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

Muktsar District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING

&

MANAGEMENT PLAN

MUKTSAR 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 MUKTSAR DISTRICT, PUNJAB

(2656 Sq. Km UNDER NAQUIFERUIM XII PLAN)

1.0 INTRODUCTION

Muktsar district lies in the south western part of the state and lies between North Latitude 29^0 54' 20" & 30^0 40' 20"and East Longitude74^0 15' , 74^0 19' and falls in Survey of India Toposheet No. 44J & 44K and covers an geographical area of 2656km ^{2}. The district has a population of 9,02,702 as per 2011 census with the population density of 348 person per sq.km. The district falls in the Ferozpur division and is divided into three tehsil subdivision two sub tehsils and four development blocks namely Kotbhai, Lambi, Malout and Muktsar for the purpose of administrative control. The district shares its boundary with Faridkot district in north and north east, in North West and eastern side with Ferozpur district. On the east, it is bounded by Bathinda district of Punjab. On the south by Hanumangarh district of Rajasthan and Sirsa district of Haryana state.

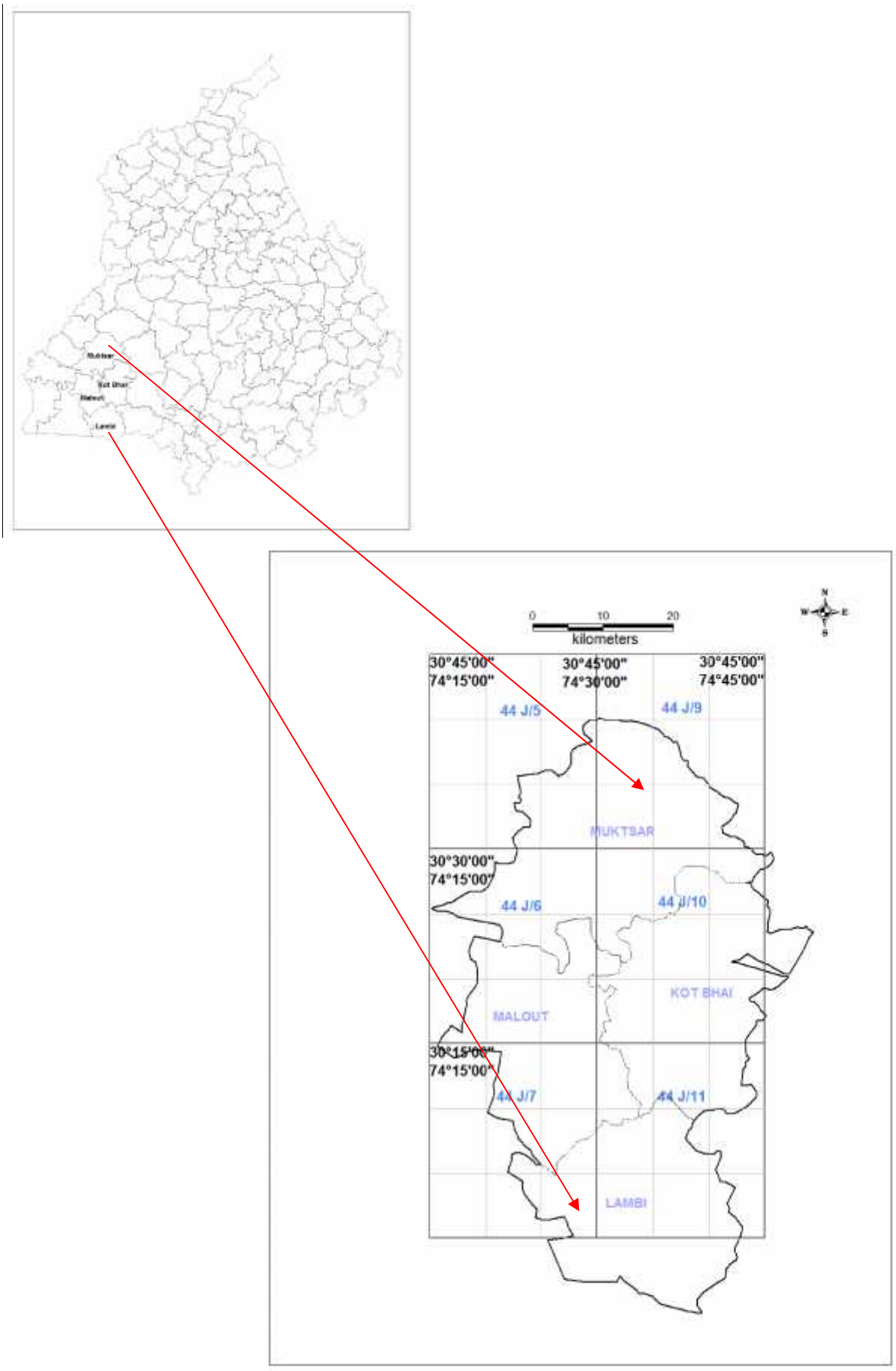
Physiographically the area has no river and is covered extensively by the canal net work of Sirhind feeder canal to meet the irrigation and drinking water needs of the people. The area is flat and plain and slopes from NE to SW. The climate of the district is dry sub humid with grass land type of vegetation. The district receives an annual rainfall of 430.7 mm in 22 rainy days .79% of the annual rainfall occurs during monsoon period and 21% occurs during non monsoon period. The district forms a part of Satluj sub basin and main Indus basin.

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

Fig 1: Base Map of Muktsar District



2. DATA COLLECTION AND GENERATION

2.1 Tube well Logs

The Litholgs of Exploratory Well/ Observation well/ Peizometer/ productive wells of CGWB, WR&ED 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 Muktsar district

MUKTSAR DISTRICT

Sl.No	Source of data	Depth Range (m)			
		< 100	**100-200**	**200-300**	**>300**
1	CGWB	2	1	1	3
2	WR&ED/WSS	22	0	0	1
3	PRIVATE	0	1	0	0
Total		**24**	**2**	**1**	**4**

2.2 Ground Water Quality

The shallow ground water of the district is alkaline in nature and is moderate to highly saline (EC 336 to 5980 us/cm). The distribution of various constituents varies greatly in the district. In some cases higher limits of certain important parameters exceed the maximum permissible limit making water unpotable.

Type of Water

Among ions, bicarbonate followed by chloride is the predominant anion dominates, whereas, among cations, sodium + potassium predominate in 50% of the samples followed by calcium+ magnesium in the remaining samples.

Suitability of Water

Domestic:

The three-fourth ground water of the district area is unsuitable for drinking as well as for domestic purposes. Only 25% of the samples have concentration of EC, Chloride , Nitrate and Fluoride within the permissible limit (BIS) for drinking water.

Irrigation :

Salinity (EC) Sodium Adsorption ration (SAR) and Residual Sodium Carbonate (RSC) are the basic parameters considered for ascertaining the irrigation suitability of ground water. It is observed that most of waters fall under classes C3S1, C3S3, C3S4, C4S1, C4S2 and C4S4.

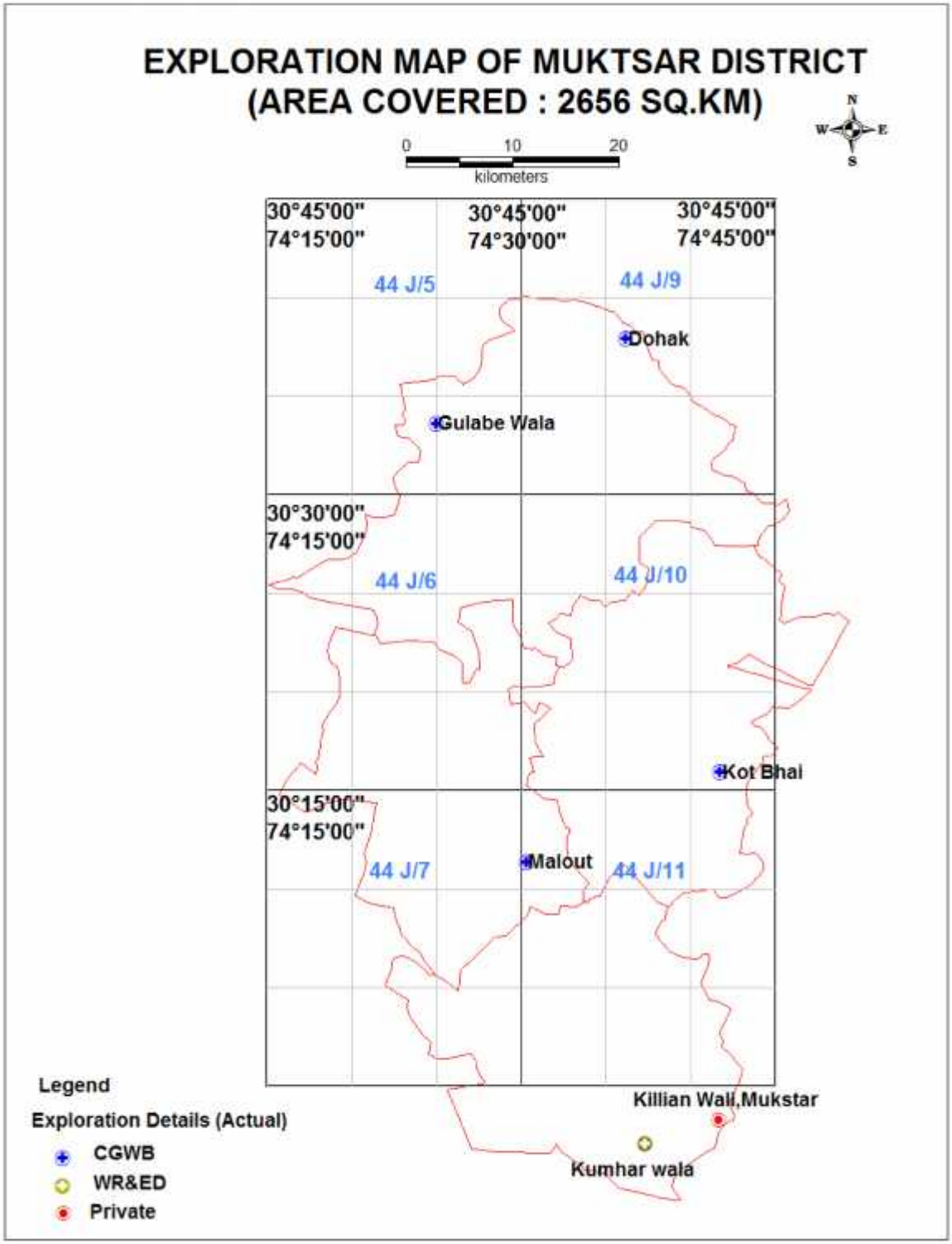
Waters falling under class under class C3S1 and C4S1 may cause salinity hazards and those falling C3S3 are likely to cause both sodium and salinity hazards. It would be better if such waters are used for irrigating salt tolerant crops along with appropriate amount of gypsum on well drained soils. Waters falling in C3S4 and C4S4 may lead to high salinity and extremely high sodic hazards and should be avoided in irrigational practices

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 II^{nd} 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.

