केंद्रीय 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

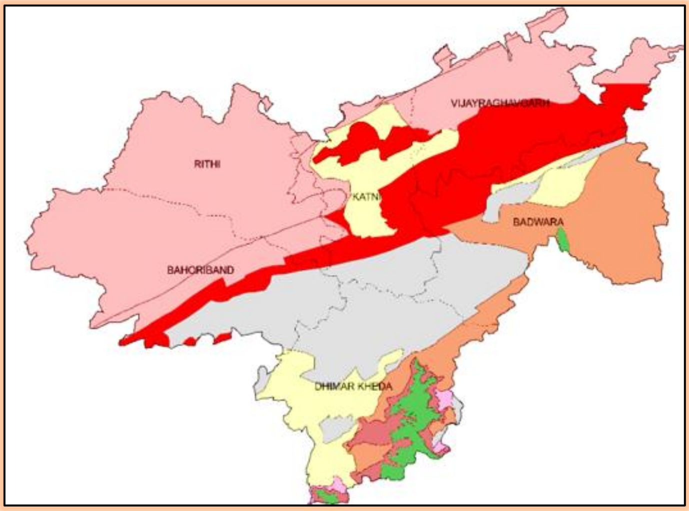
KATNI DISTRICT, MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

Government of India
Ministry of Jal Shakti, Water Resources, River Development & Ganga Rejuvenation Department
Central Ground Water Board

AQUIFER MAPPING
GROUND WATER MANAGEMENT PLAN



KATNI DISTRICT
MADHYA PRADESH

By
Lata Udsaiya, Scientist – C
Kamlesh Ojha, Sc-B
Kishan Patel, AHG
Under the Supervision
A.K. Biswal, Head of Offic

North Central Region, Bhopal
2022 - 2023

PREFACE

National Project on Aquifer Mapping (NAQUIM) is intended in knowing, understanding and managing the aquifers for sustainable development of groundwater which is the most important part for ensuring water security in India. The study involves a scientific process, where in a combination of geological, geophysical, hydrological and chemical analyses are applied to characterize the quantity, quality and sustainability of groundwater in aquifers. The result of these studies will contribute significantly to the resource management tools such as long-term aquifer monitoring networks, conceptual and quantitative regional groundwater flow models which can be used by planners, policy makers and other stakeholders for sustainable development of groundwater.

Under the project of National Aquifer Mapping (NAQUIM), Central Ground Water Board(CGWB) North Central Region, Bhopal has taken up Katni district to prepare the Aquifer maps for the entire district as well as block wise and formulate Block-wise Aquifer Management Plan. Katni district occupies an area of 4894 sq. km out of which the ground water recharge worthy area is 4666.48 sq. km. and the rest is covered by hilly and forest area. Katni district falls under two river basins i.e., Ganga & partly in Narmada basin. About 82% area of the district is drained by the Ganga basin. The Chhoti Mahanadi, Katni & Ken rivers are the major rivers of this basin. Main geological units of the area are, Archaean, Mahakoshals, Vindhayan Super group, Gondwana super group, Lametas, Deccan traps, Katni formation, Laterites and alluvium. As per the Dynamic Ground Water Resource Assessment Report (2022), the Annual Ground Water Extraction in the district is 372.37MCM and ground water extraction for all uses is 175.37 MCM, resulting the stage of ground water development to be 47.10 % as a whole for district.The Katni district falls under safe category. The interventions suggested in the report will not only have positive impact on the ground water regime but would also play a key role in augmenting the net cropping area and would ultimately enhance the agricultural productivity and economy of the district.

I would like to place on record my appreciation of the untiring efforts of **Ms Lata Udsaiya, Sc-C, Mr Kamlesh Ojha, Sc-B Kishan Patel, AHG** for preparing the Aquifer maps and Management plan and compiling this informative report. I would also thank Sh. Ashok Kumar Biswal (Head of Office) for taking painstaking efforts in scrutinizing the report I fondly hope that this report will serve as a valuable guide for sustainable development of Ground Water in the Katni district, Madhya Pradesh.

(A.K Biswal)
Head of Office

Place: Bhopal

Contents

CHAPTER - 1

INTRODUCTION

National project on Aquifer Mapping (NAQUIM) had been taken up by CGWB to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. The NAQUIM has been prioritised to study Over-exploited, Critical and Semi-Critical blocks as well as the other stress areas recommended by the State Govt. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

The vagaries of rainfall, inherent heterogeneity & unsustainable nature of hard rock aquifers, over exploitation of once copious alluvial aquifers, lack of regulation mechanism has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "**traditional groundwater development concept**" to "**modern groundwater management concept**".

Varied and diverse hydro-geological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide the **"Road Map"** for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation. The aquifer maps and management plans will be shared with the Administration Katni District for its effective implementation.

1.1 Objective and Scope: Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e., the aquifer map and management plan. The activities under NAQUIM are aimed at:

- identifying the aquifer geometry,
- aquifer characteristics and their yield potential
- quality of water occurring at various depths,
- aquifer wise assessment of ground water resources
- preparation of aquifer maps and
- Formulate ground water management plan.

This clear demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a **"Road Map"** to systematically manage the ground water resources for equitable distribution across the spectrum.

Katni district being spread over an area of 4894 sq.km have been entirely covered during the Annual Action Plan of 2022-23.

1.2 Approach and Methodology: To achieve the objectives the following approach and methods have been adopted and stepwise details have been shown in the **Fig.1.1.**

- Data compilation
- Data gap analysis
- Data generation
- Preparation of block-wise aquifer maps and management plan

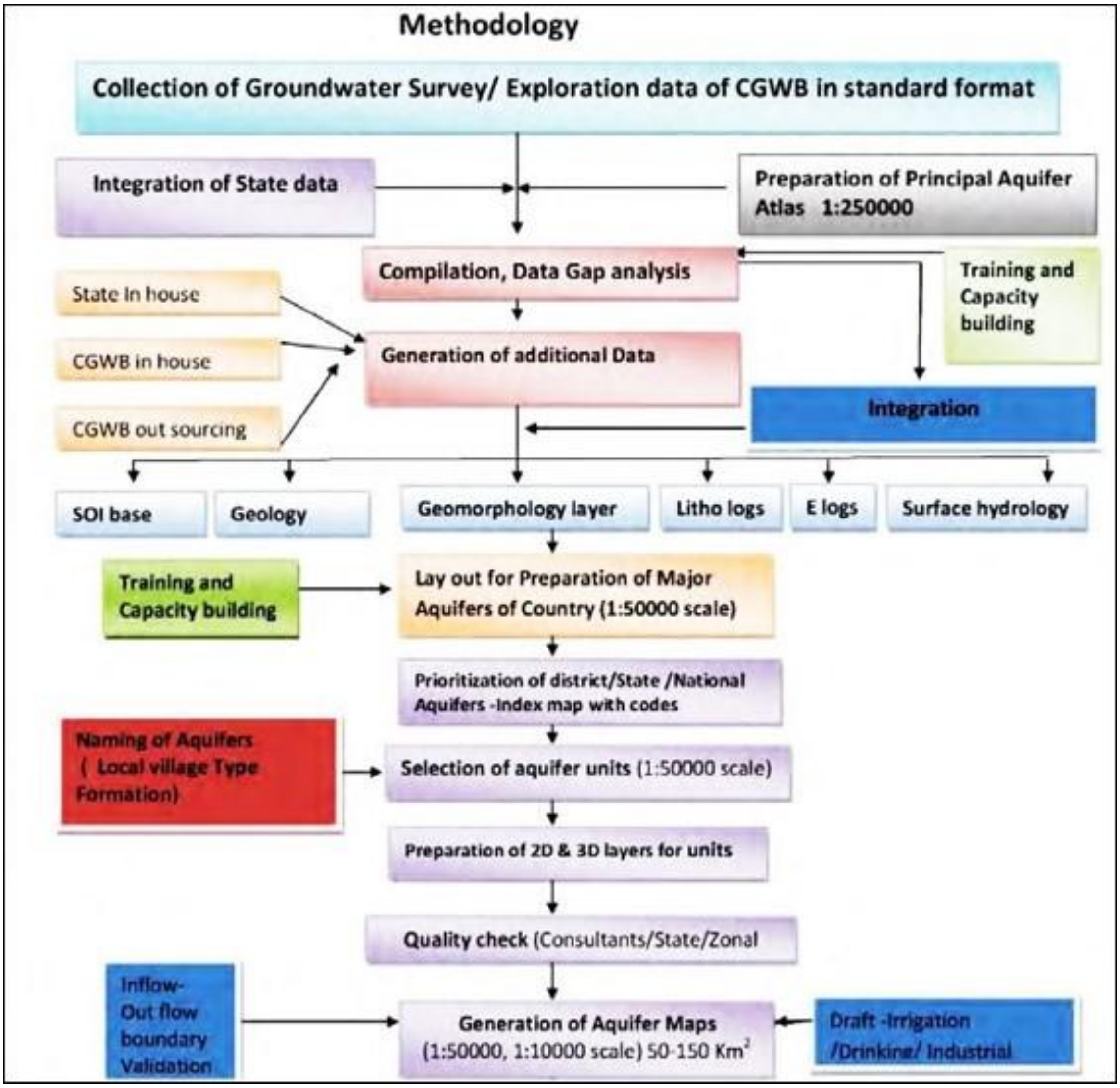


Fig.1.1: Approach and Methodology

1.3 Study area:

Entire Katni District having area of 4666 sq.km was selected for NAQUIM activities during the year 2022-23. The administrative map of the study area is presented in **Fig.1.3**. Katni is a newly formed district, situated in the eastern part of Madhya Pradesh. It came into existence by reorganization of Jabalpur districts in the year 2003. It is having 23.0% tribal population of the district. It is famous for its Cement & Lime Stone and & Fireclay industries.

Katni district in surrounded by Satna in north-east, Umaria in the east, Jabalpur & Damoh in the west & Panna in the north. The district lies between north latitude 23°59' and 24°75' and east longitude 79°57' and 80°59' falling in the Survey of India Toposheet No. 55M, 63D, 64A and 55N. The area of the district in 4504 sq. Km. It has been divided into four Tehsil and six blocks (**Table-1.1**). There are 911 villages and four towns in the district. The Index map of Katni district is in **Fig.1.2.**

According to the 2011 census Katni District has a population of 1,292,042, roughly equal to the nation of Estonia or the US state of New Hampshire. This gives it a ranking of 379th in India (out of a total of 640). The district has a population density of 261 inhabitants per square kilometre. Its population growth rate over the decade 2001-2011 was 21.38%. Katni has a sex ratio of 948 females for every 1000 males and a literacy rate of 73.62%. Scheduled Castes and Scheduled Tribes made up 12.05% and 24.59% of the population respectively. Kols are the largest tribal group which is 41% of the tribal population, while Gonds (34%) and Bharias (20%) are the other major tribes.

Table –1.1 Administrative Divisions, District Katni, M.P

S.no	Tehsil	Block	Area in Sq.Km	No. of towns
1.	Mudwara	1. Rithi 2. Katni 3. Badwara	490.00 530.08 812.63	3
2.	Vijayraghogarh	4. Vijayraghogarh	668.74	1
3.	Bahoriband	5. Bahoriband	933.25	
4.	Dhimarkheda	6. Dhimarkheda	784.59	
	Total	**6**	**4504.11**	**4**

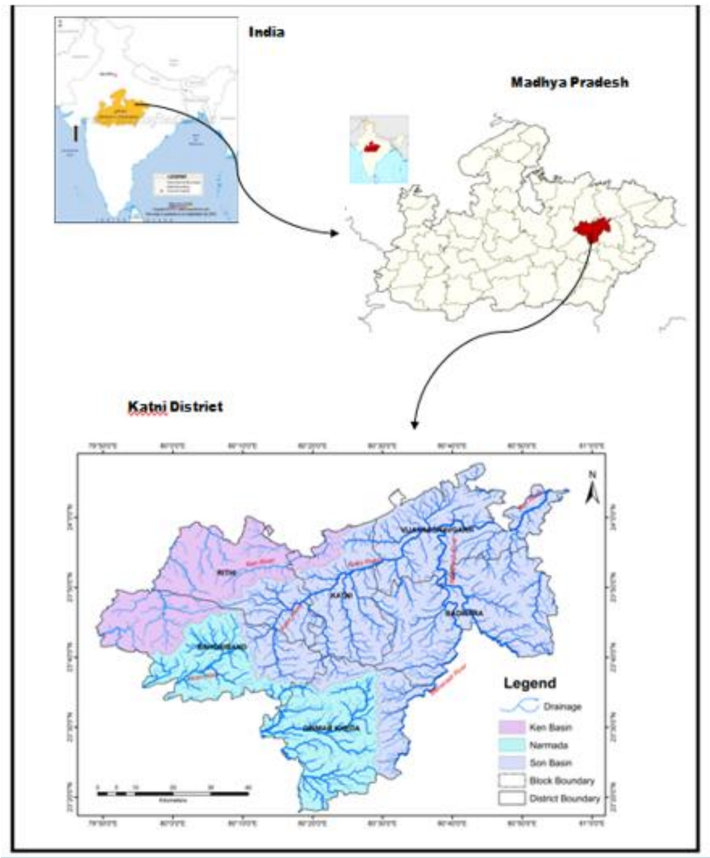


Fig.1.2: Index map, Katni District

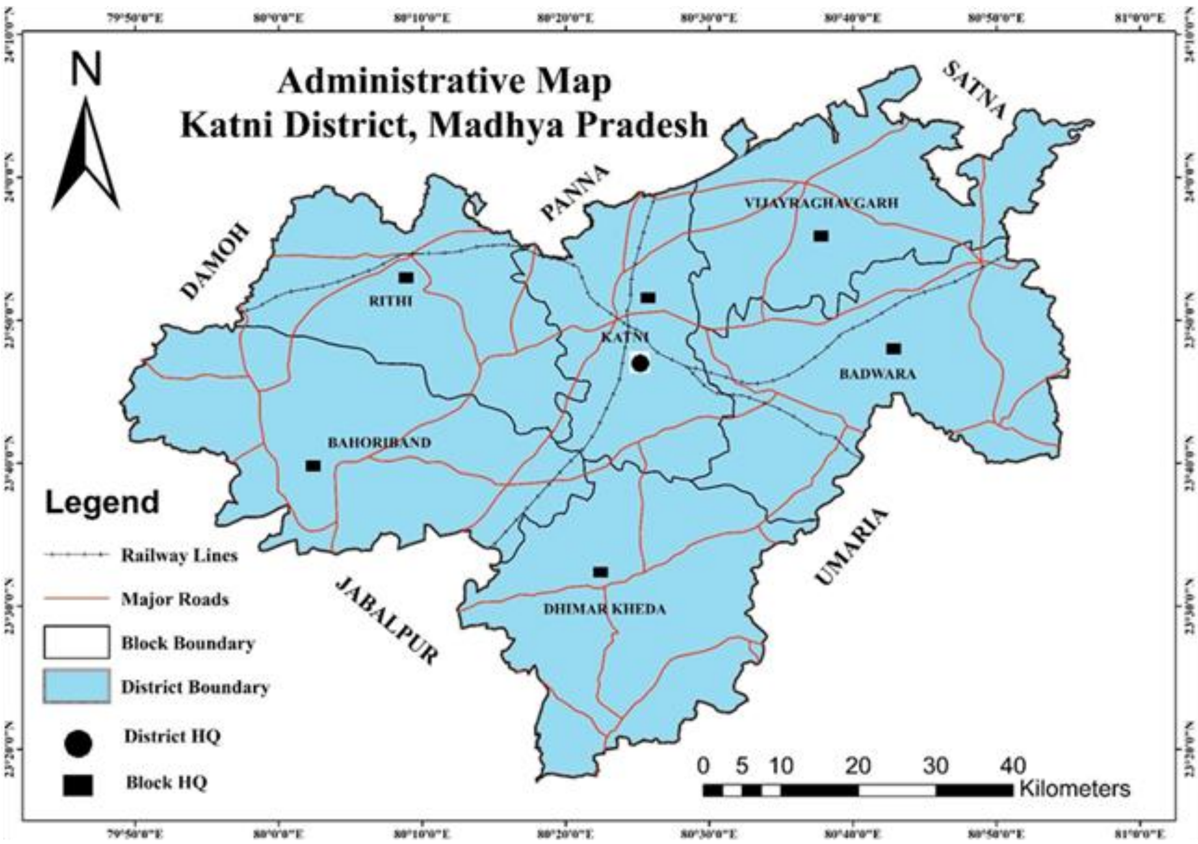
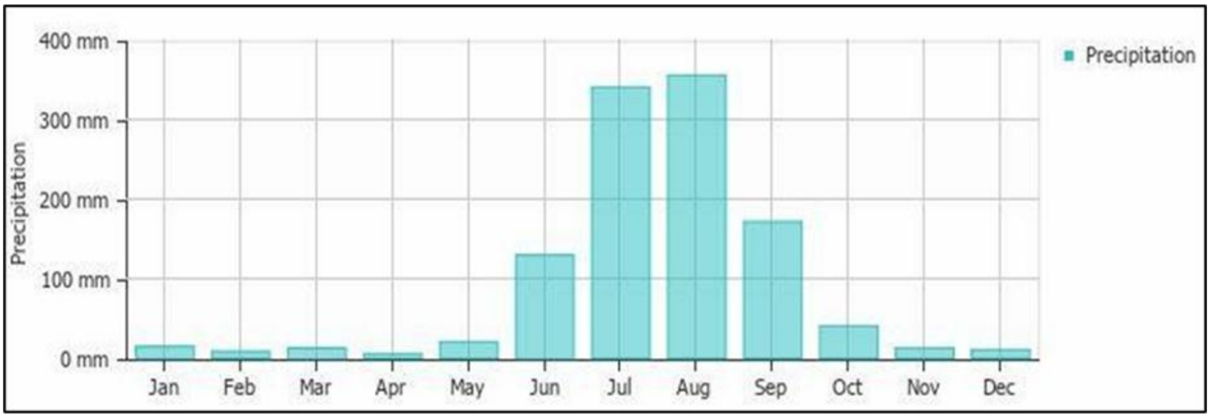


Fig.1.3: Administrative map, Katni District

1.4 Climate and Rainfall

The climate of Katni district M.P. characterized by a summer and general dryness except during the south west monsoon season. The year may divide into four seasons. The cold season, December to February is followed by the hot season from March to about middle of June. The period from the middle of June to September is the south west monsoon season. October and November form the post monsoon or transition period. The nearest Observatory is Jabalpur. The climatological parameters of Jabalpur are used for analysis of rainfall. The average annual rainfall of Katni District is 1112 mm. Katni district received maximum rainfall during south west monsoon period i.e., June to September about 56.9% of the annual rainfall received during monsoon season. Only 13.1% of the annual rainfall takes place between October to May period as shown in the **Fig.1.4**. Surplus water for ground water recharge is available only during the south west monsoon period.



(Source: Indian Meteorological Department)

Fig.1.4 Rainfall distribution yearly

The normal maximum temperature received during the month of May is 42°C and minimum during the month of December / January is 9°C. The normal annual means maximum and minimum temperature of Katni district is 32°C & 18°C respectively with an average temperature of 25.2° C as shown in **Fig.1.5**.

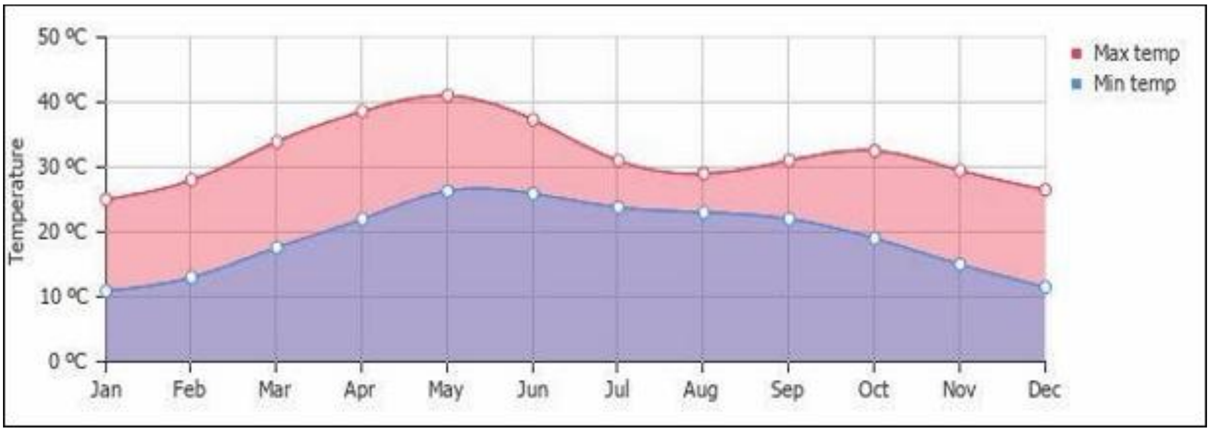


Fig 1.5 Temperature variation yearly

During the south west monsoon season the relative humidity generally exceeds 88% (August month) in the rest of the year is driver. The driver part of the year is the summer season, when relative humidity's are less 31% May is the driest month of the year as it can be observed from the no. of rainy days as shown in **Fig.1.6**. Historical variation of rainfall (last 21 Years) as shown in **Fig.1.7.** The wind velocity is higher during the pre-monsoon period as compared to post monsoon period. The maximum wind velocity 8.2 km/hr observed during the month of June and minimum 2.6 km/hr during the month of December. The average normal annual wind velocity of Katni district is 4.9km/hr. Normal climatologically parameter of Katni district is given in **Table 1.2**.

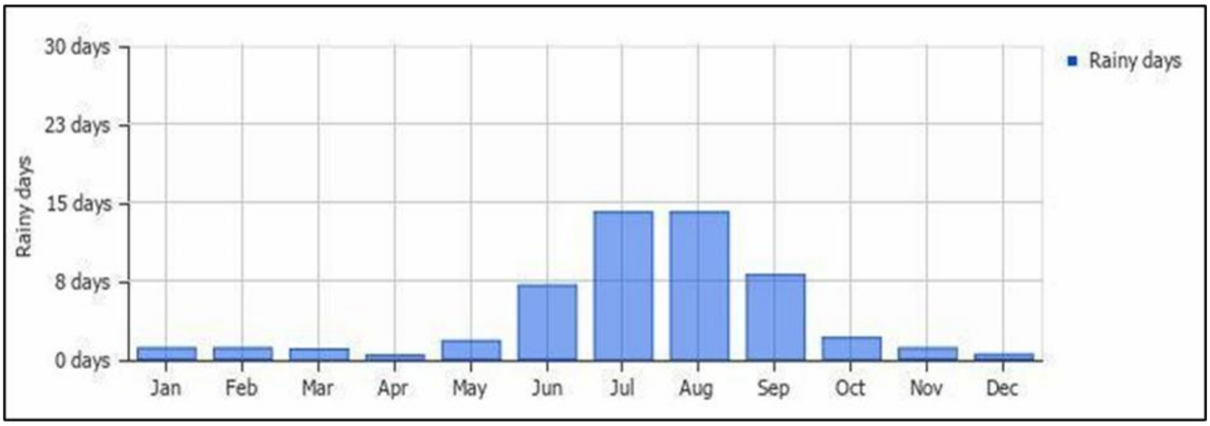


Fig. 1.6 Rainy days variation yearly

Table 1.2: Normal climatologically parameter of Katni District

S.No.	Parameter	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
1	Maximum Temperature (ºC)	26.2	29.4	34.5	39.3	42	38	31.1	29.8	31.4	32.3	29.9	26.7	32.6
2	Minimum Temperature (ºC)	9.7	12.1	16.6	21.9	26.4	26.6	24.2	23.7	23.3	7.92	13.1	9.7	18.9
3	Relative Temperature (ºC)	64	58	43	33	31	59	85	88	82	70	65	70	63
4	Wind Velocity (Km/hr)	3.2	3.7	4.3	5	6.3	8.2	7.2	6.9	5.4	3.5	2.7	2.6	4.9

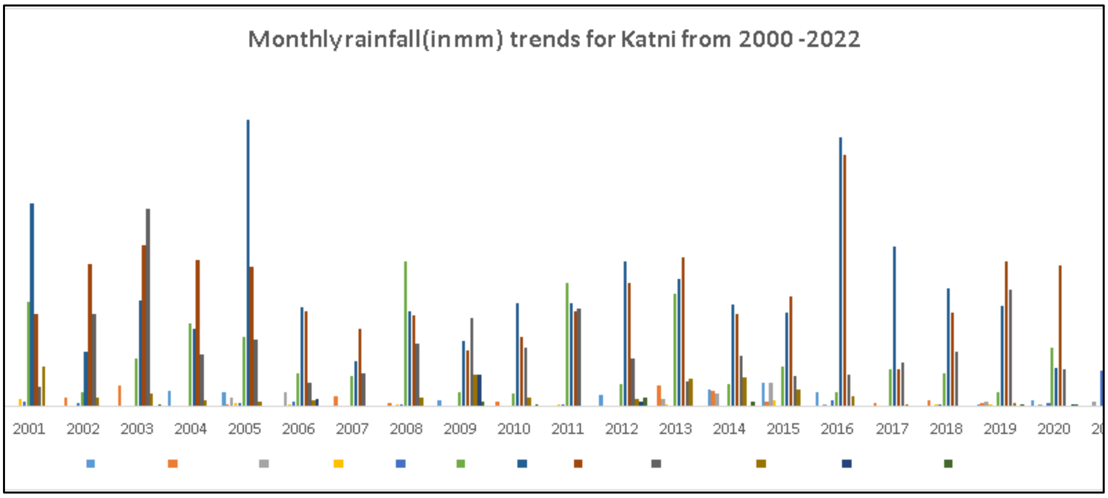


Fig 1.7 Historical variation of rainfall (last 21 Years)

1.5 Physiography/Digital Elevation Model

Katni district is endowed with the diverse physiography. The maximum elevation is 669 above mean sea level (amsl) which is recorded near southern part covering areas in Dhimarkheda and Badwara block and western part covering areas in Rithi and Bahoriband blocks. The Southern part of Bhimarkheda block covered by Malwa Plateau elevation ranging from 350 – 450m. The minimum elevation is recorded in the north-eastern part of the district. The major part of the district is having elevation having division as it can be observed from the fig below the north-eastern part of the is having average elevation of lower side ranging from 291m to 370m above mean sea level, while the elevation range on the south-western part of the district is on higher side ranging from 370m to 669m above mean sea level. The digital elevation Model (DEM) with drainage pattern is shown in the **Fig.1.8**.

1.6 Geomorphology

Katni district is predominantly hilly & forested. From geo-morphological point of view, the district consists of series of mountains ranger & rivers. It can be divided into three geo-morphological divisions.

1. Vindhyan plateau
2. Denudational slope & older flood plain
3. Structural hills & valleys of Bhitrigarh ranges.

In general, Katni district is characterised by hilly to undulating terrain with altitude ranging between 400 m & 700 m. amsl. The main high relief features of the area are the Bhander & Rampur ranger of Vindhyan Plateau. Which form the north western boundary of the district. North central part of the districts covered by denudation slope & older flood plain along the Katni river form west to east directory a proterozone works. The Bhitrigarh rangerun across the southern part of the district from south west to north east & represented by plateau, hills

& valley it consists of metamorphic rock. As per ITC classification system there are three groups of land form (a) Denudation, (b) Depositional & (c) Structural have been identified in the district. The geomorphology map of the district is shown in the **Fig.1.9**.

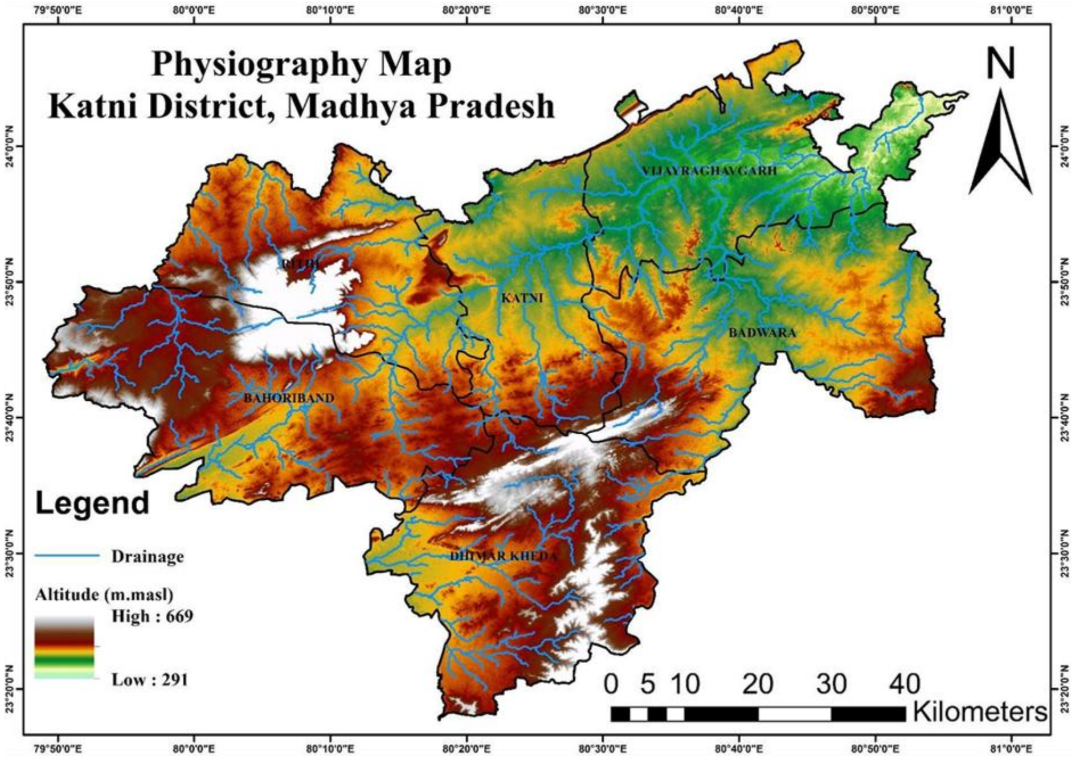


Fig 1.8 Digital Elevation map of Katni district

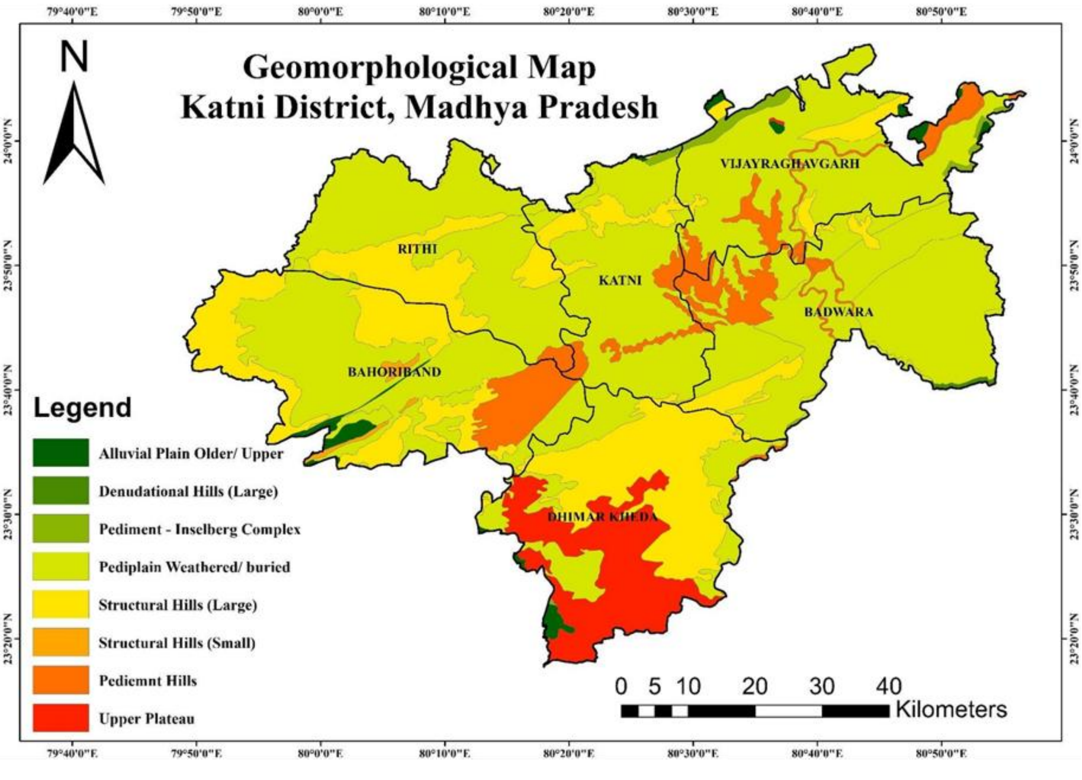


Fig 1.9 Geomorphology map of Katni District

1.7 Land Use, Agriculture, Irrigation and Cropping Pattern:

Land cover type is natural differentiation, which describes how much of an area is covered by forest, wetland, agriculture, impervious surface, and other land and water types. Land cover of an area can be determined by analysing satellite and aerial images. Land use shows how people use the landscape – whether for development, conservation, or mixed uses and therefore, cannot be determined by satellite or aerial remote sensing techniques.

In the study area district, the land cover map of the Katni district with toposheet Numbers 55M, 63 D, 64 A and 55 N were made using WMS server map images by Bhuvan portal of ISRO and further processing the data in QGIS software. Based on the type of use of the natural land system type, the land use pattern was determined and demarcated in the combined Land use Land Cover (LULC) map, which is shown in **Fig.1.10** and related legend in **Fig.1.11**. A perusal of the LULC map, based on the latest available database (2015 – 2016), shows that 14 different types of units can be categorized on the map. However, for sake of simplicity, these LULC classes are combined in the 5 five broader subdivisions, a brief description of which is given below:

Cultivated land: Cultivated land which is around 52% of the land use is visible almost all over the Katni as agriculture is the main occupation of the people.

Barren land: Such type of land, devoid of any vegetation, is exposed mostly in the central part of the district. The aerial extent of this land cover is not much, and it is predominantly associated with barren land having sandy areas and scrubland.

Vegetation: Thick, Moderate, and sparse vegetation are found to occur extensively in the study area. The thick vegetation type (dense forest cover) is by far the most extensive, followed successively by the moderate and sparse vegetation type, as observed from the LULC map. The vegetation covers around 51% of the total land use with evergreen and semi-green forest making up to 81% of the total vegetation cover, after deciduous forest making 18% of total forest cover and reaming are scrub forest and plantation forest.

Built-up/settlement: The settlements are very limited in aerial extent, except for the Katni block which is mostly an urban area as the district headquarters and other facilities are located nearby. The rural area is scattered with a limited aerial extent.

Water bodies and Pastureland: The Pasture land is closely associated with cattle grazing, covering limited land only 144.49 Square kilometres of the total land. The water bodies mostly including river streams and canals cover up to 46.64 square kilometres of the total area.

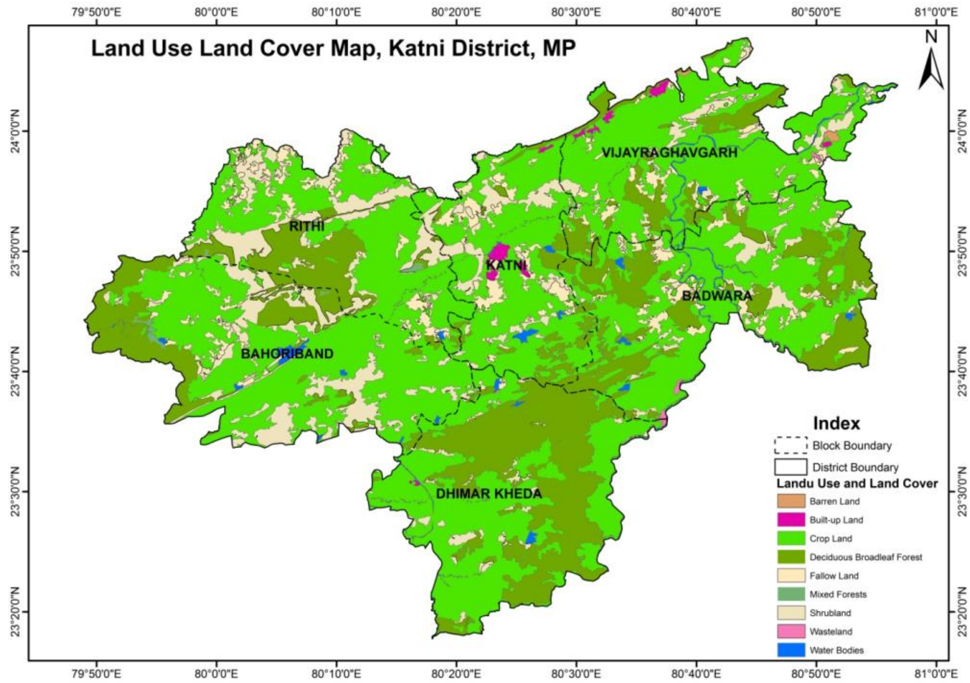


Fig 1.10 Land use and Landover map of Katni District

Irrigation:

Irrigation facilities in Katni district are under development stage only 30% of net sown area is irrigated, and rest of the area in rain fed. Surface water irrigation in the district is in developing stage ground water is the main source of irrigation in the district out of total 594.49 sq.km. area, irrigated land is 320.15 sq.km. is irrigated from ground water sources, which in about 54.57% of total irrigation in the district. There are 921 table wells & 11008 dug wells is the district for irrigation. High SAR is not good for irrigation as it leads to Sodium Hazard. Water samples in the district generally fall in C1S1, C2S1 and C3S`1 classes of US Salinity diagram. However, ground water in the district general is sage for irrigation but proper drainage system is required where EC is more than 1500 us cm-1. A distribution table is given in **Table.1.4.**

Table.1.4: Irrigation distribution

Irrigation by Different Sources	**Number**	**Area(Ha)**
Dug wells	11008	301
TubeWells/Borewells	921	12
Tanks/Ponds	2581	07
Canals	144	128
Other Sources	1623	151
Net Irrigated Area	492	
Gross Irrigated Area	592	

1.8 Soil :

Soil of the district may be classified according to their physical property, the crops grown and their position. The low-lying area is occupied by pale yellow, reddish brown & block soil. Pale yellow is occupying alluvium, reddish brown is occupying the upper Bhander sandstones & black soil is occupying the argillaceous Sirbu shale. All the agricultures fields are located over shales are covered by medium block soil & it occupying the argillaceous. Sirbu shale All the agriculture field are located over shales are covered by medium black soil it varies in the thickness from place to place from 1 to 4 m. In the north of Katni town the area. The soil map of Katni District is shown in the **Fig.1.13.**

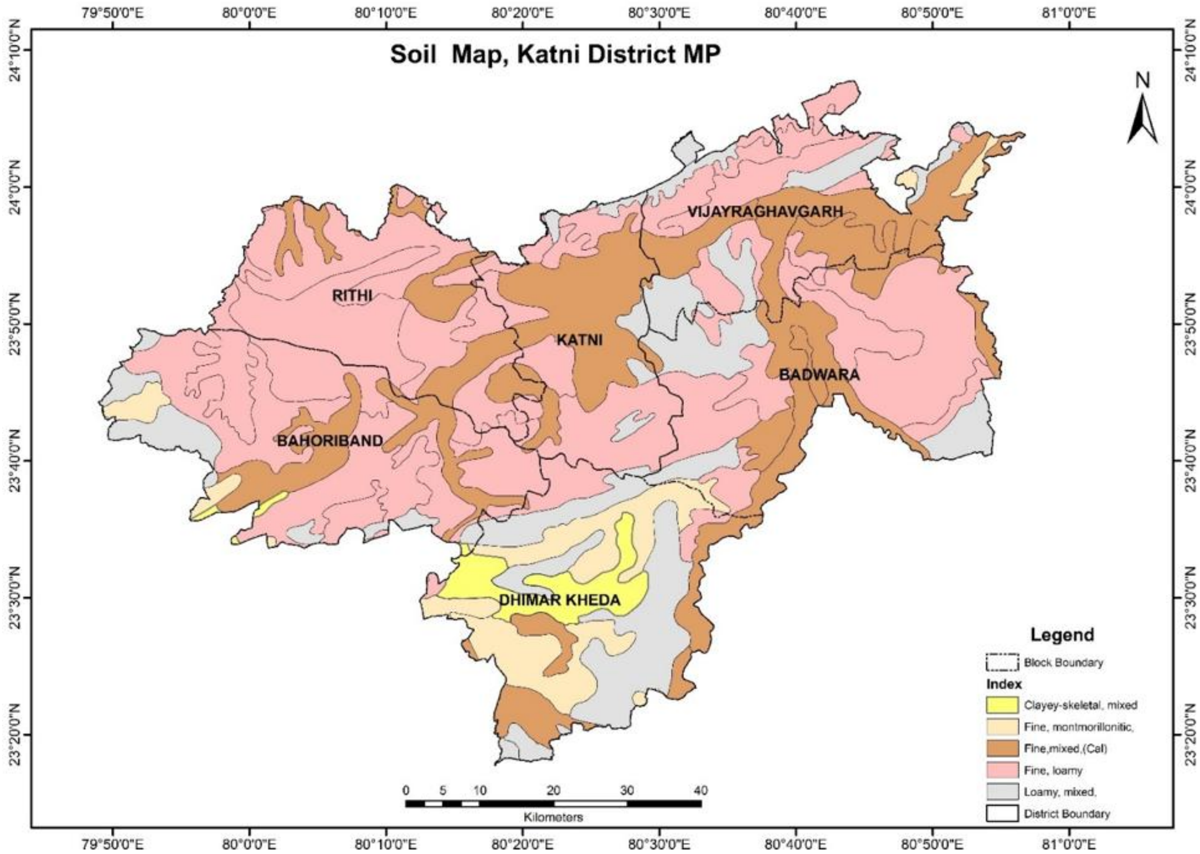


Fig.1.13: Soil Map of Katni district

1.9 Geology:

The Katni District lies in Vindhyan Super Group which has been sub divided into four groups,viz.the Semri Group, the Kaimur Group, the Rewa Group and the Bhander Group. Traditionally the Semri Group is considered to represent the Lower Vindhyan while the Kaimur, Rewa and Bhander groups constitute the Upper Vindhyan. The Semri Group has been further subdivided into four formations, viz. the Basal Formation, the Porcellanite Formation, the Kheinjua Formation and Rohtas Formation. The Rohtas Formation is dominantly made up of limestone and shale. In the Katni area, only two stratigraphic horizons of the Vindhyan Supergroup are developed. The lower is the Rohtas Formation which is under lain by the older metamorphic rocks. The Rohtas Formation is unconformably overlain by the sandstones of the Kaimur Group. However, in the northern face of a hillock near Tikaria, about 2 km southwest of the Katni railway station from where the fossils have been recovered, Rohtas Formation is capped by a thick lateritic horizon. The Rohtas Formation is represented by a thick unit of black to greyish-black micritic limestone which grades upwards into a calc-argillaceous sequence with ash-grey shale intercalating with dark-grey limestone. The fossil-bearing horizon is about 5 m thick and forms a very weak hill slope because of the dominance of shale intercalations and the fissile nature of the rock. The fossils have been recovered by splitting the shales and limestones along the bedding plane. The rocks dip about 15°WNW. Parallel lamination is the dominant bedding of the fossil-bearing horizon. The other sedimentary structures are lenticular and flaser bedding, wavy bedding, small-scale cross-lamination, ripple marks, wrinkle marks and mud cracks. These structures suggest that the fossil-bearing horizon represents a low-energy tidal fiat environment. The geological map of the Katni districtis shown in **Fig.1.14**.

