भारत सरकार

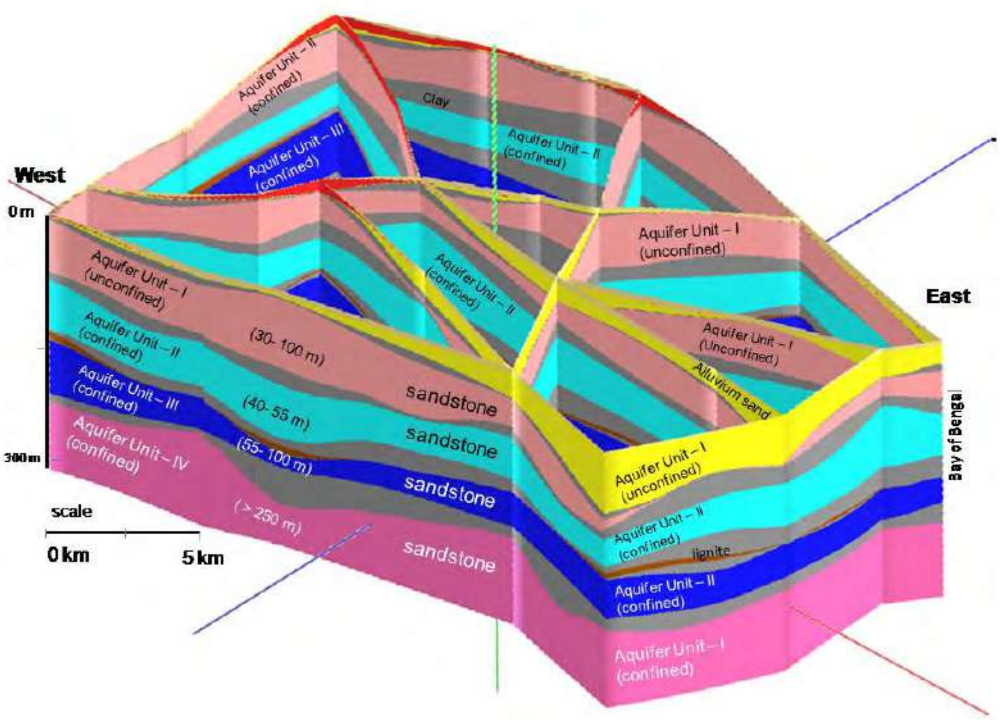
जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

केंद्रीय भूमि जल बोर्ड

Government of India

Ministry of Water Resources, River Development and Ganga Rejuvenation

CENTRAL GROUND WATER BOARD



प्रायोगिक जलभृतमानचित्रण परियोजना का प्रतिवेदन

लोअर वेल्लार वाटरशेड, कडालूर, जिला, तमिलनाडू

Pilot Project Report on Aquifer mapping in Lower Vellar watershed, Cuddalore district, Tamilnadu

दक्षिण पूर्वी तटीय क्षेत्र,चेन्नई SOUTH EASTERN COASTAL REGION, CHENNAI

दिसंबर -2015 December-2015

K. B. Biswas
Chairman

केन्द्रीय भूमि जल बोर्ड
जल संसाधन, नदी विकास
एवं गंगा संरक्षण मंत्रालय
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नई दिल्ली

Central Ground Water Board
Ministry of Water Resources,
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Government of India
New Delhi

FOREWORD

Increasing development of ground water to meet the requirements of various segments has resulted in the over-exploitation of this vital natural resource in parts of the country and consequent adverse environmental impacts include, deepening water levels and drying up of shallow wells, reduction in sustainability of wells and seawater ingress in coastal freshwater aquifers. Contamination of ground water due to natural and anthropogenic causes has also increased substantially in the recent decades. The anticipated impact of global warming and climate change are also considered to add to further complicate the issues plaguing the water resources sector in India in the not so distant future. Sustainable development of ground water through judicious management interventions becomes very important to ensure the water security of the future generations.

It is in this context that the Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India decided to take up the National Aquifer Mapping and Management (NAQUIM) Programme, aimed at detailed and systematic study of the major aquifer systems in the country and formulation of management plans for sustainable development of their ground water resources. The Programme envisaged various activities such as compilation of all available data, analysis of data gaps and generation of additional data to fill them, preparation of detailed aquifer maps and formulation of management plans. Various conventional and modern techniques of field data generation, data processing and analysis including integration of data on a GIS platform and numerical groundwater modelling were expected to be used for the programme.

With a view to understand the applicability and efficacy of the above-mentioned techniques in different hydrogeological settings, pilot projects on aquifer mapping were taken up in Six different Hydrogeological terrains in the states of Bihar, Rajasthan, Maharashtra, Karnataka and Tamil Nadu.CSIR-NGRI was engaged as a consultant by CGWB to facilitate use of advanced geophysical techniques in the programme. During the course of the study, groundwater issues have been identified by CGWB specific to the area. With inputs from aquifer mapping studies, aquifer response models have been formulated and various strategies have been tested to arrive at optimal aquifer management plan for sustainable management of precious resources.

This is one among the six reports being brought out based on the studies taken up in the pilot projects. The findings are brought out in the report very coherently and I would like to place on record my appreciation for the excellent work done by the team. I fondly hope that this report will serve as a valuable guide for sustainable development of ground water in the area.

K.B.Biswas
Chairman

18/11, Jamnagar House, Mansingh Road, New Delhi-110011
Phone : (011) 23383561 Fax : 23382051, 23386743
E-mail : chmn-cgwb@nic.in Website: www.cgwb.gov.in, www.mowr.gov.in

भारत सरकार
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केंद्रीय भूजल बोर्ड
दक्षिण पूर्वी तटीय क्षेत्र
ई-1, सी – ब्लॉक, राजाजी भवन
बेसेंट नगर, चेन्नई-600 090.

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES,
RIVER DEVELOPMENT AND GANGA REJUVENATION
Central Ground Water Board
South Eastern Coastal Region
E-1, C – Block, Rajaji Bhavan
Besant Nagar, Chennai – 600 090

PREFACE

Aquifer mapping studies has been carried out in the parts of Lower Vellar Water Shed, Cuddalore district, Tamilnadu under Pilot Project with an objective to decipher the vertical and lateral extent of the aquifer down to the depth of 300 meters and to develop a numerical model so as to bring out the aquifer management plan for effective management of the groundwater resources. This study was carried out under the guidance of Chairman and overall supervision of Central Head Quarters, CGWB.

This report eloborates the outcome of the aquifer mapping study, in particular, the vertical and lateral extent of the aquifer units, its characteristics and the response of the aquifer units to different stress conditions. Further, the groundwater management plan of the cuddalore coastal aqufier system that included the part of lower vellar water shed has been described eloborately.

I appreciate the sincere and untiring efforts by Dr. D. Gnanasundar, Scientist – C (Sr.HG) & Nodal Officer of the Project, Shri. N. Rameshkumar, AHG and Dr. M. Senthilkumar, Scientist-C (Jr.HG) and officers/staffs of South Eastern Coastal Region, CGWB in completion of Pilot project and the report on "Aquifer mapping in Lower Vellar Water Shed, Cuddalore district, Tamilnadu".

The report shall be of immense use amongst water managers & planners, hydrogeologists, engineers, profesionals and academicians working in the field of groundwater resources management.

A. SUBBURAJ
Head of Office

044-24465880 (Direct), 24913014, 24914494, 24912941 Fax: 044-24914334 Email: rdsecr-cgwb@nic.in

ACKNOWLEDGEMENT

The authors express their sincere thanks to **Er. K. B. Biswas, Chairman**, CGWB, **Dr. S. C. Dhiman** and **Sh. Sushil Gupta,** former Chairman, CGWB, Faridabad for continuous guidance and support throughout the project study.

The authors also express thanks to the **Sh. K. C. Naik**, Member (RGI), **Dr. D. Saha**, Member (SAM), **Dr. E. Sampath Kumar**, Member (SML), **Shri. S. Kunar**, **Shri. D.S.C. Thambi**, **Dr.N.Varadaraj** and **Dr. R.C. Jain** former Members of CGWB, **Sh. Avanish Kant**, Scientist - D MoWR, RD & GR, for their support and encouragement during the project.

Sincere thanks to Shri. A. Subburaj, Scientist-D & H.O.O, Dr. S. Suresh, Scientist –D, Sh. S.K.Sinha, Scientist – D, Shri. K.T.Suresha, Scientist –C (Sr.GP), Er.N.Varadaraj, Executive Engineer, Dr. K. Ravichandran, Scientist – C (Sr.Chemist) and Shri. Pankaj Kumar, Asst. Hydrogeologist for their involvement and support.

Thanks are also due to the team of officers Dr.Shakeel Ahmed, Chief Scientist, NGRI, Dr.Subhash Chandra, Dr.Rangarajan and Dr.Muralidharan from NGRI, Hyderabad for geophysical data generation and report on geophysical part.

The authors also acknowledge their sincere thanks to World Bank and its team of experts, State and Central Govt. Agencies, SG&SWRDC, PWD, Chennai and senior officials of Neyveli Lignite Corporation for providing valuable data and suggestions.

Last but not the least the authors express their sincere thanks to every person involved in this project, SECR, CGWB officers and staffs and the local administration from the project area.

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ABBREVIATIONS

AL	Alluvium
CGWB	Central Ground Water Board
GL	Ground Level
GSI	Geological Survey of India
IMD	Indian Meteorological Department
LPM	Litres per minute
LPS	Litres per second
LST	Lime stone
m	metre
mbgl	meters below ground level
MCM	Million Cubic Meter
mm	Milli meter
mg/l	milligram/litre
msl	mean sea level
NLC	Neyveli Lignite Corporation of India
Sq.Km	Square Kilometre
SST	Sand stone
µS/cm	Microsimens/centimetre

EXECUTIVE SUMMARY

Aquifer mapping studies has been carried out in the parts of Lower Vellar Water Shed, Cuddalore district, Tamilnadu under Pilot Project with an objective to decipher the vertical and lateral extent of the aquifer down to the depth of 300 meters and to develop a numerical model so as to bring out the aquifer management plan for effective management of the groundwater resources.

The study area (428 sq.km) forms a part of the Cuddalore coastal aquifer which is one of the most productive aquifers in the country. The aquifer consists of regionally extensive sandstones that crop out within the Cuddalore aquifer system and underlie towards the east coast and extend into the Bay of Bengal. The northern boundary is defined by up dip along the Ponnaiyar River while the southern boundary is defined by Vellar River. The Archaeans (Granitoid Gneiss) marks the western boundary while the Bay of Bengal Sea constitutes the eastern boundary of the Cuddalore coastal aquifer system. The largest known deposit of fossil fuel (lignite) occurs within the Cuddalore coastal aquifer system.

The aquifer map for the part of Lower Vellar watershed is generated based on the inputs from geological, geophysical, hydrogeological, and hydrochemical studies. For development of aquifer response model and aquifer management plan, the pilot project area was extended to the north, west and southern part so as to have near perfect Hydrogeological boundaries (the extended region is referred as Cuddalore Coastal Aquifer System – 1948 sq.km). The Numerical models primarily address the following hydrological stress to the Cuddalore coastal aquifer system, a) Heavy and continuous groundwater withdrawal for irrigation b) depressurized for safe mining of lignite since 1955. c) Stress on the aquifer due to groundwater withdrawal for drinking water supply to Chennai city during lean periods and finally, d) Threat of seawater intrusion in the event of reversal of hydraulic gradient or by upconning. This report elaborates the outcome of the aquifer mapping study, in particular, the vertical and lateral extent of the aquifer units, its characteristics and the response of the aquifer units to different stress conditions. Further, the groundwater management plan of the cuddalore coastal aqufier system that included the part of lower vellar water shed has been described eloborately in the report.

The salient outcome of the study is that the Cuddalore coastal aquifer system has sandstone as principal aquifer consisting of 4 aquifer units (multi-layered aquifer system). They are highly potential and most prolific aquifer system in the state. The present annual groundwater withdrawal from the Cuddalore coastal aquifer system is 1213.58 mcm. The four aquifer units (I, II, III and IV) within the principal sandstone aquifer are safe with the present annual rate of groundwater withdrawal (1213.58 mcm) and no threat of sea water intrusion exists. The detailed report shall be of immense use amongst water managers & planners, hydrogeologists, engineers, profesionals and academicians working in the field of groundwater resources management.

Chapter 1 Introduction

1.0 Introduction

Under Pilot Project study, aquifer mapping was carried out in the part of lower Vellar water shed (Study area), Cuddalore District, Tamilnadu state. The Administrative blocks that come within the study area are Kurunjipadi, Cuddalore and parts of Kammapuram of Cuddalore District. Aquifer mapping study addresses the problems arising due to development of groundwater resources. In order to resolve problems arising from development of the aquifer system, information on the vertical and lateral extent of the aquifers, characteriststics of aquifers and recharge and discharge mechanisms of the aquifer system is much required.

The aquifer mapping study has been carried out since 2012 and had contributed to 1) collection of data from previous studies 2) discriptions of the geologic and hydrogeological characteristics of the aqufier system 3) conceptualisation of the aquifer system 4) development of the numerical model for present conditions and finally 5) to bring out aquifer management plan for effective management of the groundwater resources.

The study area forms a part of the Cuddalore coastal aquifer which is one of the most productive aquifers in the country. The aquifer consists of regionally extensive sandstones that crop out within the Cuddalore aquifer system and underlie towards the east coast and extend into the Bay of Bengal. The northern boundary is defined by up dip along the Ponnaiyar River while the southern boundary is defined by Vellar River. The Archaeans (Granitoid Gneiss) in the western boundary marks the western boundary while the Bay of Bengal Sea constitutes the eastern boundary of the Cuddalore Aquifer system. The largest known deposit of fossil fuel (lignite) occurs below the coastal plains of Cuddalore district. The lignite popularly known as Neyveli Lignite constitutes the largest lignite reserve of India and is mined through open cast mining (Asia’s biggest open cast mine)

A better understanding of the hydrogeologic process that control the distribution and availability of groundwater in the Cuddalore coastal aquifer is imperative for optimal resource management. The optimization concept of managing the Cuddalore coastal aquifer system involves a procedure for aquifer use that enables the greatest number of the desired benefits to be accomplished. For water resources managers and planners to develop and implement effective long range and short range aquifer management strategies, a host of scientific questions must be answered. These questions can be best answered through a comprehensive process that integrates the available scientific data. Aquifer mapping study thus integrates the data obtained through geological, hydrogeological, geophysical and geochemical studies so as to know the disposition of the aquifer system.

To understand and to evaluate the response of the Cuddalore coastal aquifer to various hydrologic stresses, numerical groundwater flow model was carried out to understand the response of the aquifer to different stress and also to evolve better aquifer management plan for implementation.

1.2 Objectives and approach

The aquifer mapping study primarily depends on the existing data that are assembled, analysed and interpreted from available sources. The data gaps analysis carried out helped to generate data from new data-collection activites such as exploration drilling, water level measurements and groundwater quality analysis. By analysising the existing data and the data generated, regional hydrogeological maps, thematic maps, water quality maps, cross-sections, 2-D and 3 –D aquifer dispositions and potentiometric maps were generated.

The objectives of the pilot project are

i. To define the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and geochemistry of Multi-layered aquifer systems on 1:50,000 scale

ii. Intervention of new geophysical techniques and establishing the utility, efficacy and suitability of these techniques in different hydrogeological setup.

iii. Finalizing the approach and methodology on which National Aquifer mapping programme of the entire country can be implemented.

iv. The experiences gained can be utilized to upscale the activities to prepare micro level aquifer mapping.

Objectives

The activities of the Pilot Project on Aquifer Mapping can be envisaged as follows

1. **Data Compilation & Data Gap Analysis:**One of the important aspect of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled, analysed, examined, synthesized and interpreted from available sources. These sources were predominantly non-computerized data, which was converted into computer based GIS data sets. On the basis of available data, Data Gaps were identified.
2. **Data Generation:**There was also a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, remote sensing, besides detailed hydrogeological surveys. CSIR-NGRI has been hired as consultant to carry out geophysical studies including advance Heliborne Transient Electro Magnetic Method (Heli-TEM) to delineate multi aquifer system; to bring out the efficacy of various geophysical techniques and a protocol for use of geophysical techniques for aquifer mapping in different hydrogeological environs.
3. **Aquifer Map Preparation:** On the basis of integration of data generated from various studies of hydrogeology & geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out Characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).
4. **Aquifer Response Model:** On the basis of aquifer characterization, issues pertaining to sustainable aquifer management in the area have been identified. Initially, a conceptual

model has been developed for the pilot area and subsequently, a mathematical model has been formulated simulating the field situation, which was calibrated and validated with the field data. Various scenarios have been tested in the model to study the response of the aquifer to various stress conditions and predictive simulations have been carried out up to the year 2025.

5. **Aquifer Management Plan Formulation:** Aquifer response Model has been utilized to identify a suitable strategy for sustainable development of the aquifer in the area.

The approach by which the micro-level aquifer mapping studies is carried out is given as follows;

Regional Aquifer Mapping

Decipher Aquifer Units within the Principal Aquifers

↓

Conceptualization of the aquifer system

↓

Aquifer Management Plan through Numerical Modelling

↓

Information on aquifers to farmers, State Govt stakeholders for sustainable groundwater management.

Though the aquifer mapping study covers 428 sq.km, this study has enabled to entend the lateral and vertical extent of the aquifer units outside the pilot project area. This has helped to establish the aquifer boundaries, the quantity and quality of the water within the aquifer, the recharge characteristics and the discharge mechanism of the Cuddalore coastal aquifer also. To bring out the aquifer management plan, numerical model was developed. For development of the numerical model the study area was extended upto the Hydrogeological boundaries. The total area of the model area is 1950 sq.km. The historic data assembled and analysed has been used to construct the conceptual model and model the aquifer for efficient groundwater management plan.

The scientific issues to be addressed in this study are – Firstly, the cuddalore aquifer system is a coastal aquifer and forms a part of Cauvery Basin. Secondly, the aquifer is heavily utilized for irrigation and is depressurized for mining activity. Thirdly, drinking water to Chennai city is from Cuddalore aquifer during lean periods and finally, declining peizometric head and threat of seawater intrusion in the event of reversal of hydraulic gradient or by upconning and its extension into the sea.

1.3 Previous studies

Prior to this study, the groundwater hydrology has been studied only in separate parts with many areas left untouched. As a result, there was no hydrogeologic framework developed so as to understand the regional effects of groundwater development in the pilot project area as well as Cuddalore coastal aquifer. During 1943-46, the Geological Survey of India (GSI) carried out exploratory drilling activity for Lignite around Neyveli and is surroundings. Subsequently, in 1954-55, GSI again carried out detailed Geological and groundwater surveys nearby Neyveli in order to determine the structure of Lignite deposits and groundwater aspects of the overlying aquifer and economic mining of lignite deposits. Central Ground Water Board (CGWB) during 1986-87 carried out hydrogeological surveys to study the changes in groundwater regime. Since then CGWB has carried out exploratory drilling in the region especially during 2006-2010.

1.4 Location

The Parts of lower vellar water shed (Study area) comprises the catchment and command areas of Perumal'Eri' extended upto the Bay of Bengal in the East. The Lower Vellar Water Shed is located in Cuddalore district, which is one of the coastal districts of the Tamil Nadu state and is about 250 km from Chennai city. Cuddalore is the district head quarter, which is well connected by both rail and roadways. The study area (Lower Vellar Water shed) is bounded by Ponnaiyar watershed in the North and Vellar in the south western and Bay of Bengal in the east with an aerial extent of 428 sq. km. The pilot study area (Lower Vellar Water Shed) lies between North latitudes 11° 30' 10' and 11° 42' 16" and East longitudes 79° 30' 00" and 79° 46' 36"and falls is survey of India toposheet No.58 M/10.

Chapter. 2. Data Availability and Data Gap Analysis

2.1 Data Availability

The Geological, Geophysical, Hydrogeological and Hydrochemicaldata that have been generated through Systematic Hydrogeologial studies, Reappraisal Hydrogeological studies, Groundwater Management studies, Exploratory drilling, Microlevel hydrogeological studies and special studies by the Central Ground Water Board since its inception has been collated in this pilot project study. Further, data fromline departments from the state have also been collected. The data available for the pilot project area is given as table below. The data available *(Table 2.1)*on soil, Drainage, Geomorphology, Land Use and Land Cover enabled to generate respective thematic maps.

Sl.No	Themes	Data Available
1	Groundwater level data	Long term : 1. Phreatic : 3 nos 2. Peizometers : 18 nos
2	Groundwater quality Data	16 nos (Phreatic)
3	Borehole Lithology Data	12 nos
4	Geophysical Data	6 nos of Resistivity Log
5	Pumping Test	10 nos
6	Land use and Land Cover	Information available
7	Geomorphology	Information available
8	Drainage	Information Available
9	Soil	Information available

10	Climate	Data Available

2.2 Data Gap analysis

Based on the data availability, Data Gap analysis was carried out so as to generate data in places where data gap exists. The data gap analysis carried out monitoring stations for individual aquifer units, Groundwater quality and Lithology is given as figures. 2.1 to 2.6)

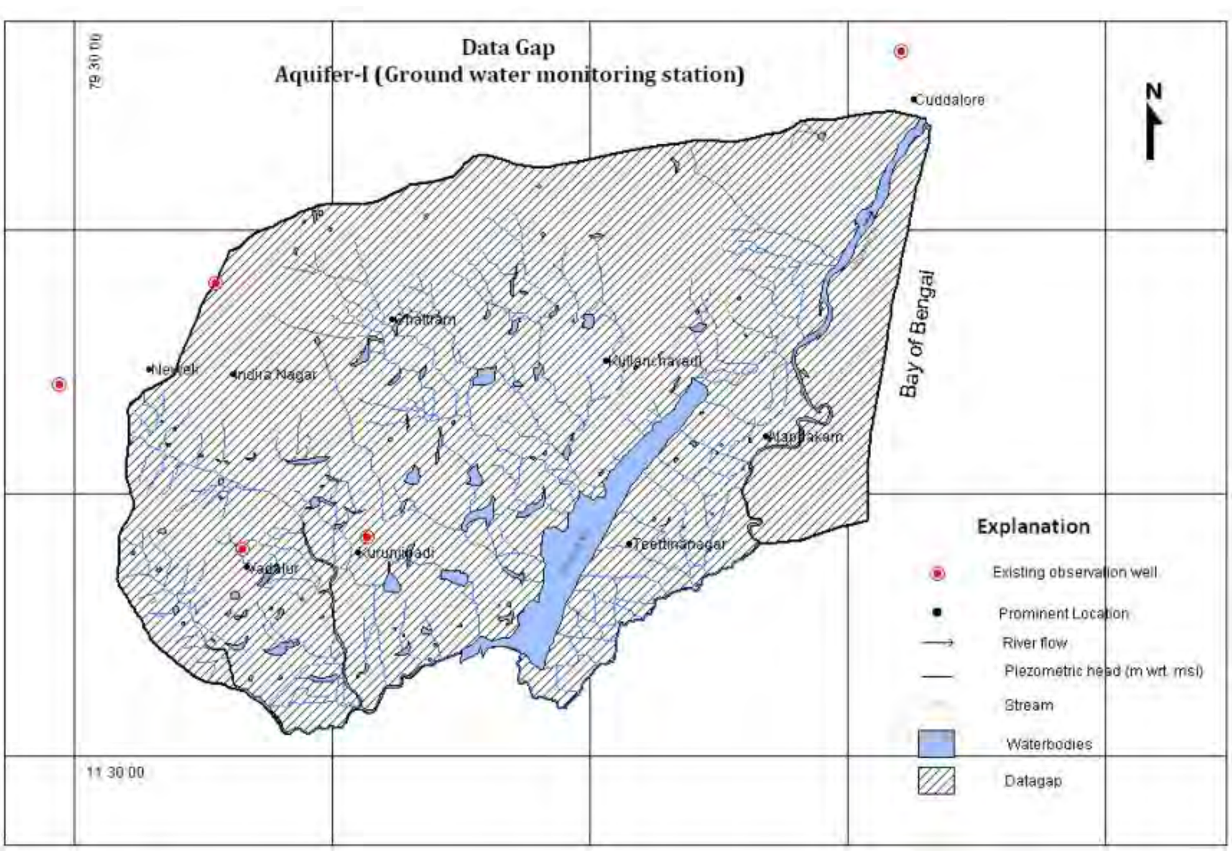


Figure 2.1 Data gap analysis of the groundwater monitoring stations in Aquifer - I

Figure 2.2 Data gap analysis of the Piezometers in Aquifer - II

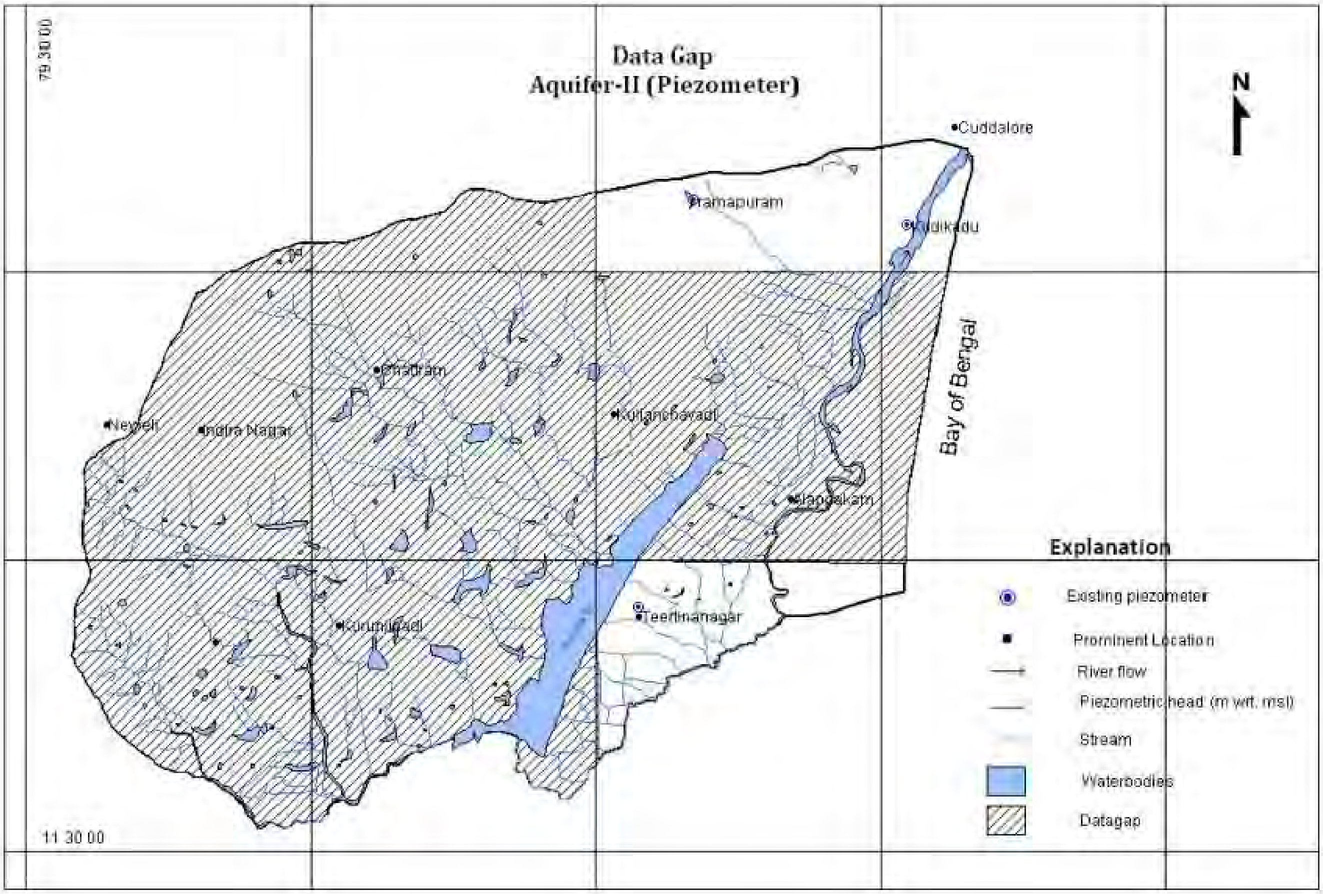


Figure 2.3 Data gap analysis of the Piezometers in Aquifer - III

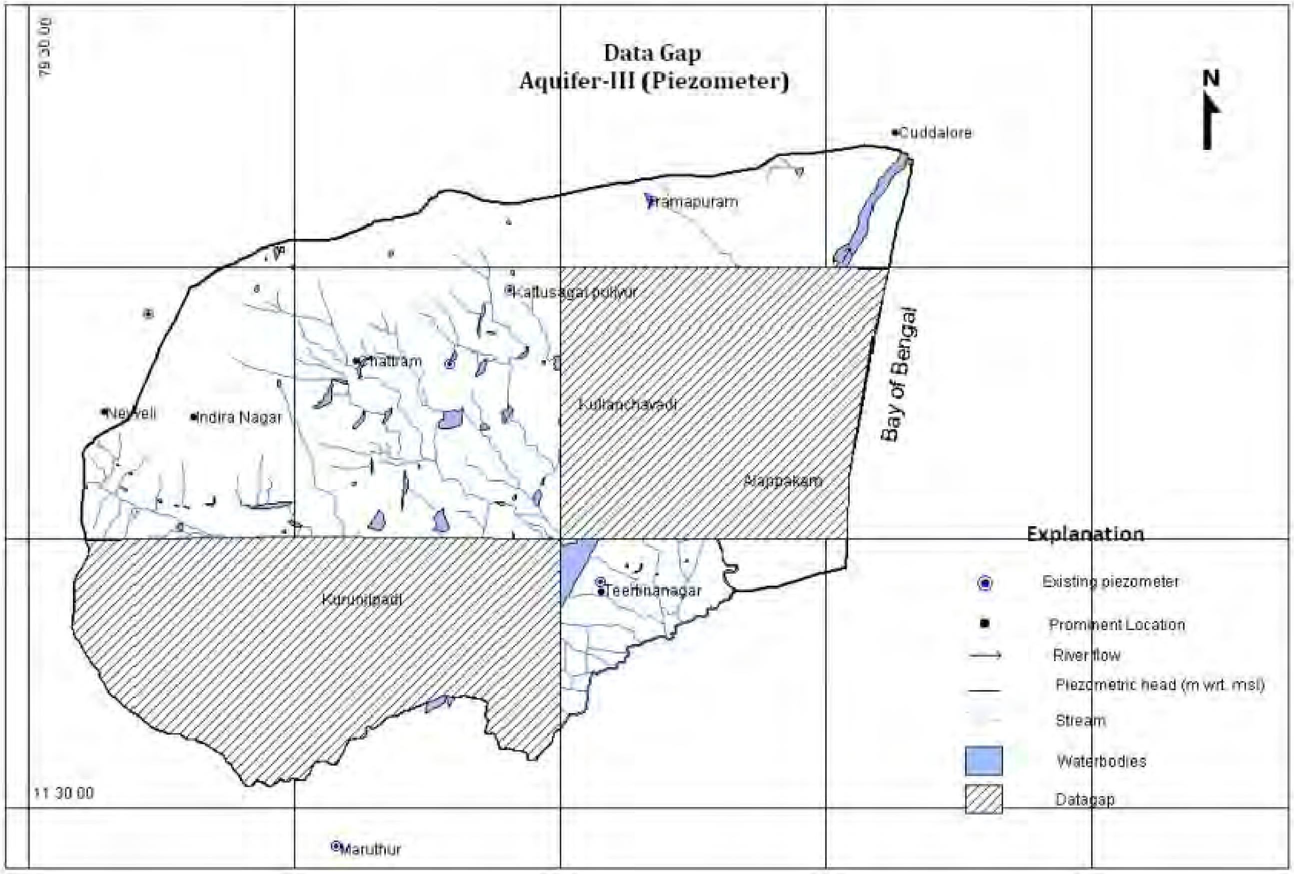


Figure 2.4 Data gap analysis of the Piezometers in Aquifer - IV

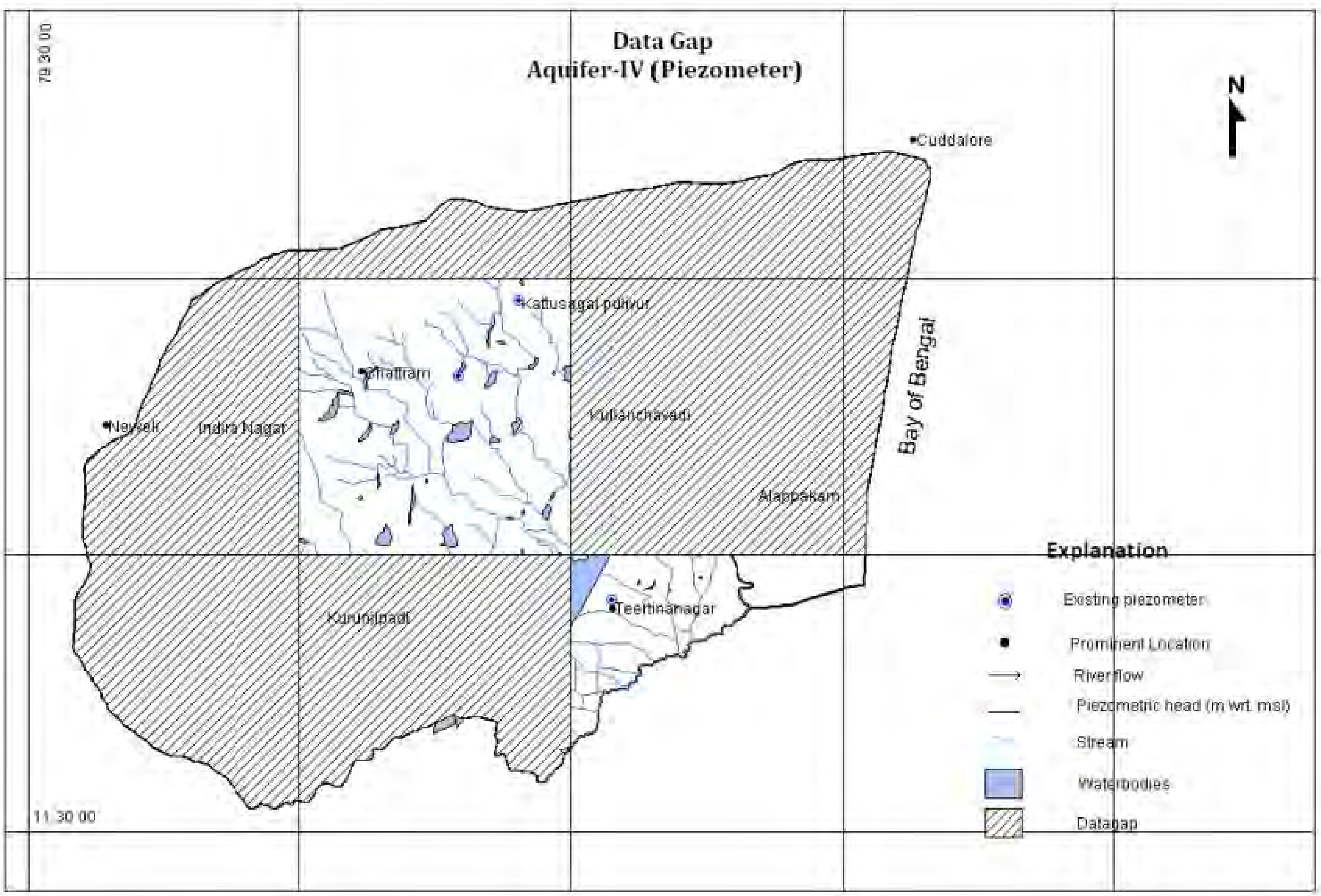


Figure 2.5 Data gap analysis of Groundwater quality

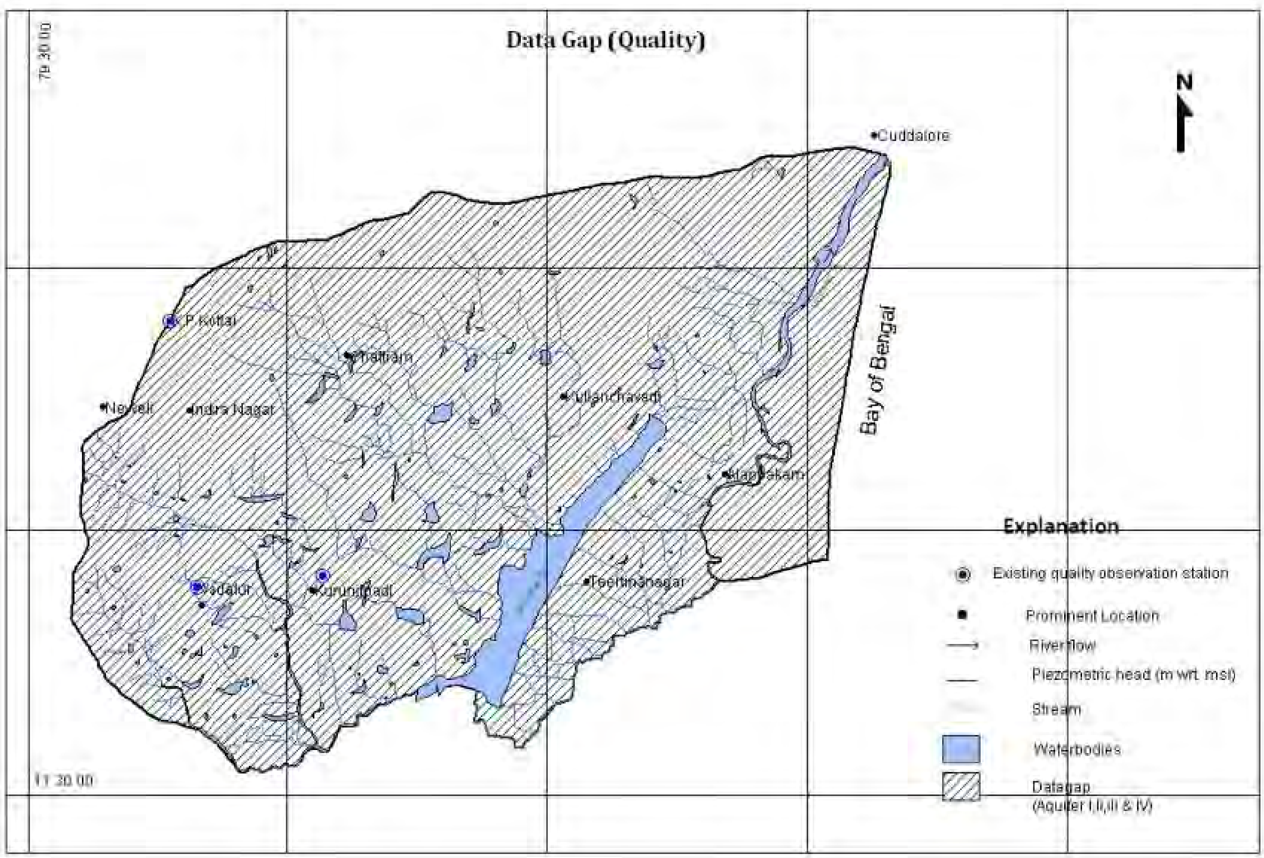
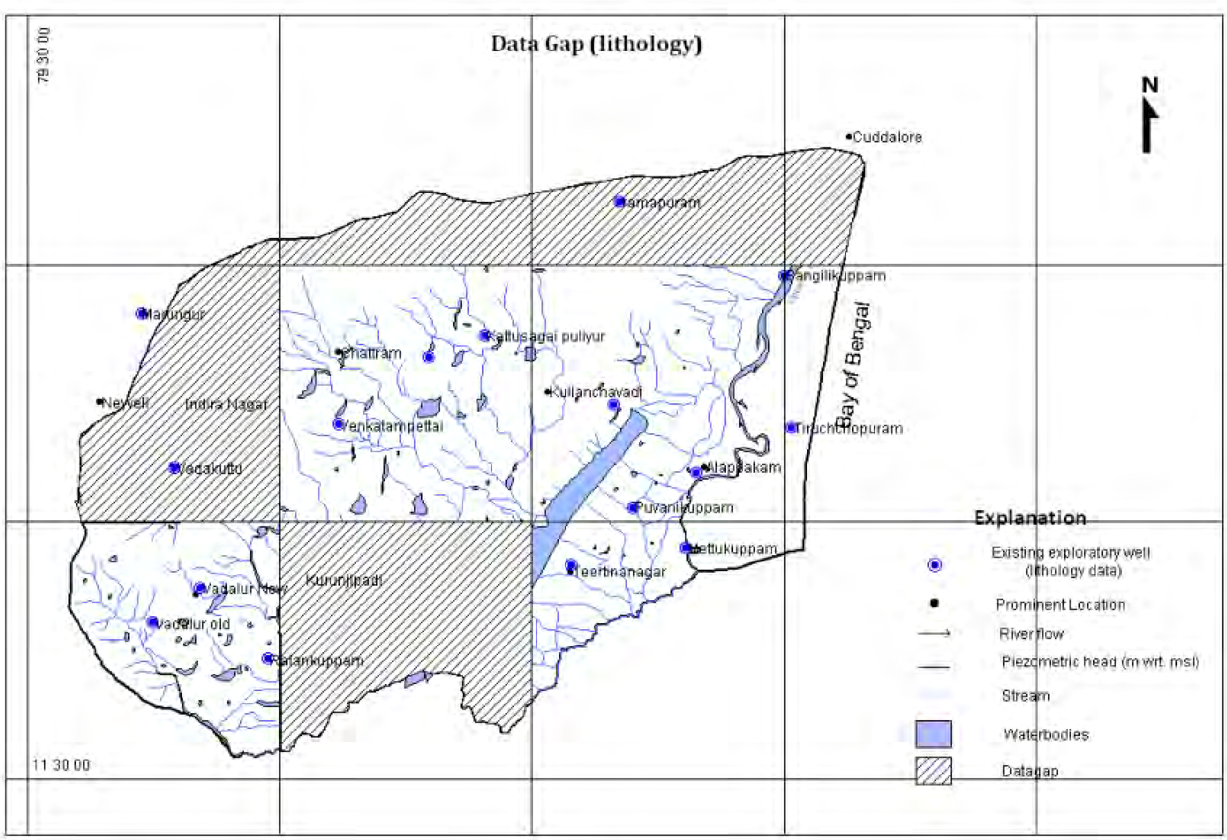


Figure 2.6 Data gap analysis of the Piezometers in Aquifer - III



The following table shows the data available, data required and the data generated in the pilot project. (Table 2.2)

S.No	theme	Data Available	Available	required	Generated	total
1	Groundwater level data	Dugwell- Aquifer-I	3	27	61	64
		Peizometers- Aquifer-II	3	5	5	8
		Peizometers- Aquifer-III	7	7	7	14
		Peizometers- Aquifer-IV	5	3	3	8
2	**Groundwater quality data**	Dugwell- Aquifer-I	3	27	44	47
		Peizometers- Aquifer-II	3	5	5	8
		Peizometers- Aquifer-III	5	3	7	12
		Peizometers- Aquifer-IV	5	3	3	8
3	Borehole Lithology Data		14	11	11	25

Chapter 3.Data Generation

3.1. Data Generation:

One of the main objectives of the pilot project study was to generate strong data base that shall enable in preparing aquifer disposition. Based on the data gap availability and data gap analysis, the sub-surface data, groundwater level data and groundwater quality data were generated. The following table shows the data generated in the project study for the part of lower velar water shed. (*Table 3.1*).

Sl.No	Themes	Data Generated
1	Sub-surface lithology	15 wells were drilled at 11 locations (CGWB) 21 deep resistivity survey (VES) (NGRI) 10 Earth Resistivity Tomography (NGRI) Heliborne Geophysical survey (SKYTEM) (NGRI)
2	Piezometers	15 piezometers were constructed to monitor the pieozmetric head of different aquifers. (CGWB)
3	Groundwater scenario	Monthly water level for 66 dugwells generated for2 years. (CGWB) Piezometric head generated for different aquifer units from 35 piezometers. (CGWB)
4	Groundwater quality	47 dugwell samples were analysed for major ions (CGWB) 11 groundwater samples from piezometers were analysed for major ions. (CGWB)

The data generated (subsurface lithology, groundwater level/piezometric head for individual aquifers and groundwater quality for individual aquifers) based on the data gap analysis is given as figures below. (3.1.1 to 3.1.6).

A major task in this study was to construct piezometers tapping different aquifers units to generate long term peizometric head data. The preliminary study carried out based on the available sub-surface data revealed the presence of different aquifer units. Therefore, the data has been generated aquifer unit wise.

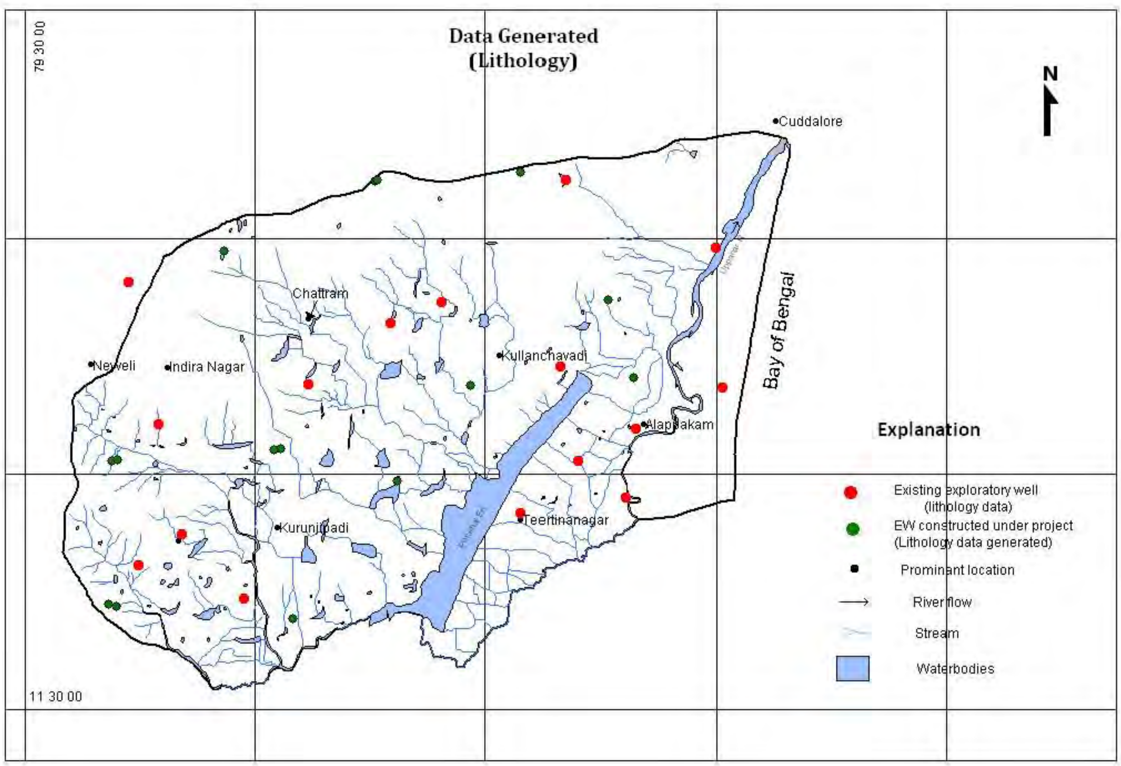


Figure 3.1 Data generated Aquifer-I(Key observation well-Dugwell)

In total, 66 number of dugwells were established as key wells (monitoring wells) and were monitored monthly for a period of 2 years. Through most of the dugwells are irrigation wells, care was taken to monitor static groundwater level from the established monitoring wells. The monthly water level data generated for 66 dugwells representing the phreatic aquifer is given as Annexure -IV.

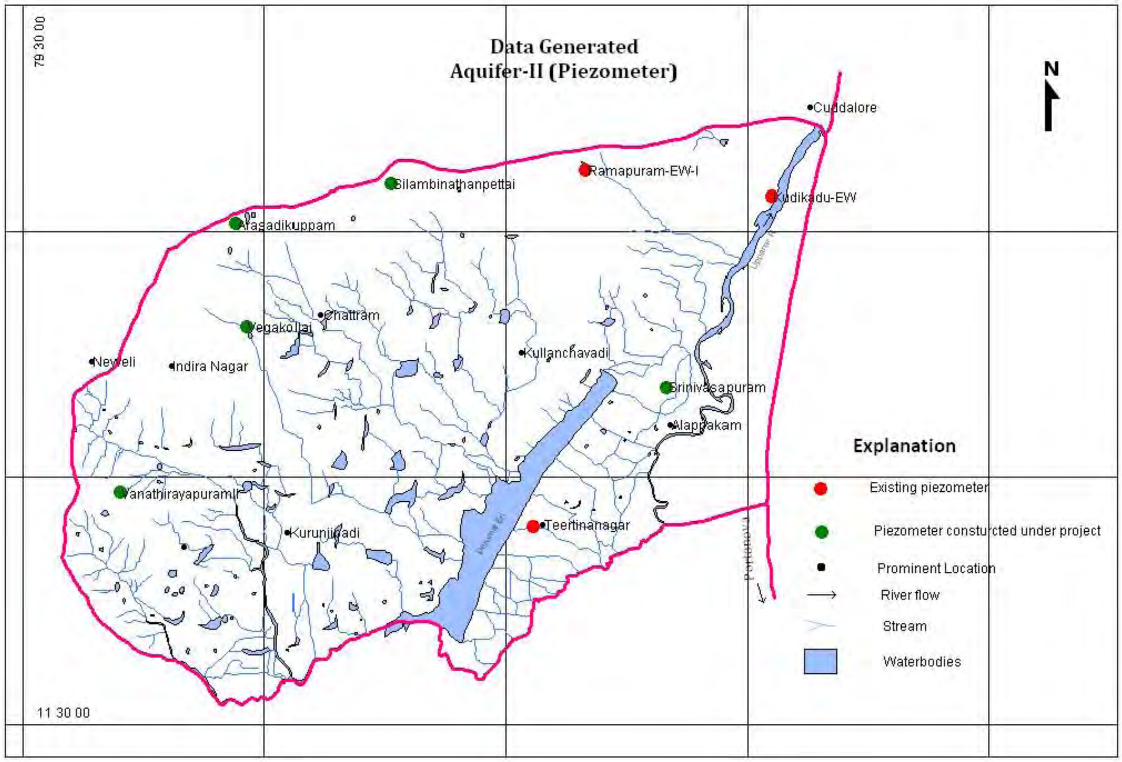


Figure 3.2 Data generated Aquifer-II (Piezometer)

Three rigs of CGWB were engaged in construction of 15 new Piezometers in 11 locations (villages) in the Pilot Project area based on the data gap analysis. The Pieozmetric head of the newly constructed piezometers and the existing piezometers were monitored monthly for a period of two years (Annexure -V). The details on the depth drilled and well assembly is given as Annexure -III .

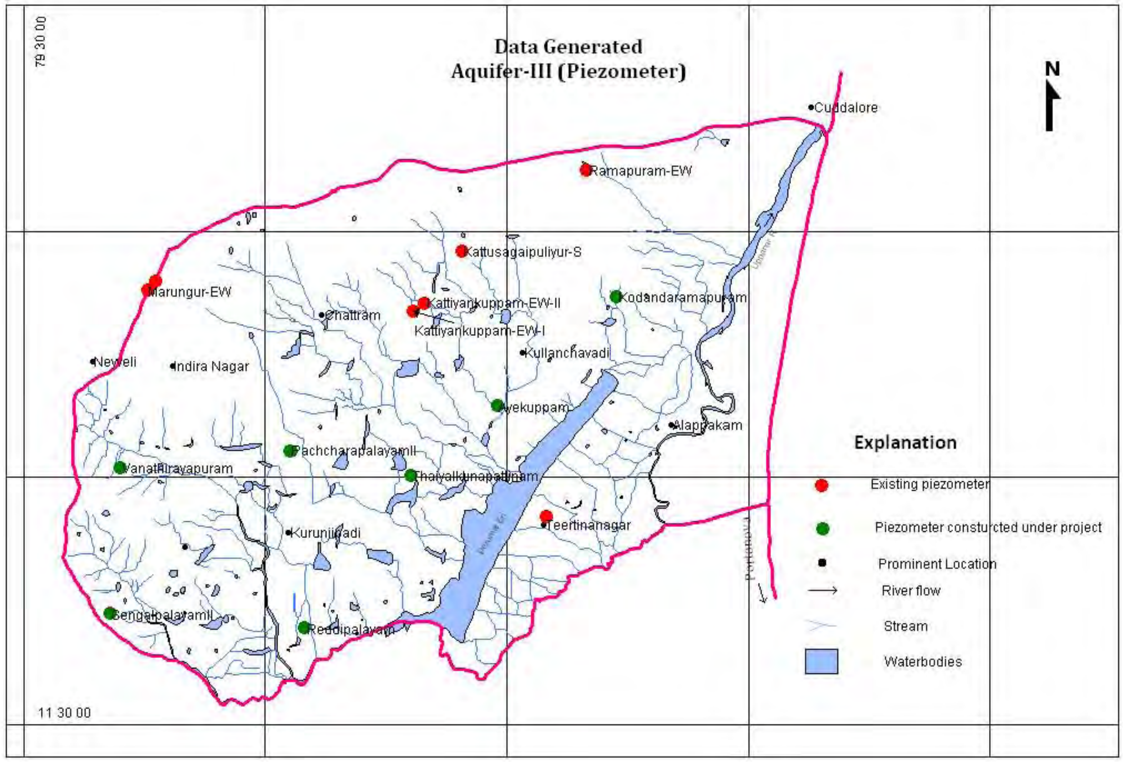


Figure 3.3 Data generated Aquifer-III(Piezometer)

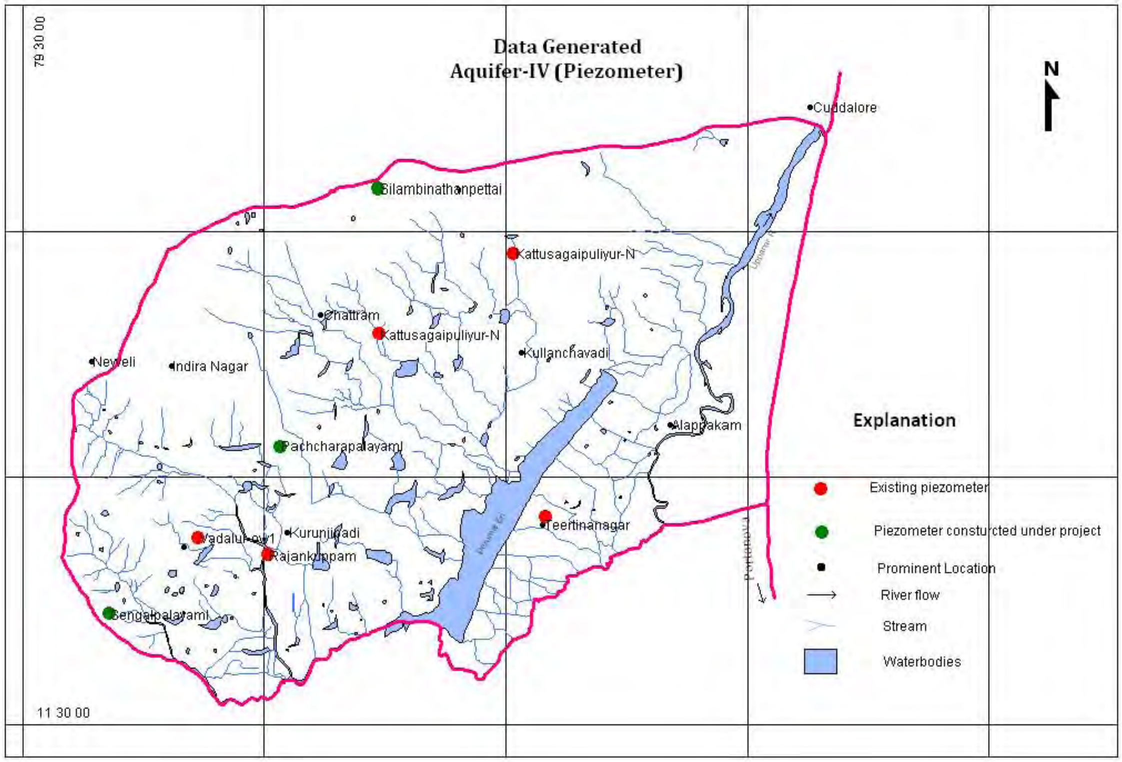


Figure 3.4 Data generated Aquifer-IV(Piezometer)

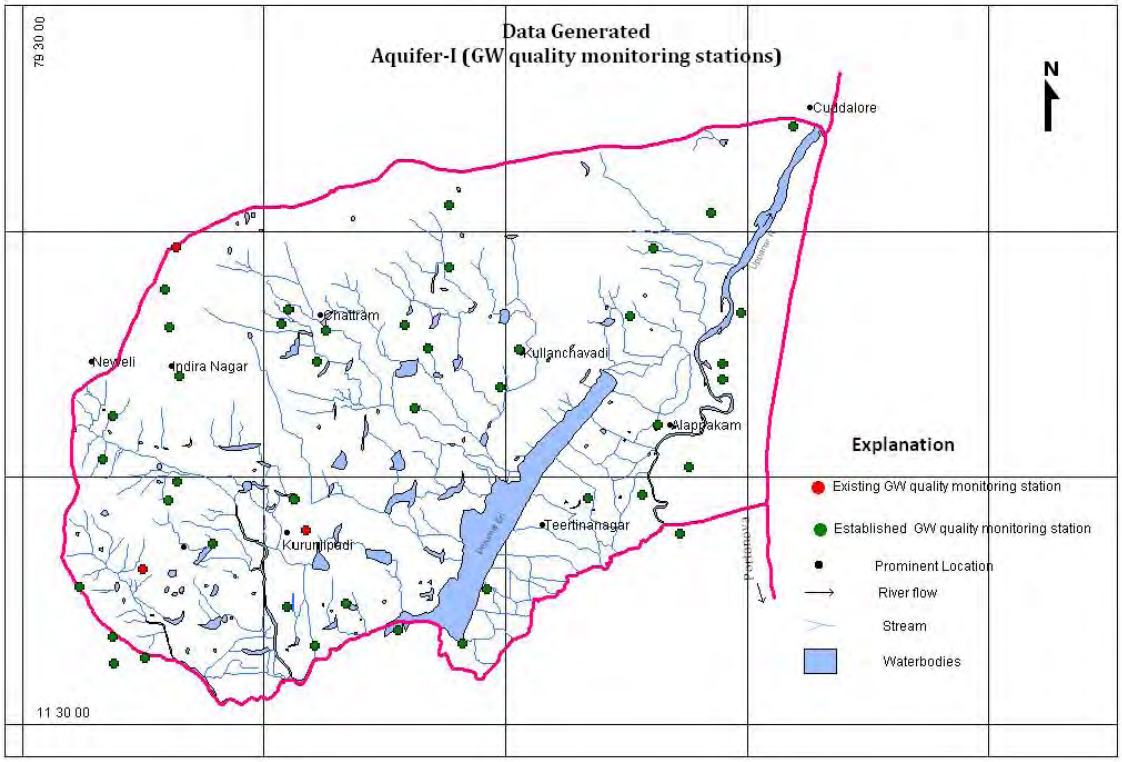


Figure 3.5 Data generated Aquifer-I(Groundwater quality monitoring station)

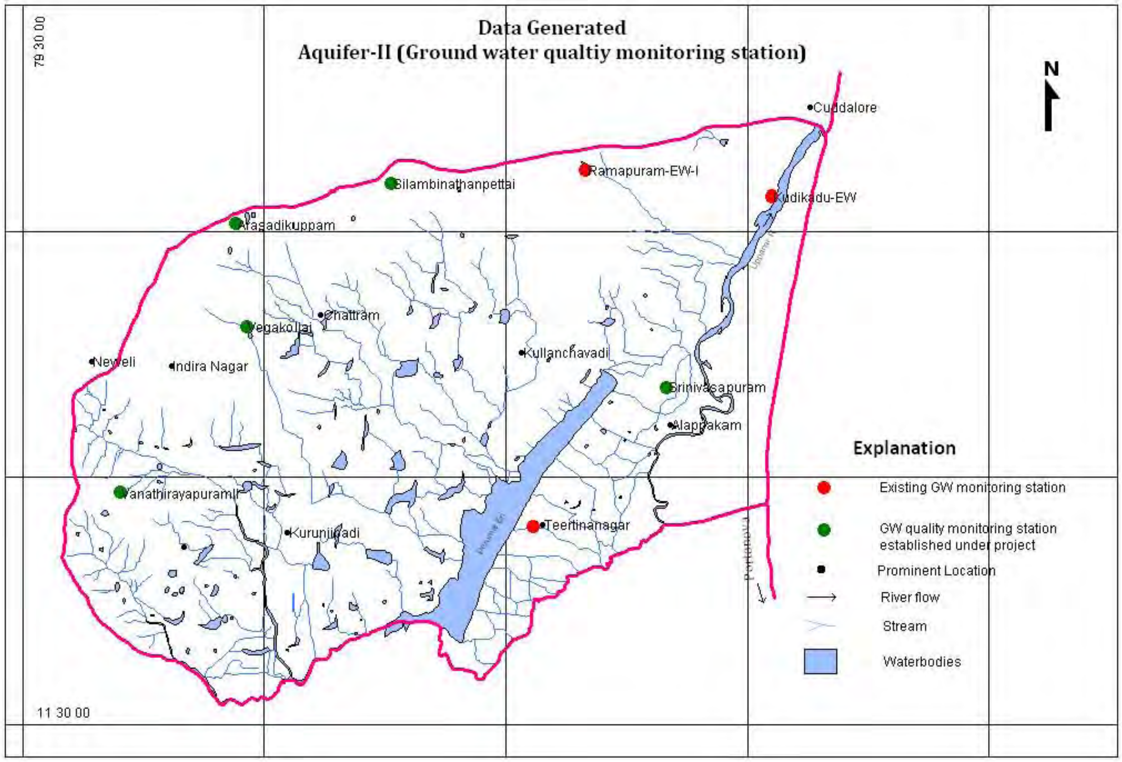


Figure 3.6 Data generated Aquifer-II(Groundwater quality monitoring station)

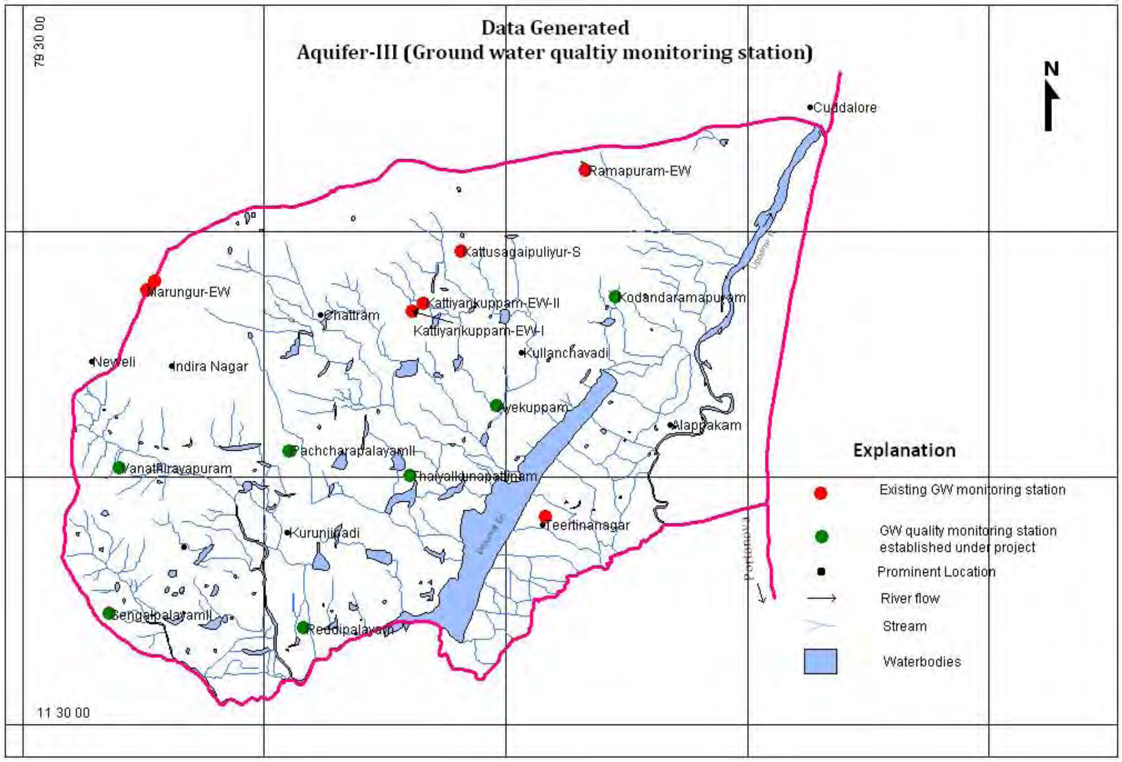


Figure 3.7 Data generated Aquifer-III(Groundwater quality monitoring station)

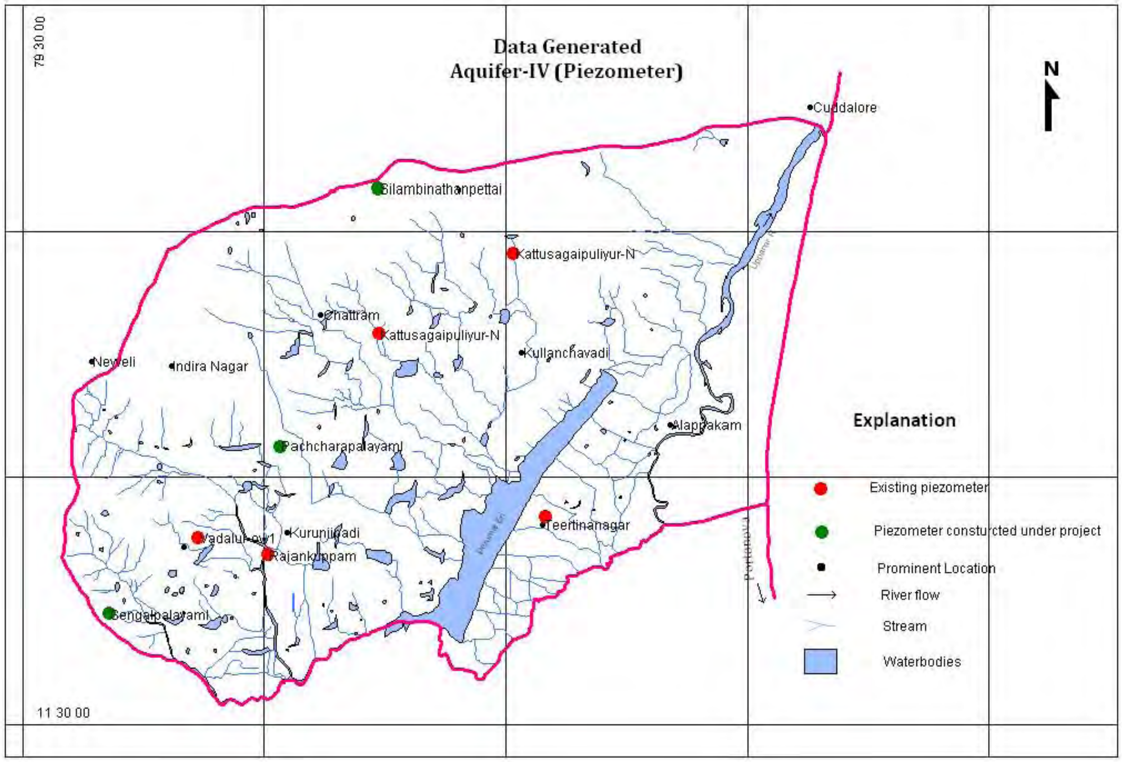


Figure 3.8 Data generated Aquifer-IV (Groundwater quality monitoring station)

3.2 Climate & Rainfall

The climate is hot and humid and winters are moderate. The climate is influenced by the adjoining Bay of Bengal and is generally uniform throughout the project area. The weather is pleasant from January to February and gradually becomes hot. March to June are the hottest months. The temperature raised to as high as 42.9 ˚C. The mean annual temperature is about 31˚ C.

Winds are moderate in strength with increase in speed during the period from April to July and from December to January. Wind speeds are highest in the month of May, being of the order of 12.5 Km/hr and lowest in October being 7.4 km/hr. The Cuddalore coastal tract is prone to Cyclone. The humidity is quite high ranging between 62 and 85 percent occurring throughout the year. Humidity remains high (85 %) during November and

February and remains quite low (62 %) during April and May. The Evaporation is higher (10.8 mm) during May to August and lower during November (2.7 mm).

The mean annual precipitation of the project area is 1290 mm. The representative rainfall station (IMD) is at Cuddalore. The monthly rainfall pattern of the region is given as graph. (Figure 3.9). Periods of excessive rainfall followed by droughts are characteristic of the area and cause major hydrological effects. The rainfall in the study area is mainly from North-east monsoon and south west monsoon. The North-East monsoon (October to December) is more effective and contributes almost 52 to 60 percent of rainfall and the south-west monsoon (June to September) contributes about 30 percent. The remaining percent of rainfall is during summer season (March to May) and winter season (January and February). The rainfall data (2004 to 2013) of Cuddalore Rainfall station is given as table 3.2. The precipitation by south-west and north-east monsoon is mostly of cyclonic in nature and is attributed to series of lows that originate in Bay of Bengal and Indian ocean. The number of rainy days in a year varies from 43 to 63 days. From the analysis of the rainfall data, it is understood that the years with the maximum and minimum number of rainy days do not correspond with the years which have maximum and minimum rainfall. This is mainly due to the variation in the storm or cyclone type and consequent variations in the intensity of the rainfall. Further, three distinct periods of precipitation have been identified. (March to May, June to September and October to January).

The monthly rainfall data for the last 10 year period (2004-2013) maximum rainfall of 1901.9 mm occurred during 2005 and minimum of 1222.4 mm occurred during 2007. Also it is observed that the rainfall of the remaining years are higher in comparison with the 30 year normal rainfall.

The drought analysis for a period of thirty years (1980 – 1981 to 2010 – 2011) inferred that, most severe drought has never been experienced by the study area. However, mild and moderate drought occur with the probability of occurrence as mid drought is 28 to 38 percent and the probability of occurrence of moderate drought is 15 to 32 percent.

3.3 Soil

Red soil, sandy loam, alluvium (Fig.3.10) and sandy soil are the type of soil occurs in the study area. Red soil and alluvium are the major soil types occur in most part of the region. The red soils are derived from the Cuddalore sandstones. The red soil occurs in the central and western part of the area and are more prominent in the following villages. Viz. Vadalur, Indira Nagar (Neyveli), Chattram, Sengalpalayam, Arasadikuppam, Badrakottai, Silambinathanpettai, Puliyur (Fig.3.11). The alluvial soil occurs in the southern part mainly in the discharge area of Perumaleri. The alluvial soil in this region is best for agriculture as they are rich in humus and fertile in nature. The sandy soil exists in eastern part and sandy loam soil is exists in the Northern part.

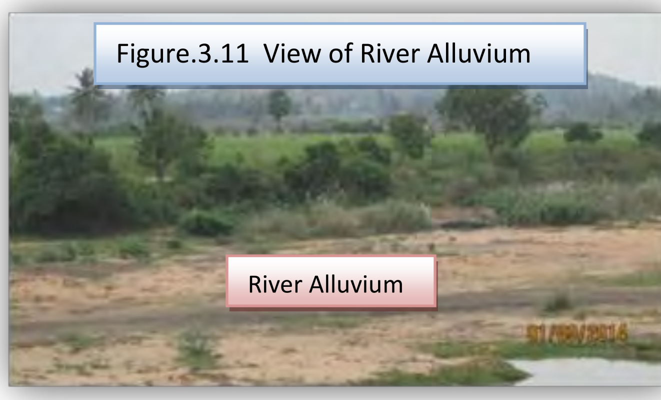


Figure.3.11 View of River Alluvium

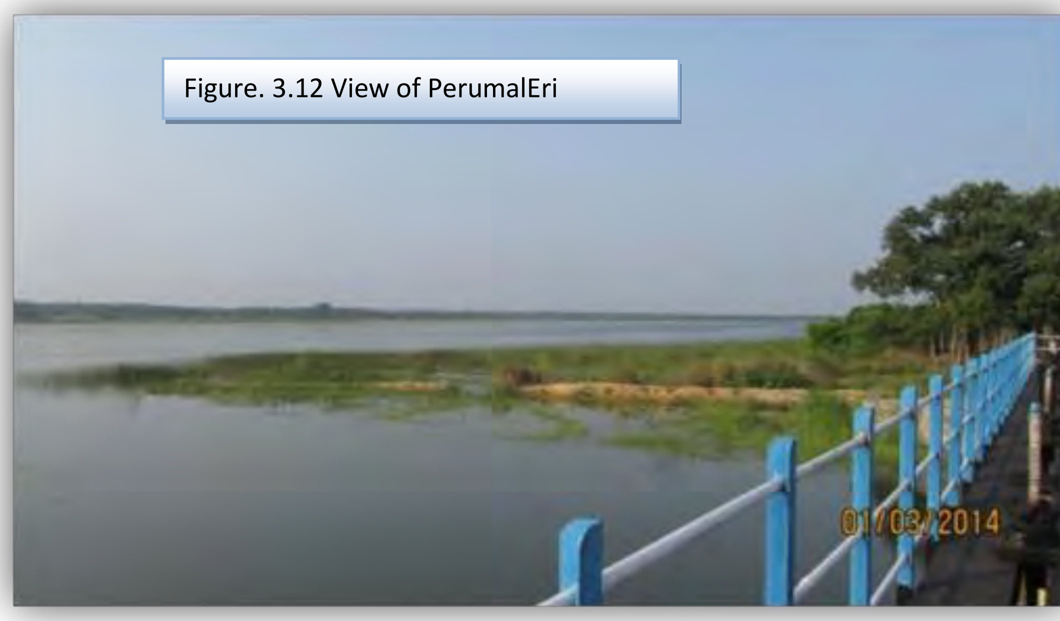


Figure. 3.12 View of PerumalEri

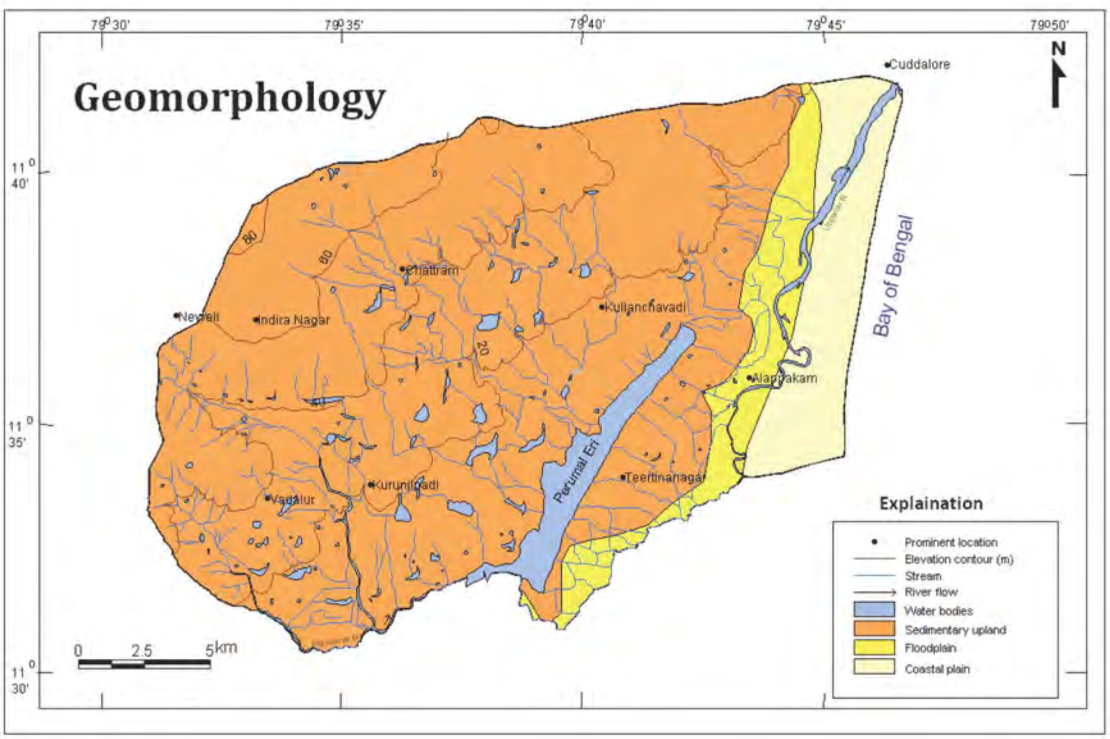
3.5 Land Use

Most part of the region is under intensively irrigated agriculture. Paddy, sugarcane and cashewnuts are mostly cultivated along with groundnut, gauva, coconuts and vegetables. Except for the portion towards the south of PerumalEri where irrigation is partially by the canal, majority of the area is irrigated by groundwater. Few square kilometres of agricultural land (Neyveli and surrounding villages) were brought under mining activity for excavation of lignite deposits (figure 3.14). Also agricultural lands surrounding Vadalur, Kurinjipadi and Kullanchavadi villages are being converted into built up area for construction of houses.

3.6 Geomorphology

The study area is a gently sloping terrain characterized by sedimentary upland, floodplain, sedimentary plain and coastal plain. The sedimentary upland covers most part of the area. (Central, Northern &Western portion). Flood plains are developed along the river course and sedimentary plains are well developed along the mouth of the river course. Sand bars are scattered along the course of the River. The major geomorphic features noticed along coastal tract are comprised of coastal plains. The coastal plain exhibits different geomorphic features which include beach ridges, dune complex, sand dunes, mud flat, salt flat and salt pan. Backwater exists in the north-western part of the study area all along the Uppanarriver. The topography of the Cuddalore coastal plain is gently rolling. The topography ranged from 80 m to 0 m and the elevation gradually dips from west towards the coast (Figure 3.16). In areas whereopen cast mine is in operation, the topography is modified due to mining and dumping of the overburden.

Figure 3.16. Geomorphology map of the lower Vellar water shed



The stratigraphic succession of the Project Area is given below;

Era	Age	Formation	Lithology
Quaternary	Recent to sub recent	**Alluvium and Laterite**	Alluvium, Coastal Sands, sand, clays and Laterite
		Unconformity	
Tertiary	Mio-Pliocene	**Cuddalore Sandstone**	**Sandstone**, clays (variegated), pebble beds
	Eocene	**NeyveliSandstone**	**Sandstone**, **lignite**, clay with pebble beds

3.7.2 Cuddalore sandstones of Mio-Pliocene age:

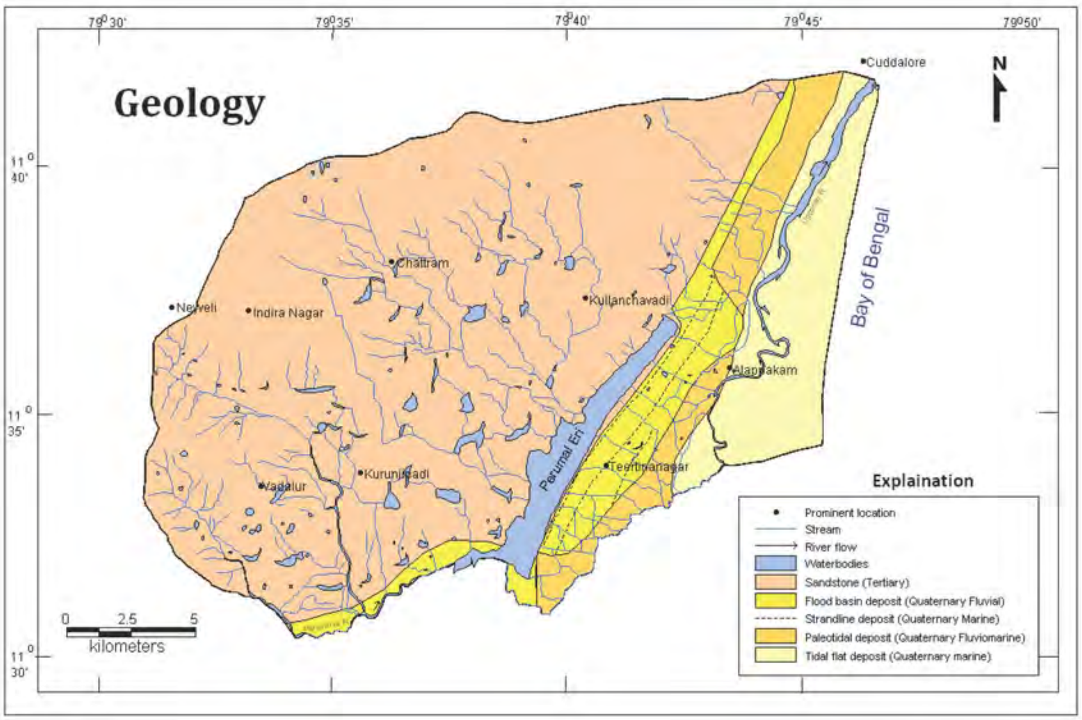
The Cuddalore sandstone comprises of argillaceous sandstone, pebble bearing sandstone, ferruginous sandstone, grits and clay beds. They are whitish, pinkish, reddishin colour and are friable in nature. The sands and sandstones of Cuddalore formation of Mio-Pliocene age range in size from fine to very coarse grained and are sub-angular to sub-round in shape.The sandstones includes rounded pebbles of quarts even upto 1 inch in diameter. The Cuddalore sandstones occur beneath the alluvium formation and in place where alluvium formations are absent they are exposed on the surface. Laterite occurs as cappingin the central and northern portion of the study area. The sandstones of Eocene age underlie the Cuddalore sandstone.

3.7.3 Neyveli Sandstones of Eocene age:

The Neyveli sandstones are of Eocene age and are pale grey in colour and comprising of fine to coarse sand with occasional clay intercalations. Like that of Cuddalore sandstones, Neyveli sandstones are friable in nature. The lignite deposits occur within the Eocene sandstones and can be considered as marker horizon between

Cuddaloresandstones and Neyveli sandstones. The thickness of Lignite is not uniform and in many places ligniteisabsent.

Figure 3.17 Geology map of the study area



3.8 Geophysics

National Geophysical Research Institute (NGRI) has carried out 36 deep resisitivity sounding 10 G-TEM, 20 ERT survey and Heliborne geophysical studies in area under Pilot Project based on the TOR and as per the agreement between CGWB and NGRI. Heliborne geophysical survey (SKYTEM) was carried out during 6^{th} to 15^{th} February 2014. The entire operation was carried out from Pedanayakan village in Kurunjipadi Block

3.8.1. Behaviour of response

Deep electrical sounding response in terms of its pattern at each site and in different directions was studied for qualitative understanding of litho-sequence reflections. In most of the cases, the behavior pattern is very similar and only variation is found laterally from west to east which may be reflecting the increase in depth of occurrence concurring with the expected dip of the formations. While preparing the geo-electrical cross sections, these qualitative observations were kept in mind while refining the interpretation apart from lithological control. An example of inferences drawn on representative geological sequences in the pattern of resistivity sounding curve observed inside the Neyveli Mines-1 area is presented (Fig. 3.18).

