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

Barnala District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING

&

MANAGEMENT PLAN

BARNALA 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 BARNALA DISTRICT, PUNJAB

(1351.7 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 Barnala district of Punjab State (**Fig. 1**), covered under Phase-III.

Barnala district of Punjab state lies between 30^0 to $30^0$52' north latitudes and $75^0$15' to 75^0

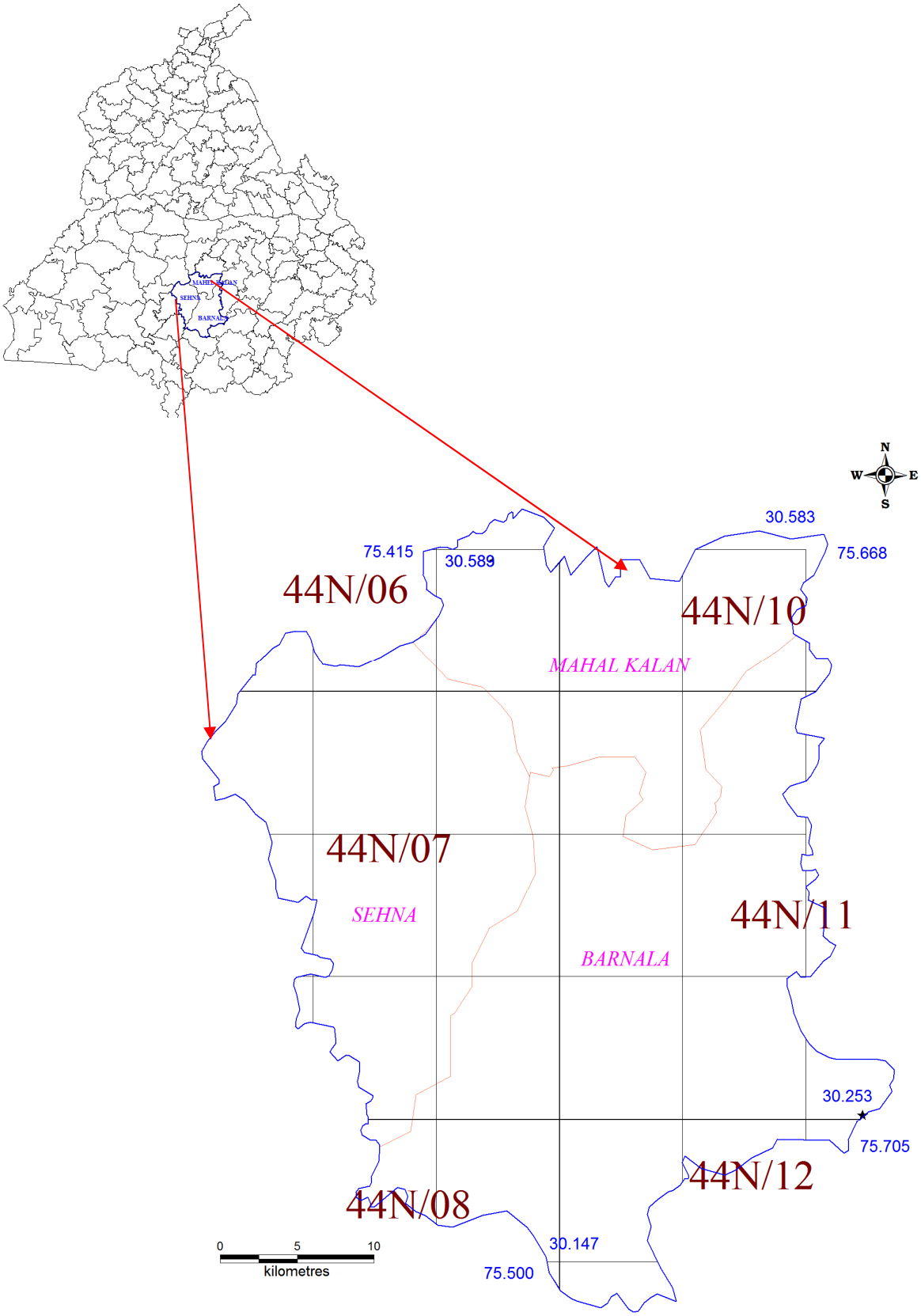
east longitudes. Total geographical area of the district is 1351.7 sq. km. The Barnala district is divided into two sub-divisions (tehsils) namely Barnala, Tappa, comprising three-community development blocks viz. Barnala, Sehna and Mahal Kalan for the purpose of administration. The district headquarter Barnala town falls in Barnala Tehsil.

The total population of the district is 190685 (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 Barnala district data, there are 617 villages and 11 towns. The total number of uninhabited villages is 19.

The area falling under Barnala distt. forms part of Indo gangetic plain. The area of the block ingeneral is plain. The master slope of the area is towards the south west direction. There is no well defined drainage system in the area except some local drains like dhaula drain. This drain carry flood water when heavy rainfall occurs in the catchment area. Abohar branch of Sirhind canal system passes in south eastern part of the block. The entire canal belongs to Sirhind canal system of Bhakhra main canal. Soils of the district is loamy sand and sandy loam kaller land is also spotted at a few places.

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.

Fig 1: Base Map of Barnala 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 Barnala district

Source of Data	*No. Of tubewells as per Depth Range*				*Total Wells*
	>100	*100-200*	*200-300*	*>300*	
PRIVATE	0	2	1	0	3
CGWB	0	0	1	3	4
WSS	0	1	0	0	1
TOTAL	0	3	2	3	8

2.2 Ground Water Quality

The ground water in the district is alkaline in nature. 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 827µS/cm in southern and northern part to 1140 µS/cm in the central part of the district particularly, in Barnala 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 2.5 in three locations, so tha here canal water mixed with tubewll water for irrigation purpose But block mahel kalan ground water suitable for irrigation purpose

