केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण
विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board
Department of Water Resources, River
Development and Ganga Rejuvenation,
Ministry of Jal Shakti
Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Dhanbad District
Jharkhand

मध्य पूर्वी क्षेत्र, पटना
Mid Eastern Region, Patna

भारतसरकार

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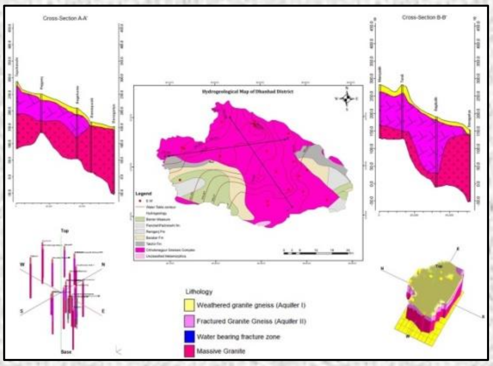
Central Ground Water Board

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

जलभृत नक्शे तथा भूजल प्रबंधन योजना धनबाद जिला, झारखण्ड



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जुलाई 2022

State Unit Office, Ranchi

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REPORT ON AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN OF DHANBAD DISTRICT, JHARKHAND 2019 – 20

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REPORT ON AQUIFER MAPS AND MANAGEMENT PLAN (PART – I) OF DHANBAD DISTRICT, JHARKHAND STATE (2019 - 20)

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AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN OF DHANBAD DISTRICT, JHARKHAND STATE

1.0 INTRODUCTION:

The vagaries of rainfall, inherent heterogenity& unsustainable nature of hard rock aquifers, over exploitation of once copious aquifers, lack of regulation mechanism etc has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "**Traditional Groundwater Development concept" to "Modern Groundwater Management concept"**. Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. This leads to concept of Aquifer Mapping and Ground Water Management Planprogramme. 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, which is continued till 2023. In pursuance of AAP 2019-2020, CGWB State Unit Office, Ranchi, has carried out Aquifer mapping and Management Plan in Dhanbad district of Jharkhand State with the aim of delianation and characterization of aquifers and its quantity, quality and sustainability of ground water in aquifers. The study is a part of the fulfilment of National Aquifer mapping and Management Plan. The aquifer maps and management plans will be shared with the Jharkhand Government for its effective implementation.

1.1 Objective and Scope of the study:

The major objectives of aquifer mapping aredelineation 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). Assessment of ground water resources

e). Preparation of aquifer maps and
f). Formulation 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 in hard rock terrain 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:

Compilation of existing data (Central & State Govt.)

↓

Generation of different thematic layers

↓

Identification of Primary Aquifer

↓

Identification of data gaps

↓

Data generation (water level, exploration, geophysical, hydrochemical, hydrogeological etc.

↓

Robust Aquifer Maps with 3D disposition

↓

Preparation of Aquifer Management Plan

↓

Capacity building in all aspects of ground water through IEC Activties

1.3 Area details:

The district of Dhanbad was created on 1st of November, 1956. Dhanbad district is situated in the North Eastern part of Jharkhand state. Dhanbad town is the administrative headquarters of Dhanbad district. The district of Dhanbad has a geographical area of 2252.47 square kilometer. According to the 2011 census the total population of the district is 2684487(As per Census 2011) personsincluding 1124093 is rural and 1560394 is rural populationwith the population density of 1300 person sq/km2. The district is bounded on the north and north-east by thtBarakarRiver which separates it from Hazaribagh, Santhal Parganas and Burdwan districts, on the south there is no natural boundary. On the west it has Hazaribagh district. On the east the Barakar River forms the boundary.

Three distinct characteristics of the landscape are perceptible for its natural boundary. They are (a) the ranges of ridges sent out by the Parasnath in the remote northern and north-western region occupying an area of about 217.54 square km, (b) the coal-fields having approximately an area of 517square kmin the southern and eastern parts and (c) the series of uplands and intervening hollows with isolated bare, ridges of varying elevation dotted here and there between them. Broadly speaking Dhanbad district has two physical divisions, southern and northern. The southern portion is the colliery area with the industrial towns and the northern portion is the area of hIlls and scattered vIllages. The landscape of the southern portion is undulating and monotonous with the smoke, the chimney and the stack of coal scattered here and there with intermittent scrubs of vegetation.

The Dhanbad district falls in the survey of India Toposheet Nos. 72L/08, 73I/01, 73I/05, 73I/06 72L/12, 73I/09, 73I/10 and 73I/13 (partly). Dhanbad located between 23037’3”N and 2404’N latitude and 8606’30”E and 86050’E Longitude The principal town and administrative headquarters is Dhanbad situated almost in the centre of the district. The district consists of one subdivision, namely, Dhanbad Sadar and ten (8) no’s of blocks namely Dhanbad, Baghmara, Nirsa, Topchanchi, Tundi, PurbiTundi, Govindpur and Baliapur. There are 216Gram Panchayats and 1229 villages in the district.The district administrative unit with geographical area (sq.km) is given in table 1 and base map of Dhanbad district is shown in figure 1.

Table 1: The district administrative unit with geographicl area (sq.km)

S.No.	Blocks	Geographical area (sq.km)	No of gram Panchayat	No of Villages
1	Dhanbad	339.89	12	85
2	Baghmara	271.12	61	227
3	Nirsa	438.83	27	119
4	Topchanchi	199.27	28	126
5	Tundi	274.58	17	296
6	PurbiTundi	120.87	9	85
7	Govindpur	329.34	39	225
8	Baliapur	151.17	23	66
	Total	**2252.47**	**216**	**1229**

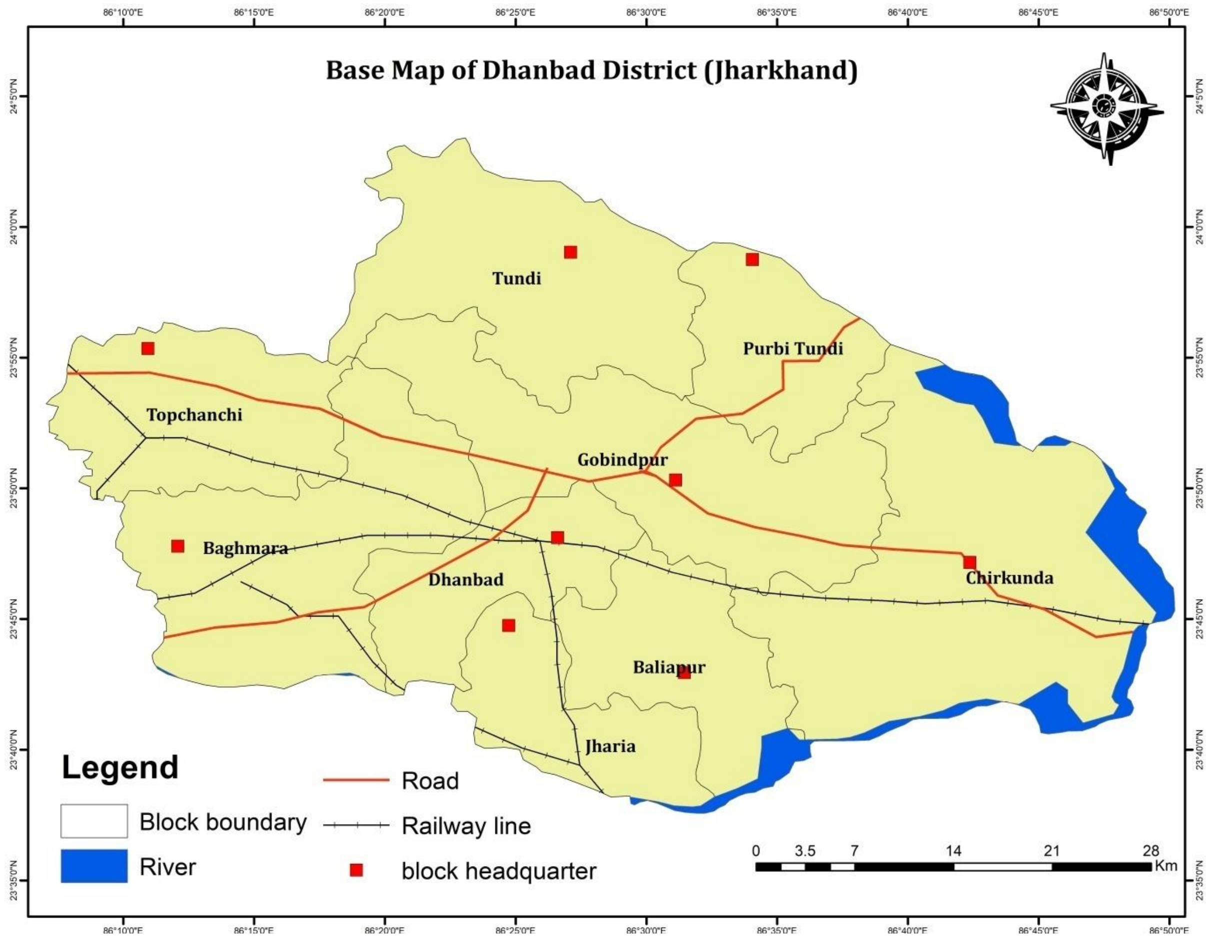


Figure 1: Base map of Dhanbaddistrict

1.4 Data Availability, Data Adequacy and Data Gap Analysis

1.4.1Data Availability:-

Central Ground Water Board has carried out exploratory drilling in the district and drilled twenty one exploratory and five observation wells by departmental (12 nos)andthrough outsourcing (09nos) as on March 2019 to know the sub–surface geology, depth and thickness of water bearing formation with their yield and determining the different aquifer parameters and variable lithology in the area. In addition of that, seven numbers of permanent observation well (HNS) of Central Ground Water Board located in the district are being monitored (4 times in a year) to assess ground water scenario 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, SUO, Ranchi, geophysical survey carried out in the area, ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analyzed for adequacy of the same for the aquifer mapping studies. After taking into consideration, the available data of ground water exploration, geophysical survey, ground water monitoring and ground water quality, the data adequacy is compiled and the summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations is given in table 2.

Table – 2: Data adequacy and data gap analysis

Exploratory data				Geophysical data				GW monitoring data				GW quality data			
Req.	Exist.	Gap	Generation	Req.	Exist.	Gap	Generation	Req.	Exist.	Gap	Generation	Req.	Exist.	Gap	Generation
21	16	5	5	13	0	0	14	26	7	19	19	26	7	0	19

Based on the data gap identification, the data generation activity was planned and completed in 2019-20.

1.5 Climate and Rainfall

The climate of Dhanbad district is very pleasant especially in the cold weather months- November to February, during which the temperature (according to the last three years' records of the Hydro-meteorological Observator at I. S. M. and A. G .• Dhanbad) varies from the lowest minimum of 8.3^{0}C to the highest maximum of 34.4°C. After February the climate becomes warmer and warmer until the rains break in the middle of June. The temperature during these four months March to June varies from the lowest minimum of 13.3°C to the highest maximum of 45.5°C. During the remaining months, July to October, which include-the rainy season, the temperature range is from the lowest minimum 15° C to 36.1°C. The average annual rainfall of the area is 55" most of which is pre-cipitated during the rainy season-middle of June to middle of October. The rainfall around Parasnath hills is reported to be more than the average. Heavy rainfall over the Damodar Valley is generally caused during the passage of cyclonic depressions following in the north-west direction. The depressions are formed in the Bay of Bengal during the monsoon months, June-October. Sometimes depressions formed over the land mass also cause heavy precipitation. The average annual rainfall over the upper Damodar basin is 127 cm, and the deltaic area receives a slightly more precipitation. Actual and Normal Rainfall Data of 2015-2019 (Unit -mm) of Dhanbad District is given in table 3

Table- 3 Actual and Normal Rainfall Data of 2015-2019 (Unit -mm) of Dhanbad District

Assessment Unit	***Year**	**Monsoon**		**Non-Monsoon**	
		***Actual (mm)**	***Normal (mm)**	***Actual (mm)**	***Normal (mm)**
JHARIA	2015-2016	813.6	1074.7	101.6	220.9
JHARIA	2016-2017	1305.6	1074.7	68.2	220.9
JHARIA	2017-2018	1136	1074.7	102	220.9
JHARIA	2018-2019	583.3	1074.7	179.4	220.9
JHARIA	2019-2020	1066.9	1074.7	167.4	220.9
BAGHMARA	2015-2016	832.2	1074.7	63.4	220.9
BAGHMARA	2016-2017	1061.6	1074.7	58.4	220.9
BAGHMARA	2017-2018	1058.1	1074.7	79.4	220.9
BAGHMARA	2018-2019	547	1074.7	181.8	220.9

BAGHMARA	2019-2020	651.9	1074.7	196.4	220.9
PURBI TUNDI	2015-2016	600.2	1074.7	25.8	220.9
PURBI TUNDI	2016-2017	901.8	1074.7	127	220.9
PURBI TUNDI	2017-2018	879.1	1074.7	158.9	220.9
PURBI TUNDI	2018-2019	575.4	1074.7	98.4	220.9
PURBI TUNDI	2019-2020	863.4	1074.7	188.9	220.9
CHIRKUNDA	2015-2016	806.6	1074.7	143.4	220.9
CHIRKUNDA	2016-2017	1675.4	1074.7	6.2	220.9
CHIRKUNDA	2017-2018	0	1074.7	0	220.9
CHIRKUNDA	2018-2019	0	1074.7	0	220.9
CHIRKUNDA	2019-2020	0	1074.7	0	220.9
TOPCHANCHI	2015-2016	1008.7	1074.7	66.8	220.9
TOPCHANCHI	2016-2017	1196.8	1074.7	86.8	220.9
TOPCHANCHI	2017-2018	1233.2	1074.7	84.2	220.9
TOPCHANCHI	2018-2019	547	1074.7	140.6	220.9
TOPCHANCHI	2019-2020	745.2	1074.7	229.4	220.9
GOBINDPUR	2015-2016	589.6	1074.7	31.6	220.9
GOBINDPUR	2016-2017	1258.2	1074.7	97	220.9
GOBINDPUR	2017-2018	1063.6	1074.7	173.8	220.9
GOBINDPUR	2018-2019	552.2	1074.7	129.7	220.9
GOBINDPUR	2019-2020	1047.8	1074.7	217.8	220.9
TUNDI	2015-2016	600.2	1074.7	25.8	220.9
TUNDI	2016-2017	901.8	1074.7	127	220.9
TUNDI	2017-2018	879.1	1074.7	158.9	220.9
TUNDI	2018-2019	575.4	1074.7	98.4	220.9
TUNDI	2019-2020	863.4	1074.7	188.9	220.9
BALIAPUR	2015-2016	834.8	1074.7	190.4	220.9
BALIAPUR	2016-2017	1406.8	1074.7	131.3	220.9
BALIAPUR	2017-2018	1358.2	1074.7	166.3	220.9
BALIAPUR	2018-2019	819.8	1074.7	180.2	220.9
BALIAPUR	2019-2020	950.6	1074.7	235	220.9
DHANBAD	2015-2016	906.4	1074.7	140.6	220.9
DHANBAD	2016-2017	1423	1074.7	66.2	220.9
DHANBAD	2017-2018	1410.8	1074.7	123.4	220.9
DHANBAD	2018-2019	626.2	1074.7	254.3	220.9
DHANBAD	2019-2020	1175.5	1074.7	236.4	220.9

1.6 Physiography:

The district forms a part of the Chotanagpur plateau, but, it is more of an up-land than a plateau. The up-land lies mainly in the northern portion of the district. Strictly speaking there are no large stretches of what may be called as plains in the district. Dhangi hills run from Pradhankhanta to Gobindpur in this district. They lie between the Grand Chord line of the Eastern Railway and the Grand Trunk Road. The highest peak in these hills is at Dhangi, Gobindpur and is 1,265 feet high. The Parasnath hills (4,480 feet) send out spurs, one of which passes through this district via Topchanchl and Tundi. This spur has no noteworthy conspicuous hills but contains two places, Viz., Lalki (1,500feet) and Dholkatta (1,250 feet) from where channels have been constructed for carrying water to Topchanchl reservoir. The Dhangi hills are dry for the most part of the year, but dunng the rains some grasses grow on them. The spur of the Parasnath hills running in Dhanbad district is forested and the non-forested area grows paddy in terraces.

Topographically the area depicts a combination of rugged hills, reserved forest, and protected forest. The general slope of the area is from south to north. The area comprises a gently rolling terrain of low relief with low, humpy, rocky elevations with a thin superficial cover of sandy loam and wide flat depression with clay and soil cover. The average topographic height of the area is about 150 meters above the Mean Sea level. The highest elevation is of 445 m in the NW part of the area. Major rivers in the area are BarakarNadi, RajoyaNadi, tributary of BarakarNadi in the north flowing towards South and form the Maithon reservoir later meets to Damoder River. General slope direction of the area here is towards south. The central part of the area forms a water divide were streams flows upstream toward Barakar and southwards to PusaiNadi and KhudiyaNadi. In the Southern part of the area surface run off towards PusaiNadi and Khudiya nala both conjoins near Mugma village and flow further southwards

1.7 Geomorphology:

The area is represented by the isolated hills, linear ridges, low uplands, buried pediment, pediplain, undulating pediplain and waterbody/ active channel. The Isolated hills are resistant formations standing out prominently due to differential erosion and are found North of Gobindpur area. Linear ridge is sheet like body of igneous rock which is discordant, i.e., cut across the bedding or other structural plains of host rocks. Dhangi ridge is a prominent linear ridge in the study area near Gobindpur (Basudeo Rai et al 2005) .The pediplain is gently rolling to sloping and a well-drained ground. It is characterized by presence of oxidized soil, occurrence of calcareous and/or ferruginous nodules / concretions and high degree of dissection caused by sheet and gully erosion as result of weathering in arid-semi arid condition. These landforms are erosional geomorphic features and have developed by the process of weathering of the hills, having a thin veneer of deposition adjacent to high relief outcrops. Major part of the study area is covered by pediplain topography. At places these pediments are covered by alluvium or weathered material, they are termed buried pediments. These buried pediments are found in the western part of the study area, covered with well-developed soil profile. Geomorphology map has been prepared by using the Landsat image interpretation as well as DEM generated hill shade maps. Geomorphologicalmap of Dhanbad district is shown in figure 2.

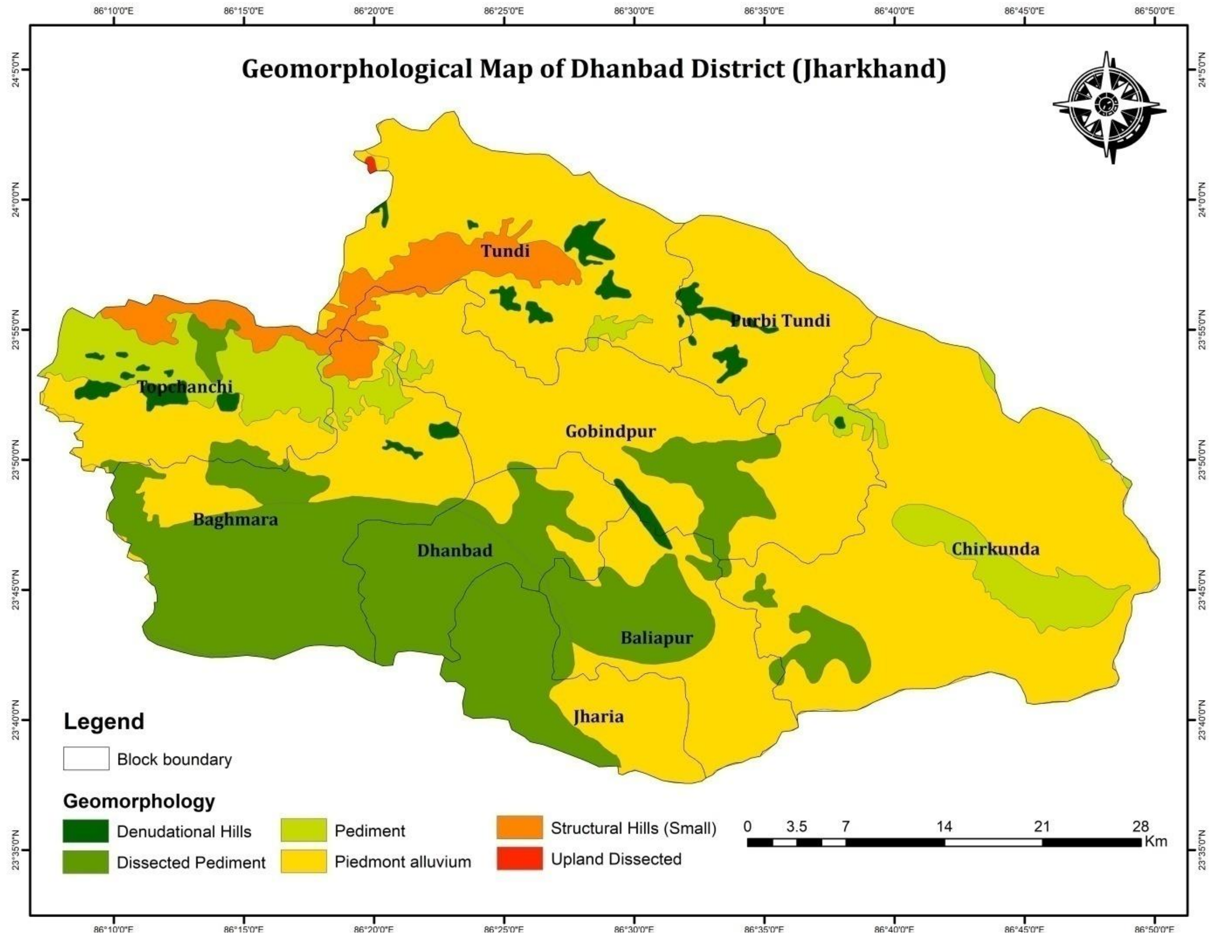


Figure2 : Geomophological Map of Dhanbad district

1.8 Land Use:

Out of the total area covered, cultivated lands (including fallow lands) constitute 65%, forest land constitutes 16% in the North West part of the area, barren land covers 10% adjoining to the cultivated land, settlement (including rural and urban) 5% along the road network covering Gobinpur and Nirsa area and water bodies constitutes Barakar, Khudiya, Pusai rivers and extend of Maithon Reservoir constitutes 4%. The land use map given in figure 3 reveals that out of the total area covered, cultivated lands (including fallow lands) constitutes 60%, forest land 20%, barren land 8% , settlement (including rural and urban) 10%, and water bodies 2%. Agriculture is the most dominant landuse in the area. The intensity of cultivation and cropping pattern are primarily governed by rainfall, irrigation facilities, soils, landforms and socio-economic conditions of the inhabitants. The land use pattern and landuse map of Dhanbad district is given in table 4 and figure 3.

