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

GUNA DISTRICT
MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

भारत सरकार

जल शक्ती मंत्रालय

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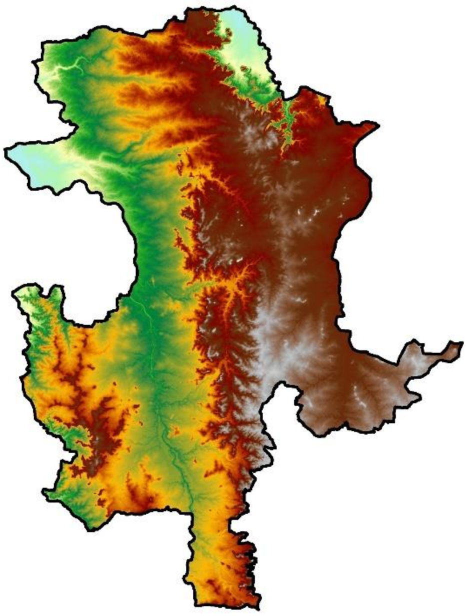
GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA REJUVENATION
CENTRAL GROUND WATER BOARD

REPORT ON

"NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN OF GUNA DISTRICT, MADHYA PRADESH" (6393.4sq.km)



SUBMITTED BY,

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NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN OF GUNA DISTRICT, MADHYA PRADESH

CONTENT

Chapter-I

1. INTRODUCTION

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 emerging 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. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrological and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. By analyzing the existing data and the data generated, regional hydrogeological maps, thematic maps, water quality maps, cross-sections, 2-D and 3 –D aquifer dispositions are prepared.

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 analysis 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 resources, 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 analysis are applied to characterize the quality, quantity and sustainability of groundwater in aquifer. Under the National Aquifer Mapping Programme, 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 filling data gaps and preparation of different aquifer layers. The flow chart is as follows.

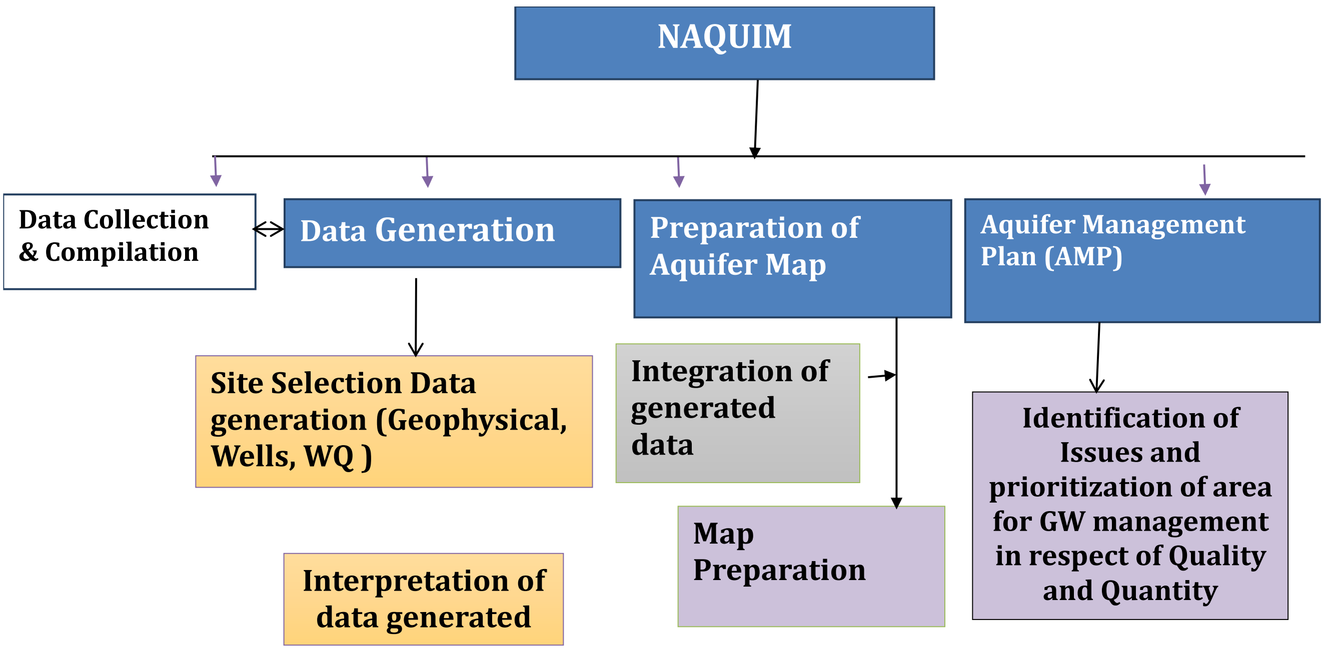

Fig1: Flow chart

Aquifer Mapping can be envisaged as follows :

1. Data Compilation & Data Gap Analysis:

One of the important aspect of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled, analysed, examined, synthesized and interpreted from available sources. These sources were predominantly non computerized data, which was converted into computer based GIS data sets. On the basis of available data, Data Gaps were identified.

2. Data Generation:

There was also a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping.

3. Previous studies:

Prior to this study, the groundwater hydrogeology has been studied only in separate parts with many areas left untouched. As a result, there was no hydrogeologic framework developed so as to understand the regional effects of groundwater development in the area .

4. Preparation of Aquifer Maps:

. Aquifer maps on 1:50000 scale, is prepared for characterizing the aquifer geometry, behavior of groundwater levels and status of groundwater development in various aquifer system to facilitate planning of their suitable management.

5. Preparation of Plan;

Preparation of Block wise ground water management plan of the Guna district that will guide the planers to manage the ground water resources in judicious manner and improve the ground water scenario of the district.

1.4 Study Area Details:

Guna district is situated in the northern part of the Madhya Pradesh and covers an area of about 6393.36 Sq. km. It lies between N Latitude 23°53’ and 25°06’and E longitude 76 ° 48’ and 78 ° 16’ and falling in Survey of India toposheet no’s 54 G, H & L. It is bounded in the northeast by Shivpuri District, on the east by Ashoknagar District, on the southeast by Vidisha District, on the southwest by Rajgarh District, on the west and northwest by Jhalawar and Baran districts of Rajasthan state.After India gained independence, Guna became part of the new state of Madhya Bharat on 28 May 1948 as one of its 16 districts. On 1 November 1956, Madhya Bharat was merged into Madhya Pradesh state.

For administrative convenience, the district is divided into into 7 tehsils and 5 blocks .It has 1338 villages and the total population of the district is 1241519 (As per census 2011). The district has a population density of 194 inhabitants per square kilometre (500/sq mi) . Its population growth rate over the decade 2001-2011 was 26.91%. Guna has a sex ratio of 910 females for every 1000 males, and a literacy rate of 65.1%. Scheduled Castes and Tribes made up 15.55% and 15.37% of the population respectively. As of 2011 India census, Guna City has a population of Males constitute 52.29% of the population and females 47.71%. Guna has an average literacy rate of 81.7%, In Guna, 13% of the population is under 6 years of age. The block area and number of villages in each block are given in Table No. 1. The administrative map of Guna district is given in Figure 2.

S. No	Block	Area in sq. km	No of villages
1.	**Guna**	**1520.40**	**279**
2.	**Bamori**	**1787.00**	**228**
3.	**Raghogarh**	**1123.27**	**296**
4.	**Aron**	**812.75**	**164**
5.	**Chachoda**	**1149.94**	**293**
Total		**6393.36**	**1260**

Table.1: Administrative units of Guna district, Madhya Pradesh.

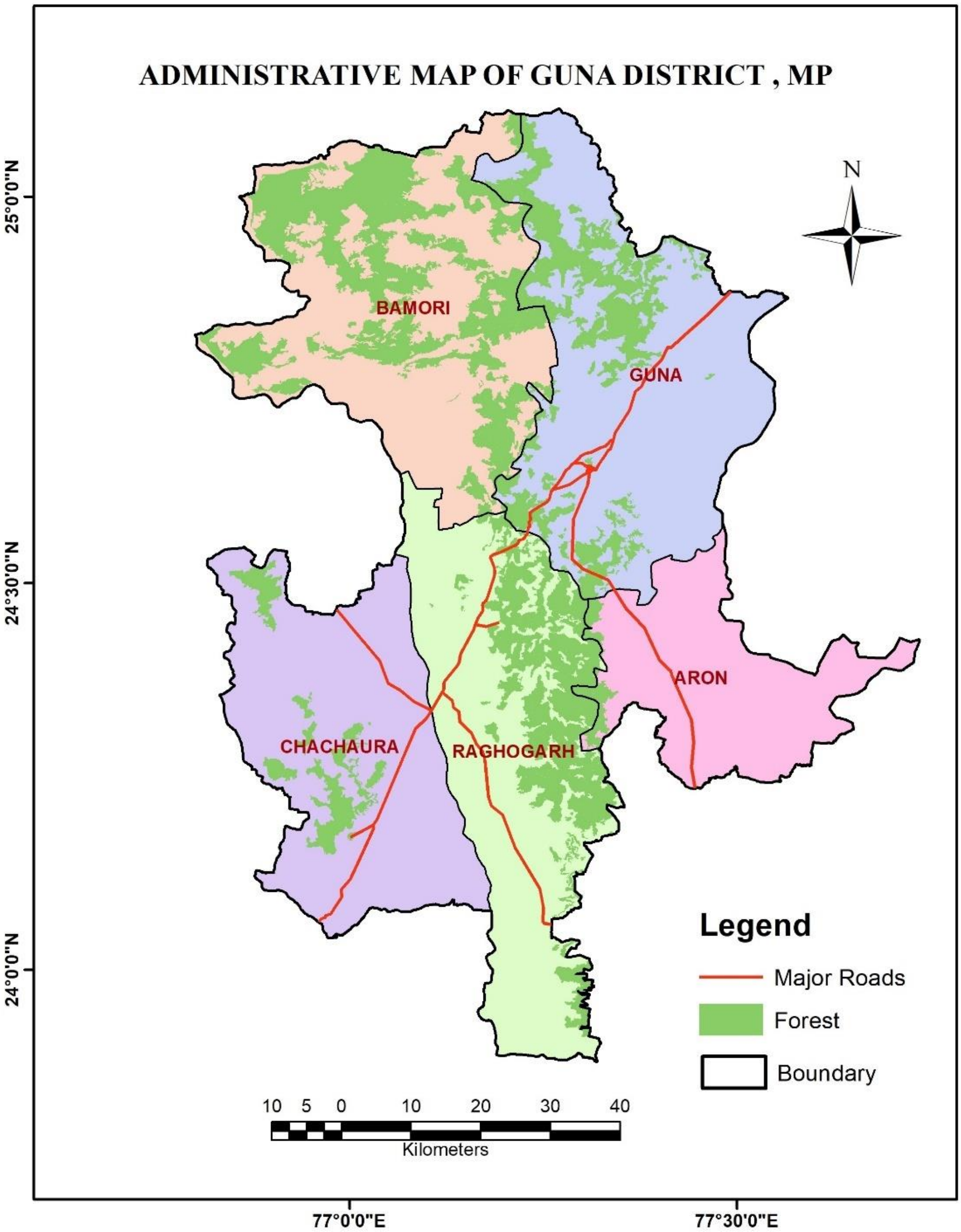

Fig:2 Administrative Map Of Guna District, MP

1.5 Rainfall& Climate:

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Decadal rainfall data from IMD were analyzed from the year 2010 to 2020 .The lowest annual rainfall was recorded in the year 2017 and the highest average rainfall was recorded in the year 2013. During the last decade highest rainfall of August was recorded in the year 2013 (614.28 mm) and lowest was recorded in the year 2017(146.41mm).

About 90 % of the rainfall takes place from June to September, only 5 - 8% takes place in the winter months and only about 2% in summer. It is only during the monsoon that surplus water for deep percolation is available in the district. The normal rainfall follows a normal distribution during the year

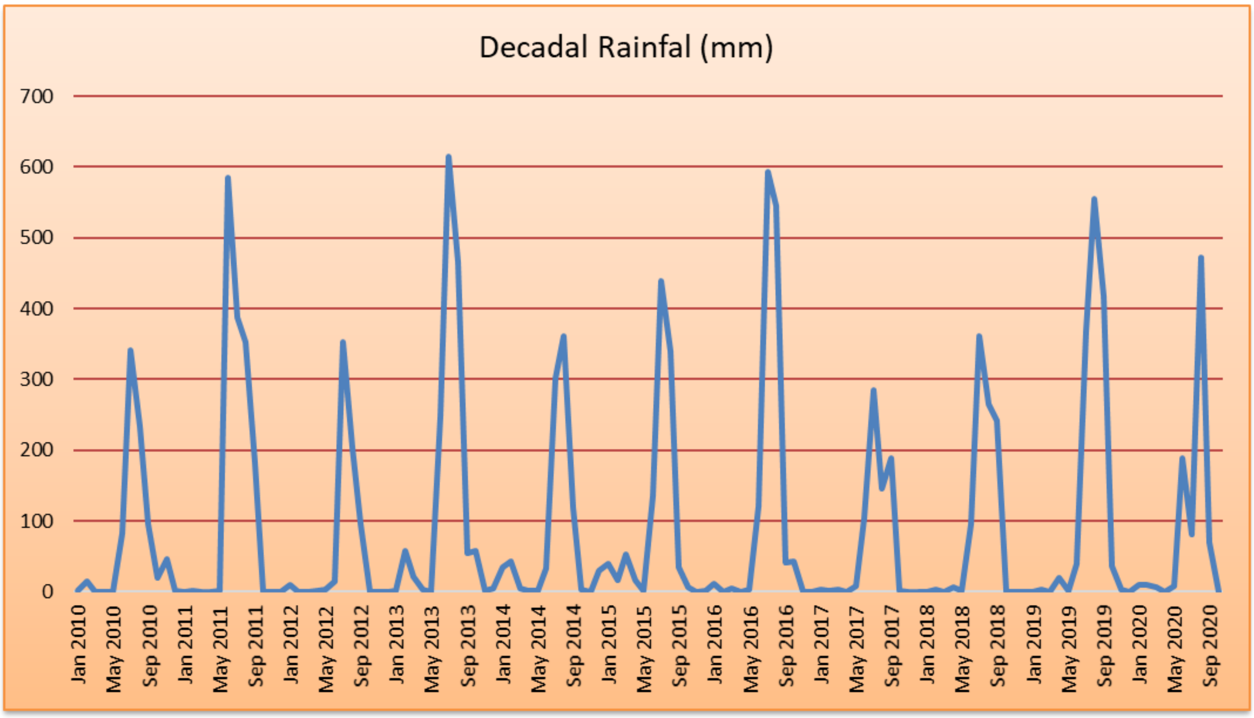


Fig3: Decadal Rainfall map of Guna district, MP

The climate of Guna district is characterized by a hot summer and general dryness except during the southwestern monsoon. A year may be divided into four seasons. Cold season, December to February followed by the hot season from March to about middle of June. The period from Middle of June to September is the southwestern monsoon season. October & November forms the post monsoon or transition period.

During the southwest monsoon season the relative humidity generally exceeds 90% (August month) and the rest of the period is dry. The driest period is summer season, when relative humidity is less than 27%. May is the driest month of the year. Normal maximum temperature during the month of May is 41.3^{0}C and minimum during January is 7.7^{0}C. Normal annual mean maximum & minimum temperatures of Guna are 32.5^{0}C & 21.8^{0}C respectively.

Wind velocity is higher during the pre- monsoon period as compared to the post monsoon period. The maximum wind velocity is 14.3 km/h during the month of June and minimum is 4.3 km/h during the month of November. Average normal annual wind velocity of Guna district is 8.1km/hr.

1.6 Geomorphology & Soil Types:

Guna district is characterized by wide spectrum of landscapes of structural, denudational and fluvial origin. Highly, moderately and low dissected hills and valleys of structural and denudational origin can be observed to occur mainly in the northern part of the district. Highly, moderately and low dissected plateaus cover major part of the district. Denudational landforms comprise pediment, buried pediment and intermontane valleys. The pediments are represented by broad, gently sloping erosional surface of low relief between hills and plains, comprised of varied lithology, crisscrossed by fractures and faults. Pediments are often buried beneath relatively thick alluvial or weathered materials.

The fluvial landforms in and around Guna district are represented by alluvial plains, valley fills, flood plains. The alluvial plains are represented by flat to gently undulating fluvial deposits of unconsolidated gravel, sand, silt and clay along rivers. Valley fills are also a result of fluvial activity comprising of boulders, cobbles, pebbles, gravels, sand, silt and clay. These units occur as consolidated to semi consolidated deposits. Flood plains occur as strips of relatively smooth land adjacent to river channels, which are subjected to periodic flooding when rivers overflow their banks. Ravines occur as small, narrow, deep, depression, smaller than gorges, larger than gulley, usually carved by running water. The map showing geomorphologic scenario of the district is presented in figure 5.

The soil of the district can broadly be divided into 3 major groups,

- Clayey soil associated with moderately stone of shallow depth occurring in well-drained moderately sloping plateau formed by severe erosion
- Very shallow, well-drained loamy soils associated with stone on gently sloping plateau formed by severe erosion.

- Moderately deep to deep fine soil developed in very gentle sloping and well drained area

The soil map of the district is presented in figure 4.

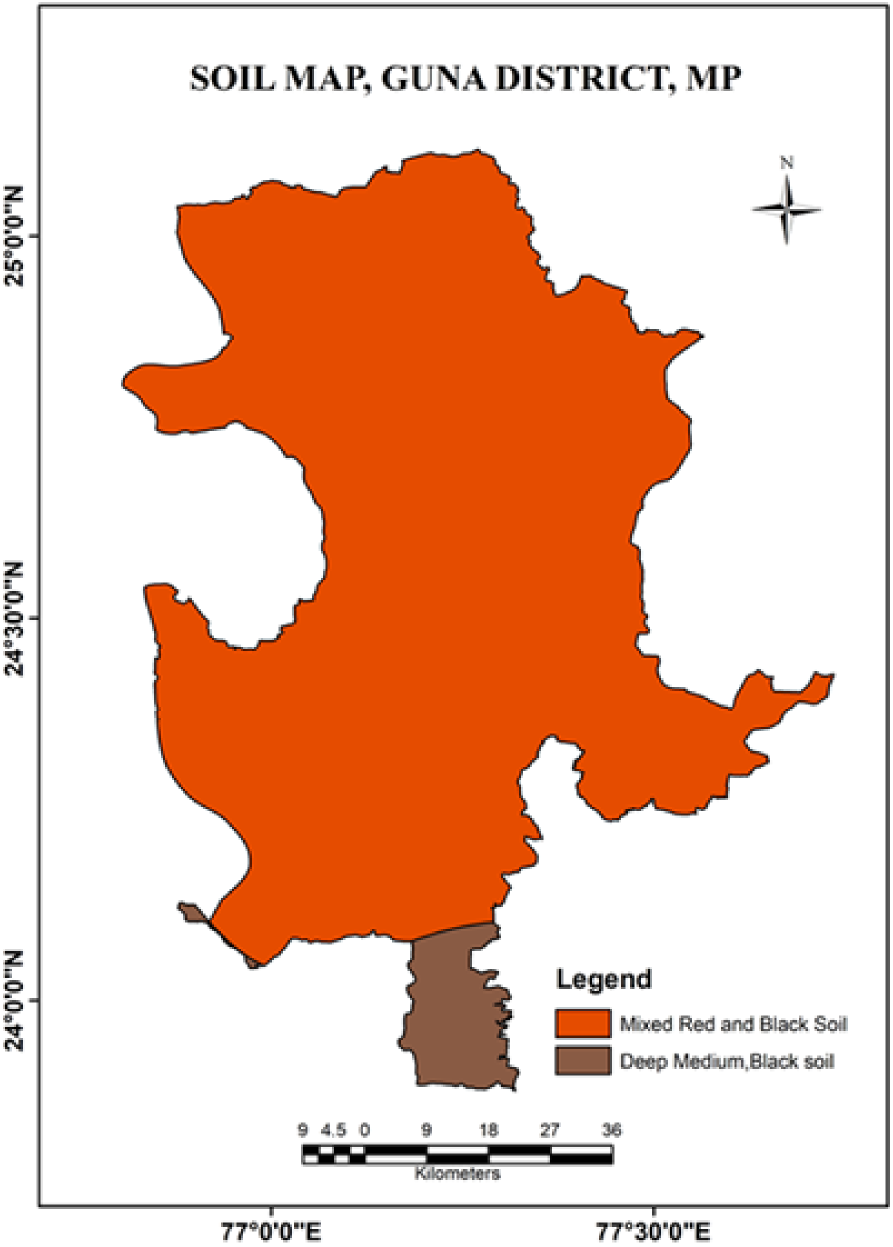


Fig4: Soil Map

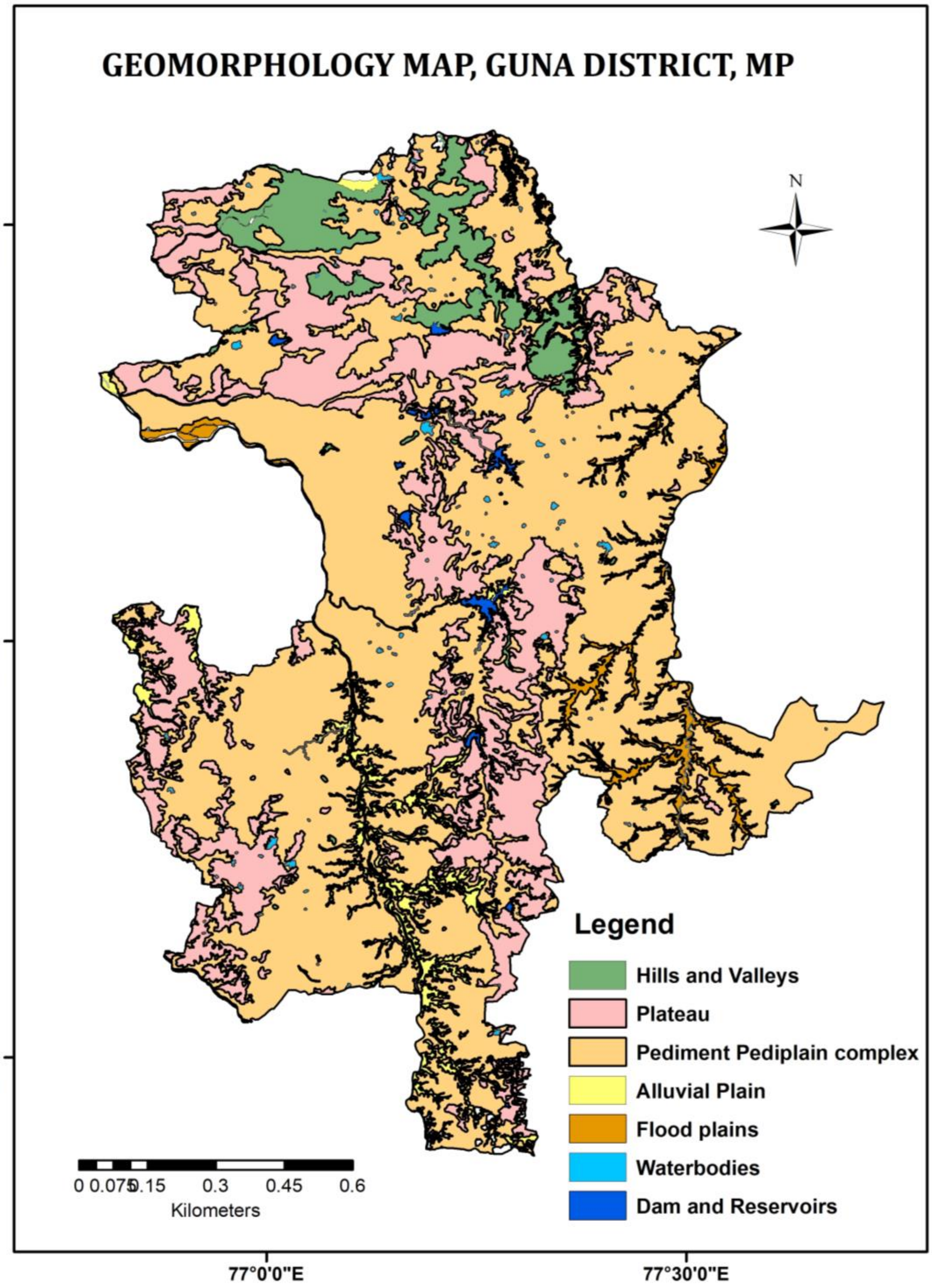


Fig5: Geomorphology map

1.7 Physiography

Physiographically, the major part exhibits a region of low level plateau plain of extrusive origin with terrace/rocky bench and flood plain (including in filled river bed) along the course of the rivers. The other landforms are low structural plateau & structural plains of Proterozoic rocks. The maximum & minimum elevations are 561 & 324 m above MSL at 9 km south of Aron in southern part and 31 km south south west of Paron in the north western part of the district respectively. The map showing geomorphologic scenario of the district is presented in figure 6.

