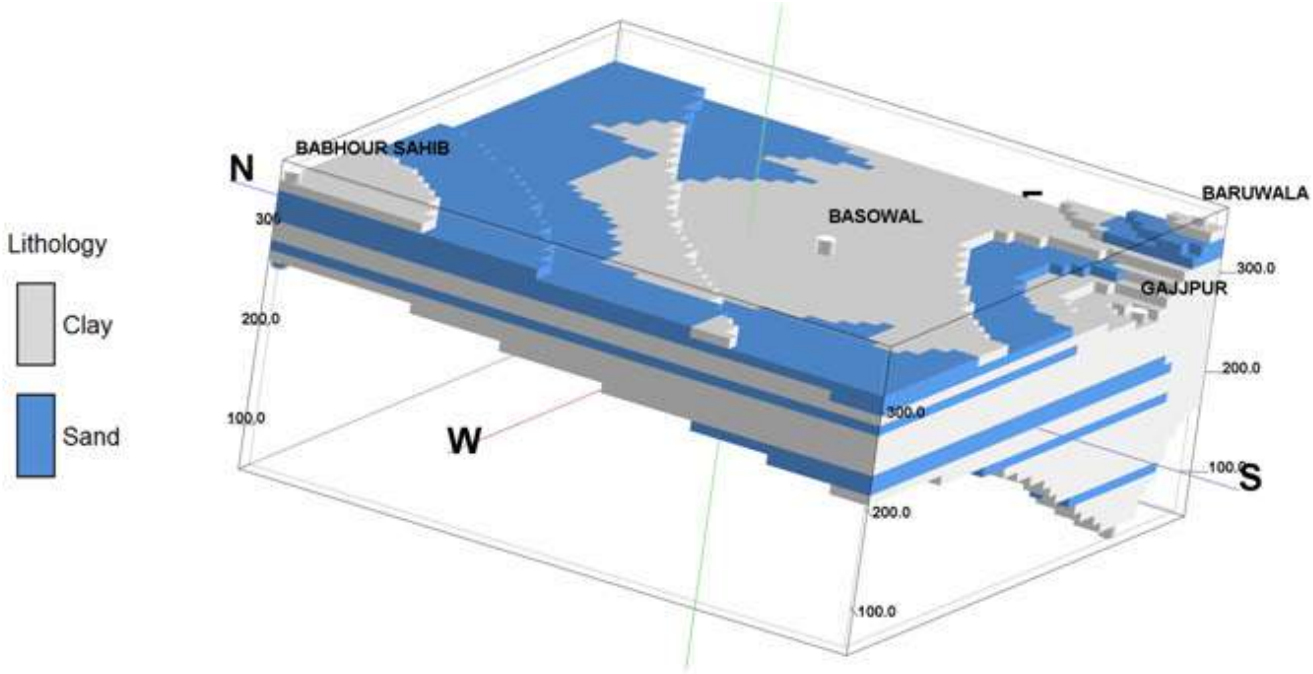
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (25-119m)	Quaternary Alluvial deposits	Unconfined	26.65	123-1180	0.072	$1.2*10^{-3}$ $7.75*10^{-4}$
Aquifer-II (121-185m)		Unconfined to Confined	26.41	-	NA	-

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

The non-aquifer material comprise of clay.

3D Lithology model



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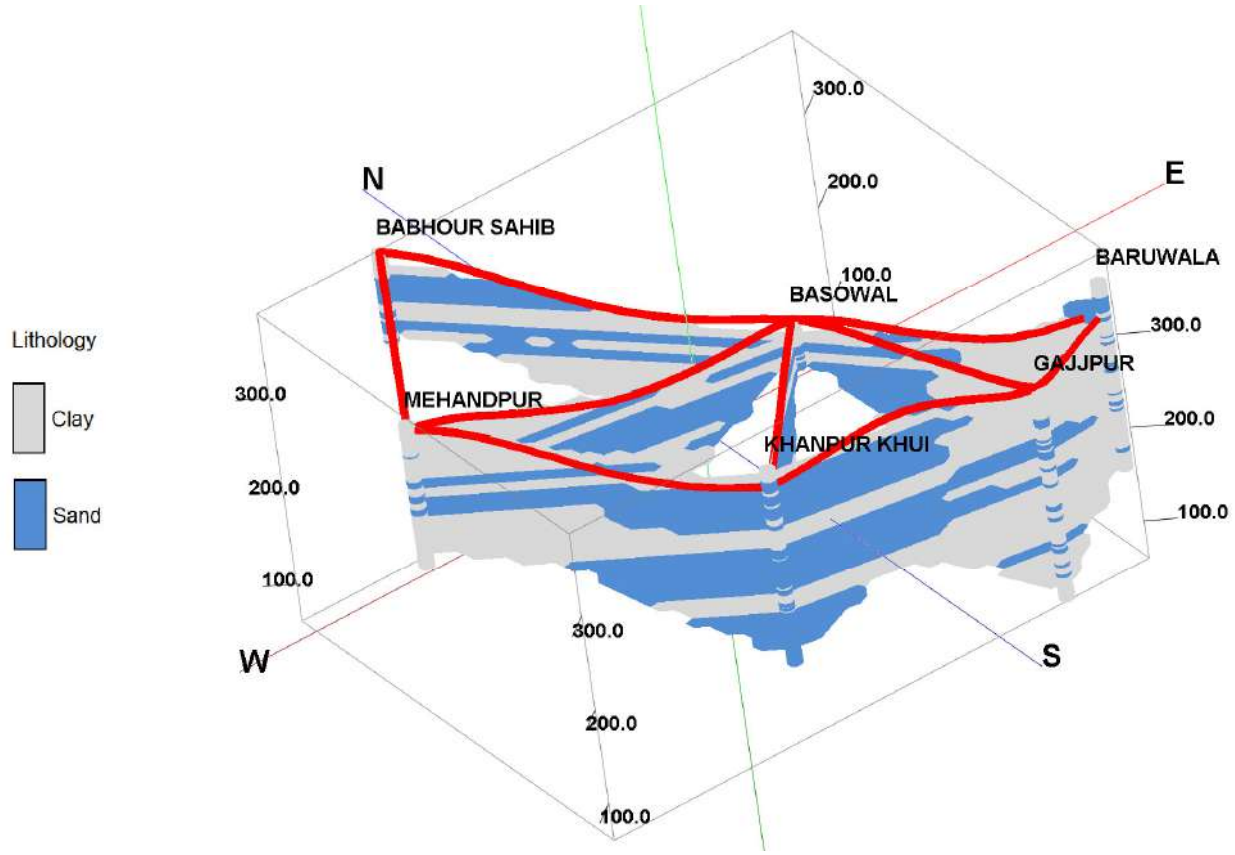

