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

RAIGARH DISTRICT, CHHATTISGARH

उत्तर मध्य छत्तीसगढ़ क्षेत्र, रायपुर

North Central Chhattisgarh Region, Raipur

Government of India
Ministry of Jal Shakti
Department of Water Resources, River Development & Ganga Rejuvenation
CENTRAL GROUND WATER BOARD

Aquifer Mapping and Management Plan in Raigarh District, Chhattisgarh

Type of Study	Blocks	Officer engaged
Data compilation, Data Gap Analysis & Data Generation	1. Dharamjaigarh 2. Gharghoda 3. Tamnar	Sri S. Acharya, Scientist-D (AAP:2015-16)
	4. Kharsia 5. Lailunga	Sri M. Gobinath. AHG (AAP:2016-17)
	6. Raigarh 7. Pusaur 8. Baramkela 9. Sarangarh	Sri R. K. Tripathy, Scientist-B (AAP:2016-17)
Data Interpretation, Integration, Aquifer Mapping, Management Plan & Report writing	All the above 9 blocks	Sri A. K. Biswal, Scientist-D

North Central Chhattisgarh Region
Raipur
2020

DISTRICT AT A GLANCE

RAIGARH DISTRICT

1.	**GENERAL INFORMATION**	
	i) Geographical area (Sq. km)	6,527.44
	ii) Administrative Divisions (As on 2017)	
	a) Number of Blocks	9
	b) Number of Villages	1485
	iii) Population as on 2011 Census	1,493,984
	iv) Average Annual Rainfall	1274mm
2.	**GEOMORPHOLOGY**	
	i) Major Geomorphological Units	Chhattisgarh plain region and Northern hill
	ii) Major Drainages	Mahanadi Basin (Mahanadi, Mand, Kurket, Kelo & Ib)
3.	**LAND USE (ha) As on 2016-17**	
	i) Forest Area	59904
	ii) Net Area Sown	267329
	iii) Double cropped Area	32538
4.	**MAJOR SOIL TYPES**	Alfisols-Red sandy gravelly & Red sandy, Inceptisols-Shallow black Ultisols- Red & Yellow, lateritic
5.	**AREA UNDER PRINCIPAL CROPS, in ha (As on 2016-17)**	Paddy-243081, Wheat-2769, Pulses-28565, Tilhans-144.35, Fruits and vegetables- 665
6.	**IRRIGATED AREA BY DIFFERENT SOURCES in ha (As on 2016-17)**	
	i) Dug wells	772
	ii) Tube wells/Bore wells	32314
	iii) Canals	18609
	iv)Tanks	4720
	v) Other sources	7200
	vi) area Irrigated more than once	29644
7.	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on March'2019)**	
	i) No of Dug wells	123
	ii) No of Piezometers	20

8. PREDOMINANT GEOLOGICAL FORMATIONS

Recent Alluvium & Laterite (Sand, clay)
Gondwana Supergroup (Sandstone, shale, coal)
Chhattisgarh Supergroup (Limestone, Dolomite, Sandstone, shale)
Basement Crystallines (Granites, Gneiss, Schists & metamorphic)

9. HYDROGEOLOGY

i) Major Water Bearing Formations	Weathered & fractured sandstone, shale, limestone, siltstone, and Granite gneisses.
ii) Pre-monsoon Depth to Water Level	1.18 to 32.6 mbgl
iii) Post-monsoon Depth to Water Level	0.01 to 22.7 mbgl
iv) Long Term Water Level Trend for 10 yrs (2008-2017 Vs 2018) in m/yr	**Pre-monsoon**-Fall: 0.02 to 3.88 Rise: 0.05 to 10.18 **Post-monsoon**-Fall: 0.02 to 4.28 Rise 0.03 to 3.27

10. GROUND WATER EXPLORATION BY CGWB (As on March'2019)

i) No of Wells Drilled	EW: 108, OW: 28, PZ: 22
ii) Depth Range (m)	21 to 400.28
iii) Discharge (litres per second)	0.2 to 22.42
iv) Transmissivity (m^2/day)	1.35 to 142.75

11. GROUND WATER QUALITY

i) Presence of Chemical Constituents	EC for Shallow aquifer is 30 to 1514 and for deeper aquifer is 84 to 2320 µS/cm at 25℃ , PH- 6.5 to 8.9, All the chemical constituents are well within permissible limit except Iron and Fluoride and Nitrate at few places.
ii) Type of Water	Calcium-Magnesium-Bicarbonate (Ca-Mg-HCO_3) and Calcium-Sulphate (Ca-SO_4) type for shallow aquifer & Calcium-Bicarbonate (Ca-HCO_3) type for deeper aquifer respectively.

12. DYNAMIC GROUND WATER RESOURCES in Ham (Estimated as on March'2013)

i) Annual Extractable Ground Water Recharge	41166.73
ii) Total Annual Ground Water Extraction	20292.35
iii) Ground Water Resources for Future use	20327.56
iv) Stage of Ground Water Development	50.09 %

13. AWARENESS AND TRAINING ACTIVITY Mass awareness at Kharsia in the year 2002-03 was organized. It was followed by two tier training at Raigarh and three tier training at Gharghoda, Kharsia.

14. EFFORTS OF ARTIFICIAL RECHARGE & RAIN WATER HARVESTING

i) Projects Completed by CGWB (No & Amount spent)	Nil
ii) Projects Under Technical Guidance of CGWB (Numbers)	Nil

15. GROUND WATER CONTROL AND REGULATION

i) Number of Over Exploited Blocks (Stage of Extraction > 100%)	Nil
ii) Number of Critical Blocks (Stage of Extraction> 90%)	Nil
iii) Number of Blocks Notified	Nil

16. MAJOR GROUND WATER PROBLEMS AND ISSUES

1. Due to large scale pumping from Raigarh Formation for irrigation, the water level in this formation goes deep in summer and the sustainability of shallow hand pumps are threatened.
2. With increasing dependency on hand pumps for drinking water, iron contamination in ground water has emerged as biggest problem in parts of Gondwana covered area of Gharghoda-Tamnar- Dharamjaigarh- Kharsia- Lailunga blocks.
3. At few locations nitrate and fluoride concentrations are found beyond the permissible limit.

CONTENTS

ABBREVIATIONS

a msl	above mean sea level
BDR	Basic Data Report
CGWB	Central Ground Water Board
Dia	Diameter
DTW	Depth To Water
EC	Electrical Conductivity
EW	Exploratory Wells
GW/ gw	Ground Water
ham	Hectare meter
lpcd	litres per capita per day
lpm	litres per minute
lps	liters per second
m bgl	meter below ground level
MCM/mcm	Million Cubic Meter
NCCR	North Central Chhattisgarh Region
NHNS/ NHS	National Hydrograph Network Stations
OW	Observation Well
PZ	Piezometre

FOREWORD

Groundwater resources are being developed over years in order to meet domestic, irrigation and industrial requirements. The spatial distribution of availability of ground water resources however, is uneven and is being indiscriminately exploited by various users thereby creating relentless pressure. On the other hand rapid urbanization, industrialization and land use changes has resulted decline of water levels in many parts of the country.

There is an urgent need for scientific approach for proper management of the available ground water resources for sustainability of this precious natural resource for present and future generation.

Central Ground Water Board has been in the forefront of activities for occurrence, development, and management of this resource through various scientific studies and techniques. Over the last four decades CGWB, NCCR, Raipur has gathered a huge amount of data regarding ground water resources of Chhattisgarh. Based on this experience aquifer mapping of Raigarh district was prepared with the vast amount of data generated and available with North Central Chhattisgarh Region. The report embodies all the features of ground water and related aspects of the study area including physiography, meteorological conditions, hydrology, drainage, geomorphology, geology, hydrogeology, ground water resources, hydrochemistry, geophysics, ground water problems etc.

The report titled " A REPORT ON AQUIFER MAPPING & MANAGEMENT PLAN IN RAIGARH DISTRICT, CHHATTISGARH" " is prepared by Sh. A.K.Biswal, Scientist-D and is the result of untiring efforts Sh. S.Acharya, Scientist-D; S. K. Shrivastava, Scientist 'D'and Sh. R.K.Tripathy, Scientist-B. It was a Herculean job and required hard working. I appreciate the concerted efforts put by the author to make it possible to bring the report in its present shape. I hope this report will no doubt be useful and worthy for the benefit of Raigarh district and would be a useful document for academicians, administrators, planners and all the stakeholders in ground water.

Though utmost care has been taken to minimize the errors, some errors may have inadvertently crept in. It is expected that these mistakes will be taken in the proper spirit.

Dr. Santanu Samanta
(REGIONAL DIRECTOR (I/C))

EXECUTIVE SUMMARY

The Raigarh district covers a geographical area of 6836.35 sq. km. It is situated in the north eastern part of the Chhattisgarh lying between latitudes 21°20'21" to 22°47'13" N and longitudes 82°55'36" to 83°42'16" E50'and is divided into 6 tehsils and 9 blocks, comprising 5 Urban Centers and 1438 villages . Raigarh district is surrounded by Jashpur district in the north, Mahasamund district in the south, the state of Odisha border in the east , Janjgir-Champa and Korba districts in the west. According to 2011 census record the total population of district is 1,493,984. Nearly 84% of the population lives in rural areas. SC and ST community constitutes 49 % of the total population. The density is 211 persons per sq.km. The percentage of literacy is 73.26. Nearly 33 % of the geographical area is covered by forests. About 27% of the net sown area is irrigated by all sources. Ground water contributes nearly 48.5% of the net irrigated area.

Raigarh district is industrially developed. There are 35 large scale industries and 8 Medium scale enterprises exist in the district. Raigarh district is full of major minerals like Coal, Quartzite, Limestone and Dolomite. As a result of which some mineral based industry can also be seen in the district. Coal mining is prominent in Dharamjaigarh & Tamnar blocks.

The district experiences Sub-tropical climate characterized by extreme cold in winter and extreme hot in summer. The average annual rainfall is 1274 mm (average of last five years i.e 2012-2017). The annual temperature varies from 10oC in winter to 46oC in summer. The relative humidity varies from 85 % in rainy season to 35-40 % during winter. The district is mainly drained by thet rivers-Mand, Kelo, Kuruket and Ib which are perennial in nature. The drainage system in Raigarh district originate at the southern part and flow in N and to NE direction before joining the Mahanadi river.

Geomorphologically the entire district can be divided into two physiographic regions namely Mahanadi plain (Chhattisgarh plain) and Northern hills of Chhotanagpur plateau. Chhattisgarh plain covers the southern part of the district and is divided into two parts by Mahanadi river. The general elevation of the plain ranges between 190 and 240m amsl. The elevation in case of structural hills ranges from 300 to 1000 m amsl. This region has a general slope towards the south. The foothills are characterized by pediments.

Geologically the district is mainly covered by rocks of Archaean to Cretaceous age, with some isolated pockets of Recent to Sub-recent alluvium. Based on the water bearing property, the rocks of the district can be divided into (i) hard rock comprising crystalline and metamorphic and consolidated sedimentary rock of Chhattisgarh Super group (ii) Soft rock comprising semi consolidated rock belonging to Gondwana Super group and younger alluvium. The Gondwana sediments cover 40% area of the district.

All the nine blocks were studied under NAQUIM program in 2012-17. The aquifer material controlling ground water flow in the district can be broadly divided into two major media (1) Porous media (Shallow Aquifer) and (2) Fractured media (Deeper Aquifer). The major aquifer groups in Raigarh district are (i)

Basement crystalline and metamorphic, (ii) Chhattisgarh Super group (Chandrapur Group ,Raipur group, Charmuria & Raigarh formation), (iii) Gondwana Super Group & (iv) Alluvium and Laterites.

Hydrogeologically, the shallow aquifers both in hard and soft rock in the district are wide spread and largely in use except in few parts of Baramkela, Pusaur and Raigarh blocks. The shallow aquifers are being tapped through dug wells, dug cum bore wells or shallow bore wells drilled to a depth of 60 m. The weathered mantle and shallow fractures mainly constitute the shallow aquifers. The thickness of weathered mantle varies from 5 to 20m bgl. The potential fractures in case of basement crystalline type of rock are mostly confined within the depth of 60 m. Depth to water level in bore wells varies from 4 to 12 mbgl. The casing depth varies from 6 to 35 mbgl. Majority of wells are showing discharge in the range of 1 to 6.5 lps . The specific capacity value for granites varies from 1.43 to 29 lpm/m. The potential fracture zones in Chandrapur group of rocks are encountered within the depth of 60 m. Depth to a water level in bore wells varies from 4 to 17 mbgl. The casing depth varies from 6 to 12 mbgl. Majority of wells are showing discharge in the range of 1 to 3 1ps. The specific capacity value for Chandrapur varies from 5 to 35 lpm/m. In case of Raipur group of rocks, the potential fractures are mostly confined to the depth of 60 m. Depth to water level in bore wells varies from 4 to 17 mbgl. The casing depth varies from 6 to 30 mbgl. Majority of wells are showing discharge in the range of 1 to 10 1ps. Transmissivity of Raigarh Formation varies from 2-35 m^2/ day whereas the Storativity is recorded between 0.14 x 10^{-4} and 1.18 x 10^{-6}. The maximum part of Gondwana area is covered by Barakar Formation. Barakar is the most promising formation covering an area of 1644 sq. km. The deeper aquifer zones encountered between 150-400m bgl has maximum of 6m piezometric head above ground level. The Barakars are represented by thick sequence (>500 m) of sandstone, shale, clay stone, and sand shale intercalation. The Barakar are only coal bearing formation in the district. Number of coal seams has been found in the area both in shallow and deeper zone. Coal mining in the district is presently restricted to Dharamjaigarh and Tamnar blocks. Barakar Formation is the good aquifers in the district and forms ground water worthy areas. Yield ranges from negligible to 10.5 lps. The Transmissivity and Storativity of Barakar Formation ranges between 1.35to 143 m^2/ day and 0.04 to 0.00079 respectively.

280 nos. of observation wells were established and monitored in pre & post monsoon period to acess the ground water regime of the district including the national hydrograph stations. The water level analysis data indicates that the static water level in the district varies from 2.01 to 32.6 mbgl in pre-monsoon, from 0.01 to 22.7 mbgl in post-monsoon period. The fluctuation varies from 0.01 to 28.32 m. Long term trend analysis of water level data of these NHS in post-monsoon period shows 64 % of the wells registered fall in water level and 36% of the dug wells showed rise in the water levels. The overall scenario shows shift in water use from phreatic to semi-confined zone and increased draft for irrigation purpose in selected pockets of Baramkela- Pusaur- Raigarh and Kharsia blocks.

The regional ground water flow direction is towards south-west. In south eastern part of the district the ground water flow direction is towards south-east. In the north -central part of the district the contours are comparatively closer indicating the steepness of the terrain thereby the gradient of ground water flow is high in comparison to the other part of the district. It may also be seen that the flow of ground water is mostly towards the major drainage suggesting that the base flow is towards the drainage system.

The Net Ground Water Availability for future use from all the sources in the district is 41166.73 ham. The Net Ground Water Availability for future use is 4318.72 ham. Current Annual Ground Water Extraction for all purposes is 20292.35 ham out of which 16093.58 ham is for irrigation. The overall Stage of Ground Water Extraction in the district is 50.09 %. As per the NAQUIM study in the district either 4863 nos. of irrigation tube wells or 8874 nos. of irrigation dug wells or combination of both can be constructed at suitable locations in the district for more ground water development and to create more irrigation potential. Also 285 nos. of Percolation tank , 952 nos of Nalas bunding cement plug/ check dam, 2286 nos. of recharge shaft and 1703nos. of Gully plugs /Gabbion structures may be constructed throughout the district that can recharge 124. 45 mcm water to underground to sustain the ground water resources in a long term basis.

A large number of springs were found to occur in the district and are mostly on the northern part of Mahanadi basin covering Dharamjaigarh, Gharghoda, Lailunga, Tamnar, Kharsia and Raigarh block. Most of the springs are restricted to Gondwana formation & Chandarpur sandstones. Majority of the springs of the district are low in discharge and seasonal in nature. To improve the discharge and sustainability of seasonal springs, rain water harvesting in suitable place can be beneficial.

The quality of ground water in the phreatic zone is well within permissible limit of BIS standards and is suitable for drinking, irrigation and industrial purposes except few locations. The ground water of Raigarh district in overall is calcium-magnesium-bicarbonate (Ca-Mg-HCO3) and calcium-sulphate (Ca-SO_4) type for shallow aquifer & calcium-bicarbonate (Ca-HCO3) type for deeper aquifer respectively.

ACKNOWLEDGEMENT

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A.K.Biswal

Scientist-D

AQUIFER MAPPING & MANAGEMENT PLAN IN RAIGARH DISTRICT, CHHATTISGARH

CHAPTER-I

INTRODUCTION

1.1 Objectives:

The groundwater is the most valuable resource for the country. The demand for ground water for various types of use is increasing day by day; consequently indiscriminate development of ground water has taken place and the ground water resource has come under stress in several parts of the country. On the other hand, there are also areas where adequate development of ground water resources has not taken place. These facts underscore the need for micro-level study of the aquifer systems of the country. Central Ground Water Board (CGWB) is involved in hydrogeological investigations covering major part of the country and as per requirement; the reappraisal of ground water regime is being taken up in priority areas to generate the background data on regional scale. CGWB has also carried out ground water exploration in different phases with prime objective of demarcating and identifying the potential aquifers in different terrains for evaluating the aquifer parameters and also for developing them in future. The reports and maps generated from the studies are mostly based on administrative units such as districts and blocks and depict the subsurface disposition of aquifer on regional scale. However, due to paradigm shift in focus from development to management of ground water in last one decade, the need for more reliable and comprehensive aquifer maps on larger scale has been felt for equitable and sustainable management of the ground water resources at local scale. Volumetric assessment of ground water and strategies for future development and management are the primary objective of aquifer mapping.

1.2 Scope of the study:

The aquifer maps are the maps depicting aquifer disposition, giving lateral and vertical extension. The maps will also provide information on the quantity and quality. Aquifer mapping is a multidisciplinary scientific process wherein a combination of geological, hydrogeological, geophysical, hydrological and quality data is integrated to characterize the quantity, quality and movement of ground water in aquifers.

It explains the components of the Aquifer Classification System, outlines the assumptions underlying the map information presented and also summarizes the content of an aquifer classification map. The goal is to help the map users understand the strengths and limitations of the information contained on the aquifer classification maps so that they can apply that information appropriately to their particular water and land management needs. The system and maps are designed to be used together and in conjunction with other available information as a screening tool for setting groundwater management priorities. They provide a way of comparing aquifers within a consistent hydrogeological context and prioritizing future actions at various planning levels. The maps may provide some background information for site-specific projects. However, the maps are not to be used for making site-specific decisions. The classification of an aquifer reflects the aquifer as a whole and at a specific time. Groundwater conditions, such as the degree of vulnerability and water quality, can vary locally and over time respectively. This variability in the data sometimes requires subjective decision-making and generalising of information for an entire aquifer. As such the following nine blocks were studied under NAQUIM program in 2012-17 as following table 1.1.

Table-1.1: Details of area covered under NAQUIM in Raigarh dist

Sl. No.	District	Block	Geographical Area (sq.km)
1	Raigarh	Dharamjaigarh	1537.69
2		Gharghoda	433.04
3		Tamnar	469
4		Kharsia	400.79
5		Lailunga	910.35
6		Pusaur	510.3
7		Raigarh	942.72
8		Sarangarh	851.12
9		Baramkela	781.34
Raigarh district		Total	6836.35

Source: District Statistical Book-2017

1.3 Methodology:

The activities under the aquifer project can be summarized as follows:

i) 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 the Central Ground Water Board and various other government organizations with a new set of data generated that broadly describe an aquifer system. The data were compiled, analysed, synthesized and interpreted from available sources. These sources were predominantly non-computerised data that were converted into computer based GIS data sets. On the basis of these available data, Data Gaps were identified.

ii) Data Generation: It was evident from the data gap that additional data should be generated to fill the data gaps in order to achieve the objective of the aquifer mapping programme. This was done by multiple activities like exploratory drilling, hydro-chemical analysis, use of geophysical techniques as well as detail hydrogeological surveys. About 133 nos. of exploratory wells & observation wells drilled by CGWB and through outsourcing in various periods in different formation, 280 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 335 nos of ground water samples from different sources representing shallow as well as deeper aquifers were studied carefully and analysed before preparing the aquifer map and management plan.

iii) Aquifer map Preparation: On the basis of integration of data generated through various hydrogeological and geophysical studies, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out the Characterization of Aquifers. These maps may be termed as Aqifer Maps depicting spatial (lateral and vertical) variation of the aquifers existing within the study area, quality, water level and vulnerability (quality and quantity).

iv) Aquifer Management Plan: Based on the integration of these generated, compiled, analysed and interpreted data, the management plan has been prepared for sustainable development of the aquifer existing in the area.

1.4 Location, Administrative set up & Demography:

Raigarh district, the Sanskardhani i.e. cultural capital of Chhattisgarh is known for its coal reserves and power generation for the state as well as the country. It is well known for its 'kosa' or tasar, a kind of fine silk created by the silkworm feeding on mulberry fruit.

Raigarh district is situated in the north eastern part of the Chhattisgarh. It is situated between latitudes 21°20’21” to 22°47’13” N and longitudes 82°55’36” to 83°42’16” E50’and is divided into 6 tehsils and 9 blocks, comprising 5 Urban Centers and 1485 villages (Table-1.2 & **Map-1.1**). Raigarh district is surrounded by Jashpur district in the north, Mahasamund district in the south, the state of Odisha border in the east and Janjgir-Champa and Korba districts in the west. Geographically it covers an area of 6836.35 Sq Km. According to 2011 census record the total population of district is 1,493,984. Mahanadi, Kelo and Mand are the main river of Raigarh district. The entire district can be divided into two physiographic regions namely Mahanadi plain (Chhattisgarh plain) and Northern hills of Chhotanagpur plateau. Chhattisgarh plain covers the southern part of the district and is divided into two parts by Mahanadi river. Raigarh is one of the mineral rich district of Chhattisgarh. It is well known for its coal mines and some minor minerals are also found here like Limestone, Dolomite and Quartzite etc. Raigarh is one of the major producers of steel in country.

Table-1.2: Administrative details of Raigarh district (As per 2017)

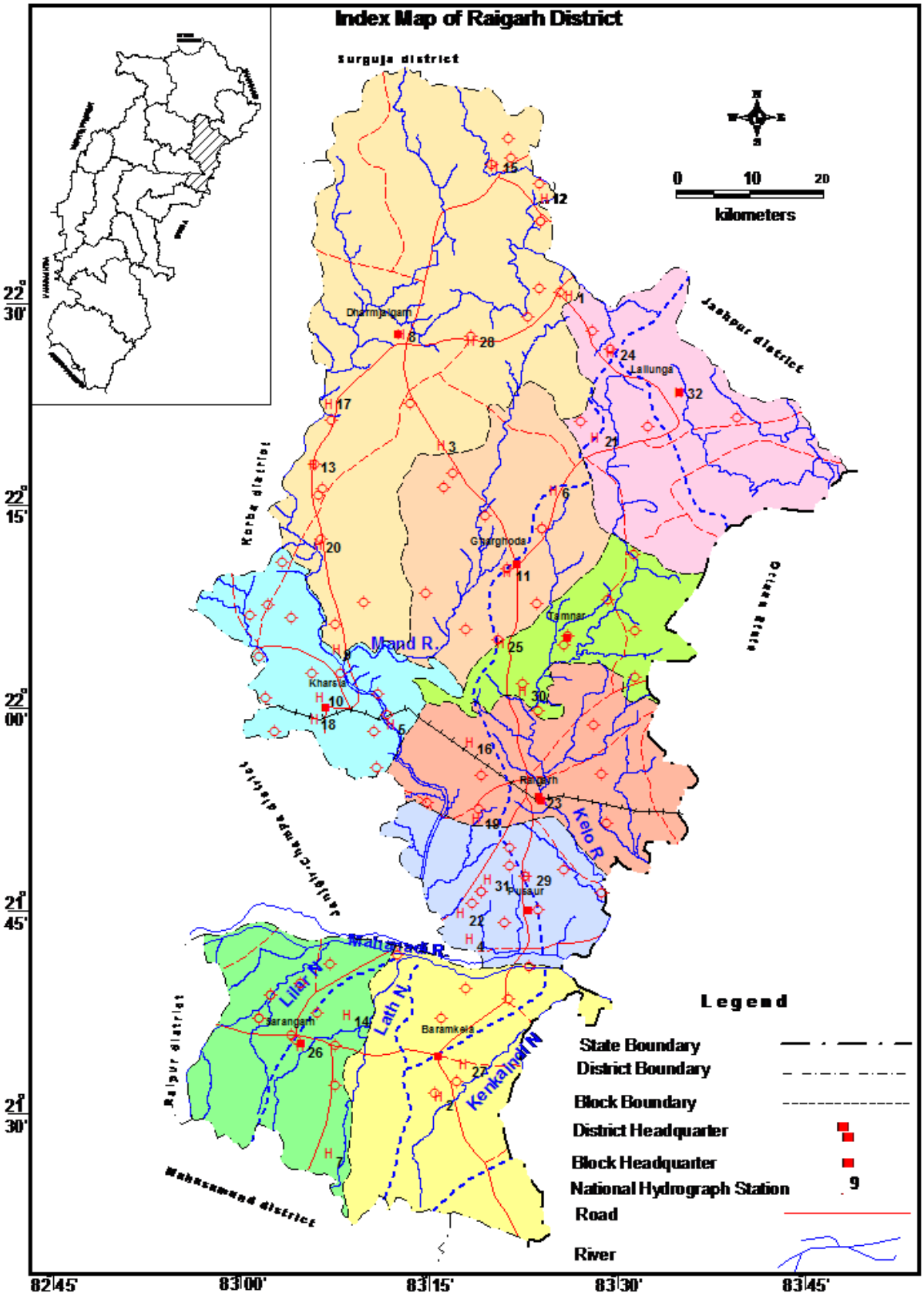
Sl.no	Tehsil	Block	Number of			
			Towns	Nagar Panchyat / Nagar Nigam	Village pancahyat	Villages
1	Dharamjaigarh	Dharamjaigarh	1	Nagar Panchayat	118	189
2	Lailunga	Lailunga	0	0	73	121
3	Gharghoda	Gharghoda Tamnar	1	Nagar Panchayat	61 42	83 117
4	Kharisya	Kharisya	1	Nagar Panchayat	82	138
5	Raigarh	Raigarh Pussore	1	Nagar Nigam	86 81	155 148
6	Sarangarh	Sarangarh Baramkela	1	Nagar Panchayat	125 93	286 248
Total	*6*	*9*	*5*	*5*	*761*	*1485*

Source: District Statistical Book-2017

1.5 Land use:

The total geographical area of the district is 6836.35 sq.km. Nearly 33 % of the total area is covered by forests. Agricultural land covers 2998.55 sq.km. Waste/Barren land covers 144.03 sq.km. Area under nonagricultural use is 561.71sq.km. The net sown area during the year 2016-17 is 2673.29 sq.km. Area sown more than once i.e double cropped area is 325.38 sq. km while the gross cropped area accounts 2998.67 sq. km. The land use/land cover map of Raigarh district is presented in **Map-1.2** and detail land use pattern for the district is shown in table 1.3.

Map-1.1: Administrative map of Raigarh district, Chhattisgarh



Map-1.2: Landuse map of Raigarh district, Chhattisgarh

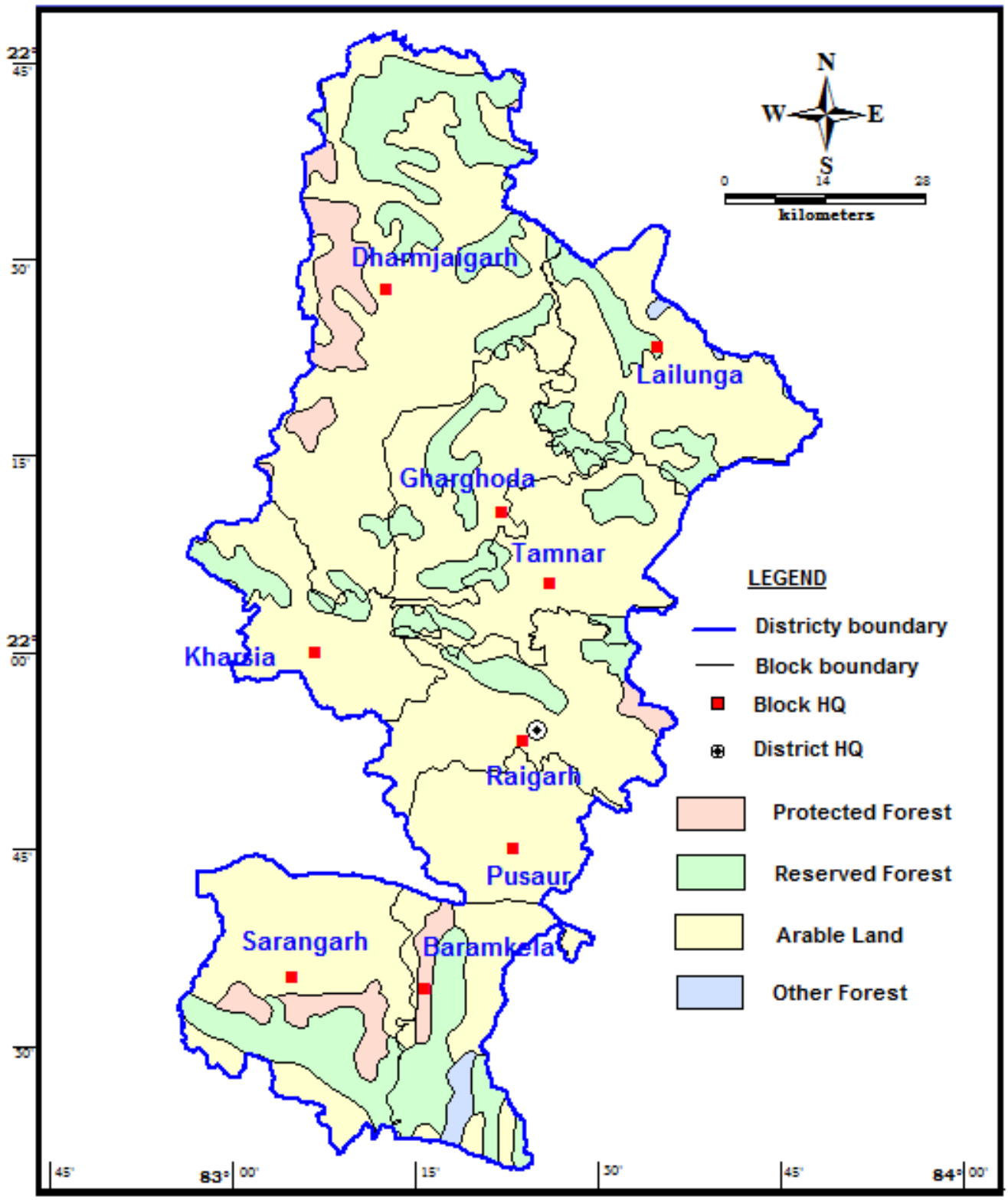


Table-1.3: Land use pattern in Raigarh district during the year 2016-17(in ha)

Sl. No	Blocks	Revenue forest area	Area not available for cultivation	Non agricultural & Fallow land	Agricultural Fallow land	Net sown area	Double cropped area	Gross cropped area
1	Dharamjaigarh	42014	13499	16096	5981	23400	2970	49611
2	Lailunga	5320	10757	8603	2719	26897	6241	35476
3	Ghorghoda	4575	4720	9047	6689	23877	1927	22582
4	Tamnar	2143	5754	4789	5593	36810	3121	24897
5	Raigarh	3391	9353	7954	4578	32244	9814	26370
6	Pussaur	246	5924	3136	3620	21252	1330	33138
7	Kharsia	1466	6000	5890	2894	24000	897	25804
8	Sarangarh	176	9345	3931	2393	32585	2891	39931
9	Baramkela	576	6506	4894	1769	46264	3347	*42058*
Total		59904	71858	64340	36236	267329	32538	*299867*

Source: District Statistical Book-2017

1.6 Cropping pattern:

Kharif is the main cropping season in the district and Paddy is the main crop followed by wheat, maize and jawar. The pulses, oil seeds, fruits, vegetables, reshe, mirch masala and sugarcane etc. are also grown in the district. Rice is sown in nearly 91% of the net sown area. The cropping pattern in the district is shown in table 1.4. Mainly paddy and cereals are cultivated both in kharif and rabi season. The season wise cropping details are presented in table-1.5 A & B.

Table-1.4: Cropping pattern in Raigarh district during the year 2016-17(in ha)

Sl. No	Blocks	Kharif	Rabi	Cereal				Pulses	Tilhan	Fruits / Vegetables	Mirch Masala	Sugar-cane
				Rice	Wheat	Jowar & Maize	Others					
1	Dharamjaigarh	46074	3537	36939	72	453	697	6838	3554	98	114	24
2	Lailunga	32546	2930	24092	303	183	382	7205	1923	39	165	60
3	Ghorghoda	21087	1495	17310	33	2	184	3232	1406	170	32	6
4	Tamnar	23937	960	20024	34	27	66	3762	493	70	61	6
5	Raigarh	23314	3056	23066	282	28	100	1093	1043	101	55	6
6	Pussaur	26878	6260	27101	797	20	315	1619	1301	19	187	90
7	Kharsia	23818	1986	22901	526	21	78	1431	456	60	27	0
8	Sarangarh	36798	3133	36705	248	56	130	1266	732	15	57	0
9	Baramkela	32216	9842	34943	474	35	254	2119	2440	93	238	243
	Total	266668	33199	243081	2769	825	2206	28565	13348	665	936	435

Source: District Statistical Book-2017

Table 1.5 A: Season wise cropping pattern

Rainfed	Irrigated
Rice, Wheat, Soyabean, Arhar kodo, Moong, Til, Maize, Mustard	Rice, Sunflower, Maize, Vegetable, Soyabean, Arhar, Sugarcane

Source: Commissioner Land record-2017

Table 1.5 B: Season wise cropping area (in ha)

Crop	Season	
	Kharif	Rabi
Paddy	215100	14430
Cereals	216090	17260
Pulses	24500	4480
Oilseeds	8090	5270
Vegetables	17980	5750
Wheat	Nil	2780
Maize	890	50
Sugarcane	Nil	440
Grand Total	*266668*	*33199*

Source: Commissioner Land record-2017

1.7 Irrigation:

The district is benefitted by two major irrigation projects namely- (i) Hasdeo Bango (ii) minimata which is completed projects which have an ultimate potential of 392 lakh hectares and 40.87 lakh hectares respectively covering Raigarh, Bilaspur and Korba districts.

The net irrigated area during the year 2016-17 is 68203 hectares. The percentage of the irrigated area to net sown area in Raigarh district is 26.8%. Irrigation by ground water covers almost 48.5 % of the net irrigated area. The area irrigated by various sources is presented in table1.6 and is also shown in **Fig-1 (A&B)**.

Table-1.6: Area irrigated by various sources in Raigarh district during the year 2016-17(in ha)

SNo	Blocks	Canal (private and Govt.)		Bore wells/ Tube wells		Dug wells		Talabs		Irrigated area by other sources	Irrigated area by GW sources	Net Irri-gated area	Irrigated area more than once	Gross irrigated area	% of Net irrigated area to. Net area sown
		Nos	Irrigated area (ha)	Nos	Irrigated area	Nos	Irrigated area	Nos	Irrigated area						
1	Dharamjaigarh	14	744	491	967	955	267	151	412	1276	1234	3708	2880	4050	8.16
2	Lailunga	13	1981	112	285	561	112	171	148	568	397	3001	1435	3273	9.22
3	Ghorghoda	12	236	368	836	394	84	77	91	407	920	1746	1233	1887	8.35
4	Tamnar	1	22	200	284	391	72	137	27	318	356	786	715	804	3.22
5	Raigarh	12	2059	1375	3890	246	59	365	544	617	3949	7105	2942	7584	28.75
6	Pussaur	0	0	3014	10489	309	102	516	1589	695	10591	12980	6141	13697	41.33
7	Kharsia	8	3795	955	1987	201	21	176	175	293	2008	6804	1904	7164	27.76
8	Sarangarh	15	6433	1036	1665	391	25	537	619	1620	1690	11120	2702	11640	29.15
9	Baramkela	6	3339	3426	11911	278	30	601	1115	1406	11941	20953	9692	21633	51.43
	Total	81	18609	10977	32314	3726	772	2731	4720	7200	33086	68203	29644	71732	24

Source: District Statistical Book-2017

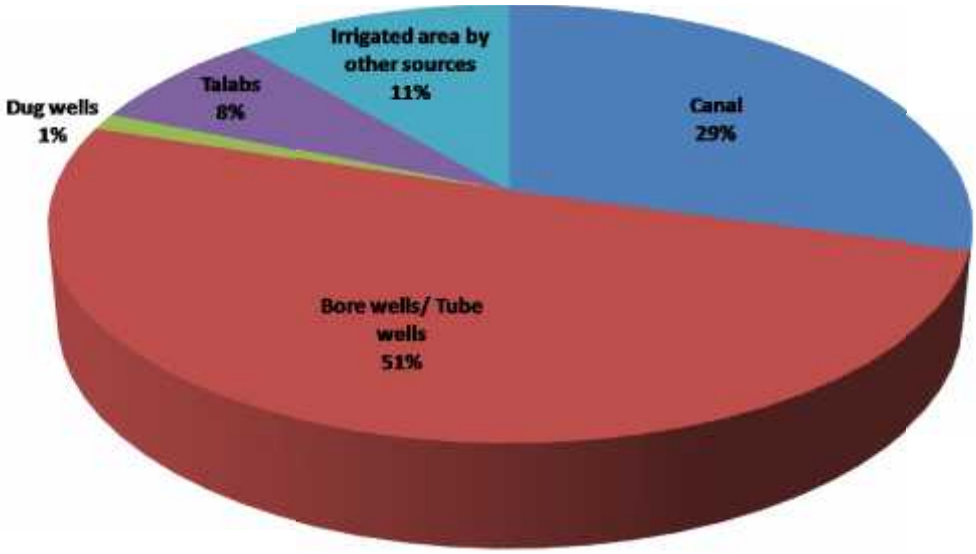


Fig.1-A: Area irrigated in % by different sources in Raigarh district, Chhattisgarh

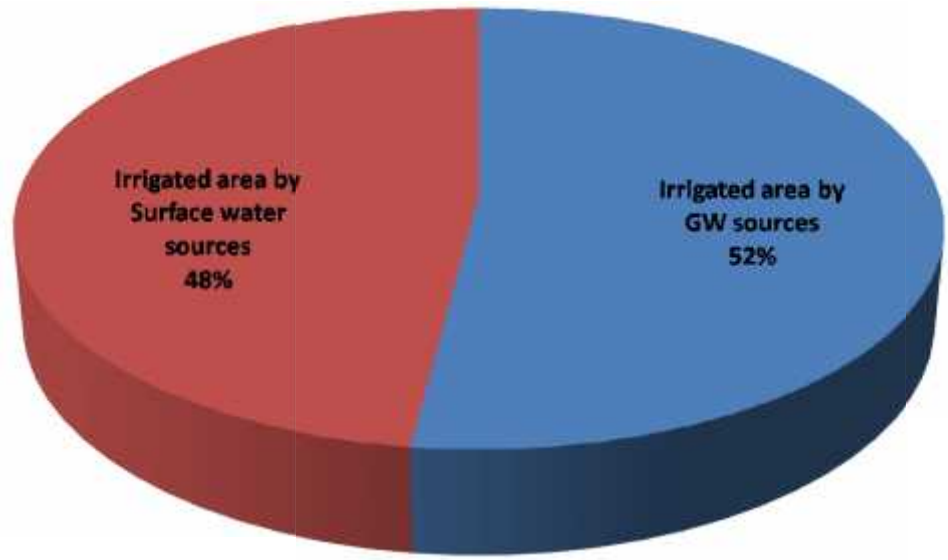


Fig.1-B: Area irrigated in % by Surface & GW sources in Raigarh district, Chhattisgarh

1.8 Minerals, Industries and Mining activities:

Raigarh district is full of major minerals like Coal, Quartzite, Limestone and Dolomite. As a result of which some mineral based industry can also be seen in the district. The production details of major & minor minerals in the district in 2011-12 are given in the table-1.7.

Table-1.7: production of mineral in Raigarh district during 2010-11

S.NO.	NAME OF MINERAL	PRODUCTION in tones
Major Minerals		
1	Coal	18611087
2	Quartzite	125860
3	Limestone	635
4	Dolomite	127
Minor Minerals		
1	Lime Stone	577855
2	Normal Stone	371220
3	Murram	3948
4	Clay (Brick)	4933

Source: - District Statistical Hand Book 2010-11, Raigarh.

Raigarh district is industrially developed. There are 35 large scale industries and 8 Medium scale enterprises exist in the district. Raigarh district is known for its coal reserves and power generation for the state. Mand Raigarh Coalfield located in Raigarh district is one of the major coal field areas in India. It lies in the valley of the Mand River, a tributary of the Mahanadi. Mand Raigarh Coalfield, along with Korba and Hasdo Arand Coalfields forms the South Chhattisgarh Coalfields. Mand Raigarh Coalfield includes the areas earlier known as North Raigarh, South Raigarh and Mand River Coalfields. Of at least twelve seams in the Mand Valley, the Mand and Taraimar seams are important. Mand Raigarh Coalfield is spread over an area of 520 square kilometres (200 sq mi). The field has a potential for mining of power grade coal, much of which can be extracted through open cast mining. Gare block has been identified for captive mining by private companies.

According to the Geological Survey of India total reserves (including proved, indicated and inferred reserves) of non-coking coal in the Mand Raigarh Coalfield is 18,532.93 million tonnes. Out of this 13,868.20 million tones is up to depth of 300 metres, 4569.51 million tonnes is at a depth of 300-600 metres and 95.22 million tonnes is at a depth of 600–1200 m.

NTPC has planned to set up the 5 x 800 MW Lara Super Thermal Power Project in Raigarh district. Coal requirement will be met from Talaipalli coal block of Mand Raigarh Coalfield.

1.9 Soils :

Generally soils are classified on the basis of texture, mineral content and presence of salts and alkalies. However in present context the classification and distribution is adopted as per the soil orders in US soil taxonomy and their Indian equivalents. There are 12 orders in US soil taxonomy but only three orders are found in Raigarh district. They are described in brief below and given in table1.8 (A). The distribution of different soil types in Raigarh district is presented in **Map-1.3**.

