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Central Ground Water Board

केंद्रीय भूजल बोर्ड

MINISTRY OF JAL SHAKTI

जल शक्ति मंत्रालय

Department of Water Resources, River Development and Ganga Rejuvenation

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

GOVERNMENT OF INDIA

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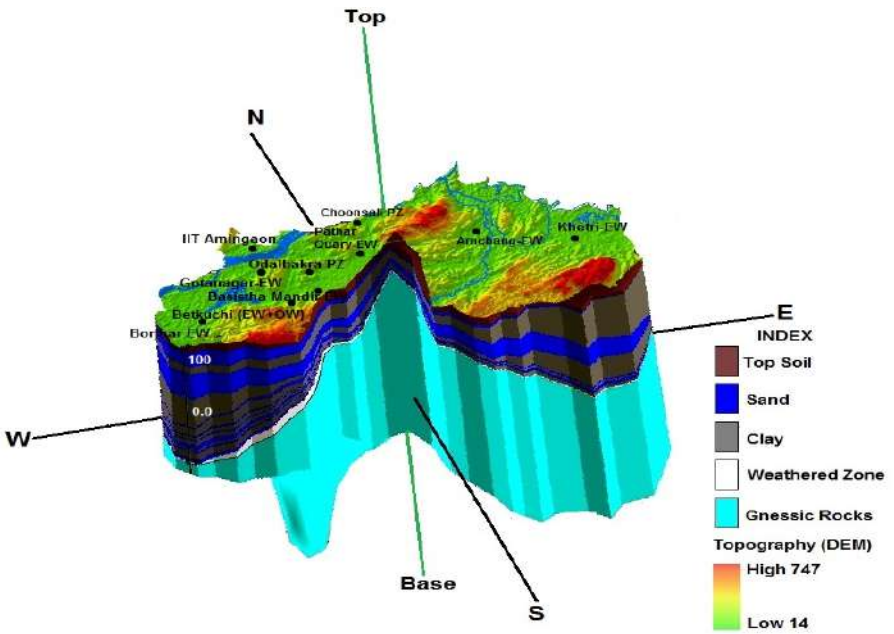
REPORT ON AQUIFER MAPPING AND MANAGEMENT PLAN OF KAMRUP (METRO) DISTRICT, ASSAM



North Eastern Region,

उत्तर पूर्वी क्षेत्र, गुवाहाटी

GUWAHATI

गुवाहाटी

JULY,2022

GOVERNMENT OF INDIA

MINISTRY OF JAL SHAKTI

DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

CENTRAL GROUND WATER BOARD

REPORT ON AQUIFER MAPPING AND MANAGEMENT PLAN OF KAMRUP (METRO) DISTRICT, ASSAM

(AAP 2021-22)

By

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1.0 Introduction

1.1 Objectives

With dwindling ground water resource in the country it is dire need of the hour to quantify and qualify the ground water in all parts of the country and give a sustainable management plan keeping future demands in mind. The objective of the current study is to prepare aquifer map of the area in 1:50,000 scale, assess the ground water resource of the area, identify the groundwater contaminated area and prepare a groundwater management plan.

1.2 Scope of the study

The Kamrup Metropolitan district is the economic hub and the gateway to north east. This district used to have vast groundwater and surface water resources. However, rapidly rising urban population, increasing number of housing societies and hotels, and finally industrialization has created a threat to ground water in the area. Moreover, the groundwater of the area is contaminated with iron and fluoride which possesses serious health hazard to the general public. Proper hydro-geologic knowledge of the area can be helpful to prepare a sustainable management plan for groundwater utilization.

1.3. Approach and methodology

The approach is to identify the aquifer types and to conceptualize the aquifer system. This will help to formulate an aquifer management plan. Finally, the scientific knowledge will be disseminated to state government and stake holders. The methodology can be illustrated as follows:

Data compilation and data gap analysis: The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, and State Groundwater Departments. All data were plotted in base map on GIS Platform (ArcGIS 10.8) using both Geographic and Projected category longitude/latitude (WGS 1984). On the basis of available data, Data Gaps were identified.

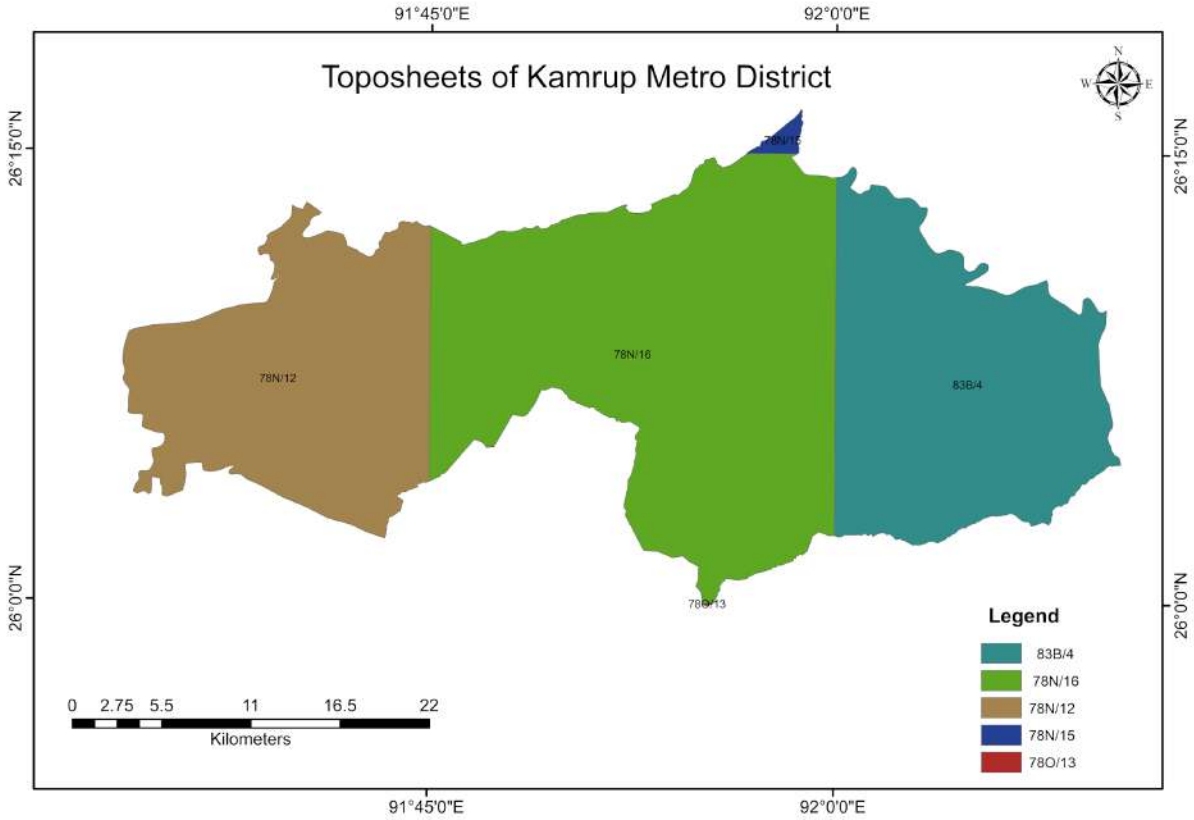
Data Generation: Efforts were made to fill the data gaps by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, soil infiltration tests, besides detailed hydro-geological surveys.

Aquifer Map Preparation: It is a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses applied to characterize the quantity, quality and sustainability of ground water in aquifers. On the basis of integration of data generated from various studies of hydrogeology and geophysics, aquifers have been delineated and characterized in terms of quality and ground water potential. Various maps have been prepared to delineate the lateral and vertical disposition of aquifers and their characterization on 1: 50,000 scale.

Aquifer Management Plan Formulation: Based on aquifer map and conceptual model a sustainable development plan of the aquifer is formulated.

1.4 Area Details

The area chosen for aquifer mapping falls under Survey of India Toposheet No.s 78N/12, 78N/12, 83B/04, 78O/13 and 78N/15 bounded by 26°00'00" and 26°17'00" northern latitude and 91°33'00" and 92°11'00" east longitude.



Administrative set up of the study area:

Kamrup Metropolitan district which is situated at the plains of the Brahmaputra Valley is bounded between 26°00'00" and 26°17'00" N Latitude and 91°33'00" and 92°11'00" E Longitude. At present, Kamrup Metro district consists of six sub- divisions and one civil subdivision. They are namely Azara, North Guwahati (Pt), Guwahati, Dispur, Sonapur and Chandrapur. Kamrup Metro district comprises 06 Revenue Circles with 216 villages. It has 03 Community Development Blocks within the district. The total area in the district is 954.57 km2, out of which 719.57 km2 area is rural and 262.00 km2 area is urban. There are total 21 Gaon Panchayats in the district.

Assessment Unit	*Total Geographical Area (ha)	*Hilly Area (ha)	*Total Recharge Worthy Area (ha)			
			*Command	*Non Command	*Poor Quality	Total
Kamrup Metro (Rural)	69257	23387	0	45870	0	45870
Kamrup Metro (Urban)	26200	6158	0	20042	0	20042
Total	**95457**	**77021**	**0**	**65912**	**0**	**65912**

Total population of the district is 12,53,938 souls (as per 2011 census) with 216927 people in rural area and 1037011 people in urban area. The average population density of the district is 1313 persons/sq.km. The decadal variation of population for 2001-2011 is 18.34 percent.

Table 1.1 Administrative Division

No. of Civil Subdivision	No. of Blocks	No. of Revenue Circles	No. of Gram Panchayats	No. of Villages (Inhabited)	Uninhabited Villages
6	3	6	21	204	12

Data Source: Assam Statistical Handbook, 2020.

Table 1.2 Block Level Geographical Area (in sq.km) and Population of Kamrup Metro District:

Blocks	Sub Division/Revenue Circle	No. of villages	Area (sq.km)	Population
Palashbari	Azara	21	137	64247
Bezera (Pt)	North Guwahati (Pt)	5	19	28400
Guwahati	Guwahati	0	81	433771
	Dispur	5	102	534872
Dimoria	Sonapur	142	488	143371
Chandrapur	Chandrapur	43	128	49277

#Data source: Census Handbook 2011

The district has a good network of roads, train and air connections. Guwahati, the earlier Headquarter of the district and state capital can be termed as the Gateway of North Eastern Region and other parts of the country.

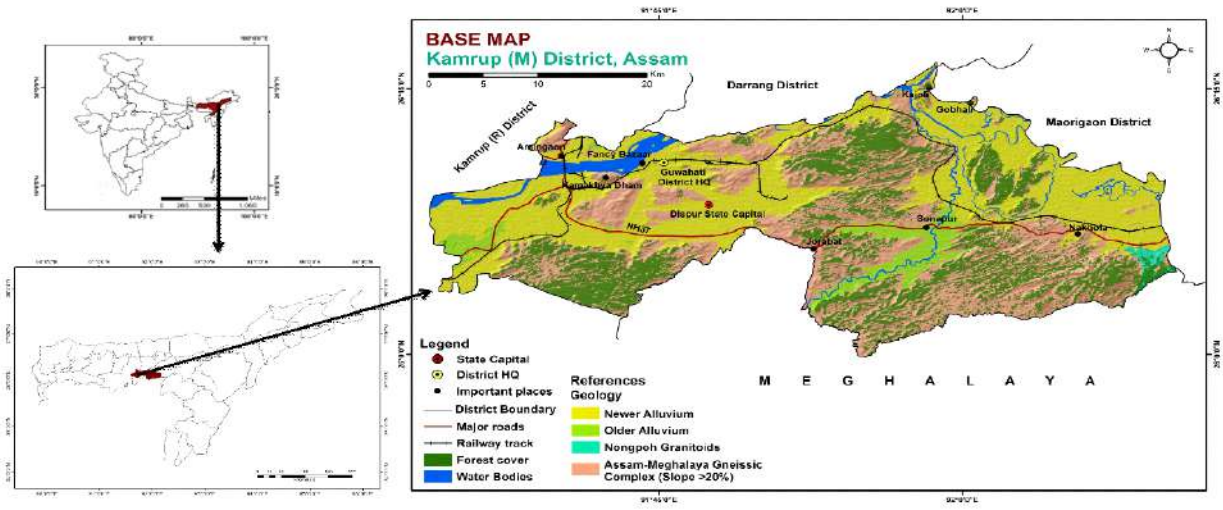


Fig.1.1: Index Map of the study area

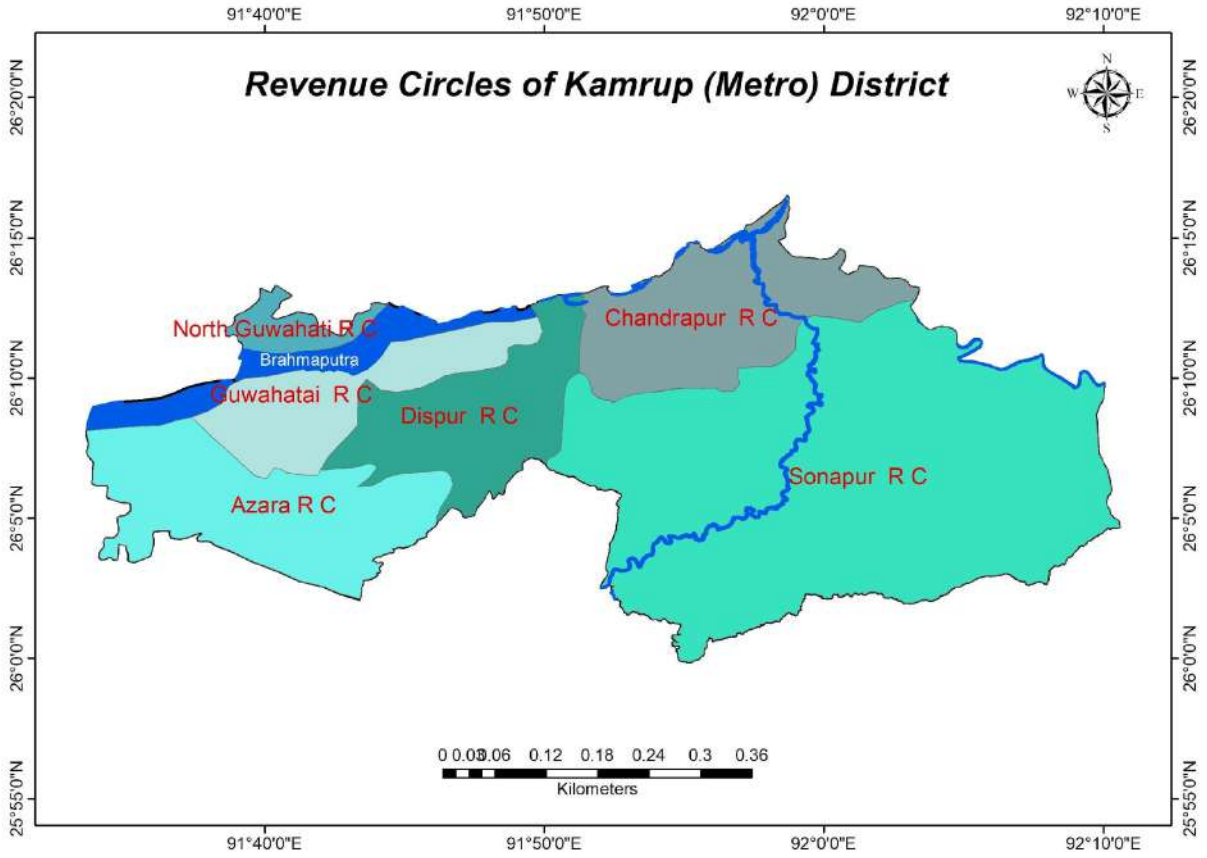


Fig.1.2: Revenue Circles of the study area

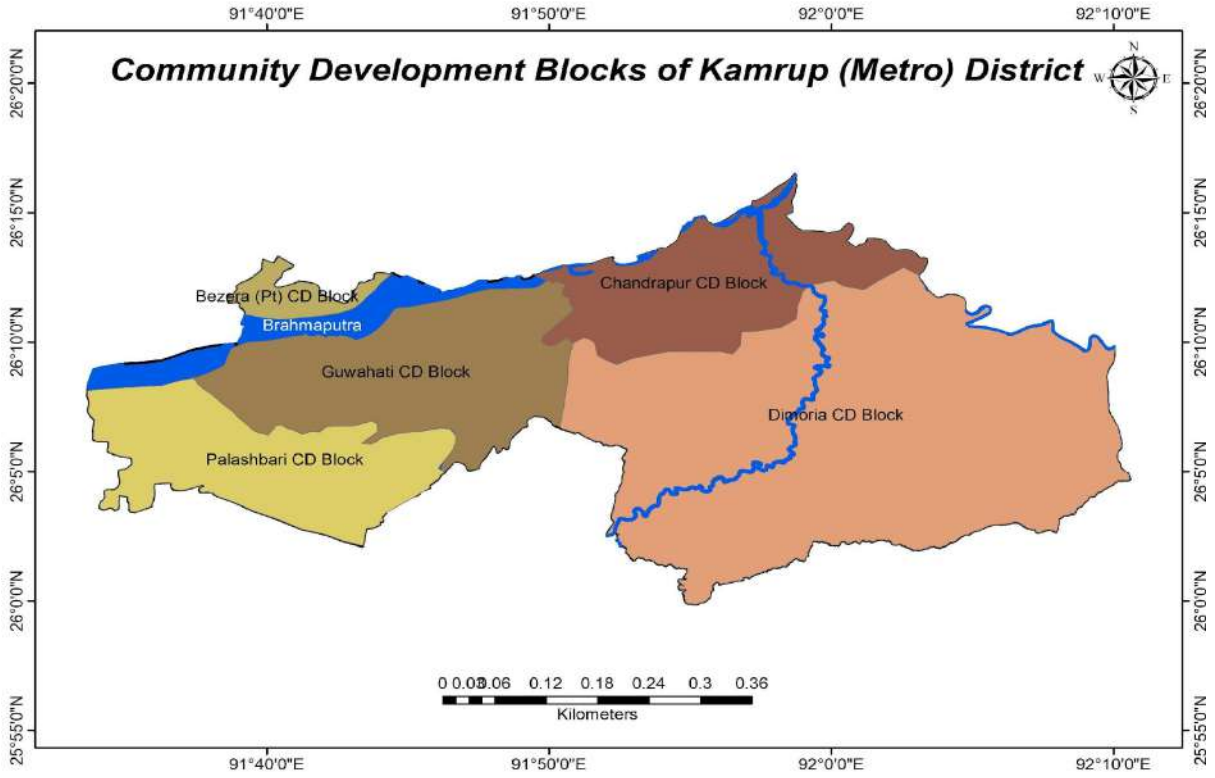


Fig.1.3: Community Development Blocks of the study area

1.5 Data availability, data adequacy, data gap analysis and data generation

The preliminary works consisted of collection and review of all existing hydrogeological, geophysical and exploration data of CGWB. All data were plotted in base map on GIS Platform (ArcGIS 10.3) using Projection category longitude/latitude (WGS 84).

The available data, data gap and data generation work is tabulated in Table: 1.3

Table 1.3: Data availability, data gap and data generation in Kamrup (Metro) district, Assam

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data		49	09	05	54	
2	Geophysical data		10	19	07	17	
3	Groundwater level data	Dug well	50	07	07	57	
		Piezometer Aquifer-I	04	08	05	09	
4	Groundwater quality data	Dugwell-Aquifer-I	19	30	30	49	
		Piezometer Aquifer-I	Nil	03	03	03	
5	Specific Yield		Nil	6	Nil	Nil	
6	Soil Infiltration Test		0	3	3	3	

The available data and data generation points are shown in following figures.

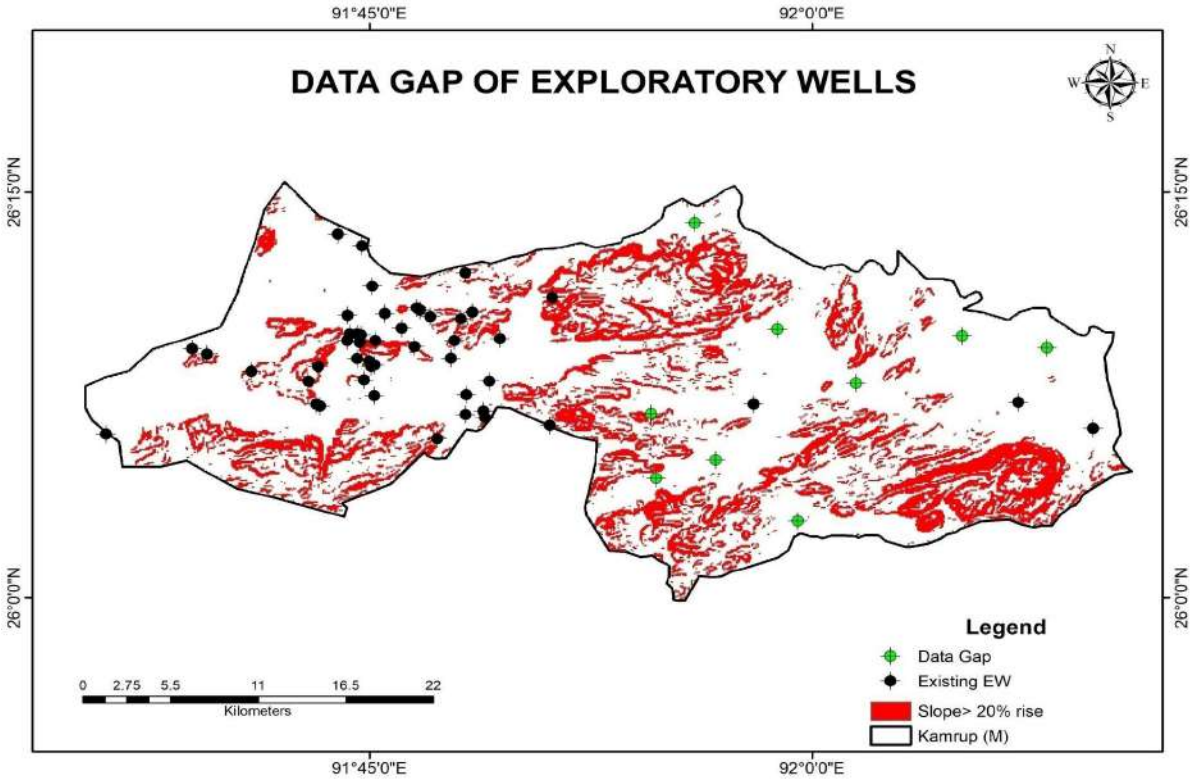


Fig. 1.4: Available data and data generation of exploration in the study area

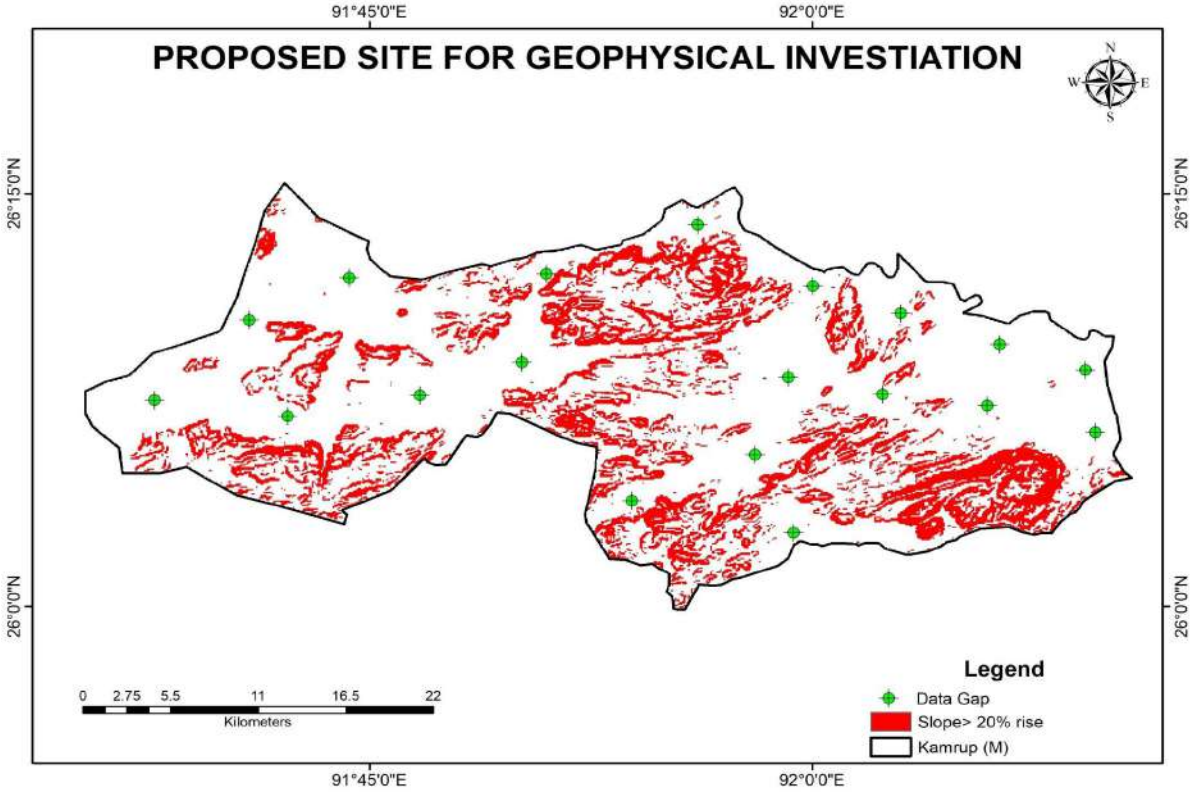


Fig. 1.5: Available data and data generation of geophysical investigation in the study area

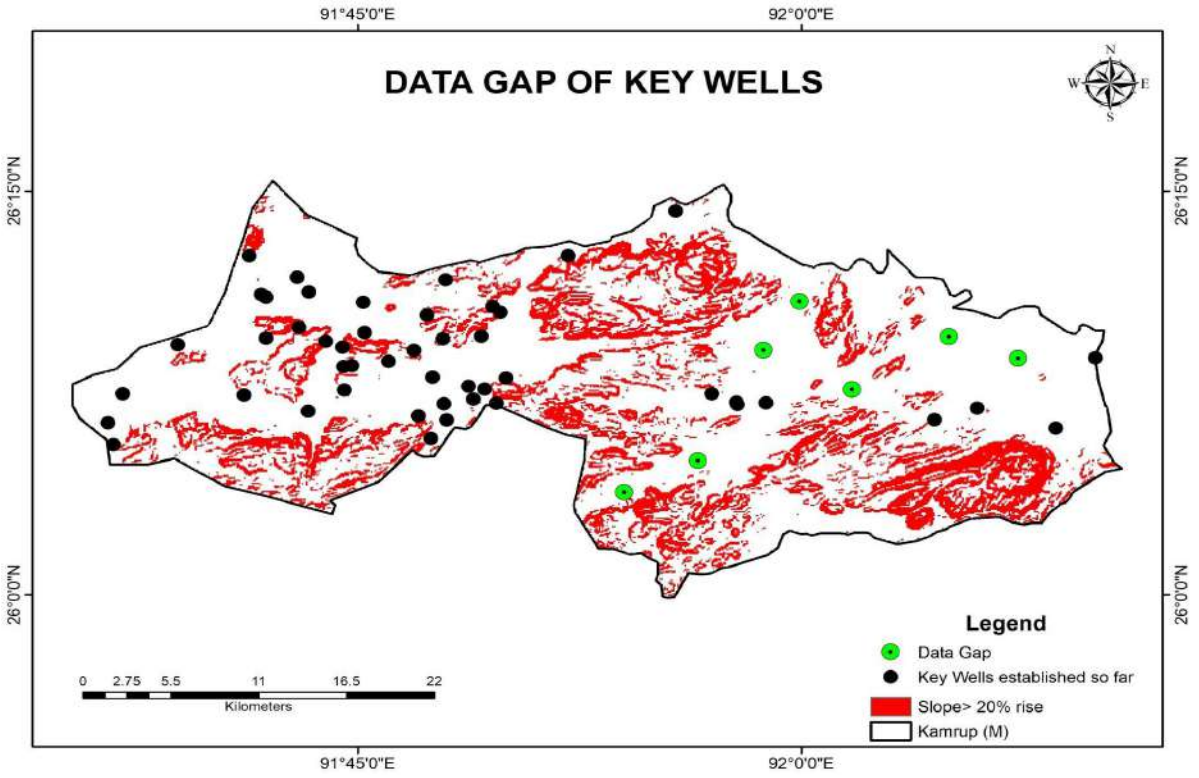


Fig. 1.6: Available data and data generation of ground water level

1.6 Rainfall distribution

The average annual rainfall recorded from 2011 to 2021 of I.M.D is 1295.42 mm. Rainfall during January to April contributes nearly 14.41% to the total rainfall whereas the rainy season which commences from May and continues up to September contributes 79.74%. October to December rainfall is only 5.8%. December receives least rainfall. (Table-1.4)

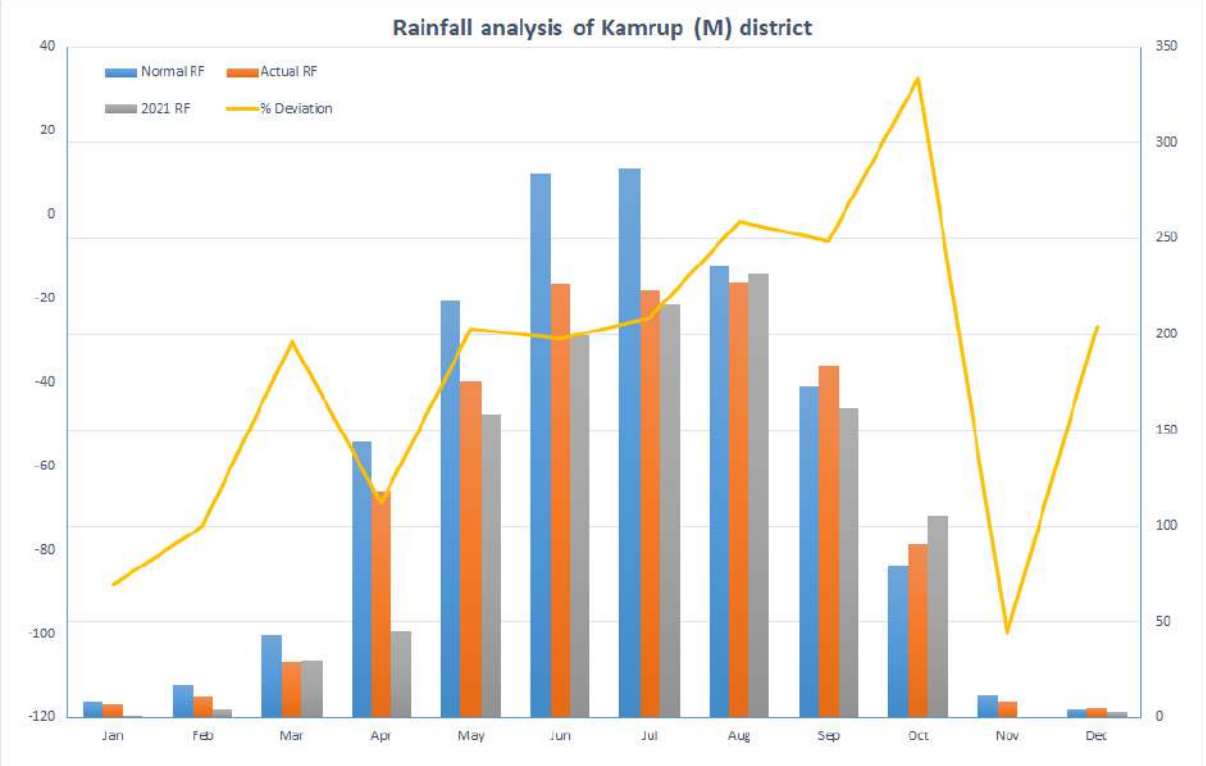


Table 1.4: Monthly rainfall distribution of Kamrup (Metro) district, Assam

When Actual monthly rainfall of last 10 years was compared with normal rainfall, it was found that there was no major changes in the rainfall pattern and quantity. But during 2021, rainfall was slightly less than the Actual rainfall. As such, the month of May to September receives highest average rainfall whereas November and December month received zero rainfall during the year 2021. Annual average rainfall of Kamrup (M) ranges from 1500mm to 2600mm.

DISTRICT	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)	Actual (mm)
KAMRUP METROPOLITAN	2011	7.25	7.27	54.01	62.94	172.64	184.91	222.29	183.04	133.81	29.31	14.11	0.89
KAMRUP METROPOLITAN	2012	9.75	2.24	10.01	157.99	93.97	279.36	247.47	199.79	0.58	0.47	0	0
KAMRUP METROPOLITAN	2013	0	9.48	26.18	68.27	238.14	263.5	298.76	251.25	184.72	109.04	0	2.27
KAMRUP METROPOLITAN	2014	1.77	24.72	15.31	62.34	145.5	237.97	160.05	393.17	364.72	36.38	2.15	1.14
KAMRUP METROPOLITAN	2015	4.7	16.21	23.5	135.15	218.19	196.66	236.66	347.48	190.25	53.92	15.58	14.34
KAMRUP METROPOLITAN	2016	8.36	0.64	31.02	183.12	200.97	200.66	268.85	103.46	241.61	127.94	9.74	5.48
KAMRUP METROPOLITAN	2017	1.28	4.83	46.72	195.02	151.01	229.28	196.12	346.13	148.63	145.25	24.82	5.73
KAMRUP METROPOLITAN	2018	0.65	3.1	21.9	97.84	116.28	256.29	199.45	200.97	130.61	44.81	3.9	18.95
KAMRUP METROPOLITAN	2019	3.35	12.53	49.26	127.75	211.38	154.45	259.01	168.07	187.39	135.42	9.75	1.93
KAMRUP METROPOLITAN	2020	12.38	20.89	11.18	134.36	206.91	289.66	149.51	69.77	271.98	204.75	6.16	1.36
KAMRUP METROPOLITAN	2021	0.91	4.45	29.98	45.11	158.28	199.66	215.75	231.45	161.56	105.23	0	3.01

The average monthly rainfall from 2011 to 2020 and also yearly rainfall distribution of Kamrup (Metro) district are illustrated in Fig.1.4 and Fig 1.5

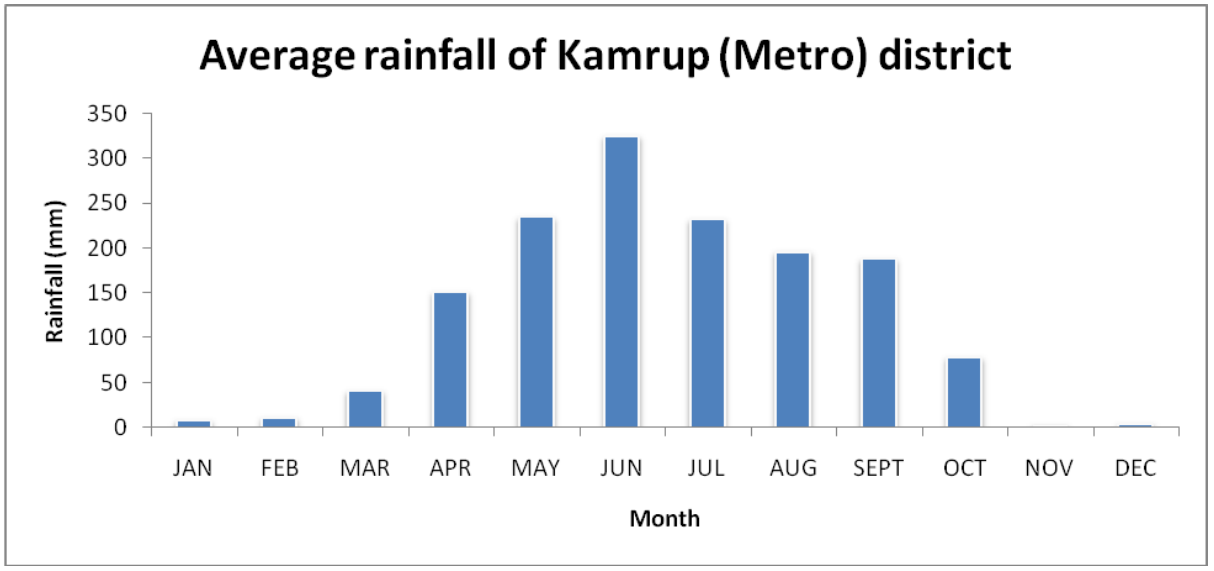
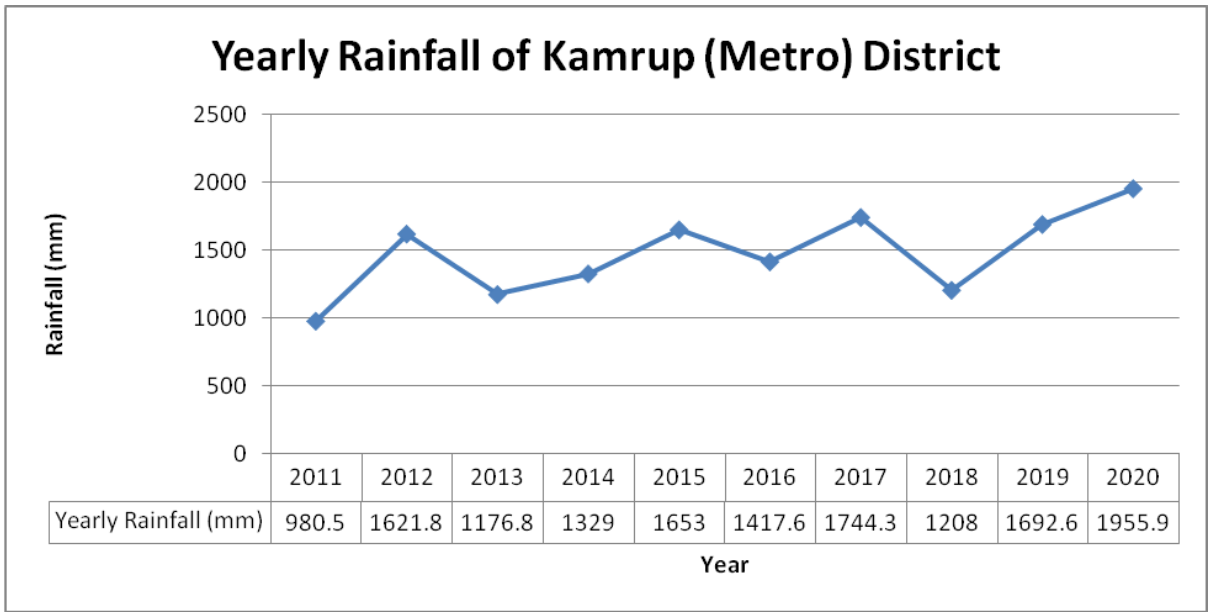


Fig. 1.4 Average monthly rainfall variations of Kamrup (Metro) district



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Yearly Rainfall (mm)	980.5	1621.8	1176.8	1329	1653	1417.6	1744.3	1208	1692.6	1955.9

Fig.1.5: Annual variation of rainfall as recorded I.M.D rain gauge stations of Kamrup (Metro) district

1.7 Temperature

The climate of the district is predominantly sub-tropical humid climate with heavy rainfall, hot semi dry summer and cold winter. The district experiences a maximum temperature of 37 to 39°C and a minimum temperature of 6 to 7°C. Average temperature ranges from 12 to 38oC during the year. In winter, temperature ranges from 15 to 25oC during day and 8 to 15oC during night. The summer temperature ranges from 25 to 38oC during day and 15 to 25oC during night. Monsoon usually starts from April and continue till end of September. Prevalence of Relative Humidity is generally high (78-80%) particularly

during the summer months. Average humidity of the state is 76%. Winter months are cool and start from November to February.

