केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

GODDA DISTRICT, JHARKHAND

राज्य एकक कार्यालय, रांची

State Unit Office, Ranchi

भारतसरकार

Government of India

जल शक्ति मंत्रालय

Ministry of Jal Shakti

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

Department of Water Resources, River Development & Ganga Rejuvenation

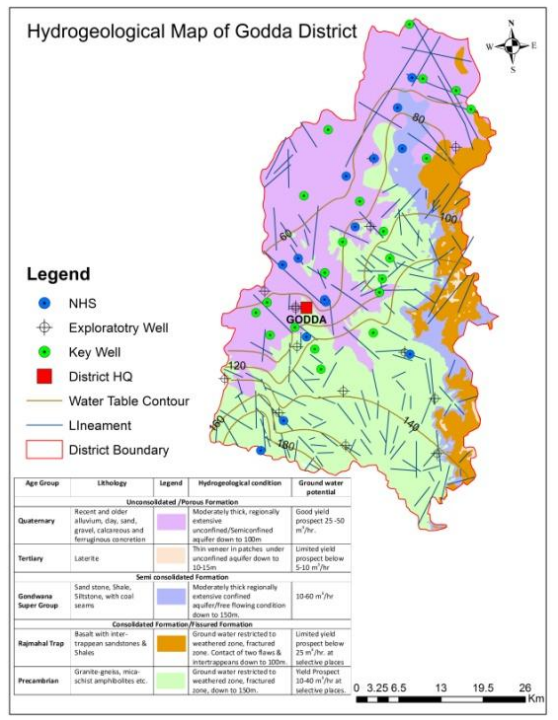
केन्द्रीय भूमि जल बोर्ड

Central Ground Water Board

Aquifer Maps and Ground Water Management Plan of Godda district, Jharkhand(2018-19)

जलभृत नक्शे तथा भूजल प्रबंधन योजना

गोड्डा जिला,झारखण्ड (2018-19)



Principal Authors

(Dr. Anukaran Kujur, Scientist-B &

Dr. Sudhanshu Shekhar, Scientist-D)

राज्य एकक कार्यालय, रांची

मध्य- पूर्वी क्षेत्र, पटना, 2020

State Unit Office, Ranchi

Mid- Eastern Region, Patna, 2020

REPORT ON AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN OF GODDA DISTRICT, JHARKHAND 2018 – 19(PART – I)

CONTRIBUTORS LIST

Principal Author

Dr. Anukaran Kujur	:	Assistant Hydrogeologist
Dr. Sudhanshu Shekhar		Scientist-D

Supervision & Guidance

A.K.Agrawal	:	Regional Director
G. K. Roy		Officer-In- Charge

Hydrogeology, GIS maps and Management Plan

Dr. AnukaranKujur	:	Assistant Hydrogeologist
Atul Beck	:	Assistant Hydrogeologist
Sunil Toppo	:	Junior Hydrogeologist

Hydrogeological Data Acquisition and Groundwater Exploration

Dr. AnukaranKujur	:	Assistant Hydrogeologist
Atul Beck	:	Assistant Hydrogeologist
Sunil Toppo	:	Junior Hydrogeologist

Geophysics

B. K. Oraon	:	Scientist-D

Chemical Analysis

Suresh Kumar	:	Assistant Chemist

REPORT ON AQUIFER MAPS AND MANAGEMENT PLAN OF GODDA DISTRICT, JHARKHAND STATE 2018 - 19 (PART – I)

CONTENTS

List of tables

List of figures

List of Annexures

(PART – I)

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN OF GODDA DISTRICT, JHARKHAND STATE (2018-19)

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 implement table 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 studies of Godda district have been taken up in AAP 2018-19 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Godda 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:

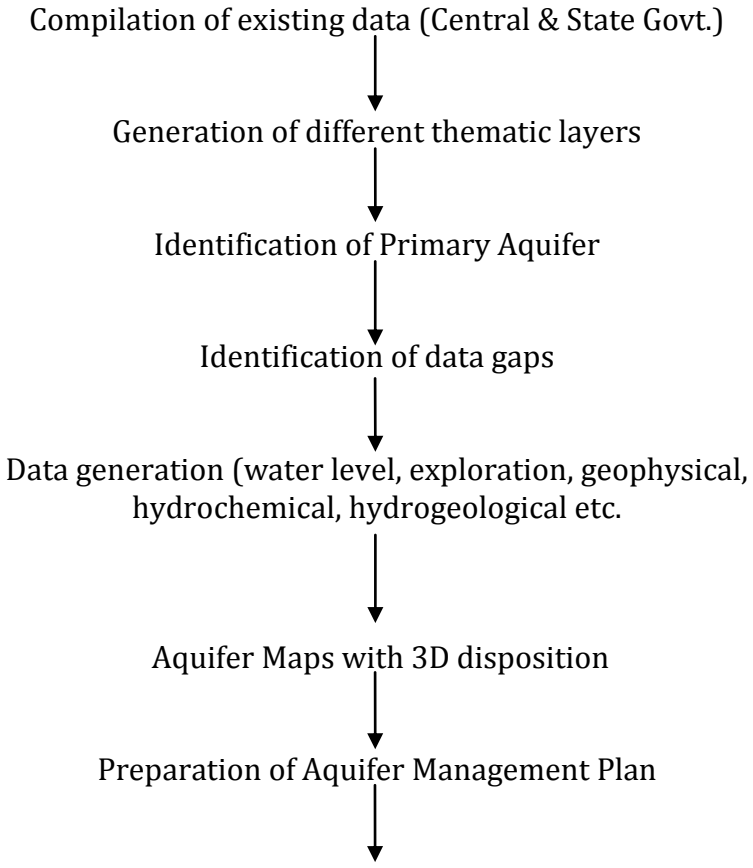
a). Identifying the aquifer geometry
b). Aquifer characteristics and their yield potential
c). Quality of water occurring at various depths
d). Aquifer wise assessment of ground water resources
e). Preparation of aquifer maps and
f). Formulate ground water management plan.

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 Aquifermapping is as given below:



1.3 Area Details: The district Godda was taken for aquifer mapping study during 2018-19. The district is spread over 2111 Sq. km of geographical area. Godda district is situated in the north–eastern part of the Jharkhand state. It is bounded in the north and west by Bhagalpur district of Bihar state, in the east by Sahebganj and Pakur districts and in the south by Godda district. The district is situated between 24^0 30' 25"and 25^0 14' 00" North latitude and 87^0 03' 04" and 87^0 30' 12" East longitude. The district covers Survey of India toposheets nos. 72 O/4, 72 O/8, 72 O/12, 72 P/5, 72 P/1, 72 P/2, 72 P/5 and 72 P/6. The district has two sub-divisions i.e. Godda and Mahagama and nine blocks namely – Godda, Basantrai, Boarijore, Mahagama, Meharma, Pathargama,

Thakurghanti, Sundarpahari and Poreyahat (Fig. 1). Total population of the district is 1313551 (as per census of 2011) with rural population 1249132 and urban population 64419. The location map of the study area is shown in figure – 1.

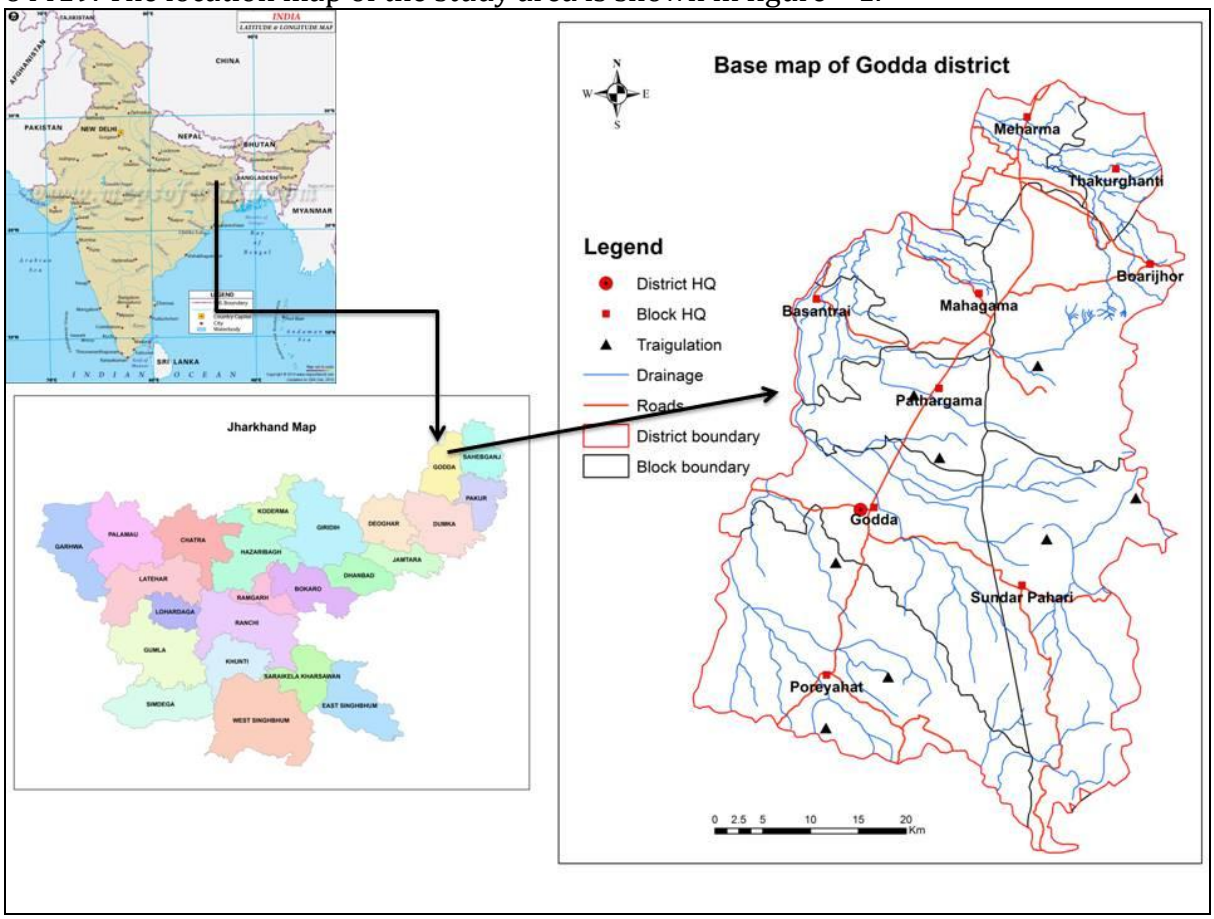


Figure 1: Location map of Godda district

Table-1: Block wise Area of Godda District, Jharkhand

Sr. No.	Block	Area in (Hectare)
1	Basantrai	8887
2	Boarijor	34390
3	Godda	35530
4	Mahagama	15955
5	Meherma	12963
6	Pathargama	15256
7	Poreyahat	47005
8	Sunderpahari	32679
9	Thakurghanti	8444
Total		**211109**

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 13 exploratory and 12 observation wells hard rock formation by departmental rig during the year 1990-97. One exploratory wells and one observation well was drilled at village Mohala in Gondwana formation in 2019. In addition, eleven numbers of permanent observation well (HNS) of Central Ground

Water Board located in the district are being monitored for 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, Mid–Eastern Region, Patna, 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 has been compiled. The summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations are given in table–2.

Table – 2: Data adequacy and data gap analysis

Exploratory data			**Geophysical data**			**GW monitoring data**			**GW quality data**		
Req.	**Exist.**	**Gap**	**Req.**	**Exis.**	**Gap**	**Req.**	**Exist.**	**Gap**	**Req.**	**Exis.**	**Gap**
25	13	12	75	0	75	30	39	0	30	39	0

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 2018-19.

1.5 Climate and Rainfall: The district is characterized by humid to sub-humid climate. During summer the hot spell prevails from March to middle of June. Rainy season starts from middle of June to middle & end of October. Winter starts from the middle of November and continues till the end of February. The district experiences great heat from March to May, when the maximum temperature reaches upto 44.4^0c. December is the coldest month, when the minimum temperatures fall down to 6.8^0c.

The area receives rainfall by South-West monsoon. The blockwise average monsoon rainfall (2008 to 2017) of the district varies from 412 to 1222.10 mm. (rainfall data of Basantrai is available only 3years). The rain fall data for the period of 2008 – 2017 has been analyzed for average annual monsoon rainfall, standard deviation and coefficient of variation which are given in table – 3.

Table – 3: Analytical data of monsoon rainfall (2008 – 2017) of Godda district

Sr. No.	**Block**	**Average monsoon rainfall**	**Standard deviation**	**Coefficient of variation (%)**
1	Godda	1059.83	348.0715	32.84
2	Pathargama	1037.80	259.06	24.96
3	Mahagama	944.84	465.5144	45.1752
4	Meherma	474.66	235.58	44.66
5	Thakurghanti	858.14	225.63	26.29
6	Boarijor	797.42	431.527	54.11
7	Sunderpahari	1112.86	361.98	30.05
8	Poreyahat	722.43	308.75	42.739
9	Basantrai	412.00	232.1034	56.335

1.6 Physiography: The predominant physical feature over major part of the district is the rolling topography dotted with isolated inselbergs except in the Boarijor and Sundarpahari blocks. A substantial part of Boarijore and Sundarpahari block is under forest cover. The altitude of the land surface increases from west to the east. The major hills are confined to the eastern part of the district comprising the Gandeshwari Pahar (238.41m) and Kesgari Pahar (268.29m) while in the western part of the district isolated hills occur in the form of the inselbergs and other small hillocks. The Digital elevation model of Godda district has been presented in Figure-2

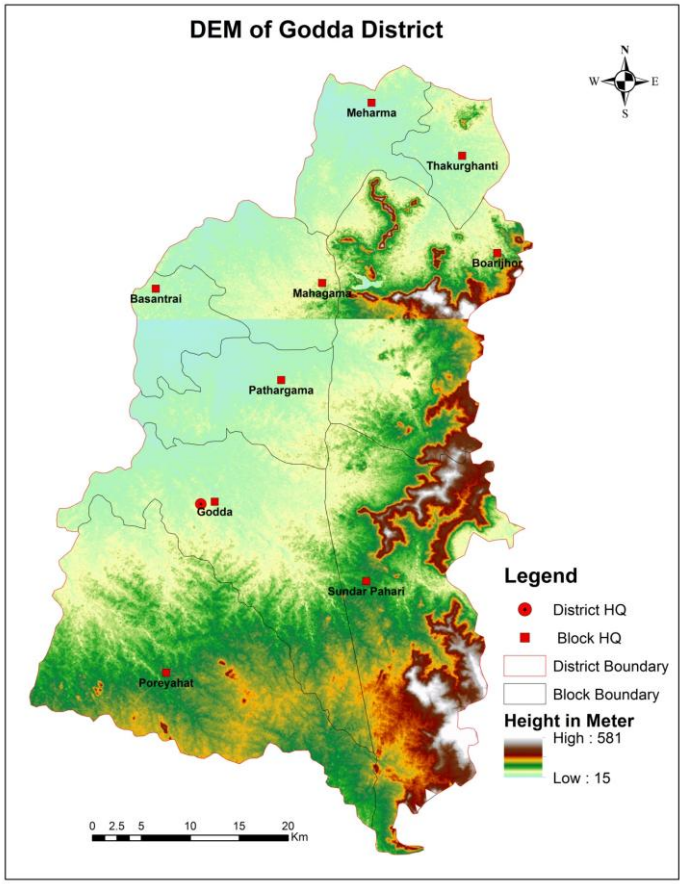


Figure – 2: Digital elevation model of Godda district

1.7 Geomorphology:

Geomorphologically (GSI, 2009) the southern part of the district represents the northerm most extremities of Chhotanagpur plateau and comprises rolling plains woth isolated hills in the form of tors, inselburgs, small hillocks, ridges and mound. The central part of the area is covered by gently sloping undulatory hills. The northermn part is represented by a more or less flat land with gently northerly slope. Brigeria river drains the area along the western margin of the district and is fed by the tributaries like Harna and other streams flowing westerly to northwesterly.

Based on visual interpretation of Landsat imageries, the various hydrogeomorphic features in the district are:-

i) **Alluvial plain: -** These are loam to sandy loam deposited over gneissic surface. The streams in this area show structural control. The ground water potential is very good.

ii) **Older alluvial plain: -** These are characterized by sandy loam at the top with highly oxidized sandy and gravelly horizons at moderate depth.

iii) **Burried pediment (Gneissic):-** These are gently slopping broad surface of weathered gneiss overlain by alluvium and colluviums of medium texture. Many prominent lineaments are occurring in this area. The ground water condition is good to moderate.

iv) **Burried pediment (Volcanic):-** This surface is mainly pediment cut out Rajmahal trap rock concealed under a thick pile of alluvium gravelly weathered soil.

v) **Pediment (Volcanic):-** The underlying lithology is basaltic rocks with thin veneer of fine soil. These are highly fractured.

vi) **Pediment (Sedimentary):-** These consist of mainly sand stone and shale as underlying rocks.The stratas are gently dipping with local small scale faulting.

vii) **Pediment (Gneissic):-** Thes are highly fractured region with gneiss and schist as the underlying rocks.

viii) **Denudational hills (Volcanic):-** Rajmahal traps are the mail rock constituting these hills.

ix) **Denudational hills (Gneissic):-**These are low hill groups with high rugged topography with gneiss as underlying lithology.

x) **Denudational hills (Sedimentary):-** These are hills of moderate height made up of horizontal gently dipping sand stone and shales.

xi) **Low dissected hills (Gneissic):-** The hills of low height mainly composed of gneissic rocks.

xii) **Low dissected hills (Sedimentary):-** An elevated tract with sand stones and shales as dominant rock types.

xiii) **Structural Ridge (Gneissic):-** These are long narrow ridges of low height with gneiss as the dominant rock types.

The geomorphological map of Godda district have been presented in Fig-3

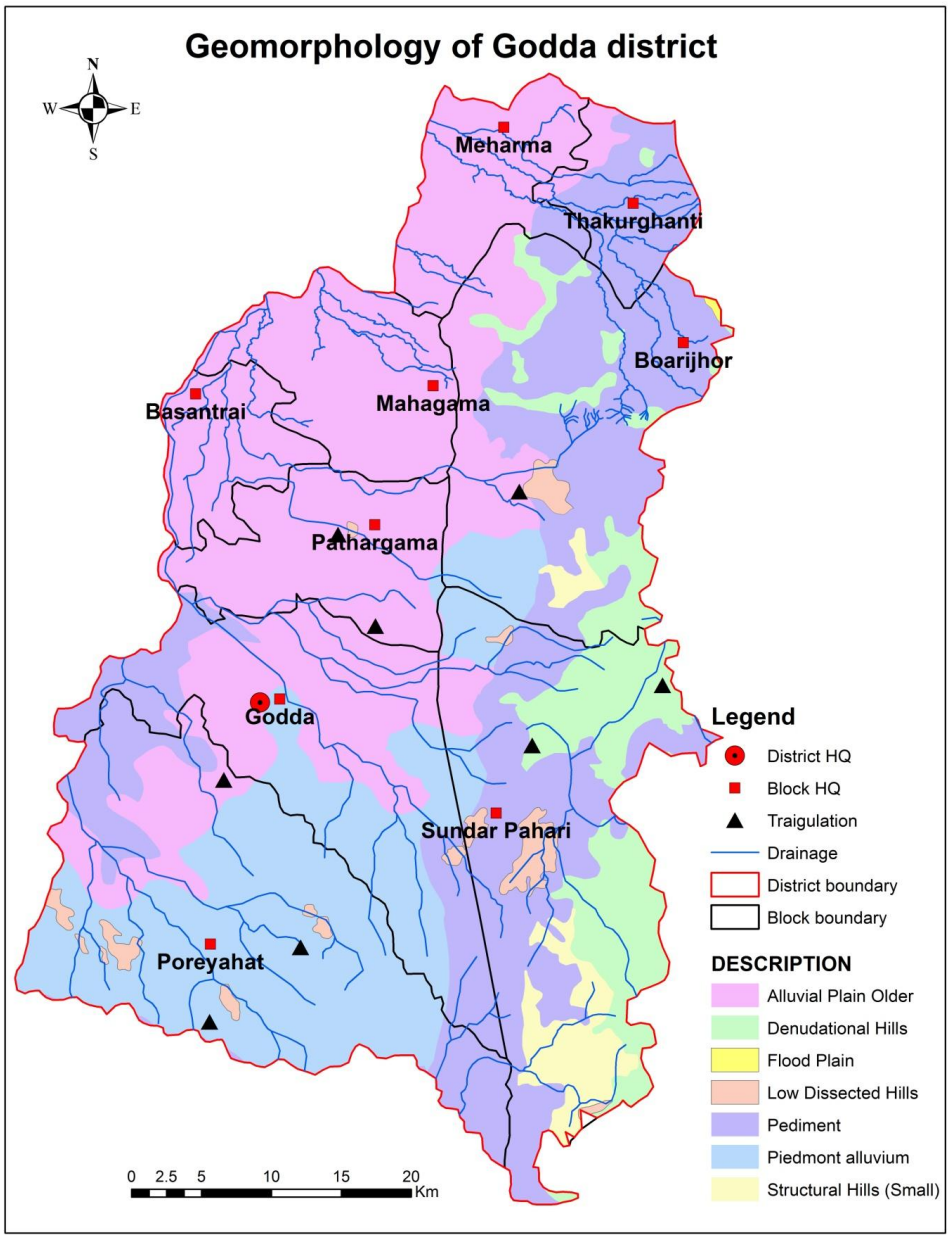


Figure – 3: Geomophology of Godda district

1.8 Land Use: Socio-economics as well as political factors have significant influence over land use pattern. Out of total geographical area of the district i.e 2111 Sq. km, nearly 33 % area comes under net sown area, 11% under forests and the rest area falls under barren, cultivable waste, pasture and other agricultural use. Bulk of the forest are confined to Boarijore and Sunderpahari blocks of the district, mainly along the slopes and foothills of Santhal Pargana and Rajmahal plateau. The land use pattern data of the area for the year 2015 – 16 is given below in table-4. The Land use map of the Godda district has been prepared and shown in figure – 4.

