केन्द्रीय 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

Giridih District
Jharkhand

मध्य पूर्वी क्षेत्र, पटना

Mid Eastern Region, Patna

भारत सरकार

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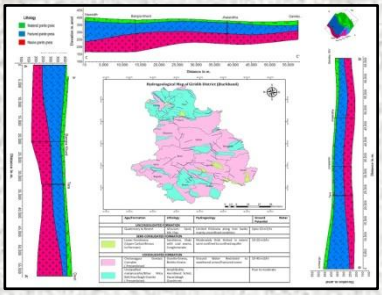
Central Ground Water Board

Aquifer Maps and Ground Water Management Plan of Giridih district, Jharkhand

जलभृत नक्शे तथा भूजल प्रबंधन योजना

गिरिडीह जिला, झारखंड



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REPORT ON AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN OF GIRIDIH DISTRICT, JHARKHAND, 2019-20

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REPORT ON AQUIFER MAPS AND MANAGEMENT PLAN OF GIRIDIH DISTRICT, JHARKHAND STATE (2019 - 20)

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REPORT ON AQUIFER MAPS AND MANAGEMENT PLAN OF GIRIDIH DISTRICT, JHARKHAND STATE, 2019 – 20

Chapter- 1

1.0 INTRODUCTION

The vagaries of rainfall, inherent heterogenity & unsustainable nature of hard rock aquifers, over exploitation of once copious aquifers, lack of regulation mechanism etc has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "**Traditional Groundwater Development concept**" to "**Modern Groundwater Management concept**". Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. This leads to concept of Aquifer Mapping and Ground Water Management Plan. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. The proposed management plans will provide the **"Road Map"** for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation.

During XII five year plan (2012-17) National Aquifer Mapping (NAQUIM) study was initiated by CGWB to carry out detailed hydrogeological investigation. The Aquifer Mapping programme has been continued till 2023 to cover whole country. The present study of Giridih district has been taken up in AAP 2019-20 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Giridih district and other user agencies for its effective implementation.

1.1 Objective and Scope of the study:

The major objectives of aquifer mapping are

- Delineation of lateral and vertical disposition of aquifers and their characterization
- Quantification of ground water availability and assessment of its quality to formulate aquifer management plans to facilitate sustainable management of ground water resources at appropriate scales through participatory management approach with active involvement of stakeholders.

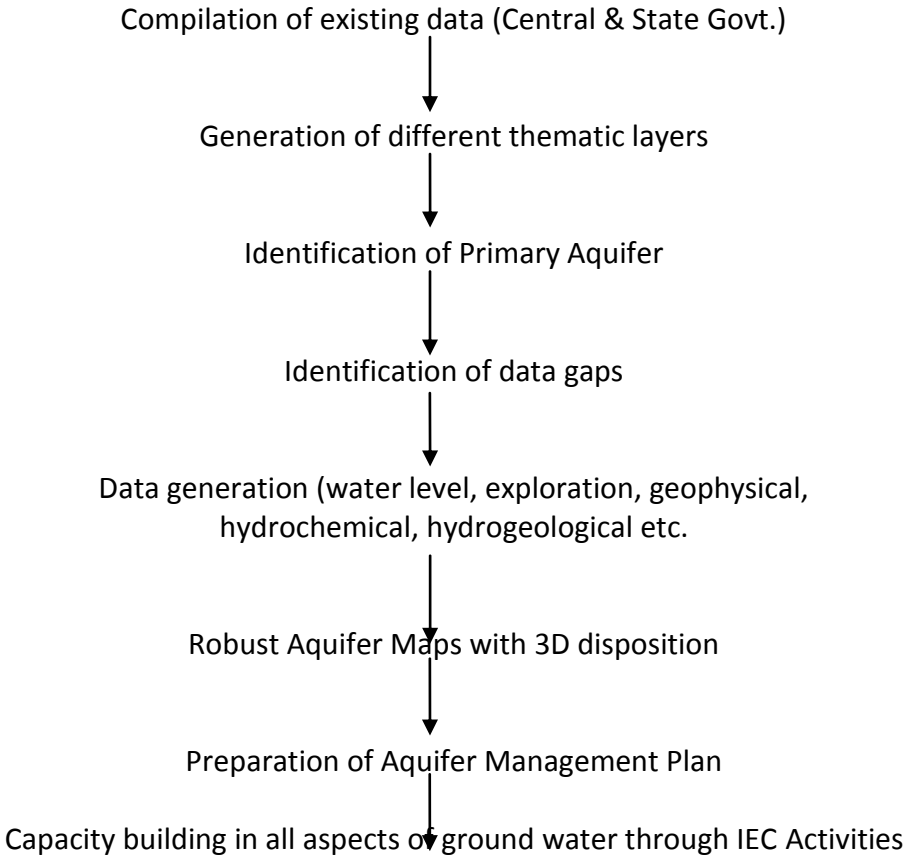
The groundwater management plan includes Ground Water recharge, conservation, harvesting, development options and other protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan.

The main activities under NAQUIM are as follows:
a). Identifying the aquifer geometry
b). Aquifer characteristics and their yield potential
c). Quality of water occurring at various depths
d). Aquifer wise assessment of ground water resources
e). Preparation of aquifer maps and
f). Formulate ground water management plan.
The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a **"Road Map"** to systematically manage the ground water resources for equitable distribution across the spectrum.

1.2. Approach and methodology:

The ongoing activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200 meters.

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilization for preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:



1.3 Area details: Giridih district is situated in Northern part of the Jharkhand state and the district is bounded on the north by Jamui and Nawada district of Bihar, on the east by the districts of Dhanbad, Jamtara and Deoghar , on the south by Bokaro and Dhanbad district and on the west by Hazaribagh and Kodarma district. It covers an area of about 5084.90 Sq. Km and is situated between 24^0 02' and 24^0 45' N latitude and 85^0 40' and 86^0 34'E longitude. The district falls in Survey of India toposheet nos. 72 H /13,14,15, 16, 72 L/ 01, 02, 03, 04,07,08, 12, 72 E/13, 72 I/1 and 5. The district which acquired the status of an independent district on 6th December, 1972, has a close linkage with the parent district Hazaribagh. In 1999, part of it became Bokaro district.

Giridih is the administrative headquarter and the principal town of the district. The district has been given this name for abundance of mountain and hillocks in the district. It has one sub – division i.e Giridih which has been further divided into thirteen blocks namely – Giridih, Pirtand, Bengabad, Gandey, Jamua, Dhanwar, Dewri, Bagodar, Gawan, Tisri, Dumri, Birni and Sariya (Fig. 1).

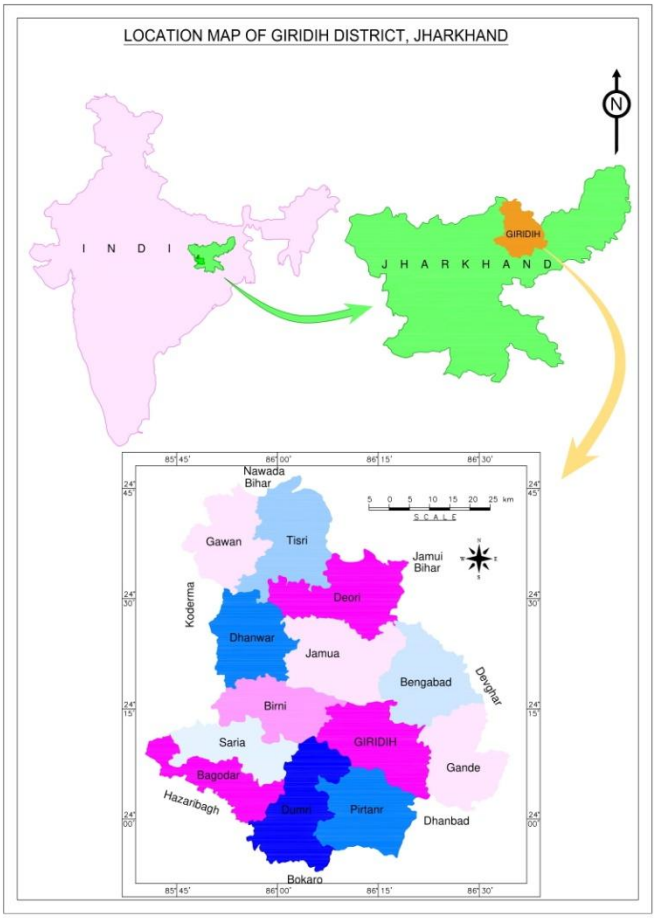


Figure -1: Location map of Giridih district

1.4 Data Availability, Data Adequacy and Data Gap Analysis

1.4.1. Data availability: Central Ground Water Board has carried out exploratory drilling in the district and drilled 08 exploratory and 09 observation wells by departmental rig during the year 1982-1983. Similarly, 14 exploratory wells and 04 observation wells were drilled during the year 2002-03. Also drilled 11 exploratory and 05 observation wells during the year 2019-21 In addition, 06 numbers of exploratory wells were drilled through outsourcing drilling during the year 2020 in the district. At least three additional exploratory and one observation wells are to be drilled in each block to know the sub–surface geology, depth and thickness of water bearing formation with their yield and determine the different aquifer parameters.

In addition, seventeen numbers of permanent observation well (HNS) of Central Ground Water Board located in the district for monitoring of ground water regime and to assess the chemical quality of ground water.

1.4.2 Data Adequacy and Data Gap Analysis: The available data of the Exploratory wells drilled by Central Ground Water Board, State Unit Office, Ranchi, Geophysical Survey carried out in the area, ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analyzed for adequacy of the same for the aquifer mapping studies.

After taking into consideration, the available data of ground water exploration, geophysical survey, ground Water monitoring and ground water quality, the data adequacy is compiled and the summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations is given below in Table-1.

Table – 1: Data adequacy and data gap analysis

Exploration data			**Geophysical data**			**GW monitoring data (HNS)**			**GW quality data**		
Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap
39	36	3	52	20	32	20	17	3	20	17	3

The data adequacy as discussed above indicates that the existing data is not sufficient for preparation of aquifer maps; hence data gap has been identified for Exploratory Wells, Geophysical Survey (VES), Ground Water Monitoring Wells and Ground Water Quality. Based on the data gap identification, the data generation activity was planned and completed in 2019-20. Each two numbers of exploratory wells are required in Tisri, Gawan and Chirki Pirtarn blocks of the district. Similarly, at least one exploratory well is required in Bengabad, Gandey, Dumri and Saria blocks. In addition 11 wells have also been proposed for outsourcing in Giridih district.

1.5 Climate and Rainfall: The district belongs to one of the 13 districts of Jharkhand, which falls in the Agro climatic sub-zone-IV. The district receives less than 1300 mm of annual rainfall. The district experiences a subtropical climate with three well marked seasons namely winter,

summer and rainy season. The winter season begins in November and continues up to February, though the first half of March remains somewhat cool. December is the coolest month of the year and the last week of the month is the coolest period. In the second half of March the temperature rises considerably and temperature goes up to 45^{o} Celsius in the month of May, which is the hottest month of the area. The monsoon season starts from the middle of June and continues till end of September or middle of October. With the cessation of rains the temperature starts falling and the climate become rather pleasant.

The district belongs to the higher rainfall class with large annual variation. The average rainfall in last ten years (2011 – 2020) of the distinct is 836.68mm. The maximum rainfall occurs during the first half of July to first half of August and contributes about 50 % of the total rainfall. The monsoon season contributes about 85 % of the total annual rainfall. However dry spell of 4-8 days have been very common in the month of July and /or August. The maximum humidity is observed during the monsoon season with mean value of 85%, where as the minimum humidity is observed during April-May which is 27 %. Generally the weather during the other seasons is more or less dry and in the comfortable zone.

The Decadal average monsoon rainfall (2011 to 2020) varies from 521.01 to 1089.94 mm. The rainfall data for the period of 2011–20 has been worked out and analyzed Decadal annual monsoon rainfall, standard deviation and coefficient of variation which are given table–2. Block wise monsoon rainfall (2011 – 2020) is presented in Annexure - I.

Table – 2: Analytical data of monsoon rainfall (2011 – 2020) of Giridih district

Sl No	Block	**Decadal average monsoon rainfall (mm)**	**Standard deviation**	**Coefficient of variation (%)**
1	Bagodar	899.53	206.60	22.97
2	Dumri	1089.94	366.00	33.58
3	Pirtarn	967.31	198.26	20.50
4	Giridih	940.99	209.90	22.31
5	Gandey	825.71	306.82	37.16
6	Bengabad	845.79	211.62	25.02
7	Jamua	921.83	271.59	29.46
8	Raj Dhanwar	686.99	315.76	45.96
9	Birni	919.83	213.97	23.26
10	Deori	697.15	292.48	41.95
11	Tisri	720.06	284.07	39.45
12	Gawan	521.01	200.94	38.57
13	Saria	840.75	189.03	22.48

1.6 Physiography: The physiography of the area is controlled by rock types occurring in the area, which are hard consolidated and semi-consolidated formations. The district represents a hilly and undulating terrain with an average elevation varying from 250 m to 600 mamsl. The district may be divided broadly into three natural divisions viz

1. The Central Plateau 2. The Lower plateau 3. The Damodar valley

The central area of the district is occupied by the central plateau, which is surrounded by lower plateaus from all sides except in the west where a ridge connects the central plateau to the Palamu district. The lower plateau with average height of 1300 ft is undulating in nature. In the north and North West the lower plateaus form tablelands until they reach ghats when they drop in height to 700 ft. The Damodar valley occurs along the southern part of the district. In the district lies the famous Parasnath hill, which has the distinction of being the highest peak of the state with an altitude of 4479 ft above mean sea level.

The majority of the area is occupied by plateau, which is moderately to shallow weathered, depending upon its area of occurrence. However major portion of the plateau area is moderately weathered. Some of the linear ridges running along E-W direction occur near Dumaria, Naukadihi Kalhamanja, Bharkatta villages and some of the residual hillocks scattered in nature, occur near Shriram nagar, Khandauli and Jonktiabad. The linear ridges and the residual hills act as run-off zone. Majority of the villages in the area occur on the inter stream divide. There is too much variation in the local slope.

Major part of the area is having elevation of 300-400 m. Area with lower elevation occur in and around the Barakar river in southern sector and in and around the Sakri river in the northern part. In major part of the district land slope varies from 10-20 m per kilometer. Land slope is highest in and around Parasnath hill and in and around the villages namely Rajakhar, Baramar, Kubri, Nima in the northern part of the district, which is 300-600 m per kilometer.

1.7 Geomorhpology: Geomorhologically the district can be broadly be divided into four units-

i). Denudational hills with or without valleys – This geomorphological unit found in northern part of the district with hills of moderate to great height, sometimes barren rocky and poor ground water prospect.

ii) Denudational hills with intervening broad undulating plains: This geomorphological unit is found in southern part of the district and in general ground water prospect is poor.

iii) Dissected plateau of denudation origin: This geomorphological unit found in NW part of the district with undulating hill region of moderate height and moderate ground water occurrences prospect.

iv). Plantation surface (pediplain and peneplain): Major part of the district is covered by this geomorphological unit with undulating plain with thick weathered zone, dissected in head water zone and good ground water prospect.

Geomorphological map of the Giridih district has been prepared and represented as figure – 2.

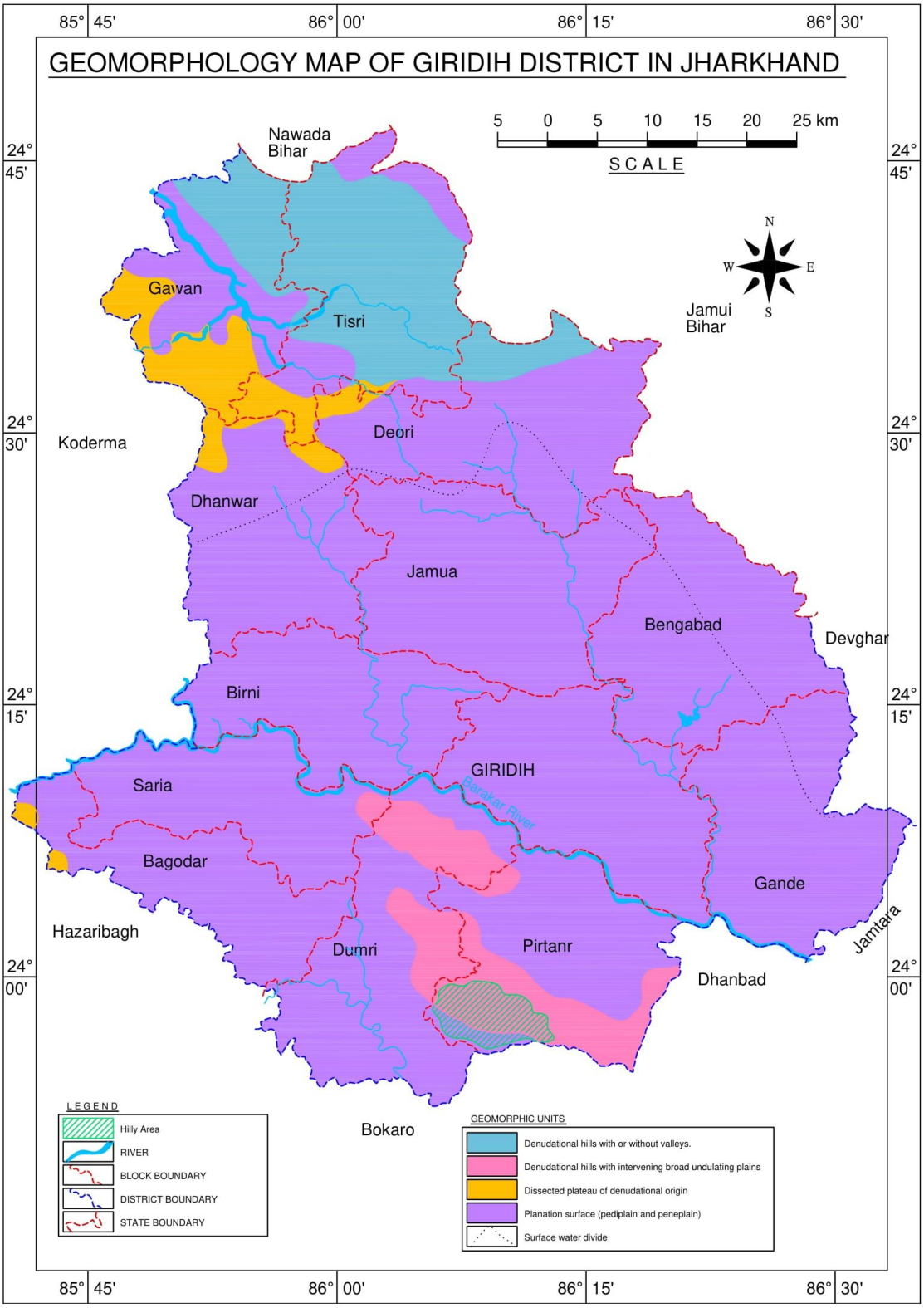


Figure – 2: Geomorphological map of Giridih district

1.8 Land use:

The district is predominantly agrarian and majority of population in rural areas depend on agriculture and other allied activities, which do not give steady and sufficient income. Therefore, poverty and illiteracy dominate the rural scenario. Our land mass is fixed, but the competition among different kinds of uses for this land is increasing because of rapidly rising global population. Therefore, integrated land resource planning and management are required to resolve these conflicts.

Out of total geographical area of the district i.e 5084.90 Sq. km, nearly 10 % area comes under net sown area, 31% under forests and the rest area falls under barren, cultivable waste, pasture and other agricultural use. Block wise land utilization data of the Giridih district for the year 2018-19 is given in table – 3.

Table: 3: Land use pattern of Giridih district (2018– 2019)

(Figures in Hectare.)

Block	Area of the block (Sq. km.)	Forest land	Barren & non cultiva-ble land	Culti-vable waste land	Perm-anent past-ures & other grazing land	Land under miscell-aneous trees	Current fallow	Fallow land other than current fallow	Net area sown	Area sown more than once
Jamua	478.47	7091.47	4999.05	2570.72	1532.17	617.03	13186.00	9544.98	6096.67	2655.83
Dumri	430.58	17302.00	2386.35	1321.16	858.59	406.58	6617.86	6338.96	4701.73	5126.20
Pirtarn	492.86	19073.59	2109.89	1726.30	1111.57	890.87	5056.75	3021.32	3413.86	4802.55
Bengabad	402.55	10431.26	3742.11	1911.85	768.77	40.57	13118.37	4213.54	5016.56	8099.27
Dhanwar	352.41	6329.66	1673.69	1925.79	1721.84	426.00	16249.29	815.19	3002.51	11794.29
Birni	319.98	4538.04	1748.14	1434.62	1579.97	582.18	6216.28	5797.91	4681.74	6430.76
Giridih	391.41	13310.70	4446.24	2340.94	1098.43	1039.07	5466.69	4437.64	4420.90	7306.81
Bagodar	287.49	8197.41	3292.10	1023.73	344.13	624.18	4334.10	4336.05	2719.83	3562.95
Tisri	429.56	24949.70	2197.22	1645.18	904.77	1151.89	9731.68	1642.10	2256.73	9272.27
Gawan	429.56	19514.53	2109.12	548.18	85.66	6.17	7115.92	828.61	2893.97	9593.16
Devri	423.81	9375.05	3773.44	1248.74	2256.96	1885.16	12873.95	4474.88	8104.09	6956.54
Gandey	366.10	10486.02	2010.79	1847.02	1118.92	939.90	12561.67	2445.88	1167.83	11964.23
Sariya	280.12	7966.51	3236.93	958.09	339.52	608.04	4859.94	4094.96	2304.38	3878.27
Total	**5084.90**	**158565.94**	**37725.07**	**20502.32**	**13710.30**	**9217.64**	**117388.50**	**51992.02**	**50780.80**	**91443.08**

Source: - District Statistic office, Giridih, Govt of Jharkhand

1.9 Soil: Soils in Giridih district has been formed as a result of insitu – weathering of crystalline basement and Gondwana sedimentaries. Climate, topography and vegetation have all contributed to the formation of soil. Soils are sandy loam to clay loam, non-calcareous and slightly to moderately acidic. The soil of the region is shallow and medium in depth generally shallow on the ridges and plateaus and deep in the valleys with low fertility status

Two types of soil occur in the district namely Alfisols (Older alluvial soil, Red sandy soil and red loamy soil) and Ultisols (red and yellow soil). Alfisols are the dominant soils covering more than 65 percent of Total Geographical Area. Different soils occurring the district have been shown in figure -3. Majority of the area is occupied by red loamy soil, which falls under Alfisol group of soil. This is followed by red and yellow which falls under Ultisol group of soil. Older alluvial soil occur over a small patch in the north western part in Gawan block near Charki, Paharpur and

Malda villages. Red loamy soil occurs over a small patch in north eastern sector near Chauki, Panitarn villages in Deori block. Red and yellow soil occur in central portion over a large chunk of area in Jamunia, Birni, and Dhanwar block. It also occurs in small patches south of Giridih and Gande block. In south western sector near Malpator, Bangargi, Beno, Ghettibari and Kusmarja villages and in western part near Dhargini and Ghagri villages.

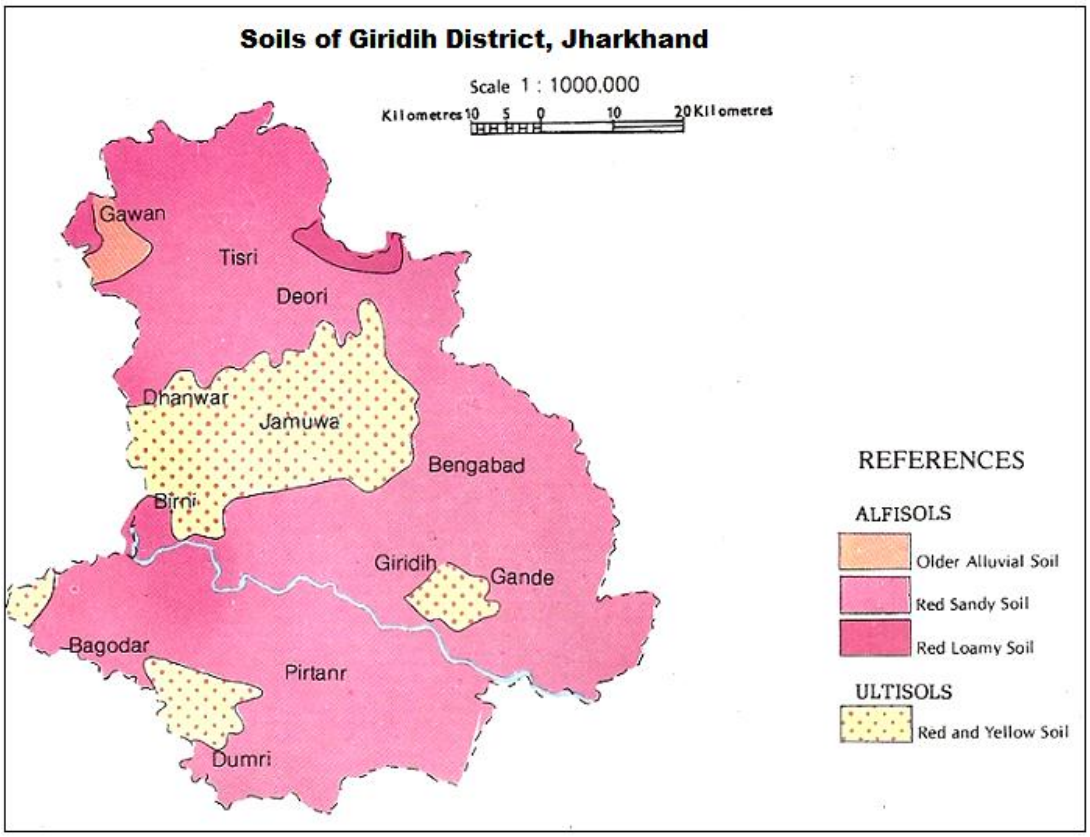


Figure – 3: Soil map of Giridih district

1.10 Hydrology and Drainage:

There is no major and medium project located in the district for irrigation. However, one medium project (Khandauli Dam) is located at about 08 km north east of Giridih town which is being used for drinking water supply to Giridih urban area. The Khandauli dam along with it's reservoir, spreading over an area of 1 sq. km, occurs near Khandauli village.

The major part of the district is having dendritic drainage pattern, controlled mainly by the topography the area. The district is divided into two main watersheds viz the Barakar and the Sakri Rivers. The Barakar River drains through major portion of the district, enters the district near the Birni block and also flows through Pirtand block. The Sakri River passes through the areas of Deori and Gawan blocks. A number of small rivers also flow in the district, the most important among them being Usri. Usri fall is one of the important fall on the river Usri situated about 13 km from Giridih town. All the rivers in the district area are seasonal in nature. During summer the flow of Barakar River is minimal. One of the major river is the Barakar river, which

flows in NW-SE direction. The Usri Nadi, which flows in NW-SE direction, takes turn near Rautgadi Dhirabar nadi near Garatanr village and starts flowing almost in N-S direction. The Usri Nadi is joined by the village. Some of the prominent streams, which flow through the district are Jaria Nala, Khakho Nadi, Chilkharo Nala etc. The drainage of the buffer zone is mainly controlled by the Barakar river, and it's tributaries namely Usri Nadi, Dhirabar nadi, Khakho Nadi ,Jaria Nala, Chilkharo Nala etc and the Sikri river. The Usri Nadi along with it's tributaries meets the Barakar river near Hazaribad village. The drainage map of the Giridih district is shown in figure - 4.

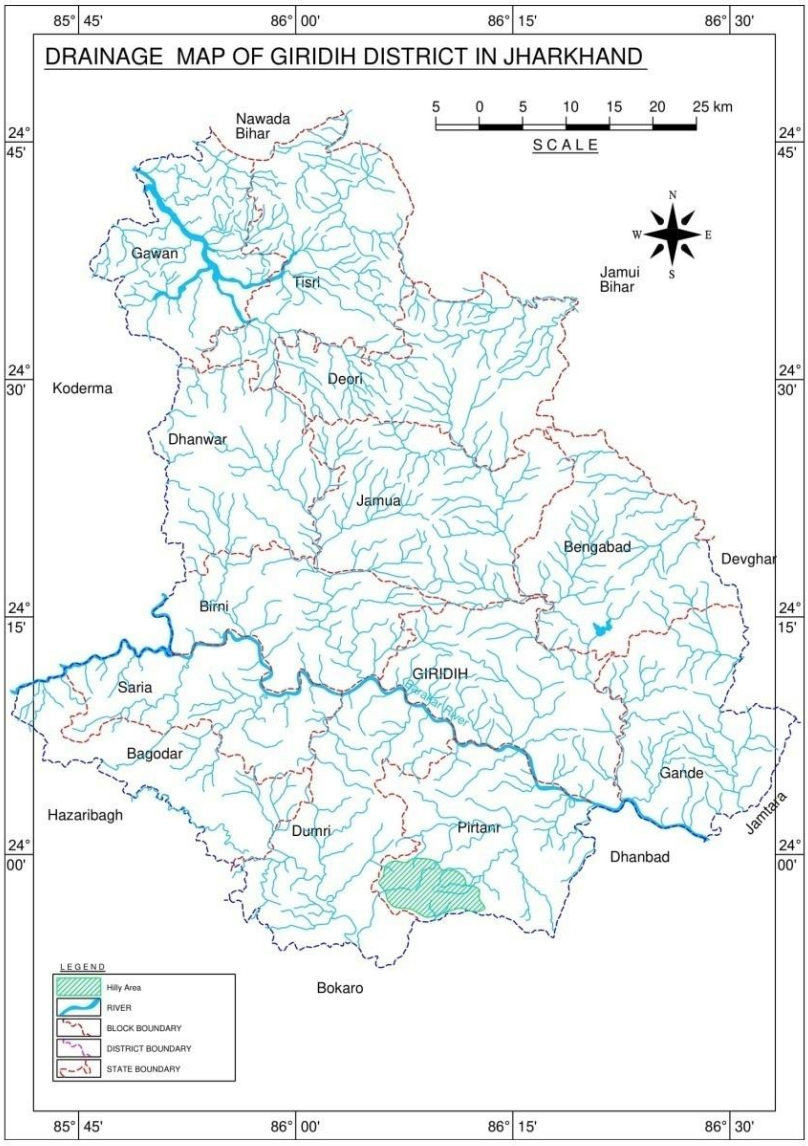


Figure – 4: Drainage map of Giridih district

1.11 Agriculture and Irrigation practice:

Agriculture is the major occupation of the rural population of the district. Since the density of population is high, there is acute pressure on land for agriculture use. But the land available for cultivation is limited because of rugged and hilly geomorphological set-up. Ponds and lift irrigation schemes are main surface water sources in this district which irrigated some hectare of land. The most common ground water source is the dug well, but this is not a very dependable source of irrigation. The major part of the district being rocky in nature, it is difficult to dig wells. The undulating nature of land makes it possible to store rain water by bunding. Apart from being dependent upon rains, these are by no means adequate. The result is that failure of rains invariably involves failure of crops. However, as per 5th Minor Irrigation census for the year 2013-14, about 62% irrigation of the district is depend on ground water sources. Distribution percentage of surface water and ground water is shown in figure – 5. Block wise number of irrigation structure and source wise irrigation data of the district is given in table – 4 & 5 respectively.

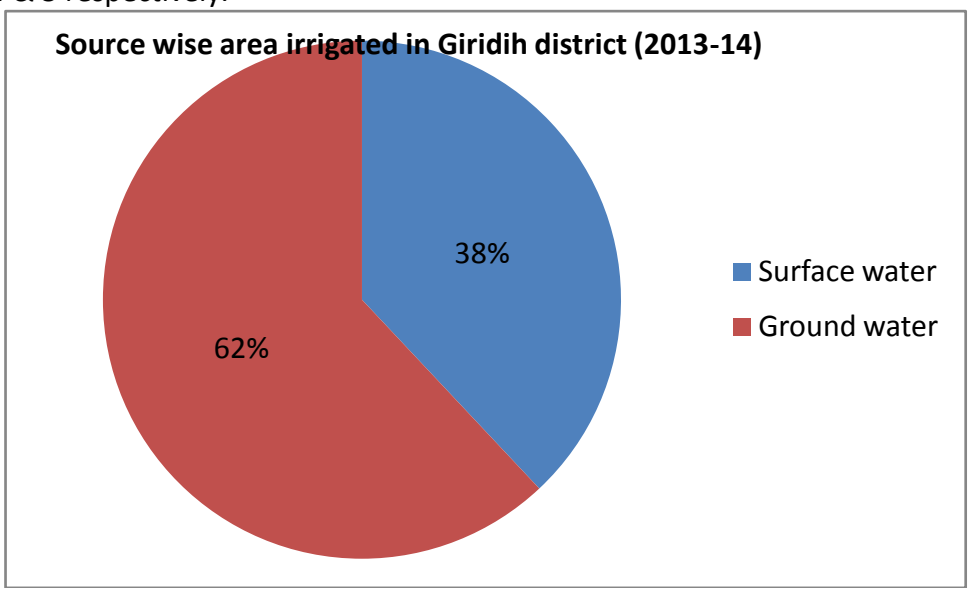


Figure – 5: Source wise irrigated area of Giridih district (2013-14)

Table – 4: Block wise number of irrigation structure of Giridih district (2013-14)

Sr. No.	Name of Block	Surface water			Ground water			
		Canal	Tanks/ Ponds	Lift irrigation	Dug well	STW	MTW	DTW
1	Bagodar	--	125	24	399	28	4	1
2	Bengabad	--	257	33	1293	92	--	2
3	Birni	--	224	44	1599	38	7	1
4	Deori	--	432	49	977	19	--	4
5	Dhanwar	--	336	23	2590	45	4	3
6	Dumri	--	215	81	1108	176	8	2

7	Gandey	--	277	40	865	10	--	--
8	Gawan	--	270	27	815	86	310	55
9	Giridih	--	323	53	1310	42	--	--
10	Jamua	--	476	144	2084	397	--	--
11	Pirtarn	--	288	111	566	43	1	--
12	Sariya	--	107	28	560	10	2	--
13	Tisri	--	217	47	581	3	--	--
Total		--	3547	704	14747	989	336	68

(Source: 5th Minor Irrigation census, GOI)

Table – 5: Source wise irrigation data of Giridih district (Area in Hectare)

Sr. No.	Name of Block	Surface water		Ground water			
		Tanks/ Ponds (including check dam, water conservation structures etc.	**Lift Irrigation (on river, stream, canal, check dam etc.**	**DW**	**STW**	**MTW**	**DTW**
1	Bagodar	318.88	55	12	110	583.29	1
2	Bengabad	488.42	46	--	154	1762.72	4
3	Birni	751.53	191.83	6.89	75.21	2510.54	2
4	Deori	940.54	159.25	--	18	1536.23	6
5	Dhanwar	646.01	22	1.0	6	822.52	2.5
6	Dumri	276.18	137.2	12.5	134	795.39	2
7	Gandey	1396.47	180.95	--	10.75	1755.15	--
8	Gawan	284.8	38.8	8.6	8	175.4	3.6
9	Giridih	587.85	98.47	--	9.5	1168.34	--
10	Jamua	1378.12	262.83	--	25.55	2693.69	--
11	Pirtarn	1008.15	381.2	1.0	24.35	677.55	--
12	Sariya	220.04	45	--	38	1408.91	--
13	Tisri	431.86	84.95	--	2.5	287.94	--
Total		**8728.85**	**1703.48**	**41.99**	**615.86**	**16177.67**	**21.1**

(Source: 5th Minor Irrigation census, GOI)

DW = Dug well, STW = Shallow Tube Well, MTW = Medium Tube Well, DTW = Deep Tube Well

1.12 Cropping pattern:

The main economic activity in the district is agriculture. Paddy and Maize are the two main crops in the district. The agro climatic condition of the district is suitable for cultivation of a variety of fruits like mango, guava, jack fruit and vegetables like cauliflower, tomato, brinjal etc. There are some good clusters of vegetable cultivation in Bengabad, Gandey and Gawan blocks in the district. However, in the absence of assured irrigation facility, agriculture in the district is primarily rain fed and as a result, mainly mono-cropping and subsistence farming is practiced in the district.

As per the agro-climatic zones delineated by Planning Commission, Giridih district falls under Zone (VII) i.e., eastern plateau and hill region. It requires strategic planning so as to maximize the use of rainwater, increased ground water utilization level to achieve balanced crop production. Water resources also need to be developed through dug wells and lift irrigation. Watershed development also holds promise in the district.

