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

Dharamjaigarh block, Raigarh DISTRICT, CHHATTISGARH

उत्तर मध्य छत्तीसगढ़ क्षेत्र, रायपुर

North Central Chhattisgarh Region, Raipur

स्वच्छ जल : स्वच्छ भारत

केन्द्रीय भूमि जल बोर्ड

उत्तर मध्य छत्तीसगढ़ क्षेत्र

द्वितीय तल, एल.के. कॉर्पोरेट एवं लॉजिस्टिक पार्क,

धमतरी रोड, डूमरतराई, रायपुर (छत्तीसगढ़)–492015

फोन–0771–2974405, फैक्स–2974405 ईमेल–rdnccr-cgwb@nic.in

भारत सरकार

Government of India

जल शक्ति मंत्रालय

Ministry of Jal Shakti

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

Department of Water Resources, River Development & Ganga Rejuvenation

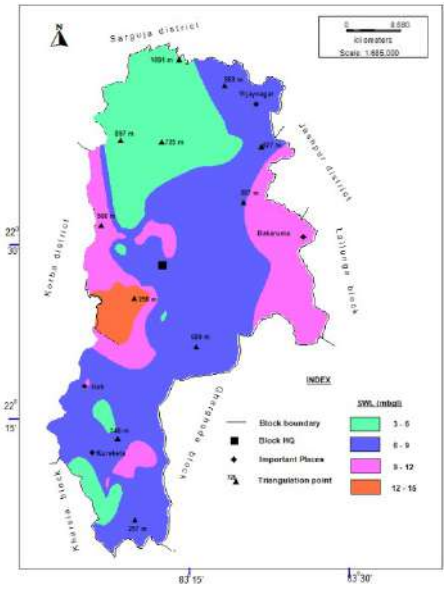
केन्द्रीय भूमि जल बोर्ड

CENTRAL GROUND WATER BOARD

Aquifer Mapping and Management Plan in Dharamjaigarh block, Raigarh District, Chhattisgarh

By

Sh. A K Biswal (Scientist-D)



North Central Chhattisgarh Region
Raipur
2020

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 Dharamjaigarh block, Raigarh District, Chhattisgarh

By
Sh. A K Biswal (Scientist-D)

Type of Study	**Officer engaged**
Data compilation, Data Gap Analysis & Data Generation	Sri S.Acharya, Scientist-D, (AAP-2015-16)
Data Interpretation, Integration, Aquifer Mapping, Management Plan & Report writing	Sri A. K. Biswal, Scientist-D

North Central Chhattisgarh Region
Raipur
2020

BLOCK AT A GLANCE

DHARAMJAIGARH BLOCK, RAIGARH DISTRICT, CHHATTISGARH

1.	**GENERAL INFORMATION**	
	i) Geographical area (Sq. km)	1537.69
	ii) Administrative Divisions (As on 2017)	
	a) Number of Villages	189
	iii) Population as on 2011 Census	179,748
	iv) Average Annual Rainfall	1517.48mm
2.	**GEOMORPHOLOGY**	
	i) Major Geomorphological Units	Structural plain on Gondwana rocks
	ii) Major Drainages	Mahanadi Basin (Mand ,Kurket & Korega)
3.	**LAND USE (ha) As on 2016-17**	
	i) Forest Area	42014
	ii) Net Area Sown	23400
	iii) Double cropped Area	2970
4.	**MAJOR SOIL TYPES**	Alfisols-Red sandy soil
5.	**AREA UNDER PRINCIPAL CROPS, in ha (As on 2016-17)**	Paddy-36939, Wheat-72, Pulses-6838, Tilhans-3554, Fruits and vegetables- 98
6.	**IRRIGATED AREA BY DIFFERENT SOURCES in ha (As on 2016-17)**	
	i) Dug wells	267
	ii) Tube wells/Bore wells	967
	iii) Canals	744
	iv)Tanks	412
	v) Other sources	697
	vi) Area Irrigated more than once	2880
7.	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on March'2019)**	
	i) No of Dug wells	40
	ii) No of Piezometers	6

8. PREDOMINANT GEOLOGICAL FORMATIONS

Gondwana Supergroup (Sandstone, shale, coal)

Basement Crystallines (Granites, Gneiss, Schists & metamorphic)

9. HYDROGEOLOGY

i) Major Water Bearing Formations	Weathered & fractured sandstone, shale, siltstone, and Granite gneisses.
ii) Pre-monsoon Depth to Water Level	3.8 to 13.8 mbgl
iii) Post-monsoon Depth to Water Level	1.4 to 12.3 mbgl
iv) Long Term Water Level Trend for 10 yrs (2008-2017 Vs 2018) in m/yr	**Post-monsoon-**Fall: 0.006 to 0.02 Rise 0.01

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

i) No of Wells Drilled	EW: 25, OW: 11
ii) Depth Range (m)	20.65 - 318
iii) Discharge (litres per second)	Neg to 10.5
iv) Transmissivity (m^2/day)	1.35 – 97.87

11. GROUND WATER QUALITY

i) Presence of Chemical Constituents	EC for Shallow aquifer is 40 to 1016 and for deeper aquifer is 84 to 1026 µS/cm at 25°C , P^H- 6.7 to 8.09 All the chemical constituents are well within permissible limit.
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	6368.46
ii) Total Annual Ground Water Extraction	2480.64
iii) Ground Water Resources for Future use	3830.98
iv) Stage of Ground Water Development	38.95 %
v) Category	Safe

13. AWARENESS AND TRAINING ACTIVITY Nil

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

16. MAJOR GROUND WATER PROBLEMS AND ISSUES

(i) In active coal-mining areas where huge quantity of groundwater is regularly pumped during mining, it's impact on the ground water regime is appreciable in & around Nawapara.

(ii) In some areas the water level remains more than 5m in the post-monsoon period in this block which may be a matter of concern in future.

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 Dharamjaigarh block 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 DHARAMJAIGARH BLOCK, RAIGARH DISTRICT, CHHATTISGARH" " is prepared by Sh. A.K.Biswal, Scientist-D (CGWB,NCCR,Raipur) and is the result of untiring efforts Sh. S.Acharya, Sc-D, (CGWB,SER,Bhubaneswar). 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 Dharamjaigarh block 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.

Sh.A.K.Biswal
(REGIONAL DIRECTOR (I/C))

EXECUTIVE SUMMARY

The Dharamjaigarh block covers a geographical area of 1537.69 sq. km. It is situated in the North Western part of Raigarh district in Chhattisgarh lying between $22^0$03' and $22^0$47'30'' N latitudes and $83^0$02' and $83^0$47'30''' E longitudes comprising 118 village panchayats and 189 villages. According to 2011 census the total population of the block is 179,748. About 15.85 % of the net sown area is irrigated by all sources. Ground water contributes nearly 33.28 % of the net irrigated area.

Dharamjaigarh block experiences Sub-tropical climate characterized by extreme cold in winter and extreme hot in summer. The average annual rainfall is 1517.48mm (average of last five years i.e 2012- 2017). The annual temperature varies from 100C in winter to 460C in summer. The relative humidity Varies from 85 % in rainy season to 35-40 % during winter. The block is mainly drained by the rivers- Mand ,Kurket & Korega which are perennial in nature. The drainage system in Dharamjaigarh block originates at the northern part and flow towards South direction before joining the Mahanadi river.

Geomorphologically the Dharamjaigarh block is characterized by Structural plain on Gondwana rocks, pediment and pediplain and region of plateau.. The general elevation of the plain ranges between 257 and 580 m amsl. The elevation in case of structural hills ranges from 580 to 1091 m amsl. This region has a general slope towards the south. The foothills are characterized by pediments.

Geologically Dharamjaigarh block is mainly covered by rocks of Archaean to Cretaceous age. Based on the water bearing property, the rocks of the block can be divided into (i) hard rock comprising crystalline and metamorphic rock (ii) Soft rock comprising semi consolidated rock belonging to Gondwana Super group.

The aquifer material controlling ground water flow in the block can be broadly divided into two major media (1) Porous media (Shallow Aquifer) and (2) Fractured media (Deeper Aquifer). The major aquifer groups in Dharamjaigarh block are (i) Basement crystalline and metamorphic, (ii) Gondwana Super Group.

Hydrogeologically, the shallow aquifers both in hard and semi-consolidated rock in the block are wide spread and largely in use. 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 17 m bgl. 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.

56 nos. of observation wells were established and monitored in pre & post monsoon period to access the ground water regime of the block including the national hydrograph stations. The water level analysis data indicates that the static water level of phreatic aquifer in the block during pre monsoon period is 3.8 to 13.8 mbgl with an average of 8.16 mbgl and during post-monsoon period it ranges from 1.4 to 12.3 mbgl with an average of 5.64 mbgl. The fluctuation ranges from 0.2 to 7.05 m with an average fluctuation of 2.52 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 regional ground water flow direction is towards south & south-west. 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.

As per resource estimation March 2017, the Net Annual Extractable Ground Water Recharge (Ham) in Dharamjaigarh block is 6368.46 ham. The Net Ground Water Availability for future use is 3830.98 ham. Current Annual Ground Water Extraction for all purposes is 2480.64 ham out of which 1979.39 ham is for irrigation. The overall Stage of Ground Water Extraction in the block is 38.95 %. The Annual GW Allocation for domestic Use as on 2025 is 558.09 ham. As per the NAQUIM study in the block, from supply side of ground water management, construction of 837 nos of irrigation tube wells (60 to 150 m deep with diameter of 100 to 150 mm) or 1862 nos of irrigation dug wells (5 to 20 m deep with diameter varies from 1 to 4 m) may be done 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.

Similarly in a long term sustaining basis 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 to recharge the area of deeper water level that can recharge 11.72 mcm ground water.

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. The ground water of Dharamjaigarh block in overall is calcium-magnesium-bicarbonate (Ca-Mg-HCO3) and calcium-sulphate (Ca-SO4) type for shallow aquifer & calcium-bicarbonate (Ca-HCO3) type for deeper aquifer respectively.

ACKNOWLEDGEMENT

The author is grateful to Shri G C Pati, Chairman, Central Ground Water Board for giving opportunity for preparation of the National Aquifer Mapping & Management report of Dharamjaigarh block, Raigarh district, Chhattisgarh. I express my sincere gratitude to Shri G.L.Meena, Member (WQ & WTT) & Sh. S.Marwaha, Member (Scientific), CGWB for giving valuable guidance, encouragement and suggestions during the preparation of this report. The author is thankful to Dr. S.K.Samanta, Head of the Office, Central Ground Water Board, NCCR, Raipur extending valuable guidance and constant encouragement during the preparation of this report. The author is also thankful to Sh. A.K.Patre, Sc.D; Sh. J.R.Verma, Sc.D; Smt.Priyanka Sonbarse , Sc-B; Sh.R.K.Dewangan, Sc-B & Sh. Uddeshya Kumar, Sc-B and other officers and officials of all the sections of the office for the help rendered & for providing the needful data during the preparation of this report on "AQUIFER MAPPING & MANAGEMENT PLAN IN DHARAMJAIGARH BLOCK, RAIGARH DISTRICT, CHHATTISGARH".