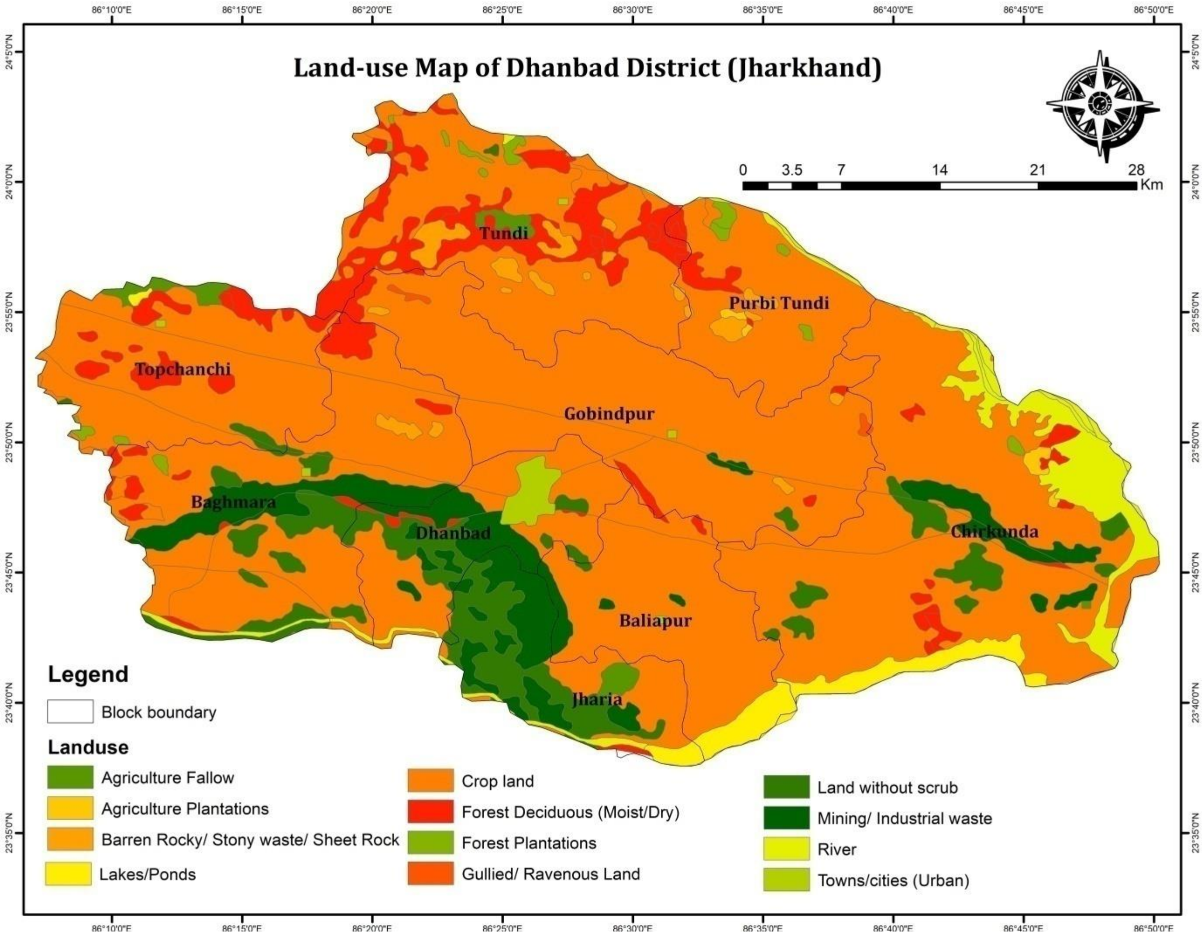


Figure 3 : Land-Use map of Dhanbad district

Table 4 Landuse pattern of Dhanbad district

LandUtilizationPattern,DhanbaddistrictforFY2017-18,Source:DistrictStatisticsOffice,Dhanbad													
Blockname	area(sq km)	Forest area(sq km)	Usar andNonagriculturalLand(sq km)	Non-Agriculturableland(sq km)			Agricultarable barrenland(sq km)	Permanent pastures&othergrazingland(sq km)	Land undermisctreugrovesnotincludedinnetarea(sq km)	Otherfallowland(till 2 to 5years)(sq km)	CurrentFallowland (sq km)	Total(4to 12 columns)	Net areasown(sq km)
				Landarea	Waterarea								
					Permanent	Seasonal							
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Dhanbad	128.21	2.13	40.24	41.08	3.07	0.88	6.18	0.125	0.667	19.17	12.45	126.04	2.172
Jharia	102.29	0.00	13.17	52.97	7.46	0.82	10.14	1.64	0.00	1.76	14.29	102.29	0.00
Baliapur	188.76	4.78	18.44	42.26	1.07	0.40	9.73	2.76	2.23	54.80	24.14	160.66	28.09
Gobindpur	310.10	9.41	31.87	30.46	23.31	25.13	30.94	26.75	22.93	58.41	40.90	300.15	9.95
Tundi	267.34	85.36	25.13	9.62	2.78	3.07	15.61	9.73	1.07	48.82	39.21	240.45	26.88
Nirsa	415.75	6.71	60.27	65.60	59.37	6.46	16.96	4.84	0.06	85.40	97.39	403.11	12.64
Baghmara	290.29	14.03	66.67	48.05	10.64	0.00	34.05	0.83	1.40	90.17	16.21	282.09	8.19
Topchanchi	191.38	24.53	16.79	20.08	7.82	4.14	12.66	7.19	9.20	44.91	22.67	170.03	21.34
PurbiTundi	143.88	22.51	18.60	14.38	2.68	0.40	6.25	5.23	2.24	20.12	35.19	127.63	16.24
Total	**2038.03**	**169.50**	**291.23**	**324.52**	**118.24**	**41.33**	**142.57**	**59.13**	**39.82**	**423.62**	**302.48**	**1912.49**	**125.54**

1.9 Soil:

The soil of Dhanbad district is infertile laterite of no great depth having a general tendency towards continual deterioration, the process being continued till the underlying heavier gravel is exposed. The climatic condition prevailing in the district is of a fairly copious rainfall and high temperature which lead to the formation of lateritic type of soil of the district. Iron, aluminium and manganese oxides are removed less rapidly than the other bases.

According to the texture of the soil, the soils of this district may be classified broadly in four classes:

Stony and gravelly.-

These soils are found near the foot of hillocks which have a large admixture of large fragments of stones, gravels, pebbles, etc. This type of soil may be classed as low grade soil.

Sandy Soils.-

These soils are locally known as bali. In the district this type of soil is found near river and stream beds. soils containing more than 60 per cent of sand are classified and are easily drained as they let the water through too readily and necessitates frequent watering. These soils are poor in respect of plant food and require heavy manuring and in frequent doses. On account of dearth of water and manure sandy soils are described as hungry soils. Cattle manure and compost, greenmanuring and the addition of tankSilt and clay will bring about great improve-mentin the retentive capacity of these soils. The soils are used for growing cucurbitas.

Loamy soils.-

This type of soil is found near the hills andformed by rain washing from higher positions and consists of detritus of decomposed rocks and vegetable matter. Soils whose sandy compounds are between 30 and 60 per cent are classed as loamy soils. Agriculturally these soils are best adapted for cultivation. They are suited to every kind of crop but in the district this soil is put under paddy, sugarcane, marua, wheat, gram, khesari, etc.

Clayey soils.-

Such soils are found near tank beds. When moist they are sticky and ploughing and other tillage in that condition will reduce them into a pasty mass. When they are dry they become very hard and difficult to break. They are difficult to drain as the water can not pass through easily on account of fineness of the particles composing them. They have a high water-holding capacity and are very fertile in respect of plant food contents. The addition of sand, lime, coarse bulky organic manures will improve their physical condition. Nitrogen applied as organic matter and that in the shape of ammonia free or combined as in the ammonium salts applied as manure becomes fixed in the soil, i.e., they do not pass out of the soil in drainage waters.

1.10 Hydrology and Drainage:

The area comprises a gently rolling terrain of low relief with low, humpy, rocky elevations with a thin superficial cover of sandy loam and wide flat depression with clay and soil cover. The average topographic height of the area is about 150 metres above the Mean Sea level. The highest elevation is 445 m to the NW part of the area. Major rivers in the area are BarakarNadi, RajoyaNadi, tributary of BarakarNadi in the north flowing towards South and form the Maithon reservoir which later meets the Damodar River. General slope direction of the area here is towards south. The central part of the area forms a water divide where streams flow upstream toward Barakar and southwards to PusaiNadi and KhudiyaNadi. In the Southern part of the area surface run off is towards Pusainadi and Khudiya nala both conjoins near Mugma village and flow further southwards. The drainage pattern of the area is sub-parallel and sub-dendritic. The drainage map of Dhanbad district is given in figure 4.

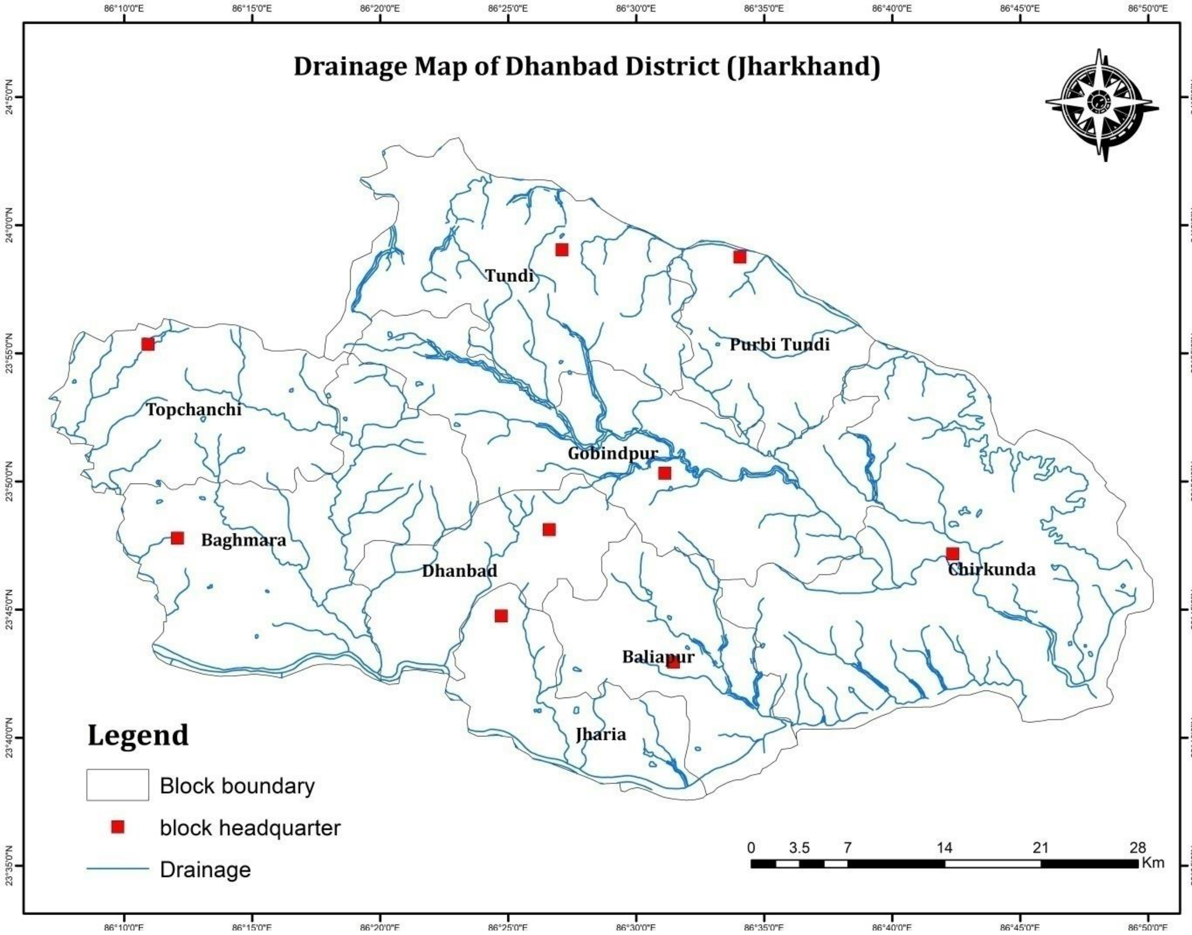


Figure4: Drainage Map of Dhanbad district

1.11 Agriculture and Irrigation Practice:

Rice is the principal crop grown in the area. Wheat, Barley, Maize, Gram, Mustard, Tur, sugarcane Potato are the other crops in the area. The crops are mainly monsoon dependent.The varieties of plantations which are commonly found are Sal, Acacia, Sisoo and Eucalyptus. The floral biodiversity of the area is rich with many flowering and non flowering plants. Dug wells are the major structure for irrigation in the district. For dug wells, considered unit draft value of varies from 0.075 to 0.3 ham for monsoon and non-monsoon period. Unit drafts of shallow tube-well and deep tube-well are considered 1.2 ham/yr and 16 ham/yrrespectively.Block-wise surface water and ground water based irrigation practices is given in table 5

Table 5 Block-wise surface water and ground water based irrigation practices

Blocks	Number of Structures			Unit Draft of GW Structures for Irrigation					
				DW		STW		DTW	
	DW	STW	DTW	Monsoon	Non Monsoon	Monsoon	Non Monsoon	Monsoon	Non Monsoon
Baghmara	350	3	1	0.1	0.4	0.3	1.2	4	16
Baliapur	232	3	0	0.1	0.4	0.3	1.2	4	16
Chirkunda	586	6	3	0.1	0.4	0.3	1.2	4	16
Dhanbad &Jharia	109	7	1	0.1	0.4	0.3	1.2	4	16
Gobindpur	518	7	0	0.1	0.4	0.3	1.2	4	16
PurbiTundi	195	0	0	0.1	0.4	0.3	1.2	4	16
Topchanchi	1626	9	2	0.1	0.4	0.3	1.2	4	16
Tundi	1030	26	1	0.1	0.4	0.3	1.2	4	16

1.12 Geological setup

The oldest geological formation of the district is unclassified metamorphics represented by amphibolite, hornblende schist and meta diorite of Archean to Lower Proterozoic age. Chhotanagpur Granit Gneiss of Archean (?) to Proterozoic age is overlying the unclassified metamorphics. Chotanagpur Granite Gneiss Complex mainly comprises quartz-biotite granite gneiss, augen gneiss and granite gneiss. The Gondwana Super Group is represented by boulder bed, sandstone shale and varved clay bearing Talchir formation at its base followed by Barakar, Kulti, Raniganj and Panchet Formations.

Barakar and Raniganj formations consist of sandstones and shales with coal seams whereas both Kulti and Panchet Formations are devoid of coal seams. Age of Gondwana Supergroup of rocks found in this area varies from Early Permian (Talchir Formation) to Late Triassic (Panchet). Rocks of the Gondwana Supergroup at places are intruded by dykes and sills of dolerite, lamprophyres and mica peridotites.
The oldest geological formations of the Dhanbad district are composed of crystalline metamorphic rocks which belong to the Dharwar system (Archeans) in Indian stratigraphy. In these formations are found rock types of both sedimentary and igneous origin. The sedimentary rocks were originally deposited as sandy, clayey and calcareous sediments, more or less impure. These sediments were consolidated as

sandstones, shales and limestones of different composition and then were subjected to regional metamorphism and converted into quartzites (granulitic and schistose varieties), mica-ceous schists, crystalline, limestones, calc-silicate granulities and calc-gneisses and in some cases to amphibolite and hornblende-schists.

The above metamorphosed-sedimentary rocks were then intruded by magmas of both basic and acid composition, possibly in the earlier post-Dharwar times. The basic magma was of doleritic and noritic composition and is now represented by intrusive dykes and masses of metadolerites, metanorites and some of the epidiorites. These rock types usually occur as prominent hillocks in the area. The acid magma which intruded later than the basic magma had given rise to the granite pegmatite, aplites and some quartz veins of the area.

In the later post-Dharwar times, the metamorphosed sedimentary rocks and the igneous intrusives were subjectedto the injection metamorphism due to which the rock types were formated, soaked, felspathised, homogenised and granitised into streaky, augen and injection gneisses. Some of the gneisses and epidiorites of the area show typical rapikivi structure (ovoids of potash felspar surrounded by rims of sodalime felspar). The Geological map of dhanbad district is given in figure 5.

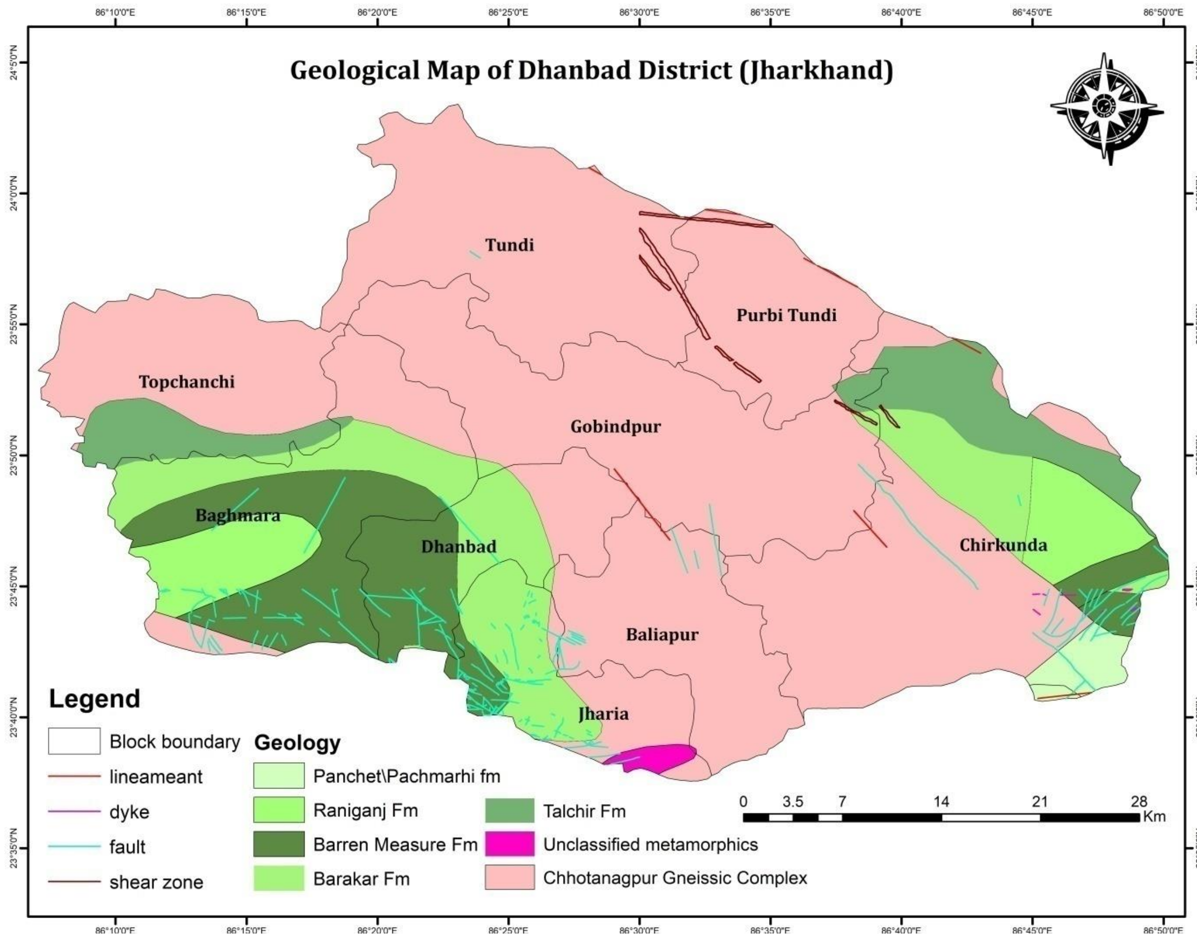


Figure 5:Geological map of dhanbad district

The above ancient rock types form the basement rocks of the Dhanbad district and it was over these rocks that the Lower Gond-wana group of sedimentary strata including the coal bearing beds were laid down. These sediments are river deposits and were deposited in slowly sinking faulted troughs (basins) in the more or less then flat country composed of Dharwar rocks, so that it was possible for the accumulation of several thousands of feet of river and stream deposits in definite linear tracts like the Jharia and the Raniganj coal-basins. At the commencement of the Lower Gond-wana period (some 300 million years ago), there was a Glacial Age in India as is evident from the glaciated boulders deposited at the bottom of the Gondwana system of rocks and the presence of un-decomposed felspar grains in the associated sandstones above them. The geological succession (as per GSI District ResourceMap) of Dhanbad district is given here under.

Geological Succession

<table>
<tr><th>Lithology</th><th>Formation</th><th>Group</th><th>Age</th></tr>
<tr><td>Alluvium</td><td>Quaternaries</td><td></td><td>Holocene</td></tr>
<tr><td>Sandstone, Shale</td><td>Panchet</td><td rowspan="6">Gondwana Supergroup</td><td>Lower Triassic</td></tr>
<tr><td>Sandstone, Shale, Coal</td><td>Raniganj</td><td rowspan="3">Permian</td></tr>
<tr><td>Sandstone, Shale</td><td>Kulti</td></tr>
<tr><td>Sanstone,Grit,Shale, Carbonaceous Shale, Coal</td><td>Barakar</td></tr>
<tr><td>Boulder bed, Sandstone, Shale, Varved clay</td><td>Talchir</td><td>Carboniferous to Lr. Permian</td></tr>
<tr><td>Granite Gneiss</td><td colspan="2" rowspan="3">Chhotanagpur Granite Gneiss Complex</td><td rowspan="3">Archean (?) Proterozoic</td></tr>
<tr><td>Augen Gneiss</td></tr>
<tr><td>Quartz-biotite Granite Gneiss</td></tr>
<tr><td>Amphibolite, hornblende schist, Metadiorite</td><td>Unclassified Metamorphics</td><td></td><td>Archean to Lower Proterozoic</td></tr>
</table>

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. There is no aquifer-wise data available from State or any other agencies.

2.1 Hydrogeology:

Dhanbad district is having complex Hydrogeological Condition. The Archaean crystallines constituting the central and southern portions of the district are generally impermeable excepting within the Zone of weathering. Ground-water is confined in these rocks in joints, frcatures, zones of shear and such other planes of weakness. The Gondwana sediments occur in basins are not generally known to be very good aquifers due to their being felspathic. The actual ground water conditions in the coalfield can be assessed only after a detailed systematic survey. The chief sources of water-supply in the coalfield are the Ragdaha reservoir at Topchanchi which supplies drinking water to Jharia and surrounding areas. The enormous expansion of the industrial zones and the mining areas has created quite a problem and sooner or later the Topchanchi dam and the reservoirs will have to be supplemented. There is an acute water scarcity in the district during the summer months and many of the villages do suffer for want of adequate water.

Within the domain of Gneissic Complex, the storage and movement of ground water are mainly controlled by numerous interconnected fractures, joints planes and fissures. In the domain of unclassified metasedimentaries, the weak planes of foliation, bedding, schistocity etc serve as aquifer zones. The shales and the sandstones of the gondwana supergroup show well developed bedding panes and joints which serve as good reservoir for groundwater storage. A few springs occur near the Damodar river within the metamorphic rocks along their faulted boundary with Gondwana Supergroups of rocks.

The occurrence and movement of ground water in the area is variable, which is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifer in the area is ChhotanagpurGnesiss Complex, where the occurrence and movement of ground water primarily depends on the degree of interconnection of secondary pores/voids developed by fracturing and weathering.Based on morpho-genetic, geological diversities and relative ground water potentialities of the aquifers, the district can be broadly divided into three Hydrogeological units: Consolidated or Fissured formations, Semi-Consolidated and unconsolidated or Porous formations.
1. Consolidated or Fissured formations - Precambrians

2. Semi-Consolidated formations -Gondwanas
3. Unconsolidated or Porous formations - Laterites and Alluvium
In major part of this district, consolidated and Semi-Consolidated formations form the principal aquifers, which include mainly Chotanagpur gneissic complex, and Gondwanas rockswhile unclassified metamorphics also found to some extent. However, in isolated areas laterites, as well as alluvial materials along the vicinity of the rivers also form potential aquifers. Hydrogeological Map of Dhanbad district is shown in figure 6.