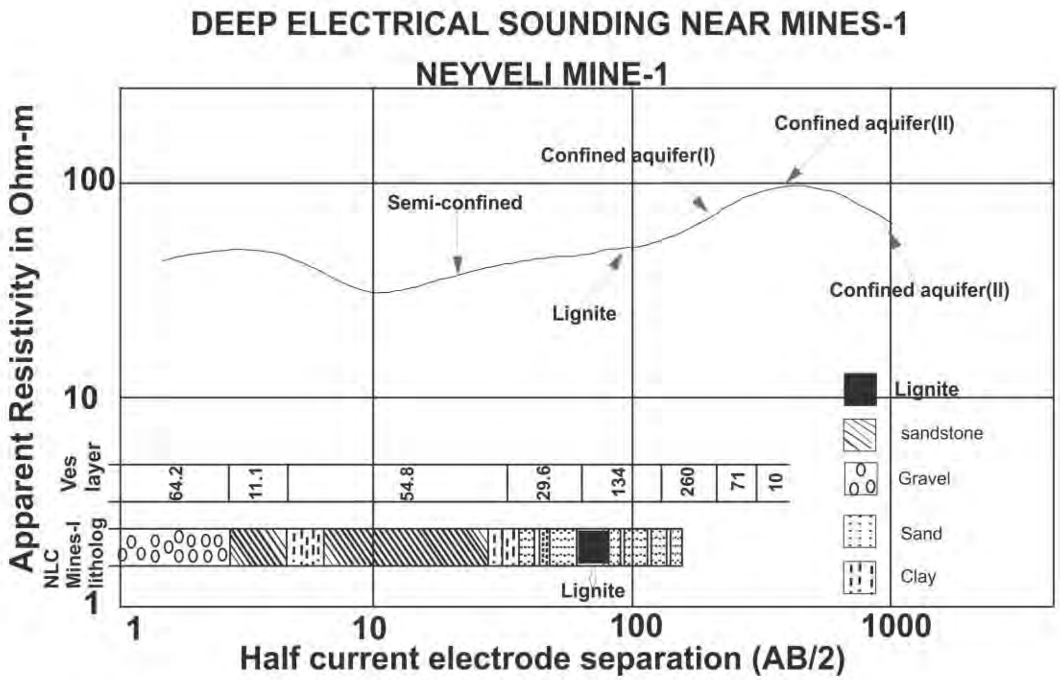


Fig. 3.18 VES-24curvenearNeyveli mines-I

3.8.2 Calibration of Vertical Electrical sounding

As part of the initial investigations, deep vertical electrical soundings were conducted near existing tube wells for which lithologs are available. Neyveli Lignite Corporation has provided litho sequences of a borehole (core drilling) south of Vadalur near village Nayinakuppam. Deep vertical Electrical Sounding was conducted at this site for calibration of geo-electrical parameters. The lithology as provided by NLC and the interpreted layer parameters are presented (Fig. 3.19). The interpretation of sounding yielded a seven layer sequence and is comparable with the major litho-sequences met in the exploratory well.

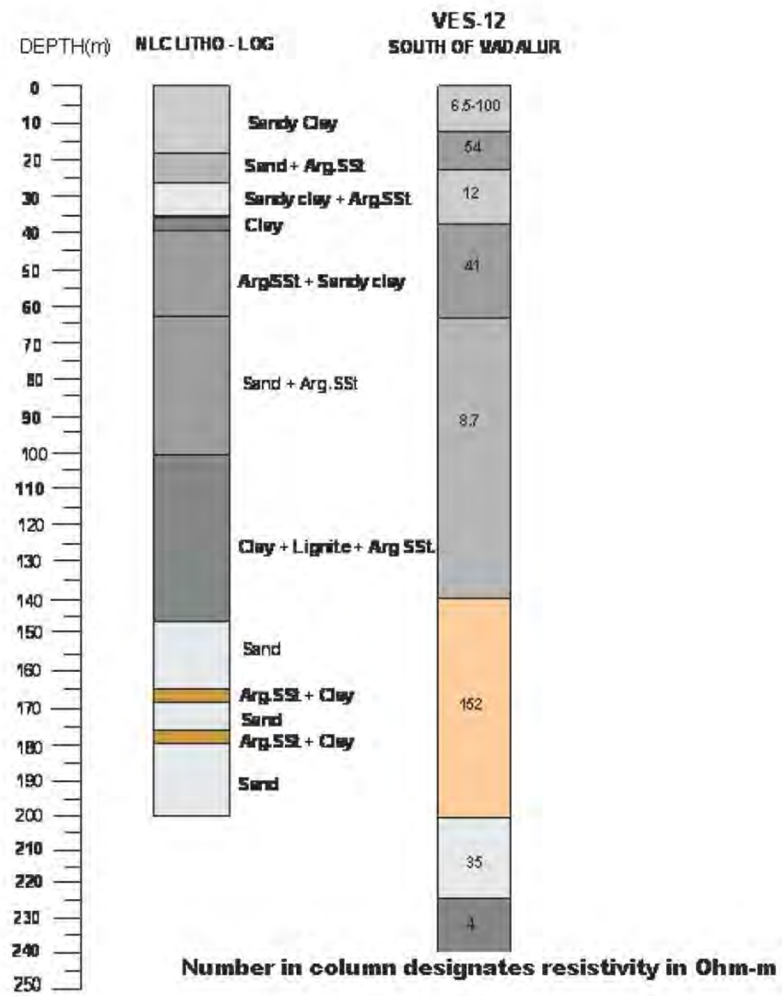


Fig. 3.19 Litholog of exploratory core drilling well (NLC) near Vadalur and interpreted layer parameter of VES-12

Similarly, lithology of another borehole recently drilled by CGWB at Ayikuppam was compared with the deep vertical electrical soundings on both sides of this drilled site. The comparison of geo-electrical layers derived from interpretation of these two soundings with the actual lithological sequences (Fig. 3.20) as another example of calibration and understanding.

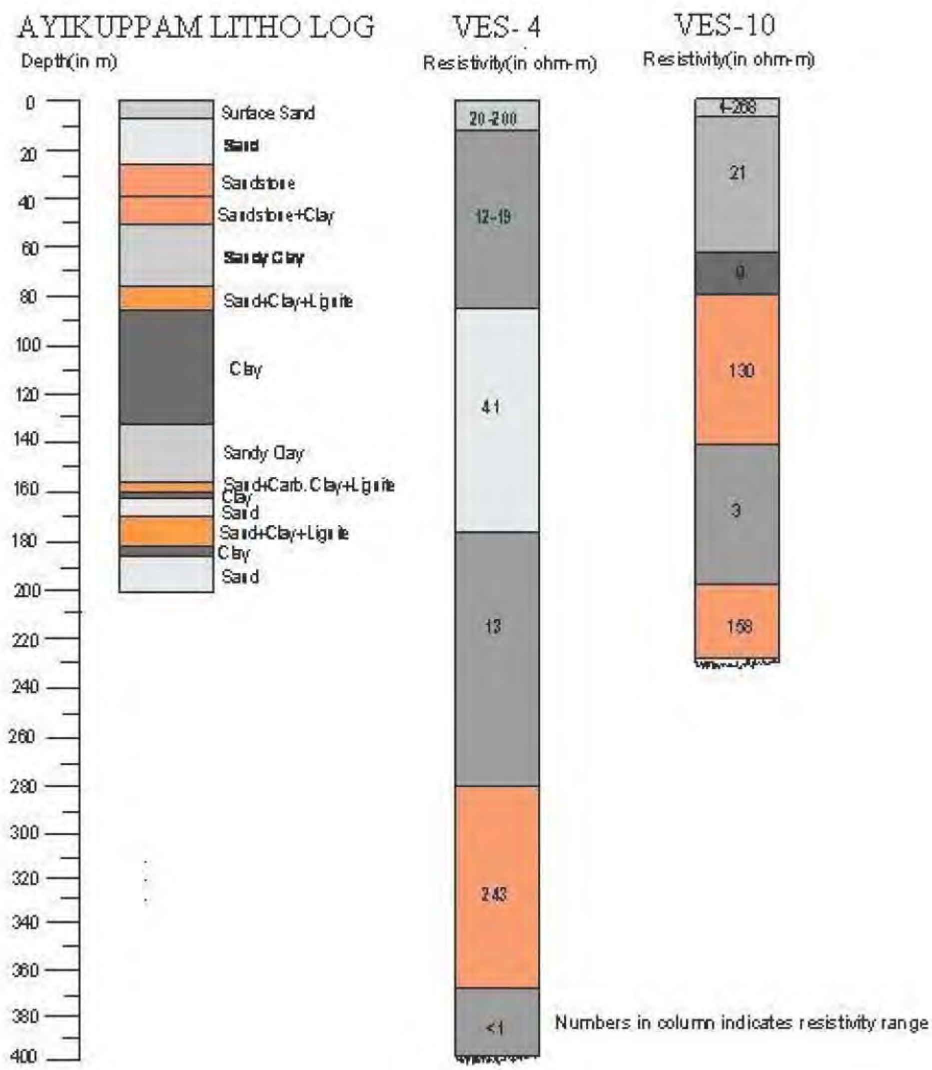


Fig. 3.20 Litholog of Aiykuppamexploratory well (CGWB) & interpreted layer Parameters of VES-2 and VES-10

Similarly, comparisons are made wherever litho logs are available all over the study area to calibrate the interpretation and the geo-electrical layers resistivity and its thicknesses. Since the drilled and sounding sites are not at the same locations, the calibration attempt resulted into an approximation. However, the calibration attempt is valid since the aquifers are of sedimentary nature and regional.

3.8.3. Interpretation of soundings

All the soundings were interpreted using three layer master curves of Orellana& Mooney and derived the layer parameters. In order to refine the interpretation and correctness of it, RESIST forward modeling program was used and final model was generated with RMS Error less than 2.5. However, as plausible approach, the sounding curve was interpreted and different models were prepared such as interpreted model, litholog model and equivalence model (Table.3.3). An example of such an attempt is presented (Fig. 3.21).

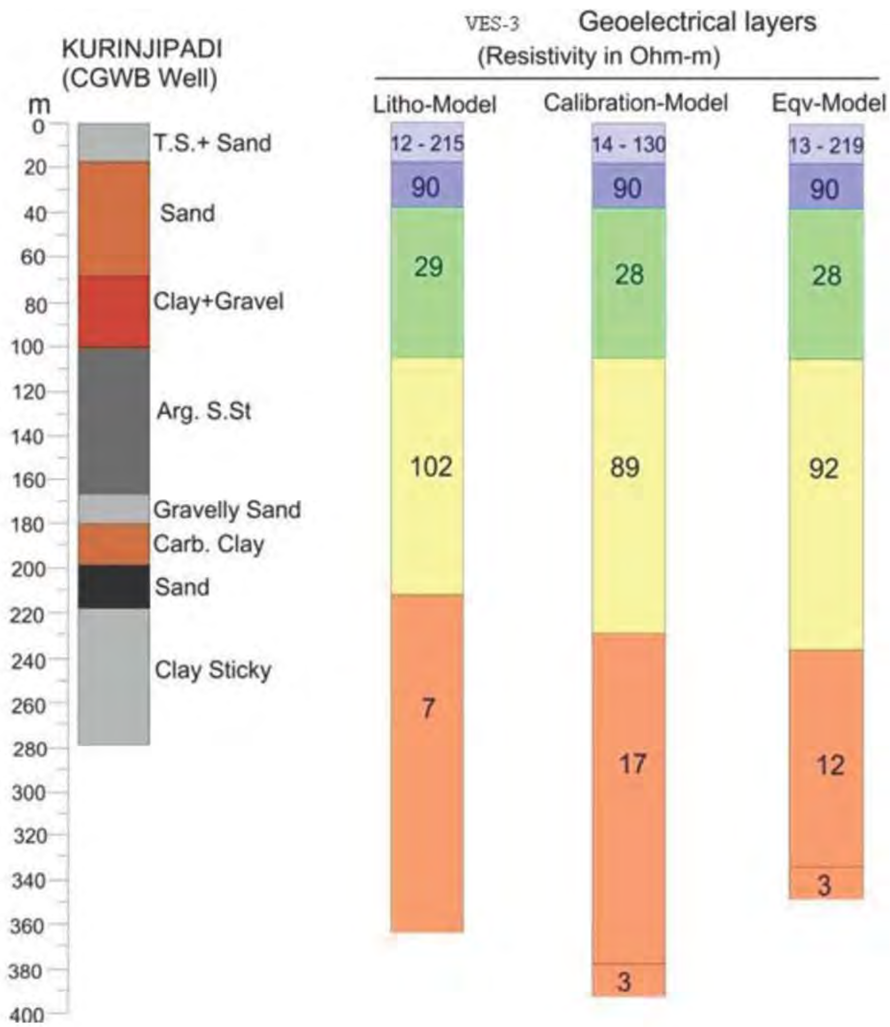


Fig. 3.21 Layer parameters of 3 different models for VES-3 near Kurunjipadi exploratory well (CGWB)

Table – 3.3 Final interpreted VES parameters

S.No	Location	Latitude	Long		Geo-Electrical layers									
					1	2	3	4	5	6	7	8	9	10
1	MEL-VADAKUT HU	79.56	11.60	P	150	294	31	245	13	247	35	358	25	3
				H	1.4	1.2	6.3	7.3	14	15.6	60	61.3	64.6	---
					T.S				C+S	S.St	L	S	S+C	SC
2	KOTTIYA KUPPAM	79.57	11.65	P	363	266	62	122	69	15	47	---	---	---
				H	2.1	4.4	8.5	56.7	74.7	90.7	---	---	---	---
					SC			CS	G+C+S		S			
3	N OF KURUNJIPADI	79.60	11.60	P	215	72	25	160	12	90	29	102	7	
				H	1.8	4.1	2.3	3.2	6.3	20.4	66	108	---	
					T S					S	SC	CS	FS+C	
4	N OF AYIKUPPAM	79.64	11.63	P	201	89	20	12	19	41	13	243	1	
				H	0.8	1.7	8.6	16.2	60.4	87	105.2	87.6	---	
					T.S				SC	S+C	C	S	C	
5	SENGAL PALEM	79.53	11.53	P	326	78.7	33.5	10	54.2	23.5	77	41	10	
				H	1.7	1.5	9	5.6	35.6	62	104.1	81	---	
					T.S+C				S.St	S.St+SC	S.St+S	S	SC	
6	NEAR NLC	79.54	11.63	P	359	120	64	160	115	1290	5			
				H	2.2	6.3	30.2	39.5	20.3	42	---			
7	VANIYAR PALAYAM	79.68	11.63	P	296	140	25	68	19	95	40	18	1	
				H	1.5	2	11	13	16	70	42	38	---	
					T.S		Cl.S+S			FS	SC	Cl.S	C	
8	CHINNA KANNADI	79.63	11.55	P	55.4	40.2	10.9	67.4	23.6	14.8	9.2			
				H	1.4	3.7	33.5	28.8	35.6	21.9	---			
					T.S	S		S.St	SC	SC	Cl.S			
9	ARSADI KUPPAM	79.59	11.67	P	1678	280	45	562	38	236	32			
				H	0.8	7.9	9	9	12.6	120	---			
					T.S			S	Cl.S	PG+S	SC			
10	PEDDANAYAKAKUPPAM	79.62	11.59	P	268	43.4	4	21	9.3	129.6	2.4	158		
				H	1.2	3.5	2.7	63.3	13.3	55.7	57.6	---		
					T.S		Cl.S	FS	Cl.S	S	C	S		
11	KUNDIYA MALLURU	79.65	11.53	P	52.5	13.2	9	2.3	92.8	4.8				
				H	0.5	4.9	8.3	9.3	8.6	---				
					S	Cl.S	Cl.S	C	S	SC				

12	NEAR VADALUR	79.55	11.54	P	105.4	31.5	6.5	53.7	12.7	41.5	8.7	152	34.7	4
				H	1.2	4.1	6.2	10.2	13.8	25.6	81.1	59	39.7	---
					TS	SC		S.St	Cl.S	S.St	SC	CS	FS	S C
13	CHANKANCHAVAD I	79.73	11.64	P	6.7	1.3	28.3	4.3	78.4	13.7	67.3	21	3	
				H	5	1.4	8.2	16.8	31.1	74.6	98.8	58	---	
					SC		S	SC	S	SC	S	FS	SC	
14	PERIYAPATTU	79.75	11.60	P	0.8	1.3	5.3	47.1	0.5	109.8				
				h	4.1	15.2	30.1	17.3	25.7	---				
					S (S)			FS	C	L.St+S				
15	TIRTANAGIRI	79.67	11.57	ρ	10.5	4	7.7	50	8					
				h	4.5	5	77.7	140	---					
					SC			S	SC					
16	ROAD TO RAMA KUPPAM	79.71	11.62	ρ	103	10.5	7	147	12.3	114	64	31	3	
				h	1	8.6	17.7	25.8	60.6	75.5	86	70.8	---	
					T.S		C	GS	CS	S	S	FS	CS	
17	POOVALI ROAD	79.68	11.51	ρ	7.6	36	8	3.5	2.5	1	46			
				h	1.4	2.6	20.4	25	127.7	216	---			
					T.S		Cl.S		S (S)	C	L.St			
18	PARADHANAPATTU	79.62	11.52	ρ	5	10.6	3.6	8.5	6.8	19.2	9.1	4.4		
				h	1.1	2	1.9	8.2	18.2	86.5	71.6	---		
					T.S	FS to MS				C	CC	SC	SC	
19	CAPPER QUARRY	79.74	11.68	ρ	1669	279.8	44.8	582	36	233.7	31.7			
				h	0.8	7.9	9.1	9.4	13.3	130.3	---			
					T.S	S.St	SC	S.St	SC	S.St	S			
20	PULUYAR-KATTUSAGI	79.65	11.65	ρ	251	159.7	35	828	34.2	713.1	40	20.1		
				h	1.6	3.2	1.8	2	6.3	15.9	130.9	---		
21	NEYVELI-PANRUTTI RD-1	79.55	11.66	ρ	340	94.5	44.7	154	295	65	14	3		
				h	0.8	13	44.7	24	81	29	65	---		
					LS	S	FS	S.St		GS	SC	C		
22	NEYVELI-PANRUTTI RD-2	79.55	11.73	ρ	1446	156.5	64.3	473	90.7	161.8	73.4	8	1.7	
				h	0.6	9.8	26.5	77.2	30.6	28.4	52.3	85.1	---	
					LS	F.SSt		G,P	SC	S.St	S	SC	CS	
23	VADAKUTTU	79.55	11.60	ρ	222	133	96	22	87	37	295	12	4	
				h	2.1	14	19.5	23.5	96	92	81	52	---	
					T.S				CS	MS	GS	SC	C	
24	NEYVELI MINES-I	79.47	11.56	ρ	43.4	64.2	11.1	54.8	29.6	134.3	260.6	71.1	10	
				h	0.8	2.1	2.5	30.7	34.8	71.7	118.3	82.8	---	
					T.S			S	SC	CS	GS	S	SC	

Similar way, different geo-electrical layer models were prepared for all soundings with an aim of facilitating in characterization of aquifer geo-electrical parameters.Further when geo-electrical cross sections were prepared for different directions, the interpretations were re-adjusted and the final interpreted values were tabulated. Table-3.3 presents the final interpreted layer parameters of soundings.

T.S - TOP SOIL	LS - LATERITIC SOIL
S - SAND	S.St- SANDSTONE
CS - COARSE SAND	MS - MEDIUM SAND
FS - FINE SAND	GS - GRAVELLY SAND
Cl.S - CLAYEY SAND	SC - SANDY CLAY
C - CLAY	L - LIGNITE
L.St - LIMESTONE	GP- GRAVEL & PEBBLE
F.Sst – Ferrugenous SANDSTONE	S (S) – SAND(Saline)

3.8.4. Geo Electrical cross sections

Generally to understand the regional aquifer disposition, hydro geological sections were prepared using the bore well litho logs. Similarly, using the interpreted geo-electrical parameters of several soundings falling on a line and in a particular direction when they are connected on the basis of resistivity sub-surface structure, the emerged cross section is called Geo-Electric Cross Section. The section depicts the vertical disposition and lateral extension of layers. For the pilot study area such an attempt was made along two N-S sections (one on the west and the other on the east) of the study area and one in W-E (South) sections. Still refinement of these sections is underway with placement of litho-controls. However, some sections were presented below as part of mid-term progress.

S-N Section (western part)

SOUTH OF VADALUR- PANIKKANKUPPAM (western part)

A Geo-Electric Cross Section covering a distance of 28 km was attempted on the western part of the study area in North-South direction using the interpreted layer parameters of 4 Vertical Electrical Soundings observed to a maximum spread of AB=2000 m. The sub-surface deeper response of two soundings observed on the northern part is distinctly different from the response of the other two soundings observed in the southern part. The unique responses of these two segments indirectly reflect the textural nature of deeper sediments forming different geo-electric layers. An example of behavior of two soundings one from the north and the other from south were drawn and presented (Fig. 3.22).

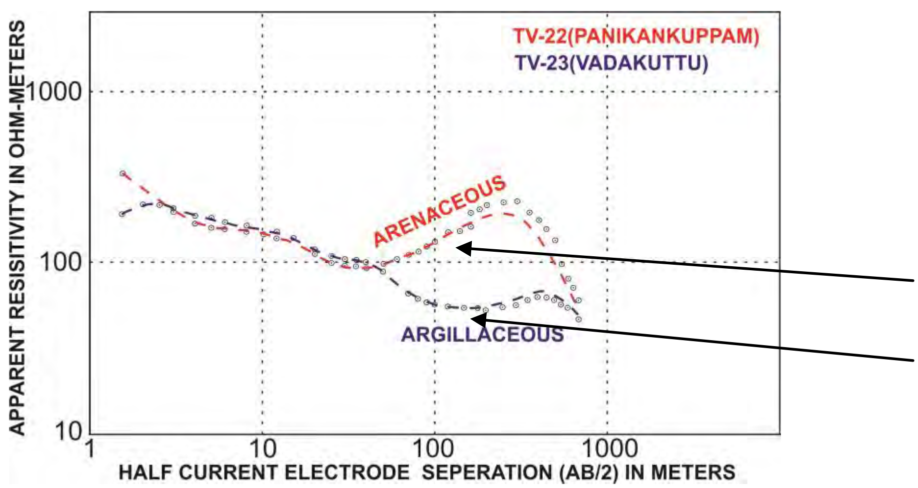


Fig. 3.22 Behavior of VES curves in the northern and southern part along the N-S section

(Panikankuppam-Vadalur)

Modern state of art Heliborne Geophysics, the major component of the AQUIM project, has been done in collaboration with Aarhus University, Denmark using dual moment SkyTEM system developed at Aarhus University and operated and owned by SkyTEM Survey Aps, Denmark. Dual moment ensures high-resolution information from top to deeper level by means of low and high transmitter moments. Originally it was planned to carry out SkyTEM surveys first, followed by the ground based investigations for spot geophysical character verification. However, due to time and administrative constraints, the heliborne survey was carried out only in the early part of the year 2014.

The heliborne survey data was acquired with closely spaced fly lines extending the acquisition in to sea bed along the coast. The result of this project also focused towards highlighting the applicability of heliborne survey for complex hydrogeological environment similar to that of AQTND as well as socio-developmental aspects in coastal areas. The pilot study aims to demonstrate that the heliborne surveys provide a very efficient, cost effective and rapid methodology with high-resolution for nationwide aquifer mapping program (NAQUIM).With a degree of variability in topography, lithological composition, air pressure variation, quality of groundwater, etc., which are likely to influence the data quality, adequate care has been taken while using the state of art data processing and inversion algorithms to generate the output employing the laterally and spatially constrained inversion (LCI& SCI) approaches.

The results from the SkyTEM survey were analyzed for several profiles along the fly-lines (W-E) independently and collated together to study their spatial behavior. The SCI database was essentially used for this purpose. The surveyed area has been gridded by 2 x 2 km and studied along profile lines by taking grid nodal Smooth Inversion (resistivity depth information) results and then converted into resistivity sections; lithological sections and finally into aquifer sections. Few attempts have also been made to derive hydraulic property of the aquifer delineated in terms of permeability (K) using the resistivity. The dense data information on sub-surface is expected to facilitate the future aquifer management program.

3.8.5 COLLECTION OF DATA

The field campaign was performed from 6th to 15thof February, 2014 and high-quality SkyTEM data were acquired.

DATA PROCESSING

The collected data were carefully processed to remove couplings and noise before the inversion.

Inversion

After processing and preliminary inversions, the data have been inverted using the spatially constrained inversion (SCI) approach.

Data Collection

The survey area

The AQTND survey was carried out during the period February 6-15, 2014. The survey area of 348 sq km was covered with 2295line km along 95 flight lines and 15 Tie Lines. The fly line spacing was kept as 250 m interval whereas for the Tie lines, it was kept as 2000 m. The average flight speed was approximately 22 m/s with an average flight altitude of 30 m.

3.8.6. Overview of the SkyTEM system

SkyTEM is a time-domain helicopter borne electromagnetic system designed for hydrogeophysical, environmental and mineral investigations. A more thorough description of the SkyTEM method is found in (Sørensen and Auken, 2004). A description of the TEM method in general can be found in (Jørgensen et al., 2003) and (Nabighian and Macnae, 1991).

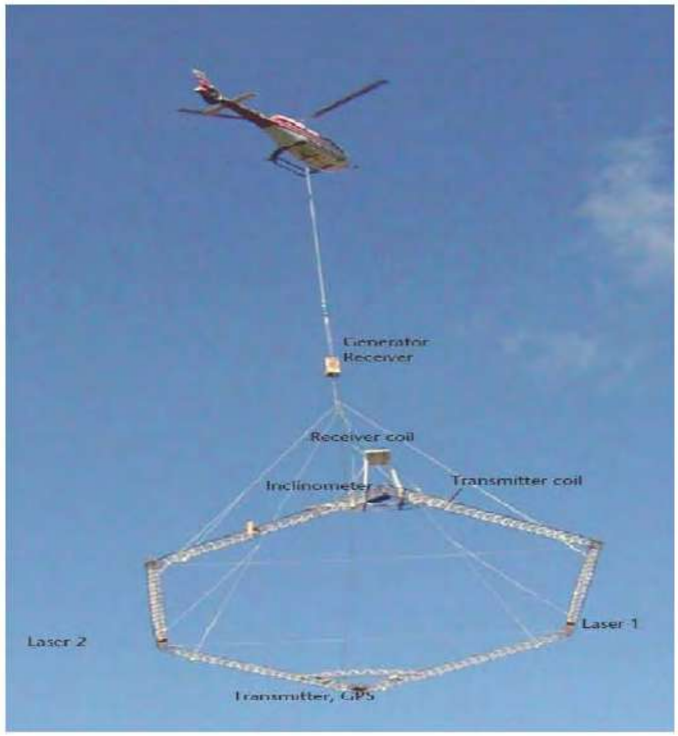


Figure 3.23. The airborne SkyTEM system. The transmitter frame holds inclinometers, ltimeters (lasers), receiver coil and instrumentation.

a. Instrument

Figure 3.16 shows a picture of the SkyTEM system with the hexagonal frame below the helicopter. The lengths of the frame sides are approximately 11 m. The transmitter loop is mounted on the frame in an octagonal polygon configuration. The receiver loop is placed approximately 2 m above the frame in what is roughly a central loop configuration with a vertical offset. Two lasers placed on the frame measure the distance to terrain continuously while flying, and two inclinometers measure the tilt of the frame. Power is supplied by a generator placed between the helicopter and the frame. The positions of the different devices on the frame are shown in Fig.3.23

B. MEASUREMENT PROCEDURE

The configuration of the system is customized for each survey. Measurements are carried out with one or two transmitter moments, depending on the geological terrain conditions. The standard configuration uses a low and a high transmitter moment applied sequentially. Each sequence has between 100 and 200 individual transient measurements. Background noise is measured for each 20 sec.

The flight altitude is depending on flight speed, topography, etc. Normal flight altitude is around 30-50 m. Over forested areas, the altitude is increased to maintain a necessary safety distance to the treetops. The operating speed is customized to the survey area and target. General flight speed opted is about 45-90 km/h, depending on the target.Apart from GPS, altitude and TEM data, a number of instrument parameters are monitored and stored digitally for quality control when the data is being processed.

C. PENETRATION DEPTH

The penetration depth for the SkyTEM system depends on the moment, the geological conditions, the level of the background noise and the speed and altitude of the frame. The influence of altitude is important and in order to achieve good data acquisition, the altitude should normally be less than 50 m. Penetration depth of approximately 200-250 m can normally be achieved in sedimentary regions. During the inversion, depth of investigation is estimated for each resistivity model.

SkyTEM – Technical Specifications

The SkyTEM system was configured in a standard two-moment setup (super low moment, SLM and high moment, HM) to obtain dB/dt decay curve (TEM sounding curve).

The system instrument setup is shown in Figure 3.24 The positioning of the instruments and the corners of the octagon described by the transmitter coil are

calibration parameters, turn-on and turn-off ramps, calibration parameters, etc. For a description of the SkyTEM file formats see (HydroGeophysics Group 2011).

2. Automatic processing: First, an automatic processing of the four data types is used. These are GPS-, altitude-, tilt- and TEM data. This automatic processing is based on a number of criteria adjusted to the survey concerned.
3. Manual processing: Inspection and correction of the results of the automatic processing for the data types in question.
4. Adjustment of the data processing based on preliminary inversion results.

All data is recorded with a common time stamp. This time stamp is used as key when linking data from different data types. The time stamp is given in GMT time.

A short description of the processing of the different data types is presented below. Elaborative description of the SkyTEM processing module of the Aarhus Workbench is found in (HydroGeophysics Group, 2011).

Inversion of the SkyTEM data

Inversion and evaluation of the inversion result are done using the Aarhus Workbench software package. The underlying inversion code is developed by the HydroGeophysics Group, Aarhus University, Denmark (Christansen et al., 2011).

Coil response inversion

The information about the near-surface geology is contained in the early part of the TEM sounding curve. In order to improve the resolution of the near-surface geology, it is important to obtain useful data as early as possible on the TEM sounding curve. The signal from the very early times also contains a signal from the instrument itself. This interfering signal is called the coil response as it is caused by the coupling of the primary field to the receiver coil. Normally, gates are discarded where the coil response is more than about 5% of the measured signal. Usually, this means that only gates from approximately 11-12 µs after turn-off can be used. With the coil response inversion concept, the signal is adaptively compensated for the coil response signal so that the coil response affected gates in the interval 7-11 μs may also be included in the interpretation. This, however, requires that SkyTEM mapping is collected with an optimized SkyTEM setup with sufficient gates in the part of the TEM sounding curve where the coil response signal can be determined.

The size of the coil response signal is determined by making measurements at high altitude (> 600 m). Here the signal from the ground makes out just a tiny portion of the measured signal, which indeed is dominated by random background noise and coil response. If data are averaged, the random background noise will be stacked out, and the coil response signal can be quantified. This principle is illustrated in figure as A in Figure 7. The grey and blue lines show data from high altitude means over TEM soundings from time intervals of 6 s (grey line) and 768 s (blue line). The two green lines illustrate how the background noise is effectively decreased by a factor of about 10 (approximately the square root of 6/768) due to averaging. The red circles show the gates that are not diminished by averaging since they are dominated by the coil response signal. The Coil response signal can be assumed to be exponentially decaying, as shown with the red slash through the red circles in figure as B in Figure 3.25. Also plotted on the figure are two (green) curves showing the typical level of the measured signals at 30 m (top) and 40 m (bottom) altitude, respectively.

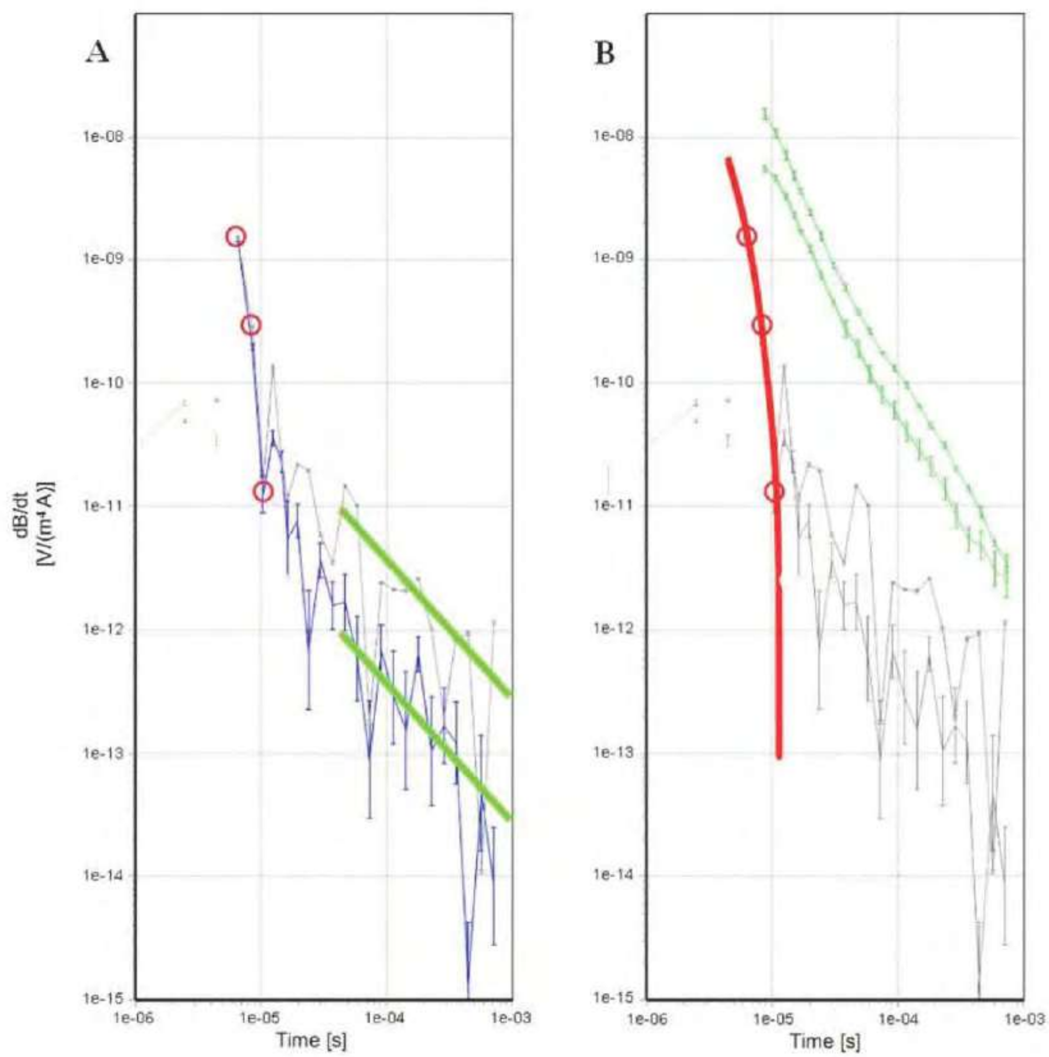


Figure3.25 The figure illustrates the principle for coil response correction.

A: Stacked SLM data from high altitude. The stacks of 6 s and 768 s, respectively, are shown as a grey and a blue line. The green lines show how the background noise is decreased by a factor of about 10 from averaging over longer time intervals. The red circles show gates that are virtually unchanged since the coil response signal dominates the background noise.

B:Stacked SLM data from high altitude. The red line shows the coil response signal. The green lines show the level of a typical measured signal from 30 m (top) and 40 m (bottom) altitude, respectively. The first gate of the measured signal at 40 m contains about 8% coil response signal and is clearly dragged down by a, in this case, negative coil response signal.

The coil response signal is not constant for a full survey. There may be slight variations in the level during each flight, and the level can also be displaced if the receiver coil is repositioned a few millimeters due to a hard landing. The shape of the coil response signal, however, is assumed to be constant. With this in mind, the coil response signal simply cannot be subtracted from the measured signal and applied to the early time gates. Instead, a coil response function is introduced with the coil response inversion concept which, during the inversion, adaptively compensates for the coil response. This is illustrated in Fig.3.26 Inversion with coil response correction is progressing similar to the normal inversion. The total forward response, consisting of the normal forward responses plus a contribution from the coil response function, is compared with the measured signal. Small adjustments of the inversion parameters and the level of coil response function are performed before the next comparison. This continues until the total forward response is sufficiently close to the measured signal to consider the inversion completed.

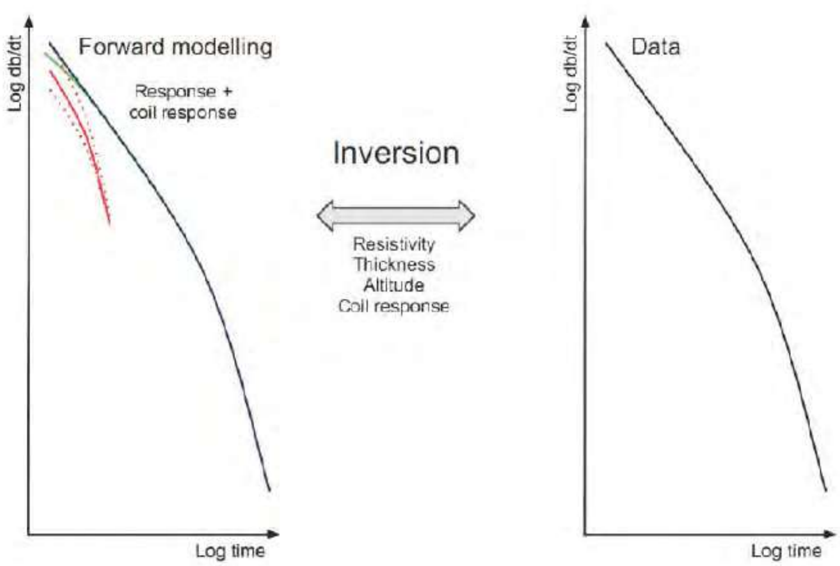


Figure 3.26 .Inversion with coil response correction.

The total forward response (blue curve) consisting of the normal forward response (green curve) plus a contribution from the coil response function (red curve), is compared to the measured signal (black curve). Small adjustments of the inversion parameters (that determine the normal forward response) and the level of the coil response function are performed before the each comparison until the total forward response is sufficiently close to the measured signal.

The coil response function is introduced based on the following assumptions:

- The shape of the coil response function is fixed and identical to the coil response signal at high altitude. The level of coil response function is variable.
- Major variations in the level of coil response function from flight line to flight line can occur.
- Only minor variations in the level of coil response function from TEM sounding to TEM sounding is observed.

Within the Aarhus Workbench those assumptions can be applied by using coil response settings that: a) sets the level of the coil response with a loose prior constraint to the level of the high altitude test and b) sets a tight lateral constraint to the level of the coil response along the flight line. If the inversion needs to shift the level of the coil response function along an entire flight line, it can do so as long as the level from TEM sounding to TEM sounding does not change too much.

Spatially constrained inversion

The spatially constrained inversion (SCI) uses constraints between the 1D-models, both along and across the flight lines, as shown in Fig. 3.27. The inversion is a 1D full non-linear damped least-squares solution in which the transfer function of the instrumentation is modeled. The transfer function includes turn-on and turn-off ramps, front gate, low-pass filters, and transmitter and receiver positions. The flight altitude contributes to the inversion scheme as a model parameter with the laser altimeter readings as a constrained prior value.

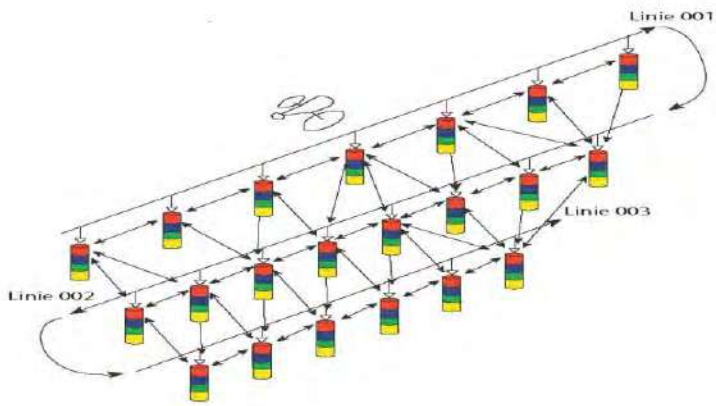


Figure 3.27.Schematic presentation of the SCI concept.

*Constraints connect not only TEM soundings located along the flight line, but also those across them.*In the SCI scheme, the model parameters are tied together with a spatially dependent covariance scaled according to the distance between TEM soundings. The constraints between the TEM soundings are designed using Delaunay triangles, also called nearest neighbors (as shown in Fig.3.28). In this way each TEM sounding is linked to its "best companions". For Airborne EM surveys, Delaunay triangulation always connects a TEM sounding to its two nearest TEM soundings along the flight line and one or more TEM soundings on each of the adjacent flight lines, which is the preliminary condition for breaking down the line orientation in the data.

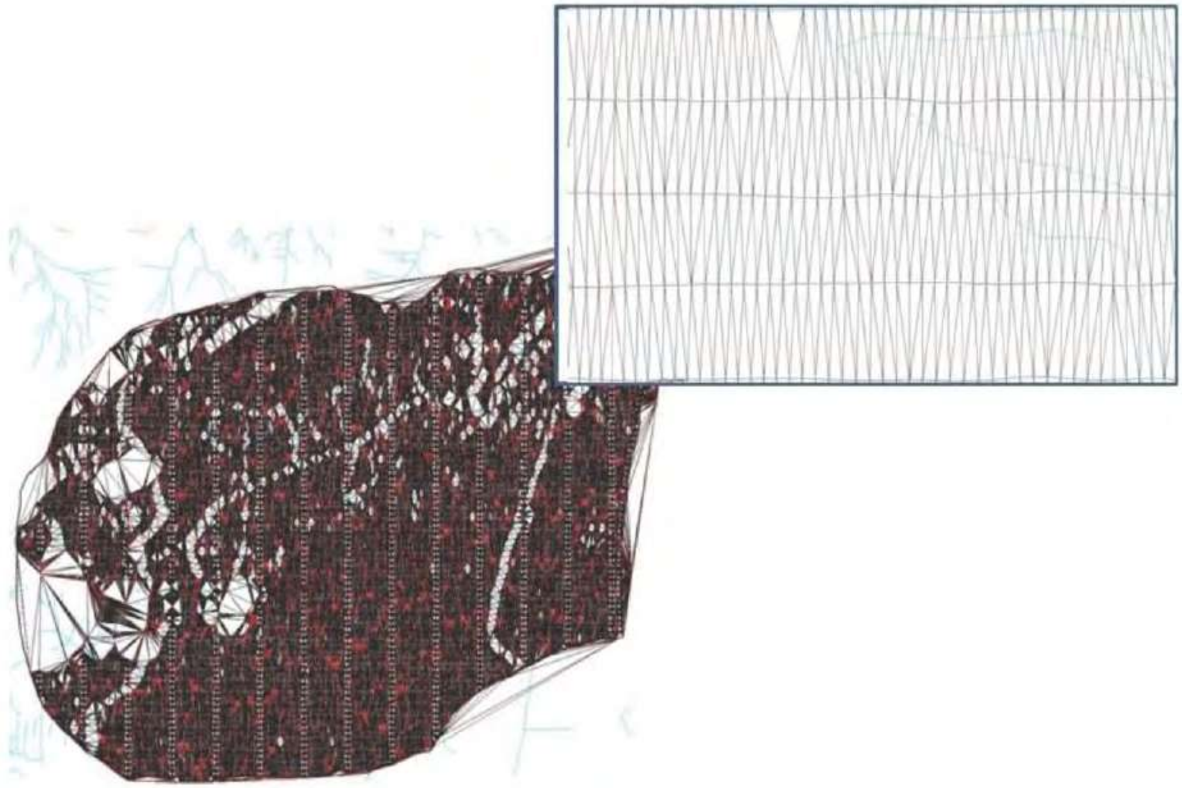


Figure 3.28.Example of setup of SCI-constraints.

The red points are the TEM sounding positions. The black lines show the constraints created with the Delaunay triangles. The line distance in this example is 250 m and the zoomed area is approximately 1.2 x 0.85 km large

In addition to constraints on model parameters, there are also lateral constraints on the altitude, however, only along the flight line.Constraining the parameters enhances the resolution of resistivities and layer interfaces that are not well resolved in an independent inversion of the TEM soundings.

In order to perform the SCI in a CPU efficient manner, a typical data set of thousands of TEM soundings must be divided into smaller subsets. Each subset is then inverted with spatial constraints, as a unit. We produce the cells using the pre-constructed Delaunay triangles, normally up to a size of 4000 model parameters. To ensure continuity over the cell boundaries, TEM soundings on the boundaries are inverted in both cells in the first inversion step. The average of the boundary models from the two cells is used as prior model for the final inversion step.

The SCI inversion scheme is developed for parameterized inversion with normally 4 or 5 layers and for smooth inversion with e.g. 20 layers, each having a fixed thickness, but a free resistivity. Vertical constraints are applied to the smooth models to stabilize the inversion. Both schemes have advantages. Layer interfaces and resistivities are best determined from the parameterized inversion. On the other hand, smooth inversion is more independent of the starting model, and gradual transitions in resistivities are more conspicuous facilitating the delineation of complex geological structures. Further details about the SCI-inversion scheme can be found in (HydroGeophysics Group, 2008) and (Viezzoli et al., 2008).

Depth of Investigation (DOI)

A concept of estimating the Depth Of Investigation (DOI) (Christiansen and Auken, 2010) for the individual models has been applied with this survey. The DOI calculation takes into account the SkyTEM system transfer function, the number of data points, and the data uncertainty.

EM fields are diffusive, and there is no specific depth below which there is no information on the resistivity structure. Therefore, always two numbers are presented for the DOI – an upper and a lower number. As a guideline the layers above DOI upper are well detected in data. Between DOI upper and DOI lower, the model is not as strong in the data and below DOI lower, the model is very weak in the data and interpreting these parts of the model should be done with utmost caution.

DOI – TECHNICAL DESCRIPTION

Depth of investigation (DOI) is a useful tool for evaluation of inversion results and holds useful information when a geological interpretation is made. However, for diffusive methods, such as ground based or airborne EM, there is no specific depth below which there is no information on the resistivity structure. The question is upto which depth the model is most reliable.

The DOI-method used by Aarhus Workbench is based on the actual inverted model and it includes the full system transfer function and system geometry, using all actually measured data and their uncertainties. The methodology is based on a recalculated sensitivity (Jacobian) matrix of the final model. A priori information, model constraints or other information added to the system are not considered. Thus, the DOI is purely data driven.

To demonstrate the methodology, an example with a SkyTEM setup with the last gate at 3 ms is used. Assuming a simple 3-layer model, the sensitivity function can be plotted versus depth as shown in Fig.3.29. The sensitivity function comes directly from the recalculated sensitivity matrix (Jacobian). As expected, the sensitivity to the second layer is low whereas there are high sensitivities to the first and the third layers.

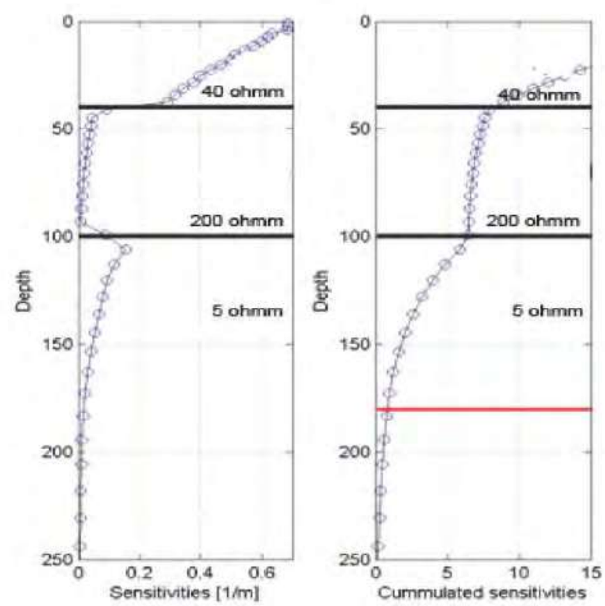


Figure 3.29. Sensitivities calculated for a rediscretized version of the model indicated by the black lines; resistivities of layers are written on the plot. The left plot is the

sensitivity function itself. The right plot shows the cumulated sensitivities. The red line indicates the DOI given by the global threshold value.

If the sensitivities are summed up from deep to shallow, the right side image in Fig. 3.29 emerges. This plot shows the total sensitivity in a given depth and downwards. Next, a threshold value that indicates the minimum amount of sensitivity needed for indicative information is set. In the example shown in Fig.11, a threshold value of 0.8 was settled upon, giving a DOI of approximately180 m.

Setting the threshold value is very much a question of tuning based on experience and comparing different models with different methods. The threshold value used here has been tested on many different models and with different systems and produces trustworthy results in all cases.

In this case the model was sub-discretized into many layers to support the visual understanding of the concept. In fact, it is not necessary to sub-discretize a model with few layers into more than maybe 12-15 layers to obtain a reasonably precise DOI.

The DOI is purely data driven, which means that information above the DOI is data controlled whereas the information below the DOI is mainly controlled by the inversion settings, such as starting model, lateral and vertical constraints. Thus, sometimes the DOI is well above the deepest layers. Figure.3.30 shows a smooth inversion of SkyTEM data from AQTND; the black dashed line indicates the DOI. In the area marked with the grey circle, the DOI indicates that data have no information on that less conductive structure. The arrow indicates an area where the high-moment data are missing, which means a shallower DOI. The effect of the constraints is clearly seen as the high-resistive layer is nicely pulled through to create a geologically reasonable interpretation. This is exactly one of the main functions of the constraints - they are user defined numbers for the geological homogeneity and thus ensure model smoothness even in areas with limited information from the data themselves.

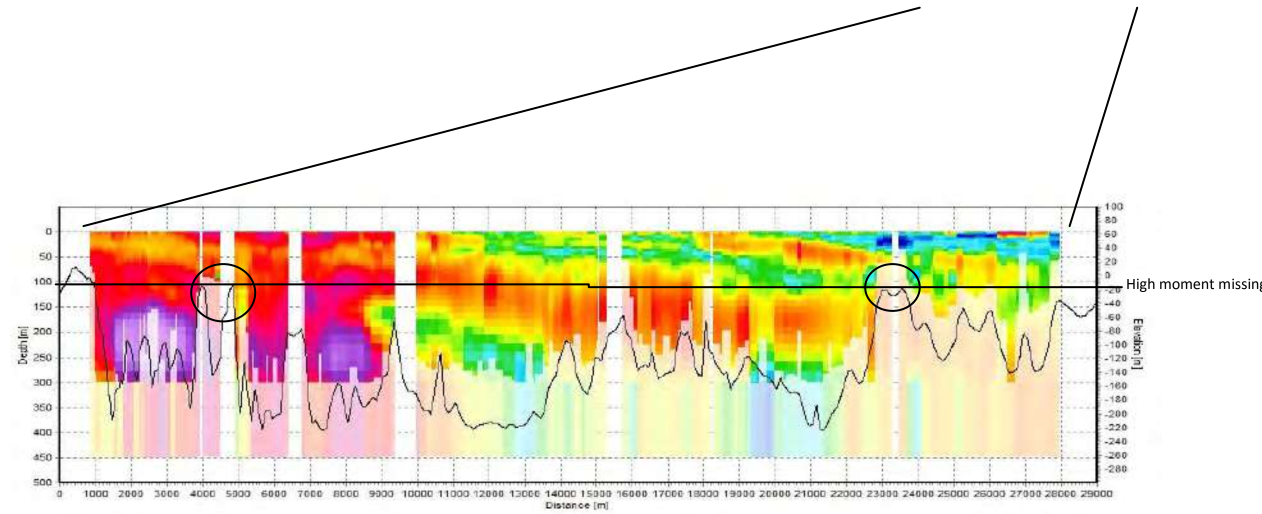
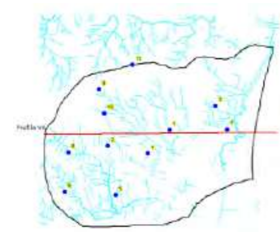


Figure 3.30 .*SkyTEM resistivity section with DOI shown as a black dashed line. In the area marked with a grey circle, the DOI indicates that there is no information on the less conductive structure. The Grey arrow marks an area where the high-moment data are missing, which results in a shallower DOI.*



Inversion - Technical specifications

The inversion settings used for the smooth inversion in the Aarhus Workbench are listed below in Table-3.4.

Item		Value
Software	Aarhus Workbench Version	4.1.1.760
Starting model	Number of layers Starting resistivities [Ωm] Thickness of first layer [m] Depth to last layer [m] Thickness distribution of layers	30 100* 3.0 220.0 Log increasing with depth

SCI constraint/ Prior constraint	Horizontal constraints on resistivities [factor] Reference distance [m] Constraints distance scaling Vertical constraints on resistivities [factor] Prior, thickness Prior, resistivities Prior on flight altitude [m] Lateral constraints on flight altitude [factor] Minimum number of gates per moment	1.3 25 (1/distance) 3.0 Fixed None +/- 2 1.3 5

Table 9. Inversion settings, smooth SCI setup.

3.8.7. THEMATIC MAPS AND CROSS SECTIONS

To visualize the resistivity structures in the mapping area, a number of geophysical maps and cross sections have been created from the smooth inversion results by using the Aarhus Workbench. Furthermore, a location map and a number of maps made for quality control (QC-maps) are found in the appendices. The Aarhus Workbench Workspace that holds the inversion results including mean resistivity maps, cross sections, etc. can, upon request, be delivered.

Mean resistivity maps

The inversion result consists of a large number of 1D-models described by depth intervals (i.e. layers) and resistivities within each model. These are then normally used to calculate mean resistivities to obtain a visualization of the resistivity distribution in the mapping area. Fig.3.31 shows how the resistivities of the layers in a model influence the calculation of the mean resistivity in a depth interval [A, B]. d_0 is the surface, d_1, d_2 and $d_3$are the depths to the layer boundaries in the model. ρ_1,ρ_2,ρ_3 and $\rho_4$are the resistivities of the layers.

The model is subdivided into sub-thicknesses Δt_{1-3}. The mean resistivity ($\rho_{vertical}$) is calculated as:

$$\rho_{vertial} = \frac{\rho_1 \cdot \Delta t_1 + \rho_2 \cdot \Delta t_2 + \rho_3 \cdot \Delta t_3}{\Delta t_1 + \Delta t_2 + \Delta t_3}$$

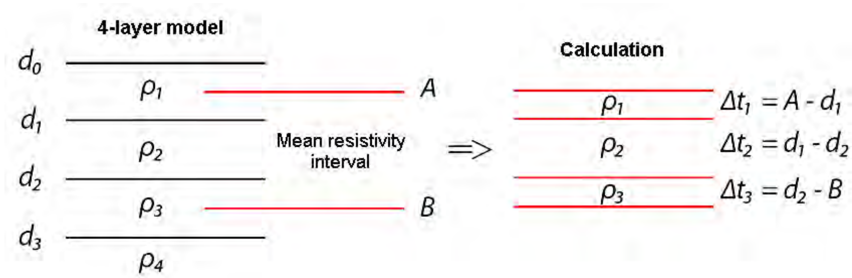


Figure 3.31. The figure illustrates how the resistivities of the layers influence the

meanresistivities in a depth interval [A:B]

In the general term the mean resistivities in a depth interval is calculated using the equation below:

$$\bar{\rho} = \frac{\sum_{i=1}^{n} \rho_i \cdot \Delta t_i}{\sum_{i=1}^{n} \Delta t_i}$$

Where: *i* runs through the interval from 1 to the number of sub-thicknesses. The mean resistivity calculated by the above formula ($\Box_{vertical}$) is named the vertical mean resistivity - equal to the total resistance if a current flows vertically through the interval.

By mapping with the TEM method, the current flows horizontally in the ground. Therefore, the mean resistivity is calculated as if the current runs horizontally in the interval. This resistance is described as the horizontal mean resistance ($\Box_{horizontal}$) and is the reciprocal of the mean conductivity (σ_{mean}).

The horizontal mean resistivity is calculated in the following way:

$$\rho_{horizontal} = \frac{1}{\sigma_{mean}} = \left[\frac{\sum_{1=1}^{n} \left(\frac{1}{\rho_i}\right) \cdot \Delta t_i}{\sum_{i=1}^{n} \Delta t_i}\right]^{-1}$$

Normally, there is no major difference in the maps of mean resistivities calculated by these two different methods. The horizontal mean resistivity weights the low resistivities more than the vertical mean resistivities: exactly the same way as the TEM-method does.

For this mapping, horizontal mean resistivity; themes have been generated from the smooth model inversion in two sets. The first set was made in 5 m elevation intervals down to a depth of 20 m below sea level. The second set was made in 10 m elevation intervals from 20 m down to 150 m below sea level. For this mapping the DOI has been used to blind resistivities of models below the DOI lower. The generated themes, consisting of mean resistivity values at each TEM sounding position, are then gridded using the Kriging (Pebesma and Wesseling, 1998) method, with a node spacing of 30 m and a search radius of500 m, to obtain a regular grid of resistivities. Finally, the nodes have been subdivided by a factor of 4 to obtain interpolated resistivity pixels for the bitmaps.

Cross sections

Several cross sections covering the survey area in a regular grid are plotted. Each cross section shows a slice through a 3D-mean resistivity grid. The 3D-mean resistivity grid is interpolated from the 2D-mean resistivity grids based on the smooth model inversion result. The calculation of the 3D-grid from the stacked 2D-grids is illustrated in Fig. 3.32.

a) For each 2D-mean resistivity grid, values are interpolated for a regular sampling along the profile.
b) The interpolation is repeated for all 2D-mean resistivity grids, creating a cross section grid.
c) Smoothing of the cross section grid is done by triangulation between the grid nodes.
d) The cross section is then colorized and the colors are faded in two steps below the DOI upper and the DOI lower values. Grey lines showing the DOI upper and DOI lower values gridded from models within 250 m are also plotted. This indicates the parts along the cross section that are most strongly founded in the data.

In the Aarhus Workbench Workspace all cross sections are also accessible with the smooth inversion result as 1D-model bars described frequently as Occam 1D model

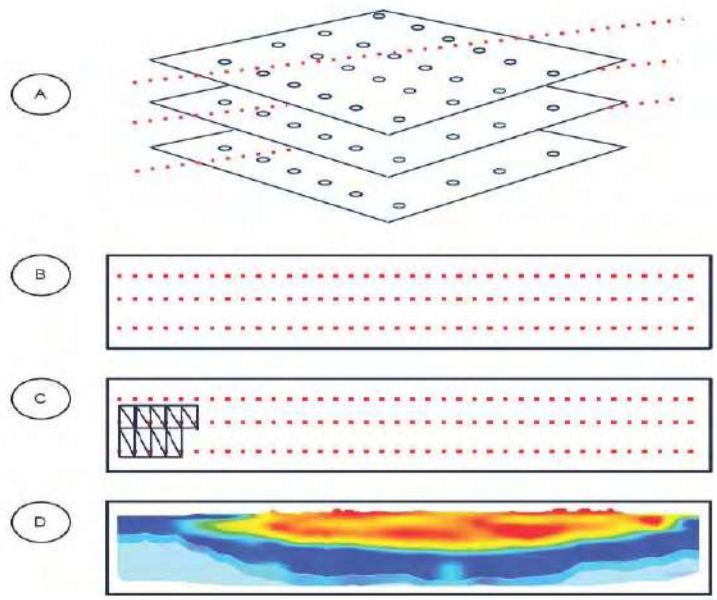
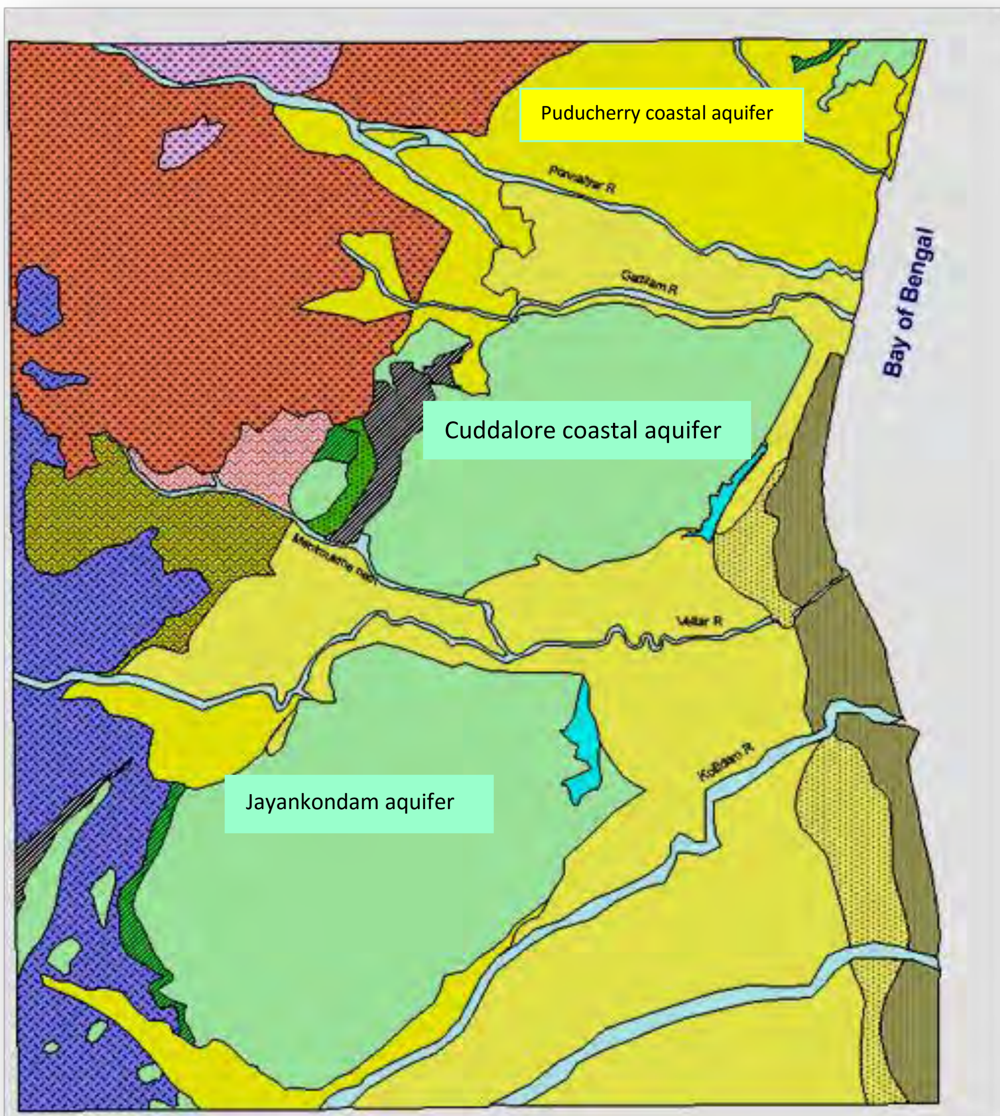


Figure 3.32.*3D grid interpolation. A) For each 2D-mean resistivity grid, values are interpolated for a regular sampling along the profile. B) The resulting cross section grid. C) Smoothing of cross section grid by triangulation. D) The resulting colorized cross section with the colors faded in two steps below the DOI upper and the DOI lower limits*.

3.33. Sub surface Information

In order to bring out the aquifer disposition of the lower velar water shed (Pilot project area), first the broader understanding of the regional aquifer system is essential. The pilot project area forms the part of the Cuddalore Coastal Aquifer system (Regional Aquifer system) which in turn forms the part of Cauvery Basin (Figure 3.33). The sedimentary tract extending from Puducherry to south of Rameshwaram is considered as Cauvery Basin *(Figure. 3.33).*Sediments of Jurassic, Cretaceous, Eocene and Miocene and Pliocene are exists within the Cauvery Basin. (Blanford, 1865).

Figure :3.33 Map showing the aerial extent of the Cauvery basin



The basement and the cretaceous rocks exposed in the western part of the Cuddalore coastal aquifer have not been encountered in the eastern and southwestern part due to thickening of the tertiary sedimentary sequence from west to east *(Subramanyam, 1969).*The tertiary upland and the coastal plain strata have been classified into a layered sequence of aquifers and confining units, each of which generally thicken and deepen to the east towards the Bay of Bengal Sea.

Aquifer mapping studies was carried out since 2011 by Central Ground Water Board (CGWB, 2011) revealed that alluvium of quaternary/recent age, cuddalore sandstones of Mio-pliocene age and sandstones of Eocene age are the aquifers of the Cuddalore Coastal aquifer system. (Figure 3.26) These sediments reflect changing depositional conditions during the past 10 million years, resulted in a sedimentary assemblage of sands, gravels, conglomerates and clays with a complex distribution of hydraulic properties. The laterite occurs in the central portion of the region with 1m to 10 m thickness. Though laterite with thickness of 3 to 19 m form aquifer system at some places, they are not potential in nature. The sandstones of the Cuddalore aquifer system have strike along NNE to SSW direction with a dip of 20 and 25 towards ESE or SE direction.

3.9.1. Borehole lithology and Resistivity log analysis

The method by with the aquifer units have been deciphered in this study is given as figure below; First, point analysis of the borehole lithology (Annexure-I) along with its corresponding e-logs (Annexure-II) of each well drilled was carried out. Later, by correlating the lithologs and the corresponding e-logs (Resistivity) with the nearby or adjacent lithologs and e-logs, aquifer disposition has been brought out. Also, the long term hydrographs of the individual aquifer units were analysed.

On observation of the litho samples collected for every three meters, two distinct formations could be deciphered based on their colour. The samples with pale pinkish colour are the sandstones of mio-pliocene age and sandstones with pale grey colour is of sandstones of Eocene age. The litholog and corresponding e-log analysis at

Pacharapalayam site clearly shows four distinct aquifer Units and the thickness of the individual aquifer units.

Thus, the principal aquifer of the cuddalore coastal aquifer is the sandstone. The aquifer material (sandstone) comprises of very fine to coarse sand with occasional clay interclations. A thin continuous and discontinuous clay layer seperates the aquifer units within the sandstone. The lignite deposits underlining the cuddalore sandstones in many places act as marker horizon between the cuddalore sandstone aquifer and Eocene sandstone aquifer. The exploratory wells that were drilled in the pilot project has enabled to decipher the aquifer zones as well as to fine tune the two dimensional (2D) aquifer dispositions that was prepared earlier based on the existing data.

Four aquifer units namely Aquifer Unit I, II, III and IV have been deciphered within the sandstones. (figure 3.34). Two aquifer units (I and II) occur within the Cuddalore sandstones of mio-pliocene sandstones and two aquifer units (III and IV) occur within Neyveli sandstones of Eocene age. The resistivities of the sandstones ranged between 25 and 60 Ohm-m and clay ranged between 5 and 18 ohm-m.

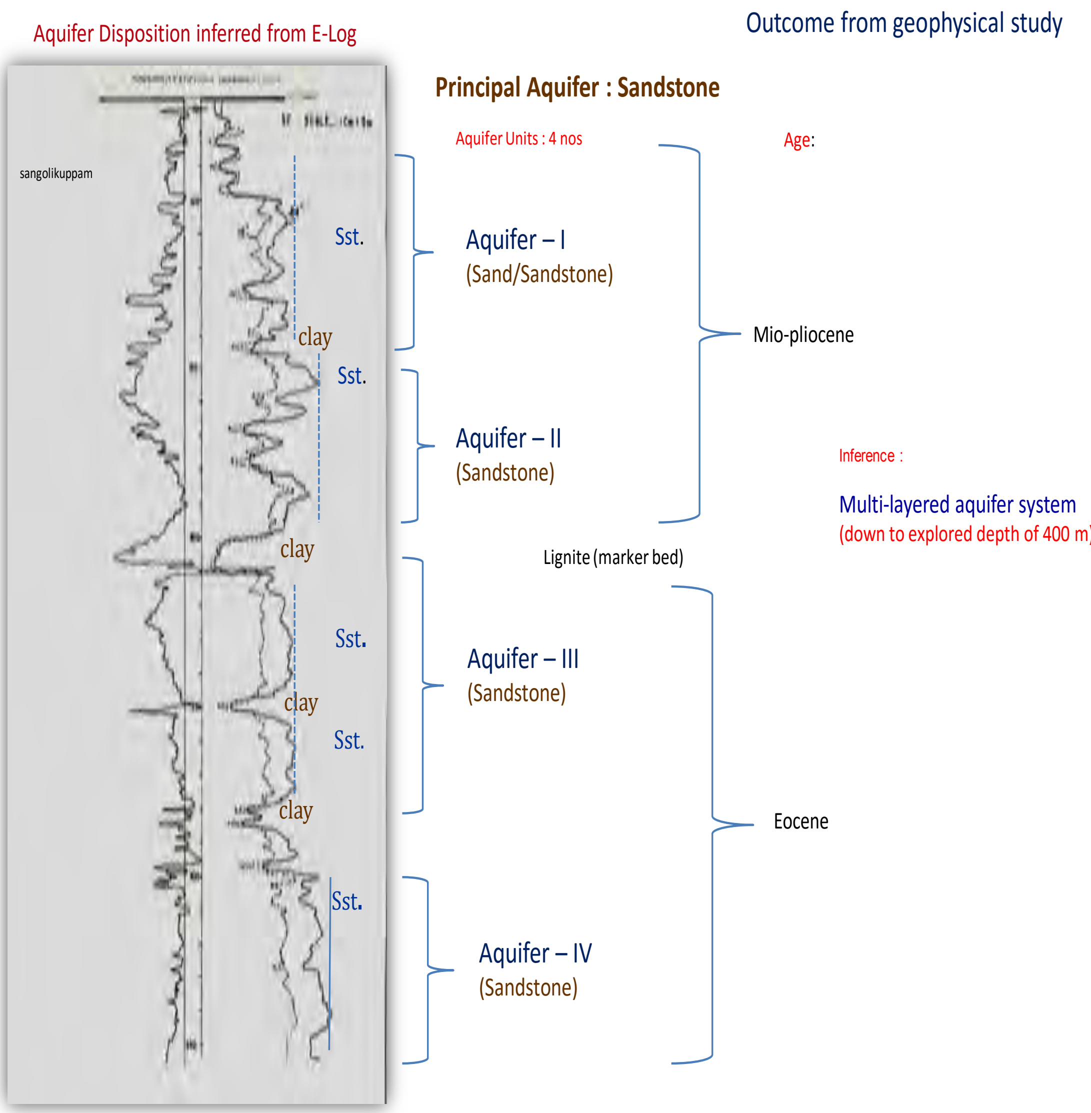


Figure.3.34 : Demarcating four aquifers from resistivity logs of Sangolikkupam village

The lignite deposits underlining the cuddalore sandstones act as marker horizon between the cuddalore sandstone aquifer and Eocene sandstone aquifer. The impervious clay layer separates the principal aquifer into four aquifer units.

The aquifer disposition and the aquifer units within the principal aquifer were deciphered for the drilled depth of 400 m below ground level is given as figure 3.35. (Annexure-I)

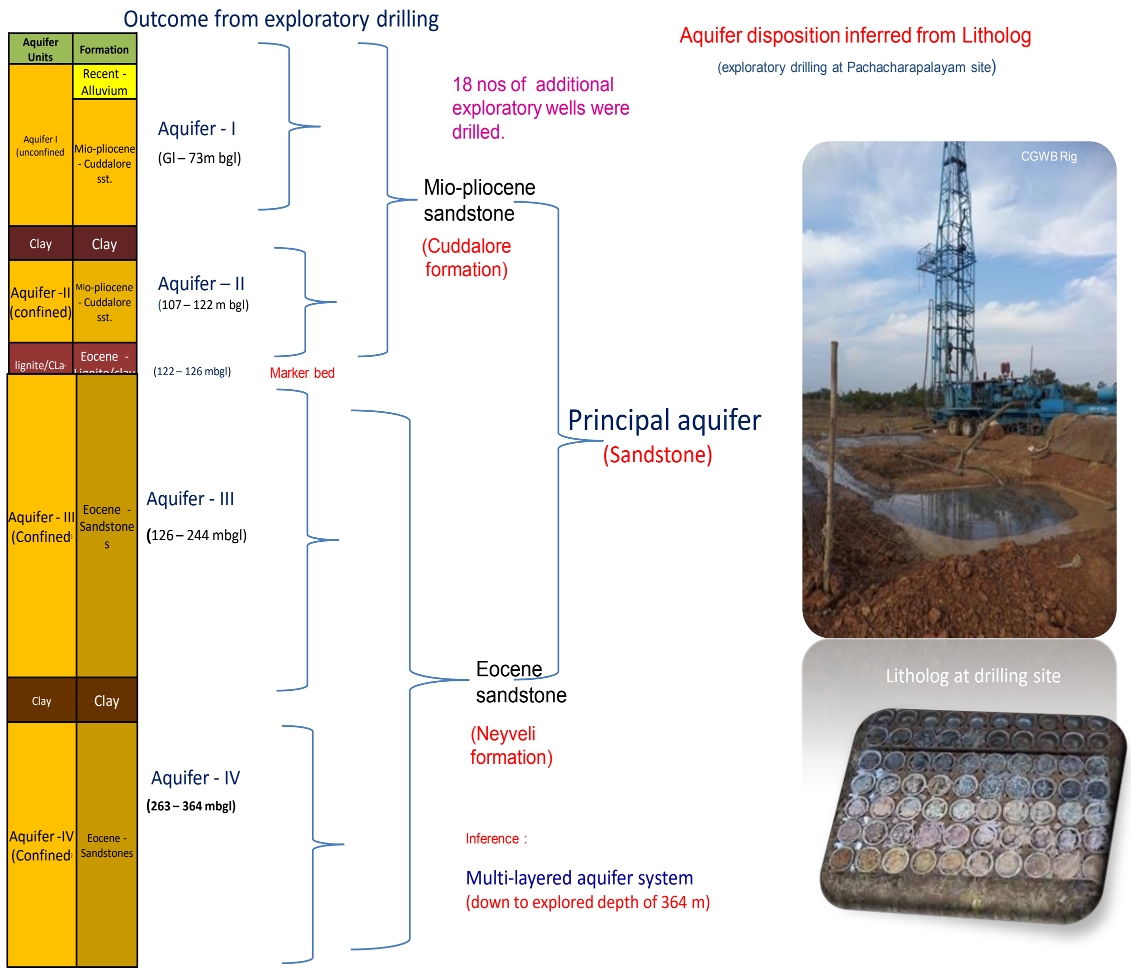


Figure.3.35 : Aquifer Disposition of Pacharapalayam village.

Thus, based on the borehole lithology, electrical logging data and long term hydrographs four aquifer units exists (I,II,III, IV) within the principal sandstone aquifer. Though lignite acts as the marker horizon between aquifer Unit II and III they don't necessarily exist in all places. The lignite is mostly restricted in the central and western parts of the area with dipping towards south east. The Lignite has maximum thickness in the western and central portion (Neyveli town and Vadalur town) of the area.

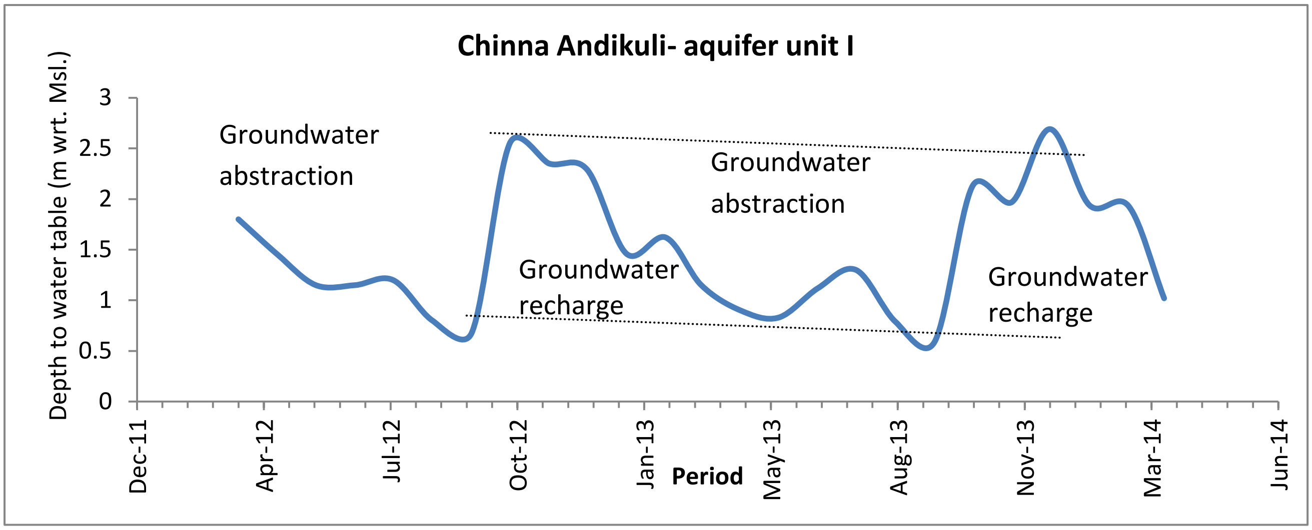
3.9.2 Water Level:

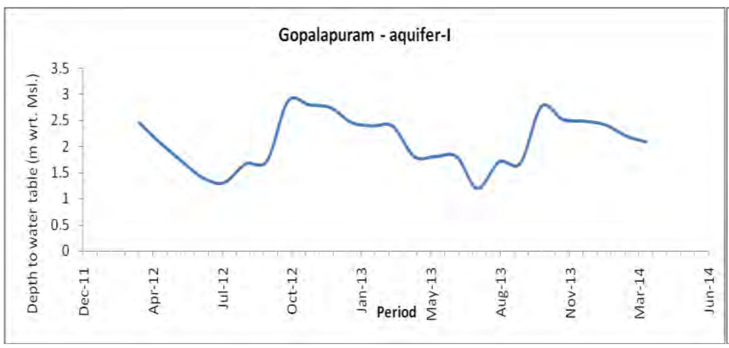
66 dugwells were established as key wells for monthly monitoring since Dec 2012. The groundwater scenario of the phreatic aquifer was brought out. Additional 15 piezometers were constructed to monitor the piezometric heads of the different aquifer units (Annexure-III). The locations were piezometers were constructed is given as figure 3.36. The information's pertaining to the depth and the slotted zones are given as table.