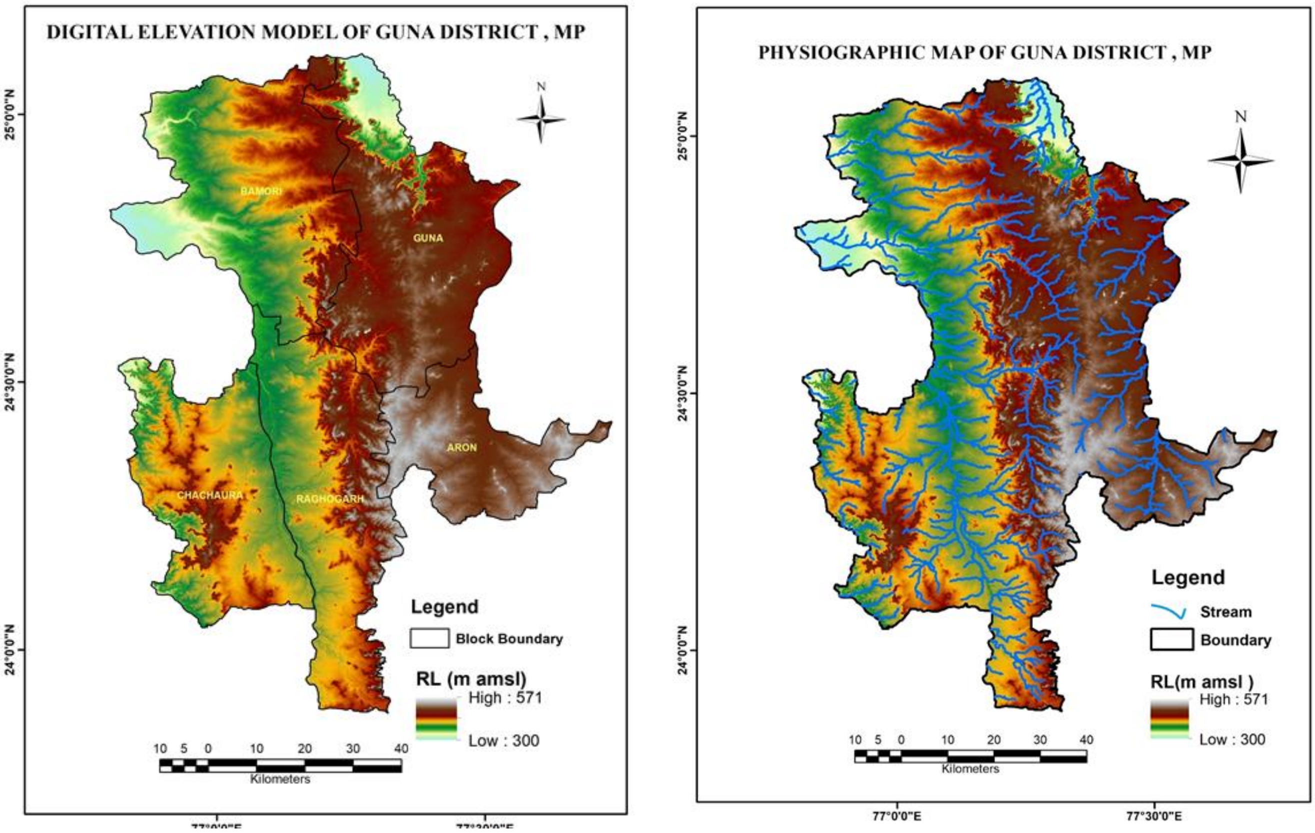


Fig6: Digital Elevation Model &Physiography map of Guna district, MP

1.8 Drainage:

The district lies in the Yamuna drainage system. It is drained by the Parbati & kuno rivers, which are the tributaries of River Chambal. The Sindh River flows northward along the eastern edge of the district, forming part of the boundary with Ashoknagar District, and the Parbati River flows northwestward through the southern portion of the district, forming part of the boundary with Baran District before flowing into Rajasthan.

The general flow direction of all the rivers is towards north with low gradient. Drainage map of Guna district is given in Fig 7.

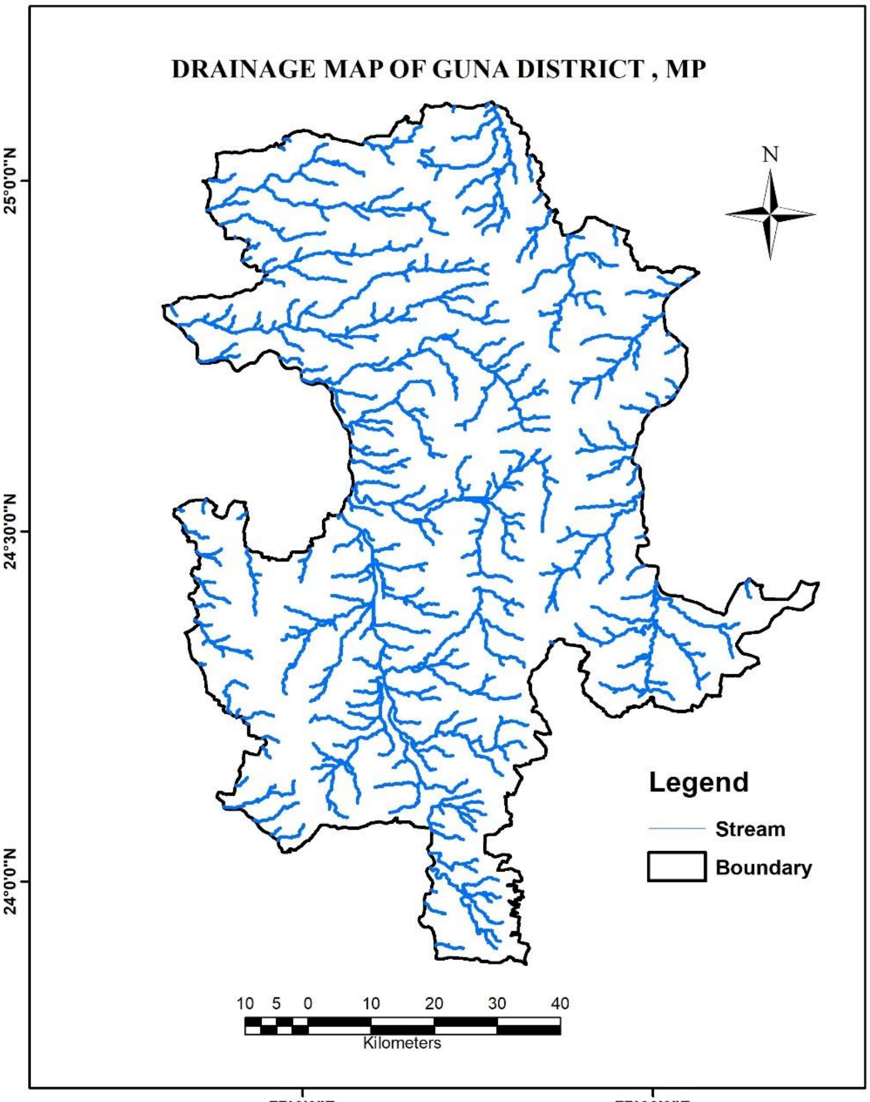


Fig.7 Drainage map

1.9 Land use Land cover:

Land Use / Land Cover (LULC) assessment is an integral part of scientific analysis related to understand climate variables, carbon budgeting and to meet the socio economic requirement of humankind. 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. National Land Use/ Land Cover Mapping on 1:50,000 scale (Second Cycle) using multi- temporal Resourcesat-2 terrain corrected Linear Imaging Self Scanning Sensor (LISS) -III data for 2015-16 is used and is presented in Table 2 and its pie chart is shown in figure 8.

Table2: LULC Classification

Classes		Guna (Area in sq.km)
L 1	L 2	
Agriculture	Crop land	4049.41
	Fallow	20.44
	Plantation	1.89
	Gullied / Ravinous Land	2.19
Barren/unculturable/ Wastelands	Scrub Land	450.35
	Mining	4
Builtup	Rural	29.17
	Urban	24.64
	Deciduous	1396.27
Forest	Forest Plantation	2.35
	Scrub Forest	198.42
Wet lands / Water bodies	River/Stream/Canals	45.28
	Water bodies	80.58

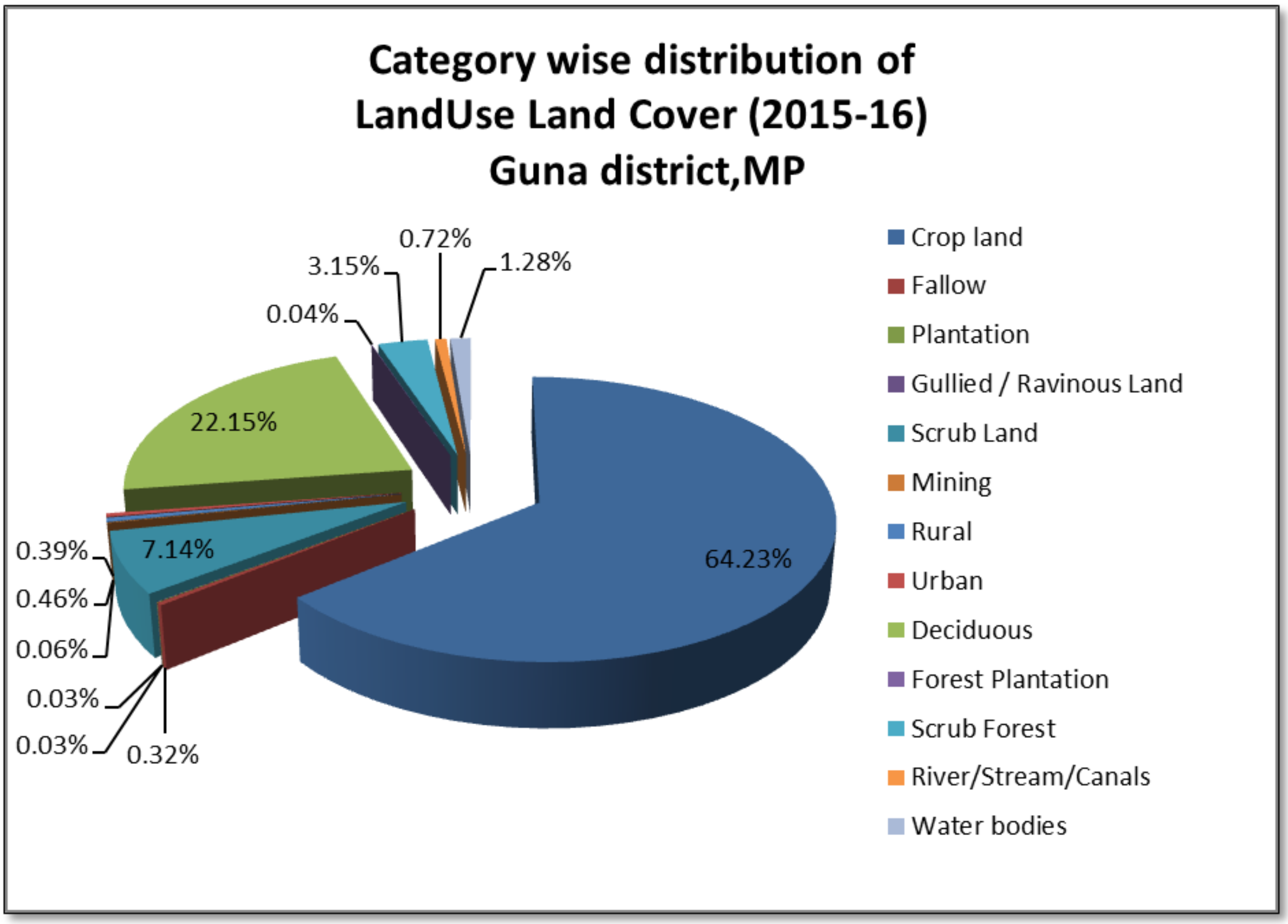


Fig8: Pie Diagram

Chapter-II

2. DATA COLLECTION AND GENERATION

2.1 Hydrogeology - Aquifer System and Aquifer Parameters

Geologically major parts of the Guna district is occupied by Deccan Trap basalts except northern part of the district which is covered by sedimentary rocks of Vindhyan super group. Occurrence and movement of groundwater in hard rock is mainly controlled by secondary porosity through joints and fractures. Presences of vesicle in basaltic lava flow of Deccan Traps play an important role in groundwater movement. Groundwater in general occurs under unconfined to semi-confined conditions. The general hydrogeological conditions of the district are depicted in figure -9 and formation wise settings are discussed below.

Laterite & Alluvium

Laterite of Cainozoic age occurs as boulders capping the Vindhyan & Deccan Trap formations in the northern parts of the district. It varies in thickness from 1 to 5 m and ferruginous on nature. Alluvium of Quaternary age occurs as a narrow belt along the major rivers like Kuno, Parvati and Sindh. It comprises pebble beds, gravel, silt and sand

In the area occupied by the laterite and alluvium the ground water occurs under water table condition. The granular portion of this formation such as sand & gravel forms good aquifers, but the thickness is shallow. The depth to water level in these formation ranges between 3.80 to 18.94 m.bgl. in pre monsoon period and water level fluctuation ranges from 1.54 to 6.50 m

Vindhyan:

The Sandstone intercalated with Shale beds are exposed in the northern & northwestern parts of the district (Bamori & Guna blocks). The rocks are hard and compact, but at places and at different depth it is fractured and jointed and forming potential aquifer at deeper levels. The ground water occurs under semi confined to confined conditions and are being exploited through bore wells. The yield of these borewells is fairly good ranging between 2 to 10 lps. The depth to water level during pre monsoon period ranges from 3.70 to 22.10 mbgl. with seasonal fluctuation of 0.07 to 9.98 m.

Deccan Trap:

Deccan trap basalts of Malwa Group of Cretaceous to Paleozoic age occupy major part of the district. Intertrappean of lacustrine or fluviatile origin occur in the top part of the each lava flow. Deccan trap consist of number of basaltic lava flows.Water bearing capacities in Deccan trap formation differ from flow to flow. Phreatic aquifer occurs in weathered, jointed and fractured basalts. In the areas where weathered basaltic layer is extensive, a continuous aquifer can be traced to some distance, however due to low permeability of the weathered basalt the aquifer sustain limited ground water withdrawal. The deeper aquifer system appear to be under unconfined to semi-confined conditions while visualizing lava flow sequence which shows alternate units of vesicular and massive horizons. The hydrogeological regime in different tires, deeper aquifer is more likely to be governed by the secondary porosity jointed/fractured form of massive units is creating possibilities of their acting as leaky confining bed consequently resulting into semi-confined condition for water bearing vesicular units occurring below it. Yield of the wells in this formation varies from 3.5 to 8 lps. Unit draft of the wells varies from 0.001 to 0.008 mcm/year for dug wells & 0.005 to 0.017 mcm/yr for tube wells**.**

Under the Ground water Exploration Programme CGWB has constructed the exploratory wells and observation wells of 61.00 to 193.00m deep. The depth to water levels in these wells varies from 12.10 to 41.20m bgl and discharge of the wells ranges from negligible to 8 lps with a draw down of 28.00m

Lameta Group

Lameta Group of Cretaceous age comprising siliceous limestone and highly fossiliferous sandstone is exposed at 8 to 25 km. southwest of Sirsi in the northern part of the district. It is horizontally disposed underneath the Deccan trap formation. The ground water in this group occurs under phreatic condition with good yield.

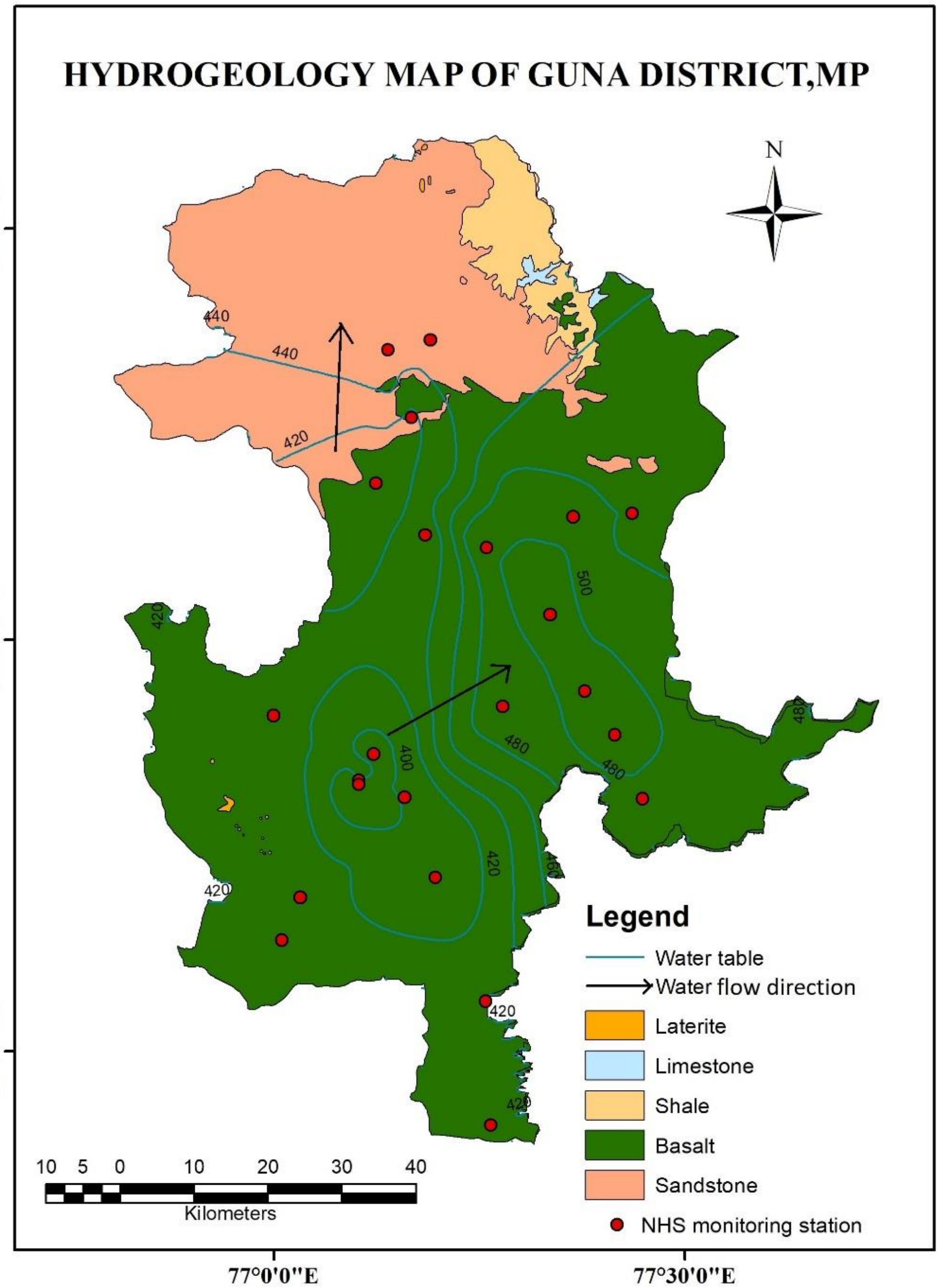


Fig 9. Hydrogeological map of Guna district

2.2 Groundwater Exploration:

The district covered mostly with basaltic lava flows of Deccan Trap and Vindhyan sandstone at places Laterite and alluvial deposits occur along the main river course. Granite is exposed in the northeastern part of the district.

In Guna district total number 10 EW drilled by CGWB under exploration during the period 2002-2004. Basic details of wells is given in Annexure –I. Groundwater exploration programme in Aspirational districts through outsourcing drilling by WAPCOS has proposed to construct 26 exploratory wells during the year 2021-22. The details of proposed exploratory wells to be drilled are listed in Table 3. Details of Constructed exploratory wells drilled through outsourcing is listed in Table 4 and location is plotted in figure11.