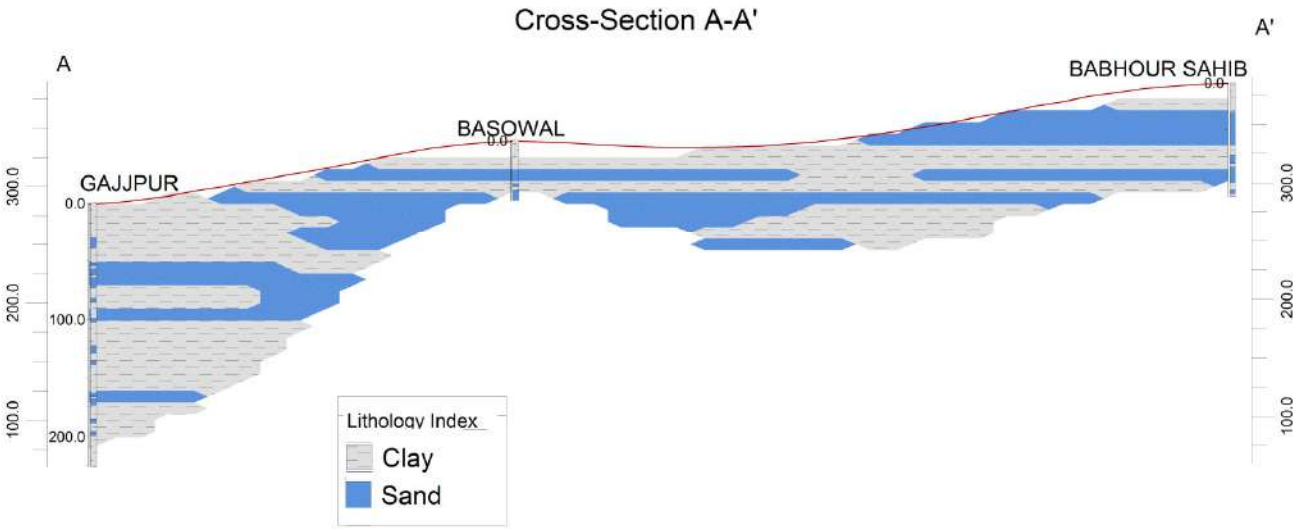

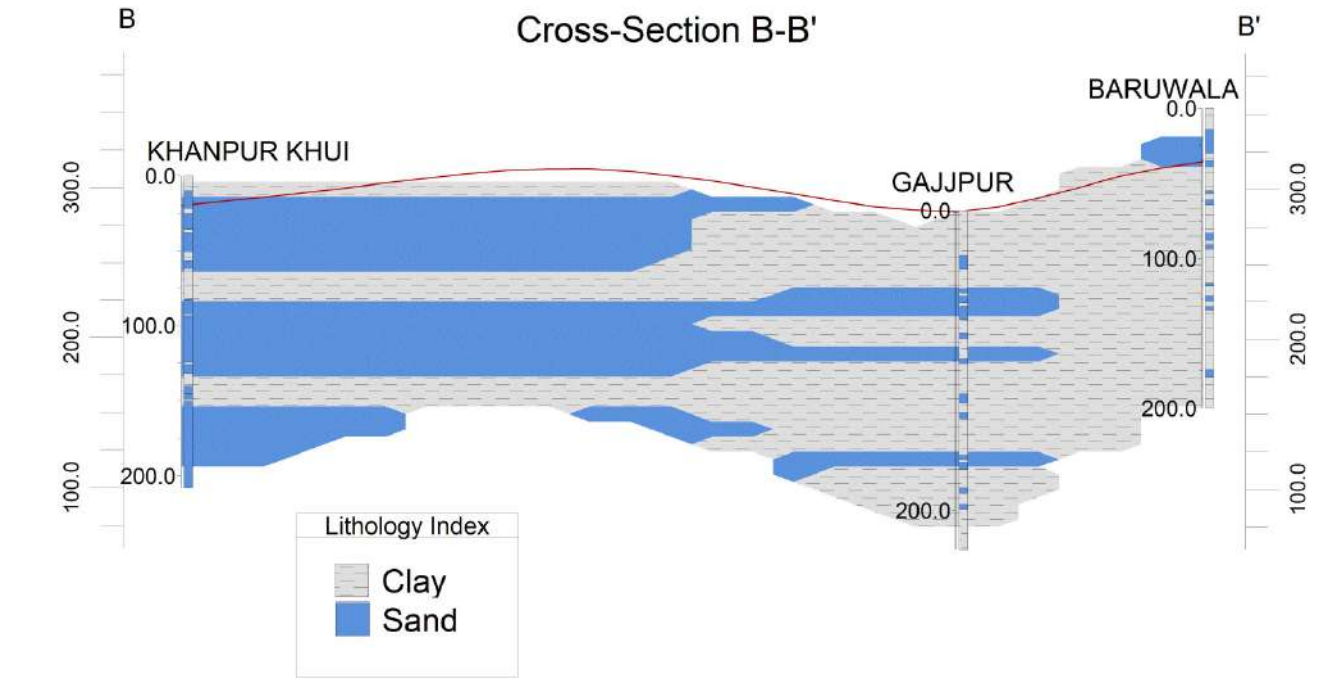
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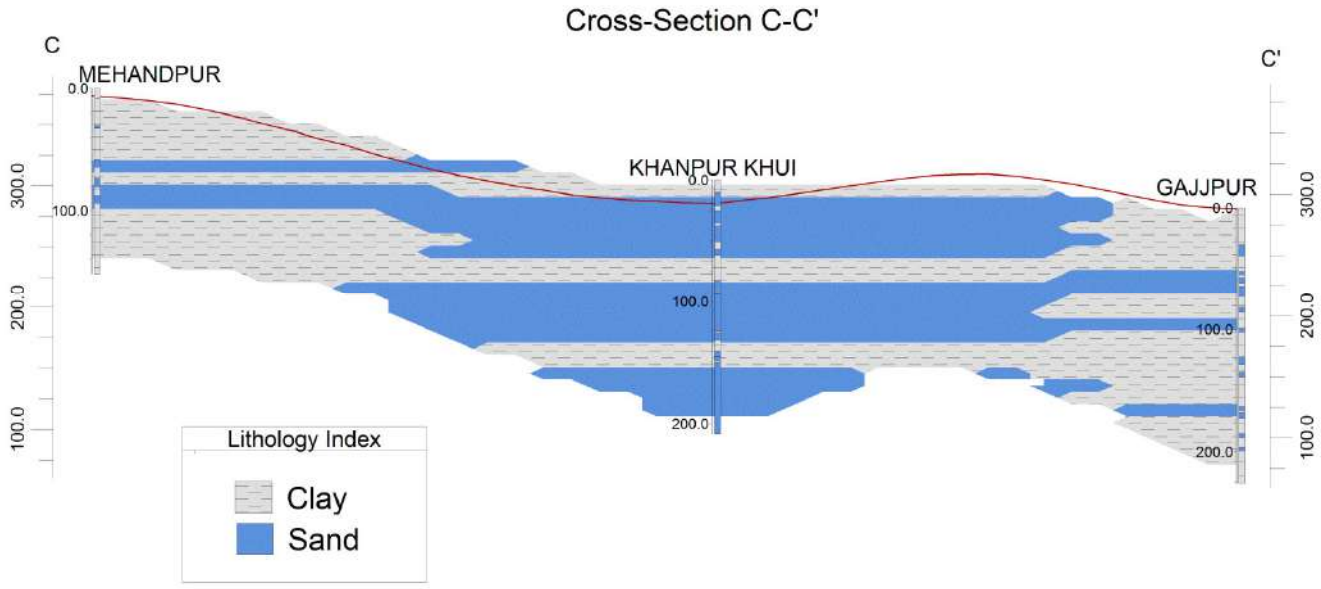
Lithology Index
Clay
Sand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Lithology Index
Clay
Sand

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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*76.15*
	In-storage Ground Water Resources	*1189.64*
	Total	1266
Ground Water Extraction (in mcm)	Irrigation	53.74
	Domestic & Industrial	3.85
Provision for domestic & Industrial requirement upto 2025 (in mcm)		4.67
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 (25.34m).
Other interventions proposed	Not Required

4. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 14.4 mcm volume of water wastage
Change in cropping pattern	Not Required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

(II) CHAMKAUR SAHIB BLOCK (151.60 SQ KM)

1. Salient Information

Population (2011) Rural-61680
Urban--
Total-61680

Rainfall 2014 (Ropar District) Average annual rainfall -776 mm

Average Annual Rainfall (Chamkaur Sahib block) 807 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 143.39 sq.km
Total Irrigated Area-144.71 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 Chamkaur Khan 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 **Safe** 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)