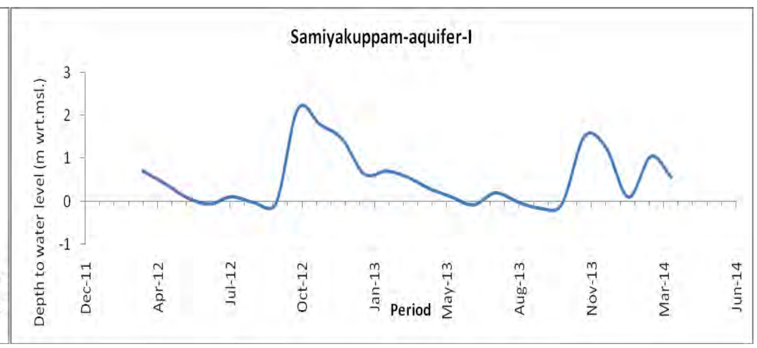
Figure. 3.36 Piezometers constructed at Silambinathanpettai village

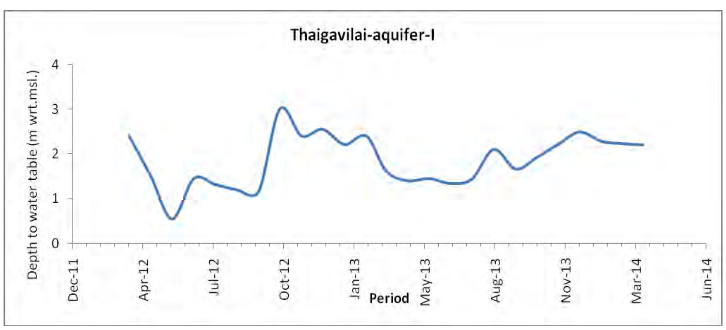
The hydrographs of most of the dugwellsresponds to rainfall recharge and groundwater withdrawal. Analysis of the hydrographs indicate that the groundwater level fluctuation varies between 10 and 20 m in the recharge zone. The hydrographs of the dugwells within the recharge zone is given as 3.30.The hydrographs of the piezometers though responds to the recharge and the groundwater withdrawal but have variation in the pattern of rise and fall

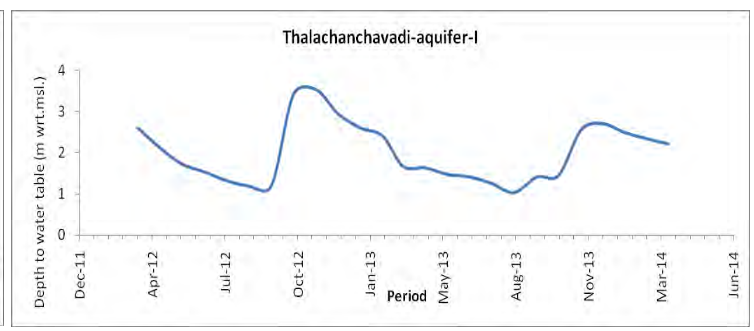
Figure 3.37 Hydrograph in the Discharge zone











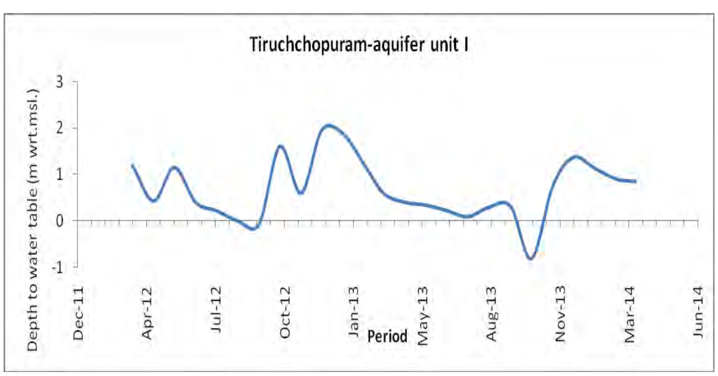
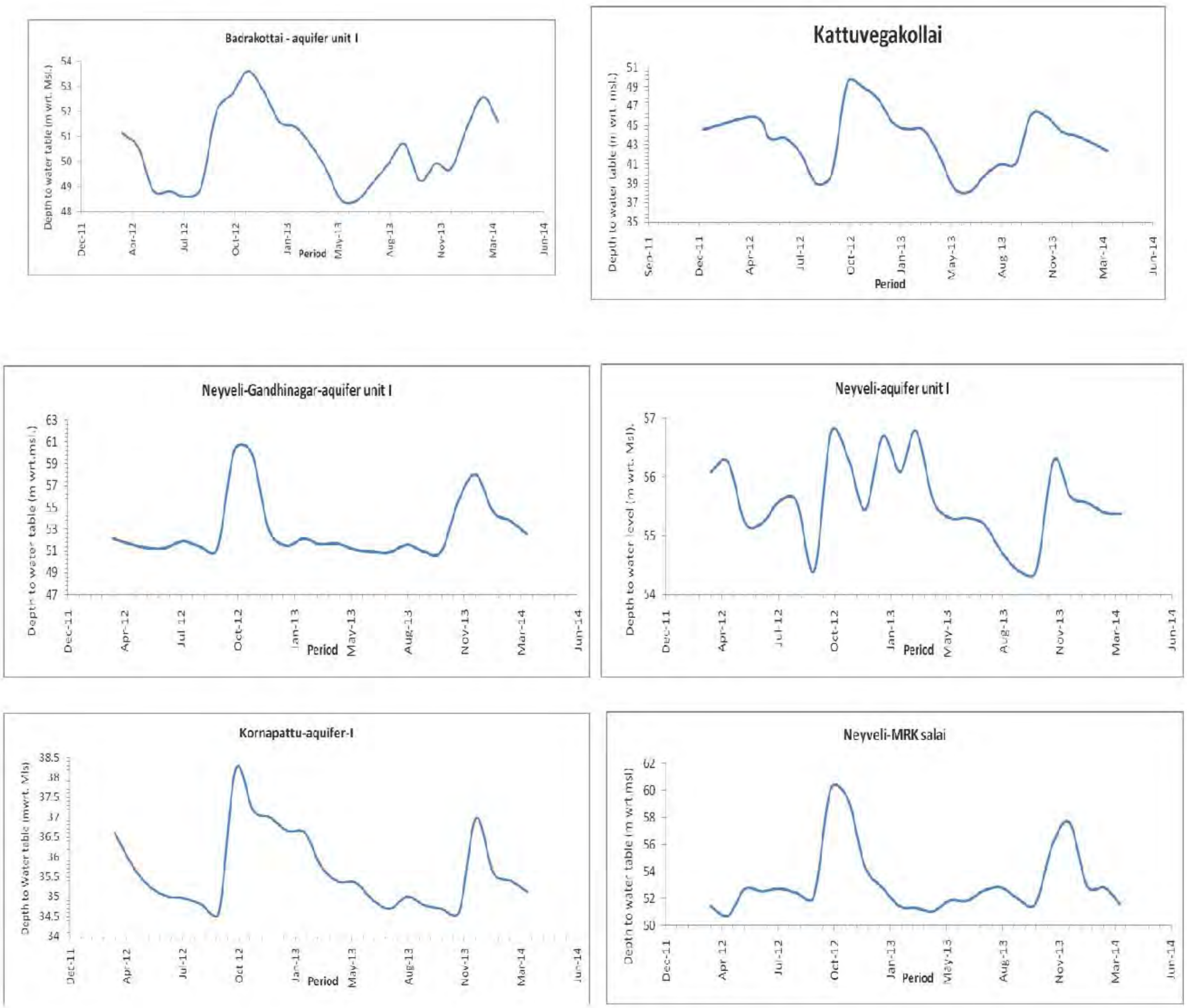
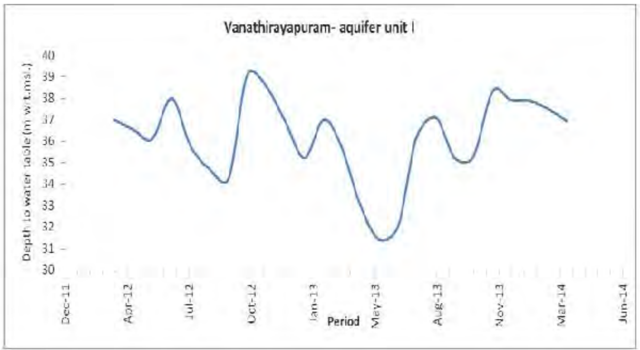
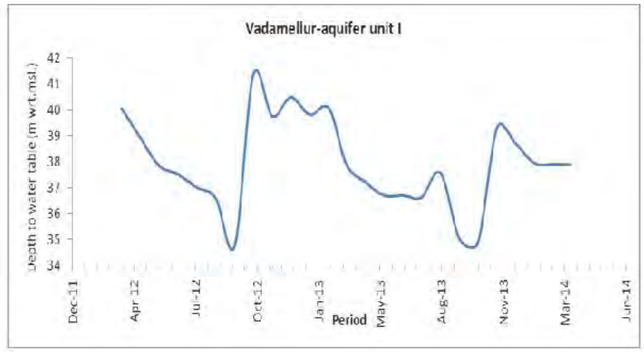
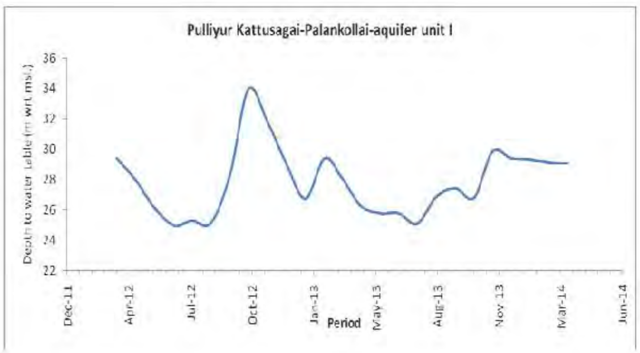


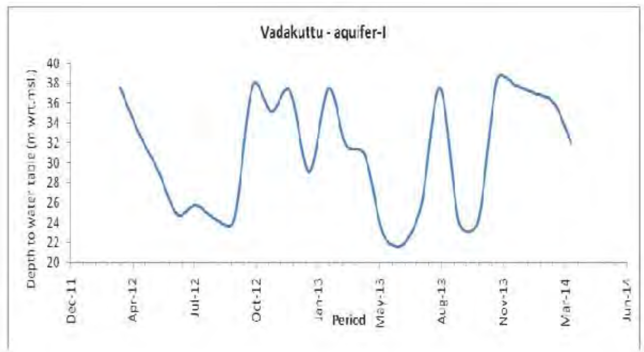
Figure 3.38 Hydrographs in the Recharge Zone

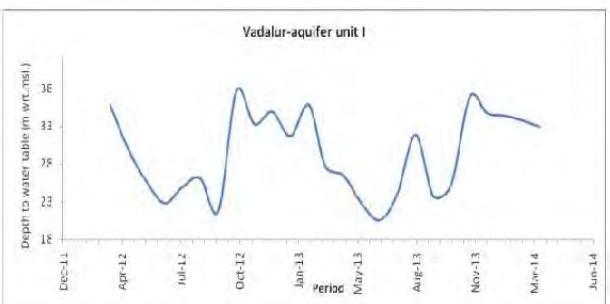


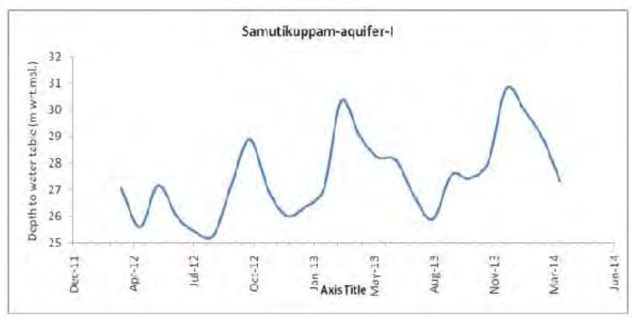

Vanathirayapuram- aquifer unit I
Depth to water table (m wrt.msl.)
Period

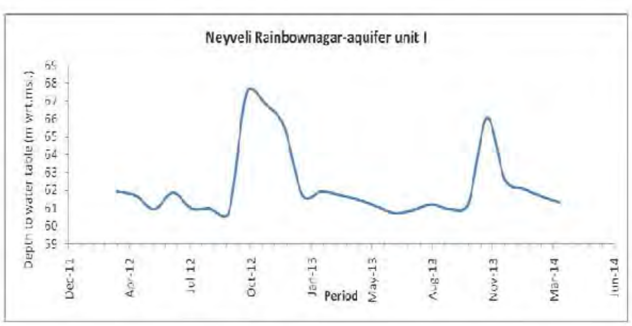

Vadamellur-aquifer unit I
Depth to water table (m wrt.msl.)
Period


Pulliyur Kattusagai-Palankollai-aquifer unit I
Depth to water table (m wrt.msl.)
Period


Vadakuttu - aquifer-I
Depth to water table (m wrt.msl.)
Period


Vadalur-aquifer unit I
Depth to water table (m wrt.msl.)
Period


Samutikuppam-aquifer-I
Depth to water table (m wrt.msl.)
Axis Title


Neyveli Rainbownagar-aquifer unit I
Depth to water table (m wrt.msl.)
Period

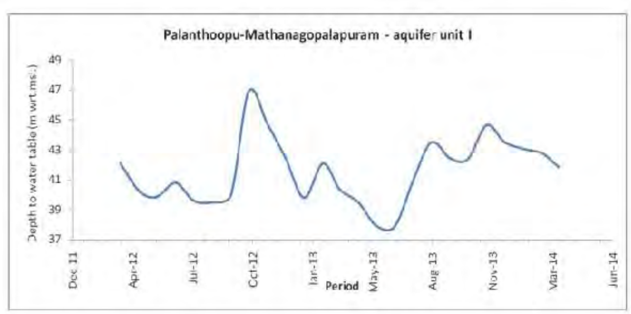

Palanthoopu-Mathanagopalapuram - aquifer unit I
Depth to water table (m wrt.msl.)
Period

Figure 3.39 Hydrographs of the dugwells located near Perumal Eri

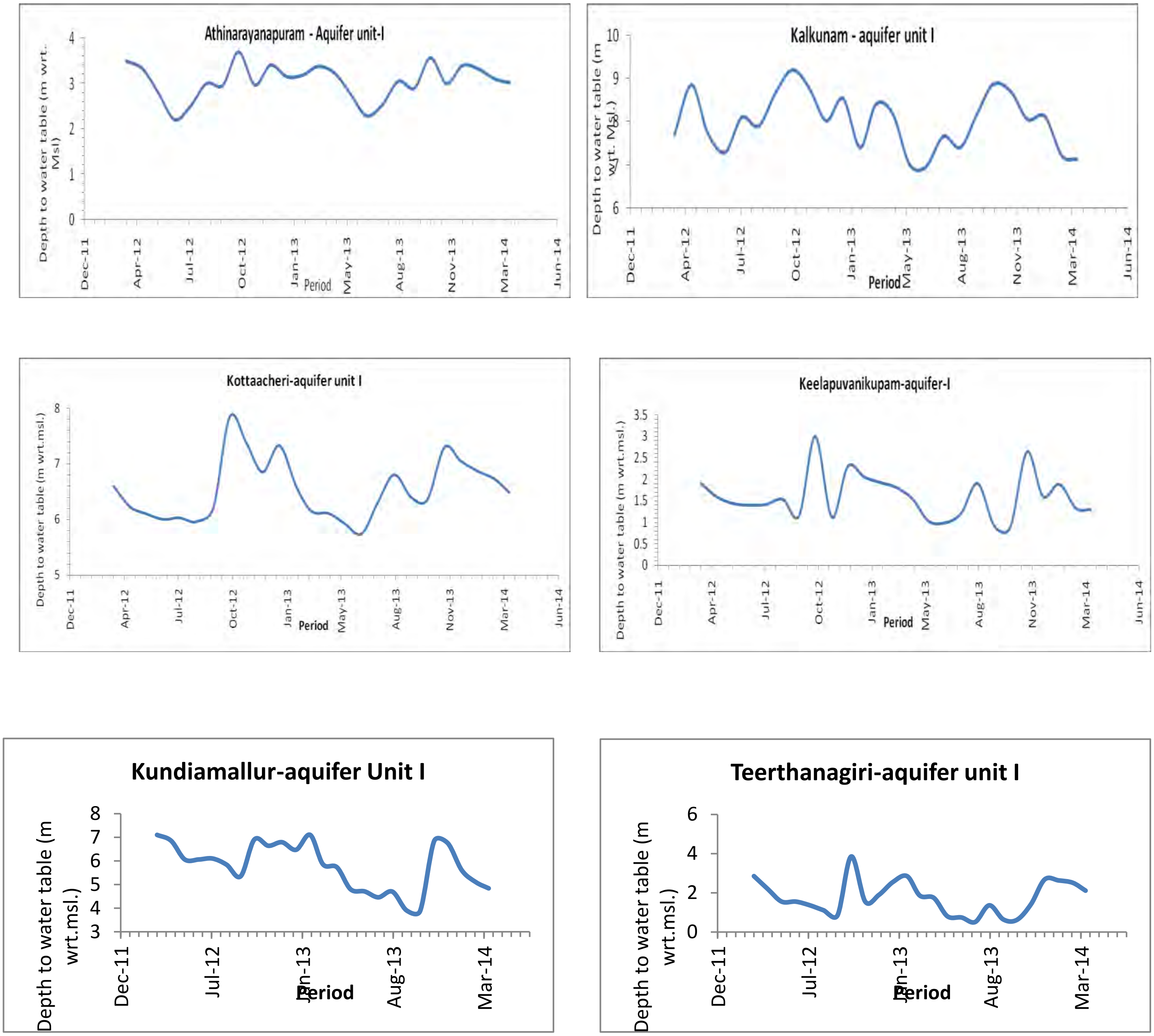


Figure 3.40 Hydrographs-Neyveli area

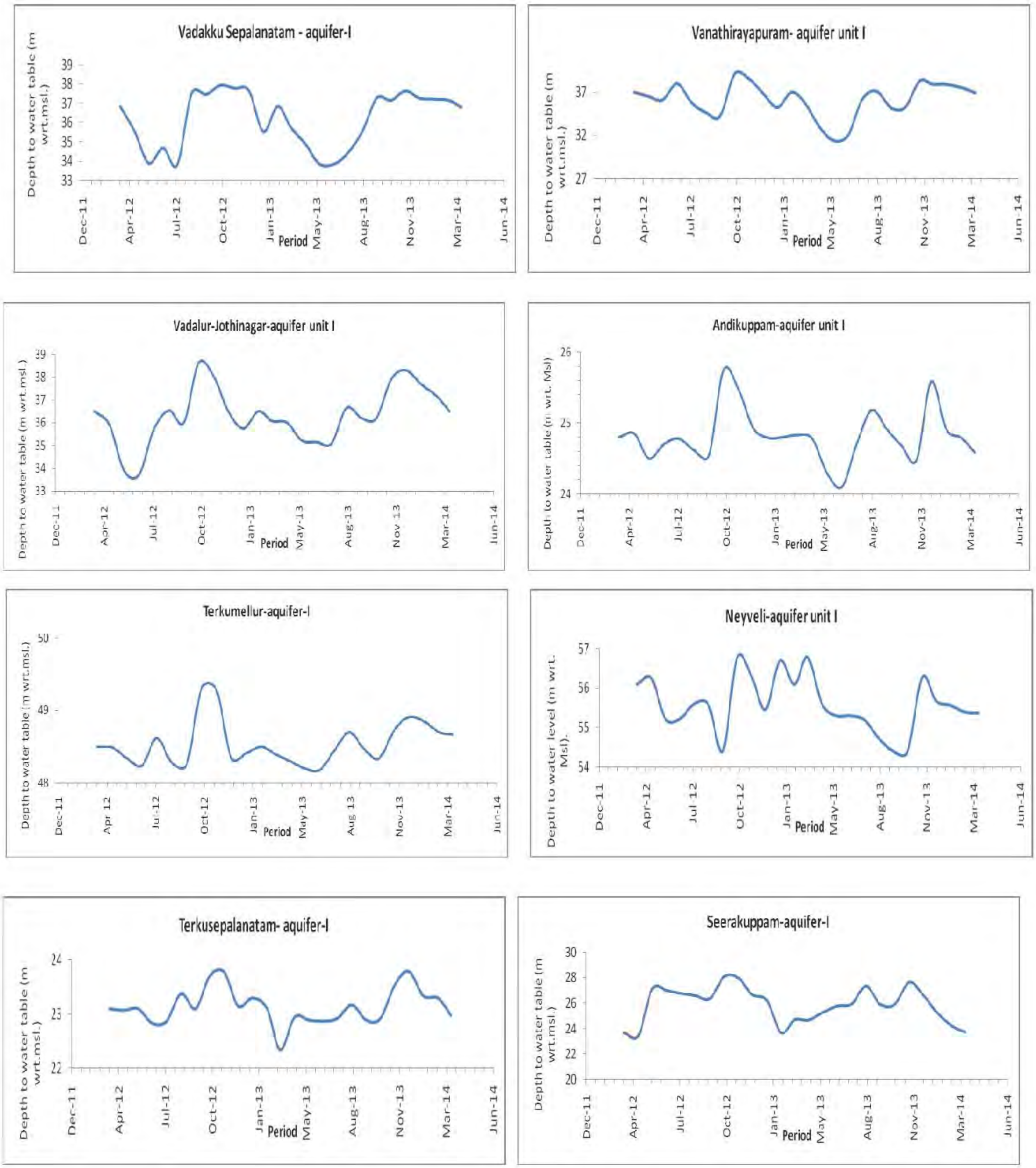
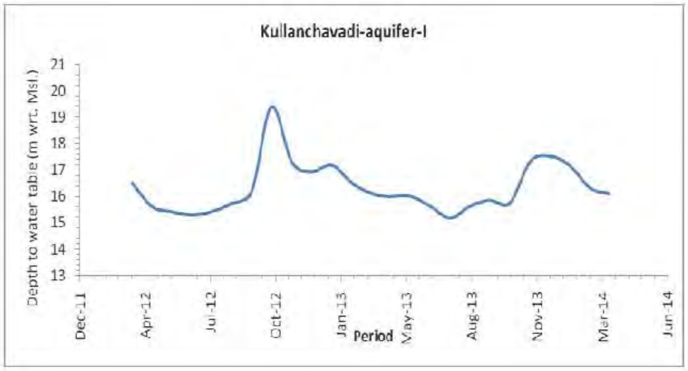
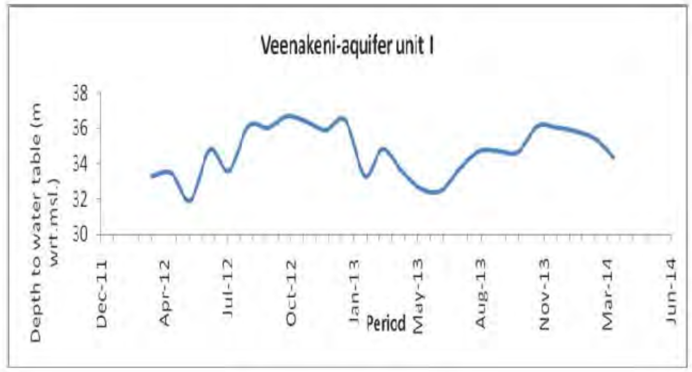
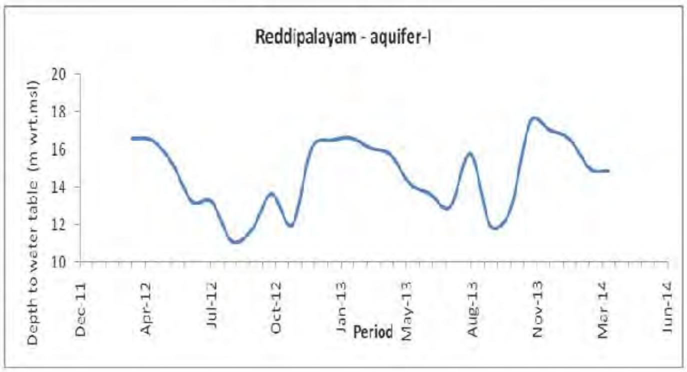
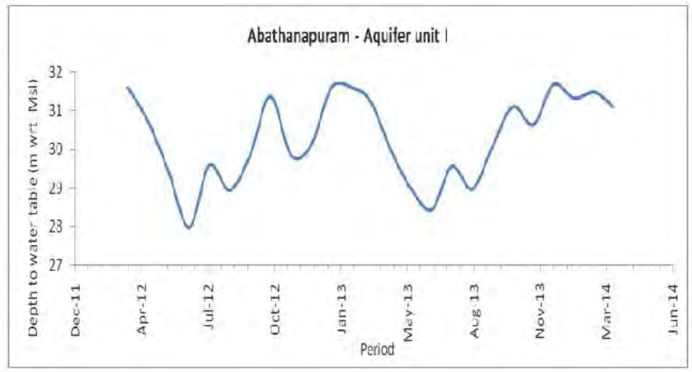


Figure 3.41 Hydrographs in mid area

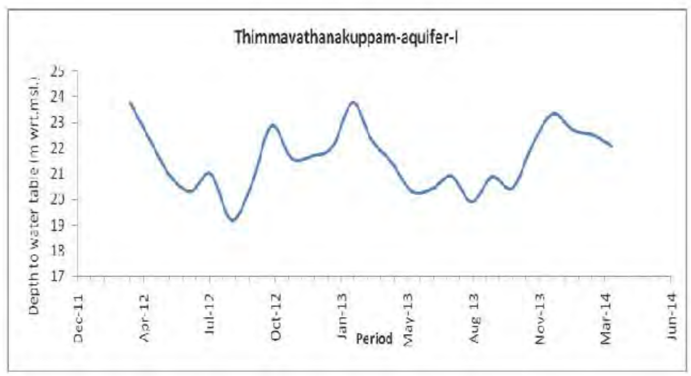

Kullanchavadi-aquifer-I
Depth to water table (m wrt. Msl)
Period


Veenakeni-aquifer unit I
Depth to water table (m wrt.msl.)
Period


Reddipalayam - aquifer-I
Depth to water table (m wrt.msl)
Period


Abathanapuram - Aquifer unit I
Depth to water table (m wrt. Msl)
Period


Ayiekuppam - aquifer unit I
Depth to water table (m wrt. Msl.)
Period


Thimmavathanakuppam-aquifer-I
Depth to water table (m wrt.msl.)
Period


Kodandaramapuram-aquifer I
Depth to water table (mwrt.msl.)
Period

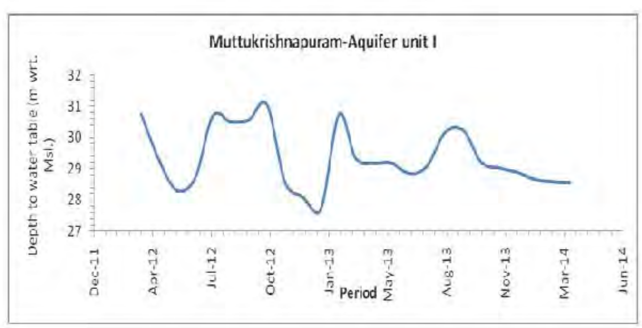
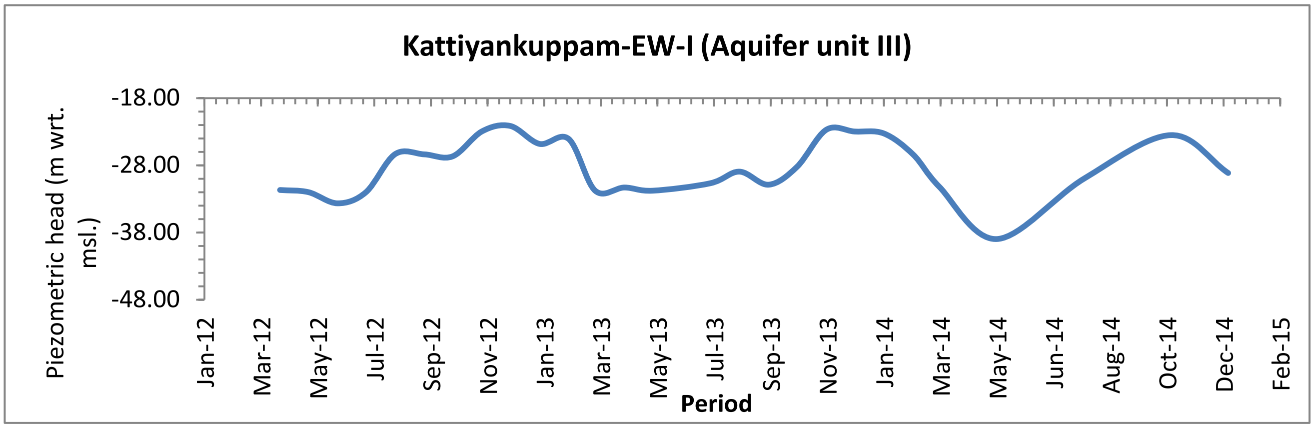
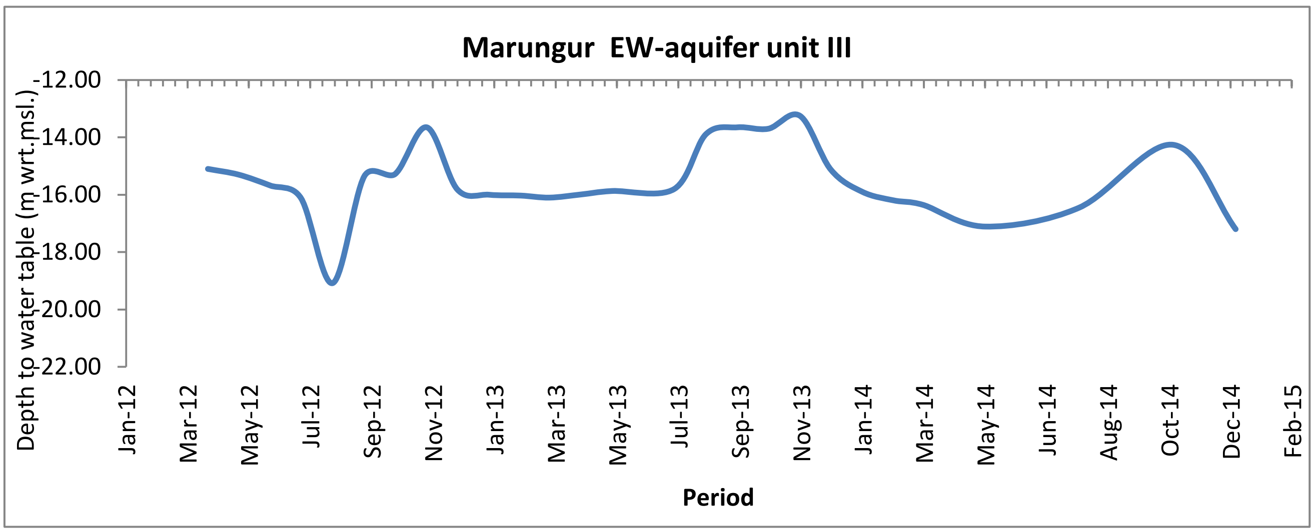
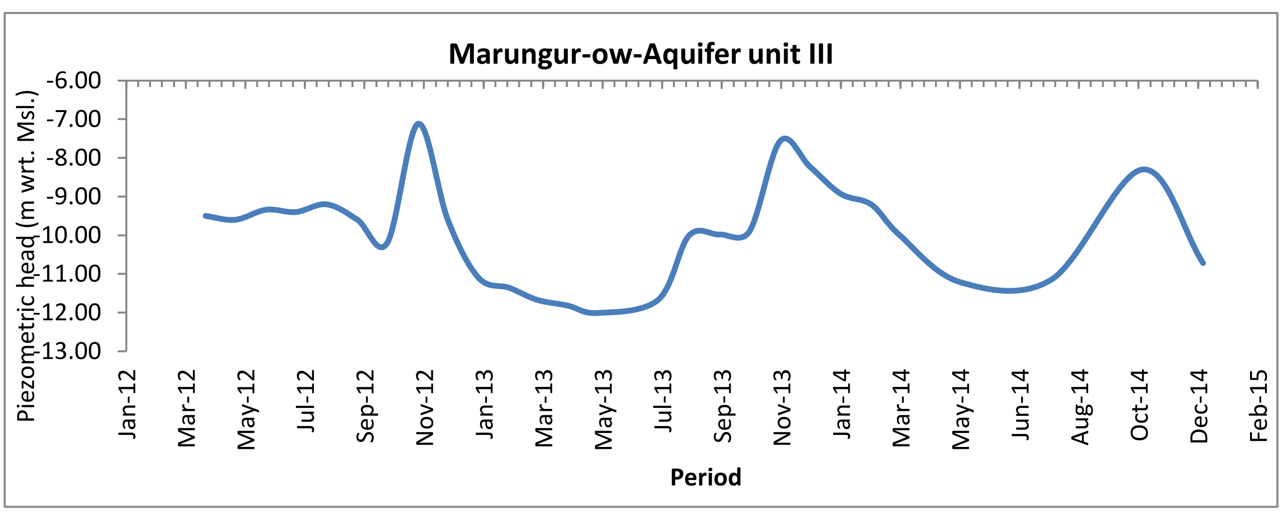
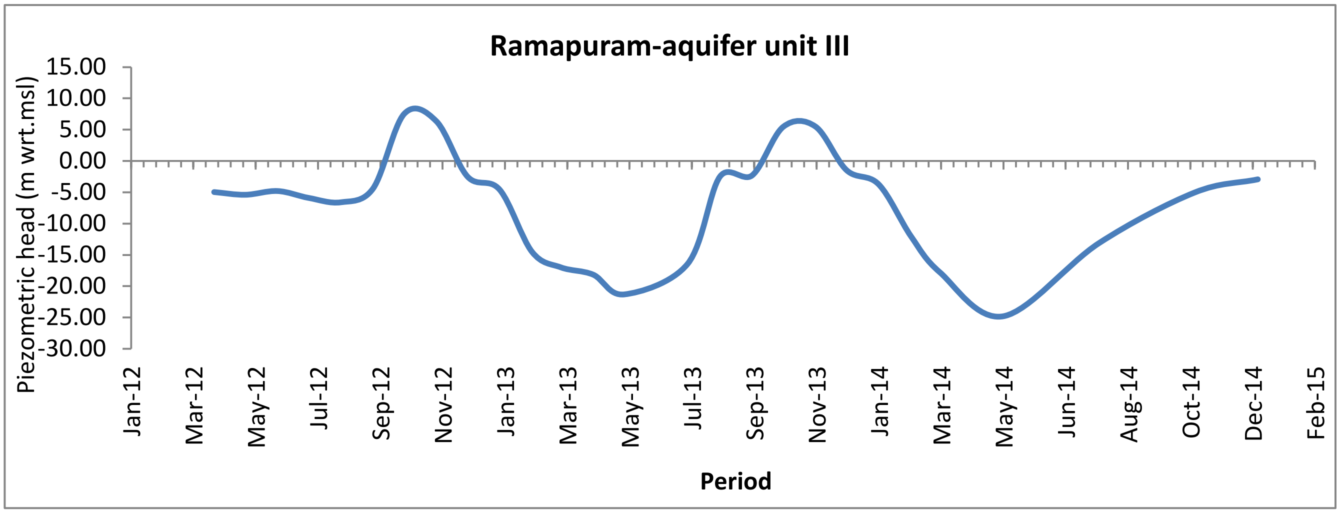

Muttukrishnapuram-Aquifer unit I
Depth to water table (m wrt. Msl.)
Period

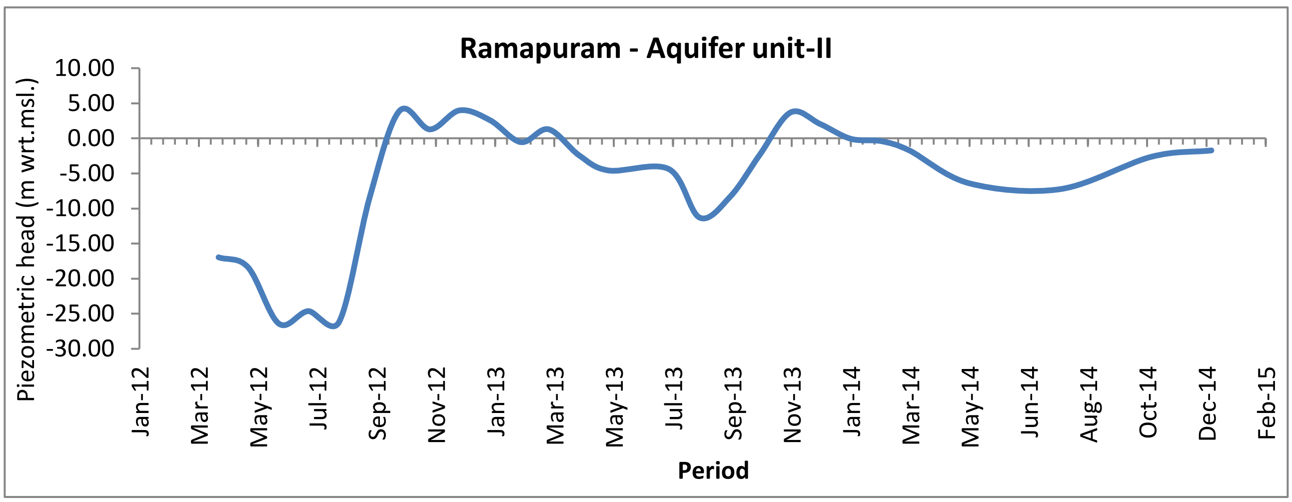
Figure 3.42 Hydrographs showing the Piezometric heads

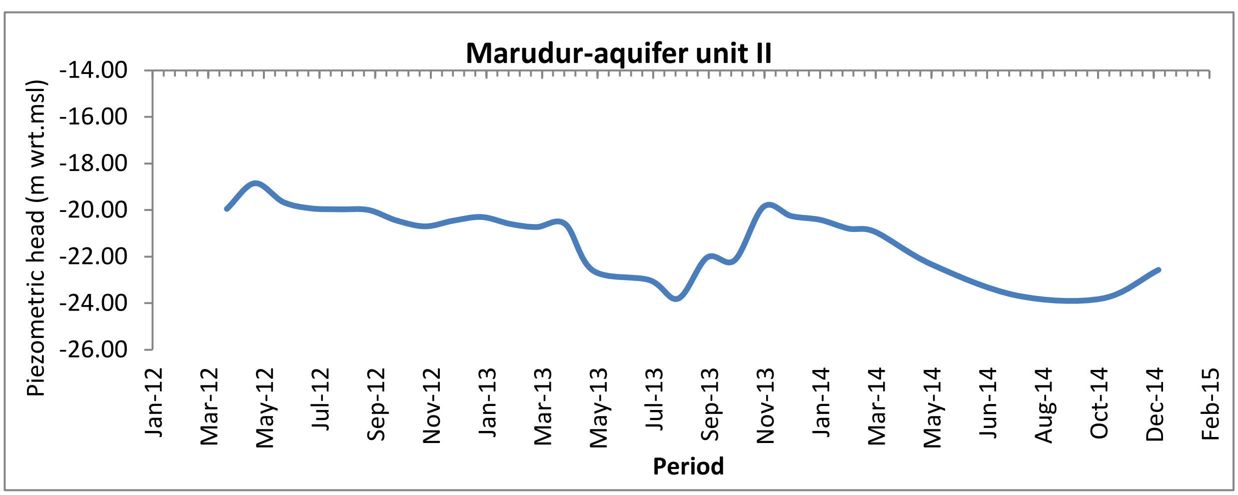


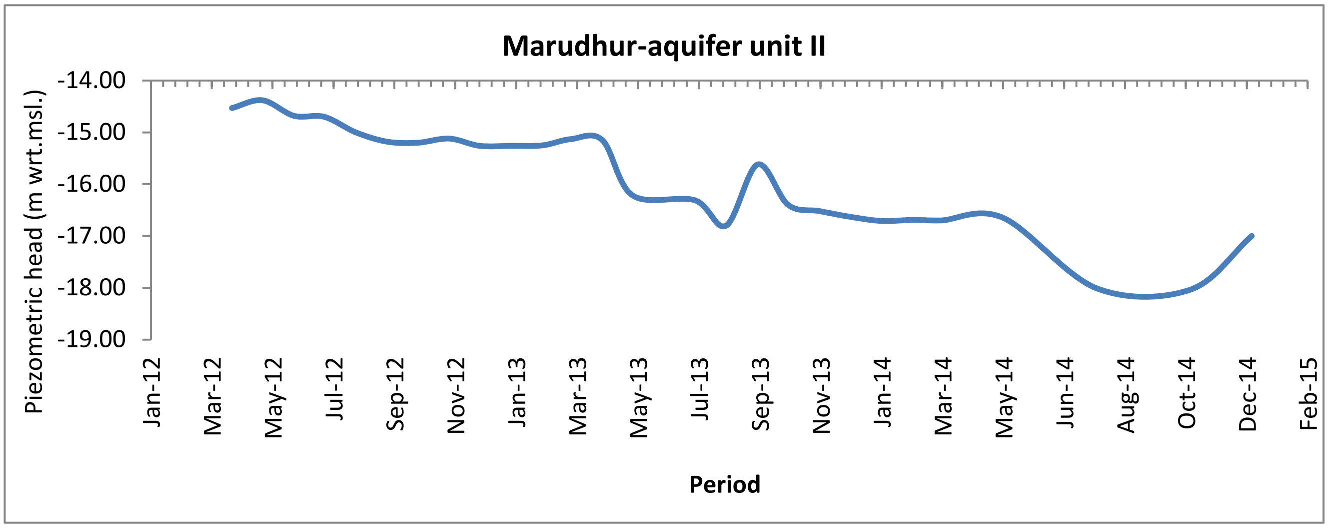


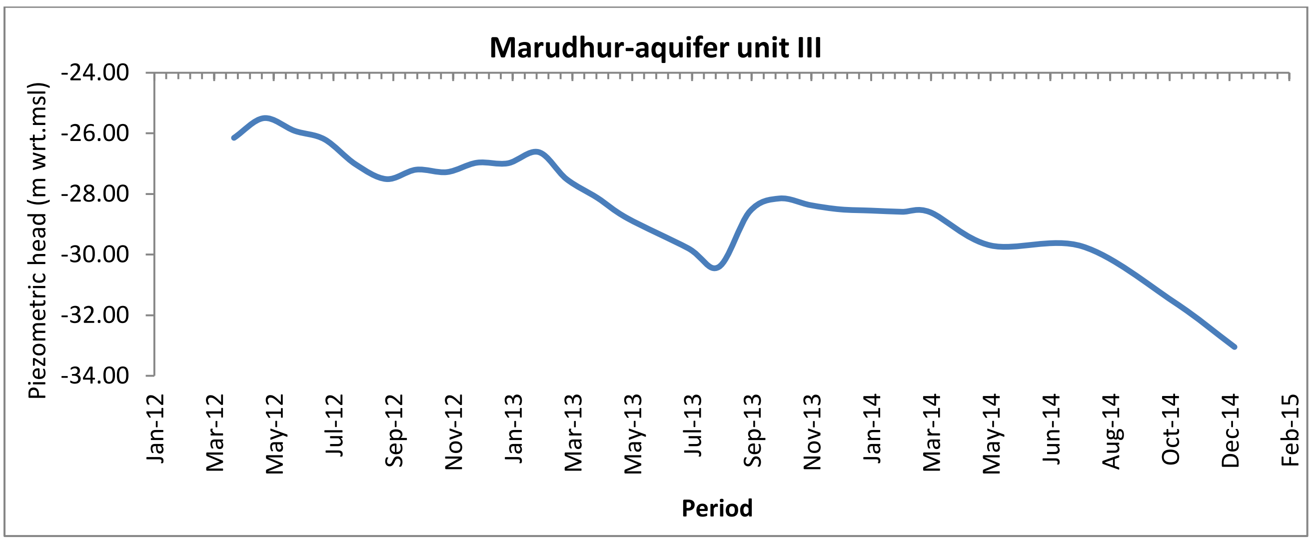


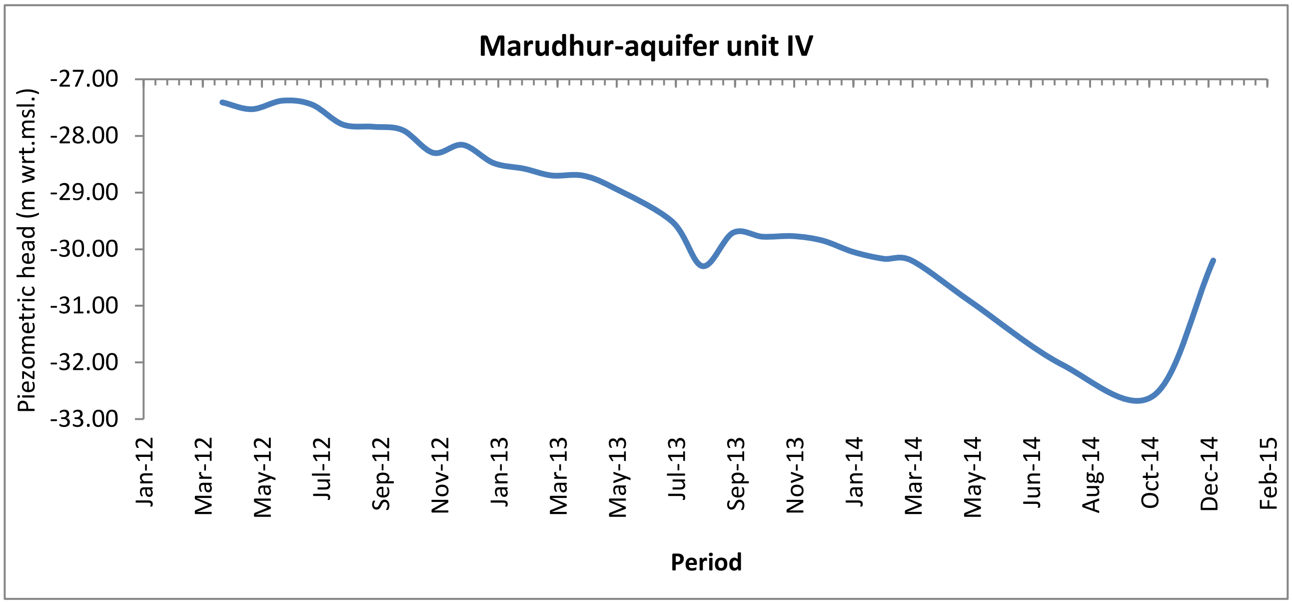

Ramapuram-aquifer unit III
Piezometric head (m wrt.msl)
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period


Ramapuram - Aquifer unit-II
Piezometric head (m wrt.msl.)
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

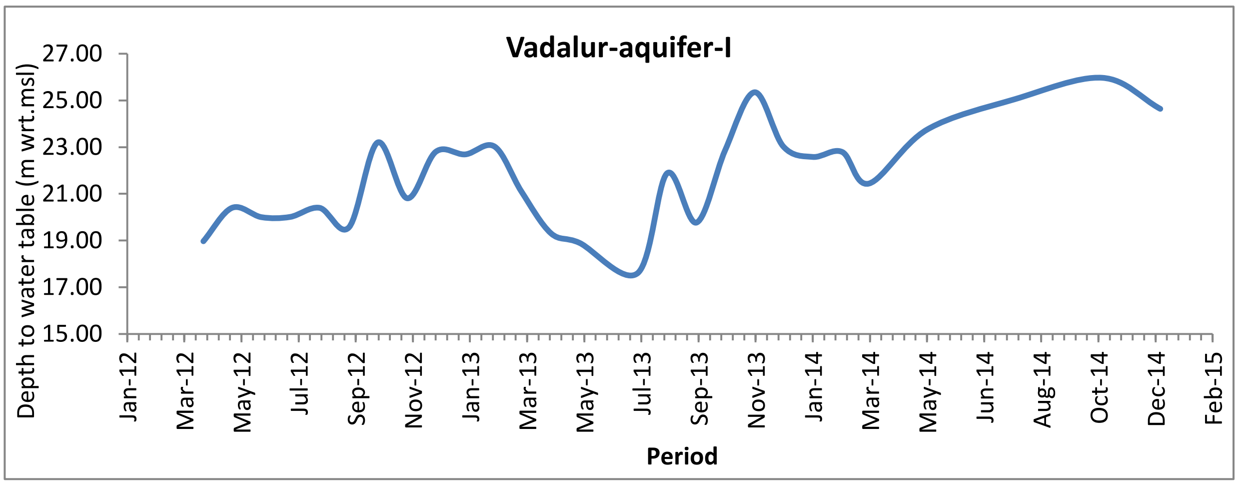

Marudur-aquifer unit II
Piezometric head (m wrt.msl)
-14.00
-16.00
-18.00
-20.00
-22.00
-24.00
-26.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period


Marudhur-aquifer unit II
Piezometric head (m wrt.msl.)
-14.00
-15.00
-16.00
-17.00
-18.00
-19.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

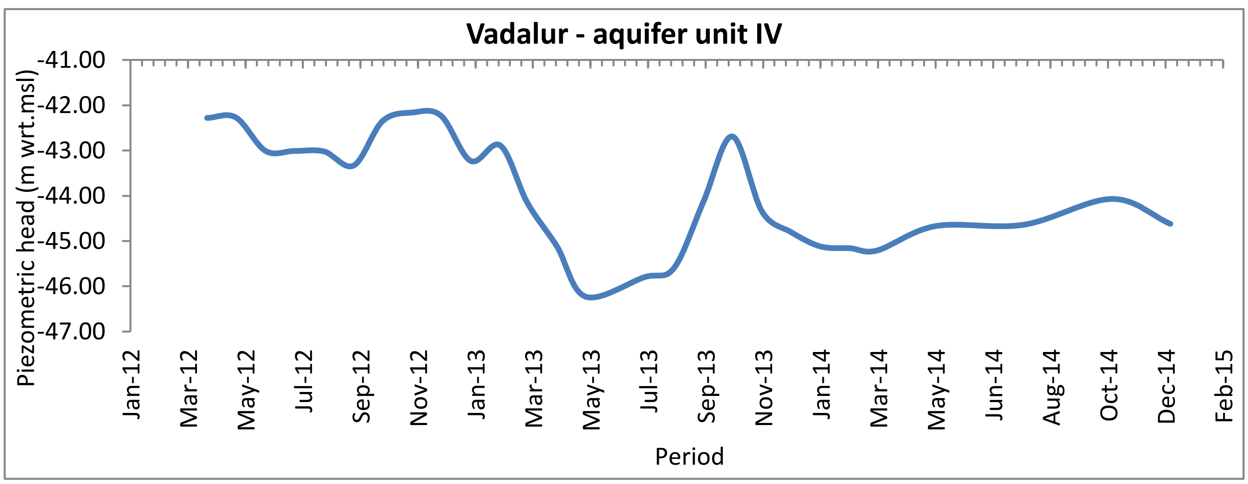

Marudhur-aquifer unit III
Piezometric head (m wrt.msl)
-24.00
-26.00
-28.00
-30.00
-32.00
-34.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period



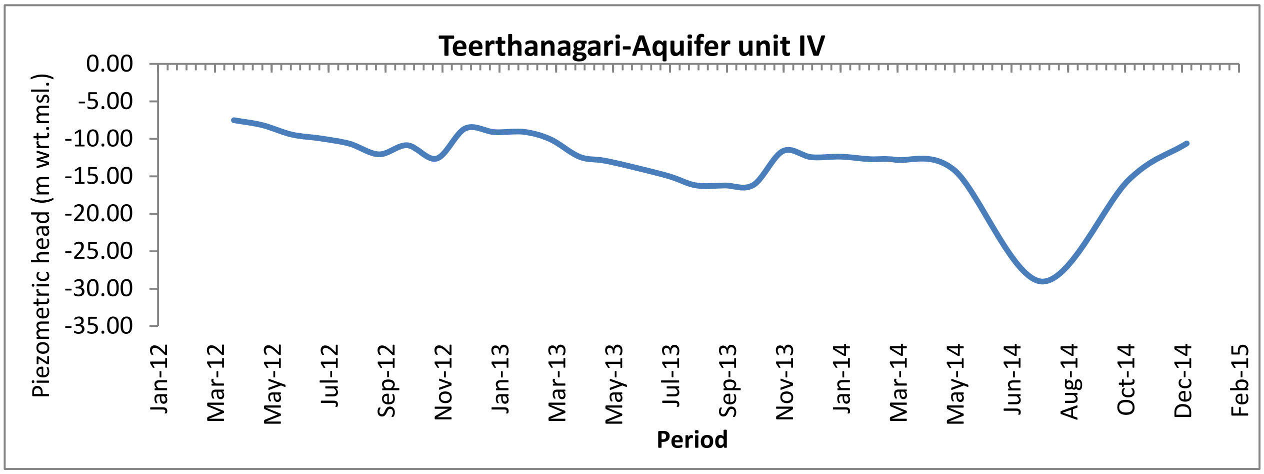
Marudhur-aquifer unit IV
Piezometric head (m wrt.msl.)
-27.00
-28.00
-29.00
-30.00
-31.00
-32.00
-33.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

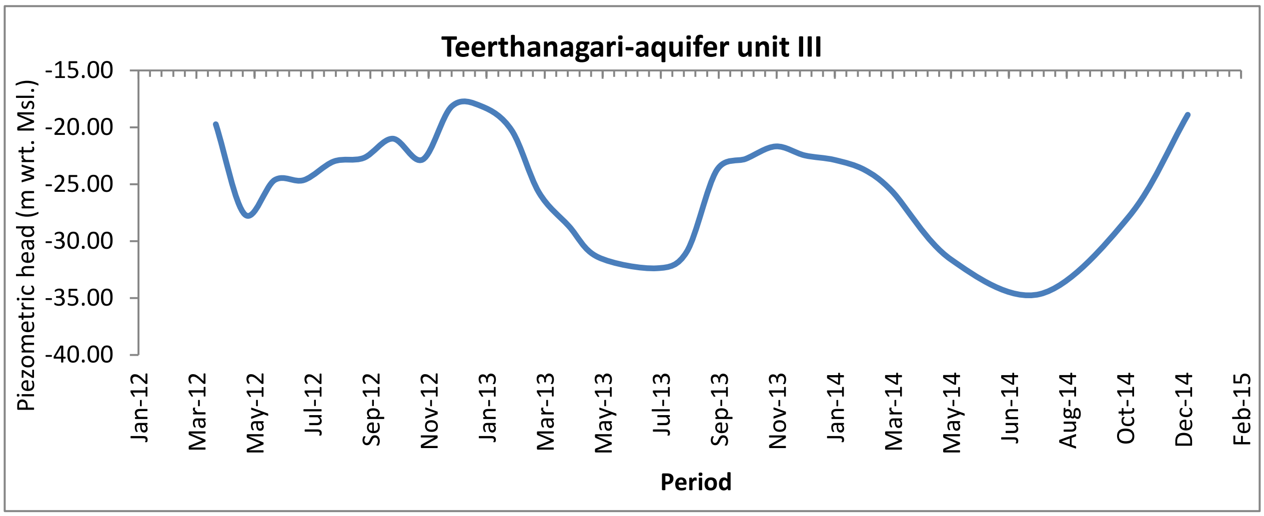


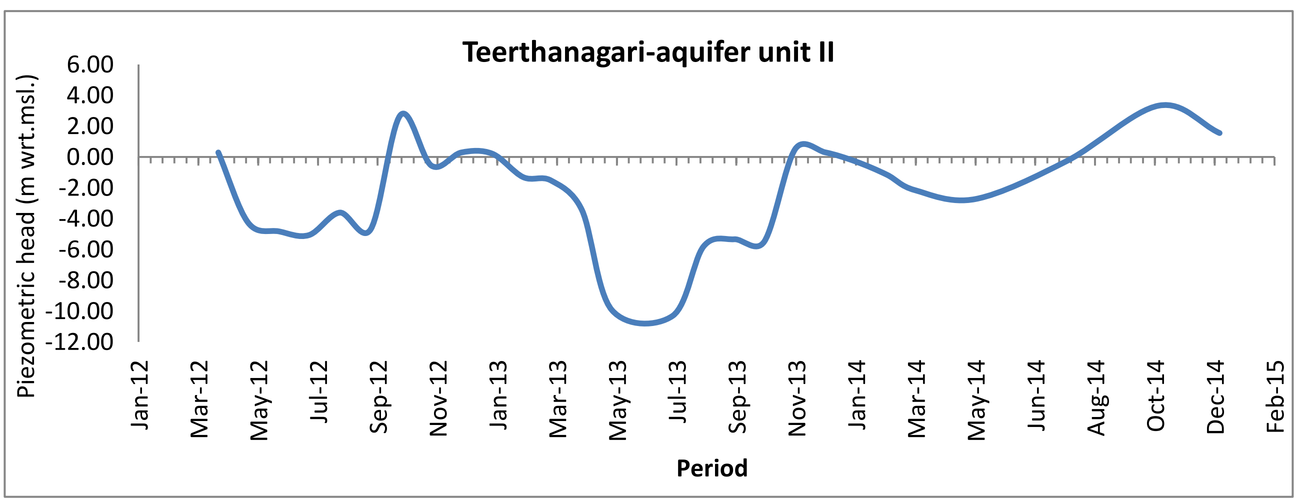
Vadalur-aquifer-I
Depth to water table (m wrt.msl)
27.00
25.00
23.00
21.00
19.00
17.00
15.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

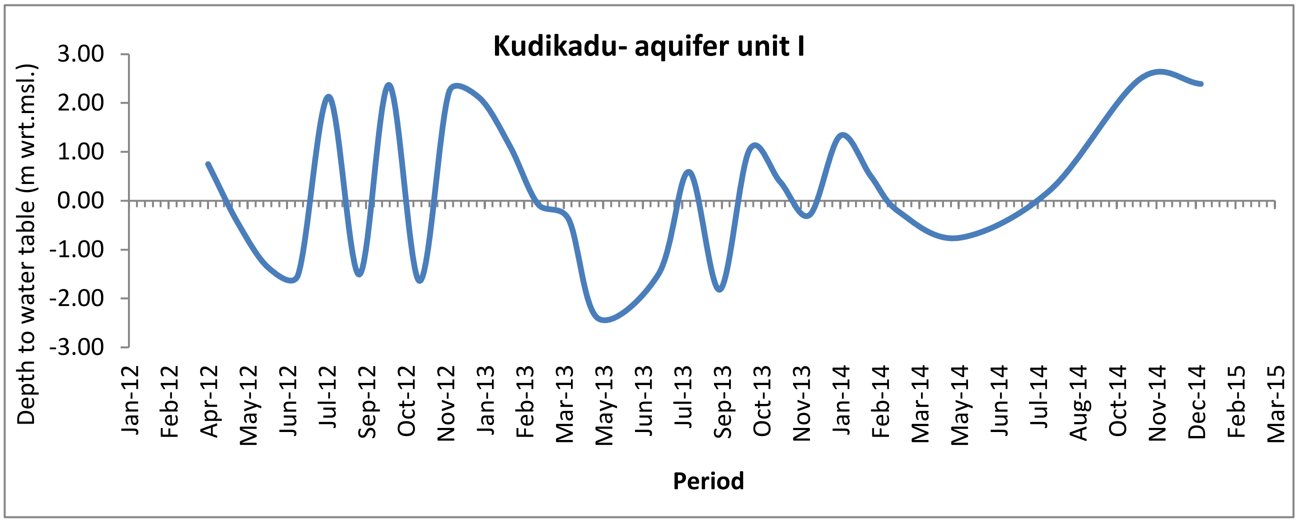


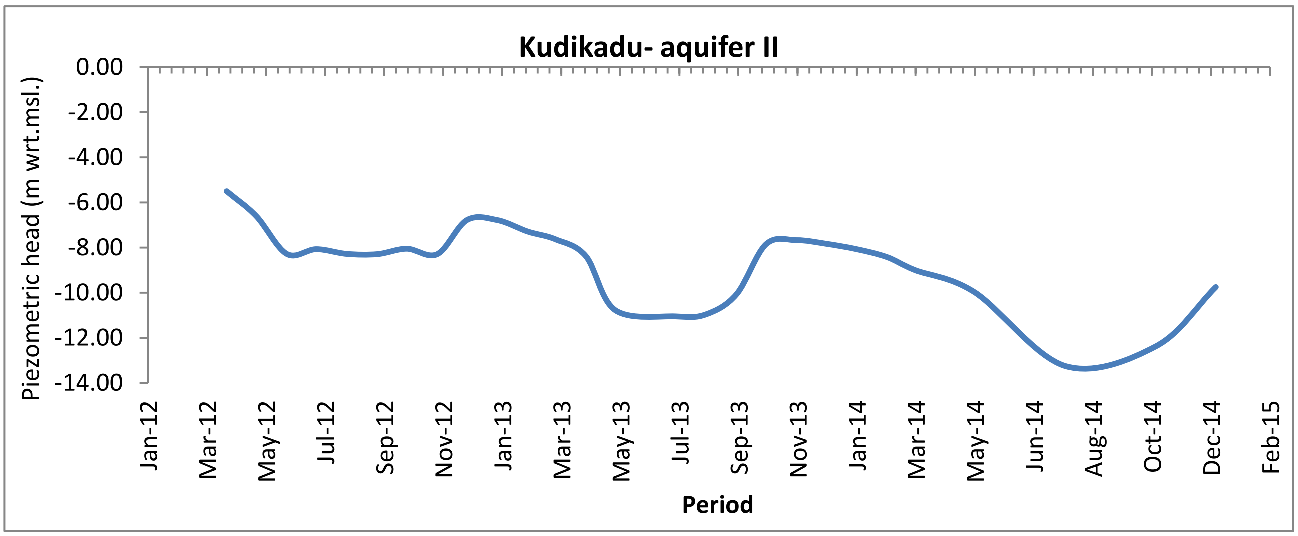
Vadalur - aquifer unit IV
Piezometric head (m wrt.msl)
-41.00
-42.00
-43.00
-44.00
-45.00
-46.00
-47.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

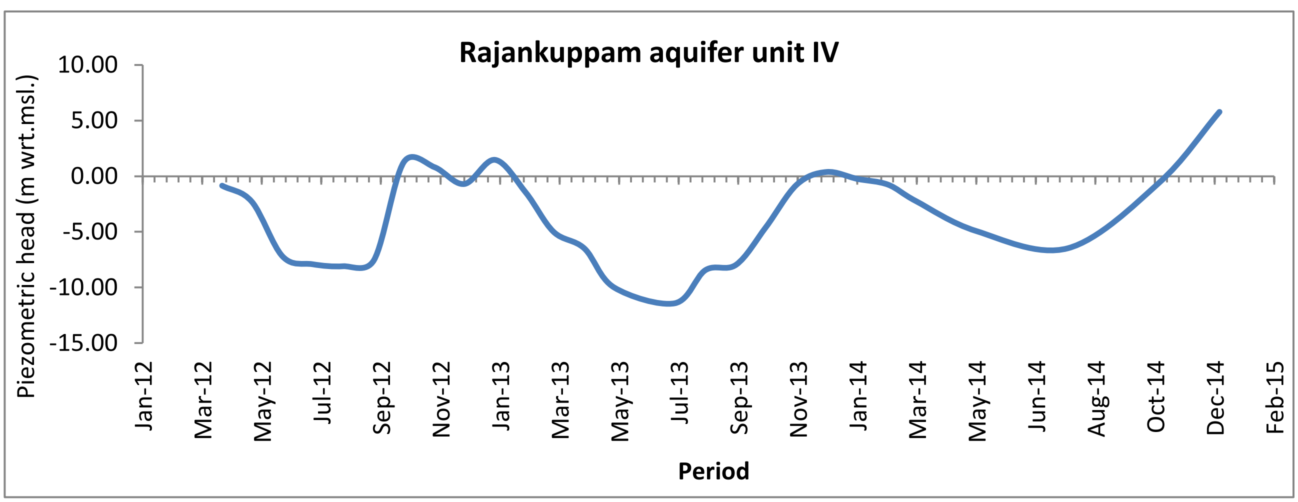

Teerthanagari-Aquifer unit IV
Piezometric head (m wrt.msl.)
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

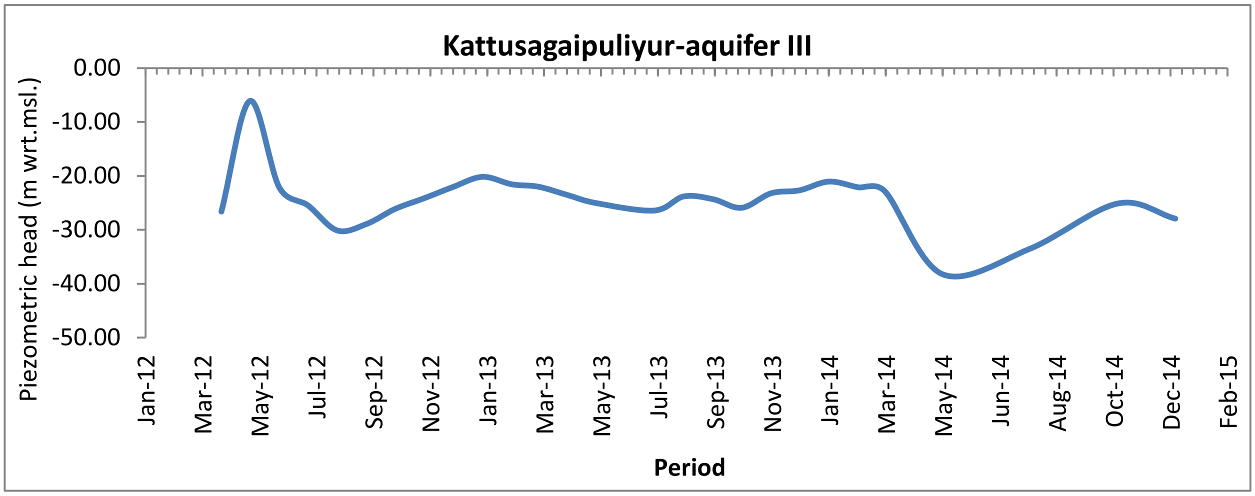

Teerthanagari-aquifer unit III
Piezometric head (m wrt. Msl.)
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

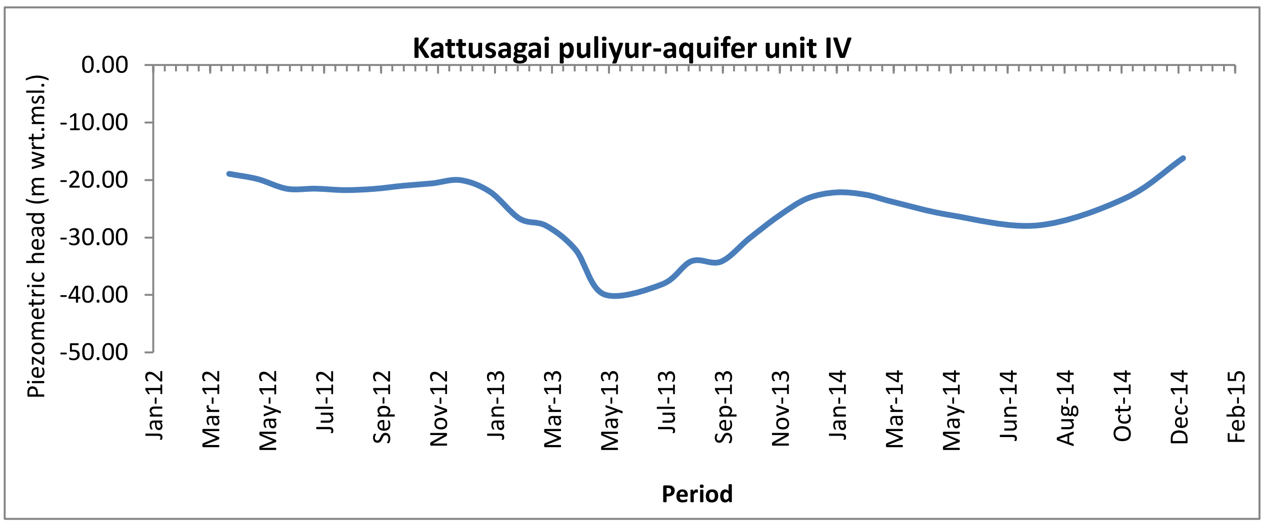

Teerthanagari-aquifer unit II
Piezometric head (m wrt.msl.)
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

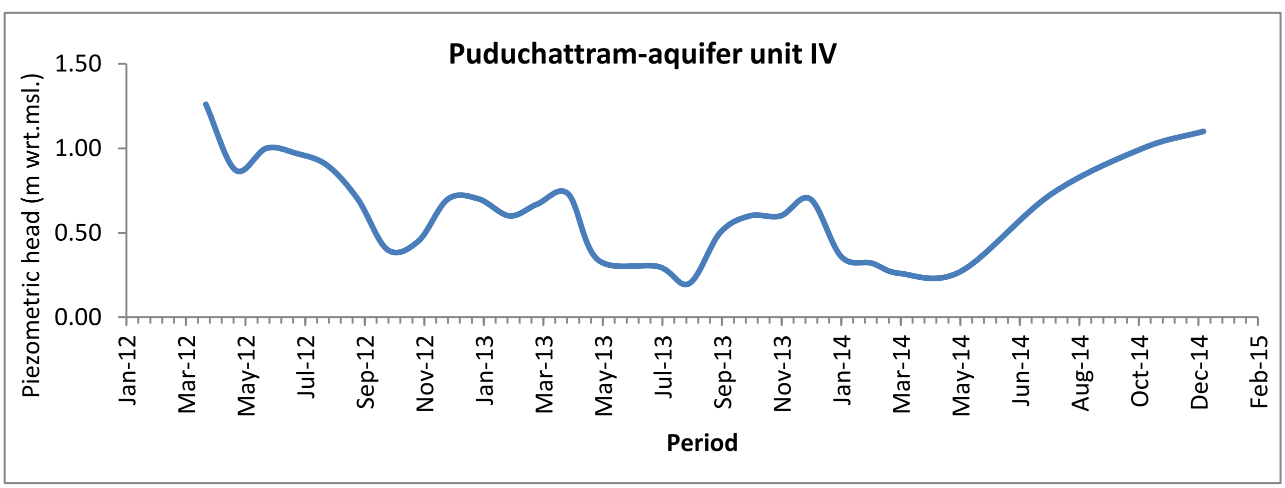

Kudikadu- aquifer unit I
Depth to water table (m wrt.msl.)
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Jan-12
Feb-12
Apr-12
May-12
Jun-12
Jul-12
Sep-12
Oct-12
Nov-12
Jan-13
Feb-13
Mar-13
May-13
Jun-13
Jul-13
Sep-13
Oct-13
Nov-13
Jan-14
Feb-14
Mar-14
May-14
Jun-14
Jul-14
Aug-14
Oct-14
Nov-14
Dec-14
Feb-15
Mar-15
Period

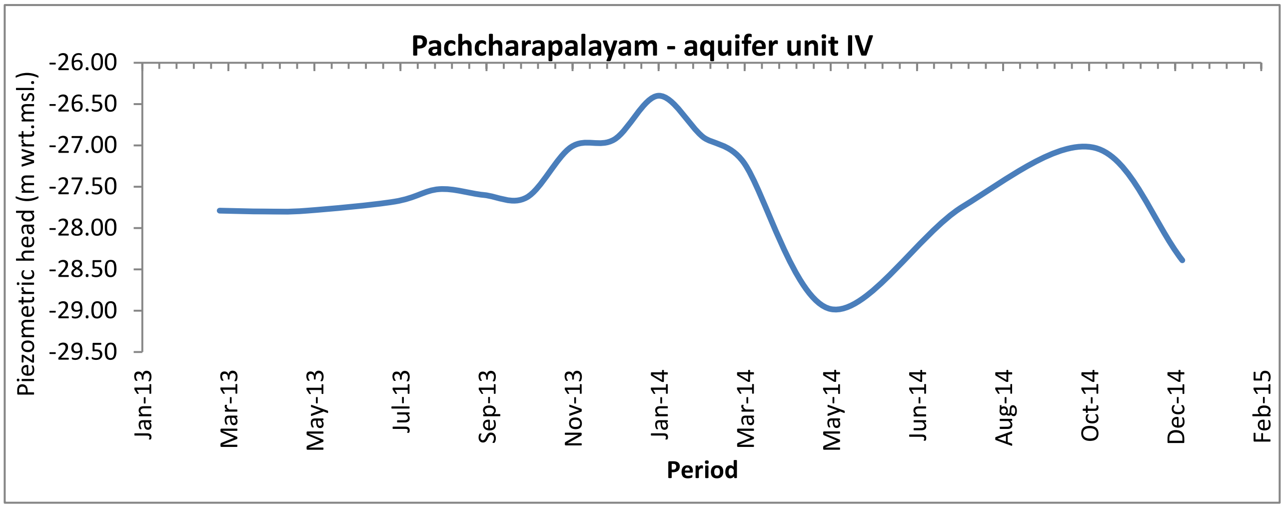

Kudikadu- aquifer II
Piezometric head (m wrt.msl.)
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

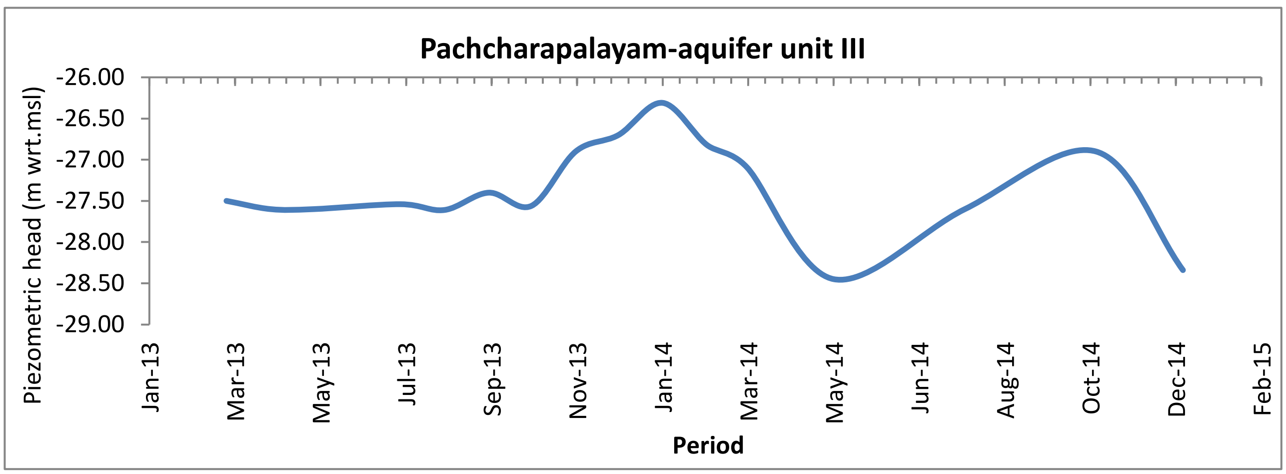

Rajankuppam aquifer unit IV
Piezometric head (m wrt.msl.)
10.00
5.00
0.00
-5.00
-10.00
-15.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

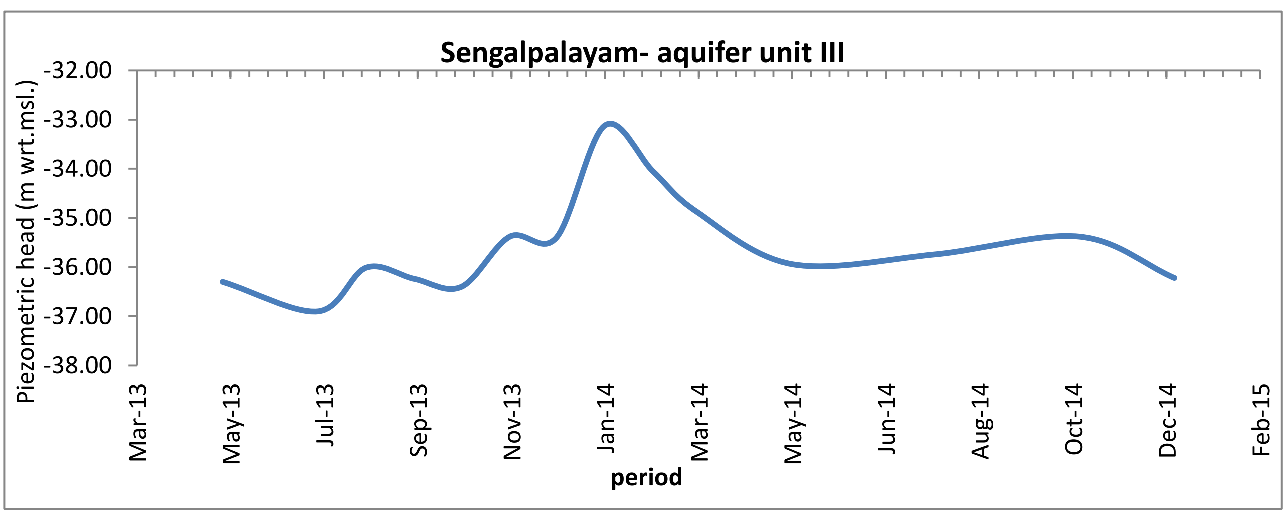

Kattusagaipuliyur-aquifer III
Piezometric head (m wrt.msl.)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

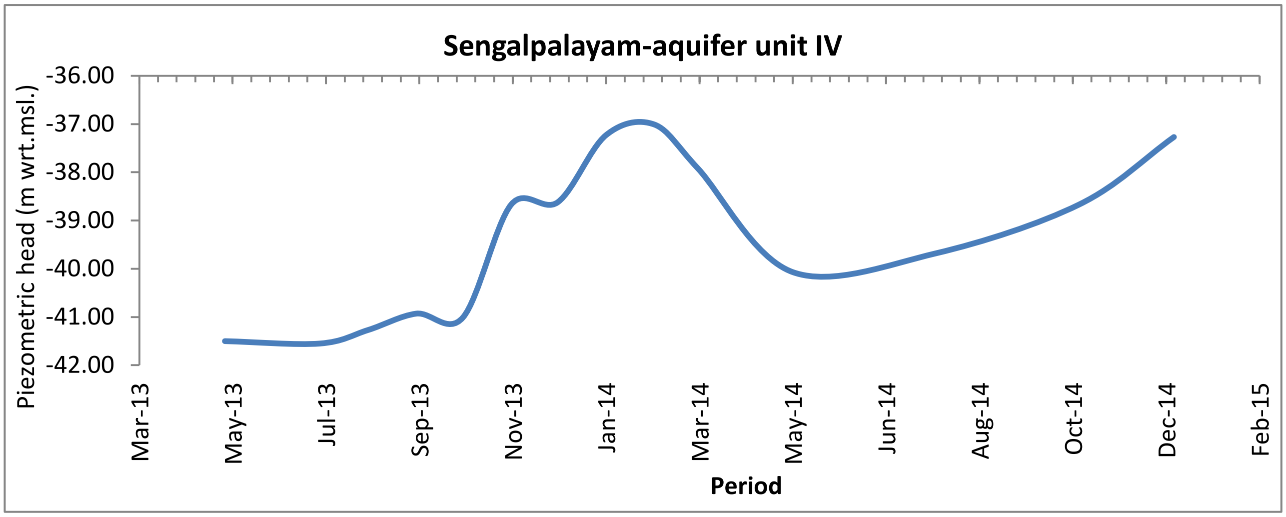

Kattusagai puliyur-aquifer unit IV
Piezometric head (m wrt.msl.)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

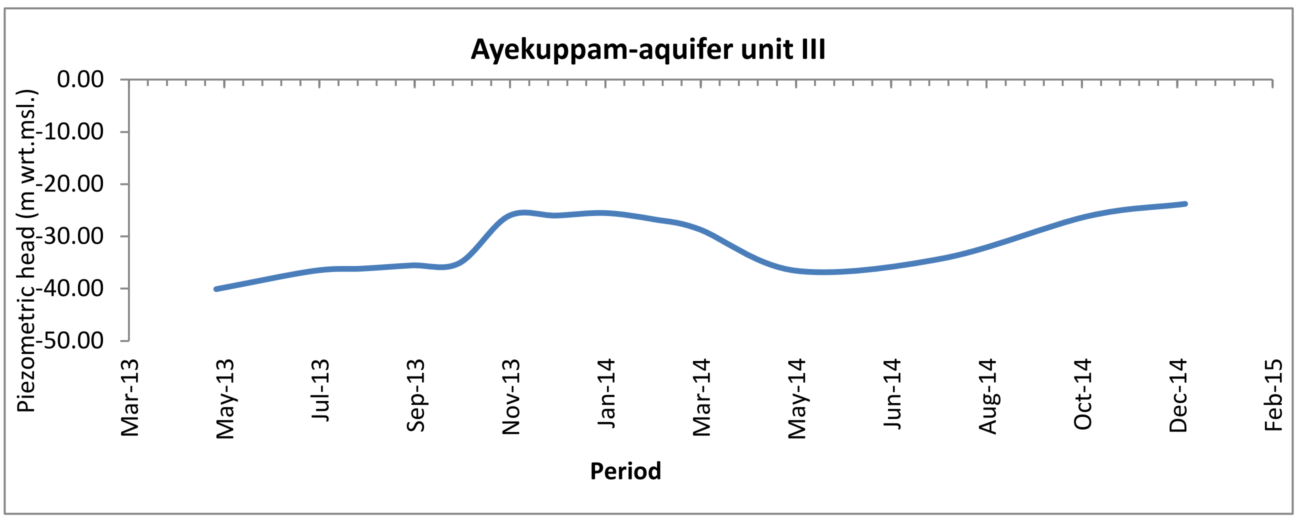

Puduchattram-aquifer unit IV
Piezometric head (m wrt.msl.)
1.50
1.00
0.50
0.00
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

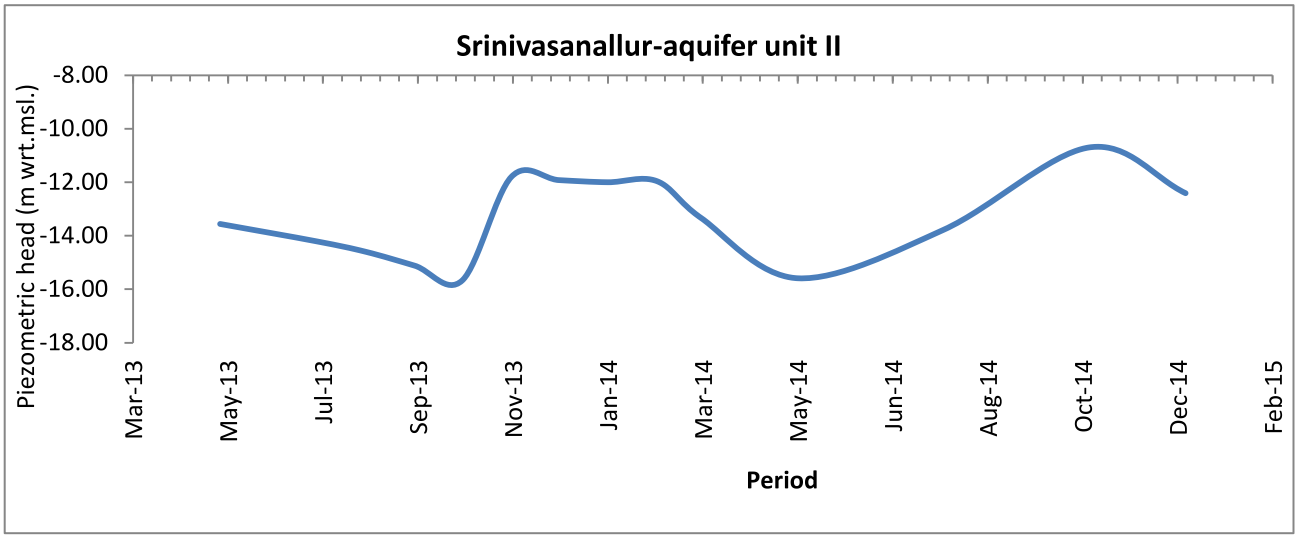

Pachcharapalayam - aquifer unit IV
Piezometric head (m wrt.msl.)
-26.00
-26.50
-27.00
-27.50
-28.00
-28.50
-29.00
-29.50
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

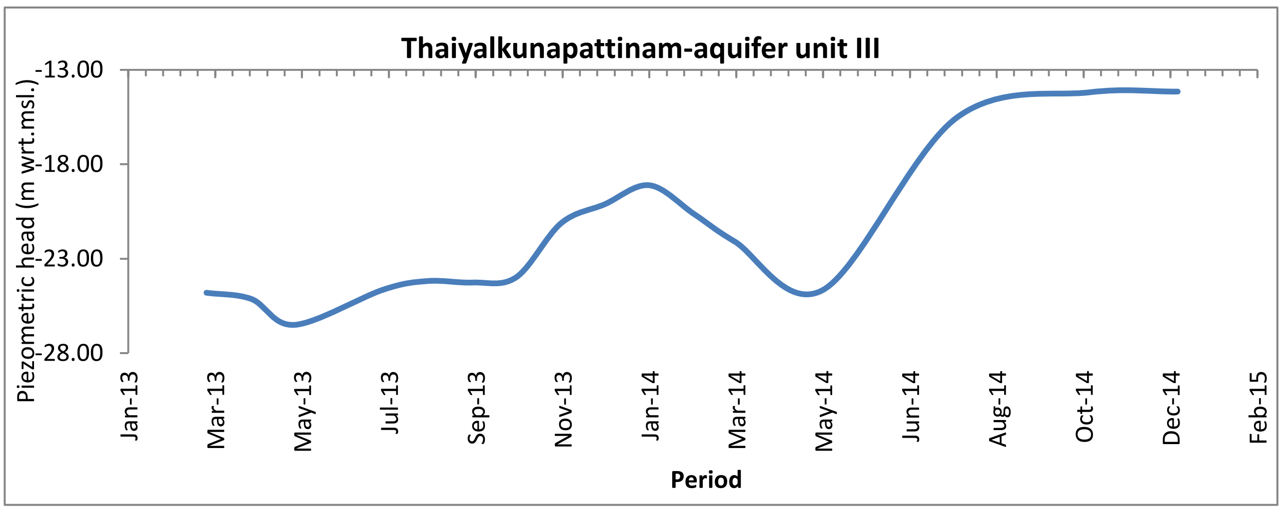

Pachcharapalayam-aquifer unit III
Piezometric head (m wrt.msl)
-26.00
-26.50
-27.00
-27.50
-28.00
-28.50
-29.00
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

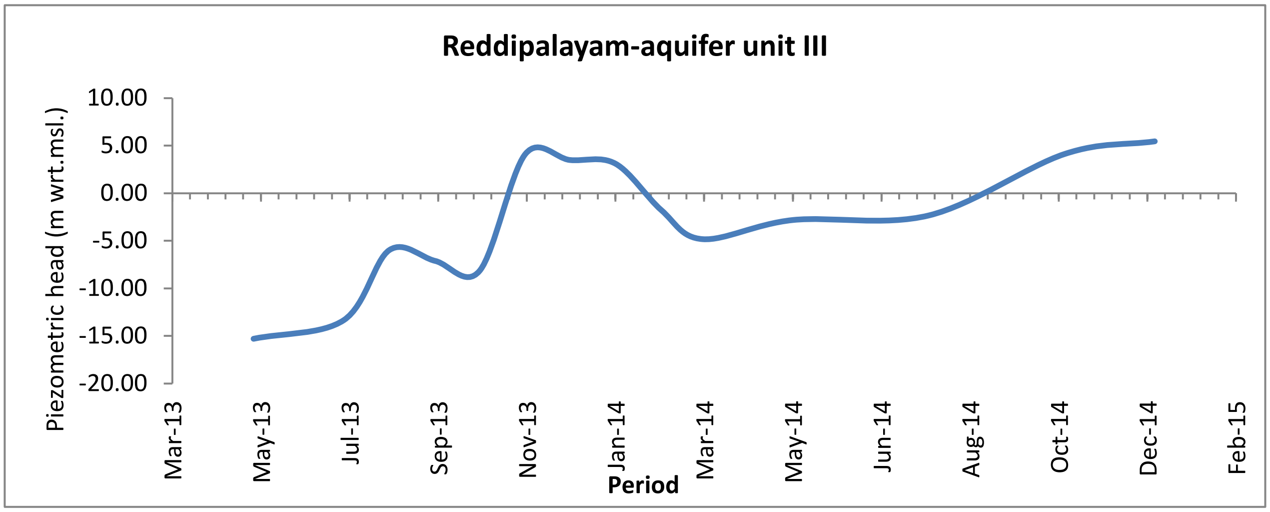

Sengalpalayam- aquifer unit III
Piezometric head (m wrt.msl.)
-32.00
-33.00
-34.00
-35.00
-36.00
-37.00
-38.00
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
period

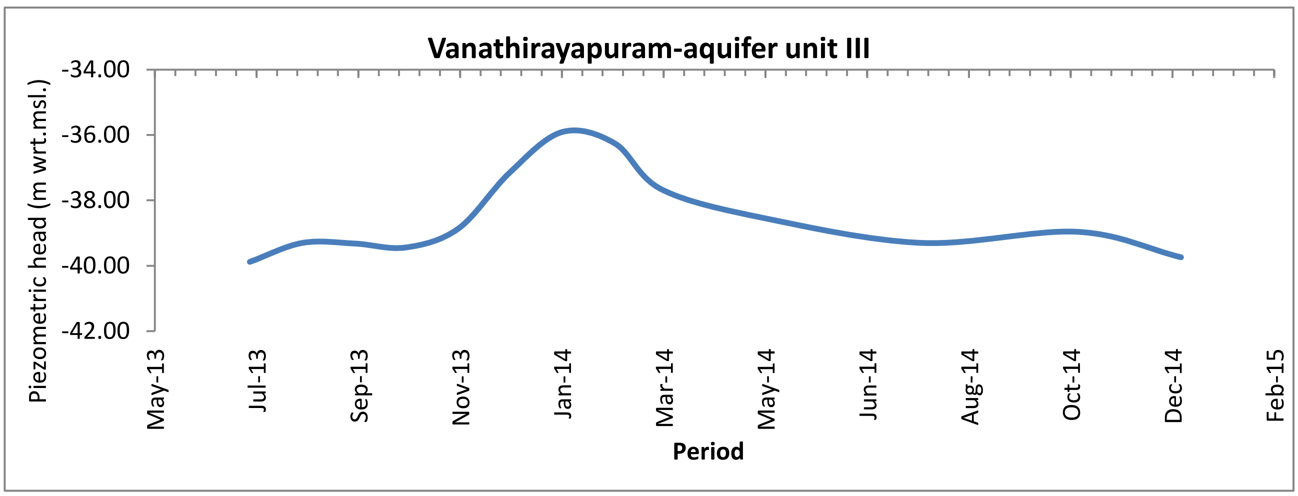

Sengalpalayam-aquifer unit IV
Piezometric head (m wrt.msl.)
-36.00
-37.00
-38.00
-39.00
-40.00
-41.00
-42.00
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

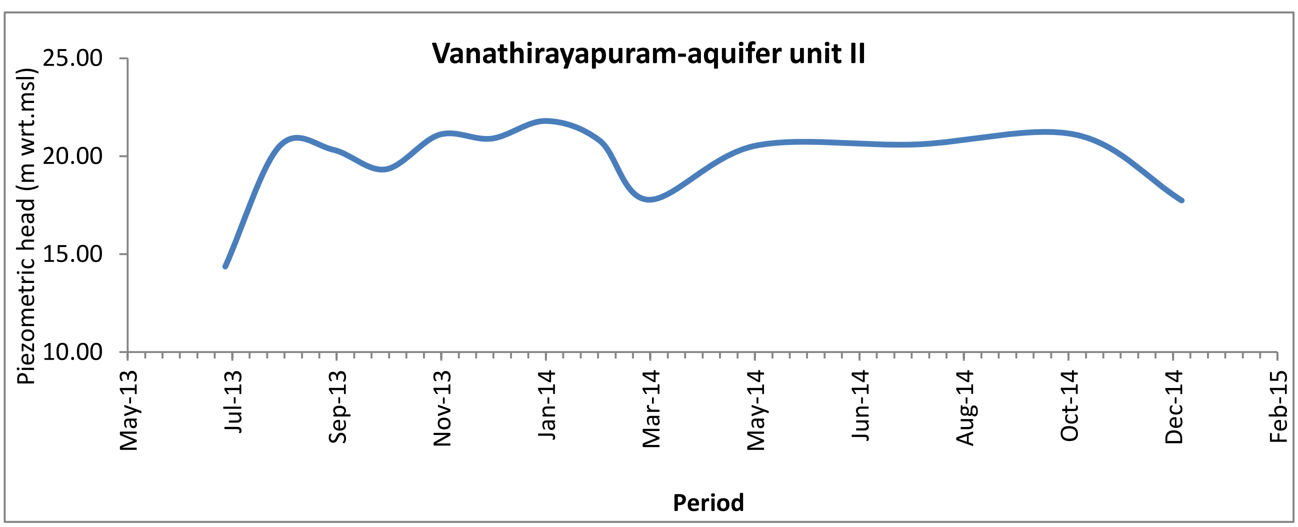

Ayekuppam-aquifer unit III
Piezometric head (m wrt.msl.)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period


Srinivasanallur-aquifer unit II
Piezometric head (m wrt.msl.)
-8.00
-10.00
-12.00
-14.00
-16.00
-18.00
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period


Thaiyalkunapattinam-aquifer unit III
Piezometric head (m wrt.msl.)
-13.00
-18.00
-23.00
-28.00
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period


Reddipalayam-aquifer unit III
Piezometric head (m wrt.msl.)
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period


Vanathirayapuram-aquifer unit III
Piezometric head (m wrt.msl.)
-34.00
-36.00
-38.00
-40.00
-42.00
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period


Vanathirayapuram-aquifer unit II
Piezometric head (m wrt.msl)
25.00
20.00
15.00
10.00
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Period

3.9.3 Groundwater scenario of all aquifers:

The behavior of the aquifer units (I, II, III and IV) to various hydrologic stresses is explained by the analysis of the long term hydrographs of the corresponding aquifer units.