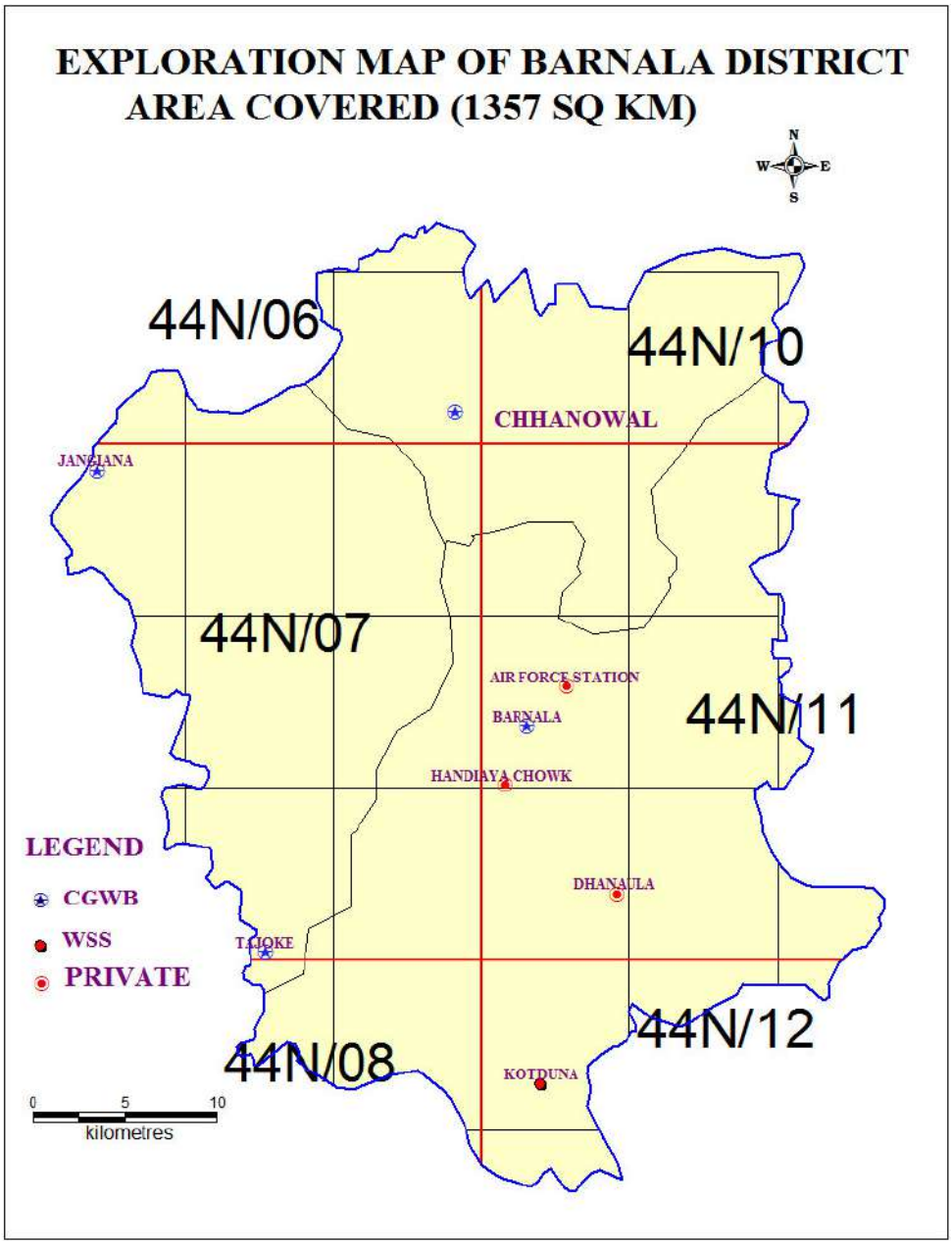
In the entire district Iron, which is an essential plant and animal nutrient, is found to be below the permissible limit with an in all block Barnala. Majority of the samples in Barnala block show within the permissible limit .

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:2. The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation.

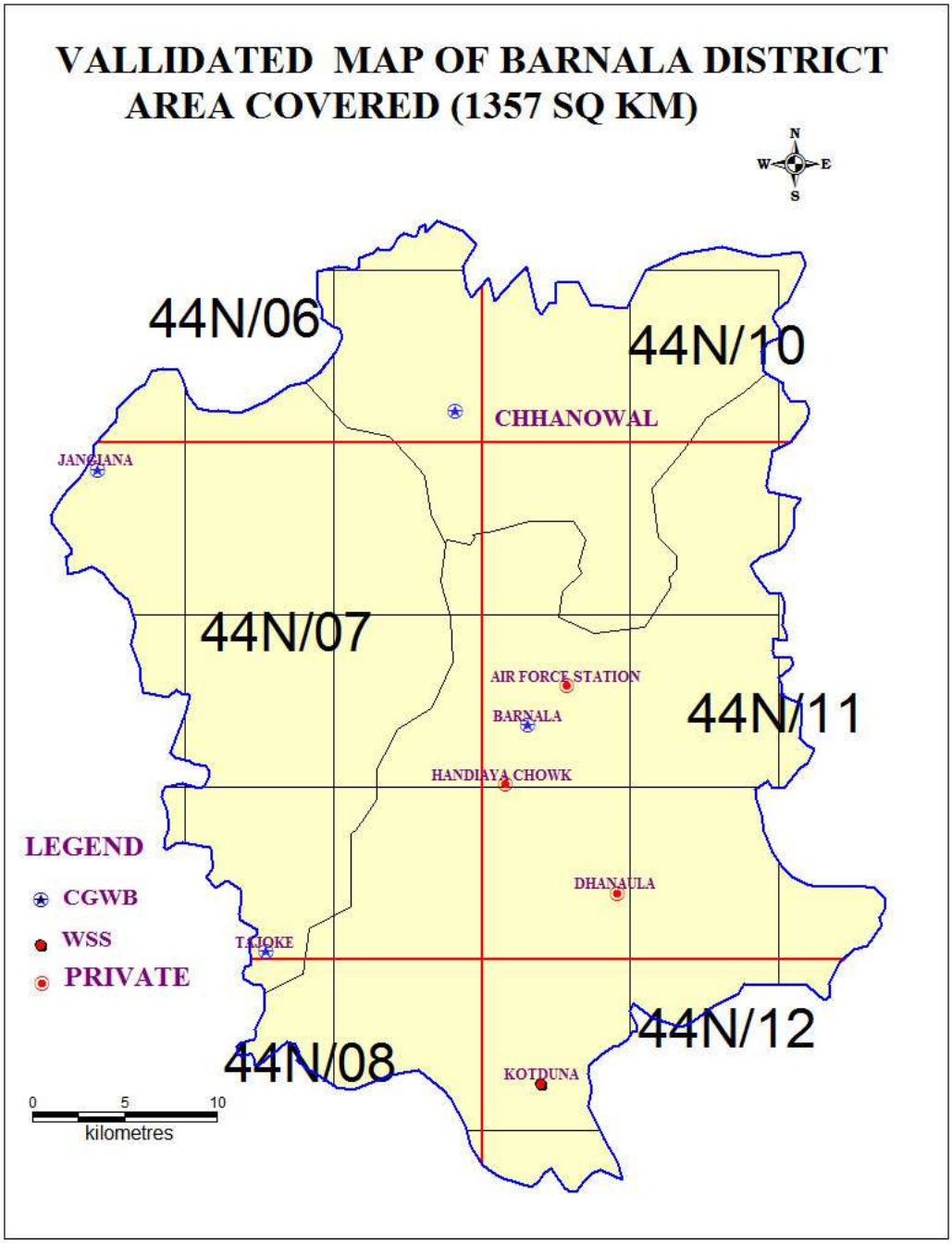
Fig-2 Location of Exploratory Bore Holes