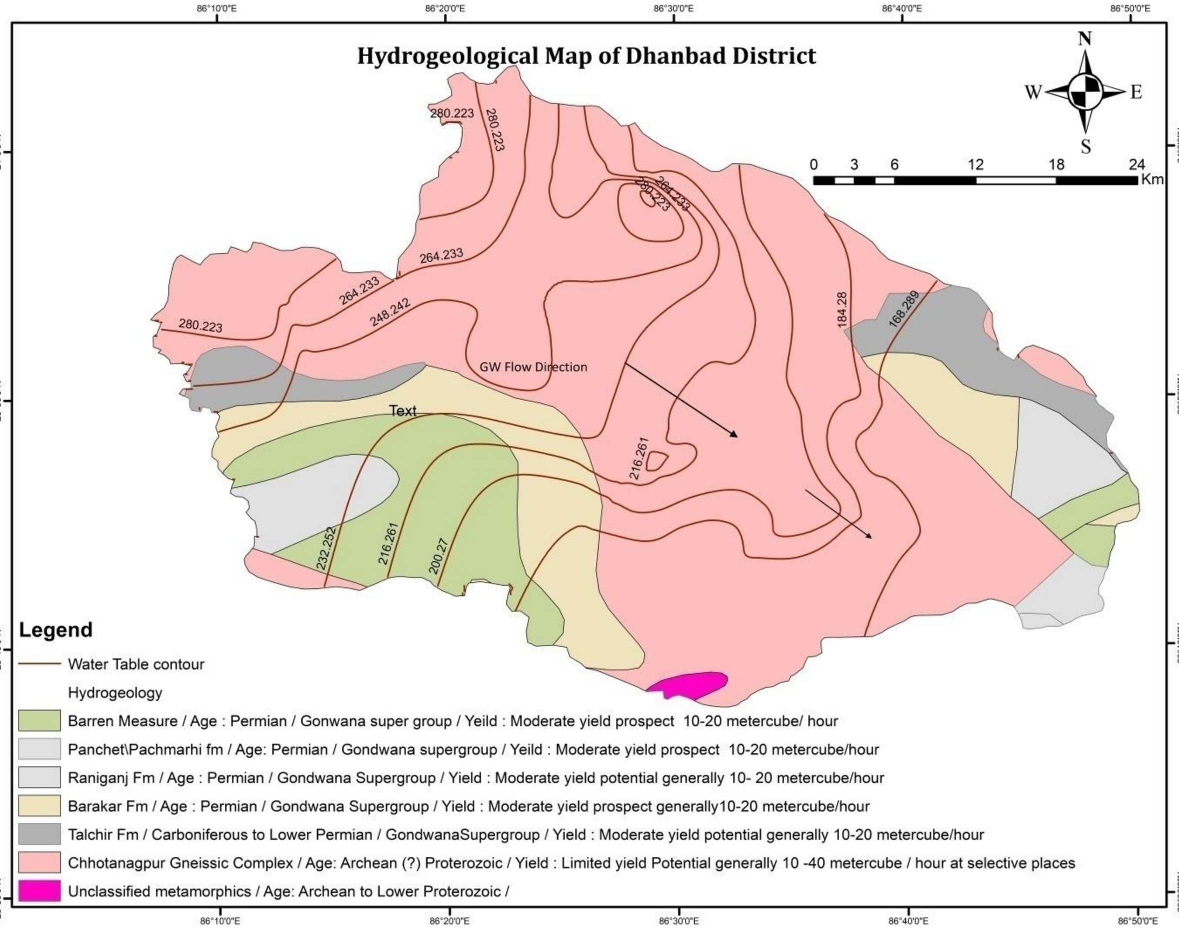


Figure 6 : Hydrogeological Map of Dhanbad district, Jharkhand

2.1.1 Ground Water InAquifer-I(Laterite/Weathered Granite-Gneiss/Weathered Shale/ Sandstone):

Ground water occurs under phreatic/ unconfined to semi-confined conditions in Aquifer-I which is represented by weathered granite and Weathered Shale/Sandstone. Ground water occurs in unconfined state in shallow Aquifer-I tapped by alluvium, laterites, weathered graniteand weathered Shale and Sandstone (Upto 30 m depth) , however in some cases depth varies from more than 30m. Yield of the wells in Aquifer-I ranges from 0.8 to 3 lpsin this formation. Weathered zones of granites and gneisses are the most productive zone for ground water development in shallow aquifer. The depth of weathering varies from place to place, which influences the aquifer characteristics. The drinking water and sanitation department has drilled a number of tube wells in Dhanbad district having a yield of approximately 80 liter per minute. The dug wells in this formation has a depth to water level range from 4 m to 10 m bgl and the wells can sustain 2 hours of pumping with a yield range of 4000 to 8000 litres per hour.

2.1.2 Ground Water In Aquifer-II (Fractured Granite-Gneiss/Fractured Shale/Sandstone):

Ground water occurs under Semi-confined to confined condition in Aquifer-II represented by Fractured/Jointed granite-gneiss, Fractured Shale and Sandstones upto the exploreddepth of 200 mtr depth. Generally extent of Aquifer-II in Precambrian formation ranges from 30-140m.Granites and Gneisses are the most predominant rock types among all other rocks falling under the consolidated unit. Tectonic disturbances in granitic rocks are pronounced and fissures and joints etc are also well developed. These rocks are traversed by numerous veins of quartz and pegmatite. Fracture porosity plays an important role but with varying degree, in different parts of the area depending upon the pattern and intensity of joints and fractures. The potentiality and yielding property of these aquifers vary considerably. Bore wells can be constructed tapping the deep-seated fractures and joints. The semi-consolidated (Gondwana) formation occurs in isolated pockets in the northern part of the district. The rocks are mainly sandstones and shales belonging to the Barakar and Talchir formation. Barakar sandstones are coarse to medium grained, weathered in nature and may be a productive zone for ground water development. However, the exploratory Driliing has not been taken up in Gondwana formation. Yield of the wells in Aquifer-II in granite-gneisses are found to be upto 12.3 lps.

2.1.2.1 Potential Fractures in Aquifer-II

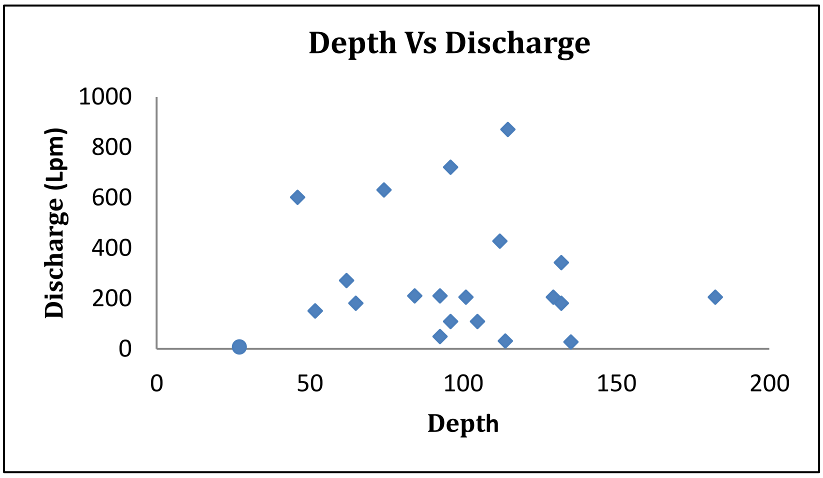
Total 26 Number of boreholes has been constructed by CGWB in the district under groundwater exploration programmeupto maximum depth of 200 m . The borehole data reveals that, in general potential fractures are encountered between 30-132 m. The other fractures have also of good potential. Table 6- shows the Potential Fracture encountered during Ground Water Exploration in Dhanbad district.

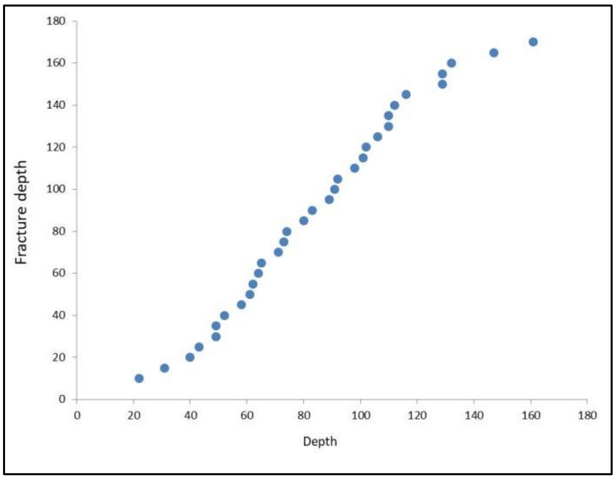
Table-6 Potential Fractures encountered during ground water Exploration in Dhanbad district, Jharkhand

S. No.	Location	Block	Depth Drilled (m)	Major Lithology Encountered	Depth of casing (m)	Potential Fracture Zone encountered (m bgl)	Discharge (lpm)
1	NNH School Bagshuma	Govindpur	153.8	Granite gneiss	19.7	40-41, 71-72, 103-104	108
2	KGBH school, Gopalganj (EW)	Nirsa	123	Granite gneiss	18.6	64-65, 113-114	870

S. No.	Location	Block	Depth Drilled (m)	Major Lithology Encountered	Depth of casing (m)	Potential Fracture Zone encountered (m bgl)	Discharge (lpm)
3	KGBH school, Gopalganj (OW)	Nirsa	74	Granite gneiss	12.1	42-43, 64-65, 74-75	630
4	Govt. middle school, Joradih (EW)	Nirsa	153.5	Granite gneiss	24	65-66, 92-93, 129-130	342
5	Govt. middle school, Joradih (OW)	Nirsa	153.5	Granite gneiss	24.5	110-111, 129-130	180
6.	Saraswati Vidya mandir, Ratanpur EW I	Tundi	153.5	Granite gneiss	23.8	51-52, 61-62	270

Statistical Analysis of Fracture System:
Statistical analysis of fracture system represents that there is two aquifer system lies in study area, which is classified by its depth ranges i.e. Aquifer I & II. Depth of aquifer I is generally 0 to 20 mtr which is weathered granite gneiss and aquifer II depth varies from 20 to 162 mbgl which is fractured granite gneiss. Majority of fractures are encountered within 30-147 mbgl in Granite Rocks. Frequency of fractures, depth of occurrence and statistical analysis of fractures system with discharge range of exploratory wells encountered in Dhanbad district is shown in figure-7.





From (Depth mbgl)	*To (Depth mbgl)*	*Fracture*	*Composite Fracture*
0	*25*	*1*	*1*
25	*50*	*5*	*6*
50	*75*	*9*	*15*
75	*100*	*6*	*21*
100	*125*	*7*	*28*
125	*150*	*5*	*33*
150	*200*	*1*	*34*

Figure 7: Statistical Analysis of Fracture System

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

- Overall in the district the major potential fractures zones are found upto 181m.
- First potential fracture zone encountered in the district widely varies from 21-142 m
- In general in fractured/jointed/fissured formations, discharge of well has been found in the range of 27-870 lpm.
- In western part of the district very less fractures were encountered whereas in eastern, northern and north-eastern part of the district having 1 to 4 set of fractures has been encountered and these sets of fractures are promising with discharge observed from 28 to 870 lpm.
- Overall in the district the major potential fractures zones are found upto 140m. At several places fractures between 120-140m have been encountered in which well yielded high discharge, i.e KGBH Nirsa (chirkunda)(870 lpm), Joradih (342 lpm).
- In few occasion 1st potential fractures was encountered beyond 100 m depth (62-82 m) and well has yielded copious amount of discharge e.g SVM tundi (270 lpm).
- Some of high yielding well where multiple fractures were encountered within 140 m depth are KGBH Nirsa (chirkunda)(870 lpm), Joradih(342 lpm).

2.1.3 Ground water Level- Aquifer – I (Shallow Aquifer):

Ground water regime is monitored through 27 dug wells in the study area shown in figure 8. With the field data, maps were prepared for visual interpretation of the behavior of the ground water levels. Depths to ground water level were demarcated into various zones in the ranges of less than 2 m, 2-5 m, 5-10 m, 10-20 m. The description of depth to water levels during pre-monsoon and post monsoon is as follows:

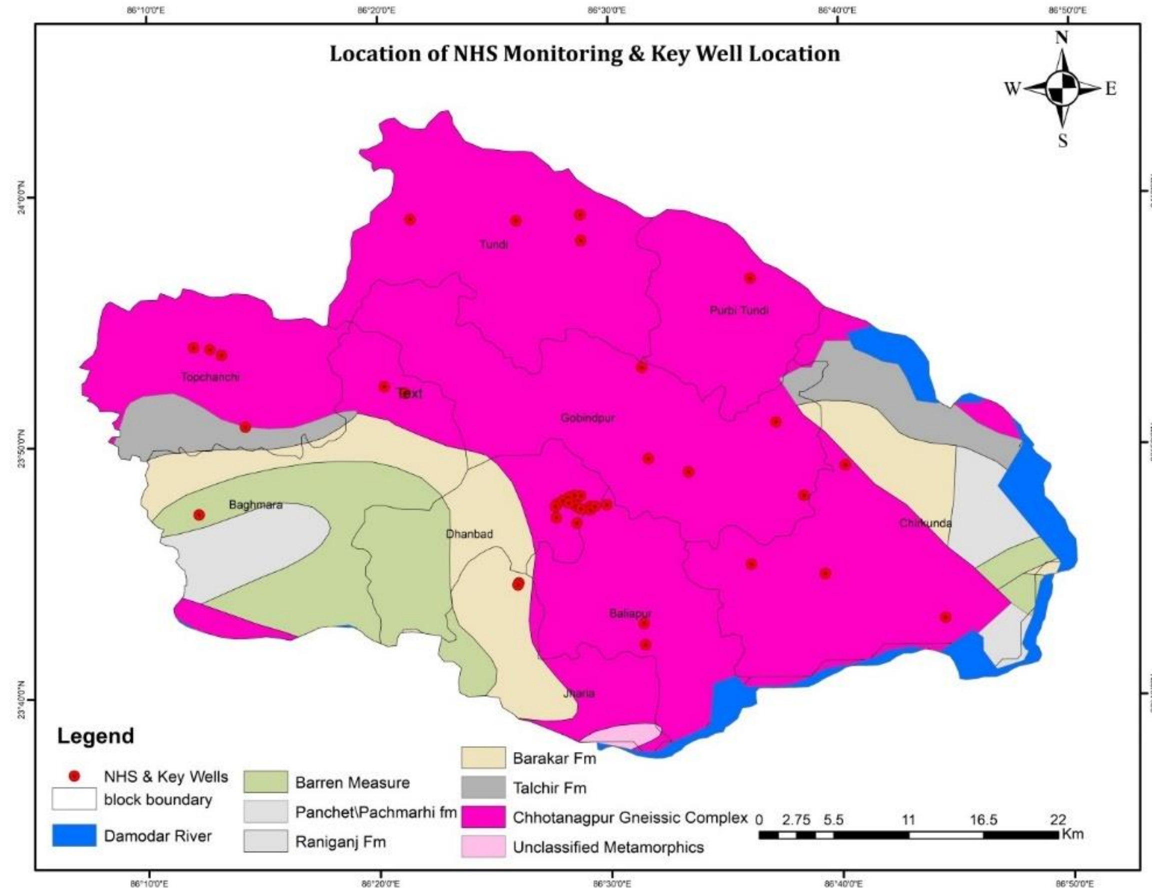


Figure 8 : Location of NHS and key wells in Dhanbad district

2.1.3.1 Depth to Water level May 2019:

Depth to ground water level during May 2019 ranges from 2.2 mbgl to 14.4mbgl. Minimum depth to water level 2.2 mbgl recorded at Nirsa Police Station of Nirsa (Chirkunda) block of Dhanbad district and maximum depth to water level 14.4 mbgl recorded at Baghmara of Katras block of Dhanbad district. Depth to water level map May 2019 is shown in figure-9

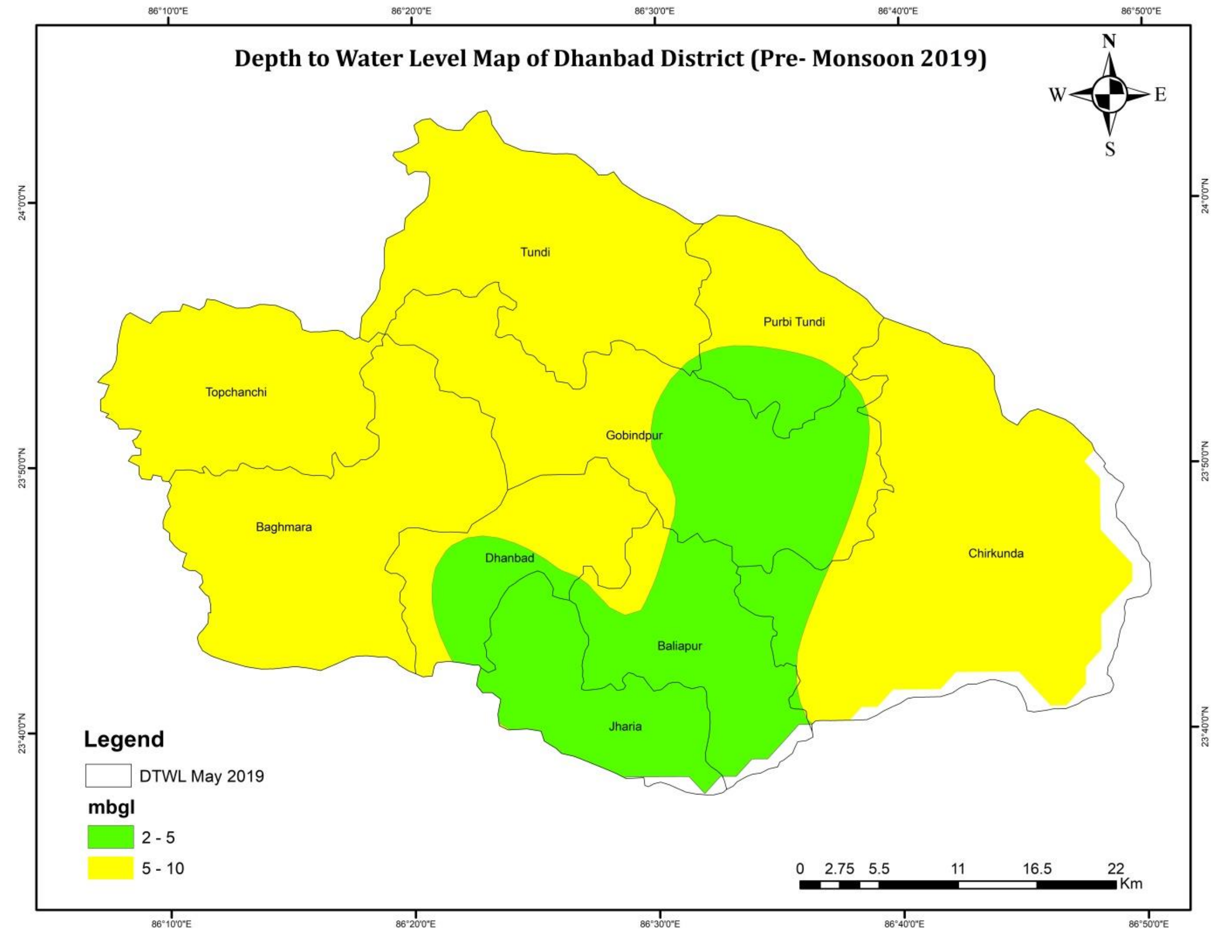


Figure-9: Pre monsoon (May 2019) depth to water level mapof Dhanbad District

2.1.3.2 Depth to Water level November 2019:

During month of November 2019 (post-monsoon) depth to water level varied from 1.51 m bgl to 8.02 m bgl. Minimum depth to water level 1.51 mbgl recorded at Jharia village of Dhanbad block of Dhanbad district and maximum depth to water level 8.02 mbgl recorded at Baghmara village of Katras block of Dhanbad district. Depth to water level map November 2019 is shown infigure10.

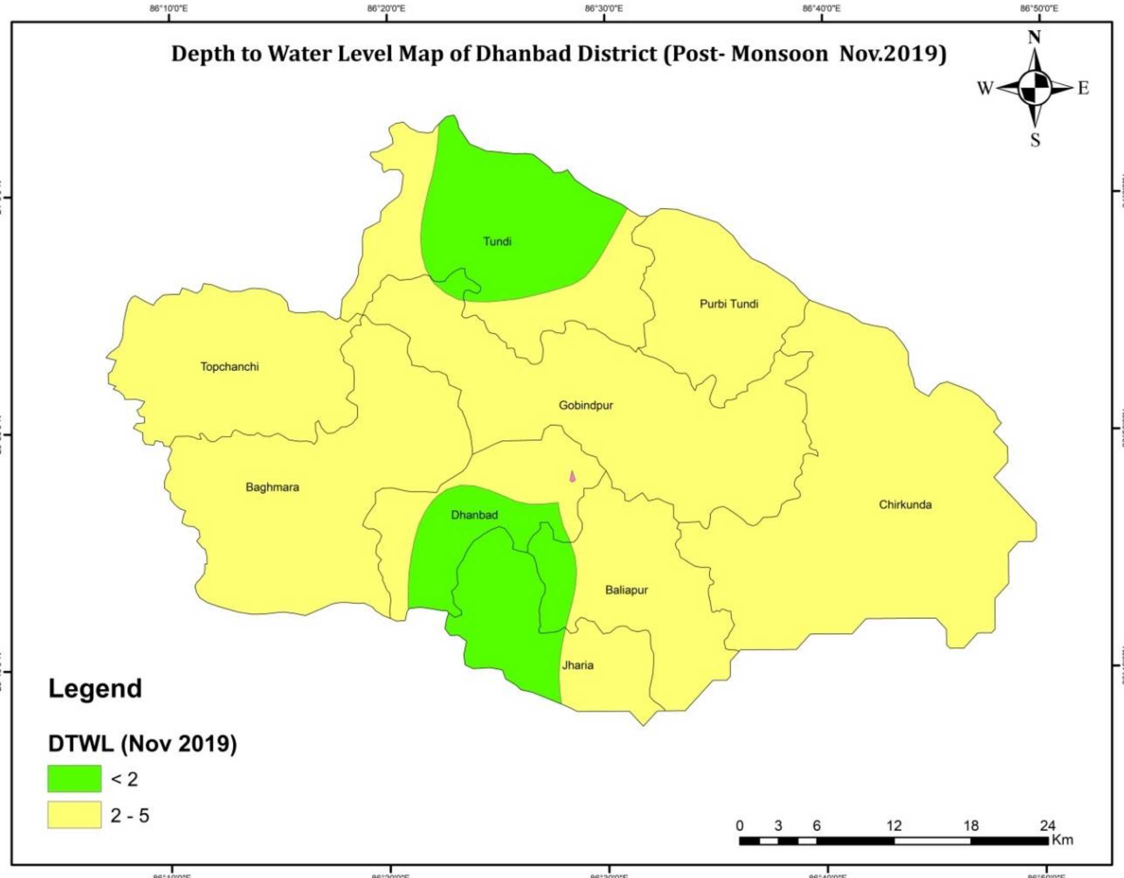


Figure 10: Post monsoon (May 2019) depth to water level map of Dhanbad District

2.1.3.3 Long Term Trend of Water level:

Pre-monsoon/Post-monsoon trend of water level:

The Pre-monsoon long-term trends of water level for the period 2000 to 2019 have been shown in table-. In the DBL bungalow of Topchanchi block of Dhanbad district the monitoring well show declining trend in the range of 0.0360 to 0.0035m/year whereas annual falling trend is 0.0016/year and has been shown in figure 11- and table-7

Table7 : Pre-monsoon Water Level Trends (2000 -2019) in Topchanchi block of Dhanbad district

Sr. No.	Block	Trend of Water Level					
		Pre-Monsoon		Post monsoon		Annual	
		Rise (m/yr)	Fall (m/yr)	Rise (m/yr)	Fall (m/yr)	Rise (m/yr)	Fall (m/yr)
(A) Topchanchi							
1	DBL bungalow, Topc		0.0360		0.0035		0.0016

	hanc hi						

The Pre-monsoon long-term trends of water level for the period 1998 to 2018 have been shown in table-. In the Sindri of Baliapur block of Dhanbad district the monitoring well show declining trend in the range of 0.2709 to 0.1653m/year whereas annual falling trend is 0.2340/year and has been shown in figure 12- and table- 8

Table 8:- Pre-monsoon Water Level Trends (1998 -2018) in Baliapur block of Dhanbad district

Sr. No.	Block	Trend of Water Level					
		Pre-Monsoon		Post monsoon		Annual	
		Rise (m/yr)	Fall (m/yr)	Rise (m/yr)	Fall (m/yr)	Rise (m/yr)	Fall (m/yr)
(A) Baliapur							
1	Sindri, Baliapur		0.2709		0.1653		0.2340

2.1.3.4 Hydrograph Analysis

Analysisof two hydrograph network stations, were carried out using GEMS software(Fig-13, 14) andanalysed for the period from 2000-2019. It is observed that the long-term water level trendsduring pre and post-monsoon seasons are declining trend in shallow aquifer-I represented by dug wells.

