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

KHARSIA BLOCK, RAIGARH DISTRICT, CHHATTISGARH

उत्तर मध्य छत्तीसगढ़ क्षेत्र, रायपुर
North Central Chhattisgarh Region, Raipur

भारत सरकार
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Department of Water Resources, River Development & Ganga Rejuvenation
केन्द्रीय भूमि जल बोर्ड
CENTRAL GROUND WATER BOARD

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

By
Sh. A K Biswal (Scientist-D)

Type of Study	**Officer engaged**
Data compilation, Data Gap Analysis & Data Generation	Sri M.Gobinath, AHG, (AAP-2016-17)
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

KHARSIA BLOCK, RAIGARH DISTRICT, CHHATTISGARH

1.	**GENERAL INFORMATION**	
	i) Geographical area (Sq. km)	400.79
	ii) Administrative Divisions (As on 2017)	
	a) Number of Villages	138
	iii) Population as on 2011 Census	150627
	iv) Average Annual Rainfall	1353.24 mm
2.	**GEOMORPHOLOGY**	
	i) Major Geomorphological Units	Structural plain on Proterozoic rocks
	ii) Major Drainages	Mahanadi Basin (Mand ,Kurket & Borai)
3.	**LAND USE (ha) As on 2016-17**	
	i) Forest Area	1466
	ii) Net Area Sown	24000
	iii) Double cropped Area	897
4.	**MAJOR SOIL TYPES**	Ultisols- Red & Yellow
5.	**AREA UNDER PRINCIPAL CROPS, in ha (As on 2016-17)**	Paddy-22901, Wheat-526, Pulses-1431, Tilhans-456, Fruits and vegetables- 60
6.	**IRRIGATED AREA BY DIFFERENT SOURCES in ha (As on 2016-17)**	
	i) Dug wells	21
	ii) Tube wells/Bore wells	1987
	iii) Canals	3795
	iv)Tanks	175
	v) Other sources	293
	vi) area Irrigated more than once	1904
7.	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on March'2019)**	
	i) No of Dug wells	6
	ii) No of Piezometers	3
8.	**PREDOMINANT GEOLOGICAL FORMATIONS**	
	Gondwana Supergroup (Sandstone, shale, coal)	
	Chhattisgarh Supergroup Sandstone, shale)	
	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	2.26 to 29.01 mbgl
iii) Post-monsoon Depth to Water Level	0.5 to 6.6 mbgl
iv) Long Term Water Level Trend for 10 yrs (2008-2017 Vs 2018) in m/yr	**Post-monsoon-**Fall: 0.01 to 0.03 Rise 0.006

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

i) No of Wells Drilled	EW: 18, , PZ: 3
ii) Depth Range (m)	28-202
iii) Discharge (litres per second)	Neg to 7.13
iv) Transmissivity (m^2/day)	14-16

11. GROUND WATER QUALITY

i) Presence of Chemical Constituents	EC for Shallow aquifer is 30 to 1514 and for deeper aquifer is 130 to 741 µS/cm at 25℃ , PH- 6.73 to 7.69, 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	2672.69
ii) Total Annual Ground Water Extraction	1705.55
iii) Ground Water Resources for Future use	922.37
iv) Stage of Ground Water Development	63.81 %
v) Category	Safe

13. AWARENESS AND TRAINING ACTIVITY One Tier-III training

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 several regions there is deeper water table due to excessive withdrawal for irrigation.

(ii) The bore wells are drilled by the farmers without taking into consideration the spacing criteria between wells. In many instances bore wells drilled are very close to each other.

(iii) Desilting of the existing tanks for increasing storage capacity and recharge to the ground water.

(iv) In some areas there is iron contamination in groundwater was recorded.

(v) The low yielding capacity of gnessic and chandrapur sandstone formation is a major issue of kharsia block.

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 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 KHARSIA BLOCK, RAIGARH DISTRICT, CHHATTISGARH" " is prepared by Sh. A.K.Biswal, Scientist-D (CGWB,NCCR,Raipur) and is the result of untiring efforts Sh. M.Gobinath, AHG, (CGWB,CHQ, Faridabad). 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 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.

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

EXECUTIVE SUMMARY

The Kharsia block covers a geographical area of 400.79 sq. km. It is situated in the eastern central part of the Chhattisgarh lying between 21.91 degree and 22.19 degree North latitudes and

83.94degree and 82.30 degree East longitudes comprising 82 village panchayats and 138 villages .

According to 2011 census record the total population of district is 150627. About 22.76 % of the net sown area is irrigated by all sources. Ground water contributes nearly 29.5% of the net irrigated area.

Kharsia block experiences Sub-tropical climate characterized by extreme cold in winter and extreme hot in summer. The average annual rainfall is 1353.24 mm (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, Kelo, which are perennial in nature. The drainage system in Kharsia block originate at the southern part and flow in N and to NE direction before joining the Mahanadi river.

Geomorphologically the Kharsia block is characterized by structural plain on proterozoic rocks, structural plain on Gondwana rocks, pediment and pediplain.. 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 Kharsia 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 and consolidated sedimentary rock of Chhattisgarh Super group (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 Kharsia block are (i) Basement crystalline and metamorphic, (ii) Chhattisgarh Super group (Chandrapur Group ,Raipur group, Raigarh formation), (iii) 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 25m bgl. 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. Similarly the average yield of Gondwana sandstone is 4.32 lps with a transmissivity of 1.35 to to 142.75 m²/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 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. 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 m²/day and average drawdown is 21.46 m. One to two sets of most potential fracture zone lies within 100 m depth.

27 nos. of observation wells were established and monitored in pre & post monsoon period to acess 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 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 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.

As per resource estimation March 2017, the Net Annual Extractable Ground Water Recharge (Ham) in Kharsia 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. As per the NAQUIM study in the block, 22 nos. of Percolation tank , 74 nos of Nalas bunding cement plug/ check dam, 177 nos. of recharge shaft and 132 nos. of Gully plugs /Gabbion structures may be constructed throughout the block that can recharge 9.63 mcm water to underground to sustain the ground water resources in a long term basis.

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 Raigarh district 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.

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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 Raigarh 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 KHARSIA BLOCK, RAIGARH DISTRICT, CHHATTISGARH".

A.K.Biswal

Scientist-D

AQUIFER MAPPING AND MANAGEMENT PLANS
IN KHARSIA 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 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 Kharsia block was studied under NAQUIM program in 2016-17.

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 19 nos. of exploratory wells & observation wells were drilled by CGWB and through outsourcing in various periods in different formation, 27 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 35 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:

Kharsia Block is situated in the western part of Raigarh district of Chhattisgarh and is bounded on the north by Korba district and Dharamjaigarh block, in the west and south by Janjhgir-Champa district, in the north-east by Ghargoda block and in the east by Tamnar and Raigarh block. The area lies between 21.91 degree and 22.19 degree N latitudes and 83.94 degree and 82.30 degree E longitudes. The geographical extension of the study area is 400.79 sq.km representing around 6 % of the district's geographical area.

Administrative map of the block is shown in **map-1**. Mond, Kurket & Borai 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 Kharsia block as per 2011 Census is 150627 out of which rural population is 19106 living in 155 nos of villages while the urban population is 44105. The decadal growth rate of the block is 16.62 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
Kharsia	150627	19106	44105	138/82

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) 1316.14 mm with 50 to 60 rainy days. The rainfall detail is presented in table-2.

Table-2: Annual Rainfall (mm) in Kharsia block for the years (2012-2017)

Block	Rainfall in mm				
	2012-13	2013-14	2014-15	2015-16	2016-17
Kharsia	1368.3	1451.3	1399.4	1113.3	1433.9
Average	1353.24				

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 Kharsia block is given in Table 3 (A, B, C, D,).

