केंद्रीय भूमि जल बोर्ड

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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

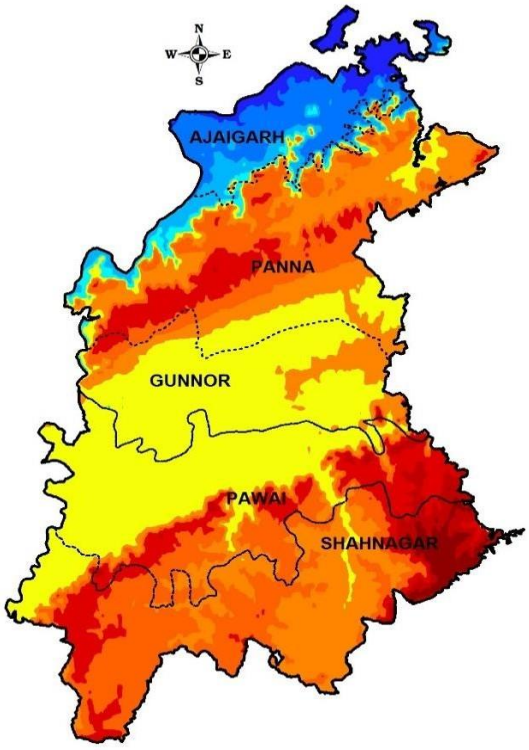
PANNA DISTRICT, MADHYA PRADESH

NORTH CENTRAL REGION
BHOPAL

CENTRAL GROUND WATER BOARD

MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVANATION

AQUIFER MAPPING AND MANAGEMENT PLAN
PANNA DISTRICT, MADHYA PRADESH



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CENTRAL GROUND WATER BOARD
NORTH CENTRAL REGION
BHOPAL
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PREFACE

Groundwater being a valuable asset and its relatively easy accessibility in comparison to surface water sources is primarily used for irrigation. The district of Panna with a total geographical area of about 7135sq. km is bounded by Banda district of Uttar Pradesh in the north, Satna district in the east, Chhatarpur in the west and Damoh and Jabalpur districts in the south west and southeast respectively. The district extends between the parallels of North latitude 230 48' 55''.

Under the National Aquifer Mapping (NAQUIM) project, multidisciplinary approach has been adopted for preparation of aquifer maps and ground water management plan for Indore district. The report consists of the existing hydrogeological, chemical and geophysical data that were compiled for the preparation of aquifer maps. The collected data was further processed to generate regional hydrogeological maps, thematic maps, water quality maps, cross-sections, 2-D and 3-D aquifer dispositions.

The aquifer management plan for Panna district has been prepared in which the ground water resources can be utilized and stage of groundwater development is increased from 38.32% to 60%. The interventions suggested in the report will not only have a 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.

Parvinder Singh
(Regional Director)

Aquifer Mapping and Management Plan of Panna District, Madhya Pradesh

CHAPTER-I Introduction

1.0 **Location :**

Panna district is located at north central part of Madhya Pradesh, is bounded by Banda district of Uttar Pradesh in the north, Satna district in the east, Chhatarpur in the west and Damoh and Jabalpur districts in the south west and southeast respectively. The district extends between the parallels of North latitude 23^0 48' 55" and 25^0 05' 00" and between the meridians of East longitude 79^0 44' 00" and 80^0 40'.

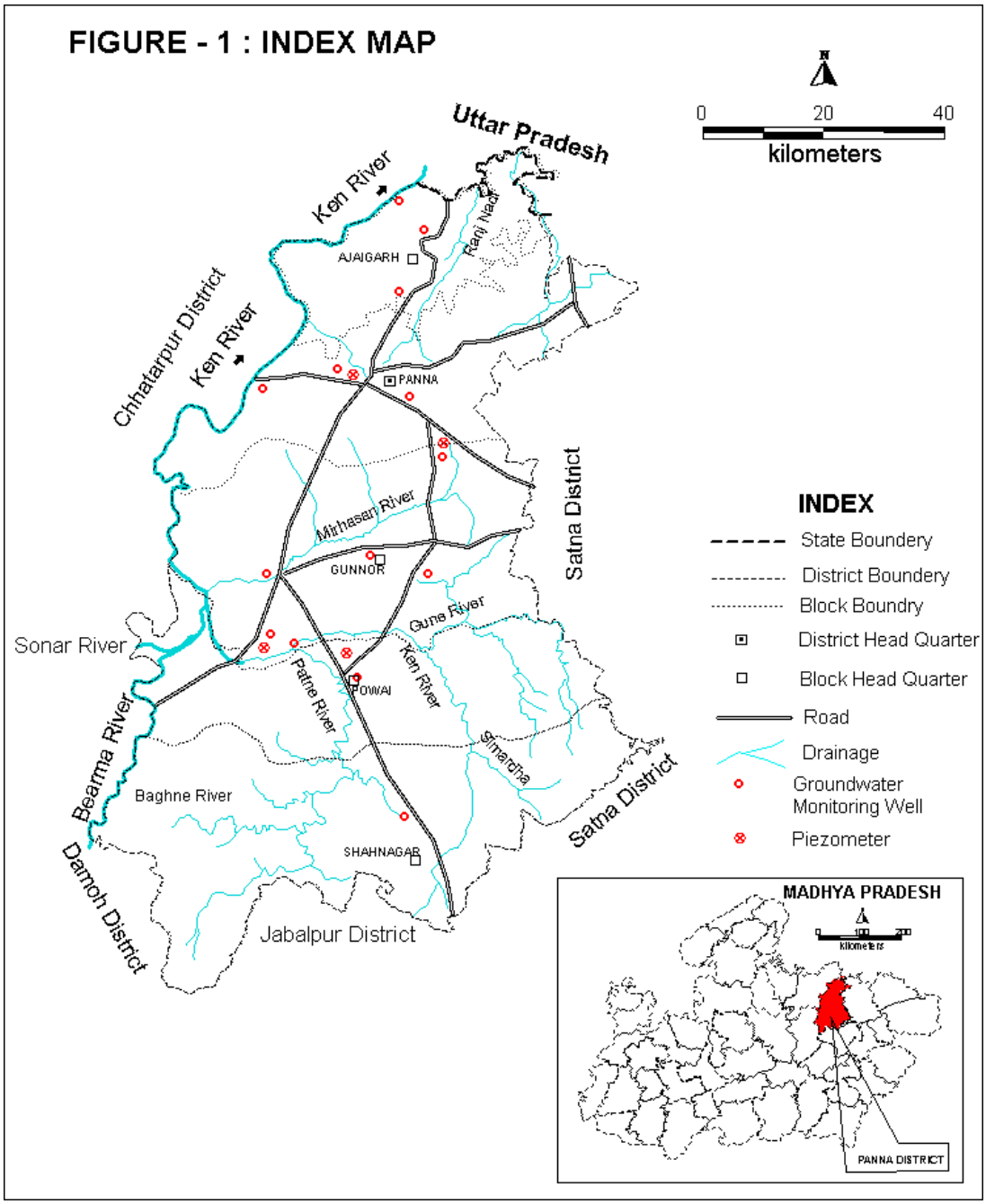
The Panna district is entirely dependent on road transport. The district is well connected by state highways. The nearest railway station is Satna, which is directly connected to Bhopal, Jabalpur and Delhi and it is 70 km away from Panna town. The nearest Aerodrome is available for air service is at Khajuraho, which is 46 km from Panna on way to Chhatarpur. The Panna is famous for its diamond mines, stylish and huge temples, spectacular seasonal waterfalls and national tiger park.

The district is divided into eight Tehsils and five development Blocks. There are 947 inhabited villages and 64 uninhabited villages and six towns in the district.

Table 1: Administrative Divisions, District Panna, M.P.

S No	Block	Area (Sq Km)	No. of towns	No. of Villages
1.	Ajaygarh	911	1	118
2.	Gunour	1156	1	221
3.	Panna	2053	3	190
4.	Pawai	1576	1	201
5.	Shahnagar	1440	0	217
	TOTAL	7135	6	947

Fig 1: Administrative Map of Panna district, Madhya Pradesh



Objectives and approach:

The aquifer mapping study primarily depends on the existing data that are assembled, analyzed and interpreted from available sources. The data gaps analysis carried out helped to generate data from data-collection activities such as BDR of exploration drilling, water level measurements and groundwater quality analysis done by CGWB & State Department. By analyzing the existing data and the data generated, regional hydrogeological maps, thematic maps, water quality maps, cross-sections, 2-D and 3–D aquifer dispositions maps were generated. The objectives of the Management plan is to define the aquifer geometry, type of aquifers, ground water regime behaviors, hydraulic characteristics and geochemistry of Multi-layered aquifer systems on 1:50,000 scale .

Aquifer Mapping can be envisaged as follows:

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

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

3. Previous studies prior to this study, the groundwater hydrogeology have been studied only in separate parts with many areas left untouched. As a result, there was no hydrogeological framework developed so as to understand the regional effects of groundwater development in the area.

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

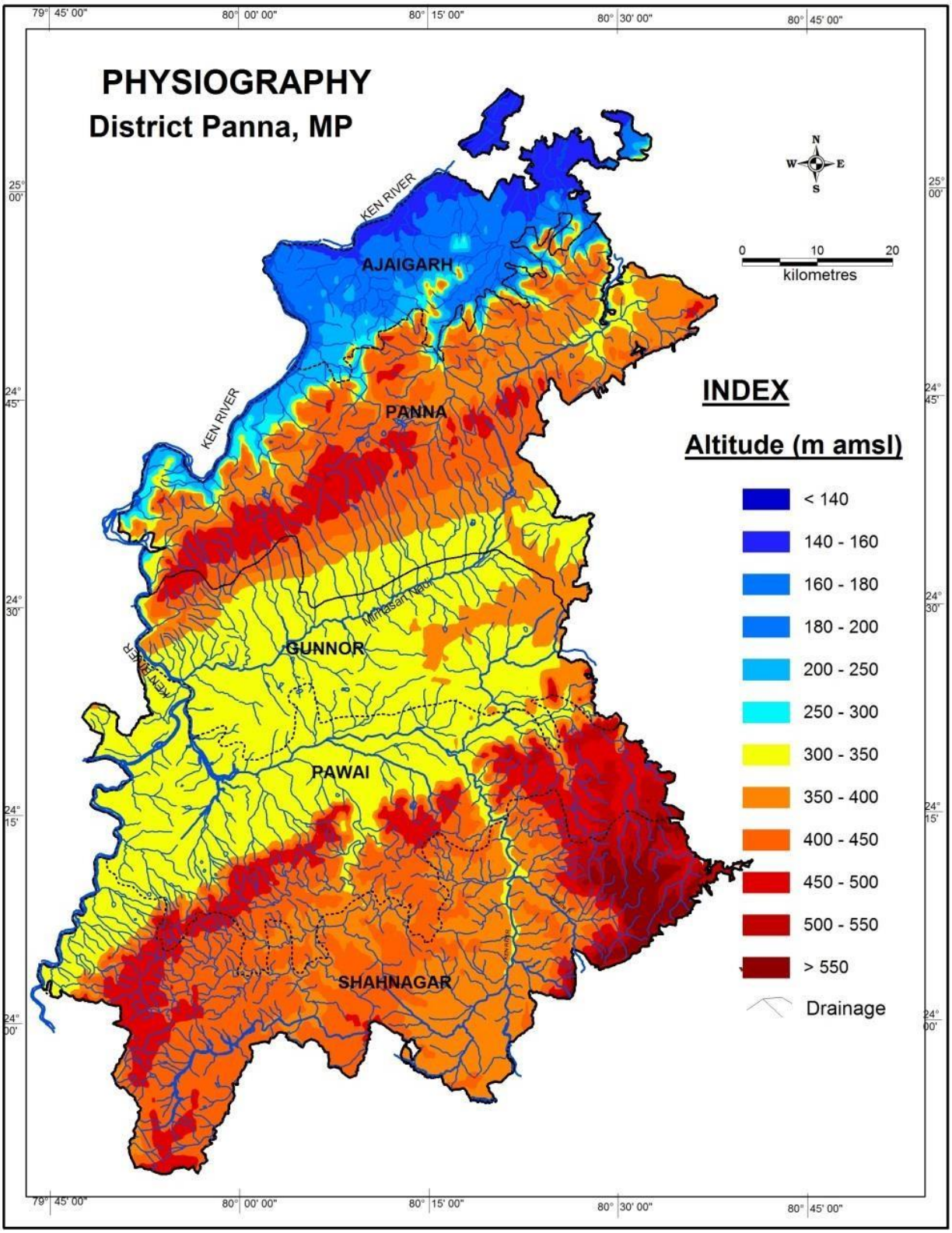
Rainfall & Climate:

The climate of Panna district is generally dry except during the southwest monsoon season. The year can be divided into four seasons. The winter commences from middle of November and lasts till the end of February. The period from March to about first week of June is the summer season. May is the hottest month of the year. The southwest monsoon starts from middle of June and lasts till end of September. October and middle of November constitute the post monsoon or retreating monsoon season. The normal annual rainfall of panna district is 1108.58 mm District received maximum rainfall during south west monsoon period i.e. June to September. About 89.5% of the annual rainfall received during monsoon season. Only 10.5 % of the annual rainfall takes place between Octobers to May period. The rainfall forms the sole source of the natural recharge to ground water regime and is mainly available during the south west monsoon period only.

Physiography:

Physiographically, Panna district forms parts of Vindhyachal ranges followed by Bundelkhand upland in the north. The Vindhyachal ranges contain two linear steps like tablelands trending ENE-WSW separated by an uneven narrow valley having an average elevation of 440 m above mean sea level. These are governed by geological formations and their lithological and structural configurations. Sandstone form the hilly areas with prominent scarps and spurs, while shale normally, because of their inherent proclivities for denudation from plain and low lying areas. The Bundelkhand upland, having an average elevation of 170 m above mean sea level, is a peneplained surface dotted with mesa and linear ridges.

Figure 2. Phusiography map of Panna District, Madhya Pradesh



Drainage:

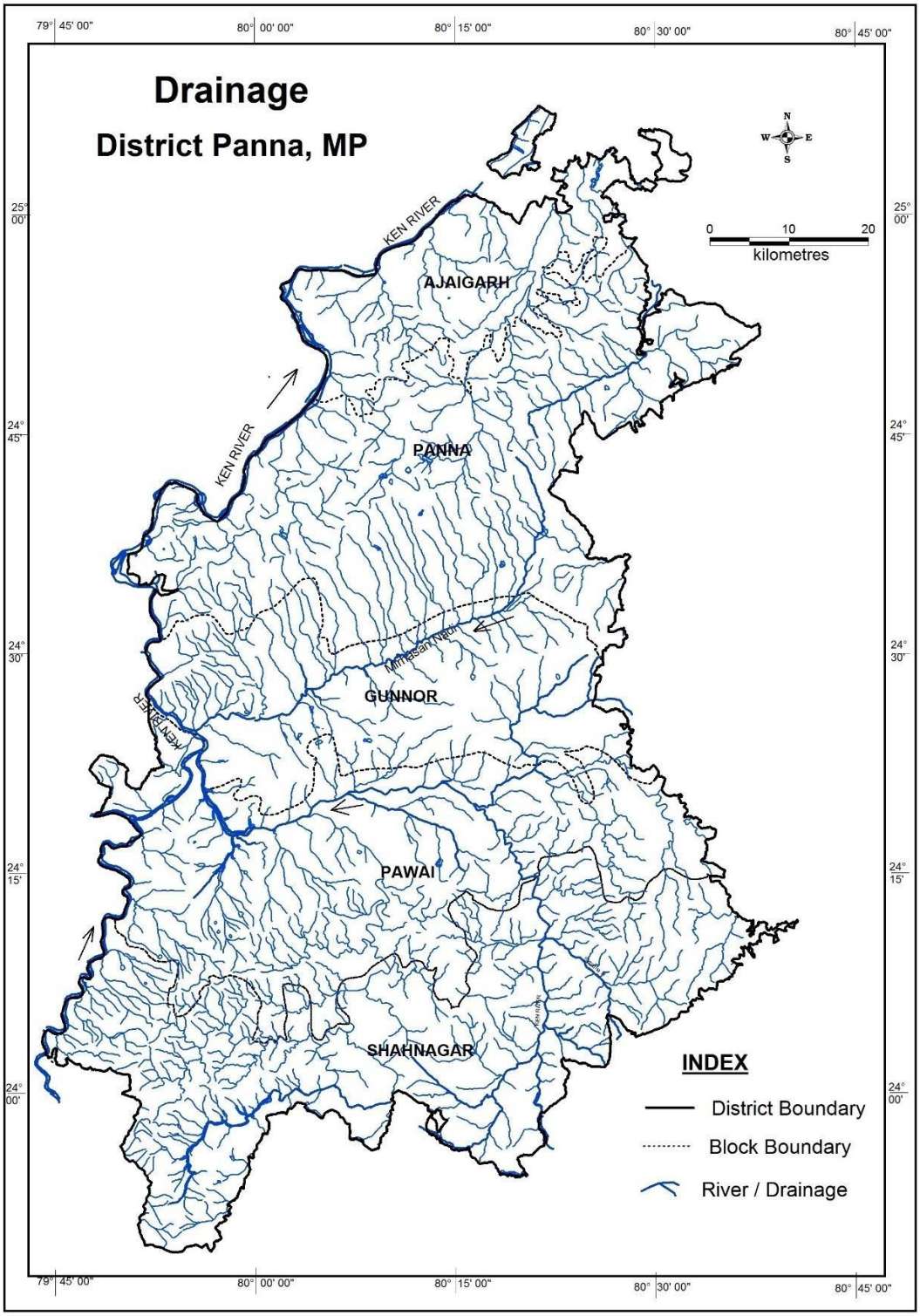
The major river drained into the district is Ken River and its tributaries such as the Bearwa, Patne, Baghne, Mihirsen, Satna etc. The general drainage pattern is dendritic and surface water flow is from south to north direction. The drainage density is again coarse, medium and fine as per lithological nature of rock formations like sandstone, calcareous sandstone, shales respectively.

Drainage pattern in granitic terrain, (as in Ajaigarh Block) is conspicuously different than that of panna, Pawai and Shahnagar which are predominantly Vindhyan hard rock terrain.

Generally granites are more fractured and weathered compared to Vindhyan sandstone and Shale. Therefore the general shape of watershed also differs in these two terrains. It is more circular in alluvium filled valley.

Overlying shales of Vindhyan (Ajaigarh and Gunour blocks) while in panna, pawai and shahnagar blocks, the watersheds are more or less elongated.

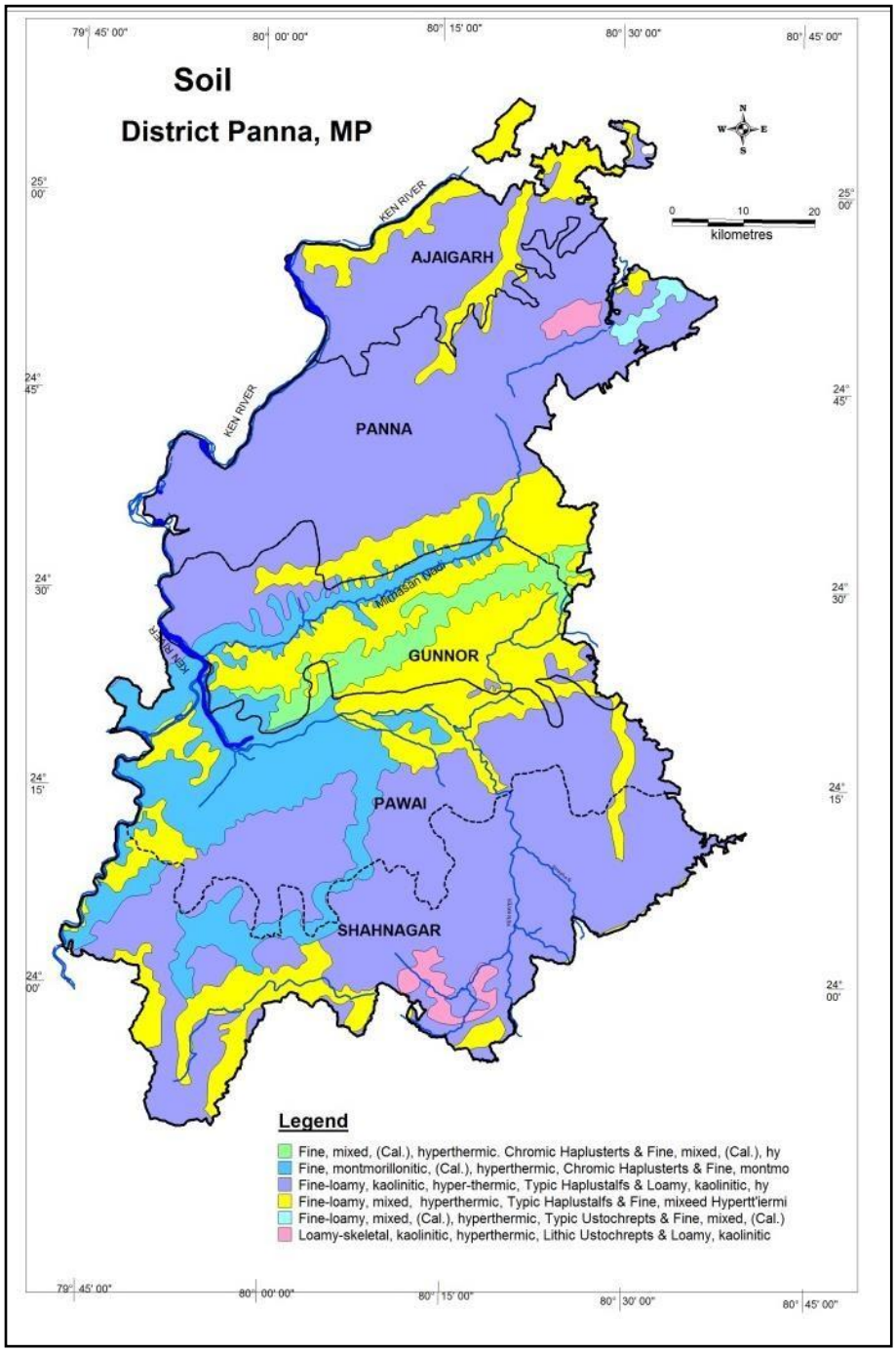
Fig 3: Drainage map of Panna District, Madhya Pradesh



Soil:

Almost three-fourth area of the district is covered with soil formed by the weathering of Vindhyan sediments. The northern part of the district area is covered with yellowish sandy soil derived from weathering of granitic rocks. The thick alluvial soil are found along the river courses.