Table: 4: Land use pattern of Godda district (2014– 2015)

(Figure: in Hactare)

District	Total area	Forest land	Barren & non agricul-turable Land	Cultiva-ble waste land	Permanent pastures & other grassing land	Land under miscella-neous trees	Current fallow	Fallow land other than current fallow	Net area sown
Godda	211142	23671	38336	9267	6256	5893	54644	22201	69312

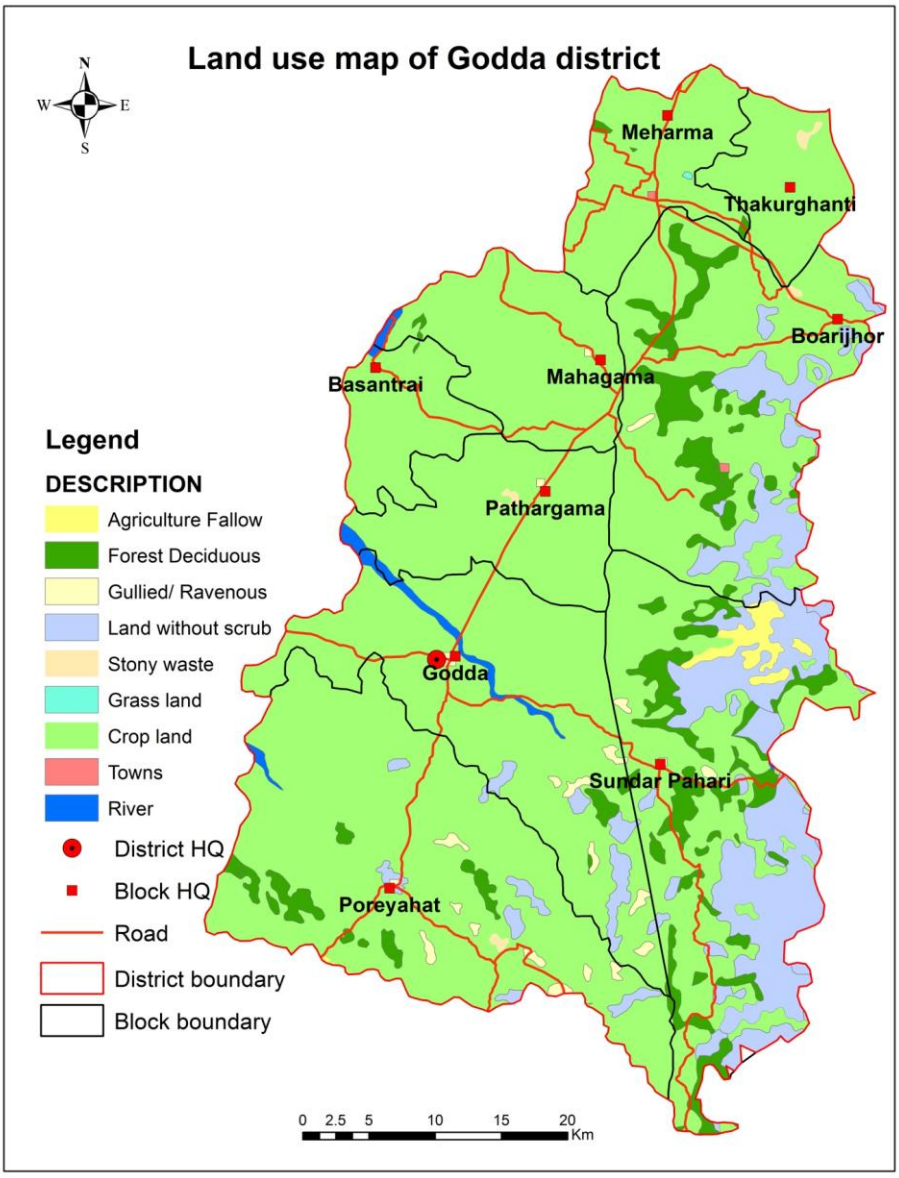


Figure – 4: Land Use Map of Godda district

1.9 Soil: The area is characterized by the following type of soils –

(i) Old Alluvium -Grey-Greyish Yellow heavy textured cracking Soil
(ii) Old Alluvium Reddish yellow-yellow- grey catenary soil
(iii) Old Alluvium –Yellowish - red-yellow Soils of foot hill
(iv) Hill & Forest Soils of steep slopes and highly desected region
(v) Red Yellow light grey Catenary soils
(vi) Yellow –Red, Yellow –blacksoils Catenary soils of Rajmahal

- **Old alluvium-Grey-Greyish Yellow heavy textured cracking Soils:-** These are greyish yellow to grey in colour, medium to heavy in texture, neutral to slightly alkaline in reactions, cracks in drying, very weakly developed profiles.
- **Old alluvium Reddish yellow-yellow- grey catenary soil:-** The well drained soils are strongly to moderately acidic containing ferruginous concretations. The poorly drained low land soils area greish in colour, slightly acidic to slightl alkaline in reaction containing ferruginous concritions in most of the cases showing a tendency to crack during dry months.
- **Old alluvium yellowish - red-yellow soils of foot hill:-** These soils resemble the siols of old alluvium reddish yellow, yellow-grey catenary excepting frequent extensive saline and alkali patches. Carbonates are present throughout the soil. Clay minerals found in soils are hydrous mica, kaolinite, chlorites etc.
- **Hill & Forest Soils of steep slopes and highly desected region:-** These are shallow to medium deep over rocks and regoliths, well drain to excessively well drained, very strongly to moderately acidic, light textured gravelly or stony covered with forest of various kind with few cultivated patches.
- **Red Yellow - light grey Catenary soils:-** Slopy and upland soils are well drained generally stongly to moderate acidic shallow to medium deep over rocks and morums. The low land valley soils are poorly drained, neutral to slightly alkaline, fairly deep and most fertile soils.
- **Yellow–Red, Yellow–blacksoils Catenary soils of Rajmahal: -** Soils developed on granites are red or yellow coloured depending upon their topographical positions. Soils developed on trap rocks are grey, heavy textured, neutral to lightly alkaline in reaction, sandy loam to loam on top and heavier below, slightly to moderate acidic and medium fertiliyty. Soil map of Godda district is given below figure – 5.

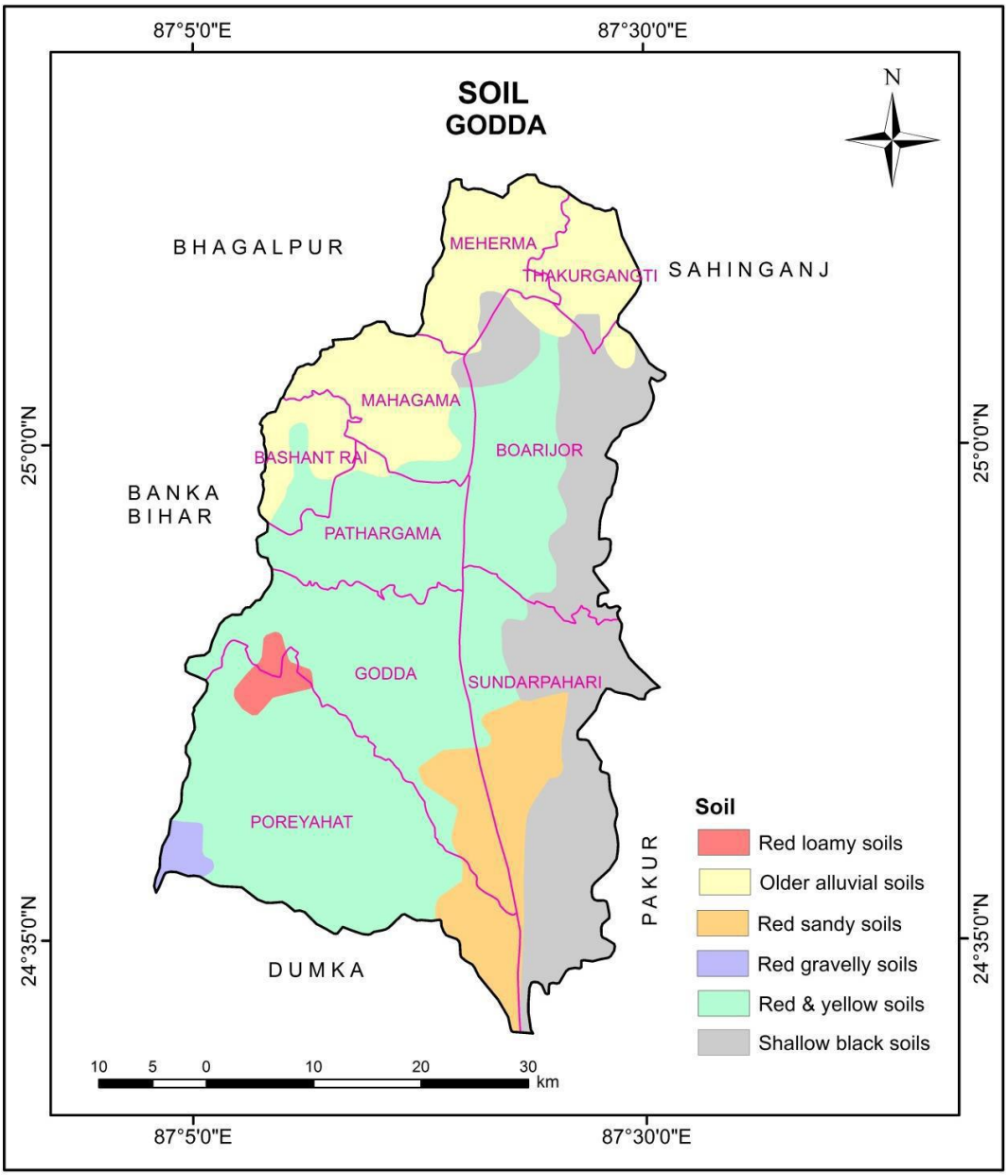


Figure 5 : Soil Map Godda (Source: Geological Survey of India, District Survey Report of Minor Minerals, Godda.)

1.10 Hydrology and Drainage:

The principal rivers of the district are Kajhia, Burigeria , Harna, Sunder, Sapin, Kao, Cheer, Gerua, Gumani, Bansloi and their tributaries. Most of these are ephemeral in character. The general trend of the drainage is SE-NW. (Drainage Map-Fig-6). The structural features particularly the foliation and joints exert profound impact upon the drainage and control the drainage pattern of the district. In the district irrigation potential for about 8600 hectare hs been created from Bateshwar Ganga pump canal projects (Ganga stem Basin).

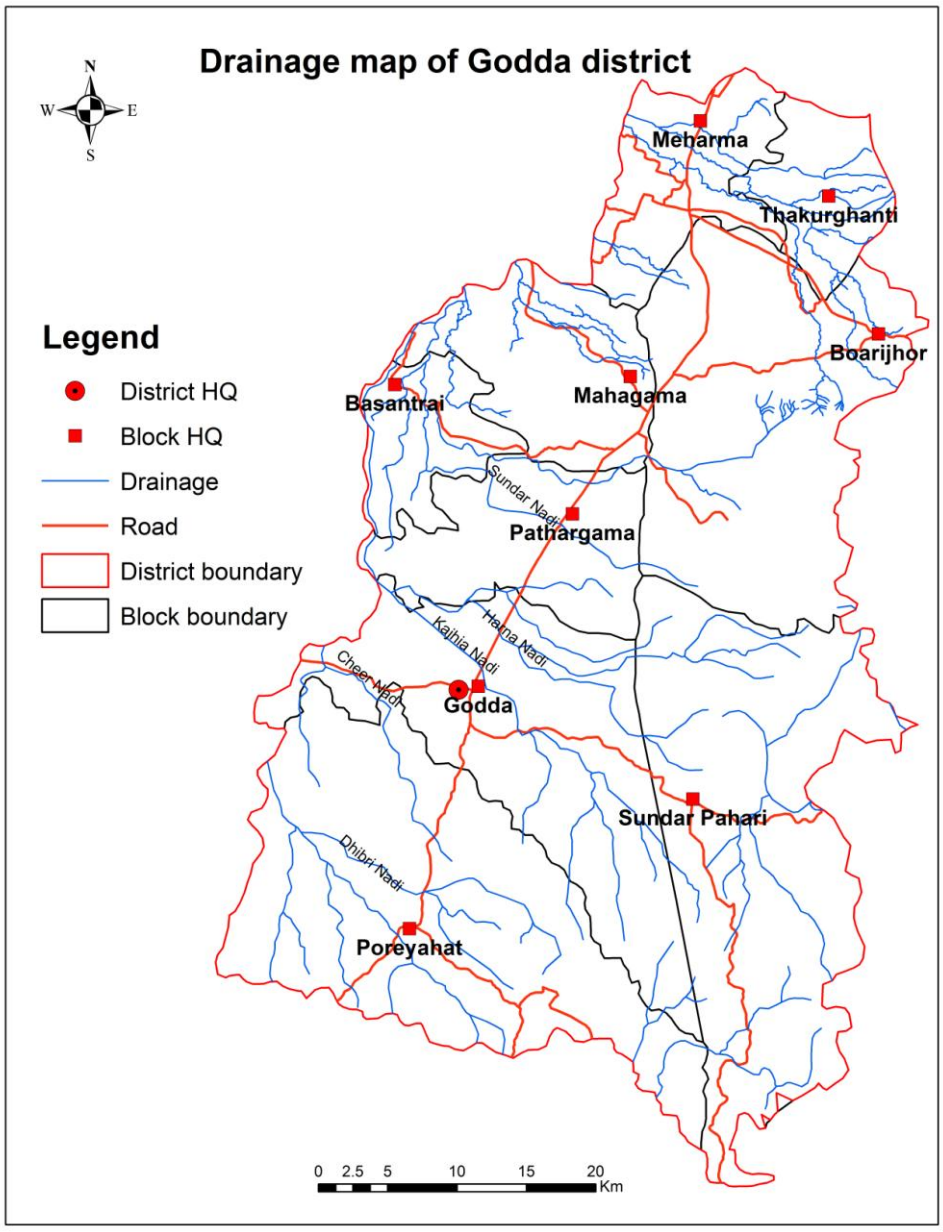


Figure – 6 : Drainage Map of Godda district

1.11 Agriculture and Irrigation Practices:

The local population of the district mostly depends on agriculture and forestry for their sustenance. The agriculture activity of the area is solely dependent upon the monsoon rainfall. Paddy is the main crop of the district. Wheat, Maize, Gram, Mustard oil Potato are other crops grown widely in Godda and its adjoining areas. Irrigational facilities are not adequate in this district. The most common 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 except in small pockets. Minor irrigation structures like surface water, tanks and ponds are the other source for irrigation. Available source wise irrigation for the 2012-13 is given in table - 5.

Table 5: Details of source wise irrigation of district (2012-13)

Block	Surface water			Ground water			Other sources
	Canal	Tank	LI	DTW	STW	DW	
Basantrai	0	67	0	226	0	19	0
Boarijor	0	172	17	695	0	1	72
Godda	0	177	1	1201	0	0	20
Mahagama	0	80	20	411	0	0	19
Meherma	0	65	20	382	6	0	28
Pathargama	0	104	0	498	0	24	14
Poreyahat	0	234	0	1556	8	4	23
Sunderpahari	0	163	16	518	7	0	42
Thakurghanti	0	42	5	563	16	0	12
Total	**0**	**1104**	**79**	**6050**	**37**	**48**	**230**

1.12 Cropping Pattern:

The major crops cultivated in the area are paddy, wheat, maize, gram, oil seeds, pulses and vegetable. But the land available for cultivation is very limited because of the hilly and rugged topography. Area under different crops for the year 2015 – 16 of the district is presented in table – 6.

Table – 6: Cropping pattern of Godda district (2015-16)

(Area in hectare)

Block	Major Crops					
	Paddy	Wheat	Gram	Maize	Mustard	Potato
Godda	**30200**	1992	1097	2540	1465	81
Pathergama		1926	1239	1621	1591	32
Mahagama		2946	1166	883	1493	12
Meherma		1593	872	596	1174	81
Thakurganti		1385	839	608	1113	101
Boarijore		569	680	1224	1206	4
Sunderpahari		156	522	1212	1032	18
Poraiyahat		956	769	2157	915	243
Total	**30200**	**13515**	**8281**	**13381**	**11454**	**572**

2. DATA COLLECTION AND 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 Data collection and Compilation:

The data collection and compilation for various components was carried out as given below

i. Hydrogeological Data: Water level data of 21 key wells were collected and historical water level trend of monitoring wells compiled representing Aquifer-I.

ii. Hydrochemical Data: To evaluate the quality of ground water, 39 samples were collected from dug wells.

iii. Exploratory drilling**:** 13 exploratory and 10 observation wells are existing in hard rock area and 1 exploratory well and 1 observation well were drilled in (Gondwana Formation) through departmental rigs.

iv. Hydrometeorological Data: Last ten years (2008 – 2017) monsoon rainfall data for each of the block from the office of District Agriculture Department, Godda.

v. Land use and cropping pattern data**:** The data of land use and cropping pattern obtained from the office of Director Statistics, Ranchi.

2.2 Data Generation:

After taking into consideration, the data available with CGWB on ground water monitoring wells (GWMW), ground water quality, geophysical survey and ground water exploration, the data adequacy was compiled. The requirement, availability and gap of major data inputs i.e., exploratory wells, geophysical data, ground water monitoring wells and ground water quality data are detailed in the table – 2.

2.2.1 Ground water Monitoring Wells: 21 key wells were established and 15 NHNS monitored to assess the ground water scenario of shallow aquifer (Aquifer-I) of the area. The depth of these dug well varies from 2.10 to 13.00 mbgl. Similarly, the diameters of key wells (dug wells) ranges from 1.60 to 4.80 m. During 2018, the pre monsoon (May) depth to water level in these wells was between 2.80 to 12.10 mbgl. The post monsoon depth to water level (Nov. 2018) in the dug wells ranges from 2.00 to 10.33 mbgl. Average pre-monsoon water level was calculated 6.32 mbgl and in post monsoon 4.33 mbgl respectively. A detail of key wells and water level data is presented in Annexure – I & II. Location of key wells and exploratory wells are shown in figure –7.

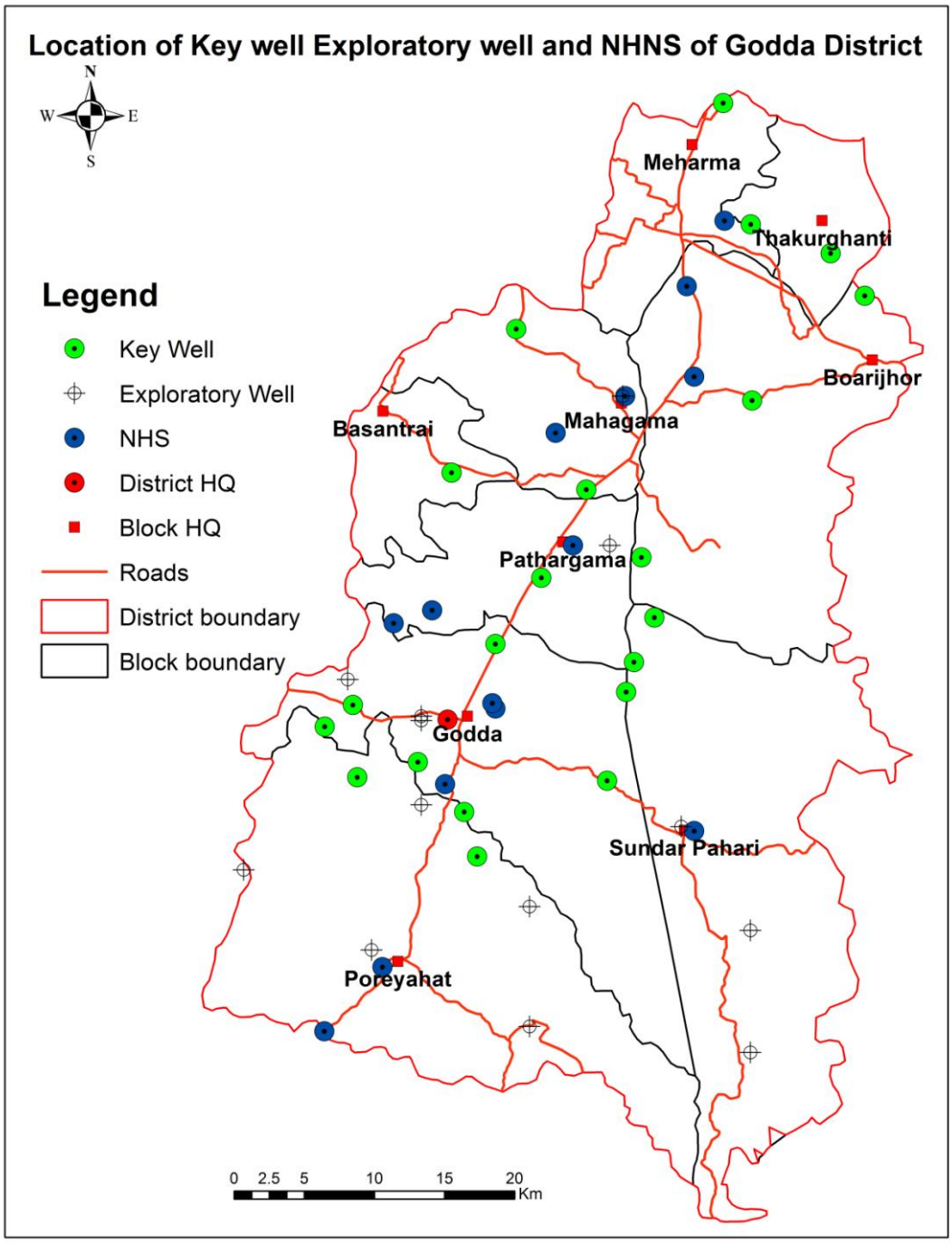


Figure – 7: Location of key wells NHNS and exploratory wells

2.2.2 Ground Water Exploration: On perusal of table- 1, exploratory well drilling in Meharma and Thakurghanti blocks is required. Accordingly additional data generation to be undertaken in hard rock & soft rock area to assess the lithological disposition of shallow aquifer (Aquifer-I) and deeper aquifer (Aquifer-II). The details of exploratory and observation wells are given in Annexure-III A & IV.

2.2.3 Ground Water Quality: To assess the quality of ground water, 39 samples were collected from dug wells representing Aquifer – I

2.2.4 Geophysical Survey: at least 75 VES is required in the district each block of Godda district.

2.2.5 Micro Level Hydrogeological Data Acquisition

In addition to the Hydrograph Monitoring Wells, micro level hydrogeological data was also acquired for deciphering the sub-surface lithological disposition, water level scenario and other hydrogeological inputs such as weathered thickness etc., of shallow aquifer (Aquifer-I). Thus 21 wells in the district were inventoried for micro level data acquisition. The details of dugwells inventoried for micro-level data acquisition are given in Annexure-II&III.

2.2.6 Thematic Layers: The following thematic layers were also generated which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

1. Drainage
2. Geomorphology
3. Elevation
4. Land use
5. Geology & structure

The thematic layers such as drainage, geomorphology, DEM and land use have been described in Chapter – I.

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 and as discussed in details.

3.1 Geological set up

Gelogically the study area represents highly deformed Archean gneisses called chotanagpur granite gneissic complex, older meta-sedimentaries, pegmatites, metabasics etc. The pre-Cambrian formations are uncomfortably overlain by lower lower gondawanas comprising Talchirs & Barakar formation. Barakar sandstone and shale contains coal seams found in major coal belt of the area. The upper Gondwana are represented by Dubrajpur formation. Rajmahal traps and intertrappeans overlie the Dubrajpur formation and in places overstep onto Barakar formation and Precambrian basement. Tertiary Laterites occur as capping in some of the parts, while Quaternary sediments represented by Sautadih, Belhar and Diara formation consisting of older and newer alluvium are found in considerable part of the area. A geological map has been prepared in Fig-8.

3.1.1 Stratigraphic Succession:

The general Stratigraphic succession found in Godda district as per GSI, 2009 are as follows:-

Lithology	**Formation**		**Age**
Sand/Silt/Clay admixture	Diara Formation		Late Holocene to Present
	Belhar formation		Middle to Late Holocene
	Sautadih formation/Jamui Formation		Middle Pleistocene to early Holocene
----------EROSIONAL SURFACE----------			
Laterites and lateritic Soil			Cainozoic
----------EROSIONAL SURFACE----------			
Dolerite			Jurrassic to Cretaceous
Basalt with Intertrappeans	Rajmahal Trap		
----------UNCONFORMITY----------			
Sandstone and Shale	Dubrajpur Formation	**Gondwana Super Group**	Triassic to Jurassic
Siltstone, Sandstone and Conglomerate with Coal seams	Barakar Formation		Permian

Shale, Sandstone and Conglomerate	Talchir Formation		Caroniferous to Permian
----------UNCONFORMITY----------			
Intrusive Granite			Proerozoic
----------UNCONFORMITY----------			
Unclassified Metabasics and metasedimentaries	Metamorphics of Chhotanagpur mica belt		Lower to Middle Proterozoic
Unclassified Granite-Gneiss with enclaves of metamorphic, augen Gneiss and Migmatites, Porphyritic Granite Gneiss Granite Biotite Gneiss	Chhotanagpur Gneissic Complex		Archean to Proterozoic
Quartzite and quarz Schist	Unclassified Metamorphics		
Khondalite/Garnet/Sillimanite biotite garnet gneiss, Acid to basic Granulite/Charnockite	Eastern Ghat Super Group		Archean to Proterozoic

3.1.2 Geological formation:-

The Lithological units identified can broadly be divided into:- Precambrian Formation, Gondwana super Group, Rajmahal traps and Quaternary Formations

3.1.2.1 Precambrian Formation:-

The study area comprises of highly deformed and metamorphosed Precambrian terrain. This group consists of

(a) Eastern Ghat Super Group & Chotanagpur gneissic complex
(b) Intrusive granites
(c) Metabasics
(d) Pegmatites/Quartz vein

a) Eastern Ghat Super Group & Chotanagpur gneissic complex

The Oldest rocks of the area are represented by Charnockites, Granite-gneiss, Khondalite, Quartzite, granites and migmatites belonging to Eastern Ghat Super Group and Chotanagpure Gneissic Complex of Archean Age.