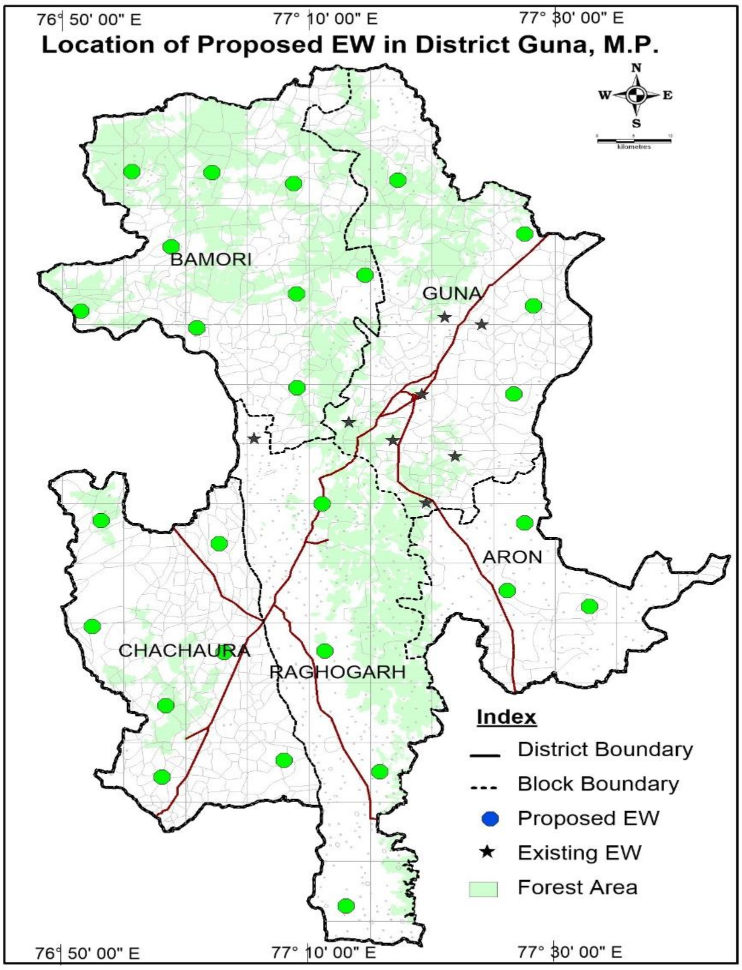


Fig 10. Proposed and existing location of Exploratory wells

Table 3: Details of Proposed Exploratory Bore wells to be drilled in Guna district

Proposed Exploratory well location details						
Sl No:	Name of the village	Block	Latitude	Longitude	Toposheet	Formation
1	Sirsi	Guna	25.0245	77.2685	54 H/5	Basalt
2	Taknera		24.8845	77.4546	55 H/5	Basalt
3	Ahmedpur (Poonamkhedi)		24.7484	77.469	56 H/5	Basalt
4	Pagara		24.6517	77.4303	54 H/8	Basalt/Sst
5	Padon	Bamori	24.9836	76.9177	54D/13	Sandstone
6	Dhimarpura		24.9748	77.0092	54H/1	Sandstone
7	Kurka		24.8757	76.9702	54D/13	Sandstone
8	Ramnagar		24.733	77.0035	54H/2	Basalt/Sst
9	Panehti		24.8341	77.0474	54H/1	Basalt/Sst
10	Rampur(Panchora)		24.7685	77.166	54H/2	Sandstone
11	Jhagar (Baksanpur)		24.6766	77.1355	54H/3	Basalt/Sst
12	Atakhedi(Kakaruadang)		24.9591	77.1634	54H/1	Basalt
13	Patan		25.0113	77.1298	54D/13	Basalt/Sst
14	Burhakhera	Aron	24.4669	77.4585	54H/7	Basalt
15	Aron		24.376	77.4161	54H/7	Basalt
16	Balapur		24.3574	77.558	54H/11	Basalt
17	Daurana	Raghogarh	24.4816	77.1802	54 H/3	Basalt/Sst
18	Jamner (Raghupura)		24.1846	77.2071	54 H/3	Basalt/Sst
19	Kanjai		24.1264	77.2539	54H/8	Basalt
20	Nasirpur		23.9549	77.2022	55E/1	Basalt/Sst
21	GujarkhediViran	Chachaura	24.3248	76.8703	54D/15	Basalt
22	Kumbharaj		24.3688	77.0533	54H/3	Basalt/Sst
23	Gomukh		24.3335	76.8588	54D/15	Basalt
24	Dadampura		24.2121	76.9926	54D/16	Basalt
25	Jhorda		24.1224	76.9764	54D/16	Basalt
26	Chopankala		24.1443	77.1512	54H/4	Basalt/Sst

Table4: List of EW constructed

S. No.	Well No	District	Taluk	Village	Latitude	Longitude	Toposheet	Depth Drilled (m bgl)	Fractures (m bgl) / Discharge(cms)	Formation
1	EW 84	GUNA	GUNA	SIRSI	N 25.0245	E 77.2685	54 H/5	204.00	11.58 - 12.10m: wet zone, 103.65 - 104 m: 1 cm	SANDSTONE, SHALE
2	EW 85	GUNA	BAMORI	PATAN	N 25.01139	E 77.1298	54 D/13	204.00	54.70 - 55.80 m: 6 cm	SANDSTONE, SHALE
3	EW 86	GUNA	BAMORI	GADLA	N 24.9365	E 77.1974	54 H/1	204.60	59.44 - 59.89 : 7 cm	SANDSTONE, SHALE
4	EW 87	GUNA	BAMORI	PANHETI	N 24.8341	E 77.0474	54 H/1	204.60	57.30 - 57.42 : wet zone, 136.55 - 136.70 : 1 cm	SANDSTONE
5	EW 88	GUNA	BAMORI	RAMPUR	N 24.7685	E 77.1660	54 H/1	207.00	50.50 - 50.76 : 5 cm	SANDSTONE
6	EW 90	GUNA	BAMORI	PADON	N 24.9836	E 76.9177	54 H/2	127.00	59.74 - 59.89 - : 3 cm, 120.40 - 120.70 : 5 cm, 123.14 - 123.60 : 11 cm	SANDSTONE
7	EW 91	GUNA	BAMORI	KISHANPURA	N 24.7592	E 76.9941	54 H/2	207.70	91.44 - 91.56 : 2 cm, 114.30 - 114.41 : 3 cm	SANDSTONE

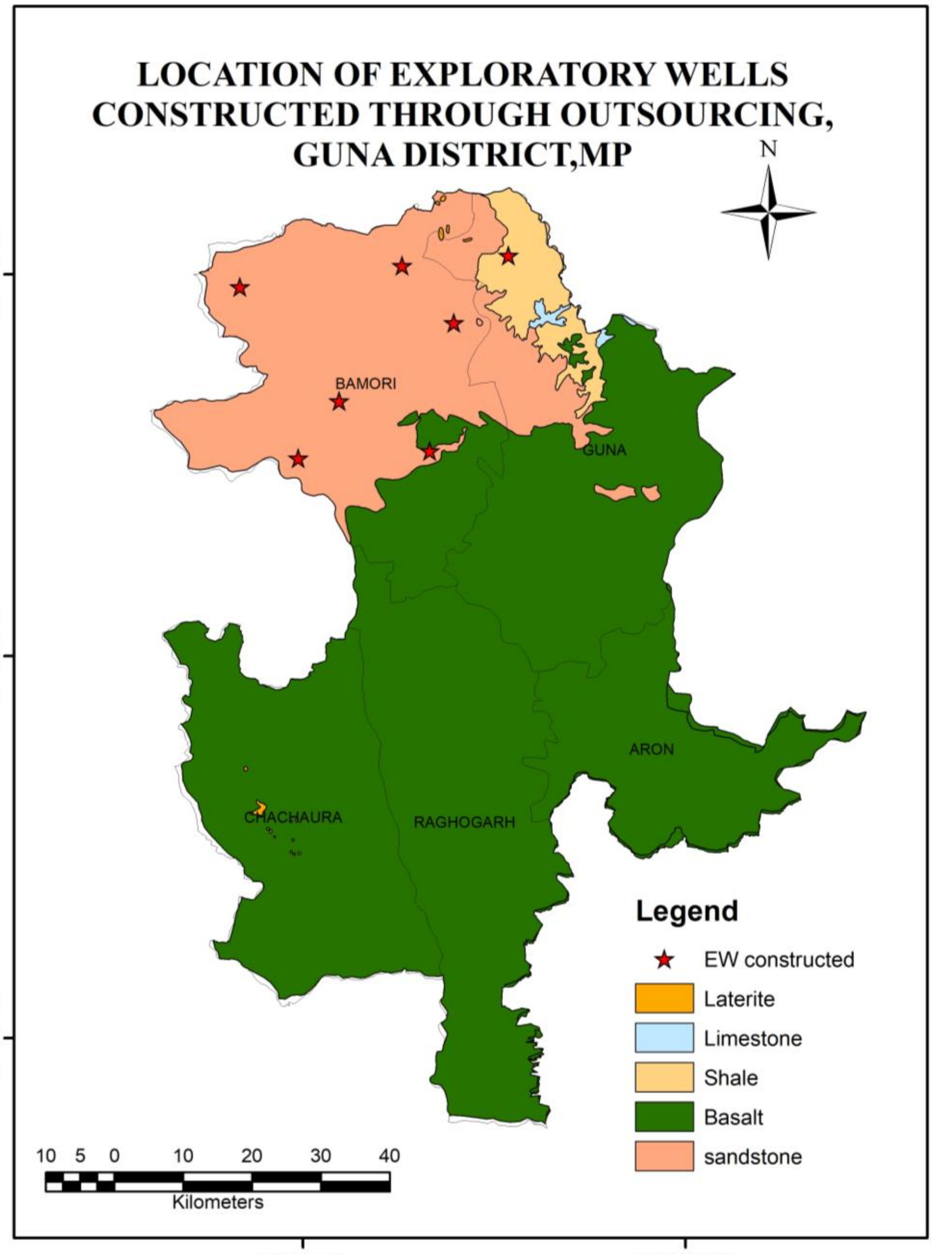


Fig11: EW constructed in Bamori block, Guna district

2.3 DEPTH TO WATER LEVELS

Periodic monitoring of the ground water levels to generate long-term data is an essential prerequisite for effective utilization, development, and management of the available ground water resources. This continuous monitoring provides a valuable tool to decipher the seasonal and long-term changes in ground water levels, and in turn helps in managing the ground water resources in a scientific and effective manner. Central Ground Water Board, North Central Region, Bhopal monitors ground water levels through a network of 20 dug wells and 5 piezometers all over Guna district. These ground water monitoring wells are monitored four times in a hydrological year in the months of May (pre-monsoon), August, November (post-monsoon) and January.

Pre-monsoon (May 2020):

Depth to water level (DTW) during May 2020 ranged from 2.96 m bgl at Singwasa observation well to 20.28 (mbgl) at Aron observation well in Guna district .Depth to water levels between 5-10 m bgl is the most prominent over the entire district. Water level more than 15 m bgl is recorded in isolated pockets in Aron block. Pre-monsoon depth to water level map for the year 2020 for Guna district is shown in fig 12.

Post-monsoon (November 2020):

During post-monsoon period, November 2020, depth to water level ranges from 1.28 m bgl at Singwasa observation well to 15.72 m bgl at Khatkiya observation well. It is observed that in northern most part of the district the water level lies between 2-5 mbgl and in southern part of district depth to water level ranges from 5-10 m bgl. Post- monsoon depth to water level map for the year 2020 for Guna district is shown in fig 13.

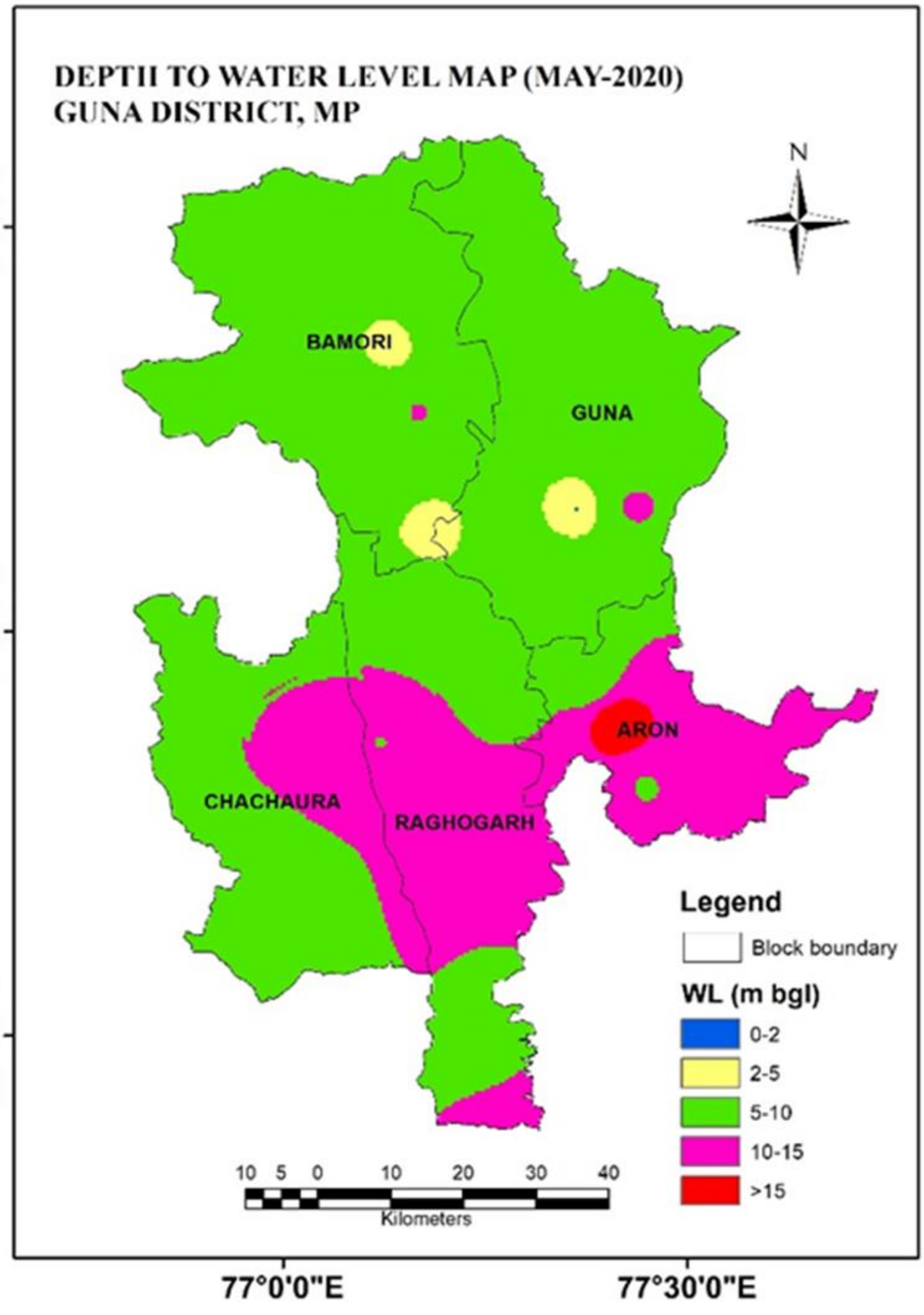


Fig 12. Depth to Water Level Map pre -monsoon 2020

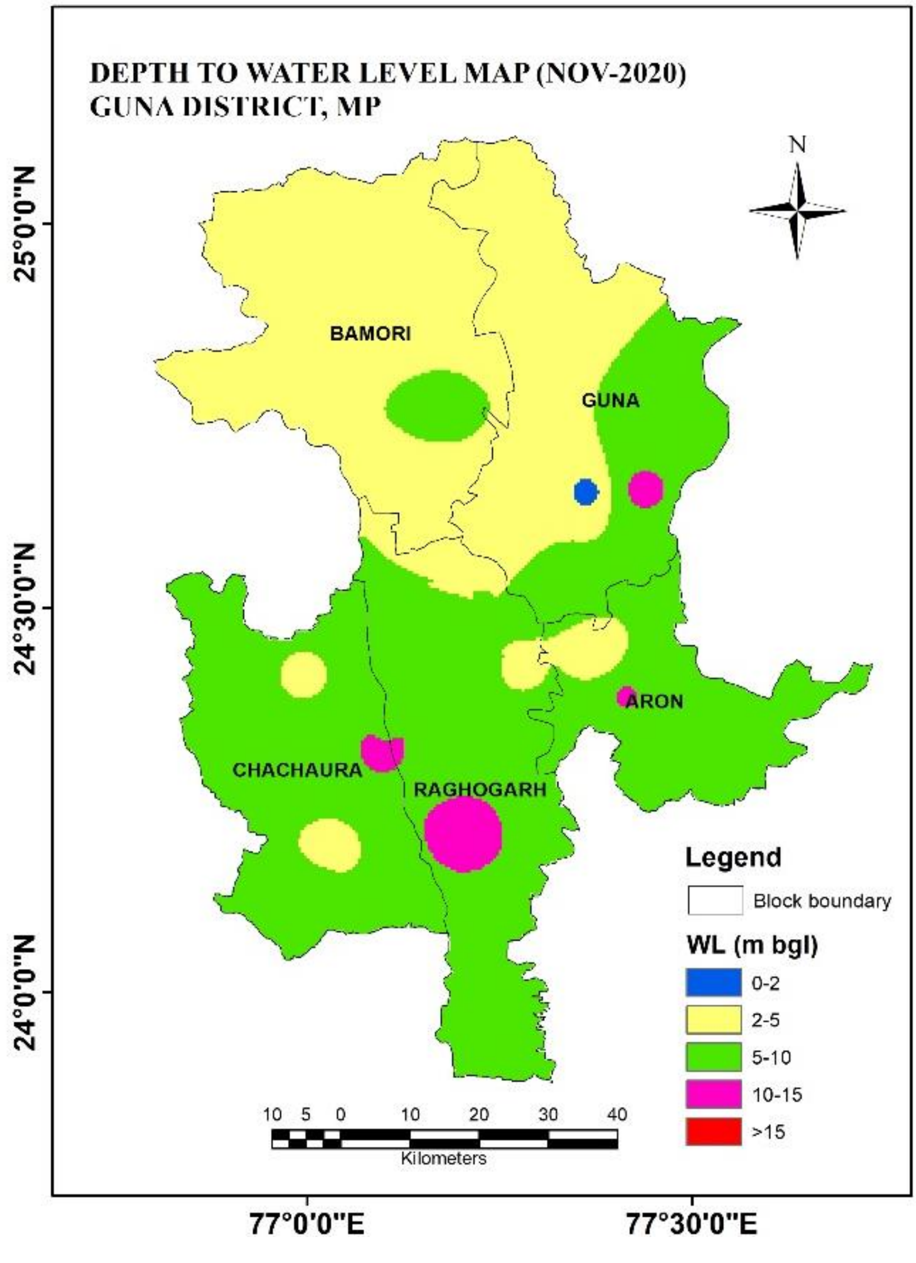


Fig 13. Depth to Water Level map post -monsoon

Annual Water level Fluctuation (May 2020-MAY 2021):

The ground water levels of monitoring wells during May 2021 were compared with those of May 2020 to decipher the changes that took place in the ground water regime. Water level is rising in northern part of Guna district , mainly in Bamori and Guna block . In Bamori block water level rise more than 4m is observed. Fall in water level is observed mainly in Chachaura block.Declining water level >4m is observed in southern part of Chachaura block. Annual water level Fluctuation map is shown in fig 8.

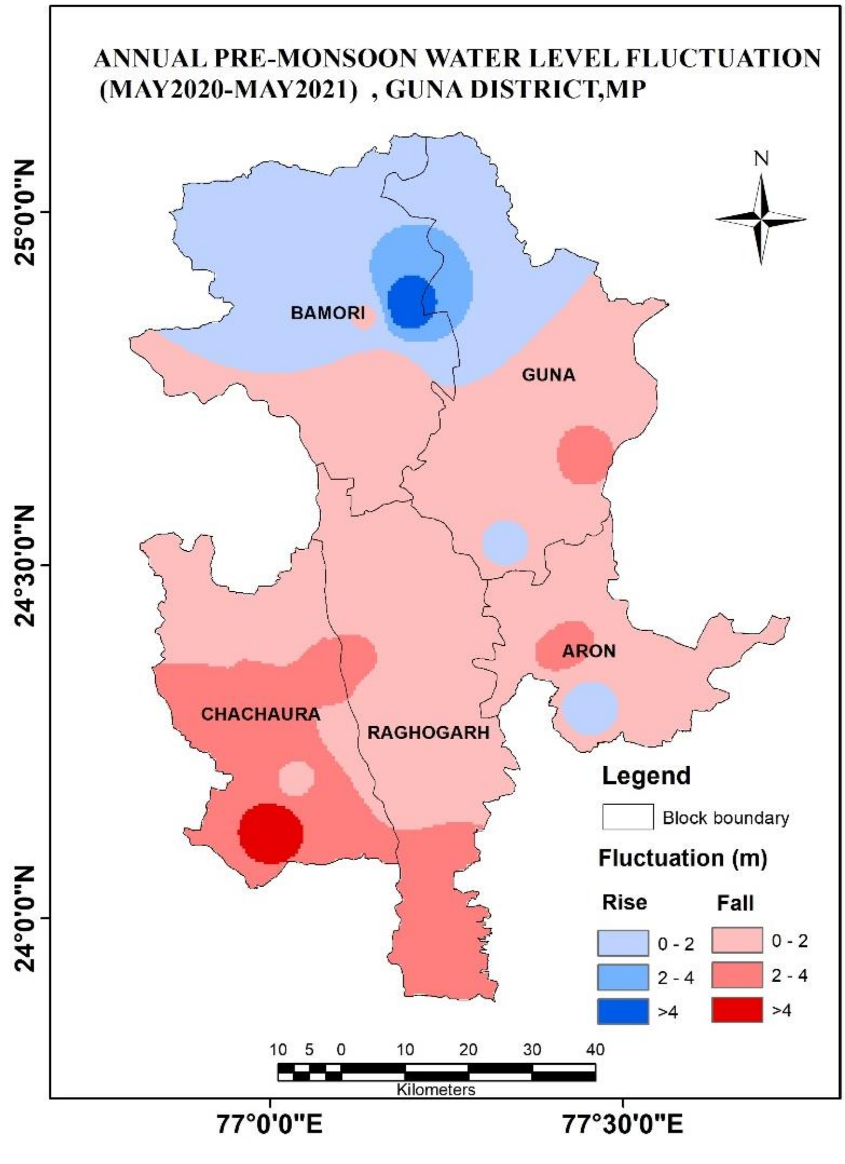


Fig 14: Water Level Fluctuation

2.4 HYDROGRAPH ANALYSIS:

Hydrographs are variations in groundwater level recorded systematically for a longer period of time, plotted in the form of a graph. The time series data of groundwater levels are cyclical with characteristics of seasonal variation. The variation in short term and long-term water level trends may be due to variation in natural recharge due to rainfall, artificial recharge, canal seepage and withdrawal of groundwater for various agricultural activity, domestic requirements and industrial needs. In general, the annual rising limbs the hydrographs indicate the natural recharge of groundwater regime due to monsoon rainfall, as the monsoon rainfall is the main natural source of water for recharge to the ground water regime. However, continuous increase in the groundwater draft is indicated by the recessionary limb.