2.4 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

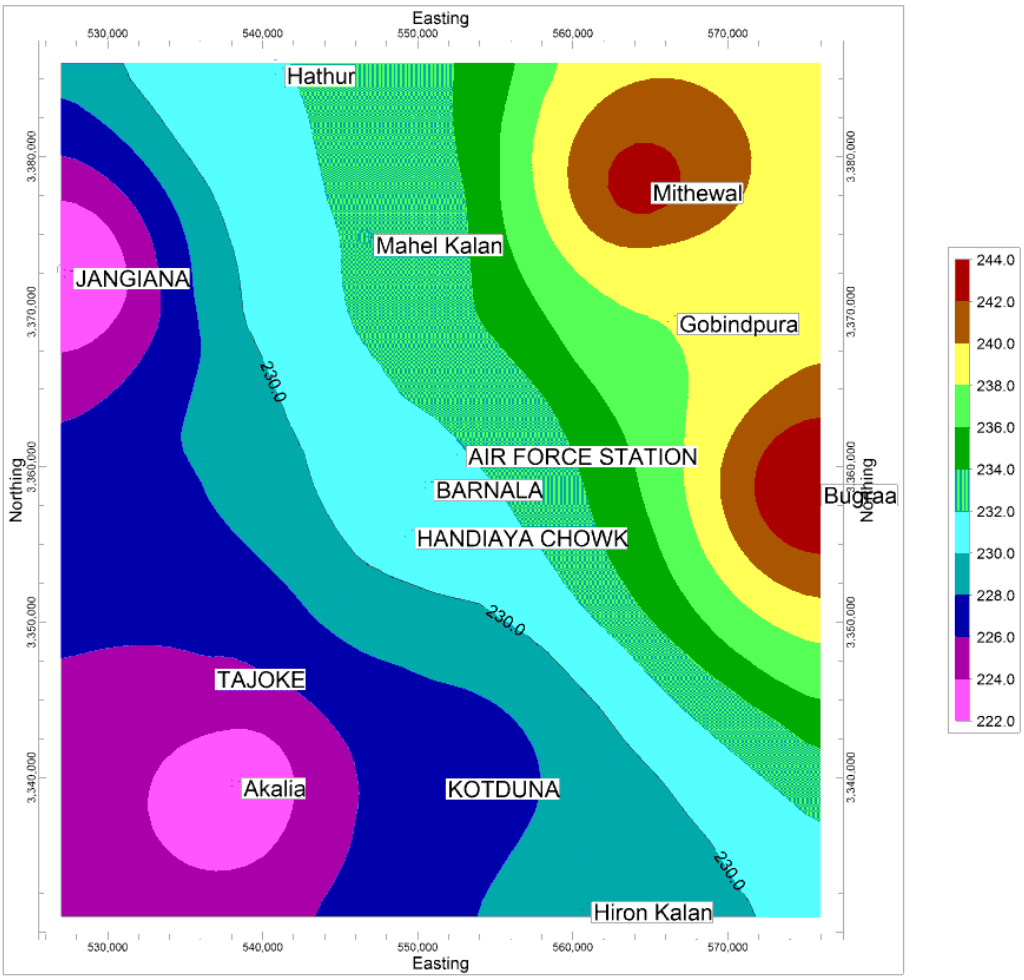
All the available data have been validated for consideration to generate aquifer map. The deepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig -3.

Fig 3: Validated Exploration Data of Barnala District :



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

Fig 4: Elevation Contour Map-Barnala 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 district is occupied by Indo-Gangetic alluvium of Quaternary age. The alluvium comprises sand, gravel, pebble, kankar and clay. Blown sands occur in the form of dunes in western, northern and northwestern part of the district. Ground water is fresh in almost the entire district. The depth to water level in the area ranges from 19 to 30 m bgl.

The Central Ground Water Board has drilled 4 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 300m. Shallow aquifers up to the depth of 60 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 60-537 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.

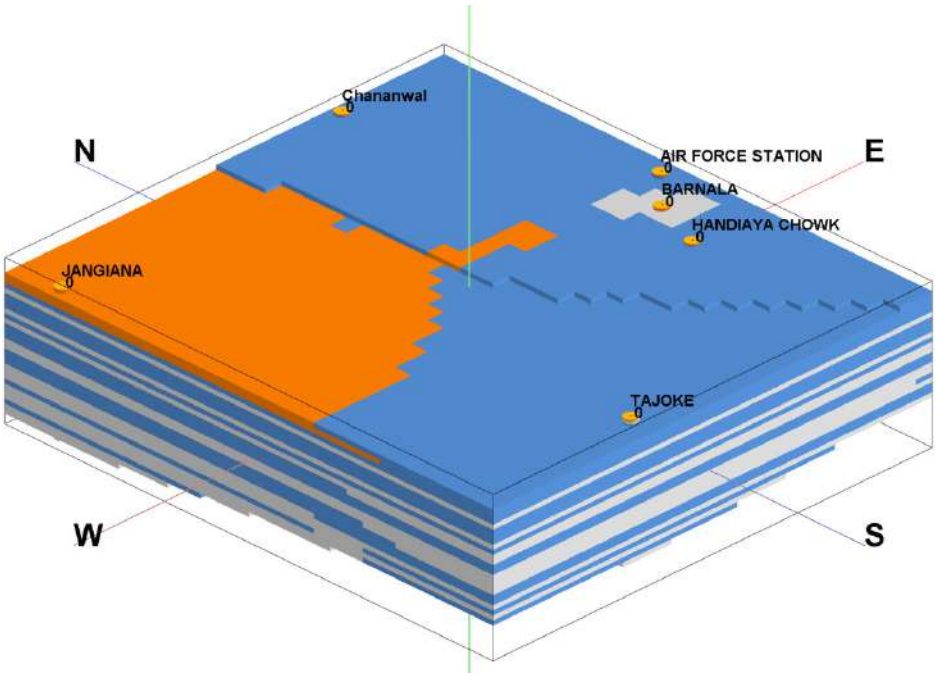
The district is occupied by Indo-Gangetic alluvial plain of quaternary age and falls in Ghaggar sub basin. The ground water occurs in alluvium formations comprising fine to coarse sand, which forms the potential aquifers. In the shallow aquifer (up to 50m) ground water occurs under unconfined/water table conditions, where as in deeper aquifer, semi-confined/confined conditions exist. The traditional dugwells tapping the shallow aquifer are not in use and most of them have been abandoned, however, this aquifer is being tapped by their hand pumps and shallow tube wells, which are widely used for domestic purposes. The deep tube wells have been constructed by CGWB, which has drilled 3 exploratory boreholes, 4 Piezometers to delineate and determine potential aquifer zones, evaluation of aquifer characteristics. The permeable granular zones comprising fine to medium grained sand and occasionally coarse sand and gravel. Their lateral and vertical extent is limited. The borehole data reveals that clay group of formations dominate over the sand group in the district area. Ground water in the district occurs in the alluvium under water table and semi confined to confined conditions. The discharge of deep tube well in the area varies between 2400 and 2680 Ipm. The tranmissivity values ranges from 1670 m²/day and storativity ranges from $7.5*10^{-2}$. Water level behavior The depth to water level ranges from 14.43 to 20.62 m bgl during pre-monsoon period and

