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CONSERVE WATER – SAVE LIFE

भारत सरकार

GOVERNMENT OF INDIA

जल संसाधन मंत्रालय

MINISTRY OF WATER RESOURCES

केंद्रीय भूजल बोर्ड

CENTRAL GROUND WATER BOARD

केरल क्षेत्र

KERALA REGION

भूजल सूचना पुस्तिका, आलपुषा जिल्ला, केरल राज्य

GROUND WATER INFORMATION BOOKLET OF ALAPPUZHA DISTRICT, KERALA STATE

तिरुवनंतपुरम

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GOVERNMENT OF INDIA
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OF
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द्वारा

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GROUND WATER INFORMATION BOOKLET OF ALAPPUZHA DISTRICT, KERALA STATE

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2.	**GEOMORPHOLOGY**	
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	Major Drainages	Pamba and its tributaries
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	Forest area	Nil
	Net area sown	85697
	Cultivable area	105158
4.	**MAJOR SOIL TYPES**	Coastal Alluvium Riverine Alluvium Brown hydromorphic soil Lateritic soil
5.	**AREA UNDER PRINCIPAL CROPS (Hectares) as in 2009-10**	
	Paddy	97976
	Coconut	257
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	Rubber	6580
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	Other Plantain	11827
6.	**AREA IRRIGATED BY DIFFERENT SOURCES (Hectares) as in 2009-10**	
	Wells (Dug wells &Tube wells / Bore wells)	6503
	Tanks / Ponds	2574
	Canals	2011
	Other Sources	22557
	Net Irrigated area	33982
7.	**NUMBER OF GROUNDWATER MONITORING WELLS OF CGWB (As in 31-3-2011)**	
	No. of Dug wells	40
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9.	**HYDROGEOLOGY**	
	Major Water bearing formations	Weathered and fractured crystalline formations, Tertiary sedimentary formation, Sub-Recent laterite and Recent Alluvium
	Depth to water level (Pre-monsoon, April 2011)	0.72 to 12.49 m.bgl
	Depth to water level (Post-monsoon, Nov. 2011)	0.08 to 6.30 m.bgl
	Long term water level trend (2002-2011)	No conspicuous change in trend in phreatic aquifers. Tertiary aquifers show a falling trend in the range of 0.05 to 0.28 m/year
10.	**GROUND WATER EXPLORATION BY CGWB (As in 31-03-2011)**	
	No. of wells drilled (EW, OW, PZ, SH, Total)	EW -19, OW – 3, Pz -18, SH – 24. Total - 64
	Depth Range (m)	30-600
	Discharge (m^3/hr)	6 -120 (Tertiary aquifer)
	Storativity(S)	1.2×10^{-3} to 4.4×10^{-3} (Tertiary aquifer)
	Transmissivity (m^2/day)	6 - 3856
11.	**GROUND WATER QUALITY**	
	Presence of chemical constituents more than permissible limits(e.g. EC, F, As, Fe)	Major chemical constituents within the permissible limits. Fluoride excess in certain tube wells.
12	**DYNAMIC GROUNDWATER RESOURCES (2009) – in MCM**	
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	Net Annual Groundwater Draft	129.35
	Projected demand for Domestic and Industrial Uses up to 2025	103.72
	Stage of Ground Water Development, %	28.51
13.	**AWARENESS AND TRAINING ACTIVITY**	
	Training Programme organized Date Place No. of Participants	1 21st December 2005 Alappuzha 100
14.	**GROUND WATER CONTROL AND REGULATION**	
	Number of Over Exploited blocks	Nil
	Number of Critical blocks	Nil
	Number of blocks notified	Nil
15.	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	Decline in water level in Tertiary aquifers, ground water quality deterioration along tidal inlets and anthropogenic pollution

GROUND WATER INFORMATION BOOKLET OF ALAPPUZHA DISTRICT, KERALA STATE

1.0 INTRODUCTION

Alappuzha (Alleppey) is one of the well-developed coastal districts in southern part of Kerala State covering an area of 1,414 sq.km and is the smallest district accounting 3.64% of the area of the State. Alappuzha district was formed on 17th August 1957. It is the only district in the State where there are no reserved forests. Kuttanad, also known as the "rice bowl of Kerala" has a predominant position in the production of rice. Alappuzha is well known for its coir industry with innumerable outlets for various finished coir products. The district lies between North latitudes 9^{o} 05' and 9^{o} 54' and East longitude 76^{o} 17' and 76^{o} 36'and is surrounded by Lakshadweep sea on the west, Kottayam and Pathanamthitta districts in the east, Kollam district in the south and Ernakulam district in the north.

According to 2011 census, the district has a population of 2121943. Of the total population 1010252 are males and 1111691 are females. The population density is 1501 persons/sq.km, the highest among all the districts of the State.

Alappuzha is the Headquarters of the district. The district has 6 taluks viz. Sherthalai, Ambalappuzha, Kuttanad, Karthikapally, Chengannur and Mavelikara which have further been subdivided into 12 Community Development Blocks and 73 Grama Panchayats. There are five municipalities namely Chengannur, Alappuzha, Kayamkulam, Mavelikara and Cherthala.

The district is well connected by good roads and rail. The National Highway NH-47, the Main Central road (M.C road) and the Delhi - Mumbai - Trivandrum broad-gauge railway line are passing through this district. Alappuzha town is crisscrossed by navigable canals that are connected to Cochin in the north and other important towns in the east.

An index map of the district is given in **Figure 1**.

Drainage

Alappuzha district is drained mainly by *Pamba* River and its tributaries viz. *Achankovil* and *Manimala* Rivers. The *Pamba* River drains an area of 804 sq.km of the district and form a deltaic region skirting the south eastern, southern and south western fringes of *Vembanad* Lake. The *Manimala* River enters the Kuttanad area at Thondara and confluences with Pamba River at Neerettupuram. Achancovil Ar enters Kuttanad at Pandalam and joins Pamba River at Veeyapuram. Vembanad Lake, the largest back water in the State lies on the north eastern part of the district separating Alappuzha from Kottayam district.

Irrigation

There are no major irrigation projects in Alappuzha district. However about 19 sq.km. in the southwestern part of the district is benefited by the Pamba Irrigation Project. Minor and lift irrigation projects irrigate an area of about 181 sq. km. The source-wise data on irrigation are given in Table1.

Table 1: Source-wise area under irrigation in Alappuzha district

Sl.No	Source	Net area irrigated (ha)
1.	Canal Irrigation	2011
2	Tank	2574
3	Well Irrigation	6503
4	Other sources	22557

(Source: Bureau of Economics & Statistics Department, Govt. Kerala, Trivandrum)

Land use

The Kerala State Land Use Board has computed the area under various uses. The following Table represents the land under various categories.

Table 2: Land use pattern in Alappuzha district

Sl.No	Category	Area in hectares	% of total area
1	Geographical area	141400	100
2	Built up land	1894	1.34
3	Agriculture land	121762	86.04
5	Water bodies	17550	12.4
6	Waste land	297	0.21
7	Others	26	0.02

Studies carried out by CGWB

Groundwater resources along the coast in the district was first studied as part of the 'Systematic hydrogeological studies' carried out by the erstwhile Groundwater Division of Geological Survey of India, Southern Region, Hyderabad during the years 1970-'71 and 1971-'72.

Exploratory drilling operations in the coastal plains were started by Exploratory Tube Well Organization, Govt. of India during the 50's itself. CGWB continued exploration and tube wells were constructed tapping potential aquifers in the Tertiary formations during the period between 1973 and 1982.

Central Ground Water Board, under its SIDA assisted Coastal Kerala Groundwater Project carried out detailed hydrogeological surveys and exploratory drilling during 1983-'88. Chemical quality of groundwater in shallow and deep aquifers was also studied in detail under this project.

Under The World Bank Assisted Hydrology Project (1996-2000) the existing infrastructure on groundwater regime monitoring was strengthened. CGWB and GWD, Govt. of Kerala jointly implemented the groundwater component of Hydrology Project. The ultimate objective of Hydrology Project was to establish a functional Hydrologic Information System where hydrogeological data can be generated, collected, processed, stored and retrieved for various user agencies. CGWB has been monitoring water level from Ground Water Monitoring Wells (GWMW) for the last 30 years, which comprises dug wells tapping phreatic aquifers and piezometers tapping semi-confined to confined aquifers.

2.0 CLIMATE AND RAINFALL

The district has a tropical humid climate with an oppressive summers and plentiful seasonal rainfall. The period from March to the end of May is the hot season. This is followed by the southwest monsoon season, which continues till the end of September. During October and major part of November southwest monsoon retreats giving place to the northeast monsoon, and the rainfall up to December is associated with northeast monsoon season.

