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

Karnal District, Haryana

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING

&

MANAGEMENT PLAN

KARNAL DISTRICT

HARYANA

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

2017

CHAPTER-1

INTRODUCTION

1.0Background:-

Water is a natural resource unique to the planet Earth. It is essential to people and the largest available source of fresh water lies underground. Increased demand for water has stimulated development of underground water resources. Water is life to us and all living things. After discounting the volumes represented by oceans and polar ice, groundwater is the next most significant source.

The primary objective of the Aquifer Mapping can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

1.1 Scope of the study:

Systematic mapping of an aquifer encompasses a host of activities such as collection and compilation of available information on aquifer systems, demarcation of their extents and their characterization, analysis of data gaps, generation of additional data for filling the identified data gaps and finally, preparation of aquifer maps at the desired scale. This manual attempts to evolve uniform protocols for these activities to facilitate their easy integration for the district as whole.

1.2 Approach and Methodology:

National Aquifer Mapping Programme basically aims at characterizing the geometry, parameters, behaviour of ground water levels and status of ground water development in various aquifer systems to facilitate planning of their sustainable management. The major activities involved in this process include compilation of existing data, identification of data gaps, and generation of data for filling data gaps and preparation of aquifer maps.

1.3 Study Area

Karnal district is bounded by north latitudes 29025'16" and 29058'01" and east longitudes 76022'59" and 77009'22" (Fig.1.1). It falls in parts of Survey of India Top sheets nos.53C and 53G covering an area of 2350 sq.km.

Karnal district covers 5.69% area of the state. The district is bordered by the river Yamuna in the east, Panipat district in the south, Kaithal district in the west and Kurukshetra district in the north. The district is well connected by roads and railways. The SherShah Sri Marg (NH No.1) runs through the entire length of the district. A broad gauge railway line connecting Delhi with Ambala runs almost parallel to the NH No.1. Karnal is the district headquarters. The main townships are Karnal, Indri, Assandh, Nissang, Nilokheri and Ghauranda. The towns are well connected by roads.

Administrative Divisions, Demographic particulars

Administratively the district comes under Rohtak division. It has the following administrative subdivisions.

Sub-Division	Tahsils	Sub-Tahsils	Blocks.	Area of blocks (sq.km)
1.Karnal	1.Karnal	1.Nissing	1.Gharaunda	362.8
2.Assandh	2.Assandh	2.Ballah	2.Indri	330.4
	3.Nilokheri	3.Nigdhu	3.Karnal	437.6
	4.Indri		4.Nilokheri	341.0
	5.Gharaunda		5.Nissing	354.4
			6.Assandh	469.9

1.1 Demography

Karnal district is one of the mostly densely populated districts of the state. The total population of the district as per 2011 census is 12,74,183. The population density is 506 persons per sq.km against the state average of 478 persons per sq.km.

The Tehsil-wise break-up of population as per 2011 census is as follows

Tehsil	Rural Population	Urban population	Total
1.Karnal	347639	231846	579485
2.Assandh	164055	22707	186762
3.Nilokheri	145447	38606	184053
4.Indri	129260	14511	143771
5.Gharaunda	149940	30172	180112

Land use, irrigation and cropping pattern

Land use

Main land use in the district is for agriculture with 84% of the land being used for agriculture. Land put to various uses in the district is given in the table

Table Land use pattern of Karnal district, Haryana

Type of Land use	Area (thousand hectares)
1.Total area	246
2.Forest	1
3.Land put to non-agricultural use	23
4.Barren and unculturable land	13
5.Permanent pastures and other grazing lands	8
6.Land under misc.tree crops and grooves not included in net area sown	1
7.Current fallows	10
8.Net area sown	190
9.Culturable area	209
10.Area sown more than once	190
11.Total cropped area	380

Cropping Pattern

Agriculture and allied activities are the main occupation of the population, which is evident from the fact that about 84% of the area in the district is under agriculture. The district has good production of food grains, cereals,

oilseeds and other crops. Details of the crops with reference of area, productions and yield are given in table

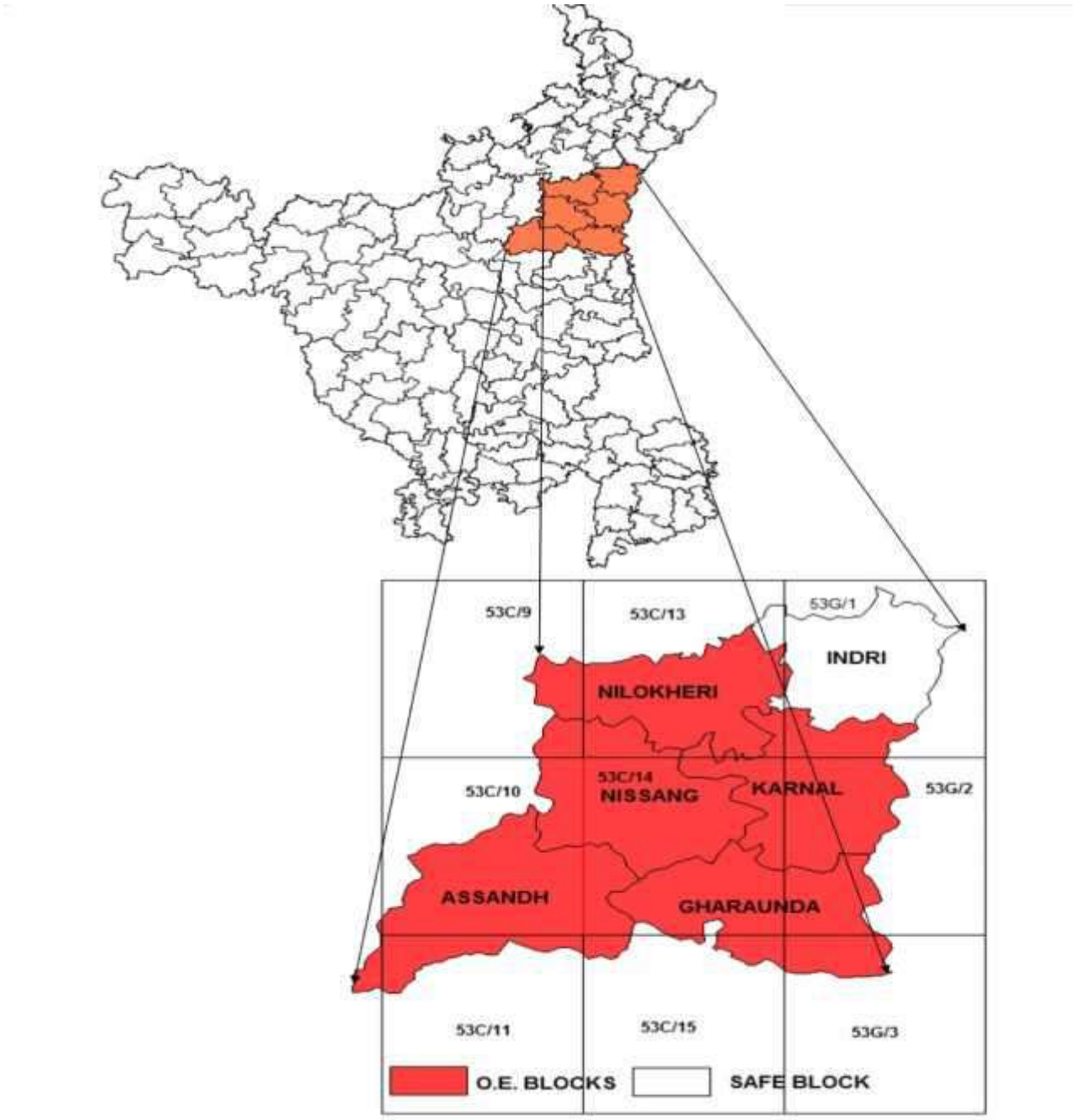
Table 1.2 : Area, Production & Yield of important crops in Karnal district

Crops	Area	Production	Average yield
	(000 hectares)	(000 tonnes)	(kg/ha)
1.Rice	159.1	426.0	2678
2.Bajra	0.9	1.0	891
3.Wheat	167.5	729	4363
4.Pulses	1.5	1.1	NA
5.Oil seeds	0.9	1.0	NA
6.Sugar cane	13.5	87.0	6185
7.Chillies	0.1	0.1	1080

Irrigation

Irrigation in the district is done by surface water as well as ground water.

LOCATION MAP OF DISTRICT KARNAL



2.0 CLIMATE

The climate of the district is characterized by the dryness of the air with an intensely hot summer and a cold winter. The year may be divided in to four seasons. The cold season starts by late November and extends to the middle of March. It is followed by hot season which continues to the end of June when the southwest monsoon arrives over the district. July to September is the southwest monsoon season. The post monsoon season period is from October to December.

Rainfall

The normal annual rainfall of the district, based on the record for the period 1978-2005 is 695.80mm recorded in 33.20 rainy days in a year. About 82.39% of the annual rainfall is recorded during the southwest monsoon from June-September. August is the wettest month of the year with an average of 8.4 rainy days and 213.90mm rainfall. During the period 1978-2005, deficient to scanty rainfall was recorded in 10 years. Maximum rainfall of 1404mm and minimum rainfall of 255mm were observed in the years 1998 and 1987 respectively.

2.1 Temperature

January is the coldest month with mean daily maximum temp.of 20.20^{0}C and mean daily minimum temp. of 7.0^{0}C. May is the hottest month with mean daily maximum temp. of 39.70^{0}C. In May and June, the maximum temp.sometimes reaches about 47^{0}C.

2.2 Humidity

The air is dry during the greater part of the year. In the monsoon months, June-Sept, humidity is high which is on an average at about 60%. April and May are usually the driest months, where in the afternoons the humidity is less than 20%. On the average , humidity ranges from 19.0% in May to 71% in August in the mornings and ranges from 45% in April to 85% in January in the evenings.

2.3 Wind velocity

Winds are generally light during the post-monsoon and winter months. They strengthen a little during the summer and monsoon months. Winds are predominantly easterly and southeasterly in the monsoon months. April to June is the period with highest incidence of thunderstorms. Rain during the monsoon months is often accompanied with thunder. Thunderstorms also occur in the winter months in association with western disturbances.

PHYSIOGRAPHY

The area constitute almost alluvial plain without any conspicuous topographical features and forms a part of the vast Indo-Gangetic plain. The elevation of the area above mean sea level ranges from 256 m.amsl in the north to 245 m.amsl in the south with an average elevation of 240m.amsl.The general slope of the area is southwards. In the north western part of the district the land slopes south west wards. There are many topographical depressions in the area of which the most pronounced is at Daha, south of Karnal.

DRAINAGE

The river Yamuna which marks the eastern boundary of the Haryana State as well as Karnal district provides the major drainage in the area. The river Yamuna emerges from Yamnotri off the Bansur-Punch glacier in Tehrigarhwal district of Uttar Pradesh at an elevation of 6330 meters. It emerges into the plains from the foothills at Kalesar just north of Tajewala.TheChantangNala is the other drainage line and flows from north to southwest in the western part of the district and disappears near Asandh.

SOILS

The soils in Gharaunda and Se half of Karnal blocks are young, stratified with no profile development. They are sandy to fine sandy loams . The soils in SE half of Nilokheri, Sw extremity of Karnal block touching Nilokheri, eastern portion of Nissang, Western half of Gharaunda block are heavily textured varying from sandy loam at the surface to clayey loam at about one meter depth.The soils of central part of Nilokheri and major portion of Nissang and Assandh blocks are mostly sandy loam to fine sandy loam.

Status Of Drinking Water Supply

Drinking water supply to rural as well as urban area of the district is both tubewell and canal based and maintained by State Public Health Department and Sewerage Department along with Municipal Council of Karnal.western part of the district the ground water is saline to marginally saline. Therefore, the canal water constitutes the major source of water supply to the villages and towns especially western part of the district. Whereas most of water works in northern part of the district are tubewell based. At some places water works are using canal water in conjunction with tubewell water, wherever either water is not available or quality of water is fit for drinking purpose.Water supply in the district is maintained by public health department.

3.1 Geology

The district is underlain by the Older and Newer alluvium of the Indo-Gangetic Quaternary alluvium. These range in age from Upper Pleistocene to Recent. These unconsolidated sediments are underlain by hard rock formations of either Siwaliks or Pre-Cambrian age.

Stratigraphic Succession

Quaternary	Recent	Newer Alluvium
	Upper Pleistocene	Older Alluvium
----------Unconformity----------		
	Siwaliks/Pre-Cambrian	

The Older alluvium consists normally of inter-bedded lenticular and inter fringing beds of clay, sands, gravels, silts, silty sands, silty clays with kankar mixed in varying proportions. The unconsolidated Newer alluvium occurs mainly along the flood plain of Yamuna river in the eastern part of the district. The Newer alluvium is light coloured and is poor in calcareous matter. It contains lenticular beds of sand, gravel and clay. Gravel and sand form the main aquifer zones.