16.99 to 24.28m bgl during post monsoon period. The seasonal fluctuation varies from 0.03 to (-) 3.66 m in the area. The long-term water levels trend indicates average fall of 0.50 m/year. The long term water level trend is also showing decline of water level from 8 to 10m. The elevation of the water table in the district varies from 230m to 300 m above mean sea level. The highest elevation is in the northeastern part and the lowest in the southwestern part and reflects the topographic gradients. The hydraulic gradient in the northern eastern part is steep, whereas, in the southwestern part, it is gentle. The overall flow of ground water is from northeast to south-west direction.

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.

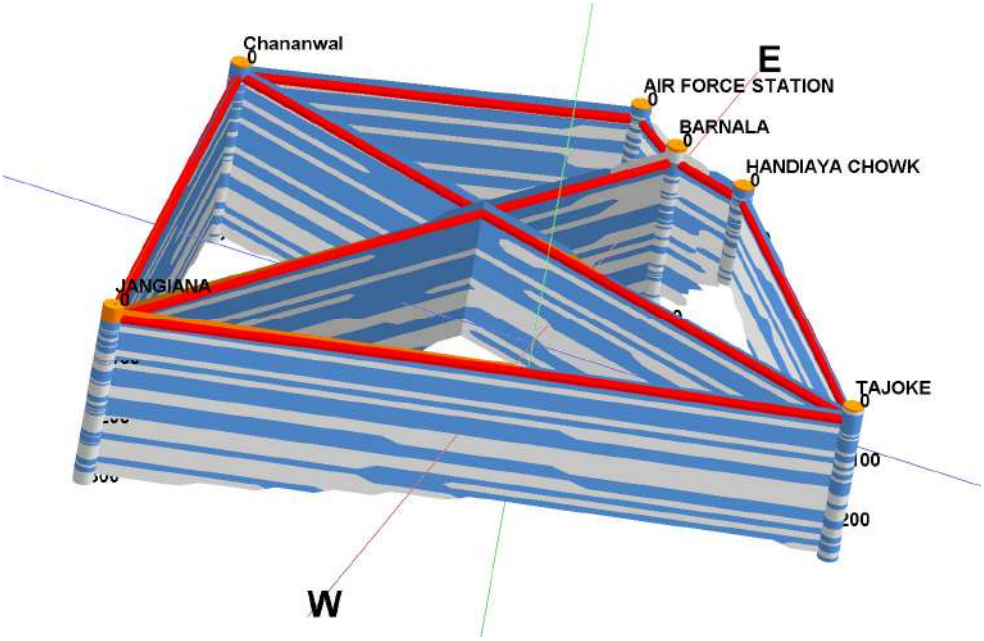
Fig 5: 3-Dimension Lithological Model of BarnalaDistrict



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 Barnala District



3.3 Aquifer Geometry

Barnal 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 Barnala 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. The resources are calculated separately

which are included in next chapter. The Lithological cross-section of Barnla district is given below:-