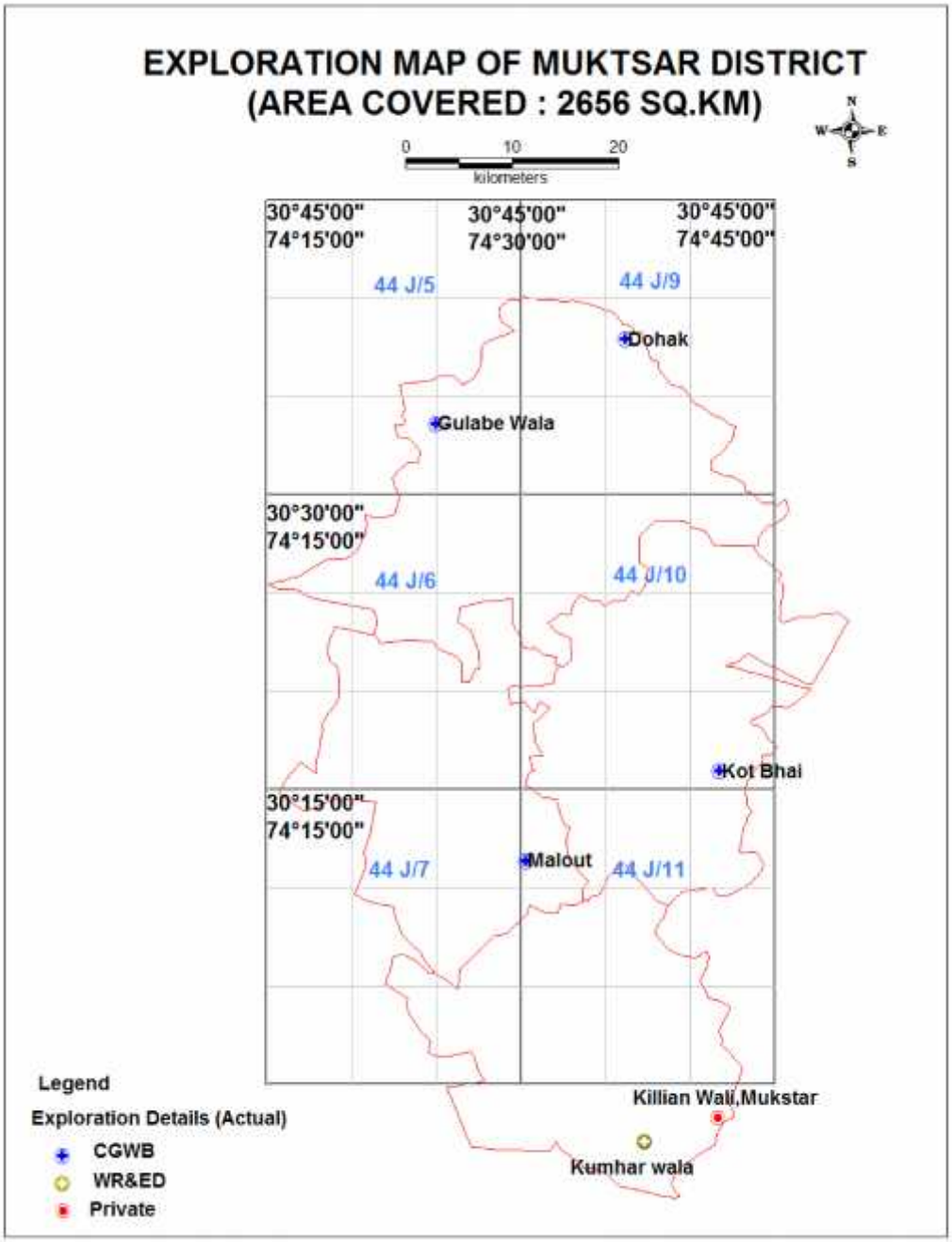
Fig-2 Location of Exploratory Bore Holes



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 Muktsar 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-Muktsar District

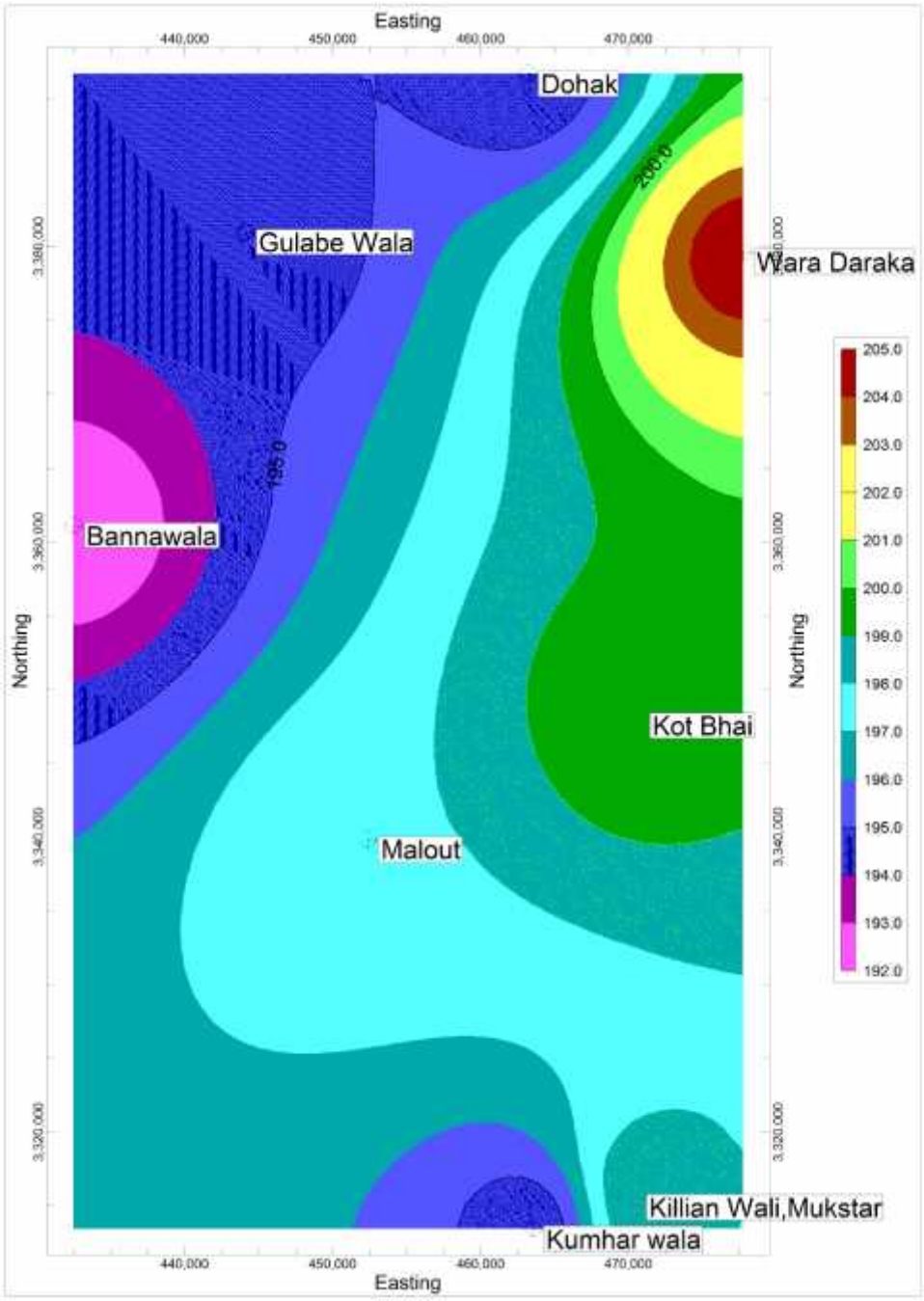


Table-3: Summery of Optimized Exploration Wells

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	Kot Bhai	44J/10	3C						300	Kot Bhai		**191**	CGWB
2	Lambi	44J/12	3A						182.92	Killian Wali,		**194**	PRIVATE
3	Malout	44J/11	1A						164.4	Malout		**199**	CGWB
4	Lambi	44J/12	1B						300	Kumhar wala		**192**	CGWB
5	Muktsar	44J/9	2B						177	Dohak		**192**	CGWB
6	Muktsar	44J/5	3B						300	Gulabe Wala		**195**	CGWB

3. HYDROGEOLOGY

3.1 PREVIOUS WORK

On the basis of two exploratory boreholes drilled by CGWB (1) Kumharwala, Lambi Block) during 1974-78 and Kotbhai Block HQ during 1999, the aquifer system belongs to huge aquifer system of Indus plains. It cannot primarily of quaternary alluvial sediments. The area has both unconfined and confined aquifer. In general unconfined condition exists only upto 30m depth. The proportion of permeable beds at deeper depth is generally low. At Kumharwala drilling down to the depth of 422m was done. At the depth of 416m Nagaur clay stone has been encountered indicating that the alluvium thickness is 416m and beyond this depth Nagaur clay stone occurs. Transmissivity $3.13X10^{-2}$ and hydraulic conductivity was computed to be 34.78m/day. At Kotbhai, drilling was done upto 331m. At both the places, well was constructed down to the depth of 54.0 and 53.0 m respectively because of poor quality beyond this depth. At Kumharwala even the EC of constructed well is 4557 which is not fit for drinking purposes.

The area is underlain by unconsolidated formation comprising sand, silt and clays etc. Extensive moderately thick unconfined to confined aquifer exists down to the drilled depth of about 30m bgl . In the district the ground water is generally saline at all levels except at local patches. There is wide lateral variation in the chemical quality depending upon the proximity of the area to the surface irrigation channels.

In whole of the district, irrigation is based on both canal and tubewell supplies. The main stress is on canal water because the whole of the district has an intense network of canal system. The two major canals Sirhind feeder and Sirhind canal are the main source of water supply which are further divided into various distributaries and minors. From the data available from Agriculture Deptt. , Punjab, about 96% of the district is being irrigated by canal water and only 4% of the area is irrigated by tube wells. Tube wells are of shallow depth ranging from 25-55 m.bgl. There are 12184 electric operated tube wells and 17136 are diesel operated tube wells in the district. From the water level monitoring data available in CGWB, only two wells are showing decline i.e. Muktsar and Bhamial . The decline at Muktsar (2002 to 2011) is 0.031 m/yr whereas at Bhaliana, decline is 0.21 m/year (2002 to 2011) which is a nominal decline in

