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MINISTRY OF JAL SHAKTI, DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN IN PARTS OF BIRBHUM DISTRICT, WEST BENGAL

By
SONAM
Scientist-B

CENTRAL GROUND WATER BOARD
Eastern Region, Kolkata

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CONTRIBUTORS

Data Acquisition	:	Sonam, Scientist-B (Hydrogeology)
Data Processing	:	Sonam, Scientist-B (Hydrogeology)
Data Compilation & Editing	:	Sonam, Scientist-B (Hydrogeology)
Data Interpretation	:	Sonam, Scientist-B (Hydrogeology) Dr. Suparna Datta, ACH, (Chemical part)
GIS & Thematic Map Preparation	:	Sonam, Scientist-B (Hydrogeology) Rajyashree Nandy, YP Mahasweta Mukherjee, YP
Report Compilation	:	Sonam, Scientist-B (Hydrogeology)
Technical Guidance	:	Sandhya Yadav, Scientist-E
Overall Supervision	:	Dr. S. K. Samanta, Regional Director

REPORT ON NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN IN PARTS OF BIRBHUM DISTRICT WEST BENBGAL

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Chapter-1
INTRODUCTION

The State of West Bengal owing to its huge thickness of unconsolidated and semi consolidated sediments is blessed with plenty of ground water resources. Abundant land and water resources, rich fertile soils, intensive agriculture activities and high population density characterize the alluvial parts of the State. Among the major geo-morphological division in West Bengal, parts of Purba Medinipur, Howrah, South 24 Parganas and North 24 Parganas district comprises the deltaic alluvial plain and coastal alluvial plain in the State. Geological set up and paleo-depositional history of the area controlled the occurrence and distribution of the sediments, so thus, the aquifers dispositions in the area. The multilayered aquifer systems with wide lateral facies variation is very much significant in the area. The fluviatile sediments forming the fresh water aquifers deposited by the ancient river systems has been subjected to multiple marine transgression and regression from sea to inlands which resulted in erosion, redistribution and re-deposition of sediments, thus, creating complex , continuous or discontinuous disposition of aquifers widely varying in hydraulic characters and water quality.

The National Aquifer Mapping and Management Programme (NAQUIM) of Central Ground Water Board (CGWB) has been envisaged to focus on the aquifer geometry, occurrences, availability of ground water resources and quality and to formulate management plan of the individual aquifer system for the sustainable development.

Under the Annual Action Plan of 2020-21 of Central Ground Water Board, Eastern Region, NAQUIM studies were undertaken in Birbhum district, West Bengal. The present study includes parts of the Birbhum district comprising a mappable area of 2099 sq km. in 10 blocks in Rampurahat Subdivision, Sadar Subdivision & Bolpur Subdivision.

1.1 Objective

The major objective of the study is the delineation and characterization of aquifers in three dimension, identification and quantification of issues and development of management plans to ensure sustainability of ground water resources.

The management plans for each aquifer system have been prepared suggesting various interventions to optimize ground water withdrawal and identifying aquifers with portable groundwater for drinking purpose in quality affected areas. The management options also include identification of feasible area for artificial recharge to ground water and water conservation which help in arresting declining water levels besides demand side management option including crop diversification, increasing water use efficiency etc.

1.2 Scope of Study

The scope of the present study is broadly within the framework of National Aquifer Mapping & Management Programme (NAQUIM) being implemented by CGWB. There are four major activity components viz.:

(i) Data collection / compilation

(ii) Data generation and

(iii) Data gap analysis

(iv)Preparation of aquifer maps and management plan to achieve the primary objective.

Data compilation includes collection, and wherever required procurement, of all maps and data from concerned agencies, such as the Survey of India, Geological Survey of India, State Governments etc., computerization and analyses of all acquired data, and preparation of a knowledge base. Collection and compilation of litholog, wells assembly, electrical log reports and yield test data of the tube wells of PHED, Govt. of west Bengal and Agri Irrigation Department of Govt. of West Bengal plays an important role in accomplishing the work.

Identification of Data Gap includes ascertaining requirement for further data generation (hydro-geological, geophysical, chemical, hydrological, hydro-meteorological etc.) in addition to the existing data in respect of prevailing hydrogeological subsurface geological condition in the area.

Data generation includes pre and post monsoon monitoring of aquifer wise water level from the existing network monitoring wells and other available feasible wells, spot measurements of electrical conductivity of the water samples from the wells, incorporation of observation based on field studies, data collection through ground water exploration work in the study area, collection of water samples etc.

1.3 Approach and Methodology

An approach and methodology adopted to achieve the major objective have been shown below step-wise.

i) Compilation of existing data and reports of CGWB

ii) Identification of data gaps

iii) Data generation through monitoring of pre and post monsoon water level from the NHNS stations and key observation wells in different aquifers, monitoring of water quality, spot measurement of conductivity, exploratory drilling for study of subsurface geology, preparation of lithological logs, yield and aquifer parameter data through construction of tube wells.

iv) Collection, compilation and analysis of lithologs , electrical logs and yield data of the water supply wells of PHED, Govt. of West Bengal and Agri Irrigation Department, Govt. of West Bengal

v) Preparation of thematic maps on GIS platform

vi) Identification /demarcation of individual aquifer systems in the area from the available lithology, electrical logs, previous literature and observation from field studies etc. Preparation of 2D/3D aquifer disposition maps in Rockworks Platform

vii) Analysis of 2D and 3D maps, assessment of existing draft and resource of individual aquifer systems. Considering the demand and supply status in drinking, domestic, industrial and agriculture sectors the suitable management plan has been designed. The scope for rain water harvesting for artificial recharge or conservation is reviewed and accordingly suitable structures are recommended.

1.4 Location, Extent and Accessibility of the study area

The study area covers a mappable area of 2099 sq km comprising ten (10 No.) blocks of Birbhum District namely Labpur, Sainthia, Rampurahat I, Rampurahat II, Murarai I, Murarai II, Nalhati I, Nalhati II, Mayureshwar-I & Mayureshwar-II The study area extends between 24°35'00"N and 23°32'30" latitude and 88°01'40"E and 87°32'00"E longitude. The area falls in Survey of India topo- sheet no 72P/11, 72P/12, 72P/14, 72P/16, 73M/9, 73M/10 & 73M/13. It is bounded in the east and north-east by Murshidabad district, on the south and south-east by Barddhaman district of West Bengal and on the west by Sahebganj and Dumka districts of Jharkhand State. The area is accessible by roads and railways.

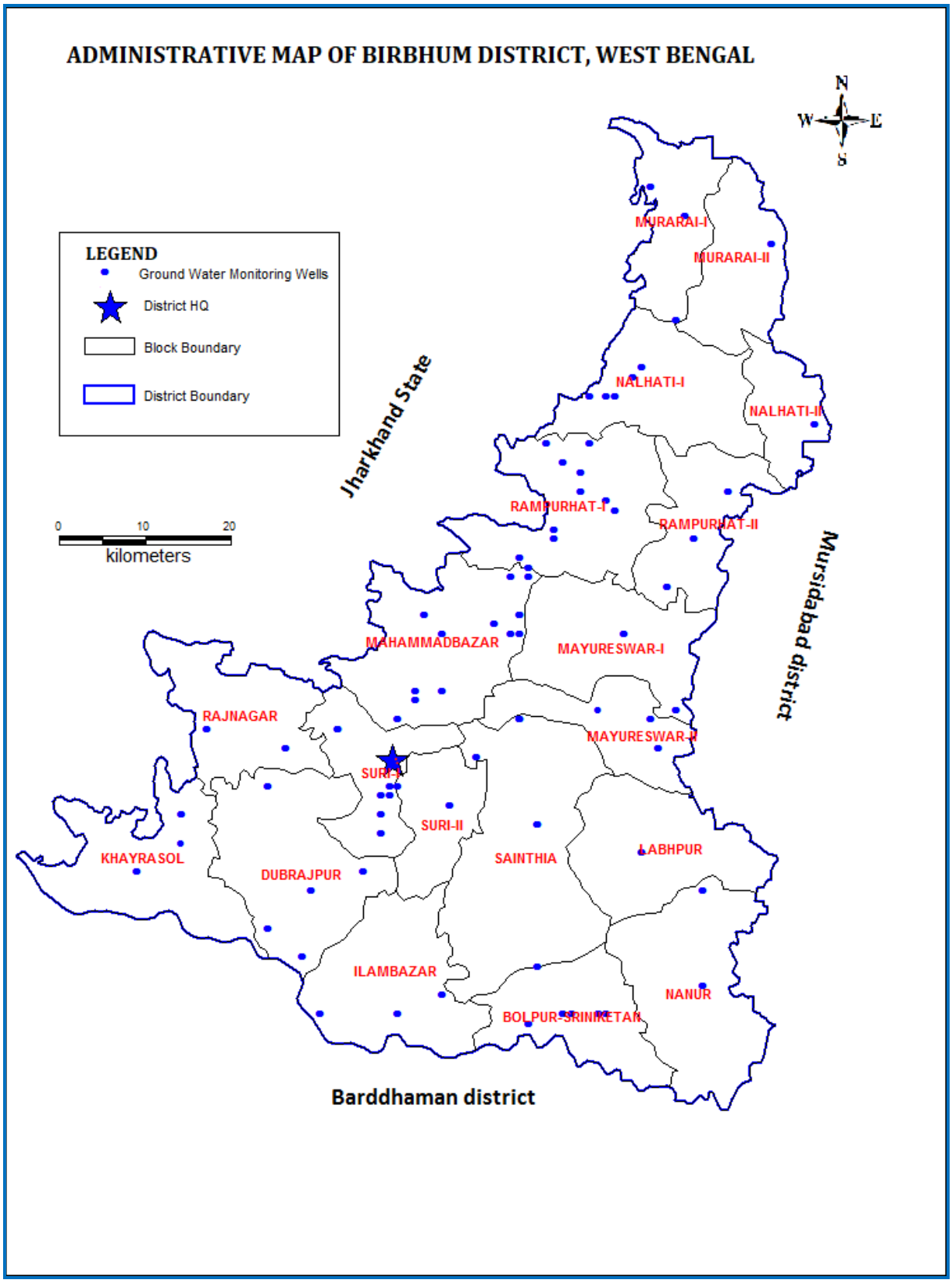


Plate 1. 1: Administrative Map of Birbhum District, West Bengal

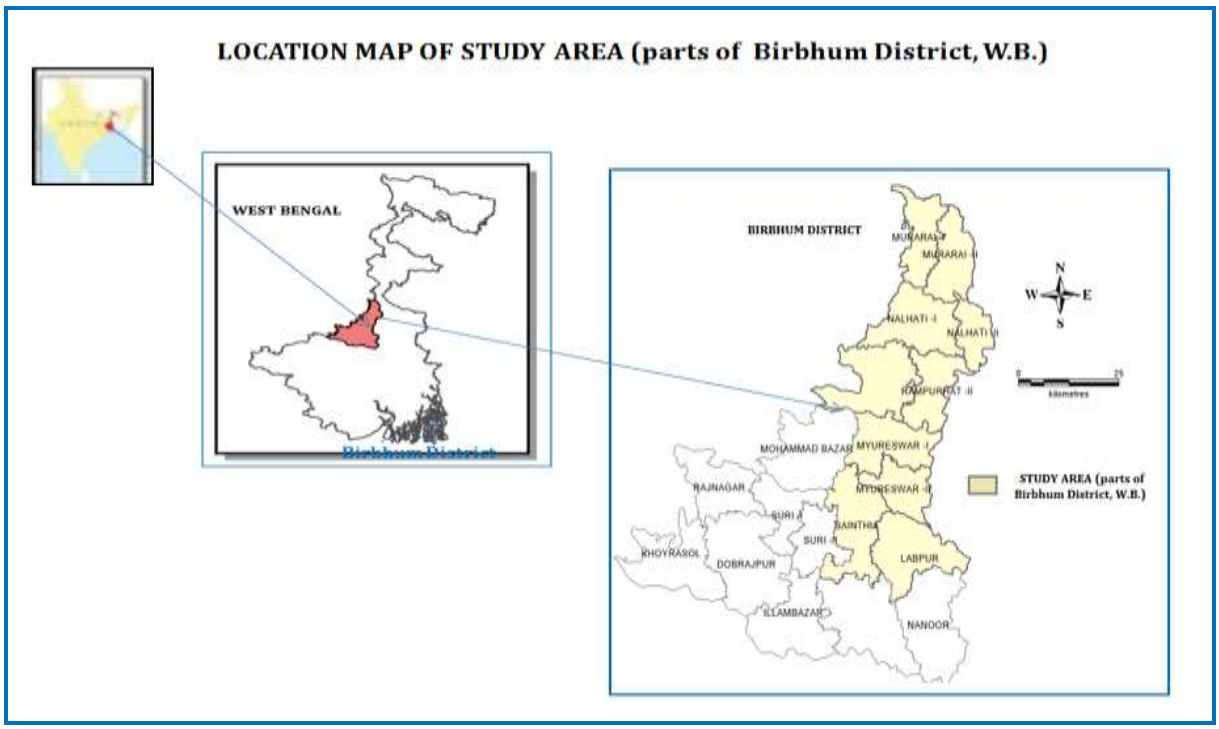


Plate 1.2: Location Map of the study area (parts of Birbhum District, W.B.)

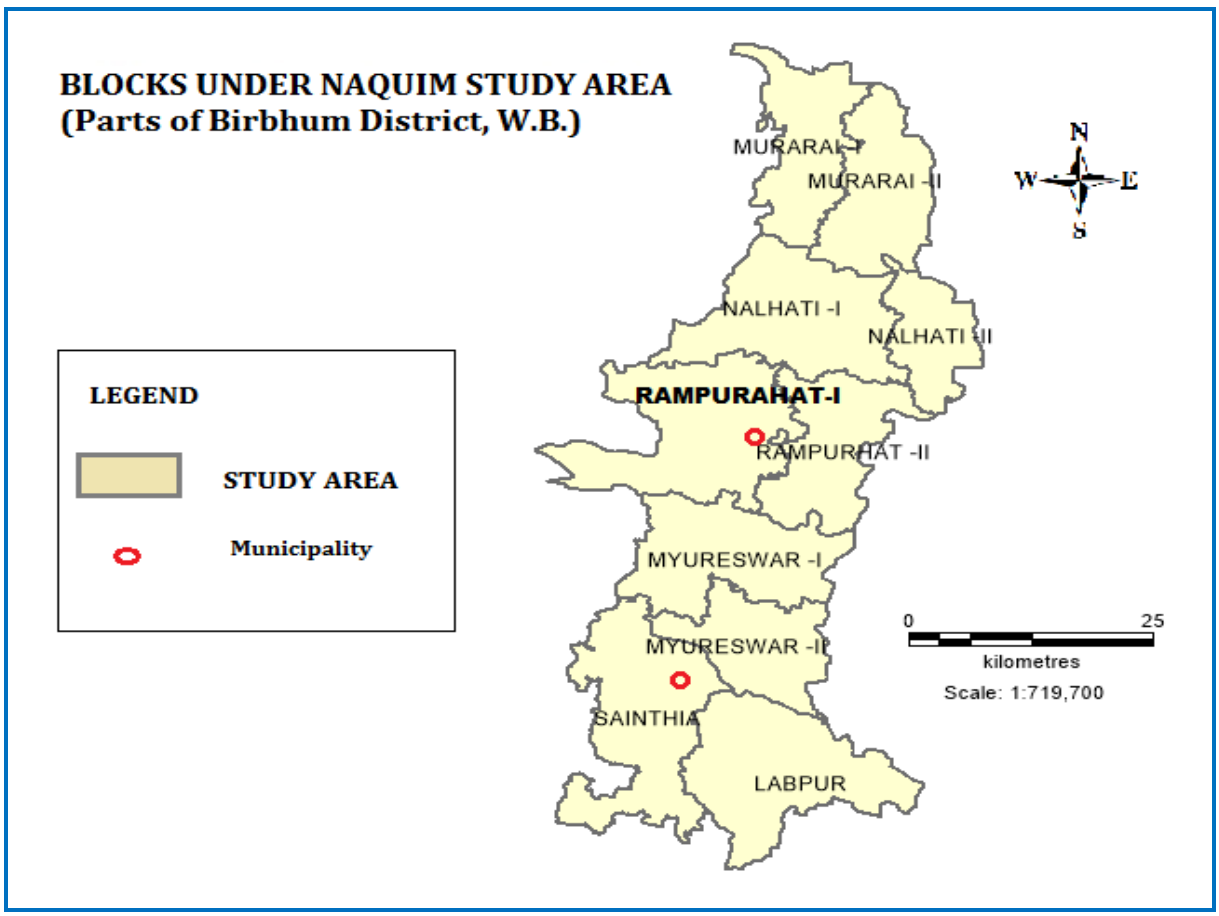


Plate 1. 3: Blocks under NAQUIM study area, (parts of Birbhum District, West Bengal)

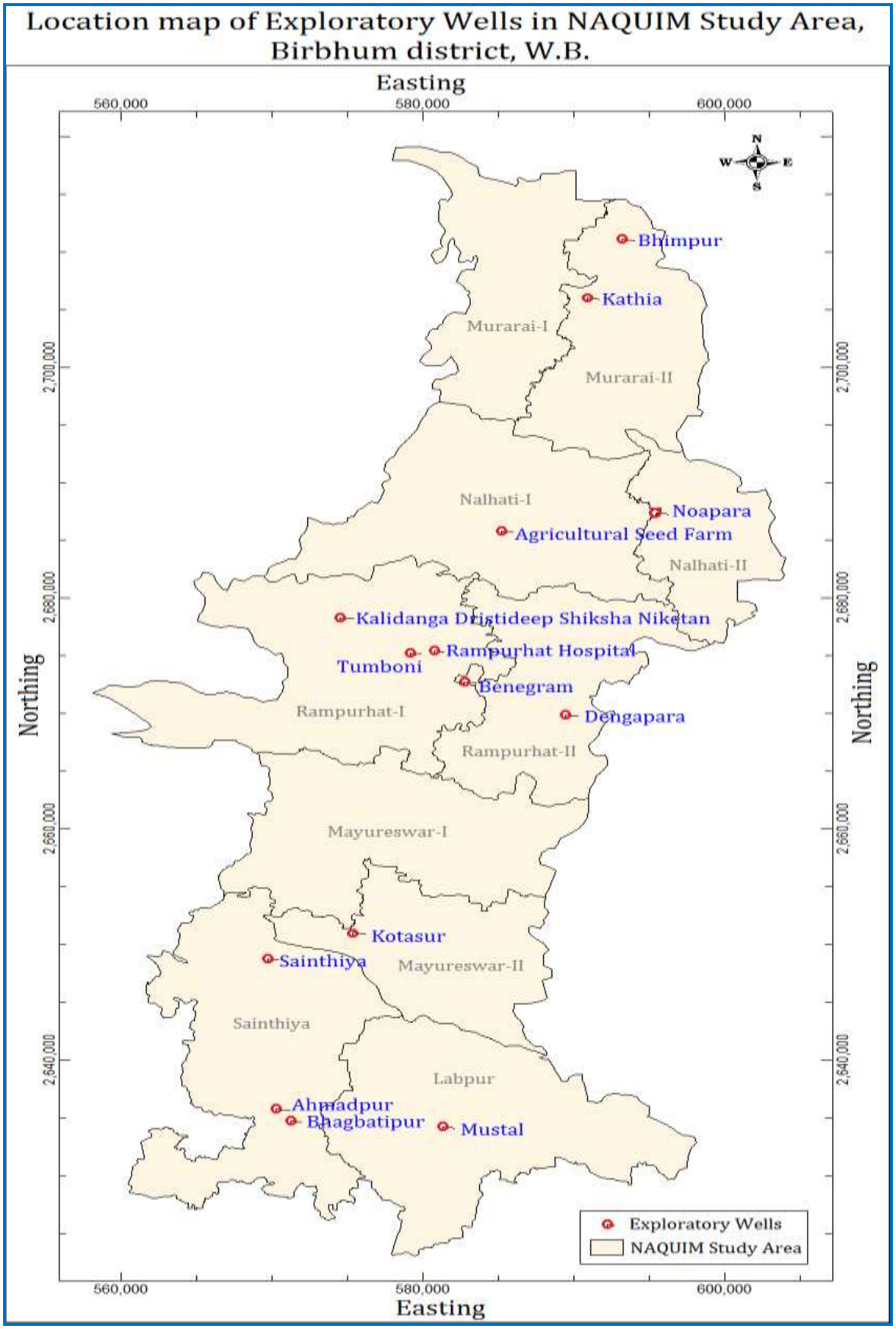


Plate 1. 4: Location Map of Exploratory wells in the Study Area (parts of Birbhum District, W.B.)

1.5 Administrative divisions and Demographic Details:

The study area comprises three subdivisions namely Rampurahat Subdivision-8 Blocks, Sadar Subdivision-1 Block and Bolpur Subdivision-1Block. The details are given in the Table no. 1.1

As per census 2011 total population of the district is 3502404 and density of population 771/sq km. The study area covers 55.69% of total population of the district. Murarai-II is the most populous block among the ten blocks of the study area contributing 6.34% of total population of the district. The demographic details are given below in Table 1.2 & 1.3.

Sub-Division	Police Station	C.D.Block/M	Panchayat			Mouzas	Inhabited	House-holds
			Samity	Gram	Gram Sansad	(2001)	(2011)	(2011)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Rampurhat Sub-Div.	5	8 / 2	8	65	975	760	718	357957
	Nalhati	Nalhati-I	1	9	139	99	89	48318
		Nalhati(M)	-	-	-	-	-	8909
		Nalhati-II	1	6	86	48	48	31058
	Murarai	Murarai-I	1	7	127	85	76	41601
		Murarai-II	1	9	144	70	66	52059
	Mayuresw	Mayureswar-I	1	9	121	114	107	37943
		Mayureswar-II	1	7	97	131	125	31171
	Rampurha	Rampurhat-I	1	9	128	119	116^	44263
		Rampurhat(M)	-	-	-	-	-	13077
	Margram	Rampurhat-II	1	9	133	94	91^	49558
Sadar Sub-Div.	11	7 / 3	1	12	146	230	216	56781
	Sainthia	Sainthia	1	12	146	230	216	46552
		Sainthia(M)	-	-	-	-	-	10229
Bolpur Sub-Div.	4	4 / 1	1	11	147	180	160	47005
	Labhpur	Labhpur	1	11	147	180	160	47005
District Total - 3	20	19 / 6	10	88	1268	1170	1093	461743
^ As per Census data, Karkaria inhabited village is situated partly in Rampurhat-I block and partly in Rampurhat-II block				Sources :	1) Directorate of Panchayat, Govt. of W.B.			
					2) Census of India, 2001 & 2011			

Table 1.1: Administrative Divisions of the study area (as per Census 2011)

Sub-Division /C.D. Block/M	Area (Sq. Km.) (2001)	Population (Number)	Density of Population (per Sq. Km.)	P.C. of population to district population
(1)	(2)	(3)	(4)	(5)
Rampurahat Sub - Division	**1574.2**	**1508506**	**958**	**43.07**
Nalhati-I	249.71	204818	987	5.85
Nalhati(M)		41534		1.19
Nalhati-II	109.15	127785	1171	3.65
Murarai-I	175.51	190802	1087	5.45
Murarai-II	185.33	222033	1198	6.34
Mayureshwar-I	224.83	159782	711	4.56
Mayureshwar-II	156.57	127661	815	3.64
Rampurahat-I	287.63	188435	655	5.38
Rampurahat-II	181.55	187823	1035	5.36
Rampurahat(M)	3.95	57833	14641	1.65
Sadar Sub - Division	**312.27**	**239950**	**768**	**32.03**
Sainthia	304.39	195349	642	5.58
Sainthia(M)	7.88	44601	5660	1.27
Bolpur Sub - Division	**267.98**	**201901**	**753**	**24.90**
Labpur	267.98	201901	753	5.77

Table 1.2: Area, Population and Density Population of the study area (as per Census 2011)

Sub-Division / C.D.Block / M	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rampurhat Sub-Div.									
Nalhati-I	107527	101115	208642	-	-	-	107527	101115	208642
Nalhati-II	54976	52682	107658	-	-	-	54976	52682	107658
Murarai-I	79214	75128	154342	-	-	-	79214	75128	154342
Murarai-II	90473	87275	177748	-	-	-	90473	87275	177748
Mayureswar-I	71650	68083	139733	-	-	-	71650	68083	139733
Mayureswar-II	58185	54846	113031	-	-	-	58185	54846	113031
Rampurhat-I	81349	77844	159193	-	-	-	81349	77844	159193
Rampurhat-II	81919	76823	158742	-	-	-	81919	76823	158742
Rampurhat (M)	-	-	-	26110	24503	50613	26110	24503	50613
Sadar Sub-Div.									
Sainthia	85748	81486	167234	4300	4111	8411	90048	85597	175645
Sainthia (M)	-	-	-	20050	19095	39145	20050	19095	39145
Bolpur Sub-Div.									
Labhpur	91065	85800	176865	-	-	-	91065	85800	176865
NB : Nalhati (M) established on 29.06.2001							Source : Census of India, 20011		

Table 1.3: Demographic Details of the study are

1.6 Land use, Cropping Pattern and Irrigation

Land use: The study area has reporting area of about 214,941 hectares covering ten (10 No.) blocks of Birbhum District. The net sown area is about 76% in the study area. The area has a forest cover of about 0.8% The details of the land utilization under study area are shown through the table below.

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11
Sainthia	31095	407	7692	1	10	32	67	424	27	22435
Labpur	26918	161	6970	-	-	4	430	-	82	19271
Mayureshwar-I	22389	5	4380	14	64	125	30	50	89	17632
Mayureshwar-II	15697	3	2792	-	6	34	9	28	41	12784
Rampurahat-I	28810	716	6458	-	-	-	-	-	-	21636
Rampurahat-II	18446	1	3215	-	-	30	-	-	-	15200
Nalhati-I	25022	209	5590	4	-	10	23	16	--	19170
Nalhati-II	10917	0	2804	-	-	-	-	-	-	8113
Murarai-I	17145	231	3906	-	-	34	-	-	16	12958
Murarai-II	18502	0	3811	-	-	5	-	-	77	14609
Total	214941	1733	47618	19	80	274	559	518	332	163808

Table 1.4 Block-wise details of Land-use pattern (Source- West Bengal Land use Land cover Department)

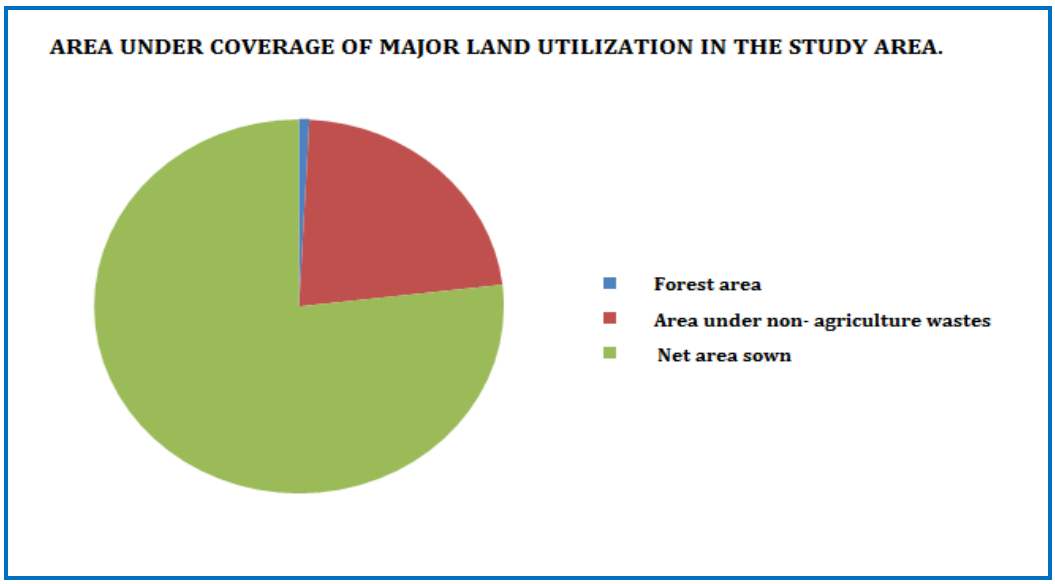


Plate1. 5: Area under coverage of major land utilization in the study area

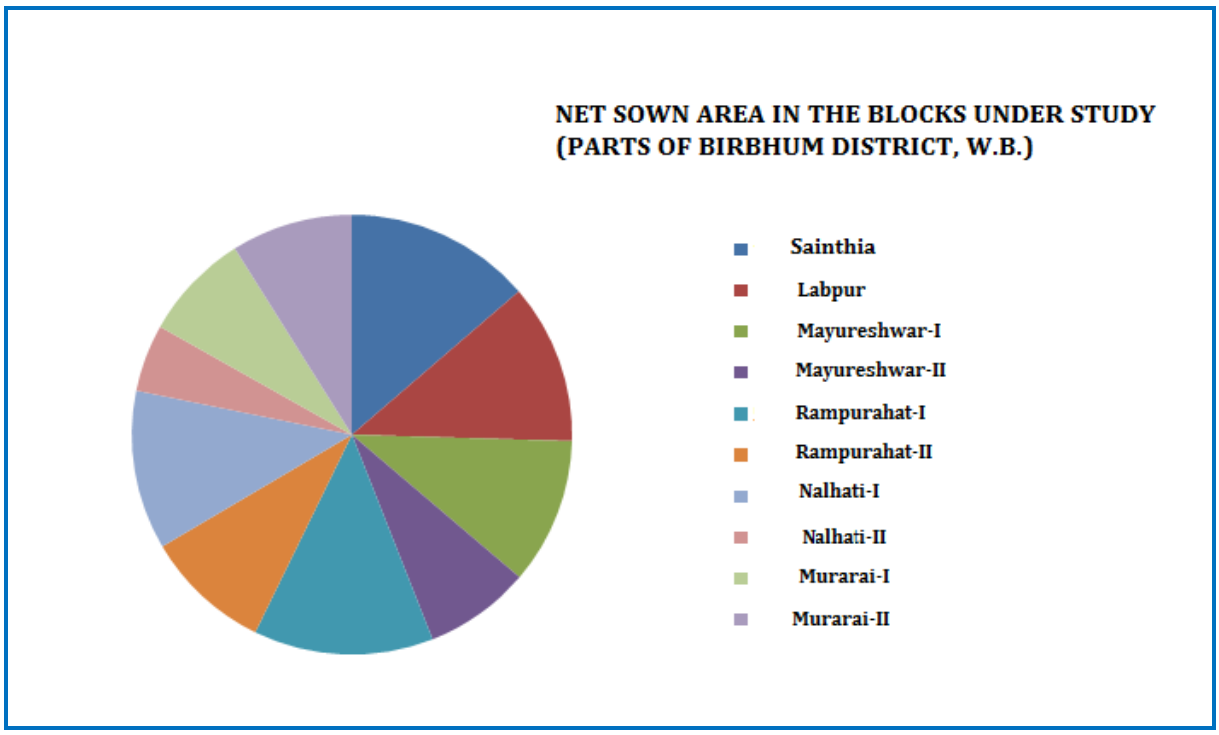


Plate 1. 6: Net sown area in the blocks under study (parts of Birbhum District, W.B.)

Agriculture

The economic condition of the study area is dominated by agriculture. The various types of soils found in the study area marks the suitability to grow various types of crops. Rice, wheat, pulses, sugarcane, oilseeds, potato etc. are the major crops grown in the study area**.** Area under principal crops and yield are shown in **Table 1.5**

Irrigation

Irrigation is a vital input of agriculture and for its productions , water is provided either by major irrigation systems or by minor irrigation systems. Major irrigation systems are generally implemented through canal network system of Mayurakshi River and Damodar valley Corporation. Minor irrigation systems are being implemented from ground water and surface water directly lifting from ponds and rivers/streams (52 RLI in Birbhum). The total no. of tanks in the study area is about 15502. The different sources of irrigation, yield and area under major crops in the study area are given in the tables below. (Table 1.5 Table 1.6)

AREA AND YIELD UNDER MAJOR CROPS (in Hectares)																								
Name of Block	Aus		Aman		Boro		Wheat		Jute		Musur		Maskalai		Khesari		Gram		Mustard		Til		Potato		Sugarcane	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield**	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
Nalhati-I	207	2627	1131	2781	1808	3405	3826	2732	-	-	27	661	-	-	31	1416	26	745	489	657	857	1648	2574	25640	24	75435
Nalhati-II	-	-	1536	2667	5164	3545	2245	3054	-	-	21	740	-	-			503	1016	690	799	300	1416	697	27640	-	-
Murarai-I	-	-	1449	2927	1375	3955	3052	2519	-	-	935	737	-	-	1258	1416	822	1167	2442	933	66	1190	2027	34148	-	-
Murarai-II	-	-	1277	2688	3650	3432	3300	3366	831	19.55	246	835	-	-	220	1416	162	772	2430	906	33	487	949	28824	11	75050
Mayureswar-I	-	-	16670	3048	3016	3295	1418	3424	14	19.55	26	586	8	201	37	1416	59	755	1311	1093	102	585	739	19159	46	77516
Mayureswar-II	208	2617	11521	2976	2700	3715	1202	3126	26	19.55	27	288	24	201	18	1416	30	687	1017	951	240	490	1745	19004	102	49573
Rampurhat-I	-	-	44719	3273	2442	3532	3684	2923	-	-	635	793	-	-	159	1416	86	845	1976	949	66	1171	209	28327	7	75383
Rampurhat-II	-	-	44844	3302	5212	3532	3921	3270	-	-	432	961	-	-	-	-	819	941	2953	1001	344	684	371	12502	82	88803
Sainthia	-	-	22907	2977	5976	3519	1759	2541	-	-	202	978	-	-	-	-	186	1310	1736	1017	427	593	1338	19629	220	63724
Labhpur	149	2231	21089	3172	7802	3492	1114	2219	-	-	405	807	-	-	28	1416	950	1266	2269	912	374	574	759	15200	69	51267
Total	564		167143		39145		25521		871		2956		32		1751		3643		17313		2809		11408		561	

Table 1.5 Area and yield under Major Crops in the study area (Source: District Statistical census of West Bengal 2014)

(Area in hectare)

Sl. No.	Name of Block	Canal	Tank		RLI		DTW		STW		ODW		Others		Total	
		Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1	Nalhati-I	4400	1257	1750	16	675	8616	5208	30	200	12	7	-	-		
2	Nalhati-II	8200	450	810	-	-	739	5300	50	100	-	-	180	560		14970
3	Murarai-I	-	800	152	7	300	527	5290	2020	2430	-	-	1	3		8175
4	Murarai-II	1500	900	1900	4	500	925	2475	-	-	5	75	-	-	1834	6450
5	Mayureswar-I	15000	1202	552	2	50	400	3040	-	-	-	-	406	3050	2010	21692
6	Mayureswar-II	10705	2725	2725	3	120	1057	10850	453	1360	-	-	7	235	4245	25995
7	Rampurha	12000	2000	3000	8	400	68	455	450	500	9	10	5	200	2540	16565
8	Rampurha	9500	1375	1400	1	-	1068	3300	-	-	-	-	-	-	2444	14200
9	Sainthia	18100	1650	1660	4	60	1000	5000	675	1350	-	-	-	-	3329	26170
10	Labhpur	12948	3143	1450	7	450	437	1820	1897	3643	-	-	-	-	5484	20311
Total		92353	15502	15399	52	2555	14837	42738	5575	9583	26	92	599	4048	21886	154528

HDTW =High Capacity Deep Tubewell
MDTW =Middle Capacity Deep Tubewell
LDTW =Low Capacity Deep Tubewell
DTW=Deep Tubewell =HDTW+MDTW+LDTW
STW =Shallow Tubewell
RLI =River Lift Irrigation
ODW = Open Dug Well

Source : All Assistant Directors of Agriculture, Birbhum

Table 1.6 Source of Irrigation and Area Irrigated by different sources in the study area for the year 2013-2014

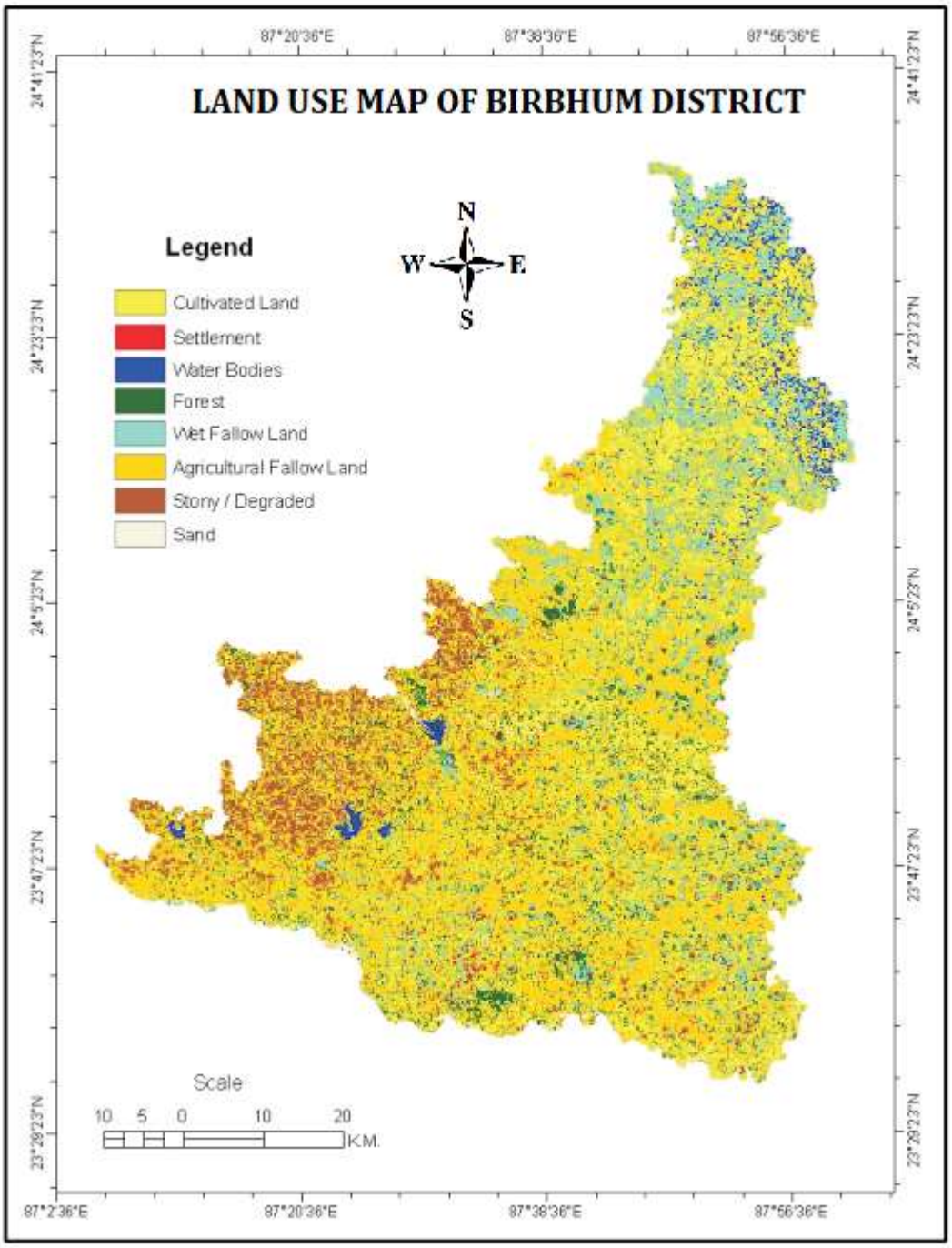


Plate 1.7: Land use Map of Birbhum District

1.7 Urban areas, Industries and Mining activities

Urban Areas: Rampurahat, Sainthia & Nalhati are important urban centers of the study area.

Industries: As the study area is not a rich storehouse of mineral, the industries which have been developed here are all agriculture or forest based. The major industries include cotton & silk harvesting and weaving, rice & oilseed milling, lac harvesting, metal ware and pottery manufacturing. Other agriculture-based industries are textile, art & craft.

Mining activities: Mining of building materials mainly from the areas covered by Rajmahal traps in Rampurahat & Nalhati blocks are extensive.