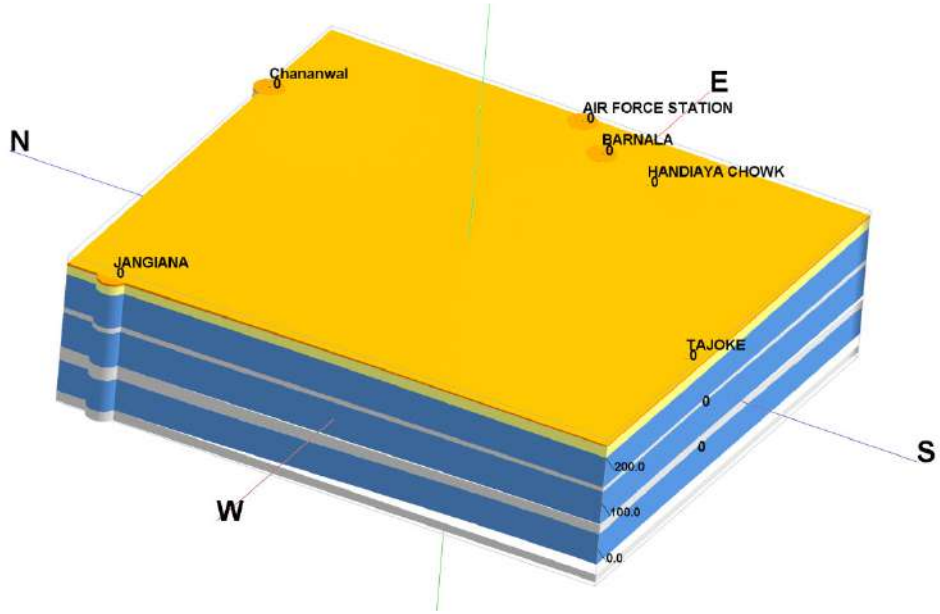


Fig 7: Cross Sections of Lithological Barnala District

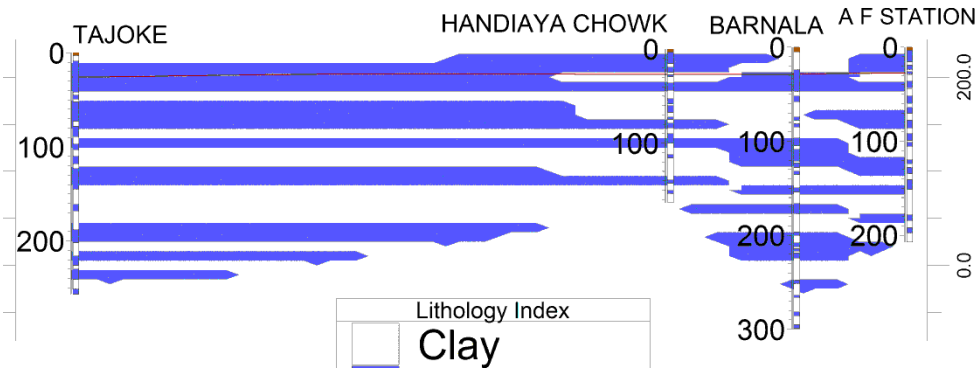
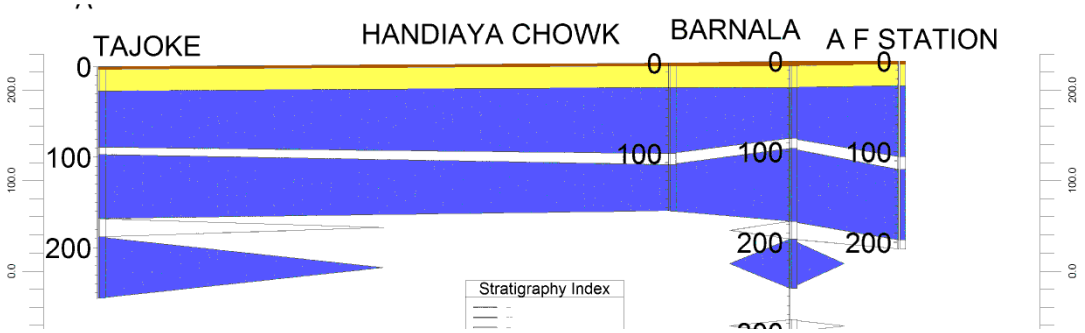


Fig 7: Cross Sections of Aquifer Map of Barnala District



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 development in all the blocks has exceeded the available recharge, thus 3 blocks have been categorized as **over exploited**. Stage of ground water development in the Barnala district has been assessed to be 194 %.

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 (%)
BARNALA	23060	55921	751	56672	999	-33859	246
MAHAL KALAN	14804	20465	310	20774	412	-6072	140
SEHNA	23654	41491	262	41753	348	-18185	177
Total (ham)	**61518**	**117876**	**1323**	**119200**	**1758**	**-58117**	**194**

