केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report
on

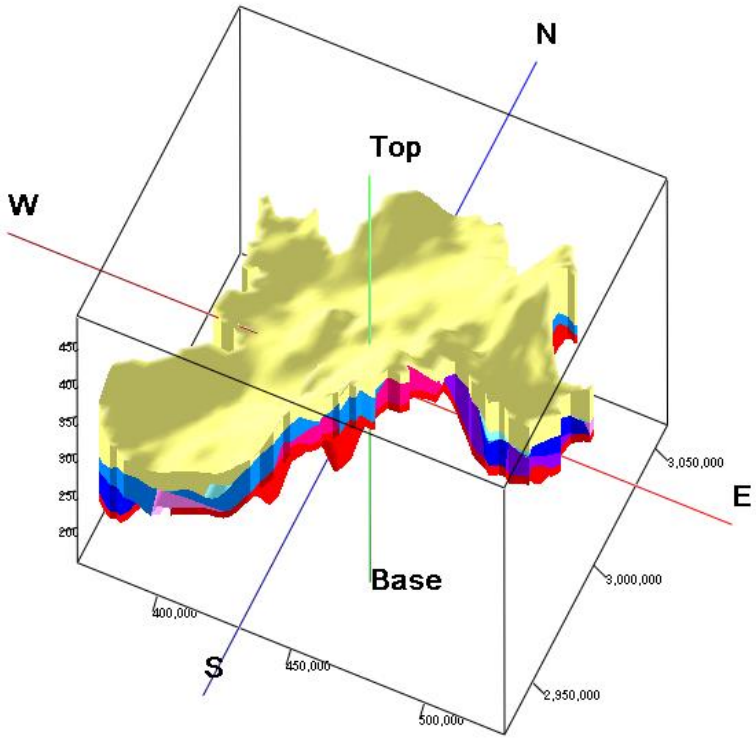
AQUIFER MAPPING AND GROUND WATER MANAGEMENT

Nagaur District, Rajasthan

पश्चिमी क्षेत्र जयपुर

Western Region, Jaipur

Report on
AQUIFER MAPPING AND GROUND WATER MANAGEMENT
DISTRICT NAGAUR, RAJASTHAN
(UNDER XII PLAN)



CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVANATION
GOVERNMENT OF INDIA
WESTERN REGION, JAIPUR

JULY, 2017

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(Based on Available Data)

District Nagaur, Rajasthan

1.0 Introduction

Nagaur district is located almost in the middle of the state of Rajasthan and extends between North latitudes 26°25' and 27°40" and East longitudes 73°10" and 75°15". It covers an area of 17778 sq. km. out of which 17448.5 sq. km is rural area and 269.5 sq. km is urban. The Nagaur district is bounded on the north by Bikaner and Churu districts, on the east by Sikar and Jaipur districts, on the south by Ajmer, and Pali districts and on the west by Jodhpur districts. Nagaur district covers only 5.18 percents of the total area of the state. There are 13 tehsil headquarters in the district viz. Nagaur, Khinwsar, Jayal, Degana, Didwana, Ladnun, Parbatsar, Makarana, Nawa, Kuchaman, Riyanbadi and Mundwa. The district is divided into 11 blocks (Panchayat Samitis) viz. Nagaur, Mundwa, Jayal, Merta, Riyan, Degana, Didwana, Ladnun, Parbatsar, Makarana and Kuchaman. A map showing the blocks of the district is presented in Figure – 1 Total Population (Census 2011) of the district is 3307743 including urban population of 637204 and rural population of 2670539. Fig 1 Administrative Map of Nagaur District.

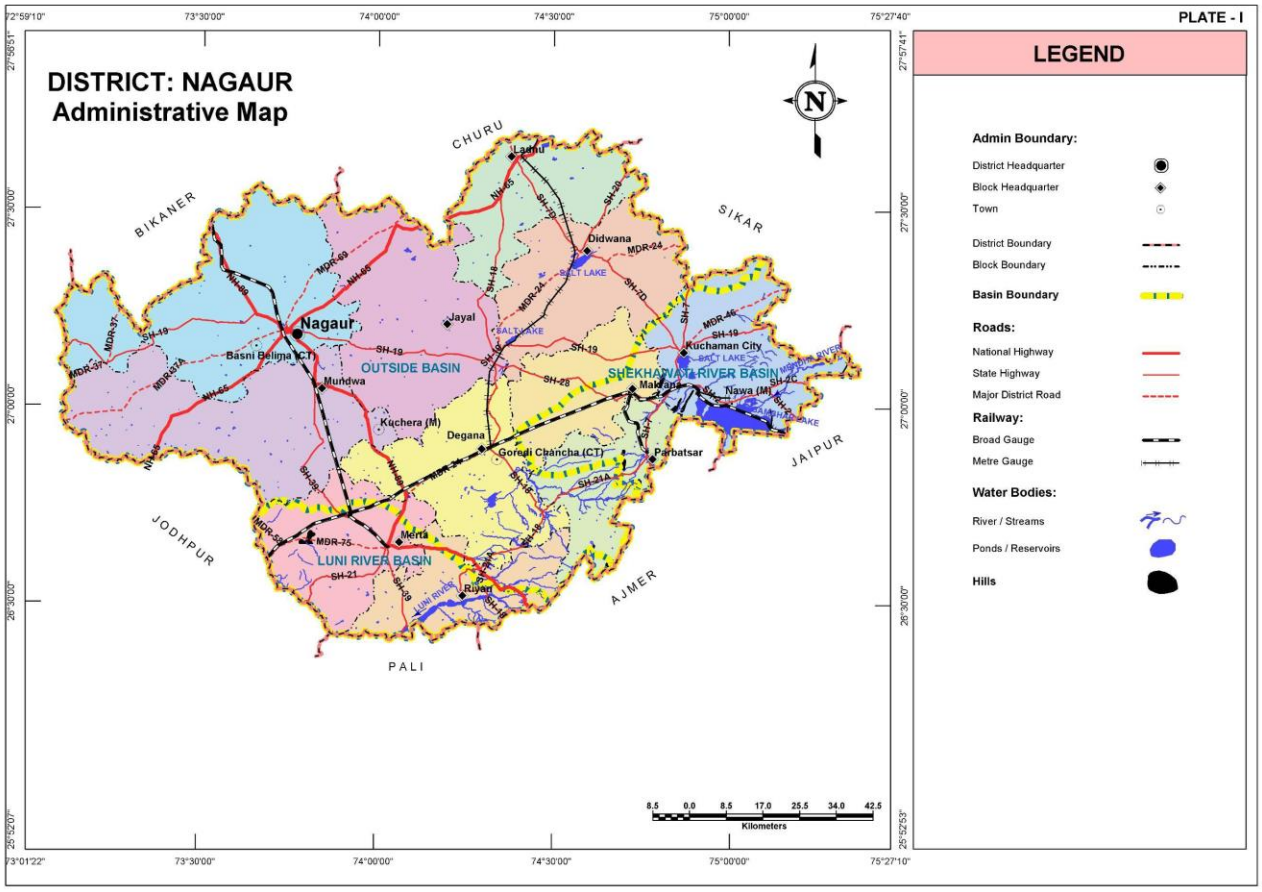


Figure 1: Map showing administrative divisions of Nagaur District

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 emergent 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 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 and chemical fields and laboratory analyses are applied to characterized 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 changes 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

As mentioned above, aquifer mapping is an attempt to integrate the geological, Geophysical, hydrological and chemical field and laboratory analyses are applied to characterize the quality, quantity and sustainability of groundwater in aquifer. Under the National aquifer Prograrmme, 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 include compilation of existing data, identification of data gaps, generation of data for feeling data gaps and preparation of different aquifer layers.

1.4 Data Availability and Adequacy

Groundwater availability, monitoring (water level and chemical quality), exploration had been carried out by CGWB and state Ground Water Department. 89 NHS have been monitored by CGWB and 105 bore holes have been constructed by CGWB.

The data collected from State GWD and CGWB WR Jaipur have been compiled and analyzed. It has been observed that validation and georeferncing of the location coordinates, lithologs and hydrogeological data is needed and State GWD data is lacking in aquifer parameters.

Geophysical data collected needs georeferncing of the hydrogeological interpretations. It has been observed that available data are limited largely to State highways and main roads only. Hence, to get a clear 3D hydrogeological geometry of the aquifer system and water level behavior, there is need to generate more data by Groundwater Exploration, VES and to establish more numbers of monitoring stations for better understanding of the groundwater regime behavior in terms of both quantity and quality.

1.5 Data Gap Analysis

Data collected from State GW agencies and CGWB has been brought to a standard format and integrated location map have been prepared regarding groundwater monitoring, exploration, surface water and agriculture data. Based on these maps and hydrogeological conditions in the area Jodhpur District needs further data to be generated in the gaps.

1.6 Rainfall and Climate

The district experiences arid to semi-arid type of climate. Mean annual rainfall (1971-2005) of the district is 410 mm whereas normal rainfall (1901-1970) is lower than average rainfall and placed at 363.1 mm. It is obvious that there is significant increase in rainfall during the last 30 years. The rainy days are limited to maximum 15 in a year. Almost 80% of the total annual rainfall is received during the southwest monsoon. The probability of occurrence of mean annual rainfall is 38%. Based on agriculture criteria, the district is prone to mild and normal type of droughts. Occurrence of severe and very severe type of drought is very rare. There is not much variation in aerial distribution of rainfall. However, the southern part of the district gets slightly more rainfall than northern part. The monsoon enters the district in the first week of July and withdraws by the middle 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 May and June respectively. The temperature varies from 46 degree in summer to 7 degree in winter. The winter season starts by middle of November and lasts till February. January is the coldest month with both mean maximum and minimum temperatures being lowest at 22.5° and 6.7° respectively. The minimum temperature sometimes drops down to below the freezing point of water and frost occurs. The diurnal variation in temperature during winter is as high as 16°C. Both maximum and minimum temperatures begin to rise rapidly from February onwards, reaching their respective maximum in late May or early June. The mean daily maximum temperature in May is 40.4°C and the mean daily minimum temperature is 25.7°C. Night temperatures in June are much higher than in May with mean daily minimum temperature of 27.9°C. Atmosphere is generally dry except during the monsoon period. Humidity is the highest in August with mean daily relative humidity at 80%. The annual maximum potential evapotranspiration in the district is quite high and it is the highest (255.1 mm) in the month of May and the lowest (76.5 mm) in the month of December.