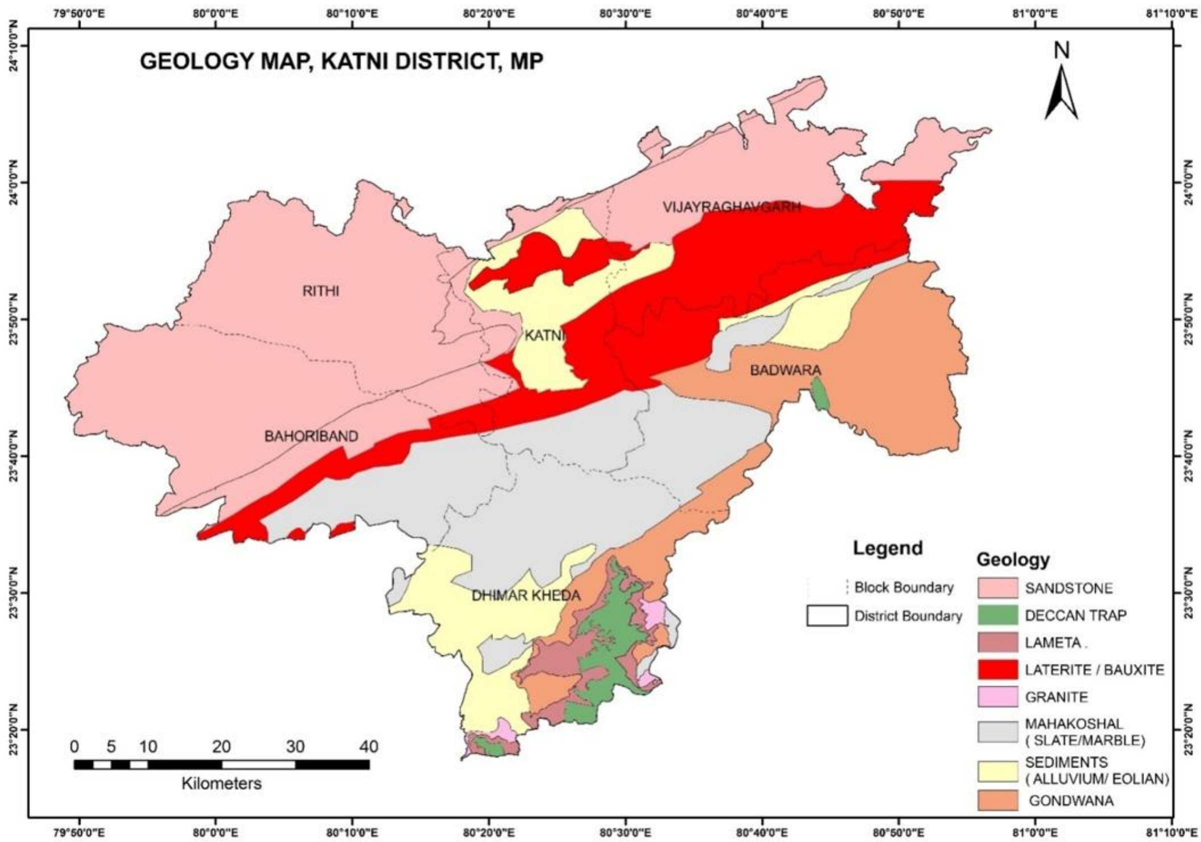


Fig.1.14: Geological Map of Katni district

General Geological Succession

The stratigraphic sequence of various geological units with their respective rock types are described below in **Table.1.5**

Table.1.5: STRATIGRAPHIC SUCCESSION OF KATNI DISTRICT

Age	Formation		Lithology
Recent			Soil/Alluvium
-Sub recent			Laterite/Bauxite
Upper cretaceous to Paleocene	Deccan Trap		Basaltic flows
Cretaceous	Lametas Group		SandStone
Cretaceous to carboniferous	Gondwana supergroup (Jabalpur Group)		Sandstone,clay
..........Unconformity..........			
Neoproterozoic	Upper Vindhyan	Bhander group	Shale and Sandstone
		Rewa group	Shale and sandstone
		Kaimur group	Shale and sandstone
Mesoproterozoic	Lower Vindhyan	Semri group	Shale,Porcellanite Quartzite,limestone,shale quartzite
..........Faulted contact..........			
------Intrusive------			Basic dykes, quartz vein and reef,quartz porphyry, syenite
-----Intrusivecontact-----			
Paleo proterozoic	Mahakoshal Group		Meta lava Quartzite,conglomerate,Phyllite and slate bands Dolomitic /limestone/Dolomitic limestone

The oldest group of rocks comprising of Achaeans and Proterozoic formation constitute nearly 45% area of the State. The next younger formation of Carboniferous to lower Cretaceous comprising Gondwana Super Group covers 10% area while the formation of Cretaceous to Paleocene comprising mostly of Deccan Trap basalt constitutes 38% area of the State. The ENE-WSW trending volcanic sedimentary sequence of Mahakoshal group consisting of metavolcanic rocks, chemical precipitates and forbidts is exposed in the southern part. Vindhyan super group represented by Semri, Kaimur, Rewa & Bhander groups consisting of sand stone, shales, limestones, Porcellanite & sand stone with glauconite partings occupy northern plateau and forms escarpment. Extensive laterite profile has developed over rocks of Vindhyan and Gondwana. Sporadic occurrence of laterite is reported over Mahakoshal rocks. Quaternary sediments mainly comprise clay and calcareous concretions.

Tight folding of the Mahakoshals, intense deformation of the Vindhyan along the contact with Mahakoshals and an overall broad shallow synclinal structure of the Vindhyan are the main structural feature of the area. The contact between the Mahakoshal and the Vindhyan is faulted all along. A number of minor faults and micro linear veins trending NNW-SSE to NW- SE have been identified.

According to the District Resource Map, Geological Survey of India classification of different formations exposed in these areas with their order as super imposition is as under:

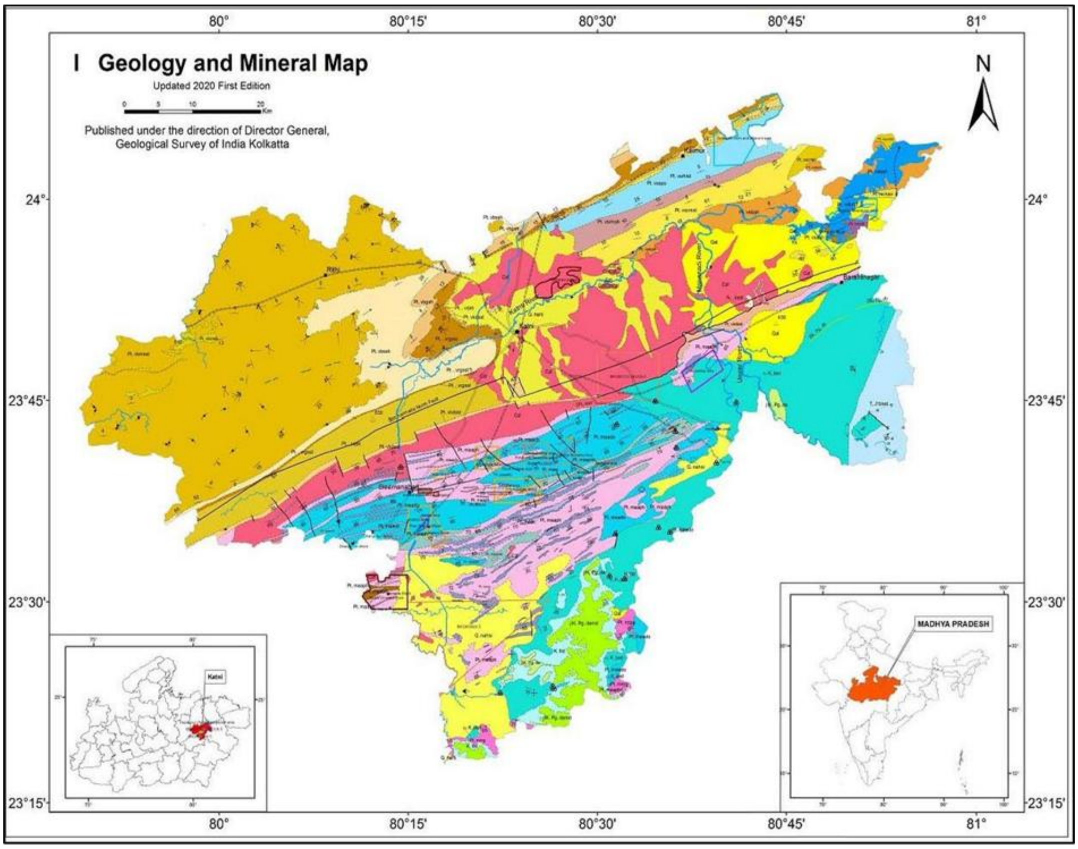


Fig.1.15: Geology and Mineral Map of Katni district

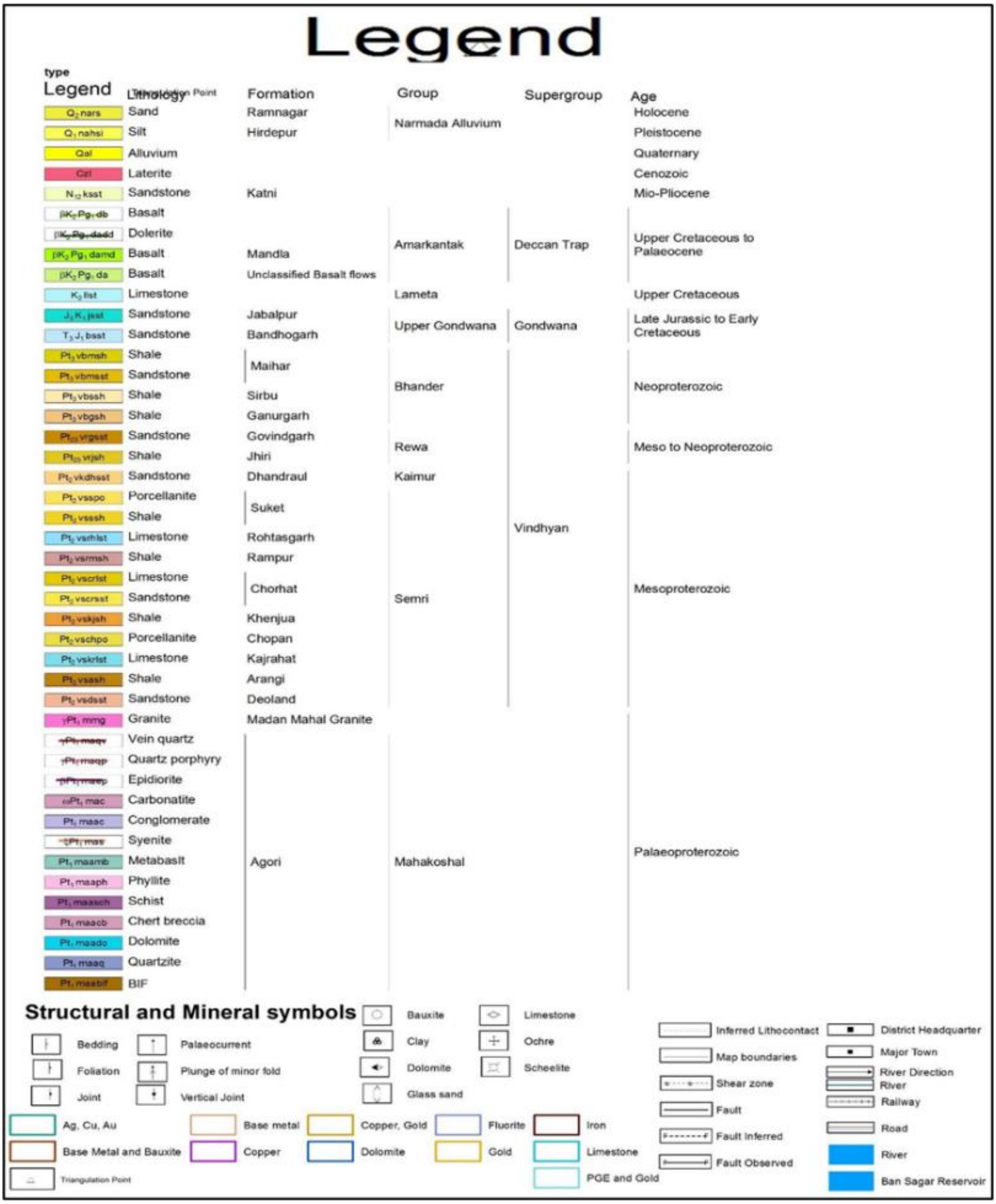


Fig.1.16: Legend of Geology and Mineral Map of Katni district

The following minerals are found in various Tehsil of Katni.

- Murwara: Limestone, Dolomite, Bauxite, Laterite, Clay and Fireclay etc. are the main minerals found in Murwara Tehsil.

- Vijayraghavgarh: Limestone, Dolomite, Fireclay, Sand and Laterite are the main minerals found in this Tehsil.
- Bahoriband: Dolomite, Bauxite, Laterite, Fireclay. Red Ochre and marble are the main minerals found in this Tehsil.
- Dhimarkheda: Limestone, Dolomite, Bauxite, Laterite, Fireclay, iron ore, Manganese, Soapstone, Quartz, Red Ochre and Sand are the main minerals found in this Tehsil.
- Rithi- Flag Stone.
- Barhi–White Clay, Sand and Stone Quarry.
- Badwara–LimeStone, Dolomite, Quartz, Soapstone, Laterite, Marble and Sand.

1.10 Hydrology and Drainage:

Katni district falls under two river basins i.e., Ganga & partly in Narmada basin. About 82 % area of the district is drained by the Ganga basin. The Chhoti Mahanadi, Katni & Ken rivers are the major rivers of this basin. Ken river flows towards north and confluences with Yamuna River. Katni river flow easterly & confluences with Chhoti Mahanadi near Hantola village of Chhoti Mahanadi takes turn towards east & ultimately confluence with Son River of Ganga basin. The drainage and River map of the Katni district is shown in **Fig.1.17** and **Fig.1.18.**

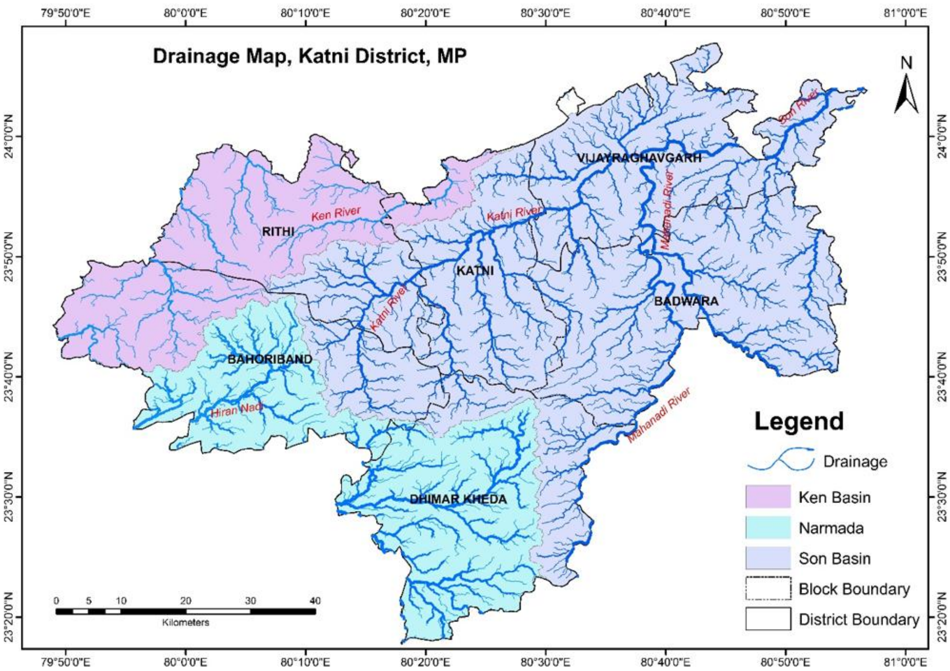


Fig.1.17: Drainage Map of Katni district

District Katni is drained by many rivers and its tributaries in which sand mining occurs like Choti Mahanadi, Son River, Umrer Nadi and Halphal Nadi etc.

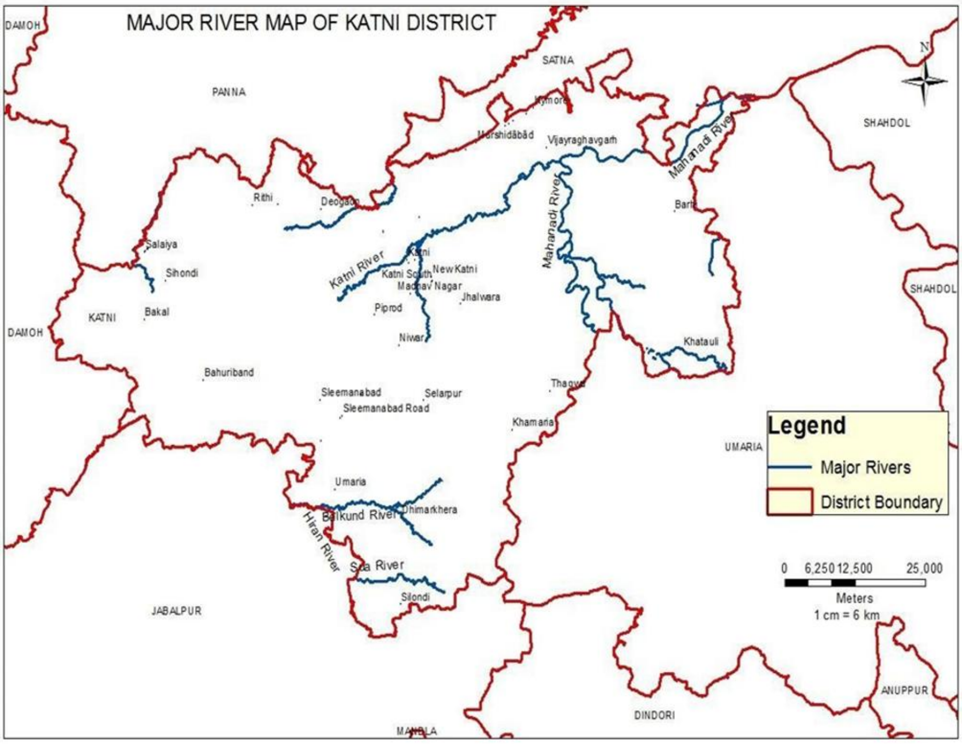


Fig 1.18: River Map of Katni district

Son River: The Son originates near Amarkantak in Madhya Pradesh just east of the headwater of the Narmada River, and flows north-northwest through Madhya Pradesh state before turning sharply eastward where it encounters the southwest-northeast- running Kaimur Range. Geologically, the lower valley of the Son is an extension of the Narmada Valley, and the Kaimur Range an extension of the Vindhya Range. The Son River at 784 kilometers long is one of the largest rivers of India. Its chief tributaries are the Tons, Choti Mahanadi, Rihand and the North Koel. The Son has a steep gradient (35– 55 cm per km) with quick run-off and ephemeral regimes, becoming a roaring river with the rain-waters in the catchment area but turning quickly into a fordable stream.

Dams: The first dam on the Son was built in 1873–74 at Dehri. The Indrapuri Barrage was constructed, 8 kilometers (5 mi) upstream, and commissioned in 1968.The Bansagar Dam in Madhya Pradesh was commissioned in 2008.

Katni River: The River Katni originates in the Katni District of Madhya Pradesh and flows from this region to Piprod and Mawai in the West. It also flows through the region of Vijayraghavgarh and Doli in the North east. However, in the West it is seen as flowing into the regions of Dukriya, Ruhniya and in some places of the region of Kua. From Ruhniya it comes southwards and is seen flowing in the regions of Pipariya and the major town of Dhimarpura. The river flows from the regions close to Panna in the north till Bakal in the west.This River is not that well known but is an important river in the state of Madhya Pradesh. The river Katni helps in irrigation and maintain fertility of the agricultural lands, it helps in the generation of electricity and is also useful for trading purposes. The river Katni originates in largest producers of lime in Madhya Pradesh as well as it is rich in resources like bauxite, iron ore.

Choti Mahanadi: A large size capacity "Dub Sagar Dam"is constructed where Choti Mahanadi turns and meets in Son River. Mahanadi enters in Umaria district near Gura Kalan.It flows down ward direction. Further near Ganeshpur river enters into Katni District where elevation of river 379 m. After crossing Ganeshpur village Choti Mahanadi flows through villages like Sakrigarh, Bansari, Suddi, Rajarwara, Ghanaur, Barhati, Barua and turns easterly near its confluence with dub Sagar dam and merge in Son River at that point. Thus, in the downstream, it carries huge load of sand (originates after weathering of sedimentary rocks and recent formations). But initially, the sandy matter is less.

Umrer Nadi: This is another river in district Katni in which availability of sand or gravel or aggregate resources are present. It originates near Darauri (23^0 51' N - 80^0 38' E) near SE Direction in district. It takes south easterly course for about 20km through basaltic terrain and turns towards south and flow to Umaria district through salaiya khurd-imaliya in zigzag course. From this point it takes a South direction in Umaria district. It is a rich source of sands and other associated aggregates as after entering into Umaria District. Moreover, due to lithology of the course, the quality of sand is also good. A large tract of this river is utmost suitable for sand mining. Many of the sand quarries operated by the MP State Mining Corporations Ltd. are in this tract.

Halphal Nadi: It originates near Kumharwara in Katni district. It runs towards easterly through Chhindahaipipariya village initially and then further flows up toNadawan in Katni district than enters Umaria district. The total length of Halphal Nadi is approx. 15 km up to Nadawan.

CHAPTER-2

DATA COLLECTION AND GENERATION

2.1 Data Collection and Compilation

The primary data such as well locations, discharge, water quality, and lithological unit inputs were available with CGWB, NCCR, Bhopal and utilized as baseline data. However, the ancillary data such as irrigation facilities, rainfall, climate data, Land use and land cover data, etc., have been collected from various sources like the National Bureau of Soil Survey and Land Use Planning, Geological Survey of India, BHUVAN (ISRO) and various state govt. departments and other internet sources and complied.

The data collection and compilation for various components were carried out as given below:

Hydrogeological data: Current and historical (last 5-6 years) water level data of 19 NHS wells and 77 key wells (established) available for Katni district from the Central Groundwater board Bhopal.

Hydro chemical data: Water quality data from 99 wells of pre-monsoon has been collected and compiled.

Exploratory drilling: Groundwater exploration data of 16 existing exploratory wells complied.

Geophysical data: TEM were conducted in the study area.

Hydrology data: Data on various irrigation projects, their utilization status, and area irrigated from the irrigation department.

Hydro meteorological data: Long-term rainfall data from IMD and WRIS and Katni district reports were compiled.

Land use and Land cover data: It is retrieved from the BHUVAN platform of the Indian Space Research Organization and compiled and processed using GIS software.

Cropping Pattern data: Data on prevailing cropping patterns from District statistical dairy and agriculture department were compiled.

2.2 Data availability and data gap analysis

After taking into consideration, the data available with CGWB on Groundwater exploration, geophysical survey, water level monitoring, and water quality, the data were compiled. The requirement, availability, and gap of major data inputs i.e., exploratory wells, geophysical data, and water quality data are detailed in **Table.2.1**.

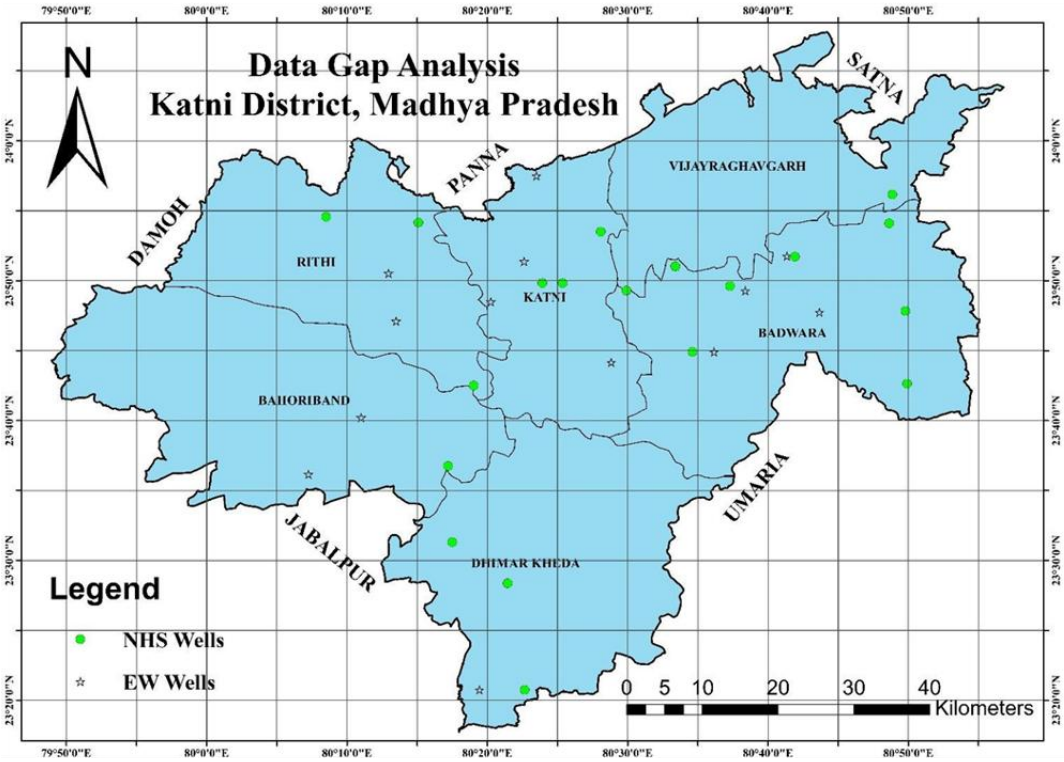


Fig.2.1: Data Gap Map

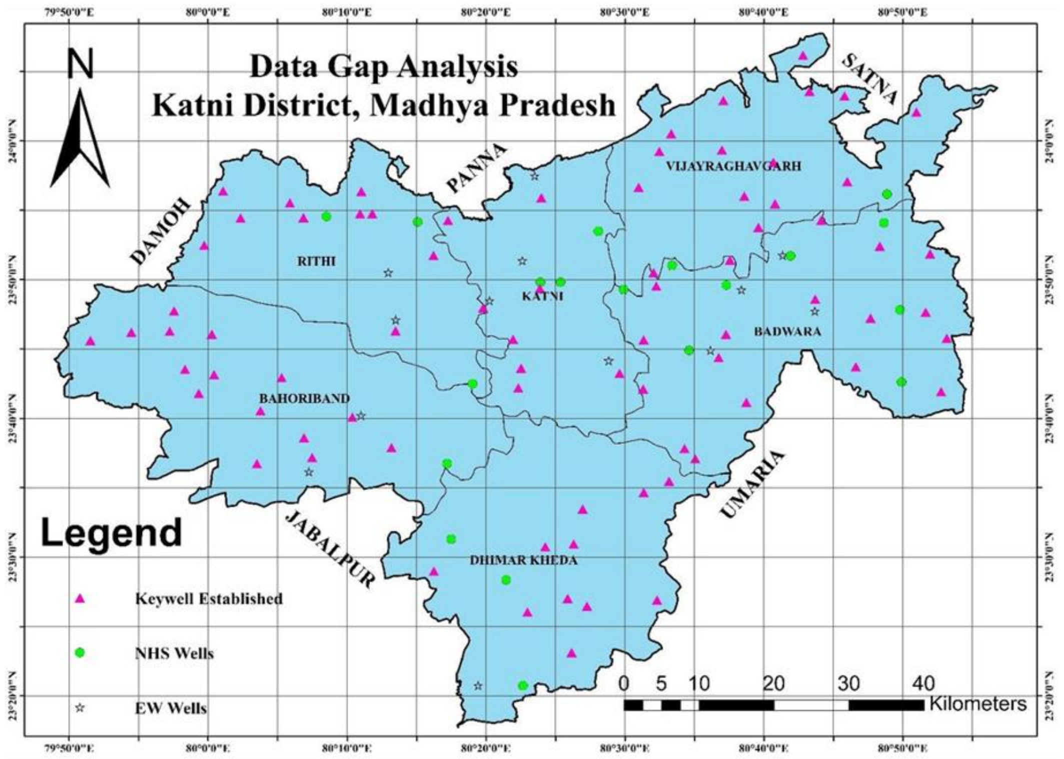


Fig.2.2: Key wells, NHS wells and EW location map with Data Gap analysis

Table.2.1: Data gap Analysis

S. No	Items	Data Requirement	Data Availability	Data Gap
1	Climate	Season-wise Rainfall pattern	Annual Rainfall of Meteorological Stations	Time series data Rainfall
2	Soil	Soil map and Soil infiltration rate	Soil Map	Soil infiltration rate
3	Land Use	Latest Land use pattern	Till 2015-16	Land use and data map. The latest updated data required
4	Geomorphology	Detailed information on the geomorphology of the area	Satellite data available	District-level information on 1:50000
5	Geophysics	Geophysical data of the study area	TEM	-
6	Geology	Detailed information on the geology of the area	Quadrangle map available	The map on 1:50000 to be provided by CHQ
7	Exploration data	Detailed information on the subsurface of the area	18 EW Data Available	Exploratory wells are required
8	Hydrogeology	Water Level	Water level from 19 NHS wells and 77 Keys is available	No Data Gap
9	Water Quality	Water quality and its suitability for Drinking, Irrigation & Industrial purposes	Data available for NHS and Key wells extablished	Aquifer wise Groundwater quality data need to be collected

Based on the data gap analysis, it indicates that the existing groundwater data are adequate to represent the area. Existing Exploratory wells data is not adequate for a better understanding of its behavior in terms of subsurface geology. Geophysical studies is required for better understanding of the sub surface data. Therefore, there is a need to increase the density of exploratory wells in the study area. The details of the location are given in **Annexure II**.

2.3 Ground Water Exploration

CGWB had drilled 13 exploratory wells (1997-2001) and 05 exploratory wells (2022-23) in the district. Hydrogeological data of exploratory wells drilled in the district is given in Annexure-I. From the perusal of Annexure-I reveals that, yield of Gondwana formations vary from 4.7 lps to 15.71 lps & drawdown ranges between 3.57 m to 8.44 m. The yield of Archean is between 2.66 of 3.0 lps for drawdown of 40.85 m. The yield of exploratory wells located in Vindhyan are showing merger discharger to 5.5 lps at Gulwara.

The Katni formation showing the yield between 3.5 lps and 14.67 lps for draw down between 21.48 m & 37.64 m. The exploration in cavernous limestone done at Kuan the yield was found 18 lps for 4 m draw down only. Aquifer tapping in shale formation have poor yield ranging from 1.5 lps to 5.5 lps.

2.4 Ground Water Monitoring Wells

Central ground water board has been carrying out water level monitoring through ground water monitoring wells since last two decades. The water levels of the monitoring wells are being monitored four times in a year during the month January, May, August and November. CGWB has established 14 Dug wells and 03 Piezometers for water level monitoring purpose. The locations of monitoring wells are shown in **Fig.2.3**.

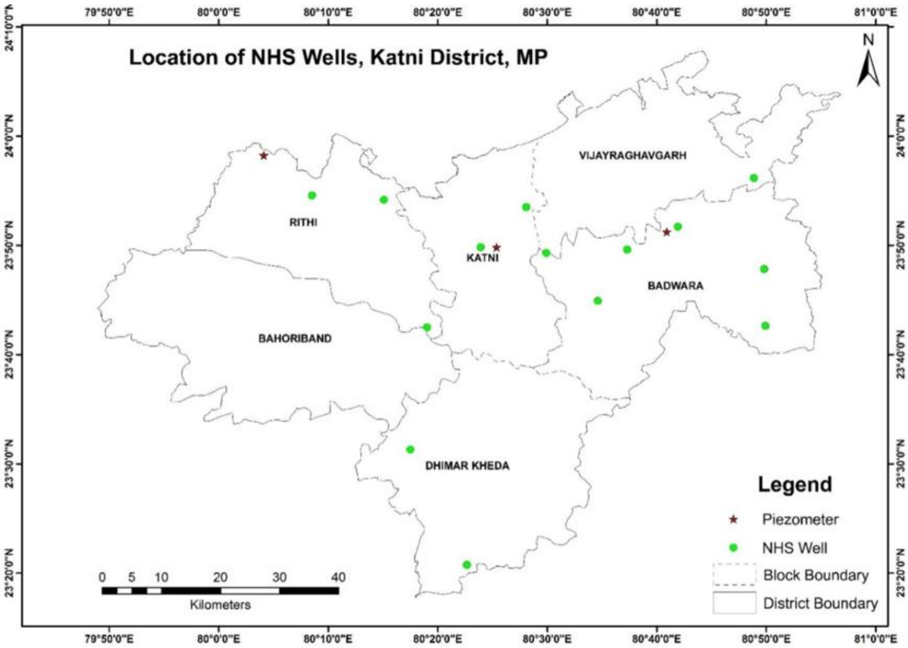


Fig.2.3 Location of NHS monitoring points in Katni District

2.5 Thematic Layers

The following 5 thematic layers were also generated on GIS platform which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

- Drainage and River
- Soil
- Land Use – Land Cover
- Geology and Structure
- Physiography

The thematic layers such as geology, drainage, soil, land use-land cover have been described in Chapter - 1.

CHAPTER-3

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Hydrogeology

Katni district is underlain by various geological formations, forming different types of aquifers in the area. Main geological units of the area are, Archaean, Mahakoshals, Vindhayan Super group, Gondwana super group, Lametas, Deccan traps, Katni formation, Laterites and alluvium. Occurrence and movement of ground water in hard rocks is mainly controlled by secondary porosity in Gondwana Sandstone & Vesicular Basalts in Deccan traps play an important role in ground water movement. Lameta are also forming potential aquifers made up of relatively loose and friable shale & sandstone. Ground water in general occurs under unconfined to semi-confined conditions. The occurrence and movement of ground water in different geological formation is described below. The hydrogeological map of the Katni district is shown in **Fig.3.1.**

Mahakoshal group (Archaean):

There rocks consisting of quartzite, shale, slate & marble are hard, compact, recrystallized and have no primary porosity & form poor aquifer: However, limestone at places have solution cavity resulting into very high secondary porosity & permeability can yield 18 lps. water in wells. There formations are found in southern part of the district in Dhimarkheda block the open wells existing in their formations can yield moderate quantity of ground water. The yield depends upon the saturated thickness of weathered mantle overlying the massive rock. The open wells have depth range between 9 to 15 mbgl. Generally, column of water available during pre-monsoon season varies from 2 to 4 m. the general yield potential of Archaean formations in less than 3 lps.

Vindhyan:

There are mostly sandstones and are devoid of primary porosity. However, due to weathering, fracturing & jointing the top position of formation behave as phreatic aquifer due to development of secondary porosity. There is poor yielding formation for the ground water point of view both in phreatic & deep aquifer zone. There formations occupied the northern part of the district in form of Kaimur ranger from west to east covering major parts of Rithi, Bahoriband & Vijayraghavgarh block. The depth of open wells exists in this formation ranges from 8 to 15 mbgl. The general yield potential of Vindhyan formation is less than 3 lps.

Gondwana:

There are sedimentary formation and are rich in granular zones forming moderately potential aquifers. Gondwana sand stone. Support both tube wells & dug wells and capable of yielding up to 5 to 16 lps of water for moderate drawdown of 4 to 8 m. There formation is occupying eastern parts of the district in Badwara & Katni blocks & underlain by older alluvium.

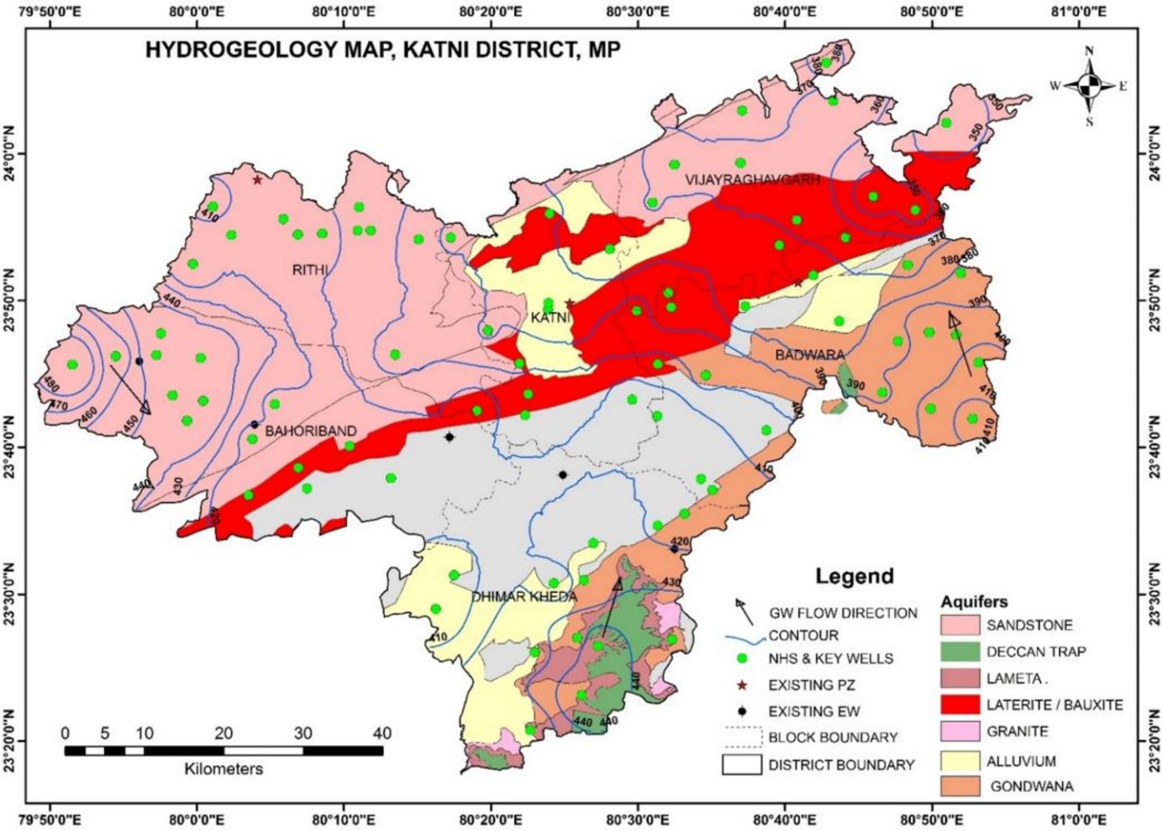


Fig.3.1: Hydrogeological Map of Katni district

Lameta bed:

This group consists of limestone, sand stone & days and lie unconformably on the older rock formations & are found usually underlying Deccan traps. There formations occupying southern part of the district in Dhimarkheda block in a narrow strip in the area. There beds are sandy containing chart, Jasper, pebble result being a calcareous grit rather than limestone & having thickness of about 8 to 15 m. and can yield poor to moderate discharge. Lameta, Gondwana contact can be explored for moderately potential aquifers.

Deccan Traps:

Deccan traps are very limited in the area in parts of Dhimarkheda block. the weathered, jointed, fractured & vesicular units of basalt form moderately potential aquifer. These formations have highly variable yield, being higher in dug wells ranging from 2 to 7 lps & generally increase with the depth.

Katni formation

These are horizontally disposed sequence belonging to Jabalpur bed of Gondwana super group with thickness varying between 13 to 52 m. It consists of thin veneer of ferruginous sediments and its base is conglomerate/pebbly ferruginous quarts wake with bauxite. This formation is exposed above 380 m. amsl over the entire Katni valley. The exploratory box wells in this formation have discharge from 3.5 to 7 lps. for 7.50 to 23 m. of draw down.

Laterite:

It is most abundant in block of Katni area & transferred pebbles of these laterites are seam at the base of Katni formation over the Jabalpur beds. This formation has poor to moderate field ranging from 3 to 4 lps.

Alluvium:

The alluvial deposits are confined mostly along and around the river courses in the Dhimarkheda & Bahoriband blocks along Balkund & Suhar rivers. This is about 10 to 12 m. thick & has very good ground water potential zones which can field up to 10 lps of discharge of ground water.

