केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

AQUIFER MAPPING REPORT

Parts of Dhemaji District, Assam

उत्तरी पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

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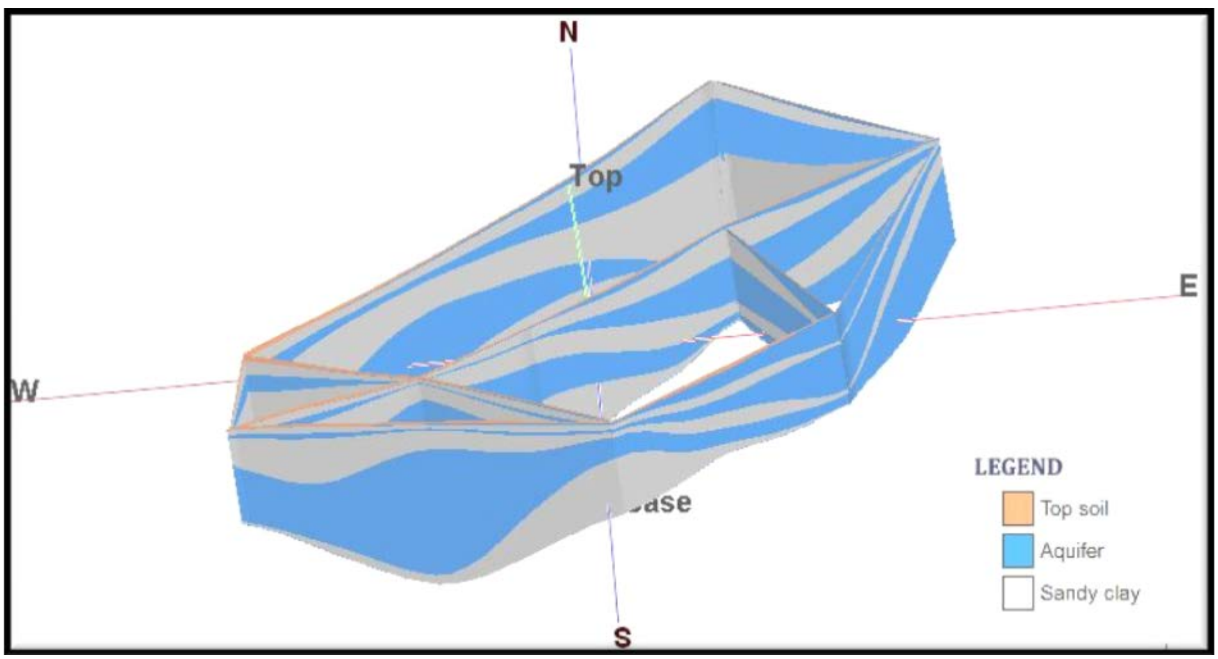
Govt. of India
Central Ground Water Board
Ministry of Water Resources, River Development & Ganga Rejuvenation

AQUIFER MAPPING IN PARTS OF DHEMAJI DISTRICT OF ASSAM
(AAP 2013-14)



State Unit Office
Naharlagun
November 2015

AQUIFER MAPPING IN PART OF LAKHIMPUR OF ASSAM
ANNUAL ACTION PLAN 2013-14

CONTENTS

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 contaminated area and prepare a groundwater management plan.

1.2 Scope of the study: The part of the Lakhimpur district has vast groundwater and surface water resources. However, the agro based economy of the area has no irrigation facility. Moreover, the groundwater of the area is contaminated with iron and arsenic which possesses serious health hazard to the general public. Proper hydrogeologic knowledge of the area can be helpful to prepare a sustainable management plan for groundwater utilization.

1.3. Approach and methodology: The approach is to identify the principal aquifers and to conceptualize the aquifer system. This will help to formulate an aquifer 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-6.5 using Projection category longitude/latitude (Indian for Pakistan, India, Bangladesh, Nepal projection). 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 and conceptual model a sustainable development plan of the aquifer is formulated

1.4 Area Details: The area chosen for aquifer mapping falls under Survey of India Toposheet No. 83I/6 and 83 I/10 bounded by 27˚ 15′ and 27˚ 45'North Latitudes and 94˚15' and 94˚ 45′ East longitudes covering an area of 1000 sq. km (Fig. 1.1) of Dhemaji district of Assam.

Table 1.1: Administrative set up of the study area

State	District	Block	Panchayat
Assam	Dhemaji	Bordoloni	1
		Dhemaji	6
		Sisiborgaon	11

Table 1.2: Population and area of the study area

District	Block	No. of villages	Population	Geographical area (Hectre)
Dhemaji, Assam	Bordoloni	5	10842	3256.73
	Dhemaji	12	53905	8187.25
	Sisiborgaon	18	20609	11545.6

Dhemaji is connected with the rest of the State by NH 52 and by railways.

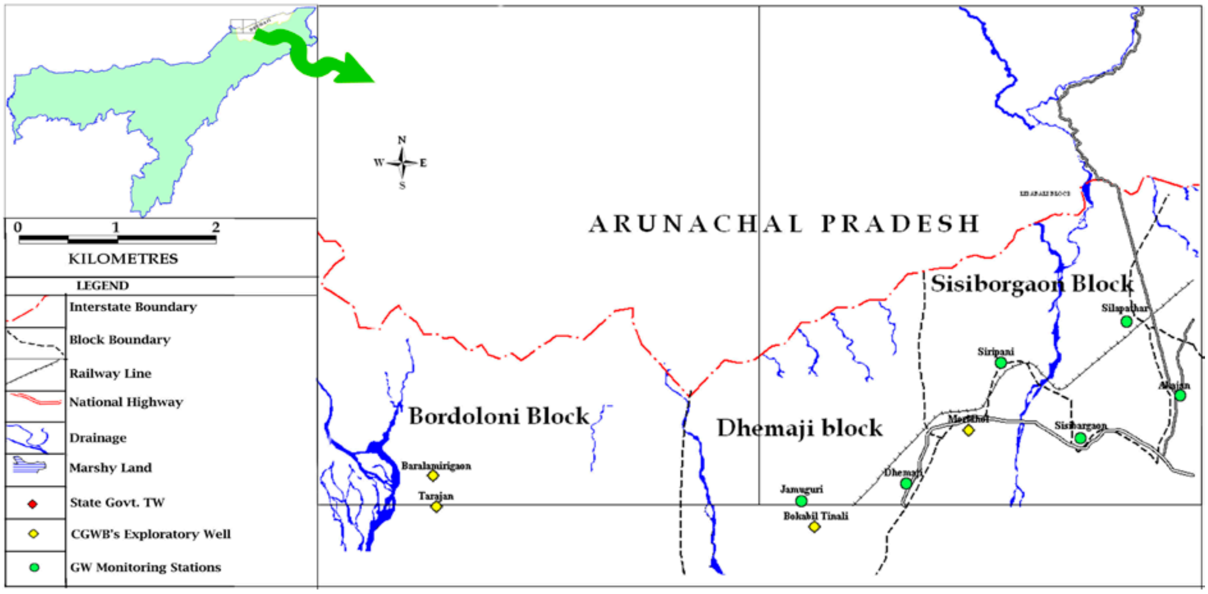


Fig. 1.1: Index map of the study area

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

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, State Groundwater Departments. All data were plotted in base map on GIS Platform (MapInfo-6.5 using Projection category longitude/latitude (Indian for Pakistan, India, Bangladesh, Nepal projection).

The available data, data gap and data generation work is tabulated in Table: 1.3 and shown in Fig. 1.2 to 1.3

Table 1.3: Data availability, data gap and data generation in Dhemaji district, Assam

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data		3	3	Nil	3	Maximum depth of well is 60mbgl only.
2	Geophysical data		Nil	23	16	16	
3	Groundwater level data	Dug well	6	13	5	11	
		Piezometer Aquifer-I	1	4	Nil	1	
4	Groundwater quality data	Dug well-Aquifer-I	6	13	5	11	
		Piezometer Aquifer-I	1	4	Nil	1	
5	Specific Yield		Nil	7	Nil	Nil	
6	Soil Infiltration Test		Nil	14	Nil	Nil	

