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

Aurangabad District
Bihar

मध्य पूर्वी क्षेत्र, पटना

Mid Eastern Region, Patna

भारत सरकार
Government of India
जल शक्ति मंत्रालय
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जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
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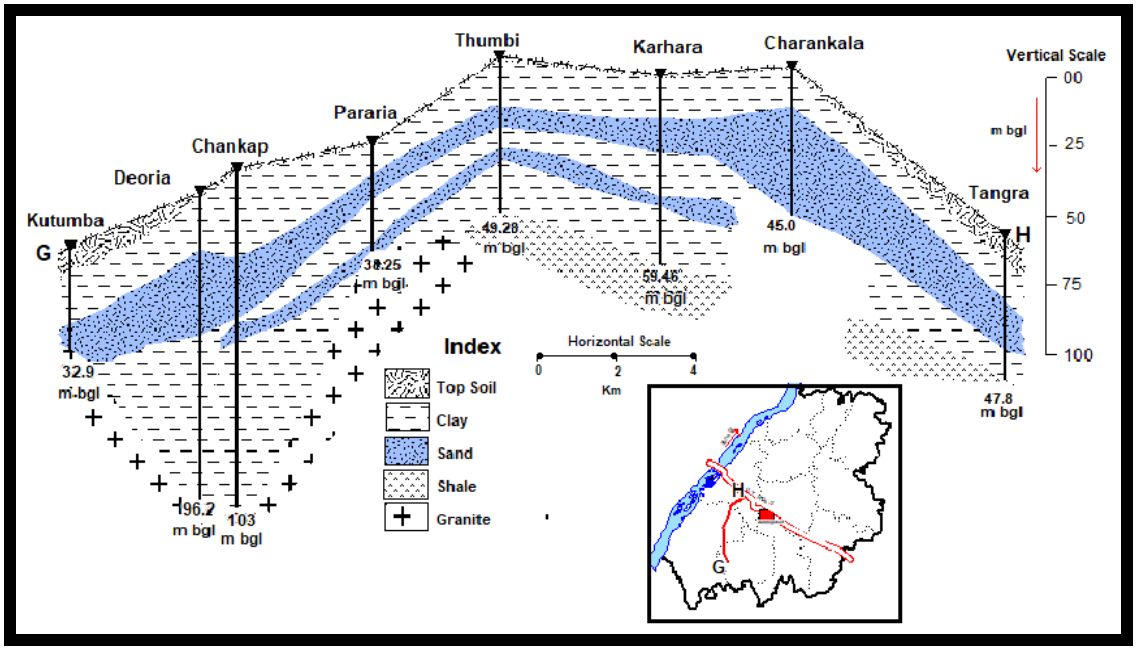
जलभृत मानचित्रण और भूजल प्रबंधन योजना
औरंगाबाद जिला, बिहार
Aquifer Mapping and Ground Water Management Plan
Aurangabad District, Bihar



क्षेत्रीय कार्यालय
मध्य-पूर्वी क्षेत्र, पटना
Regional Office
Mid-Eastern Region, Patna

June 2022

Report on

जलभृत मानचित्रण और भूजल प्रबंधन योजना
औरंगाबाद जिला, बिहार
Aquifer Mapping and Ground Water Management Plan
Aurangabad District, Bihar

AAP - 2018-19

Under Overall Guidance of

Sh. A. K. Agrawal
Regional Director
&
Sh. T.B.N. Singh
Regional Director

Dr. Indranil Roy, Scientist – 'C'
Nodal Officer

Principal Contributor:

Sh. Singaren Sandeep Purty, Scientist –'C'

Geophysist	**Chemist**
Sh. S K Das, Scientist - B	Sh. Suresh Kumar, Assistant Chemist

Aquifer Mapping and Management Plan

(2018-19)

Aurangabad district, Bihar

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CHAPTER 1

INTRODUCTION

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

During XII five year plan (2012-17) National Aquifer Mapping (NAQUIM) study was initiated by CGWB to carry out detailed hydrogeological investigation. The Aquifer Mapping programme has been continued till 2023 to cover whole country. The present studies of Aurangabad district, Bihar have been taken up in AAP 2018-19 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Aurangabad district and other user agencies for its effective implementation.

1.1 Objective and Scope

The major objectives of aquifer mapping are

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

The groundwater management plan includes Ground Water recharge, conservation, harvesting, development options and other protocols of managing groundwater. These

protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan.

The main activities under NAQUIM are as follows:

a). Identifying the aquifer geometry

b). Aquifer characteristics and their yield potential

c). Quality of water occurring at various depths

e). Preparation of aquifer maps and

f). Formulate ground water management plan.

The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a "Road Map" to systematically manage the ground water resources for equitable distribution across the spectrum.

1.2 Approach and Methodology

The on-going activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200 meters in hard rocks and 300m in soft rock

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

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.
↓
Aquifer Maps with 3D disposition
↓
Preparation of Aquifer Management Plan
↓
Capacity building in all aspects of ground water through IEC Activities

1.3 Area details and brief description

Aurangabad district with a geographical area of 3389 Km^2 lies between longitudes of 84^0 00'- 84^0 45' E and latitudes of 24^0 30' - 25^0 15' N in the South Bihar Plains (SBP) and

mostly part of the marginal alluvial plains of Ganga Basin (Fig 1). Sone River forms the western boundary of the area and at southern boundary lays the Chhotanagpur Granitic Gneissic Complex (CGGC) of Jharkhnad state. The district is bounded in the north and the east by Arwal district and Gaya district respectively.

There are eleven (11) administrative blocks which are grouped into two sub-divisions– Aurnagabad and Daudnagar. Aurangabad subdivision comprises Nabinagar, Barun, Kutumba, Deo, Aurangabad, Madanpur and Rafiganj blocks and Daudnagar, Hanspura, Goh and Obra fall in Daudnagar Sub-division. There is total 224 Gram Panchayats in the district representing 1712 villages**. (Fig -1)**

Major part of the district is characterized by fertile alluvial plain except hilly area in the southern part,. The soil type are younger alluvial, older alluvial and foothill soil. The Punpun river and its tributaries drain about 87% area of the district. Rest 13% is the north-western peripheral drained by the river Sone which flowing from south-west to north-east.

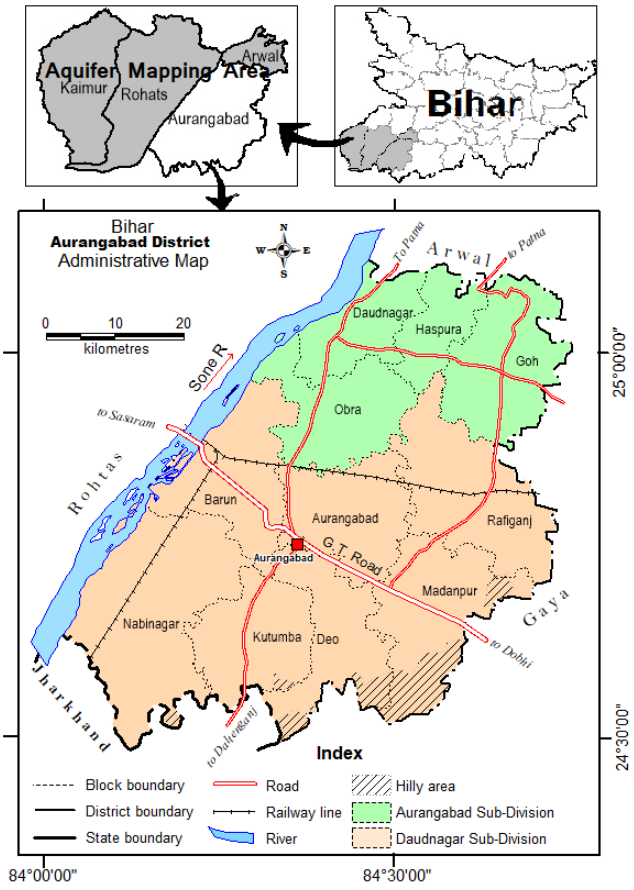


Figure 1: Administrative map

In 2011, Aurangabad had population of 2540073 (*Population Census 2011*) which was 2.44% of State population. Urban population of the district is about 9% only. Out of 11 blocks,

5 blocks have no urban population. The population density is 769 per sq. km. Nabinagar block have highest population while Hanspura block have the lowest. The demographic details is given is **Table -1**

Table 1: Demographic details of Administrative Blocks of Aurangabad district

SN	*Name*	*Geographical Area (Sq km.)*	*Rural*	*Urban*	*Total*
1	Daudnagar	197	154490	52364	206854
2	Haspura	137	152880	7940	160820
3	Goh	303	234400	0	234400
4	Obra	265	211221	14786	226007
5	Aurangabad	287	180949	102244	283193
6	Rafiganj	384	276831	35536	312367
7	Barun	310	200052	0	200052
8	Nabinagar	539	281252	23984	305236
9	Kutumba	260	226599	0	226599
10	Deo	272	173216	0	173216
11	Madanpur	350	211329	0	211329
	Total	*3305*	*2303219*	*236854*	*2540073*

1.4 Data Availability, data adequacy and data gap analysis

1.4.1 Data Availability

Central Ground Water Board has has drilled 13 exploratory wells and 3 Under Ground Water Exploration Programme from departmental rig and outsourcing till date. Out of which 2 exploratory wells have been drilled in Alluvium. Total 12 permanent observation well (National hydrograph Network Station) are being monitored by Central Ground Water Board 04 times in a year for ground water regime of phreatic (shallow) aquifer and one time ground water sampling for chemical analysis (Pre-monsoon) to assess its chemical quality.

1.4.2 Data Adequacy and Data Gap analysis

Central Ground Water Board has carried out systematic and reappraisal hydrogeological surveys, exploratory drilling under groundwater exploration programme and ground water regime monitoring etc. As per the existing data availability in the year 2017, data gap analysis has been carried out.. Salient features of data generation for filling up data gaps with regard to important components of aquifer maps are elaborated in the following **Table 3 and Table 4.**

Table 2: Data gap analysis of ground water monitoring data

SN	*Name*	*Geographical Area (Sq km.)*	*Hilly ara (Sq. km.)*	*Data requirement*	*Data availability*	*Data gap*	*Data generated*
1	Daudnagar	197		3	1	2	3
2	Haspura	137		2	1	1	4
3	Goh	303		6	3	3	4
4	Obra	265		4	1	3	4
5	Aurangabad	287		5	2	3	5
6	Rafiganj	384	62.5	6	2	4	6
7	Barun	310		5	2	3	3
8	Nabinagar	539		8	3	5	8
9	Kutumba	260		4	1	3	6
10	Deo	272	69	4	1	3	4
11	Madanpur	350	80.5	6	2	4	5

Table 3: Data gap analysis ground water exploration data

SN	*Name*	*Geographical Area (Sq km.)*	*Hilly ara (Sq. km.)*	*Data requirement*	*Data availability*	*Data gap*	*Data generated*
1	Daudnagar	197		3		3	1
2	Haspura	137		2	3		1
3	Goh	303		4	13		
4	Obra	265		3		3	
5	Aurangabad	287		3	1	2	
6	Rafiganj	384	62.5	4			1
7	Barun	310		4	1		3
8	Nabinagar	539		7	5	2	2
9	Kutumba	260		3	3		1
10	Deo	272	69	3	2	1	3
11	Madanpur	350	80.5	3	1	2	3

1.5 Climate and Rainfall

In general sub-tropical climate prevails in the district. The district experiences summer during the month of April to June and winter during December to January. During the month of January and February the climate is pleasant and salubrious. Monsoon sets during mid of June and ends in 1st week of October. The temperature varies from 25°C to 47°C in summer months and reduces to 4°C to 25°C in winter months. The humidity varies from 41% in summer month to 70% in winter month.

The rainfall is largely confined to the southwest monsoon. The district receives about 88% of the annual rainfall from southwest monsoon. In general, July is the month with the highest rainfall with an average value of 308.1 mm. On an average, there are 47 rainy days (i.e.

days with rainfall of 2.5 mm or more) in a year in the district. Month-wise normal rainfall is presented in **Figure 2**

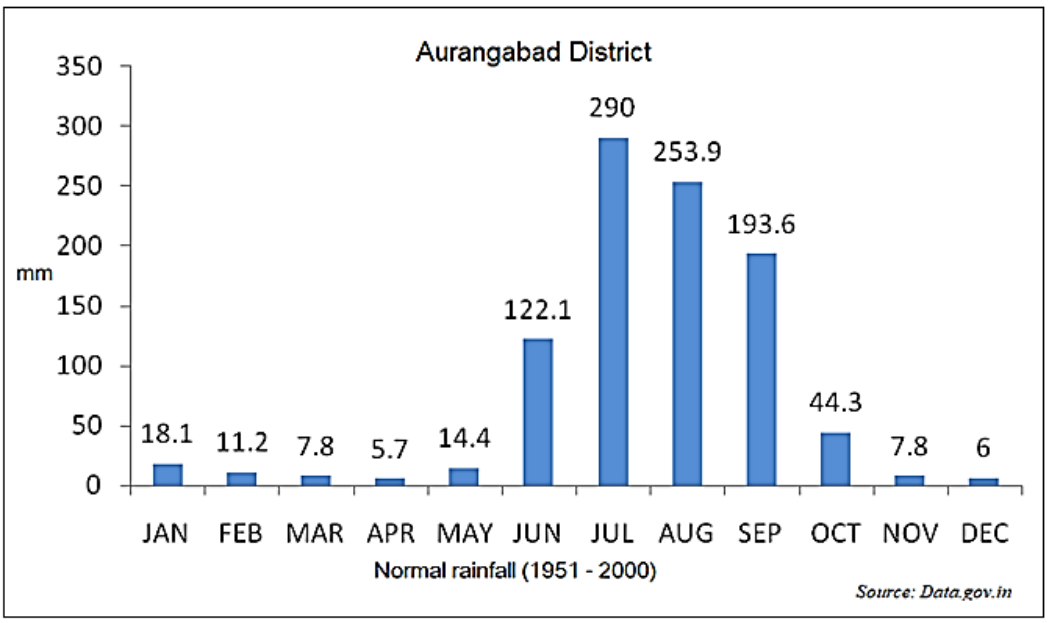


Figure 2: Monthly normal rainfall

Block-wise monthly normal rainfall is given in **Table – 5**. The table shows that during the month from June to September, area receives higher rainfall. Block wise rainfall data indicates that rainfall is slightly decreases towards eastern and western parts (Rafiganj 1142 mm Nabinagar 1108 mm).

Table 4: Block-wise Normal Rainfall (mm)

Block	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Aurangabad	22.8	20.4	14.3	6.9	12.9	131.4	333.7	378.6	219.0	48.4	11.3	3.6	1203.3
Barun	22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1	1176.8
Obra	22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1	1176.8
Daudnagar	22.9	20.8	10.4	4.9	19.7	138.4	350.1	378.4	214.4	49.9	10.5	3.0	1223.4
Hanspura	22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	213.3	48.9	11.3	4.1	1177.8
Goh	22.4	20.7	12.8	6.0	14.1	136.1	323.2	364.8	212.3	48.9	11.3	4.1	1176.7
Rafiganj	21.9	17.8	11.5	6.5	11.2	119.9	322.3	364.4	205.3	50.1	6.9	3.9	1141.7
Madanpur	22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1	1176.8
Dev	22.0	20.3	12.4	5.2	14.4	149.8	323.3	367.2	218.0	52.9	15.0	4.5	1205.0
Kutumba	22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1	1176.8
Nabinagar	22.4	23.5	15.3	6.4	12.4	140.9	287.7	335.2	204.0	43.2	12.8	4.4	1108.2

Source: Statistical Deptt. Aurngabad, Govt. of Bihar

In comparison to normal rainfall (1951-2000) pattern, it is observed that the rainfall occurring in the districts depicts that there is an absolute departure of last five years average rainfall from normal rainfall. **(Table - 6).** There is a decrease in rainfall in monsoon season except the year 2016. The rainy season is considerably delayed in the district. Hence affects the timely-sowing of Kharif crops.

Table 5: Departure from normal rainfall of last five years monthly average rainfall

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	R/F	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*	*R/F*	*%D*
2014	50.5	179	28.3	153	15	92	0	-100	27.2	89	51.5	-58	208.6	-28	142.4	-44	121.4	-37	25.8	-42	0	-100	0.5	-92
2015	17.6	-3	0.2	-98	15.3	96	28.2	395	14	-3	197.6	62	384	32	206.5	-19	69	-64	2.9	-93	0	-100	0	-100
2016	15.7	-13	0	-100	7.4	-5	0	-100	11.6	-20	124.4	2	346.4	19	288.4	14	419.3	117	152.6	244	0	-100	0	-100
2017	0	-100	0	-100	4.2	-46	3.4	-40	24.7	71	41.8	-66	467.6	61	262.4	3	95.9	-50	4.7	-89	0	-100	0	-100
2018	0	-100	0	-100	0	-100	0	-100	5.2	-64	55.2	-55	311.7	7	200.9	-21	132.3	-32	17	-62	0	-100	10.8	79

%D = %age Departure, Source:-IMD

1.6 Physiographic setup

The southern hilly ranges and the northern Gangetic Plain form two broad physiographic units of the Aurangabad district. The southern hilly area is undulating in character, occupied by hilly ranges and low valleys covering parts of Kutumba, Nabinagar, Deo and Madanpur blocks. The constituting rocks of the hills dip northward and form the basement of the northern lying Gangetic Plain. In the transition parts, from hard rock to alluvial plain, the hard rocks are exposed (linearly) at places as inliers. The northern alluvial plain gently sloped towards NNE.

1.6 Physiographic DEM

The elevation in the area ranges from 73.57 to 437.9 m above mean sea level (SRTM data with WGS 84 Spheroid).The generated elevation map by SRTM map is given in **fig-3.** It shows that general slop of the area is towards north-east direction.

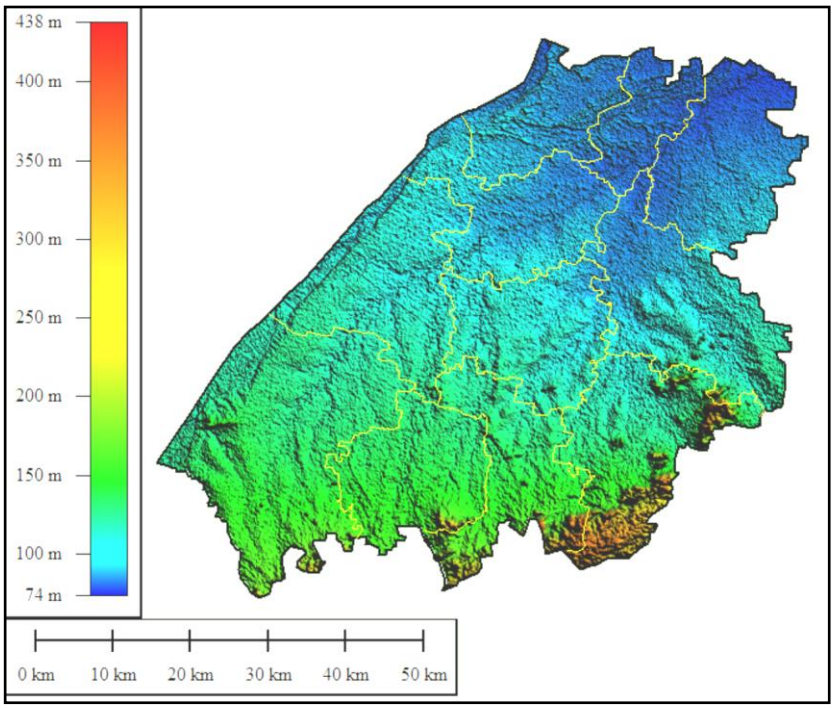


Figure 3: DEM of the area based on SRTM Data

1.7 Geomorphology

Broadly, the district can be divided into three physiographic units. Structural hills near south eastern boundary, followed by the denudational structural hill towards north and rest of the major part is alluvial plain of fluvial origin gently sloped towards NE direction. The **Fig – 4,** re-prepared from https://bhuvan.nrsc.gov.in is showing spatial distribution of geomorphic feature in the district.

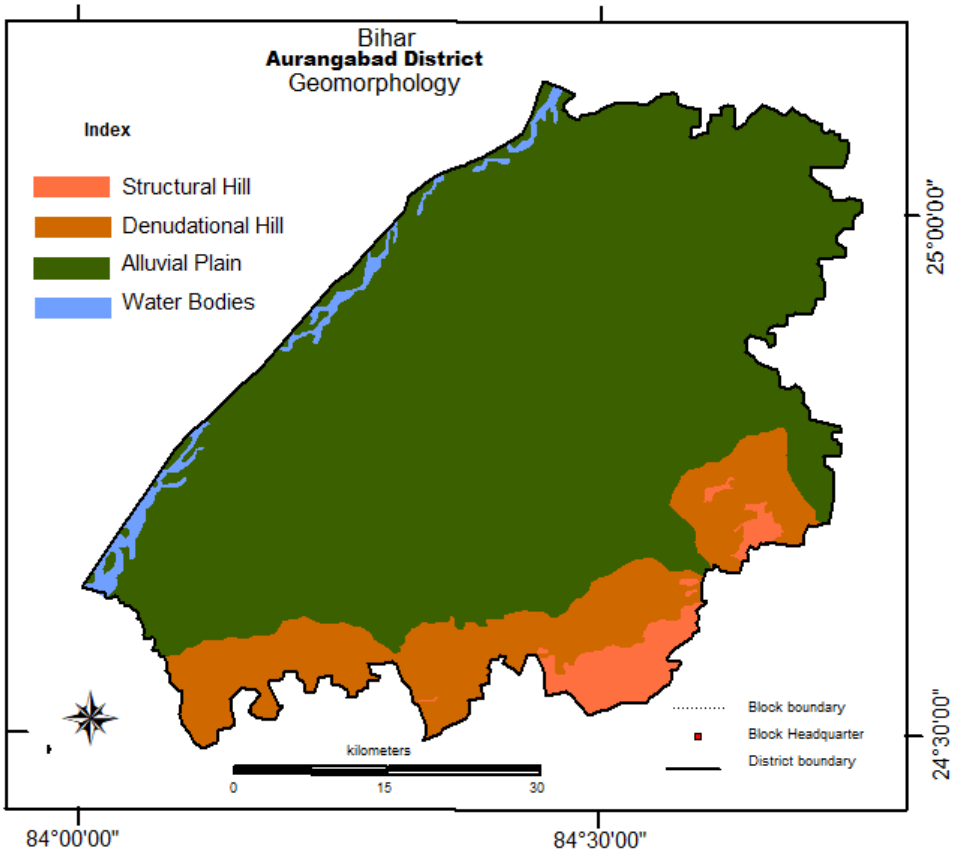


Figure 4: Geomorphology

1.8 Land Use

To know the spatial distribution of the land use pattern, a map obtains (on 20 April. 2020) from the website https://bhuvan-app1.nrsc.gov.in/ and given in **Fig. 5**. The area is mostly dominated by agricultural land which covers major part of the district. Forest area is near southern boundary of the district. Barren/uncultivable area has been found commonly along the river Sone and peripheral of the hills and hillocks.

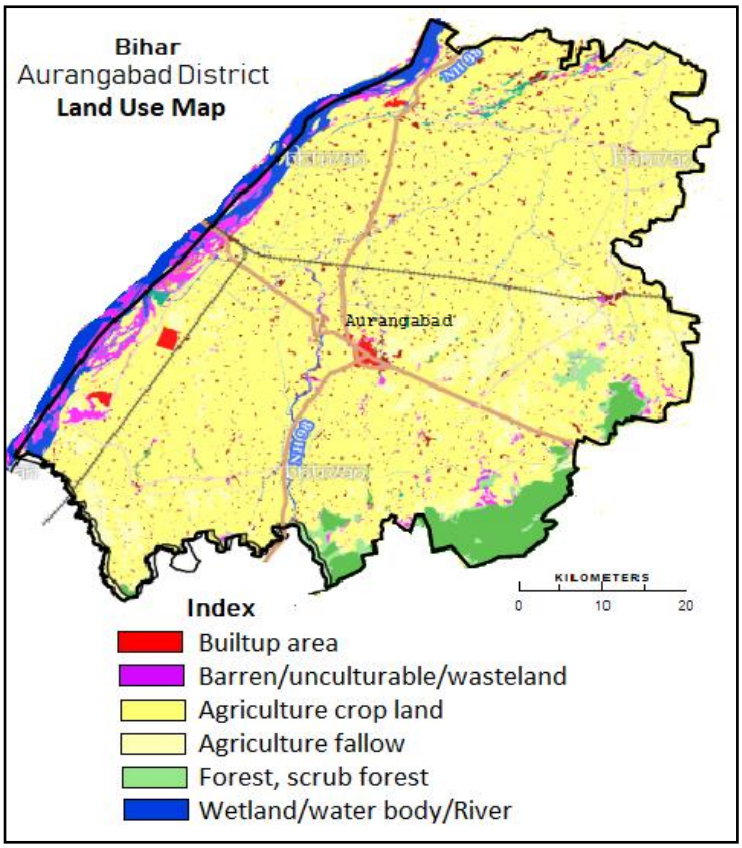
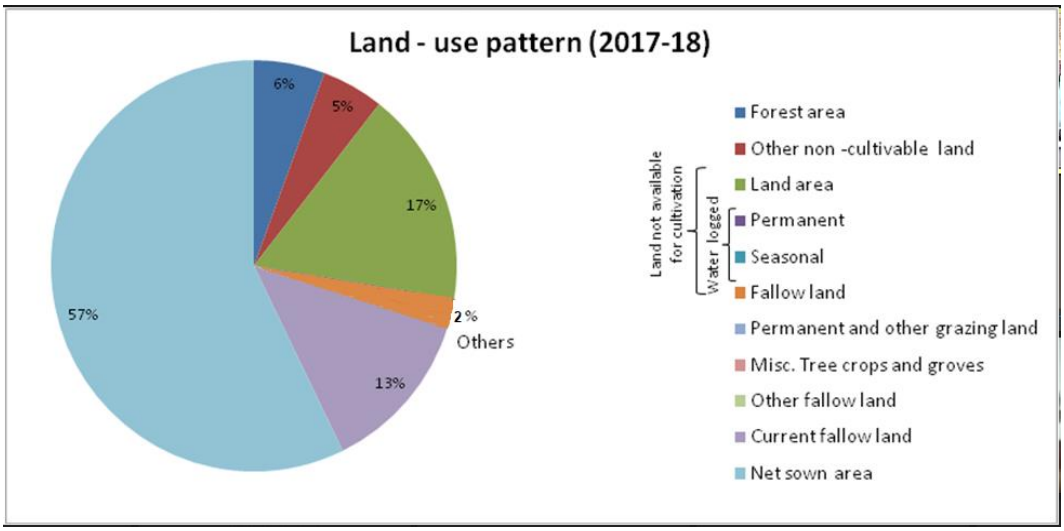


Figure 5: Land use map

Land use data has been collected from District Statistical Department, Aurangabad. The data reveals that Net Sown Area of the district is 189926 ha which constitute about 57.5% of the total geographical area of the district. Forest area covers only the part of northern blocks viz. Dev, Madanpur, Rafiganj and Nabinagar, constitutes only 5.7% area of the district. Permanent logged area is 1642 ha. The block wise land use pattern is given is **Figure-6**



Source: Directorate of Economic and statistics, Govt. of Bihar

Figure 6: Land use pattern

Table 6: Land use pattern (2017-18)

In Hactare

Block	*Area*	*Forest*	*non-cultivable land*	*Land not available for cultivation*			*Fallow land*	*Permanent and other grazing land*	*Miscelaneous tree crops and groves*	*Other fallow land*	*Current fallow land*	*Net sown area*
				Land area	*Water logged*							
					Permanent	*Temporary*						
Aurangabad	28210	0	3533	4796	294	213	708	143	486	674	2813	14548
Dev	27325	5054	2641	2977	68	210	23	0	30	33	6095	10192
Barun	31036	0	1633	9433	139	8	0	0	3	3	3501	16314
Kutumba	25965	0	981	10194	0	0	0	0	2	0	1097	13690
Madanpur	34226	10531	943	5271	99	219	75	255	4	26	4027	12775
Rafiganj	38520	971	654	779	16	134	19	42	40	87	8794	26982
Nabinagar	54817	2208	3451	7608	0	194	810	21	5	314	11392	28811
Daudnagar	19184	0	1167	2671	643	10	28	0	35	0	588	5945
Obra	26463	0	798	3395	171	615	0	0	2	0	550	20932
Hanspur	13873	0	496	1973	123	36	17	64	38	16	516	10590
Goh	30401	0	90	7319	89	136	81	8	30	41	1554	21051
Total	330020	18764	16387	56415	1642	1775	1762	533	676	1196	40926	189926

Source: District Statistical Department

1.9 Soil

Soil, the loose surface material, consists of inorganic particles and organic matter, provides water and nutrients to plants. Soils tend to become acidic when rainwater leaching away basic ions, from decaying organic matter, oxidation of ammonium and sulfur fertilizers etc.

The district is covered by mainly three (03) types of soil with different texture and colour. The **fig.** re-prepared from the District Irrigation Plan of Aurangabad district, depicts its distribution. Mainly three types of soil are observed in the district:

1. Younger Alluvial soils
2. Older Alluvial soils
3. Foot hill soils

1. Younger Alluvial soil

This type of soils covers northern part of the district. These are generally yellowish white to reddish yellow in colour, sandy to loamy sand in texture, neutral to slightly acidic in reaction with low to moderate fertility status.

2. Older Alluvial soil

Major parts of the district are occupied by the Older Alluvial soils. These soils are

composed of very fine to fine sand and clay. These are grey to greyish yellow in colour and moderate to heavy in texture. They develop wide polygonal cracks during the dry season. Layers of calcium carbonate concretions are also common in some places (**Figure 7**). These soils are neutral to slightly alkaline in reaction.

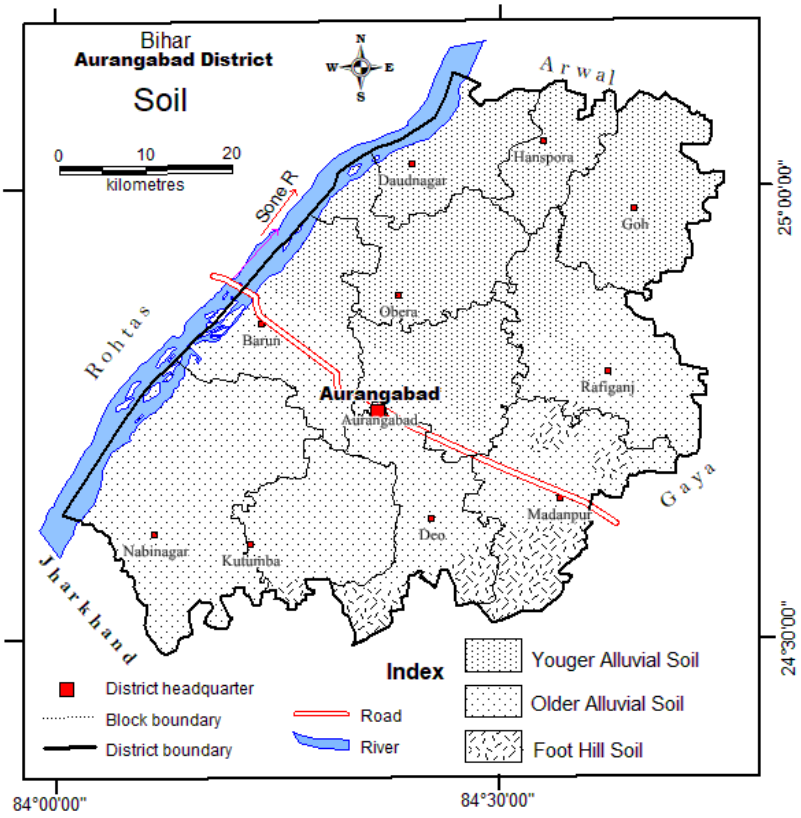


Figure 7 : Soil map

3. Foot hill soil

The foot hill soils occur at the southern parts of the district in the blocks of Kutumba, Deo, Madanpur and Rafiganj. These soils are mainly derived from the crystalline rocks. These soils form a very thin veneer over the bed-rocks. These are generally light textured, stony and gravelly, moderately acidic in nature.

1.10 Hydrology and Drainage

About 87% of the area of Aurangabad district is part of Punpun River Sub-basin. Rest 13% is drained by river Sone which flows from south-west to north-east. Punpun River is a 3rd order stream and is a tributary of the Ganges. There are other rivers namely Batane, Batre, Adri, Ramrekha, Kasman, Madar, Dhawa *etc*, which merge with Punpun at different points within the district and the trunk river flows out of the district as a single thread. The river in its

northern stretches is often braided. Though Sone and Punpun are perennial in nature, they bear little flow during non-monsoon periods.

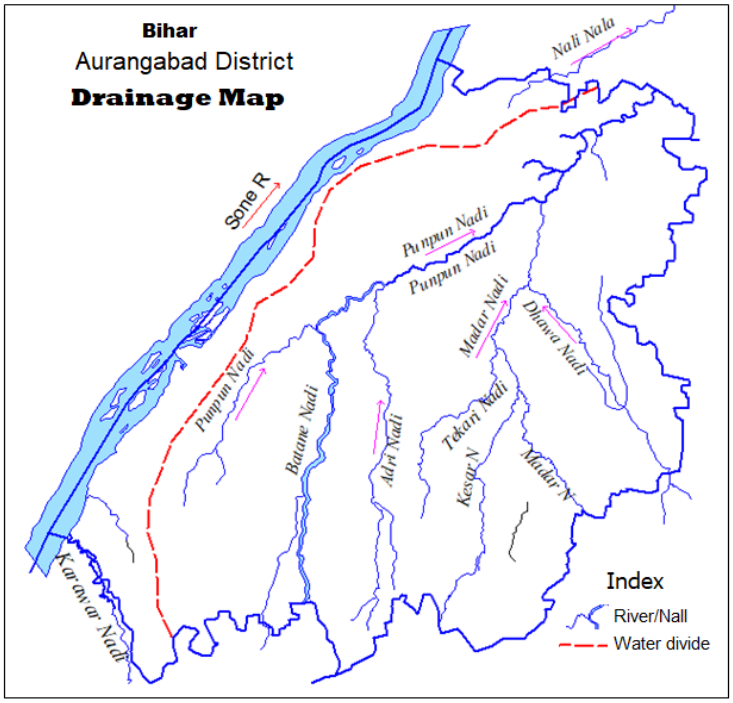


Figure 8: Drainage Map

1.11 Agriculture

The Aurangabad district has agrarian economy. About 82% of the working population is engaged in agriculture as principal economic activity in Aurangabad district. The district is part of Agro-climatic zone III of Bihar characterised by sandy loam, clay loam, loam and clay soil. Fertile alluvial plain of the district is coupled with favourable climate boosted agricultural activity. The main crops of the district are paddy, maize and wheat. The **tables-7** shows the production and productivity of major crops of last five years.

Table 7: production and productivity of major crops

S.N.	Crop	Area (ha)	Production (m tones)	Productivity (Kg/ha)
1	Paddy	155621	5524559	3550
2	Maize	2407	541575	2250
3	Wheat	70902	155984	2200
4	Pulses	42500	38250	900
5	Oil Seeds	6441	3736	580
6	Vegetable	1028	11308	11000
7	Sugarcane	232	9280	40000
8	Fruits	1679	10074	6000

https://aurangabad.kvk4.in/

1.12 Cropping Pattern

Rice is the main crop of Kharif season. Other kharif crops are maize and potato grown in the district. (Table – 9) Wheat is grown during Rabi season in the 68% of net sown area of the district. Other Rabi crops in the district are Pulses, Linseed, *etc*. Vegetables are also grown throughout the year. **Table –8**. The cropping intensity of the district is 140% (2016-17). **Table 9** shows the sowing and harvesting period of major crops of the district.