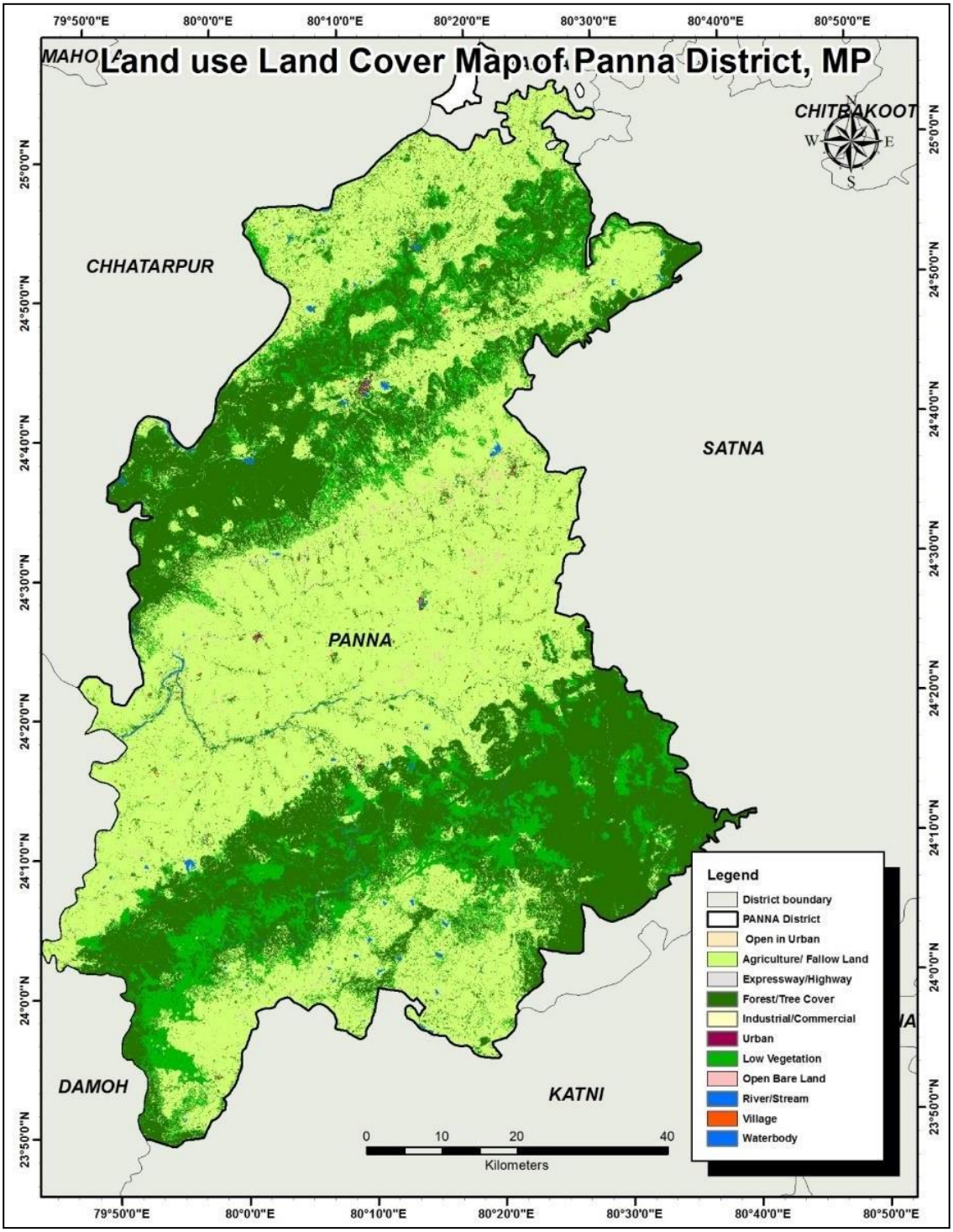
Fig 4: Soil Map



Landuse:

Major part of Panna district is covered by forest area followed by agricultural land. The hilly portion of the area is forested. Waste sandy area is sporadically distributed within the district.

Fig 5: Landuse Map



Agriculture/Irrigation/Cropping pattern

The statistical data of land use, crop sown, area irrigated by groundwater such as tubewell, dugwell and area irrigated by surface water such as Canals, Ponds etc. of Panna district has been extracted from the statistical hand Booklet- Panna district 2015. The details of irrigated area is given in table no. 2. Gross sown area of Panna district in 2014-15 is 254744 Ha, given in table no. 3

Table No.2: Area Irrigated by Different Source in Panna District as - 2015.

Block	Area Irrigated by Tube Well (Ha)	Area Irrigated by Dug Well (Ha)	Total Area Irrigated by Ground Water (Ha)	Area Irrigated by Canals (Ha)	Area Irrigated by Ponds (Ha)	Total Area Irrigated by Surface Water Area (Ha)	Kharif	Rabi
Ajaigarh	2080	2550	4630	4470	820	5290	10643	20386
Gunour	3520	3470	6990	0	240	240	23265	66786
Panna	2695	4385	7080	2325	120	2445	23844	30609
Pawai	4190	3925	8115	1850	245	2095	23990	46357
Shahnagar	2590	2200	4790	570	175	745	33638	24933
Total	**15075**	**16530**	**31605**	**9215**	**1600**	**10815**	**115380**	**189071**

Table No.3: Gross Sown Area of Panna District

Area	Type of soil	Gross Area sown (ha) (2015-16)	Area irrigated by surface water (ha) (2015-16)	Area Irrigated by GW (ha) (2015-16)
Panna District	mixed soil, gravelly sandy soil and Red Loamy soil	254744	10815	31605

Chapter II Data Collection and Generation

General Geology and Stratigraphy

ARCHEANS

The rocks of this group are basically pink colored Bundelkhand granites. The granitic rocks are observed in the Panna and Ajaygarh blocks of Panna district. The granites are fine to coarse grained with occasional porphyritic texture. The granites are hard and compact and degree of weathering is not much in Panna block. However the granitic rocks in Ajaygarh blocks are intensely weathered and form good aquifers. The dug wells located in these weathered granites sustain good yields even during summer.

VINDHYANS

SANDSTONE- Vindhyan sandstones belong to Kaimur group are exposed near Rampur, Dalhan Chowki, Majhgawan and Inota village. These sandstones are white, fine grained hard and purely siliceous in nature. The sandstone of Rewa group is well bedded, jointed, hard and compact, reddish to purple colored as observed in Bikrampur, Bilha, Kherbund, akola and Gandlha villages. Sandstone of Bhander group is reddish brown, jointed, hard and compact in nature and observed in many villages around Shahnagar, Rajapura, Chowmukha and Pawai.

The Vindhyan sandstone is fine-grained, impermeable and has no primary porosity. Circulation of groundwater is through joints, fractures and bedding planes.

SHALE- There is five types of Vindhyan shales that occur in the district- Semri shale (oldest) followed by Jhirri shale, Ganurgarh shales and Sirbu shale (Youngest) in their chronological order.

In general all the shales are fine-grained, soft, friable, thinly bedded and split along bedding planes. The shales form poor aquifer system. However based on the density of joints and fractures, shales often form good aquifer and form very good fertile land between Mirhasan and Ken River.

LIMESTONE- There is only one limestone layer, which is called as Nagod limestone. It is fined grained jointed and dark grey in colour. Solution activity in limestone formation creates potential aquifer.

ALLUVIUM- Localized patches of alluvium cover occur along the banks of major and minor rivers and streams in the district. The thickness of alluvium varies from few meters to 30 m. The thickness of alluvium found moren granitic rocks and shales, while less in sandstone and limestone rocks formation.

The general geological successions in the district are given in table No.4

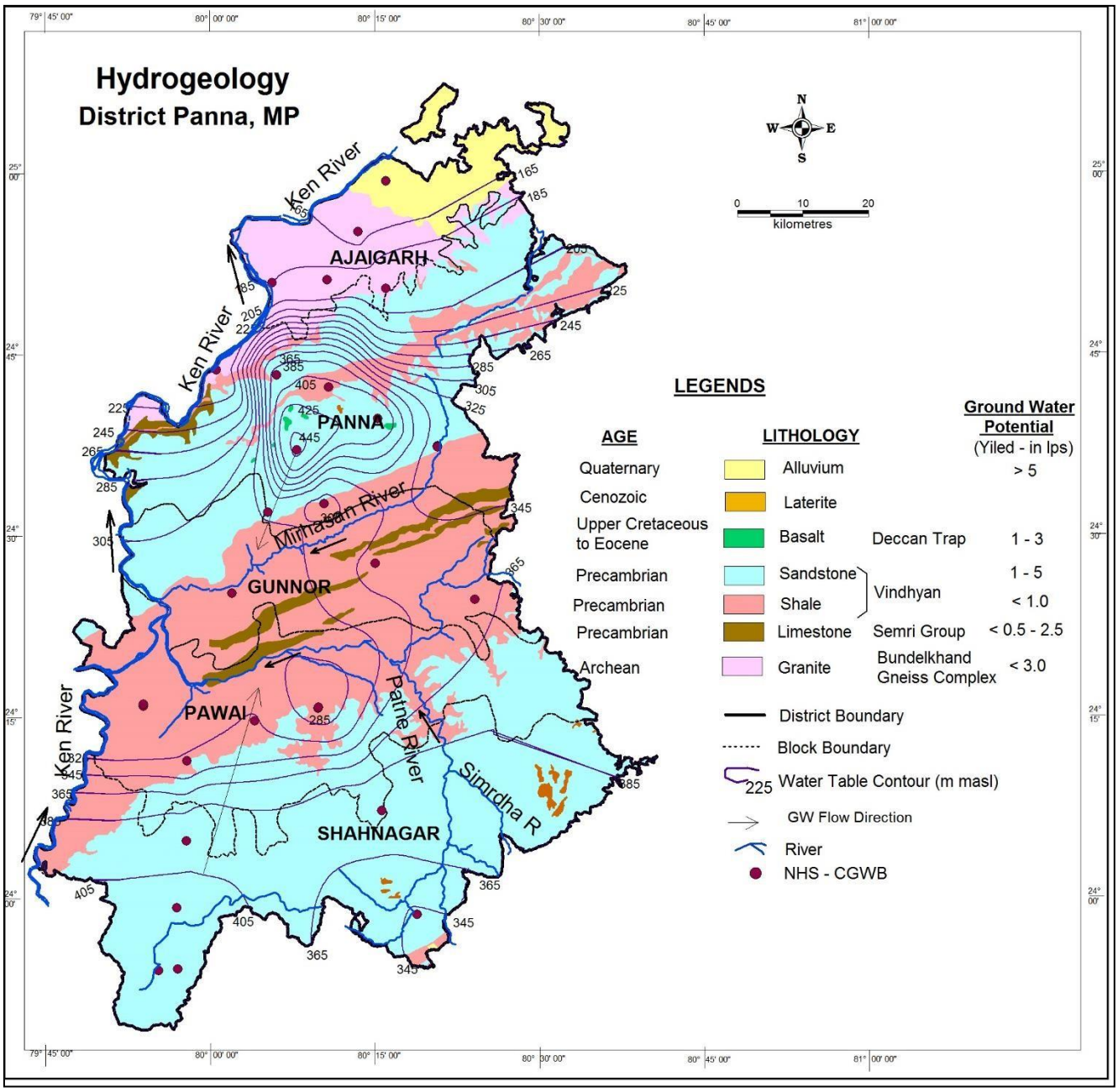
Table 4: General geological succession of Panna district.

System	Lithostratigraphic Unit	Lithological Description
Recent to Pleistocene	-	Alluvium
Rewa Group	Bhander Shale Sandstone and Limestone	Bhander Shale Sandstone and Limestone
---------- Diamond Bearing Conglomerates ----------		
Kaimur Group	Baghain Sandstone and conglomerates	Sandstone and conglomerates
Semri Group	Porcellanite Stage Basal Stage	Shales Quartzite and conglomerates
Archaean	Bundelkhand Granites	Granites

HYDROGEOLOGICAL DATA COLLECTION

Groundwater is the principal source of irrigation in the district. Map showing geology, hydrogeology, water table and location of national hydrograph stations of panna district.

Fig 6: Hydrogeology



WATER LEVELS

Ground water levels play a very important parameter of the ground water system, as these are its physical reflection. The groundwater balance expresses itself in the change in water levels; hence a continuous record is important and useful. CGWB has 26 National Hydrograph Station (NHS) and 4 Peizometers in Panna district.

Pre-monsoon (May 2017)

During pre-monsoon period, depth to water level ranges between 3.5 m,bgl to 17m bgl. 9% of wells showing water level in the range of 2-5m, bgl. 64% of wells showing water level in the range of 5-10m, bgl. 21% of wells showing water level in the range of 10-20m, bgl. And 6% of wells showing water level in the range of more than 20m depth. During May 2017, pre-monsoon the depth to water level in Panna districts as shown in Fig 8.

Post-monsoon (November 2017)

During post-monsoon period, water level ranges from 1.17 m,bgl to 16.1 m,bgl. 41.38% of wells showing water level showing in the range of 2-5 m,bgl, 41.38% of wells showing in the range of 5-10m bgl. 10.34% of wells showing water level between 10-20 m,bgl.

Water Level Trend (2008 – 2017)

The general trend of Pre-monsoon Decadal Water level trend 2008 to 2017 shows rising trend from 0 to 2m/yr in the entire district and falling trend sporadically distributed in small patches in parts of Ajaygarh, Panna, Pawai, Gunour and Shahnagar blocks. Post-monsoon decadal water level trend 2008-2017, shows thr rising trend of 0-2m/yr in the entire district except western patches of the Gunour, pawai and panna block is showing falling trend of 0-2m/yr.

Fig 7: Pre-monsoon Water Level (May-2017)

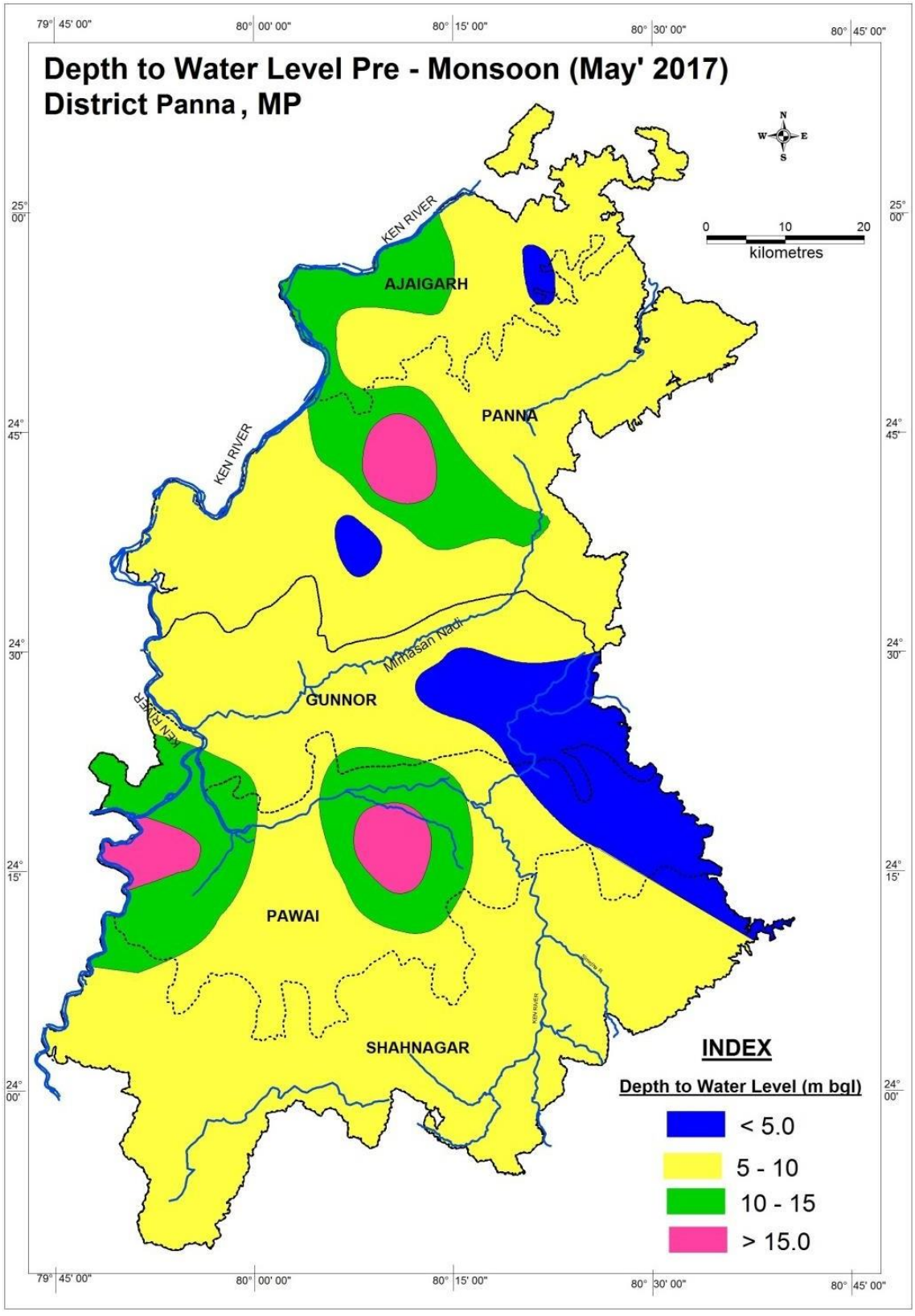


Fig 8: Post-monsoon Water Level (November-2017)

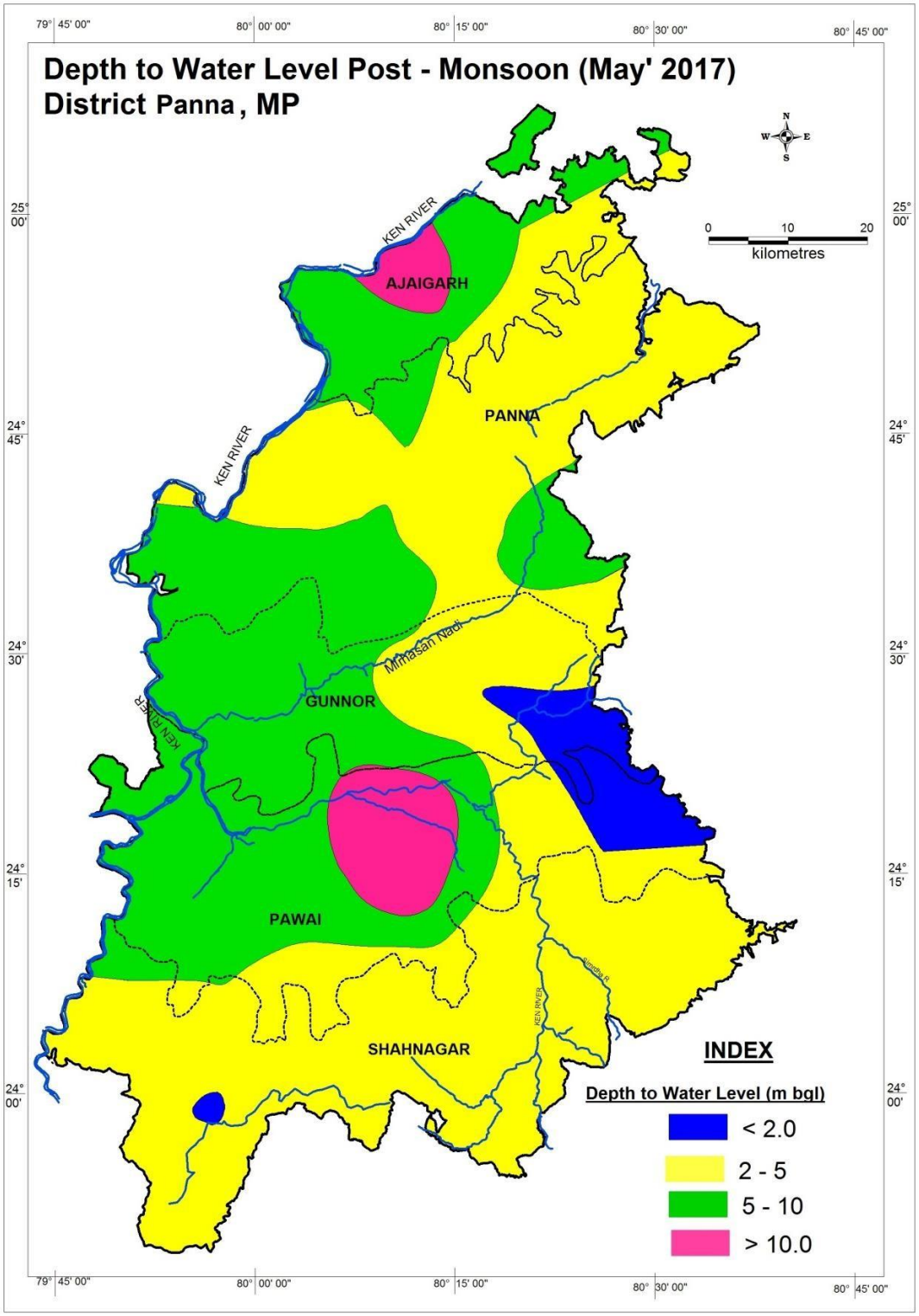


Fig 9: Pre- monsoon Water Level Trend (2008 – 2017)

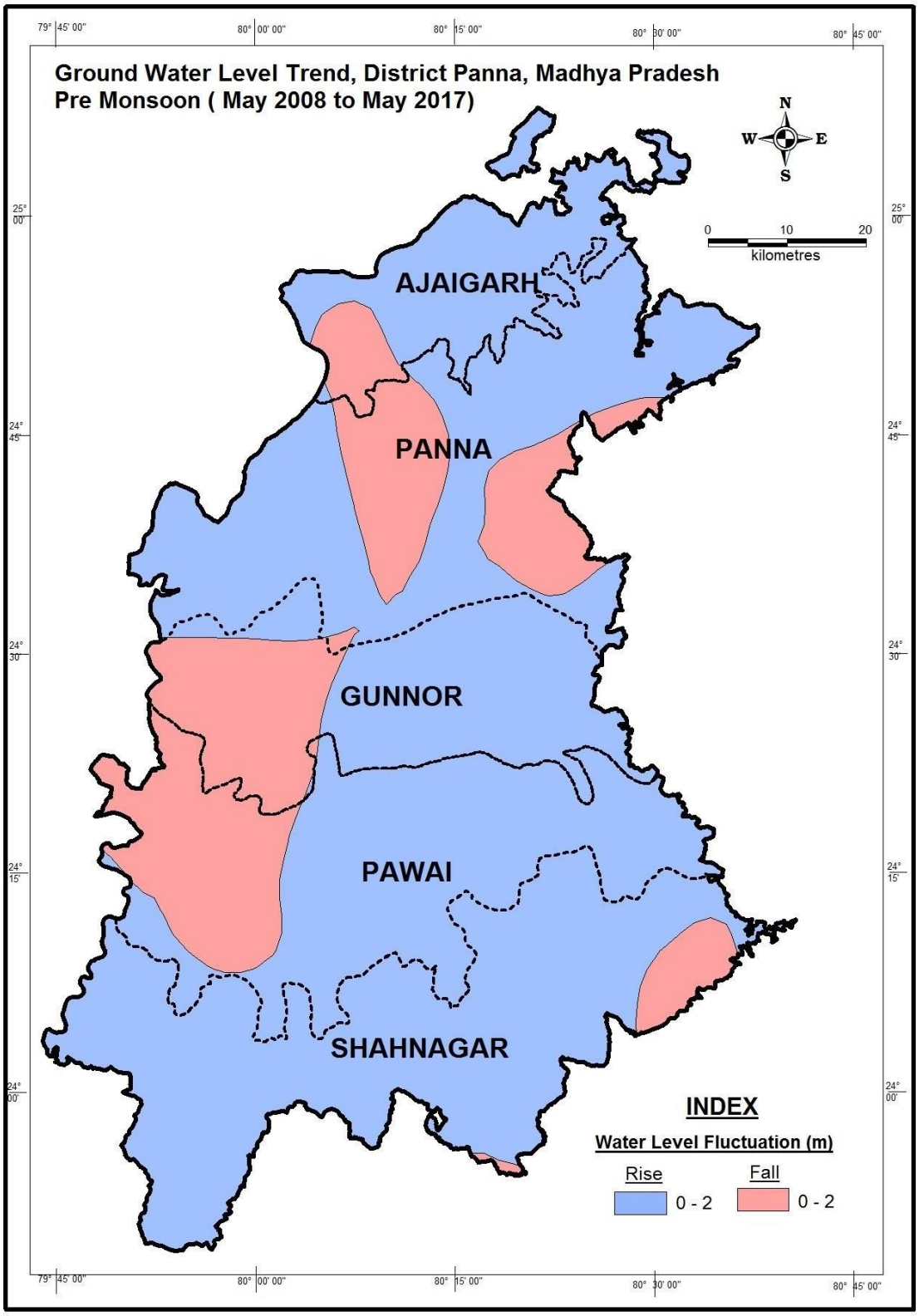
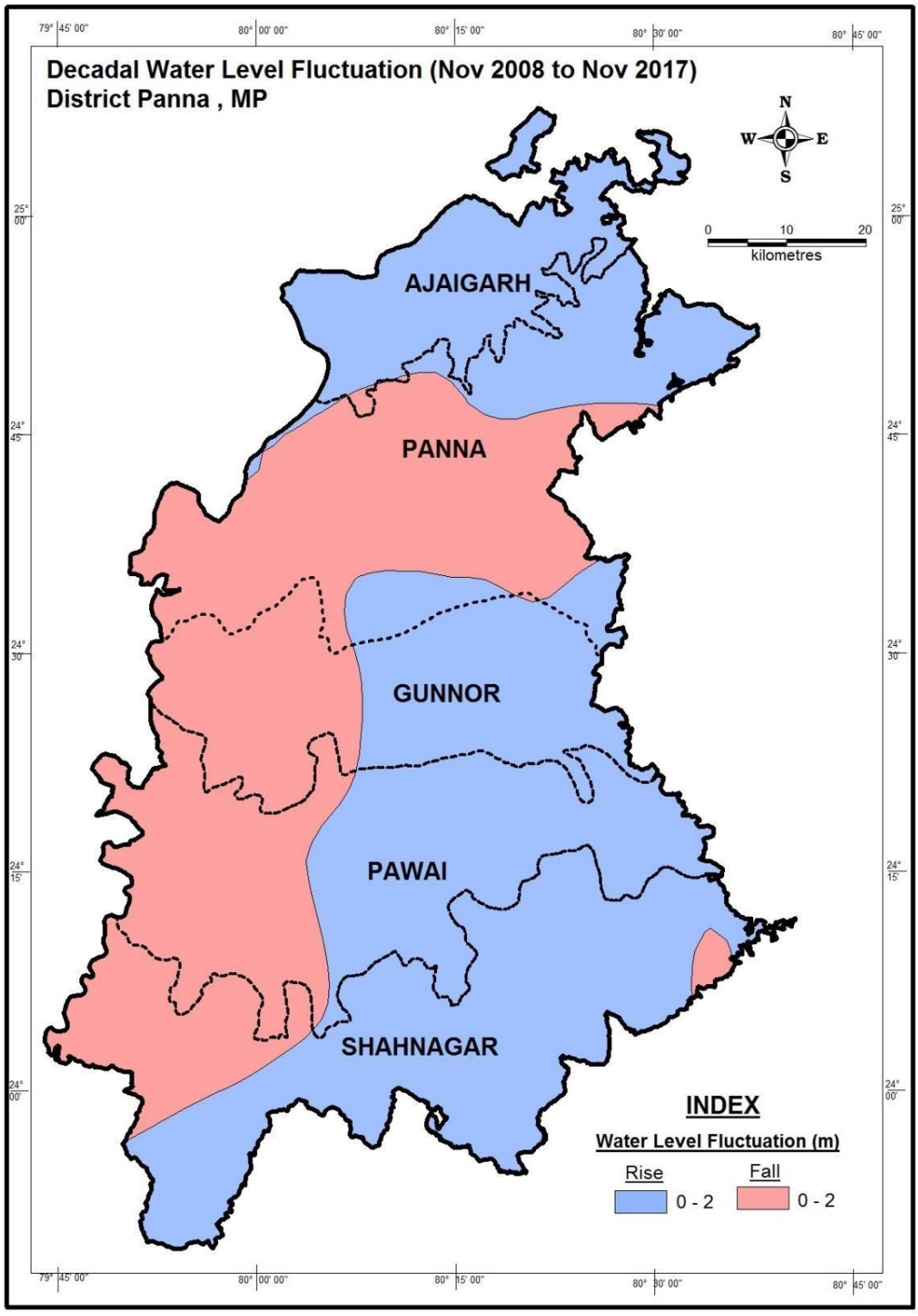


Fig 10: Post monsoon Water Level Trend (2008 – 2017) of Panna District, Madhya Pradesh



HYDROGEOLOGICAL DATA GENERATION

Sub-Surface Geology

There are total of 50 EW, 8 OW, and 39 Pzmt. have been drilled. The depth of wells varies from 82.88 – 200.0 m. bgl. The discharge ranges from Meager to 17.0 lps and Specific Capacity Range from 0 - 94.93 lpm/m of drawdown.