1.8 Physiographic set up

The district is situated in the south western part of the state, surrounded to the north and east by Darrang and Morigaon district respectively, Kamrup (Rural) on the west and Meghalaya state on the south. The mighty river Brahmaputra flows at the north-western corner of the district. The river thus has a lot of influence in the physiography of the entire district. In the immediate neighborhood of the Brahmaputra the land is low, and exposed to annual inundation.

There are three major wetlands/lakes, namely, Deepor Beel, Sola Beel and Silsako Lake, in Guwahati city which plays a major role in terms of housing a large portion of aquatic flora and faunas, acting as storm water reservoir and as a major conduit for ground water recharge in a rather concrete jungle of city.

Deepor beel also known as Pamohi channel is an abandoned channel of Brahmaputra river towards south of the river. Basistha and Kalmani rivers are the main source of water to Deepor beel. It has an area of 589 ha (source: National Wetland Atlas_Ramsar sites of India. p62). On the dry lake bed, cultivation of rice is done annually.

Borsola-Sarusola Beel is the largest lake in the Guwahati city and it is divided into Sarusola and Borsola lakes. It is situated near Paltan Bazar. Human encroachment surrounding the lake posses a major threat to the lake. It covers an area of 25 acres (10.12 ha) (source:gscl.assa.gov.in/projects) and forms a part of Bharalu water system.

Silsako Lake is a wetland surrounded by villages of Hengerabari, Sathgaon and MAthgharia. It serves as storm water reservoir for storm water runoff coming from nearby hills and Meghalaya.

The hills south of the Brahmaputra in some parts reach the height of 800 feet (240 m) (Fig.1.6).

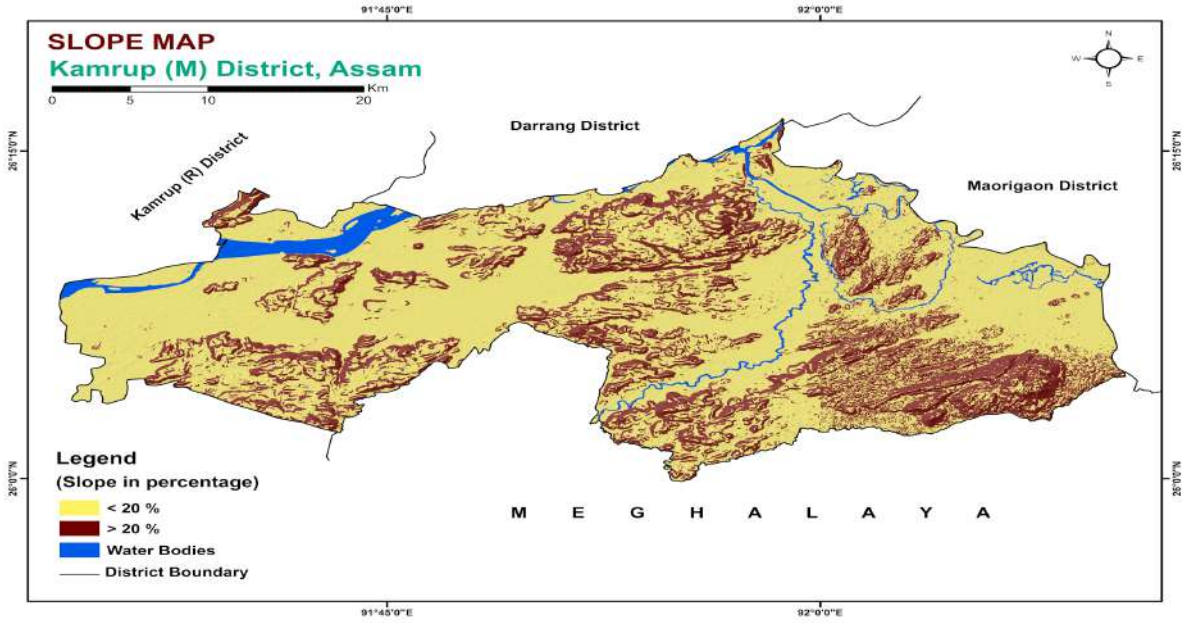


Fig.1.6: Slope map of the study area

1.9 Drainage and Morphometric Features

The Brahmaputra is the main river, which passes through the district. There are a number of tributaries of the Brahmaputra, which are the major natural water resources, such as Bharalu river, Basistha river, Kopili river, Bahini River and Digaru river. Most of these rivers carry huge volumes of water during monsoon and overflow due to heavy rainfall during the monsoon season causing flash flood hazard in certain parts of Guwahati every year. There are number of small streams, channels and sizeable areas under wet/marshy lands in the district of Kamrup (Metro).

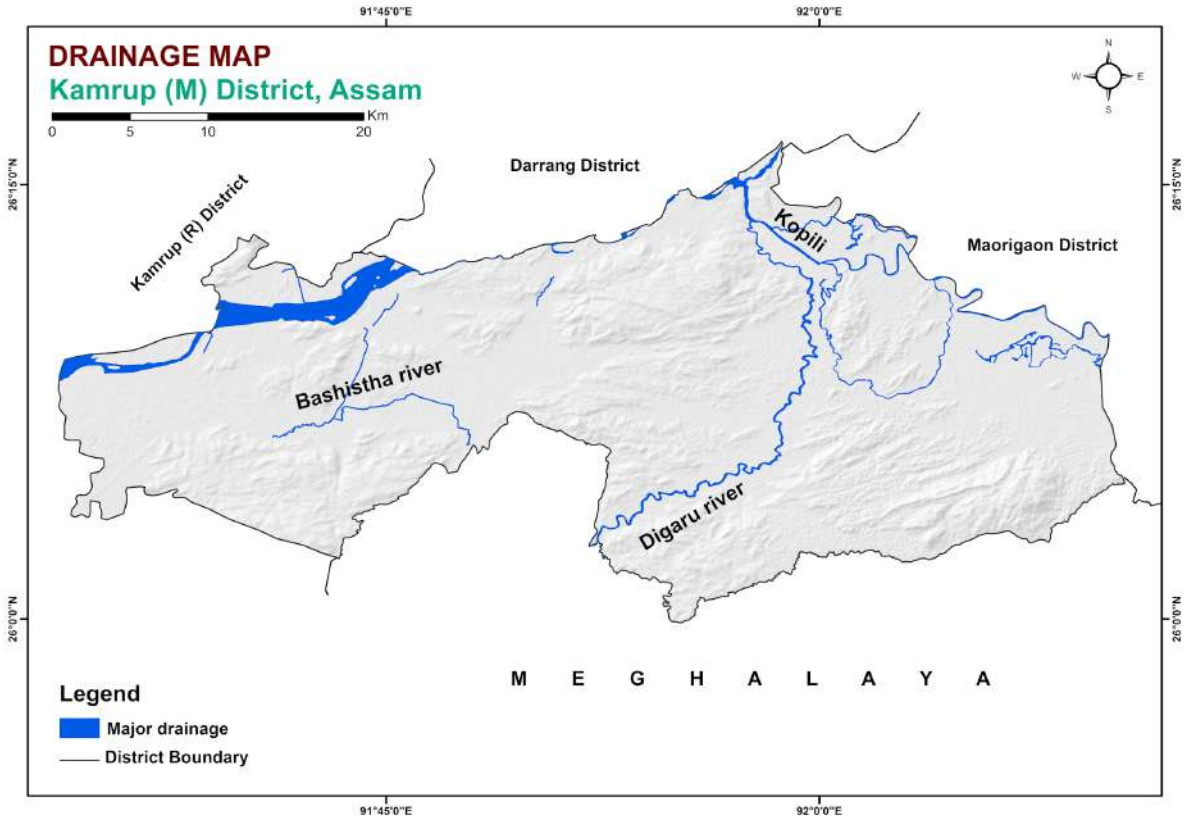


Fig. 1.7: Drainage Map of Kamrup (Metro) District, Assam

1.10 Geology

The area consists of two broad hydrogeological units – 1) Pre-Cambrian consolidated rocks and 2) Quaternary alluvium consisting of unconsolidated sediments (Fig 1.8).

The Assam-Meghalaya Gneissic Complex is the north-eastern extension of Indian Shield. It is separated from the Peninsular India by Tertiary Ganga-Brahmaputra sediments and Rajmahal volcanics. The Shillong Group comprising of Assam-Meghalaya Gneissic Complex is considered to be a detached part of Eastern Ghat Mobile Belt or Chota Nagpur Gneissic Complex. The study area is the northern extension of Shillong Group that dips into Brahmaputra plains. These Pre-Cambrian consolidated rocks are confined mainly to dissected structural hills and valley areas and some inselbergs. The oldest formation composing of Gneisses and schists, are extensively intruded by granites (for example Nongpoh Granitoid in

case of current study area) occurring as small patches. Later pegmatitic and quartz veins intrudes both.

In Hilly areas ground water occurs in shallow weathered zone and this can be developed through open wells. The joints and fractures developed due to tectonic activities forms potential water bearing zones and suitable for development through construction of bore wells. The district has a more or less undulating topography with hills and valleys with some isolated hillocks here and there. It has a gentle slope from south side towards northern direction.

The Quaternary sediments of Kamrup Metro district consists of unconsolidated sediments of Newer and Older Alluvium. They comprise mainly of Clay silt, sand and gravel. These sediments have huge potential for ground water in the Brahmaputra valley. Occurrence of such sediment is confined to the active flood plains of Brahmaputra and its tributaries and other wetland areas. Major minerals found in the district are Granite, Feldspar and Quartz.

A general geological sequence is given below:

Group	Formation	Lithology
Quaternary	Newer Alluvium	Clay, Silt, Sand and Gravel.
	Older Alluvium	Sand, Gravel, Boulder and Clay
Pre-Cambrian	Shillong Group	**Assam Meghalaya Gneissic Complex**: Pegmatite, quartzite, feldspar and epidote vein, fine grained granite, grey porphyritic granite, pink granite, Migmatitic Amphibolite, granulite, Schists and gneisses etc.

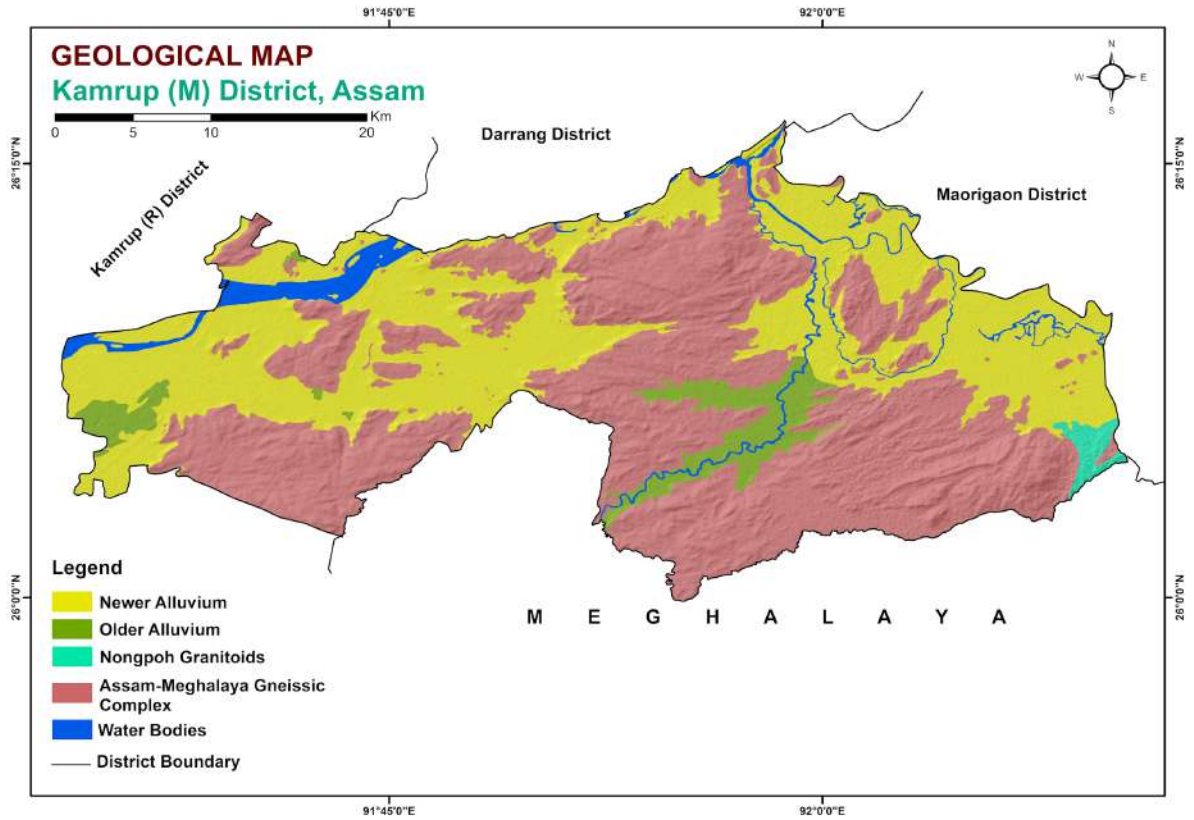


Fig 1.8: Map showing Geology of Kamrup (Metro) District

1.11 Geomorphology

Geomorphologically the area can be classified into nine divisions: active flood plain, younger alluvial plain, older alluvial plain, older flood plain, Pediment pediplain complex, low dissected structural hills and valleys, moderately dissected structural hills and valleys, highly dissected structural hills and valleys.

The active flood plain and old flood plain areas are restricted to flood plain of river Brahmaputra and its tributaries like Basistha, Digaru, Kopili and Bahini Rivers and in and around Deepar Beel wet land area consisting of unconsolidated material like gravel, sand, silt and clay. Due to seasonal floods the different depositional environment like paleo channel, natural levees, back swamps wetlands and channel bars are common features of flood plain area. These areas are good for ground water development in shallow depth.

The major part of the district is occupied by Highly Dissected Structural Hills and Valleys. Two inselbergs of Moderately Dissected Structural Hills and Valleys are located one in the area of Gauhati University and Assam Engineering College Campus at Jalukbari and the other is in the area of Amingaon (nearby Narayana Hospital, Amingaon).

In Hilly area and Inselbergs, ground water occurs in shallow weathered zone and this can be developed through dug wells. The joints and fractures developed due to tectonic activities form potential water bearing zones and suitable for development through construction of bore wells. (Fig. 1.9).

Area towards Tetelia and Dimoria is mainly Pediplain-Peniplain Complex but the areas of Mitani N. C., Maloibari N. C. and Thengbhanga area are composed of Lowly Dissected Structural Hills and Valleys

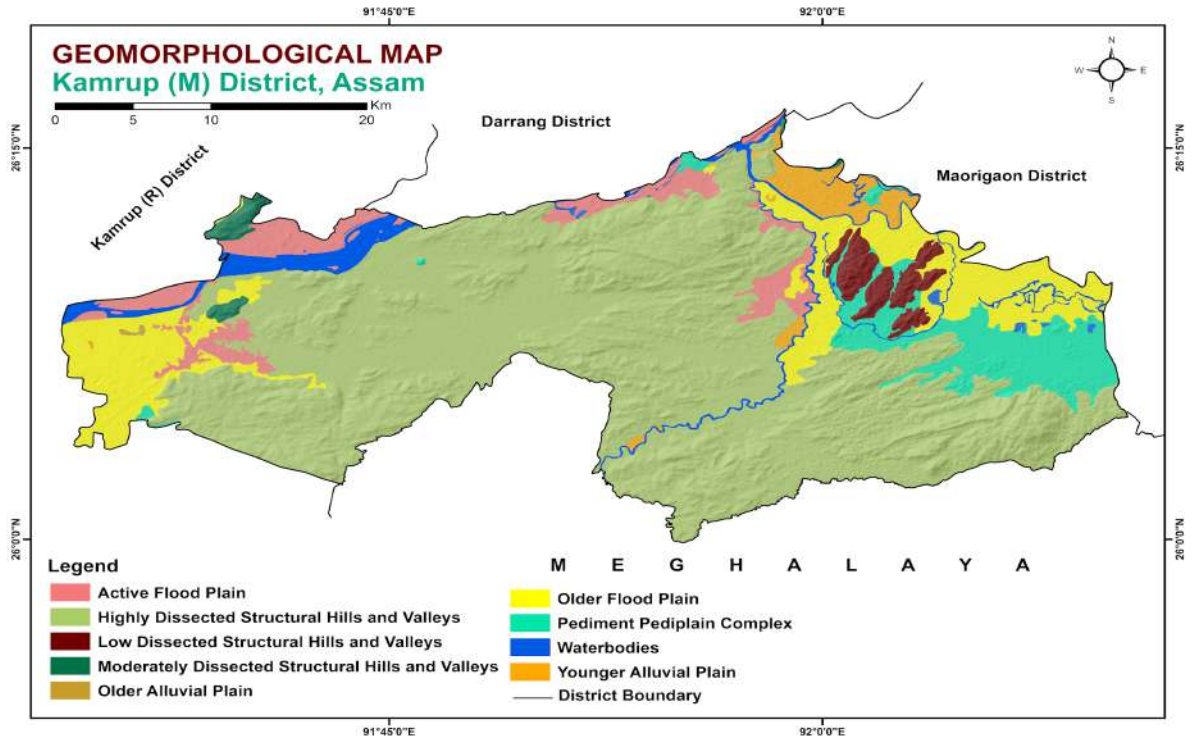


Fig. 1.9: Geomorphological Map of Kamrup (Metro) District, Assam

1.12 **Land use Pattern**

The total geographic area of the study area is 95457 ha but reporting area for land utilisation statics is 87150 ha. The net sown area of the district is 28256 ha which accounts for 32.42 percent of the total area for land utilisation statics of the district.

The gross cropped area of the district is 37678 ha with cropping intensity of 114% percent. Area cropped more than once 9422ha.

The district is covered in Moderately Dense to Very Dense Forest area covering mainly the hilly portion (slope >20% rise) of the district. Patches of Scrub Land is found in Amingaon and Maligaon area. Forest area in the district accounts for 29590 ha i.e. 2.945% of total area for land utilisation statics. Area under non-agricultural uses is 19405 ha. Barren and Uncultivable Land comes to be around 4400 ha. Grazing land of the district is around 606 ha. Cultivable waste land is around 452 ha.

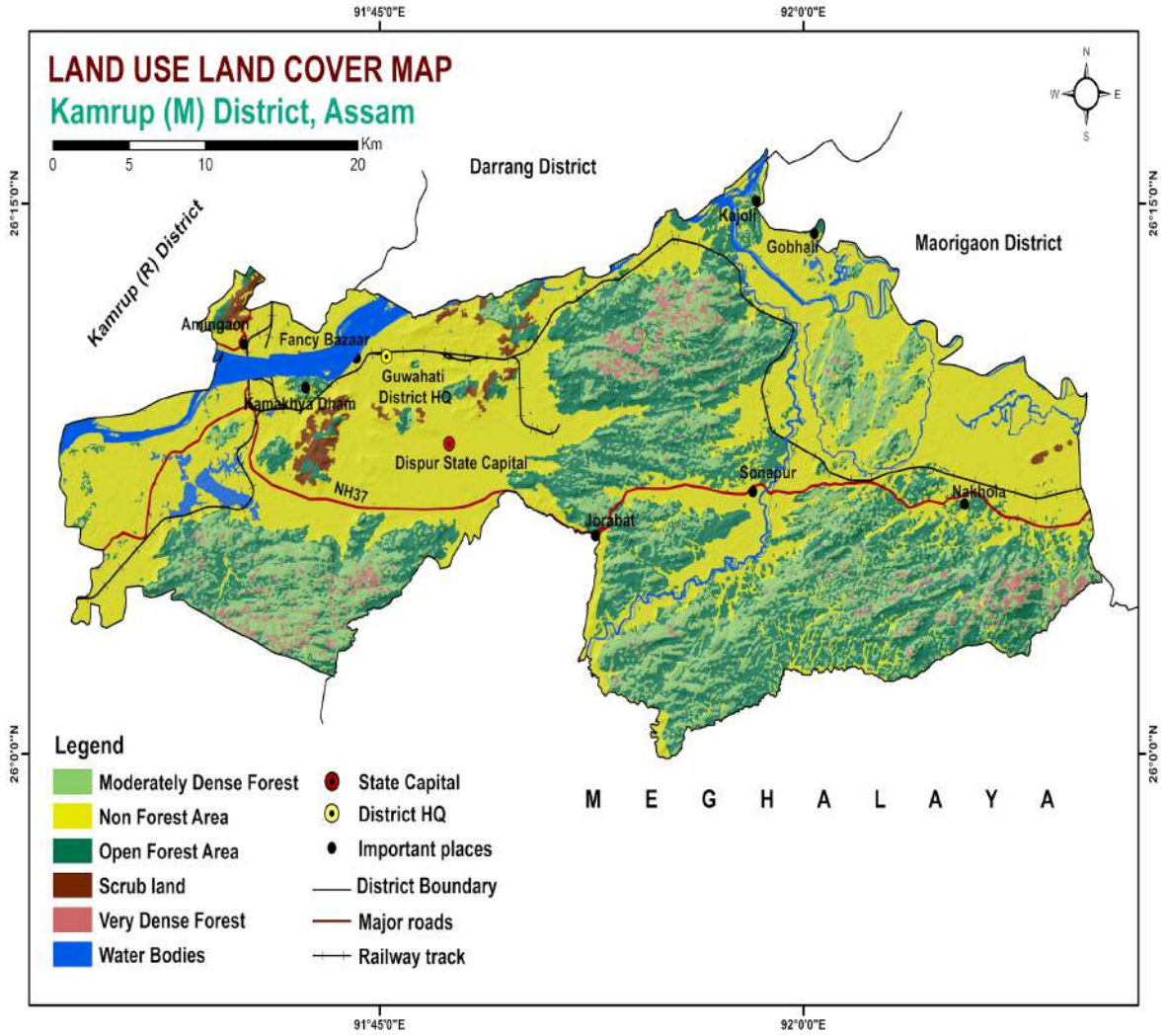


Fig 1.10: Map showing Land Use and Land Cover, Kamrup (Metro) District.

Table 1.5 Land Use Pattern in Kamrup (Metro) District (2020-21)

Source: Assam Statistical Handbook, Assam 2020.

(Area in Hectare)

Reporting Area for land utilization	Forests	Not available for cultivation		Other Uncultivated Land excluding Fallow Land			Fallow Land		Net Area Sown	Total Cropped Area	Area Sown more than once
		Area under non-agricultural uses	Barren and Unculti vable Land	Permanent Pastures and other Grazing Land	Land under Misc. Trees grooves not including in Net Area Sown	Cultivable Waste Land	Fallow Land other than Current Fallow	Current Fallow			
87150	29590	19405	4400	606	3306	452	623	512	28256	37678	9422

1.13 Soil

The major groups of soils identified in the district are recent riverine alluvial soils (Entisols), old riverine alluvial soils (Inceptisols), laterite red soils (Ultisols) and moderately leached (Alfisols). The flood plain of Brahmaputra is built up with riverine alluvial soils. The valleys soils are characterized sandy loam to clay, which are not affected by the flood.

Entisols: Also known as recent soil. These soil types occur mainly in flood plain areas. They occupy the valley portion of the Kamrup (Metro) district. These type of soil occurs on river levees to nearly leveled active flood plain and on stable river islands having sandy surface. Ground water table is usually one metre below ground level and are associate with very severe flooding. Two types of fluvaquents occure in the study area; Mollic Fluvaquents and

Aeric Fluvaquents. Mollic Fluvaquents are Entisols with aquic moisture regimes that occur on floodplains and that have thick dark surface layers. Aeric Fluvaquents are Entisols that occurs on floodplains. They have an aquic moisture regime that are not so wet. They are better aerated in the "upper" part of the soil. Valley portions of northern half of Kamrup (Metro) district parallel to River Brahmaputra has Fluvaquents.

Ultisols: These soil type forms as the ultimate of leaching. Ultisols are strongly leached, acid forest soils with relatively low native fertility. They usually occur on hill tops. Ultisols that are more or less freely drained and humus-rich. These soils are mainly in mountainous areas that have high rainfall but also have a moisture deficit during some season. They are found primarily in humid temperate and tropical areas. Occurs in older, stable landscapes. Intense weathering of primary minerals has occurred, and much Ca, Mg and K has been leached from these soils. Strong yellowish or reddish colors resulting from the presence of Fe oxides. Kandihumults are the Humults that have a kandic horizon and they occur on top of hillocks in the district.

Inceptisols: These are the young soil or inception soil confined to old riverine regimes. They form quickly through alteration of parent material. They are more developed than Entisols. They have no accumulation of clays, iron oxide, aluminium oxide or organic matter. They have an ochric or umbric horizon and a cambic subsurface horizon. Types of inceptisols are dystrochrepts, eutrochrepts and haplaquepts.

Alfisols; These type of soil is composed of aluminum and iron oxides and charecterised by the presence of ochric (thin, light colored, low in organic matter) diagnostic horizon, an argillic horizon, and moderate to high base saturation level. Hapludalf alfisol is present towards the eastern boundary of the district and it is characterized by humid, udic (wet) moisture regime.

Various factors like heavy rainfall, floods, soil erosion and undulating terrain have affected the soil formation process which gave diverse textural classification of soils in the district. As per textural classifications, red soil is 17.7%, younger alluvial soil 32.88%, old alluvial soil 48.89%, and alfisols of 0.53%. On the whole the district is having light to medium textured soils suitable for growing the wide range of crops successfully without being influenced by other inhibiting parameters for growth and development.

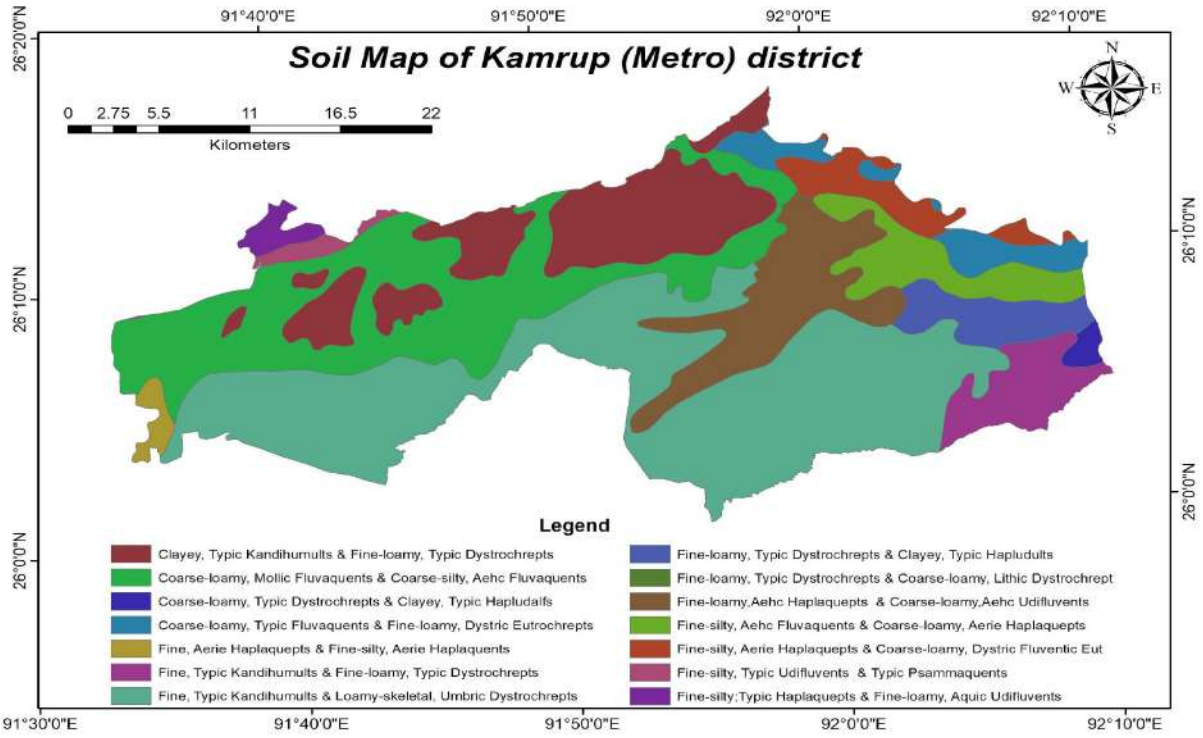


Fig. 1.11: Soil Map of Kamrup (Metro) District, Assam

1.14 Hydrology and surface water

Surface water bodies are mainly observed in the flood plain areas of Sonapur-Dimoria where north flowing river of Digaru and north-western flowing Kapil river loses its gradient and meet Brahmaputra at Digarumukh. Waterlogged and marshy lands are observed in this parts of district.

In Kamrup (M) Urban area there are number of water bodies and wetland areas such as Deepor beel, Silsako Beel, Borsola-Sarusola Beel and a number of small ponds such as Dighalipukhuri, Silpukhuri, Barshapara beel etc. These water bodies acts as reserve for storm water collection and ultimately leading to ground water recharge. Rivers of Basistha, Bharalu and Bahini traverse across the Guwahati city and meet river Brahmaputra at different points.

1.15 Agriculture

Major Agricultural Products of the district are paddy, coconut, mustard, sugarcane, orange, pineapple and lemons. Major plantation is tea and rubber. Agriculture is confined mostly to Sonapur Revenue circle in Dimoria Community Development Block. The alluvial soil of the block is very fertile and suitable for agricultural production.

The staple food of this district is rice. Paddy namely autumn (Ahu), winter (Sali) and summer (Boro) are raised in the district. The alluvial soil, humid atmosphere and enough rains are favorable for growing agricultural crops in the district.

The important paddy crops which are being grown are rice, mustard, pulse, cereals, wheat and tea. Lahi rice is grown in high fields which is an important production of the district. The Joha is the finest variety of rice commonly grown in the district. Boradhan is

also produced particularly to prepare chira and pitha (cake). Ahu and Bao are other varieties of rice grown in the district. Wheat is also gaining popularity and is supplementing rice in diet. Wheat is cultivated as a rabi crops. The varieties are Sonalika and Kalyan Sona. Rape and mustard are often grown along with Ahu rice. Pulses like Mati Kalai, Masur, Mung are also grown in the area. Arhar is also another pulse grown in the district. The vegetables of different kinds are grown in the district. The most common of them are cauliflower, cabbage, brinjal, lady's finger, pumpkin, tomatoes, peas, radish, turnip etc. These vegetables are mostly grown in rural areas and are exported to the commercial centers of the district and also to other districts of the state.

The district is very much important for growing fruits specially khasi mandarin orange and pineapple. The climatic condition and fertile soil favours huge production of orange in the Sonapur block which provides livelihood to many farmers there. Other common and important garden crops of almost every household in the district is banana, mangoes, Jack fruits, Lemons, areca nuts, coconuts etc.

The total geographical area of Kamrup Metro District is 95457 hectare. The largest Block of the district is Dimoria which comprises of a total Geographical area of 49104 hectare i.e. about 51.4% of the total Geographical area of the district. The season wise area covered and production of Rice are shown in the following Table 1.8

Table 1.8. Season wise area covered and production of Rice in Kamrup (Metro) district Area, Production and Yield of Rice, 2018-19 (*Source: NEDFI databank 2018-19)*:

District	Season	Area (Ha)	Production (Tonnes)	Yield (Tonnes/Hectare)
Kamrup (Metro)	Autumn	131	213	1.63
	Summer	8247	25458	3.09
	Winter	14204	37188	2.62
	Total	22582	62859	2.78

IRRIGATION:

Agricultural activities in the district are predominantly rain fed as out of the total cultivated area of 37678ha, only 1274ha (3.38%) area is under irrigation.

a. Existing Type of Irrigation

The Net Cropping and Gross Cropping area of the district is 28256 ha and 37678 ha respectively. As per NEDFI 2018-19 data bank, a total of 864 irrigation canals, 18 tube wells, other irrigation sources are operating in the district. The areas covered by the irrigation are shown in the following Table 1.9.

Table 1.9 a. Source and Net Irrigated Area, 2018-19 *(Area in Hectare)*

District	Canal			Tank	Well			Other Source	Total
	Govt.	Private	Total		Tubewell	Other Well	Total		
Kamrup Metro	521	343	864	39	18	-	18	71	992

Source: NEDFI databank, Ministry of Agriculture, Govt. of India.

Table 1.9 b. Source and Gross Irrigated Area, 2018-19: (Area in Hectare)

District	Canal			Tank	Well			Other Source	Total
	Govt.	Private	Total		Tubewell	Other Well	Total		
Kamrup Metro	694	363	1057	76	18	-	18	123	1274

Source: NEDFI databank, Ministry of Agriculture, Govt. of India.

Table 1.9 c. Season-wise Irrigation of Rice, 2018-19: (Area in Hectare)

District	Autumn	Winter	Summer	Total
Kamrup Metro	14	326	832	1172

Source: NEDFI databank, Ministry of Agriculture, Govt. of India.

Table 1.9 d. Irrigation of Food grains, 2018-19: (Area in Hectare)

District	Cereals and Millets	Pulses	Total Food Grains
Kamrup Metro	1187	-	1187

Source: NEDFI databank, Ministry of Agriculture, Govt. of India.

Table 1.9 e. Irrigation of Condiments and Spices, Fruits & Vegetables and Oilseeds, 2018-19: (Area in Hectare)

District	Condiments and Spices	Fruits & Vegetables	Oilseeds
Kamrup Metro	-	-	87

Source: NEDFI databank, Ministry of Agriculture, Govt. of India.

Table 1.9 f. Category wise Irrigation Potential created, 2019-20 (Cumulative): (Area in Hect.)