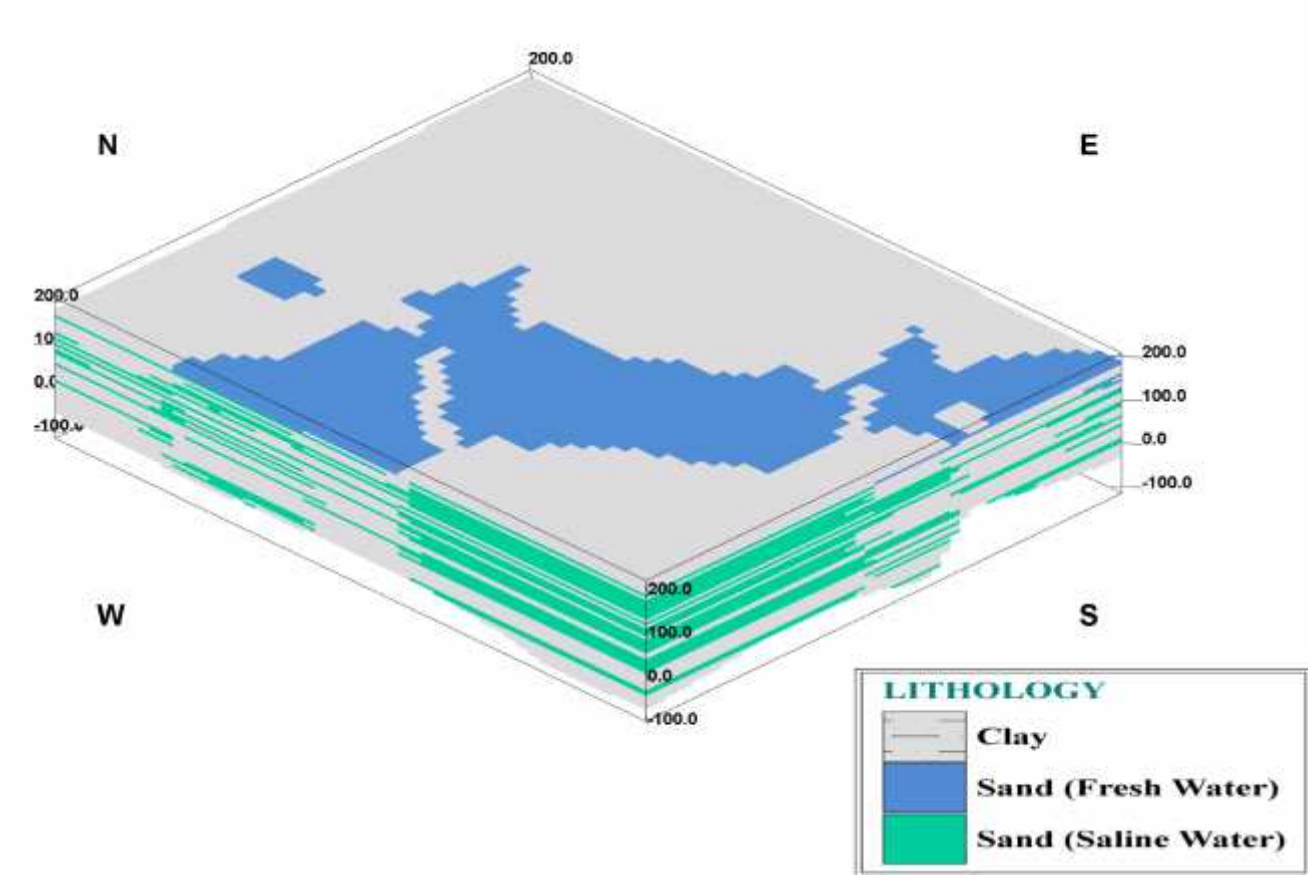
10 years (2002 to 2011) whereas all the other wells are showing rise in water levels ranging from 0.008 m/yr (Labianwali) to 0.322 m/yr (Kuthian wali).

The water level of district ranges between 2-5 m whereas only a small portion i.e. east of Kotbahai is more than 5m. Northern and western part of Muktsar block and southern and central part of Lambi block fall in less than 2m category whereas rest of district falls in 2-5m category in post monsoon 2011. Whereas based on pre monsoon water level 2011, majority of the district comes under 2-5m category except two patches near Lambi and NW of Kotbhai . All the blocks fall in the safe category ranging from 41 to 101% of development.

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 Muktsar District

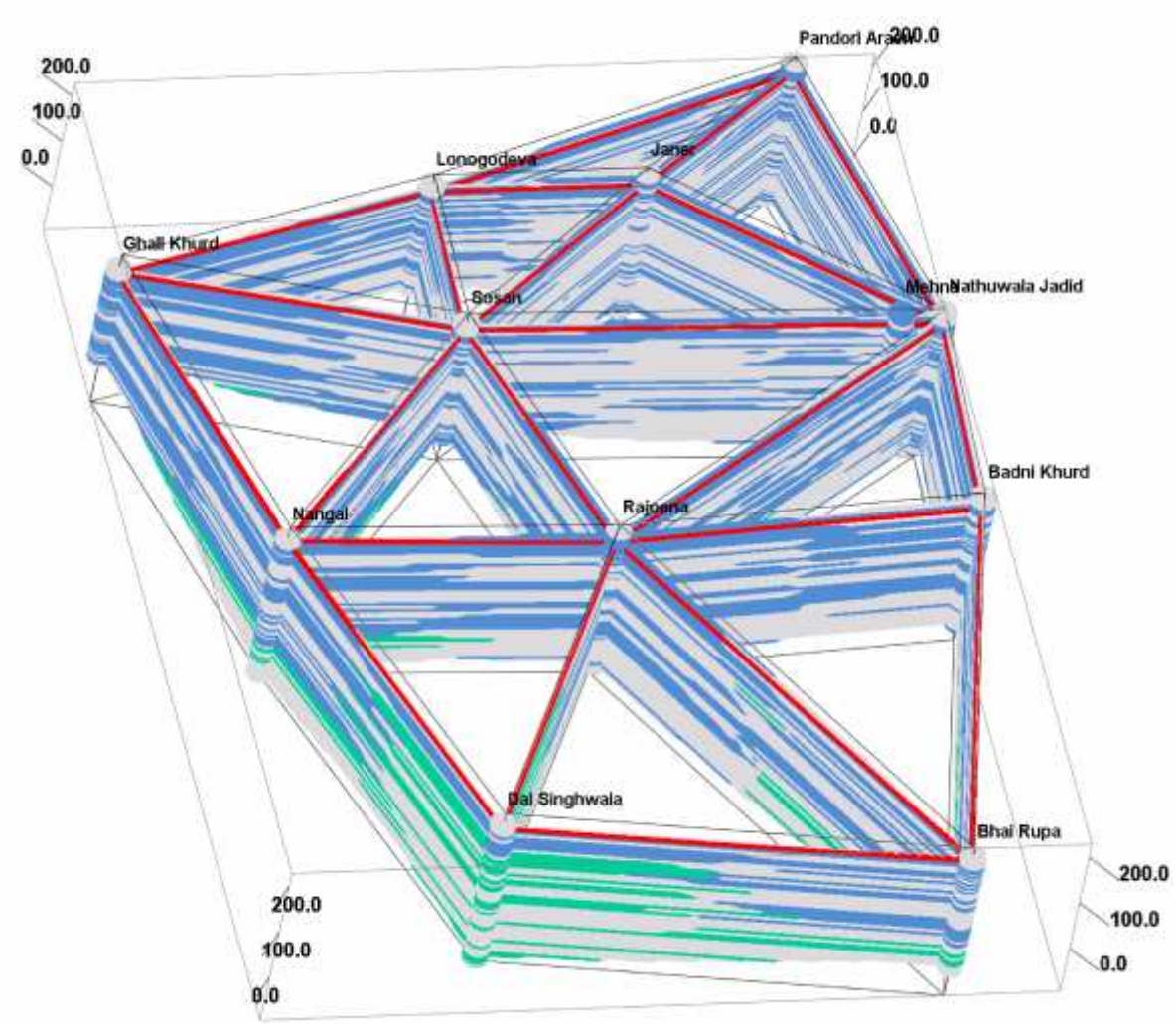


To present a three dimensional regional picture of the sub-surface conditions in the two districts a fence diagram was prepared by synthesizing the various sub-surface sections. The fence diagram thus drawn reveals broad picture of disposition, inter relationship of granular zones, nature, geometry and 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 Muktsar District

3.3 Aquifer Geometry

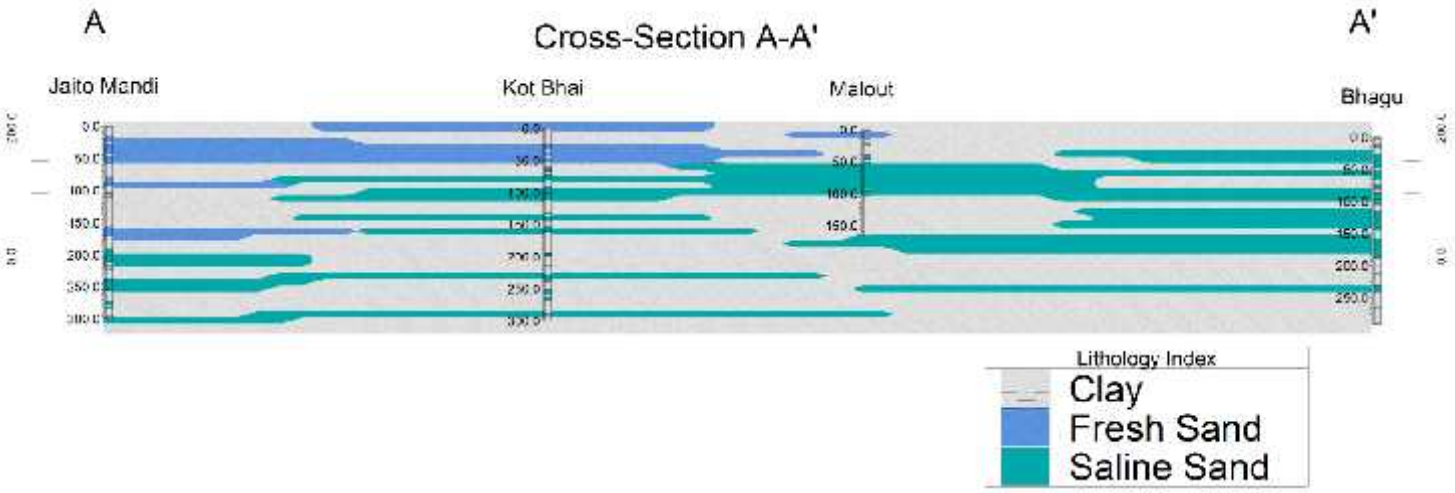
Muktsar District forms central part of sate and is underlain by formations of Quaternary age comprising of alluvium deposits belonging to vast Indus alluvial plains; therefore it belongs to a multiple aquifer system up to 300m depth with alternate bands of medium to