Map-1.3: Soil map of Raigarh district, Chhattisgarh

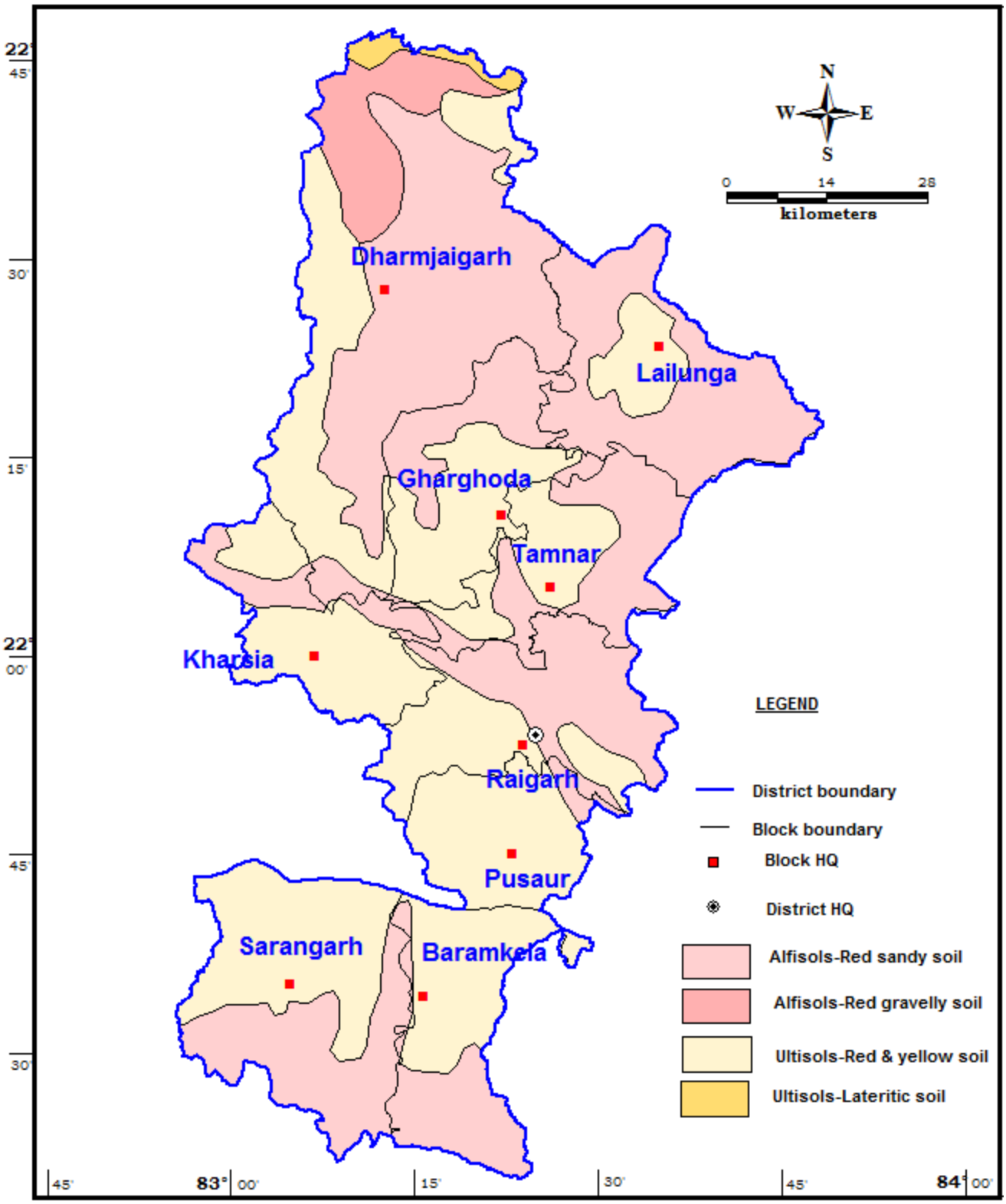


Table-1.8 (A): Soil Classification (Type wise)

Sl.No.	US Soil Taxonomy	Indian Equivalents
1	Ultisols	Red and Yellow soil
2	Inceptisols	Shallow black soil
3	Alfisols	Red gravelly soil
		Red loamy soil
		Red sandy soil

The soils of the district have a large aerial variation. The red coloured residual soil is derived from the lateritisation of shale and sandstones and the areas covered by such type of soil are known as 'Bhata'. The black coloured soils are locally known as 'Kanhar similarly there are pale yellow sandy loamy soils which are locally known as 'Matasi" and 'Dorsa'. The following table1.8 (B) gives the overall picture of soil type area wise in Raigarh district whereas the **Map-1.4** depicts the depth wise distribution of weathered layer in Raigarh district. The map indicates that the northern and central part of Raigarh district occupies weathered layer from 15 to 20 m depth. The maximum weathered layer is seen in eastern part mainly in Charmuria limestone formation which is 30 to 36 m depth. However in case of Gondwana formation, drilling is to be done through rotary drilling using slotted pipe.

Table-1.8 (B): Soil Classification (Extent wise)

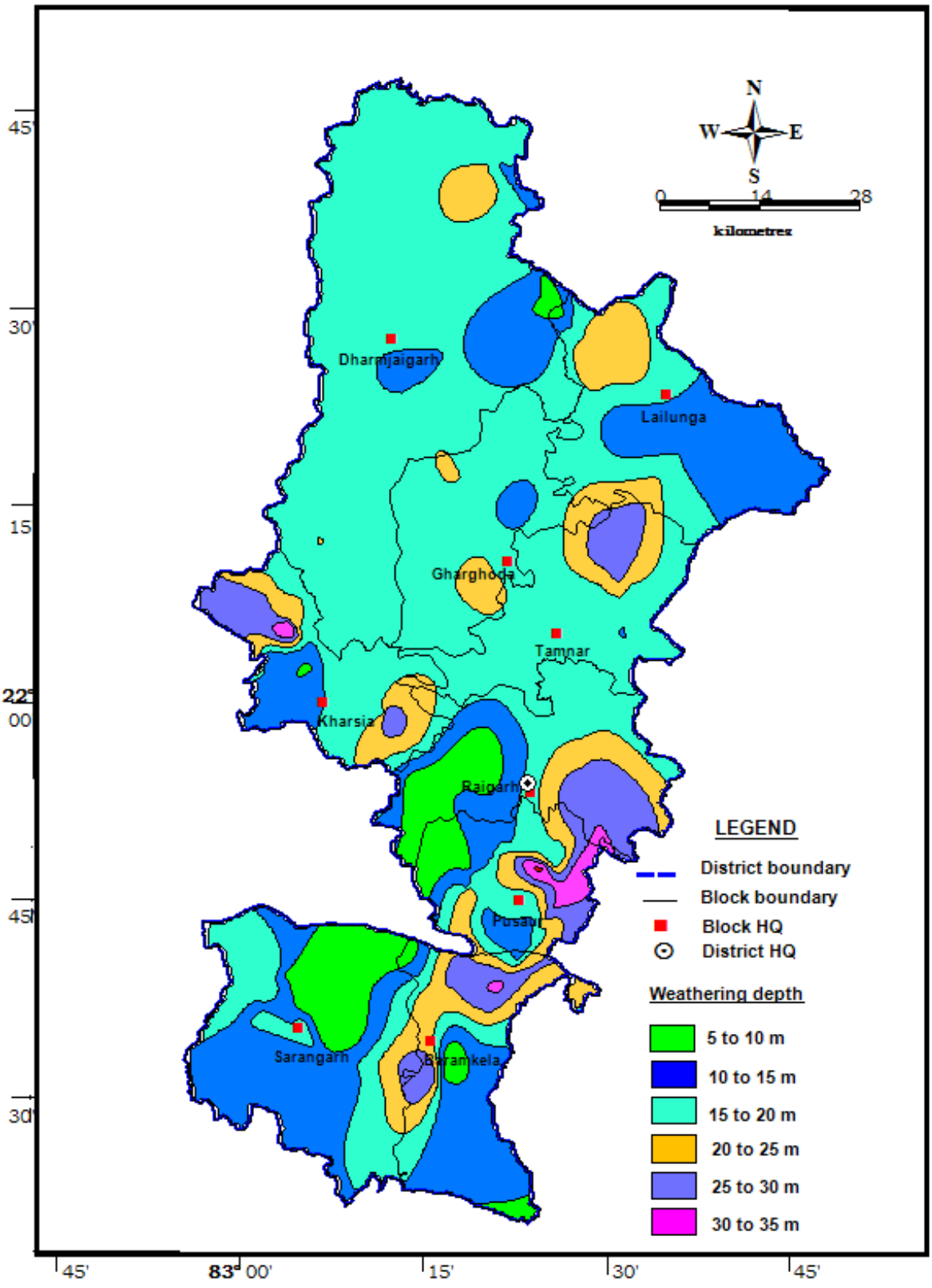
Major Soils (common names like red sandy loam deep soils (etc.,)	Area ('000 ha)	Percent (%) of total
Entisol (Bhata-gravely)	48.22	16.0
Inceptisol (Matasi-Sandyloam)	141.03	46.8
Alfisols (Dorsa-clayloam)	86.89	28.9
Vertisols (Kanhar-clayey)	22.76	7.6
Others (Sandy)	2.13	0.7
Total	301.03	100.0

Source: Directorate of Agriculture, Govt. of Chhattisgarh

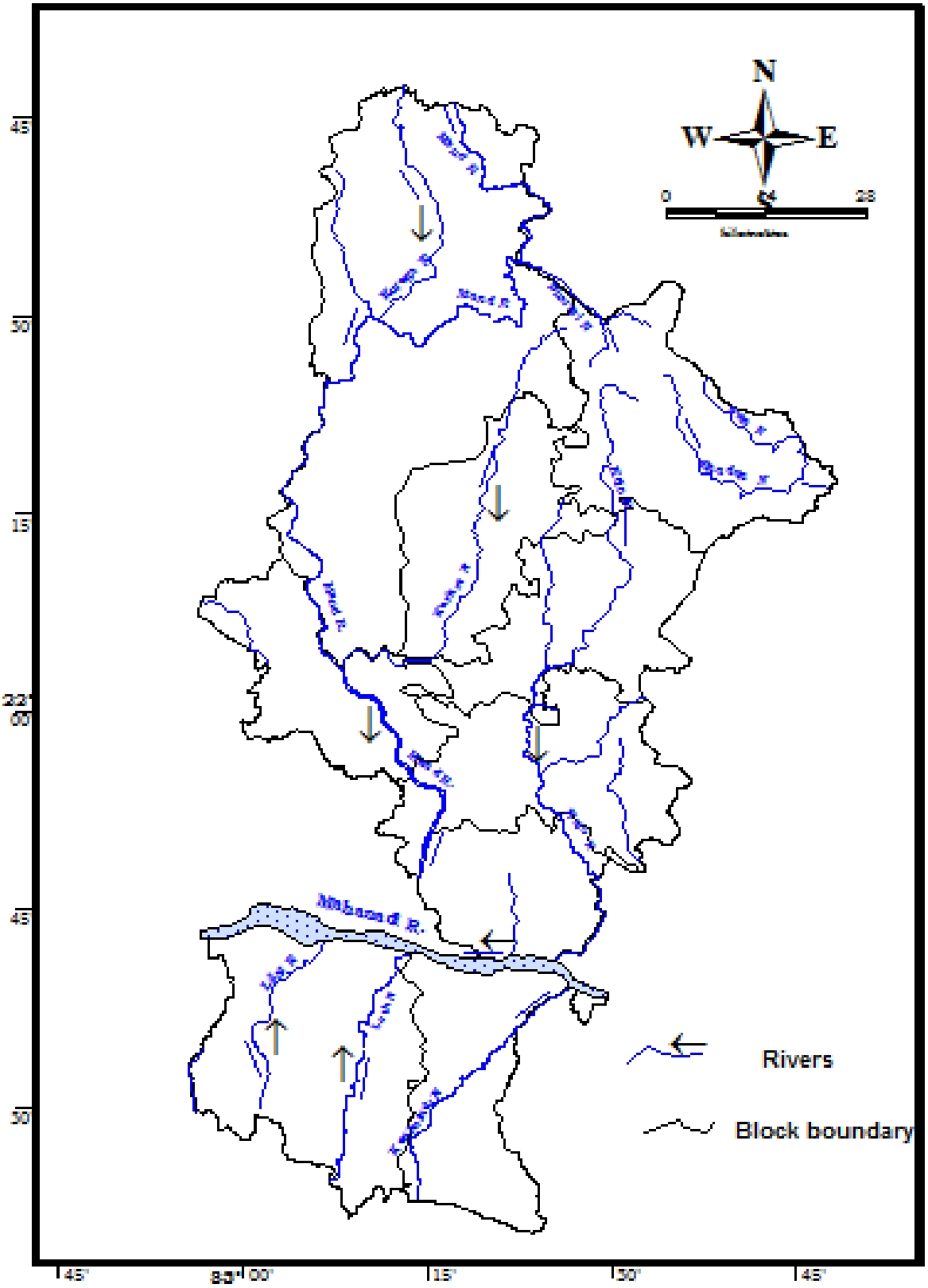
1.10 Drainage:

The drainage system of the district (**Map-1.5**) may be divided into two parts. The streams and rivers originating in the northern hills of Chhotanagpur plateau have southward slope and most of the important rivers- Mand, Kelo, Kuruket and Ib are perennial in nature. The drainage system has moderate and steep valleys between hill ranges. The drainage pattern is dendritic to sub parallel. Kuruket nala joins Mand river which finally joins Mahandi at Chanderpur before draining the entire northern and central parts of the district. Kelo and Ib rivers also join Mahanadi. The drainage system originating at the southern part of the district flow in N and to NE direction before joining the Mahanadi river. These rivers are non-perennial in nature except the Lath nala. The drainage pattern is parallel to sub parallel and controlled by the structural and linear hills developed in the southern parts of the district.

Map-1.4: Weathered Layer map (depth wise) of Raigarh district, Chhattisgarh



Map-1.5: Drainage map (major) of Raigarh district, Chhattisgarh



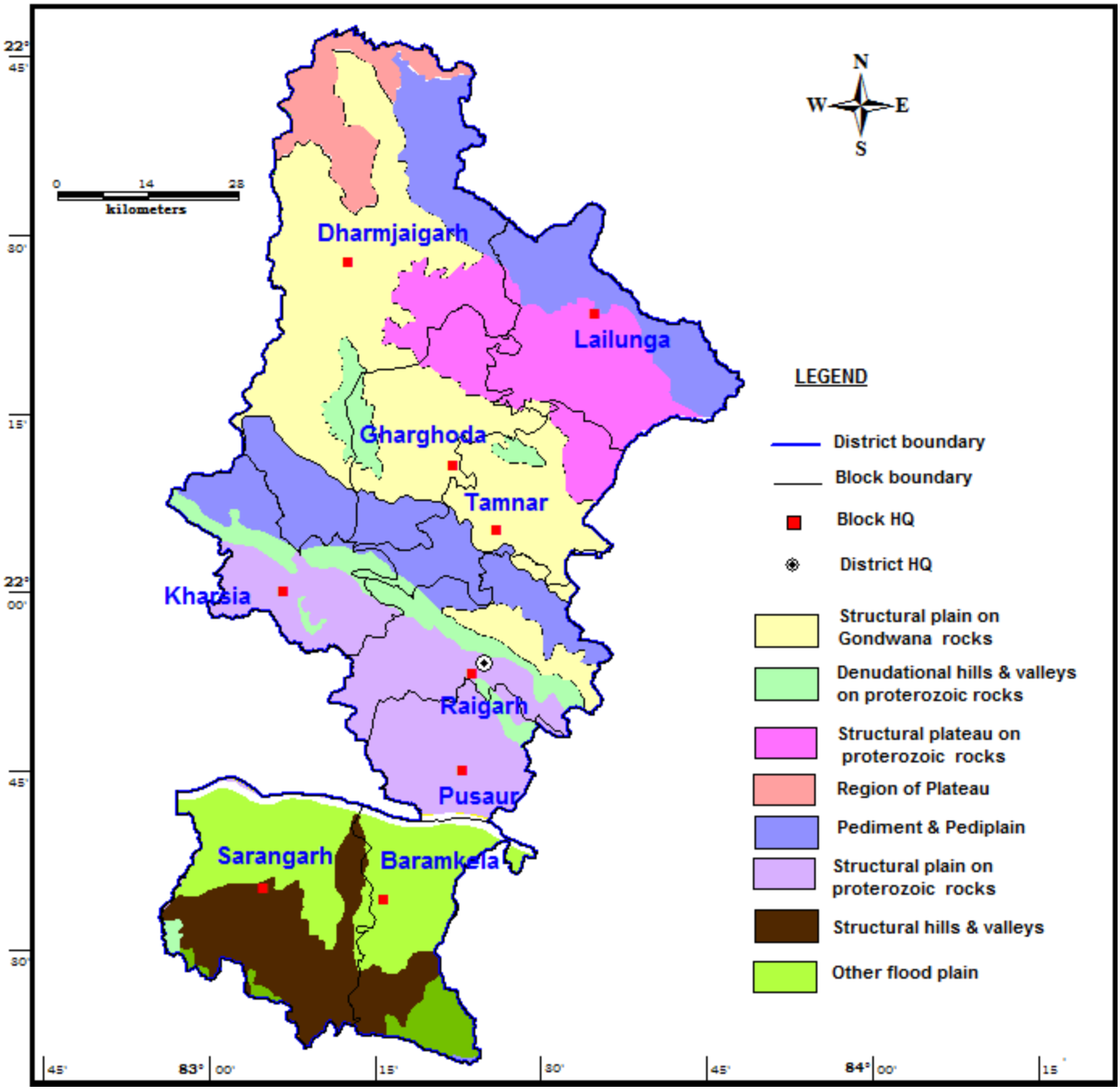
1.11Geomorphology:

Broadly, the entire district can be divided into two physiographic regions namely Mahanadi plain (Chhattisgarh plain) and Northern hills of Chhotanagpur plateau. Chhattisgarh plain covers the southern part of the district and is divided into two parts by Mahanadi river. The Mahanadi valley extends in Raigarh and Sarangarh blocks between Chanwardal and Sarangarh hills. The general width of the plain is about 24 kms on both sides of the river. The general elevation of the plain ranges between 190 and 240m amsl. This area comprises one of the most fertile tracts and is thickly populated region in the district. A linear hill range, the Chanwardal hills, runs from northwest to southwest all along the northern limits of Mahanadi plain. A linear hill range known as Sarangarh hills in Sarangarh block extend in north-south direction and towards south bifurcates in SW-NE and western direction. These hill tracts disturb the plain topography of Sarangarh block. These structural hills are covered with thick forests in the north of Chanwardal hills. The altitude goes on increasing towards Dharamjaigarh and Lailunga. The elevation ranges from 300 to 1000 m amsl. This region has a general slope towards the south. This is characterized by hilly tract and intermediate plains, flanked by high mounds or hillocks rising to an altitude of more than 700 m amsl. The foothills are characterized by pediments. This region is feeder to the drainage network of the northern portion of the district, and has narrow and moderate steep valleys between hill ranges . The geomorphological map of Raigarh district is presented in **Map-1.6**.

1.12 Prevailing Water Conservation and recharge practices:

There are 2731 nos of ponds which are used for irrigation of 4720 ha. Besides there are nos of small ponds exist in the district which are mainly used for various domestic purposes and artificial recharge. Under MGNREGA , till date 296 nos of ponds have been completed for water conservation and water harvesting purpose. 1135 nos of ponds are ongoing for water conservation and harvesting. However these ponds need to be renovated for the optimum ground water recharge. There are some check dams and nalla bunds prevailed in the district which is constructed for ground water recharge purposes.

Map-1.6: Geomorphological map of Raigarh district, Chhattisgarh



CHAPTER-II

HYDROMETEROLOGY

2.1 Introduction:

The Raigarh district experiences sub-tropical climate and is characterized by extreme summer and winter seasons. The summer months are from March to May and the months of April and May are the hottest. The rainy season extends from the month of June to September with well distributed rainfall through southwest monsoon. Monsoon generally breaks in the third week of June and is maximum in the months of July and August. Winter season is marked by dry and cold weather with intermittent showers during the months of December and January.

2.2 Temperature:

The temperature in the district changes continuously with the season and even in day and night. The temperature decreases progressively after October. The winter season lasts till February. January is the coldest month with mean daily maximum temperature at 30°C and the minimum is around 10°C. During winter season, the night temperature sometimes may drop below 10°C. The temperature increases rapidly from mid February till May and sometimes up to mid-June (summer season). The mean daily maximum temperature in summer season goes up to 46°C and nights are slightly warmer during May and mid-June. The monsoon period is generally pleasant. With the withdrawal of the monsoon by the end of September, day temperature rises a little and then both day and night temperatures begin to drop rapidly.

2.3 Evaporation

The evaporation variations are almost sympathetic with the variations of temperature. The evaporation is maximum in the month of May and minimum during the months of December and January.

2.4 Humidity

The atmospheric humidity is usually low during summer months around 25%. However humidity slowly starts building up from third week of May and it reaches maximum around 85% during monsoon period. The humidity again decreases in winter season and it varies between 30 to 40% during winter season.

2.5 Wind Velocity

The wind flows easterly or westerly during the southwest monsoon period. During post-monsoon and winter seasons the wind directions are between north and east and sometimes westerly. The wind speed of more than 10 km/hr is recorded during the monsoon months (from June to September). In the post-monsoon and winter months (from October to February), the wind speed is less than 5 km/hr and in the summer months (March to May) the wind speed is more than 7 km/hr.

2.6 Rainfall

The Raigarh district receives rainfall mainly from south-west monsoon. It sets in third/fourth week of June and continues till mid August/September with heaviest showers in the months of July and August. The average annual rainfall for the district is around 1274 mm (Average of the last five years i.e.2012 to 2017).

Table 2.1 is presented below to show annual rainfall in Raigarh district for the period of five years from 2012 to 2017. The months of July and August are the heaviest rainfall months and nearly 95% of the annual rainfall is received during June to September months.

Table-2.1: Annual Rainfall (mm) in Raigarh district for the years (2012-2017)

Block	**Rainfall in mm**				
	2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Dharamjaigarh	1234.2	1061.5	1336.9	1406.4	2548.4
Lailunga	1371.2	915.1	1022.4	1068.9	1120.5
Ghorghoda	1497	1540.3	1207.2	1290	1259.6
Tamnar	1296.1	1099.3	896.9	1011.5	1184.8
Raigarh	1443.9	1090.5	977.7	1485.6	1583
Pussaur	1139.5	1469.8	1048	1696.9	1784.8
Kharsia	1368.3	1451.3	1399.4	1113.3	1433.9
Sarangarh	964	2105.6	1620.7	1062.7	884
Baramkela	799.7	1215.8	1008.7	957.4	877.8
Average Annual Rainfall of Raigarh district	***1234.8***	***1327.69***	***1168.66***	***1231.5***	***1405.5***

Source: Land and Revenue Department, Korba district

CHAPTER-III

GEOLOGY

3.1 Geology and structure:

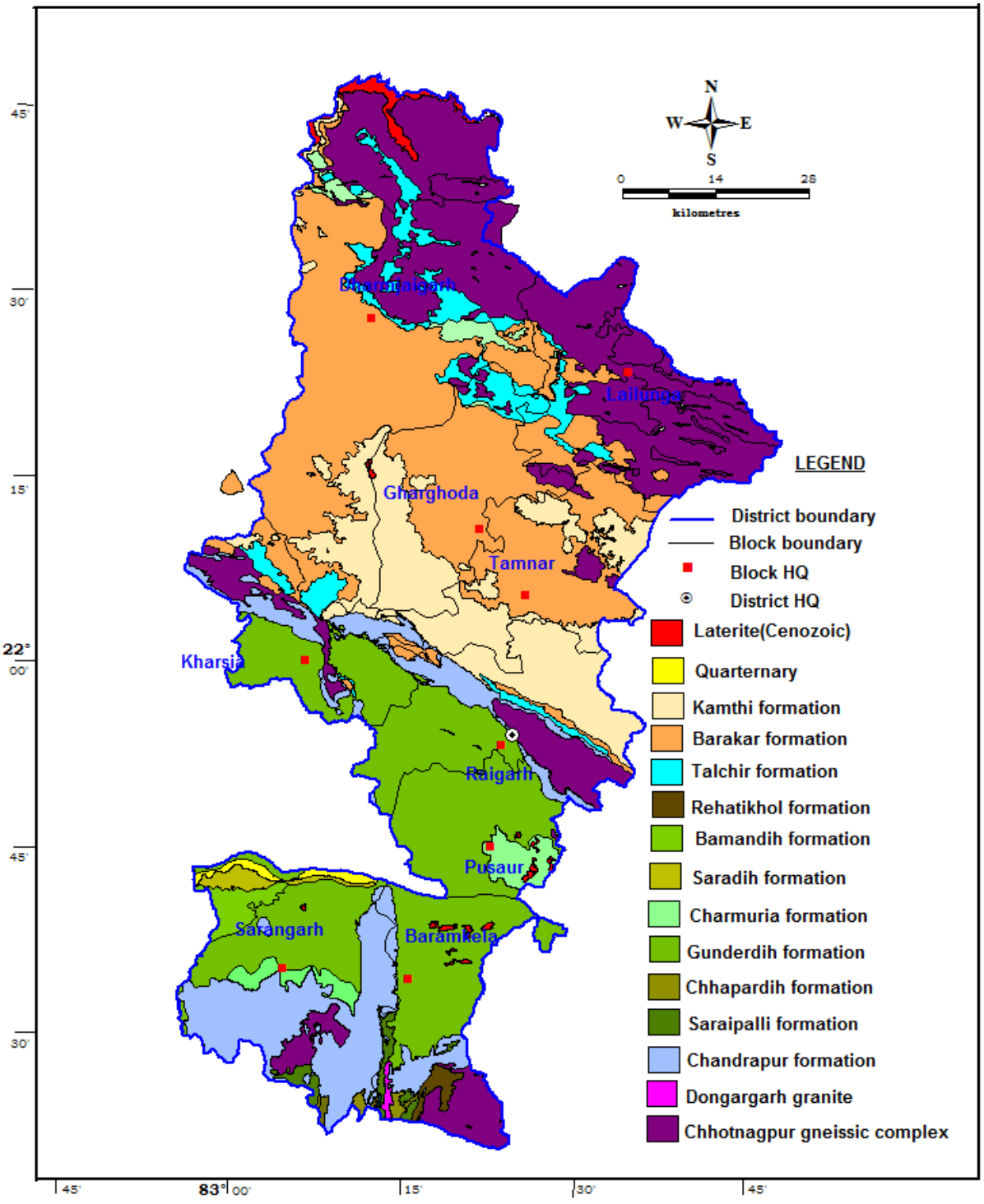
The district is mainly covered by rocks of Archaean to Cretaceous age, with some isolated pockets of Recent to Sub-recent alluvium. Based on the water bearing property, the rocks of the district can be divided into (i) hard rock comprising crystalline and metamorphic and consolidated sedimentary rocks of Chhattisgarh Super group (ii) Soft rock comprising semi consolidated rocks belonging to Gondwana Super group and younger alluvium (**Map-3.1**).

The crystalline and metamorphic rocks mainly occur along the northern boundary of the district with some patchy occurrence in Baramkela, Sarangarh, Kharsia and Raigarh blocks. The crystalline in parts of Dharamjaigarh- Lailunga- Tamnar blocks are part of Chhotanagpur- gneissic complex. These are mainly composed of quartz mica schist and quartzite with granite gneiss, intruded by granite and dolerite. The Chhotanagpur gneissic complex covers 20% of the district area. The rocks of unclassified metamorphic belt of Bilaspur- Raigarh-Ambikapur occur in parts of Kharsia, Ghargoda blocks in linear patches. The south and south central part of the district is covered with unmetamorphosed & structurally less disturbed Proterozoic sediments of Chhattisgarh Supergroup. These sediments cover nearly 40% of total area of the district; these are horizontally bedded non-fossiliferous formations. The Chhattisgarh Super group in the district can be classified into two Groups i.e. Chandrapur and Raipur group The Raigarh Formation in the district has been intruded by dolerite dyke trending WNW- ESE. The outcrop of dolerite dykes can be seen in Kharsia-Raigarh blocks around Bhupdeopur- Gejamunda- Nansian and Aneri and Karrakot villages in Baramkela block. These are mainly doleritic to gabbroic in texture, hard and massive.

The Gondwana sediments cover 40% area of the district. The Gondwana rocks of the area are divided into (1) Talchir Formation (2) Karharbari Formation (3) Barakar Formation and (4) Kamthi Formation. The Gondwana rocks are faulted and intrusives are rarely present in the district. The Talchir Formation in the district is mainly represented by shale and silty shale with occasional boulder bed at the base. The shales are thinly laminated and bedded and interbedded with silty shale. Talchir shale is found in some parts of Kharsia and Dharamjaigarh blocks and Karharbari formation in the Dharamjaigarh block. Talchir Formation is overlain by Karharbari Formation, which consists of sandstone and shale intercalation. It occupies only small patches in the district. Barakar Formation covers maximum part of Gondwana area. The Barakars are represented by thick sequence (>500 m) of sandstone, shale, clay stone, and sand shale intercalation. The Barakar are only coal bearing formation in the district. Many coal seams have been found in the area both in shallow and deeper zone. Coal mining in the district is presently restricted to Dharamjaigarh and Tamnar blocks. The Barakar sandstone/ shale is semi -consolidated, horizontally to low dipping strata. The sandstone is sub-arkosic in composition, fine to coarse grained, poor to moderately sorted. The shales are generally black and carbonaceous. Kamthi occupies the second largest area within Gondwana covered area. Being the youngest member Kamthi formation occupies the hilltops of Gondwana hills. Sandstones and shales mainly represent them. These sandstones are rich in iron contents, dirty to brownish colour. Kamthi in the district is generally devoid of coal seams.

Alluvium and Laterite occupy small isolated patches. The Alluvium is generally present all along the major streams. The right bank of Mahanadi in Baramkela block has linear patches of alluvium. These mainly consist of fine sand, silt and gravel (Panhchdhar). The thickness of this alluvium varies between 2 to 10 m. The laterites are both insitu and transported in nature and widely distributed over the district. More than 5 m. thick laterite cover over dolomite of Baramkela and Pausar has been observed.

Map-3.1: Geological map of Raigarh district, Chhattisgarh



CHAPTER-IV

DATA COLLECTION & GENERATION

4.1 Introduction:

About 136 nos. of exploratory wells & observation wells drilled by CGWB and through outsourcing in various periods in different formation, 280 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 335 nos of ground water samples collected from different sources representing shallow as well as deeper aquifers were studied carefully and analysed before preparing the aquifer map and management plan (**Map-4.1**).

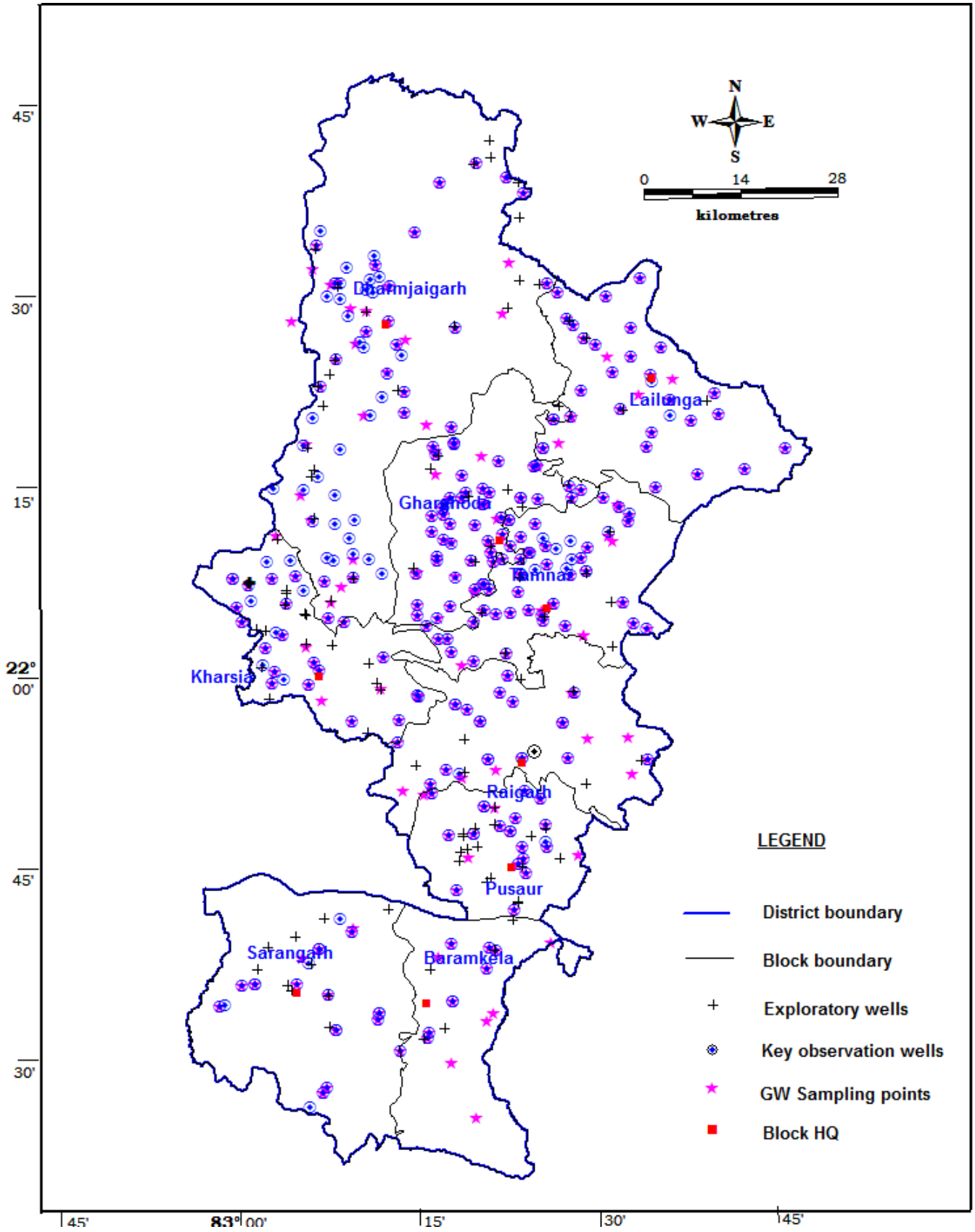
4.2 Exploration data:

Exploration was carried out in Raigarh district covering both semi-consolidated Gondwana rocks and consolidated hard Crystalline and Chhattisgarh Supergroup of rocks. The systematic hydrogeological studies (SHS) of the district was carried out in AAP 1989-90, which provided the momentum for other activity, and the exploration of the semi consolidated Gondwana formation commenced in AAP 1991-2002. Out of 136 numbers of explorations, CGWB has drilled 85 nos of EW, 28 nos of OW. 23 nos of EW also drilled under Accelerated Drilling programme in 2001. Also 22 nos of piezometers were drilled by CGWB in the district to record the static water level in various periods for shallow and deeper aquifers. The sites for exploration were selected on the basis of hydrogeological investigations that was carried out with the help of geological map, lineament map, geomorphological map based on remote sensing studies and the quadrangular map no 64 O of GSI on 1:25000 scale and also as per the requirement given by State PHED. The ultimate sites were pinpointed with the help of surface geophysical investigations at many points. The aquifer parameter of various shallow and deeper aquifers were calculated based on long term (1000 minutes) pumping tests, preliminary yield test and slug test of bore/tube wells during exploratory drilling. Variable discharge test, SDT (Step draw down test) has been conducted in several wells of Gondwana semi consolidated formation through three or four steps. The well loss and formation loss components of draw down were calculated by determining the well loss coefficients (B) and formation loss coefficients (C). The well efficiency and specific capacity determined by SDT can also be indicative of hydraulic characteristics of the aquifer. The details of the exploration is given in Annexure-I. The status of bore wells drilled in each block of the district is shown in table 4.1.

Table-4.1: Status of exploration (EW) in Raigarh district (formation wise)

S.N	Block	Gondwana formation	Gunderdih Shale	Charmuria Limestone	Chandrapur Sandstone	Crystallines	Total
1	Dharamjaigarh	16	-	-	-	9	25
2	Lailunga	-	-	-	-	4	4
3	Ghorghoda	12	-	-	-	-	12
4	Tamnar	9	-	-	-	-	9
5	Raigarh	1	4	-	-	1	6
6	Pussaur	-	14	3	-	-	17
7	Kharsia	2	8	-	1	7	18
8	Sarangarh	-	6	2	4	-	12
9	Baramkela	-	4	1	-	-	5
	Total	*40*	*36*	*6*	*5*	*21*	*108*

Map-4.1: Map showing the location of exploratory wells, key observation wells & GW sampling in Raigarh district, Chhattisgarh



4.2.1 Well design:

Hard and soft rocks need separate well design. Since Raigarh district is mostly covered by hard rock, so well construction is relatively an easy job. With the help of high capacity DTH rigs, 200 m deep wells can be constructed within 10-12 hrs in hard rock areas. In these wells of hard rock, casing the initial weathered thickness is a bit time taking. Once the weathered zone is sealed with casing, drilling through massive formation is just a matter of time. The penetration rates (depth drilled per minute) are high in general . Constraints come whenever there is collapsible fractured zone or crushed breccia struck below massive rock. Drilling through highly cavernous, clay filled zone (e.g. Temer, Semra) or zone of very high discharge (e.g. Baramkela, Kutela) also produce hindrance to drilling process. Higher the weathered thickness (more than 20-25 m) over massive hard rock need combination rigs to construct a successful well. In such area gravel pack rotary wells have to be constructed to tap the weathered zone. Many a times low yielding hard rock wells are developed for enhancing yield either through hydro-fracturing, blasting or through chemical treatment (particularly for clay filled cavernous zones by sodium hexa meta phosphate). PVC casing is preferred where ever ferric oxide problem persist in ground water of hard rock.

In these wells protective casing of 4" to 6" diameter and length varying from 9 m to 36 m is required for the weathered and collapsible zone (Fig. 2). The cavernous limestone/dolomite sometimes cause drilling problem even after the top weathered zone is cased, due to filling of sticky clay. Sometimes this zone needs casing to complete the drilling operation successfully. Alluvium covered hard rock need combination rig, so that the upper alluvium can be drilled through rotary rig to construct a gravel pack well followed by DTH drilled uncased hole. In soft rock, gravel pack wells drilled by Rotary rigs are the best. Filter point wells are preferred in very shallow alluvial cover area. Though it is easy as well as economical to construct filter point wells, normally they have short life span (less than 5 years). In semi-consolidated Gondwana rocks, gravel pack tube wells are constructed by rotary rig. The pilot hole is drilled first up to the desired depth followed by geophysical logging. Based on the litho log and geophysical log well assembly (combination of blank and slotted pipes) is recommended (Fig. 3). Well assembly is lowered after the reaming of the well bore by bit of suitable size. Lowering of assembly is followed by gravel shrouding and development of the well by cleaning the slots by jetting and air compressor.

It has been observed that State and private agencies have drilled bore wells in semi-consolidated Gondwana rocks by DTH method but the wells did not withstand pumping whereas the durability of such bores are more when they are fitted with hand pumps which implies that the semi-consolidated Gondwana rocks of the state have enough strength to stand without the support of mud cake but can't sustain pumping. The bentonite mud used during drilling operation is difficult to remove by the prevailing well development techniques for these rocks and resulted in chocking of pores as well as decline in well efficiency. So, local mud can be used as alternative for drilling which can easily be removed by developing the well as a result the efficiency of the well can be improved. Even large diameter wells drilled by DTH method followed by gravel shrouding and well development by jetting can be a cheaper alternative for construction of well in Gondwana rocks.

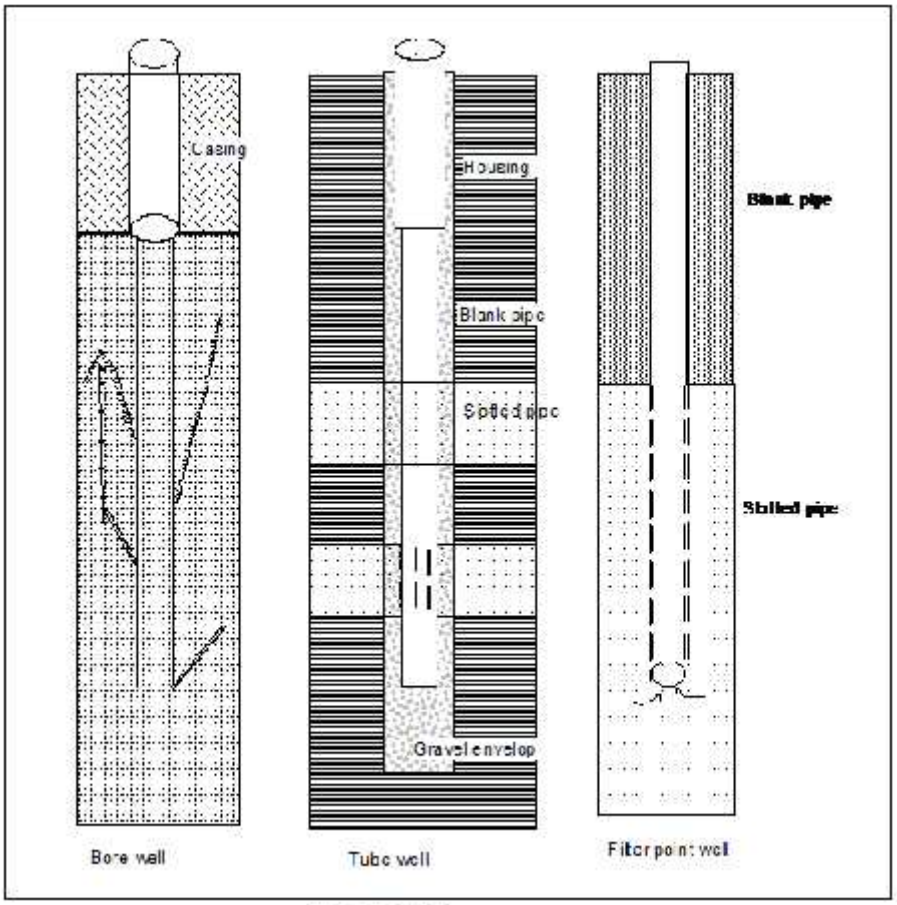


Fig 2 -Well design

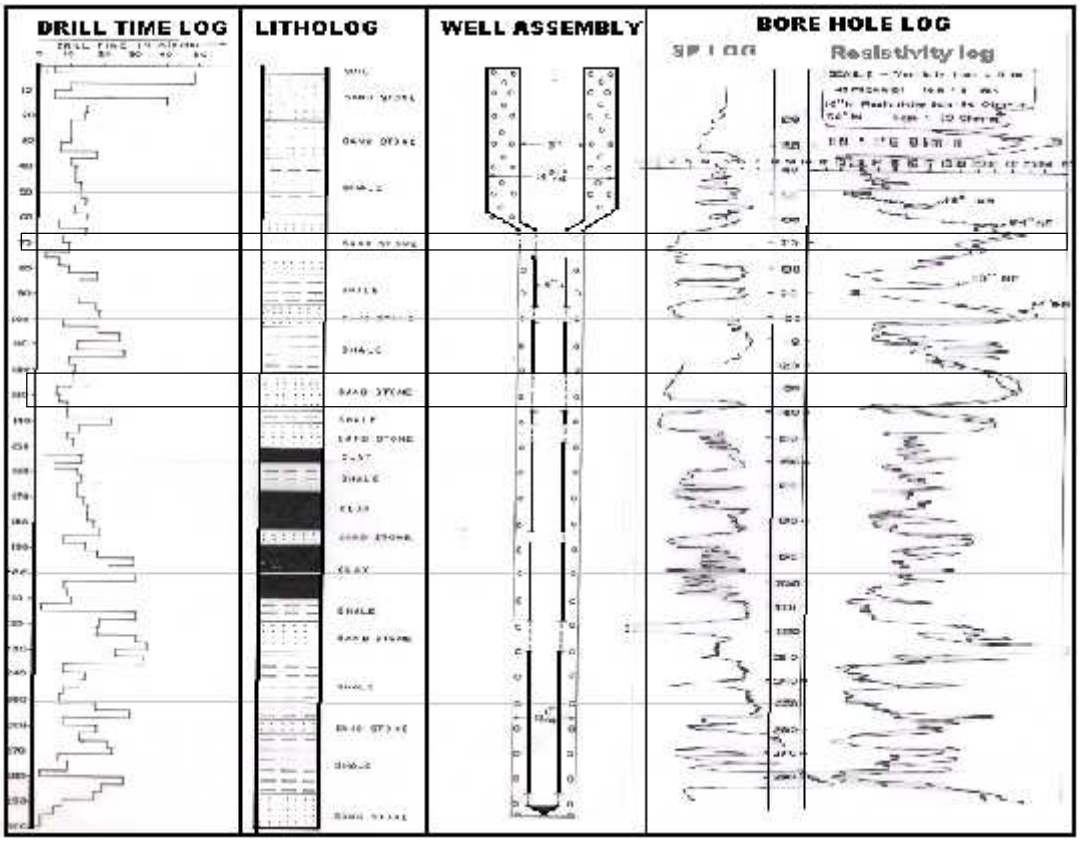


Fig. 3: Design of Kotrimal Bore well and relation with Drill Time Log, Litholog, SP Resistivity Log

4.3 Water Level data:

Ground water is a dynamic system. It always remains under the influence of time dependant recharging and discharging factors. Due to this continuous influence, water level of the aquifer system fluctuates and the range depends on the period of influence. The recharge to the ground water system is controlled by many factors such as rainfall, seepage from reservoirs, lakes, ponds, rivers and irrigation, etc. The output from the ground water system includes ground water withdrawal, natural seepage to rivers and sea, evaporation from shallow water table and transpiration through vegetation.