Chotanagpur granite-Gneiss represents the extensive plateau region to the south and central part of the study area. These rocks comprise broadly granite-gneiss, porphyritic gneiss, augen gneiss, charnokitic gneiss, migmatites etc. The varieties of one of the most important rock types granite gneisses include biotite granite gneiss, hornblende granite gneiss etc. These are generally medium to coarse grained with prominent gneissic banding and foliation. The presence of foliation in granite gneiss is due to presence flaky minerals like biotite and sillimanite. A considerable area has been occupied by porphyritic gneiss. It has been found in the form of augen gneiss in some of the area, where as in some parts its intrusive relationship with granite gneiss is observed.

b) Intrusive granites:- The Precambrian rocks exhibit several phases of intrusive granites. The non-foliated, pink coloured coarse grained granites occur as Intrusives in all rock types except dolerites.

c) Metabasics:- The metabasics include meta dolerite and metagabbro. The syntectonic basic rocks are represented by meta-dolerite and meta-gabbro shows mostly conformable relationship with the enclosing rocks.

d) Pegmatites/Quartz vein:- All the rocks types described above have been intruded by numerous veins of pegmatites of various dimensions with quartz vein and is found to occur throughout the area. These are generally of crusted nature.

3.1.2.2 Gondwana Super Group:-

The Gondwana super group rocks are confined to the area occupied by the Rajmahal hills and its adjoining areas. Gravity study of Rajmahal hills show that Gondwana supper group sediments were deposited over a rifted and highly faulted sheared margin (Choudhary 1975, Mukhopadhyay 1986). They unconformably overlie the Precambrian formations. In the study area Gondwana super group pf rocks with ages ranging from carboniferous to Triassic is represented by Talchir formation comprising shale, sandstone and Conglomerate; Barakar Formation consisting of siltstone, sandstone and Conlomerate with number of coal seams and Dubrajpur formations containing sandstone ans Shale. Common plant fossils occurring in Barakar shales include Gangamopteris Cyclopteris, Glossopteris indical and Vertebraria indica.

3.1.2.3 Rajmahal Traps:-

Tha Rajmahal hills extend with a north-south trend for more than 120 kms through the districts of Santhal Parganas(including Godda district) in Jharkhand and Birbhum in West Bengal(GSI, 1989). It consists of long flat topped hills attaining a maximum altitude of about 600 m. The basaltic lava flows of the Rajmahal Trap of middle Jurassic to lower cretaceous age occupy the major part of the district. The basaltic lava flows are associated with sedimentary intertrappeans beds. Amgdales of the flows are made up of calcite and chalcedony. The basaltic rocks are hard and fine to medium grained.It has been found that there is more than 8 no. of basaltic flows area exposed (GSI, 1985) with individual thickness ranging from 10-80m.

3.1.2.4 Laterites:-

Laterites, occurring as capping on Rajmahal Trap, show well developed profile at many places whicgh are represented by brown latosol, pisolitic laterite, bauxite, aluminous laterites, goethics and mottled lithonmergic clays.

3.1.2.5 Quarternary formations:-

The quaternary sediments identified in the study area have been classified (Sinha and Verma, GSI 1995 and GSI, 2009) into three distinct morphographic units Viz. Sautadin/Jamui formation, Belhar formation and Diara formation. Sautadih/Jamui Formation and Belhar Formation are represented by light grey to buff sticky silty clay and is mainly composed of silt, clay and fine sand characterized by occasional caliches and ferruginous concretions. The Diara formation is represented by fine sand and silt. A marked erosional unconformity lies between them. Its thickness increases from south to north. Major sediments have been derived from the Precambrian rocks as revealed

by the composition of the quaternary formations. The maximum thickness of alluvium may be in the range of 80-90 m.

3.1.3 Structural Features:-

The studies shows that the Precambrian rocks of the area have undergone several period of tectonic disturbances (Shekhar, 1999) The earlier phase appears to be folding and metamorphism on a regional scale. The high metamorphism resulted in the formation of Khondalites, Charnokites, Granulites and rocks of migmatites etc. In the study area Gondwana beds usually rest on the Precambrian basement with a pronounced unconformity. Only certain segments, Gondwana formation are faulted against the metamorphics. Regionally contact with Precambrian basement is aligned in NNW-SSE direction. The north-south trending Rajmahal coal belt is characterized by a major fault. The faults are possibly of pre-Rajmahal in age as they do not effect the volcanics. The prominent igneous structure noted in Rajmahal volcanics are flow, volcanic cone, fissured vent, plug, dyke, primary lineament of vesicales. Mudcracks, solemarks etc. have also been encountered in the intertrappean mudstone, shale in some of the section of Rajmahal series.

3.1.4 Fracture Analysis:-

The lineament map of the study area on 1:50000 scale made by visual interpretation of aerial photographs were extensively used in evaluating the structure and tectonics of the crystalline rocks. Altogether 156 no. of lineaments/fractures were analyzed. The regional fracture pattern reveals eight groups of fractures depending upon their direction. These groups may be E-W, WNW-ESE, NW-SE, NNW-SSE, N-S, NNE-SSW, NE-SW, ENE-SSW. The frequency of fracture in the above directions are 10.8%, 14.7%, 14%, 16%, 12%, 14%, 11.5%, and 6.4% respectively. The above studies reveal (Shekhar, 1999) that the area had undergone several periods of tectonic deformation resulting in development of numerous set of lineaments, fractures and shear zones.

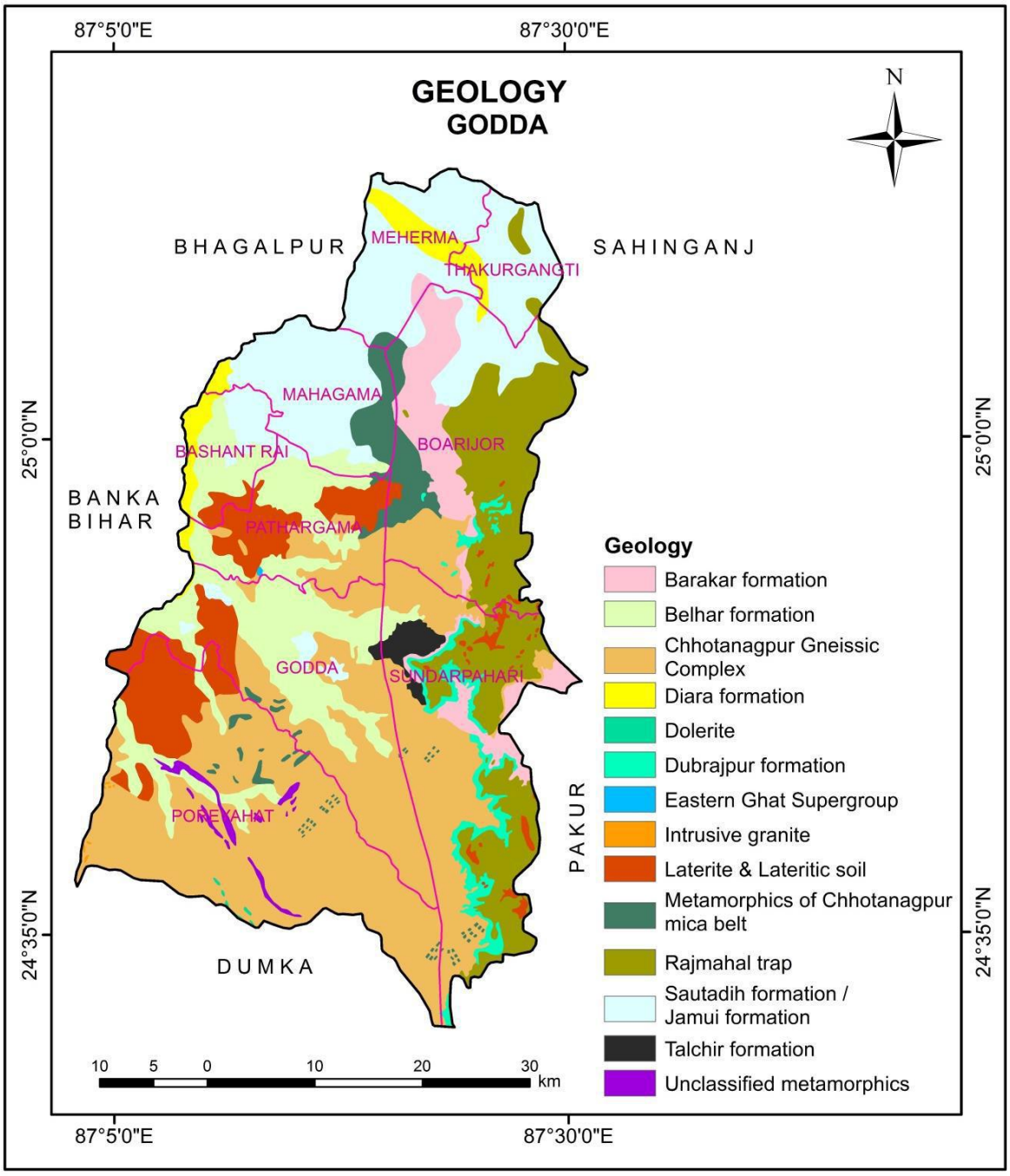


Figure –8: Geological map of Godda district (source GSI, 2009)

3.2 Hydrogeology:

The occurrence and movement of ground water in the area is variable, which depends on geomorphology, structure, geological setting, hydraulic properties, tectonic setup etc. The hydrogeological condition of Godda is complex due to diverse geological trerrain vide variability of topography, drainage etc. 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 three hydrogeological unit.

1. Consolidated formation
2. Semi-consolidated formation
3. Uncosolidated formation

The consolidated formation is commonly reffered as hard rocks, the grains of which are firmly held together by cementation, compaction and recrystalization. They do not possess primary porosity. The availability of ground water depends on secondary porosity developed due to weathering and fracturing of these rocks. The chotanagpur gneiss complex, metasedimentaries and other associated rocks of Precambrian age, Rajmahal Traps of upper jurrasic age belongs to consolidated hydrogeological unit. The consolidated formation often termed as fissured formation

The unconsolidated formation which forms porous formation is represented by tertiary laterites & quaternary alluvium. The Gondwana formations represent the semi-consolidated formation. Hydrogeological map of Godda district has been prepared (Fig-9)

3.2.1 Ground Water in Fissured Rock Formation

The chotanagpur gneissic complex, metasedimentaries and other associated rocks of Precambrian age, Rajmahal Traps the volcanic rocks of upper jurrasic age belongs to this fissured rock formation group. Ground water in precambrians rocks of the study area are dependent on thickness of weathered residuum, openness and interconnections of fractures. These rocks have been highly deformed and metamorphosed on regional scale. These have developed secondary porosity by fracturing and weathering which forms the conduits for occurrence and movement of ground water. The vesicular basalts, laterites, intratrappean beds etc in Rajmahal volcanic also form suitable conditions for gound water storage.

3.2.1.1 Ground water in Aquifer-I (Weathered Granite Gneisses, weathered basalt and Laterites):-

The Aquifer-I is represented by weathered Granite- Gneisses, weathered basalt & Laterites. Within the depth zone of dug wells, the weathered zone influences to a greater extent in the hard rock formation constituting potential phreatic shallow aquifer. Almost all the rock types in the precambrial formations show the effect of weathering however, degree and intensity varies depending on the structure, chemical and mineralogical composition of the rocks etc. The plateau and pediplain region is occupied by moderately thick weathered residium developed due to mechanical disintegration and chemical decomposition of impervious crystalline rocks. The thickness of weathered zone varies from 9.00-30.00. Geophysical spot resistivity survey in Precambrian terrain reveals that the thickness of the weathered zone varies from 2.00-28.00m (Suresha, 1995). Ground water in Rajmahal Traps depends upon topographical and structural controls. Decomposition and disintegration of Rajmahal traps have made this aquifer system heterogeneous and complex.

Laterites of tertiary age occur as cappings over Rajmahal basalt in the eastern part of the study area. Laterites are mainly of insitu origin and have formed by subaerial erosion of underlying basalts under favourable climatic condition. Wide spread laterization has been observed in eastern part of the study area. They are mainly pisolitic in nature having a very high degree of permeability. The laterites having very good effective porosity provides a productive ground water reservoir, bulk of the recharge comes from the rainfall. Open wells of 10-15m depth are the most appropriate ground water structures feasible. Thus laterite constitutes shallow aquifer in the study

area and can be an effective hydrogeological unit in providing small scale water supply for drinking purpose

Potential aquifer exists at shallow to moderate depth. Ground water occurs in unconfined to semi-confined state in Aquifer-I (upto the depth of 30m). Yield of the wells in Aquifer-I is very poor restricted to 5-10 m^3/hr in laterites/weathered Granite-Gneiss /basalt. These aquifers are generally tapped by the dugwells or shallow borewells.

3.2.2 Ground Water in Aquifer – II (Fractured Granite Gneisses, and fractured basalt):

The Chotanagpur granite-gneiss, belonging to Precabmrian age and Rajmahal traps constitutes the group of Fissured formation hydrogeological units as an Aquifer-II i.e Deeper Aquifer in the area. The aquifers in these rocks lack the primary porosity and occurrence and movement of ground water is to a large extent controlled by the extent and development of secondary porosity like joints, fissure planes etc.These rocks are the part of Chotanagpur Craton of Indian Shield. They contain hard rocks of different age, grade of metamorphism and structure. Many orogenic movements have affected the shields. Some rock types are extensively fractured; while others are almost undisturbed, even though they belong to the same tectonic environment.

Rajmahal traps in the study area constitute number of basaltic lava flow occurring in eastern part of the distict. These lava flows are separated by intertrappean bed which is argillaceous or arenaceous in nature.Weathering and erosional product of Rajmahal basalt in the form of laterites also occur as capping over it. The distinctive hydrogeological features of the basaltic rocks is the significant primary porosity in the form of vaciculs, cracks etc. The secondary porosity is developed due to fracturing during cooling of lavas, tectonic disturbances, weathering etc. The study of Rajmahal volcanic in Godda district reveals that vesicular basalts, laterites, intratrappean formation etc. Form suitable conditions for gound waterstorage.

3.2.2.1 Potential Fracture in Aquifer-II(Fractured Granite Gneisses/ Gondwana Sandstone)

The openness and interconnections of fractures are very much decisive in storage of ground water in these formation. However, the type of rocks, grade of metamorphism and brittleness are also the main geological controls which govern the occurrence and movement of ground water. The fractures in granite gneiss are more productive compared to the fractures in amphibolites/ schists.

Number of boreholes has been constructed by CGWB in the district under groundwater exploration programme upto maximum depth of 200 m (Table-7).The extensive field investigations coupled with satellite data and deep exploratory wells drilled by CGWB, Potential fractures have been identified in Precambrian formations. The structural geomorphology and morphotectonic analysis of crystalline formation of the study area reveal that the rocks have undergone several periods of tectonic deformation (shekhar, 1999). These tectonic deformations have given rise to the development of deep seated tensile and shear fractures. Based on the results of field studies, exploratory drilling and

analysis of available data, the potential fractures have been delineated. Table-7 shows the Potential Fracture encountered during Ground Water Exploration in Godda district.

Table-7 Potential Fractures Encountered during ground water Exploration in Godda district, Jharkhand

S. No.	Location	Block	Depth Drilled (m)	Major Lithology Encountered	Depth of casing (m)	Potential Fracture Zone (m bgl)	Static Water Level (m bgl) at the time of drilling	Discharge (m3/h) compressor
1	Godda	Godda	191	Granite Gneiss	24	033.00-034.00, 042.00-043.00, 047.00-048.00, 075.00-076.00	6	10.59
2	Mahgama	Mahgama	148	Granite Gneiss	21	074.00-075.00, 131.00-132.00, 136.00-139.00, 145.00-146.00, 147.00-148.00	5.17	4.75
4	Sunderpahari	Sunderpahari	191	Granite Gneiss	26.5	119.00-121.00	6.68	2.22
5	Poreyahat	Poreyahat	187	Granite Gneiss	9.7	045.00-046.00, 119.00-120.00, 129.00-130.00	-	17.04
6	Danre	Poreyahat	97	Granite Gneiss	-	030.00-031.00, 051.00-052.00, 088.00-097.00	6.29	37.5
7	Dumaria	Godda	164	Granite Gneiss	-	092.00-093.00, 098.00-099.00, 139.00-146.00 162.00-163.00	5.78	16.5
8	Godda College	Godda	129	Granite Gneiss	13.6	063.00-064.00, 104.00-105.00, 115.00-116.00, 118.00-119.00, 120.00-121.00	5.5	37.5
9	Ghatbanka	Godda	99	Granite Gneiss	9	022.00-023.00, 049.00-050.00, 092.00-093.00, 095.00-099.00	3.1	39.5
10	Chandana	Sunderpahari	138	Granite Gneiss	2	019.00-020.00, 049.00-050.00, 129.00-130.00, 133.00-136.00	2.0	29.5
11	Raghunathpur	Poreyahat	147	Granite Gneiss	12.5	038.00-039.00, 042.00-043.00, 107.00-108.00	4.6	31.5
13	Bhataunda	Poreyahat	81	Granite Gneiss	17	017.00-020.00, 031.00-032.00,	8.54	49.2

S. No.	Location	Block	Depth Drilled (m)	Major Lithology Encountered	Depth of casing (m)	Potential Fracture Zone (m bgl)	Static Water Level (m bgl) at the time of drilling	Discharge (m3/h) compressor
						051.00-052.00, 067.00-073.00, 076.00-080.00		
14	EW Primary school Mohala	Boarijor	153.80	Gondwana Sandstone	17.5	77.60	4	12.24

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 2.22-49.2 m^3/hr.
- Overall in the district the major potential fractures zones are found between 30-120 m.
- First potential fracture zone encountered in the district widely varies from 17-119 m.
- The potential fractures were encountered in Precambrian formation at shallow level upto 75.00 m with very high yielding wells. These potential fractures may be tensile in nature occurring at shallow level, which is found to be potential repository of ground water. Some of the exploratory wells encountered upto the depth of 80m which yielded high discharge eg Godda(10.59 m^3/hr),Bhataundha (49.2 m^3/hr)
- Some of high yielding wells where multiple fractures were encountered within 100 m depth are Godda(10.59 m^3/hr), Danre(37.5 m3/hr),Bhataundha(49.2 m^3/hr), Ghatbhanka (39.5 m^3/hr) etc
- In some occasion potential fractures were also encountered beyond 100 m depth (120-162 m) and yielded copious amount of discharge e.g Poreyahat(17.04 m^3/hr), Dumaria(16.5 m^3/hr), Godda College (37.5 m^3/hr), Chandna(29.5 m3/hr)
- At Mohala, potential aquifer encountered at 77.00 m in Gondwana sanstone with the yield of 12.24 m^3/hr.

3.2.2.2 Potential Fracture in Aquifer-II(Fractured Rajmahal Trap)

No exploratory drilling was undertaken in Rajamahal traps of Godda district. However many exploratory wells were drilled in adjoining districts of Pakur and Sahebganj by CGWB. The exploratory drlling in these district reveal that the vesicular basalts, intratrappean beds, contact zone of two volcanic eruptions etc in Rajmahal Traps form potential aquifer zones and can yield upto 25 m3/yr.

3.3 Ground Water in semi- consolidated Rock Formation (Gondwana)

In the study area lower gondwana rocks are represented by Talchir and Barakar formations. Barakar formations comprising sand stone, shales, and siltstone containing coal seams are most groundwater bearing units. Barakar sand stones are fine to coarse with subrounded to well rounded grains and feldpathic in nature, the feldspar being partly decomposed. The sand stone occurring as inter-seam partings are water bearing horizons. In lalmatia area, Barakar formation constitutes confined aquifer system with auto-flow conditions. Base on geological and hydrogeological consideration 5 confined aquifer system are identified in the Barakar formation containing coal seams in Lalmatia sector (CMPDIL, 1992). The thickness of aquifer ranges from 10-70 m and the cumulated yield ranges from 50-135 m3/hr, however discharge of individual aquifer ranges from 10-60 m3/hr in general. Out of 5 confined aquifers, Aquifer–III, upto the depth of 50m is most potential capable of yield of 40-60 m3/hr of water under free flowing condition.

The various aquifers are as under-

Table: 8 The confined aquifer system in Rajmahal Project, Lalmatia

Sl.no	Aquifer no.	Lithology	Thickness of aquifer(m)	Confining layer	Rematks
1	III	Medium to coarse grained sand stone	16-36.5	Clay and Seam-III	Free flowing during monsoon
2	II A	Medium to coarse sand stone and shale	Nil-33.9	Seam-III & Seam-II top	Nature of aquifer not known
3	II	Medium to coarse sand stone and sandy shale	Nil-18.22	Seam-II top & seam II Bottom	Free flowing through out the year
4	I	Coarse grained sand stone	4-22	Saem II bottom & seam I top	Free flowing through out the year pinching along split line of the seam-II Top and Seam-II Bottom
5	IA	Coarse grained sand stone and sandy shale	10-71	Seam I and metamorphic basement	Nature of aquifer not known

Water table aquifer: - The water table aquifer overlying the clay bed mainly consists of zone of aeration and water is contained in the sandy clays and alluvium. At places aquifer–III also comes in contact with water table aquifer due to local pinching of the clay bed.