The district receives an average annual rainfall of 2965.4 mm. The southwest monsoon season from June to September contributes nearly 60.3% of the annual rainfall. This is followed by the northeast monsoon season from October to December, which contributes about 20.9% of the annual rainfall, and the balance 18.8% is received during the period from January to May months. The monthly rainfall for the Alappuzha district during the period 2006-10 is tabulated in **Table 3** below

Table 3: Rainfall in mm during the years 2006 – 2011

Month	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
January	11.7	0	0	1.7	16.6	18
February	0	30.5	88.2	4.4	2.2	28
March	58.4	2.2	175.5	45.3	92.7	43
April	73.6	139.7	166.3	131.9	161.6	180
May	495.3	284.2	127.8	256.4	322	254
June	481.5	597.3	366.5	559.8	529.3	571
July	442.6	780.2	660.7	503.3	474.6	557
August	332.4	368.3	189.4	164.0	255.9	341
September	400.2	417.6	332.6	250.3	242.3	277
October	450.8	306.8	313.7	210.9	555.1	333
November	268.1	173.4	122.3	318.5	309.3	187
December	6.0	6.4	41.9	54.6	96.8	52
Total	**3020.6**	**3106.6**	**2584.9**	**2501.1**	**3058.4**	**2841**

The district has got two well-equipped observatories at Kayamkulam and Alappuzha maintained by CPCRI and IMD respectively.

Temperature

Generally March and April months are hottest and December and January months are coldest. At Alappuzha the maximum temperature ranges from 28.8 to 32.7ºC whereas the minimum temperature ranges from 22.6 to 25.5ºC. The average annual maximum temperature is 30.7ºC and the average annual minimum temperature is 23.9 ºC.

Wind

The wind is predominantly from east and northeast during morning hours and during the evening hours the predominant wind direction is from west and northwest. The wind

speed is low in Kayamkulam. The wind speed is high during May (13.6 kmph) at Alappuzha.

Humidity

The humidity is higher during the monsoon period, June to September. It is around 87% at Alappuzha and 84% at Kayamkulam. All through the year, the humidity is high during the morning hours.

3.0 GEOMORPHOLOGY AND SOIL TYPES

A major part of the district forms part of the coastal plains. The general elevation of the area is less than 6 m above mean sea level with some parts of the area below mean sea level in the range of 1-2 m. Typical coastal geomorphic features such as beaches, shore platforms, spit and bars, beach ridges etc are seen. A small part of the district in the southeast forms part of mid land hard rocks. The area east and southeast of Alappuzha town is known as 'Kuttanad region'. It represents a low-lying deltaic region characterized by wetlands. The beach ridges are suggestive of marine regression. Beach is very narrow and straight. The absence of extensive tidal plain and the intensive coastal erosion may be indicative of neo-tectonic activity. The beach between Purakkad and Trikkunnappuzha is undergoing active erosion.

3.1 Soils

On the basis of morphological and physico-chemical properties, the Soil Survey Division of Department of Agriculture, Govt. of Kerala has classified the soils of the district into four types viz. (1) Coastal alluvium (Entisols), (2) Riverine Alluvium (Inceptisols) (3) Brown hypidimorphic soil (Alfisols) and (4) Lateritic soil (Oxisols).

Coastal Alluvium (Entisols)

These soils are seen along the western parts of the district all along the coast and have been developed from recent marine and estuarine deposits. The texture is dominated by sand fraction and is extensively drained with very high permeability. These soils have low content of organic matter and of low fertility level.

Riverine alluvium (Inceptisols)

These soils occur mostly in the central pediplains and eastern parts of the area along the banks of Pamba River and its tributaries and show wide variation in their physico-chemical properties depending on the nature of alluvium that is deposited and characteristics of the catchment area through which the river flows. They are very deep soils with surface textures ranging from sandy loam to clayey loam and moderately supplied with organic matter like nitrogen and potassium.

Brown hydromorphic soil (Alfisols)

These are mostly confined in the western low-lying areas of the district along the coast. These soils have been formed as a result of transportation and sedimentation of material from the adjoining hill slopes and also through deposition by rivers and exhibit wide variation in their physical and chemical properties. They are moderately supplied with organic matter like nitrogen, potassium and deficient in lime and phosphate.

Lateritic soil (Oxisols)

The lateritic soil is the result of weathering process of Tertiary and Crystalline rocks under tropical humid conditions and is seen in the south-eastern part of the district. Heavy rainfall and temperature prevalent in the area are conducive to the process of formation of this soil type and have been formed by leaching of base and silica from the original parent rock with accumulation of oxides of iron and aluminum. They are poor in nitrogen, phosphorous, potassium and low in bases. The organic content is also low and is generally acidic with pH ranging from 5.0 to 6.0.

4.0 GROUNDWATER SCENARIO

4.1. Hydrogeology

Alappuzha district consists of Coastal alluvium comprising sand and clay along the coastal region and flood plain deposits in Kuttanad region. Residual laterite formations are encountered in the south-eastern parts of the district and granites are encountered in and around Chengannur area. Charnockite, Khondalite and Granites form the basement. Charnockites and Khondalites are encountered at depth. They are overlain by Tertiary sedimentary formations. The laterite/alluvial sediments overlay the Tertiaries. Domestic water requirements of the district are met from groundwater source on a large scale.

Requirements for drinking water supply source are met with from a large number of tube wells. The aquifer system in the district can be broadly classified into Crystalline, Tertiary and Alluvial aquifers. Large-scale abstraction of groundwater is from Tertiary sedimentary formation.

Groundwater in crystalline formations

The crystalline formations occur in the southeastern part of the district, mostly capped by thick laterite cappings. The occurrence and movement of ground water are dominantly controlled by the nature and extent of weathering and the presence of structural features like fractures, joints and shear zones which generally varies from place to place. Ground water occurs in the secondary inter-granular pores and voids, under unconfined conditions in the shallow weathered and fractured rocks and under semi-confined to confined conditions in the deeper fractured zones**.**

Exploratory drilling by CGWB has revealed the presence of low potential fractures (yield range of about 60-120 lpm) in this part of the crystalline formation. The details of exploratory wells drilled in hard rock areas are given in **Annexure IA**.

Groundwater in Tertiary formations

The Tertiary formations constitute the major aquifer in Kuttanad and the coastal area with total thickness of sediments ranging from 90.0 to more than 600 m. They are underlain by crystalline basement and overlain by laterite and unconsolidated formations. Tertiary formations consist of Aleppey beds, Vaikom beds, Quilon beds and Warkalli beds. Of these, Warkalli beds is the most extensively developed aquifer in the district. The SIDA assisted Coastal Kerala Ground Water project explored the potentialities of the deep sedimentary formations in the district. During the project, 19 exploratory bore wells were drilled. Subsequently, 18 more tube wells were drilled by CGWB under Hydrology project. Locations of these wells are shown in **Figure 1** and the details are given in **Annexure 1B**.

a. Groundwater in Alleppey bed

The bottom most unit of Tertiary sedimentary formations, the Alleppey bed, comprising of highly carbonaceous clay with intercalations of sand was encountered in tube wells at Trikunnapuzha below 522 m bgl and at Kottaram below 299 m bgl. The formation water is brackish in quality as revealed by electrical logging and hence no wells were constructed tapping this formation.

b. Groundwater in Vaikom beds

Vaikom beds overlying the Alleppey bed with thickness varying from 25 to 238 m, is the most potential aquifer among the Tertiary formations of the district. They comprise gravel, coarse sand, clay and seams of lignite. They are exposed in southeastern part of the district in the midland area and are highly lateritised at the surface. The thickness of the granular zones tapped by the tube wells constructed in this aquifer ranges between 5 and 210 m with discharges in the range of 11 to 96 m^3/hr. However, the water from Vaikom aquifer in Kuttanad region and in coastal zone west of Vembanad Lake is highly mineralized. Some of the tube wells with high discharge of 57.6 to 96.7 m^3/hr have drawdowns in the range of 2.23 to 6.76 m. The tube wells at Karuvatta, Karumadi, Karthikapalli and Kandiyur have free flow with water level in the range of 1.44 to 4.29 m agl. General groundwater flow in this aquifer is from south to north. The transmissivity ranges from 6 m^2 /day in the eastern recharge area to 3856 m^2/day at Karuvatta and the storativity is between 1.2×10^{-3} to 4.4×10^{-3}. The specific capacity of tube wells is in the range of 23.5 lpm/m at Ramankari area, to 420 lpm/m at Karthikapalli area.

c. Groundwater in Quilon bed

Compared to the underlying Vaikom beds, the groundwater potential from the Quilon bed is not very promising. The thickness of granular zones tapped in this aquifer is between 6 to 10 m and is composed of fine sand. The piezometric head is 0.1 m above ground level and the transmissivity of the aquifer is found to be 29.22 m^2/day.

d. Groundwater in Warkali bed

The Warkali aquifer overlying the Quilon bed is composed of medium to fine grained sand with an effective grain size of 0.21 to 0.30 mm. This bed is the most extensively developed aquifer in the district. Groundwater occurs in semi-confined to confined

conditions with the cumulative thickness of granular zone varying from 6 to 44 m. The piezometric head of Warkali beds in the tube wells drilled by Central Groundwater Board is in the range of 2.8 m amsl in the east (Kandiyur) and 10 m bmsl at Alappuzha.

