केंद्रीय भूमि जल बोर्ड

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

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

SONITPUR DISTRICT, ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

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Central Ground Water Board

केंद्रीय भूजल बोर्ड

MINISTRY OF JAL SHAKTI

जल शक्ति मंत्रालय

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GOVERNMENT OF INDIA

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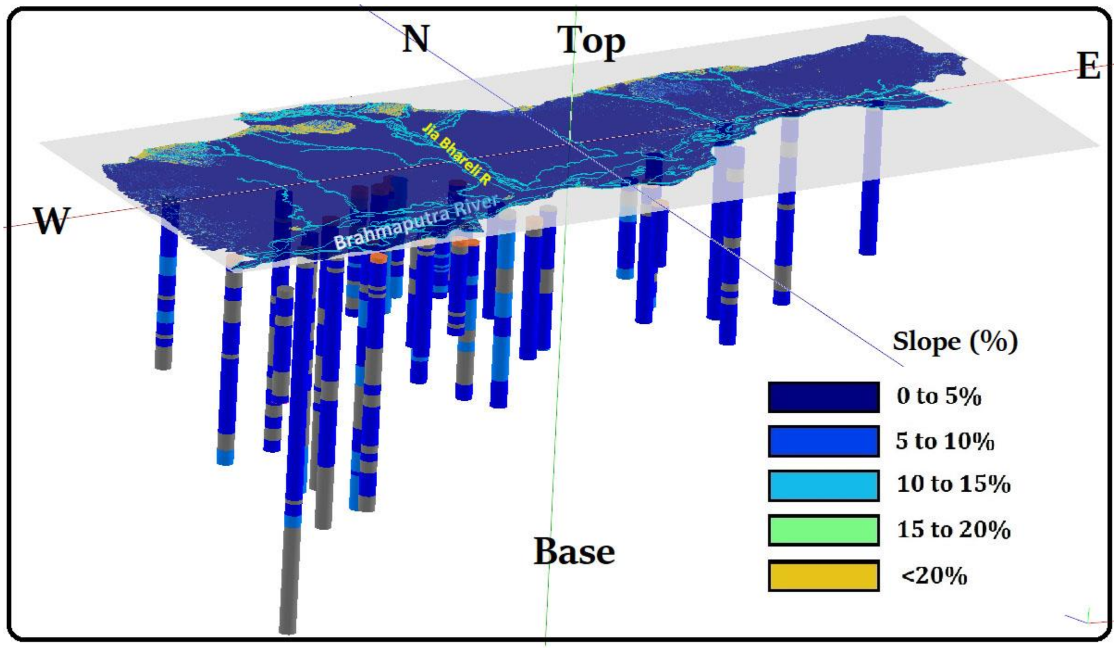

REPORT ON AQUIFER MAPPING AND MANAGEMENT IN

SONITPUR DISTRICT, ASSAM

ANNUAL ACTION PLAN, 2018-19

NORTH EASTERN REGION

उत्तर पूर्वी क्षेत्र

GUWAHATI

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December 2020

REPORT ON AQUIFER MAPPING AND MANAGEMENT IN
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ANNUAL ACTION PLAN, 2018-19

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CHAPTER 1.0

INTRODUCTION

1.0 Introduction

1.1 Objectives

The objective of the study is to prepare aquifer map of the area in 1:50,000 scale, identify the groundwater related issues and prepare a groundwater management plan.

1.2 Scope of the study

Sonitpur district has vast groundwater and surface water resources. The water resources of the district can be judiciously used for sustainable economic growth. Sustainable management plan of groundwater extraction warrants study on the occurrence of groundwater, its quantity and quality.

1.3. Approach and methodology

The approach is to identify the principal and major aquifers, quantify the resources and prepare a management plan. Finally the scientific knowledge will be disseminated to farmers, 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, State Groundwater Departments. All data were plotted in base map on GIS Platform (MapInfo-11.0 using Projection category longitude/latitude (WGS 84-EPSG 4326). 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, besides detailed hydrogeological surveys.

Aquifer Map Preparation: On the basis of integration of data generated from various studies of hydrogeology & geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out Characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

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

1.4 Area Details

Sonitpur district is covered by Survey of India Toposheet No. 83 A/12, 83A/16, 83B/5, 83B/6, 83B/9, 83B/10, 83B/13. 83B/14, 83 F/1, 83F/2, 83F/5, 83F/6, 83F/9 and 83F/10 and bounded by 26˚ 30′35” and 27˚ 02’ 11” North Latitudes and 92˚19’30” and 93˚ 47′13” East longitudes covering an area of 5324 sq. km (Fig.1.1).

Table 1.1: Administrative set up of the study area

<table>
<tr><th>State</th><th>District</th><th>Block</th><th>Circle</th><th>Panchayat</th></tr>
<tr><td rowspan="5">Assam</td><td rowspan="5">Sonitpur</td><td>Pub Chaiduar</td><td>Gohpur</td><td>17</td></tr>
<tr><td>Chaiduar</td><td>Helem</td><td>17</td></tr>
<tr><td>Behali</td><td rowspan="3">Biswanath</td><td>9</td></tr>
<tr><td>Baghmara</td><td>8</td></tr>
<tr><td>Biswanath</td><td>7</td></tr>
<tr><td rowspan="10">Assam</td><td rowspan="10">Sonitpur</td><td>Sakomatha</td><td></td><td>8</td></tr>
<tr><td>Sootia</td><td>Naduar</td><td>10</td></tr>
<tr><td>Naduar</td><td></td><td>10</td></tr>
<tr><td>Balipara</td><td>Chariduar</td><td>18</td></tr>
<tr><td>Rangapara</td><td></td><td>8</td></tr>
<tr><td>Gabharu</td><td rowspan="2">Tezpur</td><td>8</td></tr>
<tr><td>Bihaguri</td><td>9</td></tr>
<tr><td>Dhekiajuli</td><td rowspan="2">Dhekiajuli</td><td>18</td></tr>
<tr><td>Barchala</td><td>11</td></tr>
<tr><td></td><td></td><td>158</td></tr>
</table>

Table 1.2: Block wise area and population of Sonitpur District as per 2011 census

Block	Rural (No. of Villages)	Urban (No. of Town)	Population		Total Population	Geographical area (Hectre)
			Rural	Urban		
Dhekiajuli	239	0	224611	0	224611	637
Gabharu	85	8	112098	43946	156044	234
Barchala	118	0	197345	0	197345	432
Balipara	179	0	233920	0	233920	566
Rangapara	81	0	98912	0	98912	211
Bihaguri	142	0	86436	0	86436	223
Naduar	89	0	90911	0	90911	415
Chatia	111	0	124909	0	124909	384
Sakomatha	102	0	86938	0	86938	259
Bishawnath	59	0	64828	0	64828	267
Baghmara	102	0	87762	0	87762	253
Behali	115	0	87951	0	87951	267
Chaiduar	223	0	139852	0	139852	564
Pub-Chaiduar	231	0	113792	0	113792	612
Total	1876	8	1750265	0	1794211	**5324**

Sonitpur district is connected with the rest of the State by National Highway (NH) 52, by railways and also by flight service.

Fig.1.1: Index Map of Sonitpur District, Assam

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

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, State Groundwater Departments. All data were plotted in base map on GIS Platform (MapInfo-11.0 using Projection category longitude/latitude (WGS 84 EPSG 4326).

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 Sonitpur district, Assam

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data	Tube well	29	10	3	32	Maximum depth of well is 300mbgl
2	Geophysical data		Nil	25	Nil	Nil	
3	Groundwater level data	Dug well	25	16	31	56	
		Piezometer/OW Aquifer-I (Shallow zone)	Nil	35	Nil	Nil	
		Piezometer/OW Aquifer-I (Deeper zone)	2	12	Nil	2	
4	Groundwater quality data	Dug well-Aquifer-I	25	16	31	56	
		Piezometer/OW Aquifer-I (Shallow zone)	Nil	35	Nil	35	
		Piezometer/OW Aquifer-I (Deeper zone)	2	12	Nil	2	
5	Specific Yield		Nil	30	Nil	Nil	
6	Soil Infiltration Test		Nil	30	6	6	

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

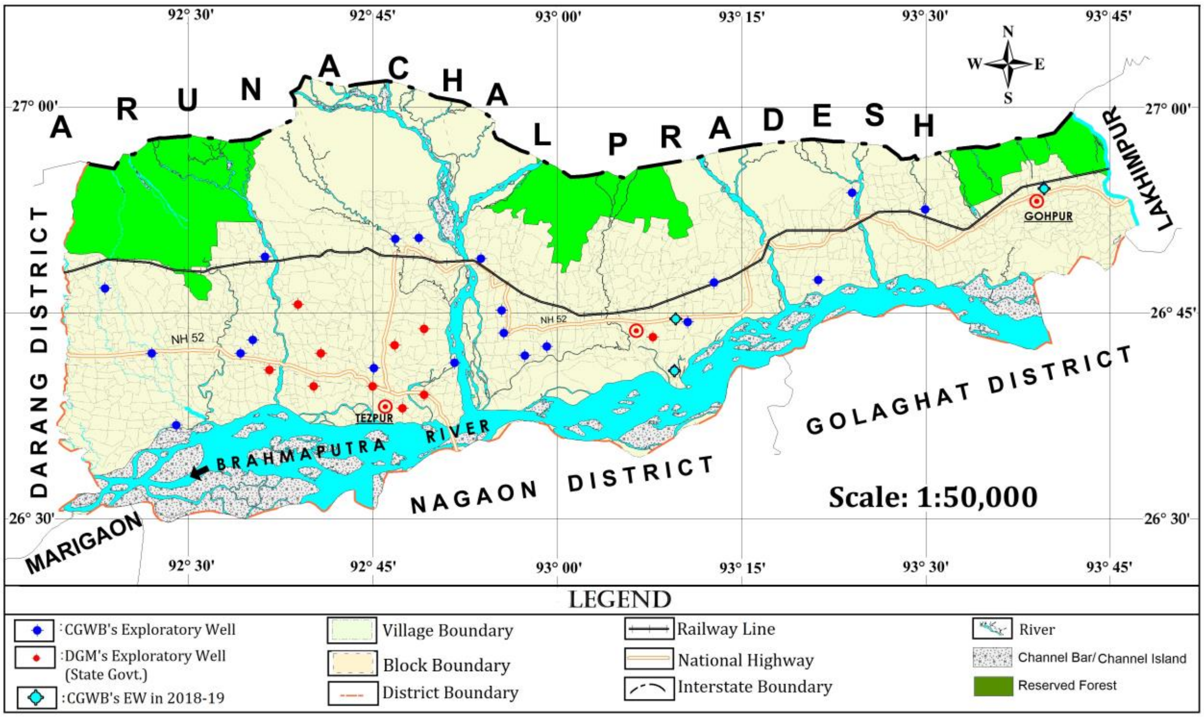


Fig. 1.2a: Available data and data generation of exploration in Sonitpur district

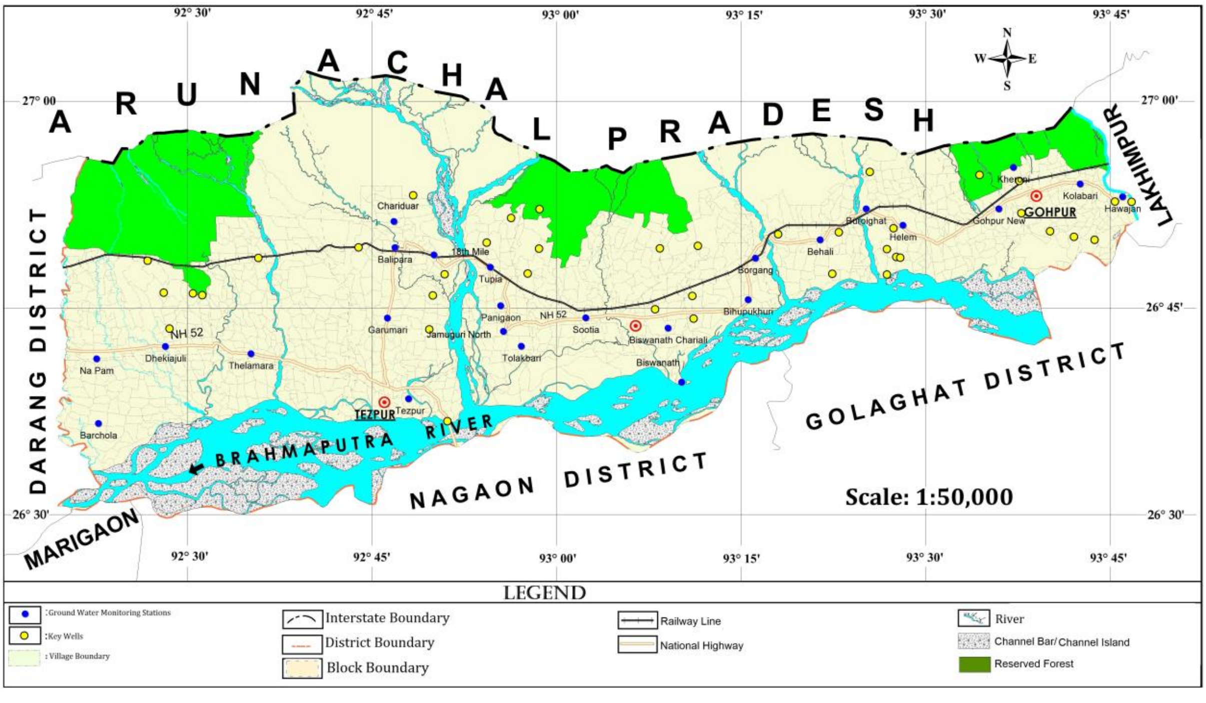


Fig. 1.2b: Available data and data generation of ground water level and quality monitoring Sonitpur district

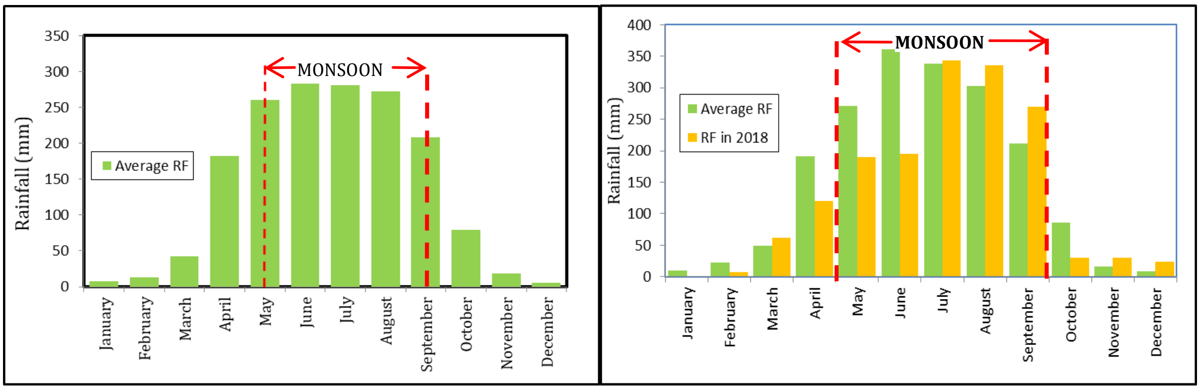
1.6 Rainfall-spatial, temporal and secular distribution

The average monthly rainfall and yearly rainfall variations are graphically illustrated in Fig. 1.3. Based on Indian Meterological Department (IMD) data set from 2004 to 2013 the average annual rainfall of the district found out to be 2837.97mm.

Average monthly rainfall and yearly rainfall variations are graphically illustrated in Fig. 2.1.

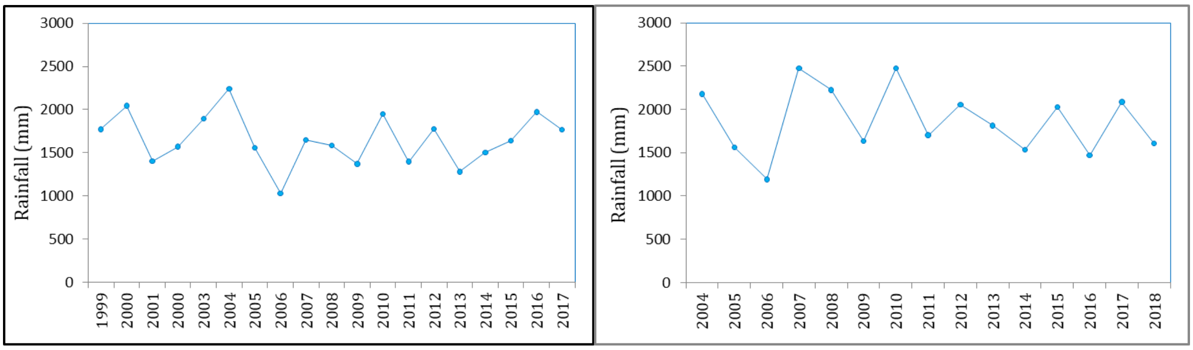
Rainfall during January to April contributes nearly 15% to the total rainfall whereas the rainy season which commences from May and continues up to September contributes 79%. October to December rainfall makes up the rest. December receives least rainfall and maximum rainfall occurs during July.

The average monthly rainfall and monthly rainfall during 2018 and also yearly rainfall distribution are illustrated in Fig.1.3. There is deficit non-monsoon rainfall in 2018 when compared with 15years average while the monsoon rainfall is more than the 15 years average monsoon rainfall.



(a) NERIWALM (b) IMD, Tezpur

Fig. 1.3: Average annual rainfall (a) NERIWALM and (b) IMD Station, Tezpur



(a) NERIWALM (b) IMD, Tezpur

Fig. 1.4: Yearly rainfall variations in two rain-gauge stations (a) Dolabari, NERIWALM, Tezpur and (b) IMD station, Salonibari, Tezpur

1.7 Physiographic set up

Phisiographically the district can broadly be divided into four zones, i.e., the hilly tract, the piedmont, flood plain and the monadnock -like remains. The hilly tract of north of

Sonitpur district rises 456mamsl while the elevation of isolated hillocks of Archean gneisses ranges from 80 to 172mamsl. The district as a whole gently slopes from north-east to south-west with an average gradient of around 13 cm per km. In the district, numbers of wetlands, locally known as *beels* are found. Most of them are abandoned river beds and get inundated every year. Above the *beels* there are the fertile alluvial plains where mostly paddy is grown.

Fig.1.5: Digital Elevation Model of the study area based on 30m resolution JAXA data.

1.8 Geomorphology

Geomorphologically the area can be classified mainly into four divisions: structural hills, piedmont zone, alluvial plan and flood plain. Piedmont zone is in the north eastern part of the study area. The piedmont zone is gravel dominated while alluvial plain and the flood plain are mixture of sand, gravel and clay in varying proportions. The alluvial flood plain consists of younger and older alluvial deposits. It represents various sub-features, viz., palaeochannel, swampy/marshy land, river terraces, flood plains, point bars, channel bar and river channel (Fig. 1.6).

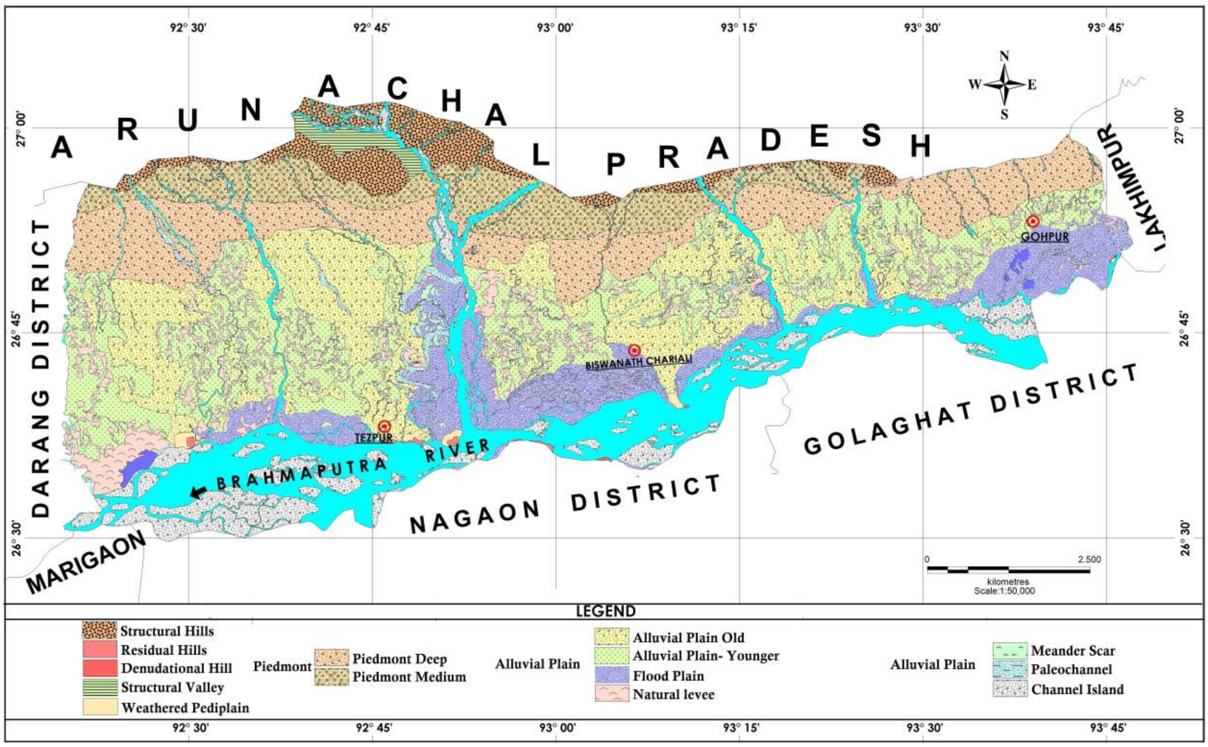


Fig. 1.6: Geomorphological Map of Sonitpur District, Assam

Geomorphic Analysis: Geomorphology can also be defined as landforms description and classification. GIS based analysis of Digital Elevation Data helps to classify landform. In this study downloaded and processed DEM is classified into 10 classes based on Terrain Power Index (TPI) (Fig.).