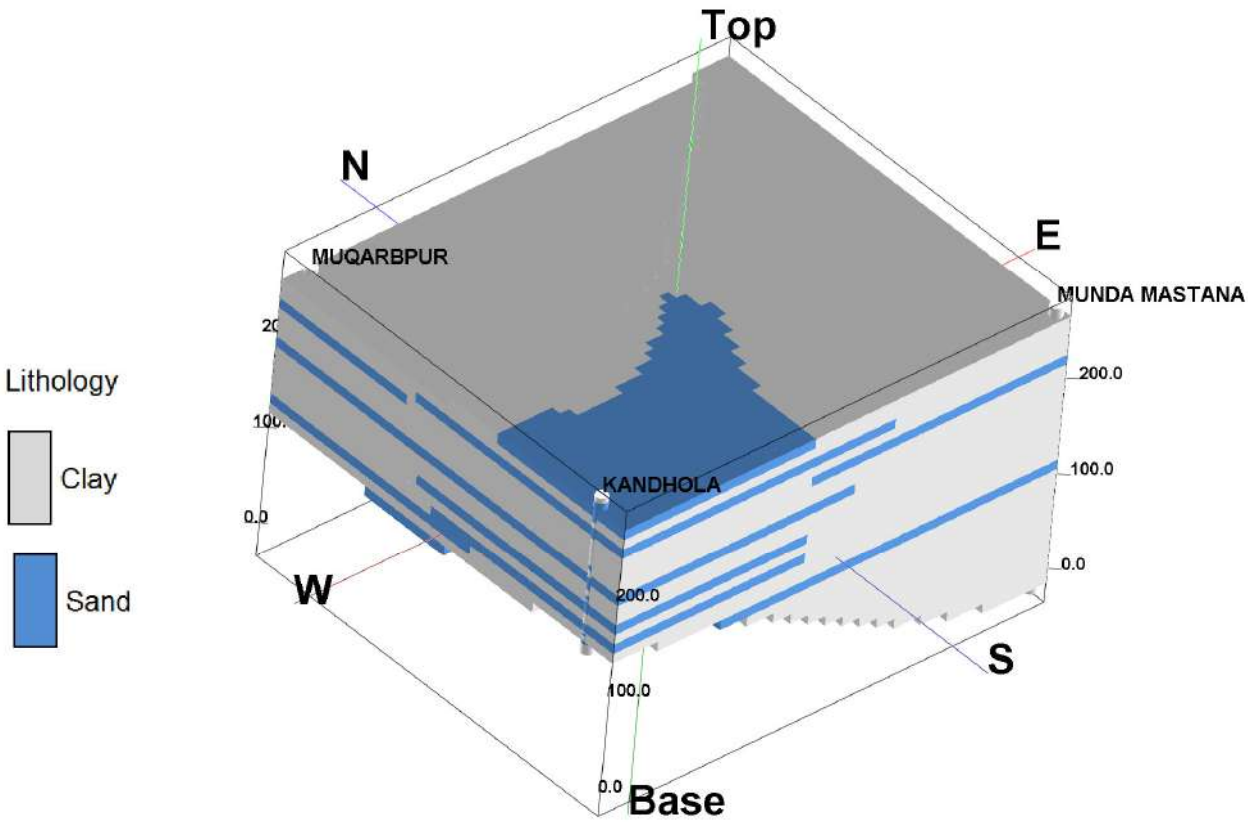
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (17-107m)	Quaternary Alluvial deposits	Unconfined	36	123-1180	0.072	$1.2*10^{-3}$ $7.75*10^{-4}$
Aquifer-II (128-181m)		Unconfined to Confined	21	-	NA	-
Aquifer-III (242-300m)		Unconfined to Confined	15	-	NA	-

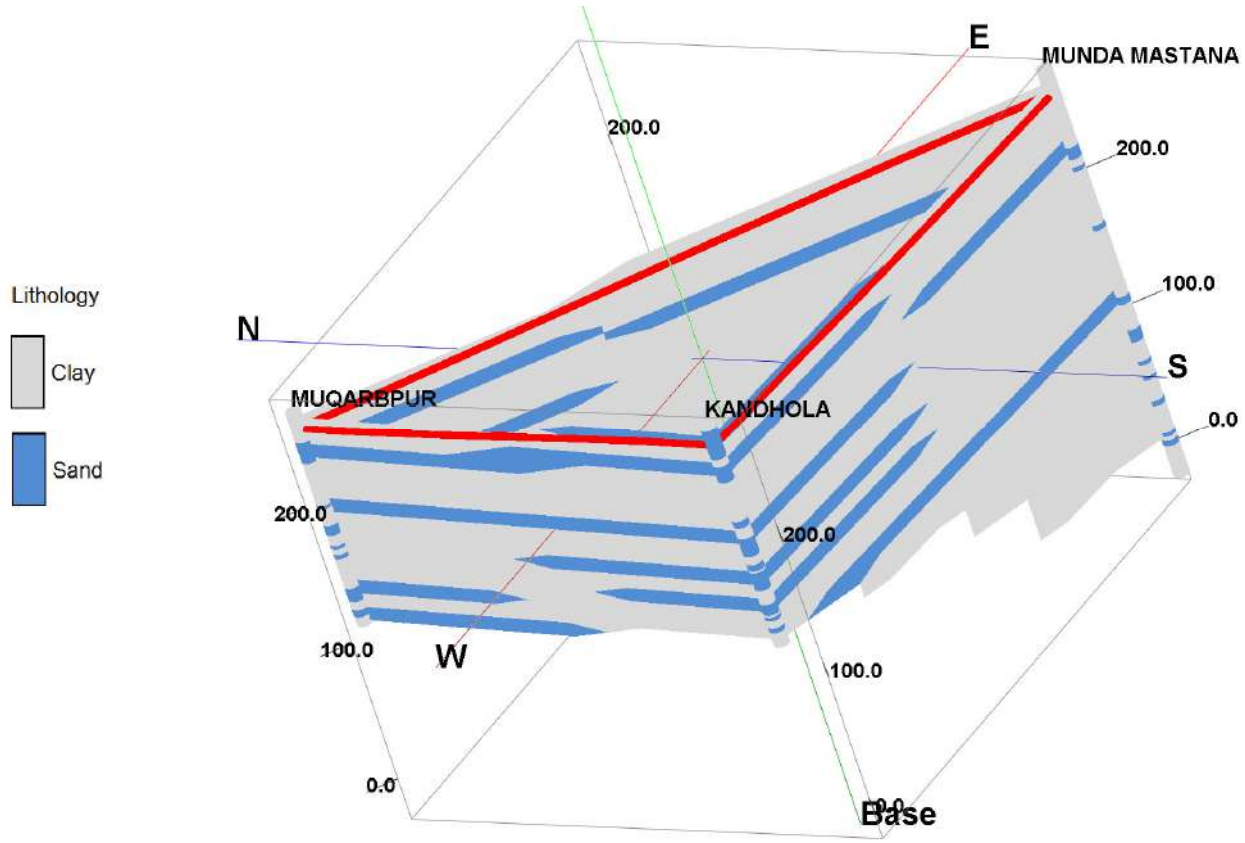
Aquifer comprises of freshwater only and the main aquifer material is sand.

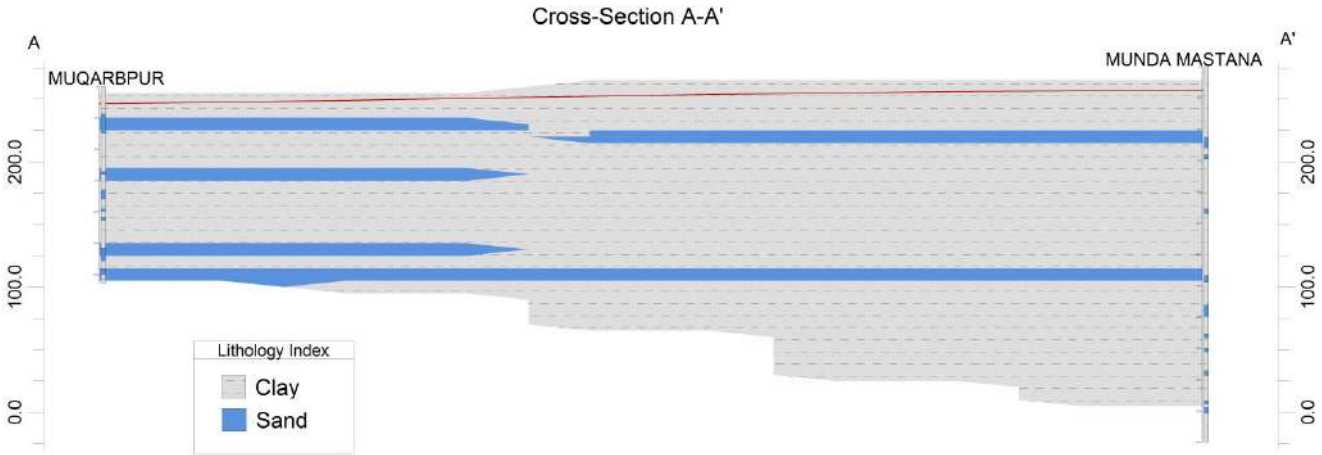
The non-aquifer material comprise of clay.