Central Ground Water Board started monitoring the ground water regime through the All India National Hydrograph Network Stations from 1969 onwards. The density of observation wells was increased year after year. During the survey 280 nos of observation wells were established including 58 nos of NHS which were monitored four times in a year for NHS and two times (Pre-monsson & Post-monsoon) for newly established key observation wells during the following periods.

May -	20th to 30th of the month - represents water level of Pre-monsoon period.
August -	20th to 30th of the month - represents peak monsoon water level
November -	1st to 10th of the month- represents water level of Post-monsoon period.
January -	1st to 10th of the month- represents the recession stage of water level

Ground water levels, observed over a period, provides valuable information on the behavior of ground water regime, which is constantly subjected to changes due to recharge and discharge. The difference between these two factors results in the decline or rise in the ground water storage. When the recharge exceeds discharge there will be rise in the ground water storage whereas decline in the storage will be observed when recharge is less than discharge. The response of these factors is ultimately reflected on the water level of the area and their fluctuation. The phreatic water table of an area is the subdued replica of surface topography, which is regionally controlled by the major river basins and locally controlled by the watersheds. This is termed as phreatic aquifer in the report which represents the weathered formation of the area. Since all the developmental activities is listed by administrative unit in the state hence the block wise or district wise water level data is needed for planning developmental activity. On the basis of analysis of water level data, the changes in the ground water regime have been discussed. For every set of measurement the data was analyzed and maps like Pre and post-monsoon depth to water level, Water level fluctuation and Long term (decadal) water level trend have been prepared. The historical water level data available were analyzed to have long-term trend in water level behavior of all the basins within the state. Separate maps were prepared for pre-monsoon and post-monsoon decadal trend. These water level trends were analyzed to understand the ground water regime variation in long-term basis. The details of the water level data is given in Annexure-II.

4.4 Hydrochemical data:

The hydrochemical analysis of the ground water of the district was based mostly on the analysis of 335 ground water samples collected during the survey and exploration from key observation wells as well as exploratory wells. The samples were distributed throughout the district representing all the aquifers **(**Map-4.1**)**. The parameters analysed were EC, pH, Ca^{+}, Mg^{+}, Na^{+}, K^{+}, CO_3^{--}, HCO_3^{-}, Cl^{-}, SO_4^{--}, NO_3^{-} and F^{-} . These analyses do not represent a particular year or period in a year (pre or post monsoon). During the year 2016, 66 numbers of ground water samples from ground water monitoring wells of CGWB in Raigarh district were analysed for Arsenic. Further, a special study has been taken up by

CGWB to assess the Uranium contamination in ground water in the year 2019 where 95 nos of ground water samples were analysed in the chemical laboratory of CGWB, Chandigarh.

All the chemical analyses presented here have been carried out in the laboratory of CGWB, NCCR, Raipur. EC and pH were analysed using EC and pH meters respectively. Ca, Fe, CO3, HCO3 and Cl were analysed using titrimetric methods. K and Na were analysed by flame photometer, SO4 and F by Spectrophotometer, NO3 by UV Spectrophotometer and Arsenic was analyzed by AAS. The samples which were analyzed for major cation and anion species are balanced electrochemically within +10 percent. The obtained results give the overall existing scenario of the ground water hydrochemistry of Raigarh district. With respect to the results the suitability of ground water for drinking, agriculture and industrial purposes has been described.

The ground water samples were collected in good quality, cleaned and well-washed polyethylene bottles of one litre with necessary precautions. The water samples were divided in two portions. The 1st portion was used for measurement of physical parameters, cations and anions. The 2nd portion was acidified with few drops of ultra pure acid (E. Merck) for analysis of the iron and arsenic. The bottles were labeled with respect to collecting points, date and time in order to avoid any error between collection and analysis. The collected water samples brought to laboratory for determining physicochemical parameters by the standard methods given in APHA 19th edition, 1995. All the chemicals were used AR grade of pure quality. Distilled water was used for the preparation of all the reagents and solutions. The pH measured by using WTW digital pH meter (model 7110) with an accuracy of ± 0.01% and Electrical Conductivity measured by WTW digital Conductivity meter (model 7110) with an accuracy of ± 0.01% respectively. Total hardness and calcium were measured by EDTA complex ometric titration method. Magnesium was calculated by the difference of total hardness and calcium ion concentration (TH - Ca). The sodium and potassium were determined by flame photometer. The carbonate and bicarbonate was measured by titration method and by the obtained concentration of carbonate and bicarbonate, the total alkalinity was computed and reported in mg/l as CaCO3. Chloride was measured volumetrically by silver nitrate titrimetric method using potassium chromate as indicator. Sulphate was measured by spectrophotometer (Cecil) method using barium chloride as precipitating agent. The nitrate was determined by UV-Visible spectrophotometer at 220 nm. Fluoride was determined by ion selective electrode (Orion 4 star) using TISAB solution. The iron was determined in the acidified water samples by ECIL Atomic absorption spectrophotometer (model no. 4141). Arsenic was analysed by the combination of hydride generator and AAS.

To know the suitability of ground water for drinking, irrigation and industrial purposes different methods are used as described below.

The result of the chemical analysis of ground water samples was compared with IS 10500 BIS: 2012 for the drinking purposes. The BIS standard mentions the acceptable limit and indicates its background. It recommends implementing the acceptable limit. Values in excess of those mentioned as “acceptable” render the water is not acceptable, but still may be tolerated in the absence of an alternative source but upto the limits indicates under “permissible limit” in the absence of alternate source, above which the sources will have to be rejected.

The type of ground water is ascertained by the pipe diagram. Ground water always contains some amount of dissolved constituents; their presence affects the soil structure, permeability and aeration which ultimately affect the plant growth. Several factors such as Sodium soluble percentage (SSP), Residual

sodium carbonate (RSC), Sodium adsorption ratio (SAR), Percentage sodium (%Na) and Kelly index (KI) are defined for irrigation water suitability . The US Salinity Diagram developed by the US Salinity laboratory in 1954 is an important tool to classifying irrigation water. It is a plot of SAR verses electrical conductivity and used to decide the suitability of ground water for irrigation purposes. Soluble Sodium Percentage (SSP) of the water is calculated by applying the equation given below in which the values are expressed in meq/l. The sodium in water replaces Ca in the soil by Base Exchange process decreasing the soil permeability. Water with less than or equal to 50 SSP value is of good quality and more than 50 is not suitable for irrigation as permeability will be very low.

$$\mathbf{SSP} = (\mathbf{Na} / (\mathbf{Ca} + \mathbf{Mg} + \mathbf{Na})) \times 100$$

The concentration of carbonate and bicarbonate also plays a very vital role for classification of irrigation water. The relative abundance of sodium with respect to excess of carbonate and bicarbonate over alkaline earth also affects the suitability of water for irrigation purpose and this excess is denoted by residual sodium carbonate (RSC) and is determined by the formula as given, where all ions in meq/l.

$$\mathbf{RSC} = (\mathbf{HCO3} + \mathbf{CO_3}) - (\mathbf{Ca} + \mathbf{Mg})$$

The most common measure to assess sodicity in water and soil is called the Sodium Adsorption Ratio (SAR). The SAR defines sodicity in terms of the relative concentration of sodium (Na) compared to the sum of calcium (Ca) and magnesium (Mg) ions in a sample. The SAR assesses the potential for infiltration problems due to a sodium imbalance in irrigation water.

$$\mathbf{SAR} = \mathbf{Na} / \sqrt{(\mathbf{Ca} + \mathbf{Mg})/2}$$

Percentage sodium (%Na) is an indication of the soluble sodium content of the groundwater and also used to evaluate Na hazard. In all natural waters, %Na is a common parameter to assess its suitability for irrigation purposes since sodium reacts with the soil to reduce permeability.

$$\%\mathbf{Na} = ((\mathbf{Na} + \mathbf{K}) / (\mathbf{Ca} + \mathbf{Mg} + \mathbf{Na} + \mathbf{K})) \times 100$$

Kelly's ratio (KR) introduced by Kelly, is an important parameter used in the evaluation of water quality for irrigation. This parameter is based the Na, Ca and Mg levels in the groundwater. According to this classification, groundwater with a KR value greater than one (>1) is deemed unfit for irrigation.

$$\mathbf{KI} = \mathbf{Na} / (\mathbf{Ca} + \mathbf{Mg})$$

Corrosivity ratio CR are used for know the suitability of water for irrigation purpose. Here it is used for industrial water suitability in ground water of Chhattisgarh. Corrosivity ratio (CR) indices formula is described below. The Corrosivity ratio (CR) is calculated using the under mentioned formula in which the ions are in mg/l units. The groundwater with corrosivity ratio <1 is considered to be safe for transport of water in any type of pipes, whereas >1 indicate corrosive nature and hence not to be transported through metal pipes and it is not suitable for industrial or domestic purposes.

$$\mathbf{CR} = (\mathbf{Cl}/35.50) + (\mathbf{SO_4}/96) / (\mathbf{CO_3} + \mathbf{HCO_3})/100$$

4.5 Achievement:

To understand the regional hydrogeological behavior of Raigarh district, this complex aquifer setup has been classified into aquifer system on the basis of their lithology and age. The aquifer characteristics, its extent and the ground water quality are analyzed on the basis of these broad classifications. Ground water flow pattern, long and short term dynamics is also studied block wise. Finally the Aquifer maps were prepared and accordingly Aquifer Management Plan has been formulated for Raigarh district.

CHAPTER-V

AQUIFER DISPOSITION

5.1 Principal & Major aquifer groups:

The aquifer material controlling ground water flow in the district can be broadly divided into two major media (1) Porous media (Phreatic Aquifer) and (2) Fractured media (Deeper Aquifer). The principal aquifer groups in Raigarh district are:

(i) Basement crystalline and metamorphic
(ii) Chhattisgarh Super group (Chandrapur Group ,Raipur group)
(iii) Gondwana Super Group
(iv) Alluvium and Laterites

The major aquifer groups in Raigarh district are (**Map-5.1**):

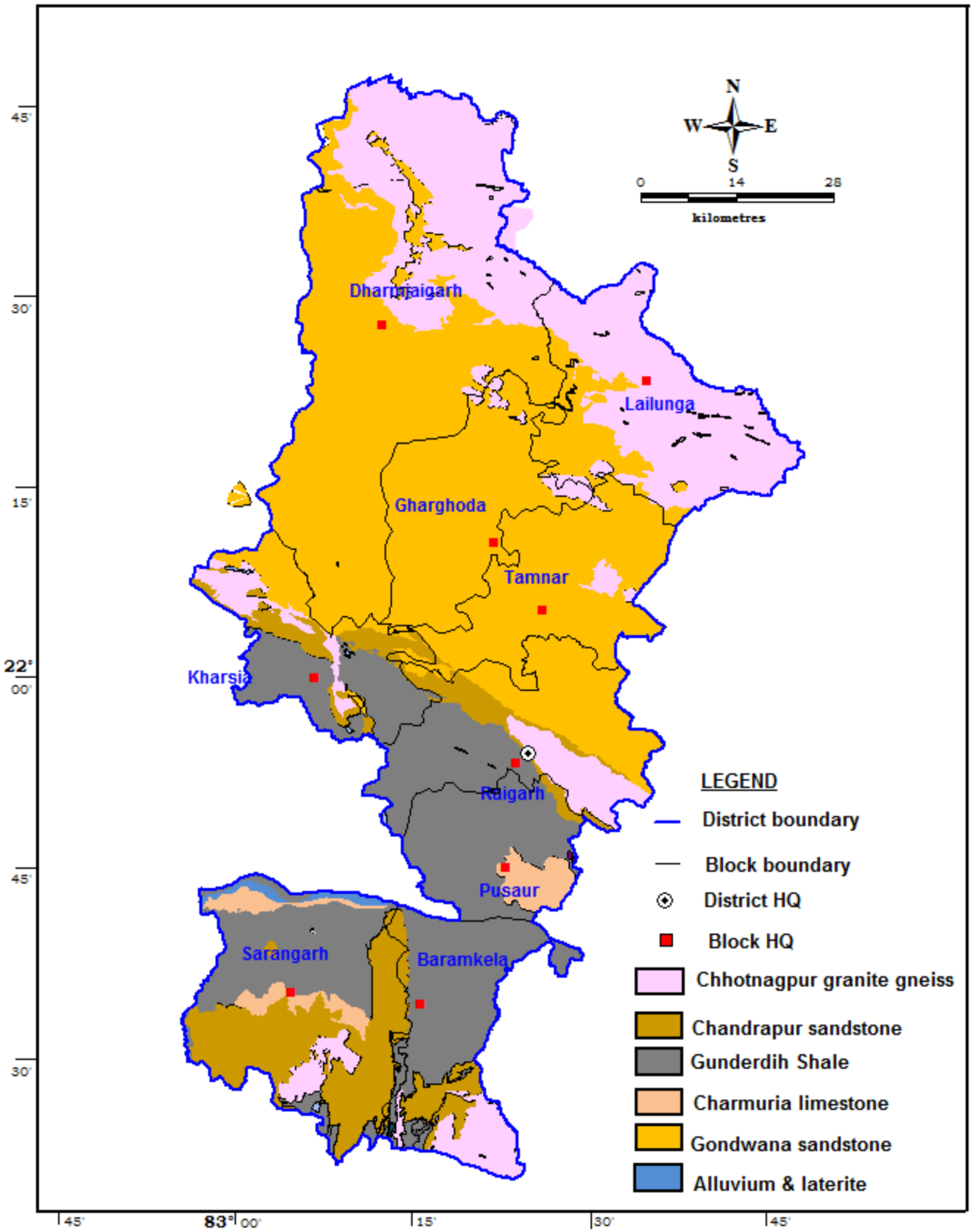
(i) Chhotnagpur Granite Gneiss
(ii) Chandrapur Sandstone
(iii) Gunderdih Shale (Raipur group represented by Raigarh formation)
(iv) Charmuria Limestone (Raipur group represented by Raigarh formation)
(v) Gondwana Sandstone
(vi) Alluvium and Laterites

The phreatic aquifer both in hard and soft rocks in the district is wide spread and largely in use. This aquifer is being tapped mainly through dug well upto a depth of 20 m broadly. However extraction of ground water is done at many places except in few parts of Baramkela, Pusaur and Raigarh blocks by tapping dug cum bore wells or shallow bore wells drilled to a depth of 60 m that generally represents shallow aquifer which is generally connected to phreatic aquifer.. The weathered mantle and shallow fractures mainly constitute the shallow aquifers. The thickness of weathered mantle varies from 5 to 20m bgl. Nearly 90% of dug wells are in the depth range between 5 and 15 mbgl. The hand pumps installed by PHED for drinking water taps the shallow fracture zone down to 60 m bgl. The deeper aquifers have been identified in both hard and soft rocks. From the data collected, the characteristic of different aquifers in the district are deciphered and described as follows:

(i) Basement crystalline and metamorphic :

These crystalline and metamorphic rocks mainly occur along the northern boundary of district with some patchy occurrence in Baramkela, Sarangarh, Kharsia and Raigarh blocks. The crystalline in parts of Dharamjaigarh- Lailunga- Tamnar blocks are part of Chhotanagpur- gneissic complex. They mainly composed of quartz mica schist and quartzite with granite gneiss, intruded by granite and dolerite. The Chhotanagpur gneissic complex covers 20 % of the district area. The rocks of unclassified metamorphic belt of Bilaspur - Raigarh-Ambikapur occurs in parts of Kharsia, Ghargoda blocks in linear patches. Equivalents of Bastar gneiss occur in Raigarh, Sarangarh and Baramkela blocks in small patches. The fracture zones are encountered in the depth range of 13 to 80 mbgl. However the potential fractures are mostly confined to within the depth of 100-200 m depth. Depth to water level in bore wells varies from 4 to 12 mbgl. The casing depth varies from 6 to 34.9 mbgl. The casing length also indicates thickness of the

Map-5.1: Map showing major Aquifer groups in Raigarh district, Chhattisgarh



weathered formation. Majority of wells are showing discharge in the range of 1 to 6.5 1ps. The highest discharge of 6.5 lps was obtained at Chaurenga village in Lailunga block. The specific capacity value for granites varies from 1.43 to 29 lpm/m. The distribution of ground water in these formations shows that the morphological low areas have better ground water prospect than the highs.

(ii) Chhattisgarh Super group (Chandrapur Group, Raipur group including Charmuria & Raigarh formation) :

The rocks of Chhattisgarh Super group comprise of both phreatic and semi confined aquifer in weathered mantle, fractures and cavernous zones. The south and south central part of district is covered with un-metamorphosed, structurally less disturbed Meso-Neo proterozoic sediments of Chhattisgarh Super group. These sediments cover nearly 40% of total area of the district. These are horizontally bedded non-fossiliferous formations. The Chhattisgarh Super group in the district can be classified into two Group i.e. (a) Chandrapur and (b) Raipur group.

(a) Chandrapur Group: The Chandrapur Group in the district consists of Orthoquartzitic to subarkosic sandstone and black shale. The sandstone mainly occupy the ridges in Sarangarh, Baramkela, Pusaur, Raigarh and Kharsia blocks, where as the black shale mainly occurs in the plains of Sarangarh block around Tamtora- Bataupali area. Purple shale interbedded with sandstones is seen at many places within the Chandrapur Group. The sandstones of Chandrapur Group in the district are affected by marginal faults. The prominent N-S trending faulted ridge which divides the Baramkela and Sarangarh blocks attains an elevation of 314 m amsl. The N 30°W- S 30°E trending sandstone ridge which divides the district into nearly two half has a faulted contact with Raigarh Formation (Raipur Group). This linear ridge attains a maximum elevation of 560 m amsl where the sandstone beds are horizontal to southerly dipping. Apart from these a small faulted block occurs in east of Kharsia, where roughly NS linear ridge of Chandrapur sandstone attends elevation of 457 m amsl having faulted contact with Raigarh Formation in north and with Granite and Gondwana sediments in east. The Chandarpur Sandstone covers 753 sq. km area mostly in hill ranges. The sandstone of Chandarpur is highly silicified and devoid of primary porosity. They produce springs in the area. The low-lying Chandarpur sandstone covered area has phreatic aquifer. However deep fractured zone at Kerajhar and Kutela has been found, controlled by deep-seated lineaments. The Chandarpur shale is aquiclude in nature; they hardly possess any weathered zone and cover a small area in Sarangarh and Raigarh block. The distribution of ground water in Chandarpur group is poor and the movement of water is restricted along joints and fractures. The fracture zones are encountered in the depth range of 60 to 120 mbgl. However the potential fractures are mostly confined to within the depth of 60 m. Depth to a water level in bore wells varies from 4 to 17 mbgl. The casing depth varies from 6 to 20.85 mbgl. The casing length also indicates thickness of the weathered formation. The discharge obtained from the wells drilled in the Chandrapur formation varies from 1 to 12.5 lps. The highest discharge of 12.5 lps was obtained at Kutela village in Sarangarh block. The specific capacity value for Chandrapur varies from 5 to 35 lpm/m.

(b) Raipur Group: The Raipur Group is represented by Raigarh Formation in the district. The Chandrapur sandstones are overlain by argillo-calcareous rocks representing Raigarh Formation in Baradwar sub basin. This formation occupies low lying area and is dominated in blocks of Baramarkela, Pusaur, Raigarh, Kharsia and parts of Sarangarh blocks. The Raigarh Formation is equivalent of Charmuria and Gunderdehi Formation of Hirri sub basin. The Raigarh Formation is mainly composed of

shale-limestone-dolomite. These are generally horizontally bedded, unmetamorphosed, thinly laminated intruded by series of dolerite dyke. The Raigarh Formation around Kudhri-Sarangarh-Hardi-Temerlaga in Sarangarh block, Kanthpali- Sahajpali in Baramkela block and Balolda in Kharisa block can be clearly distinguished into Charmuria Formation and Gunderdehi Formation. The Charmuria Formation in Sarangarh has light greenish cherty Ranidhar member (Das, etal 1992) at base. Schinitzer (1969) classified these limestones as Sarangarh bituminous and siliceous limestone. Murthy (1987) has correlated these limestones equivalent to Charmuria limestone.

Two widely spread dolomite member has been identified during the present study within the Raigarh formation. One occurring in the Baramkela block and another in Raigarh block. Approximately 300 sq.km area around Baramkela- Saria- Gobarsingha- Katangpali is occupied by these black coloured, course grained, bedded, non stromatolitic dolomite. These are facies variation of Gunderdih shale and occupy the upper part of sequence. In the transition zone, the dolomites are purple coloured and massive in nature. The outcrop of massive purple argillaceous dolomite can be seen along the Kinkari nala around Kankidipa and Manipura. The outcrop of black dolomite can be seen in Katang nala section near Katangpali and Kariganthi. The dolomite around Raigarh is dolostone in composition and is buff to cream coloured & thinly bedded to medium bedded. These dolomites are showing dip of 20° at few places. The outcrops are exposed at Raigarh- Sarangarh road at Sangitarai and on Raigarh – Jharsguda road on nala section near Tamtikra and by the side of railway crossing on Raigarh-Kotra road. The lateral facies variation is observed in the excavation being carried out for the layout of pipeline for water supply to Jindal power and steel plant from Mahanadi. Stromatolitic limestone above shale has been observed in Lath nala section near Madhopali, near Ulkhar in Sarangarh block and in the canal system near Kulba-Sarwani area in Raigarh block. These are equivalent to Chandi limestone/ Bamnidihi limestone as stromatolitic limestone is not found in Gunderdehi – Charmuria Formation and Raigarh formation.

The ground water occurrence in areas covered by Raipur group represented by Raigarh Formation, (148 sq.km) is in phreatic or semi confined condition. This formation is represented by Charmuria limestone & Gunderdih shale. The Gunderdih shale is calcareous in subsurface and many times gypsiferous, having good secondary porosity in parts of Raigarh, Pusaur and Kharsia blocks. The Charmuria formation in Pusaur block is predominantly dolomite having cavernous zones and is good repository of ground water. Seasonal weak auto flow conditions exist at few places within Raigarh Formation like Gotma village. The fracture zones are encountered in the depth range of 60 to 120 mbgl. However the potential fractures are mostly confined to within the depth of 100 m. Depth to a water level in bore wells varies from 4 to 17 mbgl. The casing depth varies from 6 to 30.56 mbgl. The casing length also indicates thickness of the weathered formation. The discharge obtained from the wells drilled in the Charmuria limestone varies from 0.5 to 19.5 lps. The highest discharge of 19.5 lps was obtained at Baramkela village in Baramkela block. The shally part of Raigarh Formation is represented by Gunderdih shale in Kharsia, Pusaur, Raigarh, Baramkela and Sarangarh blocks. The fracture zones are encountered in the depth range of 60 to 120 mbgl. However the potential fractures are mostly confined to within the depth of 100 m. The casing depth varies from 6 to 35.5 mbgl. The casing length also indicates thickness of the weathered formation. The discharge obtained from the wells drilled in the Gunderdih shale varies from 0.5 to 22.42 lps. The highest discharge of 22.42 lps was obtained at aurda village in Pusaur block. The dolerite dykes within the Raigarh Formation in Raigarh block have acted as good barrier obstructing the deeper ground water movement and thus turning the northern part of these linear dykes rich in ground water. Transmissivity of Raigarh Formation varies from 2-35 m^2/ day whereas the Storativity is recorded

between 0.14 x 10^{-4} and 1.18 x 10^{-6}. The hill range of Chandarpur sandstone, north of these dykes with slope and dip towards south act as recharge area for the narrow strip of land 5 to 1km wide where a large numbers of high yielding wells exist. The potential of ground water immediately south to the dyke is moderate. Overall the Raigarh Formation covered area in the district is good for ground water development because of its high yield potential. The aquifer can be divided into two zones shallow and deeper aquifers. The sustainability of the shallow zones in hard rocks particularly in the bore wells tapping Raigarh Formation in Baramkela- Raigarh-Sarangarh- Pusauar and Kharsia blocks are under threat. Many dug wells and hand pumps get dried up during summer. The shallow aquifer in Granitic terrain also has poor sustainability but not that severe as in areas covered by Raigarh Formation. The dug wells are abandoned or defunct in large parts of Raigarh-Pusaur and Baramkela blocks.

(iii) Gondwana Super Group :

Rocks of lower Gondwana occur in the northern and central part of district. The Gondwana sediments covers 40% area of the district . The semi-consolidated Gondwana Formations occupies the entire Gharghoda and Tamnar block and large part of Dharamjaigarh block and parts of Kharsia, Raigarh and Lailunga blocks. The area covered by Gondwana Formation has no problem of sustainability. The weathered zone followed by granular and fractured zone provides sufficient water to the wells. In the Gondwana formation the deeper aquifer to a depth of 400 m bgl has been deciphered. The deeper aquifer zones in Gondwana Formation are more productive than shallower zones. The tube wells constructed beyond 200m depth have good discharge. All other wells having depth range of 200m have limited discharge. In these wells the upper 30m zone has not been tapped. The Gondwana rock of the area is divided in to (a) Talchir Formation (2) Karharbari Formation (b) Barakar Formation and (c) Kamthi Formation. The Gondwana rock is faulted and Intrusives are rarely present in the district.

(a) Talchir Formation: The Talchir Formation in the district is mainly represented by shale and silty shale with occasional boulder bed at the base. The shale are thinly laminated and bedded and interbedded with silty shale. The Talchir is predominantly shale and are aquiclude in nature is devoid of any deeper zone and have only phreatic zone. The area is suitable for dug wells and shallow tube wells only. Talchir shale are found in small part of Kharsia and Dharamjaigarh blocks. Primary as well as secondary porosity is poor, general yielding capacity of well is less than 3 lps.

(b) Karharbari Formation: In the Dharamjaigarh block, Talchir Formation is overlain by Karharbari Formation which consists of sandstone and shale intercalation. It occupies only small patches in the district. Moderately potential formation.

(c) Barakar formation: The maximum part of Gondwana area is covered by Barakar Formation. Barakar is the most promising formation covering an area of 1644 sq. km. The ground water occurs in both phreatic and semi-confined to confined condition. Two distinct perennial auto flow zones have been demarcated, one in Tamnar and the other one at Gharghoda and Dharamjaigarh blocks in the Mand and Kelo river sub basins respectively. The deeper aquifer zones encountered between 150-400m bgl has maximum of 6m piezometric head above ground level. At Tamnar water with temperature as high as 50°C and high Sulphur contamination has been encountered in the tube wells drilled by GSI and CGWB. This free flowing zone having a linear extent of nearly 15 km from Devgarh to Milupara via Tamnar is a result of synclinal axis passing through this area within Barakar Formation (Tewari, 1999). Oozing of

springs is common in Barakar sandstone/shale area. The Barakars are represented by thick sequence (>500 m) of sandstone, shale, clay stone, and sand shale intercalation. The Barakar are only coal bearing formation in the district. Number of coal seams has been found in the area both in shallow and deeper zone. Coal mining in the district is presently restricted to Dharamjaigarh and Tamnar blocks. The Barakar sandstone/ shale are semi consolidated, horizontally to low dipping strata. The sandstone is subarkosic in composition, fine to course grained, poor to moderately sorted. The shales are generally black and carbonaceous. Barakar Formation is the good aquifer in the district and forms ground water worthy areas. Yield ranges from 0.38 to 10.5 .The highest discharge of 10.5 lps was obtained at Kudekela village in Baramkela block. The Tansmissivity value for Raigarh formation varies from 1.35 to142.75 m^2/day and Storativity ranges from 0.04 to 0.00079.

(d) Kamthi Formation: Kamthi occupies the second largest area within Gondwana covered area. Being the youngest member Kamthi Formation occupies the hill tops of Gondwana hills. They are mainly represented by sandstone and shales. These sandstones are rich in iron contents, dirty to brownish colour. Kamthi in the district is generally devoid of coal seams. Kamthi formation formed potential aquifer for ground water point of view. Kamthi covered area has good granular zone in shallow depth in comparison to that of Barakar Formation. Springs are also common in the Kamthi Formation. The Kamthi- Karharbari area is suitable for both shallow and deep tube wells.

(iv) Alluvium and Laterites :

Alluvium and laterite occupies small isolated patches. The Alluvium is generally present all along the major streams. The right bank of Mahanadi in Baramkela blocks has linear patches of alluvium. These mainly consist of fine sand, silt and gravel (Panhchdhar). The thickness of this alluvium varies between 2 to 10 m. The laterite both insitu and transported in nature is widely distributed over the district. More than 5 m. thick laterite cover over dolomite of Baramkela and Pausar has been observed.

5.2 Ground Water Regime monitoring:

During the study, 280 nos. of wells both dug wells and hand pumps were established and monitored (**Annexure-II**) both in pre-monsoon and post-monsoon period. These include 58 no. of. National Hydrograph Network Stations established in the district to monitor the water levels four times a year and water quality once a year. The water level analysis data indicates that the static water level in the district varies from 2.01 to 32.6 mbgl in pre-monsoon, from 0.01 to 22.70 mbgl in post-monsoon period. The fluctuation varies from 0.01 to 28.32 m. However the details of the water level variation is explained in block wise report. The water level map prepared for the district is presented in (**Map-5.2 A, B &C**).

5.2.1 Decadal Ground Water level fluctuation:

The pre-monsoon & post-monsoon water level data of 2018 has been compared with the pre-monsoon & post-monsoon mean decadal (2008-2017) water level data to ascertain the rise and fall of ground water level. Long term trend analysis of water level data of NHS shows fall in 80 % (59 % having upto 2 m fall) and rise in 20% of dug wells in pre-monsoon whereas in post-monsoon 62.68 % (55 % having upto 2 m fall) of the wells registered fall in water level and 37% of the dug wells showed rise in the water levels. The overall scenario shows shift in water use from phreatic to semi-confined zone and increased draft for irrigation purpose in selected pockets of Baramkela- Pusaur- Raigarh and Kharsia

blocks. The statistical analysis shows that more than 70% abstraction structures of the district lie within these blocks and tap shale- dolomite- limestone belonging to Raigarh Formation. The table-5.1(A&B) gives the comparison of pre-monsoon and post-monsoon water level data in 2019 with the mean decadal pre & post-monsoon water level data (2009-2019).

Table-5.1(A): Decadal pre-monsoon water level fluctuation in Raigarh district

No. of Wells	**Range of Fluctuation**				**No. of Wells/Percentage Showing Fluctuation**						**Total No. of Wells**	
	Rise (m)		**Fall (m)**		**Rise (m)**			**Fall (m)**			**Rise**	**Fall**
	Min	**Max**	**Min**	**Max**	**0 to 2**	**2 to 4**	**>4**	**0 to 2**	**2 to 4**	**>4**		
79	0.05	10.18	0.02	3.88	19	9	2	43	6	0	30	49
					24.05%	11.39%	2.53%	54.43%	7.59%		38%	62%

Table-5.1(B): Decadal Post-monsoon water level fluctuation in Raigarh district

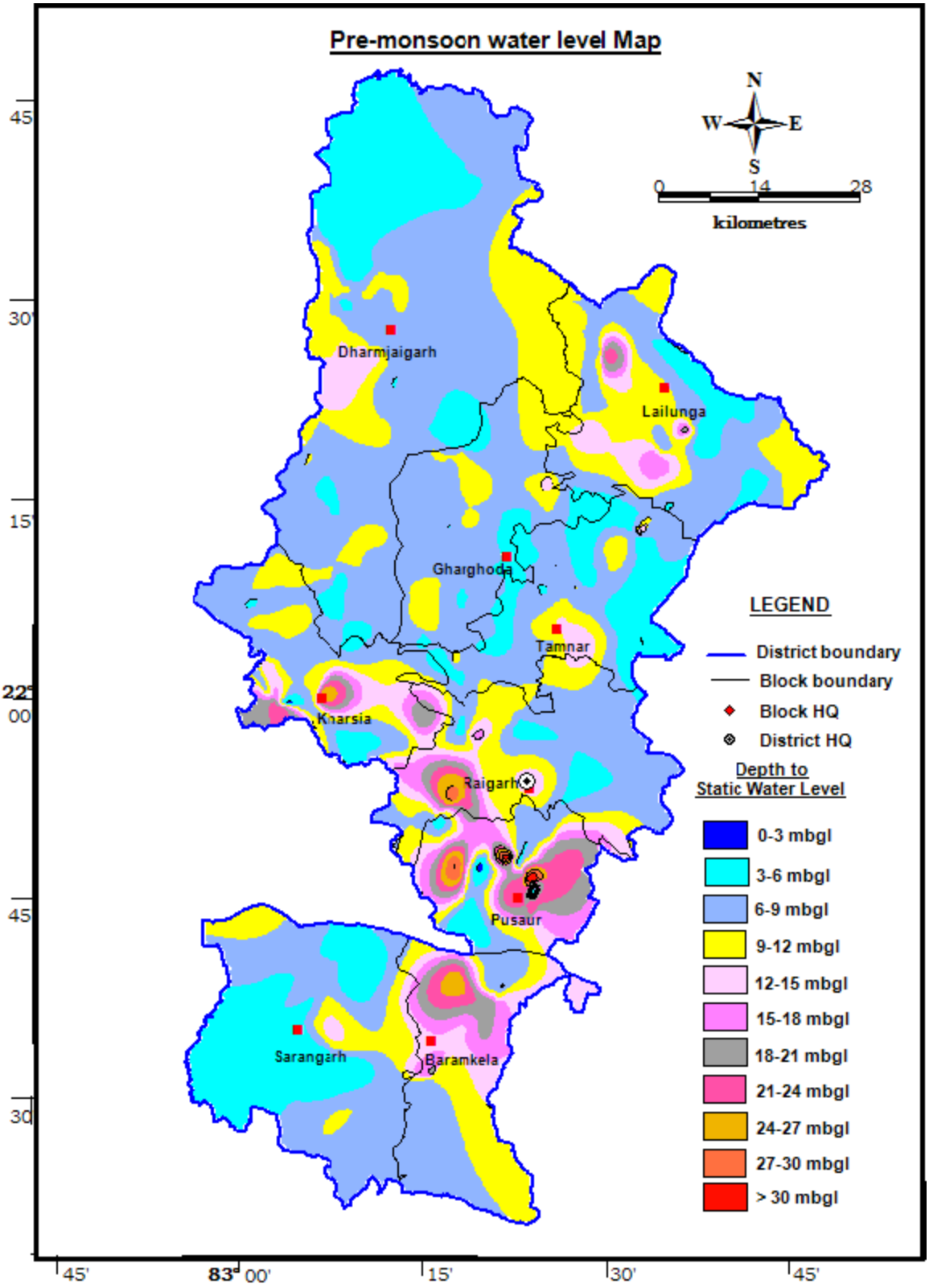
No. of Wells	**Range of Fluctuation**				**No. of Wells/Percentage Showing Fluctuation**						**Total No. of Wells**	
	Rise (m)		**Fall (m)**		**Rise (m)**			**Fall (m)**			**Rise**	**Fall**
	Min	**Max**	**Min**	**Max**	**0 to 2**		**>4**	**0 to 2**	**2 to 4**	**>4**		
67	0.03	3.27	0.02	4.28	8	1	1	41	15	1	10	57
					11.94 %	1.49 %	1.49 %	61.19 %	22.39 %	1.49	14.9 %	85.1%

The table shows that 62% of the wells show falling of water level in pre-monsoon period and 85% of the wells show falling of post-monsoon water level. The overall scenario shows shift in water use from phreatic to semi-confined zone and increased draft for irrigation purpose in selected pockets of Baramkela- Pusaur- Raigarh and Kharsia blocks. The statistical analysis shows that more than 70% abstraction structures of the district lie within these blocks and tap shale- dolomite- limestone belonging to Raigarh Formation.

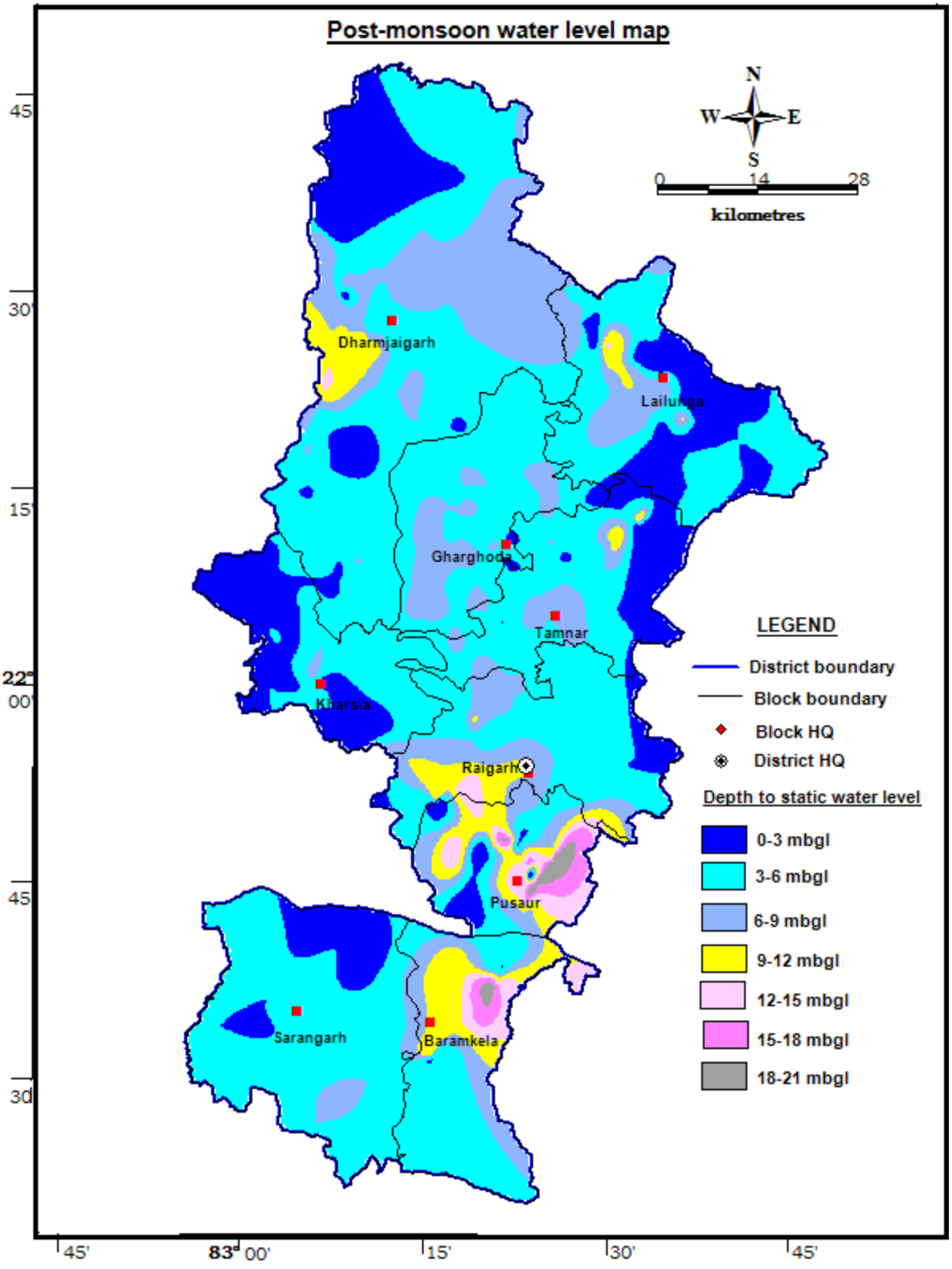
5.2.2 Ground Water Level Trend:

The historical water level data from 2009 to 2019 were analyzed to have long-term trend in water level behavior in Raigarh district. The Pre-monsoon trend shows a fall of 0.02 to 3.88 & rise of 0.05 to 10.18 cm/yr respectively. The post monsoon trend is important from the aquifer management point of view since it is related with the ground water extraction. The post-monsoon trend analysis (Table-5.2 & **Map-5.3**) indicates that 64 % of the wells show declining trend to the tune of 0-7 cm/yr with an average declining trend of 1.5 cm/yr. The rising trend is shown by 36 % of wells in the tune of 0 to1.3 cm/yr. The hydrograph of some of the wells are presented in **Fig-4 A to D**. The declining trend in post-monsoon period indicates the declining trend in ground water recharge which may be attributed to the declining trend in rainfall as well as reducing trend in the area for ground water of recharge.