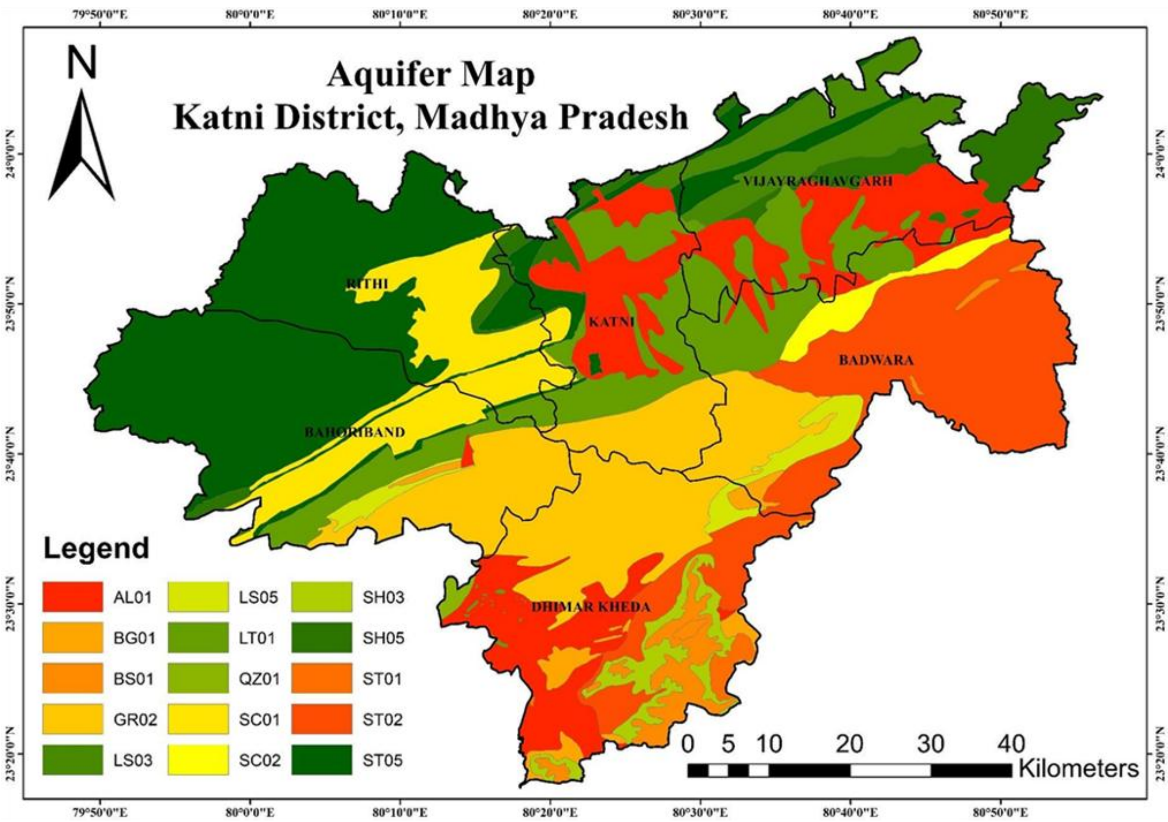


Fig.3.2 Aquifer map of Katni district

3.2 Ground Water Level Scenario

The present depth to water level scenario of aquifer was generated by utilizing water level data of 99 monitoring wells representing shallow aquifer.

3.2.1 Pre-Monsoon (May, 2022)

The **pre-monsoon** depth to water levels during May 2022 ranged between 2.5 mbgl (Gulwaram village) to 14.72 mbgl (Rohaniya village). The water levels more than 8 mbgl are observed in major (north eastern and south eastern) part and the water levels of less than 9 mbgl are observed in southern and western parts of the district. The pre-monsoon water level data is presented as Table 6, whereas depth to water level map is given in **Fig.3.3**

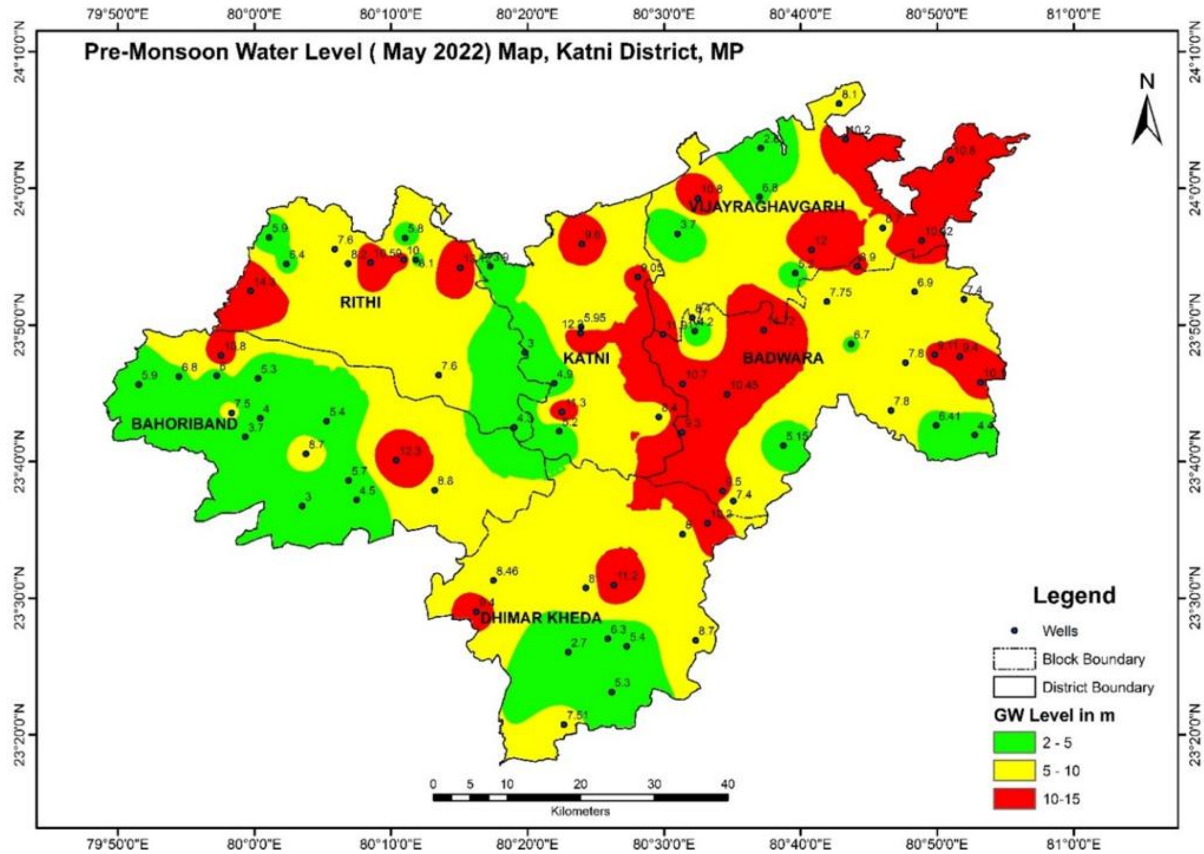


Fig.3.3: Depth to Water Level Map of Katni District (Pre-monsoon)

3.2.2 Post-Monsoon (November, 2022)

The **post-monsoon** depth to water levels during November 2022 ranged between 0.20 m - 9.76 m. The water levels more than 8 mbgl are observed in major (north eastern and south eastern) part and the water levels of less than 9 mbgl are observed in southern and western parts of the district. The pre-monsoon water level data is presented as Annexure-III, whereas depth to water level map is given in **Fig.3.4.**

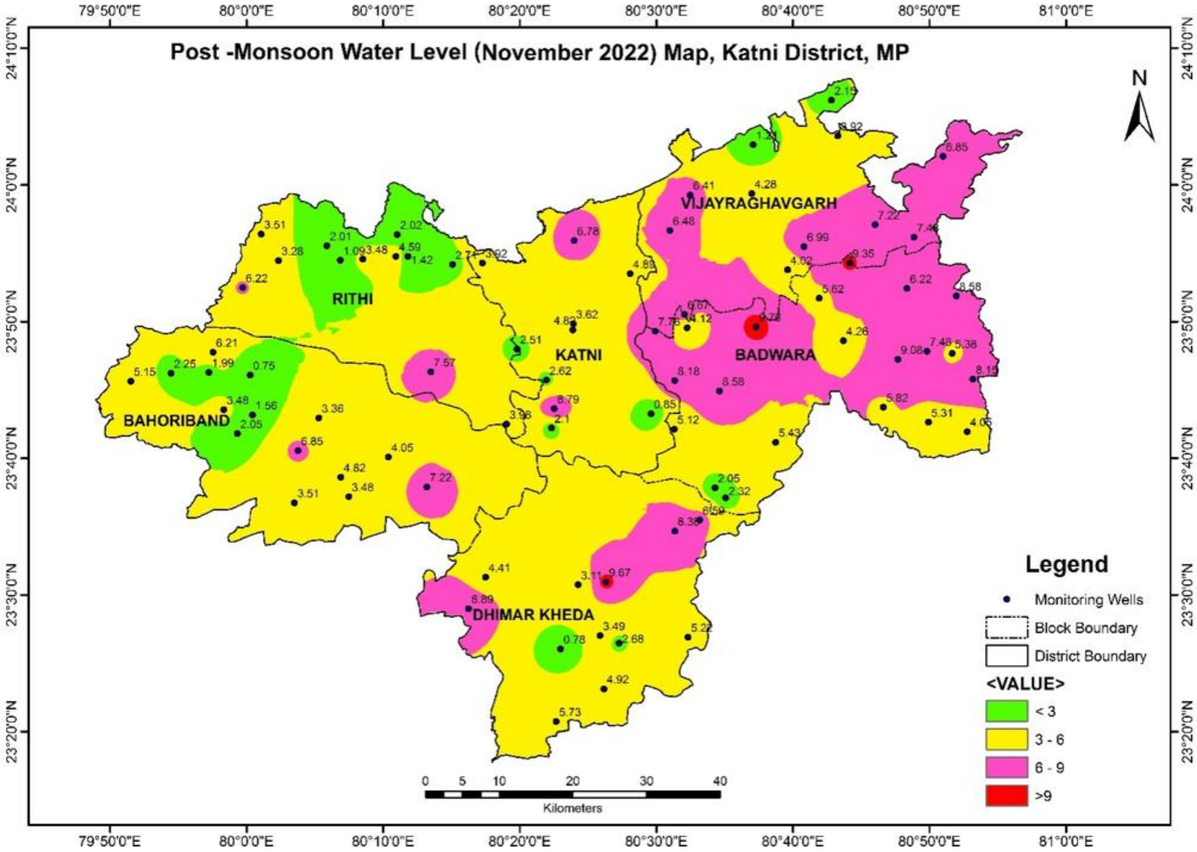


Fig.3.4: Depth to Water Level Map of Katni District (Post monsoon)

3.2.3 Water level Fluctuation

The water level measured during pre and post monsoon period (2022) was used to compute the seasonal fluctuation. The analysis of water level fluctuation data indicated that minimum water level fluctuation was 0.4 mbgl while maximum water level fluctuation was observed 6.4mbgl. The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analysed (**Table.3.1**)

Table.3.1: Analysis of Water Level Fluctuation.

S. No.	Category	Fluctuation Range	% of Wells
1.	Less water level fluctuation	0 to 2 m	33%
2.	Moderate water level fluctuation	2 to 5 m	42%
3.	High water level fluctuation	>5 m	25%

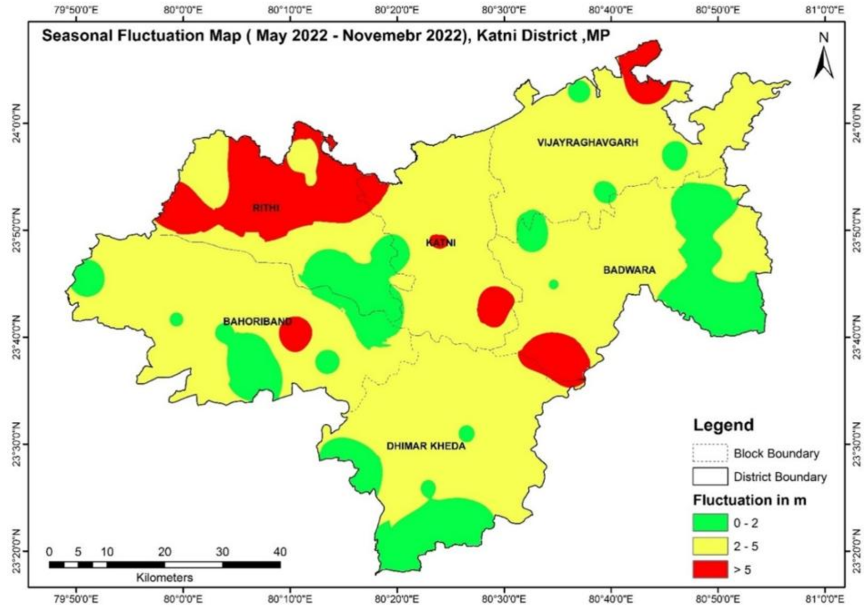


Fig.3.5 Seasonal Water Level Fluctuation map of Katni District

The analysis indicates that majority of the wells (42%) are falling in moderate fluctuation range indicating aquifer storage is good, whereas high fluctuation range were observed equal no of (25%) wells and low water level fluctuation were observed equal no of (33%) wells. The seasonal fluctuation map is presented as **Fig.3.5.**

3.2.4 Long Water Level Trend (2013-22)

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data for the period 2013-22 have been computed and analyzed.

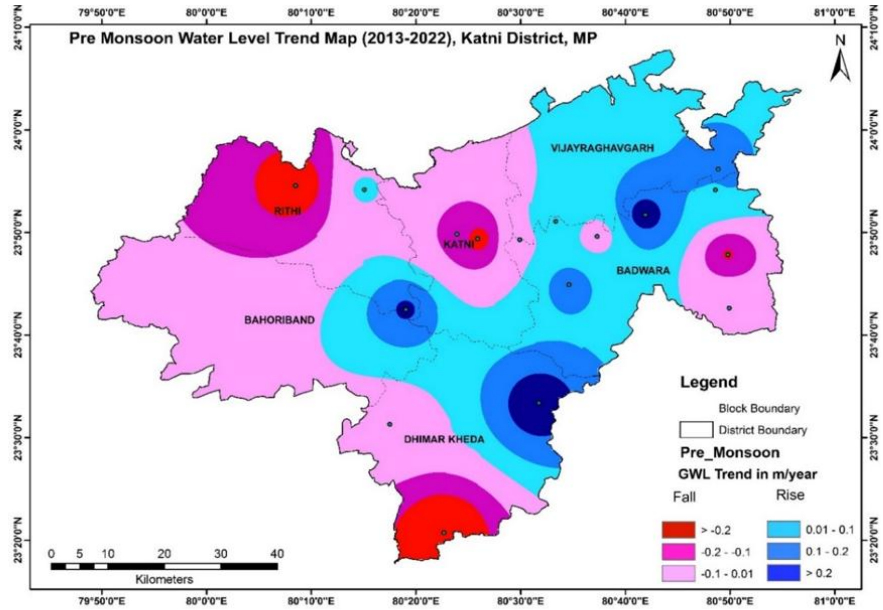


Fig.3.6 Pre-Monsoon GW level trend map (May 2013-May 2022)

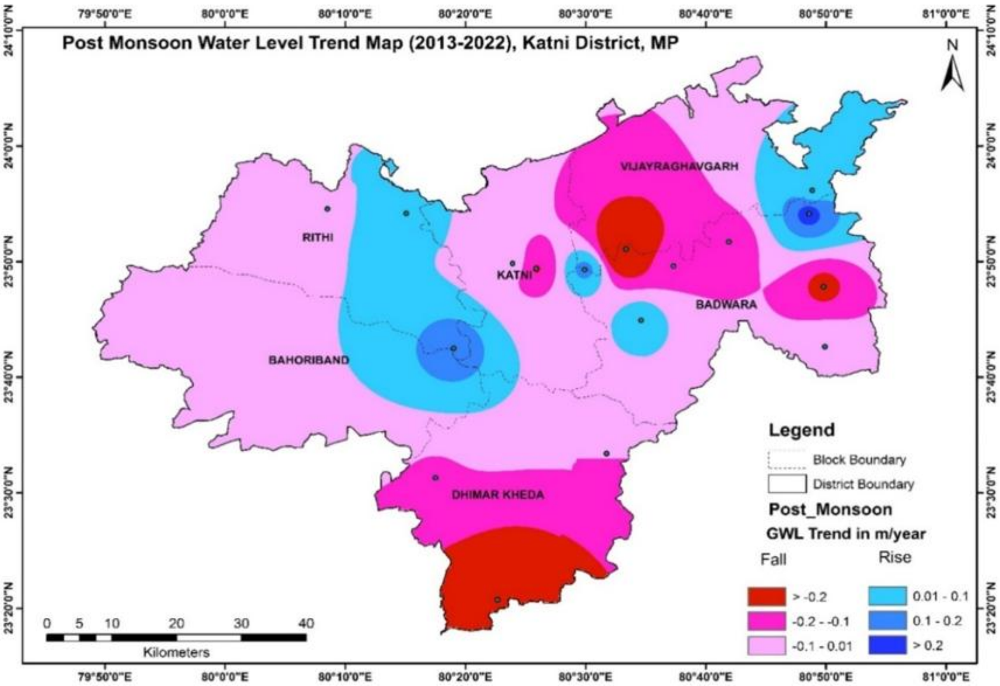


Fig.3.7 Post-Monsoon GW level trend map (Nov 2013-Nov 2022)

The decadal pre-monsoon water level trend analysis (**Fig.3.6**) indicates that during pre-monsoon period, 54% of the district are showing rising trend. Rest few parts of the district is showing falling trend.The decadal post-monsoon water level trend analysis (**Fig.3.7**) indicates that central, SE and SW area showing declining trend. Maximum falling trend is ranged between -0.01 to -0.2 m/yr.

3.3 Hydro Chemical Study (Ground Water Quality)

The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water on the growth of human being, animals, and various plants and also on industrial requirement. Though many ions are very essential for the growth of plants and human body but when present in excess, have an adverse effect on health and growth.

Hydro-chemical scenario of Katni District

The water samples were collected from NAQUIM study in clean double stopper HDPE poly ethylene bottles from 77 nos. different locations for cation and anion analysis and 18 nos. of ground water for heavy/ trace metal analysis of Katni district during pre-monsoon 2022. During post-monsoon 2022, 19 nos. of ground water samples collected for cation and anion analysis.

Quality of Ground Water for Drinking Purpose:

The ground water samples from Katni district have varied range of pH from 6.94 to 7.96. 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 Deori Phatak (7.96). The ground water of the study area can be assessed as neutral to slightly alkaline in nature. The electrical conductivity of ground water samples in Katni district varies from 248 to 3628 µS/cm at 25°C. In the 70 nos. of ground water samples recorded electrical conductivity less than 1000µS/cm; 10 nos. of water samples recorded electrical conductivity in between 1000 to 1500 µS/cm at 25°C; 4 nos. of water samples recorded electrical conductivity in between 1500 to 2000 to 3000 µS/cm at 25°C; 2 nos. of water samples recorded electrical conductivity more than 2000 µS/cm at 25°C namely Banson (2205 µS/cm at 25°C) and Badapar (2345 µS/cm at 25°C) whereas 2 nos. of water samples recorded electrical conductivity more than 3000 µS/cm at 25°C namely Hardwara (3156 µS/cm at 25°C) and Bartari (3628 µS/cm at 25°C). So, overall ground water quality in Katni district is good to slightly saline in nature and few locations are saline in nature. The maximum electrical conductivity has been observed in the water sample of Bartari (3628 µS/cm at 25°C). The electrical conductivity of post-monsoon water samples ranges between 295 to 2413 µS/cm at 25°C. In the water samples of post monsoon only 1 sample in between 1500 to 2000 µS/cm at 25°C; whereas 2 locations have been more than 2000 µS/cm at 25°C namely: Hardwara (2261 µS/cm at 25°C) and Banson (2413 µS/cm at 25°C). The electrical conductivity of water samples is more than 2000 µS/cm at 25°C shows that the water is saline in nature.

The fluoride concentration in Katni district lies in between 0.11 to 1.17 mg/l, which represents that all the samples are within the permissible limit i.e., 1.5 mg/l as per BIS (IS 10500: 2012). The maximum fluoride concentration has been observed in the water sample of Jharela village i.e., 1.17 mg/l. The fluoride concentration in water samples during post-monsoon are ranges between 0.14 to 0.95 mg/l which indicated fluoride concentrations are within the permissible limit. Nitrate concentration in ground water samples of Katni district falls within the 1 to 310 mg/l. It is observed that 21.59% samples have nitrate concentration more than the acceptable limit i.e., 45 mg/l, while rest 78.41% samples have concentration less than acceptable limit. Highest concentration (more than 100 mg/L) of nitrate is reported in the water samples of Kothi (110 mg/l), Bhamka (114 mg/l), Majhgawan (117 mg/l), Takhala (123 mg/l), Hardwara (156 mg/l), Neemkhere (186 mg/l) and Banson (310 mg/L). High nitrate in ground water samples may be due to anthropogenic activities or excessive use of fertilizers. The range of Total Hardness (as $CaCO_3$) in ground water samples of study area is 50 to 990 mg/l. During post-monsoon, nitrate concentration ranges between 10 to 232 mg/l. Highest concentration (more than 100 mg/L) of nitrate is reported during post-monsoon namely: Neemkhere and Hardwara (105 mg/l), Bhanka (150 mg/l) and Banson (232 mg/l)

In all locations, total hardness concentrations are within the permissible limit of 600 mg/l except the villages of Banson (610 mg/l), Pipariya (765 mg/l), Badapar (865 mg/l) and Bartari (990 mg/l). During post-monsoon, total hardness concentration is within the permissible limits and ranges between 100 to 560 mg/l.

The analysis of heavy/ trace metal analysis in the ground water of Katni district shows that the copper and nickel are below detectable limit whereas concentration of iron ranges between 0.013 to 1.136 mg/l. the maximum concentration has been observed in the village of Harduwa 1.136 mg/l i.e., more than permissible limit of 1.0 mg/l. The zinc concentration ranges between 0.082 to 0.432 mg/l and manganese concentration ranges between 0.011 to 0.504 mg/l. the maximum concentration has been observed in the village of Banson 0.504 mg/l i.e., more than BIS permissible limit.

Piper diagram **Fig.3.8** 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 (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) are plotted. In Anion triangle the major anions (HCO_3^{-}+CO_3^{2-}, SO_4^{2-}, Cl^{-}) are plotted. These points are then projected to the central diamond shaped field. The piper diagram of Katni district shows the ground water samples are Calcium-chloride type i.e., permanent hardness, Calcium-Bicarbonate type i.e., temporary hardness; Mixed type i.e., Calcium-Magnesium Chloride type; Mixed type i.e. Calcium-Sodium Bi-carbonate type and Sodium Chloride types i.e. saline in nature.

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 Katni district is plotted on U.S. Salinity Laboratory diagram.

U.S. Salinity Laboratory diagram **Fig.3.9**, the ground water samples of Katni district are C_1-S_1 Class (Low Salinity & Low Sodium); C_2-S_1 Class (Medium Salinity & Low Sodium) and C_3-S_1 Class (High Salinity & Low Sodium), C_4-S_1 Class (Very High Salinity & Low Sodium), C_3-S_2 Class (High Salinity & Medium Sodium), C_4-S_2 Class (Very High Salinity & Medium Sodium), C_4-S_3 Class (Very High Salinity & High Sodium) which means that these waters may be used for irrigation purpose for most of the crops. The ground water of C_3-S_1; C_4-S_1; C_3-S_2; C_4-S_2 and C_4-S_3 classes may be used for irrigation, considering the salinity content of the ground water.

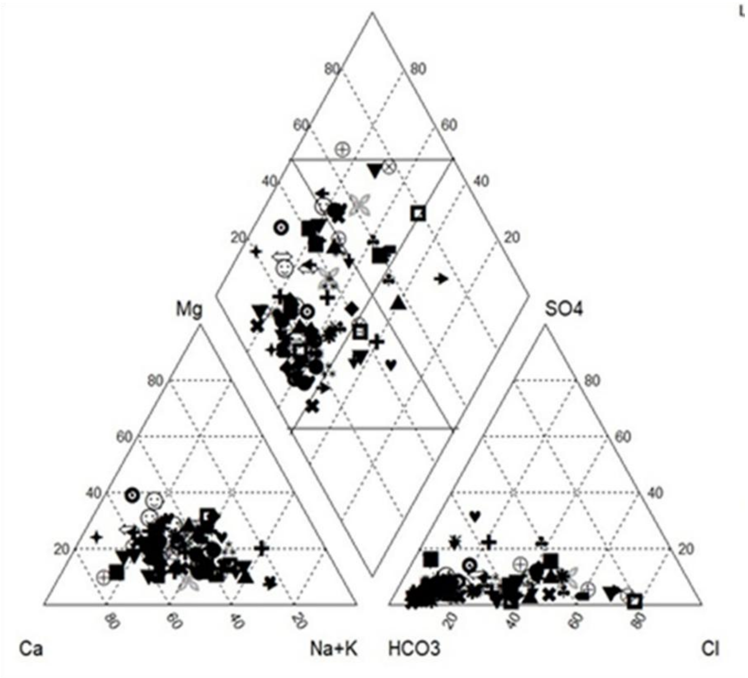


Fig:3.8 Hill Piper Diagram representing classification of water samples collected from National Hydrograph Stations, Katni District, Madhya Pradesh

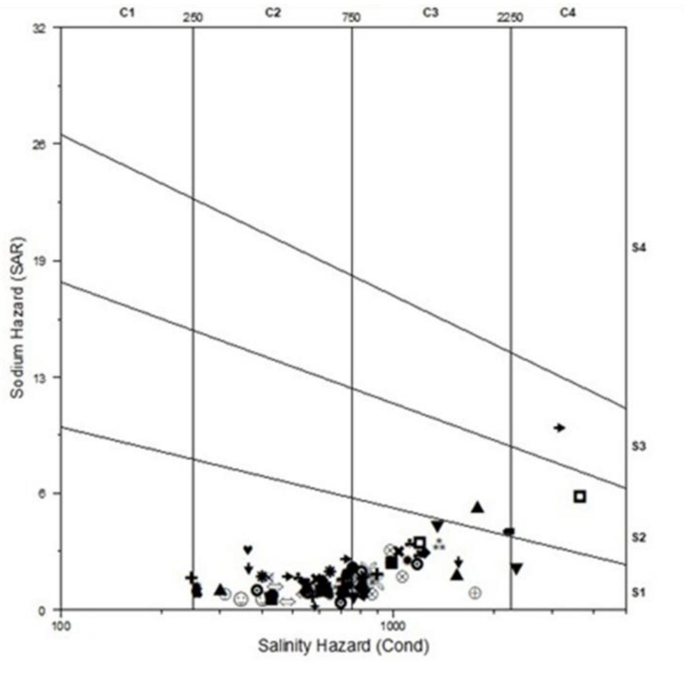


Fig:3.9 US Salinity Diagram for water samples collected from National Hydrograph Stations of Katni District, Madhya Pradesh.

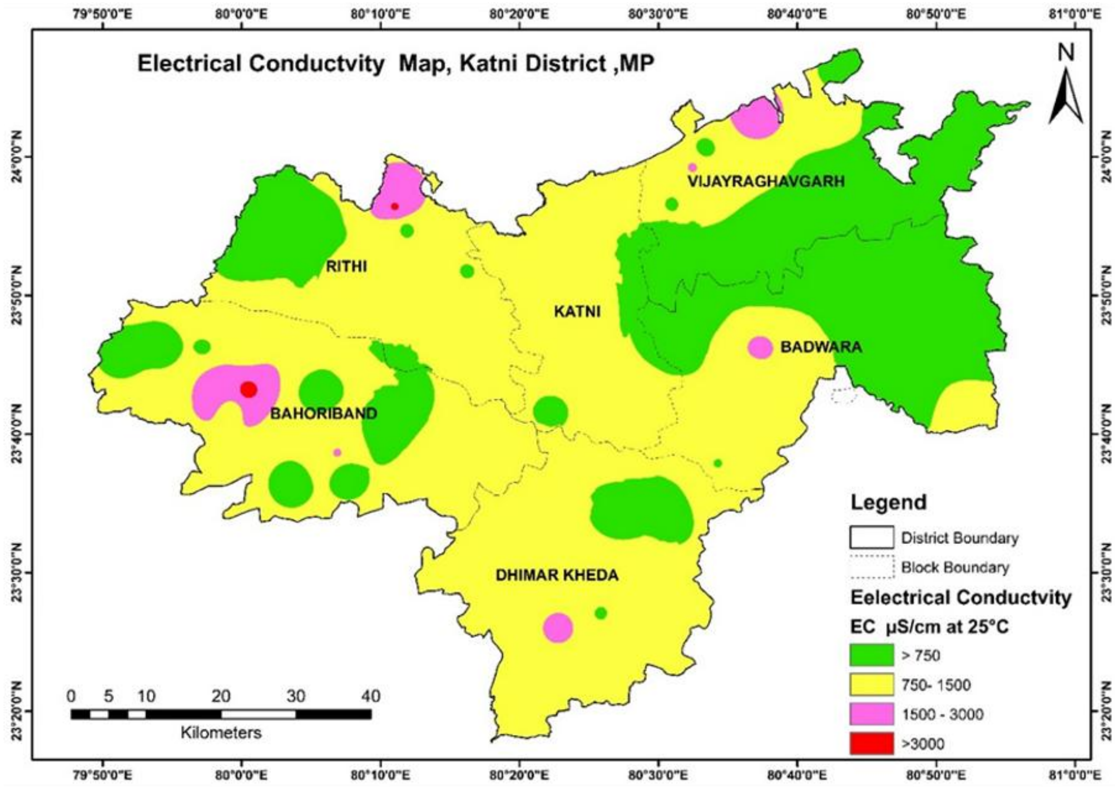


Fig.3.10: Electrical Conductivity map of Katni district

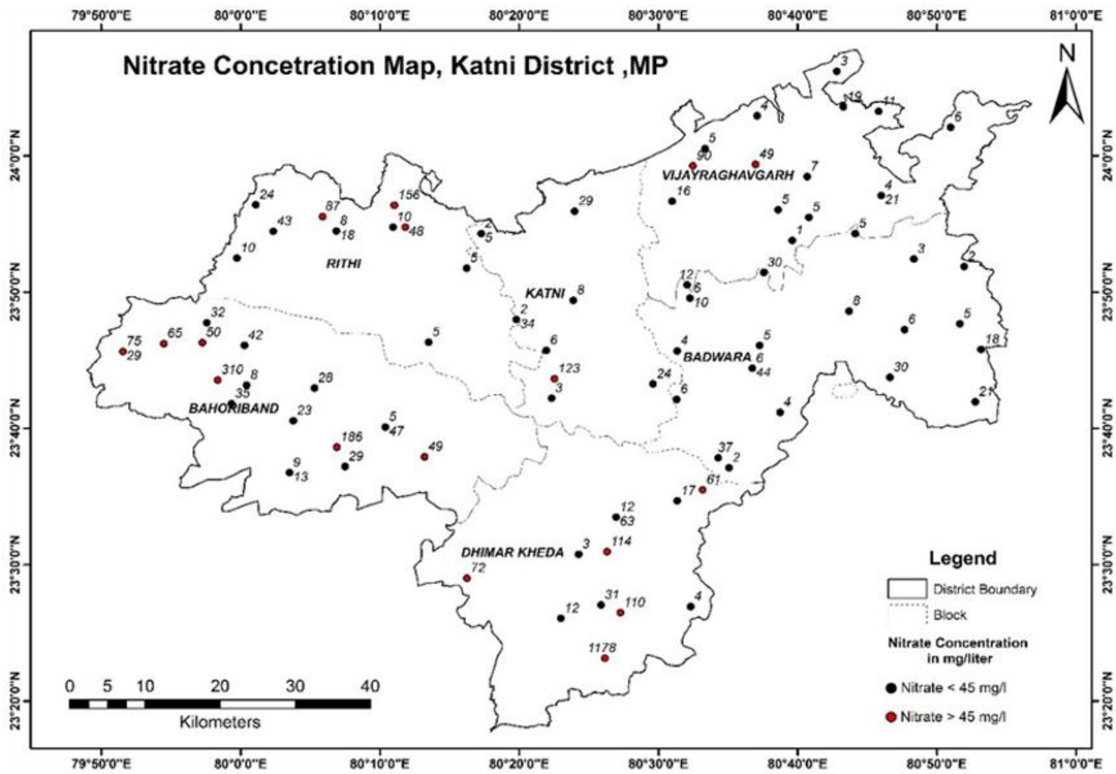


Fig.3.11: Nitrate concentration map of Katni district

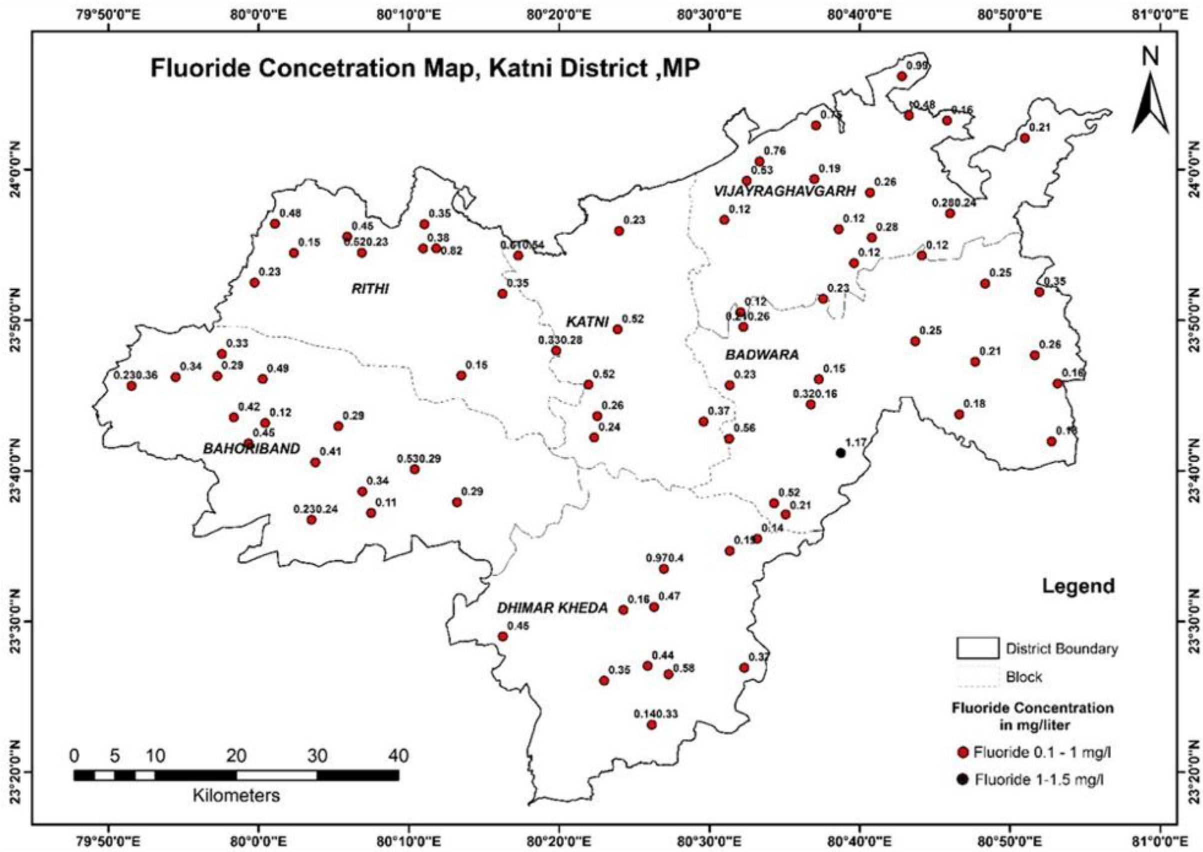


Fig.3.12: Fluoride concentration map of Katni district

3.4 3-D and 2-D Aquifer Disposition

The data generated from ground water monitoring wells, micro level hydrogeological inventories, exploratory and observation wells, various thematic layers was utilized to decipher the aquifer disposition of the area. This particularly includes the information on geometry of aquifers and hydrogeological information of these aquifers. In the area the two aquifer systems have been deciphered as listed below:

a. **Aquifer –I (Shallow Aquifer)**

b. **Aquifer – II (Deeper Aquifer)**

3.4.1 3D model

A 3-Dimensional lithological model was prepared for the Katni district after detailed analysis of the pre-existing and available bore-log data from the exploratory and observation well. A comprehensive analysis was made as per lithology and stratigraphy of the area.

The 3-D Model results concluded that the region is dominantly occupied by Laterite, Alluvium(clay & sand), Quartzite, Marble, Dolomite, Gondwana sandstone and Vindhyan limestone, sandstone, shale, Slate. The sub-surface lithology has been broadly classified into Top Laterites/Unsaturated zone, Alluvium, underlain bylimestone, Dolomite which has been considered as shallow aquifer (up to a depth of 60 meter). This Vindhyan Shale/Sandstone, Slate, Marble, Quartzite that forms the deeper aquifer (from 60-200 meters).

The 3-D representation indicating the disposition of various aquifers is presented in **Fig.3.13.** The disposition of Aquifer-I and Aquifer- II and other geological units can be observed in the 3D diagram.

3.4.2 2-Dimensional Cross Section:

2-Dimensional cross-section A-A' covering the wells Khamariya, Tigawan, Tewari and Parahua along the direction NW-SE been prepared and shown in the **Fig.3.14.** The cross section shows that the thickness of the prominent aquifer i.e., Alluvium and Shale thickness more in Khamriya (NW side) and decreases towards Parahua (SE side) and Limestone and dolomite formation is gradually increases. The thickness of the deep aquifer is also limited and confined in shale formation in Khamariya site.

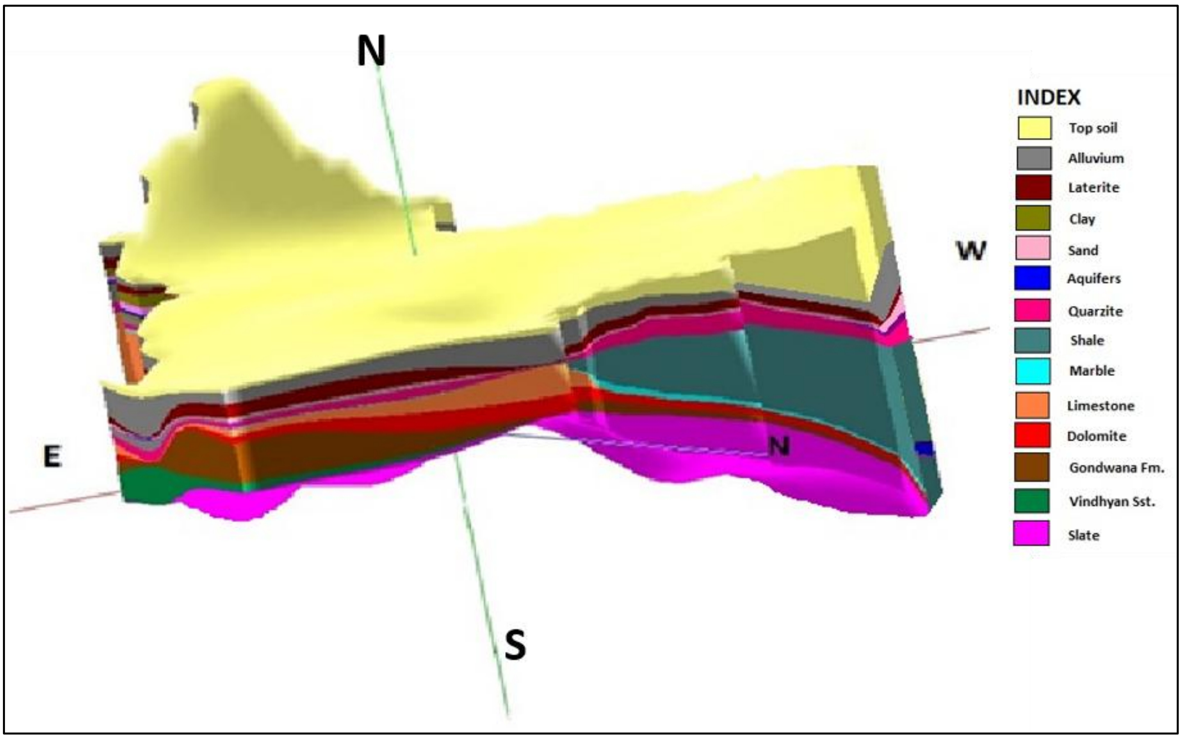


Fig.3.13: 3-D Aquifer Model, Katni District

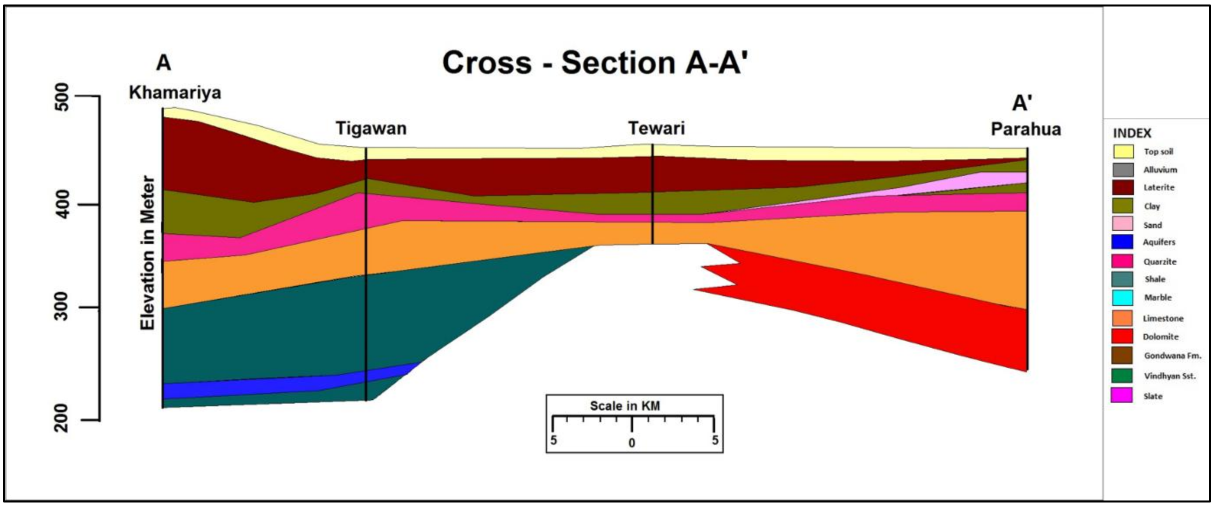


Fig.3.14:- 2-D Aquifer Cross Section, Katni District

3.5 Aquifer Characteristics

The Gondwana group of rocks, that bears the coal deposit, is also a fine groundwater repository in this district. Gondwana formation particularly the upper part of the Barakar sandstone supports development of phreatic aquifers which extends from few meters below ground level to 25 m below land surface.