District	Irrigation potential created during 2019-20					
	Minor Irrigation			Major/Medium Irrigation	Total	Grand Total
	Surface lift	Surface flow	Total	0		
Kamrup Metro	1993	3732	5725	0	0	5725

Source: Assam Statistical Handbook 2020, p90-91.

Table 1.9 g. Gross Area Irrigated under Govt. Irrigation Facilities, 2019-20: (Area in Hect.)

District	Irrigation Scheme					Grand Total
	Surface Lift	Surface Flow	Ground Water Lift	Total	Canals	
Kamrup Metro	494	630	0	1124	1124	2248

Source: Assam Statistical Handbook 2020, p94.

Table 1.9h. Net area irrigated by Govt. Irrigation Facilities, 2019-20: (Area in Hect.)

District	Gross irrigate area	Net irrigated area
Kamrup (Metro)	1124	1001

Source: Assam Statistical Handbook 2020, p99.

Table 1.9h. Season-wise information on area Irrigated in Assam through Burge (through govt. Surface lift irrigation schemes)

District	Area irrigated during by surface lift irrigation 2019-20		
	Kharif	Rabi & Pre-Kharrif	Total
Kamrup (Metro)	135	40	175

Source: Assam Statistical Handbook 2020, p93.

Table 1.9 h. Length of Irrigation Canals/ Channels Constructed upto 2017-18: (In Km.)

District	Constructed	Lined	Pipe
Kamrup Metro	107.681	68.840	0.092

Source: NEDFI databank, Ministry of Agriculture, Govt. of India.

Table 1.9 i. Target and achievement of additional irrigation potential created, 2019-20: (Area in Hect.)

District	Achievement		
	Minor Irrigation	Total M.I & M/M Irrigation	Total (AP+RLP)
Kamrup Metro	-	-	-

N.B: A- Additional, P- Potential, R- Revival, L- Lost

Source: Statistical Handbook Assam 2020, p98.

CHAPTER 2.0

2.0 Data Collection and Generation

2.1 Data collection

Various data for NAQUIM report was needed to be generated and compiled together. First of all existing data of CGWB's earlier survey data, exploration and geophysical data were compiled and based on that data gap was analysed and accordingly generation of those proceeded. Data collection also includes acquiring data from various state government organisations such as collection of rainfall data from state government, litholog collection from state groundwater departments, Population data is collected from Census of India website. Agriculture data are taken from Assam statistical Handbook and NEDFI databank for Kamrup (M) district.

So far CGWB had constructed 53 exploratory wells in this area of Kamrup (Metro) district earlier. Public Health Engineering Department and Directorate of Geology and Mining, Govt. of Assam had constructed number of tube wells in the area and the department provided lithology and chemical analysis data. However, all the wells are not incorporated in the present study due to lack of coordinate data. Details of the wells are given in Table 2.4.

Rainfall data was collected from official website of Indian Meteorological Department; the Customized Rainfall Information System (CRIS).

2.2 Data Generation

2.2.1 Hydrogeological data

The entire study area is covered by regular monitoring of existing 54 Ground Water Monitoring Stations and another 07 key wells have been established. All these wells were under monitoring after establishment (Table 2.1). There were 56 dugwells and 5 tubewells.

Table 2.1: GWMS and Key wells details

Sl no.	Location	Well Type	MP	Dia	Depth	RL	Lat	Long	Water Level August -21 (mbgl)	Water Level November-21 (mbgl)	Water Level January -22 (mbgl)	Water Level March -22 (mbgl)
1	AAU, Kahikuchi	DUG	0.91	1	8	38	26.109	91.609	1.32	3.59	5.49	
2	AAU, Khanapara	DUG	0.62	0.9	5.6	94	26.127	91.822	2.38	2.48	2.52	2.54
3	Amingaon	DUG	0.9	0.9	8	32	26.210	91.689	2.24	3.53	3.45	3.95
4	Ashwaklanta Temple	DUG	1	0.7	8	59	26.187	91.722	2		4.98	2.7
5	Assam Poultry Farm	DUG	0.79	1.34	16	13.45	26.132	91.818				5.31
6	Avayapuri	DUG	1	0.8	9	39	26.195	91.717	1.88	1.25	1.88	0.5
7	Azara PHC	DUG	0.8	1	7.5	39	26.117	91.5	1.7	3.83	4.7	5.25
8	Bakarapara	DUG	0.75	0.9	12	62	26.108	91.800	2.67	3.72	4.89	4.2
9	Basitha FG	DUG	0.9	0.8	15	59	26.097	91.791	10.99	12.20	12.59	12.5
10	Bijni Gaon	DUG	0.9		10	59	26.164	91.964		0.66		1.8
11	Boragaon	DUG	0.7		10	61	26.124	91.686	1.08	1.78	1.82	4.8
12	Borgug	DUG	0.76	1.02	10.4	15.94	26.177	92.031		2.21		2.64
13	Chakardo	DUG	0.9	1.2	12	9.34	26.109	91.641		2.96		4.6
14	Chamata	DUG	0.5	0.9	7	3.15	26.124	92.003		1.19		1.5
15	Chandrapur	DUG	0.2	1	8.5	39	26.238	91.929	1.12	2.75	3.01	2.65
16	Choonsali, Madhabpur	DUG	0.6	0.8	6.2	42	26.195	91.800	3.97	4.10	4.44	4.68
17	Dakhingaon	DUG	0.9	0.94	8	17.65	26.136	91.762		3.13		6.95
18	Dirgheshwari	DUG	0.7	1.2	5.2	49	26.239	91.740	2.84	3.57	4.38	3.62
19	Dte of Agri	DUG	0.9			39	26.129	91.812	0.3	0.50		0.83
20	Fatasil-Ambari	DUG	0.5			52	26.157	91.732	4.46	4.85	4.21	5.92
21	Ganesh Mandir, Narengi	DUG	0.8	1.2	7	32	26.175	91.830	4.01	5.68	4.08	6.15

Sl no.	Location	Well Type	MP	Dia	Depth	RL	Lat	Long	Water Level August -21 (mbgl)	Water Level November-21 (mbgl)	Water Level January -22 (mbgl)	Water Level March -22 (mbgl)
22	Garigaon	DUG	0.7	1.5	6	37	26.154	91.648	2.13	1.00	1.49	0.83
23	GMC	DUG	0.9	0.8	3	54	26.161	91.768	7.75	1.30		1.6
24	Hengrabari FG	DUG	0.32	0.8	4		26.151	91.795	3.37	3.6	3.93	1.33
25	Kacharibasti Christian Basti	DUG	0.85	0.8	12.5	58	26.151	91.781	3.64	5.15	7.52	6.05
26	Kahilipara Colony Bazar	DUG	1.02			55	26.153	91.741	8.63	10.38	11.54	11.18
27	Kahilipara L.P. School	DUG	0.8	0.8	9.3	53	26.145	91.767	0.78	1.54		2.3
28	Khanapara PP New	DUG	0.93	0.95	5	75	26.119	91.828	0.38	2.14	1.43	2.54
29	Khanapara Sc. Museum	DUG	0.9			82	26.121	91.815		2.00	2.78	5.34
30	Khetri	DUG	0.75	0.85		11.38	26.116	92.090	0.83	1.40	2.31	2.09
31	Lachitpur	DUG	0.8	0.8	15.5	41	26.185	91.661	4.4	5.97	5.51	
32	Lakhra Chariali	DUG	0.9	0.9	7	58	26.107	91.754	1.86	3.15		
33	Lakshmi Mandir	DUG	0.8	0.8	9.5	78	26.118	91.799	3.67	3.73	4.99	3.76
34	Lalganesh Chariali	DUG	0.9	0.9	11	74	26.141	91.742	3.15	6.20	9.06	9.55
35	Lalmati New	DUG	0.5			62	26.111	91.784	0.6		2.47	2.5
36	Mairapatti	DUG	0.9	0.7	8	56	26.186	91.698	5.1	3.84	6.59	6.55
37	Maligaon	DUG	0.8	0.8	7.1	52	26.159	91.698	0.73	0.60	0.64	0.9
38	Maloibari	DUG	0.95	0.92	11	11.73	26.170	92.083		5.18		5.75
40	Nazirakhat	DUG	0.9	0.9	10	29.33	26.123	91.928		1.63		
41	Odalbakra, Pahartoli	DUG	0.6	0.8	4.5	50	26.142	91.747		2.20	2.27	2.4
42	Paltan bazar	DUG	0.54	0.7	8.5	53	26.181	91.753	0.31	0.26	0.96	0.26
43	Panikhaiti	DUG	0.66	1.5	10.7	27	26.210	91.869		5.69	5.65	5.54
44	Panjabari	DUG	0.75	0.9	13.5	59	26.134	91.834	3.25	5.58	5.28	5.79

Sl no.	Location	Well Type	MP	Dia	Depth	RL	Lat	Long	Water Level August -21 (mbgl)	Water Level November-21 (mbgl)	Water Level January -22 (mbgl)	Water Level March -22 (mbgl)
45	Patgaon	DUG	0.65	1	5.7	35	26.089	91.612	1.1	1.35	1.41	1.45
46	Patharquery	DUG	0.7	0.9	4.5	48	26.161	91.821	1.54	2.15	1.93	1.94
47	Sijubari	DUG	0.81	0.8	12	55	26.131	91.775	4.8	8.15		5.45
48	Sonapur	DUG	0.1	2	6	3.86	96.117	91.964	0.75	1.76	1.63	
49	Survey Odalbakra	DUG	0.5	0.8	7.8	26	26.127	91.742	4.23	4.58	6.67	5.4
50	Tepesia	DUG	0.69	0.79	14	26.09	26.121	91.907		1.84		2.15
51	Topatoli/Bamfor	DUG	0.50	0.89	9.25	60.50	26.103	92.144	1.04	2.53	2.44	2.85
52	Udaipur	DUG	0.5	0.8	12	55	26.163	91.754	6.6	9.12	9.4	9.12
53	Vishwakarma Temple	DUG	0.8	1	5.5	56	26.165	91.717	1.44	1.5	1.71	1.5
54	West Krishna Nagar	DUG	0.71	0.9	7.8	38	26.160	91.799	1.52	4.75	4.73	4.75
55	Wireless	DUG	0.58	0.8	5.5	56	26.135	91.792	0.44	0.52	0.64	0.52
56	Zoo Narengi Road HS	DUG	0.96	1	10	34	26.174	91.789			6.14	
57	AAU, Kahikutchi	TUBE	0.6		193	38	26.106	91.609	2.57	5.78	5.42	5.78
58	Betkuchi	TUBE			144		26.113	91.722			15.12	
59	Garigaon	TUBE			198.2		26.154	91.648	2.87	9.23	8.86	9.23
60	IIT, North Guwahati	TUBE	0.75		187.2		26.186	91.696		4.43	4.02	4.43
61	West Krishna Nagar	TUBE	0.5		250.7		26.158	91.798	14.3	18.95	16	

2.2.2 Soil Infiltration studies: Infiltration test

Three soil infiltration tests were conducted during the field season in the study area. The salient features of the test sites are provided in **Table 2.2**. The test has been conducted only in barren land and the soil types encountered in the sites are sand admixtures.

Table 2.2: Summary of Soil Infiltration Test Results of Kamrup (Metro) district, Assam

SI No	Location	Latitude	Longitude	Infiltration Rate (mm/hour)	Infiltration factor	Soil Type
1	Dhirenpara	26.143679	91.72756	4	5.96	Clay Loam
2	Mikirapara	26.107205	91.63679	1	1.8	Clay
3	Hatishila	26.217864	91.88674	1	4.7	Clay

2.2.3 Water Quality

During Pre monsoon period 47 numbers and post monsoon period 49 water samples were collected from dug wells and hand pumps of the study area for analysis of detail, iron, heavy metals and arsenic.

For each station, 1000ml for Basic Parameters, 500ml of sample preserved in HNO_3 acid for Heavy Metal, 250ml of sample preserved with HCL acid for Arsenic and Iron, and 250ml of Refrigerated samples were collected. For pre-monsoon, Sample for Uranium analysis were collected in 60ml sample bottles after preserving HCL acid.

Parameters such as Temperature, pH, Electrical Conductivity, Salinity, Total Dissolved Solid, Dissolved Oxygen and Oxygen Reduction Potential were tested at location using Water Testing Tool.

2.2.4 Geophysical survey

During AAP 2021-22, 10 numbers of Vertical Electrical Sounding survey was conducted with maximum current electrode separation of around 200m and 800m using Schlumberger configuration. The interpretation of VES curves was done by matching the field curves with master curves (Orellana & Moony) to obtain the true resistivity's and thickness of different geo-electrical layers. The results were correlated with the hydrogeological data of the boreholes located near the location of VES taking ground water quality data into account. The location details of these VES survey is shown in Table 2.3.

Table 2.3 Details of VES, Kamrup (Metro) district

Sl no.	**Location**	**Latitude**	**Longitude**	**Method**	**Date conducted**
1	Brahmaputra Board1, Basistha	26.113	91.79278	Schlumberger	29.10.2021
2	NEHARI_1, Rudreswar	26.214	91.70694	Schlumberger	26.11.2021
3	NEHARI_2, Rudreswar	26.22	91.7168	Half Schlumberger	26.11.2021
4	Brahmaputra Board2, Basistha	26.112	91.79131	Schlumberger	08.02.2022
5	Urul Village, Sonapur	26.101	91.95692	Schlumberger	15.02.2022

6	Ajuri Village, Sonapur	26.122	92.09556	Schlumberger	16.02.2022
7	Maloibari Village, Khetri	26.155	92.08779	Schlumberger	17.02.2022
8	Sonapur Pathar	26.114	91.94749	Schlumberger	18.02.2022
9	Bijanigaon, Amchung	26.162	91.96577	Schlumberger	18.02.2022
10	Dhirenpara, Guwhati	26.144	91.7277	Schlumberger	24.02.2022

2.2.5 Exploratory Drilling

During AAP 2021-22, five piezometers were drilled in the study area by CGWB. A list of existing exploratory wells drilled by CGWB in the area are prepared incorporating location, well designs, etc (Table 2.4). details of piezometer constructed in current AAP is given in Table 2.5.

Table 2.4: Details of existing exploratory wells in Kamrup (Metro) District, Assam

Sl No	Location	Block	Topo sheet No	Long	Lat	Type of Well	Depth Drilled	Depth of construction (m)
1	10 th Assam police battalion Kahlipara-EW	Guwahati	78N/16	91.76655	26.14528	TW	306.30	306.30
2	Amchang-EW	Dimoria	83B/4	91.96944	26.15083	TW	47.60	23.50
3	Bakrapara-EW	Guwahati	78N/16	91.80005	26.10822	TW	69.80	60.00
4	Basistha Mandir campus -EW	Guwahati	78N/16	91.78465	26.09589	BW	92.25	
5	Betkuchi-II (Office complex)-EW &OW	Guwahati	78N/16	91.72218	26.11356	TW	154.75	138.00
6	Bhaskar Nagar-EW	Guwahati	78N/16	91.77861	26.17722	TW	98.40	64.00
7	Birubari-PZ	Guwahati	78N/16	91.75393	26.16277	BW	188.00	
8	Bomfor Village-EW	Dimoria	83 B/4	92.15889	26.10417	BW	177.65	
9	Borhojai-EW	Guwahati	78N/16	91.76704	26.11709	TW	106.15	94.00
10	Borjhar-EW	Azara	78N/16	91.60139	26.10083	TW	104.10	100.00
11	Chandmari Colony-EW	Guwahati	78N/16	91.77105	26.18598	BW	105.00	
12	Chilarai Nagar-EW	Guwahati	78N/16	91.7654	26.16699	BW	299.20	
13	Choonsali-PZ	Guwahati	78N/16	91.80417	26.2000	BW	59.00	
14	Circuit House, Ghy.-EW	Guwahati	78N/16	91.75167	26.19194	TW	68.75	57.00
15	Fatashil Ambari-EW	Guwahati	78N/17	91.7375	26.15833	TW	22.10	21.50
16	Geeta Mandir	Guwahati	78N/16	91.80023	26.17279	BW	129.10	
17	Gopinath Nagar-PZ	Guwahati	78N/16	91.74306	26.1625	BW	166.70	
18	Gotanagar-EW	Guwahati	78N/16	91.68333	26.13944	BW	130.00	
19	GPRA Colony-EW	Guwahati	78N/16	91.72	26.11917	TW	110.00	100.00
20	Gurudwara Beltola-EW	Guwahati	78N/16	91.79938	26.11184	BW	198.40	
21	Hastinapur 9th Mile-EW	Dimoria	83B/4	91.85194	26.10611	BW	226.50	

Sl No	Location	Block	Topo sheet No	Long	Lat	Type of Well	Depth Drilled	Depth of construction (m)
22	Hatigarh	Guwahati	78N/16	91.78556	26.17639	BW	141.90	
23	IIT complex-Amingaon, Ghy.-EW	North Guwahati	78N/16	91.69551	26.18578	BW	187.20	
24	ITI Sankarpur-EW	Guwahati	78N/16	91.74447	26.16476	TW	201.50	91.70
25	Jayanagar-EW	Guwahati	78N/16	91.80472	26.125	TW	221.50	221.50
26	Kahilipara South Colony-EW	Guwahati	78N/16	91.75	26.14583	BW	130.10	
27	Kahipara south Colony-EW	Guwahati	78N/16	91.75	26.14583	BW	169.00	
28	Khanapara-EW&PZ	Guwahati	78N/16	91.81778	26.13333	TW	72.02	70.00
29	Khetri-EW	Dimoria	83B/4	92.08444	26.11849	TW	93.50	82.00
30	Krishna Nagar (Kahilipara)-EW	Guwahati	78N/16	91.75557	26.14065	BW	169.00	
31	Krishna Nagar L. P. school EW	Guwahati	78N/16	91.79826	26.15824	BW	202.25	
33	Krishna Nagar-PZ	Guwahati	78 N/16	91.75557	26.14065	BW	191.00	
34	Latakata-EW	Guwahati	78 N/16	91.79895	26.10022	TW	35.40	34.50
35	Manikarneswar-EW	North Guwahati	78N/16	91.74802	26.20716	TW	20.75	18.60
36	Manikarneswar-PZ	North Guwahati	78N/16	91.74802	26.20716	BW	199.00	
37	Mathgharia-PZ	Guwahati	78N/16	91.80833	26.17583	BW	185.00	
38	MMC Hospital-EW	Guwahati	78N/16	91.74077	26.18524	BW	259.05	
39	Odalbakra-PZ	Guwahati	78N/16	91.74673	26.14177	BW	156.50	
40	Pahartoli-EW/BP Chaliha	Guwahati	78N/16	91.74057	26.15641	BW	272.10	
41	Pathar Quary-EW	Guwahati	78N/16	91.82389	26.15944	BW	202.50	
42	RBI- calony-Gitanagar-DW	Guwahati	78N/16	91.78444	26.17306	TW	53.00	53.00
43	Santi Nagar-PZ	Guwahati	78N/16	91.75111	26.1425	BW	108.00	
44	Sonapur Collage-EW	Dimoria	83B/4	26.12917	91.975	BW	289.45	
45	Sribbumi (Adagudam)-EW	Guwahati	78N/16	91.74136	26.13686	BW	305.41	
46	Sukapha Mandir Prangan-EW	Guwahati	78N/16	91.76772	26.13005	TW	306.20	306.20
47	Udaipur, Birubari-PZ	Guwahati	78N/16	91.7539	26.16285	TW	83.00	79.00
48	Vikas Nagar-EW	Guwahati	78N/16	91.75889	26.175	TW	104.50	93.00

Note: BW: Bore well TW: Tube well

Table 2.5: Details pieezometers in Kamrup (Metro) District, Assam drilled during AAP: 2021-22

Sl No	Location	Block	Topo sheet No	Long	Lat	Type of Well (DW/ BW/ TW)	Depth Drilled	Depth of construction (m)
1	DGM Dakhingaon	Guwahati	78N/16	91.7581	26.1348	Borewell	202.6	
2	Sawkuchi	Guwahati	78N/17	91.7666	26.11728	Tubewell	101.0	94
3	Bhangagarh	Guwahati	78N/18	91.76502	26.16722	Borewell	167.3	
4	Dhirenpara	Guwahati	78N/19	91.72735	26.14371	Borewell	33.7	
5	Chandmari	Guwahati	78N/20	91.77255	26.18479	Borewell	172.0	

CHAPTER 3.0

Data Interpretation, Integration and Aquifer Mapping

3.1 Data Interpretation

3.1.1 Soil infiltration Test:

As per AAP 2021-22, three soil infiltration tests were conducted at Kamrup (Metro) district to determine the soil type of the area. The test was conducted with Ring Infiltrometer of 30cm and 60cm diameter. A metal measuring scale of 1mm gradation was placed inside the inner wall of 30cm diameter Ring Infitrometer to measure the speed of water layer entering the soil per hour.

In dry soil, water enters rather rapidly inside the soil and this is called as **Initial Infitraion Rate**. As more water enters into the soil, it replaces the pore spaces with water slowly and finally reaches a steady rate. This rate of steadiness is called as **Basic Infiltration Rate** which is measured as mm/hr. **Infiltration Factor** is then calculated by dividing Recharged water with Total Quantum of water added.

Based on the table below, soil types are classified according to basic infiltration rate,

Soil type	Basic Infiltration Rate (mm/hr)
Sand	<30
Sandy Loam	20-30
Loam	10-20
Clay Loam	5-10
Clay	1-5

Observation:

Three soil infiltration tests were conducted at Dhirenpara, Mikirpara and Hatishila in Kamrup (Metro) district. Mikirapara and Hatishila sites are located nearby foothills and Dhirenpara site was towards the valley portion on A. K. Dev road.

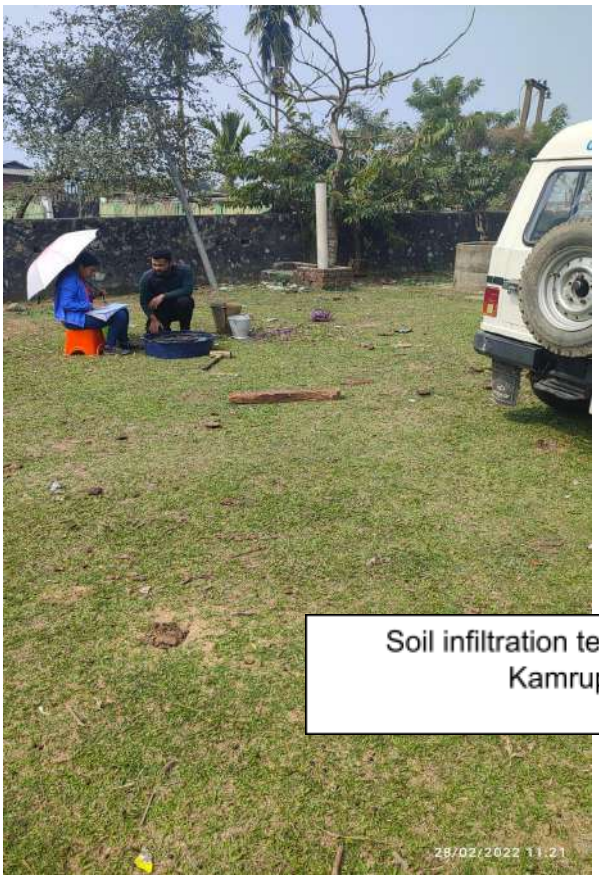
Dhirenpara soil infiltration test, conducted at Champavati High School football field, had an initial infiltration rate of 240mm/hour which eventually stabilized to basic infiltration rate of 4mm/hour. Based on the basic infiltration rate the soil type is Clay. Specific yield of 0.16 was used to calculate the total quantum of water recharged into the soil. Accordingly infiltration factor for Dhirenpara site was calculated to be 5.92.

The second soil infiltration test was conducted at Mikirapara Forest Camp site at Pamohi towards the foothill. The soil there was very compact and it had an initial infiltration rate of zero. After 91 minutes, a basic infiltration rate of 1mm/hour was resulted. It had an infiltration factor of 1.8.

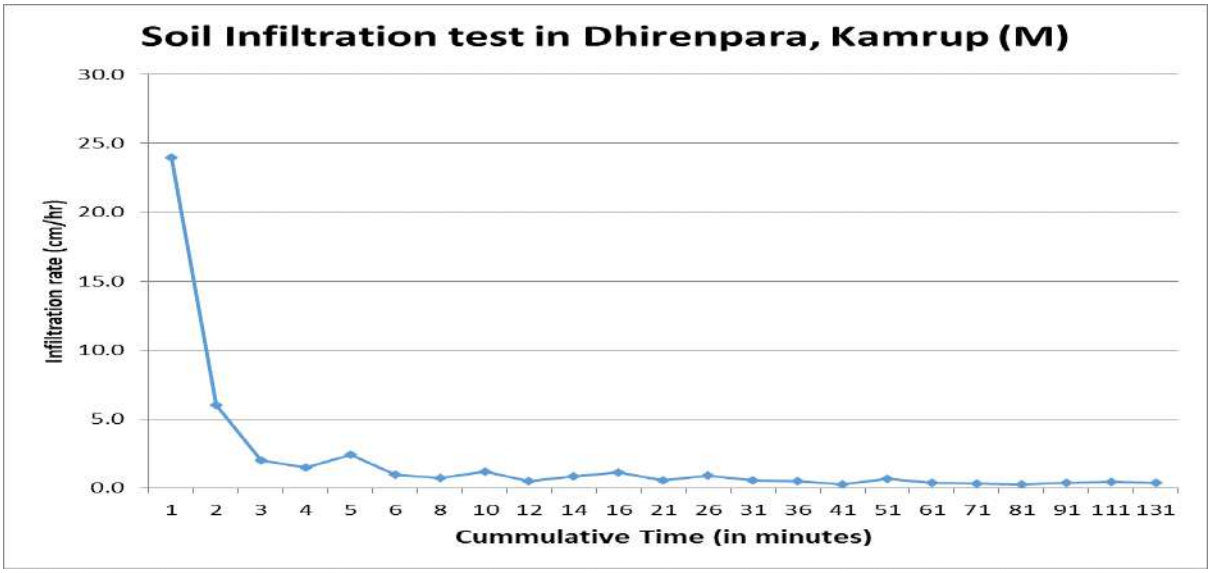
Soil infiltration test at Dhirenpara, Kamrup (M)

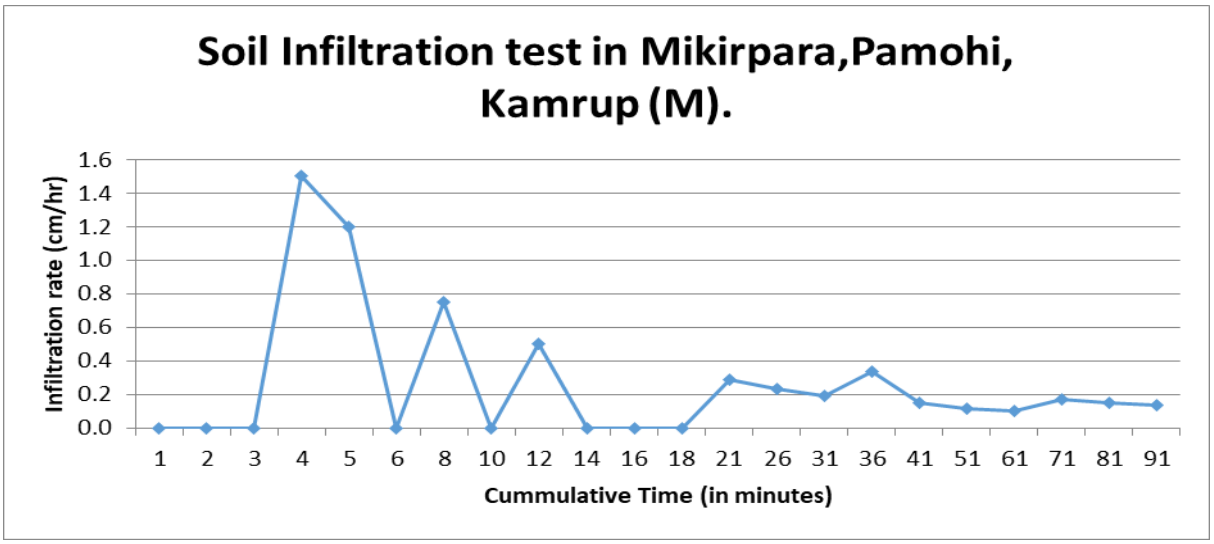
Soil infiltration test at Mikirpara, Kamrup (M)

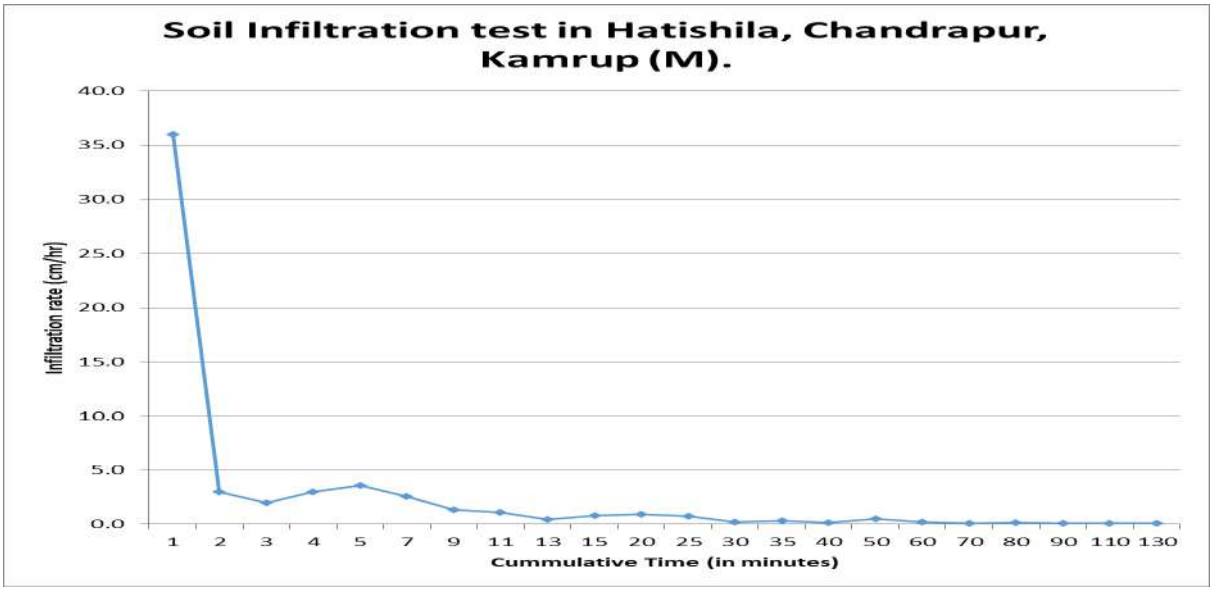
Hatishila site is at right hand side of the road towards Hatishila Ganesh temple. It had an initial infiltration rate of 360mm/hr and a basic infiltration rate of 1mm/hour. The infiltration factor was 4.7.



Soil infiltration test at Hatishila, Kamrup (M)


Soil Infiltration test in Dhirenpara, Kamrup (M)
Infiltration rate (cm/hr)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 8 10 12 14 16 21 26 31 36 41 51 61 71 81 91 111 131
Cummulative Time (in minutes)


Soil Infiltration test in Mikirpara,Pamohi, Kamrup (M).
Infiltration rate (cm/hr)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1 2 3 4 5 6 8 10 12 14 16 18 21 26 31 36 41 51 61 71 81 91
Cummulative Time (in minutes)


Soil Infiltration test in Hatishila, Chandrapur, Kamrup (M).
Infiltration rate (cm/hr)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 7 9 11 13 15 20 25 30 35 40 50 60 70 80 90 110 130
Cummulative Time (in minutes)

Result:

Location	Basic infiltration Rate (mm/hr)	Soil Type	Total Quantum of water added in m	Total Quantum of water infiltrated in m	Specific Yield	Total quantum of water recharged in m	IF = Recharged water/ added water m
Dhirenpara	5.96	Clay Loam	0.2	0.074	0.16	0.01184	5.92
Mikirpara	1.8	Clay	0.16	0.018	0.16	0.00288	1.8
Hatishila	4.7	Clay	0.16	0.047	0.16	0.00752	4.7

Conclusion:

Infiltration depends on size of the soil particle i.e. texture of soil and arrangement soil particles. Based on run off potential, 4 hydrologic Soil Groups are classified by Natural Resource Conservation Service, United States Department of Agriculture.

Hydrologic Soil Group	Soil	Characteristics
A	Sand, Loamy Sand or Sandy Loam	It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
B	Silt Loam or Loam	It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	Sandy Clay Loam	They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Clay Loam, Silty Clay Loam, Sandy Clay, Silty Clay or Clay	It has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

Based on HSG, soil type in the three locations falls in Group D where infiltration rate is low and run off is very high. Towards foothill side infiltration of water is slower than the valley portion.

3.1.2 Geophysics and aquifer Characterization:

Ten surface geophysical study was carried out during the AAP 2021-22 in Kamrup (Metro) district. In North Guwahatai block, two VES were conducted at NEHARI, Brahmaputra Board Campus. In Guwahati city, three VES was conducted, two n in Brahmaputra Board campus located at Basistha and one at Champavati High School field in Dhirenpara. Remaining five VES were conducted at Dimoria block of Kamrup (Metro) district.

The apparent resistivity curve for a three-layer structure generally has one of four typical shapes, determined by the vertical sequence of resistivities in the layers viz; K, H, A and Q Type curves.

VES conducted at Urul Village, Sonapur, Khetri:

Vertical electrical sounding conducted at Urul village, Sonapur on 15.02.2022 had a spread of 250m. Upto the depth of 49m loose formation was encountered and beyond 49m consolidated formation was encountered. The resultant curve was of KHA type.

Depth range (m)	Interpreted layer resistivity (ohm.m)	Probable lithology
G.L.-0.87	89.1	Topsoil with clay
0.87-1.94	882	Hard Clay
1.94-6.39	13.1	Clay formation
6.39-49	66.6	Sand formation
>49	11016	Consolidated formation

VES conducted at Aujuri Village, Khetri:

The VES conducted at Aujuri Village had a spread of 500m. The resultant curve was combination of H followed by an A type curve. Here initial layer had a higher apparent resistivity and as depth increases resistivity reaches minimum and increases again as soon as it encounters an intermediate layer that has a better conductivity than the top and bottom layer.

Depth range (m)	Interpreted layer resistivity (ohm m)	Probable lithology
G.L.-0.484	230	Topsoil
0.484-1.25	29.6	Clayey sand
1.25-6.91	17.8	Clay formation
6.91-59.3	31.1	Clayey sand
59.3-109	41.8	Sand formation
>109	26491	Consolidated formation

VES conducted at Aujuri Village, Khetri.

VES conducted at Maloibari Village, Khetri:

With a total spread of 500m, depth of penetration was more than 200m. upto depth of 206m loose alluvial formation was encountered and beyond 206m consolidated formation was encounetered. The resultant curve is HKH type.

Depth range(m)	Interpreted layer resistivity (ohm.m)	Probable lithology
G.L.-3.05	25.8	Topsoil with clay
3.05-6.29	9.17	Clay formation
6.29-27.3	64	Sand formation
27.3-117	25.7	Sandy clay
117-206	36.6	Clayey sand
>206	2921	Consolidated formation

VES conducted at Bijni Gaon Village, Amchung:

With a spread of 500m, VES was conducted at Bijni Gaon, Amchung, Near Goshani Than. Consolidated formation was encountered at a depth beyond 80m which had a resistivity of 13798Ωm. Quaternary sediments consisted of top soil, clay and sand. Physiography of the location is controlled by Digaru river.

Depth range (m)	Interpreted layer resistivity (ohm.m)	Probable lithology
G.L.-0.367	174	Topsoil with clay
0.367-5.37	69.7	Clayey sand
5.37-45.8	28.9	Sandy clay
45.8-80.7	18.1	Clay formation
>80.7	13798	Consolidated formation

VES conducted at Sonapur Pathar, Sonapur:

To demarcate the basement in foothill side of Sonapar (South of NH 27), a second VES was conducted at Sonapur Pathar with a spread of 500m. The quaternary formations are encountered upto depth of 68.4m. Resistivity of top soil was 190 Ωm and a thickness of 0.51m. Beyond 68.4m, consolidated formation was encountered which had an apparent resistivity of 2074 Ωm.