The aquifer formed by weathered granitic mass occurring as medium to coarse sand; poorly rivers are moderate to highly potential with higher specific capacity in its yielding are limited in areal extent usually extend in depth between 20-50 meters below ground level.

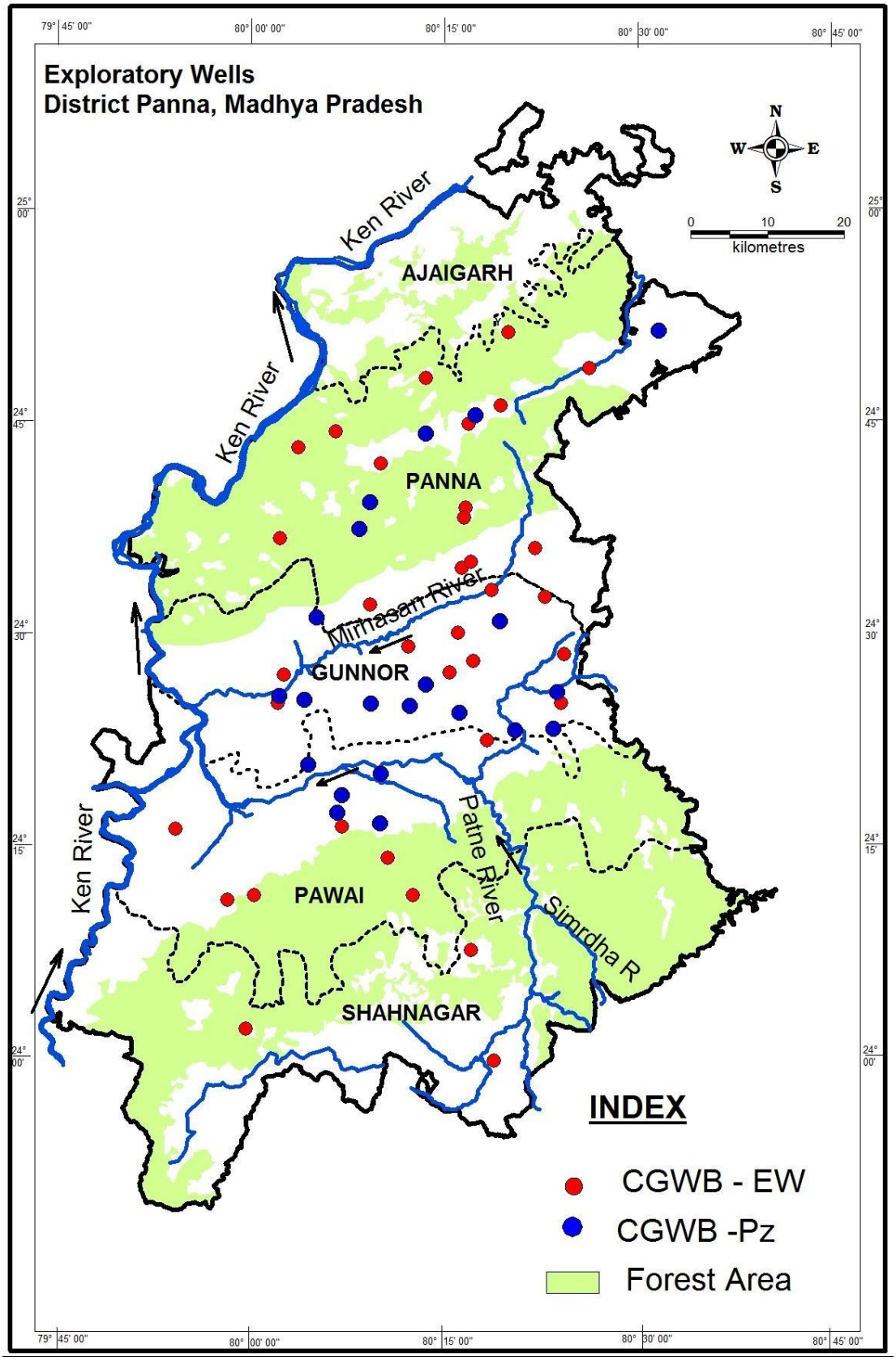
Consolidated aquifers formed by shales and jointed sandstones of vindhyans are both shallow and deep as far as occurrence is concerned. The shallow aquifers occur between 20-50m. bgl while deep aquifers are between 60-85 meters bgl.

The cavernous limestone occurring West of Panna and Pawai along Sonar river and East of Gunor block in association with bedded and jointed sandstone act as aquifer. These vindhyans aquifers are of limited width and extension. Thus they are with limited storage capacity. Groundwater from most of these aquifers comes out as base flow leakage to the adjoining river system.

The general ground water gradient is commonly steep and conforms to the physiography and merges towards drainage of the area.

There are 56 nos. of exploratory well drilling have been proposed and work is in progress under Bundelkhand contractual drilling.

Fig 11. Location of Exploratory wells



HYDROCHEMICAL DATA

The water samples were collected from National Hydrograph Stations in clean double stopped poly ethylene bottles from 26 different locations of Panna district during May 2017.

The pH of ground water of Panna district ranged in between 6.19 to 9.20. As per BIS recommendation, all water samples recorded within the permissible limit of 6.5 to 8.5. The ground water of the study area can be assessed as neutral to slightly alkaline in nature. The electrical conductivity of ground water in Panna district ranged between 112 to 2079 µS/cm at25°C. The maximum value of electrical conductivity observed in the dug well of Amanganj village. The electrical conductivity shows that the ground water in Panna district is good in nature.

The fluoride concentration in Panna district ranged in between BDL (below detection limit) to 1.32 mg/l. The maximum concentration of fluoride has been recorded in Pandepurwa village i.e. 1.32 mg/l. As per BIS recommendation, all water samples recorded fluoride concentration within the permissible limit of 1.50. In the district, nitrate concentration in ground water ranged in between BDL (below detection limit) to 148 mg/l. The concentration of nitrate more than 45 mg/l has been detected in ground water of Ajaygarh (148 mg/l) and Bariyarpur (61mg/l) dug wells. High nitrate in ground water appears may be due to anthropogenic activities or excessive use of fertilizers etc.

Total hardness of ground water in the study area ranged in between 45 to 945 mg/l. The concentration of total hardness more than 600 mg/l has been observed in the dug well of Amanganj (945 mg/l) villages.

In the district the ground water are calcium bicarbonate, calcium chloride and mixed types, it shows temporary and permanent hardness type of water respectively. The US Salinity Diagram of Panna district shows the ground water is low to high salinity classes i.e. C1S1, C2S1 and C3S1 classes. C3 class of water may be used for irrigation purpose with proper soil management.

Fig 12. Nitrate Concentration in Pheratic Aquifer- 2017

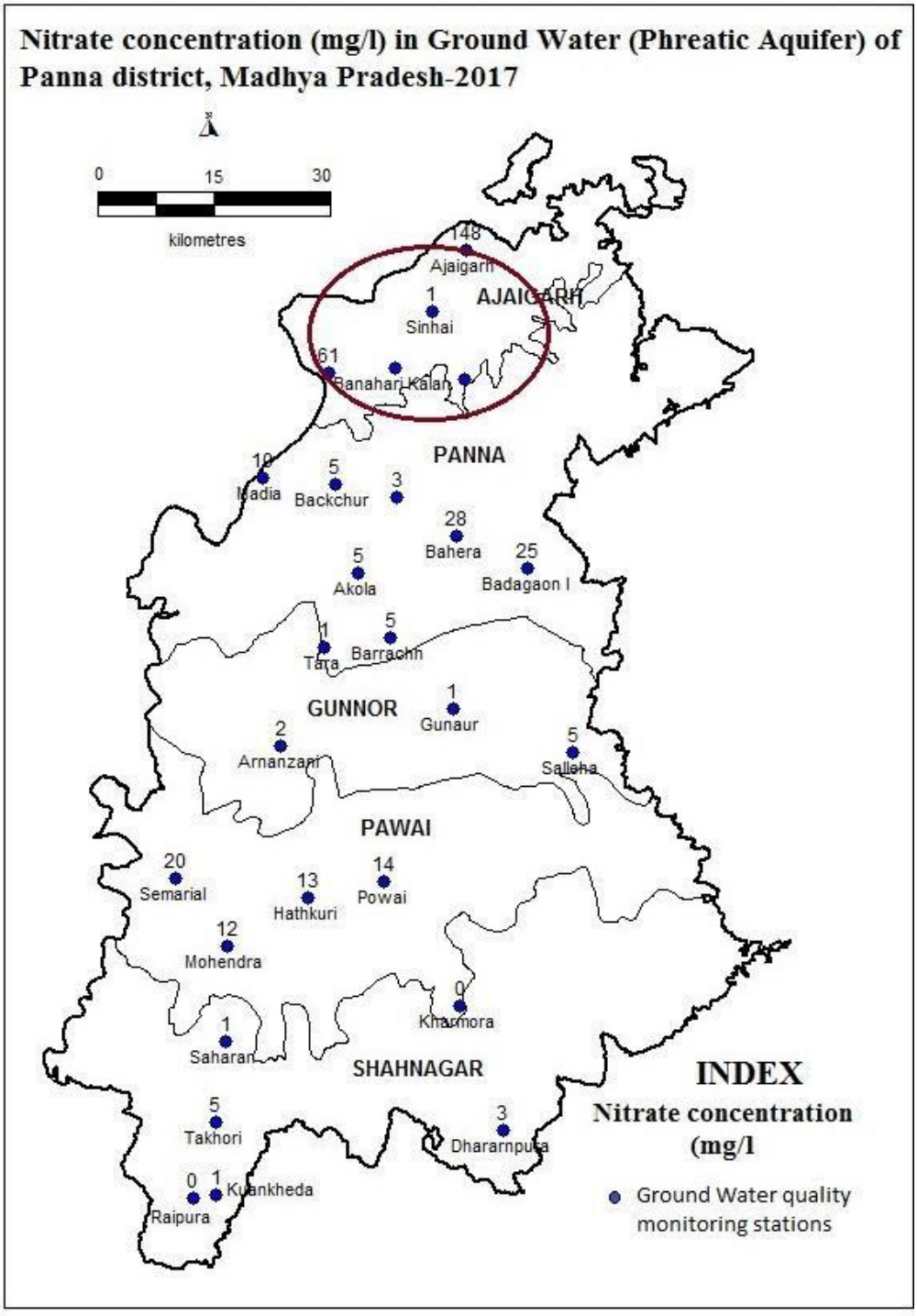
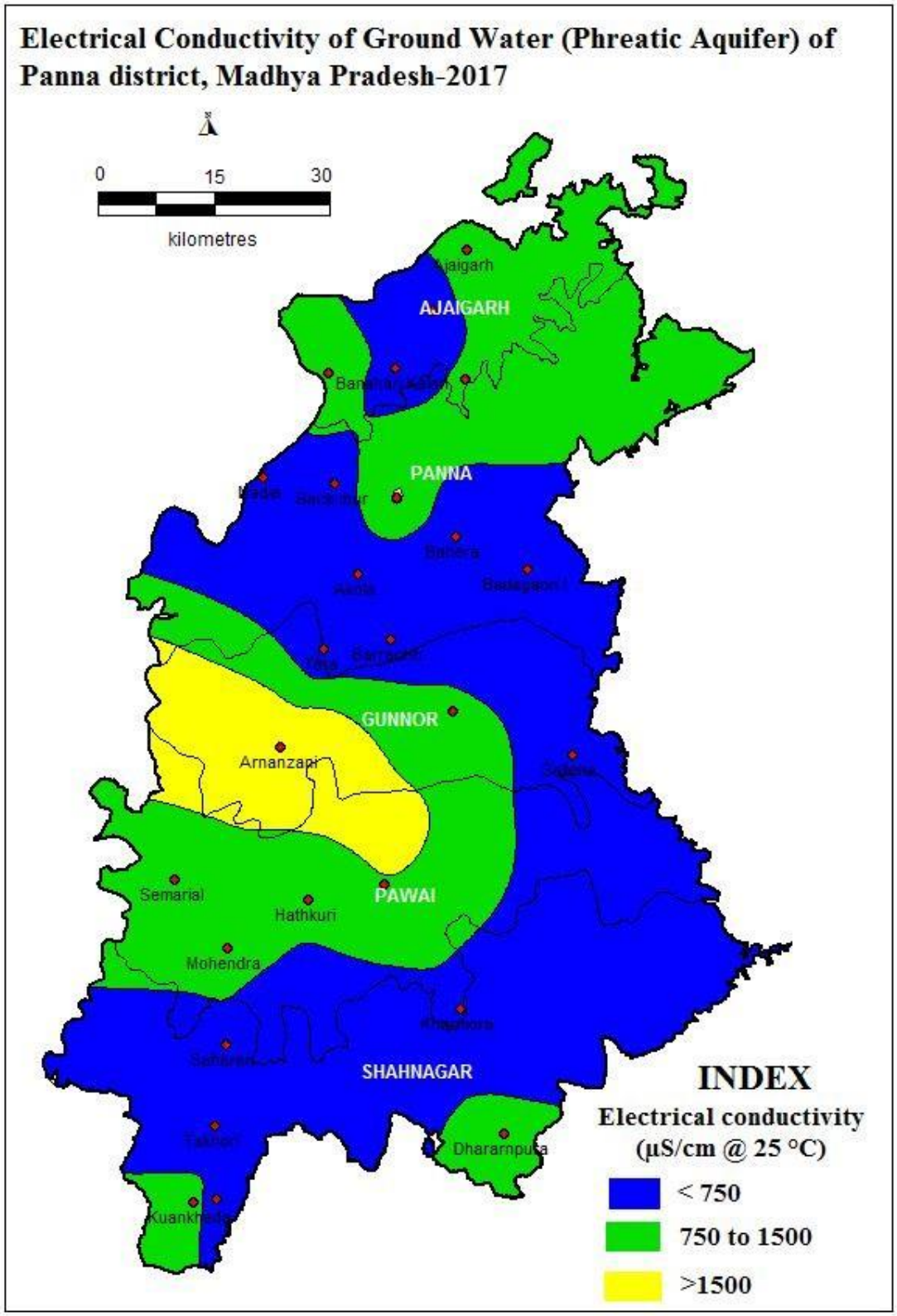


Fig 13. Electrical Conductivity of Ground Water (Pheratic Aquifer) - 2017



SOIL INFILTRATION TEST

Evaluations of the infiltration of soil of the area in order to calculation of infiltration rate of soil. The infiltration capacity of soil influences the occurrence of overland flow. The objectives of this study were to assess the infiltration capacity of some extensive soils in area and also its spatial and temporal variability. Infiltration capacity was measured using double-ring infiltrometer Infiltration capacities were reasonably stable. There was a significant relationship between infiltration capacity and the antecedent soil water content, which contributed to the seasonal effect. Capacities in weathered soil were 3.5 times the natural soil, indicating that the rate of infiltration is increased with depth.

Water entering the soil at the ground surface is called infiltration. It replenishes the soil moisture deficiency and the excess moves downward by the force of gravity called deep seepage or percolation and builds up the ground water table. The maximum rate at which the soil in any given condition is capable of absorbing water is called its infiltration capacity (f_p). Infiltration (f) often begins at a high rate (20 to 25 cm hr^{-1}) and decreases to fairly steady state rate (f_c) as the rain continues, called the ultimate f_p (= 1.25 to 2.0 cm hr^{-1}). The infiltration rate (f) at any time t is given by Horton's equation.

$$f = f_c + (f_o - f_c)\, e^{-kt}$$

$$k = \frac{f_o - f_c}{F_c}$$

Where: f_o = initial rate of infiltration capacity
f_c = final constant rate of infiltration at saturation
k = a constant depending primarily upon soil and vegetation
e = base of the Napierian logarithm
F_c = shaded area in fig. 3.6
t = time from beginning of the storm

The infiltration takes place at capacity rates only when the intensity of rainfall equals or exceeds f_p; *i.e.*, $f = f_p$ when $i \geq f_p$; but when $i < f_p$, $f < f_p$ and the actual infiltration rates are approximately equal to the rainfall rates.

The infiltration depends upon the intensity and duration of rainfall, weather (temperature), soil characteristics, vegetable cover, land use, initial soil moisture content (initial wetness),

entrapped air and depth of ground water table. The vegetal cover provides protection against rain drop impact and helps to increase infiltration.

Methods of determining Infiltration

The methods of determining infiltration are:

i. Infiltrometers
ii. Observation in pits and ponds
iii. Placing a catch basin below a laboratory sample
iv. Artificial rain simulators
v. Hydrograph analysis

Double-rind infiltrometer: A double ring infiltrometer contains two rings (22.5 to 90 cm diameter) that are driven into the ground by a driving plate and hammer, to penetrate into the soil uniformly without tilt or undue disturbance of the soil surface to a depth of 15 cm. After driving is over, any disturbed soil adjacent to the sides tamped with a metal tamper. Point gauges are fixed in the center of the rings and in the annular space between the two rings. Water is poured into the rings to maintain the desired depth (2.5 to 15 cm with a minimum of 5 mm) and the water added to maintain the original constant depth at regular time intervals (after the commencement of the experiment) of 5, 10, 15, 20, 30, 40, 60 min, etc. up to a period of at least 6 hours is noted and the results are plotted as infiltration rate in cm hr^{-1} versus time in minutes (in simple graph paper). The purpose of the outer table is to eliminate to some extent the edge effect of the surrounding drier soil and to prevent the water within the inner space from spreading over a larger area after penetrating below the bottom of the ring.

Field infiltration test Equipment required

1. Shovel/hoe
2. Hammer (2 kg)
3. Watch or clock
4. 5 litre bucket
5. Timber (75 x 75 x 400)
6. Hessian (300 x 300) or jute cloth
7. At least 100 litres of water

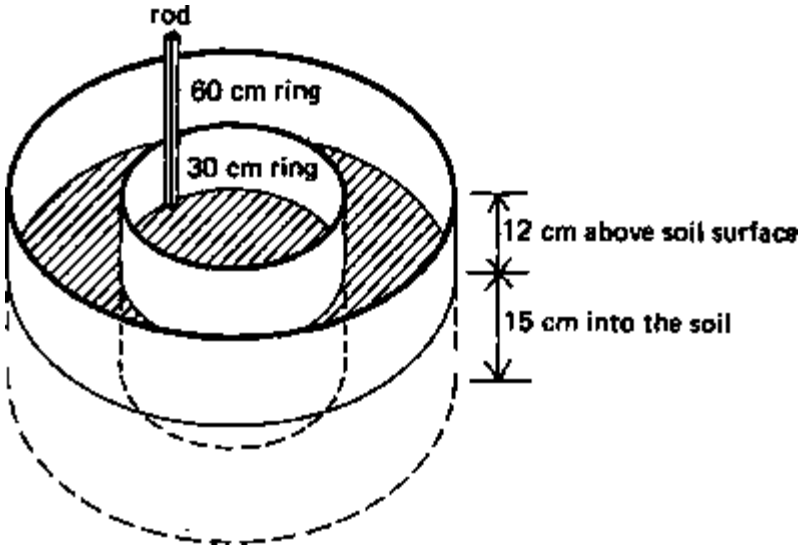


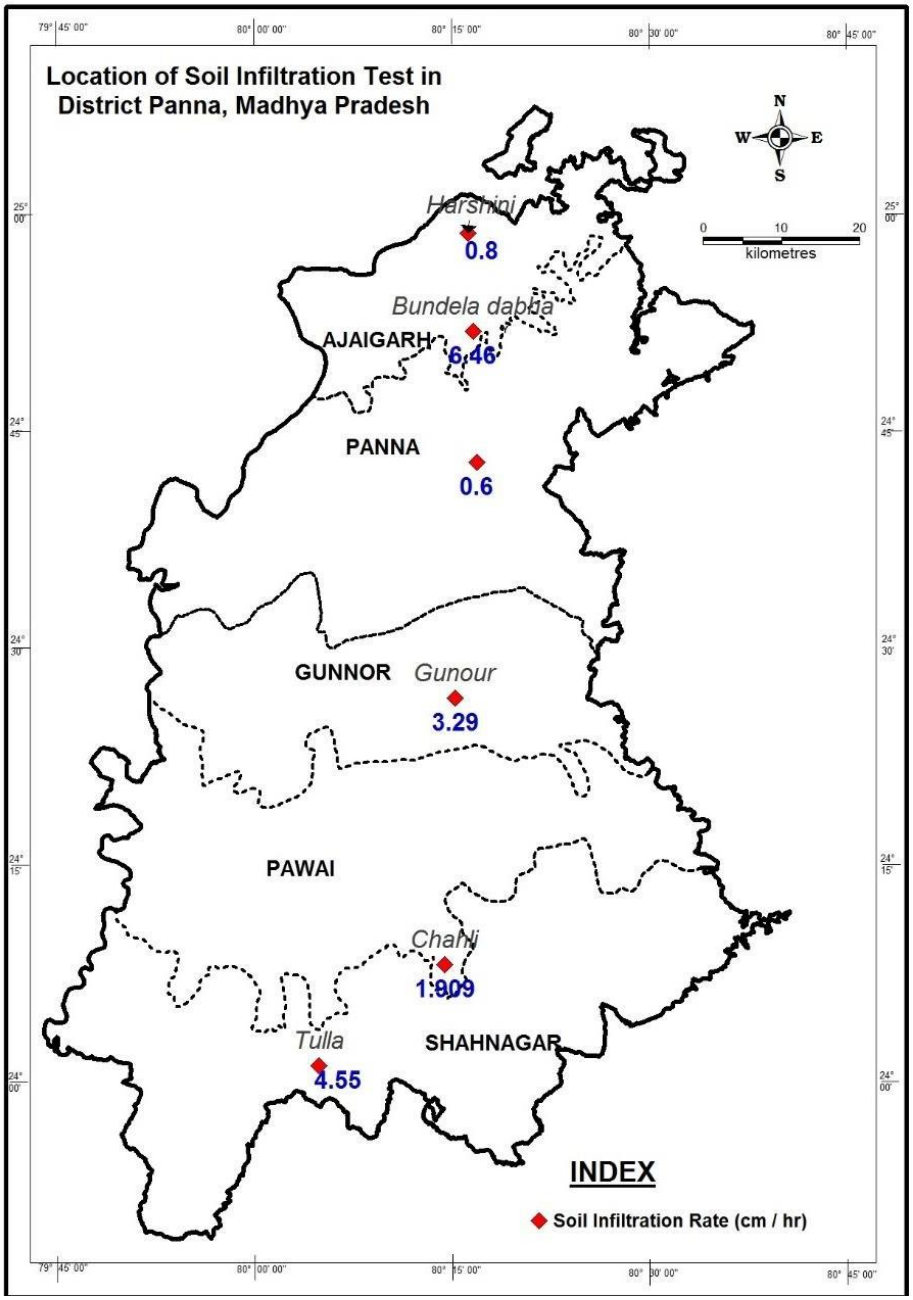
Fig14: Field infiltration test Equipment

Ring infiltro-meter of 30 cm diameter and 60 cm diameter. Instead of the outer cylinder a bund could be made to prevent lateral water flow Double ring infiltro-meter

Measuring rod graduated in mm (e.g. 300 mm ruler)

In Panna district, there are total of 6 soil infiltration tests has been conducted one in each block.