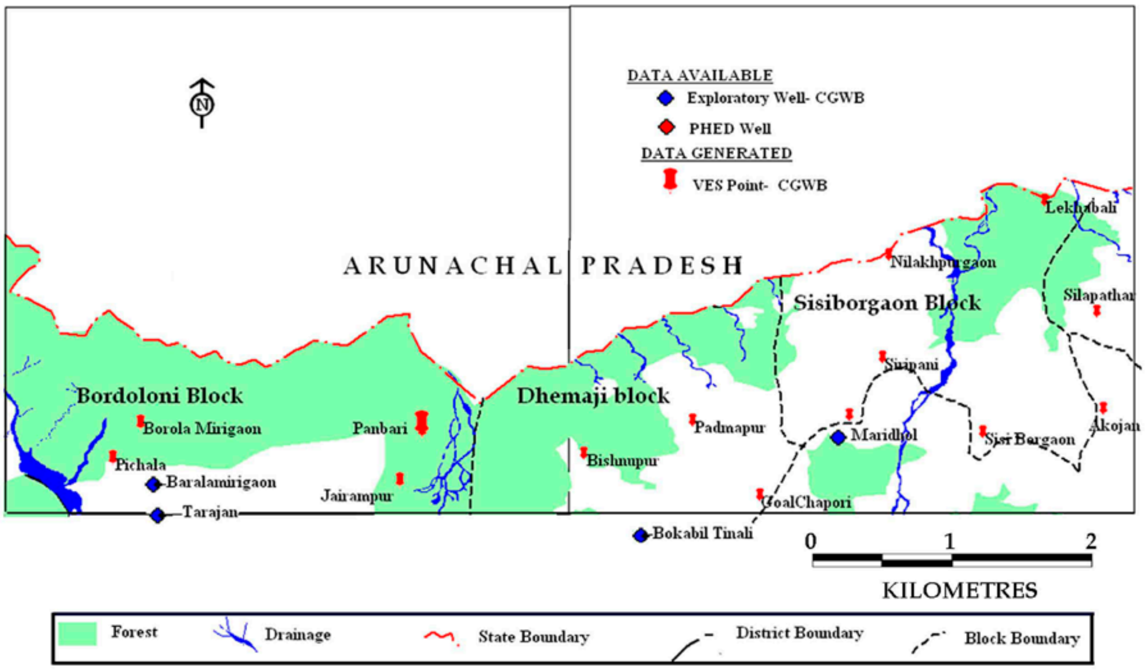


Fig.1.2: Exploration and geophysical data availability and data generation

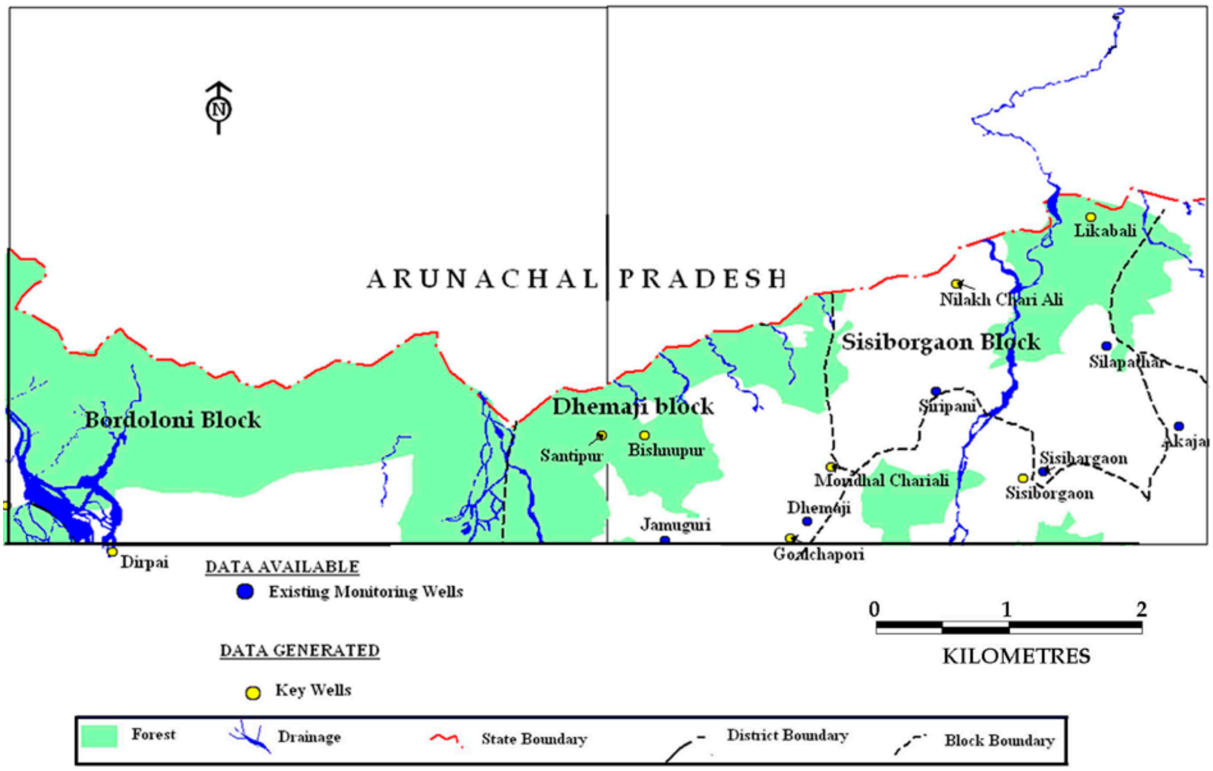
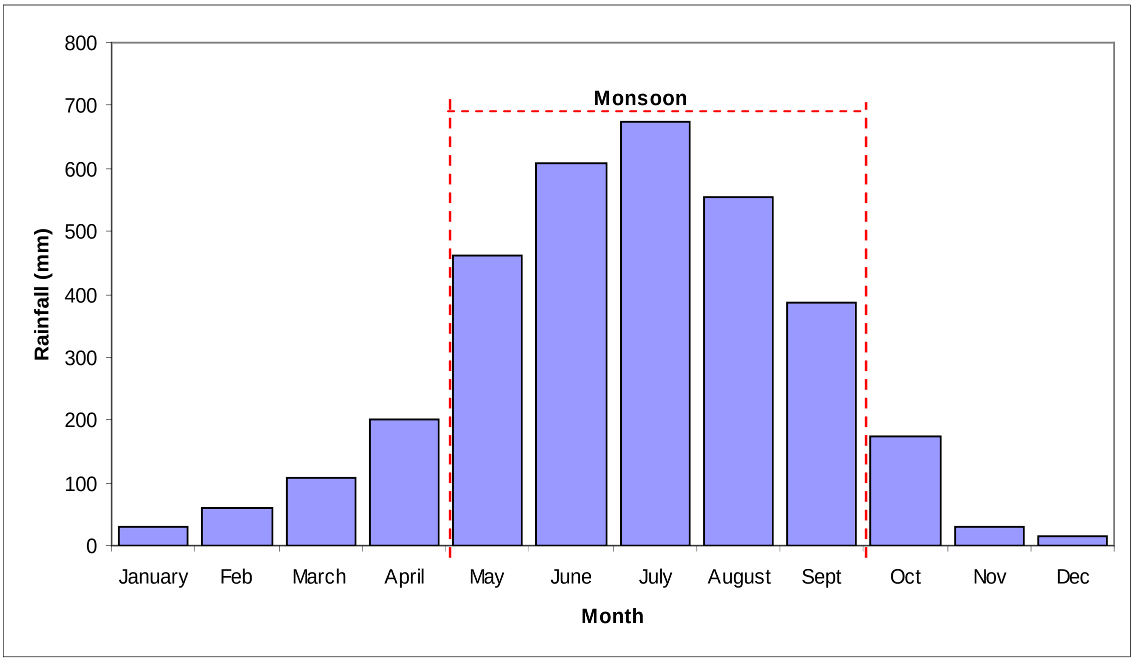


Fig.1.3: Water level monitoring and water quality monitoring data availability and data generation

1.6 Rainfall-spatial, temporal and secular distribution:

The area close to the foothills receives more rainfall than the area farther away from foothills. The average annual rainfall recorded Dhemaji District, Assam is 2995.96mm Average monthly rainfall and yearly rainfall variations are graphically illustrated in Fig. 1.4.



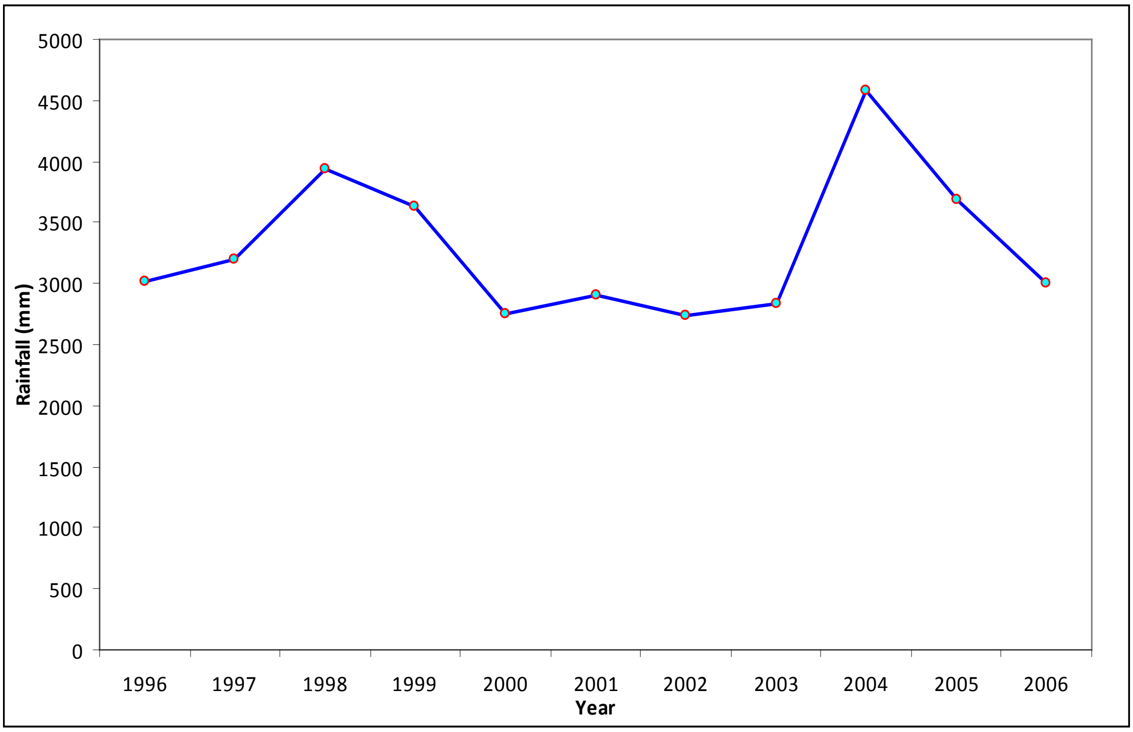


Fig. 1.4: Average monthly rainfall and yearly rainfall variations in and around the study area

1.7 Physiographic set up: Physiographically the area can broadly be divided into three parts, i.e., the hilly tract, the piedmont and flood plain. The hilly tracts are characterized by low to moderate relief hills and corrugated landform and comprise of Siwalik sediments of lesser Himalaya. The slope of the area drops from northern and eastern corners towards south. Digital Elevation Model (DEM) of the area is shown in Fig. 1.5.

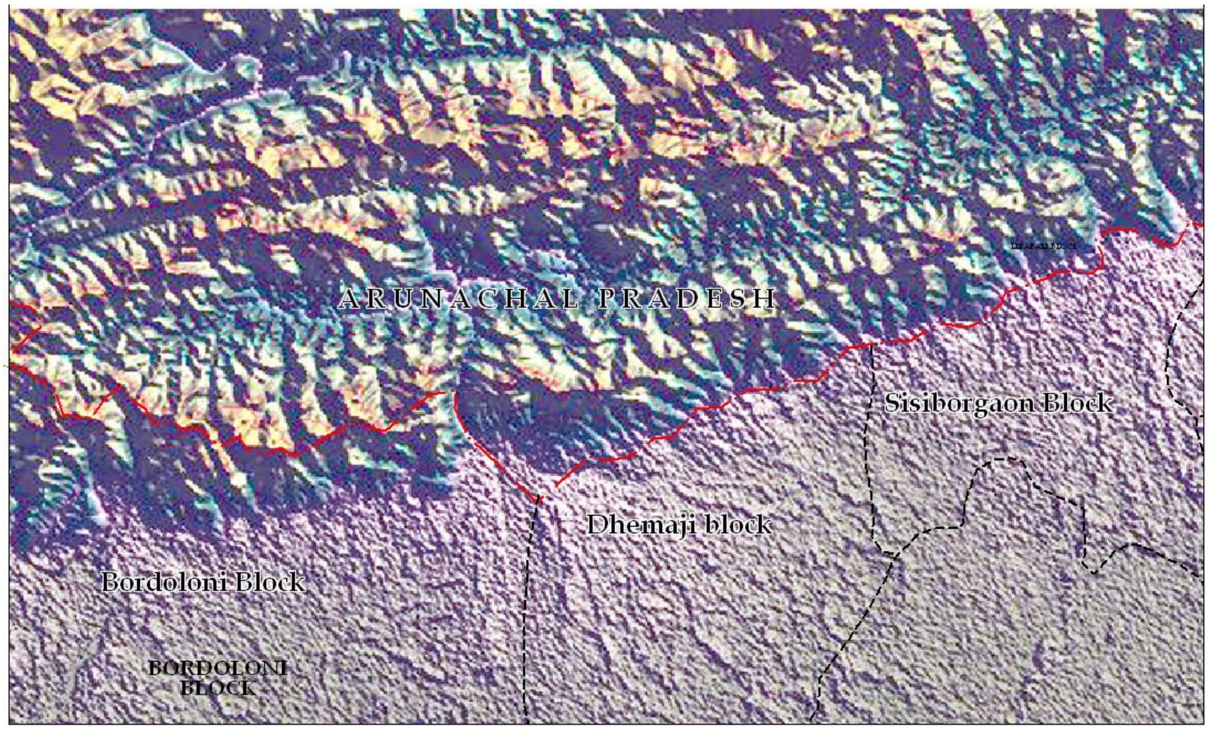


Fig.1.5: Digital Elevation model of the study area

1.8. Geomorphology: Geomorphologically the area can be classified mainly into four divisions: structural hills, piedmont zone, alluvial plain 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 area comprises of mixture of sand and silt with 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: 1.5).

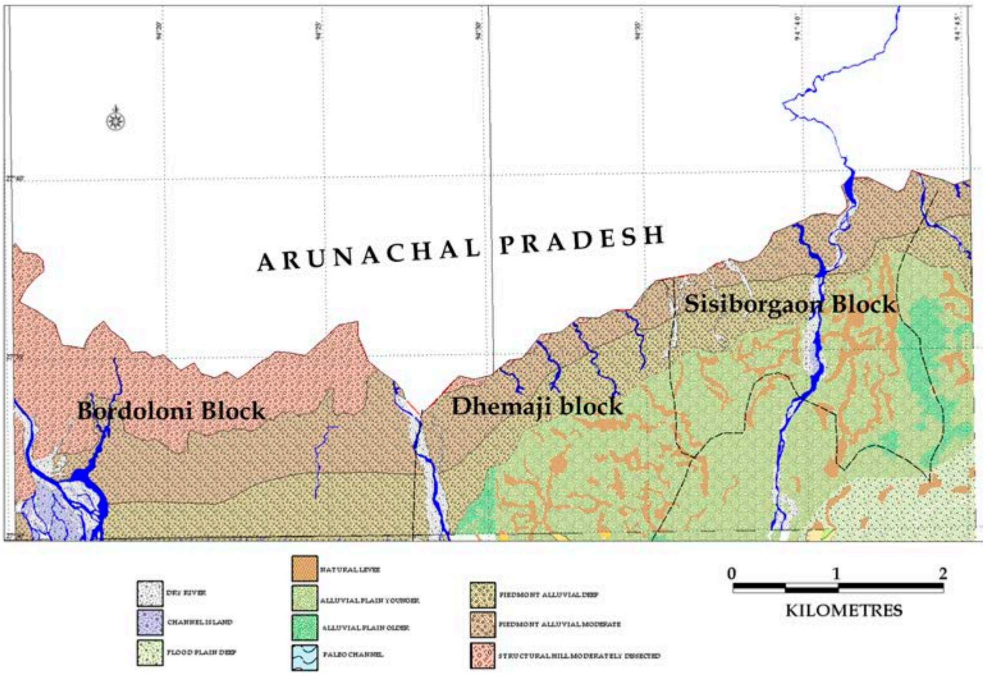


Fig.1.6: Geomorphological map of part of the study area

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

Table 1.4 Land use pattern of the study area under Dhemaji district, Assam

Block	Area (in Hectares)										
	Total Geographical Area	Forest	Area under Non-Agricultural Uses	Barren & Un-cultivable Land	Permanent Pastures and Other Grazing Land	Land Under Miscellaneous Tree Crops etc.	Culturable Waste Land	Fallows Land other than Current Fallows	Current Fallows	Net Area Sown	Net Cultivale
Dhemaji	8187.25	0	806.1	50.2	0	228.2	499.7	1157.02	2899.74	2404.35	7189.01
Bordoloni	3256.73	58.74	1011.61	21	5	136.15	2192.15	0	0	0	2333.3
Sissiborgaon	11545.6	0	1710.13	49.53	0	38	237.66	0	51.85	9355.89	9683.4

(Source: Census 2011)

1.10 Soil: The soils of this district can be broadly classified into three different types viz., the foothill/ piedmont zone soils, active flood plain soils near the river Brahmaputra and the low-lying marshy land soils.