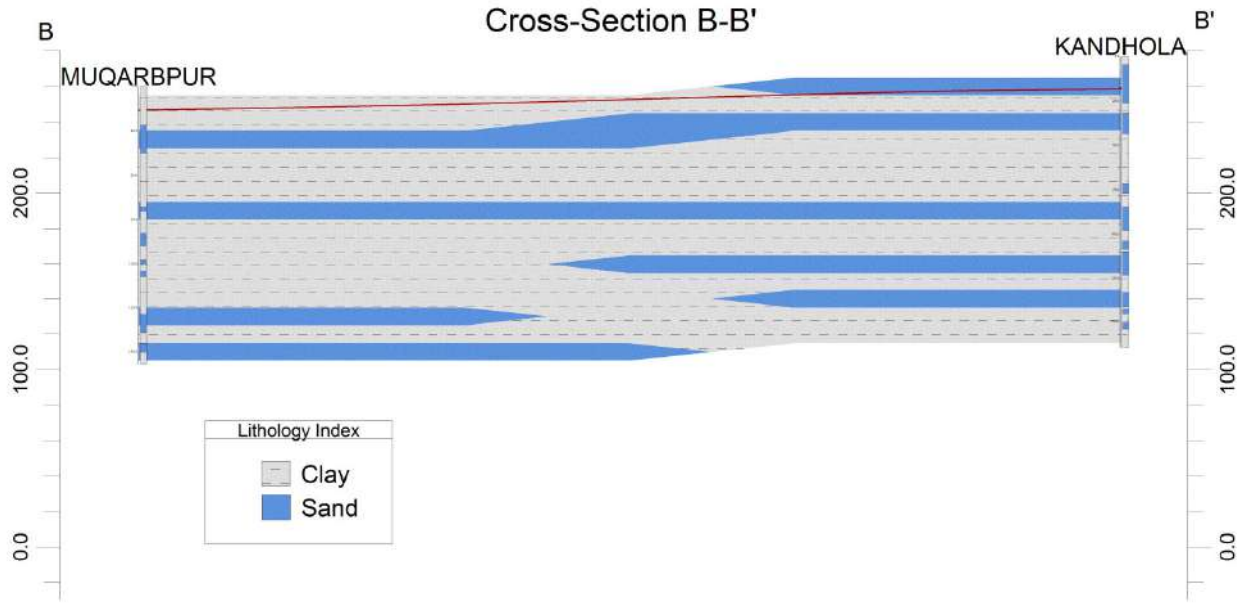
3D Lithology model



3D Lithology Fence



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B
B'
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KANDHOLA
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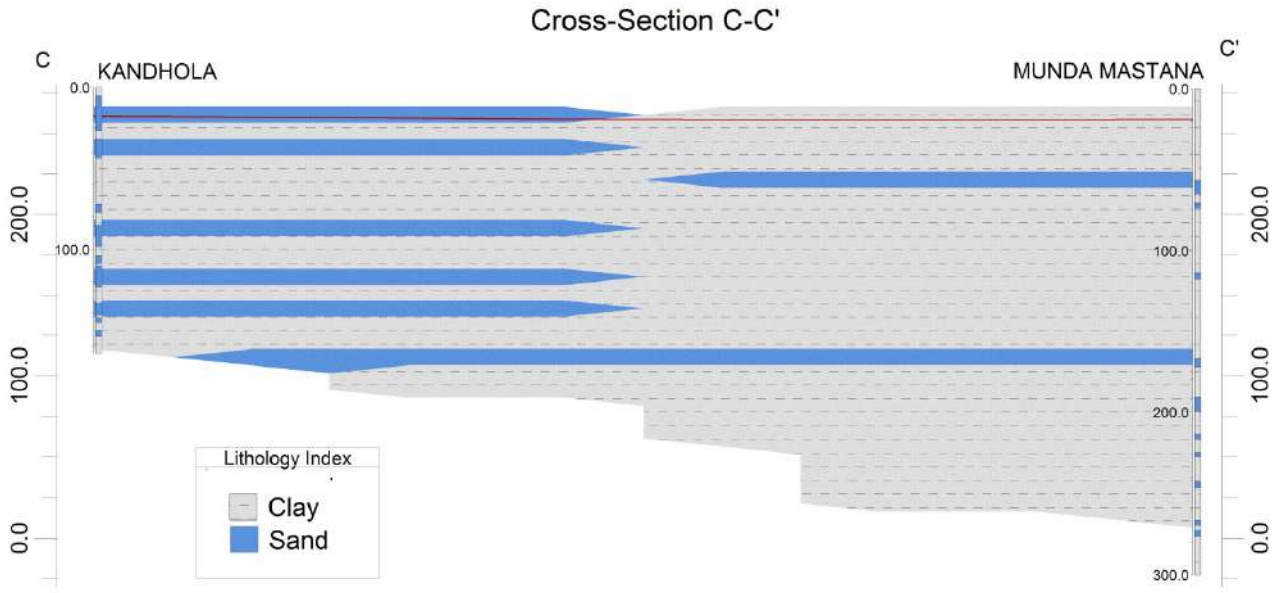
Lithology Index
Clay
Sand


Cross-Section C-C'
C
C'
KANDHOLA
MUNDA MASTANA
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100.0
200.0
300.0
Lithology Index
Clay
Sand

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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*94.41*
	In-storage Ground Water Resources	*787.59*
	Total	882
Ground Water Extraction (in mcm)	Irrigation	188.22
	Domestic & Industrial	2.67
Provision for domestic & Industrial requirement upto 2025 (in mcm)		3.24
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 (16.67m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.95 mcm volume of water

7. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 47.7mcm 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 46 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

3. MORINDA BLOCK (169.50 SQ KM)

1. Salient Information

Population (2011) Rural-63353
Urban--
Total-63353

Rainfall 2014 (Ropar District) Average annual rainfall -776 mm

Average Annual Rainfall (Morinda block) 791 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 119.85 sq.km
Total Irrigated Area-120.88 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 Morinda 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-~20.70-37.42 (mbgl) &Post Monsoon-~19.80-36.35(mbgl)

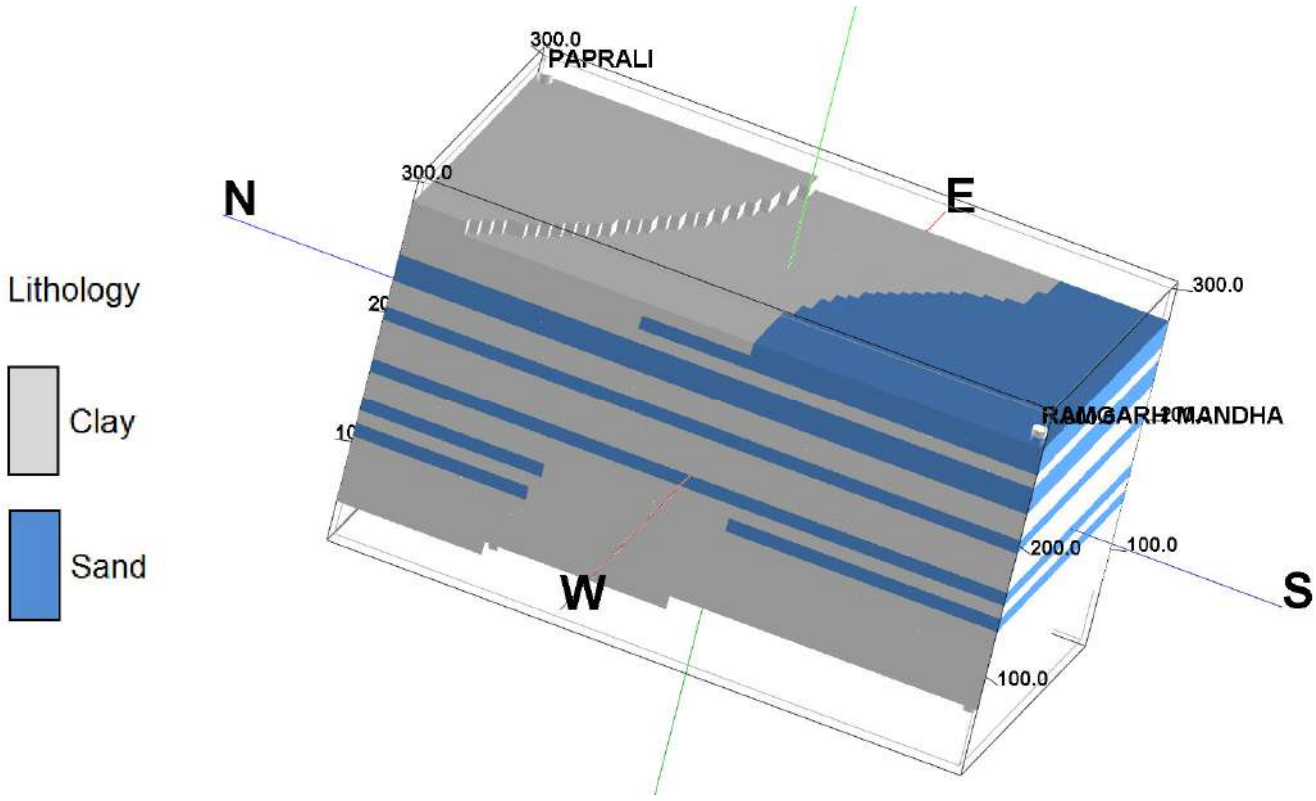
Aquifer Disposition: Combined Aquifer System