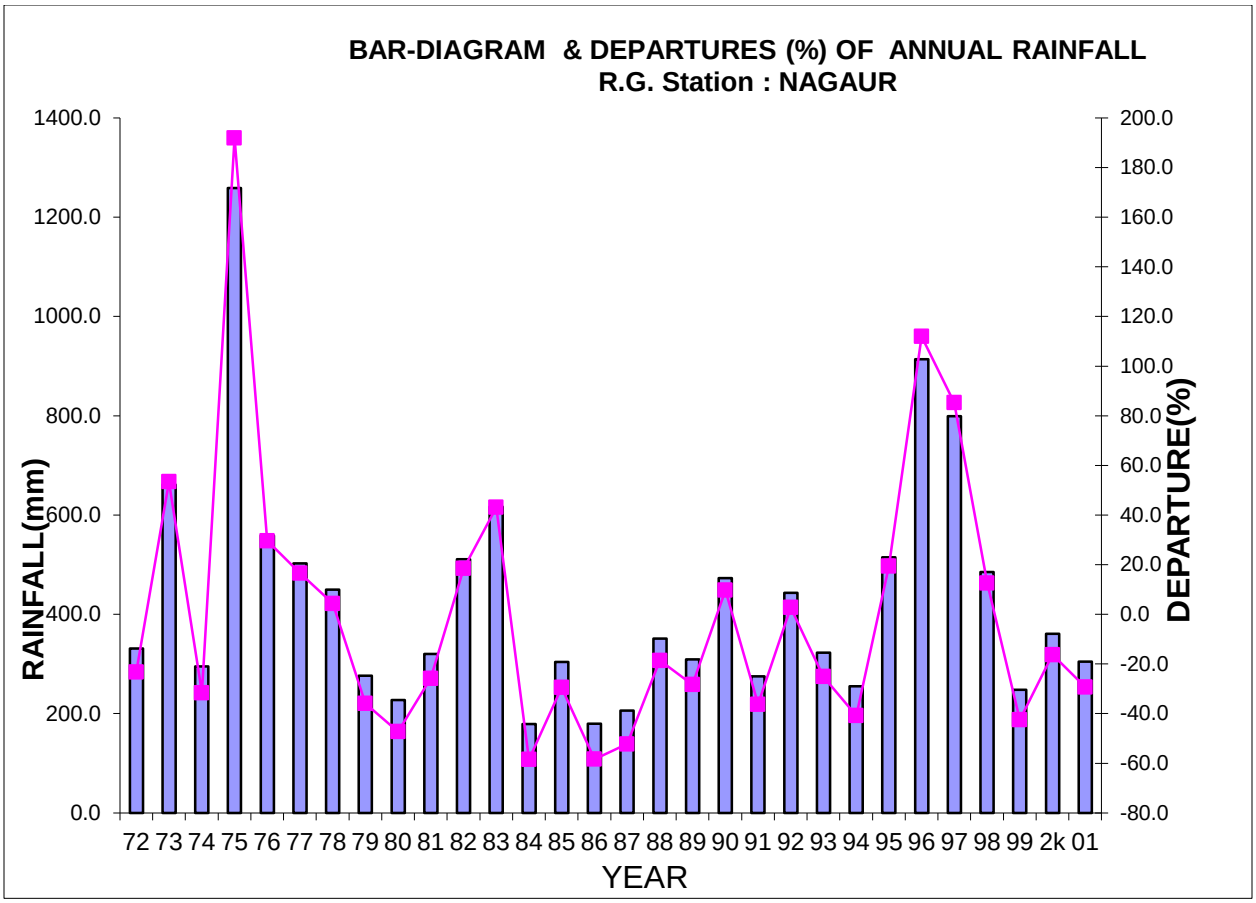


Figure 2: Bar Diagram of annual rainfall variation & Trend of Nagaur

1.7 Geomorphology and Drainage

The general topography of the area is fairly even. Slope of the area is fairly even. Slope of the land surface is towards west and elevation varies from 250 meter above msl in south to 640 m above msl in north. South-eastern part of the district comprises small scattered hillocks. The northern, north-western and north-eastern parts of the district are covered by sand dunes. The offshoots of Aravalli range are projected along the common boundary of Ajmer district and Merta, Nawa and Parbatsar tehsils of Nagaur district.

There is no river originating in the district. However, the river Luni which rises near Pushkar in Ajmer district, draining western slopes of the Aravalli, crosses the district in the southern part flowing for about 37 km in western direction. It is an ephemeral river and carries runoff that is generated in the upper reaches. Channel deposits of Luni facilitate percolation during rainstorm, thereby feeding the neighboring wells along its bank. Other nalas and streams are also ephemeral in nature which originate and die out in the district itself.

1.8 Soil Characteristics

Four types of soils have been reported in the district viz, clay, clay loam, sandy loam and sandy soil. The general texture of the soil in the area is sandy loam to clayey loam which is further classified into “Barani” or un-irrigated and “Chahi” or irrigated soil. A part of Nagaur tehsil and south-eastern part of Merta tehsil have deep sandy loam, while red loamy soil exists elsewhere in

Merta tehsil except on the banks of river Luni. Light loamy soil occurs in Parbatsar tehsil away from hill ranges. A longitudinal belt from Didwana to Nawa extending up to Sambhar Lake has the characteristics of alkaline soil. Distribution of different types of soils is shown in table 1.

Table 1 : Soil Types in Nagaur district

S. No.	Soil type	Area (hectare)	Block
1	Clay	22,840	Nagaur, Jayal, Merta, Riyan, Parbatsar
2	Clay loam	1,34,450	Nagaur, Kuchaman, Jayal, Riyan, Merta, Degana, Makarana, Ladnun, Parbatsar, Mundwa, Didwana.
3	Sandy loam	4,72,905	Makarana, Ladnun, Parbatsar, Mundwa, Didwana, Nagaur, Kuchaman, Jayal, Riyan, Merta, Degana.
4	Sandy	5,65,705	Nagaur, Khuchaman, Jayal, Riyan, Merta, Degana, Makarana, Ladnun, Parbatsar, Didwana.

1.9 Land Use

Total reported area for land utilization statistics is 1763821 hectares and about 82.79 % of the total areas are being cultivated. The district is very poor in forest covering only 18463 hectares, which forms only 0.104% of the total area of the district. Agriculture is the main occupation of the rural population. Net cultivable area of the district is 12,63394 hectares whereas non agriculture land area including fallow land is 265324 hectares. Land use pattern of Jodhpur district is given in table 2. (Census 2011)

Table 2: Land use pattern of Jodhpur district

Classification	Area (Hectares)	Percentage
Total Geographical Area	1763821	100.00
Area under forest	18463	0.104
Area not available for cultivation	145410	0.824
Permanent Pastures and other Grazing lands	71211	0.040
Miscellaneous trees crops and groves not included in the net area sown	19	0.0001
Non Agriculture Land including Fallows	265324	1.50
Net Area Sown	1263394	7.16
Area sown more than once	196890	1.11
Total Area Sown	1460284	82.79

1.10 Data collection and Generation

On the basis of available data of exploratory tube wells drilled by CGWB/GWD/PHED, the status of data were assessed and based on that gaps were identified for data to be generated in respect of quality, quantity and lithology (through exploration as well as VES). Data pertaining to available statistics on cropping pattern and land under agriculture use was collected from statistic directorate for recommending the management plan of the available resource keeping in view of the prevailing cropping pattern.

2.0 Aquifer System

2.1 Geological Framework

The geological set up of the district is presented by different sedimentary, igneous and metamorphic rocks belonging to Bhilwara Super Group, Delhi Super Group, Marwar Super Group, Palana Formation and Quaternary alluvium. A few outcrops of gneisses belonging to the Mangalwar Complex of the Bhilwara Supergroup are exposed north-east of Nawa. The Delhi Super Group includes Alwar, Ajabgarh/ Kumbhalgarh and Punagarh Group in descending order of antiquity. The rocks of Alwar Group are well exposed in the eastern part of the district and comprise of arkose, grit, conglomerate and schist. The overlying Ajabgarh/ Kumbhalgarh Group of rocks are exposed between Kerkeri and Bijathal. The Ajabgarh Group mainly consists of Quartzite with schist and marble. Kumbhalgarh comprises mica schist and marble. The overlying Punagarh Group of rocks (quartzite, slate phyllite, marble etc.) occur as isolated outcrops. The rocks of Bhilwara Super Group and Delhi Super Group are structurally isoclinal and recline fold which are exposed along south eastern margin (trend NE-SW) of the district adjacent to Ajmer district.

The rocks of Delhi Super Group have been intruded by Erinpura granite and Malani igneous suite. All these rocks are overlain by marine sedimentary sequence of the Marwar Super Group which is subdivided into Jodhpur, Bilara and Nagaur group representing arenaceous, calcareous and areno-argillaceous facies respectively. These rocks are overlain by sandstone and bentonite of the Palana formation. The Marwar Super Group of rocks have horizontal to gently inclined disposition of different beds, which are displaced by different faults. Palana and other Tertiary formations are showing same altitude.

2.2 Hydrogeology

Ground water occurs under unconfined to semi-confined conditions in rocks of Delhi Super Group, Nagaur Sandstone, Bilara limestone and unconsolidated sediments (valley fills and alluvium). These form the chief source of ground water in the district. Confined conditions is also met sometimes at deeper levels in the northwestern part of the district. The hydrogeological map of Nagaur district is depicted in figure.3.

Hydrogeologically the whole district can be classified into three formations viz. consolidated formation, semi-consolidated formation and unconsolidated formation.

2 .2.1 Consolidated Formations

The consolidated formations comprise of metamorphics like schists, gneisses, quartzites and phyllites of Precambrian age and limestone & sandstone of Marwar Super Group. Metamorphics are normally impervious except in the presence of a few weak planes, joints, weathered zones and kinks which contain moderate and limited quantity of ground water. These are basically phreatic aquifers and availability of ground water depends on good amount of precipitation. Such aquifers are mainly confined to eastern part of Riyan and Parbatsar blocks, central part of Makarana block, eastern part of Ladnun block and northern part of Didwana block.

Jodhpur sandstone mainly consists of medium to coarse grained sand, cemented with silica and ferruginous matrix. The sandstone is intercalated with siltstone and shale. The sandstone is hard, compact and forms medium aquifer. Wherever, ground water occurs, it mainly occupies either void space between the adjacent grains (primary porosity) and in the secondary porosity zones. Jodhpur sandstone mainly occurs in southwestern part of Mundwa block and central part of

Ladnun block. Ground water in this formation occurs under semi-confined to unconfined condition. Thickness of sandstone varies from 100-250m.