Using TPI at different scales, plus slope, users can classify the landscape into both slope position (i.e. ridge top, valley bottom, mid-slope, etc.) and landform category (i.e. steep narrow canyons, gentle valleys, plains, open slopes, mesas, etc.). The TPI is the basis of the classification system and is simply the difference between a cell elevation value and the average elevation of the neighborhood around that cell. Positive values mean the cell is higher than its surroundings while negative values mean it is lower.

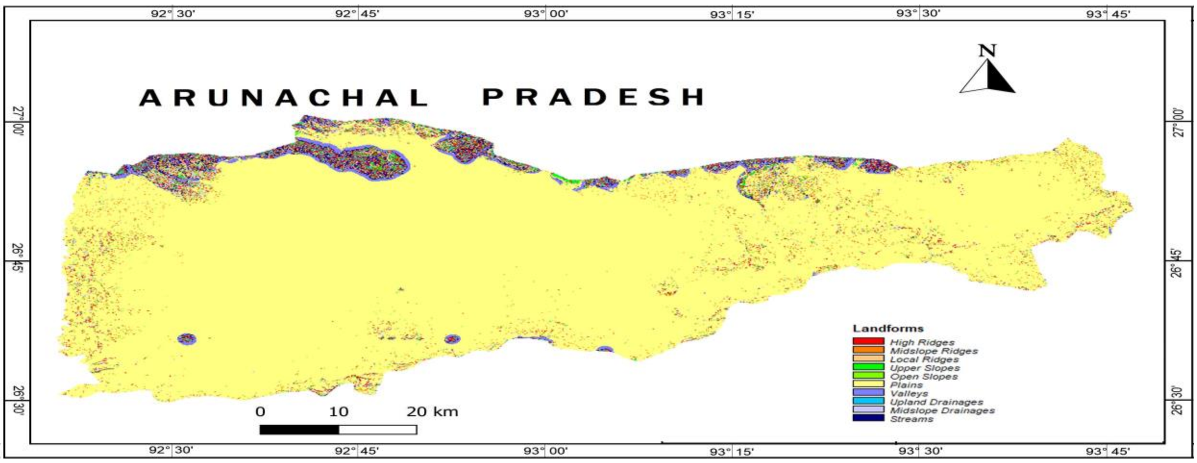


Fig. 1.7: Landform classification of Sonitpur district

The degree to which it is higher or lower, plus the slope of the cell, can be used to classify the cell into slope position. If it is significantly higher than the surrounding neighborhood, then it is likely to be at or near the top of a hill or ridge. Significantly low values suggest the cell is at or near the bottom of a valley. TPI values near zero could mean either a flat area or a mid-slope area, so the cell slope can be used to distinguish the two.

30m resolution digital elevation data downloaded from https://www.eorc.jaxa.jp/ALOS/en/aw3d30/data/index.htm and the data was processed in qgis 3.2 and SAGA 2.0 was used to classify the landform of the district based on TPI (Fig.1.6 and Table 1.4). It is observed that the district is predominantly a plain area. Ridges are found in the northern and southern parts of the district.

Table 1.4: Landform classification of Sonitpur district

CLASS	NAME	AREA (Sq.Km)	%
1	Streams	56.45	1.07
2	Midslope Drainages	95.24	1.8
3	Upland Drainages	23.64	0.45
4	Valleys	81.32	1.54
5	Plains	4743.74	89.84
6	Open Slopes	57.08	1.08
7	Upper Slopes	30.38	0.58
8	Local Ridges	10.06	0.19
9	Midslope Ridges	86.41	1.64
10	High Ridges	96.16	1.82

Slope: The slope map of the district is prepared using 30m resolution DEM data and processed in QGIS 3.4 and SAGA 2.3.1. The slope of the district is reclassified into 5 classes. It is observed that district is nearly 90% of the district is plain with slope within 0 to 5%. Area with slope more than 20% is found towards the northern and few places in the south.

Table1.5: Slope classification of Sonitpur district, Assam

Slope Class	Area (Sq.Km)	%
0 to 5%	4725.749	90.81
5 to 10%	225.3211	4.33
10% to 15%	91.39027	1.76
15% to 20%	50.03527	0.96
>20%	111.504	2.14
Total Area	**5204**	100

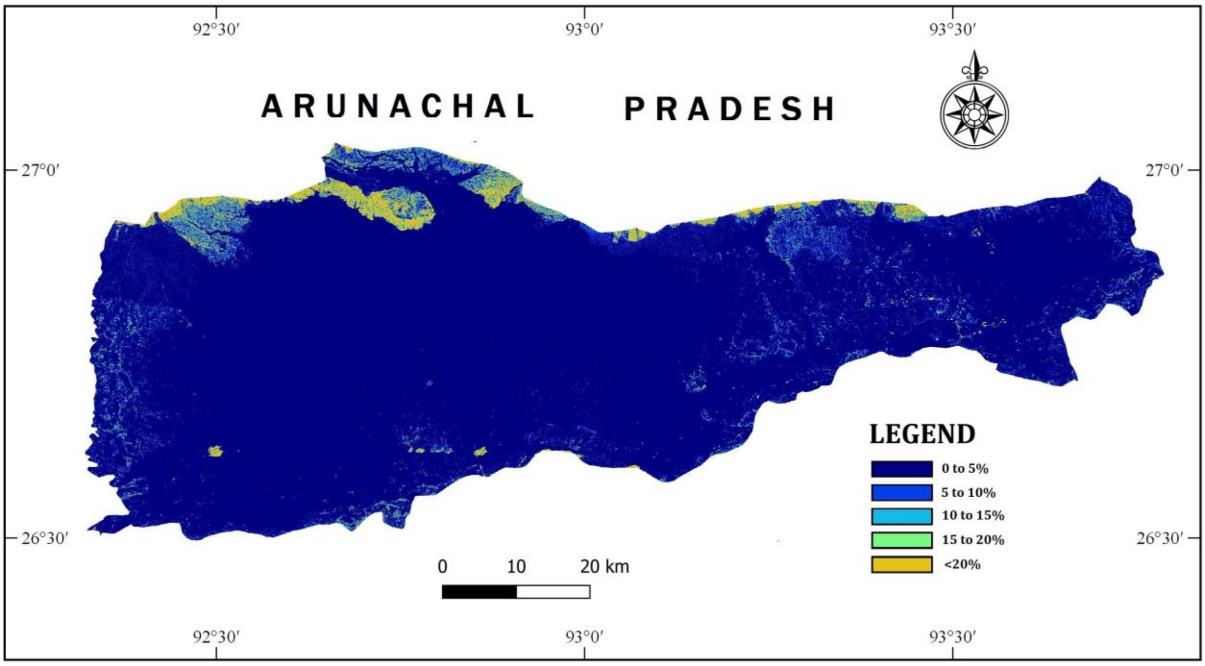


Fig. 1.8: Slope classification of Sonitpur district

1.9 Land use Pattern

Land use pattern of the villages in different blocks are given in the following table (Table: 1.4).

Table 1.5: Land use pattern of Sonitpur district, Assam

Block	Area (in Hectares)						
	Total Geographical Area	Gross cropped area	Net Area Sown	Area sown more than once	Area under wasteland	Area under forest	Area under other uses
Dhekiajuli	63748	34930	21917	13013	NA	NA	NA
Gabharu	23261	14799	7387	7412	NA	NA	NA
Barchala	43238	21720	11858	9862	NA	NA	NA
Balipara	56584	19185	11862	7323	NA	NA	NA
Rangapara	21107	7639	4044	3595	NA	NA	NA
Bihaguri	22281	10731	5859	4872	NA	NA	NA
Naduar	41510	24080	13761	10307	NA	NA	NA
Chatia	38431	19175	11113	8062	NA	NA	NA
Sakomatha	25895	10121	6801	3320	NA	NA	NA
Bishawnath	26732	12669	8845	3824	NA	NA	NA
Baghmara	25297	12538	6299	6239	NA	NA	NA
Behali	26656	11864	6727	5137	NA	NA	NA
Chaiduar	56428	21842	15058	6784	NA	NA	NA
Pub-Chaiduar	61232	30426	20336	10090	NA	NA	NA
Total	**532400**	251719	151867	99840	154563	21935	207920

(Source: District Irrigation Plan, Sonitpur District, 2016-20, Assam)

1.10 Soil

The soil of the district can broadly classified into two, viz., piedmont and alluvial soils. The piedmont soils are found in the northern part of the district along the Himalayan foothills. These soils comprise the Bhabar and Tarai group of soils. The Bhabar soil occurs in the northernmost part of the district consisting of fairly high ground formed as a result of coalescence of alluvial fans and cones. Piedmont soil is deep and is characterized by unassorted detritus of boulders, pebbles, sands and silts. The Tarai soil is found just south of Bhabar soils. This soil varies from sandy to silty loams that remain saturated and support tall grasses.

Alluvial soils are found to the south of piedmont soils and these soils cover the maximum portion of Sonitpur District. Geologically these soils are divided into khadar or newer alluvium which is generally sandy in texture and light-coloured and Bhangar or older alluvium which is of clayey composition and darker coloured. The newer alluvium occurs near riverbed where deposition takes place regularly, the older alluvium, on the other hand forms the surface in the slightly higher interfluves zones. Old alluvium is found in patches generally along the foothills.

17 textural classes of soils have been identified in the district.

The older alluvial soils are developed at higher levels and are not subjected to flooding and agriculture is practiced on permanent basis. Sali paddy, sugarcane and tea plantation is suitable for these soils. The soils are comparatively more acidic than newer alluvial soils and hence are crop sensitive.

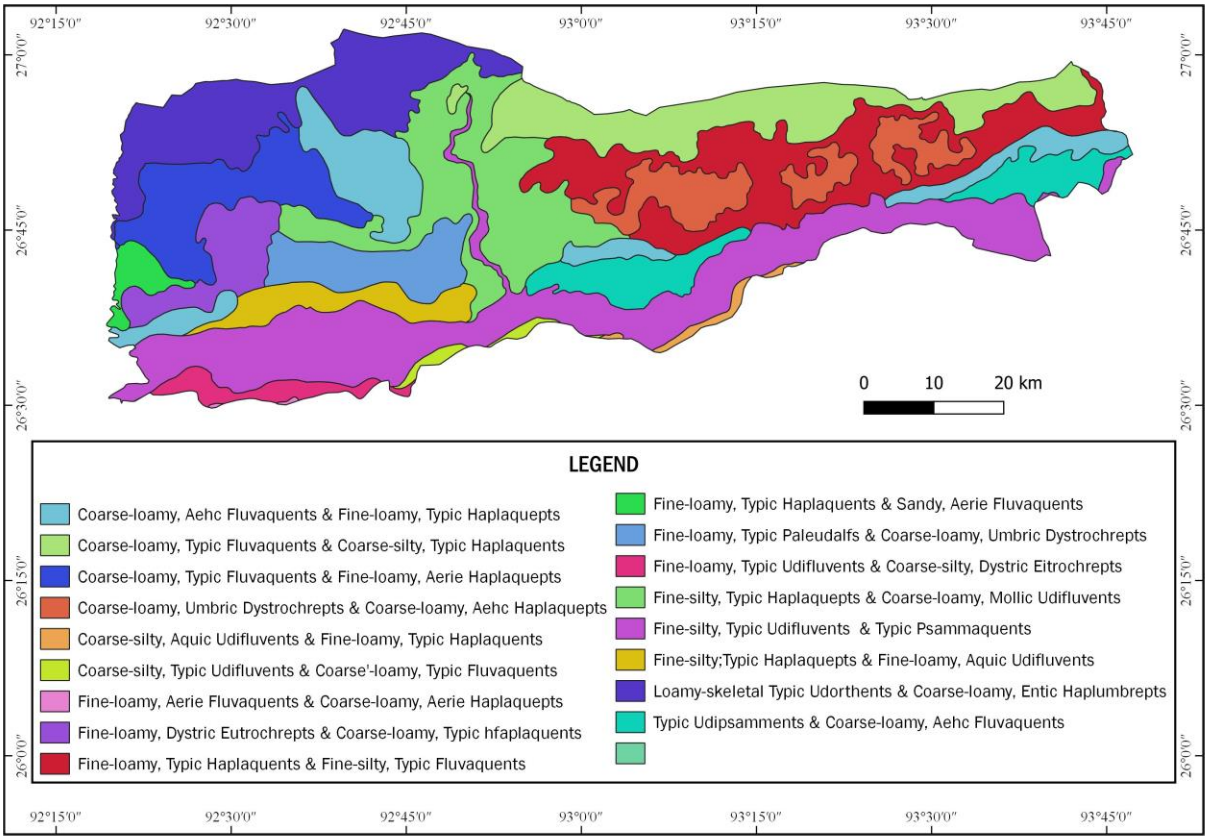


Fig. 1.9: Soil map of Sonitpur district, Assam

1.11 Hydrology and surface water

Surface water bodies are mainly observed in the flood plain area where south and south western flowing rivers looses its gradient.

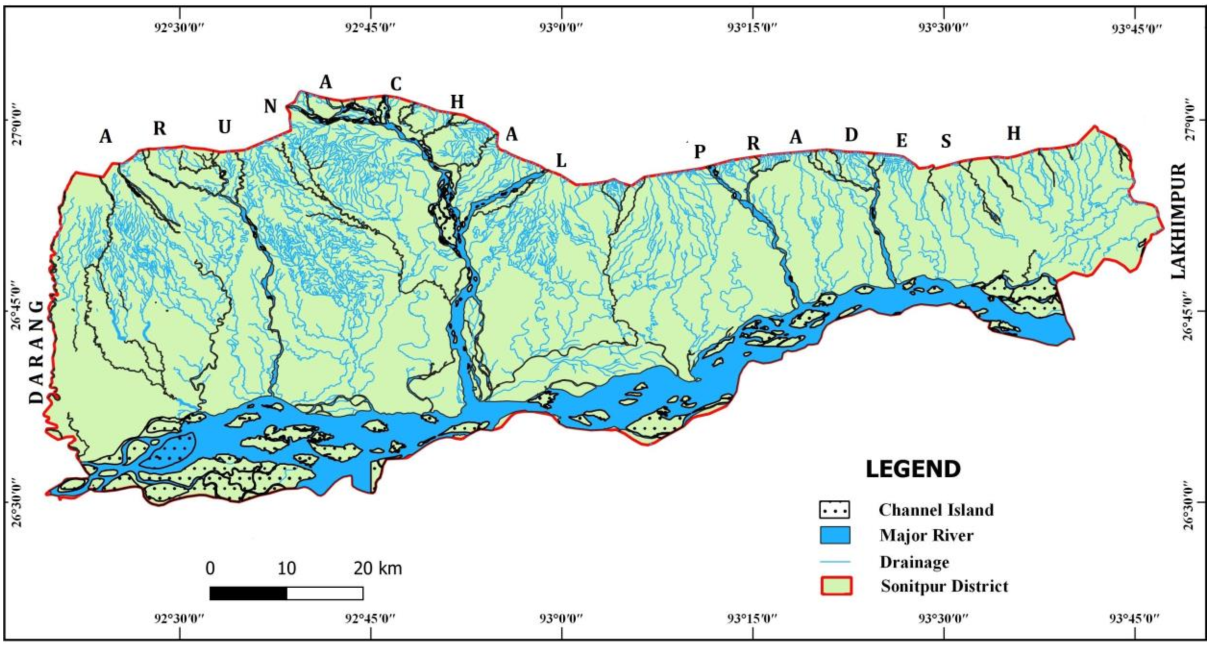


Fig. 1 10: Drainage map of Sonitpur district, Assam

Water logged and marshy lands are observed. Kawaimari bill, Chumani bil, Chakamara bil, etc. are some of the surface water bodies in the area.

The mighty Brahmaputra River marks the southern boundary of the district. The channel width of the Brahmaputra at Sonitpur (at Tezpur) is 4.5km and bed slope is 1:6750. The number of rivers enter the area from northern direction, i.e., from Arunachal Pradesh. The Jia Bhareli River is one of the principal tributary of the Brahmaputra flowing through Arunachal Pradesh and enters the Sonitpur district near Bhalukpong (27°00'45"N and 92°39'S). Total length of Jia Bhareli is 247km and out of which the river fllows 66kms in Sonitpur district from Bhalukpong to Tezpur, i.e., at the confluence of the Brahmaputra. Out of all the tributaries of Brahmapurta, Jia Bharali has the highest sediment yield (4721 tons/km2 /year) and one of the highest discharges of water per unit area of the basin (Bora, 2002).

All the major drainage, viz., the Kakoi, Bagi nadi debouches to river Subansiri in the south western part. Before debouching to Subansiri these streams create water logged and marshy condition in the southwest part of the toposheet. The Kawaimari Bill and the Bhimpara Bill are created by these two two tributaries of Subansiri in the downstream. The drainage pattern of the area is dendritic. The Subansiri River is the main drainage entering in the area from north-western direction and flowing towards south-eastern direction to meet the Brahmaputra River.

Overall the drainage network of the area shows an anastomising pattern. Collectively, the rivers after coming down from hills show a marked tendency to move towards south-westerly direction. This tendency may indicate influence of underlying fracture pattern or this may due to paleochannels of the Brahmaputra river. Individually, the rivers in the western part of the study area show dendritic drainage patterns and rivers of eastern part show parallel drainage pattern.

1.12 Agriculture

The major crops of Sonitpur district are paddy, jute, sugarcane, pulses and mustard. Potato and vegetables are major fruit crops. There are numbers of tea gardens in the district. Three types of rice are grown in the district, viz., autumn rice or *ahu,* winter rice or *Sali* and summer rice or *boro.* Farmers are more dependent on winter rice.

In the rabi season oilseed crops mainly mustard and rapseed are extensively grown in the district. Mustard is normally grown in conjunction with *ahu* or autumn rice or riparian flats. Pulses are grown mainly in alluvial flat lands near river Brahmaputra.

Net irrigated area is 42157ha. As the net sown area of the district is 151867ha, totally unirrigated or rain fed area of the district is found to be 1,09,710 ha.

Surface and ground water resources are used in the district for irrigation purposes. Two state government agencies are engaged for implementation of irrigation schemes in the district. The irrigation department is the nodal agencies in creation of major, medium and minor irrigation schemes while agriculture department is providing irrigation facilities to farmers through construction shallow tube wells. There is only one major surface irrigation scheme in the district constructed over river Bordikorai has created command area of 16994ha in Naduar and Sootea development blocks. Block wise share of surface and groundwater irrigation is shown in Table 1.4.

Table 1.6: Block wise share of surface and groundwater irrigation

SN	Block	Surface Irrigation (BCM)				Groundwater based irrigation (BCM)		
		Canal (major & medium)	Minor Irrigation Scheme (FIS)	Lift Irrigation	Various water bodies including rain water harvesting	Open Well	Shallow TW	Deep TW
1	Dhekiajuli		0.0018				0.021708	0.00018
2	Borsola		0.005				0.008	0.00018
3	Bihaguri		0.00084				0.002358	0.00027
4	Balipara		0.00045				0.01692	0.00072
5	Gabhoru			0.00045			0.01	0.00018
6	Rangapara						0.004842	
7	Naduar	0.01215					0.00756	
8	Sootea	0.003324					0.005256	0.00018
9	Biswanath		0.0015		0.00171		0.004005	
10	Sakomatha		0.0056				0.00387	
11	Behali		0.000495				0.007182	0.00018
12	Chaiduar						0.0054	0.000135
13	Pub-Chaiduar		0.000045	0.00135			0.00594	0.000405
	Total	0.015474	0.01573	0.0018	0.00171		0.103041	0.00243
	Total Surface Water Irrigation				0.034714	25%		
	Total Ground Water Irrigation				0.105471	75%		
	Total Irrigated Water				0.140185			

Table 1.7: Block wise distribution of shallow and deep tube wells (Source: District Irrigation Plan, 2016-20, Sonitpur District, Assam)

Block	Shallow Tube Well	Deep Tube Well
Dhekiajuli	2412	1
Borsola	683	1
Bihaguri	262	2
Balipara	1888	4
Gabhoru	1736	1
Rangapara	538	
Naduar	1260	
Sootea	584	1
Biswanath	445	
Sakomatha	430	
Behali	798	1
Chaiduar	600	1
Pub-Chaiduar	660	3
Total	**12517**	**15**

As per District Irrigation Plan, 2016-20, Sonitpur District, Assam majority of farmers in the district are small and marginal (Fig. 1.9). Maximum numbers of farmers are found in Dhekiajuli block and minimum numbers of farmers are found in Biswanath block.

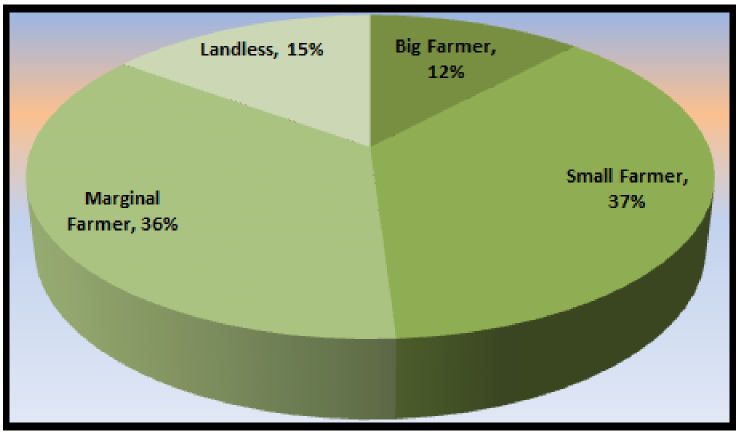


Fig.1.11: Land holding pattern of famers in Sonitpur district, Assam.

1.13 Industry:

Tea industry is the main industry in the district. Other industry includes food and beverages, food, brick, etc. The existing water demand of various industries were worked out by NABARD in the District Irrigation Plan of Sonitpur District for 2016-20 as per Table 1.9.

Table 1.8: Industrial water extraction in Sonitpur District, Assam

Block	Name of the industry	Extraction (MCM)
Borsola	Tea Industry	0.00000045
Dhekiajuli	Food & Brick Industries etc.	0.00000522
Gabharu (including town & municipal area)	Food & Beverages, Construction Industries	0.000039665
Balipara	Construction Industries	0.00000486
Rangapara	Tea Industry	0.00000675
Naduar	Food & Construction Industry	0.00000051
Sootea	Tea Industry	0.0000021
Biswanath	Food,Tea,Automobile service,Ice & Construction Industry	0.00927
Sakomatha	Food,Tea,Automobile service, Construction Industry	0.0151
Baghmara	Food,Tea,Automobile service, Construction Industry	0.0058
Behali	Food,Tea,Automobile service,Ice & Construction Industry	0.029422
Chaiduar	Food,Tea,Automobile service, Construction Industry	0.0046
Pub- chaiduar	Food,Tea,Automobile service,Ice & Construction Industry	0.002
	Total	0.066251555

CHAPTER 2.0
DATA COLLECTION AND GENERATION

2.1 Data collection

2.1.1 Hydrogeological data

The entire study area is covered by regular monitoring of 25nos. of GWMS. All the water level data were collected and the wells are monitored periodically.