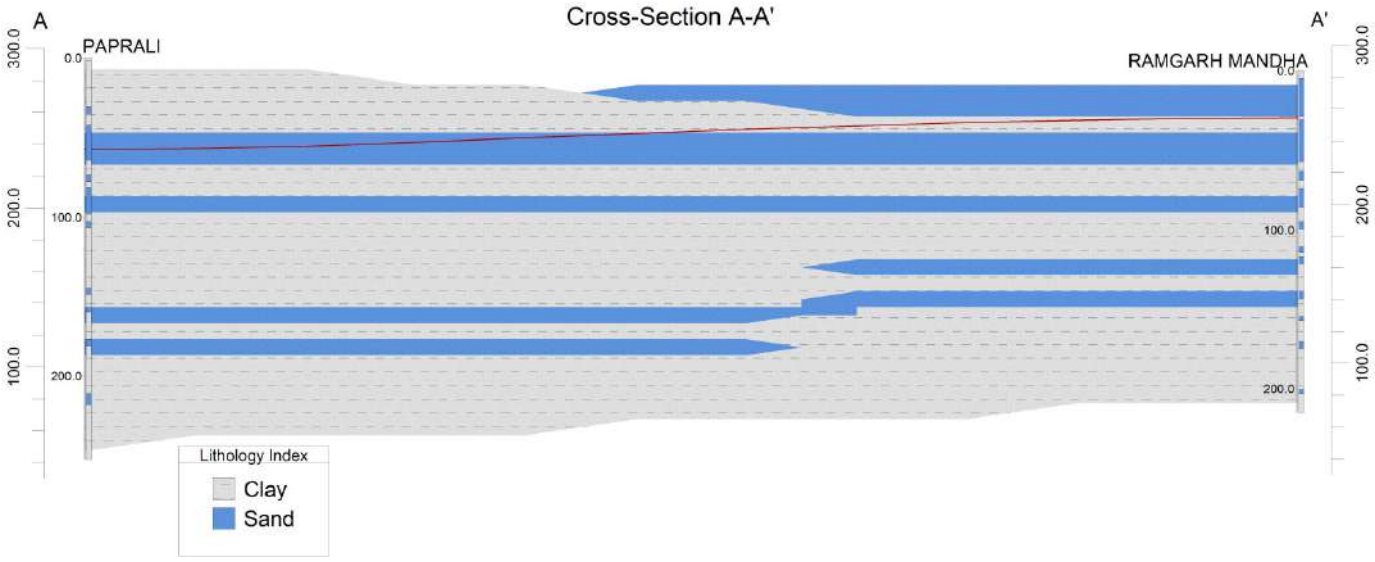
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (36-109m)	Quaternary Alluvial deposits	Unconfined	34	123-1180	0.072	$1.2*10^{-3}$ $7.75*10^{-4}$
Aquifer-II (131-200m)		Unconfined to Confined	23.55	-	NA	-
Aquifer-III (220-250m)		Unconfined to Confined	23	-	NA	-

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

The non-aquifer material comprise of clay.

3D Lithology model





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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*59.76*
	In-storage Ground Water Resources	*983.24*
	Total	1043
Ground Water Extraction (in mcm)	Irrigation	102.59
	Domestic & Industrial	2.94
Provision for domestic & Industrial requirement upto 2025 (in mcm)		3.25
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 (36m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.72 mcm volume of water

4. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 26.4mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 18 % 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 17 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

4. NURPUR BEDI BLOCK (319.80 SQ KM)

1. Salient Information

Population (2011)	Rural-105768 Urban-- Total-105768
Rainfall 2014 (Ropar District)	Average annual rainfall -776 mm
Average Annual Rainfall (Nurpur Bedi block)	828 mm
Agriculture and Irrigation	Major Crops- Rice, Wheat Other crops-Sugarcane, Potatoes, Pulses, Net Area Sown- 150.33 sq.km Total Irrigated Area- 160.88 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 Nurpur Bedi 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-~9.80-12.63 (mbgl) & Post Monsoon-~10.60-11.45 (mbgl)

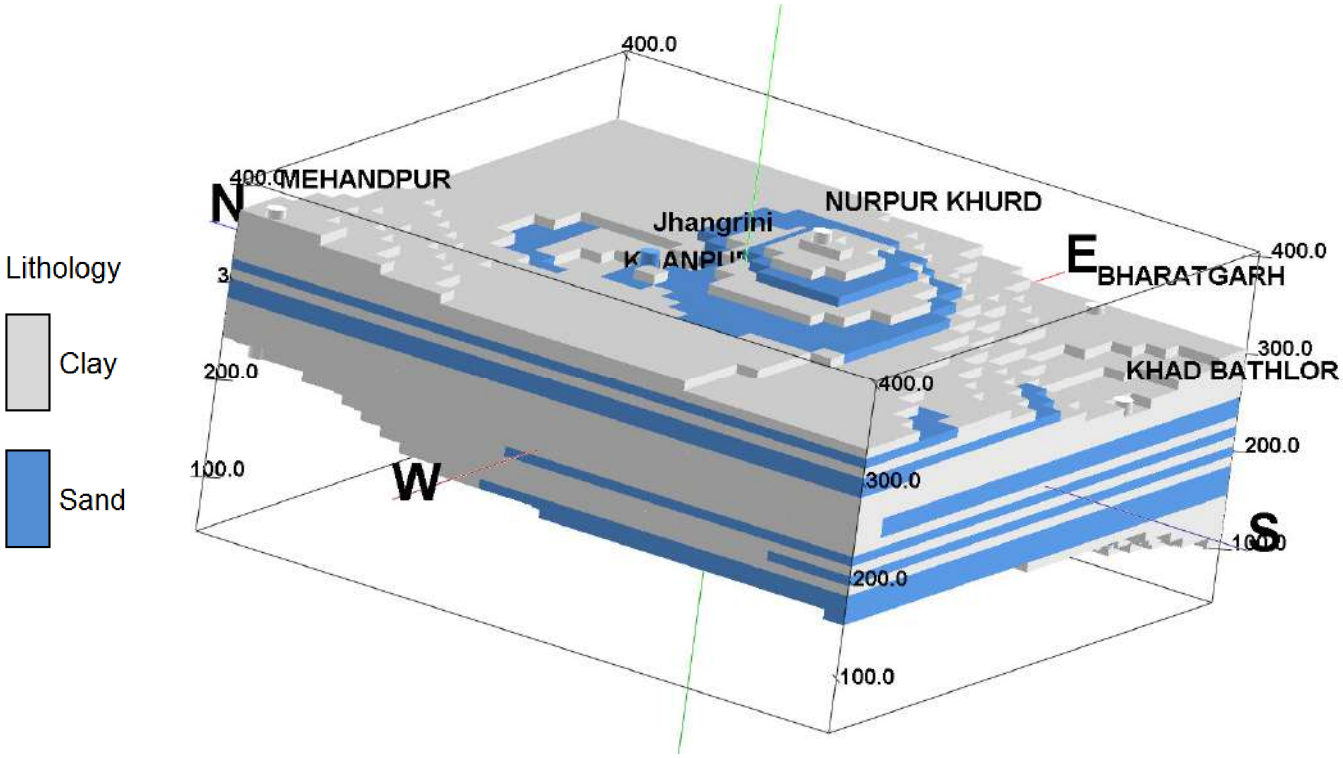
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (15-116m)	Quaternary Alluvial deposits	Unconfined	41	123-1180	0.072	$1.2*10^{-3}$ $7.75*10^{-4}$
Aquifer-II (134-193m)		Unconfined to Confined	26	-	NA	-
Aquifer-III (194-230m)		Unconfined to Confined	16	-	NA	-

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

The non-aquifer material comprise of clay.

