

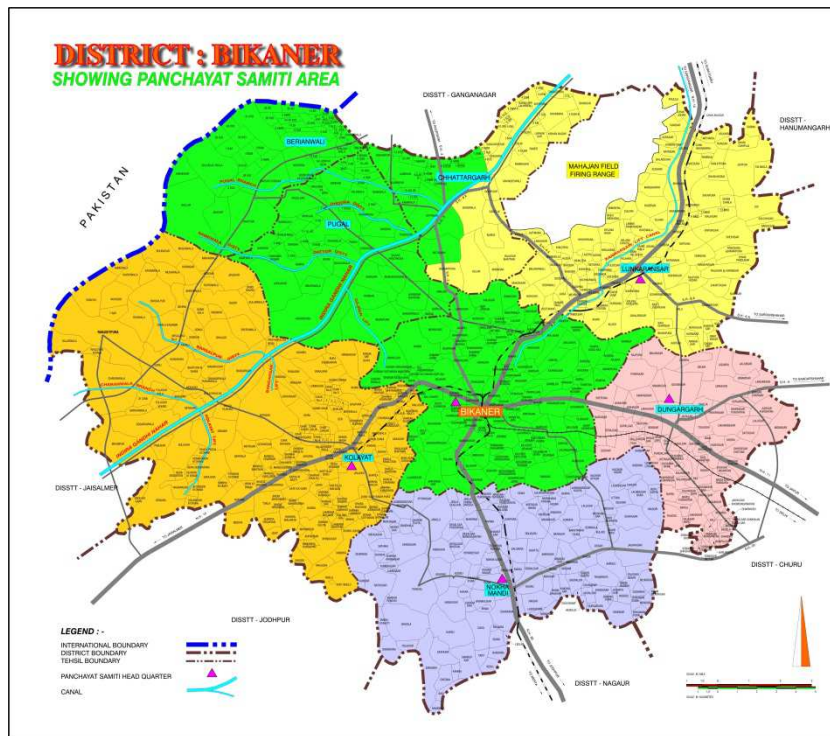
DISTRICT GROUND WATER BROCHURE



**GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD**



**GROUND WATER INFORMATION
BIKANER DISTRICT
RAJASTHAN**



**Western Region
Jaipur
2013**

DISTRICT AT A GLANCE – BIKANER DISTRICT, RAJASTHAN

S No	Item	Statistics		
1	GENERAL INFORMATION			
	(i) Geographical area (Sq. Km)	30247.90		
	(ii) Administrative Division (As on 31.3.2007)			
	Number of Tehsils	08		
	Number of Blocks	06		
	Number of Villages	874		
	(iii) Population (As per 2011 Census)	2367745		
	(iv) Average Annual Rainfall (1991-2010) in mm	277.55		
2	GEOMORPHOLOGY			
	Major Physiographic Units	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		
	Major Drainage	No Major Drainage		
3	LAND USE (sq km) 2010-11			
	(a) Forest Area	942.22		
	(b) Net Sown Area	16468.22		
	(c) Cultivable Area	18802.72		
4	MAJOR SOIL TYPE	Predominantly light textured, weak structured sand to sandy loam with the clay content.		
5	AREA UNDER PRINCIPAL CROPS			
	(As on 2010-11)	Crops	Area in Ha	
		Bajra	252548	
		Jowar	574	
		Wheat	79123	
	Gram (Rabi)	163767		

S No	Item	Statistics	
		Other pulses	330786
		Barley	3353
		Sesamum	8277
		Rape & Mustard	42172
		Groundnut	85189
		Cotton	514
		Condiments & spices	15689
6	IRRIGATION BY DIFFERENT SOURCES (2010-11)		
	Source	Net Irrigated Area in ha	Gross Irrigated Area in ha
	Other wells	5157	7700
	Tube wells/Bore wells	129424	206661
	Canals	139461	255955
	Other sources	8	8
	Net Irrigated Area (ha)	274050	
	Gross Irrigated Area (ha)	470324	
7	NUMBER OF GROUND WATER MONITORING WELLS OF CGWB (As on May 2011)		
	Number of Dug wells	36	
	Number of Piezometers	30	
8	PREDOMINANT GEOLOGICAL FORMATIONS	Sandstone, Limestone - Evaporite sequence: Sandstone - clay - Sandstone sequence, Aeolian sand, River flood Deposits.	
9	HYDROGEOLOGY		
	Major Water bearing formation	Alluvium, Tertiary sandstone, Sandstone, Limestone	
	Depth to water level (Pre-monsoon, 2011) (mbgl)	8.54 – 111.70	
	Depth to water level (Post-monsoon, 2011) (mbgl)	7.64– 116.24	
10	GROUNDWATER EXPLORATION BY CGWB (As on 31.03.2012)		

S No	Item	Statistics
	Number of wells drilled (EW, OW, PZ, SH, Total)	EW – 42, OW-09, PZ- 62 & SH -2
	Depth Range (m)	110 – 510
	Discharge (liter per second)	60 – 750
	Storativity	-
	Transmissivity (m ² /day)	36 to 720
11	GROUND WATER QUALITY	
	Range of chemical constituents in the district.	EC : 350 to 5270 μ S/ cm at 25 ⁰ C F : Traces to 1.45 mg/l No3: Traces - 420 mg/l
	Type of water	Alkaline
12	DYNAMIC GROUND WATER RESOURCES (March, 2009) in mcm	
	Net Annual Ground Water Availability	237.55
	Existing Gross Ground Water Draft for Irrigation	240.23
	Existing Gross Ground Water Draft Dom. & Ind.	74.47
	Existing Gross Ground Water Draft for All Uses	314.70
	Allocation for Domestic and Ind. Uses up to 2025	74.83
	Net Ground Water Availability for future Irrigation Dev.	48.52
	Stage of Ground Water Development	132.48 %
13	ARTIFICIAL RECHARGE & RAIN WATER HARVESTING	Project Completed: 03 No.
14	GROUND WATER CONTROL AND REGULATION	
	Number of Over-exploited blocks	03
	Number of Critical Blocks	Nil
	No of Blocks Notified	Nil
15	MAJOR GROUND WATER PROBLEMS AND ISSUES	1. Water level decline 2. Quality Problem 3. Less recharge due to scanty and uneven rainfall