Table-3 (A): Land use pattern in Kharsia 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
Kharsia	1466	6000	5890	2894	24000	897	25804

Source: District Statistical Book-2017

Table-3 (B): Cropping pattern in Kharsia 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					
Kharsia	23818	1986	22901	526	21	78	1431	456	60	27	0

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

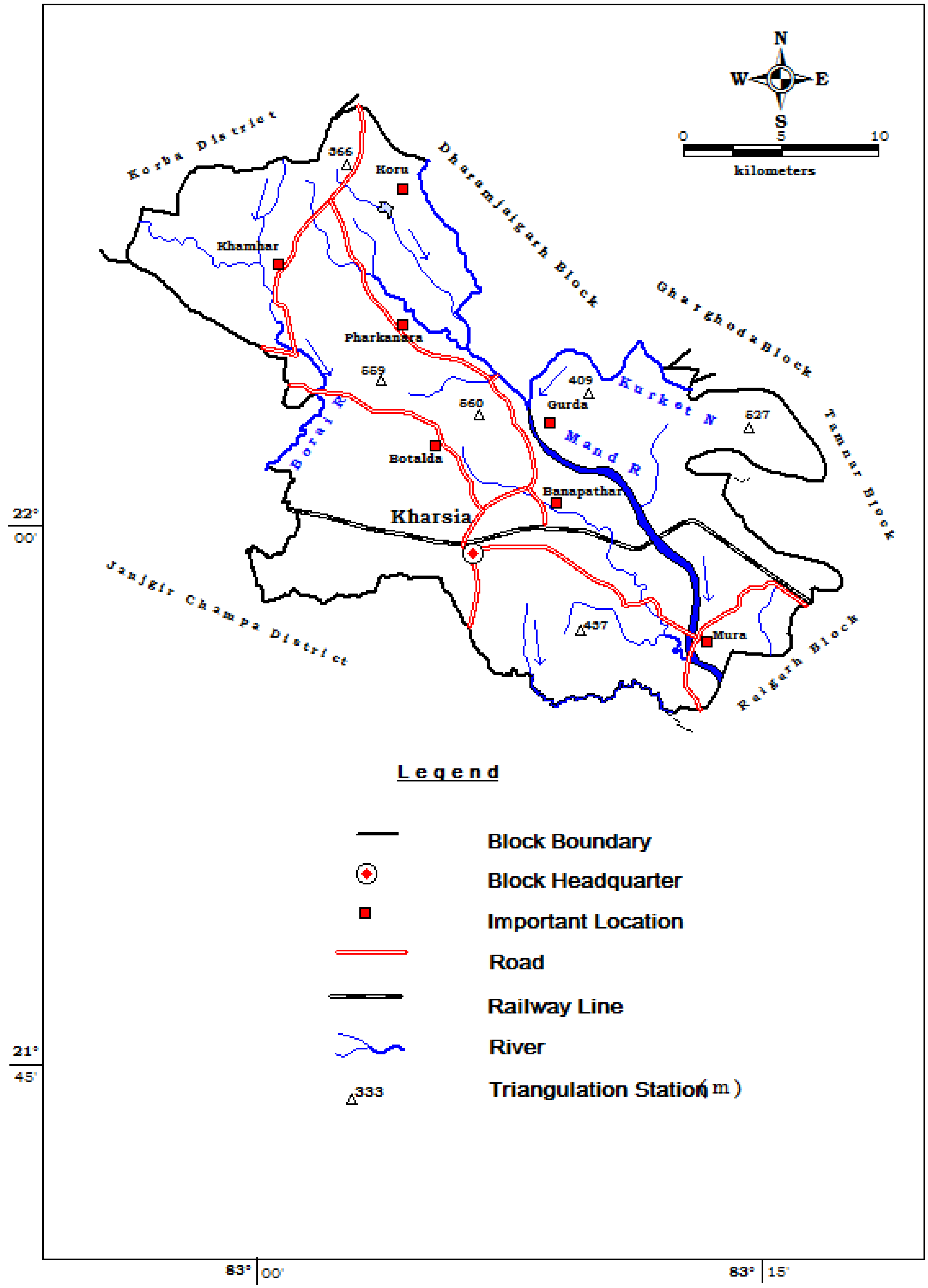
Blocks	Canal (private and Govt.)		Bore wells/ Tube wells		Dug wells		Talabs		Irrigated area by other sources	Irrigated area by GW sources	Net Irri-gated area	Irrigated area more than once	Gross irrigated area	% of Net irrigated area to. Net area sown
	Nos	Irrigated area (ha)	Nos	Irrigated area	Nos	Irrigated area	Nos	Irrigated area						
Kharsia	8	3795	955	1987	201	21	176	175	293	2008	6804	1904	7164	27.76

Source: District Statistical Book-2017

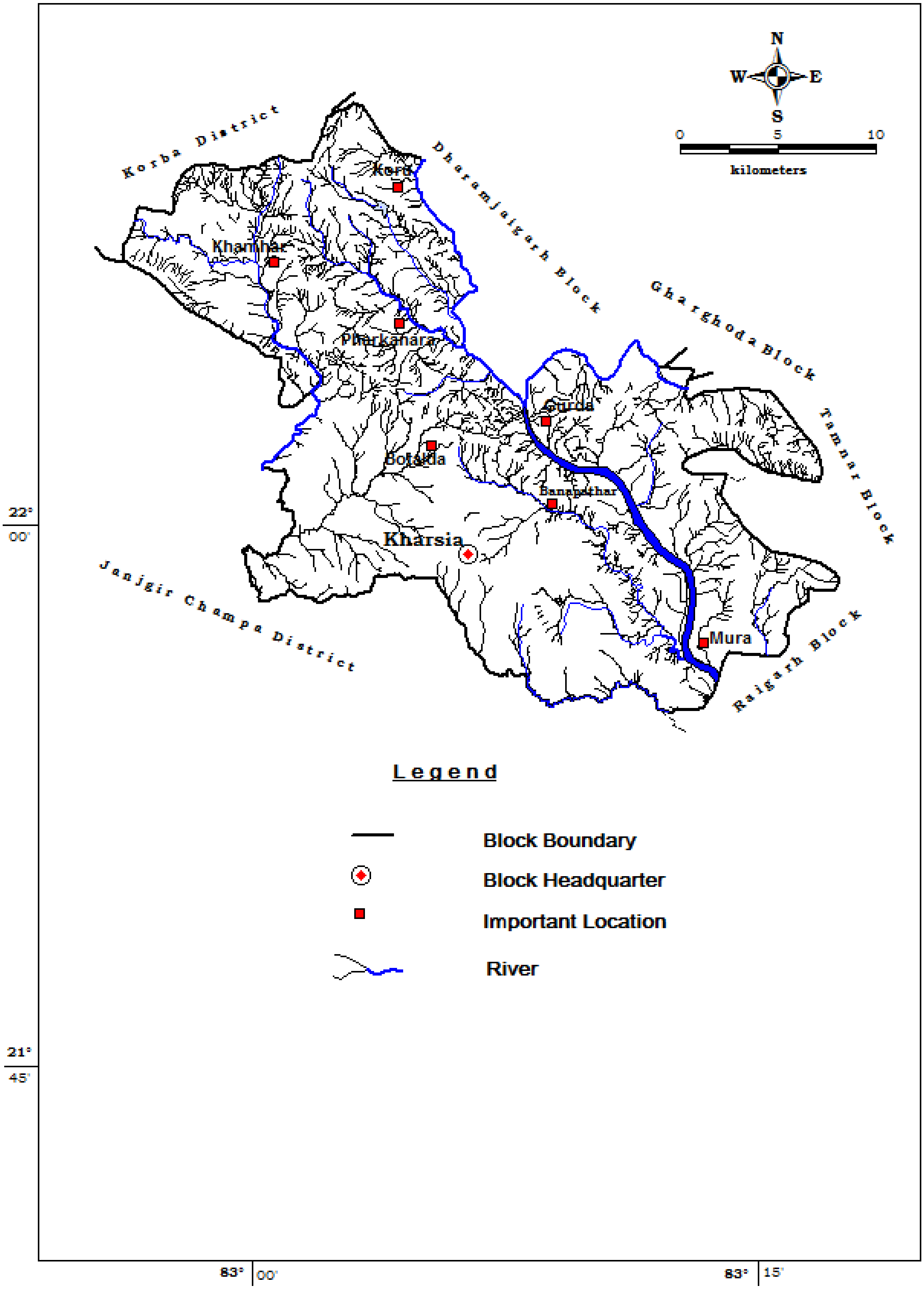
Table 3 (D): Statistics showing Agricultural land Irrigated

Block	Net Irrigated Area	Net Irrigated Area by ground water	Percentage of Area Irrigated by ground water
Kharsia	6804	2008	29.5 %

Map-1: Administrative map of Kharsia block



Map-2: Drainage map of Kharsia block



CHAPTER-2

DATA COLLECTION & GENERATION

2.1 Introduction:

About 18 nos. of exploratory wells drilled by CGWB and through outsourcing in various periods in different formation (table-4), 27 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 35 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 Kharsia block.