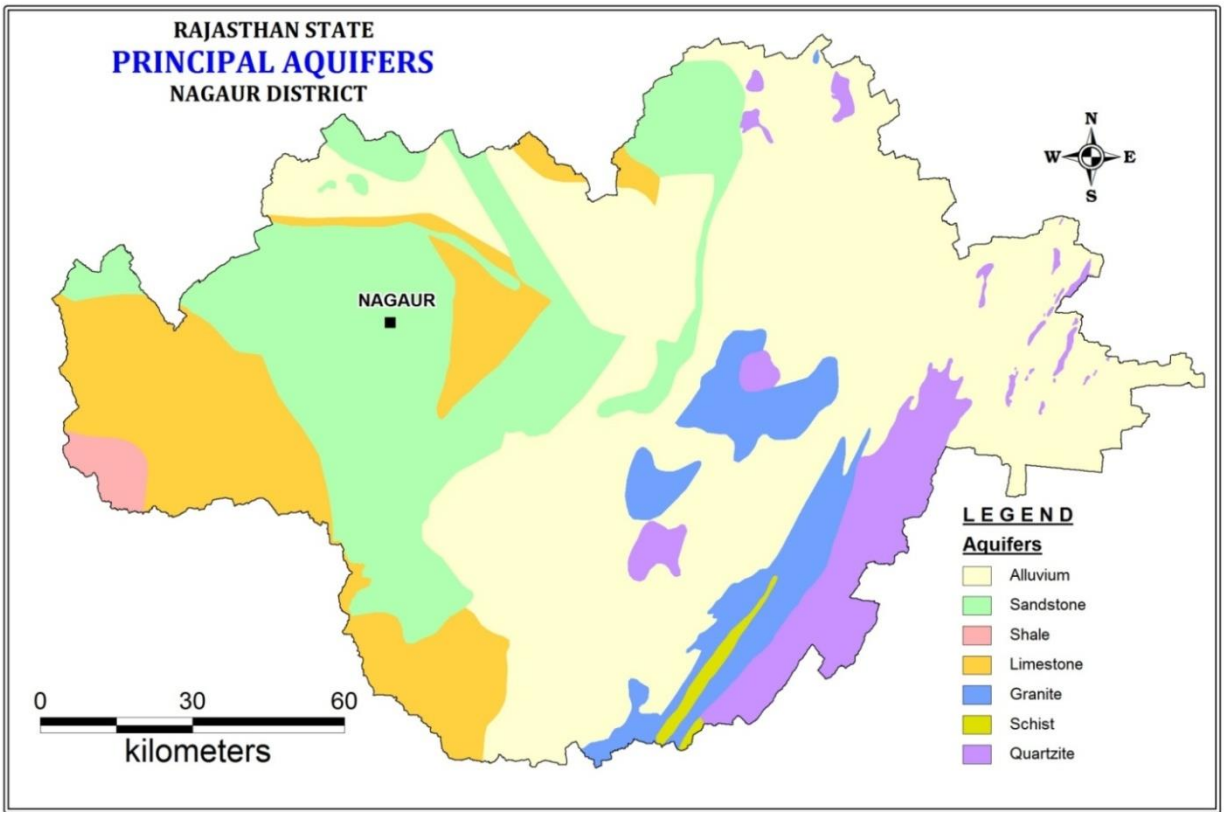


Figure 3: Principle Aquifers in Nagaur District

Bilara limestone forms the most important and potential aquifer comprising limestone, dolomite and shale. The limestone is white to grey in colour, hard and compact, cherty and dolomitic in nature. However, it is cavernous at places and susceptible to solution activity which gives rise to high discharge in wells. This formation covers western and north-central parts of Nagaur block, central part of Mundwa block, west central & eastern parts of Jayal block and part of Ladnun block. Thickness of limestone varies from 100- 300 m.

Nagaur sandstone is coarse to fine grained, loosely cemented with gravel at basal part which acts as good aquifer and occupies mainly parts of Nagaur, Jayal, Mundwa and Merta blocks. The associated rocks are siltstone and shale. Its thickness varies from 140-240 m.

2.2.2 Semi-consolidated Formation

These include only Palana sandstone consisting of very coarse grained, gravelly sand with intercalations of clay with kankar and lignite. Ground water occurs under phreatic to confined condition and saturated thickness of 40 m constitutes a potential aquifer. This mainly occurs in parts of Merta, Mundwa and Jayal blocks. Its thickness varies from 100-250 m.

2.2.3 Unconsolidated Formation

Quaternary alluvium is the main aquifer which is comprised of unconsolidated to loosely consolidated fine to coarse grained sand having intercalations and intermixing with silt, clay with `kankar`. Ground water occurs under unconfined to semi-confined conditions, Quaternary

alluvium covers parts of Riyan, Merta, Degana, Parbatsar, Makarana, Kuchaman, Didwana, Ladnun and Jayal blocks. Its thickness is limited to 200 m.

The Aquifer Disposition Based on Surface Geophysical Investigation and Lithology of Bore Wells is given in Figures 4 & 5.

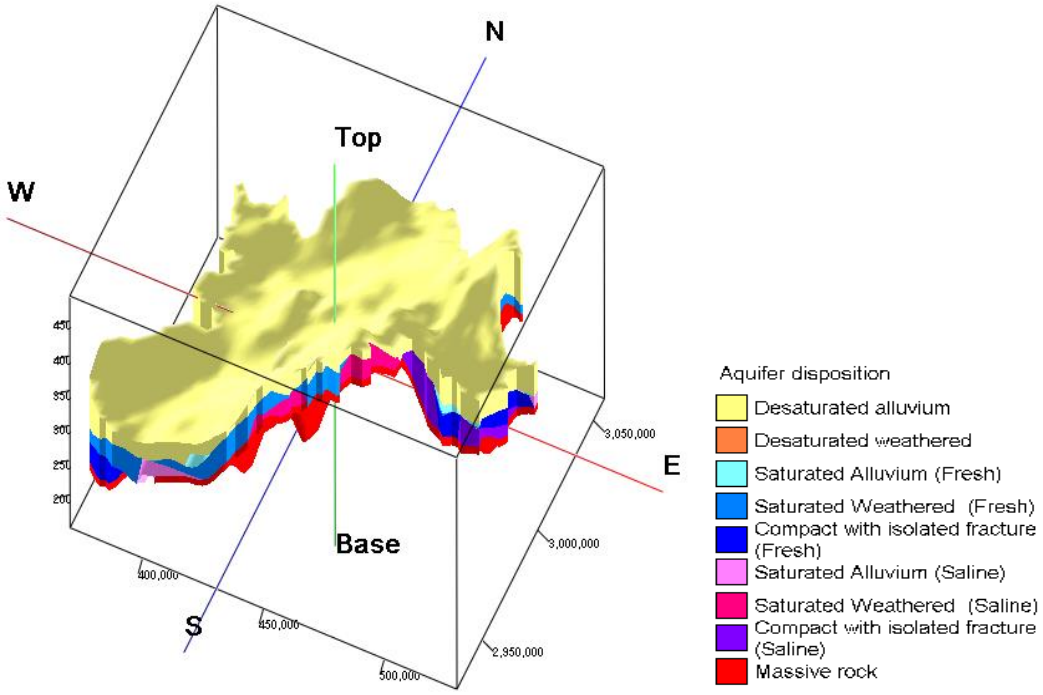


Fig 4: Aquifer disposition

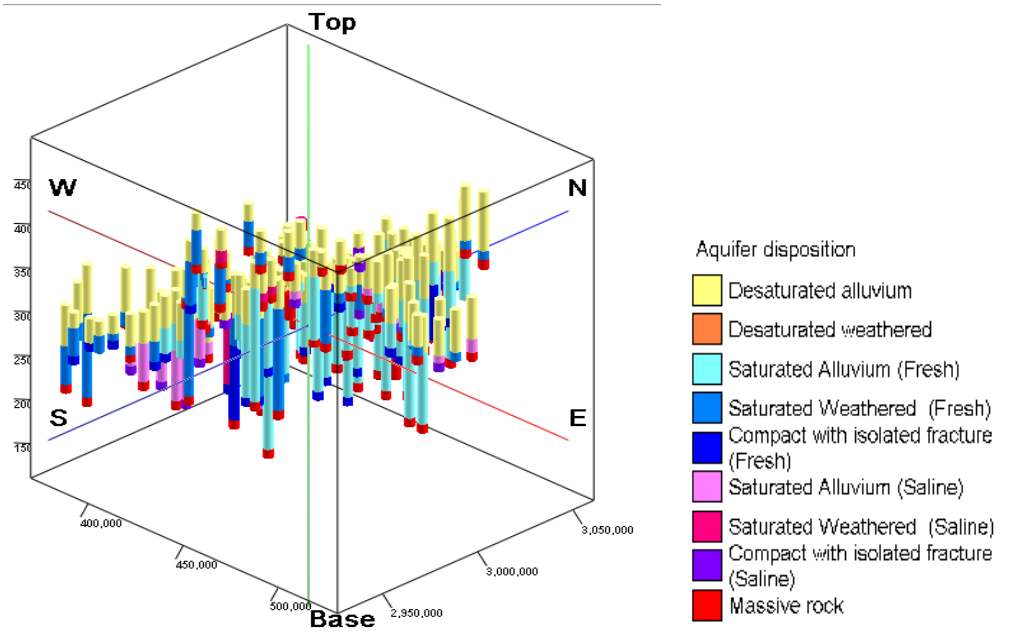


Figure 5: Aquifer disposition Based on surface geophysical investigations & lithology of bore wells

From the selected available data from exploratory wells, various cross sections depicting the aquifer disposition along with aquifer saturation using Rockworks software have been prepared which are shown below in figures 6 to 12.