SUB-SURFACE GEOLOGY:

The study of exploratory boreholes drilled in the district during the Upper Jamuna Project of Central Ground Water Board indicated presence of three aquifer groupsupto 450m depth below ground level.

Aquifer Group-I: The aquifer group I is composed of different sand and clay lenses and extends from surface downwards to different depth varying down to 90m to 180m at different places and occurs all over the area. This is composed of relatively coarser sediments. This group of aquifers is underlain by a clayey horizon 10-15m thick which is regionally extensive. The average transmissivity of this group was calculated by the Upper Jamuna Project of CGWB to be of the order of 2200 m2/day, lateral permeability of the order of 24m/day and average storativity as 0.12.

Aquifer Group-II: This group is composed of different sand and clay lenses and lies below aquifer group-I and occurs at varying depths ranging between 115m and 195 m to 215m and 285m. The sediments of this group are less coarse and are mixed with some kankar. This group is underlain by another clayey horizon, which is considerable thick at places and appears to be regionally extensive. The average transmissivity of this group is 700 m2/day, the average lateral permeability is 7.2m/day and the average storativity is 1x10-3.

Aquifer Group-III: The aquifer group III is composed of thin sand layers alternating with thicker clay layers and occurs at variable depths ranging between 314 m to 405m.bgl. The granular material of this group is generally finer and more so in the southerly direction. This group has an average transmissivity value of 525 m2/day, and average lateral permeability and average storativity values of the order of 7.1m/day and 4.5x10-4 respectively.At shallow depths the aquifer are under unconfined conditions whereas at deeper levels these are under semi confined or confined conditions. The discharge of these wells ranges from 805.83 to 4541.67 lpm for draw down varying from 4m to 20m.

Ground Water Conditions

The area falls in the Upper Jamuna Basin and the principal ground water reservoir in the area is unconsolidated alluvial deposits of Quaternary age. Ground water in near surface zone occurs under water table conditions and occurs under semi confined to confined conditions in deeper aquifers. Rain fall and seepage from the river Yamuna, canal networks and irrigation is the principal source of ground water recharge in the area.

Irrigation

GROUND WATER IRRIGATION SCENARIO

As per the data available from minor irrigation census 2006-07 the detailed number of shallow, deep, tubewells, lined, unlined water distribution system, land holdings of wells are given below for reference

Total Distribution of Tubewells According to Owner's Holding Size

Sr.no	District	Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10ha)	Public	Group of Farmers	Total
1	Karnal	66	743	5903	5805	930	32975	46422

Distribution of Tubewells According to Depth of tube well

No. by the depth of Tube well						
Sr.no	**District**	**40-60 mts**	**60-70 mts**	**70-90 mts**	**90-110**	**Total**
1	**Karnal**		**37018**	**4137**	**4290**	**46422**

Number of Irrigation tube wells with water distribution System

Ground Water Schemes according to water Distribution System				
	Open Water Channel			
Sr.no	**District**	**Lined/pucca**	**Unlined/kutcha**	**Total**
1	**Karnal**	**41320**	**5102**	**46422**

Groundwater level Monitoring and Behavior

The hydro-geological scenario and ground water behavior has been assessed by the water level data of the ground water monitoring stations established during the pre-monsoon and post-monsoon period of the year 2016.Depth to water level data in the district varies from 4 mbgl to >30.0 mbgl. western parts and along river Yamuna of the district are having relatively shallower water level, whereas in the central parts of the district have deeper water levels. Areas close to Yamuna also have relatively shallower water levels, in areas close to river water level even becomes shallower locally.

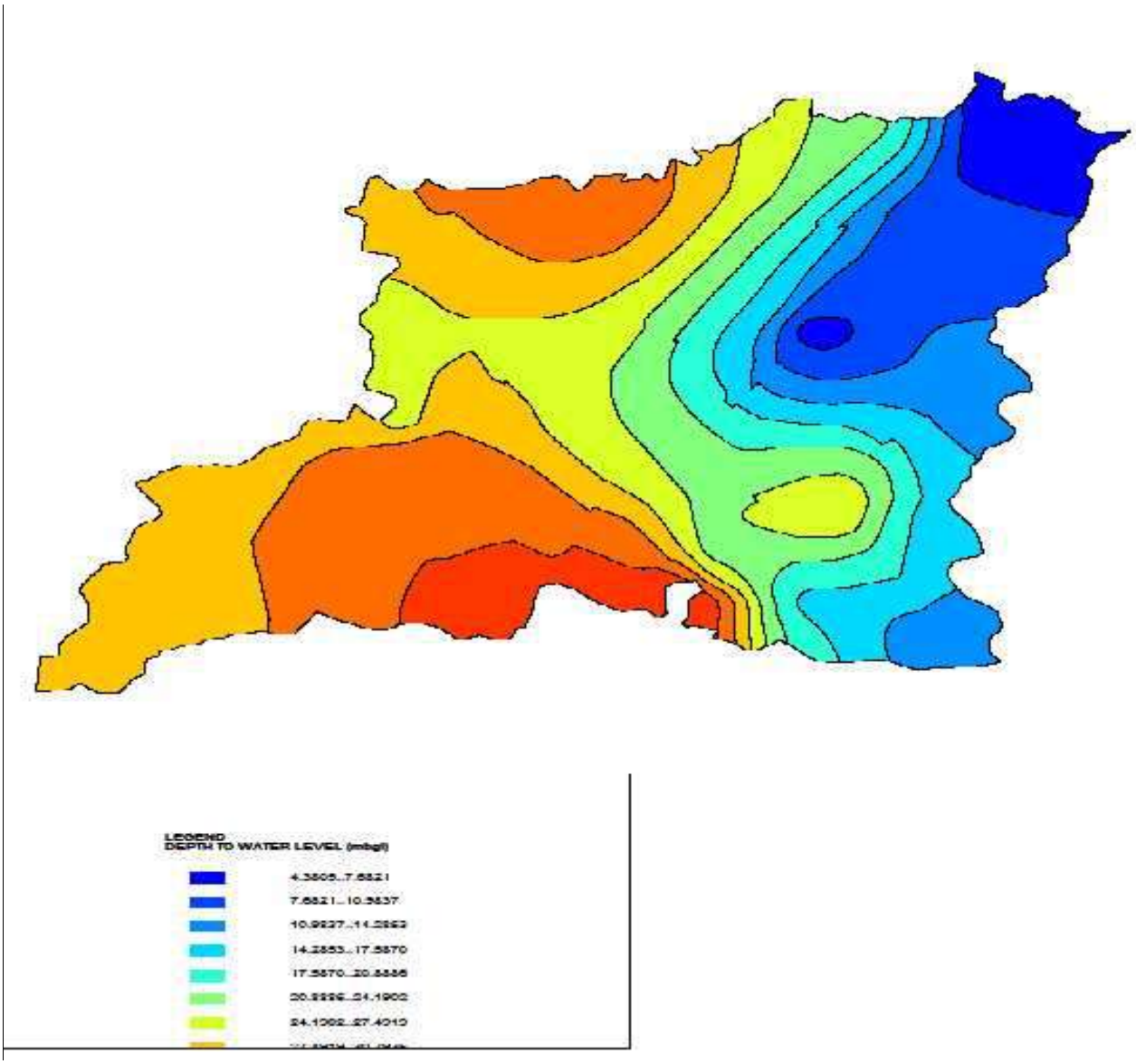


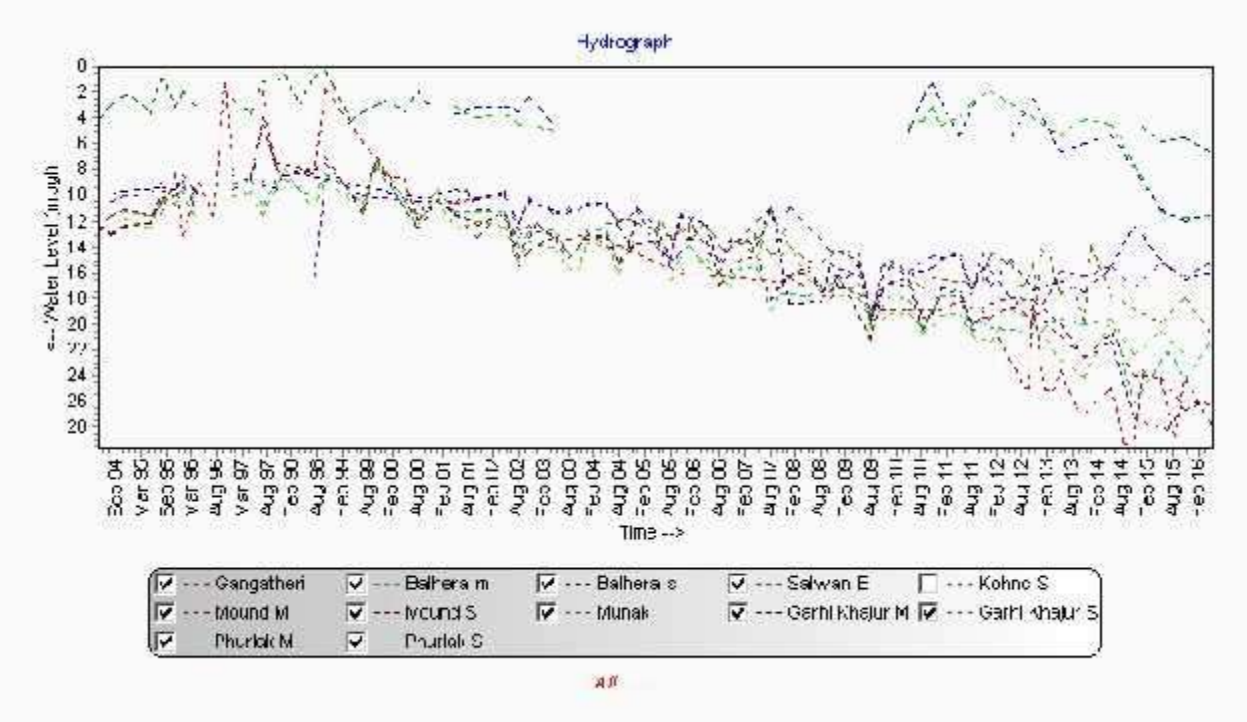
Figure: water level map Nov. 2016

Long Term Water Trend:

An attempt has been made to find out the changes ground water condition by comparing historic water level data of 1994 with the water levels of 2016. Present Water Level scenario when compared with water level of 2016, indicates the worsening ground water condition of the

district. Most of the area of the district the trend of water is declining at a slow rate continuously and it indicates that the water level is declining from 0.4 m bgl to 1 m bgl in the district.

Hydrographs of are shown here prepared by continues recording the data from 2005 to 2016.



Ground water Quality Analysis

Data of chemical analysis of water samples from shallow aquifers indicates that ground water is alkaline in nature and is fresh to moderately saline. The electrical conductivity (EC) values ranges from 346 µs/cm, to 2213 µs/cm at 250C, Nitrates from 1.9 to 498 mg/l, fluoride from 0.14 to 4.94 mg/l, and iron from 0.03 to 1.64 mg/l.arsenic in the district ranges from 0.0011 to 0.0655 mg/l. The suitability of groundwater for irrigational uses is generally ascertained by considering salinity (EC), Sodium Adsorption ratio (SAR) and Residual Sodium Carbonate (RSC). The ground water is fresh to saline with low RSC values. The US Salinity Laboratory Classification of irrigation water indicates that ground water falls under C2S1, C3S1, C3S2 and C3S3 Classes and therefore suitable for customary irrigation on well – drained soils on which semi – salt tolerant suitable crops such as wheat, gram and rice etc are

grown without any fear of sodium hazards.

Type of water:

Nearly all type of waters are available viz. Ca+ Mg – mixed anion, NaHCO3, Mixed cation – bicarbonate type or mixed cation and mixed anion type.

Exploratory drilling State - Data Availability:

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB and PHED have been collected and those supported electrical logs have been validated for aquifer map preparation. The details are given in below table.