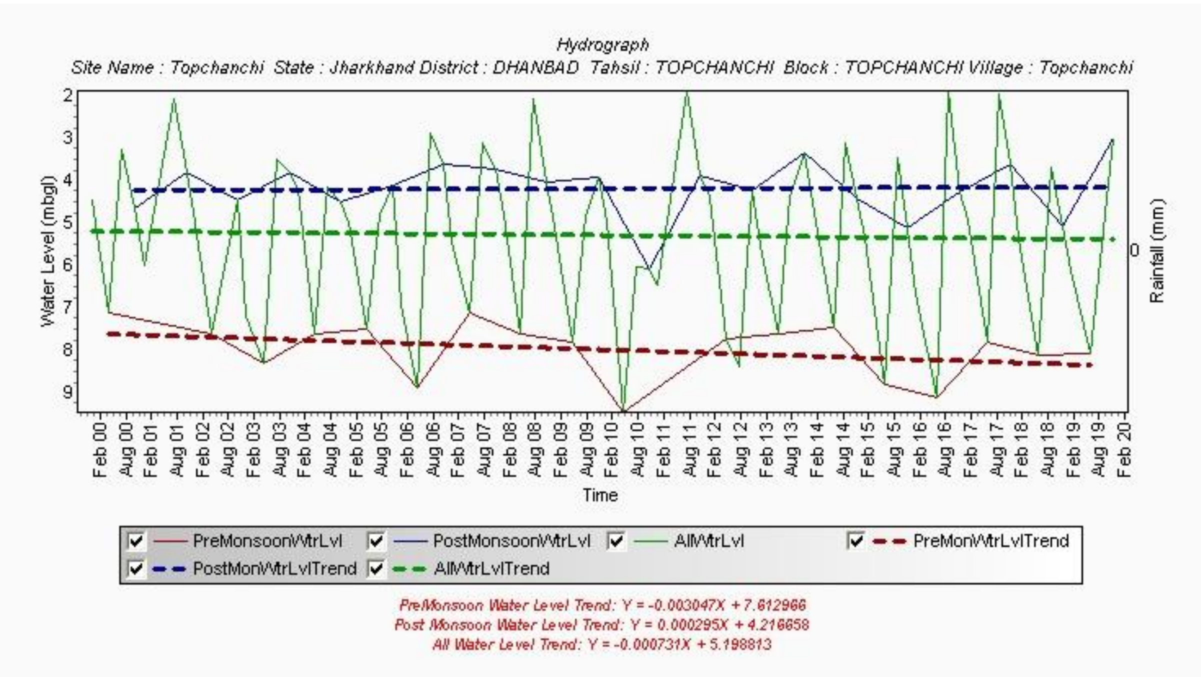


Figure 11: Hydrograph (2000-2019), Dhanbad, Dhanbad, block, Dhanbad, district

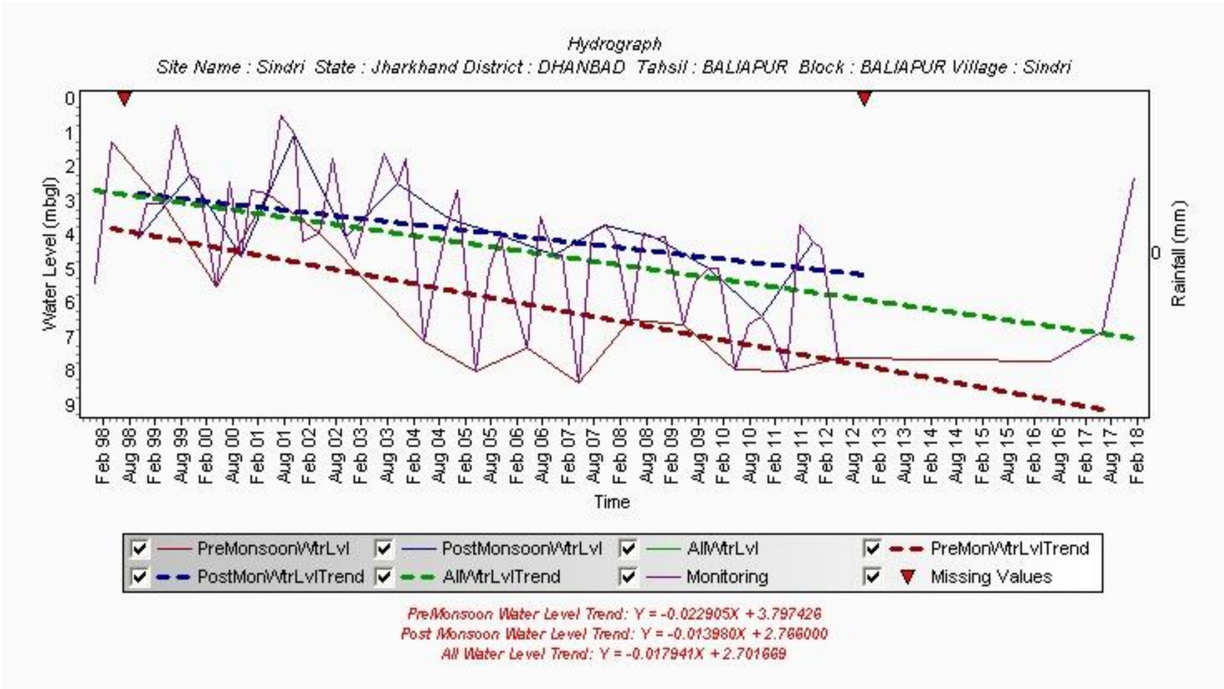


Figure 12: Hydrograph (1998-2018) Baliapur, Baliapur, block, Dhanbad, district

2.2 Ground Water Exploration: The exploratory data particularly includes the information on sub–surface geology, hydrogeological information and geometry of aquifer in hard rocks terrain. Based on exploration data, prepared litholog of exploratory wells&observatory wells, identified the potential fracture zone encountered within 200 m depth in granitic terrain. To assess the potentiality of the deep fractured rock, 26 exploratory wells were drilled in Dhanbad district. Out of 26 exploratory wells, 17 exploratory wells are drilled by Central Ground water Board i.e inhouse drilling and 09 exploratory wells constructed by outsourcing.The drilling results have indicated that granite gneiss of different colour varying from grey to dark grey to pink, having course grained texture sometime porphyritic, are the most dominant rock types met in the area. In the bore wells upper weathered zones are cased and only the fractured zones are tapped in the uncased well. The details of the exploratory and observation wells drilled in Dhanbad district is presented in Annexure 1–and location of exploratory wells is shown in figure 13 and Summary of success bore wells drilled in the district is given below in table 9.

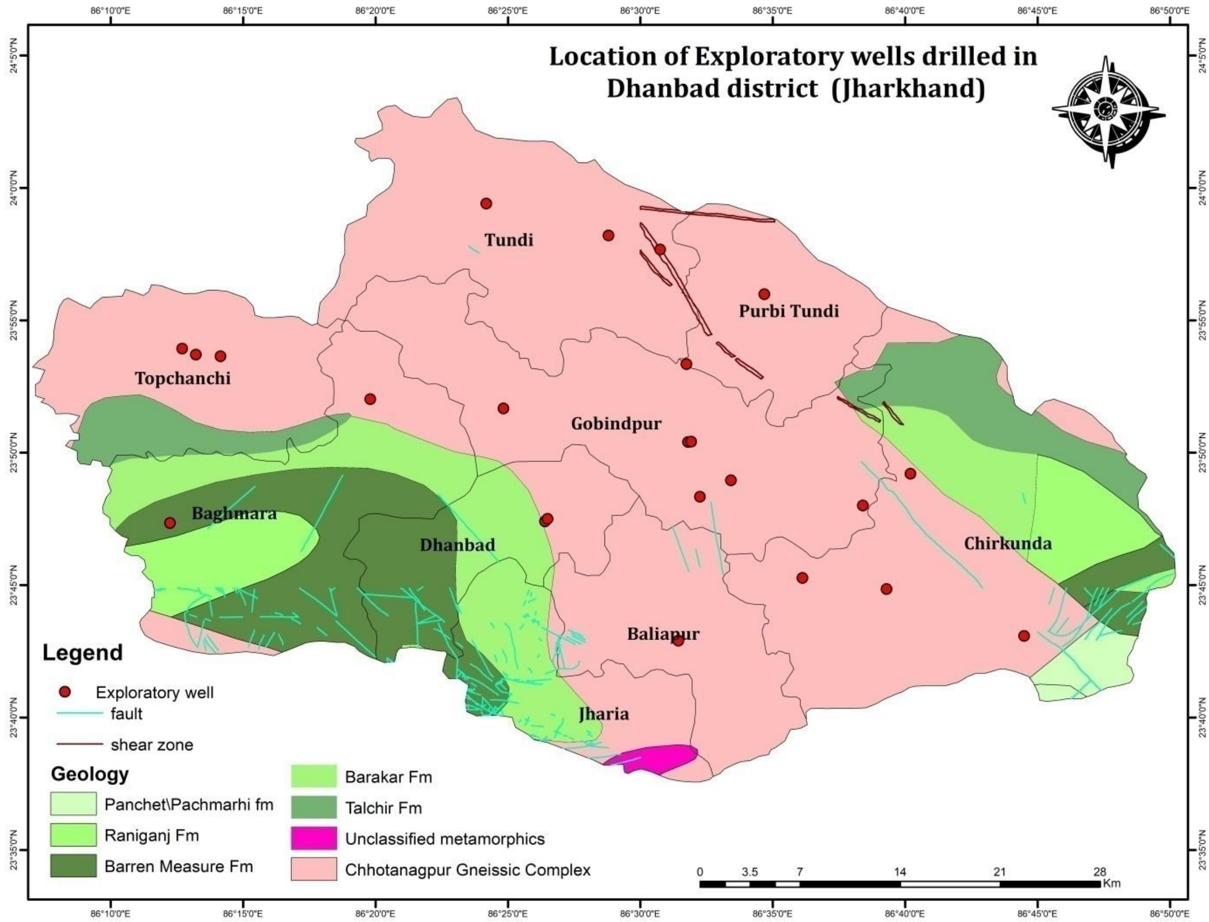


Figure 13: Location of exploratory wells drilled in Dhanbad district

Table 9 –: Summary of success bore wells drilled by CGWB in Dhanbad district

S. No.	Location	Block	Depth Drilled (m)	Major Lithology Encountered	Depth of casing (m)	Potential Fracture Zone encountered (m bgl)	Discharge (lpm)
1	NNH School Bagshuma	Govindpur	153.8	Granite gneiss	19.7	40-41, 71-72, 103-104	108
2	KGBH school, Gopalganj (EW)	Nirsa	123	Granite gneiss	18.6	64-65, 113-114	870
3	KGBH school, Gopalganj (OW)	Nirsa	74	Granite gneiss	12.1	42-43, 64-65, 74-75	630
4	Govt. middle school, Joradih (EW)	Nirsa	153.5	Granite gneiss	24	65-66, 92-93, 129-130	342
5	Govt. middle school, Joradih (OW)	Nirsa	153.5	Granite gneiss	24.5	110-111, 129-130	180
6.	Saraswati Vidya mandir, Ratanpur EW I	Tundi	153.5	Granite gneiss	23.8	51-52, 61-62	270

2.3 Geophysical survey:

A total of 10 VES were carried out at10 locations in the district area of Dhanbad under aquifer mapping in Jharkhand state through outsourcing. With the help of existing borehole lithological logs wherever available, the estimated layer parameters obtained from the VES data interpretation were standardized and resistivity ranges were generalized for different lithological predominance at the VES sites. It is likely that there will be overlaps in the resistivity ranges because of deviations from these ranges at local level. These ranges were to be considered as a guide and to be ascertained or modified for the local subsurface hydro-geological situations.

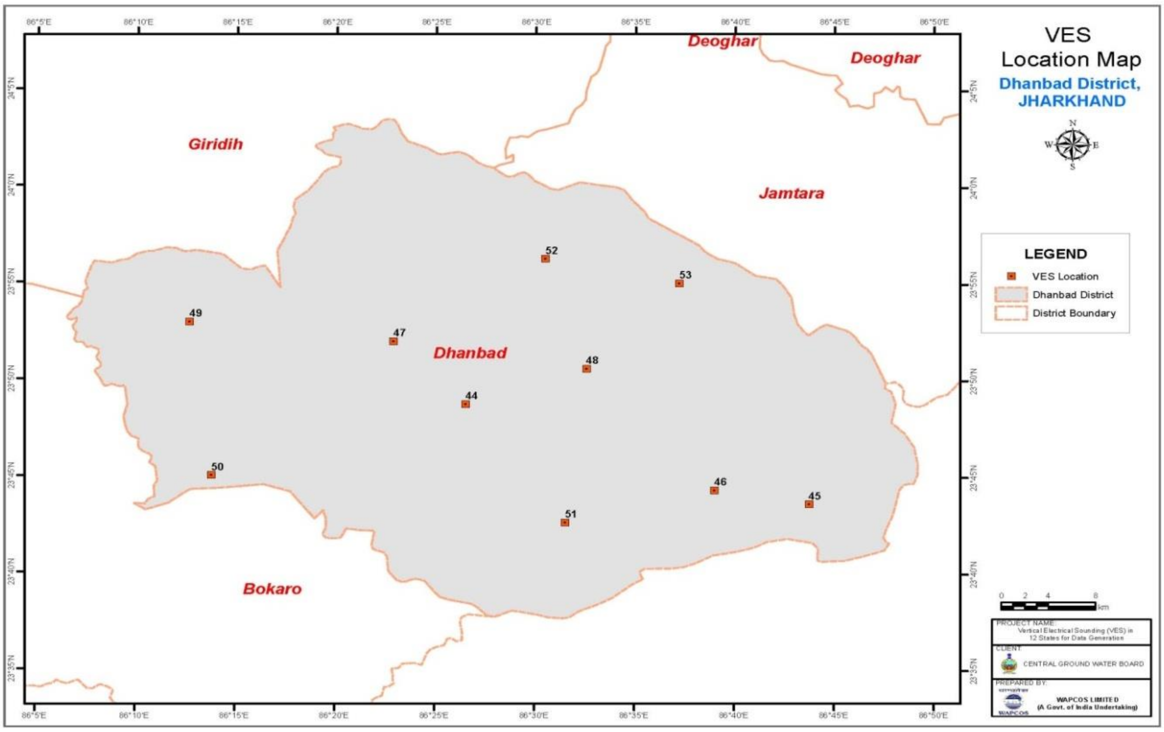


Figure 14: Location of VES conducted in Dhanbad district

Interpreted results of VES are given in Annexure-. The geoelectrical characteristics of the weathered and semi-weathered zones are given in Table 4.0. In Dhanbad district, the weathered zone in granite gneiss terrain is, in general, thin (extending up to 13 m depth) and out of 9 VES sites in granite gneiss at 4 VES sites it is absent. Only at one VES site – VES 44, the weathered zone extends to about 43 m deth. The range of resistivity for the weathered zone is 23 to 76 ohm.m. Underlying the weathered zone, the semi-weathered zone extends to a maximum depth of about 35m. The resistivity of semi weathered zone ranges from 103 to 213 ohm.m.

2.4 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 24 monitoring wells which represent the quality of phreatic/ shallow zone i.e Aquifer I. The analytical results of water samples from dug wells are given in Annexure-. 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.

With reference to analyzed parameters the water of Dhanbad urban area appears chemically potable for domestic as well as agricultural purposes in most of the locations. Groundwater is neutral to slightly alkaline in nature. Total dissolved solids (TDS) are well within the permissible limit (2000 mg/L) at each location as per BIS, 10500. Fluoride concentration is more than the permissible limit (>1.5 mg/L) at one location. Nitrate concentration has been found more than the permissible limit (>45 mg/L) at two locations. Concentration of Iron has been found more than permissible limit at one location. Concentration of Manganese has been found well within the permissible limit (<0.1 mg/L) at each sampling site. Concentration of Chromium is well within the permissible limit at each location. By looking at the results of chemical analysis it is evident that concentration of Zinc varies from BDL to 1.69 mg/L and depicts that all the samples have concentration below the 5 mg/L of permissible limit as per BIS,10500. Arsenic and lead is also well within the permissible limit at each sampling point. Concentration of Uranium varies from BDL to 16.70 ppb in groundwater samples of Dhanbad Urban Area which is well below the permissible limit of 30 ppb.

2.4.1General Range of Chemical Parameters

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. An overview of Hydro-chemical data of (phreatic aquifer) hydrograph monitoring wells existing in Dhanbaddistrict is tabulated below in table no. and the detail of water quality analysis is given in Annexure . The spot value map of water quality samples more than permissible limit is also shown in figure. Hydro-chemical data of (phreatic aquifer) monitoring wells existing in Dhanbad district is tabulated below in table 10.

Table 10 Details of Hydro-chemical data of hydrograph monitoring wells

S.No.	Constituents	Minimum	Maximum	Average	BIS (2012)	
					Desirable	Permissible
1.	pH	7.74	8.21	7.95	6.5-8.5	No relax.
2.	EC	203	1330	558		

3.	TDS (mg/l)				500	2000
4.	HCO3 (mg/l)	49.2	313.65	162	200	600
5.	Cl (mg/l)	3.69	247	58.50	98	1000
6.	TH (as CaCO3) mg/l	75	380	191	300	600
7.	Ca (mg/l)	16	116	43	75	200
8.	Mg (mg/l)	6.07	32.81	17.84	30	100
9.	Na (mg/l)	7.15	105.40	37.69	200	-
10.	K (mg/l)	0.71	76.14	8.15	200	-
11.	NO3 (mg/l)	1.4	144	38.5	45	No relax.
12.	F(mg/l)	0.04	0.79	0.34	1.0	1.5
13.	SO4(mg/l)	6	68	29	200	400

Hydrogen ion concentration (pH):

The pH of water indicates that whether the water is acidic or alkaline. The hydrogen (pH) is a measure of the hydrogen ion concentration in the water. The measurement scale of pH ranges from 1 to 14 with a pH of 7 indicating as neutral condition environment. The value of pH lower than 7 indicate acidic and more than 7 indicates alkaline. The pH of ground water in Dhanbad district ranged in between 8 to 8.55. The ground water of the study area can be assessed as slightly alkaline to neutral in nature. Minimum 8 PH value observed in Mahuda village of Katras block whereas Maximum PH value 8.55 recorded in Rajganj village of Rajganj block of Dhanbad district.

Electrical Conductivity (EC):

Electrical conductance is the ability of water to conduct electric current and it depends on, the concentration of ion, nature and types of ions and temperature. BIS has recommended desirable limit for Total Dissolve Solid (TDS) as 500 mg/l corresponding to EC value approximately as 750 µS/cm at 25°C which is extendable to permissible limit as 2000mg/l. TDS corresponding to EC value is about 3000 µS/cm at 25°C in absence of alternate source of water.

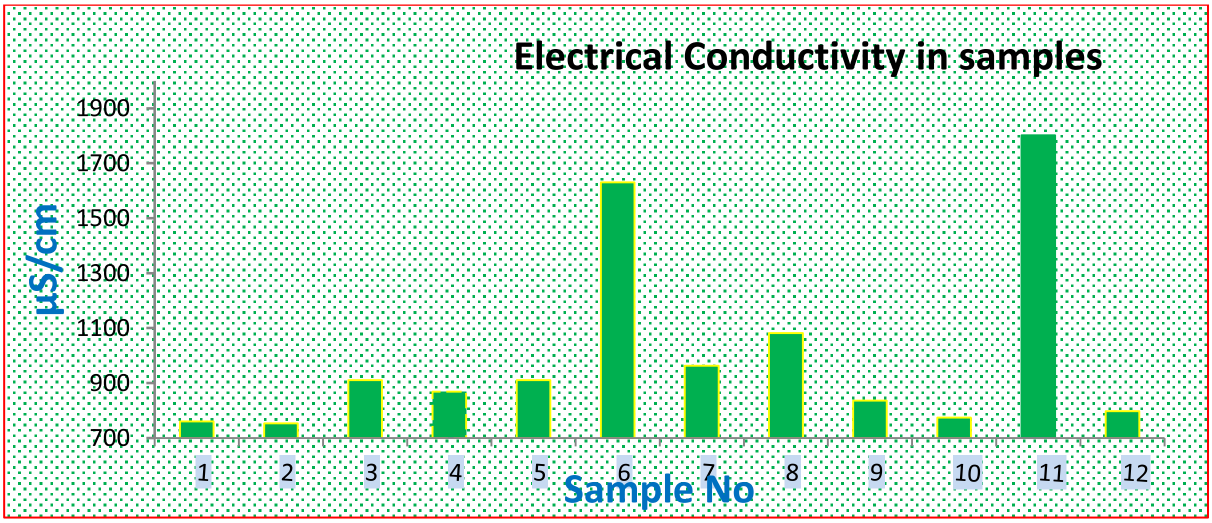


Figure 15 :Chemical quality map showing EC concentration

The electrical conductivity of ground water in Dhanbad district ranges in between 753 to 1802µS/cm at 25°C. Minimum 753 µS/cm at 25°C EC value observed in Baghmara village of Katras block whereas Maximum 1802 µS/cm at 25°C EC value recorded at Topchanchi village of Topchanchi block of Dhanbad district.

Carbonate and Bicarbonate (Alkalinity):

Presence of alkalinity in water is the capacity to neutralize a strong acid due to the presence of carbonate, bicarbonate and hydroxide of magnesium and calcium. The concentration of bicarbonate ranged in between 129.15to 479.7mg/l. Minimum concentration of bicarbonate 129.15 mg/l value has been recorded in Rajganj village of Rajganj block whereas Maximum concentration 479.7 mg/l value has been recorded in Mahudavillage of Baghmarablock of Dhanbad district.

Chloride:

Chloride in ground water can be geogenic in deep aquifers or caused by industrial or domestic wastes and pollution from brine. The BIS has set 250 mg/l chloride ions as acceptable limit and 1000 mg/l as permissible limit in the absence of alternate source in drinking water. In Dhanbad district Chloride concentration ranges in between 51.2to 246.9 mg/l. Minimum concentration value of chloride 51.2 mg/l has been recorded in Mahuda village of Baghmara block whereas Maximum concentration value of chloride 246.9 mg/l has been recorded in Topchanchi village of Topchanchi block of Dhanbad district.

Fluoride:

Fluoride occurs in low concentration in natural water. It is an essential element to maintain normal development of teeth and bones. The consumption of low fluoride concentration prevents the dental caries. The higher concentration of fluoride consumption causes mottling of teeth and skeletal fluorosis. The BIS has set the maximum concentration of fluoride in drinking water is 1.5 mg/l as permissible limit. The fluoride concentration in Dhanbad district ranged in between 0.007 to 1.74 mg/l. The maximum concentration 1.74 mg/l of fluoride has been recorded in Baghmara village of Baghmara block of Dhanbad district.

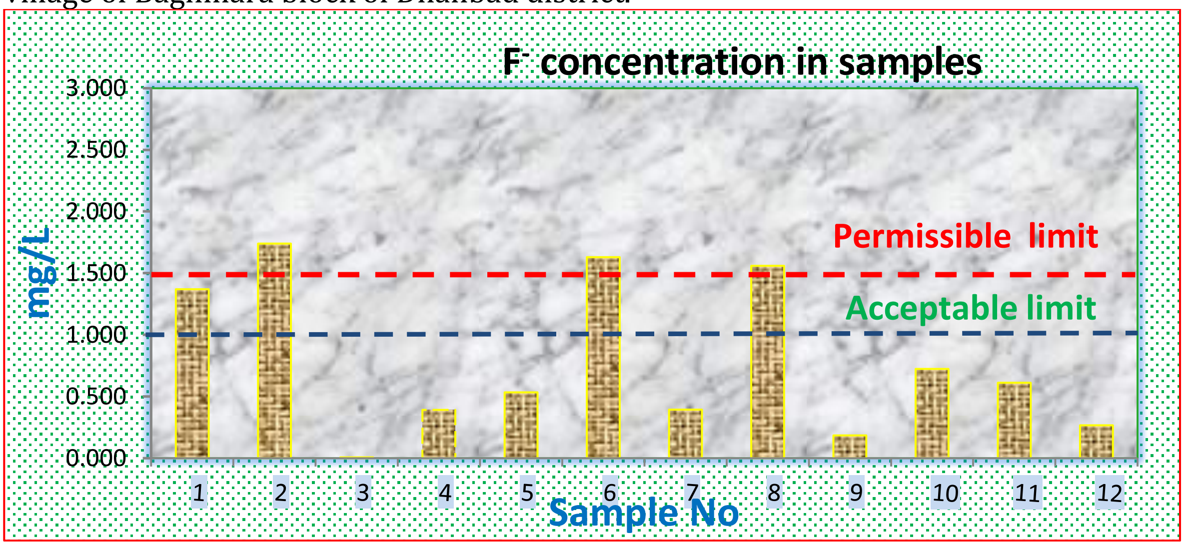


Figure 16: Chemical quality map showing fluoride concentration

Nitrate:

Nitrate is the end product of oxidation process of nitrogen in the environment and its higher concentration in ground water is an indication of pollution from human and animal wastes, nitrogenous fertilizers and industrial wastes. Nitrate is a non-essential constituent of ground water. The BIS has set a acceptable limit of nitrate concentration in drinking water as 45 mg/l with no relaxation. The consumption of nitrate more than 45 mg/l is harmful for human being, particularly to infants as it may cause blue baby syndrome. In Dhanbad district nitrate concentration in ground water ranges in between1.94 to 251.2mg/l. The maximum Nitrate concentration has been recorded at Topchanchi village of Topchanchi block of Dhanbad district.