3.3.1 Ground Water in Unconsolidated Formation (Alluvium):-

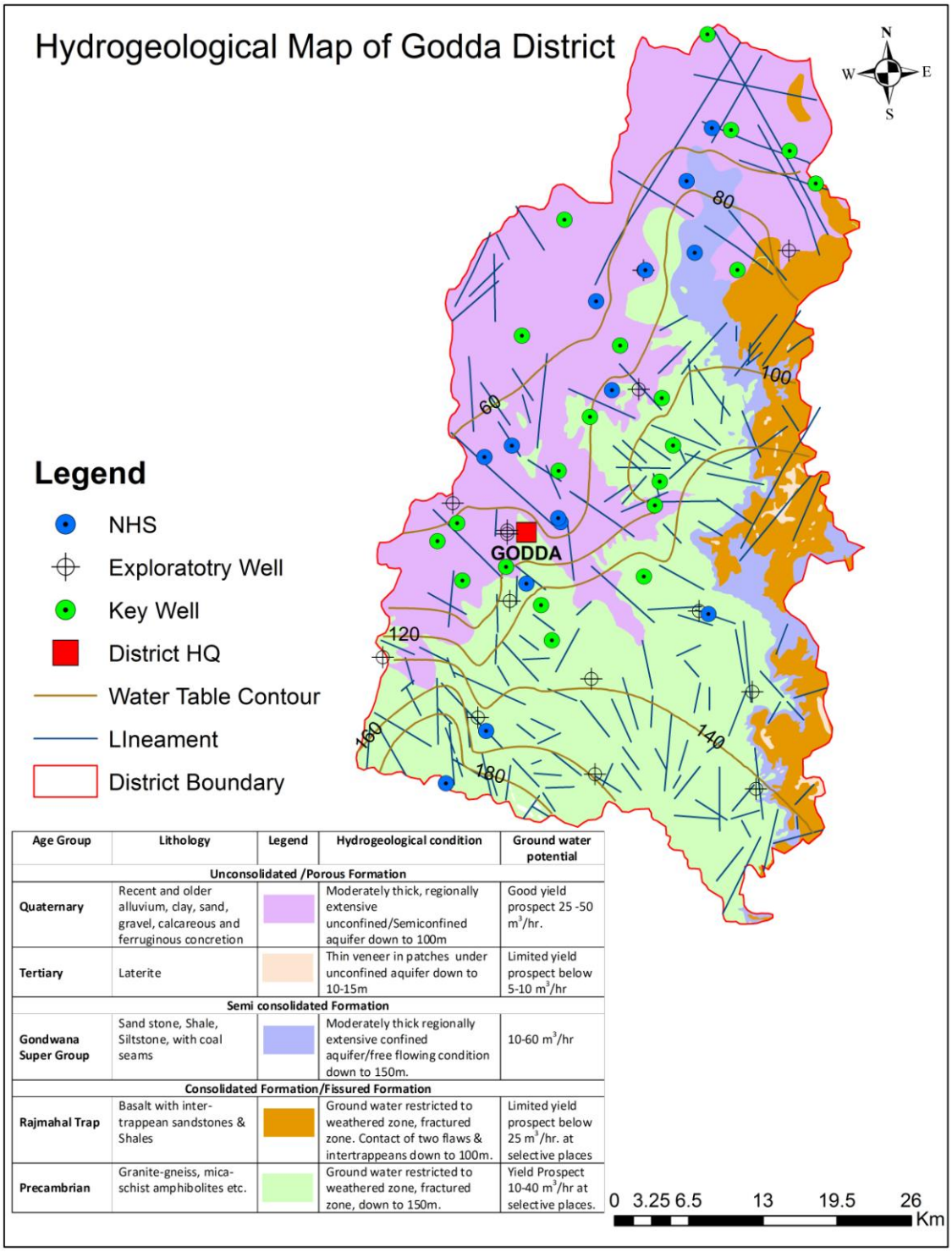
The quaternary alluvium occurring in the area constitutes three alluvial formations viz Sautadih, Belhar and Diara formations (As per GSI,2009). This is exposed in the northern and north western part of the study area covering parts of Meharma, Thakurghanti, Mahagama, Pathargama and Godda block. The thickness of alluvium varies from place to place and the thickness is more towards northern and northwestern portions of the area and is as high as 100 m. The sediments can be divided into two groups. The first group derived from rocks of chotanagpur plateaus and second constitutes an extension of the Ganga alluvium.

The area displays varying ground water potential in alluviual formation depending upon the nature and extent of aquifers. Upon the pediplain or upper slopes of Sautadih formation, the aquifer zone is compromised mantle, colluvial material and regolith. This includes oxidised yellow to reddish brown clay and silty clay with kankar and ferruginous concretions. Sand beds of variable thickness occur within this formation at different depth. In such aquifers the ground water storage is poor. In these areas large diameter dugwells is needed to augment percolation of ground water.

In Belhar formation the aquifer is made up of medium to coarse sand. Thickness of aquifer may range from 5-10m. In this tract, top alluvial layers are mainly clayey. These represent the older flood plain in which tubewell discharge range from 25-50 m^3/hr. Diara formation represents the present day flood plain deposits. The aquifer consists of sands of different grades and composition consisting of silt and little clay. This formation is found in patches in the study area along the major stream. The thickness of aquifer in this zone is considerable.

The aquifers in Alluvium can be divided into Aquifer-I i.e shallow aquifer upto the depth of 50m and aquifer-II i.e deeper aquifer between 50-100m

The hydrogeological map of area is prepared and presented in figure -9.



Age Group	Lithology	Legend	Hydrogeological condition	Ground water potential
Unconsolidated /Porous Formation				
Quaternary	Recent and older alluvium, clay, sand, gravel, calcareous and ferruginous concretion		Moderately thick, regionally extensive unconfined/Semiconfined aquifer down to 100m	Good yield prospect 25 -50 m^3/hr.
Tertiary	Laterite		Thin veneer in patches under unconfined aquifer down to 10-15m	Limited yield prospect below 5-10 m^3/hr
Semi consolidated Formation				
Gondwana Super Group	Sand stone, Shale, Siltstone, with coal seams		Moderately thick regionally extensive confined aquifer/free flowing condition down to 150m.	10-60 m^3/hr
Consolidated Formation/Fissured Formation				
Rajmahal Trap	Basalt with inter-trappean sandstones & Shales		Ground water restricted to weathered zone, fractured zone. Contact of two flaws & intertrappeans down to 100m.	Limited yield prospect below 25 m^3/hr. at selective places
Precambrian	Granite-gneiss, mica-schist amphibolites etc.		Ground water restricted to weathered zone, fractured zone, down to 150m.	Yield Prospect 10-40 m^3/hr at selective places.

Figure – 9: Hydrogeological Map of Godda district

3.4 Ground water Dynamics:-

3.4.1 Water Level Scenario – Aquifer – I (Shallow Aquifer): water level scenario of shallow aquifer was generated by utilizing water level data of 36 monitoring wells representing shallow aquifer. The pre monsoon (May 2018) depth to water level monitored between 2.80 to 12.10 mbgl and average 6.32m bgl. The post monsoon depth to water level (Nov. 2018) in the dug wells ranges from 2.00 to 10.33 mbgl and average 4.33 m bgl respectively. Pre and post monsoon depth to water level maps were prepared for the year 2018 and shown in figure – 10, 11.

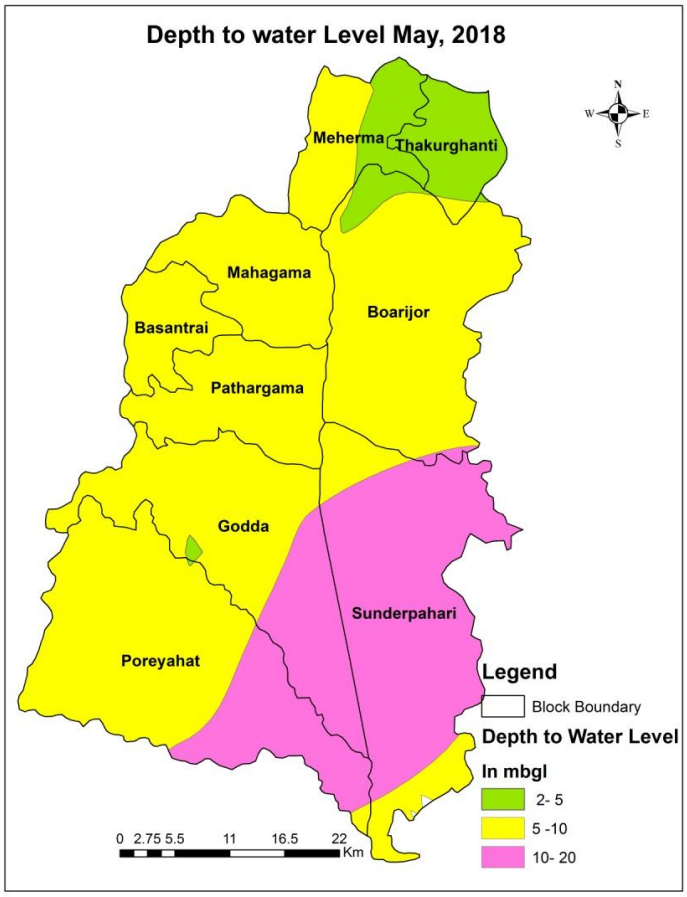


Figure – 10: Pre monsoon (May 2018) depth to water level map of Aquifer – I (shallow aquifer)

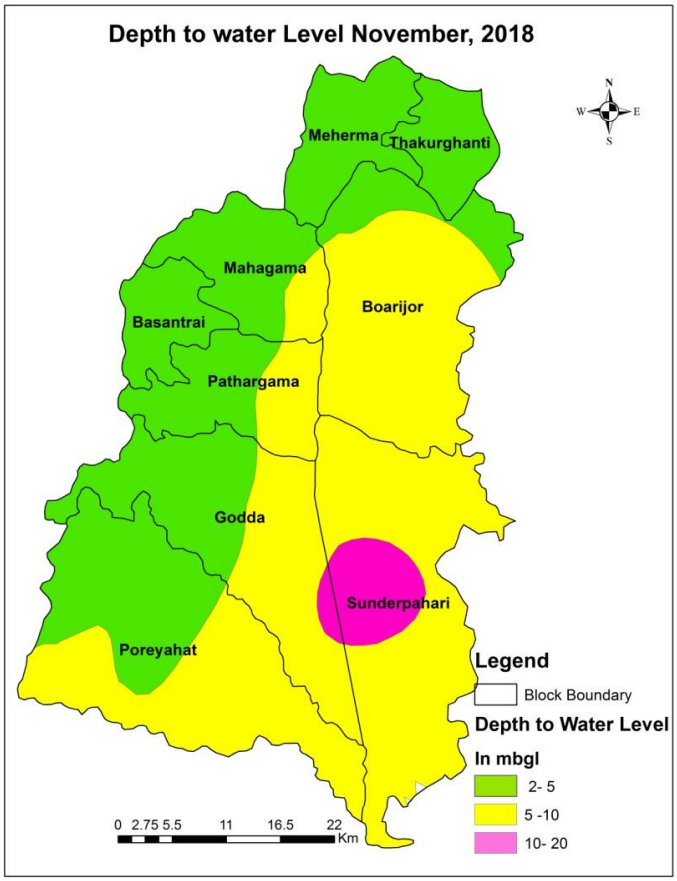


Figure – 11: Post monsoon (Nov. 2018) depth to water level map of Aquifer – I (shallow aquifer)

The water level monitored during pre and post monsoon period 2018 and 2018 was used to compute the seasonal fluctuation.

3.4.2 Water level fluctuation:

The seasonal water level fluctuation was observed between 0.10 to 3.86m for the period between pre monsoon and post monsoon 2018.

3.4.3 Ten years Long Term Water Level Trend (2009-2018):

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data for the period 2009-2018 have been computed and analyzed which is presented in table - 9. The pre- monsoon decadal water level trend analysed and observed that out of 16 hydrographs stations 5 wells were declining and 1 well was rising. Post-monsoon decadal water level trend observed 1 station rising and 5 stations falling. The annual decadal water level of the district was observed rising trend in 1 station and declining trend in 5 wells.

Table – 9: Long term water level trend of Godda district (2009 – 2018)

Sl No.	Location	PreMonsoon			PostMonsoon			Annual		
		Data Points	Rise (m/year)	Fall (m/year)	Data Points	Rise (m/year)	Fall (m/year)	Data Points	Rise (m/year)	Fall (m/year)
1	Sundar Pahari	10	-	0.244	8	-	0.3661	35	-	0.1098
2	Godda1	9		0.0659	9	0.0075		38	0.0075	
3	Maheshpur2	7	0.0345	-	6	-	0.1865	28	-	0.1837
4	Patharga ma	10	-	0.0621	9	-	0.1602	37	-	0.066
5	Mahagama1	7	-	0.1762	9	-	0.4256	34	-	0.1228
6	Doi	8	-	0.0573	9	-	0.0272	36	-	0.0454

3.4.4 Hydrograph Analysis:

Analysis of five (05) hydrograph network stations, were carried out using GEMS software (Figure-12-16) and analysed for the period from 2009-2018. It is observed that the long-term water level trends during pre and post-monsoon seasons are declining trend in shallow aquifer-I represented by dug wells.

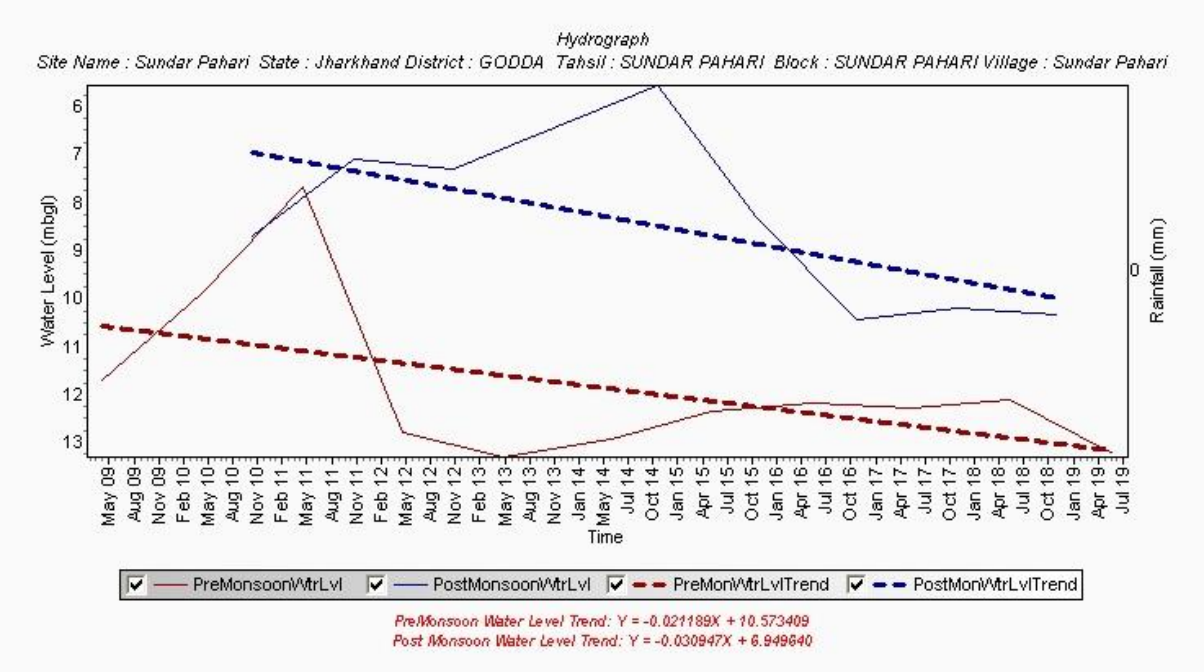


Figure 12: Hydrograph (2009-2018), Sundarpahari, Sundarpahari block, Godda district

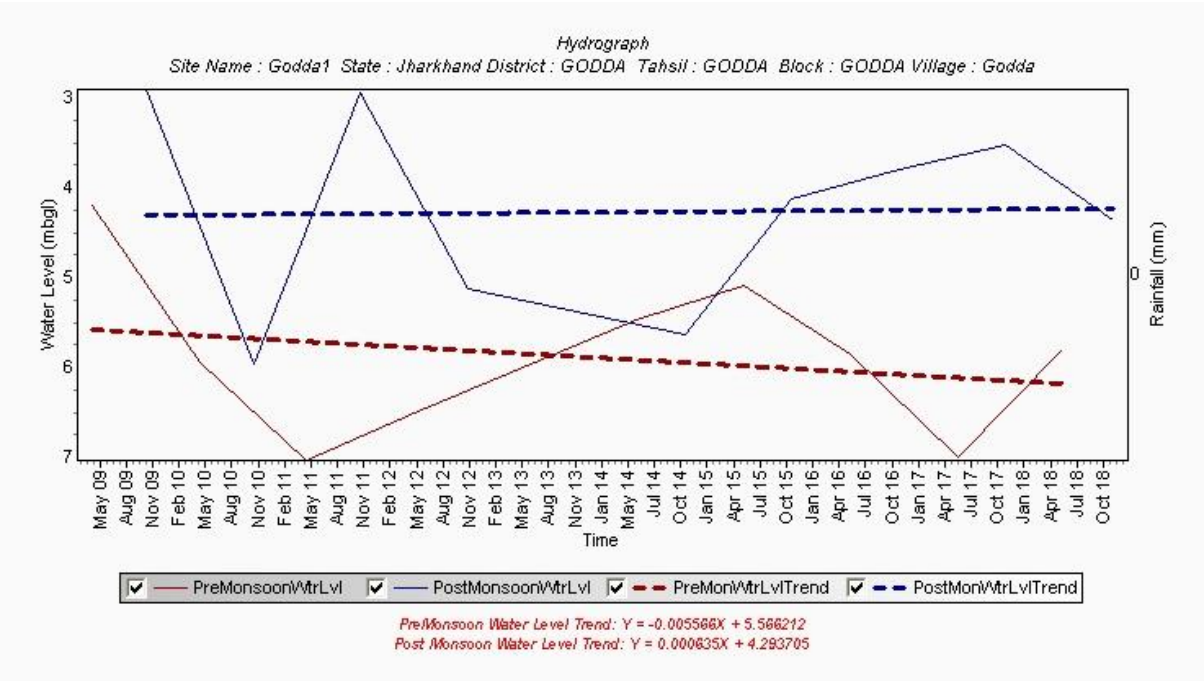


Figure-12(a): Hydrograph (2009-2018), Godda, Godda block, Godda district

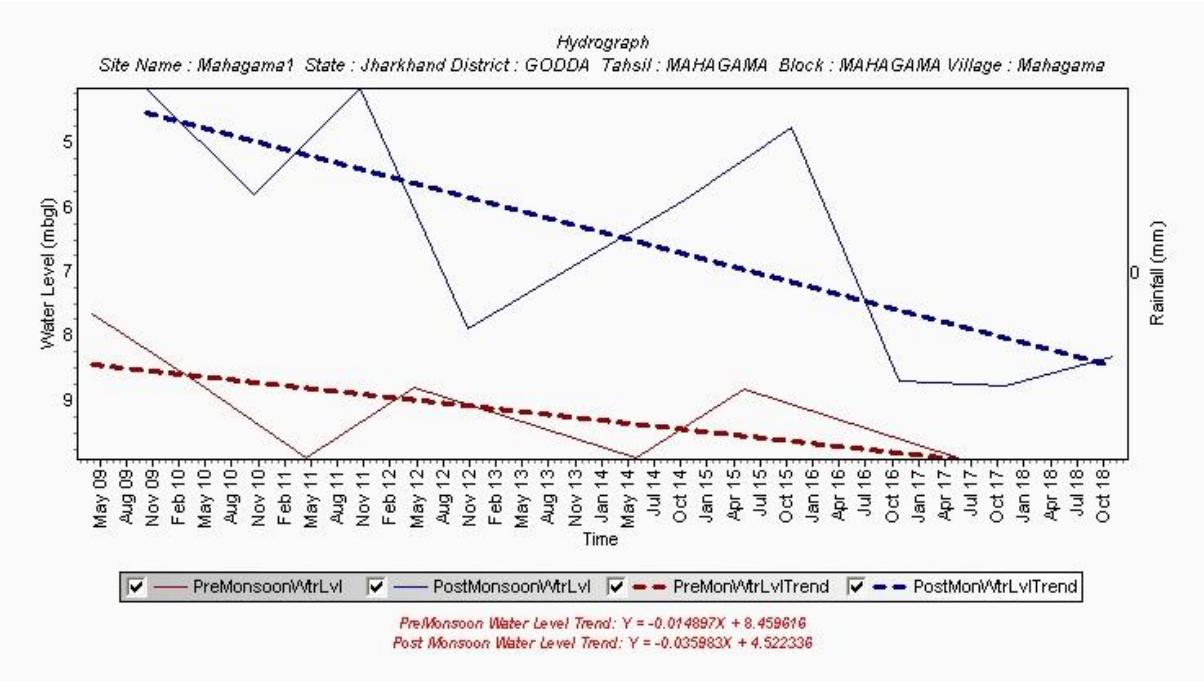


Figure- 12(b): Hydrograph (2009-2018), Mahagama, Mahagama block, Godda district

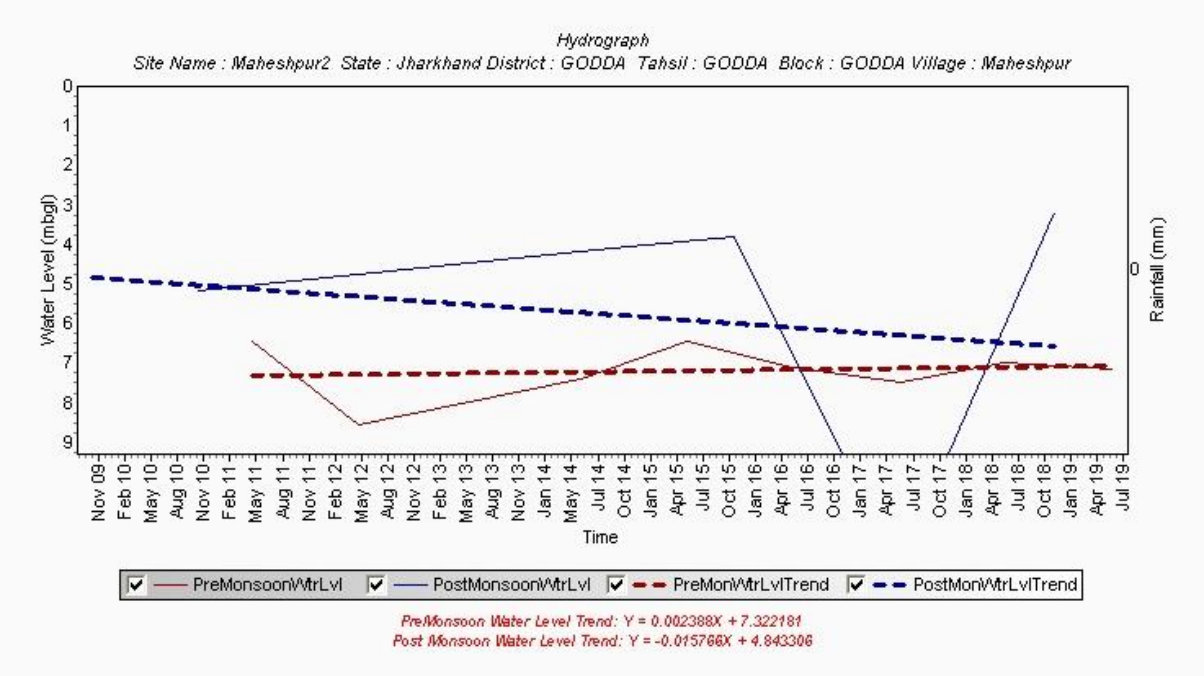


Figure- 12©: Hydrograph (2009-2018), Maheshpur, Maheshpur block, Godda district

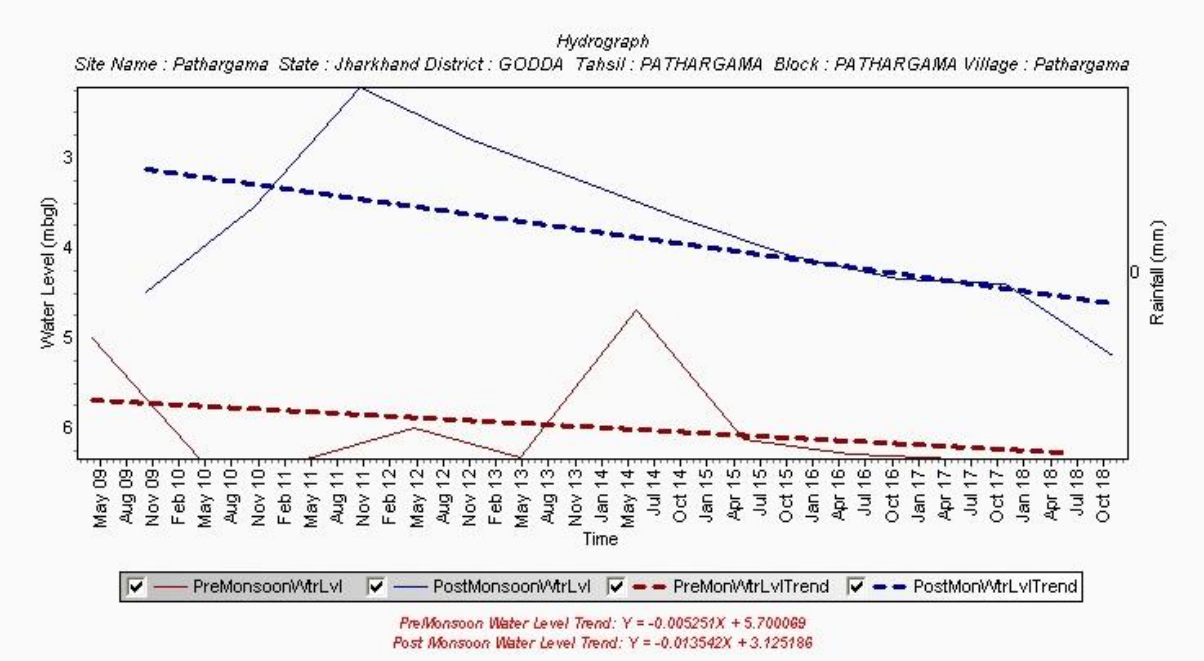


Figure- 12(d): Hydrograph (2009-2018), Pathargama, Pathargama block, Godda district

3.5 Ground Water Exploration:

The exploratory data particularly includes the information on sub–surface geology, hydrogeological information and geometry of aquifer in Alluvium as well as in hard rocks. Based on exploration data, prepared litholog of EW & OW, in hard rock area depth of fractured/joints encountered within 200m depth formation has been

presented in **table - 10.** Drilling details of the exploratory and observation wells are presented in Annexure III.