2.1.2 Exploration data

Central Ground Water Board, North Eastern Region, Guwahati had began exploration in the district since 1981 and drilled 19 exploratory wells till 2011. State government had also consturcted number of tube wells in the district. Data of 13 nos. of tube wells constructed by state government and tea gardens were collected and utilised in the present report.

2.1.3 Meterological Data

Meterological data is collected from NERIWALM, Tezpur and accessed free data of IMD.

2.1.3 Population and agriculture data

Population and groundwater dependency were collected from Census 2011. All the data pertaining to agriculture were collected from District Irrigation Plan of Sonitpur District for 2016-20 prepared by NABARD.

2.2. Data Generation:

Water level data: 39nos. of key wells have been established to fill up the data gap. All these wells are under periodic monitoring after establishment.

Table 2.1: Key wells location details

Name of Village/Site	Latitude	Longitude	Establishment date	RL (ma msl)	Total depth of Pz/Dw (mbgl)	Type (DW/Pz/Spring)	Aquifer group	Measurement point (magl)	Source/ Agency
18th Mile	26.81	92.83	NHNS Well	76		DW	Alluvium	0.77	Private
Balipara	26.82	92.78	NHNS Well	78		DW	Alluvium	0.90	Govt.
Charduar	26.85	92.78	NHNS Well	80		DW	Alluvium	0.72	Govt.
Barchola	26.61	92.38	NHNS Well	69		DW	Alluvium	1.02	Private
Na Pam	26.69	92.38	NHNS Well	89		DW	Alluvium	1.00	Govt.
Borgang	26.81	93.27	NHNS Well	85		DW	Alluvium	0.85	Private
Behali	26.83	93.36	NHNS Well	86		DW	Alluvium	0.86	CGWB
Bihupukhuri	26.76	93.26	NHNS Well	84		DW	Alluvium	0.96	Private
Buroighat	26.87	93.42	NHNS Well	95		DW	Alluvium	0.80	Private
Dhalaibil	26.78	92.91	NHNS Well	80		DW	Alluvium	0.75	Govt.
Gohpur new	26.87	93.60	NHNS Well	81		DW	Alluvium	0.85	CGWB
Helem	26.85	93.47	NHNS Well	82		DW	Alluvium	0.97	Govt.
Dhekiajuli	26.70	92.47	NHNS Well	78		DW	Alluvium	0.85	Govt.
Garumari	26.57	92.77	NHNS Well	73		DW	Alluvium	0.88	Govt.

Name of Village/Site	Latitude	Longitude	Establishment date	RL (mamsl)	Total depth of Pz/Dw (mbgl)	Type (DW/Pz/Spring)	Aquifer group	Measurement point (magl)	Source/ Agency
Jamuguri North	26.72	92.93	NHNS Well	74		DW	Alluvium	0.96	Govt.
Tolakbari	26.70	92.95	NHNS Well	75		TW	Alluvium	0.83	CGWB
Tupia	26.80	92.91	NHNS Well	81		DW	Alluvium	0.89	Govt.
Biswanath	26.66	93.17	NHNS Well	88		DW	Alluvium	0.76	CGWB
Biswanath Chariali	26.73	93.15	NHNS Well	86		DW	Alluvium	1.00	Govt.
Kheroni	26.92	93.62	NHNS Well	86		DW	Alluvium	1.00	Private
Hawajan	26.88	93.77	NHNS Well	84		DW	Alluvium	0.88	Govt.
Kolabari	26.90	93.71	NHNS Well	75		DW	Alluvium	1.18	Private
Thelamara	26.69	92.59	NHNS Well	76		DW	Alluvium	0.54	Private
Sootia	26.74	93.04	NHNS Well	77		DW	Alluvium	0.80	Govt.
Tezpur	26.61	92.38	NHNS Well	73		DW	Alluvium	0.86	Govt.
2no Chrisitan Basti	26.86	92.94	Key well	97	2.81	DW	Alluvium	0.89	Private
2no Itakhuli	26.79	92.96	Key well	58	4.75	DW	Alluvium	1.16	Private
Agari Pam	26.83	92.91	Key well	92	6.38	DW	Alluvium	0.87	Private
Amaribari	26.82	92.73	Key well	83	11.38	DW	Alluvium	0.77	Private
Batasipur	26.81	92.45	Key well	106	7.55	DW	Alluvium	1.03	Private
Bedeti Sub centre	26.84	93.38	Key well	92		DW	Alluvium	0.82	Private
Bhumuraguri	26.61	92.85	Key well	94	15.3	DW	Alluvium	0.98	Govt.
Chacara Kachari	26.73	92.48	Key well	98	5.66	DW	Alluvium	0.97	Govt.
Chengai Gaon (Ward No.1)	26.9	93.63	Key well	74	3.55	DW	Alluvium	0.73	Private
Dalikathi	26.89	92.81	Key well	80	4.01	DW	Alluvium	0.69	Govt.
Difolu Chatra	26.88	93.76	Key well	62	4.06	DW	Alluvium	1.16	Private
Fatika	26.77	93.18	Key well	86		DW	Alluvium	0.93	Private
Gadharia Pattha (Gameria)	26.81	93.46	Key well	86		DW	Alluvium	1.2	Private
Gojoria Pathar	26.81	93.47	Key well	67	6.78	DW	Alluvium	0.82	Private
Gomiri Ghat	26.79	93.45	Key well	65	7.95	DW	Alluvium	0.75	Private
Gormara	26.77	92.52	Key well	79	7.69	DW	Alluvium	1.09	Private
Hathkhola	26.83	93.19	Key well	92		DW	Alluvium	0.69	Private
Hatijuri	26.87	92.98	Key well	100	3.41	DW	Alluvium	0.46	Private
Jokobari	26.75	93.13	Key well	78		DW	Alluvium	0.9	Private
Kettle Side	26.82	93.45	Key well	88	6	DW	Alluvium	1.04	Private
Khalihamari	26.73	92.83	Key well	73	5.23	DW	Alluvium	0.77	Private
Khonabari	26.77	92.51	Key well	81	4.7	DW	Alluvium	0.59	Private
Lakhipur	26.91	93.57	Key well	87		DW	Alluvium	0.8	Private
Lohitmukh	26.83	93.73	Key well			DW	Alluvium		Private
Madhupur Burburi	26.82	92.98	Key well	70	4.04	DW	Alluvium	0.76	Private
Missamari	26.85	93.46	Key well	69	4.78	DW	Alluvium	0.97	Private
Na Pamua	26.88	93.78	Key well	77	5.96	DW	Alluvium	1.03	Private

Name of Village/Site	Latitude	Longitude	Establishment date	RL (mamsl)	Total depth of Pz/Dw (mbgl)	Type (DW/Pz/Spring)	Aquifer group	Measurement point (magl)	Source/ Agency
Natun Dhandi	26.84	93.7	Key well	61	5.33	DW	Alluvium	0.95	Private
Niz Behali	26.79	93.37	Key well	82		DW	Alluvium	0.8	Private
Nonkey Gohpur	26.87	93.63	Key well	64	5.03	DW	Alluvium	0.95	Private
Old Missamari	26.81	92.6	Key well	88	5.36	DW	Alluvium	1.08	Private
Pabhoi	26.82	93.14	Key well	91		DW	Alluvium	0.68	Private
Panbari	26.77	92.47	Key well	107	4.36	DW	Alluvium	0.76	Private
Pholpholi (No 4)	26.74	93.19	Key well	85		DW	Alluvium	0.77	Private
Rajabari	26.84	93.67	Key well	61	5.26	DW	Alluvium	0.86	Private
Rajgar	26.79	92.85	Key well	80	4.45	DW	Alluvium	0.94	Private
Roumari	26.77	92.83	Key well	75	4.3	DW	Alluvium	0.75	Private
Singlijan (Ghaushala)	26.92	93.42	Key well	100		DW	Alluvium		Private
Sukhankutti	26.84	93.3	Key well	94		DW	Alluvium		Private

N. B.: (1)Private well means wells constructed by individual household, Tea Garden, Petrol Pump, Temple, Masjid, etc.

(2) Govt. well means well-constructed in the campus of govt. institution like PWD inspection bunglaw, police station, hospitals, panchayat, BRO, Forest and other water supply wells.

Table 2.2: Water level measurement of key wells

Location	Month & depth-to-water level				
	May-18	Jun-18	Aug-18	Nov-18	Mar-19
Pholpholi (No 4)	5.45			3.62	3.21
Jokobari	2.86			3.93	5.66
Fatika	3.57			3.81	3.62
Lakhipur	6.25			5	5.81
Gadharia Pattha (Gameria)	4.36			4.45	4.06
Singlijan (Ghaushala)	4.2			4.18	5.25
Bedeti Sub centre	1.5			2.44	2.18
Niz Behali	5.25			3.8	4.92
Sukhankutti	3.3			2.86	Well demolished
Pabhoi	1.52			3.1	2.82
Hathkhola	2.81			2.3	2.81
Kettle Side		2.11		3.1	3.35
Gomiri Ghat		6.28		6.2	7.18
Gojoria Pathar		5.06		4.18	3.96
Missamari		3.62		3.54	3.12
2no Itakhuli		2.77		2.8	2.32
Madhupur Burburi		1.9		3.1	2.94
Hatijuri		1.37		1.88	1.99
2no Chrisitan Basti		2.24		3.06	2.44
Agari Pam		4.72		2.83	2.44
Difolu Chatra		1.77		2.7	1.71
Na Pamua		1.78		3.83	3.16

Location	**Month & depth-to-water level**				
	May-18	Jun-18	Aug-18	Nov-18	Mar-19
Chengai Gaon (Ward No.1)		1.57		2.1	2.59
Nonkey Gohpur		1.5		3.12	2.67
Rajabari		3.54		4.43	3.74
Natun Dhandi		3.06		3.96	3.73
Lohitmukh		1.93			4.62
Rajgar		3.25		3.23	2.80
Roumari		2.75		2.62	2.55
Khalihamari		3.86		3.58	3.20
Bhumuraguri		15		14.45	14.02
Chacara Kachari		3.93		4.4	4.13
Panbari		3.48		4.16	3.44
Batasipur		3.44		4	5.32
Khonabari		4.16		4.39	4.11
Gormara		5.8		5.93	5.07
Old Missamari		3.25			2.65
Amaribari		8.02		7.56	8.71
Dalikathi		2.67		1.87	2.59
Bihupukhuri	8.21			6.09	7.90
Biswanath Ghat	8.36			4.67	8.74
Borgang New				Well demolished	3.88
Buroighat	2.8			1.93	2.82
Gohpur New				Well demolished	1.57
Helem	2.23			1.60	2.39
Kolabari				0.66	1.15
Behali	4.81			2.74	5.37
Kheroni	2.97			1.63	2.66
Hawajan					2.54
Biswanath Chariali	9.49			7.40	9.34
18th Mile	3.05			1.70	2.68
Balipara	1.59			1.60	1.94
Barchola	2.99			1.81	2.93
Charduar	3.34			2.83	3.38
Dhalaibil				3.55	3.75
Dhekiajuli	4.14			3.00	4.07
Garumari/Ghoramari	2.45			2.02	3.25
Jamuguri North	2.19			1.47	2.82
Na Pam	1.97			1.33	2.14
Sootia				Well demolished	2.18
Porua chariali, Tezpur	6.45			6.20	7.19
Thelamara	3.48			2.16	3.58
Tolakbari	2.38			3.03	3.83
Tupia	5.74			4.01	5.43

Soil Infiltration studies: Infiltration test

Salient features of the test sites are provided in Table 4.1 &4.2. A perusal of the table shows that the tests have been conducted only in barren land and the soil types encountered in the sites are sand admixtures. The infiltration test was conducted for 145 mins. The initial infiltration

Table 2.3: Salient features of the test sites

Site	Location	Land use	Soil type	Latitude	Longitude
Gar Bhitar, Biswanath	PHED Water Supply Campus, Gar Bhitar	Barren Land	Clay loam	26˚41’18.59” N	93˚04’8.67” E
Bedeti		Barren Land	Clay loam	26˚50’56.7” N	93˚23’01” E
Gopalpur	In college campus	Barren Land	Sandy loam	26˚53’43.6” N	93˚39’37.8” E
Amlaiguri		Barren Land	Sandy loam	26˚55’15.2” N	93˚36’40.7” E
Dulung Basti		Barren Land	Clay loam	26˚51’46.7” N	92˚47’17.8” E
Dhekiajuli		Barren Land	Sandy soil	26°42'08" N	92°28'28" E

Table 2.4: Summary of Infiltration Test

Site	Land use	Soil type	Infiltration rate (mm/hr)	Duration of test (min)	Total Quantum of water added in m	IF = (4)/ (6) *100)
Gar Bhitar, Biswanath	Barren Land	Clay loam	6	130	240	2.5
Bedeti	Barren Land	Clay loam	9	130	230	3.9
Gopalpur	Barren Land	Sandy loam	30	140	218	13.76
Amlaiguri	Barren Land	Sandy loam	24	120	160	15
Dulung Basti	Barren Land	Clay loam	6	120	252	2.4
Dhekiajuli	Barren Land	Sandy soil	12	120	200	6

Water Quality: To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilisation, and existing quality data of CGWB (Figure.13) were collected. Water samples were collected from monitoring wells for detailed, iron, heavy metals and arsenic.

Geophysical survey: No geophysical survey was carried out in the district before and during NAQUIM study.

Exploratory Drilling: During AAP 2018-19 exploration activity initiated in the district focussing mainly to cover unexplored Pub-Chaiduar block and also in Biswanath block adjacent to river Brahmaputra and three exploratory wells and three observation wells were constructed in the area.A list of wells constructed in the area was prepared incorporating location, well designs, etc. Distribution of wells in the district is shown in Fig. 2.1.

Table 2.6: Details of exploratory wells in Sonitpur District, Assam

Village/ Location	Taluka/ Block	Toposheet No.	Lat	Long	Type of well	Depth (m)	Dia (mm)	Source/ Agency
Erabari	Rangapara	83I/3	92.57	26.7	TW	300.8	Housing: 304.8mm Casing: 152.4mm	CGWB
Singri	Barchola	83I/3	92.48	26.61	TW	89	Housing: 304.8mm Casing: 152.4mm	CGWB
Palasbasti	Dhekiajuli	83I/3	92.45	26.7	TW	162	NA	CGWB

Village/ Location	Taluka/ Block	Toposheet No.	Lat	Long	Type of well	Depth (m)	Dia (mm)	Source/ Agency
Napum	Balipara	83I/3	92.86	26.69	TW	51	Housing: 304.8mm Casing: 152.4mm	CGWB
Rakhyasmari	Dhekiajuli	83I/3	92.39	26.78	TW	58.1	NA	CGWB
Telengonia	Behali	83I/3	93.35	26.79	TW	121.31	Housing: 254.0mm Casing: 152.4mm	CGWB
Karigaraj	Chaiduar		93.50	26.88	TW	150.99	Housing: 304.8mm Casing: 152.4mm	CGWB
Dagaon	Rangapara	83B/10	92.59	26.72	TW	201.68	Housing: 304.8mm Casing: 152.4mm	CGWB
Missamari	Rangapara		92.60	26.82	TW	201.4		CGWB
Sijubari	Baghmari	83F/1	93.21	26.79	TW	118	Housing: 304.8mm Casing: 152.4mm	CGWB
Dekargaon	Balipara	83B/14	92.75	26.68	TW	82	Housing: 304.8mm Casing: 152.4mm	CGWB
Jamuguri	Na Duar		92.93	26.73	TW	152.33		CGWB
Japoriguri	Biswanath		93.18	26.74	TW	109.5	Housing: 203.2mm Casing: 152.4mm	CGWB
Tolakbari	Naduar		92.96	26.7	TW	137.5	Housing: 203.2mm Casing: 152.4mm	CGWB
Behali	Behali		93.40	26.9	TW	152.4	Housing: 254.0mm Casing: 152.4mm	CGWB
Gohpur	Pub Chaiduar		93.66	26.9	TW	119.9		CGWB
Gar Bhitor	Biswanath		93.16	26.68	TW	49		CGWB
Tupia	Naduar		92.90	26.82	TW	85	Housing: 254.0mm Casing: 152.4mm	CGWB
Udmari	Balipara		92.78	26.84	TW	82	Housing: 304.8mm Casing: 152.4mm	CGWB
Panigaon	Naduar		92.93	26.75	TW	88.4		CGWB
Samar Doloni	Sootea	83B/14	92.99	26.71	TW	110	Housing: 304.8mm Casing: 152.4mm	CGWB
Buragaon	Balipara		92.81	26.84	TW	91	Housing: 304.8mm Casing: 152.4mm	CGWB
Borpukhuri	Rangapara		92.61	26.68	TW	TW	Housing: 304.8mm Casing: 152.4mm	DGM
Biswanath Chariali	Biswanath		93.13	26.72	TW	TW	Housing: 300.0mm Casing: 200.0mm	DGM
Debendra Nagar	Balipara		92.82	26.73	TW	TW	Housing: 203.0.0mm Casing: 152.4mm	DGM
Khalihamari	Rangapara	83B/9	92.68	26.7	TW	TW	Housing: 304.8mm Casing: 152.4mm	DGM
Pithakhowa	Bihaguri	83B/10	92.67	26.66	TW	TW	Housing: 304.8mm Casing: 152.4mm	DGM
Phulguri	Rangapara	83B/9	92.65	26.76	TW	TW	Housing: 304.8mm Casing: 152.4mm	DGM
Tezpur	Gabharu		92.79	26.63	73.81	TW	Housing: 203.0.0mm Casing: 152.4mm	DGM
Panch-mile	Gabharu		92.82	26.65	TW	TW	Housing: 304.8mm Casing: 152.4mm	DGM
Besseria	Balipara		92.75	26.66	TW	TW	Housing: 304.8mm Casing: 152.4mm	DGM
Halleshwar	Balipara		92.78	26.71	TW	TW	NA	DGM

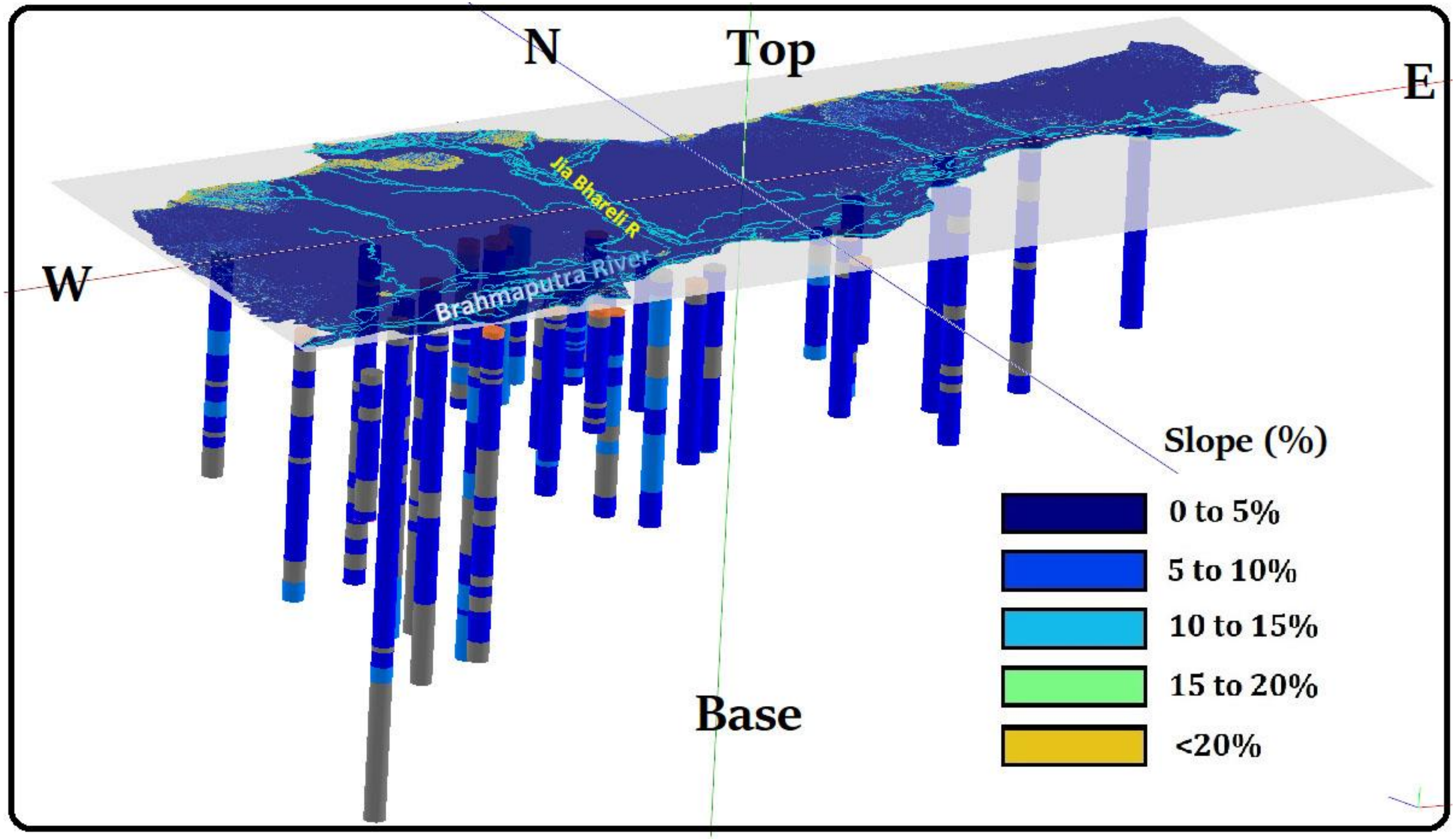


Fig. 2.1: Distribution of wells in Sonitpur District, Assam

CHAPTER 3.0

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Data Interpretation

The subsurface geology of Sonitpur District is interpreted based on exploration data of Central Ground Water Board (CGWB) and exploration data of Directorate of Geology & Mining, Govt. of Assam.