The cropping pattern followed in the region is by and large under rain fed conditions. 85% of kharif is under paddy. The other main kharif crops are maize, arhar and moong. Rabi crops are grown only in areas where there is irrigation facility. Main rabi crops are wheat, potato, mustard, linseed, etc. Productivity of agriculture is poor in the district. The erratic nature of the rainfall and its long inter spell gaps lead to frequent crop failure over a large part of the district. Area under crop for the year 2018 – 19 of the district is presented in table - 6.

Table – 6: Cropping pattern of Giridih district (2018-19)

(Area in hectare)

Sr. No.	Block	Major Crops					
		Paddy	**Pulses**	**Maize**	**Oil seeds**	**Vegetable**	**Wheat**
1.	Bagodar	2760.20	681.22	990.69	234.28	300.09	348.94
2.	Sariya	2932.39	792.44	1048.82	243.89	209.54	352.59
3.	Dumri	4939.41	855.74	1648.11	139.76	536.53	391.74
4.	Pirtarn	3943.02	698.01	964.88	258.91	379.89	410.06
5.	Giridih	6575.82	870.11	1309.82	390.89	330.80	584.04
6.	Gandey	6481.23	1136.87	1399.52	717.43	502.42	514.47
7.	Bengabad	6555.79	1503.71	1316.32	515.16	468.93	489.82
8.	Jamua	7476.96	1058.59	1448.21	581.30	1326.30	509.37
9.	Dhanwar	7214.26	1297.93	1493.58	701.01	578.07	688.85
10.	Birni	5903.46	967.53	1268.36	366.11	543.85	605.68
11.	Devri	7913.73	1018.38	1347.01	522.52	1171.74	516.07
12.	Tisri	4808.18	1016.11	1832.75	524.96	596.90	521.93
13.	Gawan	5014.30	1388.15	1936.64	514.01	400.41	696.62
	Total	**72518.75**	**13284.79**	**18004.71**	**5710.23**	**7345.47**	**6630.18**

Source: - District Statistic office, Giridih, GOJ

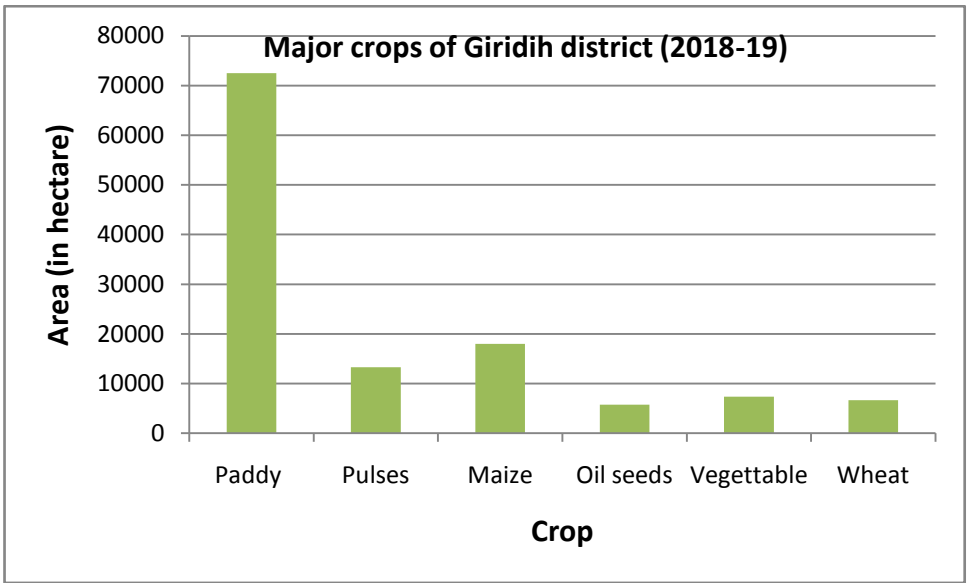


Figure – 6: Major crops of Giridih district (2018-19)

1.13 Geological set up:

The oldest geological formation which occurs in the district is the crystalline metamorphics of Archaean age, which forms the basement. The area is underlain by rocks belonging to Chotanagpur granite gneissic complex of Proterozoic age comprising of biotite and quartz biotite granite gneiss. These are overlain by lower Gondwana sedimentaries which were deposited in the slowly sinking faulted troughs or basins. The rocks of younger age include only quaternary sediments mixed with residual soil at places and are confined to small areas in and around drainage channels.

The Archaean crystalline are formed from rock types of both sedimentary and igneous origin. The sedimentaries were converted into various grades of schists by regional metamorphism. Quartz biotite granite gneiss covers a large part of the area and seems to be intruded by granites showing porphhyroblastic texture. The Chotanagpur granite gneiss contains enclaves of metasedimentaries which are aligned in almost E-W direction. The meta sedimentaries in the area include Amphibolites, hornblende schist and Epidiorite. The amphibolites /meta basics occur as interband with quartzofelsphatic rocks and also occur in the form of isolated bodies. The metamorphosed were then intruded by magmas of basic and acid composition. Intrusive dykes and epidiorites occur usually as prominent hillocks in and around the area. The general stratigraphic sequence of the district is given in below.

Age	Formation	Lithology
Quaternary	Alluvium	Sand, silt , clay
Lr. Gondwana (Upper Carboniferous to Permian)	Barakar Formation Karharbari Talchir	Sandstone, grit, shale, carbonaceous shale, coal Shale, Sandstone Sandstone, Shale, Boulders, conglomerates
----------UNCONFORMITY----------		
Archaean (Lower to Upper Proterozoic)	Chotanagpur Granite Gneiss Complex Unclassified Meta Sedimentatries	Quartz vein, breciatted quartz, pegmatites Biotite and quartz biotite granite gneiss Amphibolite,Hornblende schist Epidiorite

The Gondwana rocks which are exposed in trough like basins in the area is the Barakar formations only. This formation is extensively jointed, fractured and faulted, intruded by dykes and sills. The Gondwanas, unconformably overlie over the metamorphics and cover part of the area dipping southerly, thereby exposing the younger unit towards the south adjoining the southern faulted boundary. Sandstone, shale, carbonaceous shale, coal and clays are the major litho units of the Gondwanas.

Alluvium and residual soils occur only as superficial deposit in general. Deposits of alluvium occur along the flood plains of Barakar, Sikri and the local streams namely Usri, Dhirabar , Khakho Nadi , as thin veneer.

Geological map of Giridih district has been prepared and presented in figure – 7

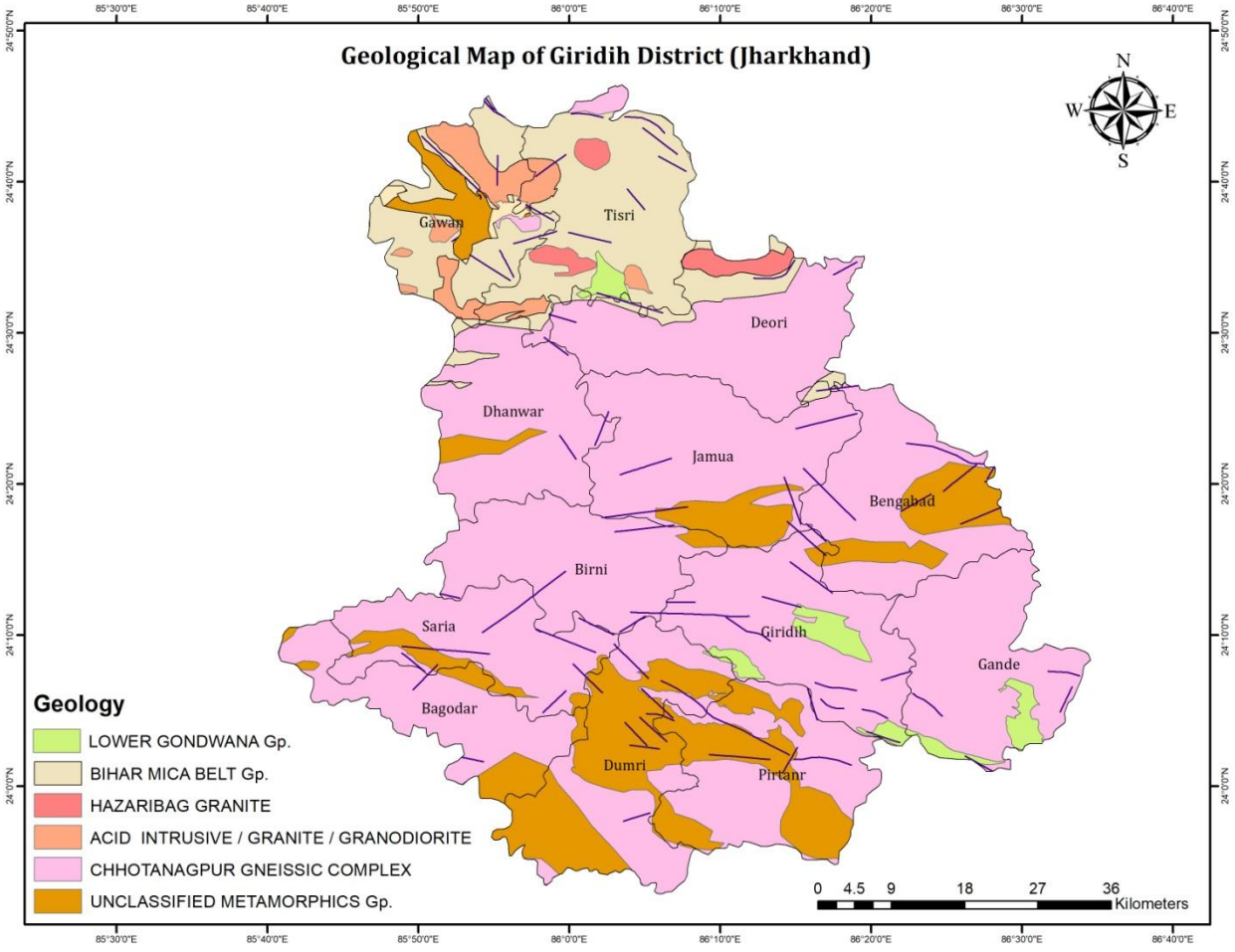


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Figure-7. Geological map of Giridih district

Chapter-2.

DATA COLLECTION AND DATA GENERATION

The primary Data such as water level, quality, geophysical data and exploration details available with CGWB has been collected and utilised as baseline data. The Central Ground Water Board has established a network of observation wells under National Hydrograph Network programme to study the behavior of ground water level and quality of ground water in the district. To understand the sub–surface geology, identify the various water bearing horizons including their depth, thickness and compute the hydraulic characteristics such as transmissivity and storativity of the aquifers, exploratory drilling programme was carried out by Central Ground Water Board. For other inputs such as hydrometeorological, Landuse, cropping pattern etc were collected from concerned state and central govt departments and compiled.

2.1 Hydrogeology:

The district is underlain by compact and hard rocks belonging to crystalline metamorphics of Archaean age and lower Gondwana sedimentaries, which are devoid of any primary porosity . The ground water in such formation occurs within the secondary porosity such as joints, fractures and bedding plains.

The ground water occurrence and movement is basically controlled by the prevailing morphology and intensity of structural discontinuities. The intensity of joints, fractures, foliation planes are more along structurally disturbed zones. Therefore structure is another controlling factor for occurrence and movement of ground water over the area.

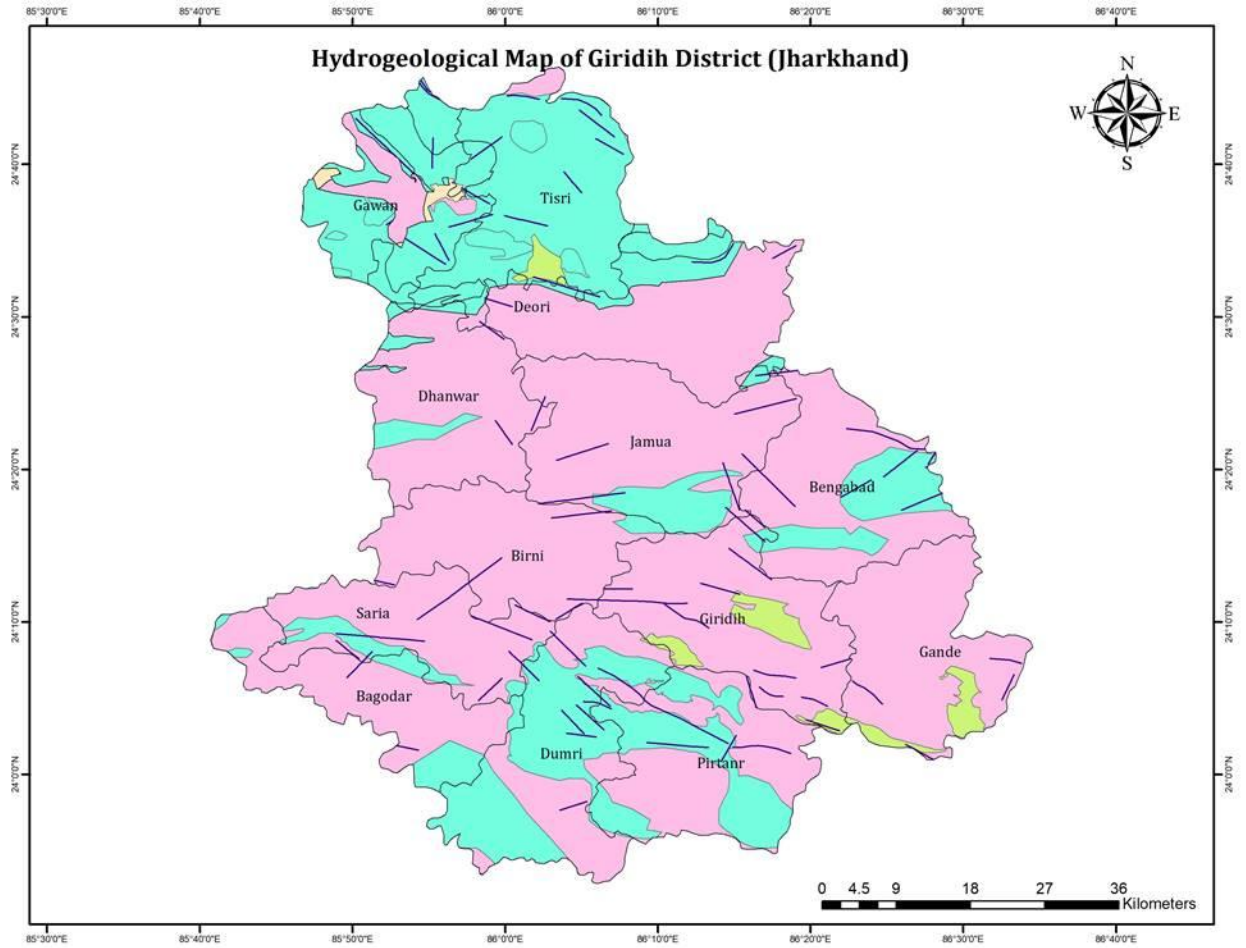
The rainfall is the main source of groundwater recharge in the area. The inconsistency between fracture zone is complicated in nature. The ground water therefore moves slow and find its way through the fractures and open joints. The district is having varied hydrogeological characteristics due to which ground water potential differs from one region to another. The hydrogeology of the district has been depicted in **Figure 8.** Based on morphogenetic and geological diversities and relative ground water potentialities in the aquifer belonging to different geological formation, the study area can be broadly sub-divided into two major formations.

I) Fissured formation: - Represented by consolidated metamorphics and semi-consolidated Gondwanas

ii) Porous formation: - Represented by the alluvium.

The consolidated formations are represented by the Archaean metasedimentaries consisting of phyllites, schist's and gneisses with associated bands of quartzites and amphibolites. Ground water occur under unconfined condition in the weathered mantle and semi-confined to confined condition in the deeper fractures.

The Gondwana rocks occur in a series of basins associated with coal measures. Gondwana sandstone in general is known to constitute good aquifers at many places. Ground water occurs under unconfined condition in the weathered mantles varying in depth from 8 –17 m as observed in the dug wells and in confined condition in deeper fractures.



	Age/Formation	Lithology	Hydrogeology	Ground Water Potential
UNCONSOLIDATED FORMATION				
	Quaternary to Recent	Alluvium- Sand, Silt, Clay	Limited thickness along river banks mainly unconfined condition	Upto 10 m3/hr
SEMI-CONSLIDATED FORMATION				
	Lower Gondwana (Upper Carboniferous to Permian)	Sandstone, Shale with coal seams, Conglomerate	Moderately thick limited in extent semi-confined to confined aquifer	10-20 m3/hr
CONSOLIDATED FORMATION				
	Chotanagpur Gneissic Complex (Precambrian)	Granite-Gneiss, Biotite-Gneiss	Ground Water Restricted to weathered zones/fractured zones	10-40 m3/hr
	Unclassified metamorphic/Bihar Mica Belt/Hazribagh Granite (Precambrian)	Amphibolite, Hornblend Schist, Hazariabagh Granite etc	-	Poor to moderate

Figure – 8: Hydrogeological map of Giridih district

2.1.1 Ground Water in Aquifer-I (Weathered/partially fractured):

The Thickness of weathered aquifers varies from 10 – 25 m in general in granite terrain. Within the depth zone of dug wells, the weathered zone influences to a greater in the hard rock formation constitute potential phreatic shallow aquifer. In the weathered and less fractured zone, the yield of the open wells upto 15 m^3/hr with intermittent pumping. This zone should be

developed either through large diameter open wells or shallow bore wells of 20 – 50 m depth which permits draft upto 20 m^3/hr for domestic as well as irrigating small holdings of land. Hand pumps generally tap first fracture zones and its depth is 30 - 55 mbgl constructed by State Government Department.

2.1.2 Ground Water in Aquifer-II (fractured): Number of boreholes have been constructed by CGWB in the district under ground water exploration programme as well as NAQUIM Programme either through in-house or through outsourcing upto maximum depth of 202.70 m. These borehole data reveals that, in general potential fractures are encountered between 22-189 m. The yield of exploratory wells found between 0.50 to 78.19 m^3/hr. Table-7 shows the Potential Fracture encountered during Ground Water Exploration in Giridih district.

Table – 7: Potential fractures encountered during ground water Exploration in Giridih district, Jharkhand

S. No.	Location	Block	Depth drilled (mbgl)	Depth of casing (mbgl)	Major lithology encountered	Potential fractured zone (mbgl)	Static water level (mbgl)	Yield (m^3/day)
1	Jorasankh	Jamua	101.00	7.30	Granite-Gneiss	22.00 – 24.00 69.00 – 70.00	4.36	10.74
2	Gandey (JNV)	Gandey	92.90	30.03	Granite-Gneiss	42.00 – 44.00	12.10	25.56
3	Arkhango	Raj Dhanwar	202.70	23.65	Granite-Gneiss	109.00 – 110.00 148.50 – 149.00 189.00 – 189.50	--	12.24
4	Khambhra	Bagodar	186.00	11.70	Granite-Gneiss	24.00 – 25.00 128.50 – 129.50	4.40	12.24
5	Sariya inter college	Sariya	202.70	17.60	Granite-Gneiss	155.00 – 156.00 182.00 – 182.50	--	12.24
6	Nawadih	Sariya	184.40	25.30	Granite-Gneiss	142.00 – 144.50	8.55	20.52
7.	Kailatand	Sariya	99.00	24.2	Granite-Gneiss	96-99.00	6.0	78.19

Source: CGWB

On the basis of field investigations and results of exploratory wells drilled in the district, salient findings are summarized as:-

- In general in fissured formations, discharge of well has been found in the range of 0.50 - 78.19 m^3/hr.
- Overall in the district the major potential fractures zones are found upto 100 m.

- First potential fracture zone encountered in the district widely varies from 22 - 189 m.
- At some places, the potential fractures were encountered at very shallow level 25-50m with very high yielding wells. These potential fractures may be tensile in nature which is found to be potential repository of ground water. Some of the exploratory wells upto the depth of 50 m which yielded high discharge- Gandey (25.56 m^3/hr, Nawadih-16.2m3/hr)
- At Naudiha well drilled at 66.00 m yielded discharge of 36 m^3/hr with auto flow at peizometeric head 1.40 magl
- Some of high yielding well where multiple fractures were encountered within 100 m depth are Jorasankh (10.74 m^3/hr) , Hat Bazar, Giridih (37.70 m^3/hr) and Khambhra-12.24m3/hr etc
- At some occasion potential fractures were encountered beyond 100 m depth (120-190 m). The well has yielded copious amount of discharge e.g Dandidih-19.8m3/hr, Arkhango (12.24 m^3/hr), Sariya Inter college (12.24 m^3/hr), Nawadih (20.52 m^3/hr), Kailatand-78.19 m3/hr

2.1.3 Ground Water Dynamics

2.1.3.1 Water Level Scenario – Aquifer – I (Shallow Aquifer): Water level scenario of shallow aquifer was generated by utilizing water level data of 48 monitoring wells representing shallow aquifer. The pre monsoon (May 2019) depth to water level monitored between 3.33 to 13.03 mbgl. The post monsoon depth to water level (Nov. 2019) in the dug wells ranges from 0.78 to 7.70 mbgl. Pre and post monsoon depth to water level maps were prepared for the year 2019 and presented in figure – 9 &10

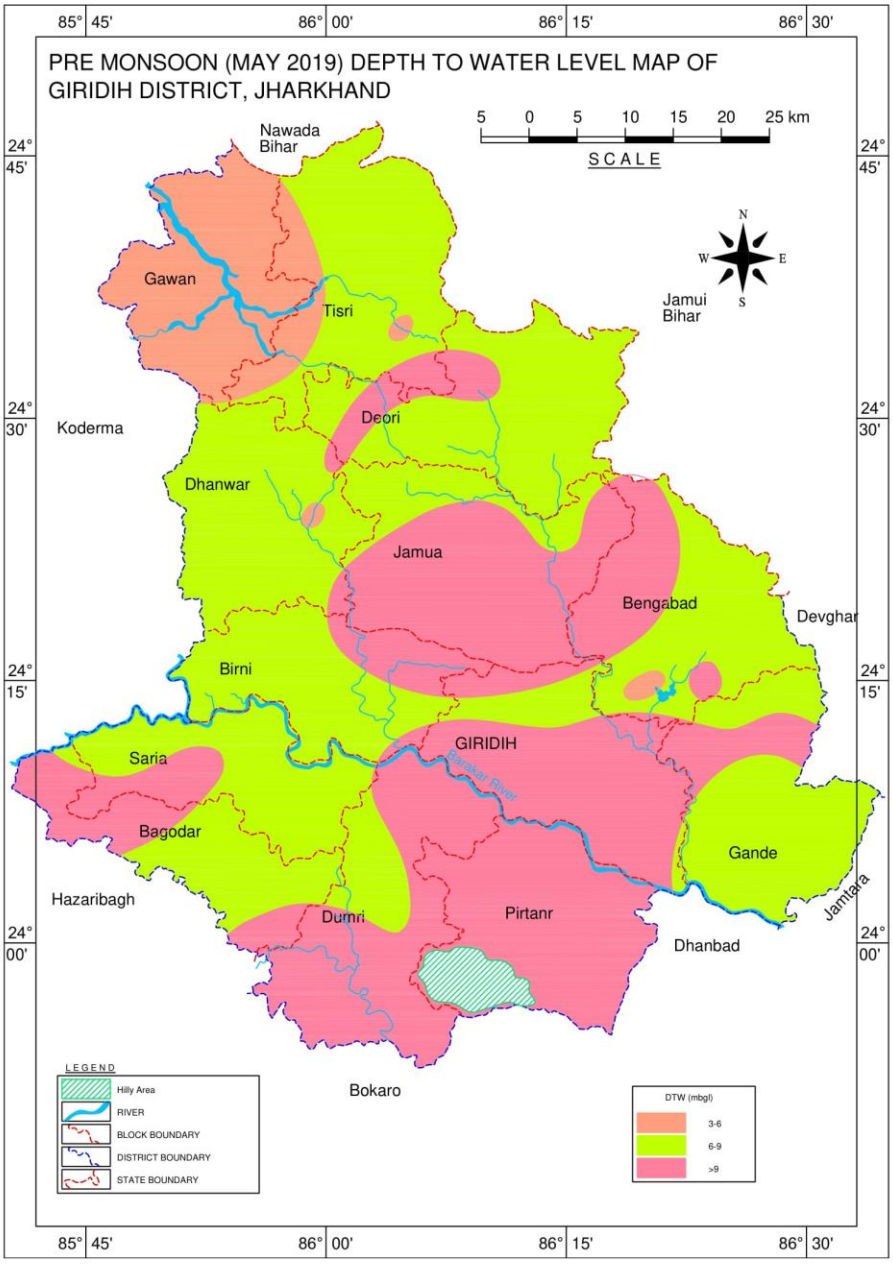


Figure – 9: Pre monsoon depth to water level map of Giridh district (May 2019)

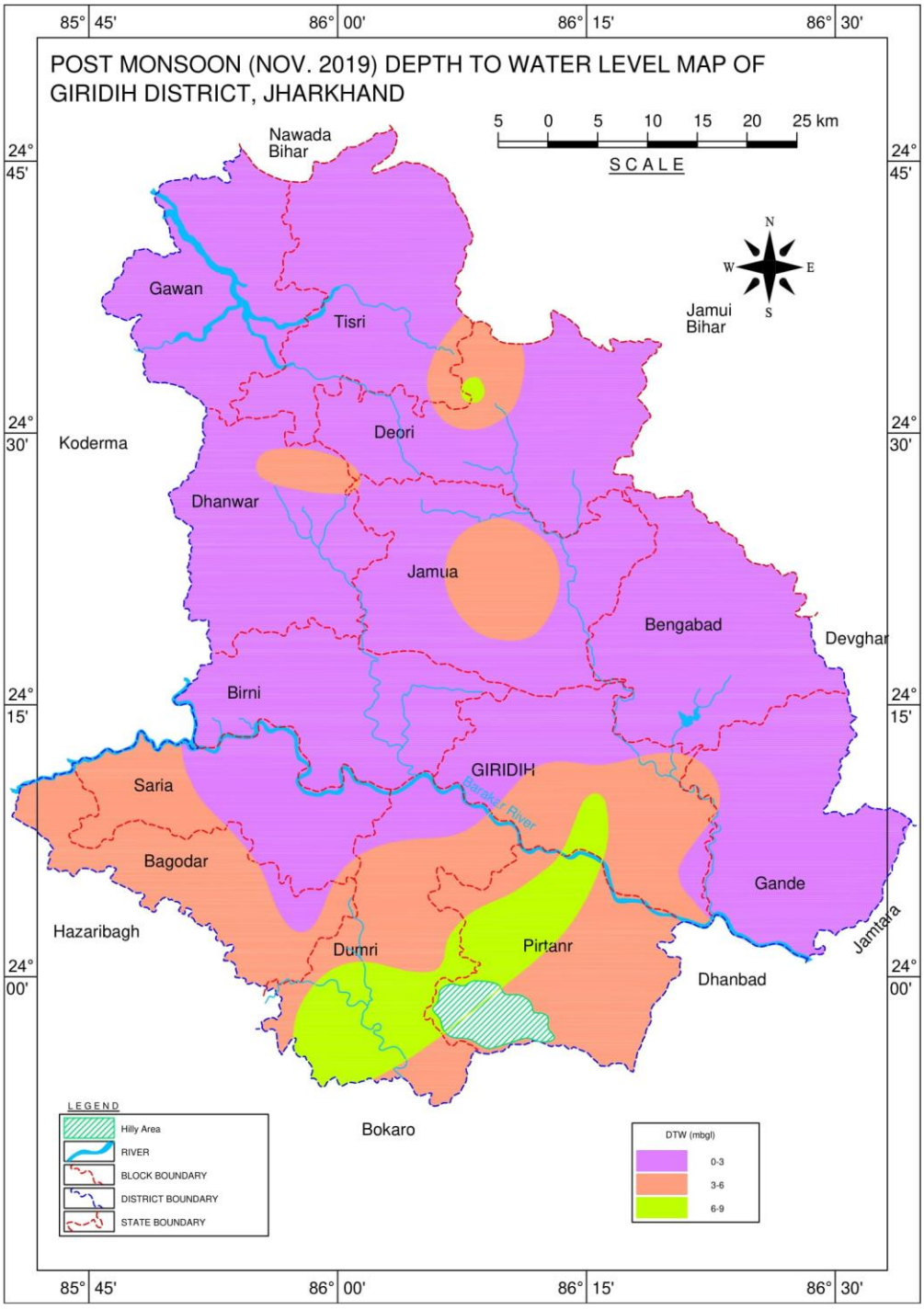


Figure – 10: Post monsoon depth to water level map of Giridih district (Nov. 2019)

2.1.3.2 Water level fluctuation: Seasonal ground water level fluctuation in shallow aquifer was studied with the help of 48 key wells which were monitored four times in different seasons during the year 2019. Any decline in water level in the dry and lean

period is immediately restored with the onset of monsoon precipitation. Deletion of water in the ground water reservoir is replenished and thus the annual cycle of decline and rise of water level is maintained through time. The seasonal rise of water level varies from place to place. The seasonal water level fluctuation between pre and post monsoon period for the year 2019 observed between 1.73 to 9.10 m in the district. Seasonal water level fluctuation map between pre monsoon (May 2019) and post monsoon (November 2019) has been prepared and presented in figure – 11.

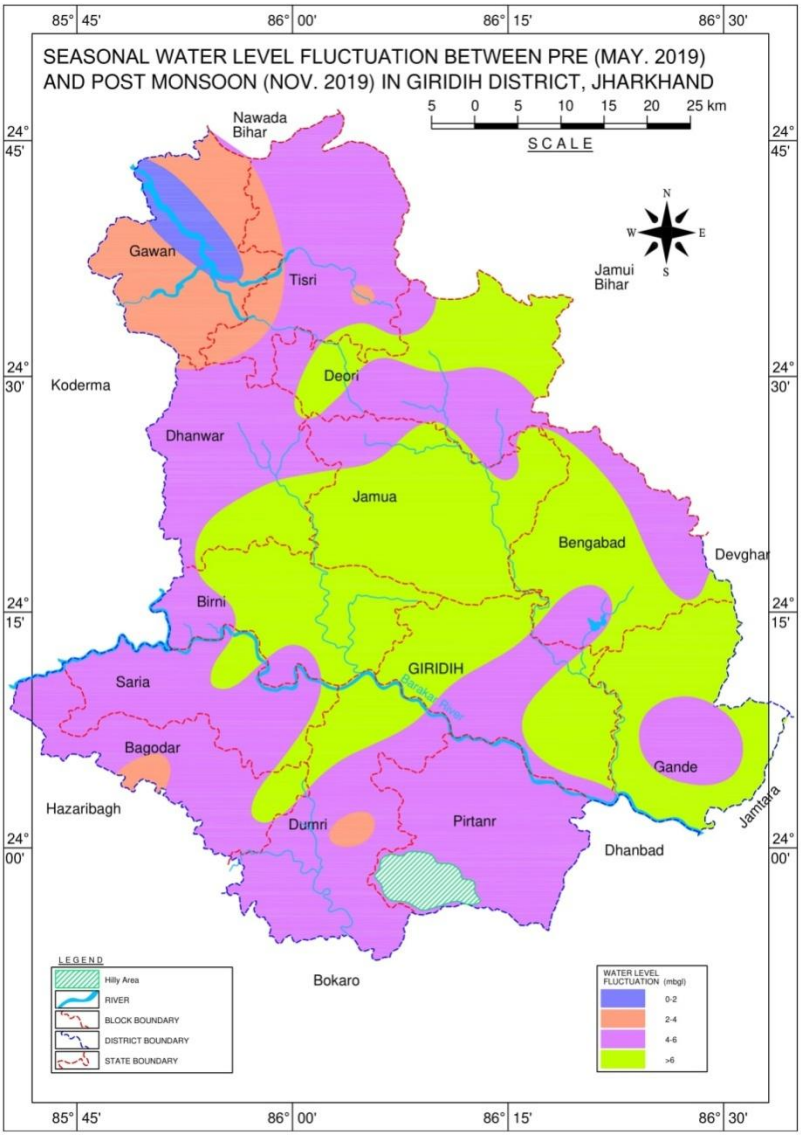


Figure – 11: Seasonal water level fluctuation map of Giridih district (2019)

2.1.3.3 Long term water level trend (2010 – 2019): In order to study long term behaviour of the water levels and also the effect of various developmental activities with time, the data for the period 2010 - 2019 have been computed ,analyzed and

presented in table - 8. The pre and post monsoon water level trend analysis showing rising trend in 85% and 77% wells respectively. It may be due to extraction of ground water from dug well is very less because sufficient availability of hand pumps in recent years. The dug well was main source for ground water extraction 20 - 30 years back.

Table -8: Last ten years long term water level trend of Giridih district (2010 – 2019)

Sr. No.	Location	Water level trend (m/year)			
		Pre monsoon		Post monsoon	
		Rise	Fall	Rise	Fall
1.	Bagodar	--	0.0100		0.0479
2.	Bandhutarn	0.0898	--	0.0696	--
3.	Bengabad	--	0.0468	0.1319	--
4.	Birni	0.0152	--	0.2694	--
5.	Chirki Pirtarn	--	0.2898	--	--
6.	Devri	--	0.2157	0.1817	--
7.	Dhanaydih	--	0.1754	0.1538	--
8.	Dhanwar	--	0.5166	0.0541	--
9.	Dumri	--	0.0025	0.0847	--
10.	Giridih	0.3822	--	0.2637	--
11.	Jamua	--	0.1193	0.0289	--
12.	khijri	--	0.5925	0.2159	--
13.	Maheshmunda	--	0.4433	0.1214	--
14.	Pandri	--	0.2979	0.398	--
15.	Saraiya	--	0.3551	--	0.1777
16.	Tisri	--	0.2452	0.074	--

2.1.3.4 Hydrograph Analysis: Analysis of seven (07) hydrograph network stations, were carried out using GEMS software (Figure -12-18) and analysed for the period from 2010-2019. It is observed that the long-term water level trends during pre monsoon seasons are declining trend (except Giridih) in shallow aquifer-I represented by dug wells. Similarly, post monsoon long term water level trend is observed rising trend in the wells located at Bengabad, Chirki Pirtarn, Deori, Giridih, Jamua and Tisri while declining trend observed in the wells located at Bagodar.