Table 8: Table 8: Area under major crops in Aurangabad district, Bihar for the year ending 2016-17

(In Hectare)

Season	*Crop*	*Area*	*Net Area Sown*	*Area Sown More Than Once*
Kharif	Rice	175198	205343	81717
	Maize	1175		
	Potato	1662		
	Vegetable	159		
Rabi	Wheat	71130		
	Pulses	23846		
	Gram	7394		
	Linseed	2593		
	Vegetable	319		

Source: Web Based Land Use Statistics Information System

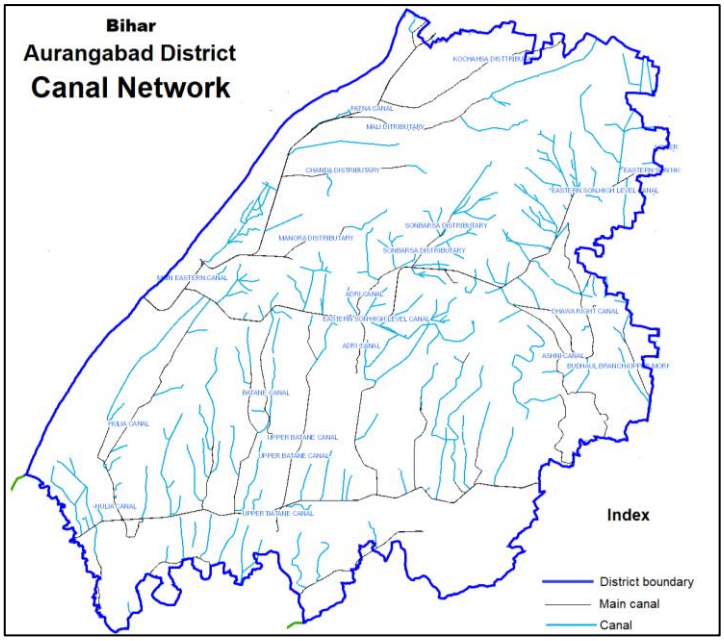
Table 9: Sowing and harvesting period of some major crops

District	*Crop*	*Season*	*From*	*To*	*Period*
Aurangabad	Greengram	Kharif	April (Beg)	July (Beg)	Sowing
	Masur/Lentil	Kharif	June (Mid)	July (Beg)	Sowing
		Kharif	November (Beg)	December (End)	Harvesting
	Rice/Paddy	Kharif	June (Mid)	July (Beg)	Sowing
		Kharif	January (Mid)	July (Beg)	Sowing
		Kharif	November (End)	December (End)	Harvesting
	Pulses	Rabi	January (Beg)	April (Beg)	Sowing
	Masur/Lentil	Rabi	October (Mid)	November (Mid)	Sowing
		Rabi	March (Beg)	March (End)	Harvesting
	Wheat	Rabi	November (Mid)	December (End)	Sowing
		Rabi	March (Mid)	April (End)	Harvesting

https://nfsm.gov.in/nfmis/rpt/calenderreport

1.13 Irrigation

Canal is the main source irrigation in the district covers major part of the area irrigated. Canal network of Aurangabad district is part of one of the oldest irrigation systems of India which was developed across the Son at Dehri in 1873-74. Water from the Son fed canal systems on both sides of the river and irrigated large areas. **(Figure – 9)**



http://gis.bih.nic.in/

Figure 9: Canal network

The Aurangabad district is irrigated by Eastern Sone High Level Canal and North Koel Main Canal. Eastern Sone High Level Canal off-takes from Indrapuri Barrage located about 10 km upstream in Sone from Barun town near Indrpuri, Rohtas. North Koel, main canal off-takes from Mohammadganj Barrage located in Palamau district, Jharkhand. Current capacity of the canals in the districts is given in **Table-10.**

Table 10: Current capacity of the canals

SN	*Canal system*	*District*	*Capacity (Cusec)**
1	Eastern Link Canal	Aurangabad	4400
2	Eastern Sone High Level Canal	Aurangabad	1403
3	Sonvarsha Disty	Aurangabad	121
4	Bhagawatipur Disty	Aurangabad	216
5	Barun Lock	Aurangabad	3000
6	Manaura Disty	Aurangabad	150
7	Chanda Disty	Aurangabad	150
8	Tuturkhi Disty	Aurangabad	80
9	Mali Disty	Aurangabad/Arwal	325
10	Kochas Disty	Aurangabad/Arwal	300
11	North Koel canal (107.50 to 152.45 RD**)	Aurangabad	3050
12	Naur Disty	Aurangabad	50
13	Riur Sub-disty	Aurangabad	320
14	Kulharia	Aurangabad	58
15	North Koel canal (152 to 211.20 RD)	Aurangabad	1200
16	Mahuadi Sub-disty	Aurangabad	120
17	Basdiha Sub-disty	Aurangabad	261
18	Karma disty	Aurangabad	300
19	North Koel canal (below 211.20 RD)	Aurangabad	600
20	Kapasiya disty	Aurangabad	156
21	Hetampur Sub-disty	Aurangabad	136

Source: Irrigation, Planning & Monitoring Division, Patna

**Cusec = cubic feet per second (roughly 28.3 lit per second) **RD = Reduced Distance and equal to 1000 feet from the head of the canal downstream)*

Groundwater is the second major source of irrigation in the district. Tube wells are main source of groundwater withdrawal for irrigation. To understand the growth and distribution of irrigation tube wells over time 4th and 5th MI census data has been collected and analysed.

Depth range categories of tube wells are slightly changed in 5th MI census. Total number of tube well from 4th MI census (2006-04) to 5th MI (2013-14) census has been increased from 8660 to 11461. It is observed that number of deep tube well (depth range of 70-90 m) is decreased from 1097 to 136. During the year 2006-04 (4th MI Census), maximum no. of shallow tube wells was within the depth of 20 m. **(Figure - 10)**

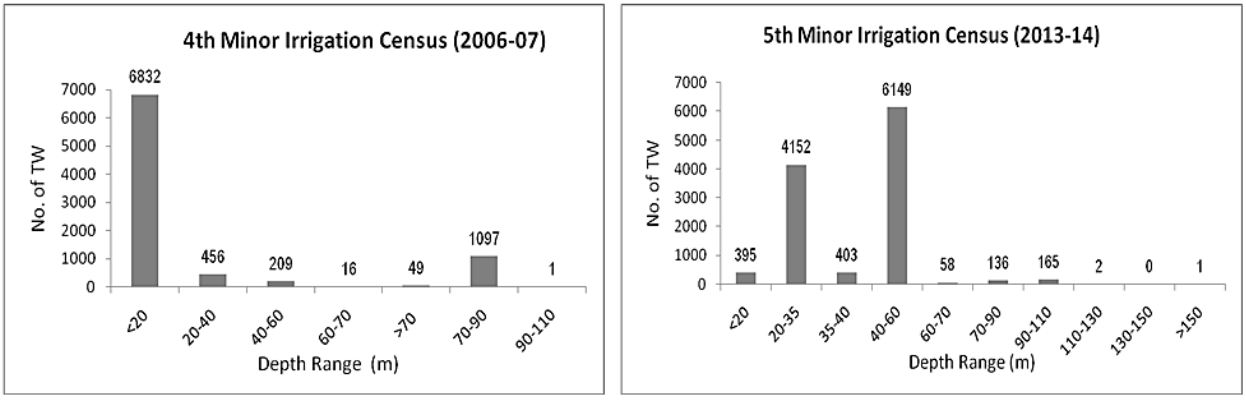


Figure 10: Number of tube well in 4th and 5th Minor Irrigation Census

The figure indicates that the net area irrigated by groundwater is almost unchanged till the 5th MI census and gross area irrigated is decreasing. From the year 2007-08 to 2016-17 the irrigation facility from canal and ground water is showing slightly increasing trend.

During 5th MI census, the tube wells within the depth range of 20 to 35 and 40 to 60 m are drastically increased in number whereas shallowest range of < 20 m is decreased. It indicates there may be drying up the shallow aquifer, availability of power energy for ground water exploitation from deeper depth and/or a sense of surety of groundwater availability for a long time. Now, the aquifer within the depth range of 20-35 and 40-60 m is being utilised for ground water extraction to fulfilled irrigation demand.

The net area and gross area irrigated by canal and ground water from the year 2010-11 to 2016-17 has been analysed to know the their contribution in irrigation. The Graphs has been prepared and presented in Figure.

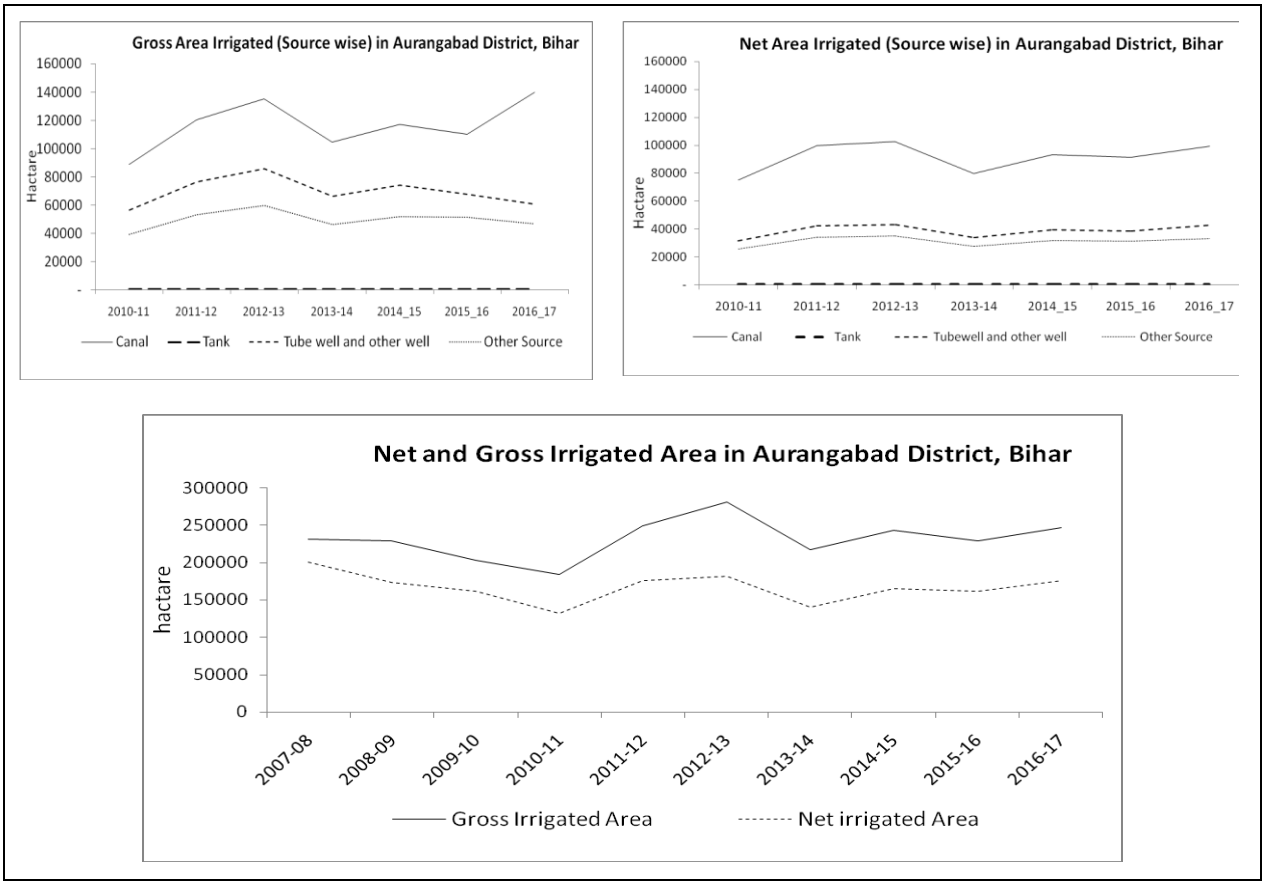


Figure 11: Source wise Net and gross area irrigated

With regard to the net and gross area irrigated from the different sources it has been observed that during the year 2010-11 the area irrigated by the canal has been increased while the area irrigated by groundwater is almost same. **(Fig. 11)** The graph reveals that after the year 2015 the gross area irrigated by groundwater is decreased while by canal is increased. This indicates that Rabi crop irrigation by canal is increased.

CHAPTER 2

2. DATA COLLECTION AND COMPILATION

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 behaviour of ground water level and quality of ground water in the district and are being monitored four times in a year within scheduled time frame. To understand the sub–surface geology, identify the various water bearing horizons including their depth, thickness and compute the hydraulic characteristics such as transmissivity and storativity of the aquifers, exploratory drilling programme was carried out by Central Ground Water Board. For other inputs such as hydrometeorological, Landuse, cropping pattern etc. were collected from concerned State and Central Govt departments and compiled.

2.1 Data collection and Compilation:

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

i. Hydrogeological Data: Water level data of 53 key wells and historical water level trend of monitoring wells were collected and compiled representing phreatic aquifer.

ii. Hydrochemical Data: To evaluate the quality of ground water, 34 samples were collected from dug wells.

*iii. Exploratory drilling***:** The data of exploratory wells from 46 locations of departmental rig as well as state agencies drilled in hard rock and alluvial has been taken.

iv. Hydrometeorological Data: Normal rainfall data for each of the block has been collected from District Statistical Office, Aurangabad.

*v. Land use and cropping pattern data***:** The data of land use and cropping pattern obtained from the website of ‘Bhuvan.nrsa’ and District Statistical Office, Aurangabad

2.2 Data Generation:

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

2.2.1 Ground water Monitoring Wells

41 key wells were established and 12 NHNS monitored to assess the ground water scenario of shallow aquifer (Aquifer-I) of the area. The depth of these dug well varies from 2.10 to 13.00 mbgl. Similarly, the diameters of key wells (dug wells) ranges from 1.60 to 4.80 m. During 2018, the pre monsoon (May) depth to water level in these wells was between 2.80 to 12.10 mbgl. The post monsoon depth to water level (Nov. 2018) in the dug wells ranges from 2.00 to 10.33 mbgl. Average pre-monsoon water level was calculated 6.32 mbgl and in post monsoon 4.33 mbgl respectively. A detail of key wells and water level data is presented in **Annexure – I & II**. Location of key wells and exploratory wells are shown in figure –7.

2.2.2 Ground Water Exploration

On perusal of table- 1, exploratory well drilling in Meharma and Thakurghanti blocks is required. Accordingly additional data generation were undertaken in hard rock area and soft rock formation (alluvium) to assess the lithological disposition of shallow aquifer (Aquifer-I) and deeper aquifer (Aquifer-II). The details of exploratory and observation wells are given in **Annexure-V A & VI.**

2.2.3 Ground Water Quality

To assess the quality of ground water, 39 samples were collected from dug wells representing Aquifer – I

2.2.4 Geophysical Survey

A geophysical study carried out along the river Sone for the development of ground water.

2.2.5 Micro Level Hydrogeological Data Acquisition

In addition to the Hydrograph Monitoring Wells, micro level hydrogeological data was also acquired for deciphering the sub-surface lithological disposition, water level scenario and other hydrogeological inputs such as weathered thickness etc. of shallow aquifer (Aquifer-I). Thus 53 wells in the district were inventoried for micro level data acquisition. The details of dugwells inventoried for micro-level data acquisition are given in **Annexure-I**

2.2.6 Thematic Layers

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

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

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

CHAPTER 3

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

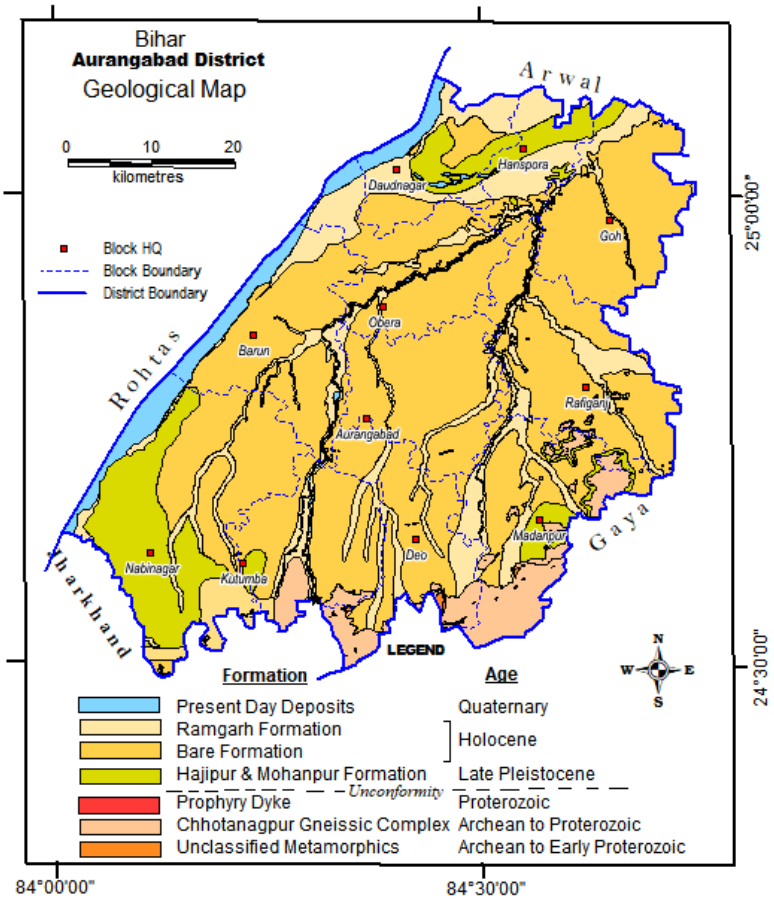
The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation, thematic layers was interpreted and integrated. Based on this the various aquifer characteristic maps on hydrogeology, aquifer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

3.1 Geological set up

Geologically, the district is made up of various formations from Archean to present day deposits. Near southern and eastern part of the district, Chhotanapur Gneissic complex of Archean age is exposed and also as inliers and covers about 20% of the geographical area. It gradually dips towards north and form the basement.

The Remaining major part is the alluvium of Pleistocene to quaternary age which lies un-conformably over the basement rocks. Alluvial is thin near southern and eastern boundary goes more than 150 m near northern boundary. The sediments are composed of finer clastics silt, clay and fine to medium sand. In the western part of the district, the sediments deposited by the river Sone are coarse to very coarse in nature.

In western part, a narrow stretch of Vindhyan rocks (sandstones and quartzite) exists and covers parts of the south western part of Nabinagar block.



Source:-Geological Survey of India

Figure 12: Geological map

Formation	*Age*	*Lithology*
Present Day Deposits	Quaternary	Unconsolidated and Un-oxidised sand
Ramgarh Formation	Holocene	Unconsolidated and Un-oxidised sand beds-channe alluvium
Bare Formation		Hard dark grey un-oxidised clay with occasional caliche.
Hajipur & Mohanpur Formation	Late Pleistocene	Yellowish to deep brown clay, hard compact, oxidised
	Unconformity	
Prophyry Dyke	Proterozoic	Prophyry Dyke
Chhotanagpur Gneissic Complex	Archaean to Proterozoic	Augen/Biotite/Granite Gneiss
Unclassified Metamorphics	Archaean To Early Proterozoic	

3.2 Hydrogeology

The occurrence and movement of ground water in the area is variable, which depends on geomorphology, structure, geological setting, hydraulic properties, tectonic setup etc. The hydrogeological condition of Aurangabad is complex due to diverse geological terrain, variability of topography, drainage etc. Based on morphogenetic and geological diversities and relative ground water potentialities in the aquifer belonging to different geological formation, the study area can be broadly sub-divided into two hydrogeological units.

(i) Consolidated formation

(ii) Unconsolidated formation

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

The unconsolidated formation which possesses primary porosity forms porous formation is represented by quaternary alluvium.

The district areas covered by the above hydrogeological units are given in **Figure 13.**

3.2.1 Ground Water in Fissured Rock Formation

The Chotanagpur gneissic complex and other associated rocks of Precambrian age belong to this fissured rock formation group. Ground water in Precambrian rocks of the study area is dependent on thickness of weathered residuum, openness and interconnections of fractures. These rocks have developed secondary porosity by fracturing and weathering which forms the conduits for occurrence and movement of ground water. This consolidated formation often termed as fissured formation.

The hard rock, exposed near south east boundary forms the basement. The thickness of alluvium which lies un-conformably over the basement rocks, gradually increases away from south-eastern crystalline boundary towards north. Thereby the fissured formation covers the southern and south-eastern part of the district includes part of Nabinagar, Kutumba, Deo, Madanpur and Rafiganj blocks with the considerable thickness of weathered residuum.

The central Ground Water Board has drilled 10 exploratory wells under the Ground Water Exploration Programme in this area. These exploratory wells constructed by casing the overlying weathered zone to get water only from fracture zone. The result of exploratory drilling has been summarized in **Annexure V**. The salient feature of the exploratory drilling are:

a) In fissured rock formation, discharge of wells are found upto 10 lps (Manjurakha, Aurangabad block).

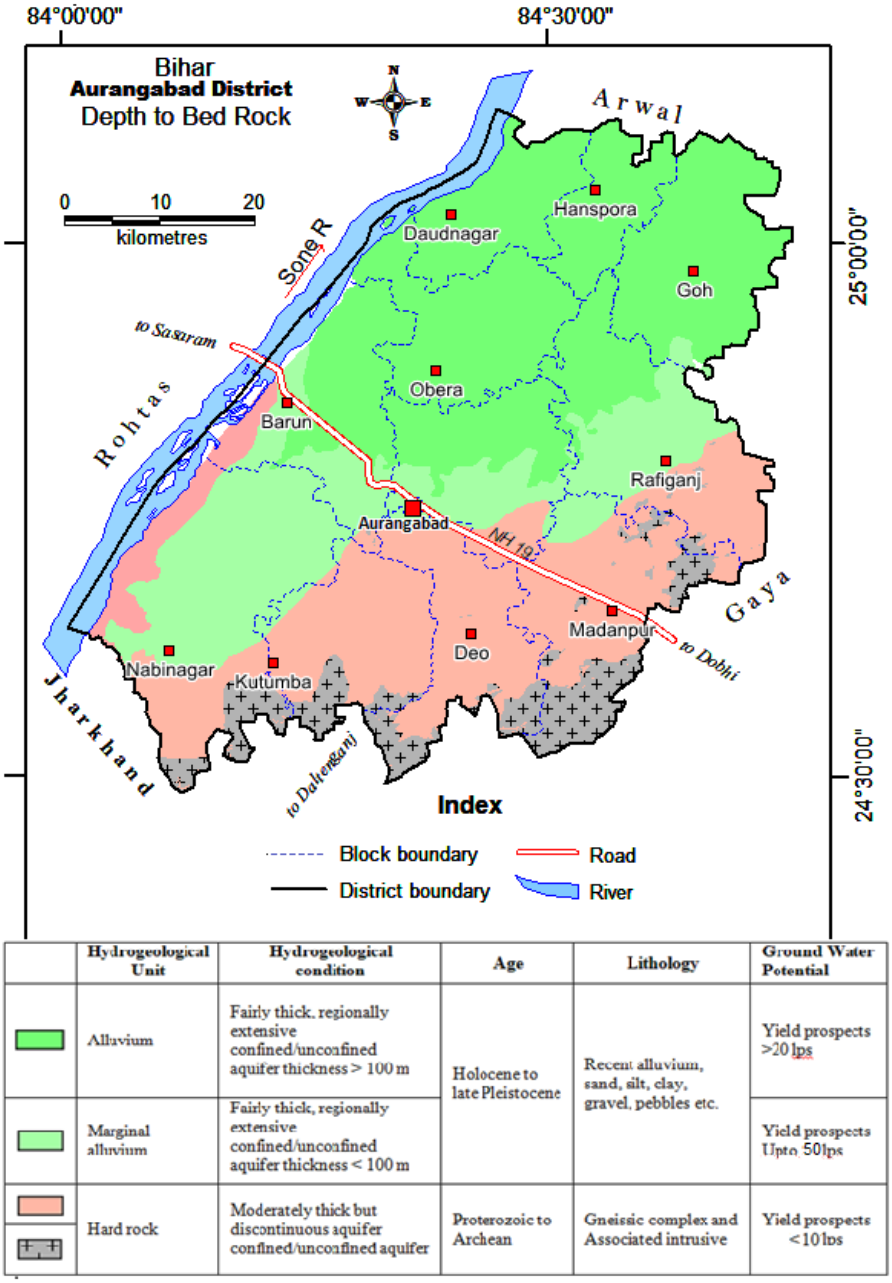
b) Overall the major potential fracture zones have been encountered between 32 to 130 m bgl (meter below ground level) down the drilling depth of 200 m bgl.
c) First potential fracture zone encountered widely varies from 32 to 97 m bgl.
d) As per the drilling locations, the depth to bed rock varied from 21 (Manjurakha) to 57 m bgl (Baulia).

3.2.2 Ground Water in Unconsolidated Formation.

. The unconsolidated formation forms porous formation and is represented here by the quaternary alluvium. Based on the depth to bed rock, this formation in the area is further divided into 'marginal alluvium' and alluvium. The depth of marginal alluvium may be considered down to 100 to 120 m bgl.

The 'marginal alluvium' covers major part of Nabinagar block and considerable part of Barun, Arurangabad, Madanpur and Rafiganj blocks. The fence diagrams (**Figure 28-30**) reveals that in Nabinagar, Barun and boardered area of Kutumba blocks, thickness of sediments varies from 30 to 100 m with two prominent sand layers within the depth of 25 to 50 m bgl. As per the old reports, high discharge wells (~50 lps) are constructed in Nabinagar blocks, few wells are also reported as 'abandoned'. Further towards Aurangabad, thickness of sand layers gradually decreases and occurs at places just above the hard rock basement. Further towards Rafiganj, only clay layers have been encountered down to the depth of ~100 m.

The 'alluvium' area has been identified by its thickness found to be more than 100 m. The 'alluvium area covers Daudnagar, Hanspura, Goh, Obra and part of Barun, Aurangabad and Rafiganj blocks. The cross sections/fence diagrams (**Figure 28-29 & 33**) indicate that there are number of sand layers in alternation with the clay layers. The total thickness of sand layers is approximately 70-80 m. Two exploratory wells at Daydnagar and Hanspura have been drilled recently in this area in which discharge of the wells has been found to be 22 and 32 lps respectively, by tapping deeper aquifer. (**Annexure-IV**)



	Hydrogeological Unit	Hydrogeological condition	Age	Lithology	Ground Water Potential
	Alluvium	Fairly thick, regionally extensive confined/unconfined aquifer thickness > 100 m	Holocene to late Pleistocene	Recent alluvium, sand, silt, clay, gravel, pebbles etc.	Yield prospects >20 lps
	Marginal alluvium	Fairly thick, regionally extensive confined/unconfined aquifer thickness < 100 m			Yield prospects Upto 50lps
	Hard rock	Moderately thick but discontinuous aquifer confined/unconfined aquifer	Proterozoic to Archean	Gneissic complex and Associated intrusive	Yield prospects <10 lps

Figure 13: Hydrogeological Map

3.3 Ground Water Dynamics

Additional wells (Key wells) have been establish and periodically monitored for water level, to understand water level behaviour in spatial and temporal domain. Water level data of total 53 dug wells are utilised for the purpose. In addition, National Hydrograph Network Station (NHNS) are utilised for understanding long-term water level behaviour. Water samples have also been collected during pre-monsoon period. The data has been given in **Annexure I**. and the Location of key wells and NHNS wells are shown in **Figure 14.**

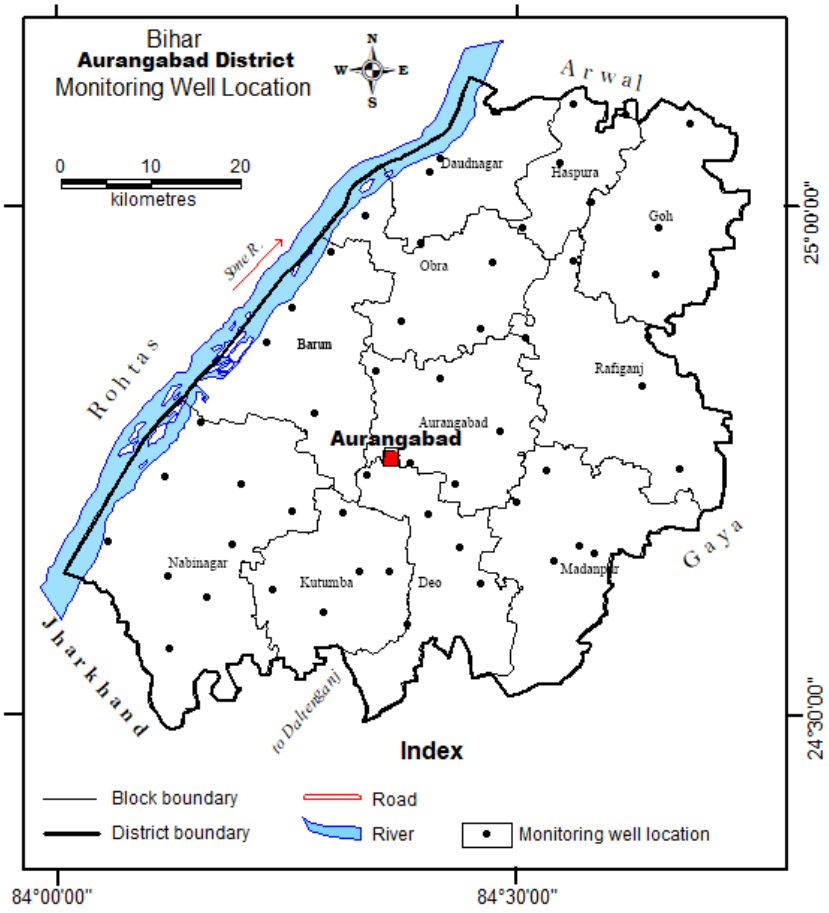


Figure 14: Location of monitoring well

Based on collected field data, maps are prepared in GIS environment, using *Mapinfo*TM and *Vertical Mapper*TM softwares. Data interpolation is done through *Natural Neighbor Interpolation method.* The data then converted to delineate area classes of 0-2, 2-5, 5-10 and >10 m bgl water level. However, southern hilly part of the district is omitted from this exercise.

3.3.1 Depth to water level – May 2018

During pre-monsoon period, majority of the area is categorized under 5-10 m bgl water level. A small northern bordering area of Daudpur, Hanspura and Obra block has shown water level between 2 and 5 m bgl. **(Figure 15)** This is expected to be due to basin topography. In a narrow stretch along the river Sone, on the south-western part of district, more than 10 m bgl depth to water level is observed. In most probability, this is due to influence of river system over groundwater flow pattern and the river is acting as a gaining river in the stretch.

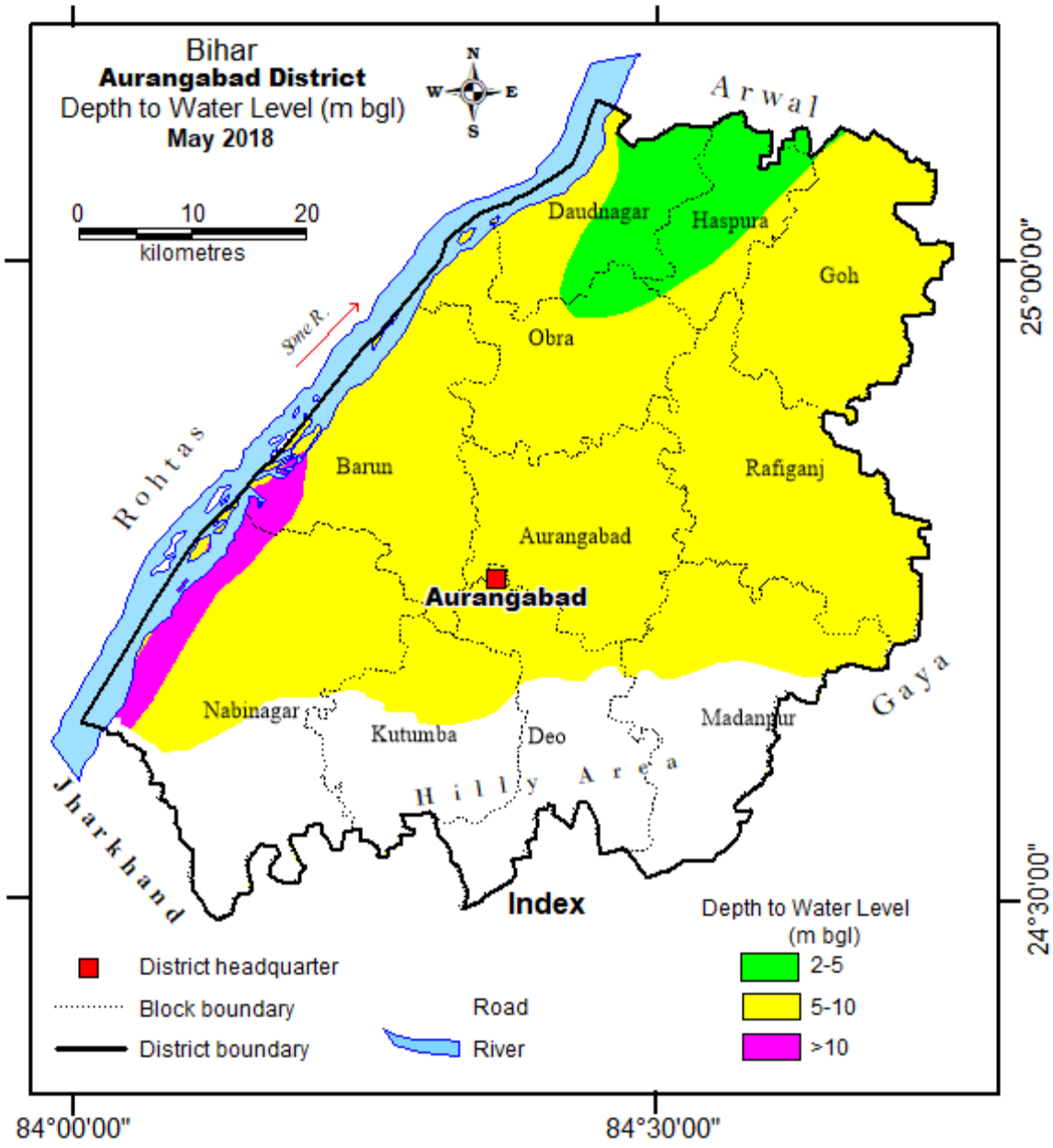


Figure 15: Depth to water level- May 2018

3.3.2 Depth to water level – November 2018

During post-monsoon period, central part of the district from north to south, near the river Punpun has Shown water level upto 2.00 m bgl. **(Figure – 16).**The water level category of 2 to 5 m bgl observed on eastern and southern part except a south-western narrow elongated area, along the river Sone where water level has been found upto 10 m bgl. Shallow water level near river Punpun indicates that general ground water flow pattern is almost following the topography of the district.

