केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

BIKANER DISTRICT
RAJASTHAN

पश्चिमी क्षेत्र, जयपुर

Western Region, Jaipur

Draft Report for office use only

AQUIFER MAPPING AND GROUNDWATER MANAGEMENT PLAN BIKANER DISTRICT, RAJASTHAN

Western Region, Jaipur

केन्द्रीय भूमि जल बोर्ड

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Report on

AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN

BIKANER DISTRICT, RAJASTHAN

(30247 sq.km)

AAP 2017-18

पश्चिमी क्षेत्र, जयपुर

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AQUIFERMAPPINGANDMANAGEMENTPLAN
BIKANERDISTRICT, RAJASTHAN
(30247 sq.km.)

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AQUIFER MAPPING AND MANAGEMENT PLAN

BIKANER DISTRICT, RAJASTHAN (30247Sq.km.)

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AQUIFERMAPPINGANDMANAGEMENTPLAN
BIKANERDISTRICT, RAJASTHAN
(30247 sq.km.)

District at a Glance

SALIENT INFORMATION		
District Name	Bikaner	
Longitude	71°52' and 74°15' East	
Latitude	27°11' and 29°03' North	
Geographical Area sq.km	30381.77	
Hilly Area (sq.km)	0	
Population (2011)	2363937	
Climate		
Average Temperature range (°C)	Maximum: 38 to 42	
	Minimum : 10 to 23	
Rainfall Analysis		
Normal Rainfall (mm)	292.2	
Mean Annual rainfall (mm)	302.2	
Highest annual rainfall (mm) with year	607.4 (1997)	
Lowest annual rainfall (mm) with year	66.3 (2002)	
Standard deviation (mm)	116.00	
Coefficient of Variation (%)	38.4	
Drought Analysis	No. of years of Drought	Frequency %
Mild (0 to -25%)	13	28
Normal (-25% to -50%)	11	23
Severe (-50% to -75%)	02	4
Most severe (-75% to -100%)	01	2
Probability of Normal Rainfall	55%	
Geomorphology	Older alluvial plains, Sandy undulating aggraded Alluvial plains, Flat Interdunal Plains, Sandy undulating interdunal plains, Flood plane, Aeolian complex, Stabilized Sand dunes, Active Sand dunes, Gravelly aggraded alluvial plains, Eroded rocky surface, Saline depressions, Sandy Plain	
Elevation (m amsl)	103.7-349.1	
Geology	Very fine, buff to grey sand, Unconsolidated to loosely consolidated sand, find to medium, silty clays and kankar with occasional horizons of gravel and coarse sand. : Age Recent to sub recent	

		Coarse and gritty sandstone usually consolidated, porous, within intercalated clays and gravel, fuller earth andLignite also occur in thin sequences : Age Tertiary Hard compactly consolidated, reddish sandstone interbedded with red shale's. Limestone, hard, massive grey to blackish in colour with occasional cavities. Age Palaeozoic	
Drainage & Hydrology			
Drainage **Basin/Sub-Basin**		No Major Drainage	
LAND USE, AGRICULTURE, IRRIGATION & CROPPING PATTERN			
Geographical Area in ha.		3040476	
Forest Area in ha.		92850	
Net Sown Area in ha.		1273208	
Area sown more than once in ha.		161004	
Irrigated Crop		Jawar/Bajra/ Wheat / Barley / Gram, Mustard/Ground nut	
Area under Irrigation (Net) in ha			
	Surface Water	318079	
	Ground Water	390763	
	Other sources	8	
Season wise crop area in ha.			
	Kharif	**Rabi**	**Zaid Rabi**
Sown	1250104	491750	1741854
Principal Crops			
Crop Type	**C**ereals	205900	
	Oil Seeds	237395	
	Pulses	499715	
Hydrogeology			
Monitoring Stations (May 2018)			
	CGWB	62	
	SGWD	347	
	NAQUIM Key Wells	144	
WATER LEVEL BEHAVIOUR		Pre-Monsoon (May-2018)	Post-Monsoon (November-2018)
Water Level (m bgl)		7.29-148	7.46-149
AQUIFER DISPOSITION			
Number of Aquifers		Three	
Number of Zones		Three	
I		Sand	

II			Sand/Sandstone	
III			Sand/Sandstone	
Status of GW Exploration			CGWB	GWD
			189	125
CHEMICAL QUALITY OF GROUND WATER				
Electrical ConductivityµS/cm at 25°C			180 to 18000	
pH			7.02 to 8.85	
Suitability for Drinking				
TDS	**Range**		**% samples**	
Fresh	0-2000		81.79%	
Brackish	>-2000		18.21%	
Hardness	**Range**		**% samples**	
Soft	0 – 75		2.00%	
Moderately Hard	75 – 150		24.70%	
Hard	150 – 300		44.44%	
Very Hard	>300		24.56%	
NO3 in mg/l>45 mg/l	permissible limit		56.98%	
F in mg/l – 1 to 1.5 mg/l	Between DL & PL		20.60%	
>1.5 mg/l	> Permissible limit		13.34%	
Suitability for Irrigation				
EC			**RSC(meq/l)**	
Type of Water	**Classification**	**% samples**	**Range**	**% samples**
			< 1.25	0%
Low Saline< 250 mg/l	Excellent	2%	1.25 - 2.0	0%
Medium Saline 250–750 mg/l	Good	21.8%	2.0 - 2.5	0%
Highly Saline 750 –2250 mg/l	Permissible	41.8%	2.5 - 3.0	0%
Very Highly saline>2250 mg/l	Doubtful	34.4%	> 3.0	100%
Na%			**SAR**	
Water Class	**Range**	**% samples**	**Water Class**	**Range**	**% samples**
Excellent	< 20	5.55%	Water Class	Range	% samples
Good	20 - 40	9.88%	Excellent	<10	70.54%
Medium	40 - 60	20.94%	Good	10 to 18	21.46%
Bad	60 - 80	47.03%	Medium	18 to 26	4%
Very Bad	> 80	16.60%	Bad	>26	4%
GROUND WATER ISSUES				
1. Low and erratic rainfall (1971-2018)			Normal annual rainfall 292.2mm	
2. Inland Salinity			In 15757.12sq.km area of Khajuwala,	

	Kolayat and lunkaransar Blocks.
3. Over-Exploitation – Resource Availability	At present the Ground water Draft is more than Annual Availability thus the district is deficit of 170.28 mcm water.
4. Rainfall and Drought	• Mild Droughts in 13% years • Normal Droughts in 11% years • Severe Drought in 2% years
4. Decadal Water Level Trend (2010-2018)-	Overall 73% area in Pre-monsoon and 67% area in Post monsoon seasons show Declining trends at an average rate of 0.58 and 0.055 m/year respectively.
GROUND WATER RESOURCE & EXTRACTION	
Ground Water Recharge Worthy Area (Sq. Km.)	30381.77
Total Annual Ground Water Recharge (mcm)	266.03
Natural Discharge (mcm)	25.05
Net Annual Ground Water Availability (mcm)	30.56
Existing Gross Ground Water Draft for All uses(mcm)	410.3
Provision for domestic and industrial requirement supply to 2025(mcm)	79.97
Stage of Ground Water Development %	170.28
Category	Over Exploited
In-Storage Resource	
Total Area (Sq. km)	30381.77
Mean aquifer	12318.94
Utilizable Volume (mcm)	307.88
Total In-storage Resource (mcm)	2998.30
Total Resource Dynamic + In-storage	3239.2
Sustainability Period in years with existing draft	11 years
SUPPLY SIDE MANAGEMENT	
GROUND WATER RESOURCE ENHANCEMENT	
Tanka (Nos.) (Capacity 50,000 liters)	24889
DEMAND SIDE MANAGEMENT	
Micro irrigation techniques	
Use of Sprinklers for Irrigation	
Irrigation Area (ha) proposed for irrigation through Sprinkler	340802.5
Water Saving by use of Sprinklers	272.64
Cropping Pattern change	
Cropping Area (ha) proposed for change in crop	22571
Water Saving by Change in Cropping Pattern	22.57
EXPECTED BENEFITS	

Net Ground Water Availability (mcm) 2017	426.70
Additional GW resources available after Supply side interventions (mcm)	1.24
Net Ground Water Availability after Supply side intervention	427.95
Ground Water Availability after Demand side intervention	272.64
Existing Ground Water Draft for All Purposes (mcm)	410.34
Net GW draft after interventions (mcm)	234.58
Present stage of G.W. development	136
Projected stage of G.W. Development	77

REPORT ON AQUIFERMAPPINGANDMANAGEMENTPLAN BIKANERDISTRICT, RAJASTHAN (30247 sq.km.)

1.0Introduction

1.1 Objectives

Various developmental activities over the years have adversely affected the groundwater regime in the state. There is a need for scientific planning in development of groundwater under different hydrogeological situation and to evolve effective management practices with involvement of community for better ground water governance. In view of sprouting challenges in the ground water sector in the state there is an urgent need for comprehensive and realistic information pertaining to various aspects of groundwater resource available in different hydrogeological setting through a process of systematic data collection, compilation, data generation, analysis and synthesis. Hence, aquifer mapping and management of the study area is the need of the hour.

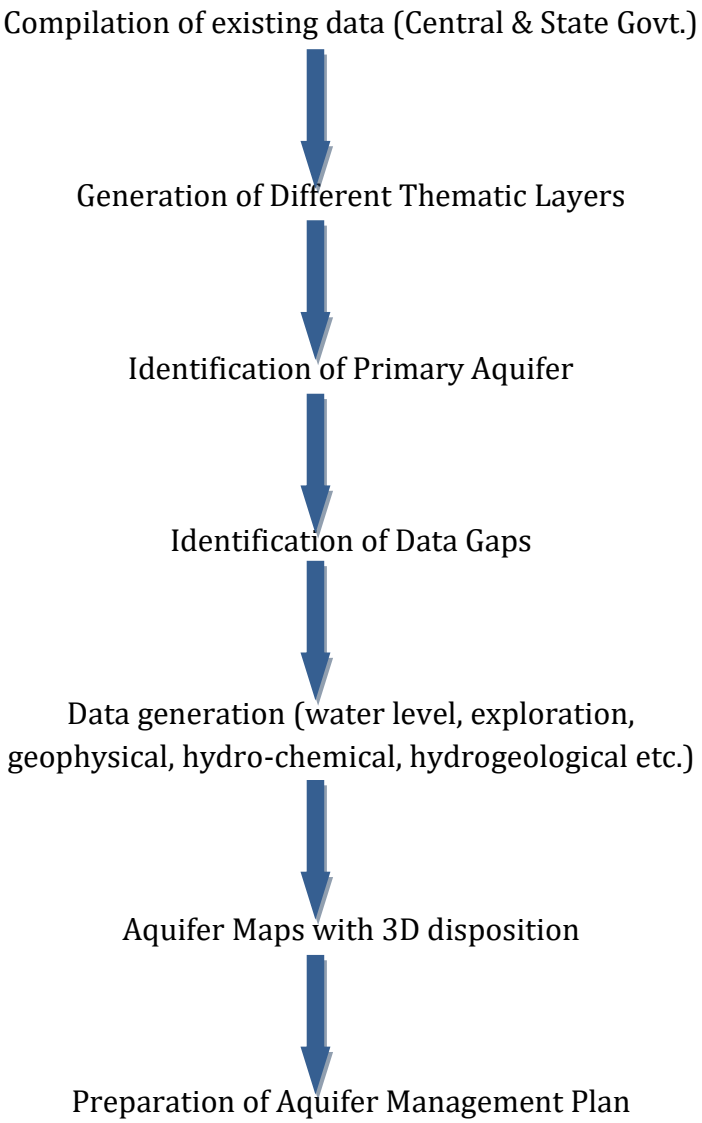
1.2 Scope of the study

Aquifer mapping can be understood as a scientific process wherein a combination of geological, geophysical, hydrological & chemical fields and laboratory analyses are applied to characterize the quantity, quality, and sustainability of ground water in aquifers. Aquifer mapping is expected to improve our understanding of the geological framework of aquifer, their hydrologic characteristics, water level in aquifer and how they change over time and space and the occurrence of natural and anthropogenic contaminants that affect the portability of groundwater. Results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring network and conceptual and quantitative regional groundwater flow models to be used by planners, policy makers and other stake holders. Aquifer mapping at appropriate scale can help to prepare, implement, and monitor the efficacy of various management interventions aimed at long term sustainability of our precious groundwater recourses, which in turn will help to achieve drinking water scarcity, improved irrigation facilities and sustainability of water resource in the state.

1.3 Approach & Methodology

Aquifer mapping is an attempt to integrate the geological, geophysical, hydrological & chemical field and laboratory analyses and are applied to characterize the quality, quantity

and sustainability of groundwater in aquifer. Under the National Aquifer Program, it is proposed to generate Aquifer Maps on 1:50000 scale, which basically aims at characterizing the aquifer geometry, behavior of groundwater levels and status of groundwater development in various aquifer system to facilitate planning of their suitable management. The major activities involved in this process encompass compilation of existing data, identification of data gaps, generation of data for feeling data gaps and preparation of different aquifer layers.



1.4 Study Area

The Bikaner District is located in the north-western part of Rajasthan State at a distance of about 334 kms to west of Jaipur, the capital of the state and covers total area of 30,247 sq.km. It was named after its founder Rao Bika. It lies between latitudes north latitudes 27°11' to 29°03' and east longitudes 71°52' to 74°15'. It is bounded on the north by Ganganagar District, on the east by Hanumangarh and Churu Districts, on south byNagaur and Jodhpur Districts and on the west by Jaisalmer District and International border with Pakistan.

For administration and development, the district is divided into eight sub-divisions i.e. Bikaner, Kolayat, Nokha, Loonkaransar, Khajuwala, Chhattargarh, Pugal and Dungargarh and eight tehsils, i.e., BIkaner, Kolayat, Nokha, Loonkaransar, Khajuwala, Chhattargarh, Poogal and Dungargarh . The developmental activities of the district are being looked after by six Panchayat Samities, i.e. Bikaner, Kolayat, Nokha, Loonkaransar, Khajuwala and Dungargarh. There are 874 villages and 219 Gram panchayats. There is one independent Sub- Tehsil Bajju situated in Kolayat tehsil for better administration. The district has one Municipal Council, 219 Gram Panchayats and 874 Villages. As per 20011 Census, the total population of the district is 2367745 out of which 1243916 is man population and 1123829 is female population and sex ratio is 903 out of 1000 male. Decadal population growth rate of the district is 24.48% since 2011.

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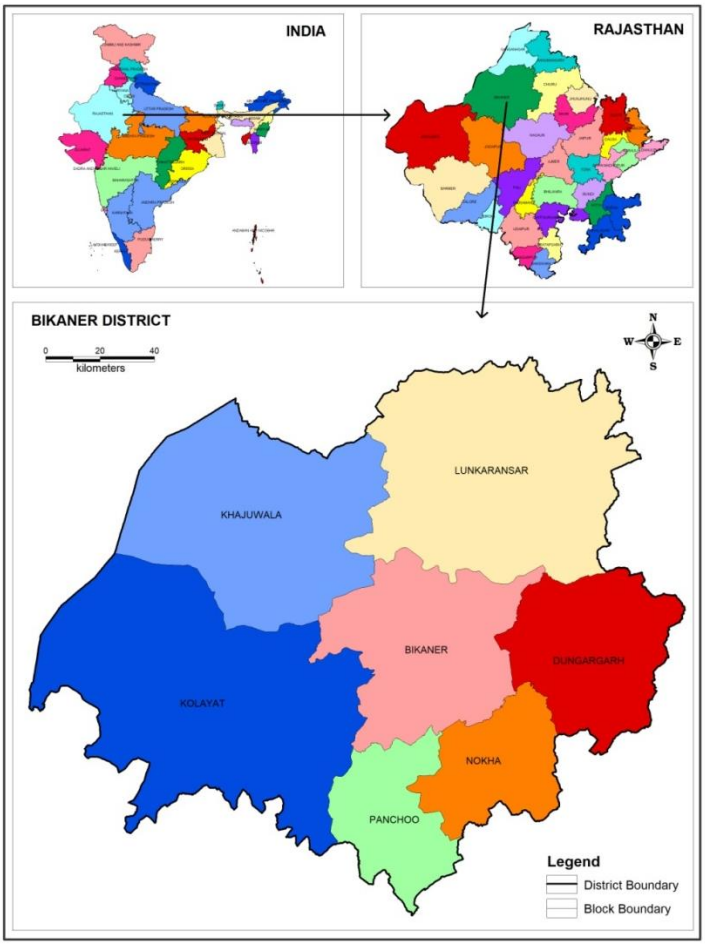


Figure1.1. Administrative Map of Bikaner District

1.5 Data Availability and Data Gap Analysis:

The available data of the Exploratory wells drilled by Central Ground Water Board, Western Region, Jaipur, Geophysical Survey carried out in the area, Ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analysed for adequacy of the same for the aquifer mapping studies. In addition to these the data on ground water monitoring stations and ground water quality stations of the State Government (GWD) was also utilized for data adequacy and data gap analysis. The data adequacy and data gap analysis was carried out for each of the quadrant falling in the study area in respect of various attributes of ground water and is presented in table 1.

Table 1.1: Data Availability and Data Gap Analysis in Bikaner District

S.No	Study Aspect	Data Requirement	Data Availability	Data Gap
1	Rainfall and Other climatic Data	5 Meterological Stations in the area	Data partially available	Other Climatic data other than rainfall
2.	Soil	Soil Map and Soil infiltration rate	Soil Map	Soil Infiltration rate across the area
3.	Land Use	Latest land use Pattern in GIS Platform	Not available	Latest data in GIS platform required
4.	Geomorphology	Digitized Geomorphological Map	Available	-
5.	Geophysics	Geophysical Survey in all toposheets	Available 11 VES	Required in every toposheet
6.	Exploration	Exploratory wells along with aquifer parameters	Exploratory wells along with aquifer parameters are available	-
7.	Recharge Parameters	Recharge parameters of different soil and aquifer types based on field studies	Recharge parameters are given in Ground Water resource estimation	-
8.	Discharge Parameters	Discharge parameters for different GW abstraction structures	Discharge parameters are given in Ground Water Resource Estimation	-

2.0 Climate and Rainfall

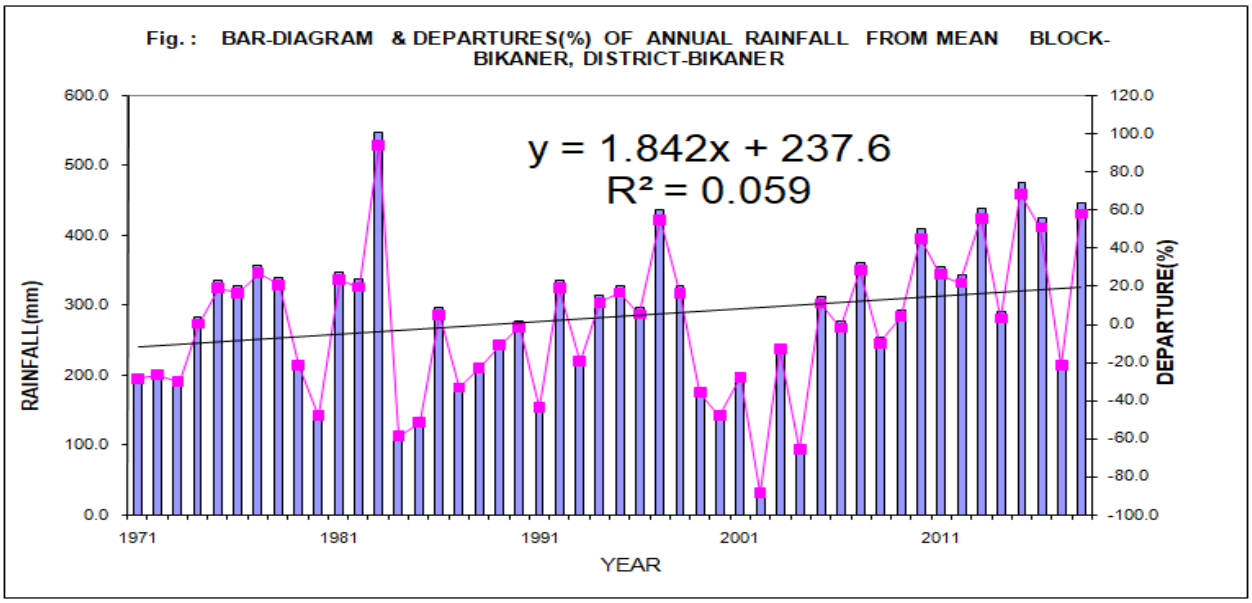
The district experiences arid type of climate in the east to extremely arid in thewest. Mean annual rainfall (1971-2018) of the district is 302.2 mm. Almost90% of the total annual rainfall is received during the southwest monsoon, which enters the district in the first week of July and withdraws in the mid of September. As the district lies in the desert area, extremes of heat in summer and cold in winter are the characteristics of the desert. Both day and night temperatures increase gradually and reach their maximum values in April, May and June. The temperature varies from 48 degree in summer to 1 degree in winter. Atmosphere is generally dry except during the monsoon period. The humidity is the highest in August with mean daily relative humidity of 71% in the morning and 52% in the evening. The General trend of annual rainfall of Bikaner district depicts the slight increase in rainfall at the rate of 1.8 m/year. Though the rainfall pattern of Bikaner district is highly erratic and shows significant variation.

2.1 Rainfall : The annual rainfall of 48 years from 1971 to 2018 have been analyzed to know the behavior of rainfall. The analysis indicates that annual variation of rainfall is large and significant. The average annual rainfall from 1971 to 2018 is 303 mm. The highest rainfall of 99% more than the average was recorded in 1997 whereas the lowest (66mm) of 78% less than the average was experienced in 2002 .

The standard deviation of rainfall from 1971 to 2018 is 121 mm which indicates that 133 mm rainfall is assured. The coefficient of variation of rainfall is 33%. It indicates that rainfall in the area is highly variable.

The trend of annual rainfall by least square method shows increasing which is insignificant. The possibility of Excess, normal, and deficient rainfall are 27%, 37%, and 37% respectively.

Rainfall study for 48 years depicts that only 37% of the years i.e.1971.,1972,1973,1974, 1979,1980,1984,1985,1986,1987,1988,1991,1993,2002,2004,2006,2009,2017experienced drought conditions. It means that study area is classified under chronically drought affected area. The probability of mild and severe drought is 27 % and 10% respectively. In 18years,1971,1972,1973,1974,1979,1980,1984,1985,1986,1987,1988,1991,1993,2002,20 04,2006,2009,2017and 2017 the amount of rainfall was much less than their corresponding normal's and ranges between -78% to - 20% and the study area is affected by five severe or thirteen mild drought conditions. One drought of mild intensity may be possible after 3or4 years. In13-years1971,1972,19741979,1980,1984,1986,1987,1988,1993,2006,2009,2017 this area is affected with drought of mild intensity. And One sevre drought would be possible within 9 years.



2.1 Average Annual Rainfall and its Departure Percentage

2.2 Temperature: There is one meteorological observatory in the area which monitors temperature. Therefore, the old normals of Bikaner district IMD station have been considered as representative, prevailing the similar meteorological conditions in the area. The cold weather season generally starts by mid November when temperature begins to drop rapidly. January is the coldest month of the year with mean daily maximum and minimum temperature being about 22.5°C and 5.10°C respectively. In association with passing of western disturbances, the district gets affected with the severe cold wave conditions and on such occasion minimum temperature may go down to freezing point of water. The rise in minimum temperature from 5°C in January to 27.2°C in May is observed.

The temperature starts rising rapidly from March to June.

June is the hottest months of the year. When the area experiences daily mean maximum and minimum temperature of 41.7°C and 29.3C respectively. The variation in maximum temperature from January to June is about 20.2°C.From about April hot westerly dust ladden winds locally known as *'Luh'* begin to blow and the weather becomes very hot under heat wave conditions. In May and June maximum temperature may generally go above 45°C. Occasional dust storms and thunder storms causes drop in temperature.

With the onset of the south-west monsoon currents into the area at the end of June, there is appreciable decline in the day temperature whereas nights temperature remain as

high as in summer. The increased moisture content in the air causes the weather sultry and unpleasant. After the withdrawal of monsoon by about mid September there is decrease in the day temperature but night temperature drops down steeply from 27.21to 5.6 Table 5 and Fig3 shows variation of temperature**.**

2.3 Humidity: The air is generally dry over the district during greater part of the year. During the southwest monsoon the humidity is high and generally being 67% to 48%. Humidity generally decreases in the post monsoon season. May and April are the driest months of the year when relative humidity being about 31% or less in the afternoon. Table 5 and Fig 3 show variation of humidity.

2.4 Cloudiness: During the south west monsoon the skies are heavily clouded or overcast particularly in July and August. Rest of the year sky is mostly clear or lightly clouded except for a brief spells of one or two days in association with the passage of western disturbances during winter season.

2.5 Winds: Winds are generally light with some strengthening of speed during summer and early part of the south west monsoon season. The maximum wind speed of 13.3 km./hr. is recorded in June. While minimum wind speed of about 3.5km./hr. is during November to January. In southwest monsoon season winds direction is mostly southerly or southwesterly. Rest of the year winds are predominantly easterly or northeasterly or calm Table 5 and Fig 4 shows variation of monthly wind speed .

3.0 Physiographic Set Up

Bikaner district is conspicuous of vast sandy areas and lack of hills. The topography is undulating interspersed with dunes of eolian origin. The table below reveals that the minimum elevation in the district is 103.7m above mean sea level (amsl) as found in Kolayat block whereas the maximum elevation is 349.1 m amsl in Nokha block where rocks of Tertiary sandstone are exposed. General slope of the terrain is from southeast to northwest

3.1: Table: Block wise minimum and maximum elevation

S. No.	Block Name	Minimum Elevation (m amsl)	Maximum Elevation (m amsl
1	Bikaner	123.2	298.6
2	Dungargarh	200.2	347.3
3	Khajuwala	107.9	163.0
4	Kolayat	103.7	315.3
5	Lunkaransar	149.5	246.8
6	Nokha	261.6	349.1

3.1 Geomorphology

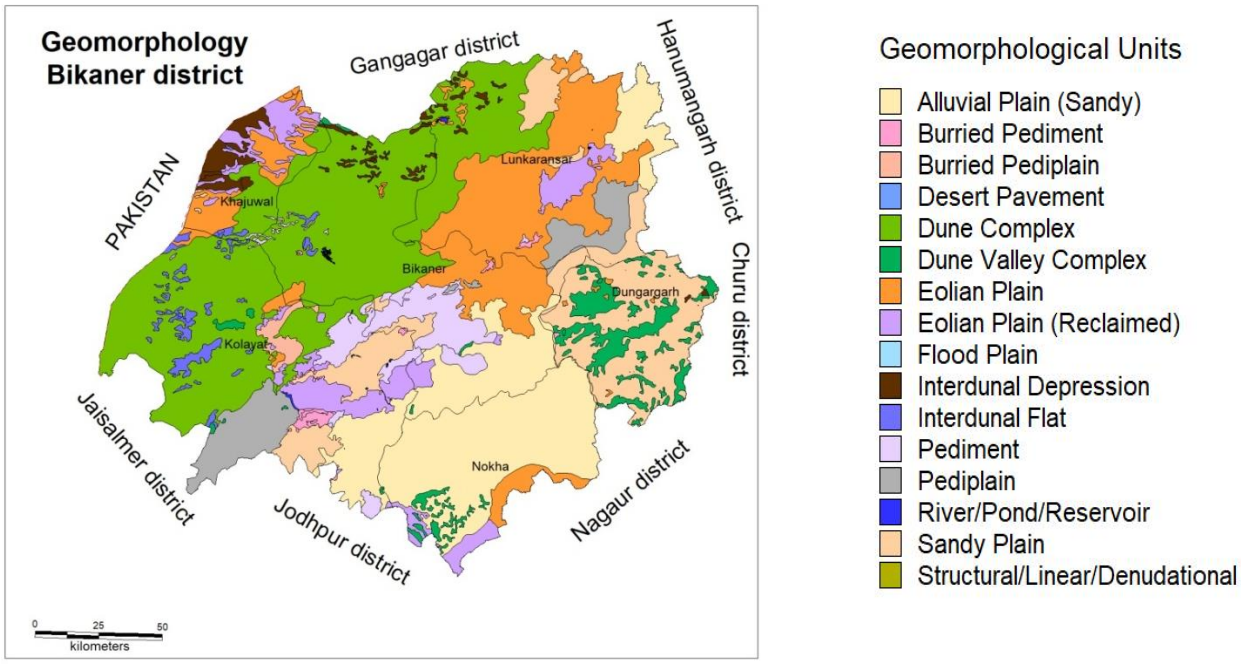
Geomorphologically, the district can broadly be divided into ten units viz. (1) flat graded older alluvial plains, (2) sandy undulating aggraded alluvial plains, (3) flat interdunal plains, (4) sandy undulating interdunal plains, (5) flood plains and Aeolian complex, (6) stabilised sand dunes, (7) active sand dunes, (8) gravelly aggraded alluvial plains, (9) eroded rocky surface and (10) saline depressions. The western, south-western, northern and north eastern parts of the district are largely covered with dunes of different types and magnitudes with flat to undulating interdunal plains. The central eastern and southern parts of the district constitute largely flat and undulating aggraded alluvial plains. The general trend of the regional slope in the area is from SSE (275 mamsl) to NNW (152 mamsl). There are only a few small hill outcrops of about 1-2 m height near Kolayat in the district.

The district has no major river system except for a few short intermittent and ephemeral channels near Kolayat. A few natural lakes or depressions are observed near Gajner, Kolayat, Nal and Lunkaransar.

The main Rajasthan Canal enters the area somewhere north of village Bhansar andleaves the district in the southern boundary near village Gogliala. The main canalhas a number of branches and distributaries like (1) Naushera Branch, (2) DatharBranch, (3) Birsipur Branch, and (4) Charanwala branch. Besides the main Rajasthan canal command area, there are other command areas of lift canals. The Indira Gandhi Nahar Pariyoajna receives water from barrage at HariKaPattan in Amritsar district of Punjab through 204 km. The IGNP canal command area is 591000 hectares in the district (Stage-I 179000 hectares and Stage-II 412000hectares).

Table 3.2: Geomorphology of Bikaner District

Aeolian	Dune Complex	An undulating plain composed of number of sand dunes of crescent shape.
	Dune Valley Complex	Cluster of dunes and interdunal spaces with undulating topography formed due to wind-blown activity, comprising of unconsolidated sand and silt.
	Eolian Plain	Formed by aeolian activity, with sand dunes of varying height, size, slope. Long stretches of sand sheet. Gently sloping flat to undulating plain, comprised of fine to medium grained sand and silt. Also scattered xerophytic vegetation
	Eolian Plain (Reclaimed)	Gently sloping with sheet of sand or sand dunes, scattered xerophytic vegetation
	Interdunal Depression	Slightly depressed area in between the dunal complex showing moisture and fine sediments
	Interdunal Flat	Flat, narrow land between dunes.
	Sandy Plain	Formed of aeolian activity, wind-blown sand with gentle sloping to undulating plain, comprising of coarse sand, fine sand, silt and clay.
Denudational	Buried Pediment	Pediment covers essentially with relatively thicker alluvial, colluvial or weathered materials
	Pediment	Broad gently sloping rock flooring, erosional surface of low relief between hill and plain, comprised of varied lithology, criss-crossed by fractures and Faults
	Pediplain	Coalescence and extensive occurrence of pediment.
Fluvial	Alluvial Plain (Sandy)	Flat to gentle undulating plain formed due to fluvial activity, mainly consists of gravels, sand, silt and clay with unconsolidated material of varyin lithology, predominantly sand along river.
Hills	Structural Hills	Linear to arcuate hills showing definite trend-lines with varying lithology associated with folding, faulting etc.



3.1 Geomorphology Map of Bikaner District

3.2 Land Use

The socio-cultural and economic factors have significantly influenced over land use both in rural and urban areas in the district. Land forms, slope, soils and natural resources are some of the important which control the land use pattern of the district. The land use pattern of district is based on the statistical outline of the district is presented in Table 3.3

Table 3.3: Land Use Pattern of Bikaner District

S.No.	Land Use	Area in hectare	%
1	Total geographical area (as per village papers)	3040476	
2	Forest	92850	03.05
3	Uncultivable land	297920	09.80
4	Land not cultivated including pasture land; barren land; trees, grooves & orchards	877571	28.86
5	Fallow and current fallow land	498927	16.41
6	Net sown area (subtracting double)	1273208	41.88
7	Gross sown area	1434212	47.17
8	Area sown more than once	161004	05.32

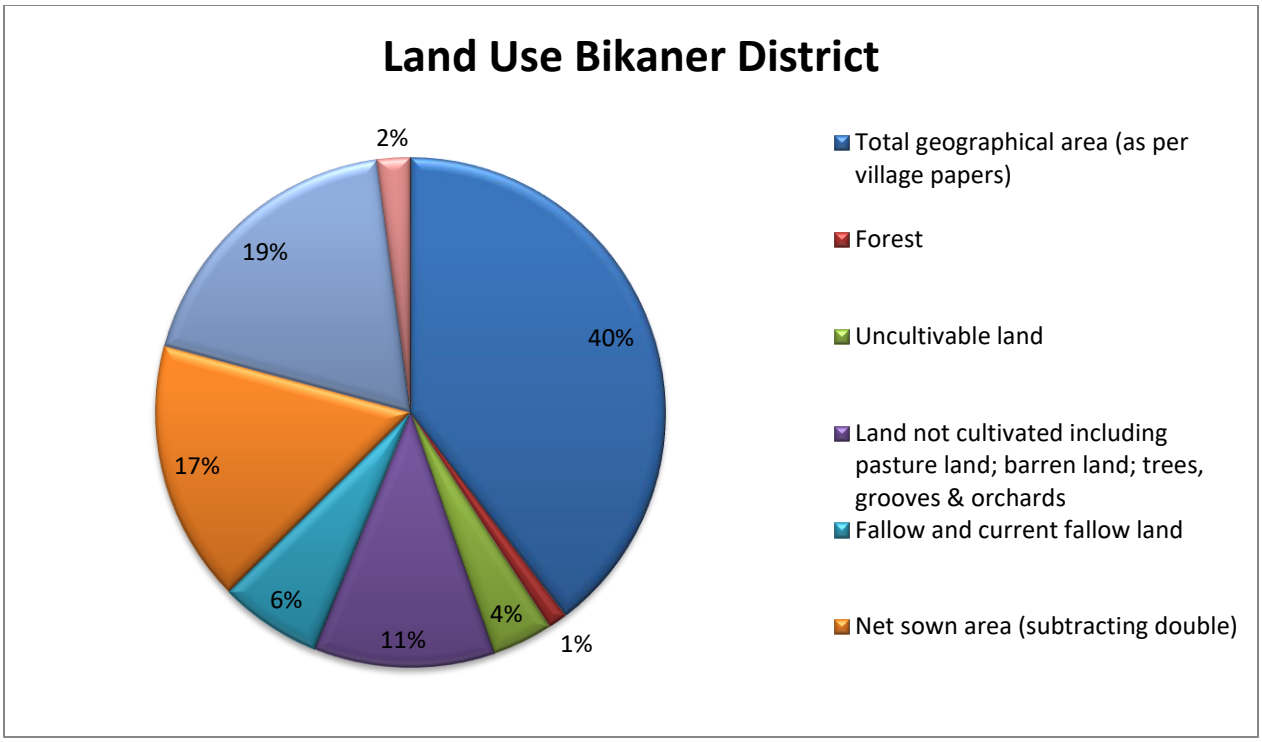


Figure 3.2: Land Use Pattern in Bikaner District.

Agriculture

Agriculture activity in the district is, by and large, confined to traditional kharif cultivation depending on monsoon rainfall and rabi cultivation is prevailing in areas where irrigation facilities are available. The major crops grown in the area are given in table no. 3.4 and season-wise crops are presented in table 3.5.

Table 3.4: Major crops of Bikaner District

Food Grain	Jowar, Bajra,Wheat, Barley, Maize, Rice
Cereals	Gram, other kharif cereals,Tur, other rabi cereals
Oil seeds	Rai&Mustard,Til, Ground Nut,Arandi/Taramira
Non-food grains	Cotton,Onion,Red chilli,Potato

Table 3.5: Season-wise crops Pattern of Bikaner District

Season	Crops covered
Kharif	Jowar, Bahra, Cotton, Tur, Castor seed, Sugarcane, Soyabean and Ground Nut
Rabi	Wheat, Barley, Gram, Rape Seed Mustard, Taramira
Zaid	Jowar, Bajra, Gram, Urad, Moong, Moth, Chaula, Fruits and Vegetables, Small Millets, Spices and Fodder

Apart from these, vegetable and fruits are also being produced in the district. Onion, Cauliflower, Muskmelon, long melon, Carrot are main vegetables and Aonla, Ber, Lime, Kinnow, Jamun are main fruits which are produced in district

Irrigation

Canals and Tube well are the main source of irrigation in the district. During 2014-15, the net irrigated area in the district was 708859 hectares of which 99.39 percent was irrigated by canals and tube well. Other sources constituted open wells and the percentage of area irrigated by them are 0.61 percent. The area irrigation by different means of irrigation in 2014-15 in the district is as given below, figures in the brackets indicate the percent of area irrigated by difference sources to total area irrigated in that category

Table 3.6: Details of Area irrigated with sources in Bikaner District

	Dugwells	Tubewells	Canals	Other	Total
Net Sown Area	4307	386465	318079	8	708859
Gross Sown Area	5757	537640	460659	8	1004064

Source: District Outline, Bikaner, 2015

3.3 Soils:

The soils of Bikaner district are predominantly light textured, weak – structured, sand to sandy loam with the clay content. Arid climate with low rainfall, high temperature and high evaporation losses has resulted in physical and mechanical disintegration of the parent material giving rise to predominance of coarse fraction in the soil. Very little chemical weathering has taken place and the development of soil is mostly indistinct.

Soils are generally of desertic type with poor fertility status and very low water retention capacity. Soil profile studied during UNDP Project (1971-74) shows that the hydraulic conductivity in the soil profile reaches upto 10.9 cm/hr while the maximum available moisture in the soil profile remains to the extent of 1.13%. In general the soils have good porosity (40%) and good to very good permeability. Details of soil characteristics observed in the district are given in Table 3.2.