Depth range(m)	Interpreted layer resistivity (ohm.m)	Probable lithology
G.L.-0.51	190	Topsoil with clay
0.51-7.48	13.3	Clay formation
7.48-68.4	31.3	Clayey sand
>68.4	2074	Consolidated formation

VES conducted at Office premises of Brahmaputra Board, Kamrup (M) district:

Two VES were conducted at Brahmaputra Board campus at Basistha in Guwahati. The first VES was conducted at North-Eastern corner of the Brahmaputra Board campus. Up to a depth of 59.3m below ground level was inferred from this survey. No hard rock was encountered as the spread was limited to 150m only.

The second VES was conducted 190m south of VES I, near NH 27. In this spread soft formation upto 77m was inferred and below 77m consolidated formations were encountered.

VES I at Brahmaputra Board (26.113714°N, 91.791361°E)			VES II at Brahmaputra Board (26.112042° N, 91.791314° E)		
Depth range (m)	Interpreted layer resistivity (ohm m)	Probable lithology	Depth range(m)	Interpreted layer resistivity (ohm.m)	Probable lithology
G.L.-2.98	161	Topsoil with clay	G.L.-3.83	56.4	Topsoil with clay
2.98-59.3	33.8	Sandy Clay	3.83-5.06	8.07	Clay formation
>59.3	96.5	Sand mixed with Gravel	5.06-77.1	42.1	Sand mixed with Gravel

			>77.1	1350	Consolidated formation

VES conducted at Office premises of NEHARI campus of Brahmaputra Board at North Guwahati, Kamrup (M) district:

Two VES were conducted at NEHARI campus in Gauripur, North Guwahati. The first VES inferred presence of basement beyond 124m with an apparent resistivity of 330Ωm. The second VES was conducted near the Hydraulic Model Hut of NEHARI and basement was encountered at a depth of 50.6m which had an apparent resistivity of 8841Ωm. Due to constrain of open space half schlumberger was applied in the second location.

NEHARI VES I (26.213889° N, 91.715347° E)			NEHARI VES II (26.2194686°N,91.7167960° E)		
Depth range(m)	**Interpreted layer resistivity (ohm.m)**	**Probable lithology**	**Depth range(m)**	**Interpreted layer resistivity (ohm.m)**	**Probable lithology**
G.L.-0.853	311	Topsoil with clay	G.L.-1.93	110	Topsoil with clay
0.853-5.98	89.8	Sand mixed with clay	1.93-24.2	28.9	Sand mixed with clay
5.98-21.4	9.02	Clay formation	24.2-50.6	9.9	Clay formation
21.4-124	138	Sand formation	>50.6	8841	Consolidated formation
>124	330	Consolidated formation			

VES conducted at Champavati High School field, Dhirenpara, Guwahati, Kamrup (M) district:

With a limited spread of 160m, a VES was conducted at Champavati High School Field in Dhirenpara. Depth upto 37m was inferred by this method. The sand formation in the location had a resistivity of 147 Ωm.

Depth range(m)	Interpreted layer resistivity (ohm.m)	Probable lithology
G.L.-0.494	116	Topsoil
0.494-13.6	38.4	Sandy clay
13.6-37.1	147	Sand formation
>37.1	43.8	Clayey sand

Based on the analysis of interpreted data of geophysical studies it is confirm that the study area consist of two broad hydrogeological unit Viz- Pre Cambrian consolidated formation and Quaternary formation consisting of unconsolidated sediments. Pre Cambrian

consolidated rocks are confined to hilly areas and inselbergs, where ground water occurs in shallow weathered zone and this can be developed through open wells. The joints and fractures developed due to tectonic activities from potential water bearing formation suitable for development through construction of bore wells.

In alluvial plain, ground water occurs in regionally extensive aquifer inferred upto the down depth of ~100m. It has a good yield prospect. The aquifers are consisting of sands of various grades with gravel that are suitable for construction of both shallow and deep tube wells. Ground water occurs under unconfined to semi confined condition.

Geophysics and aquifer Characterization

The interpreted VES results have indicated a three layered geoelectric model. The top soil identified by VES survey has resistivity value between 25.8 to 230Ωm suggesting clayey and gravelly nature. However, top soil resistivity increases depending upon presence of gravel in the area. The soil resistivity is more near the hills than the valley. Soil thickness is also increasing in the valley.

The top soil is generally followed by low resistivity zones and is interpreted as clay layer. Clay layer resistivity ranges from 9.17 to 31.3 Ωm. Sand layer resistivity ranges from 40 to 70Ωm. Generally the combined thickness of clay and sand layer ranges from 45 to more than 200m.

There is many fold increase in the value of resistivity of third layer in the three layered geoelectric model. The resistivity value ranges from 2074 to 26491Ωm. In the valley area resistivity value ranges from 2074 to 2921Ωm whereas high resistivity value within the range of 11016 to 26491Ωm is observed near the hills indicating compact nature of the bed rock. These interpretations are in conformity with the lithological log of drilled exploratory wells of CGWB.

Based on Geophysical and lithological logs of exploratory wells the aquifer system of the area can be classified into two, viz., Aquifer 1 and Aquifer2.

Aquifer 1: Younger Alluvium extended down to a depth of 200mbgl.

Aquifer 2: Gneissic

3.1.3 Exploration and Aquifer Disposition

Central Ground Water Board, North Eastern Region, Guwahati has drilled numbers of exploratory wells in the district. But for the sake of this report, only 48 wells will be considered. Public Health Engineering Department has also drilled number of wells in the area. During aquifer mapping, in the district five piezometers were drilled down to the depth of 200m through DTH Rig. The litholog of all the exploratory wells are used to identify the major aquifer in the district. The lithologs of all the exploratory wells and piezometers are dominated by Quarternary sediments like grey coloured clay and sand which indicate

deposition in riverine environment and underlain by Pre-Cambrian Gneissic rocks. The principal alluvial aquifer is further categorized as younger alluvium. The deeper aquifer present in the district is weaker zones of granite gneiss and schist.

Aquifer Disposition

To understand the disposition of aquifer, 2D sections and 3D panel diagrams are constructed using the lithologs of the exploratory wells, piezometers and VES data.

2D Aquifer Disposition:

2D disposition: Six sections are constructed to visualize the aquifer disposition

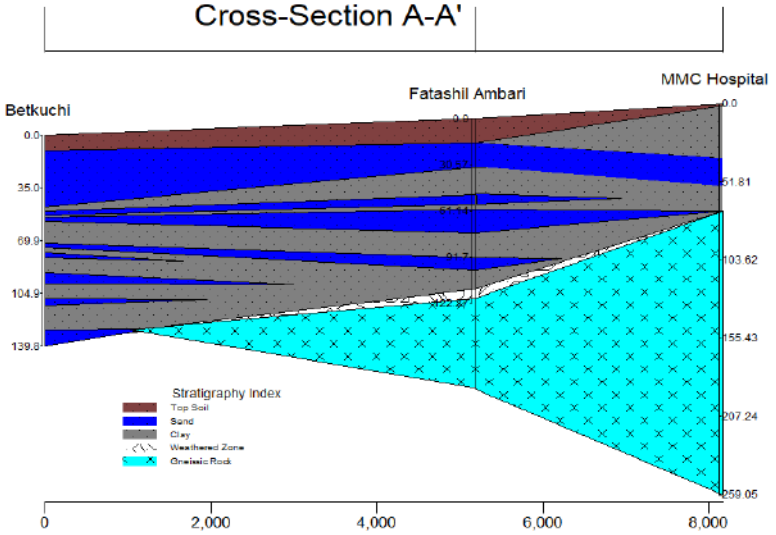
(a) A north - south section from Betkuchi to MMC Hospital via Fatashil Ambari on A K Dev Path (Fig. 3.1)
(b) A north west to south east section from Khanapara to Panbazar on Guwahati-Shillong Road (Fig. 3.2).
(c) An east - west section from Khanapara to Kahikuchi along NH 27 (Fig. 3.3)
(d) A section in the East-West Direction of the district from Panabazar to patharquery via Chandamri along GNB Road (Fig. 3.4).
(e) A section from Sonapur to Amchung across NH 27 in north south Direction (Fid 3.5).
(f) Section from Jurabat to Bamfor along NH 27 in east west direction (Fig 3.6)
(g) Section across NH 27 from Khetri to Maloibari (Fig 3.7)

3.1.3(a) Betkuchi to MMC Hospital via Fatashil Ambari:

Betkuchi to Panbazar via Fatashil Ambari has a lenear distance of 14km. exploratory well upto 259m below ground level was carried out. Bed rock was encountered at various depths of 71m at MMC Hospital and at 113m depth in Fatashil Ambari Exploratory well. Exploratory well drilled at CGWB Betkuchi office upto a depth of 154.75m below ground level was entirely of Quarternary sediments. These sediments has a huge of potential ground water storage and recharge. The pile of quarternary sediments of Younger alluvium and older alluvium are composed of Sand. Silt and clay. Top soil is prevalent almost in every place along the stretch. The first layer of granular zone is present throughout the section and has an average thickness of 23m; largest thickness being encountered towards Betkuchi and tapered towards Panbazar. In hardrocks fractures acts as the conduits for ground water. Fractures occurs at various depths ranging from as shallow as 36m to as deep as 241m below ground level.

Location	Depth Drilled (mbgl)	Zones / Fractured encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity
Betkuchi	154.75	33-34, 34-43,49-55, 108-111, 126-138	3.98	44.76	3.14	3.74	
Fatashil Ambari	122.27	17.75-21.5	9.53	11.34	3.67		51.65

Location	Depth Drilled (mbgl)	Zones / Fractured encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity
MMC Hospital	259.05	36.1-54.4, 75-105, 120-122, 151-155, 174-176, 180-181, 234-241	15.00	1.50	3.65	16.00	6.85



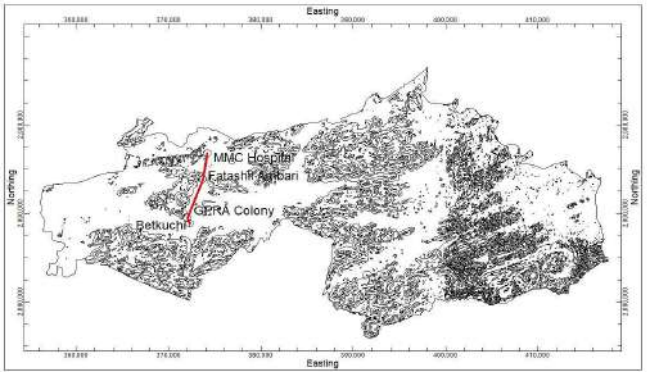


Figure 3.1: North-South Section showing aquifer disposition along A K Dev Road, Guwahati.

3.1.3(b) Khanapara to Panbazar on Guwahati-Shillong Road:

The GS road section stretching for 11km runs along Khanapara, Downtown, Bhangagarh and Panbazar. Exploration upto depth of 299m was carried out and encountered bed rock at 59m

in Khanapara, 88m in Downtown area, at 78m in Bhangagarh and at 71m in Panbazar. Bedrock is overlain by Quarternary sediments of almost uniform thickness through out the section. Top soil is very thin towards Panbazar. Two layers of Sandstone is prevalent in the section but the thickness is very less. First layer of granular zone had a thickness of 6m in Khanapara, 9m in downtown, 3m in Bhangagarh and 18m in Panbazar. The second granular zone is absent in Panbazar. In hardrocks, deeper fractures are the aquifers for ground water.

Location	Depth of Drilled (mbgl)	Zones / Fractured encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity
Chilarai Nagar	215.00	100-112,112-15, 126-129,150-152, 193-197, 212-215	27.00	0.90	5.51	8.00	2.70
AAU Khanapara	59.50	9.7-15.8, 46.3-59.5	6.65	3.82	13.32	4.42	
Downtown Hospital	152.30	12.19-13.7, 18.28-27.43, 33.53-35.0, 48.77-50.29, 79.22-88.38					
MMC Hospital-EW	259.05	36.1-54.4, 75-105, 120-122, 151-155, 174-176, 180-181, 234-241	15.00	1.50	3.65	16.00	6.85

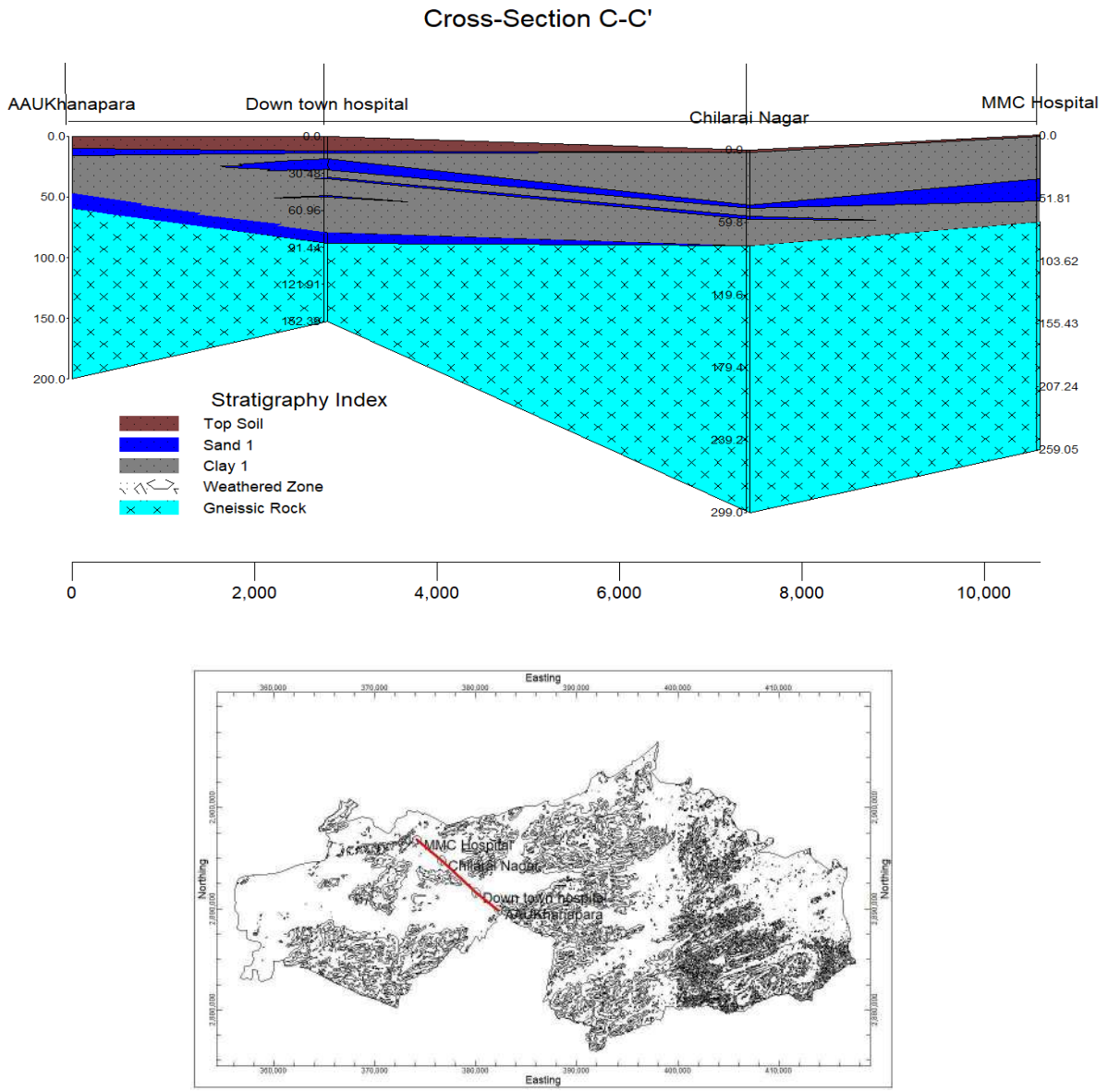
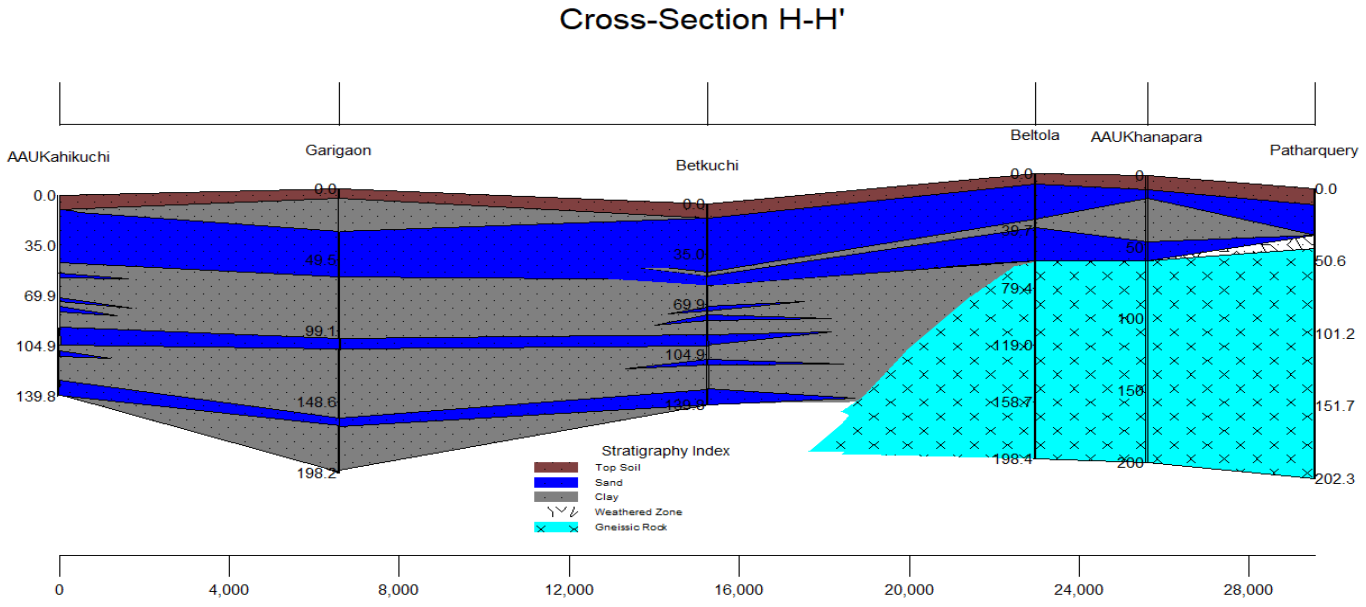


Figure 3.2: Section showing aquifer disposition along Khanapara to Panbazar on Guwahati-Shillong Road.

3.1.3(c) Khanapara to Kahikuchi along NH 27:

The stretch of NH 27 from Kahikuchi to Khanapara is of around 23km. Geology changes from Quarternary Alluvium in Jalukbari area to Archean Gneissic Complex towards Beltola and Khanapara. The wetland of Deepor Beel which is a paleo channel of Brahmaputra is responsible for the huge sediment thickness in KAhikuchi-Jalukbari area. These sediments have huge ground water potential which can be easily replenished and developed. Bedrock is encountered at a depth of 41.8m in Patharquery, 59m in Khanapara and 60.88m in beltola exploratory wells. The first granular zone of sandstone was encountered at a depth of 11m at Pathrquery, at 6m depth in Beltola, at 1m depth in Betkuchi, at 9m in Khanapara, at 10m at Kahikuchi and at 30m in Garigaon area. The first granular zone is present in every exploratory well and has a more or less uniform thickness of 20 to 30m.

Location	Depth of Drilled (mbgl)	Zones / Fractured encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity
AAU Khanapara	59.50	9.7-15.8, 46.3-59.5	6.65	3.82	13.32	4.42	4.74
Patharquary	202.50	120-128	7.12	6.54	1.112		
Garigaon	201.00	21.0-24.0, 26.0-35.0, 45.5-48.5, 60.0-66.0, 100.0-122.0, 176.0-179.0, 186.0-189.0	5.15	26.12	2.01	564	
Betkuchi	154.75	33.0-34.0, 34.0-43.0, 49.0-55.0, 108.0-111.0, 126.0-138.0	3.98	44.76	3.14	3.74	



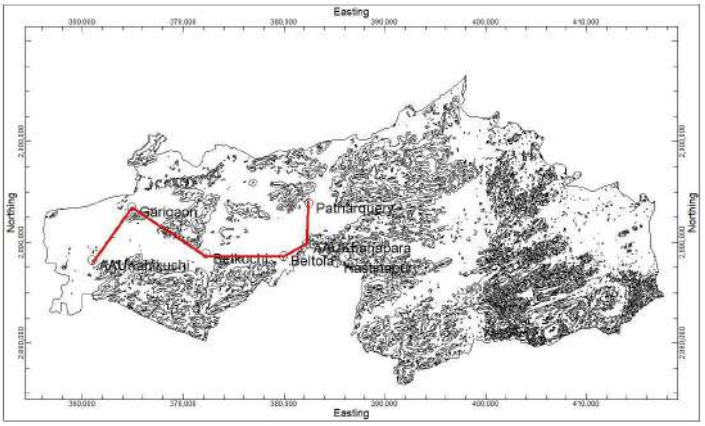


Figure 3.3: Section showing aquifer disposition from Khanapara to Kahikuchi along NH 27.

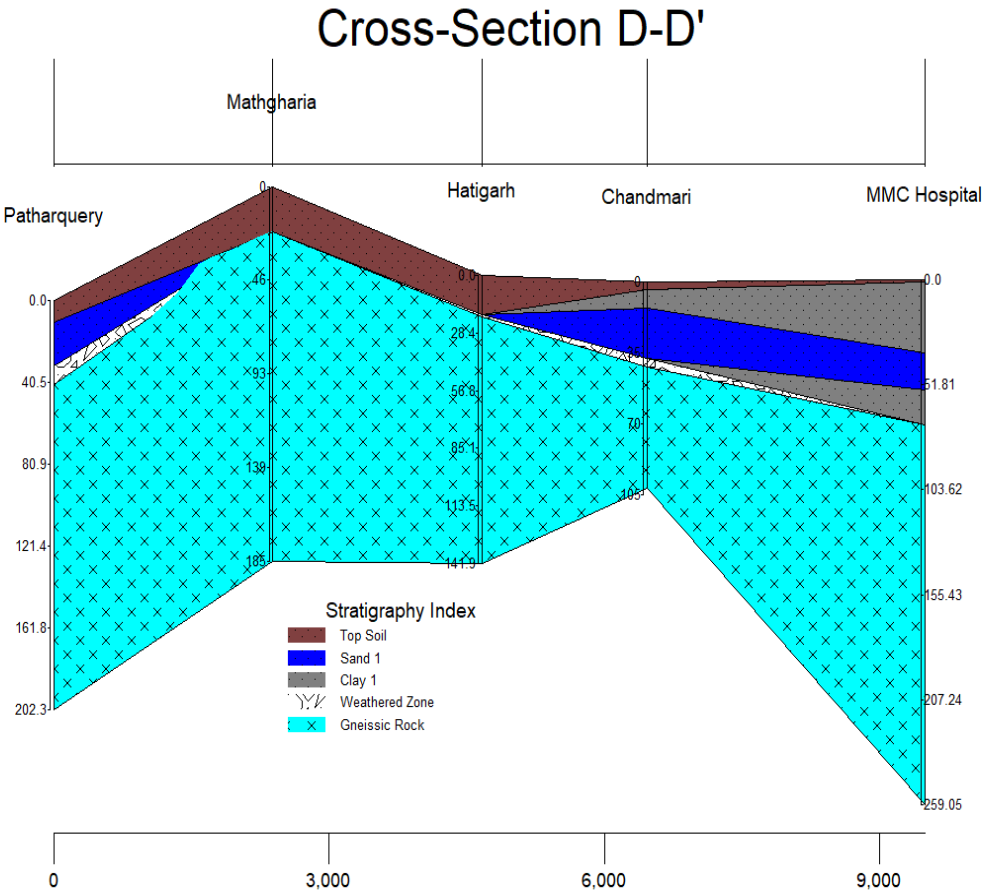
3.1.3(d) Patharquery to MMC Hospital via Hatigarh along GNB Road:

In the section along GNB road, exploratory wells drilled have encountered bedrock at very shallow depths i.e at 41.8m at Patharquery, immediately after top soil at Mathgharia and HAtigarh at 22m and 20m respectively, at 42m depths at Chandmari and at 71m in Panbazar.

Quaternary sediments containing sand and clay overlay the bedrock which is absent in exploratory wells at Hatigarh and Mathgharia. One granular zone of 18 to 24m thickness is encountered at depths from 11m at Patharquery to 36m at Panbazar.

In Hardrocks fractures were encountered at depths as shallow as 31m and as deep as 241m. These fractures give enough porosity and permeability for the ground water to move.

Location	Depth of Drilled (mbgl)	Zones / Fractured encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity
Pathar Quary	202.50	120.0-128.0	7.12	6.54	1.112		
Chandmari	105.00	57.0-58.0, 79.6-80.6, 94.5-95.2	19.93	2.40			
Hatigarh	141.90	31.5 - 32.1, 41.5- 42.5, 49.4-50.4, 79.0-80.0, 118.0- 118.7	5.85	12.00	1.90	27.53	52.63
Mathgharia	185.00		14.5				
MMC Hospital	259.05	36.1-54.4, 75.0-105.0, 120.0-122.0, 151.0-155.0, 174.0-176.0, 180.0-181.0, 234.0-241.0	15.00	1.50	3.65	16.00	6.85



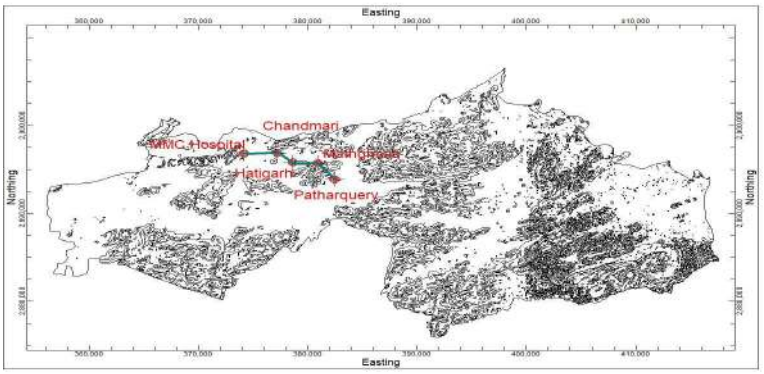


Figure 3.4: Section in from Patharquery to MMC Hospital via Hatigarh along GNB Road.

3.1.3(e) Sonapur to Amchung across NH 27:

Towards Sonapur, during 2021-22 AAP, Surface Geophysical Survey of Vertical Electrical Sounding was carried out to decipher the underlying lithology of the area. A section across NH 27 from Urul village to Bijni Gaon shows that depth of Bedrock ranges from 49m at Urul village, 52m and 47m in Sonapur and Amchung exploratory well respectively, and at 80m depth in Bijni Gaon. A shallow granular zone was encountered throughout the section.

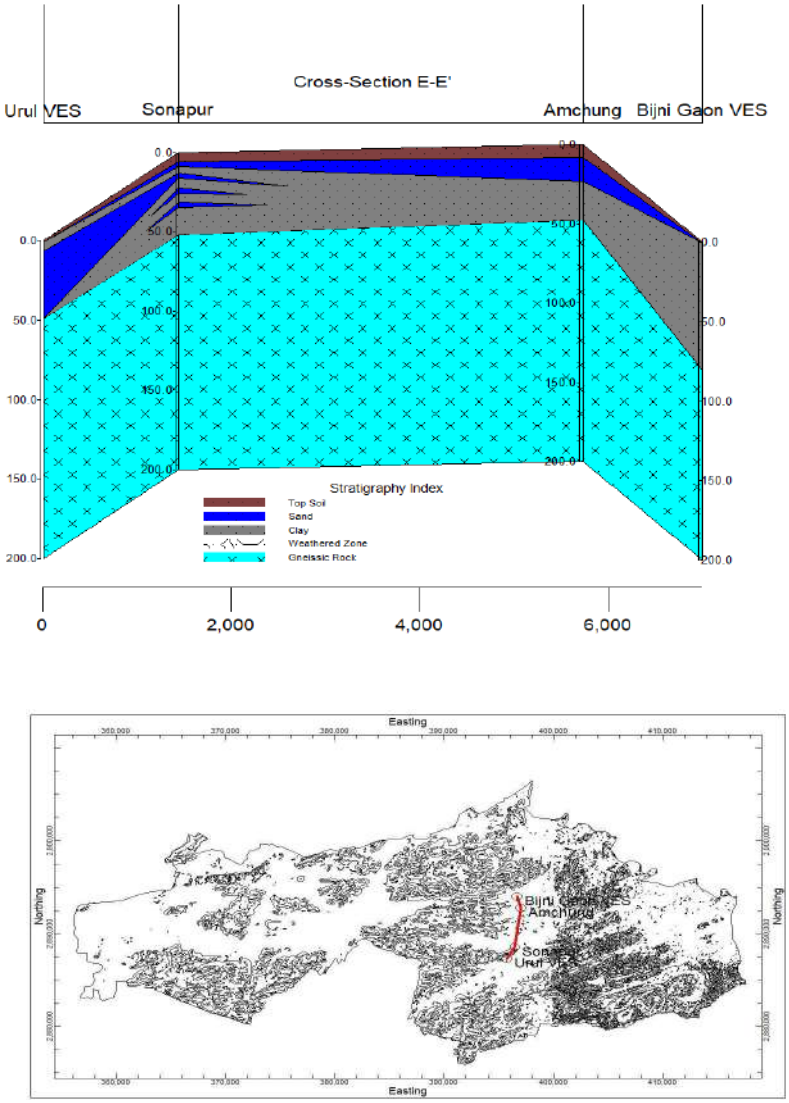


Figure 3.5: A section in the hard rock formation of the district in its eastern boundary from Sonapur to Amchung across NH 27.

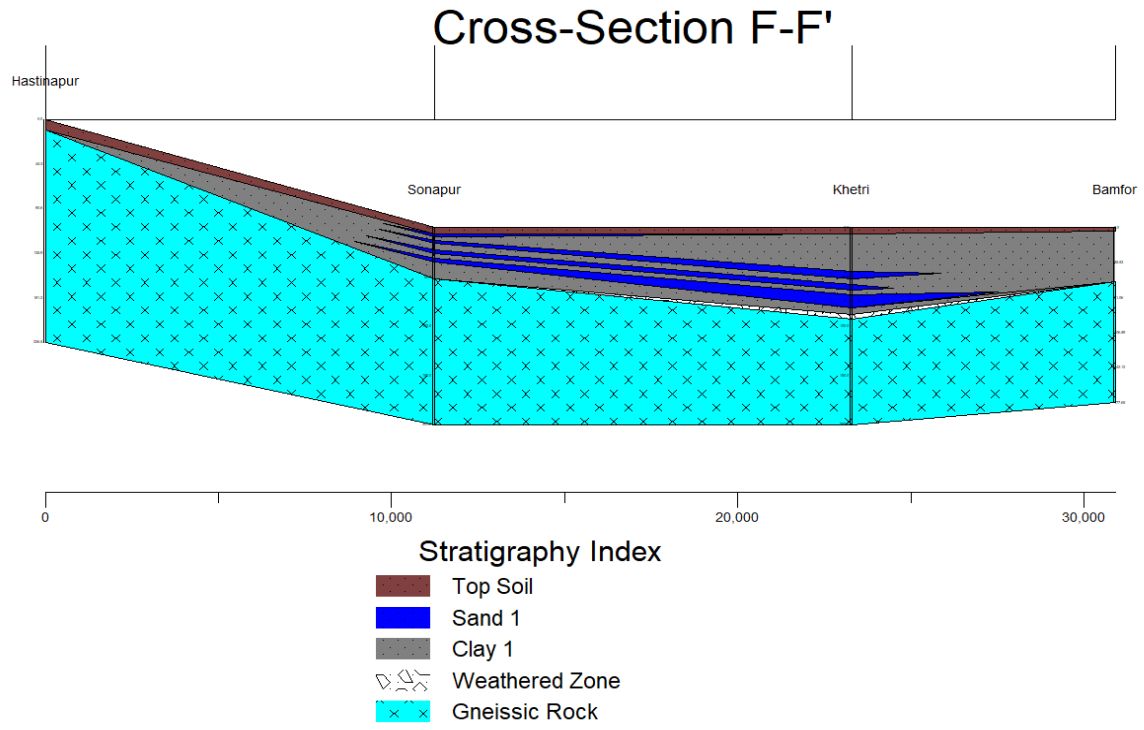
Location	Depth of Drilled (mbgl)	Zones / Fractured encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity
Amchang	47.60	11.5-21.50	1	1.122	9.08		
Sonapur Collage	289.45	182-185, 239-242	2.55	3.00	8.06	6.80	

3.1.3(f) Jurabat to Bamfor along NH 27:

Along NH 27 from 9th Mile to Bamfor, exploratory wells were drilled upto the depth of 289m. Bedrocks were encountered at a depths of 11m in 9th Mile, 52m at Sonapur, 93m at

Khetri and at 55m at Bamfor. Quarternay Alluvium overlie the bedrock and its thickness pinches out at 9th Mile. Quaternary sediment thickness is maximum in the center at Sonapur and Khetri where three thin lenses of granular sand is present. Layer of top soil is present throughout the section. Fracyures in bed rock was encountered as shallow as at 15m depth in 9th Mile and deepest fracture was encountered at 242m depth at Sonapur.

Location	Depth of Drilled (mbgl)	Zones / Fractured encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity
Sonapur Collage	289.45	182.0-185.0, 239.0-242.0	2.55	3.00	8.06	6.80	
Bomfor Village	177.65	60.0-100.0, 106.0-110.0, 116.0-112.0, 135.0-139.0, 143.0-147.0, 150.0-155.0	2.61	6.08	13.74		26.31
Hastinapur 9th Mile	226.50	15.0-22.1, 203.0-208.2	7.20	45.00	1.47		2.66
Khetri	93.50	45.0-51.0, 58.5-61.5, 70.0-79.0	1.95	80.16	16.388	89.3	81.52



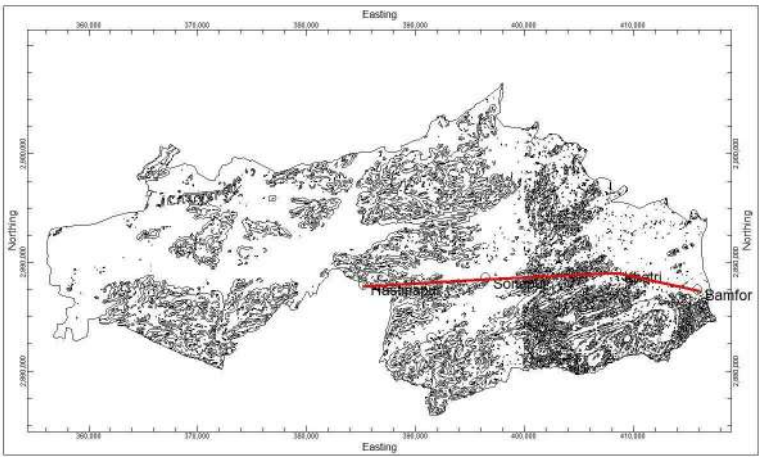
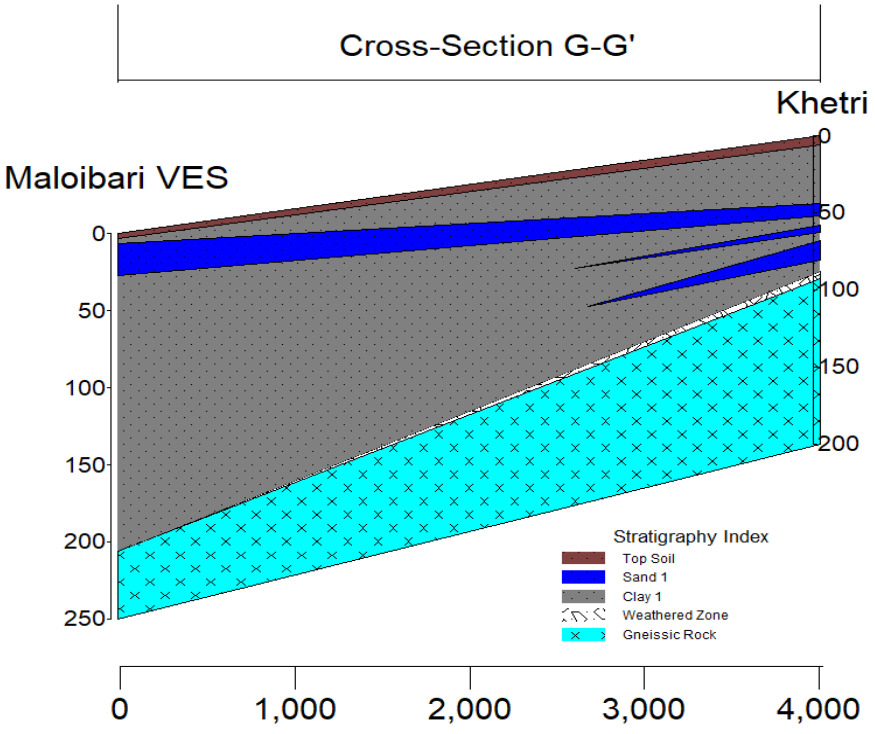


Fig. 3.6: Jurabat to Bamfor along NH 27

3.1.3(g) Khetri to Maloibari along NH 27:

One section along Khetri towards Maloibari Village was drawn to infer the underlying lithology. A shallow granular zone was encountered at depths of 6m at Maloibari village and at 44m at Khetri exploratory well. Thickness of the granular zone ranges from 8m in Khetri to 21m in Maloibari Village. Bedrock was encountered at 93m depth in Khetri and 206m depth at Maloibari Village. Fom the section it is clear that as we move toward Kopili River thickness of Alluvium increases and depth of Bedrock increases as well. Due to the huge thickness of Clay and absence of secondary granular zone, this area experiences water logging condition throughout the year.