Map-5.2 A: Pre-monsoon water level map of Raigarh district, Chhattisgarh



Map-5.2 B: Post-monsoon water level map of Raigarh district, Chhattisgarh



Map-5.2 C: Water level fluctuation map of Raigarh district, Chhattisgarh

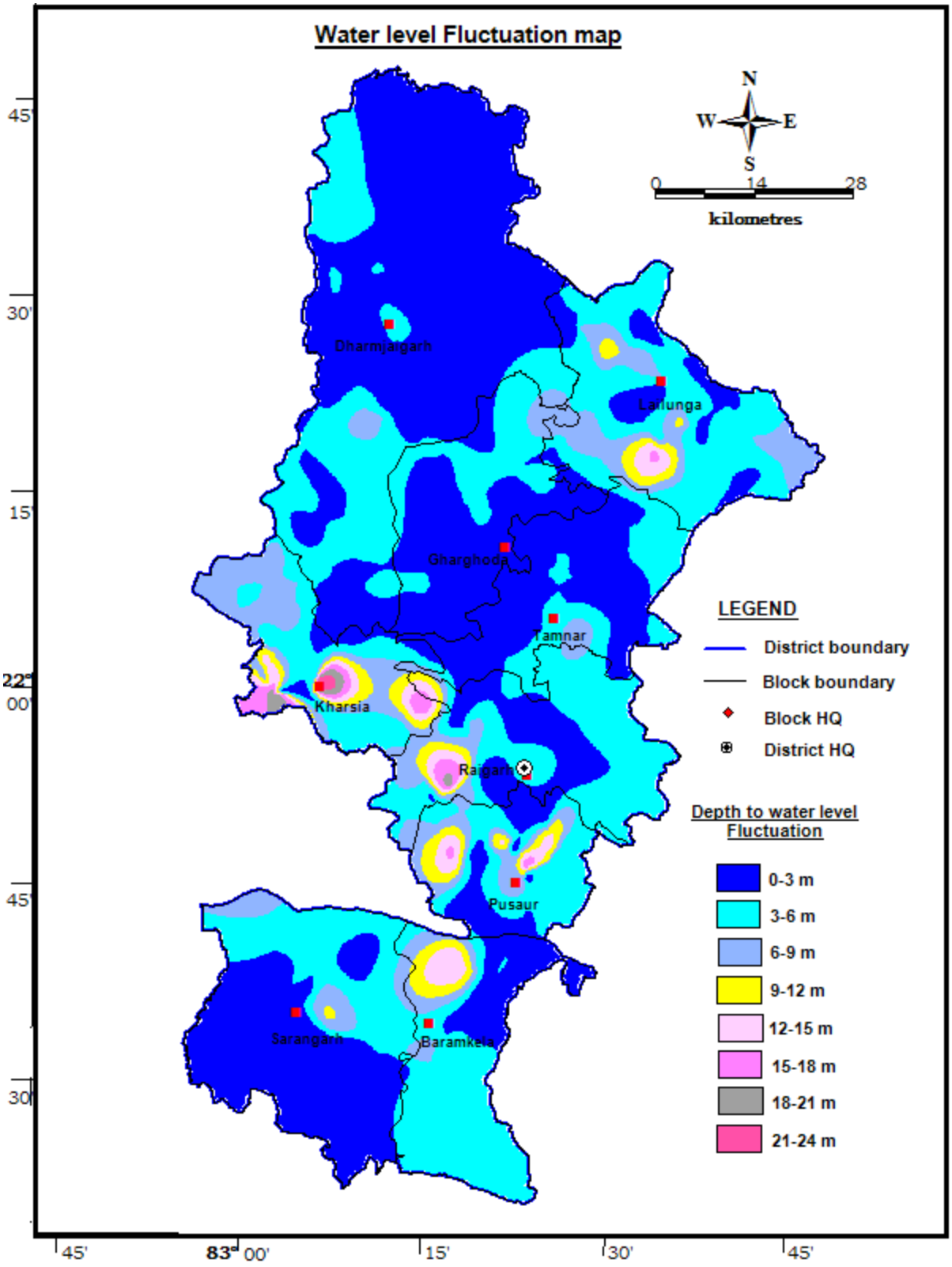
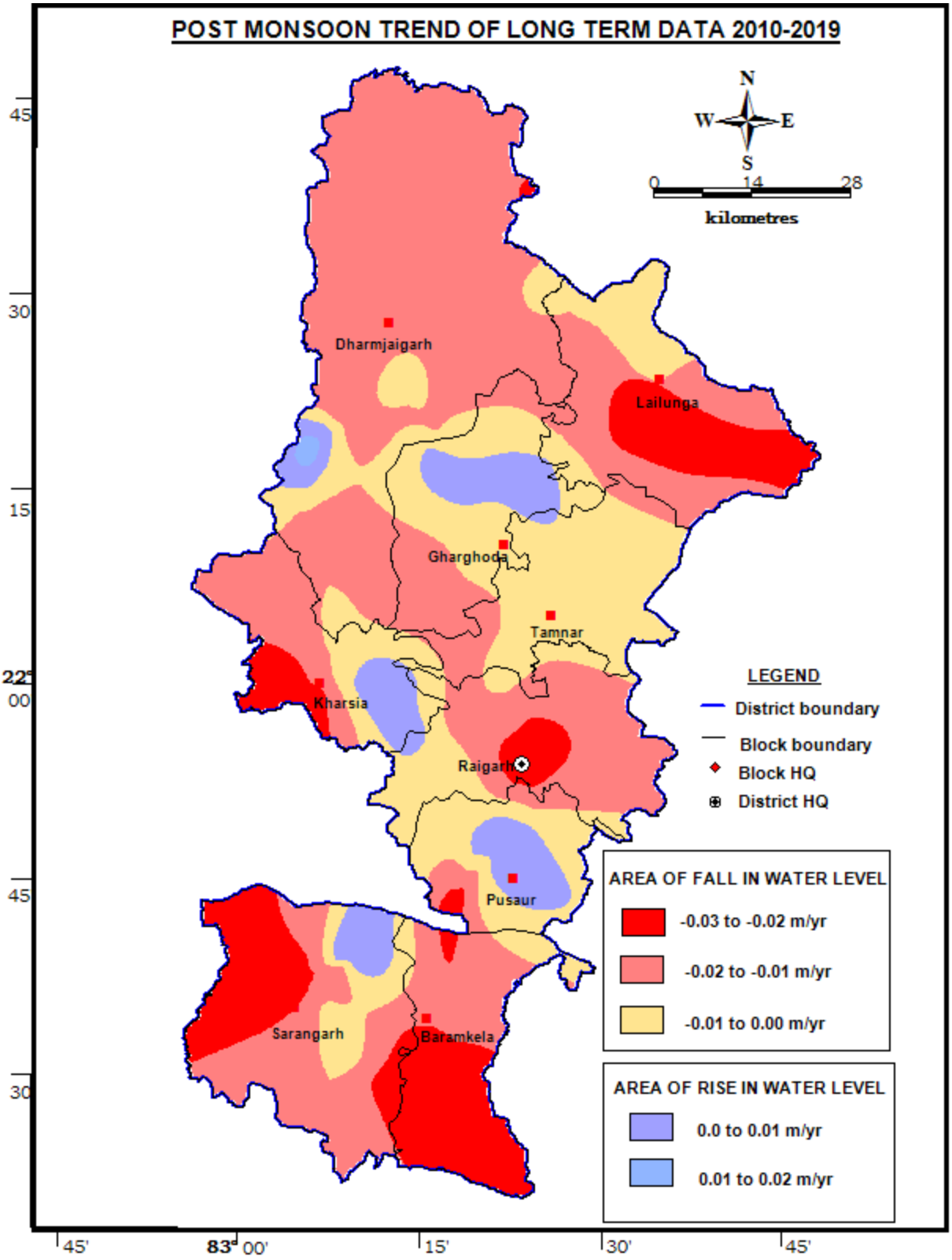


Table-5.2: Ground water level trend (2009-2019) in Post-monsoon period in Raigarh district

SN	District	Block	Site name	Longitude	Latitude	Trend (2010-2019) postmonsoon	Remarks
1	RAIGARH	Tamnar	Gare Nhs	83.49	22.14	-0.002417	Declining
2	RAIGARH	Gharghoda	Gharghoda	83.35	22.17	-0.002714	Declining
3	RAIGARH	Dharamjaigarh	Kurekela	83.1	22.2	-0.012785	Declining
4	RAIGARH	Gharghoda	Chimtapani	83.42	22.27	0.002275	Rising
5	RAIGARH	Gharghoda	Dumarpali	83.28	22.29	0.001401	Rising
6	RAIGARH	Dharamjaigarh	Hati	83.1	22.3	0.012962	Rising
7	RAIGARH	Dharamjaigarh	Barpali	83.27	22.33	-0.010652	Declining
8	RAIGARH	Dharamjaigarh	Bartapali	83.17	22.33	-0.014346	Declining
9	RAIGARH	Lailunga	Laripani	83.47	22.34	-0.01495	Declining
10	RAIGARH	Dharamjaigarh	Gersa	83.24	22.35	-0.011392	Declining
11	RAIGARH	Dharamjaigarh	Amapali	83.23	22.37	-0.006782	Declining
12	RAIGARH	Dharamjaigarh	Khadgaon1	83.12	22.38	-0.018183	Declining
13	RAIGARH	Lailunga	Lailunga1	83.58	22.38	-0.027389	Declining
14	RAIGARH	Lailunga	Lailunga2	83.58	22.39	-0.002859	Declining
15	RAIGARH	Lailunga	Salkhiya	83.52	22.42	-0.014643	Declining
16	RAIGARH	Lailunga	Rajpur.1	83.49	22.44	-0.01369	Declining
17	RAIGARH	Dharamjaigarh	Sisringa	83.31	22.46	-0.013918	Declining
18	RAIGARH	Dharamjaigarh	Dharamjaigarh PZ	83.21	22.46	-0.012405	Declining
19	RAIGARH	Dharamjaigarh	Bakaruma	83.44	22.51	-0.007178	Declining
20	RAIGARH	Dharamjaigarh	Golabuda	83.4	22.63	-0.020439	Declining
21	RAIGARH	Dharamjaigarh	Kapu	83.34	22.67	-0.012581	Declining
22	RAIGARH	Sarangarh	Damdarha	83.12	21.45	-0.017226	Declining
23	RAIGARH	Baramkela	Baramkela	83.26	21.52	-0.024171	Declining
24	RAIGARH	Sarangarh	Bataupali	83.13	21.54	-0.001644	Declining
25	RAIGARH	Baramkela	Saria1	83.3	21.56	-0.019395	Declining
26	RAIGARH	Sarangarh	Hirri1	83.14	21.63	-0.014562	Declining
27	RAIGARH	Sarangarh	Rera	83.09	21.63	-0.021415	Declining
28	RAIGARH	Sarangarh	Pindri	83.16	21.66	0.008759	Rising
29	RAIGARH	Pussore	Bonda	83.3	21.72	-0.022257	Declining
30	RAIGARH	Pussore	Tetla	83.33	21.79	0.001212	Rising
31	RAIGARH	Pussore	Tadola	83.38	21.8	0.005432	Rising
32	RAIGARH	Raigarh	Kotra	83.31	21.87	-0.0066	Declining
33	RAIGARH	Raigarh	Raigarh	83.4	21.89	-0.00959	Declining
34	RAIGARH	Raigarh	Raiharg S	83.4	21.89	-0.073682	Declining
35	RAIGARH	Raigarh	Raigarh D	83.4	21.89	0.01384	Rising
36	RAIGARH	Raigarh	Kerajhar	83.3	21.96	-0.011417	Declining
37	RAIGARH	Kharsia	Chaple	83.2	21.98	0.006123	Rising
38	RAIGARH	Kharsia	Kharsia	83.1	21.99	-0.014667	Declining
39	RAIGARH	Kharsia	Kharasia S	83.1	21.99	-0.032347	Declining
40	RAIGARH	Kharsia	Kharasia D	83.1	21.99	-0.022133	Declining
41	RAIGARH	Kharsia	Farkanara	83.11	22.02	-0.012171	Declining
42	RAIGARH	Tamnar	Taraimal1.1	83.38	22.06	-0.003101	Declining
43	RAIGARH	Dharamjaigarh	Edu	83.13	22.08	-0.008274	Declining
44	RAIGARH	Tamnar	Samaruma	83.35	22.08	-0.015655	Declining
45	RAIGARH	Gharghoda	Bhangari	83.25	22.13	-0.017466	Declining

Map-5.3: Long term trend map for Post-monsoon period of Raigarh district, Chhattisgarh



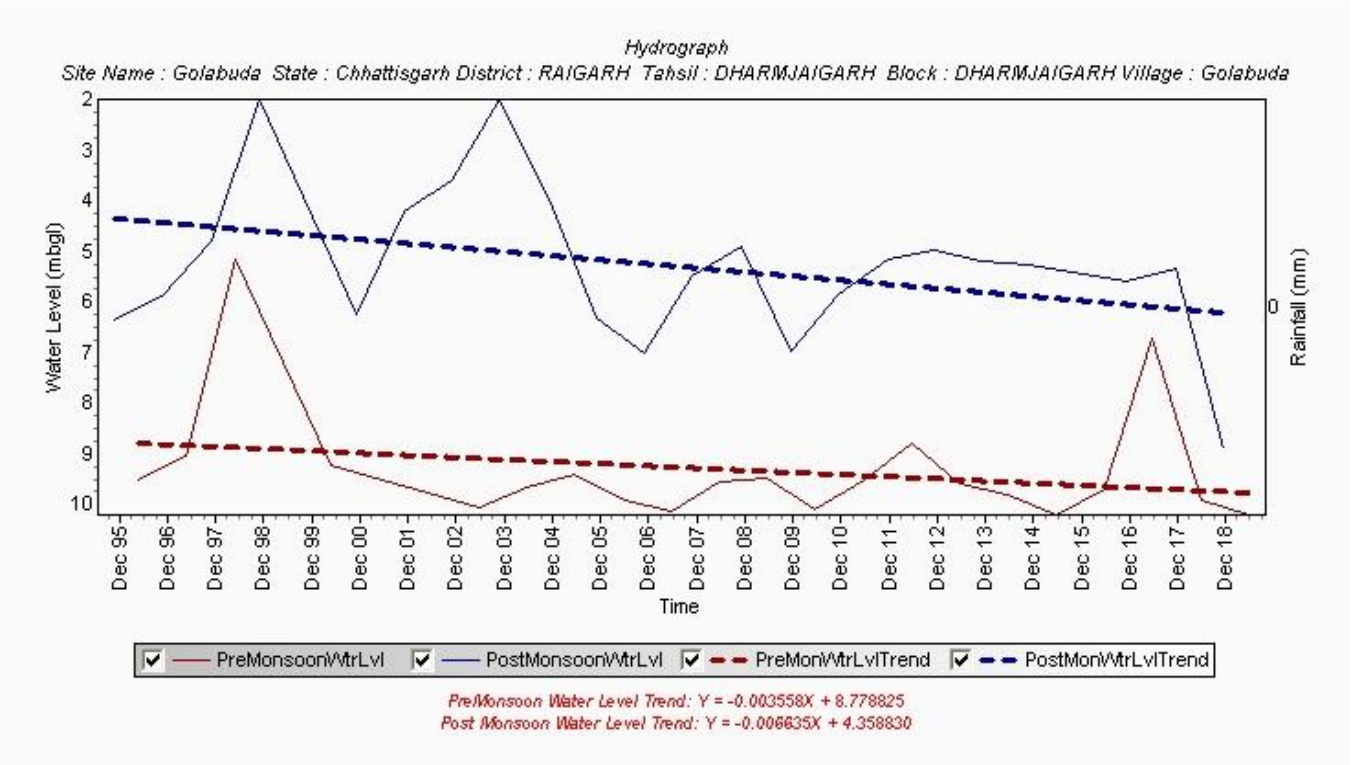


Fig-4 A: Hydrograph of Golabuda

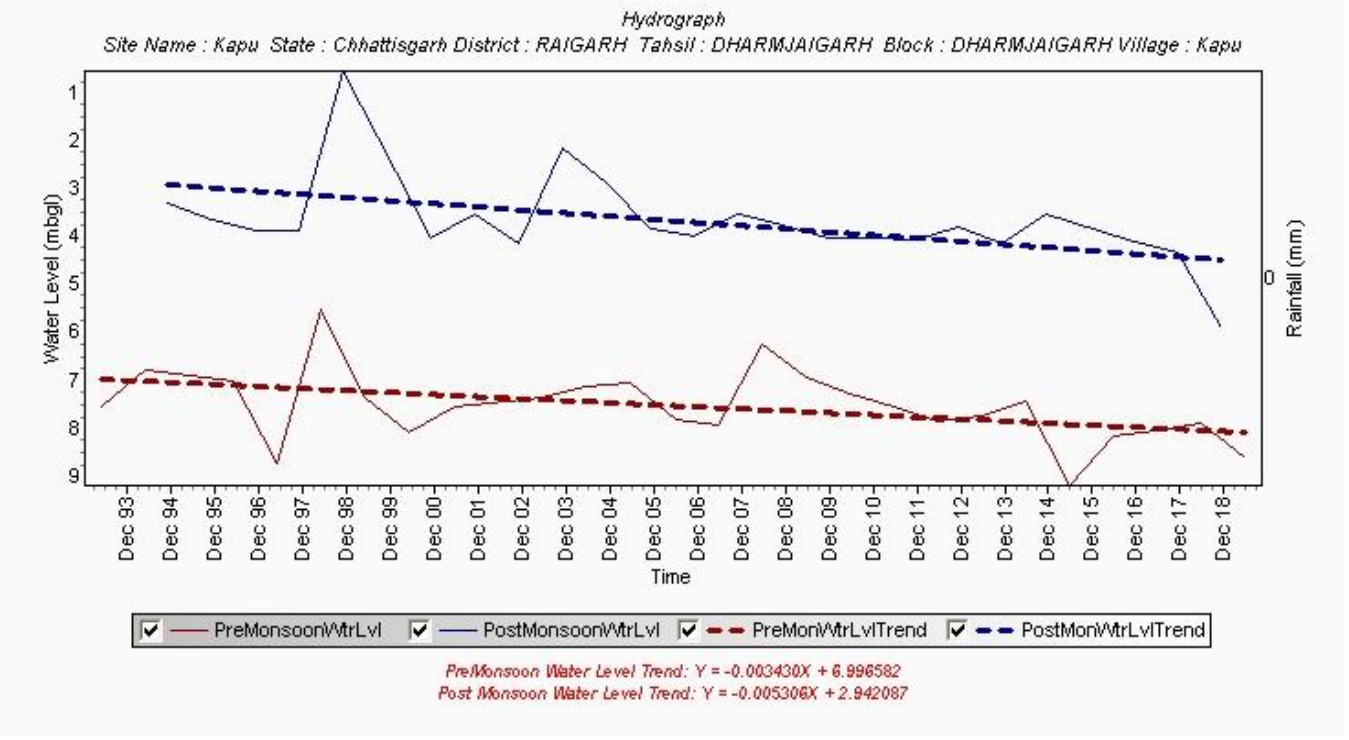


Fig-4 B: Hydrograph of Kapu

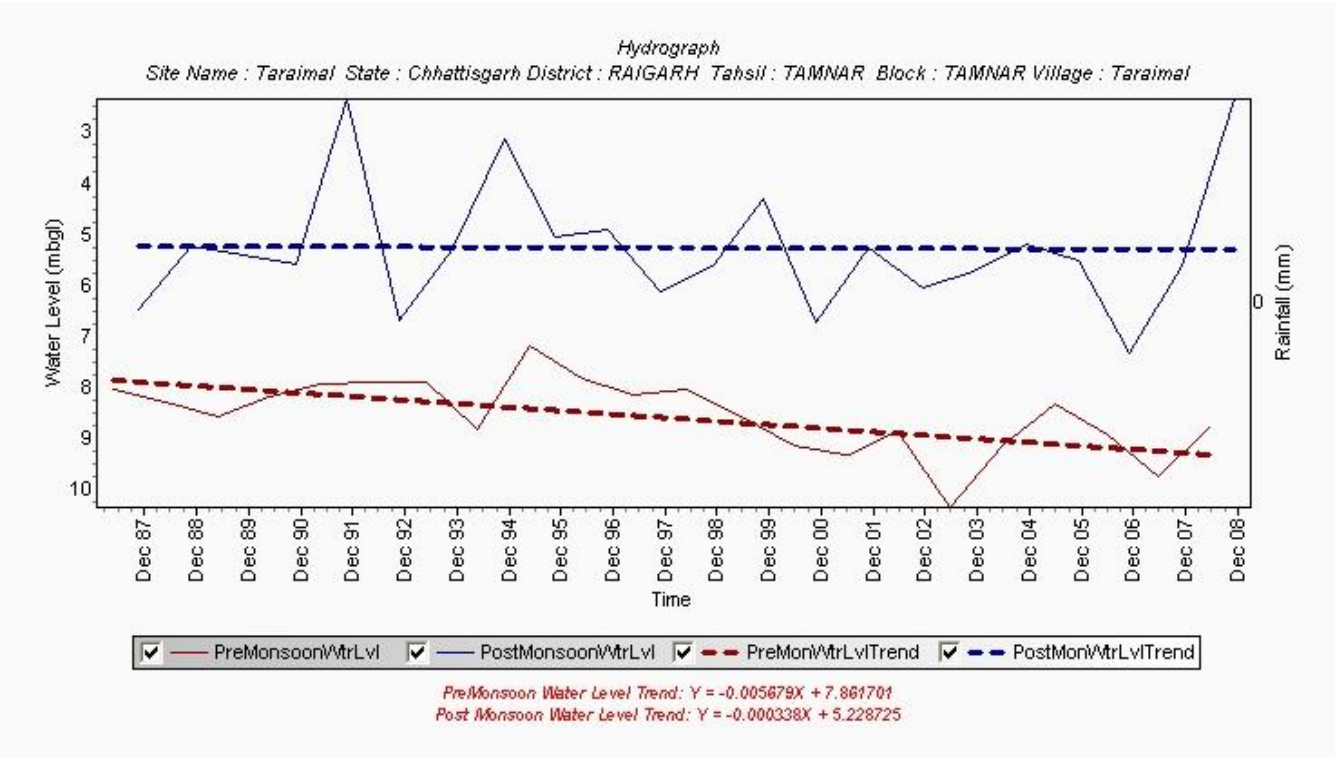


Fig-4 C: Hydrograph of Taraimal

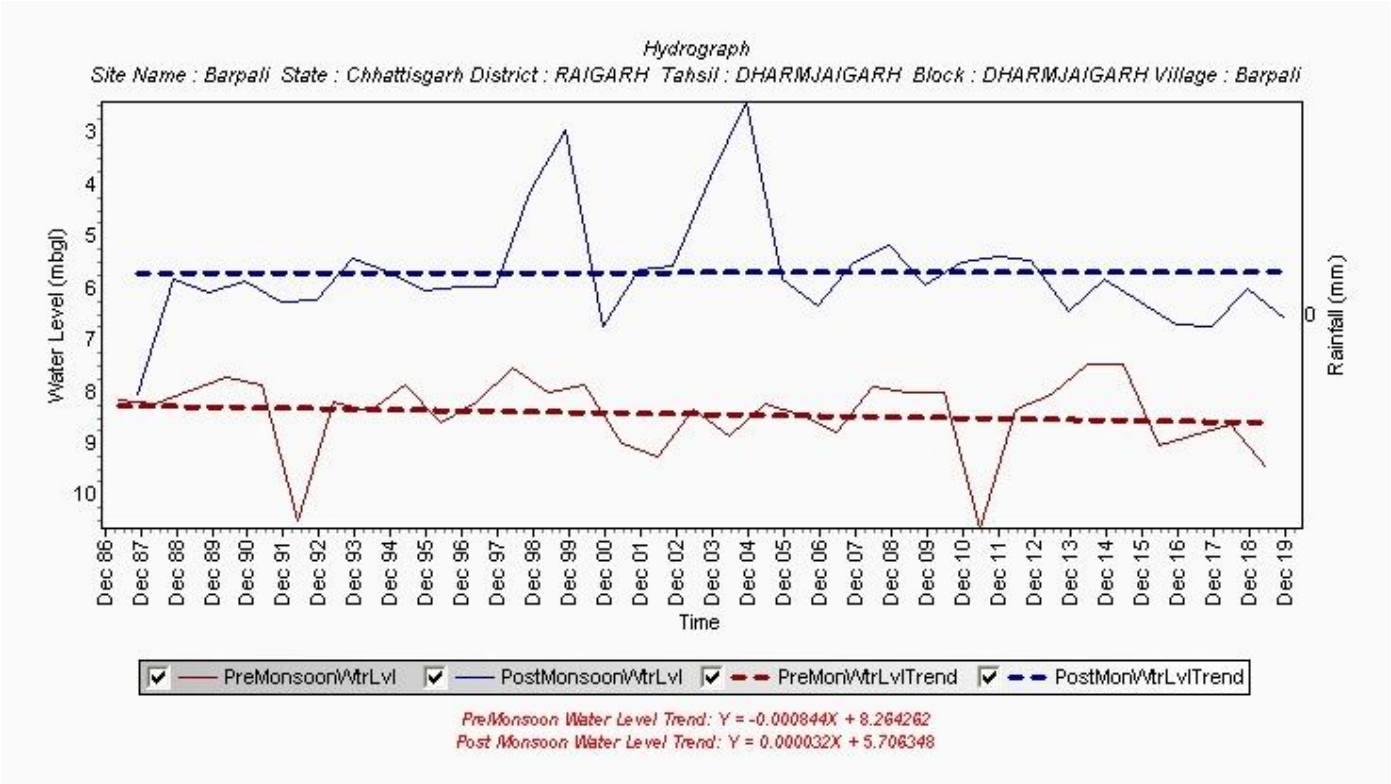


Fig-4 D: Hydrograph of Barapali

5.2.3 Ground Water flow direction:

The regional ground water flow direction is towards south-west (**Map-5.4**). In south eastern part of the district the ground water flow direction is towards south-east. In the north -central part of the district the contours are comparatively closer indicating the steepness of the terrain thereby the gradient of ground water flow is high in comparison to the other part of the district. It may also be seen that the flow of ground water is mostly towards the major drainage suggesting that the base flow is towards the drainage system.

5.3 Ground Water Resources:

The ground water Resources of Raigarh district has been estimated on the basis of revised methodology GEC 2015. Ground water resources have two components – Replenishable ground water resources or Dynamic ground water resources and Static resources.

5.3.1 Replenishable ground water resources or Dynamic ground water resources:

As per resource estimation March 2017, the Net Ground Water Availability for future use from all the sources in the district is 41166.73 ham. The Net Ground Water Availability for future use is 4318.72 ham. Current Annual Ground Water Extraction for all purposes is 20292.35 ham out of which 16093.58 ham is for irrigation. The overall Stage of Ground Water Extraction in the district is 50.09 %. Baramkela (77.72%) has the highest stage of ground water extraction while Lailunga (20.66 %) has the lowest stage of ground water extraction. The Annual GW Allocation for for domestic Use as on 2025 is 4318.72 ham with highest quantity in Raigarh block and lowest in Gharghoda block. The Net Ground Water Availability for future use is 20327.56 ham. The block wise resource is presented in **Map-5.5** and table 5.3.

Table-5.3: Block wise Resources as estimated in 2017 of Raigarh district

Sl. No	Block	Annual Extractable Ground Water Recharge (Ham)	Current Annual Ground Water Extraction (Ham)				Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semi critical/ Safe)	Does the water Level Trend during Pre and Post Monsoon show a significant falling trend (Yes /No)	
			Irrigation use	Industrial use	Domestic use	Total Extraction					Yes/No	If Yes Value (cm/yr)
1	Baramkela	6464.93	4615.03	0	409.4	5024.43	507.06	1342.84	77.72	Semi-Critical	Yes	17
2	Dharamjaigarh	6368.46	1979.39	0	501.25	2480.64	558.09	3830.98	38.95	Safe	No	
3	Gharghota	2798.23	1007.97	24.04	197.77	1229.78	224.93	1541.29	43.95	Safe	No	
4	Kharsia	2672.69	1111.15	224.02	370.38	1705.55	415.15	922.37	63.81	Safe	No	
5	Lailunga	5215.77	762.64	0	315.15	1077.79	349.93	4103.2	20.66	Safe	No	
6	Pusaur	4371.35	3009.6	0	349.98	3359.58	406.13	955.62	76.85	Semi-Critical	Yes	40
7	Raigarh	5651.97	1623.81	178.81	833.23	2635.85	966.85	2882.5	46.64	Safe	No	
8	Sarangarh	5716.85	1260.4	0	555.53	1815.93	618.52	3837.93	31.76	Safe	No	
9	Tamnar	1906.48	723.59	0	239.21	962.8	272.06	910.83	50.5	Safe	No	
Total		**41166.73**	**16093.58**	**426.87**	**3771.9**	**20292.35**	**4318.72**	**20327.56**	**50.09**			

5.3.2 Static Ground Water Resources:

An attempt has been made to assess the Static Ground Water Resources Raigarh district which is the resource that remains available below the dynamic zone of water table fluctuation. This is not replenished every year and extracting this water is ground water mining. The quantum of ground water available for development is usually restricted to long term average recharge or dynamic resources. For sustainable ground water development, it is necessary to restrict it to the dynamic resources. Static or in-storage ground water resources could be considered for development during exigencies that also for drinking water purposes. It is also recommended that no irrigation development schemes based on static or in-storage ground water resources be taken up at this stage. The following table-5.4 presents the ground water resources of Raigarh district.

Table-5.4: Ground water Resources of Raigarh district

Sl. No	Block	Recharge worthy Area (Ha)	Stage of Extraction in %	Static Resource in Ham	Dynamic Resource in Ham
1	Dharamjaigarh	95749	38.95	2982.007	6368.460
2	Baramkela	90034	77.72	1560.109	6464.930
3	Gharghoda	29935	43.95	1314.745	2798.230
4	Kharsia	31449	63.81	678.669	2672.690
5	Lailunga	75115	20.66	1278.758	5215.770
6	Pusaure	51030	76.85	423.753	4371.350
7	Raigarh	78841	46.64	598.403	5651.970
8	Sarangarh	74912	31.76	938.797	5716.850
9	Tamnar	23800	50.50	961.520	1906.480
Total		**550865**	**50.09**	**10736.76**	**41166.730**

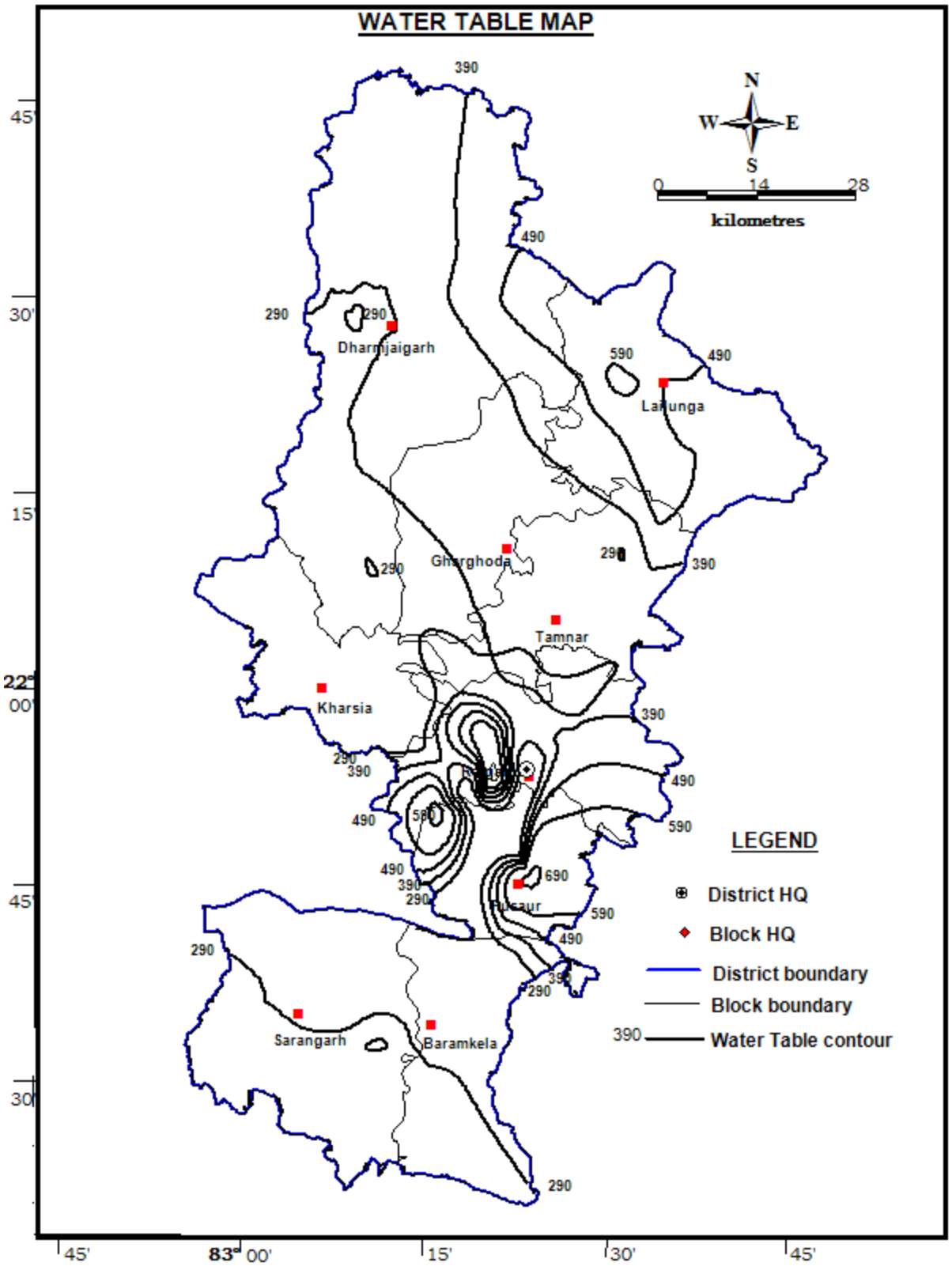
The table shows that the total static ground water resource of Raigarh district is 10736.76 Ham beside the dynamic ground water resource of 41166.73 ham. The highest Static Ground Water resource is 2982 Ham for Dharamjaigarh block whereas the lowest static ground water resource is 423.75 Ham for Pusaur block.

5.4 Ground Water Quality:

Ground water quality of shallow aquifer as well as deeper aquifer in Raigarh district for drinking, irrigation and industrial purposes is assessed on the basis of analysis of ground water samples collected from 284 nos. of observation wells for shallow aquifer & 55 exploratory wells for deeper aquifer (**Annexure-IIIA & B**). Apart from these, 60 nos. of water samples & 95 nos of water samples were also analysed to assess the arsenic and uranium contamination respectively.

5.4.1 Drinking water quality: The concentrations of various parameters for both shallow & deeper aquifers are presented in the following table5.5.

Map-5.4: Ground water table map of Raigarh district, Chhatisgarh



Map-5.5: Ground water resource map of Raigarh district, Chhatisgarh

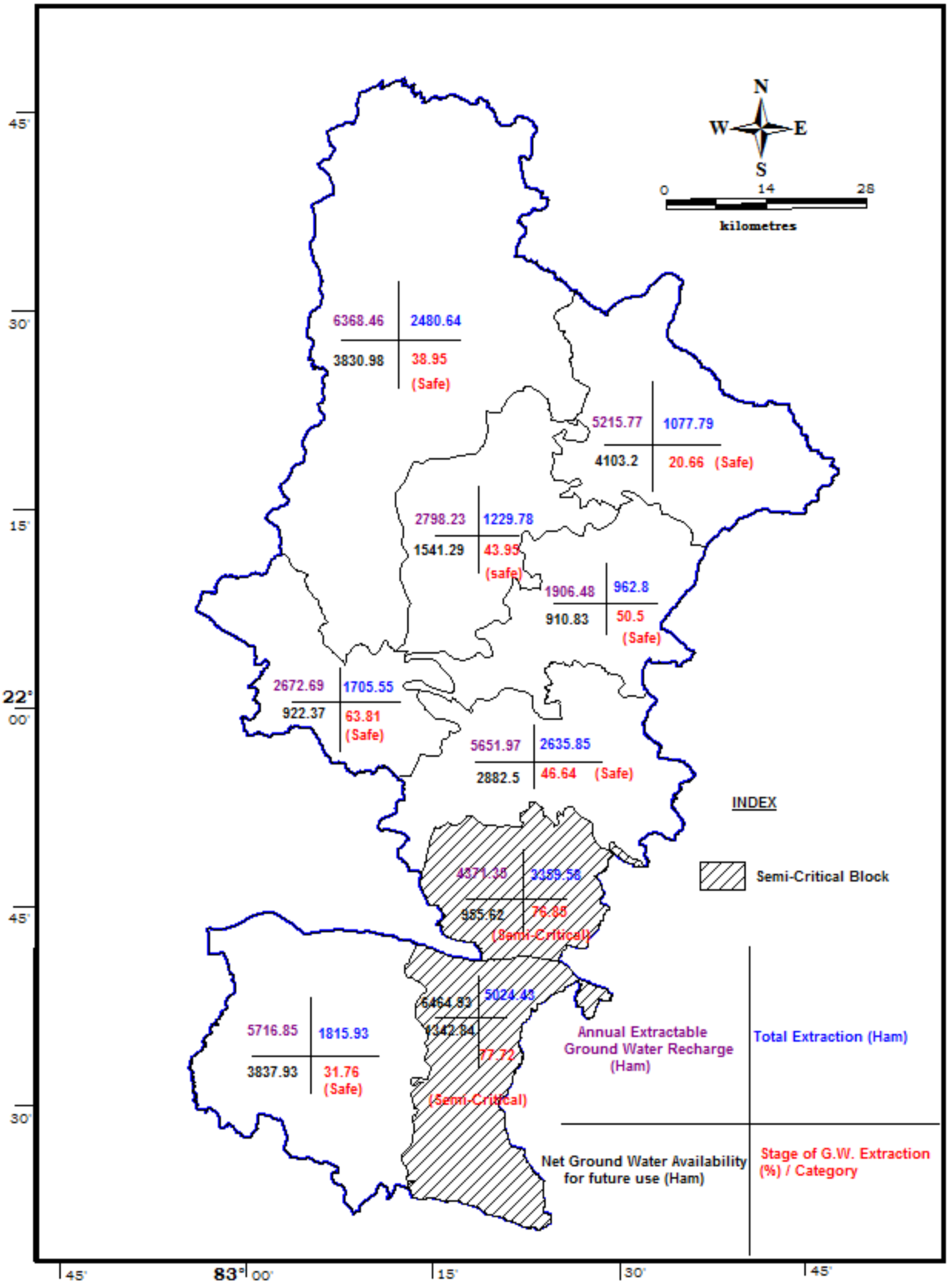
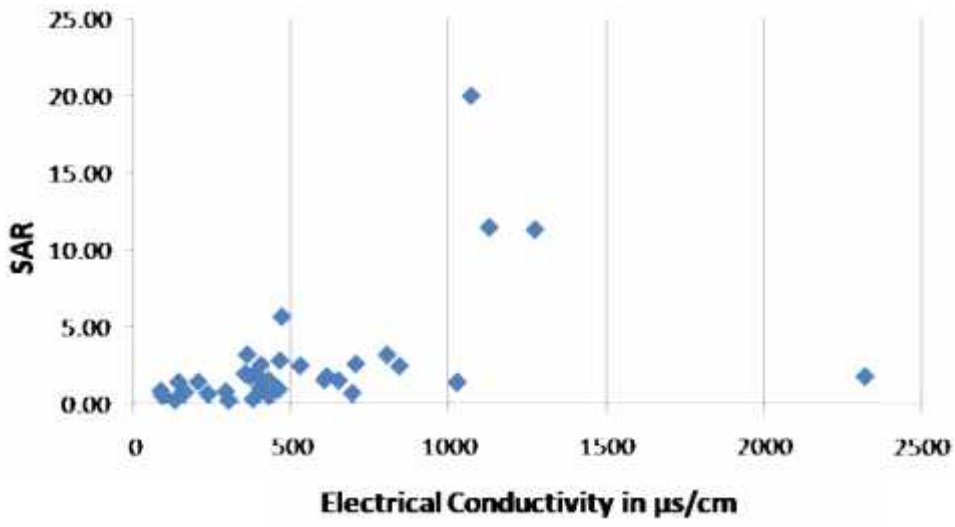


Table-5.5: Ground water quality data for shallow & deeper aquifer

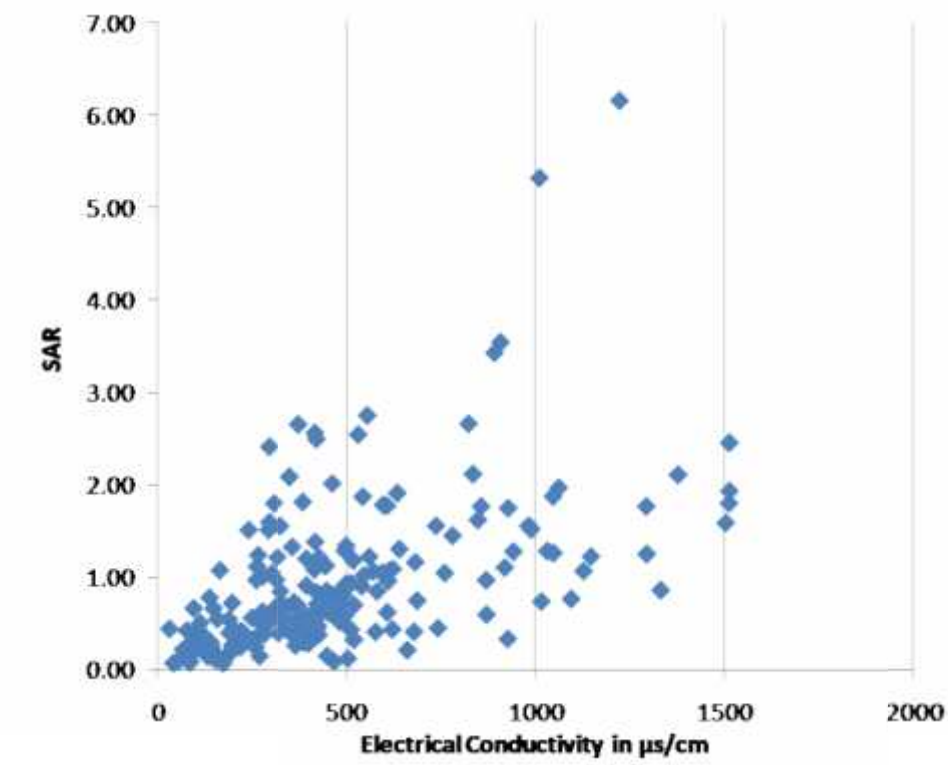
Sl. No	Parameters (in ppm)	Shallow Aquifer			Deeper Aquifer			Remarks
		Min	Max	Avg	Min	Max	Avg	
1	pH	6.5	8.4	7.43	6.59	8.9	7.85	Slightely acidic to alkaline in nature
2	EC(in µS/cm at 25° C)	30	1680	463.32	84	2320	580.16	EC is higher side at some places for both shallow and deeper aquifer.
3	Total Alkalinity	0	350	110.85	14.75	350	160.37	
4	HCO_3	6	427	138.71	18	427	195.68	
5	Cl	3.55	327	47.91	7	128	30.79	
6	SO_4	0	442.6	29.32	0	126.5	10.08	Shallow aquifer is sulphate contaminated at some places
7	F	0	2	0.3	0.02	0.99	0.47	Shallow aquifer is fluoride contaminated at some places
8	TH	10	585	150.44	20	995	163.3	Deeper aquifer is hard at some places.
9	Ca	2	190	34.98	2	364	50.18	Ca content is beyond permissible in deeper aquifer at some places
10	Mg	0	68	14.86	1	47	12.81	
11	Na	0.8	181.5	26.43	3.7	255	58.6	
12	K	0.1	140	12.03	0.7	53.3	5.51	

The above table-5.5 indicates that the ground water of shallow aquifer is slightely acidic to alkaline in nature. High concentrations of nitrate beyond the permissible limit were observed at Sayang, dhengudi, Elong, Chirra, Chunkunidand, Koradish , Dhanpuri, Bakarmuda and Boro of Dharamjaigarh block, Harradih, Bhengari, Samaruma, Chhota Nawapara, Bahirkela, Gharghori, Patrapali, Narayanpurand Rumkera of Ghorghoda block, Gourmuri, Saraipali, Kachkoba, Devgaon and Bijna of Tamnar block and Pindri of Sarangarh block. High concentrations of fluoride were found at Damdhara (1.7 mg/l), Kanakbira (2.0 mg/l) of Sarangarh block and Lipti (1.9 mg/l) of Dharamjaigarh block. In some of the locations very high iron contents was recorded. Arsenic and Uranium were not observed in ground water of the district. Except few locations where the nitrate and fluoride concentrations are found beyond the permissible limit, the ground water of Raigarh district was found suitable for drinking purposes.

5.4.2 Irrigation water quality: To know the suitability of water for irrigation purposes SSP and KI are computed. By obtained value of SAR and EC the US Salinity diagram is plotted in **Fig-5 (A&B)**. The following table-5.6 presents the locations of less suitable from irrigation point of view on the basis of SAR, SSP, KI & RSC.



Map-5 A: US salinity plot for deeper aquifer of Raigarh district, Chhatisgarh



Map-5 B: US salinity plot for shallow aquifer of Raigarh district, Chhatisgarh

Table-5.6: Area less suitable for shallow aquifer ground water Irrigation

Sl. No.	**Location**	**EC in m µ/cm**	**SAR**	**SSP**	**KI**	**RSC**
1	Karigashi	908	3.533	57.18	1.34	-1.992
2	Kerakhol	517	2.338	53.79	1.16	-0.41
3	Taraimal	477	2.478	55.34	1.24	0.393
4	Kharsia	892	3.420	55.70	1.26	-0.405
5	Amapali	555	2.743	55.59	1.25	0.2
6	Lohrapani (Poyl para)	349	2.080	53.00	1.13	1.4
7	Jharmunda	416	2.555	55.99	1.27	-0.41
8	Odekora	307	1.799	50.14	1.01	0.007
9	Bathanpali	239	1.512	54.46	1.20	0.397
10	Kotra	420	2.489	55.55	1.25	0.180
11	Bangrusian	292	1.512	54.46	1.20	0.69
12	Dhansara	531	2.536	53.23	1.14	-0.09
13	Kudhri	372	2.646	60.31	1.52	0.887
14	Godam	1223	6.14	70.51	2.39	2.6
15	Pindri	1011	5.31	69.17	2.24	2.8

SAR-Sodium absorption ratio, SSP- Sodium soluble percentage, KI-Kelly Index, RSC-Residual sodium Carbonate

The above table shows that shallow aquifer ground water is likely to be less suitable for irrigation at Karighasi, Kerakhal,Taraimal,Kharsia, Ampali,Loharpani, Jharmunda, Odekera, Bothanpali, Kotra, Bangursia, Dhansera,Kudri,Pindri & Godam on the basis of SSP & KI value. Taking RSC into consideration, only Godam & Pindri show variation that is above 2.5. However all these wells within the range of SAR. SAR value more tha 26 indicates the unsuitability from irrigation point of view due to very high soium water. But none of the sample is above SAR 26 value. However an attempt has been made to classify the shallow aquifer ground water quality on the basis of WQI (Water Quality Index). The result is presented in table-5.8.