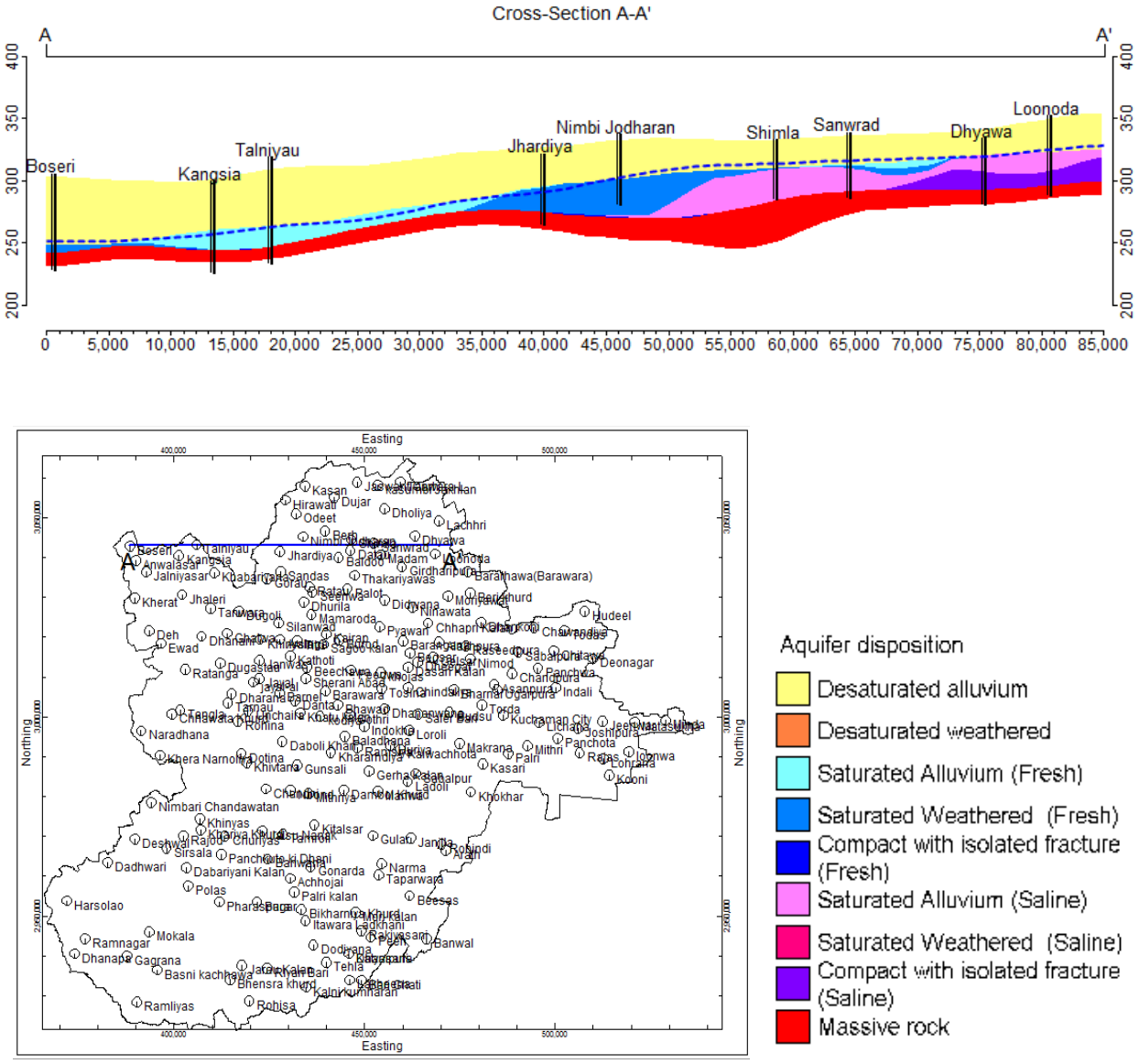
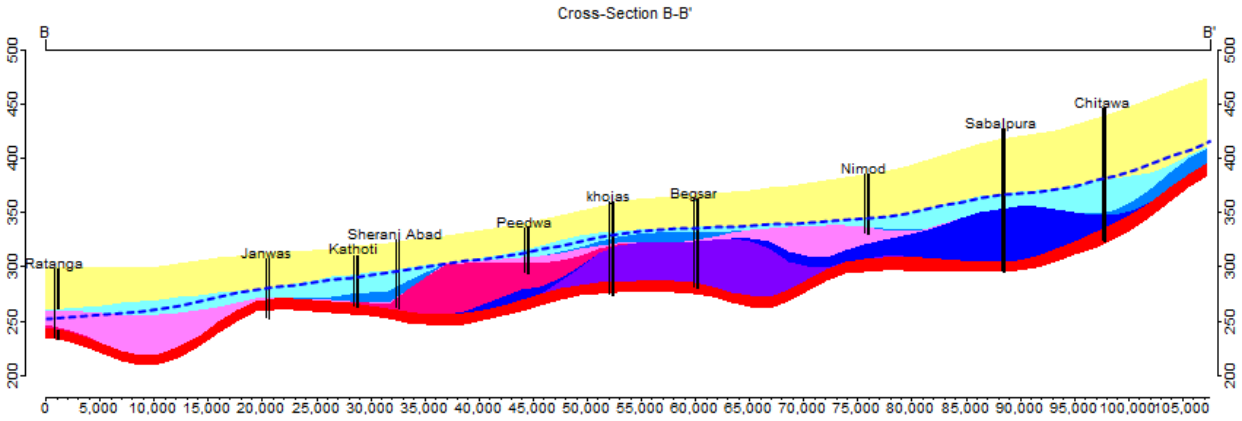


Figure 6: Cross Section along A-A'



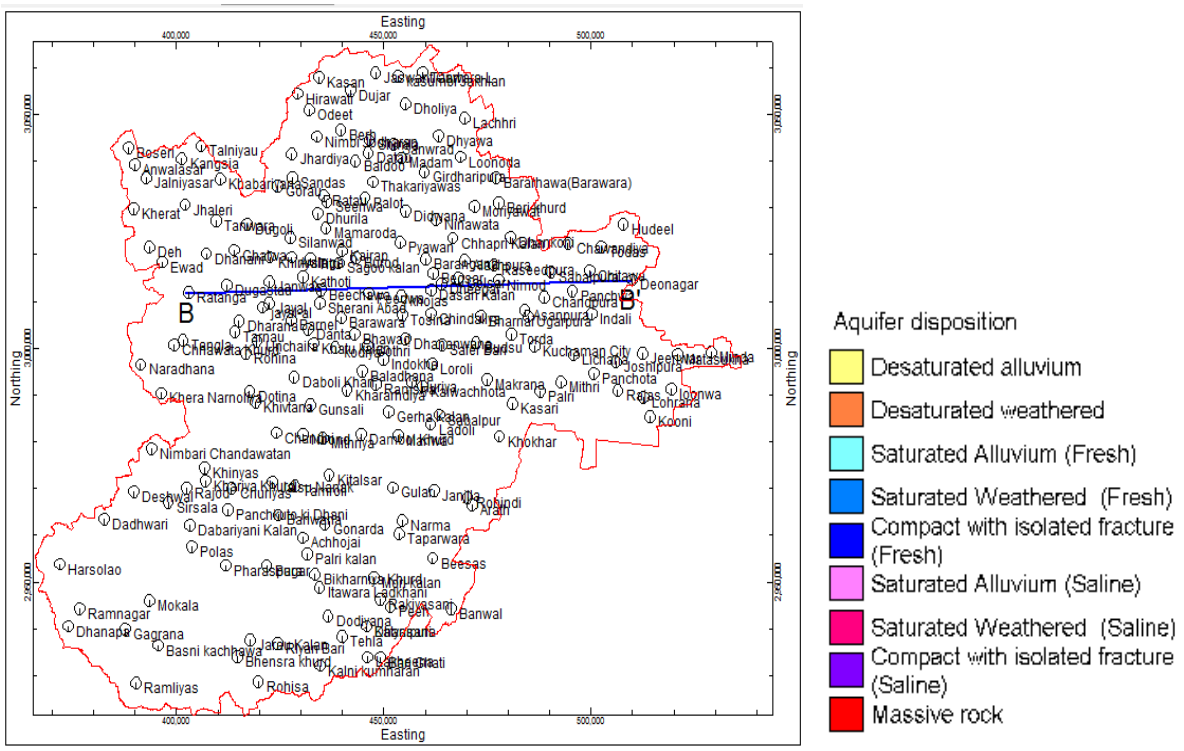
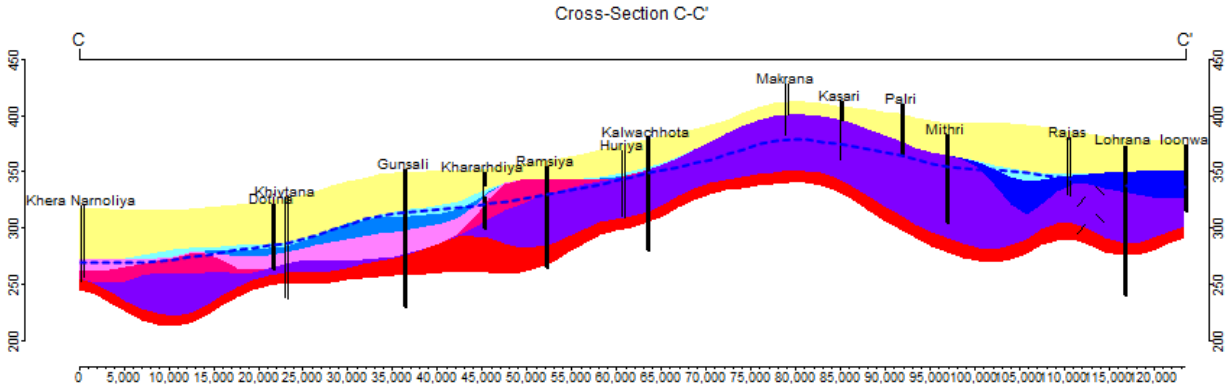


Figure 7: Cross Section along B-B'