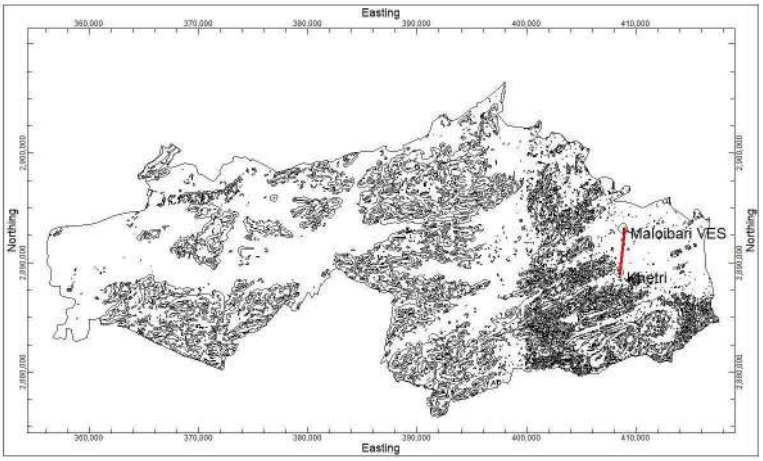
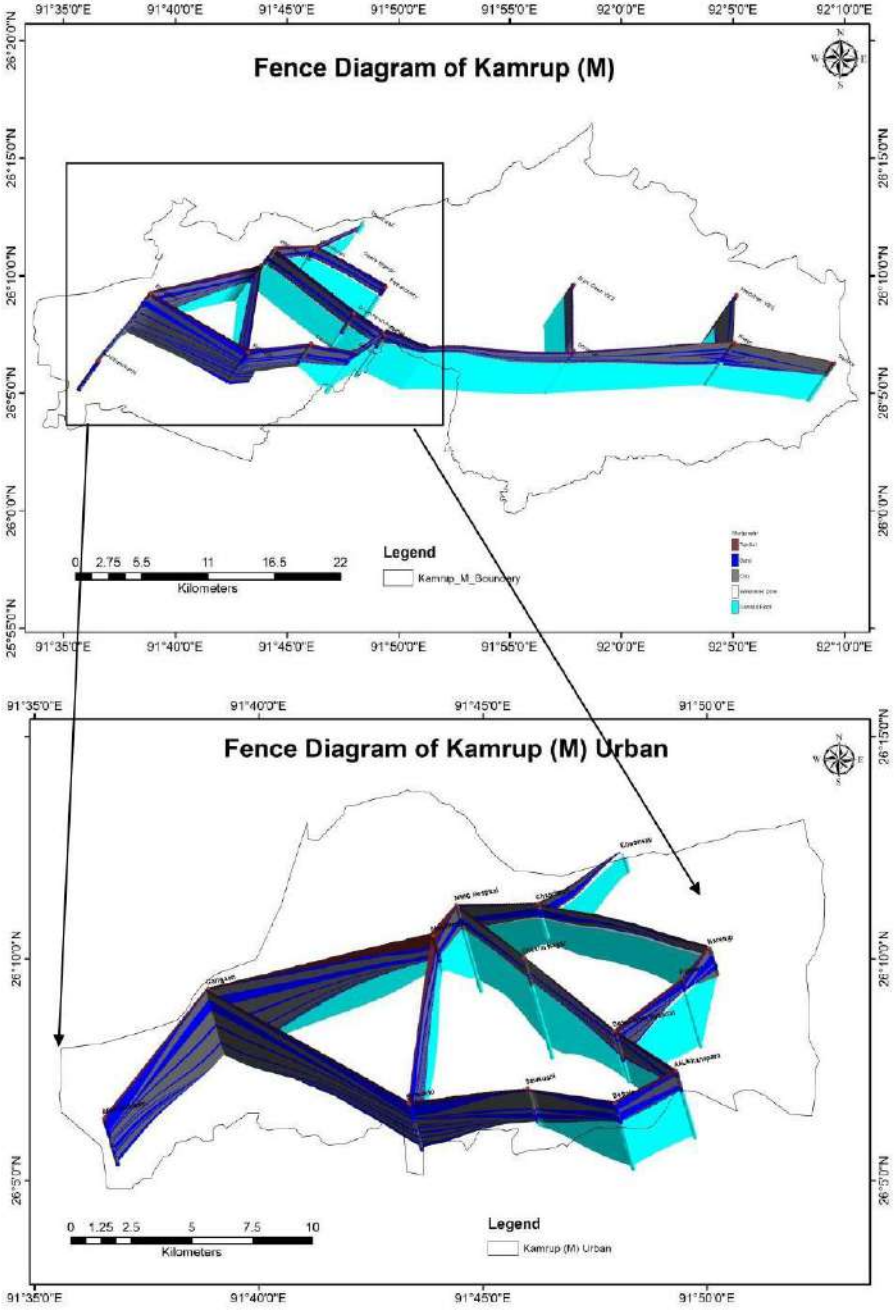


Fig. 3.7: Khetri to Maloibari across NH 27 in north south direction

3D Aquifer Disposition:


Fence Diagram of Kamrup (M)
91°35'0"E
91°40'0"E
91°45'0"E
91°50'0"E
91°55'0"E
92°0'0"E
92°5'0"E
92°10'0"E
26°20'0"N
26°15'0"N
26°10'0"N
26°5'0"N
26°0'0"N
25°55'0"N
0 2.75 5.5 11 16.5 22
Kilometers
Legend
Kamrup_M_Boundary
Fence Diagram of Kamrup (M) Urban
91°35'0"E
91°40'0"E
91°45'0"E
91°50'0"E
26°15'0"N
26°10'0"N
26°5'0"N
0 1.25 2.5 5 7.5 10
Kilometers
Legend
Kamrup (M) Urban

.

Table 3.1: Aquifer parameters:

Location	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Zones / Fractured encountered				Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Per mea bility (m/d ay)	Specific Capacity
			upto 50 m.bgl	upto 100 m.bgl	upto 200 m.bgl	upto 300 m.bgl						
10 th Assam police battalion Kahlipara-EW	306.30	306.30					19	108				
Amchang-EW	47.60	23.50	11.5-21.50				1	1.122	9.08			
Bakrapara-EW	69.80	60.00	32-35. 46-52	55-58			16.15	7.2	9.81	10.55	0.879	12.2
Basistha Mandir campus -EW	92.25		49.55-52.5 5	71.25-75. 55			1.63	3.60	6.75	110.0		
Betkuchi-II (Office complex)-EW &OW	154.75	138.00	33-34, 34-43, 49-55		108-111, 126-138		3.98	44.76	3.14	3.74		
Bhaskar Nagar-EW	98.40	64.00	46-54	57-61			8.9	14.53				
Birubari-PZ	188.00						11.27					
Bomfor Village-EW	177.65			60-100	106-110, 116-112, 135-139, 143-147, 150-155		2.61	6.08	13.74			26.31
Borhojai-EW	106.15	94.00	49-55	58-61, 67-73, 79-82, 88-91			17.09	90.0	3.93	23.21	1.11	

Location	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Zones / Fractured encountered				Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Per mea bility (m/d ay)	Specific Capacity
			upto 50 m.bgl	upto 100 m.bgl	upto 200 m.bgl	upto 300 m.bgl						
Borjhar-EW	104.10	100.00	42-54				3.78	27.00				
Chandmari Colony-EW	105.00			57-58, 79.6-80.6 , 94.5-95.2			19.93	2.40				
Chilarai Nagar-EW	299.20				100-112, 112-115, 126-129, 150-152, 193-197	212-21 5	27.00	0.90	5.51	8.00		2.70
Choonsali-PZ	59.00			57.9-58.6			0.21	28.80	6.88	13.71		
Circuit House, Ghy.-EW	68.75	57.00	28-46	51-55			10.06	38.86	1.65	1637		405.58
Fatashil Ambari-EW	22.10	21.50	17.75-21.5				9.53	11.34	3.67			51.65
Geeta Mandir	129.10		36-37	66-67, 80-81			9.72	3.12	27.17			
Gopinath Nagar-PZ	166.70		30.9-32	72-72.6,9 3-95			16.25	0.70				
Gotanagar-EW	130.00		24.8-26.32	56.3-60.8 8			7.00	1.80				
GPRA Colony-EW	110.00	100.00	42-48	54-63				28.34	6.00			1130.9

Location	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Zones / Fractured encountered				Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Per mea bility (m/d ay)	Specific Capacity
			upto 50 m.bgl	upto 100 m.bgl	upto 200 m.bgl	upto 300 m.bgl						
Gurudwara Beltola-EW	198.40			65-87	105-120, 151-164, 193-197		6.45	90.00				
Hastinapur 9th Mile-EW	226.50		15-22.1		203-208.2		7.20	45.00	1.47			2.66
Hatigarh	141.90		31.50 - 32.10, 41.50 - 42.50, 49.40 - 50.40	79.00 - 80.00, 118.00 - 118.70			5.85	12.00	1.90	27.53		52.63
IIT complex-Amingaon, Ghy.-EW	187.20			48-60	168-178, 185-188		3.40	9.12	15.66	2.64		16.07
ITI Sankarpur-EW	201.50	91.70		62-78			13.79	5.82	10.82	3.14		8.96
Jayanagar-EW	221.50	221.50			162.18-163.58, 183-184,	209-210	39.74	43.3	5.88	2.3		
Kahilipara South Colony-EW	130.10			98.4-100.4			10.00	3.06	2.08	9.56		27.00

Location	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Zones / Fractured encountered				Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Per mea bility (m/d ay)	Specific Capacity
			upto 50 m.bgl	upto 100 m.bgl	upto 200 m.bgl	upto 300 m.bgl						
Kahipara south Colony-EW	169.00		33.3-34.3		110.5-118, 130.5-131. 5, 145-146, 164.5-165. 5		11.43	28.35	12.91	10.30		
Khanapara-EW& PZ	72.02	70.00	30-35,60-70				6.65	3.82	13.32	4.42		4.74
Khetri-EW	93.50	82.00	45-51	58.5-61.5 , 70-79			1.95	80.16	16.388	89.3		81.52
Krishna Nagar (Kahilipara)-EW	169.00		83.3-84.3,	110.8-111 .80, 130.5-13 1.5, 145-146, 164.5-16 5.5			28.35	12.91	10.3			
Krishna Nagar L. P. school EW	202.25		21.5-28	73.5-74.2 ,	131.2-132. 2, 187.3-190		0.55	6.00	25.00	4.34		149.38
Krishna Nagar.LP.School-EW	202.25		34-36	77.6-79, 86.7-88.9			0.55	12.23	17.33	6.93		3.99
Krishna Nagar-PZ	191.00			100-101				1.55				

Location	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Zones / Fractured encountered				Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Per mea bility (m/d ay)	Specific Capacity
			upto 50 m.bgl	upto 100 m.bgl	upto 200 m.bgl	upto 300 m.bgl						
Latakata-EW	35.40	34.50	19-25, 29-33				4.6	16.6	15.05	657.95	65.8	
Manikarneswar-EW	20.75	18.60	9.15				1.90					
Manikarneswar-PZ	199.00		30.5-32,	98-99.10	197-198.2		1.80	1.50	12.13	1.46		0.94
Mathgharia-PZ	185.00						14.5					
MMC Hospital-EW	259.05			75-105,	120-122, 151-155, 174-176, 180-181,	234-241	15.00	1.50	3.65	16.00		6.85
Odalbakra-PZ	156.50		22.23,		124-125, 139-139.5, 154.5-155		2.2	12.00	24.88	12.36		129
Pahartoli-EW/BP Chaliha	272.10				124-128		25.11	1.38	3.20	5.93		7.16
Pathar Quary-EW	202.50				120-128		7.12	6.54	1.112			
RBI- calony-Gitanagar-DW	53.00	53.00					0.92	0.733	9.5	0.6		
Santi Nagar-PZ	108.00		35-35.42	71.5-77.5	102-103		4.75	0.90	10.47			1.43
Sonapur Collage-EW	289.45				182-185,	239-242	2.55	3.00	8.06	6.80		

Location	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Zones / Fractured encountered				Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Per mea bility (m/d ay)	Specific Capacity
			upto 50 m.bgl	upto 100 m.bgl	upto 200 m.bgl	upto 300 m.bgl						
Sribbumi (Adagudam)-EW	305.41				159.24-165 .3, 177.8-180. 5		4.706	2.94	9.364	6.51		5.23
Sukapha Mandir Prangan-EW	306.20	306.20				241-24 2.5	19	108				
Udaipur, Birubari-PZ	83.00	79.00	34-40	50-54, 70-76			13.70	2.52	2.26	8.12		19.47
Vikas Nagar-EW	104.50	93.00		62-71, 84-90			7.30	8.40				

3.1.2 Ground water level

To study ground water regime, depth to water level from 50 monitoring stations were measured periodically during the months on August 2021, November 2021, January 2022 and March 2022. Variations in water level is discussed:

During Pre-Monsoon i.e. on March 2022, 13 (26.53%) key wells show depth-to-water level of less than 2m bgl, 38.78% (19) wells key wells show water level in the range from 2 to 5 mbgl and 30.61% (15) key wells have water level from 5 to 10mbgl and two wells show water level above 10 mbgl. Minimum water level of 0.26mbgl was recorded at Paltan Bazar and maximum water level recorded is 12.5mbgl was recorded at Basistha Forest Gate well (Fig. 3.5).

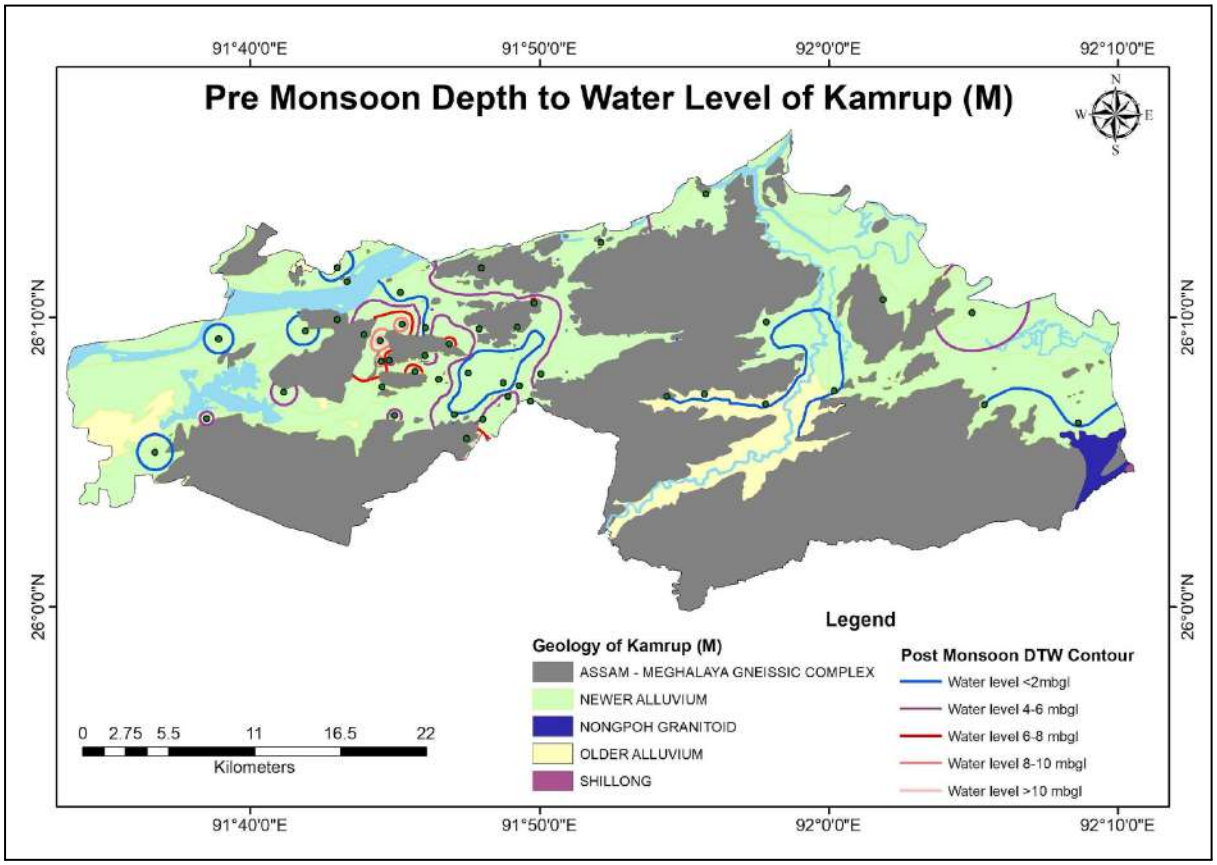


Fig. 3.5: Pre-monsoon DTW level contour of Kamrup (M) district, Assam

In Post-monsoon (November 2021) also water level data of Kamrup (M) district ranges from a minimum of 0.26m bgl recorded at Paltan Bazar to maximum 12.2m bgl at Basistha Forest Gate. The overall post monsoon water level of the district is shallow. About 32.7% well (17 numbers) shows water level less than 2mbgl, 44.23% (23) wells records water level of 2 to 5 mbgl, 19.23% (10) stations show water level from 5 to 10 mbgl and only in two (3.84%) key wells water level is above 10mbgl. (Fig. 3.6).

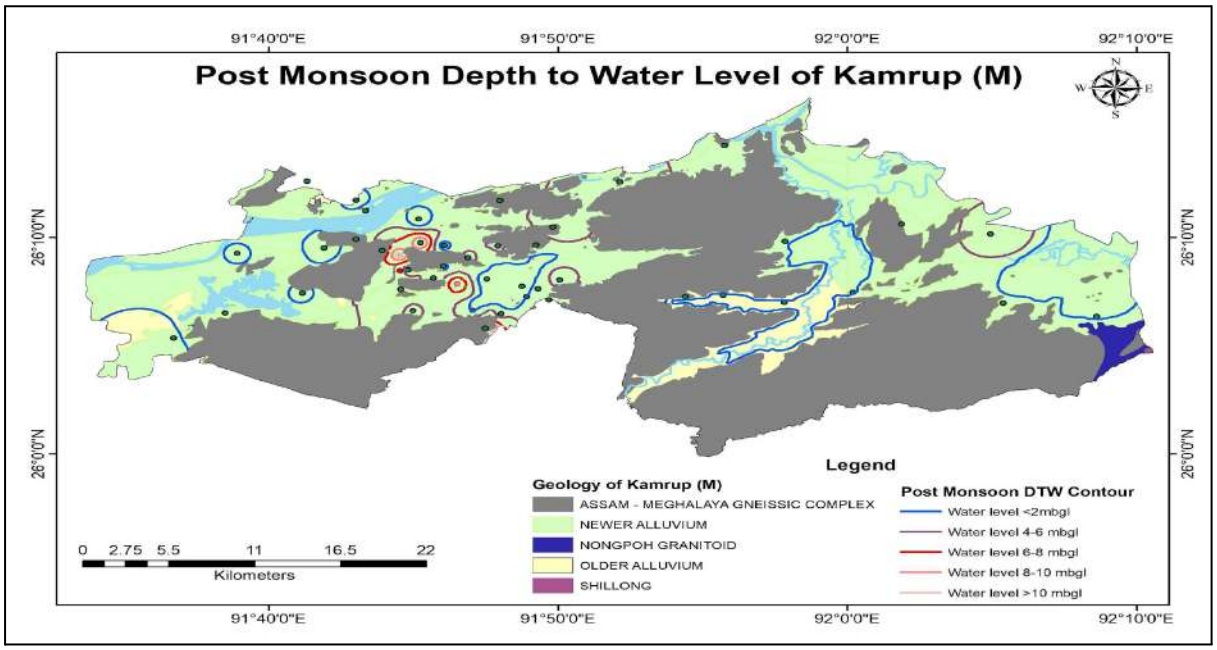


Fig. 3.6: Post-monsoon DTW contour of the study area

During Monsoon (August 2021), 42 wells were monitored out of which 40.6% (20) wells have water level less than 2mbgl, 40.5% (17) wells have water level 2 to 5 mbgl, 9.5% (4) wells have water level in the range from 5 to 10mbgl and only one well has water level >10mbgl. Maximum water level of 10.99 and minimum water level of 0.3 is recorded in Basistha Forest Gate and Directorate of Agriculture, Khanapara well respectively.

Fluctuation of water level in pre and post monsoon water level difference ranges from 0.0 to 2 m in 83% (39 wells) of the key wells and rest of the wells (17%) in the range from 2 to 4 m is observed in the monitored wells of the district. Minimum fluctuation of 0.1m and maximum of 3.82 m is recorded in Chandrapur and Dakhingaon respectively. Wells of Wireless, Vishwakarma Temple, West Krishna nagar and Udaipur show no change in pre and post monsoon water level. (Fig. 3.7)

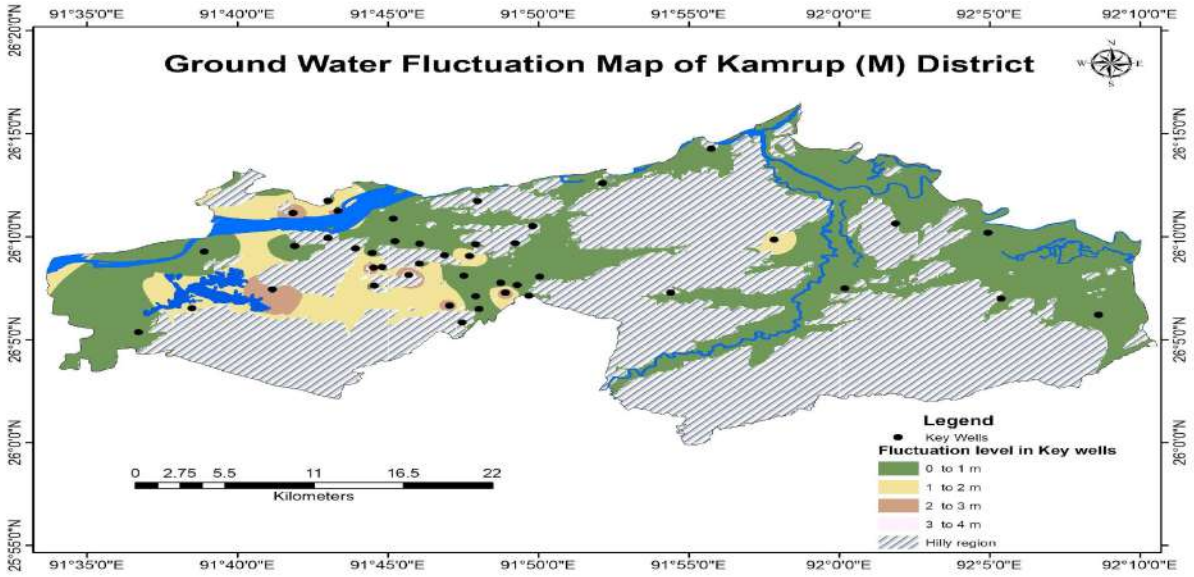


Fig. 3.7: Water Level Fluctuation map of the study area

3.1.3 Ground Water Movement

The water table contour has been prepared based on water level of ground water monitoring stations (Fig.3.8). The ground water flow direction is from the higher elevation in southern side to north-western direction towards the Brahmaputra river in Guwahati city and Soth to N-NW side in Sonapur-Dimoria area. The highest water table is 70 m above mean sea level.

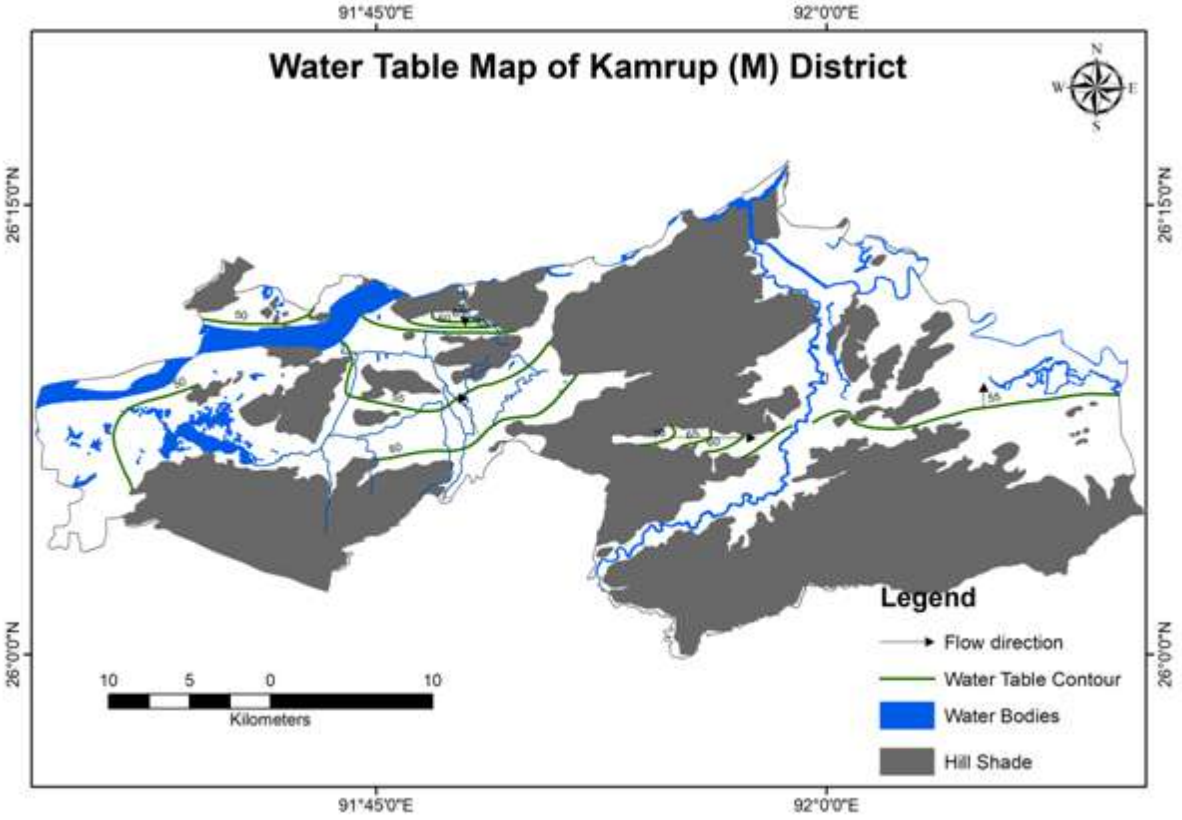


Fig. 3.8: Water table contour of the study area

3.1.4 Water level trend analysis

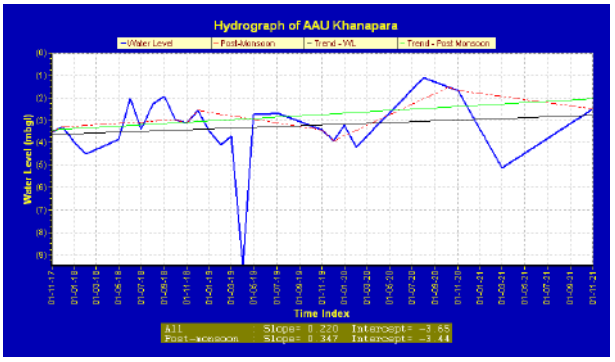
For analysis of long-term behavior of ground water level, data from Ground Water Monitoring Stations (GWMS) are utilized. Historical depth-to-water level data (in m bgl) are plotted as individual hydrographs and are given in Figure 3.9 and Table 3.2 shows the overall trend of water levels in GWMS wells.

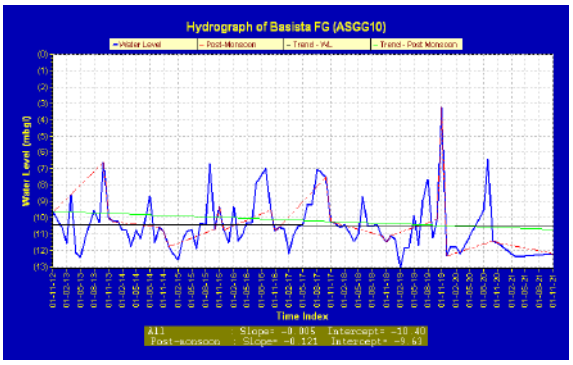
During Pre-Monsoon, 64.8% of wells show rising trend and 35.2% of wells show falling trend. During post-monsoon also most (61.1%) of the wells show rising trend and only 38.9% of monitoring wells show falling. During pre-monsoon, rise in dugwells ranges from 0.013m/year to 0.811m/year and the fall ranges from 0.004m/year to 0.408m/year. Maximum fall of 0.408m/year was recorded in Fatashil Ambari dug well and maximum rise of 0.811m/year was recorded in Directorate of Agriculture, Khanapara dugwell. During Post-Mosoon, rise in water level ranges from 0.001 to 1.362m/year and fall in water level ranges from 0.001 to 0.402m/year. Maximum fall of 0.402m/Year was also recorded in Fatashil Ambari dug well.

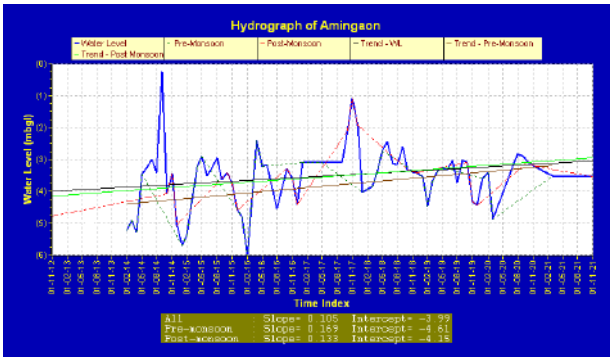
Table 3.2 Trend of Water levels in GWMS Wells

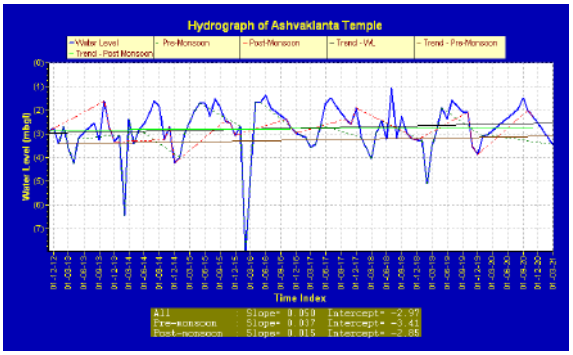
SN	Location	No. of years	Water Level Trend		SN	Location	No. of years	Water Level Trend	
			Post-monsoon	Pre-monsoon				Post-monsoon	Pre-monsoon
1	Aau-Kahikuchi TW	9	Rise	Rise	28	Kahilipara Colony Bazar	10	Rise	Rise
2	AAU Khanapara	5	Rise	Rise	29	Kahilipara Lp School	10	Rise	Rise
3	AAU-Khanapara TW	5	Fall	Fall	30	Khanapara Pp New	5	Rise	Rise
4	Adagudam TW	9	Fall	Fall	31	Khanapara Sc.museum	10	Rise	Rise
5	Amingaon	7	Rise	Rise	32	Lachitpur	10	Fall	Fall
6	Ashvaklanta Temple	8	Rise	Rise	33	Lakhra Chariali	10	Rise	Rise
7	Avayapuri	7	Rise	Rise	34	Lakshmi Mandir	10	Rise	Rise
8	Azara	10	Rise	Rise	35	Lalganesh Chariali	10	Fall	Rise
9	Bakarapara	10	Rise	Fall	36	Lalmati New	10	Rise	Rise
10	Basista FG	10	Fall	Fall	37	Mairapatti	10	Fall	Rise
11	Betkuchi TW	6	Rise	Rise	38	Maligaon	10	Rise	Rise
12	Bhellaguri	5	Rise	Rise	39	Narengi FB Office	10	Fall	Fall
13	Boragaon	10	Rise	Rise	40	Odalbakra Pahartoli	10	Fall	Fall
14	Chandrapur	6	Rise	Rise	41	Paltan Bazar	10	Rise	Rise
15	Choonsali-madhabpur	10	Rise	Rise	42	Panbazar Circuit	6	Rise	Rise
16	Dirgeswari	10	Rise	Rise	43	Panikhati	10	Fall	Fall
17	Dirt.of Agri	10	Rise	Rise	44	Panjabari	10	Rise	Rise
18	Fatasil Ambari	6	Fall	Fall	45	Patgaon	10	Fall	Fall
19	Ganesh Mandir Narengi	10	Fall	Fall	46	Patherquerry	10	Fall	Rise
20	Garigaon	10	Rise	Rise	47	Sijubari	10	Fall	Fall
21	Garigaon TW	10	Fall	Fall	48	Survey Odalbakra	10	Rise	Rise

SN	Location	No. of years	Water Level Trend		SN	Location	No. of years	Water Level Trend	
			Post-monsoon	Pre-monsoon				Post-monsoon	Pre-monsoon
22	GMC	10	Rise	Rise	49	Udaipur	10	Fall	Fall
23	Gurudwara Beltola TW	10	Fall	Fall	50	Vishwakarma Temple	10	Rise	Rise
24	Hengrabari FG	10	Fall	Fall	51	West Krishna Nagar	10	Rise	Rise
25	IIT-Guwahati TW	10	Rise	Rise	52	West Krishna Nagar TW	5	Fall	Fall
26	Kachari Basti	10	Rise	Rise	53	Wireless	10	Rise	Rise
27	Kahikuchi AAU	10	Fall	Fall	54	Zoo Narengi	10	Fall	Fall









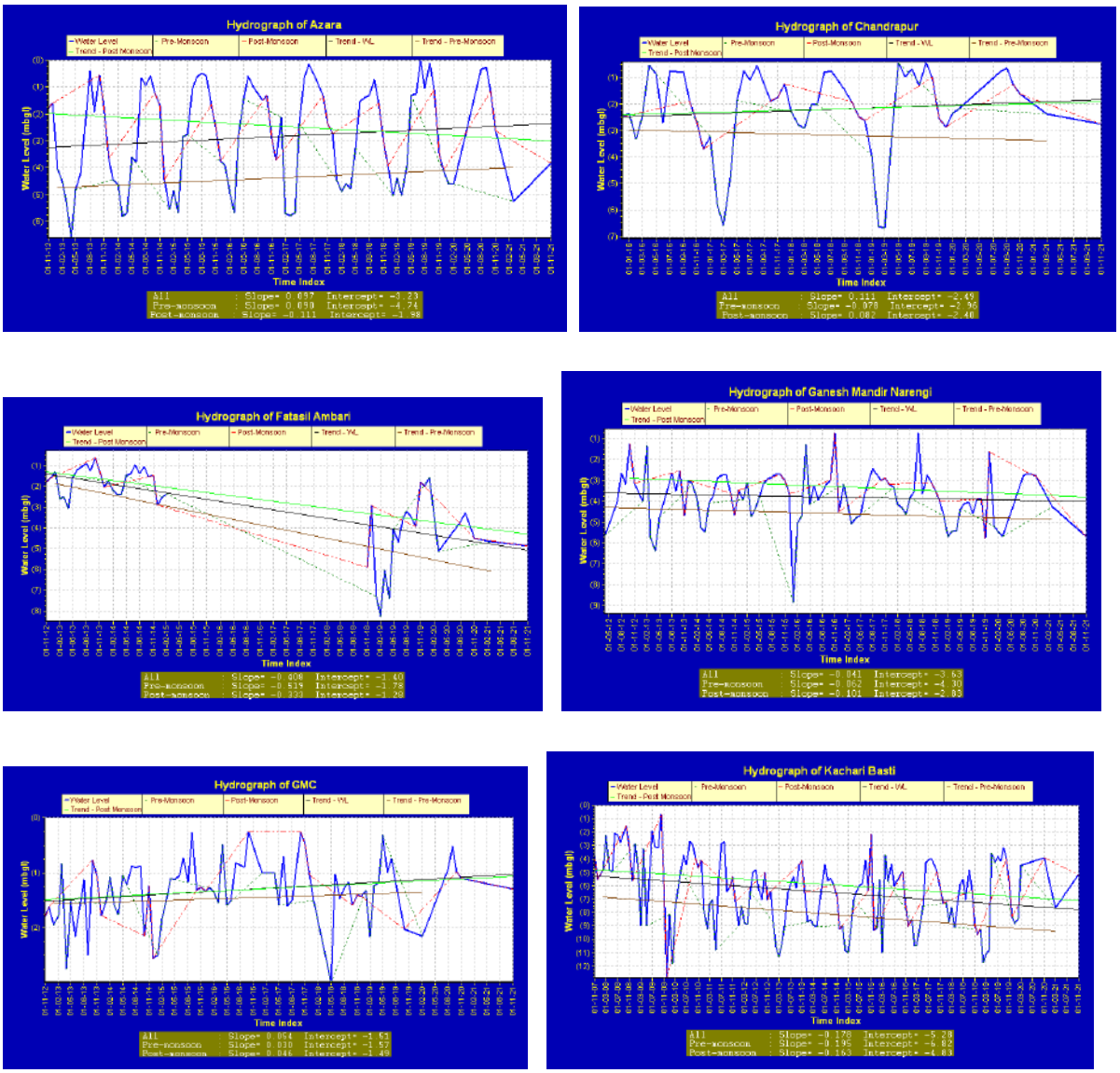


Fig.3.9: Few Hydrographs of GWMS wells

3.1.5 Ground water quality

A total of 47 samples were collected for Pre-Monsoon and 49 samples were collected for chemical analysis of ground water. Chemical analysis of ground water samples are carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati.