Table – 10: Summary of success bore wells drilled by CGWB in Godda district

Location	Depth drilled (mbgl)	Discharge (m^3/hr)	Pumping Hour (min)	Draw-Down	Transmissivity (m^2/day)	Storativity
Godda	191	5.95	1414	17.89	8.29	$9.18x10^{-5}$
Danre	97	20.17	1600	12.10	177.20	$4.30x10^{-3}$
Godda College	129	11.14	1200	8.22	139.80	$4.48x10^{-4}$
Ghatbanka	99	7.58	1400	13.60	34.30	$1.60x10^{-5}$
Chandana	138	9.40	1480	12.42	17.95	$1.29x10^{-3}$
Raghunathpur	147	11.70	500	12.40	30.90	$3.80x10^{-4}$
Bhataundha	81	31.15	2580	7.07	129.15	$5.60x10^{-4}$

3.6 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 21 dug wells .The analytical results of water samples dug wells are given in Annexure-V. 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)

3.6.1 General Range Of Chemical Parameters Of Aquifer – I :-

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 to many health problems. The variation range of the concentration in ppm of different chemical constituents and quality parameters of Aquifer I (dug wells samples) in table-11.
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 based on taste, corrosion and scale formation criteria. The pH value in Aquifer-I ranges from 7.29 to 8.53 mg/l.

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 273 to 2130 Microsemen at 25^{0c}.

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 229 to 615 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 4.47 to 401 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 Flouride concentration ranges between 0.23 to 3.35 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 2.51 to 3.35 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 12.29 to 216.70 mg/l.

Calcium:

In mineral form, it is found as Calcite, aragonite, gypsum, anhydrite, anorthite, diopside etc.

The Calcium concentration ranges between 16 to 142 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 4.86 to 49.81 mg/l.

Total Hardness:

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

Hardness range (mg/l $CaCO_3$)	-	Class
0- 60	-	Soft
61-120	-	Moderately hard
121-180	-	Hard
>180	-	Very Hard

In the study area, the total hardness value ranges from 105 to 645 mg/l.

Table - 11: Ranges of chemical constituents of Aquifer – I

Chemical Constituents and quality parameters	**Aquifer – I (Dug well samples)**
pH	7.29 – 8.53
EC (micro siemens/cm at 25^0c)	173 – 2130
TDS (ppm)	174.72 – 1363.20
TH as $CaCo_3$ (ppm)	105 – 645
Ca (ppm)	16 – 182
Mg (ppm)	4.86 – 49.81
Na (ppm)	12.29 – 216.70
K (ppm)	0.54 – 3.05
HCO_3 (ppm)	129.15 – 615
Cl (ppm)	4.47 – 401
SO_4 (ppm)	2.51 – 88.23
NO_3 (ppm)	0.78 – 136
F (ppm)	0.25 -3.35

The ground water of Aquifer – I (shallow aquifers) in the area is alkaline in nature. On the perusal of table - 11, the pH value of the area is 7.29 – 8.53. The TDS value varies between 174.72 to 1363.20 mg/l. Overall values of Calcium and Magnesium varies between 16 to 182mg/l and 4.86 – 49.81 mg/l in the area respectively. Nitrate concentration is observed between 0.78 to 136 mg/l while the Fluoride value varies from 0.25 to 3.35 mg/l within the area.

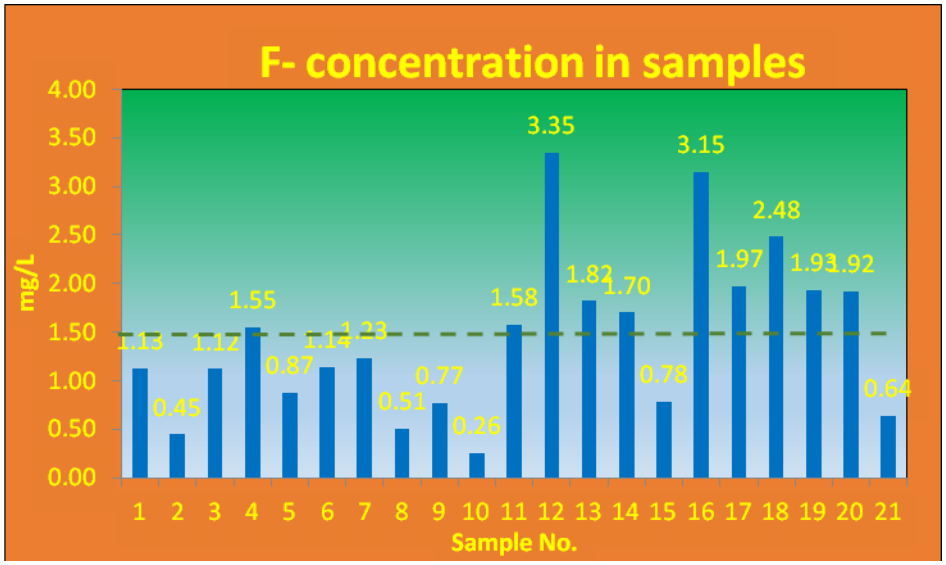


Figure 13. Flouride Concentration in Godda district

3.6.1.1 Suitability of Ground Water of Aquifer – I for Drinking Purposes: - The suitability of ground water for drinking purposes is determine 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 – 12 Aquifer – I.

Table-12: 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	20 (95%)	Nil	1(5%)
TDS (ppm)	500	2000	21 (100%)	Nil	Nil
TH as $Caco_3$ (ppm)	200	600	20 (95%)	Nil	1(5%)
Ca (ppm)	75	200	21 (100%)	Nil	Nil
Mg (ppm)	30	100	21 (100%)	Nil	Nil
Cl (ppm)	250	1000	21 (100%)	Nil	Nil
SO_4 (ppm)	200	400	21 (100%)	Nil	Nil
HCO_3 (ppm)	200	600	21 (100%)	Nil	Nil
NO_3 (ppm)	45	No relaxation	17 (81%)	Nil	4(19%)
F (ppm)	1.0	1.5	7 (33%)	4(19%)	10 (48%)

The table-12 indicates that all the water samples are falling in desirable to permissible category except pH, Hardness, Nitrate and Flouride in some of the samples. The value of pH observed beyond permissible limit (mg/l) in 01 sample. Similarly, the value of total hardness in 1 samples, Nitrate in 04 samples also found beyond permissible limit. 04 Sample of Flouride were found within permissible limit and 10 samples are found beyond permissible limit.

3.6.1.2 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. Various parameters viz. Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Salt Index (SI), Soluble Sodium Percentage (SSP) & Water Class have been evaluated to assess the suitability of ground water for irrigation purposes.

3.6.1.2.1: 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- 13: 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 %	3	14
2	Good	20 – 40 %	8	38
3	Permissible	40 – 60 %	8	38
4	Doubtful	60 – 80 %	2	10
5	Unsuitable	> 80 %		

(Where all ions are expressed in epm)

On the perusal of table 90% of water samples of aquifer – I (dug wells) falling under excellent to permissible category.

10 % i.e 2 no. of samples indicate doubtful quality water for irrigation purpose namely village pandubathan and Kumarhati.

3.6.1.2.2 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-14 which is showing that all the water samples (100%) of aquifer – I (dug wells) pertain to excellent class. In Godda district all all 21 water samples collected during the field falls in the (0-10) C1 category, ground water is excellent for irrigation.

Table: 14 Sodium Adsorption Ratio

Sodium Hazards Class	**SAR (meq/L)**	**Remarks**	**Study area quality**
C1	0-10	Excellent	All (21 sample)
C2	10-20	Good	-
C3	20-26	Doubtful	-
C4	>26	Unsuitable	-

3.6.1.2.3 Residual Sodium Carbonate (RSC)

The potential for a sodium hazard and Residual sodium carbonate (RSC) are directly proportional, and much of the calcium and magnesium are precipitated out of solution when water is supplied to the soil. In study area 16 samples are good 2 samples are doubtful and 3 samples are unsuitable for irrigation.

On The perusal of table-15, about 76 % of water samples of Aquifer – I (dug well) falling under good and 9% permissible water class and 15% are not suitable.

Table: 15 Residual Sodium Carbonate (RSC)

Parameter	**Range**	**Irrigation Suitability**	**Sample**	**Percentage**
Residual Sodium Carbonate **(RSC)**	< 1.25	Safe for all type of crops	16	76
	1.25 – 2.50	Safe for semi-tolerant to tolerant crops	2	9
	>2.50	Safe with application of gypsum of the rate of 8.5g/ham of irrigation water applied for 1.0 ml/liter RSC	3	15

(All the values are expressed in epm.)

3.6.1.2.4 Suitability of ground water based on Electrical Conductivity (EC):

To better understanding the suitability of ground water for irrigation purpose chemical result of collected water samples have been analyzed and described the different water class based on Electrical Conductivity (EC) which is presented in table – 16.

Table- 16: - Classification of ground water of Aquifer – I based on EC

Sl. No.	Water Class	Rages of EC	No. of samples falling and their percentage
			Aquifer – I
1	Excellent	< 250	Nil
2	Good	250 – 750	13 (62%)
3	Permissible	750 – 2250	8 (38%)
4	Unisuitable	>2250	Nil

3.6.1.2.5 Piper Diagrame for Classification of Irrigation 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.

Based on the major cation and major anion content in the water samples and plotting them in the trillinear diagram, hydrochemical facies could be identified. In Aquifer I cation chemistry out of 21 samples, 13 samples are no dominant type 4 samples are Calcium dominant and 4 samples are Sodium Potesium dominant. In anion part 17 samples are Bicarbonate dominant, 2 samples are no dominant (mixed typed) and 2 samples are Chloride dominant. In the dimond part plotted chemical falling 13 samples are Magnesium bicarbonate type (Mg-HCO_3) and 8 samples are mixed type. The Diamond part of the Piper Diagram reveals that most of the water samples fall in the hardness region. Figure 18 and 19 is given below.

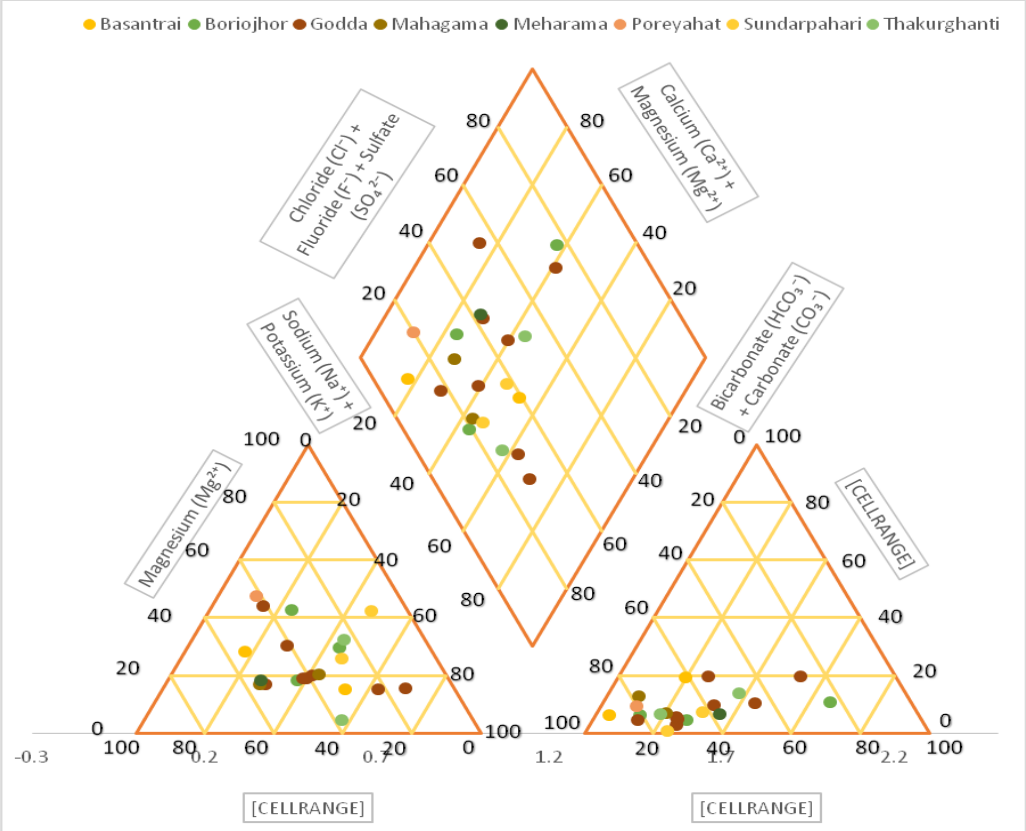


Figure:-14 Piper Diagrame for Aquifer – I

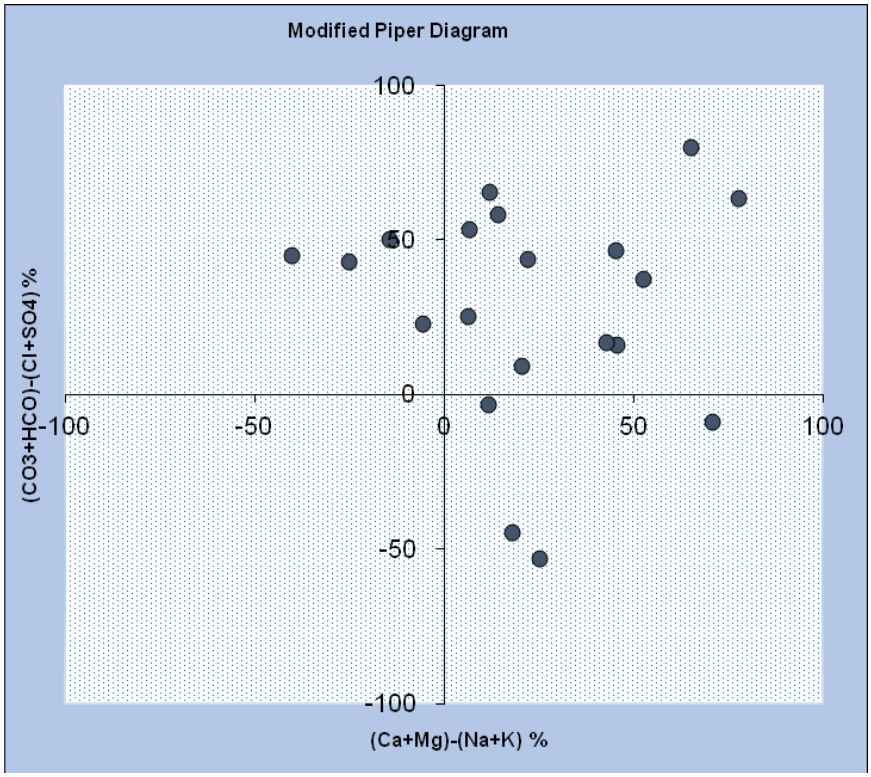


Figure:-15Piper Diagrame modified by Gibbs for Aquifer – I

3.7 3-D and 2-D 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 figure –20. Based on the drilling data of exploratory wells maximum thickness of Aquifer - I (weathered zone) in hard rock area is 27.0 m. The depth of Aquifer – II (fracture zone) ranges from 17.00 to 163.00 mbgl.

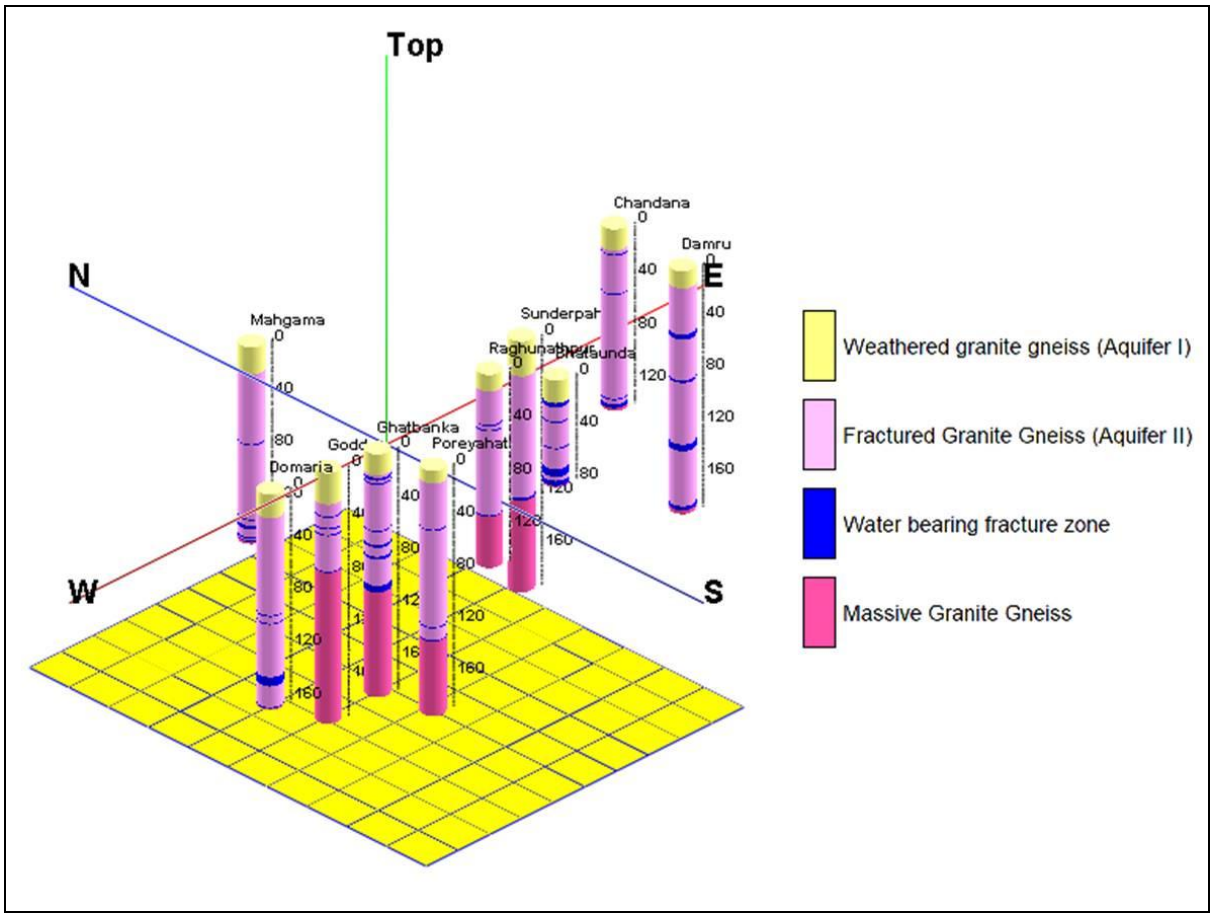


Figure –16: Three dimensional strip-log of EW drilled in Godda district

3.8 Hydrogeological Cross Section:-

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' (Central part), B-B' (NE-SW direction) and C-C' (southern part). The aquifer disposition prepared is a regional picture based on data of available exploratory wells drilled by CGWB

3.8.1 Hydrogeological cross section A-A':

Hydrogeological cross section A-A' represents the area in Central part except the alluvial portion of Godda district. Cross section covers exploratory wells of Dumaria, Godda College, Sundarpahari and Chandna. The Aquifer- I bottom ranges 13- 26 m representing weathered Granite gneiss, Granite and Laterites, while Aquifer-II ranges from 19-163 m representing fractured granite gneiss. Generally 1-5 fracture zones were encountered. Discharge ranges from 2.22 m^3/hr to 37.5 m^3/hr. Maximum discharge found at Godda college (37.5 m^3/hr) and minimum at Sundarpahari (2.22 m^3/hr).

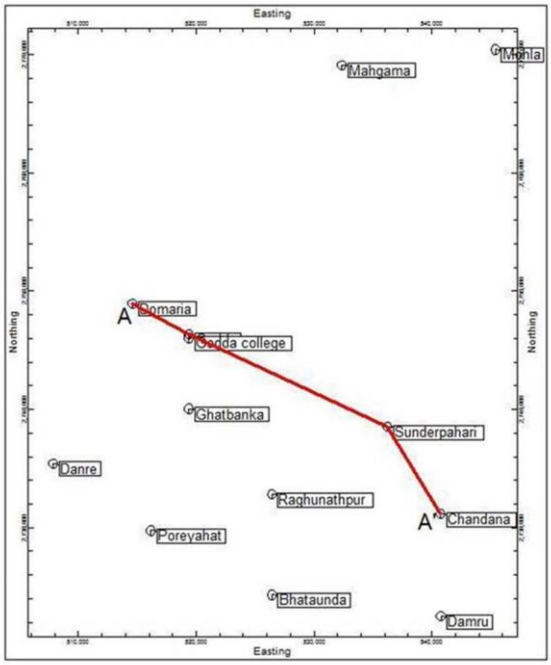


Figure -17: Location map of cross section along A-A'

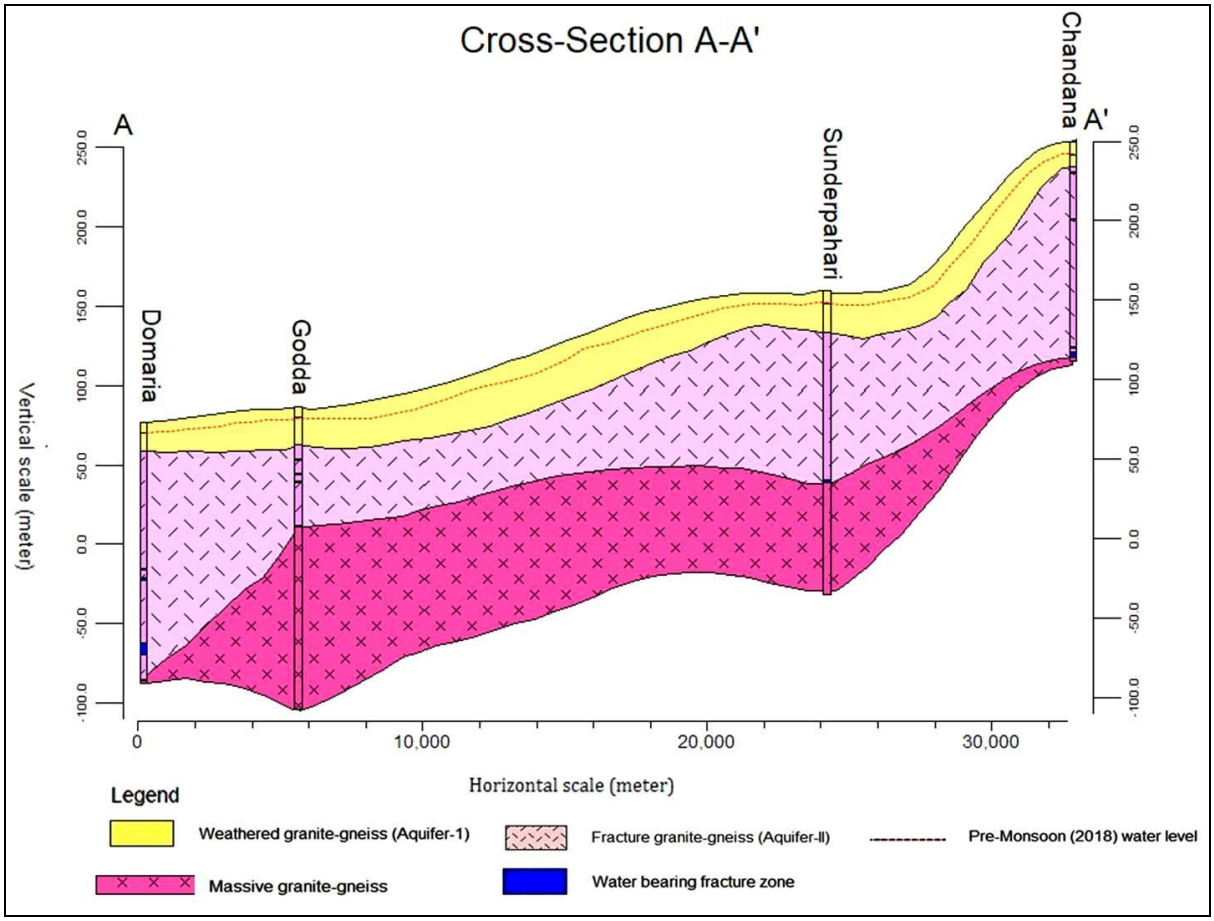


Figure-18: Hydrogeological cross section along A-A'

3.8.2 Hydrogeological cross section B-B': -

Hydrogeological cross section B-B' represents the area in NE-SW direction except the alluvial portion of Godda district. Cross section covers exploratory wells of Poreyahat, Ghatbanka, Godda College and Mahagama. The Aquifer- I bottom ranges from 9- 21 m representing weathered Granite gneiss, Granite and Laterites, while Aquifer-II ranges from 18-148 m representing fractured granite gneiss. Generally 3-5 fracture zones were encountered. Discharge ranges from 4.75 m^3/hr to 37.5 m^3/hr. Maximum discharge found at Godda College and minimum at Mahagama.