The tube wells have depth range of 22 – 258 m and have discharge in the range of 6 – 120 m^3/hr with drawdown of less than 1 to 5.60 m for a of pumping of 600 to 3000 minutes. The specific capacity is in the range of 98.01 to 168.00 lpm/m and transmissivity ranges between 221 and 712 m^2/day.

Groundwater in Recent Alluvial Deposits

The Recent unconsolidated formations constitute an important phreatic aquifer comprising coastal sands all along the coast and flood plain deposits in interior Kuttanad area. A large number of shallow dug wells and tube wells for domestic use and to a limited extent for irrigation and industrial purpose tap this aquifer. The water table is generally shallow. Depth of wells tapping coastal sediments ranges between 2.75 to 10.60 m bgl with depth to water level in the range of 1.0 to 2.0 m bgl. Open wells when tested for yield sustained pumping in the range of 20 to 80 minutes and had discharge in the range of 11.76 to 12.90 m^3/hr for a drawdown ranging from 0.7 to 5.58 m. The wells have specific capacity in the range of 10.74 to 75.23 m^3/day/m.

Water levels and their Long term behaviour

Central Ground Water Board has a network of 40 Ground Water Monitoring Wells (GWMW) in Alappuzha district. These wells are monitored for ground water level four times a year i.e April, August, November and January. Block wise distribution of groundwater levels during pre monsoon (April 2011) and post monsoon (Nov 2011) are presented in the following Tables 4 & 5 respectively. The pre monsoon depth to water levels ranged from 0.50 to 12.00 m bgl. During April 2011, shallowest water level of 0.50 was observed in Harippad block and deepest water level of 12 m was noticed in Bharanikavu block. Shallow water levels in the range of 0- 2 mbgl were observed in Ambalapuzha, Aryad, Champakulam, Chengannur, Harippad, Mavelikara, Pattanakkad and Veliyanad blocks. Depth to water levels between 2 to 10 m bgl were observed in Ambalapuzha, Bharanikavu, Champakulam, Chengannur, Haripad, Kanjikuzhy,

Mavelikara, Muthukulam, Pattanakad and Thaikkattussery blocks. Depth to water levels in excess of 12 mbgl was observed in Bharanikavu block.

Table 4: Block wise distribution of ground water levels (April 2011)

Name of Block	No. of wells analysed	Depth to water level, mbgl		No./ % of wells showing DTWL in the range of			
		min	max	0-2	2-5	5-10	10-20
Ambalapuzha	2	1.83	2.76	1/50	1/50	0	0
Aryad	1	1.70	1.70	1/100	0	0	0
Bharanikkavu	4	2.77	12.00	0	2/50	1/25	1/25
Champakulam	3	0.65	2.28	2/67	1/33	0	0
Chengannur	2	1.90	5.88	1/50	0	1/50	0
Haripad	3	0.50	2.52	1/33	2/67	0	0
Kanjikkuzhy	2	1.49	3.00	1/50	1/50	0	0
Mavelikkara	5	1.85	8.60	3/60	1/20	1/20	0
Muthukulam	1	4.61	4.61	0	1/100	0	0
Pattanakkad	2	0.62	2.24	1/50	1/50	0	0
Thaikkatussery	1	2.47	2.47	0	1/100	0	0
Veliyanad	1	1.13	1.13	1/100	0	0	0

During November 2011, shallowest water level of 0.25 was observed in Kayamkulam Municipality and deepest water level of 12.10 m was noticed in Bharanikavu block. Maps showing the spatial distribution of ground water levels are shown in **Figures 2 & 3** respectively. A generalized hydrogeological map of the district is presented in **Figure 4**.

Table 5: Block wise distribution of ground water levels (Nov. 2011)

Name of Block	No. of wells analysed	Depth to water level, mbgl		No./ % of wells showing DTWL in the range of			
		min	max	0-2	2-5	5-10	10-20
Ambalapuzha	4	0.50	2.26	3/75	0	125%	0
Aryad	1	1.10	1.10	1/100	0	0	0
Bharanikkavu	6	1.35	12.10	1/17	2/33	1/17	2/33
Champakulam	3	0.28	0.95	3/100	0	0	0
Chengannur	2	1.80	5.76	1/50	0	0	1/50
Haripad	3	0.75	1.59	3/100	0	0	0
Kanjikkuzhy	2	0.69	1.90	2/100	0	0	0
Mavelikkara	5	0.95	7.45	4/80	0	0	1/20
Muthukulam	2	0.55	3.51	1/50	0	1/50	0
Pattanakkad	2	0.85	1.64	2/100	0	0	0
Thaikkatussery	2	1.25	1.82	2/100	0	0	0
Veliyanad	1	0.52	0.52	1/100	0	0	0

The decadal average water level for the period from 2002-11 were analysed and is given in the **Table 6**.

Table 6: Block wise Decadal Average Depth to water level (2002-2011)

Sl. No	Block Name	Pre monsoon	Post monsoon
1	Ambalapuzha	2.20	1.10
2	Aryad	1.62	0.88
3	Bharanikkavu	7.91	6.27
4	Champakulam	1.50	0.44
5	Chengannur	4.36	2.78
6	Haripad	1.65	0.71
7	Kanjikuzhy	1.71	1.12
8	Mavelikkara	3.34	1.70
9	Muthukulam	2.89	1.57
10	Pattanakad	1.98	0.90
11	Thaikkatussery	2.23	1.06
12	Veliyanad	0.84	0.45

Average depth to water level in the range of 0-2 mbgl is noticed in all the blocks except Bharanikavu during pre-monsoon period. Shallow water levels less than 2mbgl is noticed in Aryad, Champakulam, Haripad, Kanjikuzhy, Pattanakkad and Veliyanad blocks. In post monsoon period average depth to water level less than 2 mbgl is noticed in all the blocks except Bharanikavu.

Long term changes in deeper aquifers

The water level hydrograph of Karthikapalli piezometer tapping Warkali formation shows a steady decline of both pre-monsoon and post-monsoon piezometeric level for last two decades. The piezometer tapping Quilon formation also behaves in the similar pattern.

Similarly, the water level data recorded in the stations at Kandiyur and Muttom tapping Vaikom and Warkali formations for the period since 1987 showed declining trend both during pre-monsoon and post-monsoon period. This indicates that extensive groundwater development is taking place over years and the recharge during monsoon season is not enough to compensate groundwater development.

Ground water Resources

Assessment of dynamic ground water resources of the district as in March 2009, computed block-wise as per the norms of Ground Water Estimation Committee (GEC) 1997 indicate net annual ground water availability of 453.65 MCM. The gross ground water draft for all uses is of the order of 129.35 MCM. The net availability of ground water for future irrigation is of the order of 320.02 MCM. The stage of ground water development for the district as a whole is about 28.5%, ranging from 13% in Velianad block to 60% in Aryad block. Salient details of the computation of ground water resources in the district are shown in **Table 7**. As per the assessment, all the blocks in the district have been categorized as 'Safe'.

Table 7: Salient Details of Assessment of Dynamic Ground Water Resources of Alappuzha District as in 2009.

