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

TAMNAR 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

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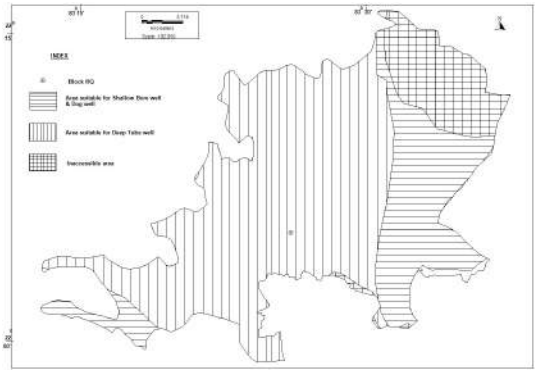
CENTRAL GROUND WATER BOARD

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

By

Sh. A K Biswal (Scientist-D)



North Central Chhattisgarh Region

Raipur

2020

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CENTRAL GROUND WATER BOARD

Aquifer Mapping and Management Plan in Tamnar 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

TAMNAR BLOCK, RAIGARH DISTRICT, CHHATTISGARH

1.	**GENERAL INFORMATION**	
	i) Geographical area (Sq. km)	469
	ii) Administrative Divisions (As on 2017)	
	a) Number of Villages	117
	iii) Population as on 2011 Census	97928
	iv) Average Annual Rainfall	1097.72 mm
2.	**GEOMORPHOLOGY**	
	i) Major Geomorphological Units	Structural plain on Gondwana rocks
	ii) Major Drainages	Mahanadi Basin (Kelo river & its tributaries)
3.	**LAND USE (ha) As on 2016-17**	
	i) Forest Area	2143
	ii) Net Area Sown	36810
	iii) Double cropped Area	3121
4.	**MAJOR SOIL TYPES**	Alfisols-Red sandy soil Ultisols-Red & yellow soil
5.	**AREA UNDER PRINCIPAL CROPS, in ha (As on 2016-17)**	Paddy-20024, Wheat-34, Pulses-3762, Tilhans-493, Fruits and vegetables- 70
6.	**IRRIGATED AREA BY DIFFERENT SOURCES in ha (As on 2016-17)**	
	i) Dug wells	72
	ii) Tube wells/Bore wells	284
	iii) Canals	22
	iv)Tanks	27
	v) Other sources	318
	vi) Area Irrigated more than once	715
7.	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on March'2019)**	
	i) No of Dug wells	12
	ii) No of Piezometers	1
8.	**PREDOMINANT GEOLOGICAL FORMATIONS**	
	Gondwana Supergroup (Sandstone, shale, coal)	

9. HYDROGEOLOGY

i) Major Water Bearing Formations	Weathered & fractured sandstone.
ii) Pre-monsoon Depth to Water Level	3.0 to 15.6 mbgl
iii) Post-monsoon Depth to Water Level	1.8 to 13.0 mbgl
iv) Long Term Water Level Trend for 10 yrs in m/yr	**Post-monsoon-**Fall: 0.003 to 0.015

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

i) No of Wells Drilled	EW: 9, OW: 04
ii) Depth Range (m)	200 – 400.28
iii) Discharge (litres per second)	1 to 9.46
iv) Transmissivity (m^2/day)	3.47 – 54.23

11. GROUND WATER QUALITY

i) Presence of Chemical Constituents	EC for Shallow aquifer is 59 to 1680 and for deeper aquifer is 285 to 470 µS/cm at 25°C, P^H - 6.6 to 8.5 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	1906.48
ii) Total Annual Ground Water Extraction	962.8
iii) Ground Water Resources for Future use	910.83
iv) Stage of Ground Water Development	50.5 %
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. Nitrate content is considerably high in shallow groundwater in some locations.
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 Tamnar 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 TAMNAR 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 Tamnar 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 Tamnar block covers a geographical area of 469 sq. km. It is situated in the north central eastern part of Raigarh district of Chhattisgarh lying between 21059' and 22016' N latitudes and 83013' and 83037'30'' E longitudes comprising 42 village panchayats and 117 villages. According to 2011 census the total population of the block is 97928. About 2.14 % of the net sown area is irrigated by all sources. Ground water contributes nearly 45.29 % of the net irrigated area.

Tamnar block experiences Sub-tropical climate characterized by extreme cold in winter and extreme hot in summer. The average annual rainfall is 1097.72 mm (average of last five years i.e 2012-2017). The annual temperature varies from 10^0C in winter to 46^0C in summer. The relative humidity Varies from 85 % in rainy season to 35-40 % during winter. The block is mainly drained by the rivers-Kelo which is perennial in nature. The drainage system in Tamnar block originates at the northern part and flow towards South direction before joining the Mahanadi river.

Geomorphologically the Tamnar block is characterized by Structural plain on Gondwana rock, pediment and pediplain. The general elevation of the plain is around 300 m amsl. The elevation in case of structural hills ranges from 400 to 632 m amsl. This region has a general slope towards the south. The foothills are characterized by pediments.

Geologically Tamnar block is mainly covered by rocks comprising semi consolidated rock belonging to Gondwana Super group with some patches of plutonic rocks in northern part.

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 Tamnar block is (i) 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 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.

31 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 3.0 to 15.6 mbgl with an average of 7.54 mbgl and during post-monsoon period it ranges from 1.8 to 13.0 mbgl with an average of 5.22 mbgl. The fluctuation ranges from 0.1 to 7.33 m with an average fluctuation of 2.33 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at most of the locations. The average weathered thickness of the phreatic aquifer is around 18 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 Tamnar block is 1906.48 ham. The Net Ground Water Availability for future use is 910.8 ham. Current Annual Ground Water Extraction for all purposes is 962.8 ham out of which 723.59 ham is for irrigation. The overall Stage of Ground Water Extraction in the block is 50.5%. The Annual GW Allocation for domestic Use as on 2025 is 910.83 ham. As per the NAQUIM study in the block, from supply side of ground water management, construction of 194 nos of irrigation tube wells (60 to 150 m deep with diameter of 100 to 150 mm) or 242 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 194 ha of paddy, 436 ha of wheat, Ground Nut, Sunflower and 581 ha of Mustard & Pulses.

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 Tamnar 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 Tamnar 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 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 TAMNAR BLOCK, RAIGARH DISTRICT, CHHATTISGARH".

A.K.Biswal

Scientist-D

AQUIFER MAPPING AND MANAGEMENT PLANS
IN TAMNAR 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 Tamnar 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 9 nos. of exploratory wells & 4 nos of observation wells were drilled by CGWB in various periods in different formation, 31 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 41 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:

Tamnar Block is situated in the north central eastern part of Raigarh district of Chhattisgarh and is bounded on the north by Lailunga block, in the west by Gharghoda block, in the east by Odisha state and in the south by Raigarh block. The area lies between $21^0$59' and $22^0$16' N latitudes and $83^0$13' and $83^0$37'30'' E longitudes. The geographical extension of the study area is 469 sq.km representing around 6.8 % of the district's geographical area.

Administrative map of the block is shown in **map-1**. kelo 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 Tamnar block as per 2011 Census is 69970 out of which rural population is 97928 living in 117 nos of villages. 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
Tamnar	97928	97928	Nil	117/42

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) 1097.72 mm with 50 to 60 rainy days. The rainfall detail is presented in table-2.