Groundwater scenario of Aquifer – I

In order to understand the recharge and discharge mechanism of the phreatic aquifer 66 dug wells have been established as Key well in the project studies and were monitored each month. The ground water fluctuation of the dugwell varied between 1m to as high as 25 m. High fluctuation of water level is observed in the dugwells existing along the northwest portion, which also implies as recharge zone. The hydrographs of these dugwells respond to rainfall recharge and groundwater abstraction. The hydrograph pattern of all the dugwells are similar in nature which infers that the entire area responses to rainfall recharge as well as groundwater abstraction. The dugwells in the coastal part (0-10 km from coast) also shows similar pattern as that of the dugwell that exist in the recharge and intermediate area. These dugwells do not exhibit declining groundwater trend, suggesting that the groundwater withdrawal is commensurately with ground water recharge.

Aquifer - II

The peizometric heads of few piezometers within aquifer - II shows marginal decline. The declining trend of the peizometric head is at the rate of 0.10 to 0.15 m per year. The declining trend suggests heavy groundwater withdrawal for irrigation by farmers over the years. The ground water fluctuation of these piezometers varied from 5 to 10 m. It is to be mentioned that the piezometric head of these aquifer prior to development was almost at mean sea level or at some places at artesian condition (south and south-eastern part including Neyveli.

Few piezometers within aquifer unit III(around Neyveli, Marungur, Marudhur and Vadalur)and thePeizometric head of Aquifer – IV at Marudhur show decline also exhibit marginal decline. The decline in the piezometric head of Aquifer – III is due to continuous groundwater withdrawal for safe mining of lignite. The hydrograph pattern of the aquifer unit II, III and IV though do not exhibit similar trend, the declining trend of all these aquifer units shows they are vertico-laterally hydraulically connected but still functions as individual aquifer units due to variation in the hydraulics heads.

Similarly the aquifer unit III and IV were in artesian condition since pre development. As such no portion of the aquifer units (based on the peizometers constructed in the project as well as field observation) exhibits artesian condition as groundwater withdrawal has reduced the storativity of these aquifer units.

About 9 piezometers exist in aquifer unit II. It is observed that the piezometric head fluctuation ranges between 1 and 3 m. except for Marudhur the remaining piezometric heads shows no decline in the long term trend. The long term hydrograph of all the aquifer units of Marudhur village shows four distinct aquifer units exist. The analysis of hydrograph (aquifer-I) infers that there is neither decline nor increase in the trend but response to the seasonal fluctuation corresponding with the rainfall. The Piezometer heads of aquifer unit II, III and IV shows declining trend. However the patterns of the hydrographs of all these four aquifer units are distinct. The hydrograph of aquifer unit-II do corresponds with the aquifer Unit I to some extent, this suggest that the aquifer unit I contributes to aquifer Unit II. The declining trend is attributed to groundwater withdrawal for irrigation by the farmers over the years. The Hydrograph of aquifer unit III and IV as mentioned earlier shows decline trend which clearly infers that the storativity reduces. It also suggests they contribute to the upper confined aquifer as upward vertical leakage. They are discontinuous and are connected hydraulically at places due to the absence of impermeable layer (clay). It is to mention, that except for Marudhur, in other places, the piezometric head decline in aquifer III and IV is marginal or in many cases totally insignificant.

The ground water flow of all the aquifer units is towards the dip direction i.e. towards southeast. The pre historic condition of the Cuddalorecoastal aquifer was before 1950,since then due to groundwater abstraction for irrigation and for mining activities the groundwater flow direction has been disturbed at few pockets however the regional flow direction is towards is southeast.

The flow direction towards southeast clearly infers that the fresh water from the cuddalore coastal aquifer seepage into sea since ages and this condition could have existed upto pre development condition. After ground water withdrawal for mining, domestic and industrial purposes have increased, the fresh water flow to the sea as seepage may have drastically reduced.

The ground water level fluctuation in the recharge area is high as observed in the dugwells. The annual average groundwater fluctuation of the phreatic aquifer is 2 to 6 mts. There are few pockets where the dugwells have almost become dry during non-monsoon periods (Kodandaramapuram, Ramapuram, S.pudur, Subramanipuram, Sedapalayam, Anavelli villages etc.). The clay lenses occurring at Vadalur act as perched aquifer system and get recharged first during the monsoon period.

The dugwells in the reacharge area shows high groundwater fluctuation. The dugwell at Kollukarankuttai hamlet in Marungur village shows the water level fluctuation of 20 m suggesting the recharge zone. The rise in water level immediately after monsoon shows impact of rainfall recharge and at the same time the decline in water level immediately after monsoon shows that aquifer lying downstream gets recharged.

The village wise draft studies has been carried out to estimate the total groundwater draft for domestic, industrial and agriculture purpose in the pilot project area and as well as in modeling area. In order to have understanding of the aquifer disposition, surrounding the Neyveli lignite mines, four wells have been drilled at two sites (Vanathirayapuram -2 nos. tapping aquifer unit II & III and Sengalpalayam - 2 nos. tapping aquifer units III & IV). Both the lithologs suggest the existence of four aquifer units and the presence of lignite as marker horizon. The piezometric head of aquifer units III at Vanathirayapuram is -40 m wrt. Msl and Sengalpalayam is -45 m wrt. msl which form the deepest piezometric head in the project area. This is due to depressurization for mining activity by Neyveli Lignite Corporation ltd. for safe mining of lignite, wherein the pressure head is maintained +8 to +10 m above the lignite seam. As the mine shifts with mining of lignite towards southwest direction the piezometric pressure head also shifts along the mine advancing direction.

Due to intensive irrigation groundwater withdrawal occurs much in the aquifer II, however during the field studies it was observed that few farmers have started to construct tubewell beyond aquifer unit II. Though as such at many places the piezometric head has not alarmingly declined, the farmers have gone for deeper due to reduction in the yield of the tubewells. During the last 10 to 15 years, the farmers have constructed tubewellstapping aquifer II. Very few irrigation wells tap aquifer III more particularly in the central part of the area. It is noticed from the field survey that near to the coastal part tubewells are constructed tapping groundwater from aquifer unit I and II only. The average pumping of the tubewells is 5 to 6 hrs per day depending upon the supply of electricity.

Paddy and sugarcane are the major crops cultivated by the farmers extensively in the area. The availability of fresh groundwater has driven the farmers to cultivate paddy and sugarcane. However the decline in its yield had made few farmers to go for cash crops like groundnut and corn.

3.10 Water Quality

The In total 47 numbers of Ground water samples from dugwells representing Phreatic aquifer were collected and were analyzed for major ions and cations including fluoride. (Annexure – VI a&b). The spatial distribution of Electrical Conductivity, Chloride and Bicarbonate of phreatic aquifer is given as figure 3.43, 3.44 and 3.5. The Electrical conductivity of the phreatic aquifer ranges between 160 to high as 3000 microsimens/cm. However the 80% of dugwells show Electrical Conductivity (EC) ranging between 200 and 1000 microsimens/cm. The pH of the samples ranges from 7.6 to 8.7 indicating the ground water of phreatic aquifers is alkaline in nature. Chloride concentration of the phreatic aquifer ranged between 28 and 540 mg/l.

The EC and the Chloride concentration infers that the Phreatic aquifer (aquifer – I) is fresh and is suitable for drinking, Domestic and Irrigation purpose. Fluoride concentration ranges from 0.03 to 1.0 mg/l and is within the permissible limit. Surface water samples were also taken at 4 locations in Paravanar and Uppanarriver. The EC of Paravanarriver is 700 and 940 micromins/cm while the EC of Uppanarriver is 24,600 microsimens/cm. The groundwater quality of the deeper aquifers (confined) have been collected and analyzed for its quality. Except for insitu salinity at very few localized pockets particularly near Upanarriver, no evidence of sea water intrusion exists. More information on the groundwater quality of the shallow and deeper aquifers have been discussed in subsequent chapters.

Figure 3.43 Electrical conductivity map aquifer-I

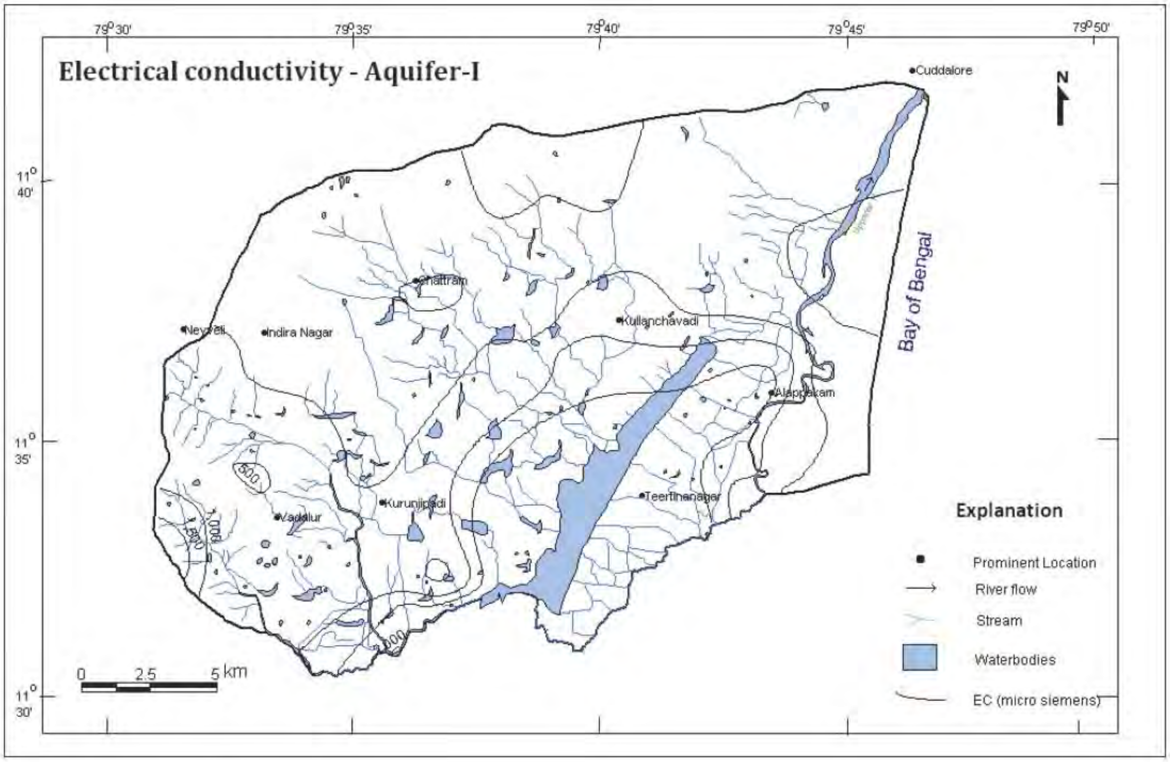


Figure 3.44 Chloride distribution map aquifer-I

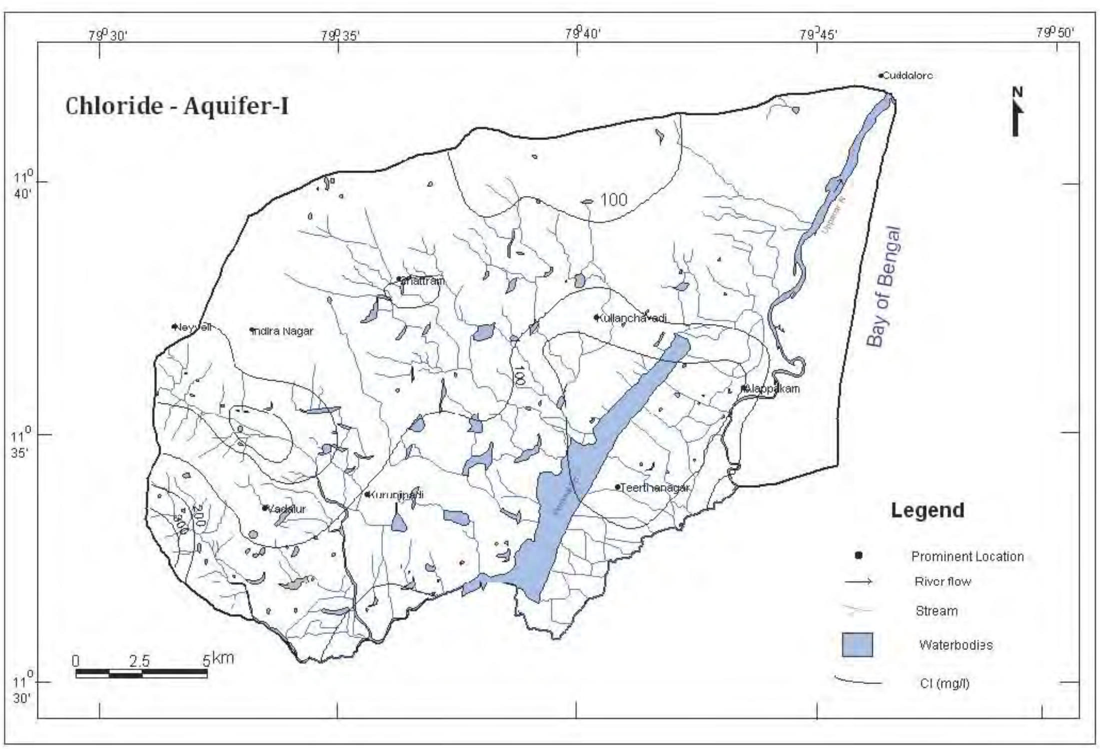
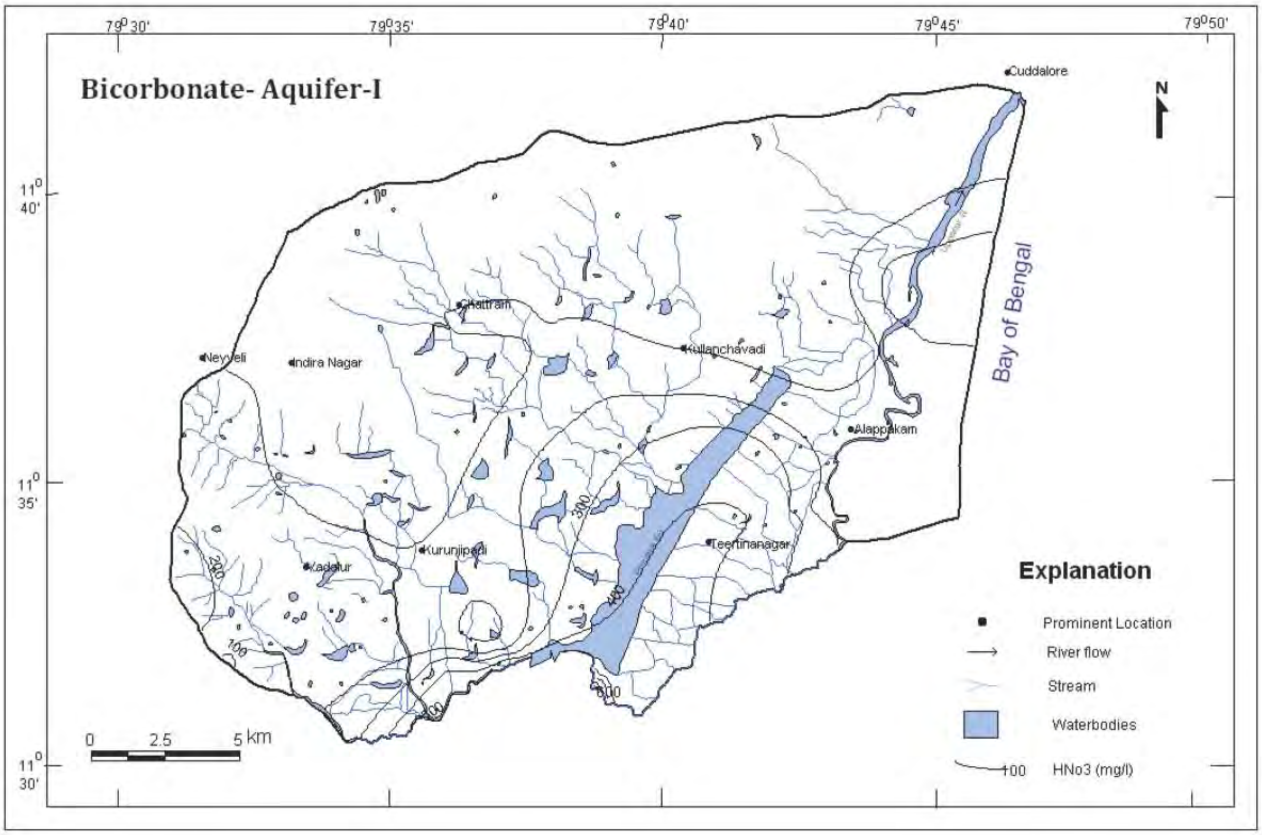


Figure 3.45 Bicarbonate distribution map aquifer-I



Chapter 4. Data Integration

4.0 Data Integration

The data generated from conventional and advanced geophysical techniques (SKYTEM) was integrated with the geological and hydrogeological data. The processed data of SKYTEM from the Aarhus workbench was integrated with the outputs from the conventional geophysical survey and sub-surface data. Fine tuning of the aquifer disposition had been done based on the outputs from data integration.

4.1 Integration of data from Conventional & Advanced Techniques:

With the help of results from the SCI based mean resistivity maps, the entire surveyed area was gridded into 2 x 2 km for analyzing the resistivity behavior laterally along the direction of W-E. The grid space was chosen in such a way that it fulfills the requirements of the National Aquifer Mapping program. West-East direction was considered because the profile lines are expected to pass through various hydrogeological environments. The objective was to look for dipping aquifer formations and to decipher the lateral extension of lignite seams. The Google image of the area with grid lines and numbering which will be referred while discussing selected profile line are presented in Fig. 4.1.

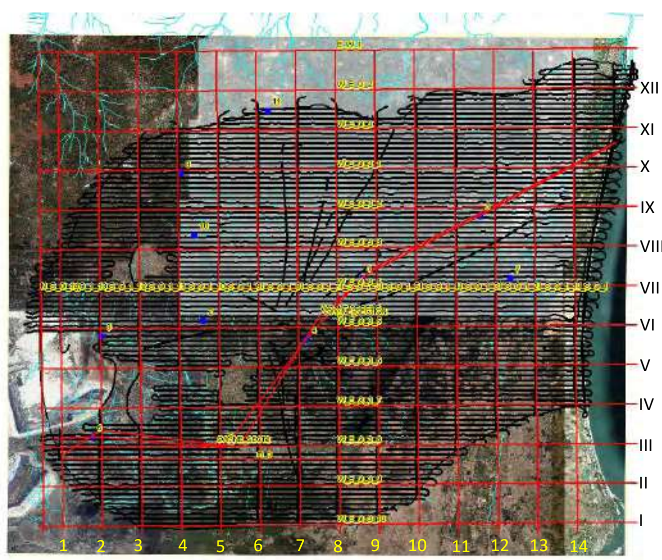


Fig. 4.1 AQTND survey area showing study grid lines with reference coding and locations of exploratory boreholes drilled by the CGWB.

The SCI Profile-I resistivity characteristics brought out the nature of sub-surface formations that are mostly of high to moderate conductivity probably indicating the poor quality of pore water. Because of this high conductive nature at shallow depths, the DOI (Depth of Investigation) along this profile is limited to depths of 90-100 m only. Since the SCI image has indicated occurrence of resistive layer just above the DOI line on the west and central part of the profile, the smooth inversion has been generated at every 2000 m distances from 6000 m to 16000 meters (10 km length) and studied for the behavior below the DOI level.

The smooth inversion of profiles on the west central part shows increase in resistivity just below the DOI (200 m) with more than 50 Ohm-m indicating the presence of an aquifer with better quality water below. It implies that while preparing aquifer section from the SkyTEM data, it is important to study the smooth inversion results below DOI also and then with the knowledge on local hydrogeological conditions, decisions should be taken on extending the depth of the aquifer section.

In order to understand the resistivity depth function as revealed by smooth inversion profile, the SCI image along this study profile has been transformed in to a resistivity section. Before preparing the resistivity section, the smooth inversions were studied with resistivity variations and depth extensions and assigned probable lithological characteristics. Various depth resistivity layers and their thicknesses with corresponding inferred lithology at all the grid nodes (3-8) of Profile-I are presented in the following Table-1.

Table-1 (Profile-I)

Grid Node	Depth Range in m	Resistivity in Ohm-m	Inferred Lithology	DOI/Remarks
I-3	0-12.7	5	Sandy clay	
	12.7-22.6	6-8	Sandy clay	
	22.6-46.2	10-11	Fine Sand	
	45.2-67.9	8-10	Sandy clay	

	67.9-93.8	11-14	Fine Sand	
	93.8-124.9	9-12	Sandy clay with Lignite	
	124.9-136.4	11-13	Fine Sand	DOI: 130 meters
	136.4-222.6	40-80	Sandstone	First Confined Aquifer (?)
I-4	0-17.5	4-6	Clay	
	17.5-39.8	5-7	Sandy clay	
	39.8-84.6	4-7	Sandy clay	
	84.6-113.8	11-16	Fine Sand with Lignite	DOI:110 meters
	113.8-206	20-50	Coarse Sand/S. St.	First Confined Aquifer(?)
I-5	0-12.7	5	Sandy clay	Water Table(?)
	12.7-22.6	6-9	Sandy clay	
	22.6-46.2	11	Fine Sand	
	46.2-67.9	8-9	Sandy clay	
	67.9-93.8	12-14	Fine Sand	
	93.8-113.8	9	Sandy clay with Lignite	
	113.8-136.4	12-13	Fine Sand	DOI:130 m
	136.4-222	40-80	Sandstone	First Confined Aquifer(?)
I-6	0-22.6	2-3	Clay	
	22.6-39.9	5-7	Sandy clay	
	39.9-84.6	4-7	Sandy clay	
	84.6-124.8	5-6	Sandy clay with Lignite(?)	
	124.8-161.8	6-9	Fine Sand	DOI:140 m and First Confined Aquifer
	161.8-222.6	8-9	Fine to Medium Sand	
	222.6-298.5	10-12	Sandstone(?)	
I-7	0-12.7	2-3	Clay	
	12.7-53	4-5	Sandy clay	
	53-76	3	Clay	
	76-136	5-14	Clayey sand to fine sand with Carbonaceous	DOI:100 m

			Clay(?)	
	136-206	11-14	Fine to Medium Sand	First Confined Aquifer
	206-		Sandstone(?)	
I-8	0-17.5	2-3	Clay	
	17.5-39.8	4-6	Sandy clay	
	39.8-84.6	2-5	Sandy clay	
	84.6-113.8	2-3	Clayey sand	DOI:100 m
	113.8-206	3-9	Sandy clay with fine sand	First Confined Aquifer(?)
	206-		Sandstone(?)	

Three dimensional perceptions of SkyTEM results

The studies on aquifer mapping requires regional disposition of aquifer to visualize the hydrogeological conditions in terms of groundwater potential. Such an attempt was made while analyzing the ground geophysical survey results to visualize the regional disposition in the form of fence diagram and presented in the Technical Report: NGRI-2014-GW-864. The aquifers were grouped in two units of unconfined and semi-confined as one unit and the unit consisting of confined aquifers.

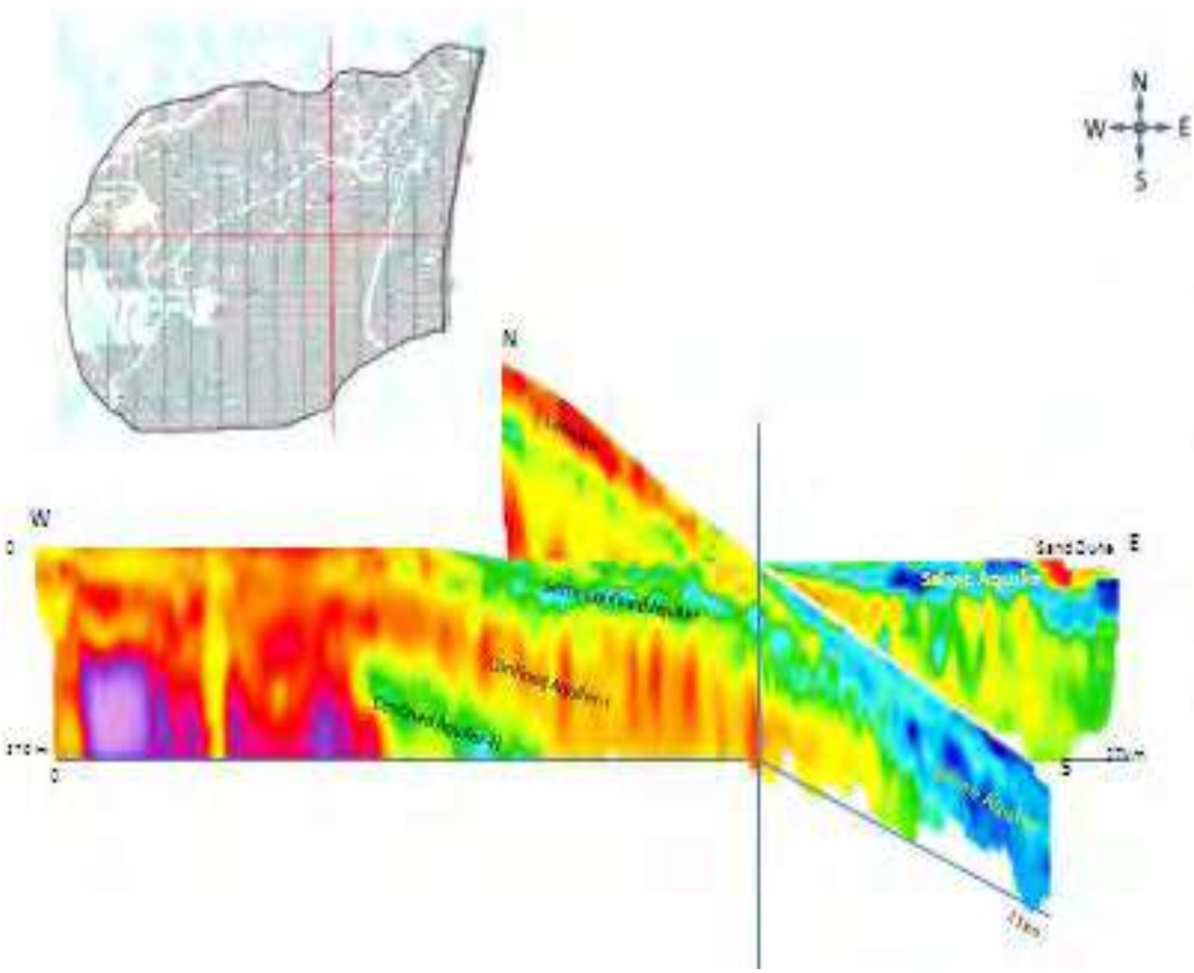


Fig.4.3 Intersecting sections projecting regional aquifer setting visualization

After the completion of heliborne survey over the study area, similar attempt was made to project the aquifer dispositions along two intersecting profiles to understand the sub-surface electrical conductivity structures and then translate them into aquifers. Such an attempt was made along two profile lines over the study area in a direction of W-E & N-S is presented in Fig.4.3. In order to get a good projection in all directions, the N-S section was projected in the figure at an angle to the W-E section. As two profile sections, the aquifer dispositions are similar to the discussion made earlier as profiles in both directions. The additional information gained in the present form of viewing the SkyTEM results in the form of aquifer layers with dipping nature in both the directions of east and south reveals the extension of inland salinity from the coast very clearly. Such sections could be prepared for any directions to get fine tuning of understanding the aquifer dispositions that will enable mapping of the aquifer extension in any directions.

Depth image analysis

Resistivity maps at various depths could be prepared from the SkyTEM results to study the planar view of the aquifer and its boundary conditions. Such an attempt was made over the study area to understand the disposition of aquifers along several depth planes. The images have been generated using the mean resistivity of SkyTEM results. The various depth images were selected on the basis of aquifer positions inferred from geophysical surveys and lithologs. The selected depth images are shown with depth range in the Figure. 4.4.

- 0-10 m: This depth part was chosen to represent the top-soil condition of the area in terms of mean resistivity. In general the order of resistivity decreases gradually in the SE direction having four major regional resistivity signatures that could be attributable to Laterite in the NW to alluvial soil in SE. Parallel to the coastline, a linear high resistivity zone is observed. These could be Strand Lines of coast geomorphological feature.

- 40-50 m: This depth range was chosen to understand the semi-confined aquifer zone over the study area. Persistence of high resistive zone in northwestern corner part of the area marks the presence of consolidated sediments that could be probably the sandstone. The sharp contact between resistive and conductive zone on the southern part of the area still persists marking the consolidated-unconsolidated/alluvium boundary with indication of quality of groundwater also. Considering the semi-confined aquifer occurs at this average depth, it is seen that most of the area in central-northern is reflecting more or less uniform resistivity. However, a low resistive zone within this area at the central part with connectivity from the south needs to be understood in terms of hydrogeological conditions.

- 80-90 m: The depth range of 80-90 m was chosen with an assumption that this depth may probably represent the bottom of semi-confined aquifer. Similar to the earlier depth range, the northwestern part depicts resistive formation when compared to the other areas. However, this resistive zone slowly extends towards south marking the presence of consolidated sediments down at this depth. The low resistive zone that was piercing in to the moderate resistive zone at depth range of 40-50 m is found to be extending linearly towards NE parallel to the contact of resistive and conductive zones probably.

- 120-130 m: This depth range was selected to represent the top of the first confined aquifer below the marker bed of lignite either associated with clay or sand in the west-central part of the area. Even at this depth range the resistive northwestern part continues and its southern extension is also seen. The conductive zone extension mapped in the earlier depth range of 80-90 m was also traced. The major contact zone between the resistive and conductive areas on the southern boundary continues to exist marking this feature to be of geological significance.

- 160-170 m: This depth range was chosen with an assumption to study the bottom of the first confined aquifer. The northwestern part remained further more resistive suggesting the consolidation of formations. Due south extension of resistive formation marks the continuity of the geological formation from north to south. However, on the southern side more conductive signatures are seen reflecting the quality of ground water as poorer compared to the previous depth range. North-central part of the area becomes resistive in most part at this depth range. However, a salient feature of conductive linear feature in north-south direction with various width features started emerging at this depth dividing the northwestern and north central parts of resistive beds. Due to constraint of conductive sediments in the eastern part, the information on resistivity variation could not be mapped due to limited DOI depth.

- 200-210 m: Considering this depth range to be part of second confined aquifer, the depth image was prepared. The northwestern resistive part still persists suggesting the depth continuation of consolidated formation. However, its southerly extension became less prominent at this depth range indicating that it could be highly saturated with more medium to finer sediments with less compaction. However, a small patch of resistive area is mapped along northern boundary. The southern conductive zone persists with probable poor quality of water or more clayey material. Due to DOI depth limitation, the eastern part was devoid of depth information.

- 240-250 m: This depth range was considered to be bottom part of the second confined aquifer or part of the third confined aquifer. The northwestern part continues to be resistive indicating continuity of formation even up to this depth range. However, a strong signature of another conductive channel formation down the northern boundary having similar feature of wavering nature starts appearing on the image.

4.2 Value Addition from Advance Geophysical studies

Based on the analysis and interpretation of Heliborne Geophysical survey (SkyTEM) the following could be inferred.

The SkyTEM results were useful to decipher the sandstones formations down to depth of 150 – 220 m bgl. However the impermeable clay layers that exist within the sandstones that act as marked horizon between different aquifers could not be deciphered beyond 100 m bgl. The dipping nature of the sandstones down to depth of 160 – 200 m can be traced from the SkyTEM results.

In the alluvial formations the SkyTEM survey could bring out information only upto 80 to 100 m bgl. In places where clay exists on the surface are near surface, the depth of investigation is limited within 80 m bgl only. The general dipping pattern of the Sandstones along the E-W direction is quite prominent and hence was used to understand the dipping nature of the formation.

4.3 Efficacy of Various Geophysical Techniques for different Hydrogeological Terrain

APPLIED GEOPHYSICAL METHOD'S EFFICACY PERTAINING TO LOWER VELLAR BASIN (AQTND)

METHODS	GEO-ENVIRONMENT					APPLICABILITY	
	Laterite	Sandstone	Alluvium	Lignite	Coastal Alluvium	Depth Factor	
VES						SHALLOW	DEEP
ERT						SHALLOW	DEEP
GTEM						MODERATE	
SKYTEM						SHALLOW@	DEEP#
AIRBORNE MAGNETIC						No significant magnetic features associated with aquifers	

@ LOW MOMENT # HIGH MOMENT

VES INSTRUMENT USED: SYSCAL WITH SCHLUMBERGER CONFIGURATION

The Vertical Electrical Sounding (VES) with maximum current electrode spacing of AB=1600 m to 2200 m with movement of current electrode with every 30/50 m spacing beyond 200 m of AB/2. This was followed at every site. The response was plotted in the field itself simultaneously and if required the observation was repeated with varying the current for confirmation of change in trend. The interpretation of carried out in the field day itself for understanding the layer parameters behavior over an area. In some cases, the sounding was repeated at nearby place or in other orientation.

MULTI-ELECTRODE IMAGING SUSTEM (ERT): ABEM IMAGING SYSTEM

Electrical Resistivity Tomography (ERT) was applied for a profile length of 800 m with inter-electrode spacing of 10m and 80 electrodes. Various protocols like Wenner, Schlumberger, Wenner-Schlumberger and Wenner Large were adopted at each site for understanding the efficacy on resolution of each method.

GTEM : TEMFAST 48

The Transient electromagnetic sounding was done using TEM Fast 48 HPC using coincident transmitter and receiver loop configuration. Two sets of magnetic moment i.e. 2500 and 5000 Am^2 (50 m x 50 m) were used prior to the SkyTEM survey to test the efficacy in mapping the complex coastal study area for designing the SkyTEM survey parameters.

SKYTEM:

SkyTEM504 dual moment time domain electromagnetic system was used to investigate 300 m below ground. The system uses 1 and 4 turns of transmitter loop for low and high moments. Line spacing of 250 m having 95 fly-lines in west-east direction nearly perpendicular to the formation found to yielded maximum sub-surface information. The average flight speed of the helicopter was 22 m/s at an average flight altitude (frame height) of 30 m above the ground was appropriate over the hydrogeological conditions. Due to experienced limited Depth of Investigation over areas of highly conductive in nature, the greater depth penetration/information, it is preferable to use a multi pulse HeliTEM System with higher moment (>500,000 Am^2) with low pulse rate frequency capable of late time measurements up to 20 milli-seconds or beyond in future.

4. 4. Protocol for Geophysical Investigation in Aquifer Mapping (AQTND)

Geophysical Tool of Application	GEO-ENVIRONMENT					Order of preference and application & Reasoning
	LATERITE	Sandstone	ALLUVIUM	LIGNITE	COASTAL ALLUVIUM	
SKYTEM	1	1	1	1	1	1. First
GTEM	3	3	4	2	4	2.Second/Supportive
ERT	2	2	2	4	3	3.Third
VES	2	2	3	3	2	4.Fourth

In order to achieve greater depth penetration/information over areas of alluvium with clay or salinity, it is preferable to use a multi pulse HeliTEM System with higher moment (>500,000 Am^2) with low pulse rate frequency capable of late time measurements up to 20 milli-seconds or beyond. The order of preference on application of various geophysical tools is made purely based on pilot scale survey results of Lower Vellar Basin (AQTND).

Chapter 5.0 Generation of Aquifer Map

5.0 Generation of Aquifer Map

The aquifer map for the part of Lower Vellar watershed is generated based on the inputs generated from geological, geophysical, hydrogeological, and hydrochemical studies. The aquifer disposition and aquifer characterization has been brought by analysis of 45 lithologs (includes 11 lithologs generated during the pilot project), 22 electrical logs (includes 9 generated in the project) , 56 hydrograph ofdugwells (53 established in project study), 35 piezometric head (15 piezometers established in project), 61 hydrochemical data (46 dugwells and 15 zone wells established in the pilot project), previous literatures and field inputs carried out from December 2011 to March 2014. The aquifer map generation was primarily based on hydrogeological studies as heliborne survey results had its own limitations as described in previous chapter. The approach in this study is to decipher principal aquifer and to delineate the vertical and lateral extent of the aquifer units existing within the principal aquifer (sandstones). The other main objective of the study is to bring out Aquifer management plan.

The sandstone is the principal aquifer system upto 400 m below ground level (discussed elaborately in chapter 3). The principal aquifer system constitutes sandstones of mio-pliocene named as Cuddalore aquifer and sandstones of Eocene age named as NeyveliAquifer. Four aquifer units (I, II, III and IV) have been deciphered within the principal aquifer system (sandstones). Aquifer I and II occurs within the Cuddalore sandstones (younger) and Aquifer III and IV occurs within the Neyveli sandstones (older). The thickness of each aquifer units, their lateral extent and their characteristics are described in the following paras. The 2-D and 3 –D aquifer disposition of the lower velar water shed is given as figures 5.1 to 5.13 and 5.14 respectively and the thematic maps are given as figures 5.15 to 5.36

5.1.0 Aquifer Disposition:

Aquifer Unit – I

The top most aquifer is the Aquifer Unit – I and is composed of sandstones (referred as Cuddalore sandstone), alluvium andLaterite formations.The sandstones of Aquifer unit –I are of mio-pliocene age and are friable and ferruginous in nature. Laterite occurs as capping over the Cuddalore sandstones and mainly occurs in the central and northern portion. The alluvium formation lie over the Cuddalore sandstones towards the eastern portion and its thickness increases towards the coast. The thickness of the alluvium ranges from 1 m to 80 m. At many places clay occurs as intercalations within the alluvium. The thickness of the Aquifer Unit – I varies from 30 to 110 m. The aquifer thickness in less in the western portion and gradually increased towards the coast. The strike directions of sandstones are NE-SW and dips towards SE. Clay occurs as intercalations within the sandstones at some locations. Clay stones occur as localized pockets at south of PerumalEri.

Clay thickness of more than 20 to 40 m thick occurs in Arasadikuppam, Silambinathanpettai, Kattiyankuppam villages from 40 to 78 m bgl. At Arasadikuppam these clay forms the perched aquifer zone. During exploratory drilling at Arasadikuppamvillage mud loss occurred from 85 to 105 m bgl. The Lateritic gravel occurs at these depths posed difficulties in drilling. Perched aquifer also exist at Siruthondamadevi village. The perched aquifer zone isapproximately around20 to 35 sq.km in areal extent and occurs from 40 to 78 m bgl. Shallow perched aquifer occur in and around Vadalur village also.

Aquifer Unit – II:

The aquifer unit – II lies below the Aquifer unit – I and the aquifer is composed of Cuddalore sandstones only. The sandstones of Aquifer – II are Miopliocene in age are also ferruginous in nature like that of sandstones of Aquifer unit - I. The impermeable layers (Clay) separate aquifer I and II and are discontinuous at many places. Clay occurs as intercalations within the sandstones at some locations..The top of the aquifer – II lies at

35 to 110 m bgl. The thickness of the Aquifer Unit – II varies from 40 to 55 m. The thickness is less in the western portion and gradually increases towards east. The strike direction of the sandstones is NE-SW and dips towards SE.

Aquifer Unit –III:

The aquifer unit – III underlies the Aquifer –II and is composed of sandstones of Eocene age. Lignite (Brown Coal) occurs on top of the sandstones and is considered as marker bed. However, Lignite seamsdooccur within the Eocene sandstones at few places. Clay occurs as intercalations within the sandstones as well within the lignite deposits. The top of the Aquifer unit – III lies at 90 to 160 m bgl. The thickness of the Aquifer Unit – III varies from 55 to 100 m. The thickness is less in the western portion and gradually increases towards east or south-east. The strike directions of the sandstones are NE-SW and dips towards SE.

The impermeable clay layers separating the different aquifer units in aquifer – III are continuous or in many places discontinuous in nature. Exploratory drilling was carried out in Reddipalayam village confirmed absence of clay that seperates different aquifer units.

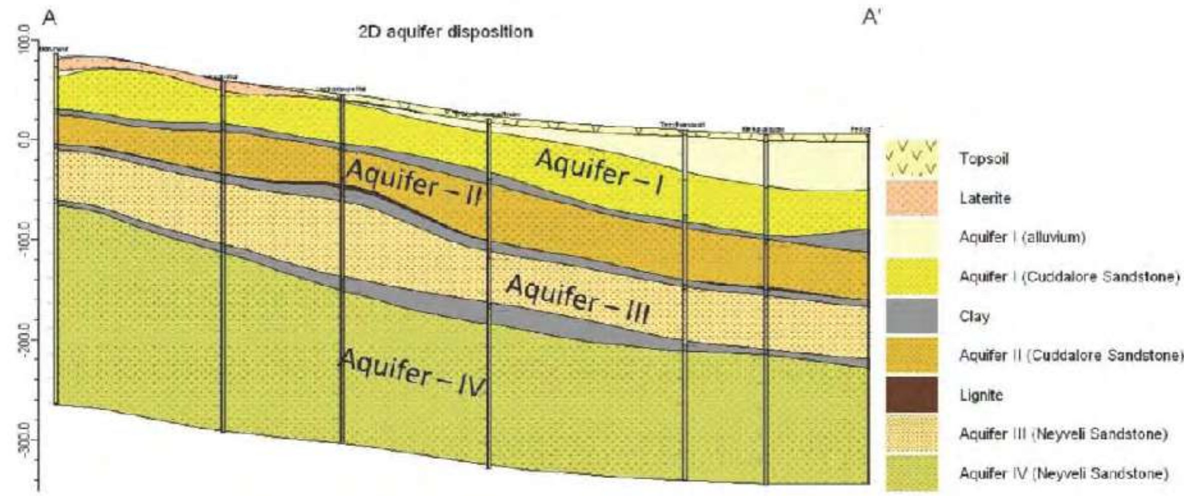
Aquifer Unit – IV:

The aquifer unit – IV lies below the Aquifer – III and is almost similar to aquifer – III in its composition. This aquifer is composed of Eocene sandstones. The clay or sandy clay occurs between the aquifer III and IV. However, these clays are discontinuous at many places. Within this aquifer, at few locations, thick clay exists ranging from 20 to as high as 80 m in thickness. The top of the Aquifer – IV lies at 150 to 280 m bgl. The thickness is minimum in the western portion and gradually increases towards east/southeast. The strike directions of the sandstones are NE-SW and dips towards SE. The aquifer unit –IV is thicker than the other aquifer units and extends beyond 400 meters bgl.

Thick sticky clay occurs from 255 to 290 m bgl at Silambinathanpettai village (Drilling at Silambinathanpettai was difficult and time consuming). At Kattiyankuppam and nearby *surrounding villages the aquifer is less potential between 240 to 280 m due to the presence of clay dominated sand.*

The 2D aquifer disposition along the east – west and north – south direction is given as figure .5.1

Figure: 5.1 2D Aquifer Disposition along East-West (A-A') and North-South (B-B')



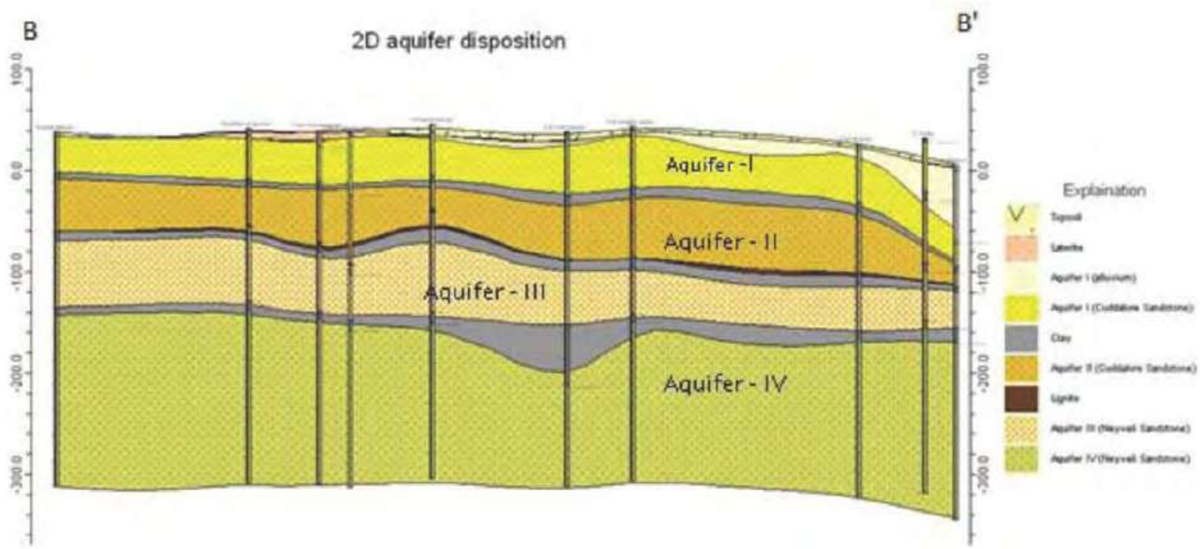


Figure: 5.2 2D Aquifer Disposition along Silambinathanpettai to Srinivasanallur

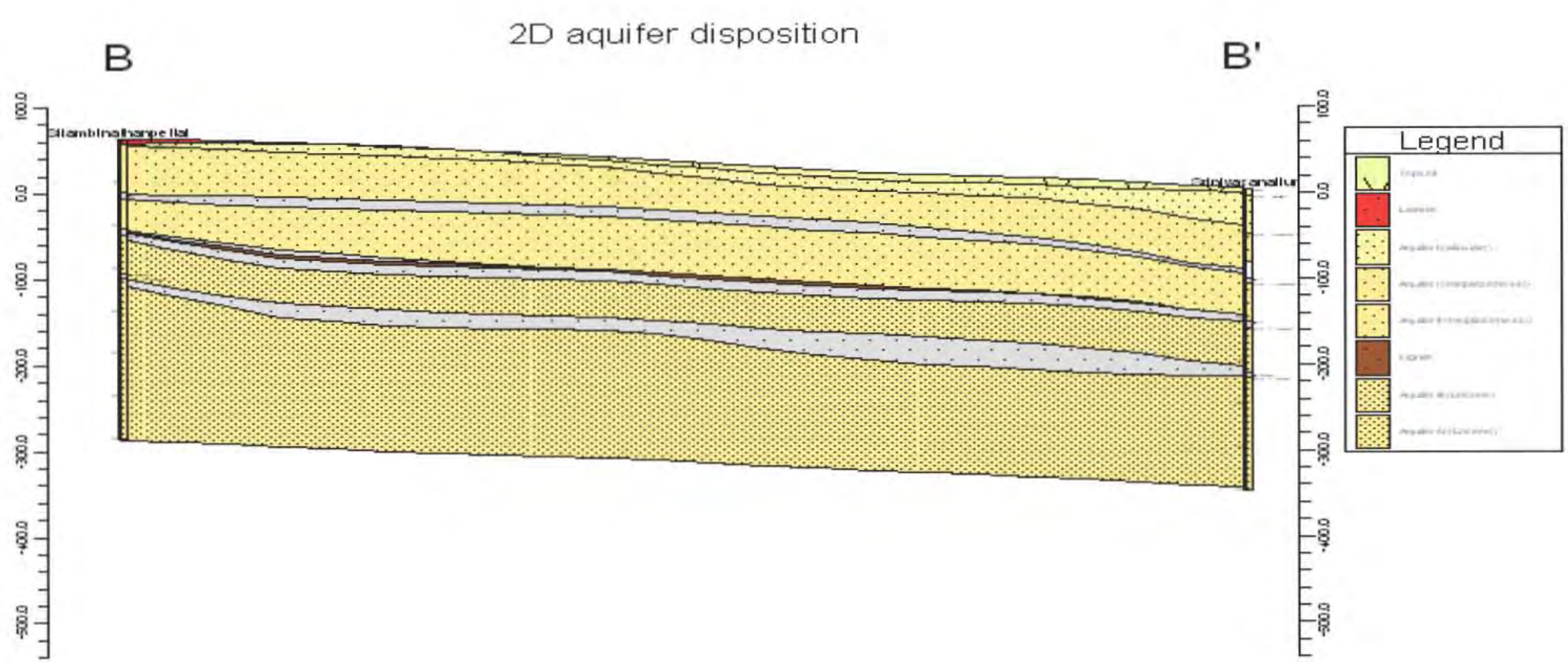


Figure: 5.5 2D Aquifer Disposition Along Marungur to Puvanikuppam

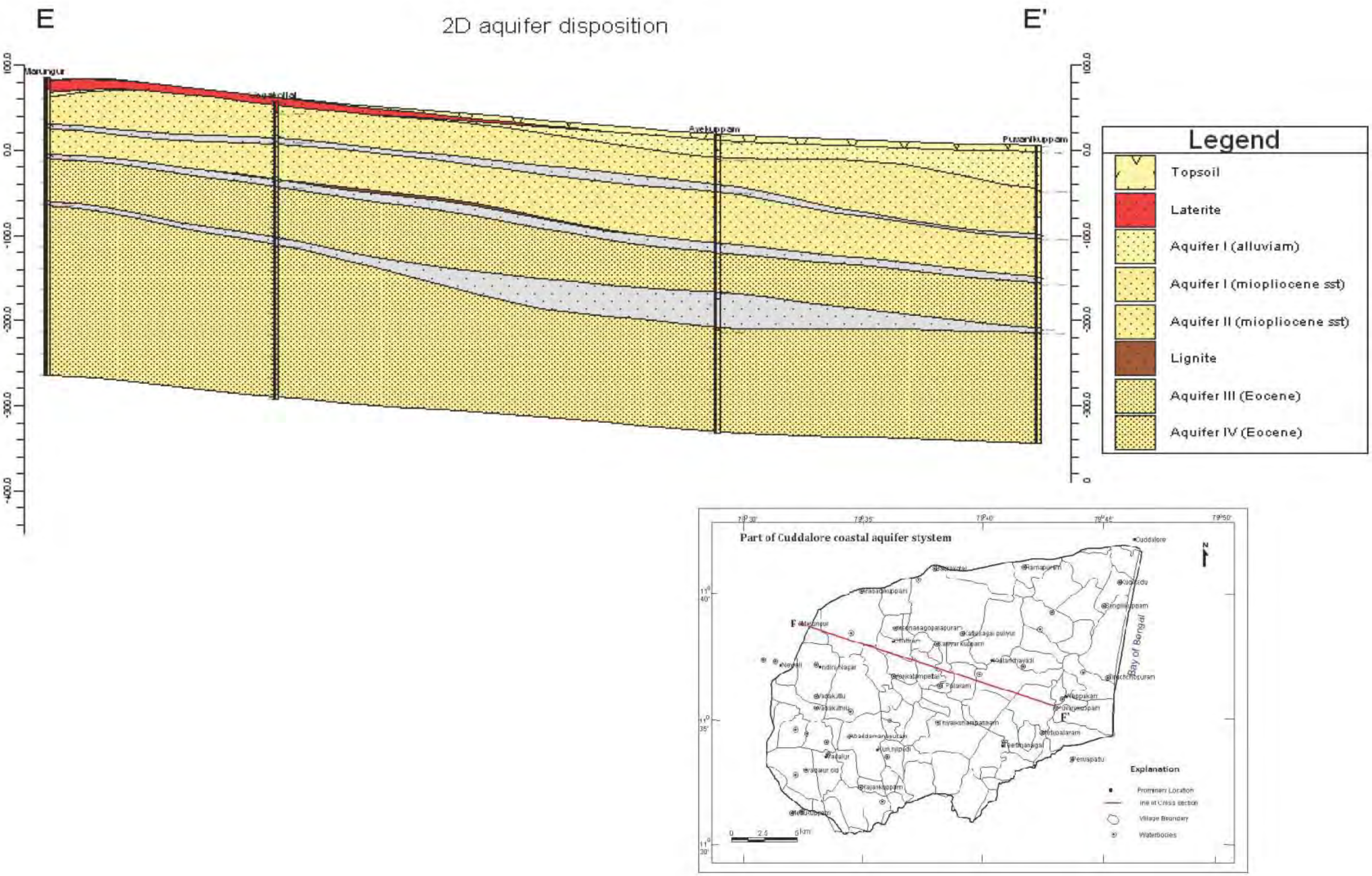
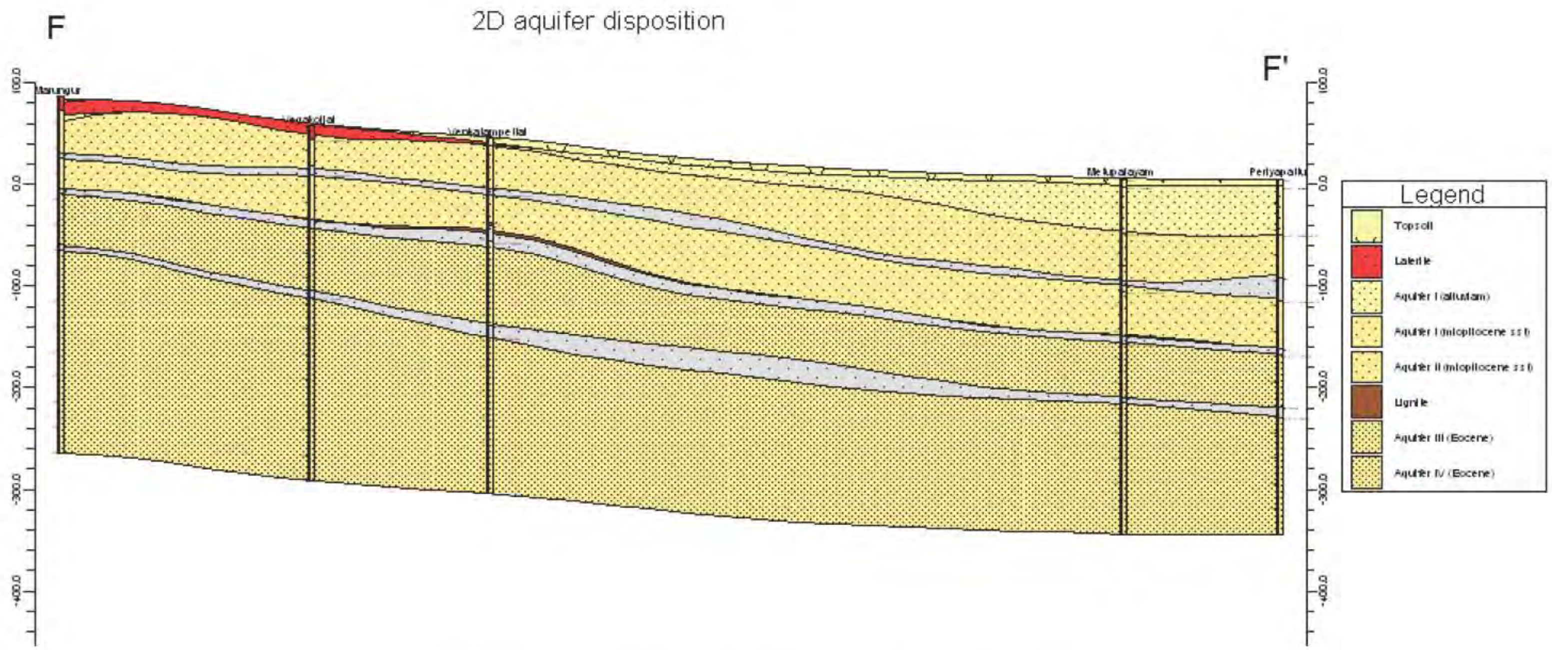