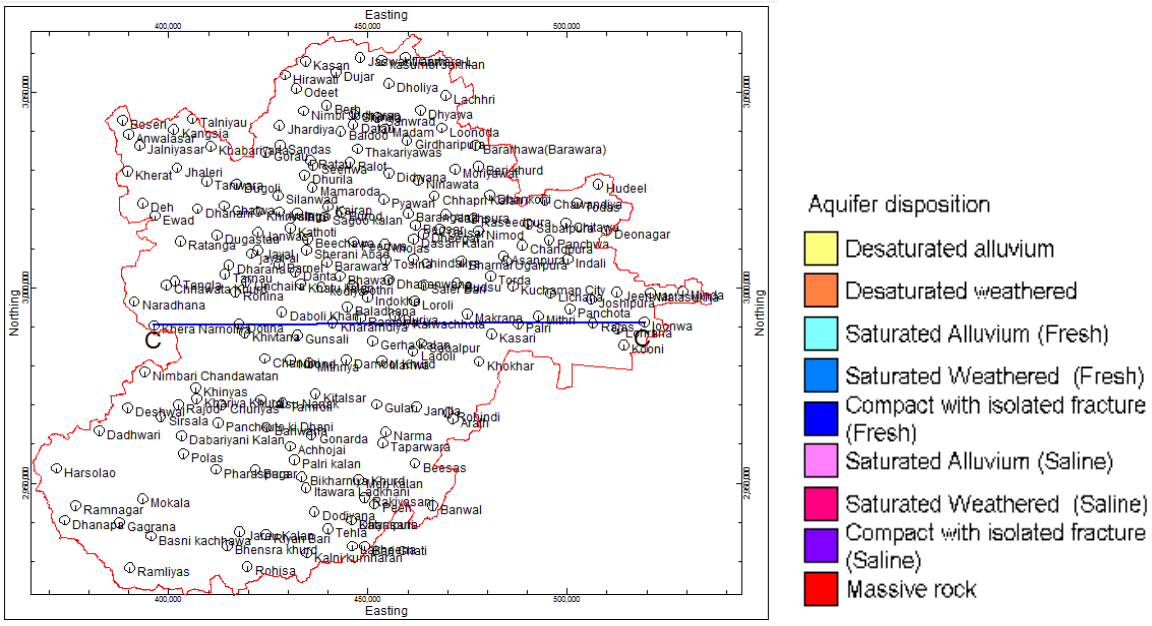


Figure 8: Cross Section along C-C'

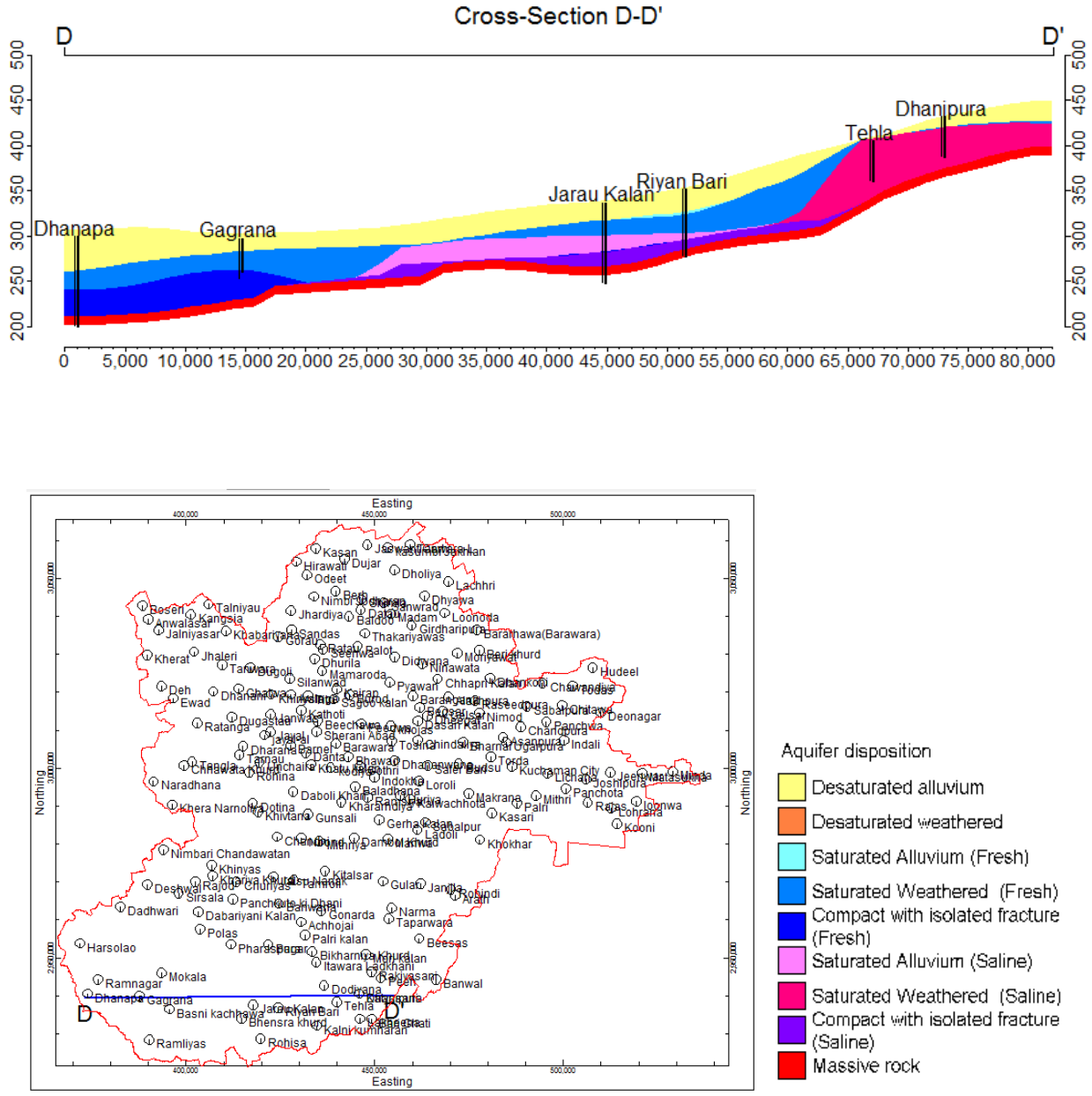


Figure 9: Cross Section along D-D'

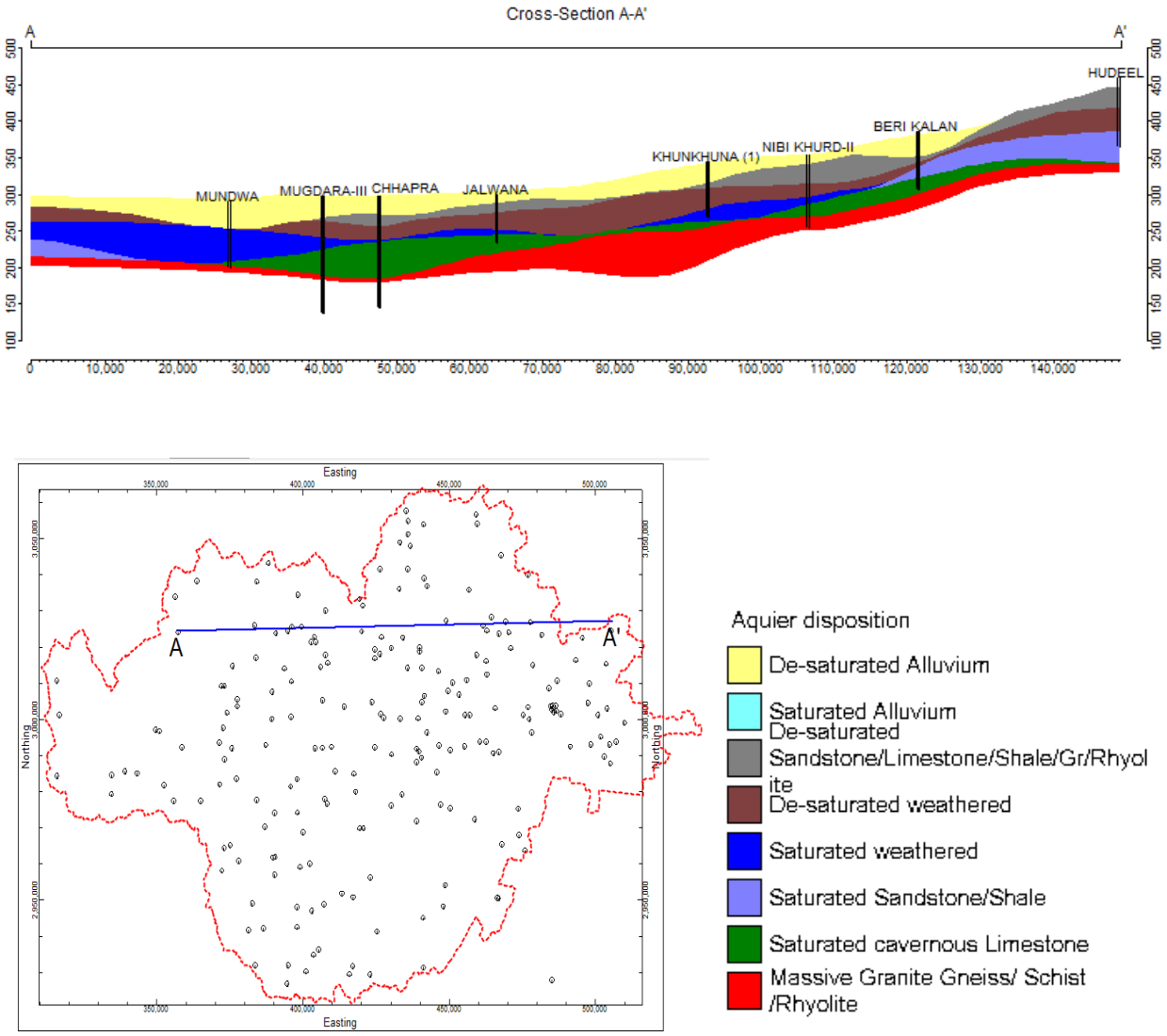


Figure 10: Cross Section along A-A'