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

Block	Rainfall in mm				
	2012-13	2013-14	2014-15	2015-16	2016-17
Tamnar	1296.1	1099.3	896.9	1011.5	1184.8
Average	1097.72				

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

Table-3 (A): Land use pattern in Tamnar 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
Tamnar	2143	5754	4789	5593	36810	3121	24897

Source: District Statistical Book-2017

Table-3 (B): Cropping pattern in Tamnar 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					
Tamnar	23937	960	20024	34	27	66	3762	493	70	61	6

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

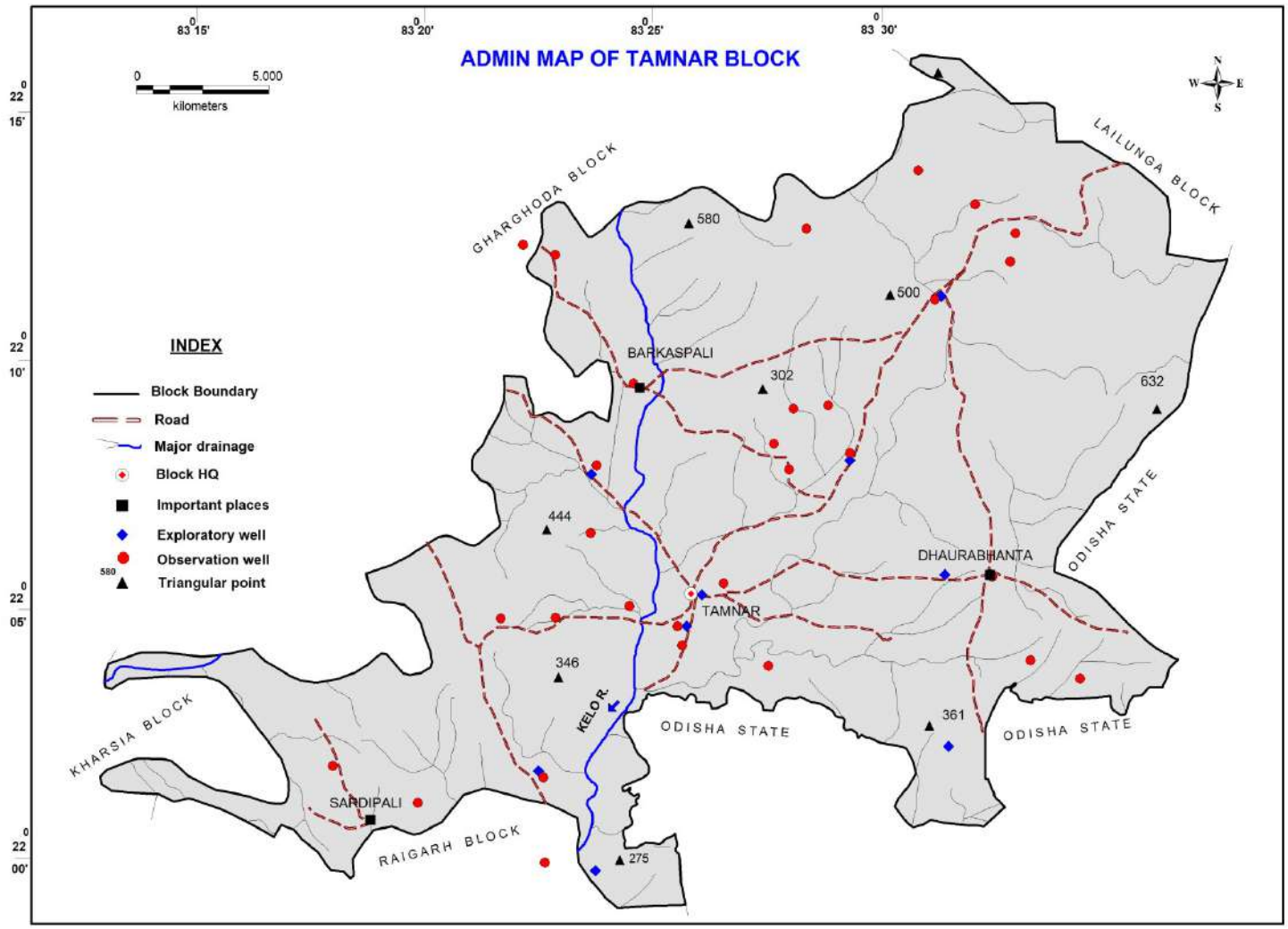
Blocks	Canal (private and Govt.)		Bore wells/ Tube wells		Dug wells		Talabs		Irrigated area by other sources	Irrigated area by GW sources	Net Irri-gated area	Irrigated area more than once	Gross irrigated area	% of Net irrigated area to net area sown
	Nos	Irrigated area (ha)	Nos	Irrigated area	Nos	Irrigated area	Nos	Irrigated area						
Tamnar	1	22	200	284	391	72	137	27	318	356	786	715	804	2.14

Source: District Statistical Book-2017

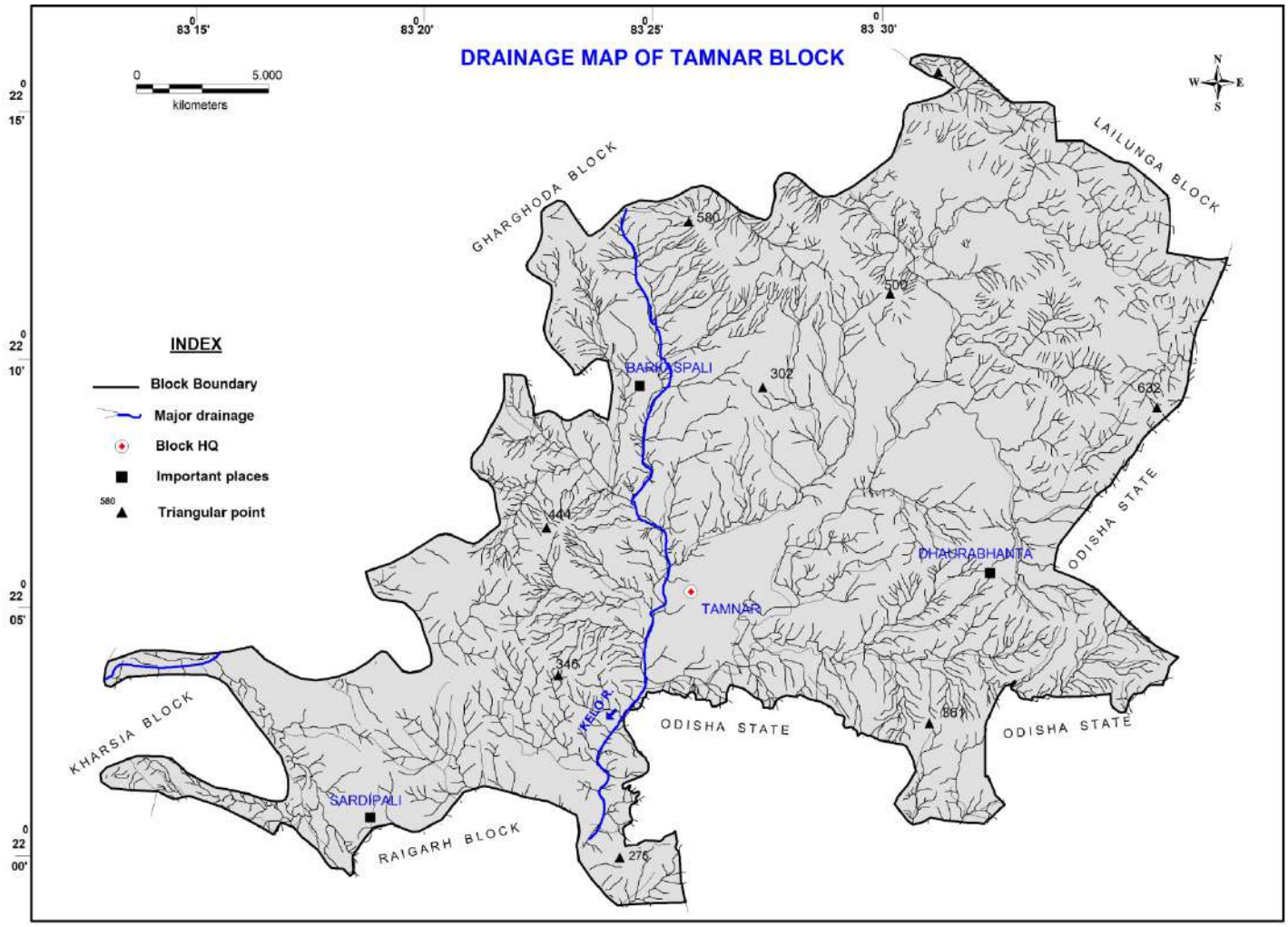
Table 3 (D): Statistics showing Agricultural land Irrigated

Block	Net Irrigated Area	Net Irrigated Area by ground water	Percentage of Area Irrigated by ground water
Tamnar	786	356	45.29 %

Map-1: Administrative map of Tamnar block



Map-2: Drainage map of Tamnar block



CHAPTER-2

DATA COLLECTION & GENERATION

2.1 Introduction:

About 13 nos. of exploratory wells drilled by CGWB out of which 4 are observation in various periods in different formation (table-4), 31 nos of key observation wells (dug wells, hand pumps and piezometers) established during the survey and 41 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 Tamnar block.