Table 3.7: Details of soil characteristics in Bikaner district

Major Soils (common names like red sandy loam deep soils etc	**Area ('000 ha)**	**Percent (%) of total**
Deep Yellowish brown sandy soils	3038	39.3
Deep Light yellowish brown loamy soils	2984	38.6
Medium Light yellowish brown loamy soil	1002	13.0
Others: Deep Pale brown	686	8.92

loamy, medium yellowish brown sandy, shallow Pale brown gravelly sandy soils		
Total	7710	100

4.0 Hydrogeological Framework

4.1 Geology:

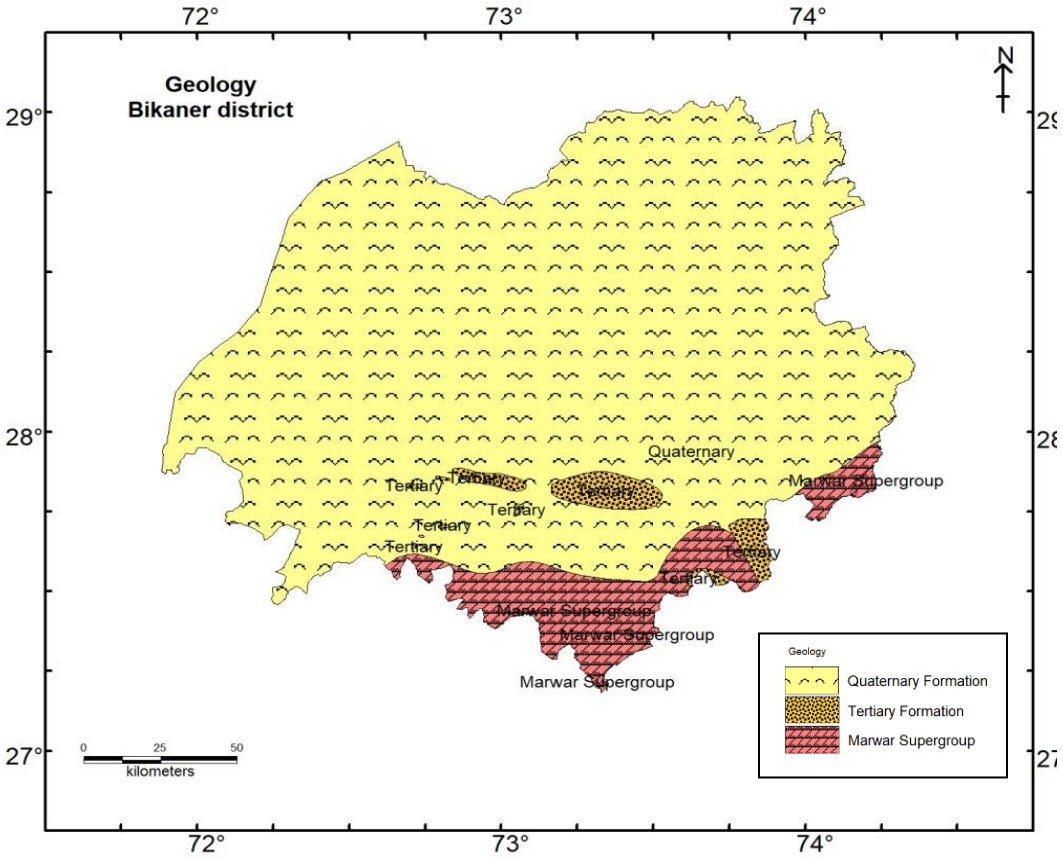
Practically, the whole of the surface geology in the greater part of the district is concealed under a thick cover of windblown sand. However, rocks belonging to Palana Series of Eocene age are exposed around Kolayat, Mar and Bikaner. Sporadic outcrops of sandstone belonging to Lathi (Jurassic) and Badhaura Series (Permo-carboniferous) occur in south-western corner of the district. Lathi and Badhaura sandstones are in small area. Palanas or the Quaternaries are directly underlain by rocks belonging to Marwar Super Group
Jodhpur sandstones and shales are encountered at very shallow depth just below the top Quaternaries in an elliptical area with its longer axis in east-west and shorter axis in north-south direction along Bamanwali-Dhirera and Dulmera line. Thickness of Quaternaries is less around Mahajan in the northern part of the district but increases both in the north towards Arjunsar and in south towards Lunkaransar. Again the Jodhpur sandstones are encountered at shallow depths just below the Quaternaries in the southern part of the district.

The subsurface regional geological correlation has revealed the presence of a major longitudinal fault (further east of Bikaner District Boundary). It separates the Precambrian basement platform of the eastern up thrown block with the lower Tertiary of the western downthrown block falling in the Bikaner district. Some smaller parallel faults and a few cross faults are also noticed. One such fault passes in the east-west direction north of Nokha with its down throw in the north. Thus, practically whole of the Bikaner area forms a syncline separated from the southern Nagaur uplift.

Table 4.1: Geologic succession

Group	Series/Super Group	Geological Unit	Formation
Quaternary	Recent	Wind-blown Sand	Very fine, buff to grey sand, well rounded to sorted by wind action
	Pleistocene	Alluvium	Unconsolidated to loosely consolidated sand, find to medium, silty clays and kankar with occasional horizons of gravel and coarse sand.
Tertiary	Eocene	Sandstone	Coarse and gritty sandstone usually consolidated, porous, within intercalated clays and gravel, fuller's earth (Bentonite)

			and Lignite also occur in thin sequences
Palaeozoic	Marwar Super Group	Nagaur Sandstone	Hard compactly consolidated, reddish sandstone Interbedded with red shales.
		Bilara Limestone	Limestone, hard, massive grey to blackish in colour with occasional cavities.



4.1 Geology of Bikaner District

4.2 Hydrogeology:

The Palana sandstone member of the Palana series is the main aquifer in the district. Other aquifer formations are sandstone and limestone of Nagaur group of rocks. Jodhpur sandstone and Quaternary alluvium also form aquifer whenever they extend in the zone of saturation.

Hydrogeological Conditions: The ground water conditions in different formations in the district are described below.

Quaternary Aquifer: The unconsolidated Quaternary sediments attain the status of aquifer in the area north of latitude 28°03' except around Dhirera and Dhulmera, Mechanical analysis of the aquifer material collected during direct rotary drilling reveals the presence of 20% clay content in the aquifer with sorting coefficient varying from 1.3 to 3.34, the average being in the range of 1.5 to 2.5. The ground water occurs under water table conditions and the yield varies from 75 lpm to less than 950 lpm. Thickness of alluvium in the exploratory well at Godwala-II is found to be 187m and the yield of well is 947 lpm (Gadwala-II). The drilled depth of this borehole was 418.49 m whereas constructed depth was 187 m. The slim hole at Karmisar has been drilled to the depth of 510.27 m. The main potential area is the Central part, where Quaternaries form potential aquifers as and when they attain saturation.

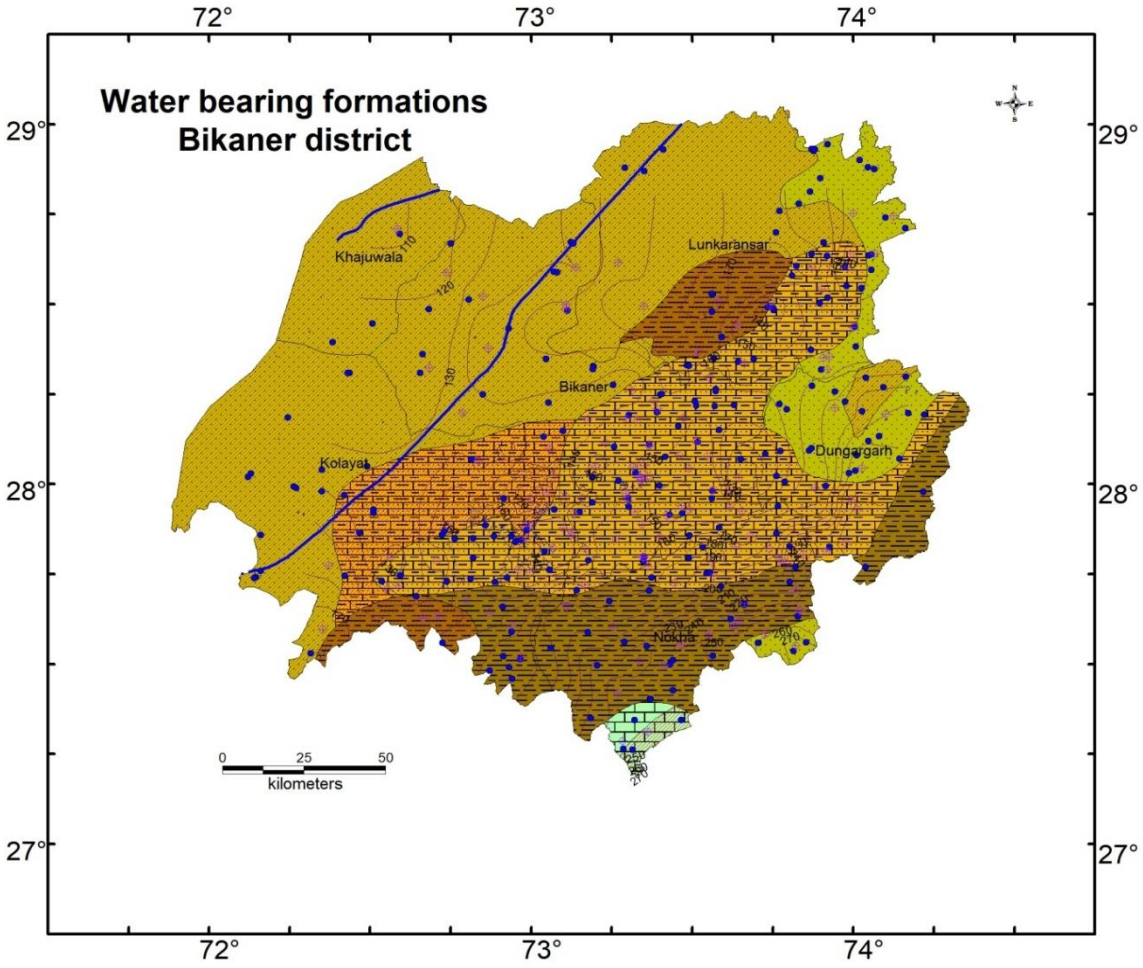
Palana Sandstone Aquifer: Palana sandstone belonging to lower Eocene to Palaeocene age forms the main and potential aquifer in the district. Palana Sandstone is overlain by Quaternary deposits and is underlain by rocks belonging to Nagaur Group of Marwar Super group. It mainly occupies eastern part of the area and extends upto the south-western boundary of the district i.e. south of Kalasar. The exploratory drilling indicates that Palana sandstone comprises mainly sandstone fine to coarse grained, well sorted white to grey with some times pink tinge, poorly to moderately cemented, soft and friable. Locally it is more gravelly, poorly sorted and is intercalated with thin clay beds especially in the lower part, close to it's contact with the thick lower members of the Palana series. In accordance with the regional structural pattern, the saturated thickness of Palana sandstone aquifer increases towards north, except in the axial part of the Bikaner syncline around Sital where it is greatly reduced to 15 meters only. North of Bikaner, the saturated thickness of Palana sandstone aquifer is about 80 meters. In Gajner, Akasar and Soa, the saturated thickness negligible but it again attains thickness of about 100 m at Kolayat and Baneri. The drilled depth in Palana sandstone varies from 105 m bgl to 505 m bgl. Palana aquifer is found to be under phreatic conditions. Specific capacity of wells ranges from 3.6 to 28.1 m^3/hr/m and transmissivity ranges up to 720 m^2/day, and permeability from 1.65 to 13.5 m/day. The values of transmissivity remain much below 100m^2/day in the axial zone of the Bikaner syncline and relatively high values are expected in the north-eastern part around Bikaner-Sujandesar and around Raneri in the west. Average specific yield of the aquifer is estimated at 7%.

Aquifers of Nagaur Group: Only the upper part of Nagaur Group of rocks comprising mainly sandstones has been encountered just below Palana series inmost of Kolayat-Bikaner-Sital-Surpura area. Ground water in Nagaur Sandstone occurs under confined conditions mostly. In the explored part its saturated thickness varies from 40 to 310 m. However, Nagaur sandstone aquifer occurs under watertable conditions in Nokha area. In this area its saturated thickness varies from a few m to little over 50 m at Nokha. Yield of wells varies from 200 to 750 lpm.

Transmissivity is low and ranges from 2.5 to 50 m^2/day. Permeability is correspondingly low. Specific capacity of wells varies from 0.17 to 1.20 m^2/ hr/ m. The specific yield of

Nagaur Sandstone is estimated at 1% only. In the southern most part of the district, the lower members of the Nagaur group comprising limestone -evaporite sequence also form an aquifer of insignificant potential in a localized patch.

Aquifers of Jodhpur Group: Jodhpur sandstone is compact, fine to coarse grained, micaceous and purple to reddish brown in colour. In most of the Bikaner area, it lies below the evaporite sequence and it contains saline ground water. Ground water occurs under phreatic conditions in Palana sandstone and Quaternary sediments whereas it occurs mostly under confined conditions in Nagaur sandstone and Jodhpur sandstone in the district. Both in Tertiaries and Quaternaries, perched water bodies are formed by arresting of downward movement of rainfall percolation by shales and claylenses in the zone of aeration. Depth to water level in such bodies varies from 5 to 30 mbgl, the shallower being in Pipal area and deeper in Lunkaransar Kutuwas area.

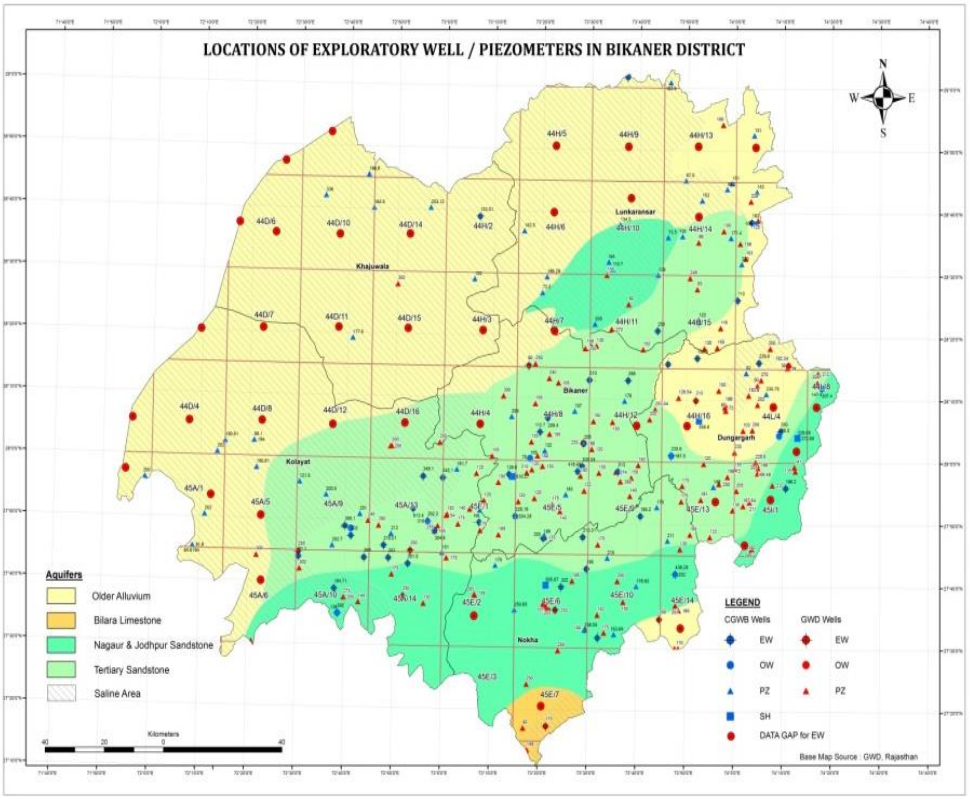


4.2 Hydrogeology of Bikaner District

4.3 Ground Water Exploration

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability.

The principal aquifers in the area are Alluvium, sedimentary formations viz. Tertiary sandstone, limestone and shales. Occurrence and movement of ground water in Alluvial aquifer is directly proportional to the granular zones i.e., the ground water accumulation will be higher in coarser formation and the formation clear of clayey admixture or intercalation. The locations of bore holes constructed in Bikaner District is prepared in figure



4.3 Boreholes constructed in Bikaner district

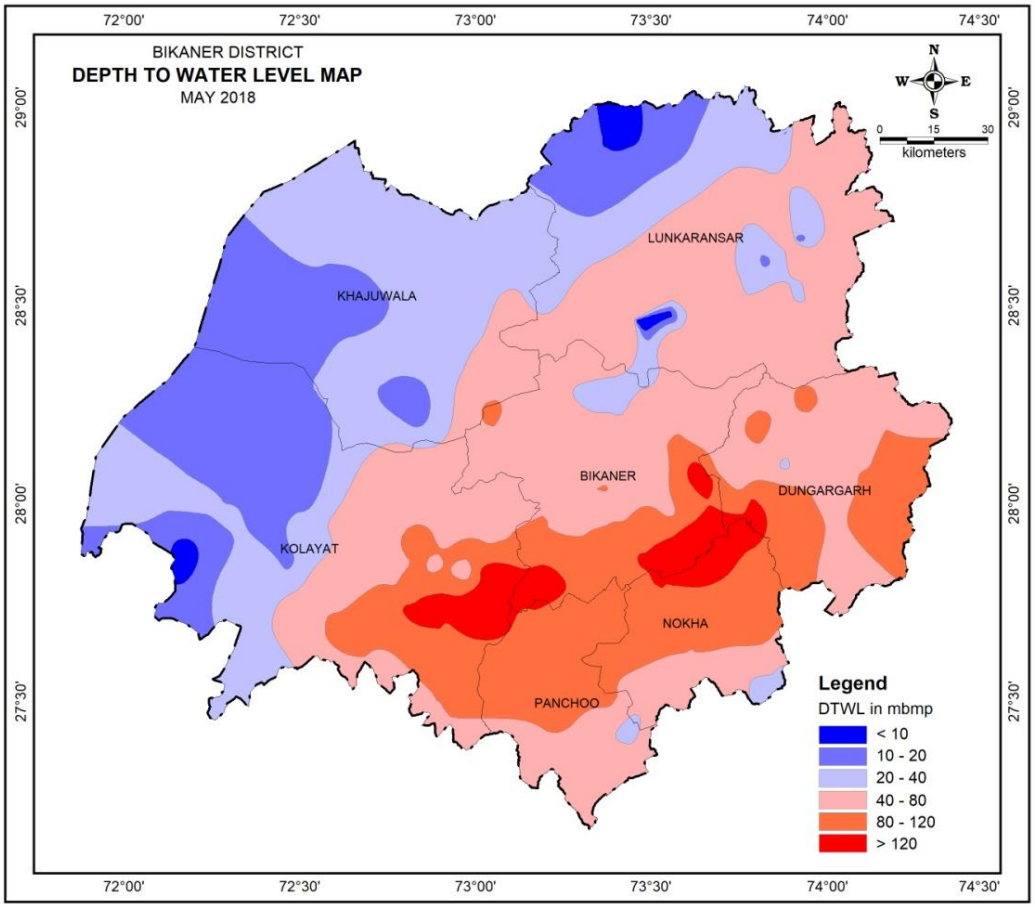
4.4 Ground Water Dynamics

Central Ground Water Board periodically monitors National Hydrograph Network Stations (NHS) stations in the Bikaner District, four times a year i.e. in January, May (Pre-monsoon), August and November (Post monsoon). The total number of hydrograph stations in the district is 62 comprising of 32 dug wells and 30 Piezometer. State Ground Water Department monitors water levels in 347 wells two times in a year i.e in May and November. The monitoring wells of state GWD comprise 134 dug wells and 213 piezometers in the district.

4.4.1Water Level Behavior

Pre-monsoon (May 2018)

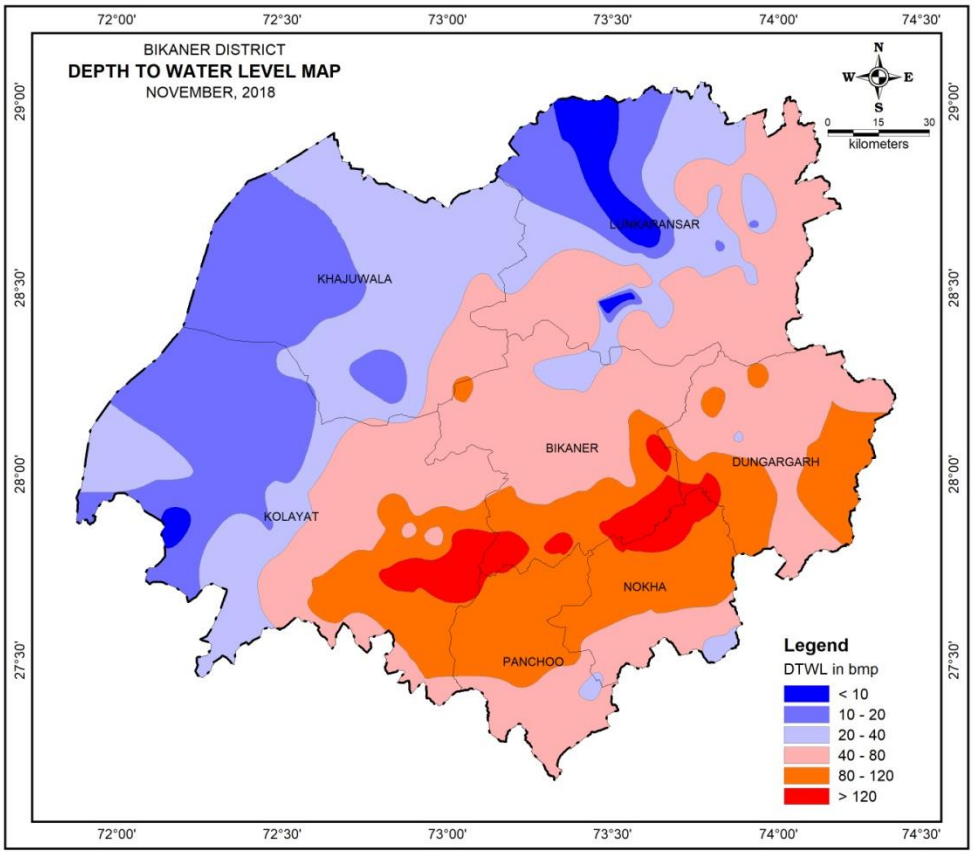
Depth to water level varied from 7.29 to 148 m during pre-monsoon, 2018.Depth to water level between 10 to 20m has been observed in 6 observation wells covering about 21 % area of the district Deeper water level i.e. more than 20 to 120 m has been recorded in 60 observation wells lying in the north eastern, south eastern and south western part of the district.. Water levels more than 120m has been recorded in 7 well covering 09 % area of the district in Nokha and Kolayat Blocks. No area in the block has water level between 0 and 2 m below ground level. About 60 wells are dry during pre -monsoon 2018. In terms of area pre monsoon scenario is presented in figure



4.4:Depth to Water Level Map of May 2018 in Bikaner District.

4.4.2 Post monsoon (November 2018)

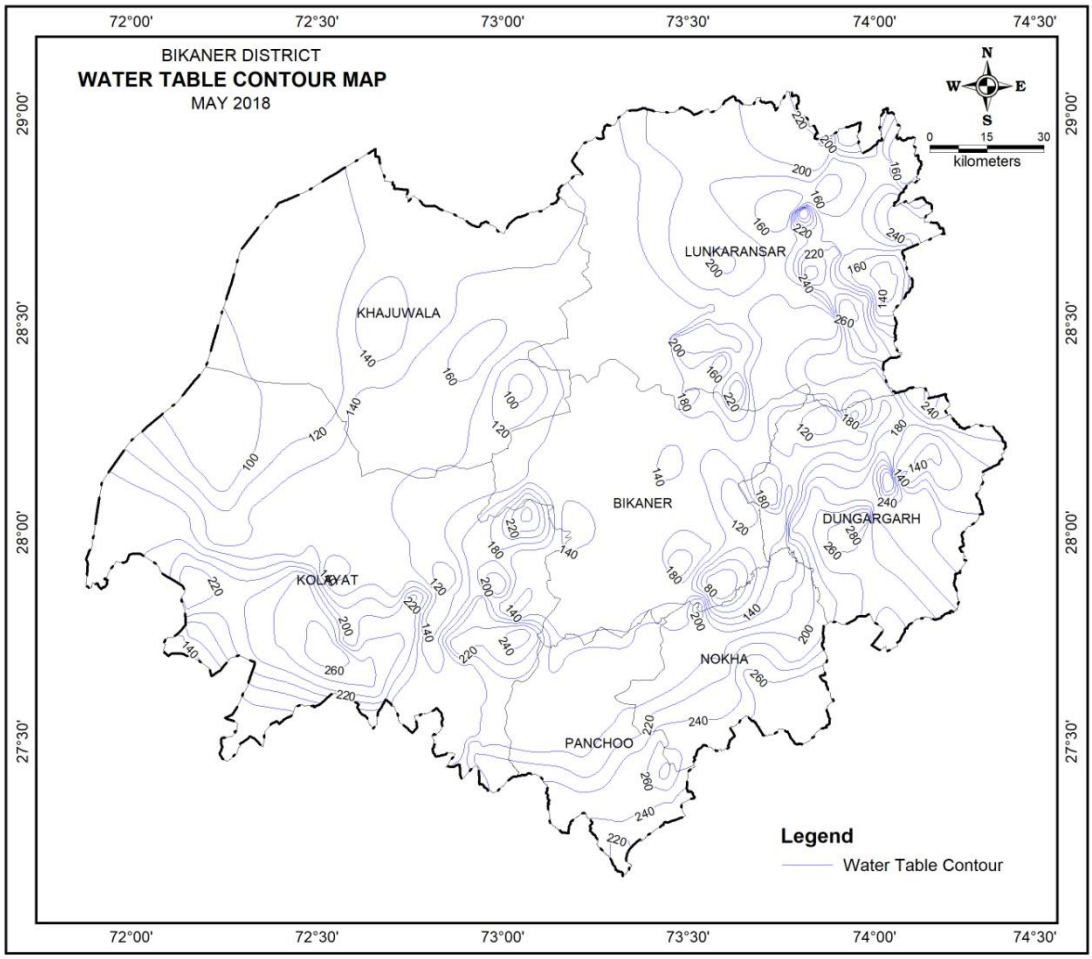
Depth to water level varied from 7.46to 149 m during the season .Depth to water level behavior is almost same as Pre-monsoon water level between 10 to 20m has been observed in 6 observation wells covering about 21 % area of the district Deeper water level i.e. more than 20 to 120 m has been recorded in 60 observation wells lying in the north eastern, south eastern and south western part of the district.. Water levels more than 120 m has been recorded in 7 well covering 09 % area of the district in Nokha and Kolayat Blocks. No area in the block has water level between 0 and 2 m below ground level. About 60 wells are remains dry during post -monsoon 2018. In terms of area pre monsoon scenario is presented in figure



4.5: Depth to Water Level Map of November 2018 in Bikaner District

4.4.3 Ground Water flow

Water table contour map of May 2018 is presented in figure 4.6. The perusal of the map shows that the water table elevation follows the topography of the area. Closely spaced contours on the eastern side of the district indicate steep slope and high rate of flow of ground water, while widely spaced contours in the other areas indicate gentle slope.



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4.6: Water Table Elevation Contour Map-Pre Monsoon 2018

5.0 Aquifer Maps and Aquifer Characteristics

5.1 Aquifer Disposition

The data generated during ground water exploration by constructing exploratory wells, observation wells, slim holes and piezometers, was utilized to decipher the aquifer disposition in the area. This particularly includes the information on geometry of aquifers and hydrogeological information of these aquifer zones. Three main types of formations are observed in the area i.e. Alluvium, sedimentary viz. Tertiary sandstone.

Quaternary Aquifer

The unconsolidated Quaternary sediments attain the status of aquifer in the area north of latitude 28°03' except around Dhirera and Dhulmera, Mechanical analysis of the aquifer

material collected during direct rotary drilling reveals the presence of 20% clay content in the aquifer with sorting coefficient varying from 1.3 to 3.34, the average being in the range of 1.5 to 2.5. The ground water occurs under water table conditions and the yield varies from 75 lpm to less than 950 lpm. Thickness of alluvium in the exploratory well at Godwala-II is found to be 187m and the yield of well is 947 lpm (Gadwala-II). The drilled depth of this borehole was 418.49 m whereas constructed depth was 187 m. The slim hole at Karmisar has been drilled to the depth of 510.27 m. The main potential area is the Central part, where Quaternaries form potential aquifers as and when they attain saturation.

Aquifer of Palana Group

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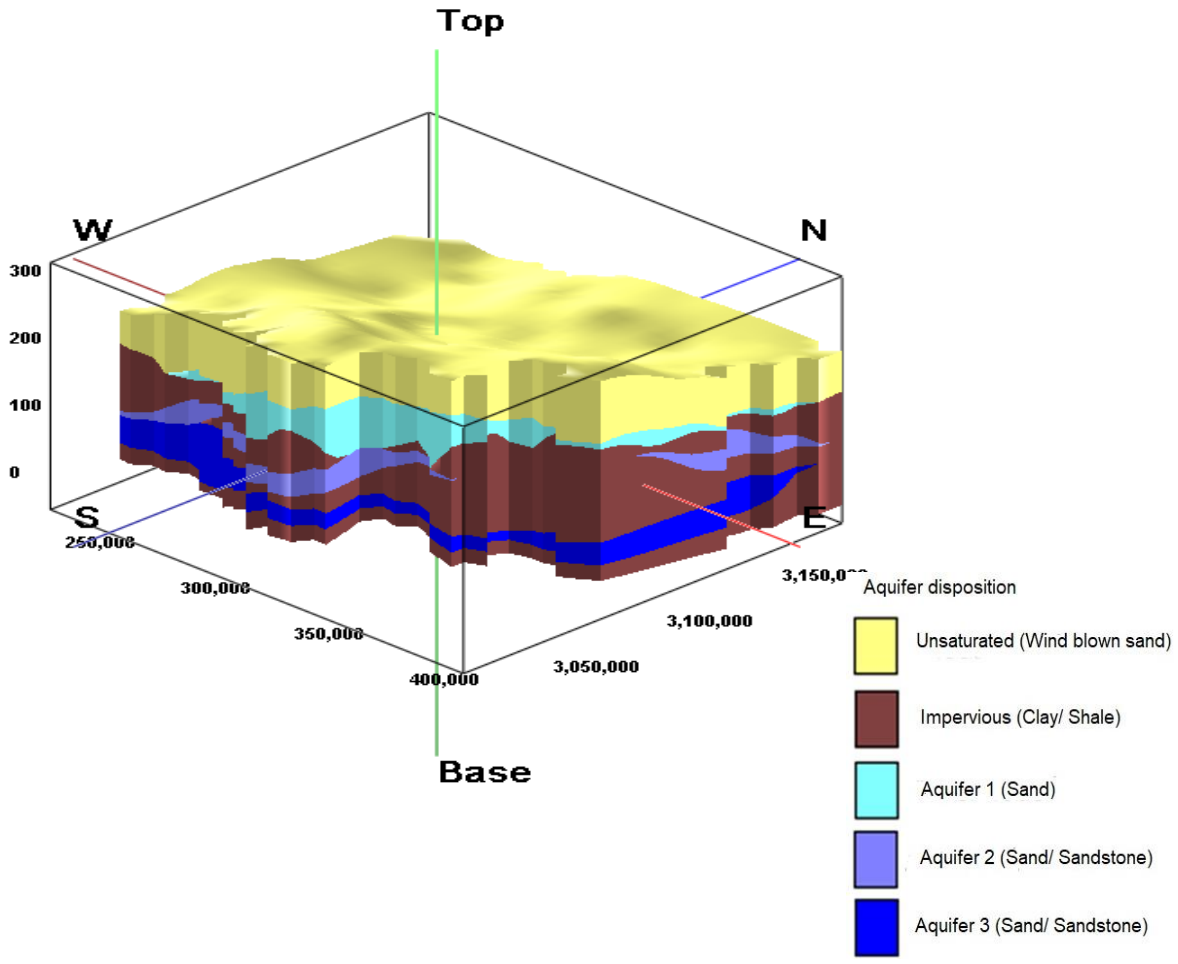
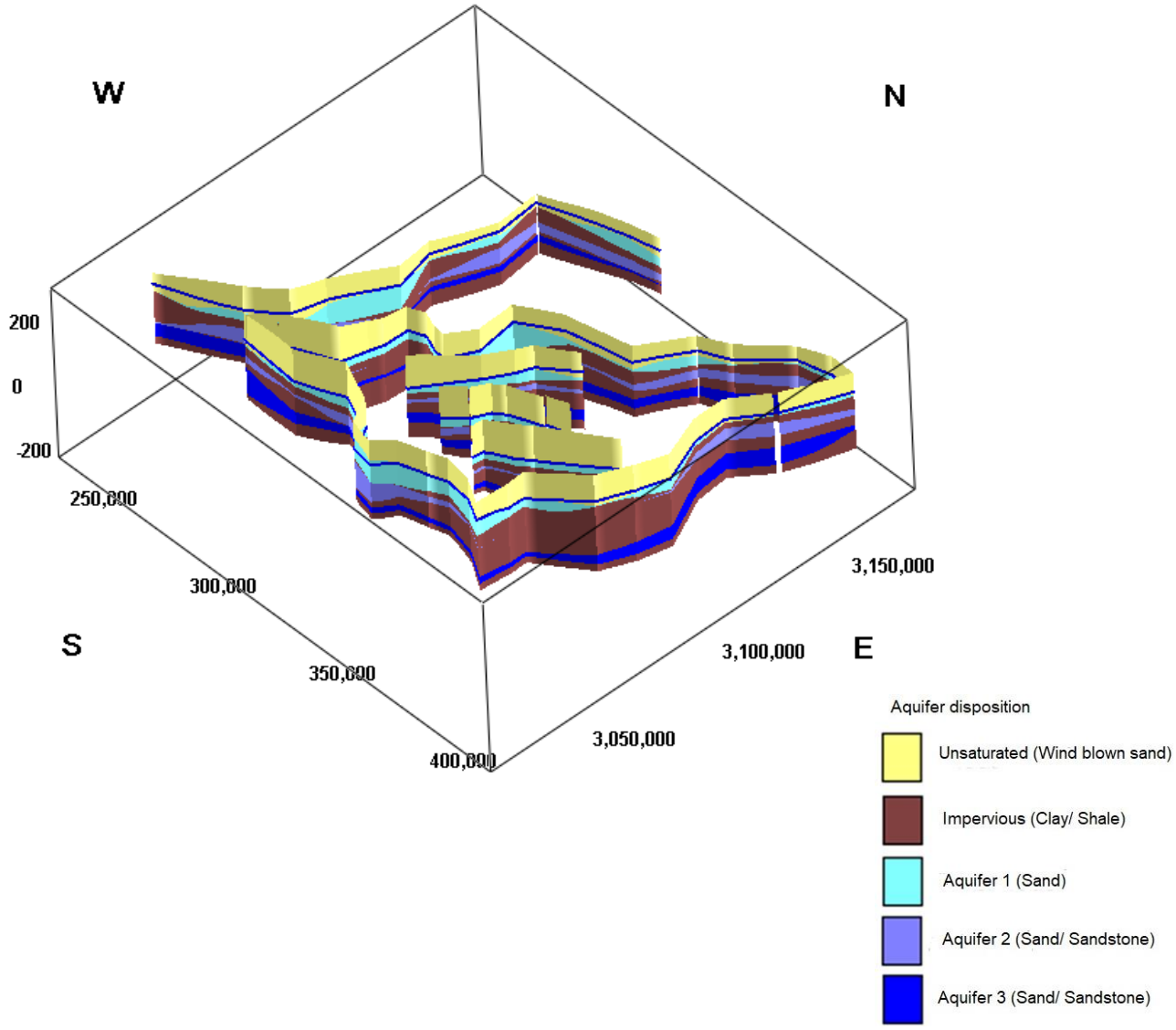
Palana Group of aquifer occurs under phreatic conditions. Specific capacity of wells ranges from 3.6 to 28.1 m^3/hr/m and transmissivity ranges up to 720 m^2/day, and permeability from 1.65 to 13.5 m/day. The values of transmissivity remain much below 100m^2/day in the axial zone of the Bikaner syncline and relatively high values are expected in the north-eastern part around Bikaner-Sujandesar and around Raneri in the west. Average specific yield of the aquifer is estimated at 7%.

Aquifers of Nagaur Group

Only the upper part of Nagaur Group of rocks comprising mainly sandstones has been encountered just below Palana series in most of Kolayat-Bikaner-Sital-Surpura area. Ground water in Nagaur Sandstone occurs under confined conditions mostly. In the explored part its saturated thickness varies from 40 to 310 m. However, Nagaur sandstone aquifer occurs under water table conditions in Nokha area. In this area its saturated thickness varies from a few m to little over 50 m at Nokha. Yield of wells varies from 200 to 750 lpm. Transmissivity is low and ranges from 2.5 to 50 m^2/day. Permeability is correspondingly low. Specific capacity of wells varies from 0.17 to 1.20 m^2/ hr/ m. The specific yield of Nagaur Sandstone is estimated at 1% only. In the southernmost part of the district, the lower members of the Nagaur group comprising limestone - evaporite sequence also form an aquifer of insignificant potential in a localized patch.