Sl. No.	Assessment Unit/ Block	Total Annual Ground Water Recharge	Provision for Natural Discharges during non monsoon season	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for All uses	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development (%)
1	Ambalappuzha	2472.49	123.62	2348.87	752.05	1556.40	32.02
2	Aryad	2785.34	139.27	2646.07	1596.81	938.60	60.35
3	Bharanikkavu	5543.94	277.20	5266.75	1180.26	4024.12	22.41
4	Champakkulam	4812.45	481.24	4331.20	607.44	3679.90	14.02
5	Chengannur	4959.67	247.98	4711.69	1740.31	2898.12	36.94
6	Harippad	3961.10	198.05	3763.04	1272.84	2601.93	33.82
7	Kanjikkuzhy	3277.26	327.73	2949.53	851.97	2038.79	28.89
8	Mavelikkara	5054.57	252.73	4801.84	1014.93	3721.22	21.14
9	Muthukulam	3907.83	195.39	3712.44	1437.64	2286.27	38.73
10	Pattanakkad	3398.54	169.93	3228.61	1118.19	2102.72	34.63
11	Thycattussery	3740.38	374.04	3366.34	791.75	2521.36	23.52
12	Veliyanad	4461.80	223.09	4238.71	570.64	3632.21	13.46
	TOTAL (ha.m)	**48375.37**	**3010.27**	**45365.10**	**12934.84**	**32001.63**	**28.51**
	TOTAL (MCM)	**483.75**	**30.10**	**453.65**	**129.35**	**320.02**	**28.51**

Groundwater potential of deeper aquifers

Among the deeper confined aquifers of Tertiary group, Warkali and Vaikom aquifers are potential and ground water development is mostly restricted to these aquifers. The Quilon bed is a poor aquifer and is not being developed much. As Alleppey bed contains brackish formation water, this aquifer is also not being developed.

Warkali aquifers

Warkali aquifer is the most potential fresh water aquifer in the Tertiary formations. Hence the maximum groundwater development has taken place in this aquifer catering to the needs of the dense coastal population. The total groundwater potential available in the aquifer has been computed as about 36 MCM. Many piezometers have been constructed in this aquifer by Central Ground water Board to monitor the groundwater development.

Vaikom aquifer

Next to Warkali aquifer, Vaikom aquifer is highly potential. The total groundwater potential available in this aquifer is of the order of 10 MCM.

Groundwater quality

The chemical characteristics of the groundwater in the shallow and deep aquifers of the district are being monitored by the Central Ground water Board through a network of shallow domestic wells, tube wells and bore wells. In addition to this, water quality in the water supply wells of Kerala Water Authority is also being studied. The electrical conductivity is an index of mineralisation of groundwater. Dug wells in most of the area show electrical conductivity (EC) in the range of 200 to 800 µs/cm at 25ºC indicating freshwater suitable for all purposes. High EC values are noted in dug wells located adjacent to tidal inlets and brackish water bodies. However, due to the poor sanitary conditions and the shallow ground water levels, ground water in a major part of the district suffers from bacteriological contamination, making it unsuitable for drinking. The range of concentration of various chemical constituents in the shallow groundwater collected during April 2009 is presented in **Table 8**.

Table 8: Range of chemical parameters in shallow monitoring wells

Sl.No.	Parameters	Range of concentration		Desirable limit	Maximum permissible limit
		From	To		
1	EC, µs/cm at 25^0C	39	1423	750	3000
2	pH	6.04	8.98	6.5-8.5	6.5-8.5
3	Ca, mg/l	1.6	46	75	200
4	Mg, mg/l	0.49	5.8	30	100
5	SO_4, mg/l	N.A	N.A	200	400
6	TH, mg/l as $CaCO_3$,	8	200	300	600
7	NO_3, mg/l	0.26	77	45	-
8	Fe, mg/l	N.A	N.A	0.54	1.0-1.5
9	F, mg/l	0.01	0.41	1.0	1.5
10	Cl, mg/l	5.7	320	250	1000

The hydrochemical data of samples collected from dug wells is given in **Annexure II**.

5.0 GROUNDWATER MANAGEMENT STRATEGY

Groundwater Development

The district is blessed with abundant groundwater resources in phreatic, semi-confined and confined conditions. Groundwater is mainly used for drinking and industrial purposes. The phreatic aquifer is tapped by dug wells and filter points generally fitted with 1.0 to 1.5 HP pumps. The deeper productive confined aquifers are extensively developed through submersible or vertical turbine pumps for drinking water supply.

Water Conservation and Artificial Recharge

The district is a coastal plain land and major part of the district lies between 2m a msl to 2m b msl. The phreatic aquifer is composed of alluvial and beach sand. Since the sand is highly porous and permeable, natural recharge takes place automatically and a major part of the percolated rainwater goes off as rejected recharge which reaches to the drain channel as surface run off or sub surface runoff. Hence there is no immediate need for Artificial Recharge in the phreatic aquifer. However, in view of the large scale bacteriological contamination of ground water in the phreatic zone as well as the salinity problems in the coastal tracts, rainwater harvesting for direct use through storage tanks is feasible in the entire district **(Figure 5).**

6.0 GROUNDWATER RELATED ISSUES AND PROBLEMS

Vulnerable areas

A major part of the district is vulnerable to bacteriological contamination due to the shallow water levels and existing sanitary practices. The area around Chandirur and Thuravur has a lot of fish processing factories. The fluid wastes from these factories are polluting the nearby canals and this in turn may pollute the sub-surface water. Proper scientific guidelines and monitoring of the industrial waste disposal system is necessary for preventing large scale groundwater pollution due to industrial waste.

Water logging and conjunctive use studies

Most of the Kuttanad area lie in submerged condition during major part of the year. It is subjected to the twin hazards of flood discharge during monsoon and sea water ingress during summer on either side of Vembanad Lake. Excess water from the paddy fields are being pumped out to the discharge channel finally leads to ocean. Canal irrigation from the Pamba-Achenkoil project is practiced in areas outside of Alappuzha and the canals in Kuttanad are mainly used for navigation and for discharging the excess water pumped out of paddy fields and for discharging the flood from Pamba River to the Vembanad Lake.

Special groundwater problems and studies

Ground Water Quality Deterioration

Bacteriological contamination of ground water from leach pits is a major problem affecting the safe drinking water supply to habitations in the district. Habitations in the close proximity of ocean, backwater canals and Vembanad Lake also suffers from quality deterioration due to ingress of saline water during the summer months.

The Kuttanad area has a very delicate ecosystem. Extensive use of hazardous chemicals would cause environmental pollution and will also lead to destruction of natural enemies of pests. People now seem to be slowly awakening to the dangers, following the suspicion that water pollution especially due to pesticides has caused the outbreak of fish disease in the recent past.

Fluoride hazard

Ground water in phreatic aquifers have fluoride concentration within permissible limit, in the range of 0.08 to 0.62 mg/l. However, a few tube wells tapping deeper confined aquifers around Alappuzha urban area have fluoride concentration in the range of 1.7 to 2.56 mg/l.

Environmental Problems and issues

The district, forming mostly coastal and complex deltaic plains, is crisscrossed by a number of canals, lagoons, estuaries and backwaters. These water bodies are the interaction zones between the open marine and the inland drainage system and are highly sensitive to changes in the environmental parameters. Backwater system and Vembanad Lake exert considerable influence on the ecology of surrounding area. The dense population and intense land use practices in the area has complicated geomorphological set-up. The various environmental problems in the district are discussed in the following paragraphs.

Effects of coastal erosion

Coastal erosion is one of the grave natural hazards affecting the district and extensive coastal erosion is taking place in the coastal areas of Thottappalli and Purakkad. Preventive measures like construction of sea walls of various lengths at Trikkunnapuzha, Arattupuzha, Pallara, Thottapalli, Purakkad, Punnapra coastal belts to arrest the sea erosion have been attempted.

Tidal effect

The tidal effect is felt mostly in the vicinity of the coast and areas adjacent to the streams and river inlets and areas surrounding backwaters, sometimes extending up to 12 km upstream. As a result of this tidal influence the quality of shallow groundwater very close to these tidal rivers is affected during summer months and the water becomes brackish.

Water pollution and degradation of ecosystem

The Indo-Dutch study programme, which went deep into the regional problems in 1990-'91 has brought out that very high concentration of DDT and its metabolites like DDE and DDD were noticed in water sediments and tissue samples of aquatic animals.

Mud banks

Ambalappuzha - Purakkad area in the Alappuzha district is famous for mud banks, which form a rich source of fish. These features appear during south-west monsoon aided by sea waves causing ejection of loose subterraneous material through churning action. The mud banks are few meters away from the high water mark and fall in the inter tidal zone. Mud banks are unique features in Alappuzha coast.

7.0 AWARENESS AND TRAINING ACTIVITY

Mass awareness programme and Water Management Training Programme

One mass awareness programme on groundwater conservation and artificial recharge and one training programme on groundwater management were organized during the year 2005.

8.0 AREA NOTIFIED BY CGWA/ SGWA

No blocks in the district has been notified by CGWA / SGWA.

9. 0 RECOMMENDATIONS

- The groundwater potential in the alluvial terrain can be developed through various groundwater structures viz. dug wells, filter points and shallow tube wells. Dug wells ranging in depth from 4.0 to 7.0 m with diameter of 1.50 to 2.0 m is recommended. Filter points are feasible in areas around Nirkunnam, Kayamkulam, Haripad, Thottapally, Alappuzha, Aryad and Shertallai, Pattanakkad and Thuravoor.
- Laterite aquifer in the southeastern parts of the district can be developed through open dug wells ranging in depth from 10 to 12 m with a diameter of 3.5 to 4.0 m. There is a big gap between dynamic phreatic groundwater resource available and utilised in the district. Accelerated groundwater development in the district would bring more area under irrigation since there is a lot of resource untapped.