Sulphate

The concentration of sulphate in drinking water set by BIS as acceptable limit is 250 mg/l and 400 mg/l permissible limit in absence of alternate source. Higher concentrations are undesirable taste because of laxative effects. Sulphates in groundwater are released by natural deposition of calcium sulphate, magnesium sulphate, or sodium sulphate. These natural sources can be applied as soil conditioners. The ground water of study area recorded sulphate concentration ranges in between 36.25 to 107.7mg/l.

Total Hardness:

As per Bureau of Indian Standard (BIS): 10500-2012 (Drinking Water), the acceptable limit of total hardness is 300 mg/l and permissible limit is 600 mg/l in absence of alternate sources.Total hardness of ground water in the study area ranges in between 212to 457 mg/l.

Sodium:

Sodium does not find freely in nature because it is very active element. It always combines with other elements. In human body, sodium helps in maintaining water balance. The higher sodium intake may cause congenial heart diseases, hypertension and also kidney problem.In Dhanbad district, water samples observed sodium concentration ranges in between 30.98to 168 mg/l.

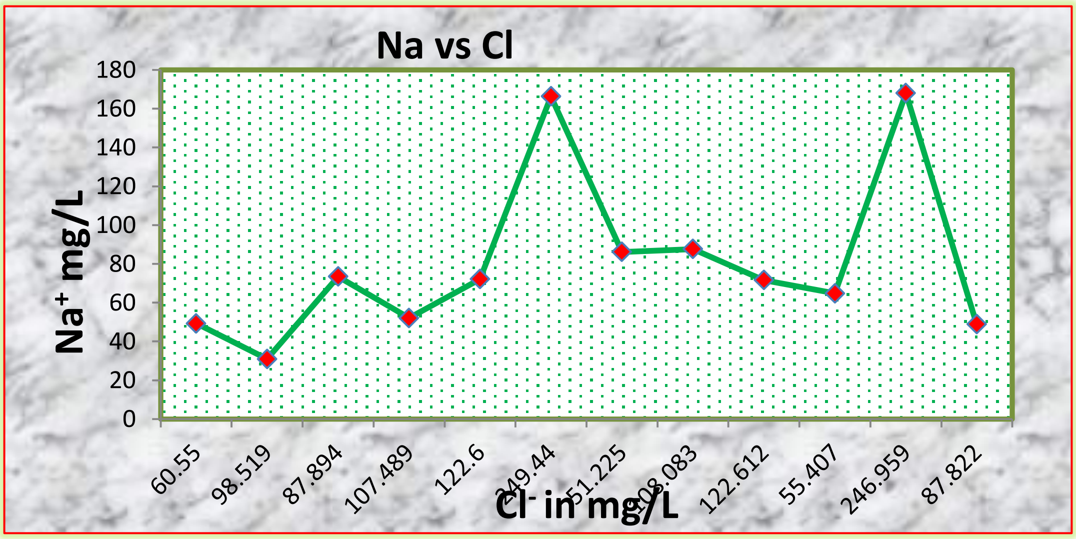


Figure 17:Chemical quality map showing Na Vs Cl concentration

Potassium:

The common sources of potassium are minerals of igneous, metamorphic and sedimentary rocks. Potassium concentration in water is generally very low. BIS has not given any guideline for potassium concentration in drinking water. In the study area of Dhanbad district, Potassium concentration observed in water samples ranged in between 0.214 to 23.80 mg/l.

***2.4.2SuitabilityofGroundWaterforDrinking Purposes*: -**

The suitability of water is evaluated on the basis of electrical conductivity which represents salinity and also the concentration of Fluoride and Nitrate ions. The maximum and minimum values and values exceeding desirable and permissible limit for drinking use of different parameters is given in the Table

The classification of water on the basis of EC it is found that 96 % wells have EC values less than 1500 µS/ cm at 25^{0}C. Regarding fluoride, in 99.64 % wells its concentration was found less than desirable and permissible limit i.e 1 to 1.5 mg/l for drinking water. The nitrate was observed more than permissible limit of 45 mg/l in 36% wells. Perusal of the analytical data reveals that there is no specific trend observed for distribution of higher values of EC, fluoride and nitrate in the ground water and higher values may be due to local pollution/ geogenic sources. As such in general the quality of ground water in the study area is good and suitable for drinking.

***2.4.3* Suitability of ground water of Aquifer–I for irrigation purposes:** -

Apart from domestic consumption, irrigation is consuming a major share of ground water for agricultural activities. The quality of water used for irrigation is an important factor in productivity and quality of irrigated crops. The suitability of water for irrigation purpose depends upon the Total Dissolved Solid in terms of EC value, concentration of Na, bicarbonate and its relative proportion to Mg and Ca. All these mentioned above either individual or with combination create concentration of Sodium (salinity) bicarbonate and alkalis type of hazard.To better understanding the suitability of ground water for irrigation purpose chemical result of collected water samples have been analyzed and described the different classifications.

Sodium Percentage Classification: -

Electrical Conductivity (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.Classification of ground water of Aquifer - I based on sodium percentis tabulated in table. 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.

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

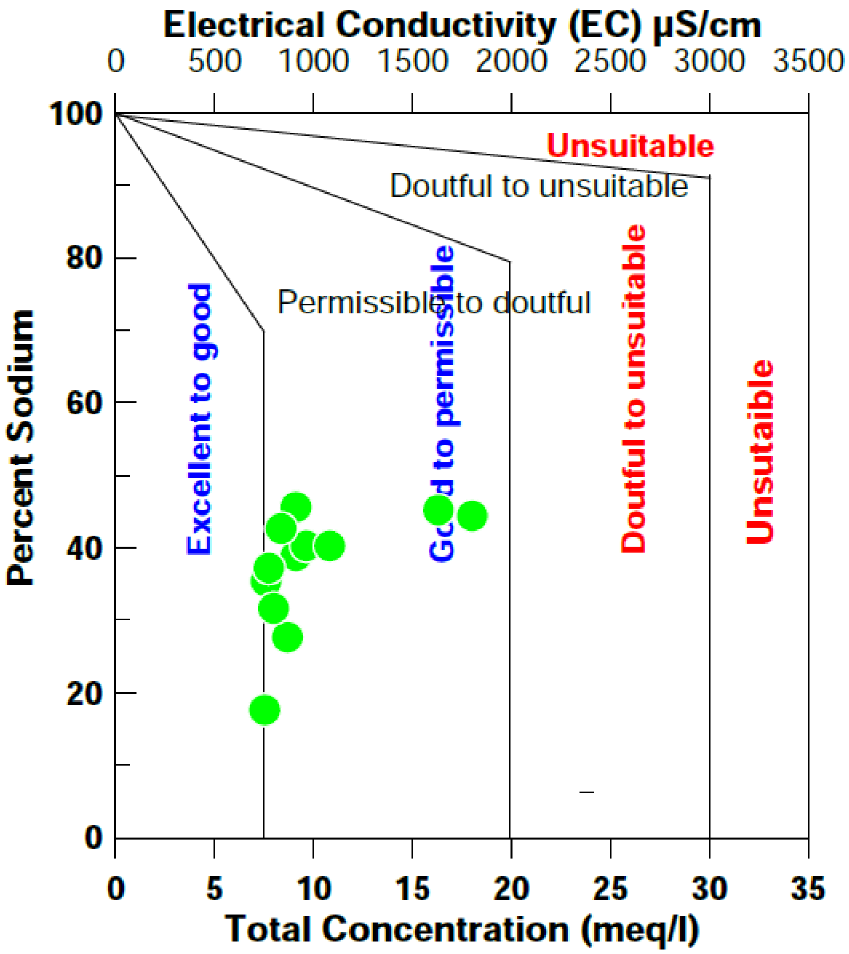


Figure 18:Chemical quality map showing Sodium Percentage

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

Sl No.	Water class or category	Sodium percent	No. of samples falling	Percentage of samples (%)
1	Excellent	< 20 %	1	4
2	Good	20 – 40 %	7	60
3	Permissible	40 – 60 %	4	36
4	Doubtful	60 – 80 %		
5	Unsuitable	> 80 %		

(Where all ions are expressed in epm)

On the perusal of above table 11-, 100 % of water samples of aquifer – I (dug wells) falling under excellent to permissible category.

2.4.4 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:

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

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 tabulated in table which is showing that all the water samples (100%) of aquifer– I (dug wells) pertain to excellent class. Classification of ground water of Aquifer – I based on SAR value is given below in table 12.

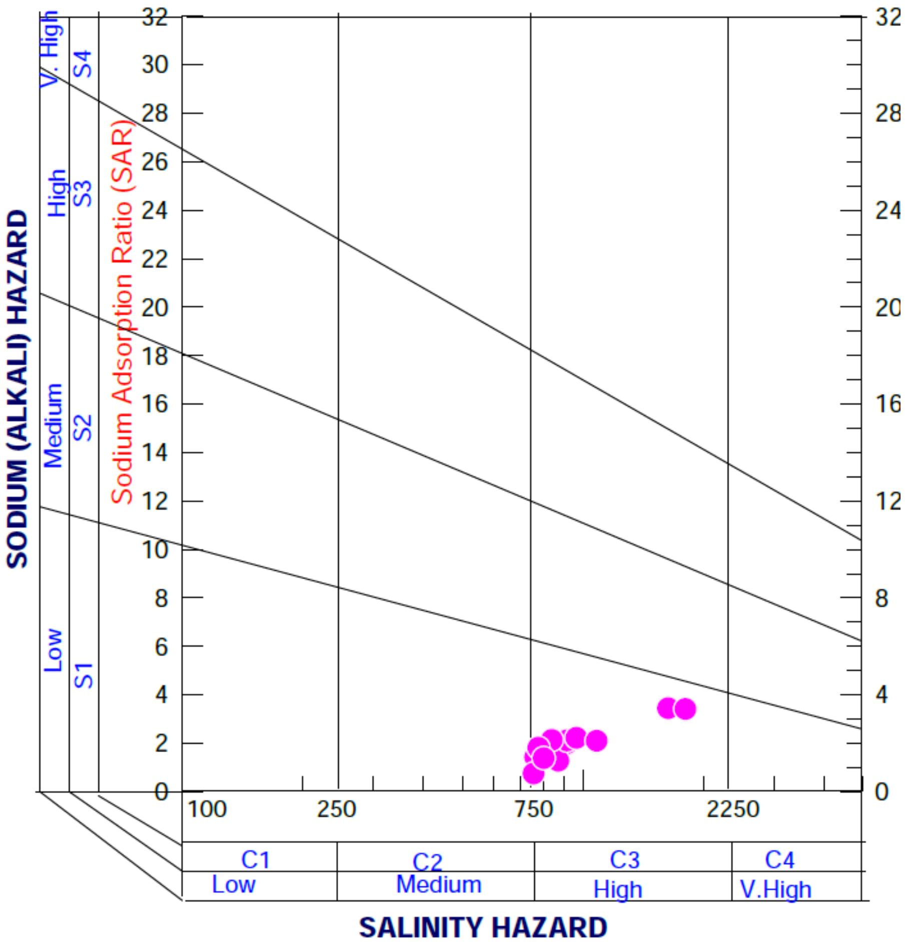


Figure 19:Chemical quality map showing Sodium Adsorption Ratio (SAR)

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

Sl No.	Water class	Type of Water	SAR Value	No. of samples falling	Percentage of samples
1	Excellent	Low sodium water	< 10	-	-
2	Good	Medium sodium water	10 – 18	-	-
3	Fair	High sodium water	18 – 26	12	100
4	Poor	Very high sodium water	> 26	-	-

(Where all ions expressed in epm)

2.4.5 Residual sodium carbonate content (RSC): -Water containing CO2 on way gets saturated with CO2 and forms bicarbonates. The excess bicarbonate of Mg and Ca are precipitated out as carbonates. This produces impermeability to the top soil. Bicarbonate concentration of water has been suggested as additional criteria of suitability for irrigation water. Groundwater samples that had RSC indices of positive value imply that the cumulative concentration of CO3-2 and HCO3-2 is higher than the combined Ca2+ and Mg2+ concentrations. This would indicate that there is a residual carbonate to react with sodium, presenting sodium hazard to the soil when irrigated with such water. Based on the RSC value the groundwater suitability classification is given in table.A negative value indicates no residual carbonate. Residual sodium carbonate is determined by using the formula –

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

(Where concentration is expressed in epm)

T*able- 13: - Classification of ground water of Aquifer – I based on RSC value*

Sl No.	RSC (mg/l)	Irrigational suitability	No. of samples falling	Percentage of samples
1	< 1.25	Safe for all type of crops	11	92
2	1.25 – 2.50	Safe for semi-tolerant to tolerant crops	1	8
3	> 2.50	Safe with application of gypsum of the rate of 8.5g/ham of irrigation water applied for 1.0 ml/liter RSC	-	-

(All the values are expressed in epm.)

On the perusal of table 13, about 92 %of water samples of aquifer - I are falling under safe for all type of crops category and about 8 % of water sample (01 No.) falling under safe for semi- tolerant to tolerant crop. Classification of irrigation water modified Piper's diagram is shown below in figure – 20 & 21.

2.4.6 Piper Diagrame for Classification of irrigation Waters

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 (HCO3-2) plus carbonate (CO3-2), chloride (Cl-), and sulfate (SO4-2). 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.

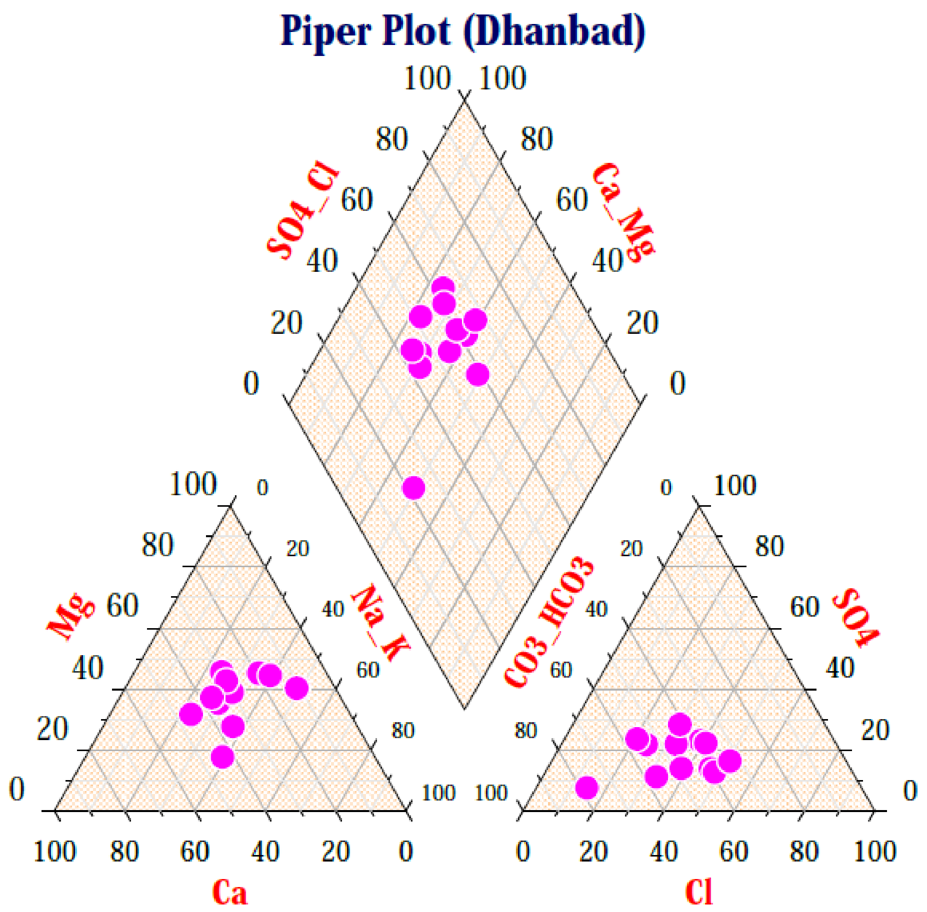


Figure 20 : Piper Diagram (Trilinear)

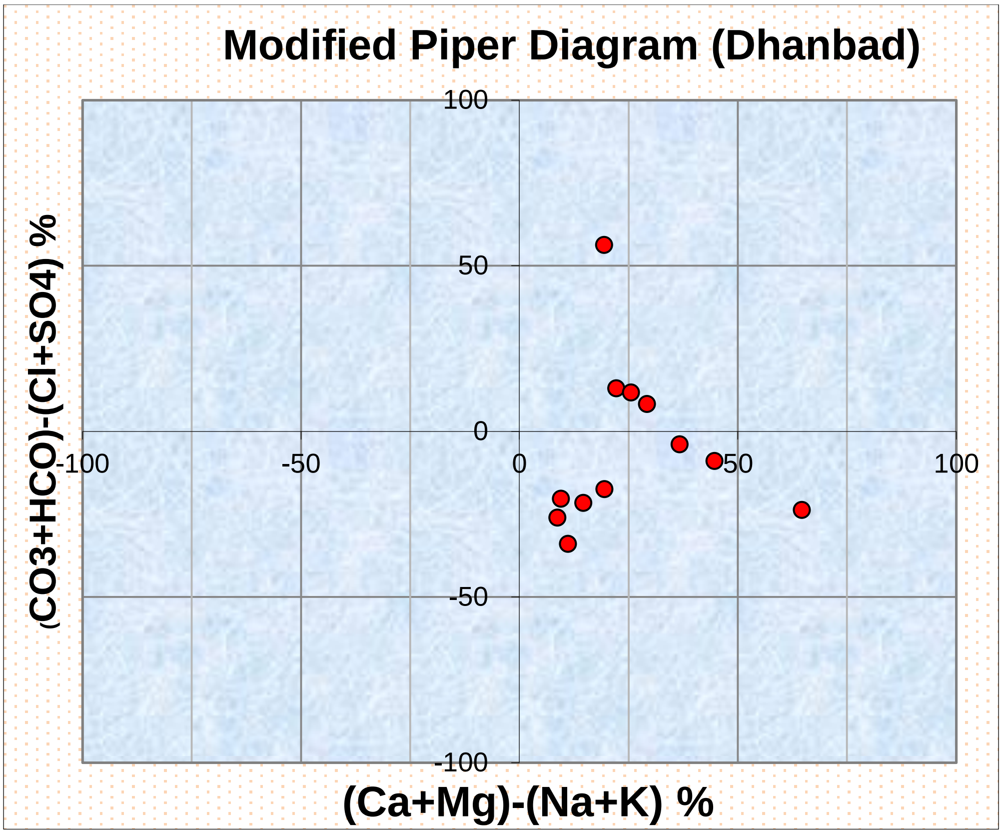


Figure 21 : Modified Piper Diagram

Interpretation of Chadha's modified Piper diagram,in shallow aquifer, 66% water sample belong to calcium–magnesium–chloride (Ca–Mg–Cl) type and only 34% water samples belong to calcium-bicarbonate (Ca-HCO3) type.

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

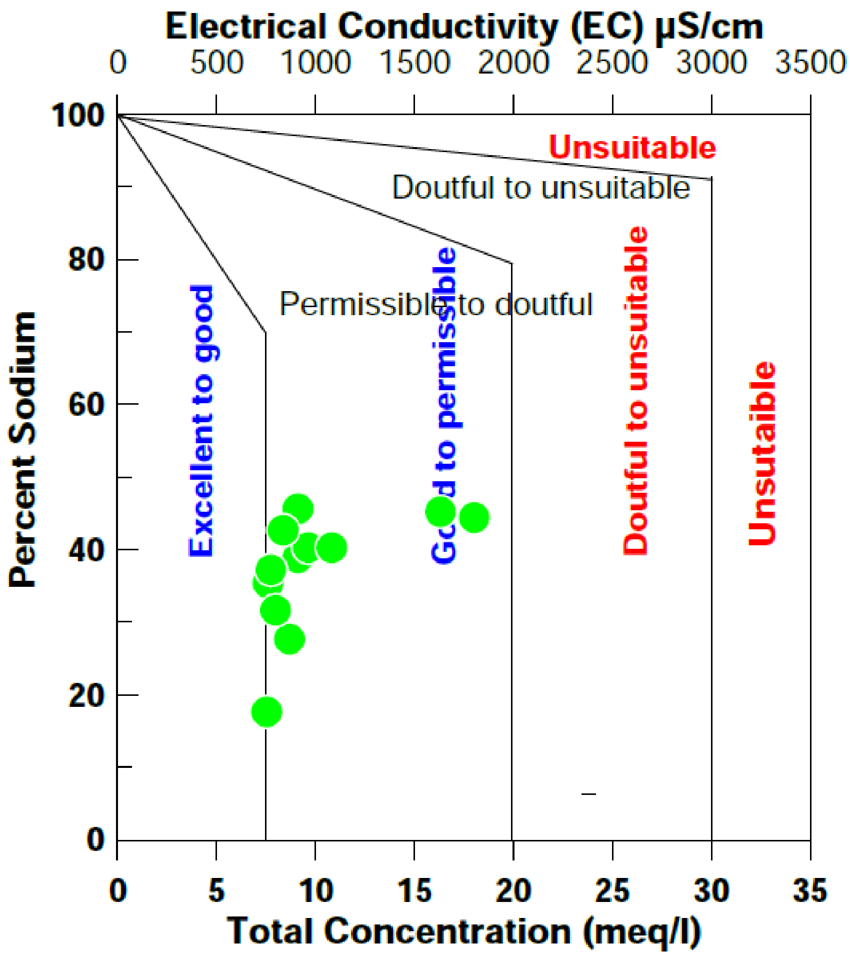


Figure 22 :Suitability of ground water based on Electrical Conductivity (EC)

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

Sl No.	Water Class	Rages of EC	No. of samples falling	Percentage of samples
1	Excellent	< 250	Nil	0%
2	Good	250 – 750	Nil	0%
3	Permissible	750 – 2250	12	100%
4	Doubtful	2250 – 3000	Nil	0%
5	Unsuitable	> 3000	Nil	0%

On the perusal of table, about 100 % of samples falling under under permissible water class.

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 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

3.1Aquifer Disposition: To study the aquifer disposition in detail, hydrogeological cross section, 2D, 3D maps, Strigraphical models indicating aquifer geometry has been prepared as under:-

3.1.1 Hydrogeological cross section A-A':

Hydrogeological cross section A-A' represents the area in North-western to South eastern part of the district. The data of 5 exploratory wells i.e.Topchanchi, Rajganj, Bagshuma, Barwapurab and Bangariya have been utilised (figure). In section A-A'two to four fracture zone has been encountered in different exploratory wells and out of five exploratory wells Topchanchi well has got fourfracture zone upto depth of 116 mbgl. The discharge range varies from 27-108 lpm. The Aquifer-I bottom ranges from 5-21m representing weathered Granite-Gneiss while Aquifer-II ranges from 21.0-106 mbgl representing fractured granite gneiss. Location and Hydrogeological cross section of A-A' is shown in figure 23 & 24 respectively.

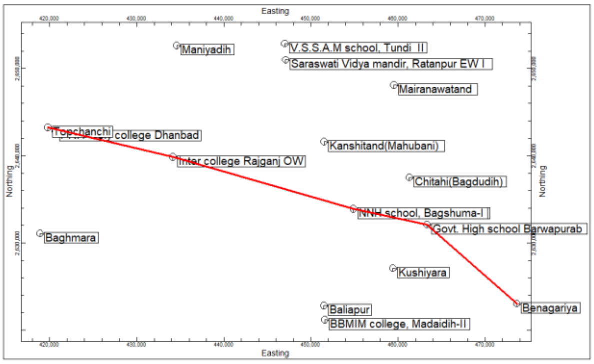


Figure 23: Location of exploratory wells under section A-A'

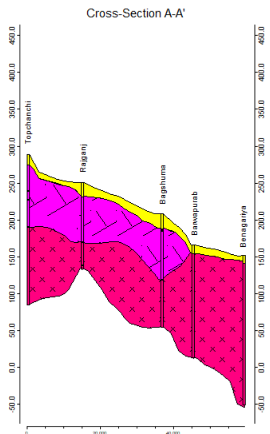


Figure24-: Hydrogeological cross section along A-A'

3.1.2 Hydrogeological cross section B-B':

Hydrogeological cross section B-B' represents the area in North-western to South-eastern Part of Dhanbad district. The data of four exploratory wells i.e.Manaydih, Tundi, Bagudih, and Bangariyawells have been utilised (figure). Out of four exploratory wells only three exploratory well has got fracture zone upto depth of 162 mbgl. The Aquifer- I bottom ranges from 8.35-21.00 mbgl representing weathered Granite-Gneiss/Laterites, while Aquifer-II ranges from 21-162mbgl representing fractured granite gneiss. Generally 1-3 sets of fracture zones were encountered. Well yield varies from 27 to 210 lpm. Location and Hydrogeological cross section of B-B' is shown in figure 25 & 26 respectively.