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

Block	Gondwana formation	Gunderdih Shale	Charmuria Limestone	Chandrapur Sandstone	Crystallines	Total
Tamnar	12	-	-	-	-	12

2.2 Exploration:

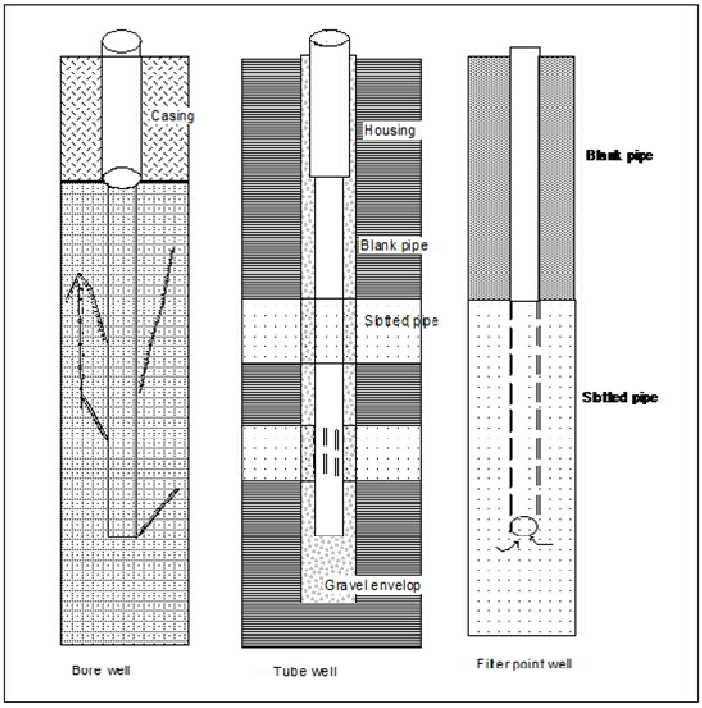
Hard and soft rocks need separate well design. Since Tamnar block is mostly covered by semi-consolidated rock, so well construction is done with rotary drilling methods. During the exploration, cutting materials are collected in every 3 m interval of depth and kept in a wooden box prepared for the sample 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 31 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 <u>Hydrochemical data</u>:

The hydrochemical analysis of the ground water of the block was based mostly on the analysis of 41 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 Tamnar 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

Tamnar 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 Tamnar 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 Tamnar block.

CHAPTER-3

AQUIFER DISPOSITION

3.1 Principal & Major aquifer groups:

The aquifer material controlling ground water flow in Tamnar 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 group in Tamnar block is (**Map-3**):

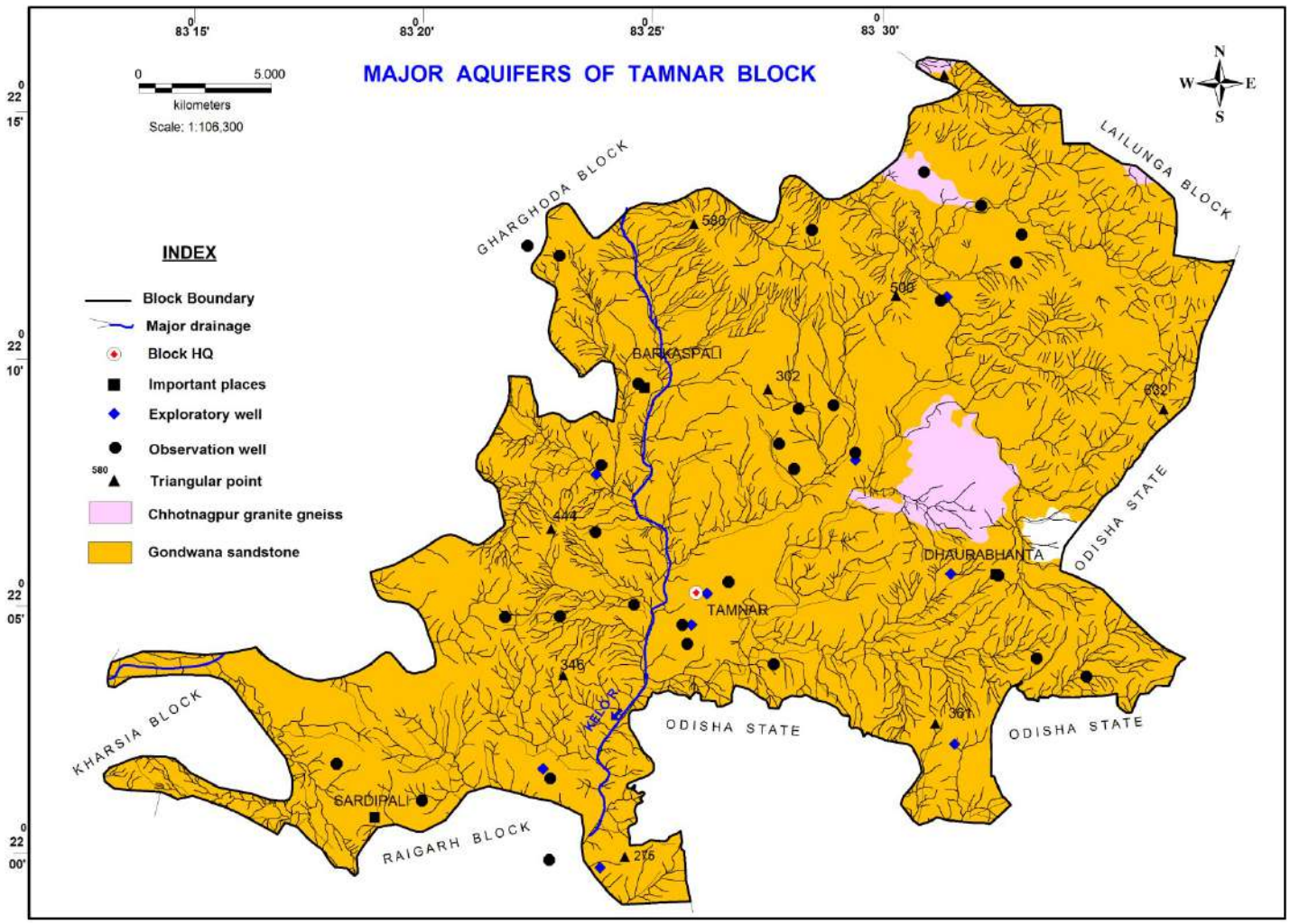
(i) Gondwana Sandstone

(i) Gondwana Sandstone: All the parts of the block is covered by Gondwana Formation except few patches which are covered by plutonic & 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.