5.1: Aquifer Disposition in Bikaner District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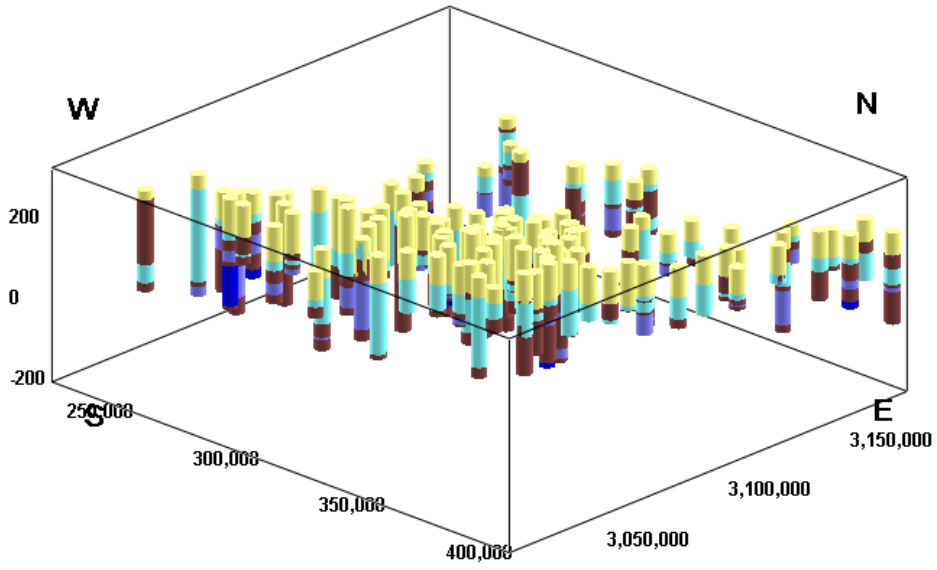
Aquifer disposition
Unsaturated (Wind blown sand)
Impervious (Clay/ Shale)
Aquifer 1 (Sand)
Aquifer 2 (Sand/ Sandstone)
Aquifer 3 (Sand/ Sandstone)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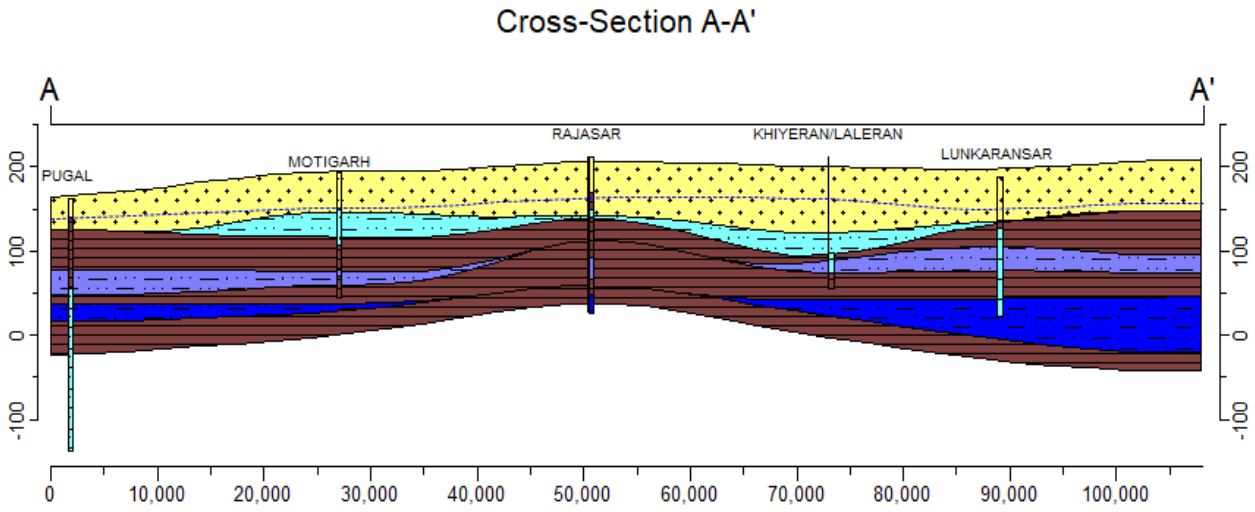
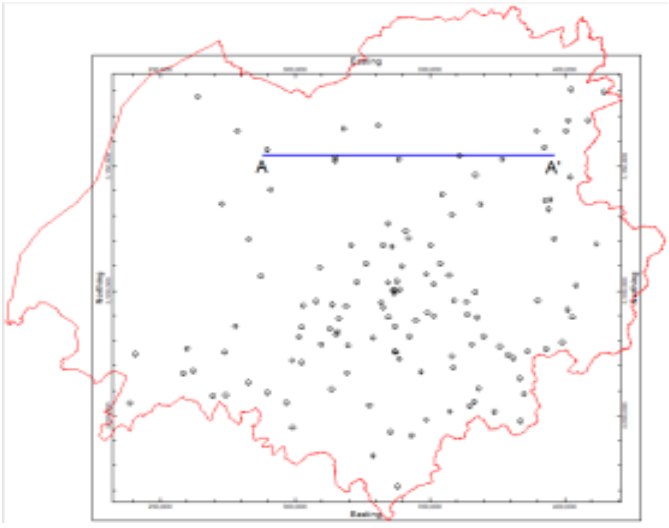
Aquifers of Jodhpur Group

Jodhpur sandstone is compact, fine to coarse grained, micaceous and purple to reddish brown in colour. In most of the Bikaner area, it lies below the evaporite sequence and it contains saline ground water.

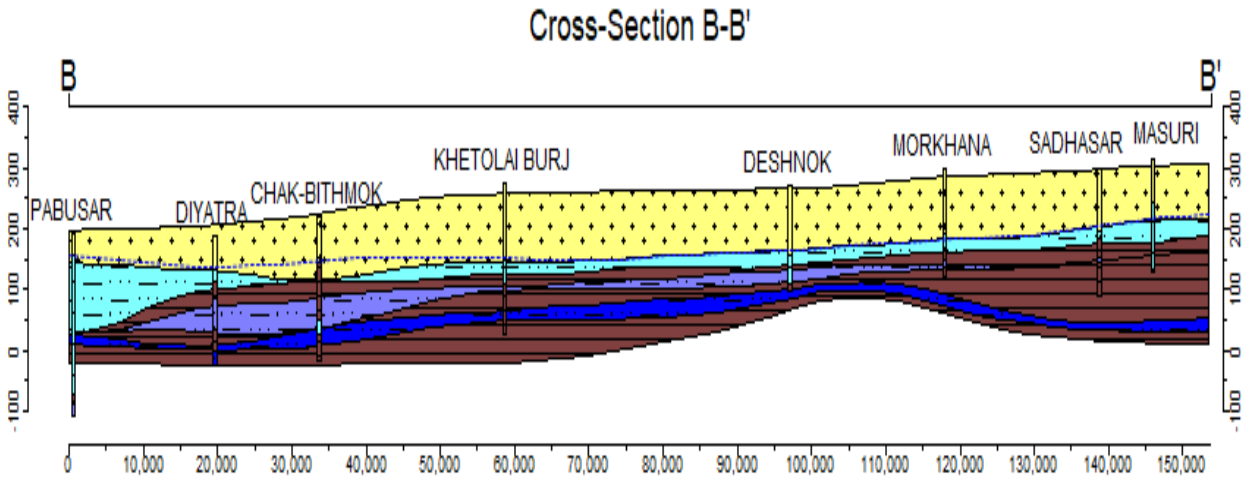
Ground water occurs under phreatic conditions in Palana sandstone and Quaternary sediments whereas it occurs mostly under confined conditions in Nagaur sandstone and Jodhpur sandstone in the district.

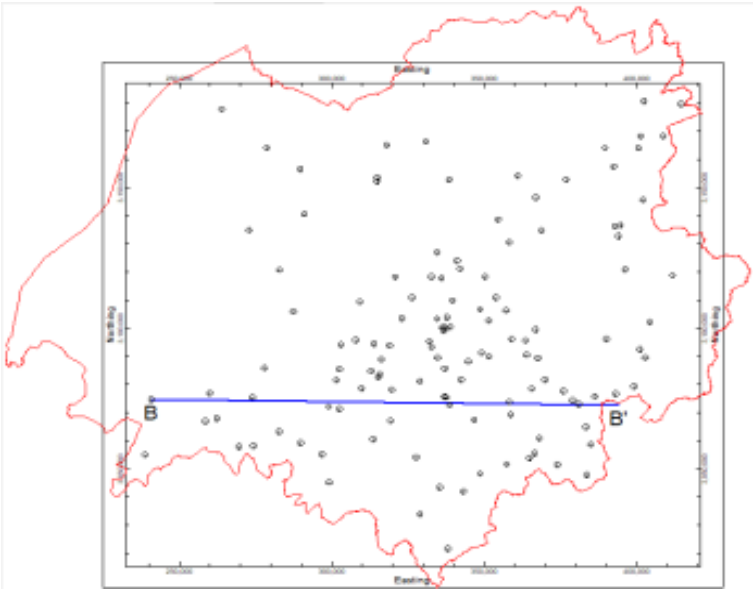
Both in Tertiaries and Quaternaries, perched water bodies are formed by arresting of downward movement of rainfall percolation by shales and clay lenses in the zone of aeration. Depth to water level in such bodies varies from 5 to 30 mbgl, the shallower being in Pipal area and deeper in Lunkaransar Kutuwas area.





5.2 :Section Line A-A'





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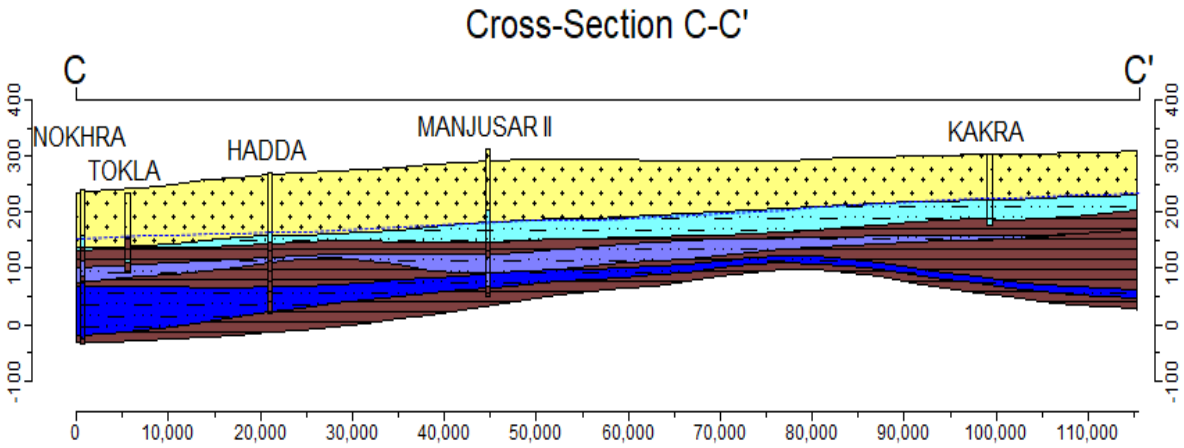
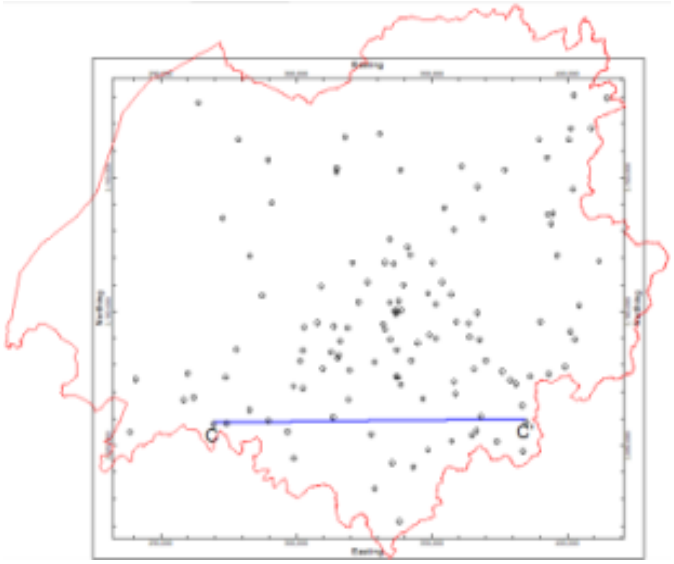




5.4: Section Line C-C'

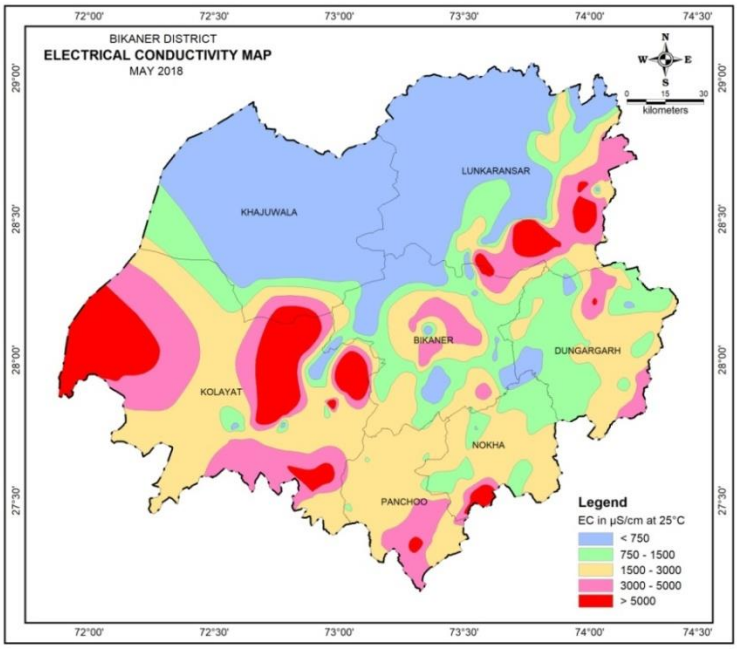
6.0 GROUND WATER QUALITY

The ground water of Bikaner district possesses relatively high mineral concentration, which varies considerably laterally and vertically. Generally, the perched water has less salt concentration except in Chandsar of Kolayat area where it is highly saline with electrical conductivity around 18000µS/cm at 25°C.Shallow ground water of the dug well zone has electrical conductivity within 3000µS/cm at 25°C.

6.1 Major Quality Parameters

Electrical Conductivity (EC)

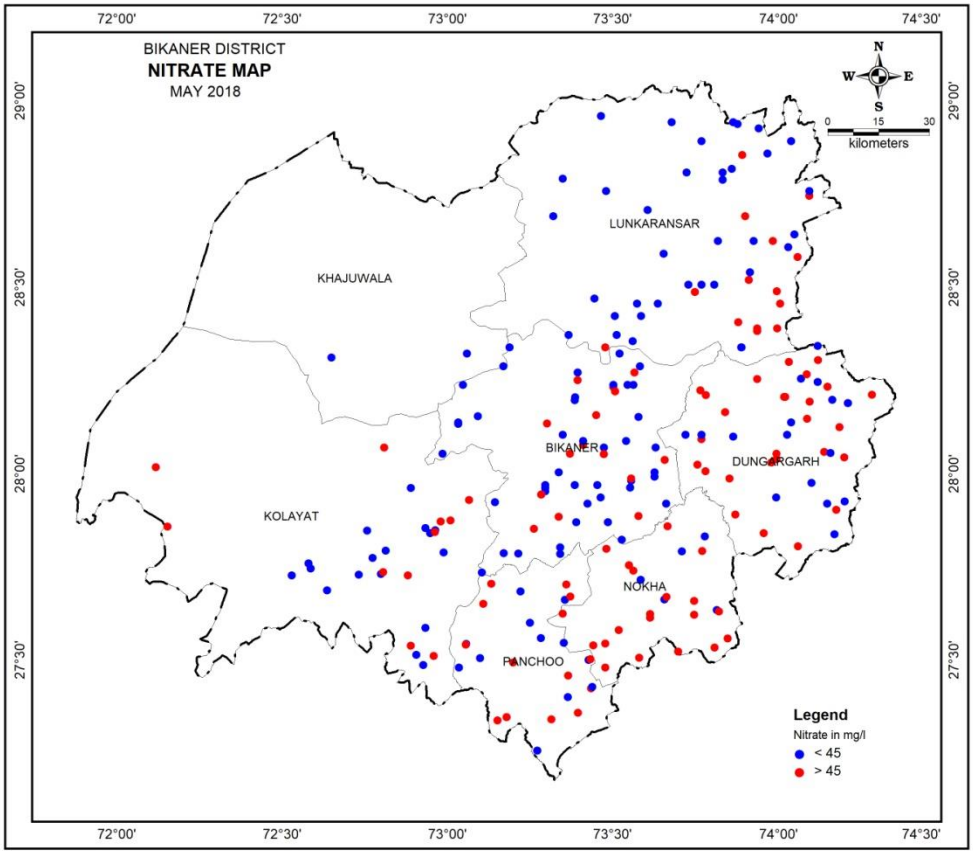
Electrical conductivity is a measure of total mineral contents of dissolved solids in water. It depends upon the ionic strength of the solution. An increase in dissolved solids causes a proportional increase in electrical conductivity. The electrical conductivity value of ground water in Bikaner found to vary from 210to 18000 µS/cm at 25°C at Malasar in Bikaner Block and Chandsar in Kolayat Block respectively. Very high concentration of 11000 to 18000 µS/cmat 25°C has been reported at Lunkaransar and Kolayat Block. The spatial variation of EC shows that in maximum area the groundwater has EC values between 750 and 3000 µS/cm at 25°C. EC between 750 to 1500 µS/cm at 25°C value has been observed in parts of Bikaner, Dungargarh, Nokha, Kolayat Blocks. As the sediments are finer, flushing of ground water is not proper and longer residence time of water in the aquifer results in dissolution of salts from the aquifer material, which leads to higher TDS content and in turn higher EC



6.1: Electrical Conductivity map of Bikaner District

Nitrate

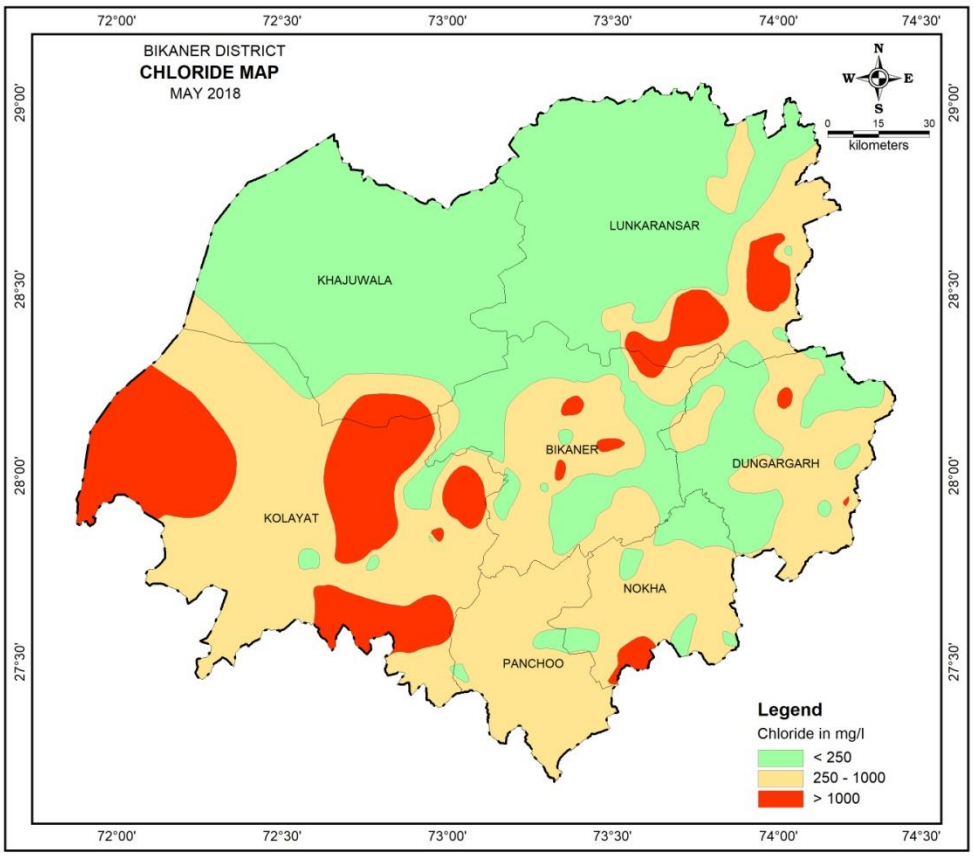
Concentration of nitrate (NO_3^-) has been found to vary from < 1 mg/l to 1070 mg/l. Nitrate concentration marginally exceeds the maximum permissible limit of 45 mg/l in drinking water prescribed by BIS (IS-10500:2012) in around 42% of the total ground water samples. Nitrate in excess of maximum permissible limit has been reported mainly from localized pockets in Kolayat, Nokha, Lunkaransar, Bikaner, Panchoo and Dungargarh Blocks. Higher concentrations of NO_3^- can be attributed to the sampling from application of more fertilizers and sewage carrying drains. Excess nitrate in drinking water can cause methaemoglobinaemia in infants, gastric cancer, goiter, birth malformations and hypertensions



6.2: Nitrate map of Bikaner District

Chloride

Concentration of chloride has been found to vary from < 250 mg/l to 3410 mg/l. Chloride concentration marginally exceeds the maximum permissible limit of 1000 mg/l in drinking water prescribed by BIS (IS-10500:2012) in around 10% of the total ground water samples. Chloride in excess of maximum permissible limit has been reported mainly from localized pockets in in Kolayat, Nokha, Lunkaransar, Bikaner and Dungargarh Blocks. Higher concentrations of NO_3^- can be attributed to the sampling from application of more fertilizers and sewage carrying drains.



6.3: Chloride map of Bikaner District

6.2 Suitability of Ground Water for Drinking Purposes

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being. The standards proposed by the Bureau of Indian Standards (BIS) for drinking water (IS-m10500-91, Revised 2012) were used to decide the suitability of ground water for drinking purpose. The overall classification of ground water samples falling below desirable limit (<DL) in the range of Desirable Limit and Maximum Permissible Limit (DL-MPL) and above maximum permissible limit (MPL) for drinking purpose is presented in table 6.1.

Table 6.1: Classification of Ground Water Samples as per BIS Drinking Water Standards

Parameters	BIS ranges for drinking		Total number of Samples	Samples< DL		Samples between DL and PL		Samples > PL	
	DL	PL		Number of Samples	%	Number of Samples	%	Number of Samples	%
pH	6.5-8.5	No relaxation	258	0	0.00	221	58	37	15
TDS mg/l	500	2000	258	68	26.36	143	55.43	47	18.21
TH mg/l as $CaCO_3$	200	600	258	118	45.74	113	43.80	14	10.46
Ca^{++} mg/l	75	200	258	217	84.10	36	13.96	5	1.94
Mg^{++} mg/l	30	100	258	128	46.62	110	42.64	20	7.74
Cl^- mg/l	250	1000	258	116	44.96	117	45.34	25	9.70
SO_4^{--} mg/l	200	400	258	196	75.96	43	16.66	19	7.38
NO_3^- mg/l	45	No relaxation	258	147	56.98	-	-	111	43.02
F^- mg/l	1	1.5	258	109	66.06	34	20.60	22	13.34

DL Desirable Limit MPL Maximum Permissible Limit

Total Hardness (TH)

Classification of ground water samples based on Total Hardness (TH) is given in Table. TH has been found to vary between 60 mg/l and 2060 mg/l, indicating soft to very hard type of ground water. High hardness may cause precipitation of calcium carbonate and encrustation on water supply distribution systems. Long term consumption of extremely hard water might lead to an increased incidence of urolithiasis, anencephaly, parental mortality and cardio-vascular disorders. In Bikaner, Total Hardness exceeds the recommended maximum permissible limit of 600 mg/l (IS-10500: 2012) in 08.66% of total analyzed ground water samples. Total hardness in excess of the maximum permissible limit has been reported from parts of Lunkaransar, Bikaner, Kolayat, Panchoo and Dungargarh Blocks of the district.

Table 6.2: Hardness Classification of water

Hardness (mg/l)	Water Class	No. of Samples	% Sample
0 – 75	Soft	3	1.18
75 – 150	Moderately Hard	60	23.62
150 – 300	Hard	110	43.30
>300	Very Hard	81	31.90

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) in water include all dissolved materials in solution, whether ionized or not. It is numerical sum of all mineral constituents dissolved in water and is expressed in mg/l. The TDS contents of ground water are controlled by the mineral dissolution rate, chemical character of ground water and ionic saturation status of solution. The concentration of total dissolved solids in the ground water has been found to vary generally between 117 mg/l to 11520 mg/l. TDS of 91% of analyzed water samples falls in the category of fresh water, while 7% samples have TDS in the range of 3000 - 10,000 mg/l and fall in brackish water category. TDS in excess of the maximum permissible limit of 2000 mg/l (IS-10500:2012) has been reported from parts of Lunkaransar, Bikaner, Kolayat, Panchoo and Dungargarh and Nokha Blocks of the district.

Table 6.3: Classification of water based on Total Dissolved Solids

Class	Range	Bikaner	Nokha	Kolayat	Lunkaransar	Dungargarh	Panchoo
TDS	mg/l	% Samples	% Samples	% Samples	% Samples	% Samples	% Samples
Fresh	0-3000	95.24	96.66	76.66	85.45	97.91	96.50
Brackish	3000-10000	4.76	3.33	16.66	14.55	2.08	3.50
Saline	>10000	0	0	6.68	0	0	0
Brine	>35000	0	0	0	0	0	0

6.3 Suitability of Ground Water for Irrigation Purposes

The ground water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. The Electrical Conductivity (EC), Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation. The quality of groundwater based on EC and SAR is discussed in tables

Table 6.4: Classification of Ground Water Samples based on EC

	Electrical Conductivity µS/cm at 25° C			Classification of water	Activity required
Type of Water	**Range**	**No. of Samples**	**% of Samples**		
Low Saline	>250	5	2.0	Excellent	• Good for all crops • little likelihood of development of salinity
Medium Saline	250-750	56	21.8	Good	• Plants with moderate salt tolerance • No special practices for salinity control required. • Moderate amount of leaching occurs.
Highly Saline	750-2250	107	41.8	Doubtful	• Cannot be used on soils with restricted drainage. • Even with adequate drainage, special management for salinity control may be required • Plants with good salt tolerance should be selected.
Very Highly saline	> 2250	88	34.4	Unsuitable	• Not suitable for irrigation under ordinary condition. • soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching • very salt tolerant crops should be selected
		256	100		

High saline water cannot be used on soils with restricted drainage and requires special management for salinity control. Plants with good salt tolerance should be selected for such areas. Very high saline water is not suitable for irrigation under ordinary conditions

but may be used occasionally under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and salt tolerance crops/plants should be selected.

Table 6.5: Classification of Ground Water Samples based on SAR

Type of Water	**Sodium Adsorption Ratio**			**Classification of water**
	Range	**No. of samples**	**% of Samples**	
Low Sodium Water	< 10	182	71.94	Excellent
Medium Sodium Water	10 to 18	51	20.15	Good
High Sodium Water	18 to 26	10	4	Doubtful
Very High Sodium Water	>26	10	4	Unsuitable
		253	100	

Table 6.6: Classification of Ground Water Samples based on Na%

Water Class	**Na%**	
	Range	**No. of samples**
Excellent	< 20	14
Good	20 - 40	25
Medium	40 - 60	53
Bad	60 - 80	119
Very Bad	> 80	42

Low sodium (alkali) water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. Medium sodium water will present an appreciable sodium hazard in fine textured soils having high cation exchange capacity especially under low leaching conditions. This water can be used on coarse textured or organic soils with good permeability.

RSC values in 256 analyzed samples of Bikaner District were found to be <1.25, 1.25 - 2.0, 2.0 - 2.5,2.5 - 3.0 samples becomes zero. 100 % samples were found in which the RSC value exceeded 3.0 meq/l limits. The high RSC value makes the groundwater unsuitable for irrigation uses.

The block-wise analysis for RSC values for assessing suitability of groundwater for irrigation is presented in table. The analysis of table indicates that groundwater in the Bikaner district is not suitable for irrigation.

Table 6.7: Classification of Ground Water Samples based on RSC

RSC (meq/l)		Bikaner	Dungargarh	Nokha	Kolayat	Panchu	Lunkaransar	District Total
Range	No.of samples	% samples	% samples	% samples	% samples	% samples	% samples	% samples
< 1.25	0	0	0	0	0	0	0	0
1.25 - 2.0	0	0	0	0	0	0	0	0
2.0 - 2.5	0	0	0	0	0	0	0	0
2.5 - 3.0	0	0	0	0	0	0	0	0
> 3.0	256	24.60	18.76	11.72	12.12	11.32	21.48	100

7.0 Ground Water Resources

The ground water resource assessment as on March 2017 has been carried out and the salient features of the resources are given in Table

As per table-, out of the total 3038177 ha area, recharge worthy areas are 1905577 ha in command areas and 1315253 ha in non-command areas.

Table 7.1 : Area for Resource assessment (as on March 2017) in Bikaner District

S.No	Blocks/Assessment Units	Total Geographical Area (ha)	Potential Area (ha)	Hilly Area (ha)	Command Area (ha)	Non Command Area (ha)
1.	Bikaner	382476	319100	0	32500	286600
2.	Dungargarh	300390	270388	0	0	270388
3.	Khajuwala	545324	54532	0	0	0
4.	Kolayat	797086	192400	0	0	192400
5.	Lunkaransar	632802	207100	0	12500	194600
6.	Nokha	188810	188810	0	0	188810
7.	Panchoo	191289	182455	0	0	182455
	Total	3038177	1905577	0	45000	1315253

7.1 Recharge Component

During the monsoon season, the rainfall recharge is the main recharge parameter, which is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge can be expressed as:-

$R = h \times Sy \times A + DG$

Where h = rise in water level in the monsoon season, Sy = specific yield

A = area for computation of recharge, DG = gross ground water draft

The monsoon ground water recharge has two components- rainfall recharge and recharge from other sources. The other sources of groundwater recharge during monsoon season include seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, and water conservation structures.

During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge.

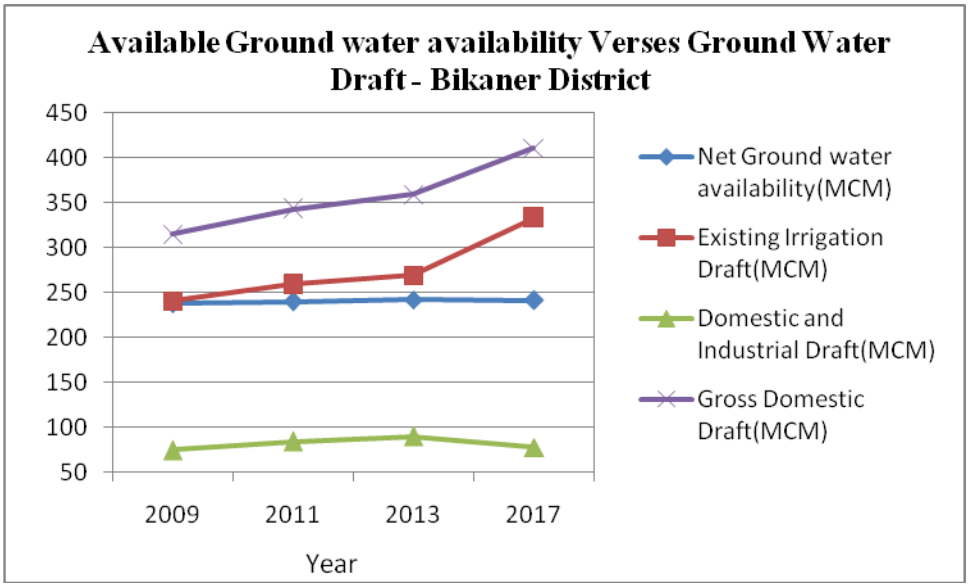
The season wise and block-wise wise assessment of recharge from various components such as rainfall and other sources for various units was done and presented in table. The recharge from rainfall contributes maximum component (253009.354 ham) during monsoon season and recharge from other sources (238.2911 ham). The total annual ground water recharge is 26603.80ham and net ground water availability after natural discharge is 3056.6623 ham.

Table 7.2: Recharge Components evaluated for Resource Estimation

Blocks/ Assessment Units	Accepted Value of Mon. Rainfall recharge Rrf (Normal)	Total Recharge from other sources	Recharge from Rainfall during non-monsoon	Recharge from other sources (Rgw+Rc+Rsw+Rt)	Total Annual ground water Recharge	Environmental flows during Non Monsoon Season	Net GW Availability
	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)
Bikaner	5353.5	177.85194	0	730.6615	6262.0134	626.2013	1320.7621
Dungargarh	5286.062	0	0	0	5286.062	373.4928	0
Khajuwala	0	0	0	0	0	0	
Kolayat	3013.7994	0	0	0	3013.7994	301.3799	0
Lunkaransar	3506.8738	60.43919	0	325.4944	3892.8073	389.2808	1678.1513
Nokha	3906.654	0	0	0	3906.654	390.6654	0
Panchoo	4242.4644	0	0	0	4242.4643	424.2464	57.7489
DISTRICT	25309.354	238.29113	0	1056.1559	26603.80	2505.2666	3056.6623

C-Command, NC Non-Command

The annual gross draft for all uses is estimated at 41034.308 hamwith irrigation sector being the major consumer having a draft of 33254.168 ham. The annual draft for domestic and industrial uses was 7780.14 ham. The allocation for domestic & industrial requirement supply up to next 25 years is about 10097.109 ham.



7.1: Ground Water Availability Vs Draft in Bikaner District

Table 7.3 : Block wise GW Resources of Bikaner (March 2017) (in ham)

Block	Potential Zone	Annual Extractable Ground Water Recharge	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Domestic & Industrial Uses	Existing Gross Ground Water Draft for all uses	Stage of Ground Water Extraction %	Category
Bikaner	319100	5635.81	12214.65	1527.76	13742.41	243.84	OE
Dungargarh	270388	4912.57	8280.72	1762.40	10043.12	204.44	OE
Khajuwala	545324	18571.55	0.00	0.00	0.00	0.00	Saline
Kolayat	192400	2712.42	1661.72	1047.04	2708.76	99.87	Critical
Lunkaransar	207100	3503.53	1224.36	746.00	1970.36	56.24	Safe
Nokha	188810	3515.99	7506.72	1664.00	9170.72	260.83	OE
Panchoo	182455	3818.22	2366.00	1032.94	3398.94	89.02	Semi Critical
Total	1905577	42670.09	33254.17	7780.14	41034.31	170.28	OE

7.2 In-storage Resources

Ground water resource assessment of the zone below water level fluctuation is carried out is presented in table7.4.

Table7.4 : Block wise In-storage Resources of Bikaner District

Block	Total Area (Sq.Km)	Main aquifer	Sp yield	Utilizable Volume (mcm)	In storage Resources (mcm)
Bikaner	3824.76	3191.00	0.01	30.49	972.888
Nokha	1888.10	1725.6	0.06	59.42	233.47
Kolayat	7970.86	1924	0.06	42.94	322.58
Dungargarh	3003.9	1582.79	0.06	71.06	636.61
Lunkaransar	6372	2071	0.06	32.47	408.8
Panchoo	1912.89	1824.55	0.06	71.50	423.96
Khajuwala	545324	0	0	0	Saline
Total	570296.5	12318.94	0.31	307.88	2998.308

The total in-storage resources of the district, comes to 2998.30 mcm. The block-wise sustainability period of aquifers, if the present ground water draft for all uses continues to be same, is calculated after considering both dynamic resources and in-storage resources and presented in table

Table 7.5: Block wise Sustainability of Aquifer in Bikaner

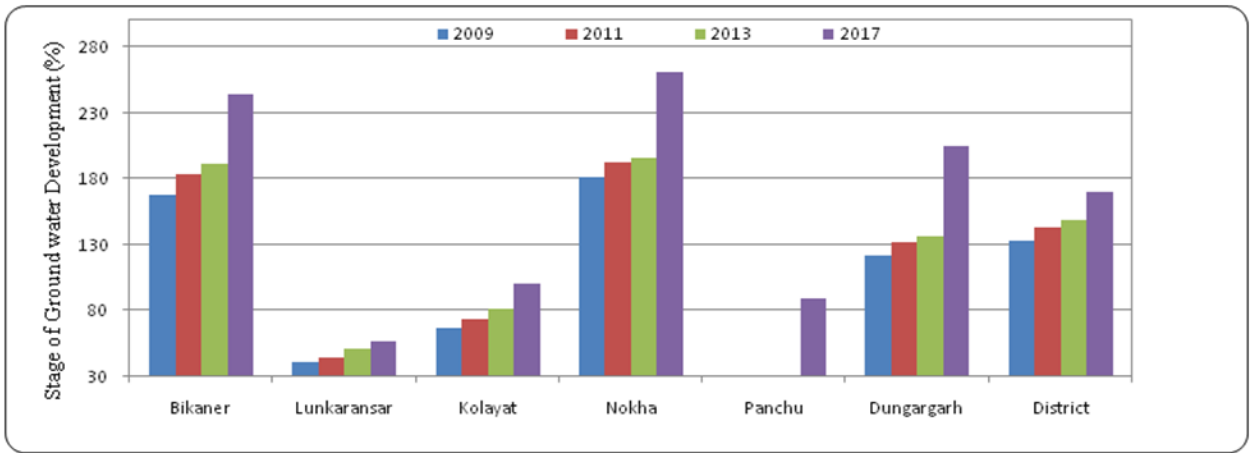
Block	Dynamic Resource (mcm)	In-Storage Resources (mcm)	Current annual gross ground water extraction for 'All Uses' (mcm)	Sustainability period of Aquifer (years)
Bikaner	56.35812	972.888	137.4241	7.489561
Dungargarh	49.12569	636.6148	100.4312	6.827963
Khajuwala	0	0	0	Saline
Kolayat	27.1242	322.58	27.0876	12.91012
Lunkaransar	35.03527	411.16	19.7036	22.64537
Nokha	35.15989	233.472	91.7072	2.929235
Panchu	38.18218	423.9654	33.9894	13.59681
Total	240.9854	2998.308	410.3431	11.06

8.0 Aquifer Management Plan

8.1 Ground Water Related Issues

Over Exploitation of Groundwater

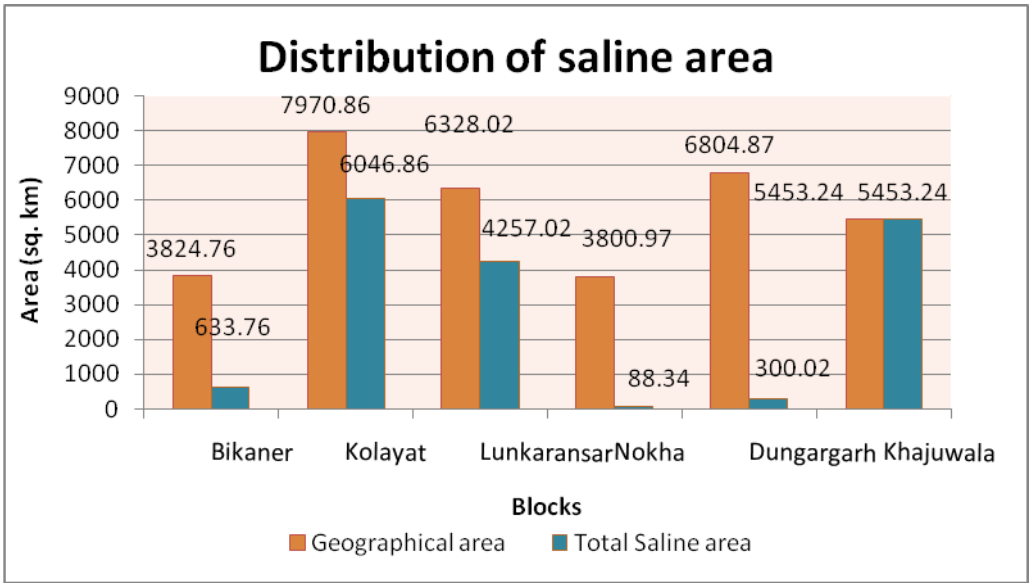
The ground water draft is more than net ground water availability in all the blocks The Stage of Ground Water is also increasing. This is due to over-exploitation of ground water for irrigation purposes. The groundwater resource estimation was done for all blocks of the district, stage of ground water development has increased over the period of time from 2009 to 2017 in almost all blocks of the District.