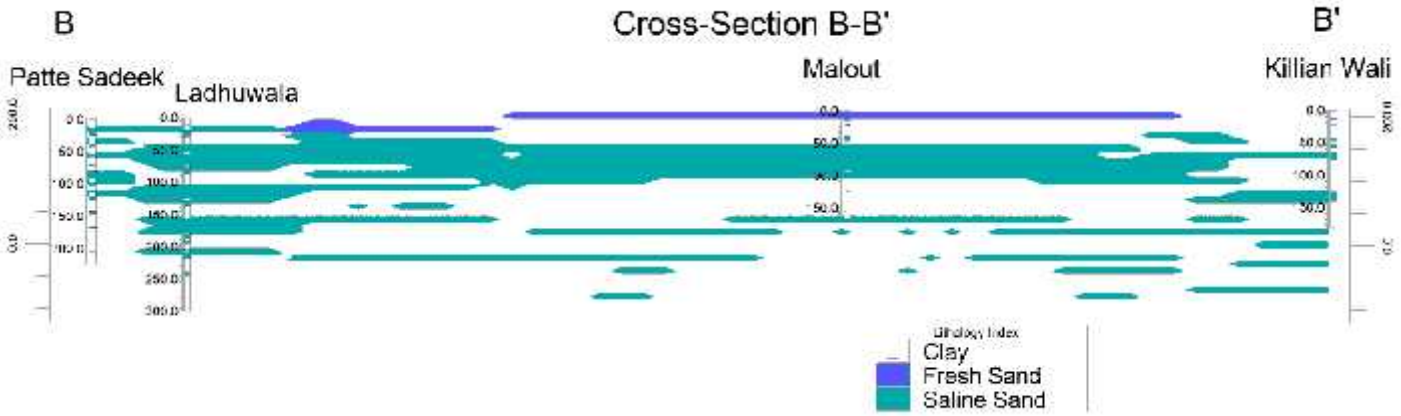


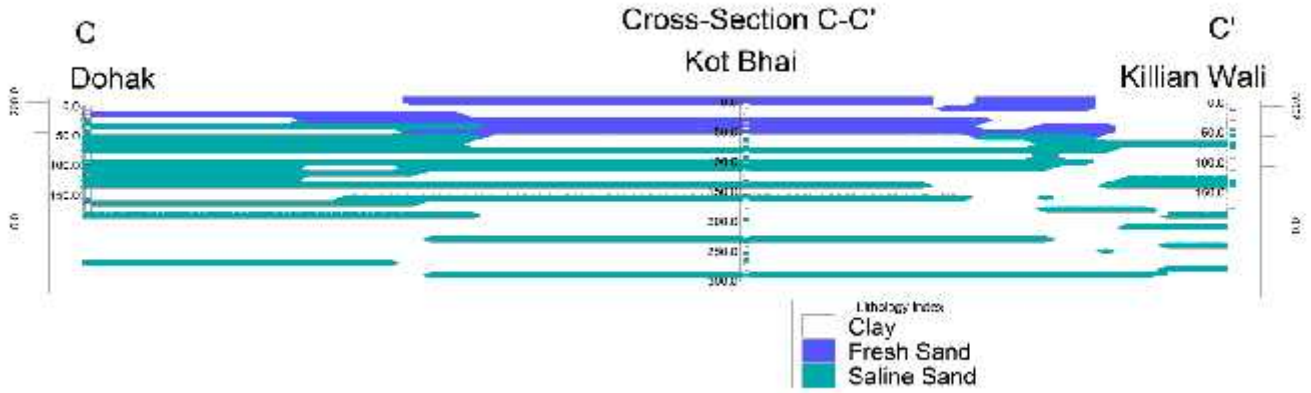
coarse sand and clay. To know the broad picture of the aquifer disposition, inter-relationship of granular zones, nature, geometry and extension of aquifers in the Muktsar district, the aquifer grouping has been done using the sub-surface lithology and a three-dimensional aquifer model has been prepared. 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 Muktsar district is given below:-

Fig 7: Cross Sections of Aquifer Map of Muktsar District







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 draft in all 4 blocks is below the ground water available due to quality problem and shallow water levels,

thus 4 blocks have been categorized as **Safe**. Stage of ground water development in the Muktsar district has been assessed to be 70%.

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 (%)
GIDDERBAHA/ (KOT BHAI)	15118	15408	464	15872	464	-754	105
LAMBI	20708	8151	213	8364	213	12343	40
MALOUT	16558	9312	578	9889	578	6669	60
MUKTSAR	23741	18190	1205	19395	1205	4345	82
Total (ham)	**76125**	**51061**	**2460**	**53521**	**2460**	**22604**	**70**

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

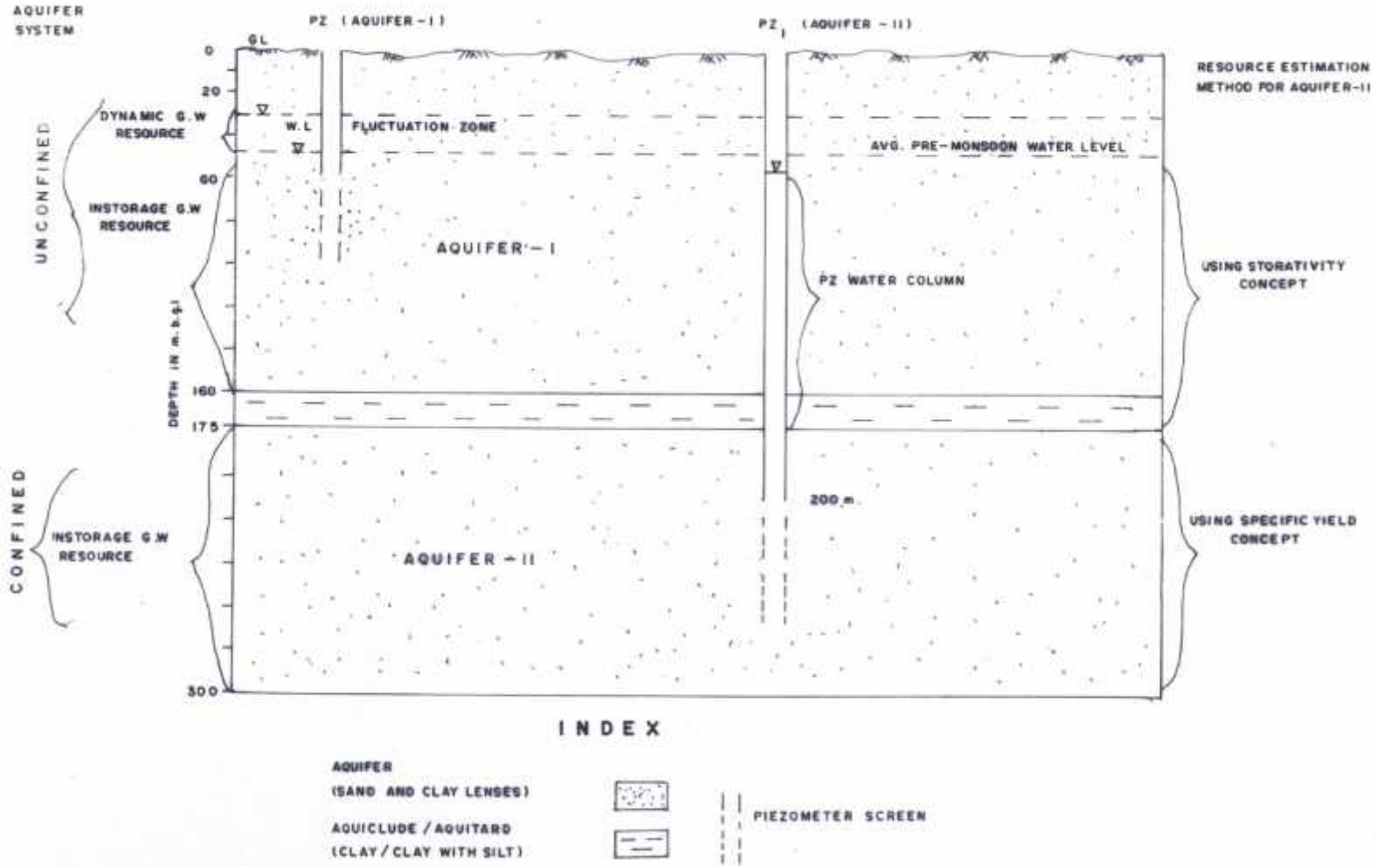


Table 5: GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT MUKTSAR, PUNJAB STATE (2013)

Type of Ground Water Assessment Unit (Block): Muktsar Blocks												
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)		Average Pre-monsoon Water Level (m bgl)	Avg Depth to bottom of Aquifer based on Geophysical Interface (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) (9-8)	Total thickness of the Granular Zones up to the depth of Fresh Water Zones (m)	Thickness of the unsaturated granular Zones up to Pre-monsoon WL (m)	Thickness of the saturated granular Zones up to the depth of Fresh water aquifer below (m)	Average Specific Yield	In-Storage Ground Water Resources up to the depth of Fresh Water Aquifer (ham) 5*13*14
			Total Geographical Area	Assessment Area Total								
1	2	3	4	5	8	9	10	11	12	13	14	15
	MUKTSAR											
1	Gidder Baha	Alluvium	58360	58360	5.1	35	29.9	13	1.5	11.5	0.072	48322
2	Lambi	Alluvium	65200	65200	4.89	25	20.11	15	1	14	0.072	65722
3	Malout	Alluvium	62770	62770	2.56	24	21.44	12	1	11	0.072	49714
4	Muktsar	Alluvium	79280	79280	2.6	32	29.4	15	1	14	0.072	79914
Dist. Total(ham)			265610	228406								243672
Dist. Total(MCM)												2437

Table 6: GENERAL DESCRIPTION OF THE SALINE GROUND WATER ASSESSMENT UNIT OF DISTRICT MUKTSAR, PUNJAB STATE (2013)

Type of Ground Water Assessment Unit (Block): Muktsar Blocks										
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)		Avg Depth to bottom of Fresh Water Aquifer based on Geophysical Interface and borehole logging (m bgl)	Avg Depth to bottom of Saline Aquifer based on Geophysical Interface and borehole logging (m bgl)	Total Thickness of formation below Fresh Water Aquifer (m) (9-8)	Total thickness of the saturated Saline Granular Zones up to the depth of 300m (m)	Average Specific Yield	In-Storage Ground Water Resources up to the depth of Saline Water Aquifer (ham) 5*13*14
			Total Geographical Area	Assessment Area Total						
1	2	3	4	5	9		10	11	14	15
	MUKTSAR									
1	Gidder Baha	Alluvium	58360	58360	35	300	265	13	0.072	54625
2	Lambi	Alluvium	65200	65200	25	300	275	15	0.072	70416
3	Malout	Alluvium	62770	62770	24	300	276	12	0.072	54233
4	Muktsar	Alluvium	79280	79280	32	300	268	15	0.072	85622
Dist. Total(ham)			265610	265610						264897
Dist. Total(MCM)										2649

Table 7: TOTAL AVAILABLE FRESH GROUNDWATER RESOURCES IN MUKTSAR DISTRICT, PUNJAB

AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN MUKTSAR DISTRICT, PUNJAB						
Sl.No	**BLOCK**	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*In-storage Groundwater Resources UPTO FRESHWATER*	**Groundwater Resources upto FRESH WATER [(3)+(4)] (HAM)**	**Total Availabilty of Fresh Groundwater Resources [(5)+(6)+(7)]**	
					ham	**mcm**
1	*2*	*3*	*4*	*5*	*8*	*9*
1	Gidder Baha	15118	48322	63440	**63440**	**634**
2	Lambi	20708	65722	86430	**86430**	**864**
3	Malout	16558	49714	66272	**66272**	**663**
4	Muktsar	23741	79914	103655	**103655**	**1037**
Dist.Total (ham)		**76125**	**243672**	**319797**	**319797**	**3198**
Dist.Total (mcm)		**761**	**2437**	**3198**		

ham : hectare metre

mcm: million cubic metre

5. GROUND WATER RELATED ISSUES

Muktsar is famous for its paddy and Wheat cultivation. The quality of ground water in the district is not potable for drinking purposes except Gidder baha block and to some extent to shallow boreholes along the canals. For irrigation purposes 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.

Almost whole of the district is facing the problem of water logging Southern and North western parts are severely affected with the water logging problem. Out of 2630km2 area of the district 2240km2 is fed by the canals and there being the quality problem the ground water exploration is low. As a result all the four blocks of the district are safe. The water logging problems is least severe in the pre monsoon period and more severe in the post monsoon period. Pre monsoon decline in last ten years is observed at only two places whereas all the other eight places (NH Stations) have shown rise in water level which has caused water logging. The breach in the canal system gives rise to recharge of the phreatic aquifer system. The quality the water is marginal to saline which can be used with proper blending with the canal water

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.