Commonly foothill/Piedmont zone soil is highly acidic. However, new alluvial soils formed due to inundation of land by river contain more percentages of fine sand and fine silt and are less acidic. Such soils are often neutral and even alkaline in character. The rest large expanse of low-lying land is characterized by heavy clay soil which shows high percentage of nitrogen. This clay rich soil is very fertile and good for rice cultivation. The soil beside the Subansiri and Ranganadi rivers are sandy, mixed with silt, which is good for cultivation of winter crops, such as raga, mustard, potato etc. Details of soil texture of cultivable land are given in Table 1.5

Table 1.5: Soil textures of the area

Soil Texture	Area under cultivable land
Sandy loam	46% of the total cultivable land
Loamy	44% of the total cultivable land
Clayey	10% of the total cultivable land

1.11. Hydrology and drainage: Surface water bodies are mainly observed in the flood plain area where south and south western flowing rivers looses its gradient. Water logged and marshy lands are observed in the area. Kawaimari bill, Chumani bil, Chakamara bil, etc. are some of the surface water bodies in the area.

The Subansiri River marks the western boundary of the district while the great Brahmaputra River marks the southern boundary. A number of rivers enter the area from northeast and northern direction. Of these Gainadi, Moridhal, Jiadhal/Kumotia, Korha/Sila, Charikaria, Nonoi, Sampara Suti, Subansiri, etc. are important. Jiadhal River and Kumotia River create water logged and marshy areas in Bordoloni block. Kanibill which is called Laipulia in the downstream side and Sisi are two important rivers draining the central part of the district after originating in the hills near Gohaingaon and Baligaon respectively.

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 be due to presence of paleo-channels 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 (Fig. 1.7).

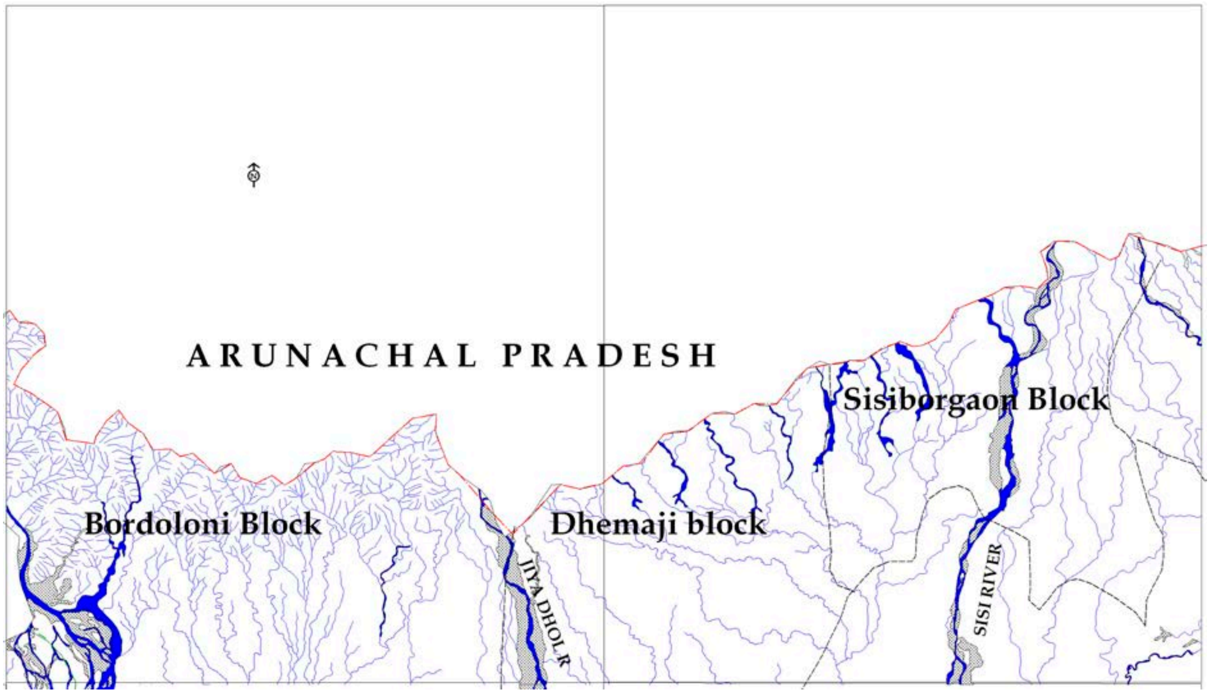


Fig. 1.7: Drainage map of part of Dhemaji District, Assam

1.12 Agriculture

In the study area paddy is the principal crops. The agriculture is rain fed. Majority of the population depend on cultivation. Paddy is the dominant crop, however, double cropping pattern is not observed in this part mainly due to lack of irrigation facility. There are two big tea gardens in the area

CHAPTER 2.0

Data Collection and Generation

2.1 Data collection

Data collection includes collection of rainfall data from state government, litholog collection from state groundwater departments, compilation of CGWB's earlier survey data, exploration and geophysical data. Population and agricultural data is collected from Census of India website.

During 2006-06 CGWB had carried out special study on arsenic occurences in Dhemaji district. The result of that study is also incorporated in the study. CGWB had constructed 4 exploratory wells in this area. Details of the wells are given in Table 2.5. CGWB has 5 groundwater monitoring station in the area and these monitoring stations were regularly monitored (Table 2.1 and 2.2).

2.1 Hydrogeological data: The entire study area is covered by regular monitoring of existing GWMS and another 15 key wells have been established. All these wells are under monitoring after establishment. The key well locations are given in the table no 2.1.1

Water level data:

Table 2.1: Key wells location details

Name of Village/Site	Latitude	Longi tude	Establish ment date	RL (mams)	Total depth of Pz/Dw (mbgl)	Type (DW/Pz/Spring)	Aquifer group	Measurement point (magl)	Source/ Agency
Bishnupur	27.55	94.52	7/4/2013	100	2.85	DW	Unconsolidated (1st aquifer)	0.73	CGWB
Santipur	27.55	94.50	7/4/2013	102	4.27	DW	Unconsolidated (1st aquifer)	0.6	CGWB
Goalchapori	27.50	94.58	7/4/2013	121	3.62	DW	Unconsolidated (1st aquifer)	0.5	CGWB
Moridhal Chariali	27.54	94.6	7/4/2013	109	4	DW	Unconsolidated (1st aquifer)	0.97	CGWB
Jamuguri	27.50	94.53	NHNS Well	86	3.08	DW	Unconsolidated (1st aquifer)	0.82	CGWB
Dhemaji	27.51	94.59	NHNS Well	89	3.88	DW	Unconsolidated (1st aquifer)	1.21	CGWB
Siripani	27.57	94.64	NHNS Well	108		DW	Unconsolidated (1st aquifer)	0.45	CGWB
Sisibargaon	27.56	94.69	NHNS Well	110	4.91	DW	Unconsolidated (1st aquifer)	0.97	CGWB
Sisiborgaon1	27.53	94.68	7/4/2013	109	2.78	DW	Unconsolidated (1st aquifer)	0.8	CGWB
Nilakh Chari Ali	27.62	94.65	7/3/2013	110	4.06	DW	Unconsolidated (1st aquifer)	1.04	CGWB
Silapathar	27.6	94.72	NHNS Well	119	6.60	DW	Unconsolidated (1st aquifer)	0.98	CGWB

Likabali	27.65	94.71	30/10/2013	109	6.28	DW	Unconsolidated (1st aquifer)	0.6	CGWB
Akajan	27.56	94.74	NHNS Well	109	4.77	DW	Unconsolidated (1st aquifer)	1.10	CGWB
Bokabil	27.50	94.54	NHNS Well	86	37.7	TW	Unconsolidated (1st aquifer)	0.80	CGWB

Table 2.2: Water level measurement of key wells

Name	Date of measurement (dd/mm/yyyy)	Depth of water level in mbgl	Name	Date of measurement (dd/mm/yyyy)	Depth of water level in mbgl
Bishnupur	26/06/2013	0.65	Dhemaji	27/08/2014	0.55
	3/12/2013	1.51		2/11/2014	0.82
	11/3/2014	2.33		8/1/2015	3.37
	29/08/2014	-0.05		7/3/2015	2.16
	8/1/2015	1.62		20/08/2015	0.24
				10/11/2015	0.73
Santipur	26/06/2013	1.02	Siripani	7/3/2013	1.6
	3/12/2013	2.64		28/08/2013	0.42
	11/3/2014	3.31		1/11/2013	0.67
	29/08/2014	0.8		8/1/2014	1.49
	8/1/2015	2.87		7/3/2014	1.6
Goal Chapori	1/7/2013			27/08/2014	-0.04
	3/12/2013	2.9		2/11/2014	
	27/08/2014	0.6		9/1/2015	1.28
	30/12/2014	3.03		8/3/2015	1.83
	8/1/2015			20/08/2015	0.12
	20/08/2015	0.61			
Moridhol Chariali	26/06/2013	0.84	Sisiborgaon	7/3/2013	2.66
	3/12/2013	2.62		27/08/2013	1.07
	7/3/2014			1/11/2013	1.03
	27/08/2014	0.58		8/1/2014	2.13
	8/1/2015	2.9		7/3/2014	2.32
	8/3/2015	3.2		28/08/2014	0.68
Jamuguri	8/3/2013	2.86		2/11/2014	1.62
	28/08/2013	0.31		9/1/2015	2.23
	1/11/2013	1.81		8/3/2015	2.35
	8/1/2014	2.61		20/08/2015	0.29
	11/3/2014	3.04		10/11/2015	1.37
	28/8/2014		Sisiborgaon1	26/06/2013	0.68
	1/11/2014	2.4		3/12/2013	2.02
	8/1/2015	3.23		27/08/2014	0.5
	7/3/2015	2.8		30/12/2014	2.4
Dhemaji	7/3/2013	2.73		8/1/2015	2.26
	29/08/2013	0.55		8/3/2015	2.73
	1/11/2013	0.94	Nilakh Chari Ali	26/06/2013	2.29
	8/1/2014	1.94		3/12/2013	3.34
				30/12/2014	3.49

Name	Date of measurement (dd/mm/yyyy)	Depth of water level in mbgl		Name	Date of measurement (dd/mm/yyyy)	Depth of water level in mbgl
Silapathar	7/3/2013	4.75		Akajan	7/3/2013	3.4
	28/08/2013	1.13			27/08/2013	1.2
	1/11/2013	2.2			1/11/2013	2.17
	8/1/2014	4.28			8/1/2014	3.15
	7/3/2014	4.96			7/3/2014	3.48
	28/08/2014	0.67			27/08/2014	0.27
	2/11/2014	1.88			2/11/2014	2
	9/1/2015	4.04			9/1/2015	4.46
	8/3/2015				8/3/2015	3.42
Likabali	30/10/2013	2.22			20/08/2015	0.13
	30/12/2014	3.55			10/11/2015	1.99

2.2 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 were collected. Water samples were collected from monitoring wells for detailed, iron, heavy metals and arsenic. However, heavy metal and arsenic analysis data are yet to be received**.**

2.3 Geophysical survey: During AAP 2013-14, 10 VES survey were conducted in the area with current electrodes spreading in the range of 200 to 500m. The obtained VES data was plotted on double logarithmic graph sheet. The VES data was interpreted by using IP2WIN software technique. H, HK, K, Q type multilayered VES curves was obtained.

The location details of these VES survey is shown in Table 2.1.3.

Table 2.3: Location details of VES survey

SN	Name of the site	Latitude	Longitude	RL (mamsl)	Agency	VES/TEM	Depth of interpretation
1	Padmapur	27.54333	94.55889	109	CGWB	VES	169
2	GoalChapori	27.50694	94.58861	101	CGWB	VES	98
3	Maridhol	27.54639	94.62833	104	CGWB	VES	188
4	Siripani	27.57444	94.64306	110	CGWB	VES	96
5	Sisi Borgaon	27.53806	94.68722	106	CGWB	VES	100
6	Akojan	27.54917	94.74056	111	CGWB	VES	157
7	Pichala	27.525	94.3025	114	CGWB	VES	69.9
8	Borola Mirigaon	27.5275	94.32444	115	CGWB	VES	209
9	Govindpur	27.53889	94.43917	124	CGWB	VES	180
10	Panbari	27.53889	94.43917	126	CGWB	VES	201
11	Lekhabali	27.65194	94.71472	134	CGWB	VES	190
12	Nilakhpurgaon	27.62528	94.64556	129	CGWB	VES	250
13	Jairampur	27.51417	94.42944	113	CGWB	VES	92
14	Bakulbari	27.43194	94.43	99	CGWB	VES	94
15	Bishnupur	27.5275	94.51083	113	CGWB	VES	209
16	Silapathar	27.5975	94.73778	116	CGWB	VES	111

2.4 Exploratory Drilling: During AAP 2013-14, there was no exploratory drilling in the area. CGWB old drilling record were collected and examined. A list of wells constructed in the area was prepared incorporating location, well designs, etc.