A.K.Biswal

Scientist-D

AQUIFER MAPPING AND MANAGEMENT PLANS
IN DHARAMJAIGARH BLOCK, DISTRICT-RAIGARH, CHHATTISGARH

CHAPTER-1
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 multi disciplinary 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 Dharamjaigarh block was studied under NAQUIM program in 2015-16.

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 25 nos. of exploratory wells & 11 nos of observation wells were drilled by CGWB and through outsourcing in various periods in different formation, 56 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 55 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 Aquifer 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 Salient Information:

Dharamjaigarh Block is situated in the north western part of Raigarh district of Chhattisgarh and is bounded on the north by Sarguja district, in the west by Korba district, in the east by Ghargoda & Lailunga block and in the south by Kharsia and Raigarh block. The area lies between $22^0$03' and $22^0$47'30'' N latitudes and $83^0$02' and $83^0$47'30''' E longitudes. The geographical extension of the study area is 1537.69 sq.km representing around 22.5 % of the district's geographical area.

Administrative map of the block is shown in **map-1**. Mond, Kurket & Koerga river flowing southwards along with its tributaries forms the major drainage system of the block. The drainage system of the block is a part of Mahanadi basin. Drainage map is shown in **map-2**.

1.5 Population:

The total population of Dharamjaigarh block as per 2011 Census is 179748 out of which rural population is 166150 living in 189 nos of villages while the urban population is 13598. The decadal growth rate of the block is 18.72 as per 2011 census. The population detail is given in table-1 below –

Table- 1: Population Break Up

Block	Total population	Rural population	Urban population	Nos of Villages/ village panchayats
Dharamjaigarh	179,748	166,150	13,598	189/118

Source: CG Census, 2011

1.6 Rainfall:

The study area 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 months of July and August are the heaviest rainfall months and nearly 95% of the annual rainfall is received during June to September months. Average annual rainfall in the study area is (Average of the last five years i.e. 2012 to 2017) 1517.48 mm with 50 to 60 rainy days. The rainfall detail is presented in table-2.

Table-2: Annual Rainfall (mm) in Dharamjaigarh block 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
Average	1517.48				

Source: Land and Revenue Department, Raigarh district

1.7 Agriculture and Irrigation:

Agriculture is practiced in the area during kharif and Rabi season every year. During the Kharif, cultivation is done through rainfall while during the Rabi season; it is done through ground water as well as partly through surface water like canals and other sources. The groundwater abstraction structures

are generally dug wells, Bore wells /tube wells. The principal crops in the block are Paddy, Wheat and pulses.

In some areas, double cropping is also practiced. The landuse (agricultural) pattern, cropping pattern and details of area irrigated in Dharamjaigarh block is given in Table 3 (A, B, C, D).

Table-3 (A): Land use pattern in Dharamjaigarh block during the year 2016-17(in ha)

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
Dharamjaigarh	42014	13499	16096	5981	23400	2970	49611

Source: District Statistical Book-2017

Table-3 (B): Cropping pattern in Dharamjaigarh block during the year 2016-17(in ha)

Blocks	Kharif	Rabi	Cereal				Pulses	Tilhan	Fruits /Vegetables	Mirch Masala	Sugar-cane
			Rice	Wheat	Jowar & Maize	Others					
Dharamjaigarh	46074	3537	36939	72	453	697	6838	3554	98	114	24

Table-3 (C): Area irrigated by various sources in Dharamjaigarh block during the year 2016-17(in ha)

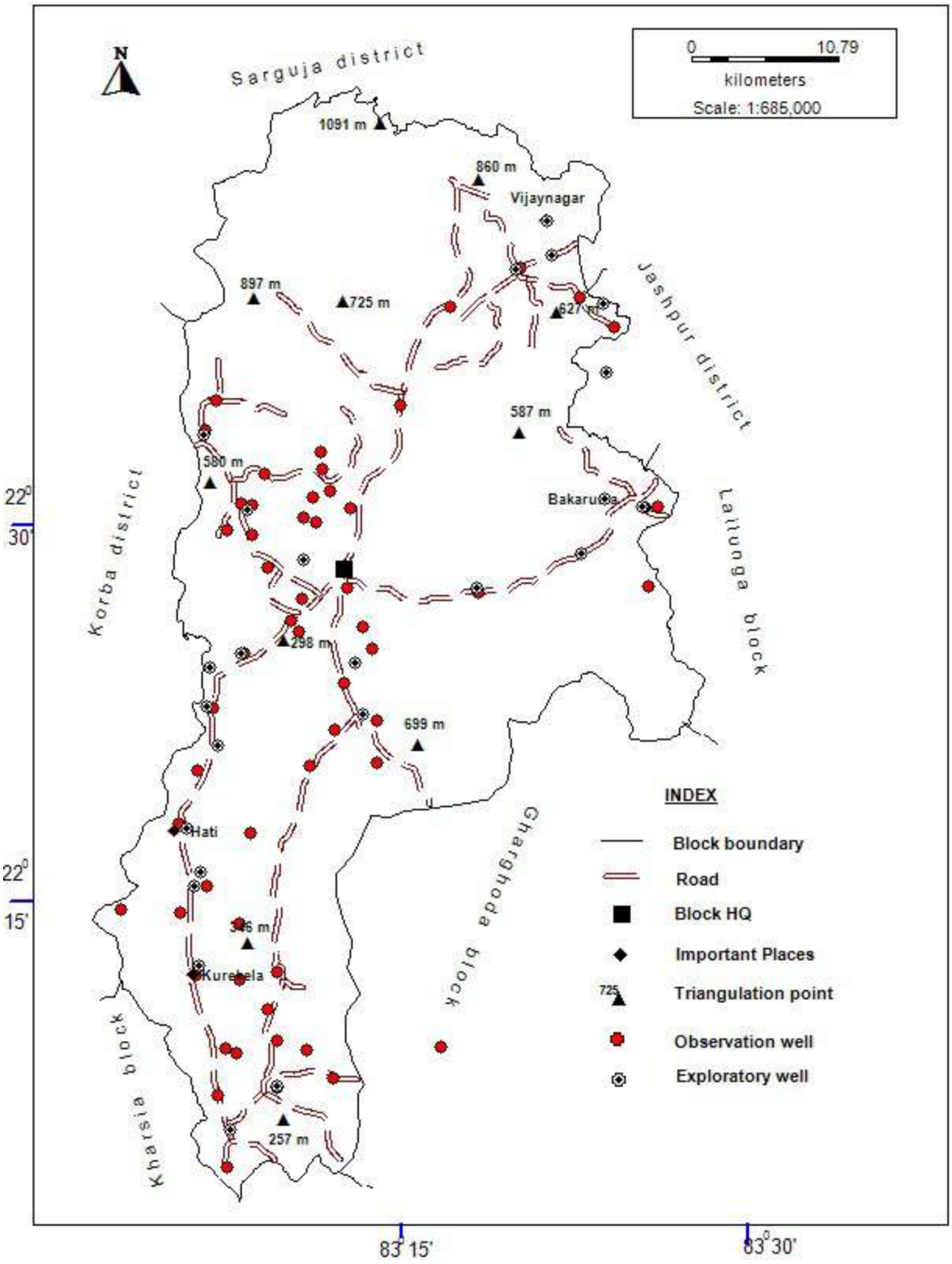
Blocks	Canal (private and Govt.)		Bore wells/ Tube wells		Dug wells		Talabs		Irrigated area by other sources	Irrigated area by GW sources	Net Irri-gated area	Irrigated area more than once	Gross irrigated area	% of Net irrigated area to net area sown
	Nos	Irrigated area (ha)	Nos	Irrigated area	Nos	Irrigated area	Nos	Irrigated area						
Dharamjaigarh	14	744	491	967	955	267	151	412	1276	1234	3708	2880	4050	15.85

Source: District Statistical Book-2017

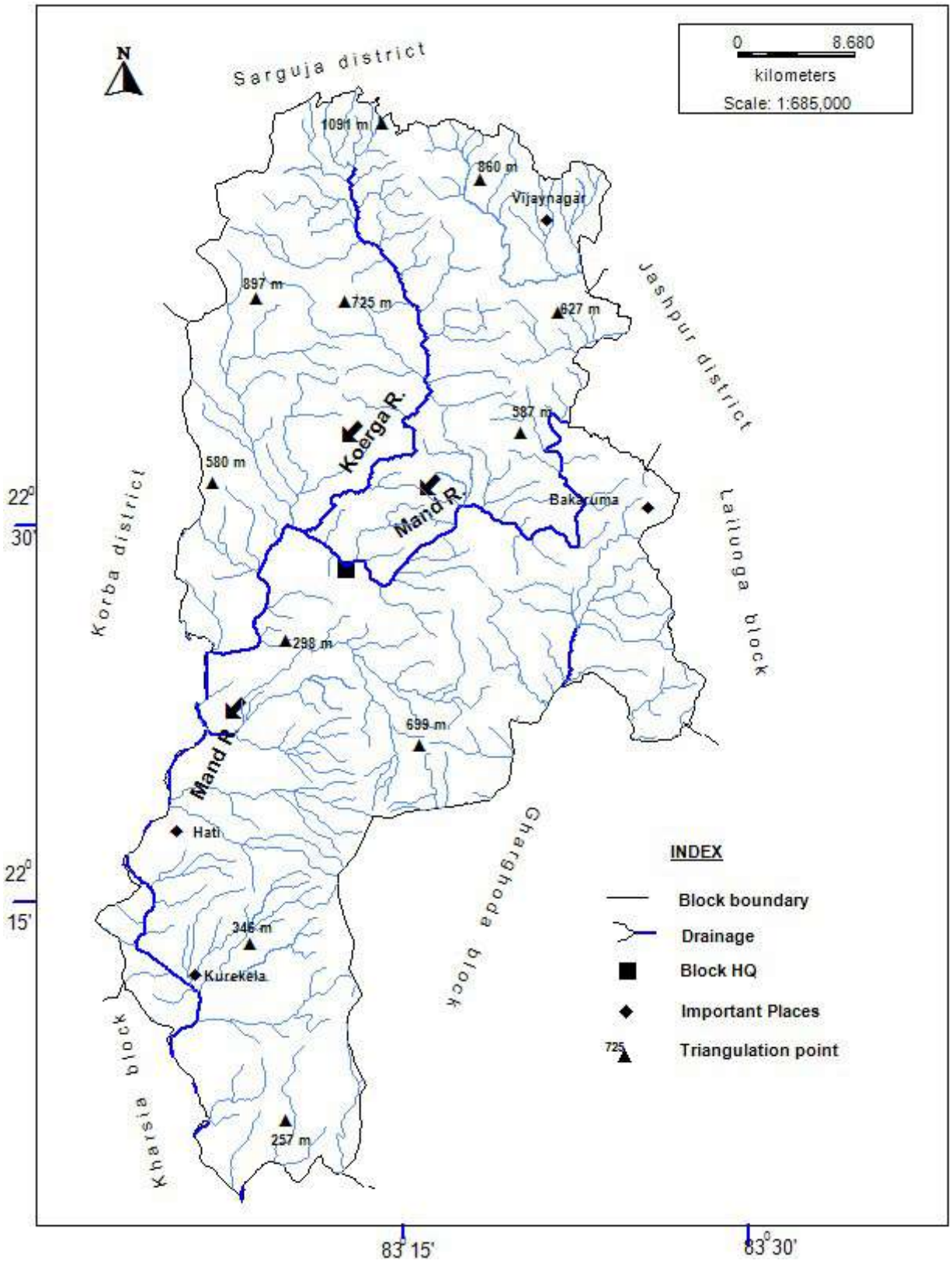
Table 3 (D): Statistics showing Agricultural land Irrigated

Block	Net Irrigated Area	Net Irrigated Area by ground water	Percentage of Area Irrigated by ground water
Dharamjaigarh	3708	1234	33.27 %

Map-1: Administrative map of Dharamjaigarh block



Map-2: Drainage map of Dharamjaigarh block



CHAPTER-2

DATA COLLECTION & GENERATION

2.1 Introduction:

About 25 nos. of exploratory wells drilled by CGWB and through outsourcing in various periods in different formation (table-4), 56 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 55 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 of Dharamjaigarh block.