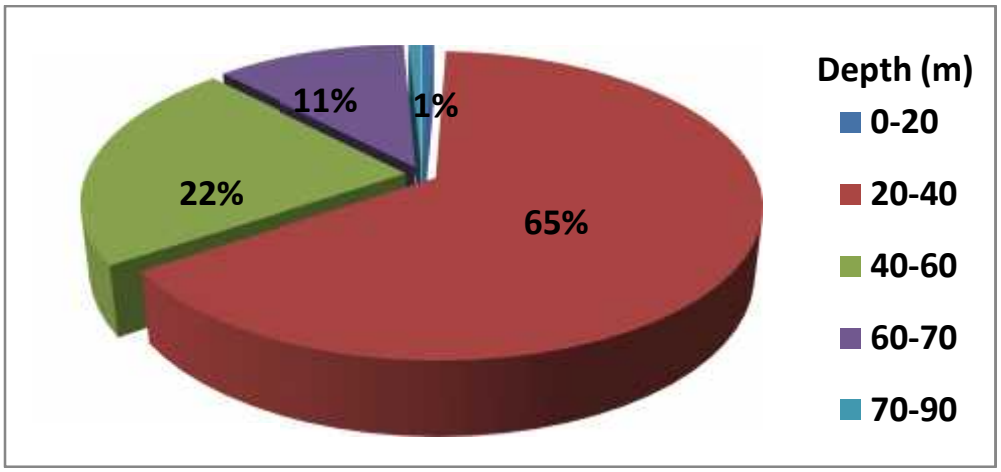


Table 7-Distribution of Tube wells According to Owner's holding Size

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	**Muktsar**	**81**	**824**	**5985**	**14055**	**7962**	**28907**

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	**Muktsar**	**209**	**18886**	**6488**	**3324**	**220**	**29127**

Table 9- Type of Ground water distribution device

Open Water Channel		
Lined/pucca	**Unlined/kutcha**	Total
22948	**6173**	**29121**

6. BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

(I) GIDDERBAHA BLOCK (583.60 SQ KM)

1. Salient Information

Population (2011)	Rural-1,72,416 Urban-0 Total-1,72,416
Rainfall 2014 (Muktsar District)	Average annual rainfall -391 mm
Average Annual Rainfall (Gidderbaha block)	382 mm
Agriculture and Irrigation	Major Crops- Rice, Wheat Net Area Sown- 523.93 sq.km Total Irrigated Area- 1026.75 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 Gidderbaha 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 shallow aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-*~2.00—10.00 (mbgl)* &Post Monsoon-*~2.00—8.00(mbgl)*

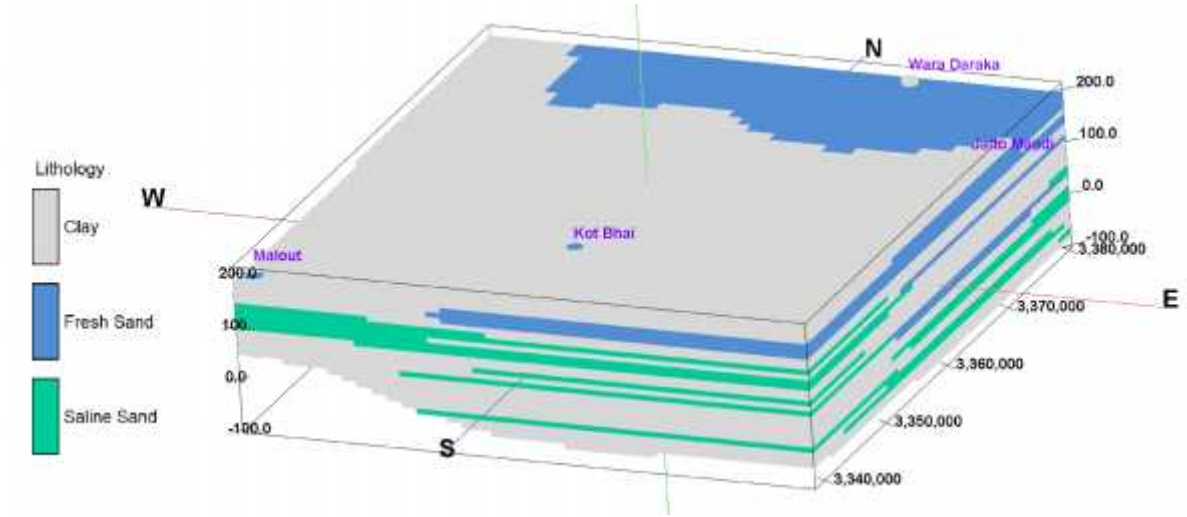
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Multiple Aquifer (5-300m)	Quaternary Alluvial deposits	Unconfined	25	*1450-7190*	0.072	$2.00*10^{-2}$

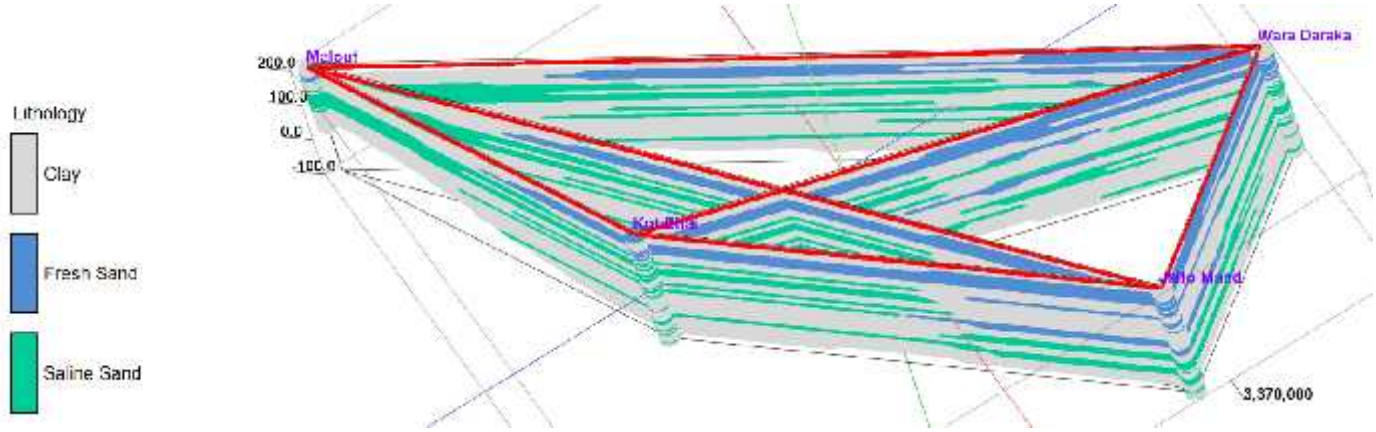
Aquifer comprises of fresh and saline water and the main aquifer material is sand.

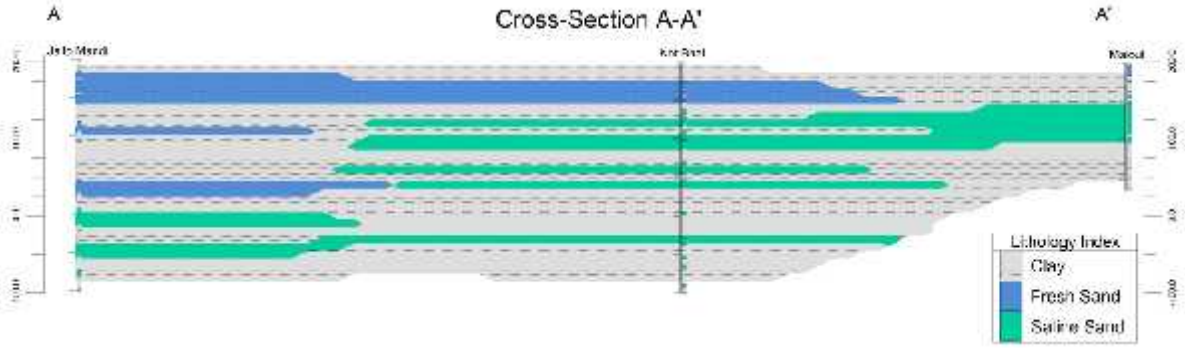
The non-aquifer material comprise of clay.

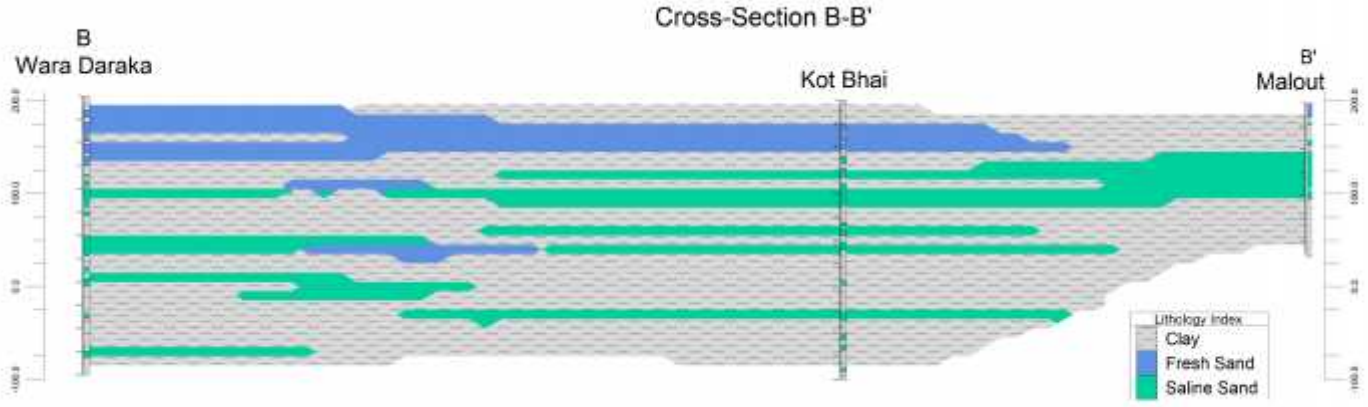
3D Lithology model



3D Lithology Fence




A
Cross-Section A-A'
A'
Malout
Lithology Index
Clay
Fresh Sand
Saline Sand


Cross-Section B-B'
B
Wara Daraka
Kot Bhai
B'
Malout
Lithology Index
Clay
Fresh Sand
Saline Sand

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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*151.18*
	In-storage Ground Water Resources	*483.22*
	Total	634.40
Ground Water Extraction (in mcm)	Irrigation	154.08
	Domestic & Industrial	4.64
Provision for domestic & Industrial requirement upto 2025 (in mcm)		4.64
Chemical Quality of ground water & contamination		Suitable for drinking and irrigation purposes at shallow depth
Other issues		rising 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 (5.10m).
Other interventions proposed	-

4. Demand Side Interventions

Advanced Irrigation Practices	Conjunctive use of canal water and ground water for irrigation
Change in cropping pattern	No changes in cropping pattern is required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

(II) LAMBI BLOCK (652 SQ KM)

1. Salient Information

Population (2011) Rural-1, 49,572
Urban-
Total-1, 49,572

Rainfall 2014 (Muktsar District) Average annual rainfall -391 mm

Average Annual Rainfall (Lambi block) 382 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Net Area Sown- 495 sq.km
Total Irrigated Area-962 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 Lambi block.

Ground Water Resource Availability: Ground Water Resources available in the multiple 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.