Fig 15. Soil infiltration tests location- 2017



A graph between Infiltration capacity and time has been plotted and on that basis infiltration rate is calculated. The details are given below:

Table 4: Infiltration test data at village Chahli, Block Pawai

Location	**Chahli**		**Longitude**	80.25653
Block	**Pawai**		**Latitude**	24.13049
time (minutes)	**time (hr)**	**depth (mm)**	**depth (cm)**	**Infiltration capacity(cm/hr)**
1	0.016667	2	0.2	12.00
2	0.033333	3	0.3	10.00
3	0.05	3	0.3	9.00
4	0.066667	5	0.5	8.20
5	0.083333	7	0.7	8.40
6	0.1	8	0.8	8.00
7	0.116667	9	0.9	7.71
8	0.133333	10	1	7.50
9	0.15	10	1	6.67
10	0.166667	11	1.1	6.60
15	0.25	14	1.4	5.60
20	0.333333	18	1.8	5.40
25	0.416667	19	1.9	4.56
30	0.5	21	2.1	4.20
35	0.583333	23	2.3	3.94
40	0.666667	24	2.4	3.60
45	0.75	25	2.5	3.33
50	0.833333	26	2.6	3.12
60	1	28	2.8	2.80
70	1.166667	30	3	2.57
80	1.333333	32	3.2	2.40
90	1.5	33	3.3	2.20
100	1.666667	33	3.3	1.98
110	1.833333	35	3.5	1.91
120	2		3.5	1.91

Graph 1: Plot between Infiltration rate (cm/hr) Vs Time (hr) at Chahli village, Pawai Block

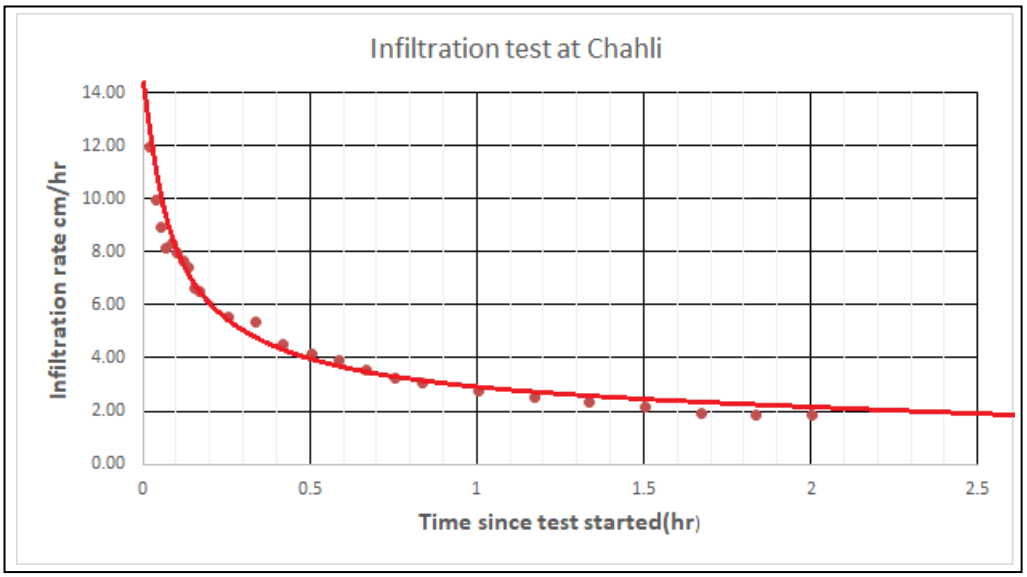


Table 5: Infiltration test data at village Gunour, Block Gunour

Location: Gunour			**Longitude:**80.25488, **Latitude:**24.44282	
time (minutes)	time (hr)	depth (mm)	depth (cm)	Infiltration capacity(cm/hr)
1	0.016667	0	0	16
2	0.033333	1	0.1	14
3	0.05	6	0.6	12
4	0.066667	7	0.7	10.5
5	0.083333	10	1	12
6	0.1	13	1.3	13
7	0.116667	15	1.5	12.85714286
8	0.133333	16	1.6	12
9	0.15	17	1.7	11.33333333
10	0.166667	20	2	12
11	0.183333	20	2	10.90909091
12	0.2	21	2.1	10.5
13	0.216667	21	2.1	9.692307692
18	0.3	26	2.6	8.666666667
23	0.383333	30	3	7.826086957
28	0.466667	33	3.3	7.071428571
33	0.55	36	3.6	6.545454545
38	0.633333	40	4	6.315789474
48	0.8	41	4.1	5.125
53	0.883333	45	4.5	5.094339623
58	0.966667	47	4.7	4.862068966
63	1.05	49	4.9	4.666666667
68	1.133333	50	5	4.411764706
73	1.216667	53	5.3	4.356164384

83	1.383333	55	5.5	3.975903614
93	1.55	56	5.6	3.612903226
103	1.716667	59	5.9	3.436893204
113	1.883333	63	6.3	3.345132743
123	2.05	68	6.8	3.317073171
133	2.216667	73	7.3	3.293233083

Graph 2: Plot between Infiltration rate (cm/hr) Vs Time (hr) at Gunour village, Gunour Block.

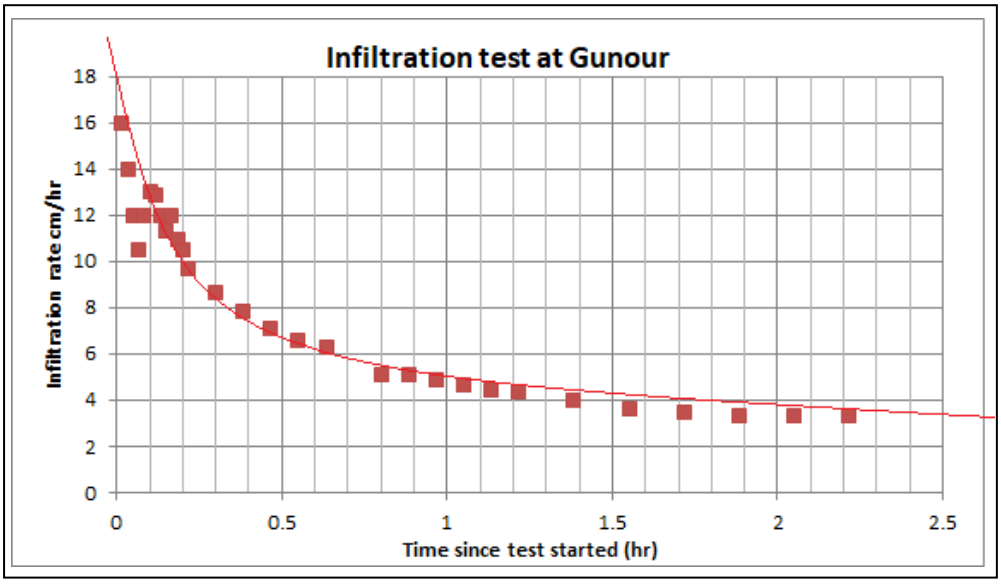


Table 6: Infiltration test data at village Tulla, Block Shahnagar

Location	Tulla		**Longitude**	80.08263
Block	Shahnagar		**Latitude**	24.01931
time (minutes)	time (hr)	depth (mm)	depth (cm)	Infiltration capacity(cm/hr)
0		0		
1	0.016667	5	0.5	30
2	0.033333	7	0.7	21
3	0.05	12	1.2	24
4	0.066667	15	1.5	22.5
5	0.083333	18	1.8	21.6
10	0.166667	28	2.8	16.8
15	0.25	35	3.5	14
20	0.333333	39	3.9	11.7

25	0.416667	44	4.4	10.56
30	0.5	50	5	10
35	0.583333	54	5.4	9.257142857
40	0.666667	57	5.7	8.55
50	0.833333	59	5.9	7.08
60	1	67	6.7	6.7
70	1.166667	74	7.4	6.342857143
80	1.333333	77	7.7	5.775
90	1.5	80	8	5.333333333
100	1.666667	85	8.5	5.1
110	1.833333	87	8.7	4.745454545
120	2	91	9.1	4.55

Graph 3: Plot between Infiltration rate (cm/hr) Vs Time (hr) at Tulla village, Shahnagar Block.

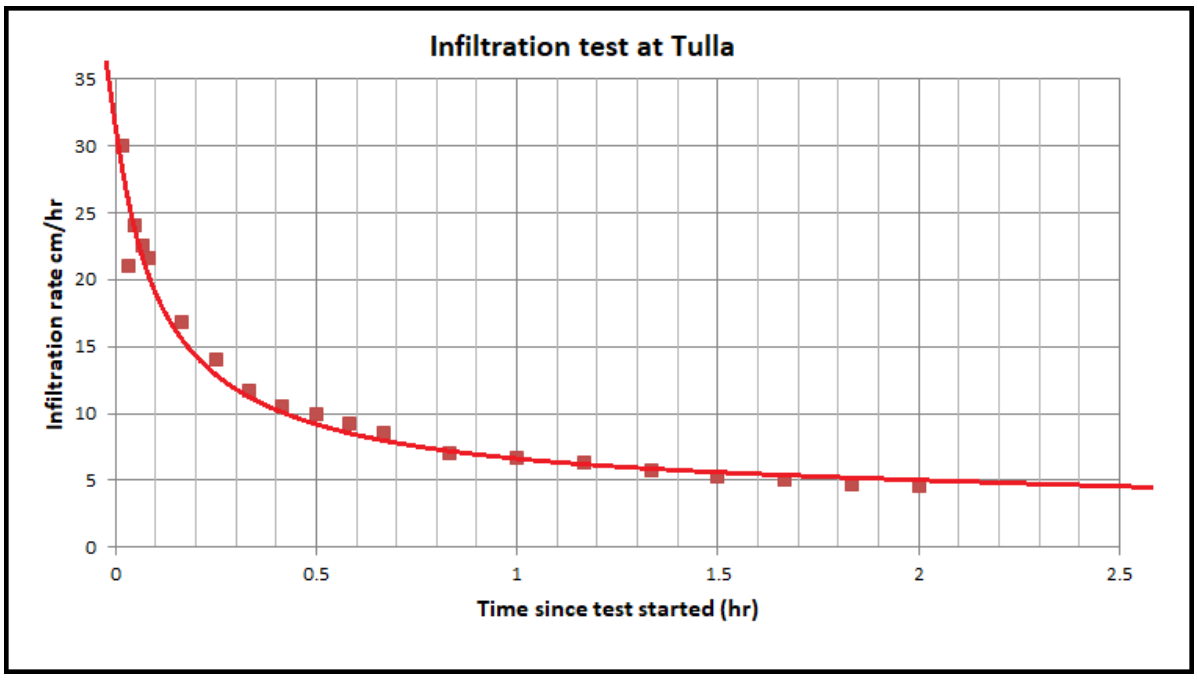


Table 7: Infiltration test data at village Vikrampur, Block Panna

Location	Vikrampur		**Longitude**	80.28194
Block	Panna		**Latitude**	24.7141
time (minutes)	time (hr)	depth (mm)	depth (cm)	Infiltration capacity(cm/hr)
	0	0	0	
1	0.016667	0	0	5
2	0.033333	1	0.1	4
3	0.05	1	0.1	3
4	0.066667	1	0.1	1.9
5	0.083333	2	0.2	1.7
10	0.166667	4	0.4	1.56
15	0.25	5	0.5	1.49
20	0.333333	5	0.5	1.5
25	0.416667	7	0.7	1.44
30	0.5	8	0.8	1.4
40	0.666667	9	0.9	1.35
50	0.833333	10	1	1.2
60	1	11	1.1	1.1
70	1.166667	12	1.2	1.028571429
90	1.5	13	1.3	0.866666667
120	2	14	1.4	0.7
150	2.5	15	1.5	0.6

Graph 4: Plot between Infiltration rate (cm/hr) Vs Time (hr) at Vikrampur village, Panna Block

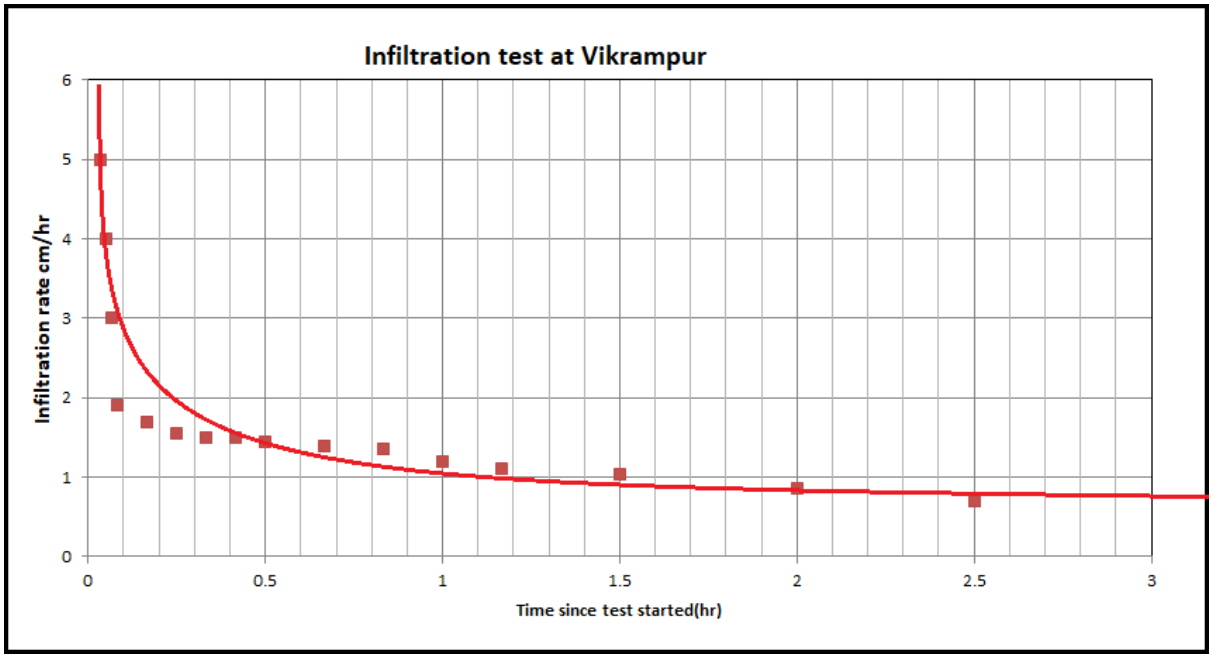


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Table 8: Infiltration test data at Bundela Dabha, Block Ajaygarh

Location	Bundela Dabha	**Longitude**	80.27746
Block	Ajaygarh	**Latitude**	24.86523
time (minutes)	time (hr)	depth (cm)	soil infiltration(cm/hr)
1	0.016667	1	60
2	0.033333	1	30
3	0.05	1	27
4	0.066667	1	23
5	0.083333	2	21
10	0.166667	3	18
15	0.25	4	16
20	0.333333	5	15
30	0.5	6	12
40	0.666667	6	9
50	0.833333	7	8.4
60	1	8	8
70	1.166667	10	8.571428571
80	1.333333	12	9
90	1.5	13	8.666666667
100	1.666667	13	7.8
110	1.833333	14	7.636363636
120	2	14	7
130	2.166667	14	6.461538462

Graph 5: Plot between Infiltration rate (cm/hr) Vs Time (hr) at Bundela Dabha, Ajaygarh Block

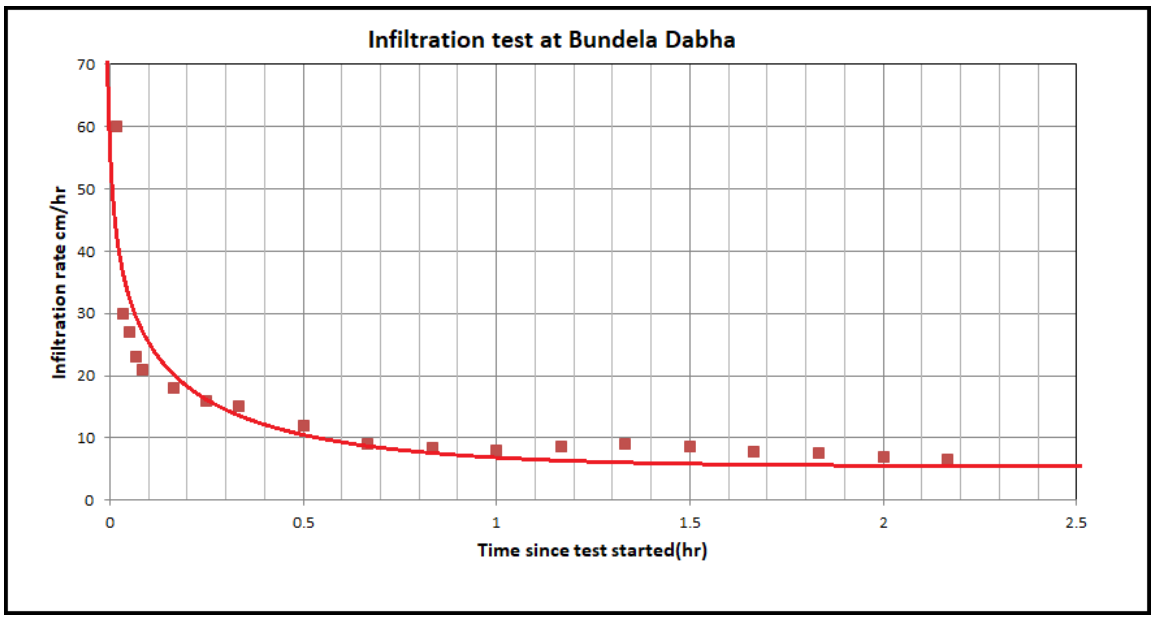


Table 9: Infiltration test data at village Harshini, Block Ajaygarh

Location	Harshini	Longitude	80.27048
Block	Ajaygarh	Latitude	24.97798
time (minutes)	time (hr)	depth (cm)	soil infiltration(cm/hr)
1	0.016667	0.2	12
2	0.033333	0.3	9
3	0.05	0.35	7
4	0.066667	0.333333333	5
5	0.083333	0.333333333	4
6	0.1	0.37	3.7
7	0.116667	0.396666667	3.4
8	0.133333	0.426666667	3.2
9	0.15	0.45	3
10	0.166667	0.45	2.7
15	0.25	0.65	2.6
20	0.333333	0.803333333	2.41
25	0.416667	0.958333333	2.3
30	0.5	1.1	2.2
35	0.583333	1.108333333	1.9
40	0.666667	1.2	1.8
45	0.75	1.2525	1.67
50	0.833333	1.258333333	1.51
55	0.916667	1.283333333	1.4
60	1	1.34	1.34
70	1.166667	1.493333333	1.28
80	1.333333	1.613333333	1.21
90	1.5	1.785	1.19
100	1.666667	1.9	1.14
110	1.833333	1.833333333	1
120	2	1.6	0.8
130	2.166667	1.733333333	0.8

Graph 6: Plot between Infiltration rate (cm/hr) Vs Time (hr) at Harshini village, Ajaygarh Block

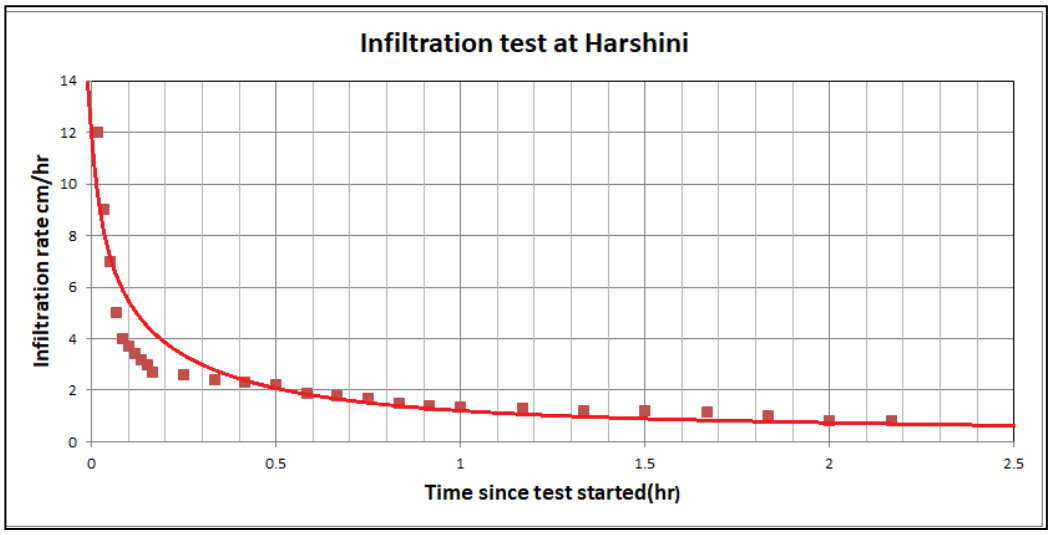


Table 10: Summarized result of Infiltration test

Sn	Location	fo in cm	fc in cm	Fc shaded area unit	k	Time for f is calculated		f Infiltration rate in cm/hr
					$k = \frac{fo-fc}{Fc}$		$fo - fc$	$f = f_c + (f_o - f_c)\, e^{-kt}$
1	Chahli	15	1.909	5	2.6182	120	13.091	1.909
2	Gunour	18	3.29	8	1.83875	133	14.71	3.29
3	Tulla	33	4.55	4	7.1125	120	28.45	4.55
4	Vikrampur	14	0.6	2.5	5.36	150	13.4	0.6
5	Bundela Dabha	70	6.46	2	31.77	130	63.54	6.46
6	Harshini	14	0.8	5	2.64	130	13.2	0.8

Micro level data collection-

128 nos. of key wells has been generated in Panna district, their pre monsoon and post-monsoon of year 2017 water level has been monitored along with the collection of 128 no. of ground water samples. Monitoring has been done in the month of July and December 2017. The July 2017 water level shows depth to water level ranges between 0.25 m,bgl to 13.5m bgl with the minimum 0.25m, bgl and maximum 13.55m bgl. 24.22% of wells showing water level in the range between 0-2 m, bgl. 25.78% of wells ranges between 2-5m, bgl. 41.41% of wells showing water level in the range of 5-10m, bgl. 8.59% of wells showing water level in the range of 10-20m bgl.