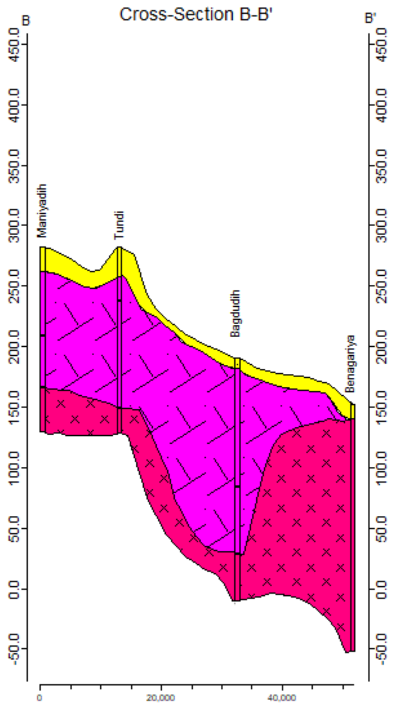


Figure 25: Location of exploratory wells under section B-B'

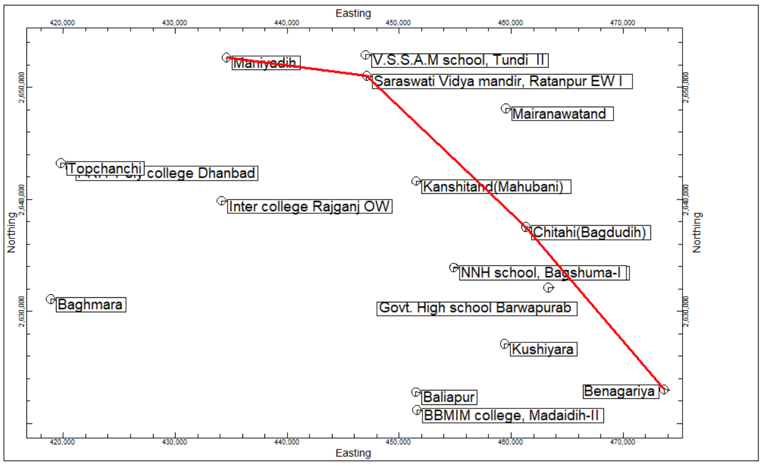


Figure 26-: Hydrogeological cross section along B-B'

3.1.3 3D Aquifer Disposition:-Hydrogeological Model has been prepared based on exploratory well data of CGWB.The inferred imaginary line between fractured rock zone and massive rock zone depicted in figure 27 are also based on exploratory data. This is a regional model of Granite gneiss. 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.

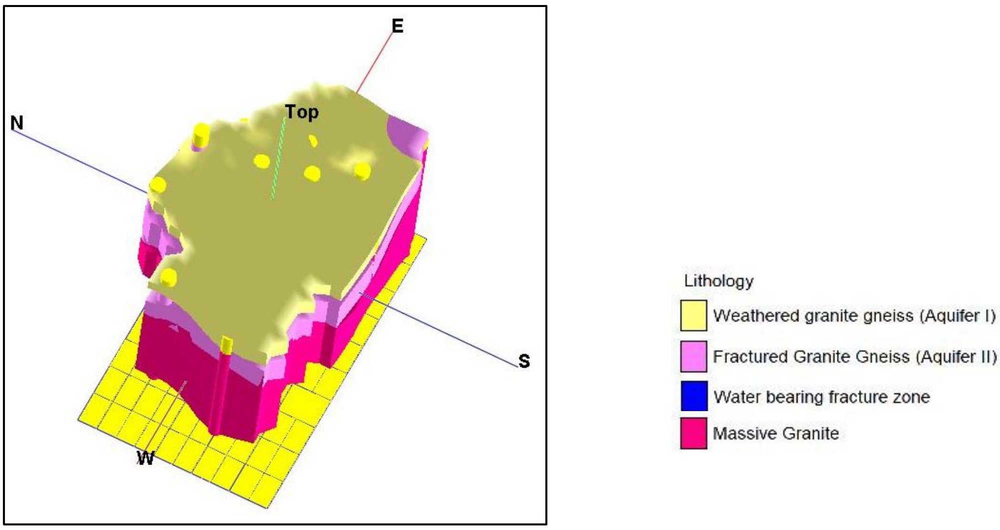


Figure 27: Three Dimensional Aquifer Disposition in Dhanbad District

3.1.4 3-D sub-surface Lithological Model

The 2D & 3-D map in hard rock area of the district showing spatial disposition and vertical extent of Aquifer-I(weathered granite-gneiss/weathered shale/sandstone)indicating its depth of weathering while the Aquifer–II (fractured granite-gneiss/fractured Shale/sandstone) showing occurrence of fractured rock thickness is presented in different stratigraphical model (exploded) of hard rock in Dhanbad district (figure-28). Based on the drilling data of exploratory wells maximum thickness of Aquifer - I (weathered zone) in hard rock area is 20.0 m. The depth of Aquifer – II (fracture zone) ranges from 20.00 to 180.00 mbgl.Three dimensional sub-surafce Stratigraphical models with Aquifer disposition in hard rock areas of Dhanbad district have also been prepared based on exploratory driiling data which is shown in figure. A stratigraphical fence diagram is also prepared in the study area and shown in figure 28.

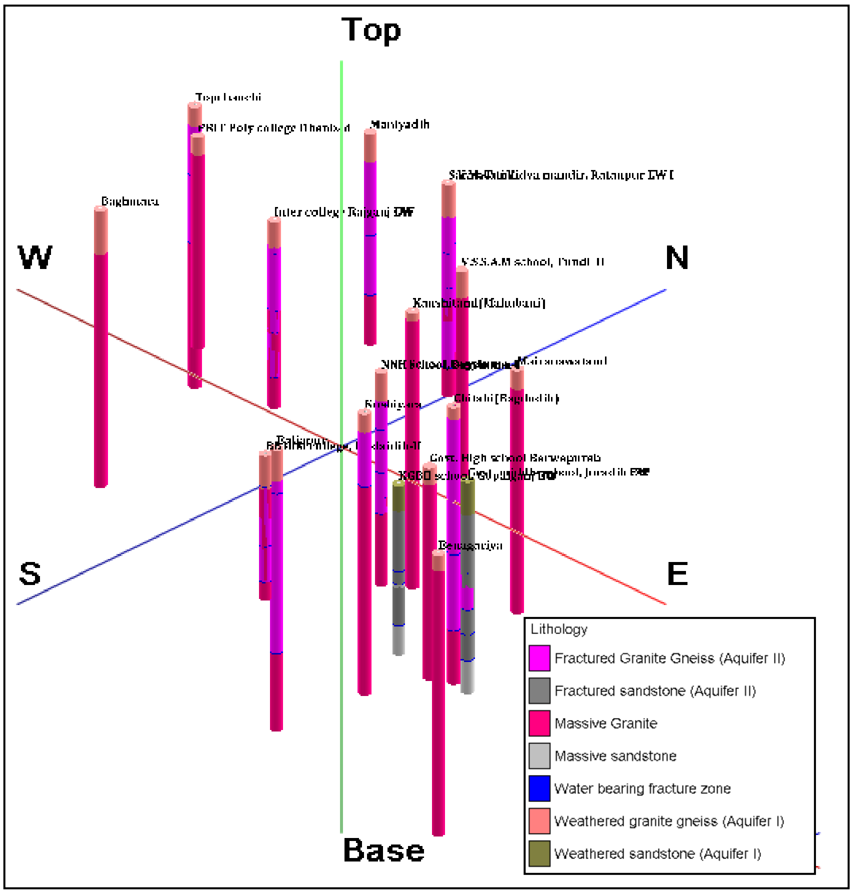


Figure28: Three-dimensional StriplogLithological ModelofDhanbad district

3.2 Aquifer Characteristics:-

The sustainability of ground water Resources are better understood by the aquifer properties. The table 15 given below depicts the aquifer characterstics in Dhanbaddistrict.

Table 15- Aquifer characteristic of Dhanbad district

Type of aquifer	Formation	Depth range of the aquifer (mbgl)	SWL (mbgl)		Thickness (m)	Yield (lpm)	Aquifer parameter	
			Pre Monsoon (2019)	Post Monsoon (2019)			T (m2/day)	Sy/S
Aquifer - I	Weathered Granite gneiss	3.00–20.00	2.2-14.4	1.1-8.05	1 - 5	0 - 60	--	--
Aquifer - II	Fractured Granite gneiss	21-162	--	--	0.50 – 2.00	27–870	-	0.13-118.9

3.2 Aquifer Maps:-Based on Aquifer Disposition, Aquifer Geometry, Aquifer Characteristics, Aquifer Maps in hard rock area of Dhanbad district have been prepared as under

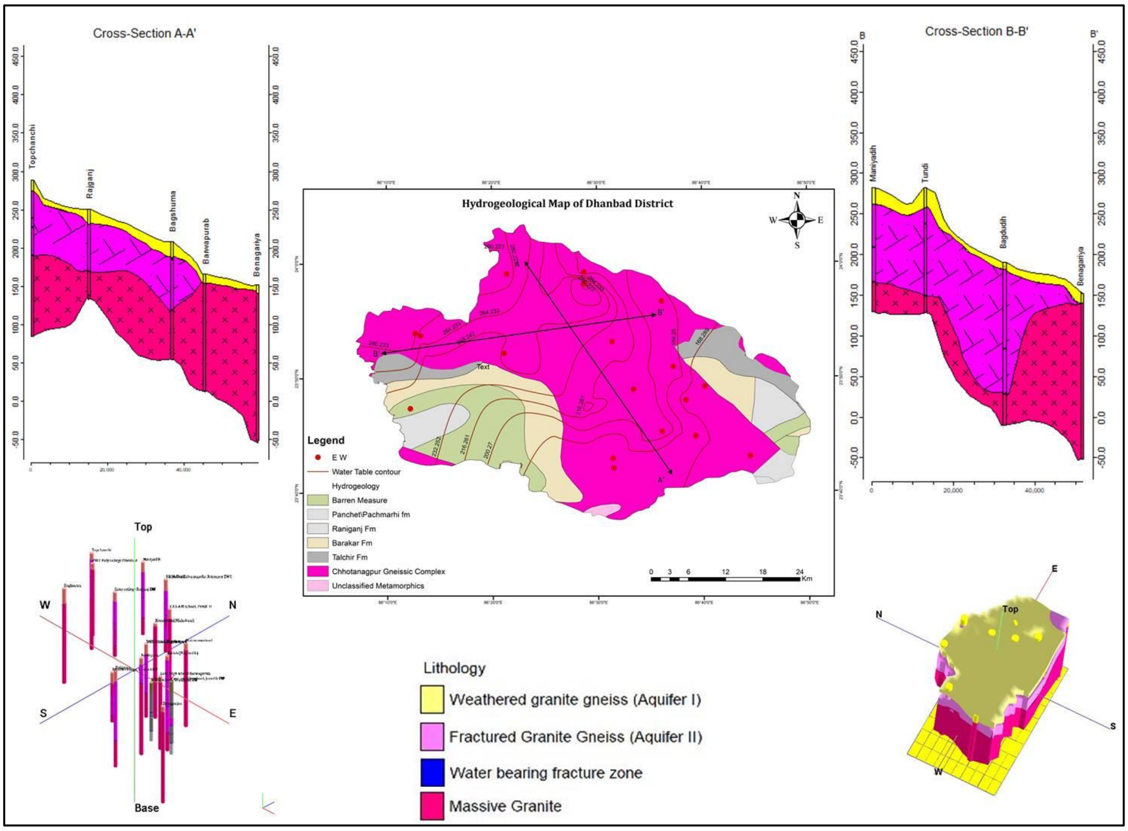


Figure 29: Aquifer Map in hard rock areas of Dhanbad

4. GROUND WATER RESOURCE

Ground Water Resource of the area has been estimated block wise with base year as on March-2020. In the present report, GEC 2020methodology has been used and based on this, 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 waterbalance 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

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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 as on 2020has been assessed by CGWB, SUO, Ranchi in association with State Ground Water Direcorate, Jharkhand based on GEC, Methodology 2020. The summarized details of Annually Replenishable or Dynamic Ground Water Resources of Dhanbad district are in table 16.

Table 16 Details of Ground Water Resource of Dhanbad District (As on March - 2020)

S.No.	Items	Ground water in ham
1	Total annual ground water recharge	25971.28
2	Total Natural discharge	2394.47
3	Annual extractable ground water recharge	23576.82
4	Current Annual Ground Water Extraction for irrigation	2574.50
5	Current Annual Ground Water Extraction for domestic	5344.05
6	Current Annual Ground Water Extraction for industrial	7905.66
7	Current Annual Ground Water Extraction for All uses	15824.21
8	Annual GW Allocation for Domestic use as on 2025	5381.17
9	Net Ground Water Availability for future use	7983.88
10	Number of semi-critical blocks	1
11	Number of critical blocks	1
12	Number of over-exploited blocks	1
13	Number of safe blocks	5
14	Stage of development	67.12%

The block wise Dynamic Ground Water Resource of Dhanbad District - (As on March - 2020) is given in *Annexure- IV*

5.0 GROUND WATER RELATED ISSUES

5.1 Identification of Issues:

The major ground water related issues of the Dhanbad are grouped into following broad categories:

a. Area of intensive mining activities
b. Quantifying aspects
c. Quality aspects
d. Administrative issues

A variety of nature's factors affect the quantity and quality aspects of ground water over space and time. The major ground water related issues are discussed as follows;

5.1.1 Area of intensive mining activities;

It is mainly associated with the mining activity with the intensive development of ground water. These are identified for the problem of depletion in the general water table and decline in the tube well discharge. Gondwana formation particularly the upper part of Barakar Sandstone support development of phreatic aquifers which extends from few meter below ground level to 30 mtr below land surface. Underground and opencast excavations behave as large sinks and create hydraulic gradient towards the mines. Mine water is pumped out for trouble free mining operations. Continuous withdrawal of water from coal mines for their mining activities is causing adverse impact on ground water regime of the area which ultimately results in declining ground water levels, drying up of wells, dwindling of their discharge and sometimes land subsidence occurs. The main ground water problem in the mining area of coal is related with the dewatering of shallow and deep aquifer dewatering from open-cast and underground mining of the area. Continued pumping from various coal mines causes depletion of water levels.

5.1.2 Quantity Aspects:

Ground water potential at any area mainly depends on the topography, rainfall, and geology. Because of plateau topography and Chotanagpur granitic gneiss complex and Gondwana formation as the litho-units occurring in the study area, the ground water potential is not uniform and it changes from one area to another. The salient features of ground water resources as on March-2020 is given in table 17.

Table 17 Ground Water Resource (As on March -2020)

S.No.	Items	in ham
1	Total annual ground water recharge	25971.28
2	Total Natural discharge	2394.47
3	Annual extractable ground water recharge	23576.82
4	Current Annual Ground Water Extraction for irrigation	2574.50

5	Current Annual Ground Water Extraction for domestic	5344.05
6	Current Annual Ground Water Extraction for industrial	7905.66
7	Current Annual Ground Water Extraction for All uses	15824.21
8	Annual GW Allocation for Domestic use as on 2025	5381.17
9	Net Ground Water Availability for future use	7983.88
10	Number of semi-critical blocks	1
11	Number of critical blocks	1
12	Number of over-exploited blocks	1
13	Number of safe blocks	5
14	Stage of development	67.12%

Thus the availability of water resource is not uniformly distributed over space and time. This resource depletes often in summer, Therefore reduction of bore well's yield in lean period. The area is covered by Chotanagpur granite gneiss complexes and Gondwana formation where ground water potential of deeper aquifer is very less and limited thickness of fracture/joints are encountered in exploratory well during drilling programme. In lower gondwana rock area weathered formation also possess low potential aquifers.

5.1.3 Quality Aspects:

The ground water quality of the study area is potable and is suitable for irrigation, however at few localities contamination in ground water due to geogenic cause. The major problems and issues related to the quality is, Flouride and nitrate. The concentration of fluoride in the study area having more than permissible limit i.e 1.5 mg/l encountered in deeper aquifer in Baghmara and Gobindpur block of Dhanbad district whereas Nitrate concentration more than permissible limit found in Katras, Topchanchi and Tundi block of Dhanbad district.

5.1.4Low Ground Water Development:

The study area experiences both very high as well low level of ground water development. In the southern, central and western part of the area the ground water resources are over utilized whereas eastern and some part of Eastern and Northern part ground water resource is underutilized. Ground water related issues and problems are not getting scientific attention of the Government, planners and stakeholders. The plan and policy of the water resources department are mostly related to the surface water only. There is urgent need to pay attention towards ground water also. The laws of compulsory Rain Water harvesting should be enacted in Nagar Nigam /Nagar Palika's of the study area. A separate pricing policy for the bulk consumers of ground water in the area should be formulated.

5.2 Participatory ground water management issues:

The public participation is an essential solicited in every for a yet in effect ground realities in all respect are ignored. At many places such activities amount of interference of alien culture or official imposition of hypothetic solutions. If corrective steps are not taken in time the present methodology adopted for people's participation will accelerate the loss of confidence among the people in their own capabilities.

6.0 MANAGEMENT STRATEGIES

Ground water management strategies for the study area, we have to prepare separate plan for over-exploited blocks, Critical and Semi-critical blocks and safe blocks based on the ground water resource availability and draft condition of the area.

6.1 Management objective and option: Prime Management objective is keeping in view of stage of development 70%and Management options are ;

- Proper utilization of mine water
- Supply side Management (Ground Water Development strategy, Implementation of Rain Water Harvesting & Artificial Recharge Techniques)
- Demand side Management (Adoption of advance irrigation practices & Change in cropping pattern)

6.2 Management plan for Over-Exploited block:

In Dhanbad district Topcanchi block comes under over exploited blocks. Topchanchi block having intensive irrigation and industrial draft. The ground water requirement pattern of over-exploited block should be managed to keep stage of development 70%. The brief descriptions of water requirement for management plan for Topchanchi over-exploited blocks are discussed below;

Topchanchi Block:

Ground Water requirement pattern to maintain stage of development at 70% of Topchanchi block the volume of water required is given in table 18

Table 18 Ground Water requirement Pattern in Topchanchi block (over-exploitedblocks) of Dhanbad Districto

S.No.	Items	Topchanchi
		Volume of water in ham
1.	Annual extractable ground water recharge	1711
2	Current Annual Ground Water Extraction for irrigation	866.50
3	Current Annual Ground Water Extraction for industrial	836.36
4	Current Annual Ground Water Extraction for domestic	274.84
5	Existing gross ground water draft for all uses	1977.70
6	Stage of Ground Water Extraction	115.57 %
7	Proposed gross ground water draft for all uses	1197.7
8	Reduction in ground water draft from Irrigation and Industrial draft/ or requirement of additional water	513.3

	for maintain stage of development 70%	

a. Demand side measures :
The Demand Side Management is proposed in areas where the Stage of Ground Water Development is relatively high and Irrigation draft is higher side. In these areas adaptation of micro-irrigation techniques (drip & sprinkler) for water intensive crops or change in cropping pattern or both are required to save water. In Topchanchi block of Dhanbad district, micro-irrigation techniques, like drip & sprinkler irrigation techniques are proposed to be adopted.

b. Supply side measures:

The supply side management of ground water resources can be done through the artificial recharge by utilization of surplus runoff available within river sub basins and micro watersheds. Also, it is necessary to understand the unsaturated aquifer volume available for recharge. The unsaturated volume of aquifer was computed based on the area feasible for recharge, unsaturated depth below 3 mbgl and the specific yield of the aquifer.

Source Water Availability:

Topchanchi block of Dhanbad district is mostly represented by undulating topography, geomorphically represented by hills and valleys. Considering surface morphology based basin configuration, for an average basin Strange's Table suggest runoff of 37.4% to rainfall. In the absence of data, the yield from the catchment has been computed using strange table and 30% of the monsoon rain fall has been considered. Further, data on committed run off is not available and hence 50% of the estimated run off has been considered available for artificial recharge. The source water availability of Topchanchi block of Dhanbad district has been computed and given below in table 19.

Table 19:Scope of Artificial Recharge in Topchanchi block of Dhanbad district, Jharkhand.

Block	Formation	Area Identified for AR (Sq.Km.)	Volume of Unsaturated Zone (MCM)	Available Subsurface Space for AR (MCM)	Water Required for Recharge (MCM)	Source water available i.e (Runoff) (MCM)	Surplus Available for Recharge (MCM)
Topchanchi	Banded Gneissic complex (BGC)	98.2452	94.32	1.41	2.35	38.29	19.14
	Sandstone (Gondwana)	31.0248	29.78	0.89	1.48	12.09	6.05
Total		***129.27***	***124.10***	***2.31***	***3.83***	***50.38***	***25.19***

Feasibility of Artificial Recharge:

The volume of surface water considered for planning the artificial recharge is based on the surplus runoff availability and the space available for recharge. The percolation tank single filling capacity is 0.094 MCM considering 100% of double filling, the gross storage capacity is 0.188 MCM in Jharkhand. For Nala Bund/Check Dam/Gully plug of 0.01-mcm capacity (single filling) will actually store 250% more due to multiple filling in monsoon. The actual storage will be 0.03 MCM based on 250% of multiple filling.
The total unsaturated volume available for artificial recharge is 2.31 MCM in Topchanchi block of Dhanbad district. The available surplus runoff i.e 25.19 MCM can be utilized for artificial recharge through construction of percolation tanks and Nala Bund/Check Dam/Gully plug at suitable sites.

Types & Locations of Artificial Recharge structures:

For consideration of suitability of artificial recharge structures, in the Topchanchi block of Dhanbad District have been worked out based on geomorphological set up and hydrogeological diversities. Terrain-wise norms adopted for different types of structures are given in table 20.

Table 20: Terrain-wise norms adopted for different types of structures

Terrain Type	Recharge Structure Type	Gross Storage Capacity (MCM)	Recharge Percentage
Hard Rock Area	Percolation Tank	0.188	50%
	NalaBund/Check Dam/Gully Plug	0.03	50%

Numbers of structures have been worked out at study area based on total surplus runoff water consider for recharge and gross storage capacity of individual structure. The proposed number of different type of artificial recharge structures is given in Table 21-

Table21 - proposed number of different type of artificial recharge structures in Topchanchi block of Dhanbad District, Jharkhand.