GROUND WATER INFORMATION

BIKANER DISTRICT

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GROUND WATER INFORMATION

BIKANER DISTRICT

1.0 Introduction

Bikaner district is located in the north-western part of Rajasthan and encompassed between north latitudes 27°11' to 29°03' and east longitudes 71°52' to 74°15' covering geographical area of 30247.90 Sq. kms. It is bounded on the north by Ganganagar District, on the east by Hanumangarh and Churu Districts, on south by Nagaur 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 2363937 out of which 1563553 is rural population and 800384 is urban population.

A map showing the blocks of the district is presented as Figure-1.

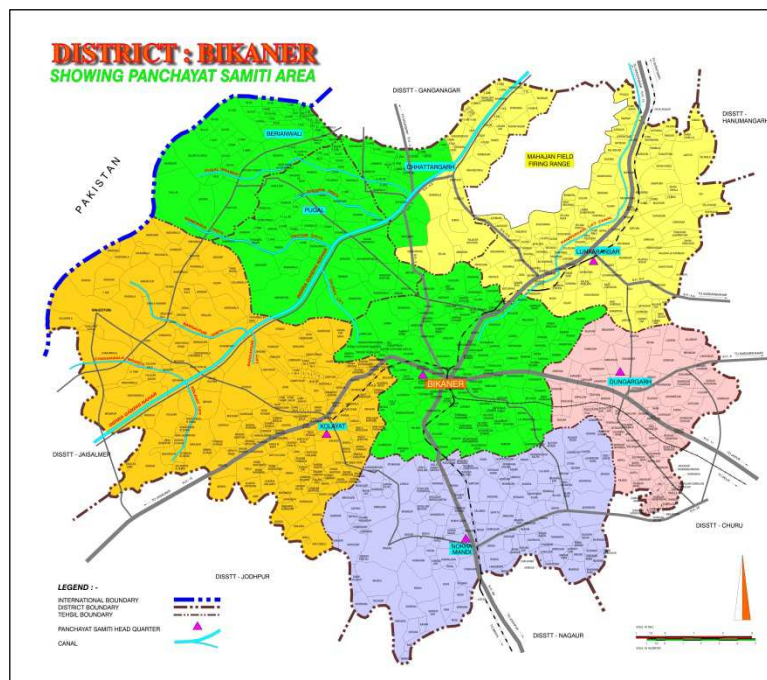


Figure 1: Map showing administrative divisions of the Bikaner District

Auden (1950), Seth (1955), Kidwai (1961-63) and Doshi (1968) of Geological Survey of India had carried out ground water studies for various purposes in the district. Various studies carried out in the district so far by Central Ground Water Board are indicated in Table 1.

Table 1: Scientific studies undertaken by Central Ground Water Board

S.No.	Officer/ Project	AAP	Type of Study
1.	UNDP Phase II	1971-74	Ground Water Surveys in Rajasthan and Gujarat
2.	R.P. Mathur	1984-85	Systematic Hydrogeological Survey
3.	G.S. Mittal	1986-87	Reappraisal hydrogeological survey in part of Kolayat and Nokha blocks

The report on Ground Water Resources and Development Potential of Bikaner district was compiled by Central Ground Water Board in the year 1988. The report on Hydrogeology and Ground Water Resources was brought out in the year 1999. Under the Ground Water Exploration Programme, Central Ground Water Board has drilled 42 exploratory boreholes, 9 Observation wells, 2 slim holes and 62 Piezometers in the district as on 31.3.2012.

Since 1973, monitoring of water regime is being regularly carried out by Central Ground Water Board on regional scale. Presently 66 National Hydrograph Network Stations (observation wells) are being monitored.

2.0 Rainfall & Climate

The district experiences arid type of climate in the east to extremely arid in the west. Mean annual rainfall (1991-2010) of the district is 277.55 mm whereas normal rainfall (1901-1971) is lower than average rainfall and placed at 257.8 mm. Almost 90% 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.

3.0 Geomorphology & Soil Types

Geomorphologically, the district can broadly be divided into ten units viz. (1) flat aggraded 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 mheight 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 and leaves the district in the southern boundary near village Gogliala. The main canal has a number of branches and distributaries like (1) Naushera Branch, (2) Dathar Branch, (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 NaharPariyoajna 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 412000 hectares).

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 2.

Table 2: Details of soil characteristics in Bikaner district

Major Soils	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 soils	1002	13.0
Others: Deep Pale brown loamy, medium yellowish brown sandy, shallow Pale brown gravelly sandy soils	686	08.9 2
Total	7710.0	100

4.0 Ground Water Scenario

4.1 Geological Framework:

Practically, the whole of the surface geology in the greater part of the district is concealed under a thick cover of wind blown 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 upthrown 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.

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 its 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 mbgl to 505 mbgl.