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

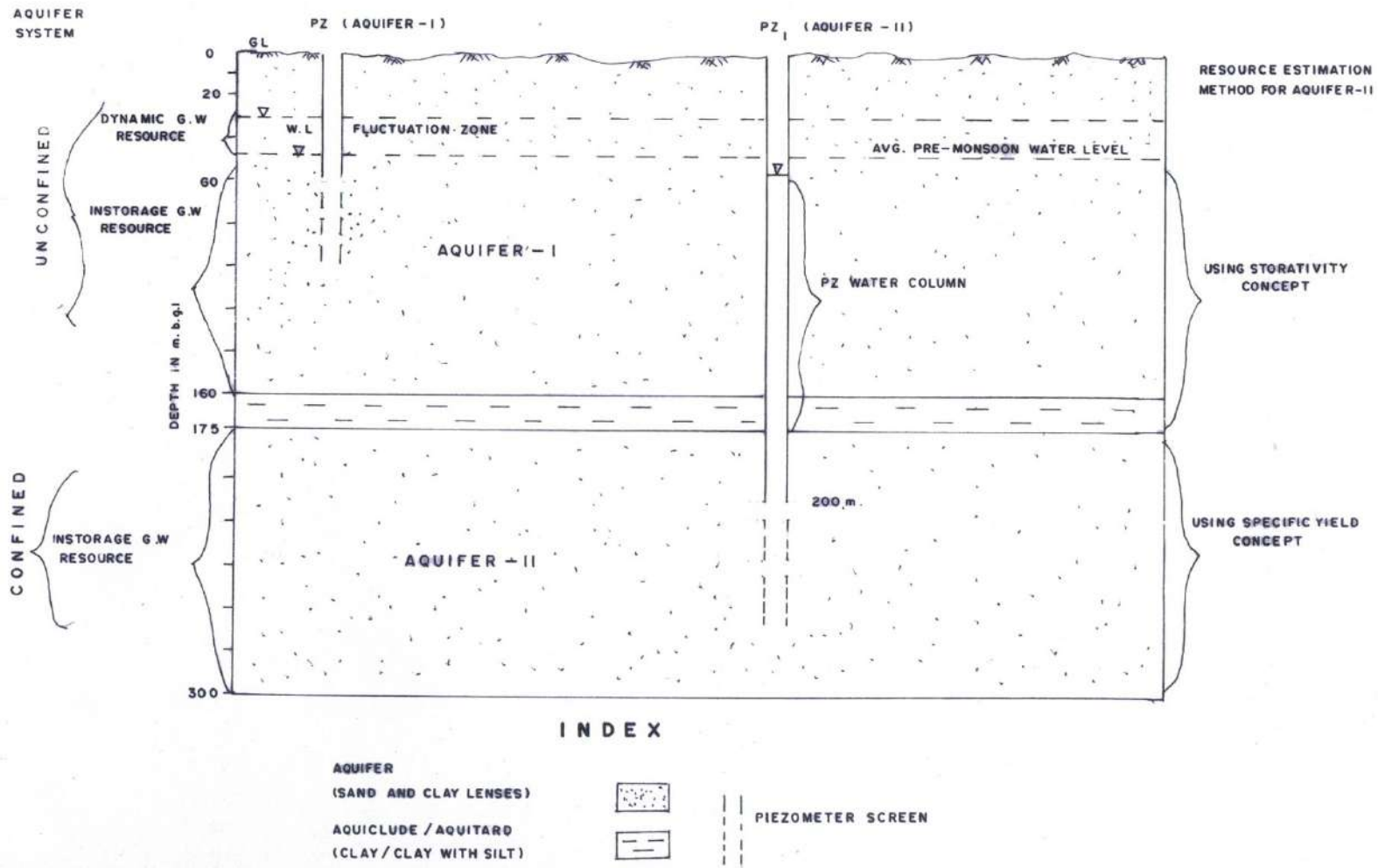


Table 5: BLOCK WISE AVAILABILITY OF TOTAL GROUNDWATER RESOURCES IN BARNALA DISTRICT

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT BARNALA, PUNJAB STATE (2013)								
Type of Ground Water Assessment Unit (Block): BARNLA Blocks								
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)		Average Pre-monsoon Water Level (m bgl)	Thickness of the unsaturated granular Zones up to Pre-monsoon WL (m)	Average Specific Yield	Volume of Unsaturated Zone up to Pre-monsoon WL (ham) 5*7*8
			Total Geographical Area	Assessment Area Total Area Fresh				
1	2	3	4	5	6	7	8	9
1	BARNALA	Alluvium	61390	61390	22.15	12.66	0.12	93264
2	MAHAL KALAN	Alluvium	34760	34760	21.50	18	0.12	75082
3	SEHNA	Alluvium	39020	39020	18.65	11	0.12	51506
Dist. Total(ham)			135170	135170				219852
Dist. Total(mcm)			1351.7	1351.7				2199

ham: hectare metre

mcm: million cubic metre

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	BARNALA	61390	61390	61390	0	22.15	80	57.85	35	0.072	154703
2	MAHAL KALAN	34760	34760	34760	0	21.50	111	89.50	58	0.072	145158
3	SEHNA	39020	39020	39020	0	18.65	116	97.35	68	0.072	191042
Dist. Total (ham)		**135170**	**135170**	**135170**							**490902**
Dist. Total (mcm)		**1351.7**	**1351.7**	**1351.7**							**4909**

ham: hectare metre

mcm: million cubic metre

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	BARNALA	61390	61390	61390	248	300	30.4	52	14	0.072	0.00195	61881	3639	65520
2	MAHAL KALAN	34760	34760	34760	225	300	30.4	75	29	0.072	0.00195	72579	2061	74639
3	SEHNA	39020	39020	39020	242	300	30.4	58	20	0.072	0.0038	56189	4508	60696
Dist. Total (ham)		**135170**	**135170**	**135170**								**190649**	**10207**	**200856**
Dist. Total (mcm)		**1352**	**1352**	**1352**								**1906**	**102**	**2009**

The Average Peizometer head value for confined Aquifer - III is 30.40 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 BARNALA 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	BARNALA	93264	23060	154703	177763	180085	65520	423369	4234
2	MAHAL KALAN	75082	14804	145158	159962	94464	74639	329065	3291
3	SEHNA	51506	23654	191042	214696	80528	60696	355920	3559
Dist. Total (ham)		**219852**	**61518**	**490902**	**552421**	**355078**	**200856**	**1108354**	**11084**
Dist. Total (mcm)		**2199**	**615**	**4909**	**5524**	**3551**	**2009**		

5. GROUND WATER RELATED ISSUES

Barnala 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.

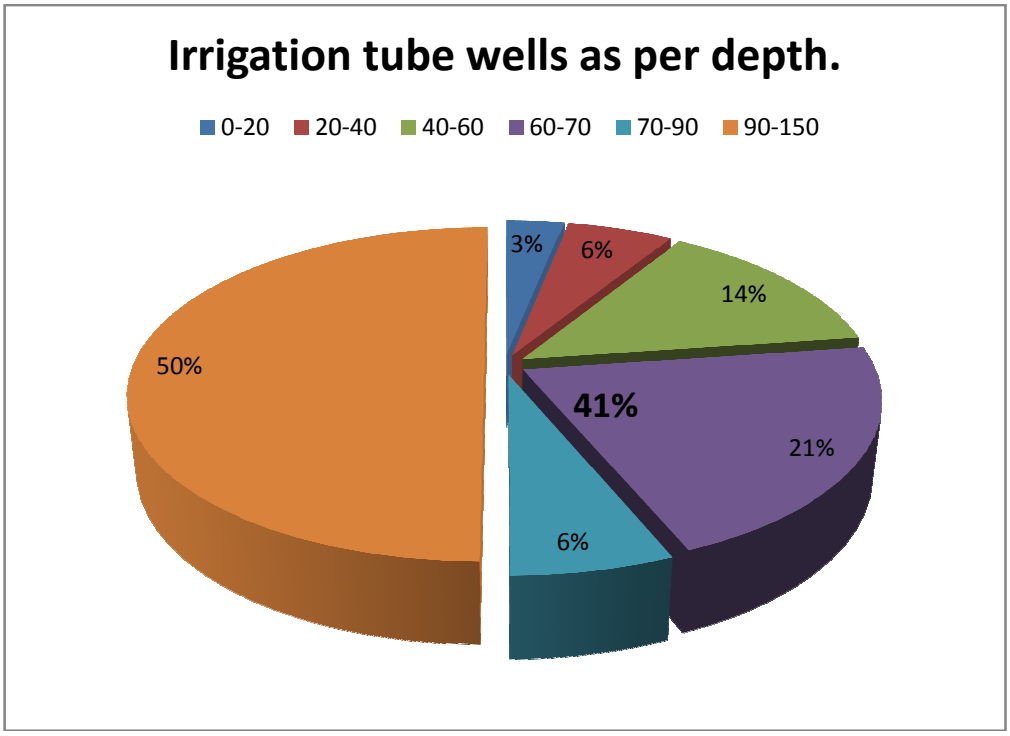


Table 7-Distribution of Tube wells According to Owner's holding Size

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	**Barnala**	**500**	**916**	**2238**	**3362**	**1001**	**8017**

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

No. of deep 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	**Barnala**	**293**	**1765**	**5024**	**14578**	**4763**	**26423**

Table 9- Type of Ground water distribution device

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	**Barnala**	**36**	**98**	**85**	**7799**	**0**	**8018**

Table -10Number of Ground Water Schemes and Potential Utilized by water distribution device

Ground Water Schemes according to water Distribution System				
	Open Water Channel			
Sr.no	**District**	**Lined/pucca**	**Unlined/kutcha**	**Under-ground pipe**
1	**Barnala**	**97**	**34256**	**76**

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 25 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 26423 operated by farmers for irrigation through unlined/Katcha (99.46%) open channel system in Barnala district where water from the tubewell 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 Barnala district is estimated at 1188.78 MCM. It is expected that around 50.73% 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 297.95 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 Barnala Districts. The measure if implemented will bring down the ground water overdraft from 204% to 153.27 %. 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

7. BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

(I) BARNALA BLOCK (613.90 SQ KM)