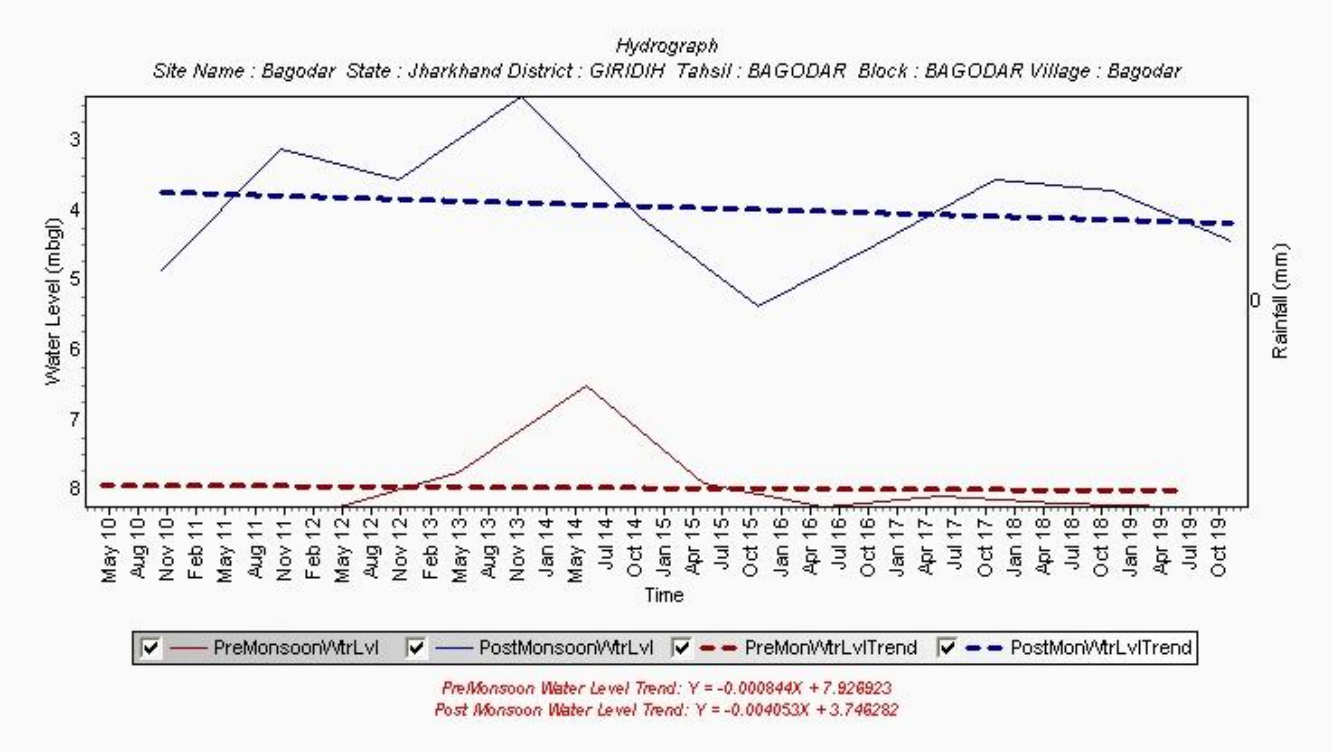


Figure – 12 : Hydrograph (2010-2019) of Bagodar network station

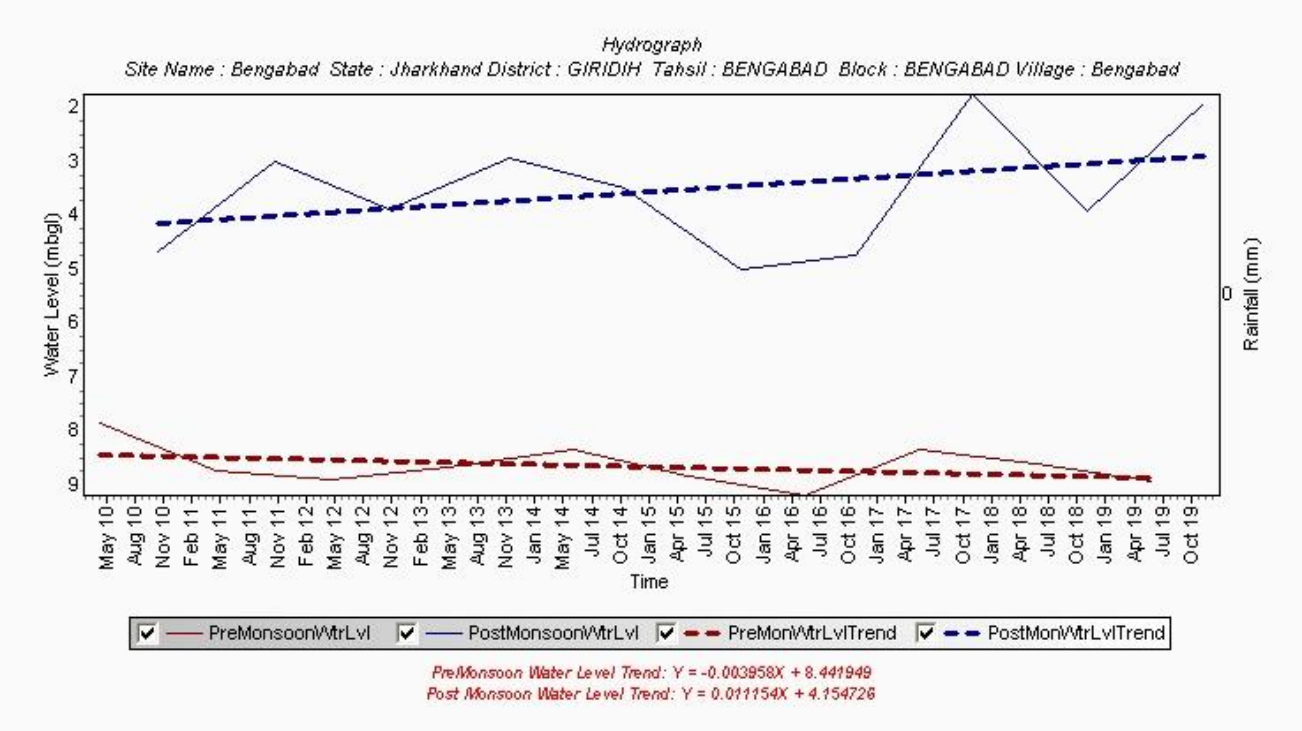


Figure – 13: Hydrograph (2010-2019) of Bengabad network station

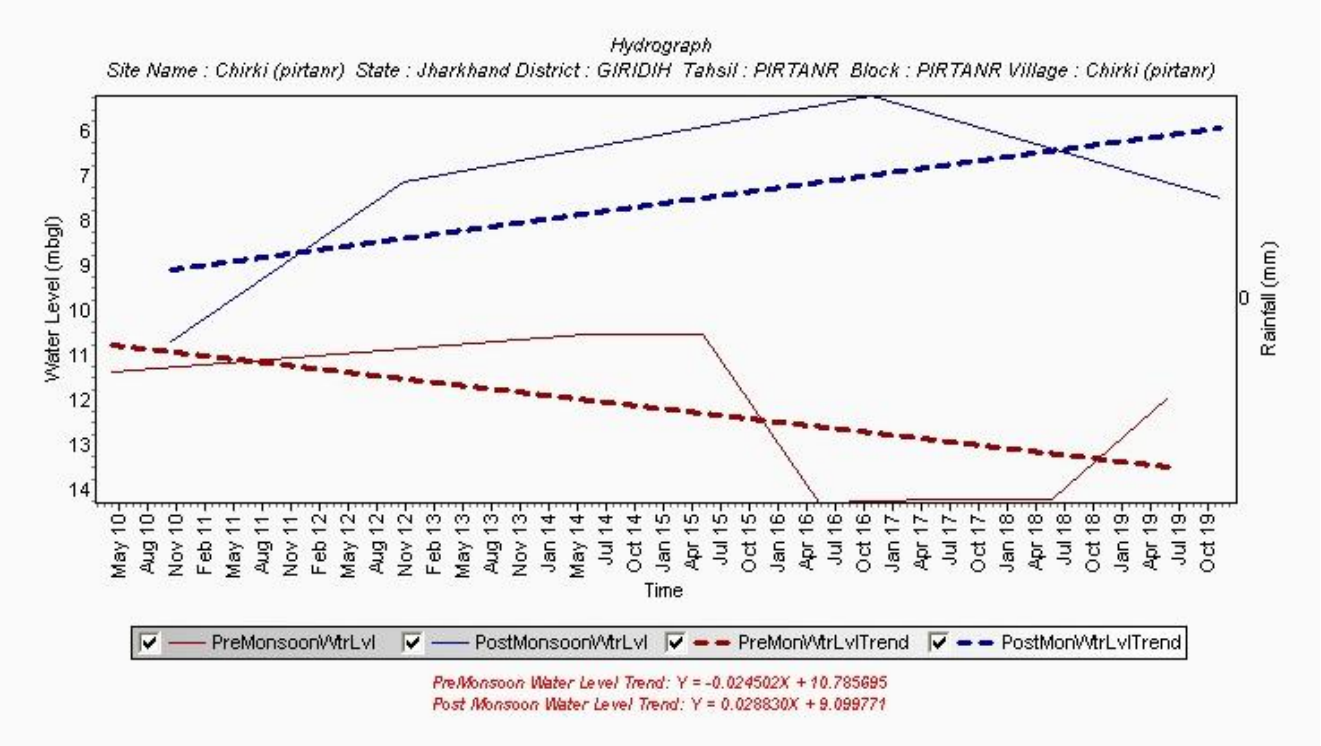


Figure – 14: hydrograph (2010-2019) of Chirki Pirtarn network station

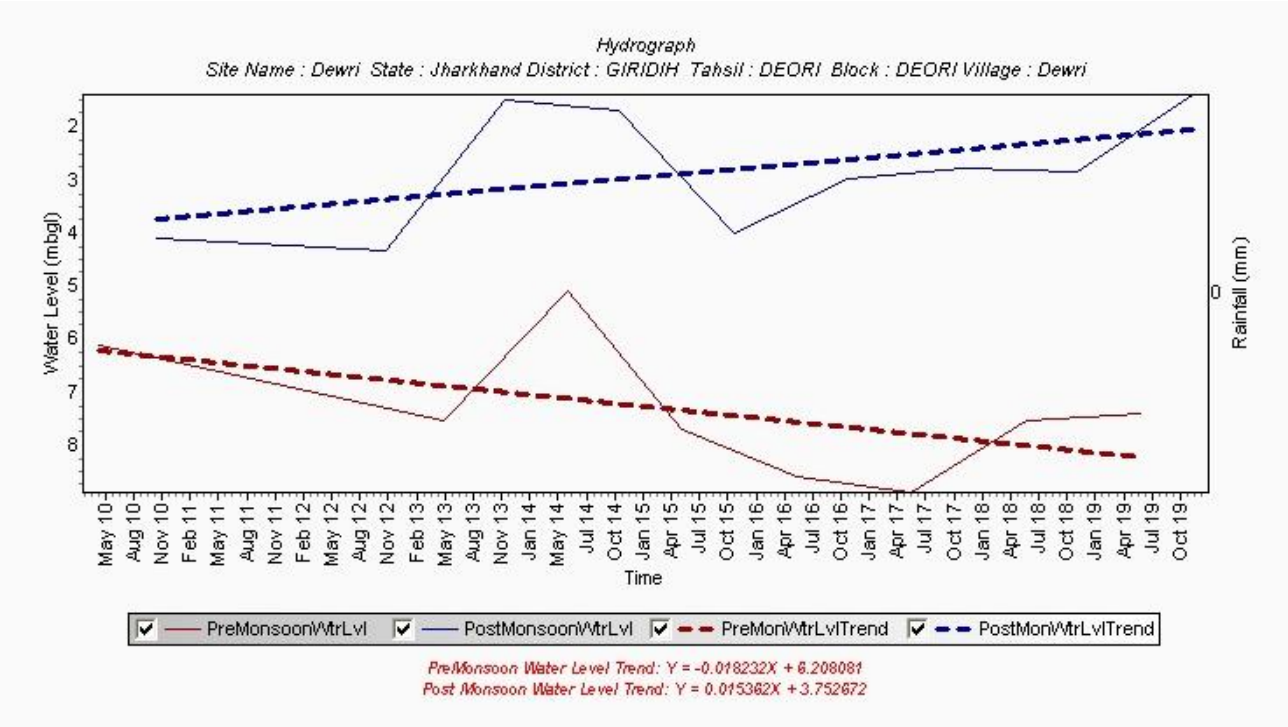


Figure – 15: hydrograph (2010-2019) of Deori hydrograph network station

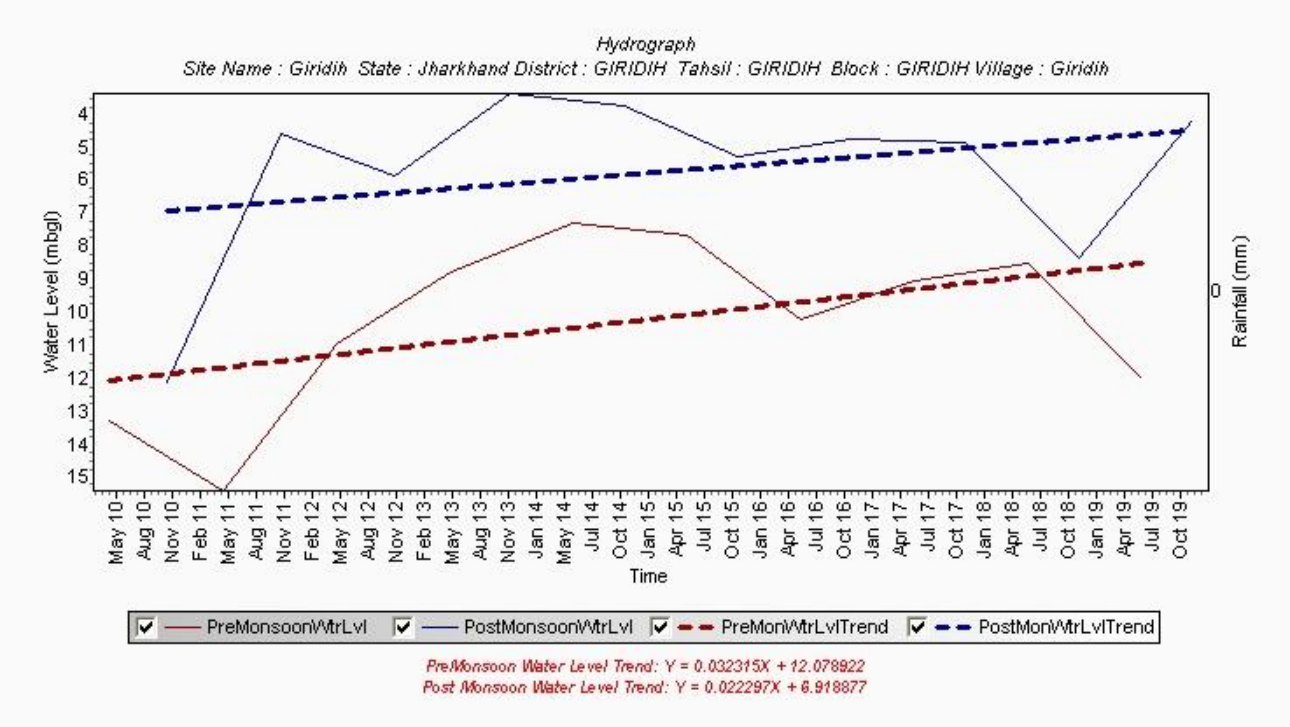


Figure – 16: Hydrograph (2010-2019) of Giridih network station

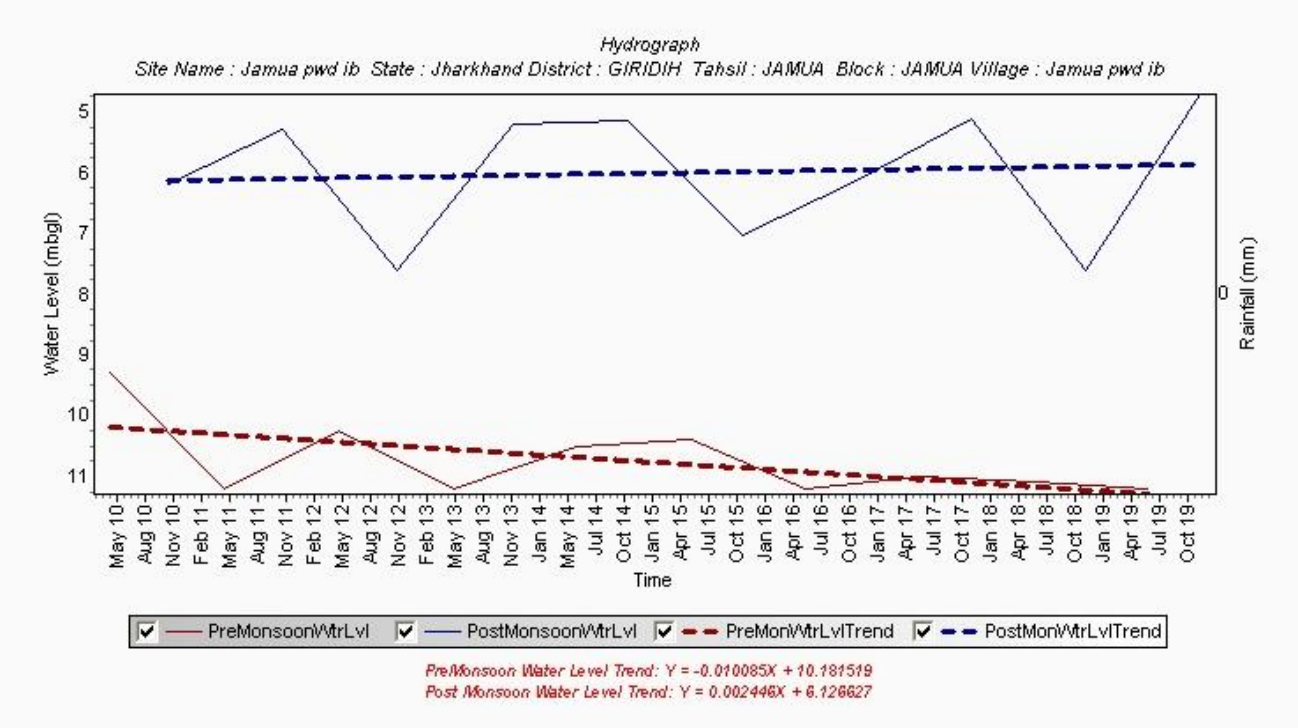


Figure – 17: Hydrograph (2010-2019) of Jamua network station

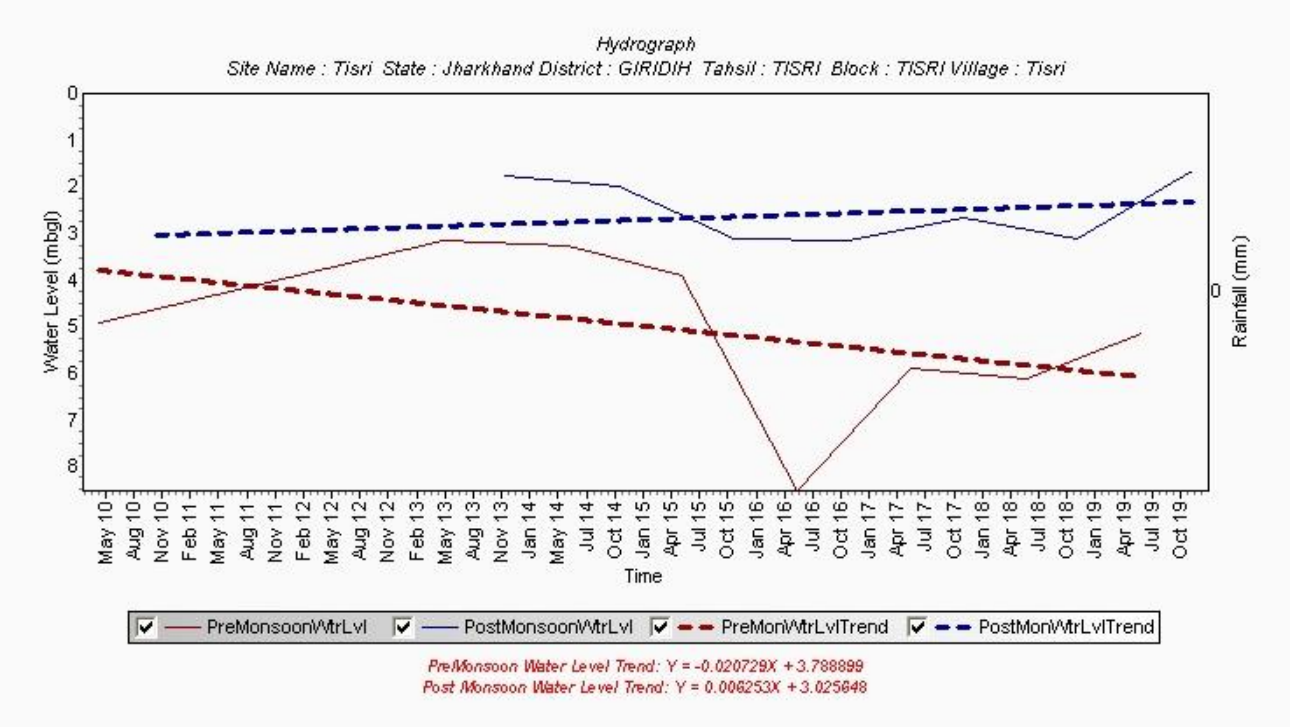


Figure –18: Hydrograph (2010-2019) of Tisri network station

2.2 Geophysical survey:

2.2.1 Inouse Study :-To identify the weathered thickness, depth of bed rock, fractures depth etc, total 20 numbers of geophysical surveys (VES) were carried out in district through in-house (CGWB).The Vertical Electrical Sounding (VES) locations map of Giridih district is shown in **Figure - 13.** The VES curves obtained in the area are H and HA types **(Fig-14a & 14b).** The interpreted results reveal that three to four geoelectrical layers have been deciphered in the study area. Interpreted results of VES are given in Table-9.The geoelectical characteristics based on the results of VES carried out in the area, it is observed that top layer resistivity varies from 58.50 ohm-m to 925 ohm-m and thickness 0.84m to 7.35m. The second layer resistivity varies from 5.95 to 225 ohm-m indicating weathered to semi weathered formation. The weathered formations were found at VES Nos. 2, 3, 4, 7, 8, 10, 11, 12, 13, 14, 15 and 18 with maximum thickness of 14.90 m and underlain by compact formation. The semi weathered formations were found at remaining locations with maximum thickness of 44.20 m. The weathered and semi weathered formations are underlain by compact formation at VES nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 and 18. The third layer are resistive and representing the resistivity variation from 815 ohm-m to 925 ohm-m with thickness of 8.49 to 40.80m. It is underlain by the compact rock.

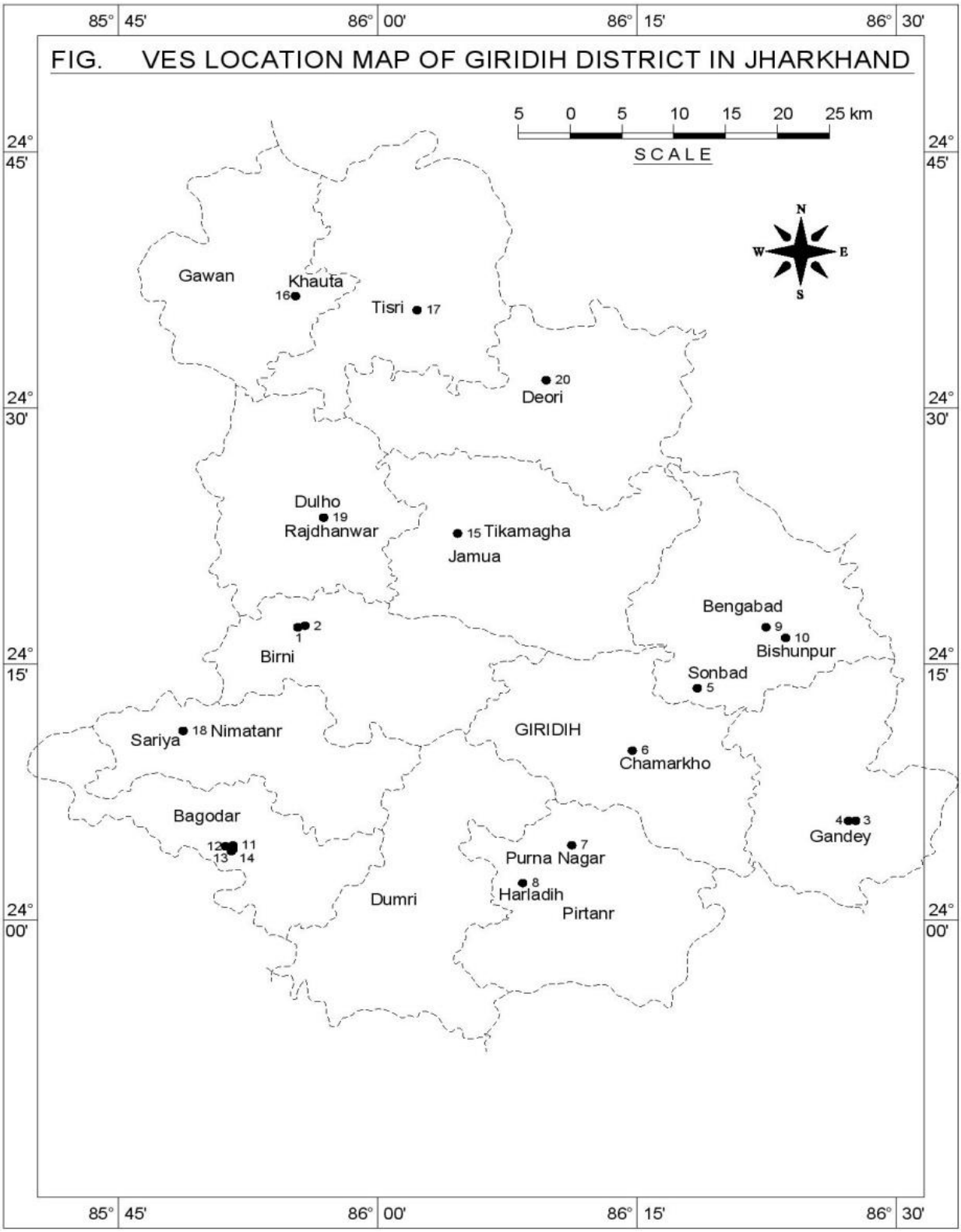


Figure -19: In-house VES location map of Giridih district, Jharkhjand state.

Table-9: Interpreted results of VES data collected from aquifer mapping areas of Giridih district, Jharkhand state

Sl. No.	VES Nos.	Layer resistivity in ohm-m				Layer thickness in m				Depth to bed rock in m
		P1	P2	P3	P4	H1	H2	H3	Total depth in m	
1	1 Birni	565	135	VH	-	0.84	34.20	-	35.00	35.00
2	2 Birni	135	55	VH	-	1.22	15.5	-	16.70	16.70
3	3 Gandey	175	65.5	VH	-	6.0	4.95	-	10.90	10.90
4	4 Gandey	95	45.5	VH	-	1.20	16.4	-	17.60	17.60
5	5 Sonbad	295	135	VH	-	0.95	15.90	-	16.80	16.80
6	6 Chamarkho	385	135	809	-	2.59	18	-	20.50	20.50
7	7 Purna Nagar	205	78.5	VH	-	1.45	4.92	-	5.97	5.97
8	8Harladih	165	90.5	VH	-	1.41	25	-	26.40	26.40
9	9 Bengabad	925	135	VH	-	2.4	5.49		7.88	7.88
10	10 Bishunpur	245	85	VH	-	0.75	7.53	-	8.28	8.28
11	11Bagodar	275	95	858	-	0.95	15.70	-	16.70	16.70
12	12 Bagodar	285	85.5	615	-	0.90	8.66	-	9.56	9.56
13	13 Bagodar	345	95	715	-	0.75	11	-	11.8	11.80
14	14 Bagodar	385	5.92	VH	-	1.39	1.20	-	2.59	2.59
15	15 Jamua	245	29.5	VH	-	7.35	8.75	-	16.10	16.10
16	16 Gawan	650	155	VH	-	5.66	7.28	-	12.90	12.90
17	17 Tisri	412	205	925	VH	0.96	2.46	8.77	12.20	12.20
18	18 Sariya	110	70	950	-	1.41	20.10	-	21.50	21.50
19	19 Raj Dhanwar	58.5	135	855	VH	3.75	8.44	40.8	53.00	53.00
20	20 Deori	1025	225	815	VH	1.29	2.49	8.49	12.30	12.30

VH: Very High

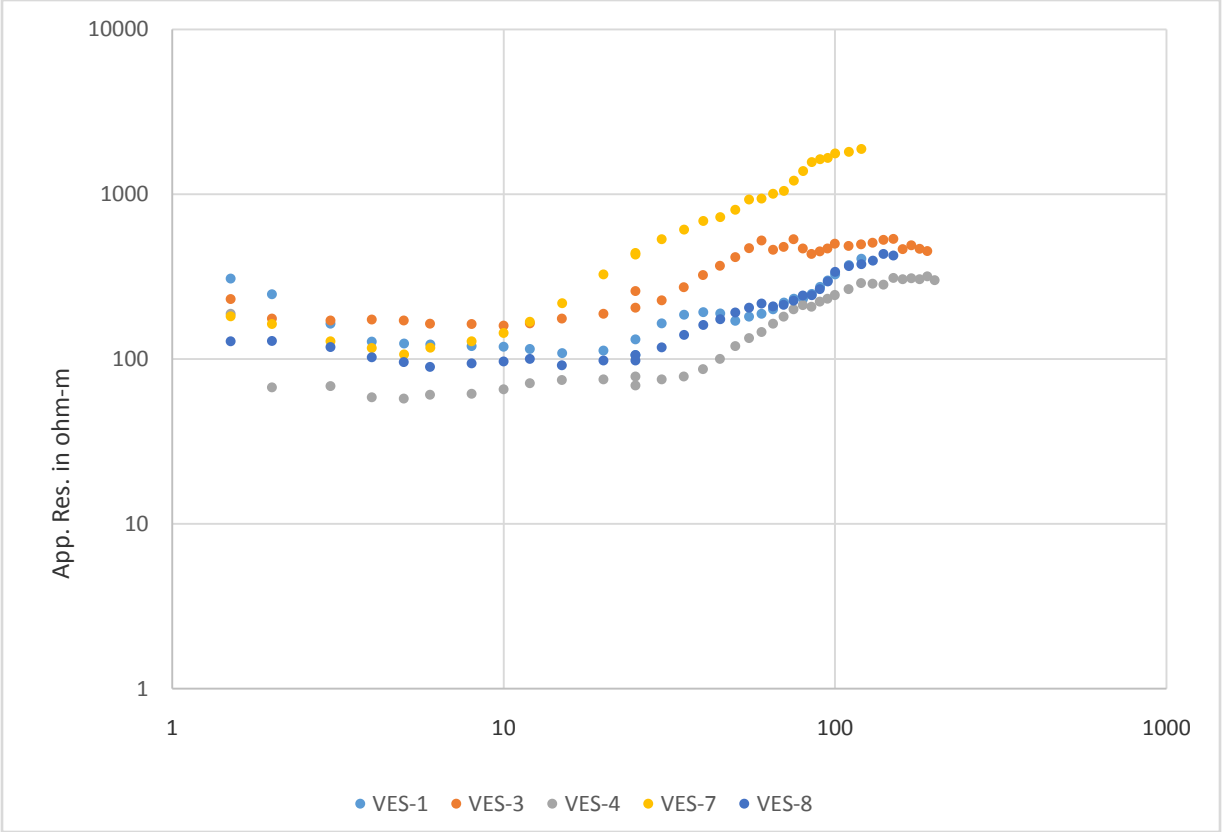


Figure -20: Some representative VES curves of Giridih district, Jharkhand state:

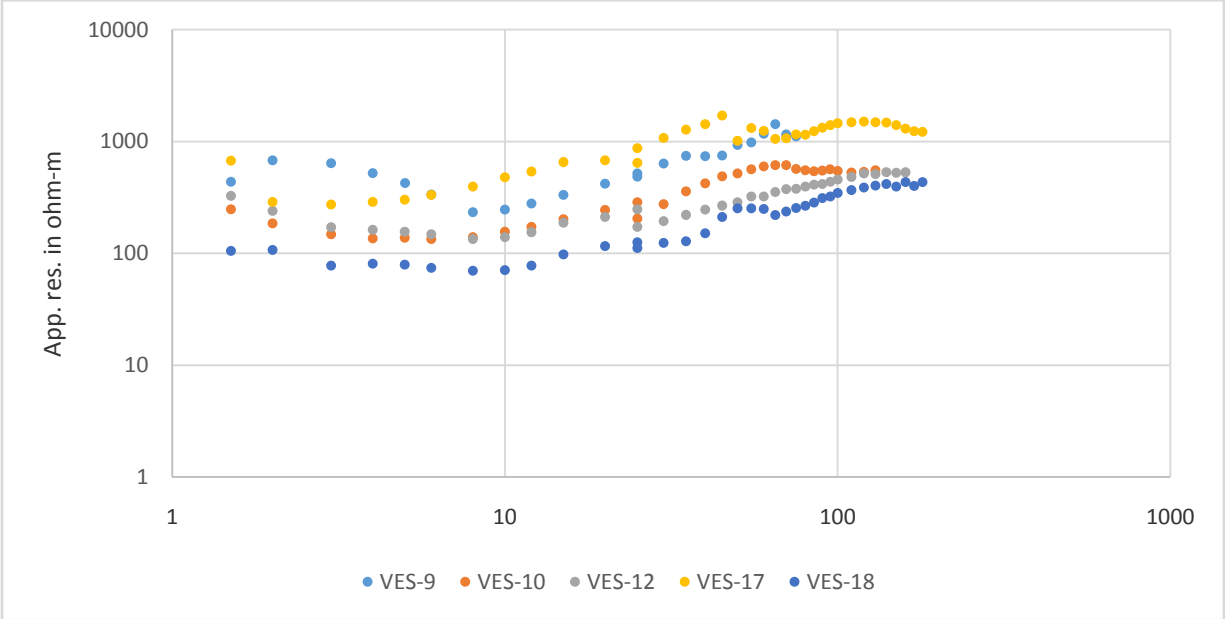


Figure -21: Some representative VES curves of Giridih district, Jharkhand state

2.2.2 Geophysical Study through Outsourcing

A total of 6 VES were carried out in 6 blocks of Giridih district (Figure 15).

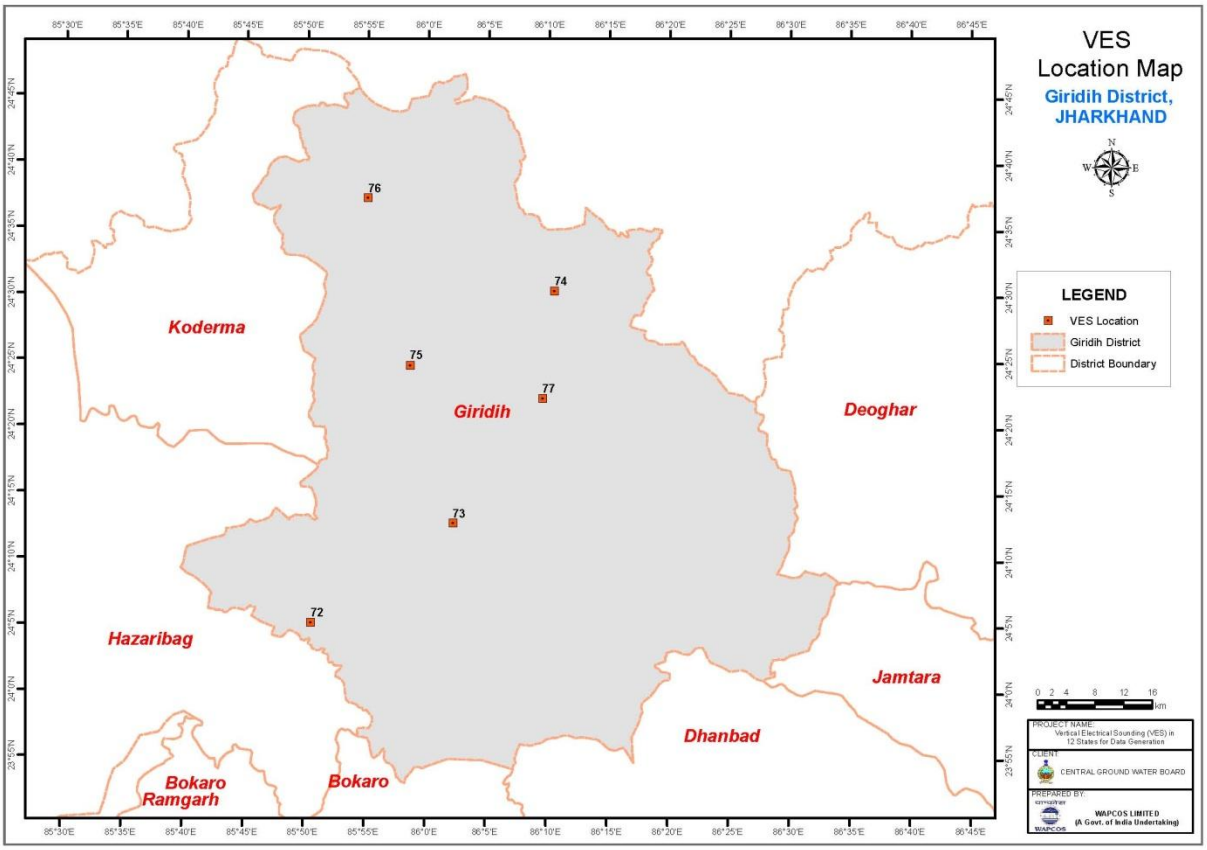


Figure 22: Map of Giridih district showing VES locations

Interpreted Results of VES

Interpreted results of VES are given in Annexure-I. The geoelectrical characteristics of the weathered and semi-weathered zones are given in Table 6.0. Based on the results of a limited number of VES, it can be said that in Giridih district, the weathered zone in granite gneiss terrain is, in general, thin (extending up to 15 m depth). Only at one VES site – VES 74, the weathered zone extends to about 36 m depth. The range of resistivity for the weathered zone is 13 to 83 ohm.m. Underlying the weathered zone, the semi-weathered zone extends to a maximum depth of about 36m. The resistivity of semi weathered zone ranges from 105 to 124 ohm.m. It is reiterated here that results of 6 VES, may not give the actual subsurface information of the blocks or the district.