The hydrographs of Rampur-I, Rampur-II, Pipalia, Pagara & Khatkiya observation wells represents the long-term water level trends of various part of Guna districts. The blue line indicate post - monsoon water level trend and red line indicate pre-monsoon water level trend. In all the five hydrographs, both the pre monsoon and post monsoon water levels are showing declining trend for the last two decades.

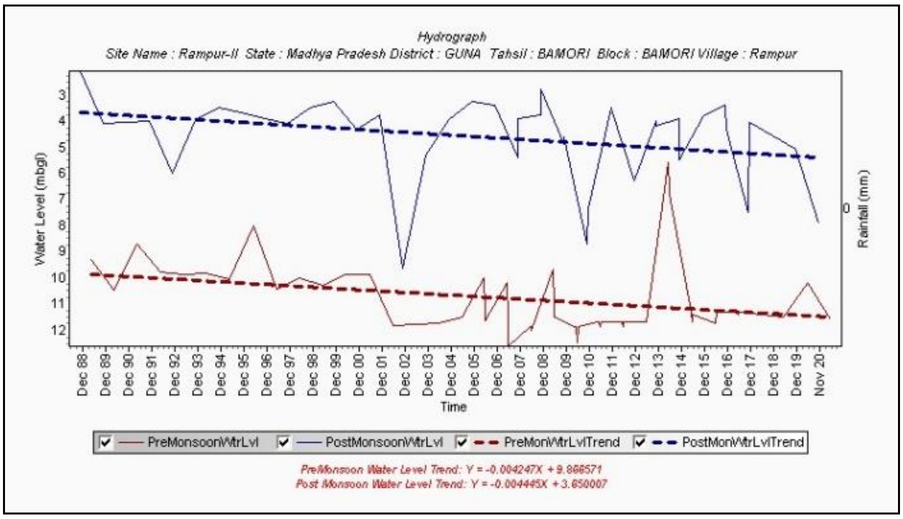


Fig15a: Hydrograph of Rampur -II station, Block Bamori,Guna district.

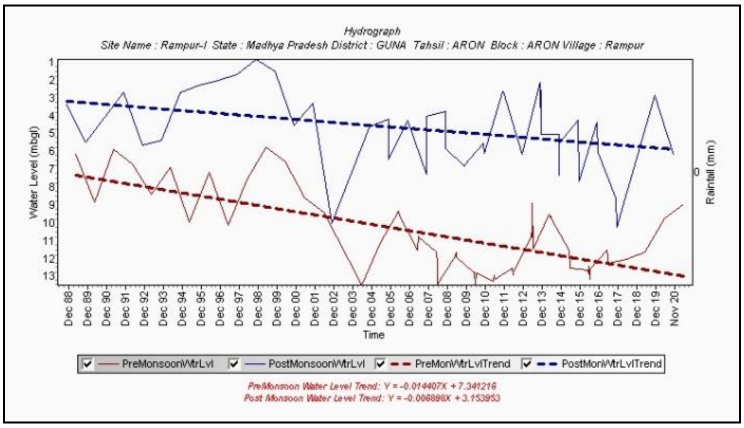
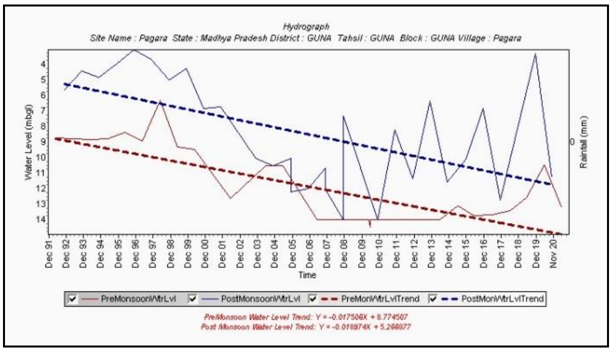


Fig15b: Hydrograph of Rampur -I station, Block Aron,Guna district.



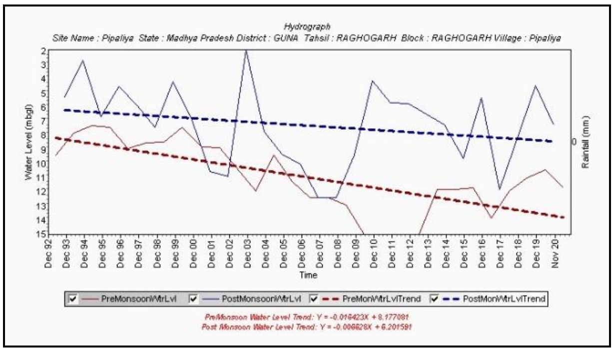


Fig15c: Hydrograph of Pipaliya station, Block Raghogarh,Guna district.

Fig15d: Hydrograph of Pagara station, Block Guna,Guna district.

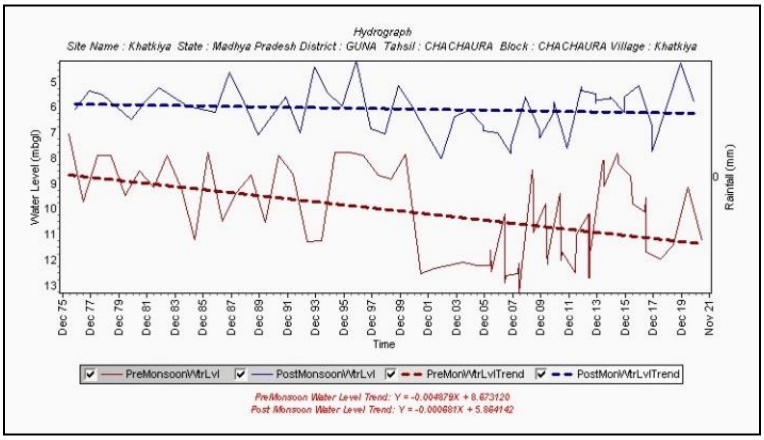


Fig15e: Hydrograph of Khatkiya station, Block Chachaura ,Guna district.

2.5 Ground Water Quality:

For the evaluation of hydrochemical status and distribution of various chemical constituents in ground water, a total of 27 water samples were collected from various observation wells located throughout the district during May 2020.

Major Quality Parameters

All the groundwater samples were analysed for basic hydrochemical parameters. The important in-situ parameters such as temperature, electrical conductivity (EC) and pH were tested at the site itself. The hydrochemical parameters examined in groundwater samples include pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH) as $CaCO_3$, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), sulphate (SO_4^{2-}), nitrate (NO_3^{-}), and fluoride (F^{-}) by using standard procedures prescribed by the American Public Health Association (APHA). The details are listed in table 5.

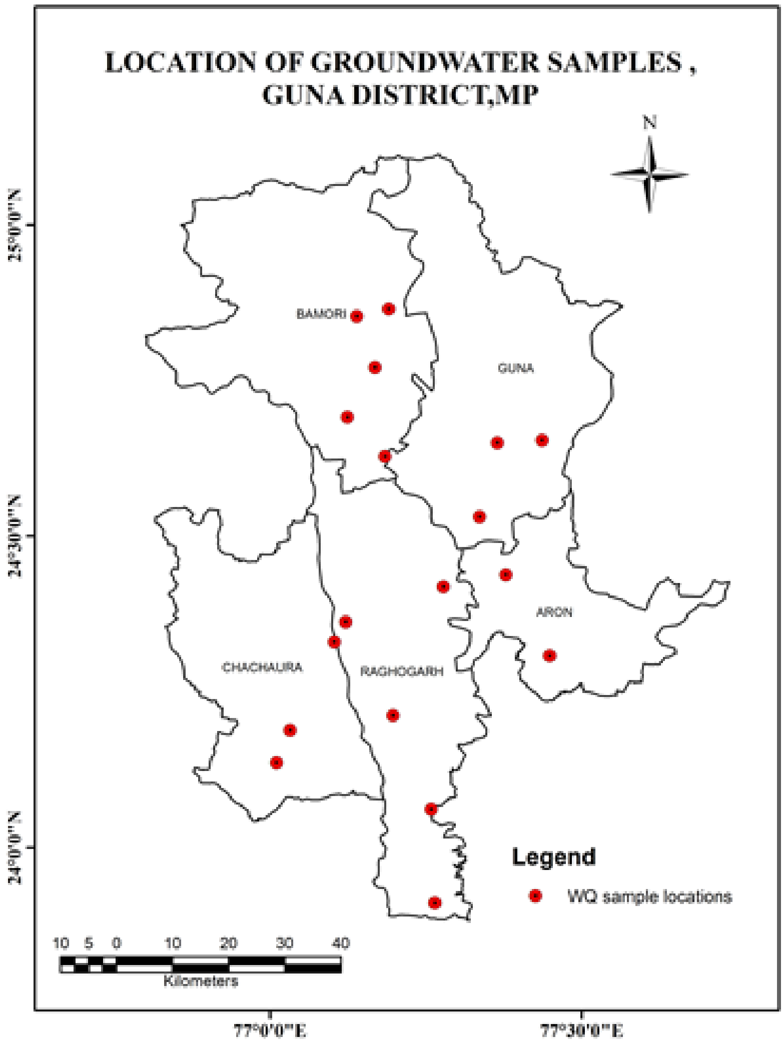


Fig-16: Groundwater Sampling locations , Guna district

Table 5: Water quality parameters

S. No.	District	Block	Location	Lat.	Long.	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K
						at 25 °C	µS/cm at 25 °C	mg/l												
1	Guna	Bamori	Akoda	24.865	77.19	7.76	435	0	201	23	6	8	0.16	BDL	32	153	40	13	27	1.9
2	Guna	Raghogarh	Amlia	24.212	77.197	7.94	1090	0	511	60	10	19	0.6	BDL	26	356	38	64	84	1
3	Guna	Aron	Aron	24.438	77.378	7.61	672	0	298	40	8	16	0.16	BDL	39	267	59	29	30	0.7
4	Guna	Bamori	Bamori New	24.853	77.139	8.11	460	0	189	30	11	20	0.23	BDL	58	193	50	17	15	1.3
5	Guna	Bamori	Berkheri	24.628	77.184	7.7	670	0	268	38	12	44	0.22	BDL	22	139	50	4	88	1.5
6	Guna	Chachaura	Binaganj	24.188	77.032	7.54	1100	0	280	203	8	15	0.06	BDL	44	485	119	46	28	1.4
7	Guna	Raghogarh	Gunjari	23.911	77.264	7.64	740	0	335	35	7	35	0.22	BDL	33	277	55	34	40	1.7
8	Guna	Guna	Jaitadongar	24.531	77.336	7.49	682	0	298	48	5	15	0.75	BDL	27	218	28	36	55	1.9
9	Guna	Raghogarh	Janjali	24.362	77.121	8.15	1820	0	596	253	20	3	0.36	BDL	44	312	42	51	272	3.3
10	Guna	Raghogarh	Khairai	24.419	77.278	7.38	368	0	146	33	8	4	0.02	BDL	42	163	44	13	8	0.7
11	Guna	Chachaura	Khatkiya	24.33	77.103	7.71	750	0	298	65	10	14	0.32	BDL	41	292	55	37	36	1.1
12	Guna	Raghogarh	Maksudangarh	24.061	77.258	7.92	600	0	292	25	5	18	0.35	BDL	26	228	42	30	32	0.9
13	Guna	Guna	Pagara	24.654	77.436	7.62	850	0	444	23	12	8	0.27	BDL	32	272	38	43	68	1.6
14	Guna	Chachaura	Penchi	24.136	77.01	7.61	1300	0	280	250	25	35	0.1	BDL	31	540	95	73	48	1.2
16	Guna	Aron	Rampur-I	24.308	77.448	8.19	1075	0	402	130	6	2	0.25	BDL	33	262	46	36	118	9.2
17	Guna	Bamori	Rampur-II	24.771	77.168	8.08	505	0	225	33	10	7	0.17	BDL	25	188	36	24	27	3.2
18	Guna	Guna	Singwasa	24.65	77.364	7.98	809	0	140	70	132	40	0.02	BDL	24	312	51	45	38	3.1
19	Guna	Bamori	Suhaya New	24.691	77.124	7.64	615	0	274	23	10	38	0.23	BDL	32	228	22	42	35	1.2

2.6 GEOPHYSICAL:

A total of 124 VES were conducted in Guna districts (Fig17). The interpreted results of the 124 nos. of VES are given in Annexure-III. In the basalt occupied area of the district 89 VES were conducted. Out of these at 64 VES sites weathered zone is delineated (Annexure-IV).

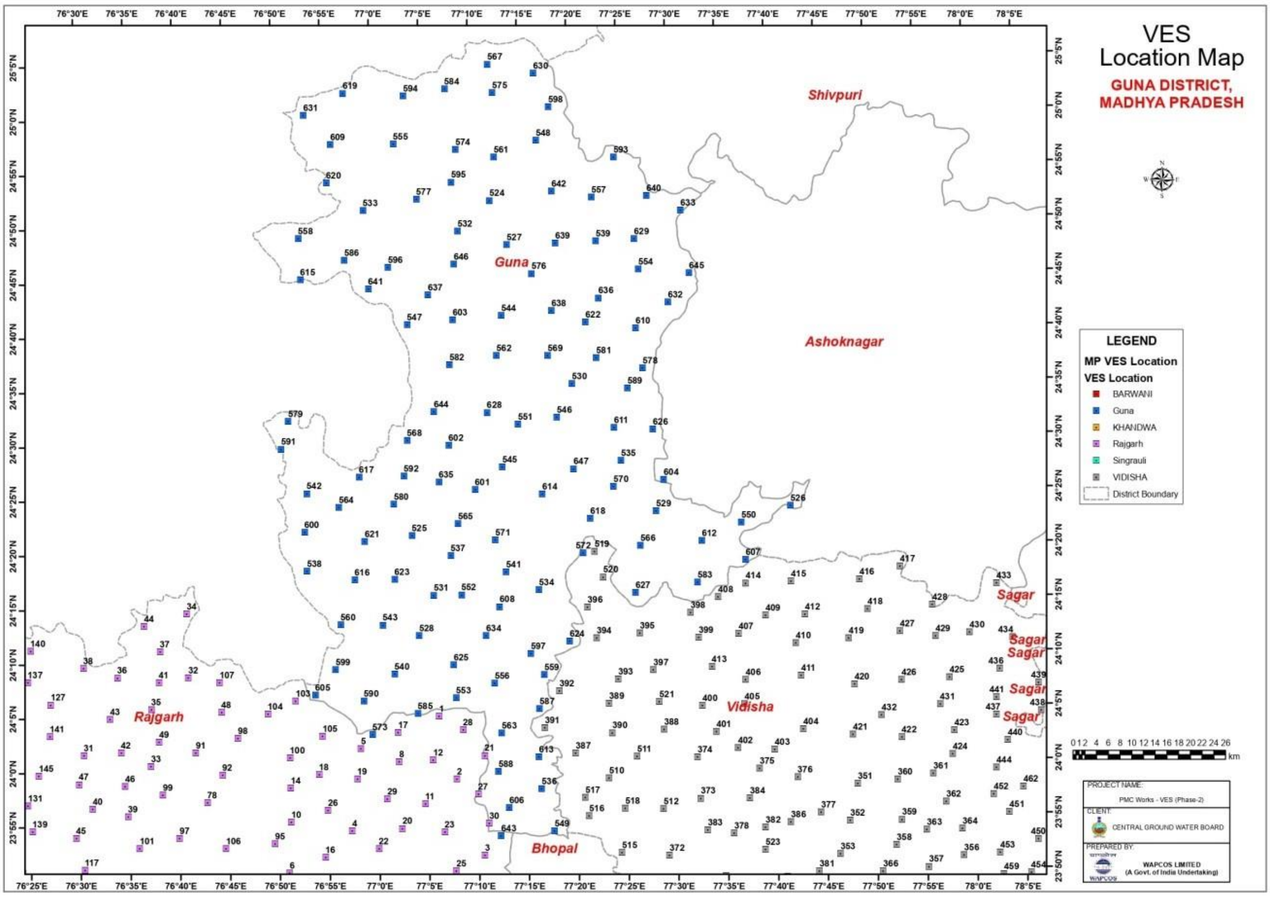


Figure 17: Map of Guna district showing VES locations

The resistivity of the weathered zone ranges from 2 to 40 ohm.m. It extends to a maximum depth of 47 m at VES 578. At 28 sites it is more than 10 m and can be tapped by dug wells. However, out of these 64 sites at 36 sites the resistivity is less than 10 ohm.m. It indicates the possible deterioration in water quality or increase in soil salinity. The weathered zone is underlain either by a highly resistive massive basalt layer or by a layer with resistivity higher than that of the weathered zone. In either case it is not possible to delineate the deeper vesicular and massive fractured basalt associated with lesser resistivities. Instead, a geoelectrical layer of varied thickness is delineated which cumulatively represents the succession of vesicular-massive –fractured basalt. The resistivity of this geoelectrical layer could be 20 ohm.m, an indicator for the possible presence of fractured basalt. Total 73 sites this vesicular- fracture basalt layer is detected. A range of resistivity value obtained for this layer is 5 to 180 ohm.m. A resistivity value less than 50 ohm.m for this geoelectrical layer is preferred. At 65 sites this geoelectrical layer was delineated. Only at 8 sites the resistivity is more than 50 ohm.m. At 12 VES sites resistivity values less than 10 ohm.m was inferred. It could be associated with deeper occurrences of poor quality water as well the presence of Red Bole (clay). The depth to the bottom of this geoelectrical layer is maximum 209 m at VES 525 and the minimum 17 m at VES 569 . The qualitative analysis has indicated the presence of thin fractured zones at different depths.

The Vindhyan sandstone and Shale are exposed over a wide area covering the entire northern part of the district. Entire Bamori block and some part of Guna block falls in this geology. Thirty five VES were conducted in Vindhyan Sandstone and Shale area. Out of these at 22 VES sites weathered zone is present. The resistivity of the weathered zone ranges from 1 to 66 ohm.m. The maximum depth to the bottom of the weathered zone is about 36 m at VES 622. At 9 sites it is more than 10 m and can be tapped by dug wells. However, out of these 22 sites at 13 sites the resistivity is less than 10 ohm.m. It indicates the possible deterioration in water quality or increase in soil salinity. Only at 17 VES sites the semi-weathered zone is delineated. The resistivity of the semi-weathered zone ranges from 17 to 632 ohm.m and maximum depth to its bottom is 215 m. It is better to consider VES sites where thick semi-weathered zone with resistivity within 50 to 60 ohm.m is delineated. At deeper levels the hard and compact rocks are fractured and jointed and formed potential aquifers. Using the empirical approaches the thin fractured zones in different depth ranges have been delineated at 21 VES sites (Annexure-v). The fractured zones are qualitative inferred. All the fractured zones need not be productive.

Out of these 89 VES is located in Deccan trap basalt formation and is expected to hold potential aquifers in the weathered zone as well as deeper fractured zones. The Vindhyan group of rocks comprising sandstone, shale and limestone are highly compact and possibility of encountering potential aquifer is meagre in weathered sandstone and shale beds. But at deeper levels the fractured and jointed Vindhyan formations are expected to hold good aquifers. As such based on the interpreted results of VES sites are recommended for borehole drilling and dug well. The list of sites is given in Annexure-V for recommendation of ground water structure in Basalt formation and Annexure-VI for Vindhyan formations respectively.

Chapter-III

3.DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1. HYDROGEOLOGICAL DATA

AQUIFER DISPOSITION

The data generated during ground water exploration by constructing exploratory wells/observation wells were 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 (figure 18). Total seven exploratory wells are constructed in Bamori block of Guna district in 2021-22. All the constructed EW 's falls in the sandstone part of Bamori block and fractured sandstone forms the major aquifer in the area. Ground water occurs in two zones, one is weathered/ fractured sandstone which is encountered within 100 m depth below ground level and the second one is deep fractured sandstone/contact zone which is encountered after 150m bgl. The elevation of the model area falls in the range from 370 m amsl to 450 m amsl (fig:18). Based on the existing exploration dataset, aquifer disposition in 3D strip logs, Fence diagram of Guna district have been prepared for understanding the subsurface disposition of aquifer system which is shown in Figure : 19,20,21. To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A', B-B' are shown in figures 22.