The drilling depth of CGWB's exploratory well ranges from 49 to 300.8 mbgl whereas DGM's exploratory well depth ranges from 62.7 to 214.11 mbgl. Distribution of well as per drilling depth indicates that 35% of exploratory wells depth ranges from 50 to 100mbgl (Table 3.1).

Table 3.1: Distribution of EW based on drilled depth.

Depth	within 50m	50- 100m	100-150	150-200	200-250	250-300	Total
No. of wells	1	12	10	5	5	1	34
% of well	3	35	29	15	15	3	100

Subsurface lithologs are mostly belonged to younger alluvium.

The available data indicate presence of one principal aquifer in the district, viz., alluvium of unconsolidated nature of Quaternary age. The sandstone of Tertiary age, i.e., Siwalik is found in the northern boundary of the district bordering Assam. Siwalik forms structural hills with slope more than 20%. It mainly acts as a run-off zone. The Archean inselbergs are found in the southern part of the district at Singri, Tezpur and Biswanath. The Archaean is also struck in the sub-surface at Singri which is located towards south west of the district. However, the groundwater potentiality of the basement is yet to be explored.

From the examination of this litholog it is observed that down to a maximum explored depth of 300.8m the sequence is dominated by gravel, sand, clay and boulders. The major aquifer of the district is younger alluvium.

3.1.1 Data Integration

Lithologic units of the district are grouped according to size of alluvial materials. The sand and gravels are grouped together into sand and gravel aquifer as two size factions generally occurs together. The pebble, cobble and boulder are grouped as boulder aquifer. Clay in the district generally occurs as sandy clay and hence all clays are grouped into clay.

3.1.2 Aquifer Disposition

Sonitpur district is located in between Arunachal Himalayas in the north and the Brahmaputra river in the south. Isolated Archean inliers are found in the south from Biswanath to Singri. The extension of Archaean basement from southern inliers up to the Siwalik ridges in the north is established by the magnetic and gravity surveys by the Oil and Natural Gas Commission (Viswanathan, et.al., 1972). The alluvial sediments were deposited over the basement. The coarsest sediments, i.e., the traction load fraction of the south flowing rivers emerge from Arunachal Himalayas were deposited over piedmont surface due to break in slope. The finer materials were deposited in nearly the flat terrain towards the south. Presence of boulders in isolated places in the south may indicative of its provenance lies towards the south, i.e., the Archaean inliers or inselbergs.

Following sections are constructed to show the 2D disposition of aquifers in the district.

(i) Northeast-southwest section : from near piedmont to alluvial plain on the left bank of Jia-Bhareli river

Presence of boulder zone ranging in size from pebble to boulder is observed in this section. This boulder zone is dominated in the section towards the northern part of the section in the Lokra well situated close to the piedmont zone. The thickness of the boulder zone decreases in the section towards the south and in Missamari EW this zone is totally missing. However, occasional pebbles are found in the Missamari EW. This zone reappears in Rakhaysmari EW at 43m and 86m depths. Rakhayasmari EW is situated near the piedmont. Grey colour clay bands struck at various depths in the southern wells which are missing towards the north. Down to a depth of 100m clay appears as lenses (Fig. 3.1).

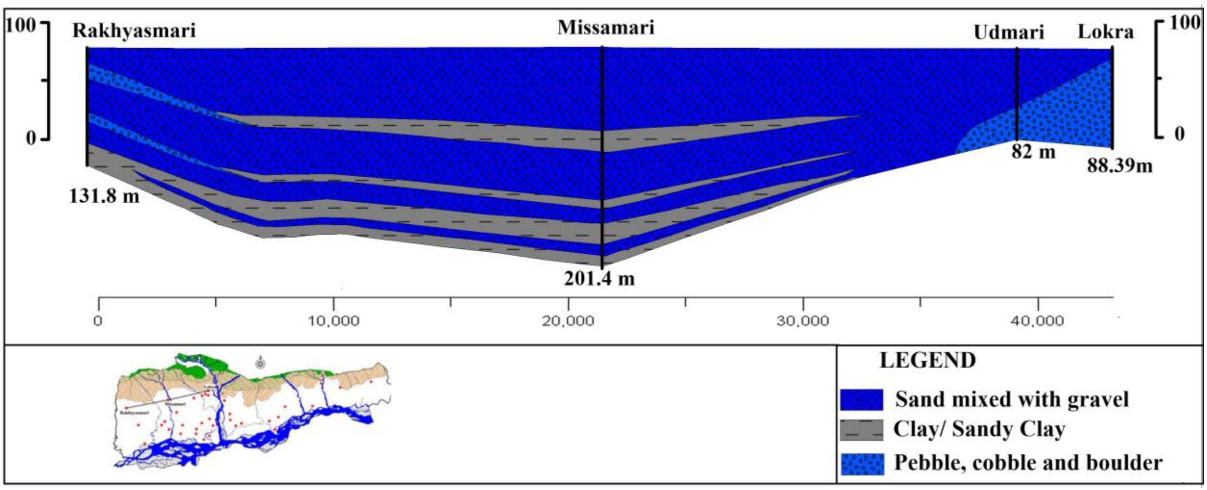


Fig.3.1: Disposition of aquifer along the piedmont from northwest to northeast on the right bank of the Jia Bhareli River, Sonitpur district, Assam

(ii) Northwest- southeast section close to the piedmont on the right bank of Jia-Bhareli River: The boulder zones are absent towards the eastern part of the district close to the piedmont zone. The lense shaped grey colour clay beds which appear in the western side of the district are absent in the eastern direction barring the lense shaped clay observed in Karigaraj EW at the bottom (Fig.3.2). The aquifer materials are sand mixed with gravel.

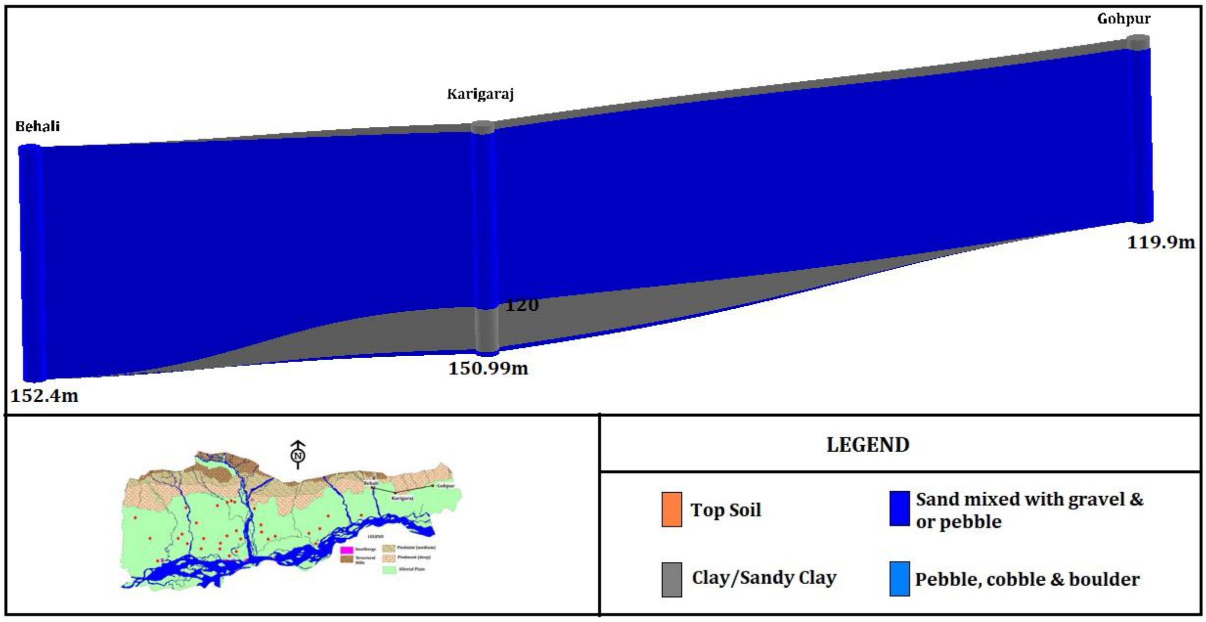


Fig.3.2: Disposition of aquifer along the piedmont in the eastern part of Sonitpur district, Assam

(iii) Northwest-southeast section in the alluvial plain: This section indicates that the aquifer materials in the alluvial plain are dominated by sand mixed with gravel with occasional presence of pebbles (Fig. 3.3). Presence of bouldery zones is noticed in the northwestern part close to the piedmont. Bouldery zone presence is also noticed in the Sijubari EW which is located eastern part of the district. Clay occurs as lenses within 100m depth in the entire section. However, beyond 100m clay is dominated in the western part the district or right bank of Jia Bhareli river.

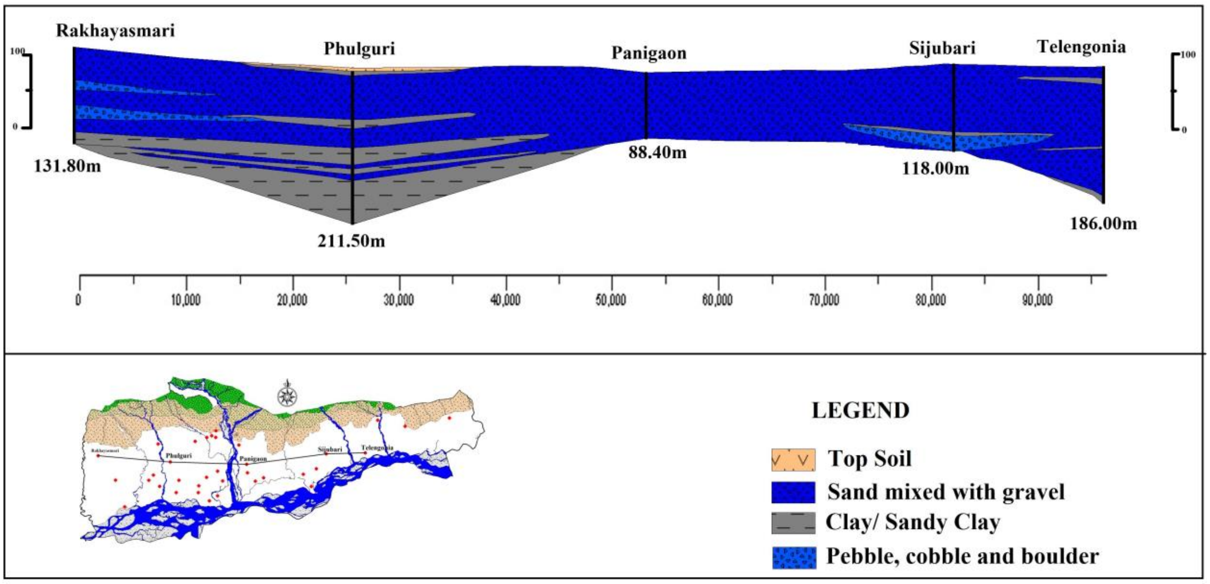


Fig. 3.3: Disposition of aquifer from northwest to southeast of Sonitpur district, Assam

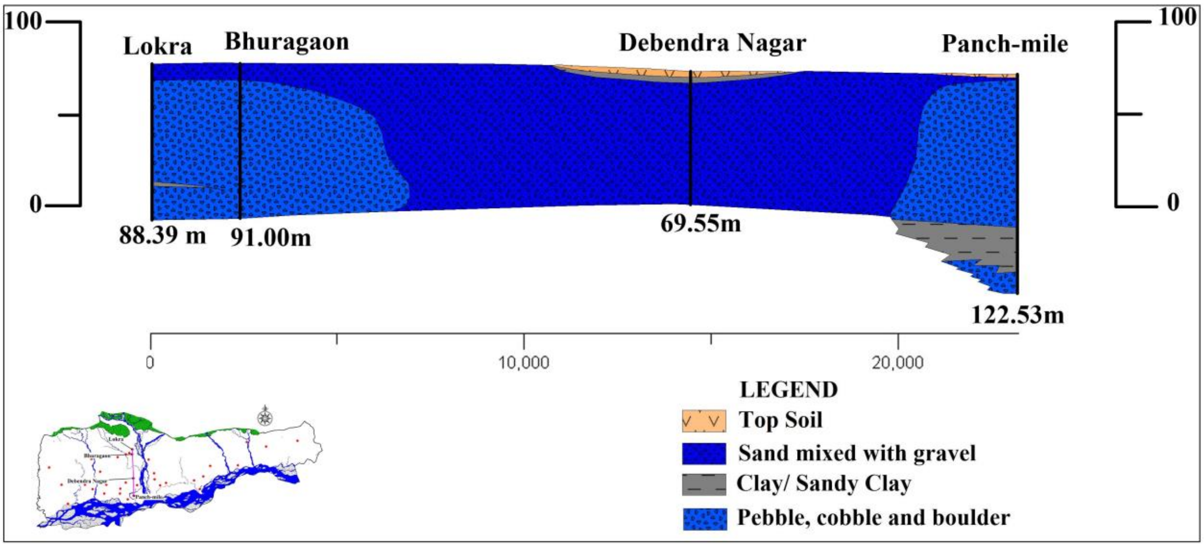


Fig. 3.4: Disposition of aquifer along the right bank of Jia Bhareli River

The sediments along the right bank of Jia Bhareli river is dominated by boulders in the northern part near piedmont and in the southern part near ancient Bhareli river (Fig.3.4).

3D disposition of aquifer: The fence diagram and 3D aquifer model of the district indicate that the subsurface formation close to the piedmont is dominated by pebble, cobble and /or boulder. This zone is encountered within 15m at around Lokra, Charduar area and the zone is pinched out towards the alluvial plain/flood plain. The pebble, cobble and bouldery zone reappears in the south near inselberg. This zone encounters at around 20m depth at Napam, Panchmile, Halleshwar areas near Tezpur and also at Biswanath Charali. This zone is found to encounter at isolated locations like Jamuguri, Sijubari area at shallow depth. The sub-surface formation in the alluvial plain is dominated by sand mixed with gravel in various proportions. Six clay layers are found to present in the sub-surface. Clay layers thickness ranges from 5 to 60m. Maximum thickness of clay layers are found in the west central and north western parts of the district. However, clay in the subsurface are very localized as evident from 3D model and also in fence diagram (Fig. 3.6, 3.7 & 3.8).

The clay is very less towards the eastern part of the district. Archean gneissic or granitic basement is encountered in the south-western corner of the district in the Singri EW which marks the vertical extension of the alluvial aquifer in the district.

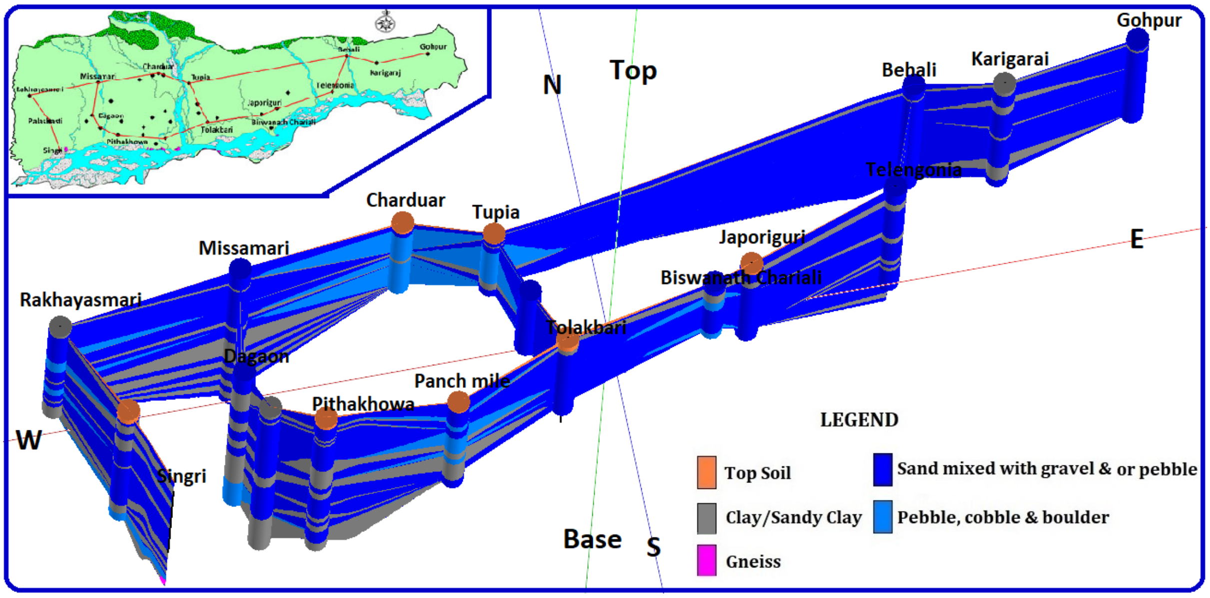


Fig. 3.5: Fence diagram of the sub-surface formation of Sonitpur district, Assam

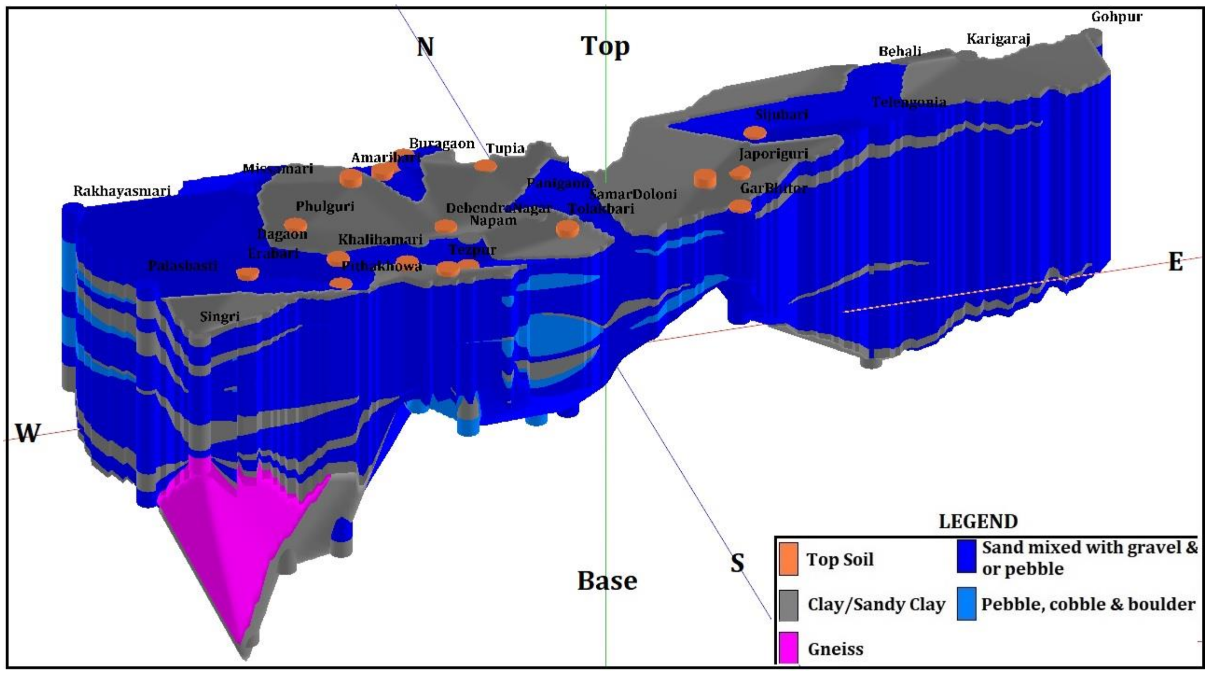


Fig. 3.6: 3D view of aquifer disposition

3.1.3 Aquifer Characteristics

Unconsolidated alluvial aquifer consists of older and younger alluvium. Older alluvial aquifer is found towards north in the piedmont zone.

The alluvial aquifer is characterized by coarse grained materials ranging in size from gravel to boulder. Bouldery zones are encountered in the area close to piedmont and some areas in the south near ancient Bhareli river and also near Archaean inliers, like Halleshwar, Na Pam, Panch-Mile, Jamuguri and Biswanath. Aquifer in the district is generally sand dominated mixed with gravel and at places pebble down to a depth 150m, below which clay content increases. Size of the aquifer materials generally decreases towards north. Broadly the aquifer in the district can be classified into two groups for ground water extraction purposes, viz., shallow aquifer and deeper aquifer. Shallow aquifer depth limit is 50m and below which deeper aquifer exists. The cumulative thicknesses of both shallow and deeper aquifers are given in Table 3.2.