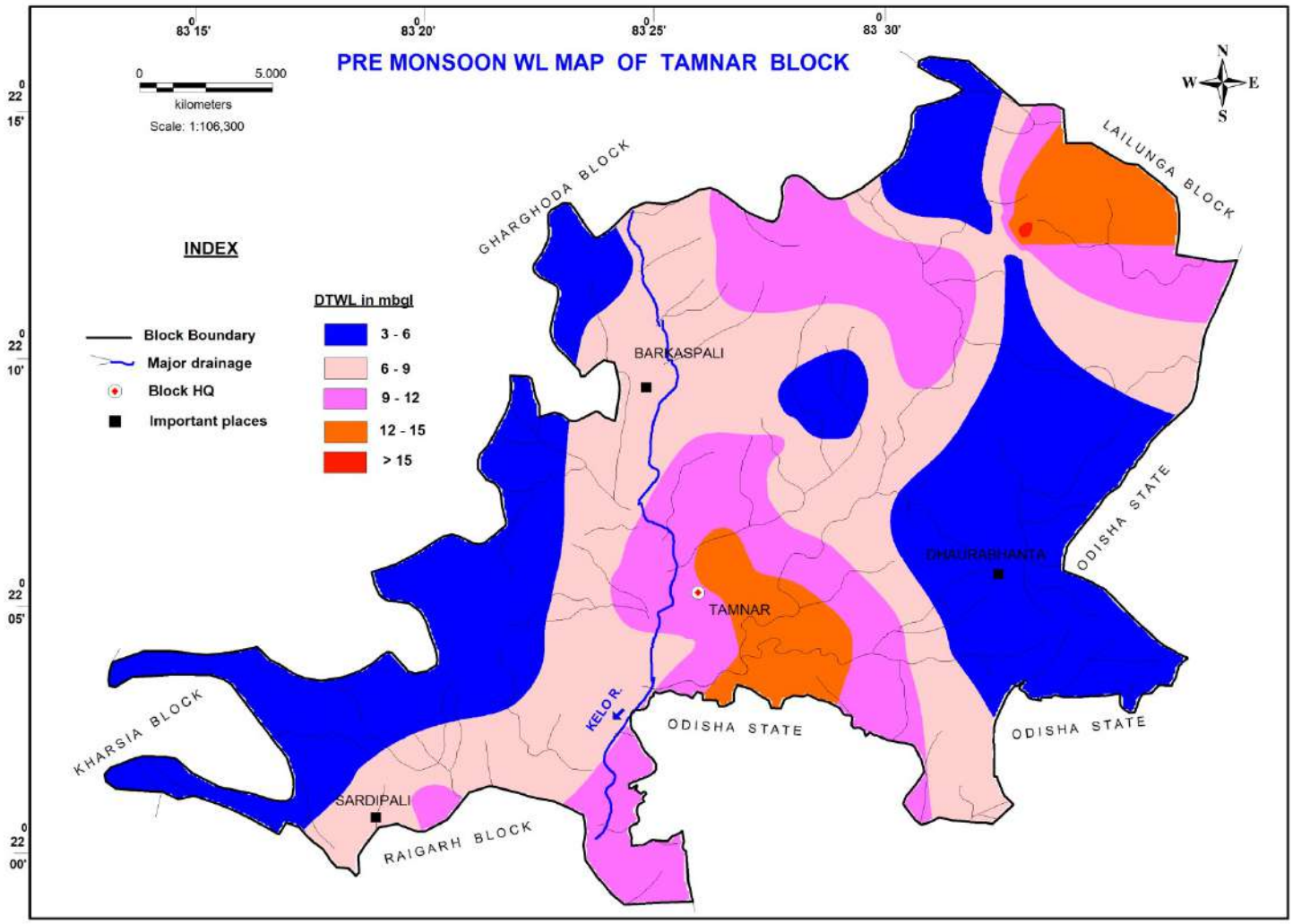
3.2 Ground Water Regime monitoring:

During the study, 31 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 3.0 to 15.6 mbgl with an average of 7.54mbgl and during post-monsoon period it ranges from 1.8 to 13.0 mbgl with an average of 5.22 mbgl. The fluctuation ranges from 0.1 to 7.33 m with an average fluctuation of 2.33 m. The long term ground water level trend indicates that there is no appreciable change in water level both in pre-monsoon and post monsoon period at most of the locations . The average weathered thickness of the phreatic aquifer is around 18 m. The water level map prepared for the district is presented in (**Map-4 A, B &C**).

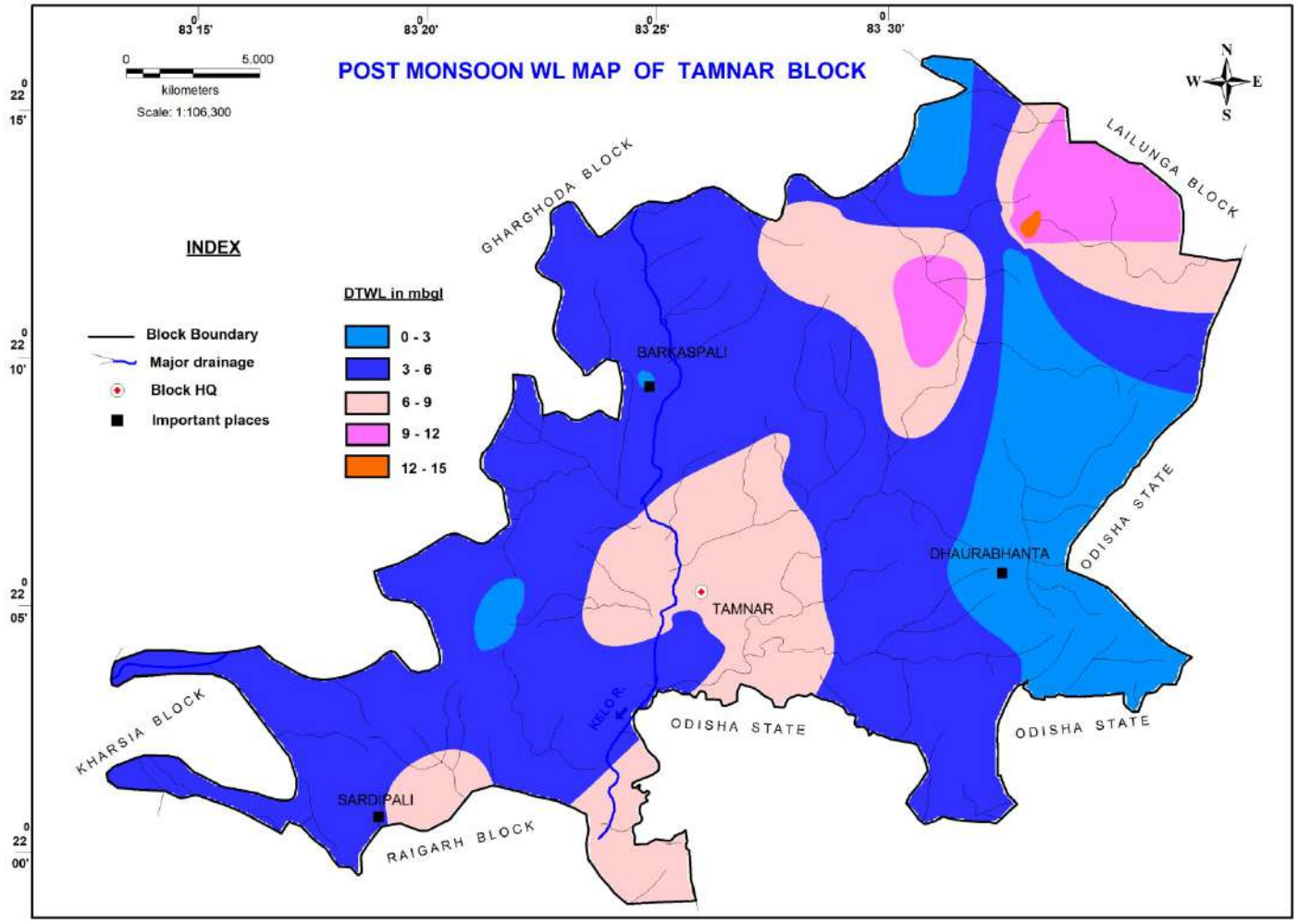
Map-3: Major Aquifer map of Tamnar block