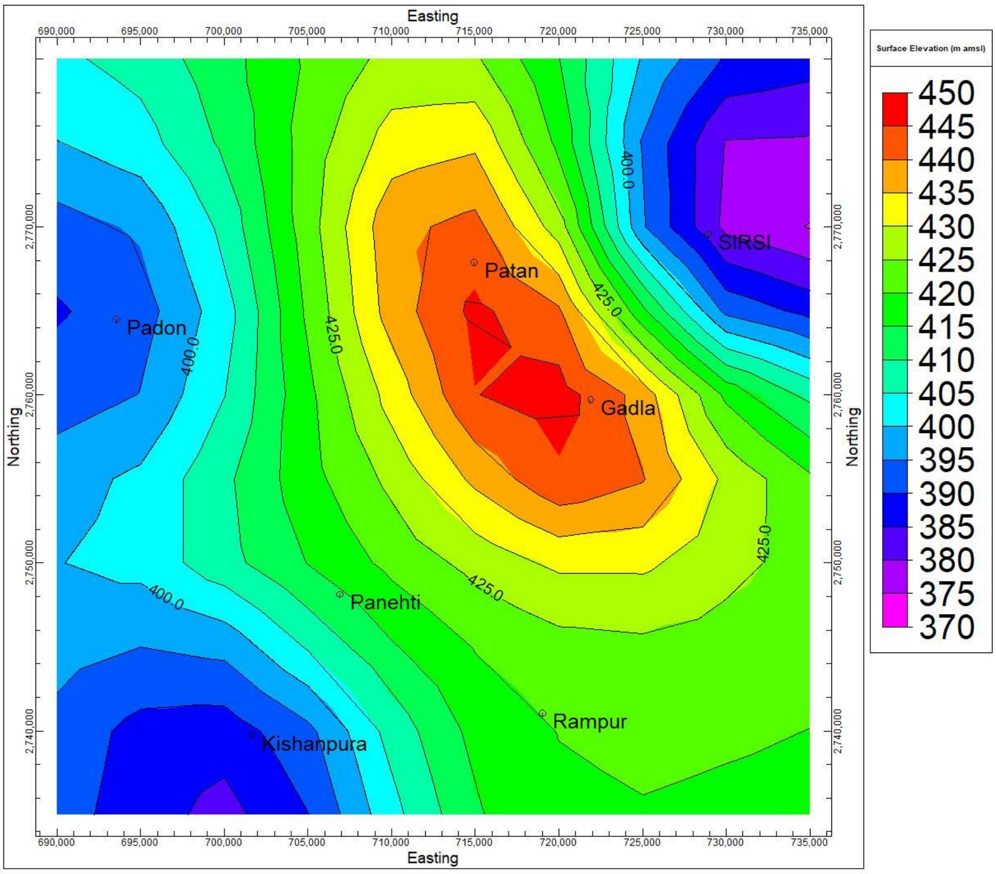


Fig18: Surface Elevation Contours of the model area

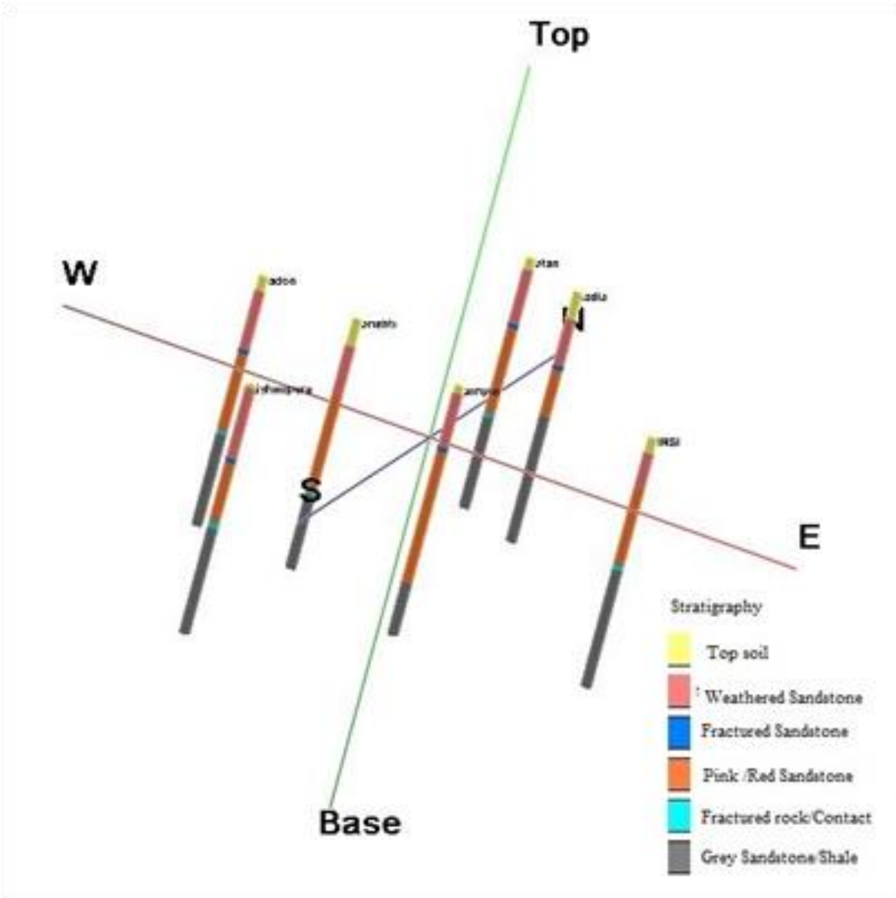


Fig19: Striplogs

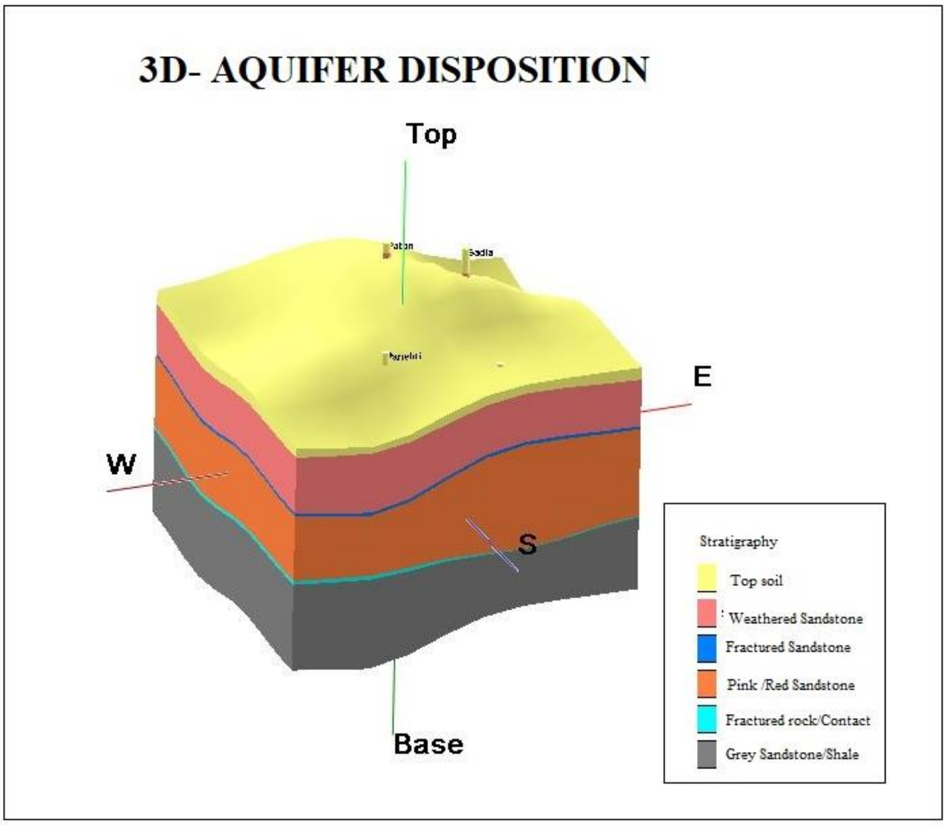


Fig20: 3D aquifer disposition

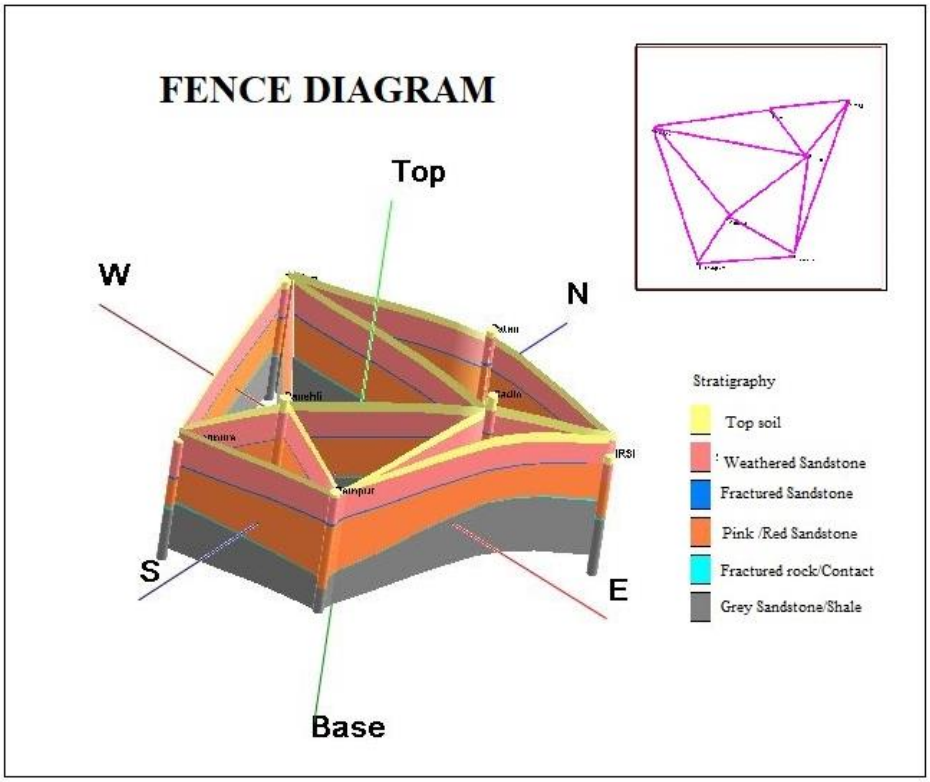


Fig21: 3D aquifer disposition

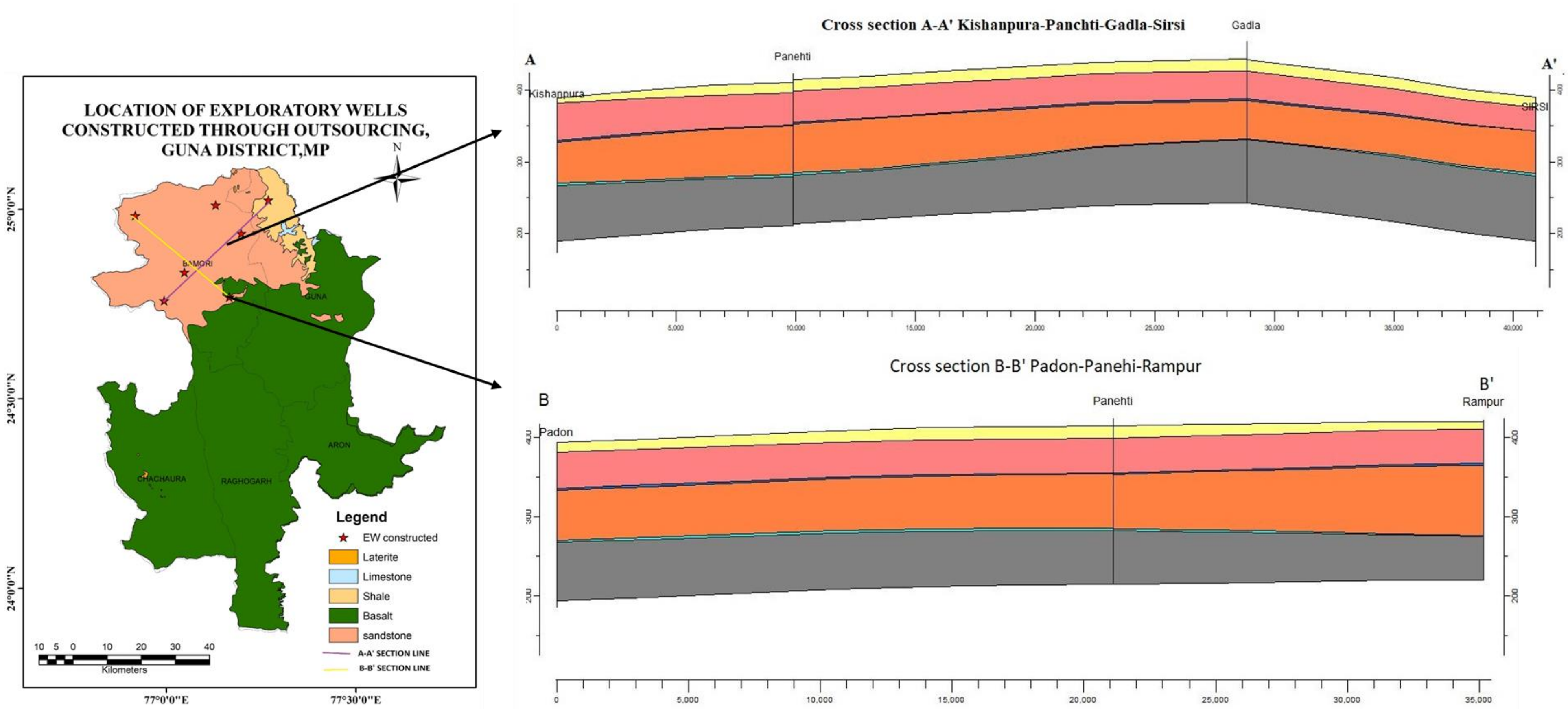


Fig22: Cross sections along A-A' and B-B'

3.2 HYDROCHEMICAL DATA INTERPRETATION

Quality of Ground Water for Drinking Purpose:

The ground water samples from Guna district have varied range of pH from 7.38 to 8.19. As per BIS (IS 10500 : 2012) recommendation, all the water samples have pH recorded within the permissible limits of 6.5 to 8.5, the maximum pH recorded in the water sample of Rampur-I (8.19). The pH of ground water can be assessed as neutral to slightly alkaline in nature. The electrical conductivity of ground water samples in Guna district varies from 368 to 1820 µS/cm at 25°C. The electrical conductivity from Guna district shows variability, one location from Janjali villages shows EC more than 1500 µS/cm i.e. 1820 µS/cm, while 4 locations sample shows EC in between 1000 to 1500 µS/cm; 11 locations sample EC is below 1000 µS/cm. So, overall ground water quality in Guna district is good.

The fluoride concentration in Guna district lies in between 0.02 to 0.75 mg/l, which represent that all the samples are within the permissible limit of 1.5 mg/l as per BIS (IS 10500 : 2012). The maximum concentration of fluoride has been observed in the village of Jaitadongar i.e. 0.75 mg/l. Nitrate concentration in ground water samples of Guna district fall in between 2 to 44 mg/l. It shows that the all samples within the acceptable limit of 45 mg/l. The maximum concentration of nitrate has been observed in the village of Berkheri i.e. 44 mg/l. The range of Total Hardness (as CaCO3) concentration in ground water samples is 139 to 540 mg/l. The maximum concentration of Total hardness has been observed in the village of Penchi (540 mg/l).

Evolution of the hydrochemical parameters of groundwater can be understood by plotting the concentrations of major cations and anions in Piper Trilinear Diagram. The Piper Trilinear diagram consists of three distinct fields among which right triangle is cation (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}), left triangle anions (CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-}) and top diamond shaped field helps to decides the water type through the percentage concentration of cations and anions. Piper diagram has three parts: a Cation triangle, an Anion triangle, and a Central diamond-shaped field. In Cation triangle, the relative percentages of the major cations (Ca2+, Mg2+, Na+, K+) are plotted. In Anion triangle the major anions (HCO3-+CO32-, SO42-, Cl-) are plotted. These points are then projected to the central diamond shaped field.

In the district; piper diagram shows that the 26% of samples of ground water samples are Mixed type whereas 74% samples shows nature of water as Calcium-Bicarbonate type, hence show temporary hardness features. (Fig23)

Quality of Ground Water for Irrigation Purpose:

In classification of water for irrigation purpose, it is assumed that the water will be used for irrigation purpose based upon its soil texture, infiltration rate, drainage and climate. The chemical data of all the water samples from Guna district is plotted on U.S. Salinity Laboratory diagram.

In the district USSL diagram shows that the 61% wells of study area are observed under C2-S1 Class (Medium Salinity & Low Sodium) which means that these waters can be used for irrigation purpose for most of the crops, 6% of ground water samples fall under C3-S1 class (High Salinity & Low Sodium). whereas 33% of ground water samples fall under C3-S2 class (High Salinity & Medium Sodium). The water from C3-S2 class (High Salinity & Medium Sodium) may be used for irrigation purpose under proper soil management(fig24).

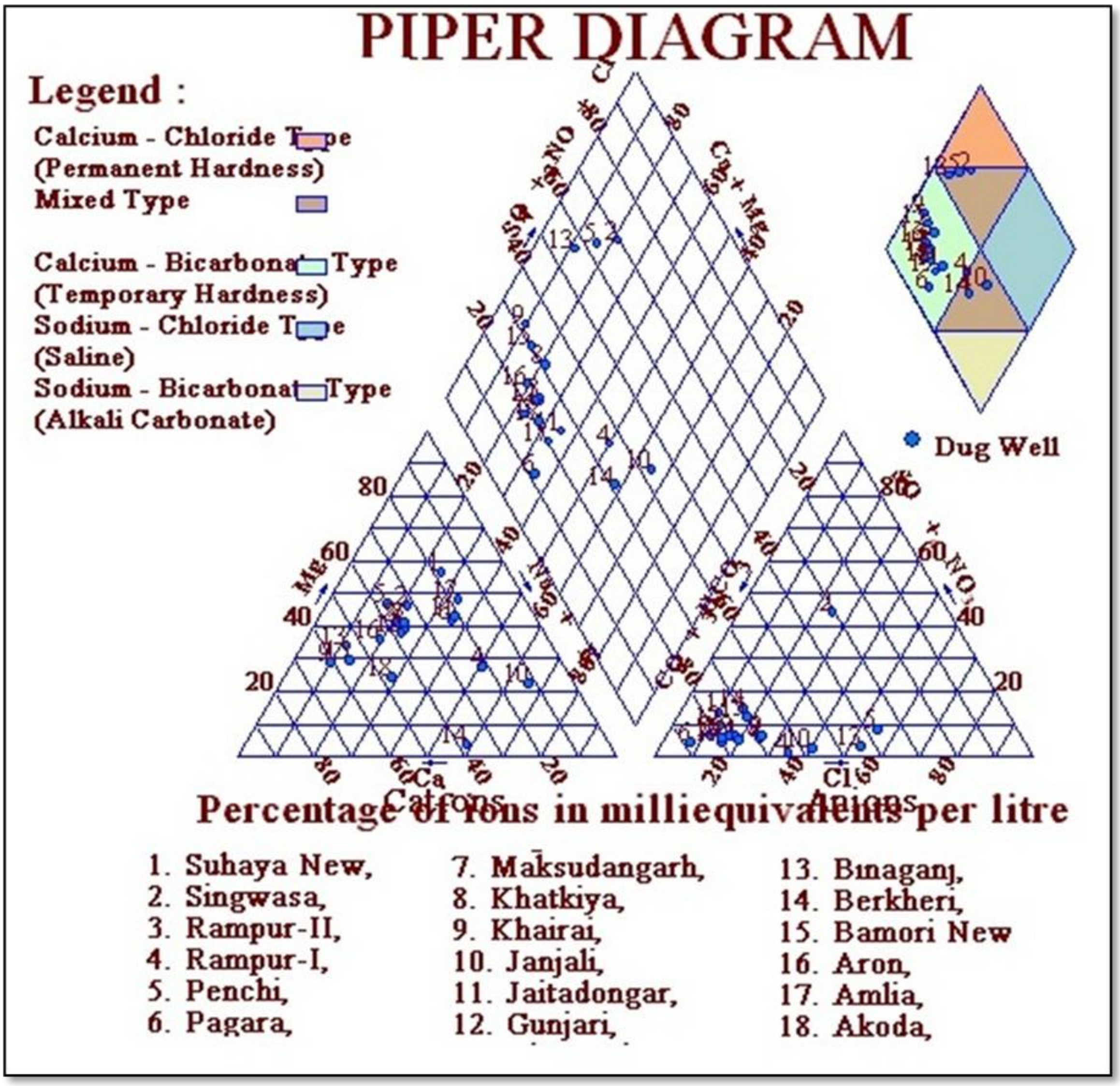


Fig 23: Hill Piper Diagram representing classification of water samples collected from National Hydrograph Stations, Guna District, Madhya Pradesh

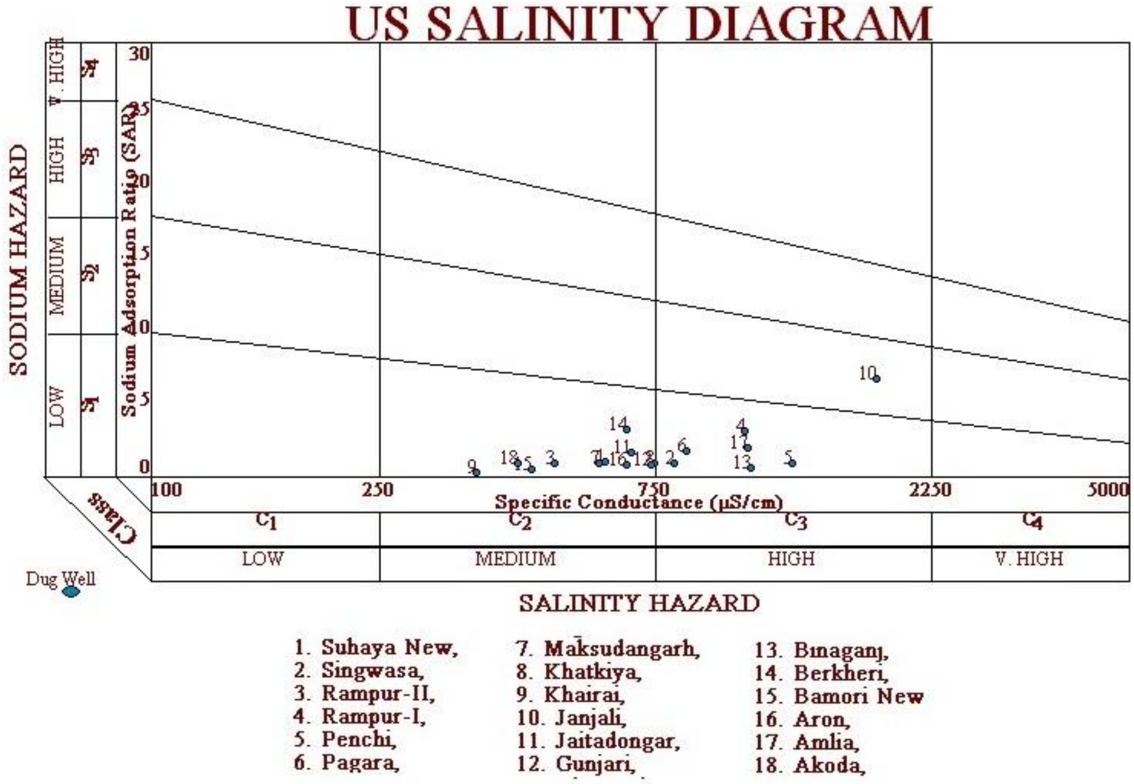


Fig 24: US Salinity Diagram for water samples collected from National Hydrograph Stations of Guna District, Madhya Pradesh

3.3 GEOPHYSICAL STUDIES:

In hard rock areas comprising basalt, granite gneiss, schist, quartzite, and phyllite etc. preparation of cross-sections and fence diagram has no usefulness and not justified because of the rapid hydrogeological variations. However, Cross sections, Fence Diagram and 3D model has been generated with very limited practical applicability. The Cross sections, Fence Diagram and 3D model analysis up to depth 200mbgl.