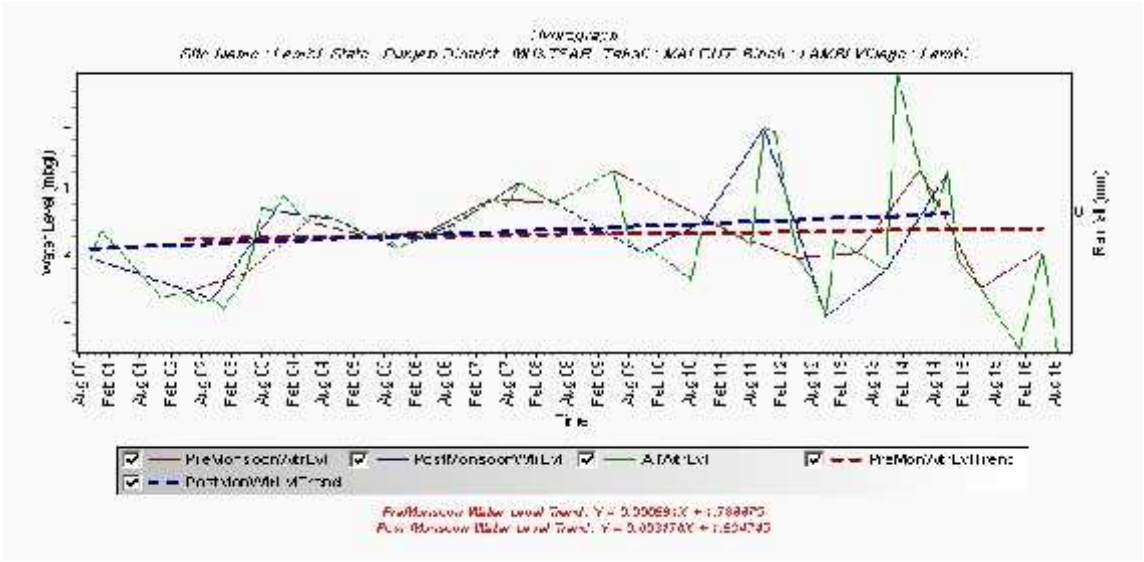
Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewells tapping combined aquifer at shallow depth and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~2.00 – 6.50 (mbgl)

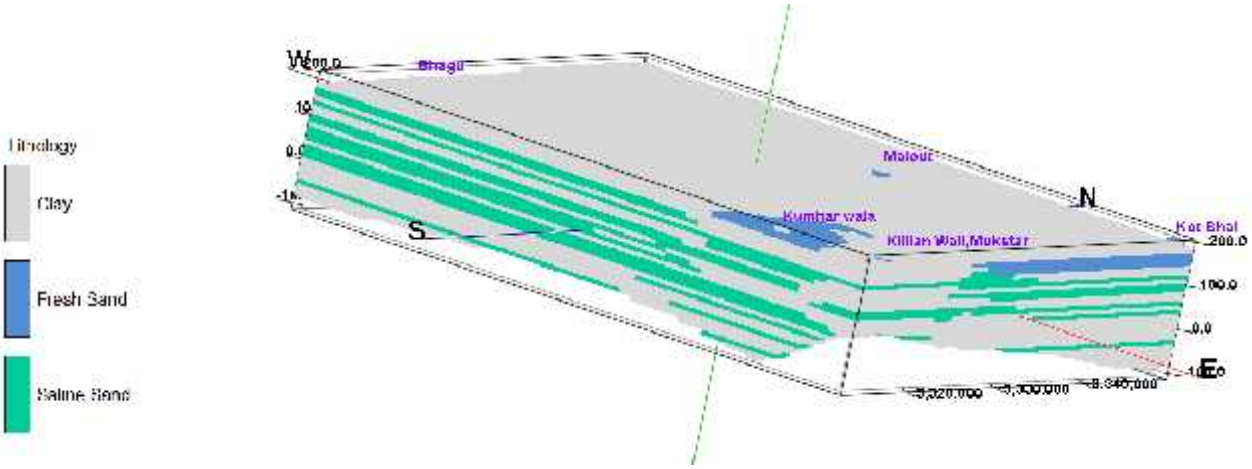
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
multiple Aquifer (4.5-300m)	Quaternary Alluvial deposits	Unconfined	29	313	0.072	$1.67*10^{-2}$

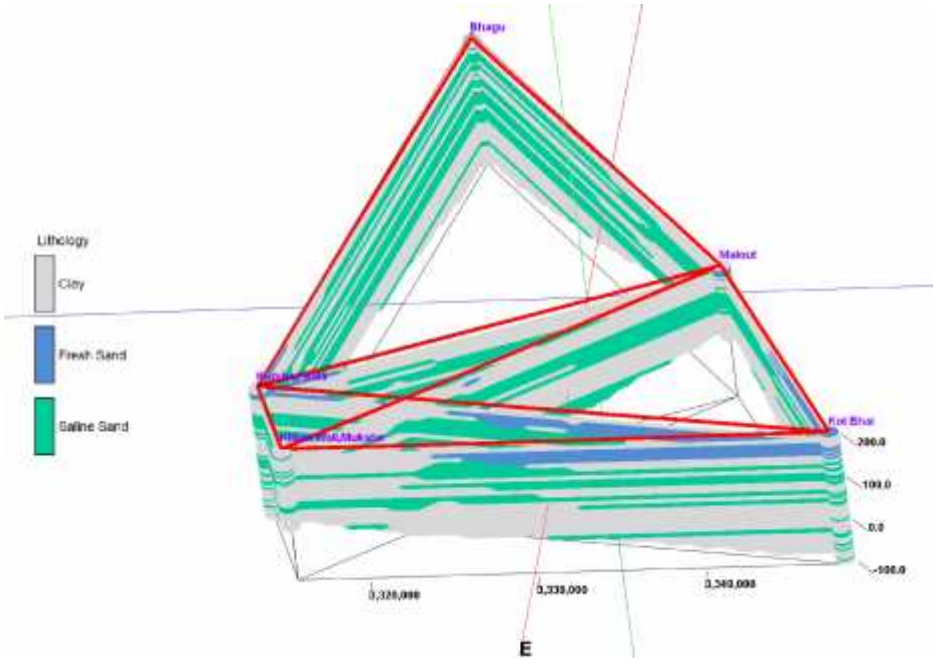
Aquifer comprises of fresh and saline water and the main aquifer material is sand.
The non-aquifer material comprise of clay.

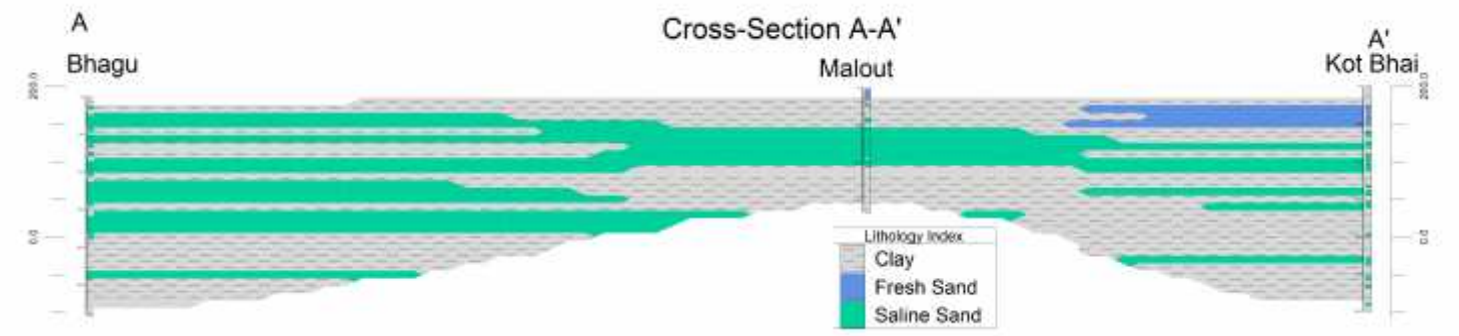


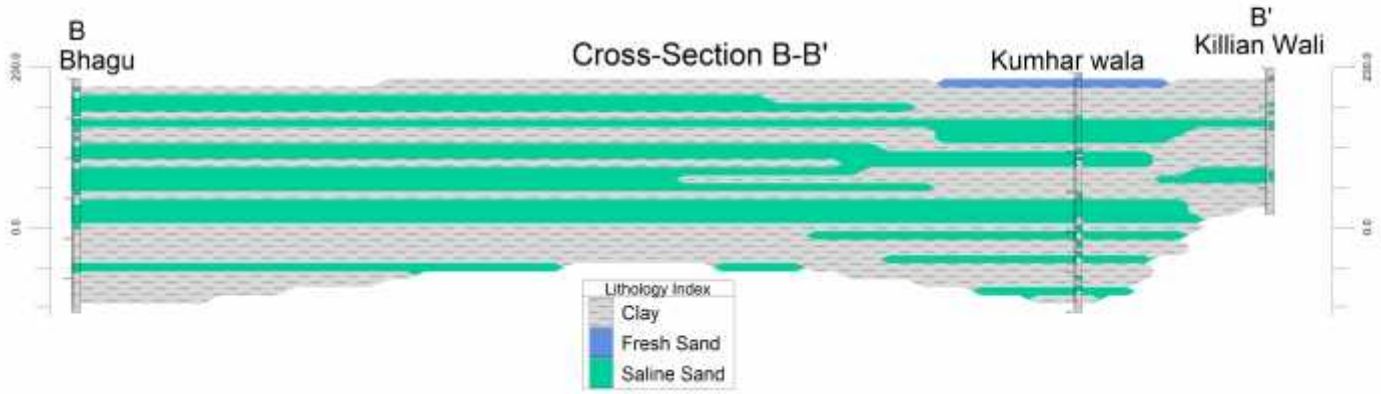
3D Lithology model



3 D Lithology Fence




A
Bhagu
Cross-Section A-A'
Malout
A'
Kot Bhai
Lithology Index
Clay
Fresh Sand
Saline Sand


B
Bhagu
Cross-Section B-B'
Kumhar wala
B'
Killian Wali
Lithology Index
Clay
Fresh Sand
Saline Sand

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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*207.08*
	In-storage Ground Water Resources	*657.22*
	Total	864.30
Ground Water Extraction (in mcm)	Irrigation	81.51
	Domestic & Industrial	2.13
Provision for domestic & Industrial requirement upto 2025 (in mcm)		2.13
Chemical Quality of ground water & contamination		Not potable for drinking purposes. Suitable for irrigation purposes only
Other issues		rising water level trend

6. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level (4.89m).
Other interventions proposed	-

7. Demand Side Interventions

Advanced Irrigation Practices	Conjunctive use of canal water and ground water for irrigation
Change in cropping pattern	No changes in cropping pattern is required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

(III) MALOUT BLOCK (627.70 SQ KM)

1. Salient Information

Population (2011)	Rural-1,38,985 Urban- Total-1,38,985
Rainfall 2014 (Muktsar District)	Average annual rainfall -391 mm
Average Annual Rainfall (Malout block)	363 mm
Agriculture and Irrigation	Major Crops- Rice, Wheat Net Area Sown- 494.21 sq.km Total Irrigated Area-962.29 sq.km