Table 2.4: Details of exploratory wells in the study area

Village/ Location	Taluka/ Block	District	Toposheet No.	Lat	Long	Type of well (DW/BW/TW)	Depth (m)	Dia (mm)	Source/ Agency
Moridhol	Dhemaji	Dhemaji	83I/10	27.54	94.62	TW	34.1	41.0mX304.8mm 19.0mX203.4mm	CGWB
Bokabil	Dhemaji		83I/10	27.50	94.54	TW	37.7	50.5mX304.8mm 13.0mX152.4mm 30.0mX152.4mm	CGWB
Barala Miri Gaon	Bordoloni		83I/6	27.52	94.32	TW	61.5	254.0mmX32.0m 152.4 mmX25.0m	CGWB
Tarajan Mohori Camp			83I/6	27.50	94.32	TW	59.5	NA	CGWB

CHAPTER 3.0
Data Interpretation, Integration and Aquifer Mapping

3.1 Data Interpretation

Geophyscis and aquifer Characterization: The interpreted results of VES curves has shown that top soil has resistivity value within 500 Ohm being approximately 5m thick comprises clays with boulders of compact nature. The layer below the top soil in the depth range of 5m and 50m with resistivity in the range of 100 Ohm m and 250 Ohm m is indicative of saturated formation comprising sands, clays with pebbles etc. The consecutive layer below 50m and 250m with resistivity more than 150 Ohm m is indicative of the probably the saturated formation comprising pebbles with sands and clays occasionally with boulders. Comparatively lesser resistivity within 70-80 Ohm m is indicative of clays predominance intercalated with thin bands of sands etc. The summary result of resistivity survey is shown in Table: 3.1

Table 3.1: Summary result of VES study

Resistivity section	Resistivity value Wm	Depth (mbgl)	Inferred Lithology
	500	0 to 5mbgl	Top soil: clays with boulders of compact nature
	100 to 250	5 to 50mbgl	Saturated formation : Sands, clays with pebbles etc.
	>150	50 to below 250mbgl	Saturated formation: Pebbles with sands and clays occasionally with boulders

	70-80	clays predominance intercalated with thin bands of sands

The result of VES survey has shown that the subsurface formation is sand or gravel dominated and clay occur as intercalations with sand. Moreover, saturated formation is extended below 250m.

Central Ground Water Board, North Eastern Region, Guwahati has drilled four exploratory wells in the area. From the examination of this litholog it is observed that down to a maximum explored depth of m the sequence is dominated by gravel, sand, clay and boulders. The lithologs and the lithology identified in VES survey are used to understand 2D and 3D disposition of aquifer.

2D disposition: A section is prepared in a north east-south west direction to know disposition of sediments in the piedmont zone. It is observed that the sediments of piedmont zone deposited in high energy conditions as coarser grain materials are dominated in sub surface formation close to the foothill. Two gravelly formations are encountered and identified in the VES and in drilling. Resistivity value of the first gravel zone ranges from 267 to 7080Ωm and perusal of litholog of Borola Miri Gaon, Tarajan Mohori Camp, Bokabil and Moridhol EW shows that the zone is dominantly gravelly mixed with sand. 2D disposition of this zone in the subsurface along the strike of piedmont is lense shaped with continuously thinning and thickening (Fig. 3.1). Towards the Brahmaputra flood plain this gravel layer is pinched out (Fig. 3.2).

The resistivity value of the second gravel zone ranges from 250 to 2644 Ωm. The highest resistivity value is found near Arunachal foot hill at Likabali and Borola Miri Gaon, etc., indicating coarseness and dryness of the zone. This zone is pinched out towards the alluvial plain/flood plain. In the piedmont zone also this zone is pinched out and reappear depending the proximity of the area to Arunachal foothill.

In the study area three clay layers encountered. The first clay layer is pinching out at Bishnupur and near Pichola. The second clay layer is pinched out towards northwestern part while third clay layer is completely absent in some locations. That is both these layers are not present throughout the area. Resistivity value of the first clay layer ranges from 53 to 97 Ωm indicating and resistivity of the second clay layer ranges from 67 to 130 Ωm. Second clay layer is absent in the piedmont zone and after emerging in the alluvial plain its presence can be detected towards the flood plain.

The aquifer zone is an admixture of sand and gravel in various proportions. However, towards the flood plain, i.e., in the area around Bakulbari, Dhemaji area the gravel percentage may be less.

A perusal of the 2D and 3D disposition of the aquifer, it can be summarized that the aquifer system of the study area in Assam is mono or single aquifer, however, locally it may behave like multi-aquifer system. (Fig. 3.3). The aquifer property identified by CGWB are given in Table

2D Disposition of Aquifer

Fig. 3.1: NE-SW SECTION PARALLEL TO PIEDMONT ZONE

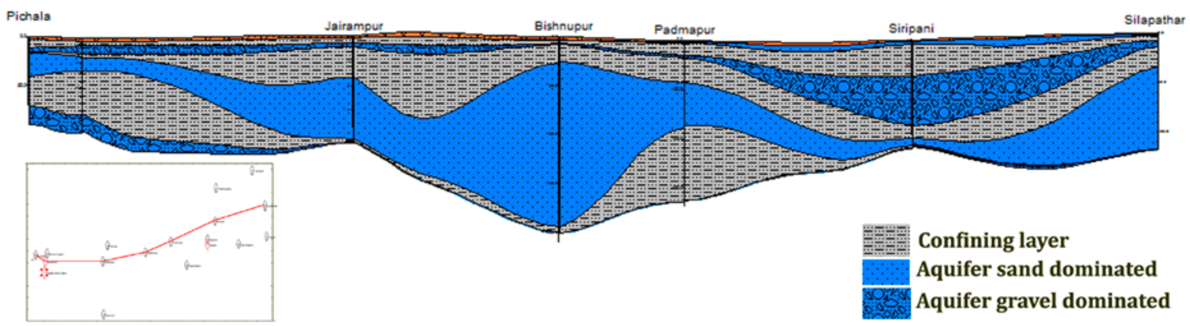


Fig. 3.2: NNE-SSW SECTION NORMAL TO PIEDMONT

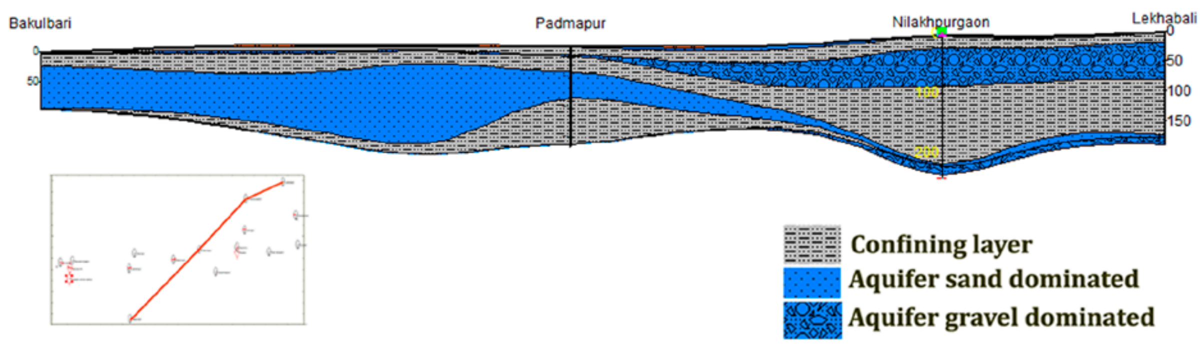


Fig. 3.3: 3D Aquifer Disposition

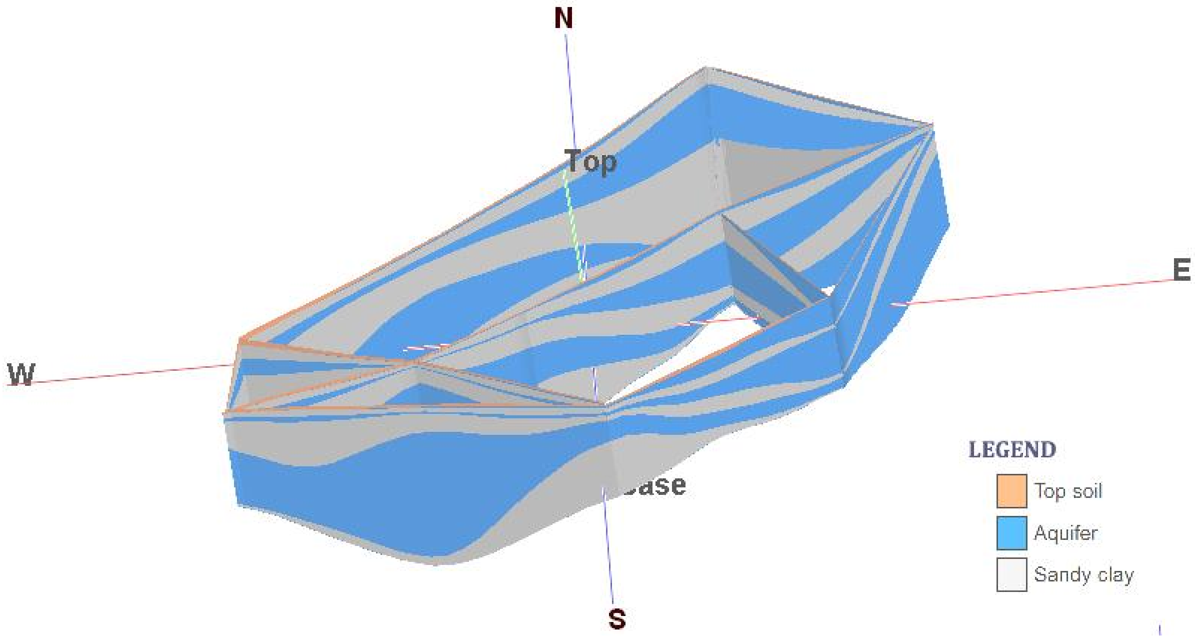


Table 3.2: Aquifer property

Village/ Location	Taluka/ Block	Lat	Long	Type of well (DW/BW/TW)	Depth (m)	Draw down (m)	Transmissivity (m^2/day)	Storativity/ S.Yield	Specific Capacity (lpm/m of dd)	Source/ Agency
Barala Miri Gaon	Bordoloni	27.52	94.32	TW	61.5	0.855	3283.2	NA	947.36	CGWB
Tarajan Mohori Camp		27.50	94.32	TW	59.5	2.08	9831	NA	358.5	CGWB
Bokabil	Dhemaji	27.50	94.54	TW	37.4	2.41	5466.0	NA	175.56	CGWB
Moridhol		27.54	94.62	TW	34.1	4.92	2032.4	NA	137.4	CGWB

Ground water level

To study ground water regime, depth to water level from 11 monitoring stations are measured seasonally. Pre-monsoon depth-to-water level of the key wells in Dhemaji block ranges from 2.73 to 2.83 mbgl and in Sisiborgaon block depth-to-water level varies from 1.6 to 4.75 mbgl. Since the survey work has began from May 2013, pre-monsoon water level data of 2013 is given from NHNS only. 2013 Depth to water level during monsoon (August 2014) period ranges from 0.76 to 2.74 m bgl. Post-monsoon water level data of Dhemaji block ranges from 0.94 to 2.9mbgl and for Sisiborgaon block DTW varies from 1.43 to 2.2 m bgl. In Bordoloni block DTW for post-monsoon period varies from-0.07mbgl to

Depths to water level for pre-monsoon and post-monsoon periods are given in Fig.3.4 and 3.5 respectively. Fluctuation of water level in the piedmont zone ranges from -0.06 to 5.06 m bgl while in alluvial plain pre- and post monsoon water level difference ranges from -0.6 t0 2.63mbgl. The water level fluctuation in the alluvial plain is generally within 3.0m.