Table-4: Status of exploration (EW) in Dharamjaigarh block (formation wise)

Block	Gondwana formation	Gunderdih Shale	Charmuria Limestone	Chandrapur Sandstone	Crystallines	Total
Dharamjaigarh	16	-	-	-	9	25

2.2 Exploration:

Hard and soft rocks need separate well design. Since Dharamjaigarh block is mostly covered by consolidated as well as semi-consolidated rock, so well construction is done with DTH as well as rotary drilling methods. 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. During the exploration, cutting materials are collected in every 3 m interval of depth and kept in a wooden box prepared for the sample collection. These rock cutting materials are observed carefully and accordingly a litholog is prepared which represents the depth wise rock type at that point. 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 exploratory well is given in **Annexure-I.**

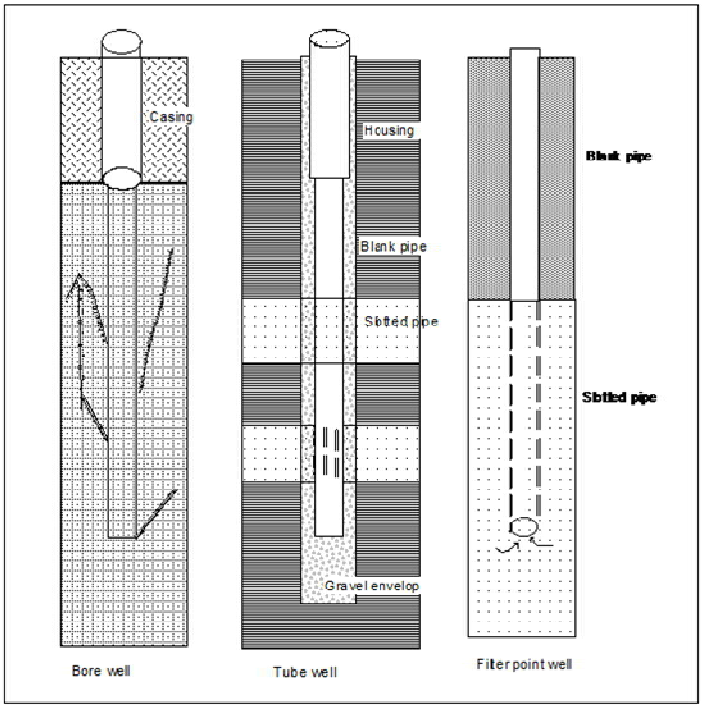
2.2.1 Well design:

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. 1).**

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-1: Well Design



2.3 <u>Water Level data</u>:

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. To study the

ground water behavior, CGWB has established some dug wells and piezometers as observation wells known as national Hydrograph station (NHS) which are monitored regularly with respect to static water level and quality from 1969 onwards. The density of observation wells was increased year after year. During the present survey 56 nos of observation wells including NHS were monitored. The NHS are monitored four times in a year and the newly established key observation wells were monitored two times (Pre-monsoon & Post-monsoon). The time period of monitoring is as follows:

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

The water samples from these wells were collected in pre-monsoon period and were analysed to ascertain the chemical quality. 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 are listed by administrative unit in the state hence the block 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. The 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**.

2.4 Hydrochemical data:

The hydrochemical analysis of the ground water of the block was based mostly on the analysis of 55 nos of ground water samples collected during the survey and exploration from key observation wells as well as exploratory wells (**Annexure-III A & B**). The parameters analysed were EC, pH, Ca^{+}, Mg^{+}, Na^{+}, K^{+}, CO_3^{--}, HCO_3^{-}, Cl^{-}, SO_4^{--}, NO_3^{-} and F^{-}. During the year 2016, ground water samples from ground water monitoring wells of CGWB in Dharamjaigarh block 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 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, SO_4 and F by Spectrophotometer, NO_3 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 Dharamjaigarh block. With respect to the results the suitability of ground water for drinking, agriculture and industrial purposes has been described. 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.

2.5 <u>Achievement</u>:

To understand the regional hydrogeological behavior of Dharamjaigarh block, 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. However, for better delineation of the aquifer characteristics, the lithologs and pumping test results of same formation but in neighboring blocks are taken into consideration. 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 Dharamjaigarh block.

CHAPTER-3

AQUIFER DISPOSITION

3.1 Principal & Major aquifer groups:

The aquifer material controlling ground water flow in Dharamjaigarh block can be broadly divided into two major media (1) Porous media (Phreatic Aquifer) and (2) Fractured media (Deeper Aquifer). The phreatic aquifer both in hard and soft rocks in the block is wide spread and largely in use. This aquifer is being tapped mainly through dug well up to a depth of 20 m broadly. 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 block are deciphered. The major aquifer groups in Dharamjaigarh block are (**Map-3**):

(i) Chhotnagpur Granite gneiss
(ii) Gondwana Sandstone

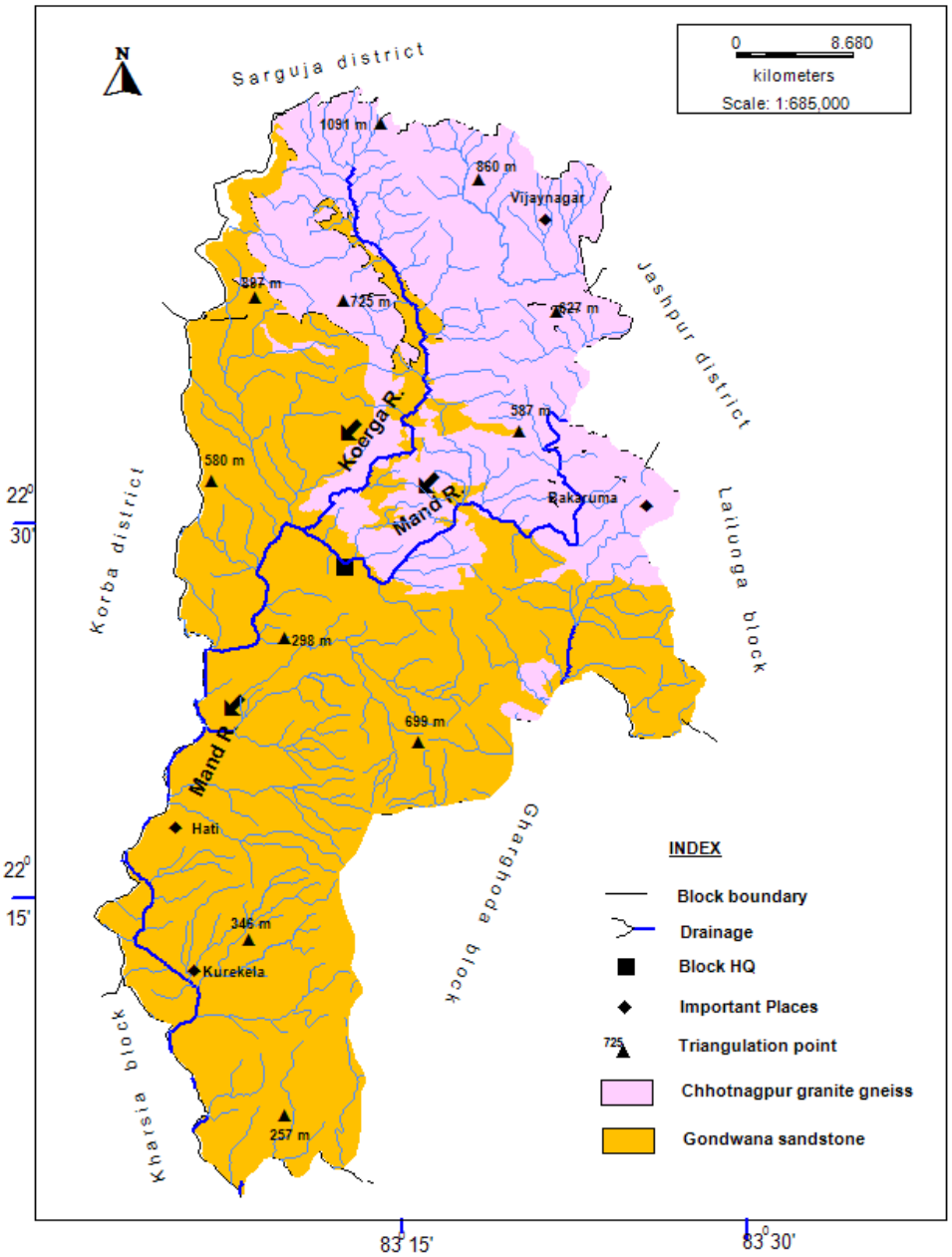
(i) Chhotnagpur Granite Gneiss : These crystalline and metamorphic rocks mainly occur along the northern boundary of the block. The average yield of Granite gneiss is 1.42 lps with transmissivity of 1-12 m^2/day & average drawdown is 26.15 m. One to two sets of potential fracture zone mostly lie beyond 100 m depth. The 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) Gondwana Sandstone: All the parts of the block except the northern part is 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. 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.