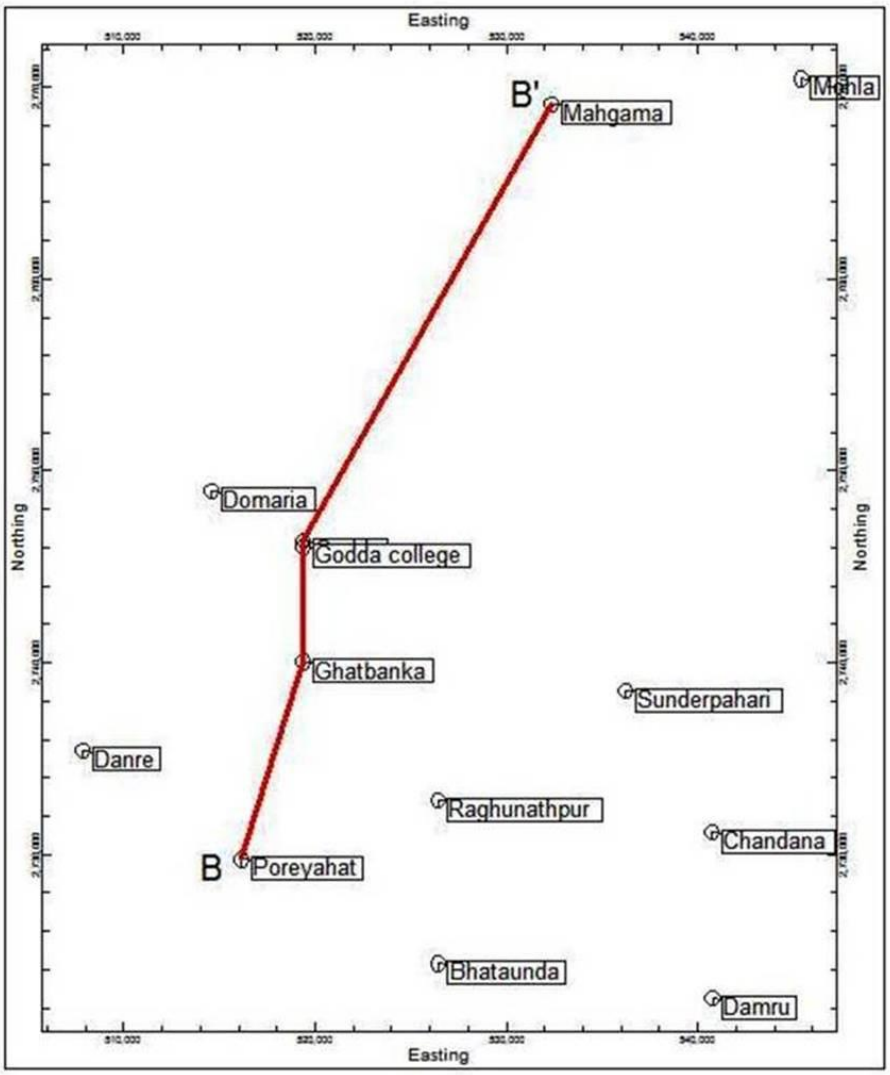


Figure -19: Location map of cross section along B-B'

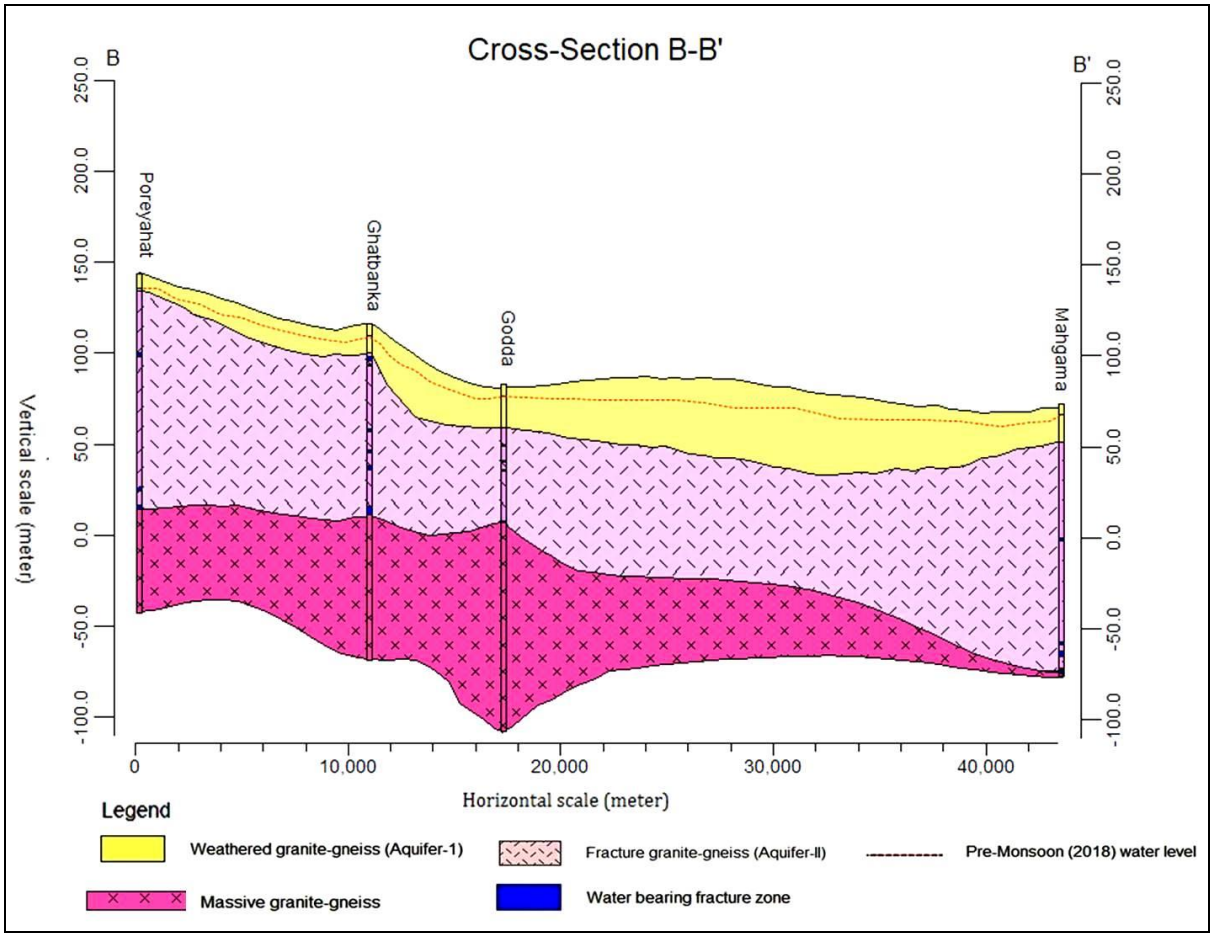


Figure-20: Hydrogeological cross section along B-B'

3.8.3 Hydrogeological cross section C-C':-

Hydrogeological cross section C-C' represents the area in Southern part except the alluvial portion of Godda district. Cross section covers exploratory wells of Darne, Poreyahat, Bhataunda and Damru. The Aquifer- I ranges 9- 17 m representing weathered Granite gneiss, Granite and Laterites, while Aquifer-II ranges from 17-130 m representing Fractured in granite gneiss. Generally 0-5 fracture zones were encountered. Discharge ranges from 0.25 m^3/hr to 49.2 m^3/hr. Maximum discharges found at Darne and minimum at Damru.

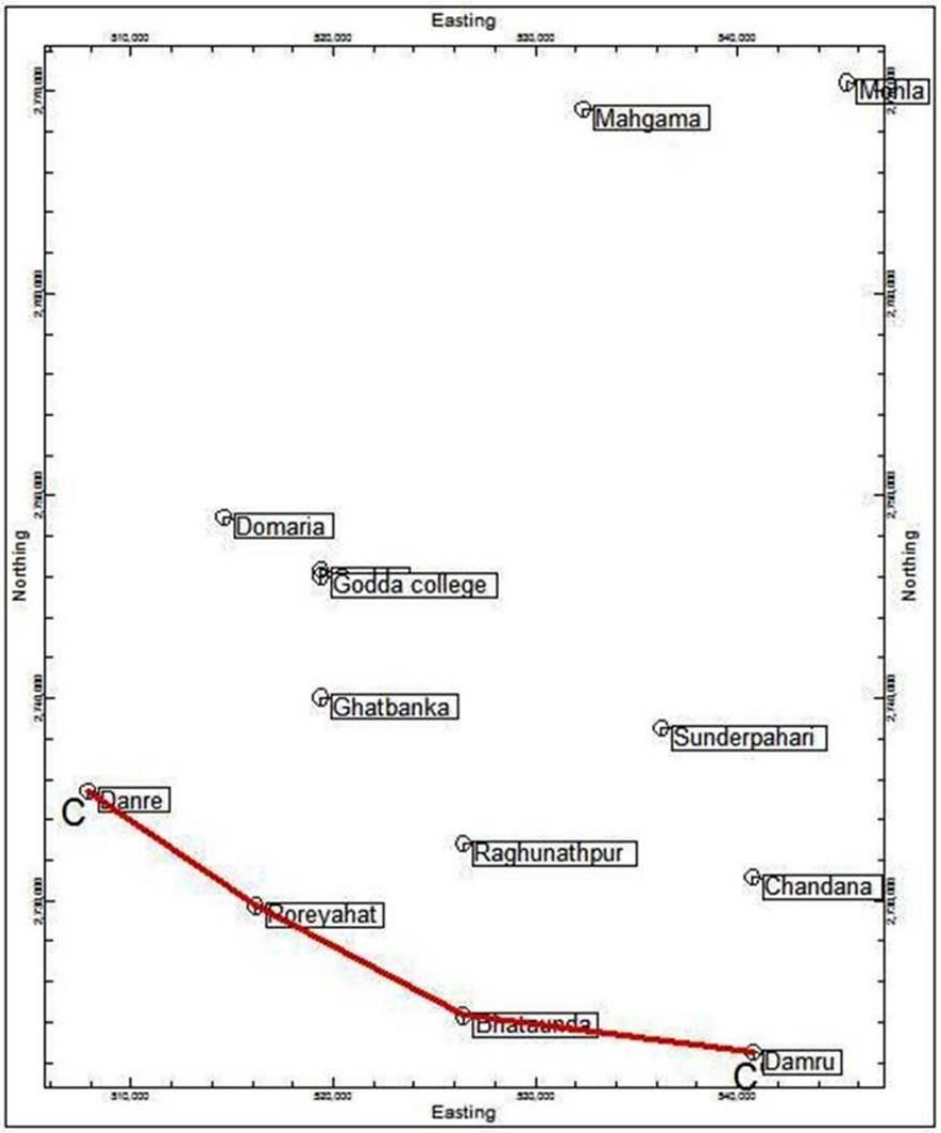


Figure -21: Location map of cross section along C-C'

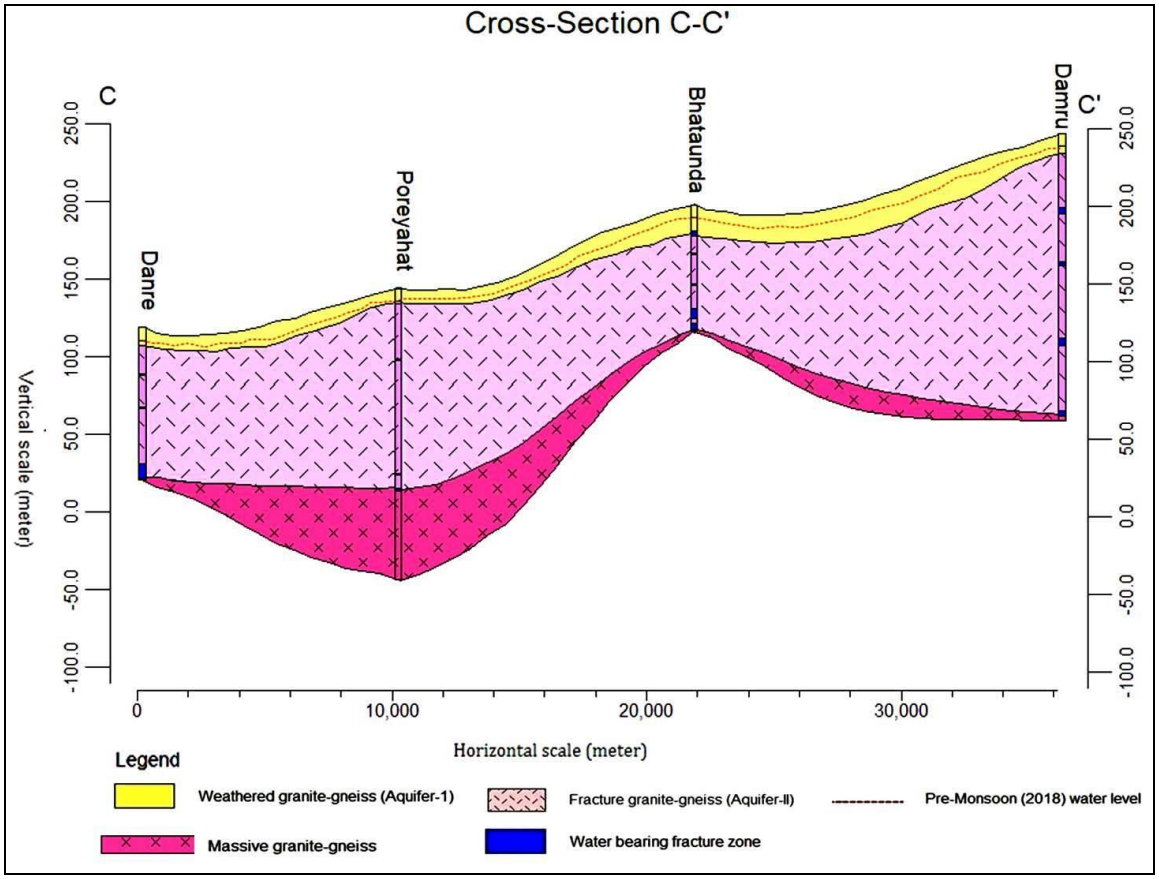


Figure -22: Hydrogeological cross section along C-C'

Hydrogeological cross section of A-A' B-B' & C-C' shown in figure- 21, 22 & 23 has been prepared based on exploratory well data of CGWB.The inferred imaginary line between fractured rock zone and massive rock zone depicted in Fig 21, 22 & 23 are also based on exploratory data. This is a regional model of hydrogeological cross setion. The heterogeneity of hard rock aquifer being high, the hydrogeological cross sections drawn by inferring the continuity of fracture zones in the second aquifer is tentative. Any additional data from the area in future may change the geometry of aquifer that can consider as well.

3.9 Aquifer Charcteristics:-

To know the aquifer characteristics, Step Drawdown test (SDT) and Aquifer Performamce Tests (APT) were conducted by CGWB. Granite Gneiss forms the main aquifer of the area and comprises two distinct units viz, weathered zone and hard rock fractured zones. Granite gneiss is hard, compact and does not have primary porosity and hence impermeable. Weathering, jointing and fracturing induces secondary porosity in massive unit of granite gneiss. Average thickness of fractures in Aquifer-II is about 2-5 m. Along with yield potential, the aquifer parameters viz., transmissivity and storativity also form an important aquifer characteristic and provide valuable input on sustainability of the aquifers. The transmissivity of Aquifer-II ranges from 8.29 – 177.20 m^2/day, whereas storativity of the aquifer ranges from 0.0000918 to 0.0043 which shows ground water is under semi-confined to confined state.

Table 17: Aquifer characteristics in hard rock areas of Godda district

Type of aquifer	Formation	Depth range of the aquifer	SWL (mbgl)		Thickness	Yield (m3/hr)	Aquifer parameter	
			Pre-Mon (2018)	Post-Mon (2018)			T (m^2/day)	Sy/S
Aquifer - I	Laterites/ Weathered Granite-Gneiss	9-27 m	2.80-9.10	2.00-7.76	2-5 m	5-10	-	-
Aquifer - II	Jointed/ fractured Granite Gneiss	18-163 m	-	-	2-5 m	Upto 49	Upto 177.20	0.0000918 to 0.0043
Aquifer-II	Gondwana Sanstone	Found at 77.60	-	-	0.5	12	-	-

Table 18 A: Results of Free Flowing Condition in Semi-consolidated Gondwana Formation of Godda district – Bansdiha Well Field (CMPDIL, 1994)

Type of aquifer	Head in m		Discharge(LPM)		Aquifer parameters		
	Min	Max	Min	Max	Transmissivity (m^2/day)	Hydraulic Conductivity (m/day)	Storativity
Aquifer - I	1.35 agl	2.55 agl	40	64	35	9	1.2x10-5
Aquifer-II	0.76 agl	2.32 agl	29	47	45	6	1.03x10-6
Aquifer-III	0.92 bgl	1.6 agl	120	180	310	30	1.03x10-6
Multiple Aquifer	-	-	85	130	454	18	2.2x10-8

Table 18 B: Aquifer characteristics in Semi-consolidated Gondwana Formation of Godda district – Bansdiha Well Field (CMPDIL, 1994)

Type of aquifer	Thickness of aquifer in m	Aquifer parameters		
		T (m^2/day)	Hydraulic Conductivity m/day	Storativity
Aquifer - I	13	193 (Avg)	14-15	2.5x10-5 to 8.35x10-5
Aquifer-II	14	162(Avg)	10-14	1.45x10-3 to 5.4x10-4
Aquifer-III	11	312(Avg)	28-29	1.24x10-3 to 9.16x10-4
Multiple Aquifer	38	670(Avg)	17	1.41x10-4

There is no exploratory data in alluvial formation of Godda district; therefore Aquifer Parameters could not be ascertained.

4 GROUND WATER RESOURCE

Ground Water Resource of the area has been estimated block wise based on for base year as on 2017. 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 Direcorate, Jharkhand based on GEC, Methodology 2015. The summarized detail of Annually Replenishable or Dynamic Ground Water Resources of Godda district is in Table-19. Other details information regarding Dynamic Ground Water Resources of Godda district is provided in Annexure-VII.

Table- 19: Dynamic Ground Water Resources Availability, Draft and Stage of GW Development 2017 (Figures in hectare meter)

Assessment Unit/ District	Annual Extractable Ground Water Recharge	Current Annual Ground Water Extraction for irrigation	Current Annual Ground Water Extraction for domestic	Current Annual Ground Water Extraction for industrial	Current Annual Ground Water Extraction for All uses	Net Ground Water Availability for future use	Stage of Ground Water Extraction in %	Category
Basantrai	1647.35	61.25	155.72	0.00	216.97	1430.37	13.17	Safe
Boarijor	2531.68	188.25	230.52	300.00	718.77	1812.91	28.39	Safe
Godda	3028.00	325.25	389.24	3.76	718.25	2309.74	23.72	Safe
Mahagama	2563.17	111.25	371.66	7.27	490.18	2072.99	19.12	Safe

Meherma	1956.44	112.50	243.84	0.00	356.34	1600.10	18.21	Safe
Pathargama	2640.63	134.75	192.74	0.00	327.49	2313.13	12.40	Safe
Poreyahat	2962.90	435.00	312.44	0.00	747.44	2215.46	25.23	Safe
Sunderpahari	1482.20	152.25	109.09	0.00	261.34	1220.86	17.63	Safe
Thakurghanti	1264.06	178.00	165.98	0.00	343.98	920.07	27.21	Safe
Total	**20076.43**	**1698.5**	**2171.23**	**311.03**	**4180.76**	**15895.63**	**20.82**	

4.2 Ground Water Resources In-storage – 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

Table 20: Assessment of In-storage ground water resource of hard rock

AQUIFER I	
Area (A) (sq km)	2111
Pre-monsoon (average) depth to water level (mbgl) (Z1)	6.32
Bottom of Unconfined Aquifer (mbgl) (Z2)	16.04
Specific yield (Sy)	3%
Saturated zone thickness (Z2-Z1) of aquifer (ST)	9.72
SGWR = A *(Z2 - Z1) * SY	615.56 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) = **200.76** *mcm +* **615.56** *mcm =* ***816.32*** *mcm*

5. GROUND WATER RELATED ISSUES

The Godda district forms part of predominantly tribal belt wherein villagers have got very small land holdings and they do not find it economical to engage in agricultural activity in comparison to the earning, they earn by working as labourer in industrial units and Govt. Deprtments. Further, the cultivators are illiterate tribal and are ignorant of improved agricultural practices. By and large the district is not favoured with surface water irrigation system because of hilly and undulating geographical setting. The major ground water related issues are:-

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 20.20%, based on 2017 GW resource assessment. Block wise stage of ground water development (SOD) varies from 12.63 to 28.39 percent. Graphical presentation of SOD is shown in figure – 24.