Limestone also bears bedding fracture planes and secondary porosity and in limestone-shale joints. Fractured marble and fractured granite are the low ground water potential zones in the area.

The felspathic medium to coarse grained sandstone, bears groundwater in the interconnected primary pores is the formation as well as the contact planes between shales and sandstone.

Based on the ground water exploration carried out in the Katni district, the following two types of aquifers can be demarcated and the details are given below in **Table 3.2**.

Table.3.2: Aquifer Characteristics

Major Aquifer	**Alluvium/Laterite/Quartzite/Vindhyan Shale/sandstone/Limestone/Gondwana Formation/Slate/Marble**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Alluvium/Laterite/Lameta sandstone/Limestone/Gondwana sandstone	Weathered/fractured Vindhyan Shale/Limestone/Marble/Sandstone/
Depth of Occurrence (mbgl)	1 to 30	30 to 200
SWL (mbgl)	0.16 to 14.26	12.36 to 32.39
Weathered/ Fractured rocks thickness (m)	2 to 14	0.5 to 17
Fractures encountered (mbgl)	Up to 30	up to 200

Yield	Up to 5 lps	Up to 18 lps
Transmissivity (m^2/day)	0.520 to 6.86 m^2/day	6 to 72 m^2/day
Specific Yield/ Storativity (Sy/S)	-	$1.0x10^{-4}$ to $5.5x10^{-5}$
Suitability for drinking/ irrigation	Suitable for both drinking and agriculture, except high Nitrate at places	Suitable for both drinking and agriculture, except high Nitrate at places

3.6 Geophysical Exploration

Geophysical survey comprising transient electromagnetic (TEM) sounding was carried out with the objectives to delineate potential ground water (Aquifer) zones as well as quantifying the resistivity and thickness of various sub-surface geological formations. In all 120 TEM soundings at 23 locations were carried out this district guided by geological, hydrogeological, geomorphological studies. The location of the TEM shown in **Fig.3.15** and the list of location with coordinates are given in Table.3.3.

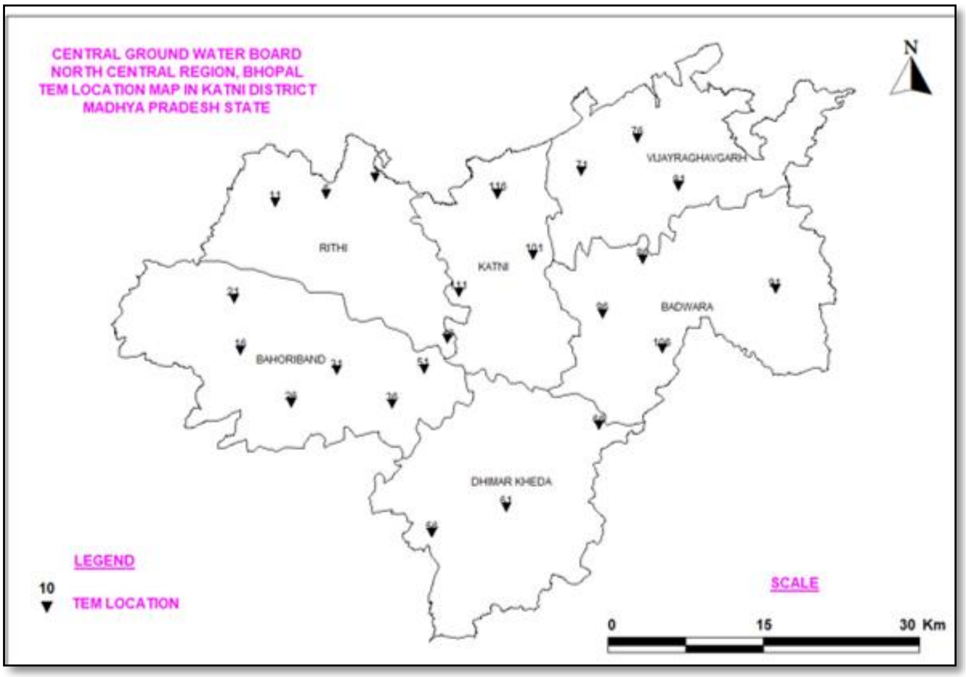


Fig.3.15: Location of TEM in Katni district, MP

Data Acquisition and Processing

TEM soundings were carried out using terra TEM-24 instrument of Monex Geo Scope Geophysical Manufacturing & Consulting Ltd. of Australia with a 40 X 40 m and 20 X 20 m coincident loop, where the transmitter and receiving coils are parallel to each other.

A time-varying current is applied into a transmitter loop, usually an ungrounded loop of wire laid on the surface. The transmitter loop generates an EM wave that propagates into the subsurface. As the EM energy encounters different subsurface materials, it induces eddy currents that generate secondary EM fields. These secondary EM fields are picked up at the surface by a receiver loop or magnetic antenna and recorded as the induced energy diffuses into the earth. The quantity acquired is the voltage measured in the receiver coil as function of time after switching off the primary field. The values are plotted on double log scale. The rate of diffusion/decay (Voltage) indicates the resistivity of the subsurface materials.

In order to construct image of subsurface, 5 to 10 TEM soundings were carried out along a profile line with sounding spacing of 5 and 10 m. Coordinates of each sounding point was taken with hand held GPS at the center of loops. The data was collected repeatedly to ensure steady state with varying current and frequencies to reduce the error. Current processing, modeling and inversion techniques were used to ensure uniformity. The data acquired were stored in the instrument receiver console.

The software TEMPLOT and IX1D were used for processing TEM sounding data. The collected data which was in BIN form was exported to TEMPLOT software to remove data points which deviated from decay curve (Ramp values and erroneous/noise values) and raw data is formatted into USF (Universal Sounding Format) which can be imported into modeling program IXID. The USF files were imported in IX1D software and selected for forward modeling process and generated a 1-D inversion model (Models of apparent resistivity as a function of apparent depth) for each sounding through. Most of the soundings reflect two to three-layer models of sub surface. At some of the GTEM locations, where the sites were drilled based on VES results, an attempt has been made for data validation and correlation.

Table.3.3. Location details of TEM conducted in Katni District, Madhya Pradesh

Sl. No	LOCATION	TEM STATIONS	LAT	LONG
1	SAIDA	5	23.9428	80.2169
2	RITHI	5	23.9192	80.1417
3	BHARATPUR	5	23.9086	80.0643
4	SANDA	5	23.7017	80.0122
5	KHAKKARA	5	23.7742	80.0020
6	PIPARIYA	5	23.6295	80.0897
7	BARKHERA	5	23.6743	80.1581
8	SLEEMANABAD	10	23.6273	80.2423
9	LAKHAPATERI	5	23.7179	80.3272
10	TIWARI	5	23.6757	80.2910
11	MURWARI	5	23.4482	80.3028
12	JINNA PIPARIYA	5	23.4835	80.4162
13	KHAMHARIYA	5	23.5978	80.5570
14	DEORA KALAN	5	23.9517	80.5305
15	BIJEYRAGOGARH	5	23.9977	80.6152
16	SINGAURI	5	23.9313	80.6784
17	BANSARI	5	23.8289	80.6243
18	KEOLARI	5	23.7875	80.8259
19	BARWARA KALAN	5	23.7535	80.5630
20	JOHLA	5	23.8352	80.4572
21	TIKARIYA	5	23.7041	80.6531
22	KATNI	5	23.7829	80.3445
23	KAILWARA	5	23.9202	80.4024
	Total	120		

1. SAIDA

Saida is located in Rithi Block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10m each. The resistivity of the top soil ranges from 101 to140 Ohm m with the thickness ranging from 0.9 to 1.5 m. This layer is followed by weathered sandstone with resistivity ranging from 69 to 103 Ohm m with the thickness of 14.6 to 33 m and this layer is followed by weathered limestone with the resistivity ranging from 46 to 80 Ohm m with the thickness ranging from 14 to 24 and this layer is followed by fractured sandstone with resistivity value ranging from 22 to 64 Ohm m with the thickness ranging from 4.7 to 20m and last layer resistivity ranging from 5.9 to 7.2 Ohm m indicates Clayey formation and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.16. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.17. Based on the pseudo section, it is inferred that there is no recorded ground level to 25 m due to poor signal and low conductance ranging in depth ranging from 25 to 80 m indicating massive sandstone at first three points where as other two points up to 100 m and high conductance values below the depth of 80m, indicating Clay at first three points.

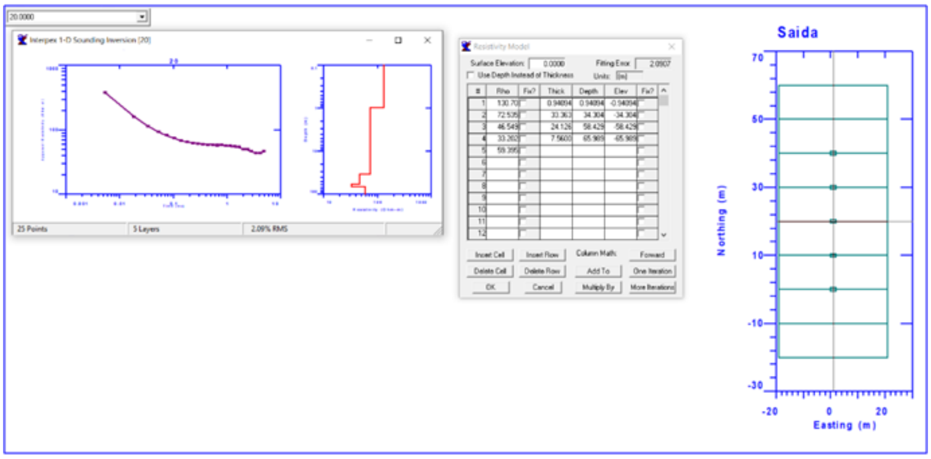


Fig. 3.16. Resistivity Curve Layers of Saida

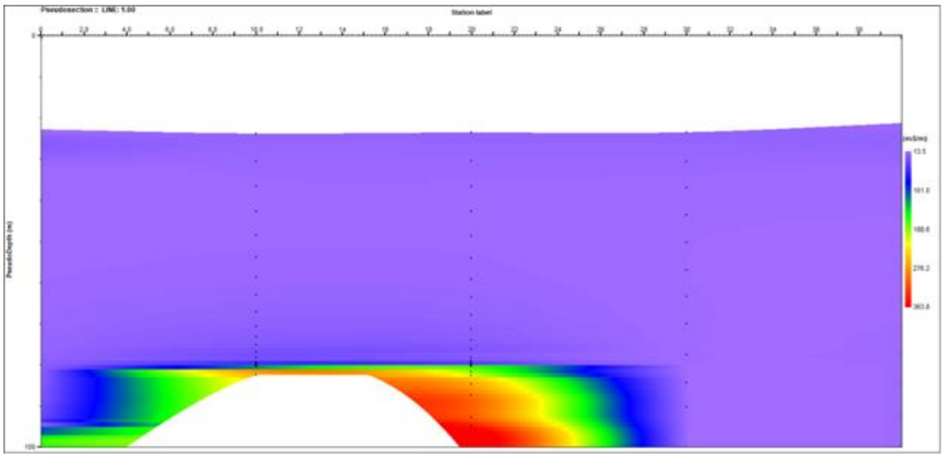


Fig. 3.17 Pseudo Section showing Conductance at Saida

2. RITHI

Rithi is located in Rithi Block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10m each. The resistivity of the top soil ranges from 107 to 304 Ohm m with the thickness ranging from 0.5 to 1.9 m. This layer is followed by weathered sandstone with resistivity ranging from 34 to 56 Ohm m with the thickness of 8 to 11m and this layer is followed by fractured sandstone with the resistivity ranging from 24 to 72 Ohm m with the thickness ranging from 9 to 11.5 m and last layer resistivity ranging from 63 to 196 Ohm m indicates massive Sandstone formation and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.18. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.19. Based on the pseudo section, it is inferred that there is no data recorded up to 10 m due to poor signal and high conductance ranging in depth ranging from 10 to 30 indicating weathered sandstone and low conductance values below the depth of 30 m, indicating massive sandstone.

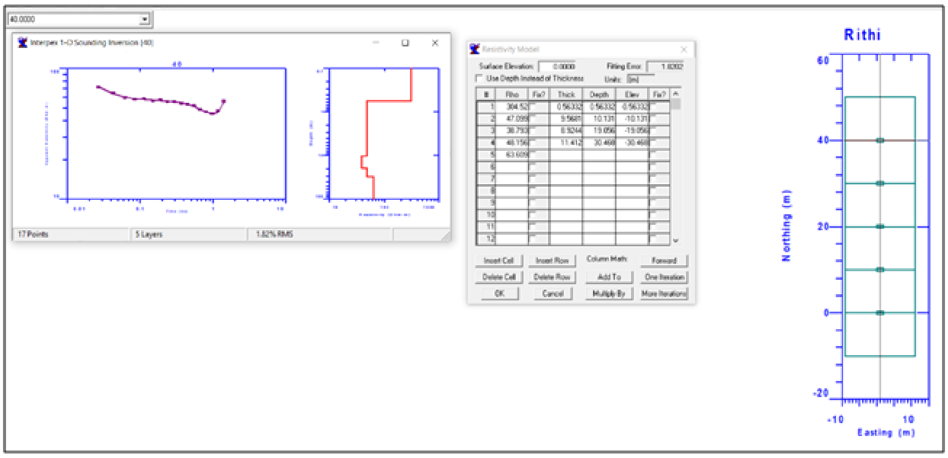


Fig. 3.18. Resistivity Curve Layers of Rithi

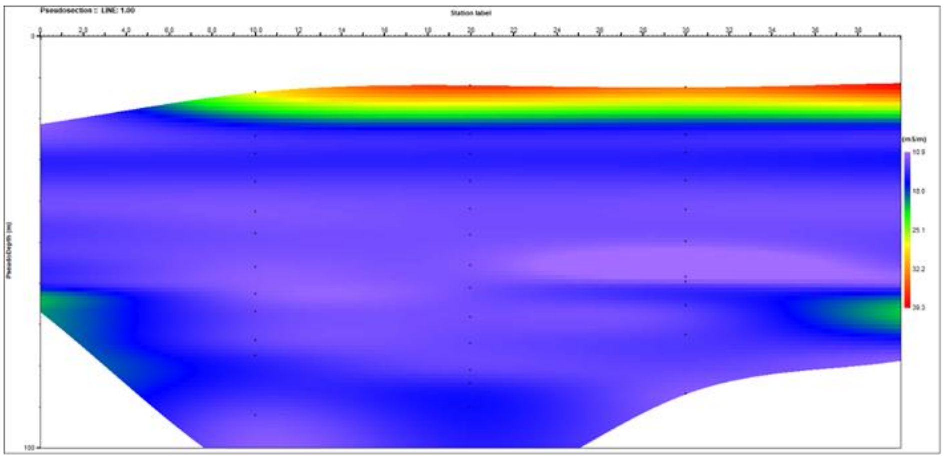


Fig. 3.19. Pseudo Section showing Conductance at Rithi

3. BHARATPUR

Bharatpur is located in Rithi Block. In total, 5 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 81.6 to 180 Ohm m with the thickness ranging from 1.2 to 1.6 m. This layer is followed by weathered sandstone with resistivity ranging from 14.8 to 30.2 Ohm m with the thickness of 5.5 to 13m and this layer is followed by fractured sandstone with the resistivity ranging from 39.4 to 80.8 Ohm m with the thickness ranging from 7.6 to 11m and last layer resistivity ranging from 76 to 149 Ohm m indicates massive Sandstone formation and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig.3.20. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.21. Based on the pseudo section, it is inferred that there is no data recorded up to 10 m due to poor signal and high conductance ranging in depth ranging from 10 to 30 indicating sandstone and low conductance values below the depth of 30 m, indicating massive sandstone.

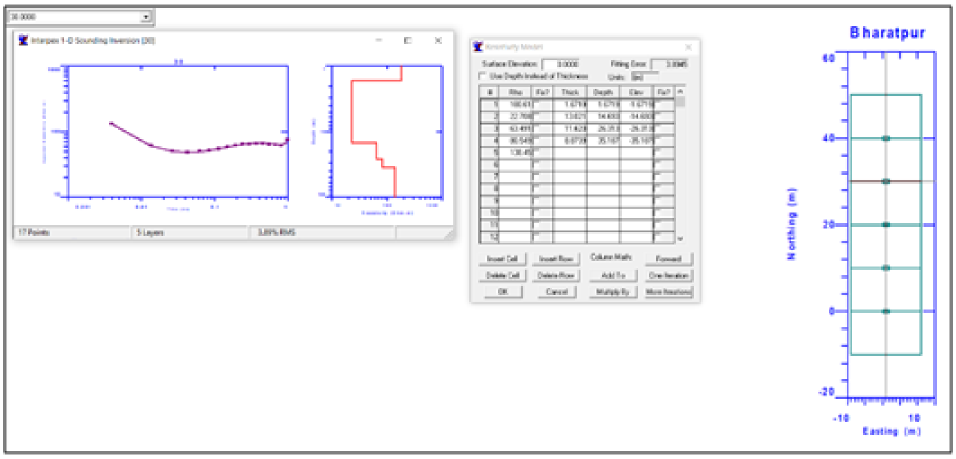


Fig. 3.20 :Resistivity Curve Layers of Bharatpur

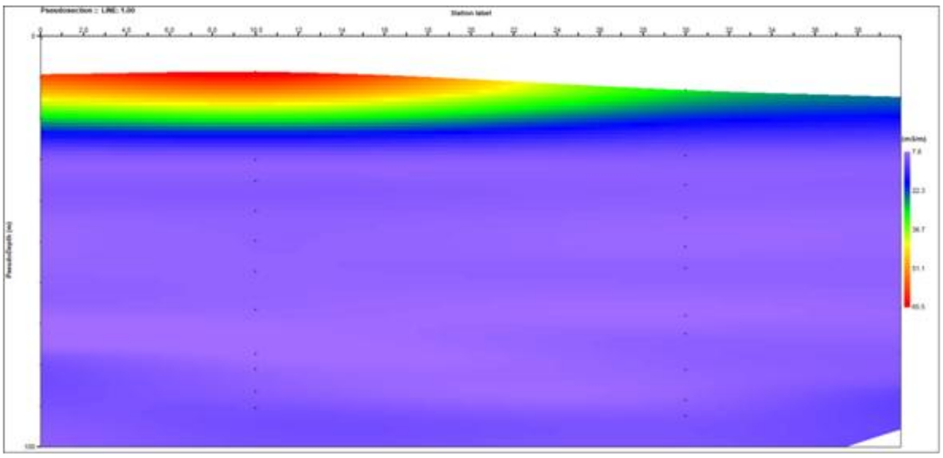


Fig. 3.21. Pseudo Section showing Conductance at Bharatpur

4. SANDA

Sanda is located in Bahoriband Block. In total, 5TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10m each. The resistivity of the top soil ranges from 52 to 76 Ohm m with the thickness ranging from 1.9 to 2.6 m. This layer is followed by weathered sandstone with resistivity ranging from 85 to 122 Ohm m with the thickness of 14 to 29 m and this layer is followed by massive sandstone with the resistivity ranging from 85 to 142 Ohm m with the thickness ranging from 24 to 66 m and this layer is followed by fractured sandstone with resistivity value ranging from 62 to 74 Ohm m with the thickness ranging from 21 to 56 m and last layer resistivity ranging from 36 to 43 Ohm m indicates fractured Sandstone/Limestone formation and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.22. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.33. Based on the pseudo section, it is inferred that there is no data recorded up to 35 m due to poor signal and low conductance ranging in depth ranges from 35 to 140 m indicating massive sandstone with occasional fractures and high conductance values below the depth of 140 m, indicating fractured sandstone/limestone with water bearing zones.

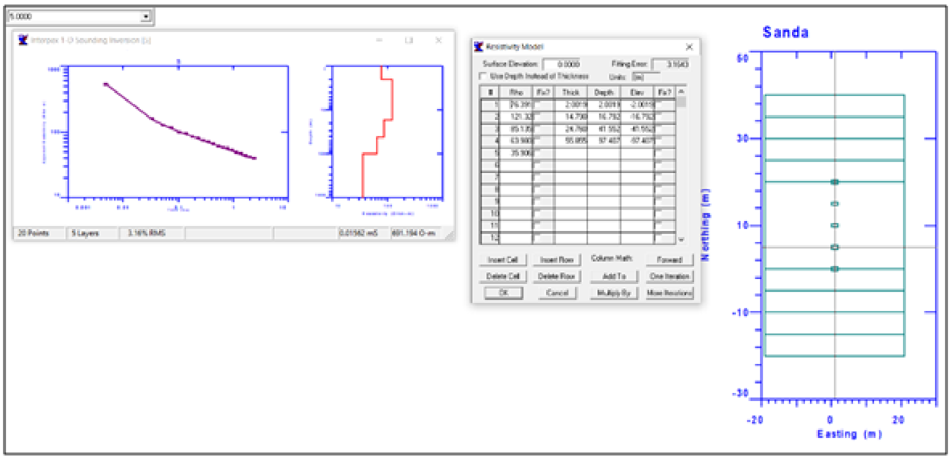


Fig. 3.22.Resistivity Curve Layers of Sanda

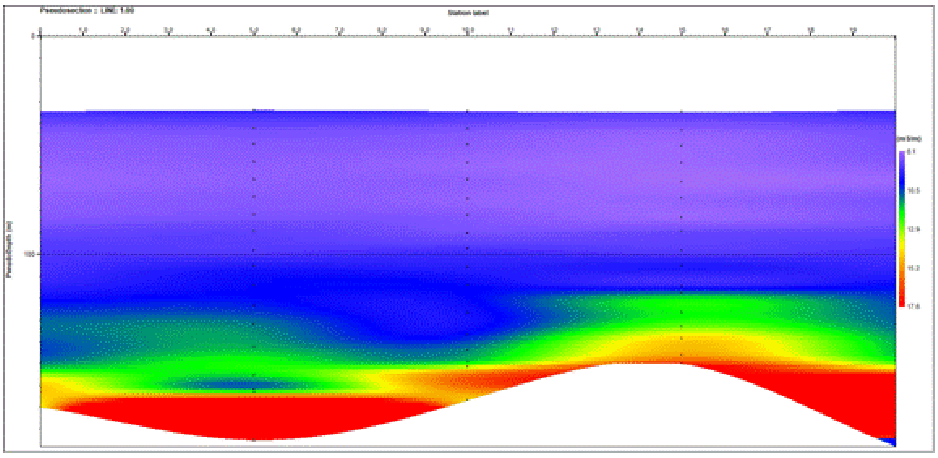


Fig.3.33. Pseudo Section showing Conductance at Sanda

5. KHAKKARA

Khakkara is located in Bahoriband Block.In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10 m each. The resistivity of the top soil ranges from 179 to 320 Ohm m with the thickness ranging from 0.6 to 2.2 m. This layer is followed by weathered sandstone/limestone with resistivity ranging from 88 to 151 Ohm m with the thickness of 11 to 27 m and this layer is followed by fractured sandstone with resistivity value ranging from 39 to 53 Ohm m with the thickness ranging from 9 to 12.8 m and last layer resistivity ranging from 89 to 157 Ohm m indicating meta sediment formation and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.34. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.35. Based on the pseudo section, it is inferred that there is no data recorded up to 28 and below 60 m due to poor signal and low conductance ranging in depth ranging from 28 to 35 and below 35 m indicating massive sandstone/limestone and high conductance values between the depth of 35 and 42 m, indicating fractured sandstone/limestone.

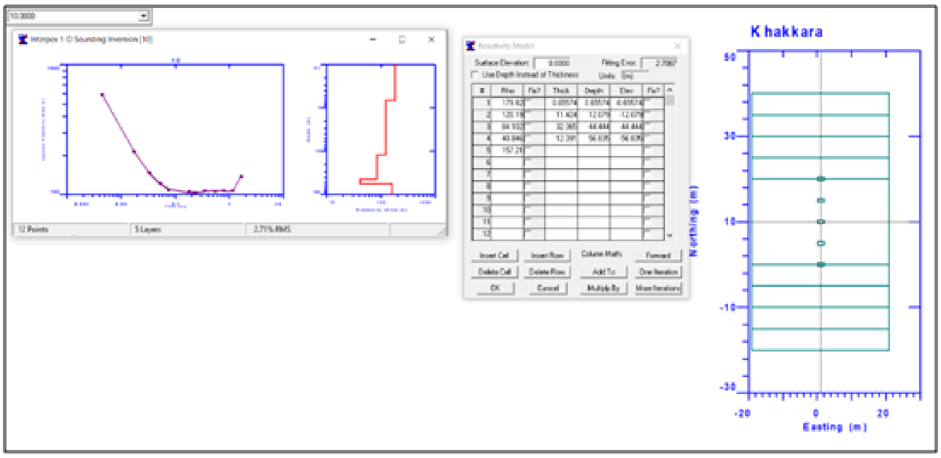


Fig.3.34. Resistivity Curve Layers of Khakkara

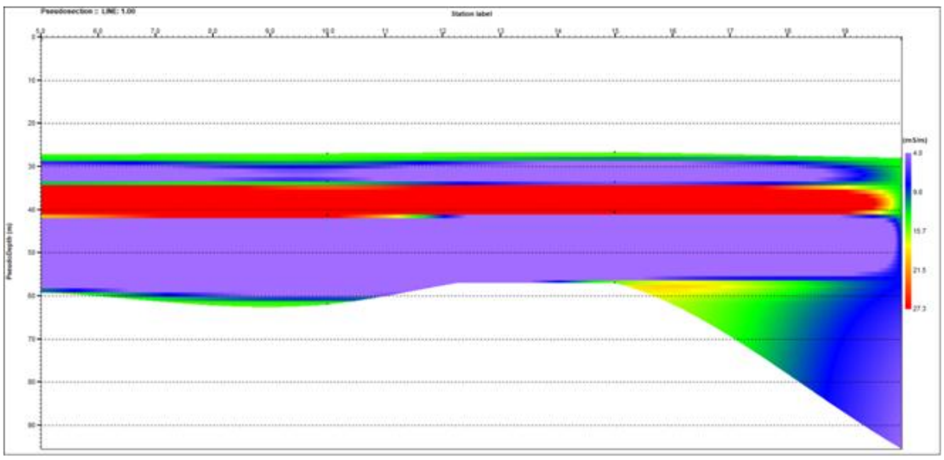


Fig.3.35. Pseudo Section showing Conductance at Khakkara

6. PIPARIYA

Pipariya is located in Bahoriband Block. In total, 5TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 67 to 164 Ohm m with the thickness ranging from 1.2 to 2.5 m. This layer is followed by weathered sandstone with resistivity ranging from 54 to 78 Ohm m with the thickness of 8 to 26.6m and this layer is followed by fractured sandstone with the resistivity ranging from 17 to 34.5 Ohm m with the thickness ranging from 8.5 to 27.7m and the last layer resistivity ranging from 3.1 to 5.3 Ohm m indicating Clay/Shale formation and extends with depth. Selected TEM sounding analysed and interpreted using IX1D software is shown in Fig. 3.36. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.37. Based on the pseudo section, it is inferred that there is no data recorded up to 12 due to poor signal and low conductance ranging in depth ranging from 12 to 45 m indicating massive sandstone/limestone and high conductance values between the depth of below 50 m indicating Clay / Shale formation.

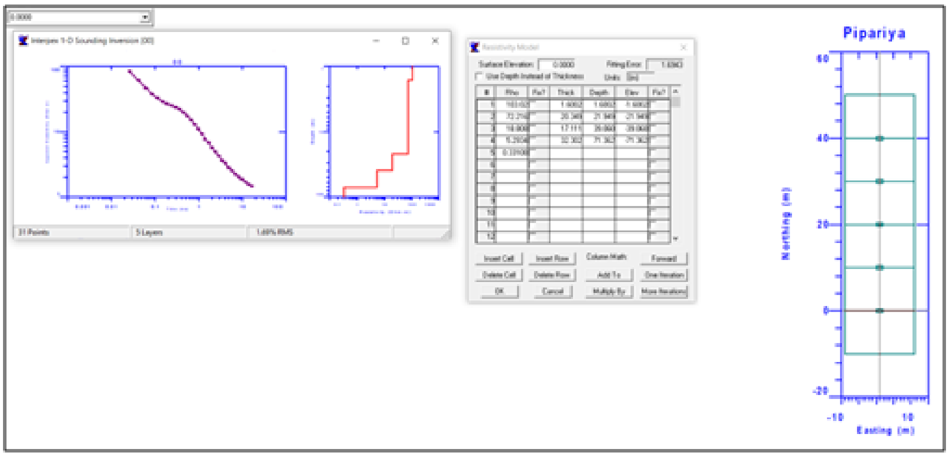


Fig.3.36. Resistivity Curve Layers of Pipariya

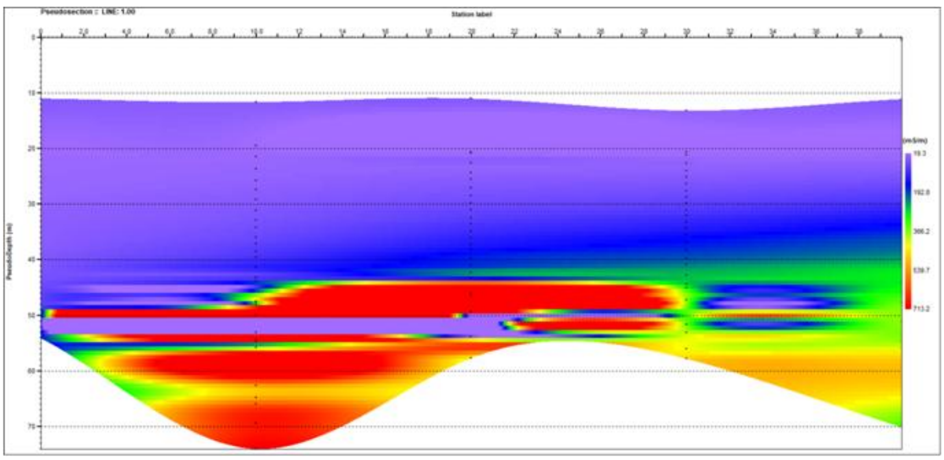


Fig.3.37: Pseudo Section showing Conductance at Pipariya

7. BARKHERA

Barkhera is located in Bahoriband block. In total, 5TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 87 to 135 Ohm m with the thickness ranging from 0.7 to 4 m. This layer is followed by weathered sandstone with resistivity ranging from 39 to 81 Ohm m with the thickness of 21.8 to 32m and this layer is followed by fractured sandstone with the resistivity ranging from 13.5 to 35 Ohm m with the thickness ranging from 12.7 to 15m and the last layer resistivity ranging from 3.5 to 5.4 Ohm m indicating Clay/Shale formation and extends with depth. Selected TEM sounding analysed and interpreted using IX1D software is shown in Fig. 3.39. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.40. Based on the pseudo section, it is inferred that there is no data recorded up to 12 to 20 m due to poor signal low conductance ranging in depth ranging up from 12 to 40 indicating massive sandstone/limestone, moderate conductance value ranging in depth from 40 to 55 m and high conductance values between the depth of below 55, indicating Clay / Shale formation.

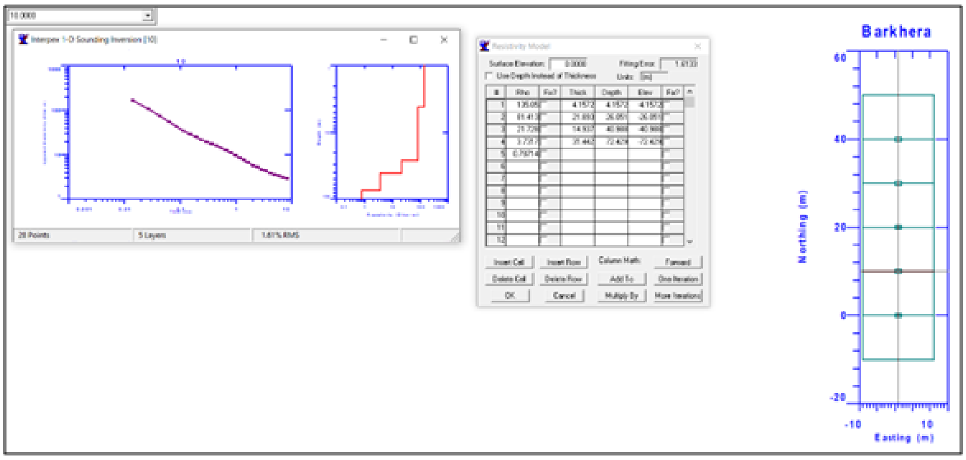


Fig. 3.40:Resistivity Curve Layers of Barkhera

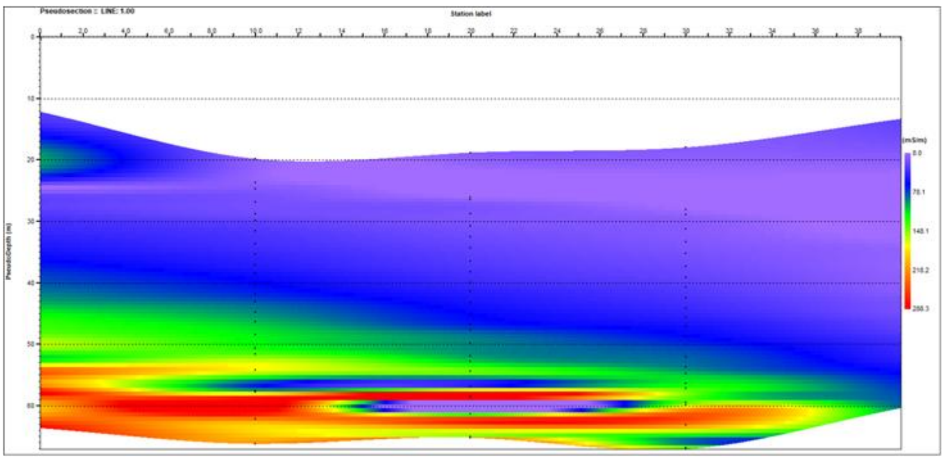


Fig. 3.41. Pseudo Section showing Conductance at Barkhera

8. SLEEMANABAD

Sleemanabad is located in Bahoriband block. In total, 10 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 5 m each. The resistivity of the top soil ranges from 96.8 to 182 Ohm m with the thickness ranging from 0.8 to 2.8 m. This layer is followed by weathered Limestone with resistivity ranging from 40 to 95.6 Ohm m with the thickness of 10 to 18.2m and this layer is followed by fractured Sandstone with the resistivity ranging from 24 to 56 Ohm m with the thickness ranging from 16.4 to 20.6m and the last layer resistivity ranging from 7.9 to 23 Ohm m water bearing fractured sandstone formation and extends with depth. Selected TEM sounding analysed and interpreted using IX1D software is shown in Fig: 3.44. Based on the TEM sounding, pseudo section has been drawn and shown in Fig: 3.45. Based on the pseudo section, it is inferred that there is no data recorded up to 20 and below 50 m due to poor signal and low conductance ranging in depth ranging from 20 to 50 indicating massive sandstone/limestone, moderate conductance value ranging in depth from 25 to 50m at centre of the section and high conductance values between the depth of below 50, indicating fractured sandstone.

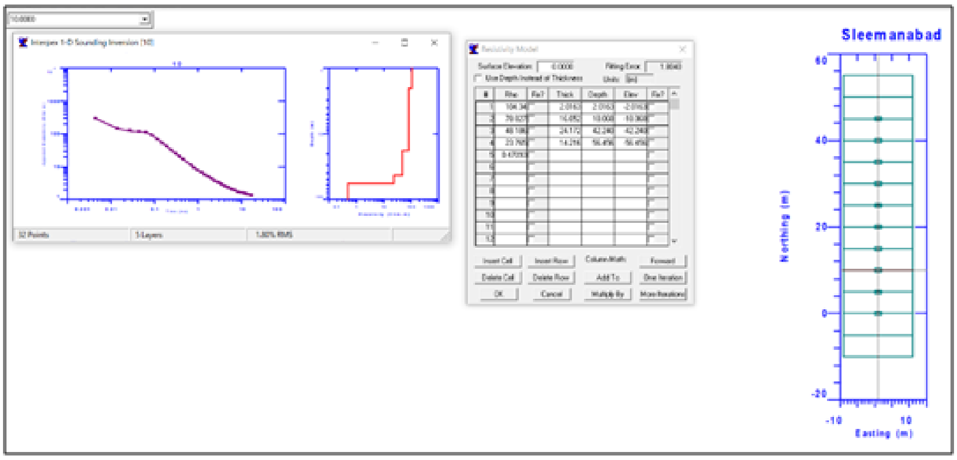


Fig. 3.42. Resistivity Curve Layers of Sleemanabad

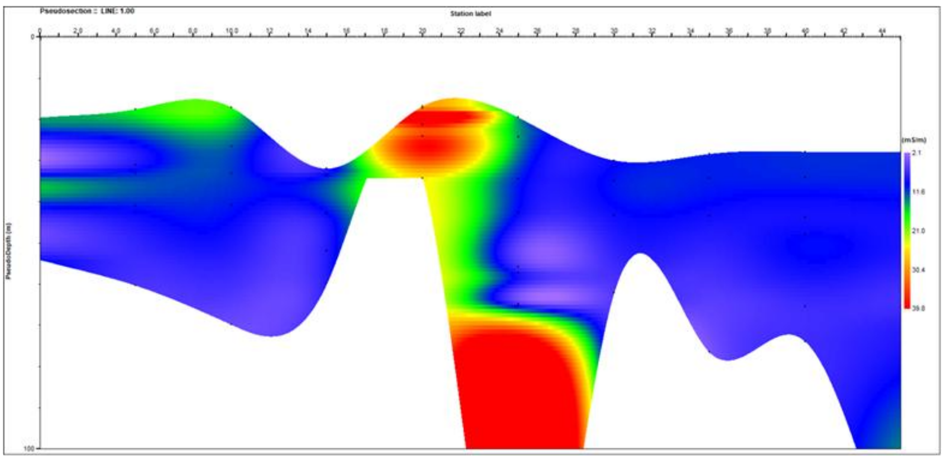


Fig. 3.43. Pseudo Section showing Conductance at Sleemanabad

9. LAKHAPATERI

Lakhapateri is located in Rithi block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10m each. The resistivity of the top soil ranges from 99 to 179 Ohm m with the thickness ranging from 1.7 to 4 m. This layer is followed by weathered limestone with resistivity ranging from 29 to 72 Ohm m with the thickness of 6.5 to 13.7 m and this layer is followed by fractured sandstone with the resistivity ranging from 18.7 to 34 Ohm m with the thickness ranging from 11 to 16 m and the last layer resistivity ranging from 15.5 to 38 Ohm m water bearing fractured sandstone formation and the last resistivity layer value ranging from 22 to 58 Ohm m, which extends with depth indicates sandstone/limestone. Selected TEM sounding analysed and interpreted using IX1D software is shown in Fig. 10(a). Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 10(b). Based on the pseudo section, it is inferred that there is no data recorded up to 18 due to poor signal and low conductance ranging in depth ranging from 18 to 25 indicating massive sandstone/limestone and high conductance values below 50 indicating fractured sandstone.

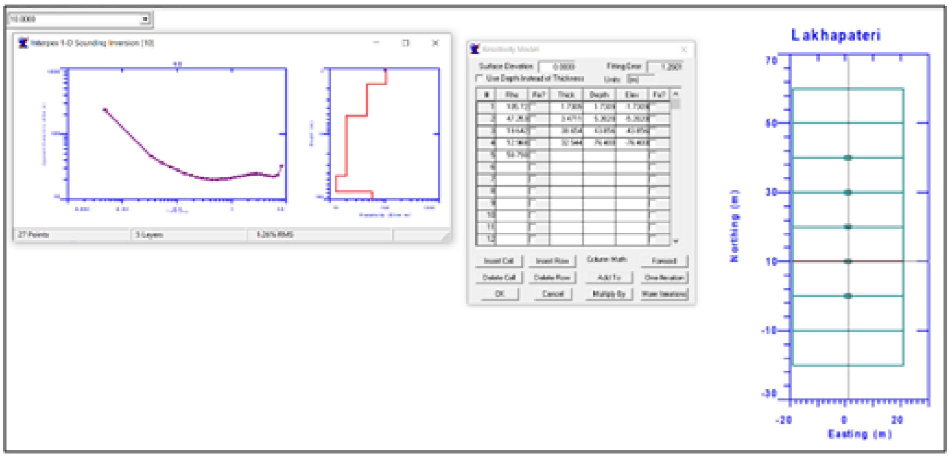


Fig. 3.44. Resistivity Curve Layers of Lakhapateri

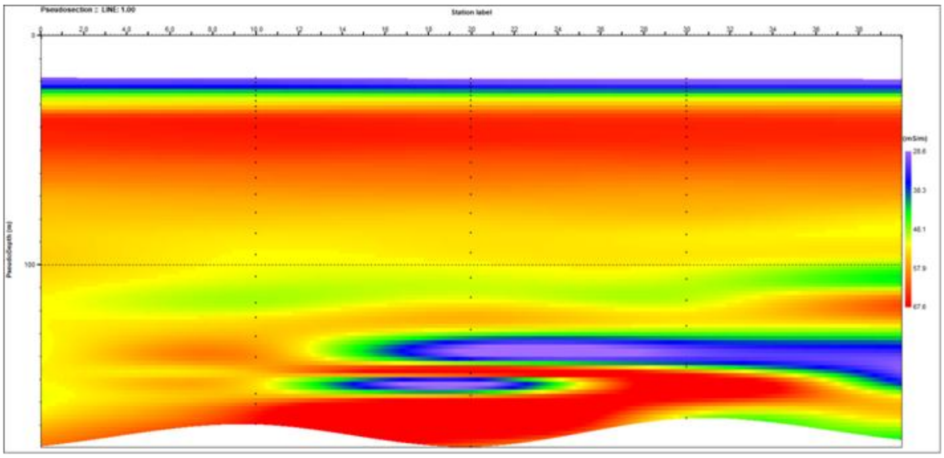


Fig.3.45. Pseudo Section showing Conductance at Lakhapateri

10. TIWARI

Tiwari is located in Bohoriband block. In total, 5 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 120 to 315 Ohm m with the thickness ranging from 1.9 to 2.7m. This layer is followed by weathered sandstone/limestone with resistivity ranging from 38 to 80 Ohm m with the thickness of 8.7 to 13.9m and this layer is followed by fractured sandstone/limestone with the resistivity ranging from 24 to 36 Ohm m with the thickness ranging from 13.6 to 28m and the last layer resistivity ranging from 180 to 356 Ohm m indicating fractured granitic rock, which extends with depth and selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig 3.46. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.47. Based on the pseudo section, it is inferred that there is no data recorded from 10 to 30 m due to poor signal and high conductance ranging in depth ranging from 10 to 22 indicating weathered sandstone/limestone and high conductance values below 22 m massive granitic rock.