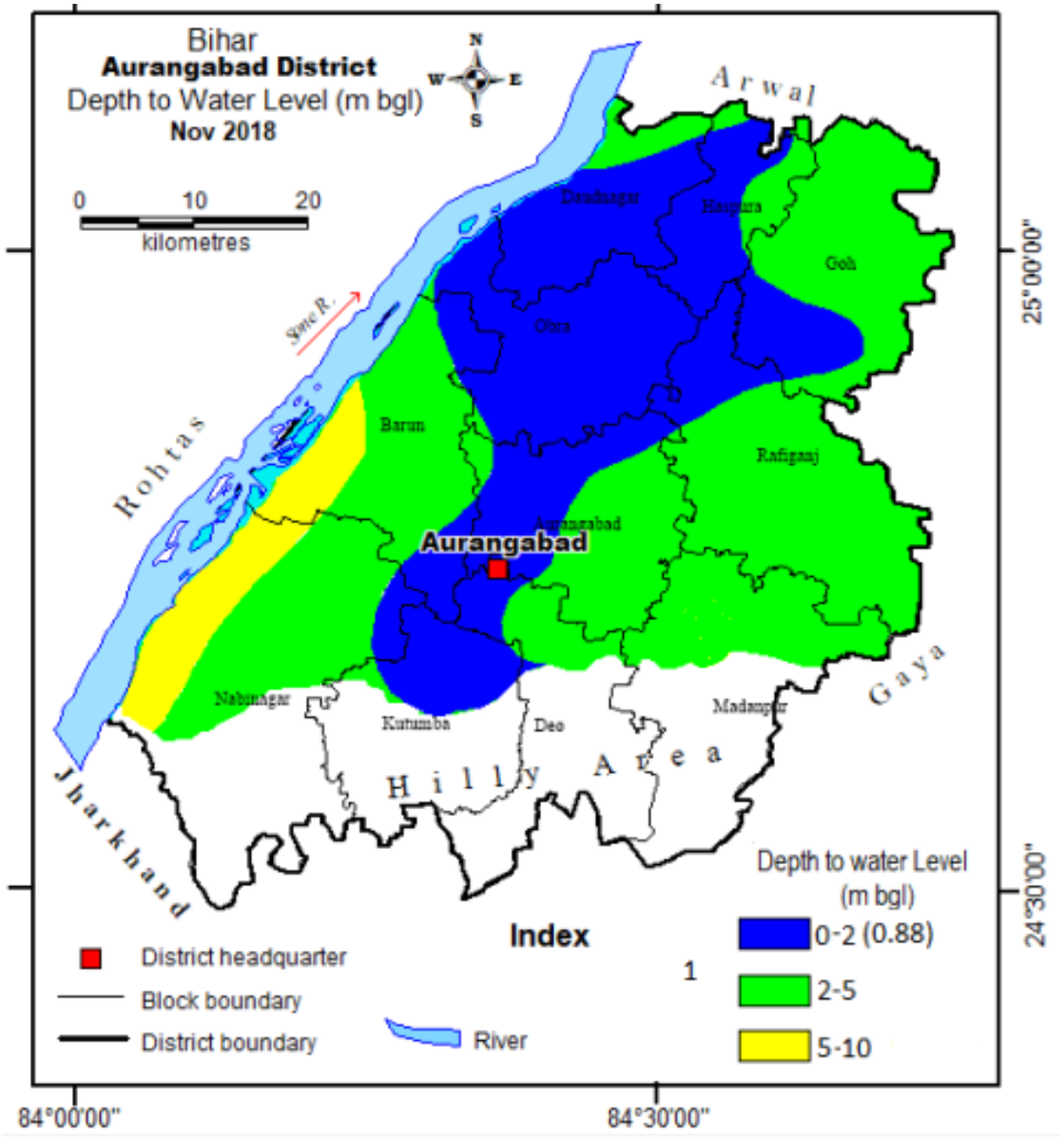


Figure 16: Depth to water level - Nov. 2018

3.3.3 Water level fluctuation during Nov. 2018 w.r.t. May 2018

Highest category (>4 m) of water level fluctuation has been observed in central Part of the district. Fluctuation up to 2 m only has been shown by the area covering northern part of Hanspura, Goh, Daudnagar blocks and south-western part of the district. Rest of the area has been categorised under 2 to 4 m water level fluctuation.

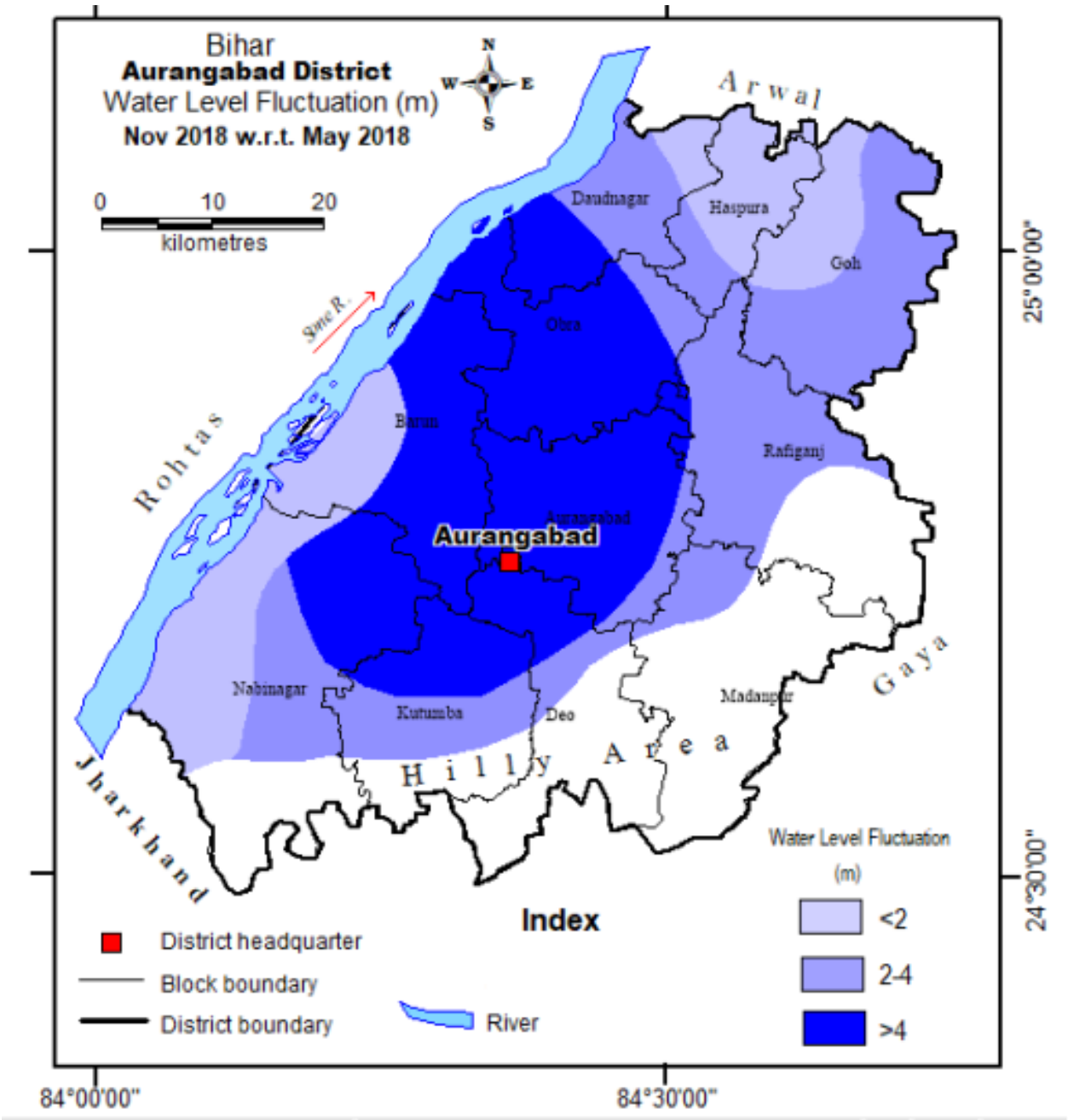


Figure 17: Water level fluctuation map (Nov.2018 w.r.t. May 2018)

3.3.4 Water Table Contour

The water table contour has been shown in the **Fig. 18.** The water table is more or less following the slop of the area. Map reveals that the general flow of groundwater in phreatic aquifer towards north-east direction. The convex contour indicates that river Punpun is an effluent river which gets water from ground water.

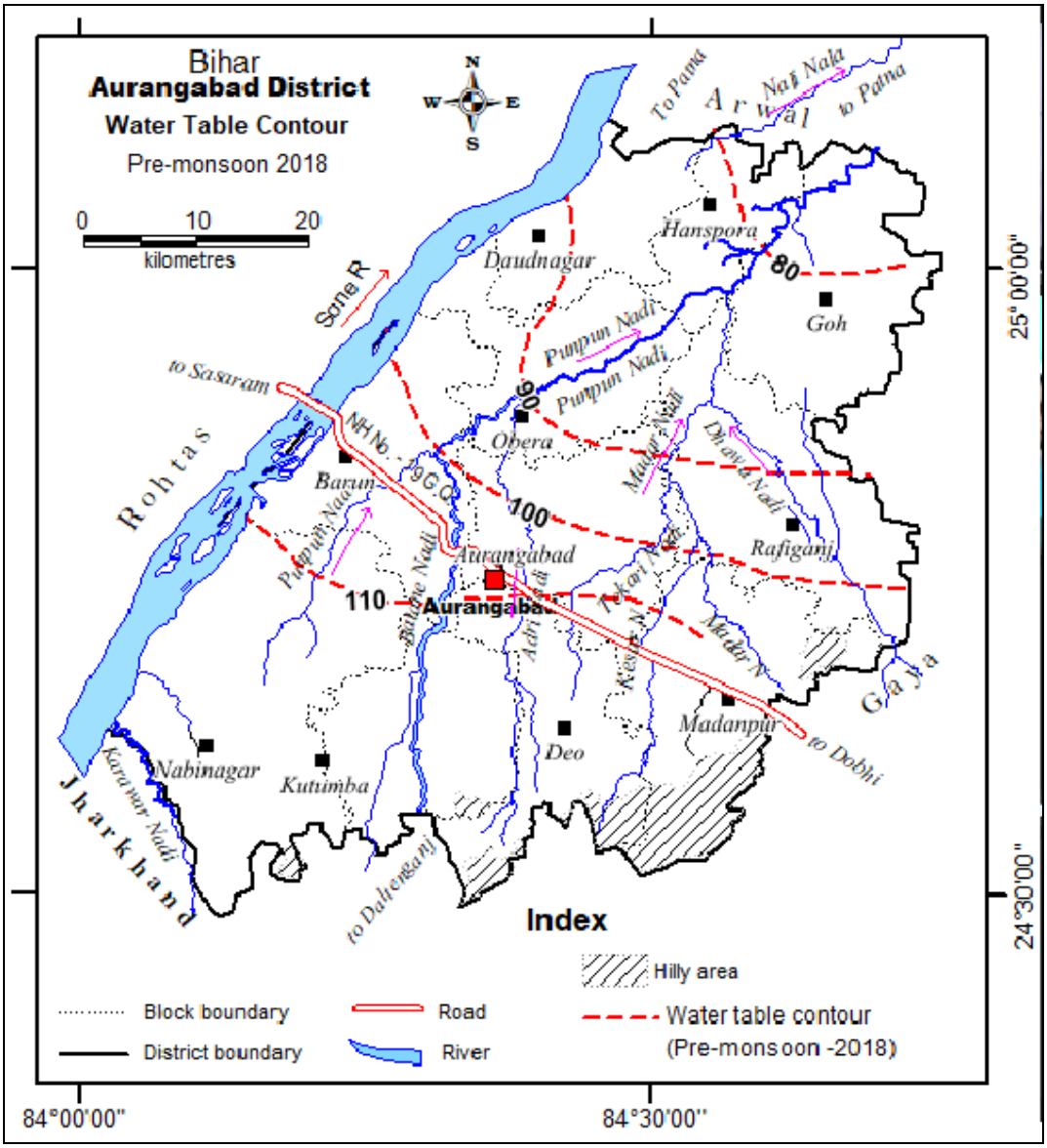


Figure 18: Water Table Contour map

3.3.4 Water Level Trend

Analysis of four (04) hydrograph network stations located at Aurangabad, Obra, Madanpur and Deo were carried out using GEMS software (**Figure-19 to 22**) and analysed for the period from 2000-2019. It is observed that out of four hydrograph analysed for long-term water level trends during pre and post-monsoon seasons, three (03) are showing declining trend are declining trend in shallow aquifer-I represented by dug wells. However, the trend is not significant. The water level of one station located at Deo is showing slightly rising trend.

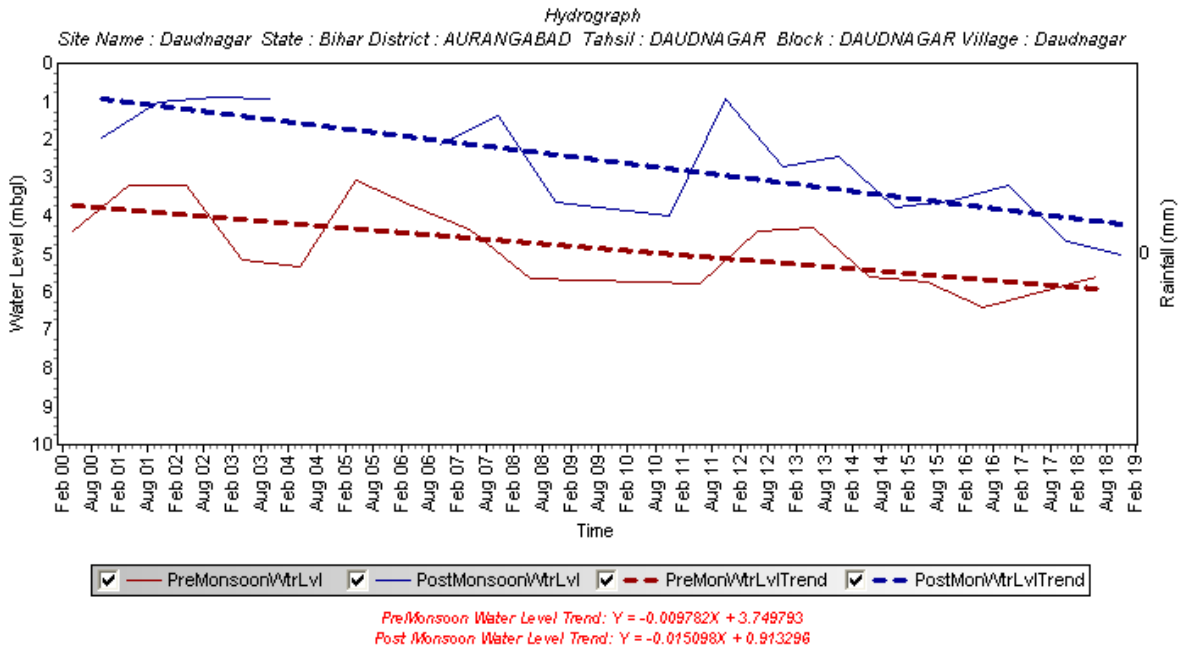


Figure 19: Water Level Trend at Daudnagar

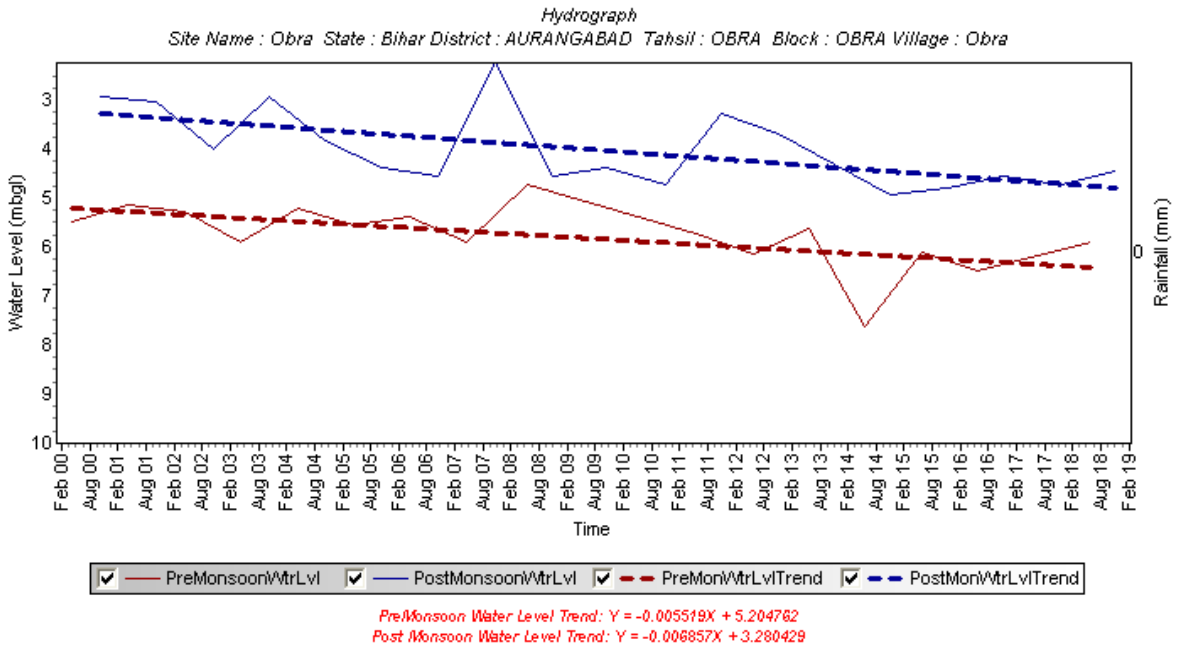


Figure 20: Water Level Trend at Obra

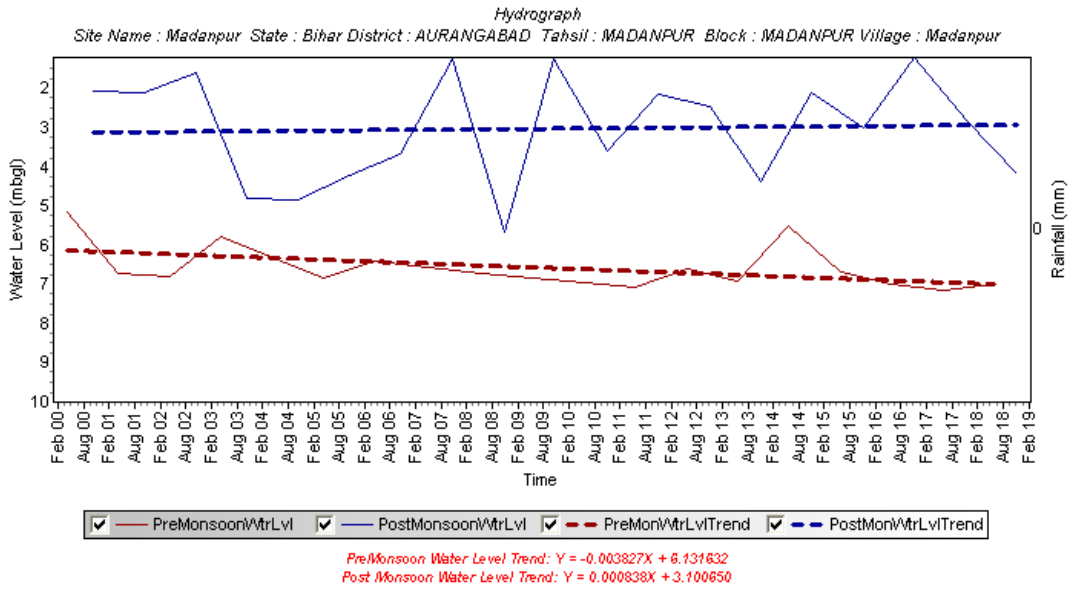


Figure 21: Water Level Trend at Madanpur

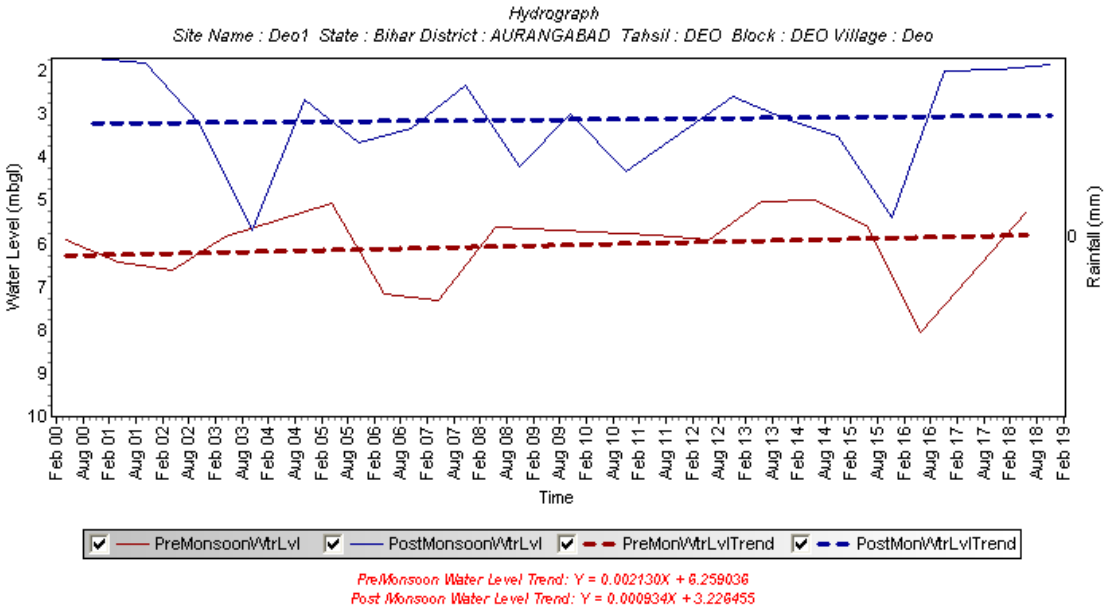


Figure 22: Water Level Trend at Deo

3.5 Ground Water Exploration

Exploratory well has been constructed in two types of aquifer–Fissured aquifer and Porous aquifer. In fissured aquifer system transmissivity has been calculated to be upto 103.8 m^2/day (Manjurakha) whereas in porous aquifer it ranged from 1106 to 1160 m^2/day. The storativity value is available for two locations viz Manjurakha and Deo in fissured aquifer which is 3.4×10^{-1} and $1.1x10^{-5}$ respectively. At only one location (Hanspura) in porous aquifer the storativity value has been calculated

to be $1.5x10^{-3}$. The data are summarized in **table – 11**.

Table 11: Pumping test details

SN	*Location*	*Depth drilled (m bgl)*	*Granular/ Fracture Zones (m bgl)*	*Aquifer*	*SWL (m bgl)*	*m2/day Yield (Lit./Sec.)*	*Transmi-ssivity (m^2/day)**	*Storati vity*	*Depth to bed rock (m bgl)*
1.	Bhatkur	201	32.0	Fracture	10.70	0.16	0.015		45
2.	Chandangarh	201	32 124	Fracture	11.80	0.4	0.018		24
3.	Chandpur Tola	180	51 57	Fracture	7.46	3.4	60.97		33
4.	Gongra Bandh	201	32 44	Fracture	16.50	1.3	24.0		21
5.	Kutumba	201	52 149	Fracture	10.97	2.3	28.8		45
6.	Madanpur	201	66 130	Fracture	6.95	5.5	82.24		24
7.	Manjurakha	123	97 118	Fracture	7.0	10.5	103.8	3.4×10^{-1}	21
8.	Pawai	201	67 176	Fracture	4.90	1.8	8.04		36
9.	Baulia	201	94 149	Fracture	18.0	1.8	1.51		57
10.	Deo	100.8	33-34 71-72 79-80	Fracture	4.6	4	14.3	$1.1x10^{-5}$	24.4
11	Daudnagar	100	5-10 25-32 45-55 70-80	Sand	5.1	22	1160		-
12.	Hanspura	167	20-28 40-43 52-62 80-86 105-112 120-132	Sand	7.6	32	1106	$1.5x10^{-3}$	-

** Calculated from slug test if discharge is < 1 lps*

3.6 Ground Water Quality

To study the groundwater chemistry of the area, the data of chemical sample collected during pre-monsoon period of May 2018 from National Hydrograph Network Station and from additional key wells has been taken. Analytical results of ground water samples are given in **Annexure II.**

3.6.1 Classification of Ground Water

The determination of groundwater facies helps for its evaluation. It can be done by the plotting of the percentage of selected chemical constituens in Modified Piper diagrame (Chadha et al 1999) which is a simplified version of Piper plot.

The plot prepared by using percentage of major cationns data on X axis and major anoions in Y axis plotted and **figure 19** has been prepared.

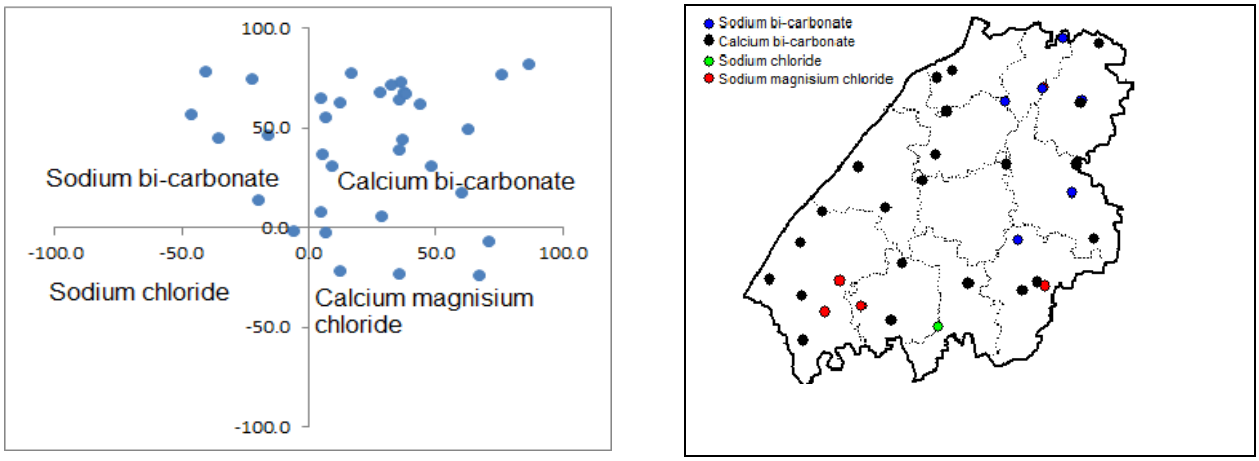


Figure 23: Classification of ground water

Three main ground water groups have been identified based on major ion concentrations. These are Na-HCO_3, Ca-HCO_3, and Ca-Mg- Cl, (Fig. 2.5 & 2.6). The Ca -HCO_3 water is primarily a result of dissolution of carbonate minerals, and the origin of water is mainly due to rainfall-derived recharge, over decades to centuries, whereby surface water charged with atmospheric and biogenic CO_2 infiltrates into the subsurface. A few of the samples are rich in Na-K which may be due to usage of fertilizers. The presence of low Cl & SO_4 indicates low residence time. Mixed Na-HCO_3 water type express mineral dissolution and recharge of freshwater. NaCl water type suggest the mixing of high salinity water caused from surface contamination sources such as irrigation return flow, domestic wastewater, and septic tank effluents, with existing water followed by ion exchange reactions.

3.6.2 Suitability for Drinking Purpose

Since water is a good solvent, it always contains some essential minerals in nature. But more mineralisation of water is not good for health. Bureau of Indian Standard (BIS) has recommended extent of mineralisation suitable for drinking purpose. The recommendation of BIS (2012) and concentration of each chemical constituent are presented in **Table 12.**

Table 12: Chemical Quality Data

SN	*Block*	*Location*	*pH*	*TH*	*Ca^{2+}*	*Mg^{2+}*	*HCO^{3-}*	*Cl^{-}*	*$SO4^{2-}$*	*NO^{3-}*	*F^{-}*
1	Barun	Baruna	8.2	185	50	15	363	67	56	12	0.64
2	Daudnagar	Daudnagar	8.25	530	134	47	438	171	72	**51**	0.45
3	Deo	Deo	8.4	240	34	38	640	27	26	2	0.98
4	Goh	Deohara	8.18	180	30	26	412	172	106	178	0.31
5	Nabinagar	Dhanibar	7.98	220	44	27	258	92	43	89	0.88
6	Goh	Deohara_goh	7.1	135	26	17	363	41	12	34	0.37
7	Goh	Dhobi Tola_Goh	8.16	200	58	13	369	11	11	6	0.53
8	Madanpur	Madanpur	8.04	285	78	22	326	167	65	26	1.28
9	Nabinagar	Mahuli	7.94	380	54	60	424	315	135	106	0.89
10	Nabinagar	Nabinagar	8.23	145	36	13	314	10	16	7	0.89
11	Nabinagar	Narai Kala	8.34	220	30	35	160	13	11	2	0.48
12	Obra	Obra	8.3	490	74	74	289	19	31	29	0.29
13	Aurengabad	Patraya	8.28	340	76	36	197	21	20	17	0.22
14	Deo	Pataya	8.11	690	98	108	412	62	62	4	0.76
15	Rafiganj	Rafiganj	8.34	230	36	34	449	73	25	21	0.61
16	Rafiganj	Tinari Morh	8.43	310	52	44	418	37	12	5	1.04
17	Hanspura	Sonhatu	7.31	120	24	15	203	67	25	39	1.04
18	Rafiganj	Barahi	8.09	85	12	13	141	11	6		**1.54**
19	Daudnagar	Thakur Bigha	7.88	310	58	40	240	64	41	27	0.58
20	Daudnagar	Mohan Bigha	7.66	192	37	24	283	18	7	5	0.36
21	Barun	Urdina	8	155	25	22	215	16	4	6	1.02
22	Nabinagar	Badem	7.94	140	18	23	192	16	12	4	1.08
23	Nabinagar	Tetariya	7.92	160	23	24	209	32	26	7	0.38
24	Nabinagar	Kharundha	7.96	135	23	19	258	21	13	5	**1.58**
25	Nabinagar	Jai hind tendu	7.72	460	36	90	295	209	105	83	0.75
26	Kutumba	Kutumba	8.04	485	42	92	394	208	202	18	1.52
27	Kutumba	Risiap	8.21	150	16	26	197	28	21	2	1.24
28	Kutumba	Kauriyari	8.16	165	32	21	210	100	34	22	1.67
29	Madanpur	Jalwand	8.14	130	18	21	271	25	12	4	1.24
30	Madanpur	Salempur	8.27	100	26	8	369	22	4	1	1.25
31	Rafiganj	Kasma	8.09	130	18	21	172	40	16	4	**1.71**
32	Goh	Goh	7.94	90	18	11	258	15	7	5	1.05
33	Goh	Uphara	8.1	150	22	23	215	18	7	4	0.76
34	Hanspura	Dewkund	8.14	60	10	9	178	28	14		0.69
BIS (2012)	*Acceptable limit*		*<6.5*	*200*	*75*	*30*	*200*	*250*	*200*	*NA*	*1*
	Permissible limit (in the absence of alternate source)		*>8.5*	*600*	*200*	*100*	*600*	*1000*	*400*	*45*	*1.5*

Value in mg/l

From the above table it can be inferred that in general, water is potable. However, slighted elevated concentration of fluoride has been found at few locations.

3.6.3 Hardness

The term hard and soft as applied to water date from Hippocratus (480-354 BC), the father of medicine, in his treaise on public hygiene. Hardness results from the presence of divalent metallic cation, of which calcium and magnesium are the most abundant in ground

water. These ions reacts with soap, hard waters are unsatisfactory for household cleansing purposes.

The degree of hardness in water is commonly based on the classification given by Sawyer and Mc Carty, 1967 (Table 2.3).

Hardness (mg/l) as $caco_3$	*Water Class*
0-75	Soft
75-150	Moderate
150-300	Hard
300-600	Very hard
>600	Extremely hard

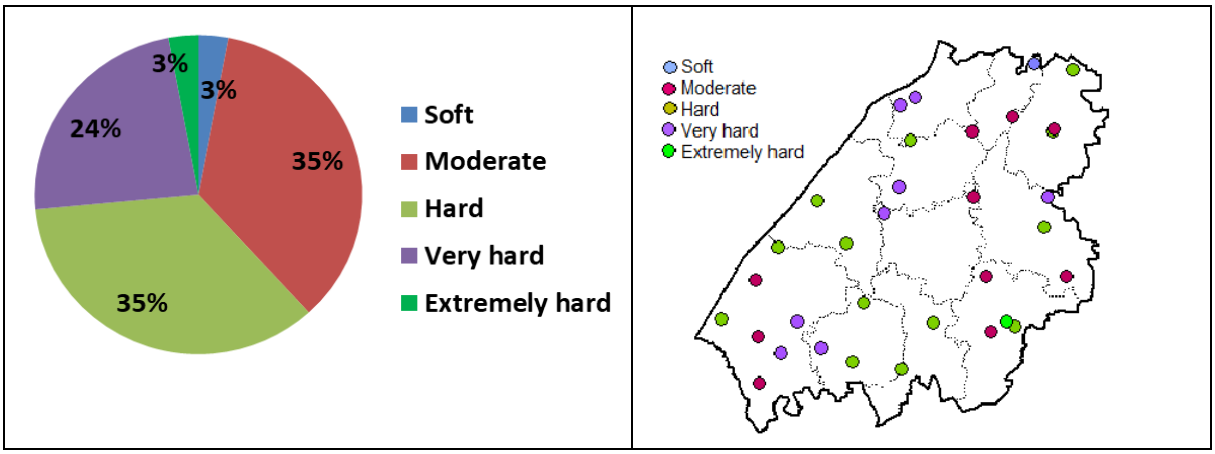


Figure 24: Hardness of ground water

In Aurangabad district, hardness ranged from 139 to 690 mg/l (as $CaCO_3$). Out of 16 sample analysed 50% are categorised as 'Hard' and 38% as 'Very hard' **(fig. 19).** Rest of the sample are 'moderately hard' have shown hardness value less than 150 mg/l (as $CaCO_3$.

3.6.4 Suitability for Irrigation

The suitability of groundwater for irrigation purpose is based on its chemical characterstics which creates soil condition hazardous to crop growth and yield. It depends on the following prevailing criteria:-

1. Salinity :- Total concentration of soluble salt
2. Sodicity: Concentration of sodium relative to calcium and magnesium.
3. Relative proportion of carbonates + bicarbonate to calcium + magnesium.
4. Concentration of boron and other that may be toxic to plant growth.