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

Block	Gondwana formation	Gunderdih Shale	Charmuria Limestone	Chandrapur Sandstone	Crystallines	Total
Kharsia	2	8	-	1	7	18

2.2 Exploration:

Hard and soft rocks need separate well design. Since Kharsia block 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. 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.**

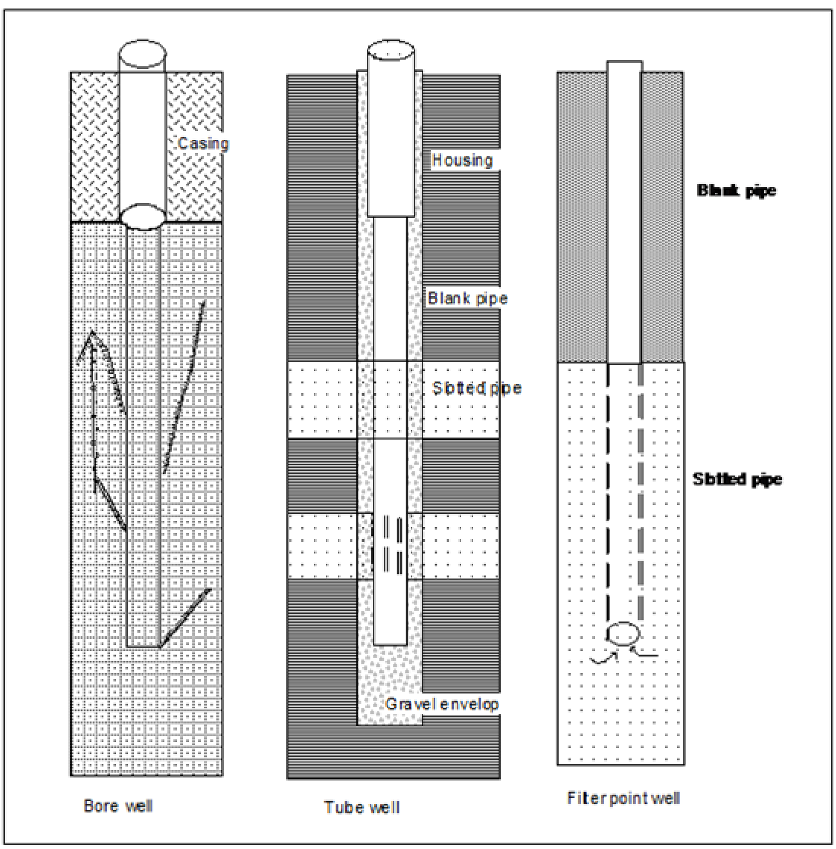
2.2.1 Well design:

Hard and soft rocks need separate well design. Since Kharsia block 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. PVC casing is preferred where ever ferric oxide problem persist in ground water of hard rock.

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 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. 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 27 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 35 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 Kharsia 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, 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 Kharsia 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 Achievement:

To understand the regional hydrogeological behavior of Kharsia 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 Kharsia block.

CHAPTER-3

AQUIFER DISPOSITION

3.1 Principal & Major aquifer groups:

The aquifer material controlling ground water flow in Kharsia 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 upto 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 Kharsia block are (**Map-3**):

(i) Chhotnagpur Granite gneiss
(ii) Gondwana Sandstone
(iii) Chandrapur Sandstone
(iv) Gunderdih Shale

(i) Chhotnagpur Granite Gneiss : These crystalline and metamorphic rocks mainly occur along the nort-western 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: The northern part of the block 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.

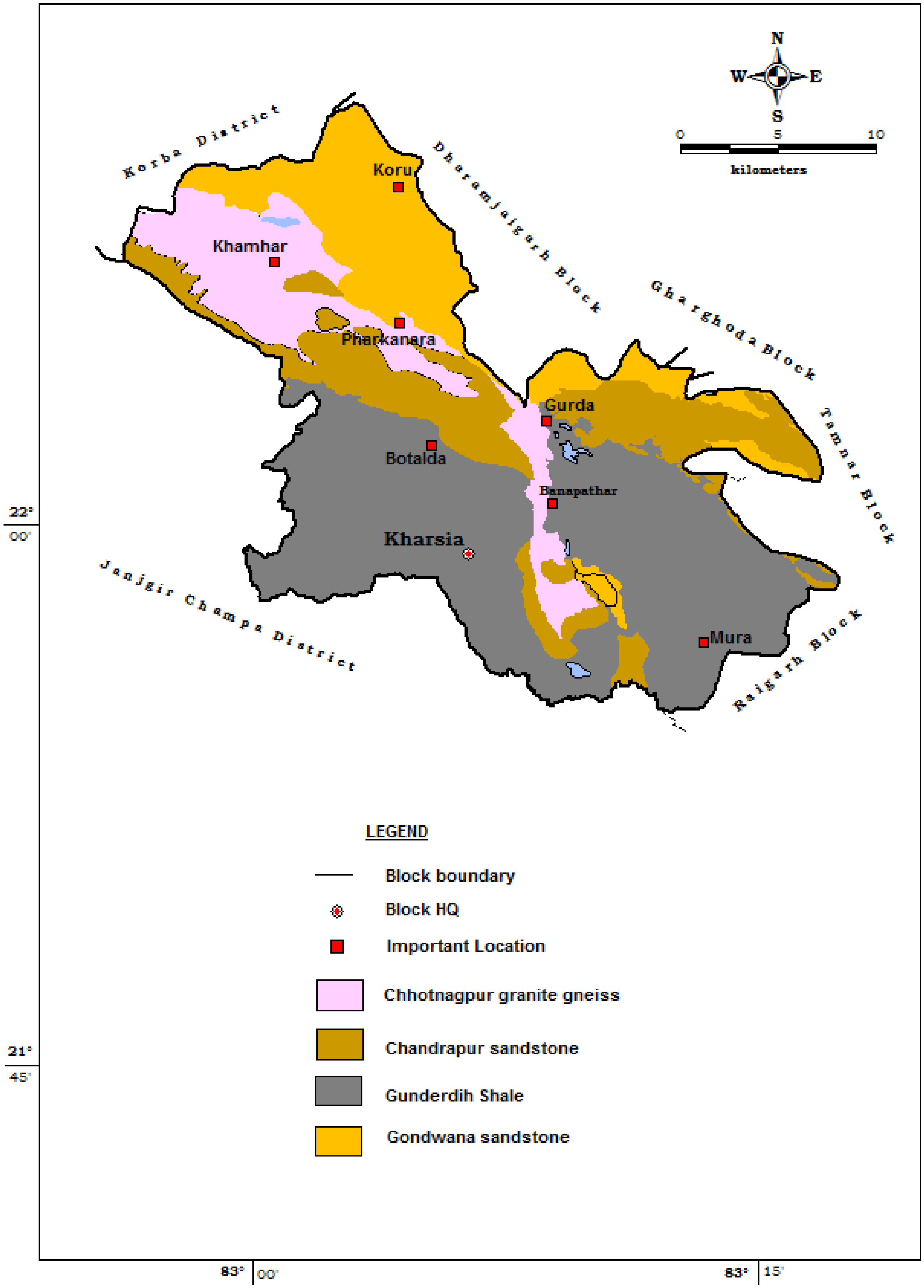
(iii) Chandrapur Sandstone : The central part of the block is occupied by Chandrapur Group which consists of Orthoquartzitic to subarkosic sandstone and black shale. The sandstone of Chandarpur is highly silicified and devoid of primary porosity. The low-lying Chandarpur sandstone covered area has phreatic aquifer. The distribution of ground water in Chandarpur group is poor and the movement of water is restricted along joints and fractures. 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.

(iv) Gunderdih Shale: The Gunderdih shale is calcareous in subsurface and many times gypsiferous, having good secondary porosity. The shally part of Raigarh Formation is represented by Gunderdih shale in the block. It is most wide spread mainly in soth-central parts of the block. 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 average yield of Gunderdih shale is 6.41 lps with avg transmissivity of 14.58 m^2/day & average drawdown is 13.91 m.