- The deeper Tertiary sediments can be developed through tube wells. There is scope for additional 55 tube wells in the district in the depth range of 100-150 m tapping the Warkali aquifer with a minimum granular thickness of 15 m.
- The deeper Vaikom aquifer in the Tertiary formation has fresh water in the area south of Karuvatta and an additional 15 tube wells in the depth range of 150-300 m tapping a minimum granular thickness of 20 m can be constructed.
- In Alappuzha district the individual land holdings are small. Hence community irrigation schemes using groundwater resources have to be given top priority.
- Development of groundwater will go a long way in providing assured irrigation and drinking water even to remote areas. Development of water resources needs a scientific management system coordinating the efforts of all concerned State and Central agencies for a speedy development of the district in the agricultural sector.
- The groundwater in Alappuzha district is the most precious resource and the recharge area has to be demarcated precisely and protected properly from pollution. If necessary the recharge area is to be notified as protective area where pollution prone industries are to be banned.
- R & D studies in Kuttanad by CGWB in collaboration with Centre for Earth Science Studies (CESS) shows microbiological contamination of rivers and other surface water bodies in Alappuzha area. It is recommended that Kerala Water Authority (KWA) may consider these facts before going ahead with drinking water schemes using Pamba river water as source.

Figure.1 Index Map of Alappuzha district

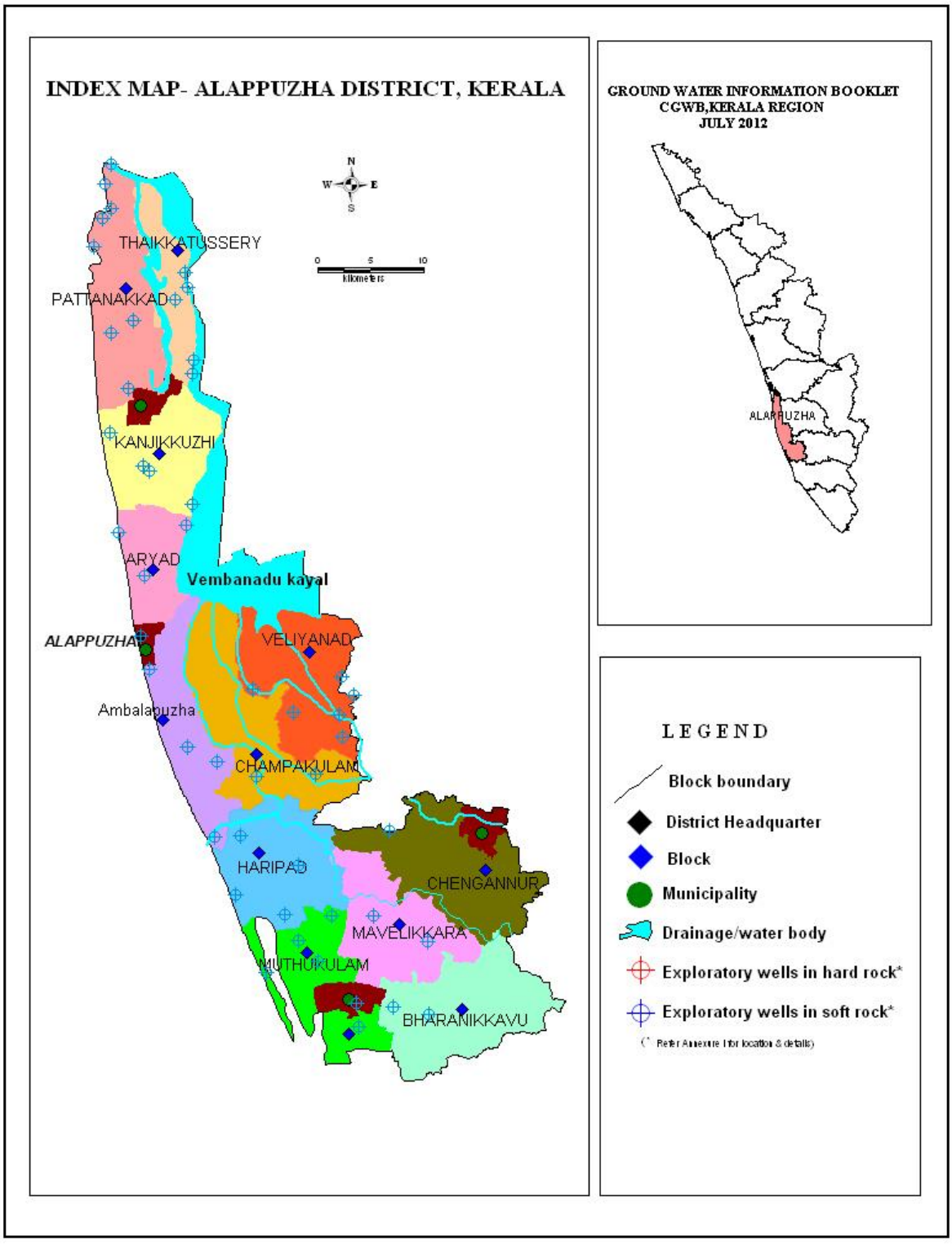


Figure.2 Pre monsoon Depth to water level of Alappuzha district (April 2002-11)

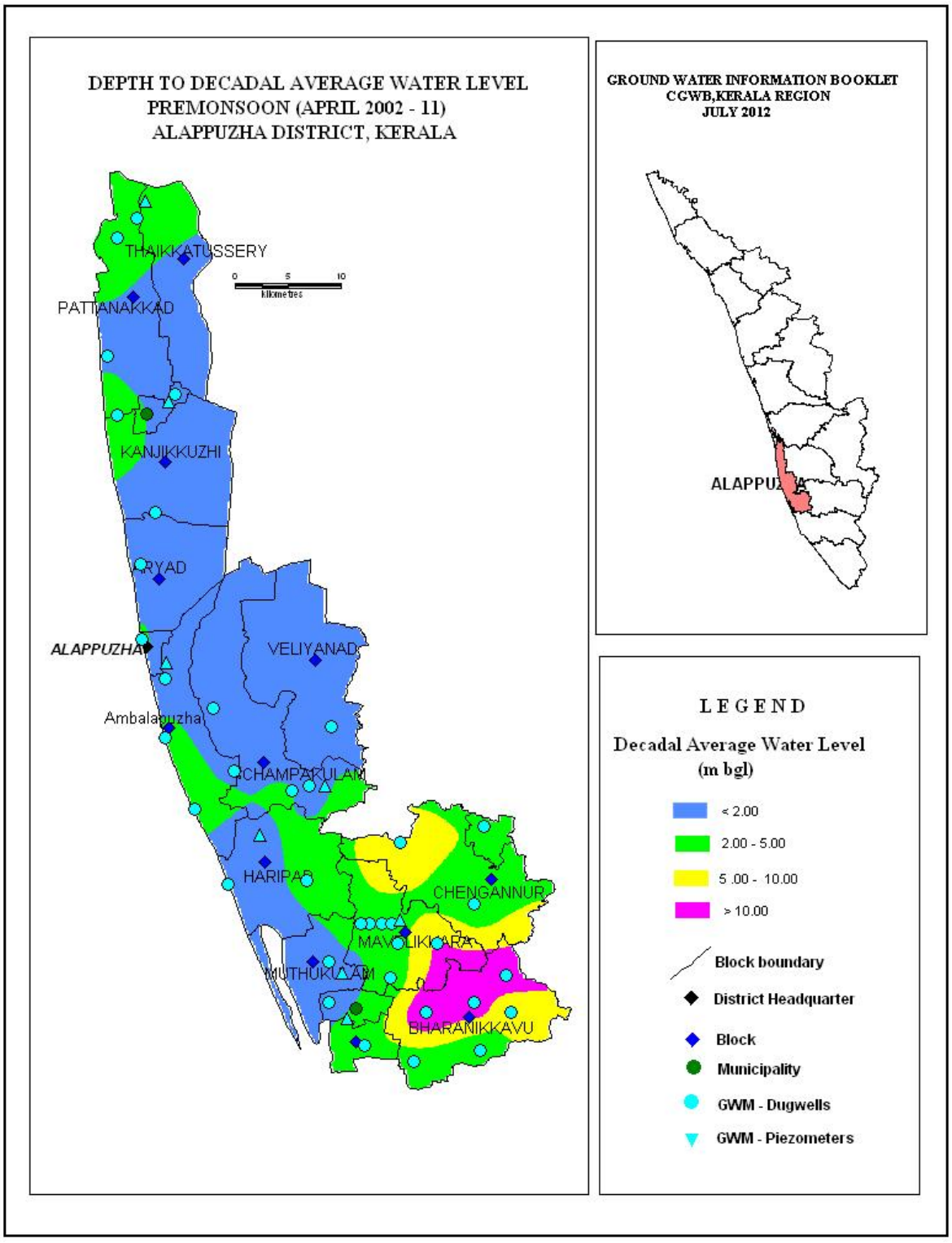


Figure.3 Post monsoon Depth to water level of Alappuzha district (November 2002-11)