Based on the above, many method has been suggested by the scientst/chemist to check its suitability. Suggsted method wise suitability of groundwater for irrigation purpose is given in the table below:-

Table 13: Suitability of ground water for irrigation purpose

Block	Location	Sodium Adsorption Ratio	Sodium Soluble Percentage	Residual Sodium Carbonate	Kelley's Index	Magnesium Ratio	Permeability Index
		Na/sqrt (Ca+Mg/2)	*Na*100/ Ca+Mg+Na*	*(HCo3+Co3) /(Ca+Mg)*	*Na/(Ca+Mg)*	*(Mg*100)/ (Ca+Mg)*	*Na+sqrtHCo3) /(Ca+Mg+Na)*100*
Barun	Baruna	0.63	25	1.6	0.33	32	1
Daudnagar	Daudnagar	0.84	30	0.7	0.43	37	5
Deo	Deo	1.36	42	2.2	0.71	**65**	7
Goh	Deohara	1.73	47	1.9	0.88	**58**	3
Nabinagar	Dhanibar	1.76	47	1.0	0.88	**50**	4
Goh	Deohara_goh	5.44	**73**	2.2	**2.72**	**52**	7
Goh	Dhobi Tola	0.11	6	1.5	0.06	27	0
Madanpur	Madanpur	0.31	14	0.9	0.16	32	1
Nabinagar	Mahuli	0.37	16	0.9	0.19	**64**	1
Nabinagar	Nabinagar	0.23	11	1.8	0.12	38	0
Nabinagar	Narai Kala	0.90	32	0.6	0.47	**66**	9
Obra	Obra	1.68	46	0.5	0.87	**62**	8
Aurengabad	Patraya	0.46	19	0.5	0.23	44	2
Deo	Pataya	1.73	47	0.5	0.90	**64**	12
Rafiganj	Rafiganj	2.73	58	1.6	1.39	**61**	9
Rafiganj	Tinari Morh	0.90	31	1.2	0.45	**58**	9
Hanspura	Sonhatu	0.90	**60**	1.4	1.47	**50**	4
Rafiganj	Barahi	0.90	36	1.4	0.55	**65**	1
Daudnagar	Thakur Bigha	0.90	19	0.6	0.24	**53**	2
Daudnagar	Mohan Bigha	0.90	31	1.2	0.44	**52**	2
Barun	Urdina	0.90	33	1.1	0.49	**59**	2
Nabinagar	Badem	0.90	27	1.1	0.38	**67**	1
Nabinagar	Tetariya	0.90	32	1.1	0.46	**64**	1
Nabinagar	Kharundha	0.90	47	1.6	0.90	**58**	2
Nabinagar	Jai hind tendu	0.90	28	0.5	0.40	**80**	4
Kutumba	Kutumba	0.90	42	0.7	0.74	**78**	7
Kutumba	Risiap	0.90	31	1.1	0.46	**73**	1
Kutumba	Kauriyari	0.90	**53**	1.0	1.13	**52**	4
Madanpur	Jalwand	0.90	44	1.7	0.78	**65**	2
Madanpur	Salempur	0.90	70	**3.1**	2.38	33	5
Rafiganj	Kasma	0.90	46	1.1	0.84	**65**	2
Goh	Goh	0.90	**61**	2.3	1.58	**51**	3
Goh	Uphara	0.90	30	1.2	0.43	**63**	1
Hanspura	Dewkund	0.90	68	2.4	2.09	**59**	3
	Suitable	***<10***	***<50***	***1.25***	***<1***	***<50***	***25-75***
	Marginal	***NA***	***NA***	***1.25-2.5***	***1.2***	***NA***	***NA***
	Not suitable	***>10***	***>50***	***>2.5***	***>2***	***>50***	***>75***

Ionic concentrations are calculated in milliequivalents per litre

Above table shows that except magnesium ratio, in general, the ground water quality of the area is within the range of 'suitable'. Thus based on the above table it can be inferred that the ground water of the phreatic aquifer is suitable for irrigation purpose.

3.6.5 USSL diagram

The United States Soil Laboratory Staff's (USSLS's) diagram classifies the water quality into 16 zones to assess the degree of suitability of water for irrigation **(Figure 20)** in which waters have been divided into C1, C2 C3 and C4 types on the basis of salinity hazard

and S1, S2, S3, S4 types on the basis of sodium hazard.

The classification of irrigation waters with respect to SAR is primarily based on the soil. Sodium sensitive plants may, however, suffer injury as a result of sodium accumulation in the plant tissue when exchangeable sodium accumulation in the physical condition of the soil. Sodium-sensitive plants may, however, suffer injury as a result of sodium accumulation in the plant tissue when exchangeable sodium values are lower than those effective in causing deterioration of the physical condition of the soil.

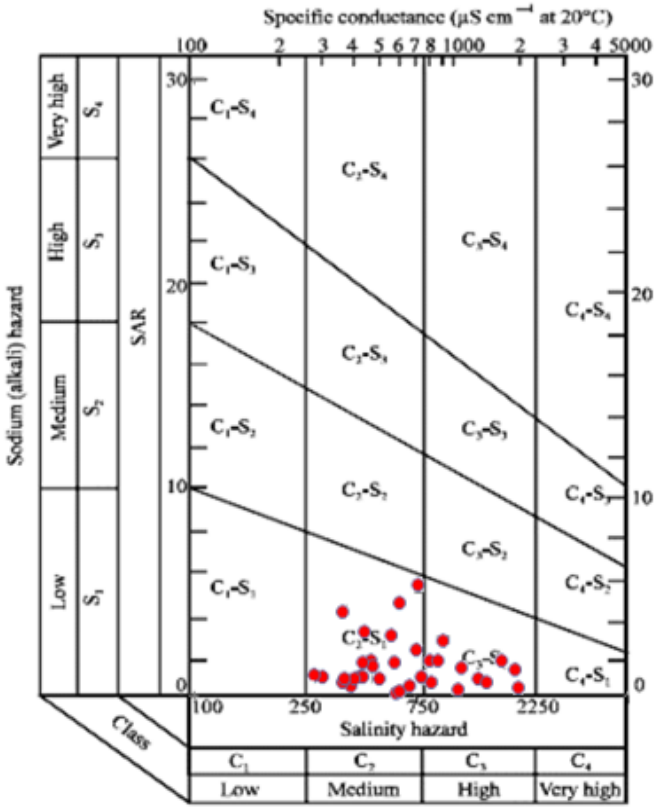


Figure 25: US Salinity Diagram

The salinity hazard classes (After Handa 1969) and the EC value observed has been given below

Classes	*EC (μS/cm)*	*Water salinity*
C_1	0-250	Low (excellent quality)
C_2	250-750	Medium (good quality)
C_3	750-2250	High (permissible quality)
C_4	2250-600	Very high

The **Figure 25** shows that all the samples have fall in low sodium hazard class and medium to high salinity hazard.

This attempt for determining salinity hazard is based on SAR only. The other factors like cropping pattern, soil type, rainfall recharge, climate etc. should also be considered.

3.7 Aquifer Disposition

Fence and panel (2-D) diagrams are prepared to identify spatial disposition and vertical extent of Aquifer. The tube wells, drilled by Central Ground Water Board as Exploratory Well and Production Well as well as the tube wells drilled by Bihar State Development Authority before 1986 also included here has been taken for the 2-D diagrams. The location of these wells are shown in **Figure – 26.**

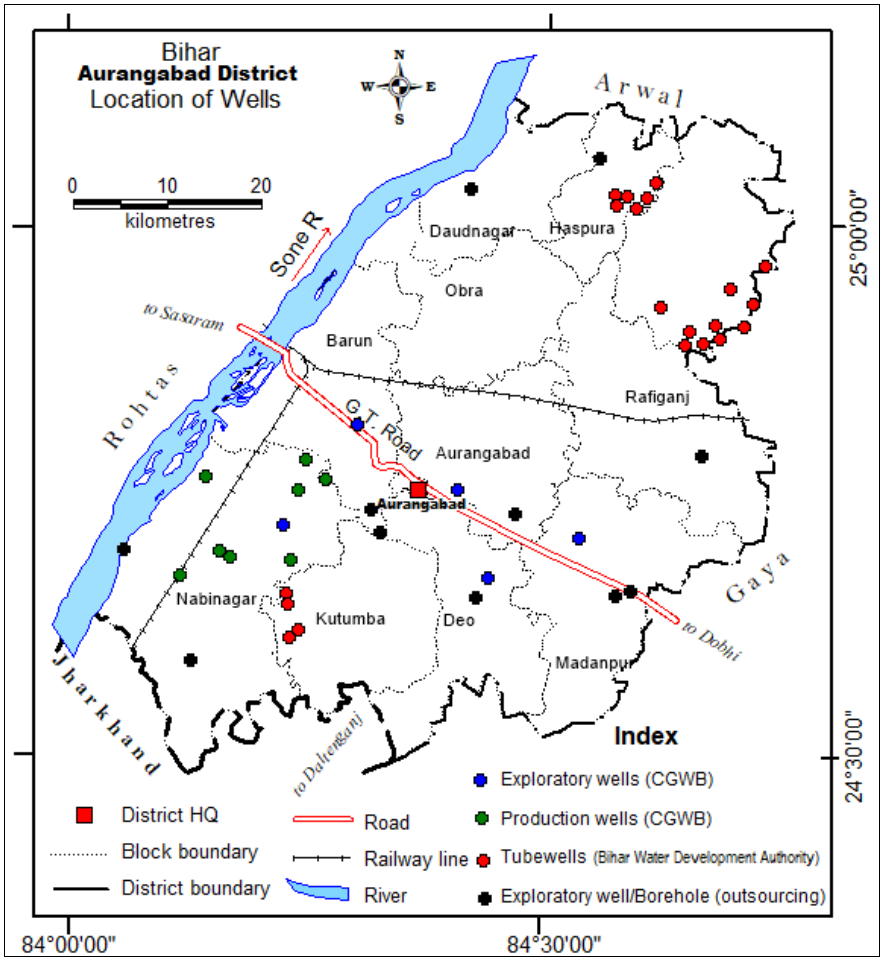


Figure 26: Location of tube wells

2.7.1 Depth to Bed Rock

To understand subsurface lithology, depth to bedrock (DTBR) map has been prepared. The map represents the lower boundary of overlying sediments **(Fig.11**). Based on the

available groundwater exploration data, VES point data and exposed crystalline rock on surface, the depth to bed rock map has been prepared in GIS environment, using *Mapinfo*™ and *Vertical Mapper*™ softwares. Data interpolation is done through *Triangulation.* However, map is prepared based on limited field data and is subject to change with incorporation of more data point.

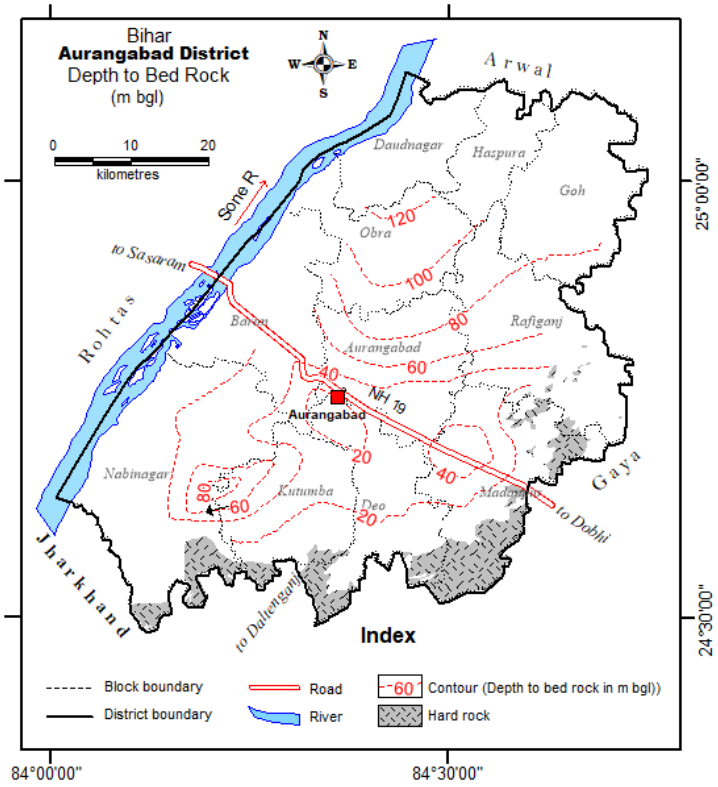


Figure 27: Depth to bedrock-contour (m bgl)

The map indicates that hard rocks are exposed near southern boundary. As we move towards northeast DTBR gradually increases with some inlier at places. Around Aurngabad town, it is nearly 40 m bgl and around Rafiganj town it is 40 to 50 and further 75-90 m bgl in southern part of Goh block. Further in the north it become deeper down to 100-135 m bgl around Daudnagar. Near Hanspura town DTBR is more than 150 m bgl.

3.1.1 Aquifer Disposition in the area

Preparation of litholog is one of the important components of ground water exploration being carried out by Central Ground Water Board (CGWB). The drilled cuttings are collected at regular interval or whenever there is any change in lithology during exploratory drilling. This data has been collected from the previous reports of CGWB as well as State agencies and new data are also generated to fill-up the data gap. Various cross sections and fence diagram has been prepared with the help of lithology to know the aquifer disposition of the area.

The aquifer geometry on regional scale has been attempted to establish in Aurangabad district to cover all administrative blocks as per the available data. Principal aquifers in the area have been delineated by grouping the fine to medium sand, coarse sand and gravelly sand as aquifers separated by considerable thickness of clay. These cross sections/fence diagrams are given below along with the map to locate the area concerned **(Figure 28 to 33).**

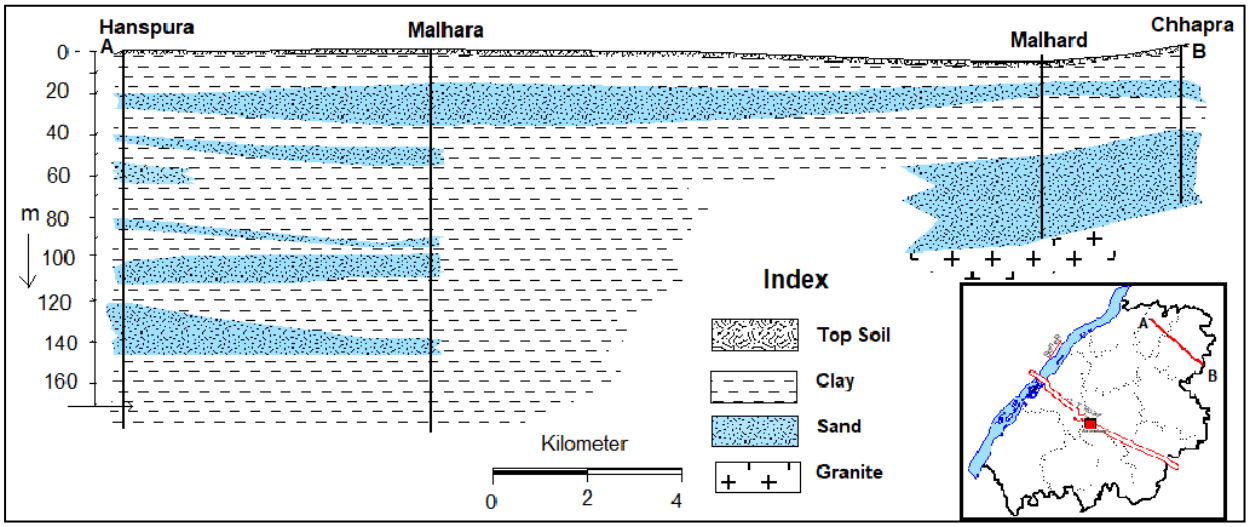


Figure 28: Cross section along the line A-B

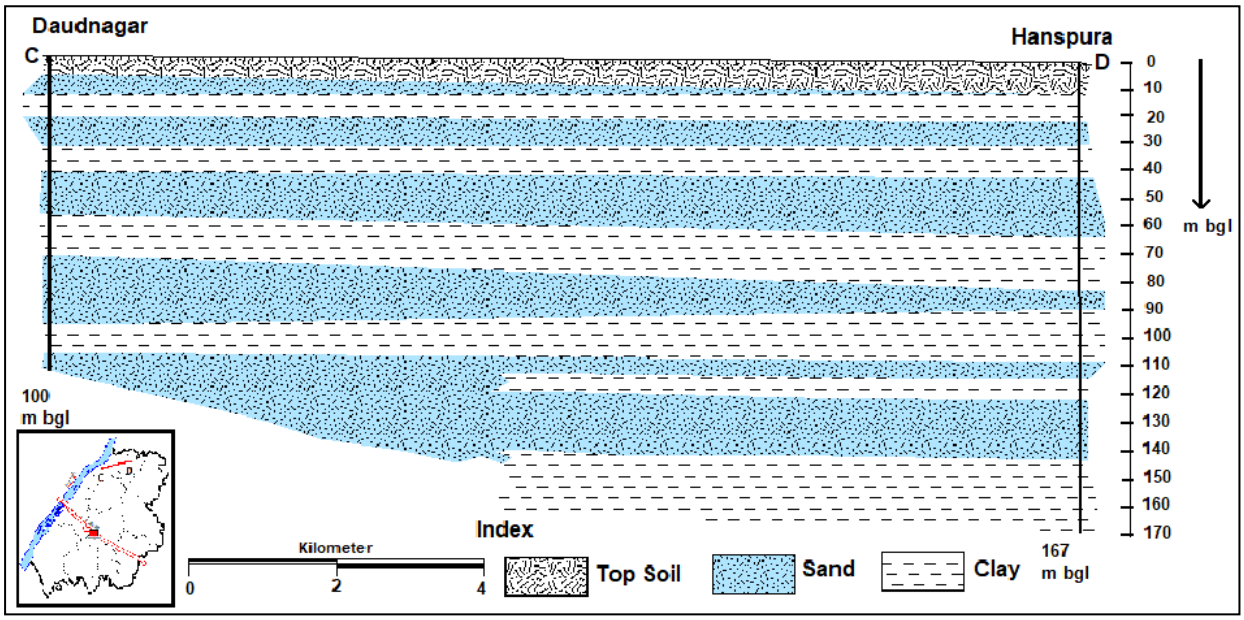


Figure 29: Cross section along the line C-D

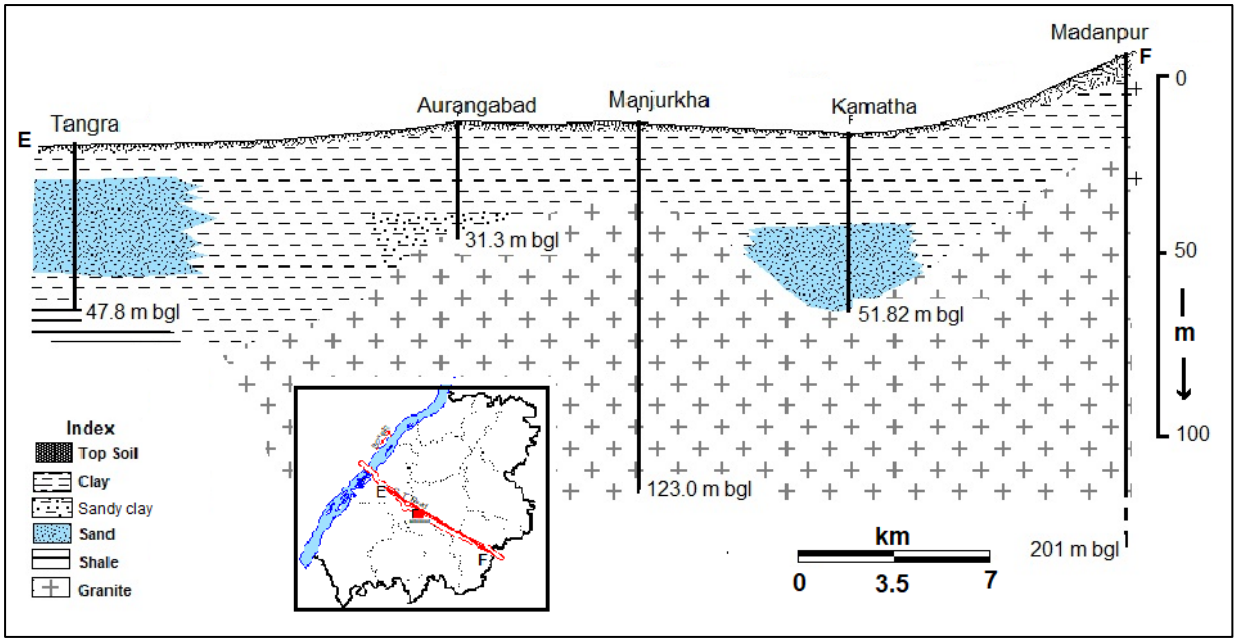


Figure 30: Cross section along the line E-F

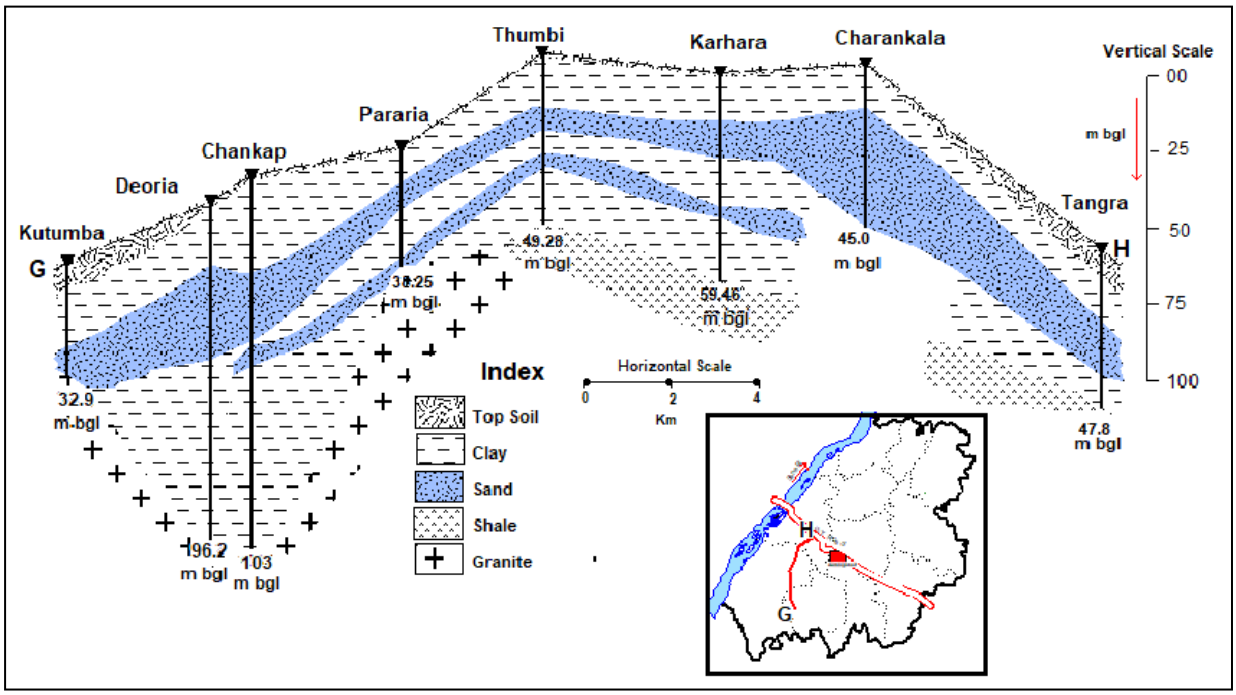


Figure 31: Fence diagram along the line G-H

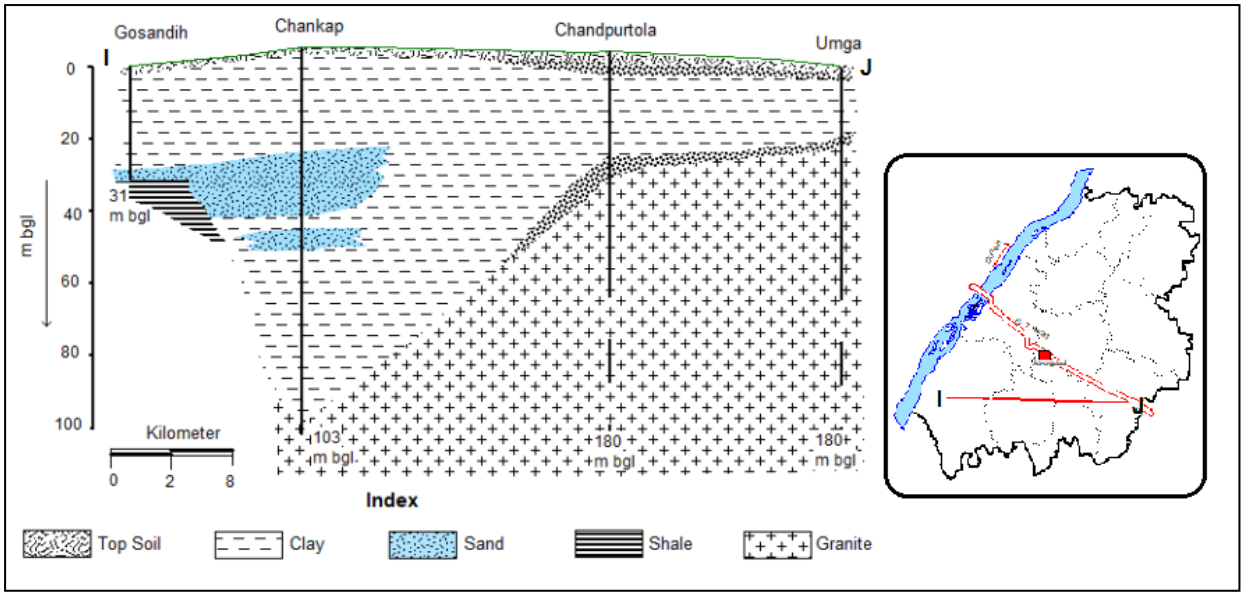


Figure 32: Cross section along the line I-J

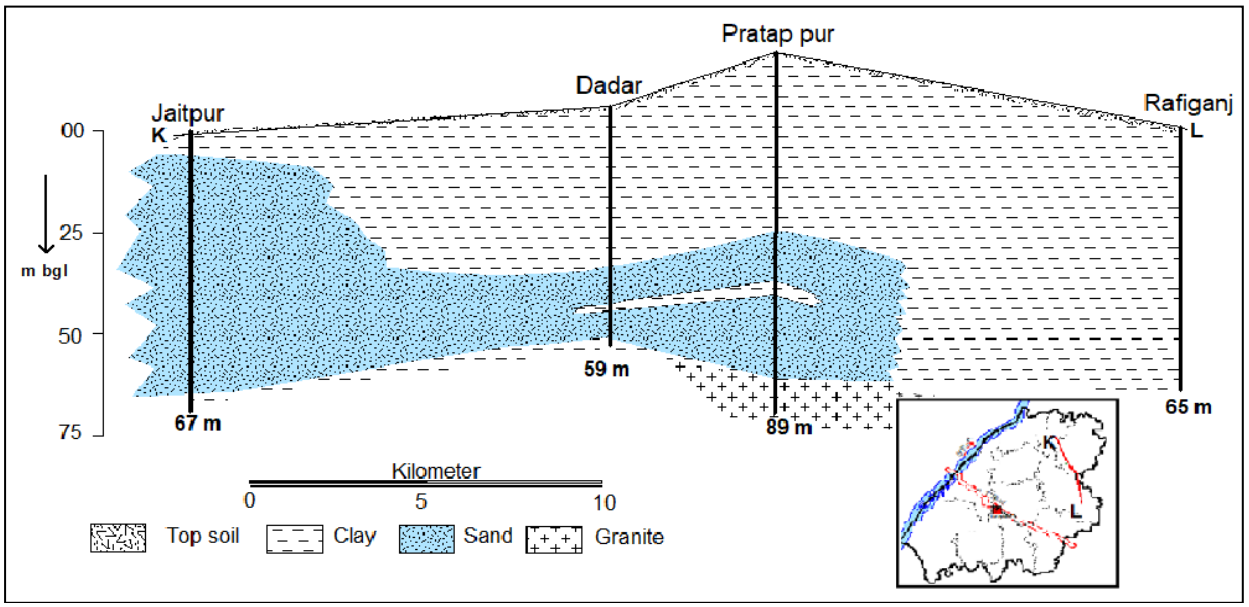


Figure 33: Cross section along the line K-L

3.2 Aquifer Characterisations

Characterization of aquifer upto ~200 m bgl in the study area has been arrived at by convergence of the observations from the study of the different lithological sections, fence diagrams, geo-electrical sections, sections based on lithologs and overall lithological model of the area. All these figures reveal the presence of a thick pile of alluvial sediments in the northern part of the district with alternation of various grades of sand with clay and silt. The area is characterized by occurrence of fairly thick sands of various grades forming aquifers.

Thickness of sediments gradually increases towards north. Near southern and eastern boundary depth to bed rock is shallow. In this zone, fissured aquifer is explored in hard rock where two set of fracture encountered. The first set of fracture encountered between 32 to 70 m bgl and 2nd fracture between 120 to 150 m bgl.

The perusals of the sections, fence diagram and lithological model indicate that there are mainly two principal aquifer systems below the top aquitard layer (water table aquifer) upto 200 m depth separated by clay and sandy clay layers.

Towards further north, in Aurangabad, Barun Rafiganj and Obra blocks, depth to bed rock is down to 100 m. The 1st porous aquifer delineated in the overlying sediments. This zone is extended towards south in part of Nabinagar, and small western part of Kutumba block. At Chnakap and Deoria village (Nabinagar) thickness of 1st aquifer is ~10 m within the depth of about 100 m bgl. In Barun block aquifer thickness has been observed 20-30 meter within the depth of 100 m. In southern part of Aurangabad block and eastern part of Rafignaj block the depth to bed rock is shallow with overlying thick clay layer. This clay layer, at places, is sandy.

In Hanspura and Dudnagar block there are two aquifer systems. The 1st aquifer of 20-30 m thick, within the depth of 70-80 m separated by 20-30 m thick clay layer from 2nd aquifer. About 20-30 m thick 2nd aquifer has been observed directly over the hard rock basement or a clay layer. The pumping test at Hanspura town indicates that 2nd aquifer is semi-confined in nature.

As per the available data the discharge of the wells located in fissured aquifer is upto 10 lit/Sec. The yield of the wells of 1st aquifer has been found upto 40 lps (Mathurapur, Nabinagar) and the maximum cumulative discharge of the 1st and 2nd aquifer in further north is 57 lps (Nagauli and Malhara village, Hanspura block.)

CHAPTER 4

4 GROUND WATER RESOURCES

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

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

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

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

The equation can be further elaborated as

$$\Delta S = RRF+RSTR+RC+RSWI+RGWI+RTP+RWCS \pm VF \pm LF - GE - T - E - B$$

Where,

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

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

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

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

The dynamic Ground Water Resources has been assessed by CGWB, MER, Patna in association with Minor Water Resources Department, Bihar based on GEC, Methodology

2015. The summarized detail of Annually Replenishable or Dynamic Ground Water Resources of Aurangabad district is in **Table-14 & 15.**

As per the assessment year 2020, all 11 block are categorised as 'safe'. The stage of ground water extraction has been ranged from 23 (Barun) to 60 % (Kutumba). It indicates that there is ample scope for ground water development. The result of the assessment of Dynamic Ground Water Recourses is given in **Table 15 and Table 16.**

Table 14: Net ground water availability (GWRE - 2020)

SN	Administrative Units	Recharge from Rainfall		Recharge from Other Sources		Total Annual Ground Water Recharge	Total Natural Discharges	Annual Extractable Ground Water Resource
		Monsoon	Non-monsoon	Monsoon	Non-monsoon			
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)
1	Aurangabad	6297	121	1109	881	8407	841	7566
2	Barun	6815	131	1347	1052	9345	935	8411
3	Daudnagar	4316	83	508	426	5332	533	4799
4	Deo	4451	85	674	220	5430	543	4887
5	Goh	6647	127	1048	953	8776	878	7899
6	Haspura	2719	58	1520	272	4568	228	4340
7	Kutumba	5698	109	537	666	7010	701	6309
8	Madanpur	5905	113	652	488	7159	716	6443
9	Nabinagar	11832	227	451	416	12926	1293	11634
10	Obra	5817	112	562	554	7045	705	6341
11	Rafiganj	7055	135	946	949	9086	909	8177
	Total	67553	1301	9354	6878	85086	8280	76806

Table 15: Stage of ground water development

SN	*Administrative Units*	*Ground Water Extraction for Irrigation Use*	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction*	*Categorization (Over-Exploited/ Critical/ Semicritical/ Safe)*
		(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*	
1	Aurangabad	1463	840	108	2411	944	5052	32	safe
2	Barun	1593	345	90	2027	387	6341	24	safe
3	Daudnagar	891	537	63	1491	603	3242	31	safe
4	Deo	917	298	54	1269	335	3581	26	safe
5	Goh	2604	404	144	3152	454	4697	40	safe
6	Haspura	1257	304	81	1642	342	2661	38	safe
7	Kutumba	3245	390	171	3806	439	2455	60	safe
8	Madanpur	2025	364	117	2506	409	3892	39	safe
9	Nabinagar	1918	608	126	2652	684	8906	23	safe
10	Obra	1897	440	117	2454	495	3832	39	safe
11	Rafiganj	3330	661	207	4198	742	3898	51	safe
	Total	21138	5192	1278	27608	5832	48557	35.95	

CHAPTER 5

GROUND WATER RELATED ISSUES

5.1 Identification of issues

There is diversity in the availability of Ground water in Aurangabad. Hard rocks are found at shallow depth in southern and eastern area of the district covering part of the Goh, Kutumba, Nabinagar, Dev, Madanpur and Rafiganj blocks. In this area thickness of alluvial is negligible to few meters. In this area, besides weathered residuum, ground water occurs in secondary porosity of rock i.e. fracture, cracks *etc*. Maximum discharge found in this area is upto 10 lps (litre per second) only. Comparison of 4^{th} and 5^{th} MI census figures indicate that the number of deep tube wells is increased in this area.

Alluvial thickness in the central part of the district has been found to be 40 to 50 meters. Ground water exploration data indicates the presence of single aquifer system. Analysis of the data reveals that canals water supply reduces the dependency on ground water. There is a possibility to increase ground water development in this area for future need.

The alluvial thickness in the northern part of the district is about 150 m. Drilling data indicates 2 (two) aquifer system in this area. Although, in this area also, canals water supply reduces the dependency on ground water, ground water may be developed further to fulfils the future need as the assessment units (blocks) are categorised as 'safe' (GWRA – 2020)

5.2 Major Ground Water Issues

1. In southern and eastern part of the district (Goh, Kutumba, Nabinagar & Rafiganj , people are shifting towards deep tube wells.
2. Ground water exploration data shows that western narrow part along the river Sone characterised by the Vindhyans rocks, have no any potential zone for ground water extraction.
3. As per the ground water resources estimation – 2020, block wise estimated Stage of Ground Water Extraction of the district is 35.95% only. It shows that there is a scope to develop ground water to fulfil need in future.

CHAPTER 6

MANAGEMENT STRATEGIES

6.1 Possibility of construction of additional shallow tube wells

On the basis of Ground Water Resource Estimation -2017, additional number shallow tube well for alluvium area for each block has been calculated within the safe limit of the Stage of Development upto 70% by considering unit draft for each tube well 1.69 ha m. As per the calculation, a total of 16618 number of tube wells can be constructed to fulfil the future demand of ground water. The block wise additional number of tube well is given in table.

Table 16: Additional Nos. of STW feasible based on GW availability

Block	*Total Annual Ground Water (Ham) Recharge*	*Annual Extractable Ground Water Resource*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025 (Ham)*	*Stage of Ground Water Extraction (%)*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Aurangaba	8407.18	7566.46	2411.17	943.78	31.87	5296.52	1326.16	1.69	785
Barun	9345.19	8410.67	2027.15	387.15	24.10	5887.47	2136.05	1.69	1264
Daudnagar	5331.98	4798.78	1490.54	602.98	31.06	3359.15	836.65	1.69	495
Deo	5430.15	4887.13	1269.42	335.21	25.97	3420.99	1130.93	1.69	669
Goh	8776.37	7898.73	3151.82	453.62	39.90	5529.11	1916.00	1.69	1134
Haspura	4568.39	4339.97	1641.91	341.96	37.83	3037.98	960.03	1.69	568
Kutumba	7010.1	6309.09	3805.89	438.52	60.32	4416.36	1454.21	1.69	860
Madanpur	7158.98	6443.08	2505.83	408.97	38.89	4510.16	1523.95	1.69	902
Nabinagar	12926.39	11633.7	2652.49	683.53	22.80	8143.63	2806.60	1.69	1661
Obra	7045.2	6340.68	2454.31	494.61	38.71	4438.48	1407.59	1.69	833
Rafiganj	9085.81	8177.23	4197.84	742.05	51.34	5724.06	1711.12	1.69	1012
Total	85085.74	76805.5	27608.3	5832.38	402.8	53763.9	17209.2		**10183**

6.2 Artificial Recharge

Although, all the block are in safe category the artificial recharge should be encouraged to arrest the decline of ground water level caused by the increasing demand of ground water.