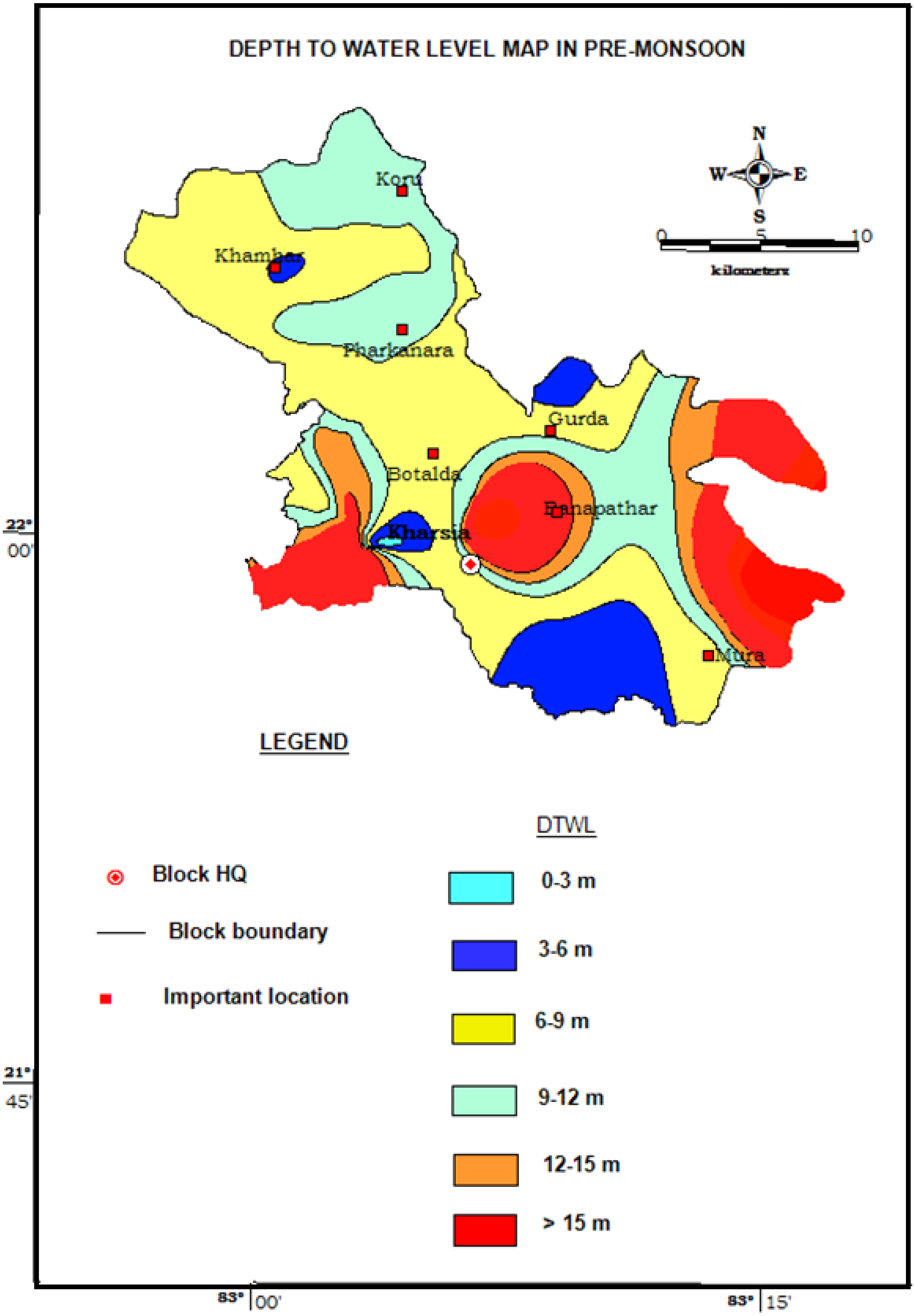
3.2 Ground Water Regime monitoring:

During the study, 27 nos. of wells both dug wells and hand pumps were established and 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 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 water level map prepared for the district is presented in (**Map-4 A, B &C**).

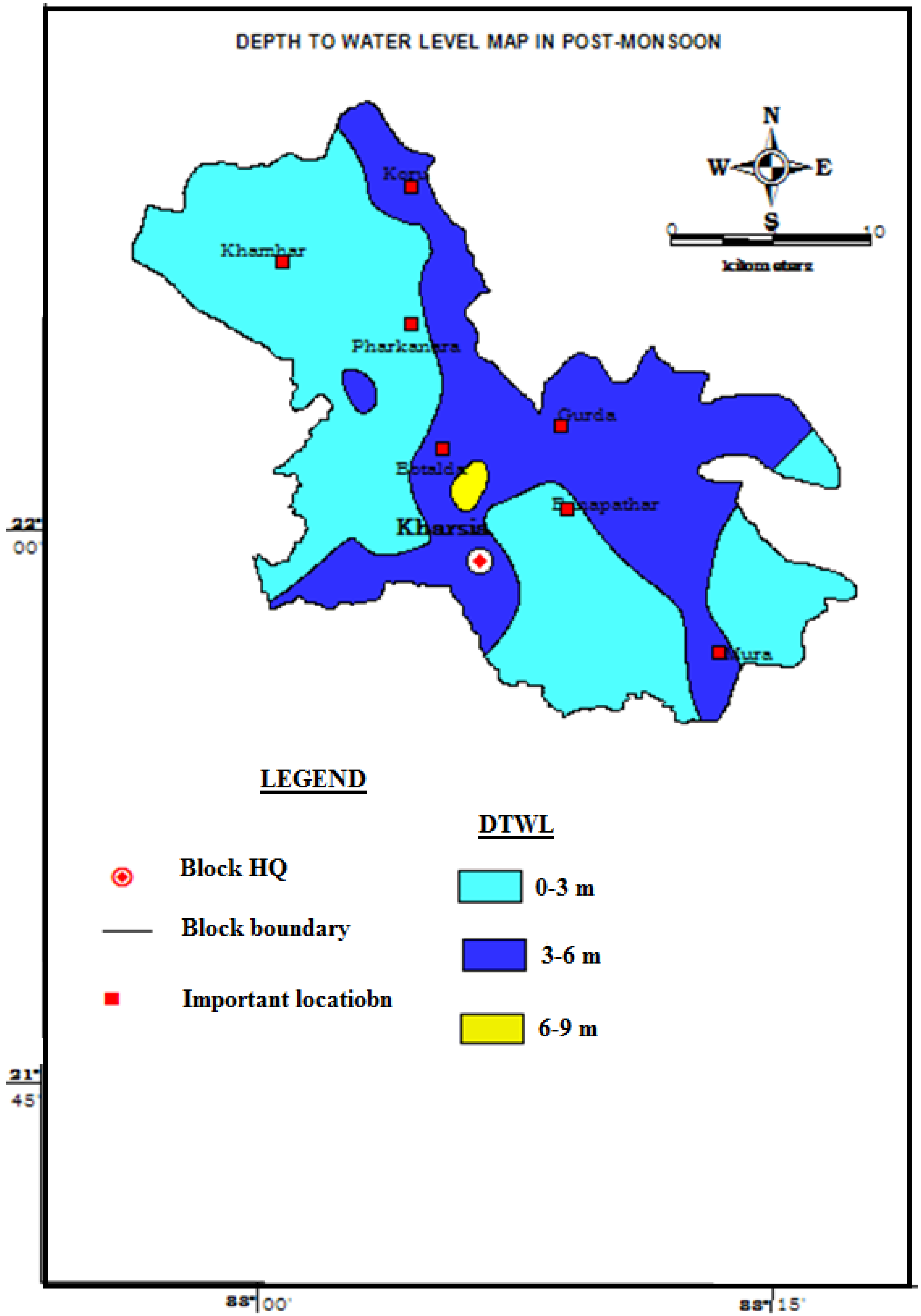
Map-3: Major Aquifer map of Kharsia block