Chapter-2

CLIMATE

The climatic condition in the area under study shows a range of variation from a tropical humid to sub humid type of climate.. The summer season usually last from the middle of March to the middle of the June, the rainy season from the middle of June to the middle of October, and the cold weather from middle of October to the middle of March. The Average Maximum & Minimum Temperature: 41^0C & 9^0C respectively. The wind is from south-east in summer and from north-west in winter.

2.1 Rainfall

District	Month	NORMAL(Mm)	Actual (mm)				
			2014	2015	2016	2017	2018
Birbhum	January	10	4	9	24	5	-
	February	23	34	4	14	-	1
	March	23	25	36	13	5	1
	April	41	2	69	3	28	52
	May	89	82	54	95	161	63
	June	234	188	322	215	157	138
	July	325	376	699	347	487	258
	August	296	282	297	308	239	160
	September	258	123	144	242	167	170
	October	105	15	21	35	215	37
	November	18	-	4	-	3	-
	December	9	-	-	-	5	25
Total	**12**	**1431**	**1131**	**1659**	**1296**	**1472**	**905**

Table 2.1 Monthly Rainfall data for the districts of Birbhum from 2014-2018. (Source: Rainfall Statistics of India)

2.2 Temperature

The average maximum and minimum temperature range for five years (from 2010 to 2014) is given in the table below.

District	Month	2010		2011		2012		2013		2014	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Bhirbhum	January	29	7	29	6	28	7	28	5	28	7
	February	33	11	35	11	35	8	32	10	32	8
	March	42	17	40	12	40	13	39	14	38	15
	April	46	20	39	19	41	19	42	19	43	20
	May	39	21	38	20	45	22	41	21	45	22
	June	43	22	39	24	46	24	38	24	43	24
	July	37	25	36	23	38	24	37	25	36	25
	August	36	24	37	24	35	24	36	24	35	24
	September	35	23	36	23	..	..	36	24	36	24
	October	35	18	34	16	35	16	34	19	35	18
	November	34	14	32	14	32	11	32	12	33	11
	December	29	8	30	7	30	7	29	9	30	8
For the year		**46**	**7**	**40**	**6**	**46**	**7**	**42**	**5**	**45**	**7**

Table 2.2. Monthly Maximum and Minimum Temperature in the Birbhum districts of West Bengal (Source: Meteorological Department, Govt. of India)

Chapter-3:

PHYSIOGRAPHY

3.1 Geomorphology

The study area has two distinct geomorphic divisions. Major portion of the study area presents a flat alluvial plain except a small portion west of Rampurahat and north-western part of Nalhati is covered by the ridges amount almost to the dimension of hills. The land surfaces in these areas are slightly uneven. In the Nalhati area there are few hillocks. In general the slope of the area is towards south east and the general elevation of the land surfaces varies from 60 to 30 mamsl.

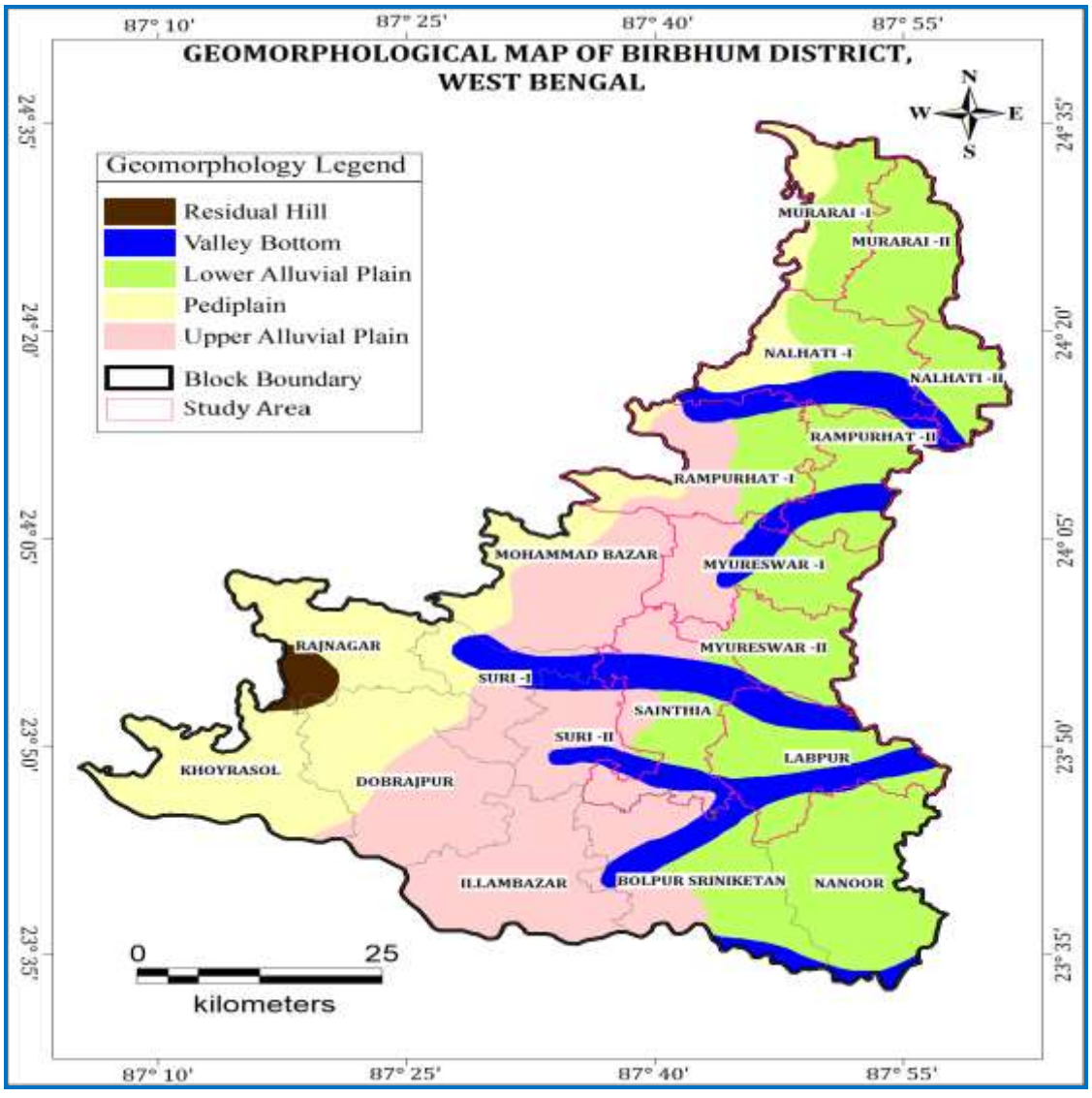


Plate 3.1:Geomorphologic map of Birbhum District demarcating the study area

3.2 Drainage

The prominent drainage channel in the area are the Mayurakshi, Ajoy, Dwarka, these are all east flowing thereby the master slope of the area is from west to east, i.e. from Rajmahal Hills to the Bengal Plains.

The river Mayurakshi may be called the main river of the area as it passes through the heart of the area and provide benefit to the large populace.

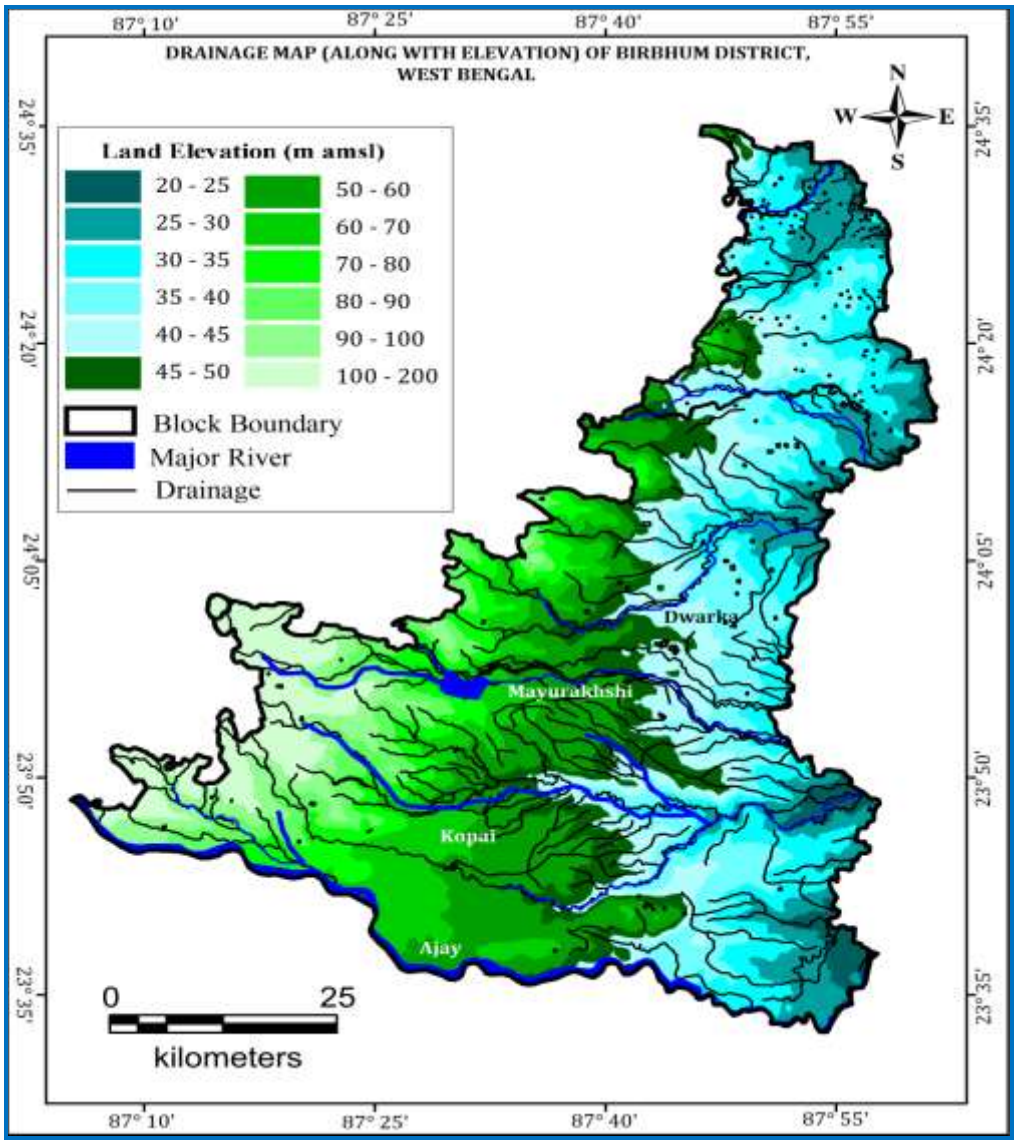


Plate 3.2: Drainage map (Along with Elevation) of Birbhum District, W.B.

3.3 Pedological Characteristics

The area under study shows the development of varied type of soils depending on different lithological units present in different parts of the area.

The north-western, western and south-western parts of the district are covered by red sandy and red loamy soils. Lateritic soil covers maximum area in the central part of the district. Older alluvial soil covers southern and south-eastern part of the district. Younger alluvial soil occurs in small patches in south -eastern and northern part of the district.

The soil type of the study area is predominantly old alluvium and red lateritic. The old alluvium is found along with the layer of clay, gravel, sand, with medium in organic matter, phosphate and medium or high level potash. The water holding capacity is very poor. The pH ranges from 4 to 6.5 i.e. acidic in nature. The whole Rampurahat Block-II and portions of Rampurahat Block-I are covered by lateritic soil, characterized by low pH and low fertility status. The basaltic trap area is associated with red sandy soil in the concave surface and gully areas. Rest of the area is covered by old alluvium.

The lateritic soil is light textured, porous, acidic in nature, pH ranges from 4.5 to 7.1 and poor in organic matter. Hard structure of iron and aluminum oxides present in the sub-surface.

The Sahibganj loop railway line more or less forms the boundary of lateritic soil and alluvium. The Ahmadpur-Labpur tract, south of Ahmadpur-Katwa branch railway line, forms a high land compared to the areas in the north. The alluvium is formed from deposits brought down mainly by Mayurakshi river system and is characterized by mild acidic to neutral reaction (pH 5.5-7.2). Low to medium iron content. The soils are low in organic matter and have medium concentration of available phosphate and potash. North of Mayurakshi river, in the western part underlain by basaltic rock in Rampurahat & Nalhati blocks shows the development of Gondwana type of alluvial soil.

Chapter-4:
GEOLOGY

4.1 General geology of Birbhum District

Birbhum district shows the development of Archean hard rock, Gondwana sedimentaries with Rajmahal traps, sub-recent laterites and Sub-recent to Recent alluvium.

General geological succession of Birbhum district is as follows (After Rao and Sinha Ray 1962-63)

Recent : Alluvium unconsolidated sand, silt, clay etc.

Plio-Pleistocene : Laterites and lateritic gravel with fossil wood

Tertiary : Clay beds, ferruginous and felspathic sandstone

Gondwana : Rajmahal Traps, Dubrajpur beds, Flaggy shales, clay and compact sandstone

Barakars: Sanstone, shales with coal seams

.....UNCONFORMITY.....

Archean : Granites, granite-gneisses, biotite-schists, calc-granulities with quartz and pegmatite veins.

The crystalline metamorphic rocks of Archaean to Proterozoic age occupy the southwestern part of the Birbhum District. The Gondwana Supergroup, overlying this basement, is represented by thick piles of pelitic and psamitic sedimentary rocks containing coal seams belonging to Barakar, Barren Measure, Raniganj and Dubrajpur Formations ranging from Permian to Jurassic in age. Patchy occurrences of Gondwana formation are exposed mainly along the Ajoy river in Khyrasol-Dubrajpur-Ilambazar tract and Md. Bazar area. The Gondwana is overlain by Rajmahal trap (basalt) occurring in the northern and north-western part of the district. The north and also the central part of the rest of the area is occupied by laterite and lateritic soil. Hard clay impregnated with caliche nodules of Rampurahat formation occupy the area in the

north-east and also in the east and is overlain by alternating layers of sand, silt and clays of Kandi formation of Quaternary age.

4.2 Geology of the Study Area

Major portion of the study area is covered by the older alluvium & recent alluvium in the east and north east of the study area. In addition the area under study has also the development of middle to upper Jurassic Rajmahal traps. The traps are fine grained, weathering of these trap rocks has resulted in lateralization which is hard and thick. Laterites in some places occur interbeded with white and purplish derived from basalt and represents intertrappean layer.

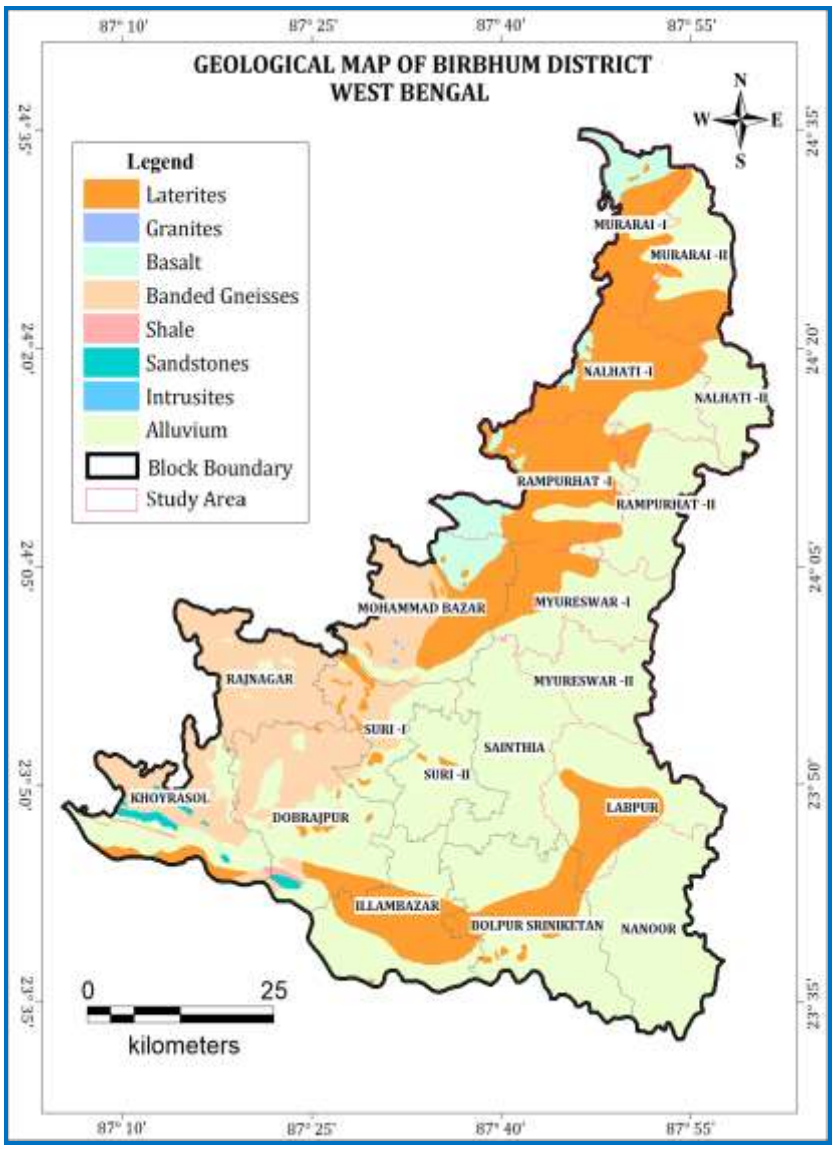


Plate 4.1: Gelogical Map of Birbhum District demarcating the study area

The different litho-units present in the study area are described as follows:

Rajmahal Traps

The Rajmahal Traps (Upper Gondwana) are exposed along the western margin of the northern part of Birbhum District near Rampurahat, Nalhati etc. The rocks are dark in colour and vary from a very tough, fine grained basalt to comparatively soft, coarsely crystalline basalt. Both vesicular and amygalidal basalts are present which are found to be altered to laterites.

Laterites

Laterites, mostly of vermicular type, occurs as a cap rock over the basalts and tertiary formations. The laterites are of diverse origin. The laterites, which occur on high lands and can be traced back to the parent basaltic materials are reported to be primary in origin, whereas low land lateritic gravels and clays are mainly detrital or secondary in origin. Geomorphologically, the laterites belong to Lalgarh surface (formation) of Pleistocene period. The thickness of the laterites capping ranges from 6m to 15 m having limited yield prospect (5 to 15 m)

Alluvium

Older alluvial deposits cover the major portion of the study area. They are coarse and generally reddish in colour and rich in calcareous and limonitic concretions.

Younger alluvium is mostly confined along the present drainage channel and is poor in calcareous matter. I t gradually merges in the east into the flood plain of Bhagirathi basin.

4.3 Sub-Surface Geology

The study of lithological logs of different exploratory wells present in the study area shows an irregular nature of disposition of bedrock in the area.

In general, bedrock basalt is common and occurs close to the surface i.e. within 100m.b.g.l. along as line passing roughly NNE-SSW through the centre of Birbhum district and west of it. It has been encurated at a shallowest depth around 50 to 70 mbgl in the places near Nalhati, Murarai etc., in the northern part. Towards east of this imaginary line bedrock occurs at increasing depth. Rock exposures are encountered in the extreme western part of the study area. Bedrock occurs at about 50 mbgl at Banior-

Basanta near Nalhati, at about 80 mbgl at Nalhati town and at 135mbgl at Rampurahat. At Benegram south of Rampurahat, bedrock has not even encountered at 200mbgl. Towards east of Nalhati bedrock is met with at about 200mbgl,but in south eastern part i.e. Mustal bedrock has not been encountered even down to 450mbgl. The bed rock is covered by laterites in sub-surface in most of the places.

The bedrock, when encountered at various depths is overlain by a grey or dark grey coloured sandy clay sequence, which is locally predominantly clayey but in a general the proportion of sand and clay are almost equal.

Recent sediments occur along the river channels traversing the area and along the border of Murshidabad district.

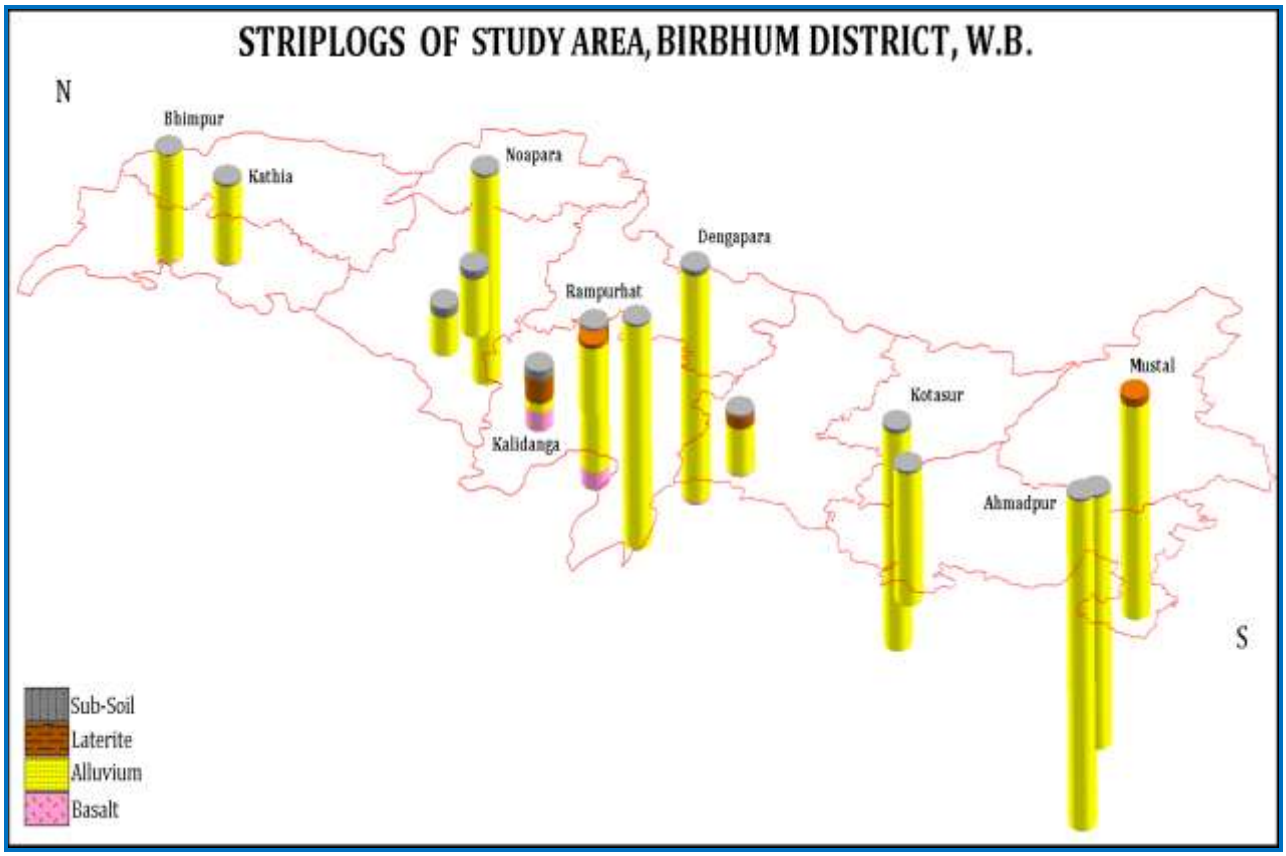


Plate 4.2: Striplogs depicting the sub-surface geology of the study area (parts of Birbhum District, W.B.)

Chapter-5

GEOPHYSICAL STUDIES

Geophysical study in field can be broadly divided into two categories, namely surface geophysical investigation or resistivity survey (VES and profiling) and borehole electrical logging.

Surface geophysical investigation is the pre- drilling approach and in ground water exploration it has many fold objectives that depends on formation characteristics likely unconsolidated, semi-consolidated and consolidated formations.

In hard rock terrain it is required to identify a) Saturated fractures/joints, faults, shear zones, dykes, quartz veins and reefs which may control the ground water occurrence/movement at varied depths, b) Thickness of the water bearing overburden (weathered residuum), c) depth to the bed rock and resistivity values and d) delineation of water filled cavities in limestone.

In alluvial areas identification of granular and non-granular formations, thickness of the individual layers and their resistivity values, identification of saline/fresh water interface etc. are required to be done. Lithology, resistivity, formation factor, formation resistivity, porosity, permeability, specific yield of water bearing formations, chemical and physical characteristics of water of a particular formation of interest can also be calculated.

Electrical resistivity investigation is also adopted in exploratory drilling program to locate a tube/bore-well site due to its wide simplicity in field proceedings and low cost of operation. To pin point an exploratory drilling site in hard rock areas in most of the cases deep fractures are identified with the help of curve break technique. It also helps for mapping potential aquifers in buried stream channels and also demarcating the areas suitable for artificial recharge and prone to water logging.

The resistivity range for different rock Formations are given in the following tables:

LITHOLOGY	Range of Resistivity (ohm-m)
Clay/ clayey sand with saline water	3-6
Clay with sand lens	8-25
Clay	10- 15
Mixed (sand +clay)	15 -25
Fine Sand	25-35
Medium sand	30-60
Sand with fresh water	20-80
Coarse sand	60-100
Sand coarse to medium	40-50
Gravel	70-100
Gravel with sand	60-70
Pebble	100-150
Boulder	150-200
Sand Stone	300-1000
Dry Sand	>1000
Sand/Sandstone saturated with fresh water	30-150
Sand saturated with saline water	<3

Table 5.1 Range of resistivity in soft rocks

LITHOLOGY	Range of Resistivity (ohm-m)
Highly weathered and fractured granite	220-300
Fractured granite	350-500
Less fractured granite	1000-2000
Fresh and massive granite	more than 20,000
Laterites (hard)	100-150
Weathered laterite	40-100
Weathered basalt	45-130
Hard and compact	>800

Table 5.2 Range of resistivity in Hard rocks

Central Ground Water Board, Eastern Region Kolkata has conducted several VES survey covering the blocks in Birbhum district. The details are as follows:-

- In the study area, **4** VES and **2** profilings were conducted in Kalidanga area of the district. From the study of profiling it is observed that the aquifer thickness is more in the southern part of the land than in the north. From the analysis carried out at different points on the profilings I & II it is inferred that the thickness of shallow granular layer varies from 8 to 24 meters in profiling I and 13 to 16 meters in profiling II. The thickness of the granular zone found to be maximum under VES 2.At VES 1 and 4, towards north, there is an existence of semi pervious layer of fine grained sand down to a depth of 115 to 200 meter bgl. Below this, partially fractured hard rock likes to occur. Granular zones occurring at these points are moderately thick. Drilling down to 200 m. is recommended at VES 2, VES 1 & VES 4 locations of the Kalidanga area.
- **4** VES were conducted in Narayanpur area (section CC'). In the area, below the thick laterite (3 to 12 meter) an impervious to semi - pervious layer is expected to exist (20 to 50 m.) Below this layer, resistivity range varies from 45 to 84

ohm-m, which may be partially weathered / fractured rock. Drilling is recommended down to a depth of 100 meter in NNW side (VES 3) and in SSE side (VES 4) of the area under investigation.

- **20** VES were carried out at Amdol, Murarai block, Sibrampur mouza of the district to locate potential water bearing zones within the depth range 15-167, 14-110 38-54, 13-82, 23-111, 10-150 and 14-133 mbgl.

Table: 5.3: Findings from Geophysical Resistivity Surveys (VES)

(At a Glance)

District	Location	Depth range of the fractures in mbgl	Depth range of the weathered/granular zones	Remarks
Birbhum	Atchaktola-Nowapara-Zunutpur area		Granular-15-55, 4-80, 3-95, 1-42	Medium to coarse grained deposit
Birbhum	Kalidanga, Rampurahat		13-16, 8-24	Weathered laterites/ granular zone
Birbhum	Narayanpur, Rampurahat		20-70	Weathered laterites/ granular zone
Birbhum	Command Area of Amdol, Sibrampur Mouja		Granular-1.4-10 Weathered 12-44	Drilling recommended maximum 180

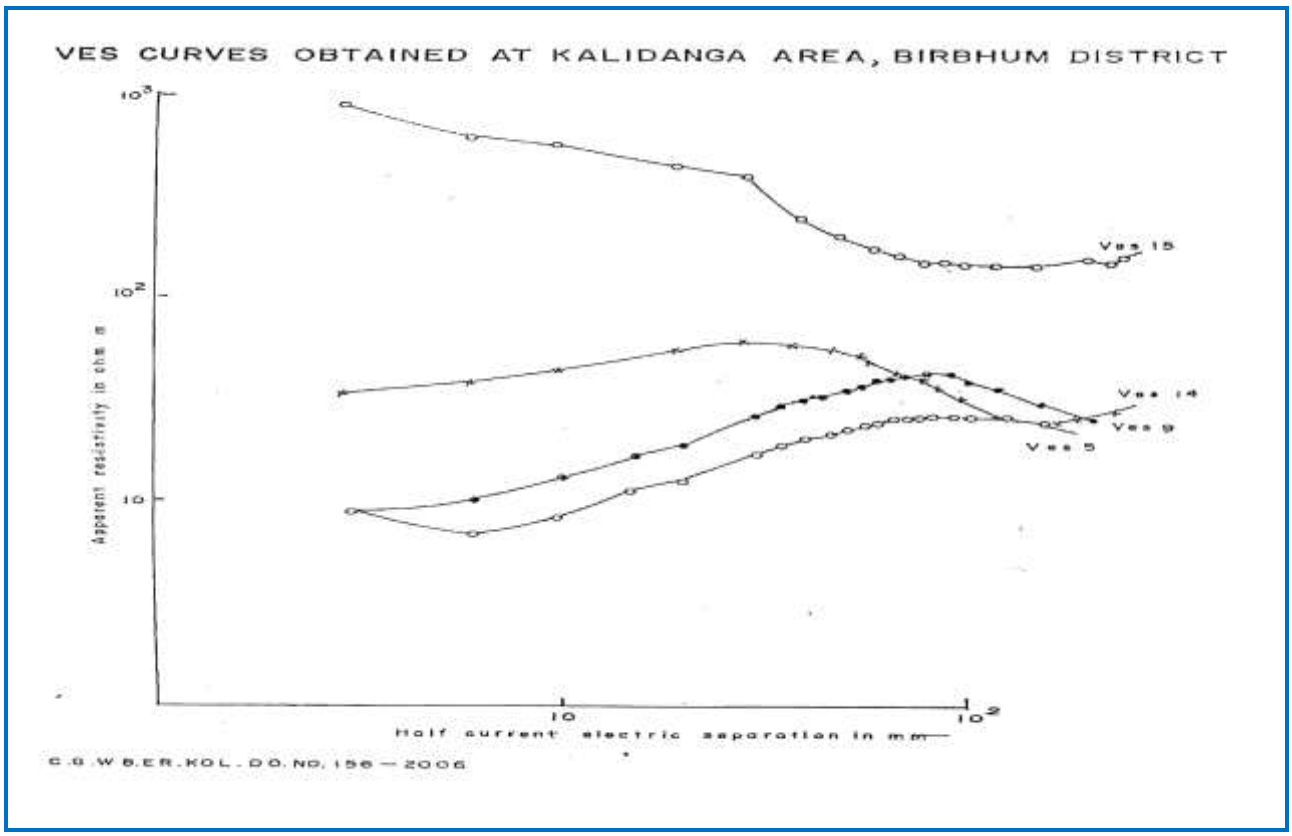


Plate 5.1: VES curve obtained at Kalidanga Area, Birbhum District

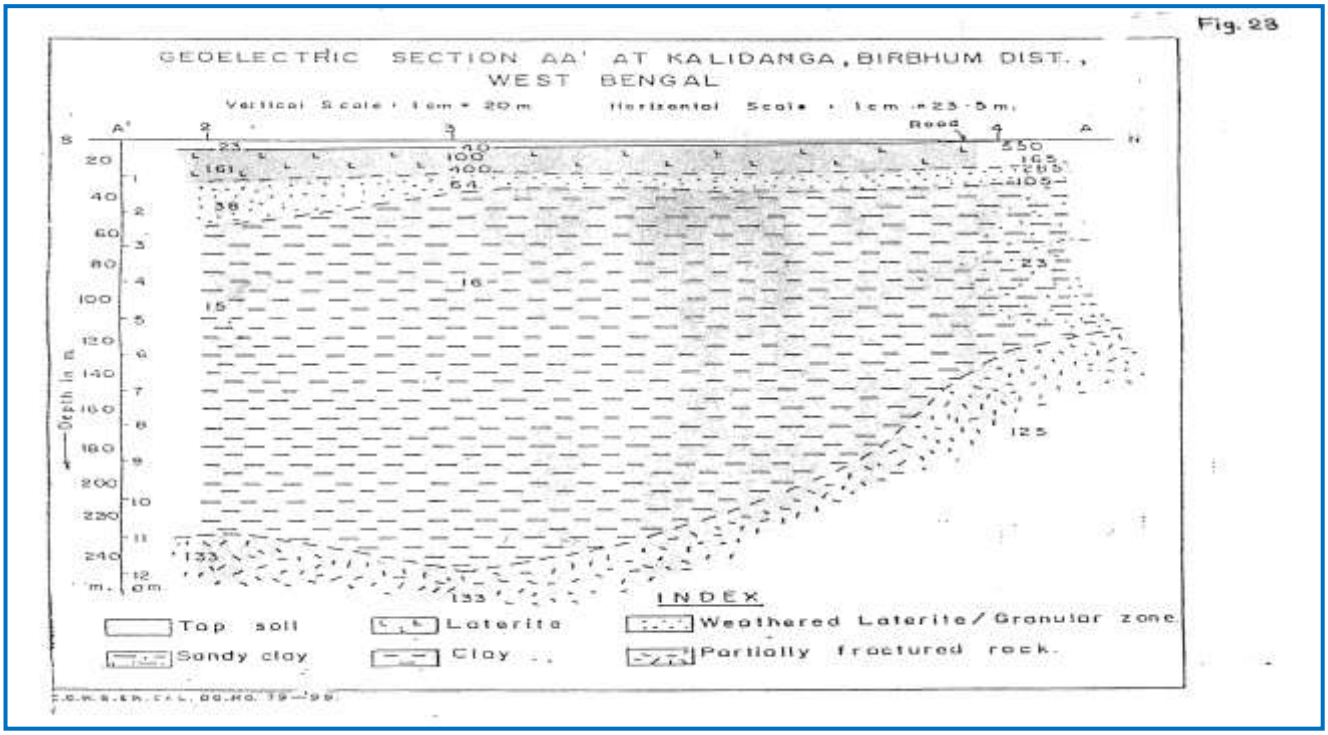


Plate 5.2: Geo electric Section AA' AT Kalidanga, Birbhum District

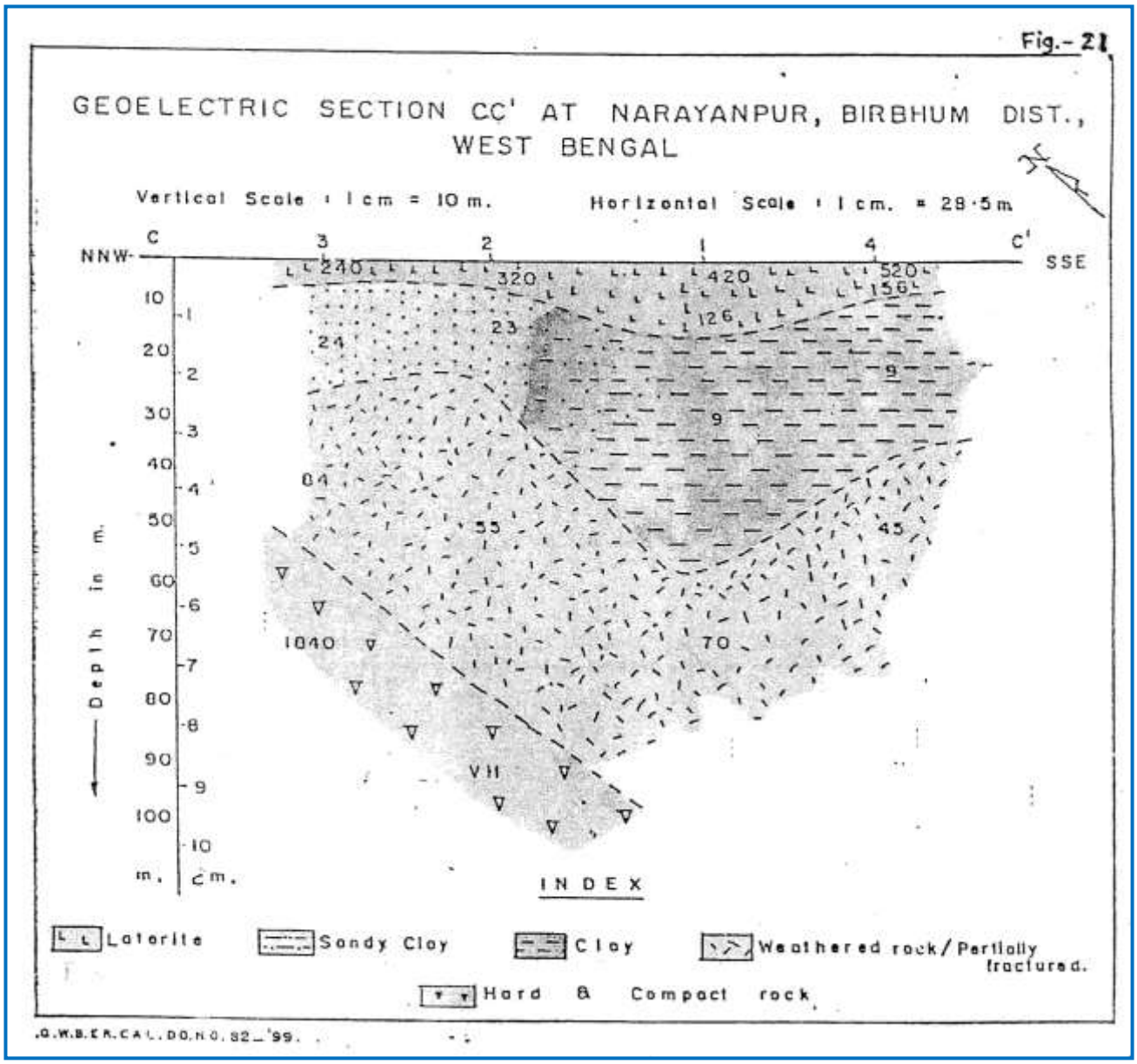


Plate 5.3: Geoelectric Section CC' at Narayanpur, Birbhum District

Chapter-6
HYDROGEOLOGY

6.1 Occurrence, movement, yield and Aquifer properties:

In the study area groundwater occurs under water table condition in the near surface aquifer and under confined condition in deeper aquifer. In the areas underlain by hard rocks (basalts) groundwater occurs under water table condition in the zone of weathering and in the zone of secondary porosities like fractures, joints etc. at shallow depth. In the alluvium covered area groundwater occurs under unconfined condition in the near surface aquifer and under confined condition in deeper aquifer. Groundwater is generally being developed through open wells in the weathered zone and the available discharges can only meet the domestic needs but is not sufficient enough for any large scale development of groundwater. However, groundwater from the zone of secondary porosities is being developed through bore wells and yield to the tune of 60-150 lpm, which, at places, goes as high as 330 lpm. There are scopes for development of ground water through bore wells in suitably selected hydrogeological sites.

Water table contours for the study area have been prepared using data from hydrograph network stations. It is observed from the map that the ground water moves from west to east or south-east direction in the study area.

The thickness of alluvium increases from west to east from < 20 to about 80 mbgl in the western part of the study area and it increases to huge thickness towards east. Major portion of the Older Alluvium cover areas in uplands, which are sometimes overlain by laterite. Recent Alluvium occupies extreme eastern parts of the district, along its border with Murshidabad district, and also comprises the area along the major river channels.

Groundwater occurs under unconfined conditions in the shallow aquifers in the area underlain by alluvium. At deeper depths it occurs under semi-confined to confined conditions. The shallow aquifers is underlain by a zone of fine to medium grained, gray coloured sand which is occasionally coarse grained and at places gravelly and is separated from the shallow aquifer zone by a layer of clay/ sandy clay. This sand zone splits up into several sand layers separated by clay/sandy clay layers and constitute the deeper aquifers, which are persistent throughout the area.