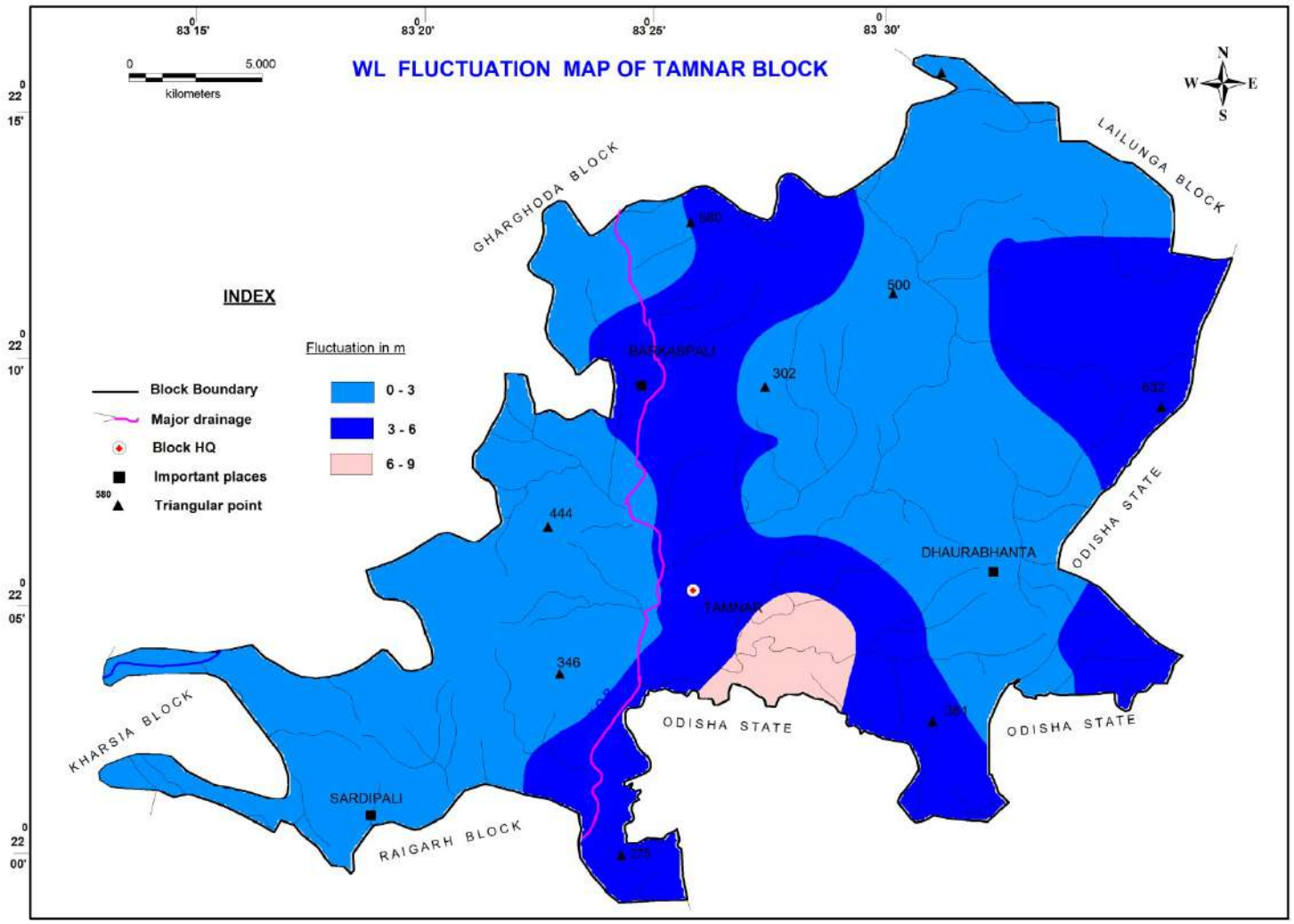
Map-4 (A): Pre-monsoon depth to water level map of Tamnar block



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



Map-4 (C): Water level fluctuation map of Tamnar 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 Tamnar 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 all the wells show declining trend to the tune of 0.003 to 0.015 m/yr. The hydrograph of some of the wells are presented in **Fig-2.** 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 Tamnar block

SN	Block	Site name	Longitude	Latitude	Trend (2010-2019) postmonsoon	Remarks
1	Tamnar	Gare Nhs	83.49	22.14	-0.002417	Declining
2	Tamnar	Taraimal1.1	83.38	22.06	-0.003101	Declining
3	Tamnar	Samaruma	83.35	22.08	-0.015655	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 Tamnar 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 Tamnar block is 1906.48 ham. The Net Ground Water Availability for future use is 910.83 ham. Current Annual Ground Water Extraction for all purposes is 962.8 ham out of which 723.59 ham is for irrigation. The overall Stage of Ground Water Extraction in the block is 50.5 %. The Annual GW Allocation for domestic Use as on 2025 is 272.06 ham. The block wise resource is presented in table 6.

Table-6: Resources as estimated in 2017 of Tamnar 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)
Tamnar	1906.48	723.59	0	239.21	962.8	272.06	910.83	50.5	Safe	No	

3.3.2 Static Ground Water Resources:

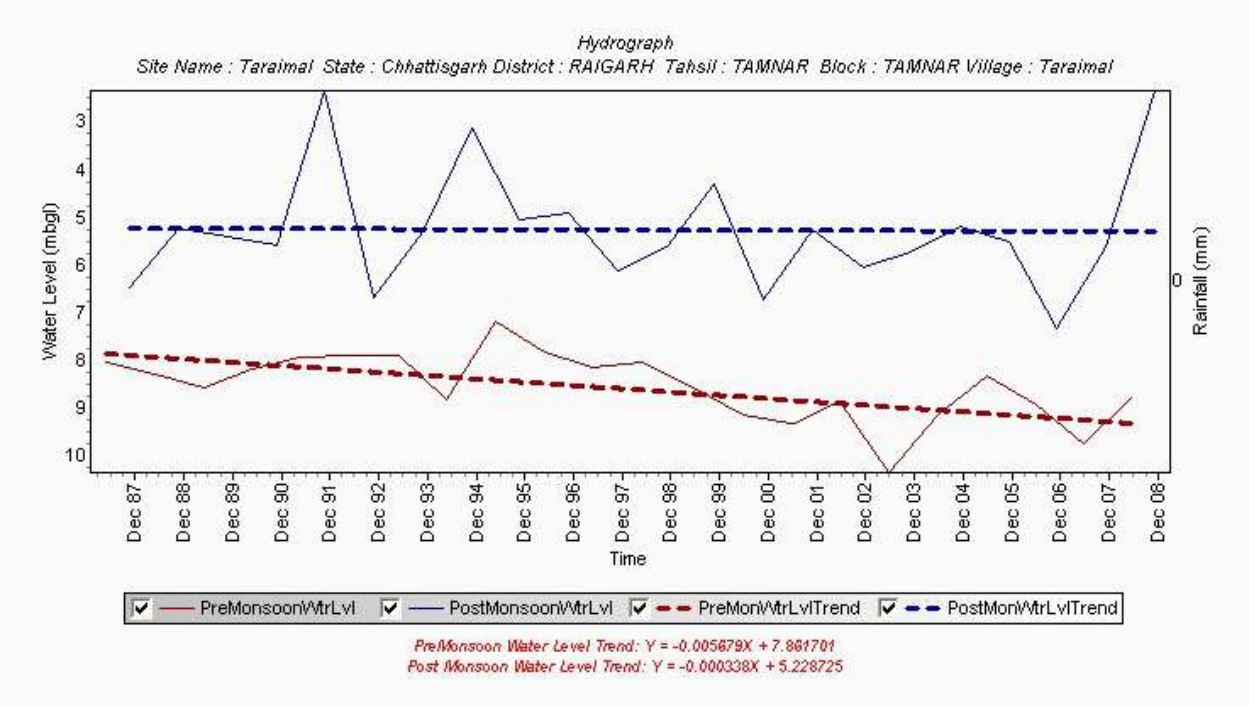
An attempt has been made to assess the Static Ground Water Resources Tamnar block which is the resource that remains available below the dynamic zone of water table fluctuation. This is not replenished every year and extracting this water is ground water mining. The quantum of ground water available 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 Tamnar block.

Table-7: Ground water Resources of Tamnar block

Block	Recharge worthy Area (Ha)	Stage of Extraction in %	Static Resource in Ham	Dynamic Resource in Ham
Tamnar	23800	50.50	961.520	1906.480

The table shows that the total static ground water resource of Tamnar a block is 961.52 ham beside the dynamic ground water resource of 1906.48 ham.

Fig- 2: Hydrograph of Taraimal, Tamnar block



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

Ground water quality of shallow aquifer as well as deeper aquifer in Tamnar block for drinking, irrigation and industrial purposes is assessed on the basis of analysis of ground water samples collected from 39 nos. of observation wells for shallow aquifer & 2 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 <u>Water quality for all purposes:</u> 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	6.6	8.4	7.8	8.5
2	EC(in µS/cm at 25° C)	59	1680	285	470
3	Total Alkalinity	0	335.24	104.9	150
4	HCO_3	12	409	128	183
5	Cl	7	327	18	25
6	SO_4	0	70	60	
7	F	0	1.4	0.7	
8	TH	25	475	45	70
9	Ca	6	86	14	16
10	Mg	0	62	1	8
11	Na	2	105	86	
12	K	1	95	19	

The above table-5.5 indicates that the ground water of Tamnar 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 Tamnar block.