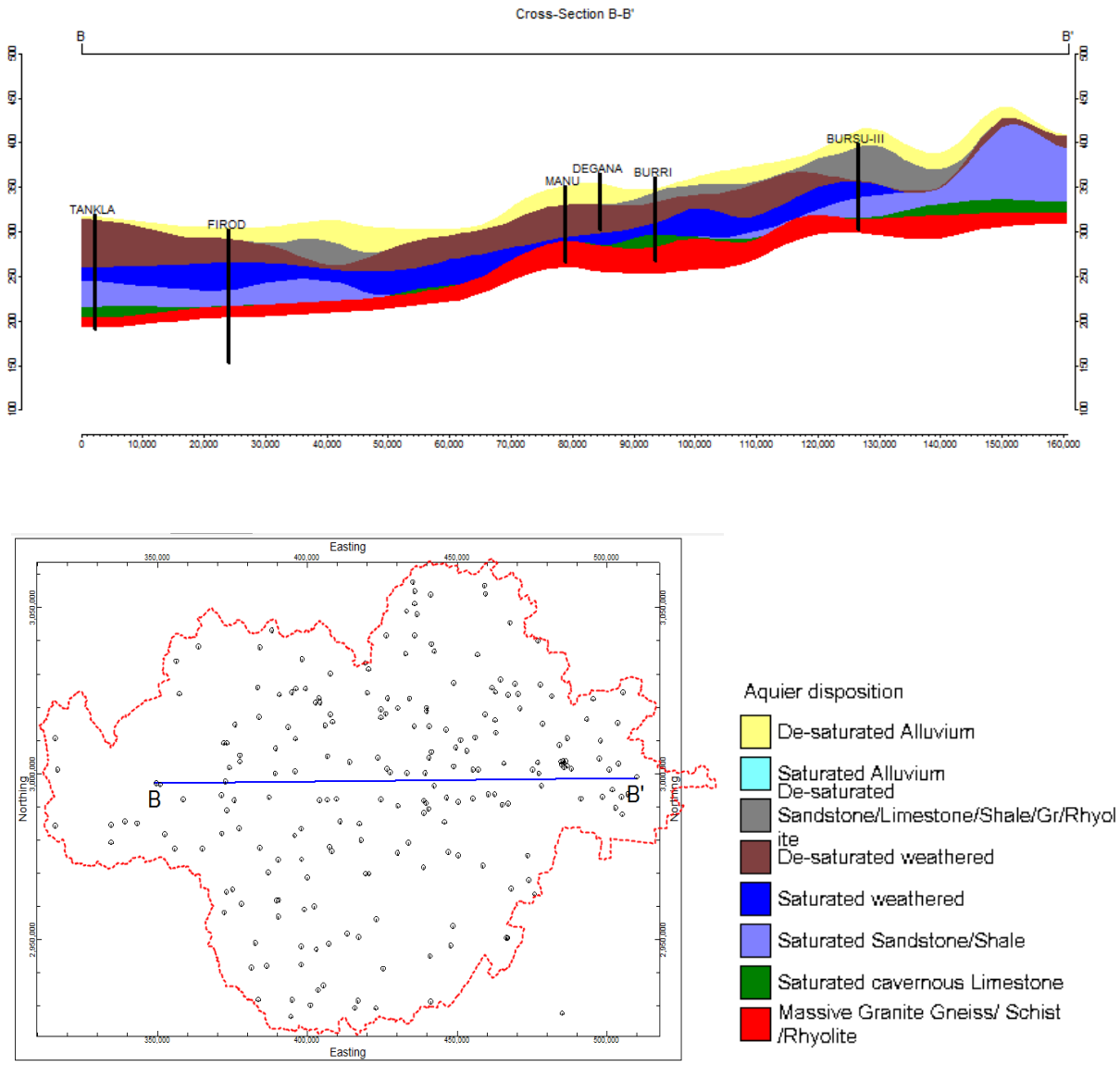


Figure 11: Cross Section along B-B'

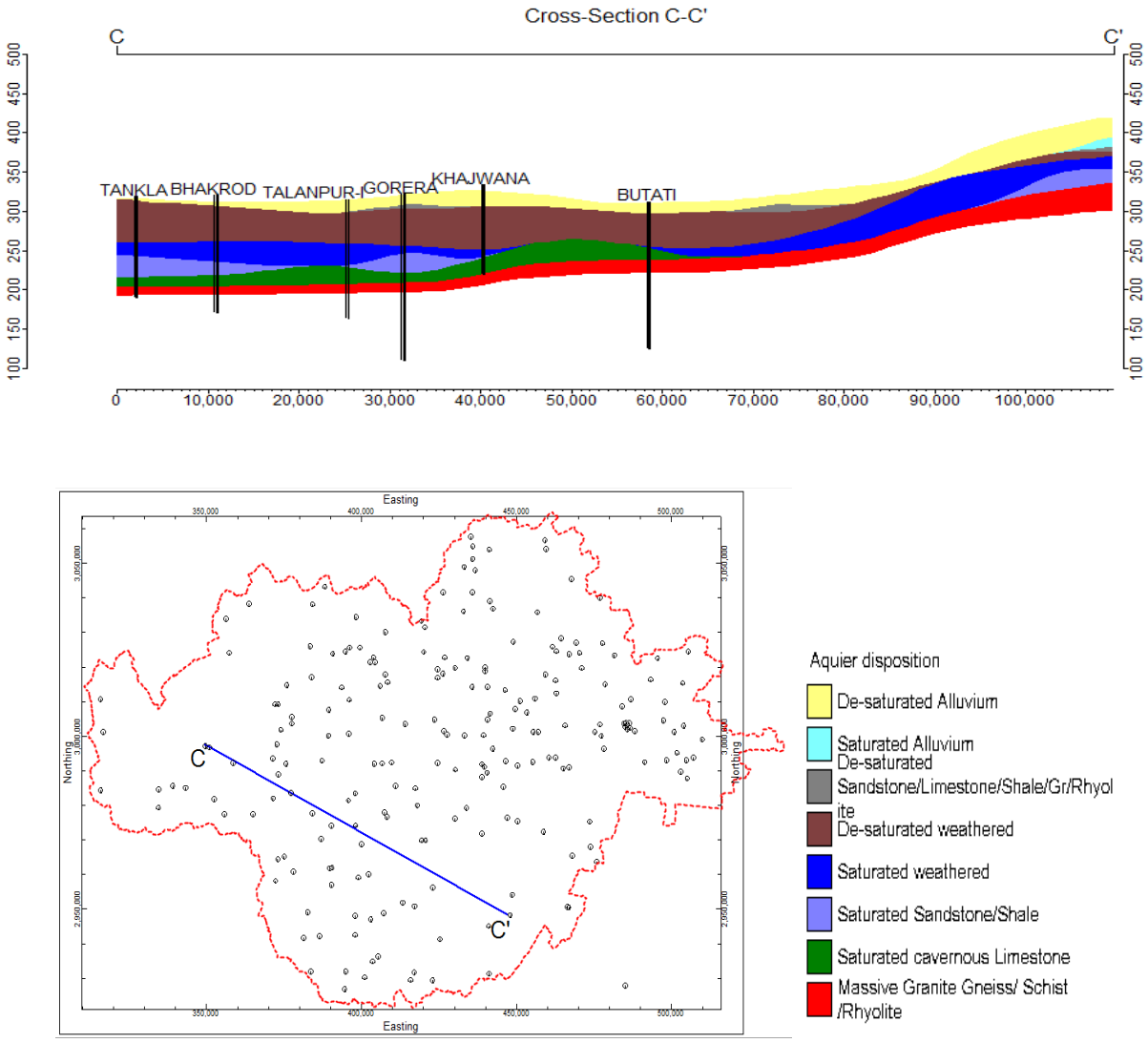


Figure 12: Cross Section along C-C'

The Aquifer Deposition Based on Lithology of Bore Hole is given in figure 13.

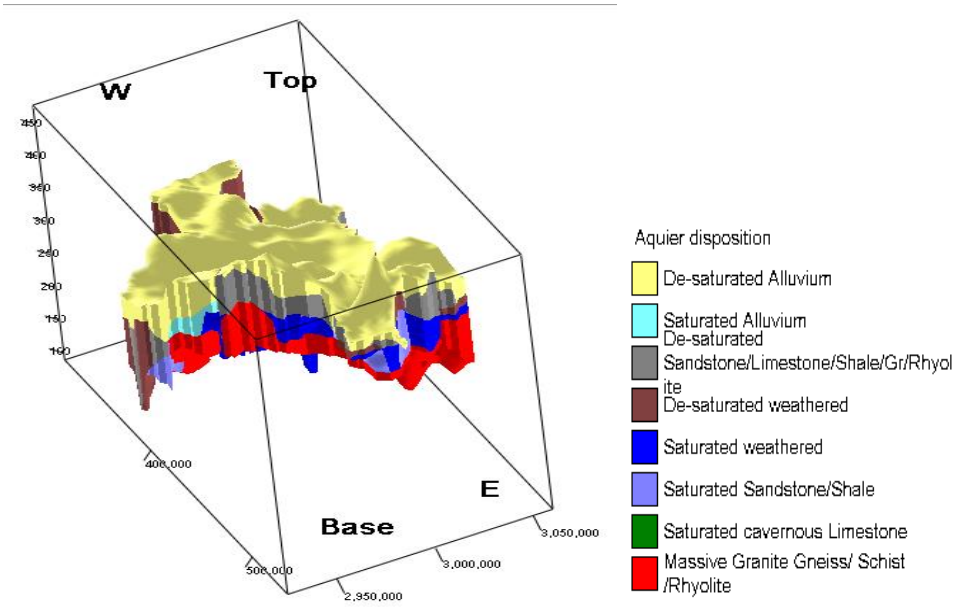


Figure 13: Aquifer Deposition Based on Lithology of Bore Hole

2.2.4 Aquifer Parameters

The aquifer parameters of dug wells and tube wells have been studied from pumping tests. The yield of tube wells\ dug wells in metamorphic rocks like schists, gneisses, quartzites, phyllites and gneisses ranges from 5-20 m^3\hr. The tube wells in Jodhpur sandstone give discharge in range of 12 to 32 m^3\hr. Discharge\yield of tube wells in Bilara limestone varies from 5 to 40 m^3\hr and that of Nagaur sandstone varies from 6.5 m^3\hr to 36 m^3\hr. The discharge of tube wells in Palana sandstone ranges from 5.0 m^3\hr to 30 m^3\hr and that of tube wells\dug wells in Quaternary alluvium varies from 12 m^3\hr to 32 m^3\hr. The deeper aquifers are being exploited extensively through low to medium duty tube wells.

2.2.5 Water table Elevation

Based on the available data the water table elevation map has been generated with the help of Rockworks software and shown in figure 14. As per the map the elevation of water table in the area ranges between 180 to 420 m amsl. Highest elevations of water table of nearly 420 m amsl in the south east part of the district while the lowest 180 m amsl in western part of Nagaur district.