2.3 Ground Water Quality:

The quality of water plays prominent role in promoting both the standards of agriculture production and human health. To evaluate the quality of ground water, samples have been collected from 44 dug wells and 48 representatives bore wells (hand pumps). The analytical results of water samples dug wells and hand pumps are given in Annexure- V respectively. The

ground water samples were analyzed for major chemical constituents by using standard procedure at chemical laboratory in CGWB, MER, Patna. These samples have been considered to assess the chemical quality of ground water and its suitability for drinking and irrigational purposes. Since the samples are collected from the dug wells, they represent the quality of Aquifer I (phreatic/ shallow zone) and the bore well samples represent the Aquifer II (deeper zone) quality of ground water.

2.3.1 General range of chemical parameter of Aquifer-I in the area: - Evaluation of ground water suitability in relation to its different purposes has been classified for drinking / domestic and irrigation. Water is very essential for life. Many a times it has raw consumption or indirectly (in food). Hence, it should be free from turbidity, odor, bacterial and poisonous contents and also chemically soft, low T.D.S value and other chemical constituents should range within low to tolerable limits. Excessive and longer use of water beyond these limits may endanger too many health problems.

The distribution of different constituent in ground water can be described as follows:-

Hydrogen ions activity:

It is expressed in terms of pH and shows the acidity & basicity of the solution. Natural water reacts with H+ & H- ions and forms H_3O or ions. The recommended limit (6.5 to 8.5) by BIS, 2012 is base on taste, corrosion and scale formation criteria. The pH value in Aquifer-I ranges from 7.5 to 8.49.

Electrical Conductivity:

Generally, the water's electrical conductivity increases in the dry periods because of evaporation and decreases in the rainy days because of the precipitation and also to the surface runoff flow into reservoir. The EC value in Aquifer-I ranges from 118 to 1684.

Carbonate & bicarbonate:

Naturally occurring carbondioxide is the foremost source of carbonate and bicarbonate ions in ground water along with the carbon cycle and carbonaceous rocks. Leaching of calcite or dolomite bearing rocks (mainly carbonate) is also a principal source of these ions at places. Carbonate content of the area is not detectable. The bicarbonate concentration ranges between 31 to 519 mg/l.

Chloride:

The chloride anions in a certain water environment are characterized by a high stability. Thus, the concentration of chlorides shows little change after long flow distance because the dissolution of chloride is greater in water and the reaction between Cl^- and other ions in stratum is insignificant. The Chloride concentration ranges between 7 to 274 mg/l.

Fluoride:

Its low solubility in water makes it different form the rest of halogen family. Fluoride geochemistry is mainly governed by fluoride bearing minerals found in Chotanagpur Gneissic

complex. The main sources are fluorite (CaF_2), fluorapatite & other minerals present in rocks contributing the ion in water. The Fluoride concentration ranges between 0.1 to 8 mg/l.

Sulphate:

Sources of sulphate are minerals pyrite (FeS_2), anhydrite ($CaSO_4$). Under some conditions considerable quantities of sulphate may be obtained from organic Sulphur compounds. The generalized formulae for sulphate reaction ius;

$$SO_4^{2-} + 2CH_2O \rightarrow 2HCO_3^- + H_2S$$

The Sulphate value ranges between 3.5 to 98 mg/l.

Sodium:

Sources of sodium are halite, sea spray, brines and some silicates. Common sodic silicates include plagioclase. The only common sink for sodium is reverse ion exchange that occurs when highly saline waters come in contact with calcium rich clays.

The Sodium concentration ranges between 6.3 to 85 mg/l.

Calcium: In mineral form, it is found as Calcite, aragonite, gypsum, anhydrite, anorthite, diopside etc. The Calcium concentration ranges between 6.77 to 162 mg/l.

Magnesium:

The most common source of large quantities of magnesium in natural waters is dolomite. Magnesium is also derived from the silicates olivine, pyroxene and amphibole. The main sink is montmomorillonite. The Magnesium concentration ranges between 1.2 to 57.11 mg/l.

Total Hardness:

It is expressed in terms $CaCO_3$ and it is equal to Calcium + Magnesium equivalent per liter. It can be classified as under:-

Hardness range (mg/l CaCO3)-	Class	
0- 60	-	Soft
61-120	-	Moderately hard
121-180	-	Hard
>180	-	Very Hard

In the study area, the total hardness value ranges from 45 to 625 mg/l.

The ground water of shallow aquifers in the area is alkaline in nature. The TDS value observed between 71 to 1010 mg/l. Nitrate concentration found between 0 to 87.77 mg/l within the district.

2.3.1.1 Suitability of ground water of Aquifer – I (shallow aquifer) for drinking purposes: - The suitability of ground water for drinking purposes is determined on the basis of drinking water specification adopted by the Bureau of India Standards IS 10500 – 91 Revised 2012 and approved by World Health Organization (WHO). The number of water samples falling under

various categories of permissible and desirable limits of various constituents and its percentage are given in table - 13.

Table - 10: Suitability of ground water of Aquifer- I for drinking purposes

Chemical constituents and quality parameters	Ranges Desirable		No. of samples under desirable limits	No. of samples under permissible limit	No. of samples under excessive limits
	Desirable limit	Permissible limits in the absence of alternate source			
pH	6.5 to 8.5	No relaxation	44 (100%)	Nil	Nil
TDS (ppm)	500	2000	42 (95.45%)	02 (4.55%)	Nil
TH as $Caco_3$ (ppm)	200	600	32 (72.73%)	11 (25%)	01 (2.27%)
Ca (ppm)	75	200	39 (88.64%)	05 (11.36%)	Nil
Mg (ppm)	30	100	41 (93.18%)	03(6.82 %)	Nil
Cl (ppm)	250	1000	43 (97.73%)	01 (2.27%)	Nil
SO_4 (ppm)	200	400	44 (100%)	Nil	Nil
HCO_3 (ppm)	200	600	29 (65.91%)	15 (34.09%)	Nil
NO_3 (ppm)	45	No relaxation	40 (90.91%)	--	04 (9.09%)
F (ppm)	1.0	No relaxation	30 (68.18%)	--	14 (31.82%)

The table- 10 indicates that all the water samples come under desirable to permissible category of TDS, Ca, Mg, Cl, SO_4 and HCO_3. The value of TH is observed beyond permissible limit in one sample. Similarly, the NO_3 value is also found beyond permissible limit in 04 samples. Major concentration of Fluoride is found beyond permissible limit in 14 samples.

2.3.1.2 Suitability of ground water of Aquifer – I for irrigation purposes: - Apart from domestic consumption, irrigation is consuming a major share of ground water for agricultural activities. The quality of water used for irrigation is an important factor in productivity and quality of irrigated crops. The suitability of water for irrigation purpose depends upon the Total Dissolved Solid in terms of EC value, concentration of Na, bicarbonate and its relative proportion to Mg and Ca. All these mentioned above either individual or with combination create concentration of Sodium (salinity) bicarbonate and alkalis type of hazard.

To better understanding the suitability of ground water for irrigation purpose chemical result of collected water samples have been analyzed and described the different classifications.

Sodium Percentage classification: -EC and sodium concentration are very important in classifying irrigation water. The salts, besides affecting the growth of the plants directly, also affect soil structure, permeability and aeration, which indirectly affect plant growth.

Sodium is a major ion used for the classification of irrigation water due to its reaction with soil that reduces its permeability. Percentage of Na is generally used for assessing the suitability of

water for irrigation purposes. Na is expressed as percent sodium or soluble-sodium percentage (Na %) using Eq.

$$Na\ \% = \left(\frac{Na^{+}+K^{+}}{Ca^{2+}+Mg^{2+}\ Na^{+}\ K^{+}}\right) * 100$$

Table- 11: Classification of ground water of Aquifer - I based on sodium percent.

Sl No.	Water class or category	Sodium percent	No. of samples falling	Percentage of samples
1	Excellent	< 20 %	04	9.09 %
2	Good	20 – 40 %	29	65.91 %
3	Permissible	40 – 60 %	11	25 %
4	Doubtful	30 – 80 %	Nil	Nil
5	Unsuitable	> 80 %	Nil	Nil

(Where all ions are expressed in epm)

On the perusal of table 14, 75 % of water samples of Aquifer – I (dug wells) falling under excellent to permissible category and rest 25% falling under permissible category.

Sodium adsorption ratio (SAR): -In assessment of the quality of water used for irrigation, sodium adsorption ratio (SAR) is a vital parameter. Enhanced salinity decreases the osmotic activity of plants as well as stops water to reach to the branches and leaves of plants resulting in inferior production. Moreover, irrigation water with high sodium and low calcium favors ion exchange by saturation of Na and is detrimental to the soil structure due to scattering of clay particles resulting in minor production because of difficulty in cultivation. The sodium adsorption ration is calculated from the ionic concentration of Sodium, calcium and magnesium according the following relationship:

$$SAR\ = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$$

SAR values can be used to predict the degree to which irrigation water tends to enter into cation exchange section in soil. The higher value of SAR indicates damage of soil. Based on the SAR value the groundwater suitability classification is shown in Table 12 which is showing that all the water samples (100%) of aquifer – I (dug wells) pertain to excellent class.

Table -12: - Classification of ground water of Aquifer – I based on SAR value

Sl No.	Water class	Type of Water	SAR Value	No. of samples falling	Percentage of samples
1	Excellent	Low sodium water	< 10	44 (100%)	Nil
2	Good	Medium sodium water	10 – 18	Nil	Nil
3	Fair	High sodium water	18 – 26	Nil	Nil
4	Poor	Very high sodium water	> 26	Nil	Nil

Residual sodium carbonate content (RSC): -Water containing Co_2 on way gets saturated with Co_2 and forms bicarbonates. The excess bicarbonate of Mg and Ca are precipitated out as carbonates. This produces impermeability to the top soil. Bicarbonate concentration of water has been suggested as additional criteria of suitability for irrigation water. Groundwater samples that had RSC indices of positive value imply that the cumulative concentration of CO_3^{2-} and HCO_3^{2-} is higher than the combined Ca^{2+} and Mg^{2+} concentrations. This would indicate that there is a residual carbonate to react with sodium, presenting sodium hazard to the soil when irrigated with such water. A negative value indicates no residual carbonate. Residual sodium carbonate is determined by using the formula –

$$RSC = (CO_3^{2-} + HCO_3^{2-}) + (Ca^{2+}) + (Mg^{2+}) \quad \ldots\ldots$$

(Where concentration is expressed in epm)

Table- 13: - Classification of ground water of Aquifer – I based on RSC value

Sl No.	RSC (mg/l)	Irrigational suitability	No. of samples falling	Percentage of samples
1	< 1.25	Safe for all type of crops	44	100 %
2	1.25 – 2.50	Safe for semi-tolerant to tolerant crops	Nil	Nil
3	> 2.50	Safe with application of gypsum of the rate of 8.5g/ham of irrigation water applied for 1.0 ml/liter RSC	Nil	Nil

(All the values are expressed in epm.)

On the perusal of table 16, 100 % of water samples of aquifer - I are falling under safe for all type of crops category. Classification of irrigation water modified Piper's diagram is shown below in figure – 23.

Classification of Ground water

The Piper diagram is used to categorize the type of water. It comprises of three parts: one diamond shaped diagram in the middle and two trilinear diagrams sideways in the bottom. The comparative concentrations of cations (left diagram) and anions (right diagram) in each sample is depicted in the trilinear diagram. For presenting ions in a piper diagram, the cations are clustered into three major divisions: sodium (Na) plus potassium (K), calcium (Ca), and magnesium (Mg). The anions are likewise grouped into three main categories: bicarbonate (HCO_3^{2-}) plus carbonate (CO_3^{2-})), chloride (Cl^-), and sulfate (SO_4^{2-}). Each sample is denoted by a point in each trilinear diagram; the type of water samples will make the grade according to the symbolic area in piper diagram. Most of the samples from shallow aquifer fall in the region where alkaline earth's ($Ca+HCO_3$) exceed alkali metals ($SO_4^2 + Cl$). This suggests that in the study area shallow aquifer is dominated by Ca-HCO3 type water.

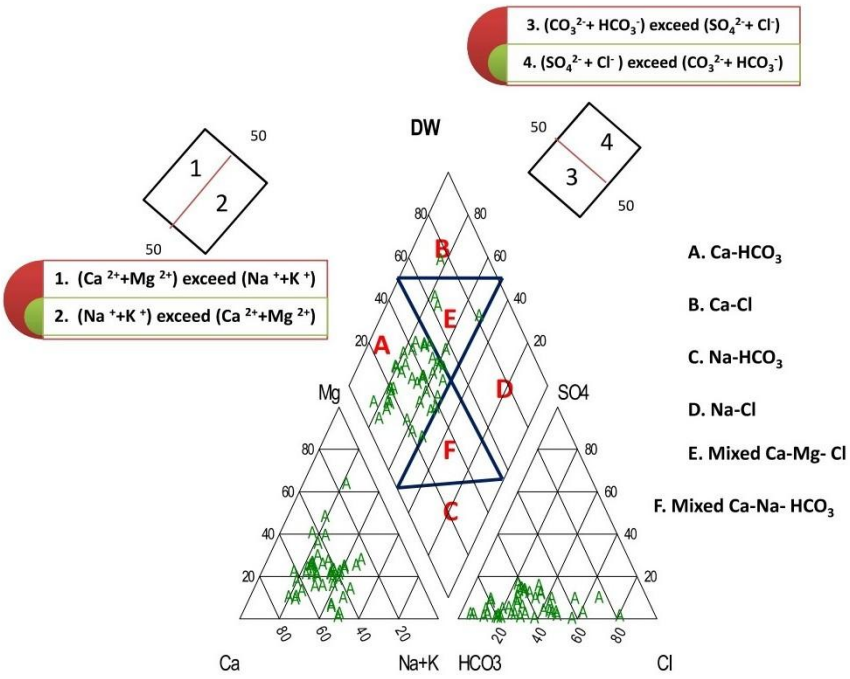


Figure – 23: Piper' diagram for shallow water samples of Giridih district

Suitability of ground water based on Electrical Conductivity (EC): - Wilcox 1948 suggested a water class classification for suitability of water for irrigation. The classification is given below as a table- 14.

Table - 14: - Classification of ground water of Aquifer - I based on electrical conductivity (EC)

Sl No.	Water Class	Rages of EC	No. of samples falling	Percentage of samples
1	Excellent	< 250	09	20.45 %
2	Good	250 – 750	27	61.36 %
3	Permissible	750 – 2250	08	18.19 %
4	Doubtful	2250 – 3000	Nil	Nil
5	Unsuitable	> 3000	Nil	Nil

On The perusal of table 17, about 20.45 % of samples falling under excellent class and 61.36 % of water samples of Aquifer – I (dug wells) falling under good water class. Rest about 18.19 % of water samples falling under permissible water class category.

EC maps of dug well samples i.e. Aquifer – I has been prepared and shown in figures- 24. The values for sodium percentage, SAR, RSC and EC of water samples Aquifer – I collected from dug wells are given in table – 15.

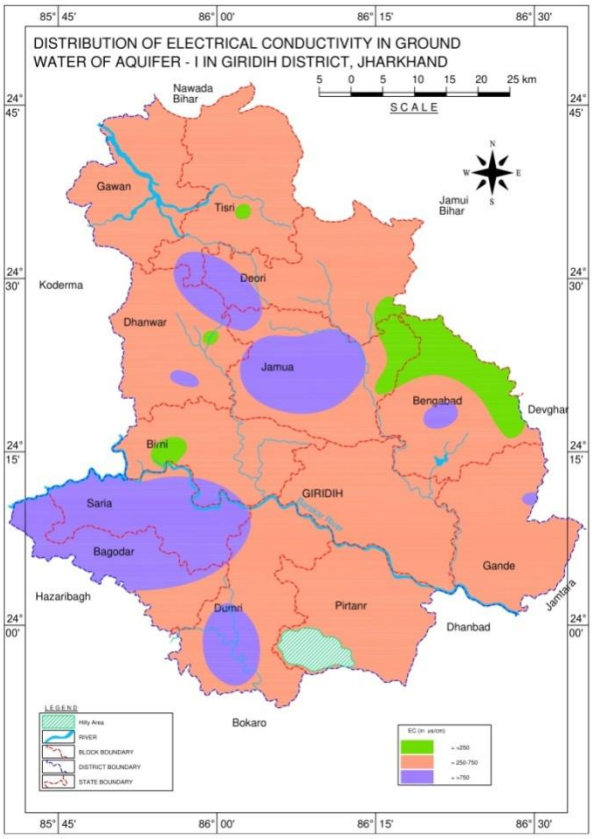


Figure- 24: EC map of Aquifer – I of Giridih district

Table - 15: Values of Sodium percentage, SAR, RSC and EC of water samples collected from Aquifer – I (Dug wells), Giridih district

Sr. No.	Village	Block	District	Na %	SAR	RSC	EC
1	Pipratol	Bengabad	Giridih	20.00	0.43	- 0.30	195
2	Bengabad	Bengabad	Giridih	40.72	2.00	0.23	884
3	Devatarn	Bengabad	Giridih	23.83	0.51	- 0.10	185
4	Siyatarn	Jamua	Giridih	23.27	0.40	- 0.20	118
5	Barasoli	Bengabad	Giridih	23.81	0.86	- 0.50	537
6	Chakradaha	Bengabad	Giridih	43.21	1.92	0.70	738
7	Maheshmunda	Gandey	Giridih	36.03	0.94	- 0.31	294
8	Gandey	Gandey	Giridih	25.05	0.79	0.53	549
9	Budhudih	Gandey	Giridih	49.35	2.33	0.80	760
10	Dahutarn	Gandey	Giridih	39.93	1.13	0.00	281
11	Pandri	Gandey	Giridih	29.39	1.23	-2.08	750
12	Gardih	Jamua	Giridih	22.08	0.59	- 0.40	308
13	Kosogondodighi (Karmatarn)	Devri	Giridih	23.95	0.48	- 0.70	175

14	Chilkhariodih	Devri	Giridih	35.94	1.05	- 0.60	287
15	Jalkhariodih	Devri	Giridih	23.28	0.88	0.80	561
16	Devri	Devri	Giridih	20.45	0.53	-0.34	303
17	Belatarn	Devri	Giridih	22.83	0.85	-2.59	677
18	Tisri	Tisri	Giridih	47.65	1.90	-0.02	442
19	Kenduadih	Gawan	Giridih	16.75	0.46	- 0.10	322
20	Gawan	Gawan	Giridih	24.08	0.82	0.00	4.98
21	Palmo Mission	Tisri	Giridih	19.52	0.48	- 0.40	242
22	Khijri Khasiyatarn	Tisri	Giridih	30.65	1.09	- 0.60	453
23	Beriya	Devri	Giridih	34.39	1.33	- 0.40	507
24	Gando	Jamua	Giridih	29.34	0.85	- 0.80	289
25	Giridih	Giridih	Giridih	37.61	1.34	0.46	464
26	Dhanaydih	Giridih	Giridih	47.68	2.29	-0.10	723
27	Malho	Jamua	Giridih	39.76	1.60	- 0.60	672
28	Doranda	Raj Dhanwar	Giridih	49.21	2.07	0.10	647
29	Hirodih	Raj Dhanwar	Giridih	43.68	2.24	- 1.70	1025
30	Nawadih (Ruputola)	Raj Dhanwar	Giridih	25.44	0.58	0.20	234
31	Itasani	Raj Dhanwar	Giridih	46.63	2.16	- 0.60	790
32	Bishunpur	Birni	Giridih	35.58	1.10	- 0.20	375
33	Arwatarn (Kendua)	Birni	Giridih	41.18	1.24	- 0.60	383
34	Palaunjia (Birni)	Birni	Giridih	22.27	0.54	-0.20	250
35	Bangra Khurd	Birni	Giridih	31.51	0.75	- 0.50	211
36	Saraiya	Saraiya	Giridih	16.87	0.87	-6.89	1306
37	Gohiyadih	Giridih	Giridih	40.78	1.77	- 1.30	605
38	Bhandaro	Dumri	Giridih	36.03	1.07	- 0.70	250
39	Kakuriadih	Dumri	Giridih	28.57	1.24	- 1.80	713
40	Keshkari	Saraiya	Giridih	23.83	1.27	- 4.0	1684
41	Atka (Jamuna Nagar)	Bagodar	Giridih	39.78	2.11	- 1.70	1069
42	Gopaldih	Bagodar	Giridih	49.44	1.56	- 1.30	365
43	Chainpur (Harijan Basti)	Dumri	Giridih	26.36	0.85	- 1.90	521
44	Dumri	Dumri	Giridih	24.02	1.22	-2.18	1126

2.3.2 General range of chemical parameter of Aquifer - II in the area: - The variation range of the concentration in ppm of different chemical constituents and quality parameters of Aquifer - II (hand pumps samples) represented in tables 16.

Table- 16: Ranges of chemical constituents of Aquifer - II in Giridih district (hand pump samples)

Chemical Constituents and quality parameters	Ranges of the concentration(in ppm)
pH	7.3 – 8.23
EC (micro siemens/cm at 25^0c)	93 – 2256
TDS (ppm)	56 – 1466
TH as $CaCo_3$ (ppm)	35 – 630
Ca (ppm)	8 – 144
Mg (ppm)	0 – 65.61
Na (ppm)	0.3 – 69.20
K (ppm)	0.1 – 15
HCO_3 (ppm)	18 - 305
Cl (ppm)	11 – 514
SO_4 (ppm)	0 – 85
NO_3 (ppm)	2.10 – 167
F (ppm)	0 – 2.16

The ground water of aquifer - II in the area is alkaline in nature. On the perusal of table - 16, the pH value ranges 7.3 to 8.23 mg/l. The EC value ranges between 93 to 2256 mg/l. Overall in the district, the TDS value varies from 56 to 1466 mg/l. and the total hardness ranges between 35 to 630 mg/l. Calcium and Magnesium values varies from 8 to 144 mg/l and 0 to 65.61 mg/l respectively. Similarly, the Nitrate value ranges from 2.10 to 167 mg/l while Fluoride value found between 0 to 2.16 mg/l.

2.3.2.1 Suitability of ground water of Aquifer – II (deeper aquifers) for drinking purposes: - To know the ground water quality of Aquifer - II, water samples were collected from bore wells (Hand pump). The number of water samples falling under various categories of permissible and desirable limits of various constituents and its percentage are given in table - 17.

Table - 17: Suitability of ground water of Aquifer- II for drinking purposes

Chemical constituents and quality parameters	Ranges Desirable		No. of samples under desirable limits	No. of samples under permissible limit	No. of samples under excessive limits
	Desirable limit	Permissible limits in the absence of alternate source			
pH	6.5 to 8.5	No relaxation	48 (100%)	Nil	Nil
TDS (ppm)	500	2000	44 (91.67%)	04 (8.33%)	Nil
TH as $Caco_3$	200	600	35 (72.92%)	12 (25%)	01 (2.08%)

(ppm)					
Ca (ppm)	75	200	41 (85.42%)	07 (14.58%)	Nil
Mg (ppm)	30	100	46 (95.83%)	02 (4.17%)	Nil
Cl (ppm)	250	1000	47 (97.92%)	01 (2.08%)	Nil
SO_4 (ppm)	200	400	48 (100%)	Nil	Nil
HCO_3 (ppm)	200	600	44 (91.67%)	04 (8.33%)	Nil
NO_3 (ppm)	45	No relaxation	43 (89.58%)	--	05 (10.42%)
F (ppm)	1.0	No relaxation	45(93.75%)	--	03 (6.25%)

On the perusal of table – 17, it is observed that about 100% ground water samples of aquifer – II falling under desirable limits to permissible limits category except Total hardness, Nitrate and Fluoride. The Fluoride value is found beyond permissible limit in 03 samples. Total hardness is observed beyond permissible limit in 01 sample while concentration of Nitrate value is found beyond permissible limit in 05 samples.

2.3.2.2 Suitability of ground water of Aquifer – II for irrigation Purposes: To better understanding the suitability of ground water for irrigation purpose chemical result of collected water samples have been analyzed and described the different classifications.

Sodium Percentage classification: - Sodium content is usually expressed estimated using the formula –

Sodium percent $= \left(\frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+}\ Na^+\ K^+}\right) * 100$ …….

Table- 18: Classification of ground water of Aquifer - II based on Na%

Sl No.	**Water class or category**	**Sodium percent**	**No. of samples falling**	**Percentage of samples**
1	Excellent	< 20 %	26	54.17%
2	Good	20 – 40 %	20	41.67%
3	Permissible	40 – 60 %	02	4.16%
4	Doubtful	30 – 80 %	Nil	Nil
5	Unsuitable	> 80 %	Nil	Nil

(Where all ions are expressed in lpm or epm)

From table 18, about 54.17 % of water samples of aquifer – II falling in excellent water class. About 45.83 % of water samples falling under permissible to good water class category.

Sodium adsorption ratio (SAR): - The sodium adsorption ration is calculated from the ionic concentration of Sodium, calcium and magnesium according the following relationship:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Ground water classification into four classes based on SAR value is given in table- 19 which is showing that all the water samples (100%) of aquifer - II falling under excellent water class.

Table - 19: - Classification of ground water of Aquifer – II based on SAR value

Sl No.	Water class	Type of Water	SAR Value	No. of samples falling	Percentage of samples
1	Excellent	Low sodium water	< 10	48 (100%)	Nil
2	Good	Medium sodium water	10 – 18	Nil	Nil
3	Fair	High sodium water	18 – 26	Nil	Nil
4	Poor	Very high sodium water	> 26	Nil	Nil

(Where all ions expressed in lpm)

Residual sodium carbonate content (RSC): Residual sodium carbonate is determined by using the formula

$$RSC = (CO_3^{2-} + HCO_3^{2-}) + (Ca^{2+}) + (Mg^{2+}) \quad \ldots\ldots$$

(Where concentration is expressed in epm)

Table - 20: - Classification of ground water of Aquifer – II based on RSC value

Sl No.	RSC (mg/l)	Irrigational suitability	No. of samples falling	Percentage of samples
1	< 1.25	Safe for all type of crops	48	100 %
2	1.25 – 2.50	Safe for semi-tolerant to tolerant crops	Nil	Nil
3	> 2.50	Safe with application of gypsum of the rate of 8.5g/ham of irrigation water applied for 1.0 ml/liter RSC	Nil	Nil

(All the values are expressed in lpm or epm)

On the perusal of table - 23, 100 % of water samples of aquifer - II falling under safe for all type of crops category. Classification of irrigation water modified Piper's diagram is shown below in figure – 25.

Suitability of ground water based on Electrical Conductivity (EC): - Wilcox 1948 suggested a water class classification for suitability of water for irrigation. The classification is given below as a table - 21.

Table - 21: - Classification of ground water of Aquifer - II based on (EC)

Sl No.	Water Class	Rages of EC	No. of samples falling	% of samples
1	Excellent	< 250	13	27.08%
2	Good	250 – 750	29	60.42%
3	Permissible	750 – 2250	06	12.50%

4	Doubtful	2250 – 3000	Nil	Nil
5	Unsuitable	> 3000	Nil	Nil

On the perusal of table - 25, about 27.08 % of water samples aquifer - II falling under excellent water class. About 60.42% of water samples falling in good water class and rest 12.50 % of water samples falling under permissible water class category.

EC maps of dug well samples i.e. Aquifer – II has been prepared and shown in figures- 18. The values for sodium percentage, SAR, RSC and EC of water samples of Aquifer – II collected from hand pumps are given in table – 22.

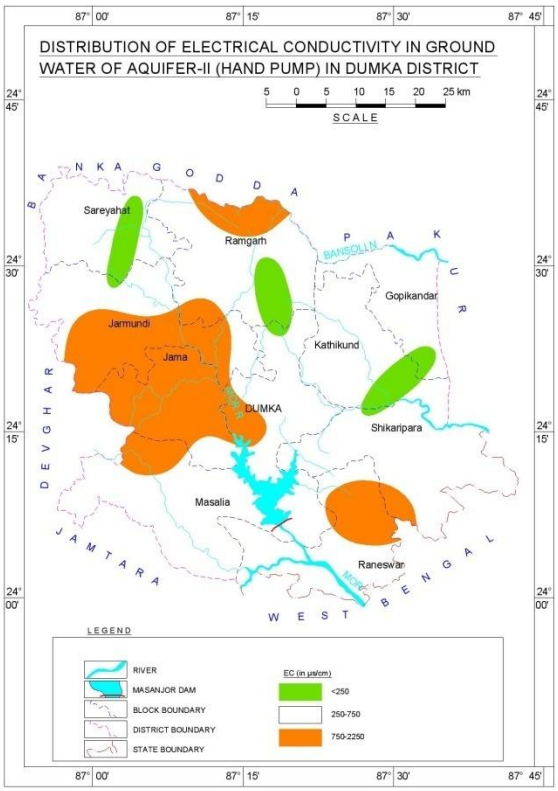


Figure – 25: EC map of Aquifer – II of Giridih district

Table - 22: Values of Sodium Percentage, SAR, RSC AND EC of water samples collected from Aquifer – II (Hand pumps), Giridih district

Sr. No.	Village	Block	District	Na %	SAR	RSC	EC
1	Pipratol	Bengabad	Giridih	33.26	0.75	- 0.55	163
2	Bengabad	Bengabad	Giridih	40.67	1.70	- 1.10	695
3	Devatarn	Bengabad	Giridih	10.87	0.21	- 0.80	168
4	Siyatarn	Jamua	Giridih	16.96	0.31	- 0.80	140
5	Barasoli	Bengabad	Giridih	12.85	0.29	- 1.40	235
6	Chakradaha	Bengabad	Giridih	24.67	0.51	- 0.50	159
7	Maheshmunda	Gandey	Giridih	17.99	0.52	- 1.60	378
8	Gandey	Gandey	Giridih	24.20	0.77	- 1.10	414
9	Budhudih	Gandey	Giridih	9.20	0.21	- 1.20	251

10	Dahutarn	Gandey	Giridih	37.87	0.46	- 0.80	260
11	Pandri	Gandey	Giridih	11.62	0.33	- 2.00	410
12	Gardih	Jamua	Giridih	30.60	0.87	- 0.90	322
13	Kosogondodighi (Karmatarn)	Devri	Giridih	25.77	0.41	- 0.20	93
14	Chilkhariodih	Devri	Giridih	30.12	0.98	- 0.90	422
15	Jalkhariodih	Devri	Giridih	34.38	0.73	- 0.70	156
16	Devri	Devri	Giridih	8.26	0.15	- 0.60	167
17	Belatarn	Devri	Giridih	21.66	0.47	- 1.00	216
18	Tisri	Tisri	Giridih	27.07	0.84	- 1.30	351
19	Kenduadih	Gawan	Giridih	37.00	1.23	- 1.20	383
20	Gawan	Gawan	Giridih	21.05	0.69	- 1.20	538
21	Palmo Mission	Tisri	Giridih	25.70	0.86	- 2.20	489
22	Khijri Khasiyatarn	Tisri	Giridih	30.61	0.62	- 0.90	266
23	Beriya	Devri	Giridih	7.44	0.17	- 1.30	253
24	Gando	Jamua	Giridih	7.20	0.18	- 1.80	355
25	Giridih	Giridih	Giridih	0.40	0.007	- 2.80	448
26	Dhanaydih	Giridih	Giridih	35.24	1.17	- 1.70	559
27	Bandhutarn	Jamua	Giridih	41.59	1.48	1.12	413
28	Jamua	Jamua	Giridih	37.78	3.01	-10.78	2256
29	Malho	Jamua	Giridih	11.76	0.28	- 1.10	303
30	Doranda	Raj Dhanwar	Giridih	12.62	0.36	- 1.50	447
31	Hirodih	Raj Dhanwar	Giridih	17.91	0.59	- 2.20	545
32	Nawadih (Ruputola)	Raj Dhanwar	Giridih	6.80	0.13	- 1.30	187
33	Itasani	Raj Dhanwar	Giridih	22.60	0.82	- 2.40	649
34	Bishunpur	Birni	Giridih	14.89	0.26	- 0.70	187
35	Arwatarn (Kendua)	Birni	Giridih	15.97	0.35	- 1.30	237
36	Palaunjia (Birni)	Birni	Giridih	16.22	0.46	- 1.40	380
37	Bangra Khurd	Birni	Giridih	6.12	0.09	- 1.70	257
38	Saraiya	Saraiya	Giridih	18.56	0.83	- 5.20	835
39	Gohiyadih	Giridih	Giridih	19.22	0.63	- 2.90	695
40	Bhandaro	Dumri	Giridih	11.84	0.40	- 3.90	769
41	Kakuriadih	Dumri	Giridih	12.47	0.25	- 0.80	183
42	Keshkari	Saraiya	Giridih	28.14	1.46	- 2.20	1030
43	Atka (Jamuna Nagar)	Bagodar	Giridih	18.98	0.86	- 3.30	833
44	Gopaldih	Bagodar	Giridih	19.29	0.64	- 2.40	505
45	Chirki Pirtarn	Chirki Pirtarn	Giridih	32.29	1.28	- 1.26	658
46	Chainpur (Harijan Basti)	Dumri	Giridih	14.10	0.15	- 2.00	561
47	Dumri	Dumri	Giridih	4.34	0.44	- 2.60	474
48	Bagodar	Bagodar	Giridih	30.21	1.60	- 2.16	1058

3.6.2.3 Geographical distribution and quantification with respect to ground water quality/ contamination:

The analyzed chemical data of groundwater samples of deeper aquifer were plotted on the Piper diagram. Interpretation of Piper diagram revealed that deeper aquifer water samples belong to calcium–magnesium–chloride (Ca–Mg–Cl) type of facies.

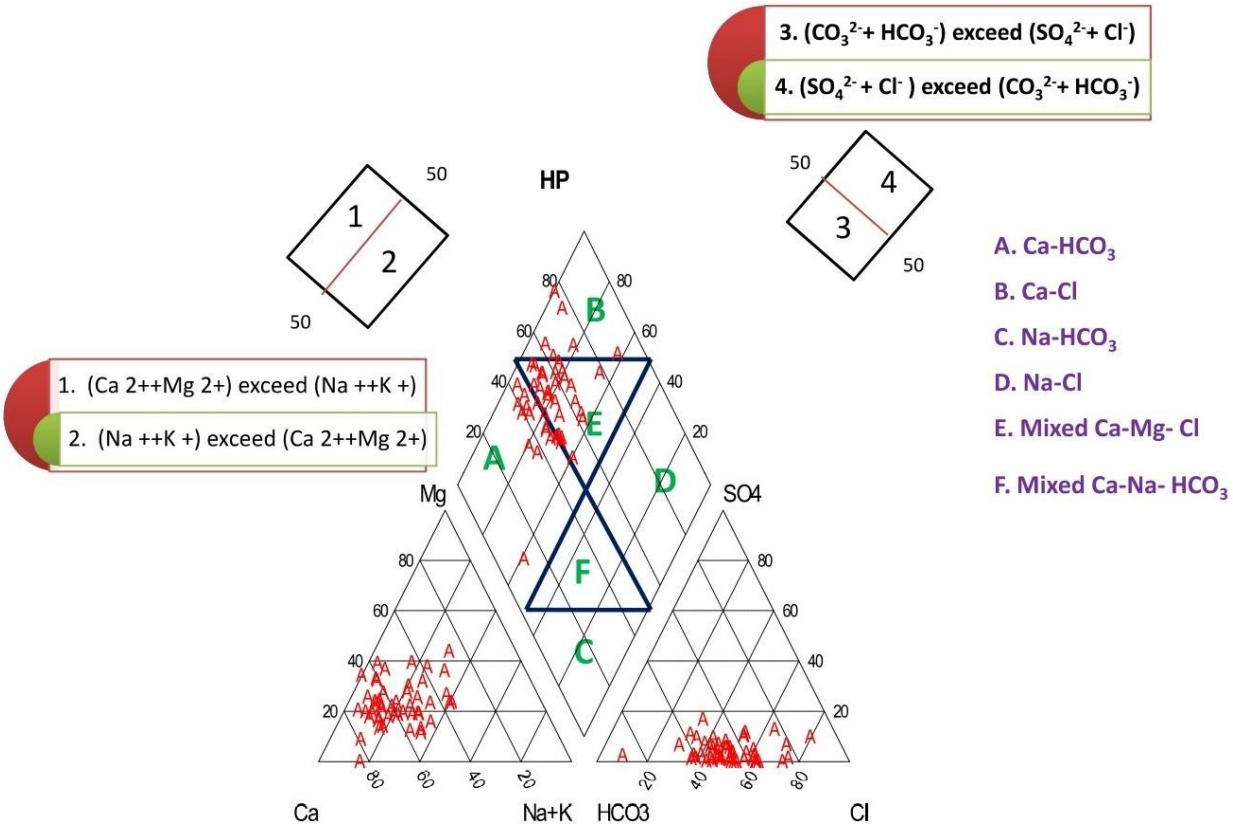


Figure – 26: Piper' diagram for deeper water samples of Giridih district

2.4 Thermal Spring study: Geological survey of India has carried thermal spring studies of Bihar, Jharkhand, West Bengal and Odisha states during the year 2015-16. The objective of the item was monitoring of temperature and discharge to identify geothermal activity, water sampling for assessing quality of water and isotope study in the area around known hot water springs of Bihar, West Bengal, Jharkhand and Odisha. Following two hot springs of Giridih district were covered under the study-

1. Kesodih hot spring
2. Lapasiatand hot spring

1. Kesodih Hot Spring: Kesodih hot spring lies at 24^0 11' 24" north latitudes and 86^0 01' 03" east longitudes falling in Toposheet No. 72L/4. It is 45 km away from district headquarter of Giridih. It is located in Domensingha village which can be approached on Bharkatta on Giridih- Bagodar

road. Barakar River which towards SE of the geothermal manifestation area is the main drainage of the area. The area around the Kesodih hot spring is a part of the metamorphic terrain consisting of the rock of Chhota Nagpur Gneissic Complex (CGC) of Archean age. CGC consists of rocks like biotite granite gneiss, amphibole granite gneiss, quartz muscovite schist, amphibole/hornblende schist, granite, amphibolites. They are traversed by pegmatite and quartz vein.