Availability of non-committed source water for the purpose of artificial recharge to groundwater is the primary concern for the preparation of the artificial recharge plan, as data availability for surplus runoff is only river-basin or sub-basin wise, and not directly co-relatable with identified feasible areas for artificial recharge.

Basin wise surface water availability with 75% dependability has been utilised from 2nd Bihar State Irrigation Commission Report (1994). However, the commission noted that for South Bihar, rainfall can be directly correlated with river discharge. The report indicates that

river basin catchments of Bihar contribute about 28.8 BCM towards surface water resource which is about 9.26% of total surface water resource of the State.

Hence, considering entire non-monsoon rainfall as committed, excess monsoon rainfall can be safely harnessed to replenish groundwater table without affecting surface water resource. For the present calculation for artificial recharge, 60% of the normal monsoon rainfall for identified feasible areas is considered as available non- committed surface runoff.

Table 17: Identified Area, Computed Storage Volume and Source Water availability for Artificial Recharge to Ground Water

Area	*Area Identified for AR*	*Volume of De-saturated Zone*	*Source Water Requirement*	*Total Surplus Runoff Available*
(sq.km.)	**(sq.km.)**	**(MCM)**	**(MCM)**	**(MCM)**
3302.84	999.55	425.41	655.13	2396.33

Considering hydrogeological diversities, geomorphological set up and relative groundwater potentialities in the district, various types of artificial recharge / conservation structure is possible for augmentation & conservation of ground water resources in different hydrogeological setup. To simplify the situation, based on generalized hydrogeological, a general norm has been adopted to arrive at number of various artificial recharge structures feasible. However, actual numbers of structures implementable may vary significantly based on scale of implementation. Based on available literature and previous experiences, unit cost of structures is also worked out. Terrain-wise norms adopted along with unit cost estimates for different types of structures are given in **Table -19, Figure - 34.** Suitable area for artificial recharge has been identified where the post monsoon (2018) water level is more than 3 m bgl

The urban area for in Aurangabad district for artificial recharge is identified as Aurangabad, Obra, Daudnagar, Hanspura and Rafiganj.

Table 18: Details of Norms adopted for Artificial Recharge

Terrain Type	*Recharge Structure Type*	*Structure ID*	*Source water Allocation Percentage*	*Storage Capacity (MCM)*	*Number of Filling*	*Dimension*	*Unit Cost (in lakhs) (Approx)*
Hard Rock Area	Percolation Tank	H1	20%	2.0	01	100 m x 4.5 m (03 Sq. Km Catchment)	30.0
	Gully Plug	H2	20%	0.05	05	10 m x 2 m	0.40
	Contour Bunding &	H3	35%	0.05	05	300 – 400 m	2

Terrain Type	*Recharge Structure Type*	*Structure ID*	*Source water Allocation Percentage*	*Storage Capacity (MCM)*	*Number of Filling*	*Dimension*	*Unit Cost (in lakhs) (Approx)*
	Trenching						
	Check Dam	H4	25%	0.20	02	15 m x 3 m	20.0
Marginal Alluvial / Alluvial Area	Nala Bunding	M1	20%	0.05	05	15 m x 2 m	1.0
	Contour Bunding & Trenching	M2-A	20%	0.05	05	300 – 400 m	2.0
	Recharge Shaft	M3	25%	0.05	01	5 m x 5 m x 10 m / 60 days Op. period	5.0
	Percolation Tank	M4	35%	2.50	01	100 m x 4.5 m (04 Sq. Km Catchment)	30.0
Alluvial Area	De-silting of existing tank /pond /talao	A1	50%	0.20	02	100 m x 80 m x 6 m	5.0
	Injection Well in Village Tank	A3	10%	0.03	02	100 m x 100 m x 3 m 40 m Boring	4.0
	Renovation of traditional Ahar-Pyne System	A4	40%	0.10	01	As per Existing Structure / Km	20.0
Urban Areas	Roof-top Rain Water Harvesting Structures	U1	80%	0.00009	01	100 m^2 (Roof) 40 m Boring	1.0
	De-silting and revival of existing ponds	U2	20%	0.006	02	50 m x 20 m x 6 m	10.0

Table 19: Type-wise Feasible Numbers / Area (Sq. Km) / Length (Km) of various Artificial Recharge Structures

Structure	*Percolation Tank*	*Gully Plug*	*Contour Bunding & Trenching*	*Check Dam*	*Nala Bunding*	*Contour Bunding & Trenching*	*Recharge Shaft*	*Percolation Tank*	*De-silting of existing tank /pond /talao*	*Injection Well in Village Tank*	*Renovation of traditional Ahar-Pyne System (km)*
Structure ID	**H1**	**H2**	**H3**	**H4**	**M1**	**M2-A**	**M3**	**M4**	**A1**	**A3**	**A4**
Feasible Numbers / Area (Sq. Km) / Length (Km)	8	131	131	6	21	165	330	15	602	802	188

Table 20: Type-wise Cost Estimate (in lakh Rs.)

Structure	*Percolation Tank*	*Gully Plug*	*Contour Bunding & Trenching*	*Check Dam*	*Nala Bunding*	*Contour Bunding & Trenching*	*Recharge Shaft*	*Percolation Tank*	*De-silting of existing tank /pond /talao*	*Injection Well in Village Tank*	*Renovation of traditional Ahar-Pyne System*	***District Total***
Structure ID	*H1*	*H2*	*H3*	*H4*	*M1*	*M2-A*	*M3*	*M4*	*A1*	*A3*	*A4*	
Cost Estimate (in lakh Rs.)	240	52.4	262	120	21	330	1650	450	3010	3208	3760	**13103.4**

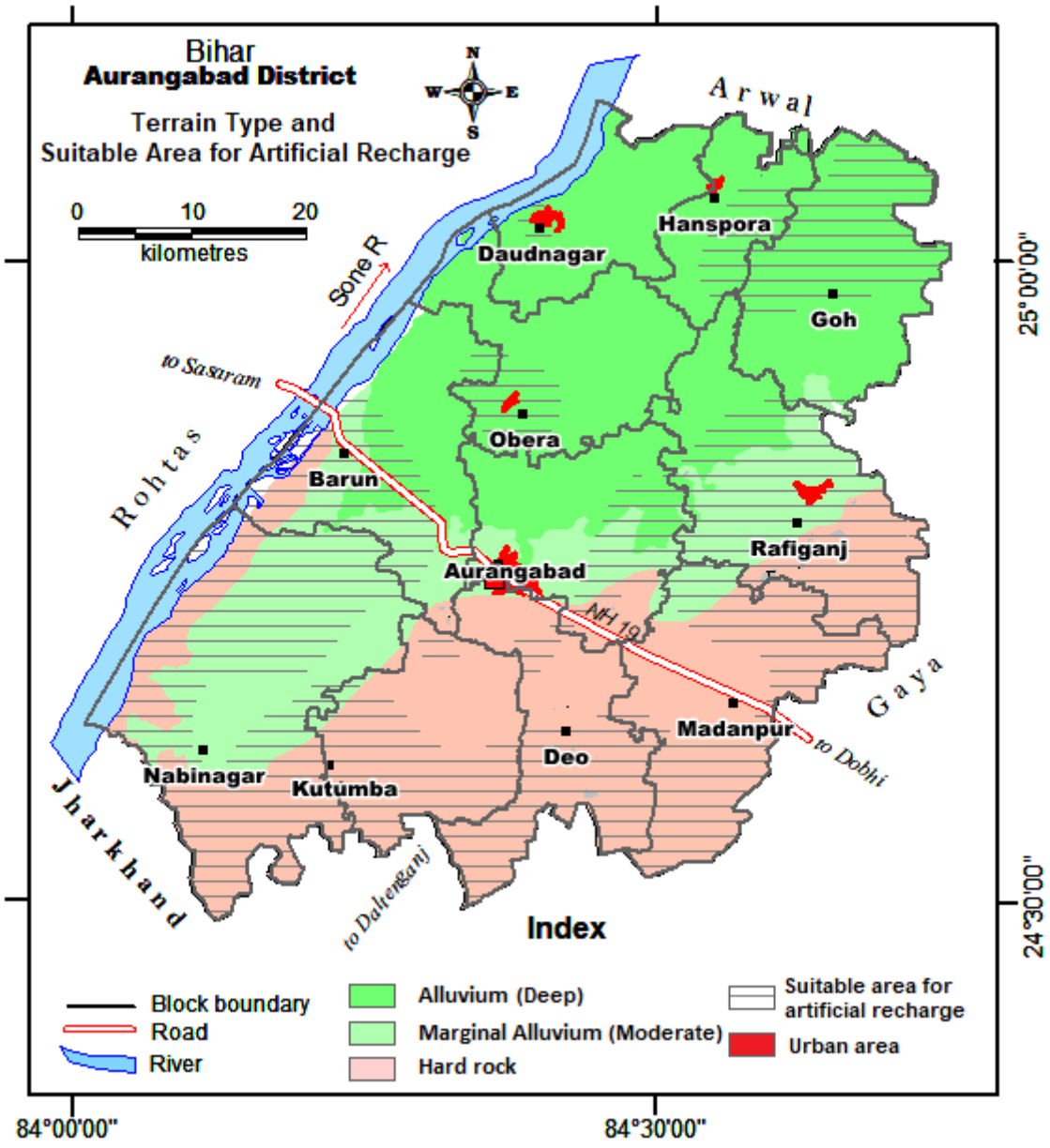


Figure 34: Terrain types and suitable area for Artificial Recharge

6.3 Ground Water Development along Sone River

In a long narrow patch along the river Sone, geologically characterised by the Vindhyan group of rocks ground water potential zone is not significant. Therefore a geophysical survey has been carried out to identify the extension of sand bed towards the land area.

The aim of the survey was to identify the thickness and areal extension of the river sand toward the land. Approximately 10.5 km profiling was carried in and around the Barun town of Aurangabad district using Schlumberger array. At each station on the profiling, a VES was conducted with AB/2= 150 m. The apparent resistivity values were joined to get the horizontal variation as well as VES were interpreted to get the vertical resistivity variation.

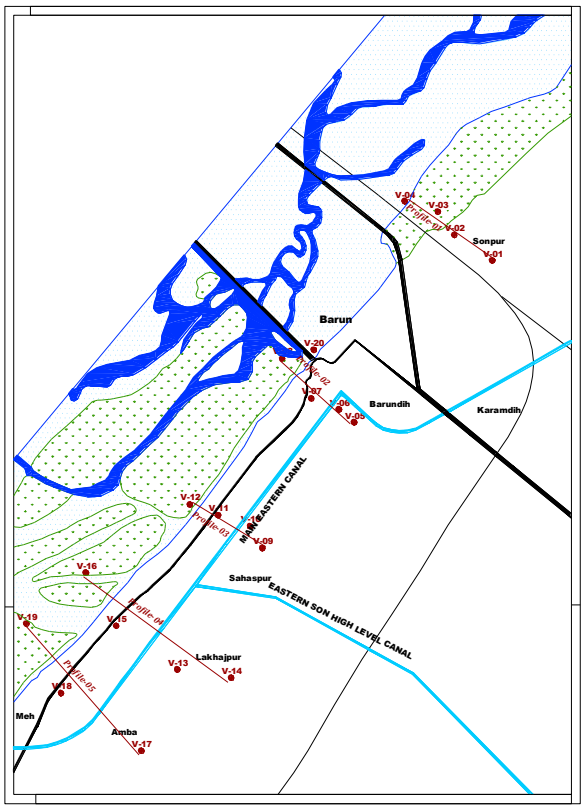


Figure 35: Location Map of Resistivity Survey in Barun, Aurangabad, Bihar.

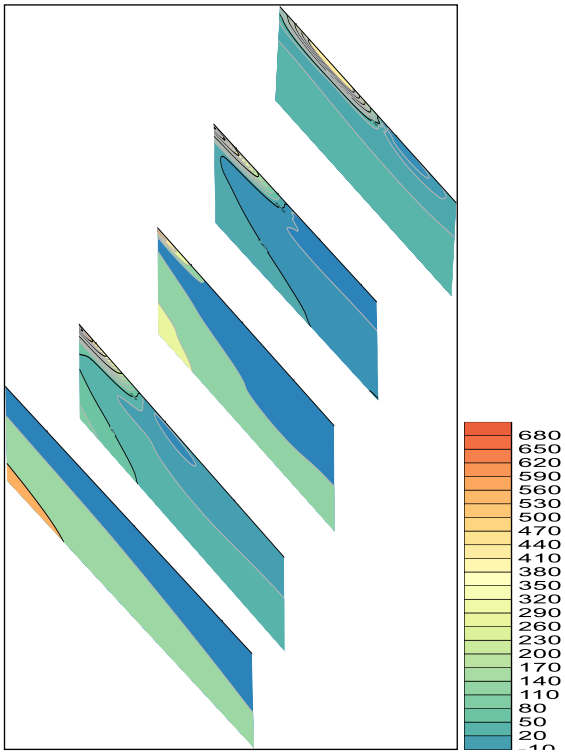


Figure 36: Apparent Resisitivity along the profil line in Barun area, Aurangabad.

Observation:-

- Bed rock is present in the river bed around the depth of 50-70 m bgl in the central part near the Barun town where as bed to bed rock is shallow in the southern part.
- Loose and dry sand zone present in the flood plain with a thickness varies from 2 to 7 m bgl.
- Sand zone present in the flood plain is entrapped by a clay layer towards the land.

- Thickness of the sand zones varies from 50 m to more than 100 m at places.
- A weathered zone/ coarse sand with rock fragments is present below the sand zone.

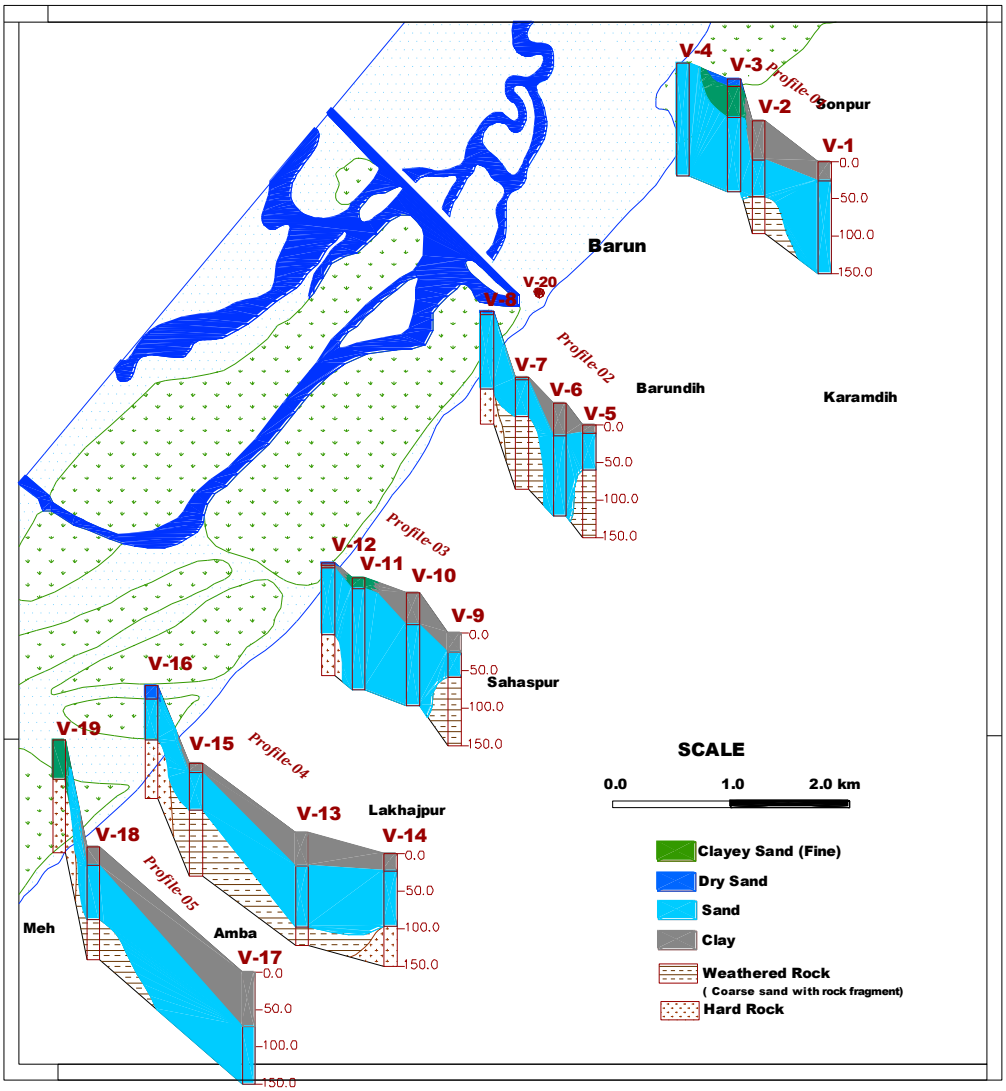


Figure 37: Disposition of different litho-units along the River Son in Barun area.

Interpretation:-

- ❖ The River Son is flowing over a hard basement and the depth to basement varies from 50.0 to 70.0 mbgl (at places it is around 100.0 m bgl).
- ❖ Above the basement a thick sand layer is present throughout the study area.
- ❖ This sand layer extends at least 1.0 t0 1.5 east ward within the land.
- ❖ In the land (eastern side of the flood plain), it is overlain by a clay zone.
- ❖ This sand bed is aerially extended over the study area and interconnected with River Son. This zone may be good source of ground water.
- ❖ Drilling upto the depth of 50.0 to 80.0 mbgl (at places 100.0 m bgl) may yield sufficient amount of water.

CHAPTER 7

BLOCK WISE AQUIFER MANAGEMENT PLANS

7.1 Aurangabad block

7.1.1 General Information

1.	Area (ha)		:	28687 ha
2.	No. of town		:	1
3.	No. of village		:	157
4.	Population	Total	:	283193
		Rural	:	180949
		Urban	:	102244
5.	Normal rainfall	(mm)	:	
6.	Depth-range wise No. of ground structure (5^{th} MI Census)	< 20 m	:	-
		20-35 m	:	-
		35-40 m	:	51
		40-60 m	:	710
		60-70 m	:	2

7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
6296.69	120.76	1108.9	880.83	8407.18	840.72	7566.46

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
1463	840.18	108	2411.17	944	5052	32	Safe

In Ha m

7.1.2 Aquifer Disposition

1. Aquifer disposition : 1^{st} aquifer only. Depth range:- 20-30 to 40- 50 m bgl
Discharge -up to 10 lps (fissured aquifer)

2. Water level (Shallow aquifer): Pre-monsoon : 5.9 to 9.93 m bgl
Post-monsoon : 1.43 to 3.71 m bgl
Fluctuation : 2.84 to 6.22 m

3. Chemical quality of ground water : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca2+*	*Mg2+*	*Na+*	*K+*	*CO32-*	*HCO3-*	*Cl-*	*SO42-*	*NO3-*	*F-*
Patraya	8.28	409	265.9	340	76	36	36.01	1.1	0	197	21	20	17	0.22

In mg/l

7.1.3 Aquifer Management Plan

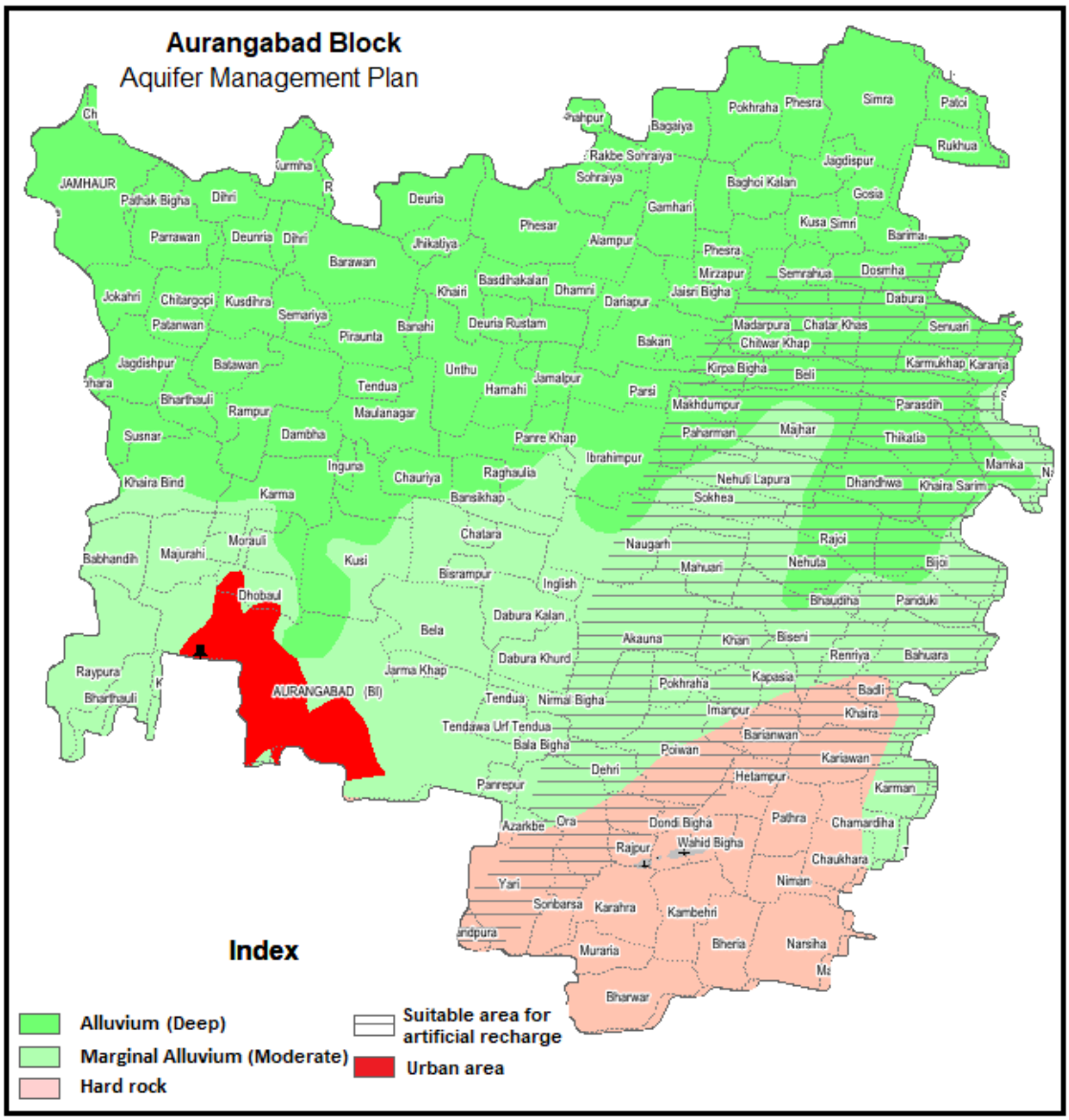
1. Ground water development :

As per the GW resources Estimation -2020, stage of development of the block is 18.34% only hence categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well by considering the SOD, upto 70% is calculated and given in table below:

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Aurangabad	8407	7566	2411	944	32	5297	1326	1.69	**785**

2. *Artificial recharge structures*

AR Structures Type	*Nala Bunding*	*Contour Bunding & Trenching*	*Lateral Recharge Shaft*	*Recharge Shaft*	*Percolation Tank*	*De-silting of existing tank /pond /talao*	*Injection Well in Village Tank*
No.	3	25	0	50	2	97	130



7.2 Barun block

7.2.1 General Information

1. Area (ha) : 31049 ha
2. No. of town : 0
3. No. of village : 185
4. Population (2011) Total : 200052
   Rural : 200052
   Urban : 0
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1

6. Depth-range wise No. of ground structure (5^{th} MI Census)
   < 20 m : -
   20-35 m : -
   35-40 m : 51
   40-60 m : 789
   60-70 m : 28
7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
6815.1	130.7	1347.28	1052.07	9345.19	934.52	8410.67

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
1592.5	344.65	90	2027.15	387.15	6341.02	24	**Safe**

In Ha m

7.2.2 Aquifer Disposition

1. Aquifer disposition : 1^{st} aquifer only. Depth :- 15-20 to 40-50 m bgl
   Discharge : – ~ 40 lps
2. Water level behavior Pre-monsoon : 6.37 to 9.02 m bgl
   Post-monsoon : 1.57 to 7.82 m bgl
   Fluctuation : 1.13 to 6.65 m
3. Chemical quality of ground water : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca_2^+*	*Mg_2^+*	*Na^+*	*K^+*	*CO_3^{2-}*	*HCO_3^-*	*Cl^-*	*SO_4^{2-}*	*NO_3^-*	*F^-*
Baruna	8.2	840	546	185	50	15	28.4	3.2	0	363	67	56	12	0.64
Urdina	8	440	286	155	25	22	34.89	2.1	0	215	16	4	6	1.02

7.2.3 Aquifer Management Plan

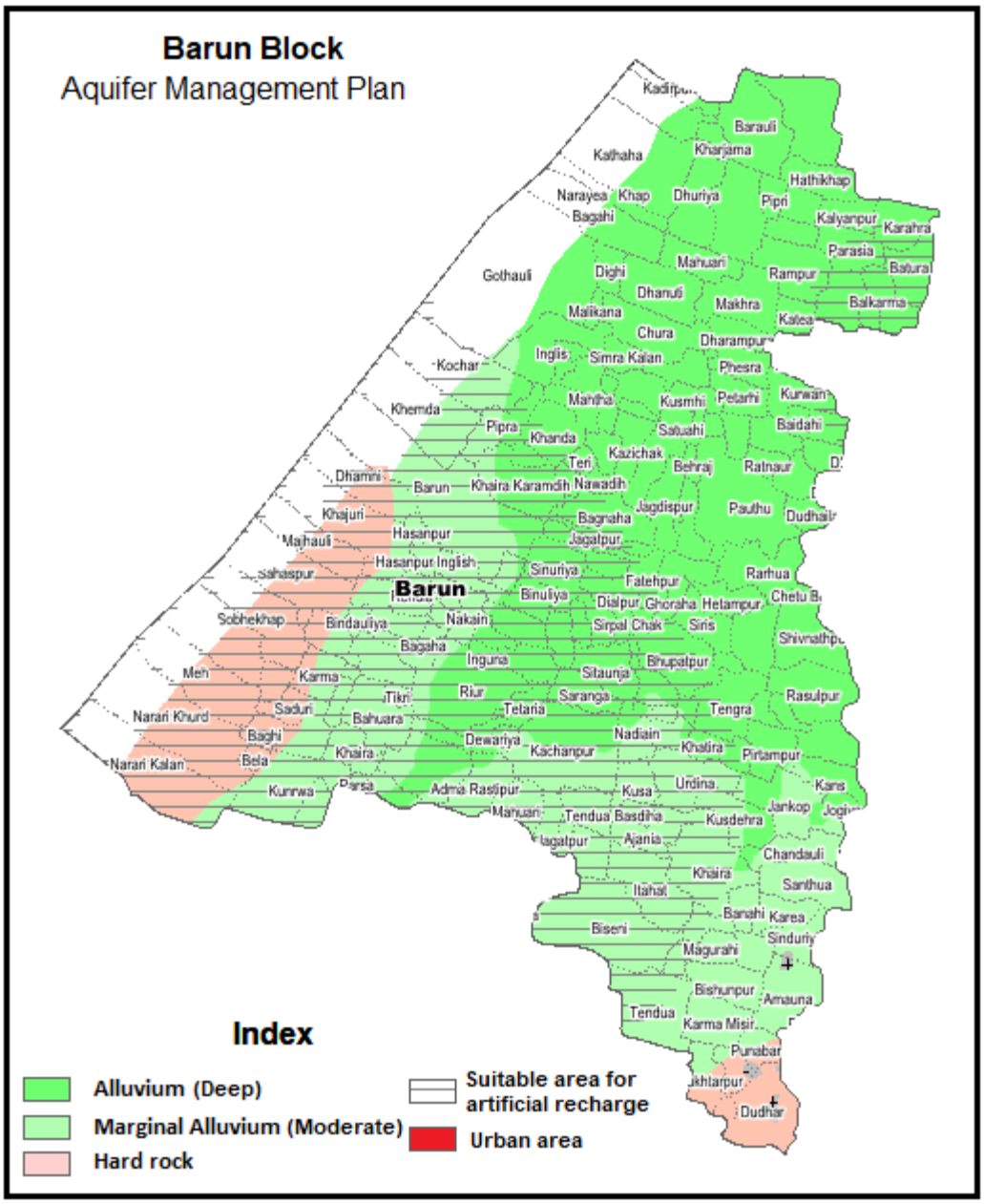
1. Ground water development :

Stage of development of the block is 24% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto the SOD, is 70% is calculated and given in table below:

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Barun	9345	8411	2027	387	24	5887	2136	1.69	**1264**

2. Artificial recharge structures

AR Structures Type	*Nala Bunding*	*Contour Bunding & Trenching*	*Recharge Shaft*	*Percolation Tank*	*De-silting of existing tank /pond /talao*	*Injection Well in Village Tank*
No. of structure	1	10	20	2	81	98



7.3 Daudnagar block

7.3.1 General Information

1. Area (ha) : 19662
2. No. of town : 1
3. No. of village : 60
4. Population (2011) Total : 206854
   Rural : 154490
   Urban : 52364
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.9	20.8	10.4	4.9	19.7	138.4	350.1	378.4	214.4	49.9	10.5	3.0

6. Depth-range wise No. of ground water abstraction structure (5^{th} MI Census)
   < 20 m : 2
   20-35 m : 11
   35-40 m : 54
   40-60 m : 411
   60-70 m : 4
7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
4316	83	508	426	5332	533	4799

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
891	537	63	1491	603	3242	31	Safe

7.3.2 Aquifer disposition

1. Aquifer disposition : 1^{st} aquifer, Depth range:-
   2^{nd} aquifer
   Discharge :- ~ 20 lps
2. Water level behavior
   Pre-monsoon : 4.54 to 6.42 m bgl
   Post-monsoon : 2.05 to 3.33 m bgl
   Fluctuation : 1.66 to 4.37 m
3. Chemical quality of Ground Water : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*CO_3^{2-}*	*HCO_3^{-}*	*Cl^{-}*	*SO_4^{2-}*	*NO_3^{-}*	*F^{-}*
Daudnagar	8.25	1297	843.1	530	134	47	105.4	52.4	0	438	171	72	51	0.45
Thakur Bigha	7.88	699	454.35	310	58	40	34.5	2.2	0	240	64	41	27	0.58
Mohan Bigha	7.66	533	346.45	192	37	24	38.92	5.3	0	283	18	7	5	0.36

7.3.3 Aquifer Management Plan

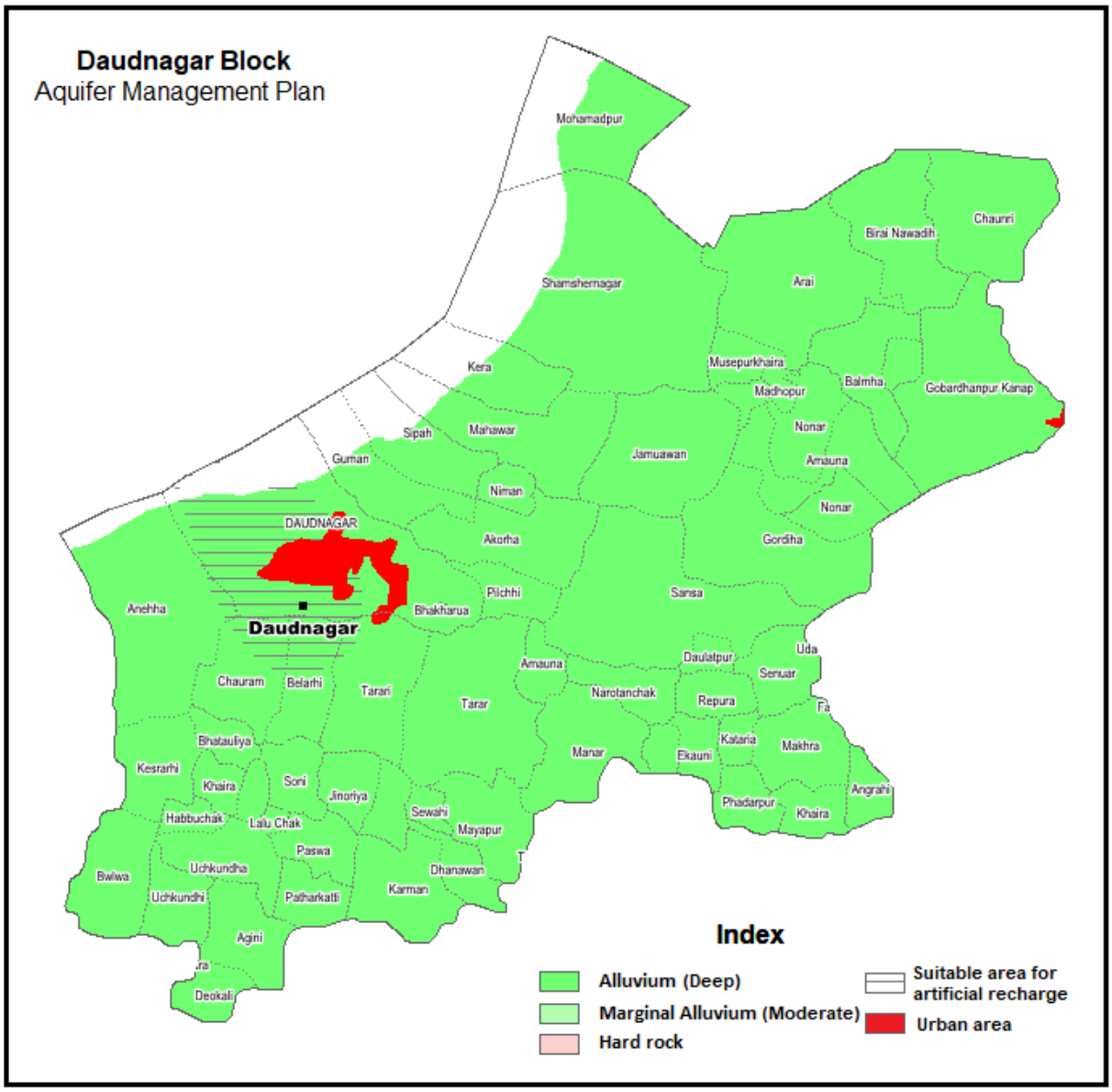
1. Ground water development :

Stage of development of the block is 31% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto the SOD, is 70% is calculated and given in table below

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Daudnagar	*5332*	*4799*	*1491*	*603*	*31*	*3359*	*837*	*1.69*	***495***

12. Artificial recharge structures

AR Structures Type	*Nala Bunding*	*Contour Bunding & Trenching*	*Lateral Recharge Shaft*	*Recharge Shaft*	*Percolation Tank*	*De-silting of existing tank /pond /talao*	*Injection Well in Village Tank*
No. of structure	1	7	0	14	0	40	66



7.4 Deo Block

7.4.1 General Information

1. Area (ha) : 27207
2. No. of town : 0
3. No. of village : 116
4. Population (2011) Total : 173216
   Rural : 173216
   Urban : 0
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.0	20.3	12.4	5.2	14.4	149.8	323.3	367.2	218.0	52.9	15.0	4.5

6. Depth-range wise No. of ground water abstraction structure (5^{th} MI Census)
   < 20 m : -
   20-35 m : -
   35-40 m : 33
   40-60 m : 448
   60-70 m : 3
7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
4451	85	674	220	5430	543	4887