Figure: 5.6 2D Aquifer Disposition along Marungur to Periyapattu



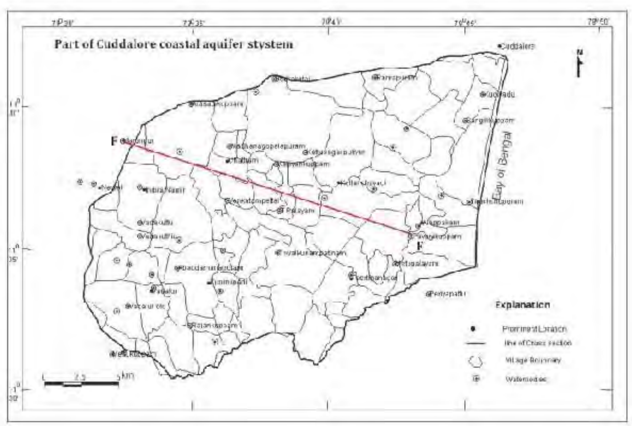


Figure: 5.7 2D Aquifer Disposition Along Vanathirayapuram to Kurunjipaddi

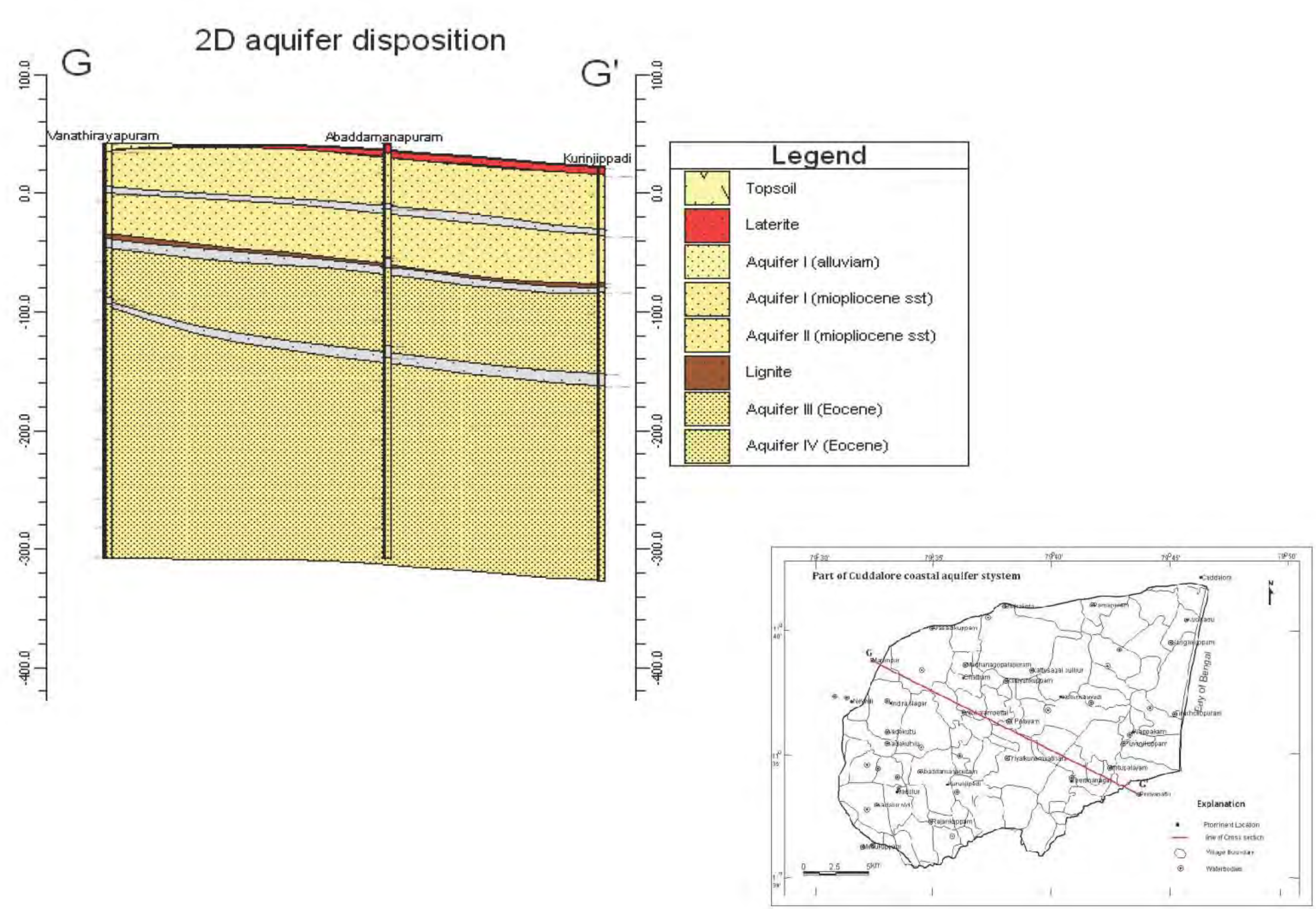


Figure: 5.8 2D Aquifer Disposition along Marungur to S.Pudur

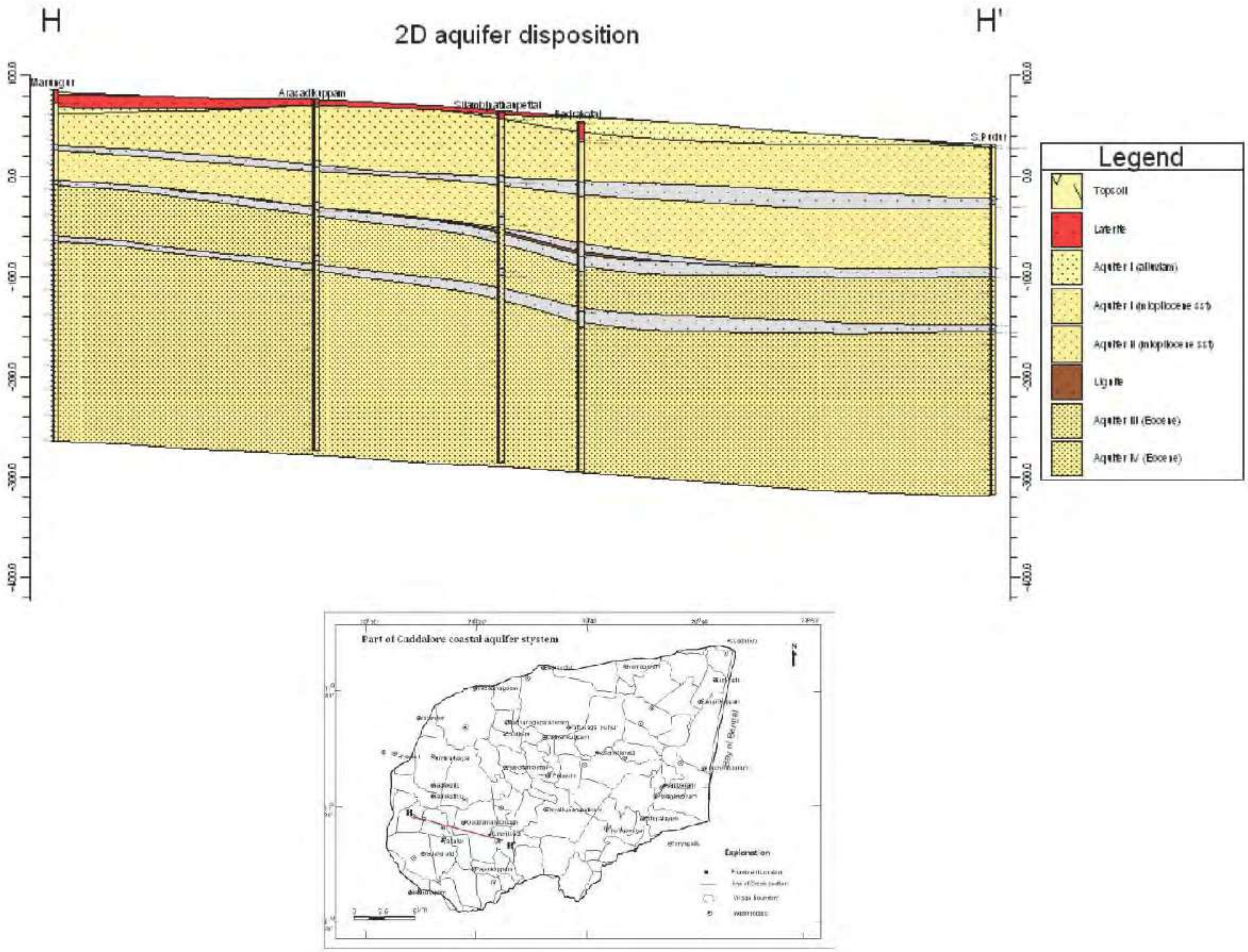


Figure: 5.9 2D Aquifer Disposition Along Vanathirayapuram to S.Pudur

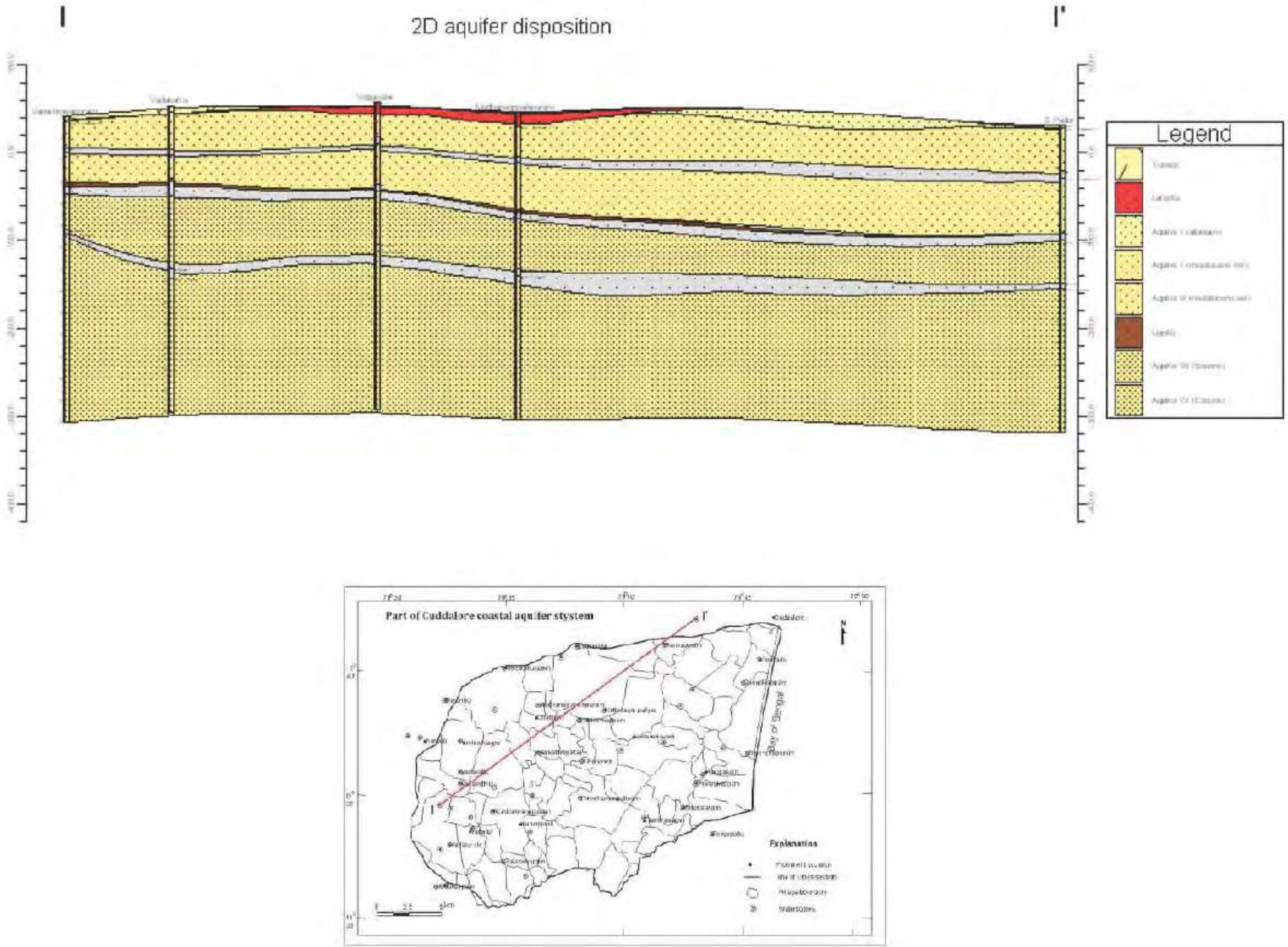


Figure: 5.12 2D Aquifer Disposition Along Rajankuppam to Sangolikuppam

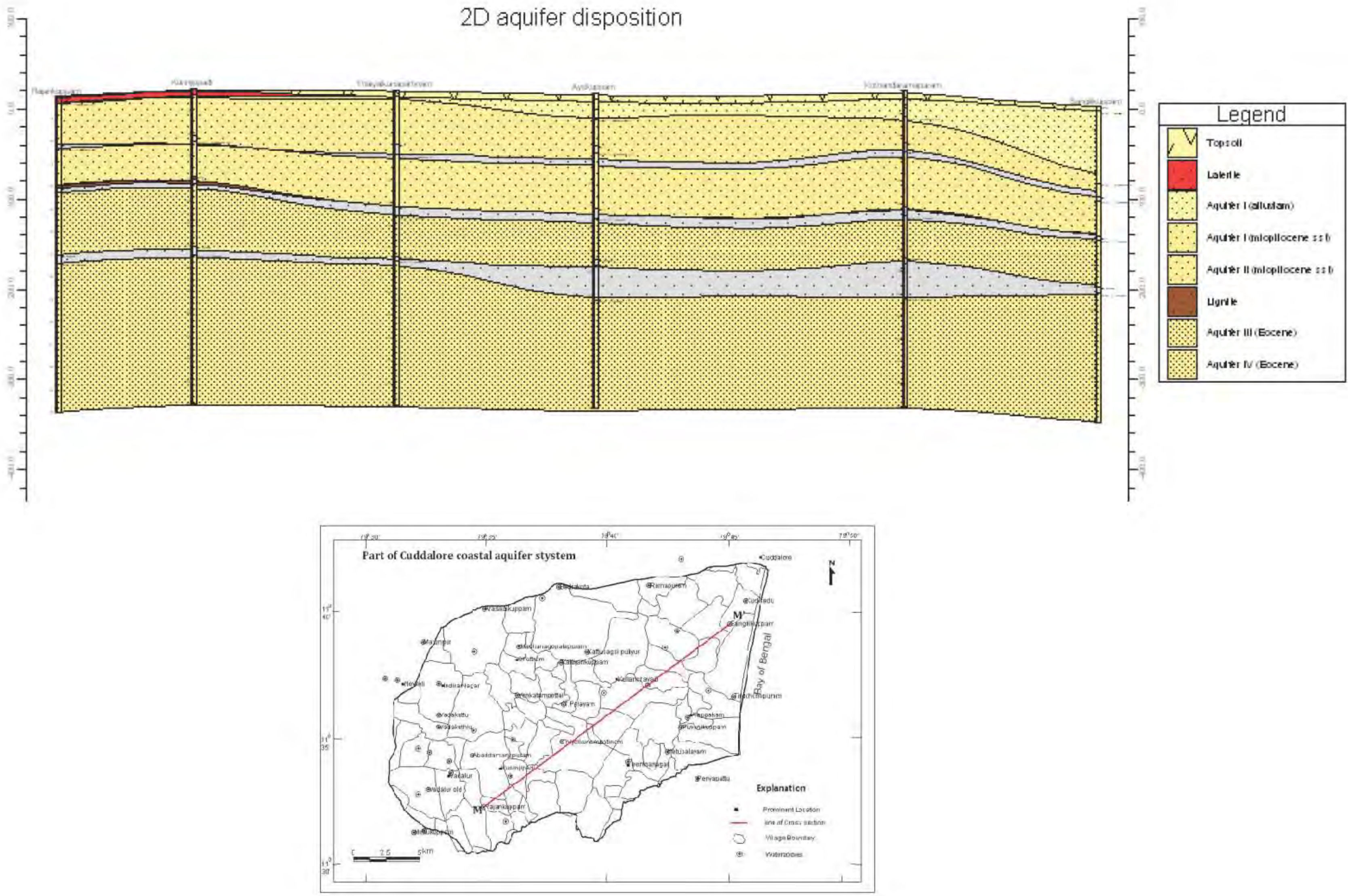


Figure: 5.14 3-D view of Aquifer Disposition

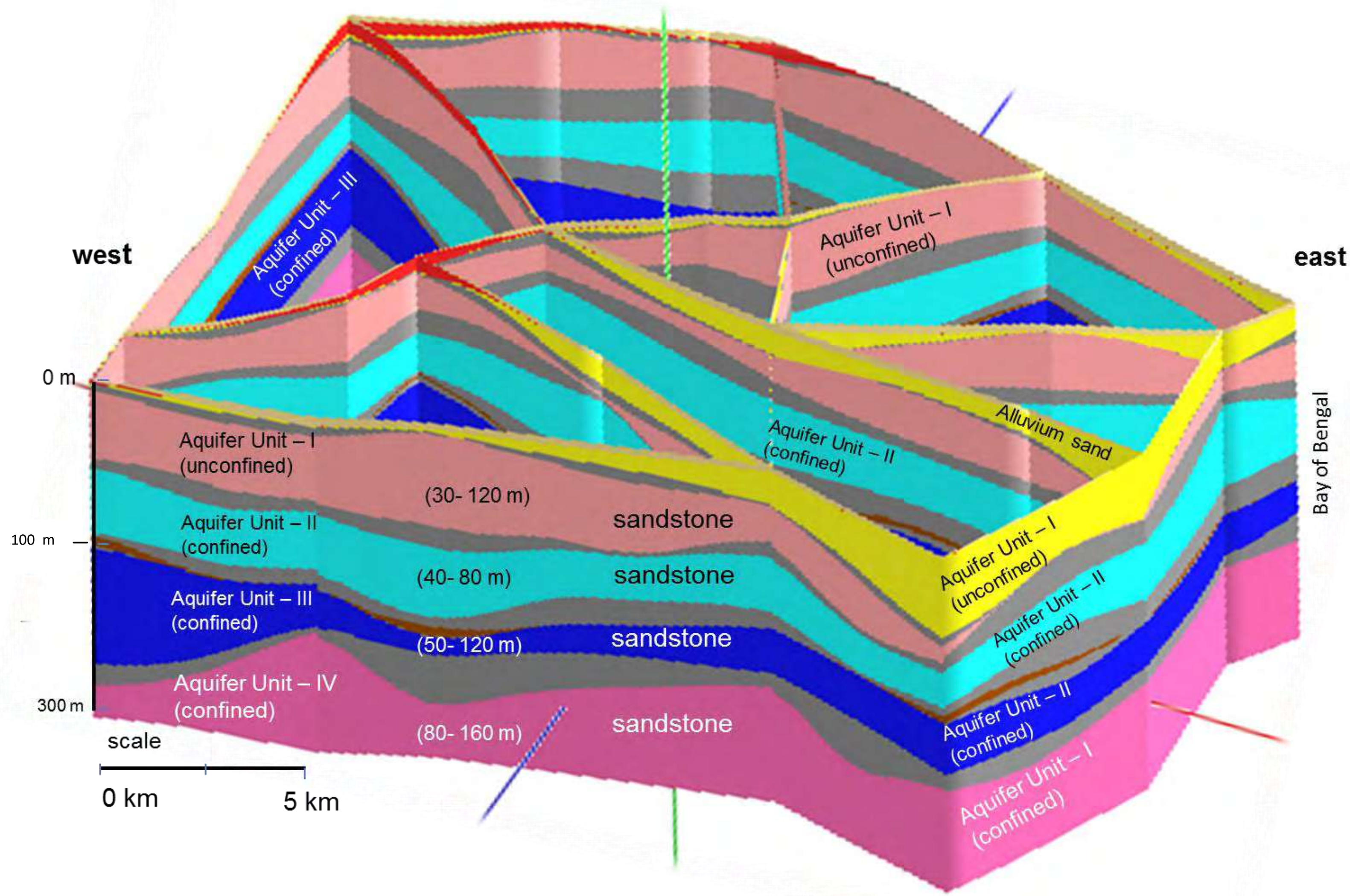


Figure: 5.15 Isopach Map-Aquifer-I

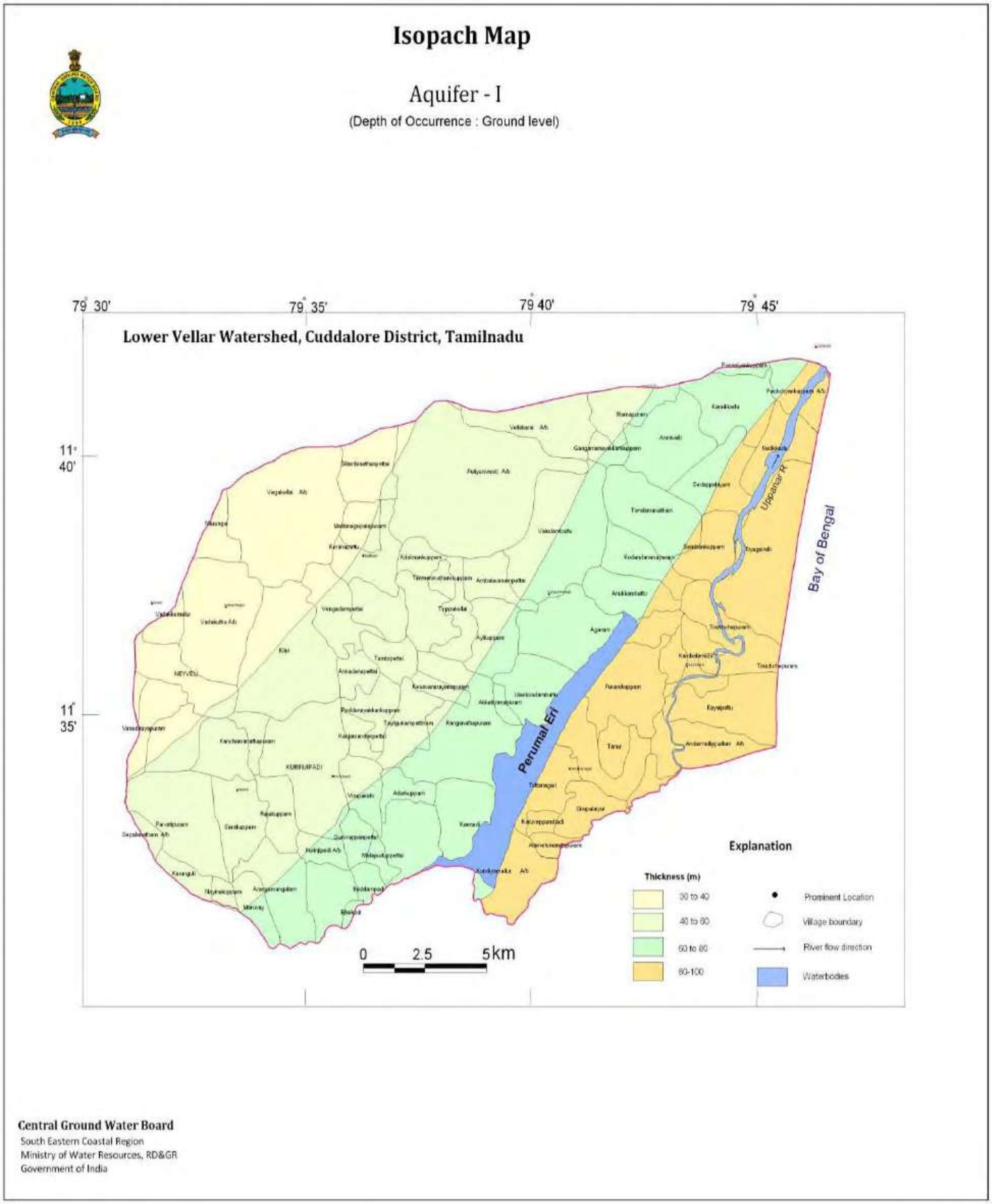


Figure: 5.16 Isopach Map-Aquifer-II

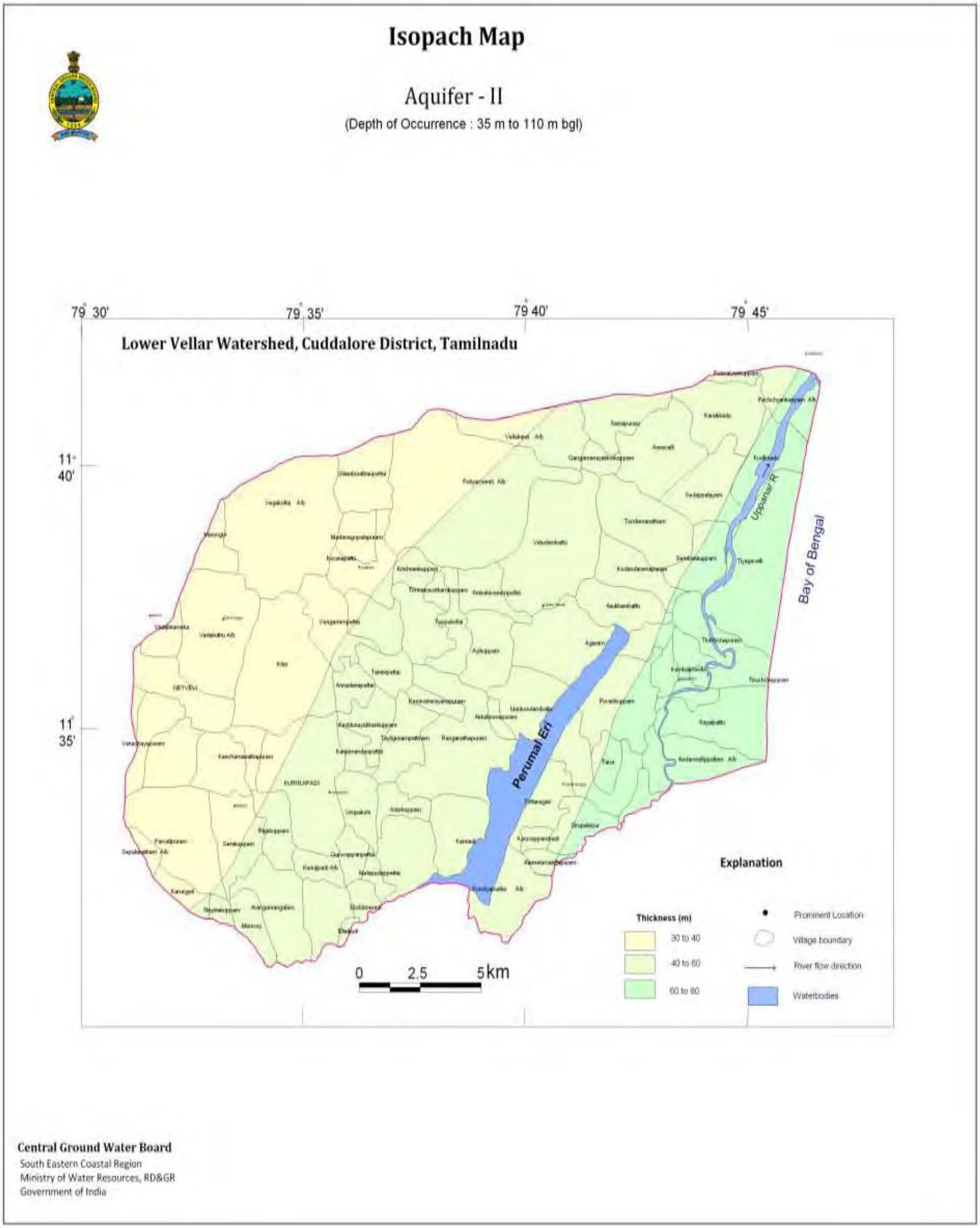


Figure: 5.17 Isopach Map-Aquifer-III

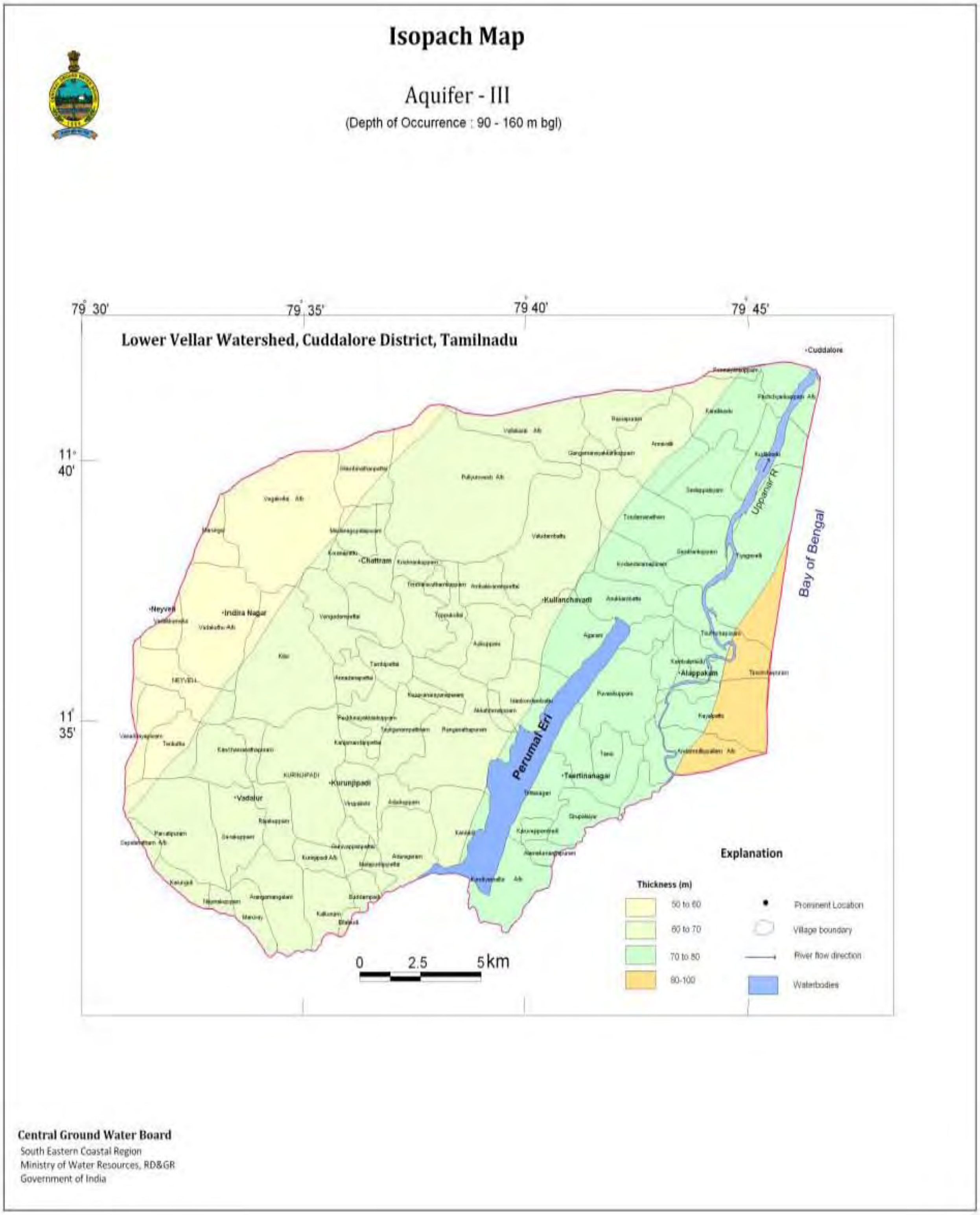


Figure: 5.18 Isopach Map-Aquifer-IV

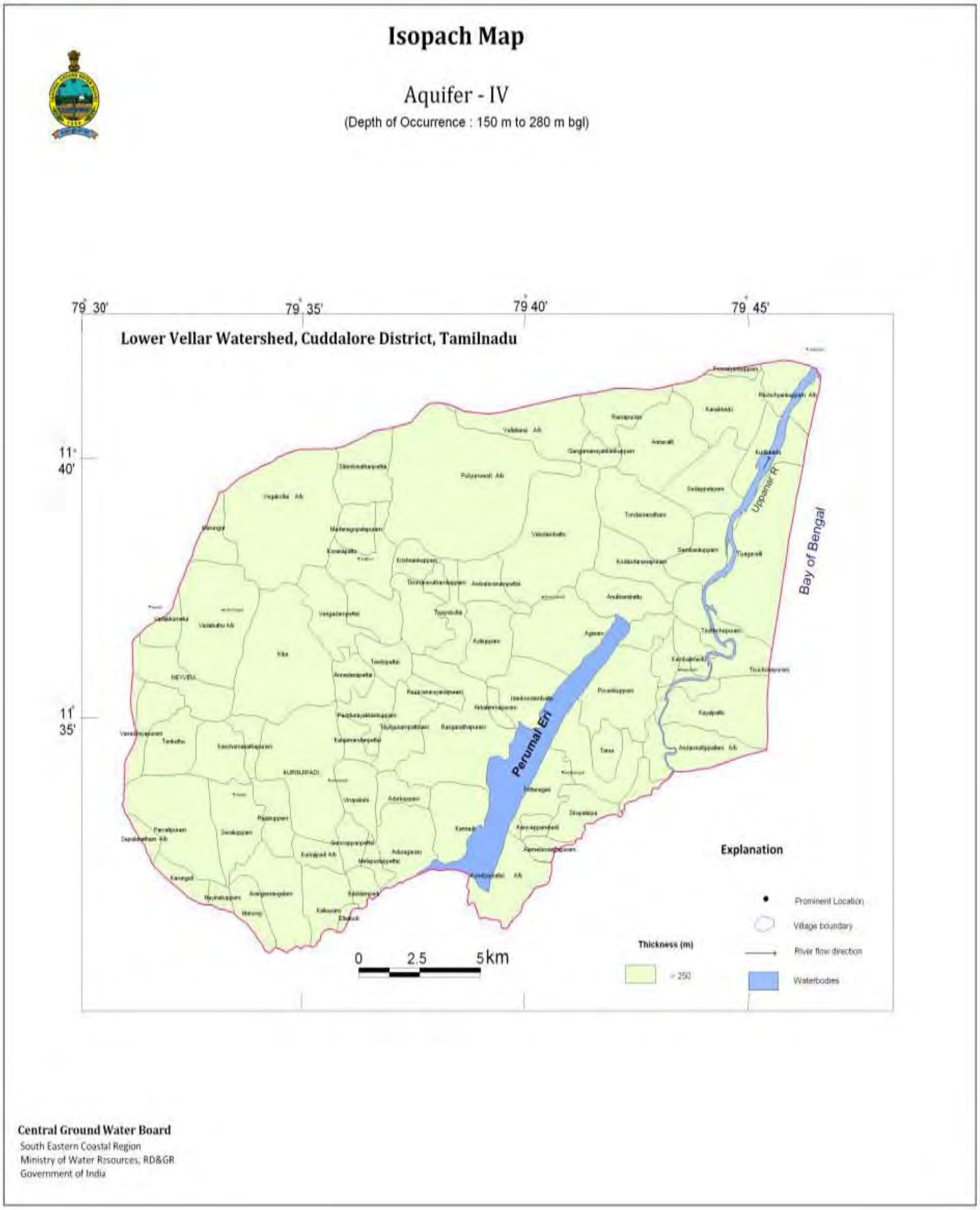


Figure: 5.19 Aquifer Vulnerability Map-Aquifer- unit I&II

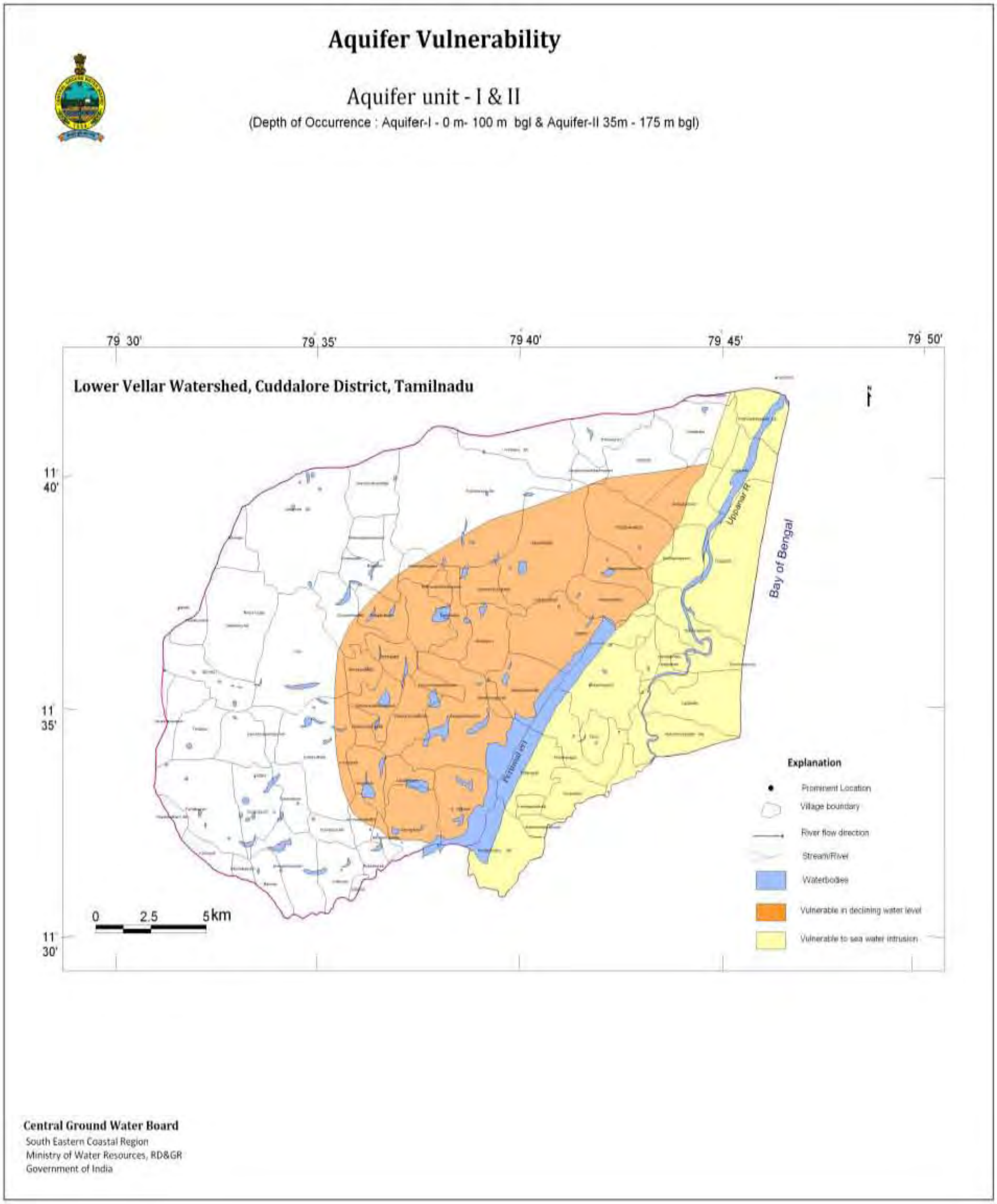


Figure: 5.20 Depth to Water level Map-Premonsoon-Aquifer-I

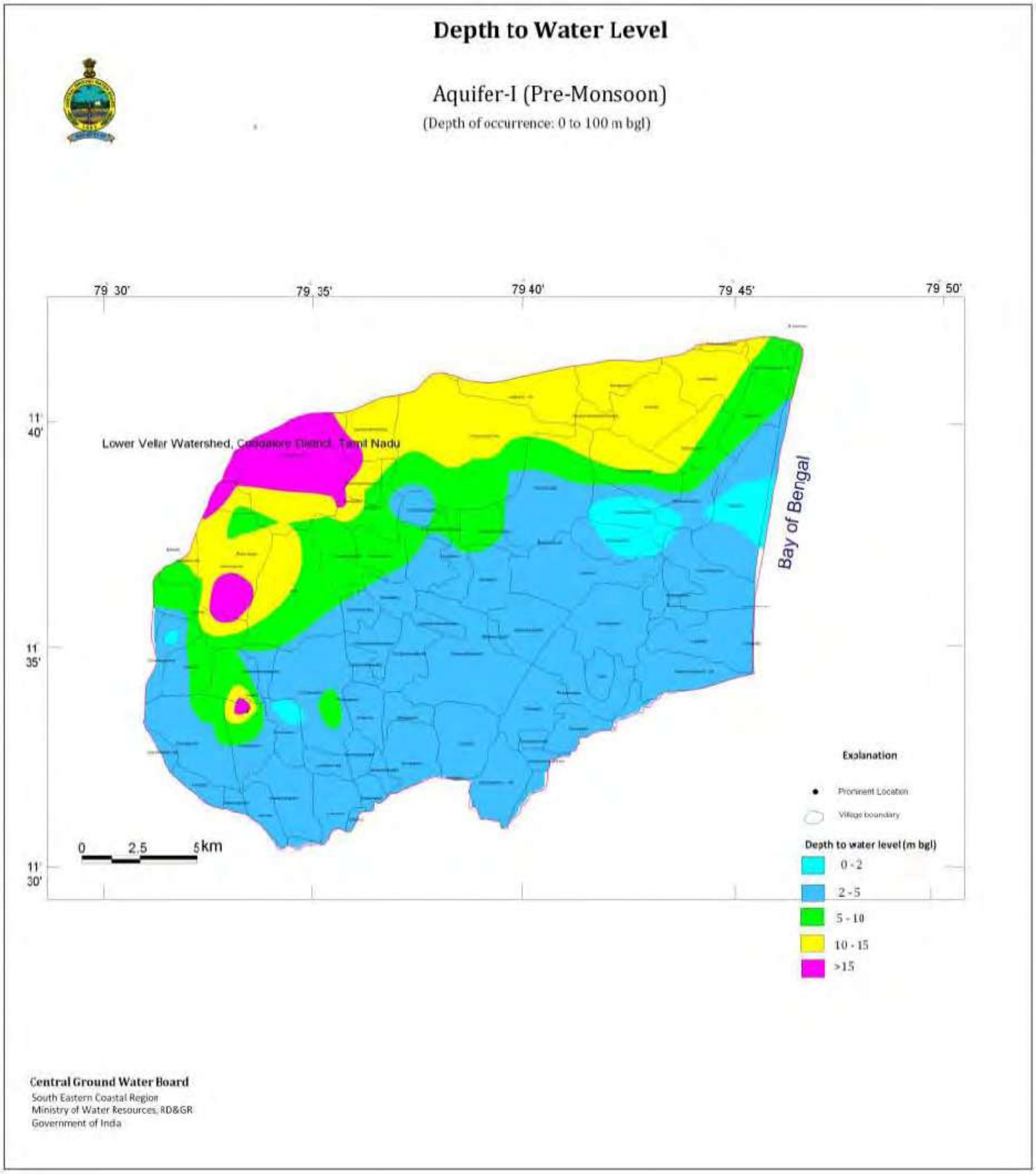


Figure: 5.21 Depth to Water level Map-Postmonsoon- Aquifer-I

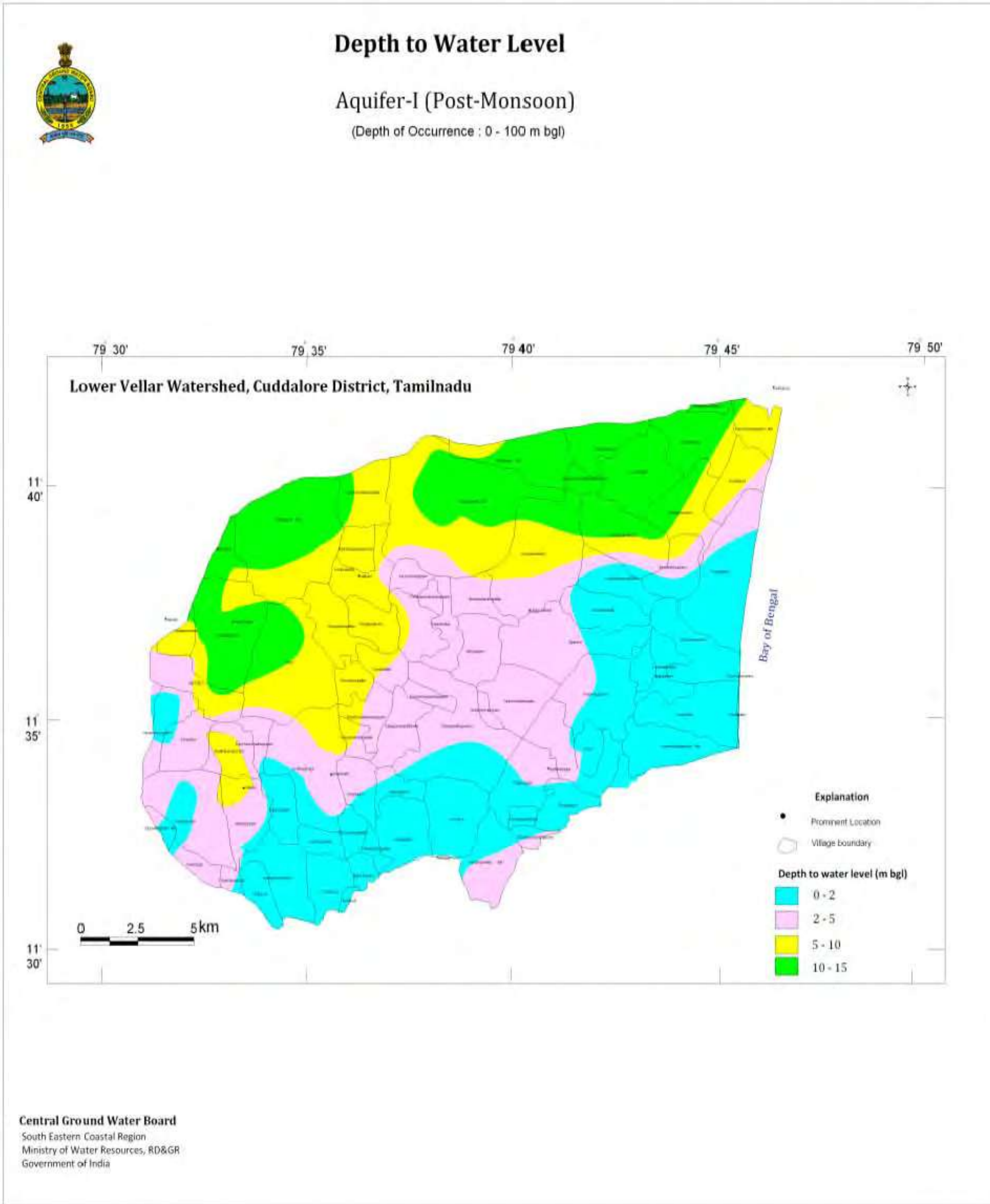


Figure: 5.22 Depth to Water table Elevation-Pre monsoon - Aquifer-I

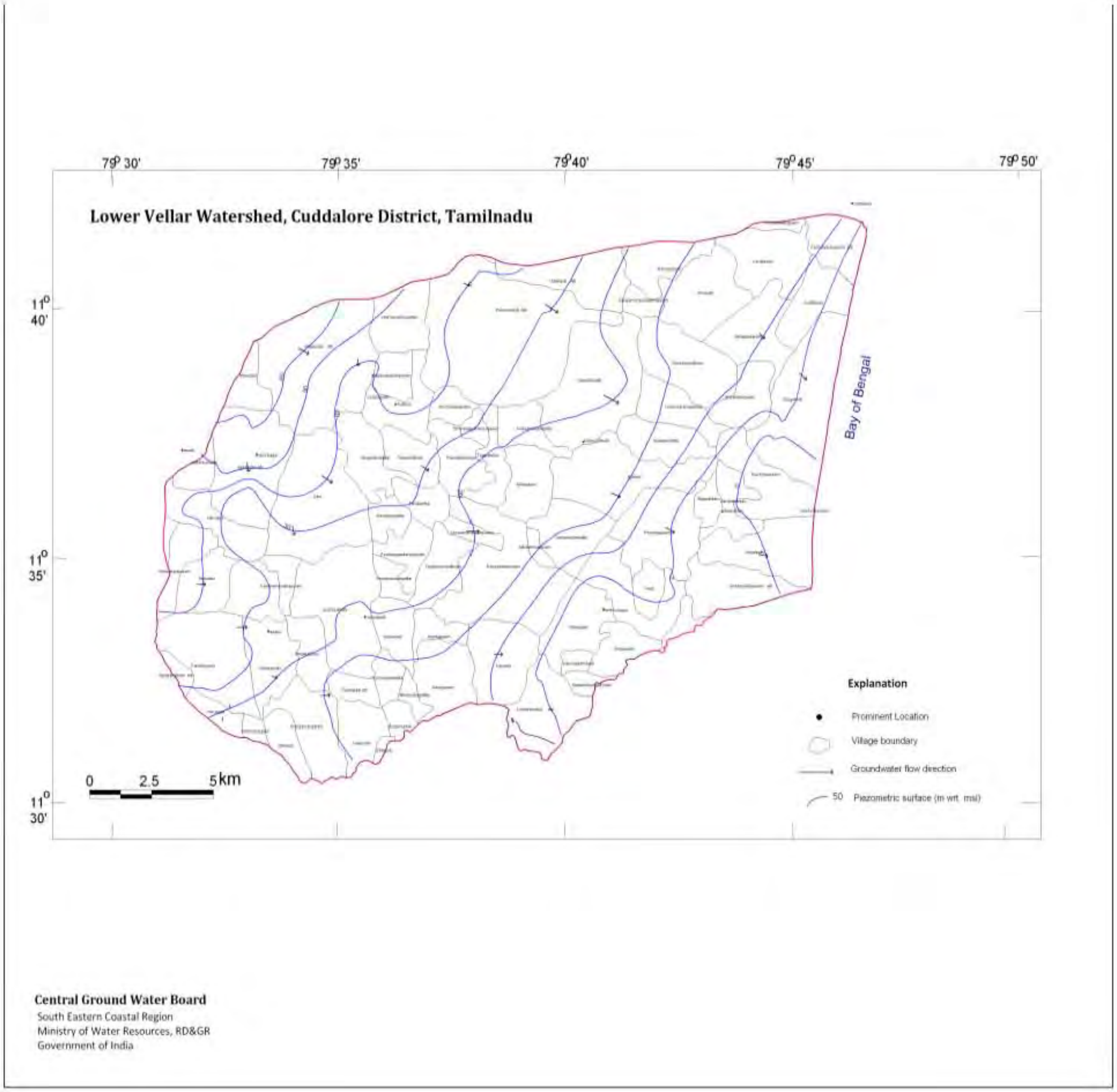


Figure: 5.23 Depth to Water level Elevation – Post monsoon-Aquifer-I

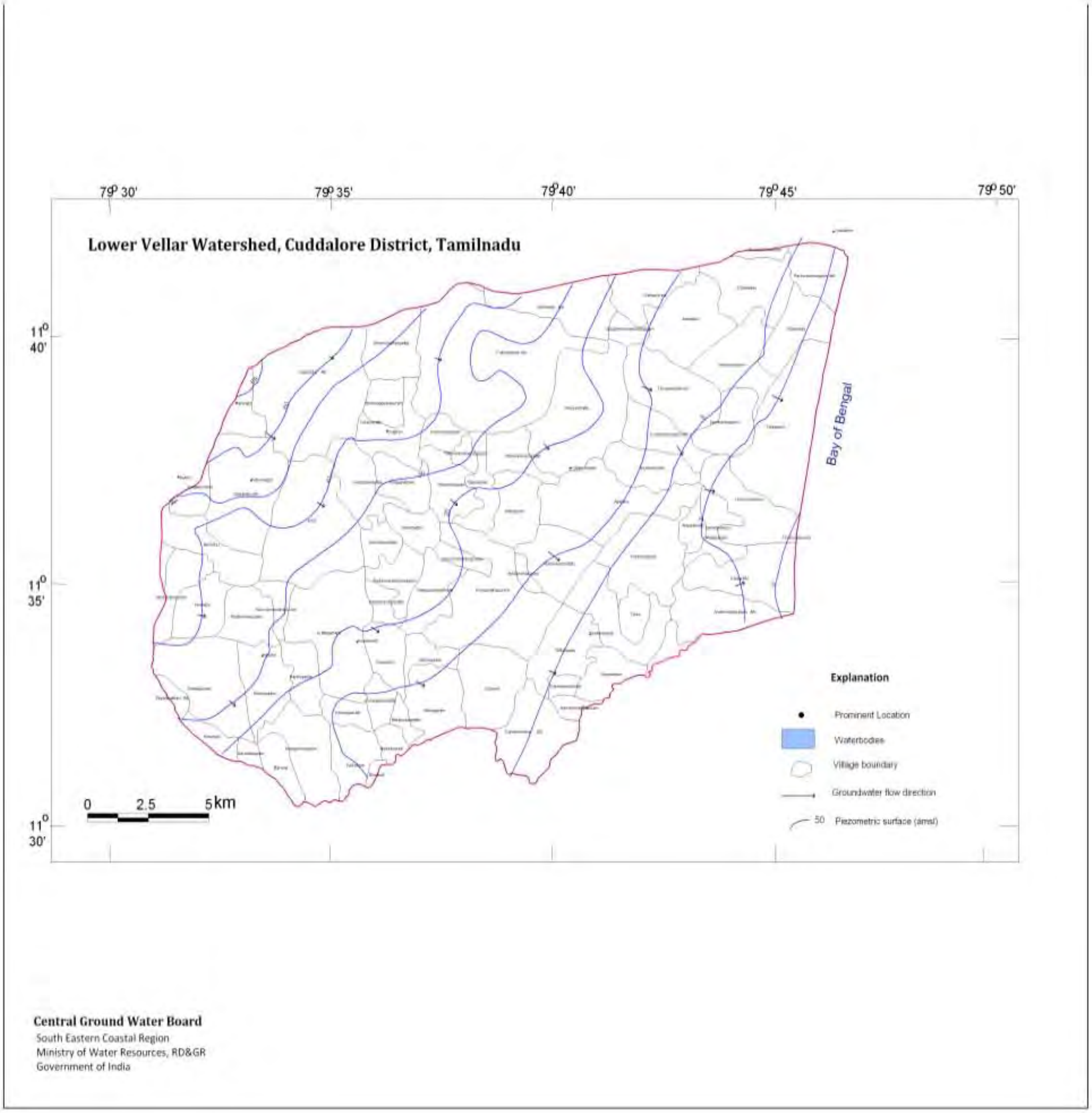


Figure: 5.24 Piezometric surface-Pre monsoon- Aquifer-II

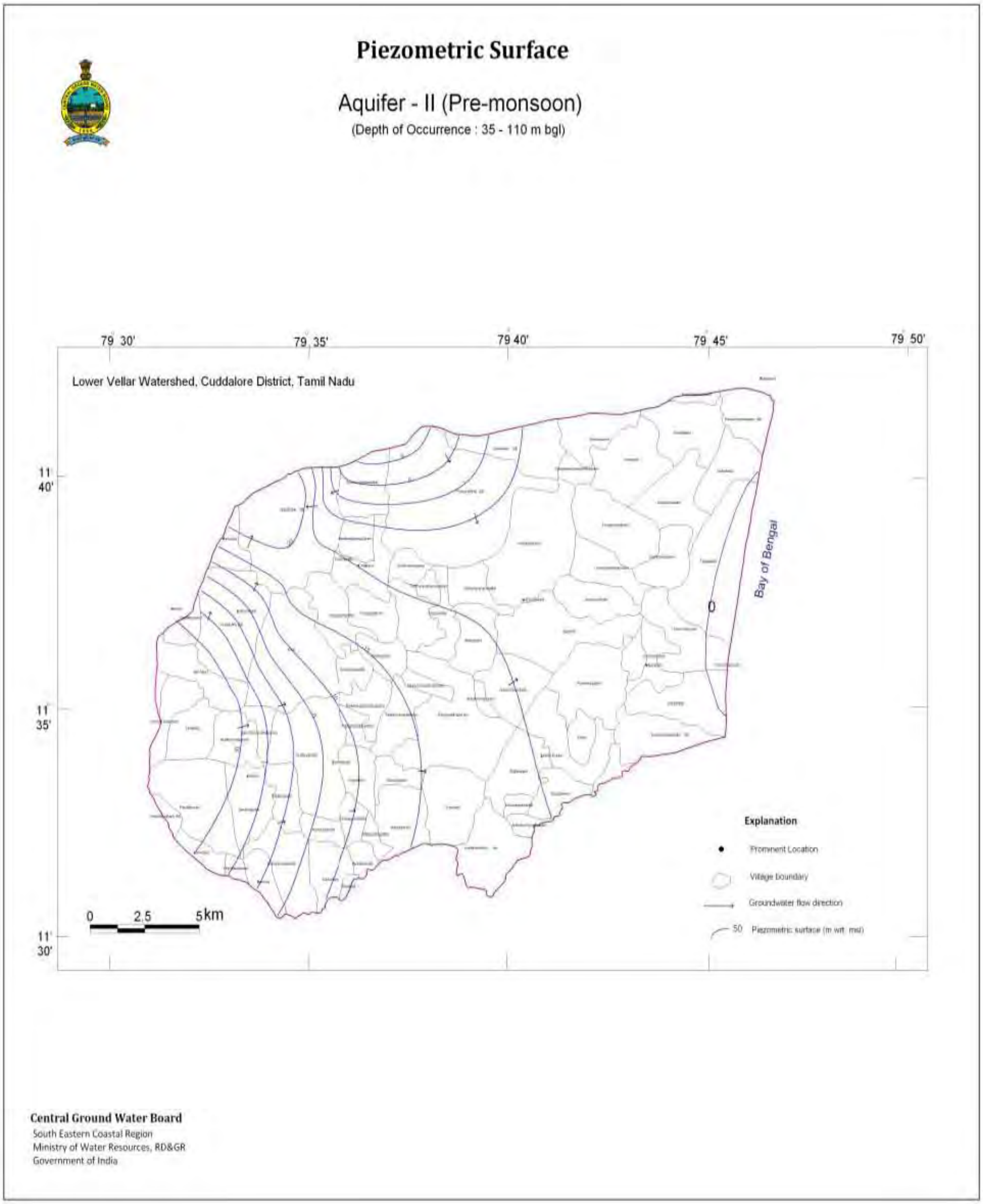


Figure: 5.25 Piezometric surface-Postmonsoon- Aquifer-II

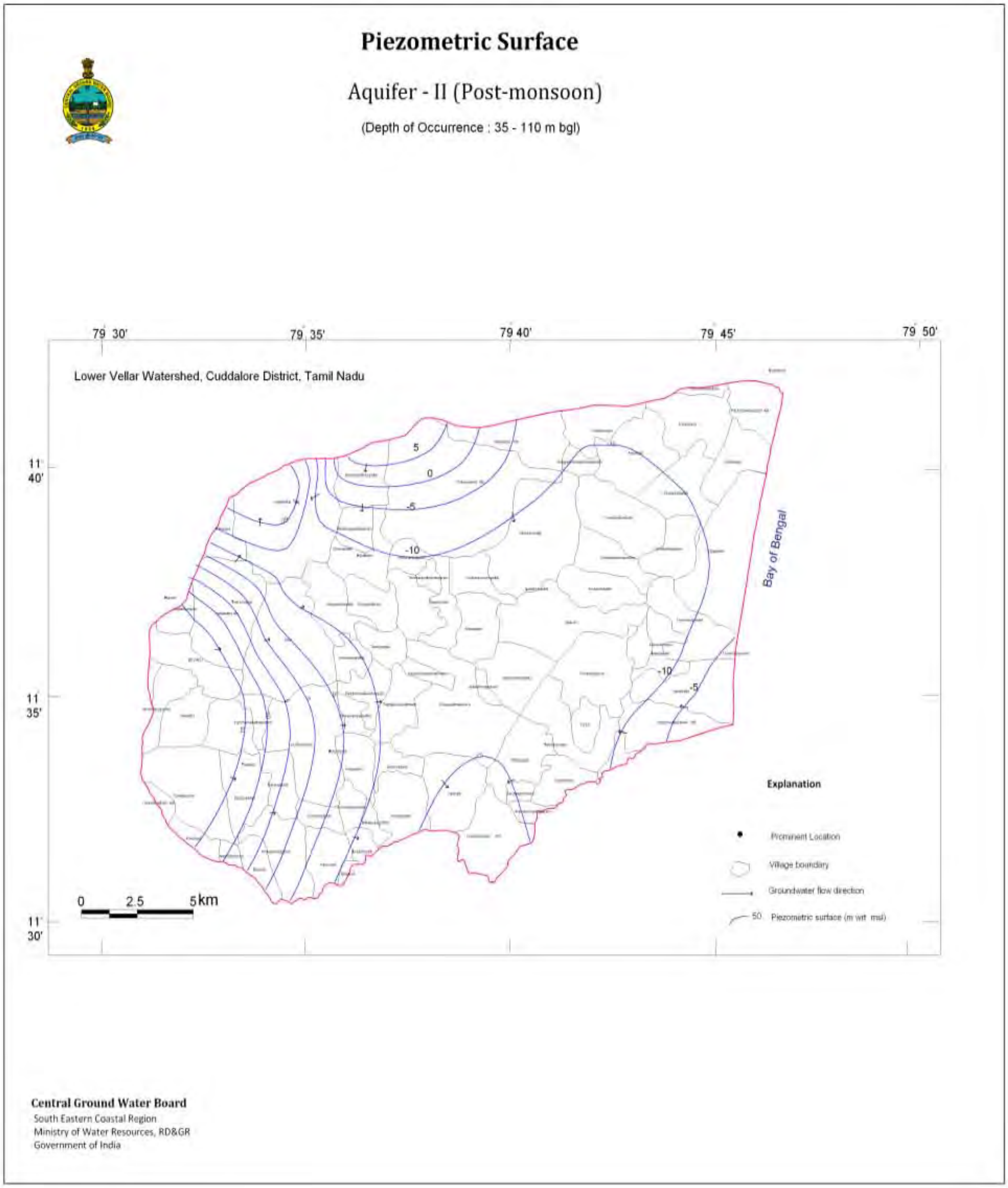


Figure: 5.26 Piezometric surface-Pre monsoon- Aquifer-III

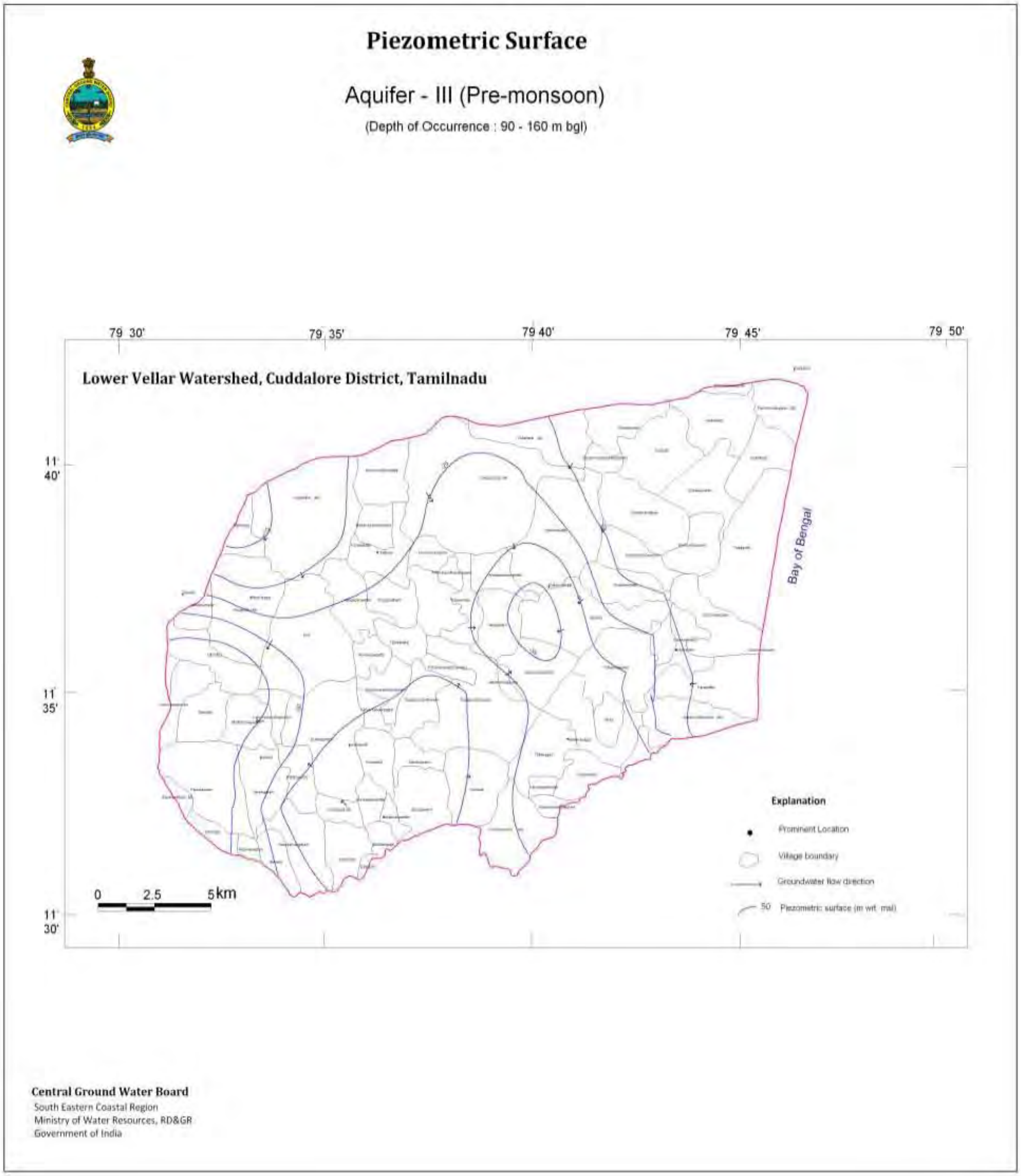


Figure: 5.27 Piezometric surface-Post monsoon- Aquifer-III

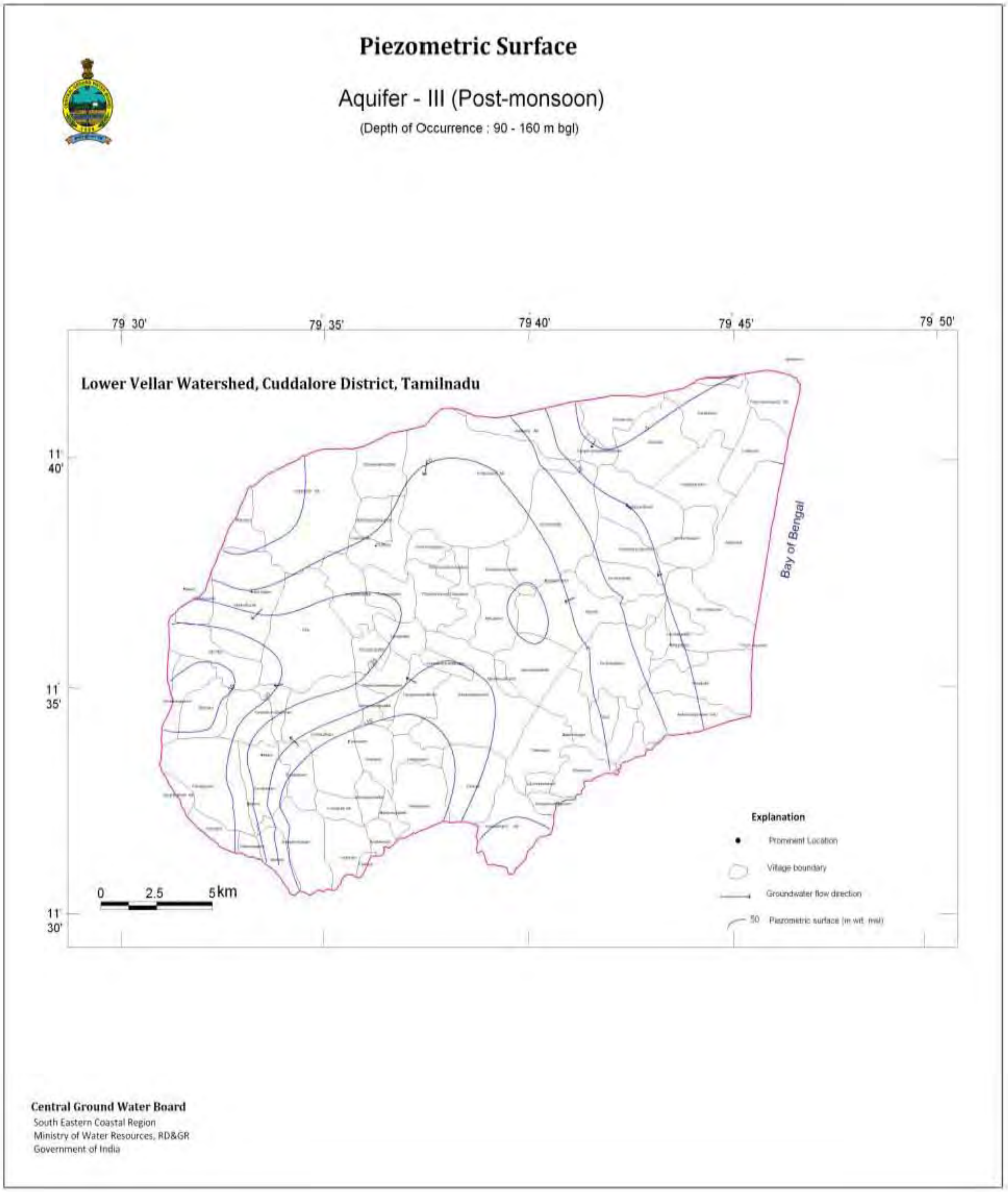


Figure: 5.28 Piezometric Surface-Pre-monsoon-Aquifer-IV

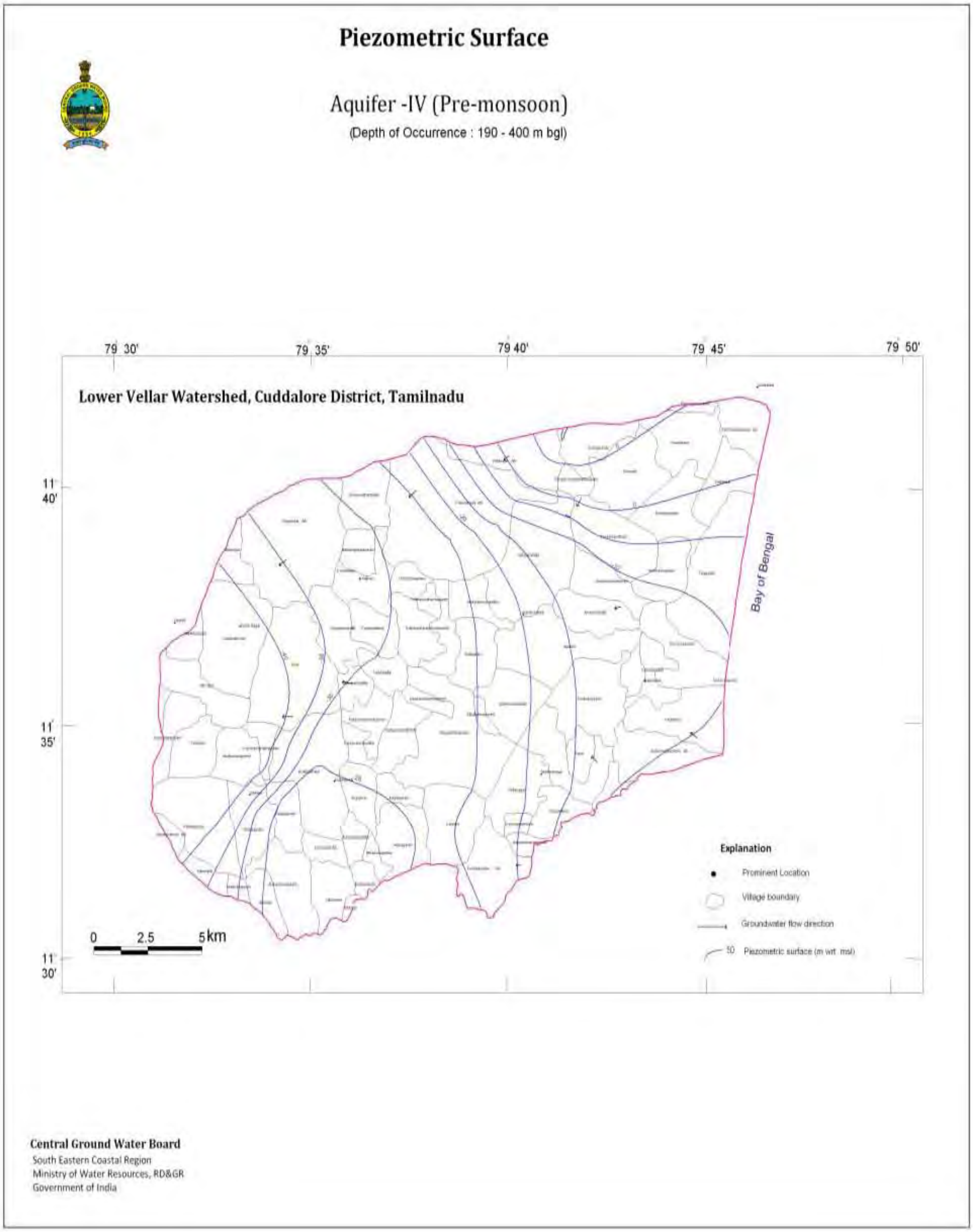


Figure: 5.29 Piezometric Surface-Post monsoon-Aquifer-IV

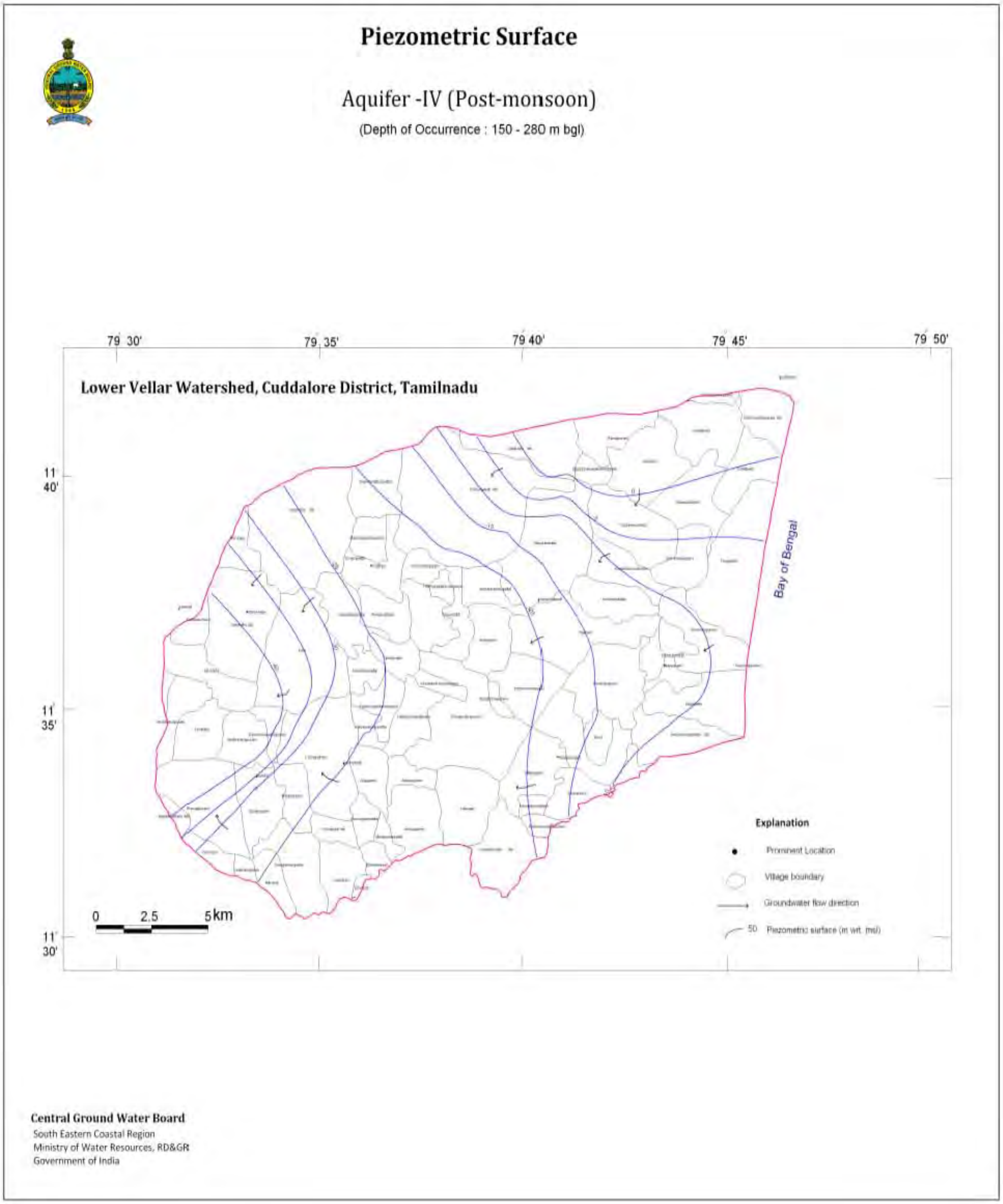


Figure: 5.30 Groundwater suitability map –Drinking and Domestic

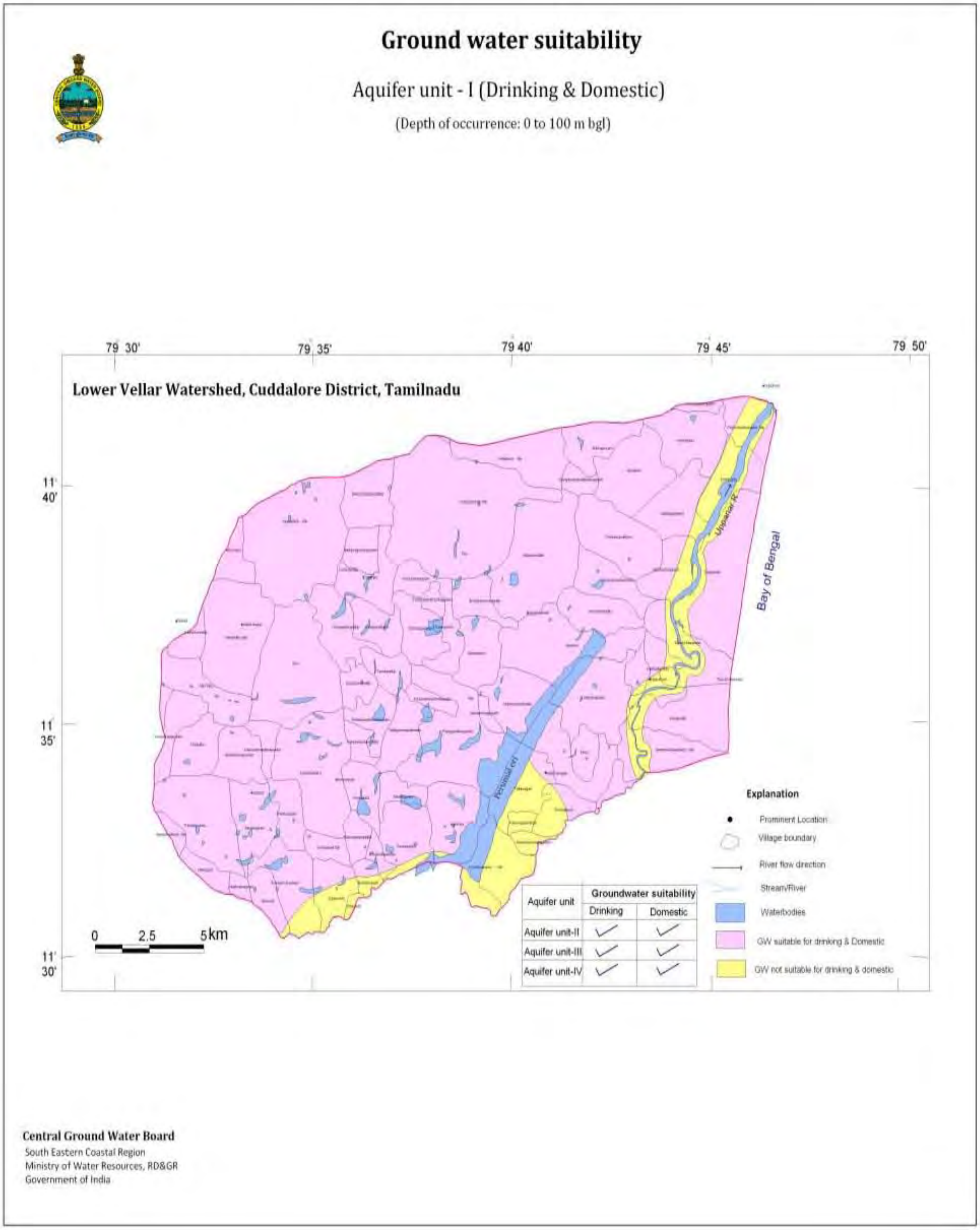


Figure: 5.31 Groundwater suitability map –Irrigation

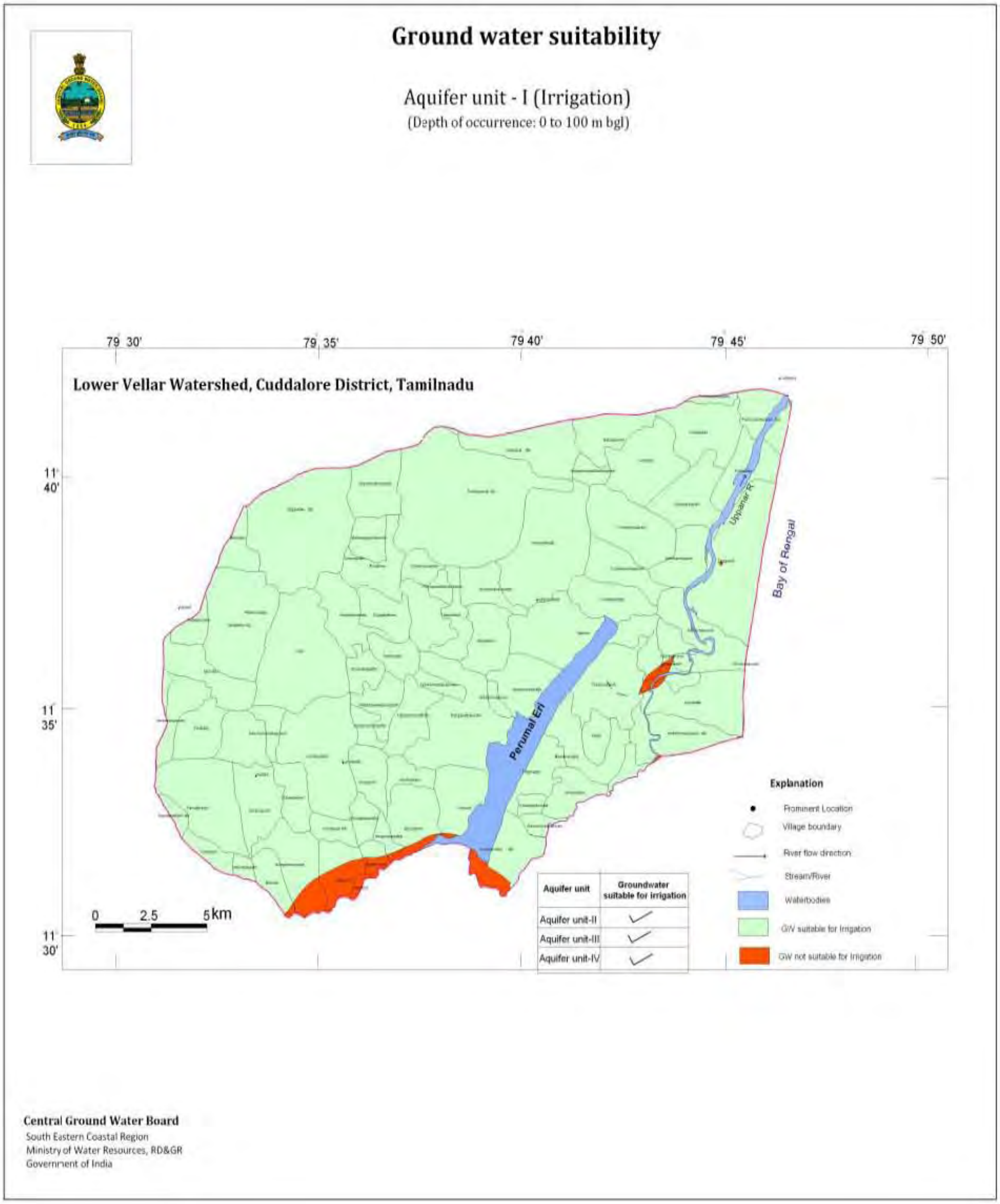


Figure: 5.32 Specific yield/Storativity map

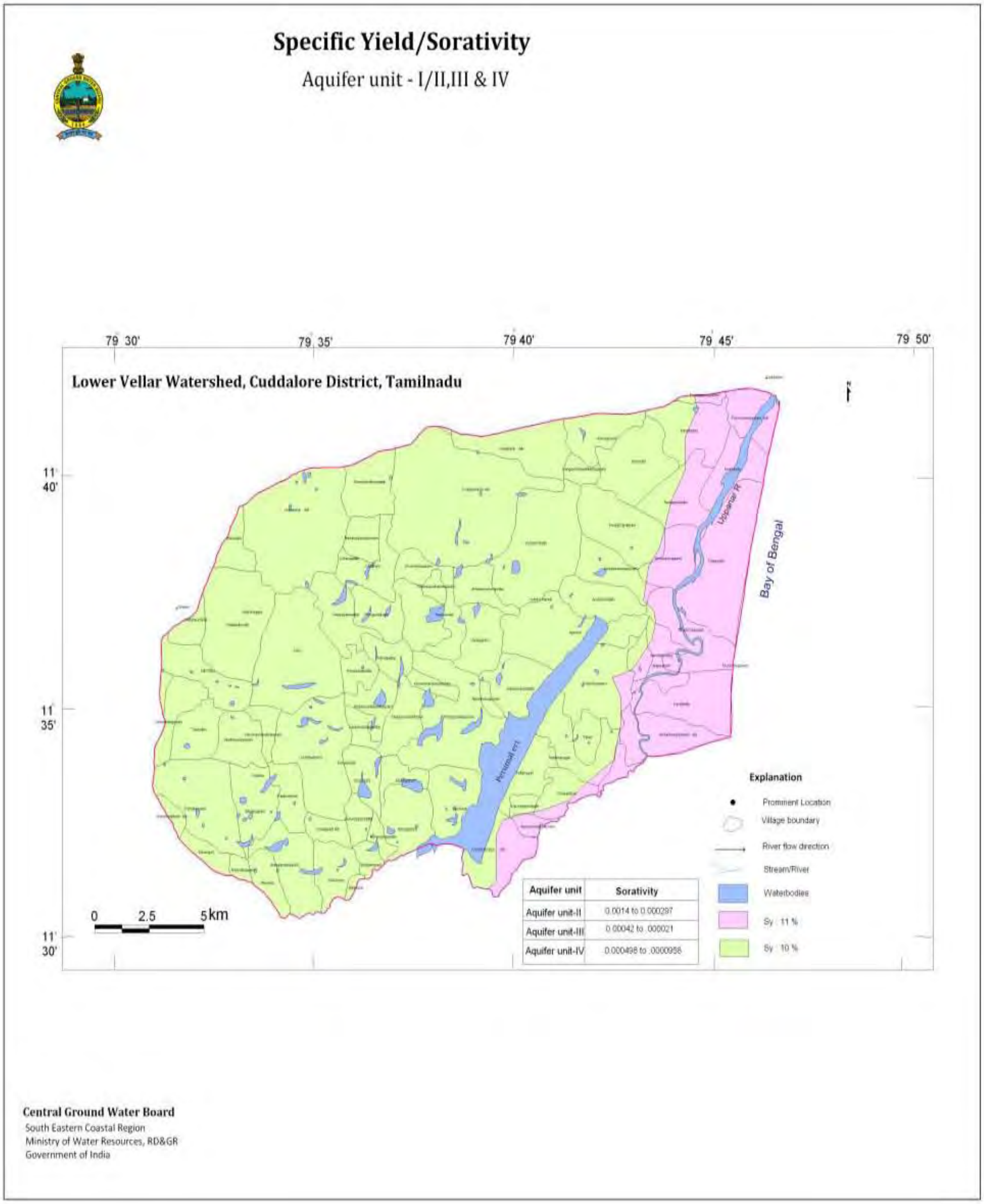


Figure: 5.33 Aquifer yield potential map

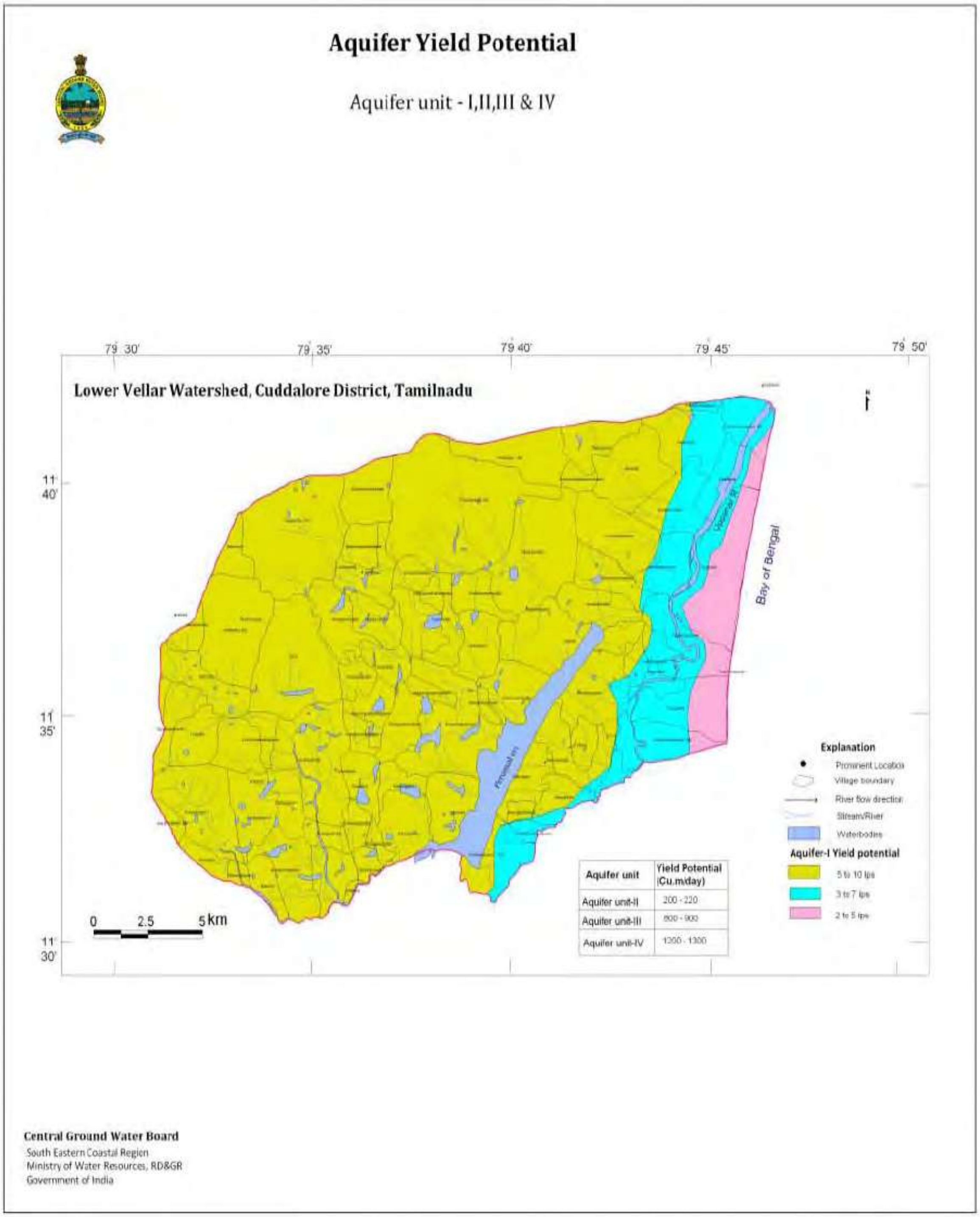
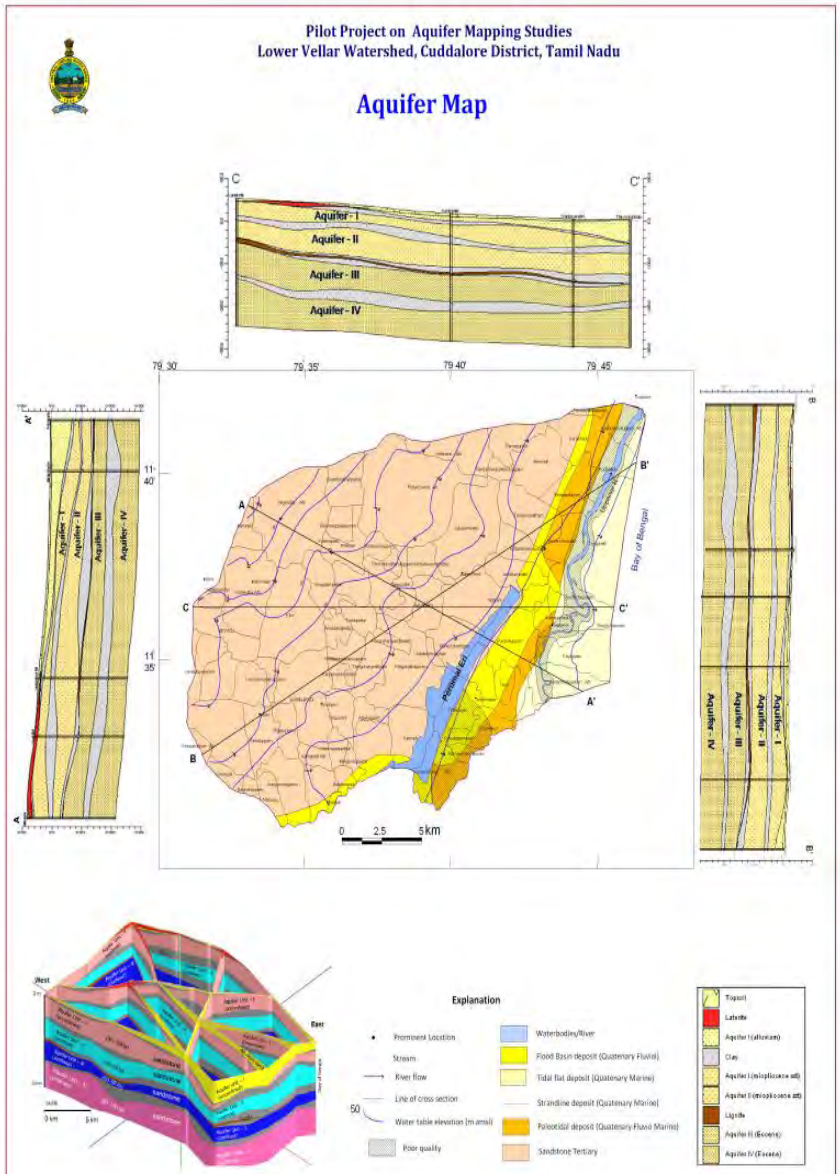


Figure: 5.34 Aquifer map



Aquifer	Prominent Lithology	Depth Range of Occurrence (m bgl)	Thickness Range (m)	Range of Yield Potential (Cu.m /day)	Range of Storage Characteristics	Range of Hydraulic conductivity (m/day)	Suitability for Irrigation	Suitability for Domestic Purposes	Remarks
Aquifer I	Alluvium/ Sandstone	Ground level	30 – 100	100-120	15% to 18%	40-60	Yes	Yes*	* High EC values at Teerthanagiri, Sirupalayur, Kanvapampadi, Alapakam Kotuvacherry, Kudikadu, Kundiyamalur, Alamelumangapuram &Padichayakuppam Villages hence not suitable for drinking
Aquifer II	Sandstone	35 - 110	40 - 55	200-220	0.000297 to 0.0014	45-55	Yes	Yes	Suitable for all purpose
Aquifer III	Sandstone	90 – 160	55 - 100	800-900	0.000021 to 0.00042	40 -50	Yes	Yes	Suitable for all purpose
Aquifer IV	Sandstone	150 to 280	> 250	1200-1300	0.0000958 to 0.000498	40-45	Yes	Yes	Suitable for all purpose

Central Ground Water Board
South Eastern Coastal Region
Ministry of Water Resources, RD&GR
Government of India

Figure: 5.35 3D Aquifer Disposition

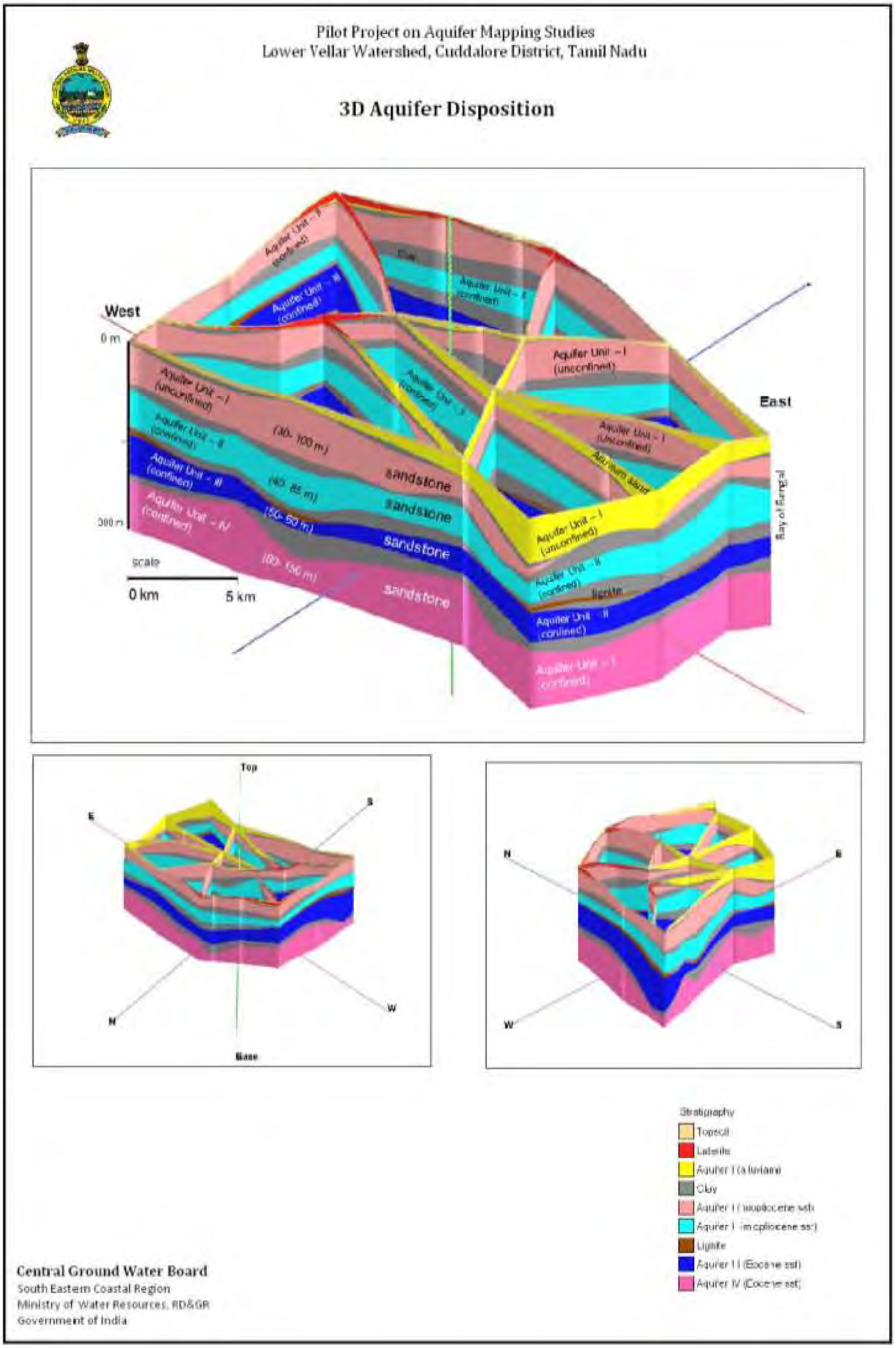
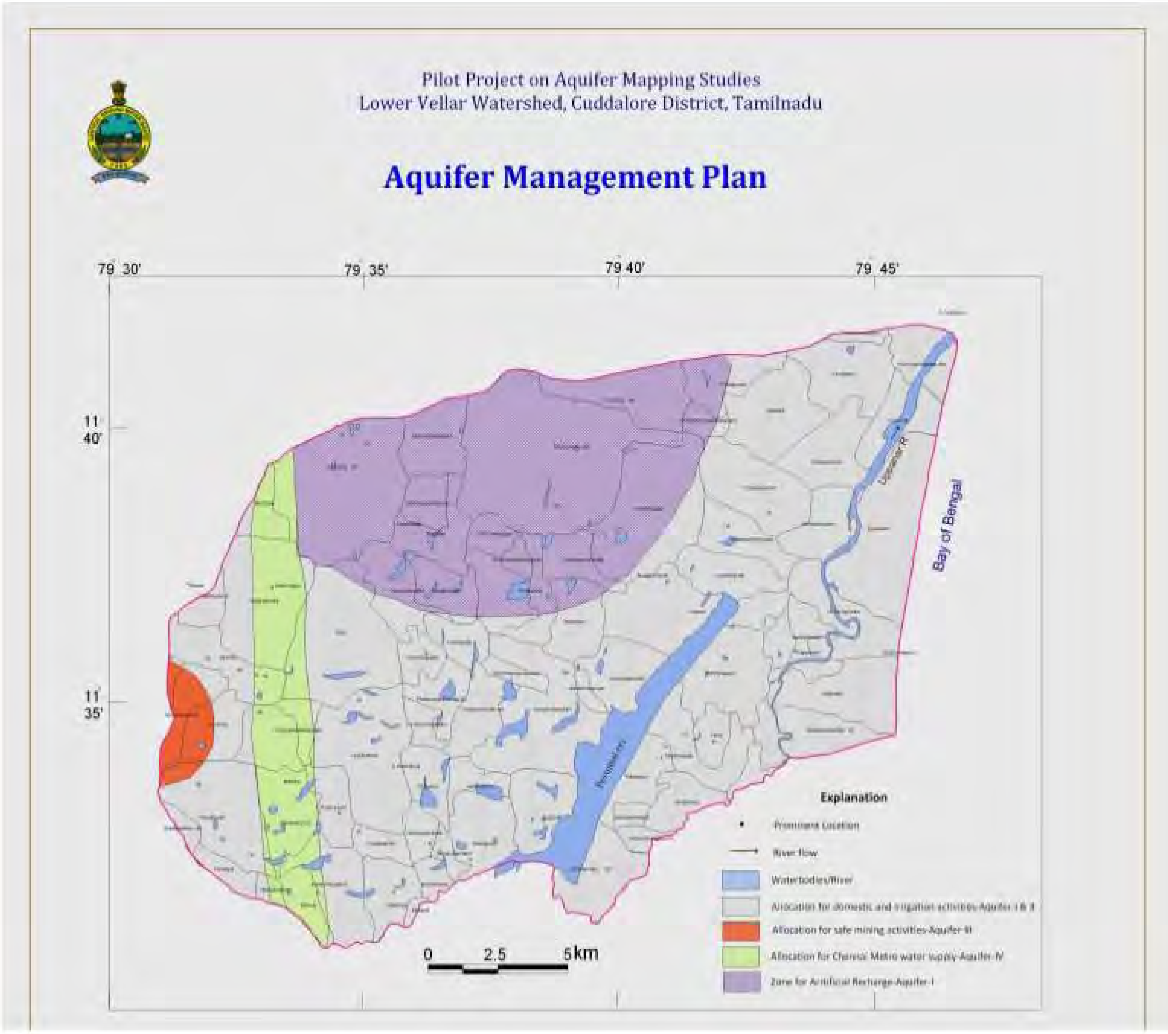


Figure: 5.36 Aquifer Management Plan



Aquifer	Depth of Occurrence (m bgl)	Thickness (m)	Current Use	Recommendations for Aquifer Development: Type	Zones/ Depth to be tapped	HP of pump to be lowered	Pumping Hours (optimum)	Yield (Cu.m /Day)	Aquifer Management Plan
Aquifer I	Ground level	30 – 100	Drinking, Domestic and irrigation	Dugwell/ Tubewell	3 – 90	5-15	6	100-120	▪ The current annual groundwater withdrawal is 85 mcm and the total annual groundwater withdrawal should be limited within 130 mcm. ▪ The groundwater withdrawal to be restricted along the coast (0 to 10 km inland). ▪ The groundwater level needs to be maintained above mean sea level. ▪ Artificial recharge to be taken up from excess run off by utilizing the existing tanks.
Aquifer II	35 - 110	40 - 55	Drinking, Domestic and irrigation	Tubewell	40 – 140	5-20	6	200-220	▪ The current annual groundwater withdrawal is 129 mcm and the total annual groundwater withdrawal should be limited within 150 mcm. ▪ The groundwater withdrawal to be restricted from coast to 10 km inland. ▪ The piezometric head to be maintained above – 20 m msl.
Aquifer III	90 – 160	55 - 100	Safe mining of lignite	Tubewell	110 – 240	40-70	11	800-900	▪ The current annual groundwater withdrawal is 165 mcm and the total annual groundwater withdrawal should be limited within 200 mcm. ▪ The piezometric head to be maintained – 40 m msl.
Aquifer IV	150 to 280	> 250	Drinking water supply to Chennai city during lean period	Tubewell	180 -400	40-70	12	1200-1300	▪ The annual groundwater withdrawal is 13 mcm. ▪ The piezometric head to be maintained – 60 m msl.

5.2 Aquifer Characterization

The aquifer characterization of the four aquifer units (Aquifer – I, II, III & IV) is brought out to enable to bring out aquifer management plan for all the four aquifer units.

Aquifer – I

The groundwater in the aquifer – I occur under unconfined conditions and are phreatic in nature. Groundwater development is mostly by dugwells and dugcum-borewells. Few tubewells also tap groundwater from this aquifer. The dugwells range from 1 to 4 m in diameter and are lined by bricks or concrete concentric rings. The depth of the dugwells ranges from 3 to 35 m bgl. The dugwells are energized mostly by electric pumps. However, the dug-cum-borewells in the sanddunes (located 1 – 3 km from the coast) are shallow in depth and ranges from 2 to 10 m. Most of the dugwells are owned by the farmers. The groundwater is abstracted mainly for irrigation (80 %), domestic (15 %) and Industrial purpose (5 %).

The groundwater level of the aquifer – I ranges between 1 and 26 m bgl. The aquifer – I is highly potential and its yield varies from 5 to 10 lps. The dugwells within the alluvium sands along the eastern portion yield 3 to 7 lps. The dug-cum-borewells in the sanddunes yield 2 to 5 lps and groundwater abstraction is partially restricted during non-monsoon periods by the farmers.

The groundwater quality of the aquifer is good and is used for drinking, domestic, agriculture and irrigation purpose. The Electrical Conductivity (EC) of the groundwater ranges from 500 to 1500 microsimens/cm. However, the groundwater along the course of the Uppanar river and a small pocket south of Perumal Eri has moderate to poor groundwater quality. The EC in these zones ranged between 2000 to 3500 microsimens/cm. The high EC in these zones are due to insitu salinity and also due to the influence of the backwaters along the Uppanar river. The EC of the backwater ranges from 12000 to 19000 microseimens/cm. During monsoon periods, the

Uppanarriver gets flushed or diluted and the EC during the period ranged between 900 and 1200 microsimens/cm.

The major source of replenishment to the aquifer is by rainfall. Apart from rainfall, groundwater recharge occurs from irrigation return flow, recharge through tanks and recharge through artificial recharge structures. The PerumalEri also forms the source of recharge. The PerumalEri (tank) is the biggest water body in the project area that holds water throughout the year. This water body also acts as a zone of recharge thereby contributing to the aquifer unit I. Siltation in PerumalEri is the common phenomena occurring as a result the surface storage capacity of the PerumalEri tank reduces from time to time. *In places where the insitu salinity exists the EC ranges from 2000 to 4000 micro Siemens/cm. The villages that exist south of PerumalEri has insitu salinity and less fresh water potential zones.* The groundwater of the phreatic aquifer along the Uppanar river courses are brackish attributing to insitu salinity and back waters during high tides.

The groundwater fluctuation is high in the western portion (recharge area) than the central and eastern portion. The annual groundwater fluctuation of the dugwells in the western portion ranges from 5 to 25 m while in the intermediate and discharge area (eastern portion) the groundwater fluctuation is ranges from 3 to 10 m. The groundwater decline is not much significant in the dugwells existing in the intermediate and eastern portion however, the dugwells in the recharge zone (western portion) show marginal decline in groundwater level over the years. The transmissivity of the aquifer – I ranged between 450 and 950 m2/day and the specific yield ranges between 11 to 17 %. The transmissivity of the aquifer unit – I along the south eastern margin is marginally less (350 to 750 m^2/day) in comparison with rest of the aquifer. The hydraulic conductivity of the sandstones range from 40 to 60 m/day and the hydraulic conductivity of the alluvium formation is existing between Ponnaiyar and Gadilam river ranged between 40 and 90 m/day. The hydraulic conductivity along the south eastern portion of the aquifer is comparatively less (20 to45 m/day) than the sandstones due to the dominance of clay within the alluvium sand.

Sand dunes occur parallel to coast act as a good aquifer locally as well as are the good recharge zone. The sand dune exists 500 to 1500 m from the coast meets the domestic needs of the hamlets exist along the sand dune. The dugwell within the sand dunes are 5 to 7 m depth with 1to 3 m dia. The yield of these dugwells ranges between 2 to 4 lps. The groundwater within the sanddunes is fresh with the EC ranging between 250 to 750 µS/cm. During the field survey it was observed (on enquiry) that the farmers in the recharge area deepen their dugwell as the yield reduces. The deepening of the dugwells started before a decade or so. This is because the groundwater level and its yield steadily declined in the recharge area. The decline in the groundwater level and yield within the recharge area indirectly infers reduction in the storage of groundwater within the aquifer unit. Artificial recharge schemes can be taken up in these zones and can be highly successful.