8.1: Block-wise Stage of GW Development

Inland Salinity

The parts of Bikaner, Lunkaransar, Dungargarh, Nokha, Panchoo, Kolayat, Khajuwala Blocks covering an area of 34182.72sq.km area has saline nature due to inland salinity problems with EC ranging from 3000 to 18000 µS/cm at 25°C. The ground water in these areas is neither suitable for drinking nor for irrigation purposes. Figure depicts the ground water quality of aquifer



8.2: Distribution of Saline Area in Bikaner District

Table 8.1: Percentage of saline area in Bikaner District

Block	Geographical area	Tertiary Sandstone	Older Alluvium	Nagaur& Jodhpur Sandstone	Bilara Limestone	Total Saline area	Saline area (%)
Bikaner	3824.76	250	383.76			633.76	3.78
Kolayat	7970.86	1968.75	3609.36	468.75		6046.86	36.04
Lunkaransar	6328.02		3319.52	937.5		4257.02	25.37
Nokha	3800.97				88.34	88.34	0.53
Dungargarh	6804.87		300.02			300.02	1.79
Khajuwala	5453.24		5453.24			5453.24	32.50
Total	34182.72	2218.75	13065.9	1406.25	88.34	16779.24	16.66

Area in sqkm

8.2 Ground Water Management Plan

The management plan has been proposed to manage the ground water resources and to arrest further decline in water levels and improve the Stage of Ground Water Development in the district which is 170 % for the district and falls in Over-Exploited category. The management plan comprises two components namely supply-side management and demand side management. The management plan proposed in all the 7 blocks of Bikaner District is discussed below.

8.2.1Supply Side Management

The supply side management of ground water resources is proposed based on availability of surplus surface water. No surplus surface water is available during rainy season for which a total of 24889Tanka (Nos.) (Capacity 50,000 liters) are proposed to be constructed in the district. After construction of water conservation structures, volume of 1.244 mcm surface water conserved.

Table 8.2: Block-wise Proposal of Water Conservation Structures in Bikaner District

Block	**Geographical Area (sq km)**	**Hilly Area (sq km)**	**Potential Area (sq km)**	**Tanka (Nos.) (Capacity 50,000 liters)**	**Average cost (Rs) of Tanka**	**Total cost (Rs in crore) of Tanka**
Bikaner	3824.76	0	3191.00	2031	200000	4.06
Dungargarh	3003.90	0	2703.88	3439	200000	6.88
Khajuwala	5453.24	0	5453.24	5292	200000	10.58
Kolayat	7970.86	0	1924.00	4312	200000	8.62
Lunkaransar	6328.02	0	2071.00	4216	200000	8.43
Nokha	1888.10	0	1888.10	2793	200000	5.59
Panchoo	1912.89	0	1824.55	2806	200000	5.61
Total	30381.77	0	19055.77	24889	200000	49.77

Block	Existing Structures constructed by State Govt.	Diggi/Jalhod	Khadin	Talai/Talab	Roof Top Rain Water Harvasting
Bikaner	77	16	55	05	01
Dungargarh	163	151	0	05	0
Khajuwala	0	0	0	0	0
Kolayat	07	0	0	04	3
Lunkaransar	14	01	0	13	0
Nokha	60	49	0	05	09
Panchoo	10	03	0	04	03
Total	331	220	55	36	13

8.2.2 Demand Side Management

The Demand Side Management is proposed in all the blocks as the Stage of Ground Water Development is 170.28 and Bikaner, Dungargarh, Nokha blocks fall in **Over Exploited** Category, Kolayat falls in Critical category, Panchoo falls in Semi- Critical category and Khajuwala is saline. Even though after implementation of supply side management options in the current scenario, the water saving is still less to compensate the with drawal.So, there is a need of adopting micro-irrigation techniques for water intensive crops or change in cropping pattern or both are required to save water.

The micro-irrigation techniques viz. sprinkler or drip irrigation, which is not in practice in the district till date is proposed to be adopted in 93194 ha. area of the district which can save a total of 74.55mcm water. Similarly, if the 50% of cropping area of wheat be changed to gram crop it can save water up to 25.71 mcm (Figure 8.5).

Table 8.3: Block-wise proposal for adopting Micro-Irrigation in Bikaner District

Blocks	**Net Irrigated Area through Ground Water (ha)**				**50% of area proposed for adopting Micro Irrigation Techniques (ha) (Sprinklers)**	**Water Saving through Micro Irrigation (mcm)**
	Canals	**TW**	**DW**	**Total**		
Bikaner	15444	77254		92698	55618.8	44.49504
Dungargarh		170464		170464	85232	68.1856
Khajuwala	81891	129		82020	41010	32.808
Kolayat	123304	36356	9631	169291	84645.5	67.7164
Lunkaransar	39008	14100	10	53118	26559	21.2472
Nokha		98504		98504	49252	39.4016
Panchu		15510		15510	7755	6.204
District	259647	412317	9641	681605	340802.5	272.642

Table 8.4: Block-wise proposal for Crop Change and Water Saving in Bikaner District

Blocks	**Area Proposed for crop change from Wheat to Gram (ha)**	**Water Saving through ChangeinCrop (mcm)**
Bikaner	3334	3.3335
Dungargarh	4342	4.342
Khajuwala	4453	4.453

Kolayat	3539	3.5385
Lunkaransar	3509	3.509
Nokha	1490	1.49
Panchu	1904	1.904
District	22571	22.57

8.2.3 Expected Benefits

The impact of groundwater management plans on the groundwater system in the district after its implementation is evaluated and the outcome shows significant improvement in groundwater scenario in all blocks as given in the table

After implementation of interventions the total Stage of Groundwater Extraction will improve from 136% to 77%.

Table 8.5 : Ground Water Availability & Stage After Interventions in Bikaner District

Block	Net G.W. Availability (mcm)	Additional Recharge from RWH & conservation (mcm)	Total Net G.W. Availability after intervention (mcm)	Existing G.W Draft for all purpose (mcm)	Saving of Ground water through projects (mcm)	Net GW draft after interventions (mcm)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. (in %)
Bikaner	56.35812	0.10	56.46	137.42	95.76	41.66	243.84	73.79
Dungargarh	49.12569	0.17	49.30	100.43	76.87	23.56	204.44	47.79
Khajuwala	185.7155	0.26	185.98	0.00	41.71	41.71	0	22.43
Kolayat	27.1242	0.22	27.34	27.09	74.79	47.71	99.87	174.49
Lunkaransar	35.03527	0.21	35.25	19.70	28.27	8.56	56.24	24.29
Nokha	35.15989	0.14	35.30	91.71	46.22	45.49	260.83	128.87
Panchu	38.18218	0.14	38.32	33.99	8.10	25.89	89.02	67.55
Total	426.7009	1.24	427.95	410.34	371.72	234.58	136.32	77.02

Conclusions

The study was carried out based on data gap analysis, data generated in-house; data acquired from State Govt. departments and GIS maps prepared for various themes. All the available data was brought on GIS platform and an integrated approach was adopted for preparation of block wise aquifer maps and aquifer management plans of Bikaner District.

Bikaner district covering an area of 30247 sq.km. Geologically, the area is occupied by Alluvium, Tertiary Sandstone and Limestone formations. The stage of ground water

development is 1369 %.The area witnessed Inland Salinity, Declining water level, Over-exploitation and low yield potential aquifers, being the major issues in the district.

Trend analysis of Pre-monsoon water during the past decade (2009 – 2018) indicates declining trend of ground water levels in most parts of the District.

Managing ground water is a grand challenging problem in its severity, pervasiveness and importance. To increase the water use efficiency, source sustainability plans of rain water harvesting and artificial recharge have been envisaged in the district.

The management plan has been proposed for all 7 blocks namely to manage the ground water resources and to arrest further decline in water levels.

The management plan comprises two components namely supply-side management and demand side management.

As a part of **Supply side Management**, a total of 24889 Tanka proposed for water conservation. After which an amount of 1.24 mcm surface water conserved.

As a part of **Demand side Management**, micro-irrigation techniques are to be adopted in3408.02 sq. km area thereby saving a total of 272.64 mcm water. Change in cropping pattern is proposed in 2257 ha of area which will save 22.57mcm water in the district and in turn bring down the Stage of Ground Water Development to 77%.

Recommendations

Awareness program to educate about conservation of precious ground water resources and training on rainwater harvesting will be beneficial to check decline in water level and justified use.

Ground water development in over-exploited, critical and semi-critical area should not be encouraged.

Use of water saving devices like sprinklers, close field distribution channels etc should be promoted.

Modern agricultural management techniques have to be adopted for effective and optimum utilization of the water resources. This can be achieved by maintain in irrigation through minimum pumping hours as per minimum requirement of water by the crop and also selecting most suitable cost effective crop pattern.

High water requirement crops to be discouraged. Proper agriculture extension services should be provided to the farmers so that they can go for alternate low water requirement economical crops.

Salt resistant crops can be grown in the area having brackish ground water.

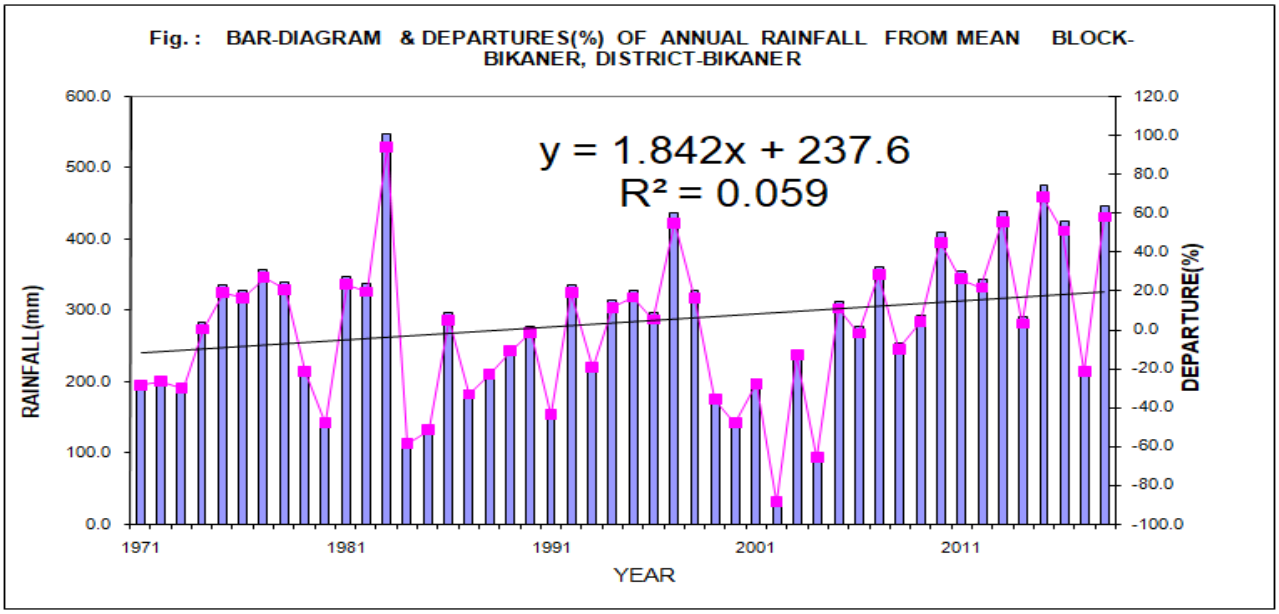
Traditional rainwater harvesting structures like tankas, roof top rain water storage should be encouraged for meeting day to day requirements which will reduce ground water withdrawal.

Large-scale recharge potentials exist in depleted aquifers. Implementation of artificial recharge in such areas through outside surface water sources like lift canal from IGNP system or floodwater during excess rainy years be promoted.

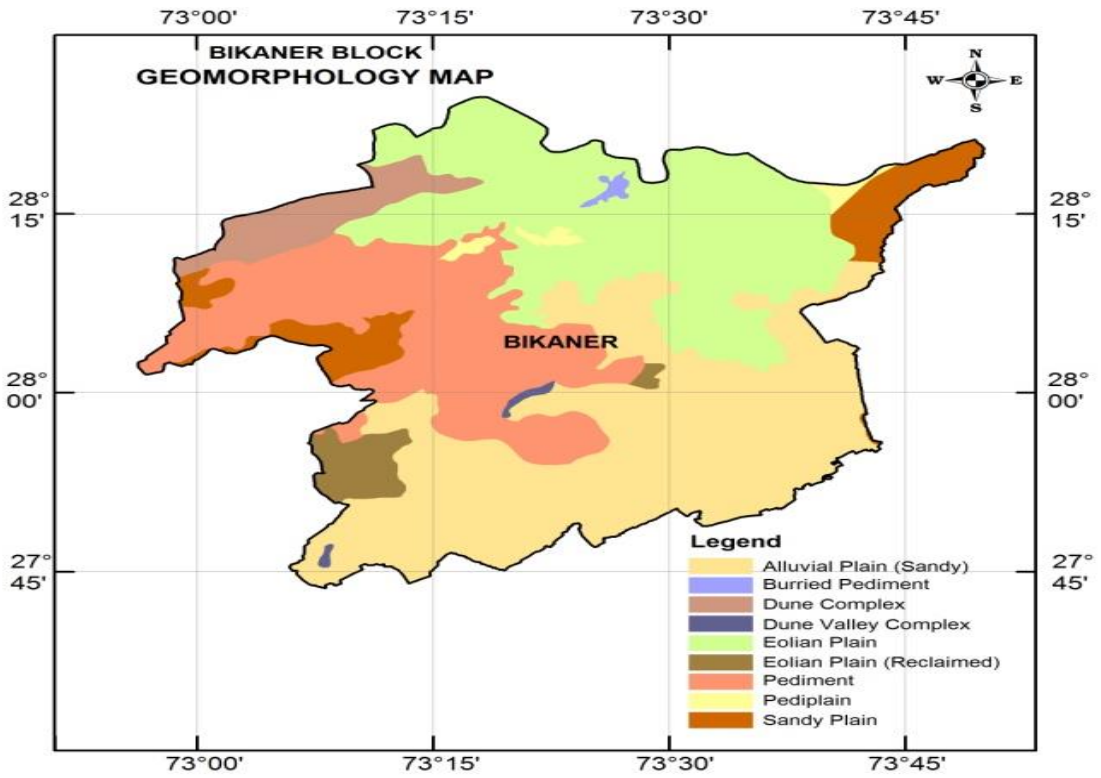
Conjunctive use of ground water and surface water should be encouraged in canal command areas to prevent further water logging in the CCA. Anti water logging measures have to be adopted in the canal command areas.

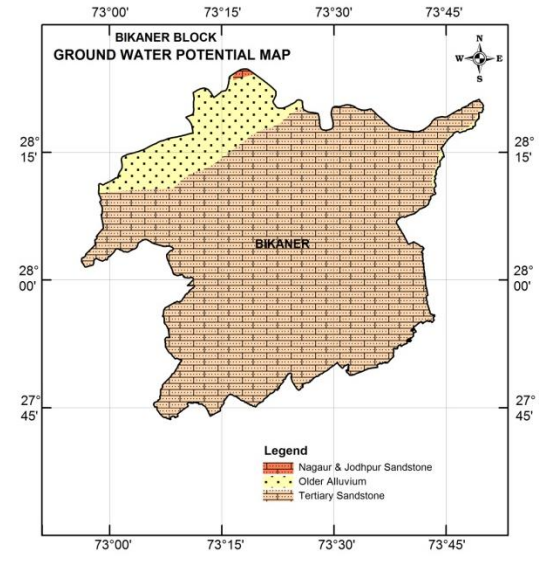
BIKANER BLOCK

SALIENT INFORMATION	
Block Name	**BIKANER**
Longitude	72°29'43" to73°50'33"
Latitude	27°44'04" to28°48'05"
Geographical Area Sq.km	3824.76
Hilly Area (Sq.km)	Nil
Population (2011)	919704
Climate	
Average Temperature range (°C)	16.9 to 47 with an average of 28
Rainfall Analysis	
Normal Rainfall (mm)	275.15
Mean Annual rainfall (mm)	282.82
Highest annual rainfall with year (mm)	547.8 (1983)
Lowest annual rainfall (mm) with year	32 (2002)
Standard deviation (mm)	104.68
Coefficient of Variation (%)	37.01

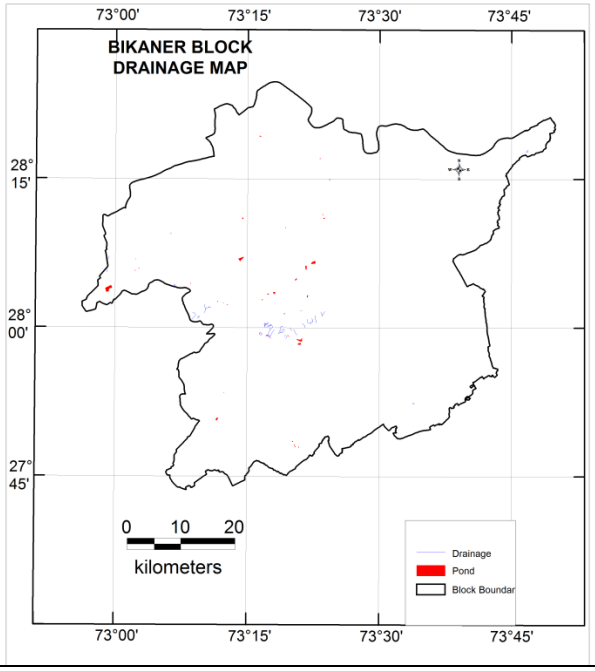


Drought Analysis	
Mild (0 to -25%)	09
Normal (-25% to -50%)	08
Severe (-50% to -75%)	3
Most severe (-75% to -100%)	01
Probability of Normal Rainfall	17%
Geomorphology	
Geomorphic Unit	Older alluvial plains, Sandy undulating aggraded Alluvial plains, Flat Interdunal Plains, Sandy undulating interdunal plains, Aeolian complex, Stabilized Sand dunes, Active Sand dunes, Eroded rocky surface, Sandy Plain.
Elevation (m amsl)	123.2 - 298.6



Geology	
• Eolian/Alluvium sand, Age: Pleistocene to recent. • Tertiary Sand stone. Age Eocene. • Jodhpur &Nagaur sand stone of Marwar super group Age: Palaeozoic	

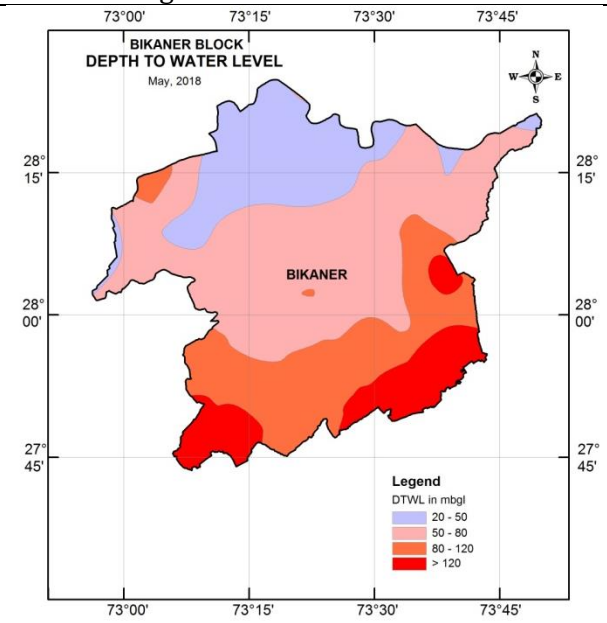
Drainage & Hydrology	
Drainage **Basin/Sub-Basin**	No major Drainage except few ephemeral stream lets
Hydrology	6 Canals

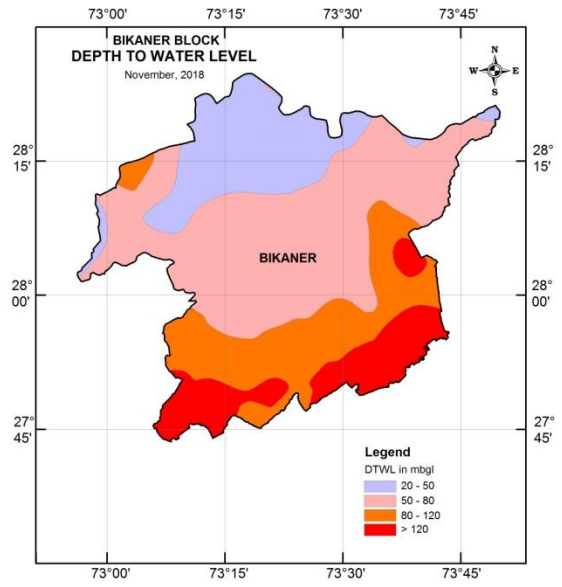


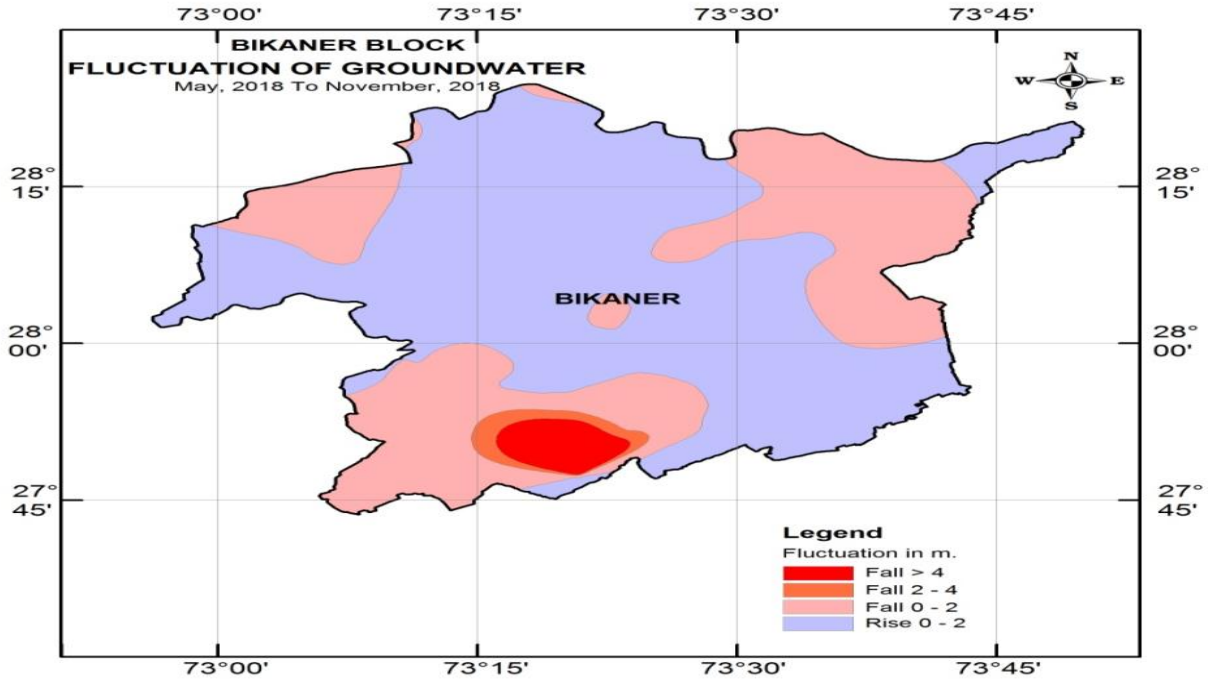
1. Kanwarsen Main lift lined 11.19 km
2. Bikaner Minor lined 13.43 km
3. Bikaner sub minor lined 11.34km
4. Nagasar minor 3.5 km
5. Jamsar Main lift lined 10.39 km
6. Husangsar Minor lined 2.19 km

Ponds		85	
LAND USE, AGRICULTURE, IRRIGATION & CROPPING PATTERN			
Geographical Area in ha.		380935	
Forest Area in ha.		8814	
Net Sown Area in ha.		191175	
Area sown more than once in ha.		7710	
Rainfed Crop		Bajra in 6224 hect. area	
Area under Irrigation (Net) in ha			
Surface Water		9329(canal)	
Ground Water		27964	
Other sources		11	
Season wise crop area in ha.			
	Kharif	**Rabi**	**Zaid Rabi**
sown	164038	27137	Nil
Irrigated	15046	22258	Nil
Principal Crop Area (ha)			
Crop Type			
Cereals		13122	
Oil Seeds		24450	
Pulses		51879	
Hydrogeology			
Monitoring Stations (May 2018)			

CGWB	09
SGWD	24
NAQUIM Key Wells	10
WATER LEVEL BEHAVIOUR	
Pre-Monsoon (May-2018) Water level	Post-Monsoon (November-2018)Water level
20 - 153 m bgl	20.43-152.21 m bgl

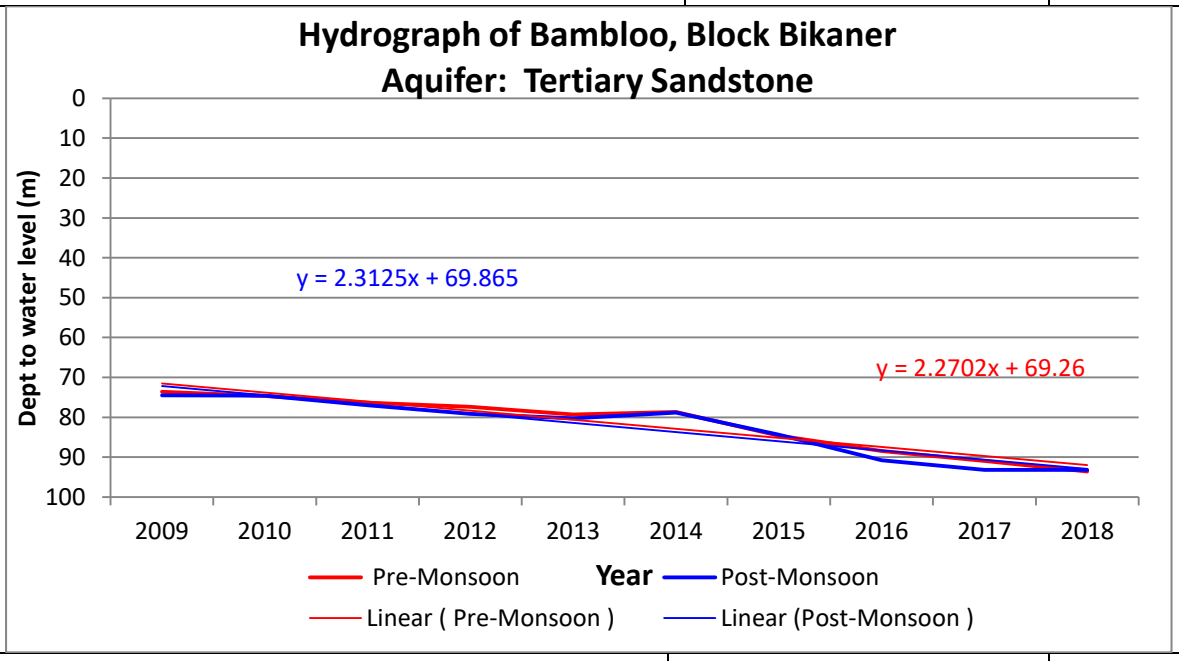




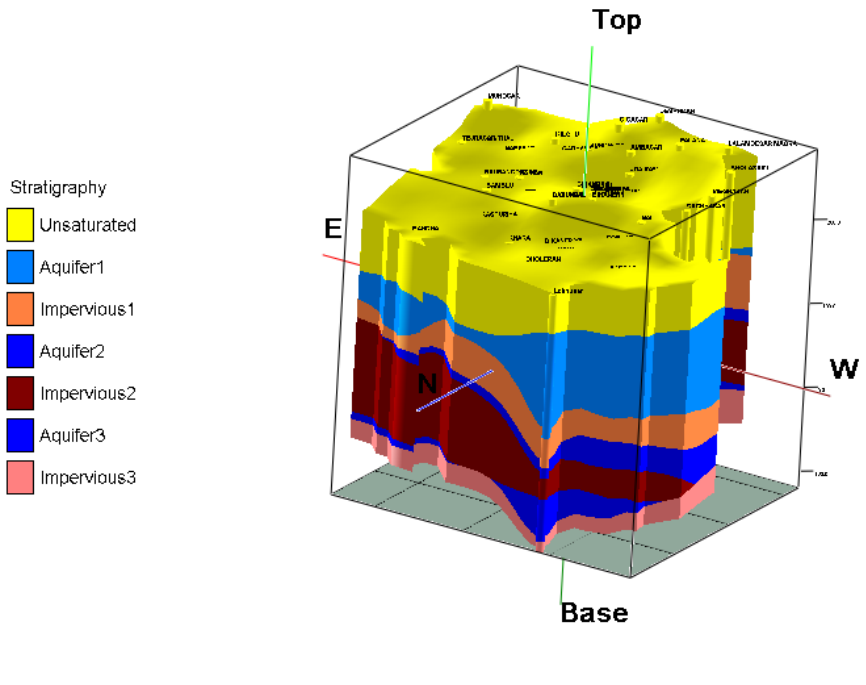


Water Level Trend (2009-2018)	Pre-monsoon	Post-monsoon
Average Trend (m/year)	Declining 0.28	Declining 0.42

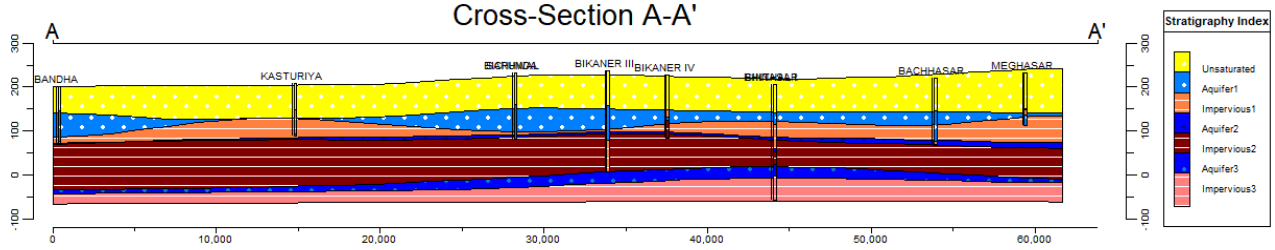
	Pre-monsoon	Post-monsoon
Rise	-6.63 – (-0.265)	-17.89- (-1.128)
Fall	1.19 – 3.98	NA



AQUIFER DISPOSITION		
Number of Aquifers (Major)	Three	
Number of Zones	Two	
I	Alluvium	
II	Tertiary Sand Stone	
III	Jodhpur-Nagaur Sand Stone	



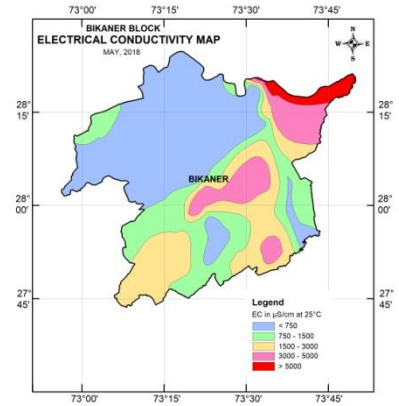
CROSS SECTIONS

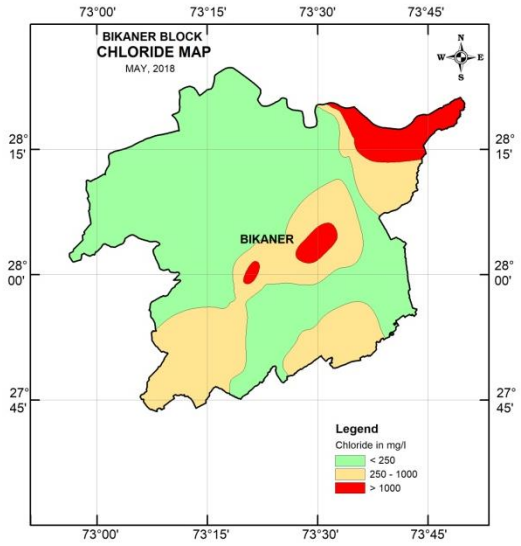


Status of GW Exploration	CGWB		GWD
No of Wells	24		15
BASIC AQUIFER CHARACTERISTICS			
Type of Aquifer	Unconfined	Confined	Confined
Depth of Occurrence (mbgl)	70-160	175-200	250-300
Yield Potential (lpm)	40-947	75-505	135-757
T(m2/day)	99.3	370	36
Drawdown(m)	14.82	5.80	39.26
EC (µs/cm at 25^{0}C)	800-2698	650-19170	890-35000

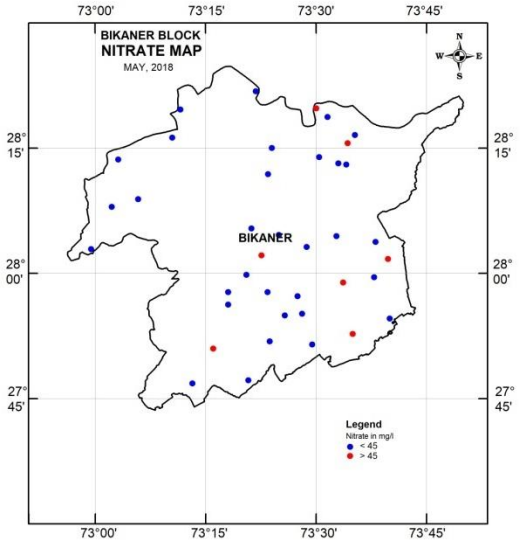
CHEMICAL QUALITY OF GROUND WATER		
Suitability for Drinking		
TDS(mg/l)	**Range**	**% Samples**
Fresh	0-3000	95%
Brackish	>-3000	5%
Hardness(mg/l)as $CaCo_3$	**Range**	**% Samples**
Soft	0 – 75	0.00%
Moderately Hard	75 – 150	37%
Hard	150 – 300	51%
Very Hard	>300	12%

CHEMICAL QUALITY MAP





VARIATION IN MAJOR & MINOR ELEMENTS	
EC < 2000 µS/cm at 25°C	78%
NO3 in mg/l>45 mg/l	16%
F in mg/l – 1 to 1.5 mg/l	12%
>1.5 mg/l	0%



Suitability for Irrigation

EC		**RSC (meq/l)**		
Type of Water	**Classification**		**Range**	**% Samples**
			< 1.25	67.40
Low Saline< 250 mg/l	Excellent	12.00	1.25 - 2.0	9.30
Medium Saline 250 – 750 mg/l	Good	30.00	2.0 - 2.5	4.70
Highly Saline 750 – 2250 mg/l	Permissible	37.00	2.5 - 3.0	9.30
Very Highly saline> 2250 mg/l	Doubtful	21.00	> 3.0	9.30

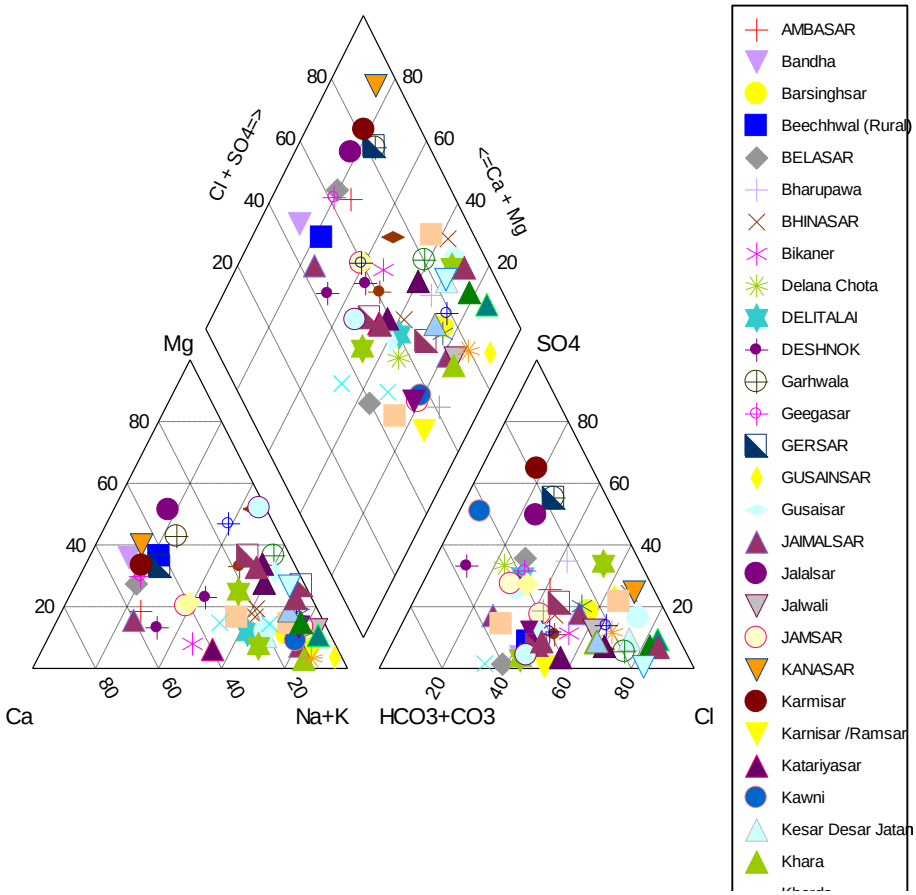
Na%			**SAR**		
Water Class	**Range**	**% Samples**	**Water Class**	**Range**	**% Samples**
Excellent	< 20	13.95	Excellent	<10	97.67
Good	20 - 40	18.60	Good	10 to 18	2.32
Medium	40 - 60	11.62	Medium	18 to 26	0.00
Bad	60 - 80	39.53	Bad	>26	0.00
Very Bad	> 80	16.27			