Table-5.8: Classification of ground water quality for irrigation use based on WQI

Sl. No	Location	WQI	Class	Restriction
1	Chharatanagar	275.19	II	Slight
2	Chhotanawapara	180.21	II	Slight
3	Banai	165.14	II	Slight
4	Saraipali	170.42	II	Slight
5	Kachkoba	257.69	II	Slight
6	Devgaon	190.31	II	Slight
7	Gare	150.41	II	Slight
8	Urba	289.19	II	Slight
9	Godhi	187.53	II	Slight
10	Bangursian	198.6	II	Slight
11	Barapali	169.6	II	Slight
12	Harradih	434.66	III	Moderate
13	Chhaldonia	342.04	III	Moderate
14	Gourmuri	321.05	III	Moderate
15	Nagoi	436.96	III	Moderate

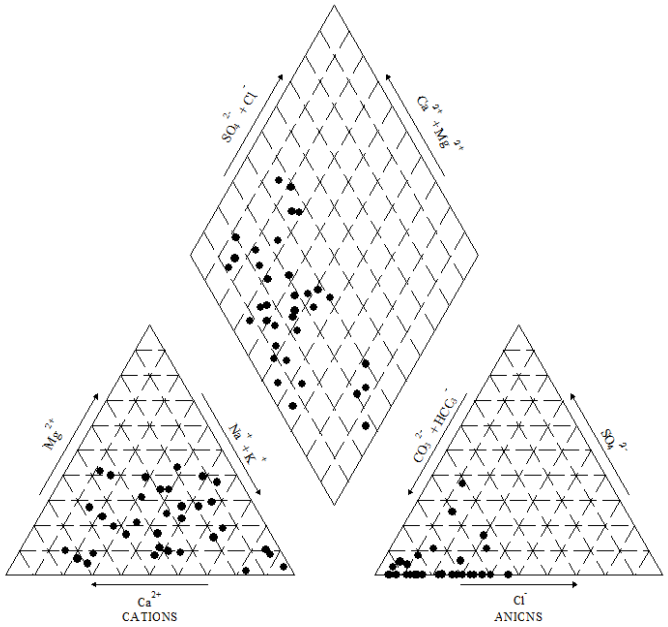
The above table shows that only 4% sample shows slightly restriction on irrigation and 1% show moderate restriction on irrigation. Hence overall it may be concluded that the ground water from shallow aquifer is suitable for irrigation purposes. However careful study may be done for irrigation in above areas as mentioned in above three tables.

5.4.3 Industrial water quality: The ground water collected from Karighashi of Dharamjaigarh block was found high value of corrosivity ratio (8.9) and water is unsuitable for industrial uses and some locations like Boro, Auranav, Kharsiya, Sisringa and Bayasi were found less corrosive nature of water and rest of the location it is suitable for industrial purposes.

5.4.4 Arsenic contamination: No arsenic contamination in ground water is found in any ground water sample collected in Raigarh district.

5.4.5 Uranium contamination: The maximum uranium content in ground water is found at Semra, Pusaure block which is about 0.00927 mg/l. There are also traces of uranium found at some locations in Lailunga block namely at Gosaibih (0.00787 mg/l), Jorapalli (0.00726 mg/l). Since according to BIS the maximum permissible limit of Uranium is 0.03 mg/l (as per WHO provisional guidelines), the ground water in Raigarh district is safe from Uranium contamination point of view.

5.4.6 Type of Ground Water: The piper diagram (**Fig-6(A&B**) indicates that the ground water of Raigarh district is calcium-magnesium-bicarbonate (Ca-Mg-HCO_3) and calcium-sulphate (Ca-SO_4) type for shallow aquifer & calcium-bicarbonate (Ca-HCO_3) type for deeper aquifer respectively.



Piper diagram for Deeper Aquifer in Raigarh dist

Fig.6 A: Piper diagram for Deeper Aquifer in Raigarh district, Chhattisgarh

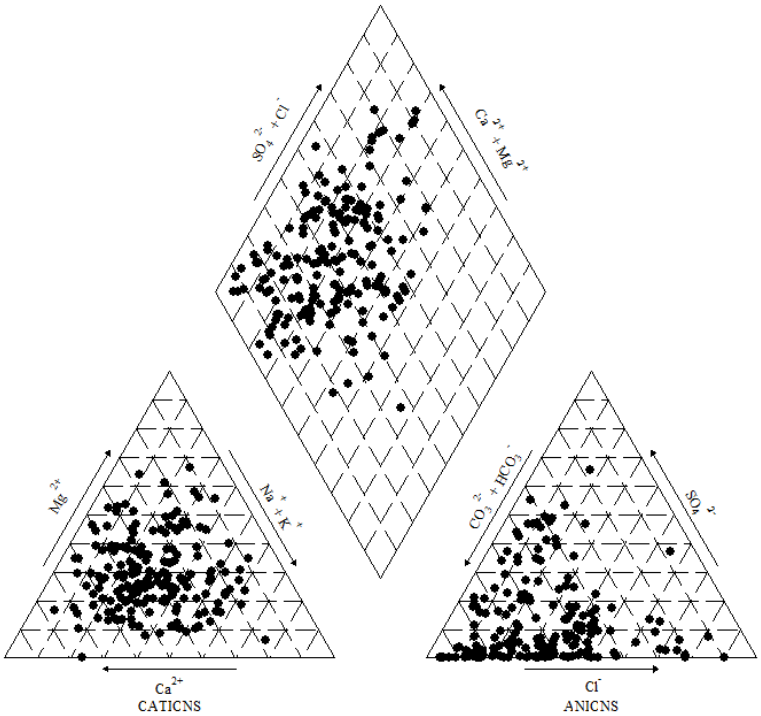


Fig.6 B: Piper diagram for Shallow Aquifer in Raigarh district, Chhattisgarh

CHAPTER-VI

AQUIFER MAPPING & MANAGEMENT PLAN

6.1 Ground Water related issues & problems:

1. Due to large scale pumping from Raigarh Formation for irrigation, the water level in this formation goes deep in summer and the sustainability of shallow hand pumps are threatened.
2. There is no spacing criteria for the drilling of bore well leading to the exploitation of groundwater resources.
3. With increasing dependency on hand pumps for drinking water, iron contamination in ground water has emerged as biggest problem in parts of Gondwana covered area of Gharghoda-Tamnar-Dharamjaigarh- Kharsiya- Lailunga blocks.
4. At few locations nitrate and fluoride concentrations are found beyond the permissible limit.
5. Drying up of existing springs.

6.2 Status of Aquifer Mapping & Salient findings:

All the 9 blocks of Raigarh district have been covered under aquifer mapping. The details of the findings of the aquifer mapping & management plan of all the 9 blocks of Raigarh district have been explained in separate chapters. However the salient features of the aquifer mapping & management plan for the nine blocks are explained as follows:

1. Dharmajaigarh block:

Area- 1537.69 sq.km taken for study. Average annual rainfall is 1517.48 mm. 23.61% of the net irrigated area is irrigated by groundwater. The Principal aquifer systems in the block are Achaean & Gondwana formation both in phreatic and fractured condition & the major aquifer groups are (i) Archaean gneissic complex and (ii) Gondwana Sandstone. Korar and Mand river forms the major drainage system in the block and Paddy, Wheat and Gram are the major crops produced in the block.

The average ground water level of phreatic aquifer during pre monsoon period is 8.16 mbgl with a range from 3.8 to 13.8 mbgl and during post-monsoon period it is 5.64 mbgl with a range from 1.4 to 12.3 mbgl. The average fluctuation is 2.52 m varying from 0.2 to 7.05 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at most of the locations. The average weathered thickness of the phreatic aquifer is around 17.32 m.

The average yield of Gondwana sandstone is 4.32 lps with a transmissivity of 1.35 to to 142.75 m^2/day and average drawdown is 23.8 m. One to three sets of most potential fracture zone lies between 100 to 200 m depth in Gondwana sandstone. Similarly the average yield of granitic terrain in the block is 1.42 lps with an average drawdown of 26.15 m. One to Two sets of potential fracture zone mostly lie beyond 100 m of depth. The average transmissivity of this aquifer is 6 m^2 /day.

Appreciable impact on ground water regime in & around Nawapara due to pumping of huge quantity of ground water because of coal-mining, considerably high nitrate content in shallow groundwater in some locations & deeper ground water level in some areas in the post-monsoon period is the major ground water issues in the block. Annual Extractable Ground Water Recharge is 6348.46ham and present stage of ground water extraction is 38.95 % thus under safe category. In terms of Supply side management, since the stage of extraction in the block is only 38.95 %, there is ample scope of development. Since the stage of development in the block is only 38.95 %. So there is ample scope of development. In order to achieve 60% stage of ground water withdrawal, development may be taken up by constructing 837 nos of tube wells or 1862 nos of dug wells at suitable places that can create an irrigation potential of 1489.5 ha of paddy, 3351.5 ha of wheat ,Ground Nut, Sunflower and 4465.7 ha of Mustard & Pulses . However in a long term sustaining basis, we have to go for artificial recharge, particularly to recharge the area of deeper water level. As such 27 nos. of percolation tank, 89 nos. of nala bunding/cement plug/check dam, 214 nos of recharge shaft and 160 nos of gully plug/gabion structures can be constructed that can recharge 11.72 mcm ground water. Ground water coming out as mine dewatering can be utilised to control the impact of mine dewatering by creating garland recharge well system.

2. <u>Ghorghoda block:</u>

Area: 433.04 sq.km taken for study. Average annual rainfall is 1358.82 mm. 33% of the net irrigated area is irrigated by groundwater. The Principal Aquifer System in the block is Gondwana formation both in phreatic and fractured condition and the major aquifer group in the block is Gondwana sandstone. Kurket and Kola River flowing towards south-west forms the major drainage system in the block. Paddy, Wheat and Gram are the major crops produced in the block.

The average ground water level of phreatic aquifer during pre monsoon period is 7.02 mbgl with a range from 3.4 to 13.1 mbgl and during post-monsoon period it is 4.99 mbgl with a range from 1.92 to 8.69 mbgl. The fluctuation ranges from 0.01 to 5.6 m with an average fluctuation of 1.872.04 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at many of the locations. The average weathered thickness of the phreatic aquifer is around 18 m.

The average yield of Gondwana sandstone is 4.32 lps with a transmissivity of 1.35 to to 142.75 m^2/day and average drawdown is 23.8 m. One to three sets of most potential fracture zone lies between 100 to 200 m depth in Gondwana sandstone.

High nitrate content at some locations & deeper water level (more than 5m in the post- monsoon period) in some areas are the major issues so far as ground water scenario in the block is concerned. Annual Extractable Ground Water Recharge is 2798.23 ham and present stage of ground water extraction is 43.95 % thus under safe category. Since the stage of development of groundwater in the block is only 43.95 %, there is ample scope of development. Since the stage of development of groundwater in the block is only 43.95 %, there is ample scope of development. In order to achieve 60% stage of ground water development in this block, development may be taken up by constructing 281 nos of tube wells or 624 nos of dug wells at suitable places that can create an irrigation potential of 499 ha of paddy, 1122.5 ha of wheat, Ground Nut, Sunflower and 1496.67 ha of Mustard & Pulses . However in a long term sustaining basis, we have to go for artificial recharge, particularly to recharge the area of deeper water

level. As such 28 nos. of percolation tank, 95 nos. of nala bunding/cement plug/check dam, 229 nos of recharge shaft and 170 nos of gully plug/gabion structures can be constructed that can recharge 12.33 mcm ground water.

3. Tamnar block:

Area: 469 sq.km taken for study. Average annual rainfall is 1097.72 mm. 51.25 % of the net irrigated area is irrigated by groundwater. The Principal Aquifer System in the block is Gondwana formation both in phreatic and fractured condition and the major aquifer group in the block is Gondwana sandstone. Kola river flowing towards south-west forms the major drainage system in the block. Paddy, Wheat and Gram are the major crops produced in the block.

The average ground water level of phreatic aquifer during pre monsoon period is 7.54 mbgl with a range is 3-15.6 mbgl and during post-monsoon period it is 5.22 mbgl ranging from 1.8 to 13 mbgl. The fluctuation ranges from 0.1 to 7.33 m with an average fluctuation of 2.33 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at many of the locations. The average weathered thickness of the phreatic aquifer is around 18 m.

The average yield of Gondwana sandstone is 4.32 lps with a transmissivity of 1.35 to to 142.75 m^2/day and average drawdown is 23.8 m. One to three sets of most potential fracture zone lies between 100 to 200 m depth in Gondwana sandstone.

High nitrate content at some locations & deeper water level (more than 5m in the post- monsoon period) in some areas are the major issues so far as ground water scenario in the block is concerned. Annual Extractable Ground Water Recharge 1906.48 ham and present stage of ground water extraction is 50.8 % thus under safe category. Since the stage of development in the block is only 50.8 %, there is ample scope of development. Since the stage of development in the block is only 50.8 %. So there is ample scope of development. In order to achieve 60% stage of ground water withdrawal in the block of Tamnar, development may be taken up by constructing 194 nos of tubewells or 242 nos of dug wells that can create an irrigation potential of 194 ha for paddy, 436 ha for wheat, Ground Nut, Sunflower & 581 ha for Mustard & Pulses .

4. Kharsia block:

Area: 400.79 sq.km taken for study. Average annual rainfall is 1353.24 mm. 35.5% area is irrigated by groundwater. The Principal aquifer system in Kharsia block are Gondwana formation, Raigarh formation & Chhotnagpur group both in phreatic and fractured condition and the major aquifer groups are (i) Chhotnagpur granite gneiss, (ii) Barakar sandstone (iii) Chandrapur Sandstone & (iv) Gunderdih shale. The drainage system is mostly controlled by Mand river, Kurket river and Borai river all flowing southwards forming part of Mahanadi basin. Paddy, Pulses, oil seeds are the major crops produced in the block.

The ground water level of phreatic aquifer during pre monsoon period ranges from 2.26 to 29.01mbgl with an average of 10.45 mbgl and during post-monsoon period it ranges from 0.5 to 6.6 mbgl with an average of 2.51 mbgl. The fluctuation ranges from 1.63 to 28.52 m with an average fluctuation of

8.04 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at most of the locations . The average weathered thickness of the phreatic aquifer is around 17.66 m.

The average yield of Granite gneiss is 1.42 lps with transmissivity of 1-12 m^2/day & average drawdown is 26.15 m. One to two sets of potential fracture zone mostly lie beyond 100 m depth. Similarly the average yield of Gondwana sandstone is 4.32 lps with a transmissivity of 1.35 to to 142.75 m^2/day and average drawdown is 23.8 m. One to three sets of most potential fracture zone lies between 100 to 200 m depth in Gondwana sandstone. The average yield of Gunderdih shale is 6.41 lps with avg transmissivity of 14.58 m^2/day & average drawdown is 13.91 m. One to three sets of potential fracture zone mostly lie within 100 m depth in Gunderdih shale. Similarly the average yield of Chandrapur sandstone is 4.79 lps with a range from 0.85 to 12.5 lps with an average transmissivity of 2.3 m^2/day and average drawdown is 21.46 m. One to two sets of most potential fracture zone lies within 100 m depth.

No proper spacing criteria between wells, silting of the existing tanks and low yielding capacity of gneissic formation are the major ground water issues in the block. Annual Extractable Ground Water Recharge 2672.69 ham and present stage of ground water extraction is 63.85 % thus under safe category.
In terms of Supply side management, we have to go for artificial recharge, particularly to recharge the area of deeper water level. As such 22 nos. of percolation tank, 74 nos. of nala bunding/cement plug/check dam, 177 nos of recharge shaft and 132 nos of gully plug/gabion structures can be constructed that can recharge 9.63 mcm ground water which will enhance the ground water resource of Kharsia block.

5. <u>Lailunga block</u>:

Area: 910.35 sq.km taken for study. Average annual rainfall is 1099.62 mm. 24% of the total irrigated area is irrigated by groundwater. The Principal aquifer system in Kharsia block are Gondwana formation & Chhotnagpur group both in phreatic and fractured condition and the major aquifer groups are (i) Chhotnagpur granite gneiss, (ii) Barakar sandstone. The drainage system is mostly controlled by Khadun river, Kelo river and San river all flowing southwards forming the part of Mahanadi basin. Paddy, Pulses, oil seeds are the major crops produced in the block.

The ground water level of phreatic aquifer during pre monsoon period ranges from 3. 3.03 to 22.55 mbgl with an average of 9.68 mbgl and during post-monsoon period it ranges from 0.43 to 12.19 mbgl with an average of 2.58 mbgl. The fluctuation ranges from 2.6m to 8.07m with an average fluctuation of 4.1 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at most of the locations . The average weathered thickness of the phreatic aquifer is around 15.76 m.

The average yield of Granite gneiss is 1.42 lps with transmissivity of 1-12 m^2/day & average drawdown is 26.15 m. One to two sets of potential fracture zone mostly lie beyond 100 m depth. Similarly the average yield of Gondwana sandstone is 4.32 lps with a transmissivity of 1.35 to to 142.75 m^2/day and average drawdown is 23.8 m. One to three sets of most potential fracture zone lies between 100 to 200 m depth in Gondwana sandstone.

Poor ground water development, silting of the existing tanks and low yielding capacity of gneissic formation are the major ground water issues in the block. Annual Extractable Ground Water Recharge 5215.77 ham and present stage of ground water extraction is 20.66 % thus under safe category. In terms of Demand side management, wherever ground water has been used for field irrigation should be replaced with micro irrigation methods such as sprinklers, drip irrigation etc. which may save 30 to 40% ground. In terms of Supply side management, we have to go for artificial recharge, particularly to recharge the area of deeper water level Percolation Tank (10) , Nala bund & Check dam (34),Recharge shafts (81) and gully plug/gabion structure (60) may be constructed that can recharge 4.39 MCM water to underground . Since the stage of development of groundwater in the block is only 20.66 %, there is ample scope of development. In order to achieve 60% stage of ground water development in this block, development may be taken up by constructing 1285 nos of tube wells or 2855 nos of dug wells at suitable locations that can create an irrigation potential of 2284.5 ha of paddy, 5140 ha of wheat, Ground Nut, Sunflower and 6853 ha of Mustard & Pulses .

6. Pusaur block:

Area: 510.3 sq.km taken for study having a total Annual Extractable Ground Water Recharge of 4371.35 ham and present stage of ground water extraction is 76.85 % and is under semi-critical category. 86.22 % of the total irrigated area is irrigated by groundwater. The Principal aquifer system in Pusaur block is Raipur group both in phreatic and fractured condition and the major aquifer groups are (i) Gunderdih Shale (ii) Charmuria Limestone.

The average ground water level of phreatic aquifer during pre monsoon period is 13.71 mbgl and during post-monsoon period it is 8.45 mbgl. The average fluctuation ranges is 5.25 m. The long term ground water level trend indicates that there is appreciable change in ground water level with a falling trend of 40 cm/year both in pre-monsoon and post monsoon period. The average weathered thickness of the phreatic aquifer is around 17.17 m.

The average yield of Gunderdih shale is 6.41 lps with avg transmissivity of 14.58 m^2/day & average drawdown is 13.91 m. One to three sets of potential fracture zone mostly lie within 100 m depth in Gunderdih shale. The average yield of Charmuria limestone is 9 lps with avg transmissivity of 17.855 m^2/day & average drawdown is 19.63 m. One to two sets of potential fracture zone mostly lie within 100 m depth in Charmuria Limestone.

The major ground water issues are: (i) In several regions there is deeper water table due to excessive withdrawal for irrigation, (ii) No proper spacing criteria between wells (iii) Silting of the existing tanks. In terms of Demand side management, change in cropping pattern from paddy in Rabi season to maize can lead to improvement of stage of ground water extraction to 36.41 from 76.85%. . In terms of Supply side management, by constructing artificial recharge structure such as Percolation Tank (40) , Nala bund & Check dam (133), Recharge shafts (320) and gully plug/gabion structures (238), the ground water resource can be increased to 17.43 mcm more.

7. Raigarh block:

Area: 942.72 sq.km taken for study having a a total Annual Extractable Ground Water Recharge 4371.35 ham and present stage of ground water extraction is 46.64 % and is under safe category. 55 % of the area is irrigated by groundwater. Most of the ground water development has been concentrated in eastern part of the block and water level is showing declining trend in eastern region. The Principal aquifer system in Raigarh block is Chhotnagpur group, Gondwana formation & Raipur group both in phreatic and fractured condition and the major aquifers are (i) Gunderdih Shale (ii) Chhotnagpur Granite Gneiss (iii) Gondwana Sandstone & (iv) Chandrapur Sandstone.

The average ground water level of phreatic aquifer during pre monsoon period is 9.76 mbgl and during post-monsoon period it is 5.88 mbgl. The average fluctuation ranges is 3.87 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at most of the locations . The average weathered thickness of the phreatic aquifer is around 13.4 m.

The average yield of Gunderdih shale is 6.41 lps with avg transmissivity of 14.58 m^2/day & average drawdown is 13.91 m. One to three sets of potential fracture zone mostly lie within 100 m depth in Gunderdih shale. The average yield of Granite gneiss is 1.42 lps with transmissivity of 1-12 m^2/day & average drawdown is 26.15 m. One to two sets of potential fracture zone mostly lie beyond 100 m depth. Similarly the average yield of Gondwana sandstone is 4.32 lps with a transmissivity of 1.35 to 142.75 m^2/day and average drawdown is 23.8 m. One to three sets of most potential fracture zone lies between 100 to 200 m depth in Gondwana sandstone. The average yield of Chandrapur sandstone is 4.79 lps with a range from 0.85 to 12.5 lps with an average transmissivity of 2.3 m^2/day and average drawdown is 21.46 m. One to two sets of most potential fracture zone lies within 100 m depth.

The major ground water issues in the block are: (i) Though the stage of g.w. development is 46.64 %, but it is concentrated only to the eastern part of the block (ii) No proper spacing criteria between wells (iii) Silting of the existing tanks (iv) Low yielding capacity Chandrapur formation. In terms of Supply side management, Since the stage of development of groundwater in the block is only 46.64 %, there is ample scope of development. In order to achieve 60% stage of ground water development in this block, development may be taken up by constructing 472 nos of tube wells or 1049 nos of dug wells that can create an irrigation potential of 838.8 ha of paddy, 1887.5 ha of wheat, Ground Nut, Sunflower and 2516.6 ha of Mustard & Pulses . However in a long term sustaining basis, we have to go for artificial recharge, particularly to recharge the area of deeper water level. As such 5.58 mcm water can be recharged to the underground by constructing Percolation Tank (13), nala bund / Check dam (42), Recharge shafts (101) and gully plug/gabion structures (75).

8. Sarangagarh block:

Area- 851.12 sq.km taken for study. Average annual rainfall is 1327.4 mm. 22% of the total irrigated area is irrigated by groundwater. The Principal aquifer system in Raigarh block is Raigarh group, Chandrapur group & Chhotnagpur group both in phreatic and fractured condition and the major aquifers are (i) Gunderdih Shale (ii) Charmuria Limestone (iii) Chhotnagpur Granite Gneiss & (iv) Chandrapur Sandstone. Mahanadi and its tributaries Lilar, Lath, Khundi, Manal Nala forms the major drainage system in the block and Paddy, Wheat and Gram are the major crops produced in the block.

The ground water level of phreatic aquifer during pre monsoon period ranges from 3.23-131 mbgl with an average of 6.39 mbgl and during post-monsoon period it ranges from 1.5-8.6 mbgl with an average of 3.96 mbgl. The fluctuation ranges from 0.3-9.3 m with an average fluctuation of 2.43 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at most of the locations. The average weathered thickness of the phreatic aquifer is around 11.21 m.

The average yield of Gunderdih shale is 6.41 lps with avg transmissivity of 14.58 m^2/day & average drawdown is 13.91 m. One to three sets of potential fracture zone mostly lie within 100 m depth in Gunderdih shale. The average yield of Charmuria limestone is 9 lps with avg transmissivity of 17.855 m^2/day & average drawdown is 19.63 m. One to two sets of potential fracture zone mostly lie within 100 m depth in Charmuria Limestone. The average yield of Granite gneiss is 1.42 lps with transmissivity of 1-12 m^2/day & average drawdown is 26.15 m. One to two sets of potential fracture zone mostly lie beyond 100 m depth. The average yield of Chandrapur sandstone is 4.79 lps with a range from 0.85 to 12.5 lps with an average transmissivity of 2.3 m^2/day and average drawdown is 21.46 m. One to two sets of most potential fracture zone lies within 100 m depth.

Inherent character of aquifer giving low yield and declining of water level are the major ground water issues in the block. Total Annual Extractable Ground Water Recharge 5716.85 ham and present stage of ground water extraction is 31.76 % and is under safe category. In terms of supply side management, since the stage of groundwater extraction in the block is only 31.76 %, there is ample scope of development. In order to achieve 60% stage of ground water development in this block, development may be taken up by constructing 1794 nos of tube wells or 2242nos of dug wells at suitable locations that can create an irrigation potential of 1794 ha of paddy, 4036.6 ha of wheat, Ground Nut, Sunflower and 5382.2 ha of Mustard & Pulses . In a long term sustainable basis, we have to go for artificial recharge, particularly to recharge the area of deeper water level by construction of Percolation Tank (64), Nala bund & Check dam (214),Recharge shafts (513) and gully plug/gabion structures (382) to recharge 27.95 mcm water to underground.

9. Baramkela block:

Area: 781.34 sq.km taken for study. Average annual rainfall is 971.88 mm. 76% of the total irrigated area is irrigated by groundwater. The Principal Aquifer systems in the block are Chhotnagpur group, Raigarh Group & Chandrapur Group both in phreatic and fractured condition & the major aquifers are (i) Gunderdih Shale (ii) Chhotnagpur Granite Gneiss & (iv) Chandrapur Sandstone. Mahanadi, Kenkamdi and Jira river flowing towards north-east forms the major drainage system in the block. Paddy, Wheat and Gram are the major crops produced in the block.

The ground water level of phreatic aquifer during pre monsoon period ranges from 3.25 to 25.5 mbgl with an average of 11.6 mbgl and during post-monsoon period it ranges from 2.5 to 19.5 mbgl with an average of 7.32 mbgl. The fluctuation ranges from 0.3 to 14.75 m with an average fluctuation of 4.29 m. The long term ground water level trend indicates that there is appreciable change in water level with a falling trend of 17 cm/year both in pre-monsoon and post monsoon period. The average weathered thickness of the phreatic aquifer is around 19.6 m.

The average yield of Gunderdih shale is 6.41 lps with avg transmissivity of 14.58 m²/day & average drawdown is 13.91 m. One to three sets of potential fracture zone mostly lie within 100 m depth in Gunderdih shale. The average yield of Granite gneiss is 1.42 lps with transmissivity of 1-12 m²/day & average drawdown is 26.15 m. One to two sets of potential fracture zone mostly lie beyond 100 m depth. The average yield of Chandrapur sandstone is 4.79 lps with a range from 0.85 to 12.5 lps with an average transmissivity of 2.3 m²/day and average drawdown is 21.46 m. One to two sets of most potential fracture zone lies within 100 m depth.

High stage of groundwater development, inherent character of aquifer giving low yield, growing water consuming crops in spite of critical stage of development and declining of water level are the major ground water issues in the block. Total Annual Extractable Ground Water Recharge 6464.93 ham and present stage of ground water extraction is 77.72 % and is under semi-critical category. In a long term sustainable basis, we have to go for artificial recharge, particularly to recharge the area of deeper water level by construction of Percolation Tank (81), Nala bund & Check dam (271), Recharge shafts (650) and gully plug/gabion structures (485) to recharge 35.40 mcm water to underground.

6.3 Status of Ground Water Development Plan:

The ground water development in the district is being done by dug wells and tube well/ bore wells. The dug well depth varies from 5 to 20 m and the diameter varies from 1 to 4 m. The bore wells drilled in the area are 60 to 150 m deep with diameter of 100 to 150 mm. Diesel or electric operated pumps of 1 to 5 HP or traditional tenda is used to lift the water from dug wells for irrigation purposes. The submersible electrical pumps of 3 to 5 HP are used for irrigation purpose in case of bore wells in the area. The bore wells in the area can irrigate an area of 0.5 to 2.5 ha for paddy.

The stage of ground water development estimated for Baramkela block is 77.72%, for Dharamjaigarh block is 38.95%, for Gharghoda block is 43.95%, for Kharsia block is 63.81%,for Lailunga block is 20.66%, for Pusaur block is 76.85%, for Raigarh block is 46.64%, for Sarangarh block is 31.76% and for Tamnar block is 50.8%.The overall stage of development in the district is 50.09%. The block wise stage of ground water extraction map in the district is depicted in **Map-5.5**. The details of artificial recharge structures to enhance ground water resource and nos. of irrigation tube wells or irrigation dug wells or combination of both that can be constructed at suitable locations in the district for more ground water development and to create more irrigation potential are presented in the table-6.1(A) & table 6.2 (B) respectively.

Table-6.1 (A): Details of AR structures in Raigarh district

Block	**Percolation tank recharge capacity 0.2192 mcm**	**Nalas bunding cement plug/ check dam recharge capacity 0.0326 mcm**	**Recharge shaft recharge capacity 0.00816mcm**	**Gully plugs Gabbion structures recharge capacity 0.0073 mcm**	**Total recharge in mcm**
Baramkela	81	271	650	485	35.40
Dharamjaigarh	27	89	214	160	11.72
Gharghoda	28	95	229	170	12.33
Kharsia	22	74	177	132	9.63
Lailunga	10	34	81	60	4.39
Pussore	40	133	320	238	17.43
Raigarh	13	42	101	75	5.58
Sarangarh	64	214	513	382	27.95
Tamnar	0	0	1	1	0.02
Total	***285***	***952***	***2286***	***1703***	***124.45***

Table-6.1 (B): Details of irrigation tube wells and dug wellsto be constructed in Raigarh district

Block	**Stage of ground water extraction (%)**	**Number of TW Recommended in each block (Assuming unit draft as 1.6 ham/structure/year)**	**Number of DW Recommended (Assuming unit draft as 0.72 ham/structure/year)**	**Irrigation potential likely to be created for paddy (Ha)**	**Irrigation potential likely to be created for wheat, Ground Nut, Sunflower (Ha)**	**Irrigation potential likely to be created for Mustard & Pulses (Ha)**
Baramkela	77.72					
Dharamjaigarh	38.95	837	1862	1489.5	3351.5	4465.7
Gharghoda	43.95	281	624	499	1122.5	1496.67
Kharsia	63.85					
Lailunga	20.66	1285	2855	2284.5	5140	6853
Pussore	76.85					
Raigarh	46.64	472	1049	838.8	1887.5	2516.6
Sarangarh	31.76	1794	2242	1794	4036.6	5382.2
Tamnar	50.8	194	242	194	436	581
Total	***50.09***	***4863***	***8874***	***7099.8***	***15974.1***	***21295.17***

Taking crop water requirement of Paddy as 90cm, wheat, groundnut & Sun flower as 40cm and Pulses & Mustard as 30cm

From the table 6.1(A), it is depicted that 285 nos. of percolation tank, 952 nos. of nala bunding/cement plug/check dams , 2286 nos. of recharge shafts and 1703 nos. of gully plug/gabion structures may be constructed at suitable locations that can enhance the ground water source to 124.45 mcm more.

Similarly from the table 6.1(B), it is depicted that 4863 nos of irrigation tube wells or 8874 nos of irrigation dug wells or combination of these two may be constructed in the district that can likely to create an irrigation potential of 7099.8 ha for paddy, 15974.1 ha for wheat, Ground Nut, Sunflower and 21295.17 ha for Mustard & Pulses respectively.

6.4 Aquifer Map:

Finally on the basis of above studies such as the aquifer characteristic of various aquifer groups & ground water level behavior in various seasons, the following maps for Raigarh district were prepared:

(i) Aquifer map 3-dimesional (**Map-6.1**)

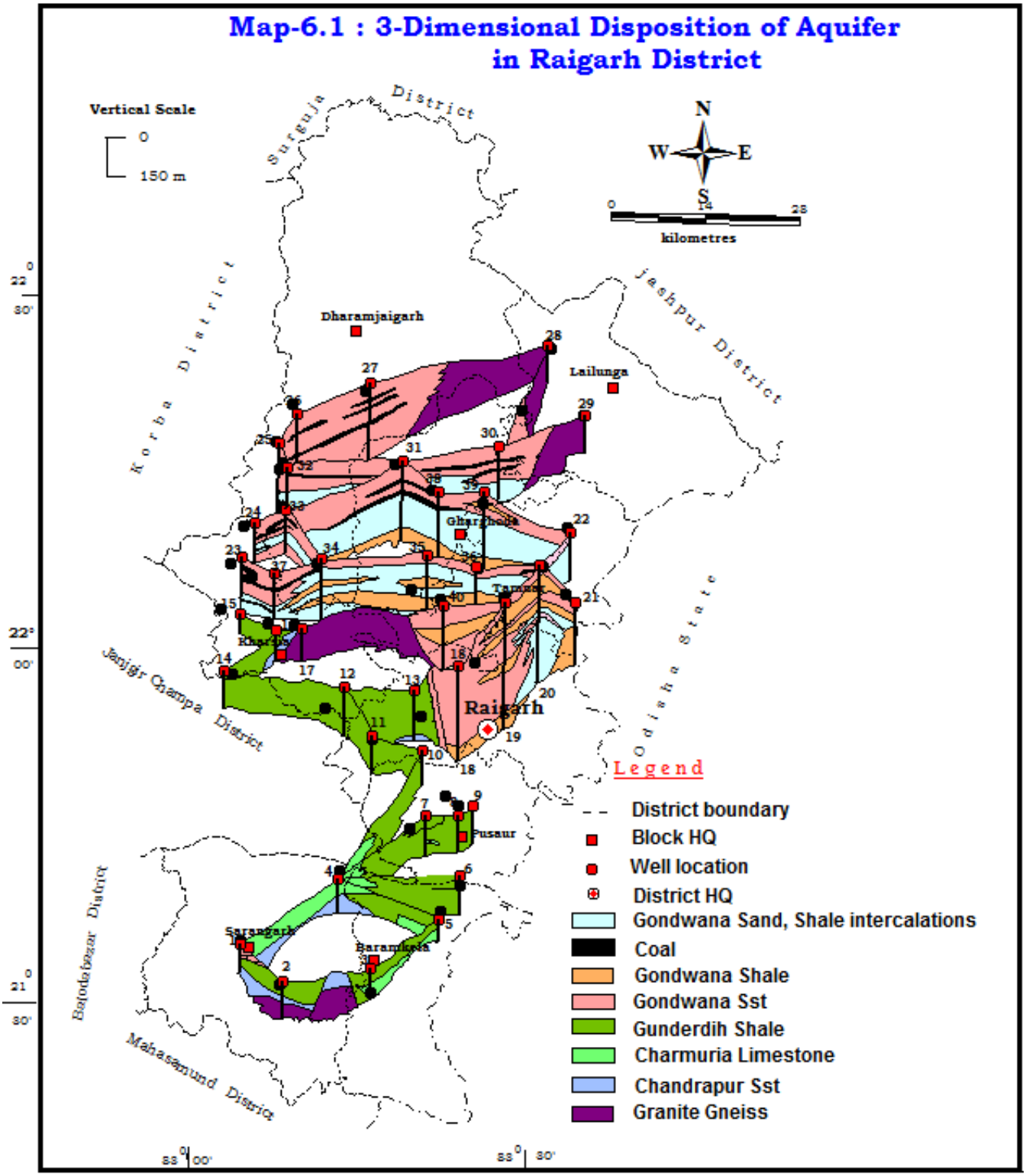
(ii) Aquifer map 2-dimensionsl, (**Map-6.2 A & B)**

(iii) Hydrogeological map of Raigarh district (**Map-6.3)**

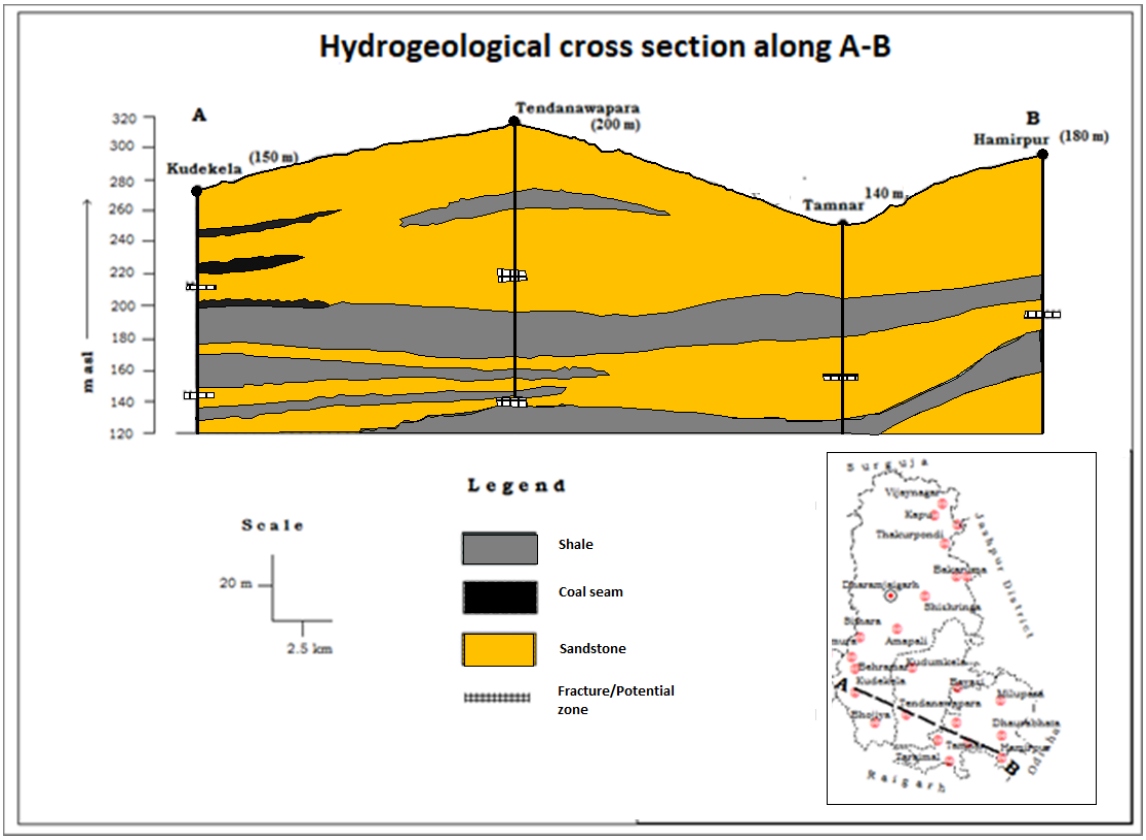
(iv) The yield potential map based on the exploration (**Map-6.4)**

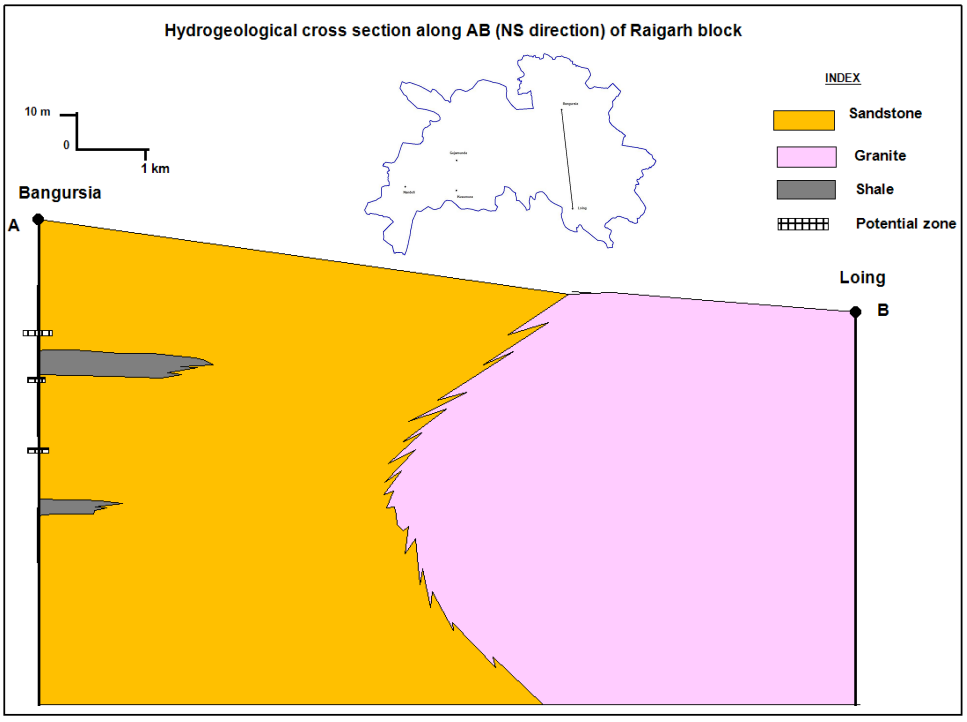
(v) Ground water development potential & Artificial recharge Prospect (**Map-6.5)**

Map-6.1: 3-Dimensional Disposition of Aquifer in Raigarh district, Chhattisgarh



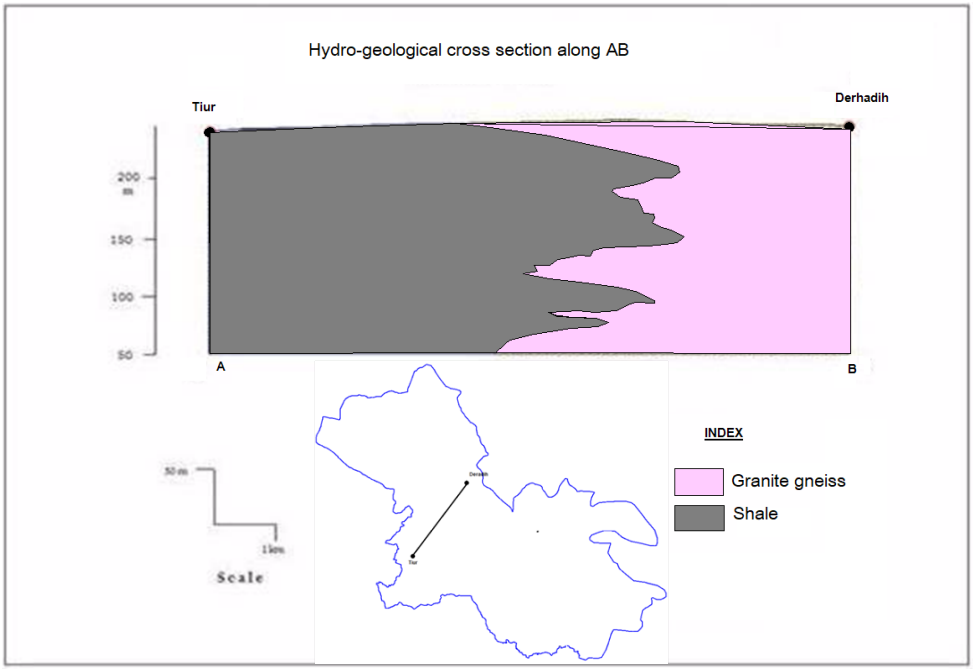
Map-6.2 A: 2-Dimensional Disposition of Aquifer in Raigarh district, Chhattisgarh