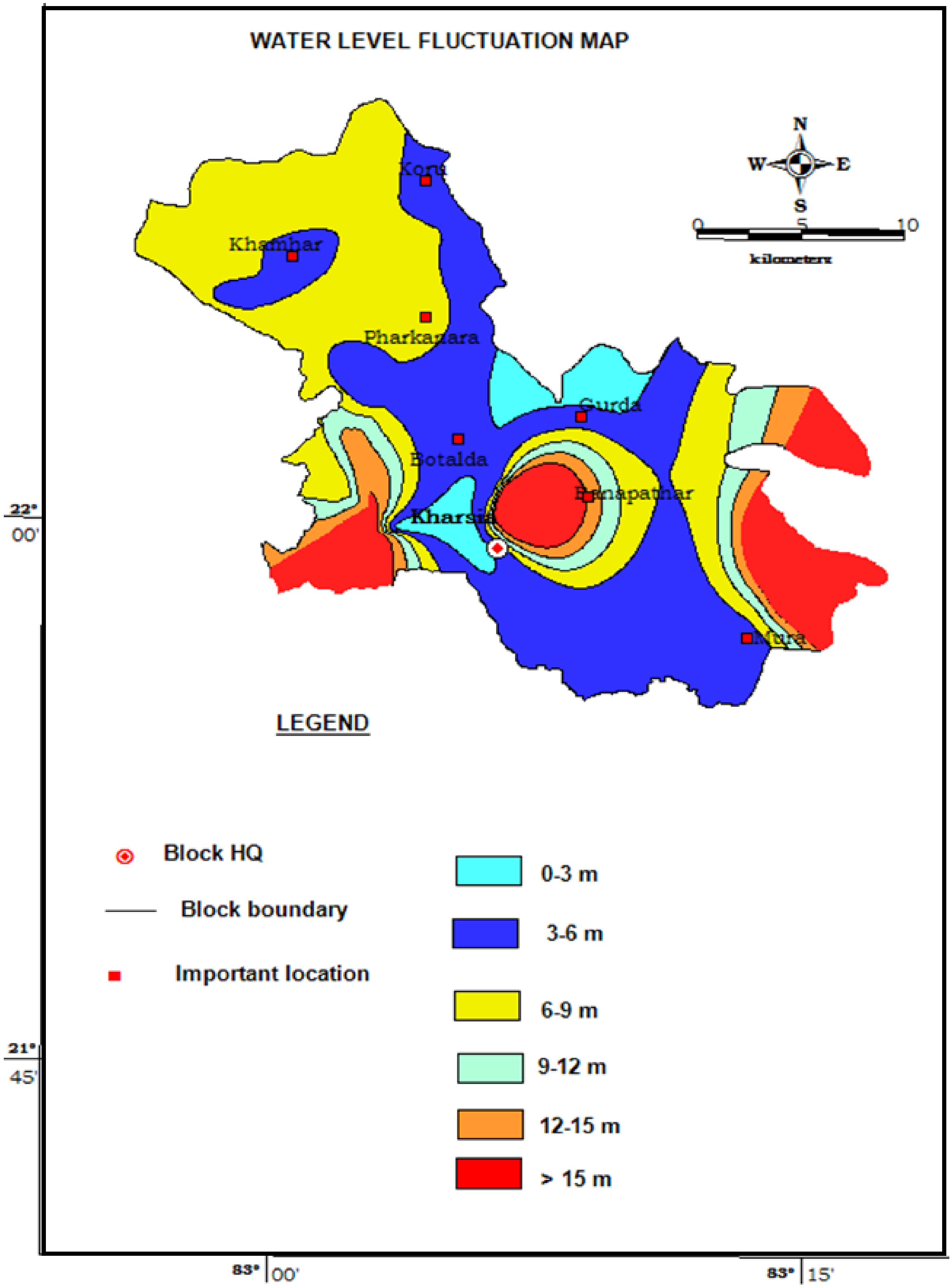
Map-4 (A): Pre-monsoon depth to water level map of Kharsia block



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



Map-4 (C): Water level fluctuation map of Kharsia 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 Kharsia 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 80 % of the wells show declining trend to the tune of 0.01 to 0.03 m/yr. The rising trend is shown by 20 % of wells in the tune of 0.006 m/yr. The hydrograph of some of the wells are presented in **Fig-2 A & B**. 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 Kharsia block

SN	Block	Site name	Longitude	Latitude	Trend (2010-2019) postmonsoon	Remarks
1	Kharsia	Chaple	83.2	21.98	0.006123	Rising
2	Kharsia	Kharsia	83.1	21.99	-0.014667	Declining
3	Kharsia	Kharasia S	83.1	21.99	-0.032347	Declining
4	Kharsia	Kharasia D	83.1	21.99	-0.022133	Declining
5	Kharsia	Farkanara	83.11	22.02	-0.012171	Declining

3.2.2 Ground Water flow direction:

The regional ground water flow direction is towards south-east. 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 Raigarh 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 Kharsia 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 Kharsia 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)
Kharsia	2672.69	1111.15	224.02	370.38	1705.55	415.15	922.37	63.81	Safe	No	

3.3.2 <u>Static Ground Water Resources:</u>

An attempt has been made to assess the Static Ground Water Resources Kharsia 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 Raigarh block.

Table-7: Ground water Resources of Kharsia block

Block	Recharge worthy Area (Ha)	Stage of Extraction in %	Static Resource in Ham	Dynamic Resource in Ham
Kharsia	31449	63.81	678.669	2672.690

The table shows that the total static ground water resource of Kharsia block is 678.669 Ham beside the dynamic ground water resource of 2672.69 ham.

Fig- 2(A): Hydrograph of Chaple, Kharsia block

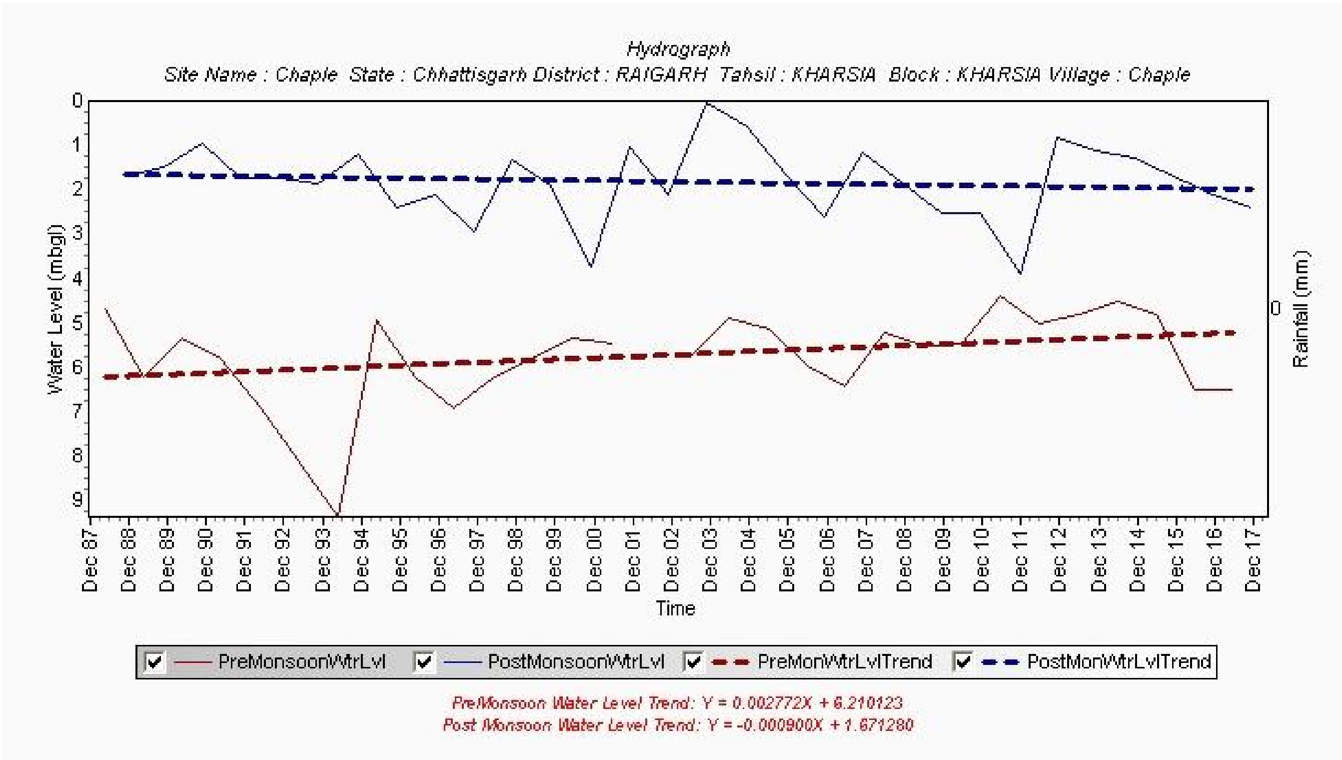
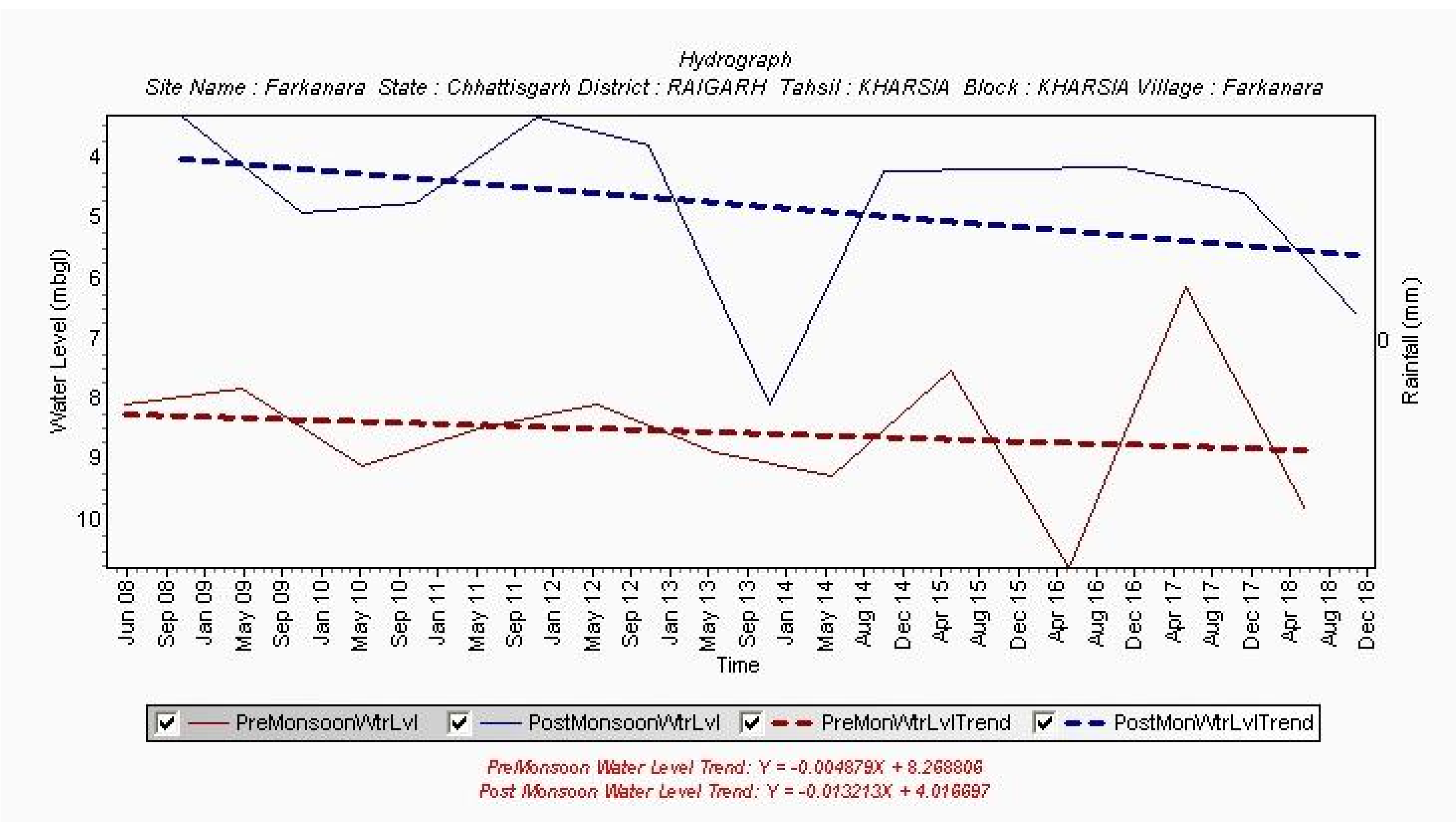