Aquifer – II

The groundwater in the aquifer –II occurs under confined conditions. The groundwater abstraction from the aquifer is by tubewells. The tubewells range from 40 to 100 m in depth and are energized by electric submersible pumps. The groundwater is abstracted mainly for irrigation (85 %), domestic (5 %) and Industrial purpose (10 %). The peizometric level of the aquifer – II ranges between 15 and - 20 m w.r.t. msl. The aquifer – II is highly potential aquifer and its yield varies from 20 to 40lps. The groundwater quality of the aquifer is good and is fit for drinking, domestic, agriculture and irrigation purpose. The Electrical Conductivity (EC) of the groundwater ranges from 500 to 1000 microsimens/cm. The major source of replenishment to the aquifer is by rainfall. Apart from rainfall, groundwater recharge occurs from leakage from aquifer – I. The annual groundwater fluctuation of the piezometers range from 5 to 12 m and the groundwater decline is quite significant in the piezometers.

The hydraulic conductivity of the sandstones range between 40 and 50 m/day. The transmissivity of the aquifer – II range between 1000 and 2200 m^2/day and the storativity ranges between 1.2 x 10^{-3} to 4.1 x 10^{-4}.

Aquifer – III

The groundwater in the aquifer –III occurs under confined conditions and is mainly developed by deep tubewells. The tubewells range from 130 to 160 m in depth and are energized by electric submersible pumps. The groundwater is abstracted mainly for mining activity (depressuration)in and around Neyveli lignite mine since 1950. Since 2010 tubewells have been constructed tapping groundwater from this aquifer for irrigation activity by the farmers. The peizometric level of the aquifer – III ranges between -15 and - 35 m w.r.t. msl. The aquifer – III is highly potential aquifer and its yield varies from 40 to 60lps.

The groundwater quality of the aquifer is good and is fit for drinking, domestic, agriculture and irrigation purpose. The Electrical Conductivity of the groundwater ranges from 200 to 1000 µS/cm. The annual groundwater fluctuation of the piezometers range from 2 to 6 m and the groundwater decline is quite insignificant in most part of the aquifer. The transmissivity of the aquifer – III range between 1000 and 2500 m^2/day and the storativity ranges between 1.6 x 10^{-4} to 2.9 x 10^{-5}. The hydraulic conductivity of the sandstones range from 35and45 m/day.

The groundwater is been pumped for the safe mining of the lignite seam in and around neyveli. The aquifer unit –III around the lignite mine area is depressurized so as to maintain positive piezometric head. As this depressurization activity has started since 1950 and still in progress a large cone of depression of 3 to 5 km radius exist around the lignite mine. The impact surrounding the neyveli region is also due to the groundwater withdrawal for irrigation by the farmers through tubewells in the aquifer unit –II and III. The farmers around these zones actually tapped the aquifer unit II and few tap aquifer unit III. The cumulative impact of the depressurization of the aquifer unit III and the groundwater withdrawal for irrigation activity of aquifer unit II and III has created a *permanent cone of depression around the lignite mine. Few quantum of the groundwater (mainly water collected in the mine pit referred as storm water) pumped for safe mining of lignite is let into Sengalodai and Kaniyakoilodai and from there on get spreads to lot of channels in the area nearby and finally reaches PerumalEri through Paravanar river. At times the water gets stagnated and floods the area. Along these places laterite occur at top the dugwell along the coarse get recharges. The dugwells along these region have high EC values ranging between 1000 to 2000 µS/cm.*

Aquifer – IV

The groundwater in the aquifer –IV occurs under confined conditions. The groundwater abstraction from the aquifer is by deep Tubewells. The tubewells range from 170 to 250 m in in depth and are energized by electric submersible pumps. The groundwater is abstracted mainly for drinking water supply to Chennai city during lean periods. The aquifer – IV is highly potential aquifer and its yield varies from 20 to 70 lps. The annual groundwater fluctuation is almost negligible in most part of the aquifer. The groundwater quality of the aquifer is good and is suitable for drinking, domestic, agriculture and irrigation purpose. The Electrical Conductivity of the groundwater ranges from 500 to 1500 µS/cm/cm. The transmissivity of the aquifer – IV range between 1000 and 2500 m^2/day and the storativity ranges between 4.3 x 10^{-4} to 9.1 x 10^{-5}. The hydraulic conductivity (K) of the sandstones range between 35 and 40 m/day.

Other salient features

Most part of the aquifer units II, III and IV were under confined conditions wherein the tube wells overflowed above ground level until late 70's and gradually the artesian condition diminished by late 80's. However, recent exploration (25 km south of the study area – near Coleroom River) by CGWB, has revealed that artesian condition with pressure head of 2 to 4 above ground level exists in aquifer unit –III and IV.

All the four aquifer units have potable ground water suitable for domestic, industrial and agriculture purposes. Currently aquifer I is used for domestic and irrigation. Aquifer II is used for irrigation and aquifer III for safe mining activity and to some extent for irrigation and Aquifer IV for drinking water supply to Chennai city during lean period. 43 tubewells pump groundwater from aquifer unit IV for drinking water supply for Chennai city during lean period (April, May June). Calcium and Bicarbonate as dominant anion and the ground water is of calcium-bicarbonate type. The order of cations and anions of the phreatic aquifers are as follows $Ca>Mg>Na>K\&HCO_3>Cl>SO_4>NO_3$.

The clay layers (aquicludes) at many places are so thin and at few places are absent. The hydraulic continuity is quite prominent within the aquifer units where the clay is thin or absent. As a result the deeper aquifers are recharged by the overlying aquifers by the downward movement of water through vertical interconnection between the different aquifer units or by lateral inter connection due to thinning of clays. As the deeper aquifer units (II, III & IV) are confining aquifers with high hydrostatic pressure the upward movement of groundwater within the aquifer units do exists.

The peizometric head of aquifer unit III and IV through at many places show minimal head difference, the EC of the groundwater within the aquifer units show marked variation. The EC of Aquifer unit – III is comparatively less than aquifer unit –IV. The hydrogeological information of the individual aquifer units generated from the aquifer mapping study is primarily used to develop conceptual model so as to develop aquifer management plan through numerical modeling. There are 209 villages within the pilot project area and the village wise aquifer information is given as annexure *-VIII .*

Chapter 6 Aquifer response model and aquifer management plan formulation

6.0 Aquifer Response Model & Aquifer Management Plan Formulation

The pilot project area forms the part of the Cuddalore coastal aquifer. For development of aquifer response model and aquifer management plan, the pilot project area was extended to the north, west and southern part so as to have near perfect Hydrogeological boundaries. Accordingly, the northern boundary was extended upto Ponnaiyar river, the southern boundary was extended upto Vellar river and the western boundary was extended upto the Hard rocks. (Figure. 6.1).Thus the aquifer response model and aquifer management plan formulation was done for the extended area which is referred as the Cuddalore coastal aquifer system. The conceptualization, development of aquifer response model and Aquifer management plan of the Cuddalore coastal aquifer system through numerical modeling is described in the succeeding paras.

The conceptualization of the Cuddalore aquifer system is the basis for development of model. The conceptual model of the Cuddalore coastal aquifer is based on a) geologic, hydrogeologic framework and hydraulic properties within with the aquifer functions b) descriptions of the spatial and temporal characteristics of the model boundaries c) estimates of inflows, outflows across model boundaries d) approaches used to estimate the steady state water budget and an assessment of the uncertainties associated with those estimates e)groundwater flow paths f) stratigraphic, structural and hydrologic controls on groundwater flow.

drawdown resulting from proposed groundwater withdrawals may modify appropriate model-input files to run predictive simulations.

The model primarily is to address the following hydrological stress pertaining to Cuddalore coastal aquifer. a) Heavy and continuous groundwater withdrawal for irrigation b) depressurized for safe mining of lignite since 1955. c) Stress on the aquifer due to groundwater withdrawal for drinking water supply to Chennai city during lean periods and finally, d) Threat of seawater intrusion in the event of reversal of hydraulic gradient or by upconning.

The objectives of the study is to 1) develop and calibrate a regional flow model that characterizes the Cuddalore aquifer system 2) apply the calibrated model as a predictive tool to assess future changes in water levels that are directly related to future water use demands.

6.3 Description of Cuddalore coastal Aquifer system

The Cuddalore coastal aquifer system is one of the most productive aquifers in the Tamilnadu state as well as in the country. The aerial view of the Cuddalore coastal aquifer is shown as figure 6.3. The aquifer consists of regionally extensive sandstones that crop out within the Cuddalore aquifer system and underlie towards the east coast and extents into the Bay of Bengal. The northern boundary is defined by updip along the Ponnaiyar River while the southern boundary is defined by Vellar River. The Archaeans*(GranitoidGneiss)*in the western boundary marks the western boundary while the Bay of Bengal Sea constitutes the eastern boundary of the Cuddalore coastal Aquifer system. The aquifer disposition and its vertical and lateral extent is described in detail in previous chapter.

The Cuddalore aquifer model area constitutes two physiographic provinces viz. tertiary upland and coastal alluvial plain (figure 6.4). The Ulundurpet – Gadilam escarpment borders the Cuddalore aquifer in the west. The boundary limit or the domain of the cuddalore coastal aquifer system is given as figure 6.4 .

6.3.1 Hydrogeologic framework

The sedimentary tract extending from Puducherry to south of Rameshwaram between 9˚ and 12˚ parallels is considered as Cauvery Basin *(Figure.6.2).*Sediments of Jurassic, Cretaceous, Eocene and Miocene and Pliocene are exists within the Cauvery Basin. *(Blanford, 1865).*The sediments that exists within the cuddalore coastal aquifer system reflect changing depositional conditions during the past 10 million years, resulted sedimentary assemblage of sands, gravels, conglomerates and clays with a complex distribution of hydraulic properties.

For the purpose of groundwater management, the sandstones of mio-pliocene age is named as Cuddalore aquifer and the sandstones of Eocene is named as Neyveli aquifer. The regional geology of the Cuddalore aquifer system is given as figure 6.5. The Cuddalore sandstones of Mio-pliocene age comprises of argillaceous sandstone, pebble bearing sandstone, ferruginous sandstone, gravel, grits and clay beds. They are whitish, pinkish, reddish or mottled in color and are ferruginous in nature. The Cuddalore sandstones are confined in nature and occur at the depth of 40 to 140 m with the piezometric head ranging between 20 and 50 m bgl. The lignite deposits underlining the Cuddalore sandstones in many places act as marker horizon between the Cuddalore sandstone aquifer and Eocene sandstone aquifer.
The sandstones of Eocene age also referred as Neyveli aquifer occurs beneath Cuddalore aquifer under confined conditions with the peizometric head varying from 60 and 105 m bgl. A thin discontinuous clay layer seperates the aquifer as lower and upper confined aquifer. The aquifer material comprises of very fine to coarse sand with occasional clay interclations. The artesian condition that existed before two decades do not exists anywhere within the Cuddalore Aquifer system. The sandstones of the Cuddalore aquifer system have strike along NNE to SSW direction with a dip of 20 and 25 towards ESE or SE direction.

Figure6.2Map showing the Cauvery Basin and the location of Cuddalore aquifer system.

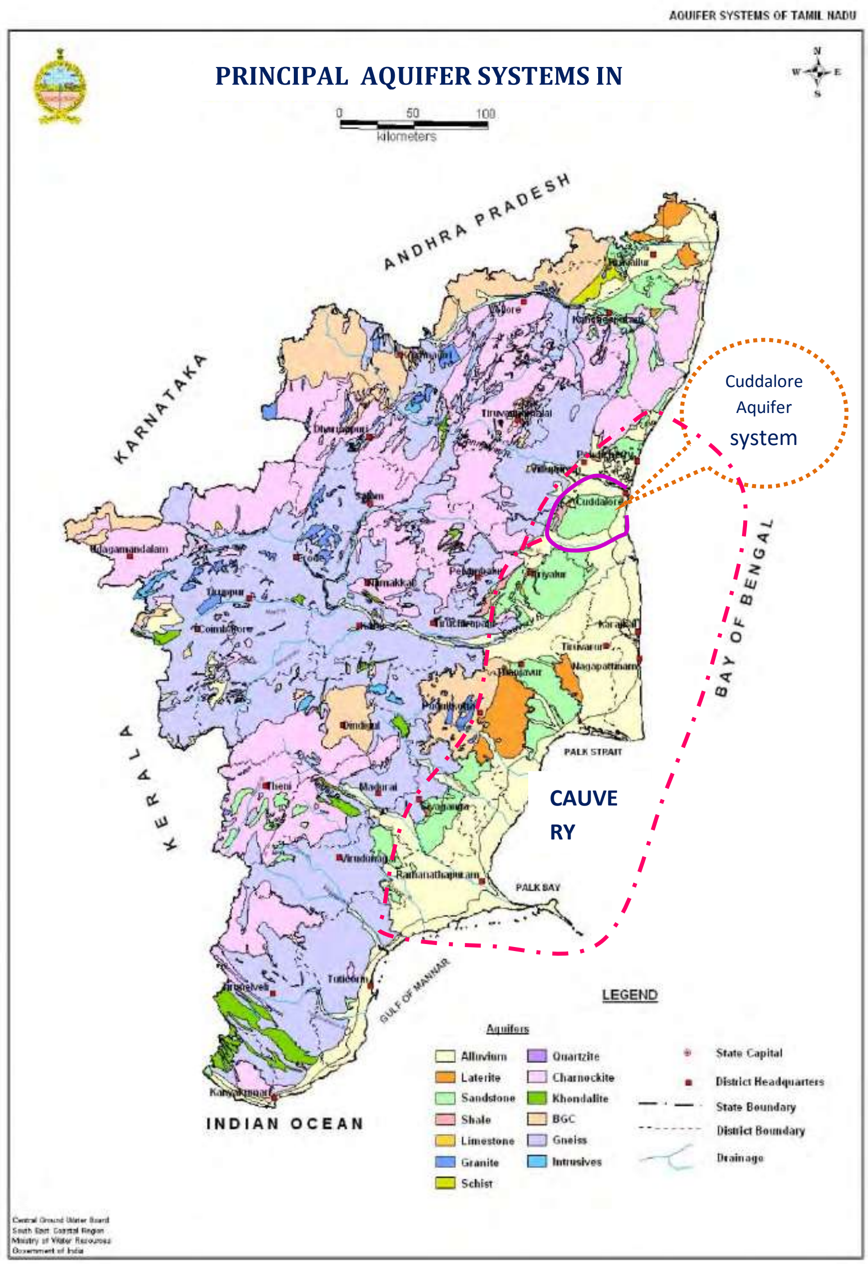
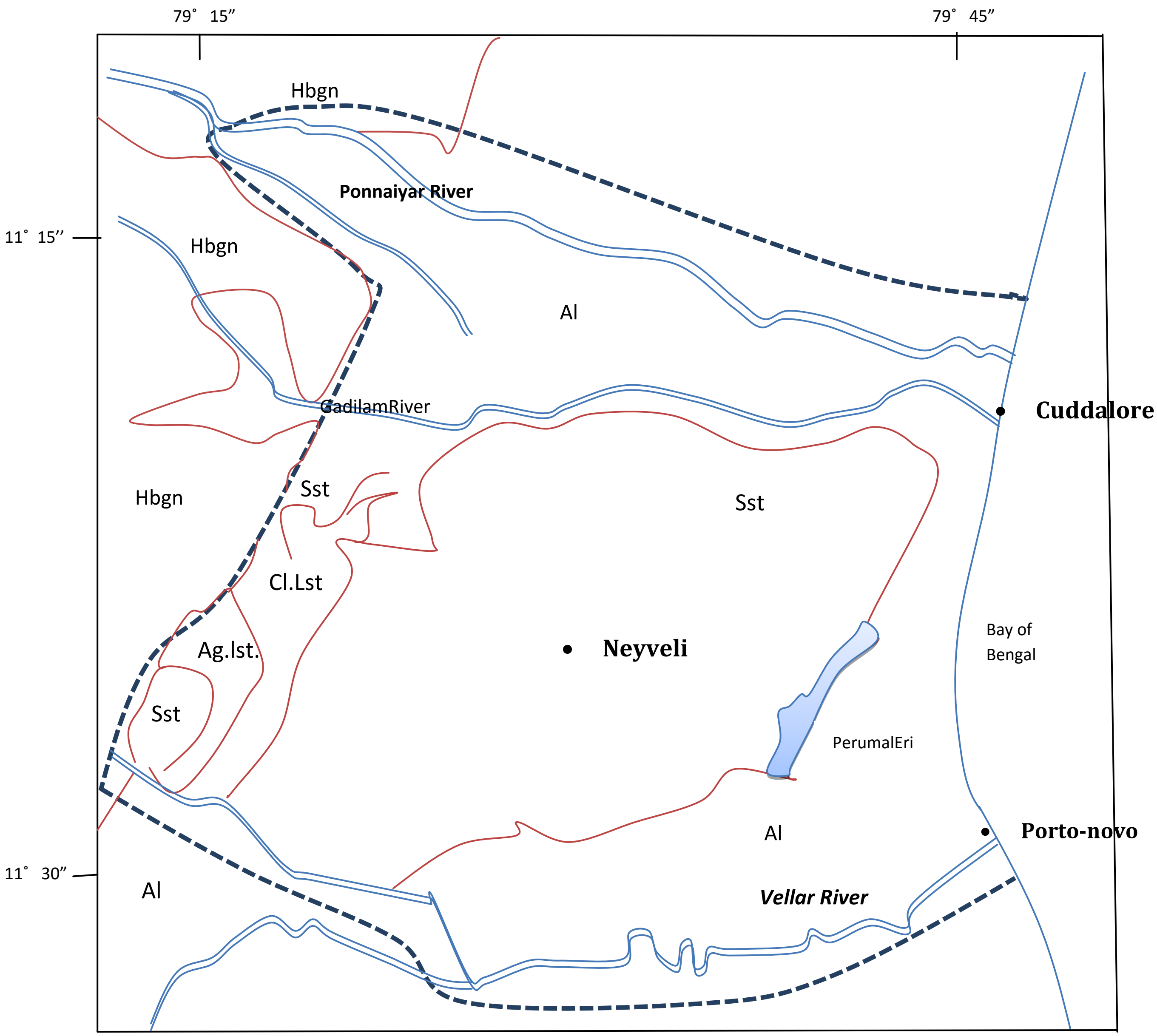


Figure 6.4 Regional Geology and boundary limit of the Cuddalore aquifer system.



LEGEND

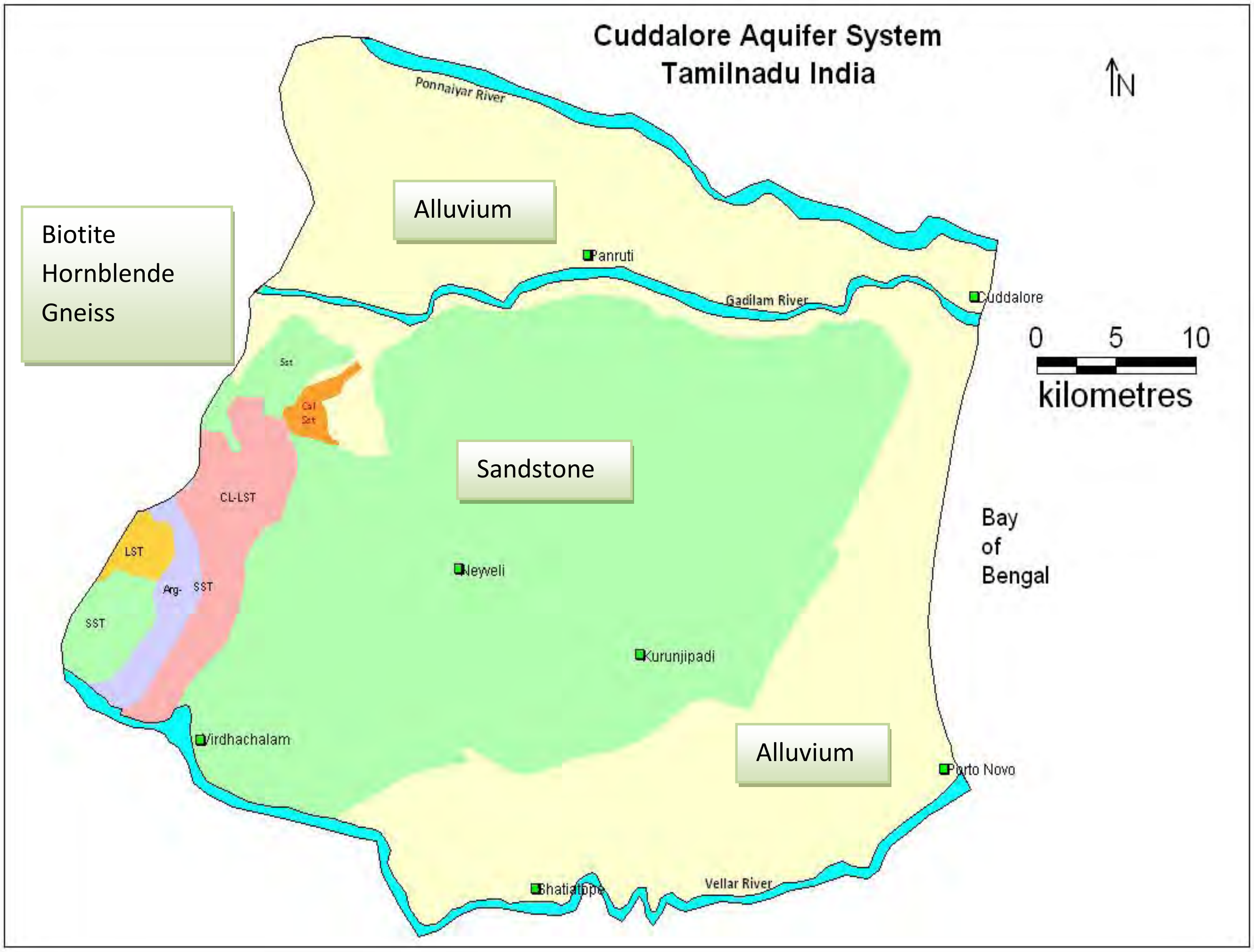
Hbgn : Hornblende Biotite Gneiss

Sst : Sandstone

Al : Alluvium

Boundary of Cuddalore aquifer system

Figure 6.5 Geology of the Cuddalore aquifer system.



The basement and the cretaceous rocks exposed in the western part of the Cuddalore aquifer have not been encountered in the eastern and southwestern part due to thickening of the tertiary sedimentary sequence from west to east *(Subramanyam, 1969).*The tertiary upland and the coastal plain strata have been classified into a layered sequence of aquifers and confining units, each of which generally thicken and deepen to the east towards the Bay of Bengal Sea.

Hydrogeologic Units within the Cuddalore coastal aquifer system

Based on the aquifer disposition, obtained from the geological, geophysical, hydrogeological and hydrochemical studies, the stratigraphic correlations of hydrogeologic units of the Pilot project area (part of lower velar water shed) as well as the cuddalore coastal aquifer system is developed. (Table. 6.1). Construction of detailed hydrostratigraphic unit of the Cuddalore coastal aquifer system was required to establish the coherence between the geologic period, series/epoch, geologic unit/formation, hydrostratigraphic unit and hydrogeological Unit. *Borehole lithologs, electrical logs were used to define the altitude of the top of each hydrogeologic unit at borehole points/sites. Cross-borehole correlation enabled generation of two each aquifer unit. Subtraction of the altitudes of the adjacent surfaces generated raster representation of the thickness of the each hydrogeologic unit.*

Aquifer mapping studies revealed 4 hydrogeologic units (Aquifer Unit – I, II, III & IV) within the Cuddalore coastal aquifer down to the depth of 300 m bgl and thus the Cuddalore coastal aquifer system functions as multilayered aquifer system. It is to mention that, though the 4 hydrogeologic aquifer units exists throughout the Cuddalore coastal aquifer, they pinch out at the lateral depositional boundaries especially at the northwestern and the western boundaries and vertical hydraulic connectivity is established between the four hydrogeologic units. Aquifer unit –V (beyond the scope of this study as the study is limited upto 300 m depth) exists below aquifer unit –IV (as mentioned in the table). They exists below 350 to 400 meters and information pertaining to this aquifer unit –V is quite less. Detailed aquifer mapping studies down to 400 m depth shall reveal more interesting information in near future.

Table 6.1.Stratigraphic correlations of hydrogeologic units of the Cuddalore coastal aquifer system.

	Period	Series/Epoch		Geologic Unit/Formation	Hydrostratigraphic Unit (detailed)	Hydrogeologic Unit		
Cenozoic	Quaternary	Holocene/Pleistocene		**Alluvium sand**	Upper Cuddalore Aquifer	**Cuddalore Aquifer**	Unconfined Aquifer Zone **(Aquifer Unit – I)**	**CUDDALORE COASTAL AQUIFER SYSTEM**
	Tertiary	Mio-Pliocene	late	**Cuddalore Formation**				
			early		Lower Cuddalore Aquifer		Confined Aquifer Zone **(Aquifer Unit – II)**	
		Unconformity						
		Eocene	late	**Neyveli Formation**	Upper Neyveli Aquifer	**Neyveli Aquifer**	Confining Aquifer Zone (**Aquifer Unit – III)**	
			middle		Middle Neyveli Aquifer		Confining Aquifer Zone (**Aquifer Unit – IV)**	
			early		Lower Neyveli Aquifer		Confining Aquifer Zone **Aquifer Unit – V** (exists beyond 400 mbgl)	
Unconformity								
Me soz	Createceous	Late		Puvanur Formation	Fossiliferrous siliceous Limestone Calcareous sandstone and marls			
Unconformity								
Prot eroz	Archaean	Intrusives		Granitoid Gneiss	Basement			

6.3.2 Conceptualization of the Cuddalore Aquifer System

The conceptualization of the Cuddalore aquifer includes description of the geologic and hydrogeologic setting within which the aquifer functions. Paleogeographic and structural features and major depositional provinces have influenced the distribution of hydrologic characteristics of the sandstones composing the Cuddalore coastal aquifer. The conceptualization of the Cuddalore aquifer system (figure.6.6) is the basis of the Cuddalore coastal aquifer model.

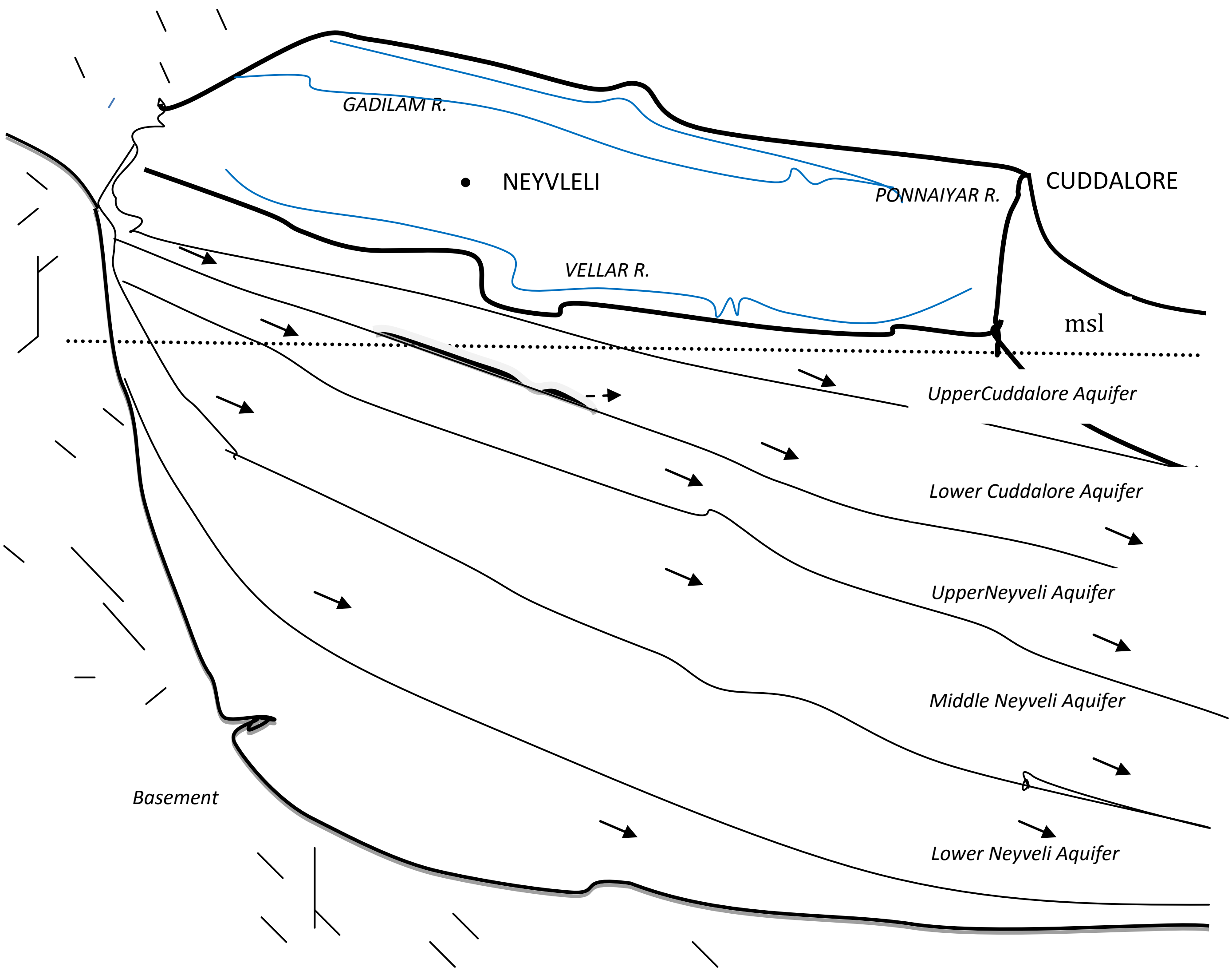
6.3.3 Precipitation

Precipitation is the large component of groundwater recharge, which is specified as a groundwater recharge to the model was quantified by simple analysis of spatial and temporal variations of precipitation. Through the average rainfall is 1300 mm, historic records have shown that the annual rainfall greater than 1700 mm occurred 6 times in the last 100 years. Also analysis of the last 100 years of precipitation, rainfall marginally increased during the last 50 years in comparison to the previous years of rainfall.

6.3.4 Evapotranspiration

Water evaporates from the water table, the intervening unsaturated zone, and through the plant stomata (transpiration). It is difficult to separate the amounts of transpiration and evaporation over vegetated land areas, and these two processes commonly are combined and represented by an evapotranspiration (ET)term in hydrologic models. In Cuddalore coastal plain, the ET losses from the saturated groundwater system do exists where the water table is deeper than 3 m below land surface as most part of the region has got thick vegetation/dense trees. The evaporation is higher during May to August. Evaporation is 10.8 mm (max)and 2.8 (min) recorded during May 2006.

Figure 6. 6 Conceptualization of the Cuddalore coastal aquifer System.

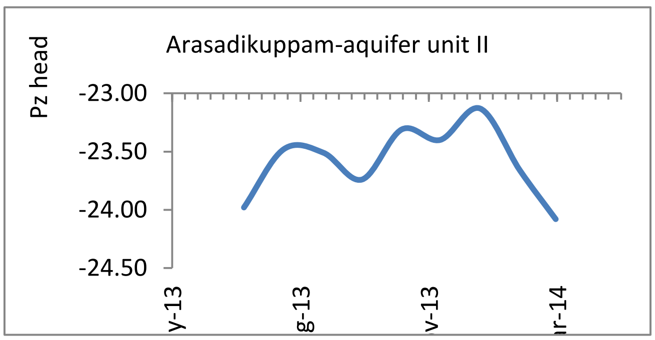


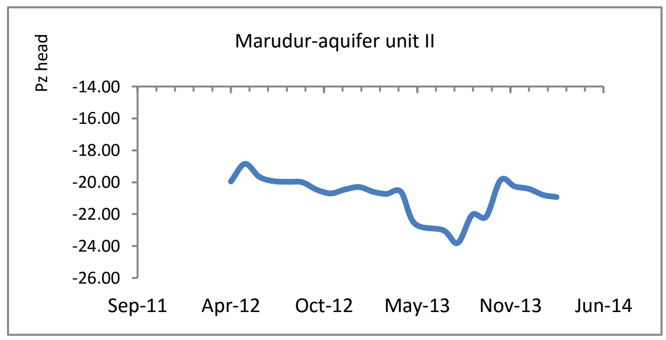
6.3.5 Groundwater flow

The regional groundwater flow is along NW-SW direction. The groundwater flow within the individual aquifer units does follow the regional groundwater direction and seeps into the Bay of Bengal Sea towards east. In places where heavy groundwater withdrawal exists, the ground water flow pattern is disturbed. It zones (central part) where cone of depression exists due to cumulative effect of groundwater withdrawal for irrigation and depressurization activity for mining of lignite, the groundwater flow direction is locally disturbed. Though the horizontal flow is the dominant flow within the aquifer units, the vertical leakance (upward or downward vertical flow) exists within the aquifer units where clay is minimal or absent.

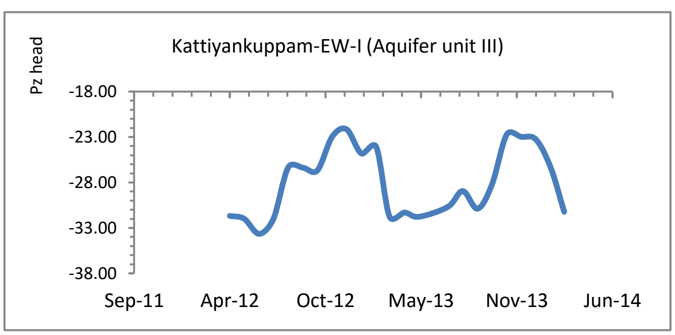
6.3.7 Water levels/Piezometric Levels

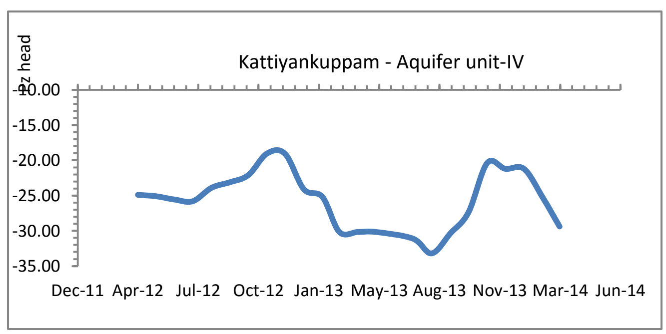
The groundwater flow directions within the aquifer units are along the dip direction *(South East).* The long term water level/piezometers of the cuddalore coastal aquifer system is given below as hydrographs (Figure 6.7). The hydrographs though reveal that the deeper aquifer units (II, III & IV) respond to hydrologic stress but decline in peizometric head is minimal/insignificant. Information pertaining to water level/peizometric heads has been described in previous chapters also.





(Figure: 6.7)





Groundwater quality

All the four hydrostigraphic aquifer units have fresh groundwater with the Electrical Conductivity (EC) varying between 150 and 1600 µS/cm. In the recharge zone (northwest and northern portion) the groundwater is fresh with EC as low as 150 to 250 µS/cm. However, the alluvium sands towards the coast has inisitu salinity (EC varying between 1800 and 2800 µS/cm) at few pockets. It is to mention that the studies carried out by CGWB so far have no evidence of seawater intrusion along the coast in all the four hydrostratigraphic aquifers. Much regarding the groundwater quality of in the individual aquifer units has been described in the previous chapters.

6.5 Hydraulic properties

The response of the unconfined and confined unit of the Cuddalore aquifer system to a change in hydraulic stress under transient groundwater flow condition in the groundwater flow equation is by either specific storage (Ss) or specific yield (Sy). Information on hydraulic properties was compiled from the previous works by CGWB and the study carried out during the project. The hydraulic properties include the hydraulic conductivity, transmissivity and storativity.

6.5.1 Hydraulic conductivity

In the early 1960's, GSI conducted several aquifer test and during 2005 to 2012, CGWB conducted long duration pumping tests. The transmissivity (T) values from the aquifer performance tests are summarized in Annexure-I. Few K values were provided by Neyveli Lignite Corporation. Hydraulic conductivity and transmissivity of the Cuddalore aquifer reflect matrix, conduct permeability and cementing materials. The transmissivity values of the unconfined aquifers ranged between 150 to as high as 3950 m^2/d. The transmissivity of the confined aquifers ranges from 500 to 600 m^2/d and in the recharge area the transmissivity of these confined aquifers are comparatively less (350 to 1100 m^2/d). The unevenness of the transmissivity and hydraulic conductivity within the Cuddalore coastal aquifer indicate the complexity in aquifer matrix or cementing material.

6.5.2 Specific yield/Storativity

Where the aquifer is unconfined, changes in storage occur primarily as drainage or filling of pore space. The specific yield of the unconfined hydrogeologic unit ranged between 0.16 and 0.19. When water levels change under confined conditions the amount of water stored or released from a representative volume of the porous media is due to the volumetric compressibility of water and the porous medium. The storativity value of the confined zone of Cuddalore aquifer ranged between 1.4×10^{-3} to $9.1 \times 10^{-5}$is given as Annexure-I.

6.6 Discharge

The discharge from Cuddalore aquifer occurs as (a) withdrawals by irrigation, industrial, mining activity (depressurization) (b) public supply wells and c) free flowing wells (artesian condition. Before 1960, discharge from the Cuddalore aquifer is mainly effected by pumping from about 145 flowing wells to the south of Cuddalore, apart from the underflow towards rivers. *(Memoirs of GSI, 1969).* Some amount of discharge is also effected by pumping of water from the few sub-artesian wells scattered in the area and some dugwells in the recharge area, where water was tapped for domestic purpose during 1950's. During the year 1955-56, the discharges of the 145 flowing wells to the south of Neyveli was measured individually by jet and volumetric methods and the total quantity worked out to about 32 MGD. Groundwater withdrawals by wells have increased with the increasing population. The lowest estimated withdrawal through pumping from Cuddalore aquifer system was 100 – 120 MCM and the pumping (by dugwells) was exclusively for irrigation and domestic purposes during 1950 - 1952. Since then the annual groundwater withdrawal (depressurization) for mining lignite increased to 140 – 150 MCM. The energisation of the dugwells during early 1970's saw increase in groundwater withdrawal for irrigation. The total annual groundwater withdrawal for irrigation during early 70's was estimated at 350 – 400 MCM. The total annual artesian flow from the Cuddalore aquifer was 32 MGD. *(Memoirs of GSI, 1969 and t*he amount of water tapped by the sub-artesian wells and the water table wells in the recharge area may not exceed 2 MGD*(Figure.11).*

The discharge of water is also effected from the Cuddalore coastal aquifer by natural underflow. The underflow towards the Gadilam river was estimated to be around 16 MGD and towards the Manimukthanadi and the Vellar rivers at about 3 MGD. *(Memoirs of GSI, 1969).*

The cuddalore aquifer is tapped by 2735 numbers of tubewells as on May 2013. Irrigation accounts to more than 85 percent of annual withdrawals. The densitiy of the wells tapping confining unit of the Cuddalore aquifer is more. The cuddalore aquifers on account of their high transmissivity and large thickness are being extensively used for irrigation and less yields towards the western margin is the result of the less saturated thickness of cuddalore sandstone.

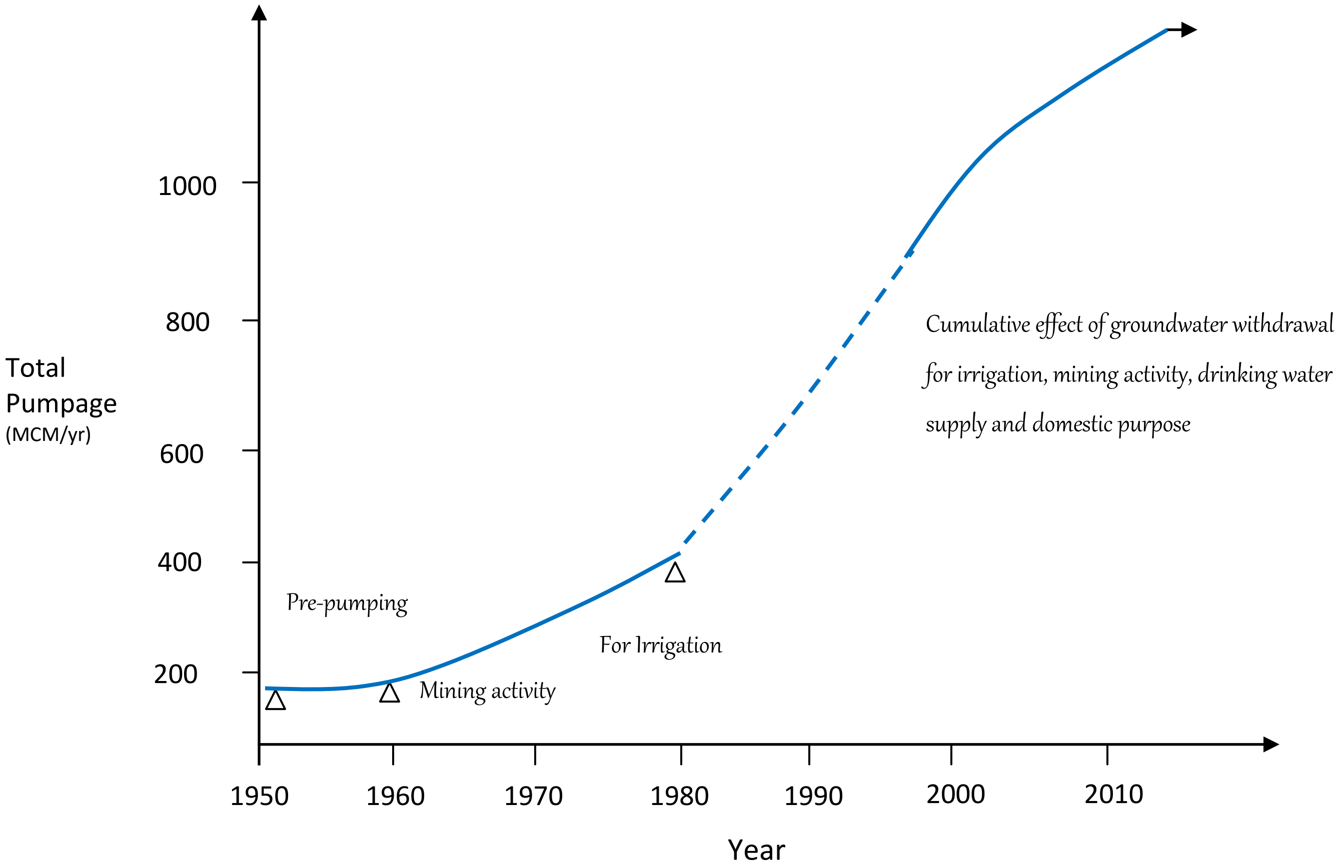
The estimated annual withdrawal by wells for irrigation is 1137 MCM (2013). This estimate is arrived from the data collected from the State statistical department and well inventory survey carried out by CGWB during 2012-2014. Withdrawal for irrigation are mostlyfrom the aquifer unit –II (confined) of the of Cuddalore aquifer (Annexure-VIII). However, 15 – 20 percent of tubewells tap water from the aquifer unit – III (confining) of the Cuddalore aquifer. The annual number of new wells constructed is increasing primarily because of increasing population and deepening of tubwells is due to the reduction in yield of tubwells tapping confining unit of Cuddalore aquifer at some pockets. The details of groundwater withdrawal of Aquifer I, II, III and IV are given as Annexure –IX.

The largest scale groundwater pumping *(depressurization activity)* for safe mining of lignite commenced during 1961 and was confined in and around Neyveli lignite mines. The groundwater pumping *(depressurization activity)* is from Aquifer unit – III (Upper Eocene aquifer – confined zone) and the total pumping is about 133.10 MCM/yr through 65 – 70 numbers of tubewells.

The Metro-water of state department withdraws 12 to 14 MCM of groundwater annually from Aquifer unit –IV (Middle Eocene aquifer – confine zone) during lean periods (April to July). The groundwater pumped from this aquifer is transported through pipelines*(200 km approx.)* to Chennai city for drinking water supply.

6.7 Recharge

Rainfall is the major source of aquifer replenishment. The recharge to the Cuddalore aquifer occurs through a) infiltration of rainfall on the outcrop and all over top of the aquifer b) seepage from the tanks and ponds c) subsurface inflow across the updip margin d) an area covering 350 sq.km between Ponnaiyar and Gadilamriver and d) return flow from irrigation activity. The Cuddalore coastal plain experiences north-east and south-west monsoon.Approximately 58 percent of total rainfall is by the north-east monsoon (October, November, December and January) while 30 percent of rainfall is contributed by the south-west monsoon (July, August and September).


Total
Pumpage
(MCM/yr)
1000
800
600
400
200
Cumulative effect of groundwater withdrawal for irrigation, mining activity, drinking water supply and domestic purpose
Pre-pumping
For Irrigation
Mining activity
1950
1960
1970
1980
1990
2000
2010
Year

6.9 Simulation of Groundwater Flow

6.9.1 Groundwater flow model – *Numerical method*

Two type of simulation were done – a steady state simulation that generally represents the long-term average conditions when inflows to and outflows from the flow system are equal, and a transient simulation that includes changes in groundwater storage over time. The eight year transient model described in this report does not simulate saltwater intrusion as it has not yet happened. The variable – density groundwater flow equation was not coupled to the mass transport equation for the eight year simulation. Therefore the three-dimensional distribution of groundwater density does not change with time in the 2920 month simulation.

6.10 Mathematical Representation

A computer model code MODFLOW *(McDonald and Harbaugh, 1988)* a modular finite-difference groundwater flow code developed by USGS, was used to simulate groundwater flow in the Cuddalore aquifer. MODFLOW uses a form of numerical processing known as finite-difference approximation to solve partial differential equations of groundwater flow. The flow equation, with specifications of flow or head conditions or both at the boundaries of an aquifer system and specification of initial head conditions, constitute a mathematical representation of a groundwater flow system.

6.10.1 Governing Equations and Model Code

The movement of groundwater through porous media is decribed by the partial differential equation, which is based on Darcy's law and the conservation of mass *(McDonald and Harbaugh, 1988)*

$$\frac{\delta}{\delta x}\left[K_{xx}\frac{\delta h}{\delta x}\right]+\frac{\delta}{\delta y}\left[K_{yy}\frac{\delta h}{\delta y}\right]+\frac{\delta}{\delta z}\left[K_{zz}\frac{\delta h}{\delta z}\right]-W=S_s\frac{\delta h}{\delta t}$$

where

K_{xx} ,K_{yy} and K_{zz}: are values of hydraulic conductivity in the x, y and z directions along Cartesian co-ordinate axes, which are assumed to align wth principal directions of hydraulic conductivity.

h is the hydraulic head

W is a volumetric flux per unit volume and represents sinks and or sources.

S_s is the specific storage of the porous material

t is the time

MODFLOW simulates the response of the aquifer system *(hydraulic heads)* to the specified hydrologic stress (recharge and its discharge). The primary sources of water simulated in the Cuddalaore aquifer model are infiltration in the recharge area, irrigation return flow and inflow of water along the northern and southern boundary. The primary simulated discharge of the water is withdrawal by wells and seepage to the Bay of Bengal *(Sea).* The results of the model simulations arehydraulic heads at each finite – difference grid cell node and mass water balances of the aquifer system.

6.11 Assumptions used in the Conceptual Model

Certain assumptions about the Cuddalore coastal aquifer and boundary condition specifications were required to make mathematical representation of the aquifer.

a. The Cuddalore aquifer is represented by seven layer model upto 300 meters below groundlevel though it includes many stratigraphic units with varying hydraulic properties.
b. The hydraulic conductivity (K) values in the x and y co-ordinate directions are the same.
c. Hydraulic connection between the Aquifer I, Aquifer – II, Aquifer III and Aquifer IV were considered where the clay layer thins out or pinches out.
d. It is assumed that vertico-lateral infiltration exists to the Aquifer – III from the Aquifer - II since the impermeable strata (Clay) separating into aquifer units are separated by thin clay layer or almost assumed to be merged at many locations. Therefore the hydraulic

conductivity of the clay layers in the updip area is assumed to be quite higher than the intermediate and towards the coast.

e. In the recharge zone, the Aquifer – I is unsaturated or thinly saturated in places.
f. The hard rocks along the western boundary are considered as no-flow boundary though minimal inflow to the Cuddalore aquifer might exist.
g. The major recharge to the aquifer is from the area between Gadilam and the Ponnaiyarriver where the Sandstone updips in these region.

The model includes the model grid and boundary conditions imposed, the aquifer dispositions, hydraulic properties of the aquifer, and the hydrologic stress (recharge and discharge mechanisms) on the aquifer. Appropriate hydrologic characteristics for appropriate cells within the grid are required to be solved by the governing partial-differential equations. The Specific parameters required for the model include a) active and inactive cells b) altitudes of the top and bottom of the layer of four aquifer units c) horizontal hydraulic conductivity *(K and, Ky) and Vertical hydraulic conductivity (Kz)* d) Specific yield (Sy) orstorativity (S) e) river stage, river bed thicknessand river conductance (*Ponnaiyar, Gadilam and Vellar river are the rivers that have been modeled)* f) initial hydraulic head of four aquifer units and conductance of the general – head boundary g) recharge rates by rainfall, tanks, irrigation return flow, canal recharge and artificial recharge structures h) groundwater withdrawal ratesand i) rate of evapotranspiration.

6.12 Model Discretization

The model discretisation is defined in terms of layers, rows, and columns that result in discrete rectangular volumes referred as cells. The total area modeled is 1948 sq.km.

6.12.1 Special Discretisation

The model area *(1948 Km^2)* was subdivided into rectangular differenced grid cells which the properties of the aquifer are assumed to be uniform. The Centre of the grid is referred to as node and represents the location for which the hydraulic head is computed by the model. The uniformly spaced finite difference grid used to spatially discretize the model area has rows and columns. The origin of the grid is in the south western corner of the model.

The finite – difference grid superimposed on the model area was constructed based on the conceptual model representing the physical properties of the groundwater system. The finite difference groundwater model grid consists of 34,629 cells *(97 rows and 51 columns oriented in an east-west and north-south respectively)* and vertically by 7 layers representing four aquifer units and three aquitard. Each layer has 4947 active cells. The Two uniform model grid spacing were used in the steady-state and transient flow models (a) a coarser grid spacing of 500 m x 500 m (25000 m^2 per model cell) in the western portion of the model area and (2) a fine grid spacing of 500 m x 500 m was taken in the central upland and the coastal plain zone of the model area as the density of the data was high in comparison with the remaining region.*(Figure.6.9)*

The vertical model grid spacing consisting of seven layers of varying thickness is modeled upto 300 m bgl. The model layer, its thickness and the corresponding lithology is given as table. 3 & 4. The sectional view of the model domain along row (i) 17 & 41 *(West-East)* and along Column (j) *(North-South)* 17 & 88 is given in figure 12 a to d respectively.

Table 6.2 : The model layer and their thickness LayerThickness(m) Formation/lithology

1	**15 – 125**	**sand/sandstone (Aquifer)**
2	02 – 18	clay/sandyclay
3	**15 – 80**	**sandstone (Aquifer)**
4	03 – 15	clay/lignite
5	**20 - 110**	**sandstone (Aquifer)**
6	03 - 12	clay/sandyclay
7	**40 – 180**	**sandstone (Aquifer)**

6.12.2 Hydrologic data input

Several types of hydrologic data were required to construct the groundwater flow model of Cuddalore coastal aquifer. *(Table 6.2).* These data facilitate the characterization of model boundary conditions, aquifer stratigraphy and aquifer and confining unit hydraulic characteristics.

Table: 6.4: Summary of model input data for each hydrostratigraphic unit.

Hydrostratigraphic Unit/Model Unit	Type of Data Required for Active Model Grid Cells	Data needed to estimate MODFLOW input item	MODLFOW input item applied to all cells in model unit	MODFLOW input item applied only to Boundary condition or applied stress cells
Layer – I (Unconfined aquifer) Upper Cuddalore Aquifer	Depth to water table	x		
	Recharge	X		
	Land surface elevation			X
	Evapotranspiration extinction depth			X
	River bed vertical hydraulic conductivity	X		
	River Bed thickness	X		
	Riverbed conductance	X		
	Fixed head at constant head cells			x
	Horizontal Hydraulic conductivity			x
	Elevation of top of Unconfined aquifer (base of layer – I)		x	
	Well discharge			x
Layer - 2	Vertical Hydraulic conductivity		x	
Layer – 3 (confined aquifer) Lower Cuddalore aquifer	Top elevation			
	Bottom elevation		x	
	Horizontal Hydraulic conductivity		x	
	Vertical Hydraulic conductivity		x	

6.13 Cuddalore Aquifer Model Boundaries

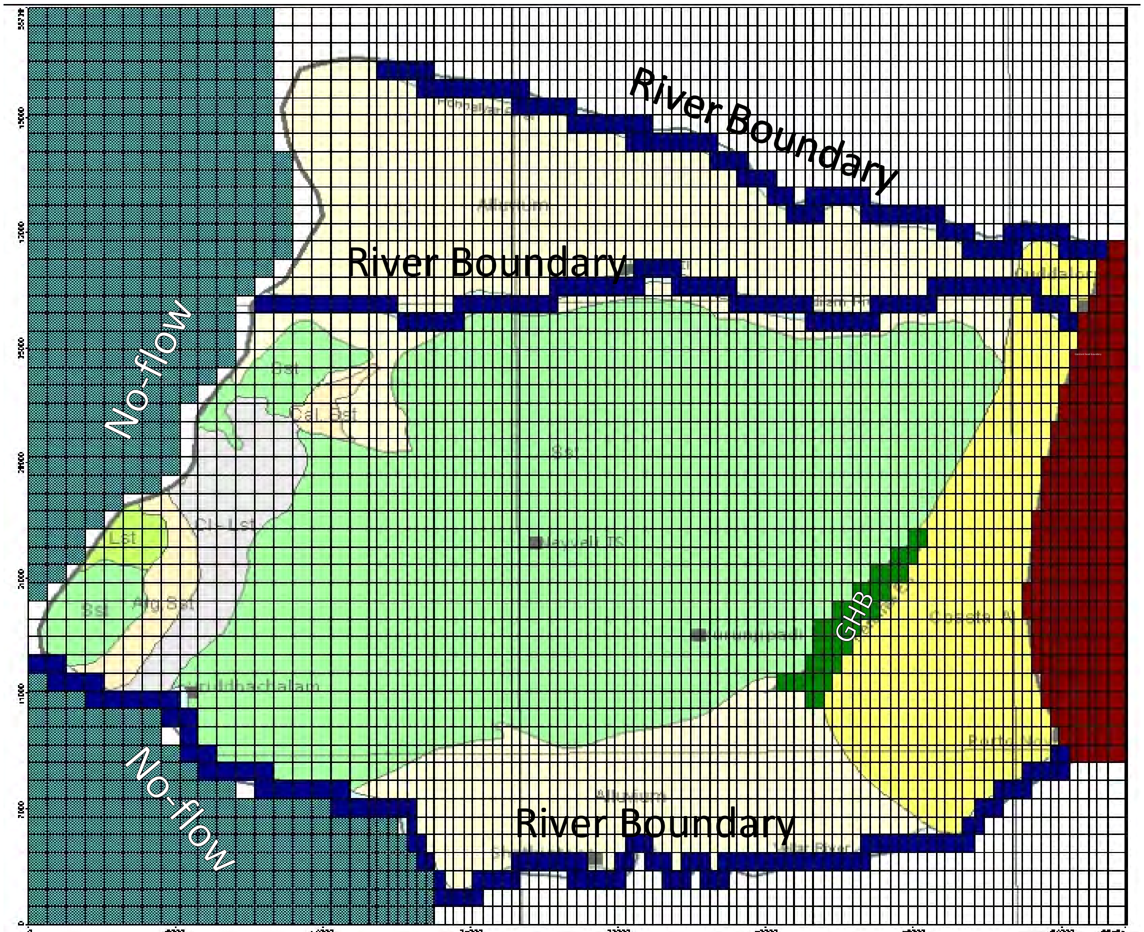
The boundary limit of the Cuddalore aquifer model along the north, south, east and west is shown as figure. The western boundary of the model corresponds to the physical limits of the aquifer.ThePonniyarriver along the north and the Vellar river along the south form the hydrogeological boundary, along the north and south respectively. The eastern margin of the aquifer is bounded by the Bay of Bengal (Sea) and was modeled as Constant Head Boundary with the head being maintained as mean sea level throughout the simulation period.(Figure 6.11)

6.13.1 Boundary Conditions

A variable head boundary, rather than a no-flow boundary was used in the northern and the southern model boundary to account for the inflow from and outflow to the adjacent Cuddalore aquifer. *(Table 6).*Groundwater along the western boundary and bottom boundaries of the model domain is simulated as no-groundwater flow boundary *(no-flow boundary)* as the quantity of water contributed by them is negligible. The lateral boundary along the north, south and eastern portion of the model domain is simulated as non-zero groundwater underflow (flow boundary).

The annual precipitation was considered spatially homogeneous but variable in time. The recharge was simulated to be the fraction of this precipitation not lost to the combined magnitude of runoff and vadoze zone evapotranspiration. Recharge to the water table was specified to the upper most active model finite-difference cell using Recharge package. This recharge flux simulates the fraction of the annual precipitation not lost to runoff and vadoze zone evapotranspiration and includes return flow from irrigation and recharge from tanks and ponds. Although this specified recharge flux is simulated as spatially homogeneous, it varies in time.

Figure.6.11: Finite-difference grid, Boundary conditions of Cuddalore aquifer model



6.14 Model aquifer structure

Model aquifer structure considerations include assigning top and bottom altitudes of the Cuddalore aquifer to model cells. Aquifer mapping studies (CGWB, 2012, 2013)carried out in the region revealed that the Cuddalore coastal aquifer is a multi-layered aquifer system consisting of four aquifer units (Aquifer unit I, II, III and IV). The aquifer unit – I is modeled as unconfined aquifer while the aquifer units II, III and IV are modeled as confined aquifer. The aquifer units (alluvium/sandstones) are separated by clay layer. The impermeable layer (clay), though are discontinuous at few places, it is assumed to be continuous in the model by assigning minimal thickness.

6.14.1 Aquifer top and aquifer Bottom altitudes

The altitudes of the aquifer top and aquifer bottom were specified for each active cell in the model grid. In the recharge zone, thealtitude of the top of the aquifer thickness coincides with the land surface altitudes. The thickness of the individual aquifer units in the northwestern part of the model area (recharge zone) is less than 10 meters, while away from the recharge zone, the thickness of these aquifer units varied from 20 to 80 meters in the tertiary upland have much layered thickness than the aquifer unit-I (unconfined) and aquifer unit –II (confined).(Figure 6.12a to h).

6.15 Model Hydraulic properties

The aquifer hydraulic properties specified in the model are horizontal hydraulic conductivity, storativity and specific yield. Hydraulic properties were assigned to each active cell and were assumed to represent average conditions within the cell. The distribution of hydraulic properties is based on the aquifer mapping, stratigraphic information from the wells as described in the previous chapters. The spatial distribution of hydraulic properties is simplified by defining zones in the model that generally follow hydrogeological units and in which the hydraulic properties are considered uniform. The hydraulic conductivity and specific yield and specific storage values assigned to each zone are initially based on independent information such as aquifer performance tests or historic data available in reports. The zonation of the hydraulic properties used for the model is shown for each model layer as*figure 6.13*.The transmissivity are computed by the model at each iteration as the product of horizontal hydraulic conductivity and saturated thickness. Saturated thickness is computed by the model on the basis of the aquifer top and bottom altitudes and the model computed hydraulic head. The transmissivity associated with the model cells in the unconfined aquifer unit of the Cuddalore aquifer (primarily the recharge zone) vary as the saturated thickness vary while the transmissitivies representing the confined part of the Cuddalore as well as the Neyveli aquifer are constant in time. The cuddaloreformations (sandstone) have hydraulic conductivity ranging between 45 and 60 m/day while the Neyveli formations (sandstone) have comparatively less hydraulic conductivity values (40 and 50 m/day). The comparatively low hydraulic conductivity of the Neyveli formation than the cuddalore formation is due to more compaction.(Annexure-XI)

Table 6.5: Summary of steady state model input of model boundaries based on the conceptual model boundary characteristics

Boundaries	Steady-state model input: Boundary characteristics (Numerical)		Inflow
	Spatial	Temporal	
Water-table boundary			
Precipitation recharge	Uniform	Constant	
Riverflow infiltration			
Ponnaiyar River	Nonuniform	Variable	
Gadilam River	Nonuniform	Variable	
Vellar River	Nonuniform	Variable	
Irrigation returnflow	Nonuniform	Variable	
Northwestern-Northern Boundary			
Ponnaiyar River	Uniform	Constant	
Southern Boundary			
Vellar River	Uniform	Variable	
Change in Aquifer	Uniform	Constant	
Base of the Aquifer	Uniform	Constant	
Outflow Boundaries			
Eastern Boundary	Uniform	Constant	
Groundwater Withdrawals			
Irrigation	Nonuniform	Variable	
Industrial	Nonuniform	Variable	
Mining activity	Nonuniform	Constant	
Drinking water supply	Nonuniform	Variable	

The 2nd, 4th and the 6th layers represent clay (impermeable) and the horizontal hydraulic conductivity are given as 2 m/day. The 1st, 3rd, 5th and the 7th model layer represents sandstone aquifer and the simulated hydraulic conductivity values are given as *Table .7.*The vertical hydraulic conductivity (Kz) is taken as 1/10th of the horizontal hydraulic conductivity.

Table.6.6 : The simulated Horizontal hydraulic conductivity (K_x and K_y) values.

Sl.No	Layer	Zone	Hydraulic Conductivity (m/day)
1.	1st (sand/sandstone)	1	90
		2	60
		3	45
		4	35
2.	3rd (Sandstone)	1	60
		2	45
3.	5th (Sandstone)	1	50
		2	45
4.	7th (Sandstone)	1	50
		2	45

The fault zone that runs parallel to the coast Is given the hydraulic conductivity value as that of the sandstone as the hydraulic properties of the formations show no variations as the sandstones on the either side of the fault are horizontally connected. *(Table. 5).*

6.15.1 Storativity

Storativity values including specific storage and specific yield were assigned to each active cell for the transient simulations. The specific yield values were assigned tothe layer I *(Sandstone)* representing the unconfined zone of the Cuddalore aquifer system. The specific yield values were given an 0.19 is recharge area while in the upland and coastal plain the specific yield values were given as 0.16*(Table.8).* The storativity values of the confined aquifers ranged between 1.4 x 10^{-3} to 9.1 to 10^{-5}*(Figure. 6.14)*

Table.6.8: The storativity values of the confined zones Cuddalore coastal aquifer system.

Sl.No	Layer	Zone	Storativity (S)
1.	1st (sand/sandstone)	Recharge	0.22
		Tertiary Upland	0.18
		Coastal Plain	0.17
2.	3rd (Sandstone)		$1.4x10^{-3}$ to $4.3x10^{-4}$
3.	5th (Sandstone)		$2.3x10^{-3}$ to $6.4x10^{-4}$
4.	7th (Sandstone)		$4.3x10^{-4}$ to $9.1x10^{-4}$

6.15.2 Recharge

The recharge rate during each stress period is specified for each active cell in the uppermost model layer (layer – I). Based on the soil type, geology and infiltration rates three recharge zones were deciphered in the model domain. (Figure.6.15). The recharge includes recharge from precipitation, irrigation return flow, recharge from tanks, ponds, recharge by rivers. The portion between Ponnaiyar and Gadilam river as Zone – A, the western portion as Zone – B and the central upland and coastal plain as Zone –C. (Table.9). The recharge values are assigned almost to the entire model area. Zone A and Zone B forms the major recharge zone wherein the recharge rate is quite high in comparison with the other region.

6.15.3 Discharge

Groundwater pumpage is the principal source of discharge from the aquifer system. The groundwater pumping is specified for each stress period in which the wells are located. In total, 2735 wells are specified in all the four Layers *(I, II, III and IV)*in the model*(Figure 16).*About 945 wells are specified in Layer –I representing Aquifer Unit -I, 1484 wells in Layer - III representing Aquifer Unit - II, 40 wells in Layer –V and 46 wells in Layer – VII representing Aquifer III and IV respectively*(Figure 17a & b).* Withdrawals were proportionately distributed across the model grid to those cells representing the field condition. The cells designated with irrigation withdrawals remained constant for the 2006 through 2013 period, although the irrigation withdrawal rates assigned to those cells changed by stress period. The annual well discharge estimates were subdivided into monthly amounts for the monthly stress periods in the Cuddalore aquifer model.*(Table.10, Annexure-I)*

6.16 Numerical Model Calibration

Model calibration was done to achieve the best fit of the simulated to observed water levels *(measured at discrete points in space and time).*Model calibration was done by trial and error method wherein the initial estimates of aquifer properties (K, Sy and Ss) were varied so as to bring out acceptable match between the measured and simulated hydraulic heads. The primary parameter varied during the steady state calibration was hydraulic conductivity, specific yield/storativity and river conductance. The primary parameter varied during the transient calibration Hydraulic conductivity and specific yield/storativity.

Also, recharge rates were also marginally adjusted at few locations. The final distributions (spatial and vertical) of the hydraulic conductivity storativity and recharge result from the outcome of trial-and-error calibration. During calibration, the input data was adjusted to minimize differences between simulated and measured hydraulic heads.

Table .6.8Simulated recharge values(m^3/day) of Cuddalore aquifer system.

year	Zone	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
2006	Zone A	0	0	0	0	0	0	0	0.005478	0.006864	0.00166	0.001483	0.006461	0.021946
	Zone B	0	0	0	0	0	0	0	0.00498	0.00624	0.001509	0.001348	0.005874	0.019951
	Zone C	0	0	0	0	0	0	0	0.0012	0.00115	0.009852	0.0041	0.001943	0.018245
2007	Zone A	0	0	0	0	0	0	0	0.006985	0.006061	0.001524	0.00605	0.010846	0.031466
	Zone B	0	0	0	0	0	0	0	0.00635	0.00551	0.001385	0.0055	0.00986	0.028605
	Zone C	0	0	0	0	0	0	0	0.001325	0.001242	0.001398	0.003778	0.002275	0.010018
2008	Zone A	0	0	0	0	0	0	0	0.007029	0.007451	0.001126	0.002387	0.007174	0.025168
	Zone B	0	0	0	0	0	0	0	0.00639	0.006774	0.001024	0.00217	0.006522	0.02288
	Zone C	0	0	0	0	0	0	0	0.00117	0.001648	0.002128	0.003418	0.001107	0.009472
2009	Zone A	0	0	0	0	0	0	0	0.0066	0.006593	0.005687	0.002034	0.009757	0.030671
	Zone B	0	0	0	0	0	0	0	0.006	0.005994	0.00517	0.001849	0.00887	0.027883
	Zone C	0	0	0	0	0	0	0	0.001158	0.00158	0.002242	0.003397	0.001152	0.009528
2010	Zone A	0	0	0	0	0	0	0	0.006	0.005994	0.00517	0.001849	0.00887	0.027883
	Zone B	0	0	0	0	0	0	0	0.00625	0.006364	0.00694	0.001713	0.002178	0.023445
	Zone C	0	0	0	0	0	0	0	0.00111	0.001517	0.002248	0.002773	0.001151	0.008799
2011	Zone A	0	0	0	0	0	0	0	0.006481	0.008787	0.001107	0.001715	0.006076	0.024166
	Zone B	0	0	0	0	0	0	0	0.005892	0.007988	0.001006	0.001559	0.005524	0.021969
	Zone C	0	0	0	0	0	0	0	0.00117	0.001648	0.002128	0.003418	0.001107	0.009472
2012	Zone A	0	0	0	0	0	0	0	0.006435	0.008492	0.001161	0.001705	0.006272	0.024065
	Zone B	0	0	0	0	0	0	0	0.00585	0.00772	0.001055	0.00155	0.005702	0.021877
	Zone C	0	0	0	0	0	0	0	0.001158	0.00158	0.002242	0.003397	0.001152	0.009528
2013	Zone A	0	0	0	0	0	0	0	0.006304	0.008169	0.001164	0.001411	0.006272	0.023319
	Zone B	0	0	0	0	0	0	0	0.005731	0.007426	0.001058	0.001283	0.005702	0.0212
	Zone C	0	0	0	0	0	0	0	0.00111	0.001517	0.002248	0.002773	0.001151	0.008799

Table.6.9 The groundwater withdrawal from the Cuddalore aquifer by Hydrogeological unit wise.

Aquifer	Hydrogeologic Unit	Irrigation	Industrial (mcm/year)	Domestic
Sand/sandstone	**Aquifer - I**	393.0	0.8	30.0
Sandstone	**Aquifer -II**		611.65	1.2
Sandstone	**Aquifer-III**		31.0	133.10
		confined		
Sandstone	**Aquifer-IV**			12.79*
Sandstone	(Aquifer – V)		(no groundwater withdrawal exists)	
Total		1035.69	135.10	42.79

*Groundwater withdrawal for drinking water supply to Chennai city during lean periods.

Within the model domain, 42 observation wells exists *(representing all 4 aquifer units modelled)* and the hydraulic heads of these observation wells have used for calibration. The observation wells are screened in more than one aquifer were not considered for calibration process, since, the screens of these wells tap more than one aquifer units. The number of the observation wells and their water level observations in each hydrogeological unit *(aquifer units)* that were used in the calibration is given as table 11.

Table: 6.10 Number of observation wells associated with aquifer units

Hydrogeological Unit	Hydrogeological Unit Name	Observations
1	Upper Cuddalore (Aquifer – I)	11
2	Lower Cuddalore (Aquifer –II)	07
3	Upper Neyveli (Aquifer – III)	11
4	Middle Neyveli (Aquifer –IV)	09

The steady state simulation was calibrated by varying the simulated recharge rates, hydraulic conductivities and storability values.*(Table.12)*

Table 6.11 : summary of changes from the initial values for steady state calibration.

Parameter	Changes in parameter from Initial values taken as input
Recharge rate	Decreased by 10 percent in region between Ponnaiyar and Gadilamriver and 10 percent near coast.
Hydraulic conductivity(K)	Decreased near the coastal region of the model domain by 5 m/day.
Specific Yield (S_y)	Decreased from 0.21 to 0.17 in the region along coast of the model domain.

6.16.1 Steady state simulation

The steady state calibration period of the Cuddalore aquifer model was 2006-07. The period 2006-07 were taken because theaverage rainfall for this period was near the 30 year normal (1290 mm) and sufficient water level/piezometric head of all four aquifer units was available and groundwater fluctuation was also representative of the normal year. The model was simulated by taking the water table/piezometric head value of January 2006.

Aquifer - I

The *Aquifer unit – I* through regionally extensive beneath the Cuddalore coastal plain, it is relatively thin along the Ponnaiyar river with corresponding low transmissivity. The simulated water tablefor the steady state stress period (January 2006) is shown as figure6. 19a. The simulated water level responds to simulated changes in annual recharge and observed changes in the water levels. Differences between the steady state and stress periods of the transient simulation is largely because of the simulated differences in recharge and stress periods.

Aquifer - II

The simulated hydraulic heads of aquifer – II for steady state stress period *(January 2006)* is depicted as *figure20b* .The simulated hydraulic head had acceptable match with the observed hydraulic head. The groundwater withdrawal for irrigation began to increase since late 70's due to construction of more tubewells and energisation of dugwells led to steady decline in groundwater levels in Lower Cuddalore aquifer. As a result the regional groundwater flow direction has changed from the pre-pumping conditions. Figure.6.20a depicts the hydraulic heads measured in the observation well corresponds with the simulated values.

Aquifer - III

The groundwater withdrawal in this aquifer exists only in the central portion where lignite is encountered through open cast mine. *(Neyveli region).* Only 20 percent of the irrigation well withdraws groundwater from this aquifer. (Figure 6.19c)

Except for a 2 observation wells located near the western region of the model domain, the fit of simulated to observed hydraulic heads is acceptable. The simulated hydraulic heads show 3 to 5 meters above the observed hydraulic heads. Uncertainty of the hydraulic conductivity and storativity values in the western region account for the differences between water levels simulated and observed. (Figure 21b)

Aquifer - IV

Groundwater withdrawal for drinking water supply to Chennai city is from this aquifer (central region). In general, the simulated water level match with the observed hydraulic heads (Figure 20d). However, the hydraulic head along the northwestern zone of the model finds mismatch with the observed hydraulic head by 3 to7 meters. (Figure6. 21c)

6.17 Water Budget

Water – budget components for the Cuddalore aquifer model was calculated with the programme ZONEBUDGET *(Harbaugh, 1990)* for the steady state and transient periods.

Table.6.13 : Steady state water –budget components for the model domain (Jan 2006).

Component	Volume (m^3/day)
Inflows	
Recharge to water table	0.0
Simulated rivers	11.72
Total	7.86×10^{8}
Outflows	
Groundwater withdrawal though pumping	8.38×10^{7}
Evapotranspiration	4.03×10^{4}
Total	7.86×10^{8}
IN – OUT	-755.00

6.17.1 Steady-state water budget

For the initial (steady-state) model stress period, the specified annual recharge flux to the water table is equivalent to 13percent of the average precipitation to the model area. Of the simulated recharged groundwater, a substantial fraction is lost as evapotranspiration from the water table.

6.17.2 Transient state water budget

During the transient simulation, the volume of the simulated recharges increases or decreases between stress periods. The simulated evapotranspiration changes in response to the different head in the uppermost active model layer. Further, the variations in recharge result in smaller changes in storage and flow thorough head dependent boundaries which also respond to the changes in specified pumpage. The transient budget components of the model is given as table.14 and Figure 22a & b.

Table.6.14 : Transient water budget components of Cuddalorecoastalaquifer.

	2010	2012
Component	Volume (m^3/day)	Volume (m^3/day)
Inflows		
Recharge to water table	$4.77x10^6$	$3.2x10^6$
River leakage	$3.22x10^2$	$3.84x10^2$
General Head	0.00	0.00
Total	$8.04x10^6$	$5.76x10^6$
Outflows		
Groundwater withdrawal though pumping	$1.84x10^6$	$8.3x10^5$
River leakage	$3.543x10^3$	$5.179x10^3$
General Head	$3.35x10^5$	$3.6x10^5$
Total	$8.04x10^6$	$5.7x10^6$
IN – OUT	50.0	25.0

The budget differences between the steady state and transient stress periods are given as table 15.

Table :6.15 Steady state and transient water budget components of Cuddalore aquifer.

Component	May-2006 Volume (m^3/day)	May- 2012 Volume (m^3/day)
	Inflows	
Recharge to water table	0.00	0.00
Simulated rivers	6.90	5.58
Total	$4.94x10^6$	$6.68x10^6$
	Outflows	
Groundwater withdrawal though pumping	$8.84x10^5$	$2.41x10^6$
Evapotranspiration	$1.47x10^6$	$2.69x10^6$
River leakage	$2.620x10^3$	$3.729x10^3$
Total	$4.94x10^6$	$6.68x10^6$
IN – OUT	79.00	-536.00

The average Darcy velocities simulated for the four aquifer units of the Cuddalore aquifer model is given in table 16. Zone budget for aperiod of excess rainfall (year 2008) and deficit rainfall (year 2007) is given in table 17a & b.

Table 6.16. Simulated Darcy velocities for the Cuddalore Aquifer System, Tamilnadu

Sl.no	Aquifer unit	V_x (m/d)	V_y (m/d)	V_z (m/d)	V_{total} (m/d)
1	Upper Cuddalore Aquifer**(Aquifer Unit–I)**	0.21	-0.16	0	0.483
2	Lower Cuddalore Aquifer **(Aquifer Unit-II)**	0.002	-0.129	0	0.21
3	Upper Neyveli Aquifer **(Aquifer Unit-III)**	0.0296	-0.21	-0.23	1.233
4	Middle Neyveli Aquifer **(Aquifer Unit-IV)**	0.025	-0.16	0.61	1.29

Table .6.17a: Simulated Zone Budget (m^3/day) for year 2008 (excess rainfall period)

Month		Recharge	River Leakage	Wells	ET	Total	Difference
JAN	INFLOW	1.68×10^6	5.04	0	0	2.09×10^7	15.05
	OUTFLOW	0	4.90×10^2	8.0×10^5	0	2.09×10^7	
FEB	INFLOW	0	5.57	0	0	6.06×10^6	-29.41
	OUTFLOW	0	4.47×10^2	8.0×10^5	6.42×10^5	6.06×10^6	
MAR	INFLOW	0	5.5	0	0	5.46×10^6	-98.31
	OUTFLOW	0	4.21×10^2	8.0×10^5	5.11×10^5	5.46×10^6	
APR	INFLOW	0	5.61	0	0	5.05×10^6	22.74
	OUTFLOW	0	4.04×10^2	8.0×10^5	3.97×10^5	5.05×10^6	
MAY	INFLOW	0	5.64	0	0	4.72×10^6	0.94

	OUTFLOW	0	3.90×10^{2}	8.0×10^{5}	2.98×10^{5}	4.72×10^{6}	
JUN	INFLOW	0	5.74	0	0	5.55×10^{6}	-10.1
	OUTFLOW	0	3.73×10^{2}	2.29×10^{5}	2.56×10^{5}	5.55×10^{6}	
JULY	INFLOW	0	5.75	0	0	5.40×10^{6}	17.1
	OUTFLOW	0	3.62×10^{2}	2.29×10^{6}	2.75×10^{5}	5.40×10^{6}	
AUG	INFLOW	0	5.77	0	0	5.31×10^{6}	-79.86
	OUTFLOW	0	3.48×10^{2}	2.29×10^{6}	2.96×10^{6}	5.31×10^{6}	
SEP	INFLOW	1.08×10^{7}	5.57	0	0	1.43×10^{7}	-152.2
	OUTFLOW	0	4.88×10^{2}	1.78×10^{6}	0	1.43×10^{7}	
OCT	INFLOW	1.14×10^{7}	12.94	0	0	1.48×10^{7}	-81.79
	OUTFLOW	0	7.11×10^{2}	1.73×10^{6}	0	1.48×10^{7}	
NOV	INFLOW	2.75×10^{6}	12.60	0	0	6.60×10^{6}	60.46
	OUTFLOW	0	8.24×10^{2}	1.73×10^{6}	0	6.60×10^{6}	
DEC	INFLOW	5.96×10^{6}	11.90	0	0	9.25×10^{6}	-20.88
	OUTFLOW	0	1.19×10^{3}	1.73×10^{6}	0	9.25×10^{6}	

Table.6.17b : Simulated Zone Budget (m^3/day) for year 2007 (deficient rainfall period)

Month		Recharge	River Leakage	Wells	ET	Total	Difference
JAN	INFLOW	1.03×10^{7}	5.85	0	0	1.97×10^{7}	20.1
	OUTFLOW	0	2.74×10^{2}	8.0×10^{5}	0	1.97×10^{7}	
FEB	INFLOW	0	5.97	0	0	9.67×10^{6}	-2.6
	OUTFLOW	0	2.49×10^{2}	8.0×10^{5}	1.71×10^{5}	9.67×10^{6}	
MAR	INFLOW	0	5.99	0	0	8.6×10^{6}	-78.1

	OUTFLOW	0	2.37×10^2	8.0×10^5	1.61×10^5	8.6×10^6	
APR	INFLOW	0	6.01	0	0	7.78×10^6	8.9
	OUTFLOW	0	2.32×10^2	8.0×10^5	1.47×10^5	7.78×10^6	
MAY	INFLOW	0	6.01	0	0	7.11×10^6	-16.1
	OUTFLOW	0	2.28×10^2	8.0×10^5	1.25×10^5	7.11×10^6	
JUN	INFLOW	0	6.01	0	0	7.84×10^6	-22.1
	OUTFLOW	0	2.23×10^2	2.15×10^5	1.15×10^5	7.84×10^6	
JULY	INFLOW	0	6.11	0	0	7.26×10^6	-24.9
	OUTFLOW	0	2.19×10^2	2.29×10^6	1.37×10^5	7.26×10^6	
AUG	INFLOW	0	6.01	0	0	6.93×10^6	15.1
	OUTFLOW	0	2.16×10^2	2.29×10^6	1.57×10^5	6.93×10^6	
SEP	INFLOW	1.08×10^7	6.01	0	0	1.67×10^7	-19.6
	OUTFLOW	0	2.26×10^2	1.83×10^6	0	1.67×10^7	
OCT	INFLOW	9.39×10^6	13.7	0	0	1.42×10^7	27.45
	OUTFLOW	0	$2.4.0 \times 10^2$	1.73×10^6	0	1.42×10^7	
NOV	INFLOW	3.87×10^6	13.52	0	0	8.73×10^6	-58.1
	OUTFLOW	0	2.95×10^2	1.73×10^6	0	8.73×10^6	
DEC	INFLOW	9.35×10^6	13.3	0	0	1.37×10^7	-65.5
	OUTFLOW	0	3.47×10^2	1.73×10^6	0	1.37×10^7	

Data limitations included a) uneven spatial distribution of wells and boreholes, aerially and vertically b) uncertainties arising from partial penetration of well that complicate interpretations of water level in few locations and c) discontinuous or nonexistent hydrologic records.

6.18 Aquifer Management Plan though numerical modeling

Aquifer Management Plan for Cuddalore aquifer system is evolved by taking into account of the hydrogeologic characteristics of groundwater development, such as link between groundwater withdrawal and groundwater discharge, the effect of increased pumping of existing groundwater users and impact of groundwater withdrawals more particularly on farmers. However, the important issue in testing future groundwater development scenarios for Cuddalore aquifer system is the impact of increased pumping on groundwater for irrigation and pumping in and around Neyveli for safe mining of lignite.

The numerical model developed for Cuddalore aquifer system is subjected to various stress scenarios (all groundwater development scenarios) so as to understand the implications of groundwater withdrawal. More importantly, subjecting aquifer to different hydrological stress would first help in understanding the regional groundwater system and how the groundwater aquifer be managed efficiently.

The management model needs to address the Management variables that can be specified that includes groundwater withdrawal from each aquifers or aquifer units. The types of constraints that can be specified include upper and lower bounds on pumping, water-supply demands, hydraulic-head constraints such as drawdowns and hydraulic gradients. As mentioned earlier in the report, the Cuddalore aquifer system has four aquifer units. Viz.UpperCuddalore Aquifer *(Aquifer Unit – I),* Lower Cuddalore Aquifer *(Aquifer Unit – II),* Upper Neyveli Aquifer *(Aquifer Unit – III)* and Middle Neyveli Aquifer *(Aquifer Unit – IV)*. The principal aquifer of the Cuddalore aquifer system is the sandstone. The aquifer unit – I is utilized for domestic and irrigation purpose, aquifer unit – II is used mainly for irrigation , aquifer unit – III is for mining activity and aquifer unit – IV is for drinking water supply to Chennai city during lean periods. Thus all the four aquifer units are utilized for specific purpose. The predictive simulations are carried out taking into consideration of the utility of the aquifer for different sectors. The response of the four aquifer units (I, II, III and IV) of the Cuddalore aquifer system to various hydrological stress has led to establish aquifer management plan.

6.18.1 Predictive simulations

The primary objective of this groundwater model development is the application of the calibrated model to the assessment of projected changes in water levels caused by projected groundwater usage patterns.

The calibrated model was used to simulate the impacts of projected rates of groundwater pumping for the next 12 years (from 2013 to 2025) upon water levels and flow rates within the Cuddalore aquifers system. This was done in five scenarios using different assumptions, mainly change in groundwater withdrawal that is likely to happen in future.

a) Model forecast with present rate (Year 2013) of groundwater withdrawal

The Cuddalore aquifer system is the most potential aquifer in Tamil Nadu state, India. As more than 80 percent of groundwater withdrawal from the Cuddalore aquifer system accounts for irrigation, there has been much concern amongst farmers regarding decline of groundwater level. In specific, the decline in the Piezometric head of Aquifer Unit – II is of great concern` to the water managers, planers and general public.

The model was run to predict the groundwater head upto 2025 by assuming that the annual groundwater withdrawal from the Cuddalore aquifer system is 1231.58 mcm continues upto 2025. The monthly average rainfall computed for normal year is given as input to the model. The groundwater withdrawal pattern for the year 2013 was given to the model upto 2025. The projected groundwater head shows that no noticeable change in the peizometric head and flow pattern and in all the four aquifer units.(figure)However, the projected groundwater head for aquifer unit – II at few pockets where withdrawal is high.

This implies that, for the annual groundwater withdrawal of 1213.58 MCM *the Cuddalore aquifer system is safe.*

b) Increase in groundwater pumpingfor irrigation.