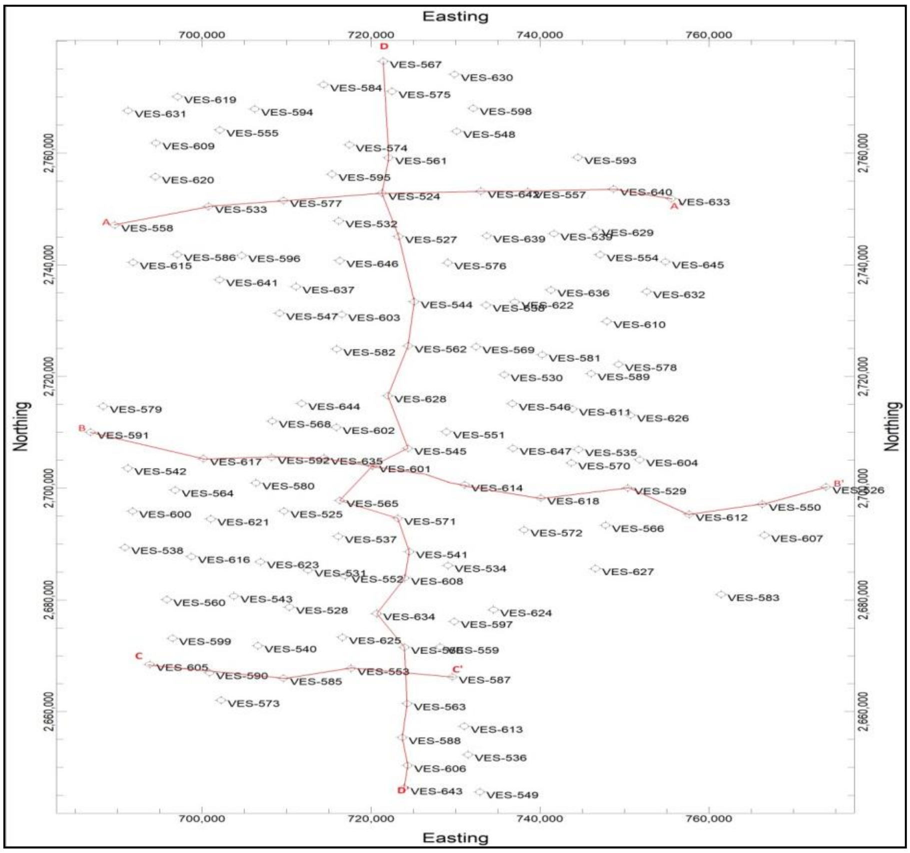


Figure 25: VES Location and Geoelectrical Cross Section AA’, BB’ ,CC’,DD’ Guna District

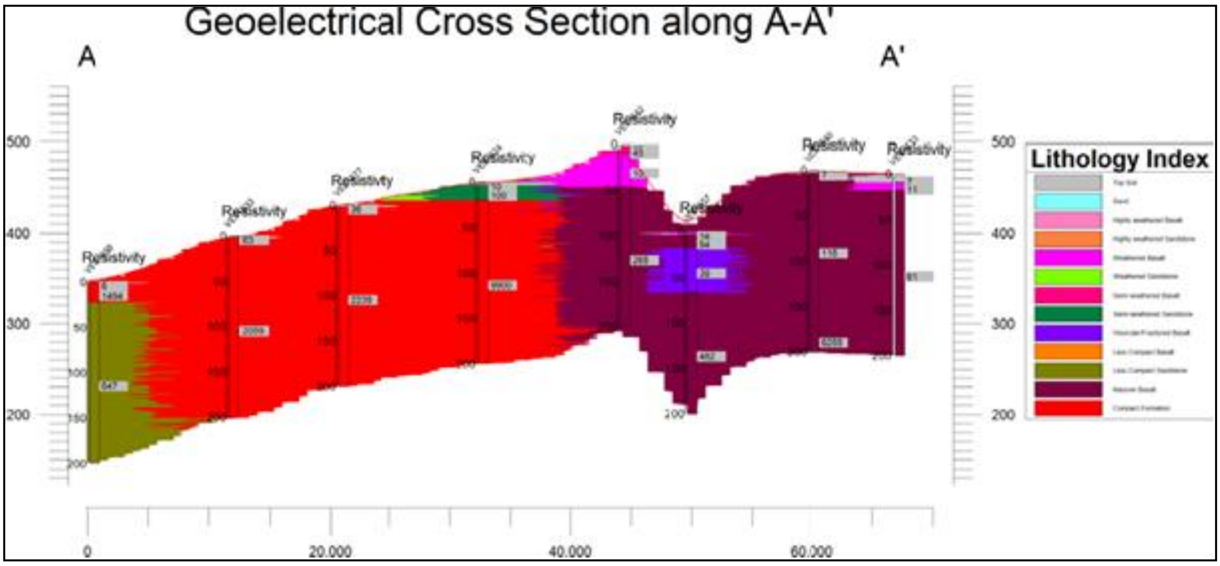


Figure 26: Geoelectrical Cross Section Along A-A', Guna District

Cross section AA' has been prepared in Guna district passing through the VES NOs 558, 533, 577, 524, 642, 557, 640 and 633. in W-E direction. In this section VES nos. 558, 533, 577 and 524 are in sandstone formation, the depth to the bed rock varies from 1m to 3m. And remain VES nos. 642, 557, 640 and 633 are in basaltic formation . Weathered basalt depth ranges 3-46 m and resistivity ranges 10-28 ohm.m. From the interpretation result analysis the VES no 642 found that deeper weathered formation depth up to 46 mbgl.

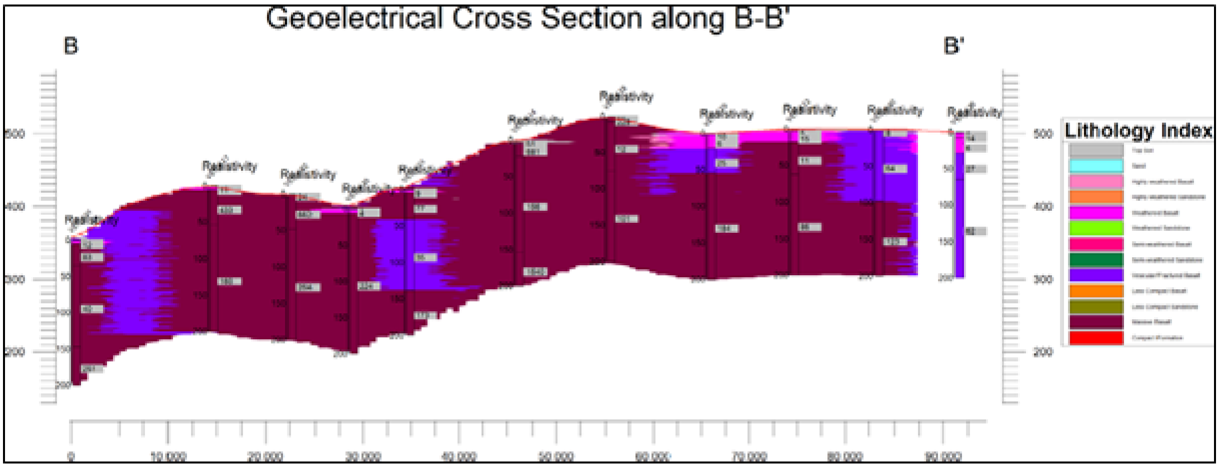


Figure. 27: Geoelectrical Cross Section Along B-B', Guna District.

Cross section BB' has been prepared in Guna district passing through the VES NOs 591, 617, 592, 635, 601, 614, 618, 529, 612, 550 and 526. in NW-SE direction. All the VES in this section found in basalt formation (weathered and vesicular basalt formation). From VES in this section found that depth to the weathered formation varies from depth range 3-29 mbgl and resistivity range 4- 15 ohm.m and vesicular basalt depth range 8 -154 mbgl and resistivity range 11 -160 ohm.m . the weathered formation found maximum depth 29m at VES no. 526 below this layer found vesicular and massive basalt. The vesicular basalt formation found maximum depth 147 mbgl at VES no.591 .

From VES in this section found that depth to the weathered formation varies from depth range 4 - 18 mbgl and resistivity range 5- 51 ohm.m and vesicular basalt depth range 83 -153 mbgl and resistivity range 34 -105 ohm.m . The weathered formation found maximum depth 18mbgl at VES no. 585 below this layer found vesicular and massive basalt. The vesicular basalt formation found more depth 153 mbgl in VES no.590 Below this depth found massive basalt. Overall observation in this Cross section CC', found that shallow weathered basalt throughout the section . along Eastern direction near VES 553 found vesicular basalt and below this massive basalt.

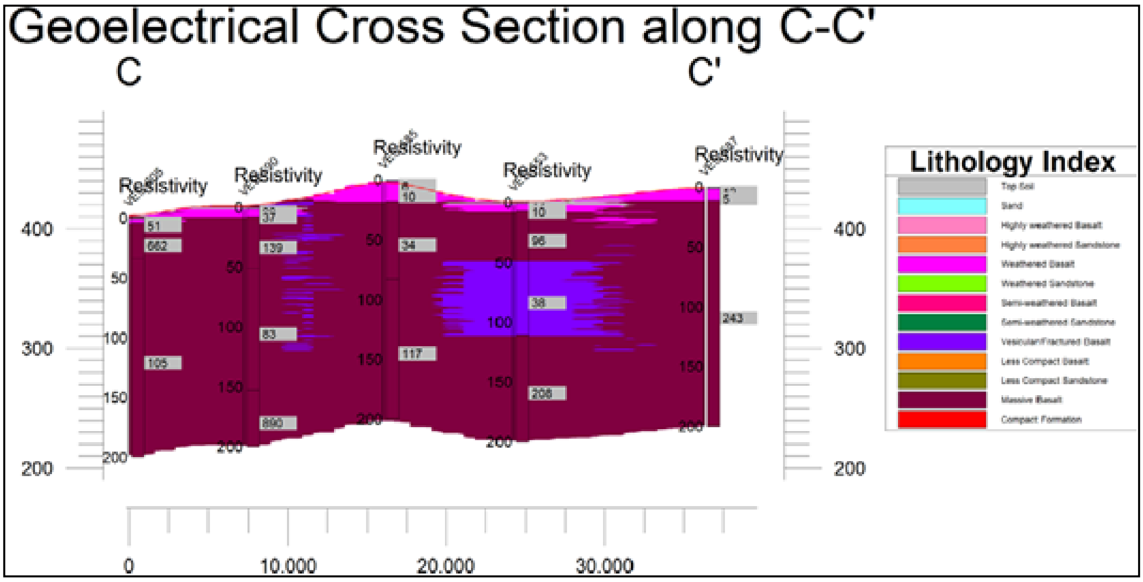


Figure 28: Geoelectrical Cross Section Along C-C', Guna District.

Cross section CC' has been prepared in Guna district passing through the VES NOs 605, 590, 585, 553 and 587 in W-E direction. All the VES in this section found in basalt formation (weathered and vesicular basalt formation). From VES in this section found that depth to the weathered formation varies from depth range 4 - 18 mbgl and resistivity range 5- 51 ohm.m and vesicular basalt depth range 83 -153 mbgl and resistivity range 34 -105 ohm.m . The weathered formation found maximum depth 18mbgl at VES no. 585 below this layer found vesicular and massive basalt. The vesicular basalt formation found more depth 153 mbgl in VES no.590 Below this depth found massive basalt. Overall observation in this Cross section CC', found that shallow weathered basalt throughout the section . along Eastern direction near VES 553 found vesicular basalt and below this massive basalt.

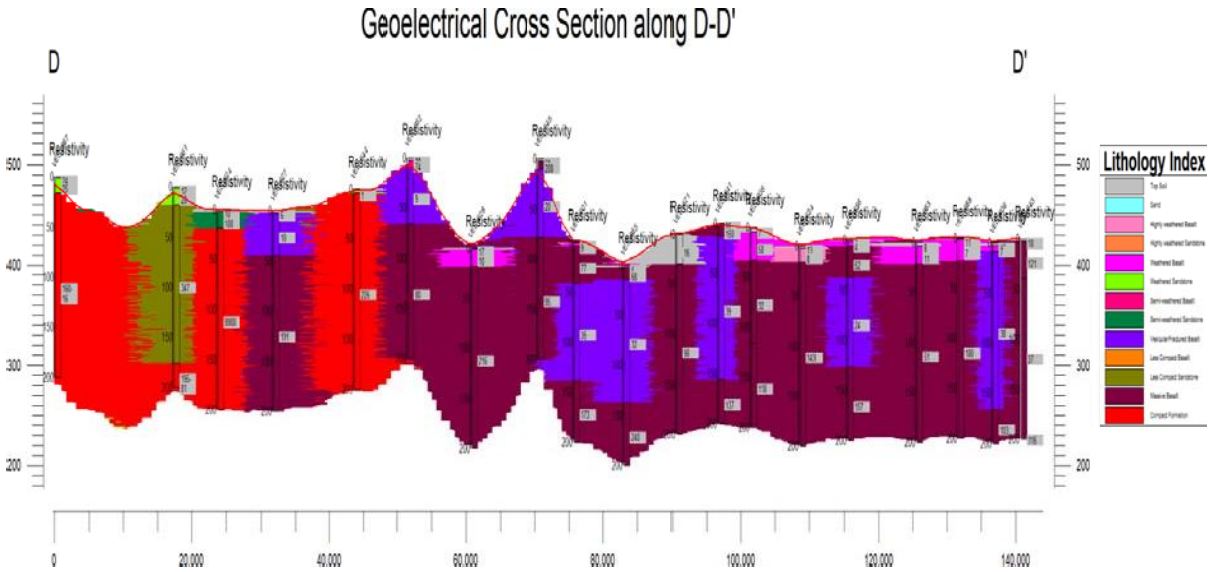


Figure 29: Geoelectrical Cross Section Along D-D', Guna District

Cross section DD' has been generated passing through the VES NOs 567, 561, 524, 527, 544, 562, 628, 545, 601, 565, 571, 541, 608, 634, 556, 563, 588 606 and 643. in N-S direction. In this section some VES points 567, 561, 524 and 544 are in the vindhayan sandstone formation and remain VES Points like 527, 562, 628, 545, 601, 565, 571, 541, 608, 634, 556, 563, 588, 606 and 643 are in basalt formation. Depth to Weathered sandstone ranges 3-18 mbgl and resistivity ranges 10-28 ohm.m . depth to the weathered basalt ranges 4-44mbgl and resistivity range 4-16 ohm.m, and vesicular basalt depth range 66-194mbgl and resistivity range 9-39ohm.m. in this section maximum depth of weathered sandstone found at VES 561, depth range up to 18mbgl and also maximum weathered basalt found at VES 527, depth range up to 44mbgl. in this section vesicular basalt found in some VES points , maximum depth found at VES 643 .

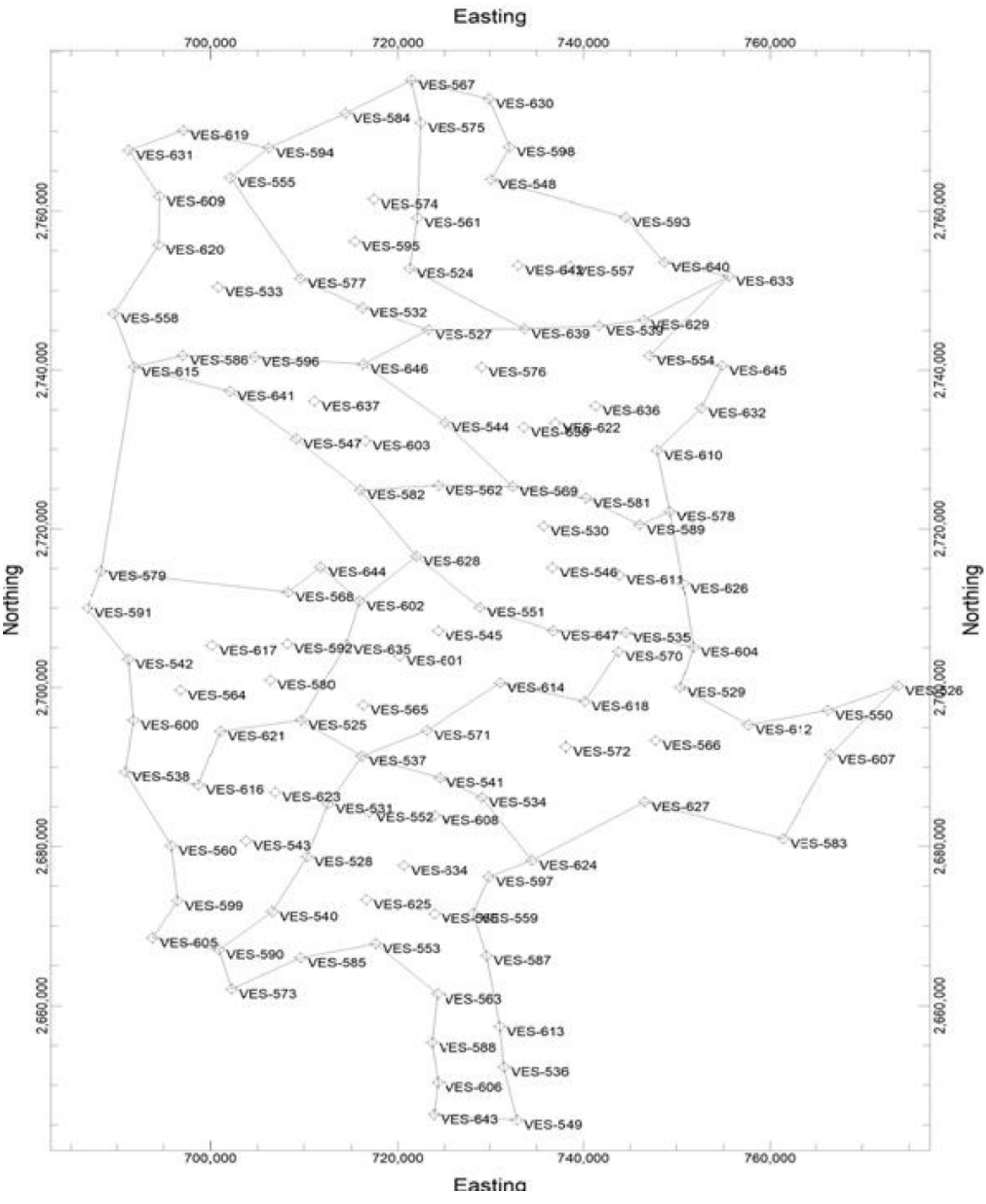


Figure 30: Lithological Fence Location Map with VES no. Guna, District

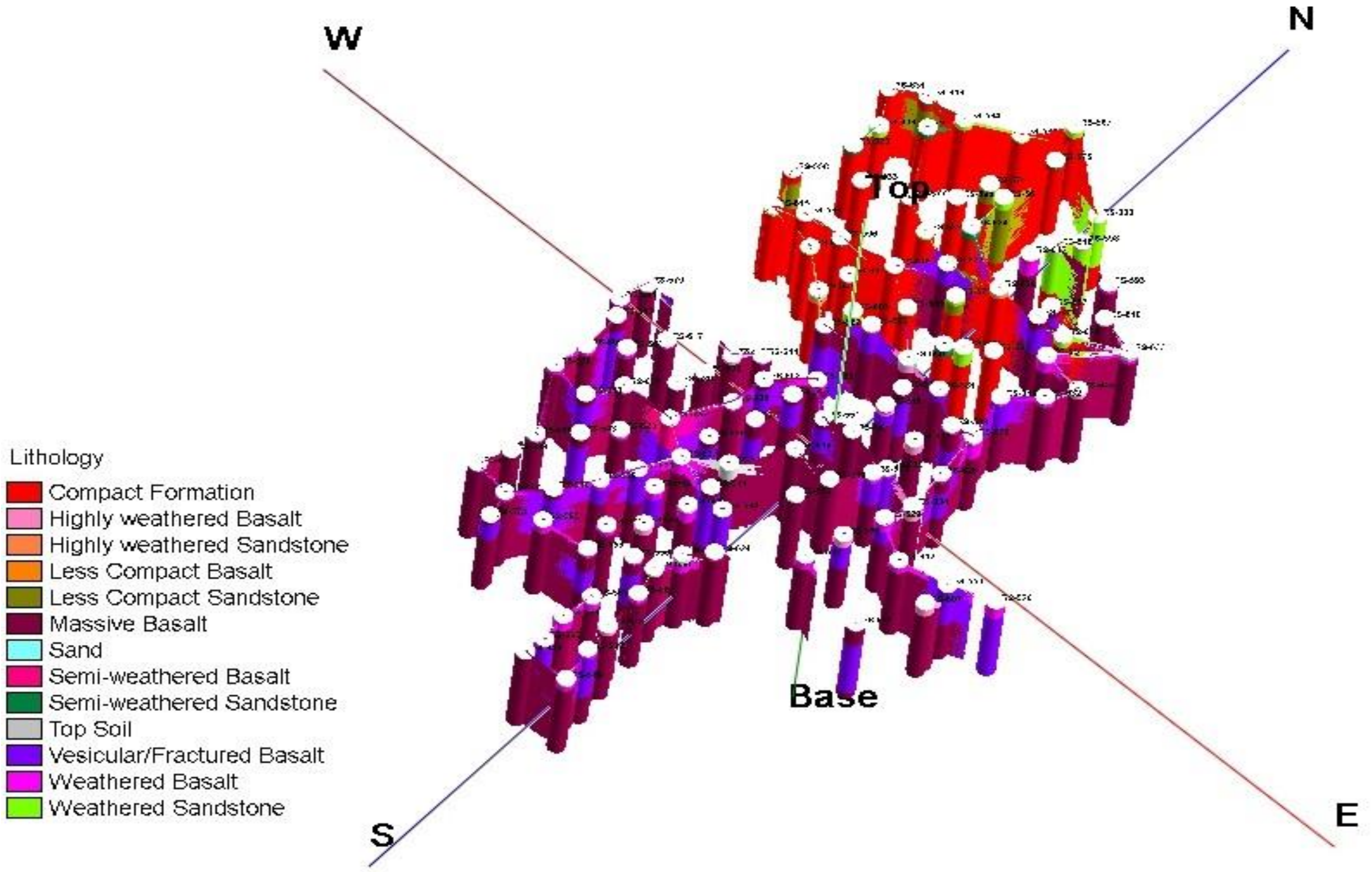


Figure 31: Lithological Fence Diagram, Gunna District

From Lithological Fence Diagram of Gunna District, observed that Northern and NW site compact formation and some VES points in Northern site shallow weathered sandstone, below this layer compact formation. Another site observed from fence diagram like; Southern ,SE and SW site found that shallow weathered basalt , shallow and deep vesicular basalt and below layer massive basalt formation.