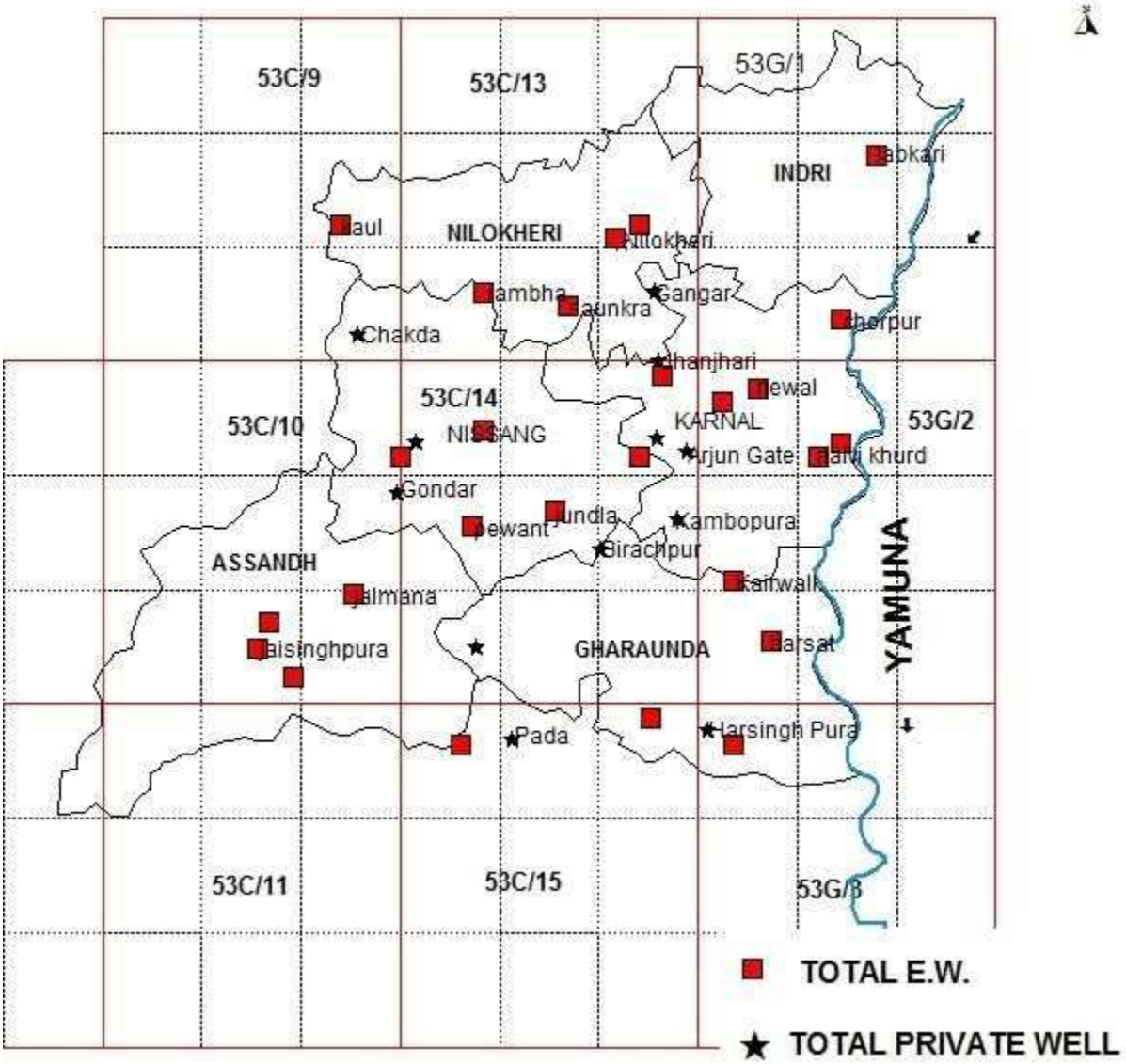
Source	No. of wells
CGWB	26
Private	22

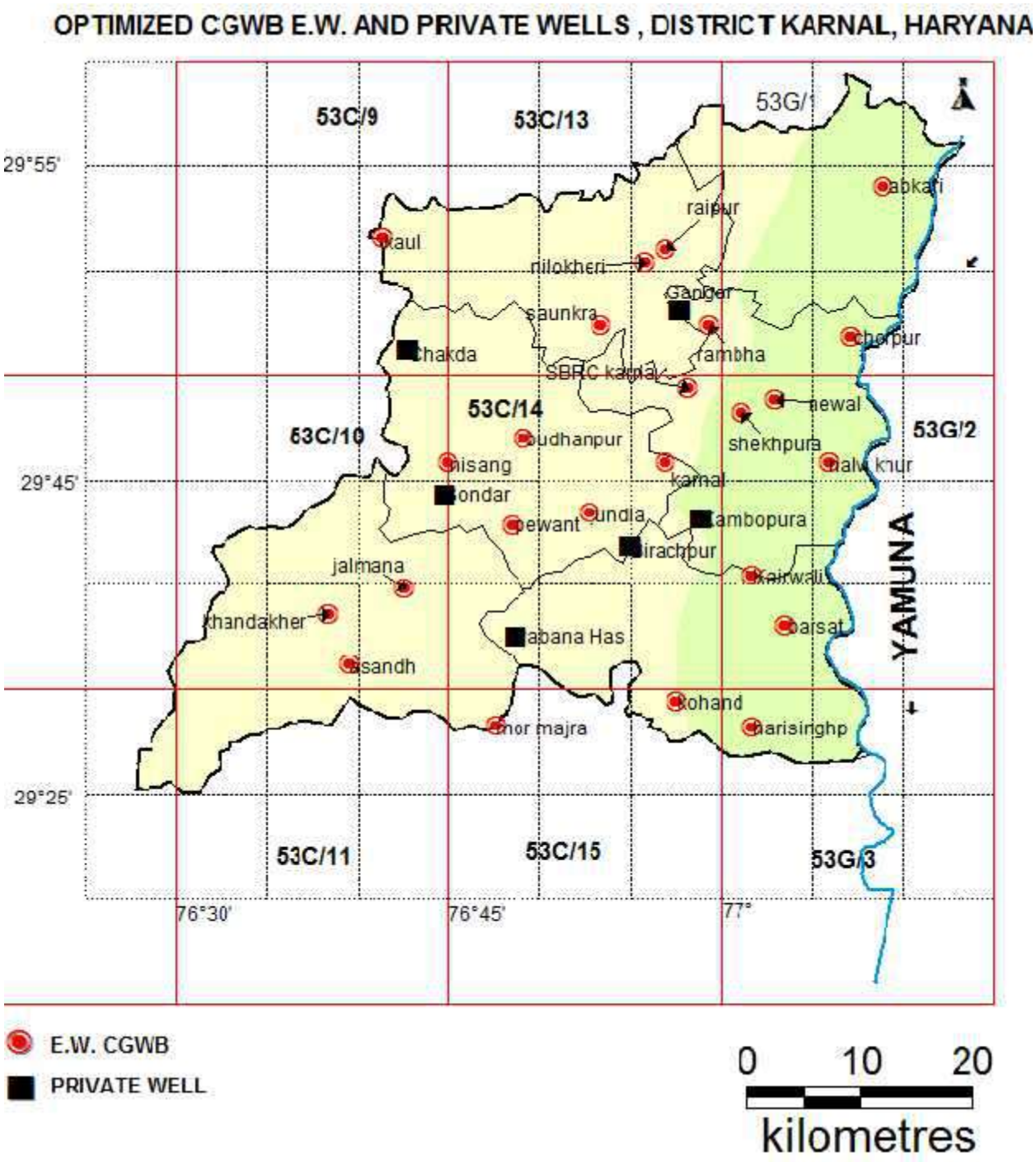
DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

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 9) km and is shown in fig.

Source	No. of wells	Depth
		>200m
CGWB	26	3
Private	11	11

LOCATION OF CGWB E.W. AND PRIVATE WELLS, DISTRICT KARNAL, HARYANA



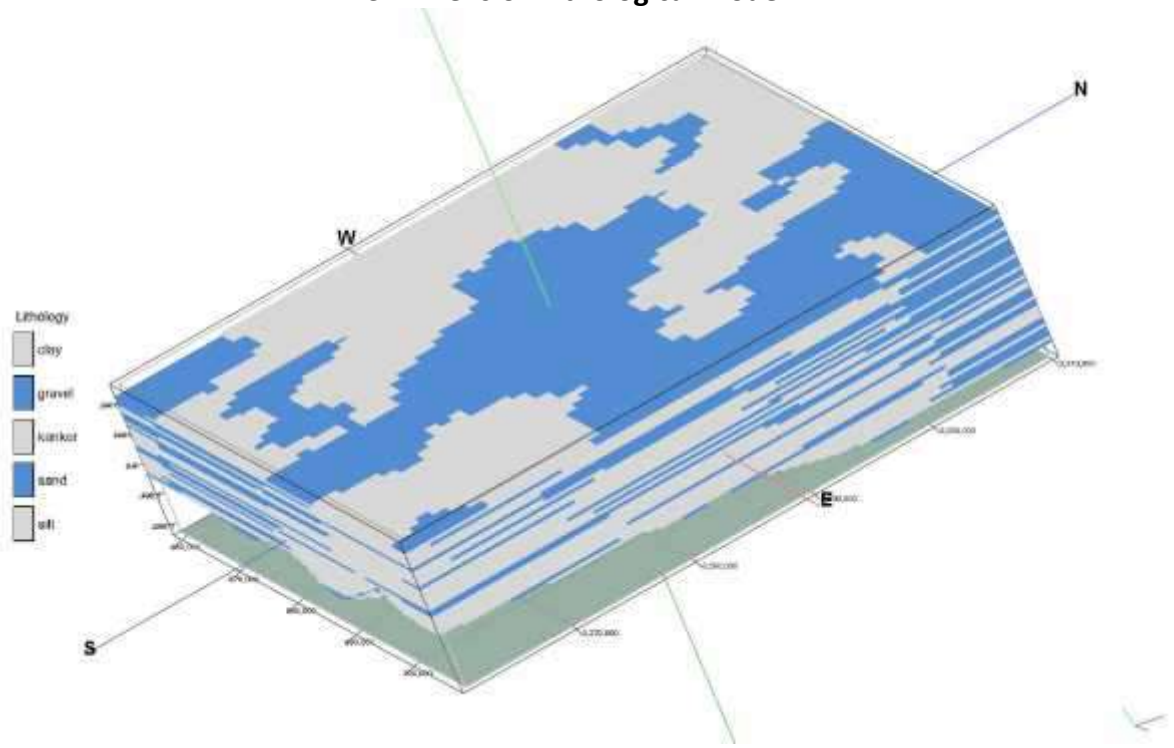


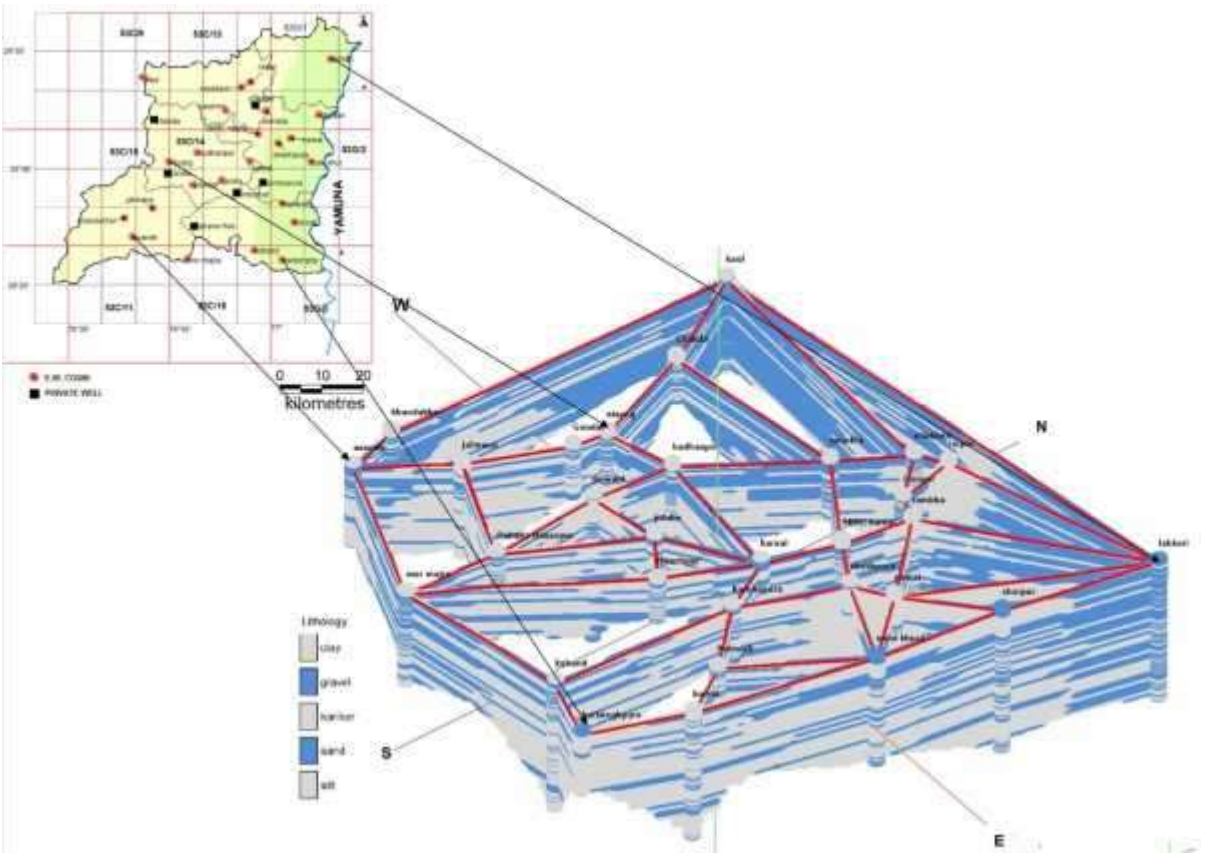
The optimized wells of CGWB, and PHED used to prepare theelevation or collar elevation map to identify the topographic variations on the ground surfaceso that it can give the synoptic picture of gradient variations in the water levels. Thetopographic elevation values have been plotted to prepare the elevation contour map and isin Fig.