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
917	298	54	1269	335	3581	26	safe

7.4.2 Aquifer Disposition

1. Aquifer disposition : Fissured aquifer,2 set of fracture, Depth range :- 34-41, 57-80 m bgl
   Discharge ~ 4 lps
2. Water level behavior
   Pre-monsoon : 5.23 to 11.93 m bgl
   Post-monsoon : 1.85 to 3.83 m bgl
   Fluctuation : 1.94 to 8.7 m
3. Chemical quality of ground water : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*CO_3^{2-}*	*HCO_3^{-}*	*Cl^{-}*	*SO_4^{2-}*	*NO_3^{-}*	*F^{-}*
Deo	8.4	1116	725.4	240	34	38	78.38	1.9	3	640	27	26	2	0.98
Pataya	8.11	901	585.7	690	98	108	285.36	5.7	0	412	62	62	4	0.76

7.4.3 Aquifer Management Plan

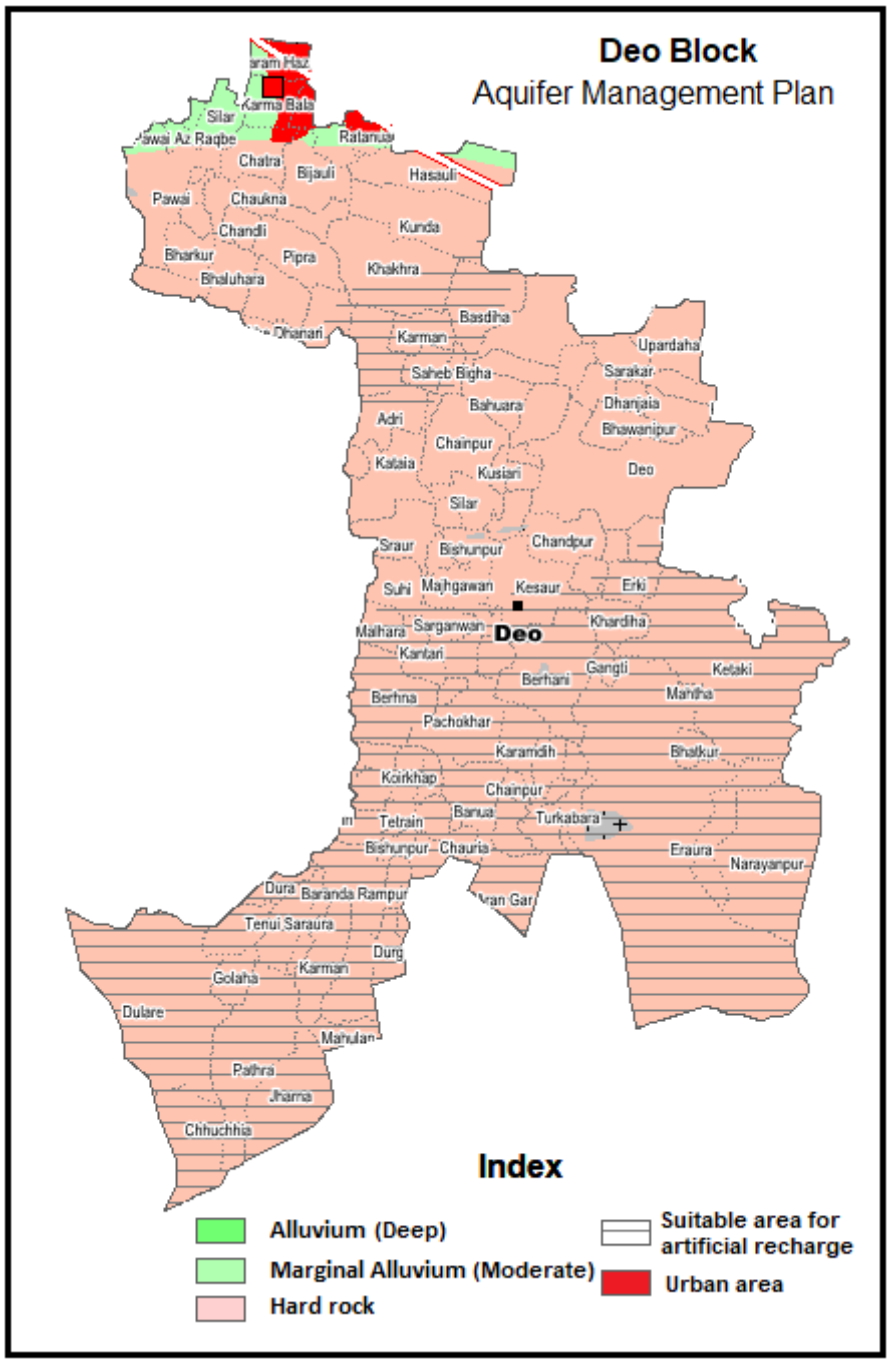
1. Ground water development :

Stage of development of the block is 26% only hence categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto the SOD, is 70% is calculated and given in table below

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Deo	5430	4887	1269	335	26	3421	1131	1.69	**669**

2. Artificial Recharge structure

AR Structures Type	Percolation Tank	Gully Plug	Contour Bunding & Trenching	Check Dam	Nala Bunding	Contour Bunding & Trenching	Lateral Recharge Shaft	Recharge Shaft	Percolation Tank	De-silting of existing tank /pond /talao	Injection Well in Village Tank
No. of structure	2	25	30	1	2	13	0	26	1	8	14



7.5 Goh Block

7.5.1 General Information

1. Area (ha) : 30285
2. No. of town : 0
3. No. of village : 164
4. Population (2011) Total : 234400
   Rural : 234400
   Urban : 0
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.4	20.7	12.8	6.0	14.1	136.1	323.2	364.8	212.3	48.9	11.3	4.1

6. Depth-range wise No. of ground water abstraction structure (5^{th} MI Census)
   < 20 m : 45
   20-35 m : 230
   35-40 m : 36
   40-60 m : 1066
   60-70 m : 1

7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
6647	127	1048	953	8776	878	7899

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
2604	404	144	3152	454	4697	40	safe

7.5.2 Aquifer Disposition

1. Aquifer disposition : Porous aquifer:-10-15 to 20-30 and 40-50 to 50 -70 m bgl
   Discharge -20 to 40 lps
2. Water level behavior
   Pre-monsoon : 5.16 to 9.4 m bgl
   Post-monsoon : 1.16 to 4.0 m bgl
   Fluctuation : 1.58 to 4.14 m
3. Chemical quality of Ground and contamination : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*CO_3^{2-}*	*HCO_3^{-}*	*Cl^{-}*	*SO_4^{2-}*	*NO_3^{-}*	*F^{-}*
Deohara	8.18	1608	1045	180	30	26	72.46	1.5	0	412	172	106	178	0.31
Deohara_goh	7.1	754	490.1	135	26	17	169.04	1.8	0	363	41	12	34	0.37
Dhobi	8.16	619	402.4	200	58	13	5.8	1.4	0	369	11	11	6	0.53
Goh	7.94	460	299	90	18	11	66.185	1.3	0	258	15	7	5	1.05
Uphara	8.1	388	252.2	150	22	23	29.62	1.8	0	215	18	7	4	0.76

7.5.3 Aquifer Management Plan

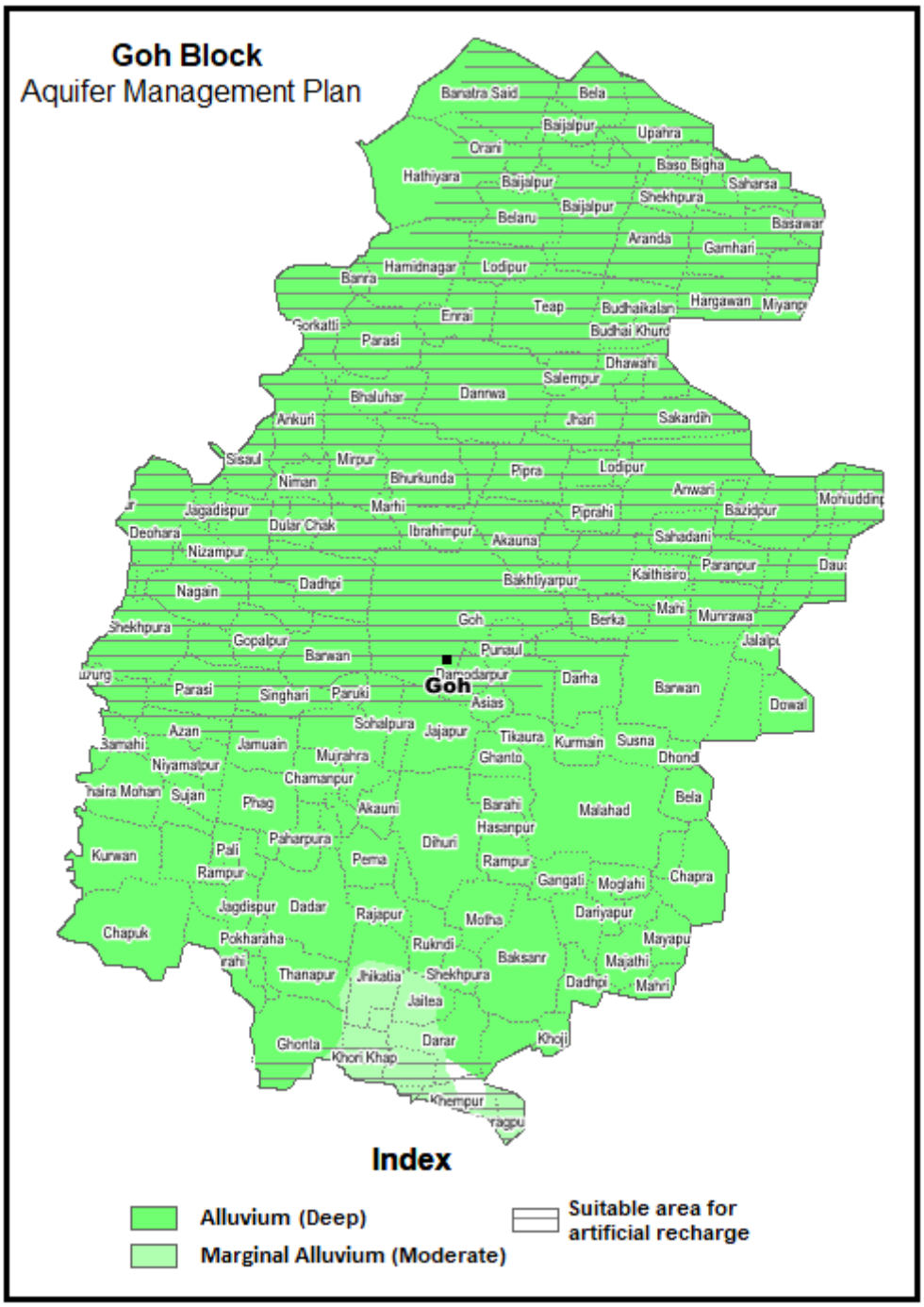
1. Ground water development :

Stage of development of the block is 40% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto 70% SOD, is calculated and given in table below:

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Deo	8776	7899	3152	454	40	5529	1916	1.69	**1134**

2. Artificial Recharge structure

AR Structures Type	*Nala Bunding*	*Contour Bunding & Trenching*	*Lateral Recharge Shaft*	*Recharge Shaft*	*Percolation Tank*	*De-silting of existing tank /pond /talao*	*Injection Well in Village Tank*
No. of structure	1	6	0	13	1	33	52



7.6 Hanspura Block

7.6.1 General Information

1. Area (ha) : 13678
2. No. of town : 1
3. No. of village : 70
4. Population (2011) Total : 160820
   Rural : 152880
   Urban : 7940
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	213.3	48.9	11.3	4.1

6. Depth-range wise No. of ground water abstraction structure (5^{th} MI Census)
   < 20 m : 157
   20-35 m : 355
   35-40 m : 49
   40-60 m : 102
   60-70 m : 0
7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
2719	58	1520	272	4568	228	4340

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
1257	304	81	1642	342	2661	38	safe

7.6.2 Aquifer disposition

1. Aquifer disposition : Two aquifer system (porous):-20-30 to 50-60 and 80-90 to 130-140 m bgl
   Discharge ~ 30 lps
2. Water level behavior
   Pre-monsoon : 2.76 to 3.3 m bgl
   Post-monsoon : 0.88 to 2.05 m bgl
   Fluctuation : 1.17 to 1.88 m
3. Chemical quality of Ground and contamination : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*CO_3^{2-}*	*HCO_3^{-}*	*Cl^{-}*	*SO_4^{2-}*	*NO_3^{-}*	*F^{-}*
Sonhatu	7.31	586	380.9	120	24	15	81.602	4.0	0	203	67	25	39	1.04
Dewkund	8.14	382	248.3	60	10	9	58.89	1.8	0	178	28	14	0	0.69

7.6.3 Aquifer Management Plan

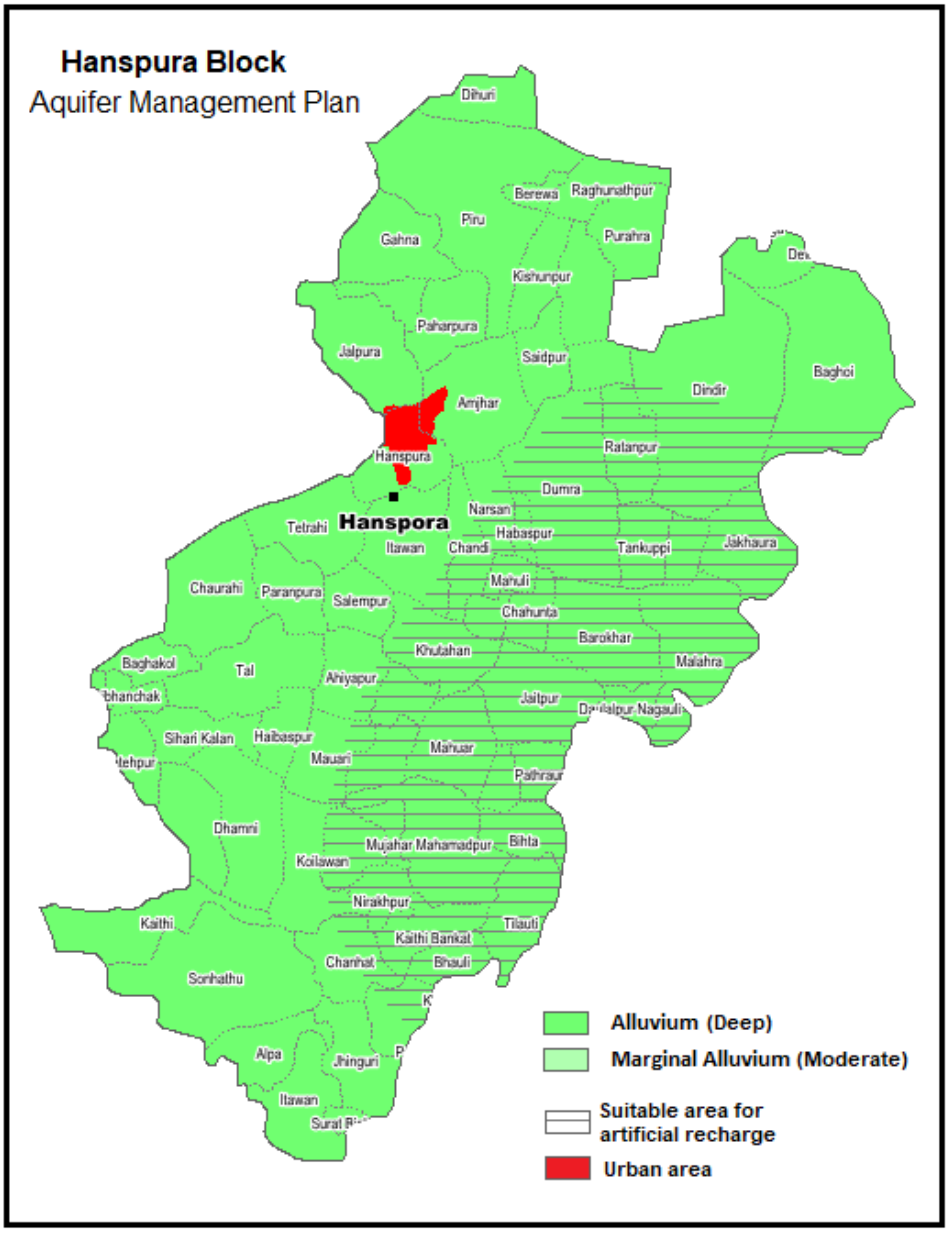
1. Ground water development :

Stage of development of the block is 38% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto the SOD, is 70% is calculated and given in table below:

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD % 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Hanspura	4568	4340	1642	342	38	3038	960	1.69	**568**

2. Artificial Recharge structure

Not suggested any. However surface spreading method may be implemented.



7.7 Kutumba Block

7.7.1 General Information

1. Area (ha) : 25961
2. No. of town : 0
3. No. of village : 216
4. Population (2011) Total : 226599
   Rural : 226599
   Urban : 0
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1

6. Depth-range wise No. of ground water abstraction structure (5^{th} MI Census)
   < 20 m : 1
   20-35 m : 21
   35-40 m : 10
   40-60 m : 1676
   60-70 m : 16
7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
5698	109	537	666	7010	701	6309

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
3245	390	171	3806	439	2455	60	safe

7.7.2 Aquifer Disposition

1. Aquifer disposition : Fissured aquifer,2 set of fracture:- ~50 and ~ 150 m bgl
   Discharge -~ 2.5 lps
2. Water level behavior
   Pre-monsoon : 4.36 to 7.9 m bgl
   Post-monsoon : 0.83 to 5.93 m bgl
   Fluctuation : 1.02 to 3.01 m
3. Chemical quality of Ground and contamination : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}
Kutumba	8.04	1792	1164.8	485	42	92	163.56	17.5	0	394	208	202	18	1.52
Risiap	8.21	425	276.25	150	16	26	31.05	1.2	0	197	28	21	2	1.24
Kauriyari	8.16	738	479.7	165	32	21	85.67	1.8	0	210	100	34	22	1.67

7.7.3 Aquifer Management Plan

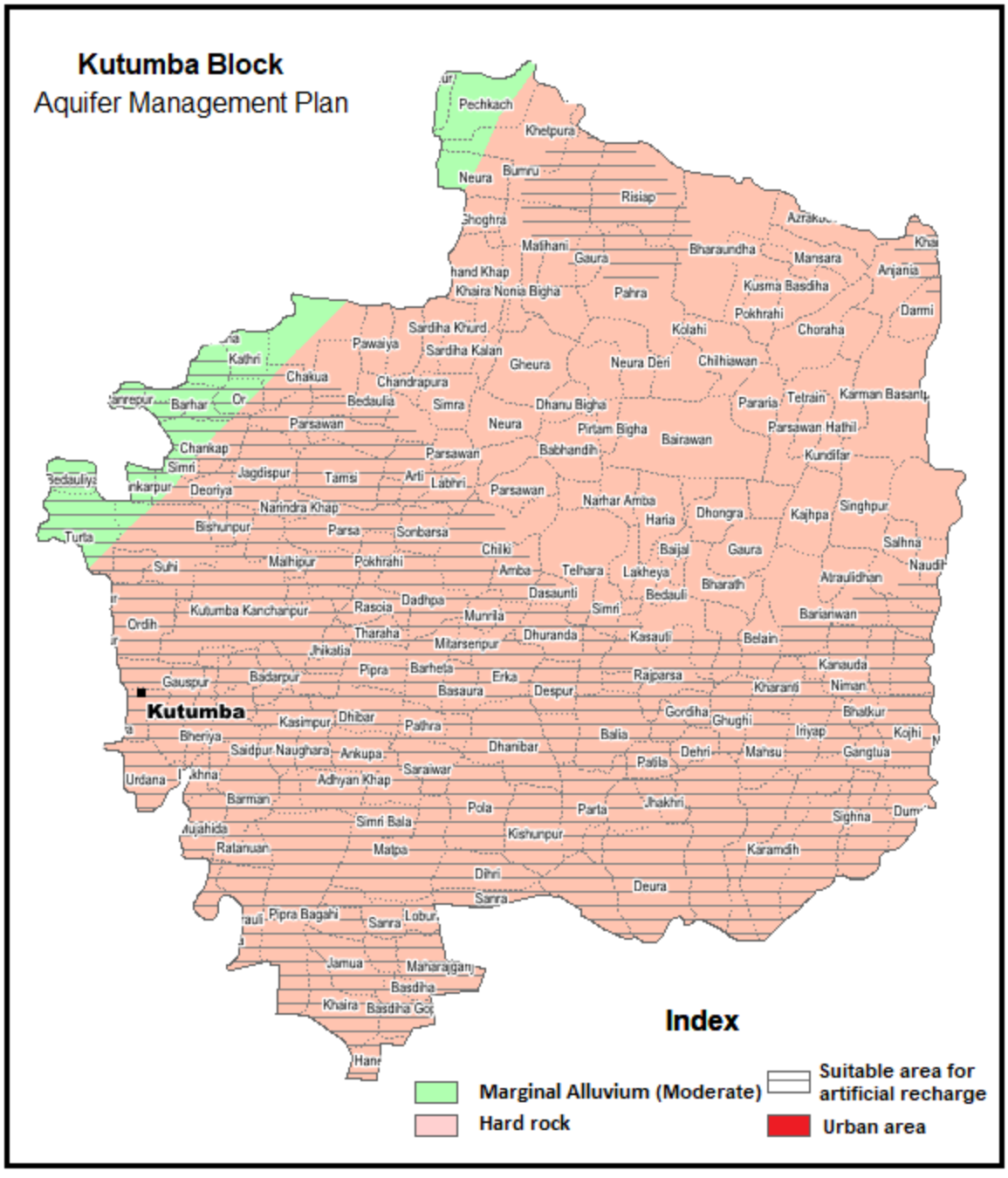
1. Ground water development :

Stage of development of the block is 60% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto the SOD, is 70% is calculated and given in table below

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Kutumba	7010	6309	3806	439	60	4416	1454	1.69	**860**

2. *Artificial Recharge structure*

Not suggested any. However surface spreading method may be implemented.



7.8 Madanpur Block

7.8.1 General Information

1. Area (ha) : 34954
2. No. of town : 0
3. No. of village : 121
4. Population (2011) Total : 211329
   Rural : 211329
   Urban : 0
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1

6. Depth-range wise No. of ground water abstraction structure (5^{th} MI Census)
   < 20 m : 1
   20-35 m : 21
   35-40 m : 10
   40-60 m : 1676
   60-70 m : 16
7. Ground Water Resources - 2020

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
5905	113	652	488	7159	716	6443

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
2025	364	117	2506	409	3892	39	safe

7.8.2 Aquifer Disposition

1. Aquifer disposition : Fissured aquifer,2 set of fracture:- ~66 to ~130 Discharge ->5 lps
2. Water level behavior
   Pre-monsoon : 5.49 to 8.53 m bgl
   Post-monsoon : 2.01 to 4.06 m bgl
   Fluctuation : 3.03 to 4.47 m
3. Chemical quality of Ground and contamination : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}
Madanpur	8.04	1075	698.8	285	78	22	21.5	1.6	0	326	167	65	26	1.28
Jalwand	8.14	502	326.3	130	18	21	46.76	1.0	0	271	25	12	4	1.24
Salempur	8.27	632	410.8	100	26	8	106.05	0.6	0	369	22	4	1	1.25

7.8.3 Aquifer Management Plan

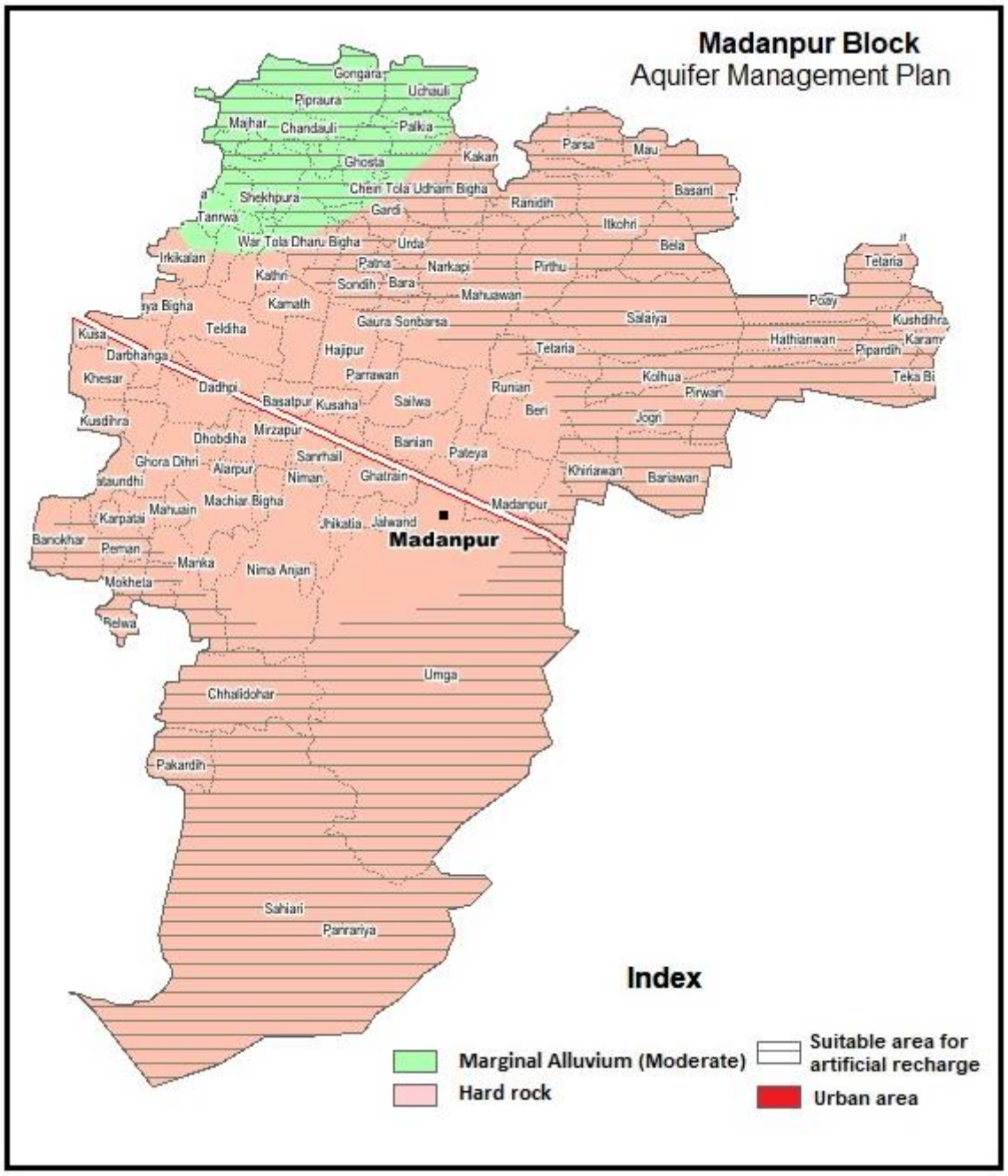
1. Ground water development :

Stage of development of the block is 39% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto the 70%SOD, is calculated and given in table below

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Madanpur	7159	6443	2506	409	39	4510	1524	1.69	**902**

2. Artificial Recharge structure

AR Structures Type	Percolation Tank	Gully Plug	Contour Bunding & Trenching	Check Dam	Nala Bunding	Contour Bunding & Trenching	Lateral Recharge Shaft	Recharge Shaft	Percolation Tank	De-silting of existing tank /pond /talao	Injection Well in Village Tank
No. of structure	3	50	43	2	3	27	0	53	2	112	110



7.9 Nabinagar Block

7.9.1 General Information

1. Area (ha) : 53906
2. No. of town : 1
3. No. of village : 300
4. Population (2011) Total : 305236
   Rural : 281252
   Urban : 23984
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.4	23.5	15.3	6.4	12.4	140.9	287.7	335.2	204.0	43.2	12.8	4.4

6. Depth-range wise No. of ground water abstraction structure (5^{th} MI Census)
   < 20 m : 7
   20-35 m : 964
   35-40 m : 15
   40-60 m : 25
   60-70 m : 4
7. Ground Water Resources - 2020 :

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
11832	227	451	416	12926	1293	11634

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
1918	608	126	2652	684	8906	23	safe

In ha m

7.9.2 Aquifer Disposition

1. Aquifer disposition : Fissured aquifer,2 set of fracture:-~35, ~130
   Discharge : fissured aquifer-upto 1.5 lps Porous aquifer- ~40 to ~ 50 lps
2. Water level behavior
   Pre- : 3.23 to 11.3 m bgl
   Post- : 1.71 to 10.86 m bgl
   Fluctuation : 0.24 to 3.12 m
3. Chemical quality of Ground water : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}
Dhanibar	7.98	833	541.5	220	44	27	89	6.6	0	258	92	43	89	0.88
Mahuli	7.94	1851	1203	380	54	60	33	2.4	0	424	315	135	106	0.89
Nabinagar	8.23	637	414.1	145	36	13	8	2.4	0	314	10	16	7	0.89
Narai Kala	8.34	315	204.8	220	30	35	48	1.6	6	160	13	11	2	0.48
Badem	7.94	380	247	140	18	23	25	1.5	0	192	16	12	4	1.08
Tetariya	7.92	456	296.4	160	23	24	33	2.2	0	209	32	26	7	0.38
Kharundha	7.96	489	317.8	135	23	19	55	1.7	0	258	21	13	5	1.58
Jai hind	7.72	1383	898.9	460	36	90	84	30.0	0	295	209	105	83	0.75
Dhanibar	7.98	833	541.5	220	44	27	89	6.6	0	258	92	43	89	0.88

7.9.3 Aquifer Management Plan

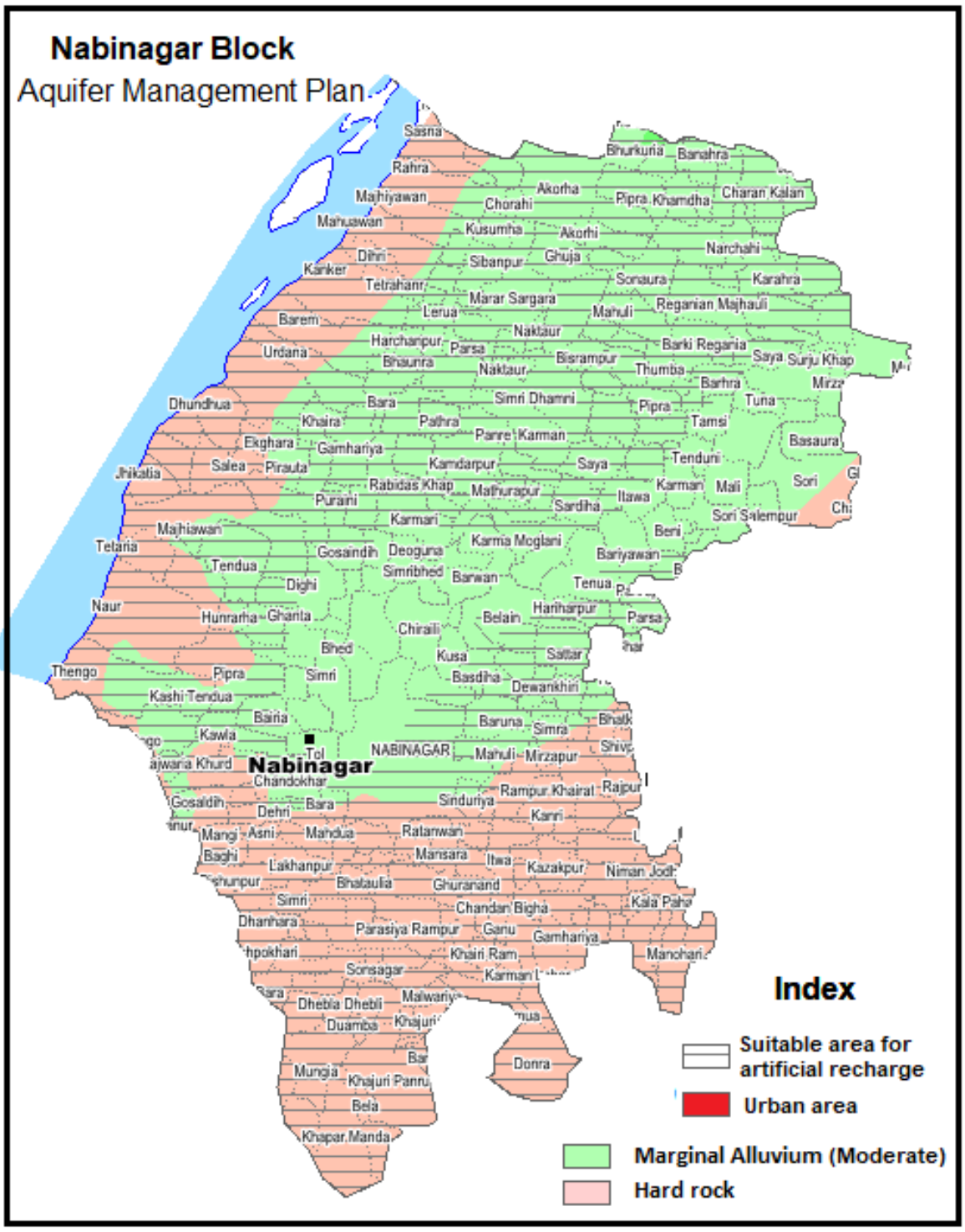
1. Ground water development :

Stage of development of the block is 23% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto 70% SOD, is calculated and given in table below

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Nabinagar	12926	11634	2652	684	23	8144	2807	1.69	**1661**

2. Artificial Recharge structure

AR Structures Type	Nala Bunding	Contour Bunding & Trenching	Recharge Shaft	Percolation Tank	De-silting of existing tank /pond /talao	Injection Well in Village Tank
No. of structure	3	23	45	3	82	117



7.10 Obra Block

7.10.1 General Information

1. Area (ha) : 26502
2. No. of town : 1
3. No. of village : 143
4. Population (2011) Total : 226007
   Rural : 211221
   Urban : 14786
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
22.4	20.7	12.8	6.0	14.1	136.1	323.3	364.8	212.3	48.9	11.3	4.1

6. Depth-range wise No. of water abstraction structure (5^{th} MI Census)
   < 20 m : 16
   20-35 m : 978
   35-40 m : 1
   40-60 m : 6
   60-70 m : 0
7. Ground Water Resources -2020 :

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
5817	112	562	554	7045	705	6341

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
1897	440	117	2454	495	3832	39	safe

In ha m

7.10.2 Aquifer Disposition

1. Aquifer disposition : Porous aquifer
   Discharge -~ 40 lps
2. Water level behavior
   Pre-monsoon : 6.68 to 10.5 m bgl
   Post-monsoon : 0.82 to 4.44 m bgl
   Fluctuation : 3.71 to 8.45 m
3. Chemical quality of Ground water : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*CO_3^{2-}*	*HCO_3^{-}*	*Cl^{-}*	*SO_4^{2-}*	*NO_3^{-}*	*F^{-}*
Obra	8.3	603	392	490	74	74	195.09	7.4	0	289	19	31	29	0.29