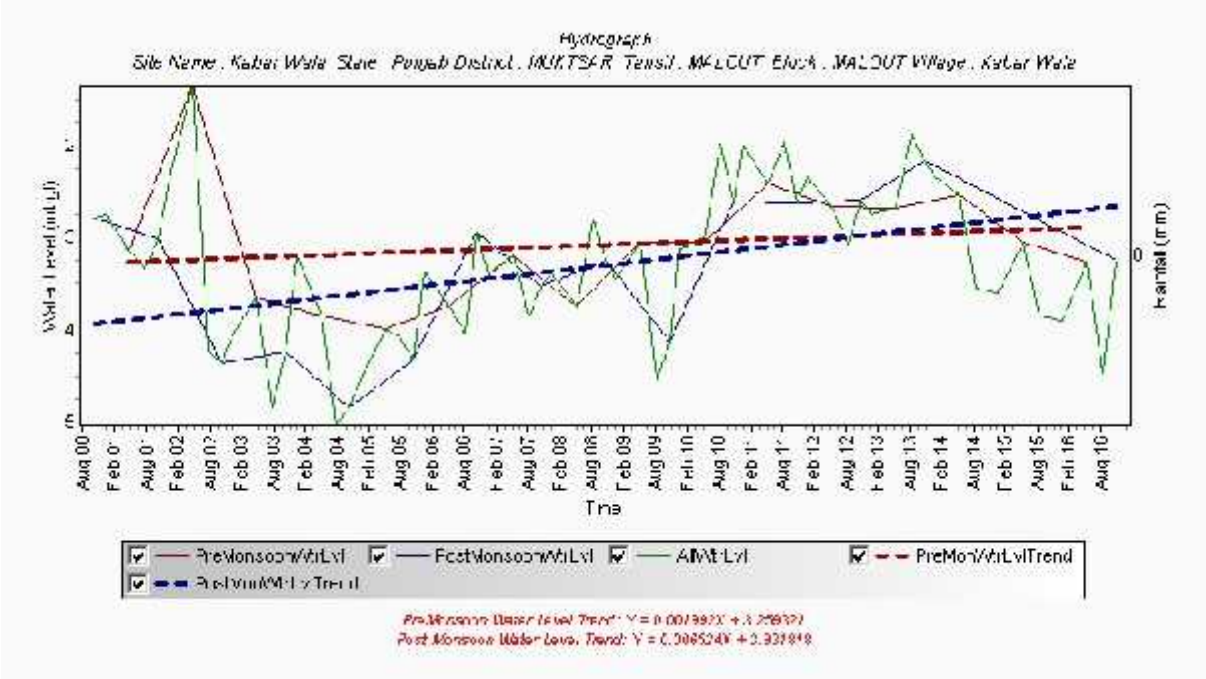
Water Bodies & Canal Irrigation

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 Malout 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 at shallow levels in some places and for irrigation purposes. Separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~1.20 -2.80 (mbgl) & Post Monsoon-~1.10 – 2.50(mbgl)



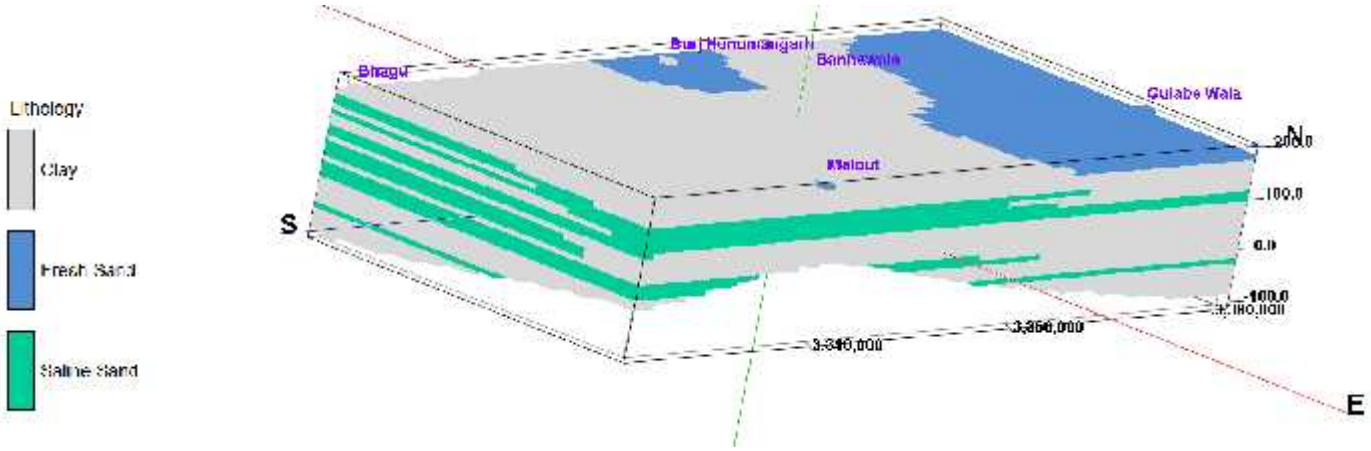
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Combined Aquifer (2.50-300m)	Quaternary Alluvial deposits	Unconfined	23	*313*	0.072	$1.67*10^{-2}$

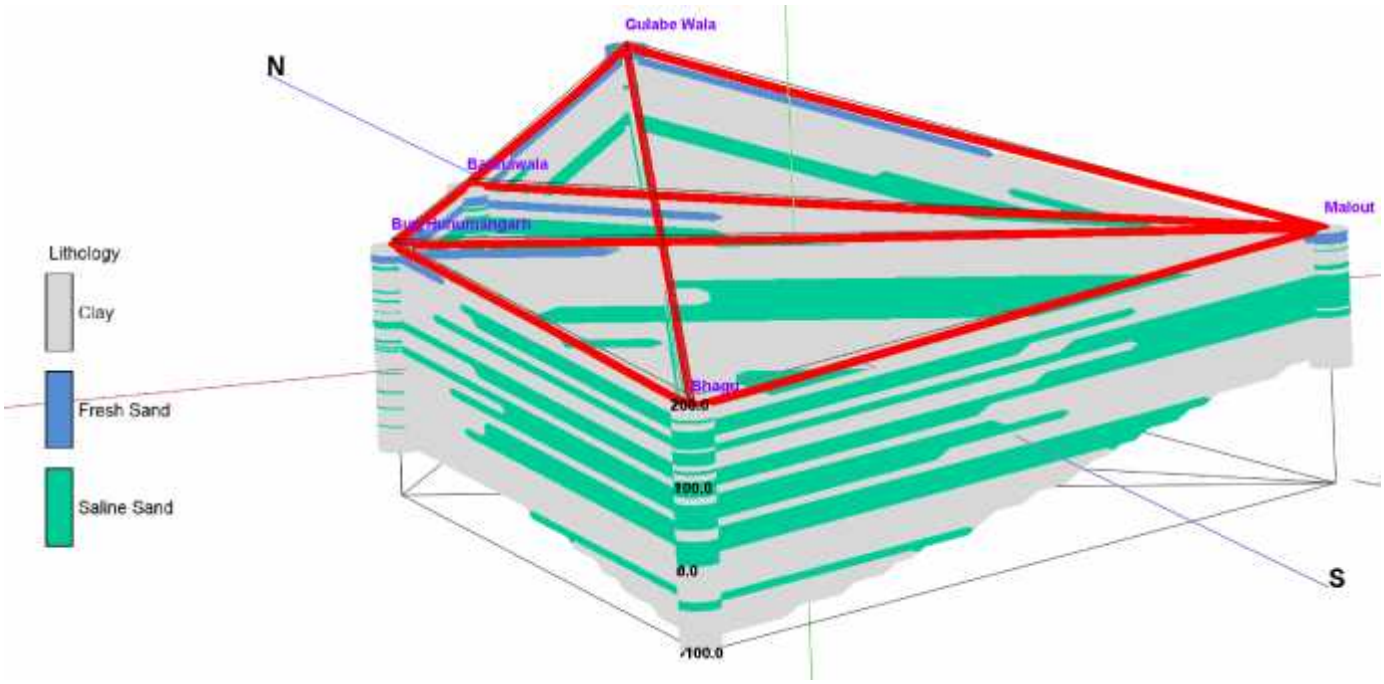
Aquifer comprises of Saline water only and fresh water in shallow depth in some pockets. The main aquifer material is sand.

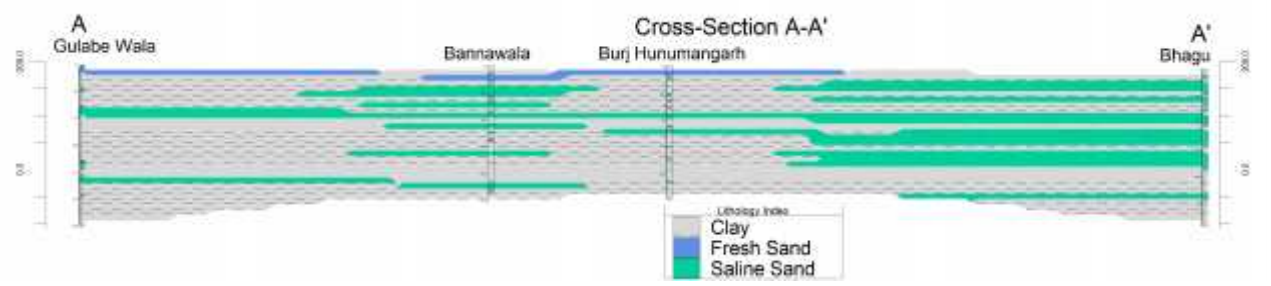
The non-aquifer material comprise of clay.

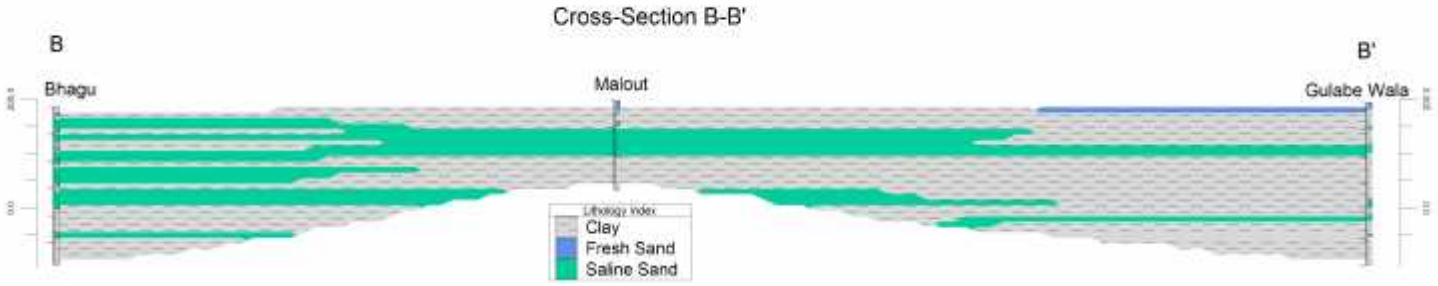
3D Lithology model



3D Lithology Fence




Cross-Section A-A'
A
Gulabe Wala
Bannawala
Burj Hunumangarh
A'
Bhagu
Lithology Index
Clay
Fresh Sand
Saline Sand


Cross-Section B-B'
B
Bhagu
Malout
B'
Gulabe Wala
Lithology Index
Clay
Fresh Sand
Saline Sand