Sub Surface Aquifer Disposition

To understand the sub surface disposition in the study area, geological sections and fence diagram have been prepared by synthesizing the various sub-surface sections on the basis of study of the lithological logs and electrical logs of boreholes drilled by CGWB, PHED using the RockWorks15 software and a 3D lithological model has been prepared (Fig.). The 2D lithology sectionsand 3D lithological fence diagramhas been prepared using lithology model and are shown in Fig. a, b & 16 respectively. The aquifers are composed of fine to medium sand with clay intercalations. The granular zones are extensive.

3-Dimension Lithological Model

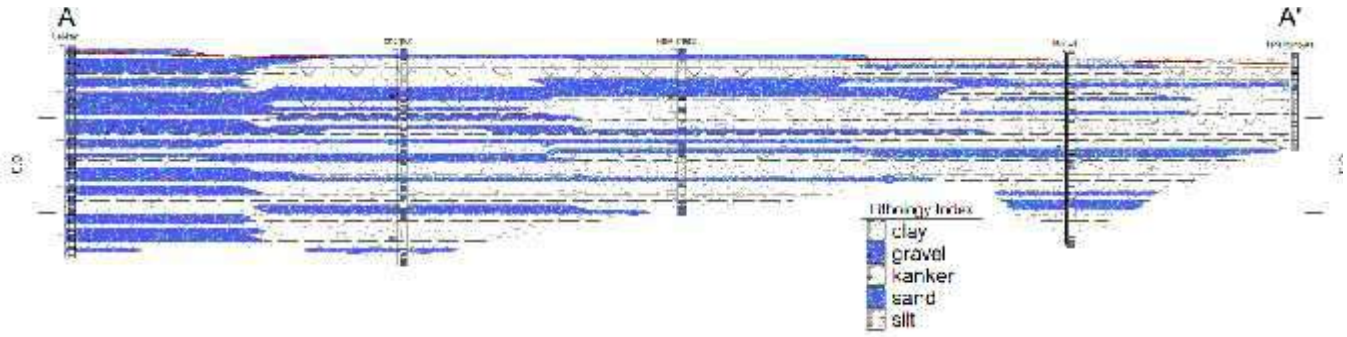




3-Dimension Lithological Fence

Aquifer Geometry:

Above fence diagram prepared by utilizing the litho logs and electrical logs of exploratory boreholes, indicating the disposition and inter-relationship of granular zones has been presented in above fig. The diagram as a whole indicates that the clay group of formations dominates over the sand group. However, comparatively the sand group percentage increases slightly in the central and northern parts of the district whereas clays exist predominantly in the southern part of the district. The granular zones are more of lenticular types in the southern and north eastern part of the district are more persistent in the rest of the area. **2-Dimension Lithological Sections**



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 aquiferspresent upto 300m depth. The assessment of dynamic ground water Resources of the studyarea have been carried out jointly by CGWB and Ground Water Cell, Department of Agriculture, Haryana on the basis of Ground Water Estimation Committee (1997)methodology.

The occurrence of potential aquifers (productive granular zones) upto 300 m depthhas been demarcated on basis of aquifer wise subsurface mapping. The total saturatedthickness of granular zones was derived from the exploratory borehole data of a particularblock. The granular zones occurring below the zone of water level fluctuation up to the firstconfining layer has been considered as static unconfined zone. The ground water resource ofthis zone has been calculated considering 12% specific yield of the formation. The specificyield value for the unconfined aquifer has been taken as 60% of 0.12 which comes as 0.072whereas for the confined aquifer, the storativity value has been considered. Since the specificyield 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 ofgranular zones, specific yield/storativity, and area of both fresh water and saline/brackishwater. It has been observed that in some of the blocks sufficient data on probable occurrenceof granular zones was not available. In those cases, the existing exploratory data of adjoiningblock/district has been either extrapolated or interpolated to derive such parametersrequired for estimation. This assessment of total groundwater resources has beencomputed based on the available data with CGWB &PHED, Haryana

Unconfined Aquifers

a. Dynamic Resources:

Block-wise ground water resource potential of the district has been assessed as per GEC-97 as on 31st March 2013. The primary source of recharge in the area is the rainfall.The ground water development in all the blocks has exceeded the availablerecharge, thus allthe blocks have been categorized as over exploited. Stage of groundwater development in the Karnal district has been assessed to be 184%. The details are explained in below Table

Table-: Dynamic Ground Water Resource & Development Potential (31.03.2013) inham

Assessment Unit/ Block	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for domestic and industrial water supply*	*Existing Gross Ground Water Draft for All uses (11+12)*	*Provision for domestic, and industrial requirement supply to 2025*	*Net Ground Water Availability for future irrigation development (10-11-14)*	*Stage of Ground Water Development {(13/10) * 100} (%)*	*Category*
Assandh	Total	**8701**	21640	52	21692	52	-12991	249
Gharaunda	Total	**9619**	10485	344	10829	344	-1210	113
Indri	Total	**18222**	11810	284	12094	348	6064	66
Karnal	Total	**13772**	13486	563	14049	401	-115	102
Nilokheri	Total	**9075**	11546	358	11904	358	-2829	131
Nissang	Total	**12557**	16344	252	16596	252	-4039	132
Total	**Total**	**71946**	**85311**	**1853**	**87164**	**1755**	**-15120**	**121**

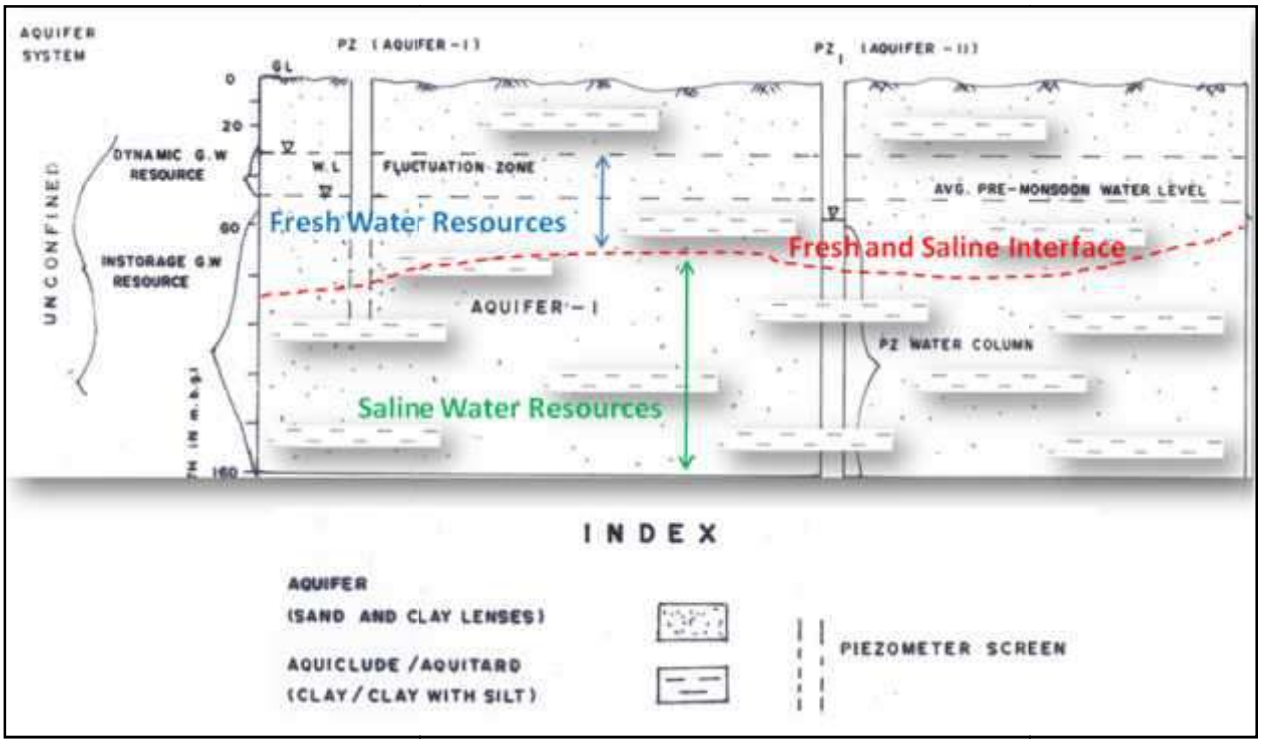
b. In-storage Ground Water Resources

As per revised guidelines recommended by the Central Level Expert Group on groundwater resources assessment, the resources are separately considered as dynamic andin-storage unconfined. In case of alluvial area, the in-storage resources of unconfined aquiferhave 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

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

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



(The clay lances are more dominant in the aquifer and sometimes huge thickness of clay deposits are also observed in the litholo

Table-: BLOCK WISE IN-STORAGE GROUND WATER RESOURCESOF UNCONFINED AQUIFER

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 unsaturated Granular Zone in AQUIFER GROUP-I above Pre-monsoon WL (m)	Thickness of the Granular Zone in AQUIFER GROUP-I below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Ground Water Resources [(5)*(10)*(11)*] (ham)	Volume of the unsaturated Granular Zone in AQUIFER GROUP-I above Pre-monsoon WL (m)
		Total Geographical Area	Fresh Water								
1	2	4	5	6	7	8	9	10	11	12	13
1	Assandh	50485	50485	17	139	122	12	83	0.072	301698.36	72698.40
2	Gharaunda	39453	39453	19	138	119	13	57	0.072	161915.11	61546.68
3	Indri	35303	35303	12	186	174	11	90	0.072	228763.44	46599.96
4	Karnal	40723	40723	15	139	124	11	61	0.072	178855.42	53754.36
5	Nilokheri	39491	39491	18	130	112	6	89	0.072	253058.33	28433.52
6	Nissang	41657	41657	18	152	134	3	70	0.072	209951.28	14996.52
	Dist.Total (ham)	**247112**	**247112**							**1334253.94**	**278029.44**
	Dist.Total (mcm)									**13342.54**	**2780.29**
	Dist.Total (bcm)									**13.34**	**2.78**

Table- BLOCK WISE INSTORAGE GROUNDWATER RESOURCES OF CONFINED AQUIFER (AQUIFER-II)

Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)		Top Aquifer II (m bgl)	Depth to bottom of Aquifer II (m bgl)	Thickness of piezometric level (m)	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	Static in-Storage Ground Water Resources [(4)*(9)*(13)*] (ham)	Dyanamic In-Storage Ground Water Resources [(6)*(11)*(12)*] FRESH (ham)	Total Ground water Resources
			Total Geographical Area	Fresh Water										
1	2	3	4	6	7	8	9	10	11	12	13	14	15	16
1	Assandh	Alluvium	50485	50485	186	219	170.5	33	20	0.072	0.00451	38821	72698.4	111519.09
2	Gharaunda	Alluvium	39453	39453	210	238	194.5	28	19	0.072	0.00451	34608	53971.704	88579.68
3	Indri	Alluvium	35303	35303	175	247	159.5	72	34	0.072	0.00451	25395	86421.744	111816.78
4	Karnal	Alluvium	40723	40723	195	248	179.5	53	46	0.072	0.00451	32967	134874.576	167841.68
5	Nilokheri	Alluvium	39491	39491	175	247	159.5	72	32	0.072	0.00451	28408	90987.264	119394.92
6	Nissang	Alluvium	41657	41657	192	239	176.5	47	28	0.072	0.00451	33160	83980.512	117140.11
	Dist.Total (ham)		**258340**	**258340**								**154537.36**	**522934.20**	**677471.56**
	Dist.Total (mcm)											**1545.37**	**5229.34**	**6774.72**
	Dist.Total (bcm)											**1.55**	**5.23**	**6.77**

Average piezometer head of Aquifer II 15.50 m. bgl

BLOCK WISE INSTORAGE GROUNDWATER RESOURCES - CONFINED (AQUIFER-III)