7.10.3 Aquifer Management Plan

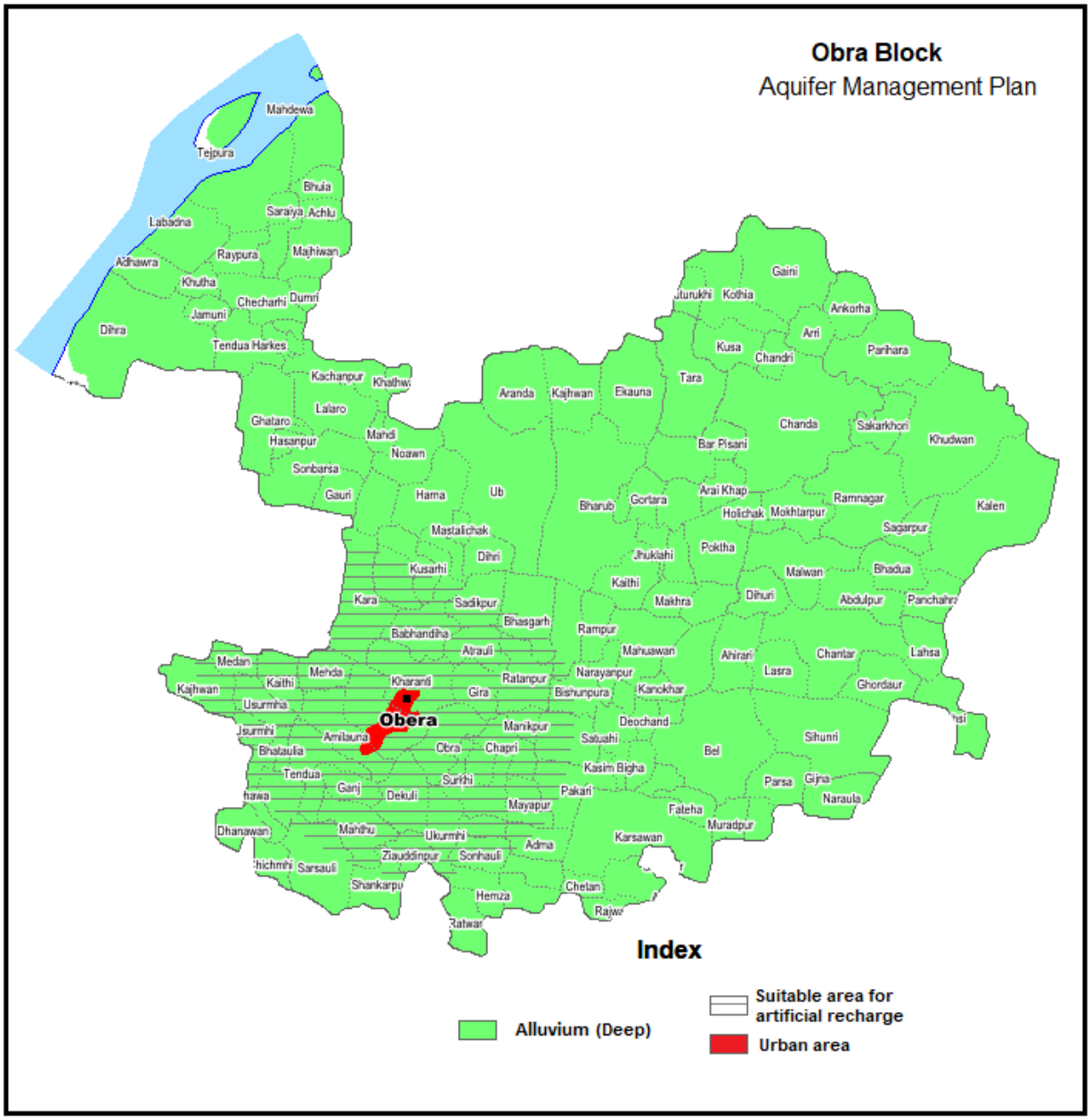
1. Ground water development :

Stage of development of the block is 39% only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto 70% SOD, is calculated and given in table below

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Nabinagar	7045	6341	2454	495	39	4438	1408	1.69	**833**

2. Artificial Recharge structure

AR Structures Type	*Nala Bunding*	*Contour Bunding & Trenching*	*Recharge Shaft*	*Percolation Tank*	*De-silting of existing tank /pond /talao*	*Injection Well in Village Tank*
No. of structure	1	4	9	0	36	71



7.11 Rafiganj Block

7.11.1 General Information

1. Area (ha) : 38393
2. No. of town : 1
3. No. of village : 300
4. Population (2011) Total : 312367
   Rural : 276831
   Urban : 35536
5. Normal rainfall (mm) :

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
21.9	17.8	11.5	6.5	11.2	119.9	322.3	364.4	205.3	50.1	6.9	3.9

6. Depth-range wise No. of water abstraction structure (5^{th} MI Census)
   < 20 m : 68
   20-35 m : 1076
   35-40 m : 103
   40-60 m : 510
   60-70 m : 0
7. Ground Water Resources -2020 :

Recharge from Rainfall		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Total Natural Discharges*	*Annual Extractable Ground Water Resource*
Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
7055	135	946	949	9086	909	8177

Ground Water Extraction for Irrigation Use	*Ground Water Extraction for Domestic Use*	*Ground Water Extraction for Industrial Use*	*Total Extraction*	*Annual GW Allocation for for Domestic Use as on 2025*	*Net Ground Water Availability for future use*	*Stage of Ground Water Extraction (%)*	*Category*
3330	661	207	4198	742	3898	51	safe

In ha m

7.11.2 Aquifer Disposition

1. Aquifer disposition : Porous aquifer :- Single aquifer system, Depth: 30 to 45 m bgl
   Discharge :- ~ 20 lps
2. Water level behavior
   Pre-monsoon : 6.73 to 10.15 m bgl
   Post-monsoon : 2.43 to 10.15 m bgl
   Fluctuation : 4.3 to 4.69 m
3. Chemical quality of ground water : In general, Potable.

Location	*pH*	*EC*	*TDS*	*TH*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*CO_3^{2-}*	*HCO_3^{-}*	*Cl^{-}*	*SO_4^{2-}*	*NO_3^{-}*	*F^{-}*
Rafiganj	8.34	936	608.4	230	36	34	147.56	1.3	3	449	73	25	21	0.61
Tinari Morh	8.43	775	503.8	310	52	44	64.85	0.7	9	418	37	12	5	1.04
Barahi	8.09	293	190.45	84.910375	12	13	21.54	1.2	0	141	11	6	0	1.54
Kasma	8.09	453	294.45	130.25346	18	21	50.122	0.7	0	172	40	16	4	1.71

7.11.3 Aquifer Management Plan

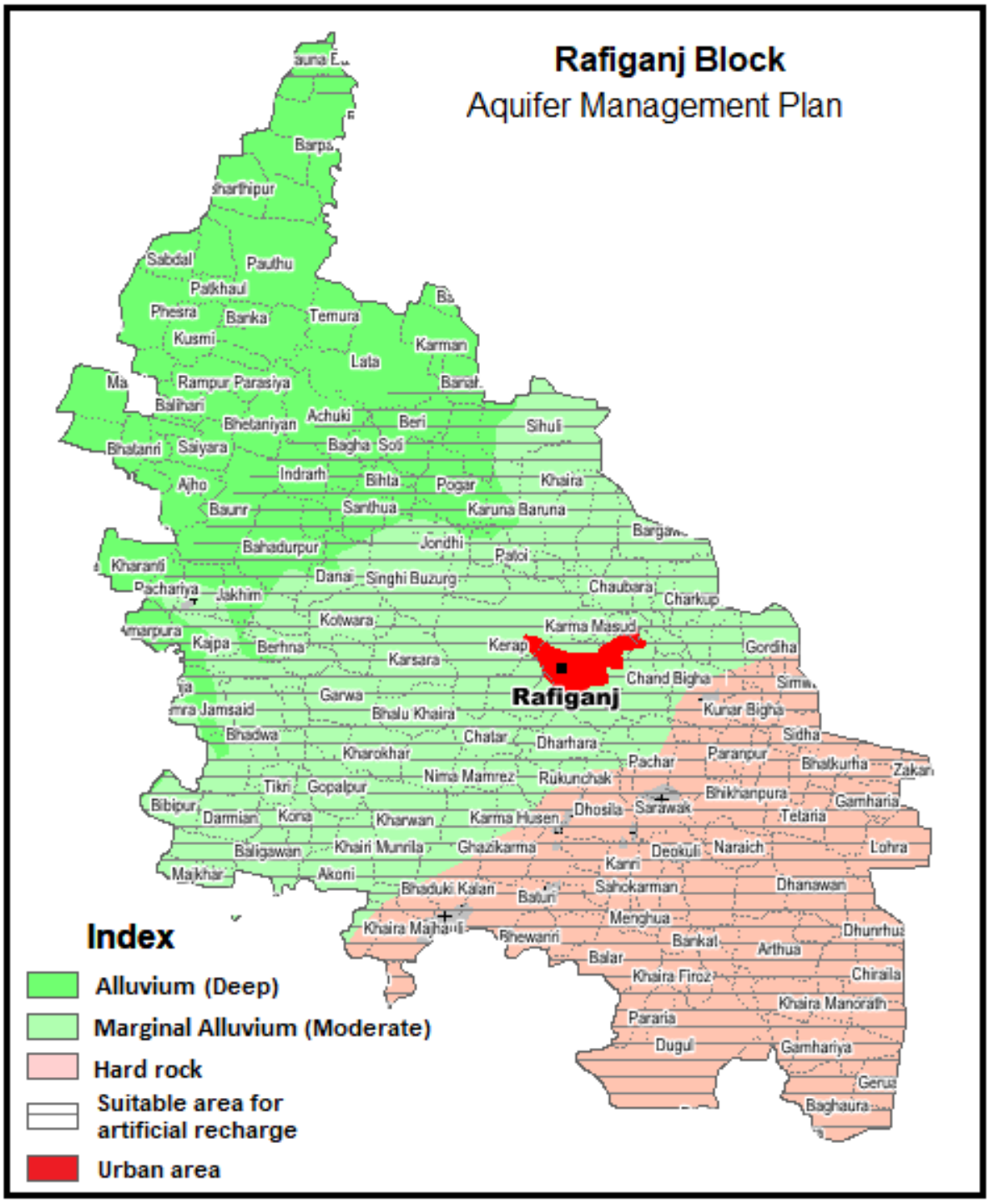
1. Ground water development :

Stage of development of the block is 51 % only therefore categorized as 'safe'. There is a possibility for further development of ground water. Additional number of tube well upto the SOD, is 70% is calculated and given in table below

Block	*Total Annual Recharge*	*Net Resource*	*Gross Draft All Uses*	*Provision for Future Domestic and Industrial Requirement*	*SOD% 2017*	*GW draft at Projected SOD*	*Additional Resource Available*	*Unit Draft of STW*	*Additional Nos. of STW feasible based on GW availability*
Rafiganj	9086	8177	4198	742	51	5724	1711	1.69	**1012**

2. Artificial Recharge structure

AR Structures Type	Percolation Tank	Gully Plug	Contour Bunding & Trenching	Check Dam	Nala Bunding	Contour Bunding & Trenching	Recharge Shaft	Percolation Tank	De-silting of existing tank /pond /talao	Injection Well in Village Tank
No. of	3	50	58	3	6	50	100	4	113	144



Summary

The district with a geographical area of 3389 Km^2 lies between longitudes of 840 00'-840 45' E and latitudes of 240 30' -250 15' N in the South Bihar Plains (SBP), constitute a part of the marginal alluvial plains of Ganga Basin. The Sone River forms the western boundary of the district and at the southern boundary lays the Chhotanagpur Granitic Gneissic Complex (CGGC) of Jharkhnad state. The district is bounded in the north and the east by the Arwal district and the Gaya district respectively.

There are 11 administrativeblocks in the district which are divided into two sub-divisions – Aurnagabad and Daudnagar. Aurangabad subdivision comprises Nabinagar, Barun, Kutumba, Deo, Aurangabad, Madanpur and Rafiganj blocks and rest of the blocks i.e. Daudnagar, Hanspura, Goh and Obra fall in Daudnagar Sub-division. There is total 224 Gram Panchayats in the district covering 1712 villages.

In central part of the district normal rainfall is slightly higher (Daudnagar, Arurangabad and deo (> 1200 mm) and slightly decreases towards eastern and western parts (Rafiganj 1142 mm Nabinagar 1108 mm).The southern hilly range and the northern Gangetic Plain are two broad physiographic units of the Aurangabad district. About 87% of the area of the district is a part of Punpun River Sub-basin. Remaining 13% is the north-western peripheral drained by the river Sone which flowing from south-west to north-east.One of India's oldest canal systems in the district is operational which contribution in irrigation reduces dependency on ground water. As per the Ground Water Resources Estimation 2020, all 11 blocks of the district are categorized as 'safe'.The Aurangabad district has been included in 'Agro-climatic zone III' of Bihar . Rice, wheat, pulses etc. are the major crops of the district.

Geologically, the district is made up of two major type of formations namely hard terrain of Chhotanagpur granite gneiss of Archaean age occupying about 20% of the geographical area and remaining is the plain of Gangetic alluvium. However in western part, a narrow stretch of Vindhyan rocks (sandstones, quartzite and shale) exists.

Total 53 key wells have been monitored during pre and post monsoon period. The depth to water level range during pre and post monsoon period was 2.76 to 11.93 and 0.82 to 10.86 m bgl respectively. The shallower water level is observed near the river Punpun whereas deeper water level observed in an elongated area covering southern part of the district along the river Sone. The average water level fluctuation is calculated to be 3.4 m bgl.

Fissured aquifer occurs near southern and eastern district boundary. In this area two sets

of fracture encountered within the depth of 200. In central part of the district 1st porous principal aquifer has been delineated within 100 m depth over the basement of hard rock. In northern part of the district, two principal porous aquifers i.e. 1st and 2nd are delineated down to 200 m depth. The 2nd (deeper) is semi-confined in nature.

As per the available data, the transmissivity of fissured aquifers (hard rock) is calculated upto 10.5 $m^{2/}$/day whereas for porous aquifer (Alluvium) it is up to 1100 $m^{2/}$day. Maximum discharge of the well found in fissured aquifer is 10.5 lps whereas in porous aquifer it is 70 lps.

Tapping the dynamic resource, up to a stage of groundwater extraction of 70% i.e. within Safe limit, block wise additional number of tube well has been calculated by considering the unit draft of 1.69 ha m. Total 10183 additional number of tube well, may be constructed to fulfil the further groundwater needs

In southern part, nalla bund, check-dam etc. may be constructed in 1st and 2nd order streams to control flooding during monsoon and to recharge the ground water.

Geophysical study carried out to delineate the extension of sand layer along the river Sone. This sand layer extends 1.0 to 1.5 k.m. towards the land area. These land areas are suitable for the construction of tube wells.

***

Monitoring Well Details

SN	*Block*	*Village*	*Longitude*	*Latitude*	*measuring Point (m agl)*	*Depth (m bgl)*	*Dia. (m)*	*WL May 18 (m bgl)*	*WL Nov 18 (m bgl)*	*Elevation (m amsl)*	*WL Fluct-uation (m)*
1	Aurangabad	Aurangabad	84.3799	24.7466	0.4	7.65	1.4	6.84	1.43	115.9	5.41
2	Aurangabad	Basdiha	84.4139	24.8296	0.6	13.72	2.3	7.22	1.68	105.5	5.54
3	Aurangabad	Nehuta	84.4795	24.7769	0.5	9.93	2	9.93	3.71	102.8	6.22
4	Aurangabad	Ora	84.4304	24.7249	0.7	9.25	1.8	5.9	3.06	113.4	2.84
5	Aurangabad	Parrawan	84.3429	24.8366	0.5	8.3	1.23	6.69	1.54	102.4	5.15
6	Barun	Barun	84.2225	24.8652	1.1	12.5	2	8.95	7.82	110	1.13
7	Barun	Inglish	84.2502	24.9004	0	9.93	2	9.2	2.55	108.8	6.65
8	Barun	Kadirpura	84.2940	24.9554	0.4	6.37	1.2	6.37	1.57	103.3	4.8
9	Barun	Urdina	84.2751	24.7947	0.7	8.65	1.3	8.65	4.62	111.9	4.03
10	Daudnagar	Bhagwan Bigha	84.4140	25.0485	0.5	6.42	1.43	6.42	2.05	91.8	4.37
11	Daudnagar	Daudnagar	84.4018	25.0347	0.5	7.8	2.4	5.6	3.33	98.1	2.27
12	Daudnagar	Mohan Bigha	84.3925	24.9640	0.8	8.2	1.1	3.38	1.08	95	2.3
13	Deo	Basdiha	84.4002	24.6946	0.2	8.12	2.1	11.93	3.23	126.6	8.7
14	Deo	Chatra	84.3323	24.7333	0.2	8.62	1.6	7.92	1.66	122.3	6.26
15	Deo	Dev	84.4341	24.6616	1	8.03	9.3	5.23	1.85	128.2	3.38
16	Deo	Ketki	84.4573	24.6259	0.55	5.77	1.32	5.77	3.83	140.7	1.94
17	Goh	Deohara	84.5788	25.0049	0.9	12.3	1.5	9.4	10.1	87.2	-0.7
18	Goh	Dihura	84.6501	24.9331	0.5	7.23	3.1	5.3	1.16	96.1	4.14
19	Goh	Goh (Dhobitola)	84.6529	24.9788	0.44	8.6	1.84	5.16	3.58	86.9	1.58
20	Goh	Uphara	84.6888	25.0819	0	7.65	2.5	6.66	4	81.3	2.66
21	Haspura	Dewkumd	84.6181	25.0909	0.5	6.8	4.5	3.3	2.02	81.5	1.28
22	Haspura	Itawan	84.5444	25.0431	0.3	3.7	2	3.3	1.92	86.2	1.38
23	Haspura	Piru	84.5599	25.1016	0	4.76	1.2	3.22	2.05	83.4	1.17
24	Haspura	Sanhathu	84.5040	24.9794	0.5	4.4	1.1	2.76	0.88	83.9	1.88
25	Kutumba	Dhanibr	84.2857	24.5973	0.3	7.56	1.9	7.9	5.93	143.8	1.97
26	Kutumba	Dhongra	84.3240	24.6380	0.2	6.23	2.13	5.23	0.83	136.8	4.4
27	Kutumba	Kajhpa	84.3577	24.6390	0.3	6.18	2.7	5.22	2.21	136.3	3.01
28	Kutumba	Kauriyari	84.3769	24.5863	0.4	8.35	2.5	6.38	4.97	149.2	1.41
29	Kutumba	Kutumba (Goap)	84.2284	24.6206	0.3	8	1.12	6.8	5.28	142.2	1.52
30	Kutumba	Risiap	84.3072	24.6963	0.5	7.76	1	4.36	3.34	127.4	1.02
31	Madanpur	Badi Erki	84.4970	24.7067	0.25	7.56	2.8	6.36	2.08	116.1	4.28
32	Madanpur	Jalwand	84.5391	24.6486	0.5	7	1.6	5.64	2.01	129.7	3.63
33	Madanpur	Madanpur	84.5828	24.6565	0.5	7.06	1	7	2.64	133.8	4.36
34	Madanpur	Pateya	84.5672	24.6637	0.5	6.75	1.2	5.49	2.46	127.3	3.03
35	Madanpur	Salempur	84.5305	24.7388	0.5	9	0.5	8.53	4.06	107	4.47
36	Nabinagar	Bairia	84.1950	24.7245	0.1	8.12	2.1	8.12	5.95	119.8	2.17
37	Nabinagar	Basaura	84.2500	24.6982	0.1	9.02	2.1	9.02	2.02	127.5	7
38	Nabinagar	Jai Hind Tendu	84.1854	24.6655	0.6	8.8	2	6.95	2.88	131.2	4.07
39	Nabinagar	Kharaundha	84.1160	24.5626	1	8.9	2.1	7.7	4.58	157.4	3.12
40	Nabinagar	Mahuli	84.1563	24.6129	0.38	9.3	1.23	6.72	4.18	138.1	2.54
41	Nabinagar	Narai Kalan	84.1505	24.7870	0.4	11.55	1.88	11.1	10.86	119.2	0.24
42	Nabinagar	Sonbarsa	84.1141	24.6343	0.7	6.8	1.4	3.23	1.71	137	1.52
43	Nabinagar	Tetariya	84.0484	24.6681	0.5	11.9	1.4	11.3	9.74	131.9	1.56
44	Obra	Jamuhara	84.3315	24.9910	0.8	7.28	1.43	6.12	0.82	98.8	5.3
45	Obra	Obra	84.3714	24.8866	0.5	7.64	2.2	9.25	4.44	98.7	4.81
46	Obra	Parsa	84.4571	24.8797	0.5	11.23	2.2	10.5	2.05	99.1	8.45
47	Obra	Ramnagar	84.4706	24.9445	0.45	7.33	5.5	6.68	2.97	91.2	3.71
48	Rafiganj	Barahi	84.5075	24.8698	0.6	7.7	1.1	6.73	2.43	90	4.3
49	Rafiganj	Kasma	84.6769	24.7400	0.5	9.1	1.32	8.4	3.71	108.6	4.69
50	Rafiganj	Kasturipur	84.5595	24.9462	0	6.56	2.64	4.36	1.56	82.2	2.8
51	Rafiganj	Rafiganj	84.6350	24.8217	0.3	14	1.1	10.15	10.15	99	0
52	Rafiganj	Tineri Morh	84.6430	24.8709	0.4	8.5	1.43	7.36	3.98	102	3.38
53	Rafiganj	Badem	84.1098	24.7327	0.3	9.76	1.5	9.23	7.16	124	2.07

Annexure II

Results of Chemical Analysis of Ground Water

SN	Block	Location	pH	EC	TDS	F-	Cl-	HCO3-	CO32-	SO42-	NO3-	TH	Ca2+	Mg2+	Na+	K+
1	Barun	Baruna	8.2	840	546	0.64	67.2	362.9	0	56.44	12	185	50	14.58	28	3.17
2	Daudnagar	Daudnagar	8.25	1297	843.1	0.45	171	437.6	0	71.99	51.3	530	134	47.38	105	52.4
3	Deo	Deo	8.4	1116	725.4	0.98	27.1	639.6	3	26.2	1.69	240	34	37.66	78	1.9
4	Goh	Deohara	8.18	1608	1045	0.31	172	412.1	0	106.04	178	180	30	25.51	72	1.52
5	Nabinagar	Dhanibar	7.98	833	541.5	0.88	91.6	258.3	0	42.54	88.6	220	44	26.73	89	6.62
6	Goh	Deohara_goh	7.1	754	490.1	0.37	41.1	362.9	0	12.39	34	135	26	17.01	169	1.76
7	Goh	Dhobi Tola	8.16	619	402.4	0.53	10.9	369	0	11.34	5.83	200	58	13.36	5.8	1.37
8	Madanpur	Madanpur	8.04	1075	698.8	1.28	167	326	0	64.96	25.8	285	78	21.87	22	1.56
9	Nabinagar	Mahuli	7.94	1851	1203	0.89	315	424.4	0	134.56	106	380	54	59.53	33	2.41
10	Nabinagar	Nabinagar	8.23	637	414.1	0.89	9.81	313.7	0	16.15	7.13	145	36	13.36	7.9	2.39
11	Nabinagar	Narai Kala	8.34	315	204.8	0.48	12.8	159.9	6	11.05	2.03	220	30	35.23	48	1.61
12	Obra	Obra	8.3	603	392	0.29	19.3	289.1	0	30.81	28.8	490	74	74.11	195	7.41
13	Aurengabad	Patraya	8.28	409	265.9	0.22	20.6	196.8	0	19.56	16.9	340	76	36.45	36	1.05
14	Deo	Pataya	8.11	901	585.7	0.76	62.2	412.1	0	62.35	4.44	690	98	108.1	285	5.72
15	Rafiganj	Rafiganj	8.34	936	608.4	0.61	72.8	449	3	24.73	20.7	230	36	34.02	148	1.26
16	Rafiganj	Tinari Morh	8.43	775	503.8	1.04	36.9	418.2	9	12.49	4.62	310	52	43.74	65	0.72
17	Hanspura	Sonhatu	7.31	586	380.9	1.04	66.9	203	ND	24.83	39.22	120.37	24.18	14.56	82	3.96
18	Rafiganj	Barahi	8.09	293	190.45	1.54	10.6	141.5	ND	6.35	0.376	84.91	11.98	13.36	22	1.15
19	Daudnagar	Thakur Bigha	7.88	699	454.35	0.58	63.8	239.9	ND	41.1	26.73	309.95	58	40.09	35	2.23
20	Daudnagar	Mohan Bigha	7.66	533	346.45	0.36	18.3	282.9	ND	7.46	5.14	192.48	37	24.3	39	5.27
21	Barun	Urdina	8	440	286	1.02	15.9	215.3	ND	4.28	5.68	155.00	25.45	21.87	35	2.14
22	Nabinagar	Badem	7.94	380	247	1.08	16.5	192	ND	11.8	3.98	140.00	18.41	23.08	25	1.49
23	Nabinagar	Tetariya	7.92	456	296.4	0.38	31.9	209.1	ND	26.09	6.65	160.00	22.86	24.19	33	2.2
24	Nabinagar	Kharundha	7.96	489	317.85	1.58	20.9	258.3	ND	12.6	4.6	135.00	22.51	18.69	55	1.71
25	Nabinagar	Jai hind tendu	7.72	1383	898.95	0.75	209	295.2	ND	104.84	82.53	459.94	36	89.91	84	30
26	Kutumba	Kutumba	8.04	1792	1164.8	1.52	208	393.6	ND	202.45	17.95	485.00	42	91.78	164	17.5
27	Kutumba	Risiap	8.21	425	276.25	1.24	28.4	196.8	ND	20.88	1.7	150.00	16	26.17	31	1.2
28	Kutumba	Kauriyari	8.16	738	479.7	1.67	99.8	209.5	ND	33.92	22.35	165.12	32	20.69	86	1.81
29	Madanpur	Jalwand	8.14	502	326.3	1.24	25.4	270.6	ND	12.1	4.03	130.38	18	20.75	47	1.02
30	Madanpur	Sdalempur	8.27	632	410.8	1.25	22.1	369	ND	4.321	1.148	100.00	26	7.736	106	0.65
31	Rafiganj	Kasma	8.09	453	294.45	1.71	39.6	172.2	ND	16.03	4.36	130.25	18	20.72	50	0.65
32	Goh	Goh	7.94	460	299	1.05	14.8	258.3	ND	6.89	5.45	90.00	18	11.21	66	1.28
33	Goh	Uphara	8.1	388	252.2	0.76	17.9	215.3	ND	7.019	4.09	150.00	22	22.74	30	1.76
34	Hanspura	Dewkund	8.14	382	248.3	0.69	28.4	178.4	ND	14.3	0.24	60.00	10	8.79	59	1.81

Annexure III

Net Irrigated Area

(*In Ha)*

Year	Canal			Tank	Well			Other Source	Total
	Govt.	Private	Total		Tubewell	Other Well	Total		
2007-08	101282	-	101282	183	93882	2819	96701	2382	200548
2008-09	86326	-	86326	-	83993	2963	86956	93	173375
2009-10	84743	-	84743	209	22185	3492	25677	51553	162182
2010-11	75012	-	75012	189	29707	1992	31699	25664	132564
2011-12	99653	-	99653	247	39452	2642	42094	34133	176127
2012-13	102540	-	102540	254	40595	2719	43314	35122	181230
2013-14	79960	-	79960	198	31656	2120	33776	27388	141322
2014_15	93475	-	93475	231	37007	2478	39485	32018	165209
2015_16	91268	-	91268	226	36133	2419	38552	31262	161308
2016_17	99427	-	99427	246	39363	3515	42878	33177	175728

Annexure IV

Gross Irrigated Area

(*In Ha)*

Year	Canal			Tank	Well			Other Source	Total
	Govt.	Private	Total		Tubewell	Other Well	Total		
2007-08	109911	-	109911	183	91136	2848	93984	27767	231845
2008-09	95589	-	95589	-	130634	2963	133597	93	229279
2009-10	100405	-	100405	209	22362	3492	25854	77358	203826
2010-11	88881	-	88881	189	54277	1992	56269	39166	184505
2011-12	120223	-	120223	250	73401	2671	76072	53035	249580
2012-13	135283	-	135283	281	82596	3005	85601	59679	280844
2013-14	104507	-	104507	217	63806	2321	66127	46103	216954
2014-15	116950	-	116950	243	71403	2597	74000	51593	242786
2015-16	110242	-	110242	229	64489	2819	67308	51082	228861
2016-17	139752	-	139752	346	55328	4940	60268	46633	246999

Annexure V

Exploratory wells details

SN	Location	Depth drilled (m bgl)	Granular Zones (m bgl)	Aquifer	SWL (m bgl)	Yield (Lit./Sec.)	Depth to bed rock (m bgl)
1.	Tangra	47.850	24.1-34.75	Sand	7.36	42.6	44.5
2.	Thumbi	49.28	24.3 - 27.40 32.0 - 41.77	Sand	6.20	70.6	47.85
3.	Kamath	51.83	Lack of granular zone	-	-	Abandoned	51.41
4.	Aurangabad	33.84	Lack of granular zone	-	-	Abandoned	31.39
5.	Kutumba	32.93	Lack of granular zone	-	-	Abandoned	32.0
6.	Majhiwan	48.16	21.95 - 46.10	Sand & gravel	11.44	46.4	-
7.	Karhara	59.49	-	-	-	Abandoned	59.43
8.	Barkagaon	46.00	18.29 - 25.10 27.69 - 33.55 34.48 - 38.28 39.72 - 44.29	Sand & gravel	11.33	50.4	-
9.	Mathurapur	57.91	21.39 - 31.79 32.59 - 54.53	Sand & gravel	8.00	61.6	
10.	Bela Khaira	43.59	19.81 - 38.35	Sand & gravel	7.51	38.4	38.1
11.	Charan Kalan	46.48	20.88 - 29.29	Sand & gravel			-
12.	Gosaindih	30.53	Lack of granular zone	-	-	Abandoned	30.48
13.	Dadar	85.95	39.6 - 49.0 50.5 - 57.3 65.8 - 82.6	Sand	7.92	18.8	82.6
14.	Mohammadpur	94.49	12.19 - 25.0 47.80 - 56.4 61.00 - 65.0 71.60 - 73.5 84.00 - 92.6	Sand	6.22	34.7	92.96
15.	Pratappur	89.0	43.9 - 56.4 59.4 - 80.1	Sand	13.1	41	80.16
16.	Jaitiya	76.81	38.70 - 61.27 65.84 - 76.2	Sand	12.19	30.2	76.2
17.	Khojhi	83.82	3.65 - 14.6 34.70 - 38.4 42.36 - 46.6 56.7 - 79.8	Sand	2.74	34.7	79.6
18.	Majathi	76.20	21.03 - 37.5	Sand	4.26	39.7	73.15

			51.82 - 60.96 64.84 - 73.15				
19.	Toralpura	76.20	4.57 - 14.63 32.0 - 33.84 48.77 - 70.10	Sand	2.43	30	73.15
20.	Simarahua	72.83	-	Sand	5.54	34.7	
21.	Mahari	60.35	3.65 - 7.62 24.68 - 28.04 29.56 - 57.19	Sand	3.04	34.7	57.91
22.	Chapra	59.43	10.66 - 23.95 32.0 - 41.45 45.11 - 65.00	Sand	5.79	34.7	-
23.	Nagauli	118.26	18.29 - 33.5 47.25 - 71.26 74.67 - 80.77 91.44 - 97.54 106.3 - 113.4	Sand	5.48	57	-
24.	Jaitpur	76.20	9.50 - 67.10	Sand	5.60	45	
25.	Chachuta	80.77	15.24 - 17.98 23.78 - 37.19 39.62 - 19.28 65.53 - 76.81	Sand	5.94	38.5	-
26.	Barokar	64.01	18.3 - 60.96	Sand	5.79	38.5	-
27.	Malhara - I	150.87	15.24 - 36.58 45.4 - 55.17 91.4 - 96.01 99.06 - 109.12 114.3 - 120.7 137.7 - 145.4	Sand	4.57	57	-
28.	Jakhora - I	82.30	18.29 - 39.2 42.6 - 78.64	Sand	6.09	50	-
29.	Jakhora - II	79.25	18.4 - 38.1 43.1 - 78.4	Sand	6.09	50	-
30.	Pararia	38.25	Lack of granular zone	-	-	Abandoned	34.74
31.	Deoriya	96.62	18.28 – 45.72 56.38 – 62.48	Sand	-	-	95.71
32.	Chankap	103.36	27.432 – 36.60 48.46 – 54.56	Sand	-	-	102.10
33.	Baksar	78.03	39.02 – 44.50 57.30 – 75.80	Sand	-	-	75.80
34.	Malhard	87.470	12.192 – 18.28 45.72 – 87.17	Sand	-	-	87.17

35.	Majathur	76.20	20.72 – 37.49 65.84 – 73.15	Sand	-	-	73.15
36.	Roralpura	73.15	4.57 – 14.63 32.00 – 33.84	Sand	-	-	-
37.	Bhatkur	201	32.0	Fracture		0.16	45
38.	Chandangarh	201	32 124	Fracture		0.4	24
39.	Chandpur Tola	180	51 57	Fracture		3.4	33
40.	Gongra Bandh	201	32 44	Fracture		1.3	21
41.	Kutumba	201	52 149	Fracture		2.3	45
42.	Madanpur	201	66 130	Fracture		5.5	24
43.	Manjurakha	123	97 118	Fracture		10.5	21
44.	Pawai	201	67 176	Fracture		1.8	36
45.	Umga	201	Lack of fracture zone.			Abandoned	21
46.	Baulia	201	94 149	Fracture		1.8	57
47.	Daudnagar	100	5-10 25-32 45-55 70-80	Sand		22	-
48.	Hanspura	167	20-28 40-43 52-62 80-86 105-112 120-132	Sand		32	-

Annexure VI

Lithological Log of the Exploratory Well

1. Location: Majhiawan Coordinates: 24.762500, 84.135278

Depth drilled : 48.458 m bgl
Construction depth: 47.625
Granular zones : 21.945 – 46.101 m bgl

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Grey (With greenish tinge), very hard, plastic, possess very little medium grained sand.	0.00	1.828	1.828
Clay	Grey, plastic, possess few quartz, sand grains.	1.828	3.048	1.220
Clay	Pale green, rather hard, plastic possess a small number of quartz and sand grains.	3.048	11.582	8.534
Clay	Brown with a little number of medium grained quartz sand.	11.582	14.935	3.353
Clay and sand with gravel	Brown plastic clay and medium grained quartz sand in nearly 50/50 ratio with a fairly large amount of quartz gravel and a few small pebbles.	14.935	17.678	2.743
Clay	Brown (with grey streaks), rather plastic, possess about 30% fine grained quartz sand.	17.678	21.945	4.267
Sand	Pale brown, medium grained, composed of quartz with very few small pebbles (3.5 cm) and gravel (1 cm), some small rounded brown clay aggregate probably fallen from above also present.	21.945	24.384	2.439
Sand with gravel	Medium grained pale brown composed of quartz, possess gravel (size 0.6 to 1 cm) nearly 30% of quartz and a few small pebbles (2.7 – 3.2 cm)	24.384	28.956	4.572
Sand	Like 21.95 – 24.38 m horizon	28.956	30.480	1.524
Sand	Same as above but possess very small amount of grey clay.	30.480	33.528	3.048
Sand	Coarse, equigranular, pale brown, composed of quartz, possess a small number of large pebbles (5.5 – 8.5) of quartz, agate and pegmatite.	33.528	35.661	3.133
Gravel	Gravel size of 0.905 to 1 cm with pebbles are constituted of quartz agate and quartz, a small amount of brown plastic clay also present.	35.661	36.291	0.630
Clay	Brown, plastic with a small amount of medium grained quartz sand and a few large quartz pebbls.	36.291	36.423	0.132
Sand	Medium to coarse grained, pale brown composed of quartz, possess a few small quartz pebbles and gravel	36.423	39.319	2.896
Sand	Same as above with a number of quartz pebbles upto 6.5 cm	39.319	41.148	1.829