Fig- 2(B): Hydrograph of Faraknara, Kharsia block



3.4 <u>Ground Water Quality</u>:

Ground water quality of shallow aquifer as well as deeper aquifer in Kharsia block for drinking, irrigation and industrial purposes is assessed on the basis of analysis of ground water samples collected from 24 nos. of observation wells for shallow aquifer & 11 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	6.73	7.69	6.59	8.3
2	EC(in µS/cm at 25° C)	30	1514	130	741
3	Total Alkalinity	10	310	65	290.11
4	HCO_3	12.2	378.2	79.3	354
5	Cl	3.55	163	11	46
6	SO_4	0.944	204	0	10.12
7	F	0	0.57	0.2	0.99
8	TH	10	585	50	240
9	Ca	2	190	14	66
10	Mg	1.2	63.6	3.6	21
11	Na	2.5	107	3.7	65.1
12	K	0.2	140	1.1	53.3

The above table-5.5 indicates that the ground water of Kharsia 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 Kharsia block is safe from Uranium contamination point of view.

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

3.5 <u>Ground Water Issues</u>:

(i) In several regions there is deeper water table due to excessive withdrawal for irrigation.

(ii) The bore wells are drilled by the farmers without taking into consideration the spacing criteria between wells. In many instances bore wells drilled are very close to each other.

(iii) Desilting of the existing tanks for increasing storage capacity and recharge to the ground water.

(iv) In some areas there is iron contamination in groundwater was recorded.

(v) The low yielding capacity of gneissic and chandrapur sandstone formation is a major issue of kharsia block.

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 Kharsia block were prepared:

(i) Aquifer map 2-dimensionsl, (**Map-5)**
(ii) Aquifer map 3-dimensionsl (**Map-6)**
(iii) Ground water Development Potential & Artificial Recharge Prospect (**Map-7)**

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) The stage of ground water extraction for Kharsia block is 63.81% 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-9 respectively.

Table-9: Details of AR structures in Kharsia 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
Kharsia	22	74	177	132	9.63

From the table 9, it is depicted that 22 nos. of percolation tank, 74 nos. of nala bunding/cement plug/check dams , 177 nos. of recharge shafts and 132 nos. of gully plug/gabion structures may be constructed at suitable locations that can enhance the ground water source to 9.63 mcm more.

(iii) 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.

(iv) 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.

(v) 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.

(vi) 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.

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

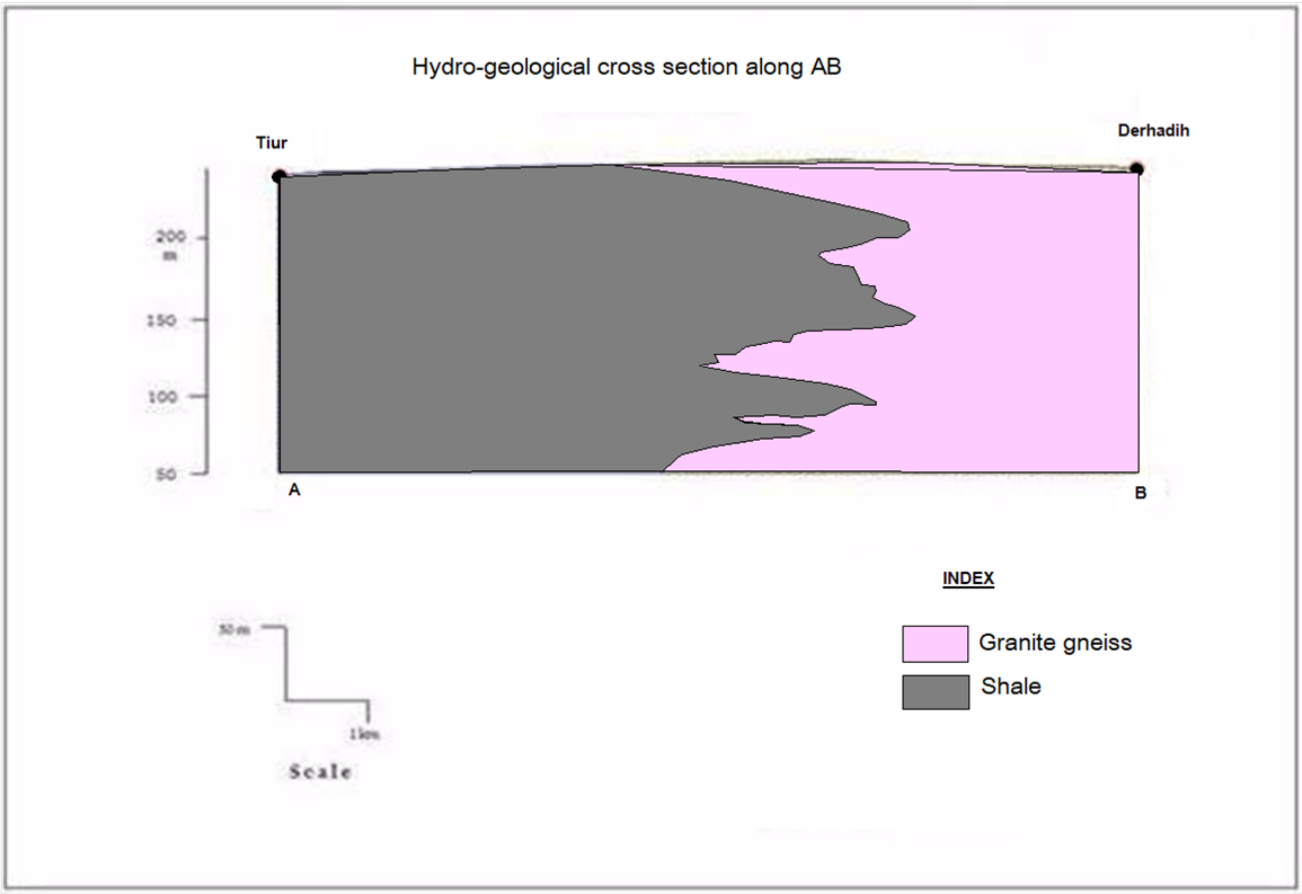
(x) Even if farmers use solar pump or other method of ground water irrigation for summer paddy, it should not be flooding method. Proper pipes are to be used to transfer water from one plot to another.