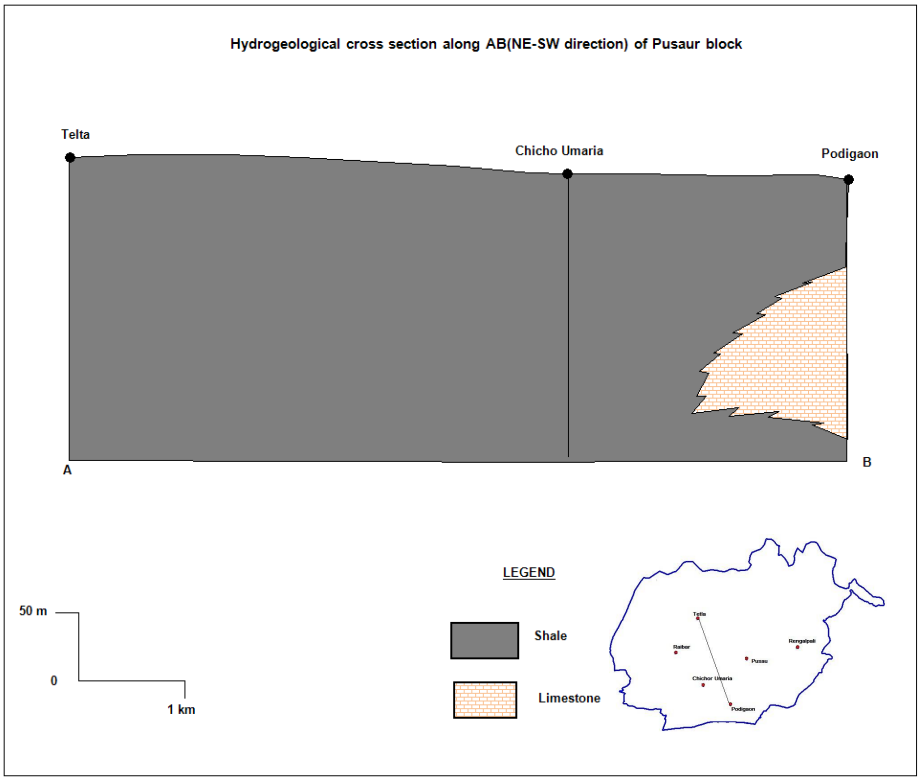




Map-6.2 B: 2-Dimensional Disposition of Aquifer in Raigarh district, Chhattisgarh

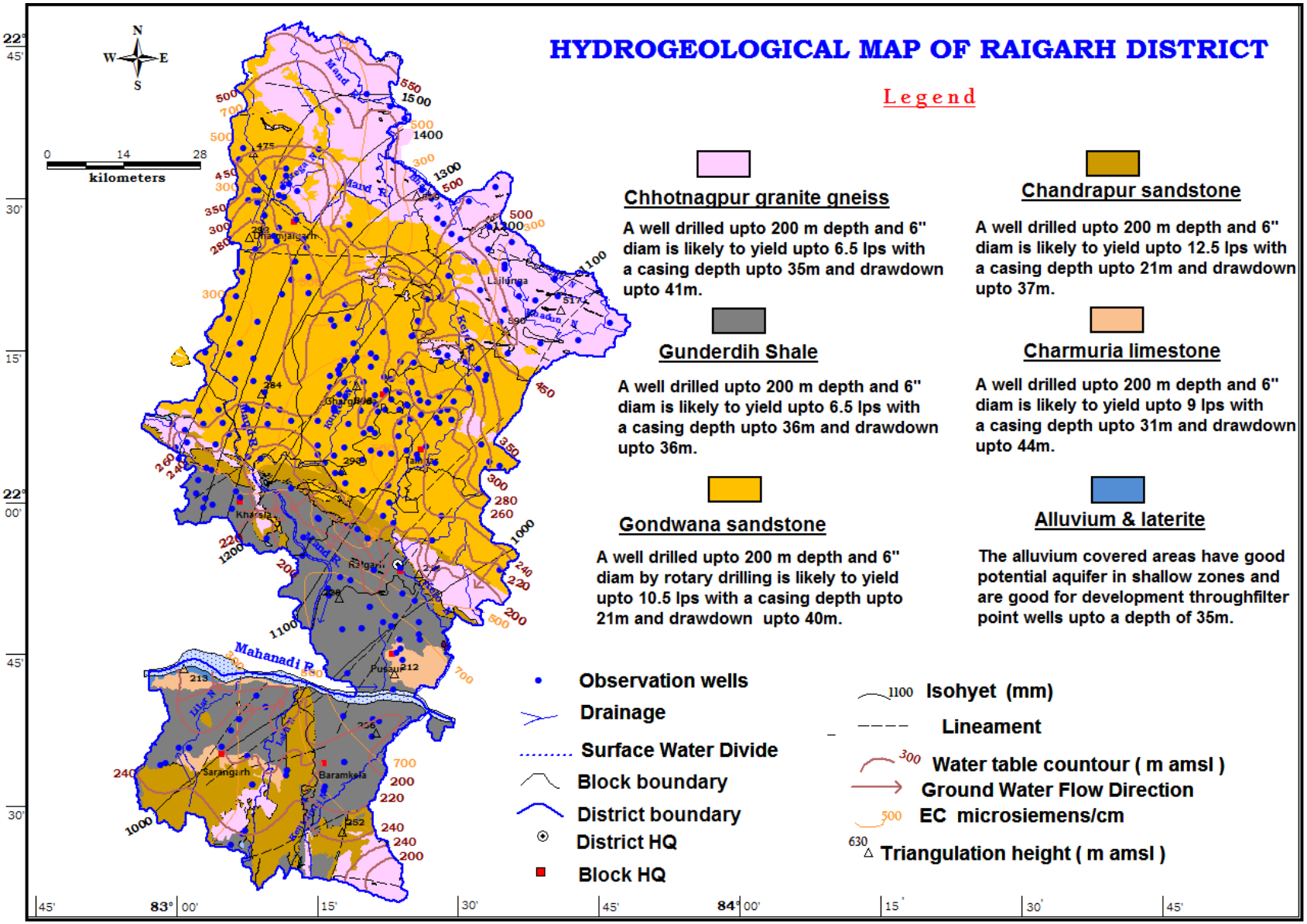
Map-6.2 C: 2-Dimensional Disposition of Aquifer in Kharsia block Raigarh district, Chhattisgarh



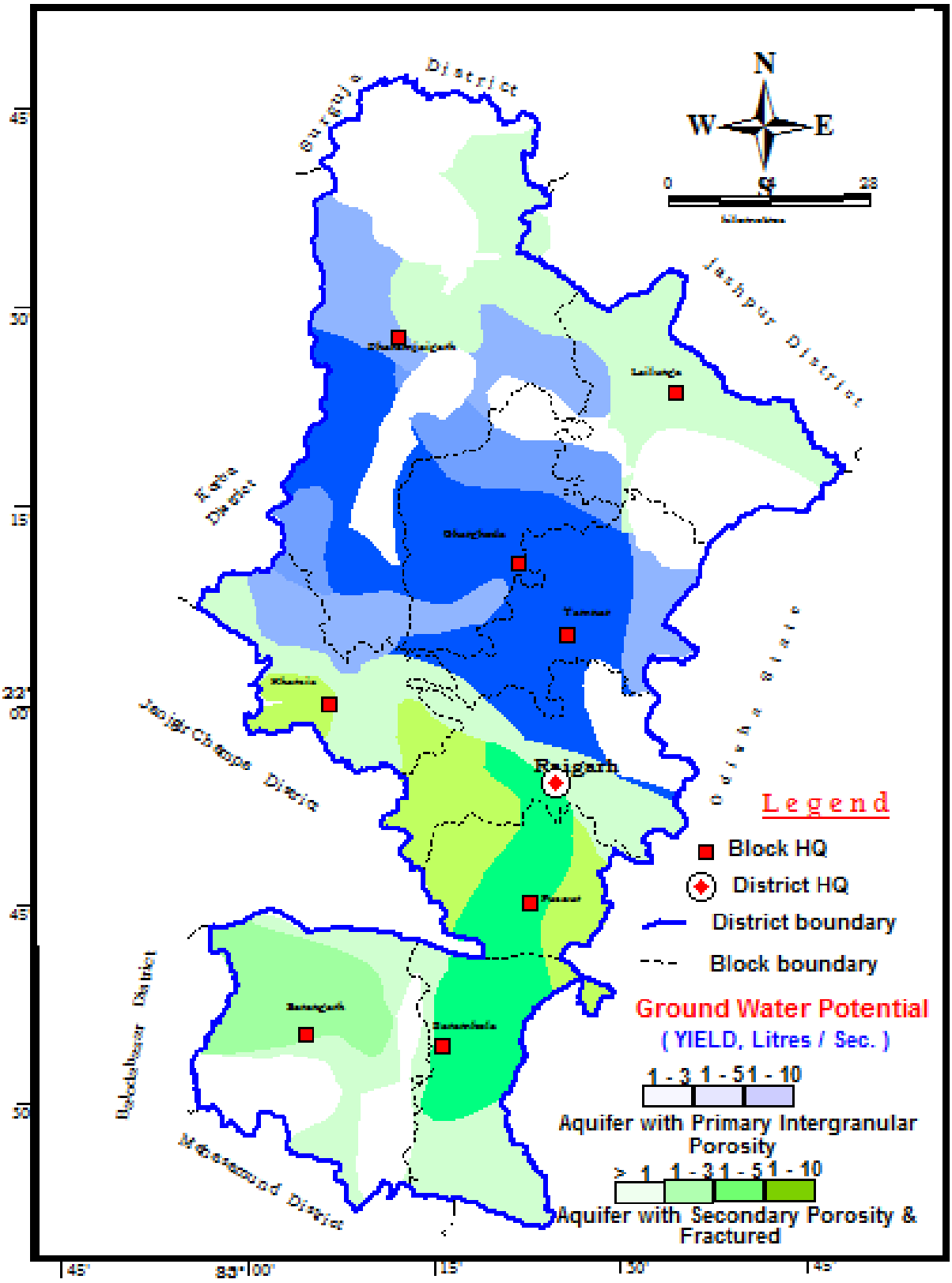


Map-6.2 D: 2-Dimensional Disposition of Aquifer inPusaure block Raigarh district, Chhattisgarh

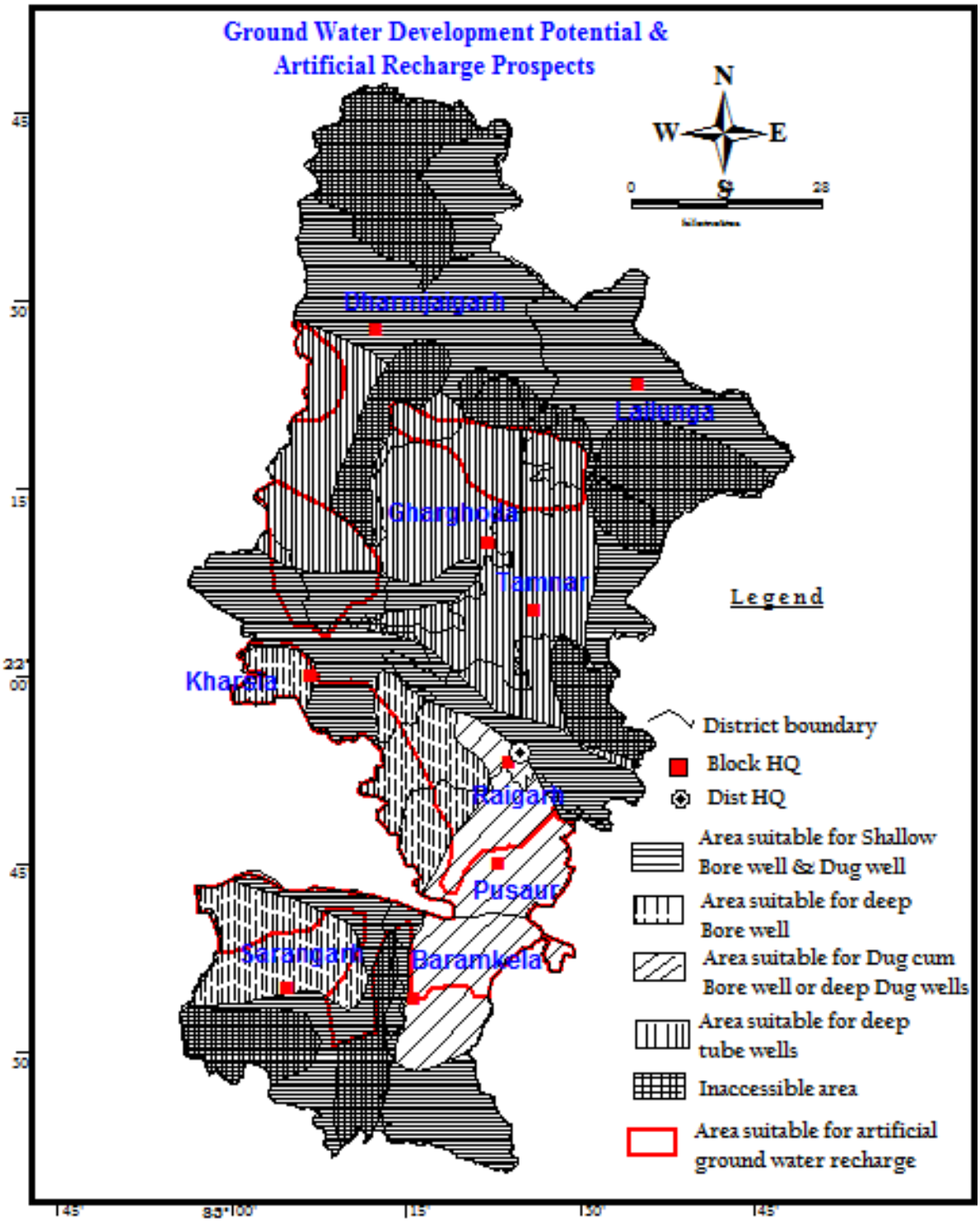
Map-6.3: Hydrogeological map of Raigarh district, Chhattisgarh



Map-6.4: Yield potential map of Aquifer in Raigarh district, Chhattisgarh



Map-6.5: Ground water Development Potential & Artificial Recharge Prospects map of Raigarh district, Chhattisgarh



CHAPTER-VII

SPRING

7.1 Study of Spring:

Spring discharge constitutes an additional source of ground water in hilly areas which emerges at the places where ground water level cuts the surface topography. The spring discharge is equal to the ground water recharge minus the outflow through evaporation and evapotranspiration and vertical and lateral sub-surface flow. Thus, Spring discharge is a form of 'Annual Extractable Ground Water Recharge'. It is a renewable resource, though not to be used for Categorisation. Spring discharges multiplied with time in days of each season gives the quantum of spring resources available during that season.

During the survey, spring study was also carried out. A large number of springs were found to occur in the district and are mostly on the northern part of Mahanadi basin covering Dharamjaigarh, Gharghoda, Lailunga, Tamnar, Kharsia and Raigarh block. Occurrence of spring is controlled by geomorphology, geology and structures and abundance of water which depends on climate, rainfall, and hydrogeological conditions in the area. Springs are not reported from the Raigarh Formation, covering large part of the area in the district (1655 Sq.km.). Most of the springs are restricted to Gondwana formation & Chandarpur sandstones such as Ramjharna of Bhupdeopur, springs of Botalda and Chhote Pandermura etc. The springs of Raipur group and Crystallines are less and are seasonal in nature. The list of some of the springs is given in Table 7.1 and is presented in The yield potential and the recommended suitable abstraction structures for the area are shown in (**Map-7.1**).

Table-7.1 : List of Springs of Raigarh district

S.No	Village	Geology	Location	Nos.	Lat	Long
1	Bargaon	Chandarpur sandstone	Foot hill	1	22.0518	83.0358
2	Basnajhar	Chandarpur sandstone	Foot hill	2	21.9401	83.1603
3	Botalda	Chandarpur sandstone	Foot hill	5	22.03709	83.09829
4	Chhoe Padermura	Chandarpur sandstone	Hill slop	1	22.0871	83.06634
5	Choara	Chandarpur sandstone	Foot hill	1	21.98808	83.12732
6	Kerajhar	Chandarpur sandstone	Foot hill	1	21.96749	83.30027
7	Parsada	Chandarpur sandstone	Foot hill	1	21.95427	83.32848
8	Ramjharna	Chandarpur sandstone	Foot hill	1	21.98204	83.27913
9	Tilaipali	Chandarpur sandstone	Foot hill	1	21.82475	83.45781
10	Amlidih	Gondwana	Plain land	1	22.04225	83.01734
11	Bangursian	Gondwana	Plain land	1	21.9704	83.45046
12	Barra	Gondwana	Plain land	1	22.56538	83.11477
13	Bojiya	Gondwana	Plain land	1	22.113	83.1629
14	Lamikhair	Gondwana	Foot hill	1	22.16957	83.21371
15	Chhaldoria	Gondwana	Plain land	1	22.10269	83.35406
16	Chikatwani	Gondwana	Plain land	1	22.45227	83.2289
17	Dharhagaon	Gondwana	Foot hill	3	22.443	83.4173
18	Jobi hills-1	Gondwana	Plain land	3	22.1519	83.03184
19	Jobi hills-2	Gondwana	Plain land		22.14861	83.03069
20	Jobi hills-3	Gondwana	Plain land		22.15265	83.01496
21	Kaharchuan	Gondwana	Foot hill	1	22.2386	83.6443
22	Kophermar	Gondwana	Plain land	1	22.1673	83.0632
23	Kurekela	Gondwana	Plain land	1	22.2577	83.286
24	Puchhiapali	Gondwana	Plain land	1	22.103	83.0506

25	Ruwalipahar-1	Gondwana	Foot hill	4	22.6977	83.12542
26	Ruwalipahar-2	Gondwana	Foot hill		22.686	83.1268
27	Ruwalipahar-3	Gondwana	Foot hill		22.6855	83.13218
28	Ruwalipahar-4	Gondwana	Foot hill		22.67573	83.14057
29	Tolge	Gondwana	Foot hill	1	22.2446	83.598
30	Tudekela	Gondwana	Plain land	1	22.16404	83.11831
31	Belpeda-1	Crystalline	Foot hill	2	22.58161	83.17866
32	Belpeda-2	Crystalline	Foot hill		22.58345	83.17536
33	Boro	Crystalline	Plain land	1	22.56538	83.11477
34	Charmatola	Crystalline	Lineament	3	22.3803	83.6577
35	Charmura	Crystalline	Lineament	2	22.4083	83.5184
36	Ganderpani	Crystalline	Foot hill	1	22.72439	83.12832
37	Rajdha	Crystalline	Foot hill	1	22.56941	83.2021
38	Kurra	Gondwana	Foot hill	1	22.419	83.4653
39	Kupakani-1	Crystalline	Lineament	3	22.3798	83.6457
40	Kupakani-2	Crystalline	Lineament		22.3779	83.654
41	Kupakani-3	Crystalline	Lineament		22.3799	83.6569
42	Nawapara	Crystalline	Lineament	1	22.39336	83.56837
43	Pitha Amma	Crystalline	Lineament	2	22.4191	83.6495

7.2 Springs in Gondwana rocks:

Large number of springs of oozing water is found at a number of places in Gondwana terrain. These springs are mostly seasonal with low discharge. At places the water small spring pool locally called as “Kurumkela” and is used for drinking and irrigation purpose. The location of the springs may be seen in various geomorphic settings such as plain gently sloping ground, foot hills, escarpments etc. The temperature of the water is around 25°C and is potable. At times the water is with soluble Fe due to around the growth of iron reducing bacteria.

7.3 Springs in Crystalline rocks:

Few isolated springs are seen in crystalline rocks mainly gneiss. Discharge is very low and is seasonal in nature. The temperature of the water is around 25°C and is potable. Mostly these are found in low lying plains or at the foot hill zones. The occurrences of springs lie along EW trending line on the northern boundary of district.

7.4 Some important springs:

1. Ramjharna : This spring is situated in Bhupdeopur village which is 15 km from Raigarh on Raigarh- Bilaspur road. The spring originates from foot hill (260-280 m amsl) of Chanderpur sandstone. The spring site was developed into as a tourist place by Forest department. The spring is collected as small pool of water and is made to flow through channels constructed along the hill slopes. The water is ultimately stored in a pond which is nearly 1 km away from its origin. It is used for irrigation and other domestic purposes by local people. The temperature of the water 26.5° C and is potable. The discharge of the spring varies from 3.5 to 5.5 lps (from pre-to post-monsoon).
2. Botalda: About 10 km from Kharsiya on Kharsiya-Bialspur road a group of springs are originating from the foot hill of Chanderpur sandstone (260-280 mamsl). These springs are developed by local Hanuman Mandir trust. The spring water temperature is around 27° and is potable. The cumulative discharge varies from 78.5 lpm in pre-monsoon to 175.6 lpm in post-monsoon. At its origin group of

temples were constructed and is a pilgrimage. Nearly at 500m downstream of the spring a collection pond was constructed and is being used for irrigation purpose.

3. Chhote Pandermura: The spring at Chhote Pandermura (Ramjharna) originates from an isolated hill of Chanderpur sandstone is approachable from Kharsiya Chhal road Edu. The village is on Edu-Barra road. The spring is originated from a height of 300 m amsl. The spring water temperature is around 25.5° and is potablein nature. The discharge varies from 26lpm (pre-monsoon) to 60 lpm (post-monsoon).

4. Basnajhar : Spring at Basnajhar originates from foot hill of Chanderpur sandstone and can be approachable from Kharsiya- Dabhra road. The spring water temperature is around 26° and is potable. The discharge is around 30 lpm. The spring water is collected in a small pond and is used for domestic purpose by the village.

5. Kukrijharia: Spring at Kukrijharia is the only thermal spring in the district. The temperature is around 35°C. The spring is originated from a fault line where Gondwana rocks overlie above basement crystalline. The spring can be approached form Kharsiya via Kharpali. The discharge is around 20 lpm. The spring is used for domestic purposes.

7.5 Management of spring water:

i) Majority of the springs of the district are low in discharge and seasonal in nature. However, discharge upto 5 lps have been found in spring of Ramjharna (Bhupdeopur) Presently, the spring water is used for drinking and irrigation purposes and also for tourism.

ii) Oozing seasonal springs are beyond the scope of economic management particularly in Gondwana rocks. Such springs are mainly used by one or two owner and are able to provide economic benefit of free irrigation in less than 1 acre of area in kharif and to some extent in rabi. Oozing of spring water along the low lying nala beds provide local moist condition for agriculture in many places.

iii) However, spring with more than 1 lps discharge can be managed properly for better utilization and more efficiently putting proper channel for outlet. The origin point must be cleaned and permanent embankment must be constructed. Local people have made some arrangement for collecting the flowing water in the form of small pond. Few such ponds exist at Bhupdeopur, Botalda, Basnagharh, Kurrajhar, Garhkurri.

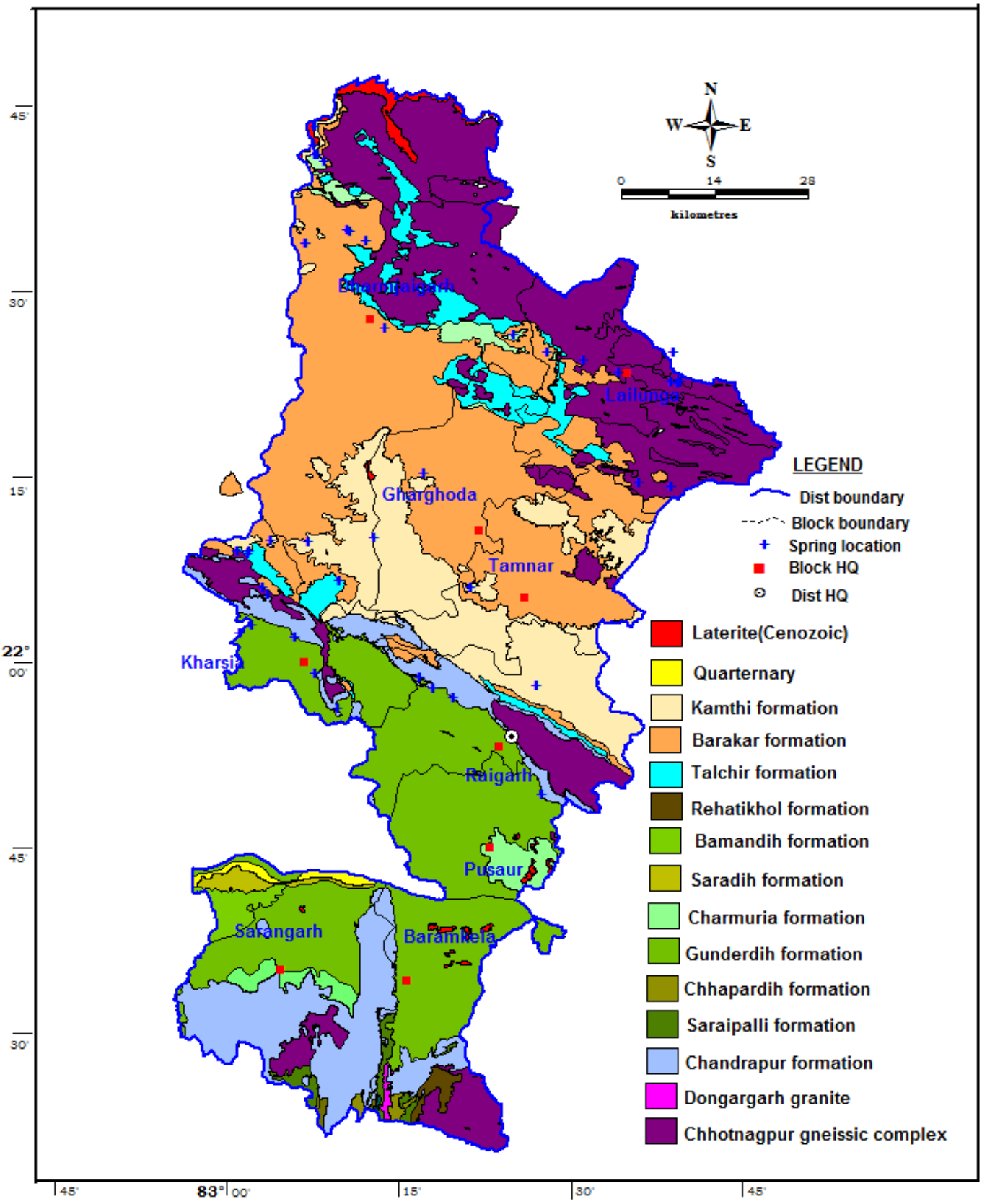
iv) The Ramghara of Bhupdeopur is used as tourist place by forest department. Large number of people visit this place annually. The water is stored in a swimming pool for tourist which is later released for the village tank from where it is used for irrigation of nearly 100-150 acres of land.

v) The potential occurrence of Chhote Pandermura Chanderpur sandstone spring is not being used optimally at present and may be harvested properly and can be used for irrigation of larger area. Its geographical location is such that it can even be developed for eco-tourism also.

vi) Few of the spring points are developed as local place of pilgrim such as Botalda, Chhora, Bargarh. The annual fair at Bargarh and Botalda attract tourist/ visitors form near by areas.

vii) To improve the discharge and sustainability of seasonal springs, rain water harvesting in suitable place can be beneficial.

Map-7.1: Map showing location of Springs in Raigarh district, Chhattisgarh



CHAPTER-VIII

SUM UP

8.1 RECOMMENDATIONS :

1. The spacing criteria between bore wells particularly in Raigarh Formation covering deeper water level area of Baramkela- Pusaur- Raigarh - Kharsia blocks should be regulated to keep control on the depletion of Ground Water level. More number of purpose build piezometers is needed to monitor behaviour of the aquifer actually in use in the district.

2. The Groundwater potential of Barakar and Kamthi Formation of Ghargoda-Tamnar-Dharamjaigar blocks are presently underutilized. The potential aquifer existing between 200 and 350 m depth has not been tapped so far. Especially designed wells can produce sustainable discharge for irrigation from these zones for the entire cultivable land of these blocks.

3. As there is scope for development in the district, either 4863 nos. of irrigation tube wells or 8874 nos. of irrigation dug wells or combination of both tube wells and dug wells can be constructed in the district for more ground water development and to create more irrigation potential.

4. Conjunctive use of water resources like creation of more ponds may be given importance.

5. Due to large scale pumping from Raigarh Formation for irrigation, the water level in this formation goes deep in summer and the sustainability of shallow hand pumps are threatened. If the water of irrigation tanks or check dam in deeper water level area of Baramkela- Pusaur- Raigarh- Kharsia blocks can be used effectively for artificial recharge through gravity head recharge well, it can enhance the sustainability of hand pumps (the life line for rural drinking water) in the area. These tanks can provide additional water for delayed recharge to aquifer after monsoon.

6. In supply side management, 285 nos. of Percolation tank, 952 nos of Nalas bunding cement plug/ check dam, 2286 nos. of recharge shaft and 1703nos. of Gully plugs /Gabbion structures may be constructed throughout the district that can recharge 124. 45 mcm water to underground.

7. Similarly 4863 nos of irrigation tube wells or 8874 nos of irrigation dug wells or combination of these two may be constructed in the district that can likely to create an irrigation potential of 7099.8 ha for paddy, 15974.1 ha for wheat, Ground Nut, Sunflower and 21295.17 ha for Mustard & Pulses respectively.

8. The deeper auto-flow zone demarcated in Devgarh-Tamnar-Milupara area may provide energy free hot water of 40 to 50°C by construction of 350-500 m deep tube wells. This zone can be explored for a probable source of geothermal energy. The shallow auto-flow zone identified in Sithra- Khadgaon area and in Dumarpali can be used for obtaining energy free source of water for irrigation by construction of tube wells of 100- 250 m depth.

9. The large number of springs existing in the Gondwana rocks and in Chandrapur sandstone ridges in the district can be given more attention for their proper utilization and management as energy free source of water. The sustainability of seasonal springs can be enhanced by construction of rainwater harvesting structures around such springs.

10. It is recommended that rotary drilling with DTH rigs can improve the efficiency over gravel packed tube wells in these semi-consolidated formations.

11. With increasing dependency on hand pumps for drinking water, iron contamination in Ground Water has emerged as biggest problem in parts of Gondwana covered area of Gharghoda-Tamnar-Dharamjaigarh- Kharsiya- Lailunga blocks. Recent experiments has shown that passing the iron contaminated water through bentonite clay sorbed considerable amount of iron from water by isomorphous replacement in the crystal lattice and can provide iron free drinking water .This can be adopted in the district.

12. All the unused dug wells may be converted to recharge structures by filling suitable filter material (Layers of equal thicknesses of Sand at the bottom followed by Gravels and then by Pebbles). Presently these dug wells are acting as a source of pollution to ground water due to dumping of domestic waste.

13. The source of nitrate in ground water is mostly anthropogenic. Hence, dug wells in the affected areas are to be substituted by borewells or tubewells to avoid the phreatic aquifer.

14. Creation of Sewage Traetment Plant (STP) in urban areas and construction of soak pit in rural areas should be given due importance to prevent ground water contamination.

15. Reuse of GW in urban area may be encouraged in urban areas particularly in Raigarh town.

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ANNEXURE-I: Exploration details in Raigarh district

SL. NO	BLOCK	LOCATION	TYPE	LAT	LONG	DEPTH	CASING	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
1	Dharamjaigarh	Amapali	EW	22.375	83.225	278.8	265	Barakar	63-78,84-89,102-124,130-139,142-145,151-175,177-182,188-194,197-213,216-224,242-262	4.93	21.86	97.87	0.000786
2	Dharamjaigarh	Behramar	EW	22.2708	83.1083	300.5	235	Barkar Fm	71-83,88-94,100-114,14-153,160-172,180-189,193-197,202-206,208-232	6.3			
3	Dharamjaigarh	Bojiya	EW	22.1294	83.1628	318	75	Barkar Fm	35-43,54-72	1			
4	Dharamjaigarh	Hati	EW	22.3	83.0978	305.2	283	Barkar Fm	175-190.5,219-225.5,252-260.5,274.5-280	3.47	28.21	15.686	
5	Dharamjaigarh	Kudekala	EW	22.2083	83.1069	293.3	138	Barkar Fm	47-67,72-75,94-102,124-135	6.3			
6	Dharamjaigarh	Sithra	EW	22.3542	83.1208	302.4	213	Barakar Fm	63-90,95-107,112-130,160-169,171-177,183-210	6.3			
7	Dharamjaigarh	Baiyamura	EW	22.2617	83.1033	201		Baraker Fm					
8	Dharamjaigarh	Kherpali	EW	22.1	83.13	201		Baraker Fm					
9	Dharamjaigarh	Bakaruma	EW	22.5122	83.4247	171	6	Biotite gneiss	28-29,114-115	1			
10	Dharamjaigarh	Rairuma	EW	22.5172	83.3978	185	14	Biotite gneiss	89-92	1			
11	Dharamjaigarh	Tejpur	EW	22.4817	83.3814	74	12	Biotite gneiss	50-51,71-74	1			
12	Dharamjaigarh	Lipti	EW	22.6467	83.3967	140	12	Biotite gneiss	15-17	0.5			
13	Dharamjaigarh	Thakurpondi	EW	22.6006	83.3983	185	20.5	Biotite gneiss	14-17,131-134	1			
14	Dharamjaigarh	Kapu	EW	22.6697	83.3344	176	20.5	Biotite gneiss	22-26	3			
15	Dharamjaigarh	Sonpur	EW	22.6006	83.3983	177	15	Granite gneiss		0			
16	Dharamjaigarh	Vijaynagar	EW	22.7014	83.3567	164	17	Granulite	17-22	1			
17	Dharamjaigarh	Alola	EW	22.6786	83.3592	177	14.5	Granite gneiss	14-18	1			
18	Dharamjaigarh	Shishringa	EW	22.4589	83.3061	176	15	Granite gneiss	53-59	1			
19	Dharamjaigarh	Khadgoan	EW	22.3797	83.1131	201	201	Barakar Sandstone	15	3.17	31.37	2.27	
20	Dharamjaigarh	Sahpur	EW	22.4772	83.1819	201	201	Barakar Sandstone	88.2	2.5	16.4	1.95	
21	Dharamjaigarh	Duliamuda	EW	22.4153	83.1375	106.5	106.5	Barakar Sandstone	66.8-	1.25	33.9	1.35	

SL. NO	BLOCK	LOCATION	TYPE	LAT	LONG	DEPTH	CASING	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
22	Dharamjaigarh	Barpali	EW	22.4044	83.0714	201	201	Barakar Sandstone	57.7	4.5	20.75	4.25	
23	Dharamjaigarh	Boro	EW	22.56	83.11	199.5	17.05	Barakar sandstone		4			
24	Dharamjaigarh	Karigadai	EW	22.51	83.1419	141.5	141.51	Barakar Sandstone	27.21				
25	Dharamjaigarh	Amapali	OW	22.375	83.225	270	265	Barakar	63-78,84-89,102-124, 130-139,142-148,151-175, 177-182,188-194, 197-213,216-244,247-262	4.66		33.15	0.000786
26	Dharamjaigarh	Hati	OW	22.3	83.0978	87		Barkar Fm	66-83	1.77			
27	Dharamjaigarh	Kudekela	OW	22.2083	83.1069	275	271	Barkar Fm	49-67,72-75,95-100,113-116,128-134,143-147, 193-199,215-220,227-233, 242-246,256-258	10.5			
28	Dharamjaigarh	Kudekela	OW	22.2083	83.1069	275	271	Barkar Fm	49-67,72-75,95-100,113-116,128-134,143-147, 193-199,215-220,227-233, 242-246,256-258	6.3			
29	Dharamjaigarh	Sahpur	OW	22.4772	83.1819	201	201	Barakar Sandstone	63.8	1.37	28.37		
30	Dharamjaigarh	Sahpur	OW	22.4772	83.1819	155.2	155.2	Barakar Sandstone	79-88	0.7			
31	Dharamjaigarh	Bojia	OW	22.1294	83.1628	20.65		Barkar Fm					
32	Dharamjaigarh	Kapu	OW	22.6697	83.3344	123.00		Biotite gneiss					
33	Dharamjaigarh	Boro	OW	22.56	83.11	107.68		Barakar sandstone					
34	Dharamjaigarh	Boro	OW	22.56	83.11	54.34		Barakar sandstone					
35	Dharamjaigarh	Amagaon	EW	22.4088	83.21937	135	135	Barakar Sandstone		2.3	29.72	5.41	
36	Dharamjaigarh	Boro	OW	22.56	83.11	46.72		Barakar sandstone					
37	Gharghoda	Bayasi	EW	22.2208	83.4	300.8	294	Barakar	75-95,116-122,131-137, 149-157,183-189,192-198,204-208,215-221, 228-234,238-252,272-282, 286-292	7.89	25.73	28.36	
38	Gharghoda	Kudumkela	EW	22.2722	83.2708	304.7	302	Barakar Fm	65-79,100-108,135-149, 163-179,198-212,267-277, 281-300	7.89	30.09	27.7	
39	Gharghoda	Dumarpali	EW	22.2897	83.2828	350	326	Barkar Fm	273-280,285-323	3.53		4.16	

SL. NO	BLOCK	LOCATION	TYPE	LAT	LONG	DEPTH	CASING	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
40	Gharghoda	Gharghoda	EW	22.1708	83.3542	300.5	282	Barkar Fm	93-95,98-101,139-141, 152-155,181-201,203-213, 226-254,259-264, 266-268,276-279	6.3			
41	Gharghoda	Kotrimar	EW	22.2208	83.4	300	292	Barkar Fm	63-75,94-100,120-135, 140-147,150-156,217-229, 285-290	7.89	19.6	142.75	0.049
42	Gharghoda	Phaguram	EW	22.2361	83.325	350.9	245	Barakar Fm	110-117,124-150,160-167,200-223,238.5-241.40	5.93	32.69		
43	Gharghoda	Phuthamara	EW	22.3528	83.4528	205	103	Barakar Fm	40-48,55-70,80-100	3.88	12.74	29.21	
44	Gharghoda	Samaruma	EW	22.0833	83.3417	223.9	208	Barakar Fm	66-81,126-138,157-163, 184-205	7.76	9.4		
45	Gharghoda	Bhendra	EW	22.1506	83.3336	201.7	24.8	Siltstone	61.40-64.50	1	25.45	1.625	
46	Gharghoda	TUPAKDHAR	EW	22.244	83.38	159.3	12.5	Barakar sandstone		1.2			
47	Gharghoda	Tendanawapara	EW	22.1417	83.2458	291.6	180	0.0-200. Kamthi Fm 200.-291.58 Barakar	65-90,93-115,145-153.159-165, 168-177	5.5	23.12	51.975	0.00055
48	Gharghoda	Kotrimar	OW	22.2208	83.4	299.2	298	Barkar Fm	61-66,69-78,120-123, 126-138,147-153,183-186, 263-272, 277.5-283.5,291.5-296				
49	Gharghoda	Phaguram	OW	22.2361	83.325	250.9	211	Barakar Fm	85-88,109-115,150-158, 200-206	4.43	15.92		
50	Gharghoda	Samaruma	OW	22.0833	83.3417	201.5	198	Barakar Fm	177-195	0.38	39.6		
51	Gharghoda	Baroud	EW	22.28718	83.34218	147	147	Barakar Fm	102-113,	3.5	26.82		
52	Gharghoda	Tendanawapara	OW	22.1417	83.2458	187		Kamthi Fm	65.0-90,93.0-11, 145-153, 159-165, 168-177	3.16		10.64	
53	Tamnar	Gare	EW	22.1333	83.4889	352.9	346	Barkar Fm	141-150,177-183,186-192,195-204, 222.-228, 236-242,255-275,290-305 , 311-322,334-343	9.46	27.67	54.23	0.0172
54	Tamnar	Gerwani	EW	21.9958	83.3958	300.2	261	0-93.1 Kamthi Fm 93.1-300.15 Barakar	70-82,99-108,114-126, 139-142,160-166,177-184,187-190,203-209, 219-222,227-236,242-244, 248-251,255-258	7.89	27.2	47.98	0.00044
55	Tamnar	Hamirpur	EW	22.0375	83.525	301.5	113	0-22.11 Kamthi Fm 22.11-301.10 Barakar Fm	87-90,92-110	2.11	31.13	3.47	
56	Tamnar	Tamnar	EW	22.0883	83.4347	305.3	303	Barakar Fm	153-159,162.5-168.5, 190.5-208.5,264-276, 279-285,288-300			9.25	
57	Tamnar	Taraimal	EW	22.0292	83.375	300.8	196	Barakar Fm	64-72,92-113,132-138, 172-193	6	15.75		

SL. NO	BLOCK	LOCATION	TYPE	LAT	LONG	DEPTH	CASING	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
58	Tamnar	Deogarh	EW	22.1286	83.3944	204	177	Baraker Fm	61-64,82-84,94-99,111-115,12-126,132-147,154-158,160-174	1.33			
59	Tamnar	Gorhi	EW	22.0778	83.4292			Baraker Fm					
60	Tamnar	Milupara	EW	22.1883	83.5222	200.4	163	Baraker Fm	144-160	1.5			
61	Tamnar	Dhaurabhata	EW	22.095	83.5236	200	90	Baraker Fm	45-85	1	16.1		
62	Tamnar	Gare	OW	22.1333	83.4889	349	335	Barkar Fm	170-182,193-199,205-220,233-239,244-250, 258-270,290-305,310-322 ,326-332	6.32			
63	Tamnar	Gerwani	OW	21.9958	83.3958	263.4	261	0.0-92.19 Kamthi Fm 92.19-263.4 Barakar	70-82,100-109,120-126, 139-142,163-166,175-184,187-190,206-210, 219-222,230-236,241-244, 249-252,255-258	5.84			
64	Tamnar	Tamnar	OW	22.0883	83.4347	400.3	354	Barakar Fm	114-126,147-270,331-351				
65	Tamnar	Milupara	OW	22.1883	83.5222	201.1	164	Baraker Fm	106-116,144-161	1			
66	Kharsia	Kapharmar	EW	22.1797	83.0547	119		Baraker Fm		2.88	16.2	14	
67	Kharsia	Nandgaon	EW	22.1106	83.0672	128		Baraker Fm					
68	Kharsia	Chaple	EW	21.9833	83.2	114	26.9	Raigarh Fm.-limestone	26-29, 92-93	1.5	2.28		
69	Kharsia	Ranisagar	EW	21.9917	83.1944	117	17.5	GR,CRY	11--14, 17-20,21-24,28-29	7.13	4.26		
70	Kharsia	Fulbandha	EW	21.9264	83.1806	185	20.85	Raigarh Fm.-Shale & Lst	31-34	5.75	3.47		
71	Kharsia	Tieur	EW	22.0125	83.0333	201	12.5	Raigarh Fm.	23-26,89-92	2	34.81	16	
72	Kharsia	Badgad	EW	22.0607	83.0392	200	13.7	Massive shale	49.5-52.5	1.4			
73	Kharsia	Faraknara	EW	22.0941	83.0668	202	34.9	Coal seam	137.9-141.00	1.4			
74	Kharsia	Domnara	EW	22.081	83.096	202	12	Fractured Granite Gneiss	Dry	0			
75	Kharsia	Deradih	EW	22.0821	83.0944	202	17.5	Massive Sanstone		2.2	24.68		
76	Kharsia	Tumidih	EW	22.0814	83.0953	202		Silt stone with Calcareous shale	97-98.3	1.4	41.3		
77	Kharsia	Khamar	EW	22.1227	83.0173	202	28.5	Sandstone	25.1-46.4, 128.8-159.3	4.54			
78	Kharsia	Chitakathara	EW	22.1136	83.0685	200		Wethered shale & Granite		0			
79	Kharsia	Dehjari	EW (ADP)	22.04167	83.131944	109.3	18.3	Granite, gneiss	19.3	0.8	26.36		
80	Kharsia	Palgada	EW (ADP)	22.0625	83.025	28	21.15	Raigarh shale	22	2	2.54		