Palana aquifer is found to be under phreatic conditions. Specific capacity of wells ranges from 3.6 to 28.1 m³/hr/m and transmissivity ranges up to 720 m²/day, and permeability from 1.65 to 13.5 m/day. The values of transmissivity remain much below 100m²/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 m²/day. Permeability is correspondingly low. Specific capacity of wells varies from 0.17 to 1.20 m²/ 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 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 LunkaransarKutuwas area.

A map depicting hydrogeological features is presented as Figure-2.

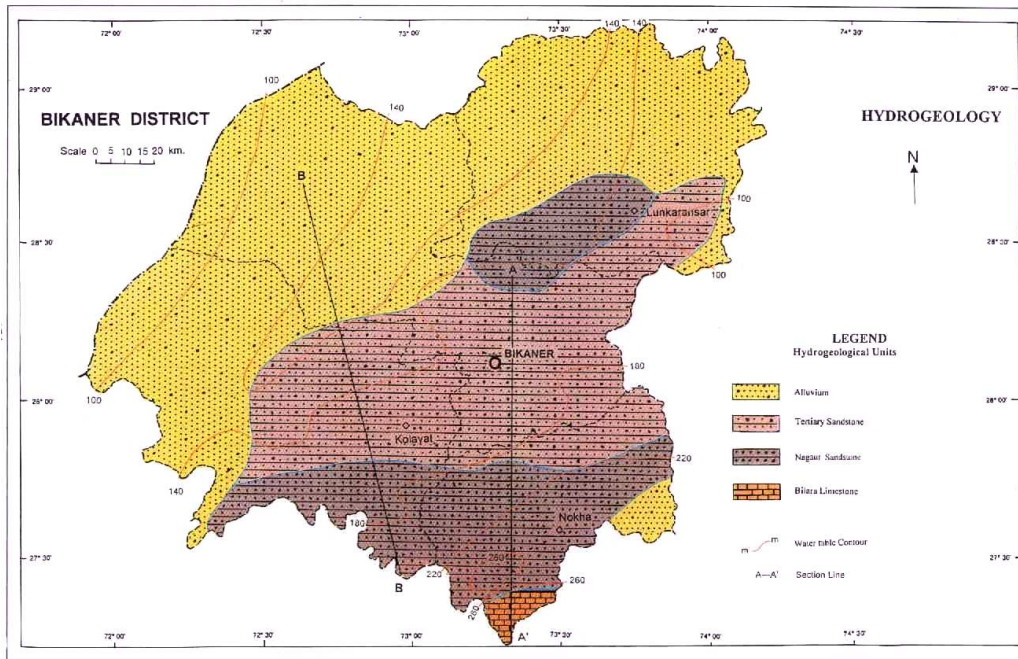


Figure 2: Hydrogeological Map of District Bikaner

4.2.1 Water Level Scenario

Central Ground Water Board periodically monitors water levels through National Hydrograph Network Stations (NHNS) stations four times a year i.e. in January, May (Pre monsoon), August and November (Post monsoon).

Block-wise details of depth to water level during pre-monsoon, post-monsoon and water level fluctuation between the two periods are given in table 3. Depth to water level in the district ranges from 8.54 to 111.70 m bgl and 7.64 to 116.40 m bgl during pre monsoon and post monsoon, 2011 periods respectively.

Table 3: Block wise details of depth to water level during May, 2011 and November, 2011 and water level fluctuation during May – November, 2011

Block	Pre-monsoon (May, 2011)		Post-monsoon (Post-monsoon)		Water level fluctuation in m (Pre – Post)			
	water level in m bgl		water level in m bgl		Rise		Fall	
	Min	Max	Min	Max	Min	Max	Min	Max
Bikaner	12.30	111.24	12.20	111.25	0.00	0.50	0.00	2.60
Kolayat	11.70	111.70	11.15	116.40	0.12	0.46	0.06	4.70
Lunkaransar	8.54	67.35	7.64	67.22	0.03	1.78	0.00	0.43
Nokha	79.33	104.66	76.34	105.65	-	2.99	0.28	7.30
Shri Dungargarh	38.35	69.90	34.13	70.15	0.01	4.22	-	0.25
District	8.54	111.70	7.64	116.40	0.00	4.22	0.00	7.30

During Pre-monsoon, shallow water level 8.54 to 38.35 m bgl exists in Bikaner, Kolayat, Lunkaransar and Dungargarh blocks and deep water level from 67.35 to 111.70 m bgl exists in parts of all the blocks.

During Post-monsoon, shallow water level 7.64 to 34.13 m bgl exists in Bikaner, Kolayat, Lunkaransar and Dungargarh blocks and deep water level from 67.22 to 116.40 m bgl exists in parts of all the blocks.

Depth to water level maps for Pre-monsoon 2011, Post Monsoon 2011 and Seasonal water level fluctuation (Pre & Post monsoon, 2011) of district have been presented in figure 3, 4 & 5 respectively.

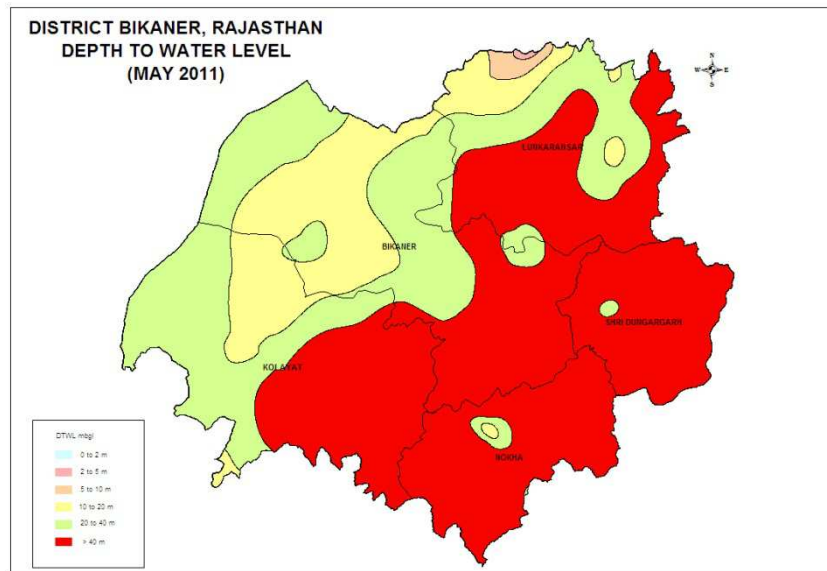


Figure 3- Depth to Water Level - Pre-monsoon 2011 (May, 2011)