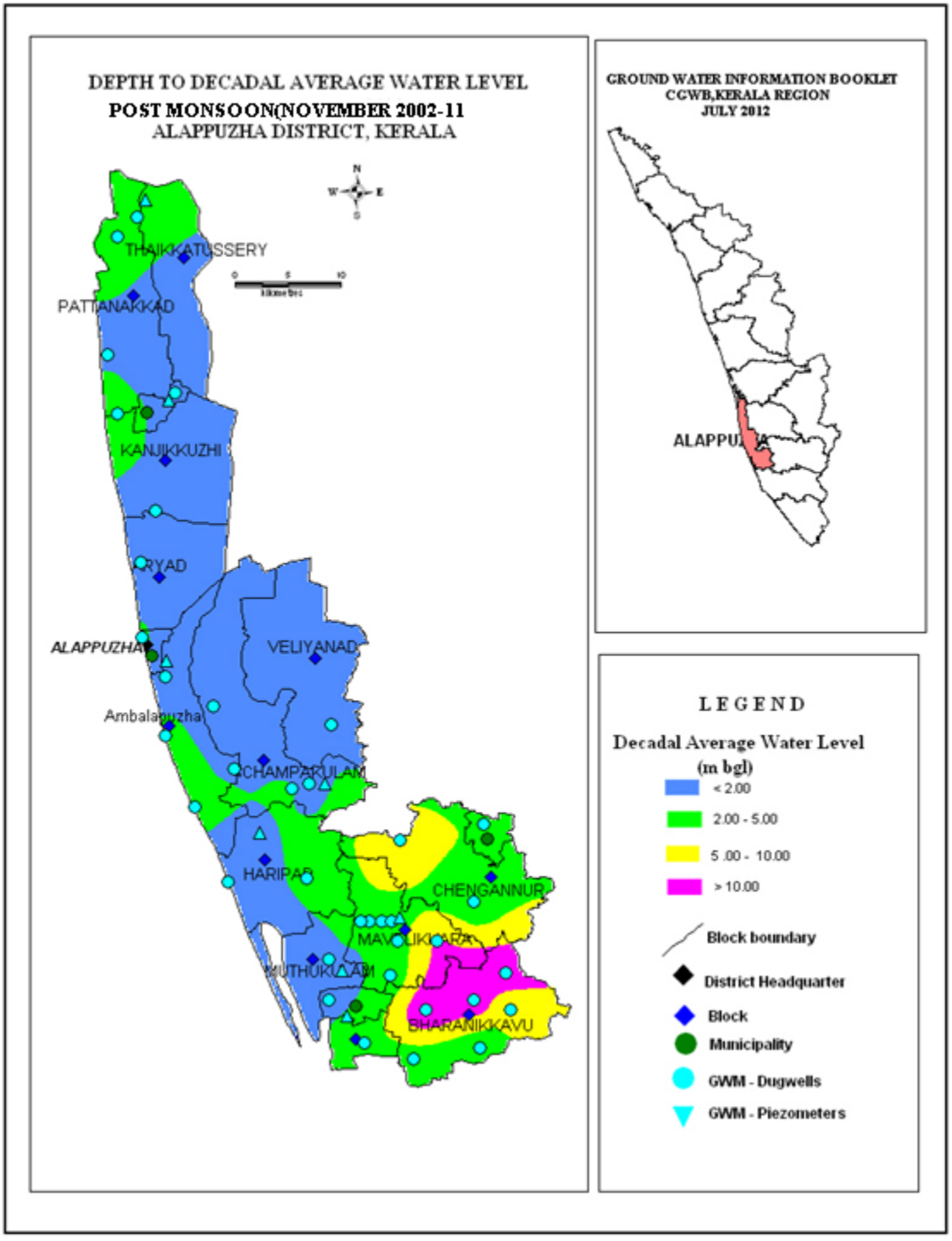


Figure.4 Hydrogeology of Alappuzha district

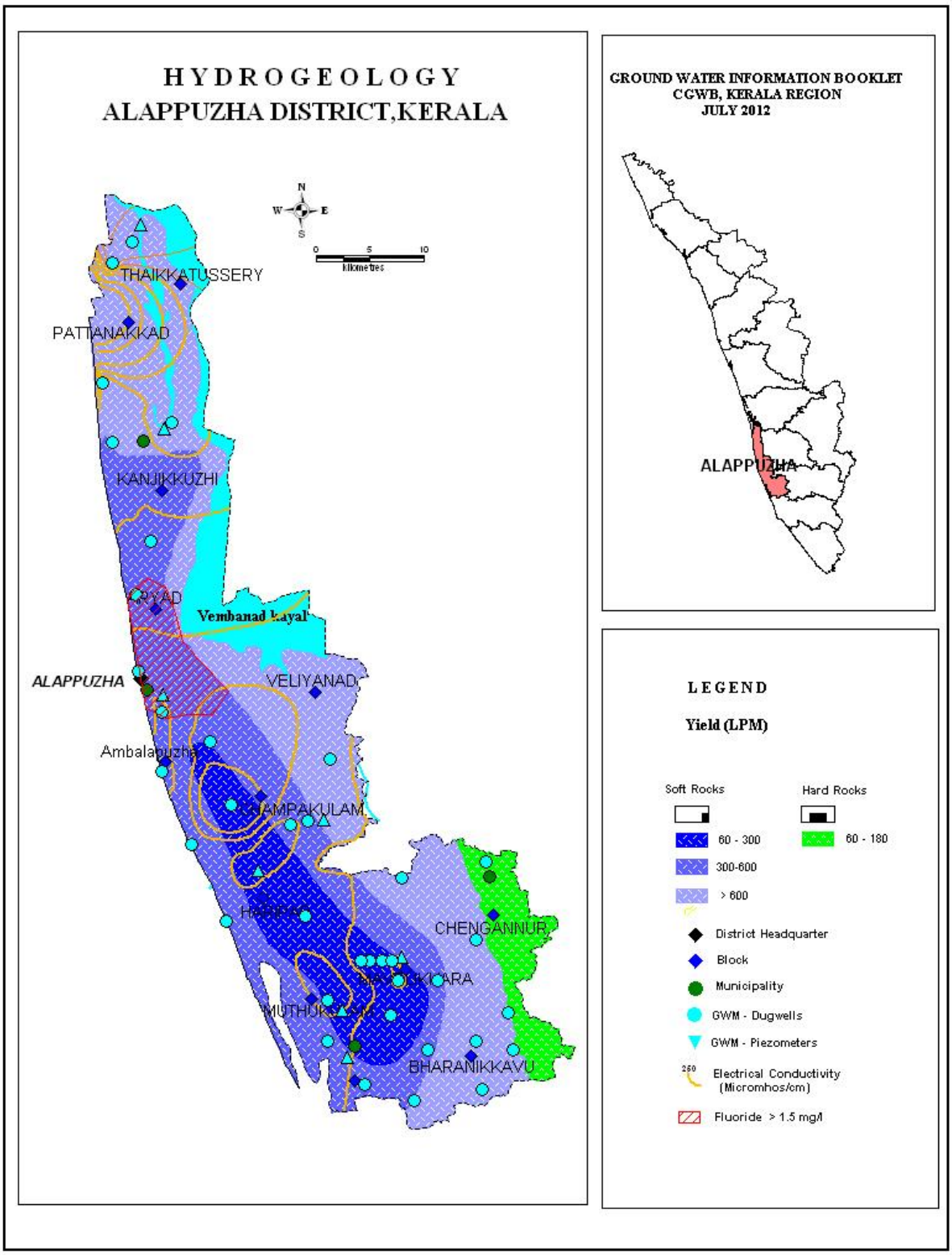
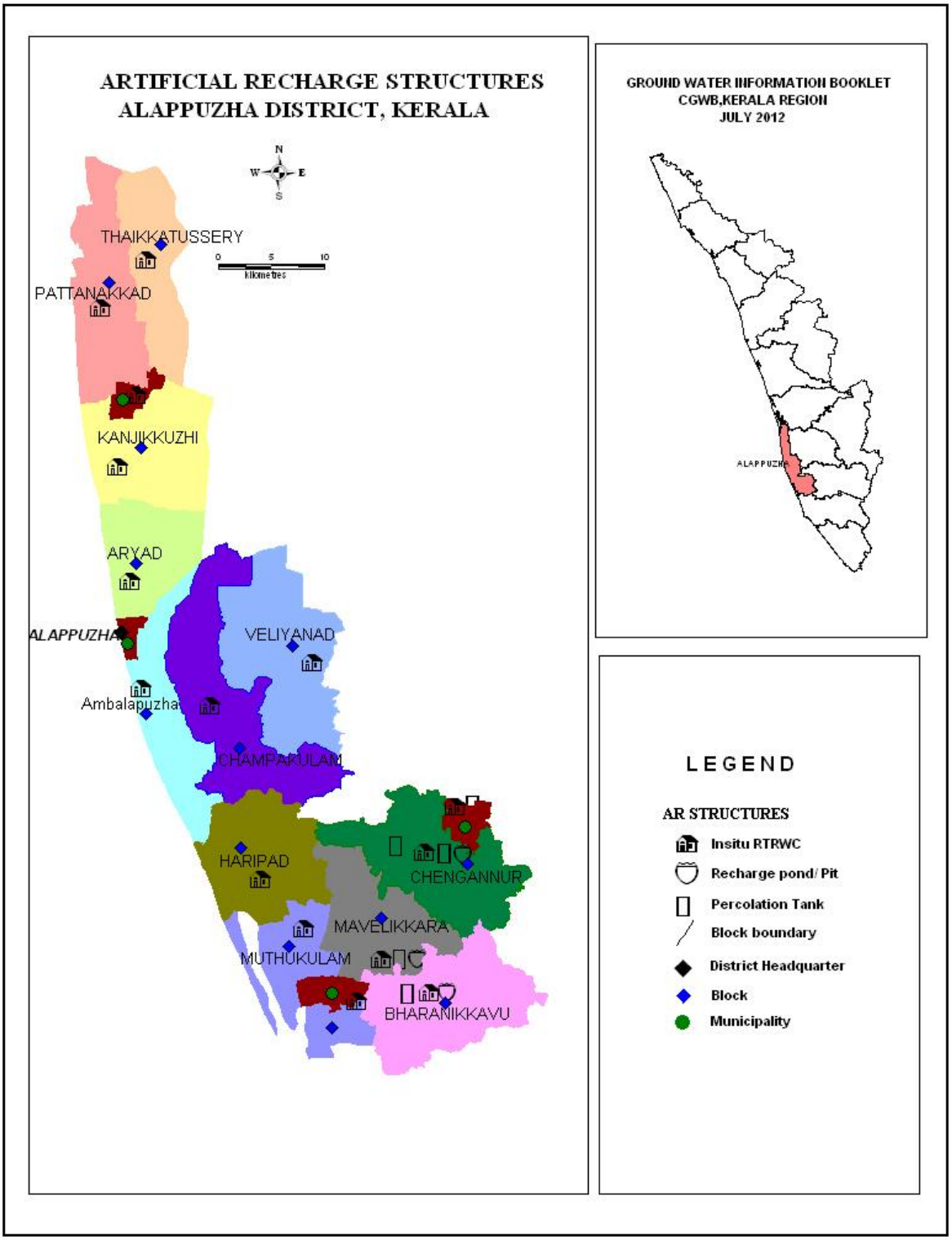