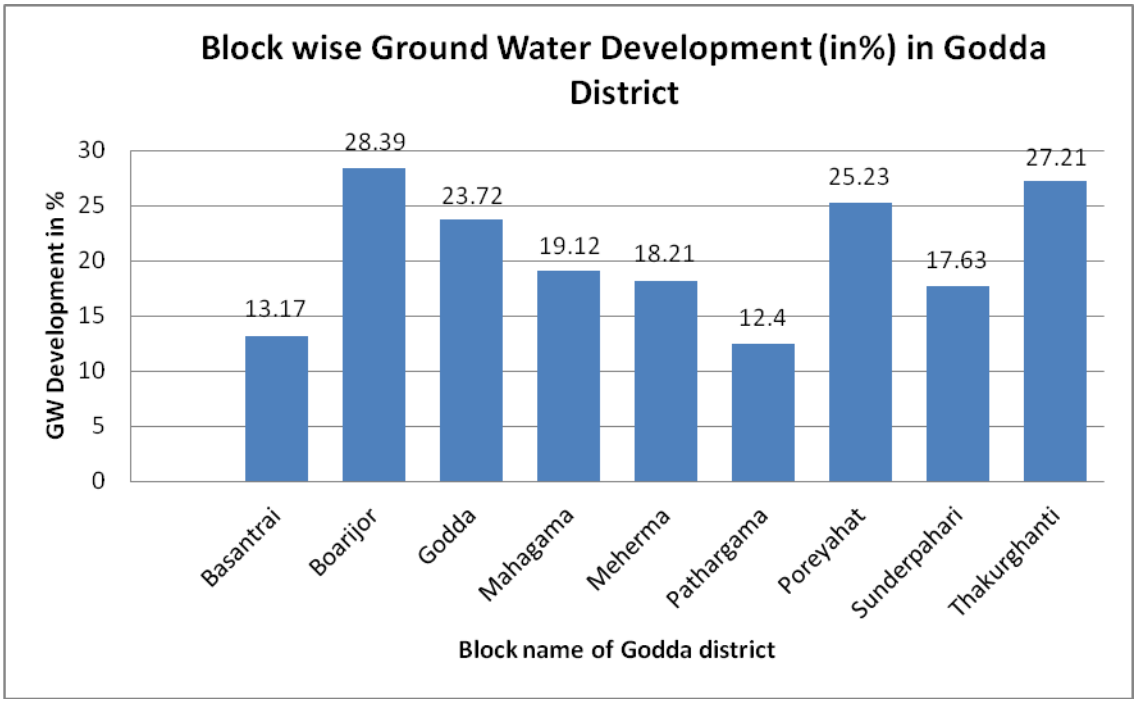


Figure 23 Block wise Ground Water Developement

5.2 Low Ground Water Potential / Limited Aquifer Thickness / Sustainability: Central Ground Water Board has constructed 14 exploratory and 13 observation wells in hard area of the district. Out of 14 Exploratory wells drilled the range of discharge were found to be in the range of (<1 lps-3 Nos, 1-3 lps- 2 Nos, 3-10 lps- 5 Nos, >10 lps- 5 Nos). Average thickness of weathering is 16.04 m and secondary porosity i.e. fracture zone is 4-5 m. Transmissivity value varies from 8.29 to 177.20 m2/day in hard rock area. The exploratory drilling results show that fractures generally die down with the depth and below 163 m there is no fracture due to occurrence of massive rocks. Maximum potential fracture exists between 75-150 m in the area. The fracture encountered of bore wells drilled in the area is classified and presented below in figure – 25.

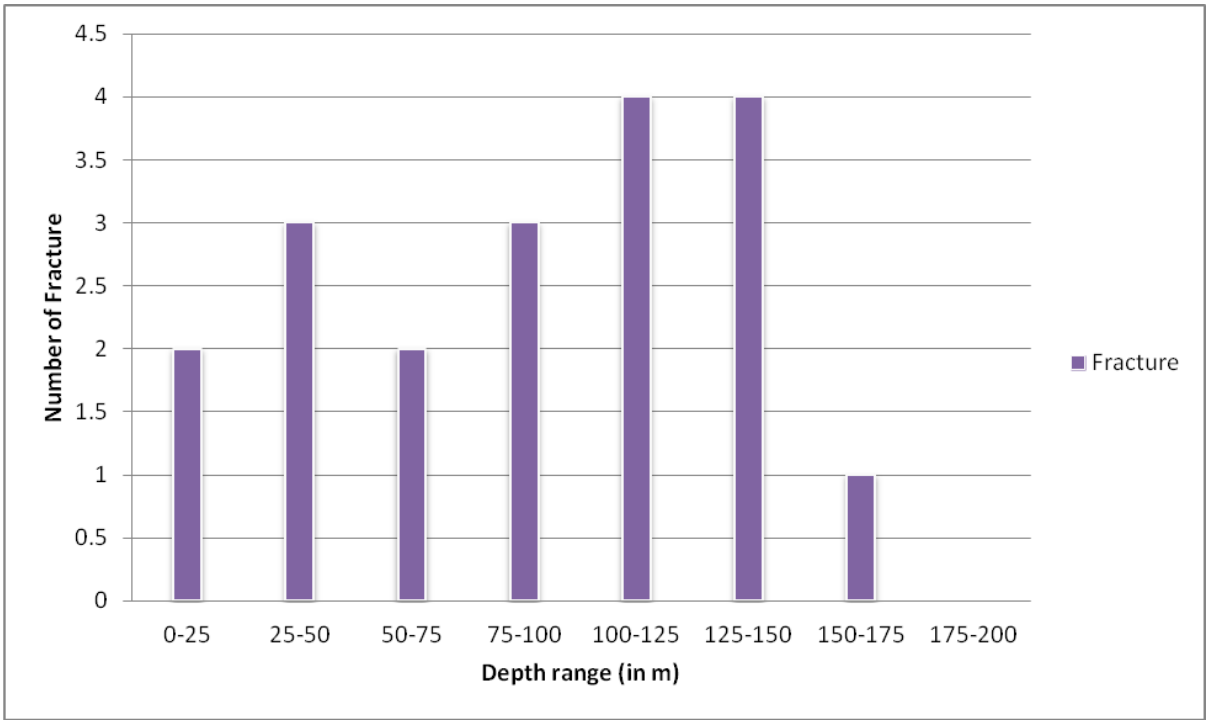


Figure – 24: Depth vs number of fracture encountered in bore wells drilled in Godda district

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 3 samples of shallow aquifer (dug well) Similarly, Fluoride concentration is found beyond permissible limit in 10 samples of shallow aquifer. In addition, very high EC value 2130 µ S/cm has been observed in dug well sample existing at Paharpur in Boarijor block. Also total hardness (TH) value found beyond permissible limit in the samples of dug wells located at villages Paharpur (645 mg/l). Uranium concentrations in Godda district were found to be in the range of 0.15 ppb to 36.33 ppb (one sample at Godda the uranium concentration was found more than permissible limit). Location details of Nitrate and Fluoride concentration found beyond permissible limit are given in table 21 and 22 respectively and also represented in figure – 26. The detail results of chemical analysis for uranium are in Annexure-VI.

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 contaminations 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 aquifer of Godda ditrict 3 water samples out of 21 have been found more than the permissible limit of NO_3 (45mg/l). Location details of NO_3 concentration found beyond permissible limit is given in table 21.

Table 21: Nitrate concentration found beyond permissible limit

Sl. no	Village	Block	Concentration NO_3
1	Sundermore tola	Godda	45.8
2	Ghorsanda	Godda	50.3
3	Gairadih	Basantrai	59.3

5.3.2 Fluoride contamination:

Consumption of water with fluoride concentration above 1.5 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 contaminated 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 10 samples, out of 21 have F concentration more than the desirable limit of 1.5mg/l. Location details of F concentration found beyond permissible limit is given in table-22 and sample wise Fluoride concentration is shown in figure-26 for shallow aquifer.

Table – 22: Location details of Fluoride concentration found beyond permissible limit

Sl. no	Village	Block	Concentration F
1	Shital	Mahagama	1.55
2	Gairadih	Basantrai	1.58
3	Baradumarhir	Boriojhor	3.35
4	Saraitola	Sundarpahari	1.82
5	Kaowadhab	Sundarpahari	1.7
6	Pandubathan	Godda	3.15
7	Parsauti	Poreyahat	1.97
8	Kurmanghat	Godda	2.48
9	Bassantpur	Godda	1.93
10	Motia	Godda	1.92

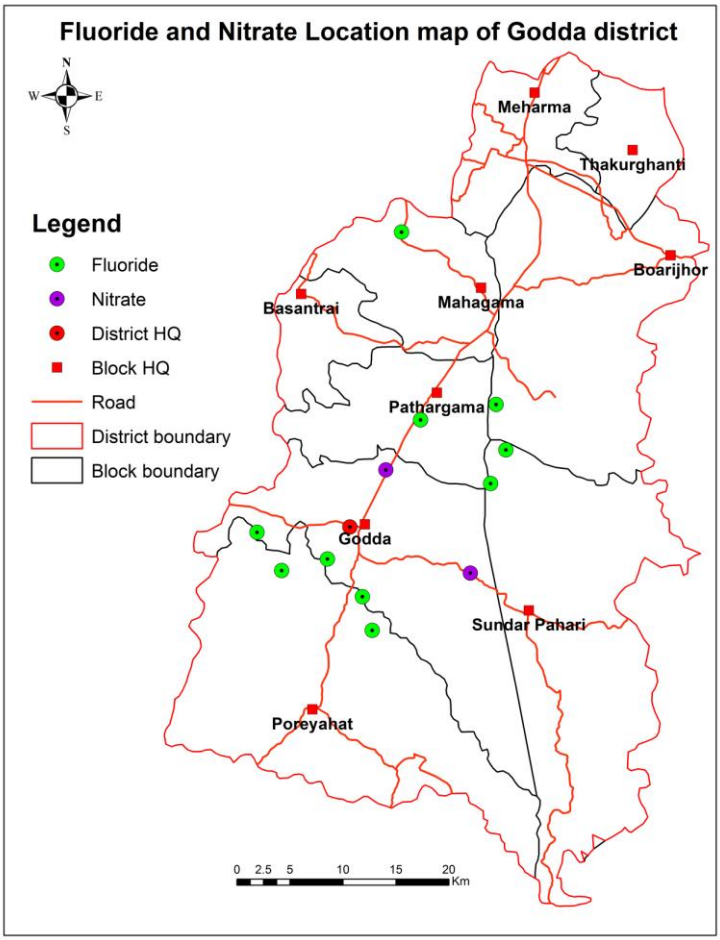


Figure – 25: Location map of NO_3 and F concentration found beyond permissible limit in ground water, Godda district.

5.3.3 Uranium Contamination

Total 17 samples were analysed for uranium concentration in Godda district. Uranium concentrations in Godda district were found to be in the range of 0.15 ppb to 36.33 ppb. Out of 17 samples, at one sample at Godda the uranium concentration was found more than permissible limit. The detail results of chemical analysis for uranium are in Annexure-VI.

6. MANAGEMENT STRATEGIES

As discussed in previous chapter, the major ground water related issue in the Godda 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 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 20.82% to 70%. Total 61816 dug wells (15-20 m depth) are recommended to be constructed in feasible areas. Similarly, 10303 shallow depth bore wells/tube wells (60-100m depth) are also recommended to be drilled in feasible areas. Proposed number of abstraction structure based on SOD 70% with future irrigation potential & unit draft (Dugwell-0.2 ha, BW- 1.2 ha). The Proposed number of abstraction structure are in Table-23

Table – 23: Future Irrigation Potential & Proposed number of Abstraction Structures based on SOD 70%

Block	Net GW Availability for Future Development	future irrigation potential available (ha) considering (Δ) 0.45m	70% of future irrigation potential to be created (ha)	Proposed number of ground water structure (Dug wells) 50%	Proposed number of ground water structure (STW/SBW) 50%
Basantrai	1430.37	3178.60	2225.02	5563	927
Boarijor	1812.91	4028.69	2820.08	7050	1175
Godda	2309.74	5132.76	3592.93	8982	1497
Mahagama	2072.99	4606.64	3224.65	8062	1344
Meherma	1600.1	3555.78	2489.04	6223	1037
Pathargama	2313.13	5140.29	3598.20	8996	1499
Poreyahat	2215.46	4923.24	3446.27	8616	1436
Sunderpahari	1220.86	2713.02	1899.12	4748	791
Thakurghanti	920.07	2044.60	1431.22	3578	596
Total	**15895.6**	**35323.62**	**24726.54**	**61816**	**10303**

The construction of above 72119 ground water abstraction structure would bring a additional area of 24726 ha under assured irrigation. It is necessary that proposed Additional ground water abstraction structure may be constructed in three 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 futher ground water development to achieve 100% utlisation.

6.2 Supply side Interventions:

At present as per Ground Water Resource Estimation 2017, the stage of ground water development is very low i.e., 20.82% 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. 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.

6.2.1 Augmentation plan of the resource through artificial recharge and water conservation 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 9m 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 in Godda district are in Table-24.

Table -24: Artificial recharge structures feasible in Godda district

Sl. No.	Block	Volume of unsaturated zone available for recharge (MCM	Total volume of Available Water for Recharge (MCM)	Percolation Tank	NalaBund/ Check dam / Gully Plug	Recharge Shaft
1	Basantrai	0.78	0.04	0	0	0
2	Boarijor	74.39	3.70	5	92	0
3	Godda	290.19	14.45	38	240	0
4	Mahagama	84.91	3.30	9	55	0
5	Meherma	6.10	0.30	0	0	6
6	Pathargama	109.91	5.47	15	91	0
7	Poreyahat	1503.24	52.03	138	867	0
8	Sunderpahari	267.95	9.84	26	163	0
9	Thakurghanti	5.44	0.27	0	0	5
		2750.16	**91.31**	**121**	**1521**	**11**

6.3 Demand Side Interventions

It is always essential to address the issue of constraining demand for groundwater abstraction since this will normally contribute more to achieving the groundwater balance. The concept of real water savings is critical in this regard. The main demand side interventions may be:-

- Promote improved irrigation technologies (drip or sprinkler irrigation, etc.)
- Crop choice management and diversification (promote less intensive crops like pulses and horticulture)

- Promote treated municipal waste water for irrigation and construction use.
- Managing energy and irrigation nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.)

6.4 Ground water management strategy for Nitrate and Fluoride affected areas:
Nitrate and Fluoride contamination are occurring in the granite gneisses of Mahagama, Basantrai, Boarijore, Sundarpahari, Godda, Poreyahat and Jarmundi 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 Flouride. Management of schemes or project related Nitrate and Flouride removal should be in hand of local peoples, so that peoples will keep the proper maintenance of machines and equipments.

6.5 Stress aspect against future demand (2021, 2031): Demand of water is increasing day by day against the increasing population. The detail demographic particular of the Godda district and water requirement for domestic purpose is worked out for the year 2031 and 2031 is presented in table – 25, 26 & 27.

Table 25: Detail demographic particular of Godda district

Population as per census			
2001		2011	
Rural	Urban	Rural	Urban
10,10,931	37,008	12,49,132	64,419

Table – 26: Projected population

Projected population			
2021		**2031**	
Rural	Urban	Rural	Urban
1542678	112127	1836224	159836

Table – 27: Requirement of water for domestic use

	Water requirement (assuming 90 liters per day per person for rural population and 130 liters per day per person for urban population)			
	2021		2031	
	Rural (Litres/day)	Urban (Litres/day)	Rural (Litres/day)	Urban (Litres/day)
	138841020	14576510	165260160	23975400
Total	**153417530 litres / day**		**189235560 litres / day**	

On perusal of table – 27, the requirement of water will be 189235560 litres per day in 2031. The demand of water is increasing due to highly increasing of population. Thus, recommended for alternate surface water supply from river to reduce the stress of ground water.

7.0 Sum-up

- The district Godda is spread over 2111 Sq. km area consisting of 2 subdivisions and 9 blocks situated in the north–eastern part of the Jharkhand state. It is bounded in the north and west by Bhagalpur district of Bihar state, in the east by Sahebganj and Pakur districts and in the south by Godda district. As per census of 2011, total population of the district is 1313551 with rural population of 1249132 and urban population 64419.

- Aquifer Mapping Study was carried in Godda district, Jharkhand covering an area of 2111 sq.km consisting of 9 blocks through collection of various data from state/Central Govt agencies, data gap analysis, data generated in-house/outsourcing All the available data/ data generated were analysed and integrated to prepare aquifer maps and aquifer management plans of the district.

- The predominant physical feature over major part of the district is the rolling topography dotted with isolated inselbergs. The major hills are confined to the eastern part of the district. The principal rivers of the district are Kajhia, Harna, Sunder, Sapin, Kao, Cheer, Burigeria and Geura. The district is characterized by humid to sub-humid climate.

- Geologically the study area represents highly deformed Archean gneisses called chotanagpur granite gneissic complex, older meta-sedimentaries. The pre-Cambrian formations are uncomfortably overlain by lower gondawanas comprising Talchirs & Barakar formation. Barakar sandstone and shale contains coal seams found in major coal belt of the area. The upper Gondwana are represented by Dubrajpur formation. Rajmahal traps and intertrappeans overlie the Dubrajpur formation. Tertiary Laterites occur as capping in some of the parts, while Quaternary sediments represented by Sautadih, Belhar and Diara formation consisting of older and newer alluvium are found in considerable part of the area.

- 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 three hydrogeological unit-Consolidated formation(represented by chotanagpur gneiss complex & Rajmahal Traps), semi-consolidated formation (represented by Gondwana formations) and Uncosolidated formation(represented by tertiary laterites & quaternary alluvium.

- Ground water occurs in consolidated formation under unconfined to semi-confined state in Aquifer-I (upto the depth of 30m). Yield of the wells in Aquifer-I is very poor restricted upto 10 m3/hr in laterites/weathered basalt/weathered Granite-Gneiss. These aquifers are generally tapped in the dugwells or shallow borewells.

- In fissured formations of the district the major potential fractures zones are found in Aquifer-II between 40-120 m. In general, discharge of well has been found in the range of 2-49 m^3/hr. The Transmissivity value and Storativity value

range from 8.29 m2/day 177 m^2/day and 1.29x10-3 to 9.18x10-5 respectively. Ground Water occurs under semi-confined to confined state in Aquifer-II.

- First potential fracture zone encountered in the district widely varies from 17-119 m.The potential fractures were encountered in Precambrian formation at shallow level upto 75.00 m with very high yielding wells(Bhataundha-49.2 m3/hr, Godda- 10.59 m3/hr). Potential fractures were also encountered beyond 100 m depth(120-162 m) with cpious amount of discharge e.g Poreyahat(17.04 m3/hr), Dumaria(16.5 m3/hr), Godda College(37.5 m3/hr), Chandna(29.5 m3/hr).

- In Gondwana sanstone, Potential aquifer encountered at 77.00 m at Mohala with the yield of 12.24 m3/hr. In Rajmahal Traps, the vesicular basalts, intratrappean beds, contact zone of two volcanic eruptions etc form potential aquifer zones.

- Investigations carried out by CMPDIL revealed the presence of 5 confined aquifers in Barakar sandstones of lowere Gondwana age in Lalmatia area. The thickness of aquifer ranges from 10-70m and the cumulated yield ranges from 50-135 m3/hr, however discharge of individual aquifer ranges from 10—60 m3/hr in general. Out of 5 confined aquifers, within aquifer–III, upto the depth of 50m is most potential capable of yield of 40-60 m3/hr of water under free flowing condition.

- The quaternary alluvium occurring in the area constitutes three alluvial formations viz Sautadih/Jamui, Belhar and Diara formations, exposed in the northern and north western part of the study area. The thickness of alluvium is as high as 100 m. in which tubewell discharge range from 25-50 m3/hr.

- Ground Water quality is generally potable, however excessive limit of Flouride concentration was found in 10 number water samples out of 21, in six blocks and Nitrate concentration was found in 4 numbers water samples out of 21 and 1 number in Urnaium concentration in Godda block.

- The stage of ground water development in Godda district is 20.82% and all the block comes under safe category.Therefore there is sufficient scope for further ground water development.

- Three major ground water related issues in Godda district are Low ground water development, Low ground water potential/ sustainability and sporadic Flouride contamination in seven blocks.

- Ground Water Management strategy suggested are construction of 61816 dugwells and 10303 Shallow Tubewells/borewells in the feasible ares in the district to enhance the overlall ground water development to 70%. This would bring a additional area of 24726 ha under assured irrigation.

- To suggest a sustainable ground water management plan there are two options-Supply Side Management Options(local water harvesting techniques) & Demand Side Management Options (real water-savings).

- The supply side interventions envisages construction of 1521 nos of Check Dam/Nala bund-, 121 nos of Percolation Tank, 11 recharge shaft and 4260 nos building RTRWH in the areas feasible for construction of recharge structures based on the long term water level scenario and recharge potential of the aquifer. 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.

- 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.

REFERENCES

- CMPDIL, 1984: A report on Hydrogeological Investigations Rajmahal Project, Block A Eastern Coalfield Limited, District Godda, Bihar.
- GSI, 2013: Geological and Mineralogical Map of Jharkhand, publication.
- GSI, 2009: District Resource Map, Godda, Jharkhand, GSI publication
- Manohar Sinha & N.P.Verma, 1995: Quaternary Geological and Geomorphological mapping of chandan-Badua sub-basin in parts of Bhagalpur, Banka, Dumka & Godda district, Bihar, GSI Report
- S.Shekhar, 1992: Hydrogeology and Ground Water Resources of Godda district, Bihar, CGWB Report
- S.Shekhar & S.Upadhyay, 1995: Ground Water Resources Development plan for the tribal district of Godda, Bihar, CGWB Report
- Sudhanshu Shekhar, 1999: An Integrated Study of Hydrogeological Condition in the diverse geologic terrain of Godda district, Bihar, Ph.D thesis, Patna University Patna

Annexure - I

DETAILS OF KEY WELLS ESTABLISHED FOR NATIONAL AQUIFER MAPPING STUDY OF GODDA DISTRICT, 2018 –19

Well No.	Village	Block	Owner	Location	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Dia. (m.)
1	Sundarmor tola	Godda	Govt.	In the village of sundarmor, sahara tola	DW	Granite Gneiss	Rope and bucket	0.75	8.80	2.25
2	Ghorsanda	Godda	Private	In front of Udeshwar Pandith's House	DW	Granite Gneiss	Motorised	0.65	5.30	1.10
3	Ghatgamharia	Mahagama	Govt.	Near Primary school Ghatgamharia	DW	Granite Gneiss	Rope and bucket	0.70	7.20	2.10
4	Shital	Mahagama	Private	About 200m before crossing of Canal LHS Narayanpur toshital	DW	Granite Gneiss	Motorised	0.90	8.75	3.50
5	Paharpur	Boriojhor	Govt.	RHS, after crossing Paharpur School on the way Lalmatia to Boarijor	DW	Granite Gneiss	Rope and bucket	1.00	7.80	1.80
6	Barashripur	Boriojhor	Govt.	In the village near Trijuction	DW	Granite Gneiss	Rope and bucket	0.77	8.40	3.60
7	Thakurghanti	Thakurghanti	Govt	Near Shiv Temple LHS Thakurghant to Meharma road about 200m from Thakurghanti Chowk	DW	Alluvium	Rope and bucket	0.67	8.63	1.80
8	Sonpur	Thakurghanti	Govt.	In the village Makuchak	DW	Alluvium	Rope and bucket	0.70	8.65	3.70
9	Babupur	Meharma	Govt.	In the boarder of Jharkhand and Bihar	DW	Alluvium	Motorised	0.00	13.00	5.10
10	Bishunpur	Basantrai	Private	Near nala Bridge, Bishunpur, anout 500m RHS from middle school, Bishunpur	DW	Alluvium	Rope and Bucket	0.35	4.30	1.65
11	Gairadih	Basantrai	Private	In gairadih village okm milestone	DW	Alluvium	Rope and bucket	0.70	2.15	1.30
12	Baradumarhir	Baorijhor	Govt.	Near Primary School ,Bara-Dumarchir	DW	Rajmahal Trap	Rope and bucket	0.52	7.18	3.00