Pebbles	Pebbles upto 5 cm and gravel (1 cm) composed of quartz and agate at 42.672 m.	41.148	42.672	1.524
Pebbles and Gravel	Same as above with a very small amount of medium to coarse grained quartz sand.	42.672	45.415	2.143
Sand	Medium grained, pale brown, composed of quartz	45.415	46.239	0.114
Clay	Reddish brown, with yellow streaks, plastic possess a small amount of quartz particles.	46.239	47.700	1.371
Clay	Yellowish with a small number of white streaks, plastic.	47.700	47.853	0.153
Clay	As above with gragment of shaly rocks. This shaly rock occurs at 150 ft. depth and continuous further down, a few chips where obtained by hammering.	47.853	48.158	0.305

2. Location: Pararia, Coordinates: 24.682500, 84.225000
Depth drilled: 38.252 m bgl
Granular zones: Nil. Abandoned due to lack of granular zones and met with hard rock at 38.252

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Green, very hard, plastic and sticky	0.00	3.048	3.048
Clay	Brown, very hard, plastic and sticky	3.048	9.1 44	6.096
Clay	Brown with very fine sand, rather plastic	9.1 44	9.75 3	0.609
Sand	find grained, brown composed of Quartz.	9.753	15.240	5.487
Sand	Brown, medium to very coarse grained, with watch and white feldspar.	15.20	16.154	0.914
Sand	Brown, with grey streaks, plastic and sticky	16.154	18.288	2.134
Clay	Grey with a large number of white feldspar gravel size grains.	18.288	18.897	0.609
Sand	Brown, with gravel, send coarse and very coarse grains, the gravel is albite feldspar and quartz.	18.897	20.421	1.524
Clay	Grey, with brown streaks contains small number of sand grains	20.421	21.336	0.915
Clay	Deep Brown, process a large number of a quartz gravel grain	21.336	24.384	3.048
Clay	Soft with white feldspar (disintegrated) gravel	24.384	32.004	7.62 0
Sand	Very coarse of white feldspar quartz and green (altered) mineral	32.004	34.747	2.743
Hard rock	Feldspathic rock, highly weathered original rock composed of white feldspar and probably dark Mica	34.747	38.252	3.505

3. Location: Kamath, Coordinates: 24.703113, 84.528074
Depth drilled : 51.82 m bgl
Granular zones :

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Black to graze black, ok hard, sticky, with ferruginous and calcareous concretion	0	2.134	2.134
Clay	Brown, plastic, hard, mixed with a little gravel of ferruginous calcareous material	2.134	12.192	10.058
Clay	Grey, Sandy, soft	12.192	14.021	1.829
Sand	Medium to very coarse grained, sub rounded, composed essentially of Quartz and feldspar, mixed with a little grey, soft clay	14.021	14.935	0.914
Clay	Brown to yellowish Brown, plastic, soft mixed with considerable amount of gravel composed of quartz, feldspar, ferruginous kankar and pieces of granite	14.935	16.549	1.614
Clay	Brown, soft and plastic with a little gravel (same as above) and sand (medium)	16.359	24.079	7.53
Clay	Brown to grayish brown Sandy with a little gravel of quartz feldspar (granite)	24.079	27.127	3.048
Silt	Micaceous (muscovite and biotite) mixed with fine grained sand and occasional thin bands of brown sticky and sandy clay(probably weathered mica schist)	27.127	51.41	24.283
Biotit-gneiss (Bedrock)	Biotite hornblende (?), gneiss and melanocratic medium to coarse grained.	51.41	51.82	30.41

4. Location: Barkagaon, Coordinates: 24.759444, 84.262500
Depth Drilled: 46.026

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Grey, hard plastic and sticky	0	3.048	3.048
Clay	yellow, hard plastic and sticky	3.048	6.096	3.048
Clay	yellow like bed from 3.042 to 26.09 m with medium grained sand in fairly large amount	6.096	9.144	3.048
Clay	like bed from 3.042 to 26.09 m	9.144	12.192	3.048
Clay	Band like like bed from 3.042 to 26.09 m	12.192	13.411	1.219
Clay	very coarse, brown, poses small amount of gravel, pebbles of quartz and gneissic rock and a small amount of clay is also present	13.411	15.24	1.829

Sand	Friend with pebbles (4.5 cm) the sand is like bad from 13.41 to 15.24 m	15.24	19.812	4.572
Sand	Coarse, brown, composed of quartz	19.812	21.336	1.524
Sand	Play with pebbles And sand. clay is brown, plastic possess small percentage of coarse sand and quartz quiet pebbles	21.336	22.96	1.624
Sand	Sand with pebbles very coarse brown sand, quartz, agate with pebbles	22.96	24.384	1.424
Clay	Deep Brown, plastic and hard	24.384	27.432	3.048
Clay	Clay with sand, the clay is yellowish Brown, rather plastic, possess fairly large amount of medium grained sand	27.432	28.346	0.914
Gravel with Sand	Gravel with very coarse sand, the gravel (size up to 0.7 cm) is of feldspar and quartz. the sand is quartzose	28.346	30.48	2.134
Gravel with Pebbles	Gravel with pebbles and very coarse sand. The gravel and pebbles (size 1.5cm) are of white it and pink feldspar and quartz. The sand is quartzes.	30.48	33.528	3.048
Clay	Dirty Brown, Plastic, possess very fine sand in small amounts.	33.528	34.747	1.219
Sand	Very coarse, brown, composed of quartz and feldspar (white)	34.747	38.100	3.353
Clay	Brown, with grey, streaky, very plastic	38.100	39.624	1.524
Sand	Very coarse, brown, composed of quartz White feldspar small amounts. A few gravel pebbles present.	39.624	42.672	3.048
Gravel with clay	Gravel with clay, gravel is of quartz with a fairly large amount of from clay	42.672	44.196	1.524
Clay	Clay, flash colour with streaks, plastic	44.196	45.11	0.916
Clay	Clay like the above horizon. The small fragments of brown and light bluish grey shale	45.11	46.024	0.914

5. Location: Kutumba, Coordinates: 24.616667, 84.233333

Depth Drilled: 32.93

Granular zone : Nil. Borehole was abandoned due to lack of productive granula zones

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Hay, dark Grey, sticky, with little coarse sand and calcareous and ferruginous concretions.	0.00	7.925	7.925
Sand	Coarse-grained with angular gravel (quartz) with pale brown clay and calcareous concentration.	7.925	9.144	1.219
Clay	Clay, a pale brown, sticky and little angular gravel of quartz and feldspar (2-8 mm)	9.144	11.8 87	2.743

Clay	Clay, yellowish brown and yellow, soft and plastic mixed with gravel of quartz and feldspar (4 mm) sand and a little kaolinitic material	11.887	17.983	6.096
Clay	Caay, yellowish brown, sandy, soft mixed with considerable amount of gravel (4-6 mm) angular to sub-angular, essentially constituted of quartz and feldspar and kaolinitic clay (the strata resembles highly Kaolinised granite)	17.983	24.079	6.196
Gravel	Gravel mixed with kaolin, essentially of quartz feldspar and little granite, angular to sub-angular (2-4 mm). (Probably derived from altered granite)	24.079	32.00	7.921
Biotite-Granite	Coarse grained, epidotised.	32.00	32.930	0.930

6. Location: Aurangabad, Coordinates: 24.750000, 84.400000

Depth Drilled: 33.84

Granular zone : Nil. Borehole was abandoned due to lack of productive granular zones

Litholog		Depth range (m bgl)		Thickness (m)
Top soil	Clayey, dark grey soft and sandy	0.000	1.524	1.524
Clay	Dark gray, sticky, plastic.	1.524	3.048	1.524
Clay	Light gray or dirty white soft, plastic, slightly sandy.	3.048	6.401	3.353
Clay	As above, with some ferruginous pebbles	6.401	13.716	7.315
Clay	Clay, soft, plastic with an increasing proportion of sand with depth.	13.716	31.390	17.674
Granite	Granite in the form of core.	31.390	33.840	2.450

7. Location: Thumbi, Coordinates: 24.716667, 84.216667

Depth Drilled: 49.280

Tube well construction depth: 41.750

Granular zones: 24.30-27.40 m, 32.00-41.75 m

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Brown, hard (occasionally soft) plastic and ferru generous and calcareous concretions	0.00	9.144	9.144
Clay	Light brown to grey, soft and plastic, mixed with fine to medium sand between 14.326 and 14.630 m	9.144	14.630	5.486
Sand	Sand fine to medium grained with a little small size gravel essentially constituted of feldspar translucent quartz and ferrugenerous nodule, white to light brown in colour, sub angular to sub rounded and micaceous.	14.630	17.983	5.353

Sand	Sand medium to very coarse grained with lot of gravel essentially composed of quartz and feldspar. Sub-rounded to angular 4 to 8 mm)	17.983	21.031	3.048
Gravel	Essentially composed of quartz, feldspar quartzite and gneiss 'Pee' size, angular to sub-rounded, mixed with medium to coarse sand and a little kaolinitic clay.	21.031	27.737	6.706
Clay	Clay light grey and yellow, gritty (due to find sand) mixed with gravel of quartz and quartzite (angular)	27.737	32.000	4.263
Sand	Sand coarse to very coarse grained angular essentially of quartz and quartzite brown.	32.000	41.750	9.750
Clay	Clay a brown to light green hard brittle with some sand of quartz and quartzite.	41.750	44.800	3.050
Clay	Clay buff, whitish grey, mixed with very little coarse sand and a considerable amount of brown olive grey hard shale palette the shale exhibits weathered surfaces.	44.800	47.850	3.050
Shale	Brown olive grey, fissile and heard.	47.850	49.280	1.430

8. Location: Gosaindih, Coordinates: 24.668837, 84.109230

Depth Drilled: 30.53

Tube well construction depth: NA

Granular zones:Nil. Borehole was abandoned due to lack of productive granula zones

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Clay, dark grey, plastic and sticky.	0.00	3.048	3.048
Clay	Clay, yellowish brown, hard, plastic and sticky contains very tiny mica flakes.	3.048	6.096	3.048
Clay	Clay, greyish, yellow, hard, plastic and sticky.	6.096	9.144	3.048
Clay	Clay, yellowish brown, hard, plastic and sticky possess small moderate white kankar.	9.144	12.192	3.048
Clay	Clay, brown, hard, plastic and sticky.	12.192	15.24	3.048
Clay	Clay, yellow, hard, plastic and sticky possess small nodules of white kankar.	15.240	27.432	12.192
Clay with sand	Clay brown and plastic possess a large amount of coarse sand and pebbles (2 to 2.5 cm)	27.432	30.48	3.048
Shale	Brown and hard contains very tiny white mica flakes and very fine sand.	30.480	30.532	0.052

9. Location: Bela Khaira, Coordinates: 24.691667, 84.150000
Depth Drilled: 43.590 m bgl
Tube well construction depth: 39.928 m bgl
Granular zones:19.812 - 38.354 m

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Clay, dark grey, plastic, hard and sticky	0.00	7.010	7.010
Clay	Clay, pale brown, hard, plastic possess a small number of medium sand grains.	7.010	10.058	3.048
Clay	Clay like bed from 7.01 to 10.058 m but with more sand grain.	10.058	14.020	3.962
Sand	Very coarse (almost gravelly) with grey plastic clay. The sand is composed of quartz and feldspar grain. The clay constitutes about 40% of the sample.	14.020	17.068	3.048
Sand	Sand like above without grey clay.	17.068	24.079	7.011
Gravel	Gravel with a small amount of very coarse sand, both dominantly composed of brown quartz with white feldspar.	24.079	28.041	3.962
Sand	Coarse to very coarse, brown composed of quartz with feldspar	28.041	31.089	3.048
Gravel	Fine gravel composed of quartz with white feldspar.	31.089	35.052	3.953
Gravel	Gravel composed of quartz and feldspar.	35.052	38.700	3.048
Sand stone	Sand, very fine, buff, very compact and hard probably crystallised.	38.700	43.586	5.486

10. Location: Charan Kalan, Coordinates: 24.779167, 84.241667
Depth Drilled: 46.481 m bgl
Tube well construction depth:45.445 m bgl
Granular zones tapped:20.878 - 29.285 and 33.20-44.50 m

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Clay, pale green, hard, plastic and sticky	0.00	6.100	6.100
Clay	Clay like above, with a small amount of medium sand, granite.	6.100	9.14	3.044
Clay	Clay with medium sand, brown and plastic.	9.14	11.582	2.438
Sand	Sand with gravel and pebbles. The sand is brown, equigranular, contains gravel and pebbles (size max. 6.5 cm) of quartz, sand stone and granite.	11.582	21.336	9.754
Sand	Sand with pebbles, sand is brown, medium and coarse grained, pebbles are of quartz and quartzite.	21.336	28.346	7.010
Pebbles	Pebbles of (size 4.5 to 8 cm) of quartz, agate and sandstone.	28.346	29.260	0.914

Clay	Clay, deep brown with white grey streaks and a small amount of sand grains.	29.260	30.480	1.220
Pebbles	Pebbles of (3-6 cm) with gravel and coarse sand. The pebbles are of quartz, granite and sandstone.	30.480	36.576	6.096
Pebbles	Pebbles with gravels, Pebbles (2.5 to 4.5 cm) and of quartz, agate and sandstone.	36.576	39.624	3.048
Pebbles	Pebbles with gravels and coarse sand like 30.48 to 36.62 m bed.	39.624	42.672	3.148
Sand	Sand with pebbles. The sand is very coarse, almost gravelly of white feldspar and quartz. The pebbles are of (4.5 cm) quartz and sandstone.	42.672	46.481	3.009

11. Location: Karhara, Coordinates: 24.750000, 84.233333

Depth Drilled: 59.486 m bgl
Tube well construction depth:45.445 m bgl
Granular zones tapped:Nil The borehole was abandoned due to lack of granular zone,

Litholog		Depth range (m bgl)		Thickness (m)
Clay	Clay, hard plastic, hard and sticky	0.00	3.05	3.050
Clay	Clay, yellowish, plastic, hard and sticky.	3.05	6.100	3.050
Clay	Clay light brown, very plastic, hard and sticky.	6.100	9.140	3.040
Clay	Clay, brown, plastic and hard.	9.140	12.800	3.660
Gravel	Gravel brown of varying size consisting of feldspar and quartz.	12.800	23.780	10.980
Clay	Clay, brown, plastic and hard.	23.780	24.380	0.600
Clay	Clay, red, plastic and hard.	24.380	31.700	7.320
Clay	Clay, greenish yellow, very hard and plastic.	31.700	33.528	1.828
Clay	Clay, yellow, very hard and plastic.	33.528	36.576	3.048
Clay	Clay with sand, the clay is similar as above and possesses a fairly large amount of very coarse quartz and feldspar.	36.576	38.100	1.524
Sand	Sand, very coarse, almost grains of quartz and white feldspar possess a small amount of brown clay.	38.100	39.624	1.524
Sand	Sand, just above without clay.	39.624	40.538	0.914
Clay	Clay, brown, with white streaks. Plastic and possess brown kankar nodules.	40.538	42.672	2.134
Clay	Clay, pale brown, with white streaks and plastic.	42.672	45.720	3.048
Clay	Clay like above with less compact white and brown shale fragment.	45.720	59.436	13.716
Shale	Brown, very hard and compact rather metamorphosed.	59.436	59.486	0.50

12. Location: Tangra, Coordinates: 24.811877, 84.294971
Depth Drilled: 47.850 m bgl
Tube well construction depth:36.270 m bgl
Granular zones tapped:24.079-34.750 m

Litholog		Depth range (m bgl)		Thickness (m)
Top soil	Clayey, brown, and plastic.	0.00	2.134	2.134
Clay	Clay, yellowish, brown, plastic with calcareous concretions..	2.134	6.706	4.572
Clay	Clay, brown and yellow with silt and sand fine to coarse grained.	6.706	9.144	2.438
Sand	Sand, fine to coarse grained, composed essentially of quartz, somewhat clayey.	9.144	13.411	4.267
Sand	Sand medium to coarse grained, mostly sub-angular, composed of quartz and few grains of feldspar.	13.411	19.507	6.096
Gravel	Gravel and sand, very coarse grained, composed of quartz and a few grains of feldspar. Gravel rounded to sub-angular, composed of quartz, quartzite, sandstone, opal and feldspar varying in size from ½" to ⅛".	19.507	35.970	16.463
Clay	Clay shaly, light brown, cream or brown coloured.	35.970	44.500	8.530
Shale	Light coloured, fine grained compact, hard with arenaceous intercalations.	44.500	47.850	3.350

13. Location: Dadar, Coordinates: 24.923527, 84.614920
Depth Drilled: 85.950 m bgl
Tube well construction depth:
Granular zones tapped:39.62 -48.98; 50.50-57.30; and 65.84-82.61 m

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	39.620	39.620
Coarse sand	39.620	48.980	9.360
Clay	48.980	50.500	1.520
Coarse sand	50.500	57.300	6.800
Clay	57.300	59.430	2.130
Sandy clay	59.430	65.840	6.410
Coarse sand	65.840	82.610	16.770
Boulder (Rock)	82.610	85.950	3.340

14. Location: Pratap pur, Coordinates: 24.886521, 84.640369
Depth Drilled: 89.000 m bgl
Tube well construction depth:
Granular zones tapped:43.89-56.38; 59.43-80.16 m

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Very hard clay	0.00	43.890	43.890
Coarse sand	43.890	56.380	12.490
Hard clay	56.380	59.430	3.050
Coarse sand	59.430	80.160	20.730
Boulder (Rock)	80.160	89.00	8.840

15. Location: Jaitiya, Coordinates: 24.900186, 84.645138
Depth Drilled: 76.810 m bgl
Tube well construction depth:NA
Granular zones tapped:38.710-61.270; 65.840-76.200 m

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	38.710	38.710
Coarse sand	38.710	61.270	22.560
Clay	61.270	65.840	4.570
Sand and pebbles	65.840	76.200	10.360
Hard rock	76.200	76.810	0.610

16. Location: Khojhi, Coordinates: 24.893689, 84.677164
Depth Drilled: 82.610 m bgl
Tube well construction depth:NA
Granular zones tapped:3.66-14.63; 34.75-38.41; 42.36;46.63; 56.69-79.86 m

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	3.660	3.660
Coarse sand	3.660	14.630	10.970
Sandy clay	14.630	21.340	6.710
Clay	21.340	34.750	13.410

Sand	34.750	38.410	3.660
Clay	38.410	42.360	3.950
Coarse sand	42.360	46.630	4.270
Clay	46.630	56.690	10.303
Coarse sand	56.690	79.860	23.170
Boulder and Rock	79.860	82.610	2.750

17. Location: Toralpura, Coordinates: 24.888350, 84.658723
Depth Drilled: 76.200 m bgll
Tube well construction depth:NA
Granular zones tapped:4.570-14.630;48.770-73.150 m

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	20.727	20.727
Medium sand	20.727	37.490	16.763
Coarse sand with clay	37.490	52.730	15.240
Sandy clay	52.730	60.960	8.230
Coarse sand	60.960	65.840	4.880
Sand with boulders	65.840	73.150	7.310
Hard rock	73.150	76.200	3.050

18. Location: Mahari, Coordinates: 24.904444, 84.702363
Depth Drilled: 76.200 m bgll
Tube well construction depth:NA
Granular zones tapped:4.570-14.630;48.770-73.150 m

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	3.658	3.658
Fine sand	3.658	7.620	3.962
Clay	7.620	24.690	17.070
Coarse	24.690	28.040	3.350
Clay	28.040	29.560	1.520
Coarse sand	29.560	50.190	20.630
Coarse sand with pebbles	50.190	57.910	7.720
Hard rock	57.910	60.650	2.740

19. Location: Chapra, Coordinates: 24.926642, 84.712239
Depth Drilled: 70.100 m bgl
Tube well construction depth:NA
Granular zones tapped: 10.668-23.950; 32.000-41.450; 45.110-70.100

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	10.668	10.668
Coarse sand	10.668	23.956	13.288
Clay	23.956	32.00	8.044
Coarse sand	32.00	41.450	9.450
Clay	41.450	45.110	3.660
Coarse sand	45.110	59.430	14.320
Coarse sand with pebbles	59.430	70.100	10.670

20. Location: Naguli, Coordinates: 25.017770, 84.588208
Depth Drilled: 118.260 m bgl
Tube well construction depth:NA
Granular zones tapped: 18.288-33.530; 47.250-71.620
74.670-80.770; 91.440-97.540
106.310; 113.390

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay - yellow	0.00	18.288	18.288
Sand - medium	18.288	33.530	15.242
Clay - yellow	33.530	47.250	13.720
Sand - medium	47.250	71.620	24.370
Clay - yellow	71.620	74.670	3.050
Sand - medium	74.670	80.770	6.100
Clay - yellow	80.770	91.440	10.670
Sand - medium	91.440	97.540	6.100
Clay - yellow	97.540	106.310	8.770
Sand - medium	106.310	113.390	7.080
Clay - yellow	113.390	118.260	4.870

21. Location: Jaitpur, Coordinates: 25.020242, 84.568148
Depth Drilled: 76.200 m bgl
Tube well construction depth:NA
Granular zones tapped: 9.449 - 67.670 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	3.962	3.962
Sand - fine	3.962	9.449	5.487
Sand - medium	9.449	24.384	14.935
Sand - coarse	24.384	52.430	28.046
Coarse sand with pebbles	52.430	67.670	15.240
Clay - sandy	67.670	67.200	8.530

22. Location: Chachuta, Coordinates: 25.031058, 84.566714
Depth Drilled: 80.770 m bgl
Tube well construction depth:NA
Granular zones tapped: 15.240-17.983; 23.774.190; 39.62-19.280; 65.530-76.810 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	15.240	15.240
Coarse sand	15.240	17.983	2.743
Clay	17.983	23.774	5.791
Coarse sand	23.774	37.190	13.416
Clay	37.190	39.620	2.430
Coarse sand with pebbles	39.620	49.280	9.660
Hard clay	49.280	65.530	16.250
Coarse sand	65.530	76.810	11.280
Clay	76.810	80.770	3.960

23. Location: Barokhar, Coordinates: 25.028550, 84.579833
Depth Drilled: 54.010 m bgl
Tube well construction depth:NA
Granular zones tapped: 18.288-60.960 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	

Clay	0.00	1.524	1.524
Find sand	1.524	18.288	16.764
Coarse sand	18.288	60.960	42.672
Clay	60.960	64.010	3.050

24. Location: Malhara – I, Coordinates: 25.027076, 84.599267
Depth Drilled: 150 m bgl
Tube well construction depth:NA
Granular zones tapped:15.240-36.580; 45.410-55.170; 91.440-96.010; 99.060-109.120; 114.300-120.700; 137.770-145.390 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	15.240	15.240
Sand - medium	15.240	36.580	21.340
Clay - yellow	36.580	45.410	8.830
Sand - medium	45.410	55.170	9.760
Clay - yellow	55.170	91.440	36.270
Sand - medium	91.440	96.010	4.570
Clay	96.010	99.060	3.050
Sand - coarse	99.060	109.120	10.060
Clay	109.120	114.300	5.180
Sand - medium	114.300	120.700	6.400
Clay - yellow	120.700	137.770	17.070
Sand - medium	137.770	145.390	7.620
Clay	145.390	150.870	5.480

25. Location: Malhara – III, Coordinates: 25.027076, 84.599267
Depth Drilled: 79.250 m bgl
Tube well construction depth:NA
Granular zones tapped: 3.048-74.670 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	3.048	3.048
Coarse sand	3.048	74.670	71.622
Clay	74.670	79.250	4.580

26. Location: Jokhara, Coordinates: 25.042355, 84.609349
Depth Drilled: 79.250 m bgl
Tube well construction depth:NA
Granular zones tapped: 18.288-73.150 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	18.255	18.288
Coarse sand	18.255	73.150	54.862
Clay	73.150	79.250	6.100

27. Location: Deoriya, Coordinates: 24.641530, 84.222104
Depth Drilled: 79.250 m bgl
Tube well construction depth:NA
Granular zones tapped: 18.288-73.150 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay - yellow	0.00	18.288	18.288
Sand-medium	18.288	45.720	27.432
Clay - yellow	45.720	56.380	10.660
Sand-fine, with clay	56.380	62.480	6.100
Clay - yellow	62.480	79.250	16.770
Clay - black, sticky	79.250	95.710	16.460
Hard rock	95.710	96.620	0.910

28. Location: Chankap, Coordinates: 24.651170, 84.220132
Depth Drilled: 103.360 m bgl
Tube well construction depth:NA
Granular zones tapped: 18.288-73.150 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay - yellow	0.00	27.432	27.432
Sand-medium	27.432	36.560	9.148
Sand - fine to medium	36.560	45.720	9.140
Clay - sticky	45.720	48.460	2.740

Sand - medium	48.460	54.560	6.100
Clay - yellow	54.560	85.950	31.390
Clay - black and sticky	85.950	98.450	12.500
Soft rock	98.450	102.100	3.650
Hard rock	102.100	103.360	1.260

29. Location: Baksar, Coordinates: 24.905346, 84.671241
Depth Drilled: 78.030 m bgl
Tube well construction depth:NA
Granular zones tapped: 39.020-44.500; 57.300-75.800 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	3.048	3.048
Sand - fine	3.048	9.144	6.096
Kankar and clay	9.144	39.020	29.876
Sand - coarse	39.020	44.500	5.480
Kankar and clay	44.500	57.300	12.800
Sand - coarse	57.300	75.800	18.500
Hard rock	75.800	78.030	2.230

30. Location: Mohammadpur, Coordinates: 24.962425, 84.724382
Depth Drilled: 94.490 m bgl
Tube well construction depth:NA
Granular zones tapped: 12.190-24.994; 47.850-56.380; 60.960-64.920; 71.620-73.460; 83.820-92.350 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	12.190	12.190
Coarse sand	12.190	24.994	12.804
Clay	24.994	47.850	22.856
Coarse sand	47.850	56.380	8.530
Clay	56.380	60.960	4.580
Coarse sand	60.960	67.920	3.960
Clay with kankar	67.920	71.620	6.700

Sand - medium	71.620	73.460	1.840
Sand with clay	73.460	83.820	10.360
Sand - medium	83.820	92.350	8.530
Sand with clay	92.350	92.960	0.610
Hard rock	92.960	94.490	1.530

31. Location: Malhard I

Depth Drilled: 87.470 m bgl
Tube well construction depth:NA
Granular zones tapped: 12.192-18.288; 45.720-87.170 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	12.192	12.192
Sand - fine	12.192	18.288	6.096
Clay	18.288	45.720	27.432
Coarse sand	45.720	84.740	39.020
Very coarse sand	84.740	87.170	2.430
Hard rock	87.170	87.470	0.300

32. Location: Malhard II

Depth Drilled: 87.470 m bgl
Tube well construction depth:NA
Granular zones tapped: 12.192-18.288; 45.720-87.170 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	20.727	20.727
Sand - coarse	20.727	37.490	16.763
Clay	37.490	52.730	15.240
Sand - very coarse	52.730	54.160	1.430
Sand - coarse	54.160	60.960	6.800
Clay	60.960	65.840	4.880
Sand - coarse	65.840	73.150	7.310
Hard rock	73.150	76.200	3.050

33. Location: Roralpura, Coordinates: 24.888350, 84.658723
Depth Drilled: 73.150 m bgl
Tube well construction depth:NA
Granular zones tapped: 14.572-14.630; 32.00-33.840 m bgl

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	4.572	4.572
Sand - medium	4.572	14.630	10.058
Clay - hard	14.630	32.000	17.370
Sand - coarse with clay	32.000	33.840	1.840
Clay - hard	33.840	41.140	7.300
Clay - sandy	41.140	48.770	7.630
Clay - hard and sandy	48.770	73.150	24.380

34. Location: Bhatkur, Coordinates: 24.708889, 84.318889

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface soil red in colour	0	6	6.00	
Kankar brown in colour	6	9	3.00	
Sticky clay and Kankar red in colour	9	45	36.00	32.0 m
Quartzite white and palm green in colour	45	201	156.00	

35. Location: Chandagarh, Coordinates: 24.586944, 84.120556

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Kankar yellowish in colour	0	18	18.00	
Sticky clay and Kankar brown in colour	18	24	6.00	
Shale dark brown in colour	39	66	37.00	32.0 m

Slate black in colour	66	102	36.00	
Phyllite palm green in colour	102	171	69.00	124.0 m
Schist black in colour	171	201	30.00	

36. Location: Gongra Bandh, Coordinates: 24.693702, 84.050269

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface Soil yellowish in colour	0	9	9.00	
Kankar Reddish brown in colour	9	21	12.00	
Phyllite Palm green in colour	21	33	12.00	32.0 m
Schist grey in colour	33	51	18.00	44.0 m
Gabbro black in colour	51	99	48.00	
Granite gneiss dark brown in colour	99	201	102	156.0 m

37. Location: Kutumba, Coordinates: 24.609167, 84.223611

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface soil red in colour	0	3	3.00	
Surface soil brown in colour	3	6	3.00	
Surface soil red in colour	6	9	3.00	
Kankar brown in colour	9	12	3.00	
Sticky clay red in colour	12	15	3.00	
Sticky clay and kankar red in colour	15	18	3.00	
Sticky clay yellowish in colour	18	24	6.00	
Kankar brown in colour	24	45	21.00	
Granite white and black in colour	45	117	72.00	52.00
Quartzite red and white in colour	117	150	33.00	149.00
Quartzite palm green in colour	150	201	51.00	

38. Location: Madanpur, Coordinates: 24.653056, 84.583056

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface soil red in colour	0	6	6.00	
Sticky clay and kankar yellow in Colour	6	24	18.00	
Granite white and black in colour	24	162	138.00	66.00 & 130.00
Quartzite palm green in colour	162	201	39.00	

39. Location: Pawai, Coordinates: 24.730255, 84.309432

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface Soil yellowish in colour	0	6	6.00	
Sticky Soil brownish in Colour	6	15	9.00	
Sticky Soil yellowish in Colour	15	36	21.00	
Granite gneiss black & white in colour	36	81	45.00	67 000 m
Granite gneiss brown in colour	81	201	193.00	176.00 m

40. Location: Umga, Coordinates: 24.647989, 84.566881

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface soil red in colour	0	3	3.00	
Sticky soil and kankar brown in colour	3	6	3.00	
Kankar brown in colour	6	15	9.00	
Sticky clay and kankar red in colour	15	21	6.00	
Granite white and black in colour	21	201	180.00	

41. Location: Baulia, Coordinates: 24.771208, 84.053458

Drilling depth: 201 m bgl

Lithology	Depth range (m)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface soil dark brown in colour	0	9	9.00	
Kankar red and brown in colour	9	12	3.00	
Kankar dark brown in colour	12	15	3.00	
Kankar yellowish in colour	15	18	3.00	
Sticky clay yellowish in colour	18	54	36.00	
Kankar dark brown in colour	54	57	3.00	
Shale dark black in colour	57	201	144.00	94 & 149 m

42. Location: **Manjurkha,** Coordinates: 24.727222, 84.461111

Drilling depth: 123 m bgl

Lithology	**Depth range (m)**		**Thickness (m)**
	From	**To**	
Surface soil brown in colour	0	3	3
Clay and kankar yellowish in colour	3	12	9
Sticky clay and kankar red in colour	12	18	6
Kankar brown in colour	18	21	3
Quartzite red and white in colour	21	78	57
Quartzite palm green in colour	78	123	45

43. Location:Chandpur Tola, Coordinates: 24.647322, 84.419875

Drilling depth: 180 m bgl

Lithology	Depth range (mbgl)		Thickness (m)	Fractured Zone encountered (mbgl)
	From	To		
Surface soil reddish in colour	0	3	3.00	
Kankar red in colour	3	6	3.00	
Sticky Clay red in colour	6	27	21.00	
Kankar reddish in colour	27	33	6.00	
Gneiss black and white in colour	33	111	78.00	41m & 57 m
Quartzite greenish and white in colour	111	180	69.00	

44. Location: Rafiganj, Coordinates: 24.781496, 84.657845

Drilling depth:65 m bgl

Site Name	PHED office campus	Latitude	24°70'81" N
Village	Rafiganj	Longitude	54°39'49"E
Block	Rafiganj	Water Level	17 mtr.

LITHOLOGY	Depth range		Thickness	FORMATION
	From	To	(m)	
Surface soil brown in colour	0	6	6	Soil
Clay yellowish in colour	6	39	33	Soil
Kankar brown in colour	39	45	6	Kankar
Clay yellowish in colour	45	65	20	Clay

45. Location: Daudnagar, Coordinates: 25.036304, 84.414416

Drilling depth: 105 m bgl

Village- Daudnagar				Co-ordinates-25.036304,84.414416
Block / District -Daudnagar /Aurangabad				Total depth-100m
S.No.	Depth Range (m)		Thickness (m)	Composite Lithology
	From	To		
1	0	5	5	Surface soil ,brown color

2	5	10	5	Sand: Medium sand ,yellow color
3	10	20	10	Sticky clay ,yellow color
4	20	25	5	Sand: Fine sand, yellow color
5	25	32	7	Sand: Fine to medium sand, yellow color
6	32	40	8	Clay, yellow color with mix few kankar
7	40	45	5	Sand: Fine sand, yellow color
8	45	55	10	Sand: Coarse sand, yellow color
9	55	60	5	Sticky clay, yellow and greyish color
10	60	70	10	Sticky clay, yellow and greyish color
11	70	80	10	Sand: Coarse sand ,yellow color
12	80	95	15	Sand: Fine sand ,yellow color mixed with clay
13	95	100	5	Clay, yellow color with mix few fine sand, yellow color

Location: Hanspura, Coordinates: 25.064949, 84.549746

Drilling depth: 105 m bgl

Village : Haspura				Co-ordinates: 25.0648523; 83.5497201
Block / District : Dhanura /Aurangabad				Total depth- 167 m
S.No.	Depth Range (m)		Thickness (m)	Composite Lithology
	From	To		
1	0	10	10	Surface soil reddish color.
2	10	13	3	Sand Medium sand yellow color.
3	13	20	7	Clay grayish color.
4	20	28	8	Sand Medium sand yellow color.
5	28	40	12	Clay grayish color.
6	40	43	3	Sand Medium sand yellow color.
7	43	52	9	Clay reddish yellow color.
8	52	62	10	Sand Medium sand yellow color.
9	62	80	18	Clay reddish yellow color.
10	80	86	6	Sand Medium sand yellow color.
11	86	105	19	Clay red color
12	105	112	7	Sand Medium sand yellow color.
13	112	120	8	Clay red color.
14	120	143	23	Sand Medium sand yellow color.
15	143	163	20	Clay reddish yellow color
16	163	167	4	Hard Clay reddish yellow color

Based on Geophysical Survey (VES)

Location: Deo

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay - Sandy	0.00	28.0	28
Hard rock	28.00	-	-

Location: Nainagar

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	24	24
Hard rock	24.00	-	-

Location: Basdihakalan (near +2 High School)

Litholog	Depth range (m bgl)		Thickness (m)
	from	*to*	
Clay	0.00	7	7
Sand - Clayey	7	82	75

References:

1. Ground Water Year Book – 2017-18
2. Hydrogeology and Ground Water Development Potential of Aurangabad district, Bihar
3. Ground Water Exploration Report – Bihar

Disclaimer:

The Report has been prepared based on the available data, observations from fields and discussion with the local farmers. Additional data, incorporated in future, may change the understanding of hydrogeological scenario of the area.