The aquifer characteristics and yield potentialities, observed from the ground water exploration carried out in the district in the study area by CGWB and other organizations, reveal that in the northern part of the district from Murarai to Rampurahat, the depth of the tube wells vary from about 50 m in the western parts to about 135 m in the eastern parts. Average yield of shallow tube wells of about 10 to 50 m depth varies from 18 to 22.7m^3/hr at reasonable draw down. In the central part of the district, covering Mayureshwar II and Sainthia blocks, there is much ground water development through shallow low duty tube wells, yielding to the tune of 13.6 to 15 m^3/hr. T varies from 250 to 400 m^2/day and Storage Coefficient (S) being $0.5x10^{-1}$

It has been observed that there are some auto-flowing shallow tube wells of 25-40 m depth along the drainage courses in parts of Sainthia, Nalhati and Murarai blocks. Ground water exploration in the district reveals that auto flowing condition also prevails in the aquifer zones between 222-342 mbgl at Ahmedpur in Sainthia block and 203-490 mbgl at Mustal in Labpur block with free flow to the tune of 4.25 lps for the piezometric head at 0.90 magl and 6.94 lps for the piezometric head at 3.27 magl respectively.

6.2 Depth to Water Level of the study area

During pre-monsoon period (2019) in major part of the area, depth to water level is in the range of 2.00 to 20.0 mbgl. During post-monsoon (2011) in central parts of the district SWL was at 2-5 mbgl, whereas at the northern parts and in the eastern parts of the district the post monsoon water level was deeper ;5-20 mbgl. Seasonal water level fluctuation between pre-monsoon and post-monsoon periods is found to be moderate to high. In Birbhum district the value of water table ranges from 102.25 m amsl in the western part to 13.40 m amsl in the eastern part of the district. Broadly the groundwater flow direction is easterly to south easterly (Plate 3 & 4).

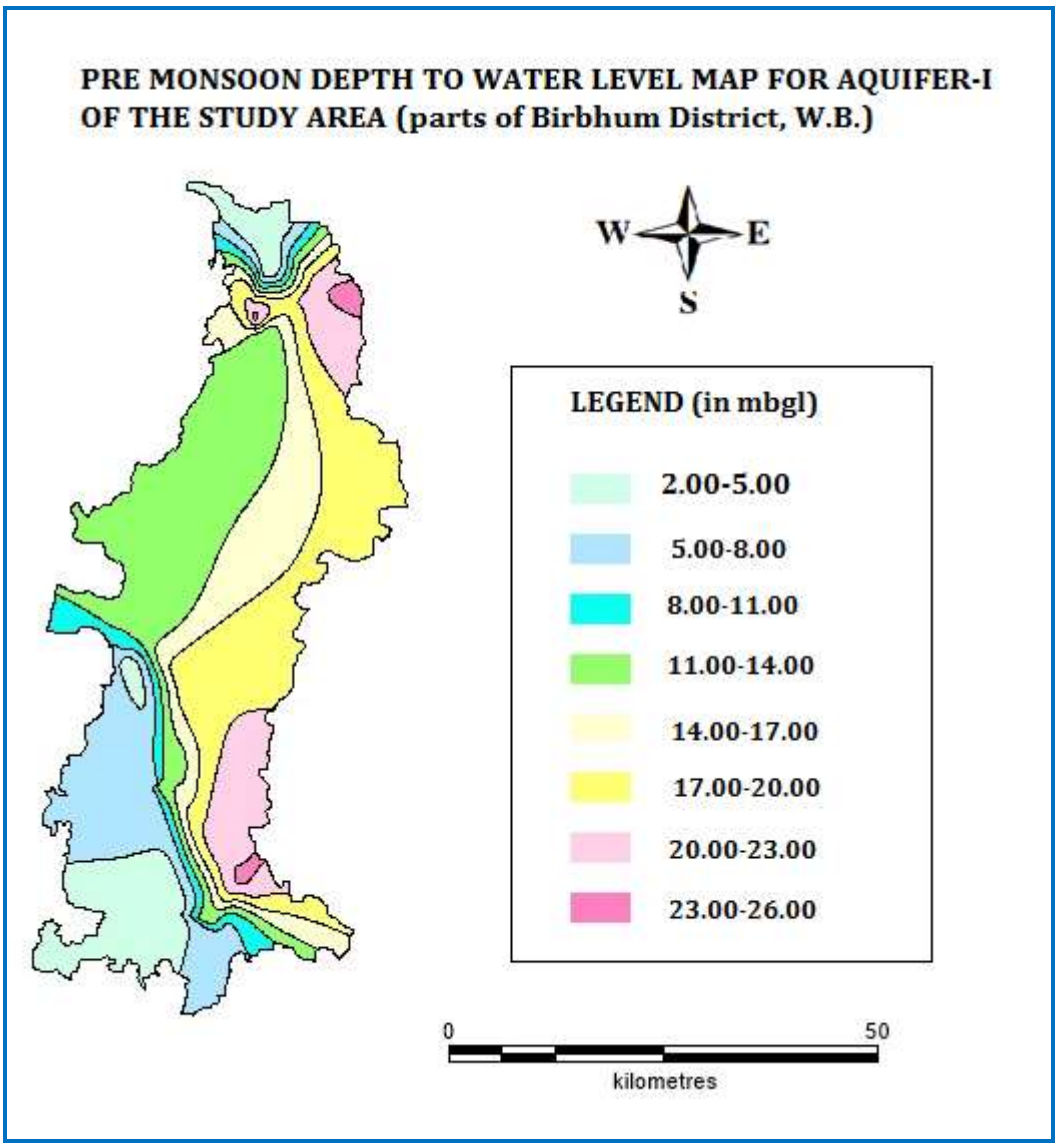


Plate 6.1: Pre Monsoon Depth to water level map for Aquifer-I of the study area (parts of Birbhum District, W.B.)

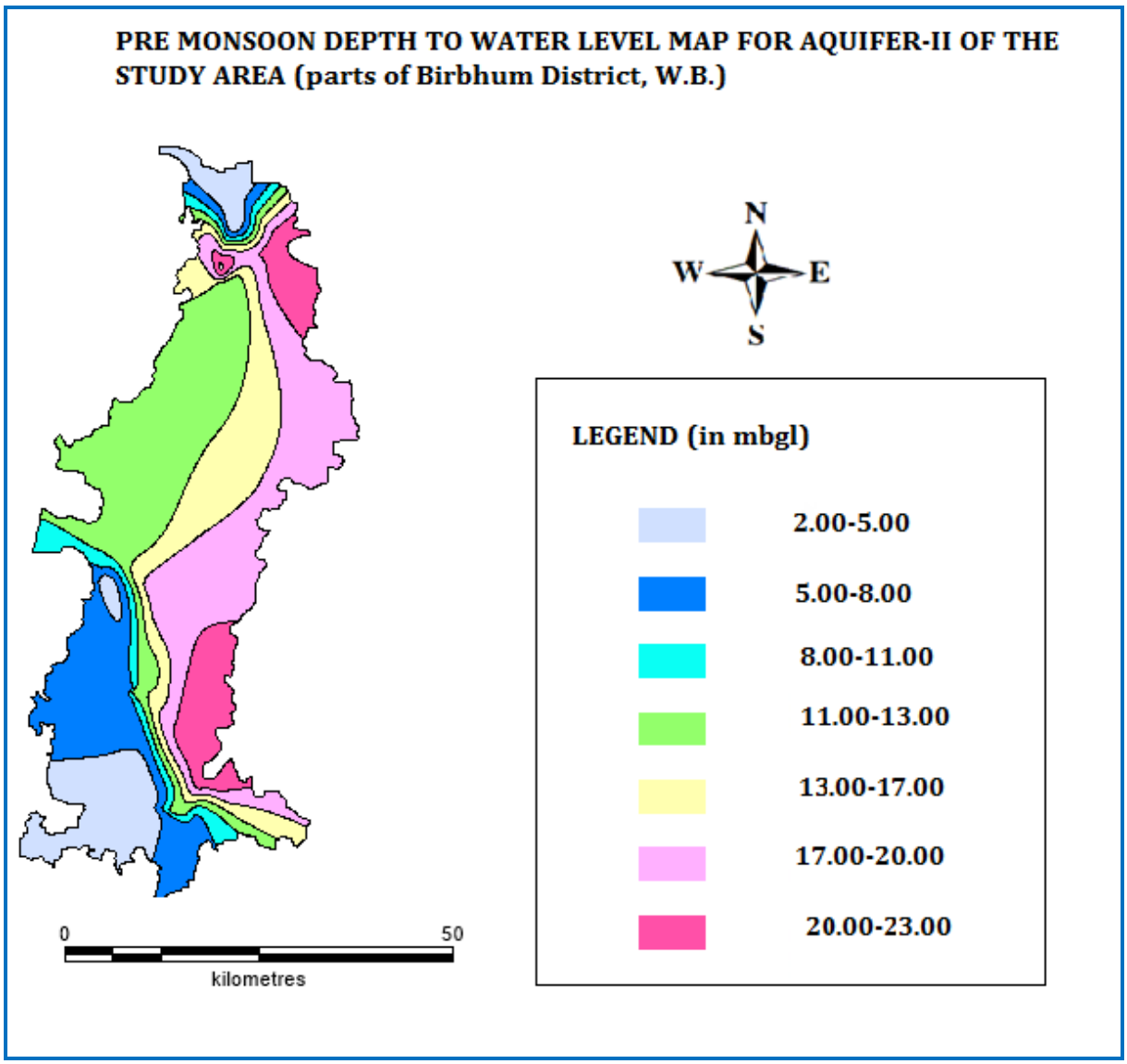


Plate 6.2: Pre Monsoon Depth to water level map for Aquifer-II of the study area (parts of Birbhum District, W.B.)

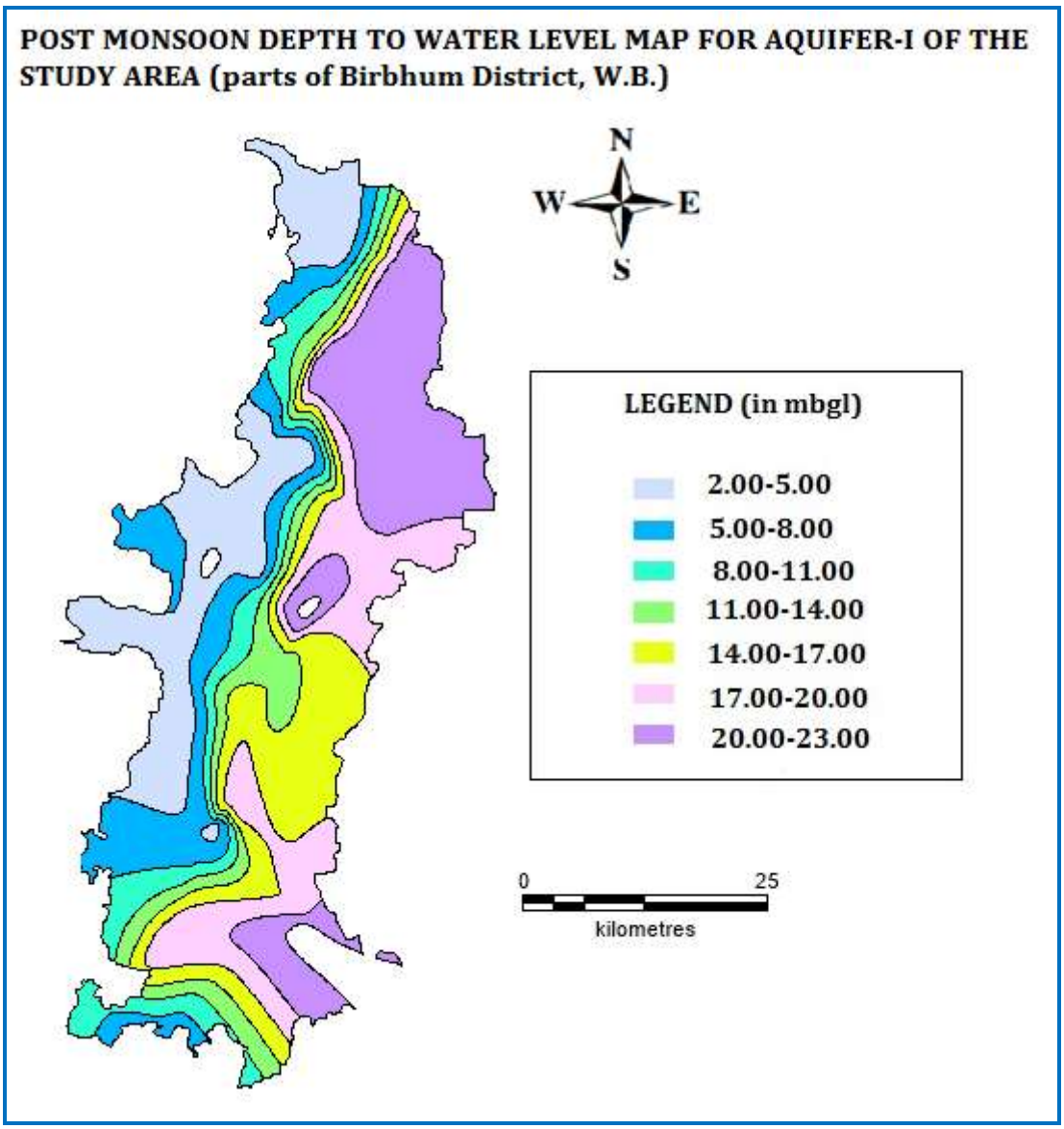


Plate 6.3: Post Monsoon Depth to water level map for Aquifer-I of the study area (parts of Birbhum District, W.B.)

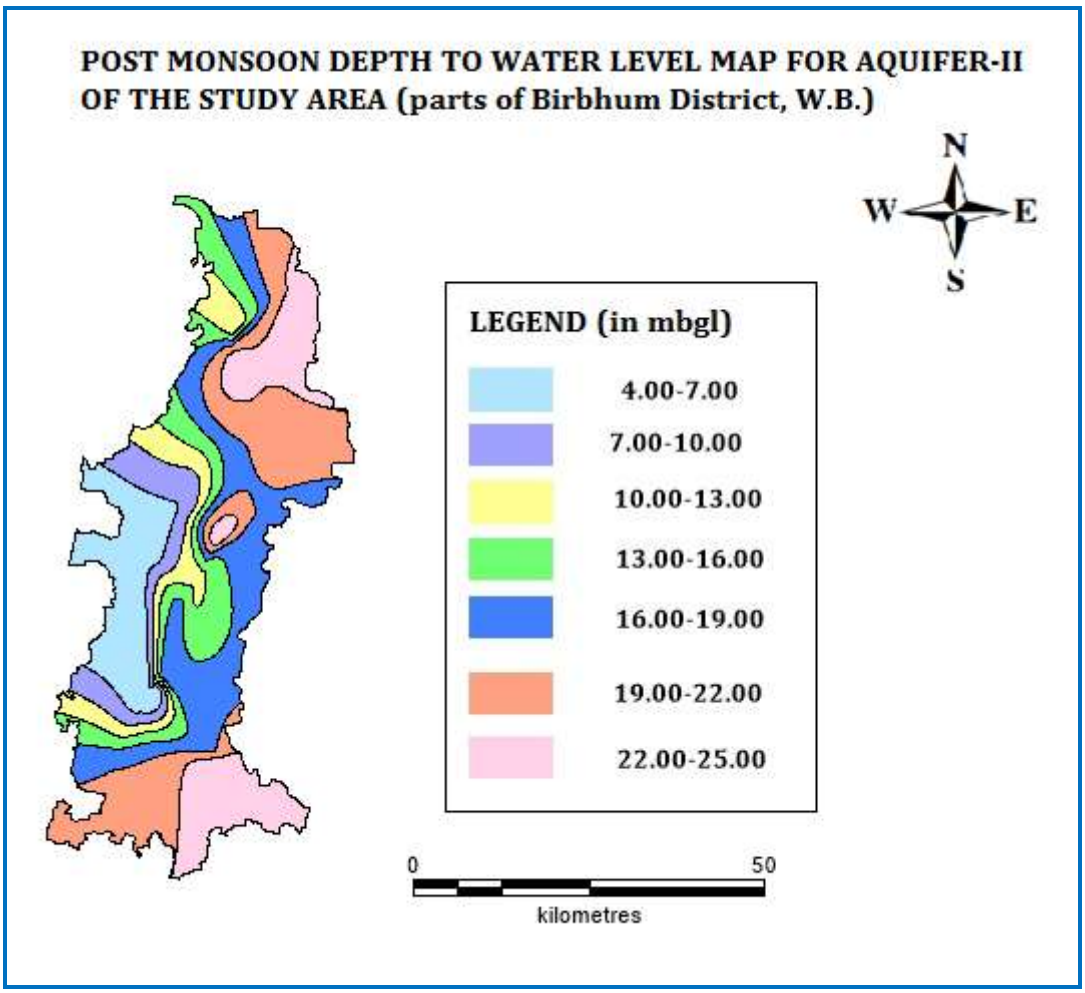


Plate 6.4: Post Monsoon Depth to water level map for Aquifer-II of the study area (parts of Birbhum District, W.B.)

6.3 Water Level fluctuation during pre-monsoon and post-monsoon

The water level fluctuation maps for Aquifer-I & Aquifer-II has been prepared based on the pre-monsoon and post monsoon water level data collected from the study area. The water level fluctuation in the area is very less, generally below 4m. (Plate 6.1,6.2,6.3 & 6.4)

6.4 Water table contour and long term trends

Water table contours for the study area have been prepared (Plate 6.5 &6.6) using data from hydrograph network stations. It is observed from the map that the ground water flow is towards east to south-east direction.

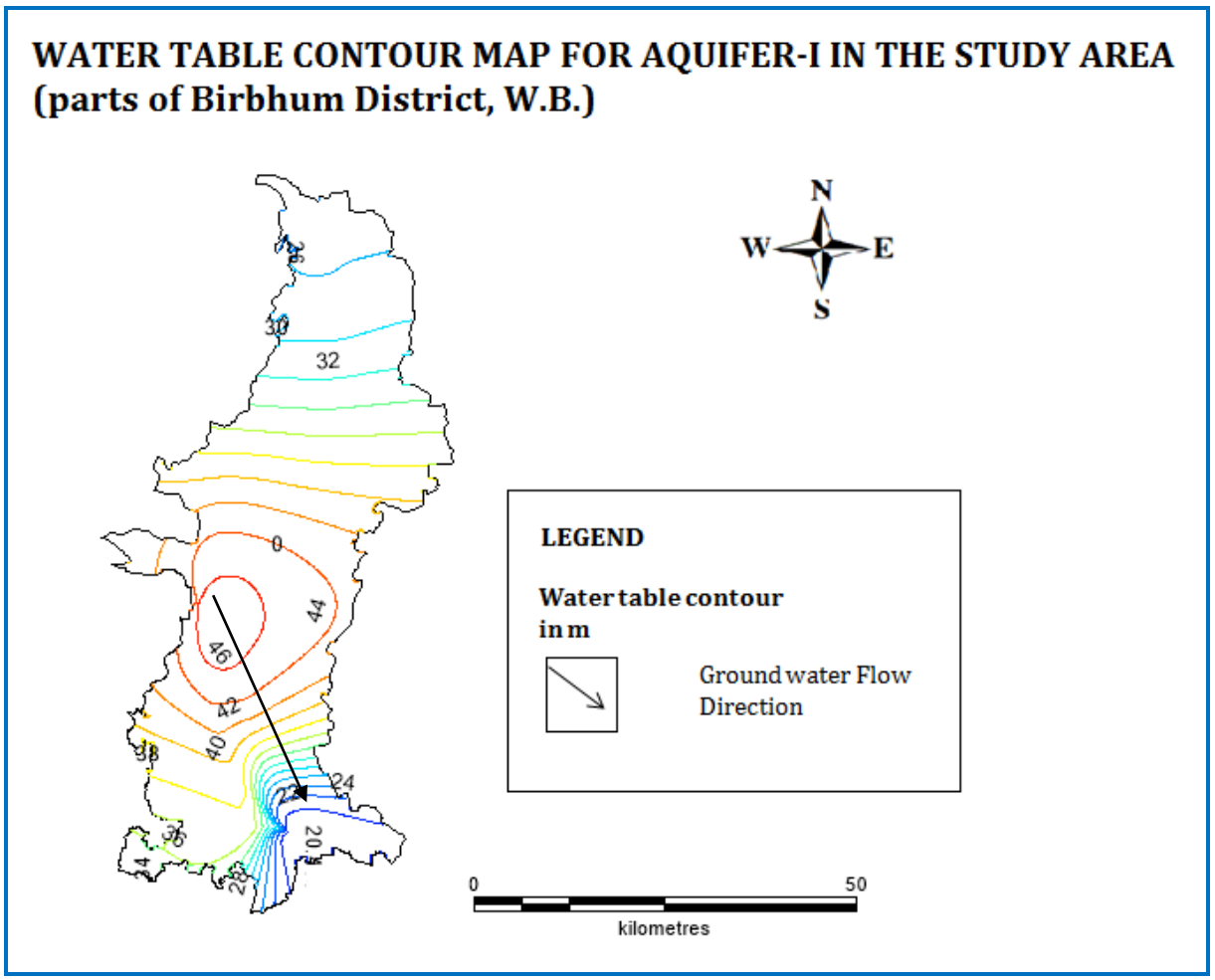


Plate 6.5: Water Table contour map for Aquifer-I of the study area (parts of Birbhum District, W.B.)

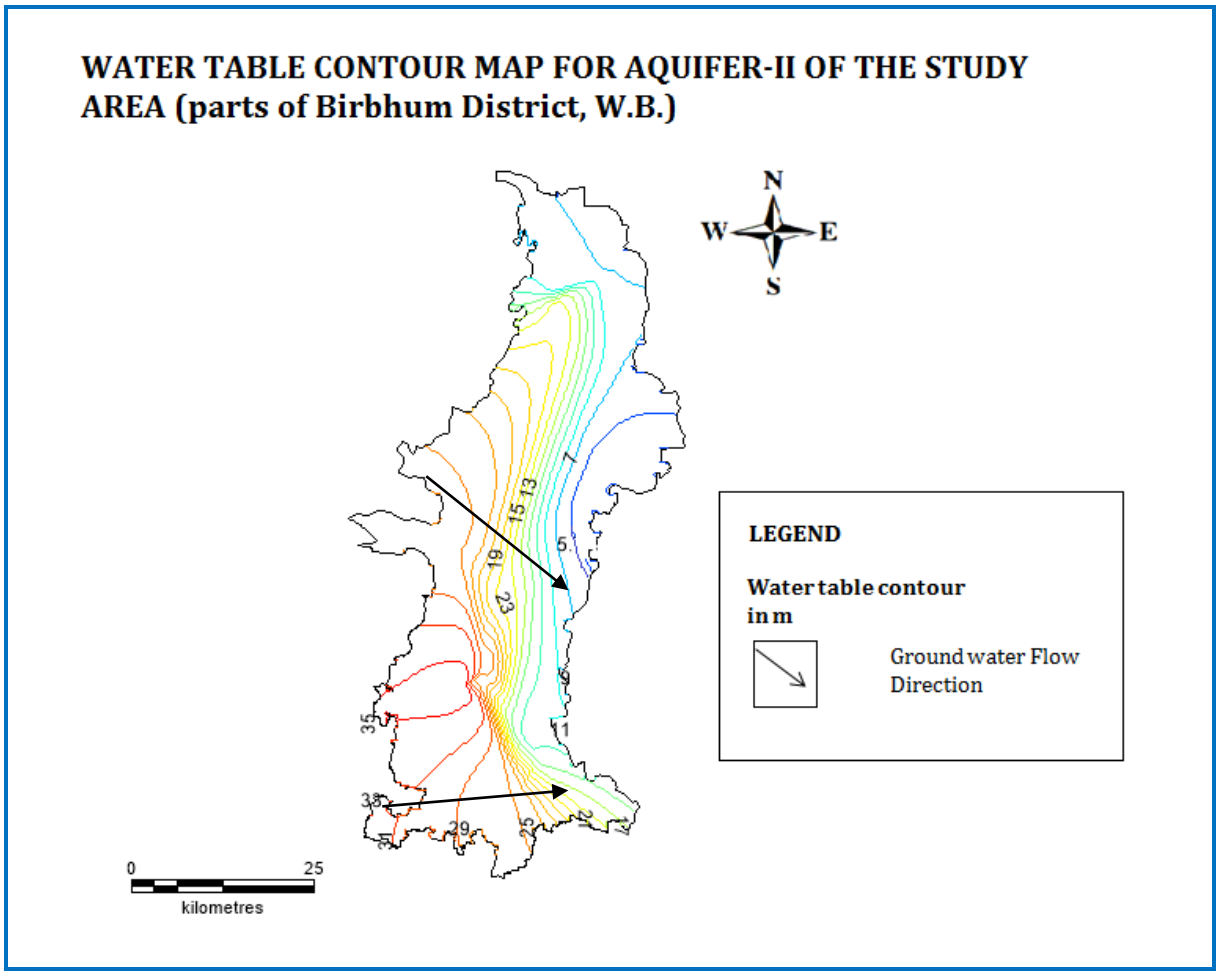


Plate 6.6: Water Table contour map for Aquifer-I of the study area (parts of Birbhum District, W.B.)

The long term trends for the blocks in the study area in the last ten years (2010-2019) has been given in the table below (Table 6.5). The pre-monsoon and post-monsoon rise/fall in Aquifer is clearly shown. It is observed that there is no significant rising or falling trend recorded as such.

BLOCK	Pre-monsoon Trend		Post-monsoon Trend	
	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)
Labpur		0.39		0.33
Sainthia		0.19		0.10
Rampurahat I	0.34		0.33	

BLOCK	Pre-monsoon Trend		Post-monsoon Trend	
	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)
Rampurahat II		0.55		0.34
Murarai I		0.3		0.2
Murarai II		0.42		0.35
Nalhati I	0.1		0.5	
Nalhati II		0.39		0.35
Mayureshwar-I		0.4		0.6
Mayureshwar-II		0.34		0.36

Table 6.5 Long term trend analysis during Pre-monsoon and post-monsoon season in the last 10 years (2010-2019)

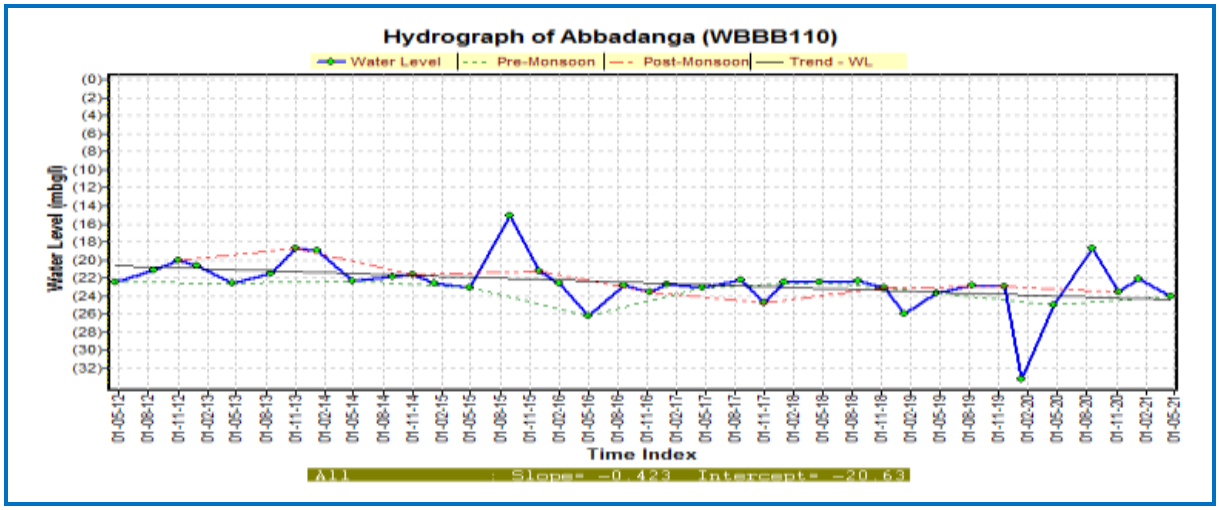


Plate 6.7: Hydrograph showing the long term trend of water level in the study area, parts of Birbhum District, W.B.

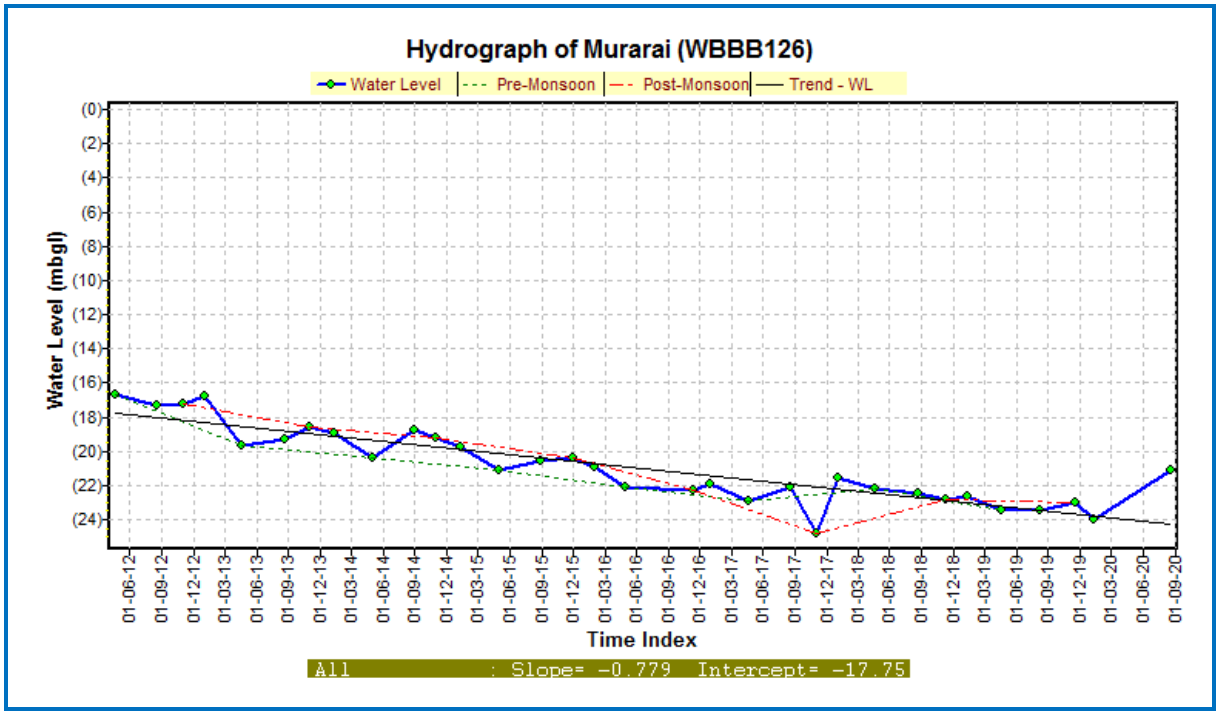


Plate 6.8: Hydrograph showing the long term trend of water level in the study area, parts of Birbhum District, W.B.

6.5 Disposition of the Aquifers

The study area has varying geology in nature. There are broadly two Principal aquifer systems namely Alluvium and Hard rocks. In hard rocks, the depth of Aquifer-I is generally considered from 0-50 mbgl and Aquifer-II from 50-200 mbgl. In Alluvium, the depth of Aquifer-I range from 0-50 mbgl, Aquifer-II from 50-150 mbgl and Aquifer-III from 150-300 mbgl. The potentiality for the aquifers in alluvial areas is much higher than those in hard rocks and there is a greater chance for better development of groundwater resources. The yield potential in hard rocks is basically low and the aquifers at depth rather than those in upper weathered portions are generally controlled by the presence and extend of secondary porosities like joints, faults, etc. The parameters for the aquifers in different formations have been listed in the above paragraphs.

The stratigraphic model and cross-sections for the study area are given below.

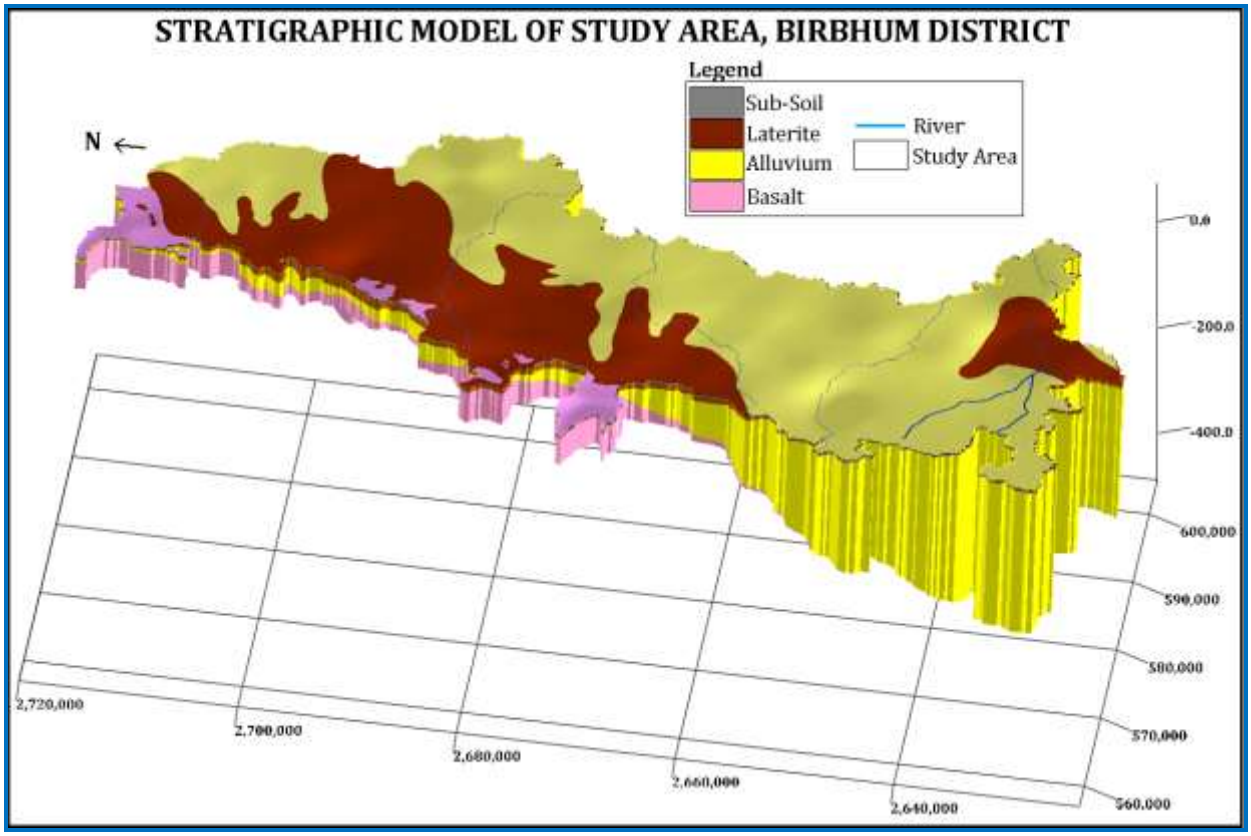


Plate 6.9: Stratigraphic Model of Study Area (parts of Birbhum District, W.B.)

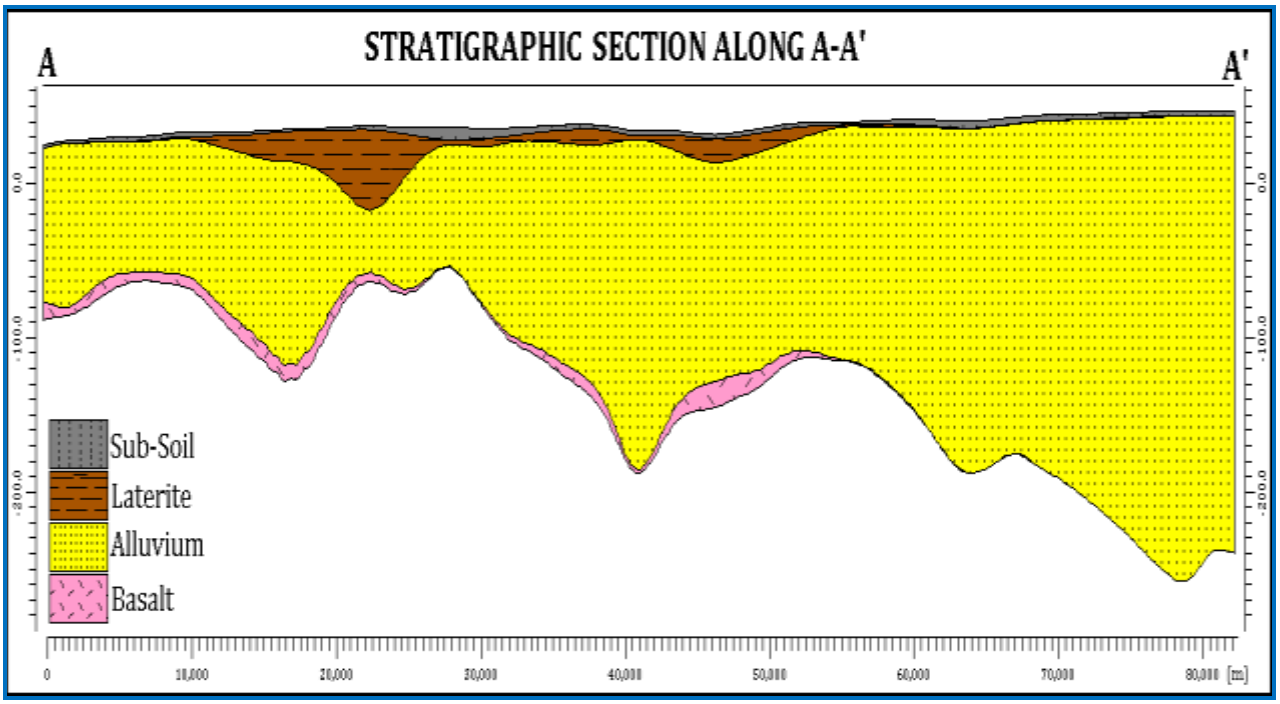


Plate 6.10: Cross-section of the Study Area along the path A-A' (parts of Birbhum District, W.B.)

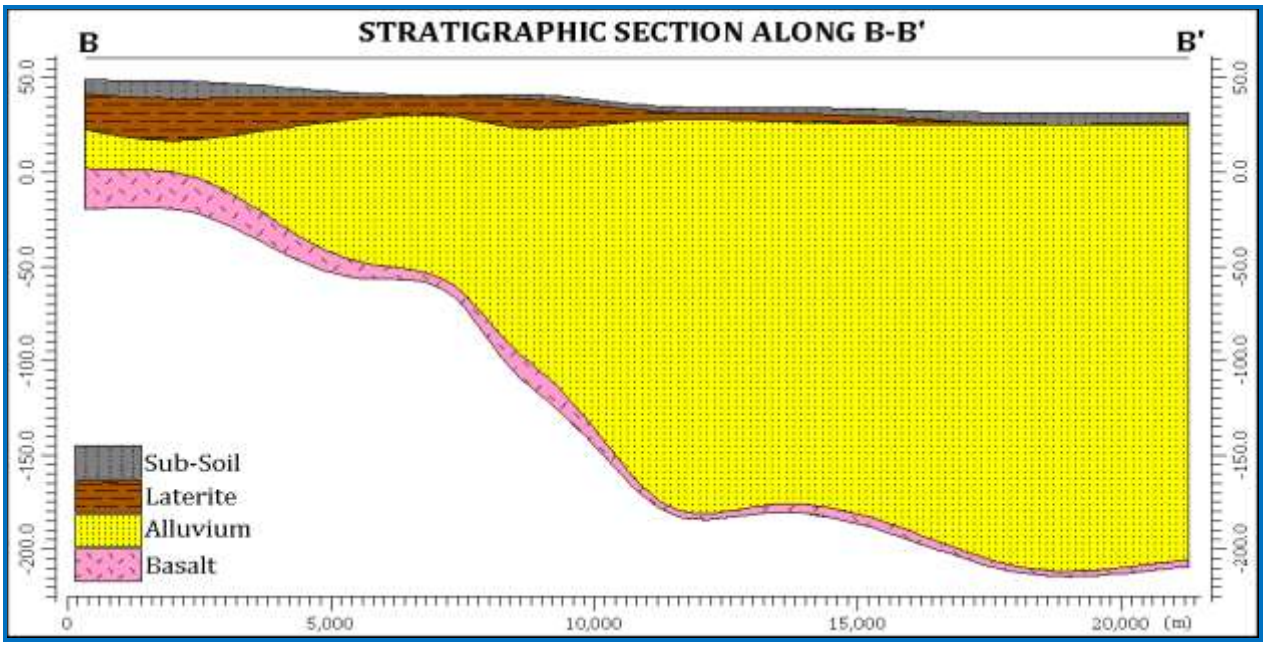


Plate 6.11: Cross-section of the Study Area along the path B-B' (parts of Birbhum District, W.B.)