Most of the chemical constituents are within permissible limit except in few locations. The summarized results are given below.

Table 3.3. Summarized result of Chemical Quality in Kamrup (Metro) district

Parameter	Post Monsoon		Pre Monsoon		IS 10500:2012	
					Acceptable limit	Permissible limit*
	Min	Max	Min	Max		
pH	6.12	8.50	6.95	8.53	6.5-8.5	6.5-8.5

Turbidity, NTU		0.10	0.50	0.00	0.40	1	5
Electrical conductivity		165.30	1417.00	96.80	1280.00	-	-
TDS		109.10	935.22	63.89	844.80	500	2000
Carbonate alkalinity as $CaCO_3$		6.00	159.00	0.00	141.00	-	
Bicarbonate alkalinity as $CaCO_3$		48.84	421.24	36.63	518.91	-	
Total alkalinity as $CaCO_3$		48.84	519.19	36.63	611.08	200	600
Chloride		10.64	212.70	10.64	194.98	250	1000
Sulphate		2.62	60.72	0.05	57.44	200	400
Nitrate	**mg/L**	0.21	48.08	0.00	47.69	45	No relaxation
Flouride		0.04	1.50	0.00	1.80	1	1.5
Calcium(as Ca)		6.00	106.08	8.01	136.11	75	200
Magnesium (as Mg)		1.18	60.66	1.15	86.14	30	100
Total Hardness (as $CaCO_3$)		75.00	380.00	45.00	490.00	200	600
Sodium		5.01	148.79	4.12	1106.50	-	
Potassium		2.82	57.95	2.67	188.30	-	
Iron		0.22	15.57	0.08	20.80	1	No relaxation
Arsenic	ppb			0.12	4.84	10	
Uranium	(µg/L)			0.02	6.54	30	-

pH and Turbidity:

pH analysis of samples collected from Kamrup (M) shows value in the range from 6.12 to 8.5 in post-monsoon and 6.95 to 8.53 in pre-monsoon i.e. mildly acidic to mildly alkaline in nature. The pH values are within the permissible limit of 6.5 to 8.5 as prescribed by BIS standards.

Turbidity measures the haziness or cloudiness of water due to presence of suspended solids. High turbidity in drinking water can shield bacteria or other organisms so that chlorine cannot disinfect the water as effectively. Some organisms found in water with high turbidity can cause symptoms such as nausea, cramps, and headaches. In the study area turbidity ranges from 0.1 to 0.5 NTU in post monsoon and 0 to 0.4 NTU pre-monsoon, hence well within permissible limit of 1 to 5 NTU BIS standards for drinking water (IS 10500:2012).

Total Hardness:

Total hardness is measured as sum of calcium and magnesium concentrations, expressed both as calcium carbonate. Based on total hardness, water is classified into soft, moderately hard, hard and very hard water. Minimum total hardness of 75 and 45 mg/L in Pre-monsoon and Post-monsoon respectively and maximum total hardness of 380 and 490 mg/L in Pre-monsoon and Post-monsoon respectively was recorded in the samples. All the samples are well within permissible limit of 600 mg/L.

Hardness (mg/l)	Water Class	% Sample	
		Post Monsoon	Pre-Monsoon
0.0-75.0	Soft	6.12	4.255
75.0-150.0	Moderately Hard	22.44	21.28
150.0-300.0	Hard	51.02	70.21
>300.0	Very Hard	20.40	4.255

Total Dissolved Solids:

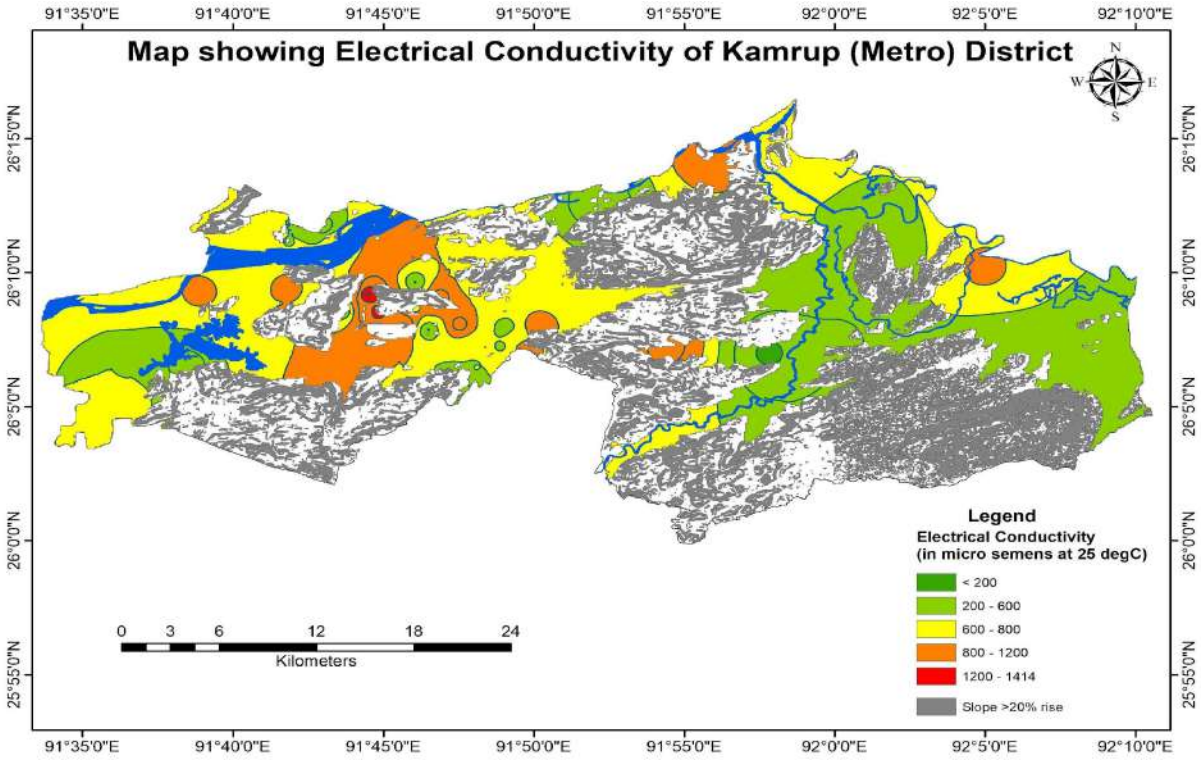
TDS is the total concentration of organic and inorganic substance present in water in molecular, ionized or micro-granular suspended form. Based on TDS, water can be classified as Fresh, Brackish, Saline and hypersaline or Brine. In post-monsoon minimum TDS of 109.10 mg/l and maximum TDS of 935.22 mg/l was recorded. In pre-monsoon, a minimum of 63.89 mg/L and maximum of 844.80 mg/L is recorded.

TDS (mg/L)	Water Class	% Sample	
		Post Monsoon	Pre-Monsoon
0-1000	Fresh	100%	100%
1000-10000	Brackish	Nil	Nil
10000-35000	Saline	Nil	Nil
>35000	Brine	Nil	Nil

Electrical Conductivity:

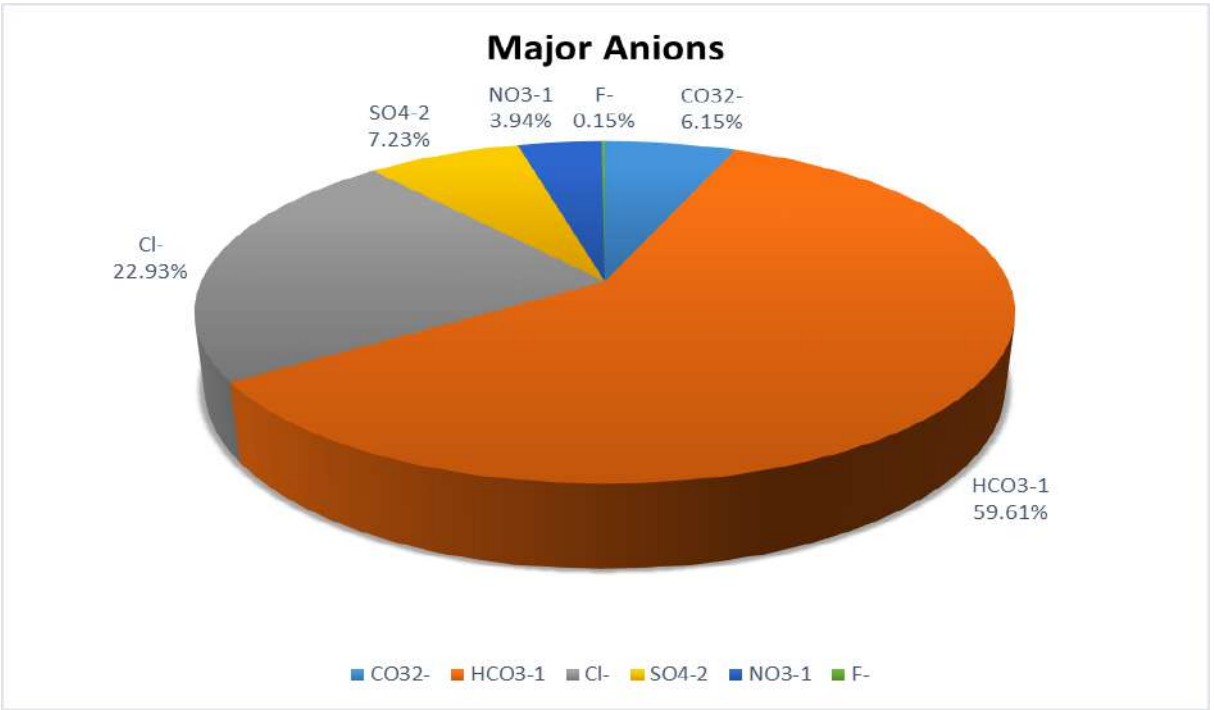
EC is the measure of water's ability to pass electrical flow which depends on the concentration of ions in water. Increase in concentration of dissolved solids increase the

electrical conductivity of the water. In Kamrup (M), EC ranges from 165.30 to 1417.00 micro S/cm in post-monsoon and 96.8 to 1280.0 micro S/cm in Pre-monsoon.



Major Anions (F^-, Cl^-, HOC_3^-, SO_4^{2-} and NO_3^-):

Major anions present in water are composed of Fluoride, Chloride, Bicarbonate, Carboante, Sulphate and Nitrate. Majority of the anion is contributed by Bicarbonate and Chloride in the samples. A distribution of major anions in the samples is shown in the pie chart below:



Bicarbonate (HCO_3^{2-}) contributes highest (59.61%) to the total anion concertation in the samples. A minimum of 48.84 mg/L and maximum of 421.21 mg/L was recorded at Solapur and Kahilipara Colony Bazar monitoring stations respectively. Bicarbonate comes to water from oxidation of CO_2 in water forming carbonic acid. Presence of Bicarbonate raises the pH value of water.

Chloride (Cl^-) contributes upto 22.93% of total anion concentration. BIS statndard for Cl^- in water is 250 to 1000mg/L. In the samples during Pre-Monsoon, concentration of Cl^- has a minimum of 14.18 mg/L and maximum of 212.7 mg/L in Chakardeo and Pahartoli monitoring wells respectively. In Post-Monsoon, minimum of 10.64 mg/L was recorded at Chakardeo and maximum value of 194.98 mg/L was recorded at Paltan Bazar monitoring station. The entire district is within permissible limit of Cl^- in water.

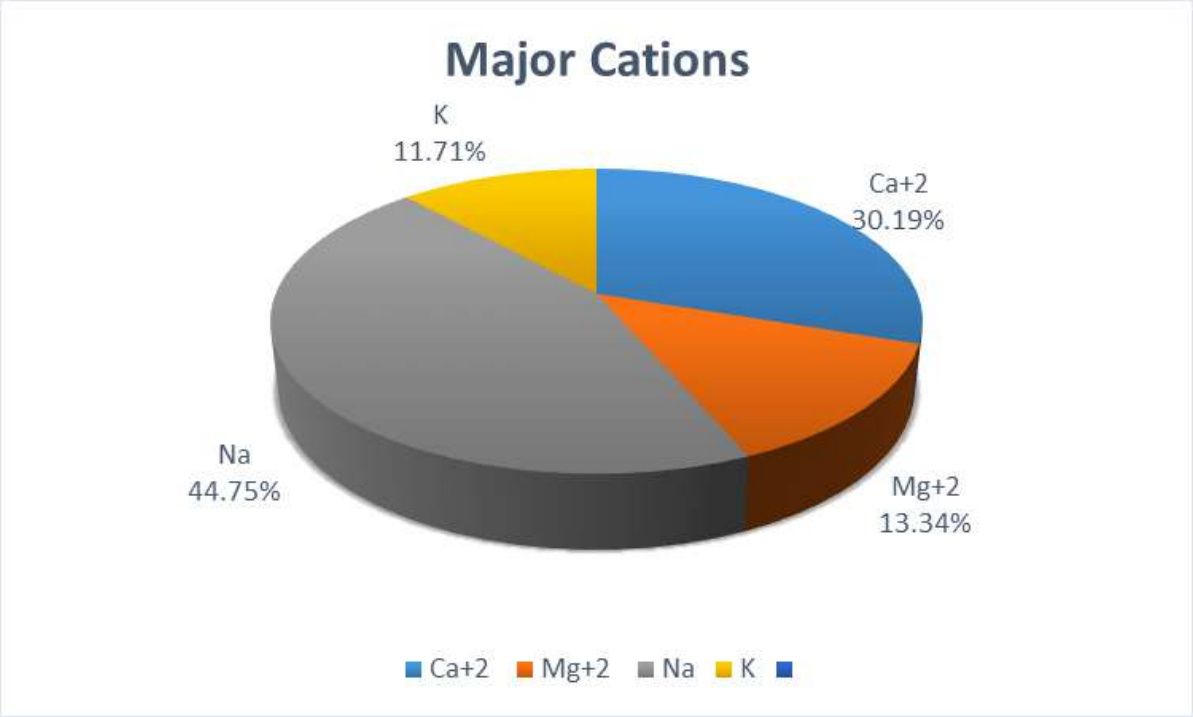
Sulphate (SO_4^{2-}) concentration in the ground water samples ranges from 2.62 to 60.72 mg/L in Pre-Monsoon and from 0.05 to 57.44 mg/L in Post Monsoon. BIS standard for Sulphate in drinking water has acceptable limit of 200mg/L and permissible limit of 400mg/L. so it is safe to say that the entire district very well within Acceptable limit. Drinking the water with high Sulphate concertation can cause diarrhea and dehydration. Sulphate may also cause corrosion of metals in the distribution system, particularly in water having low alkalinity.

Nitrate (NO_3^-) in water can come from use of fertilizers, discharge from sewage system and animal waste etc. BIS acceptable limit for nitrate in drinking water is 45mg/L and there is no permissible limit or relaxation. In Pre-monsoon, nitrate concentration ranges from 0.21mg/L in Chakardeo to 48.08 mg/L in West Krishna Nagar monitoring stations. During Post Monsoon, nitrate concentration ranges from Below Detection Limit to 47.69 mg/L, the maximum value being recorded at West Krishna Nagar monitoring well. Consuming too much nitrate can affect how blood carries oxygen and can cause methemoglobinemia (also known as blue baby syndrome).

Fluoride (F^-) is an essential element which prevents tooth decay, ensuring a healthy tooth and strengthens our bones. Standard for fluoride in drinking water has acceptable limit of 1.0mg/L and permissible limit of 1.5mg/L according to BIS standard for drinking water. During Pre-monsoon, F^- concentration ranges from Below Detection Limit to 1.5 mg/L and during post monsoon F^- concentration ranges from 0.03 to 1.8 mg/L. Concentration of F^- more than permissible limit is being reported at Bakarapara (1.65mg/L) and Chakardeo (1.8mg/L) Tubewells during post monsoon period. Fluoride occurs naturally in public water systems as a result of runoff from weathering of fluoride-containing rocks and soils and leaching from soil into groundwater.

Major Cations (Ca, Mg, Na, K):

Major cations contributing to ground water are Calcium. Sodium, Potassium and Magnesium. Kamrup (Metro) district is dominated by Alkali Metals (Na+K) as compared to alkali earth metals (Ca+Mg).



Sodium (Na) concertation in the ground water samples ranges from a minimum of 5.01 to a maximum of 148.79 mg/L in Pre-monsoon and from 4.12 to 1106.5 mg/L in Post-monsoon. It contributes about 44.75% of the total cationic concentration. Sodium in ground water comes from sodium bearing rocks and soil from which sodium is being dissolved. Sodium is an essential nutrient and adequate levels of sodium are required for good health. However, too much sodium is one risk factor for hypertension (high blood pressure).

Calcium (Ca) concentration during Pre-monsoon ranges from 6.0 to 106.08 mg/L and during Post-monsoon concentration ranges from 8.01 to 136.11 mg/L. It is the second highest contributor to concentration of Cations in the water. BIS standard for Calcium in drinking water ranges from an acceptable limit of 75mg/L to permissible limit of 200 mg/L. All the monitoring stations have calcium well within the permissible limit of 200 mg/L.

Magnesium (Mg) concentration according to BIS standard has a acceptable limit of 30mg/L and permissible limit of 100mg/L. During pre-monsoon, Mg concentration ranges from a minimum of 1.18 to a maximum of 60.66 mg/L and during post-monsoon, it ranges from 1.15 to 86.14 mg/L. All the samples show Mg values well within permissible limit.

Potassium (K) is the least contributor to the cation concentration in the ground water of that area. Its value ranges from 2.87 to 57.95 mg/L in pre-monsoon to 2.67 to 188.3 mg/L in post-monsoon. Potassium occurs in various rock forming minerals such as feldspar, clay, sylvite etc., from which it may be dissolved into ground water through weathering processes. Potassium is a dietary requirement. Potassium shortages are relatively rare, but may lead to depression, muscle weakness, heart rhythm disorder and confusion.

Water Type and Hydro-chemical Facies:

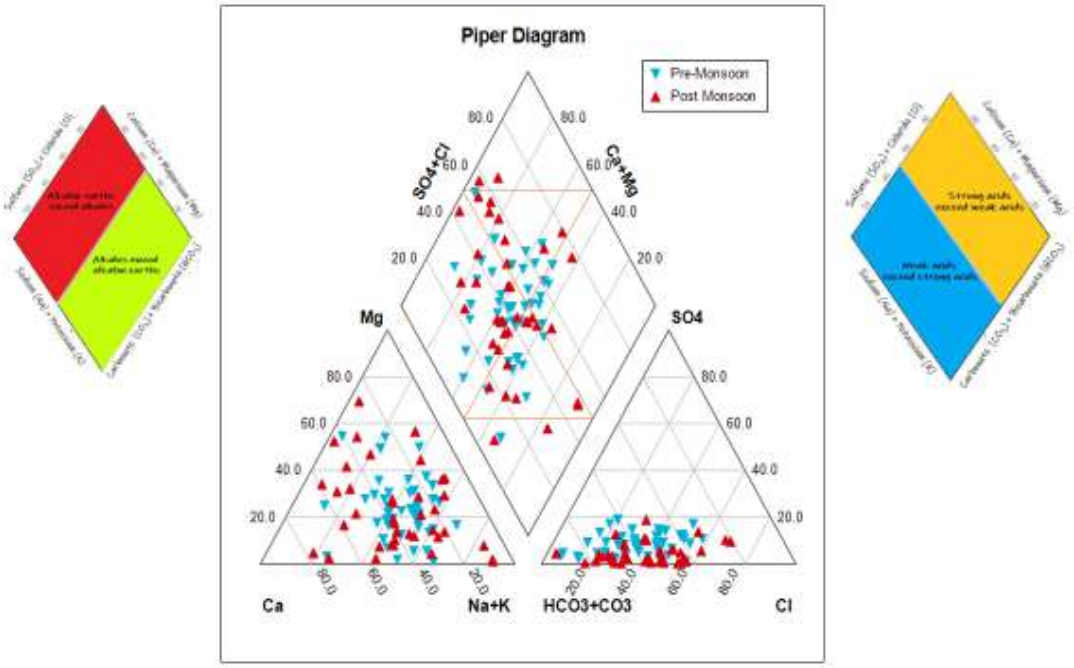
The Hill and Piper plot of ground water samples in Kamrup (M) is shown in the diagram below. The Hill and Piper plot is very useful in determining relationships of different dissolved constituents and classification of water based on its chemical characters. The triangular cationic field of Piper diagram reveals that the groundwater samples fall into Ca Type, no dominant and Na+K type, whereas in anionic triangle majority of the samples fall into bicarbonate and no dominant fields.

The plot of chemical data on diamond shaped central field, which relates the cation and anion triangles revealed that the major water types were Mixed Type (Ca-Mg-Cl-SO4, Na-K-HCO3-Cl) and Magnesium-Bicarbonate type.

In majority of the ground water samples, alkaline earth metals (Ca^{2+}+Mg^{2+}) are slightly exceeding the alkali metal cations (Na^{+}+K^{+}).

In general, the groundwater exhibits the dominance of weak (HCO_3^{-}) acid over strong (SO_4^{2-}+Cl^{-}) acid.

The facies mapping approach applied to the present study shows that Ca-Mg-HCO3, Na-K-Cl, Ca-Mg-Cl-SO4 and Na-K-HCO3-Cl are the dominant hydrogeochemical facies in the groundwater.

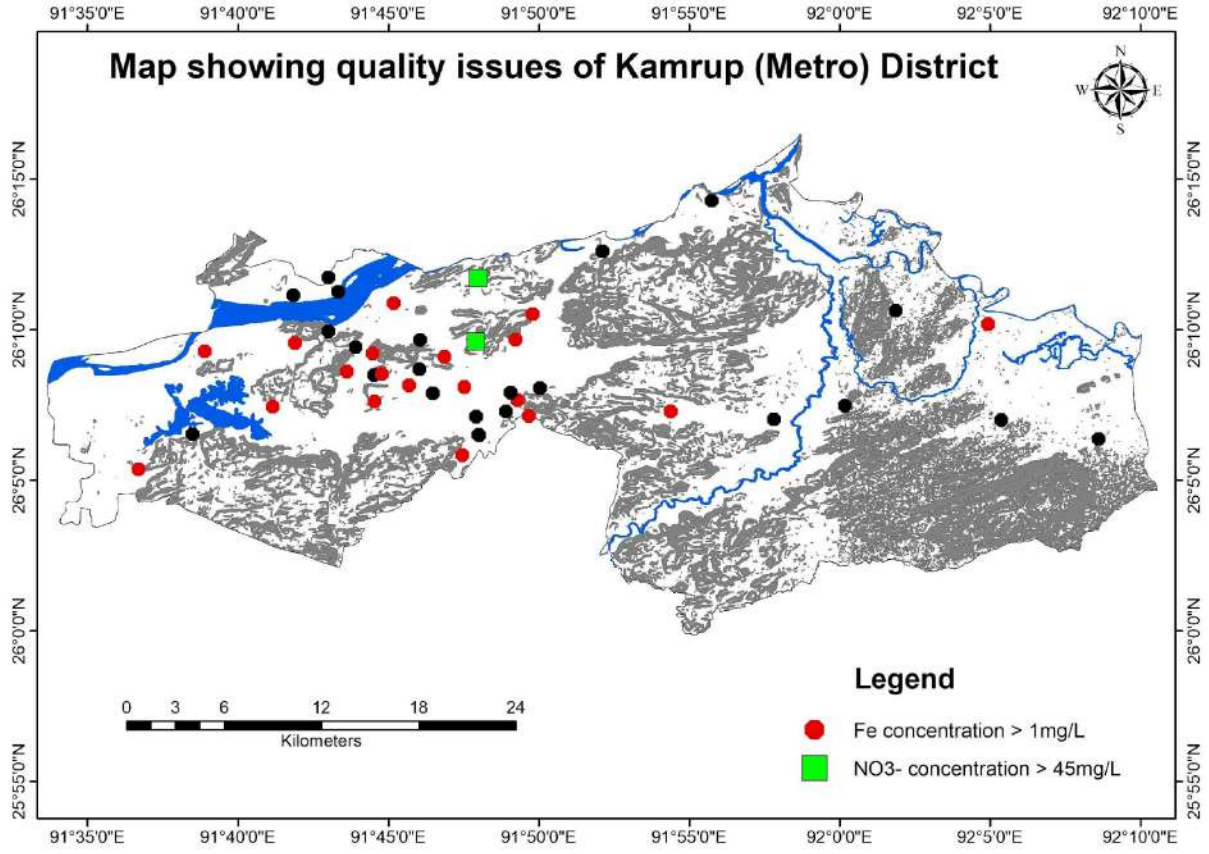


Heavy/Trace Metal Distribution:

Iron concentration permissible in drinking water is 1mg/L according to BIS (IS: 10500: 2012). During Pre-monsoon 59.57% of wells show iron concentration within permissible limit and 40.43% samples show iron concentration beyond the permissible limit. Value of iron concentration ranges from 0.22 to 15.57mg/L, maximum being reported from Pahartoli monitoring station. During Post monsoon, iron concentration in 69.39% of wells are within

the permissible limit and 30.61 wells have iron more than the permissible limit of 1mg/L. the values ranges from a minimum of 0.08mg/L and a maximum of 20.80mg/L, reported again from Pahartoli monitoring station.

Concentration of Arsenic (As) in ground water has been found to vary from Below Detection Limit (BDL) to 4.84 ppb. All the samples analyzed fall within the maximum permissible limit of 10 ppb prescribed by WHO in drinking water.



Concentration range of different chemical elements in ground water during pre- and post monsoon in the study area is given in Annexure-1(Table 1 a, b)

3.1.6 Ground Water Quality for Irrigation:

A total of 47 samples were collected and analysed in Pre-monsoon (March 2022) and 49 samples in Post Monsoon (November 2021) from dugwells covering the entire district of Kamrup (Metropolitan). To check the suitability of water for irrigation purpose following indices are analysed, namely

1. Sodium Absorption Ratio (SAR)
2. Residual Sodium Carbonate (RSC)
3. Sodium Percentage (Na%), and
4. Kelly Ratio (KR)

These indices were calculated using Aquachem 10.0 software and MS excel.

3.1.6a Sodium Absorption Ratio (SAR):

It is the ratio of sodium ion with respect to calcium ion and magnesium ion in ground water determined by following formula. If the SAR value is within 0 to 10meq/L then the water is considered Excellent, 10 to 18 meq/L is considered Good, 18 to 26 meq/L is considered Fair and beyond 26 meq/L the water is considered Poor for Irrigation. From risk point of view, > 18meq/L is considered medium to high risk.

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

where the ion concentrations are in meq/L.

In the study area, both Pre-monsoon and Post-monsoon (Fig 3.1.6a) shows that all the samples are within 18meq/L except in Mairapatti in North Guwahati.

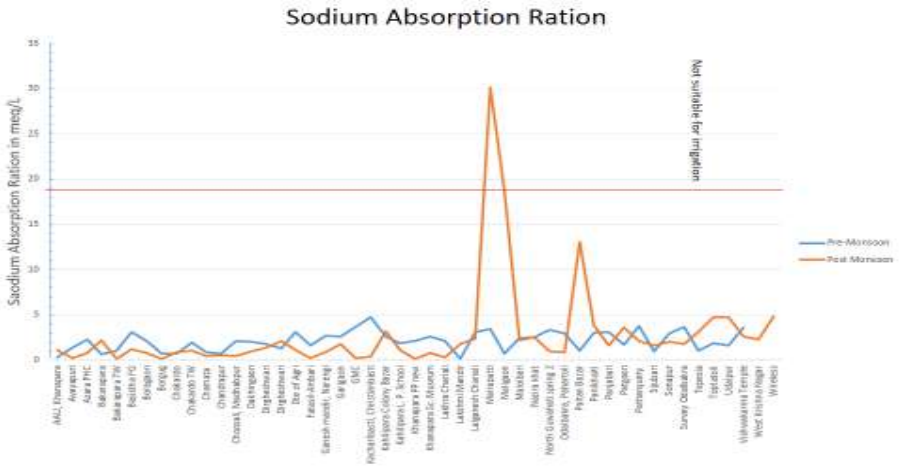


Fig 3.1.6a: Sodium Absorption Ratio.

Moreover US Salinity plot of SAR vs Electrical Conductivity (Wilcox Plot) also deems that water to be safe for irrigation in that area.

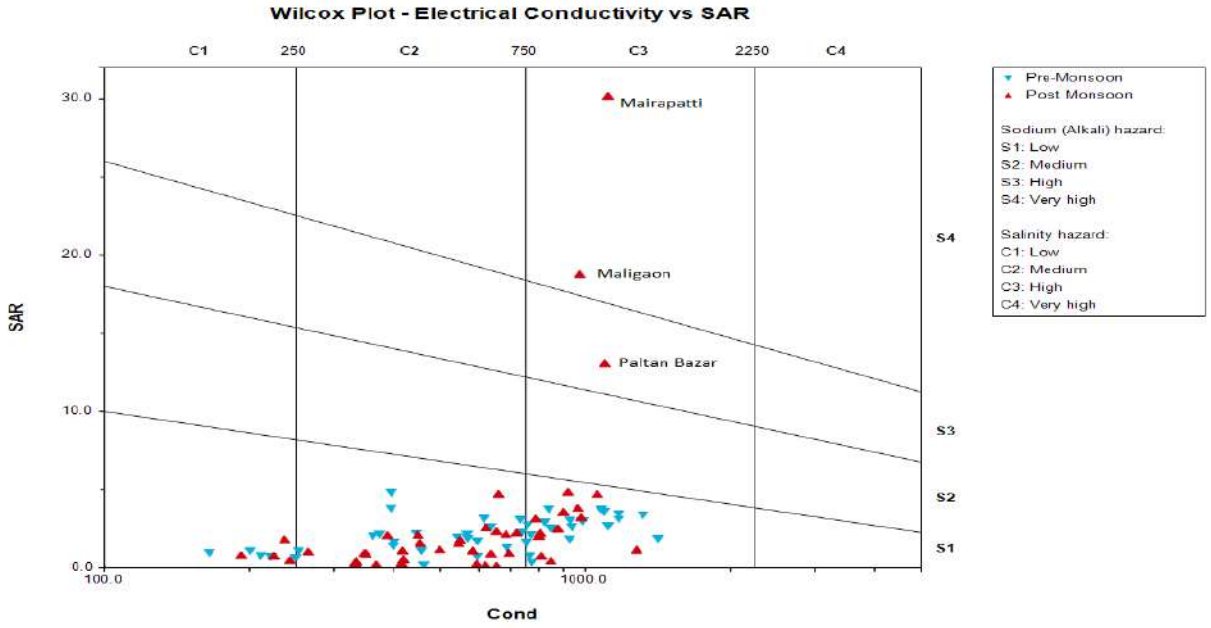


Fig 6.4.1b: Wilcox Plot

From the Wilcox plot it is very clear that both Sodium Alkali Hazard and Salinity Hazard is low for all the samples in both Pre-Monsoon and Post Monsoon except in Mairapatti, Maligaon and Paltan bazar.

3.1.6b Residual Sodium Carbonate (RSC)

This indice is used to indicate the alkalinity hazard in irrigation water. It can be calculated by the following formula.

$$RSC = (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+}) meq/L$$

If RSC value is less than 1.25 meq/L then it is considered excellent with no risk, 1.25to 2.5 meq/L is Good with low risk and more than 2.5meq/L RSC value is considered Poor quality with High Risk factor.

All the samples show RSC value less than 2.5meq/L. Hence the area safe from any residual sodium carbonate hazard and is suitable for irrigation.

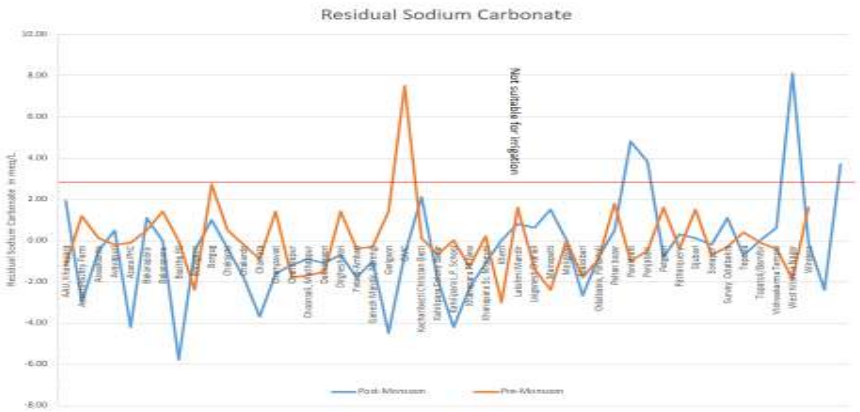


Fig 3.1.6c: Residual Sodium Carbonate

3.1.6c Sodium Percentage (Na%):

It is amount of monovalent cations with respect to total cations. All the ion concentrations are expressed in meq/L. Na% less than 40 is considered good for irrigation. Sodium percentage between 40 to 60 is poor and more 60 is considered doubtful and unsuitable for irrigation.

$$Na\% = \frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100$$

From all the samples analysed, few samples show Na% between 60 to 80 i.e. in “doubtful” category. But Pre Monsoon data shows these samples to be in “Good” category. Hence the study area can be considered suitable for irrigation.

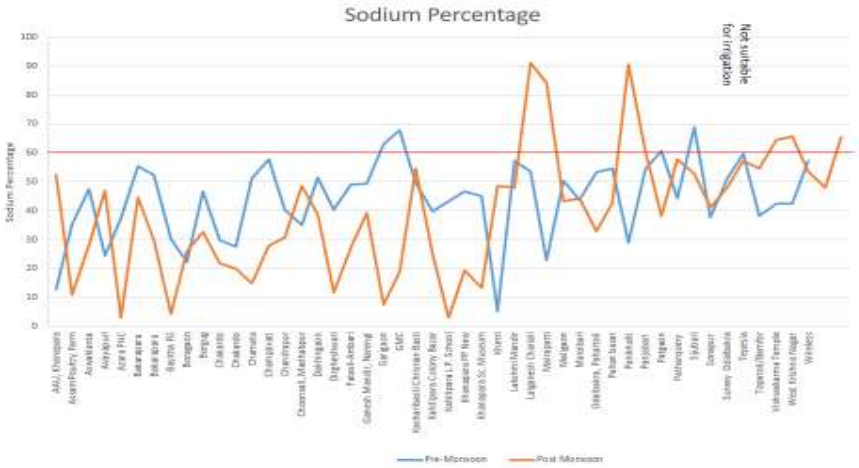


Fig 3.1.6d: Sodium Percentage

3.1.6d Kelly Ratio (KR):

It is the ration of sodium cation with respect to divalent cations, Ca^{2+} and Mg^{2+}. It can be calculated using following formula

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}}\ meq/L$$

If KR value is <1 meq/L, then water is suitable for irrigation and if KR value is >1meq/L it is unsuitable for irrigation.