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

3.4.4 Type of Ground Water: The ground water of Tamnar 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. Nitrate content is considerably high in shallow groundwater in some locations.
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 Tamnar block were prepared:

(i) Aquifer map 2-dimensionsl, (**Map-5 A,B)**
(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 Tamnar block is 50.5 %, the block can be developed through tube wells and dug wells both to achieve the stage of extraction 60%. 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 Tamnar 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)
Tamnar	50.5	194	242	194	436	581

From the table 9, it is depicted that 194 nos of irrigation tube wells or 242 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 194 ha for paddy, 436 ha for wheat, Ground Nut, Sunflower and 581 ha for Mustard & Pulses respectively.

(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.

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

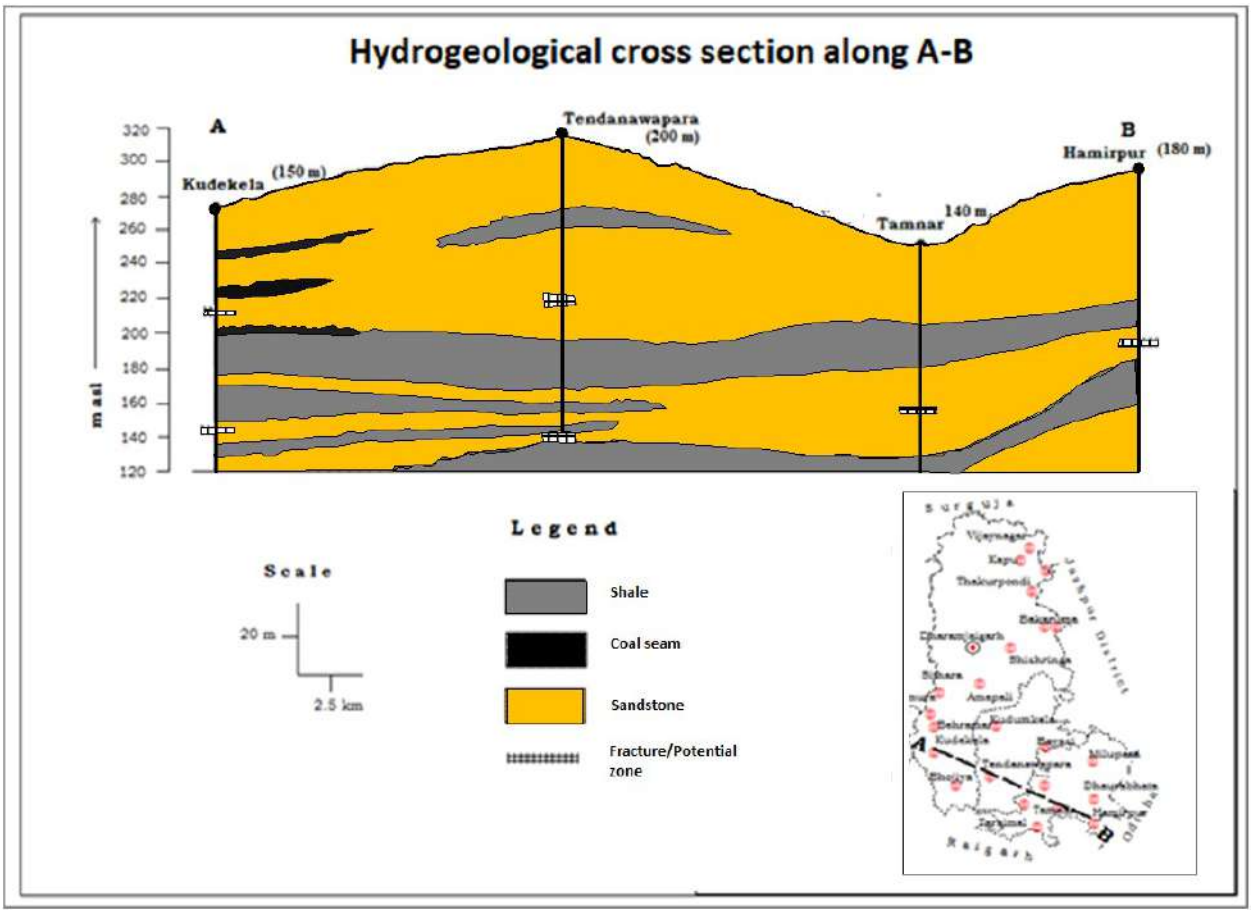
(ix) Even if farmers use solar pump or other method of ground water irrigation for summer paddy, it should not be flooding method. Proper pipes are to be used to transfer water from one plot to another.

(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.

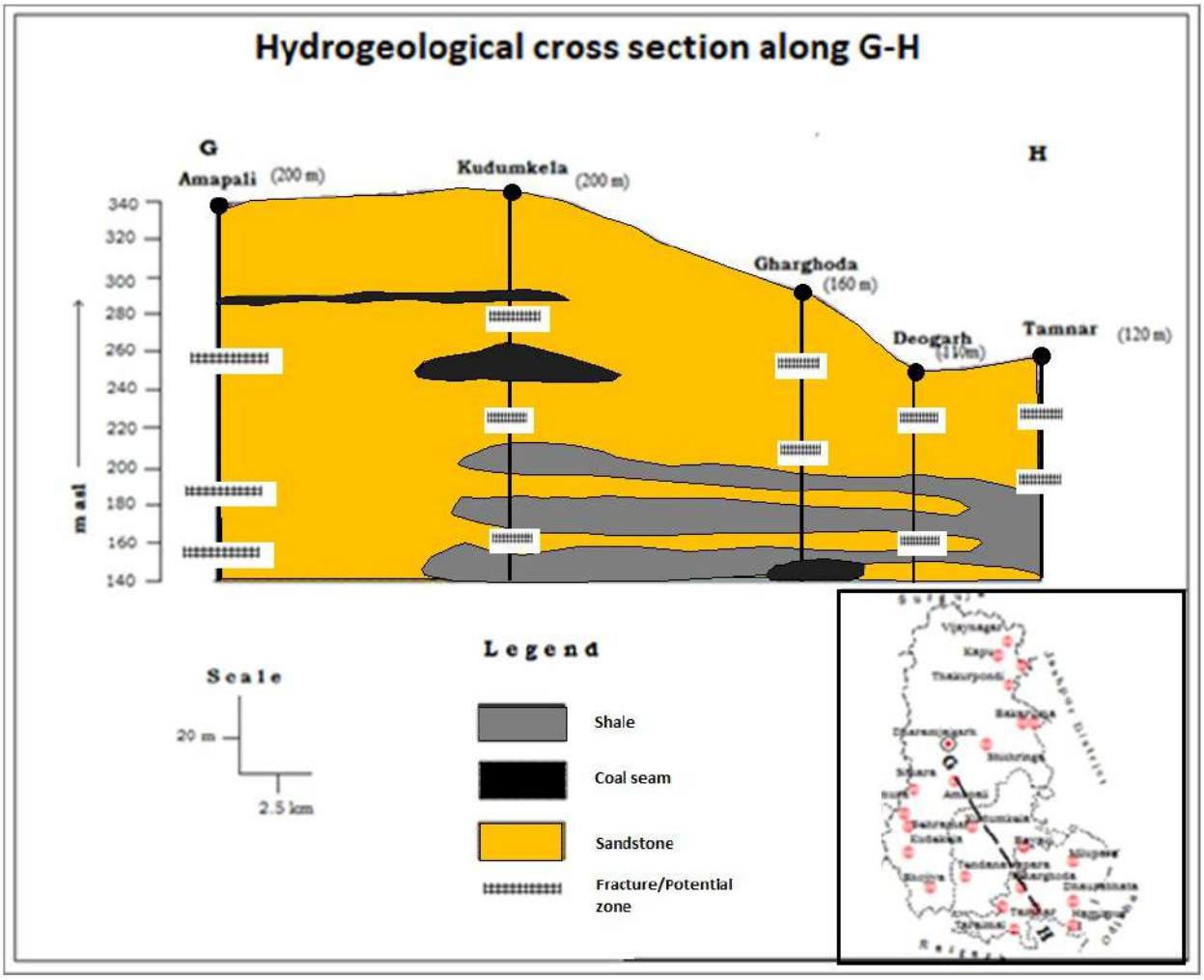
(xi) Supports for the technology development for harvesting and disposal of by-products in agriculture fields which will also increase the fertility of soil.