Sr. No.	Name of Assessment Unit	Areal extent (ha)		Depth to Top Aquifer III (m bgl)	Depth to bottom of Aquifer III (m bgl)	Thickness of piezometric level (m)	Total Thickness of confined aquifer down to explored depth (m) (9-8)	Thickness of the Granular Zone in confined aquifer down to explored depth of 300m (m)	Average Specific Yield	Average value of Storativity	Static in-Storage Ground Water Resources [(6)*(9)*(13)*] (ham)	Dyanamic In-Storage Ground Water Resources [(6)*(11)*(12)*] (ham)	Total Ground water Resources
		Total Geographical Area	Fresh Water										
1	**2**	**4**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	15	16
1	Assandh	50485	50485	264	300	250.5	36	17	0.072	0.00451	57036	61793.64	118829
2	Gharaunda	39453	39453	292	300	278.5	8	8	0.072	0.00451	49554	22724.928	72279
3	Indri	35303	35303	273	300	259.5	27	18	0.072	0.00451	41317	45752.688	87069
4	Karnal	40723	40723	288	300	274.5	12	12	0.072	0.00451	50415	35184.672	85600
5	Nilokheri	39491	39491	276	300	262.5	24	18	0.072	0.00451	46752	51180.336	97933
6	Nissang	41657	41657	300	300	286.5	0	0	0.072	0.00451	53826	0	53826
	Dist.Total (ham)	**258340**	**258340**								**298900**	**216636.264**	**515536**
	Dist.Total (mcm)										**2989.00**	**2166.36264**	**5155**
	Dist.Total (bcm)										**2.989**	**2.17**	**5.16**

Average piezometer head of Aquifer III 13.50 m. bgl

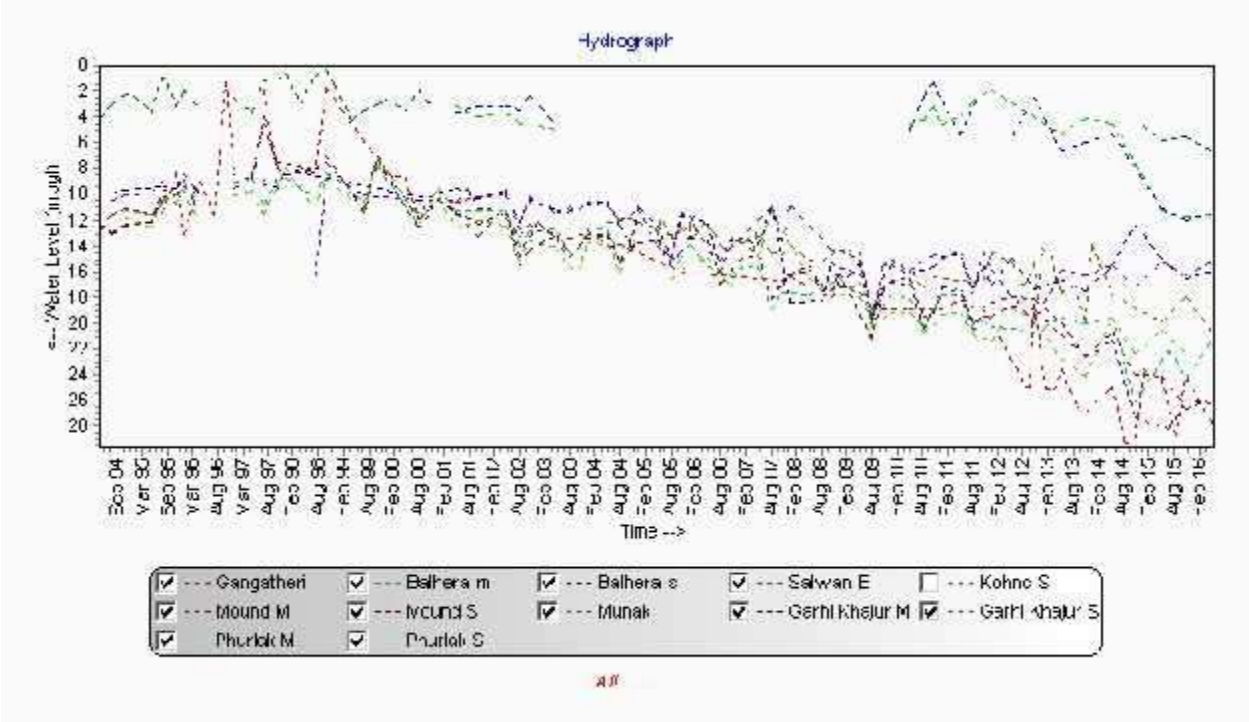
AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN KARNAL DISTRICT UPTO 300 METRE DEPTH							
Sl.No	**BLOCK**	*Dynamic Groundwater Resources (2011) AQUIFER-I*	*In-storage Groundwater Resources AQUIFER-I*	**Groundwater Resources AQUIFER-I [(4)+(5)]**	**Total Groundwater Resources AQUIFER-II**	**In-storage Groundwater Resources AQUIFER-III**	**Total Availabilty of Groundwater Resources [(5)+(6)+(7)]**
							ham
1	*2*	3	4	5	6	7	8
1	Assandh	8701	301698	310399	111519.09	118829	540748
2	Gharaunda	9619	161915	171534	88579.68	72279	332393
3	Indri	18222	228763	246985	111816.78	87069	445872
4	Karnal	13772	178855	192627	167841.68	85600	446069
5	Nilokheri	9075	253058	262133	119394.92	97933	479461
6	Nissang	12557	209951	222508	117140.11	53826	393474
Dist.Total (ham)		**71946**	**1334242**	**1406188**	**677471.56**	**515536**	**2599195**
Dist.Total (mcm)		**719**	**13342**	**14062**	**6774.72**	**5155**	**25992**
Dist.Total (bcm)		**0.72**	**13.34**	**14.06**	**6.77**	**5.16**	**25.99**

GROUND WATER ISSUES

5.1 Ground Water Depletion

Karnalis famous for its paddy cultivation and is also known as 'Rice Bowl' of Haryana.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. The hydrographs also shows the declining water level trend over the years and the district is also categorized as over-exploited.

Fig.23: Long term ground water table variation



6.0 MANAGEMENT STRATEGIES AND AQUIFER MANAGEMENT PLAN

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, PMKVY, NABARD funded schemes, Urban Development schemes, departmentally funded projects etc. may be benefitted from the recharge plan by incorporating the input in the operational guidelines/ design and for locating the specific sites.Agriculture university, engineering Collages, Academic and Research Institution, NGO may also take up the pilot or demonstrative projects in the blocks suitable to them to plan at local level as per local conditions.

A. POTENTIAL FOR REDUCTION IN OVERDRAFT AFTER RAINWATER HARVESTING AND ARTIFICIAL RECHARGE

Sr.no.	Type of Structure	No. of structures	Unit cost in Lakhs	Total cost of structure in Lakhs(IN CRORE)	Annual Recharge (MCM)
ROOF TOP RAIN WATER HARVESTING IN RURAL AND URBEN AREAS					
1	**Artificial Recharge Plan For Urban Areas.**	6185	0.25	**15.46**	**0.245**
2	**Roof Top Rain Water Harvesting in Rural Areas**	19860	0.25	**49.65**	**1.068**
	Total	**26045**	**0.25**	**65.11**	**1.313**
ARTIFICIAL RECHARGE IN FARMS					
1	**Artificial Recharge Plan Through Recharge Pits.**	23930	0.35	83.76	16.081
			Total	**148.87**	**17.394**

By the implementation of the proposed recharge structures there will be a reduction of 1.88%

in stage of ground water development as tabulated below

Sr.no.	Total Draft (present) **(mcm)**	Recharge through different proposed structures **(mcm)**	Draft Reduced due to Recharge **(mcm)**	Stage of development (present) (Average value of three OE Blocks)	Stage of development after recharge	Reduction in stage of development after recharge
1	**1218.91**	**17.394**	**1201.52**	**148%**	**146.12%**	**1.88%**

ARTIFICIAL RCEHARGE PLAN THROUGH RECHARGE PITS IN OVER EXPLOITED BLOCKS OF KARNAL DISTRICT

DISTRICT NAME	**Block Name**	**Total area of the village (in hectares rounded up to one decimal place)**	**10%of village area taken for farm recharge(sq m)**	**Total number of recharge pits (1 recharge pit / hector) for 10% area**	**Annual recharge (MCM)= (Area*Runoff 15%*Rainfall in m/1000000)**	**Cost of Pit @Rs.0.35 lakh (In Crore)**
KARNAL	Assandh	49430	49430000	4943	3.322	17
	Gharaunda	36567	36567000	3657	2.457	13
	Indri	34410	34410000	3441	2.312	12
	Karnal	38640	38640000	3864	2.597	14
	Nilokheri	39329	39329000	3933	2.643	14
	Nissang	40919	40919000	4092	2.750	14
	Total	239295	239295000	23930	16.081	84

Number of Recharge pits are based on following factors:

Availability of Irrigation wells In the farmer land

Area of sandy strata at shallow depth identified

Type of structure will be recharge pit/ Recharge well (where top three meters is clay)

ROOF TOP RAINWATER HARVESTING IN RURAL AREAS OF KARNAL DISTRICT OF HARYANA

Sr.No.	Name of CD block	Total area of the village (in hectares rounded up to one decimal place)	Number of households (2011 census)	No of Houses taken for Artificial Recharge (10% of total households)	Total No of AR Structures (one structure for 10 house holds)	Total rechaerge in MCM	Cost @0.25 lack (In Crore)
1	Assandh	49430	33617	3362	3362	0.181	8
2	Gharaunda	36567	36442	3644	3644	0.196	9
3	Indri	34410	27100	2710	2710	0.146	7
4	Karnal	38640	39566	3957	3957	0.213	10
5	Nilokheri	**39329**	**32027**	3203	3203	0.172	8
6	Nissang	40919	29842	2984	2984	0.160	7
	Total	**239295**	**198594**	**19860**	**19860**	**1.068**	49

ARTIFICIAL RECHARGE PLAN FOR URBAN AREAS OF KARNAL DISTRICT, HARYANA

District	Name of CD Block	Town Name	Total Households	Total Population of Town	HousholdS taken for Atificial Recharge (10%)	Total Roof Top Area (sqm)	Vol of water available for recharge (MCM)	Cost @0.25 lack (In Crore)
KARNAL	NILOKHERI	Nilokheri (MC)	3908	17938	391	39080	0.020	1
	NILOKHERI	Taraori (MC)	5240	25944	524	52400	0.026	1
	INDRI	Indri (MC)	3546	17487	355	35460	0.016	1
	KARNAL	Karnal (M Cl + OG)*	63280	302140	3164	316400	0.118	8
	NISSING	Nissing (MC)	3361	17438	336	33610	0.013	1
	KARNAL	UnchaSiwana (CT)	1807	8922	181	18070	0.007	0
	ASSANDH	Assandh (MC)	5081	27125	508	50810	0.018	1
	GHARAUNDA	Gharaunda (MC)	7267	37816	727	72670	0.028	2
	TOTAL				**6185**		**0.245**	15

B. POTENTIAL FOR REDUCTION IN OVERDRAFT BY ENHANCING THE GROUND WATER USE EFFICIENCY OF IRRIGATION TUBE WELLS

The micro level transformation in the ground water management have vast impact potential to counter extensive ground water depletion faced by the state of Haryana, particularly in overexploited blocks.There are around 5102 operated by farmers for irrigation through unlined/Katcha(10.95%) open channel system in Karnaldistrict 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 Karnal district is estimated at 1206.47 MCM. It is expected that around 3.79% 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 33.03 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 Karnal Districts. The measure if implemented will bring down the ground water overdraft from 148% to 144 %. 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 Haryana**. Heavy ground water overdraft can be reduced by these efforts. This will ensure **more crop per drop**.

POTENTIAL FOR REDUCTION IN OVERDRAFT BY ENHANCING THE GROUND WATER USE EFFICIENCY IN IRRIGATION TUBEWELLS, KARNAL DISTRICT

Net Annual Ground Water Availability (mcm)	**Total Draft (present) (mcm)**	**Gross Irrigation Draft (present) (mcm)**	**Gross Ground Water Draft for Domestic and industrial supply (mcm)**	**Pecentage of unlined channel**	**Wastage through unlined channel, (mcm)** **(Col 3 X Col5 X 0.25[#])**	**Potential of Reduced irrigation overdraft (Col3-col6) (mcm)**	**Gross draft after saving of water (mcm)** **(Col 7+Col4)**	**Present Stage of development (%)**	**Stage of development afterwards((Col 8/Col1)X100)** **(%)**	**Reduction in stage of development after constructing pucca canal** **(Col9-Col10) (%)**
1	2	3	4	5	6	7	8	9	10	11
822.31	1218.91	1206.47	12.44	10.95	**33.03**	1173.4	1185.88	**148**	144	3.79

#losses from open kuchha channel are around 25%.