13	Saraitola	Sundarpahari	Govt.	In the village of saraitola	DW	Granite Gneiss	Rope and bucket	0.63	8.27	3.00
14	Kaowadhab	Sundarpahari	Govt.	In the village of Kaowadhab	DW	Granite Gneiss	Rope and bucket	0.60	7.30	3.00
15	Tilobdar	Godda	Govt.	In the premises of Tilobar, Utkramit middle school	DW	Granite Gneiss	Electric motor	0.88	7.00	2.25
16	Pandubathan	Godda	Govt.	In the village of Pandubathan about 2km from Biodiversit park Godda	DW	Granite Gneiss	Rope and bucket	0.55	8.50	3.00
17	Parsauti	Poreyahat	Govt.	In the village parsauti	DW	Granite Gneiss	Rope and bucket	0.90	11.70	4.20
18	Kurmanghat	Godda	Govt.	Late Sagar Mandal owner in the village of Kumarghat	DW	Granite Gneiss	Rope and bucket	0.95	8.95	1.80
19	Basaantpur	Godda	Govt.	In the agriculture Land	DW	Granite Gneiss	Rope and bucket	0.55	7.55	4.80
20	Motia	Godda	Private	In the house of Hari Yadav in motia village	DW	Granite Gneiss	Motorised	0.55	6.45	2.00
21	Godda	Godda	Govt.	Opposite to the Office	DW	Granite Gneiss	Rope and Bucket	0.55	9.15	3.60

Annexure – II

WATER LEVEL DATA OF KEY & NHNS WELLS OF NAQUIM STUDY AREA OF GODDA DISTRICT, JHARKHAND, 2018-19

Sl No	Village	Block	District	May 2018 DWL(inmbgl)	Nov. 2018 DWL(inmbgl)	Pre-post Fluctuation
1	Sundarmor tola	Godda	Godda	7.21	3.35	3.86
2	Ghorsanda	Godda	Godda	5.1	2	3.1
3	Ghatgamharia	Mahagama	Godda	4.8	4.25	0.55
4	Shital	Mahagama	Godda	5.03	4.1	0.93
5	Paharpur	Boriojhor	Godda	4.96	4.2	0.76
6	Barashripur	Boriojhor	Godda	6.28	3.79	2.49
7	Thakurghanti	Thakurghanti	Godda	6.03	3.68	2.35
8	Sonpur	Thakurghanti	Godda	4.4	2.9	1.5
9	Babupur	Meharma	Godda	5.1	3.1	2
10	Bishunpur	Basantrai	Godda	3.9	3.8	0.1
11	Gairadih	Basantrai	Godda	2.8	2.25	0.55
12	Baradumarhir	Baorijhor	Godda	6.43	2.78	3.65
13	Saraitola	Sundarpahari	Godda	5.57	4.17	1.4
14	Kaowadhab	Sundarpahari	Godda	7.1	5.85	1.25
15	Tilobdar	Godda	Godda	6.15	4.37	1.78
16	Pandubathan	Godda	Godda	8	6.7	1.3
17	Parsauti	Poreyahat	Godda	9.1	7.76	1.34
18	Kurmanghat	Godda	Godda	6.6	3.55	3.05
19	Basaantpur	Godda	Godda	6.45	3.75	2.7
20	Motia	Godda	Godda	5.9	3.4	2.5
21	Godda	Godda	Godda	7.9	4.7	3.2
22	Bara borijore	Boarijore	Godda	7.85	3.06	4.79

23	Bisaha	Pathergama	Godda	6.04	3.10	2.94
24	Chamudih	Poreyahat	Godda	7.83	6.65	1.18
25	Doi	Mehegama	Godda	4.33	2.49	1.84
26	Gobra	Mahagama	Godda	3.77	2.77	1
27	Godda1	Godda	Godda	5.80	4.36	1.44
28	Jainipaharpur	Godda	Godda	7.80	4.51	3.29
29	Kumardih	Godda	Godda	4.88	2.65	2.23
30	Lalmatia	Mahagama	Godda	7.62	6.27	1.35
31	Mahagama	Mahagama	Godda	7.35	7.20	
32	Mahagama1	Mahagama	Godda	8.80	8.33	
33	Maheshpur2	Pathargama	Godda	7.00	3.18	3.82
34	Pathargama	Pathargama	Godda	6.35	5.21	1.14
35	Raghunathpur	Poreyahat	Godda	7.68	4.30	3.38
36	Sundar Pahari	Sundar Pahari	Godda	12.10	10.33	1.77

Annexure - III

Details of wells constructed in hard rock formation in Godda district

Sl.No.	Location	Block	Co-ordinate	Depth Drilled (mbgl)	Casing pipe (in m)	Fractured Zone (Thin zone beween) in m	Static Water level (mbgl)	Discharge $m^3/hr.$ (Air Comp)	Drawdown (in m)	Transmissivity (m^2/day)	Storativity	Diameter of assembly (mm)	Formation	Year
1	Godda EW	Godda	$24^0$49'55 & $87^0$11'30"	191	24	33.00-34.00 42.00-43.00, 47.00-48.00 75.00-76.00	6.00	10.59 5.95(P)	9.53	8.29	$9.18X10^{-5}$	165	GG	Feb-92
2	Mahgama	Mahgama	$25^0$02'15" $87^0$19'15"	148	21	74.00-75.00 131.00-132.00 136.00-139.00 145.00-146.00 147.00-148.00	5.17	4.75	-	-	-	165	-do-	Jul-90
3	Patharg ama	Patharg ama	$24^0$56'30" $87^0$18'45"	191	9	-	-	DRY	-	-	-	165	-do-	Jun-92
4	Sunderp ahari	Sunderp ahari	$24^0$45'40" $87^0$21'30"	191	26.5	119.00-121.00	6.68	2.22	-	-	-	165	-do-	Mar-92
5	Poreyah at	Poreyah at	$24^0$40'55" $87^0$09'35"	187	9.7	45.00-46.00 119.00-120.00 129.00-130.00	-	17.04	-	-	-	165	-do-	Mar-92
6	Danre	Poreyah at	$24^0$44'00" $87^0$04'40"	97	-	30.00-31.00 51.00-52.00 88.00-97.00	6.29	37.5 20.17(P)	12.1	177	$4.3X10^{-3}$	165	-do-	May-92
7	Domaria	Godda	$24^0$51'20" $87^0$08'40"	164	18.18	92.00-93.00, 98.00-99.00 139.00-146.00 162.00-163.00	5.78	16.5	-	-	-	165	-do-	Apr-93

Sl.No.	Location	Block	Co-ordinate	Depth Drilled (mbgl)	Casing pipe (in m)	Fractured Zone (Thin zone beween) in m	Static Water level (mbgl)	Discharge $m^3/hr.$ (Air Comp)	Drawdown (in m)	Transmissivity (m^2/day)	Storativity	Diameter of assembly (mm)	Formation	Year
8	Godda College	GODDA	24⁰49'45" 87⁰11'30"	129	13.6	63.00-64.00, 104.00-105.00 115.00-116.00 118.00-119.00 120.00-121.00	5.5	37.5 11.14(P)	8.22	139.8	$4.48X10^{-4}$	-	-do-	Mar-96
9	Ghatbanka- EW	Godda	24⁰46'30" 87⁰11'30"	99	9	22.00-23.00, 49.00-50.00 92.00-93.00 95.00-99.00	3.1	39.5 7.58(P)	13.6	39.7	$1.01X10^{-5}$	-	-do-	Sep-96
	Ghatbanka- OW	Godda		185	16	18.00-20.00 22.00-23.00 58.00-59.00 69.00-71.00 78.00-80.00	3.06							
10	Chandana-EW	Sunderpahari	24⁰41'40" 87⁰24'10	138	16	19.00-20.00, 49.00-50.00 129.00-130.00 133.00-136.00	2	29.5 9.40(P)	12.42	17.95	$1.29X10^{-3}$			Nov-96
	Chandana-EW	Sunderpahari		136	14.5	25.00-26.00, 75.00-77.00 125.00-126.00 127.00-128.00	2.3	23.08						
11	Raghunathpur-EW	Poreyahat	24⁰42'35" 87⁰15'40"	147	12.5	38.00-39.00, 42.00-43.00 107.00-108.00	4.6	31.5 11.7(P)	12.4	100.63	$4.8X10^{-5}$			Nov-95
	Raghunathpur-OW	Poreyahat		166	17.53	23.00-24.00, 38.00-39.00 99.00-100.00		8.4						

Sl.No.	Location	Block	Co-ordinate	Depth Drilled (mbgl)	Casing pipe (in m)	Fractured Zone (Thin zone beween) in m	Static Water level (mbgl)	Discharge $m^3/hr.$ (Air Comp)	Drawdown (in m)	Transmissivity (m^2/day)	Storativity	Diameter of assembly (mm)	Formation	Year
12.	Damru	Sunderpahari	$24^0$36'58" $87^0$24'10"	185	13	-	5.54	0.25	-	-	-	-	-	Dec-96
`	Bhataunda-EW	Poreyahat	$24^0$37'58" $87^0$15'40"	81	17	17.00-20.00 31.00-32.00 51.00-52.00 67.00-73.00 76.00-80.00	8.54	49.2 31.15(P)	7.07	129.15	$5.6X10^{-4}$	-	-	Feb-97
	Bhataunda-OW	Poreyahat		93	17.75	19.00-20.00, 32.00-033.00 70.00-71.00, 77.00-79.00 84.00-85.00 87.00-88.00	8.63	42						
14	EW Primary school Mohala	Boarijor		153.80	17.5	77.60	4	12.24	-	-	-	-	Gondwana	July2019

P-Pumping Discharge

Annexure - IV

LITHOLOGS OF EXPLORATORY /OBSERVATION WELLS IN GODDA DISITRICT

Litholog of Exploratory Well, Primary School Mohala, Block Boarijor, Godda Jharkhand

Unique ID: 1	EW
Village	Mohala, in the Campus of Govt. Primary School,
Block	Boarijor
District	Godda
Toposheet No.	72O/08
Latitude	25^0 02'58"
Longitude	87^0 27' 00"
RL (m amsl)	-
Drilled Depth (mbgl)	153.80
Casing depth (m bgl)	18.00
SWL(m bgl)	--
Discharge (m3/hr)	12.24 m3/hr
Date / Year	29/3/2019

Depth in m	**Thickness in m**	**Description of litholog**
00.0- 12.64	12.64	Soil sticky brown colour
12.64 – 35.50	22.86	Basalts dark colour angular fragments
35.50 – 54.74	19.24	Shales black colour
54.74 – 62.36	7.62	Sandstone light colour(compact like gneissic rocks)
62.36 – 69.98	7.62	Shale about 70% with coal about 20%and sands about 20%
69.98 – 88.84	18.86	Sands (fine to medium) brown in colour (Discharge 12.24 m^3/hr.)
88.84 – 96.46	7.62	Coal with Shale about 50% each
96.46 – 104.08	7.62	Shales with sand stones
104.08 – 126.94	22.86	Brown colour fine sands
126.94 – 134.26	7.32	Shales with coal
134.20 – 146.18	11.98	Sands fine to medium
146.18 – 153.80	7.62	Coal with shale

Litholog of Exploratory Well Bhatondha, Block Poreyahat, Godda Jharkhand

Unique ID: 2	EW
Village	Bhatondha
Block	Poreyahat
District	Godda
Toposheet No.	72P
Latitude	24^0 43'30"
Longitude	87^0 12' 10"
RL (m amsl)	
Drilled Depth (mbgl)	75
Casing depth (m bgl)	17.00
SWL(m bgl)	8.54
Discharge (m3/hr)	17.04 m3/hr
Date / Year	14/02/1997

Formation Granite Gneiss

Depth in m		**Description of litholog**
0.00-3.00	3.00	Surface soil, dark brown colour with weathered granite material
3.00 – 10.00	7.00	Weathered granitic gneiss
10.00 – 20.00	10.00	Granitic gneiss, feldspar, biotite
20.00 – 23.00	3.00	Weathered gneiss brown colour
23.00 – 26.00	3.00	Granite gneiss
26.00 – 33.00	8.00	Biotic gneiss with quartz veins
33.00 – 35.00	2.00	Biotite- gneiss
35.00 – 65.00	30.00	Granite gneiss (Mica dominant)
65.00 – 67.00	2.00	Biotite schist
67.00 – 73.00	6.00	Biotite schist highly fractured
73.00 – 79.00	6.00	Biotite schist highly fractured
79.00 – 81.00	2.00	Biotite schist highly fractured

Litholog of Exploratory Well Chandana, Block Sundarpahari, Godda Jharkhand

Unique ID: 3	EW
Village	Chandana
Block	Sundarpahari
District	Godda
Toposheet No.	72P
Latitude	24^0 41'20"
Longitude	87^0 22' 30"
RL (m amsl)	
Drilled Depth (mbgl)	136
Casing depth (m bgl)	14.50
SWL(m bgl)	3.22
Discharge (m3/hr)	23 m3/hr
Date / Year	19/11/1996

Formation Granite Gneiss

Depth in m		**Description of litholog**
0.00-4.00	4.00	Lateritic clay, reddish brown
4.00 – 13.00	9.00	Sands medium to fine with with weathered partical of rocks
13.00 – 20.00	7.00	Granitic gneisses, partially fractured grey colour
20.00 – 50.00	10.00	Granitic gneisses, partially fractured grey colour
50.00 – 54.00	4.00	Granitic gneisses dark colour
54.00 – 81.00	27.00	Granitic gneisses hard (compact) grey in colour
81.00 – 105.00	24.00	Granitic gneisses hard (compact) dark grey in colour
105.00 – 124.00	23.00	Granitic gneisses hard (compact) dark grey in colour
124.00 – 130.00	6.00	Granitic gneisses massive dark black in colour
130.00 – 133.00	3.00	Granitic gneisses with feldspar, quartz light yellow in colour
133.00 – 138.00	6.00	Granitic gneisses vein of garnet in chips

Litholog of Exploratory Well Ghatbanka, Block Godda, Godda Jharkhand

Unique ID: 4	EW
Village	Ghatbanka
Block	Godda
District	Godda
Toposheet No.	72P
Latitude	24^0 46'30"
Longitude	87^0 18' 20"
RL (m amsl)	
Drilled Depth (mbgl)	183
Casing depth (m bgl)	16.50
SWL(m bgl)	3.06
Discharge (m3/hr)	12.24 m3/hr
Date / Year	30/08/1996

Formation Granite Gneiss

Depth in m		**Description of litholog**
0.00-2.00	2.00	Suface soil laterite, reddish brown colour, Iron content
2.00 – 9.00	7.00	Weathered rock micaceous
9.00 – 17.00	8.00	Granite gneisses
17.00 – 19.00	2.00	Granitic gneisses, quartz prone
19.00 – 24.00	5.00	Granite gneiss with quartz-garnet
24.00 – 44.00	20.00	Biotite schists, Gneisses
44.00 – 50.00	6.00	Biotite Garnet bearing Gneisses
50.00 – 54.00	4.00	Granite gneisses with Biotite, Garnet
54.00 – 63.00	9.00	Pink granite, Gneisses, Feldspar
63.00 – 75.00	3.00	Granite, quartz % more prominent
75.00 – 78.00	3.00	Pink Granite
78.00 – 82.00	4.00	Gneisses with Biotite, quartz
82.00 – 85.00	3.00	Pink Granite
85.00 – 100.00	15.00	Quartz dominant gneisses
100.00 – 108.00	8.00	Granite gneiss
108.00 – 120.00	12.00	Gneisses with quartz and Biotite
120.00 – 158.00	38.00	Biotite gneisses
158.00 – 182.00	24.00	Pink granite with Biotite, Feldspar
182.00 – 183.00	1.00	Biotite gneisse

Litholog of Exploratory Well Damru, Block Sundarpahari, Godda Jharkhand

Unique ID: 5	EW
Village	Damru
Block	Sundarpahari
District	Godda
Toposheet No.	72P/
Latitude	24^0 38'30"

Longitude	87^0 25’ 00”
RL (m amsl)	
Drilled Depth (mbgl)	185
Casing depth (m bgl)	13.50
SWL(m bgl)	5.54
Discharge (m3/hr)	1.5 m3/hr
Date / Year	29/12/1996

Formation- Granite Gneiss

Depth in m		**Description of litholog**
0.00 - 4.00	4.00	Reddish brown colour lateritic soil
4.00 – 12.00	8.00	Weathered granite soil
12.00 – 15.00	3.00	Hard compact pink granite
15.00 – 18.00	3.00	Biotite, Granitic gneisses
18.00 – 46.00	28.00	Quartzite gneisses
46.00 – 62.00	16.00	Biotite gneisses
62.00 – 69.00	7.00	Granite gneisses
69.00 – 72.00	3.00	Biotite- gneisses
72.00 – 79.00	2.00	Mica schists
79.00 – 83.00	4.00	Quartz- Schists
83.00 – 85.00	2.00	Pink Granite
85.00 – 122.00	37.00	Biotite-Granite gneisses
122.00 – 132.00	3.00	Biotite-Granite Schists
132.00 – 137.00	5.00	Biotite-Schists
137.00 – 174.00	37.00	Biotite- gneisses
174.00 – 185.00	11.00	Granite-Gneisses

Annexure - V

Water quality data of aquifer – I (dug well samples) of aquifer mapping study area of Godda district

SL. No.	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}	TDS	$PO43^{-}$	Sio2	S S P%	SAR	RSC	%Na	K I	Mg^{+2}	P I
	mg/l																				
1	175	48.00	13.36	52.93	0.54	0	172.20	46.3	49	***45.8***	1.13	358	BDL	39.75	39.67	1.74	-0.68	39.82	0.66	31.42	68.64
2	280	74.00	23.08	89.12	0.78	0	141.45	156.9	78.79	50.3	0.446	648.32	BDL	16.47	40.90	2.32	-3.28	41.02	0.69	33.92	56.97
3	300	92.00	17.01	51.58	0.72	9	362.85	59	28.62	5.91	1.12	519.04	BDL	21.57	27.21	1.29	0.25	27.37	0.37	23.33	56.80
4	145	38.00	12.75	50.90	0.60	12	227.55	14.6	32.5	2.09	1.55	312.32	BDL	12.49	42.87	1.82	1.18	43.04	0.75	35.58	80.28
5	***645***	182.00	46.17	177.00	1.01	0	246	401	88.23	136	0.873	1363.2	BDL	35.41	37.37	3.03	-8.87	37.45	0.60	29.45	47.12
6	205	36.00	27.94	28.66	1.24	0	215.25	48.4	11.52	9.95	1.14	339.2	BDL	18.69	23.31	0.87	-0.57	23.76	0.30	56.09	58.45
7	190	68.00	4.86	116.22	1.16	0	418.2	58.5	29.7	11.8	1.23	600.32	BDL	14.55	57.08	3.67	3.06	57.22	1.33	10.52	86.65
8	355	60.00	49.81	127.55	3.05	0	375.15	170	83.34	14.1	0.506	894.72	BDL	16.22	43.86	2.94	-0.95	44.20	0.78	57.74	63.47
9	200	60.00	12.15	33.70	1.24	0	178.35	63	16.06	1.44	0.768	354.56	BDL	15.01	26.81	1.04	-1.08	27.23	0.37	25.00	58.10
10	160	42.00	13.37	14.54	1.89	0	190.65	4.47	10.63	2.9	0.258	225.92	BDL	17.77	16.50	0.50	-0.07	17.54	0.20	34.37	62.63
11	170	46.00	13.37	87.14	1.11	3	252.15	45.9	64.81	59.3	1.58	468.48	BDL	7.53	52.70	2.91	0.83	52.89	1.11	32.35	80.99
12	180	34.00	23.08	64.70	0.92	6	332.1	25.8	21.59	3.46	3.35	437.12	BDL	35.05	43.87	2.10	2.04	44.07	0.78	52.77	80.26
13	155	32.00	18.22	61.37	1.87	12	270.6	50.2	2.51	2.36	1.82	372.48	BDL	36.4	46.26	2.14	1.74	46.70	0.86	48.38	82.78
14	200	16.00	38.88	80.72	0.92	6	264.45	76.3	25.77	2.75	1.7	433.92	BDL	14.25	46.74	2.48	0.54	46.90	0.88	80.00	74.47
15	290	56.00	36.45	22.20	1.36	0	178.35	100	32.2	3.6	0.778	449.92	BDL	17.69	14.27	0.57	-2.88	14.71	0.17	51.72	39.55
16	200	38.00	25.51	216.70	1.06	15	615	127	19.37	6.98	3.15	927.36	1.03	6.16	70.20	6.66	6.58	70.26	2.36	52.49	93.86
17	225	42.00	29.16	12.29	1.29	12	196.8	13.2	20.71	16.5	1.97	301.44	BDL	29.85	10.61	0.36	-0.87	11.20	0.12	53.33	46.30
18	160	38.00	15.79	121.89	2.10	0	393.6	75	20.97	4.45	2.48	572.8	BDL	37.44	62.36	4.19	3.25	62.59	1.66	40.61	92.24
19	145	40.00	10.93	41.24	2.58	6	209.1	40	13.38	2.01	1.93	300.16	BDL	35.59	38.21	1.49	0.73	39.07	0.62	31.02	77.67
20	260	60.00	26.73	47.57	0.62	12	239.85	83.44	34.94	10.3	1.92	503.04	BDL	19	28.46	1.28	-0.87	28.61	0.40	42.30	55.74
21	105	32.00	6.07	18.80	1.63	0	129.15	10.7	5.72	0.78	0.64	174.72	BDL	25.76	28.02	0.80	0.02	29.04	0.39	23.79	77.91

Annexure-VI

Results of Ground Water Samples for Uranium(ppb) in Godda District					
Sample no.	**District**	**Block**	**Well Name**	**Type of Well**	**Uranium Concentration (ppb)**
1	Godda	Mehegama	Doi	D/W	2.81
2	Godda	Godda	Godda	HP	36.33
3	Godda	Godda	Jainipahar	D/W	5.41
4	Godda	Mahagama	Lalmatia	D/W	0.62
5	Godda	Mahagama	Mahagama	D/W	6.55
6	Godda	Pathargama	Maheshpur	D/W	0.15
7	Godda	Pathergama	Pathergama	HP	21.74
8	Godda	Poraiya Haat	Poraiya Haat	D/W	2.10
9	Godda	Sunder Pahari	Sunder Pahari	HP	1.75
10	Godda	Poreyahat	Chamudih	HP	0.39
11	Godda	Godda	Siktia	HP	3.28
12	Godda	Poreyahat	Raghunathpur	D/W	16.86
13	Godda	Pathergama	Bishaha	HP	3.87
14	Godda	Godda	Kumardih	D/W	1.69
15	Godda	Godda	Bargacha Hariyari	D/W	0.72
16	Godda	Mahagama	Gobra	D/W	2.36
17	Godda	Thakurghanti	Thakurghanti	D/W	2.33

Assessment of Dynamic Ground Water Resources of Jharkhand State (2017)

Annexure-VII

Sl. No.	District	Administrative Units	Ground water Assessment Sub- Unit	Recharge from Rainfall		Recharge from Other Sources		Total Annual Ground Water Recharge	Total Natural Discharge	Annual Extractable Ground Water Recharge
				Monsoon	Non-monsoon	Monsoon	Non-monsoon			
				(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)
1	Godda	Basantrai	Non-Command	1552.7	161.35	4.12	15.88	1734.05	86.70	1647.35
2	Godda	Boarijor	Non-Command	2480.2	122.10	70.89	139.79	2812.98	281.30	2531.68
3	Godda	Godda	Non-Command	2961.97	319.29	16.96	66.22	3364.44	336.44	3028.00
4	Godda	Mahagama	Non-Command	2609.93	199.38	7.88	30.78	2847.97	284.80	2563.17
5	Godda	Meherma	Non-Command	1871.87	126.72	12.29	48.53	2059.41	102.97	1956.44
6	Godda	Pathargama	Non-Command	2669.9	194.39	14.13	55.61	2934.03	293.40	2640.63
7	Godda	Poreyahat	Non-Command	2488.57	482.31	64.68	256.55	3292.11	329.21	2962.90
8	Godda	Sunderpahari	Non-Command	1323.06	171.36	13.46	52.33	1560.21	78.01	1482.20
9	Godda	Thakurghanti	Non-Command	1056.26	77.30	54.27	216.68	1404.51	140.45	1264.06
District Total				**19014.46**	**1854.20**	**258.68**	**882.37**	**22009.71**	**1933.29**	**20076.42**