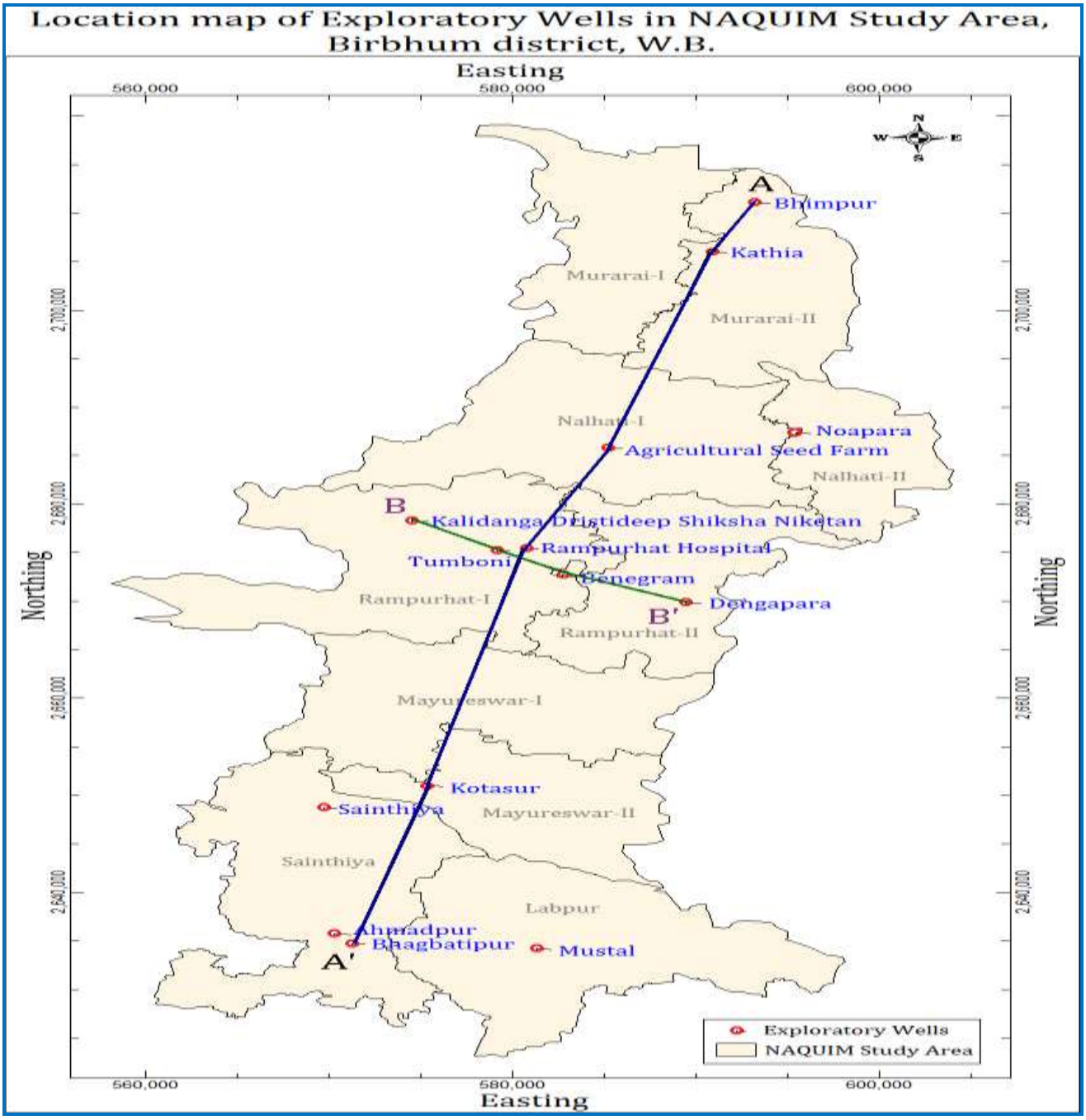


Plate 6.12: Location map of Exploratory wells in the study area (parts of Birbhum District, W.B.)

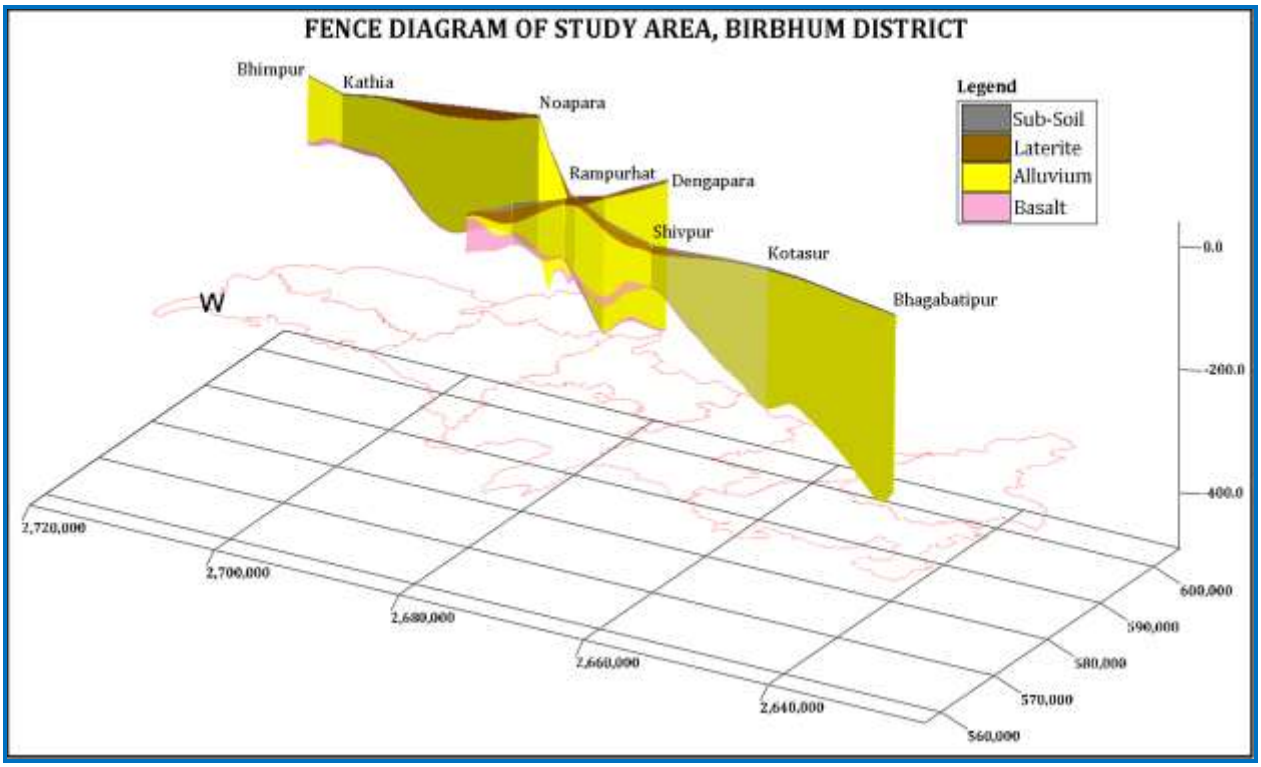


Fig.6.13 Fence Diagram of the Study area (parts of Birbhum District, W.B.)

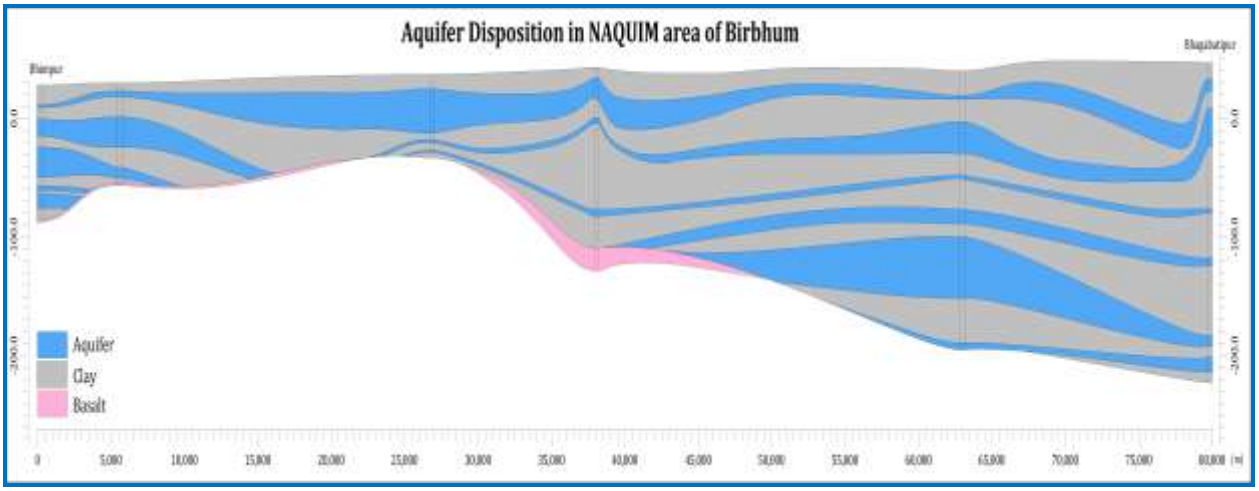


Fig.6.14 Disposition of Aquifer in the Study area (parts of Birbhum District, W.B.)

Block	Location	Latitude	Longitude	Type of Well	Depth drilled (m bgl)	Depth of Well Constructed (m bgl)	Casing Depth for Hard Rock (m bgl)	Major Lithology Encountered	Zone tapped/ Fractures encountered (mbgl)	S.W.L. (m bgl)	Discharge (lpm)	Drawdown (m)	T (m2/day)	S
Sainthia	Ahmadpur	23.762	87.662	DEW	352.83	342		Tertiary	222.00-228.00,241.00-250.00,261.00-270.00,274.0-277.00,282.00-285.00,293.00-299.00,339.00-342.00	**6.82**	**1266.6**			
Sainthia	Ahmadpur	23.762	87.662	SEW	200	170		Alluvium /Tertiary	53.00-59.00,78.00 - 84.00,95.00 - 104.00,138.00-144.00,165.00-168.00	**5.1**	**1200**	**6**	**421.91**	**9.9x10-4**
Sainthia	Sainthia	23.847	87.672	SEW	195.64	179		Alluvium	132 - 144,152 – 161, 173 - 176	**9**	**492**	**7.61**		

Sainthia	Sainthia	23.847	87.672	SOW	185.12	179		Alluvium	142-144,152-161,173-176	**8.93**	**1099.8**			
Sainthia	Sainthia	23.847	87.672	DOW	225.07	224.5			210.50-223.50					
Sainthia	Iswarpur	23.871	87.608	EW	181	175		Alluvium	58-64,97-102, 136-142,165-171	13	720		380	9.7x10-4
Sainthia	Iswarpur	23.871	87.608	OW	150	145		Alluvium	58-64,97-103,136-142	12.7	420			
Nalhati-II	Nowapara	24.282	88.45	EW	215.25	90		Alluvium	53-56,70-76,84-87	11.12	2100	3.33	2269.6	
Nalhati-II	Lohapur	24.292	87.963	EW	183	100		Alluvium	68-74,88-93,94-97	16.45	1320	1.35		
Rampurhat-I	Nischintapur	24.193	87.775	EW	49			Older Alluvium	45.00-49.00	3.55	72			
Rampurhat-I	Kalidanga Dristideep Siksha Niketan	24.139	87.746		64.8	59		Laterites & Rajmahal Trap	10.00-13.00, 18.00-30.00, 44.00-56.00	1.68	180			
Rampurhat-I	Tumboni	24.218	87.695	Borewell	75			Rajmahal Trap	-		Dry			
Rampurhat-I	Rampurahat			EW	64.8	59		Alluvium	10-13,18-30,44-56		180			

Rampurahat-I	Rampurahat			OW	59.18	58		Alluvium	10-13,18-30,44-56		150			
Rampurahat-II	Chandpara	24.188	87.9	EW	154	143		Alluvium	110-140	4.25	1260			
Rampurahat-II	Tarapur	24.107	87.82	DEW	164.4	148		Alluvium	119-125,128-132,140-145	14.65	156			
Rampurahat-II	Tarapur	24.107	87.82	SEW	80.2	80		Alluvium	38-40,75-79	17.95	126			
Rampurahat-II	Margram	24.151	87.865	DEW	225.3	160		Alluvium	125-128, 132-135,141-149, 153-157	13.77	219.6	9.96	46.28 (T Recovery)	4.81x10-8
Rampurahat-II	Margram	24.151	87.865	DOW	164	160		Alluvium	125-128, 132-135,141-149, 153-157	13.73		6.84	52.7 (Theis Recovery)	
Rampurahat-II	Margram	24.151	87.865	SEW	95.6	67		Alluvium	46-64	18.4	397.8	0.54	1638.8 (J)/1613.59 (T)	

Labpur	Mustal	23.694	87.778	EW	508.29	493		Tertiary Formation	230.52-244.52,268.89-279.32,352.93-377.00,384.00-422.77,429.79-441.98,448.00-490.35	3.27	2713.8	13.13	151.16	
Labpur	Laughata	23.849	87.803	DEW	350.6	341		Tertiary	138.00 – 144.00,179.00 – 191.00,232.00 – 238.00,244.00 – 250.00,320.00 – 338.00		396.6		46.64	3.16X10-3
Labpur	Laughata	23.849	87.803	SEW	137	130		Older Alluvium	48.00-60.00,65.00-74.00, 115.00-127.00		624			
Mayureswar-II	Kotasur	23.957	87.708	EW	235	197		Older Alluvium & Tertiary Formation	93.03-102.16,178.13-193.98					

Mayureswar-II	Mayureswar	23.975	87.776	EW	200.44	198		Older Alluvium & Tertiary Formation	180.00-195.00	9.32	210	17.16		
Mayureswar-II	Mayureswar	23.975	87.776	OW	183	181.5		Older Alluvium & Tertiary Formation	222.00-228.00,241.00-250.00,261.00-270.00,274.0-277.00,282.00-285.00,293.00-299.00,339.00-342.00	9.28	180			

Table 6.6: Details of Exploratory and observation wells constructed by CGWB, ER depicting the aquifer characteristics of the study area (parts of Birbhum District, W.B.)

Chapter-7
GROUNDWATER RESOURCES

7.1 Dynamic water resource

The dynamic ground water resources of Birbhum district has been estimated jointly by Central Ground Water Board, Govt. of India and State Water Investigation Directorate, Govt. of West Bengal, following the norms laid down by GEC 1997 methodology. The last assessment of ground water resource for the State as well as for Birbhum district was done in 2013.

Block wise assessment of the district has been done in which demographic data of 2011 Census, CGWB water level data, cropping pattern, annual monsoon rainfall and normal rainfall provided the basic input for calculating the resources of the state. Block wise (Groundwater assessment unit) geographical area, area under different hydro-geological sub-provinces (sub-units), area under command and non-command, poor ground water quality area and ground worthy recharge area has also been considered. Gross current draft for all uses, recharge from rainfall, recharge from other sources like tanks, ponds, canal seepages, return flow from ground water and surface irrigation has all been considered. The number of abstraction structures and their unit draft has been taken into account for computation of irrigation draft.

As per the computation, the net ground water availability for recharge for the study area was estimated 628617.7 ham while the total extraction for all uses was estimated 57347.4 ham. The total five blocks of the study area are under safe category namely Mayureshwar-I, Mayureshwar-II, Murarai-I, Nalhati-I & Rampurahat-I. The blocks belonging to Semi critical category in the study area are five in number namely Labpur, Murarai-II, Nalhati-II, Rampurahat-II & Sainthia.

The details of Groundwater Resources of the study area (parts of Birbhum District, W.B.) are given in table no.

Sl. No.	Name of Ground water Assessment Unit	Name of Ground water Assessment Sub- Unit	Total Annual Ground Water Recharge in ham	Net Annual Ground Water Availability in ham	Existing Gross Ground Water Draft for All uses in ham	Provision for domestic, and industrial requirement supply to 2035 in ham	Net Ground Water Availability for future irrigation development in ham	Stage of Ground Water Development in %	Category (Safe/ Semi-critical/ Critical/ Over-exploited)
1	LABPUR	Command	8155.20	7339.68	4566.73	456.35	2533.33	63.70	Semi-critical
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
2	MAYURESWAR-I	Command	8815.73	7934.16	1881.23	360.54	5863.62	24.79	Safe
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
3	MAYURESWAR-II	Command	6592.25	5933.03	3237.51	291.65	2542.38	55.73	Safe
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
4	MURARAI-I	Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Nom-Command	5548.40	5270.98	1125.69	398.23	4030.75	21.36	Safe
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
5	MURARAI-II	Command	4543.83	4316.64	2103.59	319.47	2045.31	50.49	Semi-critical
		Non-Command	1936.93	1840.08	949.27	139.15	850.79	51.59	Semi-critical
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
6	NALHATI-I	Command	2767.94	2491.15	1601.57	538.34	606.91	69.42	Safe
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
7	NALHATI-II	Command	3408.13	3237.72	1967.92	277.78	1123.94	62.82	Semi-critical
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
8	RAMPURHAT-I	Command	3894.41	3504.97	964.39	541.34	2256.33	31.18	Safe
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
9	RAMPURHAT-II	Command	5435.99	4892.39	2926.32	409.59	1751.00	61.80	Semi-critical
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil
10	SAINTHIA	Command	11762.89	10586.60	4652.20	554.20	5643.40	45.19	Semi-critical
		Non-Command	0.00	0.00	0.00	0.00	0.00	0.00	Nil
		Poor Ground Water Quali	0.00	0.00	0.00	0.00	0.00	0.00	Nil

Table 7.1 Ground water Recharge, Resource and Stage of Development & Categorization of the study area (parts of Birbhum District, W.B.)

7.2 Static water resource/In-storage

Computation of in-storage is essential not only for estimation of emergency storage available for utilization in case of natural extremities like drought conditions but also for assessment of storage depletion in over-exploited areas for sensitizing stakeholders about the damage done to environment. The in-storage for the blocks under study area is listed in the table 7.2 (as of 2009).

Sl. No.	District	Assessment Unit/ District	Fresh In-Storage Ground Water Resources (2009) in ham
1	Birbhum	Mayureshwar-I	68676.91
2	Birbhum	Mayureshwar-II	45854.72
3	Birbhum	Murarai-I	46392.60
4	Birbhum	Murarai-II	48200.01
5	Birbhum	Nalhati-II	30849.63
6	Birbhum	Rampurahat-II	40653.66
7	Birbhum	Sainthia	79680.96
8	Birbhum	Labpur	70103.15
	Soft Rock/Alluvium Total		
9	Birbhum	Nalhati-I	1555.6158
10	Birbhum	Rampurahat-I	1483.0662
	Hard Rock Total		

Table 7.2 In-storage Groundwater Resource of the study area (parts of Birbhum District, W.B.)

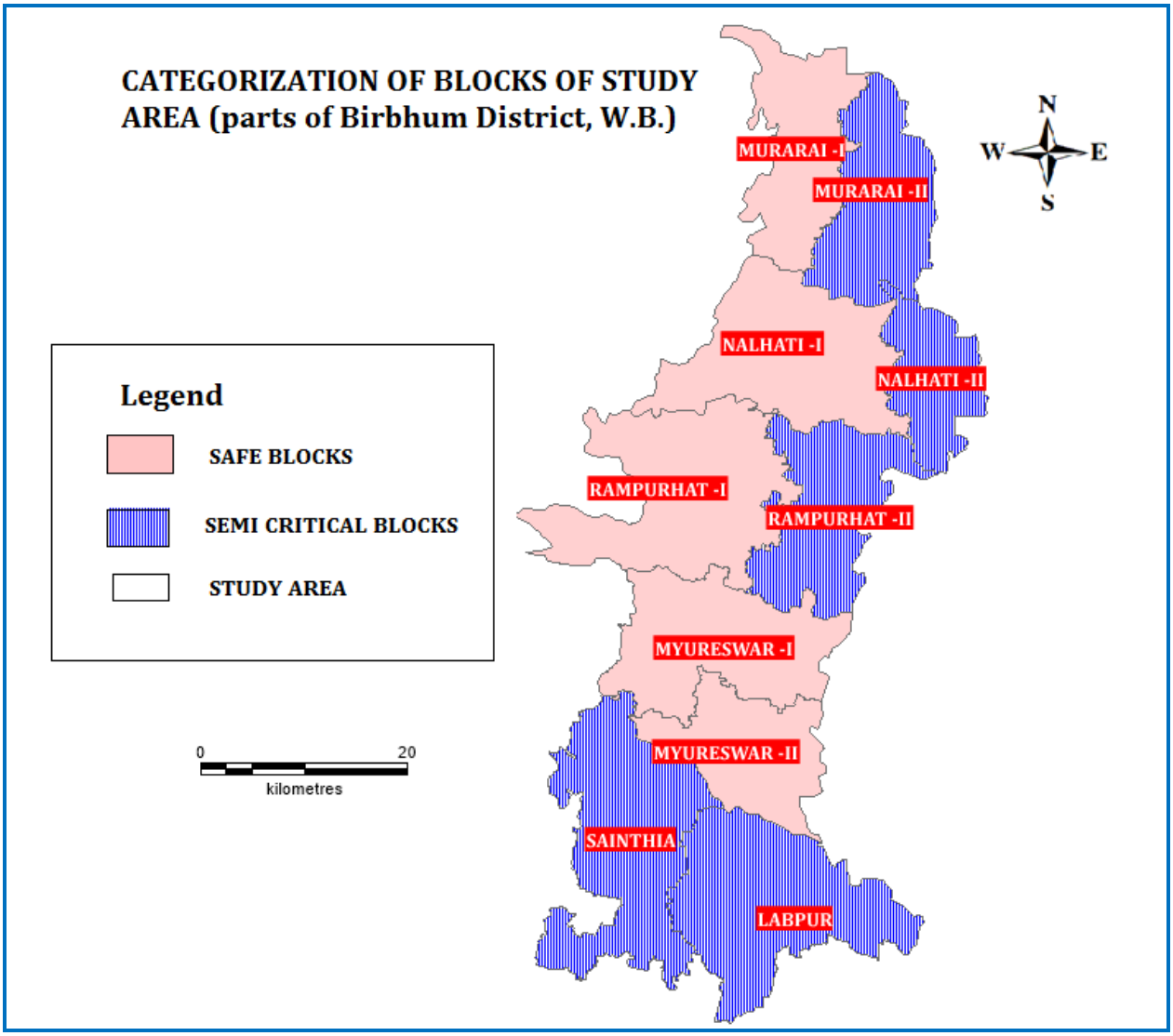


Plate7.1: Categorization of blocks of study area (parts of Birbhum District, W.B.)

CHAPTER-8

HYDROCHEMISTRY

8.1 Major Ion Chemistry and Hydrogeochemical Facies of the Study Area

For demarcating the hydrochemical facies existing in the phreatic and confined aquifer systems Piper (1953) and the modified Piper diagram by Chadha (1999) were used. The sample plotting falls in different areas are:

- The Piper's trilinear diagram (Plate 8.1) shows that 44% of groundwater samples fall into No dominant cation type. Whereas 24% of the fall into the Magnesium Type and remaining 16% samples in Sodium and Potassium type in the cation facies. Hence, the plotting on the Piper diagram for the samples from the study area shows dominance of mixed cation.
- Regarding anions, 44% of samples fall into HCO3– type, 52% Cl- type and rest 4% samples fall into no dominant type of anion facies.

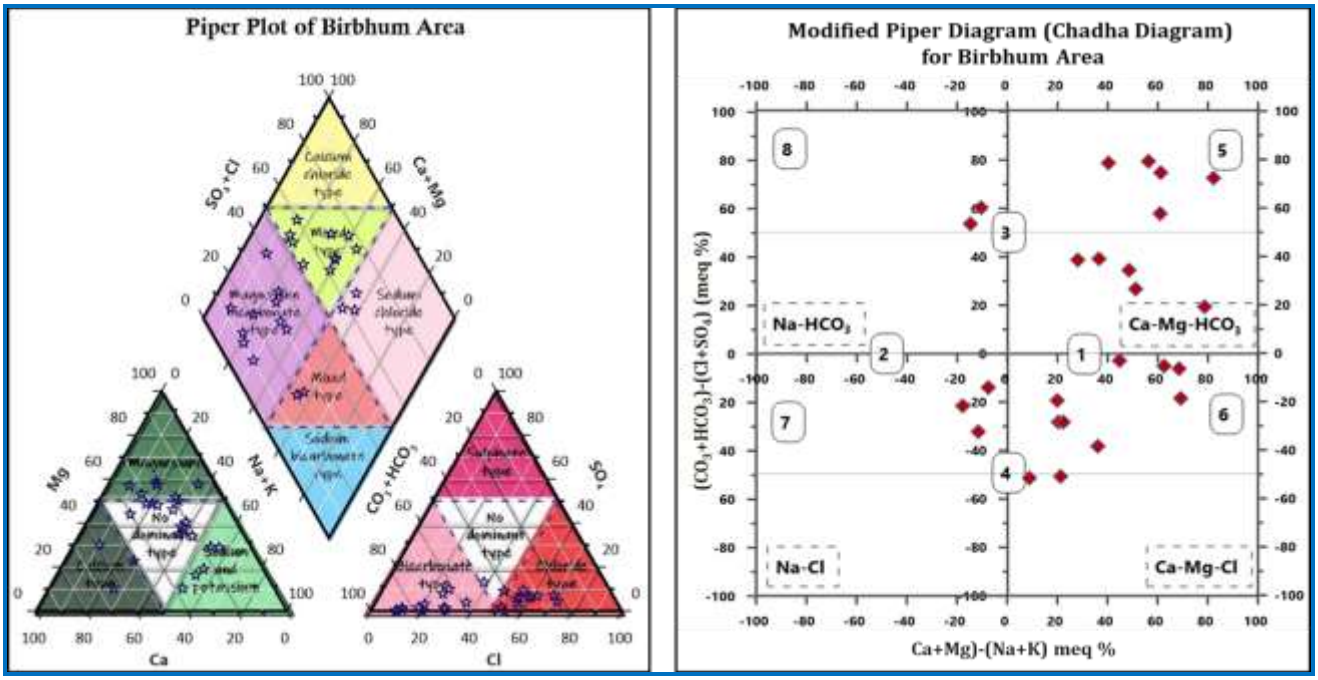


Plate 8.1(a) Piper trilinear diagram for hydrogeochemical facies (b) Groundwater samples from Phreatic aquifers of the Study Area plotted on modified Piper diagram (Chadha, 1999)

- The plot of chemical data on diamond shaped trilinear diagram reveals that 80% of the groundwater samples fall in the fields of alkaline earth exceeds alkalies and remaining 20% fall in the fields of alkalies exceed alkaline earth. 48% of groundwater sample fall in the strong acids (SO4 + Cl) exceeds weak acids (CO3 + HCO3), 52% fall in Weak acids (CO3 + HCO3) exceed strong acids (SO4 + Cl).
- Groundwater samples falling in Ca-Mg-HCO_3 type is 40%, 40% fall into Ca-Mg-Cl type, 8% fall into Na-HCO3 type and remaining 12% Na-Cl type. Therefore, facies classification indicates that maximum groundwater samples belong to Ca-Mg-HCO3 and Ca-Mg-Cl type (Fig.).

The above analysis indicates that the hydrochemical characteristics of groundwater in the phreatic aquifers show considerable variations, which could be attributed to various factors such as the composition of the lithounits, soil type and even water contamination. The Ca-Mg-HCO_3 and Ca-Mg-Cl type water indicates water type with temporary hardness.

Chemical facies	Characteristics
Ca-Mg-HCO3 type of recharge waters	water type with temporary hardness
Ca-Mg-Cl Type of reverse ion-exchange waters	water type with temporary hardness
Na-Cl type of end-member waters (seawater intrusion)	water type with permanent hardness
Na-HCO_3 type of base ion-exchange waters	water type which causes foaming

Table 8.1 Characteristics of groundwater samples in different zones derived from Chadha's diagram.

8.2 Rock-water interaction

Rock-water interaction has been assessed by uding Gibbs Diagram (Gibbs, 1970), which is a widely used method to establish the relationship of water composition and source conditions/characteristics. Three distinct fields such as precipitation dominance, evaporation dominance and rock-water interaction dominance areas are shown in the Gibbs diagram (Plate 8.1). The distribution of samples in the rock dominance region of the plot in the Gibbs diagram suggests that the major ion chemistry of groundwater is controlled by chemical weathering of rock forming minerals.

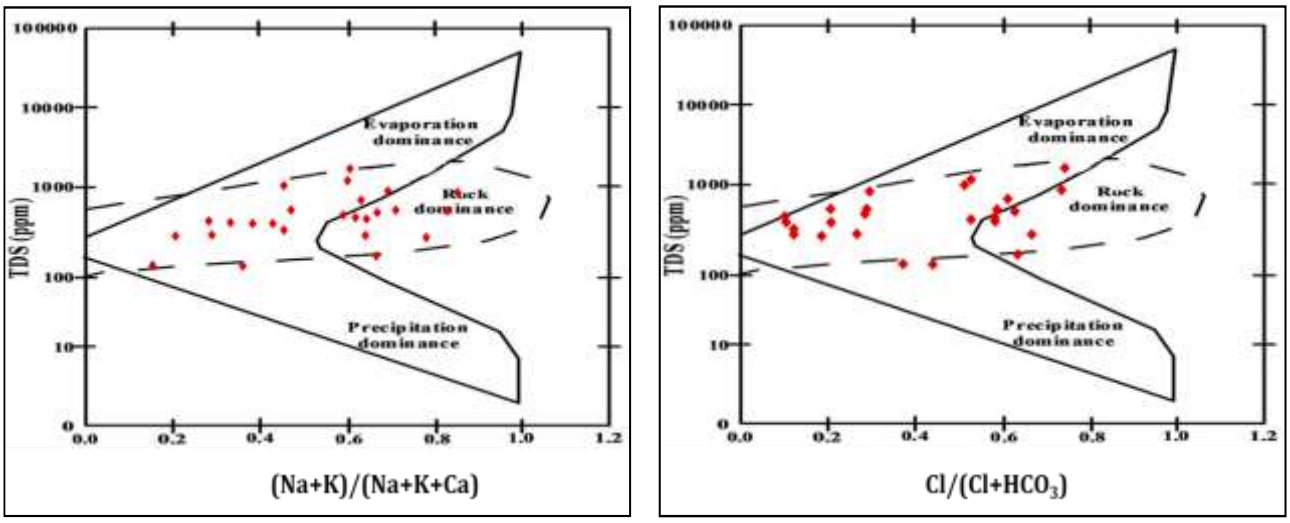


Plate 8.2.: Gibbs diagram for controlling factor of groundwater quality

8.3 Water Quality Assessment

Since groundwater is intensively used for irrigation and drinking purposes, an effort has been made to evaluate the suitability of groundwater for drinking and irrigation uses.

8.4 Suitability for Drinking Uses

To check the suitability of groundwater, hydrochemical parameters of groundwater samples of the Study area were assessed with respect to prescribed limits of Bureau of Indian Standard (BIS, 2012) for drinking water. The details of the samples and parameters exceeding the prescribed limit are mentioned in the **Table 8.2**

Sl. no.	Location	Block/ Station	Latitude	Longitude	Water Type	Type
1	Lagata	Labpur	23.80833333	87.81777778	Na-Ca-Mg-HCO3	Dug Well
2	Chouhata	Labpur	23.825	87.75416667	Ca-Na-HCO3-Cl	Dug Well
3	Mollarpur Pz	Mayureshwar-I	24.24083333	87.68055556	Mg-Ca-HCO3	Tube Well
4	Kotasur	Mayureshwar-II	23.75666667	87.69	Mg-Na-HCO3	Tube Well
5	Kotasur	Mayureswar II	24.12888889	87.71194444	Mg-Ca-HCO3	Dug Well

6	Narayanghati	Mayureswar II	24.15361111	87.7025	Na-Ca-Cl-HCO3	Subm TW
7	Palsa	Murarai-I	23.95805556	87.745	Mg-Na-Ca-HCO3-Cl	Dug Well
8	Abdullahpur	Murarai	23.95777778	87.74472222	Na-Mg-Ca-Cl-HCO3	Dug Well
9	Rajgram	Murarai I	23.95305556	87.72805556	Mg-Ca-Na-HCO3-Cl	Dug Well
10	Nasipur	Nalhati	24.48527778	87.86194444	Mg-Ca-Cl-HCO3	Dug Well
11	Dhanmara	Rampurhat	24.49777778	87.86305556	Mg-Na-Cl-HCO3	Dug Well
12	Kurukdighi	Rampurhat	24.53833333	87.86694444	Mg-Na-Ca-Cl-HCO3	Dug Well
13	Kurukdighi	Rampurhat I	24.29388889	87.76083333	Mg-Na-Ca-Cl-HCO3	Dug Well
14	Bartala	Rampurhat	24.19027778	87.73444444	Na-Mg-K-Cl-HCO3	Dug Well
15	Bartala	Rampurhat I	24.2425	87.72805556	Mg-Na-Ca-Cl-HCO3	Dug Well
16	Narayanpur	Rampurhat-I	24.2425	87.72777778	Mg-Ca-Cl-HCO3	Dug Well
17	Piarsala	Rampurhat-I	24.12083333	87.67222222	Ca-Mg-HCO3-Cl	Dug Well
18	Piarsala	Rampurhat	24.12027778	87.67333333	Ca-Na-Mg-HCO3-Cl	Dug Well
19	Barjal	Rampurhat I	24.23	87.71	Na-Mg-Ca-Cl-HCO3	Dug Well
20	Barjal Belpahari	Rampurhat I	24.22527778	87.77472222	Na-Ca-Cl-HCO3	Dug Well
21	Narayanpur	Rampurhat I	24.19861111	87.70055556	Mg-Ca-Cl-HCO3	Dug Well
22	Kopai	Sainthia	24.15277778	87.70666667	Mg-Na-HCO3-Cl	Dug Well
23	Ahmedpur	Sainthia	23.83027778	87.68833333	Na-Mg-HCO3	Tube Well
24	Paikpara	Sainthia	23.85416667	87.69694444	Mg-Ca-HCO3	Tube

						Well
25	Paikpara	Sainthia	23.85416667	87.69694444	Mg-Ca-HCO3-Cl	Tube Well

Table 8.2 Sample details with Type of water of individual sample in the Study Area

Constituents (mg/L)	Acceptable Limit	Permissible Limit	Sample Exceeding Acceptable Limit (%)	Sample Exceeding Permissible Limit (%)	Max	Min
pH	6.5-8.5	No Relaxation	-	-	8.14	6.38
Electrical Conductivity (µS/cm)	-	-	-	-	2466.0	149.9
Total Dissolved Solid (mg/L)	500	2000	24	-	1578.2	95.9
Total Alkalinity (as $CaCO_3$) (mg/L)	200	600	44	-	510.0	50.0
Chloride (mg/L)	250	1000	16	-	613.3	17.7
Nitrate (mg/L)	45	No Relaxation	-	-	48.0	0.0
Sulfate (mg/L)	200	400	-	-	62.9	0.0
Fluoride (mg/L)	1	1.5	-	-	0.8	0.1
Sodium (mg/L)	-	-	-	-	191.0	3.9
Potassium (mg/L)	-	-	-	-	75.0	0.1
Calcium (as Ca) (mg/L)	75	200	12	-	118.0	12.0

Magnesium (as Mg) (mg/L)	30	100	60	4	134.9	6.1
Total Hardness (as $CaCO_3$) (mg/L)	200	600	64	8	770.0	75.0
Iron (Fe) (mg/L)	1	No Relaxation	12	-	3.9	Traces

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

Table 8.3 Spatial Variation of Ionic Concentration in Study Area

To check the suitability of groundwater, hydrochemical parameters of groundwater samples of the study area were assessed with respect to prescribed limits of World Health Bureau of Indian Standard (BIS, 2012) for drinking water. The data in Table shows that some of the physiochemical parameters were exceeding the Acceptable limits in a number of water samples, though mostly they are falling within the maximum permissible limits.

- 64% of the sample locations were found to have the TDS concentration was more than the BIS's (2012) Acceptable limit of 500 mgL^{-1} however, all samples were found well within the Permissible limit of 2000 mgL^{-1} . The higher concentration of EC and TDS in groundwater samples may cause gastrointestinal irritation to the consumers.
- The total hardness (TH) varies from 75-770 mgL^{-1} indicating soft to very hard water types. Hardness of the water is attributable to the presence of alkaline earths elements, i.e., Ca^{2+} and Mg^{2+} which agrees the water type as attributed by Piper diagram. 8% water sample has TH beyond the BIS (2012) safe limit of 600 mgL^{-1} for drinking water.

Water Class	TH as CaCO3 in mg /L	% of Samples
Soft	<75	-
Moderately Hard	75–150	20
Hard	150–300	56
Very Hard	>300	24

Table 8.4: Hardness Classification of groundwater of the study area

- The average NO_3^- values for all the locations shows its concentration is well within the BIS (2012) permissible limit (45 mgL^{-1}).
- The consumption of water containing higher TDS concentration may cause several diseases like nausea, lung irritation, rashes, vomiting, dizziness etc. Drinking water with elevated amount of TDS for longer periods will expose body to various chemicals, toxins and may cause chronic health conditions like cancer, liver, kidney.
- Ca^{2+} concentrations are also found within the highest permissible limits (BIS 2012) with the values ranging from 12-118 mgL^{-1} but 4% of the samples have Mg^{2+} concentration more than maximum permissible limits.

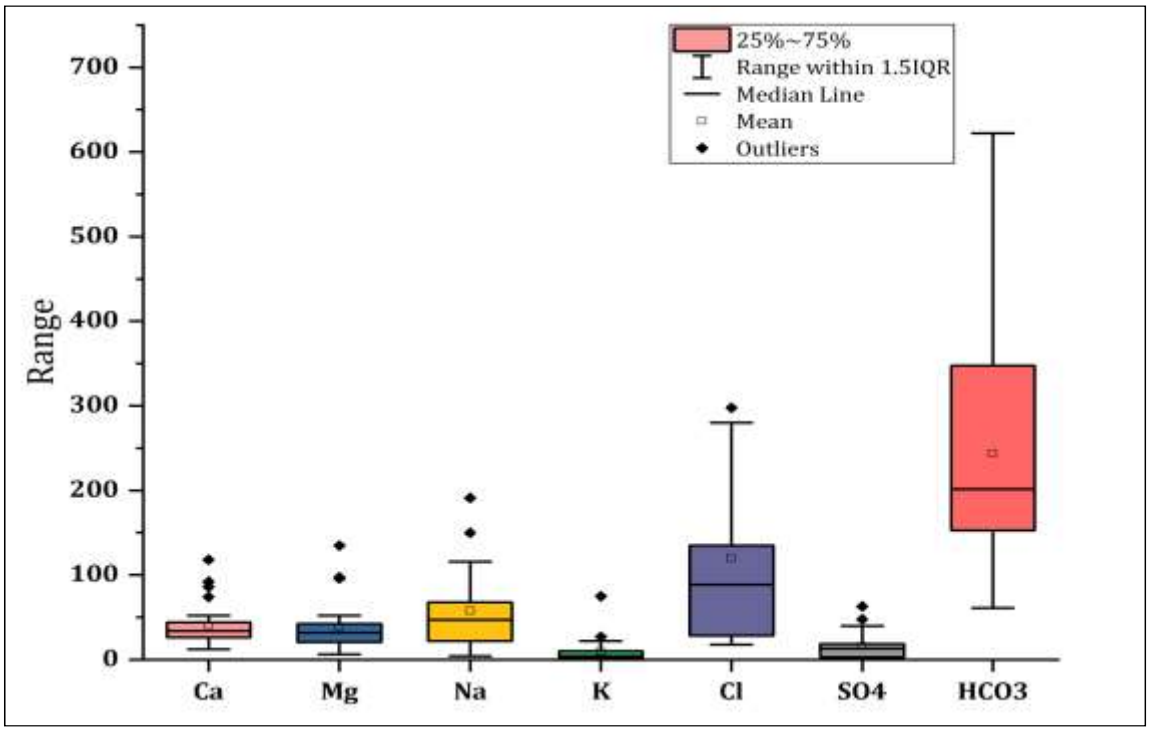


Plate 8.3: Box and Whisker Plot sowing Spatial Distribution of Major Cations and Anions in the study area

8.5 Distribution of Iron in the study area

Iron concentrations in the water samples of the study area were presented in Plate 8.4 that displays values of Iron concentration in mgL^{-1}. As per BIS, 2012 the permissible limit of iron is 1.0 mgL^{-1} beyond which water is not considered as suitable for drinking purposes without prior treatment. In the study area the Iron concentration varied from Trace-3.9 mgL^{-1} and 12% samples were detected with Iron concentration more than permissible limit. High iron in water content in drinking water can cause diabetes, hemochromatosis, stomach problems, and nausea. It can also damage the liver, pancreas, and heart.