1. Salient Information

Population (2011) Rural-35500
Urban-00
Total-35500

Normal mansoon rainfall (BARNALA block) 250 mm

Average Annual Rainfall (BARNALA block) 437 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 580.20 sq.km
Total Cropped Area-1147.99

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 Barnala 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-~20.50-34.28 (*mbgl)* &Post Monsoon-~ 34.41-35.30 *(mbgl)*

Aquifer Disposition: Combined Aquifer System

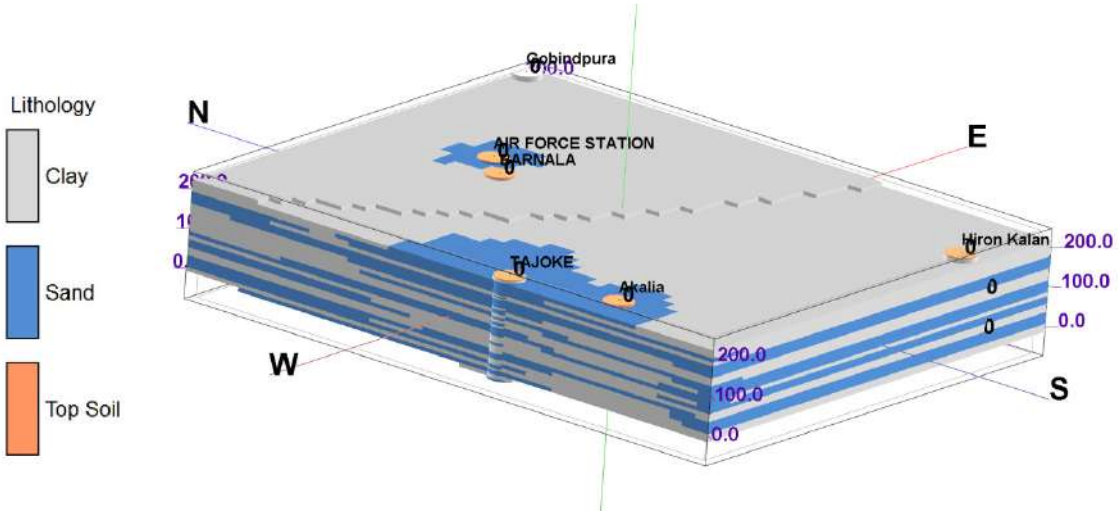
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (27-106m)	Quaternary Alluvial deposits	Unconfined	45	1620.36-2000	0.072	1.42*10-2 to 7.5*10-2
Aquifer-II (120-198m)		Unconfined to Confined	55	-	NA	-

Aquifer-II (197-251m)		Unconfined to Confined	43.5		NA	

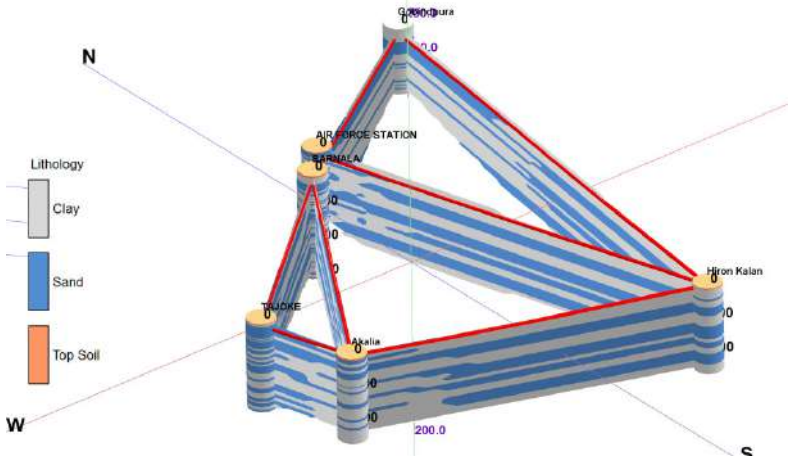
Aquifer comprises of freshwater only and the main aquifer material is sand.

The non-aquifer material comprise of clay.

3D Lithology model



3D Lithology Fence



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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer MCM	230.60
	In-storage Ground Water Resources	*4003.08*
	Total	*4234*
Ground Water Extraction (in mcm)	Irrigation	559.21
	Domestic & Industrial	7.51
Provision for domestic & Industrial requirement upto 2025 (in mcm)		9.98
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 (22.15m).
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) Mahel Kalan BLOCK (347.60SQ KM)

1. Salient Information

Population (2011) Rural-
Urban--18465
Total-18465

Normal mansoon rainfall 503 mm

Average Annual Rainfall (Mahel Kalan block) 235 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 263.24 sq.km
Total Cropped Area – 525.7sq.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 **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-~ 25.44-33.00 (mbgl)Post Monsoon-~ 21.94-35.80 (mbgl)

Aquifer Disposition: Combined Aquifer System

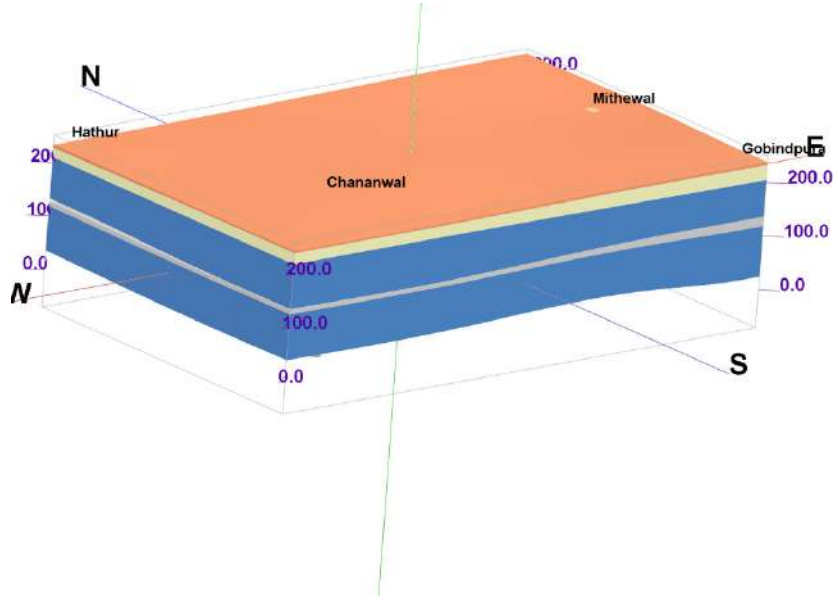
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (23-111m)	Quaternary Alluvial deposits	Unconfined	88.4	1620.36-2000	0.072	1.42*10-2 to 7.5*10-2
Aquifer-II (119-206m)		Unconfined to Confined	87.2	-	NA	-