3D Lithology model



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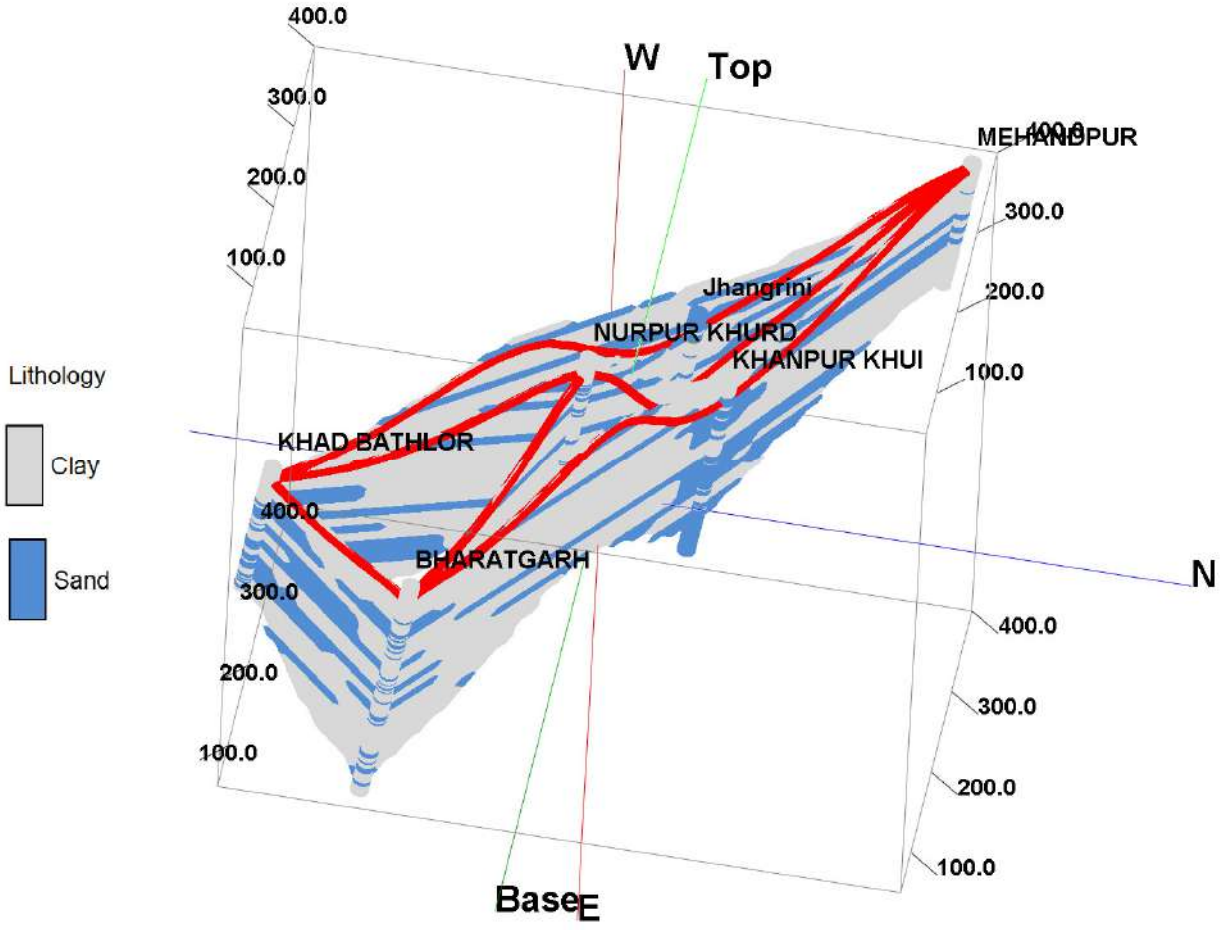

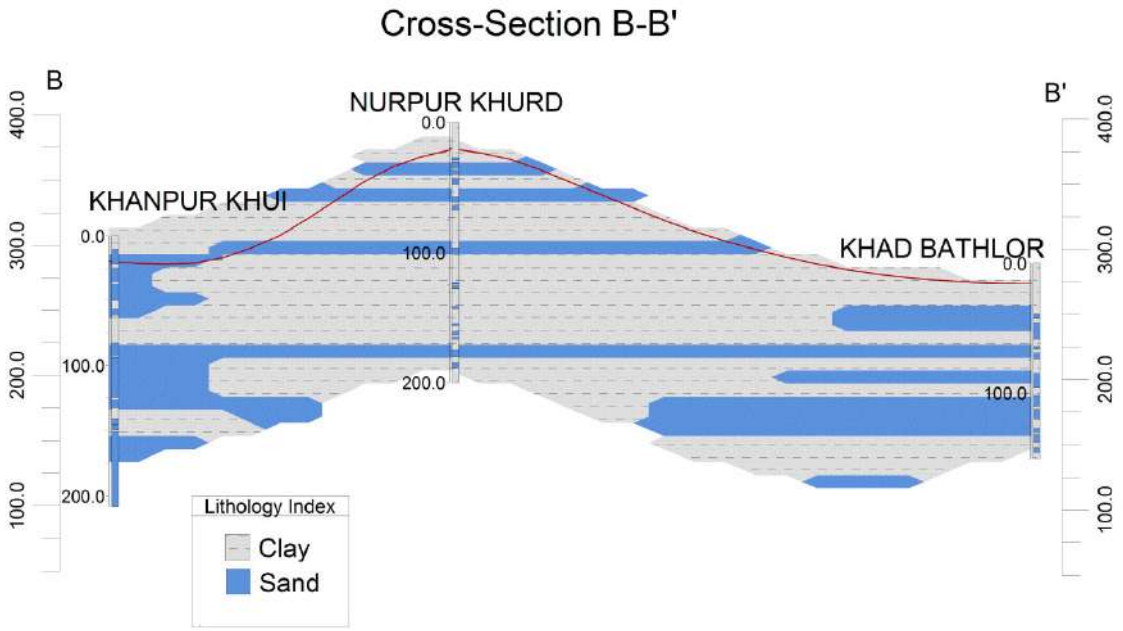
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B'
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KHANPUR KHUI
KHAD BATHLOR
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Lithology Index
Clay
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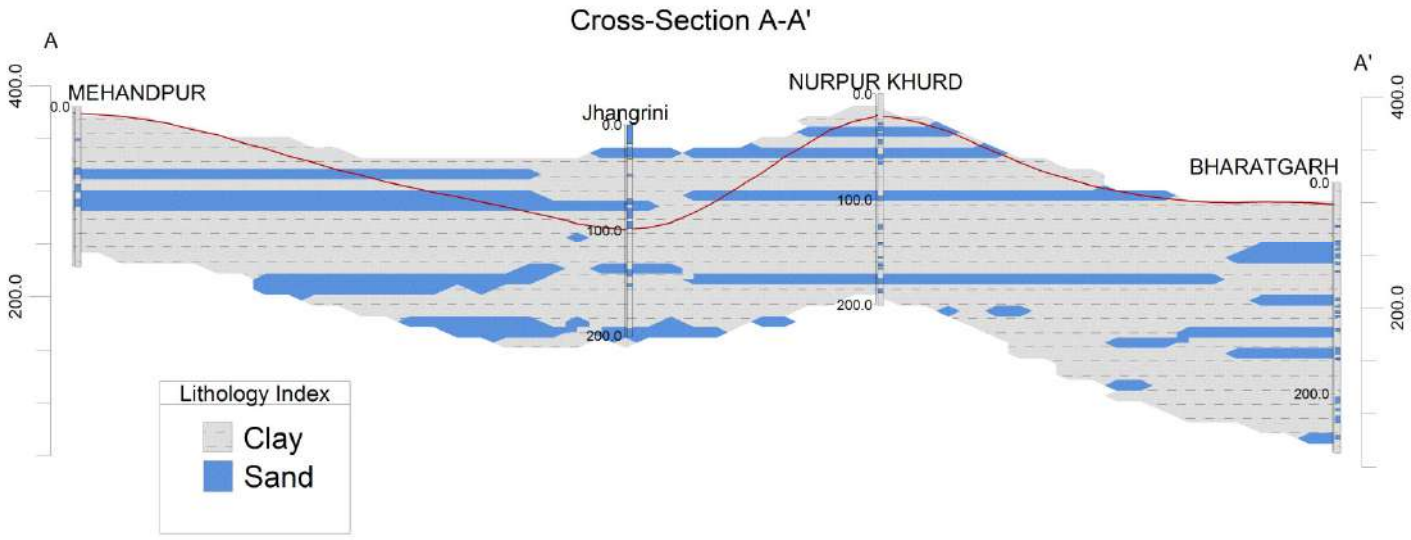
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Lithology Index
Clay
Sand

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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*47.28*
	In-storage Ground Water Resources	*1713.72*
	Total	1761
Ground Water Extraction (in mcm)	Irrigation	45.95
	Domestic & Industrial	2.25
Provision for domestic & Industrial requirement upto 2025 (in mcm)		2.73
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 4.56 mcm volume of water

4. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 12.1 mcm volume of water wastage
Change in cropping pattern	Not Required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

5. ROPAR BLOCK (418.10 SQ KM)

1. Salient Information

Population (2011)	Rural-125552 Urban-19048 Total-144600
Rainfall 2014 (Ropar District)	Average annual rainfall -776 mm
Average Annual Rainfall (Ropar block)	828mm
Agriculture and Irrigation	Major Crops- Rice, Wheat Other crops-Sugarcane, Potatoes, Pulses, Net Area Sown- 203.91 sq.km Total Irrigated Area- 205.64 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 Ropar 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 **Safe** 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-~2.84 – 5.60 (mbgl) &Post Monsoon-~2.20-5.64 (mbgl)