Geochemistry: At Kesodih, the thermal manifestation is spread over 35 sq. m. Four spouts are present with water temperature varies from 50.3 to 53.4^0 C. pH and EC value varies from 9.8 to 10.1 and 740 to 760 µS/cm respectively. The cumulative discharge is 82 lit./ min. Non thermal sources bear water with temperature ranging from 25.7 to 27.9^0 C with pH value ranging from 8.5 to 9.5 while EC value varies from 290 to 350 µS/cm.

Chemical data of two water samples from various geothermal and non geothermal sources at Kesodih area have been studied to know the geothermal condition. Thermal water is alkaline in nature with pH of 9.2. The major cations present in the thermal water are Na, K, Ca, Mg, SiO_2 while major anions are HCO_3, Cl, SO_4, F etc. Thermal water has TDS value of 308 ppm with Na content of 130 ppm, K content of 4 ppm, Ca content of 4 ppm, Mg content of 1 ppm respectively. It has Cl content 88 ppm, SO_4 content of 48 ppm, HCO_3 + CO_3 content of 65 ppm, F content of 18.40 ppm, SiO_2 content is 67 ppm. Non thermal water has TDS value of 167 ppm with Na content of 19 ppm, K content of 1 ppm, Ca content of 40 ppm with Mg content of 10 ppm. They have Cl content of 26 ppm, SO_4 content of 11 ppm, HCO_3 content of 136 ppm and F content of 2.41 ppm respectively. SiO2 content is 55 ppm. The thermal waters of Kesidih area are characterized by high Na, K, Cl, SO_4 content and low Ca, Mg and HCO_3 content. The can be grouped under Na – Cl – HCO_3 type of water. The non thermal waters are characterized by low Na, K, Cl and SO_4 content and high Ca, Mg and HCO_3 content. Geochemically they are Ca – Ma – HCO_3 type of water falling in metoric water type.

2. Lapasiatand hot spring: Lapasiatand hot spring is located in Bagodar block of Giridih district and lies at 24^0 02' 59" north latitudes and 85^0 21' 12" east longitudes falling in Toposheet No. 72H/16. It is 04 km SE from Bagodar on the GT road (NH2).The hot spring is situated on the Jamunia River bed. The area is soil covered in the gneissic country with schistose bands traversed by pegmatites. The spring is associated with pegmatite vein. Major rock types present surrounding the spring are coarse grained pink granite with pegmatite and mica schist.

Geochemistry: At Lapasiatand, thermal discharge takes place through a single sprout present in the Jamunia nala bed. The water temperature is 36.2^0 C with pH value of 8.4 and EC value of 350 µS/cm. the discharge is 40 lit./ min. Non thermal sources bear water with temperature ranging from 24.3 to 30.1^0 C with pH value ranging from 8.1 to 8.7 and EC varying from 390 to 540 µS/cm.

Chemical data two water samples from various geothermal and non geothermal sources at Lapasiatand area have been studied to know the geothermal condition. Thermal water is alkaline in nature with pH value of 7.6. The major cations present in thermal water are Na, K,

Ca, Mg, SiO_2 while major anion are HCO_3, Cl, SO_4, F etc. Thermal water has TDS value of 198 ppm with Na content of 26 ppm, K content of 2 ppm, Ca content of 40 ppm, Mg content of 8 ppm respectively. It has Cl content of 7 ppm, SO_4 content of 1 ppm, HCO3 content of 215 ppm, F content of 1.19 ppm. SiO_2 content is 56 ppm. Non thermal water has TDS value of 194 ppm with Na content of 27 ppm, K content of 2 ppm, Ca content of 38 ppm with Mg content of 10 ppm. It has Cl content of 8 ppm, SO_4 content of 2 ppm, HCO_3 content of 210 ppm and F content of 1.15 ppm respectively. SiO_2 content is 60 ppm. The thermal an non thermal water of Lapasiatand are characterized by low Na, K and low to moderate Cl, SO_4 content and high Ca, Mg and HCO_3 content. Geochemically they are Ca – Mg – HCO_3 type of water falling in metoric water type.

2.5 Ground Water Exploration: To assess the potentiality of the deep fractured rock 32 exploratory wells and 18 observation wells were drilled in Giridih district by Central Ground Water Board. In addition, six exploratory wells have been constructed by outsourcing drilling. The drilling results have indicated that granite gneiss of different shades varying from grey to dark grey to pink, having course grained texture sometime porphyritic, are the most dominant rock types met in the area. In the bore wells upper weathered zones are cased and only the fractured zones are tapped in the uncased well. The details of the exploratory and observation wells drilled in Giridih district are presented in annexure – VI and available lithologs of these wells are represented in annexure – V. Summary of success bore wells drilled by Central Ground Water Board in the district is given below in table –23.

Table – 23: Summary of success bore wells drilled by CGWB in Giridih district

Location	**Block name be added**	**Depth drilled (mbgl)**	**Depth of fractured encountered (mbgl)**	**Discharge (m^3/hr)**	**T (m^2/day)**	**S**
Jorasankh	Jamua	101.00	22.00 – 24.00, 69.00 – 70.00	10.74	--	6.30×10^{-2}
Naudiha	Jamua	66.00	--	36.00	--	--
Rathdih	Bengabad	100.00	--	15.50	--	--
Mohanpur	Giridih	87.62	--	39.60	17.39	--
Gandey block	Gandey	137.71	42-44	11.29	66.17	1.58×10^{-5}
Hat Bazar	Giridih	93.09	--	37.70	46.10	2.30×10^{-3}
Dandidih	Giridih	145.48	--	19.80	4.34	--
Tisri	Tisri	186.93	--	12.45	20.08	--
Dumri block	Dumri	198.35	--	15.30	--	--

Location	Block name be added	Depth drilled (mbgl)	Depth of fractured encountered (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S
Birangada	Pirtanr	191.53	--	27.00	--	--
Atka	Bagodar	182.54	--	11.80	--	--
Gandey (JNV)	Gandey	92.90	42.00 – 44.00	25.56	33.26	3.50×10^{-4}
Arkhango	Raj Dhanwar	202.70	109.00-110.00, 148.50-149, 189.00 – 189.50	44.28	--	--
Khambhra	Bagodar	186.00	24.00 – 25.00, 128.50-129.50	12.24	--	--
Sariya Inter college	Sariya	202.70	155.00 – 1156.00, 182.00 - 182.50	12.24	--	--
Nawadih	Sariya	184.40	142.00 – 144.50	20.52	--	--

From table–23 it is observed that one to three sets of fractures have been encountered in the bore wells drilled in Giridih district. Based on morphotectonic analysis and exploratory drilling results, it confirms that the area has undergone several phases of tectonic deformations which lead to various sets of fractures, fissures, and faults etc which are ground water repositories. Various sets of fractures have been identified, on ground water point of view. The shallow fractured aquifers upto the depth of 100 m and deep fractured aquifer exist upto 189.50 mbgl within the explored depth of 202.70 m.

Based on Aquifer Parameters evaluation in the district, Transmissivity value of deep fractured aquifer is found to be between 4.34 to 66.17 m^2/day. High value of Transmissivity correlates to tensile fracture system. The Storage co-efficient value ranging from 1.40×10^{-2} to 1.58×10^{-5} which indicates semi-confined to confined aquifer system in the district.

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation, thematic layers was interpreted and integrated. Based on this the various aquifer characteristic maps on hydrogeology, aquifer wise water level scenario both current and long term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, aquifer wise yield potential, aquifer wise resources, aquifer maps were generated which has been discussed in details.

3.1 Aquifer Disposition

3.1.1 Hydrogeological Cross Section: To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A', B-B' and C-C' .

3.1.1.1 Hydrogeological cross section A-A': Hydrogeological cross section A-A' represents the area in SW – NE direction in portion of the district. The data of 4 exploratory wells i.e. Ambadih, Bangrakhurd, Tara and Devri have been utilised. The Aquifer- I ranges 9.00 – 29.7 m representing weathered Granite Gneiss, while Aquifer-II ranges from 12.00-152.00 m representing fractured Granite Gneiss. Generally 1- 2 fracture zones were encountered. Location map of cross section is shown in figure – 27. Hydrogeological cross section of A-A' is shown in figure- 28 .

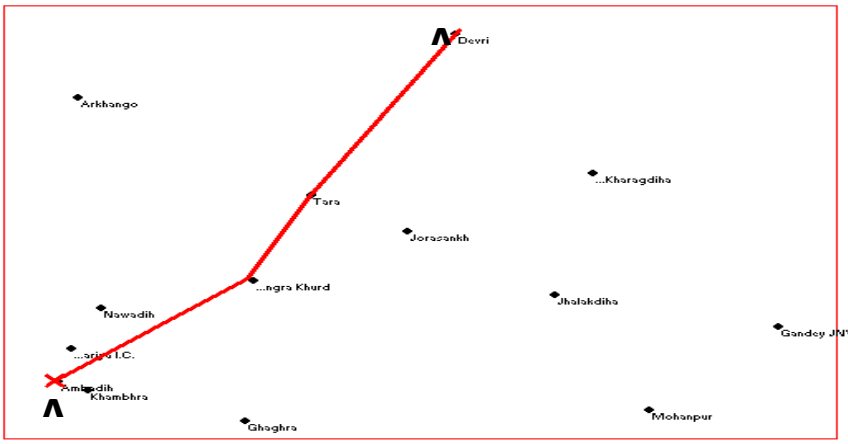
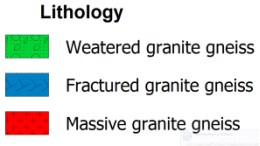


Figure – 27: Location map of cross section A-A'



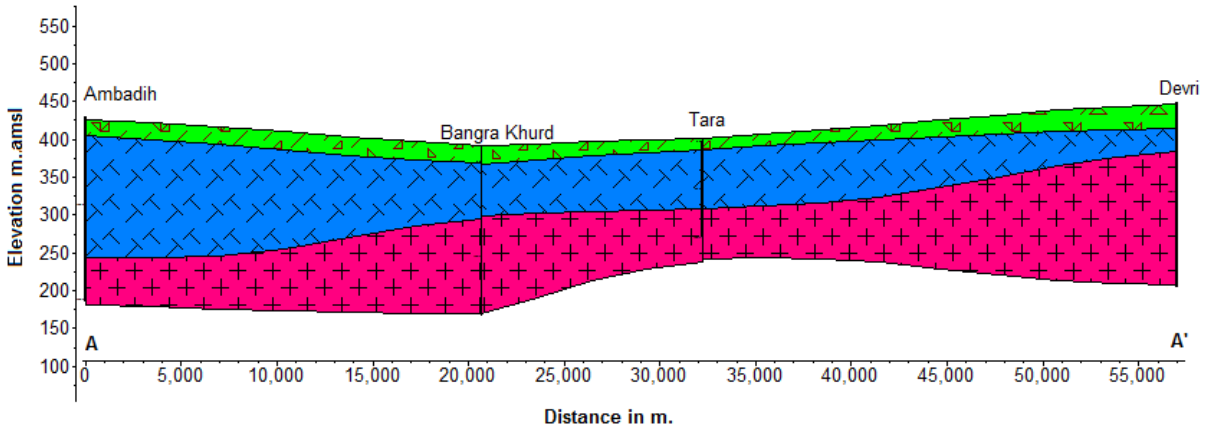


Figure –28 : Hydrogeological cross section along A – A'

3.1.1.2 Hydrogeological cross section B – B': Hydrogeological cross section B-B' represents the area in NW-SE part of Giridih district. The data of 5 exploratory wells i.e.Arkhango, Tara, Jorasangh, Jhalakdiha, Gandey have been utilised. The Aquifer- I ranges 7.3 – 30.3 m representing weathered Granite Gneiss, while Aquifer-II ranges from 11.00 – 189.5 m representing fractured Granite Gneiss. Generally 1 - 2 fracture zones were encountered.. Location map of cross section is shown in figure – 29,Hydrogeological cross section of B-B' is shown in figure - 30.

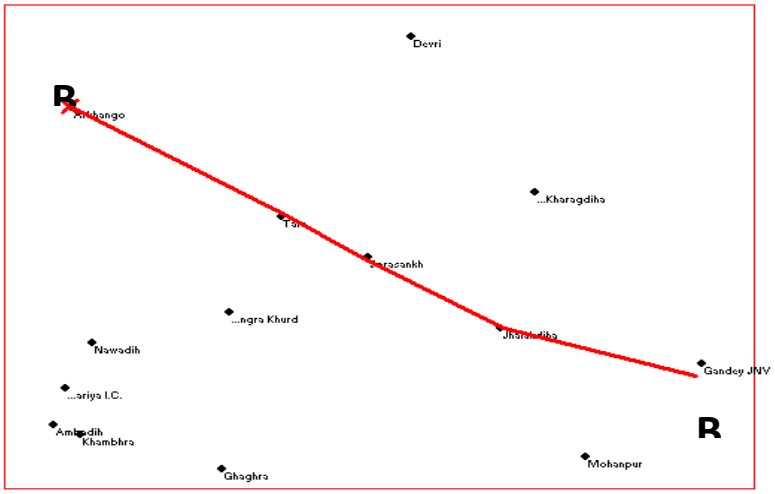
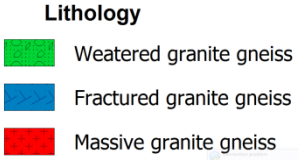


Figure – 29 : Location map of cross section B-B'



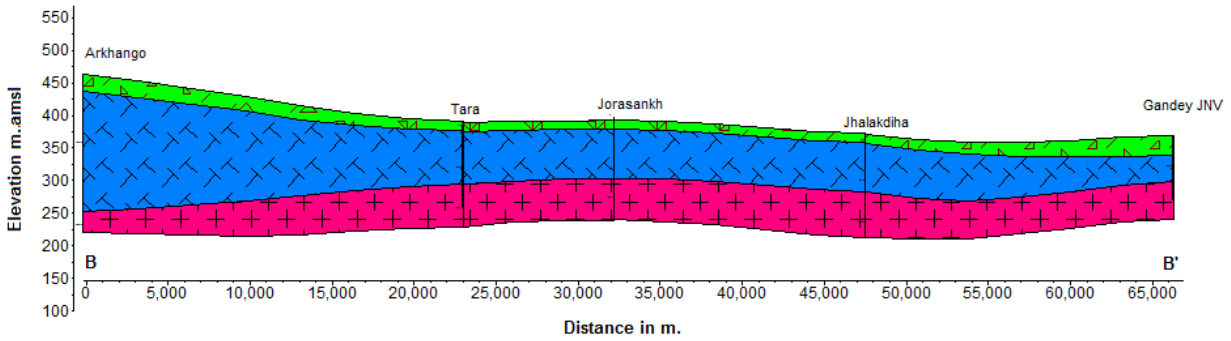


Figure – 30: Hydrogeological cross section along B – B'

3.1.1.3 Hydrogeological cross section C – C': Hydrogeological cross section C-C' represents the area in NW-SE part of Giridih district. The data of 4 exploratory wells i.e. Nawadih, Bangarakhurd, Jhalakdiha & Gandey have been utilised. The Aquifer- I ranges 7.5-30.3 m representing weathered Granite Gneiss, while Aquifer-II ranges from 12.00- 150.00 m representing fractured Granite Gneiss. Generally 1 - 2 fracture zones were encountered. Figure – 20 : Location map of cross section CC' in Fig 31. Hydrogeological cross section of C-C' is shown in figure - 32

Figure – 31 : Location map of cross section C-C'

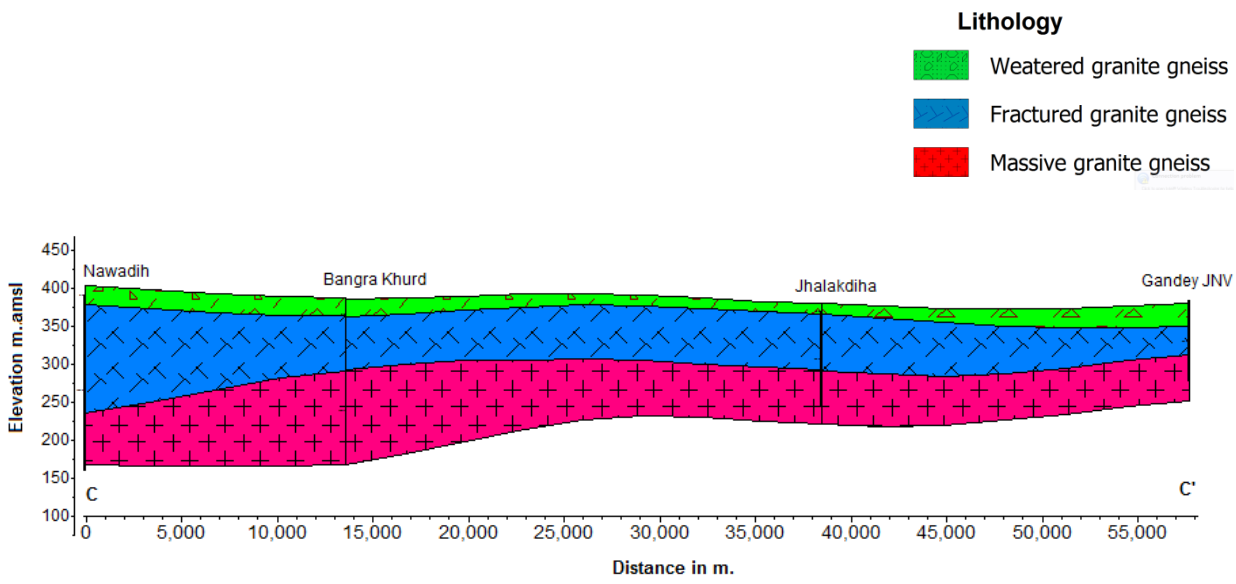
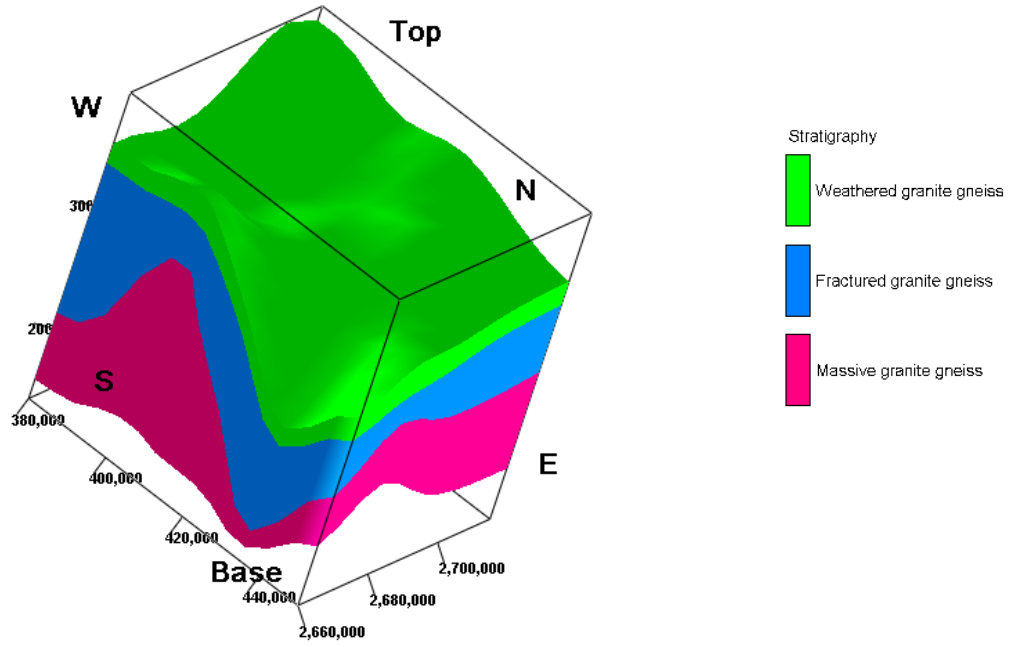


Figure –32: Hydrogeological cross section along C – C'

3.1.2 2-D & 3-D and Aquifer Disposition: The 3-D map in hard rock area of the district showing spatial disposition and vertical extent of Aquifer-I indicating its depth of weathering while the Aquifer – II showing occurrence of fractured rock thickness is presented in **figures – 33**.



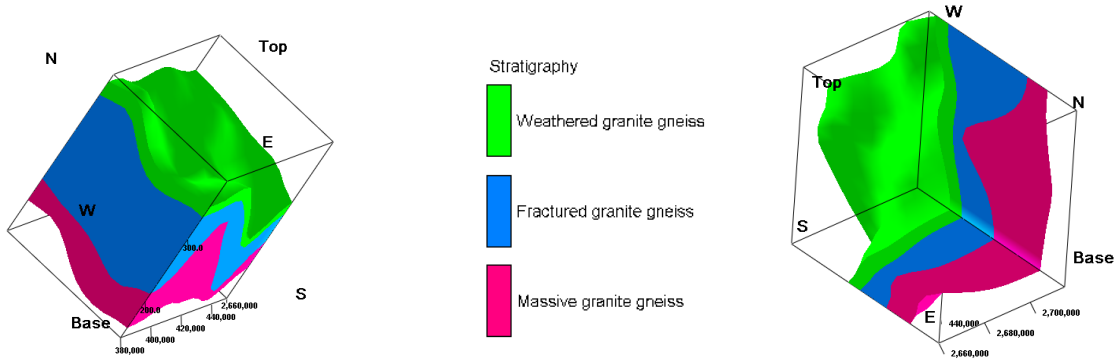


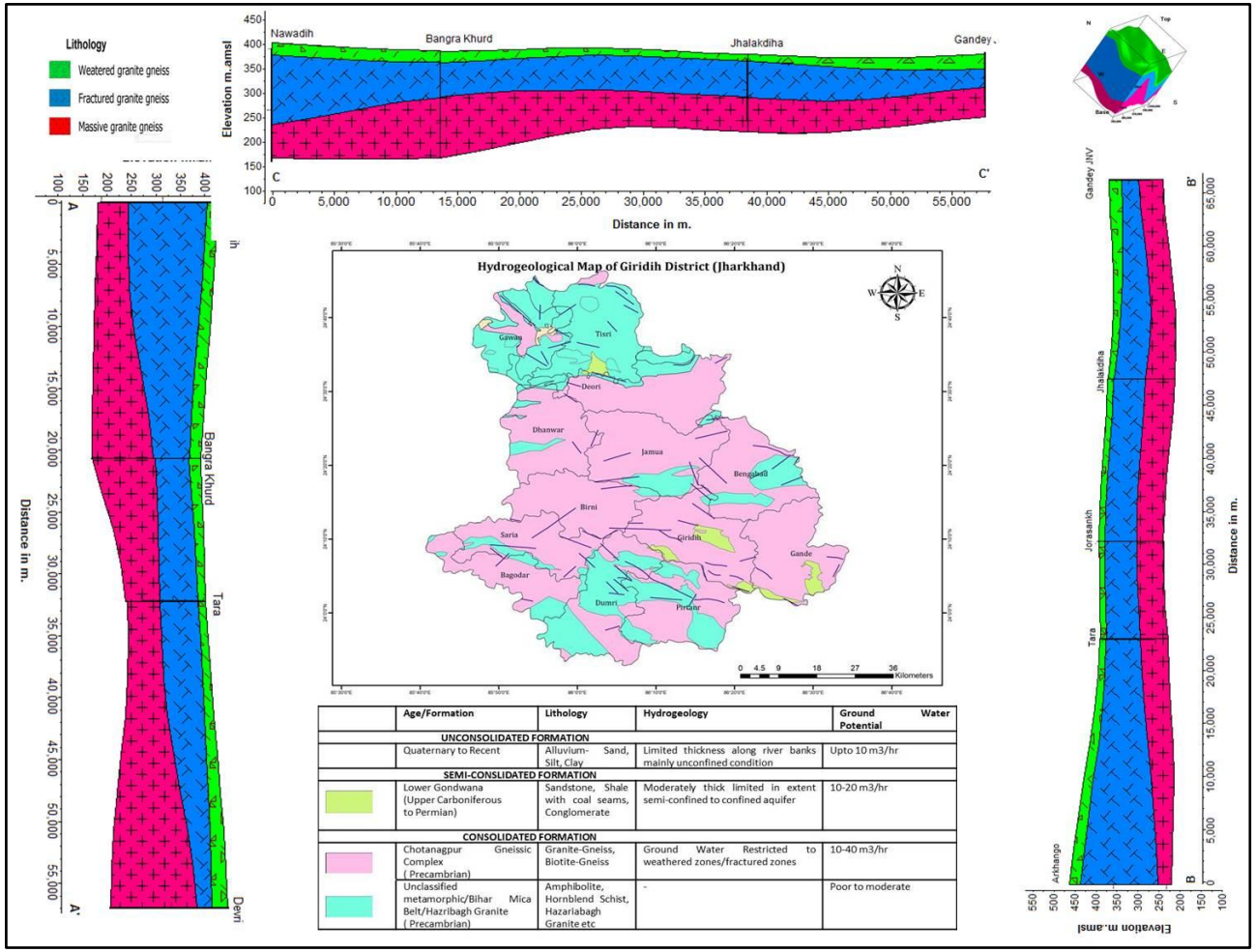
Figure – 33: 3D subsurface lithological models with Aquifer Disposition in hard rock areas of Giridih district

3.2 Aquifer Characteristics: - The sustainability of ground water Resources are better understood by the aquifer properties. The Table - 24 depicts the aquifer parameters details in Giridih district. The aquifer performance tests conducted at various exploratory wells reveal that aquifers can sustain to sufficient pumping hours and can give sustained yield with normal draw down. The transmissivity value ranges from 4.34 - 66 m^2/day. Higher values of Transmissivity may be attributed to tensile nature or openness of fractures. The storativity value also varies from 1.40 x 10^{-2} to 1.58 x $10^{-5,}$ which shows that aquifers are under semi-confined to confined condition.

Table 24: Aquifer characteristics of Giridih district

Type of aquifer	Formation	Depth range of the aquifer (mbgl)	SWL (mbgl)		Thickness (m)	Yield (m^3/hr)	Aquifer parameter	
			Pre Monsoon (2019)	Post Monsoon (2019)			T (m^2/day)	Sy/S
Aquifer - I	Weathered Granite gneiss	3.77 – 14.00	3.33 – 13.03	0.78 – 7.70	1 - 5	5 - 25	--	--
Aquifer - II	Fractured Granite gneiss	22 – 189.50	--	--	0.50 – 3.00	0.50 – 39.60	4.34 – 66.17	0.0000158 – 0.0140

3.3 Aquifer Map: Based on Aquifer Disposition, Aquifer Geometry, Aquifer Characteristics, Aquifer Maps in Giridih district have been prepared as under



	Age/Formation	Lithology	Hydrogeology	Ground Water Potential
UNCONSOLIDATED FORMATION				
	Quaternary to Recent	Alluvium- Sand, Silt, Clay	Limited thickness along river banks mainly unconfined condition	Upto 10 m3/hr
SEMI-CONSLIDATED FORMATION				
	Lower Gondwana (Upper Carboniferous to Permian)	Sandstone, Shale with coal seams, Conglomerate	Moderately thick limited in extent semi-confined to confined aquifer	10-20 m3/hr
CONSOLIDATED FORMATION				
	Chotanagpur Gneissic Complex (Precambrian)	Granite-Gneiss, Biotite-Gneiss	Ground Water Restricted to weathered zones/fractured zones	10-40 m3/hr
	Unclassified metamorphic/Bihar Mica Belt/Hazribagh Granite (Precambrian)	Amphibolite, Hornblend Schist, Hazaribagh Granite etc	-	Poor to moderate

Figure – 34: Aquifer Maps Giridih District

4. GROUND WATER RESOURCE

Ground Water Resource of the area has been estimated block wise based on for base year as on March-2020. In the present report GEC 2015 methodology has been used and based on the assessment has been made using appropriate assumptions. This methodology recommends aquifer wise ground water resource assessment of both the Ground water resources components, i.e., Replenishable ground water resources or Dynamic Ground Water Resources and In-storage Resources or Static Resources. The assessment of ground water includes assessment of dynamic and in-storage ground water resources, but the development planning should mainly depend on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

4.1 Assessment of Annually Replenishable or Dynamic Ground Water Resources (Unconfined Aquifer i. e Aquifer-I)

The methodology for ground water resources estimation is based on the principle of water balance as given below –

Inflow – Outflow = Change in Storage (of an aquifer)

The equation can be further elaborated as

ΔS= RRF+RSTR+RC+RSWI+RGWI+RTP+RWCS±VF ± LF -GE-T-E-B

Where,

ΔS – Change is storage, RRF – Rainfall recharge, RSTR- Recharge from stream channels

RC – Recharge from canals, RSWI – Recharge from surface water irrigation

RGWI- Recharge from ground water irrigation, RTP- Recharge from Tanks& Ponds

RWCS – Recharge from water conservation structures, VF – Vertical flow across the aquifer system, LF- Lateral flow along the aquifer system (through flow), GE-Ground Water Extraction, T- Transpiration, E- Evaporation, B-Base flow

The dynamic Ground Water Resources has been assessed by CGWB, SUO, Ranchi in association with State Ground Water Directorate, Jharkhand based on GEC, Methodology 2015. The summarized detail of Annually Replenishable or Dynamic Ground Water Resources of Giridih district is in Table-25.

Table-25: Dynamic Ground Water Resources of Giridih district (As on March -2020)

S. No.	Items	
1	Area in ha	508490
2	Annual Extractable Ground Water Recharge in ham	38822.41
3	Current Annual Ground Water Extraction for irrigation in ham	9022.88
4	Current Annual Ground Water Extraction for domestic in ham	3467.17
5	Current Annual Ground Water Extraction for industrial in ham	764.77
6	Current Annual Ground Water Extraction for All uses in ham	13254.80
7	Annual GW Allocation for Domestic Use as on 2025 in ham	3491.24
8	Net Ground Water Availability for future use in ham	25543.55
9	Stage of Ground Water Development (%)	34.14

4.1.1 Recharge Component: During the monsoon season, the rainfall recharge is the main recharge parameter, which is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge can be expressed as:-

$R = h \times Sy \times A + DG$

where,

h = rise in water level in the monsoon season, Sy = specific yield

A = area for computation of recharge, DG = gross ground water draft

The monsoon ground water recharge has two components- rainfall recharge and recharge from other sources. The other sources of groundwater recharge during monsoon season include seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, and water conservation structures. During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge.

The season wise assessment of recharge from various components such as rainfall and other sources was done and presented in table - 26 and figure - 35. The recharge from rainfall contributes maximum component 33955.19 ham during monsoon season and recharge from other sources is 3370.72 ham, whereas during non-monsoon season, recharge from rainfall is 2291.70 and the recharge from other sources is 2647.96 ham. The total annual ground water recharge is 42265.57 ham and total natural discharge is 3443.16 ham. Net ground water availability after natural discharge is estimated as 38822.41 ham.

Table – 26: Recharge Components evaluated for Resource Estimation

Block	Recharge from rainfall during monsoon season (ham)	Recharge from other sources during monsoon season (ham)	Recharge from rainfall during non monsoon season (ham)	Recharge from other sources during non monsoon season (ham)	Total annual ground water recharge (ham)	Total natural discharges (ham)	Annual Extractable Ground Water Resource (ham)
Bagodar	2121.72	91.81	136.8	70.53	2420.86	242.08	2178.78
Bengabad	2741.26	199.05	176.75	189.04	3306.1	330.61	2975.49
Birni	1766.15	241.45	136.87	232.38	2376.85	118.93	2257.92
Deori	2953.34	375.05	190.42	147.8	3666.61	366.67	3299.94
Dhanwar	2571.92	314.46	169.99	321.96	3378.33	168.92	3209.41
Dumri	2589.92	160.55	166.99	143.02	3060.48	306.05	2754.43
Gandey	2370.16	390.43	160.89	157.08	3078.56	153.96	2924.60
Gawan	3124.24	292.00	201.44	455.99	4073.67	407.36	3666.31
Giridih	2772.26	274.92	211.5	237.6	3496.28	174.82	3321.46
Jamua	2375.61	464.8	187.57	315.09	3343.07	167.28	3175.79
Pirtarn	2899.8	307.3	186.97	199.79	3593.86	359.39	3234.47

Saria	2067.36	89.57	133.3	88.84	2379.08	237.90	2141.18
Tisri	3601.45	169.32	232.21	88.84	4091.82	409.19	3682.63
Total	**33955.19**	**3370.72**	**2291.70**	**2647.96**	**42265.57**	**3443.16**	**38822.41**

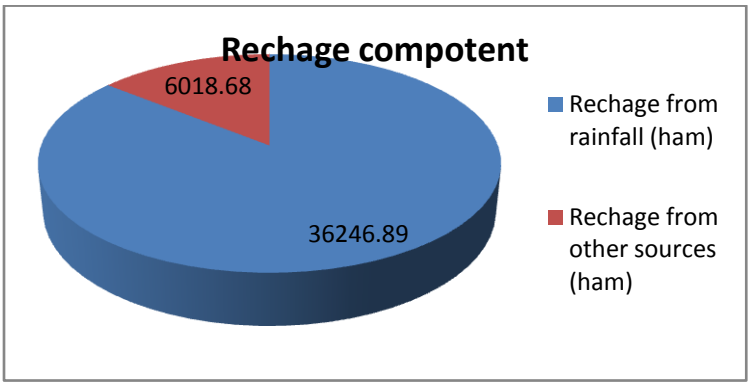


Figure – 35: Recharge from various sources

4.1.2 Ground Water Availability, Draft and Stage of GW development

The utilization of available ground water resources for various purposes is provided in table - 27 (As on 31st March 2020). The annual gross draft for all uses is estimated at 13254.8 ham with domestic sector being the major consumer having a draft of 3467.17 ham. The annual draft for irrigation use was estimated 9022.87 ham. The allocation of net ground water available for future use is 25543.55 ham. The stage of ground water development is low i.e., 34.14%.