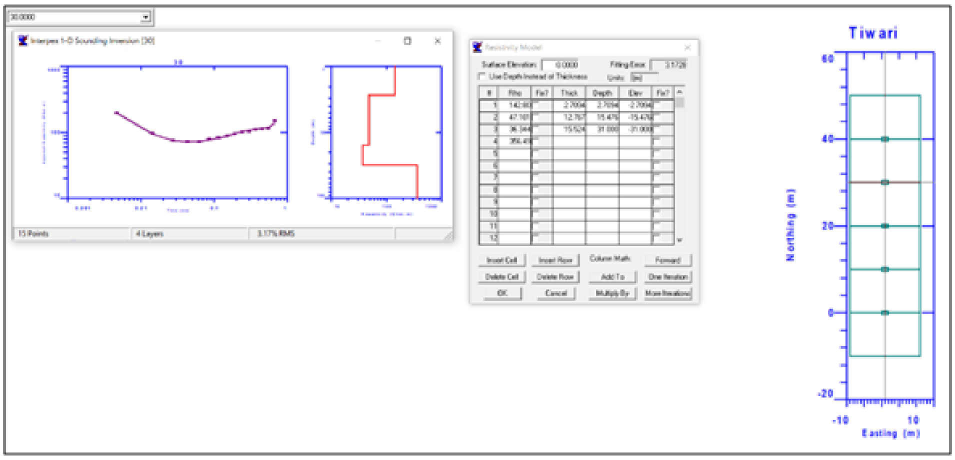


Fig. 3.46. Resistivity Curve Layers of Tiwari

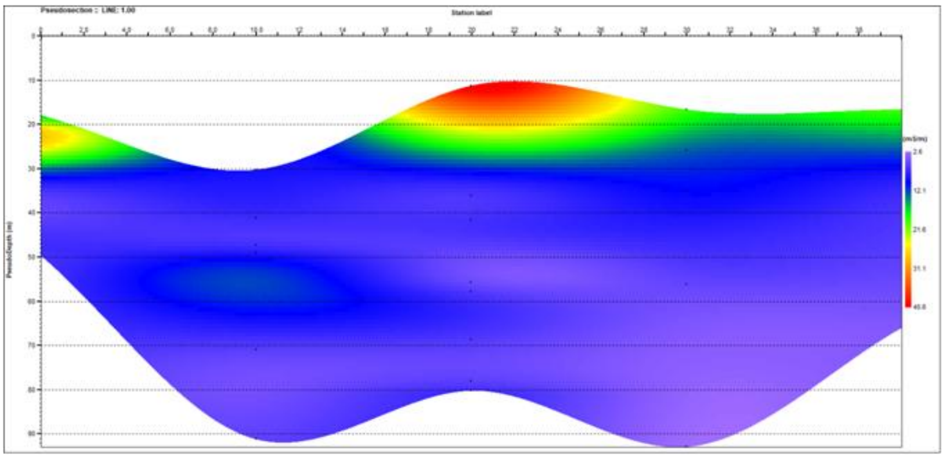


Fig. 3.47. Pseudo Section showing Conductance at Tiwari

11. MURWARI

Murwari is located in Dhimarkheda block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10 m each. The resistivity of the top soil ranges from 160 to 374 Ohm m with the thickness ranging from 2 to 3.4m. This layer is followed by sand with resistivity ranging from 10 to 25 Ohm m with the thickness of 8.5 to 31m and this layer is followed by weathered sandstone with the resistivity ranging from 24 to 63 Ohm m with the thickness ranging from 9.2 to 17m and the last layer resistivity ranging from 70 to 107 Ohm m indicating Meta sediments, which extends with depth Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.48. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.49. Based on the pseudo section, it is inferred that there is no data recorded up to 15 due to poor signal and low conductance value ranging in depth from 15 to 25 indicating sand, moderate conductance value ranging in depth from 25 to 40 indicating massive sandstone and high conductance values below 100 m indicates meta sediments.

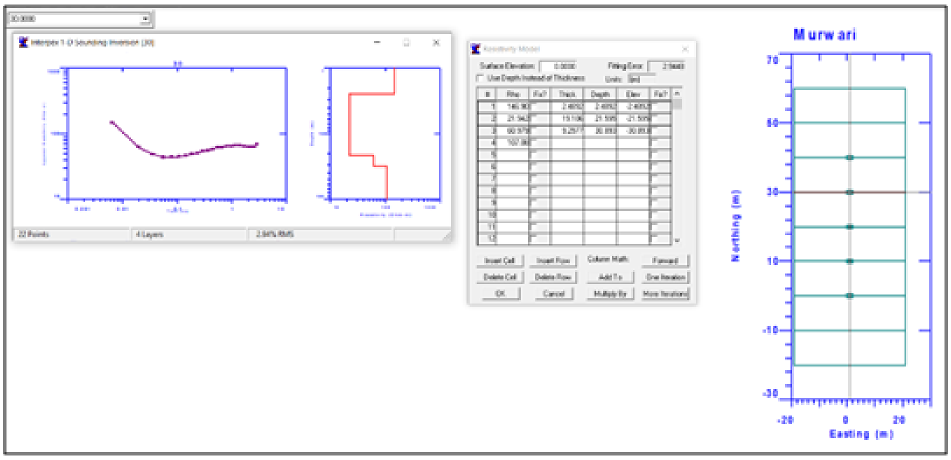


Fig.3.48. Resistivity Curve Layers of Murwari

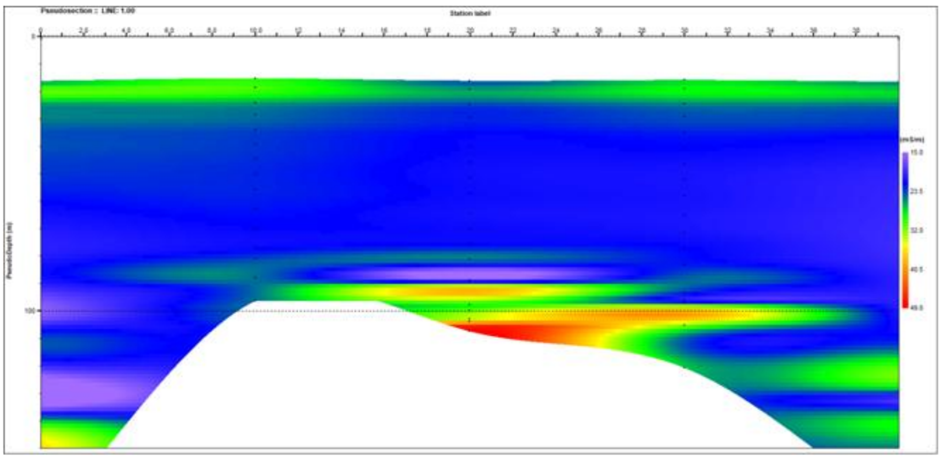


Fig.3.49. Pseudo Section showing Conductance at Murwari

12. JINNA PIPARIYA

Jinna Pipariya is located in Bahoriband block. In total, 5 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 120 to 231 Ohm m with the thickness ranging from 1.4 to 2m. This layer is followed by weathered sandstone with resistivity ranging from 15 to 25 Ohm m with the thickness of 10 to 17m and this layer is followed by weathered limestone with the resistivity ranging from 42 to 56 Ohm m with the thickness ranging from 11 to 14m, this layer is followed by fractured sandstone with the resistivity values ranging from 64 to 96 Ohm m with the thickness ranging from 10 to 10.5 and the last layer resistivity ranging from 108 to 388 Ohm m indicating Meta sediments, which extends with depth Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.50. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.51. Based on the pseudo section, it is inferred that there is no data recorded properly due to poor signal and low conductance values showing in the section indicating meta sediments.

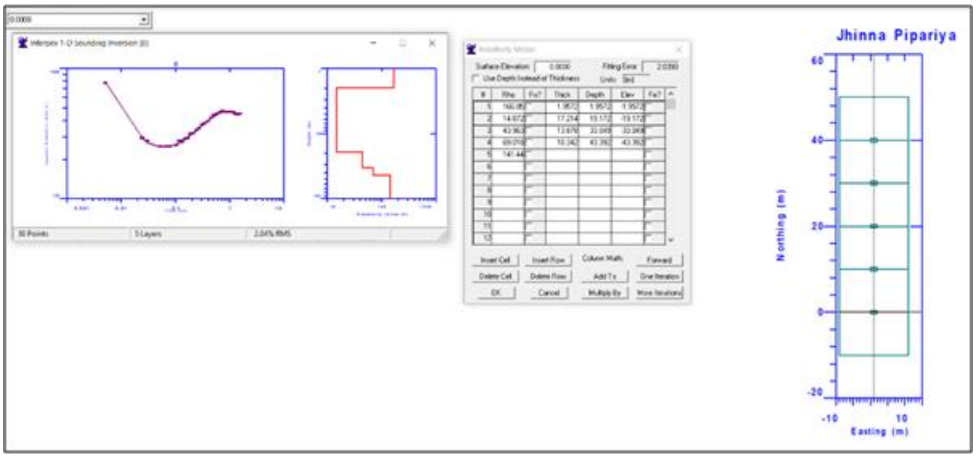


Fig. 3.50. Resistivity Curve Layers of Jinna Pipariya

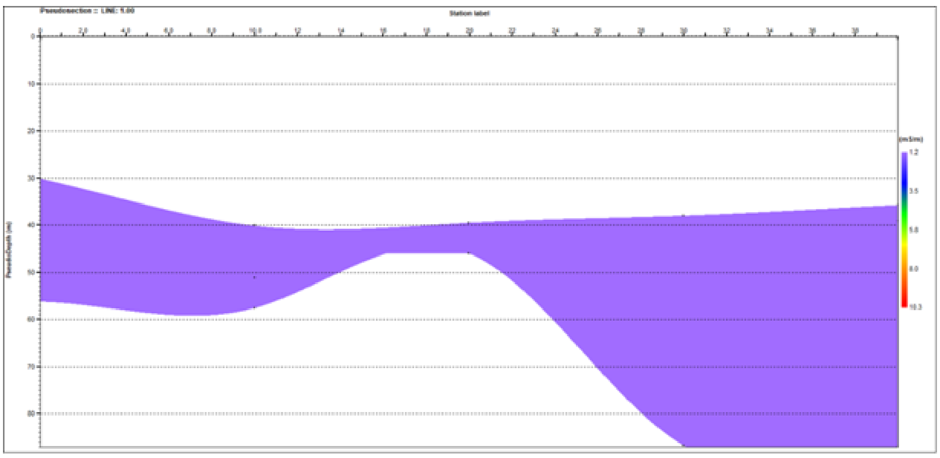


Fig. 3.51. Pseudo Section showing Conductance at Jinna Pipariya

13. KHAMHARIYA

Khamariya is located in Dhimarkheda block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10 m each. The resistivity of the top soil ranges from 96.7 to 168 Ohm m with the thickness ranging from 2 to 3.7m. This layer is followed by weathered sandstone with resistivity ranging from 30.4 to 48 Ohm m with the thickness of 9.5 to 13.6m and this layer is followed by weathered limestone with the resistivity ranging from 53 to 80 Ohm m with the thickness ranging from 6.6 to 14.4m, this layer is followed by fractured sandstone with depth with the resistivity values ranging from 64.6 to 140 Ohm m and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig.3.52. Based on the TEM sounding, pseudo section has been drawn and shown in Fig: 3.53. Based on the pseudo section, it is inferred that there is no data recorded up to 28 due to poor signal and high conductance value ranging in depth from 28 to 45 indicating water bearing sandstone, moderate conductance value ranging in depth from 45 to 80 indicating limestone cavities and low conductance values below 100 m indicating meta sediments.

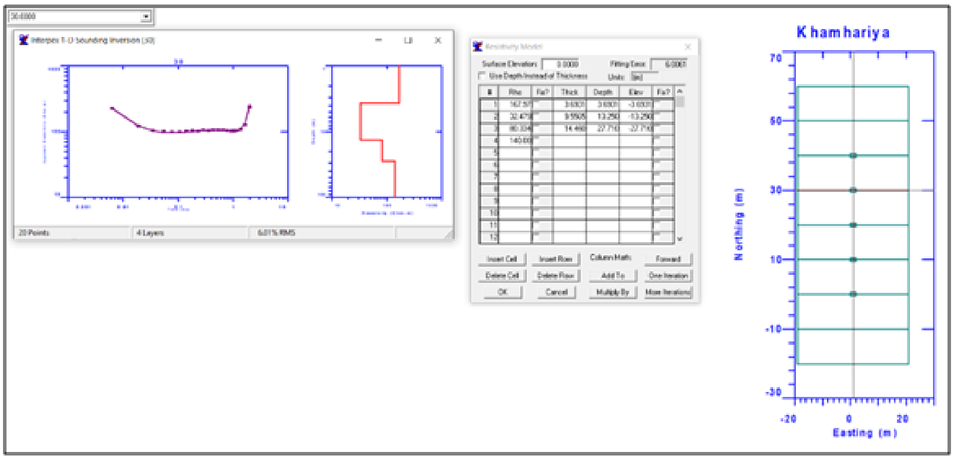


Fig. 3.52. Resistivity Curve Layers of Khamhariya

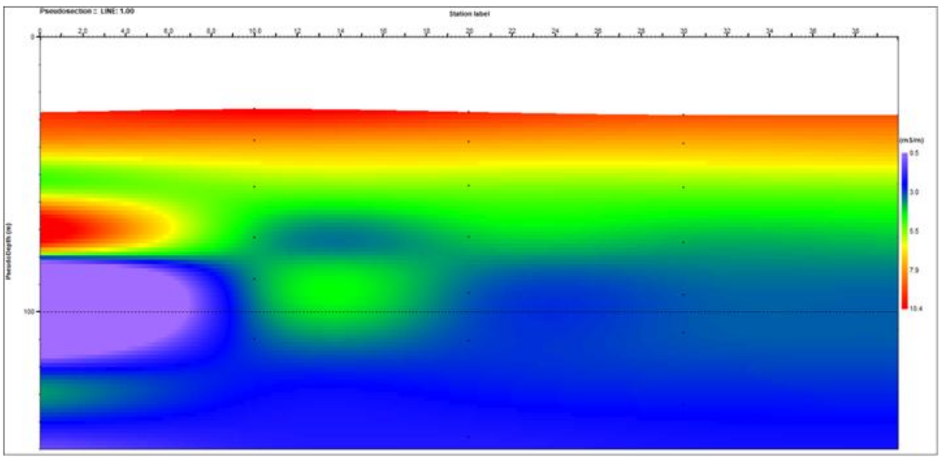


Fig. 3.53.Pseudo Section showing Conductance at Khamhariya

14. DEORA KALAN

Deora Kalan is located in Bijeraghavgarh Block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10m each. The resistivity of the top soil ranges from 345 to 866 Ohm m with the thickness ranging from 1.8 to 3.8m. This layer is followed by weathered sandstone with resistivity ranging from 167 to 248 Ohm m with the thickness of 8.3 to 22.6m and this layer is followed by weathered limestone with the resistivity ranging from 84 to 150 Ohm m with the thickness ranging from 15 to 43m, this layer is followed by fractured sandstone with the resistivity values ranging from 58 to 80 Ohm m with the thickness ranging from 11.6 to 69m and the last layer resistivity value ranging from 34 to 40 Ohm m and extends with depth indicating fractured sandstone. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig 3.54. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.55. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 32 due to poor signal and low conductance value ranging in depth from 32 to 40 indicating massive sandstone, moderate conductance value ranging in depth from 40 to 100 m indicating limestone cavities and high conductance values below 100 m indicating fractured sandstone.

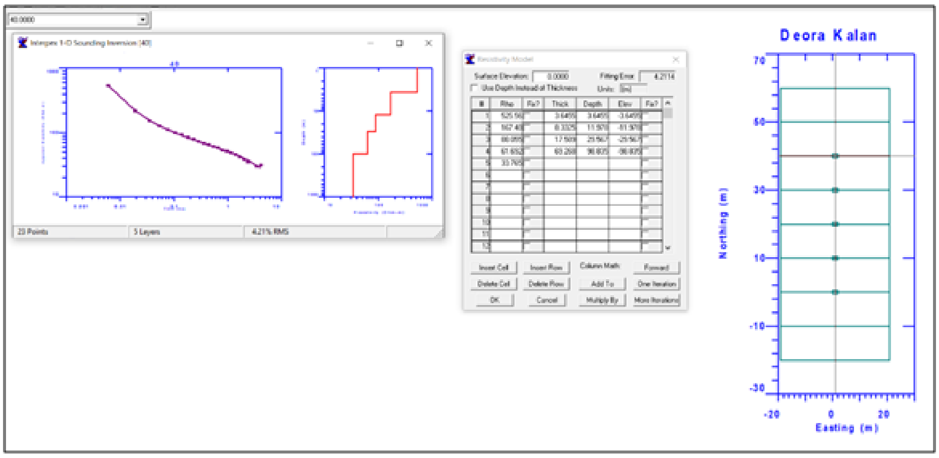


Fig.3.54. Resistivity Curve Layers of Deora Kalan

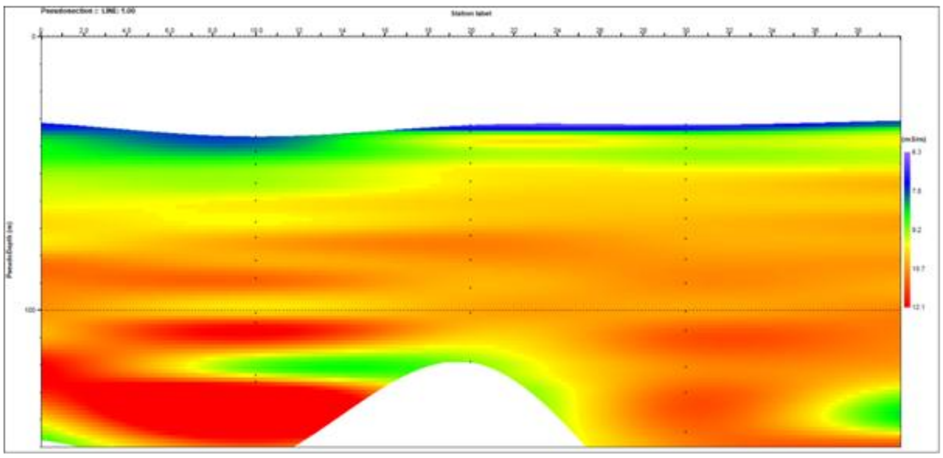


Fig.3.55. Pseudo Section showing Conductance at Deora Kalan

15. BIJERAGAVGARH

Bijeragavgarh is located in Bijeraghavgarh Block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10 m each. The resistivity of the top soil ranges from 120 to 528 Ohm m with the thickness ranging from 2 to 3m. This layer is followed by weathered sandstone with resistivity ranging from 90 to 238 Ohm m with the thickness of 10.3 to 21m and this layer is followed by weathered limestone with the resistivity ranging from 63 to 113 Ohm m with the thickness ranging from 25 to 36m, this layer is followed by fractured sandstone with the resistivity values ranging from 35 to 79 Ohm m with the thickness ranging from 15 to 36.8m and the last layer resistivity value ranging from 15 to 42 Ohm m and extends with depth indicating fractured sandstone. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig: 3.56. Based on the TEM sounding, pseudo section has been drawn and shown in Fig: 3.57. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 20 due to poor signal and low conductance value indicating massive sandstone/limestone and high conductance values indicating fractured sandstone.

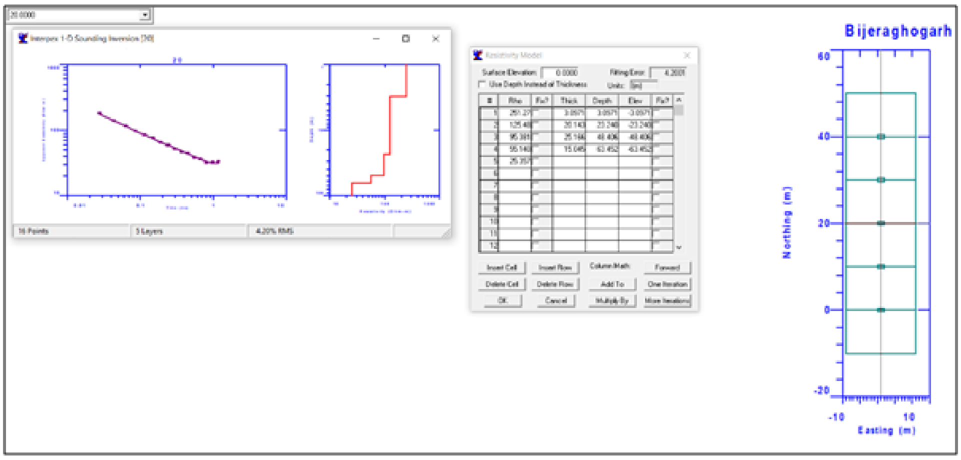


Fig.3.56. Resistivity Curve Layers of Bijeyragogarh

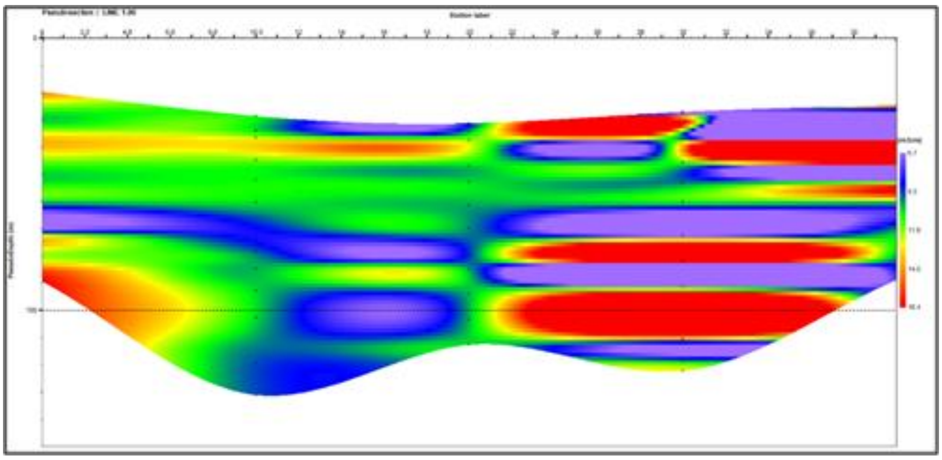


Fig.3.57. Pseudo Section showing Conductance at Bijeyragogarh

16. SINGAURI

Singauri is located in Bijeyragogarh Block. In total, 5 TEM soundings were carried out in this site with the loop size 40 X 40 m and space interval of 10m each. The resistivity of the top soil ranges from 105 to 260 Ohm m with the thickness ranging from 1.9 to 2.9m. This layer is followed by weathered sandstone with resistivity ranging from 12.5 to 70 Ohm m with the thickness of 9 to 18.8m and this layer is followed by fractured sandstone with the resistivity ranging from 17 to 20 Ohm m with the thickness ranging from 27 to 48m, this layer is followed by fractured sandstone with the resistivity values ranging from 61 to 108 Ohm m and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.58. Based on the TEM sounding, pseudo section has been drawn and shown in Fig.3.59. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 15 due to poor signal and high conductance value ranging in depth from 15 to 50 indicating fractured sandstone, moderate conductance value ranging in depth from 50 to 70 indicating limestone cavities and fractured sandstone and low conductance values below 70 m indicating massive sandstone.

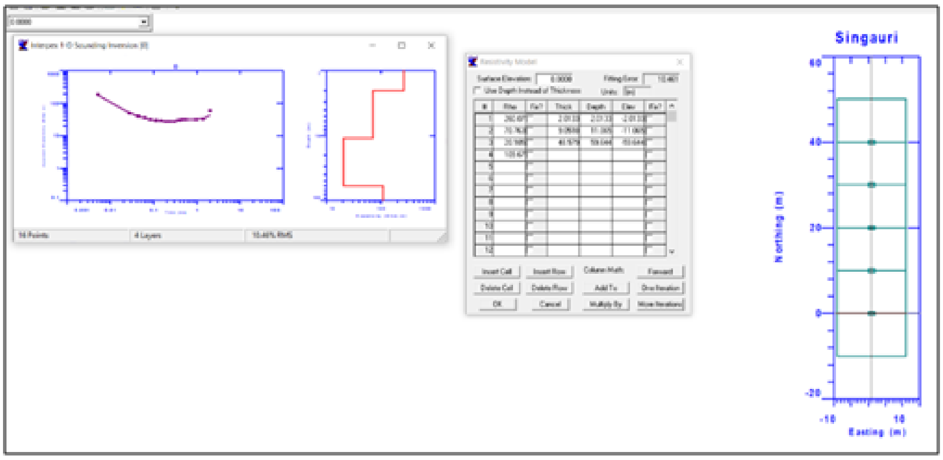


Fig. 3.58. Resistivity Curve Layers of Singauri

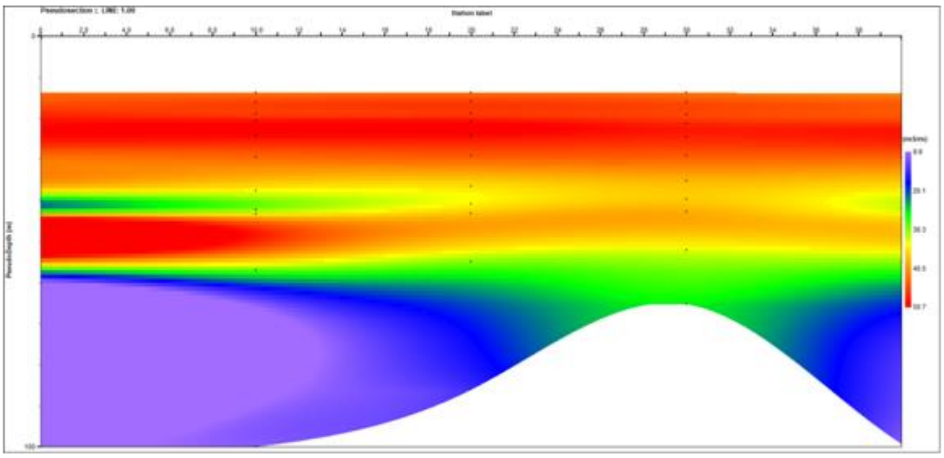


Fig. 3.59. Pseudo Section showing Conductance at Singauri

17. BANSARI

Bansari is located in BundwaraBlock.In total,5TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 148 to 212 Ohm m with the thickness ranging from 2.2 to 2.6m. This layer is followed by weathered sandstone with resistivity ranging from 110 to 136 Ohm m with the thickness of 6.5 to 15.8 m and this layer is followed by weathered limestone with the resistivity ranging from 38 to 60 Ohm m with the thickness ranging from 20.6 to 52m, this layer is followed by fractured sandstone with the resistivity values ranging from 12.2 to 19 Ohm m with the thickness ranging from 56.7 to 72.3 and the last layer resistivity ranging from 32 to 35.5 Ohm m and extends with depth fractured sandstone. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig.3.60. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.61. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 20 due to poor signal and low conductance value indicating massive sandstone and and high conductance values below 100 m indicating fractured.

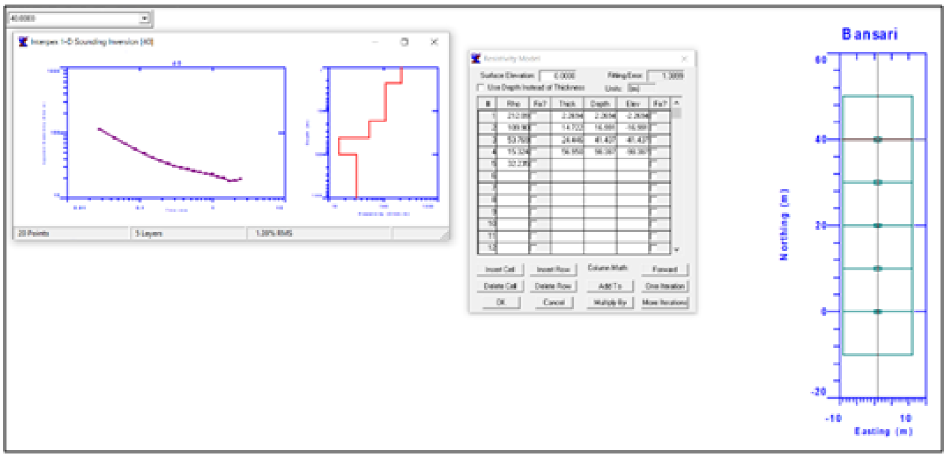


Fig.3.60. Resistivity Curve Layers of Bansari

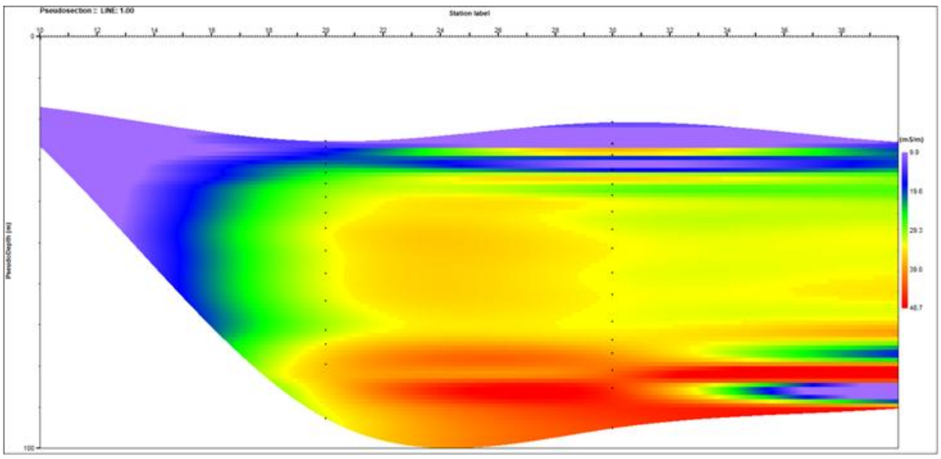


Fig.3.61. Pseudo Section showing Conductance at Bansari

18. KEOLARI

Keolari is located in Bundwara Block. In total, 5 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 215 to 235 Ohm m with the thickness ranging from 1.2 to 1.9m. This layer is followed by weathered sandstone with resistivity ranging from 102 to 122 Ohm m with the thickness of 6.3 to 7.6m and this layer is followed by weathered limestone with the resistivity ranging from 22 to 52 Ohm m with the thickness ranging from 11.3 to 45.2 m, this layer is followed by fractured sandstone with the resistivity values ranging from 14 to 18.8 Ohm m with the thickness ranging from 27.8 to 57.5 and the last layer resistivity ranging from 42 to 55.7 Ohm m and extends with depth indicating fractured sandstone. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig 3.62. Based on the TEM sounding, pseudo section has been drawn and shown in Fig 3.63. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 20 due to poor signal and low conductance value indicating massive sandstone and high conductance values below 80 m indicating fractured sandstone.

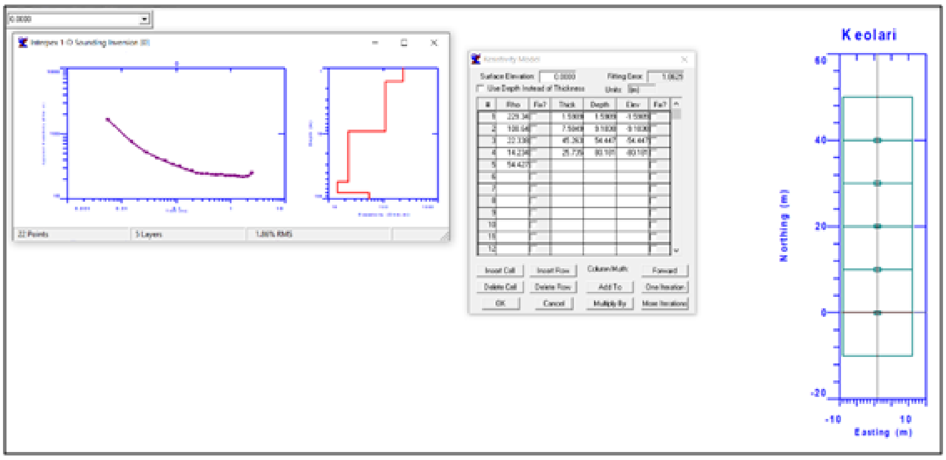


Fig. 3.62. Resistivity Curve Layers of Keolari

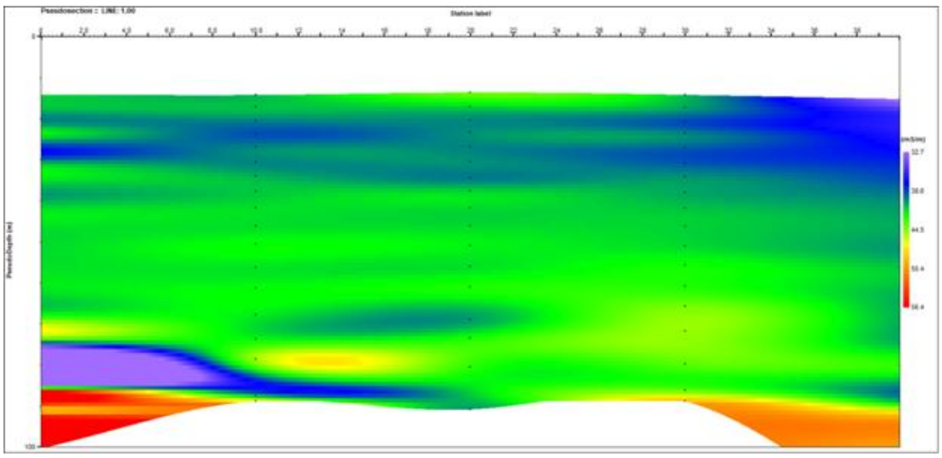


Fig. 3.63. Pseudo Section showing Conductance at Keolari

19. BARWARA KALAN

Barwara Kalan is located in Bundwara Block. In total, 5TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 95.9 to 122 Ohm m with the thickness ranging from 2.1 to 3.2m. This layer is followed by weathered limestone with resistivity ranging from 35.1 to 48.5 Ohm m with the thickness of 15 to 22.5m and this layer is followed by weathered sandstone with the resistivity ranging from 9.5 to 16.9 Ohm m with the thickness ranging from 10.6 to 33.5m, this layer is followed by Clay/Shale with the resistivity values ranging from 2.1 to 7.1 Ohm m and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig.3.64. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.65. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 20 m and below 60 m due to poor signal and low conductance value ranging in depth from 20 to 40 m indicating massive sandstone and high conductance values below 50 m are indicating Clay/Shale.

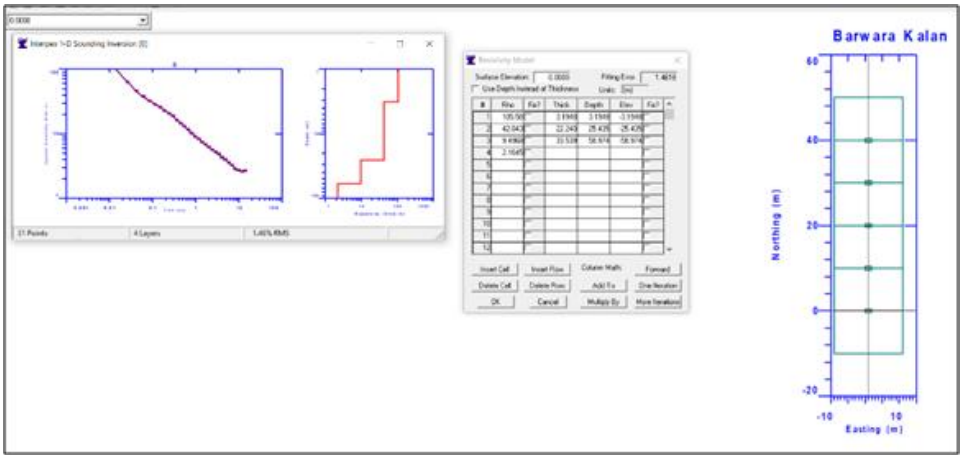


Fig.3.64. Resistivity Curve Layers of Barwara Kalan

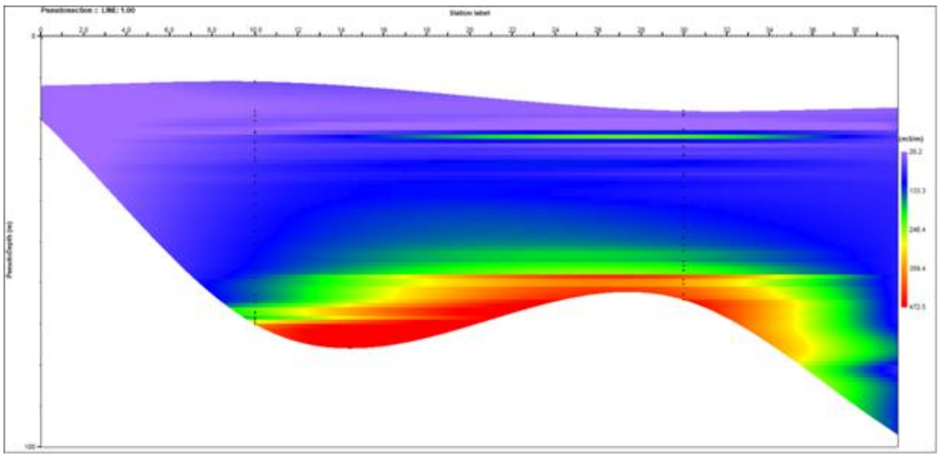


Fig.3.65. Pseudo Section showing Conductance at Barwara Kalan

20. JOHLA

Johla is located in Bundwara Block. In total, 5 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 120.4 to 206 Ohm m with the thickness ranging from 1.4 to 3m. This layer is followed by weathered limestone with resistivity ranging from 51.9 to 87.5 Ohm m with the thickness of 8.9 to 16.4m and this layer is followed by weathered sandstone with the resistivity ranging from 18 to 40.4 Ohm m with the thickness ranging from 24.3 to 48.9 m, this layer is followed by Meta sediments with the resistivity values ranging from 69.2 to 85.4 Ohm m and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.66. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.67. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 20 due to poor signal and high conductance value indicating massive limestone/sandstone and low conductance values indicating Meta sediments.

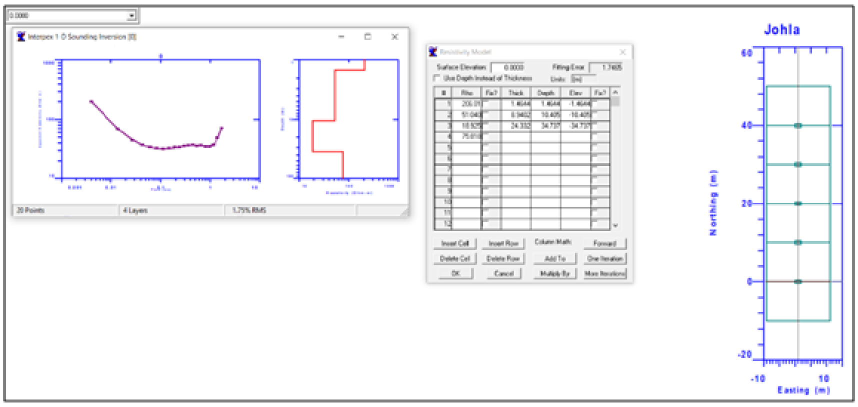


Fig.3.66. Resistivity Curve Layers of Johla

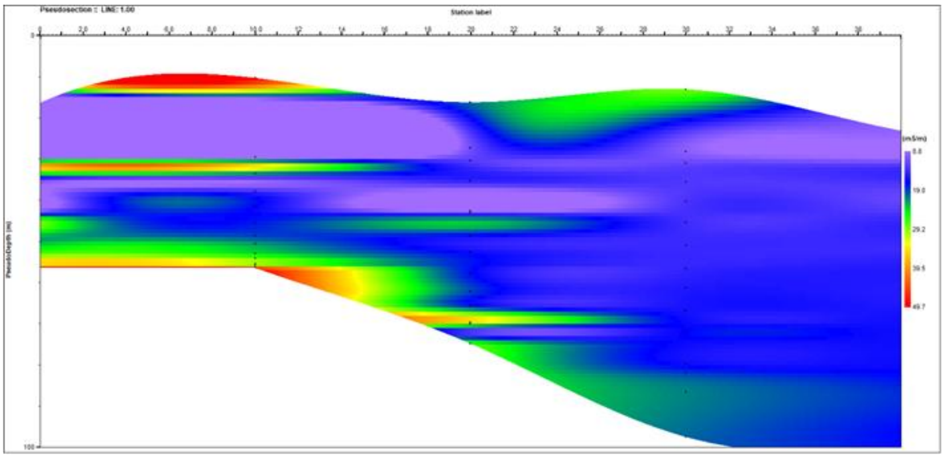


Fig. 3.67. Pseudo Section showing Conductance at Johla

21. TIKARIYA

Tikariya is located in Bundwara Block. In total, 5 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 119.1 to 128.4 Ohm m with the thickness ranging from 2.5 to 3m. This layer is followed by weathered sandstone with resistivity ranging from 31.7 to 39.7 Ohm m with the thickness of 11.6 to 14.8m and this layer is followed by weathered limestone with the resistivity ranging from 61.3 to 80 Ohm m with the thickness ranging from 13.1 to 18m, this layer is followed by Meta sediments with the resistivity values ranging from 111 to 125.7 Ohm m and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.68. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.69. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded from 10 to 30 m due to poor signal and high conductance values indicating fractured sandstone and low conductance values indicating Meta sediments.