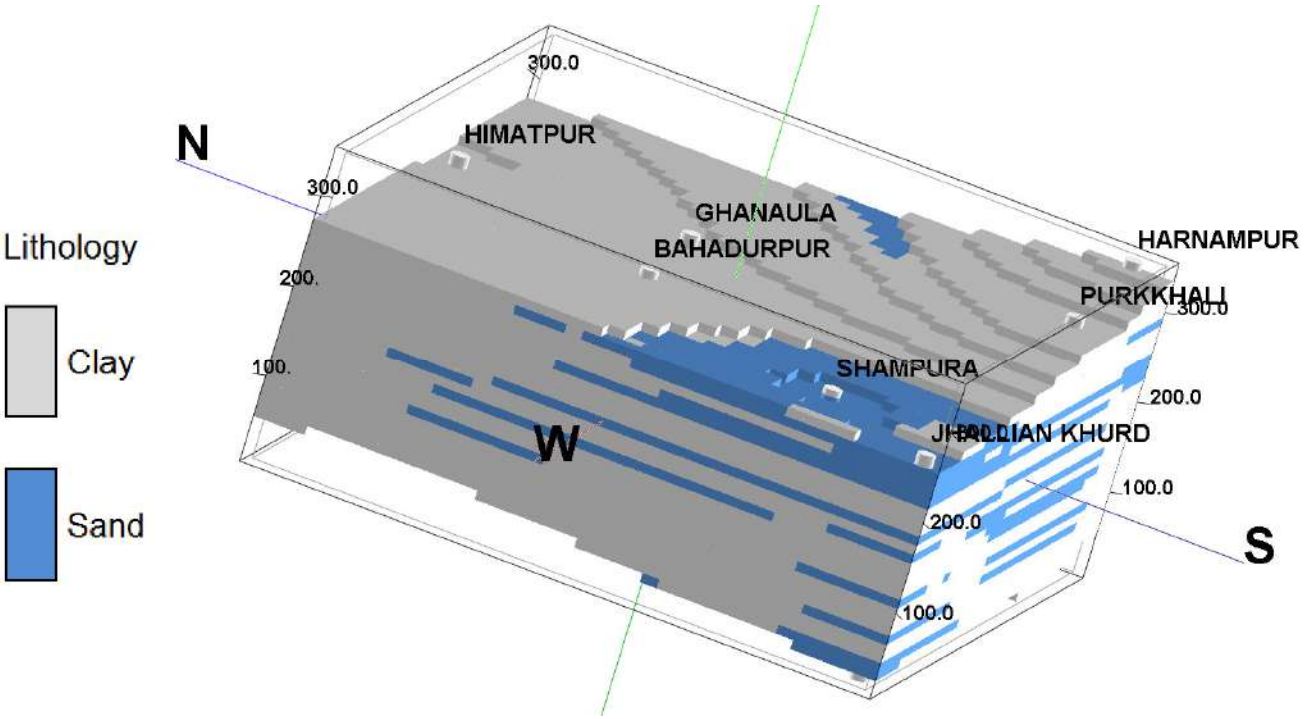
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (20-115m)	Quaternary Alluvial deposits	Unconfined	36.33	123-1180	0.072	$1.2*10^{-3}$ $7.75*10^{-4}$
Aquifer-II (146-199m)		Unconfined to Confined	18.26	-	NA	-
Aquifer-III (208-247m)		Unconfined to Confined	17.44	-	NA	-

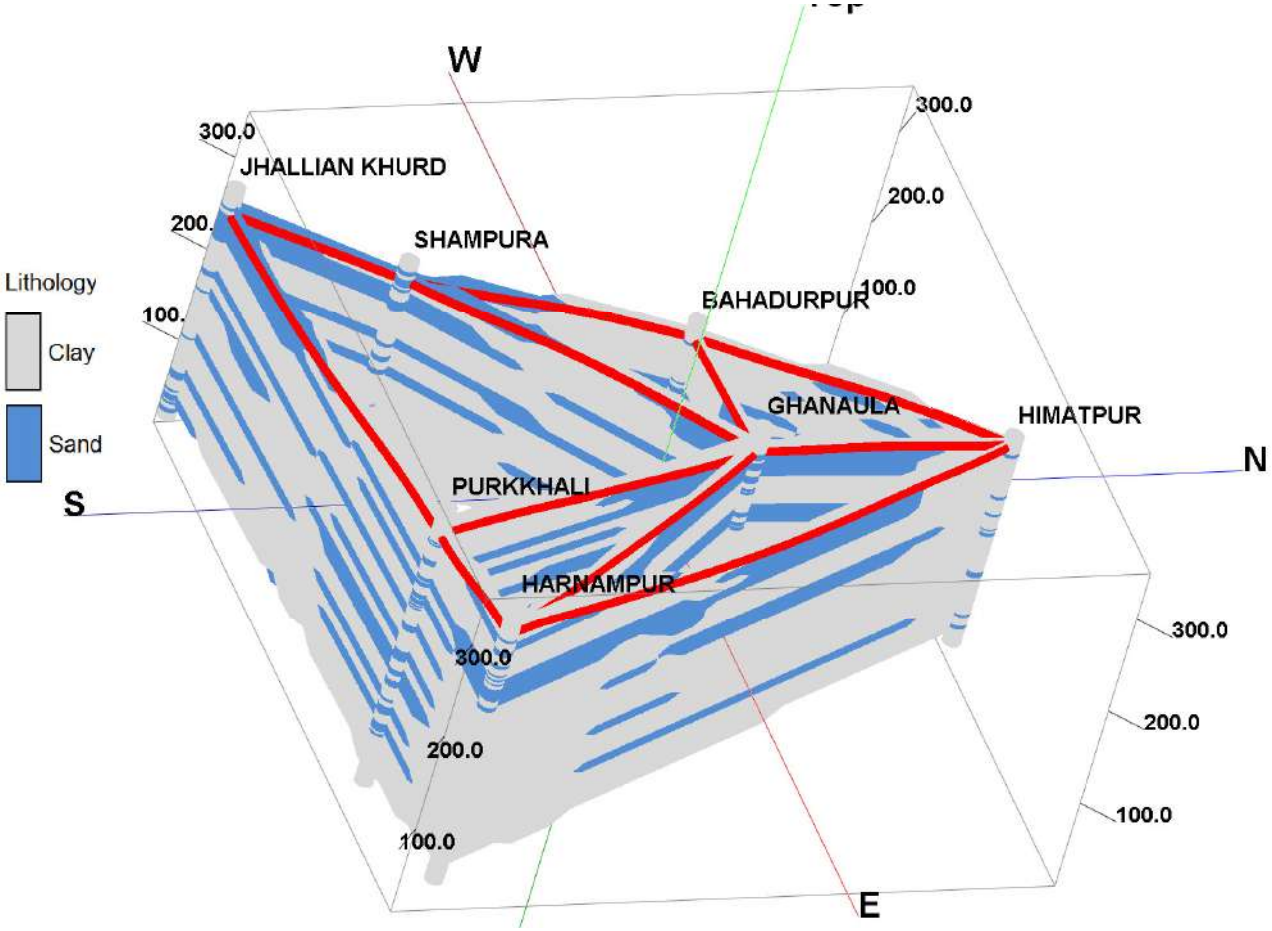
Aquifer comprises of freshwater only and the main aquifer material is sand.

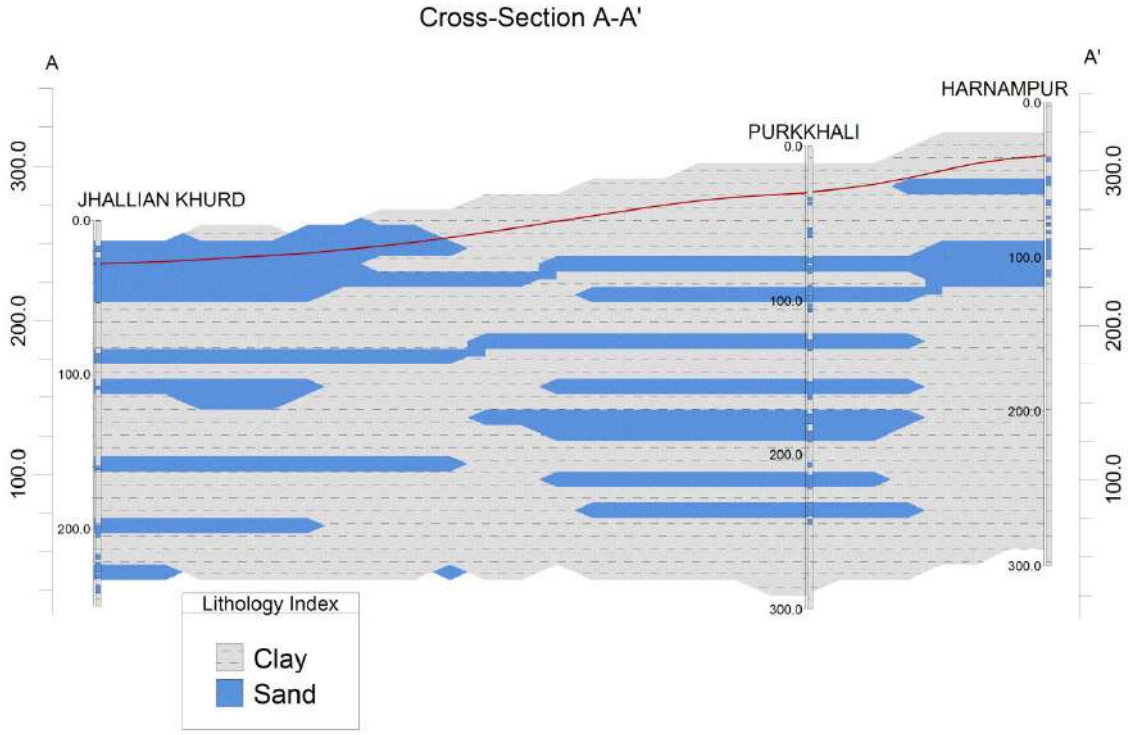
The non-aquifer material comprise of clay.