Table 3.2: Granular zones encountered in exploratory wells in Sonitpur District, Assam

Village/ Location	Drlled Depth (m)	Zones Encountered	Cummulative thickness of granular zones (m)		Village/ Location	Drlled Depth (m)	Zones Encountered	Cummulative thickness of granular zones (m)	
			GL to 50	50 to 300m				GL to 50	50 to 300m
Gar Bhitot	49	1.00-49.00	48		Biswanath Chariali	75.8	18.90-50 50-75.8	31	26
Gohpur	119.9		NA		Behali	152.4	12.19-50	38	102
Napum	51	1.0 - 51.0	15				50-152.4		
Sijubari	118	7.00-91.00 110-118	43	2	Debendra Nagar	69.55	0-50	50	20
Dekargaon	82	20.30-28.00 40.00-82.00	18	32			50-69.565		
Missamari	201.4	9-26/32-35 37-40/60-62 /65-67/69-81 / 83-85/87-90 /94-100/101- 117 /119-121/ 123-126/131- 134/135-139/ 145-162/164- 166/168-169 174-176 179-198	23	94	Erabari	300.8	50-82.8 86.3-94.5 106.3-112.8 115.2-128 137-151 167-183 198-207 241-248	36	106
Phulguri	211.5	9.90-39.90 47.1-50.3 50.30-68.9 81.3--87.5 102.9-106.1 130.9-133.9 143.3-149.5 210.5-211.5	30	39	Pithakhowa	198.86	3.81-21.96, 25.01-28.06, 34.16-50, 50-70.76 99.43-107.36 119.56-147.01 168.36-177.51	37	56
Samar Doloni	110	6 -46 65-82 85- 110	40	42	Borpukhuri	214.11	3.66-9.45/ 12.81- 50/50- 92.11 150-165.31	43	57
Telengonia	186	7-14/ 24-38 42-50/50-68 126-152 168-172	29	48	Dagaon	201.68	10.9-24.7 49-68, 82-97 108-121	15	56
Besseria	92.05	6.7-8.84/ 12.19- 49.37/ 49.37- 92.05	40	42	Tezpur	73.81	9.6-21.96/ 27.755-49.41/ 49.41-55.10/ 69.845-73.81	35	9

Village/ Location	Drlled Depth (m)	Zones Encountered	Cummulative thickness of granular zones (m)		Village/ Location	Drlled Depth (m)	Zones Encountered	Cummulative thickness of granular zones (m)	
			GL to 50	50 to 300m				GL to 50	50 to 300m
Bhuragaon	91	0-30/30-50/ 50-62/ 65-91	50	38	Lokra	88.39	2.43-12.19/ 12.19-45.72/ 45.72-68.27/ 70.10-88.39	48	37
Udmari (Balipara)	82	5-30; 32-33; 34-50; 50-55; 55-67; 69-80	42	28	Amaribari	99	5-27/39-50/ 50-71/74-84 / 93-96	33	34
Karigaraj	151	5-12/ 42-50/ 50-72/76-82/ 86-95/ 96-110 112-120	15	59	Tupia	85	1-4.5/8.5-10/ 16-50/ 50-54/ 66-68/ 75-85	39	16
Jamuguri	152.33	4.5-43 62-78 83-103 131-151	39	56	Japoriguri	109.5	12.50-15.75 25.00-31.25 37.50-47.00 50-75 81.25-90.75 106.25-109.5	19	37.75
Singri	88	6-19.75 29.5-50 50-63.5	34.25	14	Panch mile	122.53	1.7-18.9; 18.9-32.21; 35.97-38.4; 43.28-50; 50-67.66; 76.81-84.43	39.78	25.28
Panigaon	88.4	6.3-37.8 37.8-50 50-63.3 82.0-85.8	37.8	17.1	Tolakbari	137.5	12.50-46.75/53-62.5/ 62.5-65.5/ 65.5-87.5/ 90.75-97.0	34.25	40.75
Palasbasti	162	6.5-10.5 23-33 56.5-75.25 91-78.5 97.25-109.75	14	44	Khalihamari	211	3.7-12.8 15.8-34.1 40.2- 50 50-82.9/ 86-89 98.2-113.4 147-159.1 162.1-165.2 183.6-211	34.7	94

Shallow Aquifer Zones

The granular zones occurring down to a depth of 50m depth can be categorized as shallow aquifer zones. Cumulative thickness of granular zones within 50m varies from 15 to 49m (Table 3.2). It is observed that lowest thickness of this zone is found towards western part of the district near Palasbasti. Shallow aquifer zones are quite prolific as evident from construction of numbers of dug wells and shallow tube wells for domestic and irrigation purposes. The shallow tube wells are constructed down to a depth of 30 to 40m, tapping 6 to 15m granular zones, give discharge of 10 to 36m^3/hr for draw down of less than 2m.

CGWB had constructed two shallow tube wells at Napam and Garbhitor Gowatoli. The exploratory well at Napam was constructed down to a depth of 45m, tapping 15m granular zone give discharge of 45m^3/hr for a drawdown of 2m.

Aquifer characteristics of shallow zone: The aquifer materials of this zone are generally sand and gravel. Pebble, cobble and even boulders are encountered towards north of the district along both the banks of the Jia Bhareli river and towards south of the area near Tezpur. Groundwater occurs under unconfined to semic-confined condition. The storativity value of this unit 5.7x10^{-3}. Transmissivity varies from 1244.62 to 3624m^2/day. Discharge of tube wells tapping this aquifer unit varies from 19 to 45m^3/hr for drawdown of 2.0m. Hydraulic conductivity of this unit varies from 52.8 to 90m/day (Table 3.2).

Table 3.2: Aquifer properties of shallow aquifer zone

Village	Depth (m)	SWL (m bgl)	Draw down (m)	Transmissivity (m2/day)	Permeabilty (m/day)	Storativity/ S.Yield	Specific Capacity (lpm/m of dd)	Discharge (m3/hr)
Gar Bhitot	49			NA	NA	NA	NA	
Napum	51	1.06	2.09	3624	90	5.7X10^{-3}	356.94	44.76
Tezpur	73.81	3.785	1.025	1244.62	52.805		699.93	43.05

Deeper Aquifer Zone: The cumulative thickness of deeper aquifer zones beyond 200m could not be ascertained throughout the district, as sometimes drilling was not possible to continue up to the desired depth with direct rotary rig due to presence of pebbles and boulders at shallow depth. However based on the available information it can be confirmed that 70 to 80m cumulative thickness of granular zones are available except in the areas near the inselbergs. At Singri bedrock encountered at 88m depth.

The aquifer zones below 50m are in most cases are continuation of shallow zones (Table 3.3). The zones are generally sandy mixed with gravels with various proportions. Bouldery zones are found in isolated areas. Grey colour clay of considerable thickness is present towards the western part of the district. However, the clay layers are very localized. Its extension is not found in nearby wells.

Groundwater within this depth range occurs under semi-confined to confined condition as storativity value ranges from 2.7x10^{-3} to 7.36x10^{-5}. Transmissivity value ranges from 129 to 5515m^2/day. Discharge varies from 27m^3/hr to 487m^3/hr. for drawdown of 1.48 to 12.53. Drawdown more than 10m is found in Missamari and Phulguri area due to poor sorting and clayey sand nature of aquifer materials. Permeability varies from 13 to 174m/day except in Missamari area where the value is 4m/day.

Table 3.3: Aquifer properties of deeper aquifer zones

Village/ Location	Depth (m)	Zones tapped (m)	SWL (mbgl)	Draw down (m)	Transmissivity (m2/day)	Storativity / S. Yield	Permeabilty (m/day	Discharge (m3/hr)
Bhuragaon	91	39-42, 46-52, 59-62, 66-69, 76-82	2.55	8.68	1331		22	72

Borpukhuri	214.11	56.60-64.41 67.58-70.79 74.57-92.01	5.65	6.36	4950.5	$5x10^{-5}$	174	168.8
Dekargaon	82	50-62; 65-77	0.68	1.6	4969	$7.4X10^{-3}$	80	91.08
Telengonia	186	50-62 130-148	3.64	4.81	4157	-	80	281
Lokra	88.39	49.43-67.37, 71.27-83.58						
Charduar	99.00	65.73-94.25	3.66	6.096				0.146
Karigaraj	150.99	53-65 77-83 87-93 102-108 113-119	4.69	2.9	1347.32	-	17.5	487.35
Samar Doloni	110	68-80; 89-104	4.35	2.38	5515		64	81.07
Dagaon	201.68	53-65; 85-94; 109-118	6.38	2.75	1353	2.7x10-3	29	420
Jamugurihat	152.33	64-76; 88-100	1.25	1.48	2372	$9.9X10^{-4}$	69	27
Besseria	92.05	38.86-79.32		2.93	3039.38		75.12	120.24
Khalihamari	211	43.16-48.04 57.17-61.42 70.41-81.20		8.06				164.6
Phulguri	211.5	25.69-38.96 48.86-59.47 63.74-69.02 82.86-87.28	3.56	10.34	526.11	$6.08X10^{-4}$	15.67	164.6
Singri	89	35-50 & 56-62	2.5	2.3	360.14		13.12	41.58
Panigaon	88.4	36-42; 45-51; 83-86	3.33	2.076	1247.29	$1.52X10^{-4}$	83.15	42.48
Rakhyasmari	58.1	48-58; 68-72; 87-93		5.67	595	$3.4x10^{-3}$		77
Tolakbari	137.5	37-43; 64-67; 92-95	1.53	1.5	4633.88	$5.65X10^{-4}$	308.93	37.93
Pithakhowa	198.86	34.973-70.35		6.13	6632.96	$4X10^{-3}$	187.47	228
Japoriguri	109.5	40-43 63-66 83-86	7.26	1.559	1955	$1.11X10^{-4}$	109	37.24
Tupia	85	42-54; 77-83	4.025	4.582	705.73			34.47

Village/ Location	Depth (m)	Zones tapped (m)	SWL (mbgl)	Draw down (m)	Transmissivity (m2/day)	Storativity / S. Yield	Permeability (m/day	Discharge (m3/hr)
Missamari	201.4	37-40; 71-80; 95-118; 135.5-138.5; 173-176; 182-194	3.5	12.53	129		4.3	64.74
Palasbasti	162	26-32; 60-72; 83-89; 102-108	3.30	2.30	1166.00	$7.36x10^{-5}$	19	58.38
Erabari	300.8	45.45-58; 70.46-79.46; 88.3-94.55; 106.49-112.7 118.9-125; 138.8-145	6.10	6.265	4196		63	174.72
Udmari	82.0	56-68, 72-78	0.84	17.92	78.29		4.35	19.26

3.2 Ground water level of shallow aquifer zone

CGWB, NER has 25 nos. of groundwater monitoring stations in the district. During NAQUIM study 41nos. of key wells were established covering most of the blocks of the district. During AAP 2018-19, water level of the GWMS was measured four times in a groundwater year. The key wells were established in May and June 2019 and the water levels of the key wells were monitored during November 2018 and March 2019. Water level data of the district were summarized in Table 3.3.

Table 3.3: Pre- and post-monsoon depth-to-water level and fluctuation of water level

SN	Block	Pre-monsoon DTW (mbgl)	Post-monsoon DTW (mbgl)	Fluctuation(m)
1	Borchola	2.14 to 2.93	1.33 to 1.81	0.81 to 1.12
2	Dhekiajuli	3.44 to 5.32	2.97 to 3.95	0.01 to 1.37
3	Rangapara	2.65 to 3.58	2.16	1.42
4	Gabharu	7.19 to 14.02	6.2 to 13.47	0.99 to 1.85
5	Balipara	1.94 to 8.71	1.6 to 6.74	0.29 to 1.97
6	Na Duar	2.44 to 5.43	1.42 to 4.01	0.2 to 1.42
7	Sootea	1.99 to 2.94	1.64	0.2 to 1.71
8	Biswanath	5.66 to 9.34	3.03 to 7.4	1.94 to 2.64
9	Sakomatho	2.86	2.82	0.04
10	Baghmara	2.81 to 8.74	2.86 to 6.09	0.3 to 4.07
11	Behali	2.18 to 5.37	1.62 to 3.0	0.56 to 2.63
12	Chaiduar	1.57 to 7.18	1.6 to 4.18	0.55 to 5.12
13	Pub Chaiduar	1.15 to 5.81	0.66 to 4.2	0.17 to 1.61

The pre-monsoon water level in the piedmont varies from 1.99 to <17.53mbgl, in the older alluvium it varies from 1.57 to 9.34mbgl and in the younger alluvium it varies between 1.15 to 4.62mbgl. In the structural valley and weathered pediplain pre-monsoon DTW is 7.34 mbgl and 8.74 mbgl respectively. (Table 3.3 & Fig.3.7).

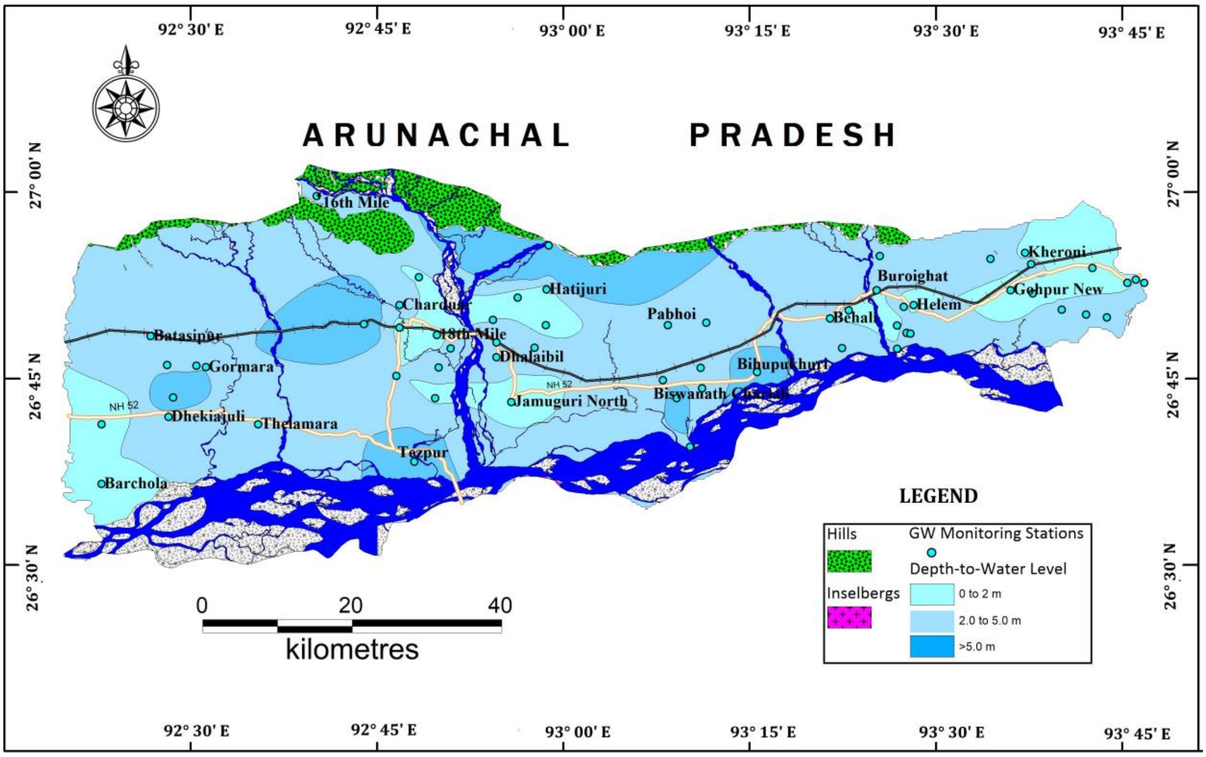


Fig. 3.7: Pre-monsoon DTW level contour of phreatic aquifer of Sonitpur District, Assam

The post-monsoon water level in piedmont zone varies from 1.36 to 15.82 mbgl, in older alluvium it varies from 1.64 to 7.40mbgl and in the younger alluvium 0.66 to 4.18mbgl. In the structural valley pre- and post-monsoon DTW is 7.34 and 2.35mbgl respectively. In the structural valley and weathered pediplain post-monsoon DTW is 8.74 mbgl and 4.67mbgl respectively (Table 3.3 & Fig.3.8).

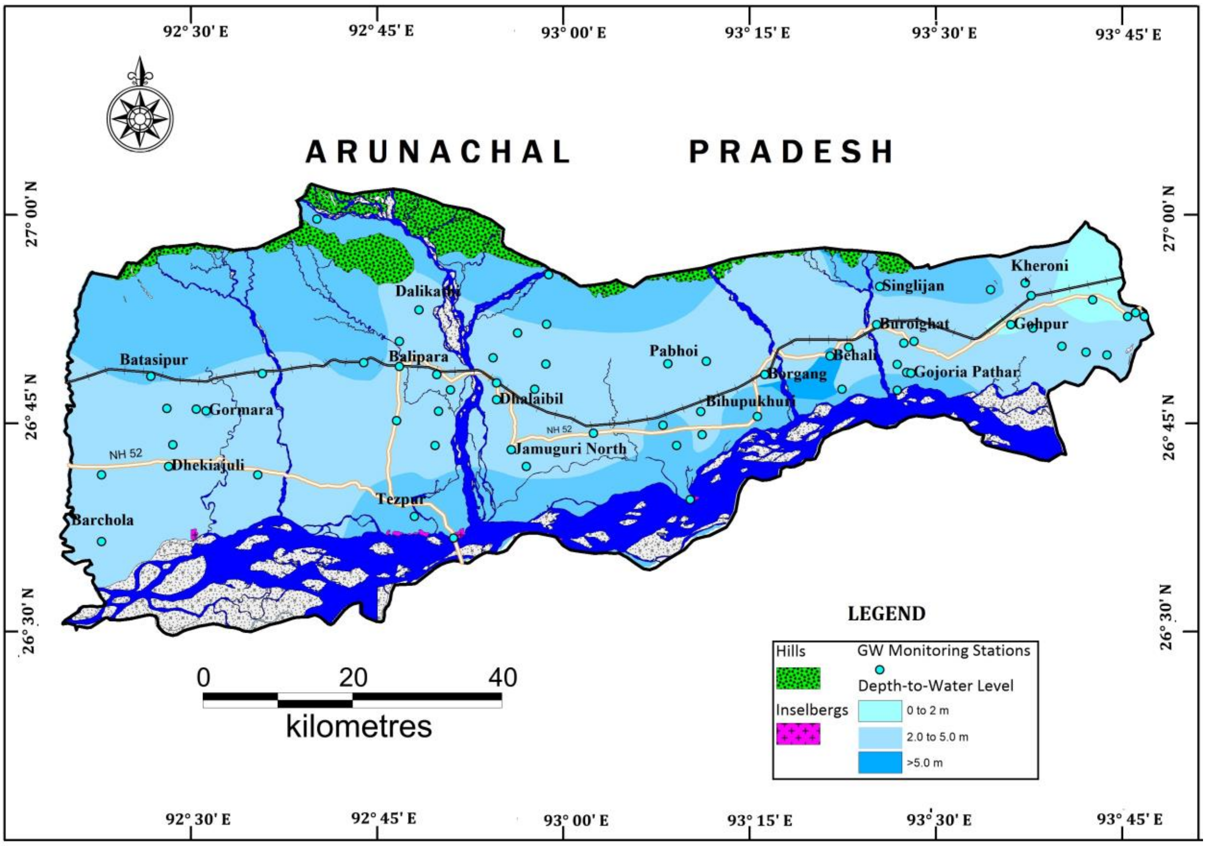


Fig. 3.8: Post-monsoon DTW level contour of phreatic aquifer of Sonitpur District, Assam

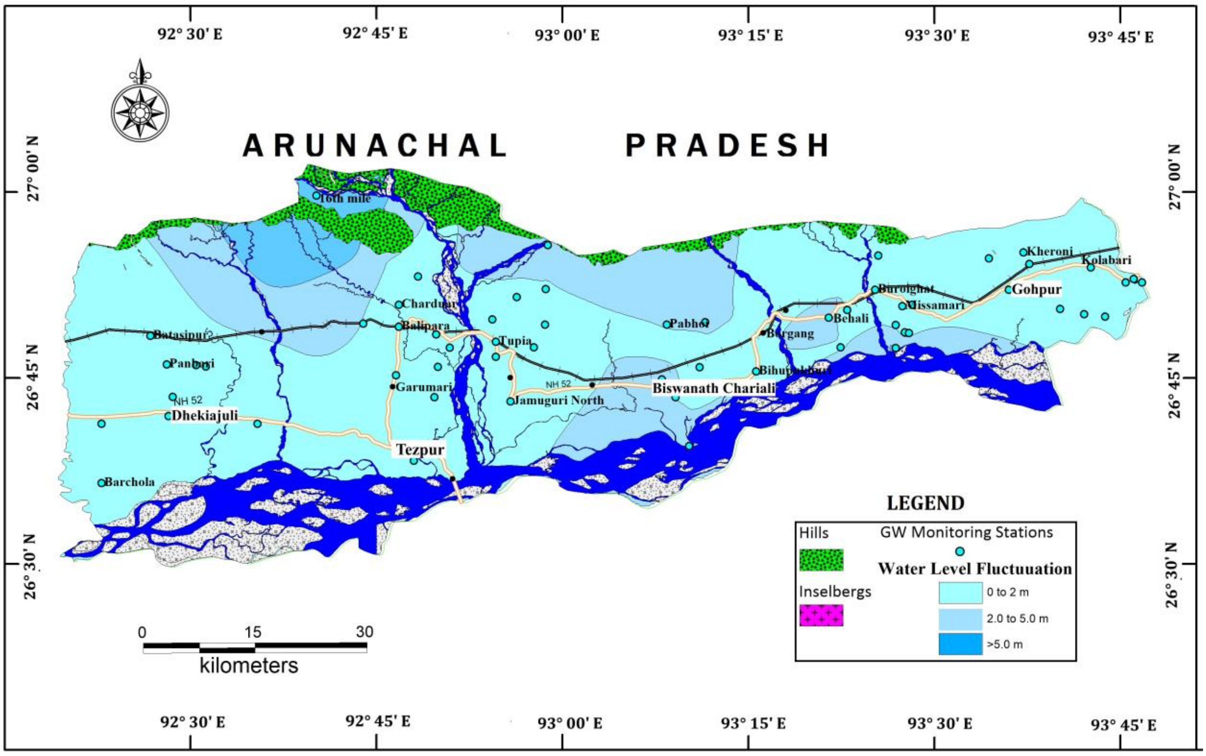


Fig.3.9: Water level fluctuation of phreatic aquifer of Sonitpur District, Assam

Fluctuation of water level in the piedmont zone is 0.68 to 1.71m while in alluvial plain water level fluctuates between 0.01 to 5.12m. The water level fluctuation in the structural valley and in the weathered pediplain is 4.95 and 4.07m respectively (Table 3.3 and Fig.3.9).

Ground Water Movement: The water table contour of phreatic aquifer has been prepared based on water level data with respect to elevation of ground water monitoring stations from mean sea level (Fig. 3.9). The contour map shows that water table contour of Sonitpur district varies from 130m to 70 m above mean sea level (Fig.3.10). In general groundwater movement is towards south, i.e., toward the river Brahmaputra and conforms to the general topography of the district. The Jia-Bhareli and other tributaries of the Brahmaputra are effluent in nature, i.e., they receive ground water.