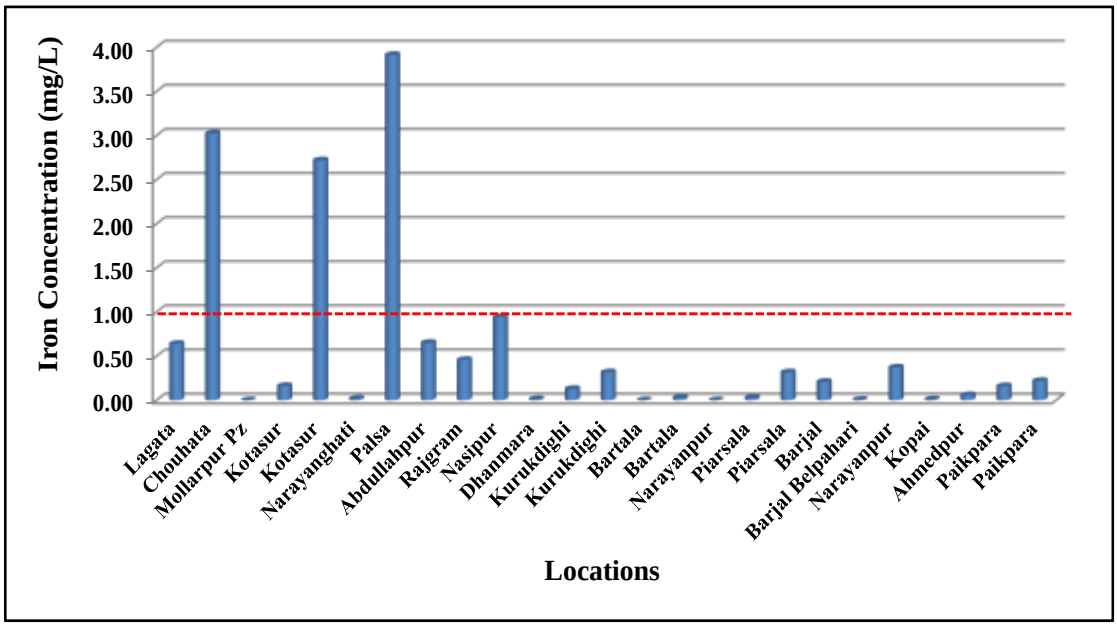


Plate: 8.4 Distribution of Iron in the study area

8.6 Suitability for Irrigation Uses

In the present study the suitability of the groundwater for irrigation is assessed by considering the irrigation indexes like Conductivity (EC), Soluble Sodium Percentage (SSP), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Magnesium Hazard (MH) and Permeability Index (PI) along with the USSL salinity and Wilcox diagrams and the result has been summarized in Table 8.5.

USSL diagram has been used to study the quality of groundwater suitability for irrigation purpose. The SAR and EC values of water samples of the study area were plotted in the graphical representation Plate 8.5(b) and found that all the samples fall in the low to medium category in salinity hazard group and low in sodium hazard group. Hence, most of the locations of the study area the ground water is suitable for the irrigation purpose.

Similar results found when the Wilcox diagram is plotted for classification of water for irrigation suitability. In this diagram, the EC was plotted against the percentage of Na. According to Wilcox classification, 84% of the water samples from the study area belonged to the good to permissible category. Remaining 8% groundwater samples falls in the permissible to doubtful category (Plate 8.5 a) and 8% in doubtful to unsuitable category.

Indices	Range	Water Class	Maximum	Minimum	Average
SAR	< 10	Excellent	3.8	0.2	2.0
	10 to 18	Good			
	18 to 26	Moderate			
	> 26	Unsuitable			
SSP	< 50	Good	76.6	14.6	45.6
	> 50	Unsuitable			
RSC	< 1.25	Good	2.4	-8.1	-2.8
	1.25 to 2.50	Moderate			
	> 2.50	Unsuitable			
MH	< 50	Good	89.9	14.0	51.9
	> 50	Unsuitable			
PI	> 75	Good	101.7	31.3	66.5
	25 to 75	Moderate			
	< 25	Unsuitable			
KI	<1	Suitable	1.3	0.1	0.7
	>1	Unsuitable			

Table 8.5: Summarized result for various indices to assess the suitability of the groundwater for irrigation

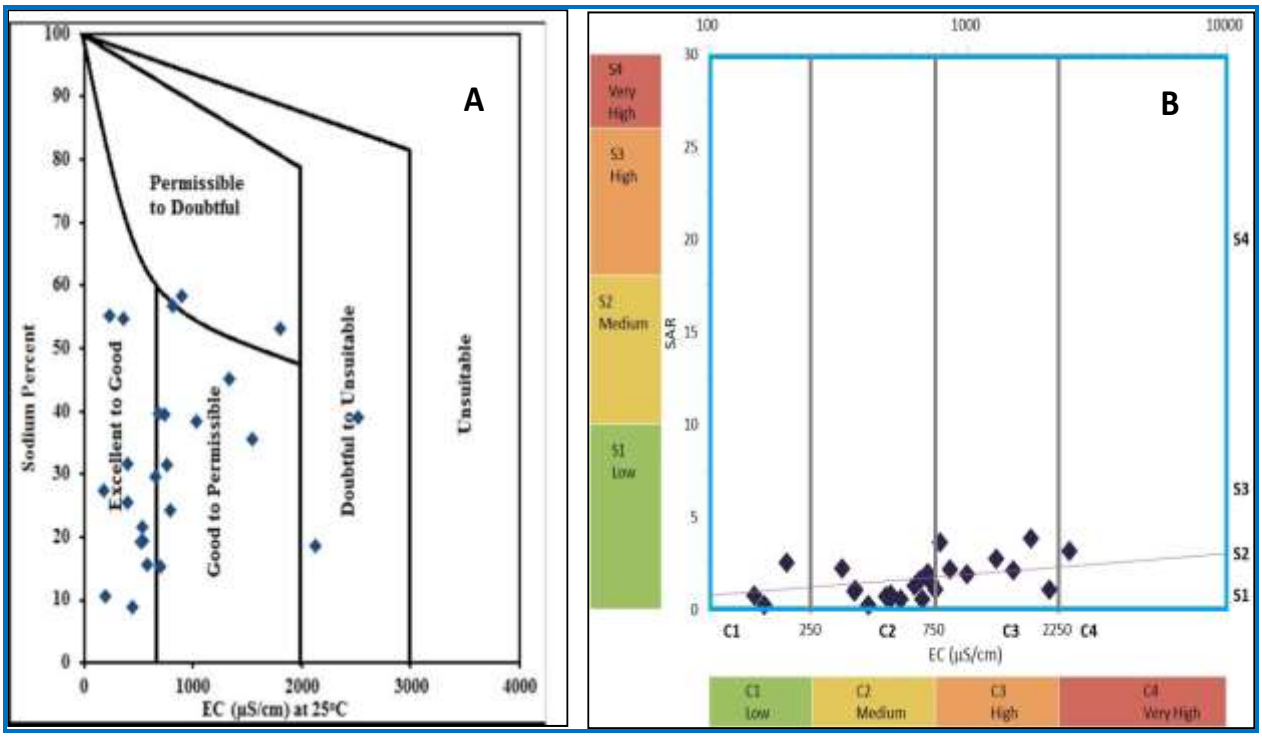


Plate 8.5. (a) Wilcox Diagram and (b) United States Salinity Laboratory (USSL) Diagram for assessing the Irrigation water quality of the study area

8.7 Major findings in Water Quality Assessment of the study area

- The reflections from the overall survey carried out in the study area revealed that the ground water quality in the area is suitable for drinking purposes with a few locations having Hardness and alkalinity problems.
- 64% of the study area depicted the TDS concentration more than the Acceptable limit of 500 mgL^{-1} (as per BIS, 2012).
- Higher concentration of Iron exceeding the permissible limit of 1.0 mg/L with alarmingly high concentrations of Iron were found in few pockets.
- In respect of suitability assessment for Irrigation water, the ground water of majority of the study area was in suitable category.
- Facies classification of the area indicates that maximum groundwater samples belong to Ca-Mg-HCO_3 and Ca-Mg-Cl type (as high as 80% locations), which indicates, water type with temporary hardness.

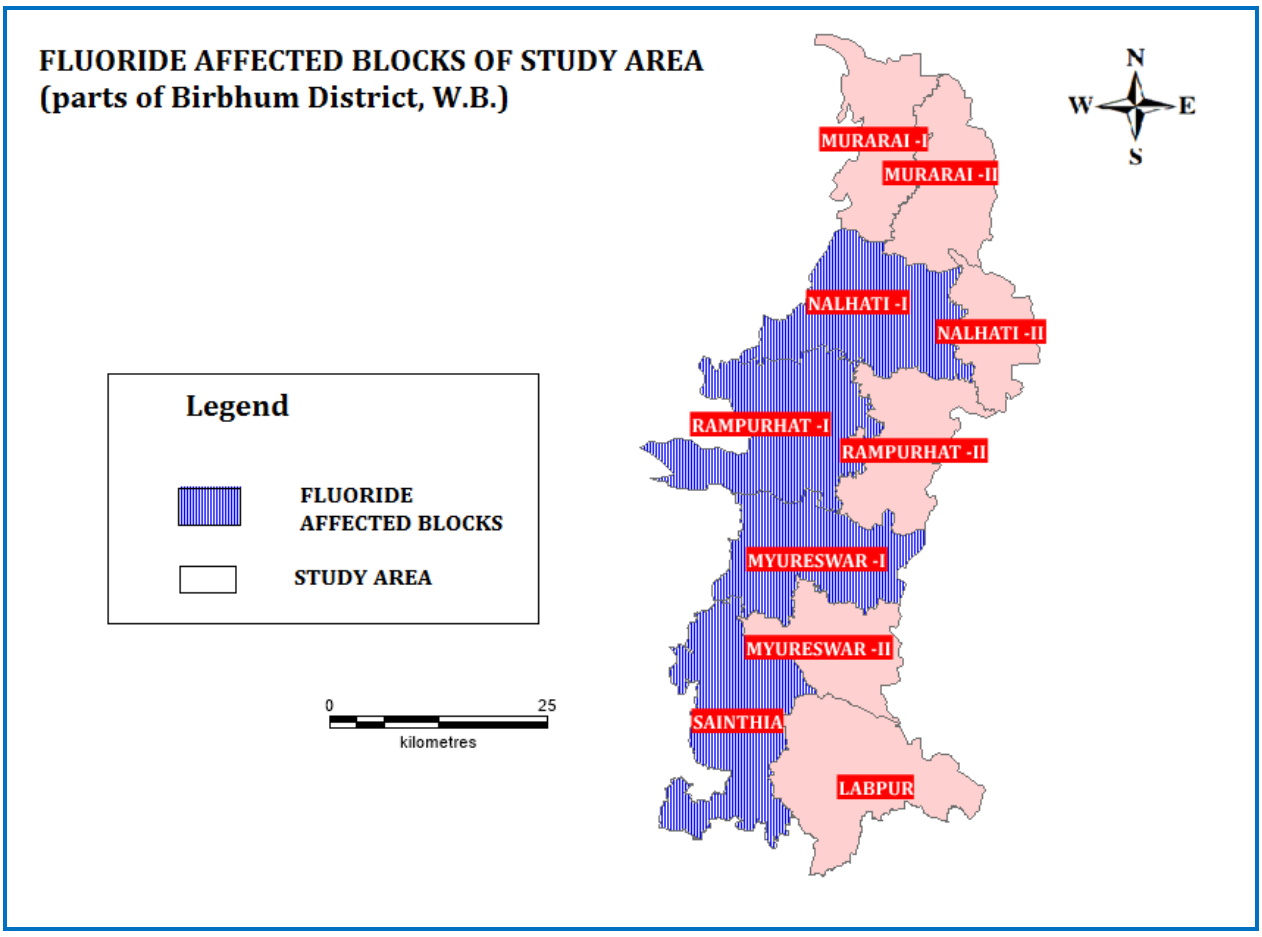


Plate 8.6: Fluoride affected blocks of study area (parts of Birbhum District, W.B.)

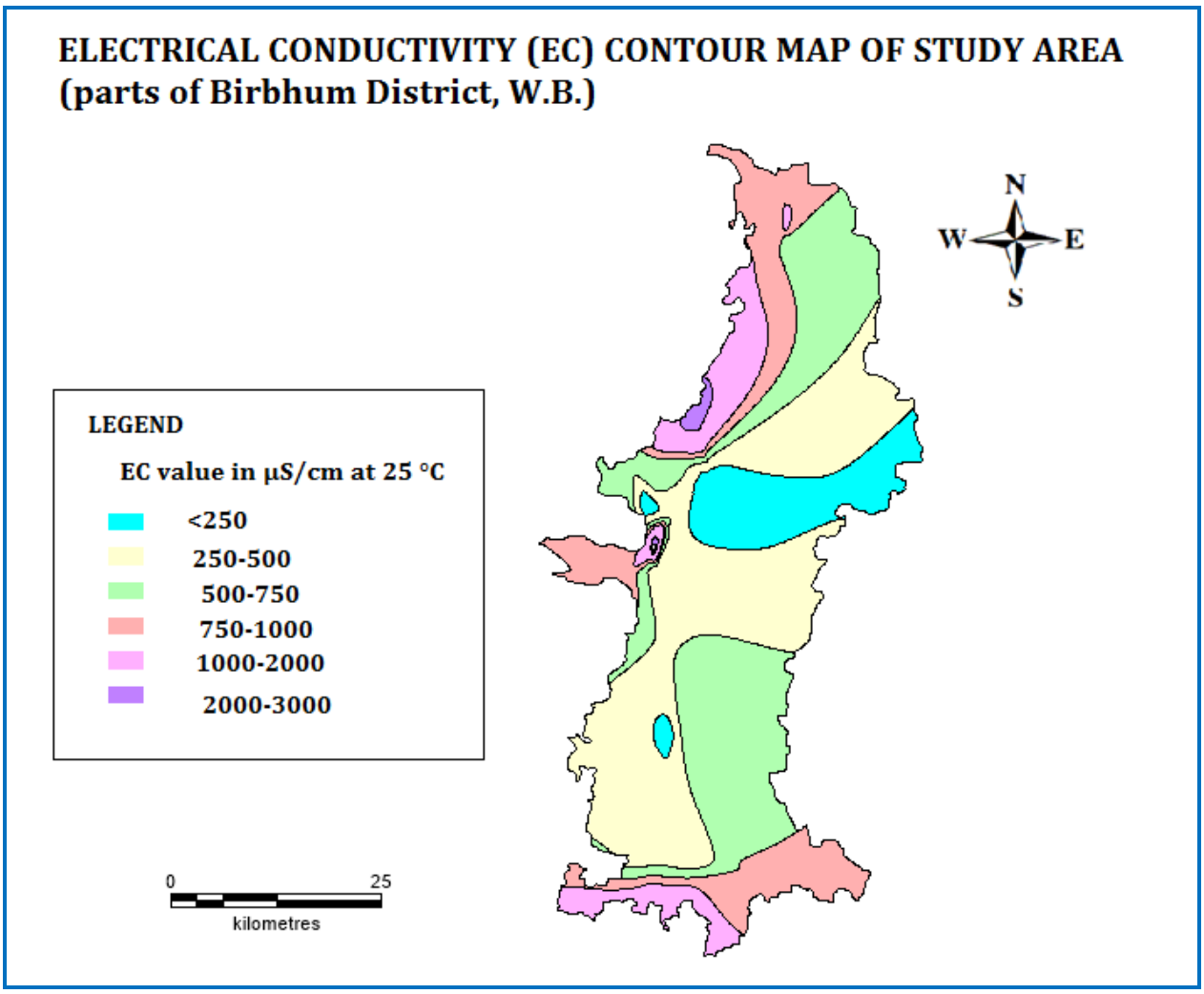


Plate 8.7: Electrical Conductivity contour map of study area (parts of Birbhum District, W.B.)

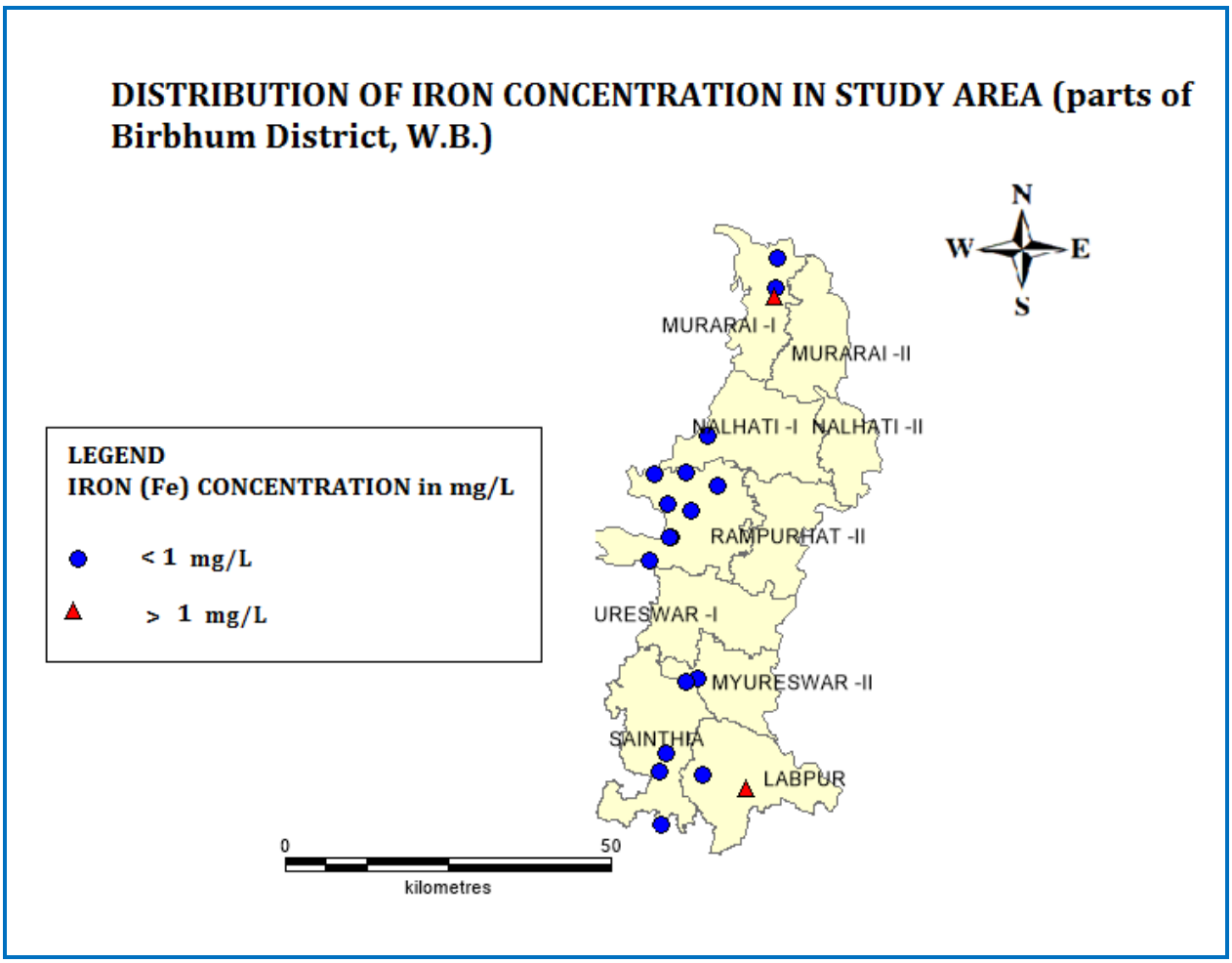


Plate 8.8: Distribution of Iron concentration in study area (parts of Birbhum District, W.B.)

CHAPTER-9

GROUNDWATER RELATED ISSUES AND PROBLEMS

9.1 Water scare area

- In the western part of the study area, underlain by Rajmahal Traps suffer from water scarcity owing to poor potentiality of the formations. In the areas, groundwater occurs under water table condition in the weathered zones (6 to 12m thick) as well as under semi-confined to confined conditions in the zone of secondary porosities, wherever available below the zone of weathering and in general within 55 - 70 mbgl.
- From the weathered zone groundwater is generally being developed through open wells and the available discharges can only meet the domestic needs, but is not sufficient enough for any large scale development of groundwater and during summer the dug wells generally go dry. Groundwater from the zone of secondary porosities is being developed through bored wells, yielding to the tune of 60-150 lpm and at places as high as 330 lpm.
- Moreover, the block Murarai-I have been declared under drought prone area by the Agriculture Department, Govt. Of West Bengal. As such, the water scare and drought prone areas need special attention from the point of view of groundwater management.

9.2 Areas with fluoride contaminated groundwater

- In the study area about 52,563 population spreading over 78 habitations in 4 blocks, namely, Nalhati-I,Rampurhat-I, Mayureshwar-I and Saithia, are affected by fluoride contaminated groundwater. In these blocks, concentration of fluoride above permissible limit, ranging from 1.52 mg/l to 17.9 mg/l, are reported from the aquifers mainly within 80 mbgl.

9.3 Areas categorised as 'Semi-critical'

- The study area comprises of 10 blocks and out of that five blocks namely, Nalhati-II, Murarai-II and Rampurhat-II, Sainthia and Labpur have been categorised as "Semi-critical", considering the ground water development with respect to the ground water resources in the blocks.

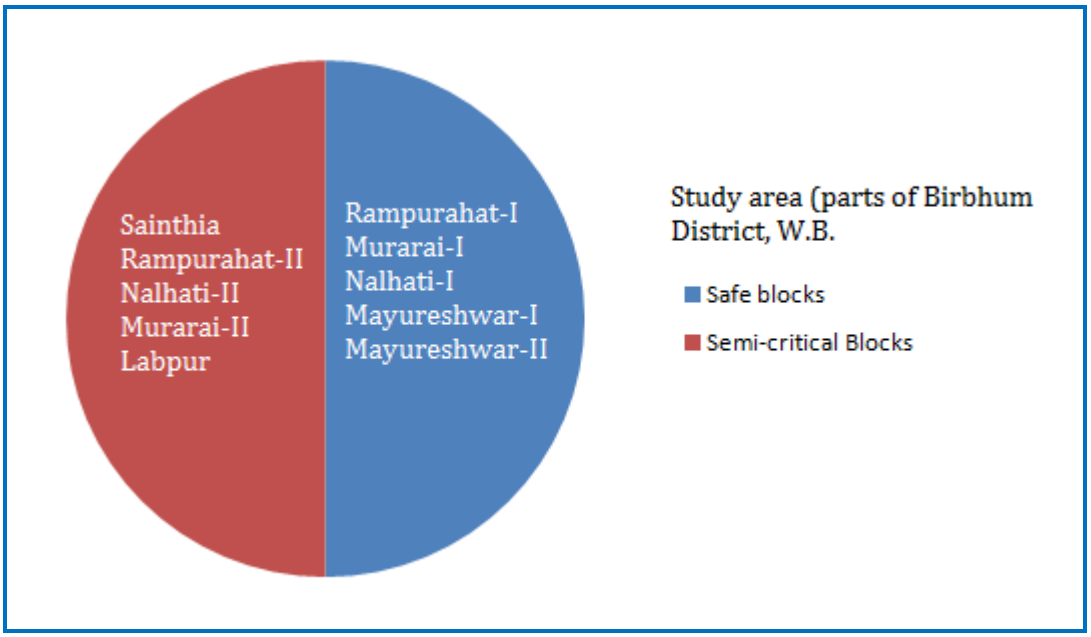


Plate: 9.1 Pie chart showing the categorization of blocks of study area (parts of Birbhum District, W.B.)

9.2 Areas with iron contaminated groundwater

- In the study area the Iron concentration varied from Trace-3.9 mgL^{-1} and 12% samples were detected with Iron concentration more than permissible limit

CHAPTER-10

GROUNDWATER DEVELOPMENT AND MANAGEMENT

10.1 Ground Water Development in study area

Groundwater Development in hard rock covered area may be done by means of large diameter open wells constructed preferably in topographic lows. Detailed study of the area may be carried out to establish the exact disposition of the water bearing formation, depth of occurrence, regional extension etc and their ground water potentiality. Depending on these factors groundwater development may be done by means of shallow and deep base wells located in suitable places. Efforts may also be made for construction of dug-cum-bored wells in suitable locations.

Major portion of the study area is found to be covered by alluvium. In alluvial terrain, thickness of alluvium gradually increases from west to east. In the transitional area the thickness of alluvium is limited within the depth range of 50 to 70 m, and it is very thick in within the depth of 450 m in the eastern part of the district. Here, ground water may be developed through different abstraction structures, considering the availability of potential and potable aquifers, thickness of potable aquifers, stage of ground water development, etc. Thus in the alluvium covered area including the top lateritic portion, ground water may be developed through shallow and deep (medium and heavy duty) tube wells constructed at suitable location.

The status of Ground Water Development in the study area covering ten (10Nos.) Blocks of Birbhum District is described in the following Table 10.1: -

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
Murarai-I	➢ Multiple aquifer system occurs, in general, in the depth span of 17-115 mbgl, beyond this depth basaltic rock occurs. ➢ T of the aquifers is about 700 m^2/d.	➢ Low duty tube wells are generally feasible. ➢ Tube well tapping granular zones within 115 mbgl may yield about 40 m^3/hr at 20.74 m. drawdown.	**Safe block**
Murarai-II	➢ Potential aquifers, in general, occur in the depth span of 30-50 mbgl and 120-150 mbgl with T about 1650 m^2/d. ➢ Depth of the basement increases from west to east. In the eastern part of the block it is generally more than 150 mbgl.	➢ Medium to heavy-duty tube wells are feasible. ➢ Successfully constructed tube wells yield about 180 m^3/hr at 6.36 m. drawdown	Since the block is under '**Semi-critical**' category, ground water development may be done with special attention for augmentation of ground water & regular monitoring of water level.

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
Nalhati-I	➢ In the western most part, at places, basaltic rock is exposed and water-bearing fractures encounter within 60 mbgl. In the eastern part, multiple aquifers occur within 50 mbgl and in the depth span of 63-120 mbgl. Basement encounters at shallow depth (around 51 mbgl) in the western side & at deeper depth in the eastern part. ➢ T & S of the aquifers are to the tune of 850-2900 m^2/d and $1.2x10^{-3}$ to $2x10^{-3}$ respectively.	➢ In the areas where trap is exposed, bore wells, tapping fractures in the depth span of 10-13, 18-30 and 44-56 mbgl yielding 10 m3/hr are feasible. ➢ Medium to heavy-duty tube wells are feasible in the alluvial part. ➢ Tube well tapping granular zones between 60-185 mbgl may yield 200-222 m^3/hr at a drawdown of 3.40 – 6.2 m.	**Safe block** Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, in the depth span of 50-80 mbgl. Hence it is suggested that measures for defluoridation may be undertaken before utilisation of water for drinking purpose.

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
Nalhati-II	➢ Multiple aquifers encountered within 185 mbgl of the drilling depth of 223 mbgl.		Since the block is under **'Semi-critical'** category, ground water development may be done with special attention for augmentation of ground water & regular monitoring of water level.
Rampurhat-I	➢ At places in the western most part, basaltic rock is exposed and towards eastern part the same is encountered at depth. In the western part, at places, water-bearing fractures encounter within 60 mbgl. ➢ In the eastern part, multiple aquifers encountered within 150 mbgl.	➢ In the alluvial part where the thickness of it is reasonably good, medium to heavy-duty tube wells are feasible. Tube well tapping granular zones within 150 mbgl may yield 220 m^3/hr at a drawdown of 9.80 m. ➢ In the areas where trap is the only hydrogeological	**Safe block** Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, as well as from the tube wells tapping shallow aquifers, in the depth span of 50-80 mbgl. Hence it is suggested that measures for defluoridation may be

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
		formation, bore wells, tapping fractures in the depth span of 10-13, 18-30 and 44-56 mbgl yielding 10 m3/hr are feasible.	undertaken before utilisation of water for drinking purpose.
Rampurhat-II	➢ Multiple aquifers encountered in the depth span of 60-95 mbgl and 106-162 mbgl. Though at places basement touches at 125.65 mbgl (Tarapith), but at most of the places basement encounters beyond this depth.	➢ Medium to low duty tube wells are feasible. ➢ Tube well tapping granular zones in the depth span of 77-88, 119-123, 128-141, 156-162 mbgl yields about 90 m^3/hr. However at some places yield of tube wells may be as low as	Since the block is under '**Semi-critical'** category, ground water development may be done with special attention for augmentation of ground water & regular monitoring of water level.

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
		40 m^3/hr.	
Mayureshwar-I	➢ Multiple aquifers encounter in the depth span of 15-75 mbgl and 170-192 mbgl. ➢ Basement encounters at shallow depth, around 63.44 mbgl near Mollarpur in the western side, but it is at deeper depth in the eastern part.	➢ Medium to heavy-duty tube wells are feasible. ➢ Tube well tapping granular zones in the depth span of 32-35, 41-53 and 56-69 mbgl yields about 249.70 m^3/hr at a drawdown of 6.02 m.	**Safe block** Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl. Hence it is suggested that the occurrence of deeper fluoride free aquifers may be identified & tapped in the tube wells.
Mayureshwar-II	➢ Multiple aquifers encounter in the depth span of 29-44, 93-102 and 179-194 mbgl.	➢ Medium to heavy-duty tube well is feasible. ➢ **Tube wells tapping** granular zones in the depth span of 29-44 mbgl	**Safe block** Large scale ground water development may be done.

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
		may yield about 180 m^3/hr.	
Sainthia	➢ Multiple aquifers, in the depth span of 53-168, 222-342 mbgl, occur up to the explored depth of 350 mbgl & the thickness of the aquifers increases towards east. T is recorded to be about 7200 m^2/day & S to be $9.1x10^{-2}$. ➢ The deeper aquifers are under auto-flowing condition & auto flow, to the tune of 4.25 lps for the head of 0.90 magl, has been observed in the tube well tapping granular zones between 222 to 342 mbgl at Ahmedpur. ➢ In the block, there is much ground water development through shallow tube wells, tapping ground water from the	➢ In general, medium-duty tube wells are feasible. ➢ Tube well tapping granular zones in the depth span of 53 to 168 mbgl or 222 to 342 mbgl may yield around 72 to 80 m^3/hr with drawdown in the range of 5.10 to 6.82 m. At places, yield from deep tube wells has been reported to be as high as 200 m^3/hr with about 6	**Semi-critical** Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl. Hence it is suggested that the occurrence of deeper fluoride free aquifers may be identified & tapped in the tube wells.

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
	aquifers occurring under unconfined condition with T & S values to the tune of 250 to 400 m^2/d & $0.5x10^{-1}$ respectively.	m drawdown, ➢ In the block, there is much ground water development through shallow tube wells yielding 13.6 to 15 m^3/hr,	
Labpur	➢ Potential aquifers encountered in the depth span of 138-490 mbgl within the drilled depth of 508 mbgl. ➢ Tube well tapping granular zones in the depth span of 204-490 mbgl yields about 163 m^3/hr with 13.13 m drawdown T is about 150 m^2/d. The well at Mustal is under autoflowing condition with free flow of about 25 m^3/hr & piezometric head	➢ Medium duty tube wells are feasible.	**Semi-critical**

Status of Ground Water Development in the study Area, Birbhum District			
Block	**Occurrence of Aquifers & its potentiality (as per data available with CGWB)**	**Feasibility of GW Abstraction Structures**	**Categorization/Remarks**
	3.27 magl.		

Table No. 10.1 : Status of Ground Water Development in the study area, parts of Birbhum District, W.B.

10.2 Groundwater Management Plan for Domestic & Irrigation Sectors

- Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, as well as from the tube wells tapping shallow aquifers, in the depth span of 50-80 mbgl. Hence it is suggested that measures for defluoridation may be undertaken before utilisation of water for drinking purpose. The water conserved in ponds, especially in fluoride affected areas, can be used for drinking purpose after treatment.

- In drinking water supply schemes, high concentration of iron and fluoride in groundwater is a serious problem. High conc. of iron has got sporadic occurrence and in water supply schemes it is being managed with the help of Iron Elimination Plants. Groundwater in 4 blocks of study area namely Sainthia, Mayureshwar-I, Nalhati-I and Rampurahat-I, is affected sporadically by high concentration of fluoride i.e. more than the permissible limit (>1.5 mg/l) in the following depth ranges in different types of hydrogeological formations
  - ✓ In basalts within 50.0 to 80.0m depth.
  - ✓ In alluvium within 50.0 to 60.0m depth.

- In Rampurhat-I blocks concentration of fluoride in groundwater has been reported to be as high as 17.9 mg/l. As per the report of PHED, Govt of West Bengal maximum concentration of F in ground water reported is 20.40 mg/lit from Nalhati I block.

- Fluoride contaminated groundwater has been reported from the tube wells within 60 m depth in the blocks of Nalhati-I, Rampurhat-I and Mayureswar-I. The deeper aquifers, beyond 60 mbgl, may be exploited for drinking purpose.

- Five blocks of the study area are categorized as Semi Critical namely Nalhati-II, Murarai-II and Rampurhat-II, Labpur & Sainthia. These blocks need spécial

attention and ground water development may be done with special attention for augmentation of ground water & regular monitoring of water level.

- Cultivation of low water requiring crops may be practiced and change in cropping pattern suitable for the area.

- Modern irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied.

- Conjunctive use of surface water as well as ground water for irrigation.

- Roof-Top rain water harvesting should be practiced all throughout the area and the water conserved in PVC/concrete tanks can be used for various domestic needs so as to reduce the pressure on ground water use at least for the non-drinking purpose.

10.3 Groundwater Management Plan for Industrial Sectors

- It is mandatory for all industries, whether existing/ new/ under expansion and drawing/ proposing to withdraw ground water of >10 KLD through energized means shall need to obtain NOC for ground water withdrawal from the State Groundwater Authority. All industries abstracting ground water > 500 m^3/day should mandatorily implement artificial recharge measures as per norms and these units are required to make 90 % quantum of recharge to that of ground water withdrawal by them.

10.4 Rain Water Harvesting and Artificial Recharge

- Rainwater harvesting may act as an effective measure to manage and control the exploitation of available fresh groundwater resource for sustained use. The

rainwater collected during rainy season may either be recharged into the groundwater aquifers or stored for direct use after very simple pretreatment.

10.5 Conservation of Rainwater:

- The western and southwestern parts of the study area underlain by hard rock formation are less potential in terms of ground water resources and as such dug wells are the main feasible ground water abstraction structure. With the onset of summer these areas generally face acute drinking water crisis. In this area where the scope of groundwater development is limited, rainwater conservation is the best option to mitigate the crisis of drinking water problem. Conservation of rainwater can be done from the water that can be available from both the rooftops and also from the lands.

- The water that can be available from roofs can be stored giving considerations to all types of losses in cemented tanks or in PVC tanks. Before conserving, the water should be sand filtered.

- The rainwater that can be available from any land surface can be stored in any ponds and in this case sites as well as designs of ponds are to be finalized considering local hydrogeological as well as terrain conditions.

- In addition to these, the surface water which flows through streams/ nallahs can be conserved with the help of check dams, giving due considerations to the surrounding farmers' lands, local hydrogeological conditions and terrain conditions.

- In undulating terrain gully plugs can be feasible on cultivated lands to conserve limited quantity of water and there by soil moisture can be increased which will be beneficial for crop production.

- In alluvial areas also, where hydrogeological conditions are feasible, rainwater conservation can be done by any of the techniques mentioned above, giving due considerations to the facts mentioned above.

10.6 Artificial Recharge to Groundwater:

- Feasibility of artificial recharge to groundwater is site specific. The guiding factors for selecting sites and type of structure for artificial recharge to ground water are as follows:
  - ✓ Non- committed rainwater is to be utilized for artificial recharge to groundwater.
  - ✓ Hydrogeological conditions should be feasible to get recharged by rainwater.
  - ✓ As far as possible any site should be selected on plain terrain & the recharged water are not drained out in natural conditions through streams/ nallahs before development of the recharged water.
  - ✓ Any structure is to be constructed on such a terrain where there is ample scope of development of groundwater and while designing the structures, the need of the people of downstream side is to be given due consideration.
  - ✓ Post-monsoon water level should be more than 3 mbgl.

10.7 Managed Aquifer Recharge (MAR)

- Managed Aquifer Recharge or Artificial Recharge to groundwater through scientifically designed structures has been proven as a viable option for augmentation of groundwater resources. As far as possible, the site for recharge should be a plain area, hydrogeologically feasible and should have ample scope for groundwater development. The non-committed rainwater should be used for recharge. Care should be taken so that recharged water do not drain out under natural conditions into streams/nallas. And also the post-monsoon water level should be more than 6 mbgl.