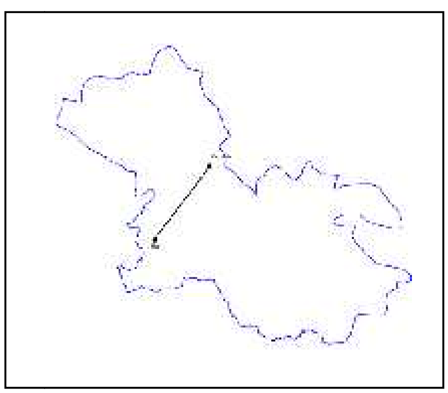
(xi) Govt. may set up network of grids to purchase electricity generated from solar panels. This will encourage the farmers not to waste electricity by extracting groundwater unnecessarily and also provide alternative income.

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

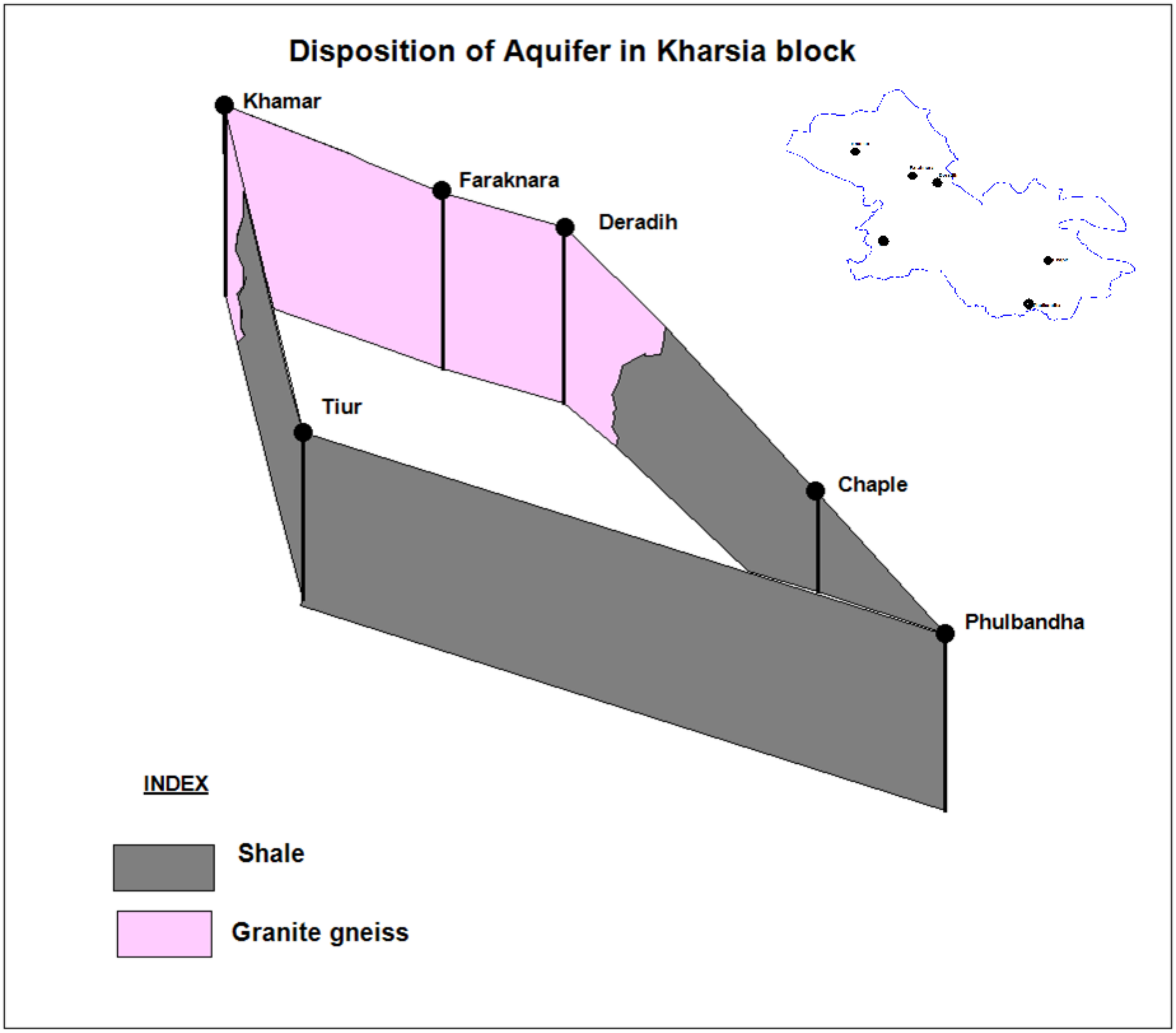
(xiii) Furthermore, in order to strike a balance between the ground water draft and the available resource, suitable artificial structures at appropriate locations be constructed through successive phases after tentatively every 20nos of groundwater abstraction structures become operative.