Name of Block	Formation	Available Subsurface Space for AR (MCM	Surplus Available for Recharge (MCM)	Proposed numbers of recharge structures (No's)	
				Percolation Tank	NalaBund/ Check dam / Gully Plug
Topchanchi	Banded Gneissic complex (BGC)	1.41	19.14	6	39
	Sandstone (Gondwana)	0.89	6.05	3	24

Based on the field condition and availability of suitable land for construction of the recharge structures is limited. So the number of recharge structures has been restricted to 25 % of feasible structures.
Proposed no of Percolation Tank in Banded Gneissic complex (BGC) formation= **02 nos**
Proposed no of Nala Bund/ Check dam/gully plug in Banded Gneissic complex (BGC) formation = **10 nos**
Proposed no of Percolation Tank in Sandstone (Gondwana) formation = **01 nos**
Proposed no of Nala Bund/ Check dam/gully plug in Sandstone (Gondwana) formation = **06 nos**

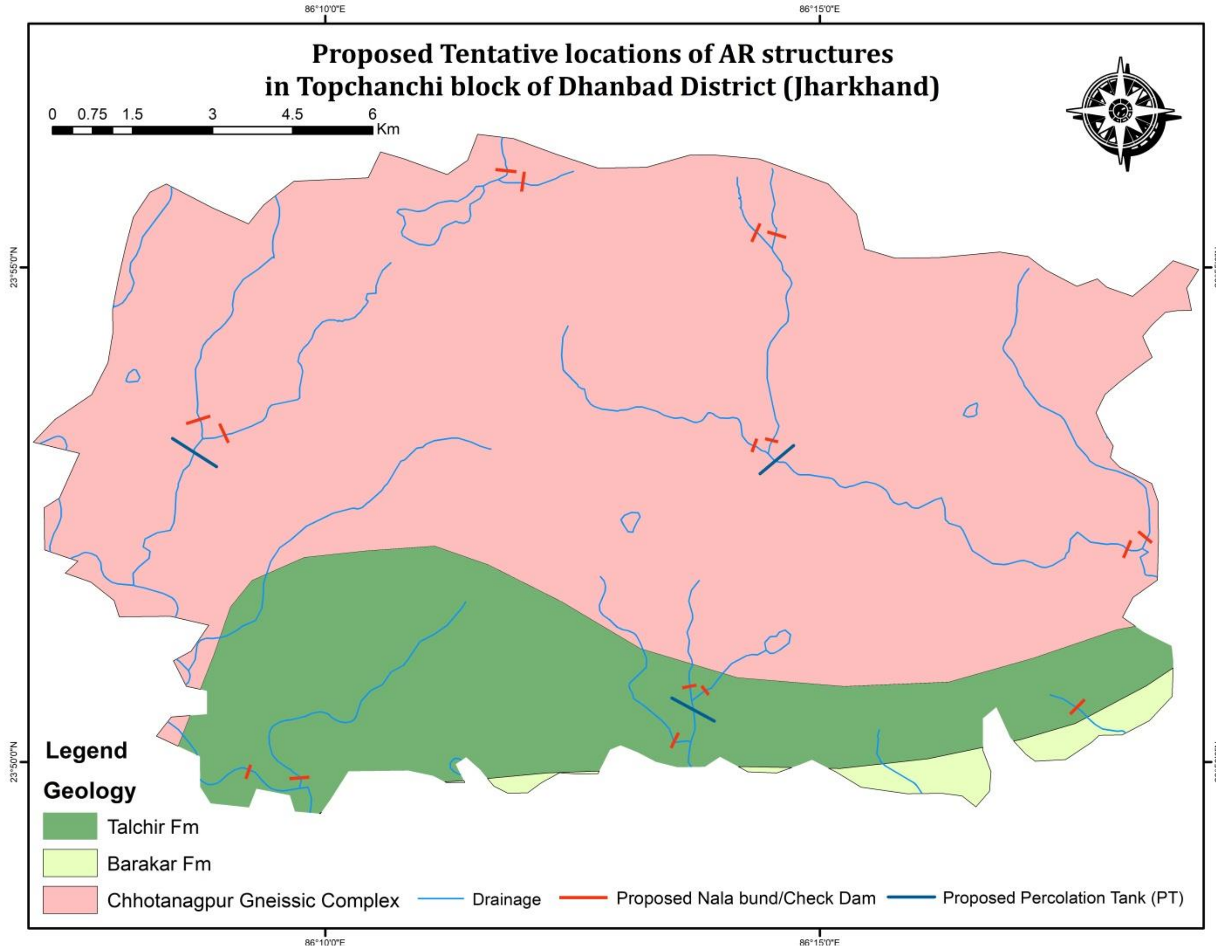

Figure30:- Proposed tentative locations of AR Structures in Topchanchi block of Dhanbad district

However before implementing the schemes in the area, detailed site specific study need to be carried out.

Roof-Top Rain Water Harvesting:

Implementation of Roof top rain water harvesting we can also enhance the ground water availability. A generalized plan for roof top rain water harvesting is given below:

- One rooftop having area 500 square feet = 45 square meters
- Rainwater that can be harvested from one roof with 75% efficiency = 34 cubic meters

Considering urban households around 1 Lac, total rainwater that can be harvested =**3.4million cubic meters (mcm)** can be recharge by roof top rain water harvesting system

Utilization of Mine water seepage:
The proposed management strategy for Topchanchi block is reduce ground water draft for irrigation and Industrial by using mine water seepage. Total 08 numbers of coal mines present in Topchanchi block and 24.4 ham volume of mine water (ham) is additionally fulfilling through mine water seepage.

Demand side management:
(A) Advance Irrigation Practices:
In demand side intervention, in Topchanchiblock total 529. 95 hectare for kharif and 27.42 hectare for Rabi outside the command area proposed to be taken where intensive irrigation practices is going on, especially in Belatanr, Khario, Korkota, Ledatanr, Lokbad and Tantri village of Topchanchi block. Principal crops of these areas are ;(Kharif)- Paddy, Maize, pea, , Green gram, Groundnut, Urd and (Rabi)- Wheat, Chickpea, Pea, Arhar, black gram. The volume of water expected to be conserved after taking 50% of the total area under advance irrigation practices is shown in *Table-22*.

Table 22 -The volume of water expected to be conserved after taking 50% of the total area under advance irrigation practices

Advanced Irrigation Practices to be Used	Area proposed to be covered in hactare	Crop	Av. Evapo - transpiration (ET) requirement for crops from sowing to harvesting in cubic meter /Hectare	Total no. of Irrigation frequency Required	General Irrigation practices used	Irrigation depth practices in cubic meter	Total volume of water utilized in irrigation (cubic meter/ hectare)	Total volume of water excess in irrigation cubic mtr/ hectare	Total volume of water to be saved cubicmtr/ hectare	Total volume of water to be saved after adoption of advance practices i.e 50% of total vol. of water consumed in irrigation in cubicmeter/hectare
Sprinkler	529.95	Wheat	2700	7 times	4 times	1000	4000	1300	1300	650
Sprinkler	27.42	Mustard	1560	5 times	3 times	1000	3000	1440	1440	720
Sprinkler	78	Linseed	1920	5 times	3 times	1000	3000	1080	1080	540

6.3 Management plan for Critical block:

In Dhanbad district Baliapur block comes under critical block. Baliapur block having intensive industrial draft ie.913.77 ham. The ground water requirement pattern of critical block should be managed to keep stage of development 70%. The brief descriptions of water requirement for management plan for Baliapurcritical block are discussed below;

BaliapurBlock:

Ground Water requirement pattern to maintain stage of development at 70% of Baliapur block the volume of water required is given in table 23.

Table 23 Ground Water requirement Pattern in Baliapur block (Criticalblock) of Dhanbad District

S.No.	Items	Baliapur
		Volume of water in ham
1.	Annual extractable ground water recharge	1338.52
2	Current Annual Ground Water Extraction for irrigation	120.50
3	Current Annual Ground Water Extraction for industrial	913.77
4	Current Annual Ground Water Extraction for domestic	208.35
5	Existing gross ground water draft for all uses	1242.63
6	Stage of Ground Water Extraction	92.84%
7	Proposed gross ground water draft for all uses to maintain SOD 70%	937
8	Reduction in ground water draft from Industrial draft/ or requirement of additional water for maintain stage of development 70%	279.63

Proposed Management Strategy for Baliapur block of Dhanbad District:

The proposed management strategy for Baliapur block of Dhanbad district is reduce ground water draft for Industrial by using mine water seepage, Artificial recharge techniques and advance irrigation practices. Total 279.63ham Volume of water required to maintain SOD 70% for Baliapurblock.

Supply side measures:

The supply side management of ground water resources can be done through the artificial recharge by utilization of surplus runoff available within river sub basins and micro watersheds. Also, it is necessary to understand the unsaturated aquifer volume available for recharge. The unsaturated volume of aquifer was computed based on the area feasible for recharge, unsaturated depth below 3 mbgl and the specific yield of the aquifer.

Source Water Availability: Baliapur block of Dhanbad district is mostly represented by undulating topography, geomorphically represented by hills and valleys. Considering surface morphology based basin configuration, for an average basin Strange's Table suggest runoff of 37.4% to rainfall. In the absence data, the yield from the catchment has been computed using strange table and 30% of the monsoon rain fall has been considered. Further, data on committed run off is not available and hence 50% of the estimated run off has been considered available for artificial recharge. The source water availability of Baliapur block of Dhanbad district has been computed and given below in table 24:

Table24: Scope of Artificial Recharge in Baliapur block of Dhanbad district, Jharkhand.

Block	Formation	Area Identified for AR (Sq.Km.)	Unsaturated Zone thickness (m)	Available Subsurface Space for AR (MCM)	Water Required for Recharge (MCM)	Source water available i.e (Runoff) (MCM)	Surplus Available for Recharge (MCM)		
Baliapur	Banded Gneissic complex (BGC)	109.053	0.1	0.16	0.27	42.39	21.19	0.2	0.2
	Sandstone (Gondwana)	12.11	0.1	0.04	0.06	4.71	2.35	0.2	0.2
Total		121.163	0.2	0.2	0.33	47.1	23.54		

Feasibility of Artificial Recharge: The volume of surface water considered for planning the artificial recharge is based on the surplus runoff availability and the space available for recharge. The percolation tank single filling capacity is 0.094 MCM considering 100% of double filling, the gross storage capacity is 0.188 MCM in Jharkhand. For Nala Bund/Check Dam/Gully plug of 0.01-mcm capacity (single filling) will actually store 250% more due to multiple filling in monsoon. The actual storage will be 0.03 MCM based on 250% of multiple filling.

The total unsaturated volume available for artificial recharge is 0.2 MCM in Baliapur block of Dhanbad district. The available surplus runoff i.e 23.54 MCM can be utilized for artificial recharge through construction of percolation tanks and Nala Bund/Check Dam/Gully plug at suitable sites.

Types & Locations of Artificial Recharge structures: For consideration of suitability of artificial recharge structures, in the Baliapur block of Dhanbad District have been worked out based on geomorphological set up and hydrogeological diversities. Terrain-wise suitable AR structures are given in table 25.

Table 25 : Terrain-wise norms adopted for different types of structures

Terrain Type	Recharge Structure Type	Gross Storage Capacity (MCM)	Recharge Percentage
Hard Rock Area	Percolation Tank	0.188	50%
	NalaBund/Check Dam/Gully Plug	0.03	50%

Numbers of structures have been worked out at study area based on total surplus runoff water consider for recharge and gross storage capacity of individual structure.

The proposed number of different type of artificial recharge structures is given in table 26-

***Table26 -proposed number of different type of artificial recharge structures in Baliapur block of Dhanbad District, Jharkhand*.**

Name of Block	Formation	Available Subsurface Space for AR (MCM	Surplus Available for Recharge (MCM)	Proposed numbers of recharge structures (No's)	
				Percolation Tank	NalaBund/ Check dam / Gully Plug
Baliapur	Banded Gneissic complex (BGC)	0.16	21.19	0	04
	Sandstone (Gondwana)	0.04	2.35	0	01

Proposed no of Percolation Tank in Banded Gneissic complex (BGC) formation= **00 nos**
Proposed no of Nala Bund/ Check dam/gully plug in Banded Gneissic complex (BGC) formation = **04 nos**
Proposed no of Percolation Tank in Sandstone (Gondwana) formation = **00 nos**
Proposed no of Nala Bund/ Check dam/gully plug in Sandstone (Gondwana) formation = **01 nos**
Based on the field condition and availability of suitable land for construction of the recharge structures in gondwana formation is limited therefore proposal of recharge structures in gondwana formation is restricted.

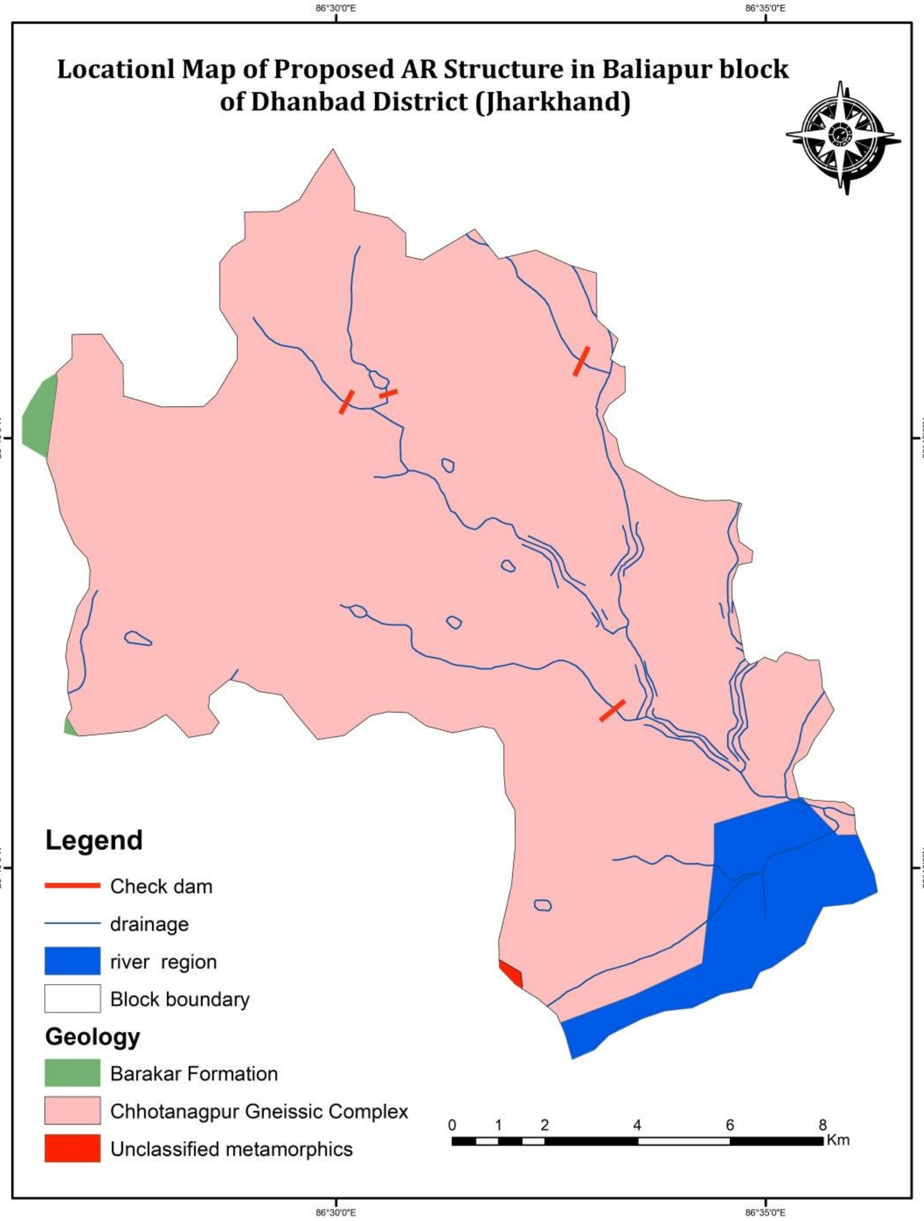

Figure 31:- Location Map of Proposed AR structure in Balipur block of Dhanbad District

Roof-Top Rain Water Harvesting: Implementation of Roof top rain water harvesting we can also enhance the ground water availability. A generalized plan for roof top rain water harvesting is given below:

- One rooftop having area 500 square feet = 45 square meters
- Rainwater that can be harvested from one roof with 75% efficiency = 34 cubic meters

Considering urban households around 1 Lac, total rainwater that can be harvested =**3.4million cubic meters (mcm)** can be recharge by roof top rain water harvesting system

Utilization of Mine water seepage:

The proposed management strategy for Baliapur block is reduce ground water draft for Industrial by using mine water seepage. Total 09 numbers of coal mines present in Baliapur block and 24.4 ham volume of mine water (ham) is additionally fulfilling through mine water seepage.

Demand side management:

(A) Advance Irrigation Practices:

In Balipur block of Dhanbad district irrigation draft is onlyi.e 120 ham so that there is no need to adoptation advance irrigation practices.

6.4 Management plan for Semi-Critical block:

In Dhanbad district Dhanbad block comes under semi-critical block. The block having intensive industrial draft ie.4471.55 ham and the domestic draft is 2983.29. The ground water requirement pattern of semi-critical block should be managed to keep stage of development 70%. The brief descriptions of water requirement for management plan for Dhanbad semi-critical block are discussed below;

Dhanbad Block:

Ground Water requirement pattern to maintain stage of development at 70% of Dhanbad block the volume of water required is given in table 27

Table 27 Ground Water requirement Pattern in Dhanbad block (Semi-Critical block) of Dhanbad District

S.No.	Items	Baliapur
		Volume of water in ham
1.	Annual extractable ground water recharge	8934.97
2	Current Annual Ground Water Extraction for irrigation	120.50
3	Current Annual Ground Water Extraction for industrial	4471.55
4	Current Annual Ground Water Extraction for domestic	2983.29
5	Existing gross ground water draft for all uses	7539.85
6	Stage of Ground Water Extraction	84.39%
7	Proposed gross ground water draft for all uses to maintain SOD 70%	6254.479
8	Reduction in ground water draft from Industrial draft/ or requirement of additional water for maintain stage of development 70%	1285.37

Proposed Management Strategy for Dhanbad block of Dhanbad District:

The proposed management strategy for Dhanbad block of Dhanbad district is reduce ground water draft for Industrial&Domestoic by using mine water seepage, Artificial recharge techniques and advance irrigation pratices. Total 1285.37ham Volume of water required to maintain SOD 70% for Baliapur block.

Roof-Top Rain Water Harvesting:

Implementation of Roof top rain water harvesting we can also enhance the ground water availability. A generalized plan for roof top rain water harvesting is given below:

- One rooftop having area 500 square feet = 45 square meters
- Rainwater that can be harvested from one roof with 75% efficiency = 34 cubic meters

Considering urban households around 1 Lac, total rainwater that can be harvested =**3.4million cubic meters (mcm)** can be recharge by roof top rain water harvesting system

Utilization of Mine water seepage:

As per BCCL, Dhanbad coalfield area daily 31530 cubic mtr water is being pumped for trouble free mining operations. Out of 31530 cubic meters per day, 10340 cubic meters is utilized and 21190 cubic meter water per day goes as discharge runoff. These figure indicate that such a huge quantity of important ground water resource go as waste. The mine discharge of Dhanbad coalfield is given in table28

Table 28 Mine water discharge details of Dhanbad coalfield

Mine Discharge Utilized and Unutilised Mine Water in Respect of BCCL Mines In Dhanbad Block								
Cluster VI (Dhanbad)	Mines	M3/day	Actual discharge	Utilization (residential and related	Other uses	Manufacturing Requirement	Utilized	Unutilized
1	East Bassuriya OC	500		90	120	290	500	0
2	Bassuriya UG	1700		320	20	1360	1700	0
3	Gondudih Khas-Kusunda	1050		545	12	493	1050	0
4	Godhur UG&OC	900		250	187	463	900	0
	G.Total	**4150**		**1205**	**339**	**2606**	**4150**	**0**
Cluster XI (Dhanbad)								
	Gopalichak UG	4100		565	70	870	1505	2595
2	Kanchi Balihari 10/12 pit UG	3780		410	30	710	1150	2630
3	PootkeeBalihari Project UG	4000		305	105	1320	1730	2270
4	Bhagaband UG	3900		700	75	635	1410	2490
5	Kendwadih UG (closed)	250		270			270	-20
6	Pootkee UG (closed)	5000		685			685	4315
7	KanchiBalihari 5/6 pit	4500		290			290	4210

	UG (closed)							
8	Moonidih UG	6000		1180	530	665	2375	3625
9	Moonidih Washery			525	400		925	-925
	G. Total	**31530**					**10340**	**21190**

In Jharia coal-field daily 9320 cubic meter water is being pumped for trouble free mining operations. Out of 9320 cubic meter per day, 5556 cubic meter is utilized and 3764 cubic meter water per day goes as discharge runoff. These figure indicate that such a huge quantity of important ground water resource go as waste. Details of mine discharge of Jharia coalfield is given in Table 29

Table29 Mine water discharge of Jharia coalfield

Table Showing Mine Discharge Utilized and Unutilized Mine Water in Respect of BCCL Mines InJharia Blocks

	Mines	M3/day	Actual discharge	Utilization (residential and related	Other uses	Manufacturing Requirement	UTILIZED	UNUTILIZED
Cluster X (Jharia)								
1	Bhowrah North UG	1485		328	328	0	656	829
2	Bhowrah North OC	640		329	329	0	658	-18
3	Bhowrah South UG	2300		330	330	0	660	1640
4	3 Pit OCP	620		331	331	0	662	-42
5	Chandan OCP (Bhowrah)	580		332	332	0	664	-84
6	Patherdih UG	2000		333	333	0	666	1334
7	Chandan OCP (Patherdih)	700		334	334	0	668	32
8	Sudamdih Incline UG	1160		335	335	0	670	490
9	Sudamdih (Shaft) UG	2340		336	336	0	672	1668
10	Amlabad Closed	0		337	337	0	674	-674
11	Sudamdih Coal Washery	0		338	338	0	676	-676
	G. Total	**11825**					**7326**	**4499**
Cluster IX (Jharia)								
1	N.T/S.T Expansion OCP (prop)	2330		636	0	1681	2317	13
2	Lodna UG	1600		723	360	203	1286	314
3	Bagdigi UG	2230		409	800	40	1249	981
4	Bararee UG	2050		425	500	56	981	1069
5	Joyrampur UG	1640		534	300	212	1046	594
6	Jealgora UG	1600		1600	0	0	1600	0
7	N.Tisra UG	1140		385	600	123	1108	32
8	Jeenagora OCP	700		300	100	300	700	0
9	N/S Tisra OCP	1745		950	135	660	1745	0
	G. Total	**15035**					**12032**	**3003**
Cluster VIII (Jharia)								
1	Bastacolla UG & OC	1840	1840	875	310		1185	655

2	Bera UG & OC	1470	1470	530	240		770	700
3	Dobari UG	1550	1550	595	120		715	835
4	Kuya UG & OC	1870	1870	782	325		1107	763
5	Goluckdih OCP	1180	1180	160	345		505	675
6	Ghanoodih OC	590	590	540	425		965	-375
7	Kujama OC	820	820	82	227		309	511
	Total	**9320**					**5556**	**3764**

Proposed Management Strategy for Dhanbad:

The proposed management strategy for Dhanbad and Jharia is reduce ground water draft for domestic and Industrial by using mine water seepage. Volume of mine water (ham) required to be used 1285.37 ham for Dhanbad &Jharia. This amount of water is additionally required to maintain SOD 70% and it's partially fulfilling through mine water seepage. Volume of mine water required to be used in given in Table 30 and supply side intervention is given in table 31 and matching of demand and availability is given in Table32 respectively.

Table.30Volume of mine water required to be used

S.No.	Items	Dhanbad
1	Existing ground water draft for Domestic & Industrial Use in ham	7454.84
2	Proposed ground water draft for Domestic& industrial use for maintain stage of development 70%	1285.37
3	Additional water requirement to be met from mine water seepage for SOD 70%	1184

Table31Supply side Intervention

S.No.	Items	Dhanbad
1	Unutilized mine water seepage (ham)	1184
2	Adoptaion of Roof top Rain Water Harvesting (ham)	340
3	Adoptation of Artifical Recharge structure (ham)	40700
Total water conserve after adaptation of supply side intervention (ham)		42224

Table 32 Matching of demand and availability

S.No.	Items	Dhanbad
1	Requirement for maintain stage of development 70%	1285.37
2	Total water conserve after adaptation of supply side intervention (ham)	42224

From the matching of demand and availability scenario, it is clearly shows that unutilized mine water seepage is a huge reservoir itself to met the present requirement and to maintain stage of development 70%. Therefore strict water management practices should be adopted for the coal mining belt. Abandoned mines can be treated as a big rainwater harvesting and artificial recharge structure.

Demand side management: In demand side intervention, the area is comes under urban aggromeration and irrigation draft is only 120.5 ham so that there is no need to adopt advance irrigation practices.

6.5Management plan for Safe blocks:

Management Strategies:

The following management strategies proposed to be adopted for safe blocks of Dhanbad district.

- Ground water development and irrigation potential creation
- No change in Industrial and Domestic ground water draft.
- No change in cropping pattern.