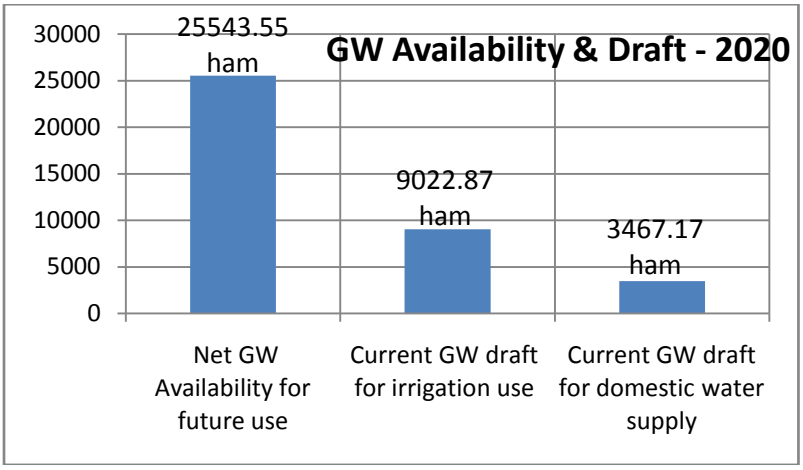


Figure – 36: Net GW Availability & Draft of Giridih district (2020)

Table – 27: Ground Water Resources Availability, Draft and Stage of GW Development of Giridih district (As on 31st March 2020)

Administrative Units	Annual Extractable Ground Water Resource	Current annual Ground Water Extraction	Current annual Ground Water Extraction	Current annual Ground Water Extraction	Current annual Ground Water Extraction	Net Ground Water Availability for future use	Stage of Ground Water Extraction

		for irrigation	for domestic	for industrial	for all uses		(%)
	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(%)
Bagodar	2178.78	162.00	208.62	0.00	370.61	1806.73	17.01
Bengabad	2975.49	703.37	202.16	0.00	905.54	2068.55	30.43
Birni	2257.92	853.00	223.60	0.00	1076.60	1179.76	47.68
Deori	3299.94	508.25	240.86	0.00	749.10	2549.17	22.70
Dhanwar	3209.41	1285.75	362.92	6.90	1655.58	1551.31	51.59
Dumri	2754.43	474.50	316.71	12.18	803.40	1948.83	29.17
Gandey	2924.60	358.87	231.04	0.00	589.91	2333.09	20.17
Gawan	3666.31	2030.37	153.02	0.00	2183.40	1481.85	59.55
Giridih	3321.46	658.12	681.35	728.18	2067.66	1249.07	62.25
Jamua	3175.79	1044.75	358.35	0.00	1403.10	1770.20	44.18
Pirtarn	3234.47	411.37	144.51	0.00	555.88	2677.58	17.19
Saria	2141.18	293.62	218.56	17.50	529.69	1609.98	24.74
Tisri	3682.63	238.87	125.46	0.00	364.33	3317.43	9.89
Total	**38822.41**	**9022.87**	**3467.17**	**764.76**	**13254.80**	**25543.55**	**34.14**

4.2 Assessment of In-Storage Ground Water Resources or Static Ground Water Resources (Unconfined Aquifer i.e Aquifer-I)

The computation of the static or in-storage ground water resources is done after delineating the aquifer thickness and specific yield of the aquifer material.

The computations can be done as follows:-

SGWR = A *(Z2 - Z1) * SY

Where, SGWR = Static or in-storage Ground Water Resources

A = Area of the Assessment Unit, Z2 = Bottom of Unconfined Aquifer, Z1 = Pre-monsoon water level, SY = Specific Yield in the In storage Zone

For Aquifer I in hard rock area of Giridih district

AQUIFER I	
Area (A) (sq. km)	5084.90
Pre-monsoon (average) depth to water level (mbgl) (Z1)	8.35
Bottom of Unconfined Aquifer (mbgl) (Z2)	17.30
Specific yield (Sy)	3%
Saturated zone thickness (Z2-Z1) of aquifer (ST)	8.95
SGWR = A *(Z2 - Z1) * SY	1365.29 mcm

4.3 Assessment of Total Ground Water Availability in Unconfined Aquifer (Aquifer-I)

The sum of Annual Extractable Ground Water Recharge and the in - storage ground water Resources of an unconfined aquifer are the Total Ground Water Availability of that aquifer.

Total Availability (unconfined Aquifer. i.e Aquifer-I) = Annual Extractable Ground Water Recharge + In-Storage Ground Water Resource

Total Availability (mcm) = 388.22 mcm +1365.29 mcm = 1753.51 mcm.

5. GROUND WATER RELATED ISSUES

Agriculture is the major occupation of the rural population of the Giridih district. About 95% population of the district is living in rural areas and depends on agriculture. Since the density of population is high there is acute pressure on land for agriculture use. But the land available for cultivation is limited because of rugged and hilly geomorphological set-up. The district of Giridih is mainly a dissected upland of ancient crystalline rocks which covers the major parts of this district.

Ground water conditions in crystalline rocks are generally considering to be poor because of the absence of two basic parameters i.e. porosity and permeability which are essential for the occurrence and movement of ground water in any rock type. Weathering aided by joints and fractures breaks down the original composition and texture of rocks producing pore spaces, hence imparting the secondary porosity and permeability. So due to the development of these properties even crystalline rocks have become good conduit for the occurrence and movement of ground water. Giridih is one of the most underdeveloped district of Jharkhand especially in the field of irrigation infrastructure (major and medium). Ground water resources of this district have to be developed on priority basis for giving a thrust to the agriculture production of this tribal dominated district.

5.1 Low Ground Water Development: One major issue of the area that is low ground water development. At present the overall stage of ground water development is only around 34.14 %, based on Ground water resource assessment as on 2020. The Block wise stage of ground water development (SOD) of the district varies from 9.89 to 62.25 percent. Block wise stage of development of the district is shown in figure – 37.

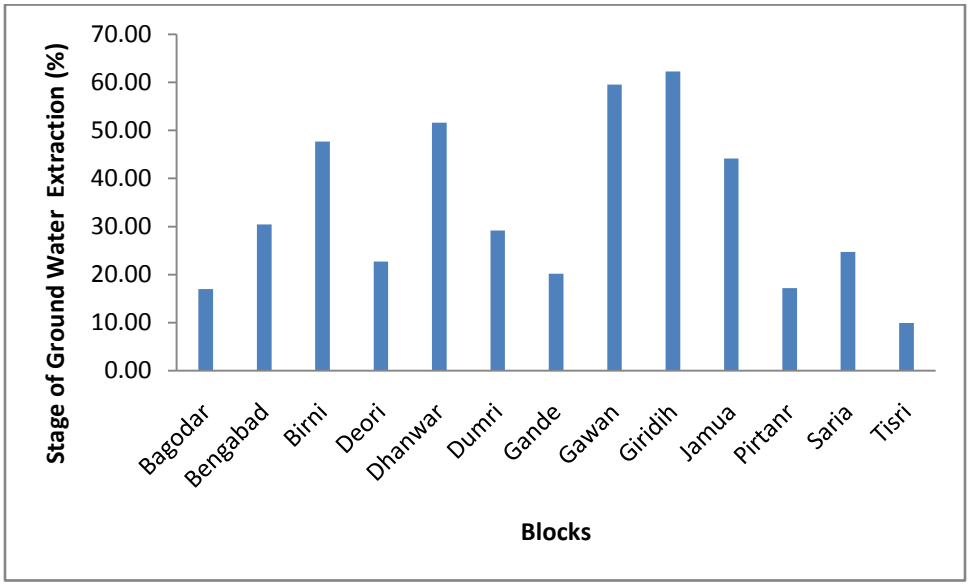


Figure –37: GW Stage of development in Giridih district

5.2 Low Ground Water Potential / Limited Aquifer Thickness / Sustainability: Central Ground Water Board has constructed 36 exploratory wells in hard area of the district. The percentage

of success bore wells (more than 3 lps discharge) is 47.22% with 19.44% of dry wells. Average thickness of weathering is 20 m and fracture zone is limited only. Low to medium Transmissivity value observed which varies from 4.34 to 66.17 m^2/day of fractured aquifer. The yield of bore wells drilled in the area is classified and presented below in figure – 38.

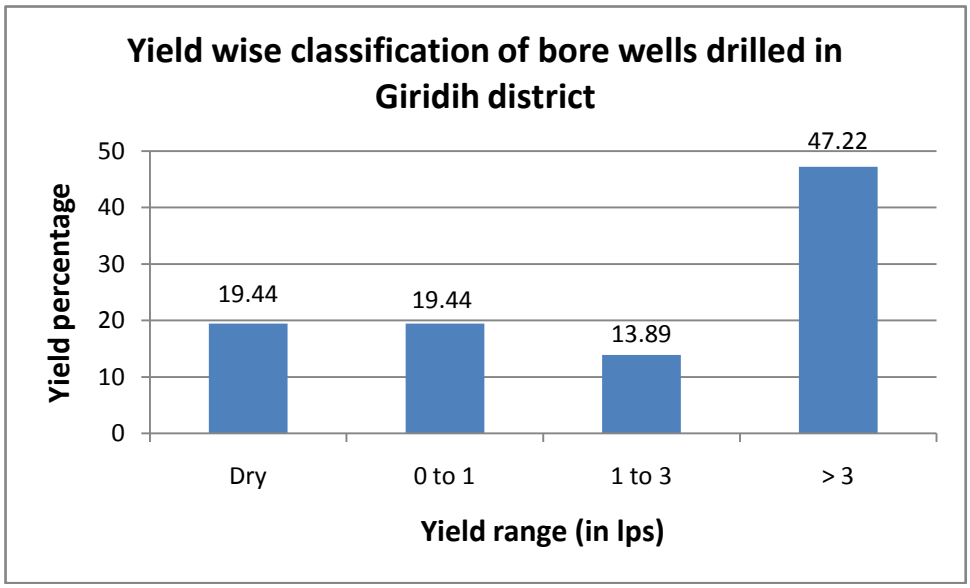


Figure – 38: Yield wise classification of bore wells drilled in Giridih district

5.3 Ground water contamination: Analytical result of water samples collected from the district, it is found the Nitrate concentration is beyond permissible limit in 04 samples of shallow aquifer (dug well) and 05 samples of deeper aquifer (hand pump). Similarly, Fluoride concentration is found beyond permissible limit in 14 samples of shallow aquifer and 03 samples of deeper aquifer. In addition, very high EC value 2256 µ S/cm has been observed in bore well sample existing at Jamua. Also total hardness (TH) value found beyond permissible limit in the sample of dug wells located at village Keshkari (625 mg/l) of Saria block and bore well (hand pump) sample located at Jamua (630 mg/l).

5.3.1. Nitrate contamination: A variety of chemical constituents including Nitrate can pass through the soil and potentially contaminate ground water. Nitrate comes from the nitrogen, plant nutrient supplied by inorganic fertilizer and animal manure. Beneath agriculture land, nitrate is primary form of Nitrogen. It is soluble in water and can easily pass through soil to the ground water table. Nitrate can persists in ground water for decades and accumulated to high levels as more nitrogen is applied to the land surface every year. Nitrate is one of the most common ground water contaminants in rural areas. It is regulated in drinking water primarily because excess level can cause methemoglobinemia or blue baby disease. Nitrate can be removed from drinking water by distillation, reverse osmosis or ion exchange.

In shallow and deeper aquifer about 9.09% and 10.42% water samples have been found more than the permissible limit of NO_3 (45mg/l)respectively. Location details of NO_3 concentration found beyond permissible limit is given in table 28.

Table – 28: Location details of Nitrate concentration found beyond permissible limit in ground water of Giridih district

Sr. No.	Village	Block	Nitrate value (mg/l)
1	2	3	4
1. Dug well samples			
1	Pandri	Gandey	87.77
2	Saria	Saria	54.46
3	Keshkari	Sariya	73.00
4	Dumri	Dumri	63.22
2. Hand pump samples			
1	Jamua	Jamua	167
2	Bangra Khurd	Birni	74
3	Gohiyadih	Giridih	62
4	Bhandaro	Dumri	74
5	Chirki Pirtarn	Chirki Pirtarn	49.05

5.3.2 Fluoride contamination: Consumption of water with fluoride concentration above 1.0 mg/l is harmful which results in acute to chronic dental fluorosis where the tooth become coloured from yellow to brown. Skeletal fluorosis which causes weakness and bending of the bones also results due to long term consumption of water containing high fluoride. Presence of low or high concentration of fluoride in groundwater is because of geogenic or anthropogenic causes or a combination of both. Natural sources are associated to the geological conditions of an area. Several rocks have fluoride bearing minerals like apatite, fluorite, biotite and hornblende. The weathering of these rocks and infiltration of rainfall through it increases fluoride concentration in groundwater. Anthropogenic sources of fluoride include agricultural fertilisers and combustion of coal. Phosphate fertilisers contribute to fluoride in irrigation lands. There are several methods available for the removal of fluoride from groundwater which is insitu or exsitu. To dilute the groundwater contamination with fluoride, artificial recharge structures can be built in suitable places which will decrease its concentration. Rainwater harvesting through existing wells also will prove effective to reduce the groundwater fluoride concentration. Exsitu methods which are conventional treatment methods like adsorption, ion exchange, reverse osmosis etc can be practiced at community level or at households to reduce fluoride concentration before ingestion.

In shallow aquifer 31.82 % samples have F concentration more than the desirable limit of 1.0 mg/l while 6.25% water samples of deeper aquifer exceed the permissible limit of 1.0 mg/l. Location details of F concentration found beyond permissible limit is given in table 29 and sample wise Fluoride concentration is shown in figure 39 and figure 40 for shallow and deeper aquifer respectively.

Table – 29: Location details of Fluoride concentration found beyond permissible limit in ground water of Giridih district

Sr. No.	Village	Block	Fluoride value (mg/l)
1. Dug well samples			
1	Pipratol	Bengabad	1.20
2	Bengabad	Bengabad	1.53
3	Devatarn	Bengabad	1.30
4	Maheshmunda	Gandey	1.03
5	Chilkhariodih	Devri	1.40
6	Devri	Devri	1.07
7	Belatarn	Devri	1.66
8	Tisri	Tisri	2.89
9	Palmo Mission	Tisri	1.50
10	Khijri Khasiyatarn	Tisri	1.97
11	Giridih	Giridih	8.00
12	Dhanaydih	Giridih	1.25
13	Doranda	Raj Dhanwar	1.80
14	Atka	Bagodar	1.30
2. Hand pump samples			
1	Tisri	Tisri	2.16
2	Beriya	Devri	2.00
3	Doranda	Raj Dhanwar	1.20

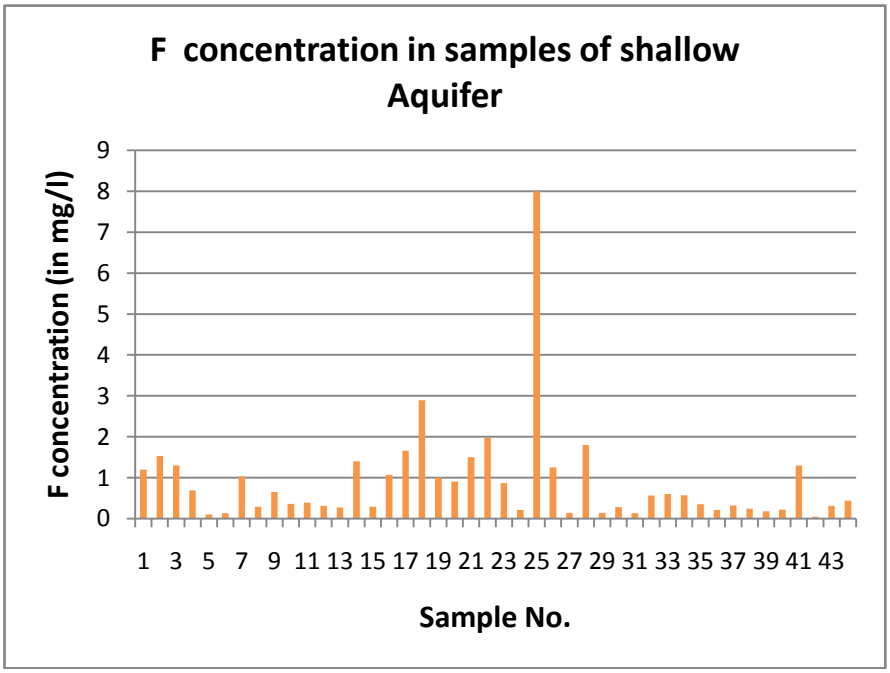


Figure – 39 Sample wise Fluoride concentration of shallow aquifer in Giridih district.

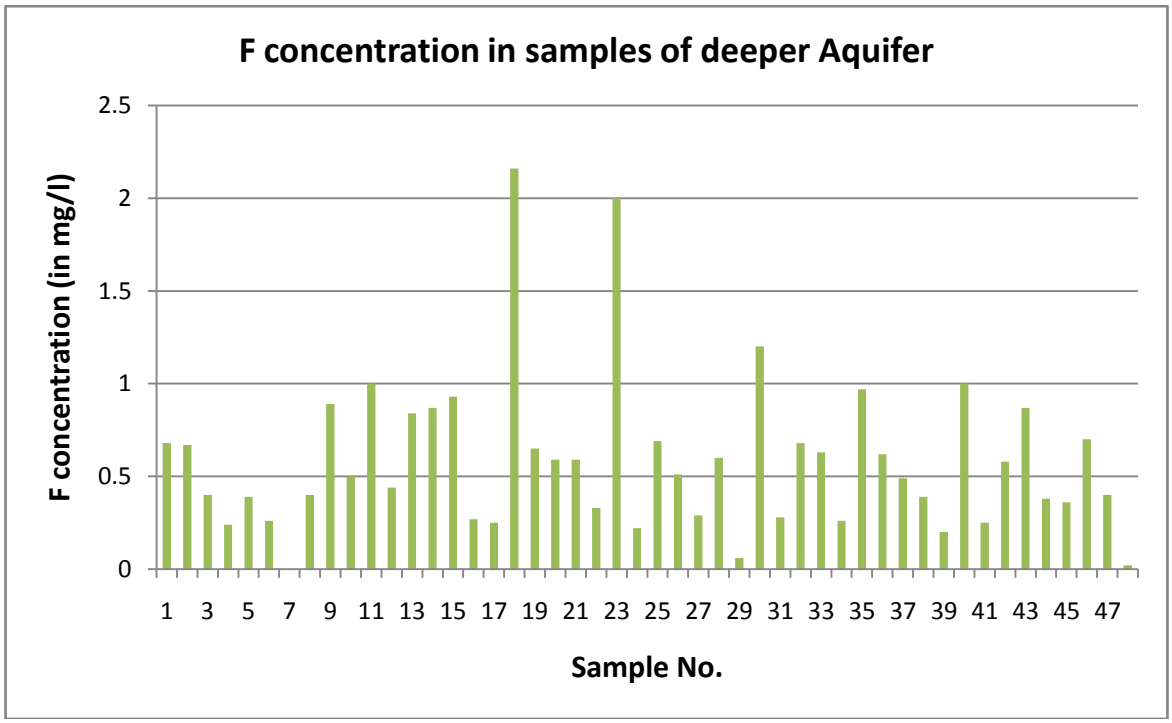


Figure – 40: sample wise Fluoride concentration of deeper aquifer in Giridih district

6. MANAGEMENT STRATEGIES

As discussed in previous chapter, the major ground water related issue in the Giridih is low ground water development owing to many socio-economic and hydrogeological reasons. To overcome these, it is imperative to have a robust ground water resource development plan for the district.

6.1 Supply Side Interventions: The supply side interventions may be done through a. Ground Water Resources Development strategies and b. Arficial Recharge to Ground Water as under:-

6.1.1 Ground Water Resource Development Strategy: In view of above, the focus of proposed management plan was to enhance the overall ground water development from the present 34.14 % , total Total 14900 dug wells (15-20 m depth; 2 to 4 m diameter @ Rs. 2.75 lakh/dug well) are recommended to be constructed in feasible areas. Similarly, 4967 shallow depth bore wells (60 - 90 m depth; 100-150 mm dia @ Rs.0.65 lakh/ bore well) are also recommended to be drilled in feasible areas. Proposed number of abstraction structure based on unit draft with future irrigation potential is given below in tables – 30 .

Table – 30: Future Irrigation Potential & Proposed number of Abstraction Structures

District	Net GW Availability for Future Irrigation Development	future irrigation potential available (ha) considering (Δ) 0.45m	70% of future irrigation potential created (ha)	Proposed number of ground water structure (Dug wells)	Proposed number of ground water structure (Bore wells)
1	2	3	4	5	6
Bagodar	1806.73	4014.96	2810.47	1054	351
Bengabad	2068.55	4596.78	3217.74	1207	402
Birni	1179.76	2621.69	1835.18	688	229
Deori	2549.17	5664.82	3965.38	1487	496
Dhanwar	1551.31	3447.36	2413.15	905	302
Dumri	1948.83	4330.73	3031.51	1137	379
Gandey	2333.09	5184.64	3629.25	1361	454
Gawan	1481.85	3293.00	2305.10	864	288
Giridih	1249.07	2775.71	1943.00	729	243
Jamua	1770.2	3933.78	2753.64	1033	344
Pirtarn	2677.58	5950.18	4165.12	1562	521
Saria	1609.98	3577.73	2504.41	939	313
Tisri	3317.43	7372.07	5160.45	1935	645
Total	**25543.55**	**56763.44**	**39734.41**	**14900**	**4967**

It is necessary that proposed Additional ground water abstraction structure may be constructed in phases with proper site selection. The results of the first phase of ground water

development together with studies of the behavior of ground water regime will guide further ground water development to achieve 100% utilization.

6.1.2 Artificial Recahrge to Ground Water

At present as per Ground Water Resource Estimation 2020, the stage of ground water development is very low i.e., 34.14 % and all the block of the district comes under safe category. However in some parts of the district long term declining trend has been noticed. Therefore, the ground water development should also be coupled with ground water augmentation, so that there is no stress on ground water regime of the area. The supply side interventions envisages construction of Rainwater Harvesting and Artificial Recharge structures in the areas feasible for construction of recharge structures based on the long term water level scenario and recharge potential of the aquifer as well as dilution of ground water contamination such as Nitrate and Fluoride observed in the district. The implementation of water conservation through artificial recharge measures will have a positive impact on drinking water sources of the area. It will ensure that the wells don't go dry during summer/lean/stress period in the areas of implementation and sufficient ground water availability is there in the wells even during the summer season. Thus not only the drinking and domestic water sources will be strengthened but additional irrigation potential can be created through artificial recharge structures.

Artificial recharge to Ground Water Master plan 2020

Recently in 2020, artificial recharge to Ground Water master plan 2020 of Jharkhand state has been prepared. The area identified for artificial recharge has been made based on post monsoon depth to water level (Nov. 2018) more than 3m bgl with declining trend of more than 0.1 m/yr (2009 – 2018). In addition, area with water level more than 9 m bgl in the district has been considered for identifying the area. The volume of unsaturated zone available for recharge in identified areas is determined by computation of average depth of the unsaturated zone below 3 m bgl and then multiplied by area considered for recharge. Based on this master plan, feasible artificial recharge structures including roof rainwater harvesting structures are in Table- 31

Table - 31: Artificial recharge structures feasible in Giridih district.

Area identified for artificial recharge (Sq. Km.)	Volume of unsaturated zone available for recharge (MCM	Available sub-surface space for AR (MCM)	Surplus available for recharge (MCM)	volume required for recharge (MCM)	Proposed numbers of recharge structures (No's)	
					Percolation Tank	Nala Bund/ Check dam / Gully Plug
2902	5138.2	205.53	241.18	308.07	819	5134

6.1.3 Initiatives by MANREGA Govt. of Jharkhand

Govt. of Jharkhand has constructed different water conservation and artificial recharge structures in the district under different rural development programmes viz. MANREGA, watershed development programme etc during the year 2007-08 to 2016-17. Block wise number of check dam is given below in table – 32.

Table – 32: Block wise number of check dam constructed by Rural Development Department in Giridih district (2007-08 to 2016-17)

Sr. No.	Block	No. of check dam constructed
1	Bengabad	20
2	Birni	07
3	Deori	16
4	Dhanwar	10
5	Dumri	03
6	Gandey	32
7	Gawan	18
8	Giridih	69
9	Jamua	06
10	Saria	17
11	Tisri	06
Total		204

(Source: Rural Development Department, Govt. of Jharkhand, Ranchi)

6.2 Demand Side Management

The demand side intervention envisages the real water savings. The main demand side interventions may be-i) Promote improved irrigation technologies (drip or sprinkler irrigation, etc.), ii) Crop choice management and diversification (promote less intensive crops like pulses and horticulture), iii) Promoting treated municipal waste water for irrigation and construction use, and iv) Managing energy and irrigation nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.) The government should encourage and provide incentive the use of drip irrigation and sprinkler system.

6.3 Ground water management strategy for Nitrate and Fluoride affected areas: Nitrate and Fluoride contamination occurring in granite gneiss of Gandey, Saria, Dumri, Jamua, Birni, Giridih, Chirki Pirtarn, Bengabad, Deori, Tisri and Dhanwar blocks. Remedial measures recommended for Nitrate and Fluoride affected areas are as follows-

1. Purification/Filtration: Purification/ filtration of Nitrate and Fluoride contaminated ground water by distillation, reverse osmosis or ion exchange etc.

2. Awareness raising Program /Participatory approach: Peoples should aware about the ground water pollution of Nitrate and Fluoride. Management of schemes or project related Nitrate and Fluoride removal should be in hand of local peoples, so that peoples will keep the proper maintenance of machines and equipments.

6.4 Water stress aspect against future demand (2025, 2030): Demand of water is increasing day by day against the increasing population. The detail demographic particular of the Giridih district and water requirement for domestic purpose is worked out for the year 2025 and 2030 is presented in table – 33 & 34.

Table – 33: Detail demographic particular of Giridih district

Population as per census **Projected population as per current growth rate (2001 – 2011 = 28.33%)**

2001		2011		2025		2030	
Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
122364	1782066	208024	2237450	8830619	94979752	11774158	126639670

Table - 34: Requirement of water for domestic use

Water requirement (assuming 90 litres per day per person for rural population and 130 litres per day per person for urban population)

2025		2030	
Urban	Rural	Urban	Rural
1147980470	8548177680	1530640540	11397570300

Total 9696158150 litres per day Total 12928210840 litres per day

On perusal of table – 37, the requirement of water will be 12928210840 litres per day in 2030. The demand of water is increasing due to highly increasing of population.

6.4.1 Urban water supply: There are four urban areas existing in the district namely Giridih, Raj Dhanwar, Sariya and Dumri. Average 9.0 MLD water supplies for Giridih urban area from Khandoli dam which is located about 8 km east of Giridih. Similarly, 1.5 MLD water supplied to Raj Dhanwar urban area from intake well exist in bank of Irgah Nadi by Drinking Water & Sanitation Department, Giridih. Sariya and Dumri urban area water supply schemes are not working at present.

6.4.2 Rural water supply: Drinking Water & Sanitation Department (DWSD), Giridih has constructed large numbers of bore wells to solve the water scarcity problem of the rural area of the district. In addition, numbers of small rural water supply schemes have been implemented by the Drinking Water & Sanitation Department, Giridih in rural area.

7.0 SUM-UP

- The district of Giridih located almost the north – eastern parts of Jharkhand state. The district which acquired the status of an independent district on **6th** December, 1972, has a close linkage with the parent district Hazaribagh**.** In 1999, part of it became Bokaro district. The territory of this district spans over an area of 5084.90 sq. Km covering 13 administrative blocks.

- Broadly, the district may be divided into three distinct physiographic units viz., the Central Plateau, the Lower plateau and the Damodar valley. The central area of the district is occupied by the central plateau. The lower plateau with average height of 1300 ft is undulating in nature. The Damodar valley occurs along the southern part of the district. In the district lies the famous Parasnath hill, which has the distinction of being the highest peak of the state with an altitude of 4479 ft above mean sea level.

- The district falls in the Agro climatic sub-zone-IV with average annual rainfall 936.68 mm. The mean monthly temperature range from 4^0C in winter to 45^0C in summer.

- The major part of the district is having dendritic drainage pattern, but overall drainage pattern is radial controlled mainly by the topography the area. The district is divided into two main watersheds viz the Barakar and the Sakri Rivers.

- Aquifer Mapping Study was carried in Giridih district falling in 13 blocks through data gap analysis, data generated in-house, data acquired from State/Central Govt. departments. All the available data were integrated to prepare aquifer maps and aquifer management plans of the district.

- Geologically the district of Giridih is mainly underlain by Archaean crystalline rocks which are highly deformed and metamorphosed. However, central part of the district near Giridih and few patches in eastern part the district is occupied by Barakar and Talchir formation of Gondwana super group. Northern part of the district is characterized by Bihar Mica Belt with small patch of Chotanagpur Granite Gneiss Complex.

- In general in fissured formations, discharge of well has been found in the range of 0.50-37.70 m^3/hr. Overall in the district the major potential fractures zones are found upto 100 m. First potential fracture zone encountered in the district widely varies from 21-195 m.

- Ground water occurs in unconfined to semi-confined state in Aquifer-I (upto the depth of 20 m). Yield of the wells in Aquifer-I is restricted upto 25 m^3/hr in weathered Granite-Gneiss.

- The Chotanagpur granite-gneiss, belonging to Precabmrian age constitutes the group of fissured formation hydrogeological units and to some extent Gondwana sandstones as an Aquifer-II i.e deeper Aquifer in the area. The Potential fractured deeper aquifers (Aquifer-II) in the district have been observed upto 195 mbgl with the yield potential upto 37.70 m^3/hr.

- The analysis of aquifer parameters in the district shows that the transmissivity value ranges from 4.34 – 66.17 m2/day. The storativity value also varies from 1.40 x 10^{-2} to 1.58 x 10^{-5}, which shows that aquifers are under semi-confined to confined condition.

- Ground Water quality is generally potable, except few patches. Similarly, Nitrate value found beyond permissible limit in 4 dug well samples and 5 samples of hand pump. Also Fluoride value has been observed beyond permissible limit in 14 samples of dug well 3 samples of bore well (hand pump).

- Based on Ground water Resources estimation 2020, the stage of ground water development in Giridih district is 34.14 % and the entire block comes under safe category. Therefore there is sufficient scope for further ground water development.

- Three major ground water related issues in Giridih district are low ground water development, low ground water potential and nitrate/ fluoride contamination in the area.
- To suggest a sustainable ground water management plan there are two options-Supply Side Management Options & Demand Side Management Options

- Supply side Management through Ground Water Management strategy are suggested for construction of 14900 dug wells and 4967 shallow bore wells in the feasible areas in the district to enhance the overall ground water development.Rain water harvesting and artificial recharge to be encouraged in feasible areas for ground water augmentation. In additional purification/filtration of Nitrate and Fluoride may also be adopted.

- Supply side management also includes Artficial Recharge to Ground Water. Based on Artificial recharge to Ground Water master plan 2020 of Jharkhand state, the area has been identified for artificial recharge in Giridih district. Based on this master plan, feasible artificial recharge structures including roof rainwater harvesting structures are 819 percolation tank, 5134 Nala Bund/Check Dam/Gully Plug, Nos of Roof Top Rainwater Harvesting structures are suggested in the district

- The demand side intervention envisages the real water savings. The main demand side interventions may be-i) Promote improved irrigation technologies (drip or sprinkler irrigation, etc.), ii) Crop choice management and diversification (promote less intensive crops like pulses and horticulture), iii) Promoting treated municipal waste water for irrigation and construction use, and iv) Managing energy and irrigation

nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.) The government should encourage and provide incentive the use of drip irrigation and sprinkler system.

Annexure - I

Last ten years rainfall data of Giridih district

Block: Bagodar (2011 – 2020)

Average monsoon rainfall (mm): 899.53

Standard deviation: 206.60

Coefficient of variation (in %): 22.97

Year	Annual rainfall (mm)	Departure %	Category
2011	656.7	- 27.00	Moderate
2012	874.20	- 2.82	Normal
2013	769.20	- 14.49	Normal
2014	1316.2	46.32	Excess
2015	871.2	- 3.15	Normal
2016	1124.8	25.04	Excess
2017	902.0	0.27	Normal
2018	622.0	- 30.85	Moderate
2019	971.8	8.03	Normal
2020	887.2	- 0.25	Normal
Total	8995.30		

Block: Dumri (2011 – 2020)

Average monsoon rainfall (mm): 1089.94

Standard deviation: 366.00

Coefficient of variation (in %): 33.58

Year	Annual rainfall (mm)	Departure %	Category
2011	1198.9	10.00	Normal
2012	1128.6	3.55	Normal
2013	546.6	- 49.85	Moderate
2014	1414.8	29.81	Excess
2015	1070.4	- 1.79	Normal
2016	1804.6	65.61	Excess
2017	841.8	- 22.77	Normal
2018	817.8	- 24.94	Normal

2019	986.0	- 9.54	Normal
2020	--	--	--
Total	9809.50		

Block: Pirtarn (2011 – 2020)
Average monsoon rainfall (mm): 967.31
Standard deviation: 198.26
Coefficient of variation (in %): 20.50

Year	Annual rainfall (mm)	Departure %	Category
2011	960.8	- 0.67	Normal
2012	1204.5	24.52	Normal
2013	604.4	- 37.52	Moderate
2014	1033.0	6.79	Normal
2015	--	--	--
2016	--	--	--
2017	--	--	--
2018	838.0	- 13.37	Normal
2019	1127.0	16.51	Normal
2020	1003.5	3.74	Normal
Total	6771.20		

Block: Giridih (2011 – 2020)
Average monsoon rainfall (mm): 940.99
Standard deviation: 209.90
Coefficient of variation (in %): 22.31

Year	Annual rainfall (mm)	Departure %	Category
2011	913.1	- 2.96	Normal
2012	794.20	- 15.60	Normal
2013	637.1	- 32.29	Moderate
2014	1158.8	23.15	Normal
2015	1244.6	32.26	Excess
2016	987.10	4.90	Normal

2017	852.0	- 9.46	Normal
2018	--	--	--
2019	--	--	--
2020	--	--	--
Total	6586.90		

Block: Gandey (2011 – 2020)
Average monsoon rainfall (mm): 825.71
Standard deviation: 306.82
Coefficient of variation (in %): 37.16

Year	Annual rainfall (mm)	Departure %	Category
2011	1006.8	21.93	Normal
2012	535.1	- 35.20	Moderate
2013	434.0	- 47.44	Moderate
2014	973.6	17.91	Normal
2015	--	--	--
2016	--	--	--
2017	--	--	--
2018	553.6	- 32.95	Moderate
2019	1174.6	42.25	Excess
2020	1102.3	33.50	Excess
Total	5780.00		

Block: Bengabad (2011 – 2020)
Average monsoon rainfall (mm): 845.79
Standard deviation: 211.62
Coefficient of variation (in %): 25.02

Year	Annual rainfall (mm)	Departure %	Category
2011	922.3	9.05	Normal
2012	642.9	- 23.99	Normal

2013	655.4	- 22.51	Normal
2014	1154.8	36.54	Excess
2015	--	--	--
2016	--	--	--
2017	--	--	--
2018	701.2	- 17.10	Normal
2019	752.5	- 11.03	Normal
2020	1091.4	29.04	Excess
Total	5920.50		

Block: Jamua (2011 – 2020)
Average monsoon rainfall (mm): 921.83
Standard deviation: 271.59
Coefficient of variation (in %): 29.46

Year	Annual rainfall (mm)	Departure %	Category
2011	778.8	- 15.52	Normal
2012	611.0	- 33.72	Moderate
2013	557.9	- 39.48	Moderate
2014	1247.6	35.34	Excess
2015	750.3	- 18.61	Normal
2016	1378.2	49.51	Excess
2017	933.0	1.21	Normal
2018	809.4	- 12.20	Normal
2019	1147.3	24.46	Normal
2020	1004.8	9.00	Normal
Total	9218.30		

Block: Dhanwar (2011 – 2020)
Average monsoon rainfall (mm): 686.99
Standard deviation: 315.76
Coefficient of variation (in %): 45.96

Year	Annual rainfall (mm)	Departure %	Category

2011	466.1	- 32.15	Moderate
2012	377.0	- 45.12	Moderate
2013	400.7	- 41.67	Moderate
2014	829.6	20.76	Normal
2015	750.2	9.20	Normal
2016	1293.7	88.31	Excess
2017	887.6	29.20	Excess
2018	491.0	- 28.53	Moderate
2019	--	--	--
2020	--	--	--
Total	5495.90		

Block: Birni (2011 – 2020)
Average monsoon rainfall (mm): 919.83
Standard deviation: 213.97
Coefficient of variation (in %): 23.26

Year	Annual rainfall (mm)	Departure %	Category
2011	876.4	- 4.72	Normal
2012	633.0	- 31.18	Moderate
2013	621.4	- 32.44	Moderate
2014	907.2	- 1.37	Normal
2015	938.5	2.03	Normal
2016	1347.2	46.46	Excess
2017	810.6	- 11.88	Normal
2018	935.2	1.67	Normal
2019	1093.6	18.89	Normal
2020	1035.2	12.54	Normal
Total	9198.30		

Block: Deori (2011 – 2020)
Average monsoon rainfall (mm): 697.15
Standard deviation: 292.48
Coefficient of variation (in %): 41.95

Year	Annual rainfall (mm)	Departure %	Category
2011	612.4	- 12.16	Normal
2012	179.0	- 74.32	Severe
2013	282.4	- 59.49	Severe
2014	789.0	13.18	Normal
2015	886.7	27.18	Excess
2016	1152.4	65.30	Excess
2017	660.4	- 5.27	Normal
2018	670.6	- 3.81	Normal
2019	801.2	14.93	Normal
2020	937.4	34.46	Excess
Total	6971.5		

Block: Tisri (2011 – 2020)
Average monsoon rainfall (mm): 720.06
Standard deviation: 284.07
Coefficient of variation (in %): 39.45