SL. NO	BLOCK	LOCATION	TYPE	LAT	LONG	DEPTH	CASING	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
81	Kharsia	Kunkuni	EW (ADP)	22.01667	83.183333	151	18.3	Chandrapur sandstone	Seepage	seepage	-		
82	Kharsia	Botalda	EW (ADP)	22.04306	83.094444	82.8	9.7	Raigarh shale	21-0-22.0	7.13	16.62		
83	Kharsia	Halaholi	EW (ADP)	21.97083	83.044444	101.2	12.2	Raigarh shale	50.0- 60.0- 68.5	8 lps	10.38		
84	Kharsia	Khamar	OW	22.1226	83.0174	141	26.8	Sandstone	122.7-125.7	2.21			
85	Lailunga	Chaurenga	EW	22.4647	83.4672	24.00		Granite gneiss					
86	Lailunga	Jhagarpur	EW (ADP)	22.34722	83.541667	101	12.2	Granite gneiss	16,22	0.2	-		
87	Lailunga	Rajpur	EW (ADP)	22.44167	83.491667	92	22.9	Granite gneiss	17,23	0.5	12.28		
88	Lailunga	Dhorabija	EW (ADP)	22.35833	83.659722	90	12.2	Granite gneiss	14	Negligible	-		
89	Lailunga	Chrirenga	OW	22.4647	83.4672	24.00		Granite gneiss					
90	Pusaur	Chikhli	EW	21.7736	83.3194	68	18.2	Raigarh Fm.-Shale	28-30, 65-68	8.68	12.22		
91	Pusaur	Chhichoruma ria	EW	21.7356	83.3517	130		Raigarh Fm.	32-32.5,75-75.5,99-99.5	7	17.34	46	
92	Pusaur	Rengalpali	EW	21.76	83.45	105	32.5	Raigarh Fm.	32-32.5,99-99.5	9	19.95	11.8	
93	Pusaur	Kondatarai	EW	21.8278	83.3583	123	14.5	Raigarh Fm.-Shale	60,90,117	3.5	5.66	15.8	0.00178
94	Pusaur	Pusaur	EW	21.7514	83.3958	91.5	18.5	Raigarh Fm.-Shale	28-29, 56,59,90-91.5	6	24.47	32.71	- -
95	Pusaur	Aurda	EW	21.8056	83.3583	72	20.5	Raigarh Fm.-Shale	22-23,44-47,51-54,69-71	22.4	3.41	4.43	- -
96	Pussore	Podigaon	EW	21.7047	83.3896	202	12	Fractured Dark colour claystone mix with	73.9-76.9, 101.3-104.4, 131.3-134.9	7	7.1		
97	Pussore	Umaria	EW	21.7302	83.3469	202	12	Raigarh Fm.-Shale	43.4-46.4, 70.8-73.9, 83.00-86.1, 168.4-170.6	6			
98	Pussore	Barbhavna	EW	21.7943	83.3136	28.71	6	Gunderdih shale					
99	Pussore	Nandgaon	EW	21.79	83.3136	202	13.5	Gunderdih shale		1			
100	Pussore	Raibar	EW	21.77	83.31	202	12.1	Gunderdih shale		0.5			
101	Pussore	Tetla	EW	21.8	83.33	202	12	Gunderdih shale		3			
102	Pussore	Basanpali	EW	21.79	83.41	202	35.5	Gunderdih shale		5			
103	Passaur	Tilgi	EW (ADP)	21.75833	83.308333	101.5	22	Fracture and Shaly L.St.	26, 82,90	15	6.81		
104	Passaur	Tadola	EW (ADP)	21.79167	83.711111	115	18.3	Shale	26, 82	10	7.7		

SL. NO	BLOCK	LOCATION	TYPE	LAT	LONG	DEPTH	CASING	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
105	Passaur	Pedigaon	EW (ADP)	21.68056	83.383333	115	13.75	Shale	32, 82	5	16.83		
106	Passaur	Bhatanpail	EW (ADP)	21.8	83.429167	113.5	18.1	Shale	32, 49, 57	11.5	13.5		
107	Pusaur	Chhichoruma ria	OWI	21.7356	83.3517	136	12.5	Raigarh Fm.-Shale	41-41.5,111-111.5	5.6			
108	Pusaur	Chhichoruma ria	OWII	21.7356	83.3517	50	12	Raigarh Fm.-Shale	32.-32.5	1.5			
109	Pussore	Podigaon	OW	21.7035	83.3896	141	12	Raigarh Fm.-Shale	40.3-43.4, 98.3-101.13, 113.5-116.6	10			
110	Pussore	Umaria	OW	21.7302	83.3469	165	6	Raigarh Fm.-Shale	89.1-92.2, 153.2-156.2	10			
111	Pusaur	Kondatarai	OW	21.8278	83.3583	122.00		Raigarh Fm.-Shale					
112	Raigarh	Bangursian	EW	21.9792	83.4694	301.3	224	0-233.05 Kamthi Fm 233.05-301.3 Barakar Fm	71-98,101-110,120-142,169-187,190-196,200-221	7.89	22.05	56.7	
113	Raigarh	Loing	EW (ADP)	21.85833	83.486111	45.67	29.9	Granite gneiss		1	-		
114	Raigarh	Nandeli	EW (ADP)	21.88333	83.248611	101	6.1	Shale with L. St.	25, 30	12	5		
115	Raigarh	Kusmura	EW (ADP)	21.875	83.316667	134	12.2	Shale with L. St.	57-69, 82-92, 105-115, 119-133	3	17.73		
116	Raigarh	Kerajhar	EW (ADP)	21.09583	83.3	115	6.1	Raigarh shale	36.8- 38.0, 43.30- 43.50	8	13.64		
117	Raigarh	Gejamunda	EW (ADP)	21.91667	83.316667	81.88	6.1	Raigarh shale	36.1- 67.5-67.90	17	3.995		
118	Sarangarh	Lendhra	EW	21.6461	83.0403	200	16.6	Raigarh Fm.	21-21.5	1.5	20.7	4	
119	Sarangarh	Resada	EW	21.6167	83.0247	21	18.5	Raigarh Fm.	8--9,170-171	3.5	34.42		
120	Sarangarh	Kudri	EW	21.6167	83.0247	175	11.2	Raigarh Fm.	8--9,170-171	3.5	34.42	4	
121	Sarangarh	Reda	EW	21.6231	83.1014	201	6.5	Raigarh Fm-.Shale & limestone	23-25,78-81,176-179	1			
122	Sarangarh	Rainisagar	EW	21.59	83.0736	120	18.5	Raigarh Fm-.Shale, limestone & chandrapur sandstone	14-18.5	0.5			
123	Sarangarh	Bharwan	EW	21.6833	83.1197	171	9.5	Raigarh Fm-.Shale & limestone	9-9.5,72-75	0.5			
124	Sarangarh	Ulkhar	EW	21.6606	83.0789	200	6	Raigarh Fm-.Shale & lst	32-35	0.5			
125	Sarangarh	Temer Lagga	EW	21.69583	83.208333	102	6.1	chandrapur sandstone	60.9	1	30.78		
126	Sarangarh	Dansara	EW	21.5833	83.125	154	6	Raigarh Fm.	23-23.5,32-32.5	1.5	37.15	2.3	

SL. NO	BLOCK	LOCATION	TYPE	LAT	LONG	DEPTH	CASING	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
127	Sarangarh	Bataupali	EW(ADP)	21.54167	83.125	124.2	12.2	Contact of chandrapur sandstone & granite	36.50,55.80, 82, 110	0.85	32.32		
128	Sarangarh	Kutela	EW(ADP)	21.59583	83.066667	116.5	12.2	Sand stone	116	12.5	8.42		
129	Sarangarh	Temer Lagga	EW(ADP)	21.69583	83.208333	102	6.1	chandrapur sandstone	60.9	1	30.78		
130	Sarangarh	Kudri OW	OW	21.6167	83.0247	190	16.4	Gunderdih Shale	8--9,170-171	2	35.7		
131	Sarangarh	Lendhra	OW	21.6461	83.0403	201	6.6	Gunderdih Shale	26-27,110-111,170-171	2	44.2	3	
132	Baramkela	Kandurpali	EW	21.5389	83.2867	200	6.5	Gunderdih Shale	26-29,99-102	0.5			
133	Baramkala	Baramkela	EW(ADP)	21.525	83.258333	92	28.55	Gunderdih Shale	18.4 -28, 46-50, 55-60	19.5	7.55		
134	Baramkala	Gobar singa	EW(ADP)	21.61667	83.266667	87.4	21.5	Gunderdih Shale	21-23, 34.8-36.8, 38-39, 85-87	16.8	9.9		
135	Baramkala	Serla	EW(ADP)	21.64167	83.356944	53.2	30.56	Gunderdih Shale	27.5, 33-34,46-48,53-55	19	2.3		
136	Baramkala	Bonda	EW	21.65445	83.3	35	26.8	Raigarh limestone		1			

ANNEXURE-II: Static Ground Water level details in Raigarh district

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
1	**Dharamjaigarh**	Amapali	83.2342	22.3706	DW	9	6.55	2.45
2	**Dharamjaigarh**	Bakaruma	83.4361	22.5125	DW	11	8.95	2.05
3	**Dharamjaigarh**	Bojia	83.1627	22.1283	DW	7.2	4.3	2.9
4	**Dharamjaigarh**	Boro	83.1119	22.5633	DW	11.1	8.9	2.2
5	**Dharamjaigarh**	Chhal	83.12085	22.1234	DW	4.15	2.3	1.85
6	**Dharamjaigarh**	Choranga	83.46297	22.46646	DW	10.5	8.5	2
7	**Dharamjaigarh**	Derpani	83.2869	22.6442	DW	3.8	2.3	1.5
8	**Dharamjaigarh**	Dharmajaigarh	83.2125	22.4639	DW	8.8	4.94	3.87
9	**Dharamjaigarh**	Edu	83.1269	22.0756	DW	7.8	5.9	1.9
10	**Dharamjaigarh**	Gersa	83.2347	22.3431	DW	6.4	6.1	0.3
11	**Dharamjaigarh**	Golabuda	83.4042	22.6306	DW	9.9	8.9	1
12	**Dharamjaigarh**	Kandadand	83.195	22.5367	DW	9	4	5
13	**Dharamjaigarh**	Kapu	83.3375	22.6708	DW	7.9	5.9	2
14	**Dharamjaigarh**	Katangdih	83.27985	22.15508	DW	8.55	7.25	1.3
15	**Dharamjaigarh**	Khadgaon	83.1167	22.3792	DW	13.4	12.3	1.1
16	**Dharamjaigarh**	Khamhar	83.2517	22.5797	DW	8.1	6	2.1
17	**Dharamjaigarh**	Lipti	83.3797	22.6508	DW	6.85	4.9	1.95
18	**Dharamjaigarh**	Sirsinga	83.3069	22.4556	DW	7.8	6	1.8
19	**Dharamjaigarh**	Deormal	83.2028	22.134	DW	6.7	3.42	3.28
20	**Dharamjaigarh**	Kansabahar	83.1339	22.1509	DW	4.6	2.6	2
21	**Dharamjaigarh**	Sarasmar	83.1259	22.1542	DW	9.2	4.1	5.1
22	**Dharamjaigarh**	Maharajganj	83.0512	22.2462	DW	6.7	3.55	3.15
23	**Dharamjaigarh**	Tumkure	83.1361	22.1993	DW	8.5	3.95	4.55
24	**Dharamjaigarh**	Banhar	83.1632	22.2047	DW	9.2	3.84	5.36
25	**Dharamjaigarh**	Chutkimar	83.1559	22.1798	DW	9.9	4.2	5.7
26	**Dharamjaigarh**	Auranar	83.1628	22.1594	DW	8.6	6.2	2.4

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
27	**Dharamjaigarh**	Singhijhap	83.1841	22.1526	DW	8.1	5.2	2.9
28	**Dharamjaigarh**	Hati	83.0924	22.3022	DW	9.1	6.12	2.98
29	**Dharamjaigarh**	Purunga	83.1439	22.2963	DW	7	2.07	4.93
30	**Dharamjaigarh**	Sithra	83.1058	22.3381	DW	8.3	3.7	4.6
31	**Dharamjaigarh**	Duliamuda	83.1393	22.4152	DW	13.8	11.55	2.25
32	**Dharamjaigarh**	Bijapara	83.1782	22.4294	DW	13.6	10.95	2.65
33	**Dharamjaigarh**	Bayasi	83.1728	22.4371	DW	12.6	10.85	1.75
34	**Dharamjaigarh**	Taraimar	83.1813	22.451	DW	6	5.1	0.9
35	**Dharamjaigarh**	Durgapur	83.1565	22.4715	DW	8.3	6.8	1.5
36	**Dharamjaigarh**	Amagaon	83.2112	22.396	DW	5.9	4.75	1.15
37	**Dharamjaigarh**	Nawagaon	83.2039	22.3647	DW	7.35	5.7	1.65
38	**Dharamjaigarh**	Deridih	83.2314	22.4185	DW	6.4	5.57	0.83
39	**Dharamjaigarh**	Tendumar	83.2245	22.4328	DW	6.2	3.35	2.85
40	**Dharamjaigarh**	Munund	83.0934	22.2435	DW	7.9	2.85	5.05
41	**Dharamjaigarh**	Behramar	83.1123	22.2609	DW	5.1	3.5	1.6
42	**Dharamjaigarh**	Bansajhar	83.1363	22.2363	DW	5.9	4.8	1.1
43	**Dharamjaigarh**	Kudekela	83.1048	22.2029	DW	6.3	4.7	1.6
44	**Dharamjaigarh**	Pandrimahua	83.1446	22.4934	DW	4.5	2.1	2.4
45	**Dharamjaigarh**	Ududa	83.1268	22.4965	DW	8.8	7.2	1.6
46	**Dharamjaigarh**	Bartapali	83.1864	22.3411	DW	10.3	3.25	7.05
47	**Dharamjaigarh**	Lakshmipur	83.2153	22.5108	DW	9.25	7.4	1.85
48	**Dharamjaigarh**	Amelipur(amt)	83.1912	22.5023	DW	6.9	4.35	2.55
49	**Dharamjaigarh**	Chunkunidand	83.2005	22.5227	DW	10.1	8.8	1.3
50	**Dharamjaigarh**	Chandidand	83.1885	22.5181	DW	10.2	8.24	1.96
51	**Dharamjaigarh**	Dadardand	83.1815	22.5051	DW	9.3	7.4	1.9
52	**Dharamjaigarh**	Jamargi	83.1938	22.5487	DW	6.15	5.55	0.6
53	**Dharamjaigarh**	Jabga	83.1542	22.5338	DW	4.1	3.9	0.2
54	**Dharamjaigarh**	Korigarhi	83.1451	22.513	DW	9.7	8.3	1.4

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
55	**Dharamjaigarh**	Koradih	83.1377	22.5139	DW	9.75	4.3	5.45
56	**Dharamjaigarh**	Sangra	83.119	22.5827	DW	5.25	1.4	3.85
57	**Ghorghoda**	Amlidih	83.3327	22.1126	DW	7.3	7	0.3
58	**Ghorghoda**	Bhalumar	83.3447	22.1194	DW	6.6	4.2	2.4
59	**Ghorghoda**	Bhangari	83.2508	22.1328	DW	10.1	6.8	3.3
60	**Ghorghoda**	Chimtapani	83.4167	22.2722	DW	12.35	7.8	4.55
61	**Ghorghoda**	Kotrimal	83.39781	22.23154	DW	5.85	4.5	1.35
62	**Ghorghoda**	Kurmibhuna	83.3665	22.28	DW	8.2	5	3.2
63	**Ghorghoda**	Samarumi	83.3458	22.0842	DW	7	5.3	1.7
64	**Ghorghoda**	Nawadih	83.3	22.32556	DW	3.95	2.9	1.05
65	**Ghorghoda**	Pusalda	83.30472	22.30444	DW	9.8	4.9	4.9
66	**Ghorghoda**	Pusalda	83.30417	22.30167	DW	10.1	5.15	4.95
67	**Ghorghoda**	Dumarpali	83.27917	22.28972	DW	6.5	4.8	1.7
68	**Ghorghoda**	Chimtapani	83.42056	22.27444	DW	13.1	7.5	5.6
69	**Ghorghoda**	Phuthamuda	83.42889	22.2975	DW	6.1	3.7	2.4
70	**Ghorghoda**	Phuthamuda	83.43028	22.29694	DW	6.3	3.9	2.4
71	**Ghorghoda**	Kusumghat	83.27472	22.29972	DW	9.7	5.25	4.45
72	**Ghorghoda**	Harradih	83.29322	22.04737	DW	9.8	7.98	1.82
73	**Ghorghoda**	Gadgaon	83.28126	22.04753	DW	4.15	3.48	0.67
74	**Ghorghoda**	Rabo	83.26369	22.06475	DW	6.18	4.39	1.79
75	**Ghorghoda**	Dokrabura	83.28005	22.07569	DW	7.1	5.17	1.93
76	**Ghorghoda**	Chharratangar	83.29758	22.09024	DW	6.6	5.83	0.77
77	**Ghorghoda**	Pandripani	83.30554	22.12875	DW	5.7	5.04	0.66
78	**Ghorghoda**	Kharamura	83.32752	22.15019	DW	7.8	5.91	1.89
79	**Ghorghoda**	Bade Gumda	83.30056	22.17327	DW	8.15	7.08	1.07
80	**Ghorghoda**	Chhote Gumda	83.28942	22.1769	DW	6.6	6.1	0.5
81	**Ghorghoda**	Katandih	83.27892	22.15051	DW	8.8	6.78	2.02
82	**Ghorghoda**	Bilaskhar	83.25096	22.09261	DW	10.7	8.69	2.01
83	**Ghorghoda**	Daharidih	83.25165	22.07786	DW	5.4	4.69	0.71

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
84	**Ghorghoda**	Tumidih	83.32981	22.06962	DW	5.9	4.18	1.72
85	**Ghorghoda**	Bhalumar	83.34384	22.11964	DW	6.15	3.67	2.48
86	**Ghorghoda**	Barpali	83.35861	22.14886	DW	7.5	5.36	2.14
87	**Ghorghoda**	Chhota Nawapara	83.35484	22.1605	DW	4.65	3.46	1.19
88	**Ghorghoda**	Jhariapali	83.37115	22.15195	DW	3.4	2.24	1.16
89	**Ghorghoda**	Kanchanpur	83.33253	22.19692	DW	7.1	4.21	2.89
90	**Ghorghoda**	Bahirkela	83.29822	22.1974	DW	7.15	4.8	2.35
91	**Ghorghoda**	Malidih	83.28884	22.21076	DW	6.8	4.3	2.5
92	**Ghorghoda**	Dhangrapara	83.28654	22.21836	DW	5.4	4.08	1.32
93	**Ghorghoda**	Gharghori	83.29077	22.22391	DW	7.9	6.61	1.29
94	**Ghorghoda**	Beldipa	83.29794	22.23249	DW	6.2	4.73	1.47
95	**Ghorghoda**	Boronakunda	83.27187	22.20803	DW	8.4	6.78	1.62
96	**Ghorghoda**	Nawagarh	83.27216	22.18863	DW	7.1	6.12	0.98
97	**Ghorghoda**	Chaldonia	83.35276	22.11299	DW	4.9	4.27	0.63
98	**Ghorghoda**	Karuwahi	83.49174	22.16625	DW	6.8	4.13	2.67
99	**Ghorghoda**	Dholnara	83.46724	22.17442	DW	5	4.4	0.6
100	**Ghorghoda**	Rodhopali	83.44695	22.16397	DW	6.5	2.4	4.1
101	**Ghorghoda**	Chirimura (Hirapur)	83.42882	22.17884	DW	8.6	6.08	2.52
102	**Ghorghoda**	Kerakhol	83.41772	22.19762	DW	7.5	5.62	1.88
103	**Ghorghoda**	Kolam	83.43211	22.16799	DW	5.9	4.75	1.15
104	**Ghorghoda**	Mauhapali	83.41663	22.13759	DW	5.7	4.55	1.15
105	**Ghorghoda**	Dolesara	83.43361	22.14439	DW	7.6	4.22	3.38
106	**Ghorghoda**	Devgarh (Chidarpara)	83.39647	22.13126	DW	7	5.81	1.19
107	**Ghorghoda**	Patrapali	83.39651	22.1516	DW	6.15	3.4	2.75
108	**Ghorghoda**	Rengal Behari	83.38203	22.1683	DW	5.9	5.12	0.78
109	**Ghorghoda**	Barkaspali	83.4092	22.16065	DW	6.8	6.14	0.66
110	**Ghorghoda**	Banai	83.39659	22.18051	DW	4.7	3.36	1.34
111	**Ghorghoda**	Charbhata	83.37243	22.18448	DW	4.8	1.92	2.88
112	**Ghorghoda**	Gharghoda	83.35191	22.17556	DW	6.5	6.49	0.01

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
113	**Ghorghoda**	Auraimuda	83.38142	22.20284	DW	5.1	3.18	1.92
114	**Ghorghoda**	Kotrimal	83.39781	22.23154	DW	6	4.49	1.51
115	**Ghorghoda**	Raikera	83.4208	22.22956	DW	8.9	6.77	2.13
116	**Ghorghoda**	Naya Rampur	83.46964	22.23097	DW	4.3	3.06	1.24
117	**Ghorghoda**	Bichhnara	83.46522	22.24657	DW	4.8	4.36	0.44
118	**Ghorghoda**	Tilaipali	83.48186	22.2415	DW	5.6	2.78	2.82
119	**Ghorghoda**	Teram	83.34444	22.22289	DW	7.7	4.33	3.37
120	**Ghorghoda**	Rumkera	83.35411	22.2381	DW	6.15	4.4	1.75
121	**Ghorghoda**	Patrapali	83.34524	22.24491	DW	8.8	5.89	2.91
122	**Ghorghoda**	Phaguram	83.32028	22.23845	DW	8.9	4.18	4.72
123	**Ghorghoda**	Karichhapar	83.31451	22.23192	DW	10.4	7.52	2.88
124	**Tamnar**	Auraimura	83.3811	22.20222	DW	4.8	4.25	0.55
125	**Tamnar**	Barkaspali	83.4097	22.15911	DW	8	2.98	5.02
126	**Tamnar**	Devgarh	83.39631	22.131672	DW	7.25	5	2.25
127	**Tamnar**	Gare	83.48895	22.13577	DW	5.5	4.7	0.8
128	**Tamnar**	Koknara	83.3694	22.2056	DW	4.95	3.8	1.15
129	**Tamnar**	Milupara	83.5199	22.1872	DW	11.2	10.5	0.7
130	**Tamnar**	Saraipali	83.31444	22.26167	DW	10.5	6.4	4.1
131	**Tamnar**	Jaradih	83.5475	22.2	DW	5.6	1.8	3.8
132	**Tamnar**	Hinjhar	83.54944	22.20944	DW	15.6	13	2.6
133	**Tamnar**	Urba	83.53472	22.21917	DW	5.2	3.7	1.5
134	**Tamnar**	Pelma	83.51389	22.23056	DW	3.8	2.4	1.4
135	**Tamnar**	Dhaurabhata	83.54083	22.09444	DW	3.3	2.3	1
136	**Tamnar**	Bijna	83.555	22.06639	DW	3	2.9	0.1
137	**Tamnar**	Karrapali	83.57306	22.06028	HP	5.5	2	3.5
138	**Tamnar**	Gourmuri	83.33092	22.0185	DW	9.17	7.3	1.87
139	**Tamnar**	Barpali	83.29987	22.03091	HP	5.57	3.67	1.9
140	**Tamnar**	Gerwani	83.37733	21.9985	DW	10.37	6.78	3.59

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
141	**Tamnar**	Taraimal	83.37549	22.02794	DW	7.83	4.73	3.1
142	**Tamnar**	Parkipahri (Gudguda)	83.36123	22.08039	DW	3.85	2.92	0.93
143	**Tamnar**	Jhingolpara	83.38124	22.08061	DW	6.9	5.62	1.28
144	**Tamnar**	Amaghat	83.40826	22.08449	DW	9.42	7.52	1.9
145	**Tamnar**	Kachkoba	83.39408	22.10897	HP	8.42	5.92	2.5
146	**Tamnar**	Gohri	83.42577	22.07773	HP	9.92	5.3	4.62
147	**Tamnar**	Kasdol (Kasinagar)	83.42756	22.07141	DW	8.89	5.64	3.25
148	**Tamnar**	Tomnar	83.4427	22.09215	DW	12.42	8.44	3.98
149	**Tamnar**	Devgaon	83.45908	22.06444	DW	13.62	6.29	7.33
150	**Tamnar**	Kunjemura	83.46659	22.13034	DW	6.85	5.54	1.31
151	**Tamnar**	Saraitola	83.48091	22.15182	DW	3.96	3.27	0.69
152	**Tamnar**	Mudagaon	83.46817	22.15062	DW	5.32	4.5	0.82
153	**Tamnar**	Pata	83.46103	22.13887	HP	9.22	6.16	3.06
154	**Tamnar**	Gare	83.48895	22.13577	HP	7.86	6.38	1.48
155	**Kharsia**	Farkanara	83.1064	22.0175	DW	9.85	6.6	3.25
156	**Kharsia**	Kharsia-s	83.098611	21.988889	PZ	7.62	5.24	2.38
157	**Kharsia**	Barra	83.048028	22.127889	DW	7.8	0.72	7.08
158	**Kharsia**	Pathrapali	83.062667	22.053694	DW	7.24	2.13	5.11
159	**Kharsia**	Ulda	83.053833	22.056944	HP	7.06	3.24	3.82
160	**Kharsia**	Masania Kalan	83.004861	22.071333	HP	7.46		7.46
161	**Kharsia**	Sajapali	82.99825	22.09	DW	8.29	2.07	6.22
162	**Kharsia**	Kothi Kunda	83.018194	22.098028	HP	9.29	2.62	6.67
163	**Kharsia**	Khamhar	83.015333	22.119222	DW	5.46	1.31	4.15
164	**Kharsia**	Khadgaon	82.993056	22.128222	DW	7.85	1.52	6.33
165	**Kharsia**	Khadgaon	82.992889	22.12825	HP	8.22	1.6	6.62
166	**Kharsia**	Bhagodih	83.064	21.995	DW	2.26	0.63	1.63
167	**Kharsia**	Turekela	83.051	22.005	HP	15.94	0.7	15.24
168	**Kharsia**	Tieur (Dharsa Para)	83.035	22.015	DW	7.9	0.5	7.4

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
169	**Kharsia**	Sarwani	83.039	22.036	HP	14.3	1.55	12.75
170	**Kharsia**	Jobi	83.041	22.151	DW	10.16	2.28	7.88
171	**Kharsia**	Koru	83.074	22.152	HP	9.67	4.3	5.37
172	**Kharsia**	Nangoi	83.081	22.13	DW	8.55	2.5	6.05
173	**Kharsia**	Nandgaon	83.092	22.112	HP	9.25	4.85	4.4
174	**Kharsia**	Pharkanara	83.069	22.095	DW	10.15	1.65	8.5
175	**Kharsia**	Barbhauna	83.149	22.071	HP	5.46	3.68	1.78
176	**Kharsia**	Binjkoth	83.204	22.023	HP	11.67	4.45	7.22
177	**Kharsia**	Bhupdeopur (TilaiPali)	83.252	21.974	HP	29.01	0.69	28.32
178	**Kharsia**	Jai-muda	83.225	21.942	DW	7.45	3.2	4.25
179	**Kharsia**	Basnajhar	83.16	21.94	HP	4.55	1.1	3.45
180	**Kharsia**	Jharidih	83.047	21.991	HP	22.8	3.33	19.47
181	**Kharsia**	Karsia (Madhanpur)	83.113	22.007	HP	26.94	2.71	24.23
182	**Lailunga**	Jegarpur	83.5388	22.3481	DW	10.5	8.5	2
183	**Lailunga**	Lailunga	83.5833	22.3833	DW	9.7	7.73	1.97
184	**Lailunga**	Bagudega (Shivaar Para)	83.4516	22.4996	DW	9	4.05	4.95
185	**Lailunga**	Choranga	83.4736	22.4574	HP	7.89	1.25	6.64
186	**Lailunga**	Rajpur	83.4884	22.4403	DW	7.26	1.25	6.01
187	**Lailunga**	Moodagaon	83.5187	22.4945	DW	7.9	3.35	4.55
188	**Lailunga**	Gudu Bahal	83.5667	22.5178	HP	10.29	5.98	4.31
189	**Lailunga**	Sardega	83.5544	22.4533	HP	6.08	4.08	2
190	**Lailunga**	Kamhar	83.553	22.4158	DW	9.25	1.18	8.07
191	**Lailunga**	Potra	83.5953	22.4277	DW	5.4	2.34	3.06
192	**Lailunga**	Hirapur	83.5041	22.4319	HP	22.55	12.19	10.36
193	**Lailunga**	Phaghat - Lureg	83.5285	22.3956	DW	12.9	9.25	3.65
194	**Lailunga**	Lailunga	83.5818	22.3913	DW	9.3	3.05	6.25
195	**Lailunga**	Tolge	83.5871	22.2438	DW	5.88	0.9	4.98
196	**Lailunga**	Tatkela	83.575	22.2966	HP	17.26	1.75	15.51
197	**Lailunga**	Kesala	83.5822	22.316	HP	6.82	1.15	5.67
198	**Lailunga**	Laripani	83.4683	22.3369	HP	13.55	5.4	8.15
199	**Lailunga**	Phulikuda	83.4443	22.3334	DW	4.55	0.64	3.91

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
200	**Lailunga**	Phulikuda	83.4443	22.3334	HP	18.45	7.62	10.83
201	**Lailunga**	Amapali	83.4827	22.3722	HP	7.66	4.09	3.57
202	**Lailunga**	Gamekala	83.6085	22.3595	DW	8.57	2.57	6
203	**Lailunga**	Jatra	83.6086	22.3377	HP	19.28	9.32	9.96
204	**Lailunga**	Lohrapani (Poyil Para)	83.6709	22.3669	DW	4.35	1.74	2.61
205	**Lailunga**	Katakilya	83.6368	22.3313	DW	3.03	0.43	2.6
206	**Lailunga**	Narayanpur (Mukya Basti)	83.6467	22.2609	HP	8.58	5.2	3.38
207	**Lailunga**	Karadega	83.7122	22.267	HP	5.05	2.35	2.7
208	**Lailunga**	Tolma	83.7689	22.2946	HP	12	4.64	7.36
209	**Lailunga**	Mukdega	83.6767	22.3389	DW	8.1	2.85	5.25
210	**Pusaur**	Aurda	83.38838	21.81203	DW	5.85	2.85	3
211	**Pusaur**	Bonda	83.3042	21.7194	DW	3	1.42	1.58
212	**Pusaur**	Surajgarh	83.3853	21.6925	DW	8.8	6	2.8
213	**Pusaur**	Tadola	83.3806	21.7958	DW	4	3	1
214	**Pusaur**	Tetla	83.3292	21.7917	DW	2.6	1.9	0.7
215	**Pusaur**	Baghadola(Maldipa)	83.398	21.759	DW	2.2	0.3	1.9
216	**Pusaur**	Loharsingha	83.343	21.828	DW	2.3	0.3	2
217	**Pusaur**	Teka	83.271	21.846	DW	4.57	0.82	3.75
218	**Pusaur**	Tadola	83.3806	21.7958	DW	3.3	2.3	1
219	**Pusaur**	Tetla	83.3292	21.7917	DW	2.01	0.01	2
220	**Pusaur**	Jharmunda	83.366	21.802	HP	31.4	18.8	12.6
221	**Pusaur**	Kusmunda	83.396	21.774	HP	32.6	15.92	16.68
222	**Pusaur**	Ghutkupali	83.432	21.774	HP	24	20.52	3.48
223	**Pusaur**	Riyapali	83.43	21.782	HP	21	10.39	10.61
224	**Pusaur**	Pusaur	83.391	21.753	HP	20.8	12.93	7.87
225	**Pusaur**	Odekera	83.402	21.74	HP	23.7	19.66	4.04
226	**Pusaur**	Garh umaria	83.401	21.849	HP	7	6.4	0.6
227	**Pusaur**	Darramuda	83.423	21.838	HP	6.53	5.3	1.23
228	**Pusaur**	Jhalmala(Dipapara)	83.43	21.803	HP	21	7.82	13.18
229	**Pusaur**	Tarapur	83.268	21.858	HP	14.3	12	2.3
230	**Pusaur**	Loharsingha	83.343	21.828	HP	30.4	22.7	7.7
231	**Pusaur**	Kensara	83.294	21.79	HP	30.2	14.63	15.57
232	**Raigarh**	Chiraipani	83.367222	21.976944	DW	9.9	7.3	2.6

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
233	**Raigarh**	jamgaon(Basti)	83.5732	21.8885	DW	6.4	3	3.4
234	**Raigarh**	Kerajhar	83.3042	21.9611	DW	5.85	4.55	1.3
235	**Raigarh**	Kotarliya	83.4611	21.8903	DW	5.35	3	2.35
236	**Raigarh**	Chiraipani	83.339	21.94	DW	6.9	2.7	4.2
237	**Raigarh**	Sambalpuri	83.454	21.937	DW	3.9	2.2	1.7
238	**Raigarh**	Bangrusian	83.471	21.977	DW	7	3.65	3.35
239	**Raigarh**	Kerajhar	83.3042	21.9611	DW	4.25	3.1	1.15
240	**Raigarh**	Lakha	83.3847	21.965	DW	5.17	3.85	1.32
241	**Raigarh**	Raigarh	83.39722	21.89167	DW	8.3	3.15	5.15
242	**Raigarh**	Jorapali	83.35	21.889	DW	4.35	3	1.35
243	**Raigarh**	Jorapali	83.35	21.889	HP	16.5	16.1	0.4
244	**Raigarh**	Kotra	83.309	21.871	HP	22.2	14.6	7.6
245	**Raigarh**	Balamgoda	83.291	21.877	HP	28.15	9.3	18.85
246	**Raigarh**	Biang	83.223	21.912	HP	16.1	8.8	7.3
247	**Raigarh**	Parsada	83.321	21.955	HP	15.7	9.35	6.35
248	**Raigarh**	Chiraipani	83.339	21.94	HP	13.1	5.6	7.5
249	**Raigarh**	Sambalpuri	83.454	21.937	HP	8.2	4.8	3.4
250	**Raigarh**	Bhupdeopur	83.25248	21.97274	HP	11.75	6.2	5.55
251	**Raigarh**	Raigarh	83.39722	21.89167	HP	18.4	15.3	3.1
252	**Sarangarh**	Bataupali	83.1344	21.5356	DW	3.3	2.9	0.4
253	**Sarangarh**	Chhind	83.0033	21.5958	DW	5.15	3.5	1.65
254	**Sarangarh**	Hirri	83.111	21.643	DW	8	5.5	2.5
255	**Sarangarh**	Kargipali (Kargidipa)	83.097	21.436	DW	6.9	4.63	2.27
256	**Sarangarh**	Kedar	82.971858	21.567419	DW	4.55	3.2	1.35
257	**Sarangarh**	Pindri	83.14147	21.681256	DW	5.6	2.1	3.5
258	**Sarangarh**	Reda	83.097	21.6241	DW	5.65	3.7	1.95
259	**Sarangarh**	Kushal Nagar(Sarangarh)	83.08001	21.59737	DW	5.65	3.4	2.25
260	**Sarangarh**	Kudhri	83.022	21.596	DW	4.8	2	2.8

S.No	Block	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
261	**Sarangarh**	Bataupali	83.1344	21.5356	DW	3.4	3.1	0.3
262	**Sarangarh**	Damdarha	83.1167	21.4542	DW	9.1	8.3	0.8
263	**Sarangarh**	Hirri	83.111	21.643	DW	8.94	3.2	5.74
264	**Sarangarh**	Kanakbirra	83.122	21.4603	DW	10.3	8.6	1.7
265	**Sarangarh**	Malda(B)	83.1956	21.5589	DW	8.42	5.5	2.92
266	**Sarangarh**	Pindri	83.1578	21.6639	DW	3.34	1.5	1.84
267	**Sarangarh**	Dansara	83.125	21.582	HP	13	3.7	9.3
268	**Sarangarh**	Kudhri	83.022	21.596	HP	5.7	3.9	1.8
269	**Sarangarh**	Kedar	82.98	21.57	HP	3.23	2.5	0.73
270	**Baramkela**	Baramkela	83.2625	21.525	DW	9	2.9	6.1
271	**Baramkela**	Malda (B)	83.1956	21.5589	DW	9.95	4	5.95
272	**Baramkela**	Kapartunga	83.225	21.508	DW	6.7	4.5	2.2
273	**Baramkela**	Budeli	83.194	21.55	DW	6.6	3.1	3.5
274	**Baramkela**	Sanda	83.298	21.573	DW	4.7	4.4	0.3
275	**Baramkela**	Panchdhar	83.349	21.643	DW	6.65	4.7	1.95
276	**Baramkela**	Saria	83.3595	21.63896	DW	5.9	2.8	3.1
277	**Baramkela**	Paraskhol	83.264	21.532	HP	18.55	10.3	8.25
278	**Baramkela**	Sanda HP	83.298	21.573	HP	22.5	18.5	4
279	**Baramkela**	Barpali	83.346	21.615	HP	20.1	19.5	0.6
280	**Baramkela**	Kandola BW	83.296	21.648	HP	25.5	10.75	14.75

ANNEXURE-III (A): Chemical Quality details of Shallow aquifer in Raigarh district

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
1	Katangdih	Dharamjaigarh	6.8	75.6	126	0	43	35.25	21	0	3.1	8	6	2.7	8.2	45	0.15	5.1		
2	Barpali	Dharamjaigarh	6.5	89.4	149	0	55	45.08	14	0.1	4.2	14	7.2	3.4	4	65	0.13	9.6		
3	Gersa	Dharamjaigarh	6.9	252.6	421	0	128	104.92	36	0.1	14.4	50	0	11.1	34.5	125	0.13	7.4		
4	Amapali	Dharamjaigarh	6.8	60	100	0	49	40.16	11	0.1	1.6	12	3.6	3.4	0.5	45	0.26	10.8		
5	Bartapali	Dharamjaigarh	6.7	78.6	131	0	55	45.08	14	0	1.6	10	7.2	2.4	5.5	55	0.11	9.6		
6	Amagaon	Dharamjaigarh	6.9	129	215	0	43	35.25	25	0	5.3	14	8.4	5.5	0.2	70	0.14	4		
7	Baroud	Gharghoda	7.3	262.8	438	0	207	169.67	25	0.4	11.8	38	15.6	19.9	7.8	160	0.14	6.6		
8	Bojia	Dharamjaigarh	6.8	218.4	364	0	73	59.84	67	0.1	2	30	13.2	14.1	1.5	130	0.11	17.3		
9	Auranar	Dharamjaigarh	6.9	24	40	0	18	14.75	7	0	1.4	6	2.4	0.8	0.2	25	0.15	5.5		
10	Khedapali	Dharamjaigarh	6.8	66	110	0	31	25.41	18	0	1.3	10	2.4	4.7	6.4	35	0.07	11		
11	Edu	Dharamjaigarh	7.1	160.8	268	0	159	130.33	14	0.3	1.4	26	14.4	3.7	8.7	125	0.15	4.9		
12	Nawapara	Dharamjaigarh	7.5	254.4	424	0	256	209.84	14	0.4	10.8	36	22.8	14.6	4.5	185	0.11	5.9		
13	Chhal	Dharamjaigarh	7.5	306.6	511	0	281	230.33	25	0.3	5.7	40	25.2	14.1	9.6	205	0.13	5.2		
14	Golabuda	Dharamjaigarh	6.7	94.2	157	0	79	64.75	11	0.8	0.9	12	9.6	10.5	2.2	70	0.09	22.4		
15	Lipti	Dharamjaigarh	6.8	97.8	163	0	85	69.67	11	1.9	4.3	14	3.6	17.5	0.5	50	0.09	24.1		
16	Kapu	Dharamjaigarh	7.1	195.6	326	0	128	104.92	32	0.2	0.9	32	10.8	14.5	1.9	125	0.16	20.7		
17	Derpani	Dharamjaigarh	7.3	289.2	482	0	189	154.92	46	0.6	24	50	15.6	23	1.7	190	0.16	16.7		
18	Khamhar	Dharamjaigarh	7.2	236.4	394	0	177	145.08	32	0.6	4.4	42	4.8	30.7	0.4	125	0.14	14.1		
19	Kandadand	Dharamjaigarh	7.2	166.2	277	0	165	135.25	11	0.6	4.3	20	10.8	22.6	5	95	0.14	4.2		
20	Lakshmipur	Dharamjaigarh	7.2	358.2	597	0	287	235.25	32	0.5	20.2	36	22.8	55.5	2	185	0.14	19.4		
21	Bansjour	Dharamjaigarh	7.1	250.2	417	0	207	169.67	25	0.4	9.5	34	9.6	35.4	1.5	125	0.15	21.5		
22	Dharamjaigarh	Dharamjaigarh	7.2	297.6	496	0	122	100.00	71	0.1	19.2	34	16.8	36.7	8	155	0.15	9.8		
23	Bakaruma	Dharamjaigarh	7.3	522.6	871	0	177	145.08	124	0.1	50.7	106	21.6	25.6	1.6	355	0.4	18.8		
24	Charkhapara	Dharamjaigarh	7.3	285	475	0	165	135.25	57	0.3	20.6	48	13.2	24.8	0.9	175	0.12	28.8		
25	Karramara	Dharamjaigarh	7.4	207	345	0	226	185.25	11	0.3	1.1	52	8.4	14.6	0.8	165	0.07	17.3		
26	Sirsinga	Dharamjaigarh	7.2	609.6	1016	0	165	135.25	188	0.2	27.1	92	38.4	33.3	11.5	390	0.14	5.9		
27	Ongana	Dharamjaigarh	7.1	214.8	358	0	116	95.08	36	0.1	9.1	26	12	9	27	115	0.14	9.3		