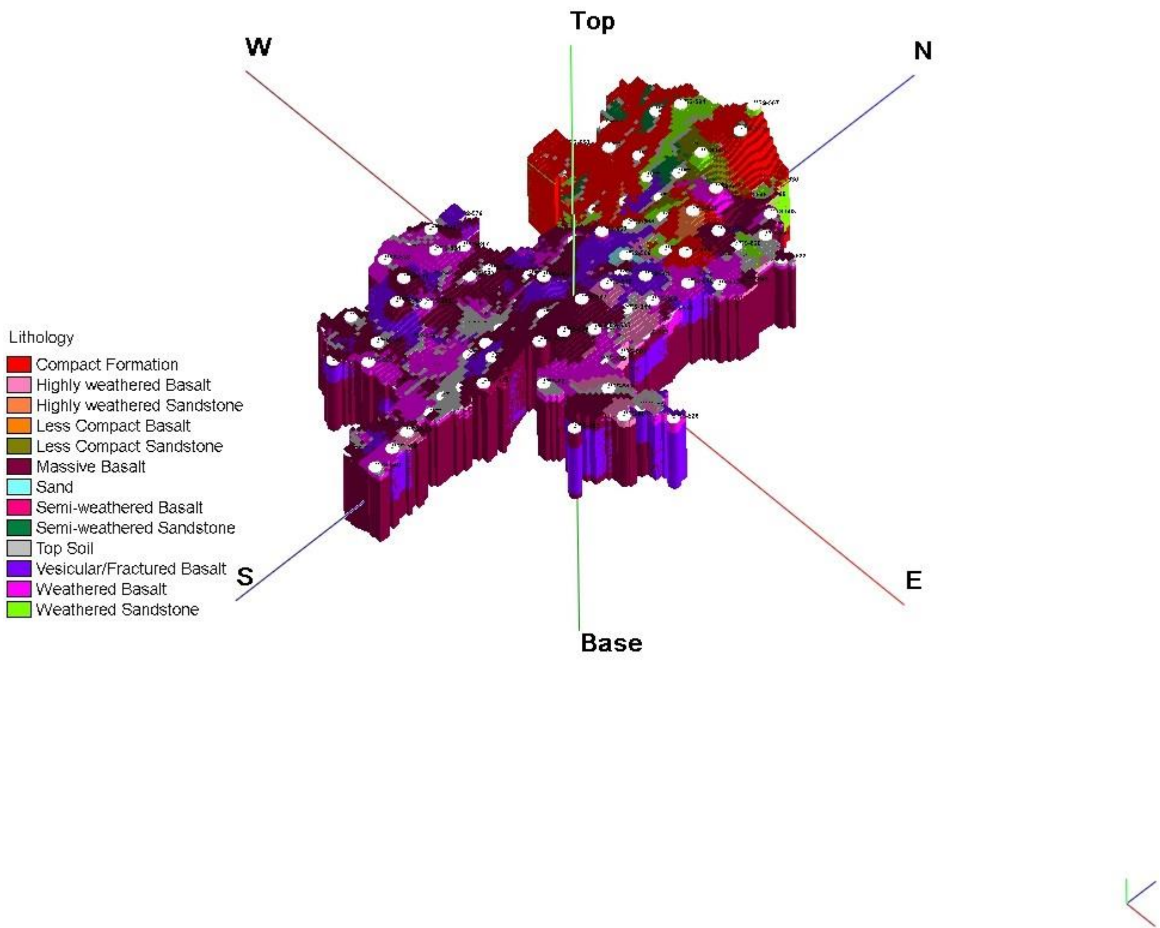


Figure 32: Lithological 3D Model, Gunna District

From Lithological 3D Model, of Guna District, observed that Northern and NW site compact formation and some VES points in Northern site shallow weathered sandstone, below this layer compact formation. Another site observed from fence diagram like; SE and SW site found that shallow weathered basalt , shallow and deep vesicular basalt vesicular basalt and below layer massive basalt formation.

Chapter-IV

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4. GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resources:

The dynamic ground water resources of the Madhya Pradesh State assessed jointly by the CGWB and State Ground Water Departments under the supervision of the State level Committees. The base year of computation of the resources is 2019-20.

The groundwater resources are calculated on the basis of recharge to groundwater from various sources viz. rainfall, inflow from various surface water bodies, return flow from irrigation etc. Similarly draft of groundwater for different uses viz. domestic water supply, industrial and irrigation requirement forms the basis of resource estimation. The dynamic ground water resources are also known as Annual Replenishable Ground Water Resources since it gets replenished/ recharged every year. The Annual Extractable Groundwater recharge is 75265.86 (Ham) for Guna district. The major source of ground water recharge is the monsoon rainfall. Block -wise Ground Water Resources of Guna District as on March, 2020 is given in Table No 6 and the presents the over-all scenario of ground water resource utilization and availability of the district. The contribution from other sources such as canal seepage, return flow from irrigation, seepage from water bodies etc in Annual Replenish able Ground Water Resource is more than of 24 % in the state.

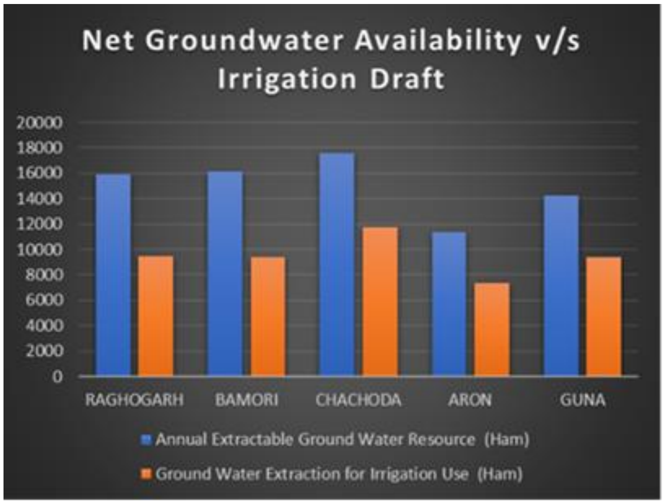
The assessment of ground water draft is carried out based on the Minor Irrigation Census data and sample surveys carried out by the State Ground Water Departments.

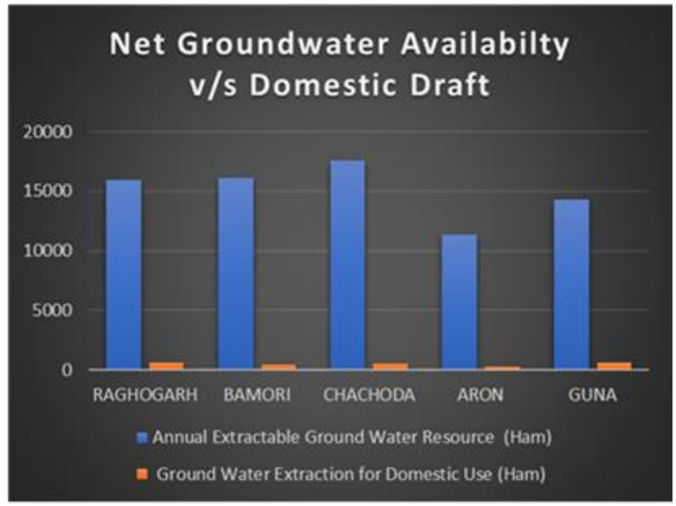
The Annual Ground Water Draft of the entire district for 2019-20 has been estimated as 49694.84 ham. Agriculture sector remained the predominant consumer of ground water resources. About 95.2 % of total annual ground water draft i.e. 47286.67 ham is for irrigation use. Only 2408.17 Ham is for Domestic & Industrial use which is about 4.8% of the total draft. An analysis of ground water draft figures indicates that in Guna district stage of ground water development is **66.03%**.

The stage of ground water development is slightly high in the two blocks i.e Chachoda (69.6%) & Aron (69.9%) implies that in these blocks the annual ground water extraction is more than annual ground water recharge. List of categorizations of Blocks / Districts is given in Table No 6.

Table 6. Dynamic Ground Water Resource (Zone of Fluctuation)

District	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-ExploitedE/ Critical/Semicritical/Safe/Saline)
GUNA	RAGHOGARH	124136	15923.26	9499.38	0	582.1721	10081.55	676.7	5747.18	63.3	safe
GUNA	BAMORI	158848	16117.94	9367.57	0	448.8909	9816.46	507.97	6242.4	60.9	safe
GUNA	CHACHODA	119318	17556.71	11713.22	0	515.8852	12229.11	568.43	5275.06	69.7	safe
GUNA	ARON	78883	11386.58	7312.83	0	272.7733	7585.6	294.11	3779.64	66.6	safe
GUNA	GUNA	157815	14281.37	9393.67	0	588.4508	9982.12	668.77	4218.93	69.9	safe





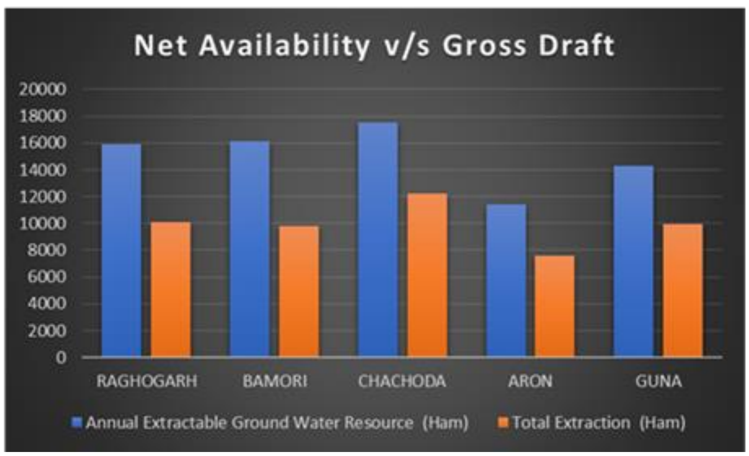


Fig33: Graphs showing Net groundwater availability v/s Groundwater extraction for irrigation, domestic and total

4.2 Total Ground Water Resources and draft :

The total ground water resources i.e. the Dynamic, In-storage and Static ground water resources of the shallow & Deeper aquifers of the district have been calculated and are given in table no 8. The total ground water resources of the district is 1404.27 MCM and the Gross ground water draft is 388.03 MCM.

Table 7. Total Ground Water Resources (Dynamic, In-storage & Static)

	RAGHOGARH	BAMORI	CHACHODA	ARON	GUNA	Total
First Aquifer						
Dynamic Resources (MCM)	159.23	161.18	175.57	113.87	142.81	752.66
Static Resources (MCM)	87.36	137.59	94.88	48.16	134.03	502.02
Total Resources (MCM)	**246.59**	**298.77**	**270.45**	**162.02**	**276.84**	**1254.68**
Irrigation	66.89	0.81	99.40	8.66	11.11	186.88
Domestic+Industries	5.64	4.32	5.18	2.88	5.60	23.62
Total GW Draft (MCM)	72.53	5.13	104.58	11.54	16.71	210.50
Second Aquifer						
Static Resources (MCM)	26.58	35.58	46.11	15.38	25.94	149.60
GW Draft (MCM	22.49	11.02	17.06	49.68	77.29	177.54
Total GW Resources (MCM)	**273.17**	**334.35**	**316.56**	**177.41**	**302.78**	**1404.27**
Gross Ground Water Draft (MCM)	**95.02**	**16.15**	**121.64**	**61.22**	**94.00**	**388.03**
Stage of Ground Water Development(%)	63.3%	60.9 %	69.7%	66.6%	69.9%	**66.03%**
Category	safe	safe	safe	safe	safe	**SAFE**

Chapter-V

5. GROUND WATER RELATED ISSUES

5.1 Declining Water levels :

Groundwater is the only source of irrigation in the entire area. Farmers solely depend on groundwater for irrigation. Every year number and depth of bore wells are increasing. The yield of the dug wells in shallow aquifer (0-30 mbgl) is reduced due to over development of deep fractured aquifer by bore wells. The phreatic aquifer is recharged during monsoon and the dug wells sustains for 3 to 4 months only The dug wells sustain only for 2 to 3 hours of pumping with a drawdown of 2 to 5 m.

The hydrographs of Rampur-I, Rampur-II, Pipalia, Pagara & Khatkiya observation wells represents the long term water level trends of various part of Guna districts. In all the five hydrographs in fig 15a,b,c,d & e both the pre monsoon and post monsoon water levels are showing declining trend for the last two decades.

5.2 Ground Water Quality:

The ground water of the study area can be assessed as neutral to slightly alkaline. The electrical conductivity of ground water samples in Guna district varies from 368 to 1820 µS/cm at 25°C. The maximum EC has been observed in the water sample of Janjali village (1820 µS/cm at 25°C).

Chapter-VI

6. GROUND WATER MANAGEMENT STRATEGIES

6.1 District & Blockwise Ground Water Management Plan

The demand of fresh water for agriculture, drinking and industrial uses etc. has significantly increased due to population growth and socio-economic development. As surface water resources in the district are in-adequate, the dependability on ground water resources has increased substantially. This has resulted in rapid exploitation of ground water resources vis a vis depletion of ground water levels in various parts of the State.

The district Guna in future will be under stress of rapid exploitation of ground water resources . The long term water level trends are showing continuous depletion which directly reflects the depletion of available resources. Thus there is urgent need for taking up suitable water management interventions based on integrated approach, which on one hand includes augmentation of ground water resources through appropriate techniques, and on the other hand requires the adoption of suitable water conservation measures, such as ensuring water use efficiency through creation of additional water storage facility, maintenance/ renovation of existing water bodies etc. Water awareness and capacity building of the stakeholders are also the important attributes of water management interventions as envisaged in the National Water Policy.

Artificial recharge to ground water is one of the most efficient, scientifically proven and cost effective technology to mitigate the problems of over exploitation of ground water resources. The technology serves as a means for restoring the depleted ground water storage, ameliorate the ground water quality problems and also enhance the sustainability of wells in the affected areas. A detailed knowledge of geology, hydrogeology, land use pattern, geomorphology and hydro-meteorological features are however, essential for selection of appropriate artificial recharge techniques as well as design and sites of ground water recharge structures.

As per directions of Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India, preparation of Aquifer Management Plan for Guna district in the State has been prepared block wise as shown in Table:8 and financial out lay plan is also shown in Table:9. Each Plan discusses the broad framework of ground water situation in the block, status of water availability (both surface and ground water), identification of feasible areas for interventions, feasibility of artificial recharge and other water conservation structures, their design considerations, numbers and cost estimates. The expected outcomes of the proposed interventions have also been elucidated and given in table 10. As Guna district having **Stage of Development 66.03 %,** after proposed intervention **Stage of Development will be 47.71%.**

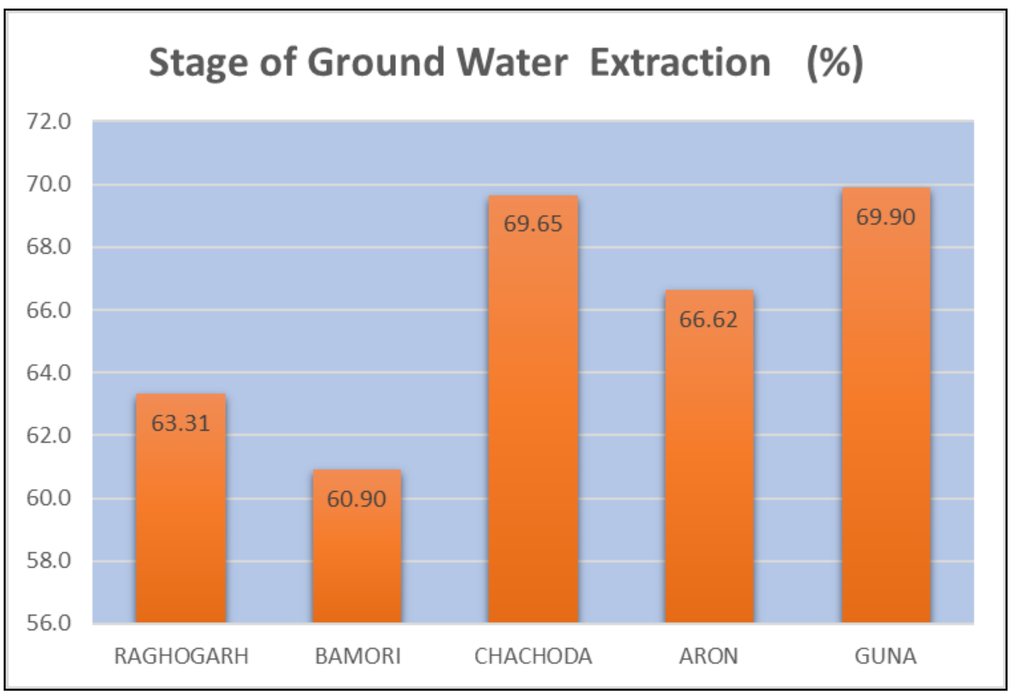


Table 8: Guna District , Block Wise Management Plan
(Source Water for Artificial Recharge and number of Recharge Structure)

Block	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Village ponds
RAGHOGARH	1241.36	1181.36	4.4	1.4	0.02	33.078	43.99	297.93	89.38	44	154	308	86
BAMORI	1588.48	1581.48	3.7	0.7	0.02	22.141	29.45	381.24	114.37	29	59	206	195
CHACHODA	1193.18	1182.32	6.6	3.6	0.02	85.127	113.22	286.36	85.91	113	226	793	168
ARON	788.83	788.83	4.4	1.4	0.02	68.500	91.11	189.32	56.80	91	182	638	223
GUNA	1578.15	1441.15	5.9	2.9	0.02	83.587	111.17	378.76	113.63	111	222	778	234
TOTAL	**6390**	**6175.1**	**5.00**	**2.00**	**0.02**	**292.4**	**388.9**	**1533.6**	**460.1**	**388**	**843**	**2723**	**906**

Table 9: Financial Outlay Plan

Block	Area Suitable for AR	Volume of Surface Water available for AR (MCM)	Volume of Water required for recharge (MCM)	Proportionate Surface water for planning AR (MCM)	Percolation Tanks		NB/ CD/ CP		Recharge shaft/ Tube well		Renovation of Village Ponds		Total Cost of RS in crores
					structure	cost	structure	cost	structure	cost	structure	cost	
					Nos	(crores)	Nos	(crores)	Nos	(crores)	Nos	(crores)	
RAGHOGARH	1181.36	297.93	43.99	89.38	44	8.8	308	30.80	154	1.54	86	1.72	42.86
BAMORI	1581.48	381.24	29.45	114.37	29	5.8	206	20.61	59	0.59	195	3.9	30.90
CHACHODA	1182.32	286.36	113.22	85.91	113	22.6	793	79.25	226	2.26	168	3.36	107.47
ARON	788.83	189.32	91.11	56.80	91	18.2	638	63.77	182	1.82	223	4.46	88.25
GUNA	1441.15	378.76	111.17	113.63	111	22.2	778	77.82	222	2.22	234	4.68	106.92
TOTAL	**6175.14**	**1533.6**	**388.9353**	**460.08**	**388**	**77.6**	**2723**	**272.25**	**843**	**8.43**	**906**	**18.12**	**376.40**

BLOCK	Net GW Availability in MCM	GW Draft for Irrigation in MCM	GW Draft for Domestic & Industrial in MCM	Gross Draft in MCM	Stage of Development (%)	Additional recharge created by AR in MCM	After intervention of AR Structure Net GW Available	Stage of Development after Intervension (%)
RAGHOGARH	159.2	94.99	5.82	100.82	63.31	33.08	192.31	**52.42**
BAMORI	161.2	93.68	4.49	98.16	60.90	22.14	183.32	**53.55**
CHACHODA	175.6	117.13	5.16	122.29	69.65	85.13	260.69	**46.91**
ARON	113.9	73.13	2.73	75.86	66.62	68.50	182.37	**41.60**
GUNA	142.8	93.94	5.88	99.82	69.90	83.59	226.40	**44.09**
Total	**752.66**	**472.87**	**24.08**	**496.95**	**66.08**	**292.43**	**1045.09**	**47.71**

Table No 10: Guna District, Management Plan after Intervention

Chapter-VII

7.1 Conclusion:

The study was carried out based on data gap analysis, data generated through in-house and outsourcing exploration, data acquired from State Govt. departments and various thematic maps was prepared through GIS platform.. 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 Guna District.

- Guna district is situated in the northern part of the Madhya Pradesh and covers an area of about 6,484.63 Sq. km. It lies between N Latitude 23o 53' and 25o 06' and E longitude 76o 48' and 78o 16' and falling in Survey of India toposheet nos 54 G, H & L. Guna district is divided into 7 tehsils and 5 blocks (Fig-1) It has 1338 villages and the total population of the district is 1241519 (As per census 2011).
- Major parts of the Guna district are occupied by Deccan Trap basalts except northern part of the district which is covered by sedimentary rocks of Vindhyans super group. Occurrence and movement of groundwater in hard rock is mainly controlled by secondary porosity through joints and fractures.
- Depth to water level ranges from 2.96 bgl to 20.28(mbgl) during pre-monsoon 2020 and 1.28 m bgl to 15.72 m bgl during post-monsoon. The ground water of the study area can be assessed as neutral to slightly alkaline.
- The Annual Ground Water Draft of the entire district for 2019-20 has been estimated as 49694.84 ham. Agriculture sector remained the predominant consumer of ground water resources. About 95.2 % of total annual ground water draft i.e. 47286.67 ham is for irrigation use. Only 2408.17 Ham is for Domestic & Industrial use which is about 4.8% of the total draft. An analysis of ground water draft figures indicates that in Guna district stage of ground water development is **66.03%.**
- As a part of Supply side Management, a total of 388 percolation tanks ,843 recharge shafts ,2723 Nalla bunds/Check dams and 906 village ponds was proposed for future water conservation.

7.2 Recommendations:

- Awareness program to educate about conservation of precious ground water resources and trainings on rainwater harvesting will be beneficial for managing and proper utilization of available groundwater resources.

- Micro irrigation technologies such as drip and sprinkler systems to be promoted as technological solutions for achieving water conservation.

- 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.

- Roof top Rain water harvesting can be adopted to meet the day to day requirements which will reduce ground water withdrawal. Implementation of artificial recharge structures in such areas through outside surface water sources or floodwater during excess rainy years be promoted.

- The Impact assessment study is to be conducted about the change in Ground water scenario in quantitative & qualitative aspects, which can be done by monitoring of Dugwells & Piezometres for water level measurements and water samples collection & chemical analysis periodically, after construction of suitable recharge structures.