During post-monsoon period, water level ranges from 0.1 m,bgl to 13.1 m,bgl. 13.28% of wells showing water level showing in the range of 0-2m,bgl. 35.94% of wells showing water level showing in the range of 2-5 m,bgl, 45.31% of wells showing in the range of 5-10m bgl. 5.47% of wells showing water level between 10-20 m,bgl.

Fig16: Location of Key observation wells

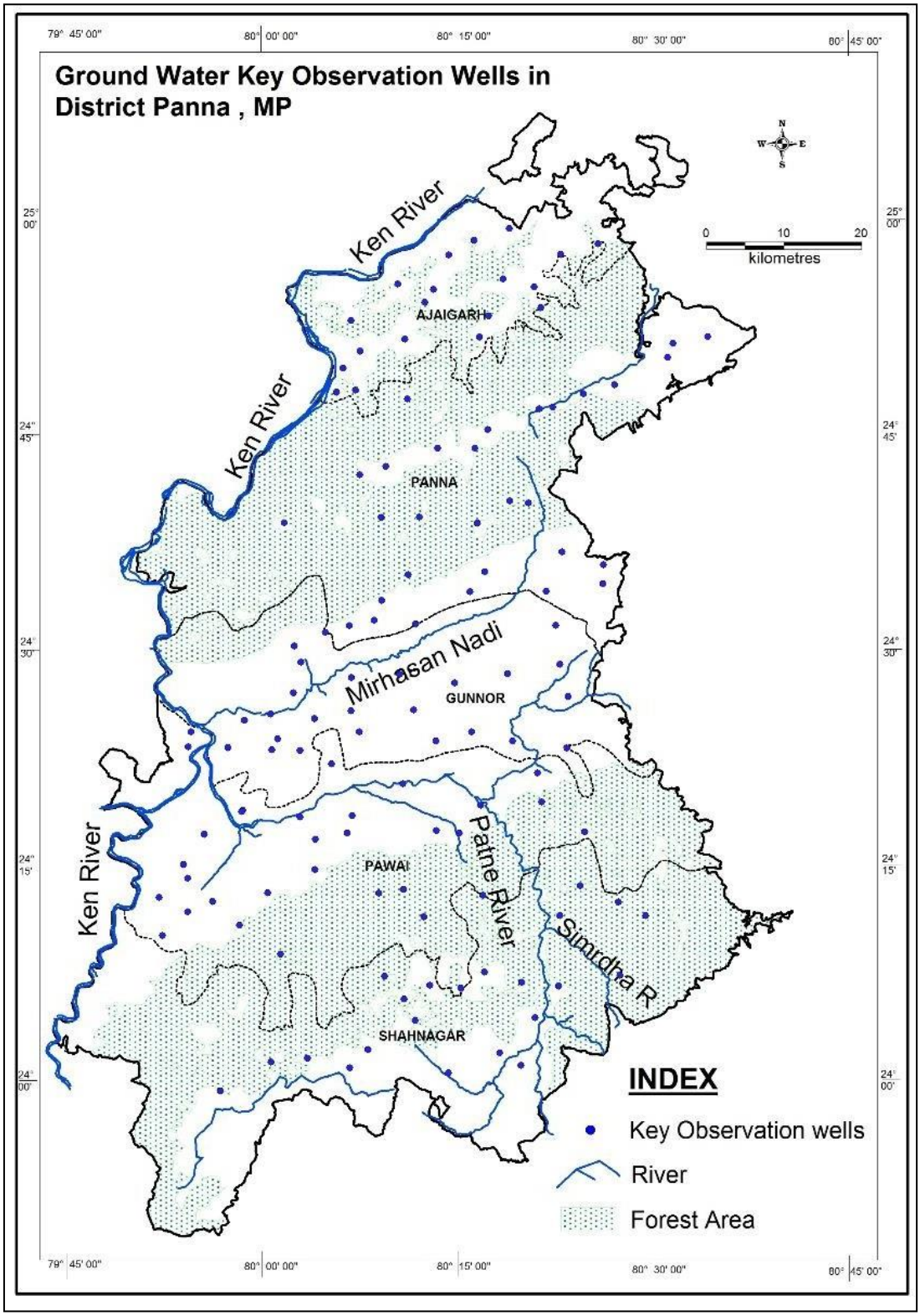


Fig 17: Pre-monsoon-2017 (key wells)

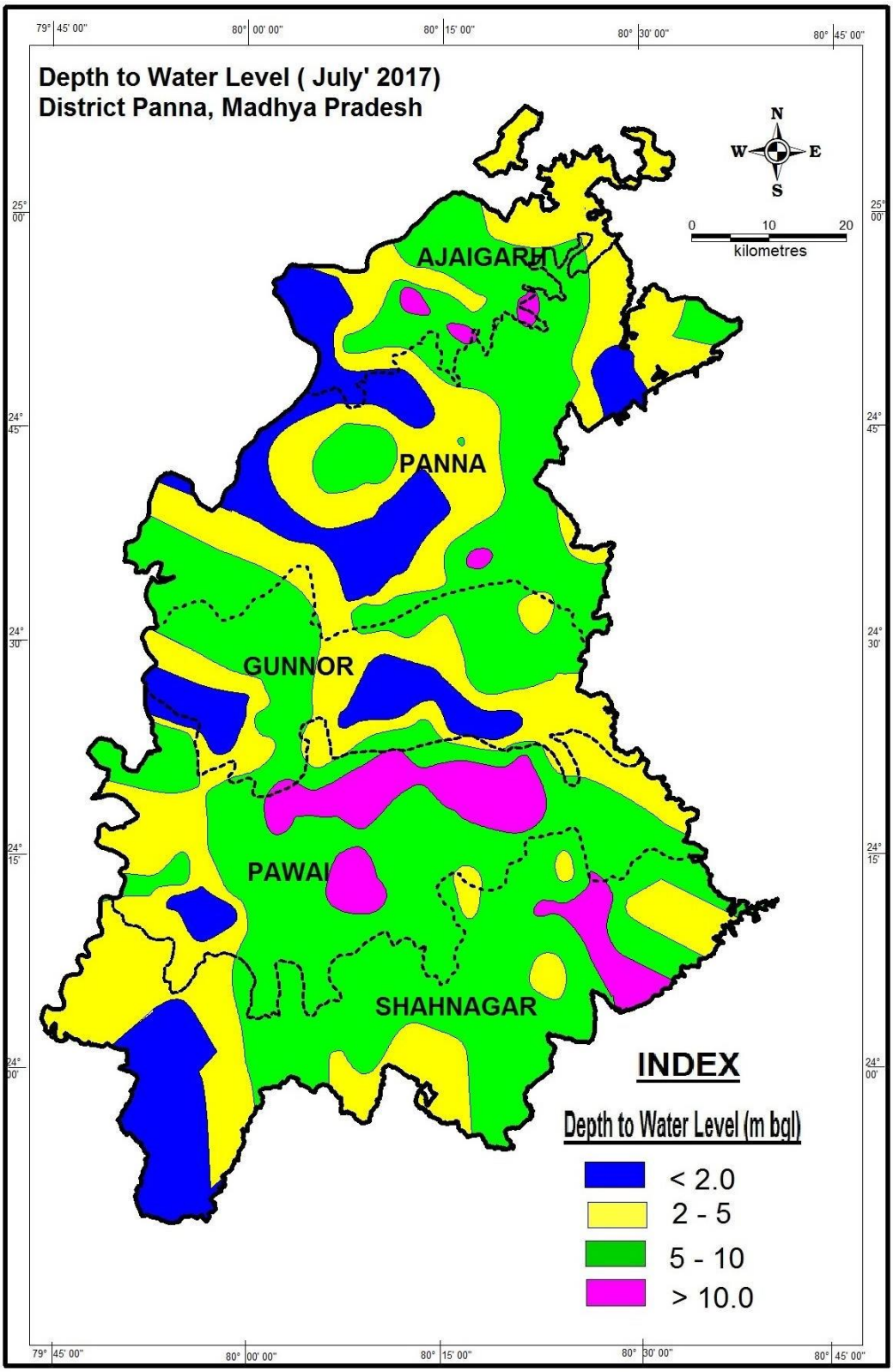
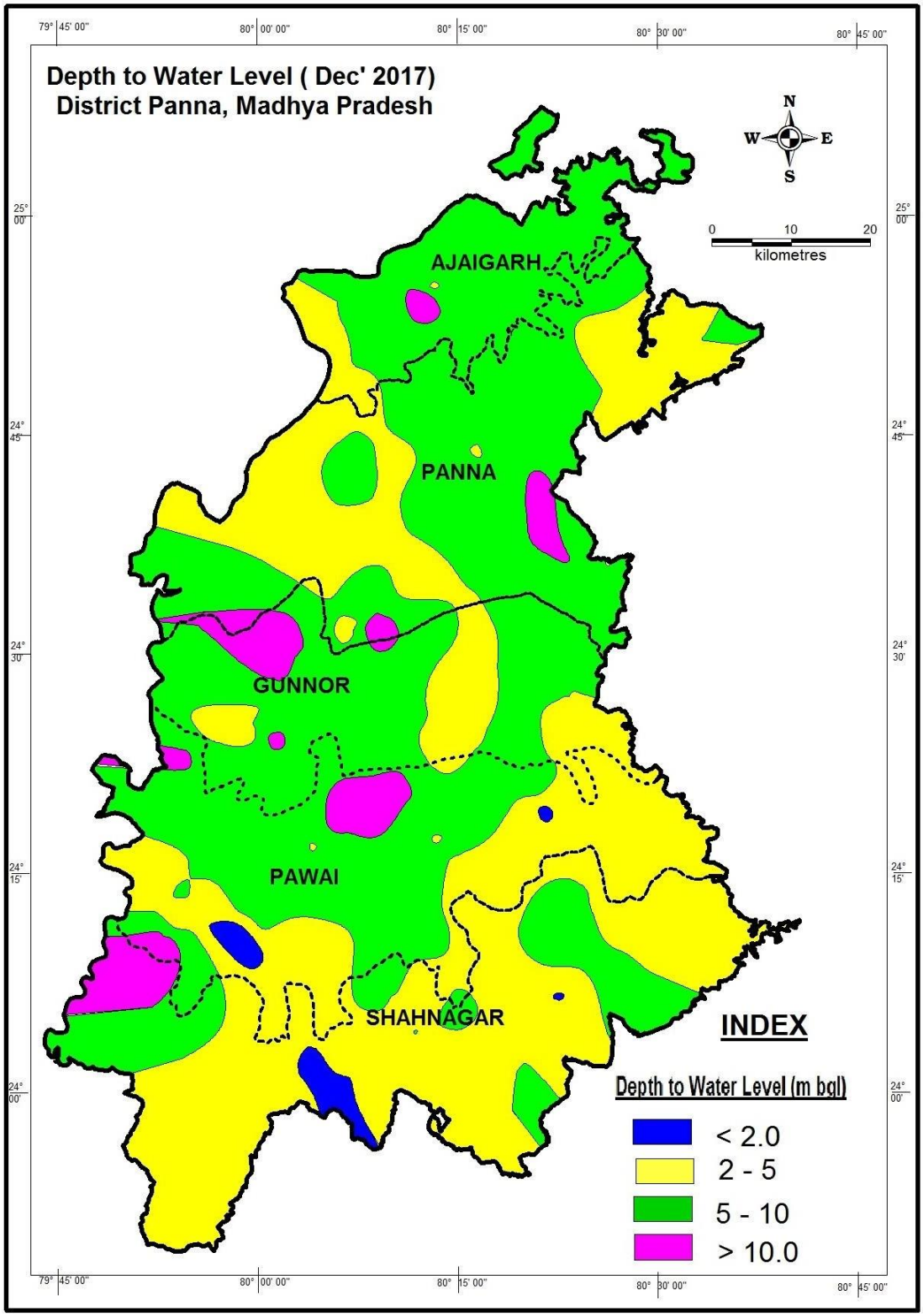


Fig 18: Post-monsoon-2017 (key-wells)



PANNA DIAMOND MINING: Panna district is famous for its diamonds. Diamond occur in both primary source and secondary source in the area. The primary source of diamond is from kimberlite pipe and secondary source in diamond bearing conglomerate, together they constitute the Panna Diamond belt spread over 80 km belt of Panna group. Majhgawan is the only active primary source of diamond mining in Asia.

Geology: Regionally the Vindhyan Super Group is underlined by the Bundelkhand granite. The Kimberlite pipe is intrusive into the lower Semri and Kaimur Groups of the Vindhyan Supergroup. The upper Rewa Bhander Group is young to the pipe and comprises of conglomerate band, which are diamondiferous.

The Majhgawan area is underlained by Baghain sandstone formation with frequent shale parting. The sandstone is light grey to white and fine to medium grained. The thickness of the Baghain sandstone formation is 90-95 m. The Pipertola conglomerate formation underlies the Baghain formation and comprises of 5-10m thick red and grey colored Jaspery conglomerate. The Kaimur Group is underlained by the Semri Group comprising of black and dark grey colored Palkawan shale formation overlies the Pandwal sandstone. The Pandwal sandstone unconformably overlies the Bundelkhand granites. The Kimberlite Diamondiferous daitremes are intrusive in to the above sequences through the Granitic basement and are exposed on the top of Baghain sandstone. Ground water table is not encountered in these bore holes up to 200m.

Fig 19: Panna Diamond mines at Majhgawan

TABLE 11 - INFORMATION REGARDING THE GROUND WATER LEVELS IN AND ARROUND DIAMOND MINING PROJECT, MAJHGAWAN DURING POST MONSOON OCTOBER 2017

S.NO.	BOREWELL/ OPEN WELLS	LOCATION NAME	Latitude	Longitude	GROUND LEVEL (M) above MSL	GROUND WATER LEVEL (BGL) POST MONSOON OCTOBER 2017
1	EBW -1	GM Residence	23.6484	80.0358	374	10.21
2	EBW -2	Near Anganvadi, Akash Nagar colonuy	24.6509	80.0418	358	4.88
3	EBW -3	Near quarter no. 75, Akash Nagar NMDC colony	24.6501	80.0411	360	4.21
4	EBW -4	Near Hospital 1st lane road, Hinauta	24.6488	80.0404	363	6.19
5	EBW -5	Near Bharath matha Mandir, Hinauta	24.6501	80.0386	364	15.74
6	EBW -8	Near Mobile tower, Hinauta	24.6475	80.0280	387	3.98
7	EOW-10	Hinauta	24.6503	80.0250	386	1.92
8	EBW-11	Hinauta foreat quarters	24.6454	80.0259	386	5.15
9	EBW -12	Infront of Govt. School, Hinauta	24.6456	80.0240	388	36.22
10	EBW - 14	Near bridge, Kaimasan	24.6554	80.0517	384	11.72
11	EBW - 15	Kaimasan colony	24.6554	80.0526	349	3.65
12	EBW - 17	Near Rashen shop, Badore village	24.6682	80.0686	359	4.9
13	EBW- 22	Sash Mathya Shala, Badore	24.6702	80.0700	359	3.01
14	EBW - 23	Behind the school, Badore	24.6674	80.0620	360	4.95
15	EOW-26	Umaravan	24.7008	80.0682	404	2.3
16	EBW-27	Infront of the School, Umravan	24.7000	80.0671	407	9.16
17	EBW-28	Umaravan	24.7043	80.0688	400	3.98
18	EBW-32	Jardhobha	24.6446	80.1133	489	17.21
19	EOW-33	Old Magazine area	24.6420	80.0310	371	5.97
20	EOW-34	Gudiyana	24.6479	80.0298	382	2.87
21	EOW-35	Near Hanuman temple	24.6439	80.0300	378	13.85

Impact of Diamond Mining on Groundwater Level:

Post monsoon Water Level near Majhgawan diamond mines for pheratic aquifer ranges between 1.92m bgl at Hinauta to 13.85m,bgl near hanuman temple and for deeper aquifer it ranges between 3.01 m, bgl to 36.22 m, bgl at Sash Mathya Shala, Badore and in front of govt. school Hinauta respectively.

The Quality analysis in and around area indicate high iron content in the mine area. At some isolated pockets of the area, higher concentration of nitrates found which are caused due to improper solid wastes and poor sanitation near the villages. However concentration is within permissible limits.

Although there is no major impact of diamond mining in groundwater level is found in the area but groundwater quality is of concern. Abandoned pit is being used as a reservoir and during summer season water supply is being done from that reservoir.

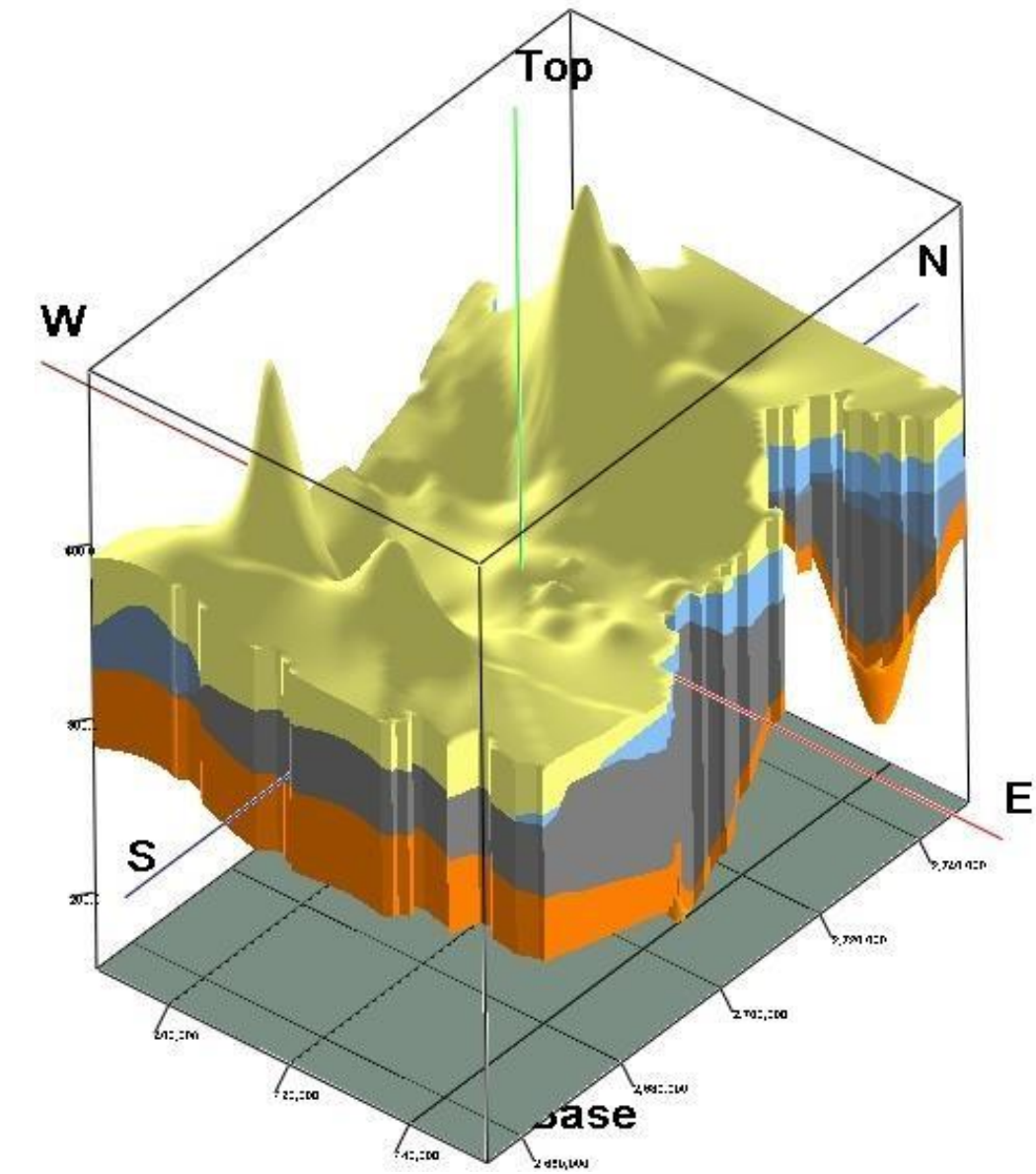
CHAPTER-III Data Interpretation/Preparation of Aquifer Map

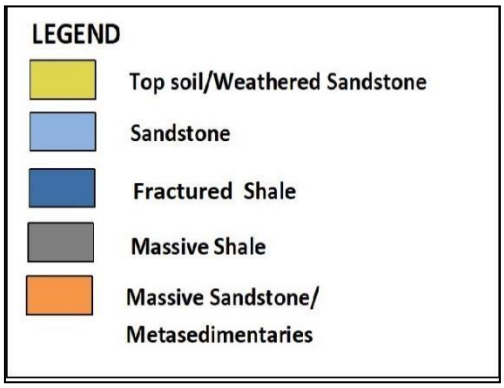
3-Dimensional Stratigraphic Model

A 3-Dimensional stratigraphic model prepared for the Panna district, Madhya Pradesh after detailed analysis of the pre-existing and available bore-log data collected from the Basic Data Reports of CGWB. A comprehensive analysis has been done as per lithology and stratigraphy of the area. The location details with RL values and their corresponding stratigraphic details as per the Rockworks format is provided in the Annexures- I ,II and III.

2-Dimensional Hydrogeological Cross- Sections

In Panna District, 2-D cross section prepared. Cross section XX' along NW-SE direction using borewells Amjhiria. Kakrahati and Saleha. Cross-section YY' in the NE-SW direction was prepared using 5 borewells Amjhiria, Janakpura, Krishnakalyanpur, Brijpur & Pahadikheda..