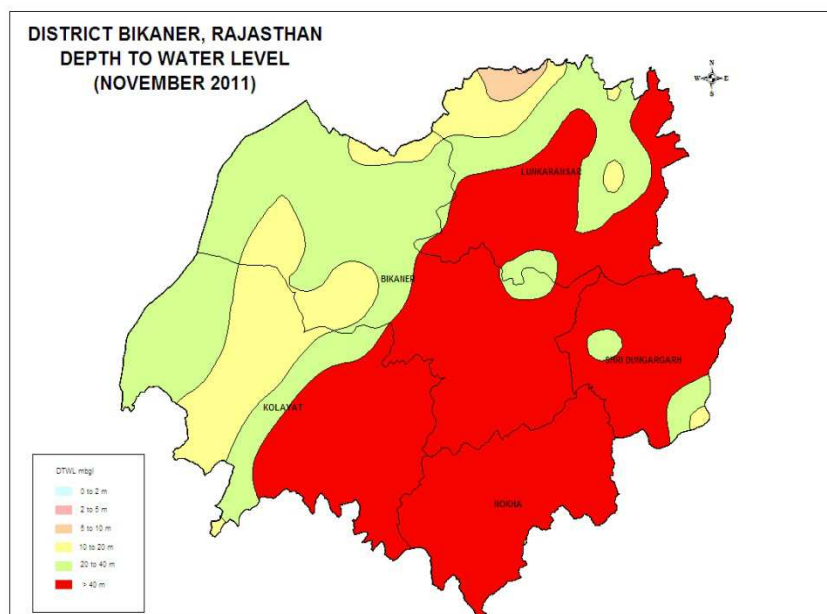


Figure 4- Depth to Water Level Post Monsoon 2011 (Nov, 2011)

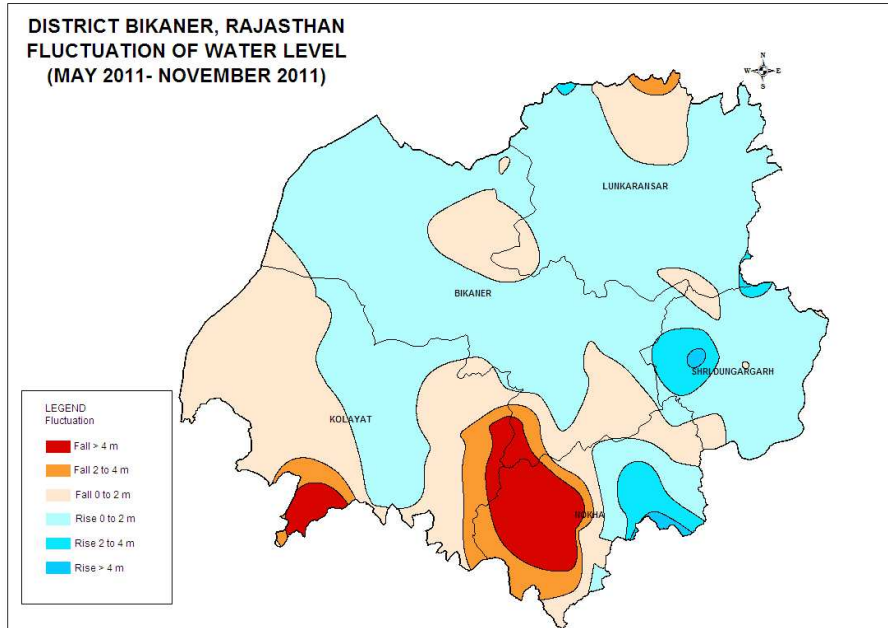


Figure 5- Seasonal water level fluctuation (Pre & Post monsoon, 2011)

Seasonal water level fluctuation of pre & post monsoon, 2011 indicates rise in all the blocks except central and western parts of Nokha, western and eastern parts of the Kolayat block, southern part of the Bikaner block and northern part of Lunkaransar block only. The rising water level may be attributed to negligible exploitation of ground water due to salinity problem.

4.2.2 Water Level Trend (2002 – 2011)

Decadal Water Level Trend for Pre monsoon, 2002–2011 and Post monsoon, 2002 - 2011 have been presented in figure 6 & 7 respectively. During Pre-monsoon period, rising trend upto 0.25 m/ year has been observed in major part of the district and in the remaining part of the district, falling trend upto 0.25 m/year has been observed.

During Post-monsoon period, rising trend upto 0.25 m/year has been observed during the decade (2002-2011) in majority of the district covering northern and central parts. Rising trend in the range of 0.25 to 0.5 m/year has also been observed in localized pockets in Bikaner and Lunkaransar blocks. Declining trend of upto 0.25 m/year has been observed in southern half of the district.