(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.

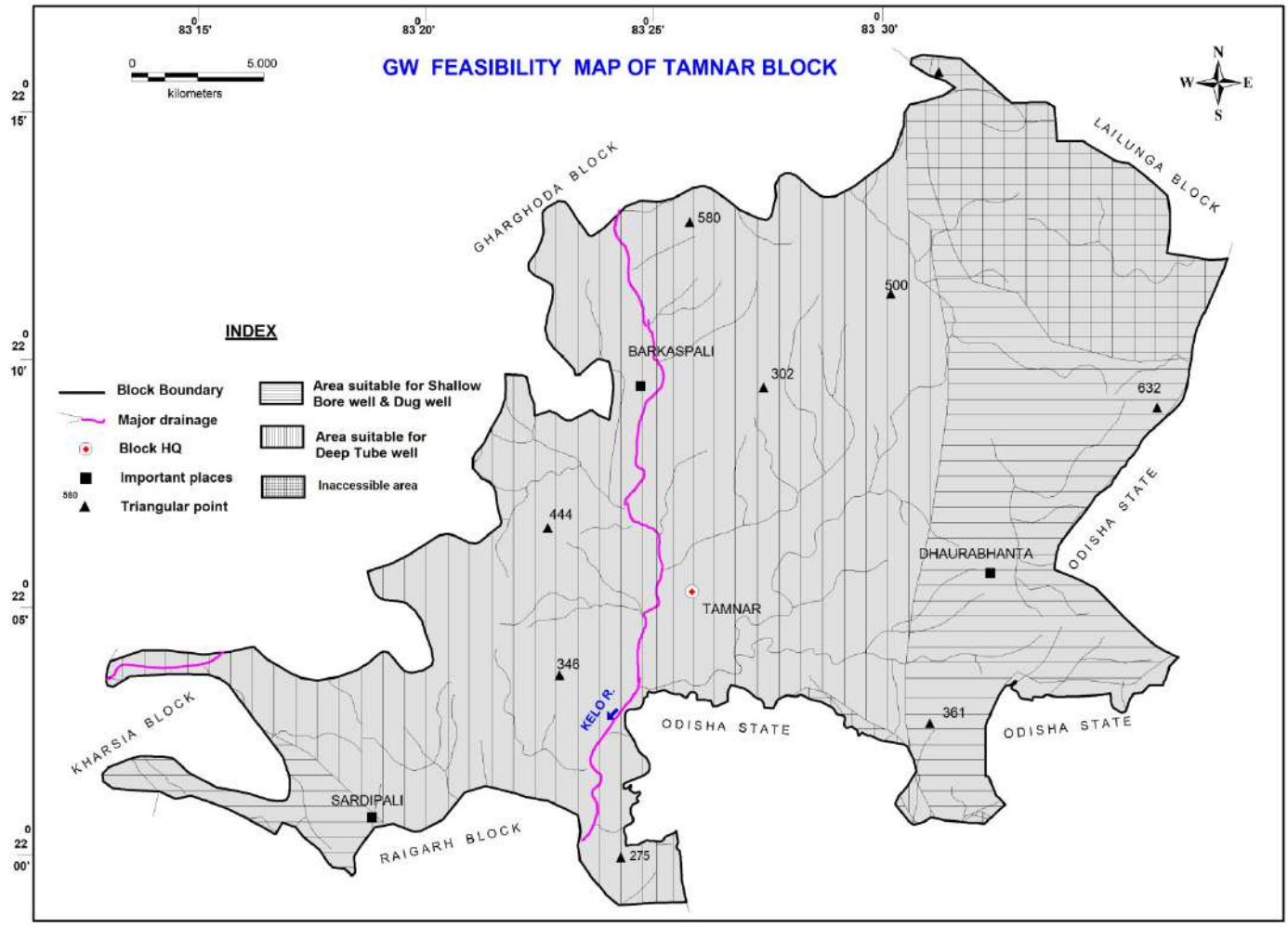
Map-5 (A): Hydrogeological cross section in NW-SE direction



Map-5 (B): Hydrogeological cross section in NNW - SSE direction



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



CHAPTER-V

SUM UP

5.1 Conclusions:

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

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

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

High nitrate content at some locations & deeper water level (more than 5m in the post- monsoon period) in some areas are the major issues so far as ground water scenario in the block is concerned. Annual Extractable Ground Water Recharge 1906.48 ham and present stage of ground water extraction is 50.8 % thus under safe category. Since the stage of development in the block is only 50.5 %, there is ample scope of development. Since the stage of development in the block is only 50.5 %. So there is ample scope of development. In order to achieve 60% stage of ground water withdrawal in the block of Tamnar, development may be taken up by constructing 194 nos of tubewells or 242 nos of dug wells that can create an irrigation potential of 194 ha for paddy, 436 ha for wheat, Ground Nut, Sunflower & 581 ha for Mustard & Pulses .

5.2 Recommendations

- Since the stage of ground water development for Tamnar, from supply side of ground water management, construction of 194 nos of irrigation tube wells (60 to 150 m deep with diameter of 100 to 150 mm) or 242 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 194 ha of paddy, 436 ha of wheat,Ground Nut, Sunflower and 581 ha of Mustard & Pulses.

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ANNEXURE-I: Exploration details in Tamnar block

SL.NO	LOCATION	LAT	LONG	DEPTH (m)	CASING (m)	FORMATION	ZONE ENCOUNTERED (m)	YIELD (lps)	DRAW DOWN (m)	TRANS MISSIVITY IN m^2/sec	STORATIVITY
1	Gare	22.133	83.488	352.87	346	Barkar Fm	141-150,177-183,186-192,195-204,222.-228,236-242,255-275,290.-305 ,311-322,334-343	9.46	27.67	54.23	0.0172
2	Gerwani	21.995	83.395	300.15	261	0-93.1 Kamthi Fm 93.1-300.15 Barakar	70-82,99-108,114-126,139-142,160-166,177-184,187-190,203-209,219-222,227-236,242-244,248-251,255-258	7.887	27.2	47.98	0.00044
3	Hamirpur	22.037	83.525	301.5	113	0.0-22.11 Kamthi Fm 22.11-301.10 Barakar Fm	87-90,92-110	2.106	31.13	3.47	
4	Tamnar	22.088	83.434	305.25	303	Barakar Fm	153-159,162.5-168.5,190.5-208.5,264-276,279-285,288-300			9.25	
5	Taraimal	22.029	83.375	300.81	196	Barakar Fm	64-72,92-113,132-138,172-193	6	15.75		
6	Deogarh	22.128	83.394	204	177	Baraker Fm	61-64,82-84,94-99,111-115,12-126,132-147,154-158,160-174	1.33			
7	Gorhi	22.077	83.429			Baraker Fm					
8	Milupara	22.188	83.522	200.43	163	Baraker Fm	144-160	1.5			
9	Dhaurabhata	22.095	83.523	200	90	Baraker Fm	45-85	1	16.1		

10	Gare OW	22.133	83.488	348.98	335	Barkar Fm	170-182,193-199,205-220,233-239,244-250,258-270,290-305,310-322,326-332	6.321			
11	Gerwani OW	21.995	83.395	263.4	261	0.0-92.19 Kamthi Fm 92.19-263.4 Barakar	70-82,100-109,120-126,139-142,163-166,175-184,187-190,206-210,219-222,230-236,241-244,249-252,255-258	5.84			
12	Tamnar OW	22.088	83.434	400.28	354	Barakar Fm	114-126,147-270,331-351				
13	Milupara OW	22.188	83.522	201.08	164	Baraker Fm	106-116,144-161	1			