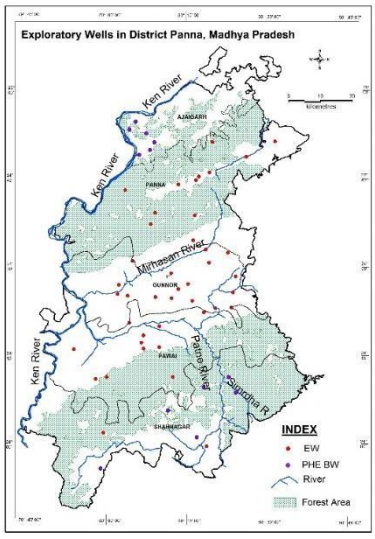


Fig 20: 3 D Lithological Model of Panna District

Fig 21: 2-Dimensional Cross-Section

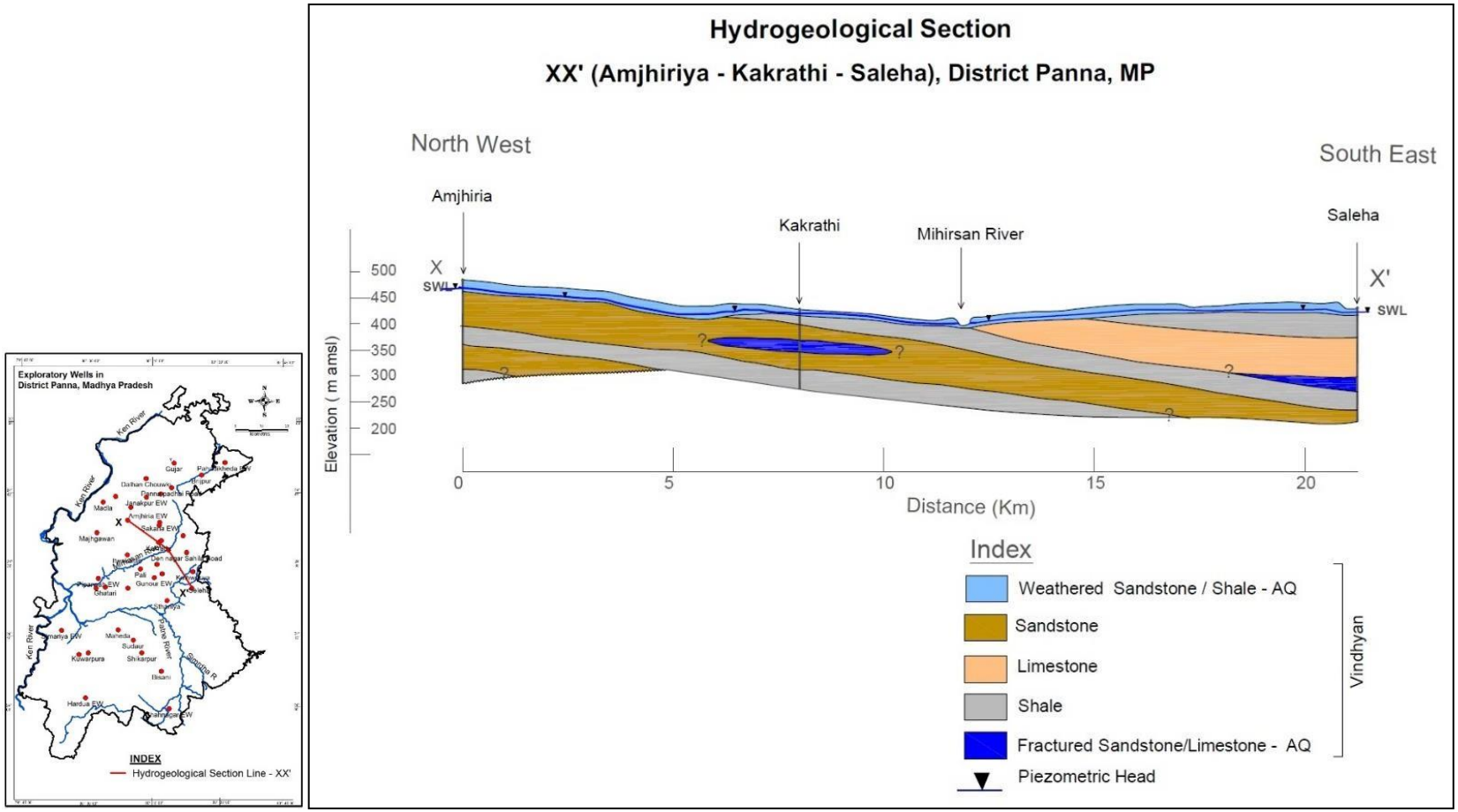
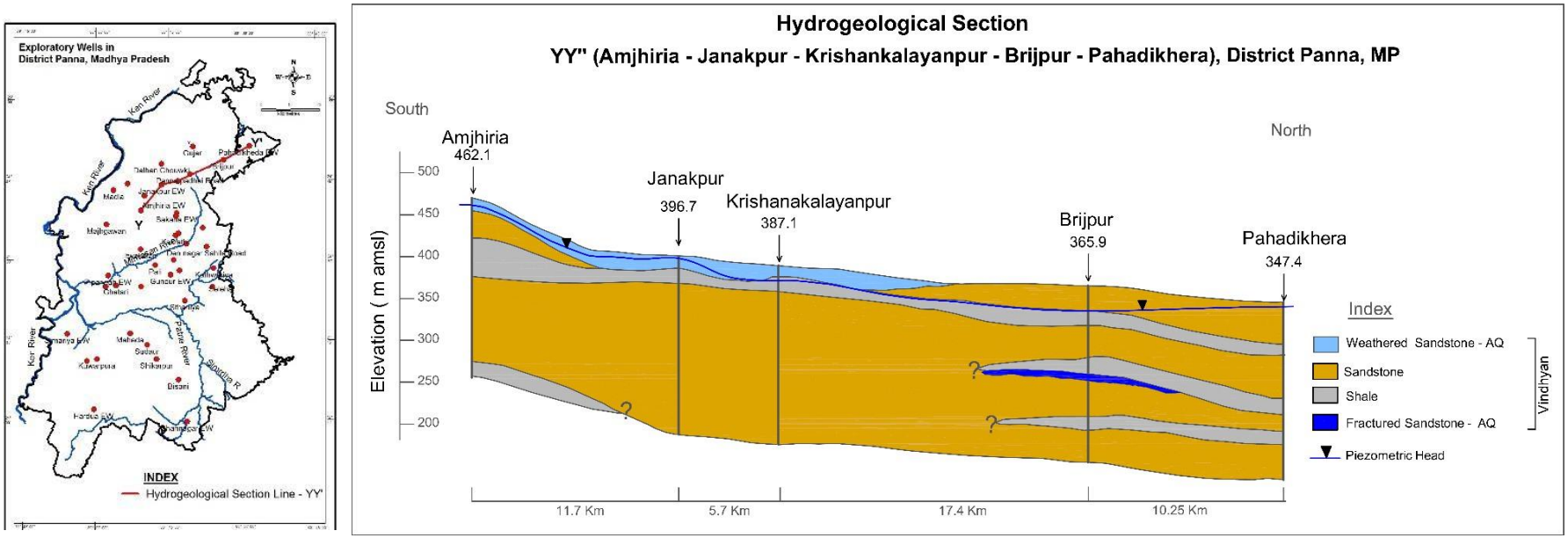


Fig 22: 2-Dimensional Cross-Section



Result and Data Interpretation:

Lithological data collected from CGWB bore wells, Piezometers, State ground water Piezometers etc. were studied and aquifer geometry and properties interpreted detail Litho logs of boreholes were studied and compressed data in form of Rockworks data sheet.

Aquifer System

From the various representative boreholes data some generalization has been made. In panna block majority of the tube wells tap weathered shales and fractured sandstone as productive aquifer. The contact of Jhiri shales and upper Rewa sandstone also proved to be water bearing. In Gunour block the Sirbu shales mainly and occasionally Bhander limestone and or Ganurgarh shale forms as aquifer. In Pawai block mostly Bhander shales which is highly weathered and overlie the fractured and jointed Bhander sandstone seems to be the productive horizon. Shahnagar shows similar disposition of aquifers.

In Ajaygarh block promising groundwater zone is alluvial- fill that occurs in the valleys formed on the weathered basement granite. An elongated narrow valley in NE to SW direction between 24˚45' to 25˚00' and longitude 80˚15'10" to 80°30'50" is very prominent for its water bearing capacity. The dug wells (8-12m. deep) sustain heavy pumping (with 5 H.P. running for 16-24 hours) with low to moderate drawdown. The surface water drainage carrier is Range Nadi which originates from the Vindhyan catchment (Rewa Sandstone) and cuts through granitic terrain (Archean). Auto-flow Artesian wells and spring have been observed around village Kushedar (Limestone aquifer) 24°27'50"/ 80°19'30" and around Harira (Limestone) 24°27'and 80°21'00". Similarly semi perennial auto flow well with poor to unsuitable quality of groundwater is seen Kakrahti (shale) 24°34'30", 80°16'30" Dubahiyan (shale) 24°36'30": 80°25'30".

The aquifer formed by weathered granitic mass occurring as medium to coarse sand; poorly rivers are moderate to highly potential with higher specific capacity in its yielding are limited in areal extent usually extend in depth between 20-50 meters bgl.

Consolidated aquifers formed by shales and jointed sandstones of Vindhyans are both shallow and deep as far as occurrence is concerned. The shallow aquifers occur between 20-50m. bgl while deep aquifers are between 60-85 meters bgl.

The cavernous limestone occurring West of Panna and Pawai along Sonar river and East of Gunor block in association with bedded and jointed sandstone act as aquifer. These vindhyans aquifers are of limited width and extension. Thus they are with limited storage capacity. Ground water from most of these aquifers comes out as base flow leakage to the adjoining river system. The general ground water gradient is commonly steep and conforms to the physiography and merges towards drainage of the area.

CHAPTER-IV Ground Water Resources

Dynamic Ground Water Resource & Draft:

The dynamic ground water resources of the Madhya Pradesh State assessed jointly by the CGWB and State Ground Water Departments under the supervision of the State level Committees. The base year of computation of the resources is 2017.

The dynamic ground water resources are also known as Annual Replenishable Ground Water Resources since it gets replenished/ recharged every year. The Annual Replenishable Ground Water Resource for the Panna District has been `assessed as 449.65 MCM. The major source of ground water recharge is the monsoon rainfall. Block-wise Ground Water Resources of Panna District as on March, 2017 is given in Table No.11 and the presents the over-all scenario of ground water resource utilization and availability of the District.

The assessment of ground water draft is carried out based on the Minor Irrigation Census data and sample surveys carried out by the State Ground Water Departments. The Annual Ground Water Draft of the entire district for 2017 has been estimated as 172.25 MCM. Agriculture sector remained the predominant consumer of ground water resources. About 83.55 % of total annual ground water draft i.e. 143.99 MCM is for irrigation use. Only 28.34 MCM is for Domestic & Industrial use which is about 16.45% of the total draft. An analysis of ground water draft figures indicates that in the district 38.32% is stage of ground water development.

Table No 11. Dynamic Ground Water Resource

DYNAMIC GROUND WATER RESOURCES (As on March, 2017)									
S. No.	**Assessment Unit**	**Sub-unit Command/ Non-Command/**	**Net Annual Ground water Availability (MCM)**	**Existing Gross Ground water Draft for Irrigation (MCM)**	**Existing Gross Ground water Draft for Domestic & Industrial water Supply (MCM)**	**Existing Gross Ground water Draft for All uses (MCM)**	**Net Ground water Availability for future irrigation development (MCM)**	**Stage of Ground Water Development (%)**	**Category**
1	Ajaygarh	Command	8.59	2.13	0.14	2.27	6.32	26.40	Safe
		Non-Command	99.30	61.34	4.47	65.81	33.48	66.28	Safe
		Block Total	107.88	63.47	4.61	68.08	39.80	63.10	Safe
2	Gonour	Command	6.09	0.21	0.65	0.85	5.24	14.00	Safe
		Non-Command	44.33	11.77	5.8	17.57	26.76	39.64	Safe
		Block Total	50.42	11.98	6.45	18.43	31.99	36.54	Safe
3	Panna	Command	9.15	2.05	0.42	2.47	6.68	27.03	Safe

		Non-Command	114.10	26.14	5.79	31.93	82.17	27.99	Safe
		Block Total	123.25	28.20	6.21	34.41	88.84	27.92	Safe
4	Pawai	Command	7.33	0.44	0.39	0.83	6.50	11.30	Safe
		Non-Command	92.36	23.90	5.89	29.79	62.57	32.25	Safe
		Block Total	99.69	24.33	6.28	30.61	69.08	30.71	Safe
5	Shahnagar	Command	9.63	0.62	0.48	1.10	8.53	11.42	Safe
		Non-Command	58.78	15.37	4.3	19.67	39.11	33.46	Safe
		Block Total	68.41	15.99	4.78	20.77	47.64	30.36	Safe
		District Total	449.65	143.97	28.33	172.29	277.36	38.32	Safe

Static Ground Water Resource & Draft- (Outcome of NAQUIM)

The Ground Water Resource of Panna district has been calculated block-wise considering the variable lithology and their associated aquifer parameters like specific yield. The In-storage resource for the shallow aquifer below zone of fluctuation (upto 30 mbgl) is computed to be around 226.54 MCM. The static resource for the deeper aquifer (30-200 mbgl) is computed as 156.83 MCM. The draft of dug well and tube well has been calculated separately to assess the ground water draft for irrigation from shallow and deeper aquifers that accounts to 172.30 MCM and 84.76 MCM respectively. The block-wise details of ground water resources and draft as an outcome of NAQUIM are presented in the Table no 12.

Table 12: Static Ground Water Resources (Outcome of NAQUIM), Panna District, Madhya Pradesh

Block	Ajaygarh	Gonour	Panna	Pawai	Shahnagar	Total
Shallow Aquifer						
Dynamic Resources (MCM)	**107.88**	**50.42**	**123.25**	**99.69**	**68.41**	**449.65**
In- Storage Resources (MCM)	**81.77**	**45.97**	**48.53**	**23.25**	**27.02**	**226.54**
Total Resources (MCM)	**189.65**	**96.39**	**171.78**	**122.94**	**95.43**	**676.19**
Irrigation (MCM)	**63.46**	**11.98**	**28.20**	**24.33**	**15.99**	**143.96**
Domestic+Industries (MCM)	**4.61**	**6.45**	**6.21**	**6.29**	**4.78**	**28.34**
GW Draft (MCM)	**68.07**	**18.43**	**34.41**	**30.62**	**20.77**	**172.30**
Deeper Aquifer						
Static Resources (MCM)	**20.23**	**28.50**	**57.52**	**27.94**	**22.63**	**156.83**
GW Draft (MCM)	**12.17**	**20.44**	**18.89**	**15.59**	**17.65**	**84.76**
Total Static Resources (Shallow+ Deeper Aquifer)						
Total GW Resources (MCM)	**209.88**	**124.90**	**229.30**	**150.89**	**118.05**	**833.02**
Gross Ground Water Draft (MCM)	**80.24**	**38.87**	**53.30**	**46.21**	**38.42**	**257.06**

CHAPTER-V Ground Water Related Issues

Low Stage of Ground Water Development

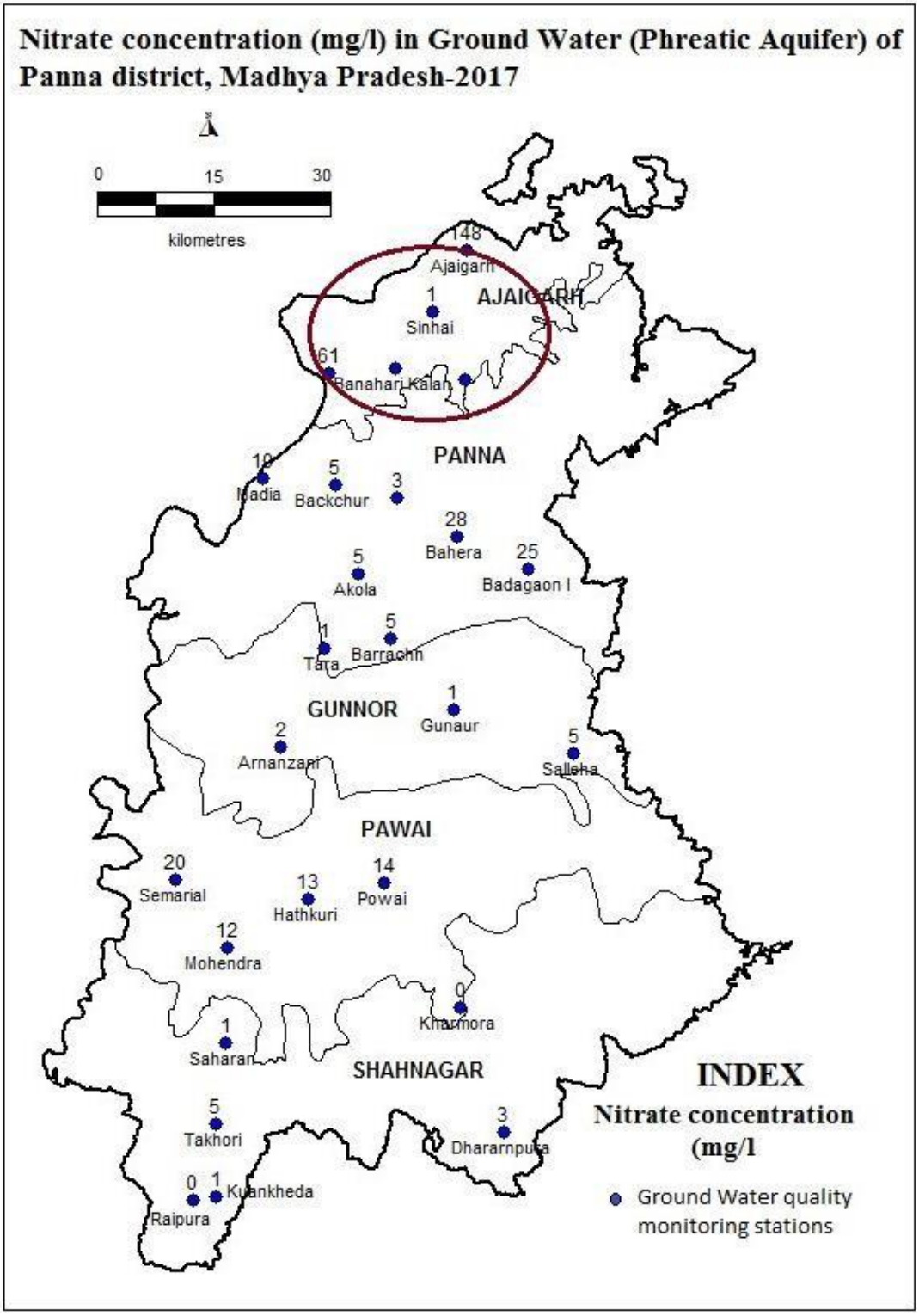
Utilisation of GW resources are poorly developed in Panna district, because of low development of groundwater, the area faces water scarcity problems in summer season. Being hard rock formation area, most of the groundwater resources is in shallow/ Pheratic in weathered sandstone. In deeper aquifer, groundwater is restricted and mostly found in fractured sandstone shale & limestone and along the bedding plane of the formation.

Ground Water Quality Problem

In parts of Ajaygarh block of panna district, nitrate contamination is there. This problem is due to anthropogenic reason and can be controlled.

The fluoride concentration in Panna district ranged in between BDL (below detection limit) to 1.32 mg/l. The maximum concentration of fluoride has been recorded in Pandepurwa village i.e. 1.32 mg/l. As per BIS recommendation, all water samples recorded fluoride concentration within the permissible limit of 1.50. In the district, nitrate concentration in ground water ranged in between BDL (below detection limit) to 148 mg/l. The concentration of nitrate more than 45 mg/l has been detected in ground water of Ajaygarh (148 mg/l) and Bariyarpur (61mg/l) dug wells. High nitrate in ground water appears may be due to anthropogenic activities or excessive use of fertilizers etc.

Fig 23: Nitrate affected area



CHAPTER-VI Ground Water Management Strategies

Need of Management Plan

The demand of fresh water for agriculture, drinking and industrial uses etc. has significantly increased due to population growth and socio-economic development. There is urgent need for taking up suitable water management interventions based on integrated approach, which on one hand includes augmentation of ground water resources through appropriate techniques, and on the other hand requires the adoption of suitable water conservation measures, such as ensuring water use efficiency through creation of additional water storage facility, maintenance/ renovation of existing water bodies etc.

District Groundwater Level Management Plan (Outcome of NAQUIM)

As per directions of Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India, preparation of Aquifer Management Plan for Panna district in the State has been prepared block wise as shown in Table no 13 and financial outlay plan is also shown in Table No 14. Each Plan discusses the broad framework of ground water situation in the block, status of water availability (both surface and ground water), identification of feasible areas for interventions, feasibility of abstraction structures and other water conservation structures, their design considerations, numbers and cost estimates. The expected outcomes of the proposed interventions have also been elucidated and given in table no 15. As Panna district having **Stage of Development 38.32%** after proposed intervention **Stage of Development will be 60%**

Supply Side Management

In Panna district, after 2017 water resource assessment all blocks are under safe category. Four blocks i.e., Panna, Pawai, Gunour and Shahnagar block are having less than 60% stage of groundwater development and Ajaygarh block is having more than 60% stage of groundwater development. Adoption of suitable water abstraction structures in Panna, Pawai, Gunour and shahnagar block and Artificial Recharge Structures in Ajaygarh block has been proposed.

Groundwater Abstraction Structures: For Panna, Gunour, Pawai, and Shahnagar block the stage of groundwater development is proposed to increase up to 60% by introducing groundwater abstraction structures such as dug wells and tube wells in the area. The number of abstraction structures has been calculated depending on amount of draft to be increased and net groundwater availability in the region. The new total draft has been calculated by multiplying net groundwater availability (taken from State groundwater resource estimation 2017) with 0.6 (as we want to increase the stage of groundwater development up to 60%). The existing total draft including all sources is subtracted from the new total draft.

After subtraction we get the required draft for proposed abstraction structures. Further, 50% of the draft calculated is considered for abstraction structure and has been allocated dug wells and bore wells equally. With the known unit draft of dug wells and bore wells block wise, the block wise number of dug wells and bore wells has been calculated by dividing allocated 50% draft of dug wells with unit draft of dug well and allocated 50% of bore well with unit draft of bore well within a block.

A financial outlay plan has also been prepared, as the cost for the dugwell is 1.5 lac and for tube well 2 lac per abstraction structure. This accounts to a total of Rs. 173 Crores to successfully implement the supply side management strategy. Table no. 13 and 14 represents the complete management plan and financial outlay plan of proposed abstraction structures i.e., for dug wells and tube wells respectively in the district and table no. 15 and 16 represent management plan and financial outlay plan in Ajaygarh block of Panna district.

Demand Side Management

In Panna district, Micro-irrigation comprises two technologies—drip and sprinkler irrigation. Both saves conveyance losses and improve water application efficiency by applying water near the root-zone of the plant. Some benefits of the micro-irrigation have been listed below:

1. 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).
2. It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities.
3. It saves costs of hired labour and other inputs like fertilizer.
4. 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.

Adoption of Sprinkler irrigation techniques would save 20% of gross ground water draft for irrigation. Also, the 60% of 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.