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
28	Tendumar	Dharamjaigarh	7.2	82.8	138	0	37	30.33	18	0	0.9	8	6	4.6	6.8	45	0.16	11.4		
29	Shahpur	Dharamjaigarh	6.9	118.8	198	0	61	50.00	18	0	0.9	12	8.4	5	9.4	65	0.15	8.8		
30	Durgapur	Dharamjaigarh	7.2	56.4	94	0	31	25.41	14	0	0.9	8	3.6	3	5.6	35	0.15	9.8		
31	Karigashi	Dharamjaigarh	7.3	544.8	908	0	92	75.41	138	1	145	46	14.4	107.5	1.6	175	0.14	6		
32	Jabga	Dharamjaigarh	7.2	111.6	186	0	79	64.75	18	0.1	2.3	18	8.4	3.3	8.5	80	0.15	9.4		
33	Boro	Dharamjaigarh	7.2	271.8	453	0	128	104.92	57	0	13.5	28	15.6	16.3	34.5	135	0.14	6		
34	Pordahi	Dharamjaigarh	7.4	253.2	422	0	220	180.33	25	0.3	8.6	48	10.8	20.9	3.3	165	0.14	7.3		
35	Taraimar	Dharamjaigarh	7.2	103.2	172	0	110	90.16	7	0.3	0.9	22	7.2	1.4	4.5	85	0.17	10.7		
36	Bayasi	Dharamjaigarh	7	131.4	219	0	73	59.84	28	0.1	4.6	16	10.8	8.7	5.4	85	0.15	8.9		
37	Duliamuda	Dharamjaigarh	7.4	51	85	0	31	25.41	11	0	0.9	6	3.6	1	6.3	30	0.14	11.7		
38	Khadgaon	Dharamjaigarh	7.5	250.8	418	0	214	175.41	21	0.4	6.5	34	13.2	13.1	30	140	0.14	6		
39	Hati	Dharamjaigarh	6.8	51	85	0	31	25.41	14	0.1	0.9	6	4.8	2.2	6.8	35	0.15	13.1		
40	Munund	Dharamjaigarh	6.9	67.2	112	0	43	35.25	18	0.1	1.5	10	6	6.5	3.1	50	0.14	6.1		
41	Kurekela	Dharamjaigarh	7.2	164.4	274	0	153	125.41	14	0.2	6.3	24	12	11.7	6.4	110	0.09	9.7		
42	Gharghoda	Gharghoda	7.1	776.4	1294	0	238	195.08	156	0.2	76	98	32.4	79	33.5	380	0.12	5.5		
43	Bhengari	Gharghoda	7	112.2	187	0	49	40.16	21	0	3.4	14	6	9.6	7.4	60	0.14	4.1		
44	Bhalumar	Gharghoda	7.1	119.4	199	0	73	59.84	21	0.1	7.8	14	7.2	8.1	10.9	65	0.14	10.5		
45	Amlidih	Gharghoda	7	236.4	394	0	98	80.33	50	0.1	18.1	28	12	22.8	10.7	120	0.14	4.2		
46	Samarumi	Gharghoda	7	31.2	52	0	24	19.67	11	0	1.6	6	3.6	1.1	0.7	30	0.1	2.4		
47	Teram	Gharghoda	6.9	228.6	381	0	201	164.75	14	0.3	8.3	38	12	11.5	5.7	145	0.11	6.6		
48	Porda	Gharghoda	7.2	216	360	0	207	169.67	18	0.8	9.7	26	16.8	19.4	10.3	135	0.13	4.8		
49	Kurmibhuna	Gharghoda	7.1	87	145	0	67	54.92	11	0.3	2	12	7.2	2.2	2.2	60	0.12	5.3		
50	Dumarpali	Gharghoda	6.7	44.4	74	0	37	30.33	7	0.1	2.4	10	2.4	2	1.9	35	0.15	12.5		
51	Baroud	Gharghoda	7.3	262.8	438	0	207	169.67	25	0.4	11.8	38	15.6	19.9	7.8	160	0.14	6.6		
52	Kotrimal	Gharghoda	7.4	223.2	372	0	183	150.00	21	0.6	11.1	30	18	9.4	9.3	150	0.12	6		
53	Chimtapani	Gharghoda	7.2	130.8	218	0	110	90.16	14	0.2	3.3	6	19.2	5.6	2.3	95	0.15	6.8		
54	Harradih	Gharghoda	7.9	620.8	970	0	244	200.00	67	0.1	47	66	7	20	134	195				137
55	Gadgaon	Gharghoda	7.6	124.8	195	0	61	50.00	18	0	7	14	8	9	10	70				22
56	Rabo	Gharghoda	7.5	56.96	89	0	18	14.75	18	0	1	6	2	7	8	25				13
57	Dokrabura	Gharghoda	7.4	135.04	211	0	37	30.33	18	0.1	7	10	6	7	26	50				37

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
58	Chharratangar	Gharghoda	7.9	513.92	803	0	287	235.25	67	0.2	4	76	8	21	85	225				22
59	Amladih	Gharghoda	7.2	145.92	228	0	49	40.16	18	0	21	16	4	11	24	55				25
60	Pandripani	Gharghoda	7.5	142.08	222	0	49	40.16	32	0	2	8	12	9	17	70				26
61	Kharamura	Gharghoda	7.6	105.6	165	0	79	64.75	21	0	4	20	4	8	10	65				4
62	Bade Gumda	Gharghoda	7.7	97.28	152	0	43	35.25	28	0	1	14	5	9	4	55				5
63	Chhote Gumda	Gharghoda	7.8	153.6	240	0	79	64.75	28	0.2	6	12	5	13	36	50				5
64	Katandih	Gharghoda	7.5	21.12	33	0	12	9.84	7	0	0	4	1	3	1	15				3
65	Bhengari	Gharghoda	6.9	182.4	285	0	6	4.92	43	0	0	14	10	19	8	75				70
66	Bilaskhar	Gharghoda	6.8	25.6	40	0	12	9.84	4	0	1	4	1	2	1	15				7
67	Daharidih	Gharghoda	7.7	153.6	240	0	67	54.92	25	0	6	14	7	20	13	65				24
68	Tumidih	Gharghoda	7.7	40.96	64	0	18	14.75	11	0	1	8	1	5	3	25				7
69	Samaruma	Gharghoda	7.5	206.72	323	0	49	40.16	36	0.1	13	10	14	30	7	85				55
70	Bhalumar	Gharghoda	7.4	95.36	149	0	49	40.16	18	0.1	4	12	5	8	11	50				8
71	Barpali	Gharghoda	7.9	239.36	374	0	201	164.75	21	0.7	0	28	16	10	27	135				2
72	Chhota Nawapara	Gharghoda	7.9	470.4	735	0	159	130.33	85	0.2	31	42	13	54	50	160				80
73	Jhariapali	Gharghoda	7.9	417.92	653	0	250	204.92	67	0.7	15	26	25	43	39	170				6
74	Kanchanpur	Gharghoda	7.4	272.64	426	0	31	25.41	82	0	3	32	8	21	29	115				45
75	Bahirkela	Gharghoda	7.8	958.72	1498	0	171	140.16	312	0.9	54	74	68	74	26	470				60
76	Malidih	Gharghoda	8.2	289.92	453	0	201	164.75	36	0.8	15	40	18	23	6	175				5
77	Dhangrapara	Gharghoda	8	62.08	97	0	18	14.75	14	0	0	6	5	5	7	35				20
78	Gharghori	Gharghoda	7.7	412.16	644	0	146	119.67	28	0.2	23	52	13	23	38	185				95
79	Beldipa	Gharghoda	8	280.32	438	0	238	195.08	32	1.2	10	30	14	42	2	135				0
80	Boronakunda	Gharghoda	8.1	154.24	241	0	92	75.41	25	0.1	9	22	8	7	9	90				4
81	Nawagarh	Gharghoda	7.7	151.04	236	0	67	54.92	25	0	12	14	7	12	15	65				19
82	Chhaldonia	Gharghoda	8.2	492.8	770	0	220	180.33	64	0.2	42	26	14	25	107	125				42
83	Karuwahi	Gharghoda	8.1	154.88	242	0	73	59.84	36	0.3	2	16	8	16	8	75				11
84	Kerakhol	Gharghoda	7.6	330.88	517	0	98	80.33	89	0	11	22	11	54	19	100				23
85	Kolam	Gharghoda	8.2	446.72	698	0	250	204.92	64	0.7	33	34	40	17	31	250				25
86	Dolesara	Gharghoda	8	199.68	312	0	134	109.84	25	0.3	11	32	6	12	23	105				6

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
87	Devgarh	Gharghoda	7.7	237.44	371	0	55	45.08	71	0.1	5	22	13	27	4	110				25
88	Patrapali	Gharghoda	8.1	689.28	1077	0	195	159.84	146	0.7	38	62	38	59	21	315				87
89	Rengal Behari	Gharghoda	8.1	307.84	481	0	195	159.84	50	0.4	0	24	18	22	26	135				2
90	Barkaspali	Gharghoda	8.1	277.12	433	0	226	185.25	28	0.8	0	26	14	18	31	125				2
91	Banai	Gharghoda	8	569.6	890	0	214	175.41	78	0.9	49	26	32	57	45	200				31
92	Charbhanta	Gharghoda	8.3	561.92	878	12	153	145.41	185	1.4	35	22	42	75	6	230				7
93	Ghorghora	Gharghoda	7.9	482.56	754	0	165	135.25	96	0.4	31	36	22	45	34	180				46
94	Kognara	Gharghoda	8.1	229.76	359	0	226	185.25	14	1	1	18	32	4	4	180				1
95	Auraimuda	Gharghoda	7	92.8	145	0	18	14.75	36	0.1	0	8	7	7	4	50				2
96	Kotrimal	Gharghoda	8.3	372.48	582	6	128	114.92	78	0.2	29	36	20	24	23	175				31
97	Raikera	Gharghoda	7.6	163.84	256	0	85	69.67	36	0.2	7	20	12	12	6	100				10
98	Nayarampur	Gharghoda	8.3	511.36	799	9	165	150.25	96	0.6	40	42	25	37	36	210				54
99	Bichhnara	Gharghoda	7.8	289.92	453	0	116	95.08	53	0.5	21	26	16	23	30	130				33
100	Tilaipali	Gharghoda	7.8	275.84	431	0	104	85.25	57	0.3	17	22	7	30	26	85				19
101	Teram	Gharghoda	7.9	261.76	409	0	159	130.33	21	0.5	32	32	11	21	9	125				2
102	Rumkera	Gharghoda	7.9	326.4	510	0	122	100.00	57	0.2	19	32	14	19	39	140				51
103	Patrapali (II)	Gharghoda	8.3	497.28	777	6	153	135.41	107	0.4	37	36	19	68	15	170				16
104	Phaguram	Gharghoda	8.3	511.36	799	12	140	134.75	124	0.7	42	26	31	65	11	195				17
105	Karichhapar	Gharghoda	8	244.48	382	0	159	130.33	14	1	17	38	5	15	35	115				28
106	Nawadih	Gharghoda	7.5	87.04	136	0		0.00	7	0.3	0	14	4	6	4	50				3
107	Pusalda	Gharghoda	7.5	163.84	256	0		0.00	36	0.2	11	14	11	10	15	80				21
108	Pusalda	Gharghoda	7.5	101.12	158	0		0.00	18	0.2	11	12	12	10	15	80				21
109	Dumarpali	Gharghoda	7.1	48.64	76	0	37	30.33	18	0.1	0	8	1	8	5	25				4
110	Chimtapani	Gharghoda	7.6	198.4	310	0	110	90.16	36	0.2	13	34	6	9	14	110				30
111	Chimtapani	Gharghoda	7.5	80	125	0		0.00	7	0.2	1	14	5	2	6	55				0
112	Phuthamuda	Gharghoda	7.5	218.88	342	0		0.00	46	0.1	24	20	10	16	29	90				16
113	Phuthamuda	Gharghoda	7.5	216.96	339	0		0.00	43	0.1	24	22	8	15	29	90				16
114	Kusumghat	Gharghoda	8	544	850	0		0.00	78	0.4	91	68	34	45	19	310				3
115	Gourmuri	Tamnar	7.8	628.48	982	0	98	80.33	131	0	60	50	17	40	95	195				143
116	Saraipali (II)	Tamnar	7.2	351.36	549	0	18	14.75	75	0	9	6	20	31	47	100				115
117	Barpali	Tamnar	7.4	42.88	67	0	12	9.84	7	0.1	1	6	4	2	5	30				20
118	Gerwani	Tamnar	8	280.32	438	0	146	119.67	39	0.1	20	30	10	22	36	115				32
119	Taraimal	Tamnar	8.2	305.28	477	0	146	119.67	67	0	20	30	6	57	7	100				22

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
120	Parkipahri	Tamnar	7.8	37.76	59	0	18	14.75	11	0	2	6	2	4	3	25				7
121	Jhingolpara	Tamnar	7.8	226.56	354	0	73	59.84	60	0	6	18	16	15	10	110				19
122	Amaghat	Tamnar	7.5	133.12	208	0	31	25.41	25	0	4	10	7	7	19	55				40
123	Kachkoba	Tamnar	7.8	586.24	916	0	195	159.84	99	0.1	40	52	26	28	75	240				102
124	Gorhi	Tamnar	7.9	305.92	478	0	104	85.25	67	0.1	8	24	12	34	21	110				40
125	Kasdol	Tamnar	7.8	173.44	271	0	79	64.75	21	0	1	26	10	13	6	105				38
126	Tamnar	Tamnar	7.9	326.4	510	0	165	135.25	50	0.1	26	46	11	28	6	160				22
127	Devgaon	Tamnar	7.7	1075.2	1680	0	195	159.84	327	0.7	70	86	62	105	45	475				132
128	Parigon	Tamnar	7.9	116.48	182	0	61	50.00	14	0.1	11	14	6	8	12	60				7
129	Kunjemara	Tamnar	7.5	120.32	188	0	43	35.25	28	0.1	1	10	5	13	13	45				24
130	Saraitola	Tamnar	8.2	329.6	515	0	250	204.92	36	0.7	11	26	17	42	31	135				3
131	Gare	Tamnar	7.9	355.2	555	0	146	119.67	60	0.4	29	26	16	33	44	130				34
132	Saraipali	Tamnar	7.8	182.4	285	0		0.00	36	0.1	11	6	20	16	8	100				15
133	Milupara	Tamnar	7.7	80.64	126	0	49	40.16	11	0.1	0	14	9.2	4.1	2	60				6
134	Milupara	Tamnar	7.9	209.92	328	0	85	69.67	43	0.1	0	36	36.9	21.1	1	110				4.8
135	Jaradih	Tamnar	7.9	142.08	222	0	79	64.75	28	0.3	9	22	1.3	8.6	9.2	85				7.2
136	Hinjhar	Tamnar	7.9	0		0	110	90.16	11	0.3	11	18	0.8	8.6	12.6	80				8.4
137	Urba	Tamnar	8.2	453.76	709	0	299	245.08	50	0.3	30	42	5.9	21.5	90	185				19.2
138	Urba	Tamnar	8	186.88	292	0	140	114.75	14	0.2	16	22	0	11.8	22.6	85				7.2
139	Pelma	Tamnar	8.2	376.96	589	0	146	119.67	89	0.1	34	42	10.5	45.7	11.2	175				16.8
140	Dhaurabhata	Tamnar	7.9	172.16	269	0	98	80.33	28	0.3	14	26	0.3	13.8	6.5	95				7.2
141	Bijna	Tamnar	8.1	684.16	1069	0	409	335.25	103	1.4	56	86	11.6	45.3	17.9	415				48
142	Karrapali	Tamnar	8.4	345.6	540	15	220	205.33	50	0.7	0	46	0.6	15.5	28.3	205				21.6
143	Taraimal	Tamnar	6.6	117	195	0	43	35.25	28	0.1	10.6	12	8.4	13.4	2.8	65	0.14	3.2		
144	Amaghat	Tamnar	6.9	117.6	196	0	43	35.25	25	0.1	7.7	12	9.6	4.9	10	70	0.11	7.8		
145	Godhi	Tamnar	7.3	522	870	0	244	200.00	163	0.1	8.9	56	33.6	37	55.1	280	0.14	3.1		
146	Tamnar	Tamnar	7.1	189	315	0	122	100.00	39	0.1	7.2	30	9.6	14.9	3.8	115	0.13	12.5		
147	Daurabhata	Tamnar	7.2	201	335	0	134	109.84	32	0.2	10	24	10.8	15.2	8.7	105	0.12	7.5		
148	Gare	Tamnar	7.3	176.4	294	0	146	119.67	21	0.9	2.9	22	12	12.2	9.3	105	0.11	6.9		
149	Milupara	Tamnar	7.1	192	320	0	159	130.33	28	0.2	8.9	16	14.4	15.4	24	100	0.18	6.4		
150	Barkaspali	Tamnar	7.2	312	520	0	281	230.33	28	0.4	2	32	24	21.4	22	180	0.15	4.4		
151	Devgarh	Tamnar	6.9	265.8	443	0	85	69.67	85	0.1	9.8	26	15.6	29.4	4	130	0.14	10.7		
152	Koknara	Tamnar	7.5	283.8	473	0	287	235.25	14	0.5	13.8	36	25.2	19.3	3.4	195	0.11	4.7		
153	Arimura	Tamnar	6.9	84	140	0	49	40.16	18	0.1	3.4	12	4.8	4.1	4.7	50	0.08	11.2		
154	Barra	Karsia	7.23	124	188	0	67.1	55.00	21.3	0.01	1.22	14	7.2	7.4	5.3	65	0.07	9.06		
155	Bothlda	Karsia	6.73	25	30	0	12.2	10.00	3.55	0.00	1.04	2	1.2	3.2	0.2	10	0.05	5.36		
156	Pathrapali	Karsia	7.4	143	216	0	128.1	105.00	10.65	0.57	1.78	22	10.8	5.7	1.9	100	0.05	7.03		

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
157	Masania Kalan	Karsia	6.8	62	94	0	12.2	10.00	17.75	0.06	0.94	6	2.4	7.6	0.2	25	0.06	5.21		
158	Sajapali	Karsia	7.65	255	418	0	213.5	175.00	21.3	0.23	4.19	50	12	11.5	0.3	175	0.21	35.42		
159	Khamhar	Karsia	7.5	203	313	0	109.8	90.00	31.95	0.00	6.50	24	7.2	21.1	7.8	90	0.13	9.27		
160	Khadgoan	Karsia	7.4	414	634	0	176.9	145.00	63.9	0.07	17.70	44	10.8	54.5	1.8	155	0.18	35.00		
161	Turekela	Karsia	7.67	305	462	0	176.9	145.00	42.6	0.20	6.69	22	14.4	49.5	0.8	115	0.05	7.34		
162	Sarwani	Karsia	7.12	108	365	0	134.2	110.00	42.6	0.24	5.94	38	10.8	7	8.7	140	0.05	9.11		
163	Kapharmar	Karsia	7.4	995	1514	0	378.2	310.00	134.9	0.03	22.32	76	37.2	104.6	8.19	345	0.11	11.56		
164	Nangoi	Karsia	7.68	606	919	0	274.5	225.00	127.8	0.06	17.06	40	25.2	36.2	140	205	0.05	5.63		
165	Pharkanara	Karsia	7.69	277	324	0	103.7	85.00	49.7	0.01	6.69	24	8.4	18.9	26.2	95	0.06	7.55		
166	Barbhauna	Karsia	7.55	297	448	0	128.1	105.00	74.55	0.03	25.57	52	18	4.83	0.8	205	0.05	8.70		
167	Binjkoth	Karsia	7.52	214	622	0	213.5	175.00	42.6	0.12	26.88	54	14.4	34.8	0.5	195	0.06	12.08		
168	Bhupdeopur (Talaipali)	Karsia	7.24	407	1514	0	274.5	225.00	120.7	0.09	122.88	94	37.2	87.5	2.73	390	0.11	10.42		
169	Jaimura	Karsia	7.47	993	1504	0	274.5	225.00	113.6	0.22	204.00	190	26.4	88	14	585	0.05	11.20		
170	Basnajhar	Karsia	7.45	43	66	0	18.3	15.00	7.1	0.07	7.98	6	2.4	2.5	0.5	25	0.06	1.82		
171	Kodha Bhatta (Gidha)	Karsia	7.66	211	319	0	109.8	90.00	28.4	0.33	19.93	36	10.8	10.4	0.3	135	0.06	9.58		
172	Jharidih	Karsia	7.68	681	1032	0	250.1	205.00	110.05	0.18	61.44	56	63.6	59.1	2.1	405	0.10	8.13		
173	Karsiaa (MADHANPUR	Karsia	7.59	329	499	0	103.7	85.00	81.65	0.13	39.65	38	14.4	38.2	0.4	155	0.09	5.68		
174	Chaple	Kharsia	7.5	493.8	823	0	268	219.67	124	0.2	15.7	46	21.6	87.4	1	205	0.12	12		
175	Domnara	Kharsia	7.2	219	365	0	207	169.67	21	0.2	8.6	38	13.2	19.5	0.6	150	0.09	19.1		
176	Farkanara	Kharsia	7.3	348.6	581	0	201	164.75	53	0.1	24.6	46	10.8	24.5	30	160	0.11	5.2		
177	Kharsia	Kharsia	7	535.2	892	0	201	164.75	163	0.2	36.4	52	13.2	107	0.7	185	0.14	5.5		
178	Bagudega (Shivaar Para)	Lailunga	7.23	90	136	0	48.8	40.00	14.2	0.11	2.43	14	1.2	11.3	0.4	40	0.08	20.83		
179	Choranga	Lailunga	7.6	231	350	0	140.3	115.00	39.05	0.38	11.59	40	12	13.2	1.2	150	0.60	19.17		
180	Moodagoan	Lailunga	7.42	327	495	0	158.6	130.00	67.45	0.03	13.44	70	6	18.8	1	200	0.15	19.27		
181	Gudu Bahal	Lailunga	7.58	879	1332	0	128.1	105.00	273.35	0.42	29.65	142	34.8	43.9	3.9	500	0.12	22.50		
182	Sardega	Lailunga	7.68	490	742	0	207.4	170.00	106.5	0.07	31.69	76	33.6	18.6	0.9	330	0.14	20.16		
183	Kumhar	Lailunga	7.62	295	446	0	128.1	105.00	53.25	0.15	15.20	46	8.4	23.9	0.5	150	0.16	22.71		
184	Potra	Lailunga	7.65	274	415	0	189.1	155.00	35.5	0.24	13.72	46	8.4	30.4	0.1	150	0.17	17.76		
185	Hirapur	Lailunga	7.66	275	416	0	164.7	135.00	35.5	0.27	9.46	52	10.8	18.9	1	175	0.15	21.46		
186	Phaghat-Lureg	Lailunga	7.73	242	366	0	103.7	85.00	46.15	0.10	11.69	46	6	10.7	0.6	140	0.22	21.20		
187	Tatkela	Lailunga	7.71	269	460	0	183	150.00	28.4	1.04	38.07	28	25.2	24.5	4.3	175	0.17	30.26		

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
188	Kesala	Lailunga	7.63	172	260	0	146.4	120.00	10.65	0.41	3.17	20	9.6	21.2	2.1	90	0.10	37.66		
189	Laripani	Lailunga	7.72	256	388	0	140.3	115.00	49.7	0.19	10.20	36	18	8.5	8.1	165	0.06	23.59		
190	Phulikuda	Lailunga	7.68	182	275	0	140.3	115.00	7.1	1.07	4.19	30	8.4	15.1	1.1	110	0.06	21.15		
191	Amapali	Lailunga	7.56	366	555	0	158.6	130.00	74.55	1.49	48.07	34	8.4	69.1	3	120	0.05	16.41		
192	Gamekela	Lailunga	7.69	234	354	0	103.7	85.00	49.7	0.15	10.39	42	7.2	12.9	1.1	135	0.19	11.35		
193	Lohrapani (Poyl para)	Lailunga	7.9	230	349	0	189.1	155.00	21.3	0.49	4.09	26	4.8	44.1	1.1	85	0.16	19.95		
194	Katakilya	Lailunga	7.71	170	257	0	140.3	115.00	14.2	0.19	4.00	28	13.2	8.5	0.3	125	0.08	23.59		
195	Narayanpur (Mukya Basti)	Lailunga	7.91	163	248	0	122	100.00	21.3	0.17	6.31	28	7.2	12.9	1.1	100	0.09	13.33		
196	Karadega	Lailunga	7.68	168	280	0	146.4	120.00	14.2	0.34	1.78	30	10.8	9.6	1.2	120	0.11	25.68		
197	Tolma	Lailunga	7.64	209	316	0	128.1	105.00	24.85	1.34	12.61	26	7.2	27.2	1	95	0.12	20.78		
198	Mukdega	Lailunga	7.8	404	612	0	164.7	135.00	85.2	0.39	30.02	64	8.4	34.1	1	195	0.13	21.25		
199	Futhahmuda	Lailunga	7	54.6	91	0	31	25.41	14	0.1	1.9	10	2.4	2.9	5.2	35	0.09	9.2		
200	Laripani	Lailunga	7.1	556.2	927	0	171	140.16	192	0.3	14.2	84	39.6	14.6	6.8	375	0.14	22.4		
201	Gosaidih	Lailunga	7.3	222	370	0	207	169.67	11	0.4	3.2	22	21.6	19.2	1.5	145	0.11	16.5		
202	Jegarpur	Lailunga	7.3	412.2	687	0	195	159.84	96	0.3	34.7	78	15.6	27.5	1.7	260	0.1	28.8		
203	Kunjara Basti	Lailunga	7.4	235.8	393	0	128	104.92	36	0.2	22.8	42	13.2	16.7	2.2	160	0.09	14.8		
204	Lailunga	Lailunga	7.3	501	835	0	140	114.75	146	0.1	63.8	88	7.2	76.7	2.5	250	0.11	20.2		
205	Salkhiya	Lailunga	7.4	118.8	198	0	128	104.92	11	0.2	1.6	24	10.8	5.3	0.4	105	0.12	18.8		
206	Rajpur	Lailunga	7.3	356.4	594	0	104	85.25	128	0.1	8.1	66	9.6	34.4	1.8	205	0.12	29.5		
207	Choranga	Lailunga	7.5	346.2	577	0	268	219.67	39	0.2	12.5	48	31.2	14.7	1.8	250	0.12	25.7		
208	Pakargaon	Lailunga	7.2	250.2	417	0	220	180.33	18	0.2	7.6	36	20.4	16.4	1.6	175	0.12	24		
209	Jharmunda	Pusaur	7.45	249.6	416	0	98	80.33	21	0.46	100	12	17	59	1.2	100	0.00	8	0.128	
210	Kusmunda	Pusaur	7.42	310.8	518	0	122	100.00	21	0.45	120	38	22	37	4.3	185	0.00	14	0.19	
211	Baghdola	Pusaur	7.24	468.6	781	0	220	180.33	14	0.44	150	82	12	53	2.3	250	0.00	12	0.19	
212	Ghuterpali	Pusaur	7.5	176.4	294	0	73	59.84	14	0.42	46	14	11	33	1.6	80	0.00	11	0.222	
213	Pusaur	Pusaur	7.27	676.8	1128	0	390	319.67	35	0.44	144	138	22	51	25	435	0.00	10		
214	Odekora	Pusaur	7.47	184.2	307	0	98	80.33	21	0.48	54	12	12	37	4.6	80	0.00	15	0.19	

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
215	Darramuda	Pusaur	7.56	158.4	264	0	98	80.33	21	0.40	26	6	12	23	7.8	80	0.00	14	0.096	
216	Bathanpali	Pusaur	7.33	143.4	239	0	73	59.84	7	0.52	58	10	3.6	22	4.6	65	0.00	15	**3.79**	
217	Jhalmala	Pusaur	7.32	133.8	223	0	92	75.41	14	0.47	4	20	6	8.1	7.8	75	0.00	14	0.128	
218	Tarapur	Pusaur	7.42	456	760	0	98	80.33	28	0.40	130	88	11	39	3.5	265	0.00	10	0.316	
219	Pacheda	Pusaur	7.26	826.8	1378	0	427	350.00	35	0.43	70	90	68	109	1.95	510	0.00	12	0.128	
220	Teka	Pusaur	7.39	190.2	317	0	79	64.75	11	0.47	68	23	13	17	1.56	120	0.00	12	0.034	
221	Loharsunga	Pusaur	7.3	508.8	848	0	183	150.00	21	0.50	150	60	31	62	37	230	0.00	12	0.159	
222	Kensara	Pusaur	7.34	364.2	607	0	134	109.84	28	0.44	130	50	14	55	16	185	0.00	10	0.096	
223	Bonda	Pussaur	7.1	312	520	0	177	145.08	53	0.3	30.3	24	37.2	10.8	1.5	215	0.11	6.9		
224	Surajgarh	Pussaur	7.3	256.2	427	0	153	125.41	50	0.1	11.3	30	13.2	31.7	0.6	130	0.11	6.1		
225	Kondatarai	Pussaur	7	513.6	856	0	128	104.92	46	0.2	194	58	28.8	65.9	1.6	265	0.12	12.1		
226	Nawrangpur	Pussaur	7.2	688.2	1147	0	85	69.67	14	0.2	442.6	118	31.2	57.8	1.9	425	0.15	8.7		
227	Tadola	Pussaur	7.4	307.2	512	0	256	209.84	18	0.1	27	46	20.4	30.2	1.4	200	0.11	14		
228	Tetla	Pussaur	7.3	628.2	1047	0	165	135.25	21	0	318	102	25.2	81.5	2	360	0.15	11.4		
229	Kathali	Pussaur	7.2	628.8	1048	0	55	45.08	50	0	394.2	104	38.4	59.2	2.5	420	0.05	8		
230	Aurda	Pussaur	7.3	384	640	0	232	190.16	75	0.1	28.5	50	24	44.8	1.1	225	0.1	4		
231	Koshmunda	Pussaur	7.4	409.2	682	0	262	214.75	21	0.2	109.8	42	37.2	42.9	1.5	260	0.2	13.8		
232	Rengalpali	Pussaur	7.3	657	1095	0	171	140.16	46	0	341	144	25.2	37.7	7.7	465	0.14	12.4		
233	Jorapali	Raigarh	7.21	336	560	0	122	100.00	7	0.46	130	50	12	37	3.5	175	0.00	9	0.879	
234	Kotra	Raigarh	7.34	252	420	0	110	90.16	18	0.45	92	18	13	57	3.5	100	0.00	10	0.096	
235	Balamgoda	Raigarh	7.29	637.2	1062	0	159	130.33	35	0.45	120	112	14	83	3.1	340	0.00	9	0.19	
236	Biang	Raigarh	7.52	194.4	324	0	98	80.33	18	0.44	54	16	11	33	7.8	85	0.00	11	0.096	
237	Parsada	Raigarh	7.43	196.8	328	0	67	54.92	35	0.46	17	30	11	18	9.75	120	0.00	10	0.096	
238	Cheraipani	Raigarh	7.39	180.6	301	0	67	54.92	18	0.45	54	24	9.6	24	8.19	100	0.00	10	0.065	
239	Sambalpuri	Raigarh	7.46	61.2	102	0	37	30.33	7	0.47	5	8	4.8	4.8	0.78	40	0.00	12	1.161	
240	Bangrusian	Raigarh	7.29	175.2	292	0	91	74.59	11	0.49	25	12	2.4	22	62	40	0.00	11	0.037	
241	Jorapali (IGKV Raigarh)	Raigarh	7.6	342.6	571	0	37	30.33	21	0.44	110	28	30	34	4.7	195	0.00	10	0.535	
242	Sariya	Raigarh	7	267	445	0	85	69.67	60	0	39.4	36	13.2	31	9.5	145	0.1	6.1		

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
243	Bhupdevpur	Raigarh	7.2	294.6	491	0	244	200.00	25	0.4	14.7	44	21.6	26	0.9	200	0.14	10.1		
244	Kerajhar	Raigarh	7.4	255.6	426	0	226	185.25	21	0.2	7.4	46	19.2	11.9	2.1	195	0.12	4.2		
245	Chiraipani1	Raigarh	7.2	47.64	79.4	0	31	25.41	7	0.1	3.4	10	2.4	1.2	0.7	35	0.12	3.4		
246	Sambalpuri	Raigarh	7.1	91.8	153	0	73	59.84	14	0.1	6.4	22	4.8	2.2	6.4	75	0.12	5.7		
247	Bangrushian	Raigarh	6.8	61.2	102	0	31	25.41	18	0	2.5	6	6	5.9	2.4	40	0.1	3.6		
248	Raigarh	Raigarh	7.1	565.2	942	0	214	175.41	96	0.1	148	92	26.4	53.9	1.4	340	0.11	8.4		
249	Mahapali	Raigarh	7.2	593.4	989	0	116	95.08	202	0.1	37.9	62	39.6	62.3	2.9	320	0.08	26		
250	Jamgaon Basti	Raigarh	7.3	364.8	608	0	153	125.41	107	0.2	24.4	48	27.6	21.7	5.1	235	0.12	12		
251	Jamga Railway stn.	Raigarh	6.9	66.6	111	0	31	25.41	18	0	3.7	6	6	7.3	2.1	40	0.11	3.2		
252	Kotarlia	Raigarh	7.4	230.4	384	0	165	135.25	36	0.4	17.4	26	10.8	43.6	0.7	110	0.09	18.4		
253	Chiraipani	Raigarh	7.5	327.6	546	0	220	180.33	43	0.4	40.4	34	25.2	32.2	6.7	190	0.11	7.2		
254	Lakha	Raigarh	6.8	45.6	76	0	31	25.41	11	0	1.5	4	4.8	5.3	0.2	30	0.12	4.2		
255	Gerwani	Raigarh	6.5	87.6	146	0	37	30.33	18	0	1.7	10	4.8	10.2	0.7	45	0.11	4.5		
256	Padigaon	Raigarh	7.3	240	400	0	207	169.67	28	0.3	1.7	26	18	7.7	30.5	140	0.16	5.2		
257	Dhansara	Sarangarh	7.18	318.6	531	0	146	119.67	85	0.48	42	18	19	65	21	125	0.00	4	0.034	
258	Kudhri	Sarangarh	7.66	223.2	372	0	146	119.67	21	0.48	25	12	11	53	3.1	75	0.00	32	2.069	
259	Kargidipa	Sarangarh	7.1	325.8	543	0	238	195.08	39	0.7	8.1	28	14.4	48.9	2.1	130	0.1	6.4		
260	Damdarha	Sarangarh	7.2	256.2	427	0	146	119.67	21	1.7	52	32	10.8	29.7	3.2	125	0.12	10.7		
261	Kanakbirra	Sarangarh	7.1	299.4	499	0	140	114.75	32	2	15.6	28	14.4	24.3	1.2	130	0.11	24.6		
262	Bataupali	Sarangarh	7.4	556.8	928	0	378	309.84	75	1.3	27.9	42	39.6	65.8	0.9	270	0.13	9.8		
263	Malda-B	Sarangarh	7.3	289.8	483	0	122	100.00	64	0.2	21.6	44	20.4	17	0.8	195	0.13	11		
264	Kushalnagar	Sarangarh	7.1	907.8	1513	0	293	240.16	316	0.2	30.1	136	43.2	94.1	1.1	520	0.16	8.6		
265	Godam	Sarangarh	7.3	733.8	1223	0	360	295.08	199	0.2	36.2	42	14.4	181.5	2.4	165	0.15	5.9		
266	Pindri	Sarangarh	7.3	606.6	1011	0	342	280.33	131	0.3	39.2	38	10.8	144.5	4.9	140	0.14	8.3		
267	Hirri	Sarangarh	7.1	289.2	482	0	207	169.67	39	0.1	15.4	54	18	17.1	0.6	210	0.15	8.4		
268	Reda	Sarangarh	7.2	407.4	679	0	244	200.00	75	0.5	29.5	100	10.8	16	4	295	0.16	8.8		
269	Chhind	Sarangarh	7.2	777	1295	0	317	259.84	209	0.1	70.8	162	19.2	63.1	10.5	485	0.14	14.2		
270	Kedar	Sarangarh	7.2	366	610	0	250	204.92	53	0.4	28.6	48	27.6	33.6	6	235	0.15	8.1		

S.NO.	Location	Block	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
271	Kapartunga	Baramkela	7.17	213.6	356	0	98	80.33	57	0.49	16	16	17	32	0.78	110	0.00	5	0.159	
272	Paraskhol	Baramkela	7.39	49.2	82	0	49	40.16	7	0.50	5	4	7.2	3.8	0.39	50	0.00	10	12.93	
273	Budeli	Baramkela	7.28	176.4	294	0	110	90.16	28	0.41	20	12	7.2	43	5	60	0.00	11	0.128	
274	Sanda	Baramkela	7.43	133.8	223	0	110	90.16	7	0.32	12	16	14	6.1	1.95	100	0.00	8	0.19	
275	Barpali	Baramkela	7.36	154.2	257	0	110	90.16	7	0.37	18	12	7.2	4.3	53	60	0.00	7	0.065	
276	Panchdhar	Baramkela	7.23	172.8	288	0	85	69.67	7	0.44	56	22	8.4	13	23	90	0.00	10	0.128	
277	Kandola	Baramkela	7.37	151.8	253	0	122	100.00	7	0.41	54	18	25	9.2	27	150	0.00	5	0.472	
278	Baramkela	Baramkela	7.5	301.8	503	0	226	185.25	21	0.6	9.3	40	27.6	3.9	1.9	215	0.14	10.4		
279	Bade Nawapara	Baramkela	7.2	324	540	0	98	80.33	85	0.2	29.2	42	15.6	26.9	1.4	170	0.14	8.3		
280	Lendra	Baramkela	7	372.6	621	0	104	85.25	99	0.2	27.8	52	27.6	15.5	0.6	245	0.09	7		
281	Jhikipali	Baramkela	7.2	442.2	737	0	128	104.92	135	0.2	43.9	56	20.4	53.5	1.1	225	0.13	22.4		
282	Mahuapali	Baramkela	7	249.6	416	0	171	140.16	21	0.3	43	30	25.2	10.9	2.1	180	0.1	6.3		
283	Kandola	Baramkela	7.3	396.6	661	0	238	195.08	18	0.3	76	22	60	8.3	2.8	305	0.11	6.1		
284	Barpali	Baramkela	7.2	280.2	467	0	201	164.75	11	0.2	16.6	20	36	2.7	2.5	200	0.11	6.1		

ANNEXURE-III (B): Chemical Quality details of deeper aquifer in Raigarh district

S.NO.	Location	Block	Type	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
1	Chhal	Dharmajaigarh	EW	7.01	168	280	0	134	109.84	21			24	19			140				
2	Hati	Dharmajaigarh	EW	7.8	615.6	1026	0	323	264.75	113		48	128	10	59	1.2	360		28	0.7	
3	Hati OW	Dharmajaigarh	EW	7.8	615.6	1026	0	323	264.75	113		48	128	10	59	1.2	360		28	0.7	
4	Kudekala	Dharmajaigarh	EW	8.1	174	290	0	85	69.67	35			40	5			120				
5	Kudekela OW-I	Dharmajaigarh	EW	8.9	534	890	0	427	350.00	53			10	6			50				
6	Ulkhar	Dharmajaigarh	EW	7.8	256.2	427	0	195	159.84	18		0	24	19	41	1.8	140		0	0	
7	Bakaruma	Dharmajaigarh	EW	7.8	240.6	401	0	220	180.33	7		0	32	5	58	1.9	100		0	0	
8	Rairuma	Dharmajaigarh	EW	7.7	423	705	0	220	180.33	39		0	62	10	82	1.5	195		0	0	
9	Tejpur	Dharmajaigarh	EW	7.8	276	460	0	152	124.59	25		0	64	2.4	27	0.9	170		0	0	
10	Lipti	Dharmajaigarh	EW	7.7	94.2	157	0	61	50.00	7		0	10	7	13	2.2	55		0	0	
11	Kapu	Dharmajaigarh	EW	7.6	54.6	91	0	43	35.25	7		0	8	4	7	1.5	35		0	0	
12	Sonpur	Dharmajaigarh	EW	7.8	50.4	84	0	24	19.67	7		0	2	4	9	0.7	20		0	0	
13	Vijaynagar	Dharmajaigarh	EW	7.9	121.8	203	0	61	50.00	21		0	16	2.4	23	1.6	50		0	0	
14	Alola	Dharmajaigarh	EW	7.6	96.6	161	0	73	59.84	7		0	14	4	12	1.3	50		0	0	
15	Shishringa	Dharmajaigarh	EW	8	231	385	0	215	176.23	9		10	38	4	46	2.1	110		nil	0.4	
16	Dumarpali	Gharghoda	EW	7.9	363	605	0	262	214.75	28		0	34	16	43	19	150			0	0
17	Phaguram	Gharghoda	EW	7.7	1260	2100	0	207	169.67	50			260	19			730				
18	Tamnar	Tamnar	EW	8.5	171	285	0	128	104.92	18			14	8			70				
19	Dhaurabhata	Tamnar	EW	7.8	282	470	0	183	150.00	25	0.7	60	16	1	86	19	45				1
20	Barra	Kharsia	EW	8.3	300	500	0	275	225.41	25			18	13			100				
21	Kapharmar	Kharsia	EW	7.8	126	210	0	110	90.16	11			16	4			55				
22	Tieur	Kharsia	EW	8	240	400	0	92	75.41	46		0	28	21	29	1.1	155			0	0
23	Dehjari	Kharsia	EW	8.1	288	480	0	287	235.25	14											
24	Palgada	Kharsia	EW	7.7	292.8	488	0	250	204.92	32			66	18			240				
25	Botalda	Kharsia	EW	8.1	188.4	314	0	165	135.25	18			38	12			145				
26	Halaholi	Kharsia	EW	7.9	444.6	741	0	354	290.16	14											
27	Deradhi	Kharsia	EW	7.07	140.4	234	0	91.5	75.00	21.3	0.2	6.0	14	12	13.3	53.3	85		0.1		

S.NO.	Location	Block	Type	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2	Fe	NO_3
28	Tumighi	Kharsia	EW	7.19	278.4	464	0	280.6	230.00	17.75	1.0	10.1	24	10.8	65.1	38.8	105		0.1		
29	Tumighi	Kharsia	EW	7.69	226.2	377	0	213.5	175.00	21.3	0.5	0.1	26	14.4	7.9	5.6	125		0.1		
30	Deradhi	Kharsia	EW	6.6	78.0	130.0	0.0	79.3	65.0	14.2	0.3	0.2	14.0	3.6	3.7	4.6	50.0		0.1		
31	Chaurenga	Lailunga	EW	7.9	258	430	0	122	100.00	39		28	46	13	14	1.1	170			0.7	26
32	Rajpur	Lailunga	EW	8.3	180	300	0	134	109.84	11	0.4	10	24	13	5	3.9	115				1.3
33	Rengalpali	pusaur	EW	8	390	650	0	146	119.67	7		0	66	13	50	1.6	220			0	0
34	Tilga	pusaur	EW	7.9	84	140	0	18	14.75	7		0	4	5	18	1	30			0	0
35	Bhatanpail	pusaur	EW	8.2	240.6	401	0	159	130.33	14			26	16			130				
36	Nandeli	pusaur	EW	7.7	481.2	802	0	177	145.08	14			100	13			305				
37	Kusmura	pusaur	EW	8	1023	1705	0	67	54.92	35			262	47			50				
38	Nandagoan	pusaur	EW	7.2	1392	2320	0	225.7	185.00	31.9	0.0	126.5	364	20.4	125	4	995	0.2			
39	Nandagoan	pusaur	EW	7.45	220.2	367	0	183	150.00	21.3	0.5	20.2	20	13.2	41.2	3.3	105	0.1			
40	Podigaon	pusaur	EW	7.45	211.2	352	0	219.6	180.00	7.1	0.6	6.1	22	10.8	44.6	1.1	100	0.1			
41	Kerajhar	Raigarh	EW	7.5	369	615	0	213	174.59	25			56	30			265				
42	Gejamunda	Raigarh	EW	8	387.6	646	0	354	290.16	11			58	35			290				
43	Ranisagar	Sarangarh	EW	8.1	174	290	0	85	69.67	25		0	32	7	19	0.7	110			0	0
44	Kudri	Sarangarh	EW	7.9	415.8	693	0	98	80.33	7		0	112	9	27	1.2	315			0	0
45	Kudri OW	Sarangarh	EW	8.2	763.8	1273	0	421	345.08	106		0	12	16	255	5.9	95			0	0
46	Bonda	Sarangarh	EW	8.2	367.2	612	0	207	169.67	53		0	24	34	57	1	200			0	0
47	Lendrhra (B)	Sarangarh	EW	7.8	214.8	358	0	195	159.84	7		0	12	9	60	1	65			0	0
48	Dansara	Sarangarh	EW	8.1	505.8	843	0	275	225.41	64		0	66	17	85	2.5	235			0	0
49	Kandurpali	Sarangarh	EW	8.1	482.4	804	0	421	345.08	35		0	14	36	98	5.2	185			0	0
50	Reda	Sarangarh	EW	7.7	316.8	528	0	214	175.41	35		0	42	6	64	1.4	130			0	0
51	Lendhra	Baramkela	EW	8.2	642	1070	0	384	314.75	82		0	4	4	237	2.2	25			0	0
52	Resada	Baramkela	EW	7.7	316.8	528	0	214	175.41	35		0	42	6	64	1.4	130			0	0
53	Chhichorumaria	Baramkela	EW	8.2	676.8	1128	0	415	340.16	128		0	10	11	221	6.3	70			0	0
54	Kutela	Baramkela	EW	8.1	174	290	0	85	69.67	35			40	5			120				
55	Baramkela	Baramkela	EW	8.4	228	380	0	195	159.84	21			34	25			190				

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