COST ESTIMATE OF UNDERGROUND PIPE LINE

District	Block	Irrigated area by ground water scheme (ha)	Percentage of Unlined Channel (%)	Area under unlined Channels	Total cost @Rs.0.50 lakh per hector(in cr) Area *0.50/100 = Crores	Total Cost in Rs.Cr. District wise
Karnal	**Assandh**	21023	10.95	2302	12	**92**
	Gharaunda	29746	10.95	3257	16	
	Karnal	30585	10.95	3349	17	
	Indri	28571	10.95	3129	16	
	Nilokheri	28590	10.95	3131	16	
	Nissing	26905	10.95	2946	15	

BLOCK WISE

AQUIFER MAPS

AND

MANAGEMENT PLAN

(PART-II)

CGWB exploration and Aquifer Disposition

4.1 Analysis of litho-logs

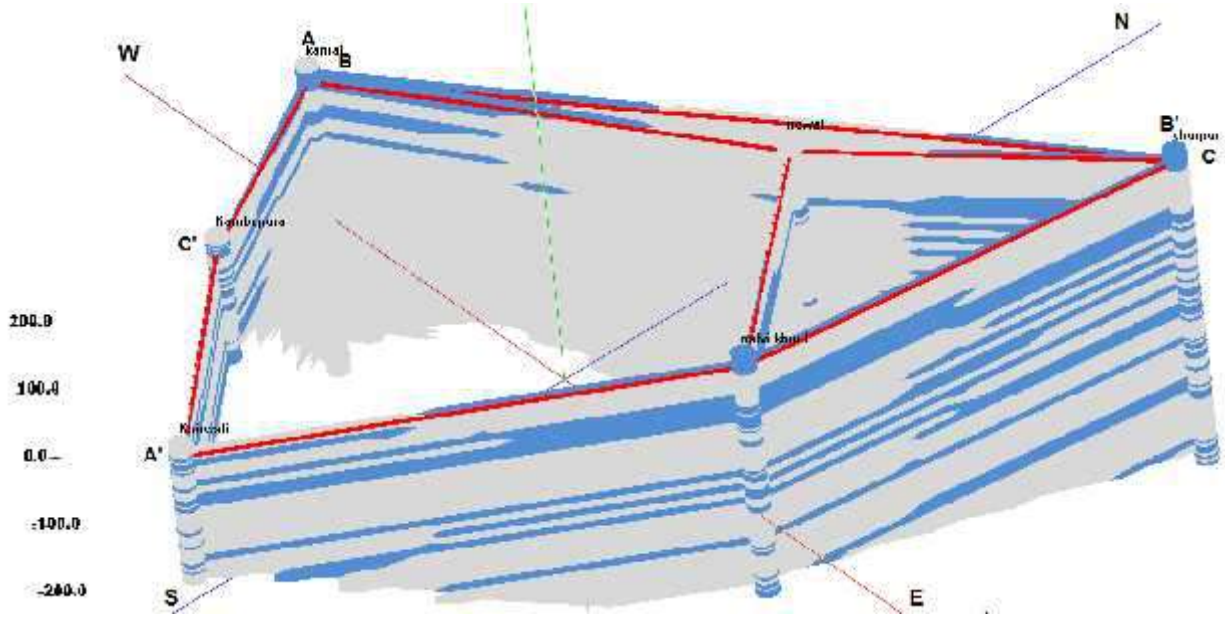
The exploration has revealed that the occurrence of relatively impermeable fine-grained material is erratic and not regularly extensive. However within the depth of 175 m bgl the probability of their occurrence is very high in the entire area which gives rise to a leaky confined aquifer conditions at depth. The aquifer system in the area can be taken as multilateral unit with possible interconnections. Results of the exploration show that tube wells within the depth range of 50-175 m in can be designed to tap aquifer. However at the time of construction of tubewell quality should be taken into account keeping requirement of water. Shallow tubewell upto depth of 50 m can be constructed in entire area depending upon quality of water in the area.

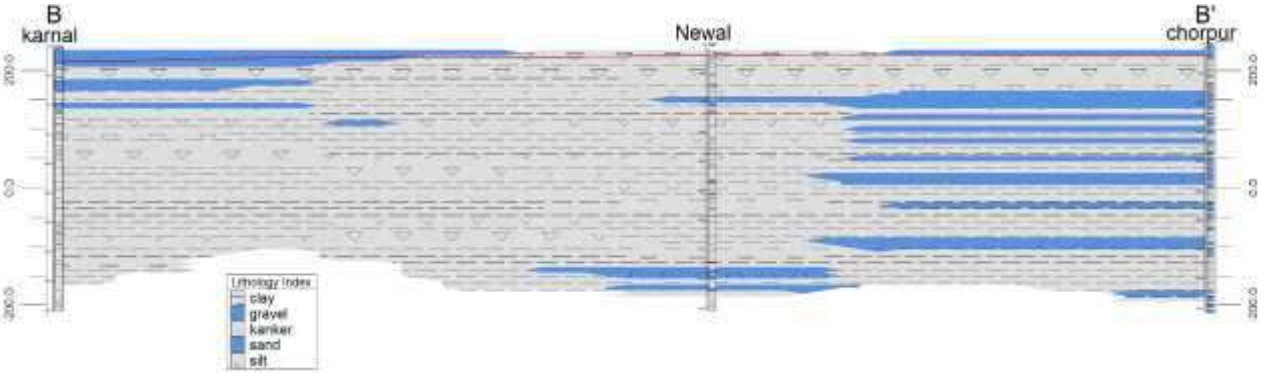
Tubewells constructed in northern part of district are high yielding and are capable of providing good quality of water whereas tubewells in the southern part of the district are giving lesser yields and poor quality of water.

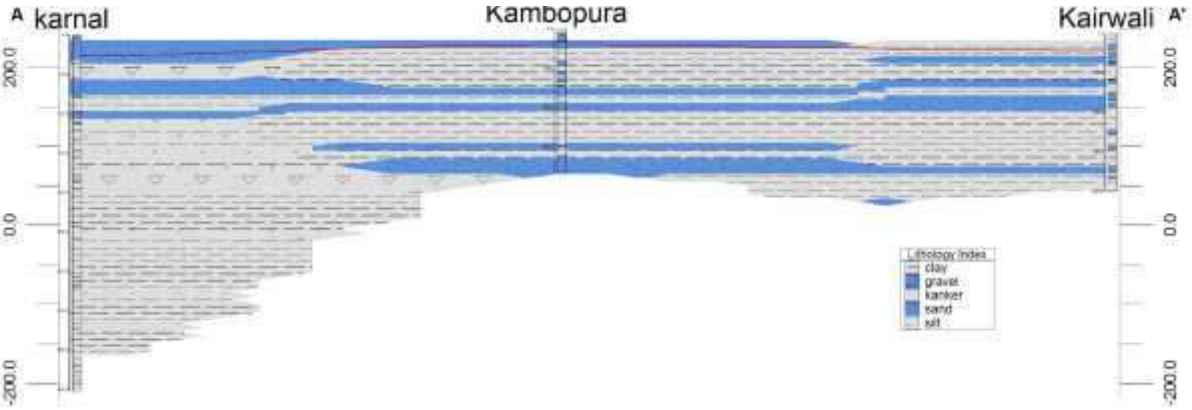
4.2 Cross section

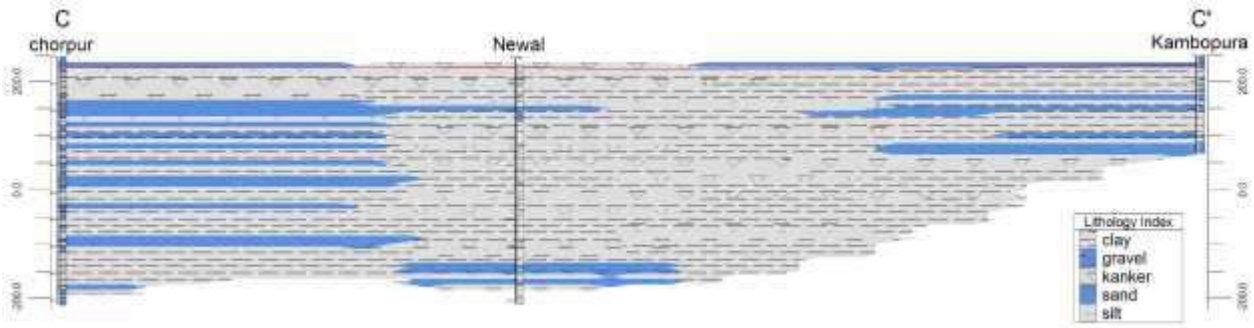
The cross sections are made to understand the sub surface geology and aquifer disposition of the Aquifer system of the area.The cross-section are made by selecting two to three lithological data of boreholes and the data was interpreted by using the Rockworks software.

(a) Block:-KARNAL









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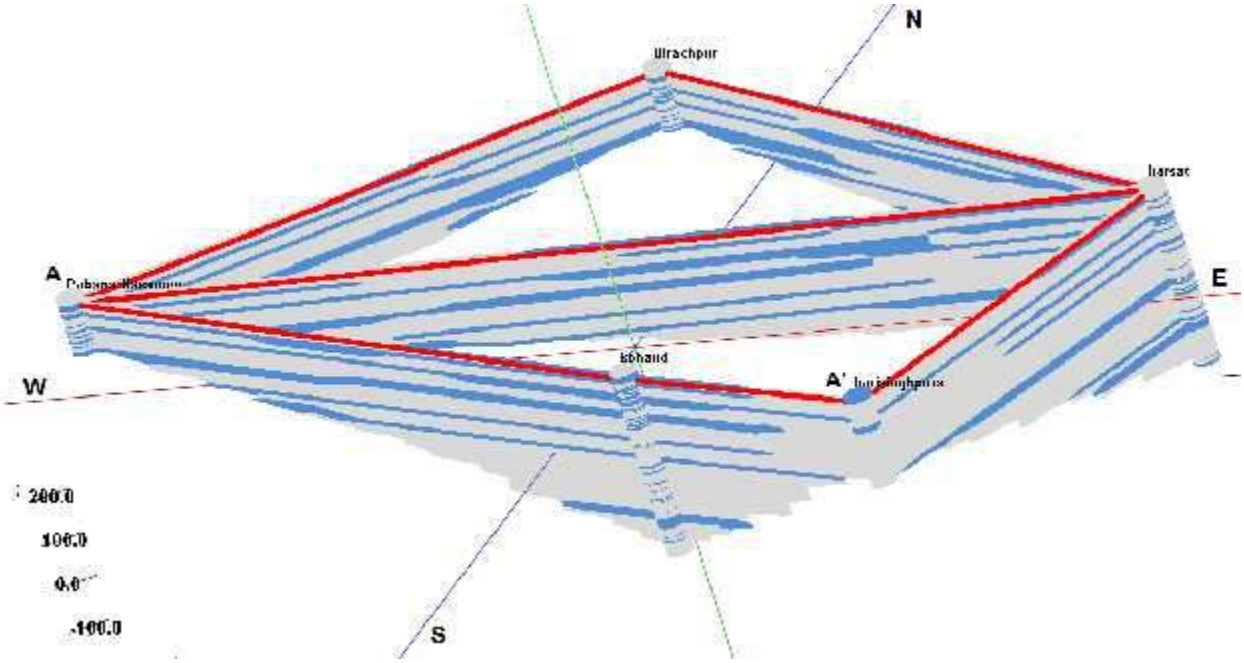
Block:-GHARAUNDA