Fig 24: Ground Water Potential zone for abstraction structures and Area for Proposed Artificial Recharge Structures

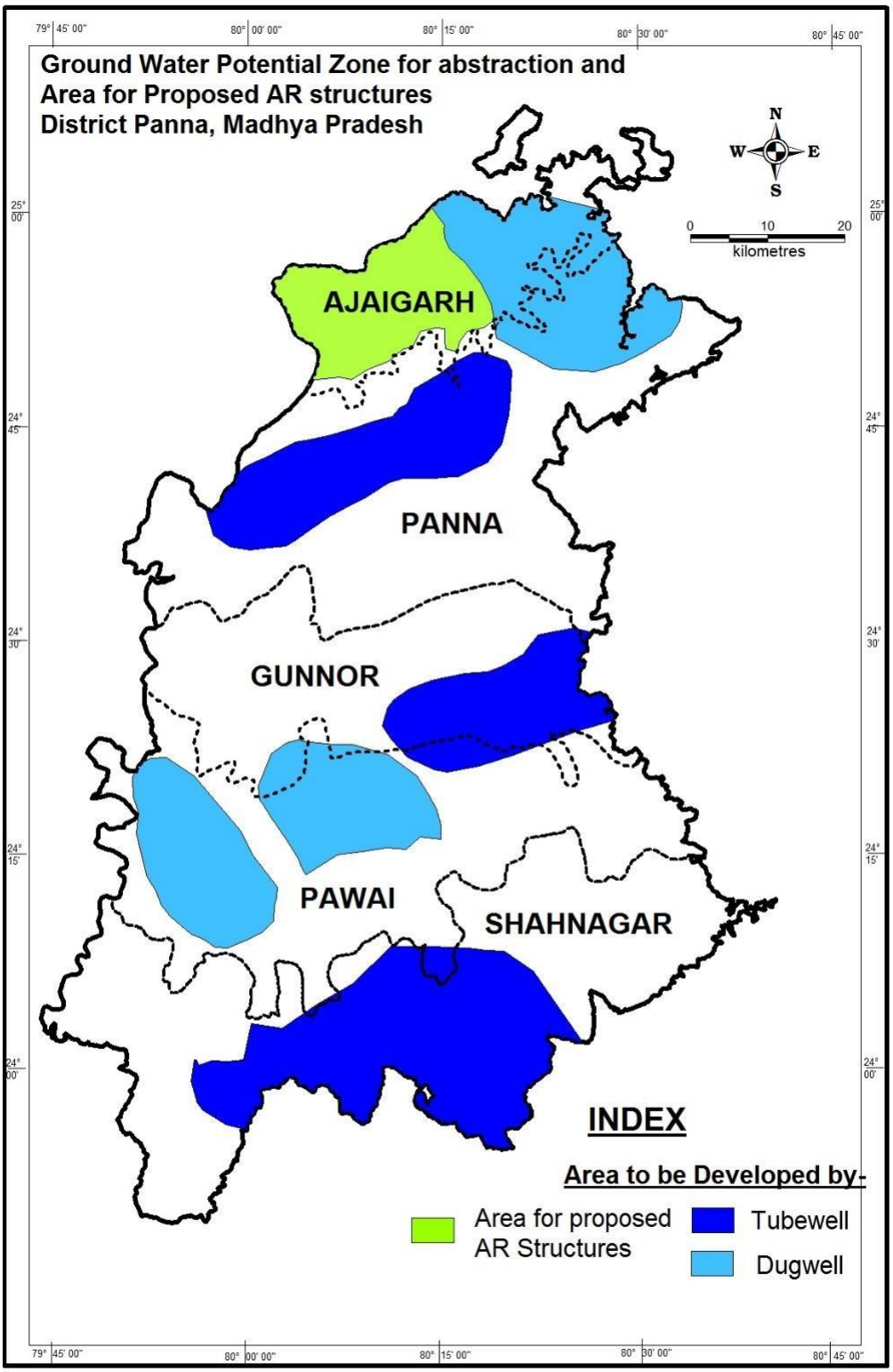


Table No 13: Panna District, Block Wise Management Plan (Proposed GW Abstraction Structures for Pheratic Aquifer)

Blocks	Ajaygarh	Gonour	Panna	Pawai	Shahnagar	Total
Net GW Availability (MCM)	**239.37**	**96.39**	**171.78**	**122.94**	**95.43**	**725.90**
Required draft (MCM) to reach upto 60% of Stage of GW development	143.62	57.84	103.07	73.76	57.26	435.54
Existing number of Dug well	8586	1187	2675	1810	1715	15973
Draft per DW (MCM)	0.0129	0.0098	0.0119	0.0142	0.0103	
Existing Draft of Dug well (MCM)	110.76	11.63	31.83	25.70	17.66	197.59
Domestic and Industrial draft (MCM)	4.61	6.45	6.21	6.29	4.78	28.34
Total required gross Draft after subtracting all other draft (MCM)	28.25	39.76	65.03	41.77	34.81	209.62
50% of Required draft (MCM)	14.13	19.88	32.51	20.88	17.41	104.81
Proposed Dug well (Nos.)	1095	2028	2732	1471	1690	9016
Cost of DW (Rs in Cr)	16.42	30.43	40.98	22.06	25.35	135.24
Irrigated area developed (Sq km)	35.31	49.70	81.28	52.21	43.51	262.02
Irrigated area developed (Ha)	3531.31	4969.70	8128.31	5221.22	4351.50	26202.05

Table No 14: Panna District, Block Wise Management Plan (Proposed Groundwater Abstraction Structure for Deeper Aquifer)

Blocks	Gonour	Panna	Pawai	Shahnagar	Total
Net GW Availability (MCM)	28.50	57.52	27.94	22.63	136.60
Required draft (MCM) to reach upto 60% of Stage of GW development	17.10	34.51	16.77	13.58	81.96
Existing Number of Bore well	528	576	447	445	1996.00
draft per BW (MCM)	0.0171	0.0228	0.0238	0.0195	
Existing Draft of Borewell (MCM)	9.03	13.13	10.64	8.68	41.48
Total required gross Draft after subtracting all other draft (MCM)	8.07	21.38	6.13	4.90	40.48
50% of Required draft (MCM)	4.04	10.69	3.06	2.45	20.24
Proposed Bore well (Nos.)	236	469	129	126	959
Cost of BW (Rs in Cr)	4.72	9.38	2.57	2.51	19.19
Irrigated area developed (Sq km)	10.09	26.73	7.66	6.12	50.60
Irrigated area developed (Ha)	1009.22	2672.58	766.01	612.25	5060.05

Table No 15: Management Plan for Artificial Recharge Structures in Ajaygarh Block, Panna District

Station	Area (Sq Km)	Area suitable for recharge (Sq Km)	Rainfall (m)	Average post-monsoon water level (m) (2008-2017)	Unsaturated zone (m)	Specific Yield %	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Village tank, pond and WCS
Ajaygarh	911	405	1.10	6.61	3.61	0.015	12.20	16.23	102.47	30.74	16	32	114	118

Table No 16: Financial Outlay Plan in Ajaygarh block, Panna District

Block	Area Suitable for AR	Volume of Surface Water available for AR (MCM)	Percolation Tanks		Recharge shaft/ Tube well		NB/ CD/ CP		Village tank, pond and WCS		Total Cost of (Rs. in crores)
			No. of structures	*Cost (in crores)*	*No. of structures*	*Cost (in crores)*	*No. of structures*	*Cost (in crores)*	*No. of structures*	*Cost (in crores)*	
Ajaygarh	**405**	**16.23**	**16**	**3.2**	**32**	**1.6**	**114**	**11.4**	**118**	**2.36**	**18.56**

The total Cost of Structures in panna district combining abstraction structures and artificial recharge structures is 172.99 Crores.

Table 17: Adoption of Sprinkler irrigation in Panna district.

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by Sprinklar (MCM)	Groundwater Availability after adopting sprinkler irrigation (MCM)	Stage of Development (%)
Ajaygarh	107.88	68.07	63.1	1.85	109.73	62.03
Gonour	50.42	18.43	36.54	2.8	53.22	34.63
Panna	123.25	34.37	27.88	2.83	126.08	27.26
Pawai	99.69	30.62	30.72	3.25	102.94	29.75
Shahnagar	68.41	20.76	30.35	1.92	70.33	29.52
Total	449.65	172.25	38.31	12.64	462.29	37.26

Table 18: Change in Stage of groundwater development in Panna district after adoption of abstraction structures.

Blocks	Shallow Aquifer			Deeper Aquifer		
	Net GW Availability in Shallow Aquifer (MCM)	Required draft to reach upto 60% of Stage of GW development	Stage of GW development in after adopting DW structures	Net GW Availability (MCM)	Required draft to reach upto 60% of Stage of GW development	Stage of GW development in after adopting BW Structures
Ajaygarh	**239.37**	143.62	60	20.23	12.14	60
Gonour	**96.39**	57.84	60	28.50	17.10	60
Panna	**171.78**	103.07	60	57.52	34.51	60
Pawai	**122.94**	73.76	60	27.94	16.77	60
Shahnagar	**95.43**	57.26	60	22.63	13.58	60
Total	725.90	435.54	60	156.83	94.10	60

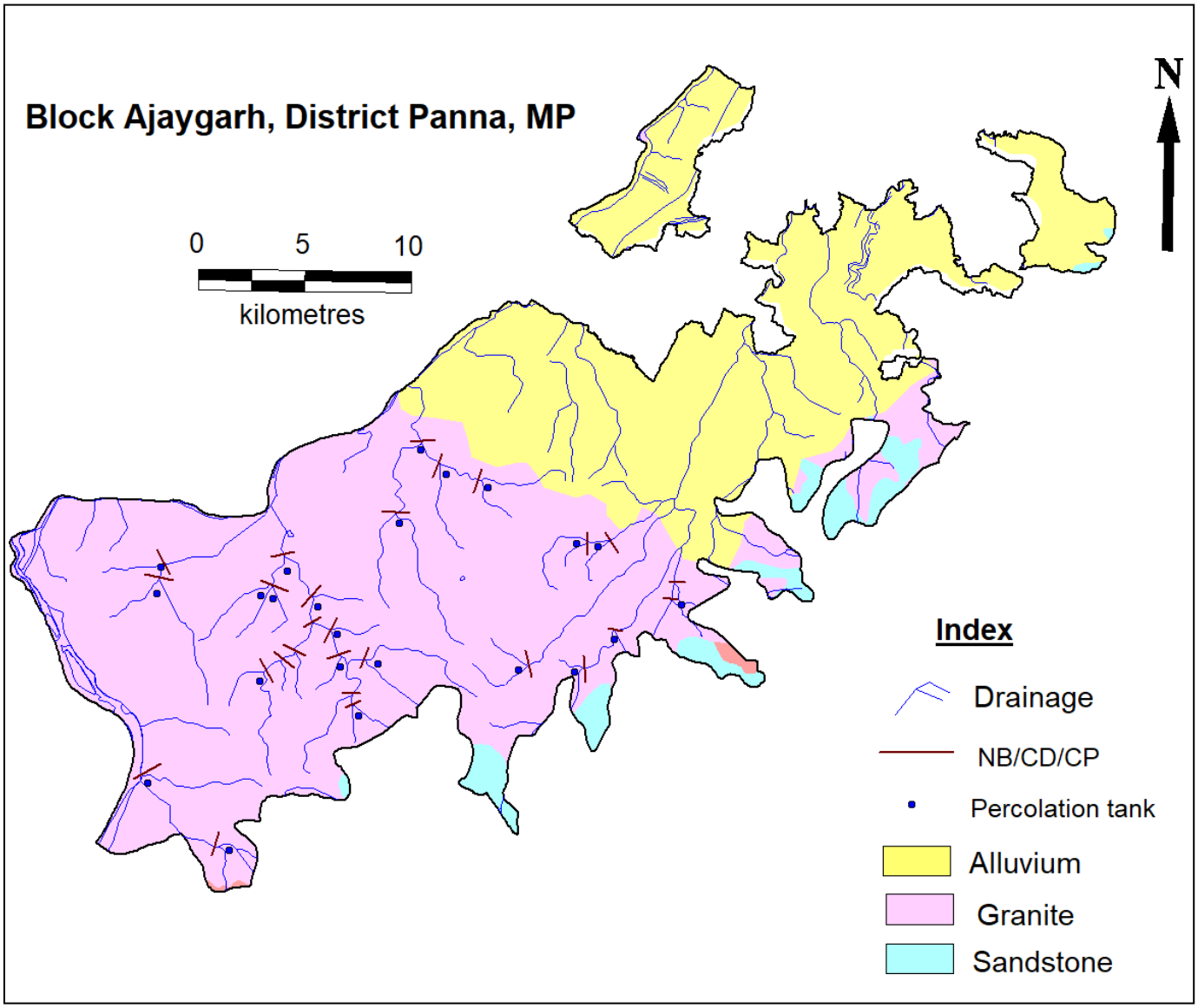
AJAYGARH BLOCK MANAGEMENT PLAN

Two fold management plan is being suggested for Ajaygarh block, one is abstraction of groundwater from pheratic aquifer and the other is artificial recharge structures in bundelkhand granites. There are 1095 nos. of dug wells is being proposed with cost of 16.42 crores irrigating 3531.31 Ha of area.

Table No 19: Management Plan of Ajaygarh Block for Pheratic Aquifer

Block	Ajaygarh
Type of Aquifer	Pheratic Aquifer
Net GW Availability	239.37
Required draft to reach upto 60% of Stage of GW development	143.62
Existing number of Dug well	8586
draft per DW (MCM)	0.0129
Existing Draft of Dug well (MCM)	110.76
Domestic and Industrial draft	4.61
Total required gross Draft after substracting all other draft (MCM)	28.25
50% of Required draft (MCM)	14.13
Proposed Dug well (Nos.)	1095
Cost of DW (Cr)	16.42
Irrigated area developed (Sq km)	35.31
Irrigated area developed (Ha)	3531.31

Figure No 25: Proposed Artificial Recharge Structures in Ajaygarh Block, Panna District



GONOUR BLOCK MANAGEMENT PLAN

In Gonour block, there are 2028 nos. of dug wells is being proposed with cost of 30.43 crores irrigating 4969.70 Ha of area and 236 nos. of bore wells with cost of 4.72 crores irrigating 1009.22 Ha of area.

Table No 20: Management Plan of Gonour Block

Blocks	Gonour	
Type of wells	Phreatic Aquifer Dug wells	Deeper Aquifer Tube wells
Net GW Availability	96.39	28.50
Required draft to reach upto 60% of Stage of GW development	57.84	17.10
Existing number of well	1187	528
draft per wells (MCM)	0.0098	0.0171
Existing Draft of well (MCM)	11.63	9.03
Domestic and Industrial draft	6.45	-
Total required gross Draft after subtracting all other draft (MCM)	39.76	8.07
50% of Required draft (MCM)	19.88	4.04
Proposed well (Nos.)	2028	236
Cost of structures (in Crores)	30.43	4.72
Irrigated area developed (Sq km)	49.70	10.09
Irrigated area developed (Ha)	4969.70	1009.22

PANNA BLOCK MANAGEMENT PLAN

In Panna block, there are 2732 nos. of dug wells is being proposed with cost of 40.98 crores irrigating 8128.31 Ha of area and 469 nos. of bore wells with cost of 9.38 crores irrigating 2672.58 Ha of area.

Table No 21: Management Plan of Panna Block

Blocks	Panna	
Type of wells	Phreatic Aquifer Dug wells	Deeper Aquifer Tube wells
Net GW Availability	**171.78**	57.52
Required draft to reach upto 60% of Stage of GW development	103.07	34.51
Existing number of well	2675	576
draft per well (MCM)	0.0119	0.0228
Existing Draft of well (MCM)	31.83	13.13
Domestic and Industrial draft	6.21	-
Total required gross Draft after subtracting all other draft (MCM)	65.03	21.38
50% of Required draft (MCM)	32.51	10.69
Proposed well (Nos.)	2732	469
Cost of structures (in Crores)	40.98	9.38
Irrigated area developed (Sq km)	81.28	26.73
Irrigated area developed (Ha)	8128.31	2672.58

PAWAI BLOCK MANAGEMENT PLAN

In Pawai block, there are 1471 nos. of dug wells is being proposed with cost of 22.06 crores irrigating 5221.22 Ha of area and 129 nos. of bore wells with cost of 2.57 cores irrigating 766.01 Ha of area.

Table No 22: Management Plan of Pawai Block

Blocks	Pawai	
Type of wells	Phreatic Aquifer Dug wells	Deeper Aquifer Tube wells
Net GW Availability	**122.94**	27.94
Required draft to reach upto 60% of Stage of GW development	73.76	16.77
Existing number of wells	1810	447
draft per Well (MCM)	0.0142	0.0238
Existing Draft of well (MCM)	25.70	10.64
Domestic and Industrial draft	6.29	-
Total required gross Draft after subtracting all other draft (MCM)	41.77	6.13
50% of Required draft (MCM)	20.88	3.06
Proposed structures (Nos.)	1471	129
Cost of structures (in Crores)	22.06	2.57
Irrigated area developed (Sq km)	52.21	7.66
Irrigated area developed (Ha)	5221.22	766.01

6.5 SHAHNAGAR BLOCK MANAGEMENT PLAN

In Shahnagar block, there are 1690 nos. of dug wells is being proposed with cost of 25.35 crores irrigating 4351.50 Ha of area and 126 nos. of bore wells with cost of 2.51 crores irrigating 612.25 Ha of area.

Table No 23: Management Plan of Shahnagar Block

Blocks	Shahnagar	
Type of wells	Phreatic Aquifer Dug wells	Deeper Aquifer Tube wells
Net GW Availability	**95.43**	22.63
Required draft to reach upto 60% of Stage of GW development	57.26	13.58
Existing number of abstraction structures	1715	445
draft per Well (MCM)	0.0103	0.0195
Existing Draft of well (MCM)	17.66	8.68
Domestic and Industrial draft	4.78	-
Total required gross Draft after substracting all other draft (MCM)	34.81	4.90
50% of Required draft (MCM)	17.41	2.45
Proposed well (Nos.)	1690	126
Cost of structures (in Crores)	25.35	2.51
Irrigated area developed (Sq km)	43.51	6.12
Irrigated area developed (Ha)	4351.50	612.25

ANNEXURE-I

DETAILS OF BORE WELLS

Blocks	Site	Year of Construction	Longitude	Latitude	Depth drilled	SWL (mbgl)	Discharge during drilling (Lps)	Aquifer Zones		Formation	Tested discharge (lps)	DD (m)	Sp. Cap. (lpm/m of dd)
								From	To				
Panna	Panna	2001-02	80.16667	24.7	200	0.8	6.94	59.0	67.0	Sand stone	1.0	31	1.54
Panna	Devendra Nagar	2001-02	80.36667	24.6	88.71	2.5	3.82	13.0	27.0	Sand stone	1.0	69.7	21.52
								37.0	51.0				
Panna	Shahnagar	2001-02	-	-	200	Dry	-	Dry		Sand stone & shale	-	-	-
Pawai	Sudaur	2001-02	80.17611	24.23472	200	1.0	4.8	24.0	35.0	Sand stone	1.0	32	1.87
Shahnagar	Bisani	2001-02	80.28333	24.125	200	-	-	Dry		Sand stone	-	-	-
Panna	Majhgawan	2001-02	80.03611	24.61111	200	0.8	5.86	32.0	34.0	Sand stone	1.0	-	-
								48.0	52.0				
Gunour	Sunglarha	2001-02	80.28639	24.46667	200	10.4	6	21.0	37.0	Sand stone	2.5	3.08	48.72
								44.0	50.0				
								103.0	112.0				
Gunour	Gunnour	2001-02	80.26667	24.5	82.86	14.6	10.77	21.0	28.0	Sand stone	2.5	0.28	5.35
								34.8	46.3				
								69.0	80.0				
Panna	Sakariya	2001-02	80.275	24.63611	200	8.5	3.5	31.0	35.0	Sand stone	2.5/5 HP	3.17	47.31
								46.0	49.0				
								110.0	114.0				
Panna	Kakrahati	2001-02	80.28333	24.58333	200	3.00	6.8	15.0	17.0	Sand stone	2.5/5 HP	2.84	52.81
								23.0	26.0				
								103.0	107.0				
								153.0	157.0				
Panna	Bhairontek	2001-02	80.10833	24.7375	200	1.5	7.56	86.0	91.0	Sand stone	-	-	-
Gunour	Seleha	2001-02	80.4	24.41667	200	3.5	5.49	5.9	14.0	Sand stone	2.5/5 HP	6.85	21.89
								112.0	116.0	Limestone			

Panna	Dalhan Chouwki	2001-02	80.225	24.8	155.98	Dry	-			Sand stone	-	-	-
Gunour	Amanganj	2001-02	80.03333	24.41667	185.97	14.00	12.45	62.0	69.0	Sand stone	2.5/5 HP	3.0	50.0
Panna	Itwakalan	2001-02	80.15278	24.53333	92.0	17.00	8.78	18.0	22.0	Sand stone	2.5/5 HP	1.58	94.93
								28	32				
Panna	Akola	2009-10	80.1393	24.6225	201.2	11	1.75			Shale and Sandstone			
Gunour	Amanganj PZ	2009-10	80.0358	24.425	106.7					Shale and Sandstone			
Panna	Amjhiria EW	2009-10	80.1535	24.654	201.2	11	1.66			Shale and Sandstone			
Panna	Amjhiria PZ	2009-10	80.1535	24.654	125	13	1.75			Shale and Sandstone			
Gunor	Asoni PZ	2010-11	80.3406	24.3846	125	7	1.2			Sandstone			
Gunor	Asoni PZ II	2010-11	80.3406	24.3846	63	35	0.5			Sandstone			
Panna	Brijpur	2010-11	80.4368	24.8125	201.2	35	0.8			Sandstone			
Panna	Brijpur	2010-11	80.4368	24.8125	122	24	0.8	118	121	Shale and Sandstone			
Gunour	Dighora pz	2009-10	80.269	24.4053	125	5.5	1.25			Shale and Sandstone			
Gunour	Dwari Pz	2009-10	80.0836	24.518	125	11	3.67			Shale and Sandstone			
Gunour	Dwari EW	2009-10			200	10.25	7.5			Shale and Sandstone			
Gunour	Dwari OW	2009-10			150	11	7.5			Shale and Sandstone			
Gunour	Ghatari	2010-11	80.0682	24.4204	185	5	2.5			Limestone			
Gunor	Ghatari PZ	2009-10	80.0682	24.4204	120	19	0.8			Shale and Sandstone			
Gunor	Ghatari PZ (s)	2009-10	80.0682	24.4204	64	3	1			Shale and Sandstone			
Gunour	Gunour EW	2010-11	80.2555	24.4532	88.4	20	7.5	36.6		Sandstone			
Gunour	Gunour OW	2010-11	80.2555	24.4532	94.5	20	7.5	15.2		Sandstone/Shale			
Shahnagar	Hardua EW	2009-10	79.9921	24.0326	204.3	25	1			Shale/Sandstone			
Panna	Janakpur EW	2010-11	80.2256	24.7346	202	2	1			Sandstone/Sh			

										ale			
Panna	Janakpur PZ	2010-11	80.2256	24.7346	115	-	2.5	28	31	Quartzite/Sandstone			
								60	65				
Gunor	Jhumta PZ	2010-11	80.2258	24.4385	124	18	1.25			Sandstone/Shale			
Gunor	Jhumta PZ II	2010-11	80.2258	24.4385	69.1	18.1	0.8			Sandstone/Shale			
Gunour	Kathwariya	2010-11	80.4041	24.4745	201.3	6.5	2.5			Sandstone/Shale			
Panna	Krishankalyanpur EW	2010-11	80.2806	24.7467	201	26	0.5			Sandstone/Shale			
Pawai	Kuwarpura	2011-12	80.0026	24.1902	200			32	33	BLACK SHALE			
								104	105				
Gunour	MAHEBA	2010-11			65			Abandoned due to air loss		Quartzitic			
Gunour	MAHEBA	2010-11	80.1544	24.4162	170.7	20	3.5	24.4		Quartzitic			
Gunour	MAHEBA OW	2010-11	80.1544	24.4162	112.8	21	3.5	22		Quartzitic			
Gunor	Maheba PZ	2009-10	80.1544	24.4162	125	12	1.6			Shale/Sandstone			
Gunor	Maheba PZ	2009-10	80.1544	24.4162	64	10	1.6			Shale/Sandstone			
Pawai	Maheda	2011-12	80.117	24.2708	200	-	-	21.86	27.33	Shale/Sandstone			
Pawai	Mohindra	2011-12	79.9679	24.1845	200								
Pawai	Murach PZ	2010-11	80.1166	24.3078	123	4	1.6			Sandstone/Shale			
Pawai	Murach PZ II	2010-11	80.1166	24.3078	63	4.8	0.8			Sandstone/Shale			
Pawai	Narayanpur PZ	2010-11	80.1667	24.3333	123	16	1.25			Sandstone/Shale			
Pawai	Nayagaon EW		80.12	24.296	204.3	48	3.33			Shale/ Sandstone			

Pawai	Nayagaon OW		80.12	24.296	201.3	11	0.8			Shale/ Sandstone			
Pawai	Nayagaon PZ	2010-11	80.1103	24.2874	125	6	0.8			Sandstone/Shale			
Gunour	Nivari PZ	2009-10	80.3207	24.5133	225	7.5	0.8			Shale/Sandstone			
Panna	Pahadikheda EW	2010-11	80.5264	24.8564	190.1	9.35	0.8			Sandstone/Shale			
Panna	Pahadikheda PZ	2010-11	80.5264	24.8564	62	9.3	0.8			Sandstone/Shale			
Gunor	Patnakalan PZ	2010-11	80.2046	24.4131	123	7.8	3			Sandstone/Shale			
Gunor	Patnakalan PZ II	2010-11	80.2046	24.4131	63	7.8	3			Sandstone/Shale			
Gunor	Patnatamoli PZ	2010-11	80.3903	24.3863	124	18	0.8			Sandstone/Shale			
Gunor	Patnatamoli PZ II	2010-11	80.3903	24.3863	63	18	0.8			Sandstone/Shale			
Pawai	Pawai pz	2009-10	80.1656	24.2747									
Gunour	Piparwah EW	2009-10	80.0412	24.4505	173.8	5	8.33	12.2	45.7	Shale and Sandstone			
Gunour	Piparwah OW	2009-11			67.1	Abandoned				Shale and Sandstone			
Panna	Rakseha PZ	2010-11	80.2895	24.7562	123	12.1	0.8			Sandstone			
Panna	Sakaria EW	2011-12	80.2765	24.6472	200			17	37	Sandstone			
Panna	Sakaria OW	2011-12	80.2765	24.6472	187.84					Sandstone and shale			
Gunor	Salehaganj PZ	2010-11	80.3956	24.4294						Sandstone and shale			
Pawai	Saptaiya PZ	2010-11	80.0731	24.3439	99.6			32	33	Sandstone			
Shahnagar	Shahnagar EW	2009-10	80.3129	23.9946	201.3	21.5	0.8			Shale and Sandstone			
Panna	Shikarpur	2011-12	80.2081	24.1899	200			21.86	27.33	BLACK SHALE			
Gunour	Simariya EW	2009-10	79.9008	24.2688	200	4.8	2.5			Shale and Sandstone			
Pawai	Sthaniya	2010-11	80.3045	24.3732	204.3					Shale			
Pawai	Pawai EW		80.1656	24.2747	201	50	0.8			Shale and sandstone			