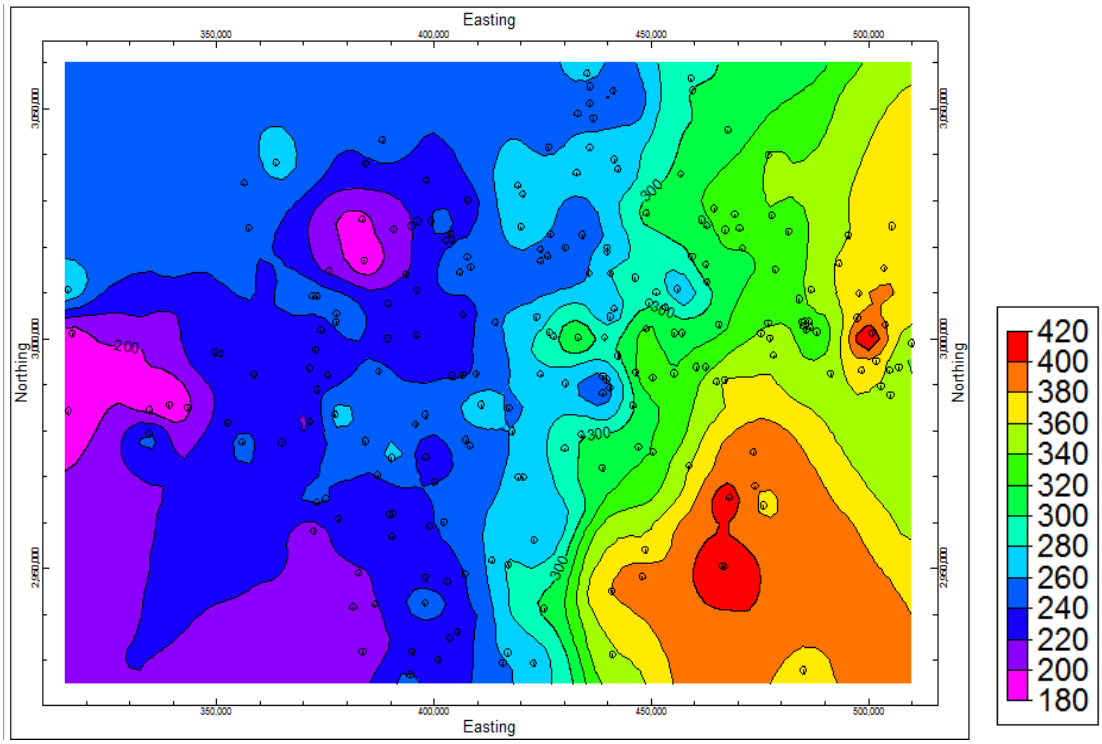


Figure 14: Water table Elevation

3.0 Water Level Scenario

Central Ground Water Board periodically monitors ground water levels four times in a year during the months of January, May (Pre-monsoon), August and November (Post-monsoon). In Nagaur district water levels are monitored through a network of 89 observation wells (National Hydrograph Network Stations).

3.1 Depth to Water Level

Depth to water level in the district varied from 5.00 to 68.46 mbgl and 4.97 to 68.06 mbgl during Pre-monsoon and Post-monsoon periods respectively. During Pre-monsoon, the water levels in major part of the district varied in depth from 20 to 40 m. Deeper water levels (>40 m) were observed in northwestern, northeastern, western, southwestern and central parts of the district (Figure 15). Shallow water levels (5 to 20 m) were observed in localized pockets in the northern part of the district. During Post-monsoon season again, water levels in major part of the district varied from 20 to 40 m and deeper water levels (>40 m) were observed in northwestern, western, southwestern and northeastern parts and localized pockets in central part of the district. Water levels in the range of 5 to 20 m were observed in the southeastern part of the district.

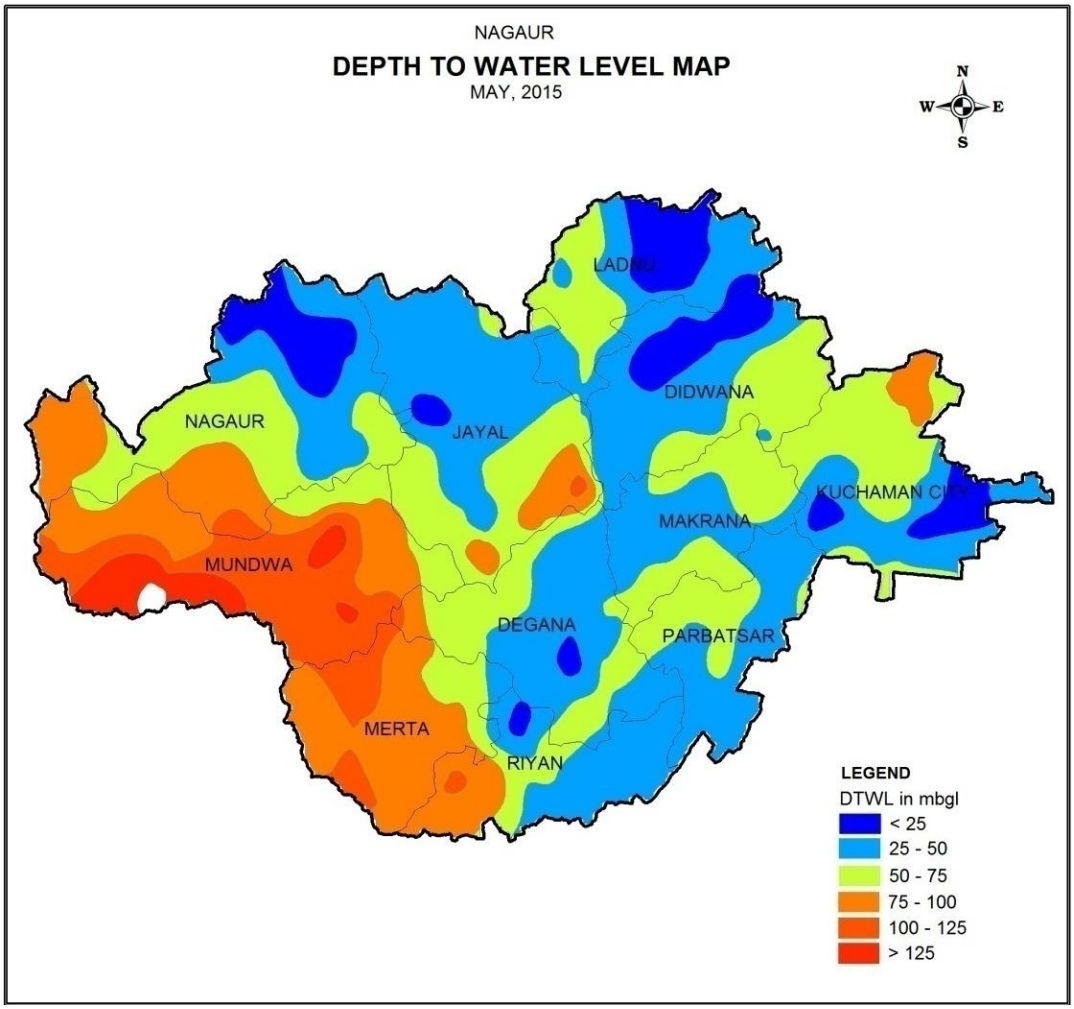


Figure15 : Pre monsoon water level map (May 2015)

4.0 Ground Water Quality

A perusal of analytical results of water samples collected during May 2015 indicates that the quality of ground water in phreatic aquifer varies widely from saline to fresh. Electrical Conductivity (EC) ranges between 1380 to 16240 micromhos/ cm at 25°C. It has been observed that by and large, EC conforms broadly with chloride concentration. In greater part of the area, it is within 5000 micromhos/ cm at 25°C. Higher values of EC have been observed in the west central part of the district and also in depressions in the vicinity of the saline lakes. The chloride content ranges from 50 to 5069 ppm in phreatic aquifer.

Fluoride in the ground water ranges between traces and 11.20 mg/l. Fluoride concentration in excess of maximum permissible limit of 1.5 mg/liter has been noticed in central and northeastern parts of the district. Nitrate concentration in ground water varies widely. Its concentration ranges between traces to as high as 1000 ppm.

4.1 Ground water quality in deeper aquifers

Ground water quality is brackish to saline from east of Merta to Degana and from Didwana to Nagaur via Jayal block in the central part of the district. In this big pocket covering about 6000

km^2 area the E.C. of ground water is more than 5000 micromhos/ cm at 25°C. There are three pockets namely around Nimri in Ladnun block, around Gotan in Merta block and in a longitudinal belt in the eastern part of the district where the E.C. of ground water is within 2000 micromhos/cm at 25°C.

Ground water in the alluvium is in general better in quality than that found in the sandstones of Nagaur and Palana series. Ground water in Quaternary alluvium has T.D.S. less than 1000 ppm (E.C. less than 2000 micro mhos/ cm) only, whereas in the eastern part, the range of T.D.S is between 1000-3000 ppm. In the wells penetrating Tertiary sediments the T.D.S exceeds 3000 ppm.

The E.C. of ground water in the shallow aquifer of Nagaur and Palana sandstone varies from 900 to 6000 micro mhos/cm at 25°C. However the quality of water deteriorates with depth. In a borehole of 421.20 m depth at Merta City, EC as high as 28496 micromhos/ cm was observed. In tube wells of average depth of around 80 m tapping sandstones, the EC of ground water is around 2000 micromhos/cm. In tube wells tapping phyllites, schists and gneisses, quality of ground water is very poor.

The fluoride content in ground water of tube wells constructed at Kanwai (Didwana block) and Roru and As Ki Dhani (Ladnun block) was observed to be more than 3 ppm. The production well at Luniawas (Merta block) and Gorera (Nagaur block) also yielded water with more than 3 ppm fluoride.