ANNEXURE-I

Location details of EW

Block	Bore	File	Easting	Northing	Elevation	CollarElevation	TotalDepth
Guna	Sirsi	Sirsi	77.2685	25.0245	353.4	353.4	200
Bamori	Patan	Patan	77.1298	25.01139	457	457	200
Bamori	Gadla	Gadla	77.19743	24.93653	467.9	467.9	200
Bamori	Panehti	Panehti	77.0474	24.8341	423.4	423.4	200
Bamori	Rampur	Rampur	77.166	24.7685	421.7	421.7	200
Bamori	Padon	Padon	76.9177	24.9836	383.9	383.9	200
Bamori	Kishanpura	Kishanpura	76.9941	24.7592	372	372	200

ANNEXURE-II

Lithology of EW constructed in Guna district

Block	village	lat	long	LITHOLOGY	DEPTH 1	DEPTH 2
Bamori	Patan	25.0114	77.1298	Top soil, Brown colour	0	6.2
Bamori	Patan	25.0114	77.1298	Sandstone; Brown, weathered	6.2	9.3
Bamori	Patan	25.0114	77.1298	Sandstone; Pink, fine grained	9.3	52.7
Bamori	Patan	25.0114	77.1298	Sandstone; Red, Fractured	52.7	55.8
Bamori	Patan	25.0114	77.1298	Sandstone; Red,fine grained	55.8	65.1
Bamori	Patan	25.0114	77.1298	sandstone; Pink with yellow clay	65.1	80.6
Bamori	Patan	25.0114	77.1298	sandstone Pink, medium fine grained sandstone	80.6	96.1
Bamori	Patan	25.0114	77.1298	sandstone Red, fine grained	96.1	99.2
Bamori	Patan	25.0114	77.1298	sandstone Red, medium to fine grained	99.2	108.5
Bamori	Patan	25.0114	77.1298	sandstone Red, fine grained	108.5	124
Bamori	Patan	25.0114	77.1298	Contact zone	124	127.1

Bamori	**Patan**	**25.0114**	**77.1298**	**Shale; Grey, medium grained**	**127.1**	**136.4**
Bamori	**Patan**	**25.0114**	**77.1298**	**Shale; Grey, fine grained**	**136.4**	**164.3**
Bamori	**Patan**	**25.0114**	**77.1298**	**Shale; Grey, medium fine grained**	**164.3**	**167.4**
Bamori	**Patan**	**25.0114**	**77.1298**	**shale; Grey, fine grained**	**167.4**	**176.7**
Bamori	**Patan**	**25.0114**	**77.1298**	**shale; Grey, medium fine grained**	**176.7**	**200**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Top soil; brown**	**0**	**6.2**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone; brown, weathered**	**6.2**	**21.7**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone; red**	**21.7**	**58.9**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone; red, fractured**	**58.9**	**62**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone; red, fine grained**	**62**	**86.8**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone ; red, fine grained**	**86.8**	**89.9**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone; grey, fine grained**	**89.9**	**93**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone; light grey fine grained with white sticky clay**	**93**	**99.2**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Shale; grey, fine grained**	**99.2**	**158.1**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Shale; brownish grey, fine grained**	**158.1**	**195.3**
Bamori	**Gadla**	**24.9365**	**77.1974**	**Sandstone; grey, medium grained**	**195.3**	**200**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, brown, weathered**	**0**	**3.1**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, re d, weathered**	**3.1**	**21.7**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, red , fine medium grained**	**21.7**	**27.9**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, red, fine grained**	**27.9**	**46.5**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, red , fine medium grained**	**46.5**	**62**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, red, fine grained**	**62**	**99.2**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, grey, fine grained**	**99.2**	**136.4**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, grey , fractured**	**136.4**	**139.5**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, grey, fine grained**	**139.5**	**145.7**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, red, fine grained**	**145.7**	**182.9**
Bamori	**Panehti**	**24.8341**	**77.0474**	**Sandstone, grey, fine grained**	**182.9**	**200**

Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; brown, weathered**	**0**	**3.1**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; red, weathered**	**3.1**	**6.2**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; red, fine medium grained**	**6.2**	**15.5**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; red, fine grained**	**15.5**	**49.6**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; red, fractured**	**49.6**	**52.7**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; red, fine grained**	**52.7**	**108.5**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; red, fine to medium grained**	**108.5**	**124**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; red, fine grained**	**124**	**158.1**
Bamori	**Rampur**	**24.7685**	**77.1660**	**Sandstone; grey, fine grained**	**158.1**	**200**
Bamori	**Padon**	**24.9836**	**76.9177**	**Sandstone; weathered yellow**	**0**	**12.4**
Bamori	**Padon**	**24.9836**	**76.9177**	**Sandstone; red colour, fine grained**	**12.4**	**58.9**
Bamori	**Padon**	**24.9836**	**76.9177**	**Sandstone; red colour, fractured**	**58.9**	**62**
Bamori	**Padon**	**24.9836**	**76.9177**	**Sandstone; red colour, fine grained**	**62**	**117.8**
Bamori	**Padon**	**24.9836**	**76.9177**	**Sandstone; red colour, fractured**	**117.8**	**120.9**
Bamori	**Padon**	**24.9836**	**76.9177**	**Sandstone; red colour, fine grained**	**120.9**	**124**
Bamori	**Padon**	**24.9836**	**76.9177**	**Sandstone; red colour, fractured**	**124**	**127.1**
Bamori	**Kishanpura**	**24.7592**	**76.9941**	**Sandstone; Top soil, weathered**	**0**	**3.1**
Bamori	**Kishanpura**	**24.7592**	**76.9941**	**Sandstone;Red colour, fine grained**	**3.1**	**89.9**
Bamori	**Kishanpura**	**24.7592**	**76.9941**	**Sandstone;Red colour, fractured sanstone**	**89.9**	**93**
Bamori	**Kishanpura**	**24.7592**	**76.9941**	**Sandstone;Red colour, fine grained sanstone**	**93**	**111.6**
Bamori	**Kishanpura**	**24.7592**	**76.9941**	**Sandstone;Red colour, Fractured sanstone**	**111.6**	**114.7**
Bamori	**Kishanpura**	**24.7592**	**76.9941**	**Sandstone;Red colour, fine grained sanstone**	**114.7**	**200**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Top soil, Brown colour**	**0**	**3.1**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Sandstone; brownish, weathered with clay**	**3.1**	**12.4**

GUNA	**SIRSI**	**25.0245**	**77.2685**	**Shale; purple colour**	**12.4**	**15.5**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**shaley sandstone**	**15.5**	**18.6**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Sandstone, grey, fine grained**	**18.6**	**21.7**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**shaley sandstone; grey colour,**	**37.2**	**40.3**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Sandstone; grey, fine grained**	**40.3**	**89.9**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Sandstone, grey, fine grained**	**89.9**	**102.3**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Shale; Grey, fractured, fine grained**	**102.3**	**105.4**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Shale; Grey, fine grained**	**105.4**	**108.5**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Shale; brown, fine grained**	**108.5**	**136.4**
GUNA	**SIRSI**	**25.0245**	**77.2685**	**Shale; grey, fine grained**	**136.4**	**200**

ANNEXURE-III

Aquifer-Resistivity characteristics of weathered zone and deeper succession inDeccan Trap basalt.

VES Nos.	**Resistivity Characteristics**				**Possible presence of thin fracturedzone in the depth range (m)**
	Weathered Zone Aquifer		**Aquifer in vesicular/fracturedbasalt sequence**		
	Resistivity (ohm.m)	**Depth to bottom(m)**	**Resistivity (ohm.m)**	**Depth to thetop and bottom (m)**	
525	--	--	38	66-209	Nil
526	6	29	27	29-65	65-70, 150-170, 180-190
527	--	--	10	2-44	Nil
528	5	10	42	10-53	65-75, 90-95, 140-150,180-190
529	6	20	25	20-54	55-60, 140-150
530	-	--	18	23-124	170-200
531	5	3	28	3-84	50-60, 70-80, 130-140, 180-190
534	--	--	34	2-151	25-30, 60-65, 70-85, 120-140
535	4	6	16	6-85	Nil
536	5	8	119	8-122	90-95, 120-130
537	10	30	--	--	60-65, 80-85
538	56	10	--	--	130-150, 180-190
539	--	--	23	20-92	Nil
540	6	12	57	12-137	65-70, 90-95, 130-140, 160-170, 180-190

541	--	--	26	26 - 90	100-150
542	--	--	--	--	Nil
543	--	--	22	26-126	Nil
545	--	--	20	10-78	130-140
546	15 7	5 12	24	12-44	65-70, 90-95, 140-150, 180-190
547	9	5-21			
548	31	5-122			
549	7	15	--	--	60-70, 90-100, 130-190
550	--	--	64	2-98	170-180, 190-200
551	--	--	38	12-84	150-170
552	43	20	28	20-101	60-70, 80-85, 100-110
553	--	--	15	16-51	100-200
554	4	31	--	--	Nil
556	4	6	24	37-126	70-80, 90-130
557	28	3	39	16-66	60-85, 120-130, 170-180
559	5	5			120-130, 140-150, 190-200
560	17	7			35-40, 70-75, 100-110, 120-140, 160-190
561	28	18			
562	--	--	9	9-66	Nil
563	11	22			65-70, 90-95, 120-130, 160-170
564	15	11			70-80, 90-95, 100-160
565	--	--	32	14-137	Nil
566	9	18	28	18-83	60-65, 75-85, 120-140, 190-200
567	25	16			
568	8	8			90-100, 110-140, 170-180
569	15	5	5	5-24	Nil
570	32	11	22	11-77	55-60, 75-80, 110-120, 160-170
571	16	30			50-55, 65-70, 75-80, 100-110, 170-180
572	--	--	20	21-119	55-60, 80-85, 110-120
573	--	--	41	7-53	170-180
576	18	9			
578			5	5-47	130-140, 150-160, 190-200
579	--	--	46	48-164	Nil
580	--	--			Nil
581	3	2	7	2-17	Nil
582	7	2	120	50-189	90-100
583	15	3	235	46-187	50-70, 150-180
585	10	18	34	18-83	60-70
587	5	11	--	--	65-70
588	7	23			85-95
589	8	8	30	59-145	35-40, 65-70, 80-85,100-150
590	37	8	83	51-153	Nil
591	12	7	40	35-147	70-75, 85-100, 120-150, 180-190
592	--	--			Nil
593	8	8	48	89-182	100-110, 120-180
594	5	12	--	--	
597	14	35	--	--	60-65, 85-90

598	9	6	32	6-167	
599	--	--	287	44-137	100-140
600	14	10	--	--	65-70, 85-95, 120-125, 130-140, 150-160, 180-200
601	--	--	35	41-138	55-65, 160-180
602	--	--	47	12-77	70-80, 120-140, 170-180, 190-200
603	14	21			
604	6	26			170-180
605	--	--	105	34-?	Nil
606	7	8	38	8-166	70-85, 110-150, 170-180
607	6	19			130-150, 170-180
608	7	5	32	33-116	70-110, 130-140
609	59	15			
610	5	6	30	6- 81	60-75, 120-130
611	4	23			50-60, 85-90, 110-120
612	15	17	11	17-62	Nil
613	7	10			120-130, 170-180
614	--	--	156	22-154	130-140, 170-180, 190-200
615	36	5			
616	--	--	41	16-97	80-85, 100-150
617	11	5			55-60, 100-120, 150-160, 170-190
618	--	--	12	8-75	60-180
621	14	5	--	--	80-100, 110-140, 160-170
622	35	8	31	8-36	
623	13	10	30	10-138	50-55, 60-70, 80-85, 130-140, 150-160, 190-200
624	45	6	6	6-26	50-55, 60-65
625	19	12	55	12-38	65-70, 90-95, 110-130, 180-200
626	5	6	8	14-31	40-45, 65-70, 85-90, 140-160
627	5	20	15	20-98	Nil

ANNEXURE-IV

Aquifer-Resistivity characteristics of weathered, semi-weathered/less compactzone and fractured zones in Vindhyan sandstone and shale

VES Nos.	Resistivity Characteristics				Possible presence of thin fracturedzone in the depth range (m)
	Weathered Zone Aquifer		Aquifer in Semi weathered/Less compact zone /fractured zone.		
	Resistivity(ohm.m)	Depth to bottom(m)	Resistivity(ohm.m)	Depth to theTop and bottom (m)	

524	--	--	100	3-19	Nil
532	9	6	--	--	Nil
533	--	--	632	36- 215	50-60, 90-100, 130-150, 180-190
544	1	4	--	--	50-55
547	9	5-21	--	--	Nil
548	12	5	31	5-122	13-140
555	--	--	86	2 - 12	Nil
558	--	--	--	--	35-40, 70-100, 170-200
561	28	18	--	--	130-140, 160-170
567	25	16	--	--	Nil
574	8	4	51	4-39	110-120, 190-200
575	66	5	--	--	130-150, 180-190
576	18	9	49	9-49	40-45, 70-75, 130-140
577	--	--	--	--	100-150
584	10	4	--	--	Nil
586	--	--	--	--	Nil
594	5	12	--	--	170-180
595	--	--	--	--	70-75, 80-85, 95-100,120-150
596	--	--	--	--	60-75, 80-90, 100-170
598	8	6	32	6-167	30-35, 50-60, 65-70, 75-80, 95-100,110-140,180-200
603	14	21	--	--	Nil
609	59	15	--	--	Nil
615	36	5	--	--	Nil
619	--	--			80-150, 170-190
620	101	8	--	--	75-80, 100-110, 120-140, 150-170 180-190
622	35	8	31	8-36	Nil
629	2	15	--	--	60-85, 120-130, 170-180
630	42	8	28	8-132	40-70, 80-90, 120-130, 180-190
631	--	--	--	--	20-40, 150-190
636	--	--	--	--	70-90, 100-110, 130-140
637	5	3	--	--	Nil
638	--	--	158	17	35-45, 50-55, 80-100, 140-200
639	8	11	--	--	Nil
641	22	4	--	--	Nil
646	5	4	77	16-?	120-130, 140-150, 180-190

ANNEXURE-V

List of VES sites recommended for dug well and bore well constructions in Basalt area of Guna district

VES Nos.	Resistivity Characteristics				Possible presence of thin fractured zone in the depth range (m)	Recommended ground water structure
	Weathered Zone Aquifer		Aquifer in vesicular/fractured basalt sequence			
	Resistivity(ohm.m)	Depth to bottom (m)	Resistivity(ohm.m)	Depth to the top and bottom (m)		
525	--	--	38	66-209	Nil	Bore well
526	6	29	27	29-65	65-70, 150-170, 180-190	Bore well
527	--	--	10	2-44	Nil	Dug well
528	5	10	42	10-53	65-75, 90-95, 140-150,180-190	Bore well
529	6	20	25	20-54	55-60, 140-150	Bore well
530	-	--	18	23-124	170-200	Bore well
531	5	3	28	3-84	50-60, 70-80, 130-140, 180-190	Bore well
534	--	--	34	2-151	25-30, 60-65, 70-85, 120-140	Bore well
535	4	6	16	6-85	Nil	Bore well
536	5	8	119	8-122	90-95, 120-130	Dug well & Bore well
537	10	30	--	--	60-65, 80-85	Dug well
538	56	10	--	--	130-150, 180-190	Dug well & Bore well
539	--	--	23	20-92	Nil	Bore well
540	6	12	57	12-137	65-70, 90-95, 130-140, 160-170, 180-190	Dug well & Bore well
541	--	--	26	26 - 90	100-150	Bore well
542			224	29.4	Nil	Bore well
543	--	--	22	26-126	Nil	Bore well
545	--	--	20	10-78	130-140	Bore well
546	15 7	5 12	24	12-44	65-70, 90-95, 140-150, 180-190	Dug well & Bore well
549	7	15	--	--	60-70, 90-100, 130-190	Dug well & Bore well
550	--	--	64	1-98	170-180, 190-200	Dug well & Bore well
551	--	--	38	12-84	150-170	Bore well
552	43	20	28	20-101	60-70, 80-85, 100-110	Dug well & Bore well
553	--	--	15	16-51	100-200	Bore well
556	4	6	24	37-126	70-80, 90-130	Dug well & Bore well
557	28	3	39	17-66	60-85, 120-130, 170-180	Dug well & Bore well
559	5	5	--	--	120-130, 140-150, 190-200	Dug well
560	17	7	--	--	35-40, 70-75, 100-110, 120-140, 160-190	Dug well
562	--	--	9	9-66	Nil	Dug well & Bore well
563	11	22	--	--	65-70, 90-95, 120-130, 160-170	Dug well

564	15	11	--	--	70-80, 90-95, 100-160	Dug well & Bore well
565	68	14	32	14-137	Nil	Bore well
566	9	18	28	18-83	60-65, 75-85, 120-140, 190-200	Dug well & Bore well
567	25	16	--	--		Dug well
568	8	8	--	--	90-100, 110-140, 170-180	Dug well
569	15	5	5	5-24	Nil	Dug well & Bore well
570	32	11	22	11- 77	55-60, 75-80, 110-120, 160-170	Dug well & Bore well
571	16	30			50-55, 65-70, 75-80, 100-110,	Dug well & Bore well
					170-180	
572	--	--	20	21-119	55-60, 80-85, 110-120	Bore well
573	--	--	41	7-53	170-180	Bore well
578	--	--	5	5-47	130-140, 150-160, 190-200	Bore well
579	--	--	46	47-164	Nil	Bore well
580	--	--	236	37-?	Nil	Bore well
582	15	3	120	49-189	90-100	Dug well & Bore well
583	15	3	235	46-187	50-70, 150-180	Bore well
585	10	18	34	18-83	60-70	Dug well & Bore well
587	5	11	--	--		Dug well l
588	7	23	180	23-?	85-95	Dug well & Bore well
589	8	8	30	59-145	35-40, 65-70, 80-85,100-150	Dug well & Bore well
590	37	8	83	51-153	Nil	Dug well & Bore well
591	12	5	40	35-147	70-75, 85-100, 120-150, 180-190	Dug well & Bore well
592	--	--	264	49-?	Nil	Bore well
593	8	8	48	89-182	100-110, 120-180	Dug well & Bore well
597	14	35	--	--	60-65, 85-90	Dug well
598	9	6	32	6-167		Dug well & Bore well
599	--	--	287	44-137	100-140	Bore well
600	14	9	--	--	65-70, 85-95, 120-125, 130-140, 150-160, 180-200	Dug well
601	9	4	35	41-138	55-65, 160-180	Dug well & Bore well
602	--	--	47	12-77	70-80, 120-140, 170-180, 190-200	Bore well
603	14	21	--	--		Dug well & Bore well
604	6	26	--	--	170-180	Dug well & Bore well
605	51	4	105	34-?	Nil	Dug well & Bore well
606	7	8	38	8-166	70-85, 110-150, 170-180	Bore well
607	6	19			130-150, 170-180	Bore well
608	--	--	32	33-116	70-110, 130-140	Bore well
610	5	6	30	6- 81	60-75, 120-130	Dug well & Bore well
611	4	23	--	--	50-60, 85-90, 110-120	Dug well & Bore well
612	15	17	11	17-62	Nil	Dug well & Bore well
613	7	10	--	--	120-130, 170-180	Dug well l
614	--	--	156	22-154	130-140, 170-180, 190-200	Bore well
616	--	--	41	16-97	80-85, 100-150	Bore well
617	11	5	160	54-?	55-60, 100-120, 150-160, 170-190	Dug well & Bore well
618	--	--	12	8-75	60-180	Dug well & Bore well
622	35	8	31	8-36	80-100, 110-140, 160-170	Dug well & Bore well
623	13	10	30	10-138	50-55, 60-70, 80-85, 130-140, 150-160, 190-200	Dug well & Bore well
624	45	6	6	6-26	50-55, 60-65	Dug well & Bore well

625	19	12	55	12-38	65-70, 90-95, 110-130, 180-200	Dug well & Bore well
626	5	6	8	14-31	40-45, 65-70, 85-90, 140-160	Dug well & Bore well
627	5	20	15	20-98	Nil	Dug well & Bore well
628	10	18	--	--	130-140, 150-190	Dug well & Bore well
630	42	8	28	8-132		Dug well & Bore well
632	6	9	--	--	110-130	Bore well
633	11	18	--	--	65-75, 130-140, 160-170, 180-190	Dug well & Bore well
634	8	16	--	--	70-75, 90-100, 190-200	Dug well
639	8	11	--	--		Dug well
640	--	--	116	3-172	Nil	Dug well & Bore well
642	45	9	10	9-46		Dug well & Bore well
643	--	--	37	39-194	Nil	Bore well
645	6	10	--	--	120-130, 160-170	Bore well
647	--	--	11	15-72		Dug well & Bore well

Annexure-VI

List of VES sites recommended for dug well and bore well constructions inVindhyan sandstone and shale formations area of Guna district

VES Nos.	Resistivity Characteristics: Weathered Zone Aquifer: Resistivity (ohm.m)	Weathered Zone Aquifer: Depth to bottom (m)	Aquifer in Semi weathered /fractured zone.: Resistivity (ohm.m)	Aquifer in Semi weathered /fractured zone.: Depth to the top and bottom (m)	Possible presence of thin fractured zone in the depth range (m)	Recommended ground water structure
524	--	--	100	3-19	Nil	Dug well
533	--	--	632	36- 215	50-60, 90-100, 130-150, 180-190	Bore well
547	38	5	9	21		
548	--	--	31	5-122	13-140	Dug well and bore well
555	--	--	86	2 – 12	Nil	Dug well
558	--	--	647	22-?	35-40, 70-100, 170-200	Bore well
561	28	18	347	18-176	130-140, 160-170	Dug well and bore well
567	25	16	--	--	Nil	Dug well
574	8	4	51	4-39	110-120, 190-200	Bore well
575	66	5	673	5-125	130-150, 180-190	Bore well
576	18	9	49	9-49	40-45, 70-75, 130-140	Dug well and bore well
577	--	--	645	64-159	100-150	Bore well
595	9	2	--	--	70-75, 80-85, 95-100,120-150	Bore well
596	113	4	--	--	60-75, 80-90, 100-170	Bore well
598	9	6	32	6-167	30-35, 50-60, 65-70, 75-80, 95-100,110-140,180-200	Dug well and bore well
603	14	21	--	--	Nil	Dug well
619	--	--	247	25-115	80-150, 170-190	Bore well
620	101	8	--	--	75-80, 100-110, 120-140, 150-170 180-190	Bore well
622	35	8	31	36	Nil	Dug well
629	2	15	--	--	60-85, 120-130, 170-180	Bore well
630	42	8	28	8-132	40-70, 80-90, 120-130, 180-190	Bore well
631	--	--	453	4-27	20-40, 150-190	Bore well
636	61	3	--	--	70-90, 100-110, 130-140	Bore well
637	5	3	--	--		Dug well
638	--	--	159 75	1-25 64-118	35-45, 50-55, 80-100, 140-200	Bore well
641	22	4	--	--		
646	5	4	--	--	120-130, 140-150, 180-190	Bore well