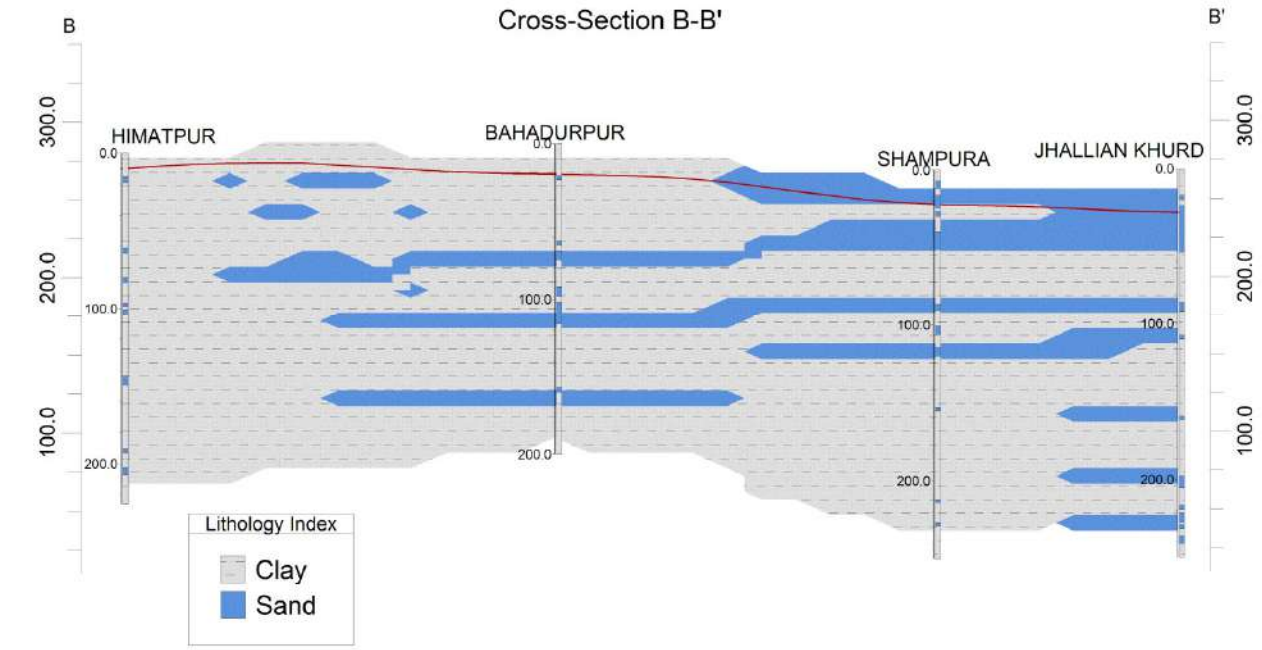
3D Lithology model

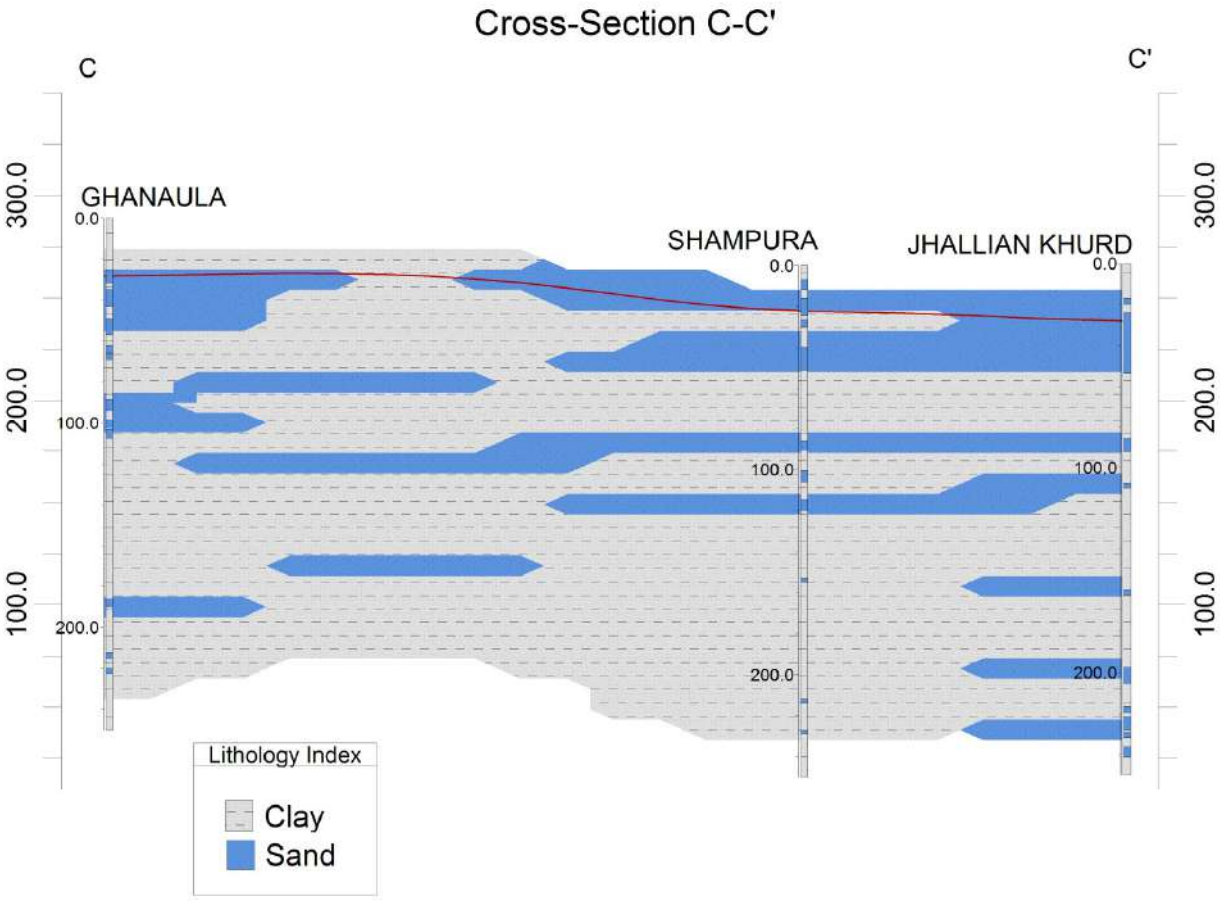


3D Stratigraphy Fence






Cross-Section B-B'
B
B'
HIMATPUR
BAHADURPUR
SHAMPURA
JHALLIAN KHURD
300.0
200.0
100.0
0.0
100.0
200.0
Lithology Index
Clay
Sand


Cross-Section C-C'
C
C'
GHANAULA
SHAMPURA
JHALLIAN KHURD
300.0
200.0
100.0
0.0
100.0
200.0
Lithology Index
Clay
Sand

Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*141.88*
	In-storage Ground Water Resources	*2168.12*
	Total	2310
Ground Water Extraction (in mcm)	Irrigation	42.60
	Domestic & Industrial	12.54
Provision for domestic & Industrial requirement upto 2025 (in mcm)		13.63
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

2. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (20m).
Other interventions proposed	Not Required

3. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 13.8 mcm volume of water wastage
Change in cropping pattern	Not Required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-