ANNEXURE-II

LOCATION DETAILS OF EXPLRATION BORE WELLS

S.No.	Bore	Easting	Northing	Elevation	Total Depth
1	Akola PZ	412877.3	2723423	508.1	205.3
2	Amanganj PZ	402252.7	2701620	313.1	106.7
3	Amjhiria EW	414336.3	2726904	462.1	201.2
4	Asoni PZ	433135.6	2696971	324.7	125
5	Brijpur	443081.4	2744302	365.9	201.2
6	Dighora pz	425879.4	2699294	351	125
7	Dwari Pz	407170.1	2711890	329.2	125
8	Ghatari	405528.3	2701087	321.8	185.7
9	Gunour OW	424539.8	2704606	353.7	94.5
10	Hardua EW	397503.8	2658207	405.2	204.3
11	Janakpur EW	421691.1	2735777	396.7	202.3
12	Jhumta PZ	421523.8	2702999	341.5	124
13	Kathwariya	439615.6	2706892	352.6	201.3
14	Krishankalyanpur EW	427255.6	2737096	387.1	201.2
15	Kuwarpura	398696.9	2675644	491.8	200
16	MAHEBA	414268.9	2700569	339.6	170.7
17	Maheda	410373.8	2684490	322.6	200
18	Mohindra	395174.3	2675036	340.1	200
19	Murach PZ	410364.8	2688594	318.7	123
20	Narayanpur PZ	415458.7	2691385	321	123
21	Nayagaon PZ	409702.8	2686337	315.9	124
22	Nivari PZ	431188.2	2711225	344	125
23	Pahadikheda EW	452149.5	2749130	347.4	201.1
24	Patnakalan PZ	419353.9	2700195	342.6	123
25	Patnatamoli PZ	438176.7	2697130	348.2	124
26	Pawai pz	415313.8	2684892	333.4	201.3
27	Piparwah EW	402820.4	2704443	313.9	173.8
28	Rakseha PZ	428159.7	2738136	384.6	123
29	Sakaria OW	426782.6	2726080	408.5	200
30	Salehaganj PZ	438734.4	2701906	341.1	124
31	Saptaiya PZ	405970.4	2692610	322	99.6
32	Shahnagar EW	430105.4	2653796	381.4	201.3
33	Shikarpur	419572.5	2675482	411.2	200
34	Simariya EW	388426.5	2684432	319.5	201.3
35	Sthaniya	429459.9	2695722	340.2	204.3

ANEXURE-III

LITHOLOGS DETAILS Of EXPLRATION BORE WELLS

Bore	Depth 1	Depth2	Stratigraphy	Comments
Akola PZ	0	27.4	Fine grained sandstone	compact reddish colour
Akola PZ	27.4	54.9	Shale	Fine grained soft red colour
Akola PZ	54.9	88.4	Massive sandstone	hard jointed reddish colour
Akola PZ	88.4	134.2	shaly sandstone	hard compact purple colour shaly
Akola PZ	134.2	173.8	Shale	Fine grained hard red colour
Akola PZ	173.8	205.3	Massive sandstone	hard compact reddish colour
Amanganj PZ	0	21.4	Fine grained sandstone	hard compact reddish colour
Amanganj PZ	21.4	42.7	Massive sandstone	hard compact reddish colour
Amanganj PZ	42.7	73.2	Fine grained sandstone	hard compact purple colour
Amanganj PZ	73.2	106.7	Massive sandstone	hard compact reddish colour
Amjhiria EW	0	15.2	Top alluvial sandstone	weathered reddish colour
Amjhiria EW	15.2	45.7	Fine grained sandstone	compact jointed reddish colour
Amjhiria EW	45.7	94.5	Shale	Fine grained soft red colour
Amjhiria EW	94.5	115.9	shaly sandstone	compact purple colour shaly
Amjhiria EW	115.9	146.4	Massive sandstone	compact jointed reddish colour
Amjhiria EW	146.4	186	Massive sandstone	compact jointed purple colour
Amjhiria EW	186	201.2	Shale	Fine grained compact red colour
Asoni PZ	0	9.1	Top alluvial sandstone	fine grained loose light brown colour
Asoni PZ	9.1	18.2	Shale	fine grained weathered soft light brown colour
Asoni PZ	18.2	30.4	Shale	fine grained soft dark brown colour
Asoni PZ	30.4	51.8	Shaly sandstone	fine grained soft light brown colour
Asoni PZ	51.8	76.2	Shale	fine grained soft dark brown colour
Asoni PZ	76.2	94.5	Shaly sandstone	fine grained soft light brown colour
Asoni PZ	94.5	112.8	Shale	fine grained dark brown colour
Asoni PZ	112.8	125	Shaly sandstone	Fine grained light brown colour
Brijpur	0	6	Fine grained sandstone	Brown colour weathered sandstone
Brijpur	6	18.2	Fine grained sandstone	Brown colour
Brijpur	18.2	27.4	Fine grained sandstone	light brown colour shaly
Brijpur	27.4	45.7	Shale	Fine grained red colour
Brijpur	45.7	60.9	Fine grained sandstone	dark brown colour shaly
Brijpur	60.9	82.3	Fine grained sandstone	compact hard brownish colour
Brijpur	82.3	100.6	Shale	dark brown colour
Brijpur	100.6	115.8	Fine grained sandstone	Light brown colour
Brijpur	115.8	134.1	Fine grained sandstone	dark brown colour
Brijpur	134.1	152.4	Fine grained sandstone	light brown colour shaly
Brijpur	152.4	164.4	Shale	dark red colour

Brijpur	164.4	173.8	Massive sandstone	Dirty whitish brown colour quartzitic hard sandstone
Brijpur	173.8	182.9	Massive sandstone	Dark brown colour hard compact quartzitic sandstone
Brijpur	182.9	201.2	Massive sandstone	Dirty brownish white colour quartzitic sandstone
Dighora pz	0	33.5	Fine grained sandstone	Reddish colour shaly
Dighora pz	33.5	48.8	Fine grained sandstone	hard compact massive purple colour
Dighora pz	48.8	51.8	Shale	fine grained hard red colour
Dighora pz	51.8	73.2	Fine grained sandstone	hard compact reddish colour
Dighora pz	73.2	100.6	Fine grained sandstone	hard dark brown colour shaly
Dighora pz	100.6	125	Shale	Reddish colour
Dwari Pz	0	27.4	Top alluvial sandstone	Medium to fine grained black colour
Dwari Pz	27.4	33.5	Shale	Fine grained red colour
Dwari Pz	33.5	42.7	Fine grained sandstone	hard compact grey colour
Dwari Pz	42.7	48.8	Shale	Fine grained black colour
Dwari Pz	48.8	51.8	Fine grained sandstone	hard compact grey colour
Dwari Pz	51.8	73.2	Shale	Fine grained red colour
Dwari Pz	73.2	100.6	Fine grained sandstone	hard compact white colour
Dwari Pz	100.6	125	Shale	Fine grained black colour
Ghatari	0	21.3	Fine grained sandstone	hard,compact reddish colour
Ghatari	21.3	42.6	Massive sandstone	hard,compact reddish colour
Ghatari	42.6	73.1	Fine grained sandstone	hard,compact purple colour
Ghatari	73.1	106.6	Shale	reddish colour soft fine grained
Ghatari	106.6	124.9	Shaly sandstone	fine grained hard purple colour
Ghatari	124.9	146.3	Fine grained sandstone	Light brown colour
Ghatari	146.3	167.4	Shale	Dark brown colour
Ghatari	167.4	185.7	Fine grained sandstone	dark brown colour
Gunour OW	0	12.2	Fine grained sandstone	Light brown colour
Gunour OW	12.2	30.5	shaly sandstone	light brown colour,compact shaly
Gunour OW	30.5	36.6	Fine grained sandstone	light brown colour
Gunour OW	36.6	70.1	Fine grained sandstone	compact light brown colour
Gunour OW	70.1	81.3	Fine grained sandstone	compact dark brown colour
Gunour OW	81.3	94.5	limestone	medium grained, dirty white colour
Hardua EW	0	11	Top alluvial Sandstone	weathered, reddish brown colour
Hardua EW	11	61	shaly sandstone	hard compact reddish brown colour shaly
Hardua EW	61	109.8	Massive sandstone	hard compact jointed reddish brown colour
Hardua EW	109.8	137.2	Massive sandstone	hard compact dark brown colour
Hardua EW	137.2	173.8	Massive sandstone	hard compact brown colour
Hardua EW	173.8	204.3	Massive sandstone	hard compact reddish brown colour

Janakpur EW	0	13.2	Top alluvial sandstone	Light Brown colour alluvial sand
Janakpur EW	13.2	31.5	Shale	Fine grained Light brown colour
Janakpur EW	31.5	40.6	Massive sandstone	Dirty whitish brown colour quartzitic hard sandstone
Janakpur EW	40.6	52.8	Massive sandstone	Dirty white colour quartzitic sandstone
Janakpur EW	52.8	74.2	Fine grained sandstone	dark brown colour
Janakpur EW	74.2	93	Fine grained sandstone	Dirty white colour
Janakpur EW	93	108.2	Fine grained sandstone	Dirty white colour
Janakpur EW	108.2	117.4	Fine grained sandstone	Light brown colour
Janakpur EW	117.4	138.7	Fine grained sandstone	Dirty white colour
Janakpur EW	138.7	156.5	Fine grained sandstone	Brown colour
Janakpur EW	156.5	202.3	Massive sandstone	Dirty white colour quartzitic sandstone
Jhumta PZ	0	8.1	Top alluvial sandstone	fine grained light brown colour
Jhumta PZ	8.1	14.2	Shale	Fine grained brown colour weathered
Jhumta PZ	14.2	32.5	Shale	Fine grained reddish brown colour
Jhumta PZ	32.5	47.8	Shaly sandstone	Fine grained reddish brown colour
Jhumta PZ	47.8	69.1	Shale	Fine grained red colour
Jhumta PZ	69.1	87.4	Fine grained sandstone	Light brown colour
Jhumta PZ	87.4	102.7	Shaly sandstone	Fine grained light brown colour
Jhumta PZ	102.7	124	Fine grained sandstone	dirty white colour
Kathwariya	0	15.2	Fine grained sandstone	Light brown colour
Kathwariya	15.2	33.5	Shale	fine grained grey colour
Kathwariya	33.5	48.8	Shale	fine grained light brown colour
Kathwariya	48.8	61	Fine grained sandstone	compact hard light brown colour
Kathwariya	61	76.2	Fine grained sandstone	compact hard dirty white colour
Kathwariya	76.2	94.5	Shale	soft fine grained dark red colour
Kathwariya	94.5	109.8	Shale	soft fine grained light brown colour
Kathwariya	109.8	121	Shale	soft fine grained dark brown colour
Kathwariya	121	146.4	Fine grained sandstone	compact hard light brown colour
Kathwariya	146.4	164.7	Fine grained sandstone	compact hard dark red colour
Kathwariya	164.7	179.9	Shale	fine grained light brown colour
Kathwariya	179.9	195.2	Fine grained sandstone	compact hard dark brown colour
Kathwariya	195.2	201.3	Massive sandstone	fine grained light brown colour
Krishankalyanpur EW	0	12.1	Top alluvial sandstone	Light brown colour
Krishankalyanpur EW	12.1	30.4	Shale	
Krishankalyanpur EW	30.4	42.6	Massive sandstone	Dirty brownish white colour hard quartzite sandstone
Krishankalyanpur EW	42.6	51.8	Massive sandstone	Dirty white colour quartzite sandstone
Krishankalyanpur EW	51.8	76.2	Fine grained sandstone	dark brown colour

Krishankalyanpur EW	76.2	94.5	Massive sandstone	Dirty white colour
Krishankalyanpur EW	94.5	109.7	Massive sandstone	Dirty white colour
Krishankalyanpur EW	109.7	115.8	Fine grained sandstone	Light brown colour
Krishankalyanpur EW	115.8	137.2	Massive sandstone	Dirty white colour
Krishankalyanpur EW	137.2	155.5	Fine grained sandstone	Brown colour
Krishankalyanpur EW	155.5	201.2	Massive sandstone	Dirty white colour quartzite sandstone
Kuwarpura	0	5.37	Top alluvial sandstone	brown colour
Kuwarpura	5.37	16.37	Shale	weathered, black colour
Kuwarpura	16.37	62.29	Shale	black colour , soft
Kuwarpura	62.29	80.78	Shale	reddish brown colour, soft
Kuwarpura	80.78	113.15	Shale	black colour, soft
Kuwarpura	113.15	126.97	Shale	reddish brown colour, soft
Kuwarpura	126.97	200	Shale	black colour, soft
MAHEBA	0	21.4	Fine grained sandstone	hard,compact,jointed,reddish
MAHEBA	21.4	42.7	Fine grained sandstone	hard,compact,jointed,reddish brown
MAHEBA	42.7	73.2	shaly sandstone	hard,compact,shaly sandstone,purple
MAHEBA	73.2	125	Shale	fine grained reddish colour
MAHEBA	125	146.4	shaly sandstone	light brown colour shaly
MAHEBA	146.4	158.6	Shale	fine grained reddish colour
MAHEBA	158.6	170.7	Shale	fine grained light brown colour
Maheda	0	5.37	Shale	grey & soft
Maheda	5.37	55.99	Shale	soft with laminated bands
Maheda	55.99	139.88	Shale	black colour, soft
Maheda	139.88	177.22	Shale	reddish brown colour, soft
Maheda	177.22	200	Shale	black colour, soft
Mohindra	0	3	Top alluvial sandstone	red colour
Mohindra	3	13.84	Shale	reddish brown, weathered
Mohindra	13.84	53.99	Shale	yellowish brown soft
Mohindra	53.99	107.91	Shale	black colour, soft with laminated
Mohindra	107.91	134.65	Shale	black colour, moderately hard with laminated
Mohindra	134.65	200	Shale	black colour, soft with laminated
Murach PZ	0	8.1	Top alluvial sandstone	fine grained light brown colour
Murach PZ	8.1	19.3	Shale	Weathered dirty brownish black colour
Murach PZ	19.3	40.6	Shale	Fine grained light brown colour slightly fractured at 31.5m
Murach PZ	40.6	65	Shaly sandstone	medium grained light brown colour
Murach PZ	65	89.4	Shale	Fine grained reddish colour
Murach PZ	89.4	107.7	Shaly sandstone	fine to medium grained light brown

				colour
Murach PZ	107.7	123	Shale	fine grained light brown colour
Narayanpur PZ	0	17.2	Top alluvial sandstone	fine to medium grained light brown colour
Narayanpur PZ	17.2	32.5	Shale	Fine grained grey colour
Narayanpur PZ	32.5	46.7	Shale	Fine grained soft light brown colour
Narayanpur PZ	46.7	58.9	Massive sandstone	hard compact light brown colour
Narayanpur PZ	58.9	77.2	Massive sandstone	hard compact dirty white colour
Narayanpur PZ	77.2	95.5	Shale	fine grained soft dark red colour
Narayanpur PZ	95.5	107.7	Shale	fine grained soft light brown colour
Narayanpur PZ	107.7	123	Shale	fine grained soft dark brown colour
Nayagaon PZ	0	11.1	Top alluvial sandstone	fine grained light brown colour
Nayagaon PZ	11.1	17.2	Shale	Fine grained dark brown colour
Nayagaon PZ	17.2	26.4	Fine grained sandstone	Light brown colour
Nayagaon PZ	26.4	41.6	Shale	Fine grained reddish brown colour fractured at 30.30m
Nayagaon PZ	41.6	63	Shale	Fine grained light green colour
Nayagaon PZ	63	75.2	Shaly sandstone	Fine grained light brown colour
Nayagaon PZ	75.2	96.5	Fine grained sandstone	light grey colour
Nayagaon PZ	96.5	124	Massive sandstone	hard compact pink colour massive
Nivari PZ	0	21.4	shaly sandstone	hard compact reddish colour shaly
Nivari PZ	21.4	67.1	Fine grained sandstone	hard jointed purple colour
Nivari PZ	67.1	94.5	Shale	Fine grained soft red colour
Nivari PZ	94.5	125	shaly sandstone	hard jointed reddish colour shaly
Pahadikheda EW	0	16.2	Shaly sandstone	Brown colour hard compact shaly sandstone
Pahadikheda EW	16.2	37.6	Massive sandstone	hard compact Dirty white brownish colour quartzitic sandstone
Pahadikheda EW	37.6	46.7	Massive sandstone	hard compact Dark grey colour
Pahadikheda EW	46.7	52.8	Shale	Fine grained soft Light brown colour
Pahadikheda EW	52.8	62	Shale	Fine grained soft reddish colour
Pahadikheda EW	62	83.3	Massive sandstone	dark grey colour
Pahadikheda EW	83.3	107.7	Shaly sandstone	light brown colour shaly
Pahadikheda EW	107.7	126	Shale	Fine grained reddish brown colour
Pahadikheda EW	126	144.3	Shaly sandstone	light brown colour shaly
Pahadikheda EW	144.3	159.6	Shale	Fine grained Light brown colour
Pahadikheda EW	159.6	174.8	Shaly sandstone	brown colour shaly
Pahadikheda EW	174.8	194	Shaly sandstone	light brown colour
Pahadikheda EW	194	201.1	Shaly sandstone	brown colour shaly
Patnakalan PZ	0	14.2	Top alluvial sandstone	fine grained light brown colour
Patnakalan PZ	14.2	32.5	Massive sandstone	fractured Light brown colour
Patnakalan PZ	32.5	63	Massive sandstone	light brown colour fractured at 44.6m
Patnakalan PZ	63	81.3	Shaly sandstone	Fine grained reddish brown colour

Patnakalan PZ	81.3	95.5	Shale	fine grained light brown colour
Patnakalan PZ	95.5	110.8	Fine grained sandstone	hard compact light brown colour
Patnakalan PZ	110.8	123	Shaly sandstone	Fine grained reddish brown colour
Patnatamoli PZ	0	5.1	Top alluvial sandstone	fine grained light brown colour
Patnatamoli PZ	5.1	26.4	Fine grained sandstone	hard compact brown colour
Patnatamoli PZ	26.4	50.8	Fine grained sandstone	hard compact Light brown colour
Patnatamoli PZ	50.8	72.1	Shale	Fine grained light brown colour fractured between 60.9-64.1m
Patnatamoli PZ	72.1	90.4	Fine grained sandstone	hard compact Light brown colour
Patnatamoli PZ	90.4	108.7	Fine grained sandstone	Dark brown colour
Patnatamoli PZ	108.7	111.8	Fine grained sandstone	Light brown colour fractured
Patnatamoli PZ	111.8	124	Shale	Fine grained light brown colour
Pawai pz	0	21.36	Top alluvial sandstone	Medium to fine grained brown colour sand
Pawai pz	21.36	91.4	Massive sandstone	hard compact reddish colour
Pawai pz	91.4	146.4	Massive sandstone	hard compact purple colour
Pawai pz	146.4	195.2	shaly sandstone	hard compact reddish colour shaly
Pawai pz	195.2	201.3	Shale	fine grained hard compact reddish colour
Piparwah EW	0	24.4	Fine grained sandstone	hard,compact,jointed,reddish colour
Piparwah EW	24.4	42.7	Massive sandstone	hard compact reddish colour
Piparwah EW	42.7	73.2	Massive sandstone	hard compact purple colour
Piparwah EW	73.2	112.8	Massive sandstone	hard compact reddish colour
Piparwah EW	112.8	158.6	Massive sandstone	hard compact purple colour
Piparwah EW	158.6	173.8	Massive sandstone	hard compact reddish colour
Rakseha PZ	0	4.3	top alluvial sandstone	Medium to fine grained brown colour
Rakseha PZ	4.3	22.6	Massive sandstone	hard compact dirty white brownish colour
Rakseha PZ	22.6	46.9	Massive sandstone	hard compact brown colour
Rakseha PZ	46.9	71.2	Shale	fine grained soft brown colour
Rakseha PZ	71.2	86.5	Massive sandstone	hard compact dirty white brownish colour
Rakseha PZ	86.5	123	Massive sandstone	hard compact brown dark brown colour
Sakaria OW	0	5.37	Top alluvial sandstone	Red clay with weathered sandstone
Sakaria OW	5.37	16.37	fine grained sandstone	brown colour,soft
Sakaria OW	16.37	21.86	fine grained sandstone	reddish brown colour
Sakaria OW	21.86	38.09	Fine grained sandstone	brown colour
Sakaria OW	38.09	53.99	Fine grained sandstone	reddish brown colour
Sakaria OW	53.99	107.91	Fine grained sandstone	brown colour
Sakaria OW	107.91	113.15	Massive sandstone	Fractured, brown colour
Sakaria OW	113.15	161.11	Shale	reddish brown colour,soft
Sakaria OW	161.11	200	Kimberlite	Dark black colour, soft
Salehaganj PZ	0	11.1	Top alluvial sandstone	fine grained light brown colour
Salehaganj PZ	11.1	17.2	Shale	fine grained light brown colour
Salehaganj PZ	17.2	29.4	Fine grained sandstone	Light brown colour
Salehaganj PZ	29.4	44.7	Shale	Fine grained reddish brown colour

Salehaganj PZ	44.7	63	Shale	Fine grained greenish colour
Salehaganj PZ	63	78.2	Shaly sandstone	Fine grained light brown colour
Salehaganj PZ	78.2	93.5	Fine grained sandstone	light grey colour
Salehaganj PZ	93.5	124	Massive sandstone	hard compact pink colour massive fractured at 105.7-108.7m
Saptaiya PZ	0	8.1	Top alluvial sandstone	fine grained light brown colour
Saptaiya PZ	8.1	20.3	Shale	Fine grained brown colour
Saptaiya PZ	20.3	35.5	Shale	Fine grained reddish brown colour
Saptaiya PZ	35.5	50.8	Shaly sandstone	Fine grained light brown colour
Saptaiya PZ	50.8	69.1	Shale	Fine grained light grey colour
Saptaiya PZ	69.1	84.2	Shaly sandstone	fine grained dark brown colour
Saptaiya PZ	84.2	99.6	Shale	Fine grained grey colour
Shahnagar EW	0	21.5	Top alluvial Sandstone	weathered, reddish brown colour
Shahnagar EW	21.5	61	Shale	fine grained reddish brown colour
Shahnagar EW	61	109.8	Massive sandstone	hard compact jointed reddish brown colour
Shahnagar EW	109.8	137.2	Massive sandstone	hard compact dark brown colour
Shahnagar EW	137.2	173.8	Massive sandstone	hard compact jointed reddish brown colour
Shahnagar EW	173.8	201.3	Massive sandstone	hard compact brown colour
Shikarpur	0	5.37	Top alluvial sandstone	red
Shikarpur	5.37	8.37	Shale	yellow colour
Shikarpur	8.37	123.97	Shale	soft
Shikarpur	123.97	134.65	Shale	reddish brown
Shikarpur	134.65	200	Shale	black colour, soft
Simariya EW	0	37	Top alluvial sandstone	Medium to fine grained brown colour sand
Simariya EW	37	88.4	shaly sandstone	reddish colour shaly
Simariya EW	88.4	143.3	shaly sandstone	purple colour shaly
Simariya EW	143.3	195.2	shaly sandstone	hard compact reddish colour shaly
Simariya EW	195.2	201.3	Shale	fine grained hard compact reddish colour
Sthaniya	0	9	Fine grained sandstone	Light brown colour
Sthaniya	9	24.4	Shale	dark brown colour fine grained
Sthaniya	24.4	48.8	Shale	Light brown colour medium grained
Sthaniya	48.8	88.4	Shaly sandstone	fine grained compact hard light brown
Sthaniya	88.4	118.9	Shaly sandstone	fine grained compact hard dark brown
Sthaniya	118.9	152.5	Shale	fine grained compact hard light brown
Sthaniya	152.5	186	Shaly sandstone	fine grained compact hard light brown
Sthaniya	186	204.3	Shale	fine grained compact hard dark brown