- In the present study area, the recharge structures feasible and their cost of constructions, utilizable surface run-offs for the blocks under study are given in the tables below. (Table 10.2& 10.3)

District	Block	Formation	Utilizable Surface Run Off (MCM)	Allocation of Utilizable Resource(MCM)						
				Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge
Birbhum	Labpur	Alluvium	56.918	28.459	11.38	17.075	0	0	0	0
Birbhum	Murarai-I	Alluvium	32.725	16.363	6.545	9.818	0	0	0	0
Birbhum	Murarai-II	Alluvium	58.858	29.429	11.77	17.657	0	0	0	0
Birbhum	Mayureshwa	Alluvium	56.053	28.027	11.21	16.816	0	0	0	0
Birbhum	Mayureshwa	Alluvium	47.721	23.861	9.544	14.316	0	0	0	0
Birbhum	Nalhati-II	Alluvium	37.017	18.951	7.403	11.105	0	0	0	0
Birbhum	Rampurahat	Alluvium	60.509	27.252	10.90	16.351	0	0	0	0
Birbhum	Sainthia	Alluvium	37.901	18.951	7.58	11.37	0	0	0	0
Birbhum	Nalhati-I	Hard Rock	43.046	10.081	0	0	3.102	0.775	0.775	0.775
Birbhum	Rampurhat-I	Hard Rock	39.090	18.31	0	0	5.634	1.408	1.408	1.408

Table 10.2 Utilizable surface run-offs and their allocation in MCM for the blocks of the study area (Source: CGWB,ER)

District	Block	Formation	Structures Feasible							Cost of Structures							
			Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour	Sub-Surface	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour	Sub-Surface Dyke	Dug Well Recharge	Total
Birbhum	Labpur	Alluvium	57	114	57	0	0	0	0	456.00	456.00	171.00	0.00	0.00	0.00	0.00	1083.00
Birbhum	Murarai-I	Alluvium	33	65	33	0	0	0	0	264.00	260.00	99.00	0.00	0.00	0.00	0.00	623.00
Birbhum	Murarai-II	Alluvium	59	118	59	0	0	0	0	472.00	472.00	177.00	0.00	0.00	0.00	0.00	1121.00
Birbhum	Mayureshwar-I	Alluvium	56	112	56	0	0	0	0	448.00	448.00	168.00	0.00	0.00	0.00	0.00	1064.00
Birbhum	Mayureshwar-II	Alluvium	48	95	48	0	0	0	0	384.00	380.00	144.00	0.00	0.00	0.00	0.00	908.00
Birbhum	Nalhati-II	Alluvium	37	74	37	0	0	0	0	296.00	296.00	111.00	0.00	0.00	0.00	0.00	703.00
Birbhum	Rampurahat-II	Alluvium	55	109	55	0	0	0	0	440.00	436.00	165.00	0.00	0.00	0.00	0.00	1041.00
Birbhum	Sainthia	Alluvium	38	76	38	0	0	0	0	304.00	304.00	114.00	0.00	0.00	0.00	0.00	722.00
Birbhum	Nalhati-I	Hard Rock	20	0	0	0	0	0	0	240.00	0.00	0.00	0.00	0.00	0.00	0.00	506.10
Birbhum	Rampurahat-I	Hard Rock	37	0	0	0	0	0	0	444.00	0.00	0.00	0.00	0.00	0.00	0.00	926.30

Table 10.3 Feasible structures and their cost of constructions in lakhs for the blocks in study area (CGWB, ER)

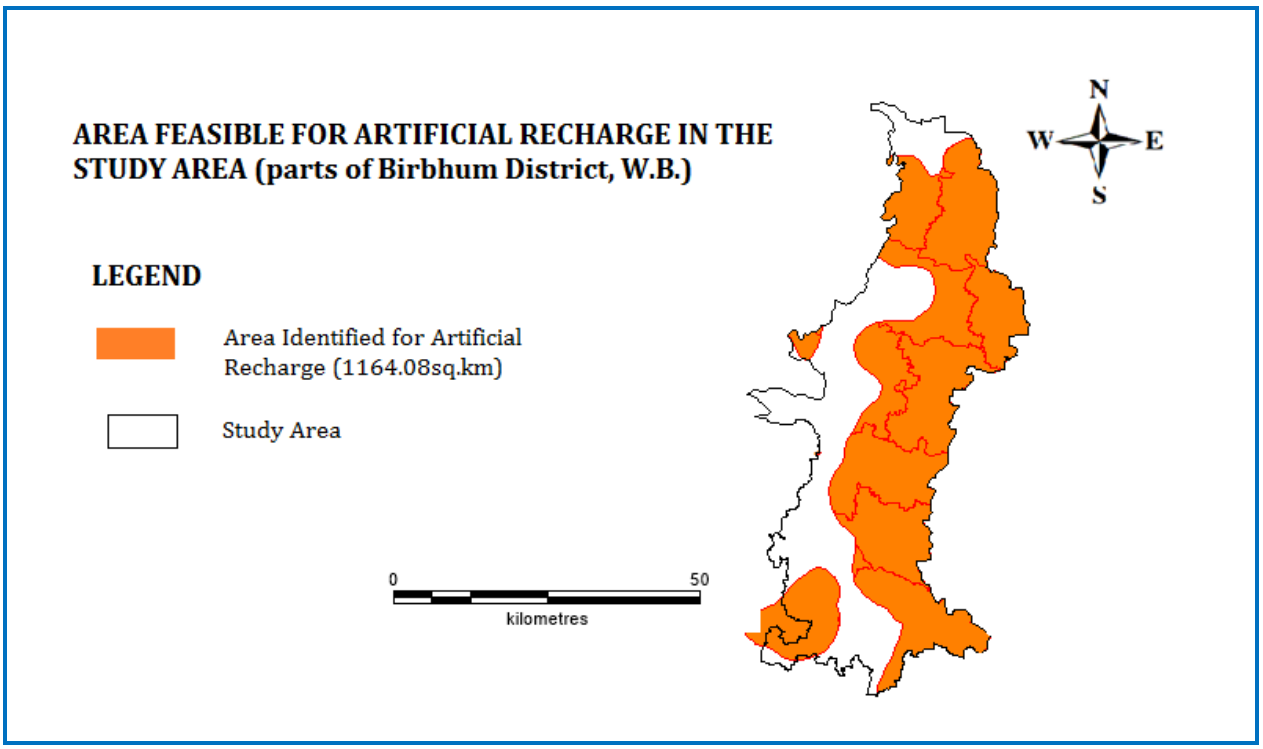


Plate 10.1: Area Feasible for Recharge in the study area (parts of Birbhum District, W.B.)

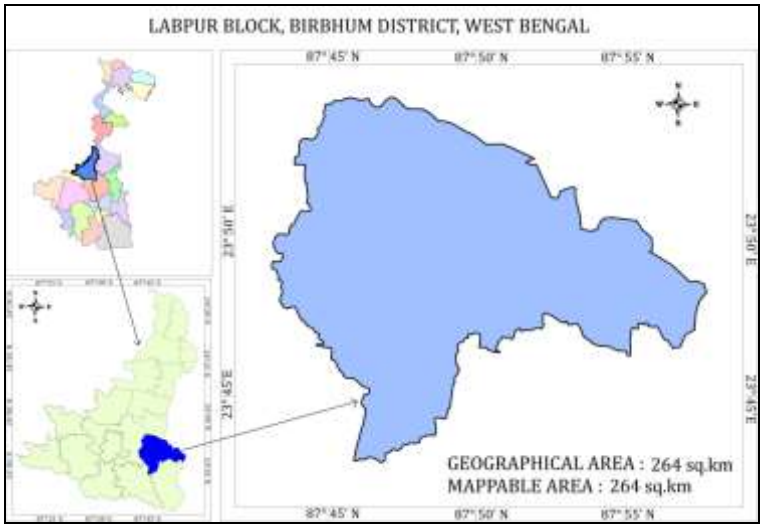
PART-II

Block -Wise Management Plan

Aquifer Information and Management System

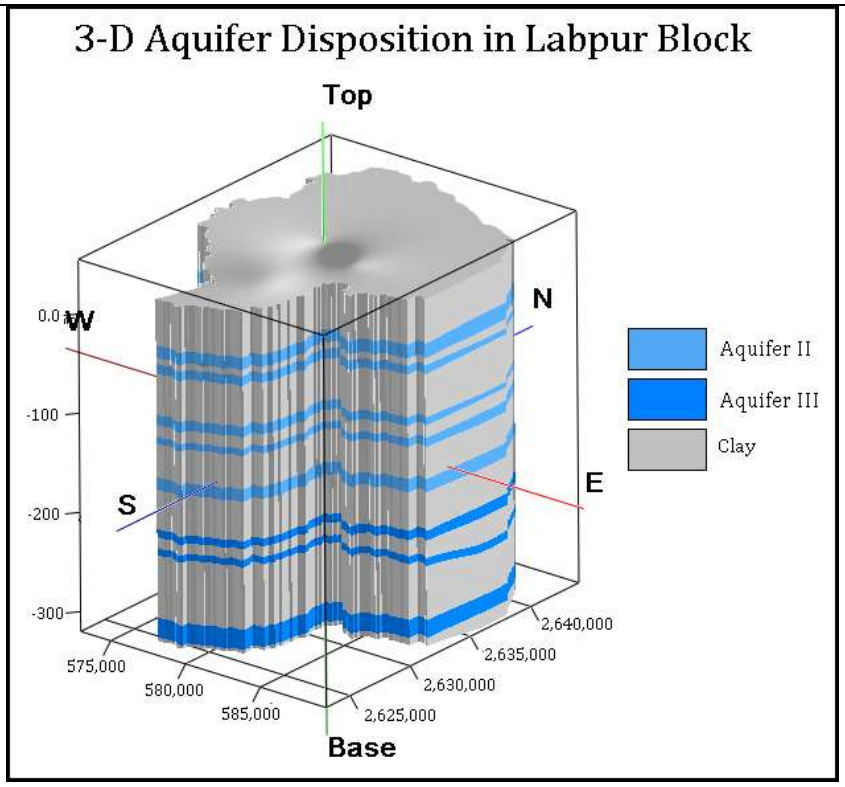
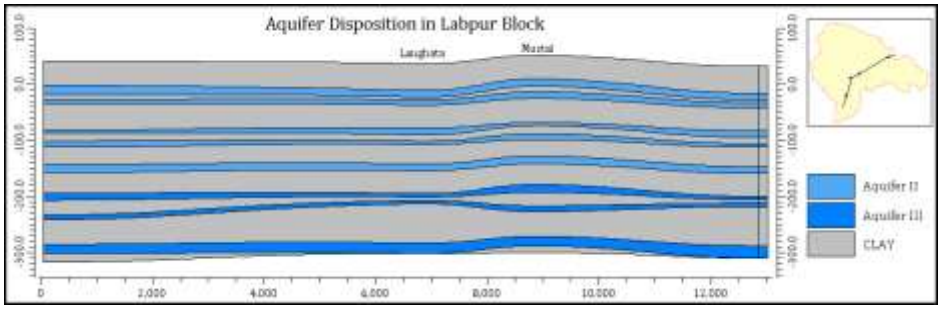
Labpur Block, Birbhum District, West Bengal
(264 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	Labpur
Location	 Figure 1: Location map of Labpur block.
Geographical Area	264 sq. km.
Basin/Sub-basin	Lower Ganga Basin
Principal Aquifer System	Alluvium
Major Aquifer System	Older Alluvium
Normal Annual Rainfall	1294.5 mm

Aquifer Disposition

Aquifer Disposition	Three Aquifer System : Aquifer-I is negligibly present. Aquifer-II: Average depth range is from 50-60, 115 -127 mbgl & 138 – 145mbgl. Thickness of water bearing zone ranges from 7m to 12m. Aquifer-III: Average depth range is from 180-192 , 230 – 245 & 268- 279 mbgl and may extend up to 490mbgl in some places, thickness of water bearing zone ranges from 10 m to 40 m.

	 **Figure 2:** Aquifer disposition (3D) in **Labpur** block.
Status of GW Exploration	Exploratory Wells : 3 Observation Wells : 0
Aquifer Characteristics	Three aquifer system: Aquifer – I: Shallow aquifer (Negligibly Present) Aquifer – II: Intermediate aquifer • Depth ranges from 50-60, 115 -127 mbgl & 138 – 145mbgl. Discharge is 37.44 m^3/hr. Aquifer – III: Deeper aquifer • Depth ranges from 180-192 , 230 – 245 & 268- 279 mbgl. Discharge is 163 m^3/hr, Transmissivity is 151.159m^2/day.  Figure 3: Cross section delineating the aquifer system in Labpur block
Groundwater Monitoring Status	5 NHS Well

<table>
<tr><td></td><td></td></tr>
<tr><td>Groundwater Quality</td><td>Sporadic occurrence of high conc. of iron in the block.</td></tr>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th><th>Aquifer-II</th><th>Aquifer-III</th></tr>
<tr><td>Depth Range</td><td>negligibly present.</td><td>50-60, 115 - 127 mbgl & 138 – 145mbgl</td><td>180-192 , 230 – 245 & 268- 279 mbgl</td></tr>
<tr><td>Yield</td><td>-</td><td>37.44 m3/hr</td><td>163 m^3/hr</td></tr>
<tr><td>Transmissivity</td><td>-</td><td>-</td><td>151.159m^2/day .</td></tr>
</table>
</td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)

* GW Availability: 73.397 MCM.
* GW Draft: 45.667 MCM.
* Stage of GW Development in the block is 62.22 %. Semi-Critical block (Based on GWRA 2013; considering long term falling trend of depth to water level).

Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)

* GW Availability: 72.9754 MCM.
* GW Draft: 52.177 MCM.
* Stage of GW Development in the block is 79.44 %. Semi Critical block.

* Total in-storage ground water resources covering the study area is 772.5329 MCM</td></tr>
<tr><td rowspan="2">Existing and Future Water Demand</td><td>Groundwater Resource Estimation 2013
*Present demand for All Usage: 45.667 MCM
*Future Demand for Domestic and Industrial Use: 25.33 MCM</td></tr>
<tr><td>Groundwater Resource Estimation 2017
*Present demand for All Usage: 52.177 MCM.
*Future Demand for Domestic and Industrial Use: 12.6928 MCM.</td></tr>
<tr><td colspan="2">Aquifer Management plan</td></tr>
<tr><td>Groundwater Management Issues</td><td>• Deep water level
• Abnormal falling trend of depth to water level both in pre-monsoon & post-monsoon seasons
• Semi-critical Block</td></tr>
</table>

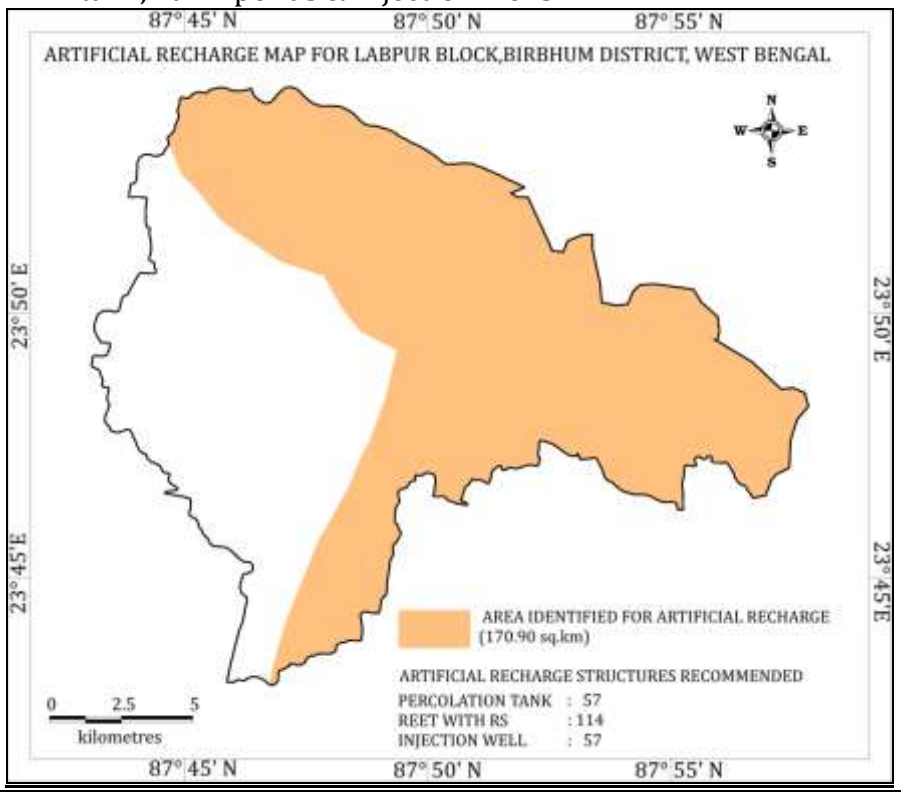
Groundwater Management Plan	**<u>Aquifer management strategy for Labpur block of Birbhum district, West Bengal</u>** <u>Problem 1:</u> Very deep water level and long term water level shows falling trend. <u>Problem 2:</u> The block is categorized as SEMI-CRITICAL and the stage of development 79.44 % (GWRE 2017) & 62.22 % (GWRE 2013). <u>Management strategy</u>: • Rain water harvesting and artificial recharge may be implemented to eliminate the problem of declining water level. Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Modern irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted since the block is Semi-Critical. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells. 

	Figure 3: Area Feasible for Artificial Recharge, Labpur block

Aquifer Information and Management System

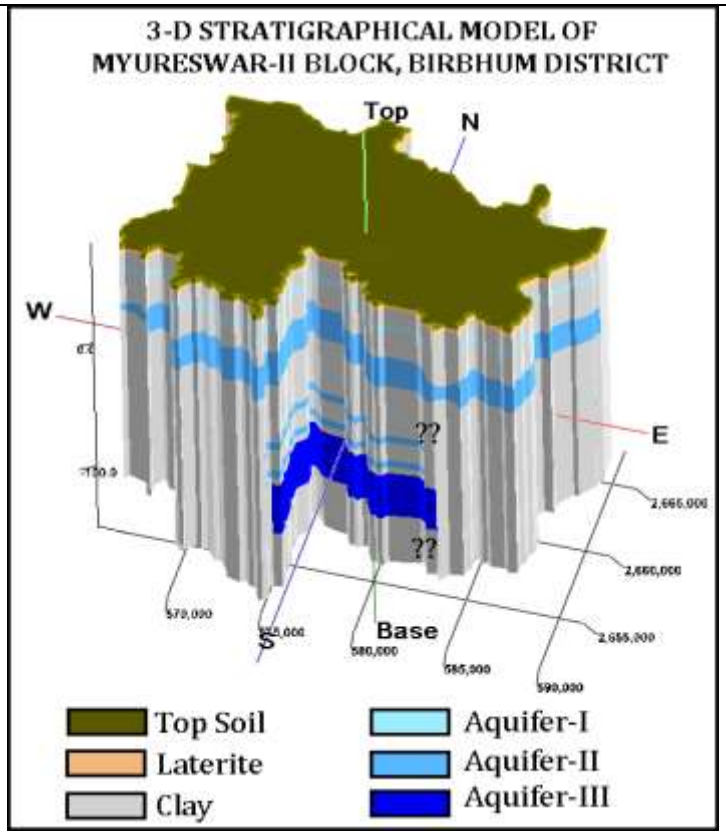
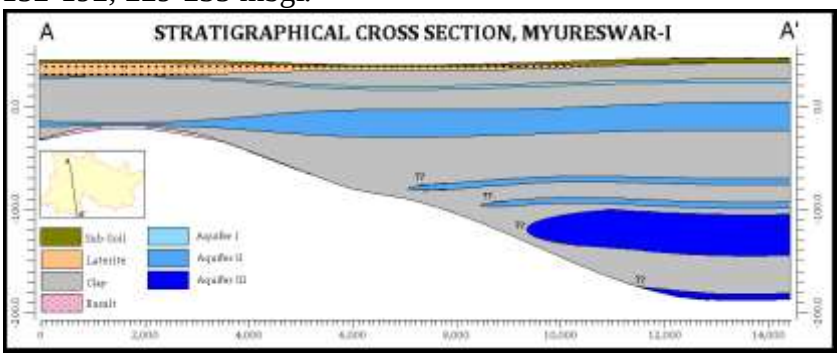
Mayureswar-I Block, Birbhum District, West Bengal
(225 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	**Mayureshwar-I**
Location	 Figure 3: Location map of Mayureshwar-I block.
Geographical Area	225 sq. km.
Basin/Sub-basin	Lower Ganga Basin / Dwarka Sub-basin
Principal Aquifer System	Alluvium
Major Aquifer System	Older Alluvium
Normal Annual Rainfall	1294.5 mm

Aquifer Disposition

Aquifer Disposition	Three Aquifer System : Aquifer – I: Shallow aquifer is negligible present. • Depth ranges from 20 - 24 mbgl; Aquifer – II: Intermediate aquifer • Depth ranges from 43-70, 117-123,140-146; thickness varies from 6 to 27 m. Aquifer – III: Deeper aquifer • Depth ranges from 152-192, 229-235, thickness varies from 6 m to 30 m.

	 **Figure 4:** Aquifer disposition (3D) in Mayureshwar-I block.
Aquifer Characteristics	Three aquifer system: • **Shallow aquifer (A 1):** Shallow aquifer is negligible present. • **Aquifer (A 2**) has been identified up to the drilled depth from 43-70, 117-123,140-146 mbgl. • **Aquifer (A 3**) has been identified up to the drilled depth from 152-192, 229-235 mbgl.  Figure 3: Cross section delineating the aquifer system in Mayureshwar-I block
Groundwater Monitoring Status	4 NHS Well
Groundwater Quality	Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl.

<table>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th><th>Aquifer-II</th><th>Aquifer-III</th></tr>
<tr><td>Depth Range</td><td>Negligible</td><td>43-70, 117-123,140-146 mbgl</td><td>152-194, 229-235 mbgl</td></tr>
<tr><td>Yield</td><td>-</td><td>-</td><td>10.8 to 12.6 m^3/hr</td></tr>
<tr><td>Transmissivity</td><td>-</td><td>-</td><td>9.28 – 9.32 mbgl</td></tr>
</table>
</td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)

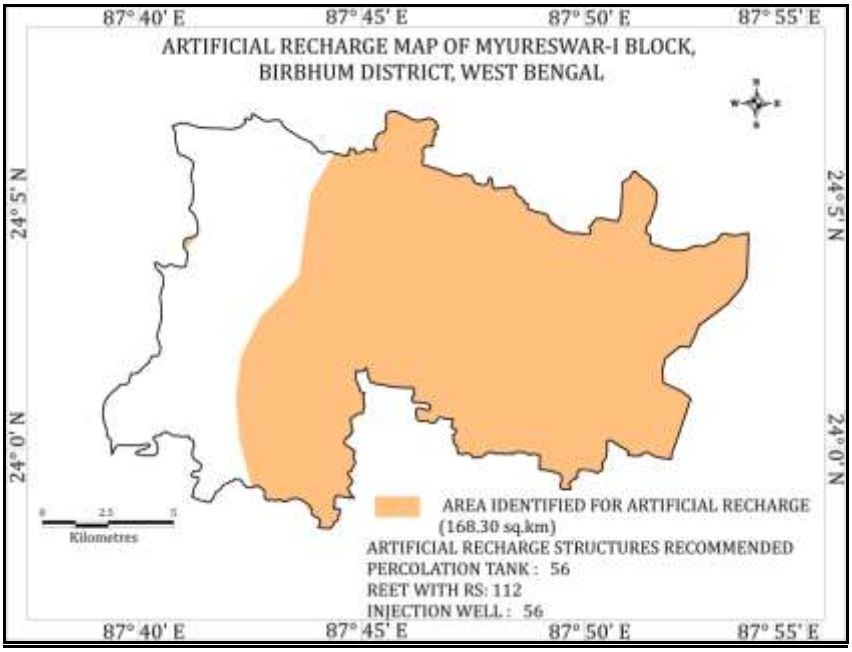
* GW Availability: 79.3416 MCM.
* GW Draft: 18.8123 MCM.
* Stage of GW Development in the block is 23.71 %. Safe block.

Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)

* GW Availability: 92.0801 MCM.
* GW Draft: 21.0988 MCM.
* Stage of GW Development in the block is 22.91%. Safe block.

* Total in-storage ground water resources covering the study area is 747.5852 MCM.</td></tr>
<tr><td rowspan="2">Existing and Future Water Demand</td><td>Groundwater Resource Estimation 2013
*Present demand for All Usage: 18.8123 MCM
*Future Demand for Domestic and Industrial Use: MCM</td></tr>
<tr><td>Groundwater Resource Estimation 2017
*Present demand for All Usage: 21.0988 MCM.
*Future Demand for Domestic and Industrial Use: 70.4113 MCM.</td></tr>
<tr><td colspan="2">Aquifer Management plan</td></tr>
<tr><td>Groundwater Management Issues</td><td>• Deep water level
• Abnormal falling trend of depth to water level both in pre-monsoon &post-monsoon seasons
• Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl.</td></tr>
<tr><td>Groundwater Management Plan</td><td><u>Aquifer management strategy for Mayureswar-I block of Birbhum district, West Bengal</u>

Problem 1: Very deep water level and long term water level shows falling trend.
Problem 2: Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the</td></tr>
</table>

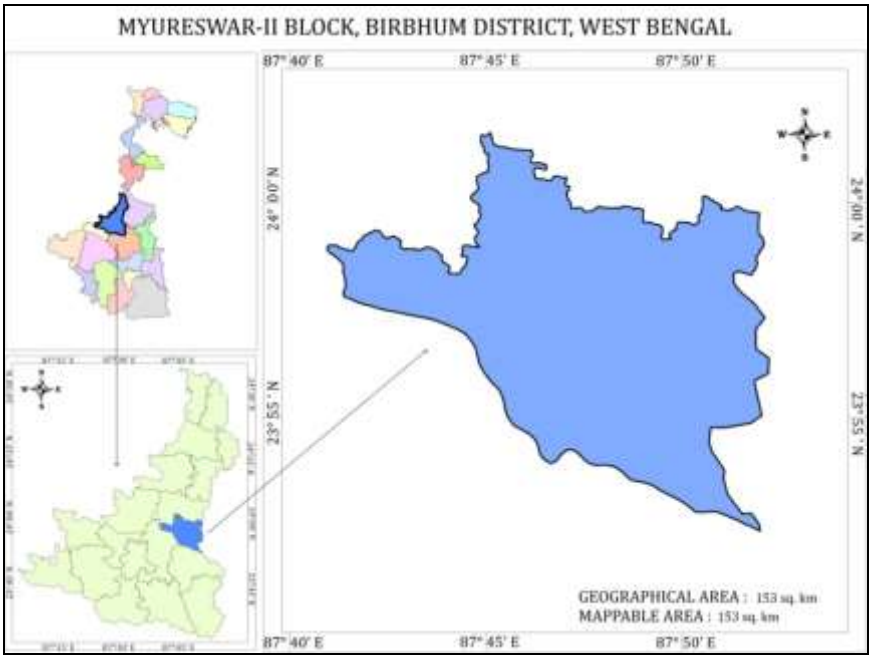
	depth of 60 mbgl. Management strategy: • Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl. • Hence it is suggested that the occurrence of deeper fluoride free aquifers may be identified & tapped. • Rain water harvesting and artificial recharge may be implemented to eliminate the problem of declining water level • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Modern irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted. • Total area suitable for recharge in this block is 168.30q km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.  Figure 4: Area Feasible for Artificial Recharge, Mayureswar-I block

Aquifer Information and Management System

Mayureshwar-II Block, Birbhum District, West Bengal

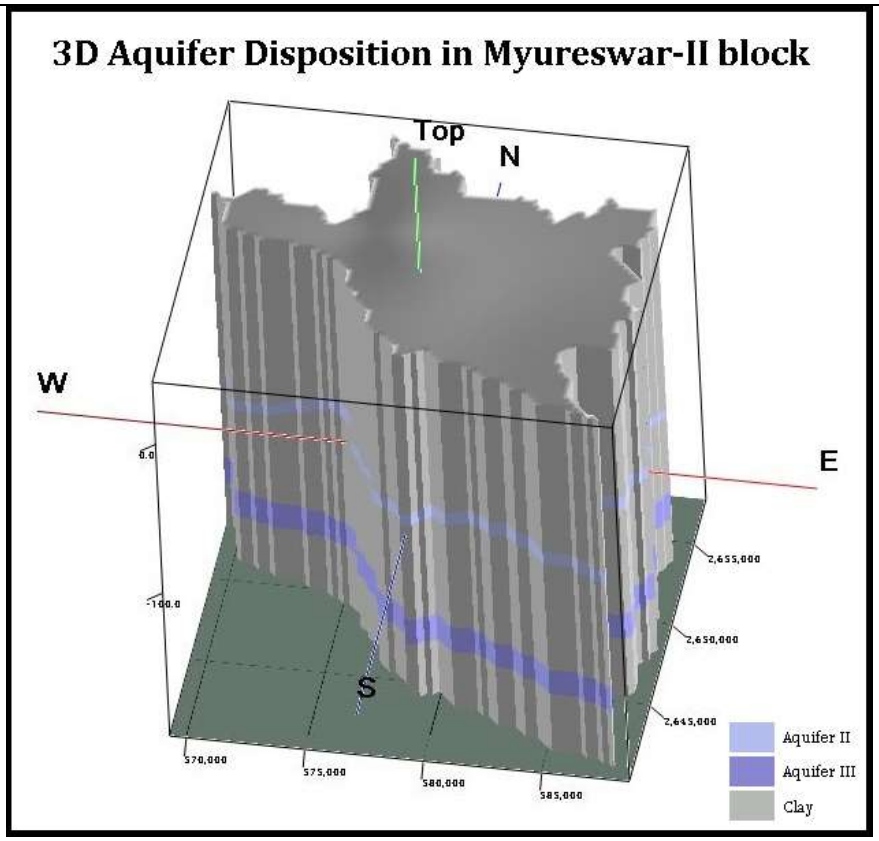
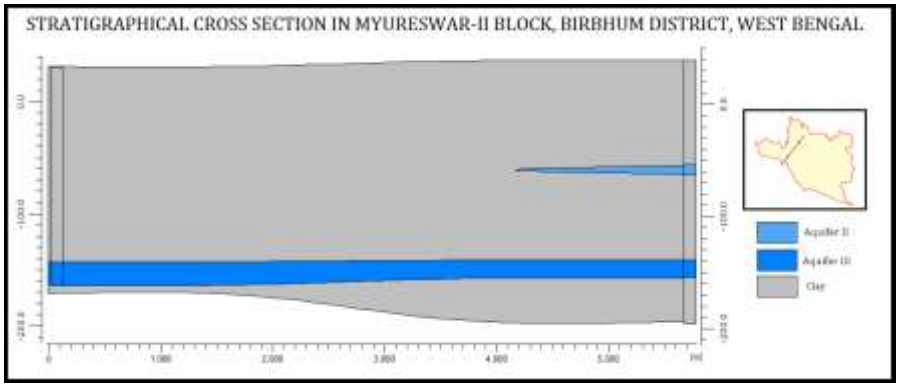
(153 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	Mayureshwar-II
Location	 Figure 5: Location map of Mayureshwar-II block .
Geographical Area	153 sq. km.
Basin/Sub-basin	Lower Ganga Basin
Principal Aquifer System	Alluvium
Major Aquifer System	Older Alluvium
Normal Annual Rainfall	1555.76 mm

Aquifer Disposition

Aquifer Disposition	Two aquifer system: Aquifer – I: Shallow aquifer is absent. Aquifer – II: Intermediate aquifer • Depth ranges from **93 -102** mbgl. • Aquifer II occurs under semi-confined to confined condition. Aquifer-III : Deeper Aquifer • Depth ranges from **179-194** mbgl. • Aquifer III occurs under confined condition. • Thickness of the water bearing zone varies from 7m to 15m.

	 Figure 6: Aquifer disposition (3D) in **Mayureswar-II** block.
Status of GW Exploration	Exploratory Wells : 2 Observation Wells : 1
Aquifer Characteristics	• **Aquifer (A 2)** has been identified up to the drilled depth from 93-102mbgl. • **Aquifer (A 3)** has been identified up to the drilled depth from 179 -194 mbgl , Yield Potential of which ranges from 10.8 to 12.6 m^3/hr.  Figure 3: Cross section delineating the aquifer system in Mayureswar-II block
Groundwater Monitoring Status	5 NHS Well
Groundwater Quality	The quality of groundwater is good for drinking, irrigation & other domestic purposes.

<table>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th><th>Aquifer-II</th><th>Aquifer-III</th></tr>
<tr><td>Depth Range</td><td>negligibly present.</td><td>93 – 102 mbgl</td><td>179-194 mbgl</td></tr>
<tr><td>Yield</td><td>-</td><td>-</td><td>10.8 to 12.6 m^3/hr</td></tr>
<tr><td>Static Water Level</td><td>-</td><td>-</td><td>9.28 – 9.32 mbgl</td></tr>
</table>
</td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)

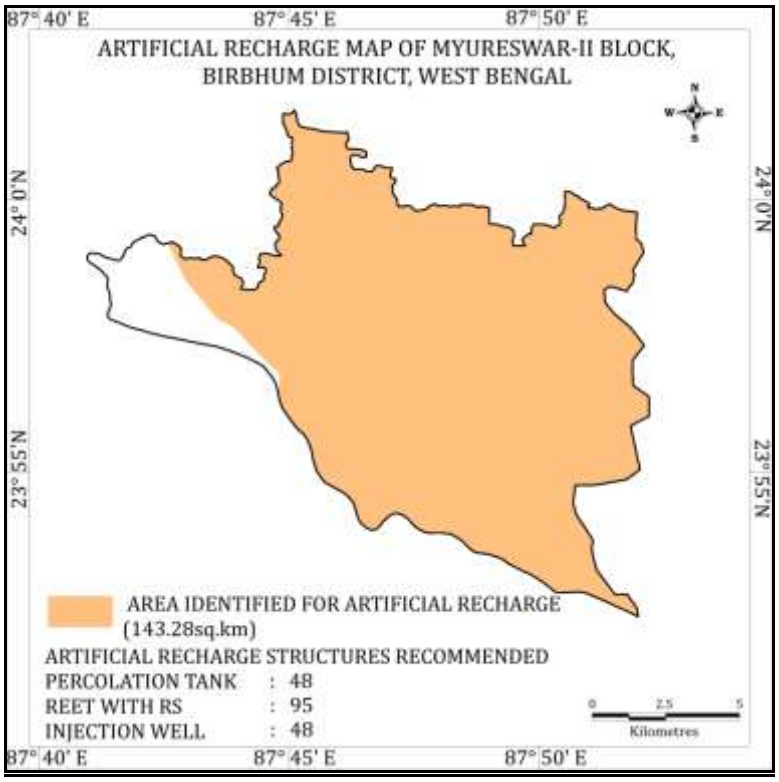
* GW Availability: 59.33028 MCM.
* GW Draft: 32.3751 MCM.
* Stage of GW Development in the block is 54.57 %. Safe block.

Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)

GW Availability: 48.8746 MCM.
* GW Draft: 32.5467 MCM.
* Stage of GW Development in the block is 66.59 %. Safe block.

* Total in-storage ground water resources covering the study area is 501.684 MCM.</td></tr>
<tr><td rowspan="2">Existing and Future Water Demand</td><td>Groundwater Resource Estimation 2013
*Present demand for All Usage: 32.3751 MCM
*Future Demand for Domestic and Industrial Use: 25.424 MCM</td></tr>
<tr><td>Groundwater Resource Estimation 2017
*Present demand for All Usage: 32.5467 MCM.
*Future Demand for Domestic and Industrial Use: 15.86 MCM.</td></tr>
<tr><td colspan="2">Aquifer Management plan</td></tr>
<tr><td>Groundwater Management Issues</td><td>• Deep water level
• Abnormal falling trend of depth to water level both in pre-monsoon & post-monsoon seasons</td></tr>
<tr><td>Groundwater Management Plan</td><td><u>Aquifer management strategy for Mayureswar-II block of Birbhum district, West Bengal</u>

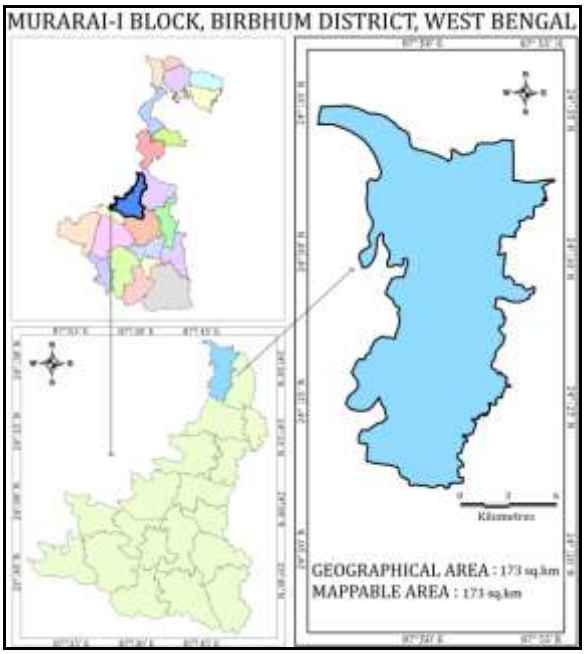
<u>Problem 1:</u> Deep water level trend.
<u>Problem 2:</u> Abnormal falling trend of depth to water level both in pre-monsoon &post-monsoon seasons</td></tr>
</table>

	Management strategy: • Rain water harvesting and artificial recharge may be implemented. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Micro irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted. • Total area suitable for recharge in this block is 143.28sq km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.  Figure 4: Area Feasible for Artificial Recharge, Mayureswar-II block

Aquifer Information and Management System

Murarai-I Block, Birbhum District, West Bengal
(173 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	**Murarai-I**
Location	 Figure 7: Location map of Murarai-I block.
Geographical Area	173 sq. km.
Basin/Sub-basin	Lower Ganga Basin / Bansoli sub basin
Principal Aquifer System	Basalt (Rajmahal Trap) and Laterites
Major Aquifer System	Basalt (Rajmahal Trap) and Laterites constitutes major aquifer system in the district.
Normal Annual Rainfall	1294.5 mm

Aquifer Disposition

Aquifer Disposition	Single aquifer system: Shallow Aquifer Depth ranges from 17–115 mbgl, beyond this depth basaltic rock occurs.

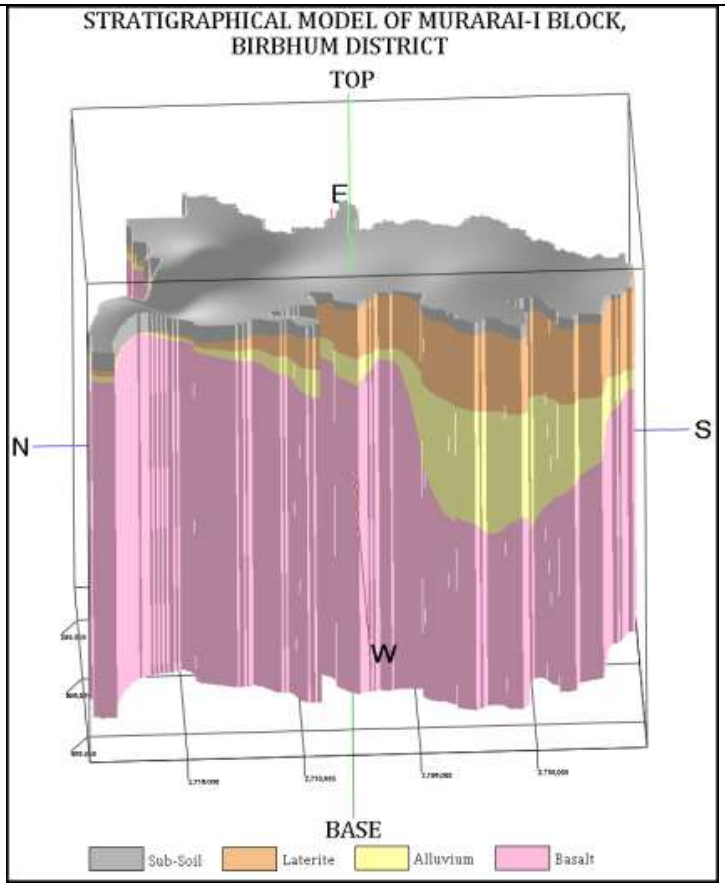
<table>
<tr><td></td><td> 

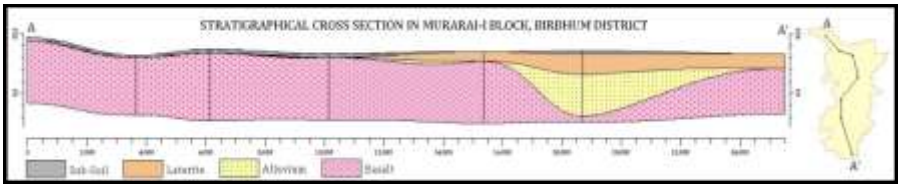
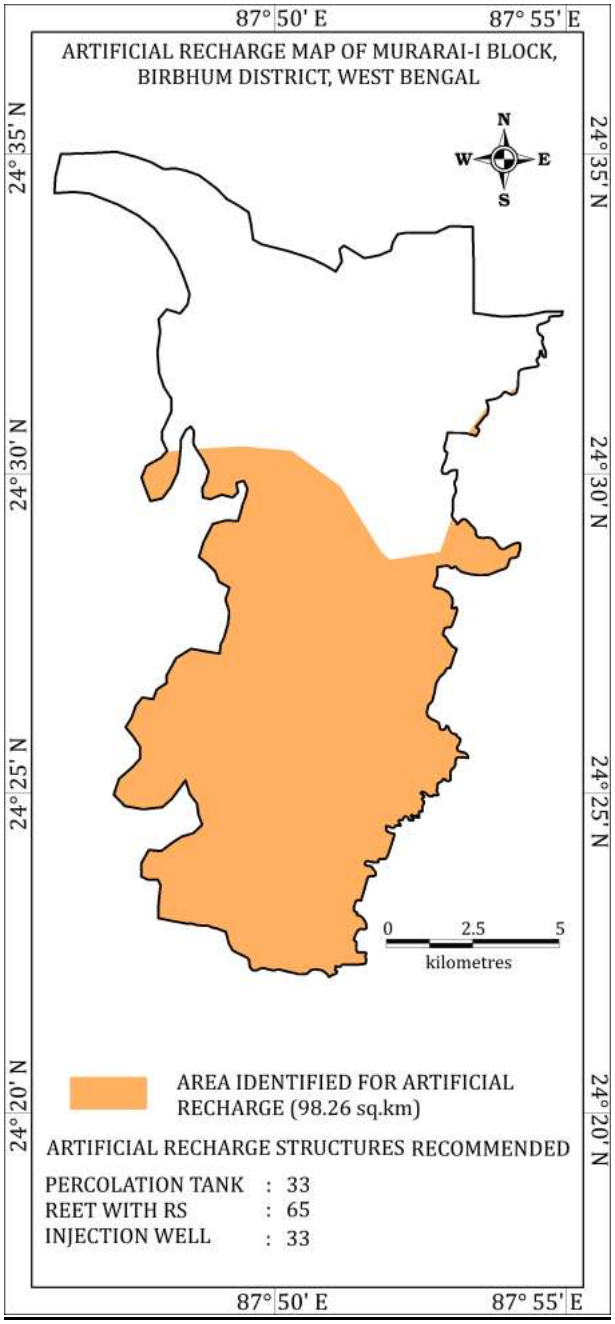
Figure 8: Aquifer disposition (3D) in Murarai-I block.</td></tr>
<tr><td>Aquifer Characteristics</td><td>Single aquifer system: Shallow Aquifer
Depth ranges from 17–115 mbgl, beyond this depth basaltic rock occurs.
Transmissivity is 700m2/day.
 