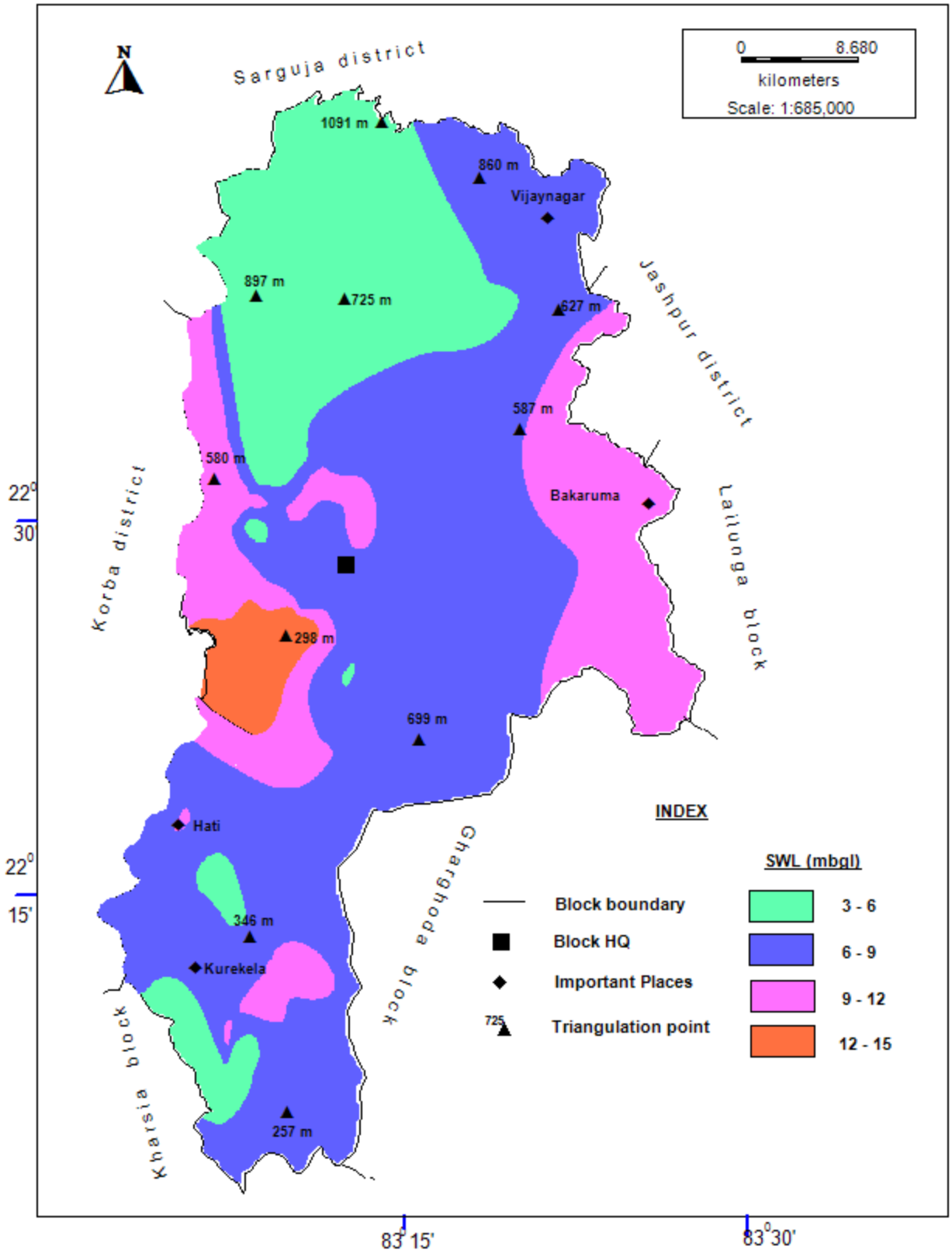
3.2 Ground Water Regime monitoring:

During the study, 56 nos. of observation wells were monitored (Annexure-II) both in pre-monsoon and post-monsoon period. The water level analysis data indicates that the ground water level of phreatic aquifer during pre monsoon period ranges from 3.8 to 13.8 mbgl with an average of 8.16 mbgl and during post-monsoon period it ranges from 1.4 to 12.3 mbgl with an average of 5.64 mbgl. The fluctuation ranges from 0.2 to 7.05 m with an average fluctuation of 2.52 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 water level map prepared for the district is presented in (**Map-4 A, B &C**).

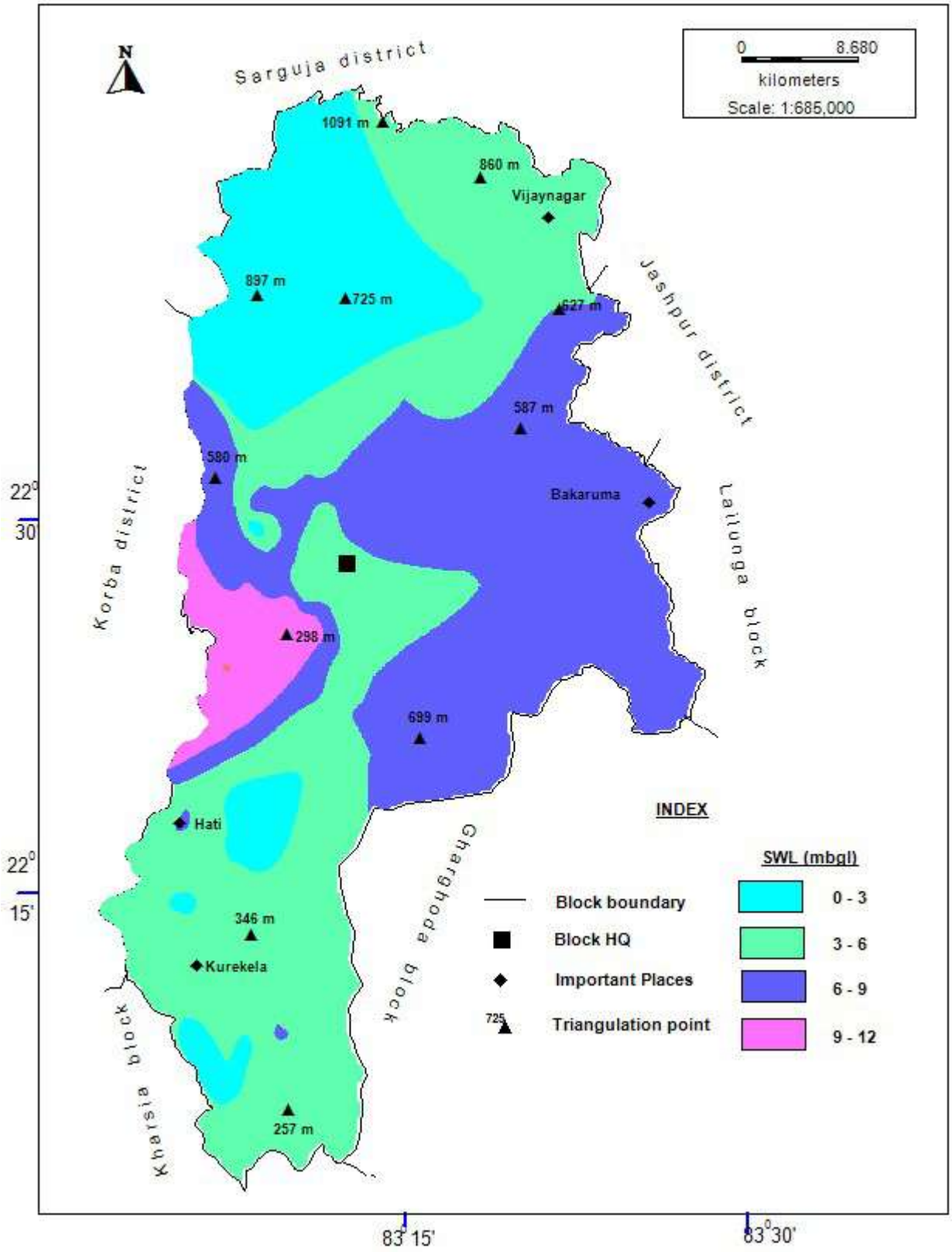
Map-3: Major Aquifer map of Dharamjaigarh block



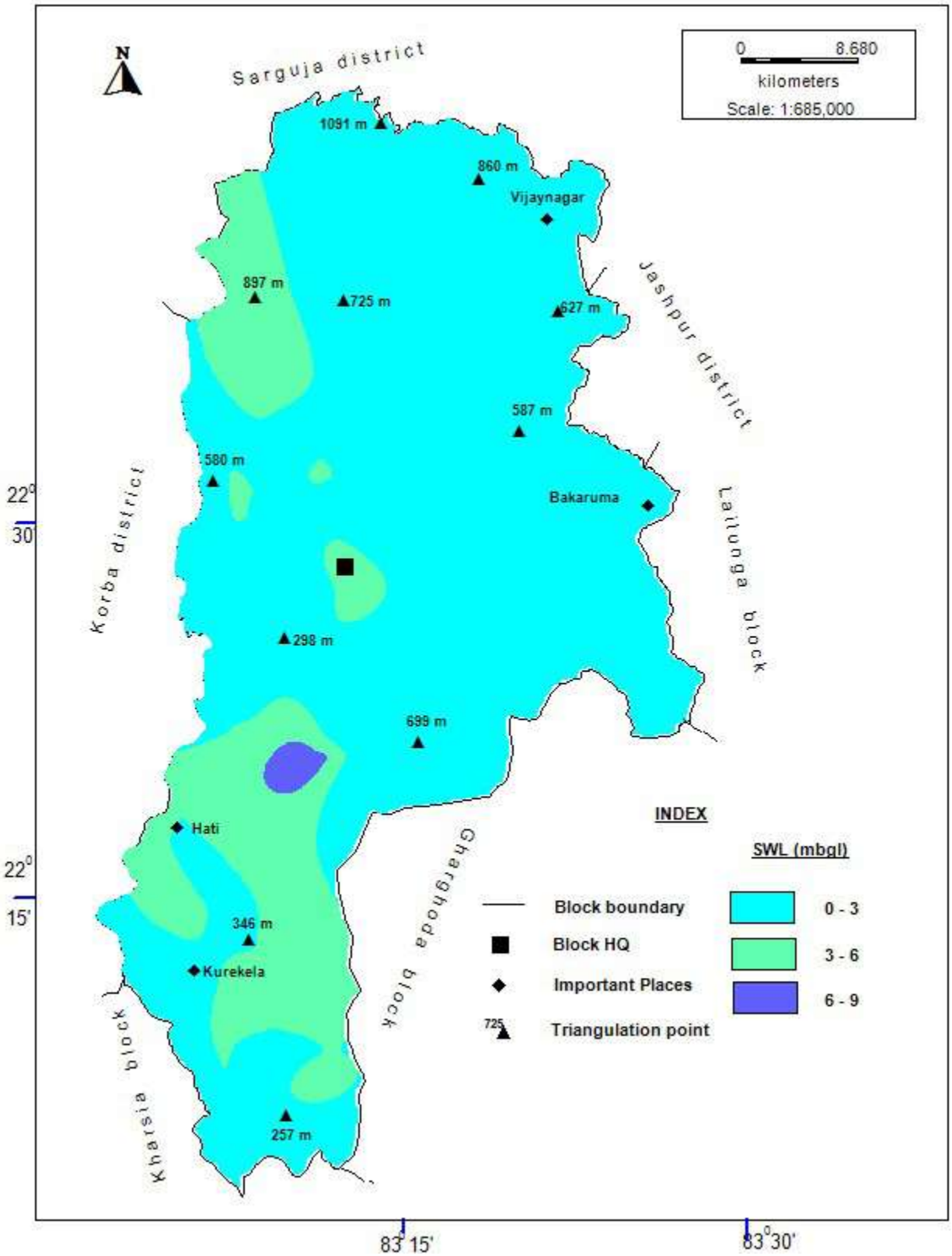
Map-4 (A): Pre-monsoon depth to water level map of Dharamjaigarh block



Map-4 (B): Post-monsoon depth to water level map of Dharamjaigarh block



Map-4 (C): Water level fluctuation map of Dharamjaigarh block



3.2.1 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 Dharamjaigarh block (Table-5). 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 indicates that 92 % of the wells show declining trend to the tune of 0.006 to 0.02 m/yr. The rising trend is shown by 8 % of wells in the tune of 0.01 m/yr. The hydrograph of some of the wells are presented in **Fig-2 A, B, C & 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.