Map-5: Hydrogeological cross section in NE-SW direction

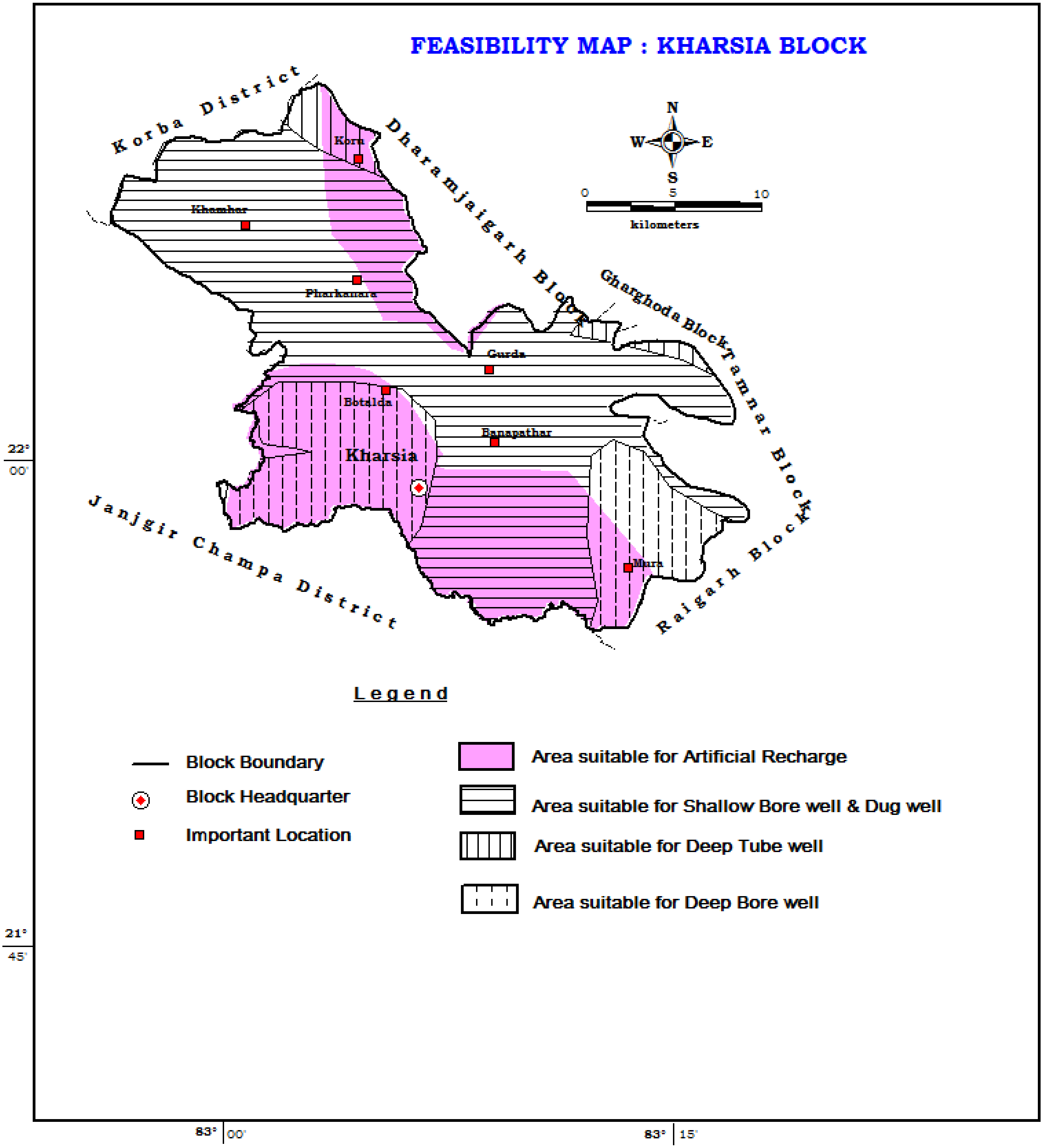




Map-6: 3-dimensional disposition of aquifer



Map-7: Ground Water Development prospect map of Kharsia block



CHAPTER-V

SUM UP

5.1 Conclusions:

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.

5.2 Recommendations

- Since the stage of ground water development for Kharsia block is 63.81%, in a long term sustaining basis, we have to go for artificial recharge, particularly to recharge the area of deeper water level. As such 9.63 mcm water can be recharged to the underground by constructing Percolation Tank (22), nala bund / Check dam (74), Recharge shafts (177) and gully plug/gabion structures (132).

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ANNEXURE-I: Exploration details in Kharsia block

Sl. no	Location	Type	Lat	Long	Depth (m)	Casing (m)	Formation	Zone encountered	Yield (lps)	Draw down (m)	Transmis sivity (m^2/sec)
1	Kapharmar	EW	22.179	83.054	119		Baraker Fm		2.88	16.2	14
2	Nandgaon	EW	22.110	83.067	128		Baraker Fm				
3	Chaple	EW	21.983	83.2	114	26.9	Raigarh Fm.-limestone	26-29, 92-93	1.5	2.28	
4	Ranisagar	EW	21.991	83.194	117	17.5	GR,CRY	11--14, 17-20,21-24,28-29	7.13	4.26	
5	Fulbandha	EW	21.926	83.180	185	20.85	Raigarh Fm.-Shale and Lst	31-34	5.75	3.47	
6	Tieur	EW	22.012	83.033	201	12.5	Raigarh Fm.	23-26,89-92	2	34.81	16
7	Badgad	EW	22.06	83.039	200	13.7	Massive shale	49.5-52.5	1.4		
8	Faraknara	EW	22.094	83.066	202	34.9	Coal seam	137.9-141.00	1.4		
9	Domnara	EW	22.081	83.096	202	12	Fractured Granite Gneiss	Dry	0		
10	Deradih	EW	22.082	83.094	202	17.5	Massive Sanstone		2.2	24.68	
11	Tumidih	EW	22.081	83.095	202		Silt stone with Calcareous shale	97-98.3	1.4	41.3	
12	Khamar(EW)	EW	22.122	83.017	202	28.5	Sandstone	25.1-46.4, 128.8-159.3	4.54		
13	Chitakathara	EW	22.113	83.068	200		Weathered shale and Granite		0		
14	Dehjari	EW (ADP)	22.041	83.132	109.31	18.3	Granite, gneiss	19.3	0.8	26.36	
15	Palgada	EW (ADP)	22.062	83.025	28	21.15	Raigarh shale	22	2	2.54	
16	Kunkuni	EW (ADP)	22.016	83.183	151	18.3	Chandrapur sandstone	Seepage	seepage	-	
17	Botalda	EW (ADP)	22.043	83.094	82.8	9.7	Raigarh shale	21-0-22.0	7.13	16.62	
18	Halaholi	EW (ADP)	21.970	83.044	101.2	12.2	Raigarh shale	50.0- 60.0- 68.5	8 lps	10.38	
19	Khamar(OW)	OW	22.122	83.0174	141	26.8	Sandstone	122.7-125.7	2.21		

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

S.No	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
1	Farkanara	83.1064	22.0175	DW	9.85	6.6	3.25
2	Kharsia-s	83.09861111	21.9888889	PZ	7.62	5.24	2.38
3	Barra	83.04802778	22.1278889	DW	7.8	0.72	7.08
4	Pathrapali	83.06266667	22.0536944	DW	7.24	2.13	5.11
5	Ulda	83.05383333	22.0569444	HP	7.06	3.24	3.82
6	Masania Kalan	83.00486111	22.0713333	HP	7.46		7.46
7	Sajapali	82.99825	22.09	DW	8.29	2.07	6.22
8	Kothi Kunda	83.01819444	22.0980278	HP	9.29	2.62	6.67
9	Khamhar	83.01533333	22.1192222	DW	5.46	1.31	4.15
10	Khadgaon	82.99305556	22.1282222	DW	7.85	1.52	6.33
11	Khadgaon	82.99288889	22.12825	HP	8.22	1.6	6.62
12	Bhagodih	83.064	21.995	DW	2.26	0.63	1.63
13	Turekela	83.051	22.005	HP	15.94	0.7	15.24
14	Tieur (Dharsa Para)	83.035	22.015	DW	7.9	0.5	7.4
15	Sarwani	83.039	22.036	HP	14.3	1.55	12.75
16	Jobi	83.041	22.151	DW	10.16	2.28	7.88
17	Koru	83.074	22.152	HP	9.67	4.3	5.37
18	Nangoi	83.081	22.130	DW	8.55	2.5	6.05
19	Nandgaon	83.092	22.112	HP	9.25	4.85	4.4
20	Pharkanara	83.069	22.095	DW	10.15	1.65	8.5
21	Barbhauna	83.149	22.071	HP	5.46	3.68	1.78
22	Binjkoth	83.204	22.023	HP	11.67	4.45	7.22
23	Bhupdeopur (TilaiPali)	83.252	21.974	HP	29.01	0.69	28.32
24	Jai-muda	83.225	21.942	DW	7.45	3.2	4.25
25	Basnajhar	83.160	21.940	HP	4.55	1.1	3.45
26	Jharidih	83.047	21.991	HP	22.8	3.33	19.47
27	Karsia (Madhanpur)	83.113	22.007	HP	26.94	2.71	24.23

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

S. NO.	Location	pH	TDS	EC	CO3	HCO3	Total Alkalinity	Cl	F	SO4	Ca	Mg	Na	K	TH	PO4	SiO2
1	Barra	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
2	Bothlda	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
3	Pathrapali	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
4	Masania Kalan	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
5	Sajapali	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
6	Khamhar	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
7	Khadgoan	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
8	Turekela	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
9	Sarwani	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
10	Kapharmar	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
11	Nangoi	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
12	Pharkanara	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
13	Barbhauna	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
14	Binjkoth	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
15	Bhupdeopur (Talaipali)	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
16	Jaimura	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
17	Basnajhar	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
18	Kodha Bhatta (Gidha)	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
19	Jharidih	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
20	Karsiaa (MADHANPUR	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
21	Chaple	7.5	493.8	823	0	268	219.67	124	0.2	15.7	46	21.6	87.4	1	205	0.12	12
22	Domnara	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
23	Farkanara	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
24	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

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

S. NO.	Location	Type	pH	TDS	EC	CO3	HCO3	Total Alkalinity	Cl	F	SO4	Ca	Mg	Na	K	TH	PO4	SiO2
1	Barra	EW	8.3	300	500	0	275	225.41	25			18	13			100		
2	Kapharmar	EW	7.8	126	210	0	110	90.16	11			16	4			55		
3	Tieur	EW	8	240	400	0	92	75.41	46		0	28	21	29	1.1	155		
4	Dehjari	EW	8.1	288	480	0	287	235.25	14									
5	Palgada	EW	7.7	292.8	488	0	250	204.92	32			66	18			240		
6	Botalda	EW	8.1	188.4	314	0	165	135.25	18			38	12			145		
7	Halaholi	EW	7.9	444.6	741	0	354	290.16	14									
8	Deradhi	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
9	Tumighi	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
10	Tumighi	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
11	Deradhi	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

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