Year	Annual rainfall (mm)	Departure %	Category
2011	321.9	- 55.30	Severe
2012	573.1	- 20.41	Normal
2013	638.0	- 11.40	Normal
2014	991.6	37.71	Excess
2015	553.6	- 23.12	Normal
2016	1231.5	71.03	Excess
2017	510.4	- 29.12	Moderate
2018	516.7	- 28.24	Moderate

2019	957.6	32.99	Excess
2020	906.2	25.85	Excess
Total	7200.60		

Block: Gawan (2011 – 2020)
Average monsoon rainfall (mm): 521.01
Standard deviation: 200.94
Coefficient of variation (in %): 38.57

Year	Annual rainfall (mm)	Departure %	Category
2011	477.0	- 8.44	Normal
2012	327.3	- 37.18	Moderate
2013	--	--	--
2014	492.4	- 5.49	Normal
2015	255.6	- 50.94	Severe
2016	688.2	32.09	Excess
2017	422.0	- 19.00	Normal
2018	588.4	12.93	Normal
2019	933.0	79.08	Excess
2020	505.2	- 3.03	Normal
Total	4689.10		

Block: Saria (2011 – 2020)
Average monsoon rainfall (mm): 840.75
Standard deviation: 189.03
Coefficient of variation (in %): 22.48

Year	Annual rainfall (mm)	Departure %	Category
2013	611.1	- 27.31	Moderate
2014	--	--	--
2015	--	--	--
2016	--	--	--
2017	--	--	--
2018	763.0	- 9.60	Normal

2019	970.3	15.41	Normal
2020	1018.6	21.15	Normal
Total	3363.00		

Annexure - II

DETAILS OF KEY WELLS ESTABLISHED FOR NATIONAL AQUIFER MAPPING STUDY OF GIRIDIH DISTRICT, 2019 –20

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
1	Pipratol	Bengabad	Bhola Mahto	01 km from Dak Bangla on Giridih road. About 40 m LHS of road on open field	24^0 16' 35" 86^0 27' 05"	Dug well	Granite Gneiss	Rope & bucket	0.58	10.42	4.75
2	Bengabad	Bengabad	Govt.	Within the premises of forest office just before block office on Bengabad – Devri road	24^0 18' 17" 86^0 21' 25"	Dug well	Granite Gneiss	Rope & bucket	0.46	14.00	1.55
3	Devatarn	Bengabad	Mustakin Ansari	Near house of owner on Bengabad – Chatro road (LHS)	24^0 21' 34" 86^0 17' 47"	Dug well	Granite Gneiss	Rope & bucket	0.40	9.00	4.15
4	Siyatarn	Jamua	Nageshwar Varma	NHO owner and LHD of Bengabad – Chhotki Khadagdiha - Chatro road	24^0 24' 41" 86^0 16' 55"	Dug well	Granite Gneiss	Rope & bucket	0.55	9.65	6.20
5	Barasoli	Bengabad	Shahid Ansari	NHO owner, 07 km from Bengabad on Giridih road	24^0 15' 10" 86^0 19' 57"	Dug well	Granite Gneiss	Rope & bucket	0.42	8.48	2.25
6	Chakradaha	Bengabad	Govt.	Near middle school, Gandey – Bengabad road.	24^0 15' 20" 86^0 23' 21"	Dug well	Granite Gneiss	Rope & bucket	0.34	11.51	2.45
7	Maheshmunda	Gandey	Govt.	Opposite to Rly station	24^0 12' 40"	Dug	Granite Gneiss	Rope &	1.05	11.50	1.94

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
				platform 1, Maheshmunda	86^0 24' 39"	well		bucket			
8	Gandey	Gandey	Govt.	Eastern part of Block office, Gandey	24^0 11' 02" 86^0 26' 48"	Dug well	Granite Gneiss	Rope & bucket	0.45	10.80	1.90
9	Budhudih	Gandey	Gura Yadav	NHO of owner on Gandey – Narayanpur road (LHS)	24^0 10' 30" 86^0 29' 20"	Dug well	Granite Gneiss	Rope & bucket	0.60	10.22	2.60
10	Dahutarn	Gandey	Govt.	About 05 km from Gandey on Tundi road (LHS)	24^0 08' 12" 86^0 28' 03"	Dug well	Granite Gneiss	Rope & bucket	0.66	8.69	2.13
11	Pandri	Gandey	Govt.	Opposite to school on Tundi – Giridih road (RHS)	24^0 04' 30" 86^0 23' 10"	Dug well	Granite Gneiss	Rope & bucket	0.50	9.73	2.80
12	Gardih	Jamua	Govt.	Near Ram mandir, Thakurwadi, Bengabad – Chatro road	24^0 23' 56" 86^0 14' 57"	Dug well	Granite Gneiss	Rope & bucket	0.38	7.97	2.61
13	Kosogondodighi (Karmatarn)	Devri	Prakash Paswan	Near house of owner, LHS of Bengabad – Charto road	24^0 26' 53" 86^0 15' 43"	Dug well	Granite Gneiss	Rope & bucket	0.30	6.88	3.10
14	Chilkhariodih	Devri	Nirmal Das	Well is located on open field, LHS of Chatro – Chakai road	24^0 28' 45" 86^0 17' 21"	Dug well	Granite Gneiss	Rope & bucket	0.54	9.61	4.80
Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
15	Jalkhariodih	Devri	Govt.	About 04 km from Chatro	24^0 27' 39"	Dug	Granite Gneiss	Rope &	0.41	8.34	2.25

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
				on Jamua road (RHS), near utkramit middle school.	86^0 12' 41"	well		bucket			
16	Devri	Devri	Prahlad Prasad Chaudhari	Bach side of the house of owner and opposite to Block office.	24^0 30' 52" 86^0 11' 35"	Dug well	Granite Gneiss	Rope & bucket	0.34	8.16	3.60
17	Belatarn	Devri	R.C. Church, Mission school	About 06 km from Devri on Tisri road, near church (eastern part of church)	24^0 32' 13" 86^0 08' 05"	Dug well	Granite Gneiss	Rope & bucket	0.52	16.48	2.90
18	Tisri	Tisri	Govt.	In the regional hospital compound, rear staff quarter	24^0 34' 45" 86^0 03' 58"	Dug well	Granite Gneiss	Rope & bucket	0.50	5.88	1.55
19	Kenduadih	Gawan	Mathura Singh	About 08 km from Gawan – Bihar road, well is located NHO of owner (LHS)	24^0 40' 50" 85^0 51' 45"	Dug well	Granite Gneiss	Rope & bucket	0.10	3.80	1.45
20	Gawan	Gawan	Govt.	Near Shiv mandir before Gawan town (RHS)	24^0 51' 40" 85^0 56' 014"	Dug well	Granite Gneiss	Rope & bucket	0.23	3.77	1.67
21	Palmo Mission	Tisri	Palmo Mission	03 km from Tisri on Gawan road, within St. Marry's Mission school campus.	24^0 35' 45" 86^0 02' 20"	Dug well	Granite Gneiss	Rope & bucket	0.65	8.35	4.50
22	Khijri Khasiyatarn	Tisri	Indradev	NHO owner, ½ km LHS of	24^0 32' 51"	Dug	Granite Gneiss	Rope &	0.45	9.55	2.25

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
			Gupta	Khiri – Tisri road.	86^0 05’ 27”	well		bucket			
23	Beriya	Devri	Satyanarayan Pandey	NHO owner, RHS of Tisri – Jamua road.	24^0 30’ 10” 86^0 06’ 16”	Dug well	Granite Gneiss	Rope & bucket	0.50	7.50	3.15
24	Gando	Jamua	Mahabir Paswan	NHO owner, RHS of Tisri – Jamua road.	24^0 26’ 20” 86^0 09’ 08”	Dug well	Granite Gneiss	Rope & bucket	0.32	9.00	3.10
25	Giridih	Giridih	Govt.	In the court compound close to the treasury building	24^0 10’ 00” 86^0 18’ 30”	Dug well	Granite Gneiss	Rope & bucket	0.80	15.50	2.25
26	Dhanaydih	Giridih	Govt.	In the premises of middle school, 13 km from Giridh on Jamua road.	24^0 13’ 20” 86^0 12’ 50”	Dug well	Granite Gneiss	Rope & bucket	0.65	9.81	1.85
27	Bandhutarn	Giridih	Sita Ram Mahto	12 km from Jamua on Giridih road, in front of the house of owner (RHS of road)	24^0 18’ 00” 86^0 07’ 05”	Dug well	Granite Gneiss	Rope & bucket	0.35	10.55	2.32
28	Jamua	Jamua	Govt.	In the compound of PWD I.B.	24^0 22’ 25” 86^0 09’ 00”	Dug well	Granite Gneiss	Rope & bucket	0.60	11.20	3.05
29	Malho	Jamua	Bhabaneshwar Pandith	NHO owner, LHS of Jamua – Koderma road.	24^0 32’ 51” 86^0 04’ 58”	Dug well	Granite Gneiss	Rope & bucket	0.42	7.00	1.55
30	Doranda	Raj Dhanwar	Madhusudan Vishwakarma	NHO owner, LHS of Jamua – Koderma road	24^0 32’ 51” 86^0 04’ 58”	Dug well	Granite Gneiss	Rope & bucket	0.10	8.75	2.90

Well No.	**Village**	**Block**	**Owner**	**Location**	**Co-ordinates**	**Type of well**	**Geology**	**Lifting device**	**MP (magl)**	**Depth (mbgl)**	**Diameter (m.)**
Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
31	Hirodih	Raj Dhanwar	Govt.	Near Shiv temple and Thana	24^0 27' 10" 86^0 00' 20"	Dug well	Granite Gneiss	Rope & bucket	0.84	11.86	1.05
32	Nawadih (Ruputola)	Raj Dhanwar	Govt.	02 km from Raj Dhanwar on Rembo road, opposite to temple near school	24^0 24' 45" 86^0 00' 16"	Dug well	Granite Gneiss	Rope & bucket	0.50	6.50	2.15
33	Itasani	Raj Dhanwar	Bansi Paswan	NHO owner, 09 km from Raj Dhanwar on Birni road (LHS)	24^0 21' 01" 85^0 57' 01"	Dug well	Granite Gneiss	Rope & bucket	0.41	8.79	1.85
34	Bishunpur	Birni	Sitaram Yadav	NHO owner, LHS on Birni – Kowad road.	24^0 13' 23" 86^0 00' 34"	Dug well	Granite Gneiss	Rope & bucket	0.25	8.25	4.15
35	Arwatarn (Kendua)	Birni	Iswar Paswan	NHO owner, 05 km from Baramasia - Kawtha road.	24^0 16' 02" 85^0 59' 05"	Dug well	Granite Gneiss	Rope & bucket	0.45	10.85	4.10
36	Palaunjia (Birni)	Birni	Shivpujan Sahay	Back side of old building of owner and 1km from Birni of Giridih road	24^0 15' 48" 85^0 56' 45"	Dug well	Granite Gneiss	Rope & bucket	0.25	10.75	2.37
37	Bangra Khurd	Birni	Harkhu Mahto	06 km from Birni on Saraiya road (LHS) near sign board	24^0 14' 12" 85^0 54' 15"	Dug well	Granite Gneiss	Rope & bucket	0.38	7.17	2.25
38	Saraiya	Saraiya	Mathura Sahu	Within the premises of	24^0 10' 28"	Dug	Granite Gneiss	Rope &	0.60	9.00	1.95

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
				house of owner near Rly station on Giridih road via Koriodih	85^0 55' 01"	well		bucket			
39	Gohiyadih	Giridih	Govt.	Back side of Satyam Dhaba on Giridih-Dumri road (07 km)	24^0 09' 22" 86^0 15' 11"	Dug well	Granite Gneiss	Rope & bucket	0.55	12.55	2.50
40	Bhandaro	Dumri	Late Bishnath Pandey	NHO owner, LHS of Giridih -Saraiya road.	24^0 09' 04" 86^0 05' 27"	Dug well	Granite Gneiss	Rope & bucket	0.43	9.47	2.50
41	Kakuriadih	Dumri	Taleshwar Das	NHO owner, RHS of Giridih -Saraiya road.	24^0 09' 13" 86^0 03' 27"	Dug well	Granite Gneiss	Rope & bucket	0.42	9.28	2.40
42	Kheshkari	Saraiya	Baldev Mishtry	NHO owner, 10 km on Saraiya – Kayriodih road (LHS).	24^0 08' 50" 85^0 58' 20"	Dug well	Granite Gneiss	Rope & bucket	0.35	10.55	3.00
43	Atka (Jamuna Nagar)	Bagodar	Kunj Bihari Pandey	NHO owner, LHS of Bagodar – Barhi road (GT road)	24^0 06' 32" 85^0 41' 29"	Dug well	Granite Gneiss	Rope & bucket	0.10	10.75	5.00
44	Gopaldih	Bagodar	Jiwadhan Mahto	On the open field of owner	24^0 01' 45" 85^0 57' 36"	Dug well	Granite Gneiss	Rope & bucket	0.23	10.30	1.80
45	Chirki Pirtarn	Chirki Pirtarn	Govt.	Block office premises	24^0 02' 27" 86^0 09' 36"	Dug well	Granite Gneiss	Rope & bucket	0.55	14.00	1.90
46	Chainpur (Harijan Basti)	Dumri	Lakhan and Pokhan Turi	NHO owner, inside the village	24^0 01' 09" 86^0 04' 00"	Dug well	Granite Gneiss	Rope & bucket	0.67	8.73	3.00

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
47	Dumri	Dumri	Govt.	Within forest office premises	23^0 59' 26" 86^0 01' 10"	Dug well	Granite Gneiss	Rope & bucket	0.62	13.80	1.84
48	Bagodar	Bagodar	Govt.	High school compound on Bagodar – Saraiya road.	24^0 04' 45" 85^0 49' 55"	Dug well	Granite Gneiss	Rope & bucket	0.38	8.00	3.15

Annexure -III

WATER LEVEL DATA OF KEY WELLS OF NATIONAL AQUIFER MAPPING STUDY AREA OF GIRIDIH DISTRICT, JHARKHAND, 2019 –20

Well No.	Village	Block	Water level (mbgl)		Seasonal fluctuation (in m.) of water level between pre and post monsoon (2019)
			Pre monsoon (May 2019)	Post monsoon (Nov. 2019)	
1	**2**	**3**	4	5	6
1	Pipratol	Bengabad	7.22	1.65	5.57
2	Bengabad	Bengabad	8.94	1.95	6.99
3	Devatarn	Bengabad	11.40	2.30	9.10
4	Siyatarn	Jamua	10.25	2.48	7.77
5	Barasoli	Bengabad	5.30	1.07	4.23
6	Chakradaha	Bengabad	9.74	2.05	7.69
7	Maheshmunda	Gandey	8.39	2.03	6.36
8	Gandey	Gandey	9.65	1.80	7.80
9	Budhudih	Gandey	10.20	1.96	8.24
10	Dahutarn	Gandey	6.20	1.44	4.76
11	Pandri	Gandey	8.30	1.95	6.35
12	Gardih	Jamua	7.97	2.05	5.92
13	Kosogondodighi (Karmatarn)	Devri	6.58	1.09	5.49

Well No.	Village	Block	Water level (mbgl)		Seasonal fluctuation (in m.) of water level between pre and post monsoon (2019)
			Pre monsoon (May 2019)	Post monsoon (Nov. 2019)	
14	Chilkhariodih	Devri	7.36	1.30	6.06
15	Jalkhariodih	Devri	6.39	1.01	5.38
16	Devri	Devri	7.42	1.39	6.03
17	Belatarn	Devri	12.58	6.23	6.35
18	Tisri	Tisri	5.15	1.65	3.50
19	Kenduadih	Gawan	3.47	1.74	1.73
20	Gawan	Gawan	3.33	1.61	1.77
21	Palmo Mission	Tisri	7.86	1.89	5.97
22	Khijri Khasiyatarn	Tisri	9.15	2.58	6.57
23	Beriya	Devri	6.67	2.24	4.43
24	Gando	Jamua	8.02	1.94	6.08
25	Giridih	Giridih	12.03	4.20	7.83
26	Dhanaydih	Giridih	8.29	1.10	7.19
27	Bandhutarn	Jamua	Dry (10.55)	2.24	> 8.31
28	Jamua	Jamua	Dry (11.20)	4.70	> 6.50
29	Malho	Jamua	6.50	0.78	5.72
30	Doranda	Raj Dhanwar	8.70	3.19	5.51
31	Hirodih	Raj Dhanwar	9.13	3.11	6.02

Well No.	Village	Block	Water level (mbgl)		Seasonal fluctuation (in m.) of water level between pre and post monsoon (2019)
			Pre monsoon (May 2019)	Post monsoon (Nov. 2019)	
32	Nawadih (Ruputola)	Raj Dhanwar	5.52	1.35	4.17
33	Itasani	Raj Dhanwar	8.29	1.59	6.70
34	Bishunpur	Birni	8.17	2.03	6.14
35	Arwatarn (Kendua)	Birni	8.89	2.20	6.69
36	Palaunjia (Birni)	Birni	7.95	1.40	6.55
37	Bangra Khurd	Birni	6.27	1.87	4.40
38	Saraiya	Saraiya	8.78	1.96	6.82
39	Gohiyadih	Giridih	11.83	6.30	5.53
40	Bhandaro	Dumri	9.02	2.34	6.68
41	Kakuriadih	Dumri	9.16	2.39	6.77
42	Kheshkari	Saraiya	6.45	1.78	4.67
43	Atka (Jamuna Nagar)	Bagodar	10.70	5.20	5.50
44	Gopaldih	Bagodar	9.14	3.12	6.02
45	Chirki Pirtarn	Pirtarn	11.95	7.47	4.48
46	Chainpur (Harijan Basti)	Dumri	8.54	5.06	3.48
47	Dumri	Dumri	13.03	7.70	5.33
48	Bagodar	Bagodar	Dry (8.00)	4.46	> 3.54

Annexure-IV

Details of weathered and semi weathered zones and possible presence of thin fractured zones, Giridih district

VES	Village/ Location	Weathered zone(WZ) or different litho-unit			Semi-weathered zone(SWZ) / Less compact zone or different litho-unit			Fractured zone (FZ)	Recommendations for borehole drilling	Remarks
		Resistivity (ohm.m)	Depth to bottom (m)	Bottom depth of probable WZ aquifer (m)	Resistivity (ohm.m)	Depth to bottom (m)	Bottom depth of probable SWZ aquifer / (Depth to compact formation) (m)	Probable occurrence of thin fractured zone aquifer in the depth range (m)		
Granite Gneiss										
72	Bagodar	13	4	NA	105	8	NA (8)	NA	NA	WZ and SWZ are thin. No indication of FZ
73	Manakdiha	54	4	NA	NA	NA	NA (4)	40-45, 70-75, 140-150	150 m	FZs my form aquifer
74	Deori	19 75	4 36	36	NA	NA	NA (36)	50-55, 100-120,	120 m	WZ may form aquifer.
75	Dhanawar	52	11	11	124	36	36 (36)	40-45,	100 m	WZ and SWZ may form aquifer. FZ may form aquifer
76	Gawan	83	15	15	NA	NA	NA (15)	45-50, 70-80	100 m	WZ may form aquifer. FZ may form aquifer
77	Jamua	42	15	15	NA	NA	NA (15)	35-40, 75-80, 120-140, 170-180	180 m	WZ may form aquifer. FZ indications are feeble

The upper limit of resistivity of the weathered zone is 85 ohm.m, however for weathered zone aquifer it is taken as 60 ohm.m. The weathered zone of thickness less than 10 m has not been considered as aquifer. The resistivity of semi weathered zone is 85 to 300 ohm.m, however the upper limit of resistivity about 150 ohm.m has been considered for semi-weathered zone aquifer. The fractured zones have been inferred through empirical approaches only.

Annexure - V

WATER QUALITY DATA OF AQUIFER - I (DUG WELL SAMPLES) OF AQUIFER MAPPING STUDY AREA OF GIRIDIH DISTRICT (2019-20)

Sr. No.	Village	Block	District	Latitude & Longitude	pH	EC (µS/cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
							← mg / l →										
1	Pipratol	Bengabad	Giridih	24^0 16′ 35″ 86^0 27′ 05″	7.9	195	117	75	26	2.4	8.5	0.2	73	14	10	4.4	1.2
2	Bengabad	Bengabad	Giridih	24^0 18′ 17″ 86^0 21′ 25″	8.03	884	575	246	56.8	25.33	72.24	9.48	314	72	54	0	1.53
3	Devatarn	Bengabad	Giridih	24^0 21′ 34″ 86^0 17′ 47″	7.8	185	111	70	24	2.4	9.8	0.3	79	11	10	0.87	1.3
4	Siyatarn	Jamua	Giridih	24^0 24′ 41″ 86^0 16′ 55″	8.0	118	71	45	12	3.6	6.3	0.1	43	7	17.3	0.38	0.69
5	Barasoli	Bengabad	Giridih	24^0 15′ 10″ 86^0 19′ 57″	8.1	537	322	200	70	6.1	28	1.2	214	50	18	5.7	0.1
6	Chakradaha	Bengabad	Giridih	24^0 15′ 20″ 86^0 23′ 21″	7.8	738	443	205	72	6.1	63	15	293	43	65	6	0.13
7	Maheshmunda	Gandey	Giridih	24^0 12′ 40″ 86^0 24′ 39″	8.11	294	191	86.8	22.4	7.50	19.69	4.38	86.1	23	15	36.11	1.03
8	Gandey	Gandey	Giridih	24^0 11′ 02″ 86^0 26′ 48″	7.85	549	357	201	48.2	19.44	25.70	8.59	277	24	3.50	15.39	0.29
9	Budhudih	Gandey	Giridih	24^0 10′ 30″ 86^0 29′ 20″	7.9	760	456	195	76	1.2	75	21	287	46	86	15	0.65

Sr. No.	Village	Block	District	Latitude & Longitude	pH	EC (µS/cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
							← mg / l →										
10	Dahutarn	Gandey	Giridih	24^0 08′ 12″ 86^0 28′ 03″	8	281	169	85	22	7.3	24	3.5	104	28	19	1.3	0.36
11	Pandri	Gandey	Giridih	24^0 04′ 30″ 86^0 23′ 10″	7.98	750	488	245	62	21.87	44.28	4.64	172	70	31	87.77	0.39
12	Gardih	Jamua	Giridih	24^0 23′ 56″ 86^0 14′ 57″	7.9	308	185	120	26	13.4	15	1.2	122	18	37	1.1	0.31
13	Kosogondodighi (Karmatarn)	Devri	Giridih	24^0 26′ 53″ 86^0 15′ 43″	7.8	175	105	60	16	4.9	8.6	0.3	31	7	53	3.2	0.27
14	Chilkhariodih	Devri	Giridih	24^0 28′ 45″ 86^0 17′ 21″	8.1	287	172	90	24	7.3	23	0.5	73	18	45	14	1.4
15	Jalkhariodih	Devri	Giridih	24^0 27′ 39″ 86^0 12′ 41″	8.2	561	337	215	62	14.6	30	0.2	311	11	5.2	6.8	0.29
16	Devri	Devri	Giridih	24^0 30′ 52″ 86^0 11′ 35″	8.26	303	197	123	38	6.70	13.32	1.77	129	35	9.62	0	1.07
17	Belatarn	Devri	Giridih	24^0 32′ 13″ 86^0 08′ 05″	8.49	677	440	240	66	18.23	30.25	3.84	135	139	10	0.21	1.66
18	Tisri	Tisri	Giridih	24^0 34′ 45″ 86^0 03′ 58″	8.2	442	287	112	36	5.27	46.30	0.69	135	31	18	30.53	2.89
19	Kenduadih	Gawan	Giridih	24^0 40′ 50″ 85^0 51′ 45″	7.9	322	193	130	38	8.5	12	0.1	153	7	15	3.1	1

Sr. No.	Village	Block	District	Latitude & Longitude	pH	EC (µS/cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
							← mg / l →										
20	Gawan	Gawan	Giridih	24^0 51′ 40″ 85^0 56′ 14″	7.7	4.98	299	175	46	14.6	25	0.6	214	21	21	4.9	0.91
21	Palmo Mission	Tisri	Giridih	24^0 35′ 45″ 86^0 02′ 20″	7.9	242	145	100	16	14.6	11	0.2	98	21	3.8	2.7	1.5
22	Khijri Khasiyatarn	Tisri	Giridih	24^0 32′ 51″ 86^0 05′ 27″	7.8	453	272	155	48	8.5	31	0.9	153	36	30	14	1.97
23	Beriya	Devri	Giridih	24^0 30′ 10″ 86^0 06′ 16″	7.9	507	304	165	50	9.7	39	1.2	177	53	27	5.6	0.87
24	Gando	Jamua	Giridih	24^0 26′ 20″ 86^0 09′ 08″	8	289	173	105	30	7.3	20	0.1	79	32	23	15	0.21
25	Giridih	Giridih	Giridih	24^0 10′ 00″ 86^0 18′ 30″	7.94	464	302	138	38	10.52	36.47	3.66	197	18	19	5.93	8.00
26	Dhanaydih	Giridih	Giridih	24^0 13′ 20″ 86^0 12′ 50″	8.07	723	470	186	34.4	24.3	71.64	11	221	68	38	14.6	1.25
27	Malho	Jamua	Giridih	24^0 32′ 51″ 86^0 04′ 58″	7.7	672	403	200	50	15.2	52	15	207	92	19	13	0.14
28	Doranda	Raj Dhanwar	Giridih	24^0 32′ 51″ 86^0 04′ 58″	8.1	647	388	160	46	10.9	60	19	201	43	47	43	1.8
29	Hirodih	Raj Dhanwar	Giridih	24^0 27′ 10″ 86^0 00′ 20″	8.2	1025	615	285	102	7.3	87	25	244	128	98	40	0.14

Sr. No.	Village	Block	District	Latitude & Longitude	pH	EC (µS/cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
							← mg / l →										
30	Nawadih (Ruputola)	Raj Dhanwar	Giridih	24^0 24′ 45″ 86^0 00′ 16″	7.91	234	152	85	28	3.65	12.15	1.87	116	10	5.35	0	0.28
31	Itasani	Raj Dhanwar	Giridih	24^0 21′ 01″ 85^0 57′ 01″	7.5	790	474	210	44	24.3	72	21	220	117	45	10	0.13
32	Bishunpur	Birni	Giridih	24^0 13′ 23″ 86^0 00′ 34″	7.9	375	225	105	28	8.5	26	1.2	116	43	8.1	0.79	0.56
33	Arwatarn (Kendua)	Birni	Giridih	24^0 16′ 02″ 85^0 59′ 05″	7.8	383	230	110	26	10.9	30	9.2	98	57	26	5.5	0.6
34	Palaunjia (Birni)	Birni	Giridih	24^0 15′ 48″ 85^0 56′ 45″	8.34	250	163	96	6.77	19.16	12.13	0.95	105	10	8.44	5.81	0.57
35	Bangra Khurd	Birni	Giridih	24^0 14′ 12″ 85^0 54′ 15″	8.1	211	127	75	18	7.3	15	1.5	61	36	12	1.8	0.35
36	Saria	Saria	Giridih	24^0 10′ 28″ 85^0 55′ 01″	7.97	1306	849	480	98.2	57.11	43.91	1.54	166	274	57	54.46	0.21
37	Gohiyadih	Giridih	Giridih	24^0 09′ 22″ 86^0 15′ 11″	8	605	363	175	48	13.4	54	2.3	134	107	40	0.96	0.32
38	Bhandaro	Dumri	Giridih	24^0 09′ 04″ 86^0 05′ 27″	7.9	250	150	95	24	8.5	24	1.3	73	28	41	18	0.24
39	Kakuriadih	Dumri	Giridih	24^0 09′ 13″ 86^0 03′ 27″	7.8	713	428	250	70	18.2	45	1.7	195	99	52	11	0.18

Sr. No.	Village	Block	District	Latitude & Longitude	pH	EC (µS/cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
							← mg / l →										
40	Keshkari	Saraiya	Giridih	24^0 08′ 50″ 85^0 58′ 20″	8	1684	1010	625	162	53.5	73	29	519	188	69	73	0.22
41	Atka (Jamuna Nagar)	Bagodar	Giridih	24^0 06′ 32″ 85^0 41′ 29″	7.9	1069	641	305	90	19.4	85	13	268	135	78	31	1.3
42	Gopaldih	Bagodar	Giridih	24^0 01′ 45″ 85^0 57′ 36″	7.8	365	219	90	34	1.2	34	11	31	85	40	2.3	0.05
43	Chainpur (Harijan Basti)	Dumri	Giridih	24^0 01′ 09″ 86^0 04′ 00″	7.6	521	313	190	54	13.37	27	7.3	116	103	25	0	0.31
44	Dumri	Dumri	Giridih	23^0 59′ 26″ 86^0 01′ 10″	8.05	1126	732	386	74	48.89	54.88	2.01	338	91	63	63.22	0.44

Annexure - VI

WATER QUALITY DATA OF AQUIFER - II (HAND PUMP SAMPLES) OF AQUIFER MAPPING STUDY AREA OF GIRIDIH DISTRICT (2019-20)

Sr. No.	Village	Block	District	Latitude & Longitude	pH	EC (µS/cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
							← mg / l →										
1	Pipratol	Bengabad	Giridih	24^0 16′ 35″ 86^0 27′ 05″	8.1	163	98	50	15	4.86	13	0.1	37	21	0.46	21	0.68
2	Bengabad	Bengabad	Giridih	24^0 18′ 17″ 86^0 21′ 25″	7.9	695	417	205	50	19.44	56	15	183	92	28	44	0.67
3	Devatarn	Bengabad	Giridih	24^0 21′ 34″ 86^0 17′ 47″	8.0	168	101	75	22	4.86	4.2	0.1	43	25	0.76	9.2	0.4
4	Siyatarn	Jamua	Giridih	24^0 24′ 41″ 86^0 16′ 55″	7.5	140	84	60	24	0	5.5	0.2	24	21	1.7	25	0.24
5	Barasoli	Bengabad	Giridih	24^0 15′ 10″ 86^0 19′ 57″	7.9	235	141	100	36	2.43	6.7	0.2	37	32	5.5	38	0.39
6	Chakradaha	Bengabad	Giridih	24^0 15′ 20″ 86^0 23′ 21″	8.0	159	95	60	12	7.29	9.0	0.12	43	21	0.88	17	0.26
7	Maheshmunda	Gandey	Giridih	24^0 12′ 40″ 86^0 24′ 39″	8.0	378	227	155	52	6.08	15	1.1	92	57	8.9	27	0.0
8	Gandey	Gandey	Giridih	24^0 11′ 02″ 86^0 26′ 48″	7.9	414	248	155	46	9.72	22	1.3	122	53	13	24	0.4

9	Budhudih	Gandey	Giridih	24^0 10′ 30″ 86^0 29′ 20″	8.1	251	151	115	36	6.08	5.3	0.13	67	25	9.1	25	0.89
10	Dahutarn	Gandey	Giridih	24^0 08′ 12″ 86^0 28′ 03″	7.4	260	156	105	26	9.72	11	3.2	79	43	1.4	9.0	0.5
11	Pandri	Gandey	Giridih	24^0 04′ 30″ 86^0 23′ 10″	7.7	410	246	175	56	8.51	10	1.3	92	64	6.2	35	1.0
12	Gardih	Jamua	Giridih	24^0 23′ 56″ 86^0 14′ 57″	7.6	322	193	110	32	7.29	21	2.5	79	43	5.2	30	0.44
13	Kosogondodighi (Karmatarn)	Devri	Giridih	24^0 26′ 53″ 86^0 15′ 43″	7.8	93	56	35	8	3.65	5.5	0.13	31	11	0.42	7.5	0.84
14	Chilkhariodih	Devri	Giridih	24^0 28′ 45″ 86^0 17′ 21″	7.9	422	253	145	42	9.72	27	3.2	122	67	4.2	8.1	0.87
15	Jalkhariodih	Devri	Giridih	24^0 27′ 39″ 86^0 12′ 41″	8.0	156	94	50	16	2.43	12	0.15	18	36	4.5	8.6	0.93
16	Devri	Devri	Giridih	24^0 30′ 52″ 86^0 11′ 35″	7.9	167	100	75	18	7.29	3.1	0.19	55	21	1.0	3.4	0.27
17	Belatarn	Devri	Giridih	24^0 32′ 13″ 86^0 08′ 05″	7.8	216	130	85	22	7.29	10	1.5	43	43	2.3	15	0.25
18	Tisri	Tisri	Giridih	24^0 34′ 45″ 86^0 03′ 58″	8.0	351	211	130	34	10.94	22	0.18	79	53	3.1	34	2.16
19	Kenduadih	Gawan	Giridih	24^0 40′ 50″ 85^0 51′ 45″	7.9	383	230	120	36	7.29	31	2.3	73	71	1.5	37	0.65

20	Gawan	Gawan	Giridih	24^0 51′ 40″ 85^0 56′ 14″	8.0	538	323	210	64	12.15	23	4.6	183	50	15	33	0.59
21	Palmo Mission	Tisri	Giridih	24^0 35′ 45″ 86^0 02′ 20″	7.9	489	293	185	52	13.37	27	4.2	92	82	24	37	0.59
22	Khijri Khasiyatarn	Tisri	Giridih	24^0 32′ 51″ 86^0 05′ 27″	7.8	266	160	85	28	3.65	13	7.2	49	50	0	15	0.33
23	Beriya	Devri	Giridih	24^0 30′ 10″ 86^0 06′ 16″	8.0	253	152	115	30	9.72	4.2	0.18	61	43	0	5.9	2.0
24	Gando	Jamua	Giridih	24^0 26′ 20″ 86^0 09′ 08″	8.1	355	213	145	42	9.72	5.1	0.19	67	67	0	6.61	0.22
25	Giridih	Giridih	Giridih	24^0 10′ 00″ 86^0 18′ 30″	7.9	448	269	175	46	14.58	0.3	0.04	43	71	19	20	0.69
26	Dhanaydih	Giridih	Giridih	24^0 13′ 20″ 86^0 12′ 50″	7.8	559	335	170	56	7.29	35	13	104	89	23	33	0.51
27	Bandhutarn	Jamua	Giridih	24^0 18′ 00″ 86^0 07′ 05″	8.23	413	268	125	30	12.15	38.12	4.53	221	14	4.82	2.10	0.29
28	Jamua	Jamua	Giridih	24^0 22′ 25″ 86^0 09′ 00″	7.75	2256	1466	630	144	65.61	174	3.66	111	514	85	167	0.60
29	Malho	Jamua	Giridih	24^0 32′ 51″ 86^0 04′ 58″	8.0	303	182	135	40	8.51	7.4	1.7	98	36	3.4	22	0.06
30	Doranda	Raj Dhanwar	Giridih	24^0 32′ 51″ 86^0 04′ 58″	7.5	447	268	180	52	12.15	11	1.5	128	53	5	21	1.2

31	Hirodih	Raj Dhanwar	Giridih	24^0 27′ 10″ 86^0 00′ 20″	7.6	545	327	220	46	25.52	20	3.4	134	85	13	28	0.28
32	Nawadih (Ruputola)	Raj Dhanwar	Giridih	24^0 24′ 45″ 86^0 00′ 16″	7.4	187	112	85	22	7.29	2.8	0.12	24	46	1.2	9	0.68
33	Itasani	Raj Dhanwar	Giridih	24^0 21′ 01″ 85^0 57′ 01″	7.9	649	389	250	76	14.58	30	6.3	159	99	23	35	0.63
34	Bishunpur	Birni	Giridih	24^0 13′ 23″ 86^0 00′ 34″	7.3	187	112	80	24	4.86	5.2	2.1	55	18	8.3	14	0.26
35	Arwatarn (Kendua)	Birni	Giridih	24^0 16′ 02″ 85^0 59′ 05″	7.5	237	142	100	32	4.86	8.1	1.3	43	43	4.6	16	0.97
36	Palaunjia (Birni)	Birni	Giridih	24^0 15′ 48″ 85^0 56′ 45″	7.8	380	228	155	50	7.29	13	1.1	104	50	9.2	25	0.62
37	Bangra Khurd	Birni	Giridih	24^0 14′ 12″ 85^0 54′ 15″	8.1	257	154	115	36	6.08	2.3	1.8	37	25	0	74	0.49
38	Saraiya	Saraiya	Giridih	24^0 10′ 28″ 85^0 55′ 01″	8.0	835	501	335	98	21.87	35	0.31	92	153	0	32	0.39
39	Gohiyadih	Giridih	Giridih	24^0 09′ 22″ 86^0 15′ 11″	7.9	695	417	250	78	13.37	23	7.3	128	107	2.1	62	0.2
40	Bhandaro	Dumri	Giridih	24^0 09′ 04″ 86^0 05′ 27″	8.0	769	461	335	104	18.23	17	6.1	171	114	17	74	1.0
41	Kakuriadih	Dumri	Giridih	24^0 09′ 13″ 86^0 03′ 27″	7.5	183	110	80	22	6.08	5.1	0.31	49	36	0	2.8	0.25