Table-5: Ground water level trend (2009-2019) in Post-monsoon period in Dharamjaigarh block

SN	Block	Site name	Longitude	Latitude	Trend (2010-2019) postmonsoon	Remarks
1	Dharamjaigarh	Kurekela	83.1	22.2	-0.012785	Declining
2	Dharamjaigarh	Hati	83.1	22.3	0.012962	Rising
3	Dharamjaigarh	Barpali	83.27	22.33	-0.010652	Declining
4	Dharamjaigarh	Bartapali	83.17	22.33	-0.014346	Declining
5	Dharamjaigarh	Gersa	83.24	22.35	-0.011392	Declining
6	Dharamjaigarh	Amapali	83.23	22.37	-0.006782	Declining
7	Dharamjaigarh	Khadgaon1	83.12	22.38	-0.018183	Declining
8	Dharamjaigarh	Sisringa	83.31	22.46	-0.013918	Declining
9	Dharamjaigarh	Dharamjaigarh PZ	83.21	22.46	-0.012405	Declining
10	Dharamjaigarh	Bakaruma	83.44	22.51	-0.007178	Declining
11	Dharamjaigarh	Golabuda	83.4	22.63	-0.020439	Declining
12	Dharamjaigarh	Kapu	83.34	22.67	-0.012581	Declining
13	Dharamjaigarh	Edu	83.13	22.08	-0.008274	Declining

3.2.2 Ground Water flow direction:

The regional ground water flow direction is towards south-west. 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.

3.3 Ground Water Resources:

The ground water Resources of Dharamjaigarh block 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.

3.3.1 Replenishable ground water resources or Dynamic ground water resources:

As per resource estimation March 2017, the Net Annual Extractable Ground Water Recharge (Ham) in Dharamjaigarh block is 2672.69 ham. The Net Ground Water Availability for future use is 922.37 ham. Current Annual Ground Water Extraction for all purposes is 1705.55 ham out of which 1111.15 ham is for irrigation. The overall Stage of Ground Water Extraction in the block is 63.81 %. The Annual GW Allocation for domestic Use as on 2025 is 415.15 ham. The block wise resource is presented in table 6.

Table-6: Resources as estimated in 2017 of Dharamjaigarh block

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)
Dharamjaigarh	6368.46	1979.39	0	501.25	2480.64	558.09	3830.98	38.95	Safe	No	

3.3.2 Static Ground Water Resources:

An attempt has been made to assess the Static Ground Water Resources Dharamjaigarh block 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-7 presents the ground water resources of Dharamjaigarh block.

Table-7: Ground water Resources of Dharamjaigarh block

Block	Recharge worthy Area (Ha)	Stage of Extraction in %	Static Resource in Ham	Dynamic Resource in Ham
Dharamjaigarh	95749	38.95	2982.007	6368.460

The table shows that the total static ground water resource of Dharamjaigarh a block is 2982.007 Ham beside the dynamic ground water resource of 6368.46 ham.

Fig- 2(A): Hydrograph of Barpali

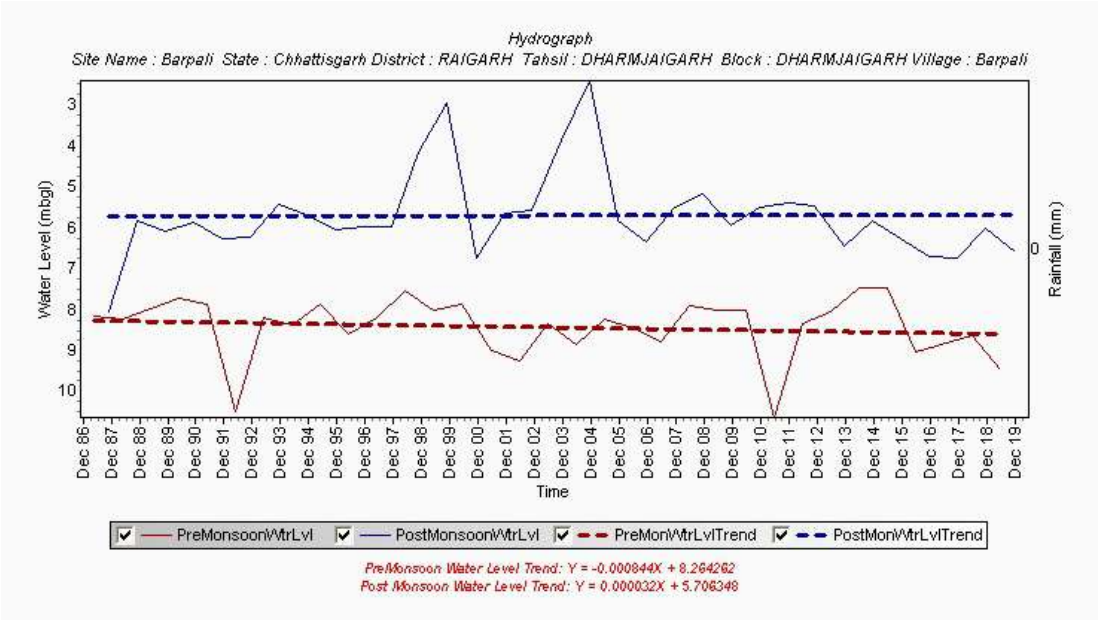


Fig- 2(B): Hydrograph of Dharamjaigarh

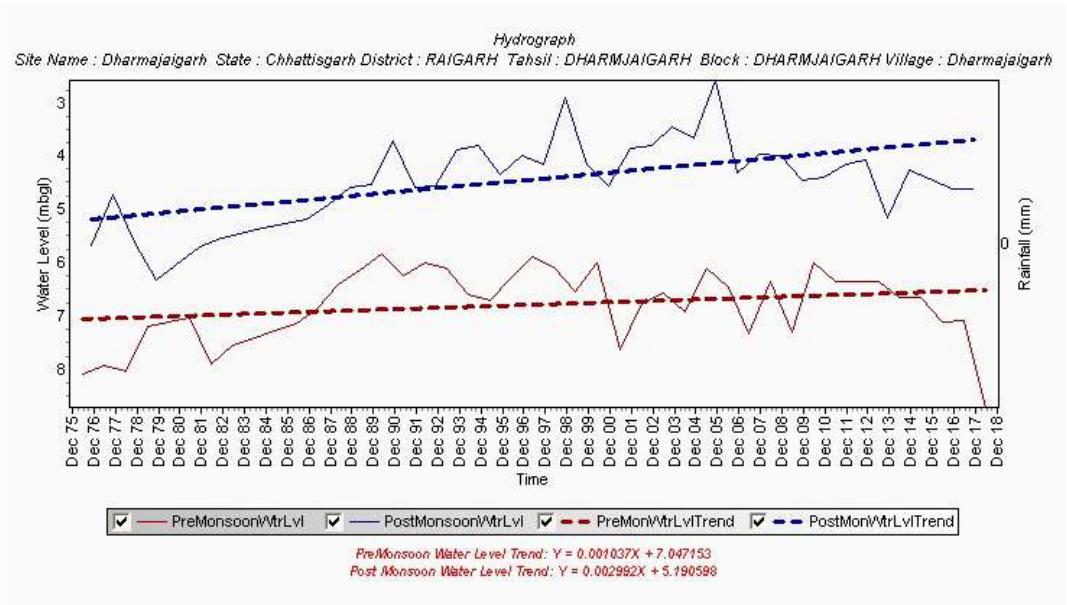


Fig- 2(C): Hydrograph of Golabuda

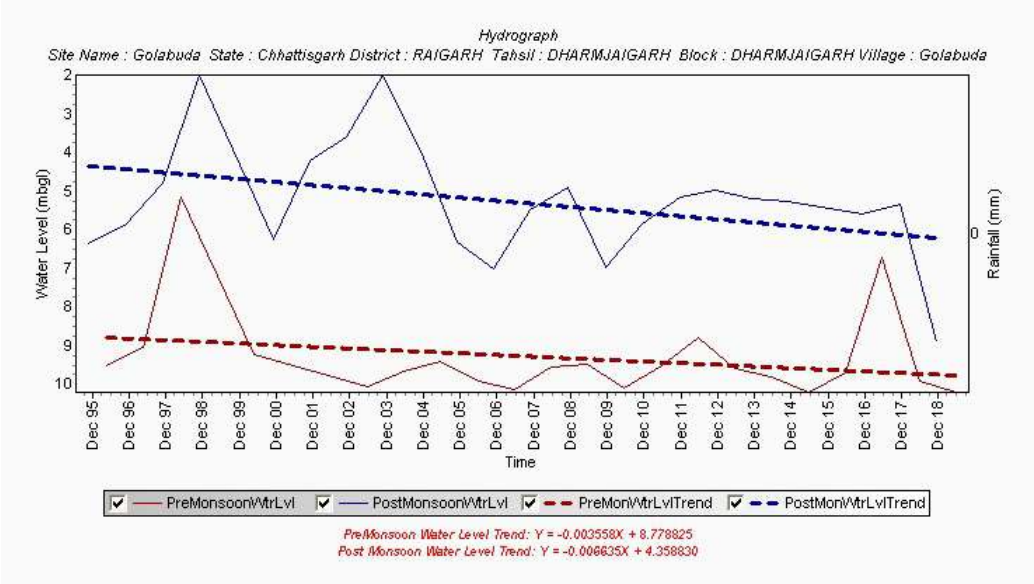
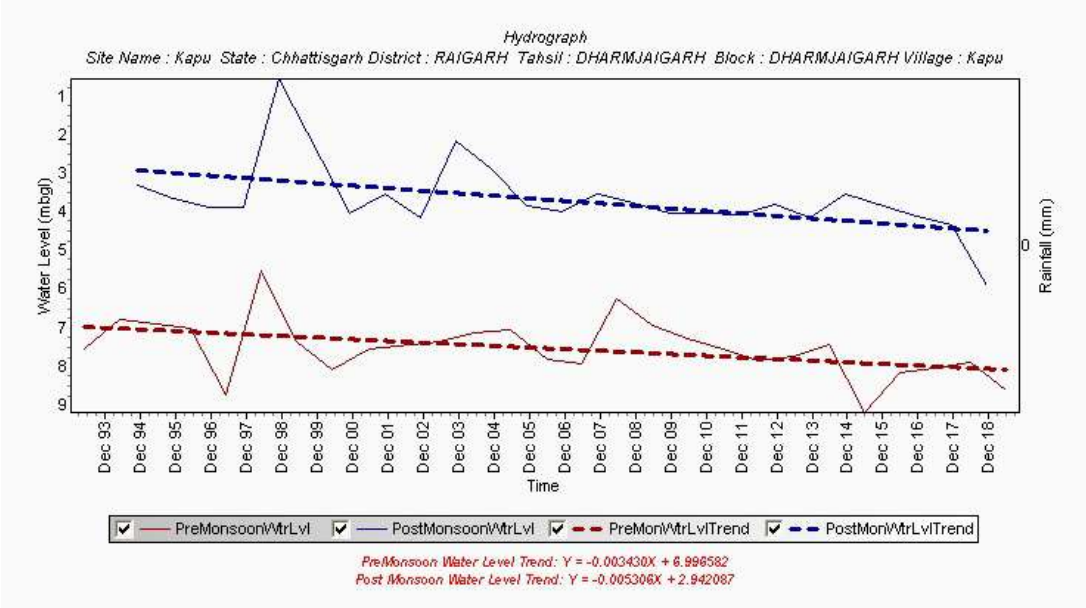


Fig- 2(D): Hydrograph of Kapu



3.4 Ground Water Quality:

Ground water quality of shallow aquifer as well as deeper aquifer in Dharamjaigarh block for drinking, irrigation and industrial purposes is assessed on the basis of analysis of ground water samples collected from 40 nos. of observation wells for shallow aquifer & 15 exploratory wells for deeper aquifer (**Annexure-III A & B**). Apart from these, water samples were also analysed to assess the arsenic and uranium contamination respectively.