Figure.5 Artificial Recharge structures feasible in of Alappuzha district



Annexure – IA

Details of exploratory wells drilled in hard rock area of Alappuzha district

Sl No.	Location, coordinates & toposheet No.	lineament Direction	Depth drilled/ SWL mbgl	Depth of casing mbgl	Fracture zones with yield (lpm)	Discharge (lpm) during drilling	T m^2/day	EC µ/cm at 25^0C	Cl ppm	Rock type
1	Vettiyar, $9^0$13'30", $76^0$36'55", 58 C/12-1B	Nil	229.01/15.5	40.8	39 - 54/108	108	0.65	400	8.5	
2	Chengannur, $9^0$18'20", $76^0$37'15", 58 C/11	Nil	200.53/ 1.82	4.20	19.0/30, 114.0/134	72	4.82	140	17	Granite

Annexure – 1B

Details of exploratory wells drilled in soft rock areas in Alappuzha District

Sl. No	Location	Year	Depth drilled (m bgl)	Depth constructed (m bgl)	Major lithology encountered	Depth tp bedrock if found (m.bgl0	Zones encountered	Zones tapped	Discharge lps	T m^2/day	S	E.C micro seimen/cm	Cl (ppm)
1	Krishnapuram	1991	317.9	295	clay, laterite, sand , limestone	306		182-185, 187-192, 251-255, 258-262, 265-270, 278-282, 284-291 (Vaikom) ll- 33-39, 43-49 (Warkalai)	13.76	133, 102	NA	l- 200, ll- 170	13 (vaikom)
2	Vetticode	1975	96.9	88.4	clay, laterite, sand , limestone	91.4	48-58, 64-70, 79-85.	48-58, 64-70, 79-85.	17.66	140	0.002	500	7
3	Kandalur	1990	132.7	95	clay, laterite, sand , calcareous clay, limestone	NA	42-51, 54-62, 67-73, 26-36, 83-90, 112-123	45-51,58-62, 67-73,83-90 Warkali	20.9	871	NA	460	34
4	Kayamkulam	1991	106.8	65	clay, laterite, sand , limestone	NA	24-29, 36-48, 56-62	36-48, 56-62, warkali	23	NA	NA	280	7.1
5	Nallanickal	1985	391.94	206	clay, sand , limestone, gravel	NA	47.5-57.5, 74.0-87.5, 113-127.5, 170-187	170-187, 191-193,197-203.	6.87	36	NA	700	400
6	Pattiyur	1991	l-254.56 ll-101.0	90	clay, laterite, sand , limestone, gravel	NA	46-56, 56-61, 107-115, 137-143, 168-176, 186-192, 195-198, 201-205, 211-217	186-192, 195-198, 201-205, 211-217. II-46-56.	l - 5.0 lI - 4.0	NA	NA	l-390 ll-370.	13(I), 7.1(II)
7	Cheppad	1958	123.2	Nil	clay, sand , gravel	NA	24-30, 42-48, 54-50, 72-78, 103-109.	24-30, 42-48, 54-60, 72-78, 103-109.	17.91	NA	NA	1718	466
8	Arunuthi-mangalam		104	81.5		NA		44.5-78.5	NA	NA		NA	

9	Kandiyur	1986	188.9	148	sand, clay, calcareous clay	NA	130-145, 151-163	129.86-145.0(Vaikom)	13.71	197.18	NA	670	51
10	Muttom	1986	274.7	253	sand, clay	NA	23-35, 43-71, 163-178, 180-185, 188-193, 201-218, 222-225	163-178, 180-185, 188-193, 201-218, 222-225.	1-free flow 6 lps	296.5	NA	560	156
11	Karthikapalli	1985	450	88	sand, clay limestone, gravel	NA	50-61, 70-76, 80-86, 159-175, 217-231, 240-258, 307-313, 330-345	70-76, 80-86(I), 159-175(II), 216-228, 240-258(III)	5	711(I), 28.23(II), 2300(III)		530	40(I), 18(II), 33(III)
12	Thrikunna-puzha	1982	600	209.2	sand, clay, variegated clay, laterite, limestone, carbonaceous clay	NA	111-122, 126-132, 137-158, 210-222, 287-292, 523-531	111-122, 126-132 (Warkalai)	41.66	659		340	14
13	Haripad	1998	55	54				38-50	12	27.6		509	
14	Parumala	1975	105.8	82.55	sand, clay, laterite	79.2	46.33-57.91,70.7-76.2, 78.02-81.07	46.33-57.91,70.7-76.2, 78.02-81.07	22.08	125	0.0023	663	53
15	Karuvatta	1987	428.2	368	sand, laterite,clay, limestone, carbonaceous clay	NA	53-63, 63-76, 76-153, 153-167, 259-263, 281-296, 354-365	259-263, 281-296, 354-365.(Vaikom)	26.82	3855.6	NA	1600	12.1
16	Thakazhi	1974	304	Nil				Nil	NA	NA		NA	
17	Edattuva	1992	205.6	109	sand, laterite, clay limestone		78-84, 87-90, 99-105, 120-127, 137-143, 147-153, 159-167	78-84, 87-90.(Quilon), 99-105.(Vaikom)	45	NA	NA	610	47
18	Karumadi	1987	437.04	329	sand, clay, laterite, limestone	437	123-142, 155-162, 184-196, 205-215, 218-226, 236-243, 247-256, 262-268, 271-280, 283-289, 298-307, 310-316, 320-326, 330-	247-256, 262-268, 271-280, 283-289, 298-307,310-316,320-326.(Vaikom)	21.98	3476	NA	3100	926