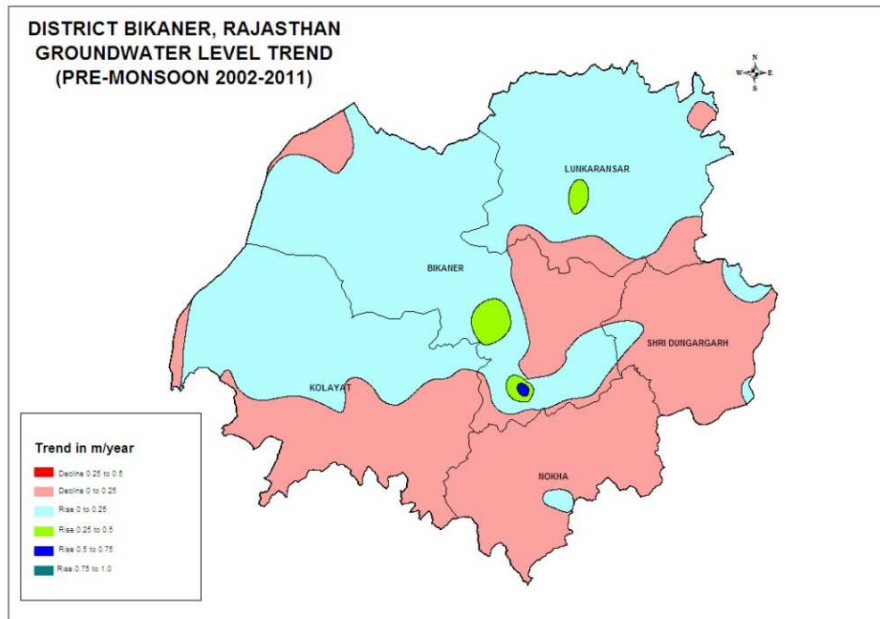


Figure 6- Water Level Trend (Pre monsoon, 2002 - 2011)

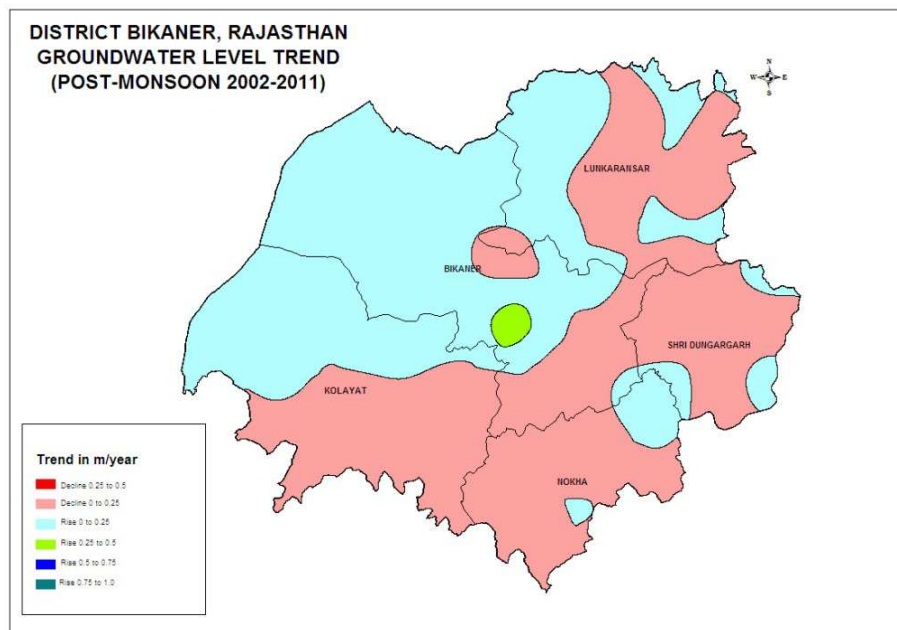


Figure 7 - Water Level Trend (Post monsoon - 2002-11)

4.3 Ground Water Resources

Central Ground Water Board and Ground Water Department, Government of Rajasthan have jointly estimated the ground water resources of Bikaner district based on GEC-97 methodology. The same are presented in Table 4 below. Ground Water Resources estimation was carried out for 13602.51 sq. km. of potential zone area out of which 450 sq. km. is under command, 13152.51sq. km. is non-command.

Ground Water Resource estimation was also carried out for 16779.24 sq. km. of saline area.

Table 4: Estimates of fresh ground water resources in Bikaner district (As on 2009)

Block	Total annual replenishable resource (mcm)	Net annual ground water availability (mcm)	Annual ground water withdrawal for irrigation (mcm)	Annual groundwater withdrawal for domestic and other uses (mcm)	Annual ground water withdrawal for all uses (mcm)	Stage of ground water development (%)	Category
BIKANER (Excl. Saline)	60.5193	57.4934	72.4800	23.6096	96.0896	167.13	Over-Exploited
LUNKARANSAR (Excl. Saline)	33.7889	32.0995	8.1336	5.0480	13.1816	41.06	Safe
KOLAYAT (Excl. Saline)	30.2889	28.7745	11.5092	7.5136	19.0228	66.11	Safe
NOKHA (Excl. Saline)	73.3410	69.6740	102.6066	23.5574	126.1640	181.08	Over-Exploited
DUNGARGARH (Excl. Saline)	52.1091	49.5036	45.5016	14.7440	60.2456	121.70	Over-Exploited
Total of District (Excl. Saline)	250.0472	237.5450	240.2310	74.4726	314.7036	132.48	Over-Exploited
Total of District (Saline)	291.3813	276.8123					

The stage of ground water development of the district (as on 31.03.2009) is 132.48% (excluding saline) where as in Khajuwala block, where ground water is saline; no ground water is being withdrawn. Out of the total 5 blocks, 3 blocks (Bikaner, Nokha & Dungargarh) lie in overexploited category, where as remaining two blocks Lunkaransar and Kolayat fall in safe category.