3.4.1 Water quality for all purposes: The concentrations of various parameters for both shallow & deeper aquifers are presented in the following table-8.

Table-8: Ground water quality data for shallow & deeper aquifer

Sl. No	Parameters (in ppm)	Shallow Aquifer		Deeper Aquifer	
		Min	Max	Min	Max
1	pH	6.7	7.5	7.01	8.09
2	EC(in µS/cm at 25° C)	40	1016	84	1026
3	Total Alkalinity	14.75	235.24	19.67	350
4	HCO_3	18	287	24	427
5	Cl	7	188	7	113
6	SO_4	0.9	145	0	48
7	F	0	1.9	0	0
8	TH	25	390	20	360
9	Ca	6	106	2	128
10	Mg	0	38.4	2.4	19
11	Na	0.8	107.5	7	82
12	K	0.2	34.5	0.7	2.2

The above table-5.5 indicates that the ground water of Dharamjaigarh was found suitable for drinking purposes, irrigation as well as industrial purposes.

3.4.2 Arsenic contamination: No arsenic contamination in ground water is found in any ground water sample collected in Kharsia block.

3.4.3 Uranium contamination: The ground water in Dharamjaigarh block is safe from Uranium contamination point of view.

3.4.4 Type of Ground Water: The ground water of Dharamjaigarh block 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.

3.5 Ground Water Issues:

I. In active coal-mining areas where huge quantity of groundwater is regularly pumped during mining, it's impact on the ground water regime is appreciable in & around Nawapara.

II. In some areas the water level remains more than 5m in the post-monsoon period in this block which may be a matter of concern in future.

CHAPTER-IV

AQUIFER MAPPING & MANAGEMENT PLAN

4.1 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 Dharamjaigarh block were prepared:

(i) Aquifer map 2-dimensionsl, (**Map-5 A,B,C)**
(ii) Ground water Development Potential & Artificial Recharge Prospect (**Map-6)**

4.2 Status of Ground Water Development Plan:

(i) The ground water development in the block 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.

(ii) Since the stage of ground water extraction for Dharamjaigarh block is 20.66%, the block can be developed through tube wells and dug wells both to achieve the stage of extraction 60%. The Gondwana formation may be developed through tube wells. The granitic area may be developed through dug wells only. The following table-9 depicts the numbers of ground water abstraction structure to be constructed for further development in the block.

Table-9: Irrigation tube wells and dug wells to be constructed in Dharamjaigarh block

Block	Stage of ground water extraction (%)	Number of TW Recommended (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)
Dharamjaigarh	38.95	837	1862	1489.5	3351.5	4465.7

(iii) The stage of ground water development for Dharamjaigarh block is 38.95 % and it has been observed from there is deeper post monsoon water level in shallow aquifer zone at many places. So in these places here the post monsoon piezomteric head is below 10 mbgl, artificial recharge structures can be constructed in a long term basis to arrest the non-committed run-off to augment the ground water storage in the area. The details of artificial recharge structures to enhance ground water resource are presented in the table-10 respectively.

Table-10: Details of AR structures in Dharamjaigarh block

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
Dharamjaigarh	27	89	214	160	11.72

From the table 9, it is depicted that 837 nos of irrigation tube wells or 1862 nos of irrigation dug wells or combination of these two may be constructed in the block that can likely to create an irrigation potential of 1489.5 ha for paddy, 3351.5 ha for wheat, Ground Nut, Sunflower and 4465.7 ha for Mustard & Pulses respectively.

From the table 10, it is depicted that 27 nos. of percolation tank, 89 nos. of nala bunding/ cement plug/check dams , 241 nos. of recharge shafts and 160 nos. of gully plug/gabion structures may be constructed at suitable locations that can enhance the ground water source to 11.72 mcm more.

(iii) Ground water coming out as mine dewatering can be utilised to control the impact of mine dewatering by creating garland recharge well system (**Fig-3**). In this system about 16 nos of recharge wells of 100 m depth may be constructed around 500 m radius of the open cast coal mine at 200 m apart each so that the extracted ground water through continuous pumping from the mine can be recharged to underground to maintain the ground water level in and around the mine.

(iv) Field to field irrigation (flooding method) should be replaced with channel irrigation in command area as there is about 30-40% conveyance loss in field irrigation. Same amount of water can be saved through channel irrigation.

(v) Information, education and Communication (IEC) activities such as mass awareness programs to be organized to sensitize people on the issues of depleting groundwater resource, spacing criteria between ells, shifting from summer rice to Maize/ Ragi, to save ground water for future generation, advantages of taking such crops, crop methodology and its related aspects.

(vi) In command or non-command area wherever ground water has been used for field irrigation should be replaced immediately with micro irrigation methods such as sprinklers, drip irrigation etc.

(vii) Government should provide attractive incentives and subsidies to encourage farmers to take up alternative crops to paddy, which are equally profitable and adopt micro-irrigation practices such as drip and sprinkler irrigation.

(viii) The practice of providing free electricity to operate irrigation bore wells should be strictly monitored and put to an end in case of overconsumption.

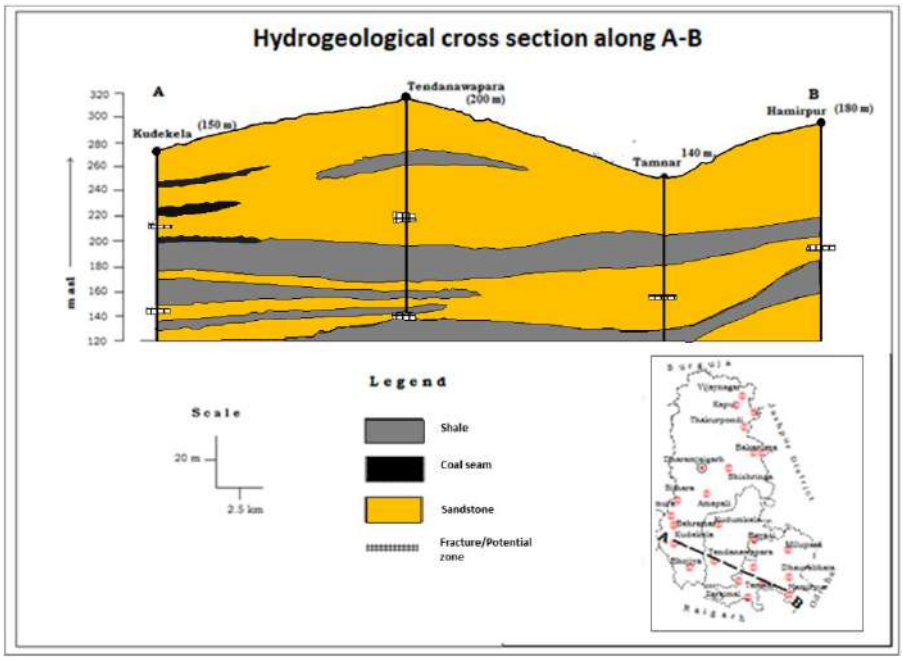
(ix) Even if farmers use solar pump or other method of ground water irrigation for summer paddy, it should not be flooding method. Proper pipes are to be used to transfer water from one plot to another.

(x) Govt. may set up network of grids to purchase electricity generated from solar panels. This will encourage the farmers not to waste electricity by extracting groundwater unnecessarily and also provide alternative income.

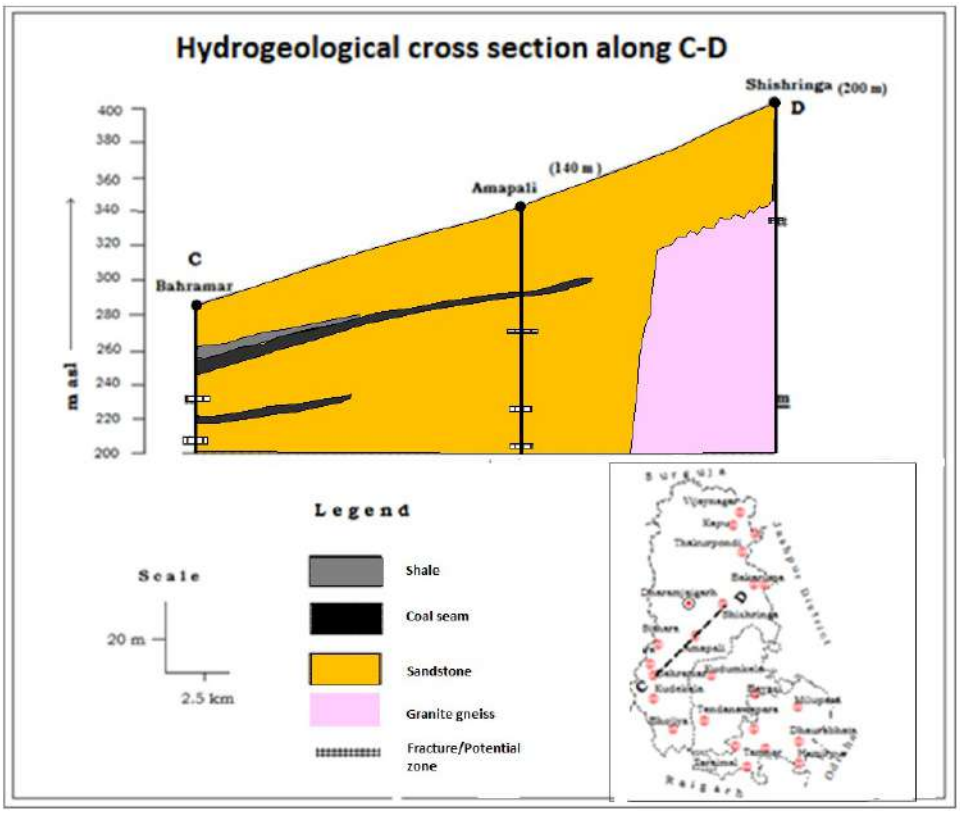
(xi) Supports for the technology development for harvesting and disposal of by-products in agriculture fields which will also increase the fertility of soil.

(xii) Furthermore, in order to strike a balance between the ground water draft and the available resource, suitable artificial structures at appropriate locations be constructed through successive phases after tentatively every 20nos of groundwater abstraction structures become operative.