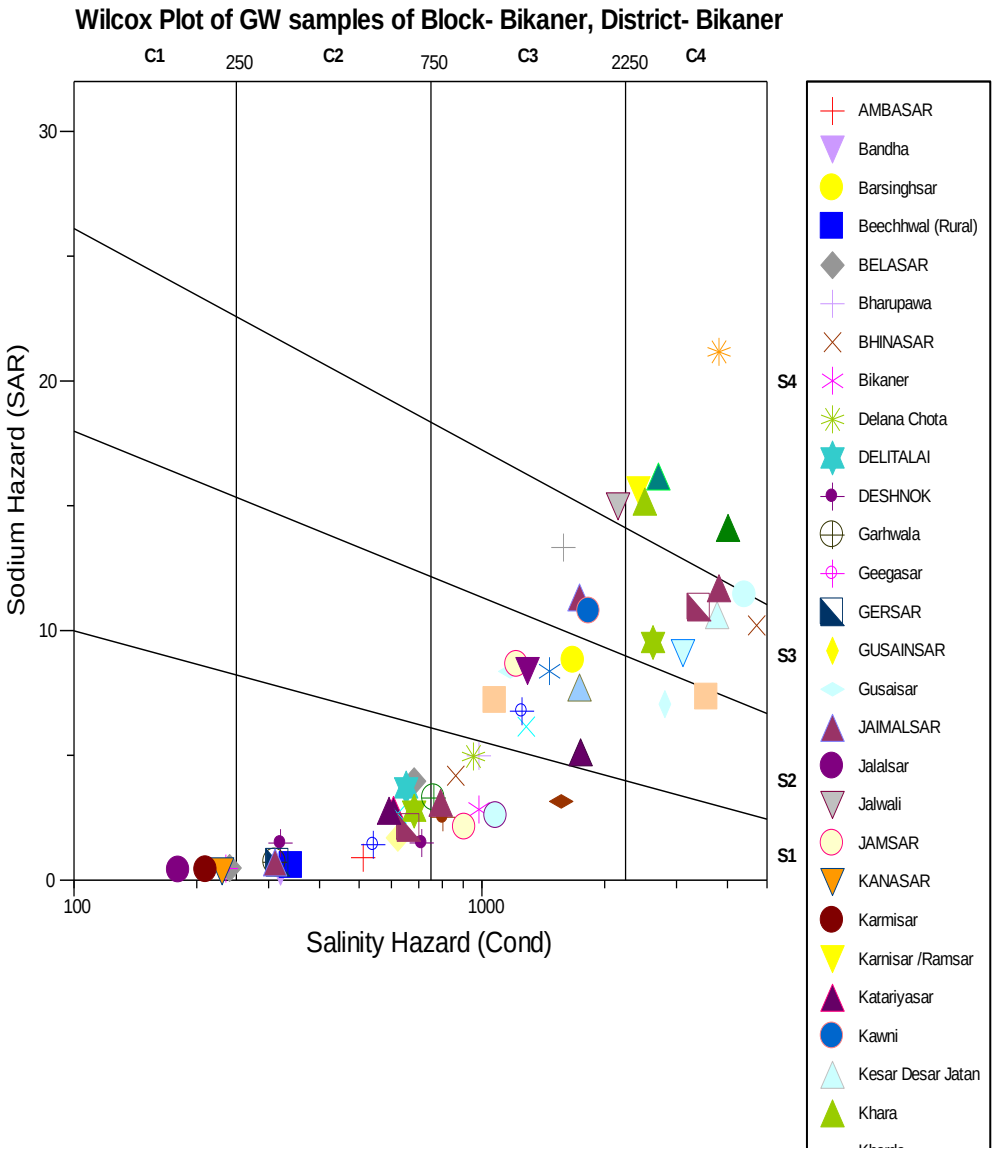
GROUND WATER ISSUES	
1. Over-Exploitation – Resource Availability	At present the Ground water Draft is more than Annual Availability thus the block is deficit of 81.06 mcm water
2. Rainfall and Drought	• Mild Droughts in 09% years • Normal Droughts in 08.00% years • Severe Drought in 6.25% years
3. Decadal Water Level Trend (2009-2018)-	Declining
4.Ground water quality issues	Highly saline, Sporadic occurrence of nitrate due to poor drainage

GROUND WATER RESOURCE & EXTRACTION(GWRE-2017)	
Ground Water Recharge Worthy Area (sq. km.)	3191
Total Annual Ground Water Recharge (mcm)	62.6201
Natural Discharge (mcm)	6.262
Net Annual Ground Water Availability (mcm)	56.358
Existing Gross Ground Water Draft for All uses(mcm)	137.42
Provision for domestic and industrial requirement supply to 2025(mcm)	13.2076
Stage of Ground Water Development %	243.84
Category	Over Exploited
In-Storage Resource	
Total Area (Sq.	3824.76
Main aquifer	3191.00
Sy	0.01
Total Resource	972.888
Utilizable Volume (mcm)	30.49
Total In-storage Resource (mcm)	972.888
Total Resource Dynamic + In-storage	1029.246
Sustainability Period with existing draft	7 years
GROUND WATER RESOURCE ENHANCEMENT	
Artificial Recharge & Water Conservation Possibilities	
Existing Structures constructed by State Govt.	77
Diggy/Jalhod	16
Khadin	55
Talai (Talab)	5
Roof Top Water Harvesting Structure	1
SUPPLY SIDE MANAGEMENT	
Water conservation structure proposed to conserve water (mcm)	
Tanka no with capacity of 50,000 liters	2031
Volume of water to be conserved (mcm)	0.101559
Type of Aquifer	
Soft Rock Area (sq.km)	Tertiary Sand stone (3824.76
Volume of Sub surface Storage Space available for Artificial Recharge (mcm)	8374.00
Surplus Surface water Availability (mcm)	0.00

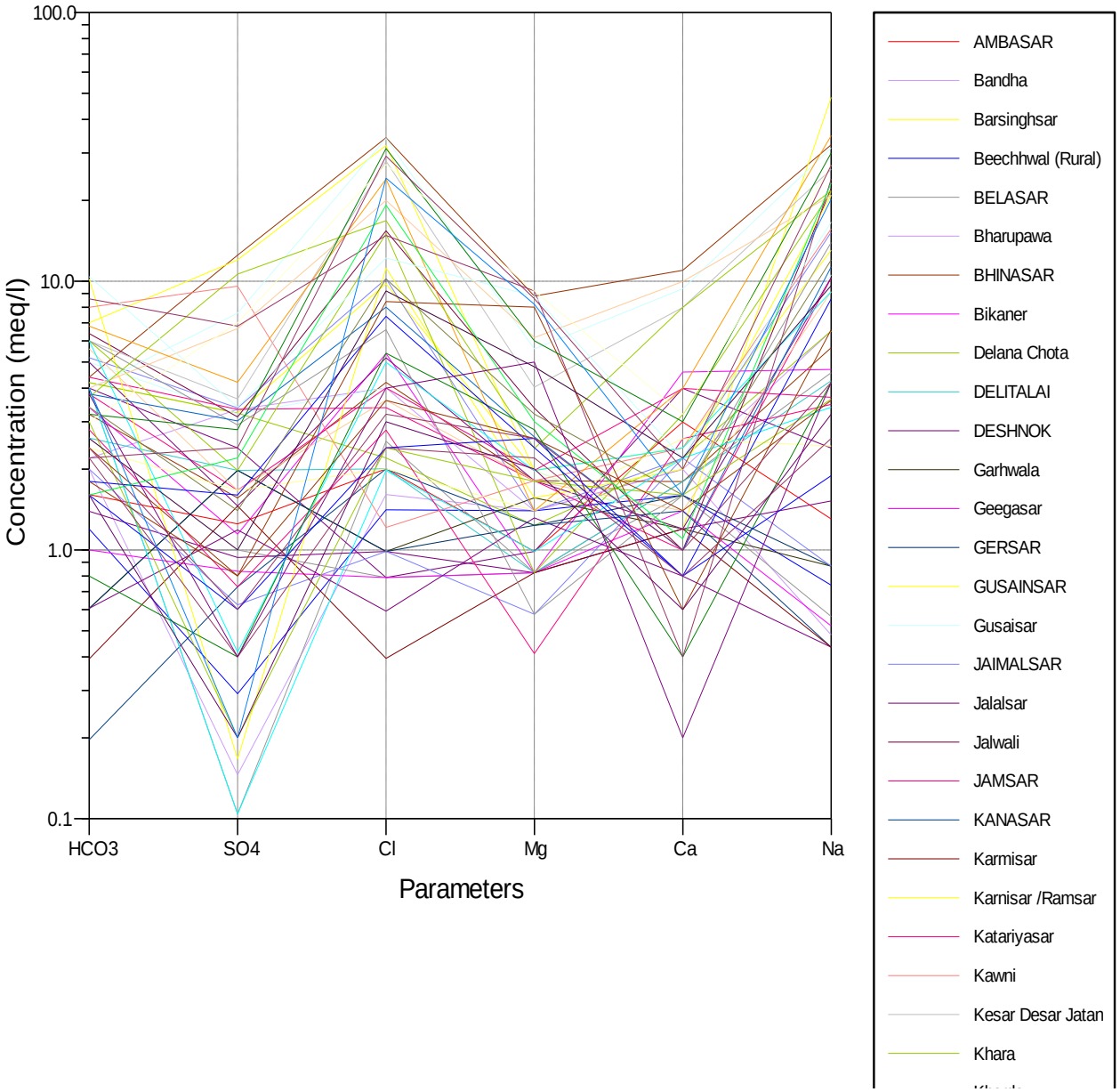
Volume of Water expected to be conserved (mcm)	0.1015
DEMAND SIDE MANAGEMENT	
Micro irrigation techniques	
Use of Sprinklers for Irrigation	
Irrigation Area (ha) proposed for irrigation through Sprinkler(55%) of irrigated area	**50983.9**
Water Saving by use of Sprinklers(mcm)	44.78
Cropping Pattern change	
Cropping area (ha) proposed for change in crop from Wheat to gram (Area 50 %)	3334
Water Saving by Change in Cropping Pattern(mcm)	3.33
EXPECTED BENEFITS	
Net Ground Water Availability (mcm) 2017	56.35
Net Ground Water Availability after Supply side intervention	56.46
Existing Ground Water Draft for All Purposes (mcm)	137.42
GW draft after Supply Side Interventions (mcm)	0.10
GW draft after Demand Side Interventions (mcm)	41.66
Present stage of Ground Water Development (%)	243.84
Projected Stage of Ground Water Development after Supply Side and Demand side interventions (%)	78
In-storage Resources	972.888
Net ground water draft after intervention(mcm)	93.68
Total Ground Water Resources (In-storage & Availability after all interventions) mcm	**1029.348**
Sustainability of GW Resources with existing Draft (in years)	79

Hill-Piper Plot of GW samples of Block- Bikaner, District - Bikaner




Wilcox Plot of GW samples of Block- Bikaner, District- Bikaner
C1
250
C2
750
C3
2250
C4
30
20
10
0
Sodium Hazard (SAR)
S4
S3
S2
S1
100
1000
Salinity Hazard (Cond)
AMBASAR
Bandha
Barsinghsar
Beechhwal (Rural)
BELASAR
Bharupawa
BHINASAR
Bikaner
Delana Chota
DELITALAI
DESHNOK
Garhwala
Geegasar
GERSAR
GUSAINSAR
Gusaisar
JAIMALSAR
Jalalsar
Jalwali
JAMSAR
KANASAR
Karmisar
Karnisar /Ramsar
Katariyasar
Kawni
Kesar Desar Jatan
Khara

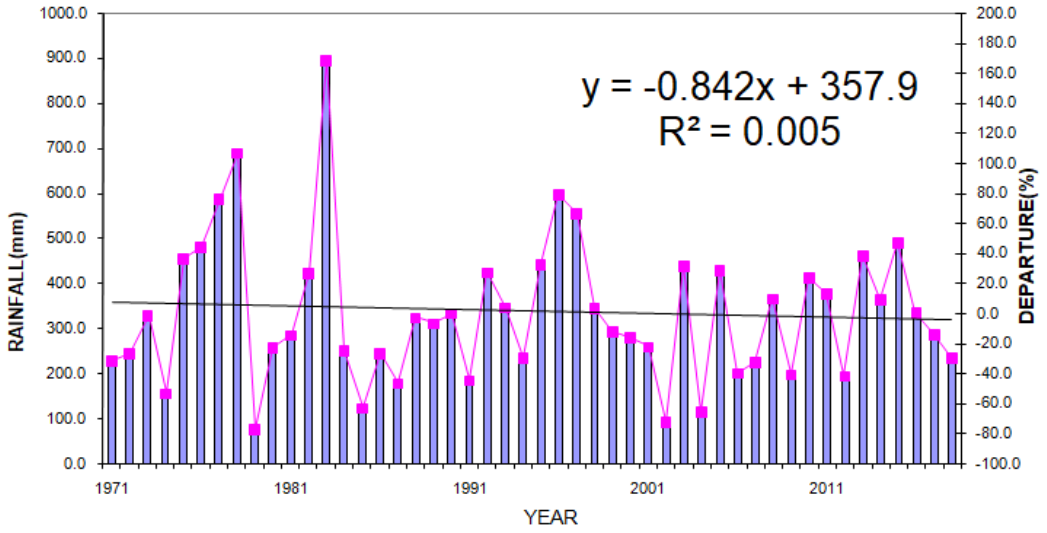
Schoeller Plot of GW samples of Block- Bikaner, District- Bikaner



DUNGARGARH BLOCK

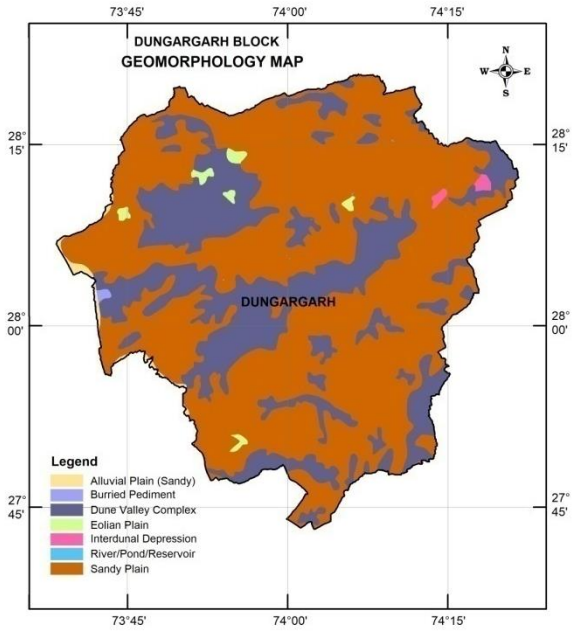
SALIENT INFORMATION	
Block Name	**DUNGARGARH**
Longitude	73°38'21" to74°21'38"
Latitude	27°43'11" to28°20'48"
Geographical Area Sq.km	3003.9
Hilly Area (Sq.km)	Nil
Population (2011)	294319
Climate	
Average Temperature range (°C)	16.9 to 47 with an average of 29
Rainfall Analysis	
Normal Rainfall (mm)	337.33
Mean Annual rainfall (mm)	342.22
Highest annual rainfall with year (mm)	904 (1983)
Lowest annual rainfall (mm) with year	76(1979)
Standard deviation (mm)	159.47
Coefficient of Variation (%)	47.27

Fig. : BAR-DIAGRAM & DEPARTURES(%) OF ANNUAL RAINFALL FROM MEAN
DUNGARGARH, DISTRICT-BIKANER



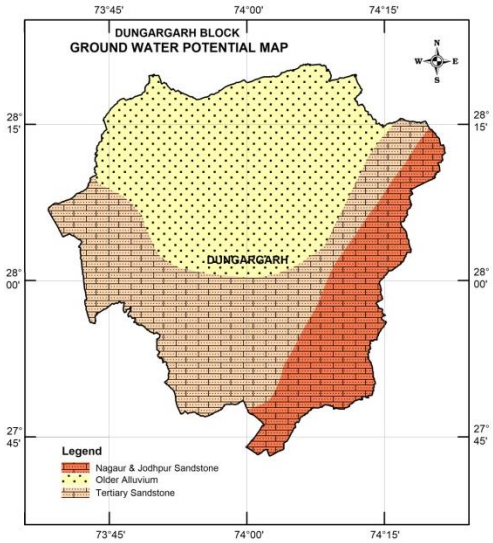
Drought Analysis	
Mild (0 to -25%)	11
Normal (-25% to -50%)	11
Severe (-50% to -75%)	4
Most severe (-75% to -100%)	1
Probability of Normal Rainfall	23%
Geomorphology	

Geomorphic Unit	Older alluvial plains, Sandy undulating aggraded Alluvial plains, Flat Interdunal Plains, Sandy undulating interdunal plains, Aeolian complex, Stabilized Sand dunes, Active Sand dunes, Eroded rocky surface, Sandy Plain.
Elevation (m amsl)	200.2 to 347.3



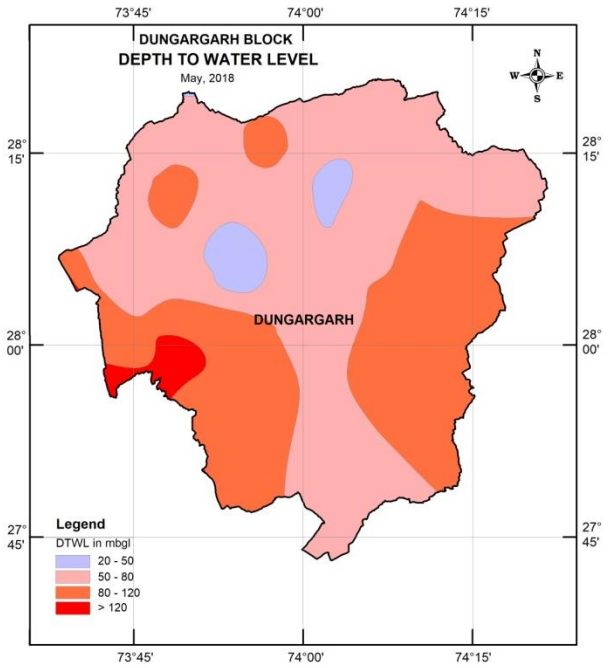
Geology

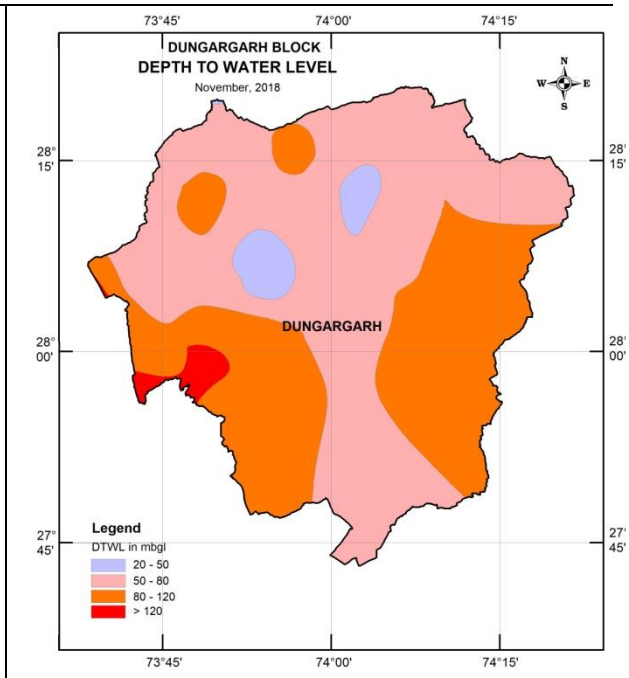
- Eolian/Alluvium sand, Age: Pleistocene to recent.
- Tertiary Sand stone. Age Eocene.
- Jodhpur &Nagaur sand stone of Marwar super group Age: Palaeozoic

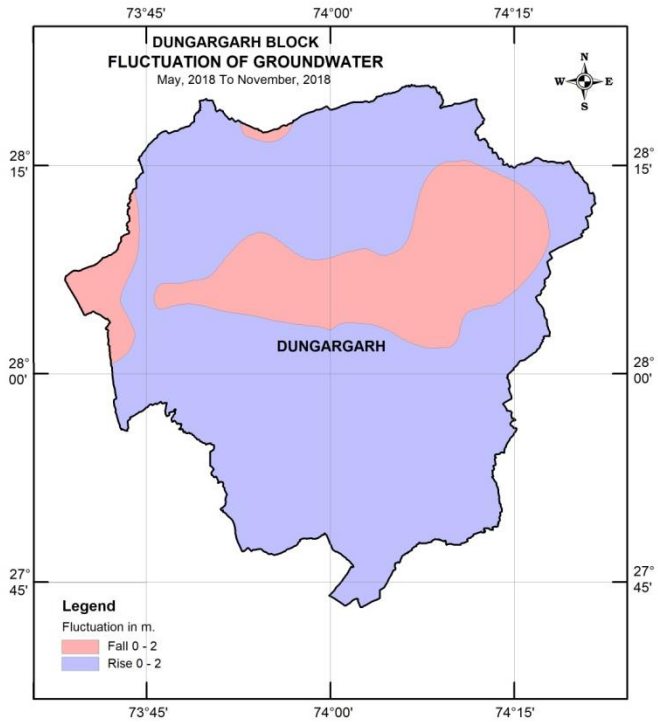


Drainage & Hydrology

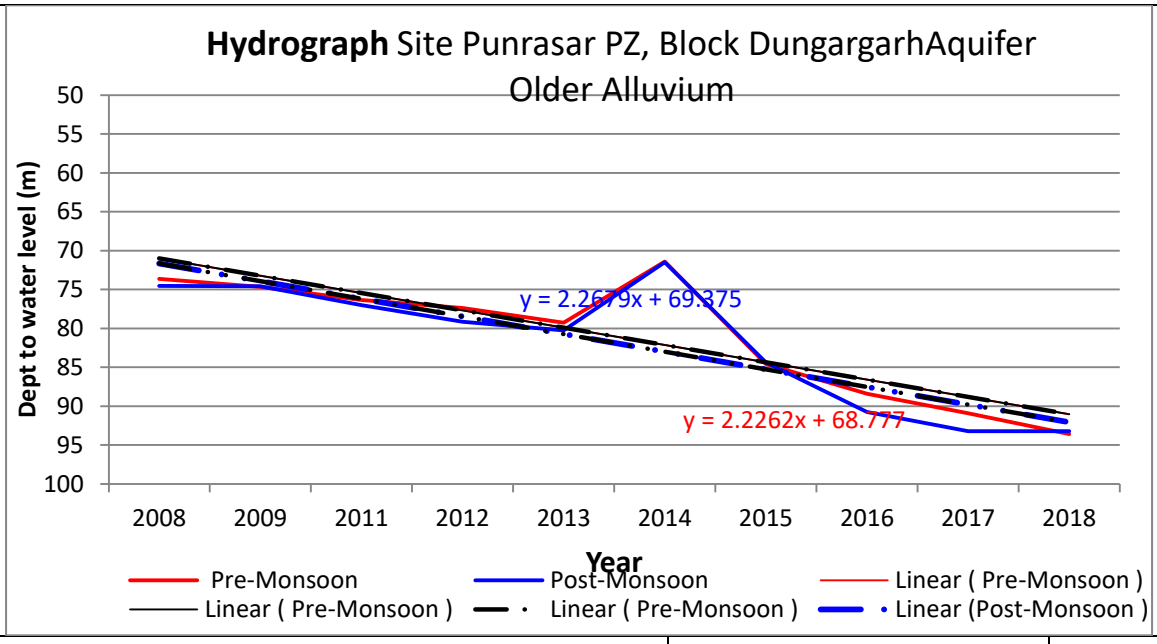
Pond		6	
LAND USE, AGRICULTURE, IRRIGATION & CROPPING PATTERN			
Forest Area in ha.		2010	
Net Sown Area in ha.		261471	
Area sown more than once in ha.		26255	
Rainfed Crop		Bajarain 45057hect. area	
Area under Irrigation (Net) in ha			
Surface Water		0	
Ground Water		46493	
Other sources		0	
Season wise crop area in ha.			
	Kharif	**Rabi**	**Zaid Rabi**
sown	230348	31085	38
Irrigated	16901	29554	38
Principal Crop Area (ha)			
Crop Type			
Cereals		53841	
Oil Seeds		19180	
Pulses		80523	
Hydrogeology			
Monitoring Stations (May 2018)			
CGWB		02	
SGWD		24	
NAQUIM Key Wells		15	
WATER LEVEL BEHAVIOUR			
Pre-Monsoon (May-2018) Water level		Post-Monsoon (November-2018)Water level	
11 – 120.71 m bgl		11.14 -119.96 m bgl	



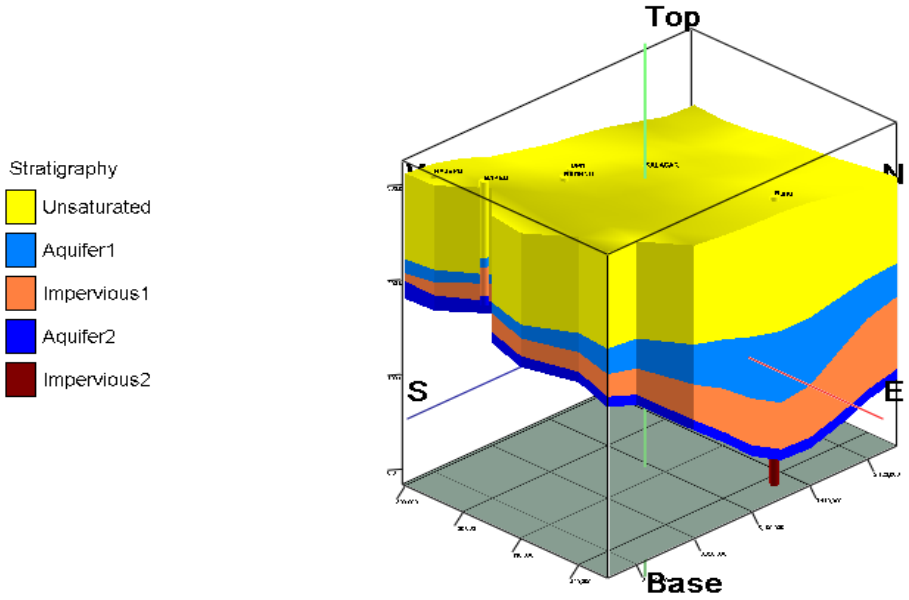




Water Level Trend (2009-2018)	Pre-monsoon	Post-monsoon
Average Trend (m/year)	0.31	0.28
	Pre-monsoon	Post-monsoon
Rise	0 – (-1.84)	0- (-2.631)
Fall	0 - 1.041	0 –5.34



AQUIFER DISPOSITION		
Number of Aquifers (Major)	Two	
Number of Zones	Two	
I	Alluvium	
II	Alluvium & Tertiary sand Stone	



Major Aquifer System	CGWB	GWD

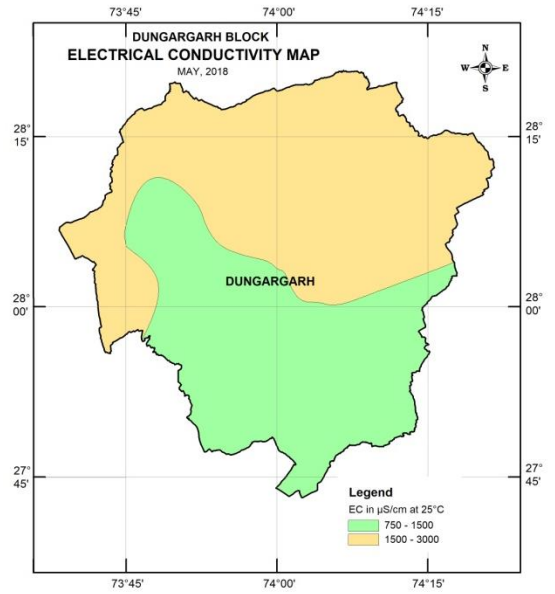
Status of GW Exploration	14	15
BASIC AQUIFER CHARACTERISTICS		
Type of Aquifer	Unconfined	Confined
Depth of Occurrence (mbgl)	65-160	180-250
Granular/Weathered/ Fractured rocks thickness (m)	60-80	40-50
Yield Potential	135-230	Meager
Specific Yield (Sy)	-	-
Drawdown	-	-
EC µS/cm at 25°C	4000-7540	

CHEMICAL QUALITY OF GROUND WATER

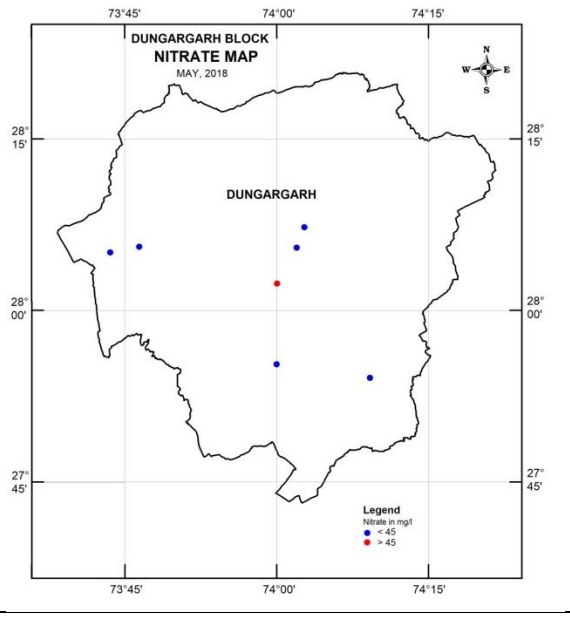
Suitability for Drinking

TDS	**Range**	**% Samples**
Fresh	0-3000	100%
Brackish	>-3000	0.00%
Hardness	**Range**	**% Samples**
Soft	0 – 75	0.00%
Moderately Hard	75 – 150	23.00%
Hard	150 – 300	43.00%
Very Hard	>300	34.00%

CHEMICAL QUALITY MAP



VARIATION IN MAJOR & MINOR ELEMENTS	
EC < 2000 µS/cm at 25°C	38%
NO3 in mg/l>45 mg/l	42%
F in mg/l – 1 to 1.5 mg/l	8%
>1.5 mg/l	15%



Suitability for Irrigation

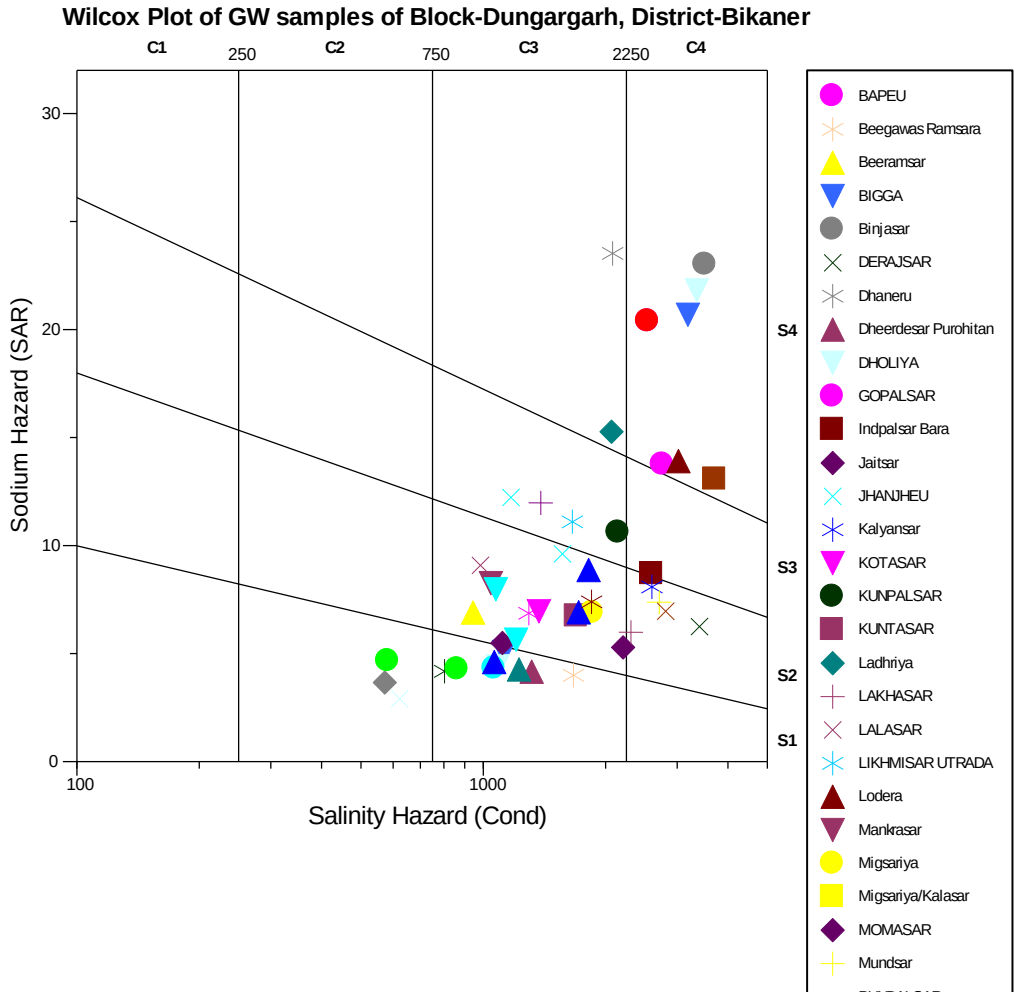
ECµS/cm at 25°C		**RSC(meq/l)**		
Type of Water	**Classification**	**% Samples**	**Range**	**% Samples**
			< 1.25	61
Low Saline< 250 mg/l	Excellent	0.00	1.25 – 2.0	0.0
Medium Saline 250 – 750 mg/l	Good	0.00	2.0 – 2.5	0.0
Highly Saline 750 – 2250 mg/l	Permissible	62	2.5 – 3.0	12
Very Highly saline> 2250 mg/l	Doubtful	38	> 3.0	27

Na%			**SAR**		
Water Class	**Range**	**% Samples**	**Water Class**	**Range**	**% Samples**
Excellent	< 20	0.0	Excellent	<10	100.0
Good	20 – 40	0.0	Good	10 to 18	0.00
Medium	40 – 60	23	Medium	18 to 26	0.00
Bad	60 – 80	38	Bad	>26	0.00
Very Bad	> 80	38			

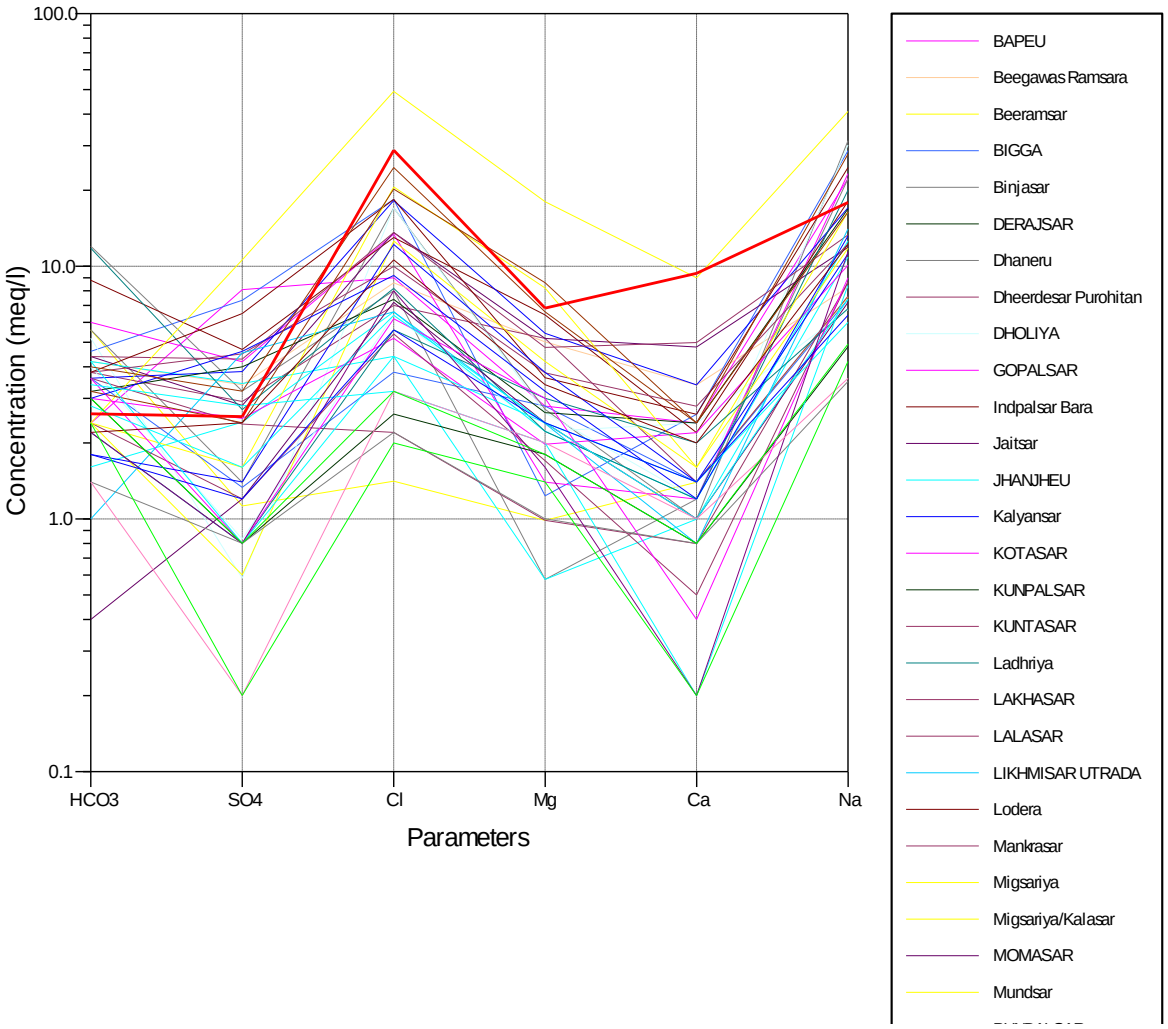
GROUND WATER ISSUES	
1. Over-Exploitation – Resource Availability	At present the Ground water Draft is more than Annual Availability thus the block is deficit of 51.3 mcm water
2. Rainfall and Drought	• Mild Droughts in 23% years • Normal Droughts in 23% years • Severe Drought in 8 % years
3. Decadal Water Level Trend (2009-2018)-	Declining
4.Ground water quality issues	High salinity
GROUND WATER RESOURCE & EXTRACTION	
Ground Water Recharge Worthy Area (sq. km.)	2703.88