4.4 Ground Water Quality

The chemical quality of ground water in the district has been studied from the available data of chemical analysis of water samples collected from the National hydrograph network stations located in various parts of the district. The analytical data of ground water samples indicate that the ground water is, in general, alkaline in nature.

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 Lunkaransar - Kutuwas area where it is highly brackish with electrical conductivity around 7000 $\mu\text{S}/\text{cm}$ at 25°C.

Shallow ground water of the dug well zone has electrical conductivity within 3000 $\mu\text{S}/\text{cm}$ at 25°C in the area Chattargarh in Lunkaransar block and in the north eastern edge of Nokha block.

A perusal of the EC map (Fig.8) prepared on the basis of analytical results of water samples collected in May 2011 indicates that specific conductance varies from 350 $\mu\text{S}/\text{cm}$ (Jaggasar) to 5270 $\mu\text{S}/\text{cm}$ (Gorabdesar) in the district. Chloride indicates almost the similar pattern. The chloride content varies from 57 to 1463 ppm.

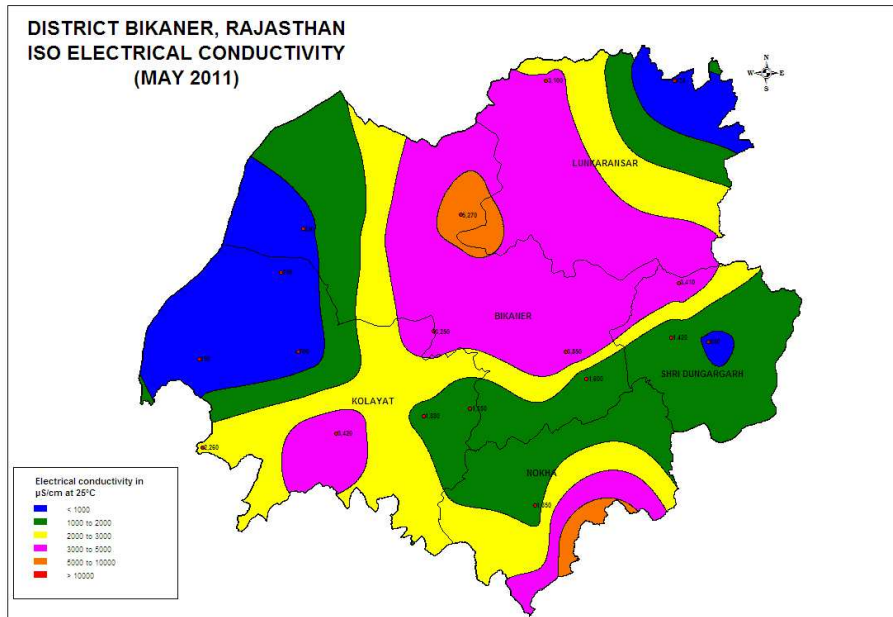


Figure-8: Map showing distribution of Electrical Conductivity in Bikaner District

Fluoride is an important constituent in determining the suitability of water for drinking purposes. High concentration of fluoride causes mottling of teeth enamel and regular in take of water with high concentration of fluoride may cause fluorosis. Fluoride concentration in Bikaner district has been found to vary from traces to 1.45 ppm (Fig. 9).

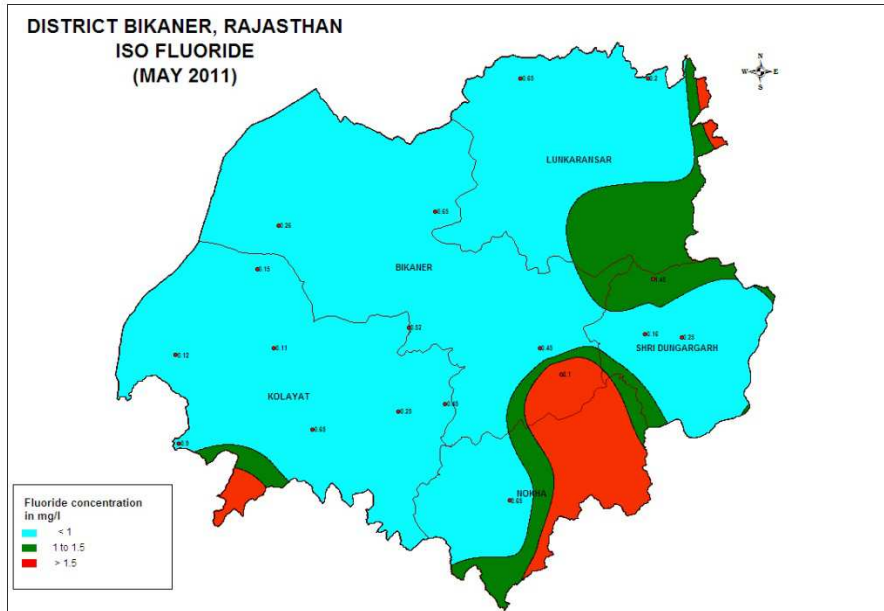


Figure-9: Map showing distribution of Fluoride in Bikaner District

The Nitrate concentration in ground water varies widely. It ranges from Traces to as high as 420 ppm. In northern and western part of the district, the concentration of nitrate is under permissible limit (Fig. 10).