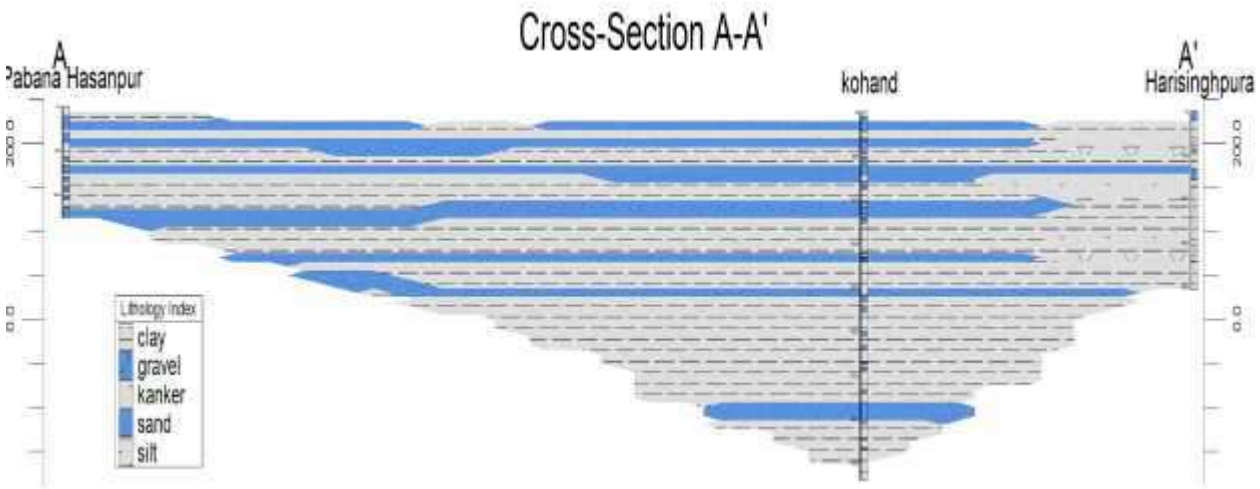
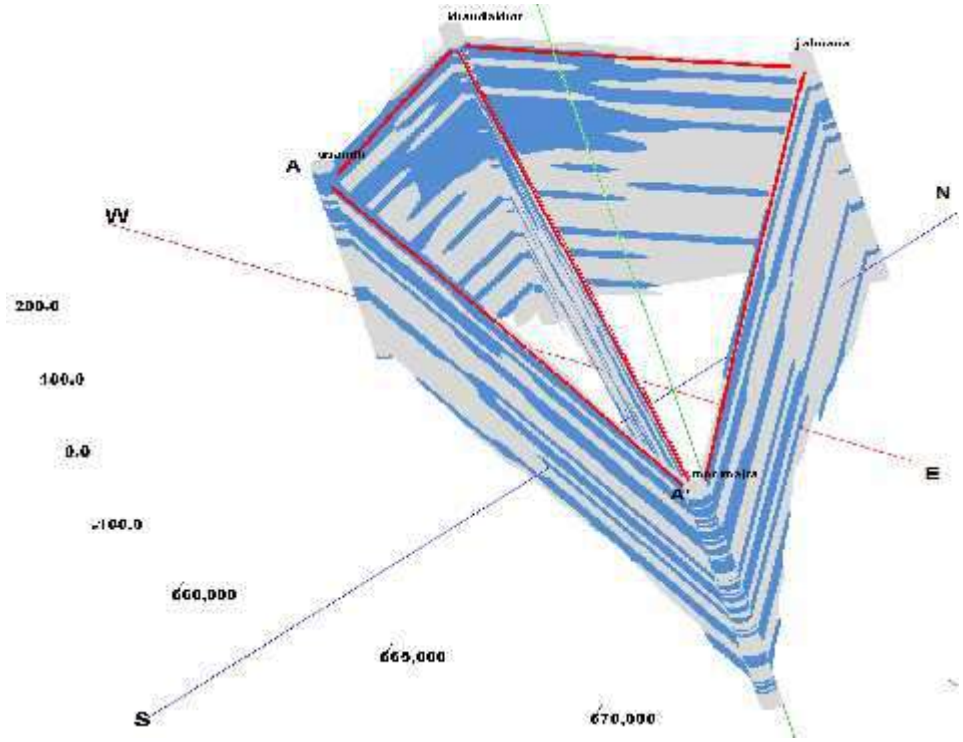


Figure 4.6Hydro-Geological Cross Section A-A`of Gharaunda Block

BLOCK ASSANDH



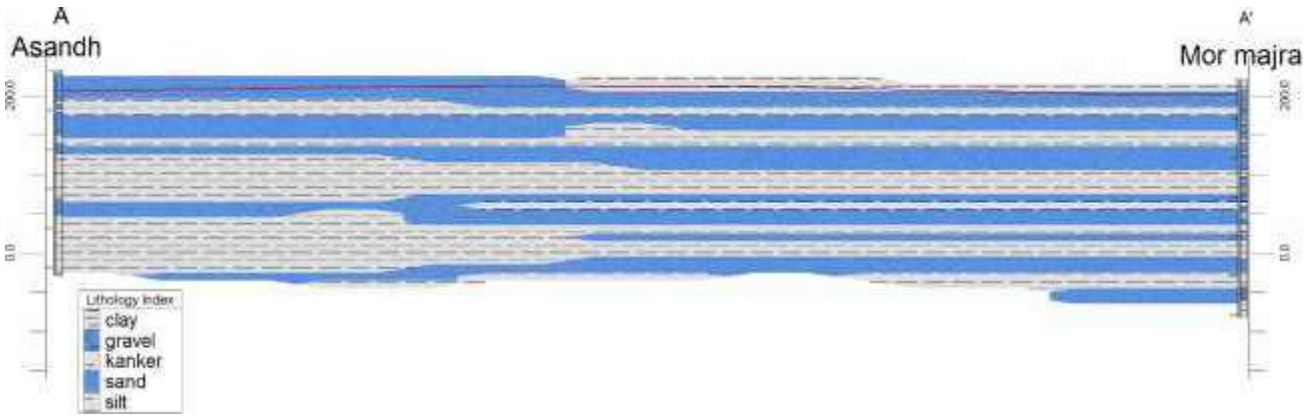
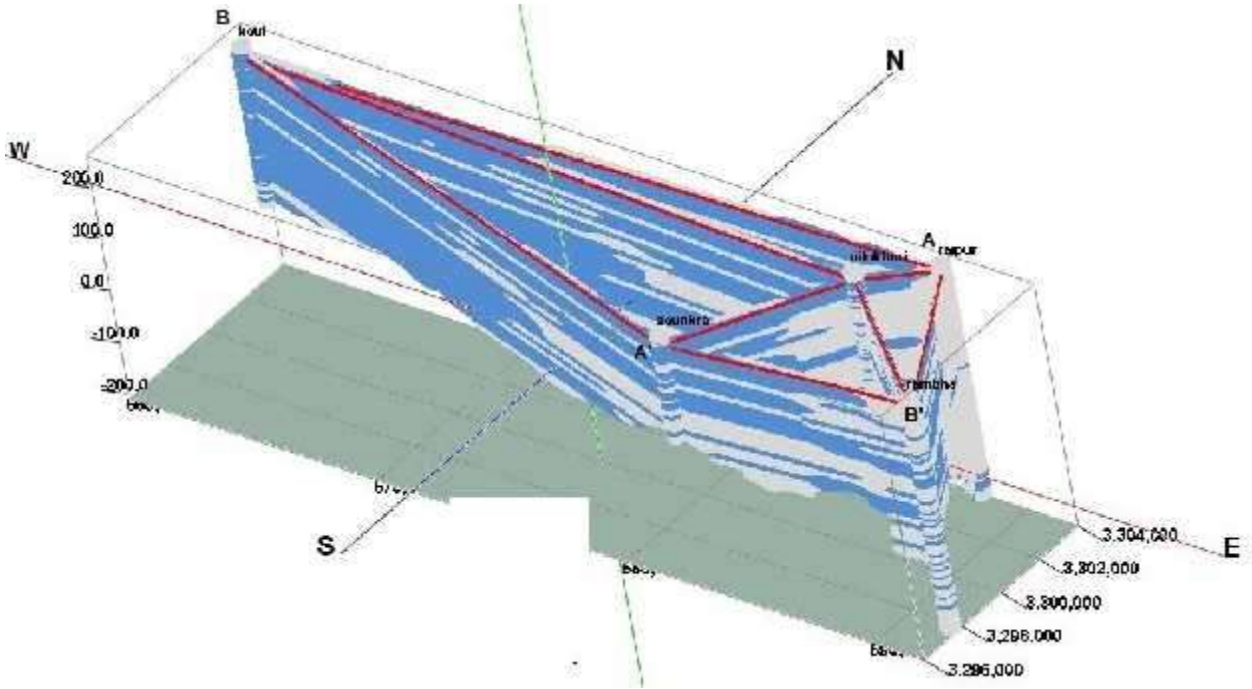
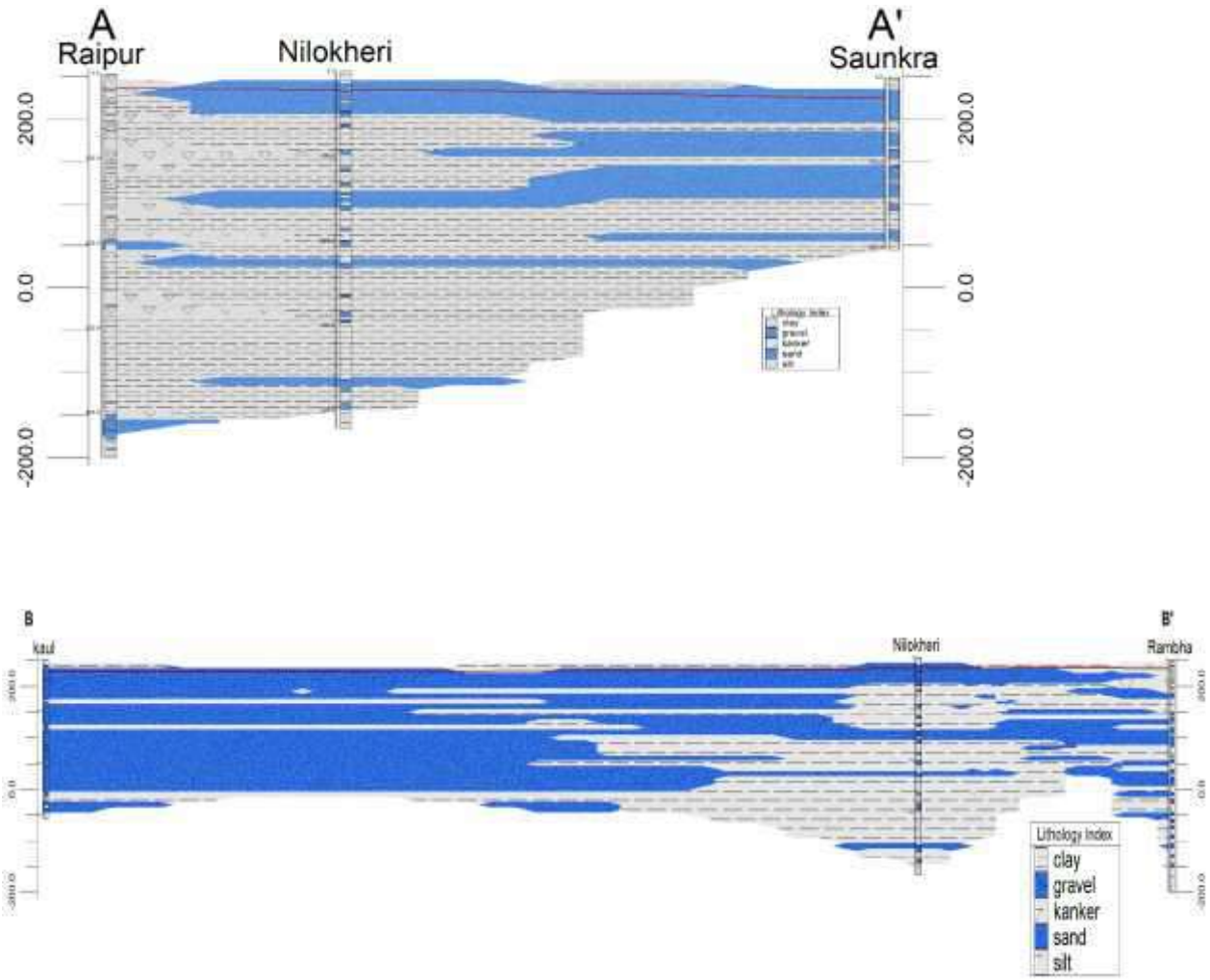