As mentioned earlier in the report, the Cuddalore aquifer system is subjected to stress since 1961. Since then the groundwater withdrawal (depressurization activity) for safe mining of lignite around Neyveli started. The groundwater withdrawal increased multifold for irrigation with the energisation of wells since 1970. The total annual groundwater withdrawal in the model is 1213.58 MCM.

About 97 percent of annual groundwater withdrawal (1034 MCM) for irrigation is from Upper Cuddalore aquifer (Aquifer Unit – I) and Lower Cuddalore (Aquifer Unit - II). While the Upper Neyveli aquifer (Aquifer Unit – III) substantiates only 3 percent for groundwater withdrawal for irrigation. The Middle Neyveli Aquifer (Aquifer Unit –IV) is devoid of groundwater withdrawal for irrigation activity. Thus, the Aquifer Unit I and II have been subjected to stress (groundwater withdrawal for irrigation) since 1970. As a result, groundwater decline has been noticed in very few isolated pockets in aquifer unit – I and few locations in aquifer unit – II.

The above situation infers that the groundwater withdrawal for irrigation in Lower Cuddalore aquifer (Aquifer Unit – II) exceeds the natural recharge by 0.15 times and most pumping is supplied by depletion of aquifer storage. Therefore, the groundwater withdrawal from Aquifer Unit I and II need to be carefully managed to prevent pumping water levels in wells from declining to the depth near the bottom of wells making them unusable (low yield). In areas with low recharge and high pumpage, the water managers need to consider pumping rates, pumping times and areal distribution of wells, so that water level decline due to pumping well will not go dry. The calibrated model developed for Cuddalore aquifer system were thus used to project the future groundwater levels/heads in Aquifer Unit I and II as this would lead to formulate groundwater management strategies or aquifer management plan.

The farmers in the model area tap groundwater for irrigation activity from Aquifer Unit I and II. Paddy and sugarcane are the major crops irrigated by groundwater. The demand for cultivating more sugarcane has increased amongst farmers during the last 10 years. This shall lead to withdraw more groundwater by the farmers for irrigation and if the yield of the existing tubewells decline, the farmers may construct additional new tubewells more particularly in Aquifer Unit – II. Thus, the demand for groundwater withdrawal for irrigation shall escalate from 1034 to 1384 mcm annually. As mentioned earlier, the dugwell/open well of the aquifer unit –I and Tubewells of the aquifer unit – II show marginal decline in groundwater head by 0.10to 0.20 m annually. If the groundwater withdrawal by farmers is increased to 1384 mcm/year (i.e., 30 % increase) the rate of groundwater decline shall be more that the present rate.

With this background the calibrated model of the Cuddalore Aquifer system was subjected to stress so as to find out the response of the aquifer system to the increase in pumping rate by 350 mcm from the present groundwater withdrawal of 1213.50 mcm/yr. The aquifer – II was subjected to additional annual groundwater withdrawal of 350 mcm. Thus the total annual groundwater pumping from all the four aquifer units is 1563.58 mcm. The recharge rates and other parameters remained the same. The projected groundwater head though mimics the groundwater head pattern but the rate of decline of the peizometric head of Aquifer Unit – II increased by 0.20and0.30 m annually.

Before predevelopment, the tubewells constructed in aquifers unit –II were free flowing wells *(the piezometric heads were 20 to 30 m amsl).* The present piezometric head of Aquifer Unit – II ranges between 10 and 15 m amsl. The predevelopment saturated thickness of Aquifer Unit – I was around 30 to 50 m. The saturated thickness of the Aquifer Unit – II (confined) ranged between 25 and 80 m. The model had predicted that the decline in piezometric head for groundwater withdrawal of 1563.58 mcm for 12 year period was 0.20 to 0.30 m annually. `

The sustainable yield of the aquifer for management purpose can be defined as the rate at which water can be withdrawn from the aquifer indefinitely without lowering water levels to less than half the predevelopment saturated thickness of the aquifer. As the Aquifer Unit-II is confined, this may not suite, however for estimating the sustainable yield of the confined aquifer, the definition can be modified as follows "The sustainable yield of the confined aquifer can be defined as the rate at which the water can be withdrawn from the confined aquifer indefinitely without lowering the piezometric heads to less than half the predevelopedpiezometric heads. If the projected rate of decline (0.20 to 0.30 m annually) by the model upto 2025 is linearly extended, the piezometric level shall decline to half in next 20 years from 2025 if the groundwater withdrawal rate of 1213.58 mcm annually continued upto 2045.

Thus, the aquifer unit – II becomes unsafe by 2045 for the groundwater withdrawal rate of 1563.58 mcm annually while the remaining aquifer units (I, III and IV) remains safe throughout.

c) Increase in pumping for mining activity

The groundwater withdrawal in Aquifer Unit – III is confined to Neyveli lignite mine area and nearby. The total groundwater pumping *(depressurization)* for mining of safe lignite is 133.10mcm.In near future, there is a plan to expand mine activity by going in for new mines. This might led to pumping of mine groundwater for safe mining of lignite. With this background, the aquifer Unit III was subjected to stress wherein the annual groundwater withdrawal in aquifer Unit –III was increased by 60 and 130 mcm. The model was run upto 2025 with the recharge rate of 2013. The projected piezometric head of Aquifer Unit – III show no change in head and groundwater flow pattern. However, there was a minimal shift of contour which on analysis infers that the cone of depression enlarged by 100 m for an increase in groundwater pumping by 60 mcm and 200 m for increase in groundwater pumping by 133 mcm annually.

It can be concluded; the aquifer unit III remain safe for an increase in groundwater withdrawal by 60 and 130 mcm annually.

d) Increase in pumping for Drinking water supply.

The groundwater in the aquifer unit – IV is withdrawn for drinking water supply to Chennai city during lean periods or during period when the water level in the reservoirs around Chennai city goes alarmingly low due to failure of monsoon. The groundwater withdrawal in

Aquifer Unit –IV occurs in the central portion of the area which is 20 to 25 kms away from the coast.The total annual groundwater withdrawal is 12.79 mcm. If in near future, drought persists around Chennai city, the demand for drinking water from this aquifer shall increase. Anticipating this scenario, the model was run upto 2025 with an increase in annual groundwater withdrawal by 6 mcm. The total annual groundwater withdrawal of the model was 1231.58 mcm.

The model predicted no significant change in piezometric head indicating that the aquifer unit – IV continues to be safe with annual groundwater withdrawal of 18.79 mcm from aquifer unit – IV.

e) Increase in pumping along the coast:

As the Cuddalore aquifer system is a coastal aquifer; increase in pumping activity along the coast or nearby shall lower the peizometric head. This might lead to reversal of hydraulic gradient or upconing or advancement of saltwater wedge inward. It is also to mention that the aquifer near the coast is presently less developed. In near future, pumping activity is likely to increase as many more industries are likely to establish all along the coast. Hence, groundwater pumping along the coast was increased by 100 mcm within aquifer unit – II so as to assess the response of the aquifer – II. The projected peizometric head showed no change in its pattern and level. This implies that the aquifer Unit – II can still be safe. The piezometric head of the aquifer unit – II and III along the coast is -9 and -14 m while the top of the aquifer unit –II and III is -120 and -160 m respectively.

For management purpose, it is considered that the aquifer unit is safe when the peizometric head of the aquifer unit is above half of the pre-development peizometric head. By this evaluation, the peizometric heads of all the confining aquifer units (II, III and IV) of the cuddalore aquifer system near to the coast*(5 km from coast)*has peizometric head above half of the predevelopment piezometric head and can be considered to be safe even with annual total groundwater withdrawal of 1213.58 mcm.

f) Model forecast with drought year once in four years

The rainfall analysis infers that it is difficult to conclude that there are no periods of five successive years during which the rainfall is generally above the arithmetic mean in 40 year period (1971 – 2010). Also, there are no periods over two years when the rainfall is generally less than the arithmetic mean. The drought analysis infers that the model area experiences moderate drought (25 to 50 percent from the percentage of departure) once in 4 years. By considering into the above, the model was run upto 2025 with reducing the recharge rate once in 4 years by 25 percent. Thus at every 4^{th} year the recharge rate was taken as 11.5 percent of total annual rainfall. The stress condition of the year 2013 was continued upto 2025. The groundwater withdrawal of the year 2013 was given to the model. *The response of the hydraulic head in all the four aquifer units shows no response.*

g) Increase in the recharge:

The simulated recharge to the cuddalore aquifer system is 14 % of the total annual precipitation. The frequency of the rainfall above the normal is quite high within the model area. The annual rainfall above 1700 mm shall have much influence on the groundwater regime. Hence, the model was run upto 2025 by considering rainfall above normal during these periods. Rainfall recharge greater by 10 percent of the total recharge rises the piezometric head by 1 to 1.5 meters in Aquifer – I and 0.5 – 1 meters in Aquifer – II

The model is much sensitive to the recharge as it responds even to 5 % increase in the recharge rate. Hence, any recharge activity undertaken in the model area shall be effective and can be taken up when the groundwater heads of aquifer unit – I and II lowers beyond the threshold limit as discussed earlier.

The model was also subjected to maximum stress condition (increase in groundwater withdrawal) so as to find the decline in peizometric head and its implication on groundwater environment.

S. No	Management Options	Groundwater withdrawal as on Dec 2013 mcm/year	Impact on Aquifer Units			
			Aquifer Unit –I	Aquifer Unit –II	Aquifer Unit -III	Aquifer Unit-IV
All Aquifer Units						
1.	Future projection upto year 2025 with present rate of groundwater pumping.	1213.58	No significant change	**Head decline 0.10 to 0.20 m /yr**	No significant change	No significant change
2.	Drought Occurrence once in four years with present rate of pumping.	1213.58	No significant change	No significant change	No significant change	No significant change
Aquifer I & II						
3.	350 mcm/year increase in irrigation pumping from AQ-I & II (1213.58 + 350 mcm)	1213.58	**Head decline 0.10 to 0.20m /yr**	**Head decline 0.20to 0.30 m /yr**	**No significant change**	**No significant change**
4.	Increase in groundwater pumping for industrial activity along the coastal tract by 100 mcm from aquifer-II (proposal for SEZ zone and textile sipcot)	1213.58	No impact	**Head decline 0.10 to 0.20 m/yr**(impact 0 – 5 km along the coastal tract)	**No Impact**	**No Impact**

S. No	Management Options	Groundwater withdrawal as on Dec 2013 Mcm/year	Impact on Aquifer Units			
			(Aquifer Unit –I)	(Aquifer Unit –II)	(Aquifer Unit -III)	(Aquifer Unit-IV)
Aquifer Unit III						
5	Increase in annual groundwater pumping for mining activity by 60 mcm from Aquifer-III (133 + 60 mcm) (proposal for expansion of mine (mine III)	1213.58 (Neyveli pumping : 133.10 mcm/yr)	No impact	Cone of depression increased by 100 m. (impact around 2 km radius)	Cone of depression increased by 200 m. (impact around 2 km radius)	No Impact
6	Increase in annual groundwater pumping for mining activity by 130 mcm from Aquifer-III (133 + 130 mcm) (proposal for expansion of mine (mine III & IIIA)	1213.58 (Neyveli pumping : 133.10 mcm/yr)	No impact	Cone of depression increased by 100 m. (impact around 2 km radius)	Cone of depression increased by 200 m. (impact around 2 km radius)	No Impact
Aquifer IV						
7	Increase in annual groundwater withdrawal by 6 mcm from Aquifer – IV (12.79 + 6 mcm/yr) During drought period in chennai	1213.58 (Drinking water supply : 12.79 mcm/yr)	No impact	No impact	No Impact	No Impact

S. No	Management Options	Aquifer unit-I	Aquifer Unit-II	Aquifer Unit-III	Aquifer Unit-IV
Vulnerability		Domestic and Irrigation	Irrigation and Industrial	Mining activity and irrigation	Drinking water supply to Chennai city
1	Threat of sea water intrusion	Vulnerable (0 – 5 km from coast)	Vulnerable (0 – 5 km from coast)	Vulnerable (0 – 5 km from coast)	Vulnerable (0 – 5 km from coast)
2	Decline in Groundwater level	Vulnerable in central portion	Entire aquifer Vulnerable	NO	NO
3	Management option	1. Change in crop that requires less water than paddy and sugarcane need to be adopted following the drought year. 2. Periodic Monitoring for water level and quality along the coast.	1. Change in crop that requires less water than paddy & sugarcane need to be adopted following the drought year. 2. Periodic Monitoring for Piezometric Head and quality along the coast.	Periodic Monitoring for water level and quality along the coast and around Neyveli Lignite Mine.	Periodic Monitoring for water level and quality along the coast.

Limitations of the model:

The model output is based on the data available with the central Ground Water Broad and state agencies. Accordingly the aquifer management plan is prepared. However, the model has its limitations regarding information on recharge rate and specific yield/storativity of the aquifers. Hence, further studies on isotope hydrology and aquifer performance test can be carried out in places of uncertainty within the model domain. The additional data thus generated can further enable to refine the model and thus shall add to the efficiency of the model than the present.

Chapter 7.Groundwater Management Plan and Recommendations

The aquifer management plan for the Cuddalore coastal aquifer system primarily based on aquifer mapping studies, responses of the Cuddalore aquifer system to various stress conditions, and taking into account of the information gathered in field survey. From the aquifer mapping and aquifer management plan studies through numerical modelling, the following are the conclusions and management plan suggested for implementation.

a. The Cuddalore coastal aquifer system has sandstone as principal aquifer consisting of 4 aquifer units (multi-layered aquifer system). They are highly potential and most prolific aquifer system in the state.
b. The present annual groundwater withdrawal from the Cuddalore coastal aquifer system is 1213.58 mcm.
c. The four aquifer units (I, II, III and IV) within the principal sandstone aquifer are safe with the present annual rate of groundwater withdrawal (1213.58 mcm) and no threat of sea water intrusion exists.
d. The positive pressure head near to the coast and the fresh water flow towards the sea suggest that the hydraulic gradient is towards the sea. It is suggested to construct Piezometers (monitoring wells- aquifer unit wise) along the coast to monitor the peizometric head and alert the local administration in case of sea water intrusion in near future due to reversal in hydraulic gradient.
e. Aquifer unit – I and II are vulnerable to sea water intrusion along the coast (0 – 10 km) if the groundwater withdrawal increases by 350 mcm along the coast from present level of pumping. Reversal in hydraulic gradient (sea water intrusion) may take place if total annual groundwater withdrawal from the entire aquifer exceeds by 700 mcm for Aquifer – I & 900 mcm for Aquifer – II.

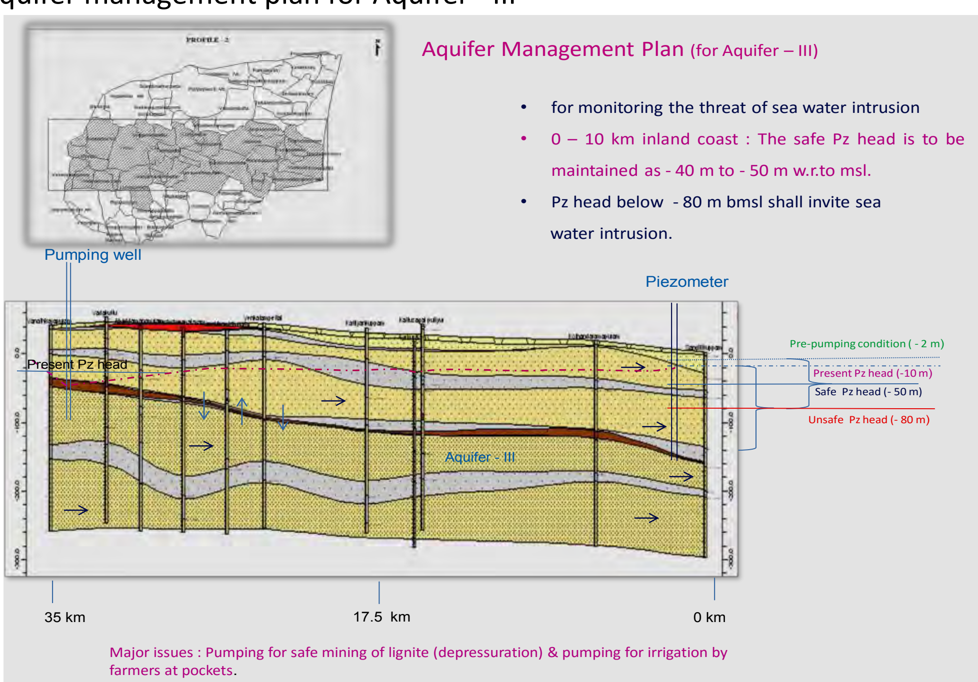
f. The safe piezometric head for individual aquifer units need to be maintained so as to efficiently manage all the four aquifer units. The safe piezometric head of individual aquifer units that needs to be maintained between coast and 10 km inland is given as table.7.1

Table 7.1 Safe Peizometric head of individual aquifer units (0-10 km from Coast)

Aquifer Units	Present water level / Piezometric Head (in msl) (0 – 10 km from coast)	Safe Piezometric Head (in msl)
Aquifer – I	0 to 2 m	Above msl.
Aquifer – II	-5 to - 15 m	- 40 m
Aquifer – III	-20 to - 30 m	- 60 m
Aquifer – IV	-5 to – 20 m	- 70 m

g. Groundwater for safe mining of lignite from Aquifer Unit – III is being pumped out since 1950 around Neyveli Region which is 32 km away from the coast. The present annual groundwater withdrawal from aquifer –III is 120.8 mcm per annum. There is a perception that continuous groundwater withdrawal (depressurization) for mining activity may lower peizometric head and would invite sea water intrusion. Hence, a management plan for Aquifer Unit – III was conceived (Figure7.1) so as to address the threat of sea water intrusion due to continuous groundwater withdrawal from aquifer unit - III for safe mining of lignite around Neyveli region.

Figure 7.1: Aquifer management plan for Aquifer– III



h. The safe peizometric head along the coast (0 to 10km from sea) is -40 to -50 m msl. The Piezometric head around lignite mine (Neyveli region) to be maintained around mean sea level. to be maintained around – 40 to – 50 m msl along the coast (0 to 10 km) and if lowering of peizometric head lowers by – 80 m msl shall invite sea water intrusion.

Management of the aquifer units within the Cuddalore coastal aquifer can be done by ensuring the annual groundwater withdrawal within the recommended groundwater withdrawal limits (Table7.2). The annual estimation of Ground water withdrawal from the aquifer is a voluminous exercise, hence, sustainable management of the Cuddalore coastal aquifer can be done by monitoring the Ground water head/Piezometers fitted with high frequency Automatic Water Level recorder.

The Cuddalore coastal aquifer is the most prolific and potential aquifer in the state as well as in the country. Due to its vulnerability to sea water intrusion, heavy groundwater abstraction along the coast (0 – 10 km) shall invite sea water intrusion. Further, the industries that exist near the coast shall contaminate the precious groundwater available. Hence, industries that withdraw groundwater near the coast (0 to 10 km from sea) may not be permitted and industries that release toxic chemicals may not be permitted to operate within the coastal aquifer system. Once the precious aquifer system is damaged or contaminated, recovery or reclamation is almost impossible.

The future aquifer management plan (Zone wise) of the ***Cuddalore Coastal Aquifer System*** *is depicted (figure 7.2) below. The zone A and B are the intensively irrigated region, where the farmers solely depend on groundwater for irrigation. Paddy and sugar cane are the major crops cultivated apart from cashewnuts. The groundwater for irrigation is presently tapped from Aquifer I and II and can be continued in future also for irrigation and domestic purpose including drinking water supply. Zone C and Zone D are along the coast and are vulnerable to sea water intrusion. Presently* *within the zone C many industries exists. Zone D is the region between coast and 10 km inland. The waste water released from the industries should be treated properly as aquifer – I and II shall be contaminated if the waste water is let out without treating within the aquifer system. Further industries tapping groundwater can lower the groundwater/peizometric head of these aquifers below the recommended limit. Hence industries tapping groundwater may be restricted within the aquifer and more particularly along the coast (0 to 10 km from sea). Zone E is the region where lignite is excavated through open case mine activity. Groundwater is pumped from aquifer – III for safe mining of lignite. As local cone of depression exists around lignite mine due to continuous pumping since 1950, continuous monitoring around lignite mine and upto the coast is essential. Zone F exists at the central portion of the aquifer system wherein groundwater is pumped from Aquifer –IV by battery of wells along North-South direction by metrowater to Chennai city through pipelines during lean periods. The aquifer – III and IV of the cuddalore aquifer system are to be kept for future use and Aquifer – I & II should to be monitored continuously as discussed in the report.*

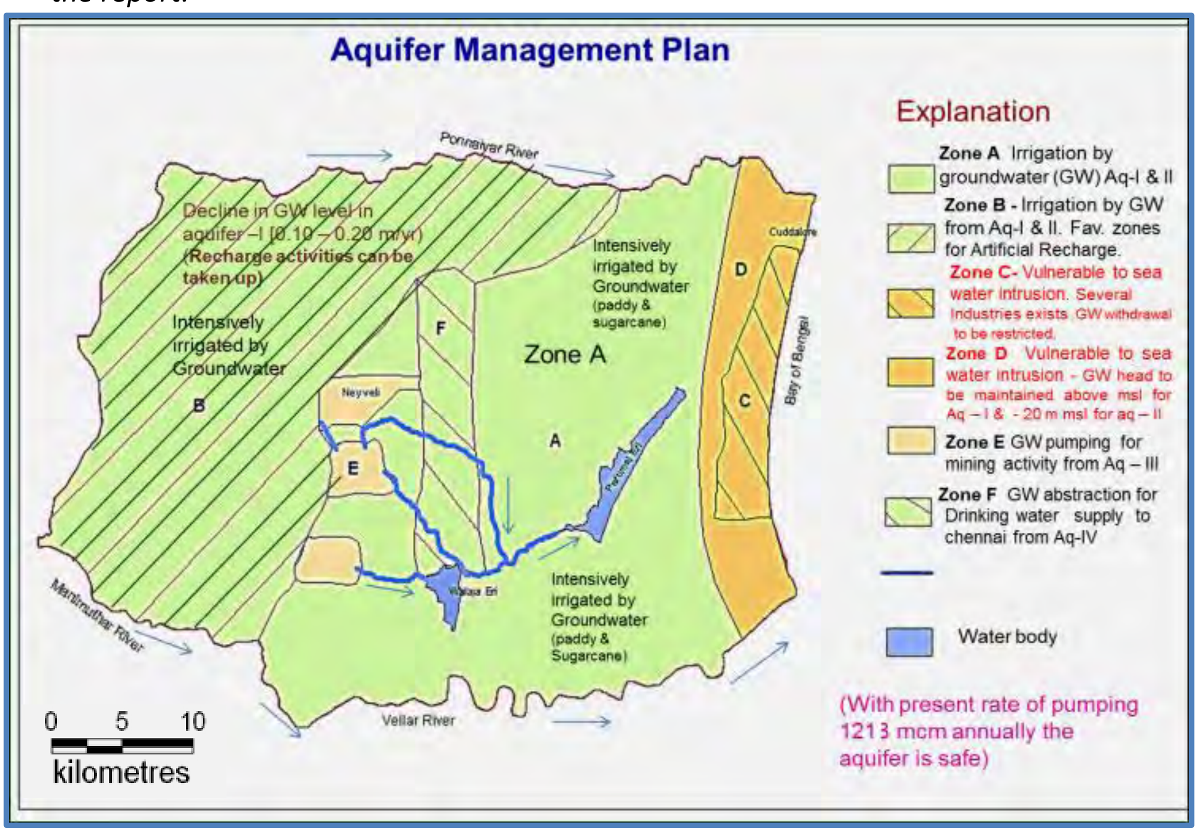


Table 7.2 Table showing the permissible water level/peizometric head of Individual aquifer units of the Cuddalore coastal aquifer system.

Aquifer Units	**Present Water Level/Piezometric head** (m w.r.t msl)	**Present groundwater withdrawal** (mcm/yr)	**Maximum permissible water level/peizometric head** (m w.r.t msl)	**Maximum permissible groundwater withdrawal** (mcm/yr)	**Suggestions for Aquifer management**
Aquifer – I (unconfined)	1 to 65	423.8	1 to 2 (0 – 10 km from coast) or above msl	525	Vulnerable to sea water intrusion. Total GW withdrawal not to exceed by 700 mcm annually.
Aquifer – II (Confined)	14 to - 27	612.85	- 40	700	Vulnerable to sea water intrusion. Total withdrawal exceeds not to exceed by 900 mcm annually.
Aquifer – III (confined)	05 to - 47	164.1	- 60	500	Groundwater withdrawal not to exceed by 750 mcm annually.
Aquifer – IV (Confined)	-10 to - 48	12.79	- 70	550	Groundwater withdrawal not to exceed by 750 mcm annually.

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Village: Pachcharapalayam
Block: Kurunjipadi

Drilling depth range From	To	Total Thickness (m)	Description of (sample) litholog	Formation
0.00	4.00	4.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized with ferrogenus matrix	Laterite
4.00	7.00	3.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized, grains are subrounded to angular with ferrogenus matrix	Laterite
7.00	10.50	3.50	Peach in colour, Predominently by clay(90%), non sticky in nature mixed with gravels	sandy clay
10.50	13.50	3.00	peach in colour, dominently by clay(70%), non sticky in nature mixed with gravels of quartz and country rock, grains are subrounded to subangular	sandy clay
13.50	16.75	3.25	peach in colour, dominently by clay(70%), non sticky in nature mixed with gravels of quartz and country rock, grains are subrounded to subangular	sandy clay
16.75	19.75	3.00	Flesh reddish brown in colour, Sand- fine to very coarse grained, sub rounded to angular mixed with little pebbles and gravels, pebbles are mainly quartz, Grains are sub rounded (may be friable)	Cuddalore Sandstone
19.75	23.00	3.25	Flesh reddish brown in colour, Sand- fine to very coarse grained, sub rounded to angular mixed with little pebbles and gravels, pebbles are mainly quartz, Grains are sub rounded (may be friable). Presence of Clay is notable (30 %), Clay brown in colour and non sticky in nature.	Cuddalore Sandstone with clay intercalation
23.00	26.00	3.00	Reddish brown in colur with grain size varing ranges from fine to coarse grain with little pebbles of quartz and sandstone, grains are angular and accasionaly rounded	cuddalore sandstone

26.00	29.25	3.25	Reddish brown in colur with grain size varing ranges from fine to coarse grain with little pebbles of quartz and sandstone, grains are angular and accasionaly rounded	cuddalore sandstone
29.25	32.25	3.00	Reddish brown in colur with grain size varing ranges from fine to coarse grain with little pebbles of quartz and sandstone, grains are angular and accasionaly rounded with clay (10%), brown in colour and non sticky in nature	Cuddalore Sandstone with clay intercalation
32.25	35.50	3.25	samples mainly of gravels with mixed colour of white and drak brown, mostly of quartz (90%) & other Mineral and rocks (10%), grains are sub- angular to angular	cuddalore sandstone
35.50	38.50	3.00	samples mainly of gravels with mixed colour of white and drak brown, mostly of quartz (90%) & other Mineral and rocks (10%), grains are sub- angular to angular mixed with little clay (5%), brown in colour and non sticky in nature	Cuddalore Sandstone with clay intercalation
38.50	41.75	3.25	Reddish in colour, Predominently by clay(60%), white in colour mixed with sand fine grained with little pebble and gravels of angular to sub rounded nature	Sandstone with clay
41.75	44.75	3.00	Reddish in colour, Predominently by clay(60%), white in colour mixed with sand fine grained with little pebble and gravels of angular to sub rounded nature	Sandstone with clay
44.75	48.00	3.25	Reddish in colour, Predominently by clay(60%), white in colour mixed with sand fine grained with little pebble and gravels of angular to sub rounded nature	Sandstone with clay
48.00	51.00	3.00	Sample pale brown to whitish in colour, Predominently of clay non sticky & nodular in nature mixed with little sand	Sandy clay
51.00	54.25	3.25	Sample pale brown to whitish in colour, Predominently of clay non sticky & nodular in nature mixed with little sand	sandy clay
54.25	57.25	3.00	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay

57.25	60.50	3.25	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay
60.50	63.50	3.00	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay
63.50	66.75	3.25	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay
66.75	69.75	3.00	Sample lusty brown to yellowish in colour, predominantly by sticky white clay with little fine to medium sand	sandy clay
69.75	73.00	3.25	Sample lusty brown to yellowish in colour, predominantly by sticky white clay with little fine to medium sand	sandy clay
73.00	76.00	3.00	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
76.00	79.25	3.25	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
79.25	82.25	3.00	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
82.25	85.50	3.25	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
85.50	88.50	3.00	Sample grey in colour, predominently by clay (grey) (90%) with gravel of quartz rounded in nature	clay
88.50	91.75	3.25	Sample grey in colour, predominently by clay (grey) (70%) with gravel of quartz rounded in nature	sandy clay
91.75	94.75	3.00	Sample grey in colour, predominently by clay (grey) (90%) with gravel of quartz rounded in nature	clay
94.75	98.00	3.25	Sample grey in colour, predominently by clay (grey) (70%) with gravel of quartz rounded in nature	sandy clay

98.00	101.00	3.00	Sample grey in colour, predominently by clay (grey) (70%) with gravel of quartz rounded in nature	sandy clay
101.00	104.25	3.25	Grey coloured clay and sticky in nature	clay
104.25	107.25	3.00	Grey coloured clay and sticky in nature	clay
107.25	110.50	3.25	Sample greish in colour, coarse to very coarse grained and predominently by boulders & pebbles and gravel of various compostion dominated by quartz and country rock with flaks of micaceous minerals and some metamorphic mineral with little clay(10%)	gravel
110.50	113.50	3.00	Sample greish in colour, coarse to very coarse grained and predominently by boulders & pebbles of various compostion dominated by quartz and country rock with flaks of micaceous minerals and some metamorphic mineral	Gravel
113.50	116.75	3.25	Sample greish in colour, coarse to very coarse grained and predominently by boulders & pebbles of various compostion dominated by quartz (transparant and smoky), grains are rounded to sub angular with flaks of micaceous minerals and some metamorphic mineral	Gravel
116.75	119.75	3.00	Sample greish in colour, coarse to very coarse grained with boulders & pebbles of various compostion dominated by quartz (transparant and smoky), grains are rounded to sub angular with flaks of micaceous minerals and some metamorphic mineral with Carbanaceous clay (20%), black in colour, nonstiky in nature with very few pieces of lignite	Sandstone underlying clay lens
119.75	123.00	3.25	Sample black in colour, predominently sand and gravels (60%), coarse to very coarse grained mixed with carbanaceous clay, lignite and cholcopirite minieral(?)	sandstone interbedded with lignite and carbonaceous clay

123.00	126.00	3.00	Sample black in colour, predominently sand and gravels (60%), coarse to very coarse grained mixed with carbanaceous clay, lignite and cholcopirite minieral(?)	sandstone interbedded with lignite and carbonaceous clay
126.00	129.25	3.25	Sample grey in colour, mainly of Gravels to very coarse grained sand of quartz and mixed with little pieces of lignite and prominent visible of chalcophyrite (?)/Macacite(?)/metamorphic mineral	Sand
129.25	132.25	3.00	Sample grey in colour, mainly of Gravels to very coarse grained sand of quartz and mixed with little pieces of lignite and prominent visible of chalcophyrite (?)/Macacite(?)/metamorphic mineral	sand
132.25	135.50	3.25	Sample grey in colour, grains are of coarse to very coarse with little gravel and presence of micaceous mineral, quartz are rounded to sub-angular and other minerals are angular	sans
135.50	138.50	3.00	Sample Dark grey in colour, with grains coarse to very coarse with marcacite	sand
138.50	141.75	3.25	Sample grey in colour, grains are subangular and coarse to gravelly-sand with micaceous minerals and country rock pieces	sand
141.75	144.75	3.00	Sample grey in colour, grains are subangular and coarse to gravelly-sand with micaceous minerals and country rock pieces	sand
144.75	148.00	3.25	sand grains are whitish in colour, grain size varies from medium to coarse, angular to sub angular with micaceous mineral with little clay	sand with clay
148.00	151.00	3.00	Sample light grey in colour, grains are fine to coarse predominently by quartz and other minerals and rusted rock fragments	sand with clay
151.00	154.25	3.25	Sample light grey in colour, grains are fine to coarse, angular, predominently by quartz and other minerals and rusted rock fragments	sand

154.25	157.25	3.00	Sample light grey in colour, grains are fine to coarse, angular, predominently by quartz and other minerals and rusted rock fragments	sand
157.25	160.50	3.25	Sample grey in colour,sand grains fine to medium with few micaceous mineral	sand
160.50	163.50	3.00	Fine to coarse grained sands with little gravels of quartz and other mineral/rock, ferrogenus and rusted minerals are accasional with some metamorphic mineral/rock (Schist ?)	sand
163.50	166.75	3.25	Fine to coarse grained sands with little gravels of quartz and other mineral/rock, ferrogenus and rusted minerals are accasional with some metamorphic mineral/rock (Schist ?) and clay (5%)	sand with interclation of clay
166.75	169.75	3.00	Fine to coarse grained sands with little gravels of quartz and other mineral/rock, ferrogenus and rusted minerals are accasional with some metamorphic mineral/rock (Schist ?) and clay (5%)	sand with interclation of clay
169.75	173.00	3.25	whitisth in colour, Sand fine to medium grain with very few coarse sand, montly angular with little clay	sand with interclation of clay
173.00	176.00	3.00	Sand fine to coarse with little gravels of quartz, rounded to angular with presence of dark colour minerals	sand
176.00	179.25	3.25	Sand fine to coarse with little gravels of quartz, rounded to angular with presence of dark colour minerals	sand
179.25	182.25	3.00	Whitish grey in colour, predominently with quartz, sand grains are fine to coarse, angular to sub rounded with micaceous mineral	sand
182.25	185.00	2.75	Whitish grey in colour, predominently with quartz, sand grains are fine(predominent) to medium, angular to sub rounded with micaceous mineral	sand
185.00	188.50	3.50	Grey in colour, predominently with quartz, sand grains are medium to coarse (predominent), angular to sub rounded with micaceous mineral and little yellow coloured clay(10%) of non sticky in nature	sand with clay

188.50	191.75	3.25	Grey in colour, predominently with quartz, sand grains are medium to coarse (predominent), angular to sub rounded with micaceous mineral and little yellow coloured clay(20%) of non sticky in nature	sand with clay
191.75	194.75	3.00	Poorly sorted sediments, whitiesh grey in colour, grains fine to coarse of angular to subangular, Predominently sand mixed with some flaks of micaceous/Metamorphic darkcoloured mineral	sand
194.75	198.00	3.25	Poorly sorted sediments, whitiesh grey in colour, grains fine to coarse with little gravels, angular to subangular, Predominently sand mixed with some flaks of micaceous/Metamorphic darkcoloured mineral. Presence of clay (grey) (5%) is noticed	sand
198.00	201.00	3.00	Sand Medium grained, grey in colour, angular to sub angular	sand
201.00	204.25	3.25	Predominently sand, coarsed grained, angular to sub angular with 25% of clay, grey in colour	Clay sand
204.25	207.25	3.00	Sample Whitish in colour, Sand (Quartz), grains fine to medium and well sorted, sub angular	sand
207.25	210.50	3.25	Sample grey in colour, Sand grains fine to coarse and sub angular with metamorphic rock fragments with clay (20%)	clay with sand
210.50	213.50	3.00	Sample grey in colour, Sand grains Medium and sub angular with metamorphic rock fragments	sand
213.50	216.75	3.25	Sample grey in colour, Sand grains Medium and sub angular with metamorphic rock fragments	sand
216.75	219.75	3.00	Sample grey in colour, grains medium to coarse, well sorted, angular to subangular	sand
219.75	223.00	3.25	Sample grey in colour, grains medium to coarse, well sorted, angular to subangular with clay	sand
223.00	226.00	3.00	Sample whitish in colour, grains medium to coarse, subrounded to rounded in nature with metamorphic minerals	sand

226.00	229.25	3.25	Sample whitish in colour, grains medium to coarse, subrounded to rounded in nature with metamorphic minerals	sand
229.25	232.25	3.00	Sample whitish in colour, grains medium to coarse, subrounded to rounded in nature with metamorphic minerals with little clay (10%)	clayeysand
232.25	235.50	3.25	Sample grey in colour, sand coarse grain, subrounded to rounded, predominently sand	sand
235.50	238.50	3.00	Grey in colour, sand fine to coarse grains, Predominendly by coarse grained sand	sand
238.50	241.75	3.25	Sample grey in colour, sand medium to coarse grained, sub rounded with little clay (5%)	Clayey sand
241.75	244.75	3.00	grey in colour, very coarse grained sand and gravel, well sorted, rounded to sub rounded predominently quartz	sand
244.75	248.00	3.25	Very coarse grain sediments of various minerology, from sand of quartz to mudstone, metamorphic minerals with 20% of clay, grey in colour, nonsticky nature and little yellow clay	Clay sand
248.00	251.00	3.00	Clay, 95 % of clay, grey in colour, slightly sticky in nature with little gravels of quartz and mudstone	clay
251.00	254.25	3.25	Clay, 95 % of clay, grey in colour, slightly sticky in nature with little gravels of quartz and mudstone	clay
254.25	257.25	3.00	Clay, 95 % of clay, grey in colour, slightly sticky in nature with little gravels of quartz and mudstone	clay
257.25	260.50	3.25	Clay, 80 % of clay, grey in colour, slightly sticky in nature with little sand medium grained with gravels of quartzite and mudstone	clay
260.50	263.50	3.00	Clay, 80 % of clay, grey in colour, slightly sticky in nature with little sand medium grained with gravels of quartzite and mudstone	clay
263.50	266.75	3.25	Predominently sand, very coarse grained rounded to subangular, grey in colour with Quartizite and Metamorphic mineral with 5% of clay	sand

266.75	269.75	3.00	Predominently sand, very coarse grained rounded to subangular, grey in colour with Quartizite and Metamorphic mineral with 5% of clay	sand
269.75	273.00	3.25	Sand very coarse grained, angular to subrounded, quartz dominent with 20% of grey coloured clay,	sand
273.00	276.00	3.00	Sand very coarse grained, angular to subrounded, quartz dominent with 20% of grey coloured clay,	sand
276.00	279.25	3.25	Clay 60%, grey in colour mixed with coarse grained sand and gravels & pebbles of quartzite	clay
279.25	282.25	3.00	Clay 60%, grey in colour mixed with coarse grained sand and gravels & pebbles of quartzite	clay
282.25	285.50	3.25	Sand, medium to coarse grained mixed with little clay	sand
285.50	288.50	3.00	Clay 70%, grey in colour, sticky in nature mixed with sand coarse grained	clay
288.50	291.75	3.25	Clay 80%, grey in colour, sticky in nature mixed with sand coarse grained	clay
291.75	294.75	3.00	Sand 60 %, coarse grained, angular to subangular mixed with clay grey in colour (40%)	Clayey sand
294.75	298.00	3.25	Sand 40 %, coarse grained, angular to subangular mixed with Predominently bt clay grey in colour	Clayey sand
298.00	301.00	3.00	Fine to medium grained sand with occasionaly pebbles with presence of Micaceous/metamorphic minerals with 20% of clay	Clayey sand
301.00	304.25	3.25	Pedominently clay mixed with sand of fine grained	clay
304.25	307.25	3.00	Whitish in colour, fine to medium grained, angular to sub rounded with micaceous mineral	sand
307.25	310.50	3.25	Whitish in colour, medium grained with micaceous mineral	sand
310.50	313.50	3.00	Fine to medium grained sand , sub rounded mixed with clay	Clayey sand
313.50	316.75	3.25	Sand medium grained, sub rounded mixed with clay 40 %	Clayey sand

316.75	319.75	3.00	Sand fine to medium grained, sub rounded, light grey in colour with little micaceous mineral	sand
319.75	323.00	3.25	Sand fine to medium grained, sub rounded, light grey in colour with little micaceous mineral	sand
323.00	326.00	3.00	sand fine to medium grained, subrounded to angular with fragments of medstone and metamophic rocks	sand
326.00	329.25	3.25	sand fine to medium grained, subrounded to angular with fragments of medstone and metamophic rocks	sand
329.25	332.25	3.00	sand fine to medium grained, subrounded, white in colour mixed with clay 40% grey in colour	sandy clay
332.25	335.50	3.25	sand fine to coarse, subanngular with boulders of molted rock fragments, rounded quartzs, with little clay (20%), Yellow and white in colour and sticky in nature	Clay sand
335.50	338.50	3.00	sand fine to coarse, subanngular with boulders of molted rock fragments, rounded quartzs, with little clay (20%), Yellow and white in colour and sticky in nature	Clay sand
338.50	341.75	3.25	Sand fine to medium grained with little boulders, pebbles and gravels of quartzite, mudstone and fragments of metamorphic rocks	sand
341.75	344.75	3.00	Sand fine grained, well sorted, rounded with little flaks of micaceous mineral	sand
344.75	348.00	3.25	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
348.00	351.00	3.00	Sand fine grained, well sorted, rounded with little flaks of micaceous mineral	sand
351.00	354.25	3.25	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
354.25	357.25	3.00	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
357.25	360.5	3.25	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
360.5	363.5	3.00	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand

363.5	364	0.50	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand

Village: Arasadikuppam-Siruthondamadevi
Block: Panruti

Drilling depth range		Total Thickness in m	Discribtion of (sample) litholog	Formation
From	To			
0.00	4.00	4.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized with ferrogenus matrix	Laterite
4.00	7.00	3.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized, grains are subrounded to angular with ferrogenus matrix	Laterite
7.00	10.50	3.50	Peach in colour, Predominently by clay(90%), non sticky in nature mixed with gravels	sandy clay
10.50	13.50	3.00	peach in colour, dominently by clay(70%), non sticky in nature mixed with gravels of quartz and country rock, grains are subrounded to subangular	sandy clay
13.50	16.75	3.25	peach in colour, dominently by clay(70%), non sticky in nature mixed with gravels of quartz and country rock, grains are subrounded to subangular	sandy clay
16.75	19.75	3.00	Flesh reddish brown in colour, Sand- fine to very coarse grained, sub rounded to angular mixed with little pebbles and gravels, pebbles are mainly quartz, Grains are sub rounded (may be friable)	Cuddalore Sandstone
19.75	23.00	3.25	Flesh reddish brown in colour, Sand- fine to very coarse grained, sub rounded to angular mixed with little pebbles and gravels, pebbles are mainly quartz, Grains are sub rounded (may be friable). Presence of Clay is notable (30 %), Clay brown in colour and non sticky in nature.	Cuddalore Sandstone with clay intercalation
23.00	26.00	3.00	Reddish brown in colur with grain size varing ranges from fine to coarse grain with little pebbles of quartz and sandstone, grains are angular and accasionaly rounded	cuddalore sandstone

26.00	29.25	3.25	Reddish brown in colur with grain size varing ranges from fine to coarse grain with little pebbles of quartz and sandstone, grains are angular and accasionaly rounded	cuddalore sandstone
29.25	32.25	3.00	Reddish brown in colur with grain size varing ranges from fine to coarse grain with little pebbles of quartz and sandstone, grains are angular and accasionaly rounded with clay (10%), brown in colour and non sticky in nature	Cuddalore Sandstone with clay intercalation
32.25	35.50	3.25	samples mainly of gravels with mixed colour of white and drak brown, mostly of quartz (90%) & other Mineral and rocks (10%), grains are sub- angular to angular	cuddalore sandstone
35.50	38.50	3.00	samples mainly of gravels with mixed colour of white and drak brown, mostly of quartz (90%) & other Mineral and rocks (10%), grains are sub- angular to angular mixed with little clay (5%), brown in colour and non sticky in nature	Cuddalore Sandstone with clay intercalation
38.50	41.75	3.25	Reddish in colour, Predominently by clay(60%), white in colour mixed with sand fine grained with little pebble and gravels of angular to sub rounded nature	Sandstone with clay
41.75	44.75	3.00	Reddish in colour, Predominently by clay(60%), white in colour mixed with sand fine grained with little pebble and gravels of angular to sub rounded nature	Sandstone with clay
44.75	48.00	3.25	Reddish in colour, Predominently by clay(60%), white in colour mixed with sand fine grained with little pebble and gravels of angular to sub rounded nature	Sandstone with clay
48.00	51.00	3.00	Sample pale brown to whitish in colour, Predominently of clay non sticky & nodular in nature mixed with little sand	Sandy clay
51.00	54.25	3.25	Sample pale brown to whitish in colour, Predominently of clay non sticky & nodular in nature mixed with little sand	sandy clay
54.25	57.25	3.00	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay

57.25	60.50	3.25	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay
60.50	63.50	3.00	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay
63.50	66.75	3.25	Sample whitish brown in colour, Predominantly with white and brown colour clay, brown clay is non sticky and white clay is sticky mixed with fine sand	sandy clay
66.75	69.75	3.00	Sample lusty brown to yellowish in colour, predominantly by sticky white clay with little fine to medium sand	sandy clay
69.75	73.00	3.25	Sample lusty brown to yellowish in colour, predominantly by sticky white clay with little fine to medium sand	sandy clay
73.00	76.00	3.00	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
76.00	79.25	3.25	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
79.25	82.25	3.00	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
82.25	85.50	3.25	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	sandy clay
85.50	88.50	3.00	Sample grey in colour, predominently by clay (grey) (90%) with gravel of quartz rounded in nature	clay
88.50	91.75	3.25	Sample grey in colour, predominently by clay (grey) (70%) with gravel of quartz rounded in nature	sandy clay
91.75	94.75	3.00	Sample grey in colour, predominently by clay (grey) (90%) with gravel of quartz rounded in nature	clay
94.75	98.00	3.25	Sample grey in colour, predominently by clay (grey) (70%) with gravel of quartz rounded in nature	sandy clay

98.00	101.00	3.00	Sample grey in colour, predominently by clay (grey) (70%) with gravel of quartz rounded in nature	sandy clay
101.00	104.25	3.25	Grey coloured clay and sticky in nature	clay
104.25	107.25	3.00	Grey coloured clay and sticky in nature	clay
107.25	110.50	3.25	Sample greish in colour, coarse to very coarse grained and predominently by boulders & pebbles and gravel of various compostion dominated by quartz and country rock with flaks of micaceous minerals and some metamorphic mineral with little clay(10%)	gravel
110.50	113.50	3.00	Sample greish in colour, coarse to very coarse grained and predominently by boulders & pebbles of various compostion dominated by quartz and country rock with flaks of micaceous minerals and some metamorphic mineral	Gravel
113.50	116.75	3.25	Sample greish in colour, coarse to very coarse grained and predominently by boulders & pebbles of various compostion dominated by quartz (transparant and smoky), grains are rounded to sub angular with flaks of micaceous minerals and some metamorphic mineral	Gravel
116.75	119.75	3.00	Sample greish in colour, coarse to very coarse grained with boulders & pebbles of various compostion dominated by quartz (transparant and smoky), grains are rounded to sub angular with flaks of micaceous minerals and some metamorphic mineral with Carbanaceous clay (20%), black in colour, nonstiky in nature with very few pieces of lignite	Sandstone underlying clay lens
119.75	123.00	3.25	Sample black in colour, predominently sand and gravels (60%), coarse to very coarse grained mixed with carbanaceous clay, lignite and cholcopirite minieral(?)	sandstone interbedded with lignite and carbonaceous clay

123.00	126.00	3.00	Sample black in colour, predominently sand and gravels (60%), coarse to very coarse grained mixed with carbanaceous clay, lignite and cholcopirite minieral(?)	sandstone interbedded with lignite and carbonaceous clay
126.00	129.25	3.25	Sample grey in colour, mainly of Gravels to very coarse grained sand of quartz and mixed with little pieces of lignite and prominent visible of chalcophyrite (?)/Macacite(?)/metamorphic mineral	Sand
129.25	132.25	3.00	Sample grey in colour, mainly of Gravels to very coarse grained sand of quartz and mixed with little pieces of lignite and prominent visible of chalcophyrite (?)/Macacite(?)/metamorphic mineral	sand
132.25	135.50	3.25	Sample grey in colour, grains are of coarse to very coarse with little gravel and presence of micaceous mineral, quartz are rounded to sub-angular and other minerals are angular	sans
135.50	138.50	3.00	Sample Dark grey in colour, with grains coarse to very coarse with marcacite	sand
138.50	141.75	3.25	Sample grey in colour, grains are subangular and coarse to gravelly-sand with micaceous minerals and country rock pieces	sand
141.75	144.75	3.00	Sample grey in colour, grains are subangular and coarse to gravelly-sand with micaceous minerals and country rock pieces	sand
144.75	148.00	3.25	sand grains are whitish in colour, grain size varies from medium to coarse, angular to sub angular with micaceous mineral with little clay	sand with clay
148.00	151.00	3.00	Sample light grey in colour, grains are fine to coarse predominently by quartz and other minerals and rusted rock fragments	sand with clay
151.00	154.25	3.25	Sample light grey in colour, grains are fine to coarse, angular, predominently by quartz and other minerals and rusted rock fragments	sand

154.25	157.25	3.00	Sample light grey in colour, grains are fine to coarse, angular, predominently by quartz and other minerals and rusted rock fragments	sand
157.25	160.50	3.25	Sample grey in colour,sand grains fine to medium with few micaceous mineral	sand
160.50	163.50	3.00	Fine to coarse grained sands with little gravels of quartz and other mineral/rock, ferrogenus and rusted minerals are accasional with some metamorphic mineral/rock (Schist ?)	sand
163.50	166.75	3.25	Fine to coarse grained sands with little gravels of quartz and other mineral/rock, ferrogenus and rusted minerals are accasional with some metamorphic mineral/rock (Schist ?) and clay (5%)	sand with interclation of clay
166.75	169.75	3.00	Fine to coarse grained sands with little gravels of quartz and other mineral/rock, ferrogenus and rusted minerals are accasional with some metamorphic mineral/rock (Schist ?) and clay (5%)	sand with interclation of clay
169.75	173.00	3.25	whitisth in colour, Sand fine to medium grain with very few coarse sand, montly angular with little clay	sand with interclation of clay
173.00	176.00	3.00	Sand fine to coarse with little gravels of quartz, rounded to angular with presence of dark colour minerals	sand
176.00	179.25	3.25	Sand fine to coarse with little gravels of quartz, rounded to angular with presence of dark colour minerals	sand
179.25	182.25	3.00	Whitish grey in colour, predominently with quartz, sand grains are fine to coarse, angular to sub rounded with micaceous mineral	sand
182.25	185.00	2.75	Whitish grey in colour, predominently with quartz, sand grains are fine(predominent) to medium, angular to sub rounded with micaceous mineral	sand
185.00	188.50	3.50	Grey in colour, predominently with quartz, sand grains are medium to coarse (predominent), angular to sub rounded with micaceous mineral and little yellow coloured clay(10%) of non sticky in nature	sand with clay

188.50	191.75	3.25	Grey in colour, predominently with quartz, sand grains are medium to coarse (predominent), angular to sub rounded with micaceous mineral and little yellow coloured clay(20%) of non sticky in nature	sand with clay
191.75	194.75	3.00	Poorly sorted sediments, whitiesh grey in colour, grains fine to coarse of angular to subangular, Predominently sand mixed with some flaks of micaceous/Metamorphic darkcoloured mineral	sand
194.75	198.00	3.25	Poorly sorted sediments, whitiesh grey in colour, grains fine to coarse with little gravels, angular to subangular, Predominently sand mixed with some flaks of micaceous/Metamorphic darkcoloured mineral. Presence of clay (grey) (5%) is noticed	sand
198.00	201.00	3.00	Sand Medium grained, grey in colour, angular to sub angular	sand
201.00	204.25	3.25	Predominently sand, coarsed grained, angular to sub angular with 25% of clay, grey in colour	Clay sand
204.25	207.25	3.00	Sample Whitish in colour, Sand (Quartz), grains fine to medium and well sorted, sub angular	sand
207.25	210.50	3.25	Sample grey in colour, Sand grains fine to coarse and sub angular with metamorphic rock fragments with clay (20%)	clay with sand
210.50	213.50	3.00	Sample grey in colour, Sand grains Medium and sub angular with metamorphic rock fragments	sand
213.50	216.75	3.25	Sample grey in colour, Sand grains Medium and sub angular with metamorphic rock fragments	sand
216.75	219.75	3.00	Sample grey in colour, grains medium to coarse, well sorted, angular to subangular	sand
219.75	223.00	3.25	Sample grey in colour, grains medium to coarse, well sorted, angular to subangular with clay	sand
223.00	226.00	3.00	Sample whitish in colour, grains medium to coarse, subrounded to rounded in nature with metamorphic minerals	sand

226.00	229.25	3.25	Sample whitish in colour, grains medium to coarse, subrounded to rounded in nature with metamorphic minerals	sand
229.25	232.25	3.00	Sample whitish in colour, grains medium to coarse, subrounded to rounded in nature with metamorphic minerals with little clay (10%)	clayeysand
232.25	235.50	3.25	Sample grey in colour, sand coarse grain, subrounded to rounded, predominently sand	sand
235.50	238.50	3.00	Grey in colour, sand fine to coarse grains, Predominendly by coarse grained sand	sand
238.50	241.75	3.25	Sample grey in colour, sand medium to coarse grained, sub rounded with little clay (5%)	Clayey sand
241.75	244.75	3.00	grey in colour, very coarse grained sand and gravel, well sorted, rounded to sub rounded predominently quartz	sand
244.75	248.00	3.25	Very coarse grain sediments of various minerology, from sand of quartz to mudstone, metamorphic minerals with 20% of clay, grey in colour, nonsticky nature and little yellow clay	Clay sand
248.00	251.00	3.00	Clay, 95 % of clay, grey in colour, slightly sticky in nature with little gravels of quartz and mudstone	clay
251.00	254.25	3.25	Clay, 95 % of clay, grey in colour, slightly sticky in nature with little gravels of quartz and mudstone	clay
254.25	257.25	3.00	Clay, 95 % of clay, grey in colour, slightly sticky in nature with little gravels of quartz and mudstone	clay
257.25	260.50	3.25	Clay, 80 % of clay, grey in colour, slightly sticky in nature with little sand medium grained with gravels of quartzite and mudstone	clay
260.50	263.50	3.00	Clay, 80 % of clay, grey in colour, slightly sticky in nature with little sand medium grained with gravels of quartzite and mudstone	clay
263.50	266.75	3.25	Predominently sand, very coarse grained rounded to subangular, grey in colour with Quartizite and Metamorphic mineral with 5% of clay	sand

266.75	269.75	3.00	Predominently sand, very coarse grained rounded to subangular, grey in colour with Quartizite and Metamorphic mineral with 5% of clay	sand
269.75	273.00	3.25	Sand very coarse grained, angular to subrounded, quartz dominent with 20% of grey coloured clay,	sand
273.00	276.00	3.00	Sand very coarse grained, angular to subrounded, quartz dominent with 20% of grey coloured clay,	sand
276.00	279.25	3.25	Clay 60%, grey in colour mixed with coarse grained sand and gravels & pebbles of quartzite	clay
279.25	282.25	3.00	Clay 60%, grey in colour mixed with coarse grained sand and gravels & pebbles of quartzite	clay
282.25	285.50	3.25	Sand, medium to coarse grained mixed with little clay	sand
285.50	288.50	3.00	Clay 70%, grey in colour, sticky in nature mixed with sand coarse grained	clay
288.50	291.75	3.25	Clay 80%, grey in colour, sticky in nature mixed with sand coarse grained	clay
291.75	294.75	3.00	Sand 60 %, coarse grained, angular to subangular mixed with clay grey in colour (40%)	Clayey sand
294.75	298.00	3.25	Sand 40 %, coarse grained, angular to subangular mixed with Predominently bt clay grey in colour	Clayey sand
298.00	301.00	3.00	Fine to medium grained sand with occasionaly pebbles with presence of Micaceous/metamorphic minerals with 20% of clay	Clayey sand
301.00	304.25	3.25	Pedominently clay mixed with sand of fine grained	clay
304.25	307.25	3.00	Whitish in colour, fine to medium grained, angular to sub rounded with micaceous mineral	sand
307.25	310.50	3.25	Whitish in colour, medium grained with micaceous mineral	sand
310.50	313.50	3.00	Fine to medium grained sand , sub rounded mixed with clay	Clayey sand
313.50	316.75	3.25	Sand medium grained, sub rounded mixed with clay 40 %	Clayey sand

316.75	319.75	3.00	Sand fine to medium grained, sub rounded, light grey in colour with little micaceous mineral	sand
319.75	323.00	3.25	Sand fine to medium grained, sub rounded, light grey in colour with little micaceous mineral	sand
323.00	326.00	3.00	sand fine to medium grained, subrounded to angular with fragments of medstone and metamophic rocks	sand
326.00	329.25	3.25	sand fine to medium grained, subrounded to angular with fragments of medstone and metamophic rocks	sand
329.25	332.25	3.00	sand fine to medium grained, subrounded, white in colour mixed with clay 40% grey in colour	sandy clay
332.25	335.50	3.25	sand fine to coarse, subanngular with boulders of molted rock fragments, rounded quartzs, with little clay (20%), Yellow and white in colour and sticky in nature	Clay sand
335.50	338.50	3.00	sand fine to coarse, subanngular with boulders of molted rock fragments, rounded quartzs, with little clay (20%), Yellow and white in colour and sticky in nature	Clay sand
338.50	341.75	3.25	Sand fine to medium grained with little boulders, pebbles and gravels of quartzite, mudstone and fragments of metamorphic rocks	sand
341.75	344.75	3.00	Sand fine grained, well sorted, rounded with little flaks of micaceous mineral	sand
344.75	348.00	3.25	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
348.00	351.00	3.00	Sand fine grained, well sorted, rounded with little flaks of micaceous mineral	sand
351.00	354.25	3.25	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
354.25	357.25	3.00	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
357.25	360.5	3.25	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand
360.5	363.5	3.00	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand

363.5	364	0.50	Sand fine to medium grained moderatly sorted, rounded to sub angular	sand

Village: Ayekuppam
Block: Kurunjipadi

Drilling depth range		Total Thickness in m	Discribtion of (sample) litholog	Formation
From	To			
0.00	4.00	4.00	Reddish in colour, surface sand, ferogenes, fine to medium grained mixed with little surface clay	Surface sand
4.00	7.00	3.00	Reddish in colour, surface sand, ferogenes, fine to medium grained mixed with little surface clay	Surface sand
7.00	10.50	3.50	Rusted reddish in colour, Ferrogenus sand, medium to fine grained, rounded, rusted, mixed with sand of kankar/marl etc	sand
10.50	13.50	3.00	Sample Yellowish in colour, fine grained mixed with mudstone/marl and kankar	sand
13.50	16.70	3.20	Reddish in colour, coarse grained to gravel, angular to sub rounded with rock fragments of mudstone/marl/kankar with little quartzite, un sorted sediment	sand
16.70	19.70	3.00	Reddish in colour, coarse grained to gravel, angular to sub rounded with rock fragments of mudstone/marl/kankar with little quartzite, un sorted sediment	sand
19.70	22.90	3.20	Reddish to yellow colour sediments, coarse grained to gravel, sub rounded to rounded with gravels of quartz, rock fragments of mudstone/marl/kankar	sand
22.90	25.90	3.00	Reddish to yellow colour sediments, coarse grained to gravel, sub rounded to rounded with gravels of quartz, rock fragments of mudstone/marl/kankar	sand
25.90	29.10	3.20	flesh red in colour, fine grained sand, sub rounded to rounded with gravels of quartz, rock fragments of mudstone/marl/kankar	Sandstone
29.10	32.10	3.00	flesh red in colour, predominently by fine grained sand, sub rounded to rounded with gravels of quartz, rock fragments of mudstone/marl/kankar	Sandstone

32.10	35.50	3.40	Flesh red in colour, fine to coarse grained, dominated by coarse sand with little gravel, sedments, rounded to sub angular, mostly quartzite and little mudstone	Sandstone
35.50	38.50	3.00	Flesh red in colour, fine to coarse grained, dominated by coarse sand with little gravel, sedments, rounded to sub angular, mostly quartzite and little mudstone	Sandstone
38.50	41.50	3.00	Reddish in colour, fine to medium grained sand mixed with clay (5%)	Sandstone
41.50	44.50	3.00	Sand very coarse grained with varing minerology, rounded to subroyunded, predominently by sands of quartz and angular fragments of mudstone, yellowish in colour	sandstone interclation with clay
44.50	47.70	3.20	Whitish grey in colour, clay, sticky in nature, mixed with little sand (20%)	Clay
47.70	50.70	3.00	whitish in colour, Sand very coarse grained, rounded to subrounded, predominently by sands of quartz with fine sand	Sandstone
50.70	53.90	3.20	Sand coarse to medium, rounded to subrounded mixed with clay brown in colour & sticky in nature with little grey and white colour clay	sandy clay
53.90	56.90	3.00	whitish in colour, Sand very coarse grained, rounded to subrounded, predominently by sands of quartz with fine sand	sand
56.90	60.10	3.20	Clay white to grey in colour with little brown colur clay mixed with sand (30%)	sandy clay
60.10	63.10	3.00	Clay white to grey in colour with little brown colur clay mixed with sand (40%)	sandy clay
63.10	66.30	3.20	Clay white to grey in colour with little brown colur clay mixed with sand (20%) fine grained	sandy clay
66.30	69.30	3.00	Clay (80%), whitish in colour with little grey colour clay mixed with sand	Clay
69.30	72.50	3.20	Clay (80%), whitish in colour with little grey colour clay mixed with sand	clay
72.50	75.50	3.00	Clay white to grey in colour with little brown colur clay mixed with sand (40%)	sandy clay

75.50	78.70	3.20	Sand coarse grained, sub angular, well sorted with little brown colour clay with little pieces of lignite	Sand interbedded with lignite and carbanaceous clay
78.70	81.70	3.00	Sand coarse grained, sub angular, well sorted with little brown colour clay with little pieces of lignite	Sand interbedded with lignite and carbanaceous clay
81.70	84.90	3.20	Clay (80%), whitish in colour with little grey colour clay mixed with little sand and gravels of quartz, rounded to subrounded with marcacite	clay
84.90	87.90	3.00	Clay (80%), whitish in colour with little grey colour clay mixed with little sand and gravels of quartz, rounded to subrounded with marcacite	clay
87.90	91.10	3.20	Sand fine to medium grained with little gravel, rounded in nature, quartz and metamorphic rock, angular mixed with yellow to brownish colour clay	clayey sand
91.10	94.10	3.00	sand fine to medium grained mixed with clay	clayey sand
94.10	97.30	3.20	Clay, whitish in colour mixed with sand coarse grained	sand
97.30	100.30	3.00	Clay (90%) mixed with little sand	clay
100.30	103.50	3.20	Clay brown in colour, sticky in nature mixed with little sand	clay
103.50	106.50	3.00	Clay brown in colour, sticky in nature mixed with little sand	sandy clay
106.50	109.70	3.20	Clay Brown in colour, sticky in nature	clay
109.70	112.70	3.00	Clay Brown in colour, non sticky in nature	clay
112.70	115.90	3.20	Clay grey to white in colour, sticky in nature	clay
115.90	118.90	3.00	Clay grey to white in colour, sticky in nature	clay
118.90	122.10	3.20	Clay Brown in colour, non sticky in nature	clay
122.10	125.10	3.00	Clay Brown in colour, non sticky in nature	clay
125.10	128.30	3.20	Clay grey to white in colour, sticky in nature	clay
128.30	131.30	3.00	Clay grey to white in colour, sticky in nature	clay
131.30	134.50	3.20	Clay mixed with sand (20%), fine grained	sandy clay
134.50	137.50	3.00	Clay mixed with sand (20%), fine grained	sandy clay
137.50	140.70	3.20	Clay mixed with sand (10%) fine grained	sandy clay

140.70	143.70	3.00	Clay whitish colour mixed with sand fine grained	sandy clay
143.70	146.90	3.20	Clay dominent mixed with sand, white in colour	sandy clay
146.90	149.90	3.00	clay mixed with sand(20%) white in colour	sandy clay
149.90	153.10	3.20	clay white in colour mixed with sand (20%), fine to medium grained, rounded to subround	sandy clay
153.10	156.10	3.00	Sand mixed with little clay, chalcophyrite and small pieces of lignite	sand
156.10	159.30	3.20	Sand medium to coarse grained mixed with boulders and gravels of quartz, mudstone, chalcophyrite and pieces of lignite	Sand interbedded with lignite and carbanaceous clay
159.30	162.30	3.00	Sand medium to coarse grained mixed with boulders and gravels of quartz, mudstone, chalcophyrite and pieces of lignite with little clay	Sand interbedded with lignite and carbanaceous clay
162.30	165.50	3.20	Sample dark grey in colour, sand very coarse grained mixed with pieces of lignite, carbanaceous clay, sample enriched with chalcophyrite mineral	sand
165.50	168.50	3.00	Sand very coarse grained with gravels, little clay (white), enriched with chalcophyrite, with little flacks of marcacite(grass green in colour), grains of sand are rounded to subrounded	sand
168.50	171.70	3.20	Grey in colour, very coarse to gravel in size, rounded to subangular, predominently by quartzite and very few boulders(rock fragments) of strained quartzite with flaks of marcacite (grass green in colour)	sand
171.70	174.70	3.00	Sand, grey in colour mixed with white non sticky clay and few pieces of lignite and carbanaceous clay	Sand interbedded with lignite and carbanaceous clay

174.70	177.90	3.20	sand coarse to gravel in size, round to sub angular , predominantly by quartzite, presense of boulders of flinty quartzite is visiable	sand
177.90	180.90	3.00	Sand, grey in colour mixed with white non sticky clay	sandy clay
180.90	184.10	3.20	Sand fine to coarse grained, coarser sands are rounded to sub rounded with little carbonaceous clay	Sand interbedded with lignite and carbanaceous clay
184.10	187.10	3.00	Sand very coarse to medium grained with quartz and charcophyrite, sub rounded to sub angular	sand
187.10	190.30	3.20	Whitish in colour, sand fine to coarse grained, subrounded to angular	sand
190.30	193.30	3.00	Coarse grained sand, whitish in colour, subangular and well sorted	sand
193.30	196.50	3.20	Fine to coarse sand , rounded to subangular with little clay (5%) white in colour	sand
196.50	200.00	3.50	Fine to coarse sand , rounded to subangular with little clay (5%) white in colour	sand

Village: Kodandaramapurm
Block: Kurunjipadi

Drilling depth range		Total Thickness in m	Discribtion of (sample) litholog	Formation
From	To			
0.00	3.80	3.80	Sample brown in colour, mostly clay brown colour, sticky in nature mixed with surface sand	Surface sand
3.80	7.30	3.50	Sample brown in colour, mostly clay brown colour, sticky in nature mixed with surface sand	Surface sand
7.30	10.30	3.00	Sand yellowish brown in colour, medium grained, rounded to sub rounded mixed with little clay	sand
10.30	13.82	3.52	Sand yellowish brown in colour, medium grained, rounded to sub rounded mixed with little clay	sand

13.82	16.82	3.00	sand white in colour, medium to fine grained, rounded to sub rounded, mostly of quartz origin	sand
16.82	20.37	3.55	sand white in colour, medium to fine grained, rounded to sub rounded, mostly of quartz origin	sand
20.37	23.37	3.00	Reddish to yellow colour sediments, medium grained, sub rounded to rounded with gravels of quartz, rock fragments of mudstone/marl/kankar	sand
23.37	26.87	3.50	sand white in colour, medium to fine grained with little silt, rounded to sub angular, mostly of quartz origin	sand
26.87	29.87	3.00	sand white in colour, medium to fine grained with little silt, rounded to sub angular, mostly of quartz origin	sand
29.87	33.37	5.15	sand white in colour, medium to fine grained with little silt, rounded to sub angular, mostly of quartz origin	sand
33.37	36.37	3.00	Flesh red in colour, fine to coarse grained, dominated by coarse sand with little gravel, sedments, rounded to sub angular, mostly quartzite-rusted and little mudstone and dark coloured minerals	Sandstone
36.37	39.87	3.50	Flesh red in colour, fine to coarse grained, dominated by coarse sand with little gravel, sedments, rounded to sub angular, mostly quartzite-rusted and little mudstone and dark coloured minerals	Sandstone
39.87	42.87	3.00	sand flesh red in colour, medium to coarse grained, mostly quartzitic, angular to sub angular, quartz are smoky, presence of dark coloured minerals are visiable	Sandstone
42.87	46.37	3.50	Sand white in colour, medium to fine grained, mostly quartzitic-rusted with dark coloured minerals, sediments are angular to subangular with little lime (kankar/limestone/white clay ?)	Sandstone
46.37	49.37	3.00	sand fine to coarse grained mixed with gravels of quartzitic origin, sediment reddish in colour, angular to sub angular	Sandstone
49.37	52.91	3.54	sand fine to coarse grained mixed with gravels of quartzitic origin, sediment reddish in colour, angular to sub angular	Sandstone

52.91	55.91	3.00	Predominently gravels, sand fine to very coarse grained mixed with gravels of quartzitic origin, sediment reddish in colour, angular to sub angular	Sandstone
55.91	59.45	0.00	Predominently gravels, sand fine to very coarse grained mixed with gravels of quartzitic origin, sediment reddish in colour, angular to sub angular	Sandstone
59.45	62.45	0.00	Predominently gravels, sand fine to very coarse grained mixed with gravels of quartzitic origin, sediment reddish in colour, angular to sub angular	Sandstone
62.45	65.97	0.00	Grey in colour, fine to coarse sand with predominently gravel mixed with clay 10%, non sticky in nature white in colour	sandstone intercalation with clay
65.97	68.97	0.00	Grey in colour, fine to coarse sand with predominently gravel mixed with clay 20%, non sticky in nature white in colour	sandstone intercalation with clay
68.97	72.51	0.00	Grey in colour, fine (20%)to coarse sand with predominently gravel mixed with clay 20%, non sticky in nature white in colour	sandstone intercalation with clay
72.51	75.51	0.00	Grey in colour, fine (20%)to coarse sand with predominently gravel mixed with clay 20%, non sticky in nature white in colour	sandstone intercalation with clay
75.51	79.01	0.00	Grey in colour, fine (20%)to coarse sand with predominently gravel mixed with clay 20%, non sticky in nature white in colour	sandstone intercalation with clay
79.01	82.01	0.00	sand yellowish In colour, fine to medium grained, rounded to sub rounded	sandstone
82.01	85.56	0.00	sand yellowish In colour, fine to medium grained, predominently by fine sand, rounded to sub rounded	sandstone
85.56	88.56	0.00	Sand white in colour fine to coarse grained, mostly of quartz, angular to sub angular	sandstone
88.56	92.21	0.00	Sand white in colour fine to coarse grained, mostly of quartz, angular to sub angular	sandstone
92.21	95.21	0.00	Sand white in colour fine to coarse grained, mostly of quartz, angular to sub angular	sandstone
95.21	98.71	#REF!	sand grey in colour, very coarse grained, angular to sub rounded mixed with pices of lignite, rusted quartz and mudstone	sandstone interbedded with lignite
98.71	101.71	3.00	sand fine to coarse grained, subangular, greish white in colour	sandstone

101.71	104.91	3.20	Sand fine grained, grey in colour mixed with carbonaceous clay and grey colour clay 20%	clayey sand
104.91	107.91	3.00	Clay 80% with sand fine to medium grained, clays are mostly carbonaceous and grey colour clay	clay
107.91	111.41	3.50	sand fine grained, grey in colour mixed with carbonaceous clay and grey colour clay 40%	sandy clay
111.41	114.41	3.00	Clay 60 %, mostly of white in colour with sand, fine to coarse grained with little carbonaceous clay	sandy clay
114.41	117.97	3.56	Clay 60 %, mostly of white(non sticky) and grey (sticky) in colour with sand, fine to coarse grained	sandy clay
117.97	120.97	3.00	Clay 60 %, mostly of white(non sticky) and grey (sticky) in colour with sand, fine to medium grained with little carbonaceous clay	sandy clay
120.97	124.52	3.55	Clay grey to white in colour, sticky in nature mixed with sand fine to medium grained, rounded to sub rounded	sandy clay
124.52	127.52	3.00	Clay grey to white in colour, sticky in nature mixed with sand fine to medium grained, rounded to sub rounded	sandy clay
127.52	131.02	3.50	Clay grey to white in colour, sticky in nature mixed with sand fine to medium grained, rounded to sub rounded	sandy clay
131.02	134.02	3.00	Clay predominent 90%, white in colour with little sand	clay
134.02	137.52	3.50	Clay predominent 90%, white in colour with little carbonaceous clay	clay
137.52	140.52	3.00	Clay predominent 90%, white in colour with little carbonaceous clay and fine sand	clay
140.52	144.02	3.50	Clay 60% mixed with sand fine grained to coarse grained mixed with lignite pieces and carbonaceous clay	sandy clay with lignite
144.02	147.02	3.00	Sand medium to coarse grained, grey in colour with more pieces of lignite and chalcopyrite mineral	sandstone interclation with lignite
147.02	150.52	3.50	Sand grey in colour, medium to coarse grained, angular to sub rounded with chalcopyrite mineral	sand

150.52	153.52	3.00	Sand grey in colour, medium to coarse grained, angular to sub rounded with chalcopyrite mineral	sand
153.52	157.02	3.50	Sand grey in colour, medium to coarse grained, angular to sub rounded with chalcopyrite mineral	sand
157.02	160.02	3.00	Sand coarse to very coarse grained, predominently by quartz and little chalophyrite, angular to sub rounded quartz are rusted mixed with little clay 5 %, grey in colour sticky in nature	sand
160.02	163.57	3.55	Sand coarse to very coarse grained, predominently by quartz, angular to sub rounded quartz are rusted mixed with little clay 5 %, grey in colour sticky in nature	sand
163.57	166.57	3.00	sand grey in colour, rounded to sub rounded, very fine to medium grained with little clay and silt	sandstone
166.57	170.12	3.55	sand grey in colour, rounded to sub angular, very fine to medium grained with little clay and silt	sandstone
170.12	173.12	3.00	sand grey in colour, rounded to sub angular, very fine to medium grained with little clay 5 % and silt	sand
173.12	176.62	3.50	Sand medium grained, grey in colour, sub angular to sub rounded mixed with chacophyrite mineral and predominently by quartz	sand
176.62	179.62	3.00	Sand medium to coarse grained, grey in colour, sub angular to sub rounded mixed with chacophyrite mineral and predominently by quartz-smokey in nature	sand
179.62	183.18	3.56	Sand medium to coarse grained, grey in colour, sub angular to sub rounded mixed with chacophyrite mineral and predominently by quartz-smokey in nature	sand
183.18	186.18	3.00	Sand fine to coarse grained, greish white in colour with gravels rouned to sub rounded, sands are subangular, mostly of quartz-smokey with chalcophyrite mineral	sand
186.18	189.68	3.50	Sand fine to coarse grained, greish white in colour with gravels rouned to sub rounded, sands are subangular, mostly of quartz-smokey with chalcophyrite mineral	sand

189.68	192.68	3.00	Sand fine to coarse grained, greish white in colour with gravels rouned to sub rounded, sands are subangular, mostly of quartz-smokey with chalcophyrite mineral	sand
192.68	196.21	3.53	Sand fine to coarse grained, greish white in colour with gravels rouned to sub rounded, sands are subangular, mostly of quartz-smokey with chalcophyrite mineral	sand
196.21	199.21	3.00	Fine sand mixed with clay, voilet, yellow, white in colour in colour 40%	sand mixed with clay
199.21	202.21	3.00	Fine sand mixed with clay, voilet, yellow, white in colour in colour 40%	sand mixed with clay
202.21	205.71	3.50	Yellowish in colour 60%, yellow clay, voilet clay, white clay with little sand fine to medium grained	sand mixed with clay
205.71	208.71	3.00	sand very coarse grained mixed with clay varied in colour 20%	sand mixed with clay
208.71	212.24	3.53	Sand medium to coarse grained, angular to sub angular, whitish in colour, mostly quartz-smokey	sand
212.24	215.24	3.00	Sand medium to coarse grained, angular to sub angular, whitish in colour, mostly quartz-smokey	sand
215.24	218.75	3.51	Sand medium to coarse grained, angular to sub angular, whitish in colour, mostly quartz-smokey	sand
218.75	221.75	3.00	Sand medium to coarse grained, angular to sub angular, whitish in colour, mostly quartz-smokey	sand
221.75	225.27	3.52	sand very coarse grained, grey in colour, angular to subangular, presence of chalcophyrite mineral and quartz-smokey	sand
225.27	230.00	4.73	sand very coarse grained, grey in colour, angular to subangular, presence of chalcophyrite mineral and quartz-smokey	sand

Village: Sengalpalayam

Block: Kamapuram

Drilling depth range (m)		Thickness (m)	Discribtion of (sample) litholog	Formation
From	To			
0.00	4.00		Pale yellow in colour, coarse grained.	Top soil
4.00	32.25		sand - medium grained, sub-rounded in nature, pale reddish brown in colour	sandstone
32.25	35.50		Sandtsone with feeble sticky clay	sandstone
35.50	38.50		sand - medium grained, sub-rounded in nature, pale reddish brown in colour	sandstone
38.50	41.75		clay, feebly st	clay
41.75	54.25		sand - medium grained, sub-rounded in nature, pale reddish brown in colour	sandyclay
54.25	57.25		clay, sticky in nature	clay
57.25	60.50		sand - medium grained, sub-rounded in nature, pale reddish brown in colour	sandy clay
60.50	63.50		medium grained sand, dull coloured.	sandstone
63.50	70.00		sandstone with clay as interclations, feebly sticky in nature.	sandy clay
73.00	113.50		sand, medium grained	sandstone
113.50	116.75		Clay - sticky clay	clay
116.75	123.00		sand, medium grained	sandstone
123.00	126.00		Clay - sticky in nature	clay
126.00	148.00		sand, medium grained	sandstone
148.00	151.00		Clay with few sand grains	sandyclay
151.00	154.25		sand with clay interclations	sandyclay
154.25	363.00		sand, medium grained	sandstone
363.5	400		sand, medium to coarse grained	sandstone

Village: Srinivasanallur

Block: Kurunjipadi

Drilling depth range		Total Thickness in m	Discribtion of (sample) litholog	Formation
From	To			
0.00	4.00	4.00	Sand mixed with topsoil and human bones	Topsoil
4.00	7.00	3.00	Sand mixed with topsoil	Topsoil
7.00	10.50	3.50	Sand mixed with topsoil	Topsoil
10.50	13.50	3.00	Gravel mixed with sand, angular to sub angular, yellowish in colour mostly quartzite	Sandstone
13.50	16.70	3.20	Gravel mixed with sand, angular to sub angular, yellowish in colour mostly quartzite	Sandstone

16.70	19.70	3.00	Gravel mixed with sand, angular to sub angular, yellowish in colour mostly quartzite	Sandstone
19.70	22.90	3.20	Gravel mixed with sand, angular to sub angular, yellowish in colour mostly quartzite	Sandstone
22.90	25.90	3.00	Clay dusty white in colour, non sticky in nature, with little yellow colour and little sand	Clay
25.90	29.10	3.20	Clay dusty white in colour, non sticky in nature, with little yellow colour and little sand	Clay
29.10	32.10	3.00	Clay dusty white in colour, non sticky in nature, with little yellow colour and little sand	Clay
32.10	35.50	3.40	Sand fine grained with little medium sand and white clay/ propabley limestone/ brown in colour with quartzite, angular	Sandstone
35.50	38.50	3.00	Sand fine grained with little medium sand and white clay/ propabley limestone/ brown in colour with quartzite, angular	Sandstone
38.50	41.50	3.00	Medium sand angular to sub angular white in colour	Sandstone
41.50	44.50	3.00	Fine to medium sand, dominently sand 60% angular to sub angular	Sandstone
44.50	47.70	3.20	Medium sand yellow in colour, equigrangular, well sorted, sub angular to angular with quartzite	Sandstone
47.70	50.70	3.00	Medium sand yellow in colour, equigrangular, well sorted, sub angular to angular with quartzite	Sandstone
50.70	53.90	3.20	Coarse grained sand, rounded mixed with clay white	Sandstone
53.90	56.90	3.00	Very coarse grained sand rounded mixed, white in colour	Sandstone
56.90	60.10	3.20	Very coarse grained sand rounded mixed, white in colour	Sandstone
60.10	63.10	3.00	Fine to medium sand , rounded to subrounded white in colour	Sandstone
63.10	66.30	3.20	Fine to medium sand , rounded to subrounded white in colour	Sandstone
66.30	69.30	3.00	Fine to coarse grained sand, dominent of medium grained sand, white in colour with rusted quartzite	Sandstone

69.30	72.50	3.20	Medium sand, sub angular to sub rounded grey in colour mixed with chalcophyrite	Sandstone
72.50	75.50	3.00	Fine to medium grained grey in colour, sub angular to sub rounded, chalcophyrite mineral	Sandstone
75.50	78.70	3.20	Medium grained sand, grey in colour sub rounded to sub rounded	Sandstone
78.70	81.70	3.00	Medium grained sand, grey in colour sub rounded to sub rounded	Sandstone
81.70	84.90	3.20	Medium grained sand, grey in colour sub rounded to sub rounded	Sandstone
84.90	87.90	3.00	Medium grained sand, grey in colour sub rounded to sub rounded	Sandstone
87.90	91.10	3.20	Sand medium, calcareous in nature sandstone	Sandstone
91.10	94.10	3.00	Sand medium, calcareous in nature sandstone	Sandstone
94.10	97.30	3.20	Sandy fine to medium grained with calcareous material	Sandstone
97.30	100.30	3.00	samd fine to coarse, 60% coarse sand, grey in colour, sub rounded	Sandstone
100.30	103.50	3.20	Fine to medium sand, white in colour mainly of quartzite	Sandstone
103.50	106.50	3.00	Fine to medium sand, white in colour mainly of quartzite	Sandstone
106.50	109.70	3.20	Medium sand white in colour, sub-angular to angular	Sandstone
109.70	112.70	3.00	Fine to medium sand , rounded to subrounded with white colour calcarous material	Sandstone
112.70	115.90	3.20	Fine to medium sand , rounded to subrounded with white colour calcarous material	Sandstone
115.90	118.90	3.00	Fine to medium sand , rounded to subrounded with white colour calcarous material	Sandstone
118.90	122.10	3.20	Fine sand to medium sand, white in colour, fine grain sand dominent	Sandstone
122.10	125.10	3.00	Fine sand to medium sand, white in colour, fine grain sand dominent	Sandstone
125.10	128.30	3.20	Fine sand mixed with little clay, calcareous nature with phylite mineral	Sandstone
128.30	131.30	3.00	Fine sand mixed with little clay, calcareous nature with phylite mineral	Sandstone

131.30	134.50	3.20	Fine to coarse sand mostly coarse sand with rusted material	Sandstone
134.50	137.50	3.00	Fine to coarse sand mostly coarse sand with rusted material	Sandstone
137.50	140.70	3.20	Clay whitish colour mixed with sand fine grained	Sandstone
140.70	143.70	3.00	Clay whitish colour mixed with sand fine grained	Sandstone
143.70	146.90	3.20	Clay 70% mixed with sand rounded, mixed with clay non stickicy clay	Sandstone
146.90	149.90	3.00	Clay 70% mixed with sand rounded, mixed with clay non stickicy clay	Sandstone
149.90	153.10	3.20	Clay 70% mixed with sand rounded, mixed with clay non stickicy clay	Sandstone
153.10	156.10	3.00	Clay white in colour, sticky mixed with little sand	Sandy clay
156.10	159.30	3.20	Clay white in colour, sticky mixed with little sand	Sandy clay
159.30	162.30	3.00	Clay white in colour, sticky mixed with little sand	Sandy clay
162.30	165.50	3.20	clay sticky in nature	Clay
165.50	168.50	3.00	clay sticky in nature	Clay
168.50	171.70	3.20	Sandy clay mixed with little pieces of lignite	Sandy clay
171.70	174.70	3.00	Clay mixed with sand and black clay	Sandy clay
174.70	177.90	3.20	Clay mixed in colour, white, brown and black, non sticky in nature with little sand, gravels of quartz enriched with lignite pices, black clay and pyrite mineral	lignite
177.90	180.90	3.00	Clay 60% mixed with medium sand, rounded to subrounded with lignite pieces	lignite
180.90	184.10	3.20	Clay with lignite pieces	lignite
184.10	187.10	3.00	lignite with sand, coarse grained, sub angular to rounded	lignite
187.10	190.30	3.20	Sand grey in colour, sub rounded to rounded with phyrite	Sandstone
190.30	193.30	3.00	Sand grey in colour, sub rounded to rounded with phyrite	Sandstone
193.30	196.50	3.20	Sand medium to coarse sand , grey in colour, sub rounded	Sandstone
196.50	199.50	3.00	Sand medium to coarse sand , grey in colour, sub rounded	Sandstone
199.50	201.00	1.50	Sand medium to coarse sand , grey in colour, sub rounded	Sandstone