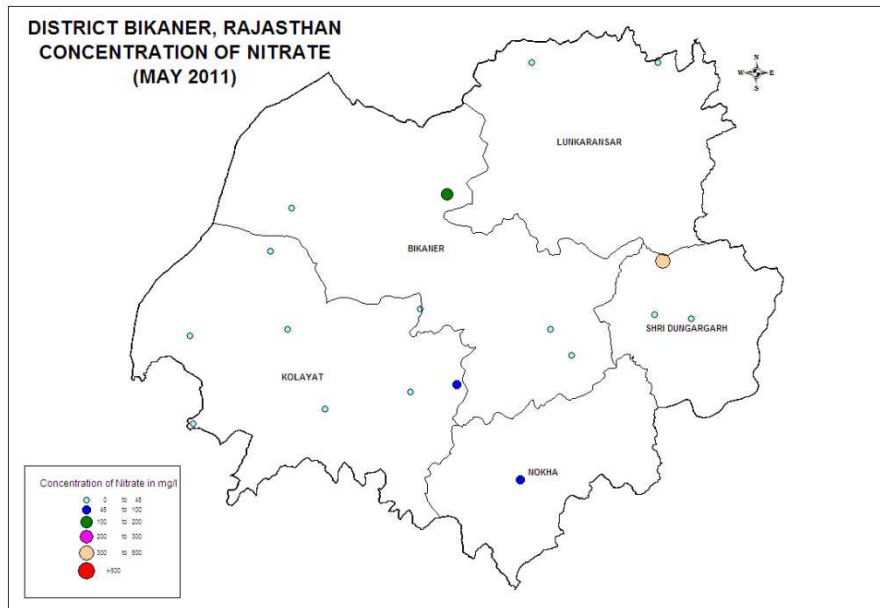


Figure-10: Map showing distribution of Nitrate in Bikaner District.

The Iron concentration has been found to range between 0.12 to 0.90 mg/l in the district (Fig. 11).

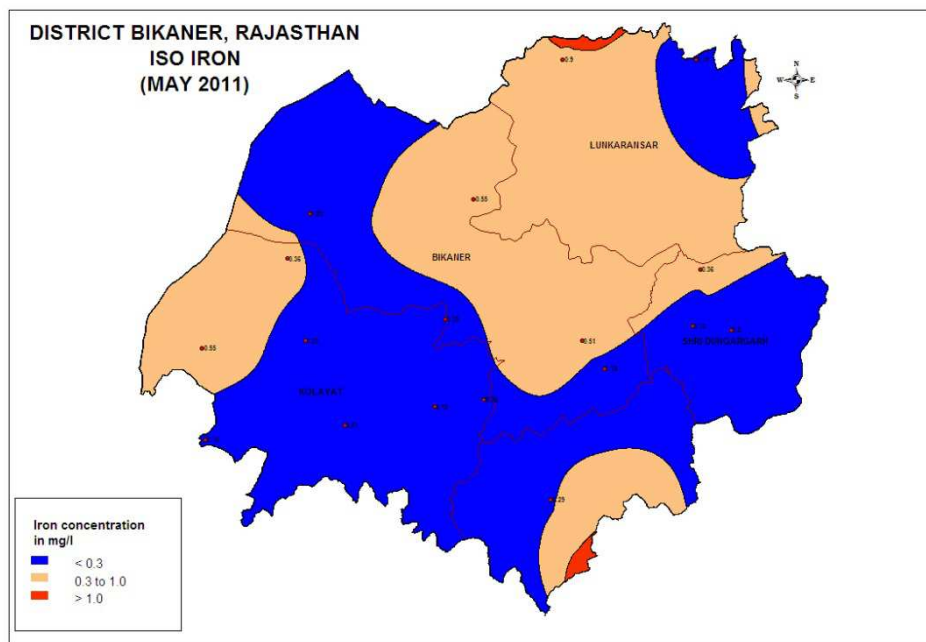


Figure-11: Map showing distribution of Iron in Bikaner District.

4.5 Ground Water quality in deeper Aquifers

Ground water of Bikaner district possesses relatively high mineral concentration which varies considerably laterally and vertically. This is due to combination of factors like physical environment, arid climate, dissolution, reduction, base exchange concentration etc. It has been observed that groundwater quality is saline at all levels in the western part of the district, and the fresh water is underlain by saline water in the northeastern part of the district. The ground water quality is good in south central and south eastern parts of the district except in some patches.

The ranges of different chemical constituents based on the results of chemical analysis of water samples collected from the exploratory bore holes, piezometers and deposit well etc., are furnished in Table 5.

Table 5: Concentrations of various chemical constituents in deeper aquifers

S. No.	Constituents	Range	
		From	To
1	Specific conductance In $\mu\text{S}/\text{cm}$ at 25°C	650 (Kaluansar)	80290 (Khajuwala)
2	Chloride in ppm	26 (Borabas)	27512 (Khajuwala)
3	Nitrate in ppm	Traces (Govindsar)	480 (Jesrasar)
4	Fluoride in mg/l	0.26 (Badnu)	3.35 (Sejrasar)

The water quality data of exploratory bore holes reveal that the specific conductance varies from 650 to 80290 $\mu\text{S}/\text{cm}$ at 25°C . The values more than 3000 $\mu\text{S}/\text{cm}$ have been reported at Khujuwala (80290 $\mu\text{S}/\text{cm}$.) in the western part of the district; Motigarh (3485 $\mu\text{S}/\text{cm}$) in the central part of the district, Sajrasar (9515 $\mu\text{S}/\text{cm}$), Lunkaransar (11760 $\mu\text{S}/\text{cm}$), Badoniwali (12575 $\mu\text{S}/\text{cm}$), Malasar (35390 $\mu\text{S}/\text{cm}$), Sobhasar (5015 $\mu\text{S}/\text{cm}$), Banjarwali (19190 $\mu\text{S}/\text{cm}$), Goganpura (13800 $\mu\text{S}/\text{cm}$), Jesrasar (3100 $\mu\text{S}/\text{cm}$), Deshnok (5590 $\mu\text{S}/\text{cm}$), Palana (5270 $\mu\text{S}/\text{cm}$) and Raisar (4095 $\mu\text{S}/\text{cm}$) in the northern, central, eastern and south eastern parts of the district; and Govindsar (18980 $\mu\text{S}/\text{cm}$) and Kolayat (7985 $\mu\text{S}/\text{cm}$) in south western part of the district. Chloride content also indicates the similar trend.