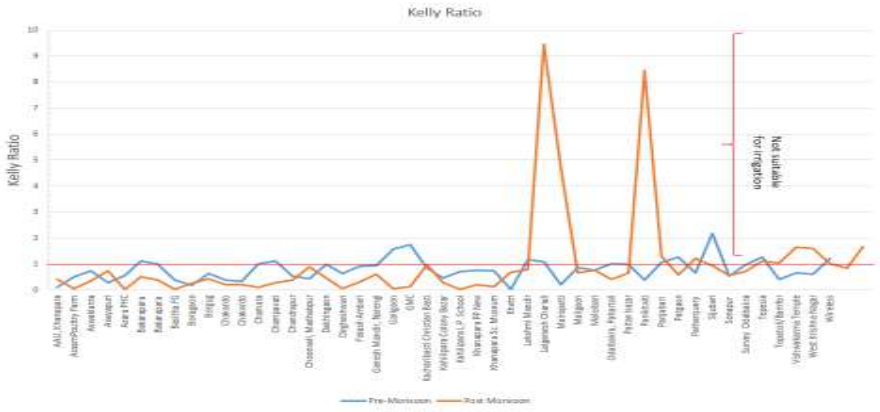


Fig: 3.1.6e: Kelly Ratio

Post Monsoon analysis of few samples show KR value >1meq/L, otherwise the study area can be said to be suitable for irrigation.

CHAPTER 4.0

Ground Water Resources

The computation of ground water resources available in the district has been done using GEC 2015 methodology. The dynamic resource estimation is done district wise due to paucity of block-wise data. In this present report the same calculation is used but resource for Kamrup (Metro) urban area and rural area is assessed separately. The resource is further proportionately divided among blocks based on their geographical areas.

Data and assumptions used in the assessment: Following data and assumptions are used in the assessment:

1) Rainfall recharge has been computed by both RIF and WLF methods. In RIF method, rainfall infiltration factor has been taken as 0.22 for major aquifer like valley fill. In WLF method, specific yield has been taken as 0.12.

2) Last ten years rainfall data is considered for groundwater resource calculation.

3) Water level data has been considered for 2020-21. Water level fluctuation based on data of March (Pre monsoon) and November (post monsoon) has been considered since deepest water levels are recorded during the month of March.

The average pre- and post-monsoon water level of Kamrup (Metro) Urban area is 6.59 mbgl and 5.36 mbgl respectively. For Kamrup (Metro) Rural area average pre- and post-monsoon water level is 3.66mgbl and 2.03mbgl respectively.

4) The population figures were collected from Census, 2011and projected to 2019. The per capita domestic requirement for the rural population has been considered as 60 lpcd for rural population and for urban population, it is 135 lpcd.

5) The dependency on ground water resource for domestic and industrial water supply in rural areas is considered as 46% and in the urban area it is 66%.

6) In order to calculate the canal seepage, the data on length of the drainage channels are taken from the Irrigation Department, Govt. of Assam. The factor for return flow from surface water irrigation has been taken as 0.50 (paddy) and 0.30 (non-paddy) and for Ground water irrigation it has been taken as 0.45 (paddy) and 0.25 (non-paddy). Recharge from tanks and ponds are calculated based on the norms suggested in GEC'2015.

7) Recharge from water conservation structure has been taken as nil.

The total replenishable ground water resources available in the study area have been computed using the average water level fluctuations in observation wells and specific yield of aquifers. These have been normalised using normal rainfall data to eliminate variations in recharge due to excess or deficit rainfall. The monsoon recharge arrived at is then compared with the recharge computed using rainfall infiltration method. In cases where the difference between the two is more than 20 percent, the recharge is computed using ad hoc method.

4.1 Ground Water Resources of Kamrup (Metro) District

Kamrup (Metro) Rural and Urban has a Total Geographic area of 692.57 sq. km. and 262.00 sq.km. Of which Hilly area having slope more than 20% is 61.58 sq.km. in Kamrup (M) Urban and in Kamrup (M) Rural area it is 233.87 sq. km. The remaining area is taken up for Aquifer Mapping which is around 659.12 sq.km which is also the total rechargeable area. Further, the district divided into command, Non Command and poor quality areas. But Kamrup (Metro) has no command and poor quality area. Therefore resource for Non-Command area is assessmed.

Assessment Unit	*Total Geographical Area (ha)	*Hilly Area (ha)	*Total Recharge Worthy Area (ha)			
			*Command	*Non Command	*Poor Quality	Total
Kamrup (Metro) Rural	69257	23387	0	45870	0	45870
Kamrup (Metro) Urban	26200	6158	0	20042	0	20042

4.2 Recharge

The aquifers of the study area are recharged through a) infiltration of rainfall on the outcrop, b) seepage from the tanks and ponds, c) subsurface inflow across the up dip margin d) recharge from surface water irrigation and ground water irrigation. The study area experiences south-east monsoon. Monsoon rainfall contributes approximately 79.74 percent of total rainfall (May, June, July, August, September) while share of post and pre monsoon rainfall are approximately 16.7 and 5.8 percent each.

Previous records show that the rainfall occurs almost in every month of a year. The month November to December has the minimum number of rainy days in any year and the period May to September has maximum number of rainy days.

4.2.1 Recharge from Rainfall:

Seasonal i.e., Monsoon and Non-Monsoon, Ground water recharge is estimated both by rainfall infiltration and water table fluctuation or water balance method for Monsoon season and by rainfall infiltration method for non-monsoon season as per guidelines. The monsoon recharge computed by WLF method is normalized for the current year rainfall.

Sl. No.	District	Rainfall Recharge (Ham)			
		Command	Non Command	Poor Quality	Total
1	Kamrup Metro (Rural)	0	13922.00	0	13922.00
2	Kamrup Metro (Urban)	0	6413.81	0	6413.81
	Total	0	20335.80	0	20335.80

4.2.2 Recharge from Other sources:

Recharge from other sources means recharge through return flow from tanks and ponds, canals, water conservation structures, surface and ground water irrigation. Existing area of tanks and ponds are from Statistical Hand Book, Assam 2018. Recharge from return flow, Irrigated area during Kharif and Rabi-Pre-Kharif seasons are taken as per 5th MI Census. Recharge from Canal and Water conservation structure is zero for Kamrup Metro.

District	Ground water irrigation		Tanks & Ponds		Surface Water Irrigation		Recharge from other source
	Non Command	Total	Non Command	Total	Non Command	Total	
Kamrup Metro (Rural)	0	0	682.18	682.18	45.56	45.56	727.738
Kamrup Metro (Urban)	0	0	122.53	122.53	0	0	122.53
Total	0	0	804.71	804.71	45.56	45.56	850.268

Total ground water recharge from all sources is 850.268 ham.

4.3 Ground Water Extraction

The ground water extraction of unconsolidated aquifer is created by natural discharge like seepages and draft created by human interference, viz., (a) withdrawals for irrigation and industry and (b) public-supply wells.

Total irrigation extraction in Kamrup Metro is 1537.2 ham, for industry 196.86 ham and extraction for domestic uses is 3639.25 ham. Total groundwater extraction for all uses is only 5373.31 ham.

District	Domestic (Ham)	Industrial (Ham)	Irrigation (Ham)	Extraction from all source
Kamrup Metro (Rural)	221.679	117.9	1537.2	1876.78
Kamrup Metro (Urban)	3417.57	78.96	0	3496.53
Total	3639.25	196.86	1537.2	5373.31

The water trend analysis shows that there is no significant change in the water level for both post-monsoon periods.

4.4 Total annual G.W. Recharge/ accumulation (in ham)

Total annual ground water recharge is the sum-total of monsoon and non-monsoon recharge from rainfall and other sources minus the resultant flows such as evaporation, transpiration, baseflow etc.

District	Rainfall Recharge	Recharge from other source	Resultant Flows (Evapotranspiration Loss) in ham	Total annual G.W. Recharge/ accumulation (in ham)
Kamrup Metro (Rural)	13921.98	727.74	-2546.9	12102.8
Kamrup Metro (Urban)	6413.81	122.53	-102.7	6433.64
Total	**20335.79**	**850.27**	**-2649.6**	**18536.5**

4.5 Annual extractable ground water resource:

Environmental flow subtracted from total Ground Water Recharge gives the Annual Extractable Ground Water Resource. An allowance is kept for Environmental Flow (un-accounted natural discharge as per GEC'97) in the non-monsoon season by deducting 5% of total annual ground water recharge, where WLF method is employed to compute rainfall recharge during monsoon season and 10% of total annual ground water recharges where RIF method is employed before getting the annual extractable ground water resource.

District	Total Annual Ground water Recharge (ham)	Environmental Flows (ham)	Annual Extractable Ground water Resource (ham)
Kamrup Metro (Rural)	12102.8	732.49	11370.33
Kamrup Metro (Urban)	6433.64	326.82	6106.82
Total	**18536.5**	**1059.31**	**17477.15**

4.6 Allocation of resources up to 2025 for domestic use

The net ground water resource is allocated for domestic sector.

Assesment Unit	Annual extractable Ground Water Resource (ham)	Current annual gross G.W. Extraction for irrigation (ham)	Current annual gross G.W. Extraction for industrial (ham)	Annual Allocation of G.W. for Domestic water supply as on 2025 (in ham)	Net G.W. Availability for future Use (in ham)
Kamrup Metro Rural	11370.3	1537.2	117.9	225.11	9490.12
Kamrup Metro Urban	6106.82	0	78.96	3467.72	2560.14
Total	**17477.2**	**1537.2**	**196.86**	**3692.83**	**12050.3**

4.7 Stage of Ground Water Extraction

The area has very little irrigation facilities. Similarly industrial development in the area is practically less. Groundwater is mainly utilized for domestic purposes. However, Public Health Engineering & Water Supply Department has supplied water mainly through surface water sources. The stage of groundwater extraction in the district is 28.39%.

Assessment Unit	Annual extractable Ground Water Resource (ham)	Current annual gross G.W. Extraction for all uses (ham)	Stage of GW Extraction (%)
Kamrup Metro (Rural)	11370.33	1876.78	16.50
Kamrup Metro (Urban)	6106.82	3496.53	57.25

Table 4.1: Tabulation of Ground Water Resource of Kamrup (Metro) district as on March 2020.

PARAMETER	Kamrup Metro Rural	Kamrup Metro Urban	Total
Total geographical area (Ha)	69257	26200	95457
Recharge worthy area (Ha)	45870	20042	65912
Rainfall Recharge (monsoon) (Ham)	255.12	191.98	447.1
Rainfall Recharge (non-monsoon) (Ham)	106.56	126.63	233.19
Annual Recharge from Other Sources (monsoon) (Ham)	401.07	4181.53	4582.6
Annual Recharge from Other Sources (non- monsoon) (Ham)	79.99	579.4	659.39
Annual G. W. Recharge (Ham)	12102.8	6433.64	18536.44
Ecological Flow (Ham)	732.49	326.82	1059.31
Total Natural discharge (Ham)	732.49	326.82	1059.31
Annual extractable Ground Water Resource (Ham)	11370.3	6106.82	17477.15
Current annual gross G.W. Extraction for domestic use (Ham)	221.679	3417.57	3639.249
Current annual gross G.W. Extraction for industrial (Ham)	117.9	78.96	196.86
Current annual gross G.W. Extraction for irrigation use (Ham)	1537.2	0	1537.2
Current annual gross G.W. Extraction for All uses (Ham)	1876.78	3496.53	5373.31
Annual G.W. Allocation for Domestic water supply as on 2025 (Ham)	225.11	3467.72	3692.83
Net Annual G.W. availability for future use (Ham)	9490.12	2560.14	12050.26
Stage of GW Extraction (in %)	16.51	57.26	
Quantity Categorisation for Future GW extraction (Safe/Semi-Critical /Critical /Over Exploited)	Safe	Safe	

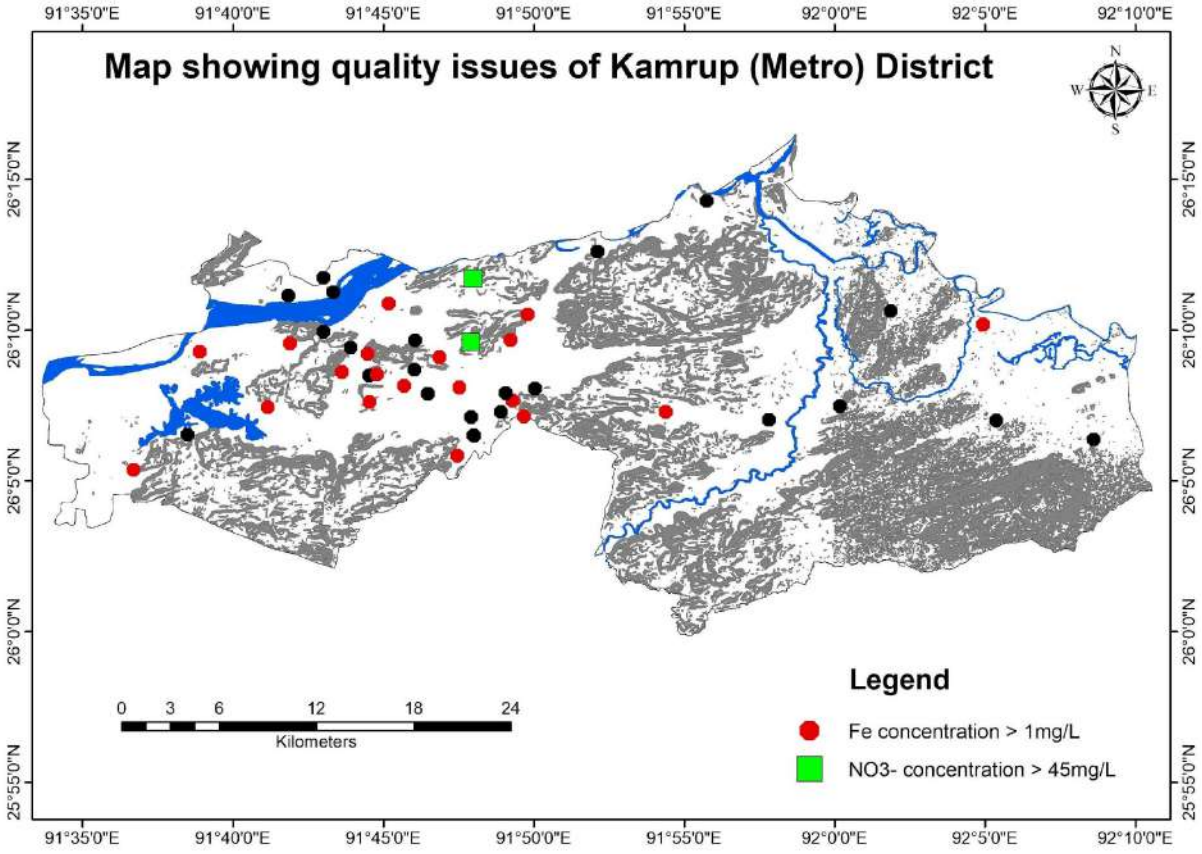
CHAPTER 5.0

Groundwater Related Issues

Based on various scientific studies that being carried out at the study area like exploratory drilling, establishing and periodic monitoring of Key Wells, and Ground water quality analysis for Pre-monsoon and Post Monsoon issues relating to ground water has been identified in Kamrup (M) area. Those issues have been addressed in this chapter.
Problems to be addressed are as follows:

5.1 Water Quality Issue

Chemical parameters exceeding the permissible limit is iron and nitrate concentration. In most of the samples of Dug wells all the other basic parameters are within permissible limit. Iron contamination is more or less spread throughout the district owing to the underlying geologic condition of Gneissic complex. Nitrate contamination is found two locations of West Krishna Nagar and Choonsali stations but the value is only marginally high.



5.2 Declining Ground Water Trend:

Central Ground water Board carries out monthly monitoring various Ground water monitoring stations (dug wells and tube wells) in Greater Guwahati. Instances of declining water level have been recorded in dug wells at Hengerabari, Fatashil Ambari, Narengi, Christian Basti, Lalganesh, Birubari and Zoo Narengi Road. Among tubewells, piezometers at Adagudam, Geetanagar, Beltola, Khanapara, Birubari and West Krishna Nagar show declining water level trend. Exponential increase in population coupled with increased

urbanization and industrialization and limited ground water recharge avenues in urban areas have led to increased water demand thereby leading to stress on the available ground water resources.

Minimum fall of 0.5cm/year is recorded at Basistha Forest Gate dug well and maximum fall of 40.8cm/year is recorded in Fatashil-Ambari LP School Dugwell. Average fall in dugwells of Guwahati area is 9.5 cm/year.

In dug wells of Narengi Forest Gate, Lakhra and Geetanagar High School there are instances of drying up of dugwells in lean period almost every year owing to receiving less rainfall in Post Monsoon.

Loaction	Latitude	Longitude	Well Type	No. of Data	Fall (m/yr)
Basista FG	26.0969	91.7912	DW	91	0.005
Fatasil Ambari	26.1568	91.7320	DW	48	0.408
Ganesh Mandir Narengi	26.1749	91.8301	DW	90	0.04
Hengrabari FG	26.1507	91.7953	DW	76	0.165
Kachari Basti	26.1514	91.7813	DW	86	0.178
Lachitpur	26.1845	91.6610	DW	66	0.021
Lalganesh Chariali	26.1413	91.7421	DW	92	0.015
Mairapatti	26.1855	91.6975	DW	82	0.005
Narengi FB Office	26.1784	91.8234	DW	88	0.215
Odalbakra Pahartoli	26.1419	91.7466	DW	52	0.015
Panikhati	26.2098	91.8688	DW	48	0.059
Patgaon	26.0891	91.6118	DW	89	0.004
Patherquerry	26.1610	91.8205	DW	92	0.016
Sijubari	26.1312	91.7748	DW	74	0.173
Udaipur	26.1627	91.7540	DW	59	0.123
Zoo Narengi	26.1735	91.7893	DW	88	0.079

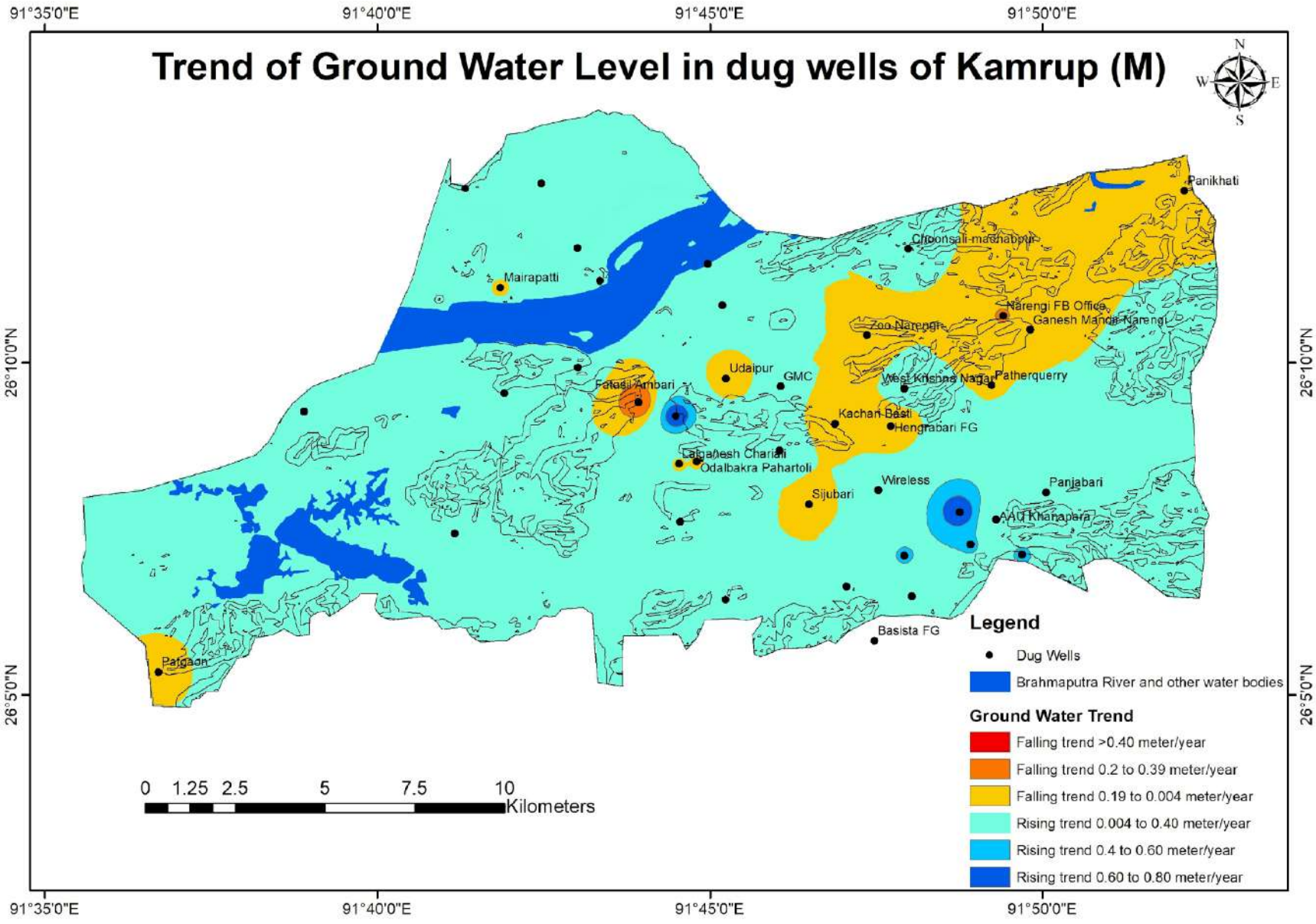
Highest fall of water level is noticed at Fatasil Ambari GWMS.

CGWB has very limited number of tube well as monitoring station in Guwahati. Minimum fall of 9.7cm/year is recorded in Adagudam and maximum fall of 31cm/year is recorded at Khanapara. Average fall of 13.5cm/year is recorded in tubewells of Guwahati area.

Instances of drying up of wells was also recorded in tubewells of Gurudwara Beltola, Adagudam, Odalbakra, Geetanagar and Bhangagarh area.

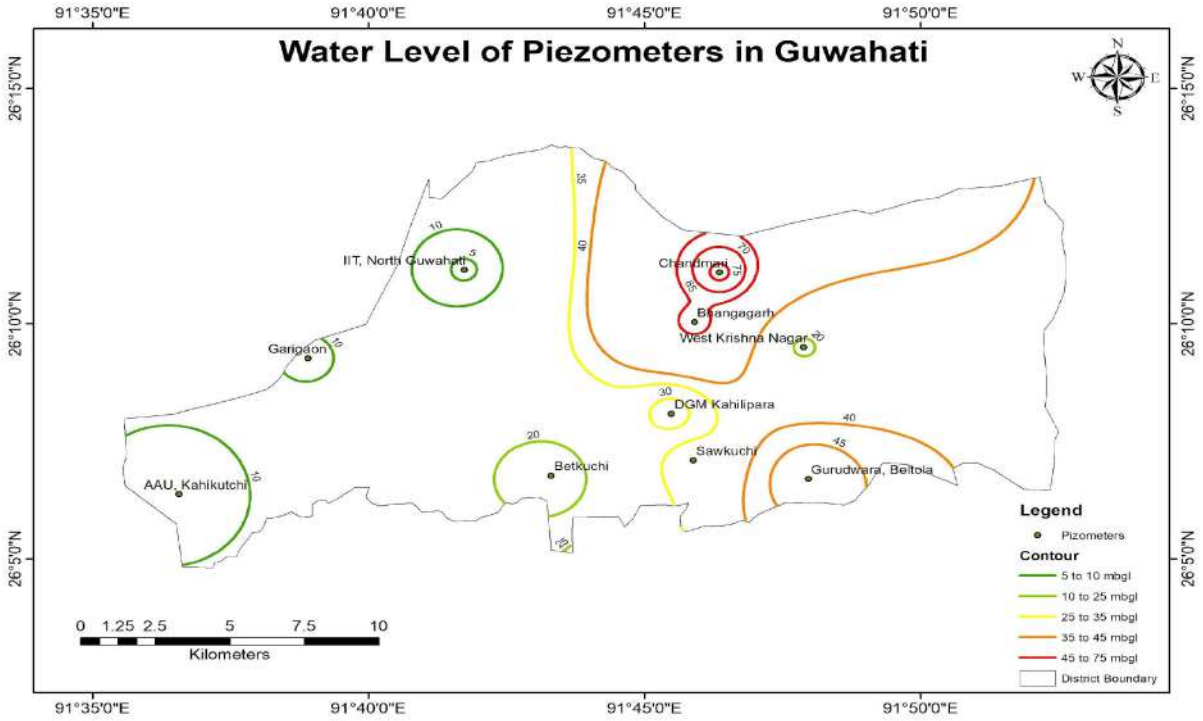
Loaction	Latitude	Longitude	Well Type	No. of Data	Fall (m/yr)
AAU-Khanapara TW	26.1290	91.8214	TW	50	1.678
Adagudam TW	26.1368	91.7414	TW	74	0.097
Geeta Nagar TW	26.1726	91.7866	TW	27	0.878
Gurudwara Beltola TW	26.1116	91.7994	TW	30	1.797
Odalbakra TW	26.1433	91.7531	TW	17	1.771
Sc .mus Khanapara TW	26.1212	91.8152	TW	28	3.111
West Krishna Nagar TW	26.1585	91.7980	TW	62	0.144

In Bhangagarh area, fractures in hard rock are drying up in areas where earlier it used to be a high ground water yielding area. These areas are also the areas of dense housing societies and commercial places.


Trend of Ground Water Level in dug wells of Kamrup (M)
91°35'0"E
91°40'0"E
91°45'0"E
91°50'0"E
26°10'0"N
26°5'0"N
N
S
E
W
Panikhati
Chhoonsali-machabpur
Mairapatti
Narengi FB Office
Ganesh Mandir Narengi
Zoo Narengi
Udaipur
GMC
West Krishna Nagar
Patherquerry
Fatasil Ambari
Kachari Basti
Hengrabari FG
Labanesh Chariali
Odalbakra Pahartoli
Wireless
Panjabari
Sijubari
AAU Khanapara
Basista FG
Patgaon
0 1.25 2.5 5 7.5 10
Kilometers
Legend
Dug Wells
Brahmaputra River and other water bodies
Ground Water Trend
Falling trend >0.40 meter/year
Falling trend 0.2 to 0.39 meter/year
Falling trend 0.19 to 0.004 meter/year
Rising trend 0.004 to 0.40 meter/year
Rising trend 0.4 to 0.60 meter/year
Rising trend 0.60 to 0.80 meter/year

5.3 Deeper Ground Water Level:

As a part of Annual Action Plan 2021-22, CGWB has constructed 5 piezometers in Guwahati. In those wells, ground water level beyond 20 meters below ground level was recorded. So far deepest water level of 76mbgl was recorded in Chandmari during Pre-monsoon.



CHAPTER 6.0

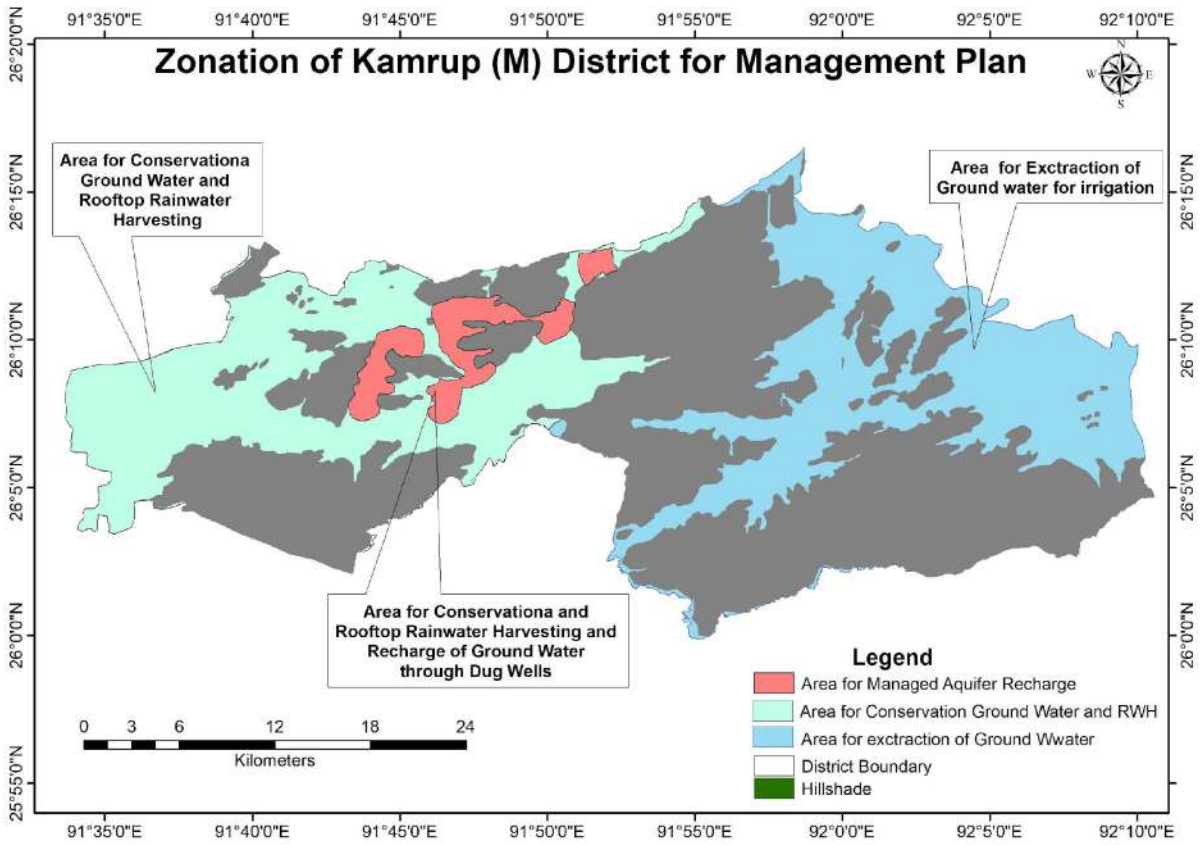
Management Strategy

The aquifer system in the study area is a dual aquifer System. The first aquifer is of Quaternary sediments composing of Sand, Sandy Clay, Silt and Clay. Granular zone of sand is the water bearing formation and its thickness ranges from 3m in Bhangagarh area to around 50m towards Jalukabari area. The second aquifer is Gneissic rock, fractured at varying depths. Thickness of Quaternary sediments is maximum towards Deepor bil area and its thickness pinches out towards Khanapara-Chandmari-Kahilipara area. Towards Sonapur area thickness of Quaternary sediments ranges from 50m at Sonapur to 200m in Maloibari area.

Table 6.1: Division of study area based on geomorphology and its characteristic features

Geomorphology	Lithology	Chemical Quality	WL condition	Population density
Alluvial plain and flood plain	Sand and Clay	High Fe	Shallow water level	High
Hilly area	Granite gneiss and Schist	High Fe	Deep Water level	High

For the sake of management plan, entire Kamrup (M) is divided into Kamrup (M) Urban comprising Greater Guwahati and Kamrup (M) Rural comprising Sonapur and Chandrapur Revenue Circles.



6.1 Water Quality Management:

Except iron and nitrate, overall quality of ground water in Kamrup (M) district is potable for drinking and other domestic and irrigation use.

Iron:

Presence of iron and manganese promotes the growth of bacteria in water. These bacteria harness energy for growth from the chemical reaction that occurs when iron and manganese mix with dissolved oxygen. Presence of iron in ground water is mainly geo-genic and it originates from the underlying rock formation. As water infiltrates into the aquifer, it dissolves some iron and accumulates in aquifer.

Since iron occurs naturally in nature, it cannot be removed in situ. There are several methods by which iron can be removed. Iron filters/iron removal plants are to be installed in order to remove iron from ground water.

1. **Iron removal by ion exchange**: Resins such as polystyrene-type gel resin in water softeners can remove iron from water by the process of ion exchange if the water is not exposed to oxygen.
2. **Iron removal by filtration**: Iron (and Manganese) can be easily removed from water by the process of gravity and pressure filtration after oxidation with air (aeration), chlorine or potassium permanganate.

Nitrate:

Nitrate have been reported from West Krishna Nagar and Choonsali dugwells only and in marginal high concentration. Nitrate may be successfully removed from water using treatment processes such as ion exchange, distillation, and reverse osmosis.

6.2 Management Plan for Kamrup (M) Urban:

The basic requirements for recharging the ground water reservoir are:

· Need for the artificial recharge, indicated by deeper water levels and declining water level trends

· Scope for artificial recharge, indicated by the availability of non-committed surplus monsoon run off in space and time and the ability of system to accept the recharge

· Benefit cost ratio

Declining water level, drying up of wells and deep water level are the issues needs addressing in Guwahati.

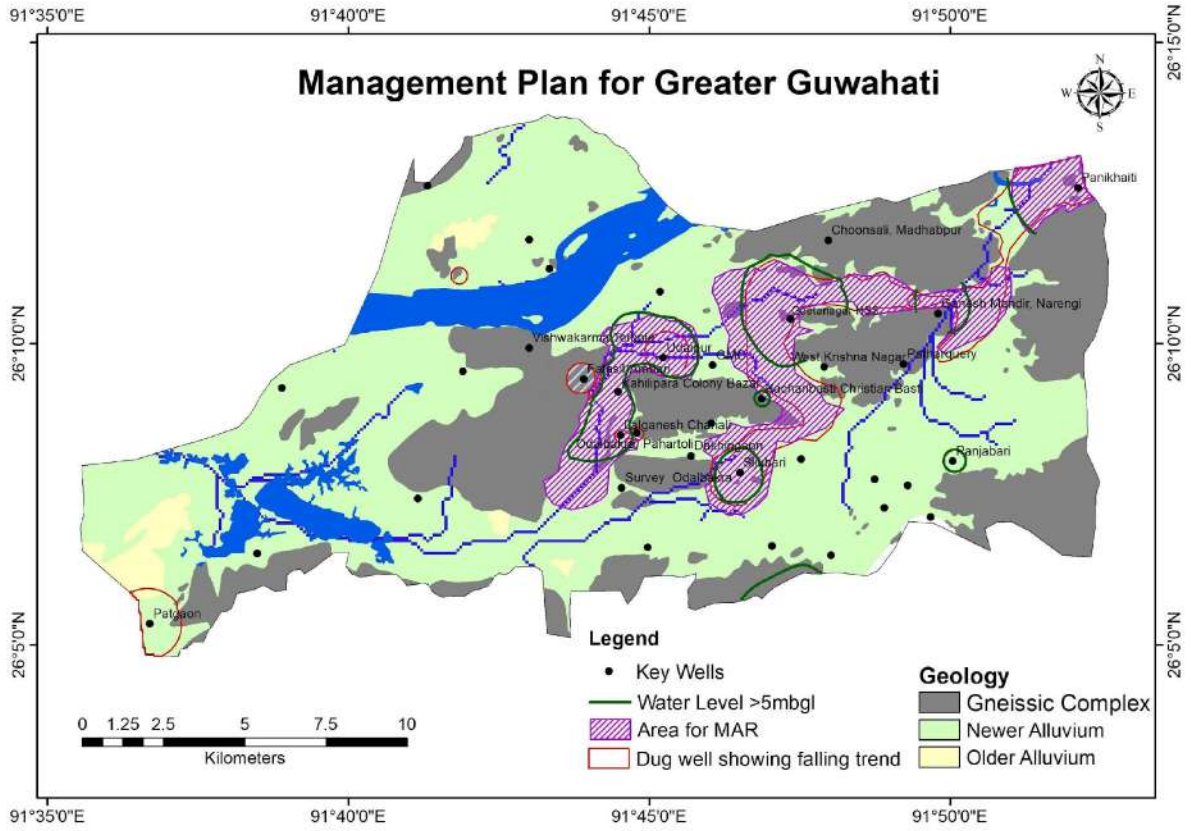
As per Master Plan to Artificial Recharge 2020 by CGWB, in urban areas, hilly areas and coastal regions priority has to be given to rain water conservation measures through roof top harvesting techniques. Since Kamrup (M) is an Urban area mostly of Hilly terrain, rooftop rainwater harvesting is the adequate solution to meet the increasing demand of ground water.

Table 6.1: Management Plan of Kamrup (M) Urban

Area	Aquifer	Ground Water Issue	Management Plan
Guwahati	Alluvium	High Fe Concentration	IRP and Conventional Iron Treatment plant.