Figure 3: Cross section delineating the aquifer system in Murarai-I block</td></tr>
<tr><td>Groundwater Monitoring Status</td><td>5 NHS Well</td></tr>
<tr><td>Groundwater Quality</td><td>Sporadic occurrence of high conc. of iron in the block.</td></tr>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th></tr>
<tr><td>Depth Range</td><td>17-115mbgl</td></tr>
<tr><td>Yield</td><td>40 m^3/hr</td></tr>
<tr><td>Transmissivity</td><td>700</td></tr>
</table>
</td></tr>
</table>

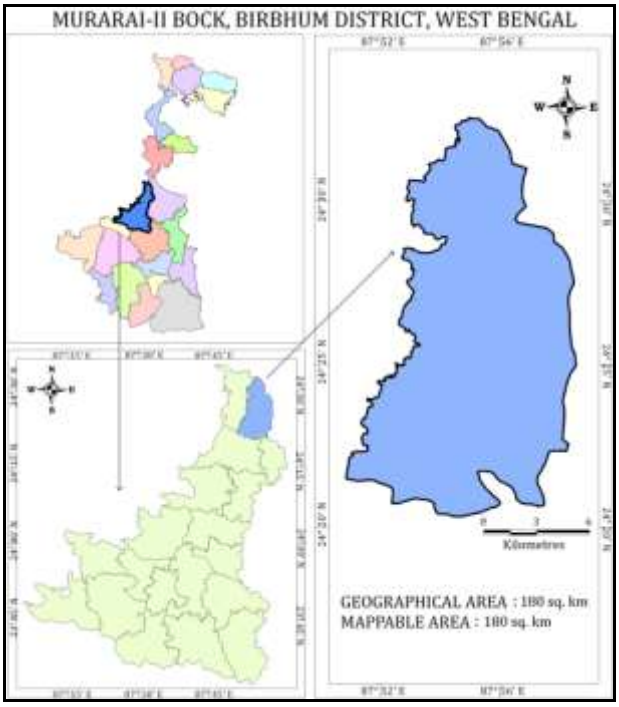
		m^2/day
Groundwater Resource	**Groundwater Resource Estimation 2013 (approved by CLEG)** * GW Availability: 52.7098 MCM. * GW Draft: 11.2569 MCM. * Stage of GW Development in the block is 21.36 %. Safe block. **Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)** * GW Availability: 54.5082 MCM. * GW Draft: 21.2325 MCM. * Stage of GW Development in the block is 38.95 %. Safe block. * Total in-storage ground water resources covering the study area is 509.2164 MCM.	
Existing and Future Water Demand	**Groundwater Resource Estimation 2013** *Present demand for All Usage: 11.2569 MCM *Future Demand for Domestic and Industrial Use: 32.4486 MCM	
	Groundwater Resource Estimation 2017 *Present demand for All Usage: 21.2325 MCM. *Future Demand for Domestic and Industrial Use: 40.3075 MCM.	
Aquifer Management plan		
Groundwater Management Issues	• Deep water level • Falling trend of depth to water level both in pre-monsoon &post-monsoon seasons.	
Groundwater Management Plan	**AQUIFER MANAGEMENT STRATEGY FOR MURARAI-I BLOCK OF BIRBHUM DISTRICT, WEST BENGAL** Problem 1: Very deep water level and long term water level shows falling trend. Problem 2: Falling trend of depth to water level both in pre-monsoon &post-monsoon seasons. Management strategy: • Rain water harvesting and artificial recharge may be implemented. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Micro irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for	

	irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted. • Total area suitable for recharge in this block is 98.25sq km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.  Figure 4: Area Feasible for Artificial Recharge, Murarai-I block

Aquifer Information and Management System

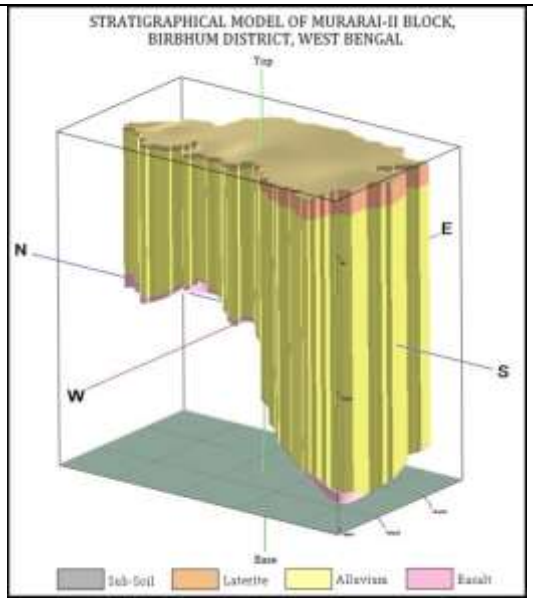
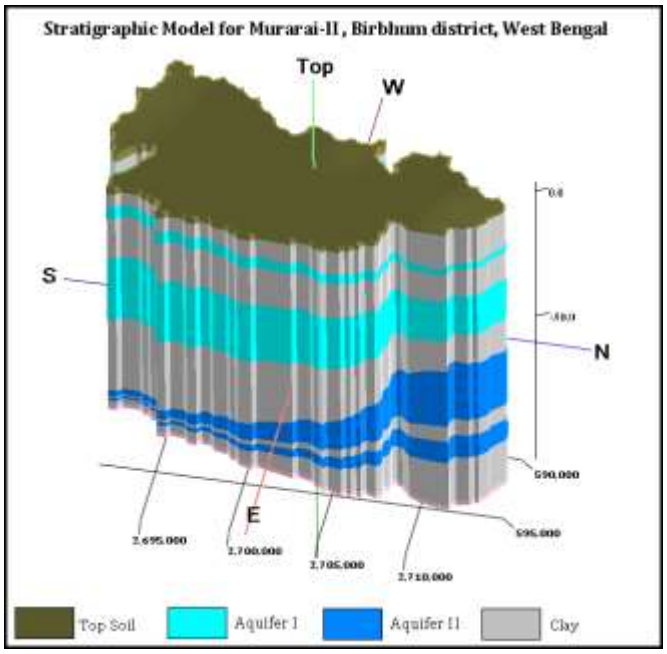
Murarai-II Block, Birbhum District, West Bengal
(180 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	**Murarai-II**
Location	 Figure 9: Location map of Murarai-II block.
Geographical Area	180 sq. km.
Basin/Sub-basin	Lower Ganga Basin
Principal Aquifer System	Alluvium and Laterites
Major Aquifer System	Older Alluvium (in major part of the district); Laterites occurs towards the southern part of the district only.
Normal Annual Rainfall	1555.76 mm

Aquifer Disposition

Aquifer Disposition	Aquifer – I: Shallow aquifer • Average depth range is from 7 to 12 mbgl and 28 to 55 mbgl, whereas in some areas it is found to extend up to 85 mbgl also. • Thickness of aquifer varies from 5m to 26m. • Aquifer I is under semi-confined to confined condition Aquifer – II: Deeper aquifer • Depth ranges from 92 to 115 mbgl, thickness ranges from 10 to 23m.

	 Figure 10: Principal Aquifer disposition (3D) in **Murarai-II** block.  Figure 3: Aquifer disposition (3D) in Murarai-II Block, Birbhum District
Aquifer Characteristics	• **Shallow aquifer (A 1):** Average depth range is from 7 to 12 mbgl and 28 to 55 mbgl, whereas in some areas it is found to extend up to 85 mbgl also. • **Aquifer (A 2**) Depth ranges from 92 to 115 mbgl, thickness ranges from 10 to 23m; Yield potential: 180 m^3/hr; Transmissivity: 1650 m^2/day

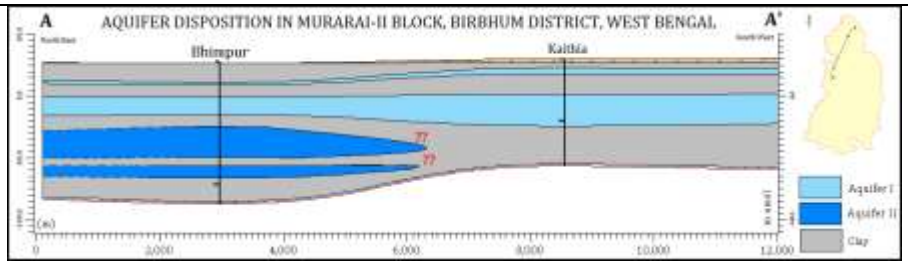
<table>
<tr><td></td><td> 

Figure 4: Cross section delineating the aquifer system in Murarai-II block</td></tr>
<tr><td>Groundwater Monitoring Status</td><td>1 NHS Well</td></tr>
<tr><td>Groundwater Quality</td><td>The quality of groundwater is good for drinking, irrigation & other domestic purposes.</td></tr>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th><th>Aquifer-II</th></tr>
<tr><td>Depth Range</td><td>7 – 12, 28 – 55 mbgl</td><td>92 – 115 mbgl</td></tr>
<tr><td>Yield</td><td></td><td>180 m^3/h</td></tr>
<tr><td>Transmissivity</td><td></td><td>1650 m^2/day</td></tr>
</table>
</td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)

* GW Availability: 61.567 MCM.
* GW Draft: 30.529 MCM.
* Stage of GW Development in the block is 49.59 %. Semi-Critical block. (Based on GWRA 2013; considering long term falling trend of depth to water level).

Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)

* GW Availability: 48.662 MCM.
* GW Draft: 31.167 MCM.
* Stage of GW Development in the block is 64.05 %. Safe block.

* Total in-storage ground water resources covering the study area is 531.57 MCM.</td></tr>
<tr><td rowspan="2">Existing and Future Water Demand</td><td>Groundwater Resource Estimation 2013
*Present demand for All Usage: 30.529 MCM
*Future Demand for Domestic and Industrial Use: 28.961 MCM</td></tr>
<tr><td>Groundwater Resource Estimation 2017
*Present demand for All Usage: 31.167 MCM.
*Future Demand for Domestic and Industrial Use: 16.532 MCM.</td></tr>
</table>

Aquifer Management plan	
Groundwater Management Issues	• Deep water level • Abnormal falling trend of depth to water level both in pre-monsoon & post-monsoon seasons
Groundwater Management Plan	**<u>Aquifer management strategy for Murarai-II block of Birbhum district, West Bengal</u>** <u>Problem 1:</u> Very deep water level and long term water level shows falling trend. Problem 2: The block is categorized as semi-critical (2013; long term water level falling trend) and the stage of development is 49.59 %. Irrigation is mainly done by ground water. <u>Management strategy</u>: • Rain water harvesting and artificial recharge may be implemented to eliminate the problem of declining water level. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Micro irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation. • Regular monitoring of water level should be done.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted since the block is Semi-Critical. • Total area suitable for recharge in this block is 176.72 sq. km • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.

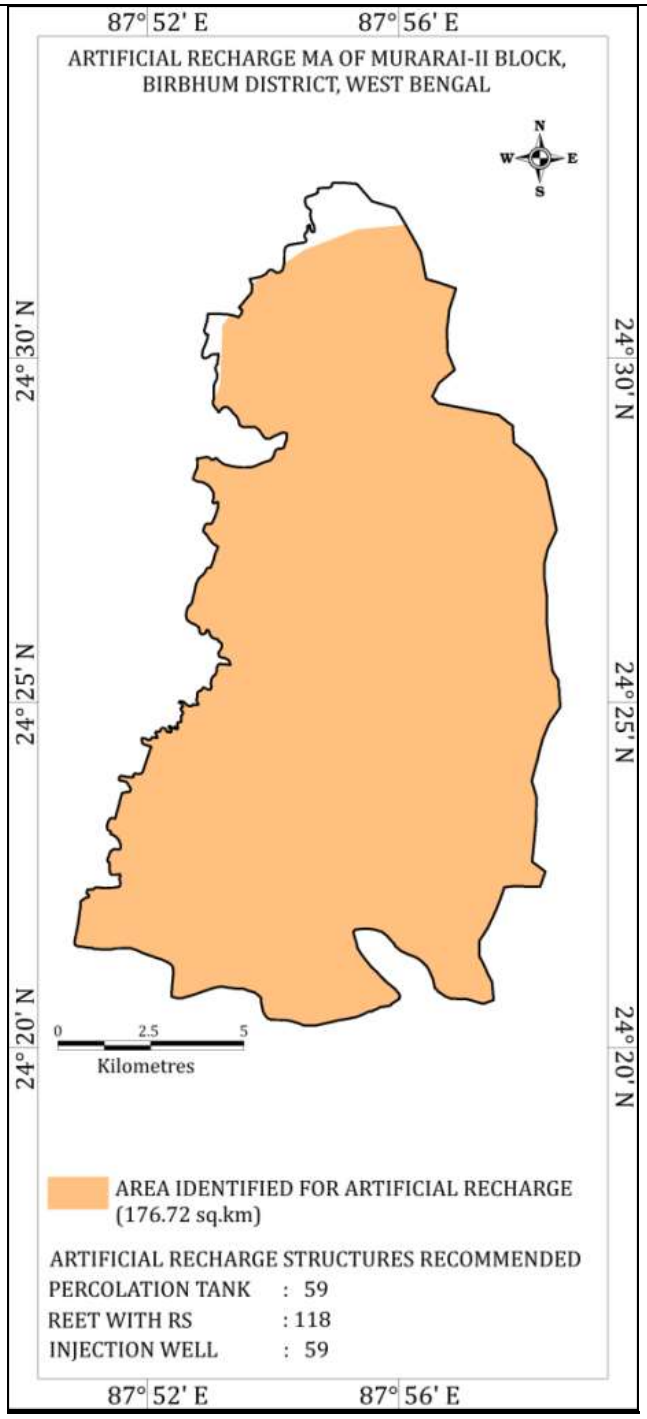
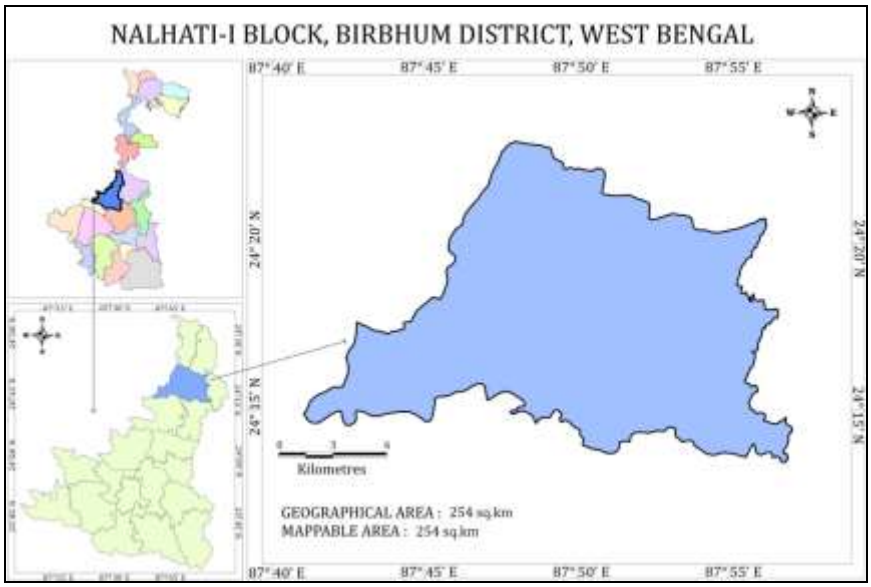


Figure 5: Area Feasible for Artificial Recharge, Murarai-II block

Aquifer Information and Management System

Nalhati – I Block, Birbhum District, West Bengal
(254 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	**Nalhati-I**
Location	 Figure 11: Location map of Nalhati-I block.
Geographical Area	254 sq. km.
Basin/Sub-basin	Lower Ganga Basin
Principal Aquifer System	Alluvium, Laterites and Traps
Major Aquifer System	Older Alluvium , Laterites and Traps
Normal Annual Rainfall	1294.5 mm

Aquifer Disposition

Aquifer Disposition	Aquifer-I : Shallow Aquifer Rajmahal Traps marginally exposed in the westernmost part of the district. Groundwater occurs in the water-bearing fractures encountered within 60 mbgl. Laterite covers major part of the district (western, northern, central and south western). Groundwater occurs under unconfined conditions in the weathered mantle with a depth range of 2 to 18 mbgl. Older Alluvium occurs towards the south eastern part of the district. Groundwater occurs in the depth span of 12 - 55 mbgl. Aquifer thickness varies from 6m to 38m. Multiple water bearing sand lenses

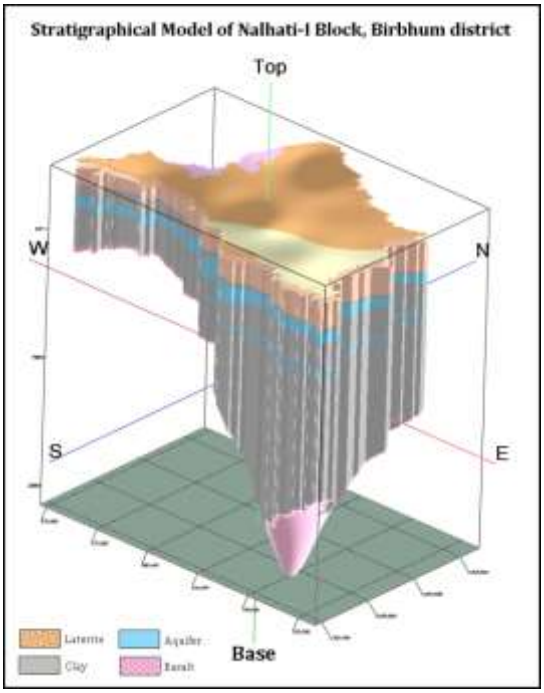
<table>
<tr><td></td><td>occur within 50 mbgl in the eastern part.
 

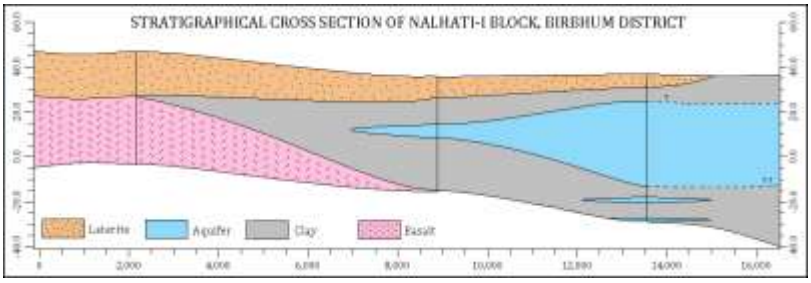
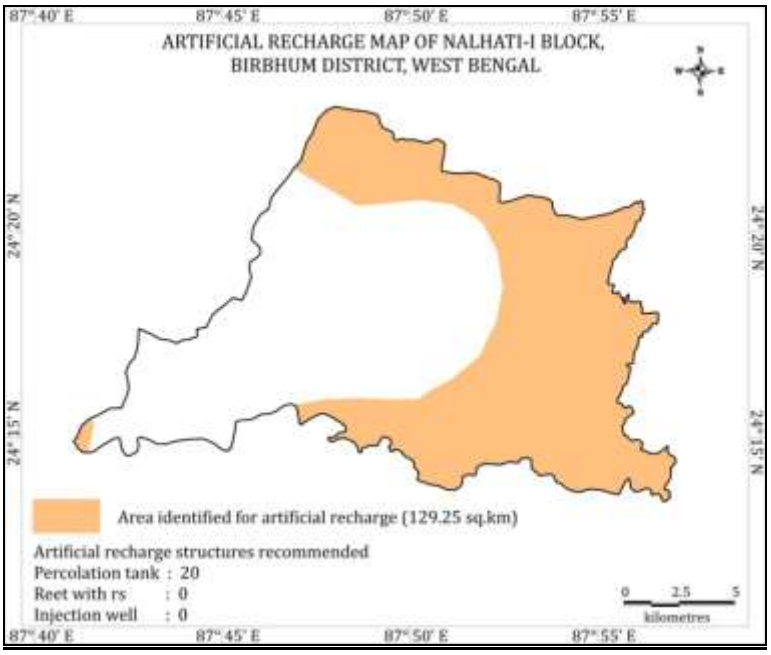
Figure 12: Aquifer disposition (3D) in Nalhati-I block.</td></tr>
<tr><td>Aquifer Characteristics</td><td>Shallow Aquifer (A 1): occurs up to the depth of 60mbgl
 

Figure 3: Cross section delineating the aquifer system in Nalhati-I block</td></tr>
<tr><td>Groundwater Monitoring Status</td><td>3 NHS Well</td></tr>
<tr><td>Groundwater Quality</td><td>Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, in the depth span of 50-80 mbgl.</td></tr>
<tr><td>Aquifer Potential</td><td><table>
<tr><th>Parameters</th><th>Aquifer-I</th></tr>
<tr><td>Depth Range</td><td>12-50 mbgl
54-57 mbgl</td></tr>
</table></td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)
* GW Availability: 24.912 MCM.</td></tr>
</table>

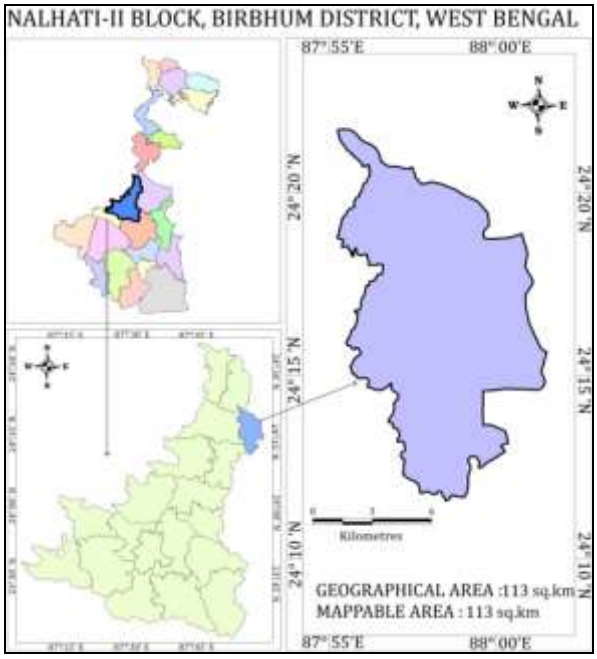
	* GW Draft: 16.016 MCM. * Stage of GW Development in the block is 64.29 %. Safe block. **Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)** * GW Availability: 32.436 MCM. * GW Draft: 21.992 MCM. * Stage of GW Development in the block is 67.80 %. Safe block. * Total in-storage ground water resources covering the study area is 15.556 MCM.
Existing and Future Water Demand	**Groundwater Resource Estimation 2013** *Present demand for All Usage: 16.016 MCM *Future Demand for Domestic and Industrial Use: 6.069 MCM
	Groundwater Resource Estimation 2017 *Present demand for All Usage: 21.992 MCM. *Future Demand for Domestic and Industrial Use: 9.588 MCM
Aquifer Management plan	
Groundwater Management Issues	• Deep water level • Abnormal falling trend of depth to water level both in pre-monsoon & post-monsoon seasons • Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, in the depth span of 60 mbgl.
Groundwater Management Plan	**<u>Aquifer management strategy for Naihati-I block of Birbhum district, West Bengal</u>** **<u>Problem 1:</u>** Very deep water level and long term water level shows falling trend. <u>Management strategy</u>: • Rain water harvesting and artificial recharge may be implemented to eliminate the problem of declining water level. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Micro irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation. **<u>Problem 2:</u>** Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in

	Rajmahal trap, in the depth span of 50-80 mbgl. <u>Management strategy</u>: • Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl. • Hence it is suggested that the occurrence of deeper fluoride free aquifers may be identified & tapped. • Micro irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted. • Total area suitable for recharge in this block is 129.94sq km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.  Figure 4 : Area Feasible for Artificial Recharge, Nalhati-I block

Aquifer Information and Management System

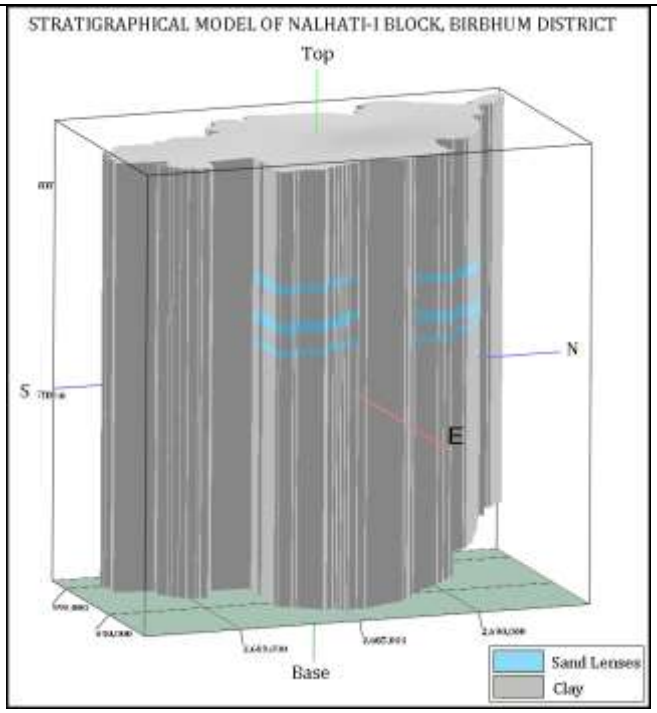
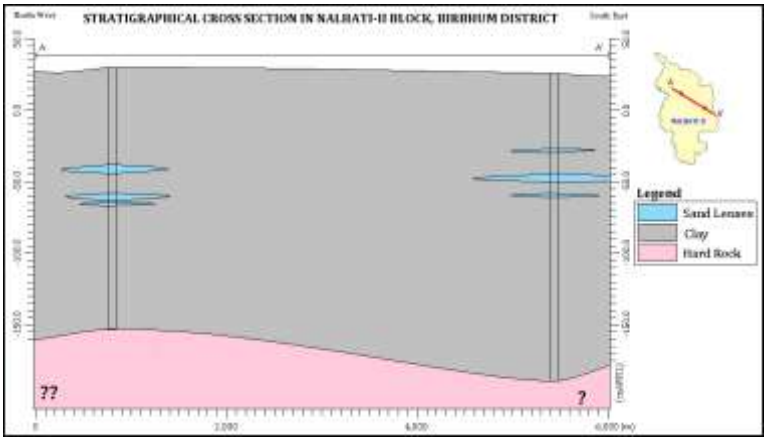
Nalhati – II Block, Birbhum District, West Bengal
(113 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	Nalhati-II
Location	 Figure 13: Location map of Nahati-II block.
Geographical Area	113 sq. km.
Basin/Sub-basin	Lower Ganga Basin
Principal Aquifer System	Alluvium
Major Aquifer System	Older Alluvium
Normal Annual Rainfall	1289 mm

Aquifer Disposition

Aquifer Disposition	Aquifer I: Shallow Aquifer is absent. Thick Clay sequence is dominant in the entire district. Water bearing sand zones are encountered at some places in the depth range of 53 – 56 mbgl, 68 – 74 mbgl, 84 – 97 mbgl. Thickness of the sand zones varies from 3 m to 6m.

	 Figure 14: Aquifer disposition (3D) in Nalhati-II block.
Status of GW Exploration	Exploratory Wells : 2 Observation Wells : 0
Aquifer Characteristics	Aquifer I: Shallow Aquifer is absent. Thick Clay sequence is dominant in the entire district. Water bearing sand zones are encountered at some places in the depth range of 53 – 56 mbgl,68 – 74 mbgl, 84 – 97 mbgl. Thickness of the sand zones varies from 3 m to 6m.  Figure 3: Cross section delineating the aquifer system in Nalhati-II block
Groundwater Monitoring Status	1 NHS Well
Groundwater Quality	The quality of groundwater is good for drinking, irrigation & other domestic purposes.

<table>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th></tr>
<tr><td>Depth Range</td><td>53 – 56 mbgl,
68 – 74 mbgl,
84 – 97 mbgl</td></tr>
<tr><td>Yield</td><td>79.2 m^3/hr to 126 m^3/hr</td></tr>
<tr><td>Transmissivity</td><td>2269.62 m^2/day</td></tr>
</table>
</td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)
* GW Availability : 32.38 MCM.
* GW Draft : 19.68 MCM.
* Stage of GW Development in the block is 60.78 %. Semi-Critical block.
(Based on GWRA 2013; considering long term falling trend of depth to water level).

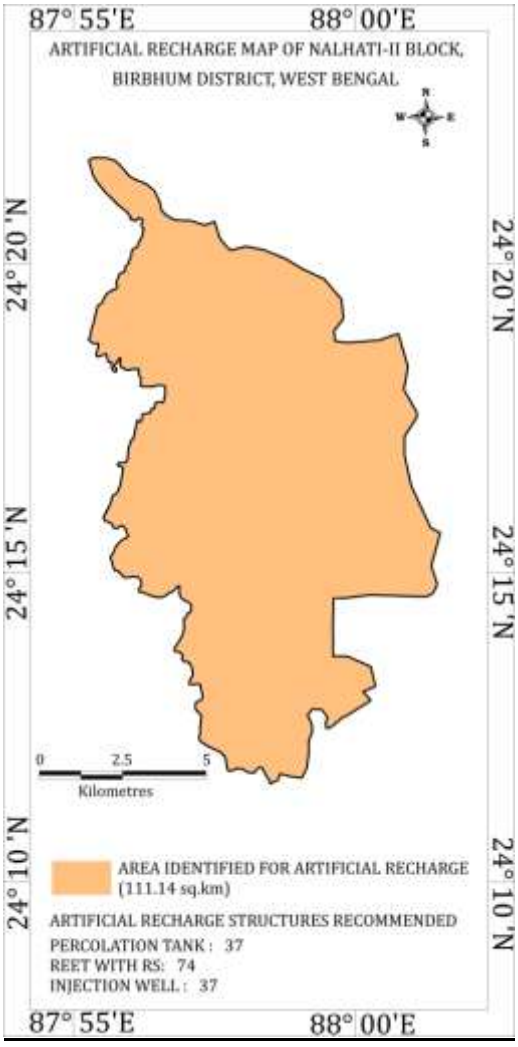
Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)

* GW Availability: 25.58 MCM.
* GW Draft: 19.10 MCM.
* Stage of GW Development in the block is 74.67 %. Semi-critical block.

* Total in-storage ground water resources covering the study area is MCM.</td></tr>
<tr><td rowspan="2">Existing and Future Water Demand</td><td>Groundwater Resource Estimation 2013
*Present demand for All Usage: 19.68 MCM.
*Future Demand for Domestic and Industrial Use: 11.24 MCM.</td></tr>
<tr><td>Groundwater Resource Estimation 2017
*Present demand for All Usage: 25.58 MCM
*Future Demand for Domestic and Industrial Use: 5.83 MCM.</td></tr>
<tr><td colspan="2">Aquifer Management plan</td></tr>
<tr><td>Groundwater Management Issues</td><td>• Deep water level
• Abnormal falling trend of depth to water level both in pre-monsoon & post-monsoon seasons</td></tr>
<tr><td>Groundwater Management Plan</td><td><u>Aquifer management strategy for Nalhati-II block of Birbhum district, West Bengal</u>

Problem 1: Very deep water level and long term water level shows falling trend.

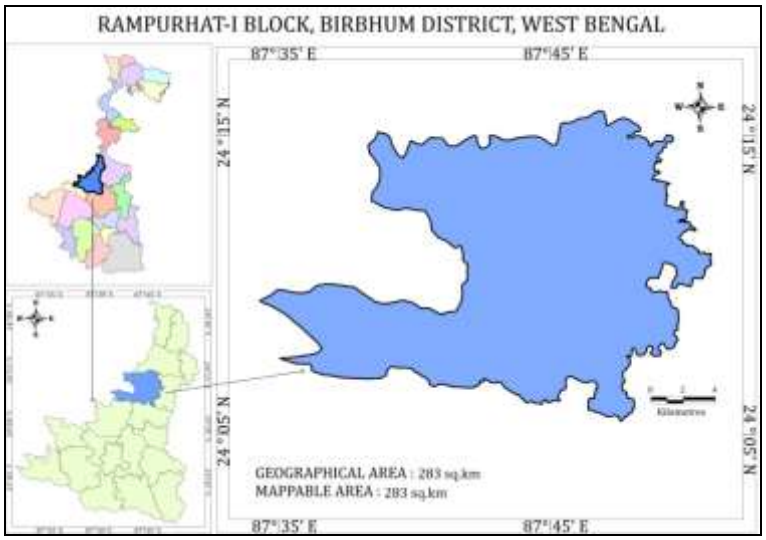
Problem 2: The block is categorized as SEMI-CRITICAL and the stage of development is 60.78 %. Irrigation is mainly done by ground water.</td></tr>
</table>

	Management strategy: • Rain water harvesting and artificial recharge may be implemented to eliminate the problem of declining water level. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Micro irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted since the block is Semi-Critical. • Total area suitable for recharge in this block is 111.14 sq km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.  Figure 3: Area Feasible for Artificial Recharge, Nalhati-II block

Aquifer Information and Management System

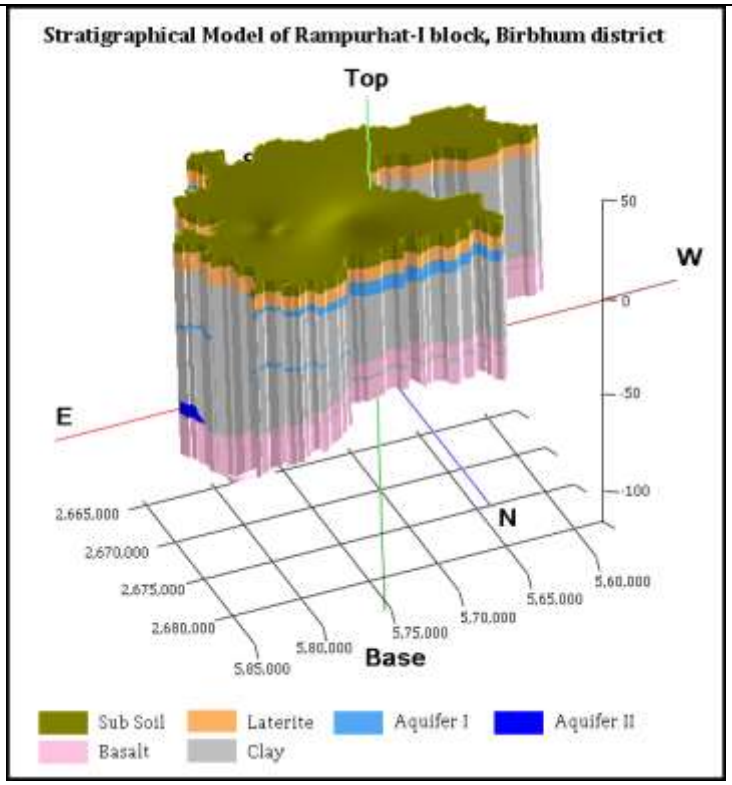
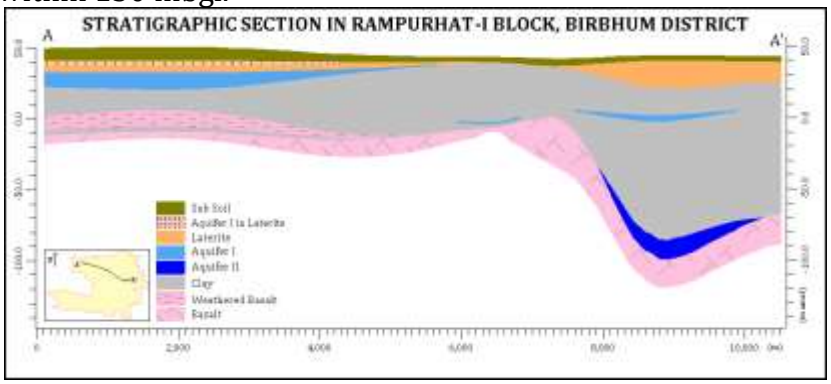
Rampurhat-I Block, Birbhum District, West Bengal
(283 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	Rampurhat-I
Location	 Figure 15: Location map of Rampurahat-I block.
Geographical Area	283 sq. km.
Basin/Sub-basin	Lower Ganga Basin
Principal Aquifer System	Laterites & Rajmahal Trap
Major Aquifer System	Laterites & Rajmahal Trap
Normal Annual Rainfall	1555.76 mm

Aquifer Disposition

Aquifer Disposition	Two aquifer system: Aquifer – I: Shallow aquifer • In the areas where trap is the only hydrogeological formation, bore wells, tapping fractures in the depth span of 10-13, 18-30 and 44-56 mbgl. Aquifer – II: Deeper aquifer • Aquifers within 150 mbgl.

	 Figure 16: Aquifer disposition (3D) in **Rampurhat-I** block.
Status of GW Exploration	Exploratory Wells : 4 Observation Wells : 1
Aquifer Characteristics	• **Shallow aquifer (A 1):** occurs up to depth of 50mbgl; Yield potential: 10m3/hr • **Aquifer (A 2)** has been identified up to the drilled depth within 150 mbgl.  Figure 3: Cross section delineating the aquifer system in Rampurahat-I block
Groundwater Monitoring Status	7 NHS Well
Groundwater Quality	Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, as well as from the tube wells tapping shallow aquifers, in the depth span of 50-80 mbgl.

<table>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th><th>Aquifer-II</th></tr>
<tr><td>Depth Range</td><td>10 – 13mbgl
18 – 30mbgl
44 – 56mbgl</td><td>Upto 150mbgl</td></tr>
<tr><td>Yield</td><td>(4.32 to 10.8 m3/hr)</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)

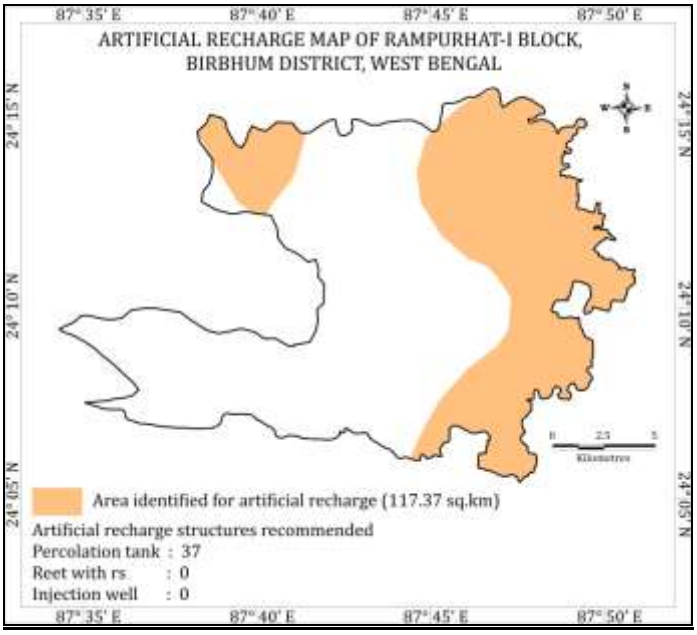
* GW Availability: 35.05 MCM.
* GW Draft: 9.644 MCM.
* Stage of GW Development in the block is 27.52 %. Safe block.

Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)

* GW Availability: 36.45 MCM.
* GW Draft: 16.88 MCM.
* Stage of GW Development in the block is 46.32%. Safe block.