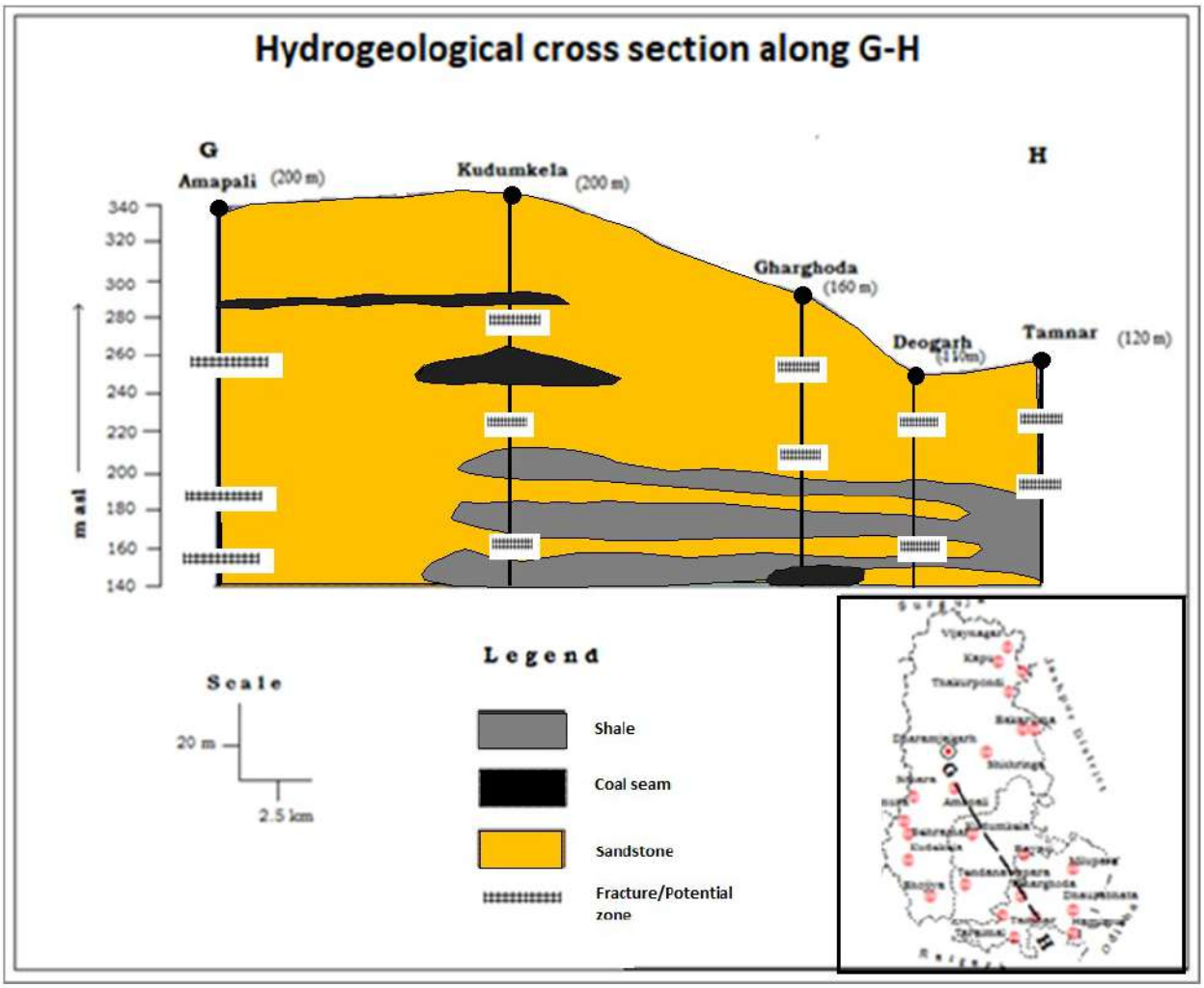
Map-5 (A): Hydrogeological cross section in NE-SW direction



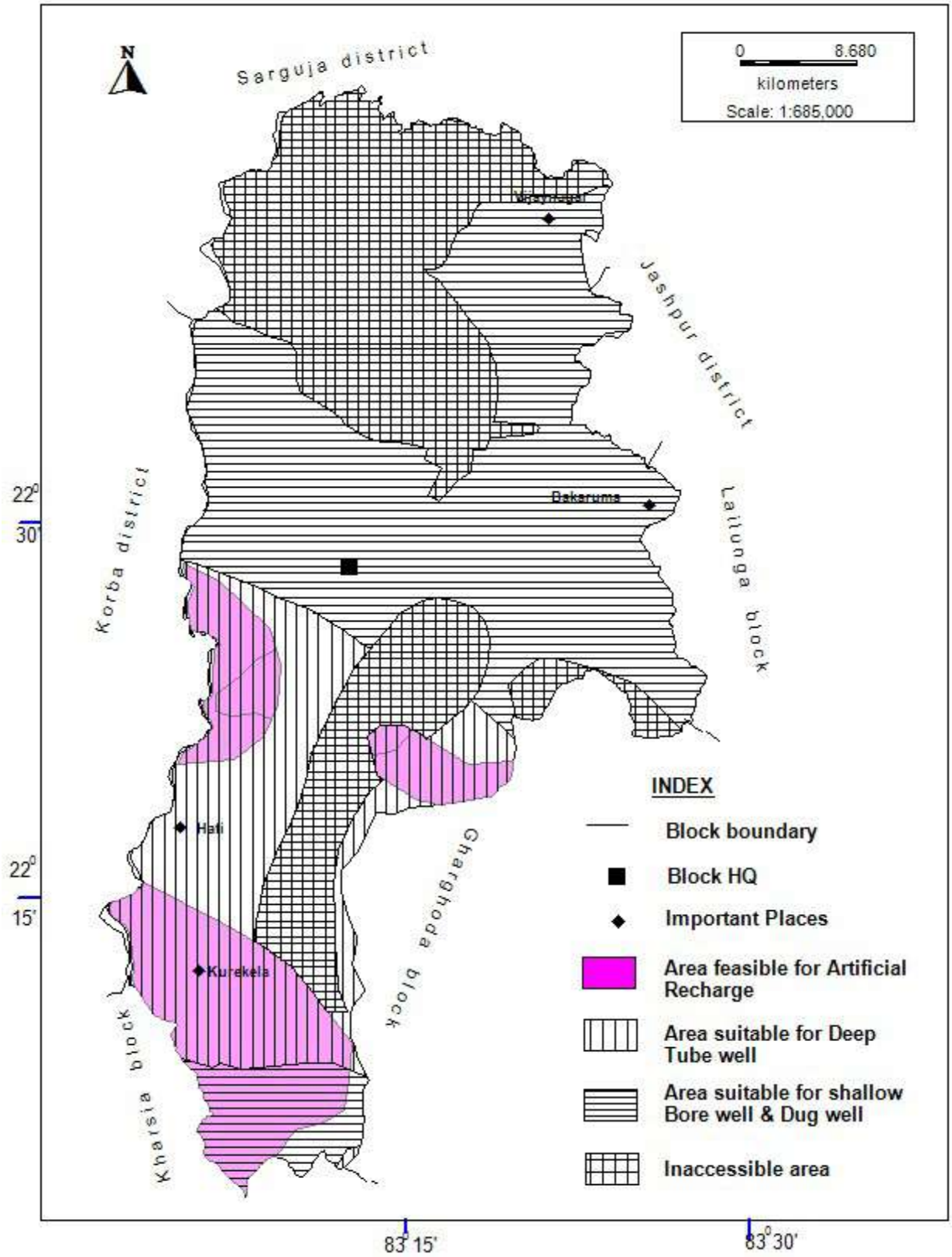
Map-5 (B): Hydrogeological cross section in NE-SW direction



Map-5 (C): Hydrogeological cross section in NE-SW direction Dharamjaigarh, Ghorghoda & Tamnar blocks



Map-6: Ground Water Development prospect map of
Dharamjaigarh block



CHAPTER-V

SUM UP

5.1 Conclusions:

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.

5.2 Recommendations

- Since the stage of ground water development for Dharamjaigarh, from supply side of ground water management, construction of 837 nos of irrigation tube wells (60 to 150 m deep with diameter of 100 to 150 mm) or 1862 nos of irrigation dug wells (5 to 20 m deep with diameter varies from 1 to 4 m) may be done 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.

- Similarly in a long term sustaining basis 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 to recharge the area of deeper water level 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.

REFERENCES

- Aquifer systems of Chhattisgarh, Central Ground Water Board, Govt. of India, 2012
- Agrawal AP. (1981) GSI Sp.Publicatios No.3, pp- 135-140
- CGWB,(2011), Geophysical Report, North Central Chhatisgarh Region, CCGWB, Raipur
- CGWB,(2018), Ground Water Year Book, Chhattisgarh-2017-18, CGWB, NCCR, Raipur
- CGWB, (2018), State Chemical report ,Chhattisgarh-2017, CGWB, NCCR, Raipur
- CGWB, (2018) Ground Water Exploration, Chhattisgarh-2017, CGWB, NCCR, Raipur
- CGWB, (2019), Master Plan for Artificial Recharge in Chhattisgarh State.
- Dinesh Tewari and Arunangshu Mukherjee (2005), Ground Water Resources and Development Potential of Raigarh district, Chhattisgarh. SHS unpublished report of CGWB, NCCR, Raipur.
- Dyanamic Ground water Resources of Chhattisgarh as on March 2013, North Central Chhatisgarh Region, CCGWB, Raipur.
- Dyanamic Ground water Resources of Chhattisgarh as on March 2017, North Central Chhatisgarh Region, CCGWB, Raipur.
- Hydrogeology of Chhatisgarh, 2014, State report, North Central Chhatisgarh Region, CCGWB, Raipur
- Karanth K.R. (1987) Ground water assessment development and management, the Tata Mc.Grow-hill publication, New Delhi
- Water Quality assessment for Drinking and Irrigation Purpose, Priyanka Tiwari, Indian J.Sci.Res. 13 (2):140-142, 2017.
- District Statistical Book (Raigarh)-2017, Government of Chhattisgarh.

ANNEXURE-I: Exploration details in Dharamjaigarh block

SL.NO	LOCATION	TYPE	LAT	LONG	DEPTH (m)	CASING (m)	FORMATION	ZONE ENCOUNTERED	YIELD (lps)	DRAW DOWN (m)	TRANSMISSIVITY IN m^2/sec	STORATIVITY
1	Amapali	EW	22.375	83.225	278.83	265	Barakar	63-78,84-89,102-124,130-139,142-145,151-175,177-182,188-194,197-213,216-224,242-262	4.925	21.86	97.87	0.000786
2	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	Bojiya	EW	22.1294	83.1628	318	75	Barkar Fm	35-43,54-72	1			
4	Hati	EW	22.3	83.0978	305.15	283	Barkar Fm	175-190.5,219-225.5,252-260.5,274.5-280	3.47	28.21	15.686	
5	Kudekala	EW	22.2083	83.1069	293.33	138	Barkar Fm	47-67,72-75,94-102,124-135	6.3			
6	Sithra	EW	22.3542	83.1208	302.37	213	Barakar Fm	63-90,95-107,112-130,160-169,171-177,183-210	6.3			
7	Baiyamura	EW	22.2617	83.1033	201		Baraker Fm					
8	Kherpali	EW	22.1	83.13	201		Baraker Fm					
9	Bakaruma	EW	22.5122	83.4247	171	6	Biotite gneiss	28-29,114-115	1			
10	Rairuma	EW	22.5172	83.3978	185	14	Biotite gneiss	89-92	1			
11	Tejpur	EW	22.4817	83.3814	74	12	Biotite gneiss	50-51,71-74	1			
12	Lipti	EW	22.6467	83.3967	140	12	Biotite gneiss	15-17	0.5			
13	Thakurpondi	EW	22.6006	83.3983	185	20.5	Biotite gneiss	14-17,131-134	1			
14	Kapu	EW	22.6697	83.3344	176	20.5	Biotite gneiss	22-26	3			