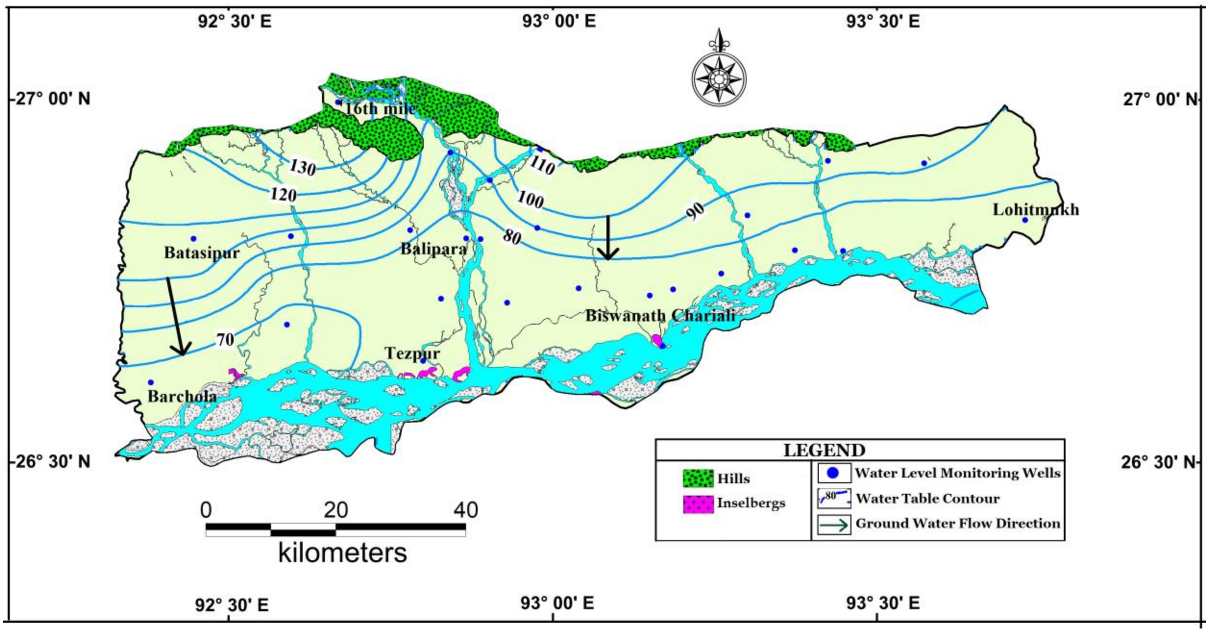


Fig. 3.10: Water table contour of Sonitpur District, Assam

Water level trend analysis

For analysis of long-term behaviour 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 shown in Figure 3.11 and Table 3.4.

Table 3.4 Trend of Water levels in GWMS Wells

SN	Well No	Locality/Name	No. of years	Water Level Trend	
				Slope	Remark
1	ASSP 25	Buroighat	5	0.072	Rise
2	83F2A8	Bishwanath Ghat	10	0.121	Rise
3	83B1D1	Charduar	10	-0.028	Fall
4	83B2D2	Tezpur	10	0.010	Rise
5	83B2B5	Barchala	10	-0.004	Fall

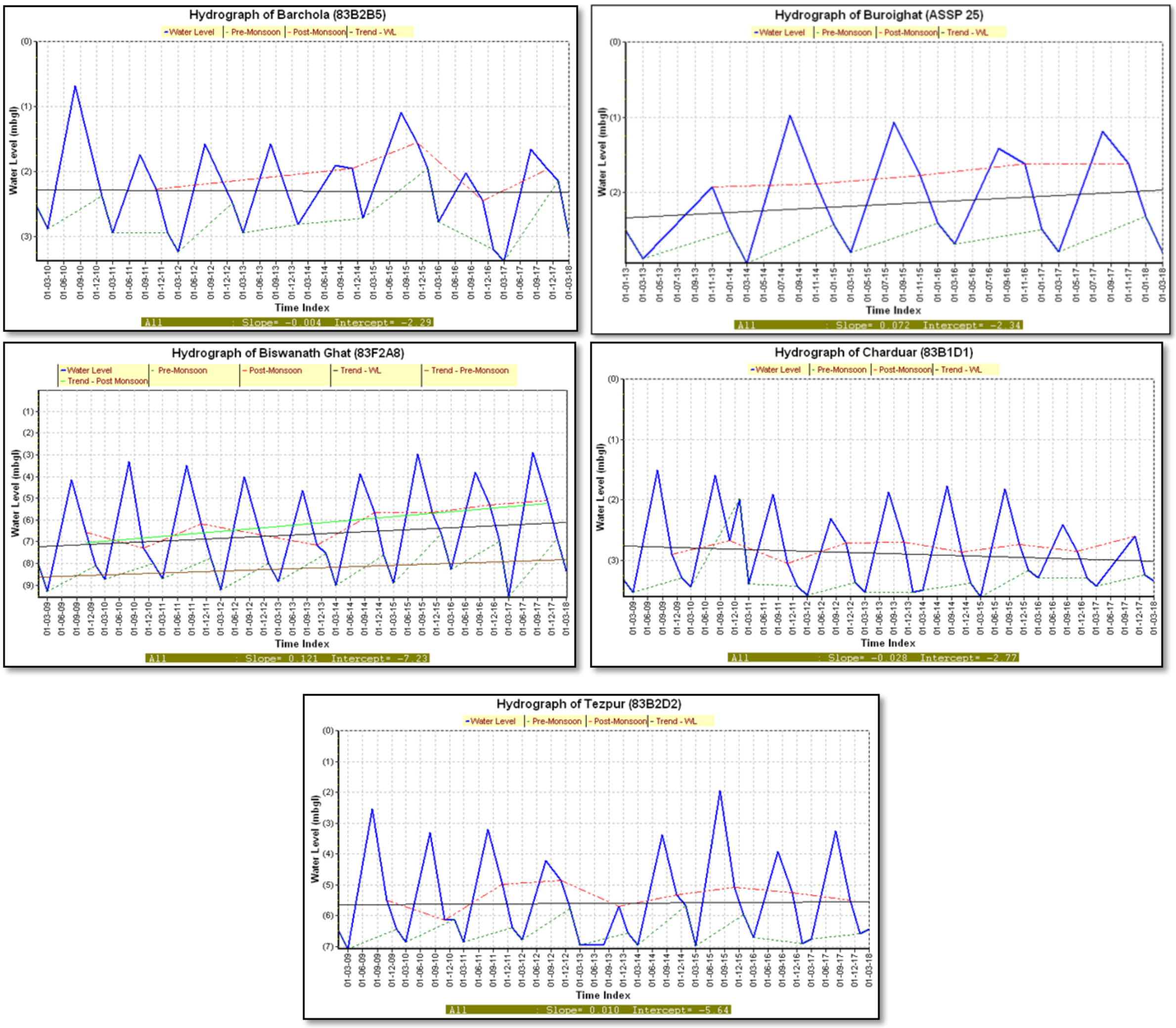


Fig.3.11: Hydrograph of Ground Water Monitoring Stations in Sonitpur District, Assam

3.3 Ground water quality

Chemical analysis of ground water samples are carried out by NABL accredited regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. Samples are analyzed for basic, heavy metals, iron and arsenic.

Basic Parameters:

Pre-monsoon pH value ranges from 6.42 to 8.13 and in the post-monsoon pH value ranges from 6.51 to 8.13. Pre-monsoon water sample mostly acidic while post-monsoon samples are mostly alkaline in nature. It is observed that in both pre- and post-monsoon groundwater samples concentration of Ca, Mg, Cl, SO_4, TDS and hardness as $CaCO_3$ are within desirable limit.

Pre-monsoon iron concentration range in Pub-Chaiduar block is 0.0 to 5.34mg/l. Post-monsoon iron concentration is found to be reduced in all the blocks.

Block wise concentration range of different chemical elements in groundwater during pre- and post- monsoon in Sonitpur district is shown in Table 3.5 and 3.6.

Table 3.5: Block-wise concentration range of chemical constituents in pre-monsoon groundwater samples of Sonitpur district, Assam

Elements	Pre-monsoon								
	Borchola	Gabharu	Balipara	Sootia	Biswanath	Baghmara	Behali	Chaiduar	Pub-Chaiduar
pH	7.06	8.31	8.31	7.88	7.96	6.46-7.62	6.42-7.09	7.652- 7.92	8.12-8.13
EC	208.9	472.9	434.8	199	196	98.53- 549.3	106.2 – 421	107.6 – 366.6	357.4-515.1
Turbidity (NTU)	0.5	0.9	0.8	0.1	0	0-0.8	0	0	0-0.3
conc. In mg/l									
TDS	111.7	255.1	232	100.1	102.7	55.43-295.3	58.65- 239.4	56.78 -194	191.6- 278.4
TH	105	160	140	264	65	30-190	35-90	30-80	125-140
Ca	12.01	38.03	30.02	9.6	20.016	8-28.02	10-24.02	6.0- 24.02	24.02- 32.03
Mg	18.2	15.76	15.76	58.25	3.63107	2.42-29.11	2.42-10.92	3.63-4.84	10.91- 19.41
Na	5.69	35.93	15.16	1.15	6.56	13.62- 34.72	4.32- 50.74	11.4- 32	21.32- 50.52
K	3.55	6.32	6.56	1.46	12.43	1.67- 19.25	3.81- 39.98	14.45- 18.95	8.43 – 9.76
CO_3^{-2}	0	20	10	BDL	0	0	0	0	0-20
HCO3	55.04	100.01	105.09	32	75.06	35.03- 100.08	15.01-90.07	35.03- 50.04	85.08- 90,07
Cl-	24.82	56.72	21.27	19.85	17.725	21.27- 70.9	6.24- 85.08	24.82- 74.44	26.11- 67.36
SO4	13.88	19.53	24.24	3.026	16.812	10.85- 40.47	6.24- 76.15	20.09- 31.96	26.11 – 57.67
NO3	19.25	10.03	9.27	1.3	0	0-6.24	0-10.25	0-4.5	0-28.35
TA (as $CaCO_3$)	55.04	120.1	115.09		75.06	35.03-90.07	15.01-90.07	35.03-50.04	90.07-105.08
F^-	0.17	0.32	0.3	0.18	0.48	0.3- 0.98	0.23-1.4	0.22-0.31	0.33-0.66
Fe	0.0777	0.1593	0.31	0.12	0.2431	0-1.5	0-0.23	0	0-5.43

Table 3.6: Block-wise concentration range of chemical constituents in post-monsoon groundwater samples of Sonitpur district, Assam

Elements	Post-monsoon									
	Borchola	Dhekiajuli	Rangapara	Balipara	Sootia	Biswanath	Baghmara	Sakomatha	Behali	Chaiduar	Pub-Chaiduar
pH	7.63	7.48-8.04	7.47	7.07-8.05	7.4 – 7.59	7.46	8.11	8.01	7.35- 8.13	6.51- 8.2	8.03- 8.13
EC	270.8	258.2 – 644.5	175.8	135.9- 351.2	113.5 – 126.1	357.7	484.6	574.2	185.6- 514.4	4.98 – 319.8	324.1 – 804.3
Turbidity (NTU)	0	0-0.1	0	0	0-0.4	0	0.3	0		0	0-0.6
conc. In mg/l											
TDS	148.7	141.6- 352.3	96.23	74.3- 192.6	61.93- 69.13	196.5	263.9	314.5	101- 279	271-174.8	177-440.6
TH	90	82-175	65	40- 110	50-55	105	175	125	55-165	80-135	40-210
Ca	14.011	16.01-26.02	10.008	6-22.02	16.01-18.01	22.0176	30.024	28.0224	10-32.03	14.01- 24.02	14.01- 20.02
Mg	13.34	9.7- 26.69	9.703883	6.06- 13.33	1.2- 3.63	12.12524	24.25728	13.33592	7.28-20.62	10.91- 19.4	1.21-42.47
Na	8.98	27.38- 48.11	25.22	15.54- 30.36	13.07- 14.73	28.2	26.03	95.6	20.9- 26.94	4.1 – 22.52	5.11 – 76.04
K	34.71	12.75- 64.77	2.47	4.31- 31.67	3.5- 17.46	29.83	40.69	3.5	15.77-63.77	10.72- 15.5	3.86- 52.1
CO_3^{-2}	0	0	0	0	0	0	0	0	0	0	0
HCO3	65.052	60.05-170.14	75.06	35.03- 140.11	45.04-50.04	70.056	160.128	135.108	45.04- 175.14	25.02-130.1	90.07- 255.20
C^{l-}	42.54	74.45-127.62	35.45	35.45-49.63	28.36-39	81.535	67.355	102.805	49.63-92.17	35.45- 464.4	49.63- 131.16
SO_4	24.1004	14.1-38.76	13.1113	6.1- 27.8	17.02- 17.65	31.2738	36.9573	49.5045	7.62- 24.39	12.64 – 18.67	5.53- 57.75
NO3	3.0021	0	0	0-2.06	0	1.8468	0	3.2482	0.51- 1.49	0-8.73	0 – 2.09
TA (as $CaCO_3$)	65.052	60.01-170.14	75.06	35.03- 140.1	45.04- 50.04	70.056	160.128	135.108	45.04- 175.14	25.02- 130.1	90.07- 255.2
F^-	0.25	0.17-0.28	0.28	0.1-0.47	0.17-0.2	0.15	0.48	0.26	0.13-0.5	0-0.68	0.31-0.77
Fe	0.0421	0.02-0.21	1.3765	0-0.49	0.15-0.25	0.006	0.0737	0.6627	0-0.04	0.0-0.17	0-0.34

Arsenic and heavy metals in shallow aquifer zone: Groundwater samples collected from dug wells from different parts of the district to detect arsenic and other heavy metals. Partial analysis of samples shows that arsenic in most cases is below detectable limit in dug well, i.e., in shallow aquifer. Wherever arsenic presence is detected, it is under permissible limit.

Table 3.7: Concentration of Arsenic in shallow aquifer zone in Sonitpur district, Assam (2018-19)

Location	Type of well	Arsenic (ppb)	
		Pre-monsoon	Post-monsoon
Balipara	DW	7.202	
Barchola	DW	4.955	BDL
Dhekiajuli	DW	BDL	
Garumari	DW	BDL	
Jamuguri North	DW	BDL	
Tezpur	DW	BDL	
Tupia	DW	BDL	
18th Mile	DW	BDL	
Thelamara	DW	BDL	BDL
Roumari	DW	BDL	BDL
Chacara Kachari	DW	BDL	
Batasipur	DW	BDL	1.550
Amaribari	DW	BDL	3.050
Dalikathi	DW	BDL	BDL
Behali	DW	4.843	
Tezpur	DW	4.843	
Kheroni	DW	4.618	
Biswanath	DW	4.506	
2no. Itakhuli	DW		BDL
Hatijuri	DW		BDL

Arsenic in deeper aquifer: Pre-monsoon ground water samples were also collected from Behali-EW, Gohpur-EW, Dolabari-EW, Sijubari-EW, Dekargaon-EW, Singri-EW, Rakhayasmari-EW and Tolakbari-EW , Karigaraj-EW, , Balipara-EW. All these tube wells were constructed tapping both shallow and deeper aquifer zones. In all the EW, arsenic is found to be below detectable limit.

Heavy metal in shallow aquifer: During 2017-18, post-monsoon samples were collected from some GWMS in the district. Analyized heavy metals in the groundwater are found within permissible limit.

Table 3.8: Concentration of heavy metals in post-monsoon samples in Sonitpur district, Assam (2017-18)

Location	Type of Well	As	Cu	Mn	Cd
		μg/L			
Balipara	DW	5.68	9.84	459.11	3.015
Barchola	DW	BDL	15.23	40.27	3.132
Bihupukhuri	DW	BDL	4.02	4.71	3.015
Biswanath	DW	BDL	9.27	54.16	3.015
BiswanathChariali	DW	BDL	42.34	357.05	2.775
Buroighat	DW	BDL	6.66	139.29	2.775
Charduar	DW	BDL	10.99	66.37	3.132
Dhekiajuli	DW	BDL	5.49	314.31	2.896
Garumari	DW	BDL	6.95	15.66	2.775
Gohpur New	DW	BDL	5.78	567.12	3.473
Helem	DW	BDL	6.07	63.32	2.896
Jamuguri North	DW	BDL	12.41	167.98	3.361
Kheroni	DW	BDL	4.61	100.47	2.653
Na Pam	DW	BDL	6.07	5.01	2.653
Tezpur	DW	BDL	5.49	189.53	2.896

Aquifer Map: Sonitpur district is underlain by older alluvium and younger alluvium. The older alluvium is found towards the northern parts of the study area in the piedmont zone. District population is mainly found in the alluvial plain area. Therefore, few tube wells are found in the piedmont zone (Fig,3.12).

Generally the tube wells in the district are constructed tapping zones from both shallow and deeper aquifers within 100m depth. The permeability and transmissivity values are thus combination of both the zones. The transmissivity values thus obtained are used to classify the district into following three sectors which will help to understand the hydrogeologic conditions of the district as well as help to formulate plan on groundwater extraction:

Sector I: 73 to 1000 m^2/day

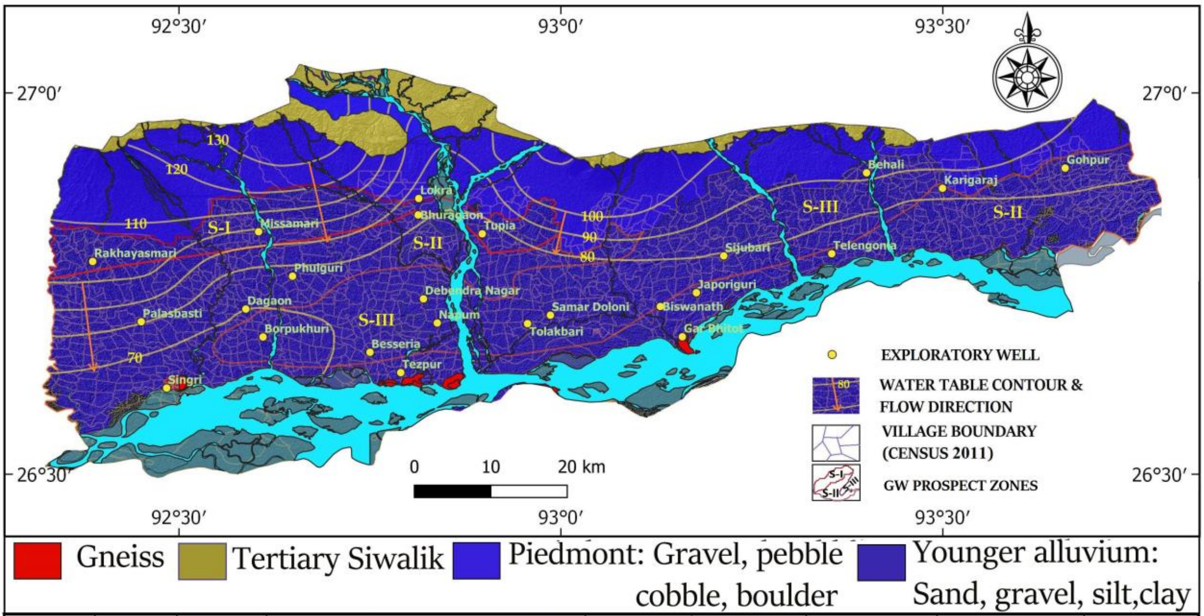
Sector II: 1000 to 2000 m^2/day

Sector III: 2000 to

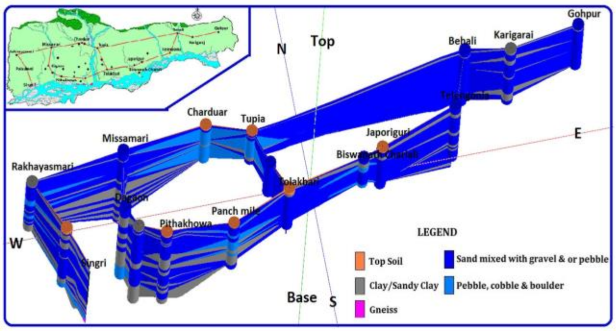
In sector I (S-I in Fig.3.12) the thickness of shallow aquifer zone (within 50m) is found to be 3 to 47m. Maximum thickness of shallow aquifer is found in the wells near piedmont. However, these zones were not tapped owing to the possibility of quick discharge of groundwater due to high permeability of aquifer materials as well as steep hydraulic gradient. Wells drilled in this sector generally tapped zones both shallow and deeper aquifer within 100m. In Lokra, Ambari, Udmari, Tupia tube wells zones tapped from both shallow and deeper aquifers. Discharge of the tube wells ranged from 19 to 77m^3/hr for drawdown of 2.75-17.918m. Transmissivity value ranges from 78.29 to 705.73. Hydraulic gradient in this sector is nearly 4 m/km.

In sector II (S-II in Fig. 3.12) the average thickness of shallow aquifer as well as deeper aquifer (within 100m) is 25m. The aquifer materials are found to dominate by sand mixed with gravel. However, pebble, cobble and/or boulder is found in areas depending upon the proximity to the piedmont areas and also near southern inselberg areas. Tube wells tapping 20m of shallow aquifer zone yield more than 40m3/hr discharge for drawdown of 1m. Generally both shallow and deeper aquifer zones (within 100m) were tapped in this sector. The hydraulic gradient is nearly 2.5 m/km.

In sector III (S-III in map) the average shallow aquifer thickness is found to be 36 m and deeper aquifer is found to be 35m. Aquifer materials are dominated by sand and gravel and hydraulic gradient is comparatively flat than other two zones. The permeability of the formation materials ranges between 64- 174m/day for deeper aquifer zone (within 100m). Transmissivity value ranges from 2000 to more than 6000m^2/day. The hydraulic gradient is nearly 1.35 m/km.