Area	Aquifer	Ground Water Issue	Management Plan
Guwahati	Alluvium	Declining water level in dug wells	▪ Use of surface water for domestic use. ▪ Recommended for artificial recharge ▪ Restoration of existing water bodies. ▪ Rooftop Rainwater Harvesting should be made mandatorily followed.
Betkuchi, Sawkuchi,	Alluvium	Deeper water level in borewells: areas having WL>20mbgl	
Khanapara, Geetanagar, Ganeshguri, Beltola, Adagudam, Odalbakra and Bhangagarh area in Guwahati	Gneiss	Declining water level in Bore wells.	▪ Dependency on GW may be reduced through use of surface water to meet the increasing demand. ▪ Artificial recharge may be taken up. ▪ Restoration of existing water bodies. ▪ Rooftop Rainwater Harvesting should be made mandatorily followed.
Chandmari, Betkuchi Dakhingao, West Krisna Nagar in Guwahati	Gneiss	Deeper water level in borewells: areas having WL>20mbgl	

Identification of site for Artificial Recharge: In plains, areas having post monsoon water level more than 5 mbgl and declining trend of 10 cm/year is taken up for artificial recharge. But in undulating/hilly terrain, areas having water level more than 4 to 8 mbgl is considered for recharge. Areas of deep pressure head in known principal aquifer is also considered for artificial recharge.



Estimation of storage for Artificial Recharge:

The thickness of available unsaturated zone (below 5mbgl) is estimated by considering the different ranges of water level. The different ranges of DTW (depth to water level) are averaged and subtracted from contour interval to arrive at thickness of unsaturated zone. Then volume of unsaturated zone is calculated by multiplying thickness of unsaturated zone and area identified for recharge. Lastly, total storage potential is calculated by multiplying Volume of unsaturated zone and Average specific yield.

Geographical area (sq.km)	Formation	Area identified for Artificial Recharge (sq.km)	Thickness of unsaturated zone (m)	Volume of unsaturated zone (mcm)	Average specific yield	Total Storage potential as volume of water (mcm)
954.57	Newer Alluvium	33.31	(5+10)/2-5 = 2.5	33.31*2.5= 83.275	0.12	83.275*2.5= 9.993
	Total	**33.31**	**2.5**	**83.275**	**0.12**	**9.993~10.0**

Source Water Requirement:

After assessing the volume of water required for saturating the vadose zone, the actual requirement of source water is to be estimated. After 25% loss at soil moisture and leakage, an average recharge efficiency of 75% of the individual structure is considered.

1. Stored water at surface (say 100%)

2. Loss at soil moisture and leakage (25% of stored water at surface)
3. Net water available for ground water recharge (75%)
4. So the reciprocal of require water is 100/75=1.33
5. Surface water requirement =Storage space x 1.33
   =9.993 mcm x 1.33=**13.29 mcm**

Therefore net surface water requirement for recharge is 13.29mcm.

Source Water Availability:

Source water availability for each sub basin includes committed run off & provision for future planning. The surplus water available is then worked out by subtracting the committed supply from total availability.

Moreover, source water available for artificial could be of following type:

i) In-situ precipitation in the watershed / area
ii) Nearby stream/ spring / aquifer system
iii) Surface water (canal) supplies from large reservoirs located within the watershed/basin
iv) Surface water supplies through trans-basin water transfer
v) Treated Municipal/industrial wastewaters

For Greater Guwahati, rainfall and surface runoff can be utilized for Managed aquifer recharge as the district receives bountiful rainfall during monsoon season. Runoff yield of a sub-basin is calculated by Stranger's Table.

Recharge structures:

Total structures suitable for recharge have been worked out as:

$$\text{No. of structures} = \frac{\textit{Total surplus surface water runoff}}{\textit{Average Gross capacity of water spreading of Recharge structures}}$$

$$= \frac{\textit{Total surplus surface water runoff}}{\textit{Average Gross capacity of water spreading of Recharge structures}}$$

The average storage capacity of different structures are as follows:

i. Percolation tank is 1.0 MCM
ii. Contour bunds is 0.15MCM
iii. Check dam is 0.15MCM
iv. Gabion structure is 0.01MCM and
v. Storage capacity of village tank is 0.01MCM

But since Guwahati is urban area, structures suitable for recharge will be percolation tank and recharge shaft only. On an average 70% of source water for recharge is assigned for percolation tanks.

Hence a total of 9.303MCM will be allocated to 9 Percolation tanks. 20% is assigned to Check dams and 10% is assigned to Boulder check dams.

Area	Amount of Surface water considered for planning Artificial Recharge to Ground Water (MCM)	Resources to be harnessed by					
		Percolation Tanks (Average Gross capacity 1mcm) 70%		Check Dams (Average Gross Capacity 0.2 mcm) 20%		Boulder Check Dams (Average Gross Capacity 0.1 mcm) 10%	
		MCM	Nos	MCM	Nos	MCM	Nos
Guwahati	13.29	9.303	9	2.658	13.29 ~13	1.329	6.645 ~7

Recharge structure in Greater Guwahati:

From the two dimensional sections it is clear that the phreatic aquifer in areas having declining trend in Guwahati is overlain by very thick poorly permeable strata of clay, hence the recharge to ground water storage by water spreading method (like Percolation tank, check dam, gabion structure etc.) becomes ineffective or has very low efficiency. Moreover Guwahati is highly populated urban area where space is very constricted and above structures cannot be built. In these areas, recharge by dugwells, Recharge shafts and Injection wells can be used to directly recharge the aquifer.

1. **Recharge by Dug wells:** In areas where the dug wells are dried up or there is decline in water level, recharge through dug wells can be proposed after proper treatment of source water. These structures are very cost effective and almost every household has these structures. Rain water from rooftops can be directly diverted to these wells through proper pipe channel.
2. **Recharge by Recharge Shaft:** Recharge shaft is an artificial recharge structure which penetrates the overlying impervious horizon and provides affective access of surface water for recharging the phreatic aquifer. In areas where low permeable sandy horizon is within shallow depths, a trench can be excavated to 3 m depth and back filled with boulder and gravel. The trench can be provided with recharge shaft to effectively recharge the deeper aquifers.
3. **Injection wells:** Because of the confining layers of low permeability the aquifer cannot get natural replenishment from the surface and needs direct injection through recharge wells.

Following measures can also be taken up to meet the water stress in the area:

1. Surface water Supply scheme for domestic use.
2. Implementation of rooftop rainwater harvesting.
3. Restoring the existing water bodies, traditional ponds and water conservation structures.
4. Shifting of ground water pumpage from the center of the cities to flood plain areas having proven capabilities of sustaining high yielding tube wells, if possible.
5. Regulatory measures through proper pricing and metering of water supplied.

The roof top rain water can be conserved and used for recharge of ground water on smaller scales in individual houses. This approach requires connecting the outlet pipes from roof top to divert the water to either existing wells/ tube wells/ bore well or specially designed wells. The urban housing complexes or institutional buildings have large roof area and can be utilized for harvesting roof top rain water and recharging.

6.3 Management Plan for Kamrup (M) Rural:

Kamrup (M) Rural area comprises of Sonapur revenue circle and a very small parts of Basistha and Azara. Issues pertaining to Sonapur area is mainly high iron concertation at Tepesia and Maloibari area and water logging condition of the valley portion owing to the huge thickness of clay beds underneath.

Iron concertation can be removed by conventional iron filters and water logging can be mitigated by implementing development of ground water for double cropping purpose.

Future demand for agriculture

`The major crops of Kamrup (Metro) Rural district are Paddy. Autumn paddy, winter paddy and summer paddy are the three main types of paddy are grown in the district. Winter paddy (Sali) is the most important crop in the district occupying 65.6 % followed by summer paddy (Boro) 27.6% and autumn paddy (Ahu) 6.7% of the total annual paddy area. The common cropping sequence next to paddy and are the vegetable produces.

Future demand of water for agriculture is estimated in the present analysis by projecting the cropping intensity to 200%. As per data provided Ministry of Agriculture, Govt. of India, in Kamrup (Metro), the net cropped area is **28256** ha. The mono cropped area of the district is 18834 ha, double cropped area 9422 ha. The Gross cropped area is 37678 ha. Out of this area 326ha area is under irrigation as per NEDFI 2018-19 databank.

Table 6.2: Season wise cropping pattern of Kamrup (M) Rural area

S N	Main Crop	Sowing season					
		Kharif		Summer		Rabi	
		Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
1	Paddy	June to July	June to July		Nov to December	-	Dec to January
2	Rape seed Mustard		-		-	October to November	-
3	Pulse			August to September			

Since stage of ground water development is only 16.51%, there is ample scope for ground water extraction for irrigation purpose which will bring unirrigated mono cropped area to double cropped area. To use groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO (Food & Agricultural

Organisation). CROPWAT 8.0 for Windows is a computer program for the calculation of crop water demand/requirements and irrigation demand/requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. FAO defined water requirements of various crops as the depth (or amount) of water needed to meet the water loss through evapotranspiration. The present season wise cropping pattern of Kamrup (M) Rural area is shown in Table 6.2.

The crop water need can be calculated using the following formula.

ETcrop= ETo * Kc

Where: ETcrop= Crop water need (mm/unit time)
ETo = Reference crop evapotranspiration (mm/unit time) [Influence of climate]
Kc = Crop factor [Influence of crop type and growth stage]

6.3 Cropping Plan

The intention of the proposed plan is to bring this fallow land under assured irrigation during Rabi season which will help to increase gross cropped area to 37016 ha and thereby increase cropping intensity up to 200%. This can be achieved by growing pulse, potato, wheat and vegetables in rice fallow with the support of irrigation. Present cropping pattern, proposed cropping pattern, intended increase in cropping intensity were shown in tabular form (Table 6.3)

Table 6.3: Cropping pattern, proposed cropping pattern, intended cropping intensity

Cropping pattern (s)				
Summer Rice- Autumn Rice-Winter Rice-Winter Rice	Present Cultivated area	Area to be cultivated	Area to be cultivated (**ha**)	Irrigation requirement (**ha m**)
Winter Vegetables-Summer Vegetables-Pulses--Potato-Oilseed	(**ha**)	(**%**)		
Cultivated Area	**18508.00**			
	1	2 (= % of 1)	3	4
Rice (main crop)	18508		18508	
Winter Rice	18508	100	18508	2991.82
Winter Vegetables		30	5552.40	1031.27
Pulse		25	4627.00	757.90
Potato		25	4627.00	1024.23
Wheat		10	1850.80	654.99
Summer Vegetables		10	1850.80	208.90
		100		6669.10
Net cultivated area	18508	37016	18508	6669.10
Gross cultivated area (Paddy/+Wheat+Pulses)	37016			

Total irrigation requirement (70% irrigation efficiency)				**9527.29**

Table 6.4 : Crop-wise and month-wise precipitation deficit (IWR) from CROPWAT 8

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Precipitation deficit												
Winter Rice	0	0	0	52.8	98.5	0	0	0	0	0	0	0
Winter Rice	0	0	0	0	198.8	0	0	0	3.2	0	0	0
Winter Rice	0	0	0	0	49.7	98.0	0	0	0	0	0	0
Winter Rice	0	0	0	0	48.5	98.0	0	0	0	2.2	0	0
Winter Rice	0	0	0	0	0.5	146.5	0	0	0	13.1	0	0
Winter Vegetable	27.5	0	0	0	0	0	0	0	0	5.1	42.4	57.3
Winter Vegetable	45.6	0	0	0	0	0	0	0	0	5.2	36.3	55.6
Pulses	62.5	40.3	0	0	0	0	0	0	0	0	10.9	43.2
Pulses	10.7	0	0	0	0	0	0	0	0	3.7	59.9	60.8
Potato	57.1	17.3	0	0	0	0	0	0	0	0	43.9	63.5
Potato	62.4	58.9	15.5	0	0	0	0	0	0	0	17.4	50.5
Winter Wheat f.f.	43.4	50.5	65.7	24.1	1.4	0	1.8	0	0	0	30.4	39.1
Summer Vegetables	0	2.1	36.4	11.2	0	7.0	0	0	0	0	0	0

Table 6.5 : Actual monthly water requirement for different crops in Kamrup (M) rural area, Assam

Crop	Net Sown area	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Cropwise Total IWR (Ham)	Total	Gross irr. Requirement with 70% irr. Efficiency
Winter Rice	1850.8	0	0	0	97.7	182.3	0	0	0	0	0	0	0	280.03	2991.82	4274.026
Winter Rice	3701.6	0	0	0	0	735.9	0	0	0	11.8	0	0	0	747.72		
Winter Rice	4627	0	0	0	0	230.0	453.4	0	0	0	0	0	0	683.41		
Winter Rice	4627	0	0	0	0	224.4	453.4	0	0	0	10.2	0	0	688.03		
Winter Rice	3701.6	0	0	0	0	1.9	542.3	0	0	0	48.5	0	0	592.63		
Winter Vegetable	1850.8	50.9	0	0	0	0	0	0	0	0	94.4	78.5	106.1	329.81	1031.27	1473.24
Winter Vegetable	3701.6	168.8	0	0	0	0	0	0	0	0	192.5	134.4	205.8	701.45		
Pulses	1850.8	115.7	74.6	0	0	0	0	0	0	0	0	20.2	80.0	290.39	757.90	1082.72
Pulses	2776.2	29.7	0	0	0	0	0	0	0	0	102.7	166.3	168.8	467.51		
Potato	1850.8	105.7	32.0	0	0	0	0	0	0	0	0	81.3	117.5	336.48	1024.23	1463.18
Potato	2776.2	173.2	163.5	43.0	119.5	0	0	0	0	0	0	48.3	140.2	687.75		
Winter Wheat	1850.8	80.3	93.5	121.6	225.1	2.6	0	3.3	0	0	0	56.3	72.4	654.99	654.99	935.71
Summer Vegetables	1850.8	0	3.9	67.4	124.7	0	13.0	0	0	0	0	0	0	208.90	208.90	298.43

Based on available groundwater resource and subsurface condition, the approximate numbers of tube wells that can be constructed in the area is worked out.

Currently as per GWRE 2020, Kamrup (Metro) Rural area has extraction by irrigation of 1537.2 ham and 11,370.3 ham extractable resource, resulting in a Stage of ground water development of 16.51%. In extracting additional requirement of 9527.29 ham of water, stage of development in Kamrup (M) Rural area will increase from 16.51% (safe category) to 97.3% (critical category). Hence to keep stage of development within 70%, the remaining 30% of irrigation water can be met by consumptive use of surface water from ponds in the nearby area and by implementation of increasing the efficiency of irrigation. Moreover as per GWRE 2020, Kamrup (M) Rural area has an additional Potential Resource of 7122.54ham under Specific Conditions of Waterlogged and Shallow Water Table Areas. This additional potential can be utilised to increase the cropping intensity up to 200%.

Groundwater draft is calculated for well discharge of 27m^3/hr. If the well is allowed to run 8 hrs a day for 120 days of a year then a tube well having discharge will create a draft of 2.592 ham. To meet irrigation demand of 6500 ham (keeping Stage of ground water development <70%) area, 2500 numbers of shallow TW can be constructed to cover unirrigated area of 18508 ha area.

Numbers Of Tube Wells To Be Constructed	
Well Discharge	27m^3/hr
Running Time Of Well	8 hrs a day for 120 days a year
Groundwater Draft created	2.592 ham
To Meet Irrigation Demand of 6500 Ham	2500 STW to be constructed
Method of drilling	Direct Rotary Rig in alluvial area DTH Rig for foothill area

Drilling: Direct Rotary Rig is useful for drilling in the Flood plain and alluvium area down to depth of 300 m. A tube well tapping 6 to 60m granular zone can expected to yield 20 to 50m3 /hr. Tube wells can be constructed by using 8" dia.

Shallow Tube wells can be designed within a depth of 50m. A tube well tapping 12m granular zone can expected to yield 10 to 20m^3 /hr.

In consolidated formation DTH Rig useful for drilling. In foothill area where ground water occurs in shallow weathered zone and this can be developed through open wells. The joints and fractures developed due to tectonic activities from potential water bearing formation suitable for development through construction of bore wells.

The pump test data of CGWB has indicated that the drawdown of the tube wells is 2 to 16 m in the flood plain area.

Annexure I

Table: 1 a. Concentration range of chemical constituents in groundwater (Pre Monsoon)

Location	Type of sample	pH	EC (µs/cm) 25C	Turbidity (NTU)	TA (as CaCO3)	TDS	CO_3^{2-}	HCO_3^{-1}	Cl^-	SO_4^{-2}	NO_3^{-1}	F^-	Ca+2	Mg+2	Na	K	Fe	TH (as CaCO3)
AAU, Khanapara	DUG	7.28	775.80	BDL	225.88	512.03	BDL	225.88	49.63	6.89	5.90	0.75	70.06	16.96	11.24	9.17	7.87	245.00
AssamPoultry Farm	DUG	8.33	399.30	BDL	268.40	263.54	12.00	256.40	24.82	7.86	5.29	0.60	36.03	19.40	39.96	4.87	0.22	170.00
Aswaklanta	DUG	8.47	736.90	0.20	259.09	486.35	21.00	238.09	92.17	27.55	17.96	0.40	50.04	24.25	76.56	29.24	0.62	225.00
Avayapuri	DUG	7.90	249.70	BDL	128.20	164.80	BDL	128.20	21.27	26.61	0.95	0.06	44.04	1.19	14.61	4.33	0.56	115.00
Azara PHC	DUG	7.68	253.50	BDL	103.78	167.31	BDL	103.78	35.45	10.50	4.74	0.15	26.02	6.06	22.80	3.17	0.56	90.00
Bakarapara	TUBE	8.40	445.50	BDL	219.67	294.03	6.00	213.67	21.27	4.41	0.95	1.11	26.02	12.12	52.53	8.47	0.84	115.00
Bakarapara	DUG	8.35	705.80	BDL	243.88	465.83	18.00	225.88	92.17	33.45	16.84	0.23	28.02	29.11	96.35	21.43	0.48	190.00
Basitha FG	DUG	7.11	211.60	0.20	115.99	139.66	BDL	115.99	17.73	5.15	3.26	0.15	22.02	9.70	16.17	4.72	3.23	95.00
Boragaon	DUG	8.40	767.30	BDL	274.40	506.42	18.00	256.40	95.71	32.11	13.32	0.81	44.04	60.66	31.17	27.30	1.23	360.00
Borgug	DUG	8.47	542.80	BDL	383.56	358.25	60.00	323.56	46.09	40.32	1.60	0.67	80.06	7.24	66.51	43.27	0.46	230.00
Chakardo	TUBE	7.99	305.20	0.20	195.36	201.43	BDL	195.36	14.18	4.50	0.21	1.13	38.03	9.69	23.77	4.26	0.42	135.00
Chakardo	DUG	7.35	222.10	0.10	115.99	146.59	BDL	115.99	21.27	6.13	0.38	0.15	26.02	9.70	15.55	4.71	0.46	105.00
Chamata	DUG	6.37	373.80	BDL	79.36	246.71	BDL	79.36	74.45	32.94		BDL	14.01	18.20	50.72	3.58	0.36	110.00
Champavati	TW	7.77	362.10	BDL	183.15	238.99	BDL	183.15	31.91	18.64	0.91	0.75	28.02	2.41	41.20	15.45	4.18	80.00
Chandrapur	DUG	8.46	927.80	BDL	228.67	612.35	15.00	213.67	134.71	60.72	3.29	0.14	46.04	42.45	70.14	34.23	0.46	290.00
Choonsali, Madhabpur	DUG	6.54	687.40	BDL	140.41	453.68	BDL	140.41	74.45	21.33	47.68	0.12	46.04	20.61	40.07	16.42	0.90	200.00
Dakhingaon	DUG	8.19	1175.00	BDL	207.57	775.50	BDL	207.57	159.53	45.48	25.60	0.80	58.05	24.24	110.64	13.76	3.57	245.00
Dirgheshwari	DUG	8.35	400.60	BDL	265.30	264.40	15.00	250.30	10.64	7.97	1.85	1.37	44.04	12.11	46.20	5.55	0.46	160.00
Fatasil-Ambari	DUG	8.35	759.80	0.30	222.46	501.47	21.00	201.46	120.53	18.41	34.28	0.45	50.04	23.03	92.02	9.44	0.36	220.00
Ganesh Mandir, Narengi	DUG	8.36	636.40	0.30	192.04	420.02	15.00	177.04	99.26	23.51	22.85	0.45	56.04	10.90	80.06	4.53	1.40	185.00
Garigaon	DUG	8.33	840.40	BDL	243.99	554.66	12.00	231.99	120.53	34.90	10.57	0.23	48.04	4.83	100.48	15.48	4.02	140.00
GMC	DUG	8.40	395.10	BDL	519.19	260.77	159.00	360.19	28.36	27.30	2.95	0.48	72.06	1.18	148.79	50.60	0.56	185.00

Location	Type of sample	pH	EC (µs/cm) 25C	Turbidity (NTU)	TA (as CaCO3)	TDS	CO_3^{2-}	HCO_3^{-1}	Cl^-	SO_4^{-2}	NO_3^{-1}	F^-	Ca+2	Mg+2	Na	K	Fe	TH (as CaCO3)
Kacharibasti Christian Basti	DUG	7.53	1116.00	0.40	311.35	736.56	BDL	311.35	109.90	19.65	39.72	0.89	52.04	29.10	95.07	30.86	9.50	250.00
Kahilipara Colony Bazar	DUG	7.45	1417.00	BDL	421.24	935.22	BDL	421.24	109.90	41.15	37.99	0.88	98.08	32.72	81.38	57.95	2.77	380.00
Kahilipara L.P. School	DUG	8.40	772.90	BDL	259.30	510.11	9.00	250.30	85.08	36.75	1.87	0.34	72.06	9.67	70.66	11.15	0.76	220.00
Khanapara PP New	DUG	8.33	938.50	BDL	246.99	619.41	15.00	231.99	131.17	59.11	41.89	0.27	34.03	47.31	98.36	24.90	1.03	280.00
Khanapara Sc. Museum	DUG	8.40	569.10	0.20	237.88	375.61	12.00	225.88	60.27	35.69	7.95	0.20	34.03	26.68	66.97	10.78	0.84	195.00
Khetri	DUG	7.54	462.30	BDL	146.52	305.12	BDL	146.52	70.90	35.54	3.47	BDL	46.04	37.60	5.01	2.82	0.74	270.00
Lakshmi Mandir	DUG	8.37	732.70	BDL	277.30	483.58	27.00	250.30	70.90	28.89	12.59	0.16	26.02	25.47	91.69	22.10	0.44	170.00
Lalganesh Chariali	DUG	7.50	1175.00	BDL	213.67	775.50	BDL	213.67	180.80	38.34	10.26	0.35	62.05	21.81	121.34	14.64	0.50	245.00
Mairapatti	DUG	8.34	596.10	BDL	170.62	393.43	18.00	152.62	88.63	35.31	9.62	0.04	40.03	42.46	26.31	18.72	0.60	275.00
Maligaon	DUG	7.80	866.20	BDL	238.09	571.69	BDL	238.09	85.08	29.18	12.12	0.86	44.04	20.61	78.10	21.77	1.05	195.00
Maloibari	DUG	8.40	847.40	BDL	192.04	559.28	15.00	177.04	155.98	51.80	3.29	0.24	48.04	33.96	91.49	3.25	1.89	260.00
Odalbakra, Pahartoli	DUG	8.40	1320.00	BDL	268.40	871.20	12.00	256.40	212.70	2.62	24.89	1.50	106.08	2.38	127.60	26.96	15.57	275.00
Paltan bazar	DUG	8.36	988.90	BDL	359.87	652.67	18.00	341.87	88.63	9.68	19.85	0.47	58.05	18.18	100.06	36.15	2.64	220.00
Panikhaiti	DUG	7.53	200.90	BDL	170.94	132.59	BDL	170.94	49.63	34.14	3.61	0.57	38.03	23.04	33.57	3.48	0.44	190.00
Panjabari	DUG	7.35	929.90	BDL	213.67	613.73	BDL	213.67	131.17	23.93	18.14	0.32	32.03	29.11	97.65	19.62	0.48	200.00
Patgaon	DUG	8.30	616.50	BDL	262.20	406.89	18.00	244.20	77.99	14.20	6.91	0.14	38.03	13.33	87.03	33.44	2.77	150.00
Patharquery	DUG	6.80	596.45	BDL	170.94	393.66	BDL	170.94	70.90	7.50	20.84	0.60	38.03	15.76	48.24	17.17	3.60	160.00
Sijubari	DUG	8.50	394.70	0.10	173.83	260.50	9.00	164.83	24.82	27.18	4.44	1.45	14.01	9.70	74.59	3.64	0.46	75.00
Sonapur	DUG	6.12	165.30	BDL	48.84	109.10		48.84	35.45	11.40	9.67	BDL	6.00	14.56	18.33	4.34	0.36	75.00
Survey Odalbakra	DUG	8.34	823.10	0.20	231.67	543.25	18.00	213.67	131.17	34.58	20.27	1.45	48.04	24.25	98.09	13.40	2.00	220.00
Tepesia	DUG	8.30	1081.00	BDL	268.40	713.46	12.00	256.40	163.07	16.33	19.30	0.64	56.04	16.96	122.72	34.46	11.21	210.00
Topatoli/Bamfor	DUG	8.33	457.30	0.30	186.04	301.82	9.00	177.04	39.00	47.25	2.35	0.11	40.03	15.76	31.22	26.26	0.56	165.00
Vishwakarma Temple	DUG	8.40	570.80	0.50	198.15	376.73	15.00	183.15	67.35	29.86	14.03	0.68	56.04	13.32	59.12	11.66	0.48	195.00

Location	Type of sample	pH	EC (µs/cm) 25C	Turbidity (NTU)	TA (as CaCO3)	TDS	CO_3^{2-}	HCO_3^{-1}	Cl^-	SO_4^{-2}	NO_3^{-1}	F^-	Ca+2	Mg+2	Na	K	Fe	TH (as CaCO3)
West Krishna Nagar	DUG	7.07	755.40	BDL	85.47	498.56	BDL	85.47	92.17	22.48	48.08	0.04	44.04	13.33	46.02	17.10	0.48	165.00
Wireless	DUG	8.33	1096.00	BDL	344.77	723.36	9.00	335.77	99.26	14.43	27.31	0.76	32.03	31.54	117.97	20.26	3.67	210.00

Table: 1 b. Concentration range of chemical constituents in groundwater (Post Monsoon)

Location	Type of sample	Temp ºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe	As
						(in mg/L)														
AAU, Khanapara	DW	25	7.74	583.80	BDL	385.31	21.00	280.82	301.82	39.00	0.61	5.69	1.10	50.04	10.90	170.00	32.02	91.56	0.35	1.116
Avayapuri	DW	24.5	7.78	331.70	0.20	218.92	BDL	97.68	97.68	99.26	11.86	BDL	0.89	36.03	33.96	230.00	6.28	11.65	0.23	0.03
Azara PHC	DW	24.5	7.70	225.10	0.30	148.57	BDL	103.78	103.78	39.00	BDL	BDL	0.36	24.02	12.12	110.00	17.75	3.65	0.28	0.138
Bakarapara	DW	26.1	8.34	684.50	BDL	451.77	15.00	262.51	277.51	85.08	8.49	0.10	0.93	64.05	13.32	215.00	72.05	26.02	0.80	0.138
Bakarapara TW	TW	28.6	8.30	336.20	BDL	221.89	15.00	231.99	246.99	127.62	BDL	BDL	1.65	32.03	83.72	425.00	4.12	3.49	0.32	BDL
Basistha FG	DW	24.9	8.25	498.50	BDL	329.01	15.00	201.46	216.46	46.09	8.69	BDL	0.60	52.04	1.19	135.00	30.92	32.00	1.06	0.03
Boragaon	DW	26.4	7.92	192.90	0.40	127.31	BDL	128.20	128.20	21.27	BDL	0.74	0.86	30.02	7.27	105.00	18.52	3.36	0.49	BDL
Borgug	DW	24.8	8.37	620.90	BDL	409.79	12.00	219.78	231.78	184.34	9.23	BDL	0.03	54.04	86.14	490.00	7.14	5.01	0.25	1.445
Chakardo	DW	26.3	8.53	637.70	BDL	420.88	21.00	311.35	332.35	56.72	13.55	0.76	1.12	122.10	2.37	315.00	35.76	25.38	0.79	0.897
Chakardo TW	TW	26.6	8.34	265.90	0.40	175.49	9.00	207.57	216.57	10.64	BDL	BDL	1.80	36.03	10.90	135.00	26.78	5.54	0.14	BDL
Chamata	DW	22.9	8.05	243.50	BDL	160.71	BDL	140.41	140.41	28.36	BDL	BDL	0.56	32.03	13.33	135.00	12.20	8.46	0.15	BDL
Chandrapur	DW	25.3	7.53	419.20	BDL	276.67	BDL	109.89	109.89	77.99	9.29	BDL	0.26	30.02	25.47	180.00	15.94	8.18	0.30	BDL
Choosali, Madhabpur	DW	25.8	8.35	849.30	BDL	560.54	15.00	183.15	198.15	134.71	22.01	BDL	0.32	92.07	31.51	360.00	18.62	17.81	0.08	BDL
Dakhingaon	DW	25.2	8.29	694.70	0.20	458.50	BDL	213.67	213.67	85.08	BDL	35.34	0.33	60.05	25.46	255.00	34.17	18.93	0.15	BDL
Dirgheshwari	TW	26.1	8.05	387.80	BDL	255.95	BDL	109.89	109.89	109.90	BDL	0.68	0.84	50.04	2.40	135.00	54.78	6.17	0.32	BDL
Dirgheshwari	DW	26.5	8.30	866.60	BDL	571.96	18.00	286.93	304.93	120.53	8.78	20.06	0.69	128.10	1.15	325.00	57.05	15.99	20.80	BDL
Dte of Agri	DW	25.4	7.95	417.20	BDL	275.35	BDL	97.68	97.68	85.08	BDL	5.62	0.65	32.03	13.33	135.00	28.71	18.17	0.47	BDL

Location	Type of sample	Temp ºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe	As
Fatasil-Ambari	DW	25.9	8.07	368.30	BDL	243.08	BDL	201.46	201.46	28.36	BDL	BDL	0.25	74.06	3.60	200.00	6.02	10.34	0.11	BDL
Ganesh mandir, Narengi	DW	24.3	8.02	350.30	0.30	231.20	BDL	140.41	140.41	99.26	0.09	BDL	0.34	58.05	14.53	205.00	28.43	11.11	0.19	BDL
Garigaon	DW	25	8.31	548.20	BDL	361.81	12.00	170.94	182.94	99.26	2.07	16.37	0.42	48.04	21.82	210.00	58.35	6.27	0.64	BDL
GMC	DW	26.4	8.03	594.90	0.20	392.63	BDL	225.88	225.88	152.44	0.29	BDL	0.30	104.08	36.36	410.00	10.51	7.84	0.21	0.463
Kacharibasti, Christianbasti	DW	25.3	7.73	334.30	BDL	220.64	BDL	177.04	177.04	39.00	3.10	15.33	0.21	68.05	2.39	180.00	11.64	12.68	5.80	0.138
Kahilipara Colony Bazar	DW	25.8	8.36	982.30	BDL	648.32	15.00	427.34	442.34	99.26	15.00	15.95	1.09	80.06	16.95	270.00	120.90	48.80	3.50	1.143
Kahilipara L. P. School	DW	25.1	7.34	1280.00	BDL	844.80	BDL	415.13	415.13	120.53	10.32	3.11	1.27	136.11	22.99	435.00	54.15	20.27	0.69	0.676
Khanapara PP new	DW	25.3	7.76	654.10	BDL	431.71	BDL	286.93	286.93	120.53	9.09	0.46	0.43	82.07	58.21	445.00	4.64	3.04	0.67	BDL
Khanapara Sc. Museum	DW	23.7	8.29	810.40	0.10	534.86	15.00	244.20	259.20	109.90	3.64	0.00	0.44	82.07	32.73	340.00	31.19	10.94	0.28	BDL
Lakhra Chariali	DW	25.3	7.74	415.60	0.00	274.30	0.00	73.26	73.26	56.72	1.17	0.48	0.26	24.02	13.34	115.00	6.54	2.67	3.13	BDL
Lakshmi Mandir	DW	26.2	6.95	551.00	0.00	363.66	0.00	201.46	201.46	88.63	1.03	0.00	0.29	56.04	6.04	165.00	52.09	32.71	0.22	BDL
Lalganesh Chariali	DW	26.3	8.35	653.80	0.00	431.51	9.00	299.14	308.14	74.45	0.91	21.27	0.24	74.06	8.46	220.00	78.90	24.03	0.21	BDL
Mairapatti	DW	25.2	8.46	1116.00	0.00	736.56	21.00	305.24	326.24	187.89	1.57	23.49	0.39	92.07	6.02	255.00	1106.50	172.30	2.34	BDL
Maligaon	DW	26.1	8.36	975.90	0.00	644.09	27.00	518.91	545.91	152.44	0.05	2.20	0.39	82.07	46.08	395.00	856.40	188.30	0.91	0.326
Maloibari	DW	25.9	7.80	806.60	0.00	532.36	0.00	335.77	335.77	88.63	32.62	10.03	0.23	96.08	8.45	275.00	83.82	21.77	1.23	BDL
Nazira khat	DW	23.7	8.13	878.80	0.00	580.01	0.00	170.94	170.94	173.71	57.44	4.71	0.64	76.06	20.59	275.00	94.77	9.34	0.37	0.093
North Guwahati spring 2	Spring	17.3	7.76	347.40	0.10	229.28	0.00	103.78	103.78	39.00	30.70	1.04	0.22	8.01	25.48	125.00	23.54	7.66	0.17	BDL
Odalbakra, Pahartoli	DW	27.2	7.60	96.80	0.10	63.89	0.00	85.47	85.47	17.73	12.96	0.11	0.10	12.01	3.63	45.00	13.49	3.32	13.40	BDL
Paltan Bazar	DW	26.6	8.37	1100.00	0.00	726.00	6.00	354.08	360.08	194.98	9.42	36.05	0.08	20.02	2.42	60.00	232.40	56.75	1.96	1.495
Panikhaiti	DW	24.9	8.47	966.50	0.00	637.89	15.00	470.08	485.08	77.99	5.40	17.32	0.00	56.04	19.39	220.00	129.90	45.70	0.22	1.26

Location	Type of sample	Temp ºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe	As
Panjabari	DW	25.2	8.31	454.00	0.00	299.64	15.00	140.41	155.41	67.36	24.82	6.04	0.12	40.03	19.40	180.00	48.11	5.21	0.35	BDL
Patgaon	DW	24.3	8.36	901.30	0.00	594.86	9.00	256.40	265.40	138.26	22.21	16.70	0.34	26.02	35.18	210.00	118.20	24.56	1.34	0.093
Patharquery	DW	25.2	8.01	449.30	0.00	296.54	0.00	158.73	158.73	60.27	24.18	3.80	0.00	28.02	13.34	125.00	53.41	18.72	1.39	0.91
Sijubari	DW	25.9	8.42	545.90	0.20	360.29	6.00	219.78	225.78	63.81	11.26	25.97	0.54	20.02	36.40	200.00	50.78	22.29	2.11	BDL
Sonapur	DW	24.1	8.46	802.00	0.30	529.32	3.00	305.24	308.24	81.54	30.78	14.83	0.66	36.03	26.68	200.00	65.32	33.08	0.15	BDL
Survey Odalbakra	DW	26.1	7.46	237.10	0.00	156.49	0.00	36.63	36.63	63.81	12.87	12.55	0.41	12.01	8.49	65.00	33.17	11.32	0.23	BDL
Tepesia	DW	24.9	8.37	790.40	0.00	521.66	6.00	262.51	268.51	141.80	17.21	19.64	0.40	18.01	43.68	225.00	107.65	27.35	0.54	BDL
Toptatoli	DW	25.9	8.41	1060.00	0.00	699.60	9.00	268.61	277.61	177.25	29.47	20.79	0.70	56.04	15.75	205.00	155.15	25.00	7.85	0.209
Udaipur	DW	25.6	8.40	660.00	0.30	435.60	141.00	470.08	611.08	17.73	27.89	5.13	0.08	52.04	20.61	215.00	158.50	52.56	1.63	2.551
Vishwakarma Temple	DW	26.3	8.50	622.10	0.00	410.59	9.00	164.83	173.83	70.90	28.15	30.16	0.10	14.01	29.12	155.00	73.09	15.59	0.15	BDL
West Krishna Nagar	DW	25.8	7.86	720.40	0.10	475.46	0.00	73.26	73.26	141.80	25.59	47.69	0.11	58.05	8.47	180.00	68.45	12.85	0.14	BDL
Wireless	DW	25.1	8.31	920.50	0.00	607.53	21.00	439.55	460.55	85.08	14.50	44.43	0.51	74.06	6.03	210.00	160.80	36.10	3.74	0.676