							336, 355-361, 372-379, 392-404						
19	Nirkunnam	1981	600.79	Nil	sand, clay, laterite, clay with lignite, calcareous clay, limestone	NA	73-81, 82-88, 97-106, 134-143, 203-214, 320-327, 330-336, 340-350, 357-366, 375-385, 406-416	320-327, 330-336, 340-350, 357-366, 375-385, 406-416	NA	NA	NA	NA	NA
20	kidangara	1975	97.14	Nil	sand, clay, calcareous clay, gravel, carbonaceous clay	94.5	39-48, 67-74.4, 84.7-93.2.	39-48, 67-74.4, 84.7-93.2.	NA	NA	NA	2580	700
21	Ramankari	1988	116.9	113	sand, clay, limestone		76-91, 102-110	103-110.(Vaikom)	0.9	6.07	0.0014	2500	646
22	Mancombu	1974	258.51	70	sand, clay, limestone, gravel		37-42, 46.5-49.5, 54-68, 93-99, 150-162, 170-179, 224-231	37-42, 46.5-49.5, 54-68	7.1	278.9	NA	2300	717
23	Thottappalli	1981	269.44	174.14	sand, clay, laterite, variegated clay, limestone	NA	87-93, 106-120, 130-136, 164-174(Warkalai)	87-93, 106-120, 130-136, 164-174(Warkalai)	49.26	370	NA	1220	14
24	Kalarkod	1983	601	430	sand, clay, laterite, calcareous clay,			372-393, 408-416, 419-427.	4.98	NA	NA	8600	2900
25	Alisserey	1992	l-247.56, 209.0	122	sand, clay, limestone		69-77, 109-119, 123-128, 158-162, 196-200	l-109-119.0, 123-128.(Quilon) ll-158-162, 170-174, 196-200.(Vaikom)	1.5, 0.75	NA	NA	490, 2300	
26	Aryad	1991	400.1	Nil	sand, clay, laterite, limestone		62-68, 78-108, 118-124, 144-151,	102-114, 144-156.(Warkalai)	NA	NA	NA	7800	2556
27	Kattoor	1983	504	358	sand, clay, limestone, clay with lignite	NA	101-107, 111-117, 126-133, 138-143, 204-219, 233-248, 299-308, 319-333.5, 351-355, 416-420	299-308, 319-333.5, 351-355.	Free flowing	NA	NA	8800	2702
28	Mannancherry	1997	202.73	199				193-196 Vaikom	2.38	NA		228	

29	North Mararikolam		357.48	Nil	sand, clay, laterite		64-74, 78-82, 88-94, 118-124	70-74, 78-82, 88-92.	NA	NA	NA	1850	476
30	Shertallai	1957	237	Nil	sand, clay, laterite, gravel, calcareous clay	NA	33-39, 67-73, 83-89, 172-178, 197-203, 215-221.	33-39, 67-73, 83-89, 172-178, 197-203, 215-221.	NA	NA	NA	Top zone 3880. Bottom zone 5747.	NA
31	Arthungal	1986	444.9	103	sand, clay, laterite, carbonaceous clay, limestone		90-100, 139-145,	91-100(Warkalai)	11.16	220.69	NA	870	181
32	Kottaram	1989	EW-326.45 OW-178.7.	EW-172.5, OW-172.5	sand, clay, carbonaceous clay, limestone	322	17-23, 148-151, 156-160, 162.5-165.5, 167.5-169.50, 202-208, 235-245, 254-261	EW-148-151, 156-160, 162.5-165.5, 167.5-169.50(Quilon)	EW-2.60, OW-2.50	NA	NA	EW-3000 OW-3200	795
33	Pattanakad	1973	274.31	214.3	sand, clay, clay with lignite, limestone, gravel	268	71-80, 82-92, 178-188, 191.4-194.5, 197.4-211.2	178-188, 191.4-194.5, 197.4-211.2.	12.61	97.5	0.0044	2300	662
34	Thuravur	1989	222.8	Nil	sand, clay, laterite, carbonaceous clay, limestone, gravel	222	54.62, 88-96, 98-105	87-93, 98-101.(Quilon)	0.75	NA	NA	3200	845
35	Thakattusseri	1973	127.4	Nil 86 m hole.	sand, clay, laterite, limestone	123	24.3-32.9, 37.8-42.6, 66.45-69.5, 89.0-90.83, 93.88-115.22.		NA	NA	NA	TDS- Top 1650, Bottom 1100	NA
36	Chandirur	1973	180.44	Nil	sand, clay, clay with lignite, limestone, gravel	146	49.99-54.16, 62.18-73.15, 77.42-79.25, 89.00-90.22, 92.66-95.71, 96.62-103.02, 107.9-112.78, 122.53-135.94.		NA	NA	NA	TDS-Top 1800, Middle-1550, Bottom-1750.	NA

Annexure – II

Hydrochemical data of water samples collected from Ground Water Monitoring Wells in Alappuzha district during April 2009

S:No	Location	pH	Ec in us/cm 25^0C	TH as CaCO3	Ca	Mg	Cl	F	NO_3
				<----------conc. In mg/L---------->					
1	Alleppey	8.75	161	48	13	3.9	20	0.34	3
2	Aranootimangalam	7.57	149	36	11	1.9	17	0.41	7.5
3	Arukutti	-	172	48	16	1.9	21	0.21	5.3
4	Chandirur	8.28	523	80	29	1.9	41	0.13	5.4
5	Chettikulangara	7.79	121	34	11	1.5	14	0.19	2.9
6	Edathua	8.19	402	164	46	12	26	0.28	16
7	Haripad	-	197	44	10	4.4	30	0.33	4.3
8	Idakkunnam	7.92	55	8	2.4	0.49	11	0.04	8
9	Kaidavana	-	192	68	24	1.9	20	0.23	5.9
10	Kallissery	8.08	89	30	9.6	1.5	8.5	0.11	4.2
11	Kandiyoor	7.72	178	46	16	1.5	36	0.05	7.3
12	Karuvatta	7.52	138	26	4	3.9	27	0.29	5.1
13	Kattanam	7.94	39	16	1.6	2.9	7.1	0.25	0.98
14	Kattoor	-	117	32	12	0.49	4.3	0.24	1.1
15	Kayankulam	8.17	323	98	30	5.4	31	0.02	3.8
16	Kudassanad	7.6	102	20	5.6	1.5	11	0.05	14
17	Kuzhamathu	6.04	81	10	3.2	0.49	13	0	14
18	Mavelikara	8.56	255	54	17	2.9	27	0.13	32
19	Muttam	7.95	445	114	36	5.8	54	0.37	3.8
20	Nedumudi	-	338	24	6.4	1.9	60	0.45	1.8
21	Neerkunnam	8.98	161	54	16	3.4	13	0.46	3.5
22	Nooranad	7.29	53	8	1.6	0.97	5.7	0.01	5
23	Oachira	8.15	198	78	31	0	14	0.27	0.67
24	Pacha	-	1423	145	8	30	320	0.39	5
25	Pallarimangalam	8.41	162	62	23	0.97	5.7	0.17	1.2
26	Parumala	7.82	67	18	5.6	0.97	7.1	0.05	7.1
27	Pattanakkad	8.11	197	82	25	4.9	16	0.28	2.3
28	Pattiyur	8.54	1209	200	52	17	206	0.31	77
29	Purakkad	8.84	322	90	24	7.3	34	0.16	0.86
30	Ramankari	8.63	197	52	14	3.9	27	0.11	0
31	Sherthalai	8.06	950	145	40	11	181	0.24	0.26
32	Taikattusseri	7.95	183	72	25	2.4	5.7	0.22	0
33	Thakazhi	8.42	707	105	20	13	100	0.15	3.7
34	Thamarakulam	7.52	86	12	3.2	1	17	0	0.38
35	Thevery	8	375	108	25	11	31	0.3	0.31
36	Thuravur	8.66	362	124	45	2.9	30	0.29	7
37	Valavanad	8.58	243	82	29	2.4	18	0.03	0.44
38	Vallikunnam	-	187	32	12	0.49	8.5	0.27	2.4
39	Venmani(Thazhakam)	8.63	304	92	18	12	27	0.24	0.53