Sector	Aquifer zone	Av. depth range of tapped aquifer zones (m)	Groundwater Level (mbgl)		Discharge (TW) m³/day	Drawdown (m)	Permeability m/day	Transmissivity m²/day	Storativity
			Dug Well	Tube Well					
Sector I (S-I)	0-50	15-50	Pre-monsoon: 1.99-9.9 Post-monsoon: 1.42-6.74						
	50-100	50-70							
	0-100	15-50 75-85		0.84 - 3.66	19 to 77	2.75-17.918		78.29 to 705.73	
Sector II (S-II)	0-50	20-45	Pre-monsoon: 1.15-9.34 Post-monsoon: 0.66-7.40	3.785	43.05	1.025	52.805	1244.62	
	50-100	50-75							
	0-100	20-45 50-80		2.5 – 7.26	37.24 to 164.6	0.52 to 2.30	22 to 109	1166-1955	$1.11X10^{-4}$ to $7.36x10^{-5}$
Sector I (S-III)	0-50	10-48	Pre-monsoon: 2.18-5.81 Post-monsoon: 1.47-4.2	1.05	44.76	2.09	90	3624	$5.7X10^{-3}$
	50-100	50-85		0.68-5.65	27 to 169	1.48 to 6.36	64- 174	2372 to 5515	$7.4X10^{-3}$ to $5x10^{-5}$
	0-100	10-50 50-85		1.53-8.06	38 to 228	1.5-6.13	75 to 309	4634-6633	$4X10^{-3}$ to $5.65X10^{-4}$



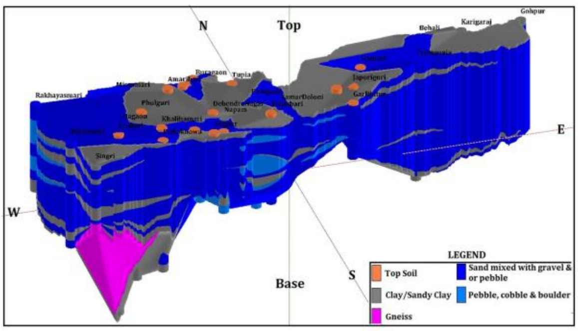


Fig. 3.12: Aquifer map of Sonitpur District, Assam

CHAPTER 4.0
GROUND WATER RESOURCES

The rechargeable area of Sonitpur district with slope ≤20% is identified by downloading 30m resolution DEM of Shuttle Radar Topography Mission (SRTM) from **http://earthexplorer.com**.

The rechargeable area is found to be 516498 ha. As block boundary is not available, it was not possible to carry out block wise resource calculation. Here district wise resource calculation is presented.

The computation of ground water resources available in the district has been done using GEC 2015 methodology.

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. Rainfall infiltration factor of 22% for younger alluvium as per norms is taken for calculation. In WLF method, specific yield has been taken as 0.12 for younger alluvium following the norms recommended by GEC'2015. The rainfall of Sonitpur district is 1761.27mm.
2) Water level data has been considered for 2018-19. Water level fluctuation based on data of May (Pre monsoon) and November (post monsoon) has been considered. The average pre- and post-monsoon water level of Sonitpur district is 4.10mbgl and 3.52mbgl. The average water level fluctuation is 0.35m
3) The population figures were collected from Census, 2011and projected to 2018. The per capita domestic requirement is considered as 60 lpcd.
4) Ground water extraction for irrigation and industrial use are estimated using Table 1.8 and 1.9 provided in District Irrigation Plan, Sonitpur (2016-20).
5) Recharge from other sources includes recharge from minor surface and ground water irrigation.

Recharge: The aquifers of the study area are recharged by rainfall. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 87 percent of total rainfall (June, July, August, September) while share of post and pre monsoon rainfall are approximately 7 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 June to September has maximum number of rainy days.

The monsoon recharge of the 516498 ha of recharge worthy area is 112195ham while non-monsoon recharge is 51873ham. Recharge from other sources is 6040.87ham. Total ground water recharge is 170062ham.

Extraction: The agriculture in the area generally rain fed. 25% of cropped area has irrigation facilities and groundwater irrigation is nearly 75% of total irrigation. Total groundwater extraction for irrigation purpose is 10026ham. Total industrial extraction is 6625.16ham. So ground water is extracted only for domestic use. Dependency on ground water is taken from public amenities in census 2011 and it is nearly 86%. Ground water extraction is estimated by consumptive use is 6577.32ham. Total groundwater extraction of Sonitpur district is 23228.1755ham

Allocation of resources up to 2025: The net ground water resource is allocated for domestic use 10209.28 ham. Net available resource for future use is 102969 ham.

Stage of groundwater development: Groundwater is mainly utilized for domestic purposes. The stage of groundwater extraction in the district is 14%.

Table 4.1: Net groundwater availability, extraction and stage of extraction of Sonitpur district as on March 2019

Total annual GW recharge Ham	Environmental flow Ham	Annual extractable GW resource Ham (1-2)	Existing gross GW draft for all uses Ham	Stage of GW extraction [(4/3)*100%]
1	2	3	4	5
1,44,254	14425	1,29,829	23228.18	18%

Extraction from unconfined aquifer/deeper aquifer: Groundwater in the district is utilized for (a) irrigation, (b) drinking or domestic purposes and (c) industrial purpose.

75% of irrigation demand is met by groundwater. Groundwater is extracted by installing shallow tube wells. As per district irrigation plan of Sonitpur, there are 10126nos of shallow tube wells in the district utilized for irrigation. Another 15 nos. of deep tube wells are also constructed for irrigation. Shallow tube wells are within 50m depth whereas deep tube wells depth generally ranges from 50 to 200m.

In domestic sector, dug wells and hand pumps are main source of groundwater extraction. As per 2011 census, the district has 1,93,375 nos of dug wells and 118961nos. of hand pumps in both urban and rural areas of the district. There are 16215nos. of tube wells in the district. Public health Engineering Dept. supplies water through groundwater and also by surface water. Generally the groundwater extracted from shallow aquifer.

Potential resource:

(i) Shallow water table areas: Potential resource due to shallow water table areas was estimated from aquifer area where depth-to-water level was within 5mbgl. The area within depth-to-water level 0f 5mbgl is 3066sq.km which is 87% of total area of the district. The potential resource of shallow water table areas is 58206.56 ham.

(ii) Flood prone area: As per District Irrigation Plan, Sonitpur, the flood prone area of the district is 15686 ha and it is considered that flood water remained in the area for at least 15days. Potential resource in flood prone area is 3294.06 ham.

(iii) Total potential resource of Sonitpur district is 61500.62 ham.

Static resource: Here also the administrative district has been considered as the assessment unit due to paucity of block-wise data. Hilly areas having slope more than 20% are deleted from the total area to get the area suitable for recharge. The average thickness of saturated unconfined aquifer below ground level as obtained from dug wells / bore wells in the district has been considered.

The Pre-monsoon (month of March) Water Level from Monitoring Wells of CGWB in Sonitpur district has been considered as the maximum depth below ground level up to which the zone of water level fluctuation occurs. Since the north eastern states receives pre-monsoon showers, which commences from the first week of April, resulting in rise in water levels in the phreatic zones, the deepest water levels are recorded during the month of March. Specific yield value of 0.12 is considered for the district.

(e) Finally the Static Ground Water Resource is computed from the data as obtained:

$$Y = A^* (Z_1 - Z_2)^* Sy$$

Where, Y = Static ground water resources,

A = Area of ground water assessment unit

Z_1 = Thickness of saturated unconfined aquifer below ground level

Z_2 = Pre-monsoon water level

Sy = Specific yield of the unconfined aquifer

Table 4.3: Salient information of static resource of Sonitpur district, Assam

Type of rock formation	Alluvium
Total Geographical Area (Ha)	532400
Assessment Area (Ha)	515620.2
Bottom of the unconfined aquifer (m)	41
Average Pre- monsoon Water Level (m)	3.94
Thickness of the saturated zone of the un-confined aquifer below WLF zone (m)	37.06
Volume of Saturated zone of the unconfined aquifer below WLF zone (ham)	19108884.51

Static/In-storage Ground Water Resources (ham): Volume of saturated zone X specific yield

= 19141415.88X0.12= 2293066 ham

CHAPTER 5.0
GROUNDWATER RELATED ISSUES

Identification of issues: The main groundwater issues identified in the area are-low stage of groundwater extraction, vulnerable areas under water logging and flood as well as high iron concentration and arsenic detection.

Low stage of groundwater extraction: Compared to vast dynamic groundwater resource of Sonitpur district, groundwater extraction for domestic, irrigation and industrial purposes is low. Vast tract of agricultural land remain fallow after harvesting of paddy only due to lack of irrigation facility. The stage of groundwater extraction is only 14%.

Permanently water logged area: Permanently water logged areas are observed mostly in Chaiduar and Pub-Chaiduar blocks. The post monsoon depth-to-water level varies from **1.33 to 2.0**. The pre-monsoon depth-to water level varies from 1.71 to 1.99mbgl. Water logged area is 10410ha.

Water logged areas are found in the alluvial plain, flood plain and gently sloping piedmont zone. In the water logged areas high iron concentration is also observed. In the eastern side of the district, presence of sticky clay layers from near the surface is established in the exploratory wells of CGWB at Karigaraj and Gohpur . The sandy top surface enhances the water infiltration while underlying clay inhibits downward movement of water thus causing water logged situation. Moreover, the water logged areas are near the piedmont. The sudden break in slope is another reason due to which shallow aquifer could not accommodate the recharged water from the piedmont. Near water logged area of Balipara hydraulic gradient is nearly 3m/km while just north of it hydraulic gradient is nearly 5m/km. All the water logged areas are more or less within the flood hazard zones.

Flood affected area: Sonitpur district is traversed by a number of rivers. Most of the revenue blocks are inundated by flood water. National remote sensing agency has prepared a flood hazard zonation map considering inundation frequency. The map is simplified to show flood prone area of the district. 15686ha of cultivable area is flood affected which is 9.5% of total cultivable area of the district.

It is observed that water logged areas of the district in most of the blocks coincides with the flood prone areas (Fig. 5.1)

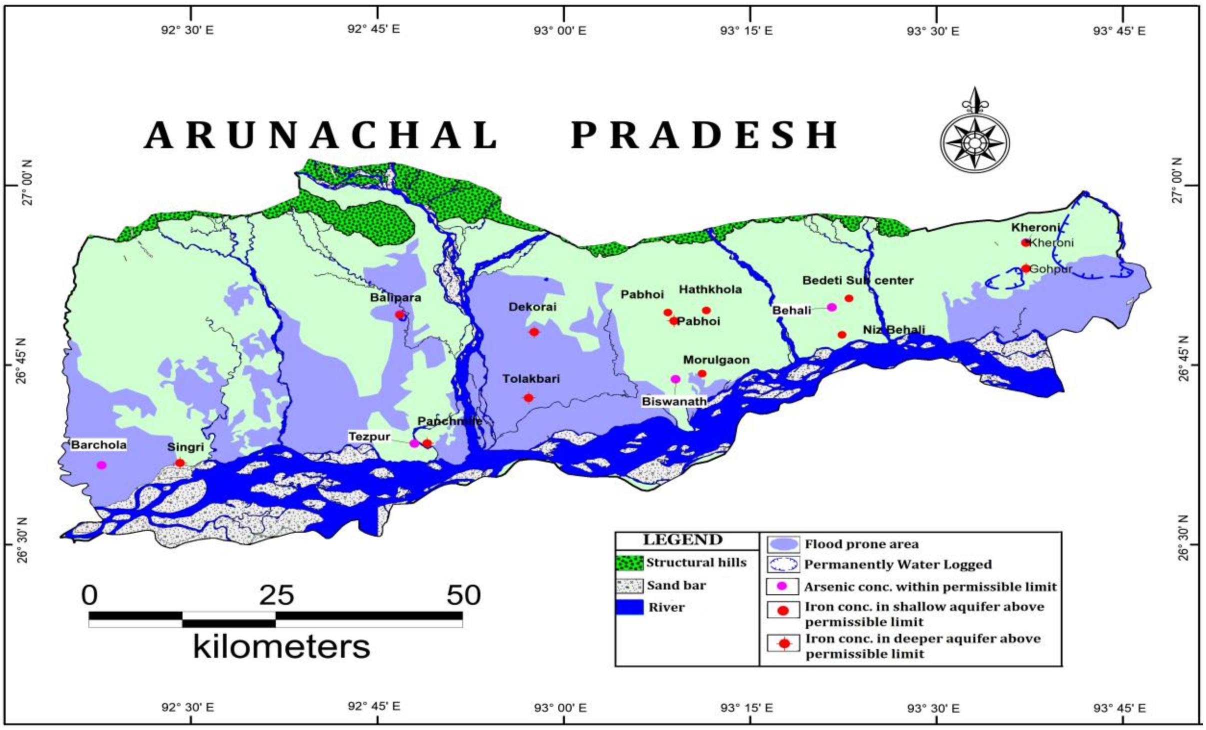


Fig. 5.1: Vulnerability Map of Sonitpur District, Assam

Area vulnerable to arsenic pollution: During the survey, samples were collected from shallow as well as deeper aquifers. Arsenic is detected in groundwater samples of shallow aquifer. However, in all the samples arsenic concentration is within permissible limit.

Area vulnerable to iron pollution: Iron content in ground water, above permissible limit is found in some areas.

Future demand: Future demand of ground water is analyized for domestic purpose and for irrigation purpose

Domestic purpose: The domestic requirement is worked out for projected block population and requirement is considered as 60litre per person per day. The block wise requirement up to 2030 is worked out and tabulated (Table 5.1)

Table 5.1: Projected population and water demand for domestic purpose of the area

Blocks	Census 2011 Population	Decadal growth	Projected Population		Projected water demand (ham)	
			2018	2025	2018	2025
Dhekiajuli	224611	13.52	437183	649755	823.4	1230.34
Gabharu	156044	13.52	303724	451404	572.03	853.68
Barchala	197345	13.52	384112	570880	723.44	1079.65
Balipara	233920	13.52	455302	676684	857.51	1284.46
Rangapara	98912	13.52	192522	286133	362.6	543.08
Bihaguri	86436	13.52	168239	250042	316.86	472.13
Naduar	90911	13.52	176949	262987	333.26	494.8
Chatia	124909	13.52	243123	361337	457.9	683.3
Sakomatha	86938	13.52	169216	251494	318.7	475.17
Bishawnath	64828	13.52	126181	187534	237.65	353.93

Baghmara	87762	13.52	170820	253878	321.72	478.62
Behali	87951	13.52	171188	254425	322.42	479.01
Chaiduar	139852	13.52	272208	404564	512.68	768.55
Pub-Chaiduar	113792	13.52	221485	329177	417.15	625.79
	Total		3492252	5190294	6577.32	9822.51

Future demand for agriculture: Future Water demand of the district for agricultural sector is assessed by projecting cropping intensity to 200% through assured irrigation in agricultural field. As per District Irrigation Plan, 2016-20, Sonitpur, the net sown area of the district is 151867ha and area sown more than once is 99840ha. The gross cropped area of the district is 251707ha and the cropping intensity is nearly 166%. The rainfed or un-irrigated area of the district is 122972ha and net irrigated area is 42157ha. However, there are few blocks in the district like Gabhoru, Borsola, Baghomari where the cropping intensity ranges from 188 to 200%. But the cropping intensity of blocks in the eastern part of the district is below 150%.

The crop water requirement for unirrigated area of the district is estimated based on soil condition, flooding and geomorphic classification using FAO's Cropwat 8.0 software following guidance of Assam Agriculture University.

Stress Aspects of aquifer

Table 5.4: Total water requirement for the district

District	Drinking water requirement up to 2025 Ham	Water requirement to increase cropping intensity to 200% (Ham)	Water allocated for drinking and domestic purposes up to 2025 (Ham)	Water allocated for future use Ham
Sonitpur	9822.51	60458	10209.28	102969

Supply and demand gap: It is observed that drinking water allocation is sufficient to meet the future demand and it will not give additional stress in the aquifer.

The demand of groundwater in irrigation sector can sufficiently be met from future allocation of resources.

Table 5.5: Supply and demand gap in drinking water sector

District	Drinking water demand up to 2025 Ham	Water allocated for drinking and domestic purposes up to 2025 Ham	Gap between supply and demand Ham
Sonitpur	9822.51	10209.28	387

Table 5.6: Supply and demand gap in irrigation

District	Total irrigation demand Ham	Water allocated for future use Ham	Gap between supply and demand Ham
Sonitpur	60458	102969	42511

CHAPTER 6.0
MANAGEMENT STRATEGY

The groundwater regime of Sonitpur district is influenced by lithological variation and geomorphologic set up. The district can be divided into two slope classes, viz., slope >20% and slope <=20%. Areas with slope more than 20% are found in northern and southern extremities of the district. Geomorphologically these areas include northern structural hills and southern inselbergs. Areas with slope less or equal to 20% slope include piedmont, both older and younger alluvial deposits. Generally the grain size of aquifer materials becomes finer towards southern direction in a north-south section. In the piedmont zone water level fluctuation is more in comparison to alluvial plain. Water logged areas are found in alluvial plain.

Sustainable Management Plan of Resource: Some important points have to be taken into consideration during preparation of aquifer management plan.

1. From flood zonation map it becomes clear that barring the structural hills and high piedmont areas, the entire district is ravaged by flood.
2. Irrigated area is just 26% and separate management plan needs to be prepared for severe flood prone and mid-low land areas as per action plan of Assam Agriculture University.
3. Stage of groundwater development in the district is just 18%
4. Groundwater quality data indicates that the phreatic aquifer contains arsenic and heavy metals in some pockets within permissible limit.

Management of resources for agricultural sector: The crop water requirement for unirrigated area of the district is estimated based on soil condition, flooding and geomorphic classification and the estimation is carried out in accordance to the suggestion of Assam Agriculture University. AAU has identified characteristics cropping sequence for different geomorphologic conditions. The cropping sequence suitable for flood prone area is shown below:

Table 6.1: Cropping sequence of medium/medium low land areas of North Bank

February to May	Late August to November	December to February
Early Summer Rice (Direct seeding)	Late Winter Rice (T)	
Summer Vegetables	-do-	Pea/Potato
-do-	-do-	Groundnut/Pea
Summer Vegetables/Pulses	Fallow	Potato/Vegetables/ Wheat/ Pea
Groundnut/melons/vegetables	Fallow	Early Pulse
Summer Rice (February to June)	Fallow	Sweet Potato

The AAU devised a cropping sequence for medium/medium low land area for the North bank districts (Table 6.2)

Table 6.2: Cropping sequence of medium/medium low land areas of North Bank

March-July	July/August –November	November/December –February
Green gram	Rice (T)	Potato (Toria)
		Rajmah/Pea
		Wheat/Vegetables
		Oat (fodder)

From census 2011 village map and agricultural land use map, it is observed that almost entire villages and crop lands of the district are scattered from Brahmaputra flood plain to lower piedmont. Medium piedmont zone is generally less populated as this geomorphic unit is covered by forest.

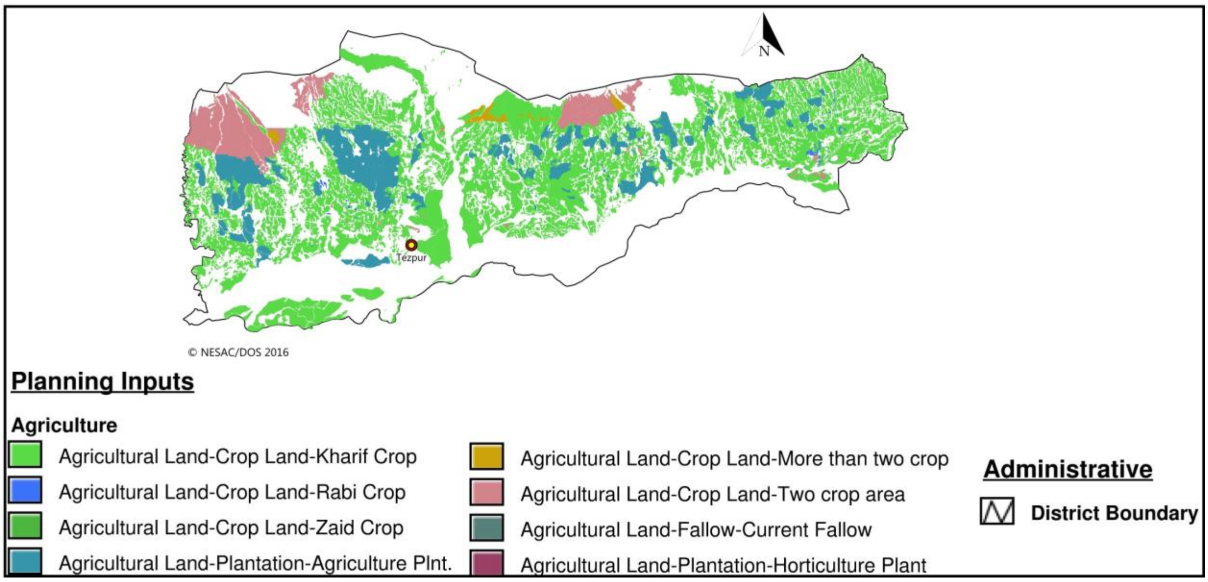


Fig. 6.1: Agriculture map of Sonitpur District, Assam

As per information, **15686**ha **cultivable area** of the district is chronically flood affected (District Irrigation Plan 2015-16). Block wise data of flood affected crop land is not available. From the agricultural map, it is observed that double or multi-cropped area is not available near flood affected area. Therefore, the water demand of agricultural sector to provide assured irrigation potentiality to un-irrigated flood prone areas and medium/medium low land will be calculated separately using Cropwat 8.0 software of FAO. Assam Agriculture University suggested cropping sequence can be followed which will provide flood affected people assured irrigation facility.

A management plan has been prepared for chronically flood affected crop land of 15686 ha based on cropping pattern suggested by Assam Agriculture University (Table 6.3)/

Table 6.3: Water requirement for chronically flood affected areas of Sonitpur district

Early Summer Rice-Late Winter Rice Summer vegetables- Late Winter Rice Pulses-Late Winter Rice- Potato/ Vegetables/ Wheat	Present Cultivated area (ha)	Area to be cultivated **(%)**	Area to be cultivated **(ha)**	Irrigation requirement **(ha m)**
Cultivated Area	**15686**			
Maize-Millet	1	2(= % of 1)	3	4
Rice (main crop)	15686		15686	
Rice (main crop)	15686	50	15686	4681.18
vegetables		10	3137.2	306.12
Wheat		10	3137.2	479.99
Pulses		15	4705.8	435.13
Potato		5	1568.6	347.13
Groundnut		10	3137.2	532.7
		100	**31372**	
Net cultivated area	**15686**		15686	
Gross cultivated area (Paddy/+vegetables/+Wheat+Pulses+Potato + Groundnut)	15686		**31372**	
Total irrigation requirement				**6782.25**
Total irrigation requirement (70% irrigation efficiency)				9689
Cropping intensity	**100**		**200% (Intended)**	

In this cropping pattern rice will be the principal crop and more thrust will be given to grow summer rice locally known as *Boro* rice. Sowing season of this rice is November and can be harvested during summer season. Winter rice sowing month is fixed as July last and August first depending upon cessation of flood water from the crop land. If flood water retains in paddy field during July and August then the winter rice may not be cultivated, instead other crops like vegetables, wheat, pulses and potato can be cultivated with assured irrigation facilities provided by construction of tube wells.