Ground Water Movement

The water table contour has been prepared based on water level of ground water monitoring stations. The ground water flow direction is from the higher elevation in northwestern towards the plain area while in 83I/6 the groundwater flow direction is almost north-south and 83I/10 the flow direction is from northeast to southwest. The highest water table is 190 m above mean sea level in the piedmont zone area while lowest contour is 80m towards south in the flood plain. In general the gradient of flow is high towards north than the other part. The entire piedmont zone forms the recharge zone for the entire area. Water table contour map for shallow aquifers is given (Fig. 3.6)

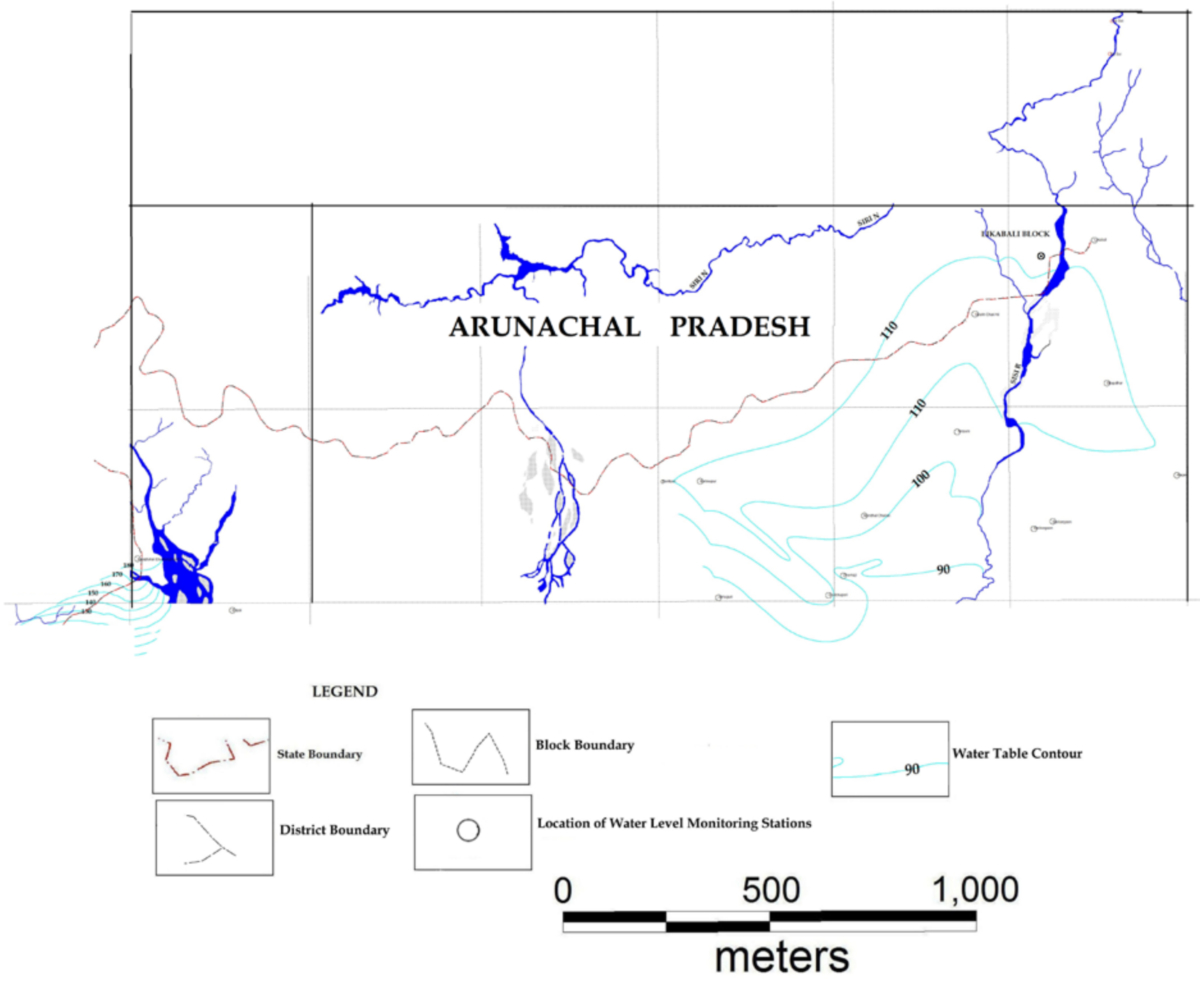


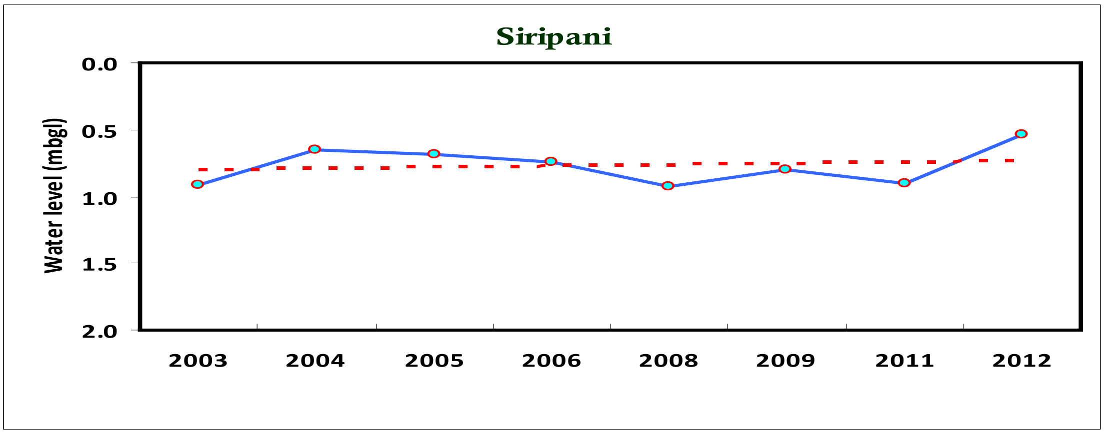
Fig. 3.6: Water table contour map of the study area

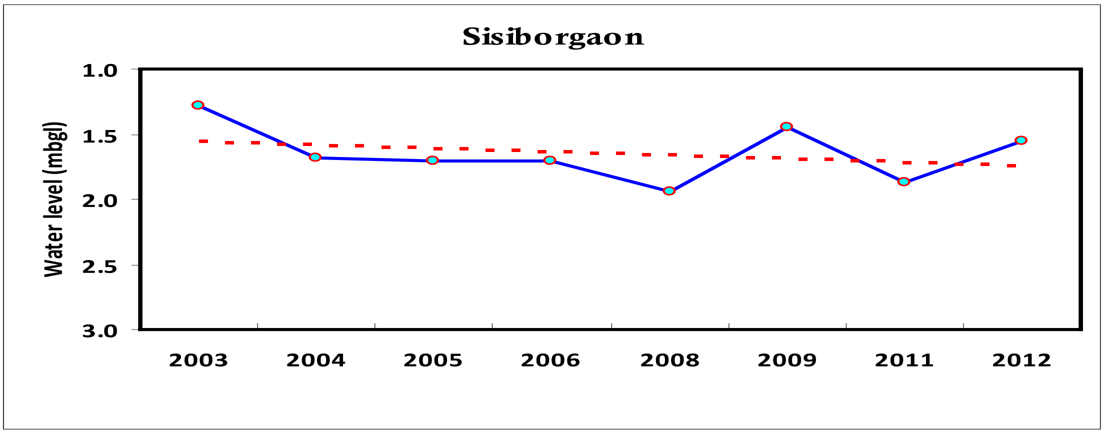
Water level trend analysis

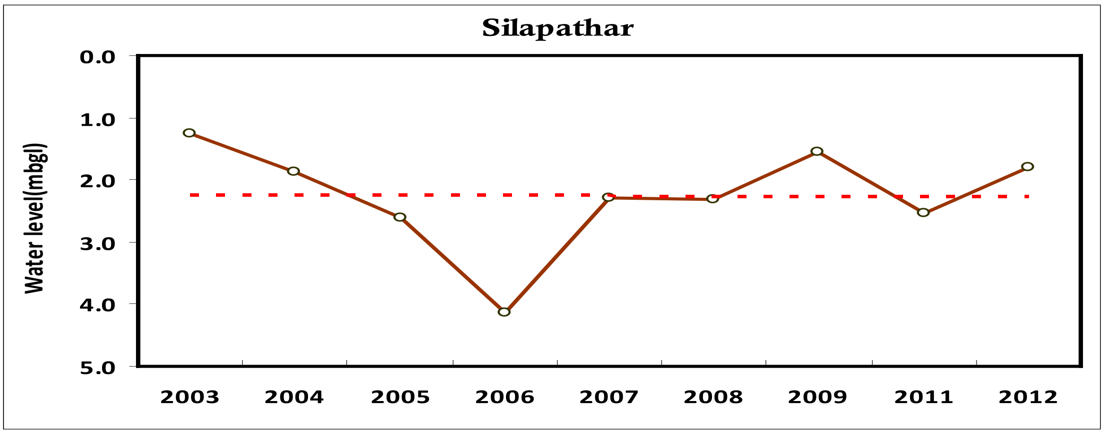
For analysis of long-term behaviour of ground water level, data from Ground Water Monitoring Stations (GWMS) are utilized. Historical depth-to-water level data (in m bgl) are plotted as individual hydrographs and are given in Figure 3.7 and3.8 Table 3.3 shows the overall trend of water levels in GWMS wells.

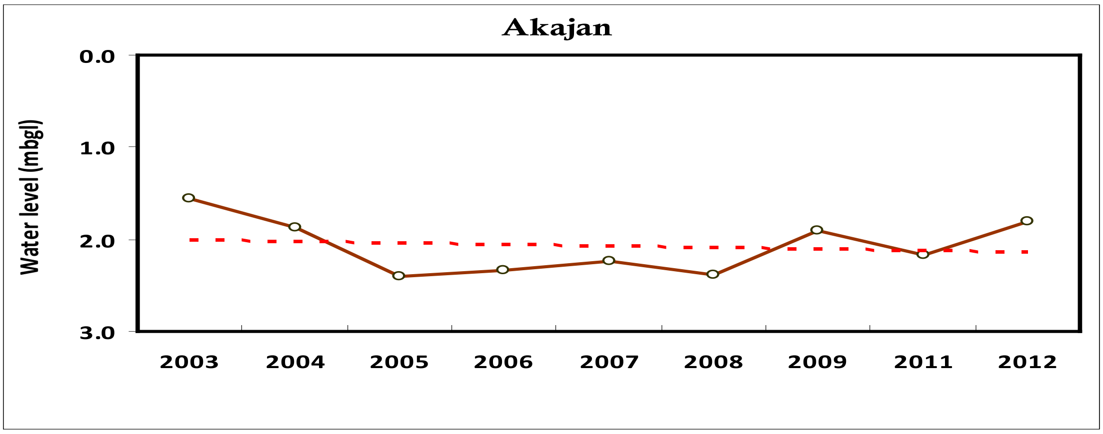
Table 3.3: Trend of Water levels in GWMS Wells

SN	Well No	Locality/Name	No. of years	Water Level Trend	
				Post-monsoon	Pre-monsoon
1	ASDM16	Siripani	9	Rise	Fall
2	ASDM17	Sisiborgaon	9	Fall	Fall
3	ASDM15	Silapathar	9	Unchanged	Fall
4	ASDM01	Akajan	9	Rise	Fall
5		Dhemaji	10	Rise	Fall