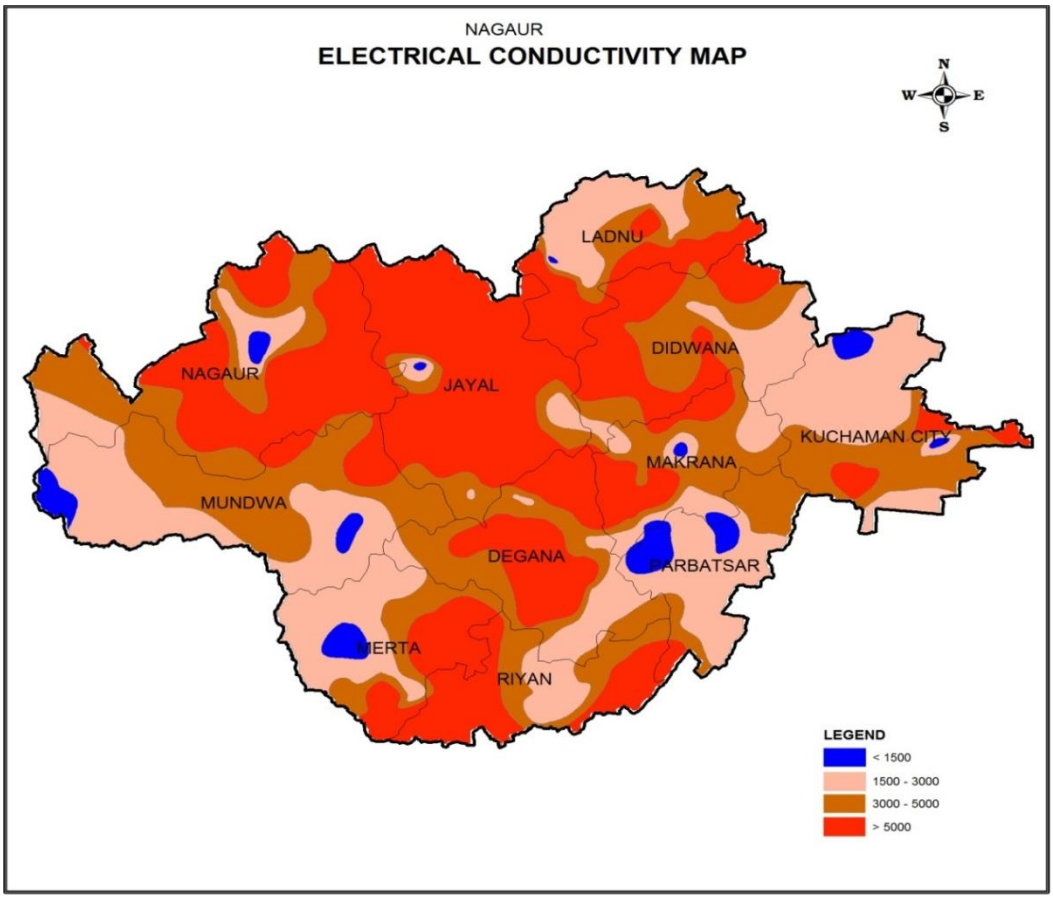


Figure 16: Iso Electrical Conductivity Map

5.0 Ground Water Resources

Groundwater resources have been reassessed as on 31.3.2013 based on Groundwater Estimation Committee (1997) and are given in Table 3.

Table 3: Groundwater resource, Draft and stage of development (as on 31.03.2013)

BLOCK	AREA IN Sq.Kms.	POTENTIAL ZONE AREA IN Sq.Km.	TOTAL ANNUAL G.W RECH. IN MCM	NATURAL DISCH. DURING NON MONSOON IN MCM	NET ANNUAL G.W AVAILABILITY IN MCM	Existing Gross Ground Water Draft for Irrigation	Existing Gross G.W. Draft for Dom. & Ind. Use	Existing Gross Ground Water Draft for all uses	Allocation for Dom. & Ind. Requirement	Net G.W. availability for future irrigation Dev.	Stage of G.W. Development	CATEGORY
Degana	1463.34	1203.34	41.5772	4.1577	37.4195	52.5990	14.5840	67.1830	15.1320	0.4361	179.54	OVER EXPLO.
Didwana	1637.59	1637.59	64.0105	6.4010	57.6095	77.0125	19.7920	96.8045	20.6191	6.7031	168.04	OVER EXPLO.
Jayal	1948.08	1724.58	58.4687	5.8469	52.6218	37.2475	17.4400	54.6875	18.9600	12.0687	103.93	OVER EXPLO.
Kuchaman	1507.13	1125.88	69.8514	6.2037	63.6477	159.4623	21.1920	180.6543	21.5001	1.6047	283.83	OVER EXPLO.
Ladnu	1530.08	1448.83	44.5149	4.4515	40.0634	26.7926	13.2093	40.0019	16.6332	8.1652	99.85	CRITICAL
Makrana	1140.08	1065.08	42.7148	4.2715	38.4433	28.1600	19.6400	47.8000	13.7675	1.2876	124.34	OVER EXPLO.
Merta	1434.80	1378.55	49.0509	4.2149	44.8360	130.6965	13.6000	144.2965	13.6000	2.3411	321.83	OVER EXPLO.
Mundwa	2207.29	2207.29	70.5936	7.0593	63.5343	188.4880	32.5840	221.0720	32.5840	0.0000	347.96	OVER EXPLO.
Nagaur	2532.90	2270.40	53.2360	5.3236	47.9124	26.6640	19.7280	46.3920	21.9271	8.7713	96.83	CRITICAL
Parbatsar	1071.70	1071.70	32.5911	3.2591	29.3320	46.4375	10.2144	56.6519	10.2144	0.0000	193.14	OVER EXPLO.
Riyan	1245.26	1245.26	48.5947	4.8594	43.7353	49.8025	10.9488	60.7513	10.9488	0.0000	138.91	OVER EXPLO.
Total	17718.25	16378.50	575.2039	56.0486	519.1553	823.3624	192.9325	1016.2949	195.8862	41.3778	195.76	OVER EXPLO.

Groundwater resources estimation data of Nagaur district shows that net ground water availability is 43.73 (MCM) whereas ground water draft for all purposes is 60.75 (MCM). In Nagaur district 09 blocks are fall under overexploited category and 02 blocks are critical. The stage of groundwater development in the district is 195.76%.

6.0 Ground Water Related Issues & Problems

Major part of the disctrict is covered by hard rock formations such as Jodhpur sandstone, Nagaur sandstone Bilara Limestone, Delhi Super Group metamorphics and granites. These have poor water yielding capacity except rocks of Marwar Super Group. 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 scarcity of drinking water and the situation becomes very critical in summers and in drought years.

Another problem of concern in the district is that most of the potential zones have witnessed 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 more than 15 m has been observed in Mundwa, Merta, Jayal and Kuchaman blocks during last 10 years.

7.0 Management Strategies

Due to over development, further exploitation of precious resource must be checked. For sustainable development of ground water, artificial recharge measures to be employed to augment ground water and surface water resources. Exploratory drilling results show potential zone having inferior quality water, which can be blended with fresh water for irrigation use.

Table 4. Supply Side Management

Block	Potential Zone Area (Sq. Km)	Surplus Available in Zone (mcm)	Surplus Available as per the Water Level (mcm)	No of Rs 0.03 mcm/ Shaft	No of Shafts possible in block (as per water bodies)
Degana	1448.82	0.3050	0.3050	10	10
Kuchaman	1543.46	0.5859	0.5859	20	20
Merta	1347.94	0.2969	0.2969	10	10
Mundwa	262.19	0.0799	0.0799	2	2
Parbatsar	1048.28	0.2919	0.2919	10	10
Riyan	1109.47	0.3133	0.3133	10	10
Total	6760.16	1.8729	1.8729	62	62

The area has undergone polyphase deformation in geological past, which has resulted in a complex structure (folded, faulted and jointed) that may not be conducive for such structures. Therefore, site of these structures should be selected carefully. The groundwater can also be recharged by use of sprinklers. The description of sprinkler and estimated cast are mentioned in the table 5.

Table 5. Demand Side Management

Block	Irrigated Area (ha)	Water Saving by Sprinkler in mcm @ 0.08 m	Water Saving by Change in Cropping Pattern in mcm @ 0.1m	Total Water Saving (mcm)
Degana	22199	8.88	1.40	10.28
Didwana	32168	12.87	5.17	18.04
Jayal	13438	5.38	1.13	6.51
Kuchaman	62370	24.95	10.59	35.54
Ladnu	7845	3.14	0.86	4.00
Makrana	6335	2.53	1.23	3.76
Merta	61860	24.74	5.77	30.51
Mundwa	87328	34.93	1.71	36.64
Nagaur	7742	3.10	3.56	6.66
Parbatsar	12279	4.91	1.84	6.75
Riyan	22340	8.94	1.90	10.84
Total	335904	134.36	35.17	169.53

The above study have shown that surplus water available for the ground water recharge is 1.87 mcm and recharge shaft 62 nos are required for the percolation of surface water to underground. The surplus water can be used for recharge through this net groundwater saving would be 169 mcm and total cost of proposed intervention is nearly 3 crore.

The water saving of the Nagaur district can be done by change in cropping pattern and advance irrigation practices. Irrigated area to be brought under irrigation by sprinkler – 1679 sq km and net Water saving - 134 MCM (20% of crop water requirement). The expected cost for sprinklers – Rs 840 crore @Rs 50,000 per hectare. Similarly if cropping pattern changes from wheat to gram in 352 sq km irrigated area than net water saving would be 35 mcm and total water saving will be nearly 169 mcm and expected cost of the project is 840 crores.

The expected outcomes after implementation of the above suggested various methods are shown in Table 6.

Table 6 Expected Outcomes of project

Block	Existing G.W. draft for all purposes	Ground water savings through RWH & AR projects (mcm)	Net G.W. draft after intervention	Percentage stage of G.W. Development	Projected stage of G.W. development
Degana	67.18	10.28	56.90	179.54	150.83

Block	Existing G.W. draft for all purposes	Ground water savings through RWH & AR projects (mcm)	Net G.W. draft after intervention	Percentage stage of G.W. Development	Projected stage of G.W. development
Didwana	96.80	18.04	78.76	168.04	136.71
Jayal	54.87	6.51	48.17	103.93	91.54
Kuchaman	180.65	35.54	145.11	283.83	225.91
Ladnu	40.00	4.00	36.00	99.85	89.86
Makrana	47.80	3.76	44.04	120.34	114.56
Merta	144.29	30.51	113.78	321.83	252.10
Mundwa	221.07	36.64	184.43	347.96	289.92
Nagaur	46.39	6.66	39.73	96.83	82.92
Parbatsar	56.65	6.75	49.90	193.14	168.44
Riyan	60.75	10.84	49.91	138.91	113.30
Total				186	120

If we use the above suggested method for the ground water conservation and recharge then the stage of ground water development decrease successively from 186 % to 120 %. Similarly if cropping pattern changes from wheat to gram will not affect farmers economy and sustainable ground water supply will be maintained and the details of change in cropping pattern are mention in the table 7.

Table 7. Water Saving By Change In Cropping Pattern (Wheat to Gram)

Irrigated Area (ha)	Irrigated Area (ha) under wheat proposed for Gram cultivation	Production of wheat (ton)/ha	Production of gram (ton)/ha	Unit cost (Rs) of wheat /ton	Unit cost (Rs) of gram /ton	Market value (Rs) of wheat (ton)/ha	Market value (Rs) of gram (ton)/ha
335904	70313	2.7	1.5	16000	53000	43200	55650