Figure 4.8Hydro-Geological Cross SectionA-A` ofAssandh Block

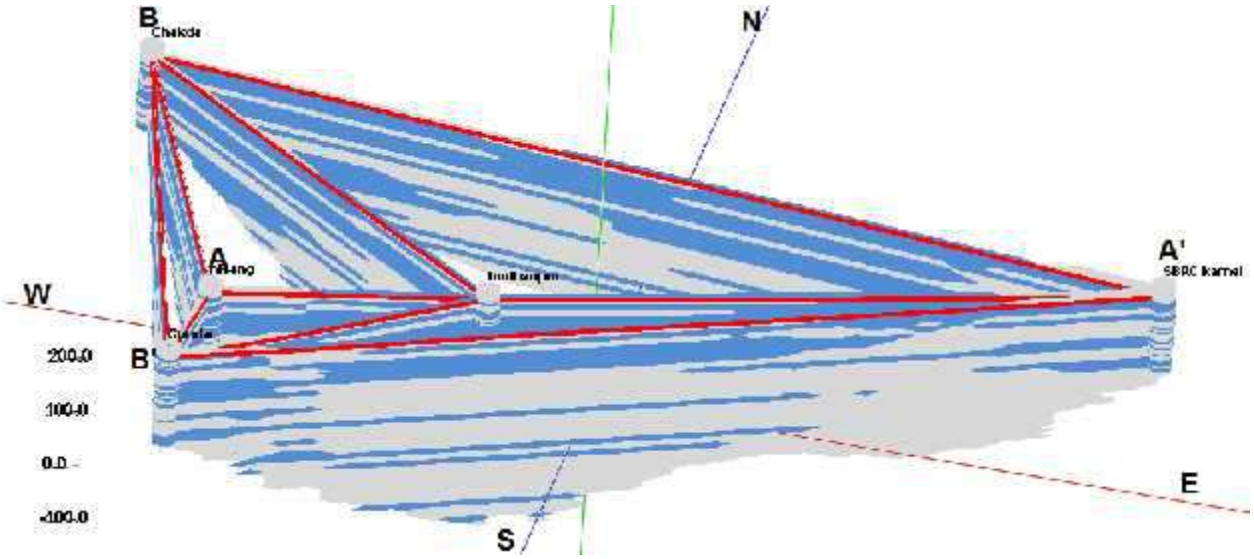
BLOCK NEELOKHERI

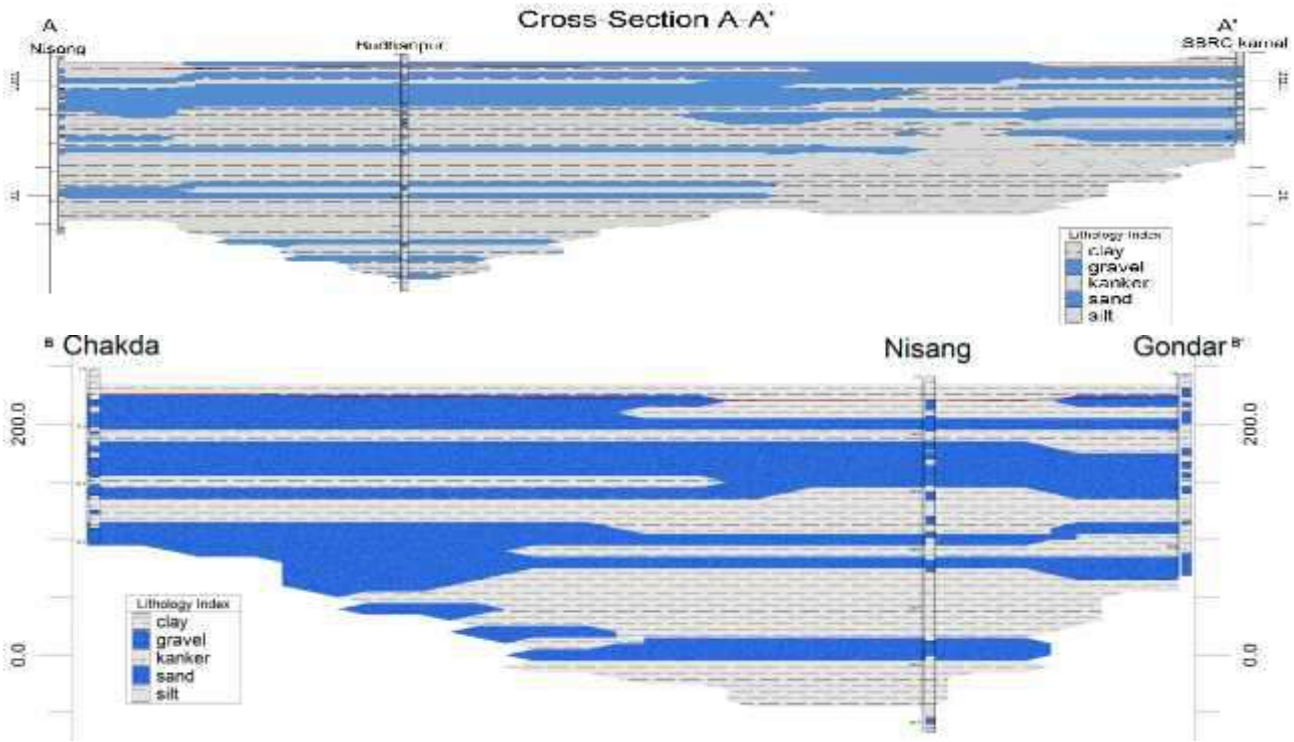




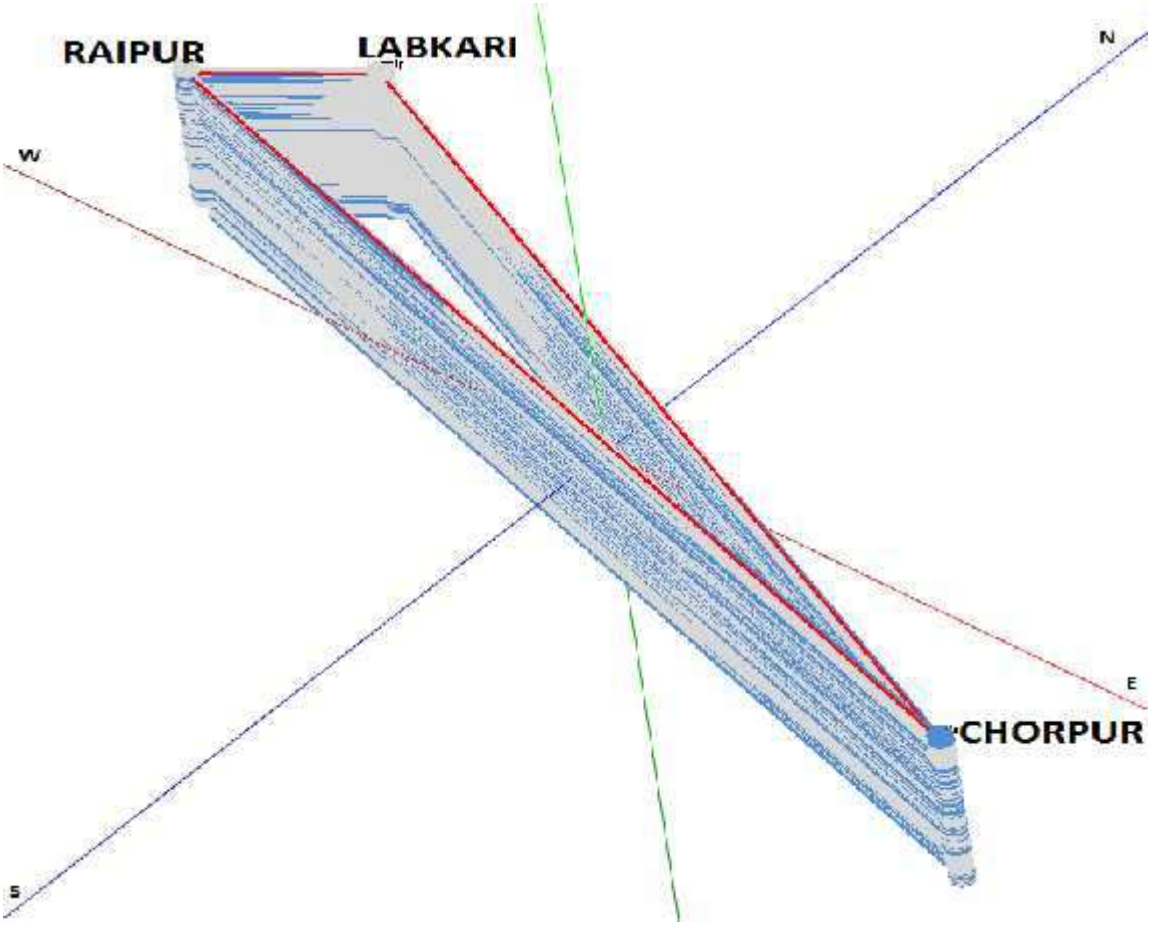
CROSS SECTION IN NEELOKHERI BLOCK

BLOCK NISSING





BLOCK INDRI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CHORPUR
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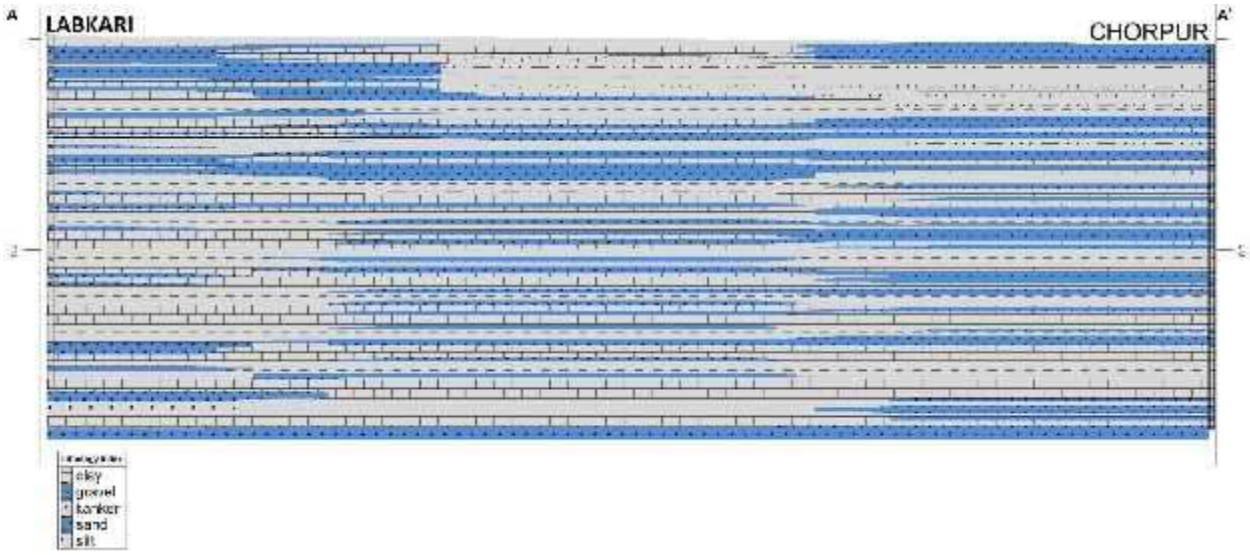
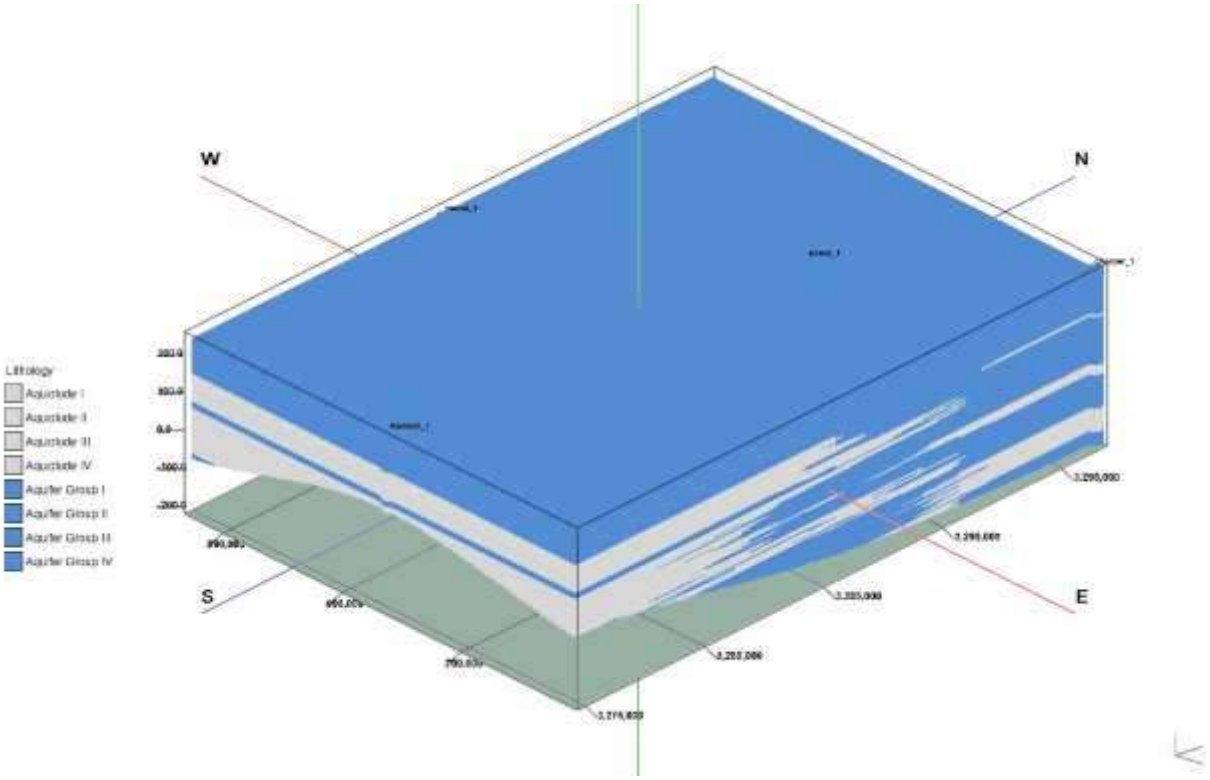

A
LABKARI
CHORPUR
A'
clay
gravel
kankar
sand
silt

4.3 Aquifer Groups

After studying the cross sections and litho log of wells it is observed that the whole area of the Karnal district consist mainly three aquifer groups below the ground surface. The area has both unconfined and confined aquifers.Thickness of 1stgroup extending down to a maximum depth of 186mbgl varies from place to place and water occurs under water table conditions. The ground water occurring under unconfined conditions are tapped by shallow tube wells but the IInd and IIrd aquifers are present 98 to 294 & 182 to 377 mbgl



Aquifer Grouping in Karnal District

Aquifer Group	Range		Thickness	
	From	To	Min	Max
Aquifer I	0	186	94	186
Aquifer II	98	294	10	117
Aquifer III	182	377	27	104
Aquifer IV	322	464	21	47