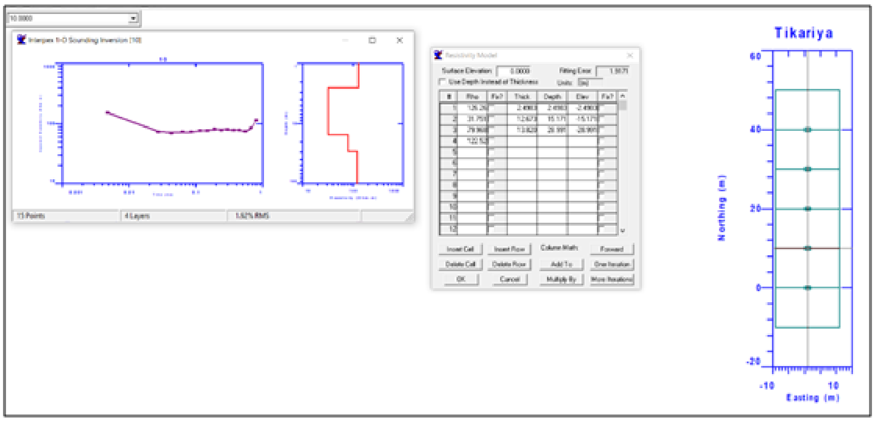


Fig.3.68. Resistivity Curve Layers of Tikariya

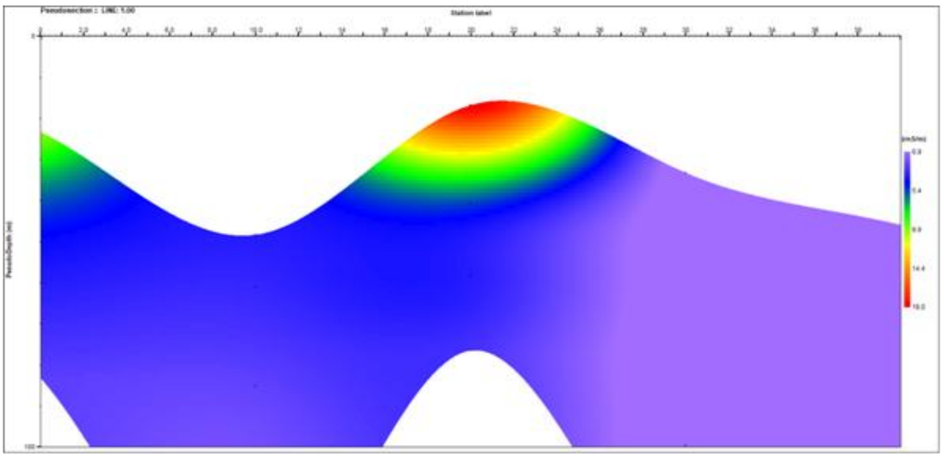


Fig.3.69. Pseudo Section showing Conductance at Tikariya

22. KATNI

Katni is located in Katni Block. In total, 5TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 73.5 to 112.5 Ohm m with the thickness ranging from 2 to 3m. This layer is followed by weathered sandstone with resistivity ranging from 33.1 to 50.5 Ohm m with the thickness of 13.5 to 19.3m and this layer is followed by fractured sandstone with the resistivity ranging from 22.1 to 27.8 Ohm m with the thickness ranging from 18 to 28.8m, this layer is followed by Clay/Shale with the resistivity values ranging from 4.3 to 8.6 Ohm m and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.70. Based on the TEM sounding, pseudo section has been drawn and shown in Fig. 3.71. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 15 due to poor signal and low conductance values massive sandstone and high conductance values indicating Clay/Shale.

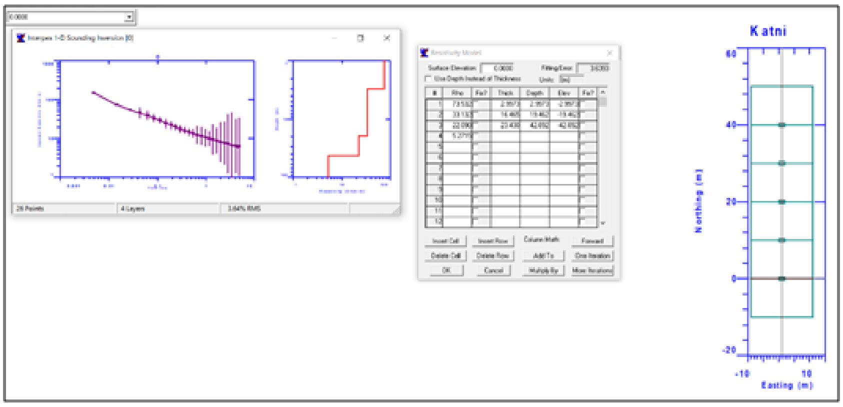


Fig. 3.70. Resistivity Curve Layers of Katni

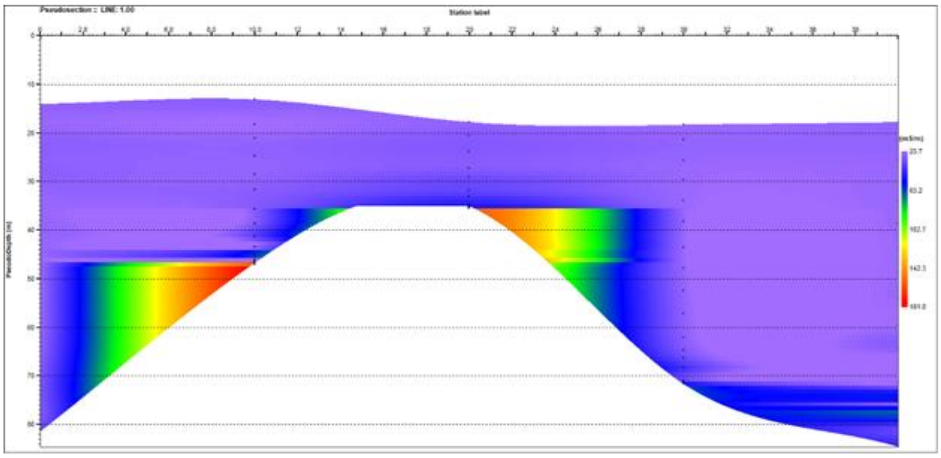


Fig. 3.71. Pseudo Section showing Conductance at Katni

23. KAILWARA

Kailwara is located in Katni Block. In total, 5 TEM soundings were carried out in this site with the loop size 20 X 20 m and space interval of 10m each. The resistivity of the top soil ranges from 60 to 78.9 Ohm m with the thickness ranging from 1.9 to 2.7m. This layer is followed by sand with resistivity ranging from 14.9 to 17.2 Ohm m with the thickness of 14.7 to 19m and this layer is followed by weathered sandstone with the resistivity ranging from 30.7 to 39.7 Ohm m with the thickness ranging from 21.9 to 36.2m, this layer is followed meta sediments with the resistivity values ranging from 54.8 to 67.2 Ohm m and extends with depth. Selected TEM sounding analyzed and interpreted using IX1D software is shown in Fig. 3.72. Based on the TEM sounding, pseudo section has been drawn and shown in Fig.3.73. Based on the pseudo section, it is inferred that it is inferred that there is no data recorded up to 10 to 20 m due to poor signal and high conductance values sand and fractured sandstone and low conductance values indicating meta sediments.

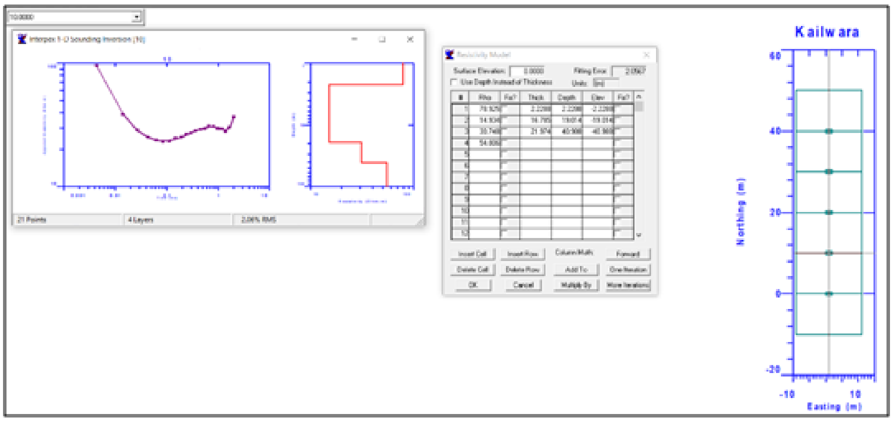


Fig.3.72. Resistivity Curve Layers of Kailwara

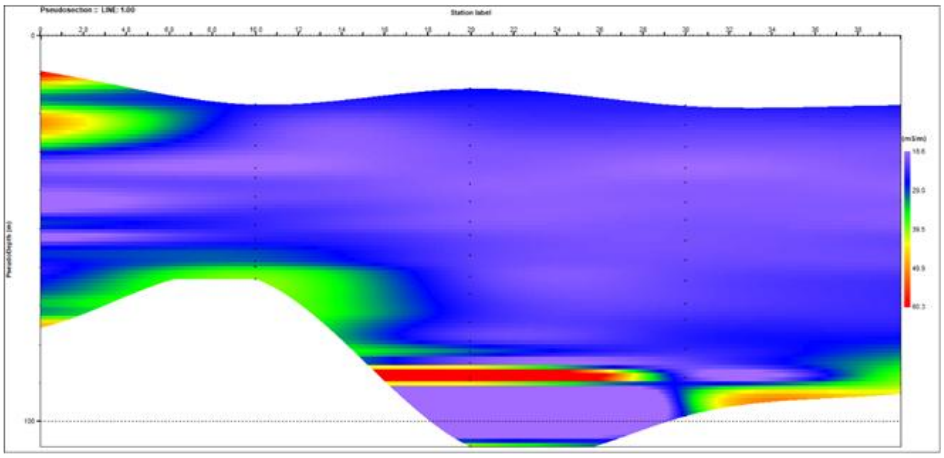


Fig 3.73. Pseudo Section showing Conductance at Kailwara

CHAPTER-4
GROUND WATER RESOURCES

In Katni district the Ground Water Resources are estimated considering entire area as a single aquifer system. Block wise Dynamic Ground Water Resources are computed as per the guidelines laid down in GEC methodology 2015.The ground water resources have been assessed for two types of aquifers existing in the area i.e., Aquifer-I and Aquifer-II. The details of the assessment are discussed below as on GWRE 2022.

4.1 Ground Water Resources – Aquifer-I

The ground water resource assessment has been carried out for Katni district and the salient features of the resources are given in **Table.4.1, 4.2 and 4.3.**

As per **Table.4.1**, out of the total 489400 ha area, recharge worthy areas are 33404 ha in command areas and 433244 ha in non-command areas, whereas 86300 ha area is not worthy for recharge on account of its hilly nature.

Table 4.1: Ground Water Recharge Worthy Areas for Resource Estimation.

District	Predominant Formation	Total Geographical Area (ha)	Hilly Area (ha)	Ground Water Recharge Worthy Area	
				Command area (ha)	Non-command area (ha)
Katni	Laterite, Alluvium, Gondwana & Vindhyan formations	489400	22752	33404	433244

4.1.1 Recharge Component

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

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

where,

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

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

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

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

The season wise assessment of recharge from various components such as rainfall and other sources was done and presented in **Table.4.2**, **Table.4.4** and **Fig.4.1**. During monsoon season recharge from rainfall contributes maximum component (33540.81 ham) and recharge from other sources is 1637.48 ham, whereas during non-monsoon season, recharge from rainfall is 0.00 ham and the recharge from other sources is 4560.65 ham. The total annual ground water recharge is 39738.94 ham and Annual Extractable Ground Water Resource after natural discharge is estimated as 37236.74 ham.

Table 4.2: Recharge Components evaluated for Resource Estimation.

Command / Non-Command / Total	Recharge from rainfall during monsoon season (ham)	Recharge from other sources during monsoon season (ham)	Recharge from rainfall during non-monsoon season (ham)	Recharge from other sources during non-monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges (ham)	Annual Extractable Ground Water Resource (ham)
Total	**33540.81**	**1637.48**	**0.00**	**4560.65**	**39738.94**	**2502.2**	**37236.74**

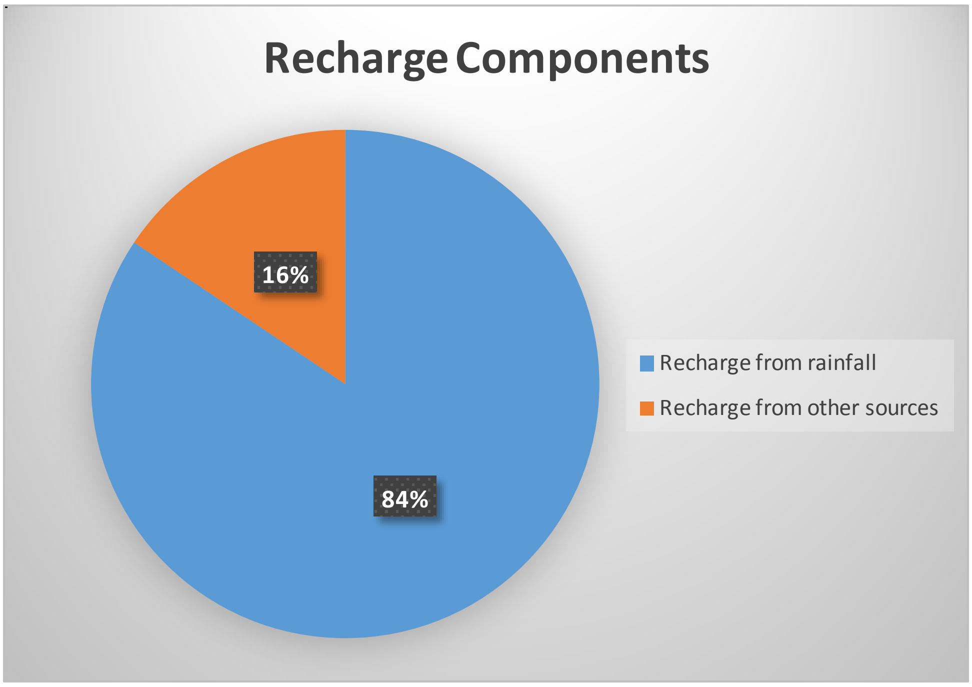


Fig.4.1: Recharge from various sources

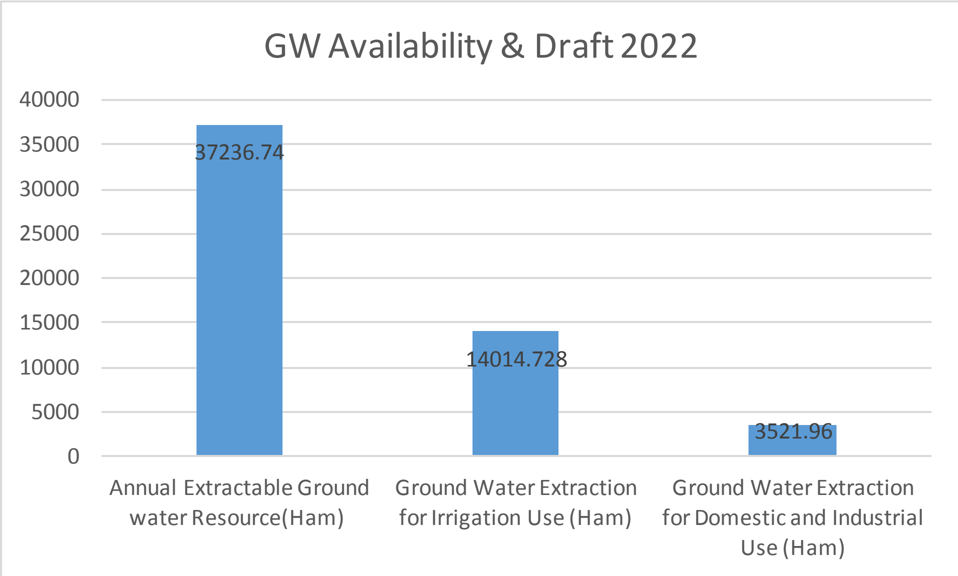


Fig.4.2: GW availability and Draft

The utilisation of available ground water resources for various purposes is provided in **Table.4.3**. The annual gross draft for all uses is estimated at 17536.688 ham with irrigation sector being the major consumer having a draft of 14014.728 ham. The annual draft for domestic and industrial use was estimated as 3521.96 ham. The allocation for domestic & industrial requirement supplies up to 2025 is about 2996.11 ham. the static ground water resource of Aquifer-I was estimated as 516.30 MCMis provided in **Table.4.5**

The stage of ground water development is **47.10%** as on **GWRE 2022**.

Table 4.3: Dynamic Ground Water Resources Availability, Draft and Stage of GW Extraction

Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Stage of Ground Water Extraction (%)	Categorization
BADWARA	3517.47	53.36	548.58	4119.41	51.89	safe
BAHORIBAND	2345.63	1.35	538.17	2885.15	34.08	safe
DHIMAR KHEDA	1184.87	0.00	481.12	1665.98	32.10	safe
MURWARA	3089.88	240.40	331.80	3662.06	55.97	safe
RITHI	1398.28	0.00	344.17	1742.44	45.98	safe
VIJAYRAGHAVGARH	2478.60	487.50	495.51	3461.61	65.19	safe
DISTRICT TOTAL	**14014.73**	**782.62**	**2739.34**	**17536.65**	**47.10**	**safe**

Table.4.4: Ground Water Recharge

Assessment Unit Name	Recharge from Rainfall-Monsoon Season (Ham)	Recharge from Other Sources-Monsoon Season (Ham)	Recharge from Rainfall-Non-Monsoon Season (Ham)	Recharge from Other Sources-Non-Monsoon Season (Ham)	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
BADWARA	6532.95	514.3	0	1379.61	8426.86	488.06	7938.8
BAHORIBAND	7608.21	342.6	0	1023.47	8974.28	508.36	8465.92
DHIMAR KHEDA	5062.47	114.42	0	285.97	5462.86	273.14	5189.72
MURWARA	5885.52	399.4	0	984.6	7269.52	726.95	6542.57
RITHI	3523.06	121.84	0	371.11	4016.01	226.22	3789.79
VIJAYRAGHAVGARH	4928.6	144.92	0	515.89	5589.41	279.47	5309.94
DISTRICT TOTAL	**33540.81**	**1637.48**	**0**	**4560.65**	**39738.94**	**2502.2**	**37236.74**

Table.4.5: Static Ground Water Resources of Aquifer-I

	Units	
Recharge worthy Area	Sq. km	4666.48
Pre-monsoon (average) depth to water level	m	9.81
Av. depth of Dug well	m	14.43
Specific Yield (Sy)%	Fraction	0.024
Saturated thickness of aquifer (ST)	m	4.61
Resource (A * Sy * ST)	**MCM**	**516.30**

4.2 Ground Water Resources – Aquifer-II

The ground water resource of the Aquifer –II was also assessed to have the correct quantification of resources so that proper management strategy can be framed. To assess these resources, the average thickness of fractures in deeper aquifers from exploratory wells was calculated and the following formula for static ground water resources was utilised i.e.

GWR =Recharge worthy Area x Thickness of fractures in deep aquifer x Specific yield

By applying above formula, the static ground water resource of Aquifer-II was estimated as 420.823 MCM and is presented below in **Table.4.6**

Table.4.6: Ground Water Resources of Aquifer-II.

	Units	Total
Recharge worthy Area	Sq.km	4666.48
Thickness of fracture in deeper aquifer	M	3.34
Specific yield(Sy)%	Fraction	0.024
Resource (A * Sy * ST)	MCM	**420.823**

As a part of NAQUIM project 2021-22, groundwater resources of dynamic and static aquifers were calculated using water level fluctuation methods draft is calculated using unit draft method for each block in Katni district as given in the **Table.4.7** below.

Table 4.7: Block-wise Unit draft of Katni District (in mcm)

Block	BADWARA	BORIBAND	DHERKHEDEA	MURWARA	RITHI	VIJAYRAGHOGARH
Dug Well with Pump	0.920203545	0.922500478	0.972	0.872591057	0.755547104	0.648
Bore Well	1.900836288	1.816126235	1.458	1.554013958	1.221851375	2.268

CHAPTER-5

GROUND WATER RELATED ISSUES

5.1 DECLINING WATER LEVEL

The decline in the water level both in pre and post monsoon is observed in major part of the district. The decadal pre-monsoon water level trend is presented in the **Fig.5.1**, which indicates that during pre-monsoon period, more than 80 % of the area showing declining trend. Similarly, the decadal post-monsoon water level trend is presented in the **Fig.5.2**, which indicates that the whole district is showing declining trend.

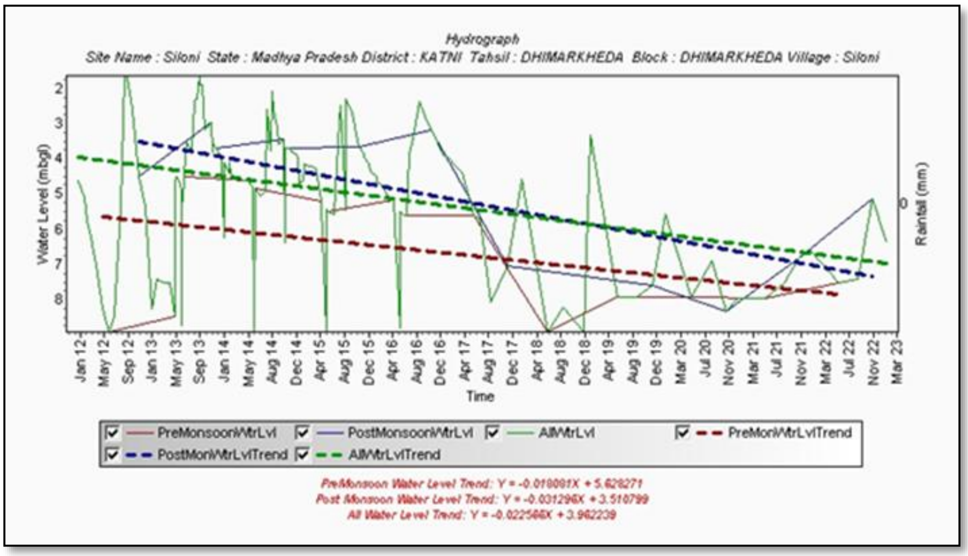


Fig.5.1: Hydrograph showing declining water level trend at site Siloni village, Dhimarkheda

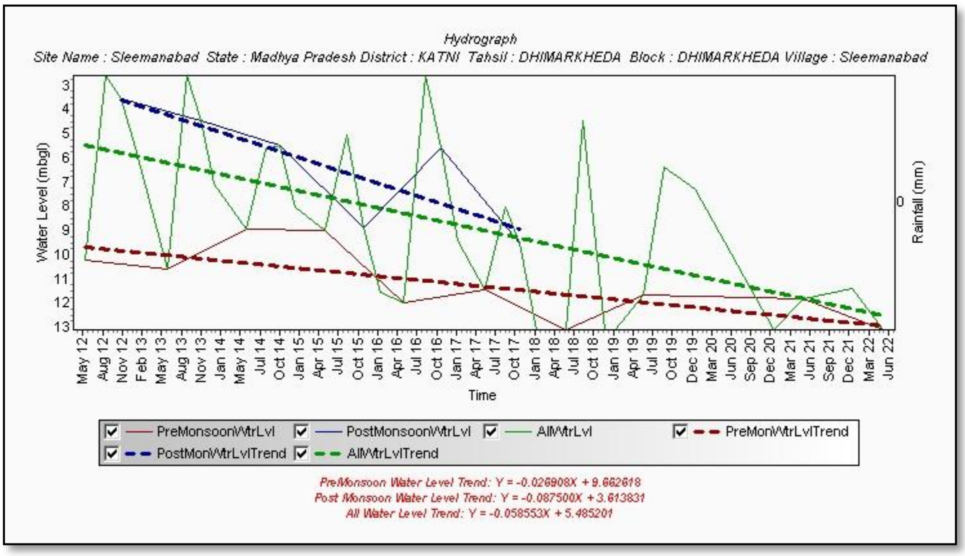


Fig.5.2:Hydrograph showing declining water level trend at site Sleemanabad village, Block-Dhimarkheda

5.2 INFERIOR GROUND WATER QUALITY AT SOME PLACES

In some parts of the district there is higher concentration nitrate, It is observed that 21.59% samples have nitrate concentration more than the acceptable limit i.e. 45 mg/l, while rest 78.41% samples have concentration less than acceptable limit. Highest concentration (more than 100 mg/L) of nitrate is reported in the water samples of Kothi (110 mg/l), Bhamka (114 mg/l), Majhgawan (117 mg/l), Takhala (123 mg/l), Hardwara (156 mg/l), Neemkhere (186 mg/l) and Banson (310 mg/L). High nitrate in ground water samples may be due to anthropogenic activities or excessive use of fertilizers.

5.3 AQUIFERS HAVING LIMITED YIELD POTENTIAL

Hard rock shallow aquifer occupies the first few 8-14 of meters from the top. Groundwater occurs in weathered zone, lateritic zone and clay zone (alluvium) under the unconfined condition, which has specific hydrodynamic properties from top to bottom. The shale formation which has negligible effective porosity and ground water mostly found in bedding planes.

5.4 LACK OF AWARNESS AND INVOLVEMENT OF STAKE HOLDERS IN DECISION MAKING

Lack of awareness and involvement of stake holders in decision making related to groundwater is also a very important issue. Stakeholders need to participate because management decision taken by the regulatory agency without social consensus is often impossible to implement. Essential management activities (such as monitoring, inspection, etc.) can be carried out more effectively and economically through cooperative efforts and shared burdens. Benefits that arise from the stakeholder's participation are-

- more informed and transparent decision-making
- Conflict prevention by development of consensus and information sharing.
- Economic benefits, because it tends to optimize pumping and reduce energy costs.
- Technical benefits, because it usually involves stakeholders in maintenance and leads to better estimates of water abstraction
- Management benefits, because the trigger local stakeholder initiatives to implement demand and supply measures and reduce the cost of regulation.

Stakeholder involvement should be seen as on-going, long-term process that adapts to the contextual conditions needs and changes therein.

CHAPTER-6

PART I-GROUND WATER MANAGEMENT STRATEGIES

India is the largest user of groundwater in the world and therefore highly dependent on it and it will remain the lifeline for years to come. In the current scenario about 70-80 % water supply for agriculture is from groundwater rather than surface water irrigation. Groundwater is the major source of drinking water, agriculture and industry which is increasing day by day because of increased population growth and socio-economic development in the district. This rapid over-exploitation of groundwater and intensive irrigation has posed serious problems in the district e.g. declining water level, drying of aquifers and groundwater pollution. If this trend continuous unchecked, district is going to face a major water crisis in the near future. In district sufficient and adequate amount of **rainfall** is there each year almost (except for some years) which is **sufficient** to rise the water table and can met the water requirement and demand of the district with good socio-economic conditions but because of **lack of awareness**, involvement **of stake holders in decision making, lack of groundwater management the condition of the district is same since decades**. **Groundwater management** is recognized as critical to support the **long-term viability of aquifers, sustainability of aquifers and improving socio-economic condition.** Effective groundwater management is underpinned by sound science that actively engages the wider community and relevant stake holders in the decision-making process. Therefore, an integrated approach is needed to overcome this major problem, which includes augmentation of groundwater resources through appropriate techniques and adoption of suitable water conservation measures such as **creation of water storage facility, maintenance of existing structures, proposing different structure for recharge.**

6.1 District Ground Water Management Plan (Outcome of NAQUIM)

Groundwater management entails both quality and quantity related groundwater resource management. Quantification of groundwater resources and understanding of hydrogeological processes is a basic pre-requisite for efficient and sustainable management of groundwater resource development and management because **fresh water resource is shrinking** at an alarming rate or it is under used. For managing the groundwater resource, to control the decline of water level, to increase the area under more irrigation and for sustaining the aquifers, groundwater management plan is to be prepare for the district. As per the directions of **Ministry of Jal Shakti,** Department of Water Resources, River Development and Ganga Rejuvenation preparation of Aquifer Management Plan and its financial layout for the Katni district in the State has been prepared **block wise.**

Katni district has been facing problems of under developed and not using the resources available in a correct direct so that they will be benefited in terms of availability of groundwater and in terms of getting developed socially & financially. This needs to evolve sustainable water conservation and management practices through an integrated approach. The ground water management plan for Katni district has been made keeping in view the area specific details and includes the strategies like enhancing the ground water resources through construction of artificial recharge structures such as percolation tanks, check dams with recharge shaft, nala bands/cement plugs, village/farm ponds. Also, adoption of micro-irrigation techniques such as sprinkler irrigation/drip irrigation, which would not only conserve ground water resources by reducing the draft, but would also increase the net cropping area thereby, augmenting the agricultural economy of the district.

6.2 Supply Side Management Plan

Supply side management plan is proposed to overcome the above said major issues through rainwater harvesting and artificial recharge. Recharge to ground water artificially is one of the most efficient, scientifically proven and cost-effective technology for sustainable groundwater management. The artificial recharge aims at augmentation of groundwater reservoir and addresses important things in these crises. It addresses-

- To enhance the sustainable yield in areas where-development has depleted the aquifer.
- Conservation and storage of excess surface water for future requirements.
- Improve the quality of existing groundwater through dilution.

For Katni district, the supply side management plan has been formulated using the basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the total area with the respective specific yield and the unsaturated zone thickness obtained by subtracting 3 mts from the post-monsoon water level. The volume of ground water recharge generated through pre-existing rain water harvesting/water conservation structures is subtracted from the sub-surface storage to assess the available storage potential. Thus, the surface water requirement to completely saturate the sub-surface storage is obtained by multiplying a factor of 1.33 to available storage potential. The volume of unsaturated zone available in the Khargone district is 250.12 MCM. The volume of water required for recharging this much amount of water in the area is 332.6 MCM, but non commuted runoff available in the district the water available in the district is 204.08 MCM and artificial recharge created as per the sub-surface storage and non-commuted runoff available is 153.44 MCM.

The number of recharge structures as mentioned above, required to store and recharge the ground water reservoir has been worked out as follows.

The artificial recharge Structures are proposed shown in **Fig.6.1**: on the basis of Geology of the study area having slope less 20%, Pre-Monsoon water level more than 3.00mbgl, Weathering or Alluvium thickness of the area, drainage and Forest cover of the area.

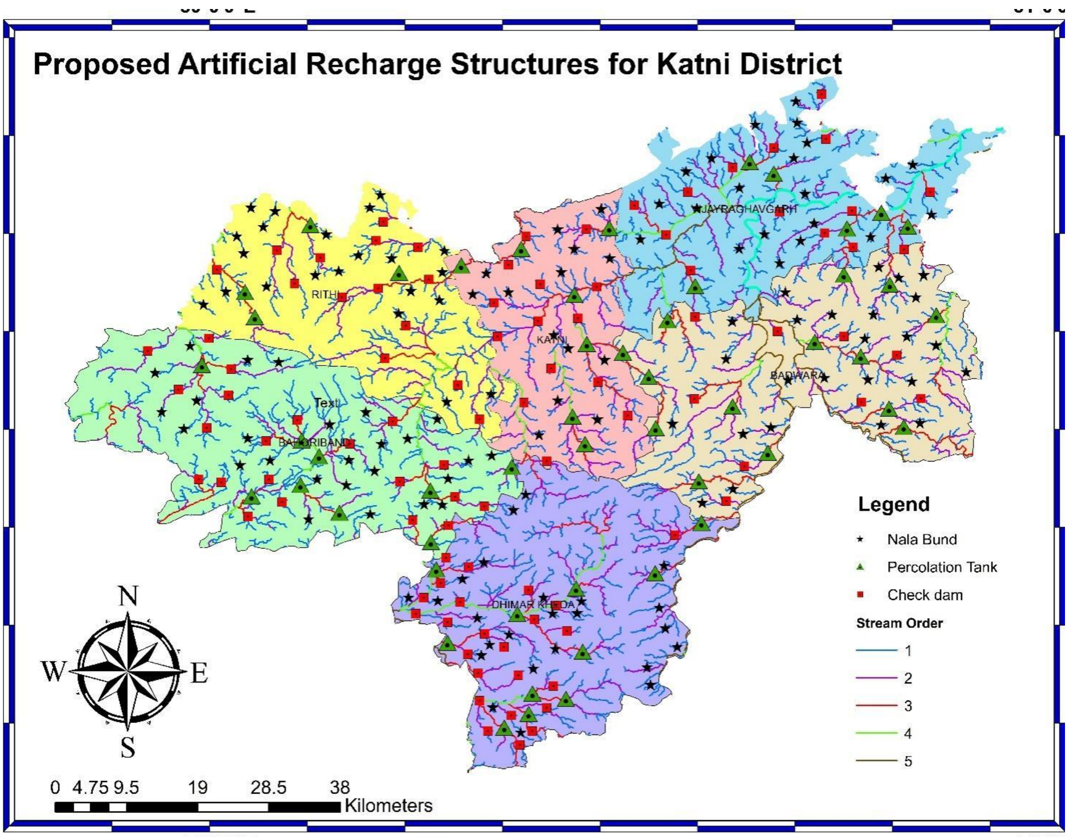


Figure 6.1: Proposed Artificial Recharge Structures for Phase-I in Katni District

A runoff coefficient factor of 0.1 per sq. km has been considered for Katni district to calculate the total surface water runoff, 30% of which accounts to the non-committed runoff which is available to sustain the proposed artificial recharge structures. Further, the number of structures has been calculated by allotting 35%, 45%, 15% and 5% of non-committed runoff to Percolation tanks, check dam with recharge shafts, Nala bund/Cement Plugs and village/farm ponds respectively. Supply Side Ground Water Management given in **Table 6.1** & **6.2**

A financial outlay plan has also been formulated, assuming the cost for the artificial recharge structures to be Rs. 20 lakhs each for percolation tanks, Rs. 7 lakhs each for check dam with recharge shafts/Tube wells, Rs. 1 lakh each for nala bund/cement plugs and Rs. 2.5 lakhs each village/farm ponds. This accounts to a total of Rs.341.78 crores to successfully implement the supply side management strategy. **Table.6.3** represents the complete financial outlay plan- Supply Side Management for the district.

6.3 Demand Side Management

Micro-irrigation is a modern method of irrigation and there is scope for increasing areas under this irrigation because of the increasing demand of water especially for the purpose of agriculture. Micro-irrigation is transforming the lives of millions of farmers across the world. **Micro-irrigation** is a slow application of water as discrete or continuous drips, tiny streams or miniature spray on, above or below the soil by surface drip, sub-surface drip, bubbler and micro-sprinkler systems. It is applied through emitters connected to a water delivery line through low pressure delivery. Drip irrigation methods range from simple bucket kit systems for small farms to automated systems linking release of water to soil moisture conditions measured continuously by tension meters. Micro-irrigation is of two types -**drip irrigation and sprinkler irrigation**. Sprinkler irrigation is a system which delivers water for irrigation in a pressurized form. This form of irrigation provides water efficiently. In drip irrigation emitters directly deliver water to the plant root into the soil. These emitters optimize and distribute the pressure from the water source using vents, twisters and convoluted or long flow paths which allows only a limited amount of water to pass through. Emitters can place on the ground or can also be planted deep in the soil.(**Fig.6.2)**

Micro-irrigation is often promoted by Central and State governments as a way to tackle the **growing water crises** or ground water related issued. Because of the rapid increase in the demand of water especially in agriculture sector this micro-irrigation has become a policy priority in India and technological solutions for achieving water conservation. These micro-irrigation techniques also called as low volume irrigation and have the potential to save water and nutrients by allowing water to drip slowly to the roots of plants. The goal is to place both saves conveyance losses and improves water application efficiency by applying water near the root-zone of the plant. Some benefits of the micro-irrigation have been listed below:

- The increase in yield for different crops ranges from 27 per cent to 88 per cent and water saving ranges from 36 per cent to 68 per cent vis-à-vis conventional flow irrigation systems (Phansalker and Verma, 2005).
- It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities and higher yield.
- It saves costs of hired labour and other inputs like fertilizer.
- Joint management of irrigation and fertilization.
- Reducing pest problem.
- It reduces the energy needs for pumping, thus reducing energy per ha of irrigation because of its reduced water needs. However, overall energy needs of the agriculture sector may not get reduced because most farmers use the increased water efficiency to bring more area under irrigation.

- It suits for all type of soils, e.g., clay soil requires a slow procedure to avoid surface water collection and runoff and for sandy soils needs higher emitter discharge rates to ensure sufficient wetting of the soil.

Adoption of Sprinkler irrigation techniques would save 30 % of gross ground water draft for irrigation. Also, additional recharge created by construction of artificial recharge structures can be utilized to increase the total cropping area, thereby enhancing the productivity and economy of the district. In Badwara, Bahoriband, Dhimarkheda, Murwara and Rithi block 100%, in Vijayraghavgarh block 80% of the additional recharge created by construction of AR structures is utilizing to increase the cropping area and in Badwara, Bahoriband, Dhimarkheda, Murwara and Rithi block 10 % of the net groundwater available as per GWRE 2022 is also utilizing to increase the cropping area in the mentioned blocks. A summarized table for the demand side management is given in the **Table.6.4.**

6.4 Management Plan for Ground Water Quality

Higher Concentration of nitrate has been encountered in the district. The use of fertilizers and sewage/ domestic waste is one of the reasons for ground water contamination. Therefore, it is recommended for proper lining of sewage lines and proper waste management in the district. In agriculture field, the use of organic fertilizers instead of the use of harmful fertilizers.