6.6Plan for Ground Water Development:

The net dynamic ground water availability in the area is 23576.82 ham and ground water draft for all uses is 15824.21 ham, making stage of ground water development 67.12% as a whole for the studyarea.Although the ground water development in southern, and Central part is more, there are ample scope of ground water development in part of northern, easternl and western part of the area. The Net ground water availability for future irrigation development and stage of ground water development of safe blocks are given in *Table 33.*

Table-33 Net GW availability for future irrigation development and SOD

District	Assessment unit	Net ground water availability for futureuse in ham	Stage of ground water development (%)
Dhanbad	Baghmara	1694.82	45.95
	Chirkunda	2644.15	31.20
	PurbiTundi	556.75	22.72
	Tundi	938.69	42.99

The average stage of ground water development is less than 50%. Out of 8 blocks, there are 4 blocks having stage of development is less than 50% has been considered for further ground water development. District wise balance ground water for future irrigation potential is determined by deducting ground water draft for irrigation and allocation for next up to year 2025. The ground water available for future irrigation is divided by an average depth of irrigation (∆.45), considering of 0.45m for Jharkhand, which ultimately gives irrigation potential *(Table.30).*Considering 70% of future irrigation potential as optimum utilization with .45 ha area for dug well and considering 60% for dug well, and shallow tube wells the numbers of proposed ground water abstraction structures are obtained which is shown in*Table 34*

Table 34 Future irrigation potential created and proposed number of dug wells

District	Assessment unit	Net ground water availability and future irrigation development (ham)	future irrigation potential available (ha)	70% of future irrigation potential created (ha)	Proposed number of ground water structure (Dug wells)	Proposed number of ground water structure (STW)
Dhanba	Baghmara	1694.82	3766.267	2636.38	3954.58	768.9461

d	Chirkunda	2644.15	5875.889	4113.12	6169.683	1199.661
	PurbiTundi	556.75	1237.222	866.05	1299.083	252.5995
	Tundi	938.69	2085.978	1460.18	2190.277	425.8871
Total		***5834.41***	***12965.35***	***9075.74***	***13613.62***	***2647.09***

Development of ground water for the safe blocks in Dhanbad area requires thorough understanding of the heterogeneity of the formations, e.g degree of weathering, thickness of fracture zones and depth of occurrences of the aquifer. Dug wells and shallow tube wells are feasible ground water structures for the study area. The construction of **16261** additional ground water abstraction structures would bring an additional area of **9075.74 ha** under assured irrigation.

7.0 Summary

- The district of Dhanbad has a geographical area of 2252.47 square kilometer. The district is bounded on the north and north-east by the Barakar River which separates it from Hazaribagh, Santhal Parganas and Burdwan districts, on the south there is no natural boundary. On the west it has Hazaribagh district. On the east the Barakar River forms the boundary.

- Three distinct characteristics of the landscape are perceptible for its natural boundary. They are (a) the ranges of ridges sent out by the Parasnath in the remote northern and north-western region occupying an area of about 217.54 square km, (b) the coal-fields having approximately an area of 517square km in the southern and eastern parts and (c) the series of uplands and intervening hollows with isolated bare, ridges of varying elevation dotted here and there between them. Broadly speaking Dhanbad district has two physical divisions, southern and northern. The southern portion is the colliery area with the industrial towns and the northern portion is the area of hIlls and scattered vIllages.

- Topographically the area depicts a combination of rugged hills, reserved forest, and protected forest. The general slope of the area is from south to north. The area comprises a gently rolling terrain of low relief with low, humpy, rocky elevations with a thin superficial cover of sandy loam and wide flat depression with clay and soil cover. The average topographic height of the area is about 150 meters above the Mean Sea level. The highest elevation is of 445 m in the NW part of the area. Major rivers in the area are BarakarNadi, RajoyaNadi, tributary of BarakarNadi in the north flowing towards South and form the Maithon reservoir later meets to Damoder River. General slope direction of the area here is towards south,

- The oldest geological formations of the Dhanbad district are composed of crystalline metamorphic rocks which belong to the Dharwar system (Archeans) in Indian stratigraphy. In these formations are found rock types of both sedimentary and igneous origin. The sedimentary rocks were originally deposited as sandy, clayey and calcareous sediments, more or less impure. These sediments were consolidated as sandstones, shales and limestones of different composition and then were subjected to regional metamorphism and converted into quartzites (granulitic and schistose varieties), mica-ceous schists, crystalline, limestones, calc-silicate granulities and calc-gneisses and in some cases to amphibolite and hornblende-schists.

- Within the domain of Gneissic Complex , the storage and movement of ground water are mainly controlled by numerous interconnected fractures, joints planes and fissures. In the domain of unclassified metasedimentaries, the weak planes of foliation, bedding, schistocityetc serve as aquifer zones. The shales and the sandstones of the gondwana supergroup show well developed bedding panes and joints which serve as good reservoir for groundwater storage. A few springs occur near the Damodar river within the metamorphic rocks along their faulted boundary with Gondwana Supergroups of rocks.

- To assess the potentiality of the deep fractured rock, 26 exploratory wells were drilled in Dhanbad district. Out of 26 exploratory wells, 17 exploratory wells are drilled by

Central Ground water Board i.e inhouse drilling and 09 exploratory wells constructed by outsourcing. The drilling results have indicated that granite gneiss of different colour varying from grey to dark grey to pink, having course grained texture sometime porphyritic, are the most dominant rock types met in the area.

- Total 26 Number of boreholes has been constructed by CGWB in the district under groundwater exploration programme upto maximum depth of 200 m .The borehole data reveals that, in general potential fractures are encountered between 30-132 m. The other fractures have also of good potential.

- Statistical analysis of fracture system represents that there is two aquifer system lies in study area, which is classified by its depth ranges i.e. Aquifer I & II. Depth of aquifer I is generally 0 to 20 mtr which is weathered granite gneiss and aquifer II depth varies from 20 to 162 mbgl which is fractured granite gneiss. Majority of fractures are encountered within 30-147 mbgl in Granite Rocks.

- Overall in the district the major potential fractures zones are found upto 181m. First potential fracture zone encountered in the district widely varies from 21-142 m.

- In general in fractured/jointed/fissured formations, discharge of well has been found in the range of 27-870 lpm.

- In western part of the district very less fractures were encountered whereas in eastern, northern and north-eastern part of the district having 1 to 4 set of fractures has been encountered and these sets of fractures are promising with discharge observed from 28 to 870 lpm.

- Overall in the district the major potential fractures zones are found upto 140m. At several places fractures between 120-140m have been encountered in which well yielded high discharge, i.e KGBH Nirsa (chirkunda)(870 lpm), Joradih(342 lpm).

- In few occasion 1st potential fractures was encountered beyond 100 m depth (62-82 m) and well has yielded copious amount of discharge e.g SVM tundi (270 lpm).

- Some of high yielding well where multiple fractures were encountered within 140 m depth are KGBH Nirsa (chirkunda)(870 lpm), Joradih(342 lpm).

- Due to limited fractured thickness and the well yield depends on occurrence of potential fractures, therefore before going to any ground water exploration detailed hydrogeological, geophysical studies should be carried out.
- To suggest a sustainable ground water management plan there are two options-
  - Supply Side Management Options(Ground Water Resources development strategy, local water harvesting techniques etc) &
  - Demand Side Management Options (real water-savings)

- Supply Side Management Plan-I:- The supply side interventions envisages construction of 10438 nosof Check Dam/Nala bund-, 626 nos of Percolation Tank and 5329nos building RTRWH(area having more than 1000 sqm) 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.

- Supply Side Management Plan-II:- The average stage of ground water development is less than 50%. Out of 8 blocks, there are 4 blocks having stage of development is less than 50% have been considered for further ground water development. The construction of **16261** additional ground water abstraction structures would bring an additional area of **9075.74 ha** under assured irrigation.

- In demand side intervention, advance irrigation practices (Drip &Sprinklar) method should be implemented in Topchanchi block where 529. 95 hectare for kharif and 27.42 hectare for Rabi outside the command area proposed to be taken where intensive irrigation practices is going on, especially in Belatanr, Khario, Korkota, Ledatanr, Lokbad and Tantri village of Topchanchi block. Other demand side intervention includes
    - Crop choice management and diversification (promote less intensive crop like pulses and horticulture),
    - Promoting treated municipal waste water for irrigation and construction use, and
    - Managing energy and irrigation nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.)

<u>REFERENCES</u>

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2. *GSI, 2013: Geological and Mineralogical Map of Jharkhand, publication.*
3. *GSI, 2009: District Resource Map, Dhanbad, Jharkhand, GSI publication*
4. *GEC 2020, Ground Water Resource Estimation, CGWB Report*

Annexure - I

DETAILS OF EXPLORATORY WELLS DRILLED IN DHANBAD DISTRICT

Wells Drilled through Department Rigs

Sl No	Location	Block	Co-ordinate	Depth Drilled	Casing Depth/ Dia.	Fractures encountered	Static Water level	Discharge	Draw down	Specific Capacity	T	S	Formation	Year
				m	m/mm	m	m bgl.	m^3/hr	m	m^3/hr/m	m^2/day			
2	ISM EW 2	Dhanbad	$23^0$47'30" $86^0$26'30"	127	20		1.56	20.8					Chotanagpur granite gneiss	9/03
3	Govindpur EW-I	Govindpur	$23^0$50'25" $86^0$31'56"	77.15	29			-		Abandoned due to caving			Chotanagpur granite gneiss	11/03
4	Govindpur EW 2	Govindpur	$23^0$50'25" $86^0$31'55"	199.17	32.27			Dry					Chotanagpur granite gneiss	12/03
5	Maharajganj	Tundi	$23^0$57'40" $86^0$30'45"	199.02						Very Low Discharge			Chotanagpur granite gneiss	2/04
6	Nowadih	Govindpur	$23^0$51'40" $86^0$24'50"	39	39					Abandoned due to caving			Chotanagpur granite gneiss	3/04
7	Boradaha	Govindpur	$23^0$48'20" $86^0$32'15"	199.02						Very Low Discharge			Chotanagpur granite gneiss	3/04
8	Bagshuma	Govindpur	$23^0$48'57.6" $86^0$33'25"	153.5	19.8	22.3-25.4 89.4-92.5		2.88					BG	2019-20
9	Bagshuma	Govindpur	$23^0$48'57.24" $86^0$33'25"	153.5	19.7	40.6-43.7 71.1-74.2 101.6-104.7		6.48					BG	2019-20
10	Barwapurab	Govindpur	$23^0$48'00" $86^0$38'24"	153.5	12.1			0.504					BG	2019-20

Sl No	Location	Block	Co-ordinate	Depth Drilled	Casing Depth/ Dia.	Fractures encountered	Static Water level	Discharge	Draw down	Specific Capacity	T	S	Formation	Year
				m	m/mm	m	m bgl.	m^3/hr	m	m^3/hr/m	m^2/day			
11	Gopalganj	Nirsa	$23^0$44’51” $86^0$39’18”	123	18.6	62-65 101.6-115	28.8	52.2					ST	2019-20
12	Joradih	Nirsa	$23^0$49’12” $86^0$40’12”	153.5	24	65.0-68.1 92.5-95.5 129.1-132.1		20.52					ST	2019-20
13	Tundi	Tundi	$23^0$58’12” $86^0$28’48”	153.5	23.8	43.7-46.7 132.1-135		27					BG	2019-20

Through Outsource Drilling (WAPCOS)

Sl.No.	Location	Block	Co-ordinate	Depth Drilled	Casing Depth/Dia.	Fractures encountered	Static Water level	Discharge (Comp)	Discharge (Pumping Test)	Drawdown	Specific Capacity	T	S	Quality	Formation	Year
				m	m/mm	m	m bgl.	m^3/hr	m^3/hr	m	m^3/hr./ m.	m^2/day		Ec FCl F No3		
14	Mairanawa tand	Purvi Tundi	$23^0$56'39.3" $86^0$36’07.7”	176	13.5	99.2-99.46 158.6-160.0	4.53	9	**3.6**	**4.75**		10.20		511.7 31.9 0.05 1.96	Granite Gneiss	**2020**
15	Chitahi(Bagdudih)	Givindpur	$23^0$50'55.4" $86^0$37’12.2”	204	8.35	Not encountered	48.25	negligible				0.34(slug test)		228.8 17.01 0.09 1.88	Granite Gneiss	**2020**

Sl.No.	Location	Block	Co-ordinate	Depth Drilled	Casing Depth/Dia.	Fractures encountered	Static Water level	Discharge (Comp)	Discharge (Pumping Test)	Drawdown	Specific Capacity	T	S	Quality	Formation	Year
				m	m/mm	m	m bgl.	m^3/hr	m^3/hr	m	m^3/hr./ m.	m^2/day		Ec FCl F No3		
16	Kanshitand (Mahubani)	Govindpur	$23^0$53'07.9" $86^0$31'24.8"	204	5.9	Not encountered	8.10	0				0.14		310.4 14.18 0.08 1.43	Granite Gneiss	**2020**
17	Baghmara	Baghmara	$23^0$47'20.86" $86^0$12'12.8"	204	31.3	39.8-40.6 94.8-95.4 107.0-107.4 123.1-124.4 145.6-146.0 181.47-182.0	**9.45**	9	**3.6**	**10.24**		3.08		291.4 16.3 0.04 2.05	Granite Gneiss	**2021**
18	Topchanchi	Topchanchi	$23^0$53'55.5" $86^0$12'42.0"	204	13.5	Not encountered	**8.53**	6.48	**3.6**	**10.98**		2.71		317.8 20.58 0.06 2.31	Granite Gneiss	**2021**
19	Maniyadih	Tundi	$23^0$59'04.2" $86^0$21'24.5"	153	20.25		**16.87**	54	**3.6**	**0.74**		**118.9**		**336.4 18.85 0.08 2.46**	Granite Gneiss	**2021**
20	Baliapur	Baliapur	$23^0$42'56.1" $86^0$31'26.8"	204	22.4	**47.77-48.19 49.5-50.0**	**5.40**	0.468				**1.329slug test)**		**228.2 19.14 0.10 1.53**	Granite Gneiss	**2021**
21	Kushiyara	Chirkunda	$23^0$45'16.472" $86^0$36'05.97"	204	13.25	Not encountered	**7.69**	0				**0.13(slug test)**		**196.2 19.14 0.07 0.94**	Granite Gneiss	**2021**
22	Benagariya	Chirkunda	$23^0$43'05.723" $86^0$44'29.286"	204	11.7	Not encountered	**8.0**	0				**0.16(slug test)**		**220.3 20.56 0.09 0.99**	Granite Gneiss	**2021**

__Annexure – II__

LOCATION OF NHS &KEY WELLS ESTABLISHED UNDER NAQUIM STUDY IN DHANBADDISTRICT, JHARKHAND,

S.No.	District	Block	Village	Village		Long	Lat	Pre_15	Post_15	Type
1	Dhanbad	Jharia	Jharia	Jharia		86.43389	23.74306	1.2	2.7	Dug Well
2	Dhanbad	Baghmara	Baghmara new	Baghmara new		86.47	23.79944	6	12.25	Dug Well
3	Dhanbad	Katras	Balajee mandir	Balajee mandir		86.47889	23.80056	8.8	7.05	Dug Well
4	Dhanbad	Dhanbad	Basudeopur	Basudeopur		86.48583	23.79361	7.15	5.3	Dug Well
5	Dhanbad	Dhanbad	Bhuli A Block	Bhuli A Block		86.47111	23.79972	10.6	8.1	Dug Well
6	Dhanbad	Dhanbad	ChiragoraHirapur	ChiragoraHirapur		86.47444	23.80083	8.6	5.85	Dug Well
7	Dhanbad	Dhanbad	DblBuglow	DblBuglow		86.46167	23.795	6.1	3.65	Dug Well
8	Dhanbad	Dhanbad	Dhaiya Ism	Dhaiya Ism		86.47528	23.79361	4.1	2.86	Dug Well
9	Dhanbad	Dhanbad	Dhanbad New	Dhanbad New		86.47	23.79944	6.49	4.56	Dug Well
10	Dhanbad	Jharia	Dhansar MRS	Dhansar MRS		86.48583	23.79111	8.8	3.2	Dug Well
11	Dhanbad	Dhanbad	Godhar Basti	Godhar Basti		86.48917	23.79361	8.2	6.4	Dug Well
12	Dhanbad	Gobindpur	Govindpur	Govindpur		86.52778	23.825	9.1	2.7	Dug Well
13	Dhanbad	Jharia	Jharia	Jharia		86.43333	23.74167			Dug Well
14	Dhanbad	Jharia	Kandra Mandal Basti	Kandra Mandal Basti		86.46056	23.79361	7.8	5.6	Dug Well
15	Dhanbad	Baghmara	Mahuda	Mahuda		86.23722	23.84722	10.92	6.95	Dug Well
16	Dhanbad	Dhanbad	Matkuria	Matkuria		86.49778	23.79444	4.1	2.75	Dug Well
17	Dhanbad	Nirsa	Nirsa	Nirsa		86.46111	23.78611	2.94	1.73	Dug Well
18	Dhanbad	Dhanbad	Panderpalli	Panderpalli		86.46583	23.7975	7.4	6.45	Dug Well
19	Dhanbad	Dhanbad	Pkroy College	Pkroy College		86.47889	23.79194	6.2	2.75	Dug Well
20	Dhanbad	Dhanbad	PurandihJorapokhar	PurandihJorapokhar		86.47611	23.7825	9.7	5.4	Dug Well
21	Dhanbad	Rajganj	Rajganj	Rajganj		86.3375	23.87361	7.58	5.08	Dug Well
22	Dhanbad	Jharia	SindriGosala More	SindriGosala More		86.47028	23.79583	6.2	4.42	Dug Well
23	Dhanbad	Topchanchi	Topchanchi	Topchanchi		86.2	23.9	8.78	5.1	Dug Well
24	Dhanbad	Tundi	Tundi	Tundi		86.43333	23.98333	6.5	4.6	Dug Well

Annexure – III

CHEMICAL ANALYSIS RESULT OF WATER SAMPLES COLLECTED TROUGH KEY WELLS UNDER NAQUIM STUDY IN DHANBADDISTRICT, JHARKHAND

S.N	District	Block	Location	Lattitude	Longitude	Type of well	pH	EC(µs/cm) at 25^{0}C	TDS	F-	Cl-	HCO3-	CO3 2-	SO4 2-	NO 3-	PO4 3-	TH	Ca2+	Mg 2+	Na+	K+	Li+
									mg/L								as CaCO3			mg/L		
																	mg/l					
1	Dhanbad	Jharia	Jharia	23°47'58'' N	86°28'12'' E	HP	8.06	760	494	1.37	60.6	233.7	ND	73.973	6.638	BDL	224.55	49.62	24.42	49.291	12	
2	Dhanbad	Baghmara	Baghmara new	23°48'02'' N	86°28'44'' E	DW	8.13	753	489.45	1.74	98.5	166.05	ND	78.522	25.22	BDL	320.06	67.4	36.83	30.986	0.9	0.02
3	Dhanbad	Katras	Balajee mandir	23°47'58'' N	86°28'12'' E	HP	8.23	911	592.15	0.01	87.9	264.45	ND	41.198	53.71	BDL	255	50	31.59	73.456	2	BDL
4	Dhanbad	Dhanbad	Dhanbad New	23°47'28'' N	86°29'09'' E	DW	8.39	868	564.2	0.39	107	239.85	9	97.755	1.943	BDL	312.8	61.2	38.83	52.07	5	0.04
5	Dhanbad	Jharia	Dhansar MRS	23°49'30'' N	86°31'40'' E	DW	8.29	911	592.15	0.53	123	190.65	ND	90.046	25.36	BDL	219.5	47.8	24.3	72.113	21	0.03
6	Dhanbad	Gobindpur	Govindpur	23°50'50'' N	86°14'14'' E	HP	8.08	1631	1060.2	1.63	249	369	ND	101.41	15.97	BDL	440	62	69.26	166.32	1.3	0.08
7	Dhanbad	Baghmara	Mahuda	23°47'10'' N	86°27'40'' E	DW	8	963	625.95	0.39	51.2	479.7	ND	36.25	2.89	BDL	283.29	20	56.69	86.111	3	BDL
8	Dhanbad	Nirsa	Nirsa	23°52'25'' N	86°20'15'' E	HP	8.13	1082	703.3	1.56	108	252.15	ND	136.19	15.99	BDL	327.73	24	65.06	87.625	24	0.03
9	Dhanbad	Rajganj	Rajganj	23°47'45'' N	86°28'13'' E	DW	8.55	836	543.4	0.19	123	129.15	21	43.624	14.43	BDL	212.13	44	24.82	71.625	1.7	BDL
10	Dhanbad	Jharia	SindriGosala More	23°54'00'' N	86°12'00'' E	DW	8.2	774	503.1	0.72	55.4	258.3	ND	85.691	7.493	BDL	240	56	24.3	64.744	1.1	BDL
11	Dhanbad	Topchanchi	Topchanchi	23°59'00'' N	86°26'00'' E	HP	8.12	1802	1171.3	0.61	247	276.75	ND	107.77	251.3	BDL	457.45	54	78.36	168	0.2	0.36
12	Dhanbad	Tundi	Tundi	24°04'45'' N	85°49'55'' E	HP	8.26	798	518.7	0.27	87.8	190.65	ND	43.53	59.16	BDL	233.84	62	19.16	48.824	1.6	BDL

__Annexure-IV__

DYNAMIC GROUND WATER RESOURCES (2020) DHANBAD DISTRICT, JHARKHAND

Sl. No	State	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-ExploitedE/Critical/Semicritical/Safe/Saline)
1	Jharkhand	DHANBAD	BAGHMARA	3143.14	199.5	674.8088	570.0621	1444.36	574.02	1694.82	45.95277	safe
2	Jharkhand	DHANBAD	BALIAPUR	1338.52	120.5	913.772	208.3531	1242.63	209.8	94.44	92.83612	critical
3	Jharkhand	DHANBAD	CHIRKUNDA	3850.71	362	86.19	753.1383	1201.33	758.37	2644.15	31.19762	safe
4	Jharkhand	DHANBAD	DHANBAD & JHARIA	8934.97	85	4471.553	2983.291	7539.85	3004.01	1374.4	84.38585	semi_critical
5	Jharkhand	DHANBAD	GOBINDPUR	2229.01	269.5	922.9806	353.4417	1545.92	355.9	680.63	69.35456	safe
6	Jharkhand	DHANBAD	JHARIA	0.00	0	0	0		0	0		
7	Jharkhand	DHANBAD	PURBI TUNDI	721.00	97.5	0	66.29524	163.79	66.76	556.75	22.71706	safe
8	Jharkhand	DHANBAD	TOPCHANCHI	1711.22	866.5	836.3569	274.8438	1977.7	276.75	0	115.5725	over_exploited
9	Jharkhand	DHANBAD	TUNDI	1648.25	574	0	134.6259	708.63	135.56	938.69	42.99287	safe

Annexure-V

INTERPRETED RESULT OF VES IN DHANBAD DISTRICT JHARKHAND

VES No.	Village/ Location	Weathered zone (WZ) or other litho-unit			Semi-weathered zone (SWZ)/Less compact zone or other litho-unit			Fractured zone (FZ)	Recommendations for borehole drilling	Remarks
		Resistivity (ohm.m)	**Depth to bottom (m)**	**Bottom depth of probable WZ aquifer (m)**	**Resistivity (ohm.m)**	**Depth to bottom (m)**	**Bottom depth of probable SWZ aquifer / (Depth to compact formation) (m)**	**Probable occurrence of thin fractured zone aquifer in the depth range (m)**		
44	ISM	35 70	8 43	43	NA	NA	NA (43)	95-100, 170-180	100 m	The WZ is considerably thick. The base of the layer with resistivity 70 ohm.m at 43 m depth is expected to hold groundwater. The FZ indications are feeble.
45	Chirkunda	NA	NA	NA	126	8	NA (8)	12-15, 40-60, 100-110, 150-160	120 m	WZ and SWZ are not considerable. FZs up to 110 m depth may form aquifer
46	Bhursa	NA	NA	NA	123	19	19 (19)	25-30, 70-80, 110-140,	NA	SWZ is not thick. FZs are feeble
47	Asanbari	61	8	8	NA	NA	NA (8)	NA	NA	WZ is only up to 8 m depth. FZ may occur at 20-25 m depth
48	Gobindpur	NA	NA	NA	90	5	NA (5)	60-65, 140-150	150 m	FZs are feeble
49	Topchanchi new	59	13	13	NA	NA	NA (13)	25-30, 60-70, 130-140	150 m	FZs are feeble
50	Baghmara	22 65	10 30	30	Gondwana sediments			45-50, 100-110,	110 m	FZs are feeble
51	Baliapur	23	13	13	112	35	35 (35)	50-60, 120-150	150 m	FZs are feeble
52	Kamardih	70	4	NA	200	10	10 (10)	40-50, 120-130	130 m	FZs are feeble
53	Pakharia	NA	NA	NA	103 213	10 10-25	25 (25)	60-70, 130-140	140 m	FZs are feeble
The upper limit of resistivity of the weathered zone is 85 ohm.m, however for weathered zone aquifer it is taken as 60 ohm.m. The weathered zone of thickness less than 10 m has not been considered as aquifer. The resistivity of semi weathered zone is 85 to 300 ohm.m, however the upper limit of resistivity about 150 ohm.m has been considered for semi-weathered zone aquifer. The fractured zones have been inferred through empirical approaches only.										