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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*165.58*
	In-storage Ground Water Resources	*497.14*
	Total	662.72
Ground Water Extraction (in mcm)	Irrigation	93.12
	Domestic & Industrial	5.78
Provision for domestic & Industrial requirement upto 2025 (in mcm)		5.78
Chemical Quality of ground water & contamination		Not potable for drinking purposes. Suitable for irrigation purposes only
Other issues		Rising water level trend

3. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level (2.56m).
Other interventions proposed	-

4. Demand Side Interventions

Advanced Irrigation Practices	Conjunctive use of canal water and ground water for irrigation
Change in cropping pattern	No changes in cropping pattern is required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

(IV) MUKTSAR BLOCK (792.80 SQ KM)

1. Salient Information

Population (2011) Rural-1,88,732
Urban-
Total-1,88,732

Rainfall 2014 (Muktsar District) Average annual rainfall -391 mm

Average Annual Rainfall (Muktsar –II block) 377 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Net Area Sown- 731 sq.km
Total Irrigated Area- 1239.60 sq.km

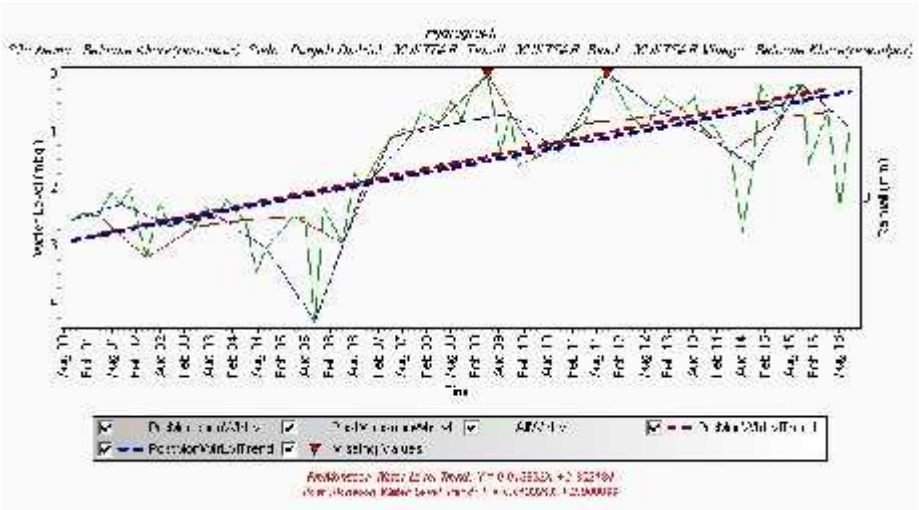
Water Bodies & Canal Irrigation

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 Muktsar 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-~0.77 – 2.55(mbgl) & Post Monsoon-~1.10-2.70(mbgl)



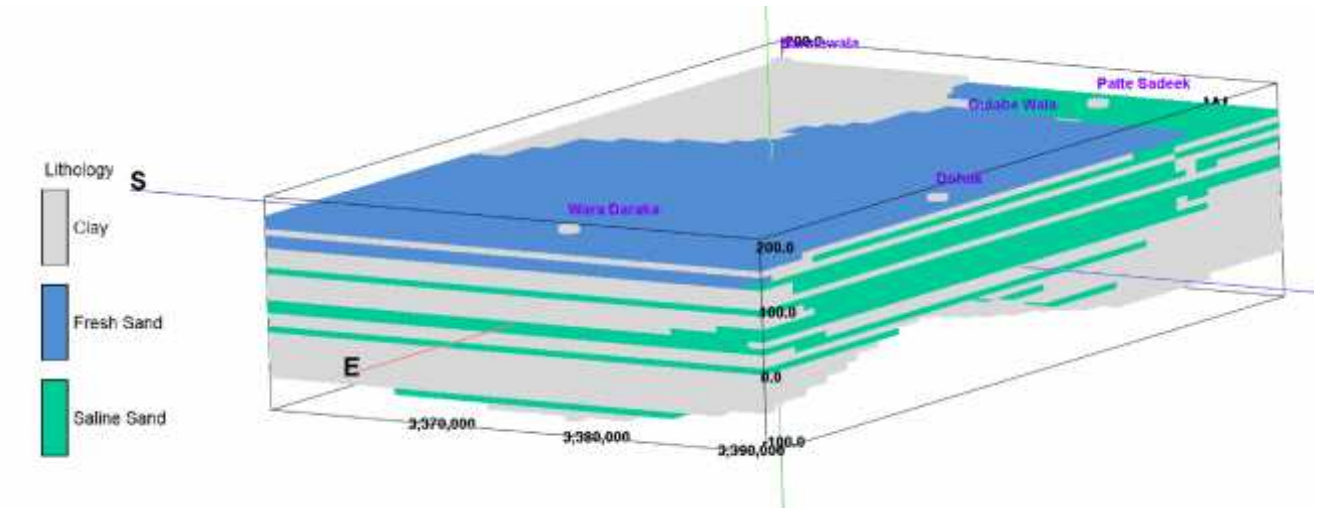
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Combined Aquifer (2.60-300m)	Quaternary Alluvial deposits	Unconfined	29	*313*	0.072	$1.67*10^{-2}$

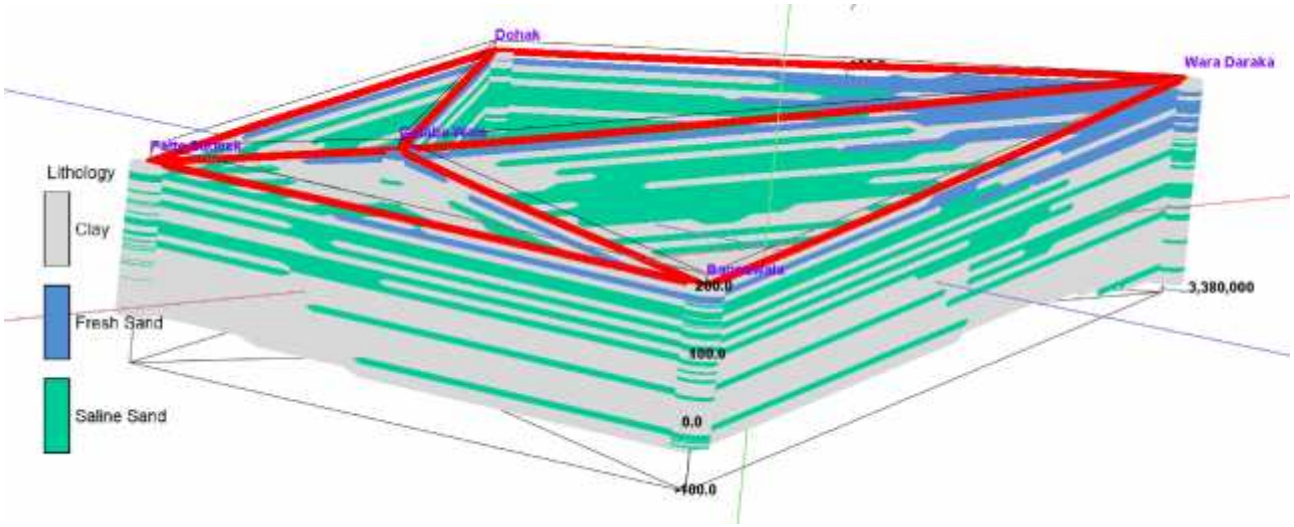
Aquifer comprises of Saline water only and fresh water in shallow depth in some pockets. The main aquifer material is sand.

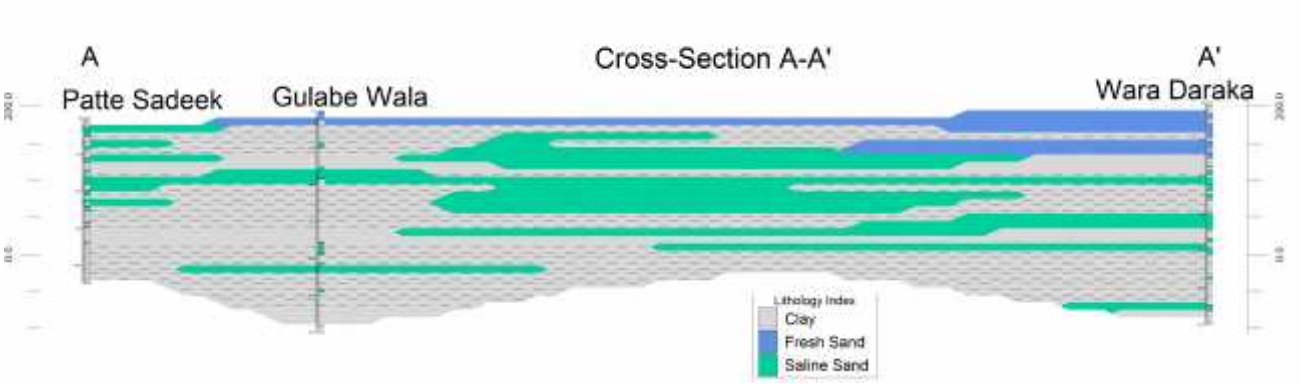
The non-aquifer material comprise of clay.

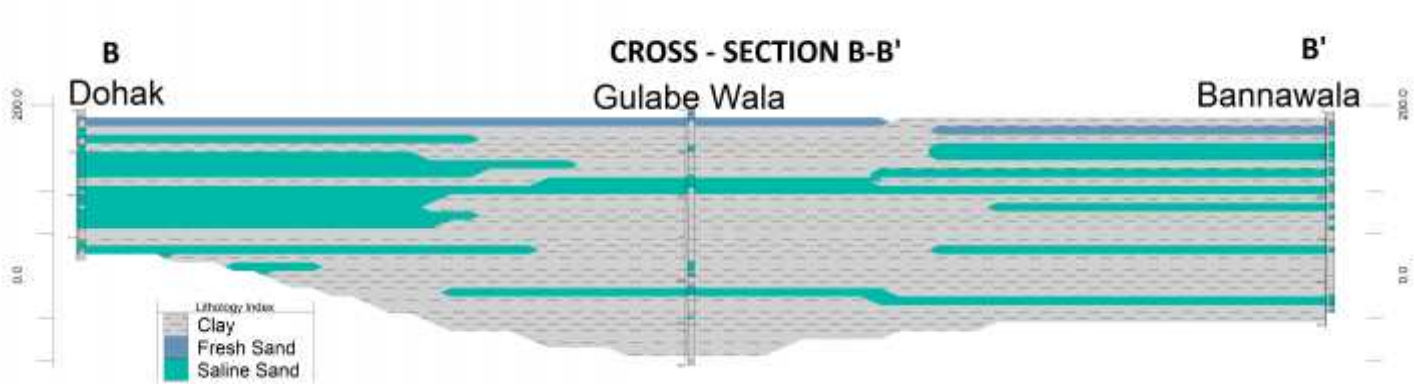
3D Lithology model



3D Lithology Fence







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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*237.41*
	In-storage Ground Water Resources	*799.14*
	Total	1036.55
Ground Water Extraction (in mcm)	Irrigation	181.90
	Domestic & Industrial	12.05
Provision for domestic & Industrial requirement upto 2025 (in mcm)		12.05
Chemical Quality of ground water & contamination		Not potable for drinking purposes. Suitable for irrigation purposes only
Other issues		Rising 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 (2.56 m).
Other interventions proposed	-

4. Demand Side Interventions

Advanced Irrigation Practices	Conjunctive use of canal water and ground water for irrigation
Change in cropping pattern	No changes in cropping pattern is required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-