Total Annual Ground Water Recharge (mcm)		52.86
Natural Discharge (mcm)		5.286
Net Annual Ground Water Availability (mcm)		49.30
Existing Gross Ground Water Draft for All uses(mcm)		100.43
Provision for domestic and industrial requirement supply to 2025(mcm)		23.79
Stage of Ground Water Development %		204.44
Category		Over Exploited
In-Storage Resource		
Total Area (Sq.KM)		3003.9
Specific yield		0.06
Utilizable Volume (mcm)		71.06
Total In-storage Resource (mcm)		636.61
Total Resource Dynamic + In-storage		686
Sustainability Period with existing draft		7 years
GROUND WATER RESOURCE ENHANCEMENT		
Artificial Recharge & Water Conservation Possibilities		
Existing Structures constructed by State Govt.		163
Diggy/Jalhoj	151	
Johad	02	
Talai	05	
SUPPLY SIDE MANAGEMENT		
Water conservation structure proposed to conserve water (mcm)		
Tanka with capacity of 50,000 litters (nos)		3439
Volume of water to be conserved (mcm)		.01719
Type of Aquifer		
Soft Rock Area (sq.km)		Alluvium 1121.09,Tertiary, Jodhpur and Nagaur Sandstone 1582.79
Volume of Sub surface Storage Space available for Artificial Recharge (mcm)		5795.89
Surpulus Surface Water Available (mcm)		00
Volume of expected water to be conserved		.017
DEMAND SIDE MANAGEMENT		
Micro irrigation techniques		
Use of Sprinklers for Irrigation		
Irrigation Area (ha) proposed for irrigation through Sprinkler		85232
Water Saving by use of Sprinklers		68.18
Cropping Pattern change		

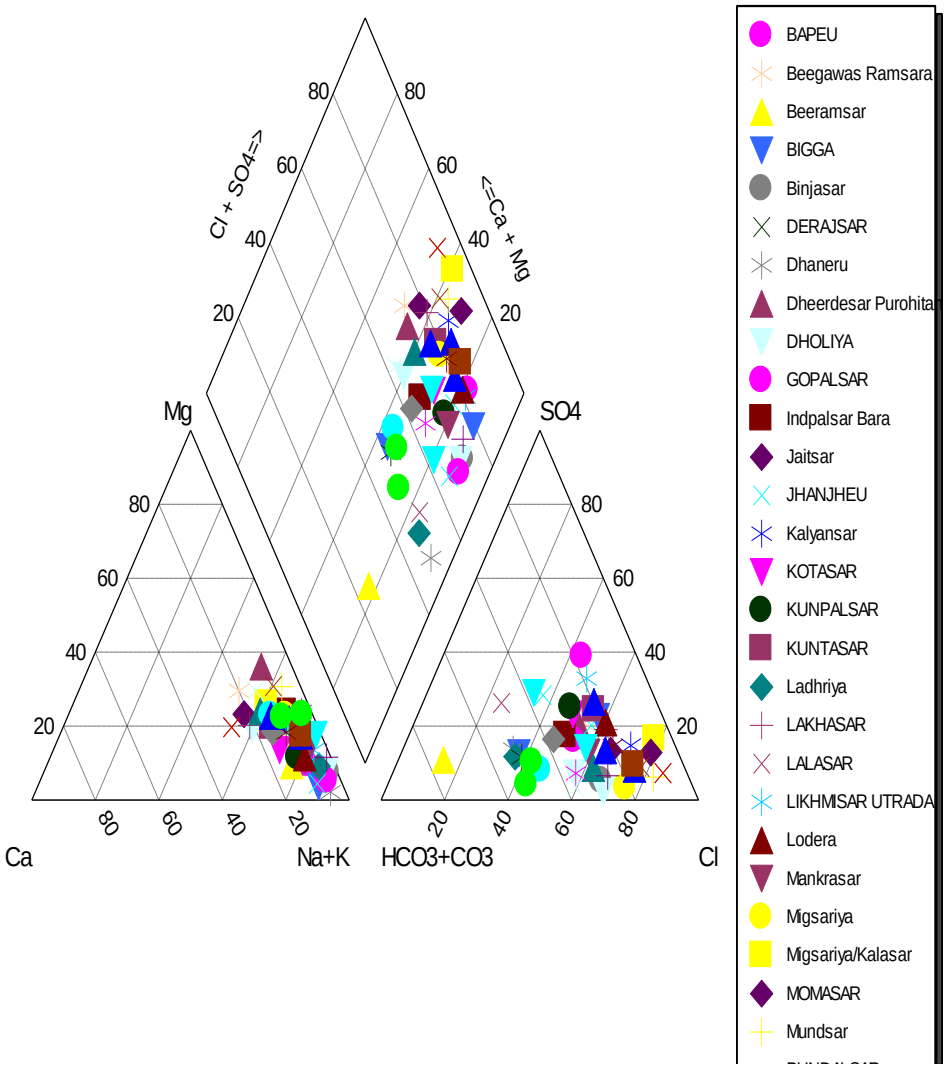
Cropping Area (ha) proposed for change in crop	4342
Water Saving by Change in Cropping Pattern	8.684
EXPECTED BENEFITS	
Net Ground Water Availability (mcm) 2017	49.12
Existing Ground Water Draft for All Purposes (mcm)	100.43
GW draft after Demand Side Interventions (mcm)	27.73
Present stage of Ground Water Development (%)	204.44
Projected Stage of Ground Water Development after Supply Side andDemand Side interventions interventions (%)	56.45
Sustainability of GW Resources with existing Draft (in years)	72


Wilcox Plot of GW samples of Block-Dungargarh, District-Bikaner
C1
250
C2
750
C3
2250
C4
30
20
10
0
Sodium Hazard (SAR)
100
1000
Salinity Hazard (Cond)
S4
S3
S2
S1
BAPEU
Beegawas Ramsara
Beeramsar
BIGGA
Binjasar
DERAJSAR
Dhaneru
Dheerdesar Purohitan
DHOLIYA
GOPALSAR
Indpalsar Bara
Jaitsar
JHANJHEU
Kalyansar
KOTASAR
KUNPALSAR
KUNTASAR
Ladhriya
LAKHASAR
LALASAR
LIKHMISAR UTRADA
Lodera
Mankrasar
Migsariya
Migsariya/Kalasar
MOMASAR
Mundsar

Schoeller Plot of GW samples of Block-Dungargarh, District-Bikaner

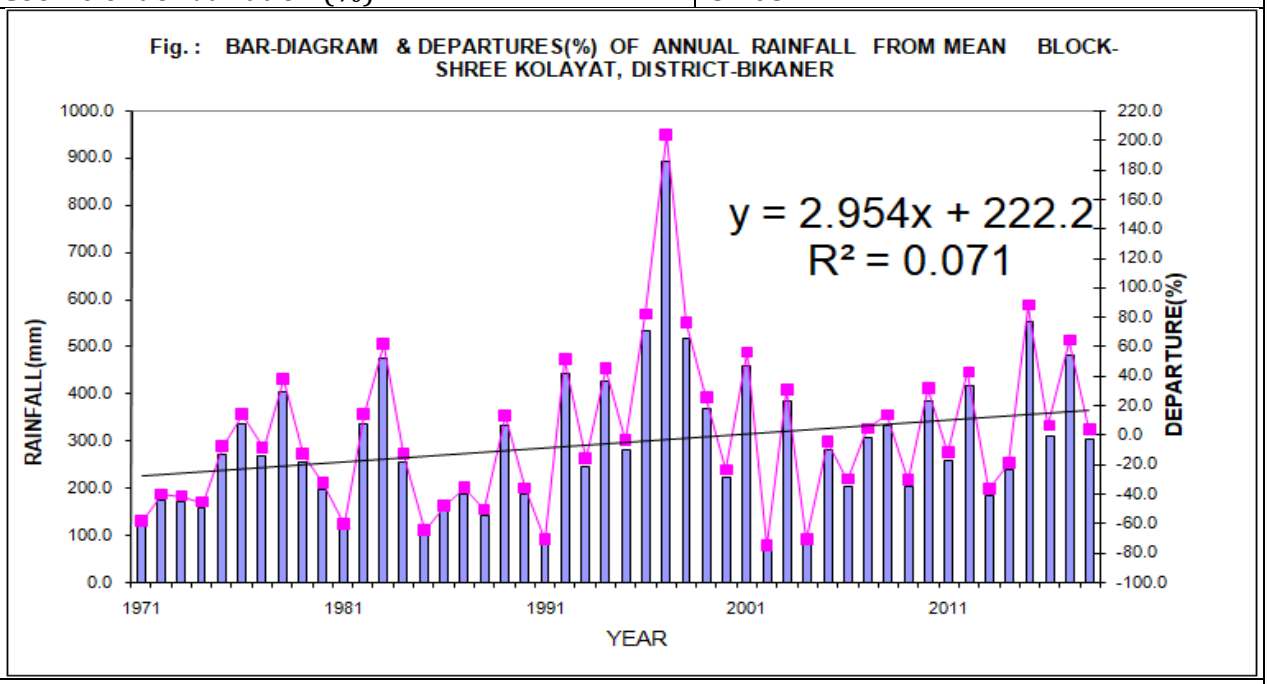


Hill-Piper Plot of GW samples of Block-Dungargarh, District-Bikaner



KOLAYAT

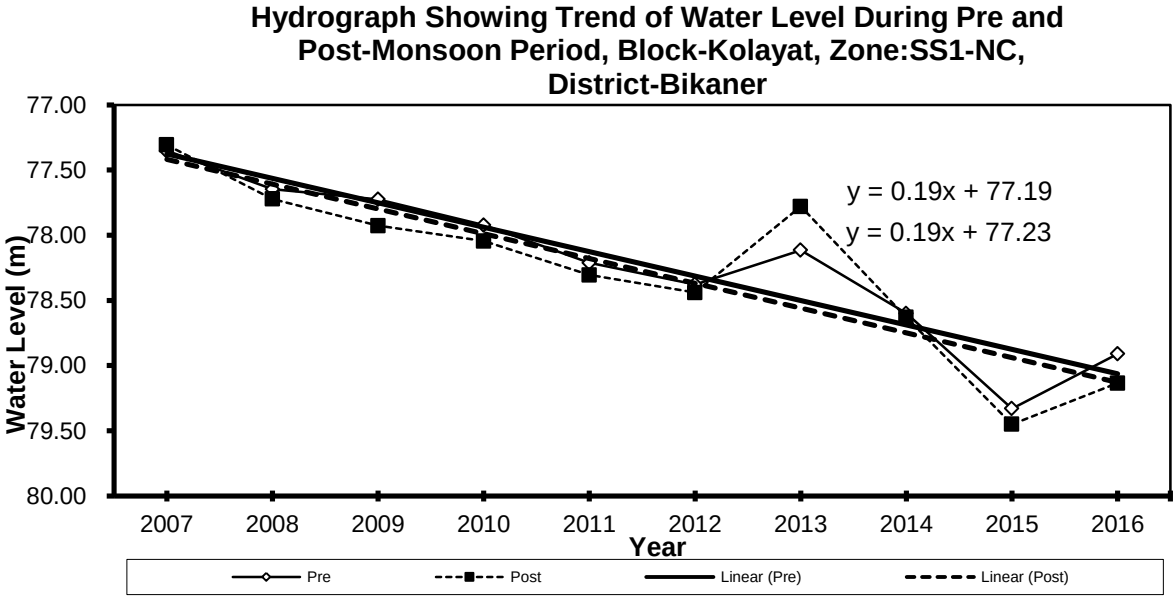
SALIENT INFORMATION	
Block Name	**KOLAYAT**
Longitude	71°53'33" to73°11'12"
Latitude	27°22'16" to28°24'10"
Geographical Area Sq.km	7970.86
Hilly Area (Sq.km)	Nil
Population (2011)	261028
Climate	
Average Temperature range (°C)	16.9 to 47 with an average of 28
Rainfall Analysis	
Normal Rainfall (mm)	294
Mean Annual rainfall (mm)	305
Highest annual rainfall with year (mm)	894 (1992)
Lowest annual rainfall (mm) with year	72.1 (2002)
Standard deviation (mm)	153.39
Coefficient of Variation (%)	52.05



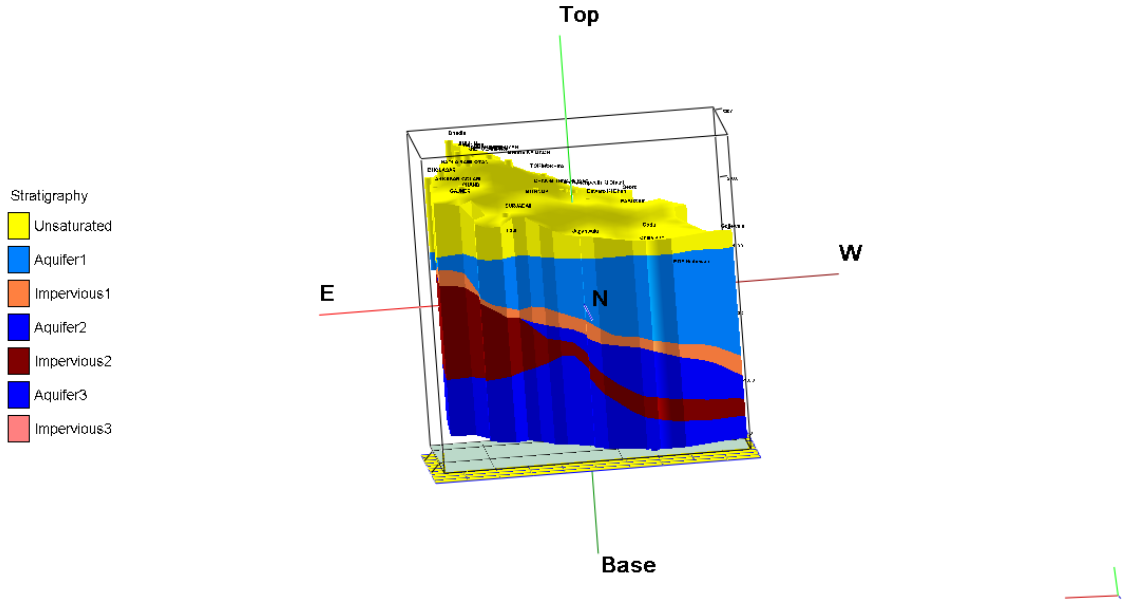
Drought Analysis	
Mild (0 to -25%)	20
Normal (-25% to -50%)	20
Severe (-50% to -75%)	43
Most severe (-75% to -100%)	3
Probability of Normal Rainfall	21%
Geomorphology	
Geomorphic Unit	Older alluvial plains, Sandy undulating aggraded Alluvial plains, Flat

	Interdunal Plains, Sandy undulating interdunal plains, Aeolian complex, Stabilized Sand dunes, Active Sand dunes, Eroded rocky surface, Sandy Plain.		
Elevation (m amsl)	261.6 - 349.1		
Geology			
• Eolian/Alluvium sand, Age: Pleistocene to recent. • Tertiary Sand stone. Age Eocene. • Jodhpur &Nagaursand stone of Marwar super group Age:Palaeozoic			
Drainage & Hydrology			
Drainage/Basin/Sub Basin	No Major drainage except few ephemerals streamlets and inter dunal area		
Hydrology			
Ponds	08		
LAND USE, AGRICULTURE, IRRIGATION & CROPPING PATTERN			
Geographical Area in ha.	797086		
Forest Area in ha.	7599		
Net Sown Area in ha.	154771		
Area sown more than once in ha.	23661		
Rainfed Crop	Bajra in 12596 hect area		
Area under Irrigation (Net) in ha			
Surface Water	56292		
Ground Water	10842		
Other sources	11		
Season wise crop area in ha.			
	Kharif	**Rabi**	**Zaid Rabi**
sown	87976	66732	0
Irrigated	16852	50230	0
Principal Crop Area (ha)			
Crop Type			
Cereals	19884		
Oil Seeds	31660		
Pulses	39046		
Hydrogeology			
Monitoring Stations (May 2017)			
CGWB	14		
SGWD	37		
NAQUIM Key Wells	12		
WATER LEVEL BEHAVIOUR			

Pre-Monsoon (May-2018) Water level	Post-Monsoon (November-2018)Water level	
40.4 to 117.2 m bgl	40.2 to 117.2 m bgl	
Water Level Trend (2009-2018)	Pre-monsoon	Post-monsoon
Average Trend (m/year)	Declining 0.28	Declining 0.27
	Pre-monsoon	Post-monsoon
Rise	-1.301 – (0)	-2.28- (0)
Fall	NA	NA



AQUIFER DISPOSITION	
Number of Aquifers (Major)	Two
I	Alluvium followed by tertiary Sand Stone
II	Jodhpur –Nagaur Sand Stone



Major Aquifer System	CGWB	GWD
Status of GW Exploration	06	01
BASIC AQUIFER CHARACTERISTICS		
Type of Aquifer	Aquifer-I	Aquifer-II
Depth of Occurrence (mbgl)	101-150	180-240
Discharge (lpm)	110-1200	18-396
Specific Yield (Sy)	-	-
Drawdown(m)	1.2	2.25
EC µS/cm at 25°C	1700-16080	2015-18980

CHEMICAL QUALITY OF GROUND WATER

Suitability for Drinking

TDS(mg/l)	**Range**	**% Samples**
Fresh	0-3000	70.00%
Brackish	>-3000	30.00%
Hardness (mg/l)as $CaCO_3$	**Range**	**% Samples**
Soft	0 – 75	0.00%
Moderately Hard	75 – 150	0.00%
Hard	150 – 300	42.00%
Very Hard	>300	58.00%

CHEMICAL QUALITY MAP	VARIATION IN MAJOR & MINOR ELEMENTS	
	EC < 2000 µS/cm at 25°C	36%
	NO3 in mg/l>45 mg/l	0%
	F in mg/l – 1 to 1.5 mg/l	47%
	>1.5 mg/l	53%

Suitability for Irrigation

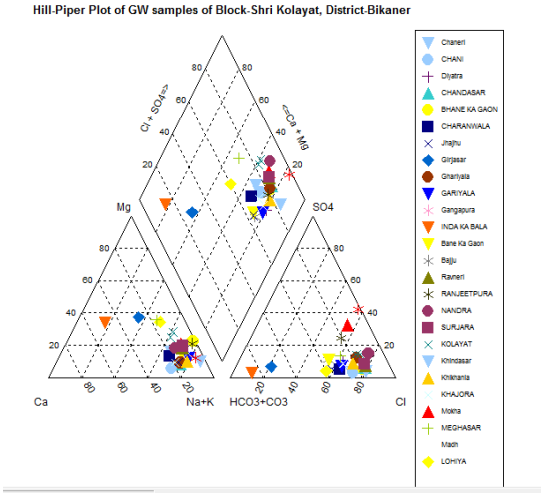
EC		**RSC (meq/l)**		
Type of Water	**Classification**	**% Samples**	**Range**	**% Samples**
			< 1.25	0
Low Saline< 250 mg/l	Excellent	0.00	1.25 - 2.0	0
Medium Saline 250 – 750 mg/l	Good	9.00	2.0 - 2.5	0
Highly Saline 750 – 2250 mg/l	Permissible	36.00	2.5 - 3.0	0
Very Highly saline> 2250 mg/l	Doubtful	55.00	> 3.0	100

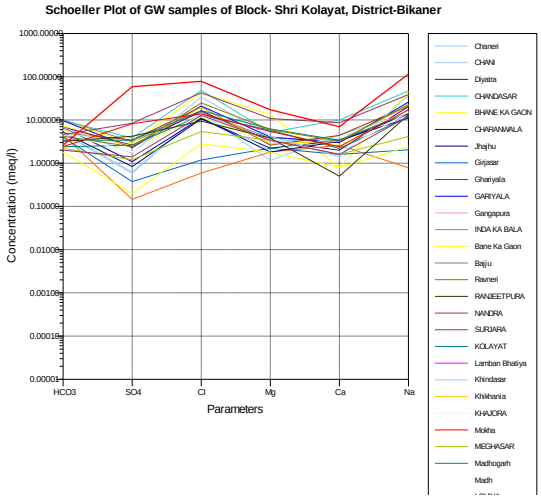
Na%			**SAR**		
Water Class	**Range**	**% Samples**	**Water Class**	**Range**	**% Samples**
Excellent	< 20	0.00	Excellent	<10	54
Good	20 - 40	3.00	Good	10 to 18	29
Medium	40 - 60	6.00	Medium	18 to 26	03
Bad	60 - 80	70.00	Bad	>26	14
Very Bad	> 80	21.00			

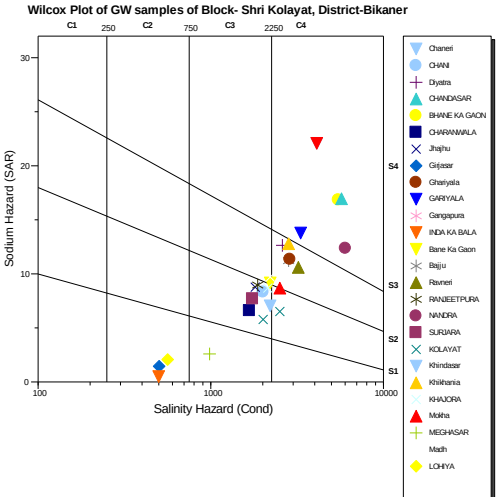
GROUND WATER ISSUES	
1. Over-Exploitation – Resource Availability	At present the Ground water Draft 33.9894 is more than Annual Availability(38.18218)mcm
2. Rainfall and Drought	• Normal Droughts in 11% years • Severe Drought in 2.00% years
3. Decadal Water Level Trend (2010-2017)-	Declining
4.Ground water quality issues	High salinity
GROUND WATER RESOURSE & EXTRACTION(GWRE-2017)	

Ground Water Recharge Worthy Area (sq. km.)	1924.00
Total Annual Ground Water Recharge (mcm)	30.138
Natural Discharge (mcm)	3.013
Net Annual Ground Water Availability (mcm)	27.12
Existing Gross Ground Water Draft for All uses(mcm)	27.08
Provision for domestic and industrial requirement supply to 2025(mcm)	14.13
Stage of Ground Water Development %	99.87
Category	Critical
In-Storage Resource	
Total Area (Sq. Km)	7970.86
Specific yield	0.06
Total Resource	322.58
Utilizable Volume (mcm)	42.94
Total In-storage Resource (mcm)	322.58
Total Resource Dynamic + In-storage	349.70
Sustainability Period with existing draft	13 years
GROUND WATER RESOURCE ENHANCEMENT	
Artificial Recharge & Water Conservation Possibilities	
Existing Structures constructed by State Govt.	07
Roof Top Water Harvesting Structure	03
Talai(Talab)	04
SUPPLY SIDE MANAGEMENT	
Water Supply(mcm)	
Tanks (Nos) Capacity 50.000 lts	4312
Volume of water to be conserved (mcm)	0.22
Type of Aquifer	
Soft Rock Area (sq.km)	1. Tertiary Sand Stone : 259.42 2. Jodhpur Nagaur Sand Stone&Bilara Lime Stone: 1565.13
Volume of Sub surface Storage Space available for Artificial Recharge (mcm)	5680.67
Surplus Surface water Availability (mcm)	0.00
Volume of Water expected to be conserved (mcm)	0.22
DEMAND SIDE MANAGEMENT	
DEMAND SIDE MANAGEMENT	
Micro irrigation techniques	
Use of Sprinklers for Irrigation	
Irrigation Area (ha) proposed for irrigation through Sprinkler	84645
Water Saving by use of Sprinklers(mcm)	67.71
Cropping Pattern change	
Cropping Area (ha) proposed for change in crop	3538

Water Saving by Change in Cropping Pattern(mcm)	3.5
EXPECTED BENEFITS	
Net Ground Water Availability (mcm) 2017	27.12
Saving of ground water through project(mcm)	71.47
Existing Ground Water Draft for All Purposes (mcm)	27.09
Present stage of Ground Water Development (%)	99.87
Projected Stage of Ground Water Development after Supply Side andDemand Side interventions interventions (%)	174.49
In-storage Resources(mcm)fresh	322.58
Total Ground Water Resources (In-storage & Availability after all interventions) mcm fresh	**349.92**
Sustainability of GW Resources with existing Draft (in years)	Sustainable for long period of time

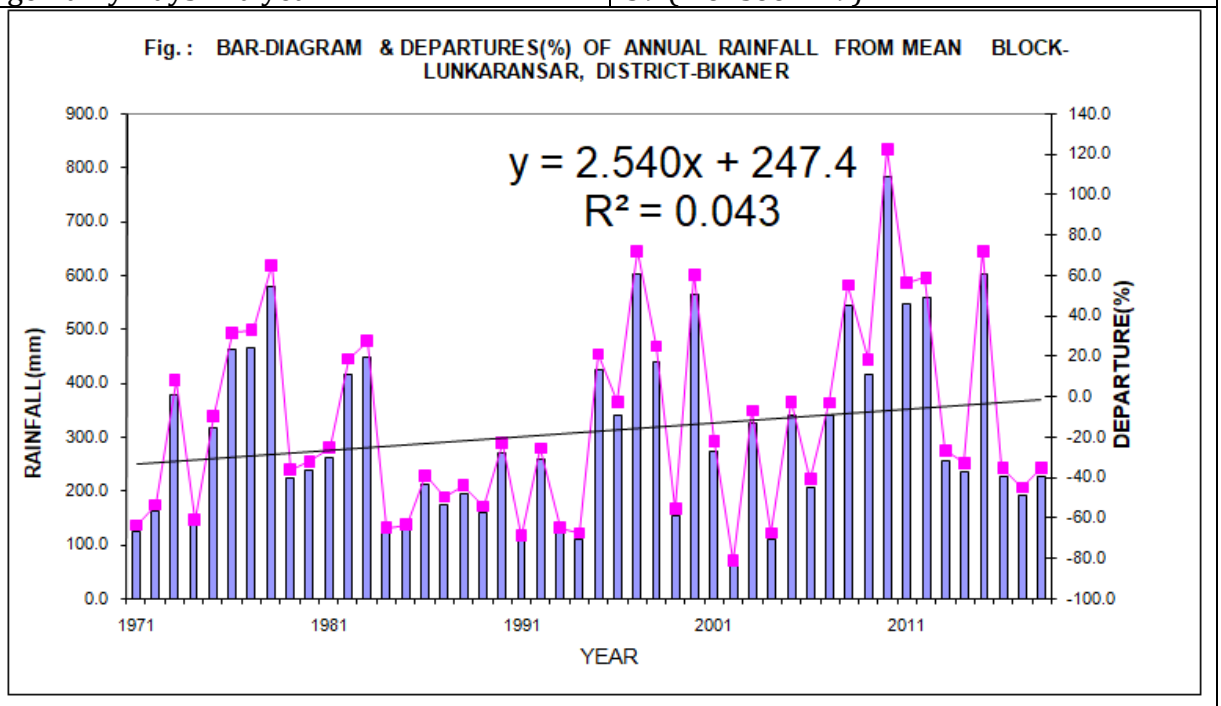




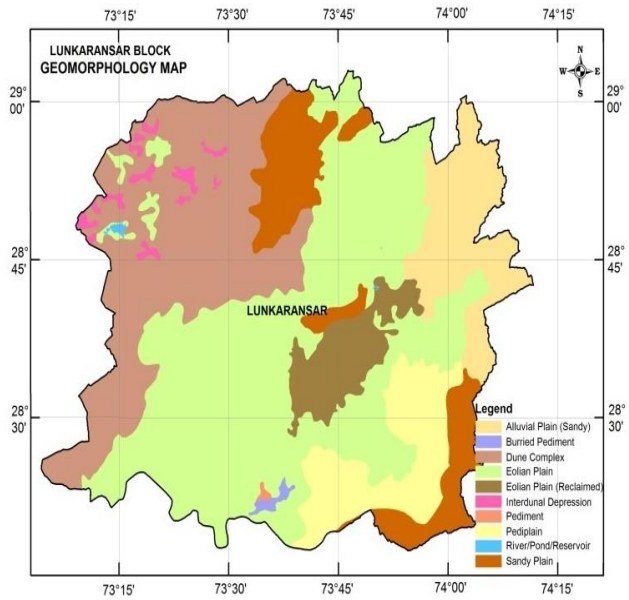
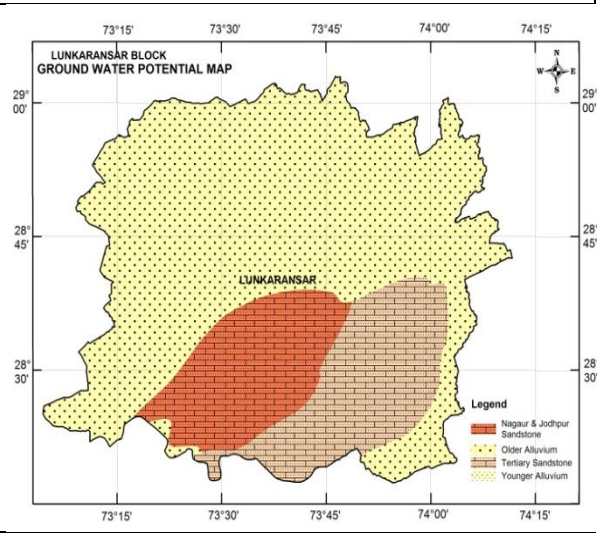

Wilcox Plot of GW samples of Block- Shri Kolayat, District-Bikaner
C1
250
C2
750
C3
2250
C4
30
20
10
0
Sodium Hazard (SAR)
100
1000
10000
Salinity Hazard (Cond)
S4
S3
S2
S1
Chaneri
CHANI
Diyatra
CHANDASAR
BHANE KA GAON
CHARANWALA
Jhajhu
Girjasar
Ghariyala
GARIYALA
Gangapura
INDA KA BALA
Bane Ka Gaon
Bajju
Rawneri
RANJEETPURA
NANDRA
SURJARA
KOLAYAT
Khindasar
Khikhania
KHAJORA
Molha
MEGHASAR
Madh
LOHIYA

LUNKARANSAR BLOCK

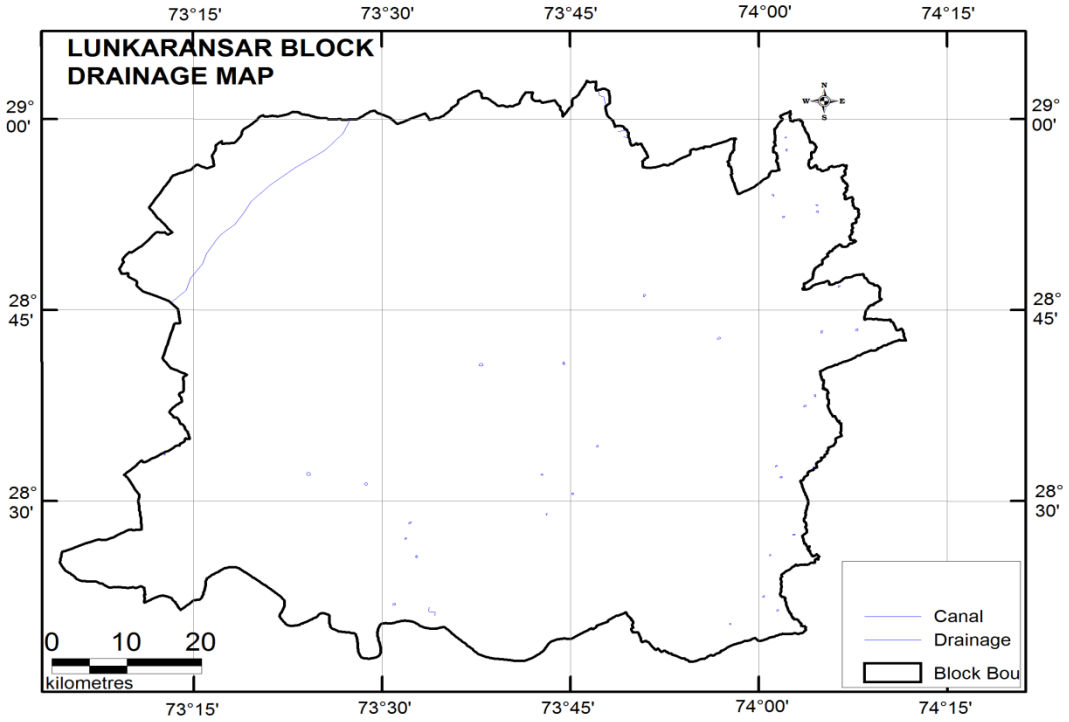
SALIENT INFORMATION	
Block Name	**LUNKARANSAR**
Longitude	71°52'59" to73°11'20"
Latitude	27°22'56" to28°24'01"
Geographical Area Sq.km	6328.02
Hilly Area (Sq.km)	Nil
Population (2011)	213627
Climate	
Average Temperature range (°C)	16.9 to 47 with an average of 28
Rainfall Analysis	
Normal Rainfall (mm)	315.25
Mean Annual rainfall (mm)	352.2604
Highest annual rainfall with year (mm)	738(2010)
Lowest annual rainfall (mm) with year	64 (2002)
Standard deviation (mm)	326.11
Coefficient of Variation (%)	92.57
Average Rainy Days in a year	39 (Monsoon-29)



Drought Analysis	
Mild (0 to -25%)	Nil
Normal (-25% to -50%)	11

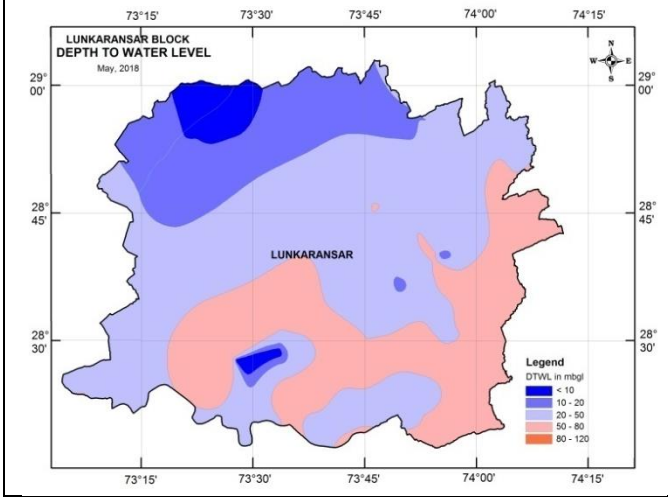
Severe (-50% to -75%)	Nil
Most severe (-75% to -100%)	1
Probability of Normal Rainfall	23%
Geomorphology	
Geomorphic Unit	Older alluvial plains, Sandy undulating aggraded Alluvial plains, Flat Interdunal Plains, Sandy undulating interdunal plains, Aeolian complex, Stabilized Sand dunes, Active Sand dunes, Eroded rocky surface, Sandy Plain.
Elevation (m amsl)	149.5 - 246.8
	
Geology	
• Eolian/Alluvium sand, Age: Pleistocene to recent. • Tertiary Sand stone. Age Eocene. • Jodhpur &Nagaur sand stone of Marwar super group Age: Palaeozoic	

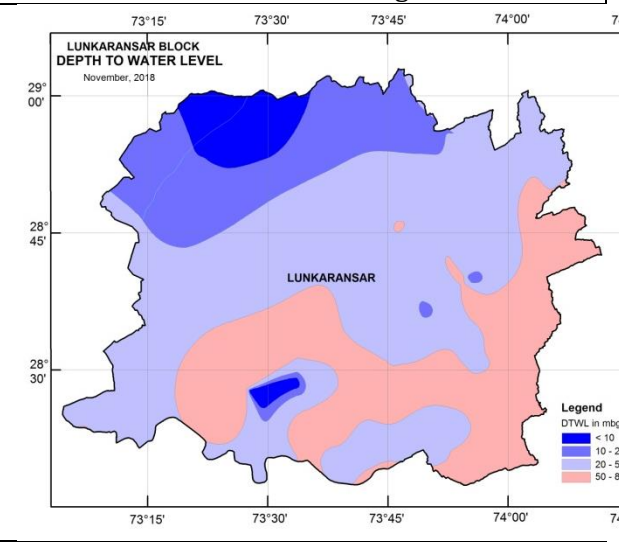
Drainage & Hydrology	
Drainage **Basin/Sub-Basin**	No Major Drainage except few short lived streamlets
Hydrology	**IGNP Canals** 1. Kanwarsen main lift canal lined and 13.34 km long 2. Lunkaransar Distributary lined 3.57 km 3. Malkisar Minor lined 2.23 km 4. Dulmera Minor lined 2.04 km
Ponds	**49**

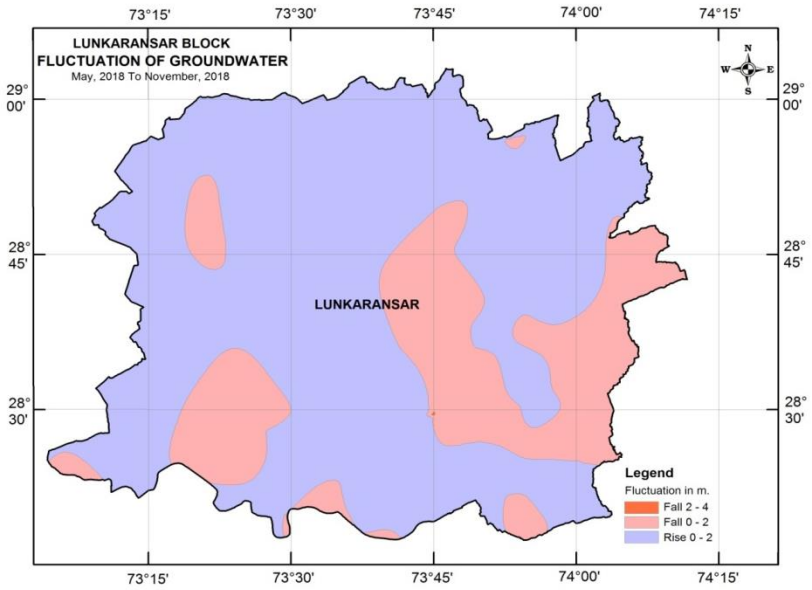


LAND USE, AGRICULTURE, IRRIGATION & CROPPING PATTERN			
Geographical Area in ha.		503670	
Forest Area in ha.		1677	
Net Sown Area in ha.		233223	
Area sown more than once in ha.		19698	
Rainfed Crop		Bajra in 8162 hect area	
Area under Irrigation (Net) in ha			
	Surface Water	141815	
	Ground Water	5731	
	Other sources	0	
Season wise crop area in ha.			
	Kharif	**Rabi**	**Zaid Rabi**