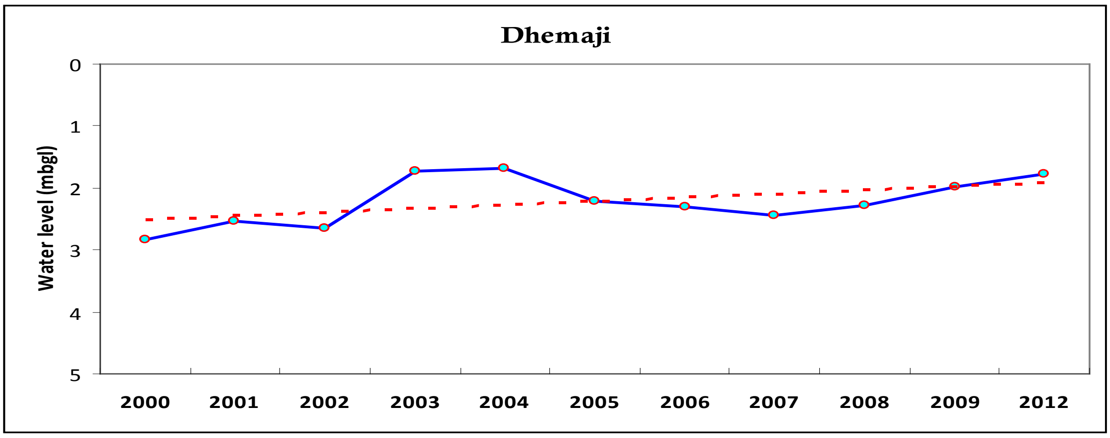
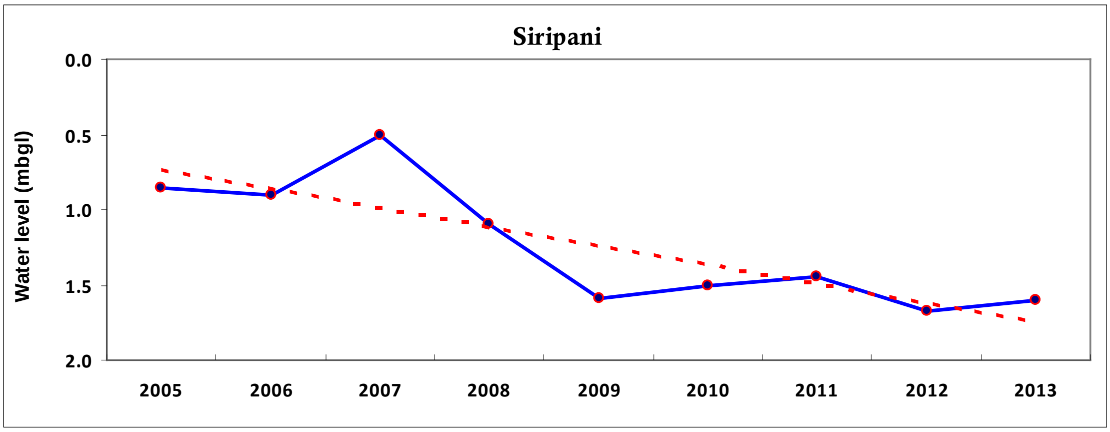
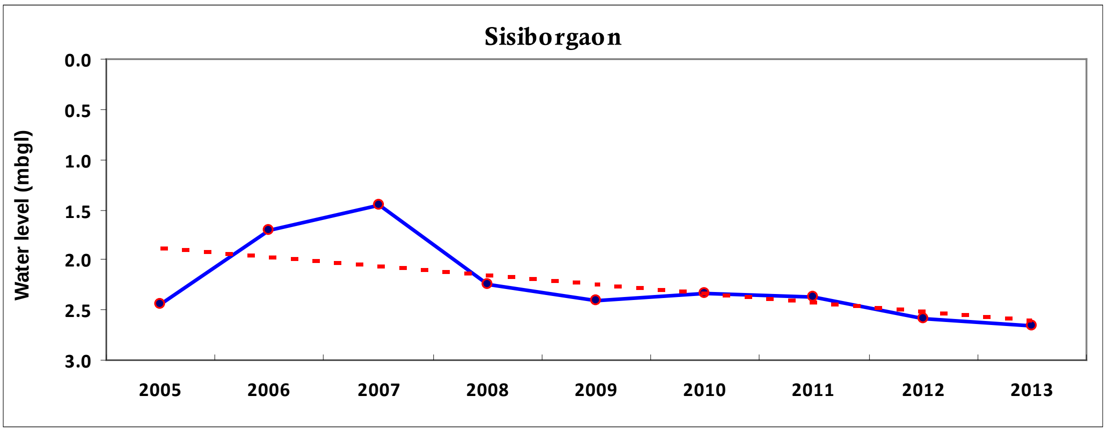


Fig. 3.7: Post –monsoon Hydrograph of GWMS wells





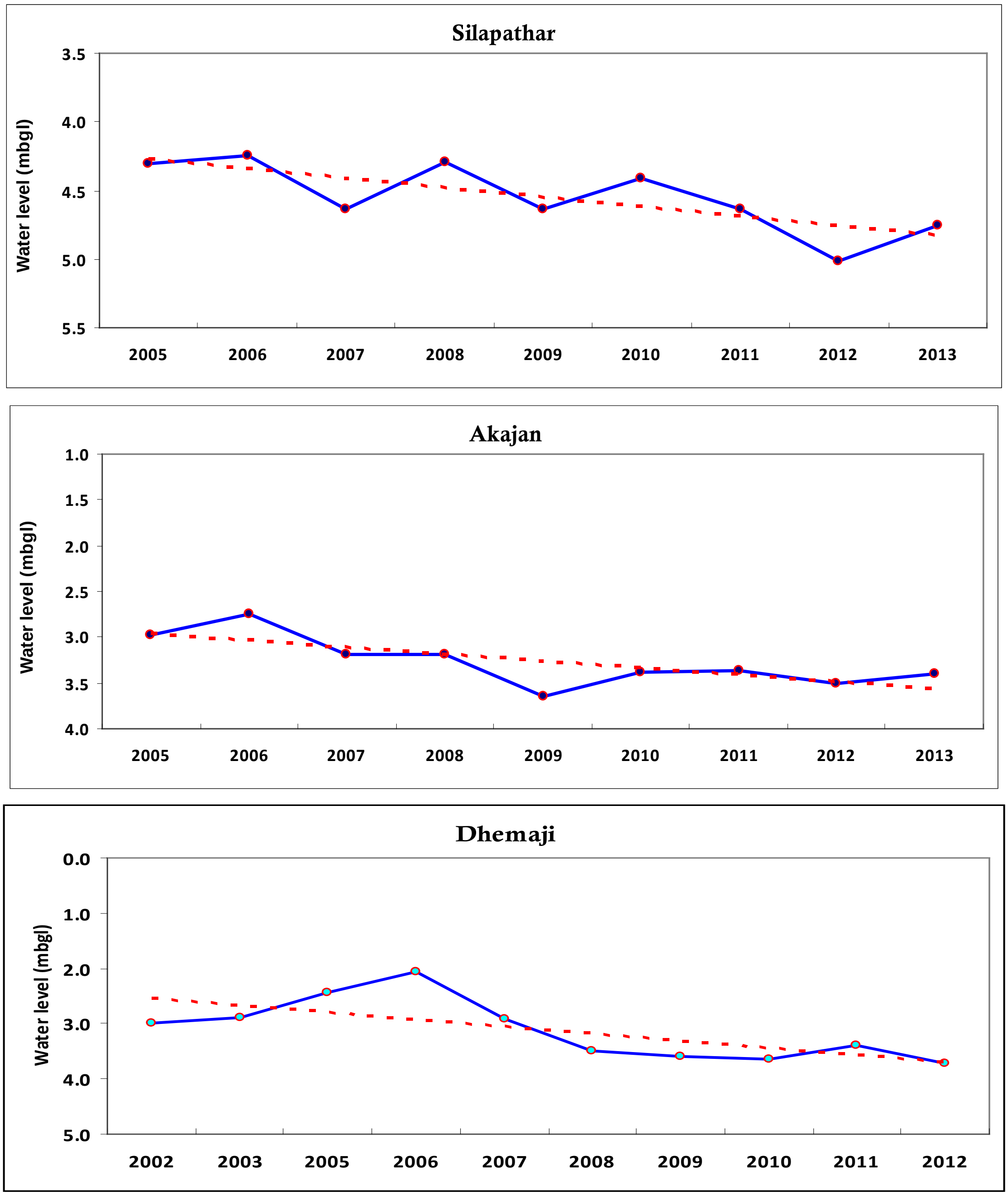


Fig.3.8: Pre-monsoon Hydrograph of GWMS wells

Ground water quality: Chemical analysis of ground water samples are carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. Groundwater contamination data from CGWB's earlier study is also utilized in this work. In the present study also groundwater samples were collected for arsenic and other heavy metal analyses, however, the analysis results are yet to obtain.

Pre-monsoon pH value ranges from 7.4 to 8.4 and in the post-monsoon pH value ranges from 6.1 to 7.6 indicating wide variation in pH. Pre-monsoon water sample mostly alkaline while post-monsoon samples are mostly acidic in nature. Pre-monsoon pH value increases the chance of bacterial contamination. In post monsoon water samples also iron concentration is above permissible limit. In Dhemaji block its value ranges from 0.4 to 4.87mg/l while in Sisiborgaon block iron occurs within 0.56 to 2.39mg/l. It is observed that in both pre- and post-monsoon groundwater samples concentration of Ca, Mg, Cl, SO_4, TDS and hardness as $CaCO_3$ in mg/l are within desirable limit. Results of pre- and post monsoon chemical analysis of water samples in the study area is given in Table **3**.4

Table 3.4: Block-wise concentration range of chemical constituents in groundwater

Elements	Pre-monsoon		Post-monsoon	
	Dhemaji	**Sisiborgaon**	**Dhemaji**	**Sisiborgaon**
pH	7.4-7.9	8-8.4	6.3-6.6	6.5-7.6
EC (μS/cm)	165.5-391.5	296.4-386.9	363-805	293-502
	conc. In mg/l			
TDS	77.3-183	138.6-180	193-426	156-266
TH	60-152	100-172	70-196	84-204
Ca	16-40	36.8-40	36.8-40	20.8-52
Mg	4.9-12.6	0-19.4	2.72-13.59	5.05-12.62
Na	3.7-7.7	5.1-6.1	1.89-15.16	2.55-16.81
K	3.3-5.9	3.3-5.5	1.77-7.18	2.93-17.73
CO3	16-24	16-32	BDL	BDL
HCO3	48-100	60-76	BDL-80	BDL-1118
SO4	0.99-32.01	7.57-23.55	1.93-17.44	2.71-19.95
NO3	0.2-0.5	0.1-2.1	1.3-2.2	BDL-17.2

Arsenic in groundwater: Dr. I. Roy carried out a special study on occurrence of arsenic in Dhemaji district, Assam during AAP 2006-07. In that survey, ground water samples were collected from ninety four (94) key sampling wells that include hand-pump, tube well and dug-well. To check the reliability of analytical results, during pre-monsoon season, two identical sets of samples were collected and sent separately to CGWB, SR, Hyderabad and North Eastern Regional Institute of Water and Land Management (NERIWALM), Tezpur. The comparison shows that results are quite comparable with correlation coefficient of 0.74 with few outliers. The results indicate that analyses of CGWB, SR are more reliable, hence for the present study, analytical values of CGWB, SR has been accepted. Arsenic concentration in different blocks of the study area is quoted from the report (Table 3.5)

Table 3.5: Block wise arsenic values (in ppb)

Block Name	Pre-monsoon		Post-monsoon	
	Min	Max	Min	Max
Bordoloni	-BDL-	249	-BDL-	75.8
Dhemaji	-BDL-	108	-BDL-	109.5
Sissiborgaon	-BDL-	54	-BDL-	50.2

Aquifer Map: The aquifer map of the area is prepared and it clearly shows that the piedmont area is extending almost east-west direction and is gravel dominated. The alluvial plain area is sand dominated. Water logged areas are found in the flood plain and alluvial plain area. The aquifer map is shown in Fig. 3.9.

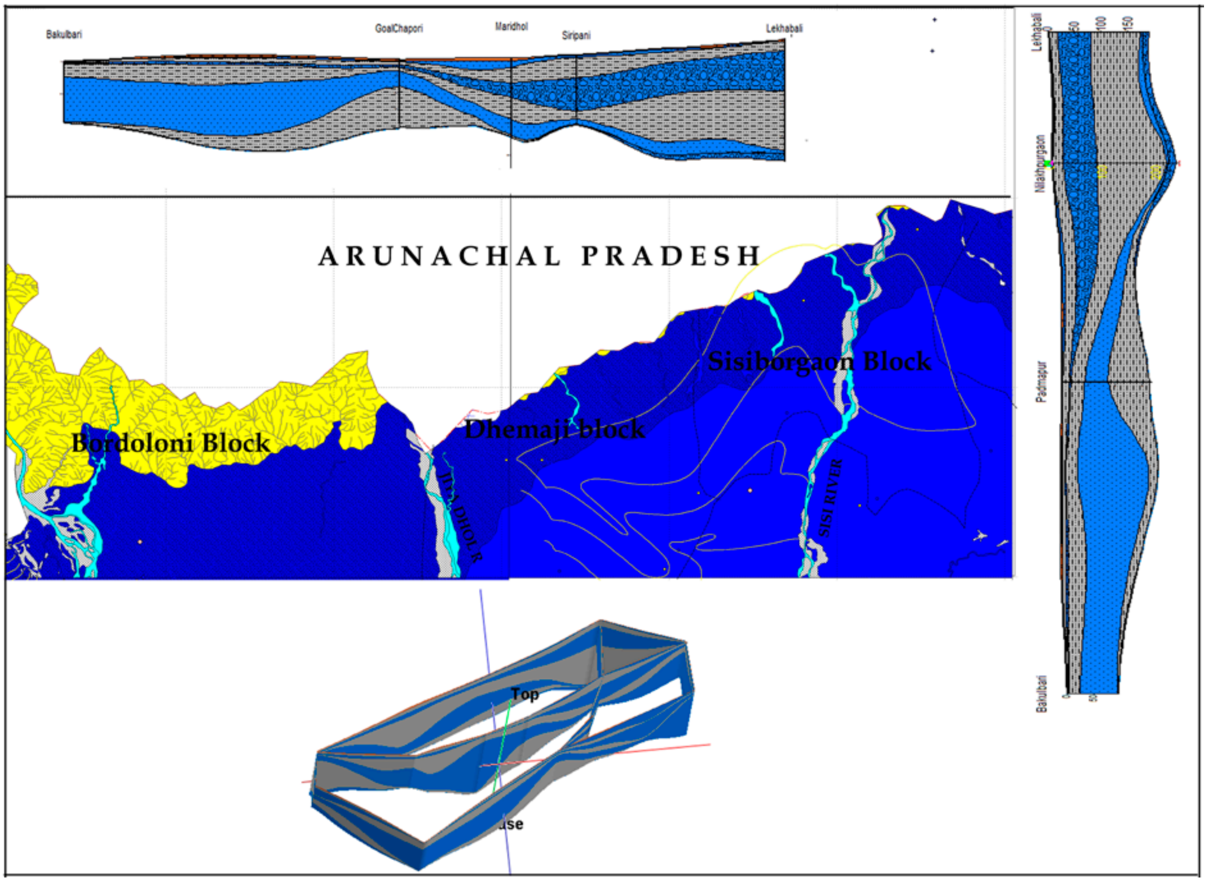


Fig. 3.9: Aquifer Map of the study area

CHAPTER 4.0

Ground water Resources

The computation of ground water resources available in the district has been done using GEC 1997 methodology. The dynamic resource estimation presented here is taken from 2013 dynamic groundwater resources of Assam where resource was estimated district wise due to paucity of block-wise data. In the present report the same calculation is used and the resource is proportionately divided among blocks based on their geographical areas. Data and assumptions used in the assessment: Following data and assumptions are used in the assessment:

1) Rainfall recharge has been computed by both RIF and WLF methods. In RIF method, rainfall infiltration factor has been taken as 0.20 for Indo-Gangetic plains and inland area and 0.08 where clayey contents are more. In WLF method, specific yield has been taken as 0.20 for coarse grained sandy alluvium and 0.08 for silty alluvium following the norms recommended by GEC'97.