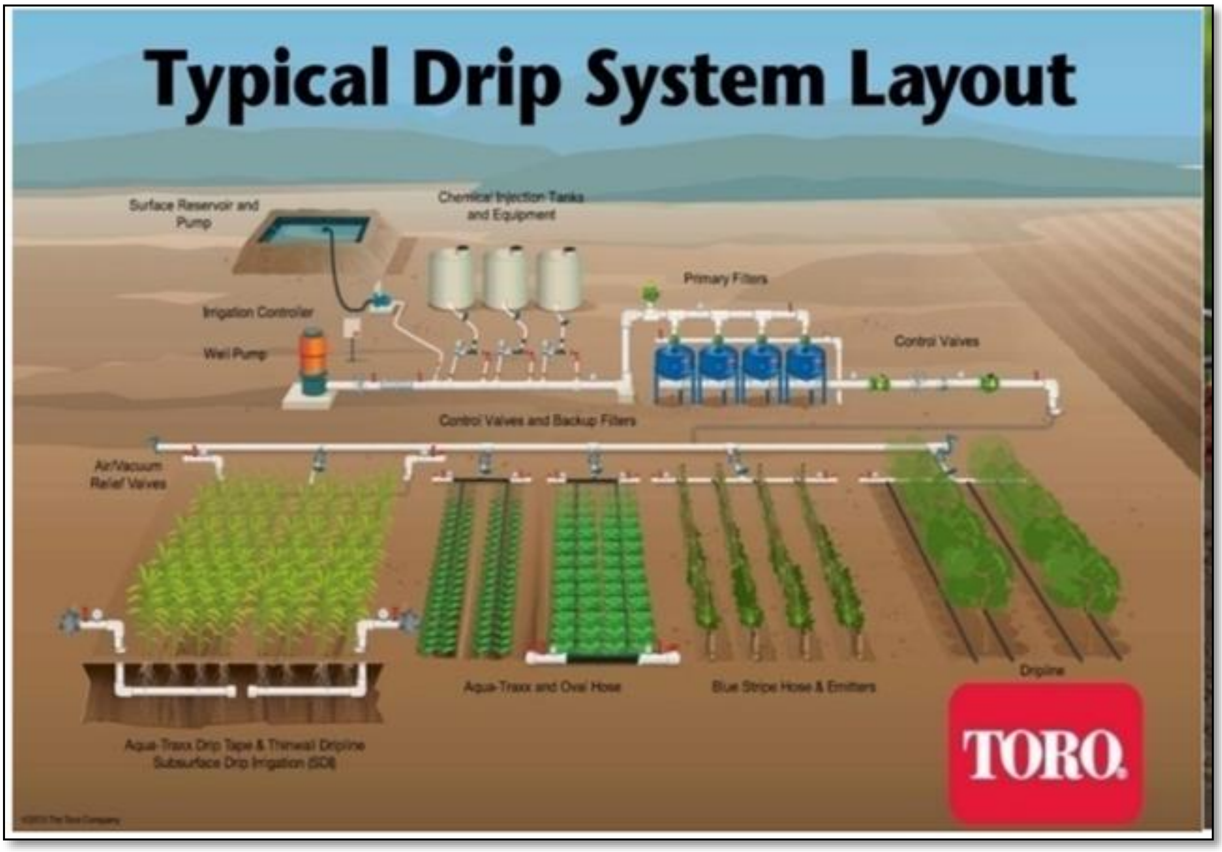


Figure 6.2: Schematic Diagram of Micro-irrigation (Drip Irrigation system)

Fig.6.3 Cultivation through drip irrigation

Fig.6.4 Cultivation through sprinkler irrigation

Table.6.1: Ground Water Management– Supply Side, Katni District, Madhya Pradesh

Sl. No	District	Assessment Unit Name	Area (Sq.KM)	Annual Rainfall 5 years (mm)	Average Post-monsoon Water Level (mbgl)	Suitable Area for AR (sq.km)	Un Saturated Zone	Specific Yield	Sub-surface storage (mcm)	Surface water required (mcm)	Available water for AR (MCM)	Artificial Recharge created against the sub-surface storage and non-commuted runoff available (MCM)
1	**Katni**	BADWARA	942	1072.00	5.68	928.58	2.68	0.02	49.77	66.20	39.28	29.53
2	**Katni**	BAHORIBAND	979	1072.00	5.68	979.00	2.68	0.02	52.47	69.79	40.82	30.69
3	**Katni**	DHIMAR KHEDA	925	1072.00	5.68	841.20	2.68	0.02	45.09	59.97	38.57	29.00
4	**Katni**	MURWARA	662	1072.00	5.68	662.00	2.68	0.02	35.48	47.19	27.61	20.76
5	**Katni**	RITHI	635	1072.00	5.68	512.70	2.68	0.02	27.48	36.55	26.48	19.91
6	**Katni**	VIJAYRAGHAVGARH	751	1072.00	5.68	743.00	2.68	0.02	39.82	52.97	31.32	23.55
	Total		**4894.00**			**4666.48**		**0.02**	**250.12**	**332.66**	**204.08**	**153.44**

Table.6.2: Ground Water Management– Supply Side, Katni District, Madhya Pradesh

Sl. No	District	Assessment Unit Name	Runoff /sq.km	Runoff MCM	Non-Commuted Runoff	No. of percolation tanks	No. of Check Dams with Recharge shaft in each CD	No. of nala bunds/cement plugs	No. of village ponds/ Farm Ponds
1	**Katni**	BADWARA	0.14	130.94	39.28	69.00	589.00	589.00	196.00
2	**Katni**	BAHORIBAND	0.14	136.08	40.82	71.00	612.00	612.00	204.00
3	**Katni**	DHIMAR KHEDA	0.14	128.58	38.57	68.00	579.00	579.00	193.00
4	**Katni**	MURWARA	0.14	92.02	27.61	48.00	414.00	414.00	138.00
5	**Katni**	RITHI	0.14	88.27	26.48	46.00	397.00	397.00	132.00
6	**Katni**	VIJAYRAGHAVGARH	0.14	104.39	31.32	55.00	470.00	470.00	157.00
	Total				**204.08**	**357.00**	**3061.00**	**3061.00**	**1020.00**

Table.6.3: Financial Outlay Plan- Supply Side Management, Katni District, Madhya Pradesh

Sl. No	District	Assessment Unit Name	Sub-surface storage (mcm)	Surface water required (mcm)	Available water for AR (MCM)	Artificial Recharge created against the sub-surface storage and non-commuted runoff available	Non-Commuted Runoff	No. of percolation tanks	cost of percolation tanks in crores @0.2crores per pt.	No. of Check Dams with Recharge shaft in each	cost of Check Dams with recharge shaft in crores @0.07 crores per pt	No. of nala bunds/cement plugs	cost of nala bund/cement plugs in crores @0.01 crores per pt	No. of village ponds/ Farm Ponds	cost of village pond in crores @0.025 crores per pt	Total cost
1	**Katni**	**BADWARA**	49.77	66.20	39.28	29.53	39.28	69	13.80	589	41.23	589	5.89	196	4.90	65.82
2	**Katni**	**BAHORIBAND**	52.47	69.79	40.82	30.69	40.82	71	14.20	612	42.84	612	6.12	204	5.10	68.26
3	**Katni**	**DHIMAR KHEDA**	45.09	59.97	38.57	29.00	38.57	68	13.60	579	40.53	579	5.79	193	4.83	64.75
4	**Katni**	**MURWARA**	35.48	47.19	27.61	20.76	27.61	48	9.60	414	28.98	414	4.14	138	3.45	46.17
5	**Katni**	**RITHI**	27.48	36.55	26.48	19.91	26.48	46	9.20	397	27.79	397	3.97	132	3.30	44.26
6	**Katni**	**VIJAYRAGHAV GARH**	39.82	52.97	31.32	23.55	31.32	55	11.00	470	32.90	470	4.70	157	3.93	52.53
		TOTAL	**250.12**	**332.66**	**204.08**	**153.44**	**204.08**	**357**	**71.40**	**3061**	**214.27**	**3061**	**30.61**	**1020**	**25.50**	**341.78**

Table.6.4: Post-Intervention Impact – Demand side of Katni District, Madhya Pradesh

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by micro irrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW Availability (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for additional Area Irrigation (%)	Additional area irrigated by GW after intervention (Ha)
BADWARA	79.38	35.17	6.01	41.19	51.88	10.55	29.53	108.91	29.53	7.94	68.10	62.53	9368.22
BAHORIBAND	84.65	23.45	5.39	28.85	34.07	7.04	30.69	115.34	30.69	8.47	60.96	52.85	9789.99
DHIMAR KHEDA	51.89	11.84	4.81	16.65	32.10	3.55	29.00	80.89	29.00	5.19	47.29	58.46	8547.72
MURWARA	65.42	30.89	5.72	36.62	55.97	9.27	20.76	86.18	20.76	6.54	54.64	63.41	6824.48
RITHI	37.89	13.98	3.44	17.42	45.97	4.19	19.91	57.80	19.91	3.79	36.92	63.88	5924.60
VIJAYRAGHAVGARH	53.09	24.78	9.83	34.61	65.19	7.43	23.55	76.64	18.84	0.00	46.01	60.04	4709.28
TOTAL	**372.32**	**140.11**	**35.20**	**175.34**	**47.09**	**42.03**	**153.44**	**525.76**	**148.73**	**31.92**	**313.93**	**59.71**	**45164.30**

6.5 Post-Intervention Impact

The supply side interventions by implementation of artificial recharge/water conservation will increase the resource by 153.44 mcm. These supply side interventions are not sufficient to bring the district under sustainable management. Therefore, demand side interventions are also proposed in which micro-irrigation system is taken up to tackle the issues related to groundwater. Therefore, after the supply side and demand side interventions the outcome of the proposed interventions has been described in **Table.6.4** and **Table.6.5.** The Stage of ground water extraction for the entire Katni district, changed from 47.09 % to 59.71 % with 45164.30 ha additional area irrigated by ground water after intervention for sustainable ground water management so that district will remain in safe category with more area under irrigation

Table 6.5 Quantitative impact on GW Resources after the supply side and demand side interventions

Block	Stage of GW Extraction (%)	Stage of GW Extraction after intervention (%)	Additional area irrigated by GW after intervention (Ha)
BADWARA	51.88	62.53	9368.22
BAHORIBAND	34.07	52.85	9789.99
DHIMAR KHEDA	32.10	58.46	8547.72
MURWARA	55.97	63.41	6824.48
RITHI	45.97	63.88	5924.60
VIJAYRAGHAVGARH	65.19	60.04	4709.28
TOTAL	**47.09**	**59.71**	**45164.30**

6.6 Block-wise Ground Water Management Plan (Outcome of NAQUIM)

As per directions of Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India, Aquifer Management Plan for district has been prepared block-wise. The plan for each block discusses the broad framework of ground water situation in the block, status of water availability, feasibility of artificial recharge and other water conservation structures and their numbers and cost estimates.

CHAPTER 7

PART II-BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

7.1 BADWARA BLOCK

Table.7.1. Salient Information

Area			Sq Km	942
Normal Rainfall			mm	1171.4
Principal crops				Paddy, pulses seeds,Wheat,Gram
Data Utilized		Monitoring Wells for Water Level		Dugwell-04
		Monitoring Wells for Quality		Dugwell-04
Water level behavior	**Shallow Aquifer**	Pre-monsoon WL (2022)	mbgl	Min-6.41,Max-14.72
		Post-monsoon WL (2022)		Min-4.31,Max-7.78

Table.7.2. Aquifer Disposition

Major Aquifer	Alluvium/Weathered and Fractured Granite	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Laterite/Limestone	Lametas/Gondwana sandstone/
Depth of Occurrence (mbgl)	1 to 30	30 to 200
Weathered/Fractured rocks thickness(m)	0.5 to 18	2 to 5.5
Fractures encountered (mbgl)	Upto30	Upto200
Yield (lps)	-	4.4 to 10.2
Transmissivity (m^2/day)	-	23.6 to 110.65

Table.7.3. Ground Water Resource

GROUND WATER RESOURCE OF BADWARA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	79.39
Static Resources (MCM)	114.05
Total Resources (MCM)	**193.44**
Deeper Aquifer	
Static Resources (MCM)	81.06
Total GW Resources (MCM)	274.50
Irrigation GW Draft (MCM)	**35.17**
Domestic + Industries GW Draft (MCM)	**6.02**
Gross Ground Water Draft (MCM)	**41.19**
Stage of Ground Water Extraction (%)	**51.89**
Category	**safe**

Table.7.4 Supply Side Management Plan

Area suitable for recharge (Sq. Km)	Sq. km	928.58
SP Yield (%)	%	0.029
Sub-surface storage (mcm)	M	49.77
Surface water required (mcm)	mcm	66.20
Available water for AR (mcm) as per non commuted runoff available (mcm)	mcm	39.28
Artificial Recharge created against the sub-surface storage and non-commuted runoff available (mcm)	mcm	29.53
Surface water (Run-off) available (mcm)	mcm	130.94
Non-committed Run-off (mcm)	Mcm	39.28

Table.7.6. Artificial Recharge Structures Proposed

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	69	13.80 (0.2 crore per structure)
Check Dams with recharge	589	41.23 (0.07 crore per structure)
Nala bunds/cement plugs	589	5.89 (0.01 crore per structure)
Village ponds/ Farm Ponds	196	4.90 (0.025 crore per structure)
Total Cost		65.82 crore

Table.7.7 Demand Side Management Plan

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by micro irrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for additional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
BADWARA	**79.38**	**35.17**	**6.01**	**41.19**	**51.88**	**10.55**	**29.53**	**108.91**	**29.53**	**7.94**	**68.10**	**62.53**	**9368.22**

7.2 BAHORIBAND BLOCK

Table 7.8 Salient Information

Area			Sq Km	979
Normal Rainfall			mm	1171.4
Principal crops				Paddy, pulses seeds, Wheat, Gram
Data Utilized		Monitoring Wells for WaterLevel		Dugwell-01
		Monitoring Wells for Quality		Dugwell-01
Water level behavior	**Shallow Aquifer**	Pre-monsoon WL (2022)	mbgl	Min-5.69,Max-15.56
		Post-monsoon WL (2022)		Min-3.68,Max-7.23

Table 7.9:Aquifer Disposition

Major Aquifer	Vindhyan Sandstone/Fractured Slate	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Laterite/Limestone Weathered Sandstone	Fractured Marble/Shale/Slate
Depth of Occurrence (mbgl)	1 to 30	30 to 200
Weathered/Fractured rocks thickness(m)	0.5 to 10	2 to 5.5
Fractures encountered (mbgl)	Up to30	Up to200
Yield (lps)	-	0.27 to 6.3
Transmissivity (m^2/day)	-	0.558 to 6.2

Table.7.10. Groundwater Resources

GROUND WATER RESOURCE OF BAHORIBAND BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	84.66
Static Resources (MCM)	118.67
Total Resources (MCM)	**203.33**
Deeper Aquifer	
Static Resources (MCM)	85.91
Total GW Resources (MCM)	289.23
Irrigation GW Draft (MCM)	**23.46**
Domestic+IndustriesGW Draft (MCM)	**5.40**
Gross Ground Water Draft (MCM)	**28.86**
Stage of Ground Water Extraction (%)	**34.08**
Category	**safe**

Table 7.11: Supply Side Management Plan

Area suitable for recharge (sq. Km)	Sq. km	979
SP Yield (%)	%	0.027
Sub-surface storage (mcm)	M	52.47
Surface water required (mcm)	mcm	69.79
Available water for AR (mcm) as per non commuted runoff available (mcm)	mcm	40.82
Artificial Recharge created against the sub-surface storage and non-commuted runoff available (mcm)	mcm	30.69
Surface water (Run-off) available (mcm)	mcm	136.08
Non-committed Run-off (mcm)	Mcm	40.82

Table 7.12: Proposed Artificial Recharge Structres

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	71	14.20 (0.2 crore per structure)
Check Dams with recharge shaft	612	42.84 (0.07 crore per structure)
Nala bunds/cement plugs	612	6.12 (0.01 crore per structure)
Village ponds/ Farm Ponds	204	5.10 (0.025 crore per structure)
Total Cost		68.26 crore

Table 7.13: Demand Side Management Plan

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by micro irrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for additional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
BAHORIBAND	84.65	23.45	5.39	28.85	34.07	7.04	30.69	115.34	30.69	8.47	60.96	52.85	9789.99

7.3 DHIMARKHEDA BLOCK

Table 7.13: Salient Information

Area			Sq.Km	925
Normal Rainfall			mm	1171.4
Principal crops				Paddy, pulses seeds, Wheat, Gram
Data Utilized		Monitoring Wells for Water Level		Dugwell-04
		Monitoring Wells for Quality		Dugwell-04
Water level behavior	**Shallow Aquifer**	Pre-monsoon WL(2022)	mbgl	Min-7.51,Max-8.46
		Post-monsoon WL(2022)		Min-3.91,Max-5.13

Table 7.14: Aquifer Disposition

Major Aquifer	Alluvium / Gondwana sandstone/Fractured Shale	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Alluvium/ Laterite / Gondwana sandstone	Fractured Shale/Sandstones
Depth of Occurrence (mbgl)	1 to 30	30 to 200
Weathered/Fractured rocks thickness(m)	0.5 to 19	4 to 13.56
Fractures encountered (mbgl)	Up to30	Up to200
Yield (lps)	-	4.6 to 22.64
Transmissivity (m^2/day)	-	11.20 to 60.88

Table 7.15: Ground Water Resource

GROUND WATER RESOURCE OF DHIMARKHEDA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	51.90
Static Resources (MCM)	31.01
Total Resources (MCM)	**82.91**
Deeper Aquifer	
Static Resources (MCM)	27.09
Total GW Resources (MCM)	109.99
Irrigation GW Draft (MCM)	**11.85**
Domestic+IndustriesGW Draft (MCM)	**4.81**
Gross Ground Water Draft (MCM)	**16.66**
Stage of Ground Water Extraction (%)	**32.10**
Category	**Safe**

Table 7.16 Supply Side Management Plan

Area suitable for recharge (sq. Km)	Sq. km	841.2
SP Yield (%)	%	0.014
Sub-surface storage (mcm)	M	45.09
Surface water required (mcm)	mcm	59.97
Available water for AR (mcm) as per non commuted runoff available (mcm)	mcm	38.57
Artificial Recharge created against the sub-surface storage and non-commuted runoff available (mcm)	mcm	29.00
Surface water (Run-off) available (mcm)	mcm	128.58
Non-committed Run-off (mcm)	Mcm	38.57

Table 7.17 Proposed Artificial Recharge Srtuctres

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	68	13.60 (0.2 crore per structure)
Check Dams with recharge shaft	579	40.53 (0.07 crore per structure)
Nala bunds/cement plugs	579	5.79 (0.01 crore per structure)
Village ponds/ Farm Ponds	193	4.83(0.025 crore per structure)
Total Cost		64.75 crore

Table 7.18: Demand Side Management Plan

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by micro irrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for additional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
DHIMARKHEDA	51.89	11.89	4.81	16.65	32.10	3.55	29.00	80.89	29.00	5.19	47.29	58.46	8547.72

7.4 MURWARA BLOCK

Table.7.19: Salient Information

Area			Sq.Km	662
Normal Rainfall			mm	1171.4
Principal crops				Paddy, pulses seeds, Wheat, Gram
Data Utilized		Monitoring Wells for Water Level		Dugwell-04
		Monitoring Wells for Quality		Dugwell-04
Water level behavior	**Shallow Aquifer**	Pre-monsoon WL (2022)	mbgl	Min-4.3,Max-21.15
		Post-monsoon WL(2022)		Min-2.98,Max-10.81

Table.7.20: Aquifer Disposition

Major Aquifer	Alluvium/ Laterite /Fractured Slate/Marble	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Alluvium/ Laterite	Fractured Slate/Marble
Depth of Occurrence (mbgl)	1 to 30	30 to 200
Weathered/Fractured rocks thickness(m)	2.5 to 17	7.5 to 14.2
Fractures encountered (mbgl)	Up to 30	Up to 200
Yield (lps)	-	0.642 to 11.543
Transmissivity (m^2/day)	-	0.8 to 8.34

Table.7.21: Ground Water Resource

GROUND WATER RESOURCE OF MURWARA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	65.43
Static Resources (MCM)	158.25
Total Resources (MCM)	**223.68**
Deeper Aquifer	
Static Resources (MCM)	60.77
Total GW Resources (MCM)	284.45
Irrigation GW Draft (MCM)	**30.90**
Domestic + IndustriesGW Draft (MCM)	**5.72**
Gross Ground Water Draft (MCM)	**36.62**
Stage of Ground Water Extraction (%)	**55.97**
Category	**safe**

Table 7.23 Supply Side Management Plan

Area suitable for recharge (sq. Km)	sq. km	662
SP Yield (%)	%	0.034
Sub-surface storage (mcm)	M	35.48
Surface water required (mcm)	mcm	47.19
Available water for AR (mcm) as per non commuted runoff available (mcm)	mcm	27.61
Artificial Recharge created against the sub-surface storage and non-commuted runoff available (mcm)	mcm	20.76
Surface water (Run-off) available (mcm)	mcm	92.02
Non-committed Run-off (mcm)	Mcm	27.61

Table 7.24: Proposed Artificial Recharge Structures

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	48	9.60 (0.2 crore per structure)
Check Dams with recharge shaft	414	28.98 (0.07 crore per structure)
Nala bunds/cement plugs	414	4.14 (0.01 crore per structure)
Village ponds/ Farm Ponds	138	3.45(0.025 crore per structure)
Total Cost		46.17 crore

Table 7.24: Demand Side Management Plan

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by micro irrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for additional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
MURWARA	**65.42**	**30.89**	**5.72**	**36.62**	**55.97**	**9.27**	**20.70**	**86.18**	**20.76**	**6.54**	**54.64**	**63.41**	**6824.48**

7.5 RITHI BLOCK

Table.7.25. Salient Information

Area			Sq.Km	662
Normal Rainfall			mm	1171.4
Principal crops				Paddy, pulses seeds, Wheat, Gram
Data Utilized		Monitoring Wells for Water Level		Dugwell-02
		Monitoring Wells for Quality		Dugwell-02
Water level behavior	**Shallow Aquifer**	Pre-monsoon WL (2022)	mbgl	Min-10.59,Max-13.12
		Post-monsoon WL(2022)		Min-1.83,Max-2.62

Table 7.26:Aquifer Disposition

Major Aquifer	Laterite /Fractured Vindhyan Shale/Sandstone	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Laterite/ Fractured Vindhyan Sandstone	Fractured Shale
Depth of Occurrence (mbgl)	1 to 30	30 to 200
Weathered/Fractured rocks thickness(m)	2.0 to 10.5	3.5 to 58.9
Fractures encountered (mbgl)	Up to30	Up to200
Yield (lps)	-	0.2 to 4.56
Transmissivity (m^2/day)	-	0.553 to 6.67

Table 7.27: Ground Water Resource

GROUND WATER RESOURCE OF RITHI BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	37.90
Static Resources (MCM)	49.53
Total Resources (MCM)	**87.43**
Deeper Aquifer	
Static Resources (MCM)	24.94
Total GW Resources (MCM)	112.37
Irrigation GW Draft (MCM)	**13.98**
Domestic+IndustriesGW Draft (MCM)	**3.44**
Gross Ground Water Draft (MCM)	**17.42**
Stage of Ground Water Extraction (%)	**45.98**
Category	**safe**

Table 7.28:Supply Side Management Plan

Area suitable for recharge (sq. Km)	sq. km	512.7
SP Yield (%)	%	0.019
Sub-surface storage (mcm)	M	27.48
Surface water required (mcm)	mcm	36.55
Available water for AR (mcm) as per non commuted runoff available (mcm)	mcm	26.48
Artificial Recharge created against the sub-surface storage and non-commuted runoff available (mcm)	mcm	19.91
Surface water (Run-off) available (mcm)	mcm	88.27
Non-committed Run-off (mcm)	Mcm	26.48

Table 7.29: Proposed Artificial Recharge Structures

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	46	9.20 (0.2 crore per structure)
Check Dams with recharge shaft	397	27.79 (0.07 crore per structure)
Nala bunds/cement plugs	397	3.97 (0.01 crore per structure)
Village ponds/ Farm Ponds	132	3.30(0.025 crore per structure)
Total Cost		44.26 crore

Table.7.30. Demand Side Management Plan

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by micro irrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for additional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
RITHI	37.89	13.98	3.44	17.42	45.97	4.19	19.91	57.80	19.91	3.79	36.92	63.88	5924.60

7.6 VIJAYRAGHAVGARH BLOCK

Table 7.31: Salient Information

Area			Sq.Km	751
Normal Rainfall			mm	1171.4
Principal crops				Paddy, pulses seeds, Wheat, Gram
Data Utilized		Monitoring Wells for Water Level		Dugwell-04
		Monitoring Wells for Quality		Dugwell-04
Water level behavior	**Shallow Aquifer**	Pre-monsoon WL (2022)	mbgl	Min-7.75,Max-15.63
		Post-monsoon WL(2022)		Min-5.16,Max-8.79

Table 7.32:Aquifer Disposition

Major Aquifer	Alluvium/Laterite /Fractured Vindhyan Shale/Sandstone/ Limestone	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Alluvium/Laterite/ Fractured Vindhyan Sandstone	Fractured shale/Limestone /Sandstone
Depth of Occurrence (mbgl)	1 to 30	30 to 200
Weathered/Fractured rocks thickness(m)	0.5 to 20	5.5 to 35
Fractures encountered (mbgl)	Up to30	Up to200
Yield (lps)	-	1.75 to 8.6
Transmissivity (m^2/day)	-	3.34 to 27.5

Table 7.32:Ground Water Resource

GROUND WATER RESOURCE OF VIJAYRAGHAVGARH BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	53.10
Static Resources (MCM)	63.10
Total Resources (MCM)	**116.20**
Deeper Aquifer	
Static Resources (MCM)	47.70
Total GW Resources (MCM)	163.89
Irrigation GW Draft (MCM)	**24.79**
Domestic+IndustriesGW Draft (MCM)	**9.83**
Gross Ground Water Draft (MCM)	**34.62**
Stage of Ground Water Extraction (%)	**65.19**
Category	**safe**

Table 7.33: Supply Side Management Plan

Area suitable for recharge (sq. Km)	sq. km	743
SP Yield (%)	%	0.02
Sub-surface storage (mcm)	M	39.82
Surface water required (mcm)	mcm	52.97
Available water for AR (mcm) as per non commuted runoff available (mcm)	mcm	31.32
Artificial Recharge created against the sub-surface storage and non-commuted runoff available (mcm)	mcm	23.55
Surface water (Run-off) available (mcm)	mcm	104.93
Non-committed Run-off (mcm)	Mcm	31.32

Table 7.34: Proposed Artificial Recharge Structures

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	55	11.00 (0.2 crore per structure)
Check Dams with recharge shaft	470	32.90 (0.07 crore per structure)
Nala bunds/cement plugs	470	4.70 (0.01 crore per structure)
Village ponds/ Farm Ponds	157	3.33(0.025 crore per structure)
Total Cost		52.53 crore

Table.7.35: Demand Side Management Plan

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by micro irrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for additional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
VIJAYRAGHAVGARH	53.09	24.78	9.83	34.61	65.19	7.43	23.55	76.64	18.84	0.00	46.01	60.04	4709.28

CHAPTER-8

CONCLUSION AND RECOMMENDATIONS

- Katni District occupies an area of 4894 Sq.Km and recharge worthy area is 4666.48 sq. km, and the rest is covered by hilly areas i.e., 227.52 sq.km.
- The main body of the district is drained by the five important rivers ,viz, the Son ,Ken, Mahanadi, Katni and Hiran river.
- Agriculture is the prominent land use aspects in Katni district. Crop land forms 58 %and fallow land form 5.50 % of total area followed by forest land (23.64%), water bodies and Shrubland.
- Major Socio–economy of the district is dependent on Agriculture. The livelihood of rural population of district is dependent on Agriculture.
- The maximum elevation is 669 m amsl in Bahoriband block and minimum elevation is 291 mamsl in Vijayraghavgarh Block. The surface gradient is from south to north.
- In the district mostly two types of soil are present namely Clayey and loamy ,black soil.
- Main geological units of the district are Laterite, Lameta beds, Gondwana Group and Mahakoshal group and Vindhyan formations.
- The principal aquifers in the area are Alluvium, Sandstone ,Shale and Slate and Limestone, Lameta beds.
- In the shallow aquifer water levels between 10 to 20 mbgl in pre-monsoon and between 2to 5, 5 to 10 and 10 to 20 mbgl in the post-monsoon are observed in major parts of the district. The decadal pre-monsoon water level trend analysis indicates that during pre-monsoon period, more than 54 % of the area showing rising trend. Similarly, the decadal post-monsoon water level trend analysis indicates that about 65% of the area showing declining trend. Maximum falling trend is ranged between-0.1 to -0.2m/yr.
- Electrical conductivity of ground water in Katni district ranged between 248 to 3628 µS/cmat 25°C in pre-monsoon season and EC ranged between 295 to 2413 µS/cmat 25°C in post-monsoon season range in between 6.94 to 7.96, fluoride concentration was ranged in between 0.11 to 1.17 mg/l, nitrate concentration ranged inbetween1 to 310mg/l. Total hardness range in between 50 to990 mg/l.
- On the basis of the 16 Exploratory wells drilled by CGWB, NCR under its NAQUIM program, it has been observed that the yield varies upto18.33lps and Transmissivity

varies in ranges of 4 to 3173 m^2/day.

- During annual recharge from rainfall contributes maximum component (335.41 mcm) and recharge from other sources is 61.98 mcm. The Annual Extractable Ground Water Resource is 372.36 mcm, which is 93.7% of the total annual Groundwater recharge. Total extraction of ground water for all uses in district is calculated as 175.37 mcm. The overall stage of groundwater extraction in the district is 47.10 %.
- All the blocks are categorised as 'Safe'. The stage of groundwater extraction for Bahoriband block is 34.08%, for Dhimarkheda block is 32.10%, for Murwara block is 55.97% and for Rithi block is 45.98%. In these blocks GW extraction can be increase for irrigation in additional irrigated area created for cultivation of more crops i.e., pulses.
- In Katni district, the main groundwater issues are Limited Alluvium thickness, Decline in the water level , Limited Aquifer Thickness/Sustainability of hard rock, and high nitrate concentration in aquifers of some areas.
- As per the Management plan prepared under NAQUIM of all the Block of Katni District, a total number of 357 Percolation Tanks, 3061 check dams/Recharge Shafts, 3061 Nala Bunds / Cement Plugs and 1020 village ponds / farm ponds have been proposed and financial expenditure is expected to be Rs.341.78 Crores in Katni District for sustainable development and management of ground water resources.
- The number of artificial recharge structure and financial estimation has been proposedbasedontheCentralGroundWaterBoardMasterplan2022.Itmaybedifferedfrom thefieldconditionas well as changes in Dynamic Groundwater resources.

ANNEXURE - I: Hydrogeological Details of EWs Drilled in 2022-23 and 1997-2000

S No	Block	Site	Location	Well Type	Coordinates		Start date	Completion date	Drilling Depth (M)	Water Level (M)	Casing	Well Assembly	Aquifer zone	Formation	Discharge
					Lat	Long									
1	Boharibaand	Tigawan	In the premises of govt middle school	EW-1	23.693	80.06538	29.07.2022	03.08.2022	200.2	19.1	0.5 magl to 38.0 mbgl with 7" blank pipe	0.5 magl to 38.0 mbgl - 7" blank pipe, 38.0 to 200.20 mbgl- Naked hole	11.00-14.00	Laterite and Shale	Merger
2	Boharibaand	Khamariya	Inside the premises of Govt Primary School	EW-2	23.771	79.93241	24.08.2022	28.08.2022	200.2	30.8	0.5 magl to 14.70 mbgl with 7" blank pipe	0.5 magl to 14.70 mbgl - 7" Blank pipe, 14.70 to 200.20 mbgl - Naked	11.00-14.00	Alluvium and Shale	Merger
3	Boharibaand	Tewari	Inside the premises of khel ground, teori	EW-3	23.678	80.28638	01.09.2022	25.09.2022	69.1	17.05	0.5 m agl to 7.0 mbgl with 10" blank pipe and 7.0 to 64 mbgl with 7" blank pipe	0.5 magl to 7.00 mbgl - 10" blank pipe, 7.00 to 64.00 mbgl - 7" blank pipe & 64.00 to 69.10 mbgl - Naked hole	Seepage zone at 61 m with 0.5" discharge and Water zone at 68.5 m with 0.8 lps discharge	Laterite, bauxite	0.8 lps
4	Dhimerkheda	Paharua	Inside the campus of H.S school	Ew-4	23.551	80.54146	30.09.2022	04.10.2022	200.2	10.32	0.5 magl to 18.00 mbgl with 7" blank pipe	0.5 magl to 18.00 mbgl with 7" blank pipe, 18.00 to 200.20 mbgl - Naked	Wet zone at 26 m with 1.5" discharge and Water zone at 140 m with 3.5 "	Clay,unconsolidated sand, Marble	2.6 lps
5	Dhimerkheda	Sailarpur	Inside the campus of H.S School, Jhinna	Ew-5	23.636	80.41496	03.01.23	23.01.23	200.2	6.34	0.5 magl - 12 m bgl with 7" blank pipe	0.5 magl - 12 m bgl with 7" blank pipe , 12m - 200.2 mbgl	17.2 - 20.3 m, 41.6 - 44.7 m	Dolomite	1.5 lps

S. No.	Location	Depth Drilled(M)	Zones tapped (m)	Discharge(lps)	W.L.M. bgl	Draw Down(m)	Formation
1.	Dharmapur 23⁰13'45" / 80⁰17'55"	81.75	18.00-19.50 22.50-31.00 41.50-53.00 65.50-73.00	2.00	5.72	14.41	Clay Kankar slate
2.	KoluBarkhera 23⁰13'45" / 80⁰17'55"	77.30	52.00-61.00 64.00-67.00 70.00-73.00	3.50	5.32	21.48	Laterite, clays and, slate
3.	Basari 23⁰13'45" / 80⁰17'55"	80.00	36.00-39.00 41.00-43.00 45.00-51.00 56.00-59.00 61.00-63.00	5.25	9.7	8.44	Laterite, sandstone (Gondwana shale)
4.	IG Ward Katn i23⁰13'45" / 80⁰17'55"	70.00	34.00-43.00 59.00-65.00	7.00	10.20	7.49	Laterites and stone (Gondwana clay & limestone)
5.	Khirhani (Pipariya) 23⁰13'45" / 80⁰17'55"	70.00	25.00-31.00 37.00-55.00	4.7	15.05	3.57	Clay/sandstone (Gondwana)
6.	Bramhanwara (Kailwara) 23⁰13'45" / 80⁰17'55"	70.00	50.00-70.00	14.67	6.16	37.64	Clay limestone
7.	Barkhera 23⁰13'45" / 80⁰17'55"	183.00	Abandoned	meagre	discharge		
8.	Lakha-Khera 23⁰13'45" / 80⁰17'55"	92.8	17.00-30.00 33.00-38.00 52.00-62.00	15.71	12.41	4.05	Sandstone (Gondwana)
9.	Nadawar 23⁰13'45" / 80⁰17'55"	95.00	33.00-42.00 51.00-60.00	2.6	9.31	36.37	Alluvium shale
10.	Gulwara 23⁰13'45" / 80⁰17'55"	135.2	44.00-75.00 134.00-135.00	5.5	6.37	22.91	Shale's
11.	DevriHatai 23⁰13'45" / 80⁰17'55"	183.00	44.00-48.50 119.00-122.00 146.00-152.5	2.66	51.00	408.85	Shale's
12.	Kuan 23⁰13'45" / 80⁰17'55"	59.00	13.70-26.70 37.00-55.00	18.00	6.3	4.00	Clay limestone (cavernous)
13.	Kauriya 23⁰13'45" / 80⁰17'55"	82.00	35.00-37.00 43.00-44.50	1.50	12.85	19.00	shale's

ANNEXURE-II-Water level of Key wells pre-monsoon 2022

S.No	District	Village	Type of Well	Latitude	Longitude	Post monsoon WL	Pre_Water level (bmp)	Elevation	RL
1	Katni	Amuwari	Key well	23.9876	80.5413	6.41	10.8	377.2	366.4
2	Katni	Badapar	Key well	24.0489	80.6181	1.21	2.8	386.5	383.7
3	Katni	Banjari	Key well	23.9894	80.6163	4.28	6.8	368.5	361.7
4	Katni	Jamuwani Khurd	Key well	24.1032	80.7135	2.15	8.1	393.5	385.4
5	Katni	Karatilai	Key well	24.0598	80.7214	3.92	10.2	374	363.8
6	Katni	Patharhata	Key well	23.9247	80.6801	6.99	12	379.1	367.1
7	Katni	Hatheda	Key well	23.8964	80.6602	4.02	5.2	379	373.8
8	Katni	Nanhwara Khurd	Key well	23.8421	80.5343	6.67	8.4	389.1	380.7
9	Katni	Itama	Key well	24.0348	80.8497	6.85	10.8	349.8	339
10	Katni	Devra Khurd	Key well	23.9515	80.7667	7.22	8.7	349.1	340.4
11	Katni	Lurmi	Key well	23.9048	80.7355	9.35	8.9	369.8	360.9
12	Katni	Karaundi Khurd	Key well	23.8738	80.8057	6.22	6.9	374.2	367.3
13	Katni	Jajagarh	Key well	23.8645	80.866	8.58	7.4	387.6	380.2
14	Katni	Salaiya Sihora	Key well	23.7873	80.7946	9.08	7.8	392.3	384.5
15	Katni	Baran Mahgawan	Key well	23.729	80.777	5.82	7.8	397	389.2
16	Katni	Bagdara	Key well	23.6991	80.8792	4.05	4.4	423.8	419.4
17	Katni	Harrwah	Key well	23.7631	80.8861	8.15	10.1	416.8	406.7
18	Katni	Barmani	Key well	23.7945	80.8608	5.38	9.4	401.4	392
19	Katni	Surajpura	Key well	23.81	80.7282	4.26	6.7	373.8	367.1
20	Katni	Luharwara	Key well	23.6184	80.5844	2.32	7.4	422.8	415.4
21	Katni	Jharela	Key well	23.6862	80.6456	5.43	5.15	405.6	400.45
22	Katni	Bhajiya	Key well	23.6307	80.5715	2.05	9.5	442.2	432.7
23	Katni	Nanhwara Sejha	Key well	23.7021	80.5219	5.12	9.3	439.2	429.9
24	Katni	Pondi	Key well	23.7613	80.5224	8.18	10.7	412.2	401.5
25	Katni	Bhadoura	Key well	23.8258	80.5376	4.12	4.2	389.4	385.2

26	Katni	Majhgawan	Key well	23.3856	80.436	4.92	5.3	459.1	453.8
27	Katni	Pipariya	Key well	23.4343	80.3831	0.78	2.7	428.9	426.2
28	Katni	Kothi	Key well	23.4413	80.4545	2.68	5.4	455.7	450.3
29	Katni	Katariya	Key well	23.4486	80.5386	5.22	8.7	448.5	439.8
30	Katni	Khamtara	Key well	23.578	80.5225	8.38	8	426.4	418.4
31	Katni	Khamahariya	Key well	23.5914	80.5529	6.59	10.3	421.6	411.3
32	Katni	Jirri	Key well	23.5581	80.4493	5.39	14.65	453.4	438.75
33	Katni	Bhamka	Key well	23.5159	80.4385	9.67	11.2	431	419.8
34	Katni	Harrai	Key well	23.4506	80.4313	3.49	6.3	443.1	436.8
35	Katni	Ghughari	Key well	23.4833	80.2708	8.89	9.4	408.2	398.8
36	Katni	Sagawan	Key well	23.5126	80.4045	3.11	8	420.5	412.5
37	Katni	Pahadi	Key well	23.7035	80.3721	2.1	5.2	407.9	402.7
38	Katni	Pakar	Key well	23.6968	79.9888	2.05	3.7	456.8	453.1
39	Katni	Banson	Key well	23.7258	79.9723	3.48	7.5	454.3	446.8
40	Katni	Bartari	Key well	23.7195	80.0072	1.56	4	460.2	456.2
41	Katni	Kishanpatan	Key well	23.676	80.0629	6.85	8.7	424.2	415.5
42	Katni	Kuwan	Key well	23.6199	80.1248	3.48	4.5	420	415.5
43	Katni	Pondi	Key well	23.6124	80.0585	3.51	3	407.6	404.6
44	Katni	Kaudiya	Key well	23.6682	80.1731	4.05	12.3	427.6	415.3
45	Katni	Neemkhere	Key well	23.6436	80.115	4.82	5.7	411	405.3
46	Katni	Padwar	Key well	23.6318	80.22	7.22	8.8	431	422.2
47	Katni	Harduwa	Key well	23.9048	80.2878	3.92	3.9	391.2	387.3
48	Katni	Deori Phatak	Key well	23.9128	80.1969	1.42	6.1	407.2	401.1
49	Katni	Bargaon	Key well	23.9077	80.039	3.28	6.4	432.1	425.7
50	Katni	Majhgawan	Key well	23.7715	79.954	1.99	6	448.6	442.6
51	Katni	Sakarwara	Key well	23.7703	79.9079	2.25	6.8	475.7	468.9
52	Katni	Patauha	Key well	23.7606	79.8589	5.15	5.9	510.5	504.6
53	Katni	Patori	Key well	23.7959	79.9592	6.21	10.8	452.2	441.4
54	Katni	Patna	Key well	23.7681	80.0044	0.75	5.3	452.8	447.5

55	Katni	Pithradi	Key well	23.7159	80.0882	3.36	5.4	422.9	417.5
56	Katni	Herdua	Key well	23.9444	80.5165	6.48	3.7	373.4	369.7
57	Katni	Kauwara	Key well	23.9321	80.3997	6.78	9.6	390.1	380.5
58	Katni	Gulwara	Key well	23.7996	80.33	2.51	3	392.1	389.1
59	Katni	Deori	Key well	23.9127	80.1823	4.59	10	413.2	403.2
60	Katni	Umariya Muhas	Key well	23.908	80.1144	1.09	8.2	420.5	412.3
61	Katni	Bheda	Key well	23.94	80.018	3.51	5.9	409.4	403.5
62	Katni	Gurji Kalan	Key well	23.8748	79.9954	6.22	14.3	421	406.7
63	Katni	Khamh	Key well	23.9257	80.0981	2.01	7.6	420.3	412.7
64	Katni	Hardwara	Key well	23.9395	80.1838	2.02	5.8	409.7	403.9
65	Katni	Badkhera	Key well	23.772	80.2248	7.57	7.6	404.6	397
66	Katni	Bharauli	Key well	23.762	80.3658	2.62	4.9	403.9	399
67	Katni	Takhala	Key well	23.7272	80.37546	8.79	11.3	417.6	406.3
68	Katni	Deori Hatia	Key well	23.721	80.4935	0.85	8.4	426	417.6
69	Katni	Katni South	Key well	23.8231	80.3981	4.82	12.2	388.2	376
70	KATNI	Badwara	NHS	23.7486	80.5769	8.58	10.45	408	397.55
71	KATNI	Basadi	NHS	23.8269	80.6217	9.76	14.72	386.8	372.08
72	KATNI	Deogawan	NHS	23.9028	80.2514	2.71	13.12	410.8	397.68
73	KATNI	Katni1	NHS	23.8306	80.3986	3.62	5.95	389	383.05
74	KATNI	Kewlari	NHS	23.7972	80.83	7.48	9.11	418.3	409.19
75	KATNI	Khamtra	NHS	23.8917	80.4681	4.89	9.05	376.1	367.05
76	KATNI	Khitoli	NHS	23.7106	80.8319	5.31	6.41	407.8	401.39
77	KATNI	Lakhapateri	NHS	23.7083	80.3172	3.98	4.3	425	420.7
78	KATNI	Majhgawan1	NHS	23.8217	80.4986	7.76	11.91	405.3	393.39
79	KATNI	Piparia2	NHS	23.8619	80.6986	5.62	7.75	392.4	384.65
80	KATNI	Rithi	NHS	23.9094	80.1419	3.48	10.59	433.4	422.81
81	KATNI	Siloni	NHS	23.3458	80.3778	5.73	7.51	429.8	422.29
82	KATNI	Ubra	NHS	23.9361	80.8144	7.48	10.32	355.3	344.98
83	KATNI	Umariapan	NHS	23.5217	80.2917	4.41	8.46	413	404.54

ANNEXURE-III Chemical Quality Parameters of Key Well Water Pre-Monsoon samples May 2022

S. No.	Location	Source	Lat.	Long.	pH at 25°C	EC µS/cm at 25°C	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K
1	Amuwari	DW	23.9876	80.5413	7.42	1565	439	210	22	90	0.53	0	22	580	178	33	109	0.6
2	Nanhwara Kalan	DW	24.0089	80.5555	7.58	577	275	30	14	5	0.76	0	56	240	64	19	25	6.2
3	Badapar	DW	24.0489	80.6181	7.2	2345	354	535	45	4	0.75	0	48	865	296	30	152	11.2
4	Banjari	DW	23.9894	80.6163	7.47	1245	427	161	14	49	0.19	0	29	350	104	22	133	3.2
5	Ghunaur	DW	23.9339	80.6432	7.06	439	220	17	12	5	0.12	0	24	150	34	16	35	0.8
6	Jamuwani Khurd	DW	24.1032	80.7135	7.61	645	317	17	24	3	0.99	0.2	19	255	64	23	27	11.1
7	Karatilai	DW	24.0598	80.7214	7.47	812	214	111	32	19	0.48	0	26	350	98	26	30	0.6
8	Harduwa	DW	24.0543	80.7634	7.46	712	244	89	14	11	0.16	0	38	285	82	19	38	1
9	Singhanpura	DW	23.9745	80.6781	7.63	612	305	17	16	7	0.26	0.1	27	195	38	24	51	8.2
10	Patharhata	DW	23.9247	80.6801	7.28	256	110	12	10	5	0.28	0	43	80	18	9	21	4.6