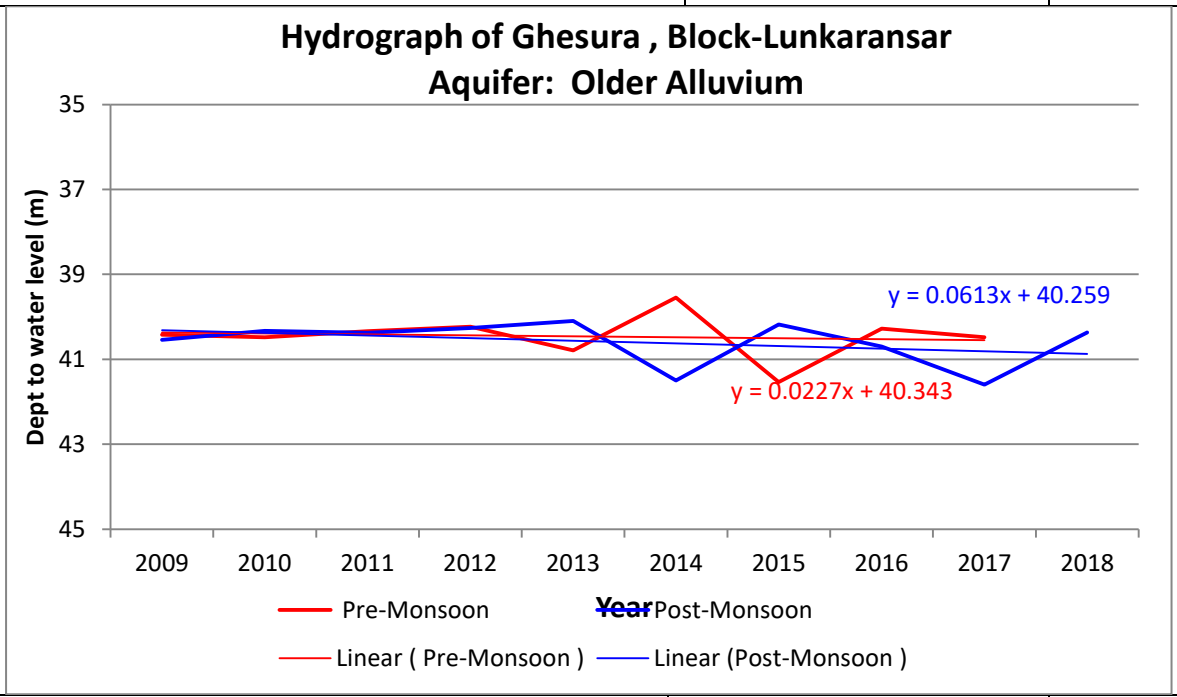
sown	292284	51939	0
Irrigated	123338	24208	0
Principal Crop Area (ha)			
Crop Type			
Cereals		16302	
Oil Seeds		20021	
Pulses		56238	
Hydrogeology			
Monitoring Stations (May 2018)			
CGWB		23	
SGWD		22	
NAQUIM Key Wells		11	
WATER LEVEL BEHAVIOUR			
Pre-Monsoon (May-2018) Water level		Post-Monsoon (November-2018)Water level	
7.75-82.01 m bgl		6.85 – 81.24 m bgl	





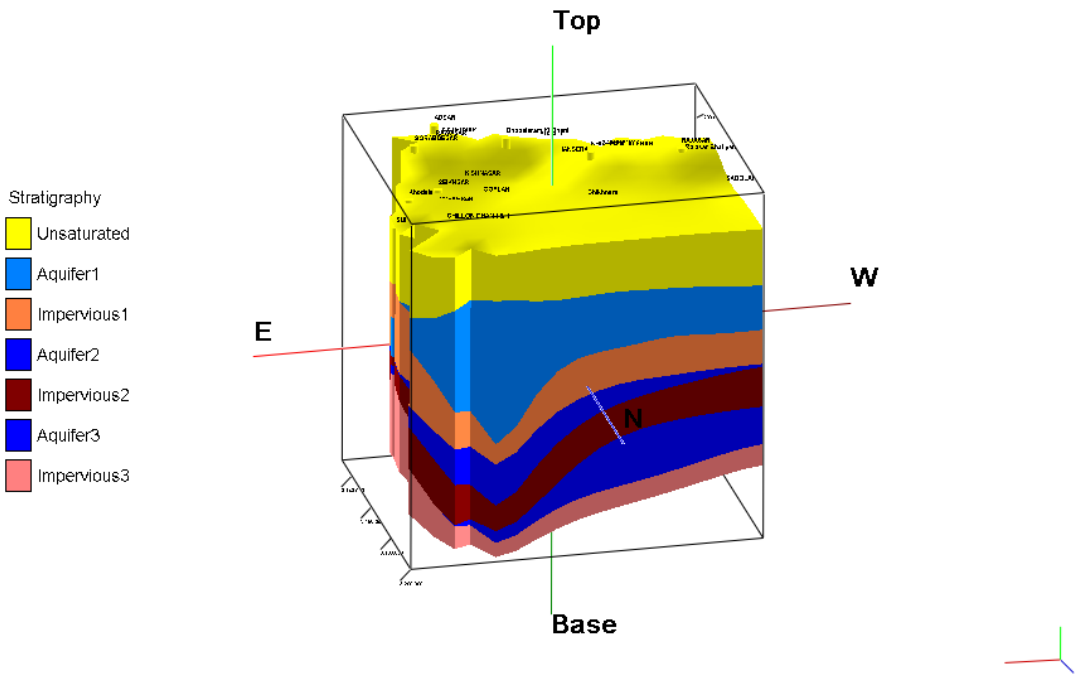


Water Level Trend (2008-2018)	Pre-monsoon	Post-monsoon
Average Trend (m/year)	0.36	0.19
	Pre-monsoon	Post-monsoon
Rise	-10.3 – (-0.233)	-9.76- (-0.41)
Fall	0.407 – 4.04	0.024 –3.06

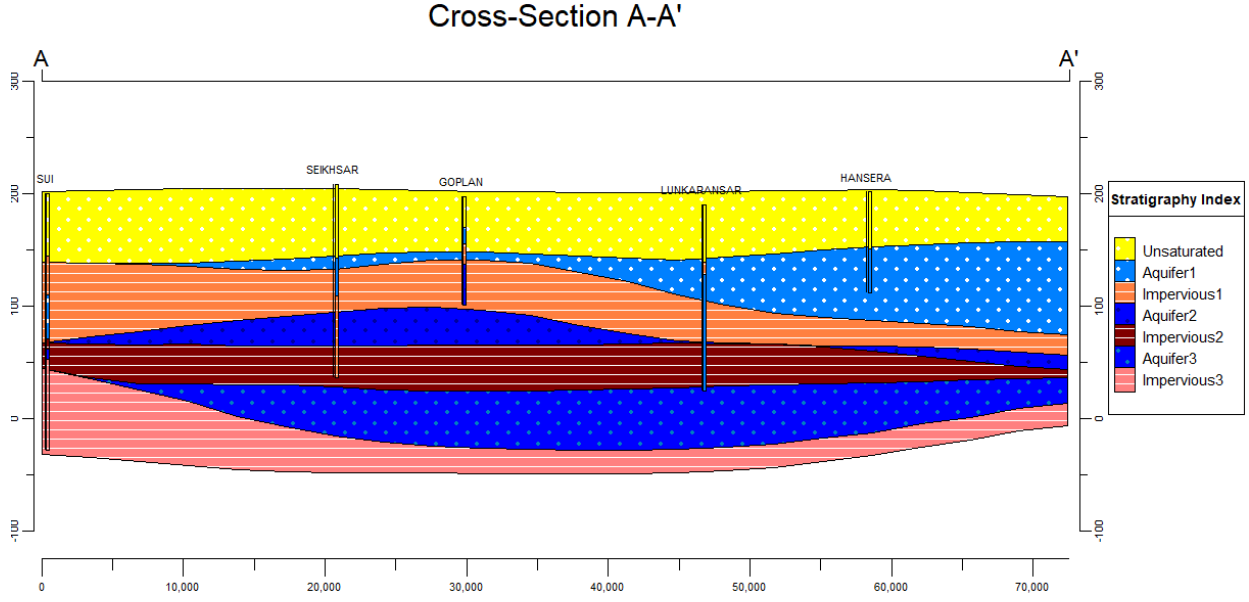


AQUIFER DISPOSITION		
Number of Aquifers (Major)	Three	
Number of Zones	Two	

I	Alluvium	
II	Alluvium followed by tertiary Sand Stone	
III	Jodhpur –Nagaur Sand Stone	



CROSS SECTIONS



Major Aquifer System	CGWB	GWD
Status of GW Exploration	25	15

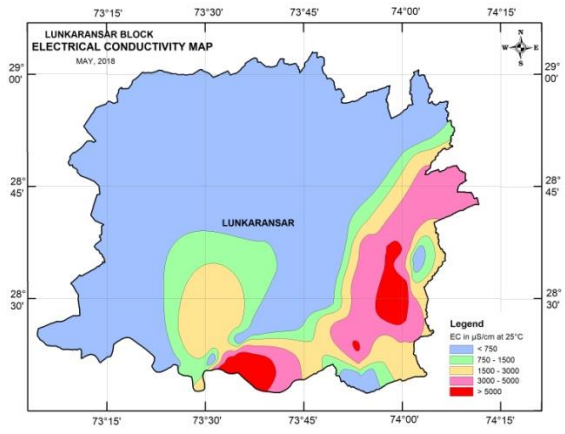
BASIC AQUIFER CHARACTERISTICS			
Type of Aquifer	Aquifer -I	Aquifer -II	Aquifer - III(Confined)
Depth of Occurrence (mbgl)	70-140	170-220	250-290
Discharge (lpm)	Meager to 421	100-220	10-132
Specific Yield (Sy)			
Drawdown	0.5-893	4-30.8	5.44
Ec	1260-9719	9515-12575	2450-5395

CHEMICAL QUALITY OF GROUND WATER

Suitability for Drinking

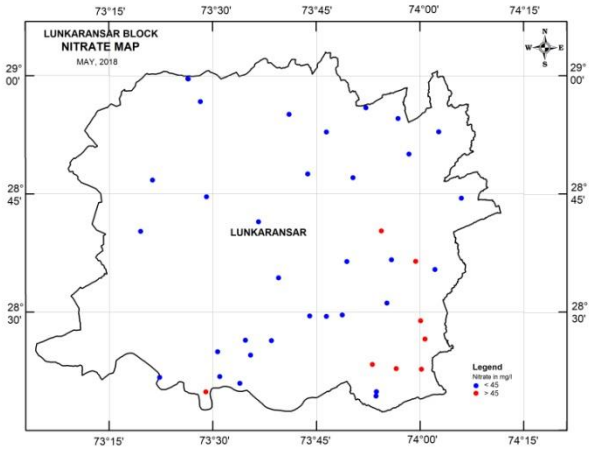
TDS	**Range**	**% Samples**
Fresh	0-3000	84%(Mainly Near Canal Command area And Available as Perched aquifer
Brackish	>-3000	16%
Hardness	**Range**	**% Samples**
Soft	0 – 75	0.00%
Moderately Hard	75 – 150	27.00%
Hard	150 – 300	50.00%
Very Hard	>300	13.00%

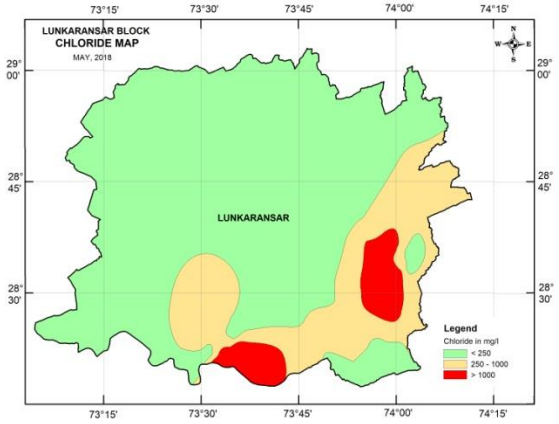
CHEMICAL QUALITY MAP



VARIATION IN MAJOR & MINOR ELEMENTS	
EC < 2000 µS/cm at 25°C	22%
NO3 in mg/l>45 mg/l	22%
F in mg/l – 1 to 1.5 mg/l	24%

	>1.5 mg/l	13%





Suitability for Irrigation

EC		**RSC (meq/l)**		
Type of Water	**Classification**	**% Samples**	**Range**	**% Samples**
			< 1.25	82
Low Saline< 250 mg/l	Excellent	0.00	1.25 - 2.0	7.0
Medium Saline 250 – 750 mg/l	Good	69.0	2.0 - 2.5	2.0
Highly Saline 750 – 2250 mg/l	Permissible	9.00	2.5 - 3.0	0.0
Very Highly saline> 2250 mg/l	Doubtful	22.00	> 3.0	9.0

Na%			**SAR**		
Water Class	**Range**	**% Samples**	**Water Class**	**Range**	**% Samples**
Excellent	< 20	16.0	Excellent	<10	84.0
Good	20 - 40	27.0	Good	10 to 18	16.0
Medium	40 - 60	24.0	Medium	18 to 26	0.00
Bad	60 - 80	07.0	Bad	>26	0.00
Very Bad	> 80	26.0			

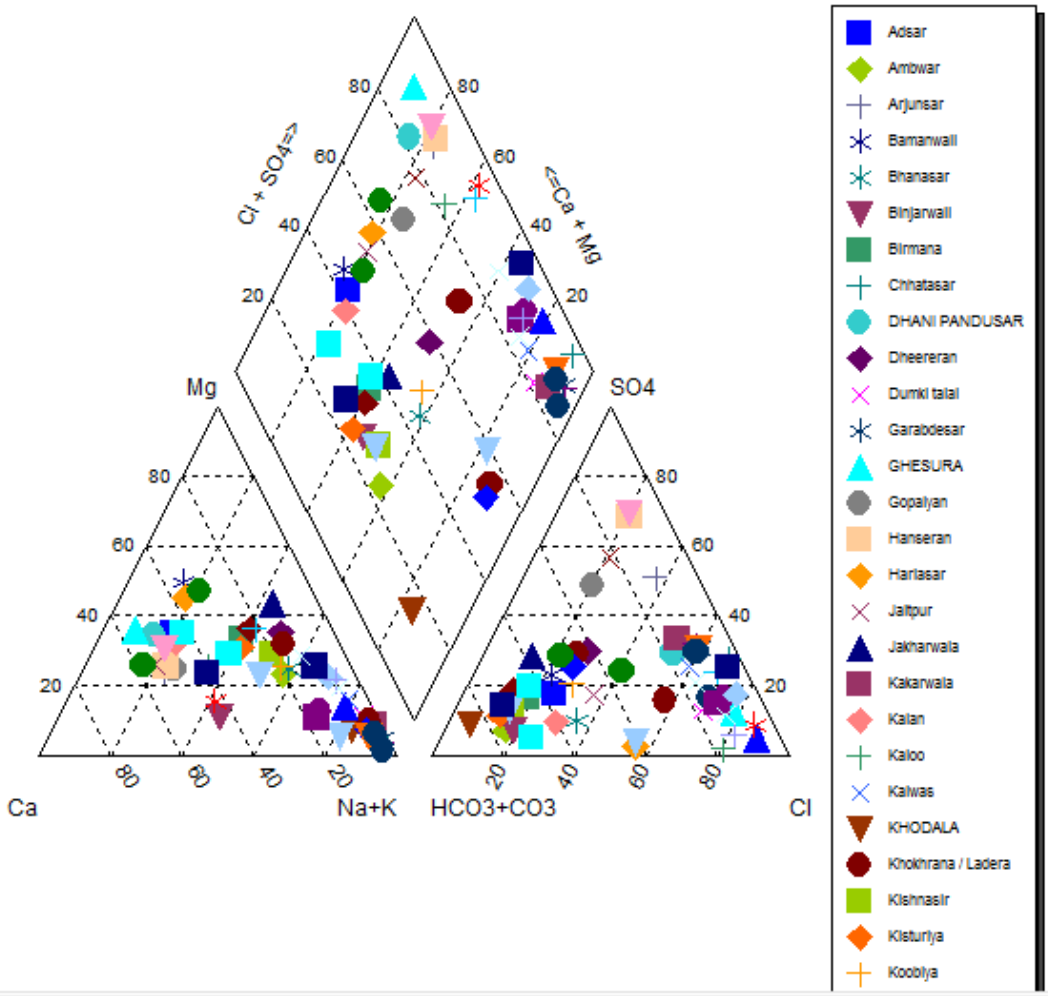
GROUND WATER ISSUES	
1. Ground water Quality Issues	High Salinity High Chloride
2. Rainfall and Drought	• Low and erratic rainfall, High evaporation rate • Normal Droughts in 23.00% years • Most Severe Drought in 2.00% years
3. Decadal Water Level Trend (2009-2018)-	Not significantly dips

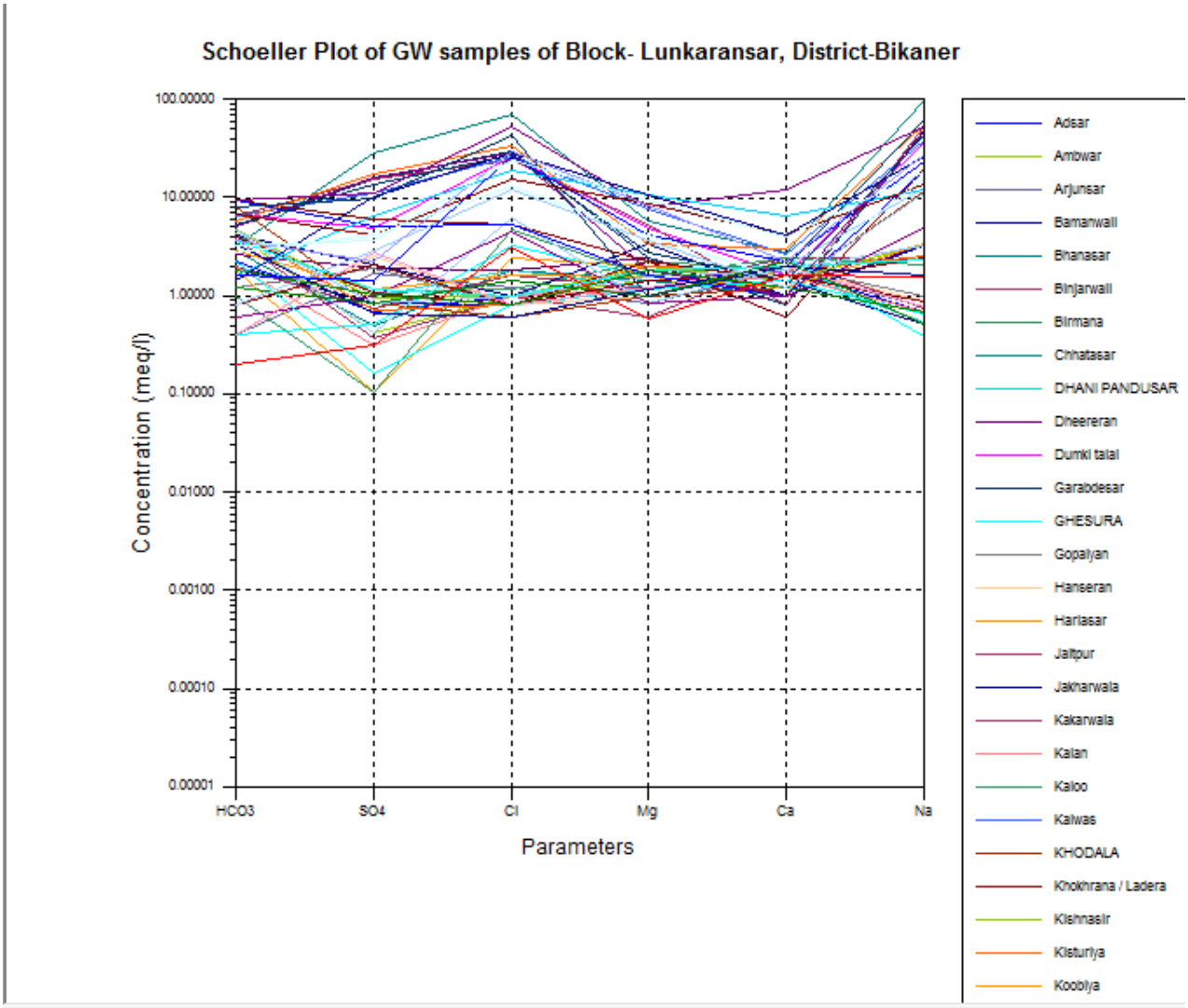
GROUND WATER RESOURCE & EXTRACTION(GWRE-2017)	
Ground Water Recharge Worthy Area (sq. km.)	2071
Total Annual Ground Water Recharge (mcm)	38.92
Natural Discharge (mcm)	3.89

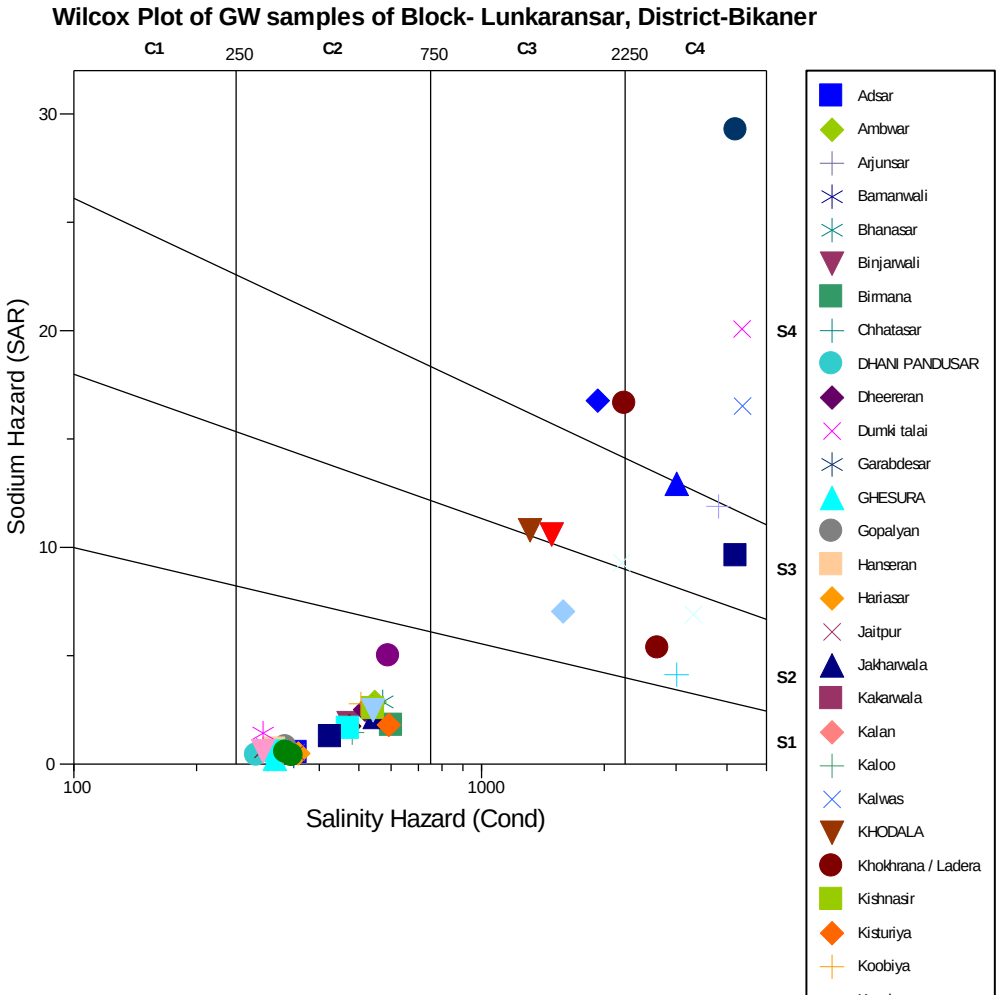
Net Annual Ground Water Availability (mcm)		35.03
Existing Gross Ground Water Draft for All uses(mcm)		12.24
Provision for domestic and industrial requirement supply to 2025(mcm)		6.01
Stage of Ground Water Development %		56.24
Category		Safe
In-Storage Resource		
Total Area (Sq.km)		6372
Main aquifer		2071
Specific yield		0.06
Utilizable Volume (mcm)		32.47
Total In-storage Resource (mcm)		408.8
Total Resource Dynamic + In-storage(mcm)Fresh		444
Sustainability Period with existing draft		Sustainable for long period of time
GROUND WATER RESOURCE ENHANCEMENT		
Artificial Recharge & Water Conservation Possibilities		
Existing Structures constructed by State Govt.		14
Johad	01	
Talai(Talab)	13	
SUPPLY SIDE MANAGEMENT		
Water Supply(mcm)		
Tanka no with capacity of 50,000liters		4216
Volume of water to be conserved (mcm)		0.21
Area of Block (Sq. Km.)		1453.81
Area suitable for Artificial recharge (sq.km)		421.7
Type of Aquifer		
Soft Rock Area (sq.km)		Alluvium(930) Tertiary sand stone (1141)
Volume of sub surface space available for artificial recharge (mcm)		7732.05
Surplus surface water availability (mcm)		0.00
Volume of water expected to be conserved		0.21
DEMAND SIDE MANAGEMENT		
Micro irrigation techniques		
Use of Sprinklers for Irrigation		
50%of Irrigation Area (ha) proposed for irrigation through Sprinkler (Surface water saving as well as GW saving)		26559
Water Saving by use of Sprinklers(mcm)		21.24
Cropping Pattern change		

50% of Cropping Area (ha) proposed for change in crop from wheat to gram (Surface water saving as well as GW saving)	3509
Water Saving by Change in Cropping Pattern(mcm)	3.5
EXPECTED BENEFITS	
Net Ground Water Availability (mcm) 2017	35.04
Existing Ground Water Draft for All Purposes (mcm)	19.70
GW saving through project (mcm)	24.97
Present stage of Ground Water Development (%)	56.24
Projected Stage of Ground Water Development after Supply Side and Demand side interventions (%)	24.29
Total Ground Water Resources (In-storage & Availability after all interventions) mcm	444.08
Sustainability of GW Resources with existing Draft (in years)	Sustainable for long periods

Hill-Piper Plot of GW samples of Block-Lunkaransar, District-Bikaner

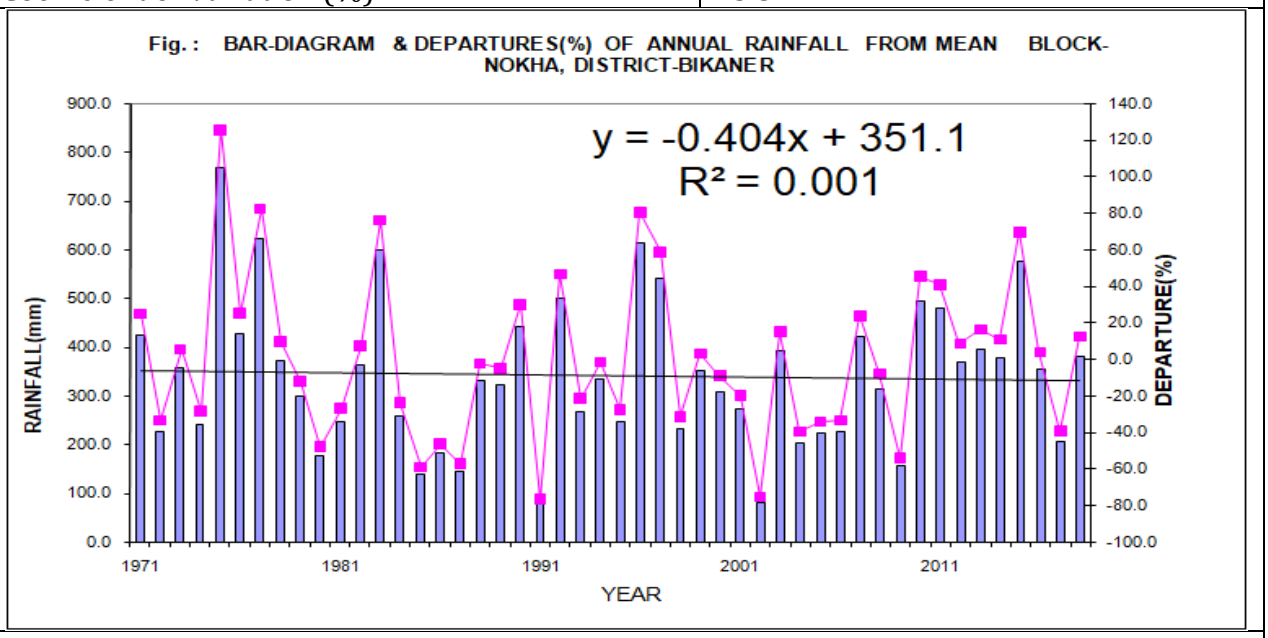



Schoeller Plot of GW samples of Block- Lunkaransar, District-Bikaner
100.00000
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
Concentration (meq/l)
HCO3
SO4
Cl
Mg
Ca
Na
Parameters
Adsar
Ambwar
Arjunsar
Bamanwali
Bhanasar
Binjarwali
Birmana
Chhatasar
DHANI PANDUSAR
Dheereran
Dumki talai
Garabdesar
GHESURA
Gopaliyan
Hanseran
Harlasar
Jaitpur
Jakharwala
Kakarwala
Kalan
Kaloo
Kalwas
KHODALA
Khokhrana / Ladera
Kishnasir
Kisturiya
Koobiya

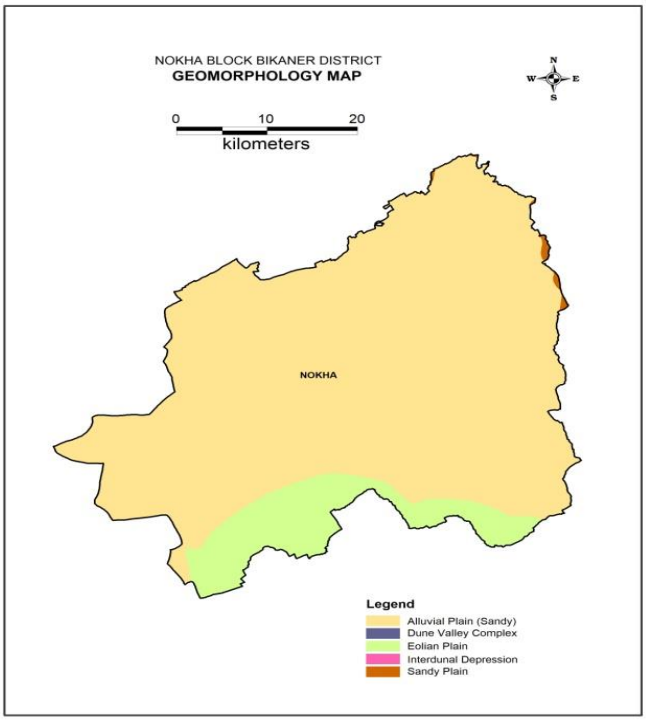

Wilcox Plot of GW samples of Block- Lunkaransar, District-Bikaner
C1
250
C2
750
C3
2250
C4
30
20
10
0
Sodium Hazard (SAR)
S4
S3
S2
S1
100
1000
Salinity Hazard (Cond)
Adsar
Ambwar
Arjunsar
Bamanwali
Bhanasar
Binjarwali
Birmana
Chhatasar
DHANI PANDUSAR
Dheereran
Dumki talai
Garabdesar
GHESURA
Gopalyan
Hanseran
Hariasar
Jaitpur
Jakharwala
Kakarwala
Kalan
Kaloo
Kalwas
KHODALA
Khokhrana / Ladera
Kishnasir
Kisturiya
Koobiya

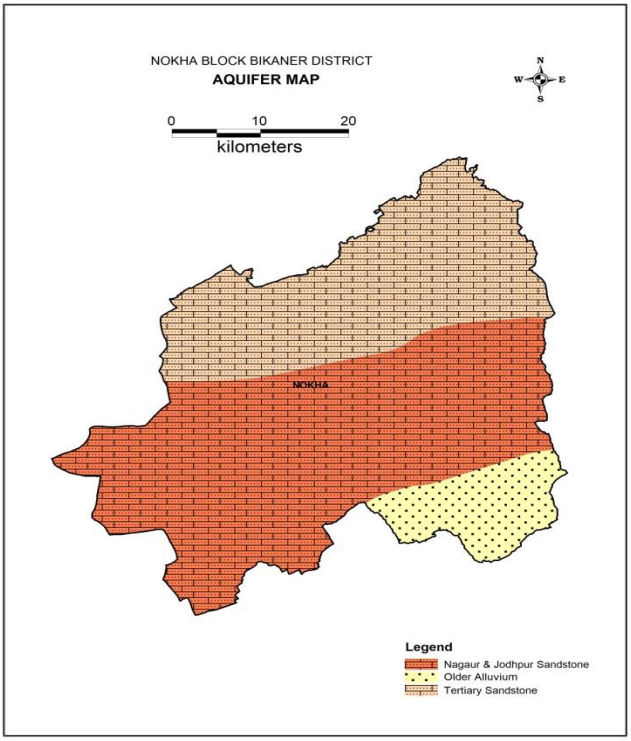
NOKHA

SALIENT INFORMATION	
Block Name	**NOKHA**
Longitude	73°18'53" to73°53'51"
Latitude	27°16'27" to27°57'59"
Geographical Area Sq.km	1888.10
Hilly Area (Sq.km)	Nil
Population (2011)	436876
Climate	
Average Temperature range (°C)	16.9 to 47 with an average of 28
Rainfall Analysis	
Normal Rainfall (mm)	341.27
Mean Annual rainfall (mm)	383
Highest annual rainfall with year (mm)	769.4 (1975)
Lowest annual rainfall (mm) with year	79 (1991)
Standard deviation (mm)	147.82
Coefficient of Variation (%)	43.31



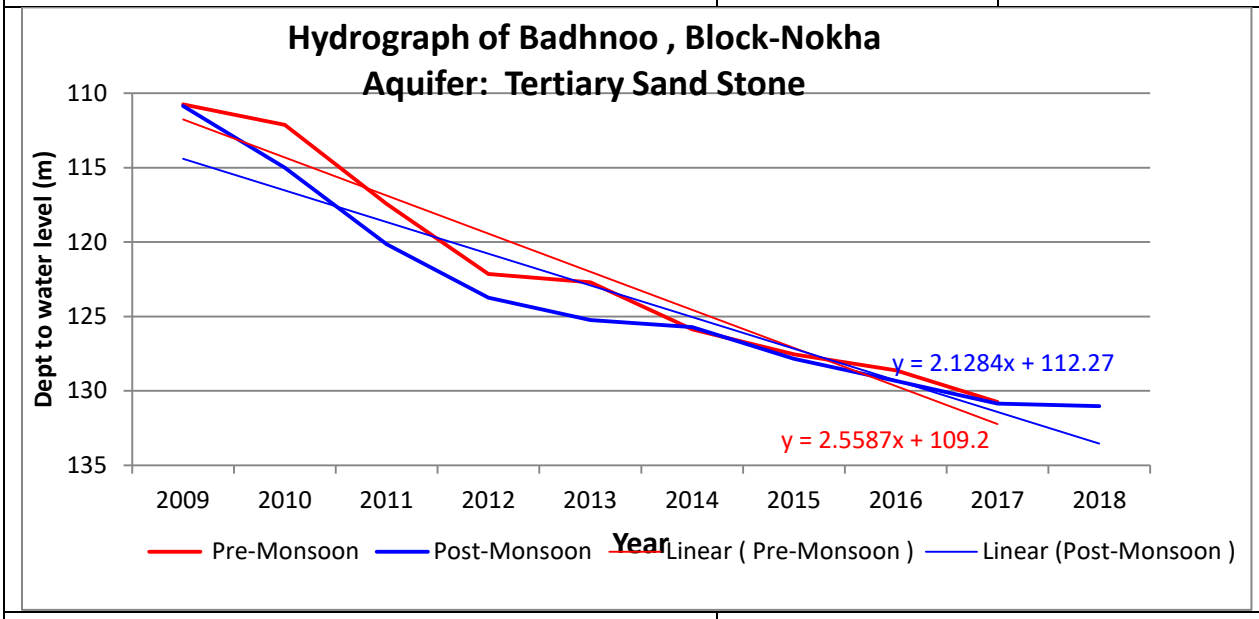
Drought Analysis	
Mild (0 to -25%)	09
Normal (-25% to -50%)	11
Severe (-50% to -75%)	3
Most severe (-75% to -100%)	02
Probability of Normal Rainfall	23%
Geomorphology	
Geomorphic Unit	Older alluvial plains, Sandy undulating aggraded Alluvial plains, Flat Interdunal Plains, Sandy undulating

	interdunal plains, Aeolian complex, Stabilized Sand dunes, Active Sand dunes, Eroded rocky surface, Sandy Plain.
Elevation (m amsl)	261.6 - 349.1
	
Geology	
• Eolian/Alluvium sand, Age: Pleistocene to recent. • Tertiary Sand stone. Age Eocene. • Jodhpur &Nagaursand stone of Marwar super group Age:Palaeozoic	