* Total in-storage ground water resources covering the study area is 14.831 MCM.</td></tr>
<tr><td>Existing and Future Water Demand</td><td>Groundwater Resource Estimation 2013
*Present demand for All Usage: 9.644 MCM
*Future Demand for Domestic and Industrial Use: 22.563 MCM.</td></tr>
<tr><td></td><td>Groundwater Resource Estimation 2017
*Present demand for All Usage : 16.88 MCM.
*Future Demand for Domestic and Industrial Use: 18.962 MCM.</td></tr>
<tr><td colspan="2">Aquifer Management plan</td></tr>
<tr><td>Groundwater Management Issues</td><td>• Deep water level.
• Abnormal falling trend of depth to water level both in pre-monsoon &post-monsoon seasons.
• Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, as well as from the tube wells tapping shallow aquifers, in the depth span of 50-80 mbgl.</td></tr>
<tr><td>Groundwater Management Plan</td><td><u>Aquifer management strategy for Rampurhat-I block of Birbhum district, West Bengal</u>

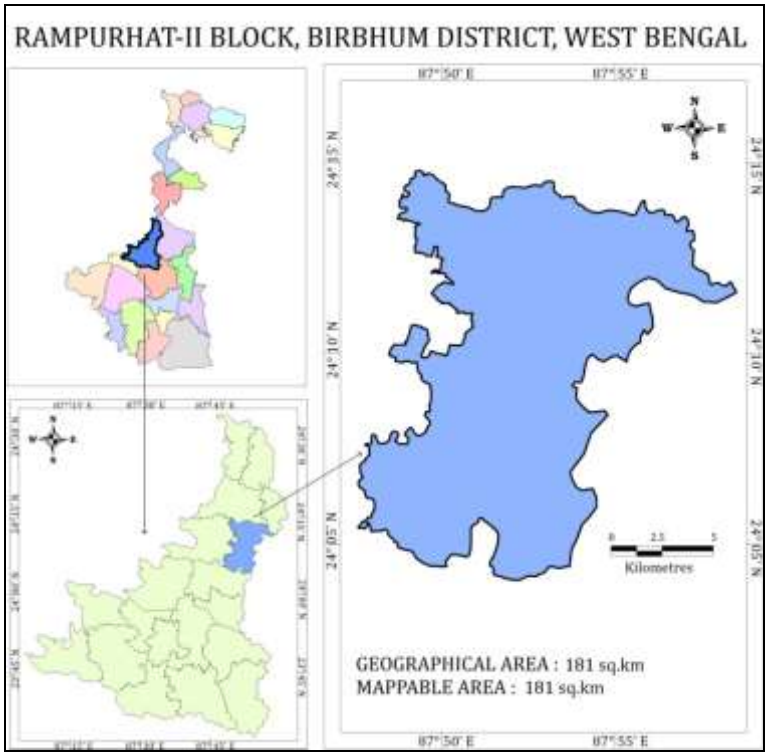
<u>Problem 1:</u> Very deep water level and long term water level shows falling trend.</td></tr>
</table>

	Problem 2: Ground water with high fluoride concentration is reported from the dug & bore wells, tapping weathered residuum & fractures in Rajmahal trap, as well as from the tube wells tapping shallow aquifers, in the depth span of 50-80 mbgl. Management strategy: • Rain water harvesting and artificial recharge may be implemented to eliminate the problem of declining water level. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Modern irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted. • Total area suitable for recharge in this block is 117.36sq km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.  Figure 3: Area Feasible for Artificial Recharge, Rampurahat-I block

Aquifer Information and Management System

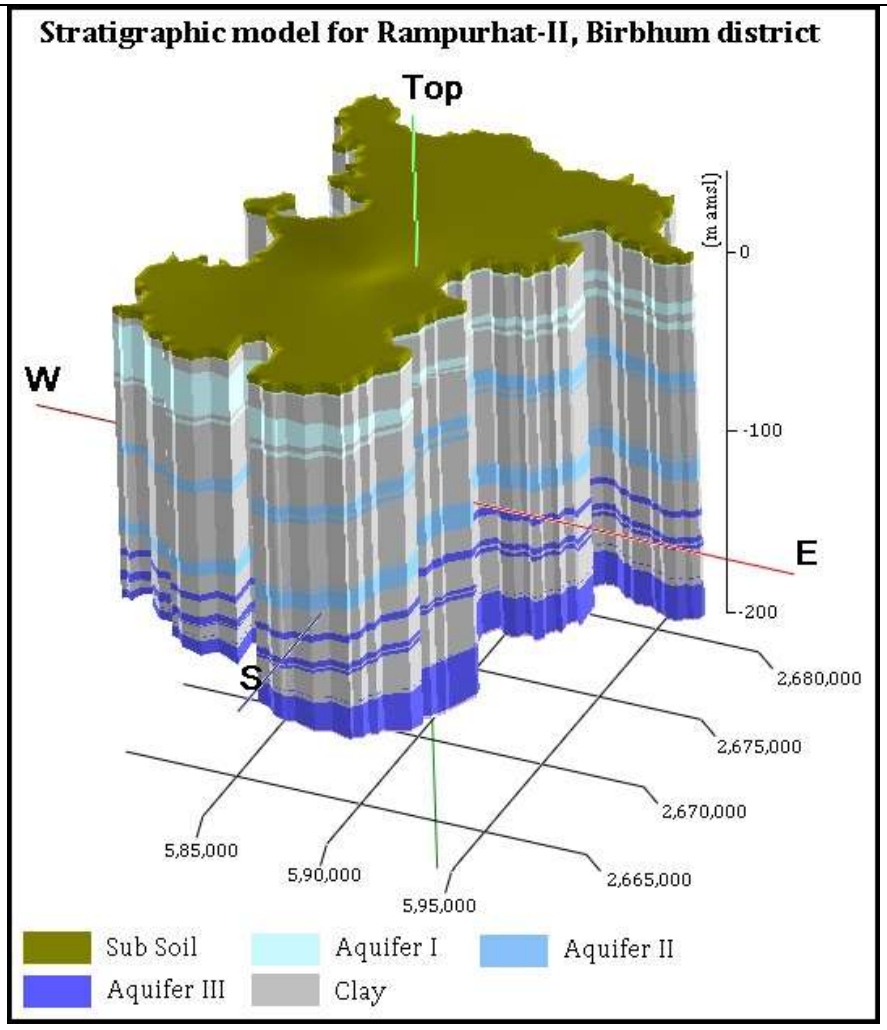
Rampurhat-II Block, Birbhum District, West Bengal
(181 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	Rampurhat-II
Location	 Figure 17: Location map of Rampurhat-II block.
Geographical Area	181 sq. km.
Basin/Sub-basin	Lower Ganga Basin / Dwarka-Brahmani sub Basin
Principal Aquifer System	Alluvium
Major Aquifer System	Older Alluvium
Normal Annual Rainfall	1289 mm

Aquifer Disposition

Aquifer Disposition	Three Aquifer System : Aquifer I (Shallow Aquifer): Depth range of 4 to 55 mbgl. Aquifer II (Intermediate Aquifer): Depth range of 46 to 157 mbgl. Aquifer III (Deeper Aquifer): Depth range of 162 to 250 mbgl.

	 Figure 18: Aquifer disposition (3D) in Rampurhat-II block.
Status of GW Exploration	Exploratory Wells : 5 Observation Wells : 1
Aquifer Characteristics	Three aquifer system: **Aquifer I (Shallow Aquifer) :** The Shallow Aquifer is present in multiple layers in the depth range of 4 to 55 mbgl with the thickness varying from 4 to 20 m with occasional coalesced aquifer of about 30 m thickness. **Aquifer II (Intermediate Aquifer) :** The intermediate Aquifer is encountered within the depth range of 46 to 157 mbgl with thickness of the layers varying from 4 to 18 m. **Aquifer III (Deeper Aquifer) :** The Deeper Aquifer is encountered within the depth range of 162 to 250 mbgl with the thickness of the layers varying from 3 to 25 m with occasional coalesced aquifer of 40m thick. At places basement touches at 125.65 mbgl (Tarapith), but at most of the places basement encounters beyond this depth.

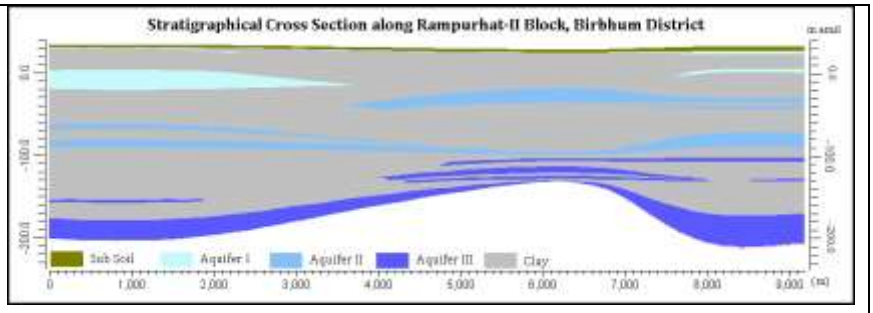


Figure 3: Cross section delineating the aquifer system in Rampurhat-II block

Groundwater Monitoring Status	3 NHS Well
Groundwater Quality	The quality of groundwater is good for drinking, irrigation & other domestic purposes

Aquifer Potential

Parameters	Aquifer-I	Aquifer-II	Aquifer-III
Depth Range **(mbgl)**	6 – 9.75, 27 – 30, 31 – 55	55-64, 75-79, 119-125, 125-132, 140-149, 153-157	161-165 189 – 192, 206 - 245
Yield	453.6 to 1432.08 m3/hr	561.6 to 790.56 m3/hr	-

Groundwater Resource

Groundwater Resource Estimation 2013 (approved by CLEG)

* GW Availability: 48.92 MCM.
* GW Draft: 29.26 MCM.
* Stage of GW Development in the block is 59.81 %. Semi-Critical block. **(Based on GWRA 2013; considering long term falling trend of depth to water level).**

Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B)

* GW Availability: 46.995 MCM.
* GW Draft: 35.592 MCM.
* Stage of GW Development in the block is 75.74 %. Semi-critical block.

	* Total in-storage ground water resources covering the study area is 455.17 MCM.
Existing and Future Water Demand	**Groundwater Resource Estimation 2013** *Present demand for All Usage: 29.26 MCM *Future Demand for Domestic and Industrial Use: 17.51 MCM.
	Groundwater Resource Estimation 2017 *Present demand for All Usage : 16.88 MCM. *Future Demand for Domestic and Industrial Use: 10.467 MCM.
Aquifer Management plan	
Groundwater Management Issues	• Deep water level • Abnormal falling trend of depth to water level both in pre-monsoon &post-monsoon seasons • Semi-critical Block
Groundwater Management Plan	**Aquifer management strategy for Rampurhat-II block of Birbhum district, West Bengal** Problem 1: Very deep water level and long term water level shows falling trend. Problem 2: The block is categorized as SEMI-CRITICAL and the stage of development is 59.81 % (2013) & 75.74 % (2017).Irrigation is mainly done by ground water. Management strategy: • Rain water harvesting and artificial recharge may be implemented to eliminate the problem of both declining water level and arsenic contamination. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Modern irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted since the block is Semi-Critical. • Total area suitable for recharge in this block is 181.68sq km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.

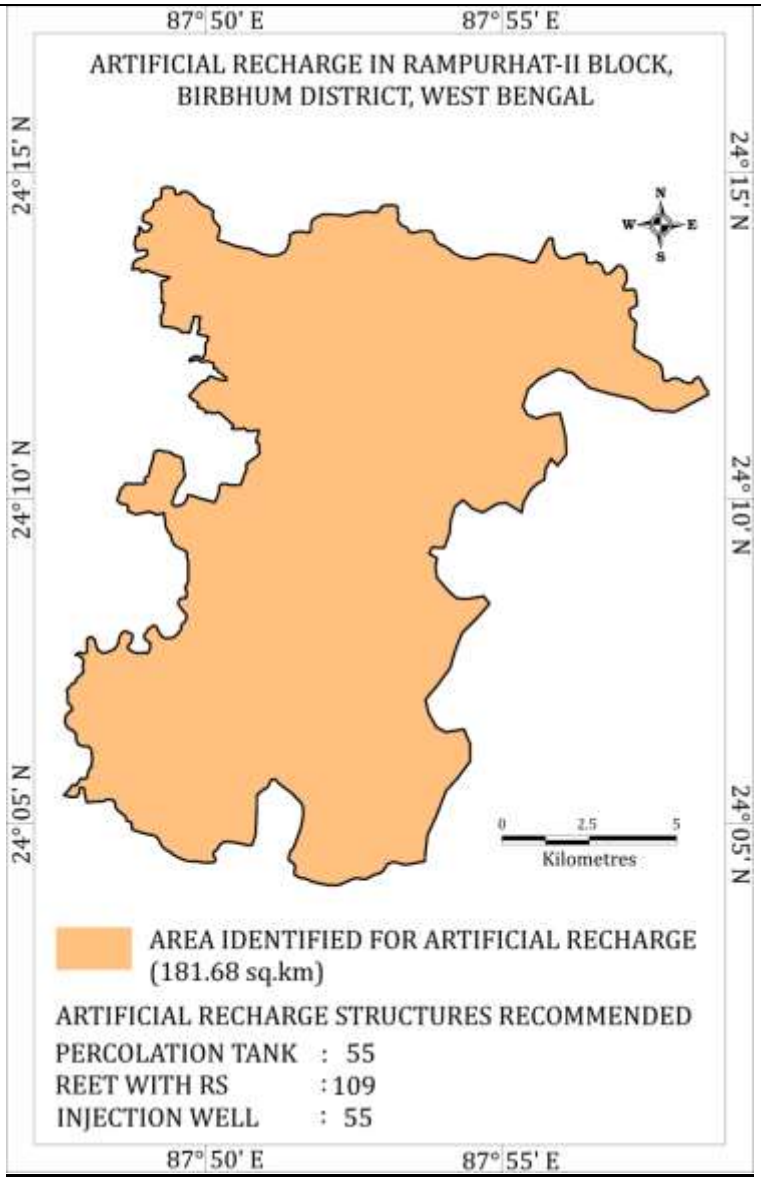
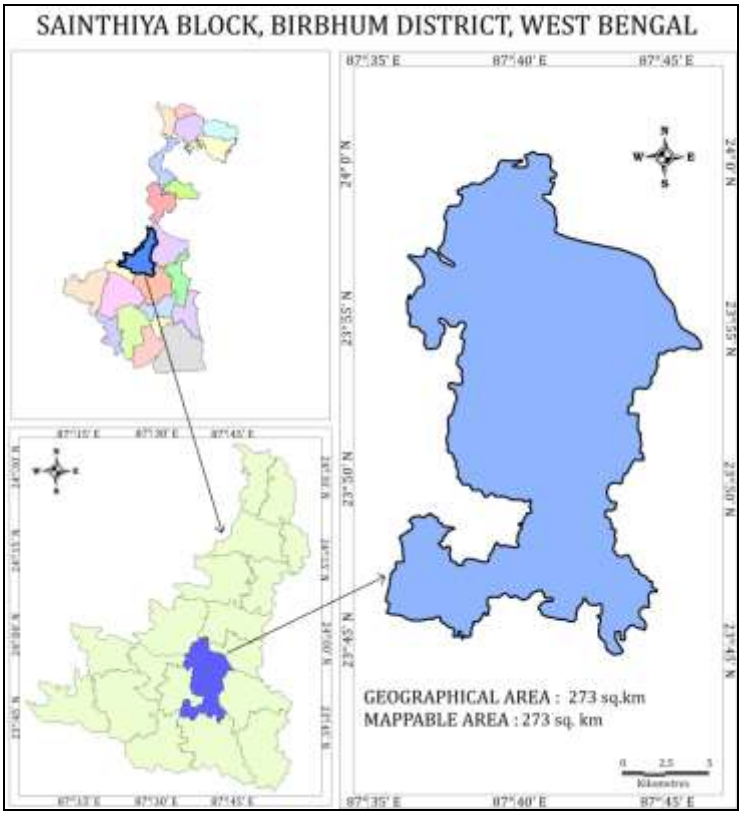


Figure 4: Area Feasible for Artificial Recharge, Rampurahat-II block

Aquifer Information and Management System

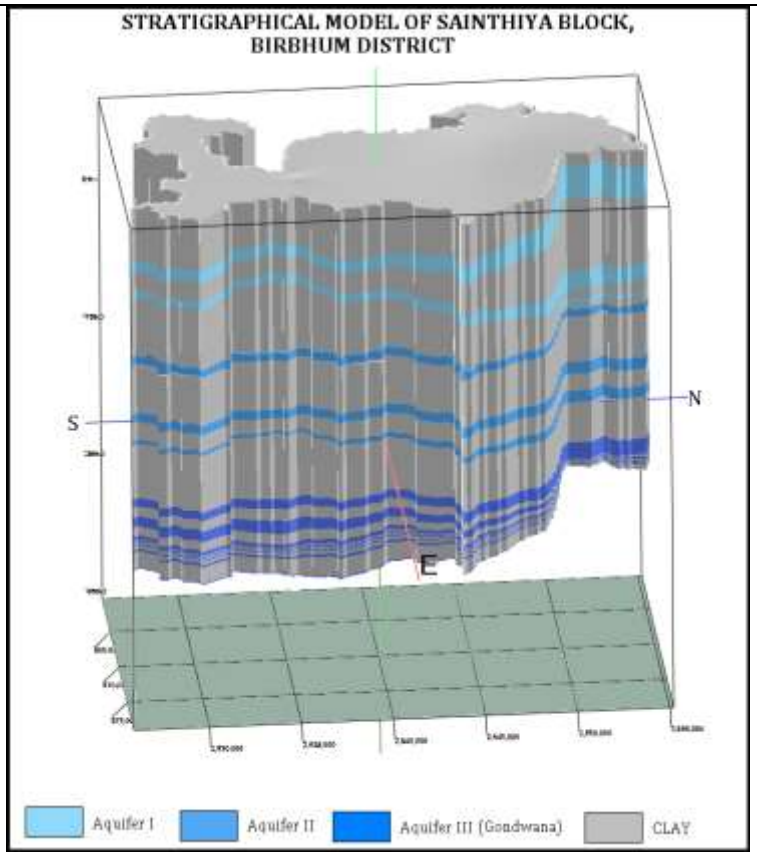
Sainthia Block, Birbhum District, West Bengal
(273 sq.km. area covered under NAQUIM)

General Information

State Name	West Bengal
District name	Birbhum
Block Name	**Sainthia**
Location	 Figure 19: Location map of Sainthia block.
Geographical Area	273 sq. km.
Basin/Sub-basin	Lower Ganga Basin/ Mayurakshi Sub Basin
Principal Aquifer System	Alluvium
Major Aquifer System	Older Alluvium
Normal Annual Rainfall	1294.5 mm

Aquifer Disposition

Aquifer Disposition	Three Aquifer System : Aquifer-I: Average depth range is from 53–64 mbgl, Granular zone of 6 m. Aquifer-II: Average depth range is from 78 -106mbgl. Aquifer-III: Average depth range is from 132-342 mbgl. Aquifer III constitutes prolific water bearing zones at varied depths, viz. III A : 132-176 mbgl; III B : 210-228 mbgl ; IIIC : 241-250 mbgl; IIID : 261 – 299 mbgl, IIIE : 339-342 mbgl.

	 Figure 20: Aquifer disposition (3D) in Sainthia block.
Status of GW Exploration	Exploratory Wells : 4 Observation Wells : 3
Aquifer Characteristics	Three aquifer system: • **Shallow aquifer (A 1):** Average depth range is from 53–64 mbgl, Granular zone of 6 m; Discharge is 13.6--15m^3/hr. • **Intermediate aquifer (A 2**) Average depth range is from 78 - 106mbgl&, Discharge is 70-80 m3/hr, Transmissivity is 1618m2/day. • **Deeper aquifer (A 3**) Average depth range is from 132-342 mbgl. Aquifer III constitutes prolific water bearing zones at varied depths, viz. III A: 132-176 mbgl; III B : 210-228 mbgl ; IIIC : 241-250 mbgl; IIID : 261 – 299 mbgl, IIIE : 339-342 mbgl. Yield : around 72 to 80 m3/hr with drawdown in the range of 5.10 to 6.82 m. At places, yield from deeper aquifers has been reported to be as high as 200 m3/hr with about 6 m drawdown.

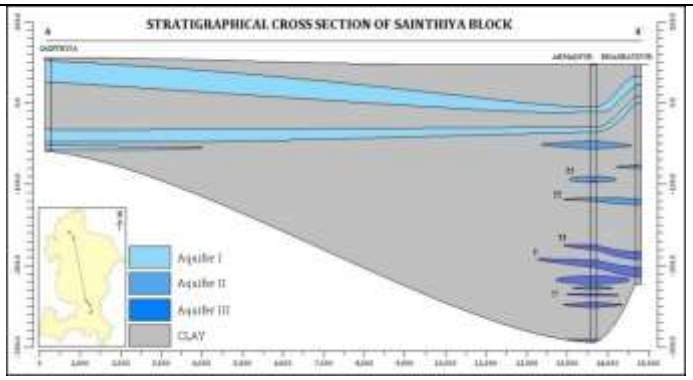
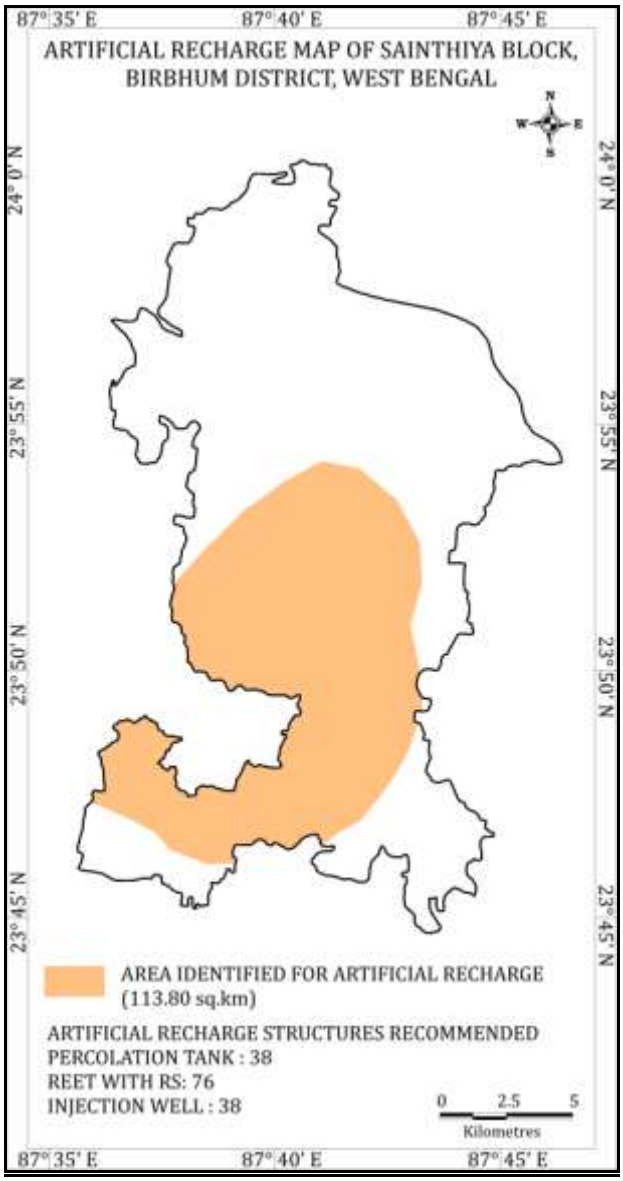
<table>
<tr><td></td><td> 

Figure 3: Cross section delineating the aquifer system in Sainthia block</td></tr>
<tr><td>Groundwater Monitoring Status</td><td>6 NHS Well</td></tr>
<tr><td>Groundwater Quality</td><td>Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl</td></tr>
<tr><td>Aquifer Potential</td><td>
<table>
<tr><th>Parameters</th><th>Aquifer-I</th><th>Aquifer-II</th><th>Aquifer-III</th></tr>
<tr><td>Depth Range</td><td>53 – 64 mbgl</td><td>78-106mbgl</td><td>132-342mbgl
III A: 132-176 mbgl;
III B : 210-228 mbgl ;
IIIC : 241-250 mbgl;
IIID : 261 – 299 mbgl,
IIIE : 339-342 mbgl.</td></tr>
<tr><td>Yield</td><td>13.6 -15m^3/hr</td><td>70 - 80m^3/hr</td><td>72 to 80 m^3/hr</td></tr>
<tr><td>Transmissivity</td><td>59.30 – 601 m^2/day</td><td>1618 m^2/day</td><td></td></tr>
</table>
</td></tr>
<tr><td>Groundwater Resource</td><td>Groundwater Resource Estimation 2013 (approved by CLEG)
* GW Availability: 105.86 MCM.
* GW Draft: 46.52 MCM.
* Stage of GW Development in the block is 43.94 %. Semi-Critical block. (Based on GWRA 2013; considering long term falling trend of depth to water level).</td></tr>
</table>

	Groundwater Resource Estimation 2017 (approved by SLC, Govt. of W.B) * GW Availability: 76.257 MCM. * GW Draft: 49.982 MCM. * Stage of GW Development in the block is 65.54 %. Safe block. * Total in-storage ground water resources covering the study area is 878.31 MCM.
Existing and Future Water Demand	**Groundwater Resource Estimation 2013** *Present demand for All Usage: 56.434 MCM *Future Demand for Domestic and Industrial Use: 56.434 MCM.
	Groundwater Resource Estimation 2017 *Present demand for All Usage : 25.407 MCM. *Future Demand for Domestic and Industrial Use: 10.467 MCM.
Aquifer Management plan	
Groundwater Management Issues	• Deep water level • Abnormal falling trend of depth to water level both in pre-monsoon &post-monsoon seasons • Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl
Groundwater Management Plan	**<u>Aquifer management strategy for Sainthia block of Birbhum district, West Bengal</u>** Problem 1: Very deep water level and long term water level shows falling trend. Problem 2: The block is categorized as SEMI-CRITICAL and the stage of development is 43.94 %. Irrigation is mainly done by ground water. Problem 3: Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl. <u>Management strategy</u>: • Ground water with high fluoride concentration is reported from the tube wells tapping shallow aquifers, generally down to the depth of 60 mbgl. Hence it is suggested that the occurrence of deeper fluoride free aquifers may be identified & tapped. • Rain water harvesting and artificial recharge may be implemented. • Cultivation of low water requiring crops and change in cropping pattern suitable for the area. • Micro irrigation practices like drip water irrigation system; sprinklers can be implemented for creating efficiency in

	irrigation methods applied. • Conjunctive use of surface water as well as ground water for irrigation.
AR & Conservation Possibilities	• Schemes for Artificial recharge structures/ techniques to be adopted since the block is Semi-Critical. • Total area suitable for recharge in this block is 113.79sq km. • Recharge structures recommended are: Re-excavation of existing tank with Recharge Shaft, Irrigation cum recharge tank, Farm ponds & Injection wells.  Figure 4: Area Feasible for Artificial Recharge, Sainthia block

PART-III

DATA GAP ANALYSIS FOR AQUIFER MAPPING PROGRAMME IN STUDY AREA (parts of Birbhum District, W.B.)

DATA GAP ANALYSIS FOR AQUIFER MAPPING PROGRAMME IN STUDY AREA (parts of Birbhum District, W.B.)

The study area covers a mappable area of 2099 sq km comprising ten (10 No.) blocks of Birbhum District namely Labpur, Sainthia, Rampurhat I, Rampurhat II, Murarai I, Murarai II, Nalhati I, Nalhati II, Mayureshwar-I & Mayureshwar-II The study area extends between 24°35'00"N and 23°32'30" latitude and 88°01'40"E and 87°32'00"E longitude. The area falls in Survey of India topo- sheet no 72P/11, 72P/12, 72P/14, 72P/15,72P/16, 73M/9, 73M/10 & 72M/13 & 72M/14. Data Gap in terms of exploratory wells (EW), water level monitoring stations, water quality monitoring stations etc. to study the aquifers in the area has been tabulated quadrant wise in different toposheets.

A. Data Gap for Exploratory Wells

The exploratory wells constructed by CGWB, ER, Kolkata and wells outsourced by private company has been considered for the study. The existing exploratory wells were plotted on the map and as per the guidelines it has been observed that a total of 4 Exploratory wells(EW), 6 Observation wells (OW) and 1 Well Fields are required in the study area.

Toposheet No.	Quadrant	No. of Additional EW/OW required	Depth of Drilling (Meters)
72P/14	3A	1 EW	300
		1 OW	300
72P/15	2B	1 EW	300
		1 OW	300
		1 Well Field	300
		1 OW	200
72P/12	2B	1 EW	300
		1 OW	300
		1 Well Field	300
72M/13	2A	1EW	300
		1 OW	200
		1 OW	300

Table 1: Table suggesting extra Exploratory wells and their depths for the study area

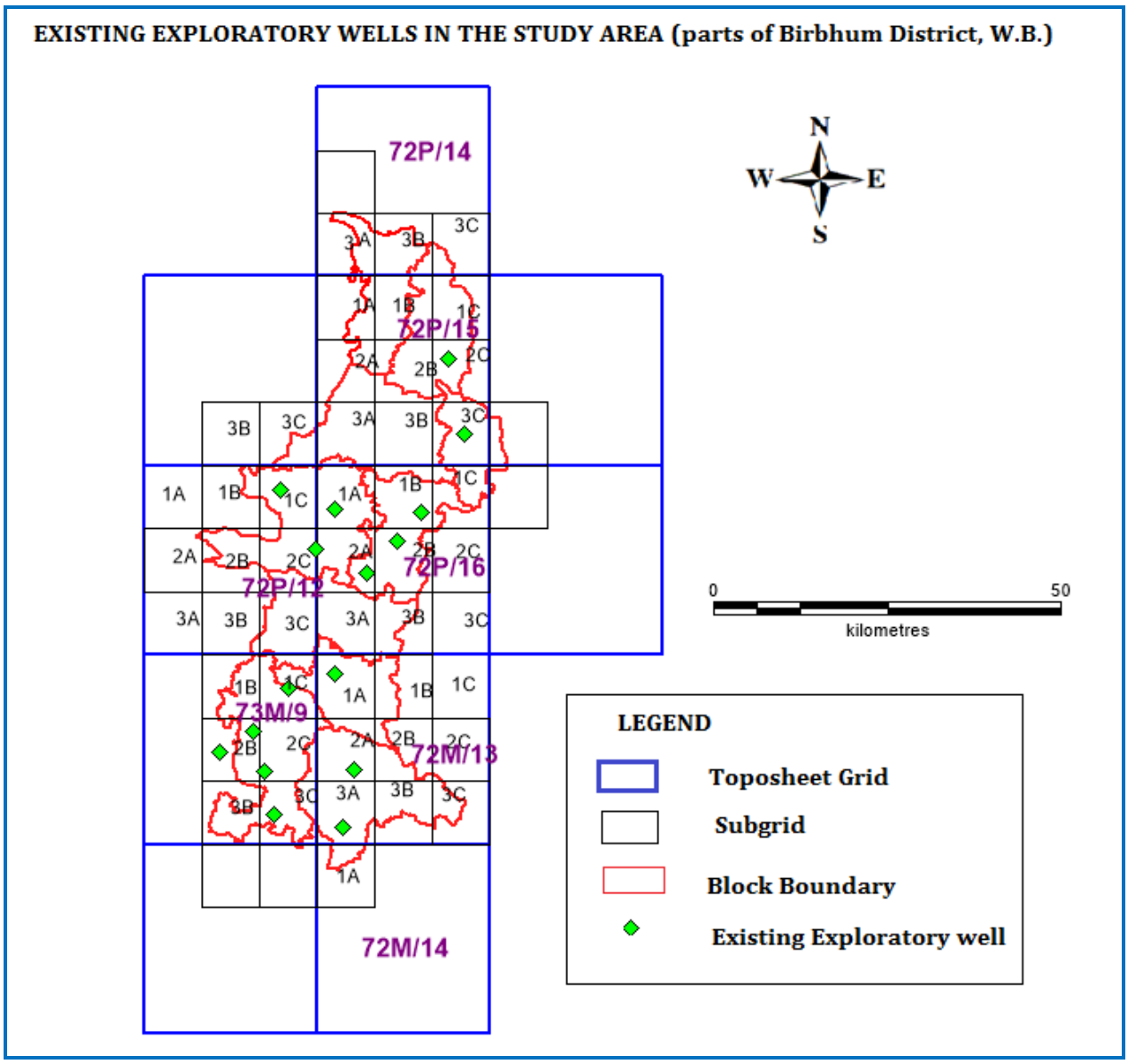


Plate: 1 : Map of existing exploratory wells in the study area.

B. Data Gap for Monitoring stations (Key wells)

Monitoring wells in terms of key wells were plotted for data gap analysis. The NHS monitoring wells of CGWB and SWID (State Water Investigation Directorate) has been combined for the study. It has been observed that an extra of 27 wells tapping Shallow Aquifer & 12 wells tapping Deeper Aquifer are required for future monitoring.

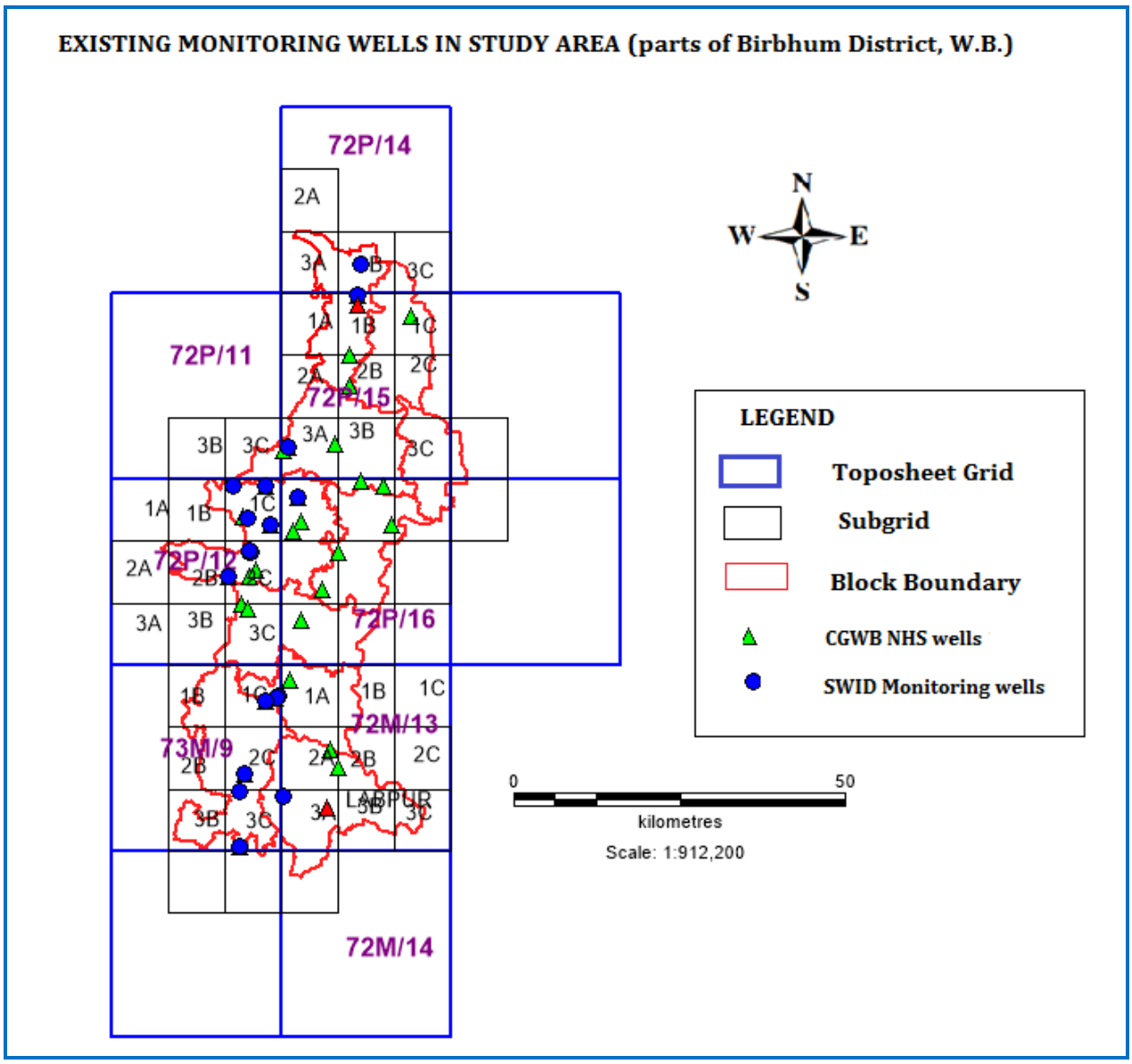


Plate: 2: Map of existing NHS monitoring wells of CGWB & SWID in the study area.

Toposheet No.	Quadrant	No. of Additional Key Wells required Aquifer wise
72P/11	3B	Shallow Aquifer: 1, Deeper Aquifer: 0
72P/12	1A	Shallow Aquifer: 2, Deeper Aquifer: 1
	1B	Shallow Aquifer: 1, Deeper Aquifer : 0
	2A	Shallow Aquifer: 1, Deeper Aquifer : 0
72P/14	3A	Shallow Aquifer: 1, Deeper Aquifer : 0
	3C	Shallow Aquifer: 1, Deeper Aquifer : 1
72P/15	1A	Shallow Aquifer: 2, Deeper Aquifer : 1
	1C	Shallow Aquifer: 1, Deeper Aquifer : 1
	2A	Shallow Aquifer: 1, Deeper Aquifer : 0
	2C	Shallow Aquifer: 1, Deeper Aquifer : 0
	3B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3C	Shallow Aquifer: 2, Deeper Aquifer : 1
72P/16	1C	Shallow Aquifer: 1, Deeper Aquifer : 1
	2B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3A	Shallow Aquifer: 1, Deeper Aquifer : 1

	3B	Shallow Aquifer: 1, Deeper Aquifer : 0
73M/9	1B	Shallow Aquifer: 1, Deeper Aquifer : 0
	2B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3B	Shallow Aquifer: 1, Deeper Aquifer : 1
72M/13	1A	Shallow Aquifer: 0, Deeper Aquifer : 1
	1B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3A	Shallow Aquifer: 1, Deeper Aquifer : 1
	3B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3C	Shallow Aquifer: 1, Deeper Aquifer : 1
72M/14	1A	Shallow Aquifer: 1, Deeper Aquifer : 1

Table 2: Table suggesting aquifer wise extra key-wells for the study area

C. Data Gap for Ground Water Quality Monitoring stations

Water quality monitoring stations are required to study the chemical property of groundwater viz. pH, EC, TDS, Total Hardness, F, Na, K, As, Fe, Cl etc. It has been found that an extra of 39 total wells are required for future monitoring tapping 27No. of shallow aquifer and 12No. tapping Deeper aquifer.

Table 3: Table suggesting aquifer wise extra water quality monitoring stations for the study area

Toposheet No.	Quadrant	No. of Additional Water Quality stations required Aquifer wise
72P/11	3B	Shallow Aquifer: 1, Deeper Aquifer: 0
72P/12	1A	Shallow Aquifer: 2, Deeper Aquifer: 1
	1B	Shallow Aquifer: 1, Deeper Aquifer : 0
	2A	Shallow Aquifer: 1, Deeper Aquifer : 0
72P/14	3A	Shallow Aquifer: 1, Deeper Aquifer : 0
	3C	Shallow Aquifer: 1, Deeper Aquifer : 1
72P/15	1A	Shallow Aquifer: 2, Deeper Aquifer : 1
	1C	Shallow Aquifer: 1, Deeper Aquifer : 1
	2A	Shallow Aquifer: 1, Deeper Aquifer : 0
	2C	Shallow Aquifer: 1, Deeper Aquifer : 0
	3B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3C	Shallow Aquifer: 2, Deeper Aquifer : 1
72P/16	1C	Shallow Aquifer: 1, Deeper Aquifer : 1
	2B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3A	Shallow Aquifer: 1, Deeper Aquifer : 1
	3B	Shallow Aquifer: 1, Deeper Aquifer : 0
73M/9	1B	Shallow Aquifer: 1, Deeper Aquifer : 0
	2B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3B	Shallow Aquifer: 1, Deeper Aquifer : 1
72M/13	1A	Shallow Aquifer: 0, Deeper Aquifer : 1
	1B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3A	Shallow Aquifer: 1, Deeper Aquifer : 1
	3B	Shallow Aquifer: 1, Deeper Aquifer : 0
	3C	Shallow Aquifer: 1, Deeper Aquifer : 1
72M/14	1A	Shallow Aquifer: 1, Deeper Aquifer : 1

REFERENCES

1. Ground Water Year Book 2019-20

2. Ground Water Exploration Report -West Bengal

3. Dynamic Groundwater Resource of West Bengal as on 31st March, 2013

4. Master Plan for Artificial Recharge to Groundwater in India-2020