Rainfall data is taken from IMD. The rainfall of Dhemaji district is 2996mm.

2) Water level data has been considered for 2012. Water level fluctuation based on data of March (Pre monsoon) and November (post monsoon) has been considered since deepest water levels are recorded during the month of March.

The average pre- and post-monsoon water level of Dhemaji district is 3.585mbgl and 1.245mbgl.

3) The population figures were collected from Census, 2011and projected to 2013. The per capita domestic requirement for the rural population has been considered as 60 lpcd and for urban population, it is 135 lpcd.

4) The dependency on ground water resource for domestic and industrial water supply in rural areas is considered as 90% and for urban areas, the dependency is 50%.

5) In order to calculate the canal seepage, the data on length of the drainage channels are taken from the Irrigation Department, Govt. of Assam. The factor for return flow from surface water irrigation has been taken as 0.50 (paddy) and 0.30 (non-paddy) and for Ground water irrigation it has been taken as 0.45 (paddy) and 0.25 (non-paddy). Recharge from tanks and ponds are calculated based on the norms suggested in GEC'97.

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

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

Recharge: The aquifers of the study area are recharged through a) infiltration of rainfall on the outcrop b) seepage from the tanks and ponds c) subsurface inflow across the updip margin. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 81 percent of total rainfall (May, June, July, August, September) while share of post and pre monsoon rainfall are approximately 13 and 6 percent each.

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

The monsoon recharge of the 323700hectre of recharge worthy area is 157318ham while non-monsoon recharge is 53993ham. Recharge from other sources during monsoon is 3337 ham and during non-monsoon is 724ham. Total ground water recharge is 215372ham.

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

In the district natural discharge is considered to be 10% of the total groundwater recharge, i.e., 215372ham. Total irrigation draft created is 7920ham. There is no major industry in the area. Draft for domestic uses is 1472ham. Total groundwater draft for all uses is only 9392ham.

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

Allocation of resources up to 2025: The net ground water resource is allocated for domestic and industrial and irrigation sector. 1924ham of resource is allocated for domestic and industrial purposes while 183991ham resource is allocated for irrigation.

Stage of groundwater development: The area has very little irrigation facilities. Similarly industrial development in the area is practically nil. Groundwater is mainly utilized for domestic purposes. However, Public Health Engineering & Water Supply Department has supplied water mainly through surface water sources. The stage of groundwater development in the district is 16%.

Block wise dynamic ground water resource: As mentioned earlier, due to paucity of block level irrigation data, ground water uses for domestic purpose and rainfall data, the resource estimation is carried out district wise. However, in the present study the total district resource is divided block wise based on geographical area of block. In doing so, it is assumed that all other hydrogeological, climatic conditions and draft are same for the entire district. Salient features of this approximation is shown in Table 4.1

Table 4.1: Recharge and net GW availability

Block	Recharge from rainfall during monsoon	Recharge from other source during monsoon	Recharge from rainfall during non-monsoon	Recharge from other source during non-monsoon	Total GW Recharge	Provision for natural discharges	Net Annual GW availability
	Unit in ham						
Bordoloni	22671.56	480.9048	7781.089	104.3377	31037.89	3103.789	27934.1
Dhemaji	27596.84	585.3791	9471.493	127.0046	37780.72	3778.072	34002.65
Sisiborgaon	22352.09	474.1284	7671.446	102.8675	30600.54	3060.054	27540.48

Table 4.2: Block wise draft, resource allocation up to 2025 and stage of GW development

Block	Net Annual GW availability	Existing gross GW draft for irrigation	Existing gross GW draft for domestic and industrial water supply	Existing gross GW draft for all uses	Provision for domestic and industrial requirement supply to 2025	Net GW availability for future irrigation developm ent	Stage of GW development
Bordoloni	27934.1	1141.374	212.1342	1353.508	262.862	26515.48	4.845363
Dhemaji	34002.65	1389.332	258.2194	1647.552	319.9675	32275.84	4.845363
Sisiborgaon	27540.48	1125.291	209.1451	1334.436	259.158	26141.85	4.845363

Static resource: The static groundwater resource of the district has been calculated for the base year 2009. 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 Dhemaji 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 0.20 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 feature of static ground water resource of the area

Name of the assessment unit	Type of rock formation	Total Geographical Area Ha	Assessment Area Ha	Bottom of the unconfined aquifer (m)	Average Pre-monsoon Water Level (m)	Thickness of the saturated zone of the un-confined aquifer below WLF zone (m) [(5)-(6)]	Volume of Saturated zone of the unconfined aquifer below WLF zone (ham)
1	2	3	4	5	6	7	8
Dhemaji District	Alluvium	323700	323700	100	3.12	96.88	31360056

Static/In-storage Ground Water Resources (ham): Volume of saturated zone X specific yield
= 31360056X0.2=6272011.2ham

Extraction from unconfined aquifer/deeper aquifer: As mentioned earlier that groundwater in this area is utilized mainly for drinking or domestic purposes. Public Health Engineering Department water supply projects are mainly based on groundwater. However, exact number of water supply projects was not obtained from PHED, Dhemaji.

As per verbal communication and earlier record of CGWB, it is observed that PHED tube well depth is generally within 50m. Besides the public water supply scheme rural population utilize dug wells for drinking and domestic water purposes. Dug well depth is generally more towards piedmont zone. Dug well depth in this area is generally within 10m. In the alluvial plain area dug well depth 3 to 7m.

There is no record of ground water utilization for irrigation purpose.

CHAPTER 5.0
Groundwater Related Issues

Identification of issues: The main groundwater issue in this area is vulnerability issue. The vulnerable areas generally include areas vulnerable to water logging and polluted areas (Fig. 5.1).

Area vulnerable to water logging: Water logged areas are observed in the southern part of the study area. The post monsoon depth-to-water level varies from 0.94 to 2.17. Even in pre-monsoon season the depth-to-water level varies from 0.65 to 2.86. The water logged areas are roughly parallel to piedmont zone. 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 observed.

Area vulnerable to arsenic pollution: CGWB study carried out by Dr. I. Roy, Scientist-B, NER, Guwahati in 2006 has confirmed the presence of arsenic and also established that arsenic is present in Bordoloni block also. The study found that arsenic and iron concentration is high during Pre monsoon Period. Comparison of concentration with depth of well for both pre- and post-monsoon seasons shows that concentration of As and Fe is mostly within 10 m depth.

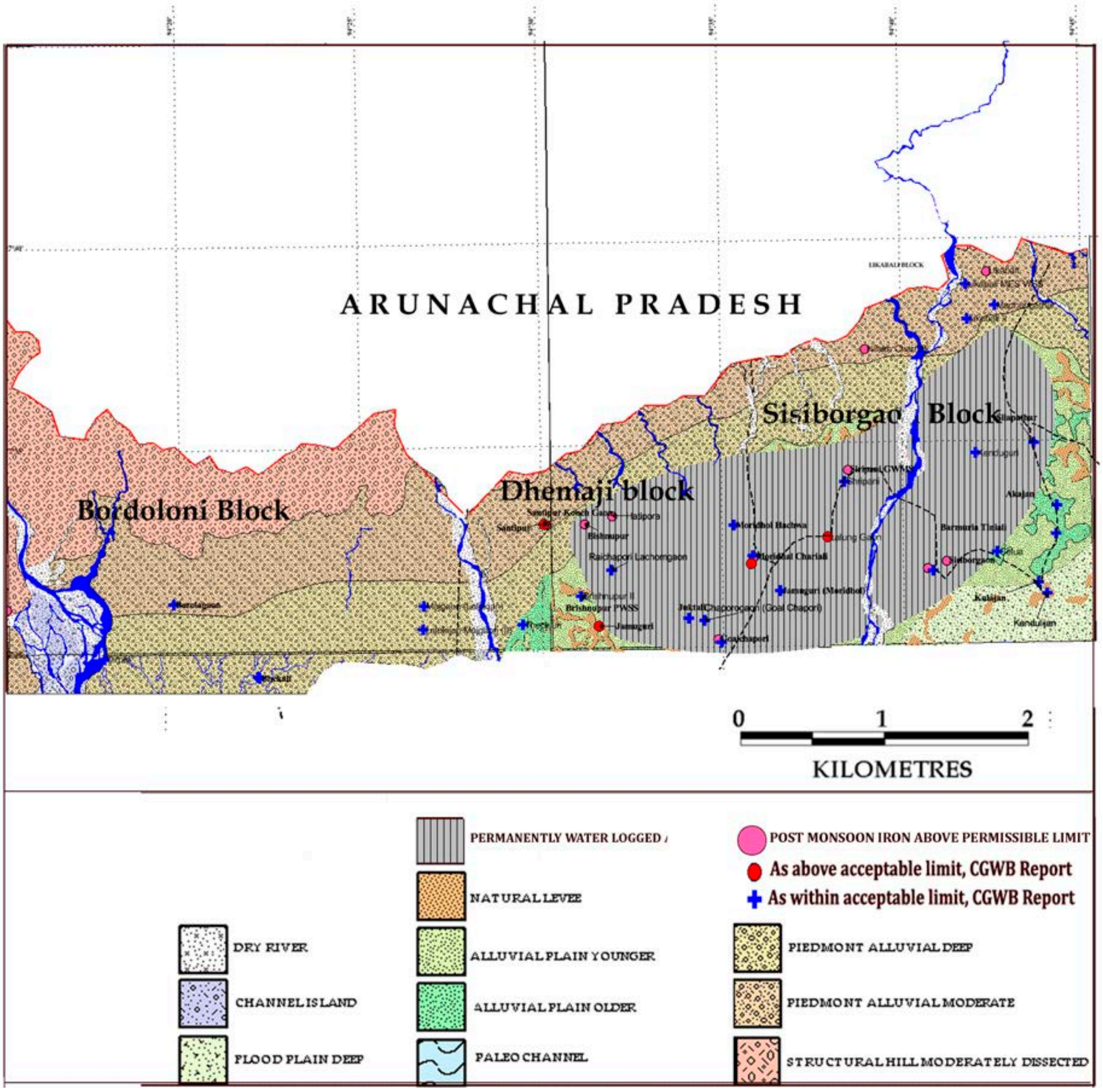


Fig. 5.1: Vulnerability map of the study area

Future demand: Future demand of ground water is analyzed for domestic, drinking and irrigation purposes.

Domestic and drinking purpose: The drinking and 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)

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

Block	**Block Population 2011**	**% Decadal population growth**	**Projected Population**			**Projected Water Demand considering per person water need of 60litre per day (ham)**		
			2013	**2025**	**2030**	2013	**2025**	**2030**
Bordoloni	112710	**20.3**	112710	117212	398098	213.06	723.62	936.36
Dhemaji	127104		127104	132180	448938	232	787	1018
Sisiborgaon	208368		208368	216690	735967	130	162	178

Future demand for agriculture: The area has saucer shaped topography. In the northern part there is Arunachal Himalayas and towards south the Brahmaputra River. The Brahmaputra River bed is elevated after 1950's great earthquake. Water logging problem of the area can be related with this changing physiography.

As a result during monsoon season, the increase in surface run-off in the form of increased discharge of hilly rivers flow to this part of land and immediately losses its velocity due to sudden fall of slope and as such agriculture field and human settlement area is inundated. The flood water remains in the land for longer period if Brahmaputra River is also flowing at a higher level.