42	Kheshkari	Saraiya	Giridih	24^0 08′ 50″ 85^0 58′ 20″	7.6	1030	618	360	106	23.09	64	1.4	305	153	1.2	41	0.58
43	Atka (Jamuna Nagar)	Bagodar	Giridih	24^0 06′ 32″ 85^0 41′ 29″	7.7	833	500	350	116	14.58	37	1.3	226	149	3.5	39	0.87
44	Gopaldih	Bagodar	Giridih	24^0 01′ 45″ 85^0 57′ 36″	7.9	505	303	205	58	14.58	21	2.9	104	110	0	18	0.38
45	Chirki Pirtarn	Chirki Pirtarn	Giridih	24^0 02′ 27″ 86^0 09′ 36″	8.21	658	428	194	36.2	25.19	41	2.92	160	65	43	49.05	0.36
46	Chainpur (Harijan Basti)	Dumri	Giridih	24^0 01′ 09″ 86^0 04′ 00″	7.9	561	337	270	64	26.73	4.6	0.18	171	78	0.37	31	0.70
47	Dumri	Dumri	Giridih	23^0 59′ 26″ 86^0 01′ 10″	7.8	474	284	195	58	12.15	14	1.1	116	64	13	39	0.40
48	Bagodar	Bagodar	Giridih	24^0 04′ 45″ 85^0 49′ 55″	8.17	1058	688	349	52	53.41	69.20	1.11	295	148	25	3.88	0.02

Annexure-VII

DETAILS OF EXPLORATORY WELLS CONSTRUCTED IN HARD FORMATION OF GIRIDIH DISTRICT, JHARKHAND

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered (mbgl)		Aquifer	Static water level (mbgl)	Dis-charge (m^3/hr)	D.D. (m)	T (m^2/d)	S (Storativity)
								From	To						
1	Jaganathdih EW 24.405555 86.163888	Jamua	Giridih	100.00	100.00	7.00	7.50	--	--	Fractured granite gneiss (F.G.N.)	1.60	9	11.40	13.76	1.36×10^{-3}
2	Jhalakdiha EW 24.215277 86.275	Jamua	Giridih	101.00	101.00	7.00	7.50	21.00 57.00	24.00 59.00	F.G.N.	3.43	7.48	9.09	28.5	5.30×10^{-3}
3	Jorasankh EW 24.2875 86.152777	Jamua	Giridih	101.00	101.00	7.00	7.30	22.00 69.00	24.00 70.00	F.G.N.	4.36	10.74	13.40	--	6.30×10^{-2}
4	Tara EW 24.327777 86.072222	Jamua	Giridih	100.00	100.00	8.50	9.00	--	--	F.G.N.	6.81	4.50	7.62	24.8	1.40×10^{-2}
5	Belatarn EW 24.544444 86.008333	Devri	Giridih	100.00	100.00	16.00	16.20	--	--	F.G.N.	1.95	5.40	6.50	18.7	3.90×10^{-3}
6	Nawadih EW 24.308333 86.155555	Jamua	Giridih	100.00	100.00	18.50	19.00	--	--	F.G.N.	6.23	2.16	--	--	--
7	Naudiha EW	Jamua	Giridih	66.00	66.00	8.50	9.00	--	--	F.G.N.	1.40 magl	36.00	10.50	--	--

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered (mbgl)		Aquifer	Static water level (mbgl)	Dis-charge (m^3/hr)	D.D. (m)	T (m^2/d)	S (Storativity)
								From	To						
	24.383333 86.286111														
8	Rathdih EW 24.30 86.352777	Bengabad	Giridih	100.00	100.00	5.00	5.00	--	--	F.G.N.	7.20	15.5	--	--	--
9	Mohanpur EW 24.083333 86.352777	Giridih	Giridih	87.62	87.62	12.50	12.50	--	--	F.G.N.	23.90	39.6	1.68	--	--
10	Officers colony EW 24.152777 86.336111	Giridih	Giridih	199.02	199.02	--	--	--	--	--	--	Dry	--	--	--
11	Gandey Block EW 24.081944 86.388888	Gandey	Giridih	137.71	137.71	--	--	--	--	F.G.N.	7.17	11.29	11.7	66.17	1.58×10^{-5}
12	Bazar Hat EW 24.161111 86.336611	Giridih	Giridih	93.09	93.09	--	--	--	--	F.G.N.	5.25	37.70	18.30	46.10	2.30×10^{-3}
13	Dandidih EW 24.169444 86.341666	Giridih	Giridih	145.48	145.48	--	--	--	--	F.G.N.	35.22	19.80	2.92	4.34	--
14	Pachambha EW 24.169444 86.319444	Giridih	Giridih	199.07	199.07	--	--	--	--	--	--	Dry	--	--	--

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered (mbgl)		Aquifer	Static water level (mbgl)	Dis-charge (m^3/hr)	D.D. (m)	T (m^2/d)	S (Storativity)
								From	To						
15	Raj Dhanwar EW 24.391666 85.986111	Raj Dhanwar	Giridih	199.07	199.07	--	--	--	--	--	--	2.70	--	--	--
16	Mica Thana Tisri - EW 24.580555 86.077777	Tisri	Giridih	186.93	186.93	--	--	--	--	F.G.N.	6.38	12.45	7.92	20.08	--
17	Dumri Block EW 23.990555 86.019444	Dumri	Giridih	198.35	198.35	--	--	--	--	F.G.N.	--	15.30	--	--	--
18	Birangada EW 23.986111 86.172222	Pirtarn	Giridih	191.53	191.53	--	--	--	--	--	--	27	--	--	--
19	Atka EW 24.061111 85.9125	Bagodar	Giridih	182.54	182.54	--	--	--	--	--	--	11.8	--	--	--
20	Gandey (JNV) EW 24.179166 86.459722	Gandey	Giridih	92.90	92.90	29.50	30.03	42.00	44.00	F.G.N.	12.10	25.56	16.44	33.26	3.50×10^{-4}
	OW	Gandey	Giridih	111.20	111.20	29.50	30.00	39.00	40.00	F.G.N.	12.33	6.48			
21	Chhotki Kharagdiha EW 24.355277 86.304722	Bengabad	Giridih	202.70	202.70	23.50	23.90	130.00	130.50	F.G.N.	12.33	2.88	--	--	--
22	Devri	Devri	Giridih	202.70	202.70	29.00	29.70	32.00	33.00	F.G.N.	1.03	2.88	--	--	--

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered (mbgl)		Aquifer	Static water level (mbgl)	Dis-charge (m^3/hr)	D.D. (m)	T (m^2/d)	S (Storativity)
								From	To						
	EW 24.514166 86.190555														
23	Arkhango EW 24.439166 85.8775	Raj Dhanwar	Giridih	202.70	202.70	23.00	23.65	109.00 148.50 189.00	110.00 149.00 189.50	F.G.N.	--	12.24	--	--	--
	OW	Raj Dhanwar	Giridih	199.00	199.00	29.50	29.90	70.00 194.00	70.50 195.00	F.G.N.	--	18.36			
24	Birni EW 24.285833 85.929722	Birni	Giridih	202.70	202.70	17.00	17.62	--	--	--	--	Dry	--	--	--
25	Ghutwali EW 23.963611 86.011944	Dumri	Giridih	202.70	202.70	17.00	17.66	--	--	--	--	Dry	--	--	--
26	Ghaghra science college EW 24.07169 85.86077	Bagodar	Giridih	190.50	190.50	23.00	23.50	26.50	27.00	F.G.N.	5.10	0.50	--	--	--
27	Khambhra UH School EW 24.102835 85.889239	Bagodar	Giridih	186.00	186.00	11.50	11.70	24.00 128.50	25.00 129.50	F.G.N.	4.40	12.24	--	--	--
	OW	Bagodar	Giridih	178.30	178.30	11.50	11.60	100.00	101.00	F.G.N.	4.45	12.24	--	--	--
28	Ambadih EW	Bagodar	Giridih	202.70	202.70	17.50	17.80	152.00	152.50	F.G.N.	--	0.50	--	--	--

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered (mbgl)		Aquifer	Static water level (mbgl)	Dis-charge (m^3/hr)	D.D. (m)	T (m^2/d)	S (Storativity)
								From	To						
	24.113570 85.863742														
29	Sariya Inter College EW 24.150555 85.874722	Sariya	Giridih	202.70	202.70	17.50	17.60	155.00 182.00	156.00 182.50	F.G.N.	--	12.24	--	--	--
	OW	Sariya	Giridih	202.70	202.70	17.50	17.65	189.00	190.00	F.G.N.	--	12.24	--	--	--
30	Nawadih EW 24.197373 85.898618	Sariya	Giridih	184.40	184.40	25.00	25.30	142.00	144.50	F.G.N.	8.55	20.52			
	OW	Sariya	Giridih	62.40	62.40	20.00	20.20	21.00	25.00	F.G.N.	8.11	16.20	--	--	--
31	Bangra Khurrd EW 24.23353 85.90391	Birni	Giridih	191.50	191.50	20.50	20.70	42.00	43.00	F.G.N.	--	1.62	--	--	--
32	Dabarsaini EW 24.29241 85.95729	Birni	Giridih	202.70	202.70	13.50	17.65	--	--	--	--	--	--	--	--
33*	Pokhariya EW 24.013194 85.948816	Bagodar	Giridih	204.00	204.00	14.50	14.66	--	--	--		Dry	--	--	--
34*	Baghanal EW 24.255666 86.003166	Birni	Giridih	204.00	204.00	17.50	17.71	--	--	--		Dry	--	--	--
35*	Jhumri	Dhanwar	Giridih	204.00	204.00	18.50	18.58	123.00	123.50	F.G.N.	--	6.48	--	--	--

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered (mbgl)		Aquifer	Static water level (mbgl)	Dis-charge (m^3/hr)	D.D. (m)	T (m^2/d)	S (Storativity)
								From	To						
	EW 24.343138 85.873055														
36*	Chatro EW 24.343138 85.873055	Deori	Giridih	204.00	204.00	29.00	29.50	48.00	48.50	F.G.N.	--	0.28	--	--	--
37*	Jamua EW 24.343138 85.873055	Jamua	Giridih	202.50	202.50	29.00	29.15	32.00	33.00	F.G.N.	--	11.88	--	--	--
38*	Gawan EW 24.343138 85.873055	Gawan	Giridih	203.00	203.00	17.50	17.67	--	--	--		Dry	--	--	--

F.G.N. = Fractured Granite Gneiss

* Exploratory wells drilled through outsourcing drilling during 2020.

LITHOLOG

Unique ID: GD1	EW
Village	Jhalakdiha (land of Shri Harsiram Naik)
Block	Bengabad
District	Giridih
Latitude	24^0 12’ 55”
Longitude	86^0 16’ 30”
Drilled Depth (mbgl)	101.00
Casing depth (m bgl)	7.50
SWL(m bgl)	3.43
Discharge (m^3/hr)	7.48
Date / Year	March 1982

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	10.00	10.00	Top soil, reddish yellow colour
10.00	21.00	11.00	Granite gneiss – highly weathered with pegmatite veins, slightly fractured
21.00	40.00	19.00	Granite gneiss with quartz veins slightly fractured with more biotite
40.00	42.00	2.00	Amphibolite, fresh, massive
42.00	51.00	9.00	Biotite gneiss, fresh, massive
51.00	57.00	6.00	Granite gneiss pinkish, grey, fresh massive
57.00	59.00	2.00	Granite gneiss slightly fractured
59.00	63.00	4.00	Biotite gneiss, fresh, massive
63.00	71.00	8.00	Granite gneiss with little quartz veins, fresh, massive
71.00	78.00	7.00	Granite gneiss, fresh, massive
78.00	89.00	11.00	Biotite gneiss, fresh, massive
89.00	93.00	4.00	Granite gneiss pinkish, fresh massive

93.00	101.00	8.00	Biotite gneiss, fresh, massive

LITHOLOG

Unique ID: GD2		EW	
Village		Jorasankh	
Block		Jamua	
District		Giridih	
Latitude		24^0 17’ 15”	
Longitude		86^0 09’ 10”	
Drilled Depth (mbgl)		101.00	
Casing depth (m bgl)		7.30	
SWL(m bgl)		4.36	
Discharge (m^3/hr)		10.74	
Date / Year		June 1982	
Depth range(m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	7.00	7.00	Top soil, sandy, yellowish red
7.00	11.00	4.00	Top soil, grayish, highly weathered Amphibolite
11.00	22.00	11.00	Hornblende, schist, highly weathered
22.00	44.00	22.00	Granite, gneiss, weathered and slightly fractured
44.00	58.00	14.00	Granite gneiss, fresh, massive
58.00	66.00	8.00	Granite gneiss, slightly fractured
66.00	69.00	3.00	Granite gneiss, grayish coloured, fresh and massive
69.00	75.00	6.00	Hornblende – schist, slightly fractured
75.00	101.00	26.00	Hornblende, schist, fresh and massive

LITHOLOG

Unique ID: GD3	EW

Village	Gandey (Jawahar Navoday Vidyalaya campus)
Block	Gandey
District	Giridih
Latitude	24^0 10’ 45”
Longitude	86^0 27’ 35”
Drilled Depth (mbgl)	92.90
Casing depth (m bgl)	30.03
SWL(m bgl)	12.10
Discharge (m^3/hr)	25.56
Date / Year	August 2019 (10/08/2019 to 13/08/2019)

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	13.00	13.00	Top soil, yellowish blown in colour, sticky nature
13.00	29.50	16.50	Granite gneiss – weathered
29.50	42.00	12.50	Granite gneiss – white to light pink in colour, predominating with quartz (white) and feldspar (light pink)
42.00	44.00	2.00	Fractured granite gneiss
44.00	62.50	18.50	Granite gneiss – white to light pink in colour, predominating with quartz (white) and feldspar (light pink)
62.50	68.50	6.00	Granite gneiss – grey in colour, predominating with biotite
68.50	80.50	12.00	Granite gneiss – white to light pink in colour, predominating with quartz (white) and feldspar (light pink)
80.50	92.90	12.40	Granite gneiss – grey in colour, predominating with biotite

LITHOLOG

Unique ID: GD4	OW

Village	Gandey (Jawahar Navoday Vidyalaya campus)
Block	Gandey
District	Giridih
Latitude	24^0 10’ 45”
Longitude	86^0 27’ 35”
Drilled Depth (mbgl)	111.20
Casing depth (m bgl)	30.00
SWL(m bgl)	12.33
Discharge (m^3/hr)	6.48
Date / Year	August 2019 (17/08/2019 to 19/08/2019)

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	13.00	13.00	Top soil, yellowish blown in colour, sticky nature
13.00	29.50	16.50	Granite gneiss – weathered
29.50	39.00	9.50	Granite gneiss – white to light pink in colour, predominating with quartz (white) and feldspar (light pink)
39.00	40.00	1.00	Fractured granite gneiss
40.00	68.50	28.50	Granite gneiss – grey in colour, predominating with biotite
68.50	80.50	12.00	Granite gneiss – white to light pink in colour, predominating with quartz (white) and feldspar (light pink)
80.50	86.50	6.00	Granite gneiss – white in colour, predominating with quartz and feldspar
86.50	93.00	6.50	Granite gneiss – white to light pink in colour, predominating with quartz (white) and feldspar (light pink)
93.00	105.00	22.00	Granite gneiss – grey in colour, predominating with biotite
105.00	111.20	6.20	Granite gneiss – white to light pink in colour, predominating with quartz (white) and feldspar (light

			pink)

LITHOLOG

Unique ID: GD5	EW
Village	Chhotki Kharagdiha (near grampanchayat bhawan)
Block	Bengabad
District	Giridih
Latitude	24^0 21’ 19”
Longitude	86^0 18’ 17”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	23.90
SWL(m bgl)	8.03
Discharge (m^3/hr)	2.88
Date / Year	September 2019 (22/09/2019 to 30/09/2019)

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	17.00	17.00	Top soil, yellowish blown in colour, sticky nature
17.00	23.50	6.50	Granite gneiss – weathered
23.50	26.00	2.50	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.
26.00	72.00	46.00	Granite gneiss – grey in colour, predominating with biotite
72.00	81.00	9.00	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.
81.00	99.00	18.00	Granite gneiss – grey in colour, predominating with biotite
99.00	117.00	18.00	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.
117.00	126.50	9.50	Granite gneiss – grey in colour, predominating with biotite
126.50	130.00	3.50	Granite gneiss – white in colour, predominating with

			quartz and feldspar hard and compact.
130.00	130.50	0.50	Fractured granite gneiss
130.50	151.00	20.50	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.
151.00	172.00	21.00	Granite gneiss – grey in colour, predominating with biotite
172.00	178.00	6.00	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.
178.00	196.50	18.50	Granite gneiss – grey in colour, predominating with biotite
196.50	202.70	6.20	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.

LITHOLOG

Unique ID: GD6	EW
Village	Devri (block campus)
Block	Devri
District	Giridih
Latitude	24^0 30’ 51”
Longitude	86^0 11’ 26”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	29.70
SWL(m bgl)	1.03
Discharge (m^3/hr)	2.88
Date / Year	October 2019 (22/10/2019 to 29/10/2019)

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	25.50	25.50	Top soil, yellowish blown in colour, sticky nature
25.50	29.50	4.00	Granite gneiss – weathered
29.50	32.00	2.50	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.

32.00	33.00	1.00	Fractured granite gneiss
33.00	62.00	29.00	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.
62.00	68.00	6.00	Granite gneiss – light pink colour, feldspar predominating.
68.00	111.00	43.00	Granite gneiss – grey in colour, predominating with biotite
111.00	142.00	31	Granite gneiss – white to light grey colour, predominating with quartz and biotite.
142.00	202.70	60.70	Granite gneiss – white in colour, predominating with quartz and feldspar hard and compact.

LITHOLOG

Unique ID: GD7	EW
Village	Arkhango (+ 2 High School campus)
Block	Raj Dhanwar
District	Giridih
Latitude	24^0 26’ 21”
Longitude	85^0 52’ 39”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	23.65
SWL(m bgl)	
Discharge (m^3/hr)	12.24
Date / Year	Nov./Dec. 2019 (29/11/2019 to 05/12/2019)

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	0.50	0.50	Top soil
0.50	17.00	16.50	Weathered granite gneiss, deep grey in colour, predominating with biotite.
17.00	23.00	6.00	Weathered granite gneiss, light grey in colour, predominating with mica (muscovite).

23.00	62.50	39.50	Granite gneiss, deep grey in colour, predominating with biotite.
62.50	109.00	46.50	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
109.00	110.00	1.00	Slightly fractured granite gneiss.
110.00	142.00	32.00	Granite gneiss, white in colour, predominating with quartz and feldspar
142.00	148.50	6.50	Granite gneiss, light grey in colour, coarse grain rock cutting, predominating with quartz and biotite
148.50	149.00	0.50	Slightly fractured granite gneiss.
149.00	189.00	40.00	Granite gneiss, light grey in colour, coarse grain rock cutting, predominating with quartz and biotite
189.00	189.50	0.50	Slightly fractured granite gneiss.
189.50	202.70	13.20	Granite gneiss, white in colour, predominating with quartz and feldspar

LITHOLOG

Unique ID: GD8	OW
Village	Arkhango (+ 2 High School campus)
Block	Raj Dhanwar
District	Giridih
Latitude	24^0 26’ 21”
Longitude	85^0 52’ 39”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	23.65
SWL(m bgl)	
Discharge (m^3/hr)	12.24
Date / Year	Nov./Dec. 2019

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	2.00	2.00	Top soil

2.00	14.00	12.00	Weathered granite gneiss, deep grey in colour, Predominating with biotite.
14.00	56.00	42.00	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
56.00	70.00	14	Granite gneiss, deep grey in colour, predominating with biotite.
70.00	70.50	0.50	Slightly fractured granite gneiss.
70.50	74.60	4.10	Granite gneiss, white in colour, predominating with quartz and feldspar
74.60	102.00	27.40	Granite gneiss, deep grey in colour, Predominating with biotite.
102.00	132.50	30.50	Granite gneiss, white in colour, predominating with quartz and feldspar
132.50	141.50	9.00	Granite gneiss, deep grey in colour, Predominating with biotite.
141.50	160.00	18.50	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
160.00	194.00	34.00	Granite gneiss, white in colour, coarse grain rock cutting, predominates with quartz and feldspar.
194.00	195.00	1.00	Fractured granite gneiss.
195.00	202.70	7.70	Granite gneiss, white in colour, coarse grain rock cutting, predominates with quartz and feldspar.

LITHOLOG

Unique ID: GD9	EW
Village	Birni (+ 2 High School campus)
Block	Birni
District	Giridih
Latitude	24^0 17’ 09”
Longitude	85^0 55’ 47”
Drilled Depth (mbgl)	202.70

Casing depth (m bgl)	17.62
SWL(m bgl)	--
Discharge (m^3/hr)	Dry
Date / Year	February 2020

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	15.00	15.00	Top soil
15.00	17.50	2.50	Weathered granite gneiss, white in colour, predominating with quartz and feldspar
17.50	32.00	14.50	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
32.00	50.00	18.00	Granite gneiss, deep grey in colour, predominating with biotite.
50.00	56.00	6.00	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
56.00	74.50	18.50	Granite gneiss, deep grey in colour, Predominating with biotite.
74.50	80.50	6.00	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
80.50	105.00	24.50	Granite gneiss, deep grey in colour, Predominating with biotite.
105.00	111.00	6.00	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
111.00	141.50	30.50	Granite gneiss, deep grey in colour, Predominating with biotite.
141.50	148.00	6.50	Granite gneiss, white in colour, powdery rock cutting, hand & compact.
148.00	202.70	54.70	Granite gneiss, deep grey in colour, Predominating with biotite.

LITHOLOG

Unique ID: GD10	EW
Village	Ghutwali (College campus)
Block	Dumri
District	Giridih
Latitude	23^0 57’ 49”
Longitude	86^0 00’ 43”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	17.66
SWL(m bgl)	--
Discharge (m^3/hr)	Dry
Date / Year	March 2020

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	13.00	13.00	Top soil
13.00	17.50	4.50	Slightly weathered granite gneiss
17.50	117.00	99.50	Granite gneiss, deep grey in colour, Predominating with biotite.
117.00	129.50	12.50	Granite gneiss, white in colour, predominating with quartz and feldspar
129.50	141.50	12.00	Granite gneiss, grey in colour, Predominating with biotite.
141.50	172.00	30.50	Granite gneiss, white in colour, predominating with quartz and feldspar
172.00	190.00	18.00	Granite gneiss, grey in colour, Predominating with biotite.
190.00	202.70	12.70	Granite gneiss, white in colour, predominating with quartz and feldspar

LITHOLOG

Unique ID: GD11	EW

Village	Ghaghra (Inter Science college)
Block	Bagodar
District	Giridih
Latitude	24.005018
Longitude	85.001069
Drilled Depth (mbgl)	190.50
Casing depth (m bgl)	23.50
SWL(m bgl)	5.10
Discharge (lps)	0.14
Date / Year	June 2020

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	22.00	22.00	Top soil: yellowish brown in colour, sticky nature
22.00	25.00	9.40	Slightly weathered granite gneiss
25.00	26.50	1.50	Granite gneiss – light pink in colour, predominating with feldspar
26.50	27.00	0.50	Slightly fractured and jointed granite gneiss
27.00	47.00	20.00	Granite gneiss – light pink in colour, predominating with feldspar
47.00	62.00	15.00	Granite gneiss – grey in colour, predominating with biotite
62.00	68.50	6.50	Granite gneiss – light pink in colour, predominating with feldspar
68.50	86.50	18.00	Granite gneiss – grey in colour, predominating with biotite
86.50	93.00	6.50	Granite gneiss – light pink in colour, predominating with feldspar
93.00	147.00	54.00	Granite gneiss – grey in colour, predominating with biotite
147.00	150.00	3.00	Granite gneiss – light pink in colour, predominating with feldspar

150.00	160.00	10.00	Granite gneiss – grey in colour, predominating with biotite
160.00	169	9.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
169.00	190.50	21.50	Granite gneiss – grey in colour, predominating with biotite

LITHOLOG

Unique ID: GD12	EW
Village	Khambhra (in front of high school building)
Block	Bagodar
District	Giridih
Latitude	24.102835
Longitude	85.889239
Drilled Depth (mbgl)	186.00
Casing depth (m bgl)	11.70
SWL(m bgl)	4.40
Discharge (lps)	3.40
Date / Year	September 2020

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	11.50	11.50	Top soil: yellowish brown in colour, sticky nature
11.50	24.00	12.50	Moderately weathered granite gneiss
24.00	25.00	1.00	Fractured granite gneiss with quartz vein.
25.00	35.00	10.00	Granite gneiss – light pink to black in colour, predominating with quartz and biotite.
35.00	38.00	3.00	Granite gneiss – light pink in colour, predominating with feldspar
38.00	44.00	6.00	Granite gneiss – light pink to grayish black in colour, predominating with quartz and biotite.
44.00	53.50	9.00	Granite gneiss – light pink to black in colour,

			predominating with quartz and biotite.
53.50	62.50	9.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
62.50	71.50	9.00	Granite gneiss – grey in colour, predominating with biotite
71.50	77.50	6.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
77.50	87.00	9.50	Granite gneiss – light pink to black in colour, predominating with quartz and biotite.
87.00	93.00	6.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
93.00	96.00	3.00	Granite gneiss – grey in colour, predominating with biotit
96.00	128.50	32.50	Granite gneiss – light pink to black in colour, predominating with quartz and biotite.
128.50	129.50	1.00	Slightly fractured granite gneiss, light pink in colour.
129.50	141.50	12.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
141.50	148.00	6.50	Granite gneiss – grey in colour, predominating with biotite
148.00	175.00	27.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
175.00	186.00	11.00	Granite gneiss – light pink to black in colour, predomienating with quartz and biotite.

LITHOLOG

Unique ID: GD13	EW
Village	Ambadih
Block	Bagodar
District	Giridih
Latitude	24.113570
Longitude	85.863742
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	17.80

SWL(m bgl)	17.00
Discharge (lps)	0.14
Date / Year	2020 - 21

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	11.50	11.50	Top soil: yellowish brown in colour, sticky nature
11.50	24.00	12.50	Moderately weathered granite gneiss
24.00	25.00	1.00	Fractured granite gneiss with quartz vein.
25.00	35.00	10.00	Granite gneiss – light pink to black in colour, predominating with quartz and biotite.
35.00	38.00	3.00	Granite gneiss – light pink in colour, predominating with feldspar
38.00	44.00	6.00	Granite gneiss – light pink to grayish black in colour, predominating with quartz and biotite.
44.00	53.50	9.00	Granite gneiss – light pink to black in colour, predominating with quartz and biotite.
53.50	62.50	9.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
62.50	71.50	9.00	Granite gneiss – grey in colour, predominating with biotite
71.50	77.50	6.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
77.50	87.00	9.50	Granite gneiss – light pink to black in colour, predominating with quartz and biotite.
87.00	93.00	6.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
93.00	96.00	3.00	Granite gneiss – grey in colour, predominating with biotit
96.00	128.50	32.50	Granite gneiss – light pink to black in colour, predominating with quartz and biotite.
128.50	129.50	1.00	Slightly fractured granite gneiss, light pink in colour.
129.50	141.50	12.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact

141.50	148.00	6.50	Granite gneiss – grey in colour, predominating with biotite
148.00	175.00	27.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
175.00	186.00	11.00	Granite gneiss – light pink to black in colour, predomienating with quartz and biotite.

LITHOLOG

Unique ID: GD14	EW
Village	Sariya Inter College
Block	Sariya
District	Giridih
Latitude	24.150555
Longitude	85.874722
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	17.60
SWL(m bgl)	--
Discharge (lps)	3.40
Date / Year	December 2020

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	9.50	9.50	Top soil: yellowish brown.
9.50	12.50	3.00	Moderately weathered granite gneiss
12.50	86.00	73.50	Granite gneiss – grey in colour, predominating with biotite, hard & compact
86.00	147.00	61.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
147.00	155.00	8.00	Granite gneiss – white to black in colour, predominating with quartz and biotite.
155.00	156.00	1.00	Fractured granite gneiss
156.00	166.00	10.00	Granite gneiss – white to black in colour, predominating

			with quartz and biotite.
166.00	178.00	12.00	Granite gneiss – grey in colour, predominating with biotite.
178.00	182.00	4.00	Granite gneiss – white to black in colour, predominating with quartz and biotite.
182.00	182.50	0.50	Fractured granite gneiss
182.50	196.50	14.00	Granite gneiss – white to black in colour, predominating with quartz and biotite.
196.50	202.70	6.20	Granite gneiss – grey in colour, predominating with biotite.

LITHOLOG

Unique ID: GD15	OW
Village	Sariya Inter College
Block	Sariya
District	Giridih
Latitude	24.150555
Longitude	85.874722
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	17.65
SWL(m bgl)	--
Discharge (lps)	3.40
Date / Year	February 2021

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	14.00	4.50	Top soil: yellowish brown.
14.00	56.00	42.00	Granite gneiss – grey in colour, predominating with biotite, hard & compact
56.00	59.00	3.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact

59.00	83.50	24.50	Granite gneiss – grey in colour, predominating with biotite, hard & compact
83.50	132.50	49.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
132.50	138.50	6.00	Granite gneiss – grey in colour, predominating with biotite, hard & compact
138.50	151.00	12.50	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
151.00	172.00	21.00	Granite gneiss – grey in colour, predominating with biotite.
172.00	189.00	17.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
189.00	190.00	1.00	Fractured granite gneiss
190.00	202.70	12.70	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact

LITHOLOG

Unique ID: GD16	EW
Village	Nawadih
Block	Sariya
District	Giridih
Latitude	24.197373
Longitude	85.898618
Drilled Depth (mbgl)	184.40
Casing depth (m bgl)	25.30
SWL(m bgl)	8.55
Discharge (lps)	5.70
Date / Year	March 2021

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	20.00	20.00	Top soil: yellowish brown in colour, sticky nature

20.00	25.00	5.00	Granite gneiss – light pink colour, predominating with quartz and feldspar, highly fractured.
25.00	32.00	7.00	Granite gneiss – white in colour, predominating with quartz and feldspar
32.00	59.50	27.50	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
59.50	68.50	9.00	Granite gneiss – grey in colour, predominating with biotite,
68.50	80.50	12.00	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
80.50	99.00	18.50	Granite gneiss – grey in colour, predominating with biotite,
99.00	117.00	18.00	Granite gneiss – grey in colour, predominating with biotite.
117.00	135.50	18.50	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
135.50	142.00	6.50	Granite gneiss – white in colour, predominating with quartz and feldspar
142.00	144.50	2.50	Fractured granite gneiss
144.50	147.50	3.00	Granite gneiss – white in colour, predominating with quartz and feldspar
147.50	154.00	6.50	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
154.00	184.40	30.40	Granite gneiss – grey in colour, predominating with biotite.

LITHOLOG

Unique ID: GD17	OW
Village	Nawadih
Block	Sariya
District	Giridih
Latitude	24.197373
Longitude	85.898618

Drilled Depth (mbgl)	62.40
Casing depth (m bgl)	20.20
SWL(m bgl)	8.11
Discharge (lps)	4.50
Date / Year	March 2021

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	20.00	20.00	Top soil: yellowish brown in colour, sticky nature
20.00	25.00	5.00	Granite gneiss – light pink colour, predominating with quartz and feldspar, highly fractured.
25.00	44.00	19.00	Granite gneiss – grey in colour, biotite predominating, hard & compact
44.00	56.50	12.50	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
56.50	62.40	5.90	Granite gneiss – grey in colour, predominating with biotite,

LITHOLOG

Unique ID: GD18	EW
Village	Bagra Khurd
Block	Birni
District	Giridih
Latitude	24.23353
Longitude	85.90391
Drilled Depth (mbgl)	191.50
Casing depth (m bgl)	20.70
SWL(m bgl)	--
Discharge (lps)	0.45
Date / Year	April 2021

Depth range (m bgl)		Thickness (m)	Litholog
From	To		
0.00	13.50	13.50	Top soil: yellowish brown in colour, sticky nature
13.50	20.50	7.00	Weathered granite gneiss
20.50	30.00	9.50	Granite gneiss – white in colour, predominating with quartz and feldspar
30.00	42.00	12.00	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
42.00	43.00	1.00	Fractured granite gneiss
43.00	47.00	4.00	Granite gneiss – white in colour, predominating with quartz and feldspar
47.00	123.00	76.00	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
123.00	126.50	3.50	Granite gneiss – white in colour, predominating with quartz and feldspar
126.50	132.50	6.00	Granite gneiss – grey in colour, predominating with biotite.
132.50	135.50	3.00	Granite gneiss – white in colour, predominating with quartz and feldspar
135.50	142.00	6.50	Granite gneiss – grey in colour, predominating with biotite.
142.00	154.00	12.00	Granite gneiss – white in colour, predominating with quartz and feldspar
154.00	160.00	6.00	Granite gneiss – grey in colour, predominating with biotite.
160.00	163.00	3.00	Granite gneiss – white in colour, predominating with quartz and feldspar
163.00	178.00	15.00	Granite gneiss – grey in colour, predominating with biotite.
178.00	184.50	6.50	Granite gneiss – white in colour, predominating with quartz and feldspar
184.50	191.50	7.00	Granite gneiss – grey in colour, predominating with biotite.

LITHOLOG

Unique ID: GD19	EW
Village	Dabarsaini
Block	Birni
District	Giridih
Latitude	24.29241
Longitude	85.95729
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	17.65
SWL(m bgl)	--
Discharge (lps)	Dry
Date / Year	August 2021

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	4.00	4.00	Top soil: yellowish brown in colour, sticky nature
4.00	13.50	9.50	Weathered granite gneiss
13.50	114.00	100.50	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
114.00	117.00	3.00	Granite gneiss – white in colour, predominating with quartz and feldspar
117.00	123.50	6.50	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
123.50	138.50	15.00	Granite gneiss – white in colour, predominating with quartz and feldspar
138.50	160.00	21.50	Granite gneiss – grey in colour, biotite predominating with quartz and feldspar associated
160.00	202.70	42.70	Granite gneiss – white in colour, predominating with quartz and feldspar

Annexure – IX

DATA OF SOIL INFILTRATION TEST

Unique ID: SIT/GD-1	Ghaghra
Date	18/03/2020
Location	Ghaghra Inter Science College, Ghaghra
Block	Bagodar
District	Giridih
Latitude	24^0 04’ 15”
Longitude	85^0 51’ 39”
Initial Water level (mm)	146
Geology	Granite Gneiss
Final infiltration rate (mm/hr)	22.8

Sr.No.	Clock time	Time interval (min.)	Cumulative time (min.)	Water level depth (mm)	Infiltered water depth (mm)	Infiltration rate (mm/min.)	Infiltration rate (mm/hr)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	13.32	2	2	139	7	3.5	210
2	13.34	2	4	137	9	2.25	135
3	13.36	2	6	135	11	1.83	109.8
4	13.38	2	8	134	12	1.50	90
5	13.40	2	10	132	14	1.40	84
6	13.45	5	15	130	16	1.07	64.2
7	13.50	5	20	128	18	0.90	54
8	13.55	5	25	127	19	0.75	45
9	14.00	5	30	126	20	0.66	39.6

10	14.05	5	35	125	21	0.60	36
11	14.10	5	40	124	22	0.55	33
12	14.15	5	45	122	24	0.53	31.8
13	14.20	5	50	121	25	0.50	30
14	14.25	5	55	119	27	0.49	29.4
15	14.30	5	60	117	29	0.48	28.8
16	14.35	5	65	115	31	0.48	28.8
17	14.40	5	70	113	33	0.47	28.2
18	14.45	5	75	111	35	0.47	28.2
19	14.50	5	80	109	37	0.46	27.6
20	14.55	5	85	107	39	0.46	27.6
21	15.00	5	90	106	40	0.44	26.4
22	15.05	5	95	105	41	0.43	25.8
23	15.10	5	100	104	42	0.42	25.2
24	15.15	5	105	103	43	0.41	24.6
25	15.20	5	110	102	44	0.40	24
26	15.25	5	115	101	45	0.39	23.4
27	15.30	5	120	100	46	0.38	22.8