15	Sonpur	EW	22.6006	83.3983	177	15	Granite gneiss		0			
16	Vijaynagar	EW	22.7014	83.3567	164	17	Granulite	17-22	1			
17	Alola	EW	22.6786	83.3592	177	14.5	Granite gneiss	14-18	1			
18	Shishringa	EW	22.4589	83.3061	176	15	Granite gneiss	53-59	1			
19	Khadgoan (EW)	EW	22.3797	83.1131	201	201	Barakar Sandstone	15-	3.17	31.37	2.27	
20	Sahpur (EW)	EW	22.4772	83.1819	201	201	Barakar Sandstone	88.2-	2.5	16.4	1.95	
21	Duliamuda (EW)	EW	22.4153	83.1375	106.5	106.5	Barakar Sandstone	66.8-	1.25	33.9	1.35	
22	Barpali (EW)	EW	22.4044	83.0714	201	201	Barakar Sandstone	57.7-	4.5	20.75	4.25	
23	Boro EW (Deep),	EW	22.56	83.11	199.54	17.05	Barakar sandstone		4			
24	Karigadai (EW)	EW	22.51	83.1419	141.5	141.51	Barakar Sandstone	27.21-				
25	Amapali OW	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	Hati OW	OW	22.3	83.0978	87		Barkar Fm	66-83	1.77			
27	Kudekela OW-I	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	Kudekela OW-II	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	Sahpur (OWI)	OW	22.4772	83.1819	201	201	Barakar Sandstone	63.8-	1.37	28.37		

30	Sahpur(OW II)	OW	22.4772	83.1819	155.2	155.2	Barakar Sandstone	79-88	0.7			
31	Bojia	OW	22.1294	83.1628	20.65		Barkar Fm					
32	Kapu	OW	22.6697	83.3344	123.00		Biotite gneiss					
33	Boro	OW	22.56	83.11	107.68		Barakar sandstone					
34	Boro	OW	22.56	83.11	54.34		Barakar sandstone					
35	Amagaon	EW	22.4088	83.21937	135	135	Barakar Sandstone		2.3	29.72	5.41	
36	Boro	OW	22.56	83.11	46.72		Barakar sandstone					

ANNEXURE-II: Static Ground Water level details in Dharamjaigarh block

S.No	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
1	Amapali	83.2342	22.3706	DW	9.00	6.55	2.45
2	Bakaruma	83.4361	22.5125	DW	11.00	8.95	2.05
3	Bojia	83.1627	22.1283	DW	7.20	4.30	2.90
4	Boro	83.1119	22.5633	DW	11.10	8.90	2.20
5	Chhal	83.12085	22.1234	DW	4.15	2.30	1.85
6	Choranga	83.46297	22.46646	DW	10.50	8.50	2.00
7	Derpani	83.2869	22.6442	DW	3.80	2.30	1.50
8	Dharmajaigarh	83.2125	22.4639	DW	8.80	4.94	3.87
9	Edu	83.1269	22.0756	DW	7.80	5.90	1.90
10	Gersa	83.2347	22.3431	DW	6.40	6.10	0.30
11	Golabuda	83.4042	22.6306	DW	9.90	8.90	1.00
12	Kandadand	83.195	22.5367	DW	9.00	4.00	5.00
13	Kapu	83.3375	22.6708	DW	7.90	5.90	2.00
14	Katangdih	83.27985	22.15508	DW	8.55	7.25	1.30
15	Khadgaon	83.1167	22.3792	DW	13.40	12.30	1.10
16	Khamhar	83.2517	22.5797	DW	8.10	6.00	2.10
17	Lipti	83.3797	22.6508	DW	6.85	4.90	1.95
18	Sirsinga	83.3069	22.4556	DW	7.80	6.00	1.80
19	Deormal	83.2028	22.134	DW	6.7	3.42	3.28
20	Kansabahar	83.1339	22.1509	DW	4.6	2.6	2.00
21	Sarasmar	83.1259	22.1542	DW	9.2	4.1	5.10
22	Maharajganj	83.0512	22.2462	DW	6.7	3.55	3.15
23	Tumkure	83.1361	22.1993	DW	8.5	3.95	4.55
24	Banhar	83.1632	22.2047	DW	9.2	3.84	5.36
25	Chutkimar	83.1559	22.1798	DW	9.9	4.2	5.70
26	Auranar	83.1628	22.1594	DW	8.6	6.2	2.40
27	Singhijhap	83.1841	22.1526	DW	8.1	5.2	2.90
28	Hati	83.0924	22.3022	DW	9.1	6.12	2.98
29	Purunga	83.1439	22.2963	DW	7	2.07	4.93
30	Sithra	83.1058	22.3381	DW	8.3	3.7	4.60
31	Duliamuda	83.1393	22.4152	DW	13.8	11.55	2.25
32	Bijapara	83.1782	22.4294	DW	13.6	10.95	2.65
33	Bayasi	83.1728	22.4371	DW	12.6	10.85	1.75
34	Taraimar	83.1813	22.451	DW	6	5.1	0.90
35	Durgapur	83.1565	22.4715	DW	8.3	6.8	1.50
36	Amagaon	83.2112	22.396	DW	5.9	4.75	1.15
37	Nawagaon	83.2039	22.3647	DW	7.35	5.7	1.65

38	Deridih	83.2314	22.4185	DW	6.4	5.57	0.83
39	Tendumar	83.2245	22.4328	DW	6.2	3.35	2.85
40	Munund	83.0934	22.2435	DW	7.9	2.85	5.05
41	Behramar	83.1123	22.2609	DW	5.1	3.5	1.60
42	Bansajhar	83.1363	22.2363	DW	5.9	4.8	1.10
43	Kudekela	83.1048	22.2029	DW	6.3	4.7	1.60
44	Pandrimahua	83.1446	22.4934	DW	4.5	2.1	2.40
45	Ududa	83.1268	22.4965	DW	8.8	7.2	1.60
46	Bartapali	83.1864	22.3411	DW	10.3	3.25	7.05
47	Lakshmipur	83.2153	22.5108	DW	9.25	7.4	1.85
48	Amelipur(amt)	83.1912	22.5023	DW	6.9	4.35	2.55
49	Chunkunidand	83.2005	22.5227	DW	10.1	8.8	1.30
50	Chandidand	83.1885	22.5181	DW	10.2	8.24	1.96
51	Dadardand	83.1815	22.5051	DW	9.3	7.4	1.90
52	Jamargi	83.1938	22.5487	DW	6.15	5.55	0.60
53	Jabga	83.1542	22.5338	DW	4.1	3.9	0.20
54	Korigarhi	83.1451	22.513	DW	9.7	8.3	1.40
55	Koradih	83.1377	22.5139	DW	9.75	4.3	5.45
56	Sangra	83.119	22.5827	DW	5.25	1.4	3.85

ANNEXURE-III (A): Chemical Quality details of Shallow aquifer in Dharamjaigarh block

S.NO.	Location	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	PO_4	SiO_2
1	Katangdih	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	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	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	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	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	6.9	129	215	0	43	35.25	25	0	5.3	14	8.4	5.5	0.2	70	0.14	4
7	Bojia	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
8	Auranar	6.9	24	40	0	18	14.75	7	0	1.4	6	2.4	0.8	0.2	25	0.15	5.5
9	Khedapali	6.8	66	110	0	31	25.41	18	0	1.3	10	2.4	4.7	6.4	35	0.07	11
10	Edu	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
11	Nawapara	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
12	Chhal	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
13	Golabuda	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
14	Lipti	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
15	Kapu	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
16	Derpani	7.3	289.2	482	0	189	154.92	46	0.6	24	50	15.6	23	1.7	190	0.16	16.7
17	Khamhar	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
18	Kandadand	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
19	Lakshmipur	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
20	Bansjour	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
21	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
22	Bakaruma	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
23	Charkhapara	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
24	Karramara	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
25	Sirsinga	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
26	Ongana	7.1	214.8	358	0	116	95.08	36	0.1	9.1	26	12	9	27	115	0.14	9.3

27	Tendumar	7.2	82.8	138	0	37	30.33	18	0	0.9	8	6	4.6	6.8	45	0.16	11.4
28	Shahpur	6.9	118.8	198	0	61	50.00	18	0	0.9	12	8.4	5	9.4	65	0.15	8.8
29	Durgapur	7.2	56.4	94	0	31	25.41	14	0	0.9	8	3.6	3	5.6	35	0.15	9.8
30	Karigashi	7.3	544.8	908	0	92	75.41	138	1	145	46	14.4	107.5	1.6	175	0.14	6
31	Jabga	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
32	Boro	7.2	271.8	453	0	128	104.92	57	0	13.5	28	15.6	16.3	34.5	135	0.14	6
33	Pordahi	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
34	Taraimar	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
35	Bayasi	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
36	Duliamuda	7.4	51	85	0	31	25.41	11	0	0.9	6	3.6	1	6.3	30	0.14	11.7
37	Khadgaon	7.5	250.8	418	0	214	175.41	21	0.4	6.5	34	13.2	13.1	30	140	0.14	6
38	Hati	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
39	Munund	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
40	Kurekela	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

ANNEXURE-III (B): Chemical Quality details of deeper aquifer in Dharamjaigarh block

S.NO.	Location	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	SO_4	Ca	Mg	Na	K	TH	SiO_2	Fe
1	Chhal	7.01	168	280	0	134	109.84	21		24	19			140		
2	Hati	7.8	615.6	1026	0	323	264.75	113	48	128	10	59	1.2	360	28	0.7
3	Hati OW	7.8	615.6	1026	0	323	264.75	113	48	128	10	59	1.2	360	28	0.7
4	Kudekala	8.1	174	290	0	85	69.67	35		40	5			120		
5	Kudekela OW-I	8.9	534	890	0	427	350.00	53		10	6			50		
6	Ulkhar	7.8	256.2	427	0	195	159.84	18	0	24	19	41	1.8	140	0	0
7	Bakaruma	7.8	240.6	401	0	220	180.33	7	0	32	5	58	1.9	100	0	0
8	Rairuma	7.7	423	705	0	220	180.33	39	0	62	10	82	1.5	195	0	0
9	Tejpur	7.8	276	460	0	152	124.59	25	0	64	2.4	27	0.9	170	0	0
10	Lipti	7.7	94.2	157	0	61	50.00	7	0	10	7	13	2.2	55	0	0
11	Kapu	7.6	54.6	91	0	43	35.25	7	0	8	4	7	1.5	35	0	0
12	Sonpur	7.8	50.4	84	0	24	19.67	7	0	2	4	9	0.7	20	0	0
13	Vijaynagar	7.9	121.8	203	0	61	50.00	21	0	16	2.4	23	1.6	50	0	0
14	Alola	7.6	96.6	161	0	73	59.84	7	0	14	4	12	1.3	50	0	0
15	Shishringa	8	231	385	0	215	176.23	9	10	38	4	46	2.1	110	nil	0.4

Central Ground Water Board
North Central Chhattisgarh Region
2nd Floor, L K Corporate and logistic Park
Dumartarai, Raipur – 492015
email:rdnccr-cgwb@nic.in