Table 6.4: Precipitation deficiency

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
Rice	69.9	224.5	75.3	34.5	0	0	0	0	0	0	0	0
Rice	0	183.8	130.6	34.7	0	0	7.6	0	0	0	0	0
Rice	0	0	0	0	0	48.9	98	0	0	22.2	29.6	0
Rice	0	0	0	0	0	0	147	52	0	23.6	61.8	4.4
Spring Wheat	20	61.5	61.6	0	0	0	0	0	0	0	0	9.9
Pulses	0	9.8	34.2	31.1	0	0	0	0	0	0	0	0
Pulses	0	0	1.7	7.7	0	2.9	0	0	0	0	0	0
Pulses	38	64.4	38.7	0	0	0	0	0	0	0	0	14.7
Potato	29.3	62.8	69.8	7.8	0	0	0	0	0	0	0	14.5
Potato	45.1	63.8	58.4	0	0	0	0	0	0	0	1.2	27.2
Small Vegetables	42	57.2	24.3	0	0	0	0	0	0	0	0	28.3
Small Vegetables	22.6	48.6	60.7	9.1	0	0	0	0	0	0	0	0
Small Vegetables	0	25.5	45.3	17.9	0	0	0	0	0	0	0	0
Small Vegetables	0	0	0	0.1	0	0	0	0	0	0	0	0
Groudnut	18.8	58.3	72.6	12.7	0	0	0	0	0	0	0	7.4

Table 6.5: Actual monthly requirement (Ham) for different crops for chronically flood prone area

Crop	Area (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total IWR (Ham)
Rice	5	2192903	7043014	2362312	1082334	0	0	0	0	0	0	0	0	1268.06
Rice	10	0	5766174	4097183	1088608	0	0	238427.2	0	0	0	0	0	1119.04
Rice	10	0	0	0	0	0	2301136	4611684	0	0	1044688	1392917	0	935.04
Rice	15	0	0	0	0	0	0	6917526	2447016	0	1110569	2908184	207055.2	1359.04
Spring Wheat	5	627440	1929378	1932515	0	0	0	0	0	0	0	0	310582.8	479.99
Pulses	5	0	307445.6	1072922	975669.2	0	0	0	0	0	0	0	0	171.45
Pulses		0	0	26666.2	120782.2	0	45489.4	0	0	0	0	0	0	19.29
Pulses	4	596068	1010178	607048.2	0	0	0	0	0	0	0	0	230584.2	244.39
Potato	5	459599.8	985080.8	1094883	122350.8	0	0	0	0	0	0	0	227447	181.27
Potato		282975.4	400306.7	366425	0	0	0	0	0	0	0	7529.28	170663.7	165.86
Small Vegetables	8	395287.2	538343.5	228701.9	0	0	0	0	0	0	0	0	266348.3	142.87
Small Vegetables	5	212702.2	457403.8	571284.1	85645.56	0	0	0	0	0	0	0	0	107.51
Small Vegetables	5	0	159997.2	284230.3	112311.8	0	0	0	0	0	0	0	0	55.65
Small Vegetables	3	0	0	0	627.44	0	0	0	0	0	0	0	0	0.09
Groundnut		176938.1	548696.3	683282.2	119527.3	0	0	0	0	0	0	0	69645.84	532.7
IWR (HAM)		**494.39**	**1914.6**	**1332.75**	**370.79**	**0**	**234.66**	**0.03**	**244.7**	**0**	**215.53**	**430.86**	**148.23**	**6782.25**

Total unirrigated area of the district is 1,09,710ha and out of which 15686ha is flood prone. So after estimating the irrigation water requirement of the flood prone area, irrigation requirement of the balance un-irrigated area will be assessed utilizing cropping plan envisage by Assam Agriculture University for medium/medium low land areas of North Bank.

Table 6.6: Water requirement for medium/medium low land areas of Sonitpur district

Pulse-Rice-Potato Rice-Wheat-Vegetables Rice-Pulses Rice-Millet	Present Cultivated area **(ha)**	Area to be cultivated **(%)**	Area to be cultivated **(ha)**	Irrigation requirement (**ha m**)
Rice-Rapseed Mustard	1	2 (= % of 1)	3	4
Rice (main crop)	94024		94024	25184.34
Pulses		10	18804.8	32.91
Potato		5	9402.4	1738.13
Wheat		5	9402.4	1479
Oilseed		10	18804.8	3373.11
Vegetables		10	18804.8	2455.91
Millet		10	18804.8	1274.97
		50		
Net cultivated area	94024		188048	
Gross cultivated area (Paddy/+Maize/+Wheat+Pulses+ Millet)	94024		**282072**	
Total irrigate n requirement				**35538.37**
With 70% irrigation efficiency				**50769.1**
Cropping intensity	**200% (Intended)**			

Table 6.7: Month wise and crop wise water requirement in medium/medium low land areas of Sonitpur district

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	0	0	0	0	0	147.1	50.6	0	0	17.8	2.8	0
2. Rice	0	0	0	0	0	49.1	148.6	0	0	21.1	18.3	0
3. Rice	0	0	0	0	0	0	197.7	0	0	23.1	41	0
4. Rice	0	0	0	0	0	0	147	52	0	23.7	61.9	4.4
5. Rice	0	0	0	0	0	0	49.1	148.7	0	23.7	64.4	23.4
6. Pulses	0	0	1.4	2.1	0	0	0	0	0	0	0	0
7. Pulses	0	0	0	0	0	0	0	0	0	0	0	0
8. Potato	51.9	63.8	39.8	0	0	0	0	0	0	0	9.8	32
9. Potato	21.9	57.6	71.2	16.6	0	0	0	0	0	0	0	6
10. Spring Wheat	46.2	62.7	24.9	0	0	0	0	0	0	0	4.4	16.9
11. Mustard	43	50.4	49.8	8.9	0	0	3.2	0	0	0	7.1	37.1
12. Mustard	34.7	50.4	49.8	8.9	0	0	0	0	0	0	0	11.9
13. Small Vegetables	49	23.1	0	0	0	0	0	0	0	0	29.4	49.4
14. Small Vegetables	47.7	52.3	0	0	0	0	0	0	0	0	8.4	42.3
15. Small Vegetables	0	25.5	45.3	18	0	0	0	0	0	0	0	0
16. MILLET	2.1	21.2	48.4	6.5	0	0	0	0	0	0	0	0
17. MILLET	0	9.5	39.5	8.4	0	0	0	0	0	0	0	0

Actual monthly water requirement for different crops in mid low land area of Sonitpur district, Assam

Crop	Area (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total IWR (Ham)
1. Rice	10	0	0	0	0	0	2766	951.52	0	0	334.73	52.65	0	4105.09
2. Rice	10	0	0	0	0	0	923.3	2794.39	0	0	396.78	344.13	0	4458.62
3. Rice	5	0	0	0	0	0	0	1858.85	0	0	217.2	385.5	0	2461.55
4. Rice	10	0	0	0	0	0	0	2764.31	977.85	0	445.67	1164	82.74	5434.59
5. Rice	15	0	0	0	0	0	0	1384.97	4194.4	0	668.51	1816.5	660.05	8724.48
6. Pulses	5	0	0	13.16	19.8	0	0	0	0	0	0	0	0	32.91
7. Pulses	5	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Potato	2	195.19	239.95	149.69	0	0	0	0	0	0	0	36.86	120.35	742.04
9. Potato	3	123.55	324.95	401.67	93.7	0	0	0	0	0	0	0	33.85	977.67
10. Spring Wheat	5	434.39	589.53	234.12	0	0	0	0	0	0	0	41.37	158.9	1458.31
11. Mustard	5	404.3	473.88	468.24	83.7	0	0	30.09	0	0	0	66.76	348.83	1875.78
12. Mustard	5	326.26	473.88	468.24	83.7	0	0	0	0	0	0	0	111.89	1463.95
13. Small Vegetables	2	184.29	86.88	0	0	0	0	0	0	0	0	110.57	185.79	567.53
14. Small Vegetables	4	358.8	393.4	0	0	0	0	0	0	0	0	63.18	318.18	1133.56
15. Small Vegetables	4	0	191.81	340.74	135	0	0	0	0	0	0	0	0	667.94
16. MILLET	5	19.75	199.33	455.08	61.1	0	0	0	0	0	0	0	0	735.28
17. MILLET	5	0	89.32	371.39	79	0	0	0	0	0	0	0	0	539.69
	100	2046.5	3062.9	2902.3	556	0	3690	9784.13	5172.3	0	2062.9	4081.6	2020.6	35378.99
Gross irr. Requirement with 70% irr. Efficiency (Ham)		**2923.6**	**4375.6**	**4146.2**	**795**	**0**	**5271**	**13977.33**	**7388.9**	**0**	**2947**	**5830.8**	**2886.5**	**50541.42**

Total water requirement to bring the un-irrigated area of the district and water availability for future use are summarized in Table: 6.70

Table 6.7: Summarised results of water requirement to bring the un-irrigated area of Sonitpur district, Assam

Area	Geographical Area (Ha)	Irrigation water requirement (Ham)	Water allocated for future use (Ham)
Flood prone	15686	9689	102969
Medium/medium low land areas	94024	50541.4	
Total	109710	60230.4	

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

Discharge of the tube wells constructed by CGWB and State Govt. tapping 15 to 35m in shallow alluvial aquifer varies from 44.75 to 228m^3/hr. It is expected that tube wells of 50m depth tapping 15 to 30m of granular zones of the shallow alluvial aquifer can yield 40 to 60 m^3/hr. If the well is allowed to run 8hrs a day for 180days then a tube well having discharge of 40 m^3/hr will extract 5.76ham groundwater annually.

Total numbers of shallow tube wells require to construct in the district to fulfil the irrigation requirement of 60230ham, is found to be 10457nos. On the other hand consideration of safe distance of 200m permits to construct 27460nos.

Extraction of 60230ham of groundwater will increase the stage of groundwater extraction to 64%. The average water level in the flood plan area with slope within 15% is 2.96m. On implementation of this management plan the average water level will be nearly 4.5m. This will also reduce the water logged areas. Potential resource of the district is 61500.62 ham.

Lowering of Groundwater Level: If the above management plan is implemented then the groundwater level will decline during pre and post monsoon seasons.

Table 6.8: Season wise irrigation water requirement in chronically flood affected and mid low land area of Sonitpur district, Assam

Type of area	Irrigation water requirement (ham)		Irrigation water requirement (ham)	
	October-March	Area (ha)	April-September	Area (ha)
Chronically flood prone	4536.36	11764.5	850.18	3921.5
mid low land area	23109.7	94024	23109.7	94024

It can be estimated that the water level during pre-monsoon season will lower by 2.18m and 2.04m during pre- and post-monsoon seasons. The average pre-monsoon and post-monsoon water levels of the district are 4.0m and 2.94m respectively. After implementation of the project the pre-monsoon ground water level will be 6.18 m and 4.98m.

Lowering of water level will increase the groundwater recharge. Increase recharge will fill the aquifer as well as lower surface run-off and soil erosion.

PMKSY-HKKP(GW): During 2018-19, Water Resources Dept., Govt. of Assam had submitted a plan of Rs.246 crore for construction of 14337nos. of tube wells of 50m depth fitted with solar and electrical pumps to irrigate 19116ha land. Ministry of Water Resources, River Development & Ganaga Rejuvenation had given administrative proposal for implementation of plan. As per the proposal 2376 nos. of TW had to be constructed in Sonitpur district to irrigate 3168ha land. The feasibility of the proposal was assessed by CGWB, NER, Guwahati based on NAQUIM study.

After construction of 2376 nos. of TWs, total numbers of TWs to be constructed in the district as per the management plan is 8081Nos (10457-2376nos.).

Aquifer wise availability of unsaturated zone:

To identify areas for artificial recharge, post-monsoon depth-to-water level map and long term post-monsoon GW level trend map have been prepared (Fig. 6.2 & 6.3). For this purpose, depth-to-water level contour maps are prepared based on post-monsoon water level of GWMS and the key wells of Sonitpur District, Assam. Post-monsoon depth-to-water level map has been superimposed over long term water level trend (2007 to 2018) map. Those areas are considered suitable for artificial recharge where post-monsoon depth-to-water level is more than 5mbgl and there is a falling trend of GW level more than 10cm/yr. It is observed that there is no area where the DTW more than 5mbgl and falling trend of GW level 10cm/yr coincides.

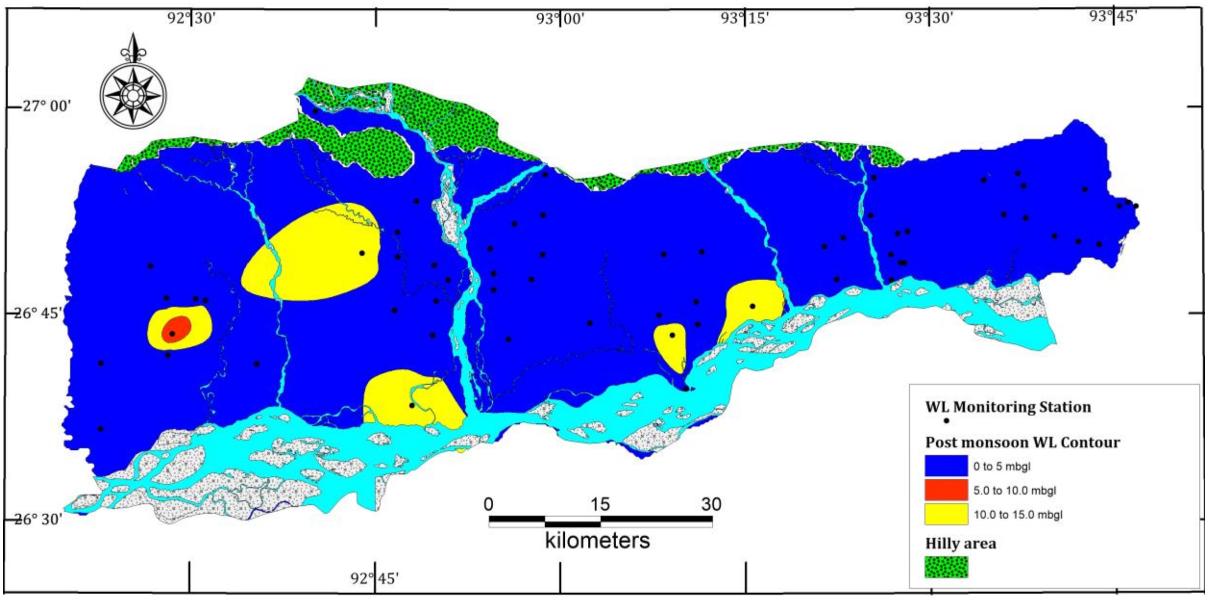


Fig. 6.2: Post-monsoon DTW contour to determine unsaturated zone in phreatic aquifer of Sonitpur District, Assam.

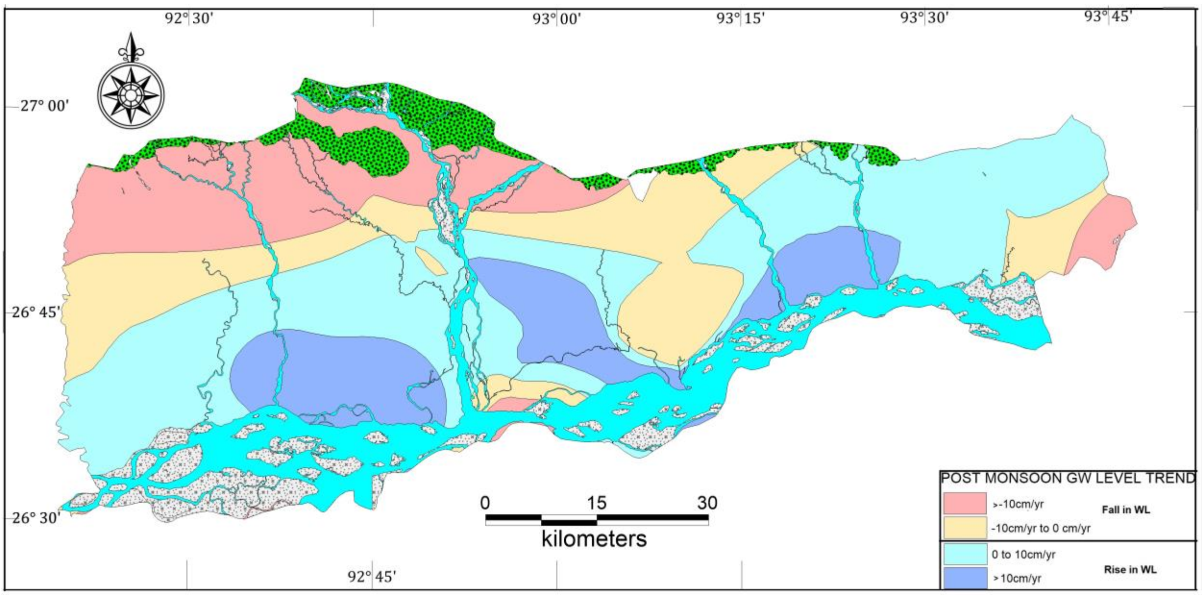


Fig. 6.3: Long term post-monsoon water level trend of phreatic aquifer of Sonitpur District, Assam.

Therefore, the volume of unsaturated zone could not be calculated in the district.

6.3 Demand side management

Demand side management implies sustainable management of water. In irrigation and in drinking water supply also sufficient quantity of water loss occurs.

The general slope of the area is towards southeast. The slope is greater near piedmont zone than in the flood plain. Therefore water logging condition is observed in the flood plain, alluvial plain or in the gently sloping piedmont zone. Therefore water use efficiency should be high in all sectors particularly in the irrigation sector. Loss in irrigation water will increase water logged area.

Irrigation efficiency can be increased by

(i) reducing convenience loss

(ii) improving water application efficiency

Following demand side interventions will increase water use efficiency

1) Use of water efficient irrigation method: Drip and sprinkler irrigation methods are very useful in saving water. Both of them save conveyance losses and improve water application efficiency by applying water near the root-zone of the plant. Drip systems convey water in small quantities through drippers/micro-tubes while sprinklers are pressurized systems where a fountain or spray of water is released by the sprinkler connected by pipes, resulting in foliar irrigation. Drip irrigation can increase crop yield per hectre and also saves water up to 70% than conventional irrigation.
2) Water loss through supply canals can be minimized by proper lining in the canals.
3) Adopting water saving rice irrigation: In this method instead of submerging the paddy field for longer duration, the rice field have to provide water through irrigation only after a certain number of days when the ponded water disappears. This technology is known as alternate wetting and drying (AWD) irrigation. With the optimal

management, this technology reduces the amount of water required by about 25% without reduction in yields.

International Rice Research Institute (IRRI) has developed a simple tool to help farmers make decisions on when to irrigate. They found that when field water level recedes to 15 cm below the soil surface, soil water tension in the root zone is always <10 kPa, ensuring good yield. Thus a practical way to implement safe AWD is to monitor the depth of ponded water using a field water tube/ pipe This tube can be made of plastic pipe or bamboo 30 cm long and 15 cm or more in diameter and having perforations on all sides (Fig. 6.4).

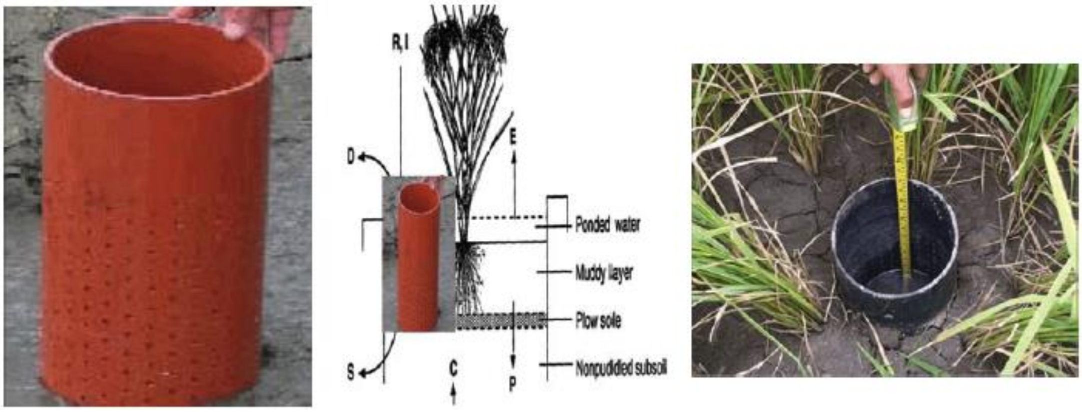


Fig. 6.4: A simple perforated pipe (water tube) installed in the rice field allows farmer to monitor water level beneath the soil surface (Kulkarni, 2011)

After transplanting, farmers would keep the field submerged for about 2 weeks to suppress weed growth. The tube is then inserted into the soil by leaving 10 cm above the soil surface. Soil inside the tube is then taken out.

4) Reduce losses of water during leveling: As per Food Agriculture Organization, 200mm of water per hectre is required to level the rice field by traditional method. However, use of laser land leveler help in fine leveling of rice field by eliminating unnecessary depression and elevated contour. It saves 40 to 50% water. A uniformly leveled field allows uniform spreading of irrigated water. It is reported that in Punjab 100% use of laser land leveler in the existing cropping pattern (rice-wheat) can prevent 19cm groundwater draft in entire state (Aggarwal, et. al., 2010)

Approximate Water saving through use of Laser Land Leveler in the rice cultivated area of the district

Type of paddy cultivated area	Paddy cultivated area (as per District Agriculture Plane 2016-20) (ha)	40% reduction of water for land leveling by the use laser land leveler	Approximate saving of water **ham**
Flood affected area	15686	**0.08**	1254.88
Medium/medium low land	94024	**0.08**	7521.92
Total water saving			8776.8

Stress aspect future demand: Numerical modelling and aquifer simulation study could not be done due to paucity of various data; it was not possible to test a model under different stress conditions. However, groundwater resource of the district is sufficient to meet drinking water demand and also irrigation and other industrial demands under different condition.

Following recommendations are suggested

1) Water distribution mechanism should minimize water loss by using lining distribution canals. Locally available materials are to be preferred as these materials are cheap and eco-friendly.
2) Conservation of rain water in the up dip of cultivated field. During rabi season the conserved water can be drained to paddy field through gravity.