11	Hatheda	DW	23.8964	80.6602	7.63	248	79	17	24	1	0.12	0	29	50	10	6	28	9.5
12	Suddi	DW	23.857	80.626	7.14	536	250	15	16	30	0.23	0	35	165	42	15	46	2.8
13	Nanhwara Khurd	DW	23.8421	80.5343	6.94	401	92	67	18	12	0.12	0.1	34	115	36	6	44	1.2
14	Itama	DW	24.0348	80.8497	7.18	723	354	25	22	6	0.21	0	29	235	48	28	56	9.5
15	Devra Khurd	DW	23.9515	80.7667	7.52	552	244	25	24	21	0.28	0	24	205	50	19	29	10.4
16	Devra Khurd	HP	23.9515	80.7667	7.21	812	366	52	16	4	0.24	0	19	270	72	22	65	1.2
17	Lurmi	DW	23.9048	80.7355	7.72	623	342	22	2	5	0.12	0.3	23	220	76	7	45	1.3
18	Karaundi Khurd	DW	23.8738	80.8057	7.59	555	287	20	5	3	0.25	0	41	195	64	9	40	1.8
19	Jajagarh	DW	23.8645	80.866	7.31	542	281	17	12	2	0.35	0	34	205	62	12	33	2.6
20	Salaiya Sihora	DW	23.7873	80.7946	7.52	612	281	12	45	6	0.21	0	29	230	70	13	36	2.7
21	Baran Mahgawan	DW	23.729	80.777	7.74	485	214	17	14	30	0.18	0	34	140	36	12	48	0.9
22	Bagdara	DW	23.6991	80.8792	7.87	989	220	139	65	21	0.18	0	28	280	84	17	99	11.1

23	Harrwah	DW	23.7631	80.8861	7.26	587	281	45	8	18	0.16	0.2	24	200	64	10	54	2.9
24	Barmani	DW	23.7945	80.8608	7.29	645	299	59	15	5	0.26	0	31	200	62	11	68	2.4
25	Surajpura	DW	23.81	80.7282	7.25	722	360	30	20	8	0.25	0	38	180	58	9	85	1.6
26	Luharwara	DW	23.6184	80.5844	7.7	808	421	17	12	2	0.21	0	29	265	84	13	65	2.6
27	Jharela	DW	23.6862	80.6456	7.42	785	421	17	5	4	1.17	0	34	290	86	18	48	2.9
28	Bargawan	DW	23.74	80.6124	7.62	698	384	17	2	6	0.32	0.2	42	285	82	19	27	4.2
29	Bargawan	HP	23.74	80.6124	7.28	895	445	17	16	44	0.16	0	28	295	96	13	75	1.2
30	Rohaniya	DW	23.7679	80.6212	7.31	1802	445	282	85	5	0.15	0	26	375	112	23	250	1.6
31	Bhajiya	DW	23.6307	80.5715	7.6	735	317	35	16	37	0.52	0	32	225	70	12	69	2.3
32	NanhwaraSejha	DW	23.7021	80.5219	7.35	1202	427	156	6	6	0.56	0.3	29	295	84	21	145	5.6
33	Pondi	DW	23.7613	80.5224	7.26	423	171	15	45	4	0.23	0	35	125	36	9	45	1.1
34	Bhadoura	DW	23.8258	80.5376	7.07	365	140	12	35	10	0.21	0	24	80	24	5	45	2.1
35	Bhadoura	HP	23.8258	80.5376	7.65	255	116	15	5	6	0.26	0	26	75	22	5	25	0.8
36	Majhgawan	DW	23.3856	80.436	7.39	802	415	20	10	8	0.14	0	34	250	70	18	75	1.2
37	Majhgawan	HP	23.3856	80.436	7.07	1045	458	22	15	117	0.33	0	29	265	76	18	118	8.8

38	Pipariya	DW	23.4343	80.3831	7.82	1765	354	376	43	12	0.35	0.2	31	765	272	21	59	0.9
39	Kothi	DW	23.4413	80.4545	7.59	989	397	37	24	110	0.58	0	29	275	72	23	97	8.2
40	Katariya	DW	23.4486	80.5386	7.55	892	287	101	12	4	0.37	0	34	280	68	27	62	1.8
41	Khamtara	DW	23.578	80.5225	7.78	302	122	15	11	17	0.19	0	29	100	24	10	25	2.7
42	Khamahariya	DW	23.5914	80.5529	7.13	1372	604	89	17	61	0.14	0	38	355	86	34	156	1.9
43	Jirri	DW	23.5581	80.4493	7.23	522	98	54	42	63	0.97	0	42	160	36	17	50	1.2
44	Jirri	HP	23.5581	80.4493	7.46	365	122	15	54	12	0.4	0.1	29	60	18	4	59	1.6
45	Bhamka	DW	23.5159	80.4385	7.52	1189	397	94	32	114	0.47	0	32	330	98	21	124	6.2
46	Harrai	DW	23.4506	80.4313	7.47	698	256	42	42	31	0.44	0	19	330	76	34	14	1.2
47	Ghughari	DW	23.4833	80.2708	7.05	844	262	74	28	72	0.45	0	28	285	74	24	63	6.7
48	Sagawan	DW	23.5126	80.4045	7.43	765	397	20	14	3	0.16	0.1	38	320	102	16	29	2.3
49	Pahadi	DW	23.7035	80.3721	7.7	585	281	22	27	3	0.24	0	29	280	84	17	6	1.2
50	Pakar	DW	23.6968	79.9888	7.19	1125	268	200	21	35	0.45	0	34	270	78	18	135	3.6
51	Banson	DW	23.7258	79.9723	7.3	2205	372	347	22	310	0.42	0	42	610	196	29	242	1.1
52	Bartari	DW	23.7195	80.0072	7.54	3628	500	1064	22	8	0.12	0.1	18	990	312	51	445	1.7
53	Kishanpatan	DW	23.676	80.0629	7.32	826	226	89	28	23	0.41	0	26	315	98	17	36	1.6

54	Kuwan	DW	23.6199	80.1248	7.07	430	134	47	12	29	0.11	0	31	180	62	6	17	1.4
55	Pondi	DW	23.6124	80.0585	7.37	686	201	87	27	13	0.23	0	27	235	64	18	48	2.5
56	Pondi	HP	23.6124	80.0585	7.78	478	195	35	12	9	0.24	0	34	210	58	16	15	1.6
57	Kaudiya	DW	23.6682	80.1731	7.78	312	67	27	15	47	0.53	0	42	115	34	7	20	2.3
58	Kaudiya	HP	23.6682	80.1731	7.62	402	171	27	12	5	0.29	0	51	170	38	18	15	1.8
59	Neemkhere	DW	23.6436	80.115	7.15	1565	384	188	28	186	0.34	0.2	26	510	162	26	132	1.9
60	Padwar	DW	23.6318	80.22	7.33	1102	427	92	22	49	0.29	0	34	330	84	29	112	2.7
61	Harduwa	DW	23.9048	80.2878	7.83	810	366	45	24	5	0.61	0	28	305	88	21	43	2.9
62	Harduwa	HP	23.9048	80.2878	7.52	789	378	32	27	2	0.54	0	19	295	94	15	47	3.5
63	Deori Phatak	DW	23.9128	80.1969	7.96	565	244	17	14	48	0.82	0	34	205	62	12	36	2.4
64	Bargaon	DW	23.9077	80.039	7.14	389	140	20	12	43	0.15	0	26	140	38	11	29	1.9
65	Majhgawan	DW	23.7715	79.954	7.49	612	183	74	8	50	0.29	0	31	235	58	22	32	1.8
66	Sakarwara	DW	23.7703	79.9079	7.04	430	92	47	18	65	0.34	0.1	28	180	48	15	23	2.3
67	Patauha	HP	23.7606	79.8589	6.98	422	98	54	24	29	0.23	0	34	160	38	16	22	3.4
68	Patauha	DW	23.7606	79.8589	7.14	623	195	45	23	75	0.36	0	26	240	62	21	34	2.8

69	Patori	DW	23.7959	79.9592	7.25	1069	122	243	14	32	0.33	0	31	360	104	24	77	2.6
70	Patna	DW	23.7681	80.0044	7.26	748	153	124	32	42	0.49	0	39	280	78	21	53	2.4
71	Pithradi	DW	23.7159	80.0882	7.39	345	85	40	12	28	0.29	0	42	145	36	13	13	3.1
72	Herdua	DW	23.9444	80.5165	7.82	732	366	32	5	16	0.12	0	28	260	68	22	49	2.7
73	Kauwara	DW	23.9321	80.3997	7.82	785	384	25	14	29	0.23	0.1	26	260	72	19	62	1.9
74	Gulwara	DW	23.7996	80.33	7.29	812	360	47	14	34	0.33	0.1	31	275	64	28	59	1.9
75	Gulwara	HP	23.7996	80.33	7.86	1365	525	161	11	2	0.28	0	37	300	82	23	182	2.6
76	Biruhali	DW	23.8626	80.2704	7.1	734	384	20	14	5	0.35	0	28	220	62	16	68	2.5
77	Deori	DW	23.9127	80.1823	7.49	845	421	37	22	10	0.38	0	42	255	86	10	82	3.2
78	UmariyaMuhas	DW	23.908	80.1144	7.75	623	165	101	10	18	0.52	0.1	35	235	72	13	34	2.3
79	UmariyaMuhas	HP	23.908	80.1144	7.59	712	268	74	14	8	0.23	0.1	26	225	64	16	57	1.8
80	Bheda	DW	23.94	80.018	7.55	545	244	25	8	24	0.48	0	15	205	60	13	30	3.4
81	Gurji Kalan	DW	23.8748	79.9954	7.75	635	299	25	13	10	0.23	0.2	36	245	68	18	36	4.6
82	Khamh	DW	23.9257	80.0981	7.59	542	146	30	19	87	0.45	0.1	26	200	58	13	26	6.2
83	Hardwara	DW	23.9395	80.1838	7.29	3156	433	698	68	156	0.35	0	27	510	156	29	515	1.2

84	Badkhera	DW	23.772	80.2248	7.77	756	403	25	12	5	0.15	0.1	32	220	70	11	78	1.9
85	Bharauli	DW	23.762	80.3658	7.41	765	348	25	14	6	0.52	0	29	195	44	21	72	2.1
86	Takhala	DW	23.7272	80.3755	7.1	1185	445	54	35	123	0.26	0.2	34	360	102	26	108	3.2
87	Deori Hatia	DW	23.721	80.4935	7.49	865	409	25	12	24	0.37	0.1	28	355	106	22	35	2.3
88	Katni South	DW	23.8231	80.3981	7.48	985	336	116	24	8	0.52	0	25	245	76	13	116	1.4

ANNEXURE - IV Chemical Quality of Water Samples of Post-Monsoon 2022

S. No.	Block	Location	Source	Lat.	Long.	pH	EC	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												
1	Dhimerkheda	Bhamka	DW	23.5159	80.4385	7.49	1251	323	117	32	150	0.32	BDL	44	365	108	23	105	6.5
2	Bohriband	Neemkhere	DW	23.6436	80.115	7.28	1336	415	150	20	105	0.69	0.2	35	450	150	18	95	5.7
3	Bohriband	Padwar	DW	23.6318	80.22	6.98	1181	464	107	18	41	0.41	BDL	35	395	116	26	87	3
4	Bohriband	Takhala	DW	23.7272	80.3755	7.49	472	189	30	10	15	0.53	BDL	23	170	42	16	26	2
5	Bohariband	Majhgawan	DW	23.3856	80.436	7.33	762	183	135	24	10	0.53	BDL	15	240	64	19	62	1.7
6	Bohriband	Patori	DW	23.7959	79.9592	7.27	1511	336	300	28	32	0.94	BDL	29	400	122	23	159	5.8
7	Bohariband	Banson	DW	23.7258	79.9723	7.14	2413	500	407	25	232	0.67	BDL	50	560	188	22	296	9.8
8	Bohriband	Sakarwara	DW	23.7703	79.9079	7.67	565	220	47	14	20	0.3	0.2	13	125	26	15	68	4.1
9	Rithi	Deori Phatak	DW	23.9128	80.1969	7.57	532	262	15	12	12	0.95	BDL	22	210	42	26	23	2.2
10	Rithi	Khamh	DW	23.9257	80.0981	7.49	402	171	20	15	11	0.3	BDL	12	170	38	18	11	2.2
11	Rithi	Hardwara	DW	23.9395	80.1838	7.45	2261	543	355	51	105	0.73	BDL	49	430	126	28	310	1.6
12	Dhimerkheda	Khamahariya	DW	23.5914	80.5529	6.96	1176	433	107	30	50	0.14	BDL	28	390	114	26	86	5.5
13	Dhimerkheda	Katariya	DW	23.4486	80.5386	7.38	1230	342	160	23	98	0.49	BDL	26	450	146	21	72	4
14	Vijayragavgarh	Banjari	DW	23.9894	80.6163	7.34	1071	378	107	30	42	0.31	BDL	19	410	128	22	55	1.4
15	Vijayragavgarh	Amuwari	DW	23.9876	80.5413	7.1	1182	421	107	29	60	0.67	0.2	27	370	106	26	96	7.1
16	Bohriband	Kaudiya	DW	23.6682	80.1731	6.91	295	110	17	8	10	0.27	BDL	15	100	24	10	15	7.1
17	Dhimerkheda	Jirri	DW	23.5581	80.4493	6.9	391	153	27	15	10	0.53	BDL	26	115	26	12	30	8.4
18	Dhimerkheda	Majhgawan	DW	23.7715	79.954	7.48	805	427	20	8	12	0.57	BDL	45	310	86	23	38	3
19	Dhimerkheda	Ghughari	DW	23.4833	80.2708	7.11	1152	305	160	30	75	0.32	0.2	31	375	112	23	88	5.1

ANNEXURE - V Heavy Metals Analysis of Key Wells Water Samples (Pre-monsoon 2022)

S. No.	District	Location	Source	Lat.	Long.	Fe	Cu	Ni	Zn	Mn
						mg/liter				
1	Katni	Amuwari	DW	23.9876	80.5413	0.023	BDL	BDL	BDL	0.011
2	Katni	Jamuwani Khurd	DW	24.1032	80.7135	0.013	BDL	BDL	0.085	0.116
3	Katni	Devra Khurd	DW	23.9515	80.7667	0.018	BDL	BDL	0.092	0.015
4	Katni	Salaiya Sihora	DW	23.7873	80.7946	0.024	BDL	BDL	BDL	BDL
5	Katni	Bargawan	DW	23.74	80.6124	0.121	BDL	BDL	0.135	BDL
6	Katni	Bhadoura	DW	23.8258	80.5376	0.144	BDL	BDL	BDL	0.381
7	Katni	Majhgawan	DW	23.3856	80.436	0.11	BDL	BDL	BDL	0.389
8	Katni	Jirri	DW	23.5581	80.4493	0.154	BDL	BDL	0.182	0.224
9	Katni	Pahadi	DW	23.7035	80.3721	0.2	BDL	BDL	BDL	0.447
10	Katni	Banson	DW	23.7258	79.9723	0.037	BDL	BDL	0.226	0.504
11	Katni	Pondi	DW	23.6124	80.0585	BDL	BDL	BDL	BDL	BDL
12	Katni	Kaudiya	DW	23.6682	80.1731	0.204	BDL	BDL	0.082	0.014
13	Katni	Harduwa	DW	23.9048	80.2878	1.136	BDL	BDL	0.432	BDL
14	Katni	Bargaon	DW	23.9077	80.039	0.029	BDL	BDL	BDL	BDL
15	Katni	Patna	DW	23.7681	80.0044	0.018	BDL	BDL	BDL	BDL
16	Katni	Umariya Muhas	DW	23.908	80.1144	0.113	BDL	BDL	0.138	0.082
17	Katni	Badkhera	DW	23.772	80.2248	0.114	BDL	BDL	0.112	BDL
18	Katni	Katni South	DW	23.8231	80.3981	0.013	BDL	BDL	BDL	0.028

Annexure-VI Proposed Artificial Recharge Structures Locations for Phase-I Implementation

Proposed Check Dam/Nala Bund/Percolation Tank for Phase-I											
Sl.No.	Structure	Latitude	Longitude	SL. No.	Structure	Latitude	Longitude	SL. No.	Structure	Latitude	Longitude
1	NB	23.3444	80.3631	1	CD	23.3461	80.3236	1	PT	23.7343	80.6173
2	NB	23.3744	80.3297	2	CD	23.382	80.3138	2	PT	23.679	80.6594
3	NB	23.4208	80.3783	3	CD	23.3645	80.3517	3	PT	23.6449	80.5768
4	NB	23.4369	80.3158	4	CD	23.3294	80.362	4	PT	23.595	80.58
5	NB	23.4494	80.3258	5	CD	23.3737	80.394	5	PT	23.5349	80.5243
6	NB	23.4816	80.311	6	CD	23.3458	80.3767	6	PT	23.5165	80.4294
7	NB	23.4616	80.3492	7	CD	23.4126	80.36	7	PT	23.4409	80.4375
8	NB	23.469	80.5367	8	CD	23.4149	80.3122	8	PT	23.3846	80.4172
9	NB	23.4937	80.5293	9	CD	23.438	80.2996	9	PT	23.3909	80.3771
10	NB	23.4013	80.5189	10	CD	23.3998	80.4024	10	PT	23.3501	80.3433
11	NB	23.4868	80.4013	11	CD	23.4463	80.3428	11	PT	23.3665	80.3726
12	NB	23.5015	80.436	12	CD	23.4625	80.3197	12	PT	23.4516	80.2752
13	NB	23.4872	80.4308	13	CD	23.4761	80.2751	13	PT	23.4861	80.359
14	NB	23.528	80.2932	14	CD	23.5053	80.2465	14	PT	23.5395	80.2616
15	NB	23.5059	80.2286	15	CD	23.4861	80.237	15	PT	23.572	80.2554
16	NB	23.502	80.2637	16	CD	23.4795	80.3792	16	PT	23.6337	80.2547
17	NB	23.548	80.3188	17	CD	23.4655	80.4185	17	PT	23.6072	80.1455
18	NB	23.5059	80.3904	18	CD	23.4962	80.4057	18	PT	23.6403	80.0987
19	NB	23.6104	80.3544	19	CD	23.5424	80.3005	19	PT	23.6271	80.0401
20	NB	23.6291	80.3692	20	CD	23.5229	80.2671	20	PT	23.6937	80.1001
21	NB	23.6174	80.2472	21	CD	23.5001	80.2904	21	PT	23.6749	80.121
22	NB	23.617	80.2689	22	CD	23.5532	80.2732	22	PT	23.7837	79.9805
23	NB	23.6057	80.1826	23	CD	23.5145	80.3723	23	PT	23.8713	80.0321
24	NB	23.5996	80.1084	24	CD	23.5981	80.2333	24	PT	23.8413	80.0439
25	NB	23.6473	80.1188	25	CD	23.5918	80.2763	25	PT	23.9515	80.1106
26	NB	23.6703	80.157	26	CD	23.6148	80.3193	26	PT	23.8943	80.217
27	NB	23.6404	80.1539	27	CD	23.6262	80.2843	27	PT	23.903	80.2916
28	NB	23.6573	80.1878	28	CD	23.6444	80.2178	28	PT	23.9229	80.3635
29	NB	23.6894	80.196	29	CD	23.6023	80.036	29	PT	23.9477	80.4692
30	NB	23.6482	80.2759	30	CD	23.647	80.0611	30	PT	24.0269	80.6377
31	NB	23.6699	80.3006	31	CD	23.6436	80.0039	31	PT	24.0129	80.6667
32	NB	23.6959	80.2273	32	CD	23.6473	79.9764	32	PT	23.9662	80.7958
33	NB	23.7276	80.1774	33	CD	23.6898	80.1578	33	PT	23.9498	80.8275
34	NB	23.7129	80.134	34	CD	23.6927	80.0573	34	PT	23.8434	80.8617
35	NB	23.6643	80.0263	35	CD	23.7086	79.9861	35	PT	23.7318	80.8048
36	NB	23.6964	80.0355	36	CD	23.7178	80.095	36	PT	23.7098	80.8226
37	NB	23.6699	80.0624	37	CD	23.7543	79.9526	37	PT	23.7942	80.771
38	NB	23.7077	79.9591	38	CD	23.779	80.0154	38	PT	23.8919	80.7508
39	NB	23.7281	79.9322	39	CD	23.748	80.0121	39	PT	23.88	80.8059

40	NB	23.7415	79.9743	40	CD	23.6198	80.0766	40	PT	23.8783	80.5725
41	NB	23.7749	79.9244	41	CD	23.8008	79.9155	41	PT	23.8678	80.4274
42	NB	23.807	79.9665	42	CD	23.8158	79.9887	42	PT	23.8092	80.4424
43	NB	23.8565	79.9825	43	CD	23.898	79.9985	43	PT	23.7987	80.4856
44	NB	23.7901	80.0355	44	CD	23.9209	80.0704	44	PT	23.7698	80.5167
45	NB	23.7875	80.0728	45	CD	23.8811	80.0917	45	PT	23.7223	80.4253
46	NB	23.8717	80.0094	46	CD	23.9122	80.1225	46	PT	23.6895	80.4403
47	NB	23.9177	80.0307	47	CD	23.865	80.1484	47	PT	23.7084	80.525
48	NB	23.8782	80.058	48	CD	23.9328	80.1897	48	PT	23.662	80.3523
49	NB	23.9724	80.0394	49	CD	23.9552	80.1982	49	PT	23.8372	80.5392
50	NB	23.968	80.0684	50	CD	23.8756	80.1918	50	PT	23.9474	80.7546
51	NB	23.9494	80.0541	51	CD	23.8861	80.2528	51	PT	23.8116	80.7159
52	NB	23.9381	80.0224	52	CD	23.9246	80.24				
53	NB	23.9403	80.1296	53	CD	23.8308	80.2254				
54	NB	23.8917	80.1166	54	CD	23.7918	80.2001				
55	NB	23.8964	80.1448	55	CD	23.8582	80.3312				
56	NB	23.9724	80.1821	56	CD	23.9035	80.3481				
57	NB	23.9876	80.1947	57	CD	23.8805	80.3867				
58	NB	23.9155	80.1683	58	CD	23.8774	80.454				
59	NB	23.9116	80.2082	59	CD	23.8178	80.3353				
60	NB	23.9207	80.2715	60	CD	23.8364	80.3839				
61	NB	23.8726	80.2312	61	CD	23.8399	80.4317				
62	NB	23.8617	80.2655	62	CD	23.7796	80.3996				
63	NB	23.8938	80.3219	63	CD	23.9379	80.3695				
64	NB	23.8951	80.2691	64	CD	23.9465	80.4416				
65	NB	23.8687	80.3056	65	CD	23.9747	80.4992				
66	NB	23.8456	80.2167	66	CD	23.9398	80.5376				
67	NB	23.8712	80.3486	67	CD	23.8971	80.5672				
68	NB	23.8951	80.4118	68	CD	23.9909	80.5635				
69	NB	23.9462	80.4074	69	CD	24.0199	80.6173				
70	NB	23.9227	80.4272	70	CD	24.0436	80.6667				
71	NB	23.9705	80.4597	71	CD	24.0543	80.7294				
72	NB	23.9344	80.5068	72	CD	23.9671	80.6736				
73	NB	23.977	80.5295	73	CD	23.9416	80.728				
74	NB	23.9714	80.5745	74	CD	23.9909	80.8545				
75	NB	24.0156	80.5615	75	CD	23.922	80.8228				
76	NB	24.0314	80.5919	76	CD	23.9249	80.7619				
77	NB	24.0716	80.6447	77	CD	23.8241	80.6714				
78	NB	24.074	80.695	78	CD	23.8412	80.5722				
79	NB	24.0995	80.6933	79	CD	23.818	80.7508				
80	NB	24.0501	80.7067	80	CD	23.7394	80.7721				
81	NB	24.0318	80.6909	81	CD	23.7437	80.8434				
82	NB	23.9888	80.7043	82	CD	23.7432	80.5714				
83	NB	23.9961	80.6256	83	CD	23.6627	80.6316				

84	NB	23.9405	80.6556	84	CD	23.621	80.6097				
85	NB	24.0075	80.8012	85	CD	23.7234	80.4914				
86	NB	24.0237	80.8337	86	CD	23.7634	80.4555				
87	NB	23.9641	80.856	87	CD	23.6687	80.3942				
88	NB	23.9373	80.783	88	CD	23.5804	80.5482				
89	NB	23.9535	80.7152	89	CD	23.7388	80.3669				
90	NB	23.906	80.6739	90	CD	23.6644	80.2707				
91	NB	23.9012	80.7927	91	CD	23.7599	80.2874				
92	NB	23.8914	80.8467	92	CD	23.7161	80.2094				
93	NB	23.8886	80.8167	93	CD	23.7186	80.3139				
94	NB	23.8444	80.7862	94	CD	23.9683	80.7604				
95	NB	23.8651	80.8373	95	CD	23.7957	80.8143				
96	NB	23.8444	80.7367	96	CD	24.1076	80.7241				
97	NB	23.8156	80.7761								
98	NB	23.818	80.8264								
99	NB	23.8075	80.8617								
100	NB	23.7758	80.8978								
101	NB	23.7645	80.8325								
102	NB	23.7146	80.8422								
103	NB	23.7126	80.7956								
104	NB	23.7665	80.7797								
105	NB	23.7689	80.7274								
106	NB	23.7661	80.684								
107	NB	23.8383	80.695								
108	NB	23.8363	80.6171								
109	NB	23.8712	80.6808								
110	NB	23.7913	80.6094								
111	NB	23.9328	80.699								
112	NB	23.9231	80.6252								
113	NB	23.7093	80.6633								
114	NB	23.7016	80.6301								
115	NB	23.6359	80.6179								
116	NB	23.6193	80.581								
117	NB	23.5442	80.5351								
118	NB	23.4469	80.551								
119	NB	23.4225	80.5147								
120	NB	23.4444	80.4046								
121	NB	23.6758	80.3283								
122	NB	23.7194	80.2629								
123	NB	23.74	80.2744								
124	NB	23.7492	80.3277								
125	NB	23.7004	80.3851								
126	NB	23.7418	80.4075								
127	NB	23.8198	80.4029								

128	NB	23.8037	80.4201								
129	NB	23.9116	80.4701								
130	NB	23.7136	80.5452								
131	NB	23.7188	80.4551								
132	NB	23.79	80.4637								

Annexure-VII Interpreted TEM Results in Katni District, MP

Interpreted TEM Results in Katni District, MP																	
TEM NO	LOCATION	Station	Latitude	Longitude	Resistivity in ohm.m						Thickness in meter					Total Depth (H)
					P1	P2	P3	P4	P5	P6	h1	h2	h3	h4	h5	
1	SAIDA	0	23.9427	80.2168	140	80	61	24	6.6		0.9	14.6	15.2	4.7		35.4
2		10	23.9427	80.2168	101	69	46	22	7.2		1.2	17.7	14.4	5		38.3
3		20	23.9428	80.2168	130	72	46	33	6.3		0.9	33	24	8		65.9
4		30	23.9428	80.2167	156	85	56	44	5.9		1.5	23	15	15		54.5
5		40	23.9428	80.2167	151	103	80	64	6		1.4	24	14	20		59.4
6	RITHI	0	23.9192	80.1417	214	34	24	72	196		1.3	8	11	15		35.3
7		10	23.9192	80.1418	196	36	24	61	123		1.9	11	11	9.1		33
8		20	23.9192	80.1418	107	56	34	55	94		1	9.8	11.5	8.8		31.1
9		30	23.9192	80.1419	238	48	39	71	91		0.7	11	9	10		30.7
10		40	23.9192	80.1419	304	47	38	48	63		0.5	9.5	9	11.4		30.4
11	BHARATPUR	0	23.9087	80.0643	81.6	16.3	32	66.2	76		1.6	7.4	8.1	10.1		27.2
12		10	23.9087	80.0644	89.6	16	43	73	99		1.2	8	9	6		24.2
13		20	23.9086	80.0644	171	30.2	64	80.8	149		2	5.5	10.9	13.8		32.2
14		30	23.9086	80.0644	180	22.7	64	80.5	138		1.6	13	11	9		34.6
15		40	23.9086	80.0644	102	14.8	39	55	99		2	8	7.6	8.5		26.1
16	SANDA	0	23.7016	80.0122	76	122	87	66	37		1.9	15	25	56		97.9
17		5	23.7017	80.0122	76	121	85	64	36		2	14	24	55		95
18		10	23.7017	80.0122	58	85	110	70	43		2.6	29	66	23		121
19		15	23.7017	80.0122	52	97	142	62	37		2.2	20	55	21		98.2
20		20	23.7017	80.0121	61	86	131	66	36		2	22	58	25		107
21	KHAKKARA	0	23.7743	80.0020	269	151	104	49	89		2.2	25	10.4	9.9		47.5
22		5	23.7743	80.0020	320	88	143	53	98		0.8	27	16.6	12.8		57.2

Interpreted TEM Results in Katni District, MP																	
TEM NO	LOCATION	Station	Latitude	Longitude	Resistivity in ohm.m						Thickness in meter					Total Depth (H)
					P1	P2	P3	P4	P5	P6	h1	h2	h3	h4	h5	
23		10	23.7743	80.0019	179	120	84	41	157		0.6	11	32	12		55.6
24		15	23.7743	80.0019	239	150	100	39	99		2	24	15	9		50
25		20	23.7742	80.0019	224	127	104	44	99		2.5	15.3	27	9.4		54.2
26	PIPARIYA	0	23.6292	80.0897	103	72.2	18.8	5.3			1.6	20	17			38.6
27		10	23.6293	80.0898	99.4	57.7	34.5	3.1			1.3	8	27.7			37
28		20	23.6293	80.0898	164	78	28	3.2			2.5	12.3	17.4			32.2
29		30	23.6294	80.0898	85	55	27	2.2			2.4	11.3	18.3			32
30		40	23.6295	80.0898	67	54	17	2			1.2	22.6	8.5			32.3
31	BARKHERA	0	23.6746	80.1581	102	39	13.5	3.5			0.7	23	11			34.7
32		10	23.6745	80.1581	135	81	21	3.7			4	22	15			41
33		20	23.6745	80.1581	87	70	30	3.6			2	29	12.7			43.7
34		30	23.6744	80.1582	114	68.5	35	5.5			1.6	32	13.6			47.2
35		40	23.6743	80.1582	95	66	33	4			1.8	21.8	14			37.6
36	SLEEMANABAD	0	23.6274	80.2423	109	48	33	12.5			2.2	11.1	24.3			37.6
37		5	23.6274	80.2422	179	95.6	42.2	11			2	13.4	16.4			31.8
38		10	23.6274	80.2422	104	78	48	23			2	16	24			42
39		15	23.6274	80.2421	182	98	56	21			2	10	25			37
40		20	23.6273	80.2421	185	40	24	7.9			0.8	12.8	17.4			31
41		25	23.6273	80.2421	135	69	27	19.9			2.3	13.8	17.4			33.5
42		30	23.6273	80.2421	138	60	37	13			2.6	18.2	19.4			40.2
43		35	23.6273	80.2420	117	54	25	17.5			2.8	18.4	45			66.2
44		40	23.6273	80.2420	125	57	33	20			2.4	15.4	20.4			38.2
45		45	23.6273	80.2419	96.8	47.2	33.1	16.1			2.2	15.4	20.6			38.2
46	LAKHAPATERI	0	23.7176	80.3271	179	72	34	11	22		1.8	11.8	12.5	30.6		56.7
47		10	23.7177	80.3271	105	47	19	13	58		1.7	3.4	38	32		75.1

Interpreted TEM Results in Katni District, MP																	
TEM NO	LOCATION	Station	Latitude	Longitude	Resistivity in ohm.m						Thickness in meter					Total Depth (H)
					P1	P2	P3	P4	P5	P6	h1	h2	h3	h4	h5	
48		20	23.7177	80.3270	116	42	33	16	25		2.5	13.7	15.5	25.3		57
49		30	23.7178	80.3270	126	29	19	12	35		2	12	23	31		68
50		40	23.7179	80.3270	99	39	18.7	11.7	40		4	6.5	23	34		67.5
51	TIWARI	0	23.6759	80.2910	315	40	24	286			2.3	18	16			36.3
52		10	23.6759	80.2909	120	80	36	180			2.4	13.9	28			44.3
53		20	23.6758	80.2909	164	46	33	259			1.9	8.7	20			30.6
54		30	23.6757	80.2909	142	47	36	356			2.7	12.7	15.5			30.9
55		40	23.6757	80.2909	151	38	30	301			2.4	10.3	13.6			26.3
56	MURWARI	0	23.4481	80.3029	243	25	46	70			2.8	13.2	10			26
57		10	23.4482	80.3030	341	10	24	75			2	31	17			50
58		20	23.4482	80.3031	374	19	63	78			3.4	8.5	28			39.9
59		30	23.4482	80.3032	147	22	61	107			2.5	19	9.2			30.7
60		40	23.4482	80.3032	160	17.4	51.6	106			2.7	14.2	9.8			26.7
61	JINNA PIPARIYA	0	23.4833	80.4162	166	15	44	69	141		2	17	14	10		43
62		10	23.4834	80.4162	231	16	56	96	212		1.4	17	14	10		42.4
63		20	23.4834	80.4161	120	16	42	64	388		2	13	11	10.5		36.5
64		30	23.4835	80.4161	136	16	51	85	200		2	10	12	10		34
65		40	23.4835	80.4161	208	25	44	77	108		2	14	11	10		37
66	KHAMHARIYA	0	23.5978	80.5571	96.7	30.4	54.4	64.6			2.5	12.1	8			22.6
67		10	23.5978	80.5571	148	48	86	113			3.8	10	6.6			20.4
68		20	23.5978	80.5572	128	32	53	94			2	13.6	9.5			25.1
69		30	23.5978	80.5573	168	32	80	140			3.7	9.5	14.4			27.6
70		40	23.5978	80.5574	130	30	67	135			3.7	7.2	9.5			20.4
71	DEORA KALAN	0	23.9516	80.5305	866	212	112	80	35		3.2	19.2	19.7	34		76.1
72		10	23.9517	80.5304	348	230	150	60	35		3.8	22.6	43	11.6		81

Interpreted TEM Results in Katni District, MP																	
TEM NO	LOCATION	Station	Latitude	Longitude	Resistivity in ohm.m						Thickness in meter					Total Depth (H)
					P1	P2	P3	P4	P5	P6	h1	h2	h3	h4	h5	
73		20	23.9517	80.5303	559	248	129	86	40		3	12	15	31		61
74		30	23.9517	80.5302	728	170	84	58	34		1.8	11.3	15.6	47.6		76.3
75		40	23.9517	80.5301	525	167	88	61	34		3.6	8.3	17.5	69		98.4
76	BIJEYRAGOGARH	0	23.9978	80.6152	120	90	64	35	15		2	21	34	22		79
77		10	23.9978	80.6153	146	104	63	55	17		2.1	10.3	36	15.2		63.6
78		20	23.9978	80.6153	251	125	95	55	25		3	20.1	25	15		63.1
79		30	23.9977	80.6154	528	238	113	79	42		2.1	14.4	25	36.8		78.3
80		40	23.9977	80.6155	254	105	85	64	32		2.8	14.3	25	25		67.1
81	SINGAURI	0	23.9312	80.6783	260	70	20	108			2	9	48			59
82		10	23.9312	80.6783	260	70	20	109			2	9	48			59
83		20	23.9312	80.6782	105	24	17	61			2.9	12.8	32			47.7
84		30	23.9313	80.6782	152	66	19	107			1.9	18.8	37.5			58.2
85		40	23.9313	80.6781	101	12.5	18	75			2.3	10	27			39.3
86	BANSARI	0	23.8291	80.6242	148	112.8	38	12.2	33		2.2	6.5	52	72.3		133
87		10	23.8290	80.6242	197	112	50.8	18.5	35.4		2.5	13.2	20.6	65.9		102.2
88		20	23.8290	80.6241	218	136	60	16	32		2.6	15.8	23	56.7		98.1
89		30	23.8289	80.6241	193.5	122	56	19	35.5		2	14.4	21.5	58.4		96.3
90		40	23.8289	80.6241	212	110	54	15	32		2.2	14.7	24.4	57		98.3
91	KEOLARI	0	23.7872	80.8259	229	108	22	14	54		1.6	7.6	45.2	27.8		82.2
92		10	23.7873	80.8259	235	102	52	16	55.7		1.9	6.3	18.6	57.5		84.3
93		20	23.7873	80.8259	215	121	50	17	53.3		1.5	6.8	14	54		76.3
94		30	23.7874	80.8259	218	106	51	16.6	46.5		1.2	7.2	11.3	56.4		76.1
95		40	23.7875	80.8260	225	122	51	18.8	42		1.5	7.2	12.8	50.6		72.1
96	BARWARA KALAN	0	23.7532	80.5630	105.5	42	9.5	2.1			3.2	22.4	33.5			59.1
97		10	23.7532	80.5630	98.5	35.1	10.8	4.3			2.6	21.3	23			46.9

Interpreted TEM Results in Katni District, MP																	
TEM NO	LOCATION	Station	Latitude	Longitude	Resistivity in ohm.m						Thickness in meter					Total Depth (H)
					P1	P2	P3	P4	P5	P6	h1	h2	h3	h4	h5	
98		20	23.7533	80.5630	95.9	39.7	10.9	2.5			2.6	22	18.3			42.9
99		30	23.7534	80.5631	103.1	48.4	16.7	3.3			2.1	15	20.8			37.9
100		40	23.7535	80.5631	120	48.5	16.9	7.1			2.9	16.9	10.6			30.4
101	JOHLA	0	23.8355	80.4572	206	51.9	18	75.8			1.4	8.9	24.3			34.6
102		10	23.8354	80.4573	120.7	81.6	40.4	85.4			2.4	9.4	48.9			60.7
103		20	23.8353	80.4573	120.4	63.2	34.7	77.2			1.9	11.3	36.4			49.6
104		30	23.8353	80.4574	146	56.2	33.9	69.2			3	12	37			52
105		40	23.8352	80.4574	147	87.5	35	80.6			3.1	16.4	38			57.5
106	TIKARIYA	0	23.7044	80.6532	121.3	36.2	61.3	118.2			2.5	13.3	13.1			28.9
107		10	23.7043	80.6532	126.2	31.7	80	122.2			2.5	12.6	13.8			28.9
108		20	23.7042	80.6533	119.1	37.5	77.3	125.7			2.7	11.6	18			32.3
109		30	23.7042	80.6534	128.4	39.4	70.3	113			2.5	14.8	16			33.3
110		40	23.7041	80.6534	120.8	38.2	66.8	111			2.6	14.1	16.3			33
111	KATNI	0	23.7832	80.3445	73.5	33.1	22.1	5.3			3	16.4	23.4			42.8
112		10	23.7831	80.3445	94.3	44.3	22.4	4.3			3	13.5	21.5			38
113		20	23.7830	80.3445	98.5	42.3	25	4.8			3	19.3	18			40.3
114		30	23.7830	80.3445	112.5	48.3	25.3	5.8			2	16.8	28.8			47.6
115		40	23.7829	80.3445	100	50.5	27.8	8.6			2.6	17.1	23			42.7
116	KAILWARA	0	23.9201	80.4024	68.5	15.2	34.5	67.2			1.9	15.2	36.2			53.3
117		10	23.9201	80.4025	78.9	14.9	30.7	54.8			2.2	16.7	21.9			40.8
118		20	23.9201	80.4026	75.8	17.2	35.3	58.5			2.2	15.1	25.4			42.7
119		30	23.9201	80.4026	63.5	15.9	39.7	55			2.3	14.7	23.9			40.9
120		40	23.9202	80.4027	60	16.5	34	64.6			2.7	19	24.1			45.8

ACKNOWLEDGEMENT

The author is grateful to the Central Ground Water Board (CGWB) for providing the assignment to prepare and write this report.

The author is deeply indebted to Sh.Ashok Kumar Biswal, Head of office, CGWB, NCR, Bhopal for providing consistent encouragement, motivation, support, valuable guidance and advice in completing this assignment.

The author is thankful to Dr V Arul Prakasham, Sc -D, for providing geophysical data, Dr Vinay Kumar Kulshretha, Sc-C for providing chemical data, Mrs Anakha Ajai, Sc-C for providing NHS water level monitoring data.

The author is thankful to young professional Mr. Alok Mishra, Young professional for monitoring & sampling of Key wells during post-monsoon; Mr. Kamlesh Birla, Young Professional for preparation of maps and data compliation.

Lastly, the author is grateful to other officers an officials of Central Ground Water Board, North Central Region, Bhopal for their guidance and cooperation from time to time.

ABBREVIATION

μS: Micro siemens
^{0}C: Degree Centigrade2-D:2-Dimensional
D: 3-DimensionalAR:ArtificialRecharge
bcm: Billion Cubic Meter
BGC: Bundelkhand Granitoid Complex BIS: bureau of Indian Standards
CD: Check Dam
CGWB: Central Ground Water Board cm: Centimeter
CR: Corrosivity Ratio
DEM: Digital Elevation Model DIP : District Irrigation Plan
E: East
EC: Electrical Conductivity
EFC: Expenditure Finance Committee
ERT: Electrical Resistivity Tomography are collected and compiled EW : ExploratoryWell
GEC: Groundwater Estimation Committee GRP: Gradient Resistivity Profiling
GSI: Geological Survey of IndiaGW : Ground Water
Ha: hectare
Ham: Hectaremeter
IMD: India Meteorological Department KI: Kelly's Index
Km: Kilometer
l: liter
lps: Liter Per Second M.P.: Madhya Pradesh m: Meter
Max: Maximum
mbgl: Meter below Ground Level
mcm: Million Cubic Meter
mg: Milligram
MGNREGA: Mahatma Gandhi National Rural Employment Guarantee Act 2005
Min: Minimum
N:North
NAQUIM: National Aquifer Mapping and Management Plan
NB: Nala Bund
NCR: North Central Region
Nov : November
OW: Observation Well
PI: Permeability Index
PL: Permissible Limit
PMKSY: Pradhan Mantri Krishi Sinchayee Yojana
PT: PercolationT ank
RS: Recharge Structure
RSC: Residual Sodium Carbonate
S: South
SAR: Sodium Absorption Ratio
Sq: Square
SSP: Soluble Sodium Percentage
TEM: Transient Electromagnetic
TH: Total Hardness
USSL:U.S. Salinity Laboratory
VES: Vertical Electrical Sounding
VP: Village Pond
W:West
WL: Water Level

CENTRALGROUNDWATERBOARD
North Central Region, Bhopal
DepartmentofWaterResources,RD& GR
Ministry of Jal Shakti
Government of India
Email:rdncr-cgwb@nic.in