The rainfed agriculture is badly affected by longer flood period. If flood period is to be considered for no need for agriculture then objective of irrigation should aim to bring the entire net sown area under assured irrigation. Assured irrigation can bring a change in cropping pattern. Cropping pattern change is always associated with increase in irrigation.

As vast part of the land area is under shallow water level condition, large or medium surface irrigation scheme is not advisable. Therefore, groundwater based irrigation scheme coupled with small scale surface water irrigation has to be adopted.

Since the area has shallow water level condition, the **total depth of water required to raise a crop over a unit area (Δ) is considered as 1.2m**

Table 5.2: Block wise water requirement for winter paddy cultivation through irrigation

Block	Irrigated Area	Un irrigated Area	Total Area	60% of net sown area bring under paddy cultivation and irrigation	Δ in m	Water requirement for 60% of net sown area (ham)
Dhemaji	0	17841.8	17841.8	9589.02	1.2	12846.0
Sissiborgaon	0	36672.2	36672.2	22003.32		26404
Bordoloni	0	5447.22	5447.22	7368.22		3922
Total water requirement					43172 Ham	

Table 5.2: Block wise water requirement for rabi crops other than paddy through irrigation				
Block	**Total Area**	**Δ in m**	**Base period for crops other than Rice**	**Water requirement for 40% of net sown area (ham)**
Dhemaji	6392.68	0.3	100days	2141.016
Sissiborgaon	14668.88			4400.664
Bordoloni	4912.14			653.6664
Total water requirement				7195.35 **Ham**

Stress Aspects of aquifer: Stress aspects of aquifer are discussed comparing water demand in various sectors and supply (Table 5.3).

Table 5.3: Water requirement in all sectors

Block Name	Drinking water requirement up to 2025 Ham	Water requirement to bring 60% of net sown area under irrigation for paddy cultivation Ham	Water requirement to bring 40% of net sown area under irrigation for non-paddy cultivation Ham	Water allocated for drinking and domestic purposes up to 2025 Ham	Water allocated for irrigation up to 2025 Ham
Dhemaji	88	11506.82	2141.016	262.862	26515.48
Sissiborgaon	162	26403.98	4400.664	319.9675	32275.84
Bordoloni	99	8841.864	653.6664	259.158	26141.85

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. However, if entire net sown area will required to bring under irrigation then allocated water for irrigation will not be sufficient to meet the future demand. Supply and demand gap in drinking and irrigation are shown in Table 5.4 and 5.5 respectively.

Table 5.4: Supply and demand gap in drinking water sector

Block Name	Drinking water demand up to 2025 Ham	Water allocated for drinking and domestic purposes up to 2025 Ham	Gap between supply and demand Ham
Dhemaji	88	263	175
Sissiborgaon	162	329	167
Bordoloni	99	259	160

Table 5.5: Supply and demand gap in irrigation

Block Name	Total irrigation demand Ham	Water allocated for irrigation up to 2025 Ham	60% of the allocated water for irrigation available for use	Gap between supply and demand Ham
Dhemaji	13647.84	26515.48	15909.29	2261.45
Sissiborgaon	30804.65	32275.84	19365.5	(-) 1439.15
Bordoloni	9495.53	26141.85	15685.11	6189.58

CHAPTER 6.0
Management Strategy

6.1 Sustainable Management of GW resource

The aquifer system in the study area is a mono or single aquifer type. From the panel diagram it is clear that bouldery or gravelly bed is present all along the foothills from south west to north east direction of the study area while the aquifer material become finer towards the flood plain. The variation of lithology and geomorphic set up of the study area has also influenced the ground water regime. In the piedmont slope pre-monsoon water level is deeper and difference of pre and post monsoon water level is high. In the piedmont zone water level fluctuation is less compared to piedmont slope while flood plain area is characterized by water logged condition.

Based on the hydrogeomorphic set up in mind the area can broadly be classified into three zones. The characteristic feature of these zones are enumerated in the following table (Table 6.1)

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

Zone	Geomorphology	Lithology	Chemical Quality	WL condition	Population density
Zone-I	Alluvial plain and flood plain	Sand, silt dominated with occasional gravel	High Fe and also arsenic	Shallow water level/ water logged	High
Zone-II	Piedmont	Gravel, pebbles, boulder with little sand and clay	Arsenic nil or within acceptable limit	Post monsoon water level is generally 3 to 4 mbgl	Sparse to medium
Zone-III	Piedmont slope and highly dissected structural hills	Gravel, pebbles, boulder with little sand and clay	As not reported and Fe is within acceptable limit	Deeper pre-monsoon WL, WL fluctuation is high	Sparse

Sustainable Management Plan of Resource: It is observed that the groundwater resource of this area is not sufficiently utilized for economic development of the area and is evident from the stage of groundwater development index. Moreover due to its unique geomorphic setting the area is recharged annually and this causes water logging condition in the plain area. Again due to water logging condition the aquifer can not be utilized to receive additional recharge and thus surface run-off is increasing causing flood havoc in the area.

In this context the withdrawal of groundwater in the area will be helpful for economy of the region and also it makes room for recharge also.

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

Groundwater draft is calculated for well discharge of 40m^3/hr. If the well is allowed to run 10hrs a day for 150days of a year then a tube well having discharge will create a draft of 0.06MCM.

Therefore with available resource and to create a draft of 0.06MCM, 8493 numbers of tube wells can be constructed in the area. Block wise break up is given below (Table 6.3).

Table 6.3: Block wise tube well construction

Block	Resource allocated for irrigation (ham)	60% of allocated resource (ham)	No of TW
Dhemaji	26515.48	15909.288	2652
Sissiborgaon	32275.84	19365.504	3228
Bordoloni	26141.85	15685.11	2614
Total	84933.17	50959.902	8494

However, based on total net sown area and total unirrigated status of the land is worked out. Therefore, the required numbers of tube wells are worked out and shown in Table 6.4.

Table 6.4: Numbers tube well required for irrigation

Block Name	Total irrigation demand (Ham)	No. of TW required with Q=40m^3/hr for 10 hrs pumping hrs for 150days Draft to be created =0.06MCM
Dhemaji	13647.84	2275
Sissiborgaon	30804.65	5134
Bordoloni	9495.53	1583
Total	53948.02	**8992**

Arsenic pollution: CGWB has confirmed the presence of high arsenic content in the groundwater in and around the study area. However, it is observed that arsenic is detected in shallow hand pump, dug well or tara pumps only. Therefore, arsenic detection is restricted mostly within 10m depth. Therefore tube wells can be constructed down to a depth of 50m tapping lower 20m granular zones. From the 2D and 3D disposition of aquifer diagram it is observed that clay or sandy clay layers are present in many areas. These confining layers can be utilized to separate the arsenic occurrence zone by adopting proper well construction technique.

Deep tube well in the flood plain and arsenic affected areas may be constructed by proper cement sealing and clay filling as shown in Fig. 6.1

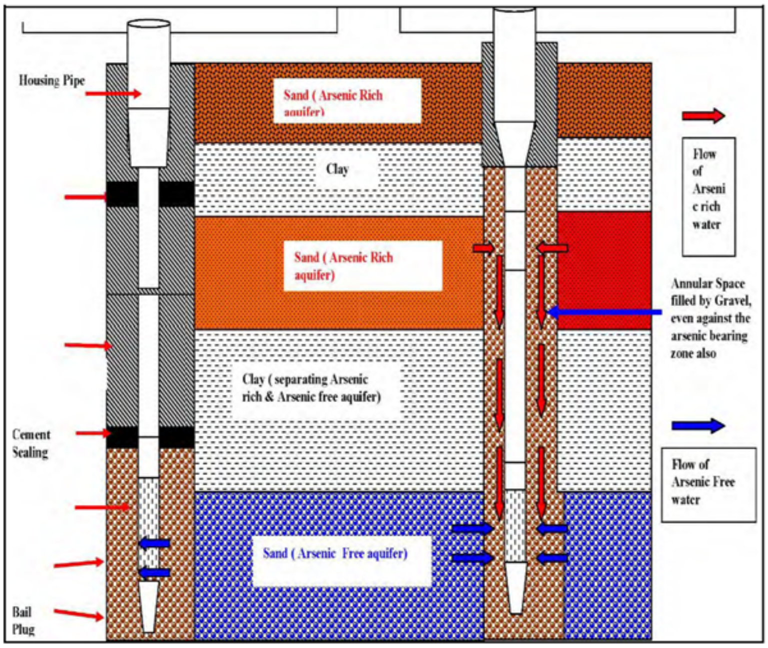


Fig.6.1: Tube-well design of a deep tube well tapping safe deeper aquifer
(Source: Concept note on geogenic contamination of groundwater in India)

6.2 Aquifer wise availability of unsaturated zone: Aquifer wise availability of unsaturated zone is found out from the area enclosed by 3.0mbgl post monsoon water level contour (Manual of Artificial Recharge: CGWB, 2007). The area is found to be 14.64sq.km. However, the groundwater monitoring stations are not uniformly spread out in the area due to lack of dug wells. The area can be further extended after establishing representative monitoring stations.

The marked area belongs to phreatic unconsolidated aquifer. Volume of sub-surface storage space available for recharge= Area (3m WL contour)X Specific yield

$=14.64X0.2=2.928m^3$

Considering recharge efficiency of individual recharge structure 70%, surface water required to recharge the unsaturated storage space is

= (Sub-surface volumeX100)/recharge efficiency

= (2.928X100)/0.7 m^3 or $418m^3$

The area identified for recharge is piedmont zone. However, long term post and pre-monsoon water level trend do not show significant change in water level. Moreover, ground water development in the area is only 5%. A major part of the area is under shallow water table and water logging conditions. As such there is every possibility that artificial recharge in the piedmont area may increase water logged area. Therefore artificial recharge is not recommended for the area.

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 slope of the area is towards south. 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 conveyance 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 (Figure 1). 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.

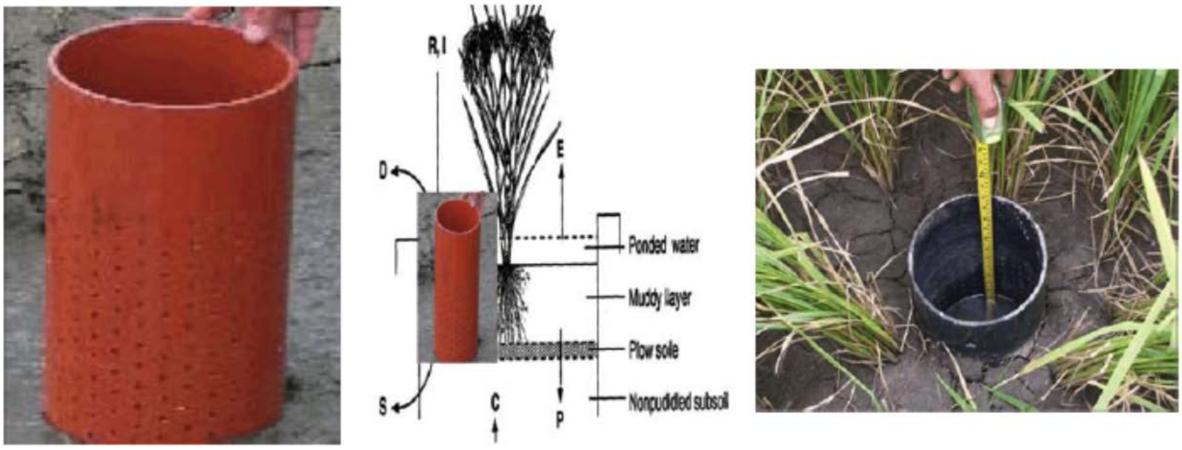


Fig. 6.2: A simple perforated pipe (water tube) installed in the rice field allows farmer to monitor water level beneath the soil surface (Kulkarni, 2011)

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

Block	**Paddy cultivated area (as per Agriculture Census 2010-11) (ha) (From Table: 5.2)**	**40% reduction of water for land leveling by the use laser land leveler**	**Approximate saving of water ham**
Dhemaji	9589.02		767.1216
Sissiborgaon	22003.32		1760.266
Bordoloni	7368.22		589.4576
Total water saving			3116.85

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, stress aspects of aquifer is analyized for different situations.

Stress on aquifer due to drinking water supply: The population of the study area has been projected based on 2011 census data up to 2025. Based on this projected population drinking water demand of the area is calculated.

There will surplus of supply in domestic and industrial demand considering groundwater 80% dependency on groundwater (Table 5.4).

Irrigation:

Barring Sisiborgaon block other two blocks irrigation water requirement is less than the allotted dynamic groundwater resource for irrigation. In Sisiborgaon block there is 12906.05ham of supply and demand gap. Average pre and post monsoon water level fluctuation in 2013 in Sisiborgaon block is 1.4m. In the block the water level fluctuation if allowed to vary up to 3m then it will release 27595ham of water.

The additional withdrawal of water can be recharged by construction of percolation tank. It is found that rechargeable area in this block is 14.64sq.km.

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.