Nitrate values vary from Traces at Govindsar to 480ppm at Jesrasar. The values of Nitrate more than 45 ppm have been found at Borabas (152 ppm), Raisar (384 ppm), Surpura (134 ppm), Hurlidhar Vyas colony, Bikaner (140 ppm), Civil lines Bikaner (210 ppm).

5.0 Status of Ground Water Exploration

A total of 42 exploratory wells, 9 observation wells, 2 slim holes and 62 piezometers have been constructed in unconsolidated/ semi-consolidated formations. The exploratory drilling data indicate that the depth of drilling of boreholes in unconsolidated / semi-consolidated formation ranges from 110.00 to 530m depth of construction of wells varies from 124 to 405 m. The discharge of wells varies from 60 to 750 lpm having drawdown from 1 to 39.26 m. The transmissivity of formation lies between 36 and 720 m^2/day .

The status of ground water exploration as on 31.03.2012 is furnished in Table 5.

Table 5: Status of exploratory drilling out in Bikaner district (As on 31.3.2012)

Type of bore hole	Unconsolidated Formation	Semi-consolidated Formation	Total as on 31.03.2007	Drilled during 01.04.2007 to 31.03.2012		
				Alluvium	Semi-consolidated	Total
EW	14	21	35	5	2	42
OW	4	3	7	2	-	9
SH	1	1	2	-	-	2
PZ	5	17	43	18	1	62

6.0 Ground Water Related Issues & Problems

The environmental impact due to development of water resources encompasses the socio-cultural set up created by man to adapt to the demands, and challenges of his naturally occurring circumstances. The ecological system, once disturbed, may not be reverted back in most of the cases especially the problems related to ground water pollution.

With the introduction of canal system these have been perceptible changes in the ground water regime in its command area. There has been rise in water levels in tubewells located in the command area in the entire tract of Indira Gandhi Nahar Pariyojana of which district Bikaner is a part. In the Bikaner District rise in water levels along the canal has been observed in the National Hydrograph Stations at Amarapura, CharanwalaChattargarh, Khakhli, Kherbas, Lakhasar etc.

There are no water logged areas at present in the Bikaner District. However, the areas around Kharbara, Dantor, Manaksar, Modayat, Charanwala Bhikampur etc. are more prone to water logging.

The main hazard in the development of ground water in the district is its salinity. The ground water of Bikaner district possesses relatively high mineral concentration, which varies laterally and vertically.

Also such areas suffer from water quality problem and in some of the areas ground water is highly saline. Villages located in such areas have the basic problem of drinking water requirement and the situation becomes very critical in summers and in drought years.

Another issue of concern in the district is that most of the potential zones have registered heavy ground water development causing lowering of water table and drying up of large number of shallow wells or reduction in their yields. Heavy decline of water level in the wells located in Tertiary formation and Quaternary alluvium observed during last 15 years.

7.0 Ground Water Management Strategy

7.1 Ground Water Development

Though the overall stage of ground water development of district as on 31.03.2009 is 132.48% (excluding saline), out of total of five blocks having fresh ground water, 2 blocks (Lunkaransar and Kolayat) fall under safe category. Ground water development in these blocks needs to be promoted. Irrigation wells are required to be constructed where groundwater levels are shallow and ground water is suitable for irrigation

7.2 Well Design

The district is underlain by unconsolidated to semi-consolidated formations where direct rotary drilling technique is used for construction of wells. The deep tube wells of 100 – 200 m depth can be constructed in alluvial areas and Tertiary sandstone with 200 to 250 mm diameter of housing pipe and 200 mm diameter pipes for well assembly. About 30 to 40 m of saturated granular zones are required to be screened. In case saturated zones are predominantly fine grained, slot size of 1.16 mm is required for tapping such zones. The diameter of the housing pipe should be large enough to accommodate the pump with adequate clearance for installation and efficient operation. Housing pipe should have diameter at least 5 cm greater

than the nominal diameter of the pump. Depending upon the discharge to be lifted, the optimum diameter of screen in deep tube wells is 200 – 250 mm.

7.3 Water Conservation and Artificial Recharge

Precious Groundwater resources have to be conserved for sustainable availability. Artificial recharge measures are to be employed for augmenting ground water resources by roof top rain water harvesting, construction of sub surface barriers and anicuts at suitable locations. Inferior quality water can be blended with fresh water for irrigation use.

Three number of Roof top rain water harvesting structures have been constructed under Demonstrative Artificial Recharge Projects in Bikaner city which were financially aided by CGWB. Watershed Development & Soil Conservation Department has constructed permanent (masonry) check dams under Integrated Watershed Development Project to harvest rainwater, reduce soil erosion and check runoff velocity.

8.0 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 maintaining 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 sown in the area having brackish ground water.
- In Kolayat and Lunkaransar blocks, which fall under safe category, further ground water development is suggested.
- 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.