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

S.No	Village	Long	Lat	Source	Pre-Monsoon SWL (mbgl)	Post-Monsoon SWL (mbgl)	Fluctation (m)
1	Auraimura	83.3811	22.20222	DW	4.8	4.25	0.55
2	Barkaspali	83.4097	22.15911	DW	8	2.98	5.02
3	Devgarh	83.39631	22.131672	DW	7.25	5	2.25
4	Gare	83.48895	22.13577	DW	5.5	4.7	0.8
5	Koknara	83.3694	22.2056	DW	4.95	3.8	1.15
6	Milupara	83.5199	22.1872	DW	11.2	10.5	0.7
7	Saraipali	83.31444	22.26167	DW	10.5	6.4	4.1
8	Jaradih	83.5475	22.2	DW	5.6	1.8	3.8
9	Hinjhar	83.54944	22.20944	DW	15.6	13	2.6
10	Urba	83.53472	22.21917	DW	5.2	3.7	1.5
11	Pelma	83.51389	22.23056	DW	3.8	2.4	1.4
12	Dhaurabhata	83.54083	22.09444	DW	3.3	2.3	1
13	Bijna	83.555	22.06639	DW	3	2.9	0.1
14	Karrapali	83.57306	22.06028	HP	5.5	2	3.5
15	Gourmuri	83.33092	22.0185	DW	9.17	7.3	1.87
16	Barpali	83.29987	22.03091	HP	5.57	3.67	1.9
17	Gerwani	83.37733	21.9985	DW	10.37	6.78	3.59
18	Taraimal	83.37549	22.02794	DW	7.83	4.73	3.1
19	Parkipahri (Gudguda)	83.36123	22.08039	DW	3.85	2.92	0.93
20	Jhingolpara	83.38124	22.08061	DW	6.9	5.62	1.28
21	Amaghat	83.40826	22.08449	DW	9.42	7.52	1.9
22	Kachkoba	83.39408	22.10897	HP	8.42	5.92	2.5
23	Gohri	83.42577	22.07773	HP	9.92	5.3	4.62
24	Kasdol (Kasinagar)	83.42756	22.07141	DW	8.89	5.64	3.25
25	Tomnar	83.4427	22.09215	DW	12.42	8.44	3.98
26	Devgaon	83.45908	22.06444	DW	13.62	6.29	7.33
27	Kunjemura	83.46659	22.13034	DW	6.85	5.54	1.31
28	Saraitola	83.48091	22.15182	DW	3.96	3.27	0.69
29	Mudagaon	83.46817	22.15062	DW	5.32	4.5	0.82
30	Pata	83.46103	22.13887	HP	9.22	6.16	3.06
31	Gare	83.48895	22.13577	HP	7.86	6.38	1.48

ANNEXURE-III (A): Chemical Quality details of Shallow aquifer in Tamnar 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	NO_3
1	Gourmuri	7.8	628.48	982	0	98	80.33	131	0	60	50	17	40	95	195			143
2	Saraipali (II)	7.2	351.36	549	0	18	14.75	75	0	9	6	20	31	47	100			115
3	Barpali	7.4	42.88	67	0	12	9.84	7	0.1	1	6	4	2	5	30			20
4	Gerwani	8	280.32	438	0	146	119.67	39	0.1	20	30	10	22	36	115			32
5	Taraimal	8.2	305.28	477	0	146	119.67	67	0	20	30	6	57	7	100			22
6	Parkipahri	7.8	37.76	59	0	18	14.75	11	0	2	6	2	4	3	25			7
7	Jhingolpara	7.8	226.56	354	0	73	59.84	60	0	6	18	16	15	10	110			19
8	Amaghat	7.5	133.12	208	0	31	25.41	25	0	4	10	7	7	19	55			40
9	Kachkoba	7.8	586.24	916	0	195	159.84	99	0.1	40	52	26	28	75	240			102
10	Gorhi	7.9	305.92	478	0	104	85.25	67	0.1	8	24	12	34	21	110			40
11	Kasdol	7.8	173.44	271	0	79	64.75	21	0	1	26	10	13	6	105			38
12	Tomnar	7.9	326.4	510	0	165	135.25	50	0.1	26	46	11	28	6	160			22
13	Devgaon	7.7	1075.2	1680	0	195	159.84	327	0.7	70	86	62	105	45	475			132
14	Parigon	7.9	116.48	182	0	61	50.00	14	0.1	11	14	6	8	12	60			7
15	Kunjemara	7.5	120.32	188	0	43	35.25	28	0.1	1	10	5	13	13	45			24
16	Saraitola	8.2	329.6	515	0	250	204.92	36	0.7	11	26	17	42	31	135			3
17	Gare	7.9	355.2	555	0	146	119.67	60	0.4	29	26	16	33	44	130			34
18	Saraipali	7.8	182.4	285	0		0.00	36	0.1	11	6	20	16	8	100			15
19	Milupara	7.7	80.64	126	0	49	40.16	11	0.1	0	14	9.2	4.1	2	60			6
20	Milupara	7.9	209.92	328	0	85	69.67	43	0.1	0	36	36.9	21.1	1	110			4.8
21	Jaradih	7.9	142.08	222	0	79	64.75	28	0.3	9	22	1.3	8.6	9.2	85			7.2
22	Hinjhar	7.9	0		0	110	90.16	11	0.3	11	18	0.8	8.6	12.6	80			8.4
23	Urba	8.2	453.76	709	0	299	245.08	50	0.3	30	42	5.9	21.5	90	185			19.2
24	Urba	8	186.88	292	0	140	114.75	14	0.2	16	22	0	11.8	22.6	85			7.2
25	Pelma	8.2	376.96	589	0	146	119.67	89	0.1	34	42	10.5	45.7	11.2	175			16.8
26	Dhaurabhata	7.9	172.16	269	0	98	80.33	28	0.3	14	26	0.3	13.8	6.5	95			7.2

27	Bijna	8.1	684.16	1069	0	409	335.25	103	1.4	56	86	11.6	45.3	17.9	415			48
28	Karrapali	8.4	345.6	540	15	220	205.33	50	0.7	0	46	0.6	15.5	28.3	205			21.6
29	Taraimal	6.6	117	195	0	43	35.25	28	0.1	10.6	12	8.4	13.4	2.8	65	0.14	3.2	
30	Amaghat	6.9	117.6	196	0	43	35.25	25	0.1	7.7	12	9.6	4.9	10	70	0.11	7.8	
31	Godhi	7.3	522	870	0	244	200.00	163	0.1	8.9	56	33.6	37	55.1	280	0.14	3.1	
32	Tamnar	7.1	189	315	0	122	100.00	39	0.1	7.2	30	9.6	14.9	3.8	115	0.13	12.5	
33	Daurabhata	7.2	201	335	0	134	109.84	32	0.2	10	24	10.8	15.2	8.7	105	0.12	7.5	
34	Gare	7.3	176.4	294	0	146	119.67	21	0.9	2.9	22	12	12.2	9.3	105	0.11	6.9	
35	Milupara	7.1	192	320	0	159	130.33	28	0.2	8.9	16	14.4	15.4	24	100	0.18	6.4	
36	Barkaspali	7.2	312	520	0	281	230.33	28	0.4	2	32	24	21.4	22	180	0.15	4.4	
37	Devgarh	6.9	265.8	443	0	85	69.67	85	0.1	9.8	26	15.6	29.4	4	130	0.14	10.7	
38	Koknara	7.5	283.8	473	0	287	235.25	14	0.5	13.8	36	25.2	19.3	3.4	195	0.11	4.7	
39	Arimura	6.9	84	140	0	49	40.16	18	0.1	3.4	12	4.8	4.1	4.7	50	0.08	11.2	

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

S.NO.	Location	pH	TDS	EC	CO_3	HCO_3	Total Alkalinity	Cl	F	SO_4	Ca	Mg	Na	K	TH	NO_3
1	Tamnar	8.5	171	285	0	128	104.92	18			14	8			70	
2	Dhaurabhata	7.8	282	470	0	183	150.00	25	0.7	60	16	1	86	19	45	1

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