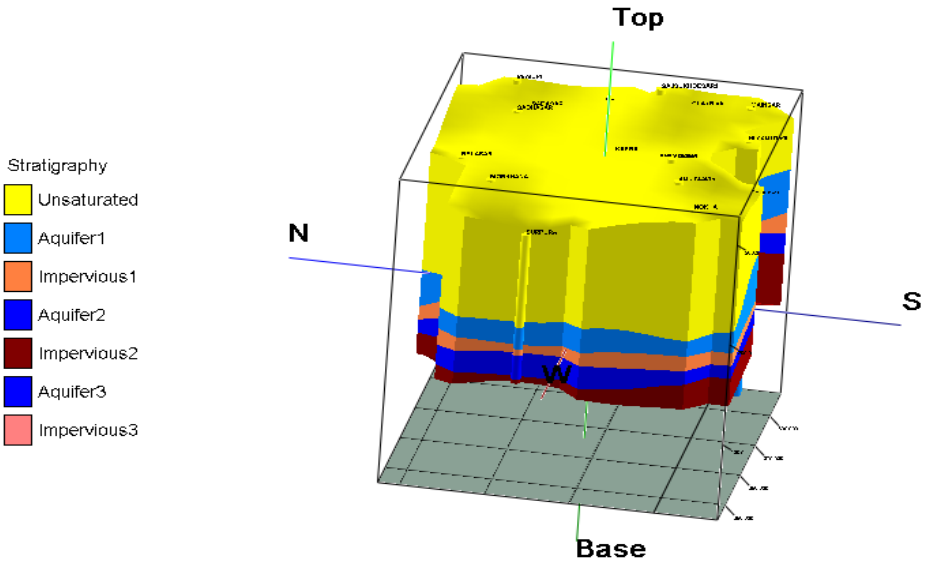


Drainage & Hydrology			
Drainage/Basin/Sub Basin		No Major drainage except few ephemerals streamlets and inter dunal area	
Hydrology			
Ponds		10	
LAND USE, AGRICULTURE, IRRIGATION & CROPPING PATTERN			
Geographical Area in ha.		188810	
Forest Area in ha.		446	
Net Sown Area in ha.		143468	
Area sown more than once in ha.		6221	
Rainfed Crop		Bajra in 49080 hect area	
Area under Irrigation (Net) in ha			
	Surface Water	0	
	Ground Water	15480	
	Other sources	0	
Season wise crop area in ha.			
	Kharif	**Rabi**	**Zaid Rabi**
sown	133920	9552	0
Irrigated	5954	9536	0
Principal Crop Area (ha)			
Crop Type			
	Cereals	152527	
	Oil Seeds	7786	

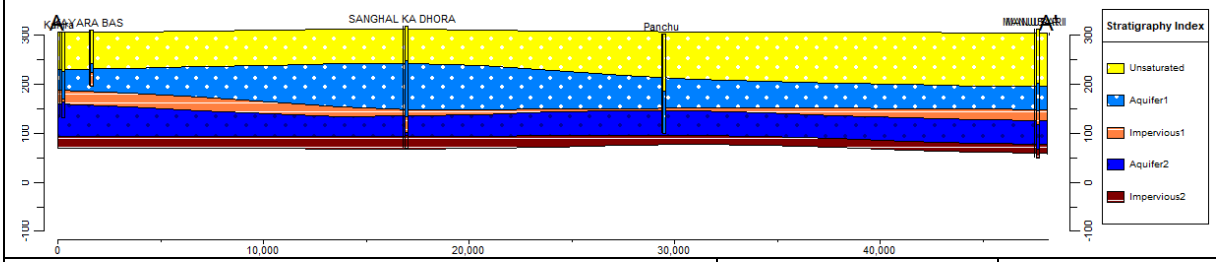
Pulses	66820	
Hydrogeology		
Monitoring Stations (May 2017)		
CGWB	02	
SGWD	17	
NAQUIM Key Wells	19	
WATER LEVEL BEHAVIOUR		
Pre-Monsoon (May-2018) Water level	Post-Monsoon (November-2018)Water level	
40.4 to 117.2 m bgl	40.2 to 117.2 m bgl	
Water Level Trend (2009-2018)	Pre-monsoon	Post-monsoon
Average Trend (m/year)	Declining 0.28	Declining 0.27
	Pre-monsoon	Post-monsoon
Rise	-1.301 – (0)	-2.28- (0)
Fall	NA	NA



AQUIFER DISPOSITION	
Number of Aquifers (Major)	Two
I	Alluvium followed by tertiary Sand Stone
II	Jodhpur –Nagaur Sand Stone

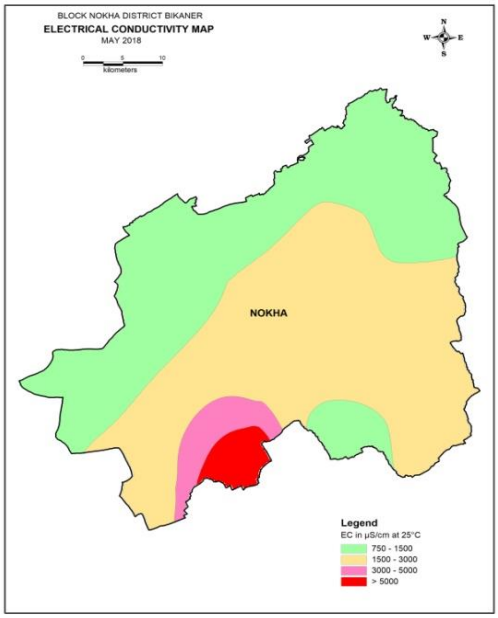


Cross-Section A-A'

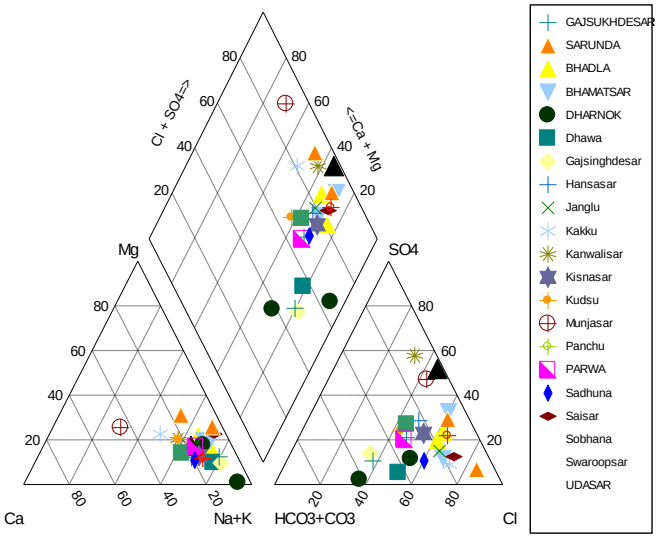


Major Aquifer System	CGWB	GWD
Status of GW Exploration	10	05
BASIC AQUIFER CHARACTERISTICS		
Type of Aquifer	Aquifer-I	Aquifer-II
Depth of Occurrence (mbgl)	62-160	180-258
Yield Potential(lpm)	80-360	80-280
Drawdown(m)	1.35-8.35	0.02
EC µS/cm at 25°C	2000-5310	1050-2181
CHEMICAL QUALITY OF GROUND WATER		
Suitability for Drinking		

TDS(mg/l)	**Range**	**% Samples**
Fresh	0-3000	96.0%
Brackish	>-3000	4.00%

Hardness (mg/l)as $CaCO_3$	**Range**	**% Samples**
Soft	0 – 75	0%
Moderately Hard	75 – 150	06.00%
Hard	150 – 300	33.0%
Very Hard	>300	61%
CHEMICAL QUALITY MAP	VARIATION IN MAJOR & MINOR ELEMENTS	
	EC < 2000 µS/cm at 25°C	36%
	NO3 in mg/l>45 mg/l	26%
	F in mg/l – 1 to 1.5 mg/l	93%
	>1.5 mg/l	07%

Hill-Piper Plot of GW samples of Block- Panchu, District-Bikaner

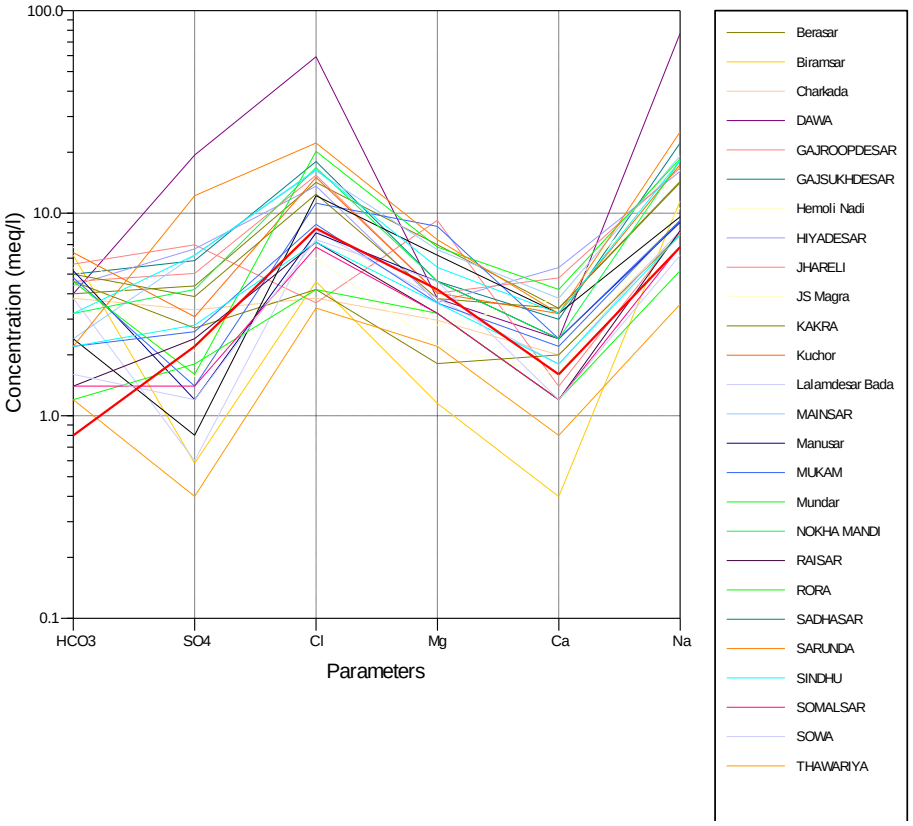


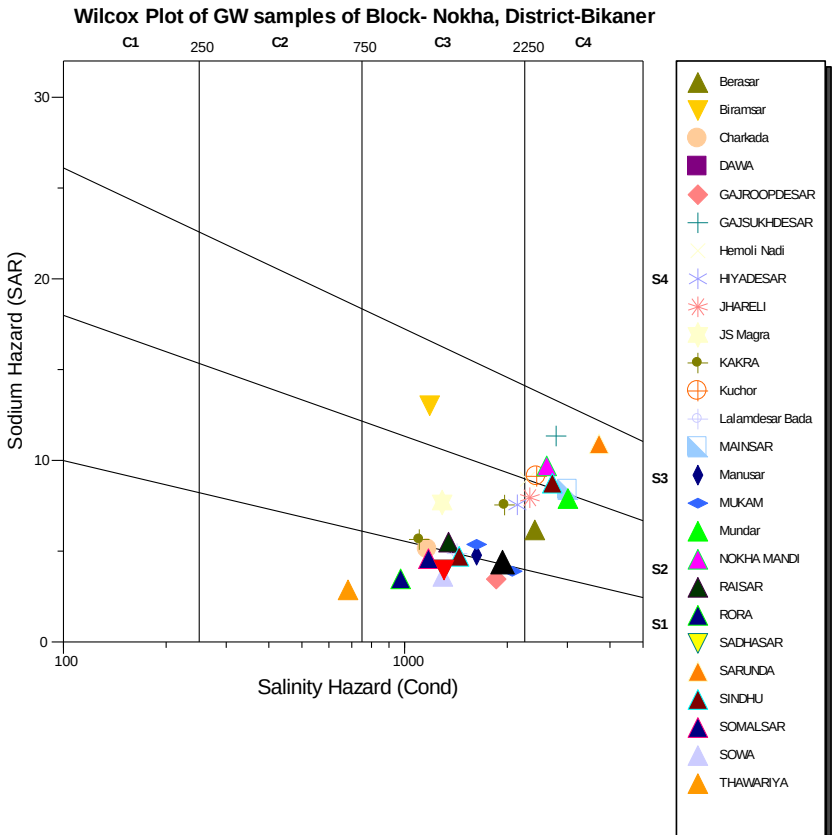
Suitability for Irrigation					
EC			**RSC (meq/l)**		
Type of Water	**Classification**		**% Samples**	**Range**	**% Samples**
				< 1.25	0
Low Saline< 250 mg/l	Excellent		0.00	1.25 - 2.0	0
Medium Saline 250 – 750 mg/l	Good		6.00	2.0 - 2.5	0
Highly Saline 750 – 2250 mg/l	Permissible		30.00	2.5 - 3.0	0
Very Highly saline> 2250 mg/l	Doubtful		74.00	> 3.0	100
Na%			**SAR**		
Water Class	**Range**	**% Samples**	**Water Class**	**Range**	**% Samples**
Excellent	< 20	0.00	Excellent	<10	86.0
Good	20 - 40	0.00	Good	10 to 18	14.0
Medium	40 - 60	13.0	Medium	18 to 26	0.00
Bad	60 - 80	69.0	Bad	>26	0.00
Very Bad	> 80	18			

GROUND WATER ISSUES	
1. Over-Exploitation – Resource Availability	At present the Ground water Draft 91.71 is more than Annual Availability(35.15)mcm
2. Rainfall and Drought	• Normal Droughts in 11% years • Severe Drought in 2.00% years
3. Decadal Water Level Trend (2010-2017)-	Declining
GROUND WATER RESOURCE & EXTRACTION(GWRE-2017)	
Ground Water Recharge Worthy Area (sq. km.)	1888.10
Total Annual Ground Water Recharge (mcm)	39.06
Natural Discharge (mcm)	3.9
Net Annual Ground Water Availability (mcm)	35.15
Existing Gross Ground Water Draft for All uses(mcm)	91.71
Provision for domestic and industrial requirement supply to 2025(mcm)	22.46
Stage of Ground Water Development %	260.83
Category	Over Exploited
In-Storage Resource	
Total Area (Sq.Km)	1888.10
Specific yield	0.06
Total Resource	233.47
Utilizable Volume (mcm)	59.42

Total In-storage Resource (mcm)	233.47	
Total Resource Dynamic + In-storage(Fresh)	268.63	
Sustainability Period with existing draft	03 years	
GROUND WATER RESOURCE ENHANCEMENT		
Artificial Recharge & Water Conservation Possibilities		
Existing Structures constructed by State Govt.	60	
Diggi/ Jalhoj	49	
Roof Top Water Harvesting Structure	09	
Talai(Talab)	05	
SUPPLY SIDE MANAGEMENT		
Water Supply(mcm)		
Tanks (Nos) Capacity 50.000 lts	2793	
Volume of water to be conserved (mcm)	0.1396	
Type of Aquifer		
Soft Rock Area (sq.km)	3. Tertiary Sand Stone : 620.60 4. Jodhpur Nagaur Sand Stone: 1105.00	
Volume of Sub surface Storage Space available for Artificial Recharge (mcm)	3815.06	
Surplus Surface water Availability (mcm)	0.00	
Volume of Water expected to be conserved (mcm)	0.1396	
DEMAND SIDE MANAGEMENT		
DEMAND SIDE MANAGEMENT		
Micro irrigation techniques		
Use of Sprinklers for Irrigation		
Irrigation Area (ha) proposed for irrigation through Sprinkler	39252	
Water Saving by use of Sprinklers(mcm)	39.40	
Cropping Pattern change		
Cropping Area (ha) proposed for change in crop	1490	
Water Saving by Change in Cropping Pattern(mcm)	1.49	
EXPECTED BENEFITS		
Net Ground Water Availability (mcm) 2017		35.16
Existing Ground Water Draft for All Purposes (mcm)		91.71
GW draft after Demand Side Interventions (mcm)		50.68
Present stage of Ground Water Development (%)		260.83
Projected Stage of Ground Water Development after Supply Side and demand side interventions (%)		128.87
Total Ground Water Resources (In-storage & Availability after all interventions) mcm		268.77
Sustainability of GW Resources with existing Draft (in years)		40

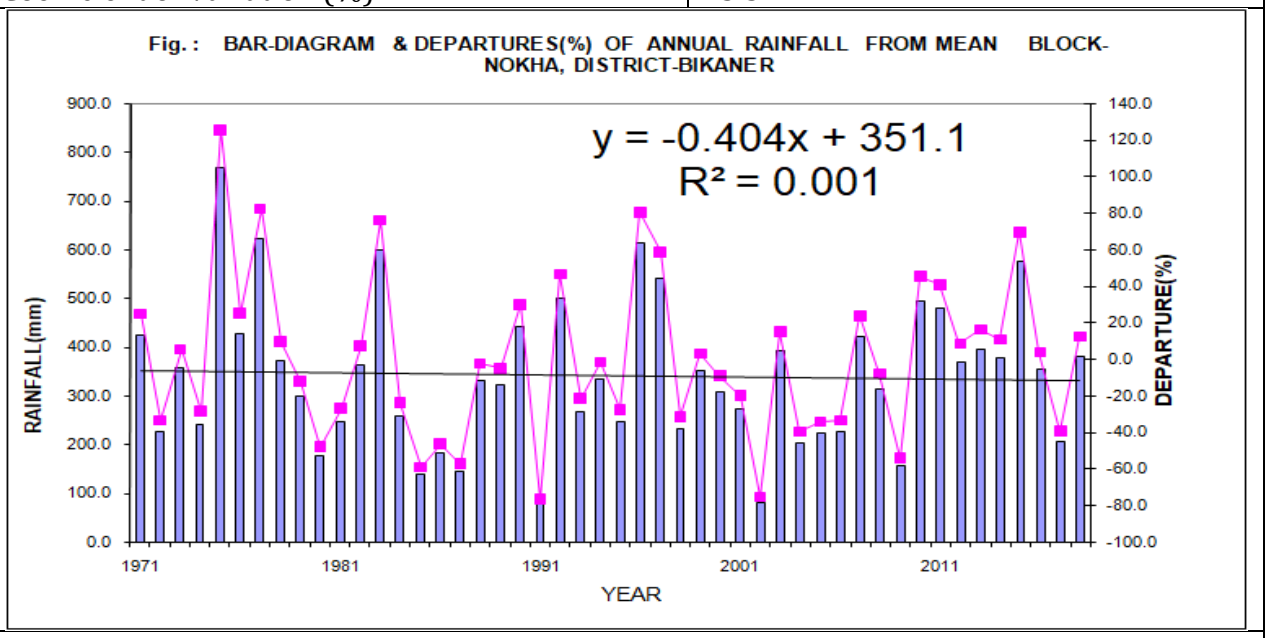
Schoeller Plot of GW samples of Block- Nokha, District-Bikaner




Wilcox Plot of GW samples of Block- Nokha, District-Bikaner
C1
250
C2
750
C3
2250
C4
30
20
10
0
Sodium Hazard (SAR)
100
1000
Salinity Hazard (Cond)
S4
S3
S2
S1
Berasar
Biramsar
Charkada
DAWA
GAJROOPDESAR
GAJSUKHDESAR
Hemoli Nadi
HIYADESAR
JHARELI
JS Magra
KAKRA
Kuchor
Lalamdesar Bada
MAINSAR
Manusar
MUKAM
Mundar
NOKHA MANDI
RAISAR
RORA
SADHASAR
SARUNDA
SINDHU
SOMALSAR
SOWA
THAWARIYA

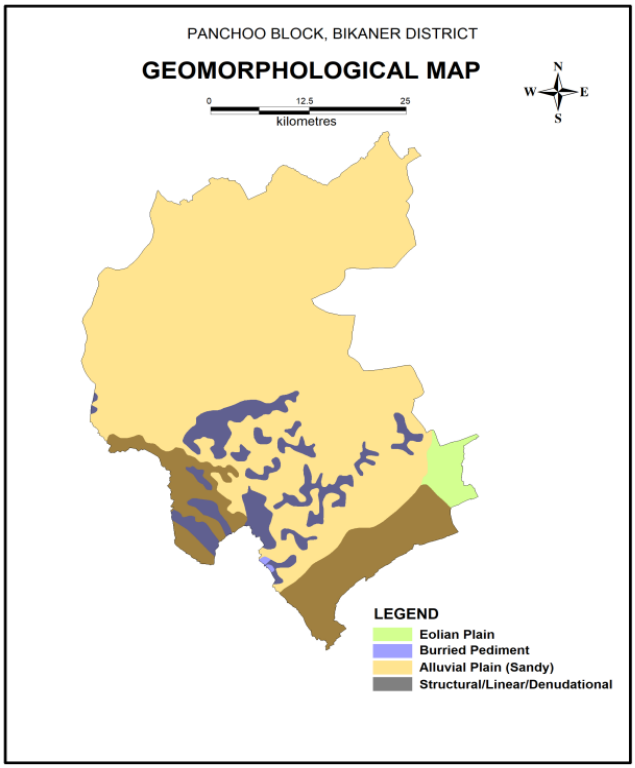
PANCHU

SALIENT INFORMATION	
Block Name	**PANCHU**
Longitude	73°00'47" to73°31'20"
Latitude	27°10'51" to27°49'05"
Geographical Area Sq.km	1912.86
Hilly Area (Sq.km)	Nil
Population (2011)	17370
Climate	
Average Temperature range (°C)	16.9 to 47 with an average of 28
Rainfall Analysis	
Normal Rainfall (mm)	341.27
Mean Annual rainfall (mm)	352
Highest annual rainfall with year (mm)	769.4 (1975)
Lowest annual rainfall (mm) with year	79 (1991)
Standard deviation (mm)	147.82
Coefficient of Variation (%)	43.31

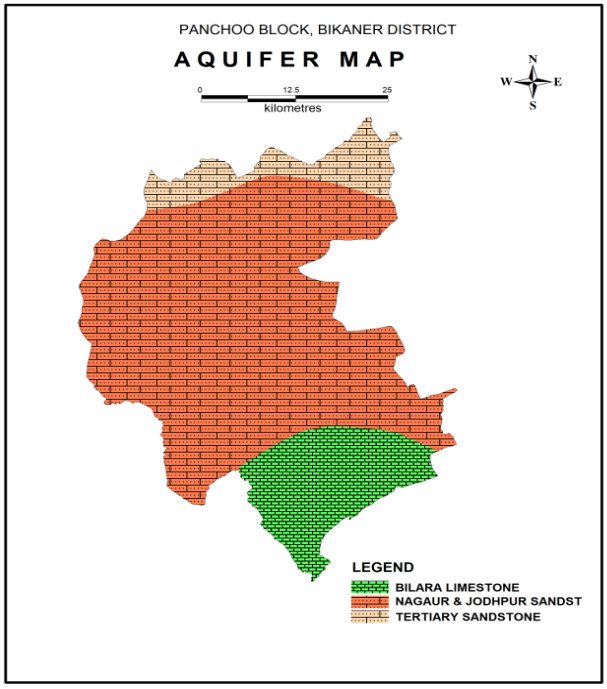


Drought Analysis	
Mild (0 to -25%)	09
Normal (-25% to -50%)	11
Severe (-50% to -75%)	3
Most severe (-75% to -100%)	02
Probability of Normal Rainfall	23%
Geomorphology	
Geomorphic Unit	Older alluvial plains, Sandy undulating aggraded Alluvial plains, Flat Interdunal Plains, Sandy undulating

	interdunalplains, Aeolian complex, Stabilized Sand dunes, Active Sand dunes, Eroded rocky surface, Sandy Plain.
Elevation (m amsl)	261.6 - 349.1

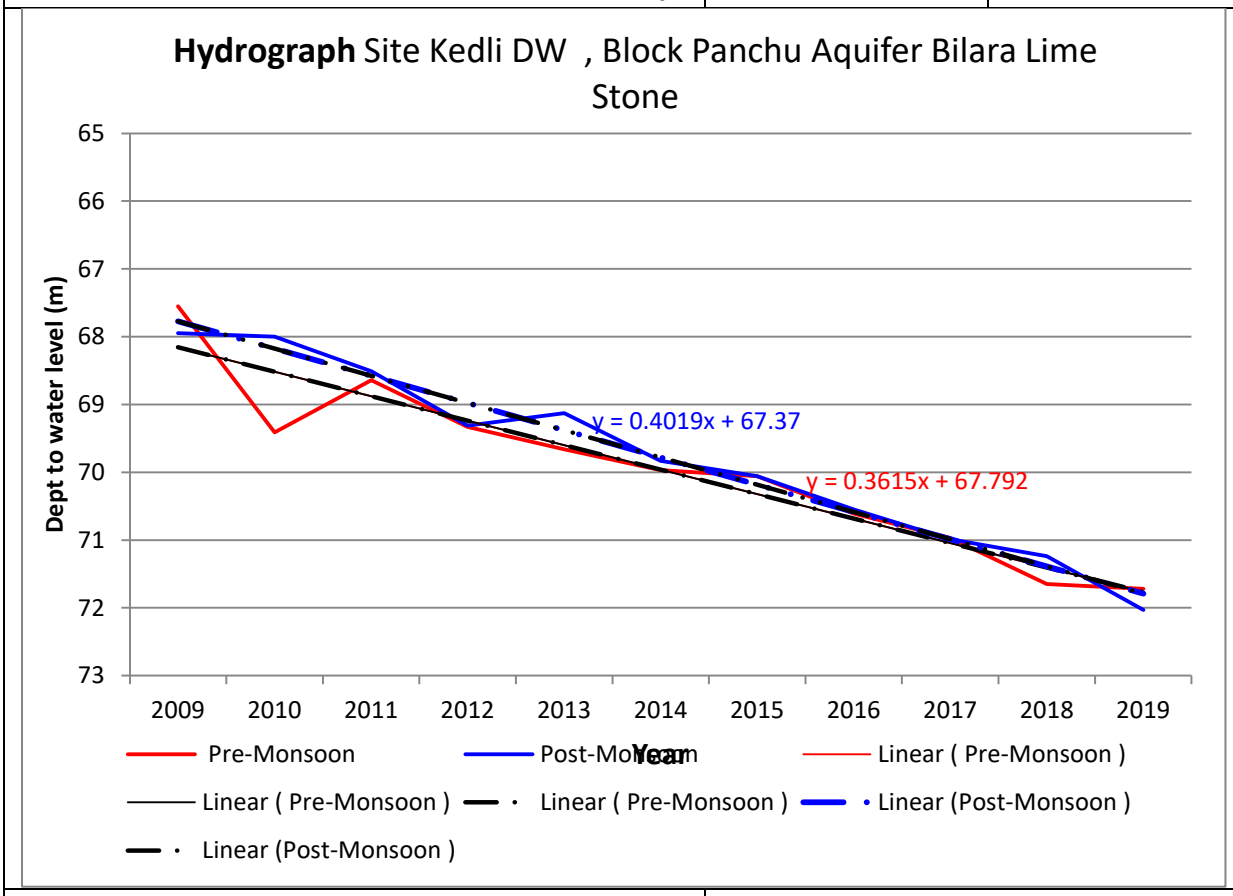


Geology	
• Eolian/Alluvium sand, Age: Pleistocene to recent. • Tertiary Sand stone. Age Eocene. • Jodhpur &Nagaursand stone of Marwar super group Age:Palaeozoic	

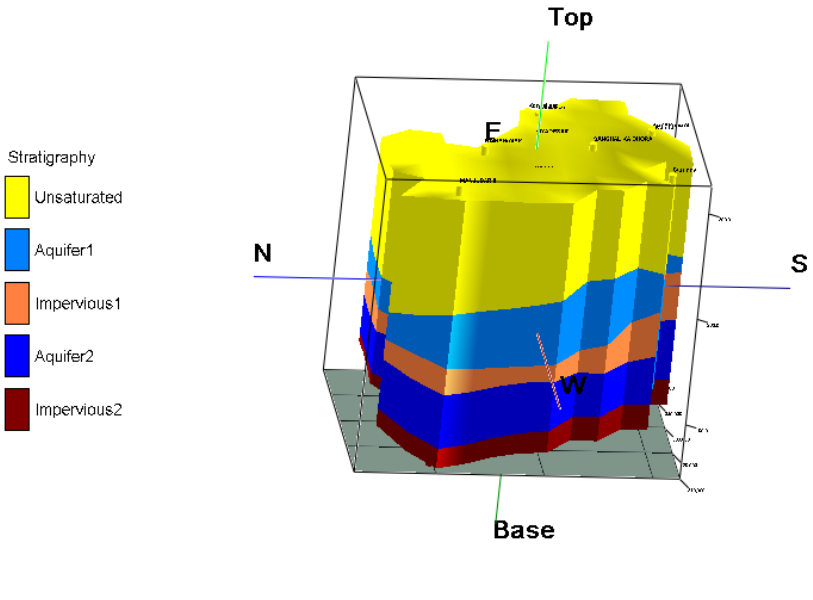


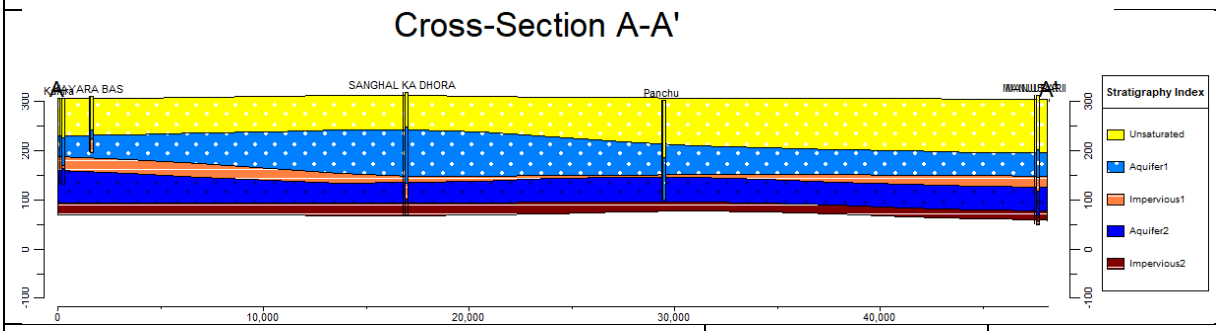
Drainage & Hydrology			
Drainage/Basin/Sub Basin		No Major drainage except few ephemerals streamlets and inter dunal area	
Hydrology			
Ponds		08	
LAND USE, AGRICULTURE, IRRIGATION & CROPPING PATTERN			
Geographical Area in ha.		191286	
Forest Area in ha.		450	
Net Sown Area in ha.		143480	
Area sown more than once in ha.		6230	
Rainfed Crop		Bajra in 49100 hect area	
Area under Irrigation (Net) in ha			
	Surface Water	0	
	Ground Water	15510	
	Other sources	0	
Season wise crop area in ha.			
	Kharif	**Rabi**	**Zaid Rabi**
sown	267841	19107	0
Irrigated	11914	19076	0
Principal Crop Area (ha)			
Crop Type			

Cereals	105054	
Oil Seeds	15584	
Pulses	133645	
Hydrogeology		
Monitoring Stations (May 2017)		
CGWB	0	
SGWD	18	
NAQUIM Key Wells	29	
WATER LEVEL BEHAVIOUR		
Pre-Monsoon (May-2018) Water level	Post-Monsoon (November-2018)Water level	
40.4 to 117.2 m bgl	40.2 to 117.2 m bgl	
Water Level Trend (2009-2018)	Pre-monsoon	Post-monsoon
Average Trend (m/year)	Declining 0.28	Declining 0.27
	Pre-monsoon	Post-monsoon
Rise	-1.301 – (0)	-2.28- (0)
Fall	NA	NA



AQUIFER DISPOSITION	
Number of Aquifers (Major)	Two
I	Alluvium followed by tertiary Sand Stone
II	Jodhpur –Nagaur Sand Stone



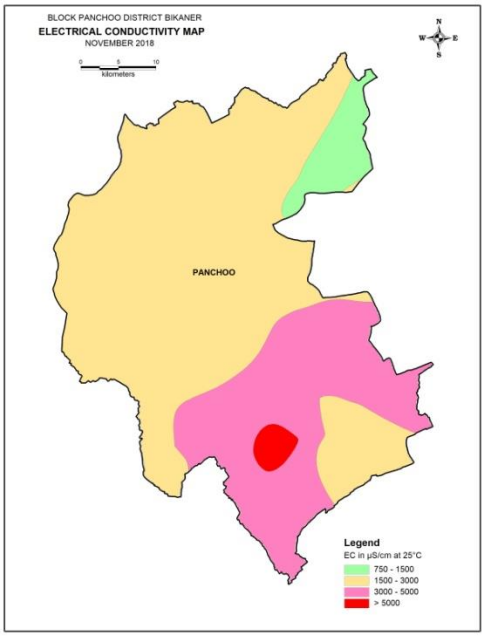


Major Aquifer System	CGWB	GWD
Status of GW Exploration	06	01
BASIC AQUIFER CHARACTERISTICS		
Type of Aquifer	Aquifer-I	Aquifer-II
Depth of Occurrence (mbgl)	105- 160	170- 220
Discharge (lpm)	40-250	14- 600
Specific Yield (Sy)	-	-
Drawdown(m)	-	2.25
EC µS/cm at 25°C	1800-3000	2161-2270

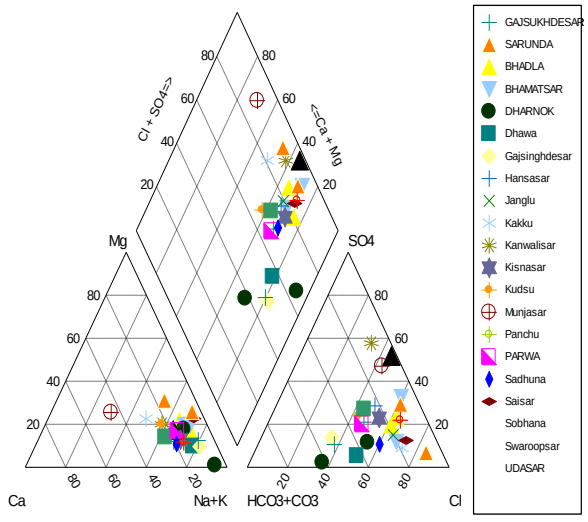
CHEMICAL QUALITY OF GROUND WATER

Suitability for Drinking

TDS(mg/l)	**Range**	**% Samples**
Fresh	0-3000	100.00%

Brackish	>-3000	0.00%
Hardness (mg/l)as $CaCO_3$	**Range**	**% Samples**
Soft	0 – 75	03.00%
Moderately Hard	75 – 150	07.00%
Hard	150 – 300	36.00%
Very Hard	>300	54.00%
CHEMICAL QUALITY MAP	VARIATION IN MAJOR & MINOR ELEMENTS	
	EC < 2000 µS/cm at 25°C	35%
	NO3 in mg/l>45 mg/l	55%
	F in mg/l – 1 to 1.5 mg/l	85%
	>1.5 mg/l	15%

Hill-Piper Plot of GW samples of Block- Panchu, District-Bikaner



Suitability for Irrigation					
EC			**RSC (meq/l)**		
Type of Water	**Classification**		**% Samples**	**Range**	**% Samples**
				< 1.25	0
Low Saline< 250 mg/l	Excellent		0.00	1.25 - 2.0	0
Medium Saline 250 – 750 mg/l	Good		0.00	2.0 - 2.5	0
Highly Saline 750 – 2250 mg/l	Permissible		52.00	2.5 - 3.0	0
Very Highly saline> 2250 mg/l	Doubtful		48.00	> 3.0	100
Na%			**SAR**		
Water Class	**Range**	**% Samples**	**Water Class**	**Range**	**% Samples**
Excellent	< 20	0.00	Excellent	<10	72
Good	20 - 40	03.0	Good	10 to 18	21
Medium	40 - 60	21.0	Medium	18 to 26	07
Bad	60 - 80	59.0	Bad	>26	0
Very Bad	> 80	17.0			

GROUND WATER ISSUES	
1. Over-Exploitation – Resource Availability	At present the Ground water Draft 33.9894 is more than Annual Availability(38.18218)mcm
2. Rainfall and Drought	• Normal Droughts in 11% years • Severe Drought in 2.00% years
3. Decadal Water Level Trend (2010-2017)-	Declining
4.Ground water quality issues	High salinity
GROUND WATER RESOURSE & EXTRACTION(GWRE-2017)	
Ground Water Recharge Worthy Area (sq. km.)	1824.55
Total Annual Ground Water Recharge (mcm)	42.42
Natural Discharge (mcm)	4.2
Net Annual Ground Water Availability (mcm)	38.18
Existing Gross Ground Water Draft for All uses(mcm)	33.98
Provision for domestic and industrial requirement supply to 2025(mcm)	13.94
Stage of Ground Water Development %	89.02
Category	Semi Critical
In-Storage Resource	
Total Area (Sq.	1912.89
Mean aquifer	1824.55
Specific yield	0.06
Total Resource	423.96
Utilizable Volume (mcm)	71.50

Total In-storage Resource (mcm)	423.96
Total Resource Dynamic + In-storage	462.14
Sustainability Period with existing draft	13 years
GROUND WATER RESOURCE ENHANCEMENT	
Artificial Recharge & Water Conservation Possibilities	
Existing Structures constructed by State Govt.	10
Diggi/ Jalhoj	03
Roof Top Water Harvesting Structure	03
Talai(Talab)	04
SUPPLY SIDE MANAGEMENT	
Water Supply(mcm)	
Tanks (Nos) Capacity 50.000 lts	2806
Volume of water to be conserved (mcm)	0.1403
Type of Aquifer	
Soft Rock Area (sq.km)	5. Tertiary Sand Stone : 259.42 6. Jodhpur Nagaur Sand Stone&Bilara Lime Stone: 1565.13
Volume of Sub surface Storage Space available for Artificial Recharge (mcm)	2129.48
Surplus Surface water Availability (mcm)	0.00
Volume of Water expected to be conserved (mcm)	0.1403
DEMAND SIDE MANAGEMENT	
DEMAND SIDE MANAGEMENT	
Micro irrigation techniques	
Use of Sprinklers for Irrigation	
Irrigation Area (ha) proposed for irrigation through Sprinkler	7755
Water Saving by use of Sprinklers(mcm)	6.204
Cropping Pattern change	
Cropping Area (ha) proposed for change in crop	1904
Water Saving by Change in Cropping Pattern(mcm)	1.9
EXPECTED BENEFITS	
Net Ground Water Availability (mcm) 2017	38.18
Existing Ground Water Draft for All Purposes (mcm)	33.99
Saving of Ground Water through project (mcm)	8.25
GW draft after Demand Side Interventions (mcm)	25.74
Present stage of Ground Water Development (%)	89.02
Projected Stage of Ground Water Development after Supply Side and demand side interventions (%)	67.42
In-storage Resources	423.96
Total Ground Water Resources (In-storage & Availability after all interventions) mcm	**462.29**

Sustainability of GW Resources with existing Draft (in years)	55