Aquifer-III (231-289m)		Unconfined to Confined	58	-	NA	-

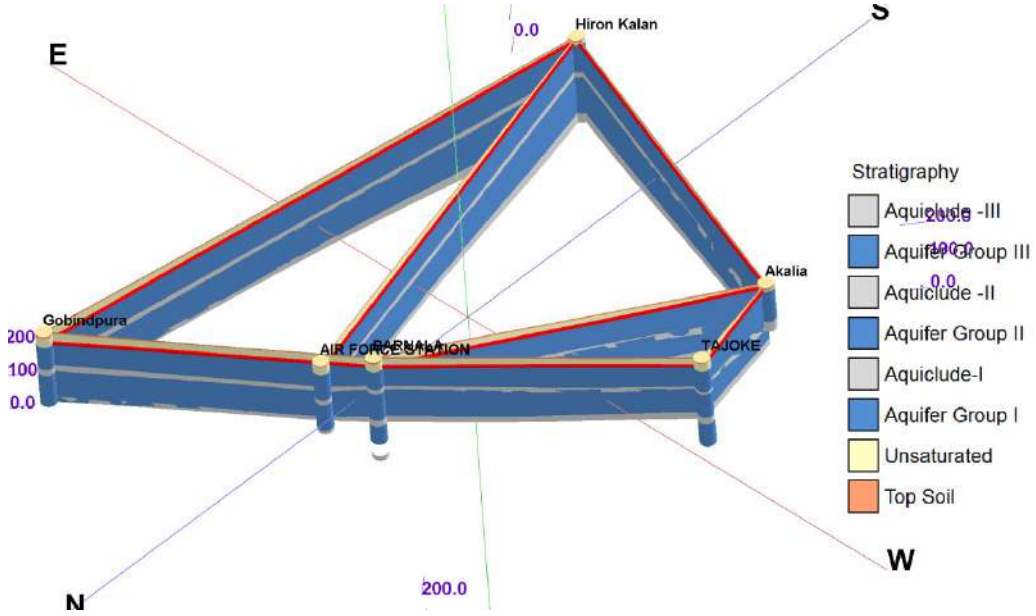
Aquifer comprises of freshwater only and the main aquifer material is sand.

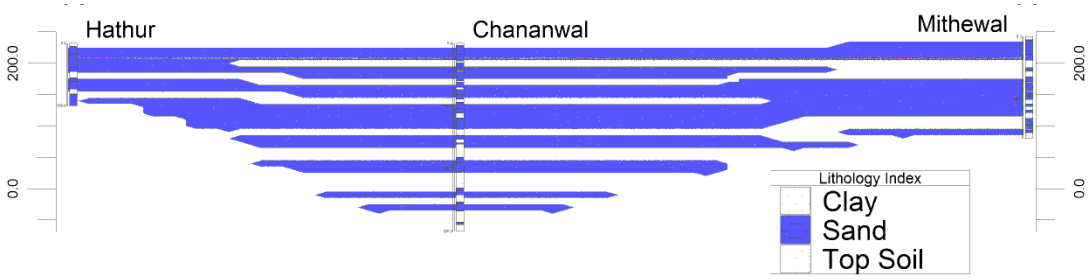
The non-aquifer material comprise of clay.

3D Aquifer model



3D Lithology Fence





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

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	148.04
	In-storage Ground Water Resources	3142.61
	Total	3291
Ground Water Extraction (in mcm)	Irrigation	204.65
	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 (21.15m).
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. Sehna BLOCK (390.20 SQ KM)

1. Salient Information

Population (2011) Rural-22692
Urban--
Total-22692

Normal rainfall 265 mm

Average Annual Rainfall (Sehna block) 422 mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 312.75 sq.km
Total Cropped Area-620.96 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 sehna 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 18.60-27.20 (mbgl) &Post Monsoon-~19.45-28.90 (mbgl)

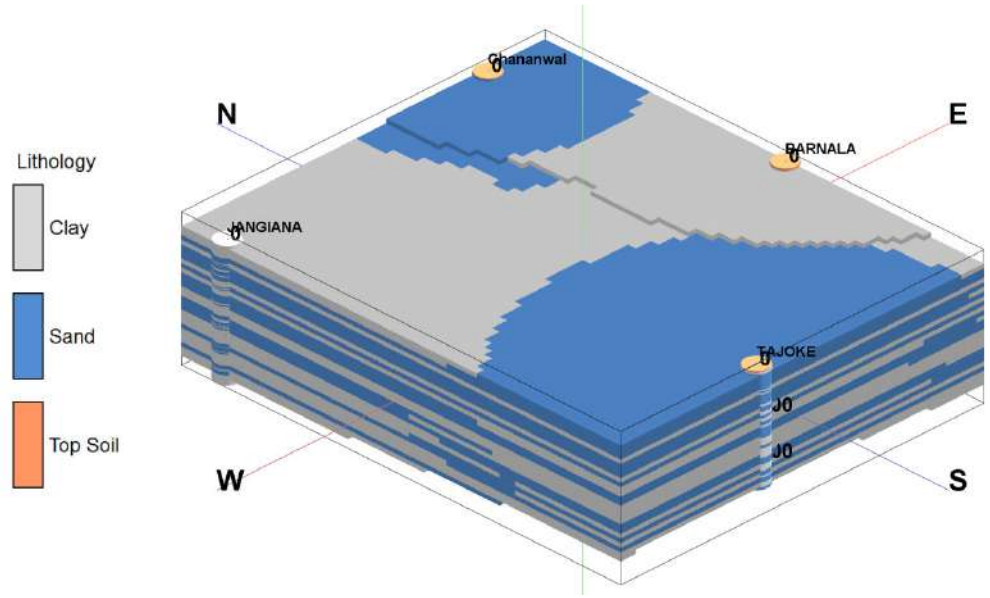
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (24-97m)	Quaternary Alluvial deposits	Unconfined	47	811-1680	0.072	1.42*10-2 7.75*10-2
Aquifer-II (107182m)		Unconfined to Confined	32	-	NA	-
Aquifer-III (211-290m)		Unconfined to Confined	38	-	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	236.45
	In-storage Ground Water Resources	3322.66
	Total	3559
Ground Water Extraction (in mcm)	Irrigation	414.19
	Domestic & Industrial	2.62
Provision for domestic & Industrial requirement upto 2025 (in mcm)		3.47
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	-