Village: thaiyalkunapattinam
Block: Kurunjipadi

Drilling depth range (m)		Total Thickness (m)	Discribtion of (sample) litholog	Formation
From	To			
0	3	3	Sample brown in colour, sand mixed with clay	Topsoil
3	6.5	3.5	Sample brown in colour, sand mixed with clay	Topsoil
6.5	10	3.5	Sand fine to medium grained, predominently by fine sand brown in colour	Sandstone
10	13	3	Sand fine grained with little lime/kankar and clay white in colour	Sandstone
13	16.55	3.55	Sample pale brown in colour, mostly silty to fine grained sand with little medium sand, rounded in nature	Sandstone
16.55	19.55	3	Sample yellowish in colour, sand white in colour, fine to medium grained, subrounded, mostly of quartzite	Sandstone
19.55	23.1	3.55	sample white in colour, medium to coarse grained, rounded to sub rounded, quartzite	Sandstone
23.1	26.1	3	sample white in colour, medium to coarse grained, rounded to sub rounded, quartzite	Sandstone
26.1	29.65	3.55	sample white in colour, medium to coarse grained, rounded to sub rounded, quartzite	Sandstone
29.65	32.65	3	Sample yellowish in colour, sand white in colour, fine to very coarse grained, subrounded, mostly of quartzite with little clay yellow in colour	Sandstone
32.65	36.19	3.54	Sample yellowish in colour, sand white in colour, fine to very coarse grained, subrounded, mostly of quartzite with little clay yellow in colour	Sandstone
36.19	39.19	3	Sand, fine to medium, rounded to sub rounded, mostly quartzitic, 40% fine sand.	Sandstone
39.19	42.74	3.55	Sand, fine to medium, rounded to sub rounded, mostly quartzitic, 40% fine sand.	Sandstone
42.74	45.74	3	Sand, fine to medium, rounded to sub rounded, mostly quartzitic, 40% fine sand.	Sandstone

45.74	49.29	3.55	Sand fine to coarse grained yellow in colour, mostly of quartzitic, angular to sub angular	Sandstone
49.29	52.29	3	Sand fine to coarse grained yellow in colour, mostly coarse grained, sand are rusted, angular to sub rounded	Sandstone
52.29	55.79	3.5	Fine sand with little medium sand, yellow in colour	Sandstone
55.79	58.79	3	Sand fine to medium grained with little clay brown, yellow and red in clolour	Sandstone
58.79	62.34	3.55	Sand medium grained	Sandstone
62.34	65.34	3	Sand fine to medium grained mixed with grey colour clay, sand are sub rounded	Sandstone
65.34	38.89	-26.45	Sand grey in colour, fine to medium grained, sub rounded to angular with clay grey in colour sticky in nature	Sandstone
38.89	71.89	33	Sand fine to coarse sand, 60% of medium sand, rounded in nature of quartz with little clay	Clayeysand
71.89	75.41	3.52	Clay grey in colour, sticky with little coarse sand	clay
75.41	78.41	3	clay grey in colour with little sand 5%	clay
78.41	81.95	3.54	Clay with little sand 20% coarse grained, rounded	Sandyclay
81.95	84.95	3	Sand medium grained, grey in colour with little clay	Sandyclay
84.95	88.45	3.5	Sand mixed with clay 40% and sand 60% clay grey in colour, coarse grained sand rounded to subrounded with sicky clay	Sandyclay
88.45	91.45	3	Sand mixed with clay, 90% clay grey sticky	Clay
91.45	95.05	3.6	Sand clay, 40% sand, very coarse	Sandyclay
95.05	98.05	3	Clay with little sand	Clay
98.05	101.6	3.55	Clay with little sand	Clay
101.6	104.6	3	Clay with little sand	Clay
104.6	108.1	3.5	Clay with little sand	Clay
108.1	111.1	3	Clay mixed with very coarse grained sand	Clay
111.1	114.6	3.5	Clay 95% with little sand very coarse grained with little rounder pebble	Clay
114.6	117.6	3	Clay sticky, grey in colour with sand fine to coarse grained	Clay
117.6	121.15	3.55	Clay sticky in nature	Clay
121.15	124.15	3	Clay sticky in nature	Clay
124.15	127.65	3.5	clay with 5 % of sand	Sandyclay
127.65	130.65	3	Clay sticky in nature	Sandyclay

130.65	134.1	3.45	Clay sticky in nature	Sandyclay
134.1	137.1	3	Clay with sand	Sandyclay
137.1	140.75	3.65	clay with sand coarse grained	Sandyclay
140.75	143.75	3	clay with sand coarse grained	Sandyclay
143.75	147.31	3.56	Sand fine to coarse grained sand rounded to sub angular	Sandstone
147.31	50.31	97	Fine to medium grained sand with little clay and phyrite minerals	Sandstone
50.31	153.83	103.52	Fine to medium grained sand with little clay and phyrite minerals	Sandstone
153.83	156.83	3	Fine grained sand with little clay and phyrite minerals	Sandstone
156.83	160.38	3.55	Sand dominant, medium grained sand, grey in colour with clay	Sandstone
160.38	163.33	2.95	Sandy clay with brown colour clay, sand medium grained	Sandstone
163.33	166.88	3.55	sand medium to coarse grained, sub rounded with little clay	Sandstone
166.88	169.88	3	sand medium to coarse grained, sub rounded with little clay	Sandstone
169.88	173.42	3.54	Sand fine to medium grained	Sandstone
173.42	176.42	3	Sand fine to medium grained with clay	Sandstone
176.42	179.94	3.52	sand fine grained , rounded	Sandstone
179.94	182.94	3	sand fine to coarse grained with little clay	Sandstone
182.94	186.44	3.5	Medium sand	Sandstone
186.44	189.44	3	medium sand	Sandstone
189.44	192.98	3.54	Medium sand	Sandstone
192.98	195.98	3	Sand fine to medium grained, sub angular to angular	Sandstone
195.98	198.98	3	Sand medium	Sandstone
198.98	201.98	3	sand medium	Sandstone

Village: Vanathirayapuram
Block: Kurunjipadi

Drilling depth range From	To	Total Thickness in m	Discribtion of (sample) litholog	Formation
0.00	3.80	3.80	Sample brown in colour, mostly clay brown colour, with fine sand	Topsoil, sand and clay
3.80	7.30	3.50	Sample brown in colour, mostly clay brown colour, with fine sand	Topsoil, sand and clay
7.30	10.30	3.00	sand fine grained mixed with clay white/brown/yellow in colour	Topsoil, sand and clay
10.30	13.82	3.52	sand fine grained mixed with clay white/brown/yellow in colour	sandy clay
13.82	16.82	3.00	sand fine grained mixed with clay white/brown/yellow in colour	sandy clay
16.82	20.37	3.55	sand fine grained mixed with clay white/brown/yellow in colour	sandy clay
20.37	23.37	3.00	sand fine grained mixed with clay white/brown/yellow in colour	sandy clay
23.37	26.85	3.48	Fine sand flesh red in colour	sand
26.85	29.85	3.00	Sand fine grained mixed with clay, yellow and white in colour	sandy clay
29.85	33.35	3.50	Sand fine grained mixed with clay, yellow and white in colour	sandy clay
33.35	36.35	3.00	Sand medium grained with 40% of clay	sandy clay
36.35	39.91	3.56	Sand, medium grained with 40% of clay	sandy clay
39.91	42.91	3.00	Sand, fine to medium grained with 30% of clay	sandy clay
42.91	46.41	3.50	Sand, fine to medium grained with 30% of clay	sandy clay
46.41	49.41	3.00	Sand, fine to medium grained with 30% of clay	sandy clay
49.41	52.91	3.50	Sand, fine to medium grained with 30% of clay	sandy clay
52.91	55.91	3.00	Sand, fine to medium grained with 30% of clay	sandy clay
55.91	59.51	3.60	Gravel, rounded mostly quartzitic	gravel
59.51	62.51	3.00	Gravel, rounded mostly quartzitic	gravel
62.51	66.06	3.55	Sand coarse grained with clay white in colour	Sandy clay
66.06	69.06	3.00	Sand coarse grained with clay white in colour	Sandy clay

69.06	72.56	3.50	Sand coarse grained with clay white in colour	Sandy clay
72.56	75.56	3.00	Sand coarse grained with clay white in colour	Sandy clay
75.56	79.11	3.55	Lignite mixed with carbonaceous clay and sand medium grained	Lignite mixed with clay and sand
79.11	82.11	3.00	Lignite mixed with carbonaceous clay and sand medium grained	Lignite mixed with clay and sand
82.11	85.64	3.53	Lignite mixed with carbonaceous clay and sand medium grained	Lignite mixed with clay and sand
85.64	88.64	3.00	Sand coarse grained with clay white in colour	sand and clay
88.64	91.89	3.25	Sand coarse grained, dark grey in colour	sandstone
91.89	94.89	3.00	Sand coarse grained, dark grey in colour with little clay	sandstone
94.89	98.43	3.54	Sand dark grey in colour, medium grained with carbonaceous clay	sand and clay
98.43	101.43	3.00	Sand dark grey in colour, medium grained with carbonaceous clay	sand and clay
101.43	104.91	3.48	Sand dark grey in colour, medium grained with carbonaceous clay	sand and clay
104.91	107.93	3.02	Sand fine to medium grained with little pices of lignite	Lignite mixed with clay and sand
107.93	111.53	3.60	sand medium, rounded to sub-rouned	sand
111.53	114.53	3.00	sand medium, rounded to sub-rouned	sand
114.53	118.03	3.50	Sand with black/grey coloured clay	sandy clay
118.03	121.03	3.00	Sand fine grained whitish in colour with little clay	sandy clay
121.03	124.57	3.54	Fine sand rounded to subrounded	sand
124.57	127.57	3.00	Fine sand rounded to subrounded	sand
127.57	131.09	3.52	Fine sand rounded to subrounded	sand
131.09	134.02	2.93	Sand medium grained, subrounded to sub angular	sand
134.02	136.09	2.07	Sand medium grained, subrounded to sub angular	sand
136.09	139.59	3.50	Sand mixed with pieces of lignite	sandstone intercalation with clay
139.59	142.59	3.00	sand, rusted in nature	sand
142.59	146.15	3.56	Black clay with sand medium grained	clay

146.15	149.15	3.00	sand medium grained drak grey in colour	sand
149.15	152.65	3.50	sand medium grained drak grey in colour	sand
152.65	155.65	3.00	sand medium grained drak grey in colour	sand
155.65	159.15	3.50	sand medium grained drak grey in colour	sand
159.15	162.15	3.00	Sand medium grained, subrounded to sub angular,white in colour	sand
162.15	165.67	3.52	Sand medium grained, subrounded to sub angular,white in colour	sandstone
165.67	168.67	3.00	Sand medium grained, subrounded to sub angular,white in colour	sandstone
168.67	172.22	3.55	Sand medium grained, subrounded to sub angular,white in colour	sand
172.22	175.22	3.00	Sand medium grained, subrounded to sub angular,white in colour	sand
175.22	178.82	3.60	Black clay with sand medium grained	clay
178.82	185.32	6.50	Black clay with sand medium grained	clay
185.32	188.32	3.00	Sand medium grained, subrounded to sub angular,white in colour	sand
188.32	191.82	3.50	Sand medium grained, subrounded to sub angular,white in colour	sand
191.82	194.82	3.00	Sand medium grained, subrounded to sub angular,white in colour	sand
194.82	198.32	3.50	Sand with black/grey colour sticky in nature	clay
198.32	200.32	2.00	Sand dark grey in colour, medium grained with black clay	sand and clay

Village: Vegakollai
Block: Panruti

Drilling depth range		Total Thickness in m	Discribtion of (sample) litholog	Formation
From	To			
0.00	4.00	4.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized with ferrogenus matrix	lateritic soil
4.00	7.00	3.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized, grains are subrounded to angular with ferrogenus matrix	lateritic soil

7.00	10.50	3.50	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized, grains are subrounded to angular with ferrogenus matrix	lateritic soil
10.50	13.50	3.00	Laterite mixed with yellow and sticky clay	lateritic soil
13.50	16.75	3.25	Clay yellow in colour sticky in nature and mixed with Laterite	clay
16.75	19.75	3.00	Clay yellow in colour sticky in nature and mixed with Laterite	clay
19.75	23.00	3.25	Clay yellow in colour sticky in nature and mixed with Laterite	clay
23.00	26.00	3.00	Pebbles of quartzite and sst mixed with yellow colour sticky clay	pebble clay
26.00	29.25	3.25	Pebbles of quartzite and sst mixed with yellow colour sticky clay	pebble clay
29.25	32.25	3.00	sample reddish brown in colour, grains Pebbles to gravels of quartzite with little white coloured clay	clayey sand
32.25	35.50	3.25	sample reddish brown in colour, grains Pebbles to gravels of quartzite with little white coloured clay	clayey sand
35.50	38.50	3.00	clay brown in colour sticky in nature mixed with fine sand	sandy clay
38.50	41.75	3.25	clay brown in colour sticky in nature mixed with fine sand	sandy clay
41.75	44.75	3.00	Clay, sticky in nature with cream in colour with very little sand	clay
44.75	48.00	3.25	Clay sticky and hard with very little sand brown in colour	clay
48.00	51.00	3.00	Clay sticky and hard with very little sand brown in colour	clay
51.00	54.25	3.25	Fine sand mixed with clay (40%)white in colour	sandy clay
54.25	57.25	3.00	Fine sand mixed with clay (40%)white in colour	sandy clay
57.25	60.50	3.25	Fine sand mixed with clay (40%)white in colour	sandy clay
60.50	63.50	3.00	Clay Yellowish brown colour and sticky in nature mixed with fine to medium sand	sandy clay
63.50	66.75	3.25	Clay Yellowish brown colour and sticky in nature mixed with fine to medium sand	sandy clay
66.75	69.75	3.00	Clay Yellowish brown colour and sticky in nature mixed with fine to medium sand	sandy clay

69.75	73.00	3.25	Clay Yellowish brown colour and sticky in nature mixed with fine to medium sand and gravel	sandy clay
73.00	76.00	3.00	Sample Dusty white in colour, Clay (90%), white in colour and sticky in nature with sand (10%)-mostly quartz	clay
76.00	79.25	3.25	Gravel rounded to sub rounded of quartz and fragment of rock with clay (30%) and fine sand	gravel
79.25	82.25	3.00	Very fine sand mixed with clay 40%	clayey sand
82.25	85.50	3.25	Find sand reddish white in colour	sand
85.50	88.50	3.00	Find sand with little clay	sand
88.50	91.75	3.25	sand white colour and fine to medium grained	sand
91.75	94.75	3.00	sand white colour and fine to medium grained. Rounded to sub rounded	sand
94.75	98.00	3.25	Sand with clay white in colour	sand
98.00	101.00	3.00	Sand fine to coarse grained, white to greyish in colour, sub angular	sand
101.00	104.25	3.25	Medium grained grey colour sand mixed with little fine sand	sand
104.25	107.25	3.00	Medium grained grey colour sand mixed with little fine sand	sand
107.25	110.50	3.25	Medium sand, sub angular with metamorphic minerals mafic in nature	sand
110.50	113.50	3.00	Medium sand, sub angular with metamorphic minerals mafic in nature	sand
113.50	116.75	3.25	Medium to coarse grained sand	sand
116.75	119.75	3.00	sample greyish/black in colour, sand medium to coarse grained mixed with phyrite mineral	sand
119.75	123.00	3.25	sample greyish/black in colour, sand medium to coarse grained mixed with phyrite mineral with little clay	sand
123.00	126.00	3.00	Coarse grained sand with little find sand	sand
126.00	129.25	3.25	Sand Medium grained, grey in colour, angular to sub angular	sand
129.25	132.25	3.00	Sand fine to coarse grained sand with little gravel to pebble	sand
132.25	135.50	3.25	Sand fine to coarse grained sand with little gravel to pebble	sand
135.50	138.50	3.00	Sand fine to coarse grained sand with little gravel to pebble	sand

138.50	141.75	3.25	Sand fine to medium with carbanaceous clay and lignite?	sandy clay lignite
141.75	144.75	3.00	Sand fine to medium with carbanaceous clay and flaks of lignite	sandy clay lignite
144.75	148.00	3.25	Sand mixed with lignite	sand lignite
148.00	151.00	3.00	Carbanaceous clay mixed with little fine sand	clay
151.00	154.25	3.25	Carbanaceous clay mixed with little fine sand	clay
154.25	157.25	3.00	Medium to coarse grained sand, grey in colour	sand
157.25	160.50	3.25	Coarse grained sand mixed with pebbles of quartzite, rounded to sub rounded	sand
160.50	163.50	3.00	Coarse grained sand mixed with pebbles of quartzite, rounded to sub rounded with gravel	sand
163.50	166.75	3.25	Coarse grained sand mixed with pebbles of quartzite, rounded to sub rounded with gravel	sand
166.75	169.75	3.00	Gravel rounded to subrounded mostly quartizitc mixed with litte coarse sand	gravel
169.75	173.00	3.25	Gravel rounded to subrounded mostly quartizitc mixed with litte coarse sand	gravel
173.00	176.00	3.00	Medium to coarse sand mixed with gravel, rounded in shape	sand
176.00	179.25	3.25	Medium to coarse sand mixed with gravel, rounded in shape	sand
179.25	182.25	3.00	Medium to coarse sand mixed with gravel, rounded in shape	sand
182.25	185.00	2.75	Medium to coarse sand mixed with gravel, rounded in shape	sand
185.00	188.50	3.50	Medium to coarse sand mixed with gravel, rounded in shape	sand
188.50	191.75	3.25	Fine to coarse grained sand	sand
191.75	194.75	3.00	Fine to coarse grained sand with little clay, grey in colour and non sticky	clay
194.75	198.00	3.25	Fine to coarse sand	sand
198.00	201.00	3.00	Medium graind, sub angular sand grey in colour	sand
201.00	204.25	3.25	Medium graind, sub angular sand grey in colour	sand
204.25	207.25	3.00	Medium graind, sub angular sand grey in colour	sand

207.25	210.50	3.25	Fine to coarse sand, angular to sub angular grey in colour	sand
210.50	213.50	3.00	Medium to coarse grained sand angular to sub angular, grey in colour	sand
213.50	216.75	3.25	Fine to medium grained, grey colour sand	sand
216.75	219.75	3.00	Medium to coarse grained sand angular to sub angular, grey in colour	sand
219.75	223.00	3.25	Fine to coarse sand, angular to sub angular grey in colour	sand
223.00	226.00	3.00	Fine grained sand mixed with coarse sand	sand
226.00	229.25	3.25	Fine to medium grained, grey colour sand	sand
229.25	232.25	3.00	Fine to medium grained, grey colour sand with little yellow coloured clay	sand
232.25	235.50	3.25	fine to medium grained sand with little yellow and white coloured clay	sand
235.50	238.50	3.00	gravel rounded to subrounded mostly quartizitc mixed with litte coarse sand and carbanacous clay and yellow coloured clay	gravel
238.50	241.75	3.25	gravel rounded to subrounded mostly quartizitc mixed with litte coarse sand and carbanacous clay and yellow coloured clay	gravel
241.75	244.75	3.00	fine to medium grained sand mixed with flakes f lignite and pebbles of quartizite	sand
244.75	248.00	3.25	Gravels with little sand and pyrite mineral are occasionaly seen	gravel
248.00	251.00	3.00	gravel with little clay	gravel
251.00	254.25	3.25	gravel with sand	gravel
254.25	257.25	3.00	Coarse grained sand with gravels	gravel
257.25	260.50	3.25	gravels with little clay, white in colour	gravel
260.50	263.50	3.00	fine to coarse sand with gravel	sand
263.50	266.75	3.25	fine to coarse sand with gravel	sand
266.75	269.75	3.00	fine to coarse grained sand, sub angular, grey in colour	sand
269.75	273.00	3.25	fine to coarse grained sand, sub angular, grey in colour	sand
273.00	276.00	3.00	fine to coarse grained sand, sub angular, grey in colour	sand
276.00	279.25	3.25	Sand white in colour fine to coarse grained, rounded to sub angular with phyrite minerals	sand
279.25	282.25	3.00	Sand white in colour fine to coarse grained, rounded to sub angular with phyrite minerals	sand
282.25	285.50	3.25	Medium to coarse grained sand	sand

285.50	288.50	3.00	coarse grained sand	sand
288.50	291.75	3.25	fine to medium grained white coloured sand	sand
291.75	294.75	3.00	fine to medium grained white coloured sand	sand
294.75	298.00	3.25	fine to medium grained white coloured sand	sand
298.00	301.00	3.00	fine to medium grained white coloured sand	sand
301.00	304.25	3.25	Medium grained sand	sand
304.25	307.25	3.00	Medium grained sand	sand
307.25	310.50	3.25	Medium grained sand	sand
310.50	313.50	3.00	Fine to medium grained sand	sand
313.50	316.75	3.25	Fine to medium grained sand	sand
316.75	319.75	3.00	Fine to medium grained sand	sand
319.75	323.00	3.25	Fine to medium grained sand with little clay	clay
323.00	326.00	3.00	Fine to medium grained sand with little clay	clay
326.00	329.25	3.25	Medium to coarse grained sand	sand
329.25	332.25	3.00	Medium to coarse grained sand	sand
332.25	335.50	3.25	Medium to coarse grained sand	sand
335.50	338.50	3.00	Medium to coarse grained sand	sand
338.50	341.75	3.25	Medium to coarse grained sand with little clay	clay
341.75	344.75	3.00	medium to coarse grained sand with little gravel	sand
344.75	348.00	3.25	medium to coarse grained sand with little gravel	sand
348.00	351.00	3.00	medium to coarse grained sand with little gravel and clay	sand
351.00	354.25	3.25	Medium to coarse grained sand	sand
354.25	357.25	3.00	medium to coarse grained sand with little gravel	sand
357.25	360.5	3.25	medium to coarse grained sand with little gravel	sand
360.5	363.50	3.00	medium to coarse grained sand with little clay 10%	sand
363.5	366.75	3.25	medium to coarse grained sand with little clay 30%	clay
366.75	369.75	3.00	coarse grained sand with little clay 30%	clay
369.75	373.00	3.25	coarse grained sand with little clay 30%	clay
373.00	376.00	3.00	Fine to coarse grained sand with 10% of clay grey in colour	sand
376.00	379.25	3.25	Fine to coarse grained sand	sand
379.25	382.25	3.00	Fine to coarse grained sand	sand

382.25	385.50	3.25	Fine to medium grained sand	sand
385.50	388.50	3.00	Medium to coarse grained sand	sand
392	395.25	3.25	Medium to coarse grained sand	sand
395.25	398.25	3.00	Medium to coarse grained sand	sand
398.25	400	1.75	Medium to coarse grained sand	sand

Village: Silambinathanpettai
Block: Panruti

Drilling depth range		Total Thickness in m	Discribtion of (sample) litholog	Formation
From	To			
0.00	4.00	4.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized with ferrogenus matrix	laterite
4.00	7.00	3.00	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized, grains are subrounded to angular with ferrogenus matrix	laterite
7.00	10.50	3.50	Reddish brown in colour, Grain size-Gravel to pebble rusted and laterized, grains are subrounded to angular with ferrogenus matrix	laterite
10.50	13.50	3.00	Sand reddish in colour, fine grained with clay brown in colour	sand
13.50	16.75	3.25	Sand reddish in colour, fine grained with clay brown in colour	sand
16.75	19.75	3.00	Sand fine to medium, reddish in colour mixed with clay brown in colour non sticky	sand
19.75	23.00	3.25	Sand fine to medium, reddish in colour mixed with clay brown in colour non sticky	sand
23.00	26.00	3.00	Sand reddish in colour with little gravel, sub rounded mixed with brown colour clay non stikcy in nature	sand
26.00	29.25	3.25	Sand reddish in colour with little gravel, sub rounded mixed with brown colour clay non stikcy in nature	sand
29.25	32.25	3.00	Sample yellowish brown in colour, sand medium to coarse grained, angular to subangular	sand

32.25	35.50	3.25	Sample yellowish brown in colour, sand medium to coarse grained, angular to subangular	sand
35.50	38.50	3.00	Sandy clay	sand
38.50	41.75	3.25	Sandy clay	sand
41.75	44.75	3.00	Sandy clay	sand
44.75	48.00	3.25	Clay sticky, brown in colour mixed with sand fine grained	clay
48.00	51.00	3.00	Clay sticky, brown in colour mixed with sand fine grained	clay
51.00	54.25	3.25	Sandy clay, clay 60%	clay
54.25	57.25	3.00	Sandy clay, clay 60%	clay
57.25	60.50	3.25	Sandy clay, clay 60%	clay
60.50	63.50	3.00	Clay mixed with sand 30 %	clay
63.50	66.75	3.25	Clay mixed with sand 30 %	Clay
66.75	69.75	3.00	Clay mixed with sand 30 %	Clay
69.75	73.00	3.25	Clay brown in colour and stikcy in nature	Clay
73.00	76.00	3.00	Clay brown in colour and stikcy in nature	Clay
76.00	79.25	3.25	Clay brown in colour and stikcy in nature	Clay
79.25	82.25	3.00	Sand fine grained with white colour matrix, ?????calcareous sst, white in colour	Sand
82.25	85.50	3.25	Sand fine grained with white colour matrix, ?????calcareous sst, white in colour	Sand
85.50	88.50	3.00	Sand fine to medium grained with clay matrix???????calcareous sst	Sand
88.50	91.75	3.25	Sand fine to medium grained with clay matrix???????calcareous sst	Sand
91.75	94.75	3.00	Sand fine to coarse grained un sorted subangular, white to reddish in colour	Sand
94.75	98.00	3.25	Reddish brown colour sand, fine to medium grained sub angular	Sand
98.00	101.00	3.00	Reddish brown to white colour sand, mostly quartzite, fine to medium grained	Sand
101.00	104.25	3.25	Medium to coarse grained sand, quartzitic, rounded to sub rounded	Sand
104.25	107.25	3.00	Medium to coarse grained sand, quartzitic, rounded to sub rounded	Sand
107.25	110.50	3.25	Sediment dark grey in colour, sand fine to gravely mixed with little pieces of lignite	Sand
110.50	113.50	3.00	Grey colour sediment, sand fine to medium grained unsorted of various mineral, presence of phyirite mineral is noticiable	Sand
113.50	116.75	3.25	Medium grained sand grey in colour, sub angular	Sand

116.75	119.75	3.00	Medium grained sand grey in colour, sub angular	Sand
119.75	123.00	3.25	Medium grained sand grey in colour, sub angular	Sand
123.00	126.00	3.00	Medium grained sand grey in colour, sub angular	Sand
126.00	129.25	3.25	Fine grained sand grey in colour	Sand
129.25	132.25	3.00	Fine to medium grained sand grey to white in colour	Sand
132.25	135.50	3.25	Fine to medium grained sand grey to white in colour	Sand
135.50	138.50	3.00	Fine to medium grained sand grey to white in colour	Sand
138.50	141.75	3.25	Fine to medium grained sand grey to white in colour	Sand
141.75	144.75	3.00	Fine to medium grained sand grey to white in colour	Sand
144.75	148.00	3.25	Fine to medium grained sand grey to white in colour	Sand
148.00	151.00	3.00	Fine grained sand	Sand
151.00	154.25	3.25	Fine grained sand	Sand
154.25	157.25	3.00	Fine to medium grained sand	Sand
157.25	160.50	3.25	Fine to medium grained sand with little clay	Clay
160.50	163.50	3.00	Fine to medium grained sand with little clay	Clay
163.50	166.75	3.25	Fine to medium grained sand with little clay	Clay
166.75	169.75	3.00	Fine to medium grained sand with little clay	Sand
169.75	173.00	3.25	Fine sand mixed with carbonaceous clay, dark black in colour	Sand
173.00	176.00	3.00	Sand fine to medium gravel, grey in colour, unsorted subangular	Sand
176.00	179.25	3.25	Sand mixer of sandstone and metamorphic mineral, grey to yellowish brown	Sand
179.25	182.25	3.00	Medium grained sandy grey in colour	Sand
182.25	185.00	2.75	Fine grained sand grey in colour	Sand
185.00	188.50	3.50	Fine grained sand grey in colour	Sand
188.50	191.75	3.25	Fine sand grey to white in colour equigranular, in dark grey colour clay	Sand
191.75	194.75	3.00	Sand fine grained, grey in colour	Sand
194.75	198.00	3.25	Sand fine grained, grey in colour	Sand
198.00	201.00	3.00	Sand fine grained with dark grey coloured clay	Sand
201.00	204.25	3.25	Sand fine grained with dark grey coloured clay	Sand

204.25	207.25	3.00	Clayey sand, sand medium grained, rounded, grey in colour	Sand
207.25	210.50	3.25	Sandy clay, clay 80%, sticky in nature and mixed with sand fine to medium grained	Clay
210.50	213.50	3.00	Clay, sticky, dark grey coloured	Clay
213.50	216.75	3.25	Sandy clay, clay 80%, sticky in nature and mixed with sand fine to medium grained	Clay
216.75	219.75	3.00	Clay mixed with little sand	Clay
219.75	223.00	3.25	Sandy clay, clay 70% sticky in nature	Clay
223.00	226.00	3.00	clay hard mixed with medium sand	Clay
226.00	229.25	3.25	clay hard mixed with medium sand	Clay
229.25	232.25	3.00	clay hard mixed with medium sand	Clay
232.25	235.50	3.25	Clay	Clay
235.50	238.50	3.00	clay sand	Clay
238.50	241.75	3.25	sand medium grained	Sand
241.75	244.75	3.00	sand medium grained mixed with clay	Sand
244.75	248.00	3.25	sand medium grained mixed with clay	Sand
248.00	251.00	3.00	Sand fine to medium grained mixed with shale	Sand
251.00	254.25	3.25	Sand fine to medium grained mixed with shale	Sand
254.25	257.25	3.00	Sand fine to medium grained mixed with shale	Sand
257.25	260.50	3.25	Clay, shalely	Clay
260.50	263.50	3.00	Clay, shalely	Clay
263.50	266.75	3.25	Clay grey in colour	Clay
266.75	269.75	3.00	Clay grey in colour	Clay
269.75	273.00	3.25	Clay grey in colour	Clay
273.00	276.00	3.00	Clay grey in colour	Clay
276.00	279.25	3.25	Clay grey in colour	Clay
279.25	282.25	3.00	Clay grey in colour	Clay
282.25	285.50	3.25	Clay grey in colour	Clay
285.50	288.50	3.00	Clay grey in colour	Clay
288.50	291.75	3.25	Clay grey in colour	Clay
291.75	294.75	3.00	Clay grey in colour	Clay
294.75	298.00	3.25	Sandy clay	sandy clay
298.00	301.00	3.00	Sandy clay	sandy clay
301.00	304.25	3.25	Sandy clay	sandy clay
304.25	307.25	3.00	Sandy clay	sandy clay
307.25	310.50	3.25	Sandy clay	sandy clay
310.50	313.50	3.00	Clay	Clay
313.50	316.75	3.25	Sand fine to medium grained rounded mixed with clay sticky in nature	Sand

316.75	319.75	3.00	Sand fine to medium grained rounded mixed with clay sticky in nature	Sand
319.75	323.00	3.25	Clay	Clay
323.00	326.00	3.00	Sand fine to coarse grained mixed with clay and little gravel	Sand
326.00	329.25	3.25	Sand fine to coarse grained mixed with clay and little gravel	Sand
329.25	332.25	3.00	Sand fine to coarse grained mixed with clay and little gravel	Sand
332.25	335.50	3.25	Fine to medium grained sand, grey in colour sub angular	Sand
335.50	338.50	3.00	Fine to medium grained sand, grey in colour sub angular	Sand
338.50	341.75	3.25	Sand medium grained with very little fine sand	Sand
341.75	344.75	3.00	medium to coarse grained sand with little gravel	Sand
344.75	348.00	3.25	Sand medium grained, equigranular, grey coloured well sorted	Sand
348.00	351.00	3.00	Sand medium grained, equigranular, grey coloured well sorted	Sand
351.00	354.25	3.25	Sand medium grained, equigranular, grey coloured well sorted	Sand
354.25	357.25	3.00	Sand medium grained, equigranular, grey coloured well sorted	Sand
357.25	360.50	3.25	Sand medium grained, equigranular, grey coloured well sorted	Sand
360.5	363.50	3.00	Sand medium with clay 40%	Sand
363.5	366.75	3.25	clay 70% mixed with sand grey in colour	Clay
366.75	369.75	3.00	sand fine to medium with clay 30%	Sand
369.75	373.00	3.25	Clay	Clay
373.00	376.00	3.00	Sand with clay	Sand
376.00	379.25	3.25	clay with sand	Clay
379.25	382.25	3.00	Clay, dark grey, sticky mixed with little sand	Clay
382.25	385.50	3.25	Clay, dark grey, sticky mixed with little sand	Clay
385.50	388.50	3.00	Clay, dark grey, sticky mixed with little sand	Clay

Village : Venkatampettai
Block: Kurunjipadi

Depth range(m bgl)	Total thickness(m)	Formation	Description
0.00-3.00	3.00	Sand	Light grey ,fine to course, sub angular to sub rounded mixed with ferruginous and calcareous material
3.00-7.00	4.00	Sand	Light brown ,fine to coarse, sub angular to sub rounded mixed with ferruginous and more calcareous material with little clay
7.00-20.00	14.00	Clay	Light Grey ,plastic, hard mixed with little sand
20.00-22.00	2.00	Sand	Light Grey ,fine to coarse, sub angular to sub rounded mixed with ferruginous and calcareous material
22.00-30.00	8.00	Clay	Light Grey ,plastic, hard
30.00-35.00	5.00	sandstone	Light brown, fine to medium
35.00-37.00	2.00	Clay	Light grey ,plastic, hard
37.00-42.00	5.00	Sandstone	Light brown, fine to medium.
42.00-48.00	6.00	clay	Light grey ,plastic, hard
48.00-62.00	14.00	Sand stone	Light brown, fine to medium.
62.00-65.00	3.00	Clay	Light grey ,plastic, hard
65.00-86.00	21.00	Sand stone	Light brown, fine to medium.
86.00-88.00	2.00	clay	Light grey, plastic, hard, sticky
88.00-120.00	32.00	Sand stone	Light brown, fine to medium.
120.00-122.00	2.00	clay	Light Grey, plastic, hard, sticky
122.00-132.00	10.00	Sand stone	Light brown, fine to medium.
132.00-134.00	2.00	clay	Light Grey, plastic, sticky, carbonaceous
134.00-140.00	6.00	Sand stone	Light brown, fine to medium.
140.00-144.00	4.00	lignite	Light Grey
144.00-150.00	6.00	Sand stone	Light brown, fine to medium.
150.00-159.00	9.00	Clay	Light Grey ,plastic, sticky, hard
159.00-179.00	20.00	Sand stone	Light brown, fine to medium.
179.00-184.00	5.00	clay	Light Grey plastic, hard, sticky
184.00-189.00	5.00	Sand stone	Light brown, fine to medium.
189.00-200.00	11.00	clay	Light Grey, plastic, hard, sticky
200.00-204.00	4.00	Sand stone	Light brown, fine to medium.
204.00-210.00	6.00	clay	Light Grey, plastic, hard, sticky
210.00-221.00	11.00	Sand stone	Light brown, fine to medium.
221.00-247.00	26.00	clay	Light Grey, plastic, hard, sticky
247.00-252.00	5.00	Sand stone	Light brown, fine to medium.
252.00-300	48.00	clay	Light Grey, plastic, hard, sticky

Village: Alappakkam
Block: Cuddalore

Depth Range From	Depth Range To	Thickness in (m)	Litholog
0.00	7.32	7.32	Clay, grey sand
7.32	16.76	9.44	Sand, coarse grained mainly of quartz with little clay brown in colour
16.76	23.16	6.4	Clay brown in colour & semi-plastic in nature
23.16	27.43	4.27	Sand mixed with gravel
27.43	38.10	10.67	Sand, coarse to very coarse grained, sub-angular to sub-rounded
38.10	47.24	9.14	Clay with a little sand fine to coarse
47.24	75.29	28.05	Sand, fine to very coarse grained with a little clay
75.29	81.99	6.7	Sand, very coarse grained with clay
81.99	156.97	74.98	Clay, grey sand
156.97	161.24	4.27	Lignite with carbonaceous clay
161.24	171.91	10.67	Clay, ash coloured with sand
171.91	188.37	16.46	clay grey in colour with carbonaceous material
188.37	192.94	4.57	Clay grey with little gravel
192.94	209.40	16.46	Sand and gravel
209.40	303.28	93.88	Limestone, arenaceous with fossils
303.28	365.15	61.87	Sand, Coarse to very coarse grained mainly quartztic
365.15	375.21	10.06	Limestone, arenaceous with fossils
375.21	396.24	21.03	Shale, Calcareous with fossils
396.24	457.20	60.96	sand, medium to coarse grained mainly of quartzitc

Village: Mettukuppam
Block: Kammapuram

Depth Range From	To	Thickness in (m)	Litholog
0	2.13	2.13	Laterite
2.13	6.4	4.27	Clay, Laterite
6.4	9.45	3.05	sand, Medium to Very coarse grained
9.45	13.41	3.96	gravel, lateritic with very coarse grained sand
13.41	37.19	23.78	Sandstone, mottled with intercalations of clay
37.19	41.45	4.26	Clay, mottled, plastic
41.45	66.14	24.69	sandstone with prominent intercalations of clay
66.14	75.29	9.15	clayey sand
75.29	81.29	6	Sand
81.29	99.67	18.38	sand with intercalation of clay
99.67	119.48	19.81	Gravel, Pea-size with very coarse grained sand
119.48	133.81	14.33	sand, Medium to Very coarse grained
133.81	134.72	0.91	Clay
134.72	143.87	9.15	Lignite
143.87	145.09	1.22	Clay, plastic in nature
145.09	153.92	8.83	Gravel
153.92	163.37	9.45	Sand, Very coarse grained
163.37	166.42	3.05	Gravel, quartizitic pea-sized
166.42	170.69	4.27	sand, very coarse grained with brown clay
170.69	181.97	11.28	clayey sand
181.97	194.46	12.49	Sand, Coarse to very coarse grained mixed with some gravel and occasionallay clay

Village: Vadakkuttu
Block: Kurujnipadi

Depth Range		Thickness in (m)	Litholog
From	To		
0	7.32	7.32	Surface soil, sandy with laterite material
7.32	14.02	6.7	sanstone, medium to coarse grained, lateritized
14.02	15.85	1.83	clay, white mixed with sand
15.85	28.65	12.8	clay, sandy, coarse to very coarse grained
28.65	52.43	23.78	Clay mottled with a little sand
52.43	86.56	34.13	Sandstone, medium to coarse grained
86.56	99.37	12.81	Lignite
99.37	102.11	2.74	Lignite mixed with sand
102.11	128.02	25.91	sand coarse to vey coarse grained with clay and intercalations of clay between 117.96 to 119.79
128.02	130.45	2.43	Clay, white, plastic with a little sand
130.45	146.91	16.46	sand coarse to vey coarse grained with clay and intercalations of clay between 137.47-139.29 m
146.91	154.84	7.93	Clay with a little sand
154.84	185.32	30.48	Sand, fine to medium grained, sub-angular and with a little clay
185.32	208.79	23.47	Sand, fine to medium grained with mottled clay between 185.32-185.93 m and 207.57-208.79
208.79	247.8	39.01	Sand, medium to coarse grained, subandgular composed of quartz and altered feldspar

Village: Kurunjipadi
Block: Kurunjipadi

Depth Range From	To	Thickness in (m)	Litholog
0	3	3	Top soil, clay drak broun, sandy
3	16.29	13.29	sand, brown, medium to coarse with streaks of clay
16.29	19.03	2.74	Clay, light brown, hard with streaks of sand
19.03	32.23	13.2	Sand brown medium to coarse with streaks of clay
32.23	67.26	35.03	Sand , brown, very coarse gravelly with occasional clay streaks
67.26	100.17	32.91	Clay light grey with gravel
100.17	164.25	64.08	Argillaceous sandstone, mottled
164.25	180.52	16.27	Sand light grey, very coarse, gravelly with streaks of clay
180.52	186.95	6.43	Clay, brown, sticky, sandy
186.95	197.04	10.09	claly, grey, sandy, with occasinal lignite
197.04	207.46	10.42	Sand, grey, fine to medium to coarse with streaks of clay
207.46	217.53	10.07	Sand, grey , medium to coarse with streaks of clay
217.53	233.72	16.19	Clay grey, sticky, sandy
233.72	278.51	44.79	clay, grey, sticky

Village:Ramanathakuppam
Block: Kurunjipadi

Depth Range		Thickness in (m)	Litholog
From	To		
0	4.5	4.5	Topsoil, sand clayey brown
4.5	11	6.5	sand clayey, fine to medium brown
11	30.84	19.84	Sand, medium to coarse with clay streaks
30.84	49.7	18.86	sand, Coarse to very coarse with clay streaks
49.7	58	8.3	Sand, Coarse to very coarse brown in colour
58	168	110	Sand medium to coarse, with clay intercalations
168	184	16	Sand, medium to coarse
184	212	28	Sand, medium to coarse with clay
212	225	13	Clay, black and sticky
225	242	17	Sand medium to coarse, with clay intercalations
242	250	8	Clay, black and sticky
250	254	4	Sand medium to coarse, with clay intercalations

Village: Rajakuppam
Block: Kurunjipadi

Depth Range		Thickness in (m)	Litholog
From	To		
0	9	9	Clayey, sandstone with kankar and pebbles
9	18	9	Sandy clay
18	30	12	Mottled clayey sandstone
30	39	9	mottled sandy clay
39	54	15	Clayey, sandstone with pebbles
54	60	6	Clay with pebbles
60	72	12	Sandstone, greyish black with pebbles
72	84	12	Clay, grey black with pebbles
84	102	18	Sandstone with pebble
102	108	6	Pebbles
108	114	6	Sandstone, fine grained
114	138	24	Sandyclay with pebbles
138	150	12	Sandy clay
150	171	21	Sandy clay with pebbles
171	174	3	Clayey sandstone, mottled
174	186	12	Sandy clay with pebbles
186	189	3	Clay, grey
189	195	6	Sandstone clayey
195	204	9	Sandy clay
204	222	18	Sand with pebbles
222	234	12	Sand, fine grained
234	240	6	Sandy clay, yellow
240	301	61	Sand, fine grained

Village : Abaddharanapuram

Depth Range From	To	Thickness in (m)	Litholog
0	7	7	Lateritic sandstone
7	23.8	16.8	Sandstone, medium to coarse
23.8	27.15	3.35	Sandy clay, mottled
27.15	39.44	12.29	Sandstone, fine to medium
39.44	64.49	25.05	Clayey sandstone, medium to coarse
64.49	77.69	13.2	Sandy clay, sand medium to coarse, clay, dirty white
77.69	118	40.31	sandy clay, grey, sand medium grained
118	121	3	clay, sandy with lignite pieces
121	124	3	Clayery sandstone, clay black
124	131	7	Lignite, contaminated
131	137.33	6.33	Sand, medium to coarse grained
137.33	140.33	3	Lignitic clay
140.33	143.33	3	Lignitic clay with sand
143.33	151.33	8	Clayey sandstone, black
151.33	232.83	81.5	Clay dirty white
232.83	240.66	7.83	Sand, fine to medium grained
240.66	247.17	6.51	Sand with clay
247.17	278.51	31.34	Sandstone, hard with marcasite pieces and clay
278.51	300	21.49	Sand, coarse grained

Village : Kattusagai-Puliyur
Block: Kurunjipadi

Depth Range From	To	Thickness in (m)	Litholog
0	3	3	Soil reddish brown
3	7	4	Clayey soil, brown, admixed with coarse sand
7	10	3	Sand, coarse reddish brown, composed mostly of sbu-rounded quartz
10	16	6	Sand, medium to coarse grained
16	31.84	15.84	Sand, dirty brown, medium to coarse
31.84	63	31.16	Sand, very coarse, gravelly, mostly composed of sub-rounded to rounded quartz
63	65	2	Clayey soil, brown, admixed with coarse sand
65	76	11	Sandstone, admixed with clay, reddish brown
76	87	11	Clay brownish
87	107	20	Sandstone, fine grained admixed with clay
107	110	3	Clay, brownish
110	130	20	Sandstone, fine to mdium, brownish with intercalatins of clay
130	140	10	Clay, greyish black with lignite
140	155	15	Sandstone, with minor clay intercalations and stray pieces of lignite
155	173	18	Sandstone, medium to coarse, composed mostly of sub-rounded to rounded quartz
173	179	6	Limestone, greyish with some stray shells
179	188.84	9.84	Limestone, greyish with some stray shells
188.84	222	33.16	Greyish clay
222	226	4	Clay with medium to coarse sand
226	230	4	Sandstone medium to very coarse, composed mostly of bu-rounded to rounded quartz
230	245	15	Sandstone, with admixtures of clay
245	254	9	Greyish clay
254	266	12	Sandstone, medium to very coarse
266	270.5	4.5	Clay, brownish
270.5	275.5	5	Sandstone, very coarse, gralvelly, with sub-rounded to rounded pebbles of quartz
275.5	287	11.5	Sandstone, very coarse, gralvelly, with sub-rounded to rounded pebbles of quartz with clay
287	291.5	4.5	Sandstone medium to coarse grained
291.5	295.5	4	Sandstone with admixtures of clay
295.5	300	4.5	Sandstone medium grained

Village : Mettupalaiyam
Block: Kurunjipadi

Depth Range From	Depth Range To	Thickness in (m)	Litholog
0	4.5	4.5	Sandy soil, light brown
4.5	11	6.5	sand, dirty white, medium to coarse grained
11	13.5	2.5	Sand, light brown, medium grained
13.5	19.78	6.28	Sand, light brown, medium to coarse grained
19.78	42.7	22.92	Sand, light brown, medium to very coarse grained, composed of sub-angular to sub-rounded quartz mixed with broken shells
42.7	50	7.3	Clay, yellowish, soft with sand admixed
50	54	4	sandstone, light brown, fine grained
54	61	7	sandstone, reddish white, medium to coarse grained, mostly sub-rounded quartz
61	71	10	Sandstone, dirty white to light brown, medium to corse grained, mostly of sub-rounded quartz
71	75	4	San, clayey, light brownish
75	82.58	7.58	sandstone, greyish white, very coarse
82.58	104.5	21.92	Gravelly mostly composed of sub-rounded quartzz
104.5	109.5	5	Sandly clay
109.5	129	19.5	Sandstone, greyish white medium to coarse grained with thin clay lenses
129	141	12	Sandstone, greyish, medium to coarse grained mosty of sbu-rounded quartz
141	144	3	sandy clay, greyish
144	183	39	sandstone, greyish, medium to coarse grained with thein lenses of clay and stray pieces of lignite
183	185	2	sandy clay, greyish
185	203	18	sandstone, medium to coarse grained with thin clay lenses
203	235	32	Clay, lenses, greysih sandy
235	254	19	Sandstone, medium to coarse grained
254	267.9	13.9	Sandstone, medium to coarse grained, mostly of sub-rounded quartz with thin clay lenses
267.9	273	5.1	Clay, greyish

273	275.5	2.5	sandstone medium to coarse grained
275.5	283.5	8	sandstone, medium to coarse with the clay lenses and stray pieces of lignite
283.5	289.5	6	Sandstone, greyish, coarse to very coarse, gravelly, mostly of sub-rounded quartz and some broken shells
289.5	300	10.5	Gravel, very coarse, mostly of sub-rounded and rounded grains and pebbles of quartzwhitish and greyish

Village: Kattiyankuppam

Block: Kurinjippadi

Litho logy		**Depth Range of Tube well**		**Thickness**
		From	**To**	**(m)**
Top soil	Sandy, fine brownish	0.00	7.00	7.00
Sand	Sand, fine grained, grey	7.00	26.00	19.00
Clay	Clay , whitest to grayish, with sand , fine	26.00	29.00	03.00
Sand	Sand, fine to medium grained, sub angular, grey	26.00	32.25	6.25
Clay	Clay , whitest to grayish, with sand , fine	32.25	35.50	3.25
Sand	Sand, fine to medium grained, sub angular, grey	35.50	41.75	6.25
Sand	Sand, fine to medium grained, sub angular, grey	41.75	44.75	3.00
Clay	Clay , whitest to grayish, with sand , fine	44.75	51.00	6.25
Sand clayey	Sand, fine to medium grained, sub angular, grey admixed with clay, grey	51.25	60.50	9.25
Clay	Sandstone, calcareous compact grayish white admixed with clay and sand	60.50	69.75	9.25
Sand clayey	Sand clayey, fine to medium grained, sub angular, grey admixed with clay, grey	69.75	79.25	9.50
Clay	Calcareous clay, plastic, sticky, dark gray,	79.25	91.75	12.5
Sand	Sand, fine to medium grained, sub angular, grey	91.75	94.75	3.00
Clay	Calcareous clay, plastic, sticky, dark	94.75	101.00	6.25

	gray,			
Sand	Sand, fine to medium grained, sub angular, grey	101.00	107.25	6.25
Clay	Calcareous clay, plastic, sticky, dark gray,	107.25	110.50	3.25
Sand	Sand, fine to medium grained, sub angular, grey	110.50	113.50	3.00
Clay	Sandstone, calcareous compact grayish white admixed with clay and sand	113.50	119.75	6.25
Clay	Calcareous clay, plastic, sticky, dark gray,	119.75	123.00	3.25
Sand	Sand, fine to medium grained, sub angular, grey	123.00	132.25	9.25
Caly	Lignite, dark plastic, Sticky, admixed with clay and	132.25	141.25	9.00
Sand	Sand, fine to medium grained, sub angular, grey	141.25	151.00	9.75
Sand clayey	Sand ,fine to medium grained, sub angular, grey admixed with clay, grey	151.00	154.25	3.25
Sand	Sand, fine to medium grained, sub angular, grey	154.25	173.00	18.75`
Sand clayey	Sand, fine to medium grained, sub angular, grey admixed with clay, grey	173.00	179.25	6.25
Sand	Sand, fine to medium grained, sub angular, grey	179.25	188.50	9.25
Sand clayey	Sand, fine to medium grained, sub angular, grey admixed with clay, grey	188.50	191.75	3.25
Sand	Sand, fine to medium grained, sub angular, grey	191.75	194.75	3.00
Sand clayey	Sand, fine to medium grained, sub angular, grey admixed with clay, grey	194.75	201.00	6.25
Sand	Sand, fine to medium grained, sub angular, grey	201.00	207.25	6.25
Sand clayey	Sand, fine to medium grained, sub angular, grey admixed with clay, grey	207.25	210.50	3.25
Sand	Sand, fine to medium grained, sub angular, grey	210.50	213.50	3.00
Sand	Sand, fine to medium grained, sub	213.50	216.75	3.25

clayey	angular, grey admixed with clay, grey			
Sand	Sand, fine to medium grained, sub angular, grey	216.75	219.75	3.00
Sand clayey	Sand, fine to medium grained, sub angular, grey admixed with clay, grey	219.75	226.00	7.00
Sand	Sand, fine to medium grained, sub angular, grey	226.00	229.25	3.25
Sand clayey	Sand, fine to medium grained, sub angular, grey admixed with clay, grey	229.25	232.25	3.00
Sand	Sand, fine to medium grained, sub angular, grey	232.25	235.50	3.25
Clay	Calcareous clay, plastic, sticky, dark gray,	235.50	241.75	6.25
Sand	Sand, fine to medium grained, sub angular, grey	241.75	244.75	3.00
Clay	Calcareous clay, plastic, sticky, dark gray,	244.75	263.50	18.75
Sand	Sand, fine to medium grained, sub angular, grey	263.50	273.00	9.50
Clay	Calcareous clay, plastic, sticky, dark gray,	273.00	360.50	87.50
Clay	Calcareous clay, Hard and compact, plastic, sticky, dark gray,	360.50	363.50	3.00
Clay	Calcareous clay, plastic, sticky, dark gray,	363.50	400.00	36.50

Village: Marungur

Block: Panruti

Litho logy		Depth Range of Tube well From	To	Thickness (m)
Laterite	Surface Top soil and Laterite granular, reddish brown in colour	0.00	13.50	13.50
Sandy Caly	Sand, medium to Coarse grained, mixed with clay	13.50	19.65	6.15
Sandy Caly	Sand, fine to medium grained, mixed with clay	19.65	38.35	18.70
Sandstone	Sandstone, Pale grey, medium to coarse grained, mostly of quartz	38.35	53.65	15.30
Sand	Sand, fine to medium grained	53.65	63.05	9.40
Sand	Sand, medium to coarse grained	63.05	72.20	9.15
Sandstone	Sandstone, Pale grey, medium to coarse grained, mostly of quartz	72.20	75.20	3.00
Sandy Caly	Sand, medium to Coarse grained, mixed with clay	75.20	87.70	12.50
Sand	Sand, fine to medium grained	87.70	100.35	12.65
Sand	Sand, medium to coarse grained	100.35	112.65	12.30
Sandy Caly	Sand, medium to Coarse grained, mixed with clay	112.65	155.90	43.25
Sand	Sand, fine to medium grained, grey	155.90	165.20	9.30
Clay	Clay, grey in colour, mixed with sand	165.20	168.20	3.00
Sand	Sand, fine to medium grained, grey	168.20	187.15	18.95
Sandy Caly	Sand, medium to Coarse grained, mixed with clay	187.15	199.70	12.55

Village: Thiruchovapruam
Block: Cuddalore

Description	Depth range (mbgl) From - To	Thickness (m)
Sand, fine, yellowish	00.00 - 7.00	7.00
Sand, greyish to white, medium grained with kankar and pieces of fossils	7.00 - 10.50	3.50
Sand, greyish to white, medium grained , quartzitic, sub angular to sub rounded.	10.50 - 23.50	13.00

Sand yellowish, quartzitic, coarse grained	23.50 - 36.50	13.00
Sand,brownish ,quartzitic , very coarse with feldspars	36.50 - 43.00	6.50
Sand stone, clayey,yellowish pink	43.00 - 49.50	6.50
Sandstone,clayey,brownish	49.50 - 56.00	6.50
Clay, mottled sticky mixed with sand, quartzitic	56.00 - 65.50	9.50
Sandstone,clayey,brownish	65.50 - 82.00	16.50
Clay, greyish with interclations of sandstone	82.00 - 85.00	3.00
Sandstone,clayey,brownish	85.00 -95.00	10.00
Clay, greyish with interclations of sandstone	95.00 – 98.00	3.00
Sandstone, greyish to black, medium grained with Clay black hard.	98.00-140.50	42.50
Clay, greyish black mixed with sand and Lignite	140.50-166.50	26.00
Sand stone, fine to medium .	166.50-176.00	9.50
Clay black mixed with sand	176.00-179.50	3.50
Limestone,greyish, hard,compact with fossils	179.50-202.00	22.50
Sand stone, greyish to black, medium grained	202.00-208.50	6.50
Sand, greyish,coarse to very coarse with clay lenses between 247.50-251.00, 283.50-287.00, 351.50-355.00	208.50-454.00	245.50

Village Thazhangudakuppam

Block: Cuddalore

Total (m)	***Depth range(mbgL)***	**formation**	**Description**
0.00-7.00	7.00	sand	Light Grey,fine to medium with ferrogineous
7.00-38.00	31.00	sand	Light brown ,fine to coarse ,sub angular to sub rounded mixed with ferrugineous and shell fragements
38.00-39.00	51.00	clay	Dark Grey, carbonaceous ,plastic ,sticky
89.00-91.00	2.00	Sand stone	Light brown ,medium to course
91.00-94.00	3.00	clay	Light Grey, plastic ,sticky ,hard
94.00-102.00	8.00	Sand stone	Light brown, medium to coarse quartzitic
102.00-104.00	2.00	clay	Dark Grey, carbonaceous ,plastic ,sticky
104.00-106.00	2.00	Sand stone	Light brow n ,medium to course
106.00-111.00	5.00	clay	Dark Grey, carbonaceous ,plastic

Total (m)	*Depth range(mbgL)*	formation	Description
			,sticky
106.00-111.00	5.00	clay	Dark Grey, carbonaceous ,plastic ,sticky
111.00-128.00	17.00	Sand stone	Light brown ,medium to course
128.00-136.00	8.00	clay	Dark Grey, carbonaceous ,plastic ,sticky
136.00-145.00	9.00	Sand stone	Light brown ,medium to course
145.00-148.00	3.00	clay	Dark Grey, carbonaceous ,plastic ,sticky
148.00-156.00	8.00	Sand stone	Grey ,fine to medium
156.00-160.00	4.00	clay	Grey colour ,plastic hard
160.00-171.00	11.00	Sand stone	Grey ,fine to medium
171.00-186.00	15.00	clay	Grey ,plastic
186.00-190.00	4.00	Sand stone	Grey ,medium to coarse
190.00-192.00	2.00	clay	Grey ,plastic
192.00-194.00	2.00	Sand stone	Grey ,medium to coarse compact with coarse gravel bed inter calations
194.00-201.00	7.00	clay	Grey ,plastic
201.00-208.00	7.00	Sand stone	Grey ,medium to coarse compact with coarse gravel bed inter calations
208.00-231.00	13.00	clay	Grey, plastic
231.00-235.00	4.00	Sand stone	Grey ,medium to coarse compact with coarse gravel bed inter calation
235.00-244.00	9.00	clay	Grey ,plastic
244.00-250.00	6.00	Sand stone	Grey ,medium to coarse compact with coarse gravel bed inter calations

Village: Manjakuppam

Block : Cuddalore

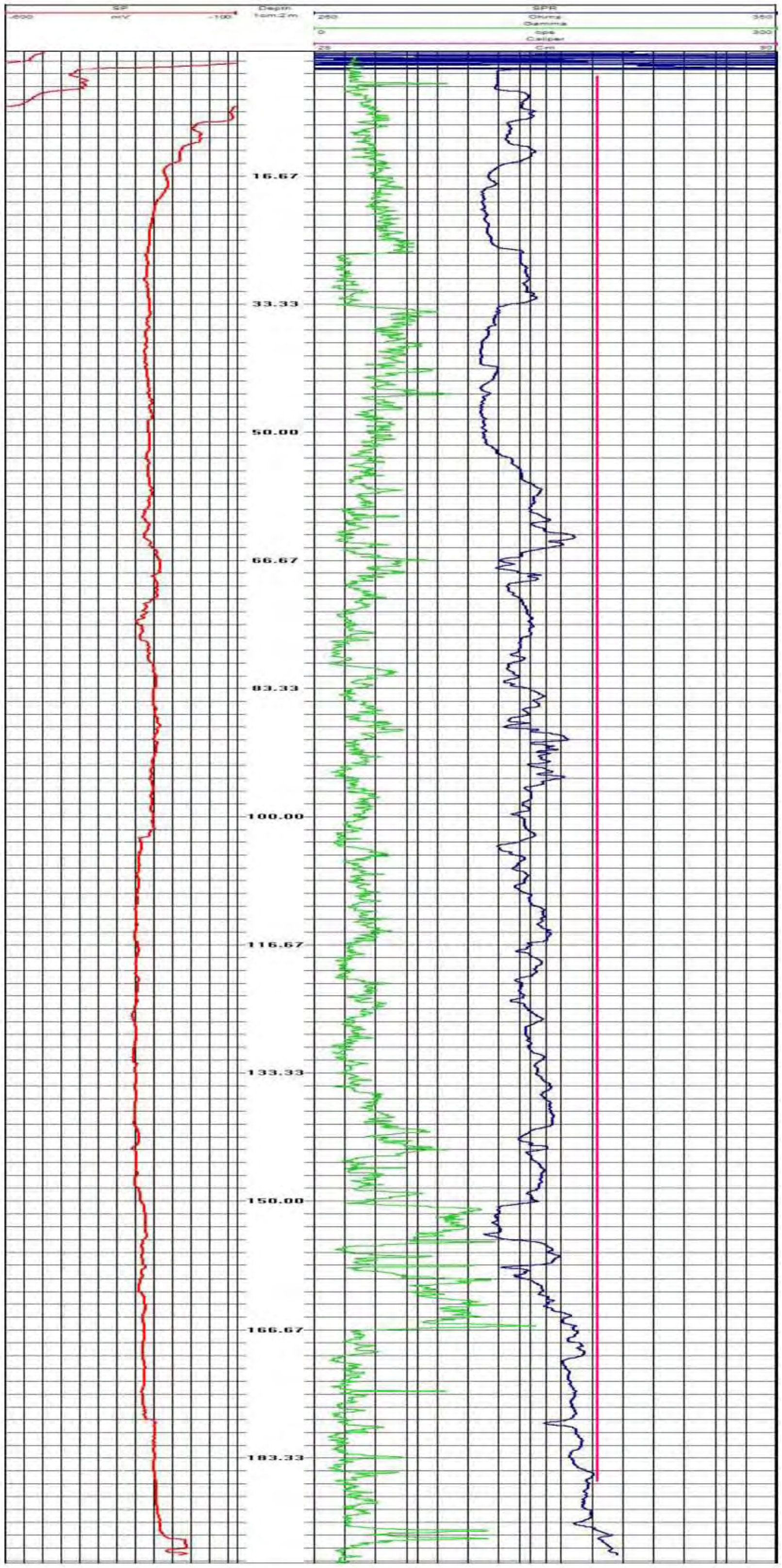
Depth range(mbgL)	*Total (m)*	Geological formation	Description
0.00-4.00	4.00	Sand	Light brown ,fine coarse quartz ,sub-angular to angular mixed with ferruginous
4.00-7.00	3.00	Sand	Light brown ,fine to coarse ,quartz tic ,sub –angular to angular mixed with ferruginous material with shell fragments
7.00-10.50	3.50	Clay	Grey ,mixed with sand find to medium and shell fragments
10.50-13.50	3.00	Clay	Pale brown ,mixed with sand to medium and shell fragments
13.50-16.65	3.10	Sand	Light brown .fine to coarse ,quartz tic, sub-angular to angular mixed with gravel and little clay
16.65-19.95	3.00	Clay	Pale brown ,mixed with gravel medium
19.95-25.80	6.15	Sand	Light brown ,fine to coarse quartz tic ,sub –angular to angular mixed with ferruginous material with gravel and shell fragement
25.80-31.95	6.15	Clay	Grey ,mixed with sand find to medium
31.95-38.10	6.15	Gravel	Light Grey ,coarse ,quartz tic, sub rounder to angular
38.10-50.40	12.30	Sand	Dark brown ,fine to coarse ,quartz tic, sub angular to angular mixed with gravel and little
50.40-68.85	12.45	Gravel	Light Grey ,coarse ,quartz tic ,sub-rounder to angular
68.85-75.00	6.15	Gravel	Light Grey, coarse ,quartz tic and sub rounded to angular with little clay
75.00-81.15	6.15	Gravel	Light Grey ,coarse ,quartz tic and sub rounder to angular with sand
81.15-124.05	42.9	Clay	Pale Grey, hard, plastic
124.05-148.65	24.6	Clay/lignite	Dark Grey ,hard
148.65-154.80	6.15	Sand	Pale Grey ,light brown ,fine to coarse, quartz tic, sub-angular to angular mixed with ferruginous material
154.80-160.95	6.15	Sand	Pale Grey, light brown, fine to coarse

			,quartz tic, sub-angular to angular mixed with clay
160.95-170.25	9.3	Sand	Pale Grey ,light brown, fine to coarse ,quartz tic, sub-angular to angular
170..25-176.40	6.25	Clay	Pale Grey, hard, plastic
176.40-200.00	23.36	Sand	Pale Grey, light brown ,fine to coarse ,quartz tic, sub angular to angular mixed with clay

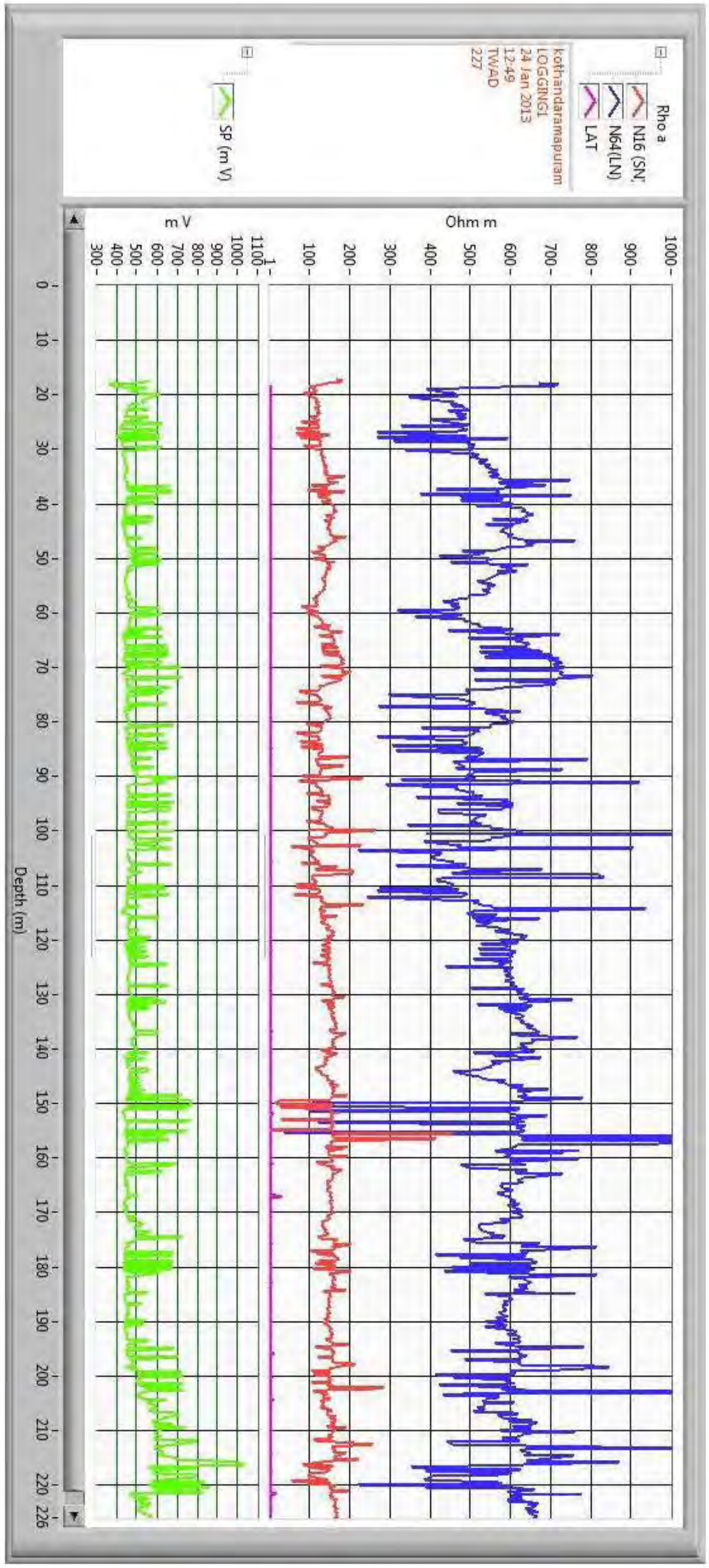
Village Periyapattu
Block: Portonov

Description	**Depth range (mbgl) From - To**	**Thickness (m)**
Sand, fine, yellowish	00.00 - 7.00	7.00
Sand, greyish to white, medium grained with kankar and pieces of fossils	7.00 - 10.50	3.50
Sand, greyish to white, medium grained , quartzitic, sub angular to sub rounded.	10.50 - 23.50	13.00
Sand yellowish, quartzitic, coarse grained	23.50 - 36.50	13.00
Sand,brownish ,quartzitic , very coarse with feldspars	36.50 - 43.00	6.50
Sand stone, clayey,yellowish pink	43.00 - 49.50	6.50
Sandstone,clayey,brownish	49.50 - 56.00	6.50
Clay, mottled sticky mixed with sand, quartzitic	56.00 - 65.50	9.50
Sandstone,clayey,brownish	65.50 - 82.00	16.50
Clay, greyish with interclations of sandstone	82.00 - 85.00	3.00
Sandstone,clayey,brownish	85.00 -95.00	10.00
Clay, greyish with interclations of sandstone	95.00 – 98.00	3.00
Sandstone, greyish to black, medium grained with Clay black hard.	98.00-140.50	42.50
Clay, greyish black mixed with sand and Lignite	140.50-166.50	26.00
Sand stone, fine to medium .	166.50-176.00	9.50
Clay black mixed with sand	176.00-179.50	3.50
Limestone,greyish, hard,compact with fossils	179.50-202.00	22.50
Sand stone, greyish to black, medium grained	202.00-208.50	6.50
Sand, greyish,coarse to very coarse with clay lenses between 247.50-251.00, 283.50-287.00, 351.50-355.00	208.50-454.00	245.50

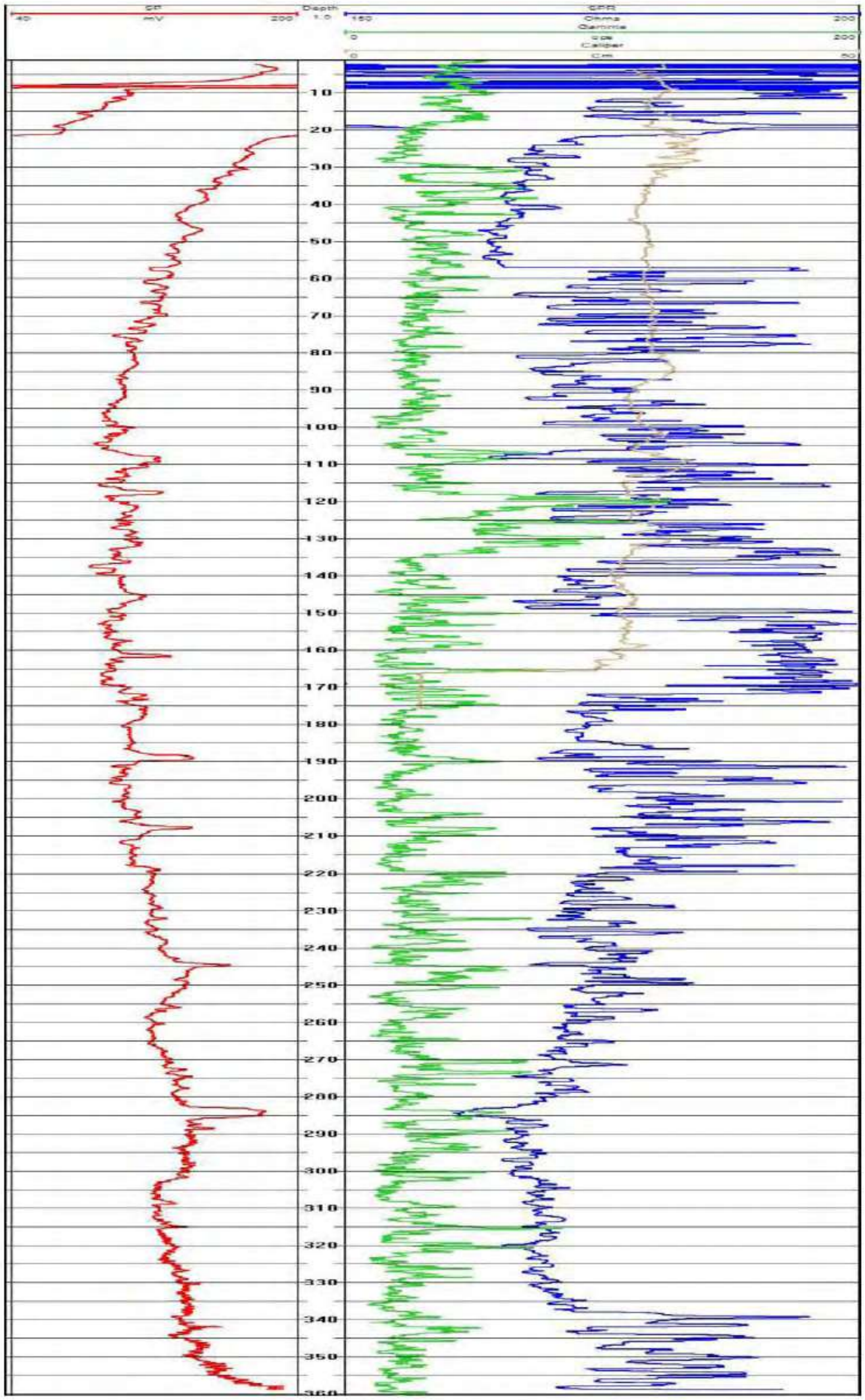
Village: Ayekuppam
Block: Kurunjipadi



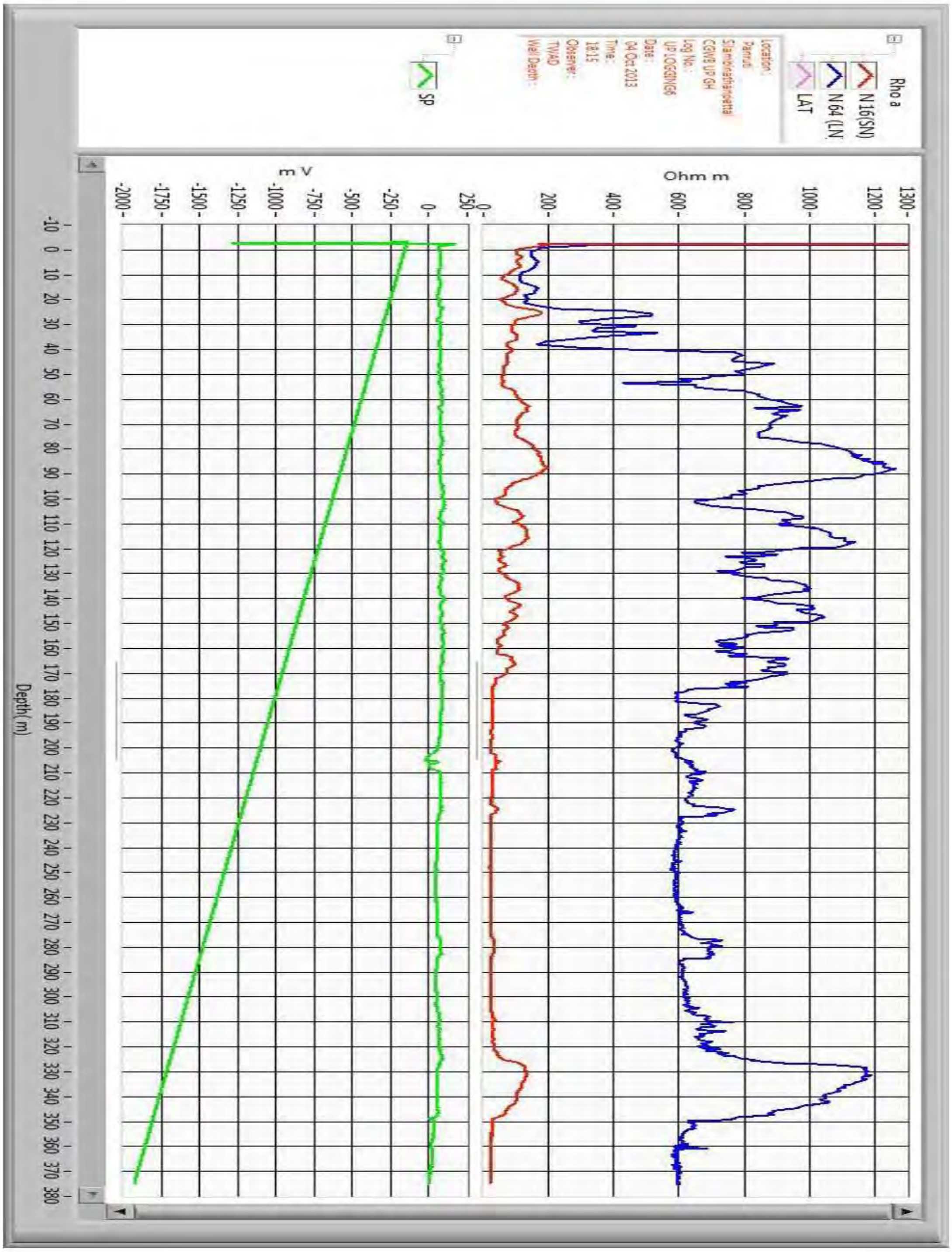
Village: Kothandaramapuram
Block: Kurunjipadi



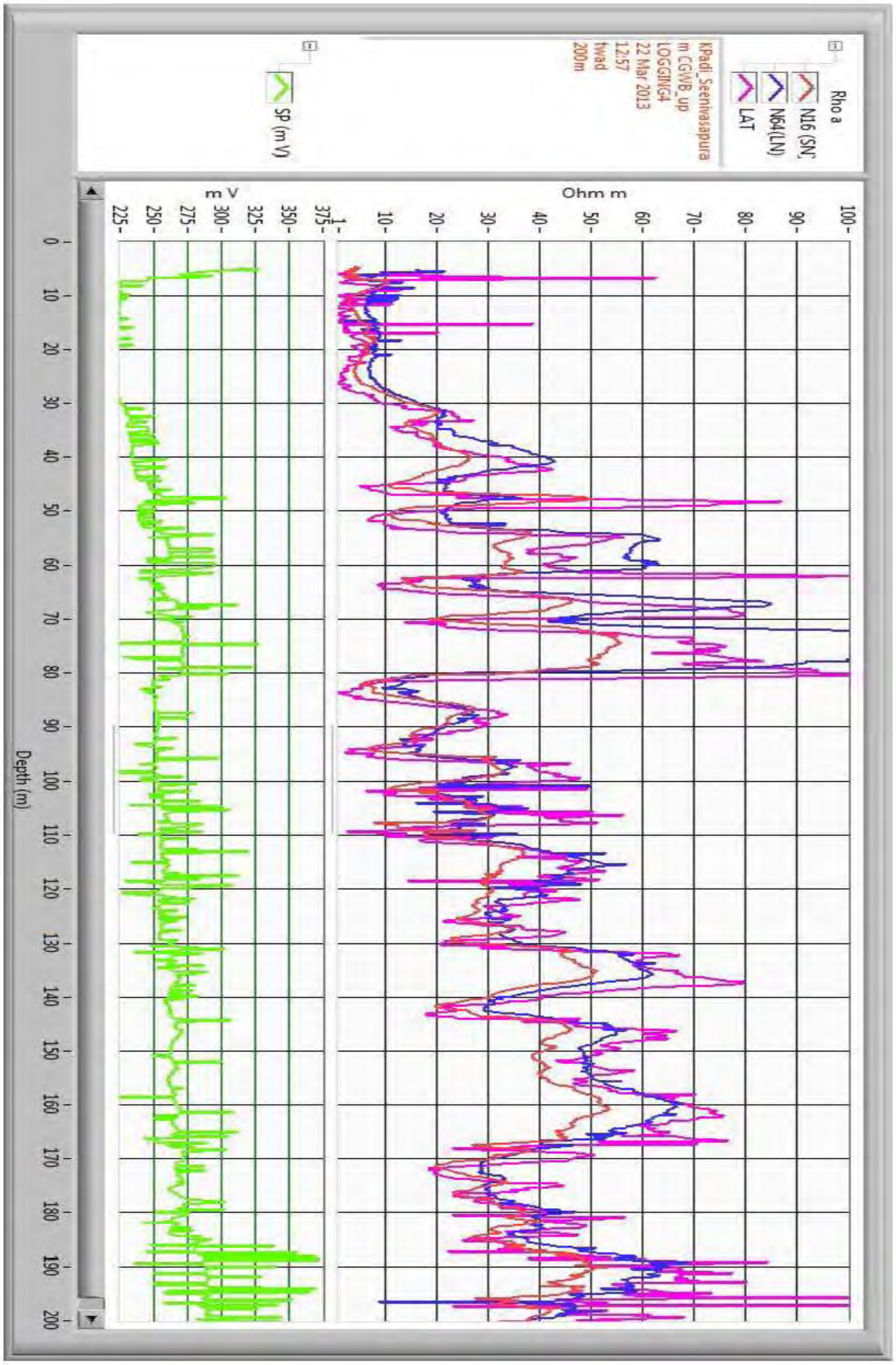
Village : Pachcharapalayam
Block: Kurunjipadi



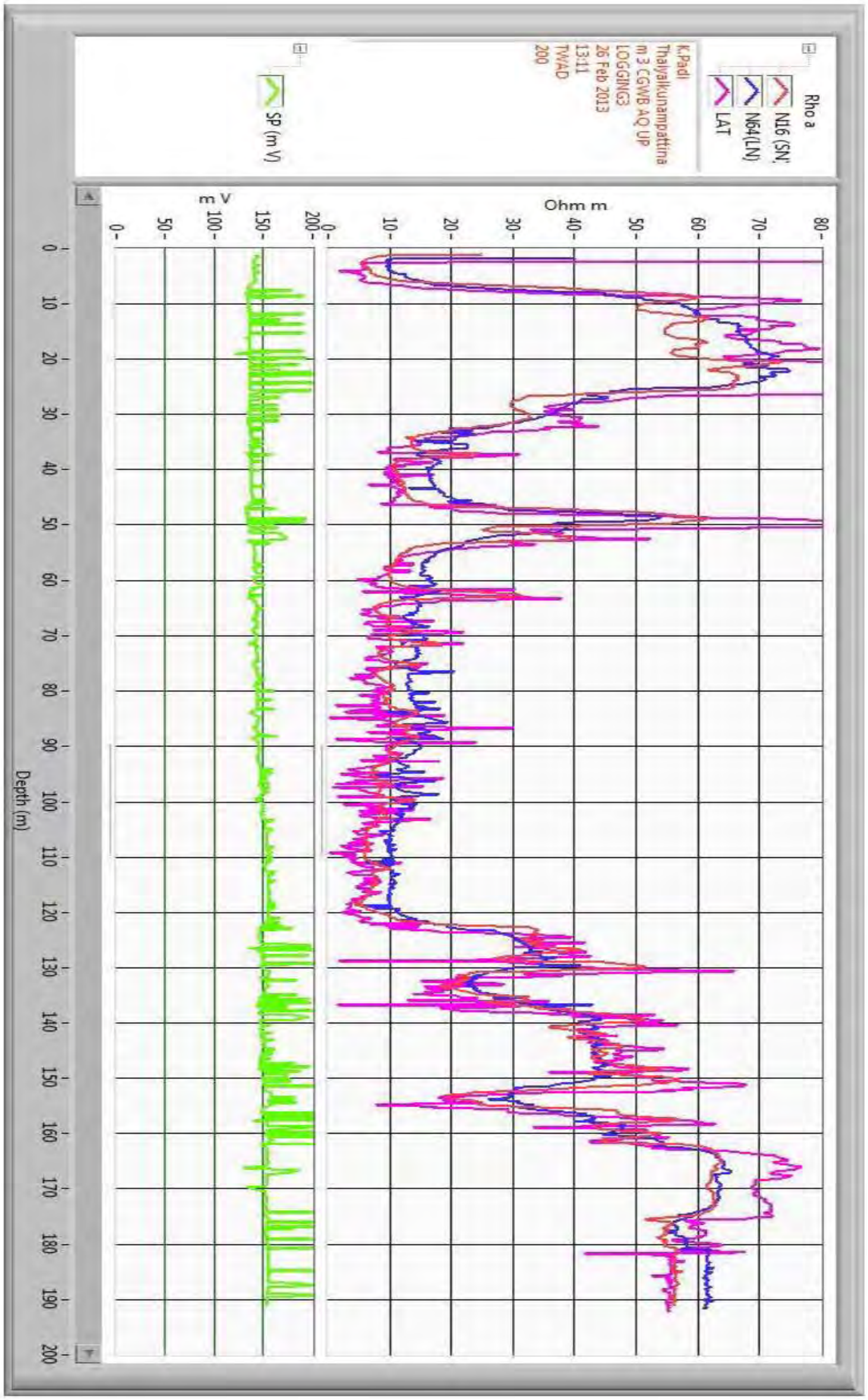
Village : Silambinathanpettai
Block: Kurunjipadi



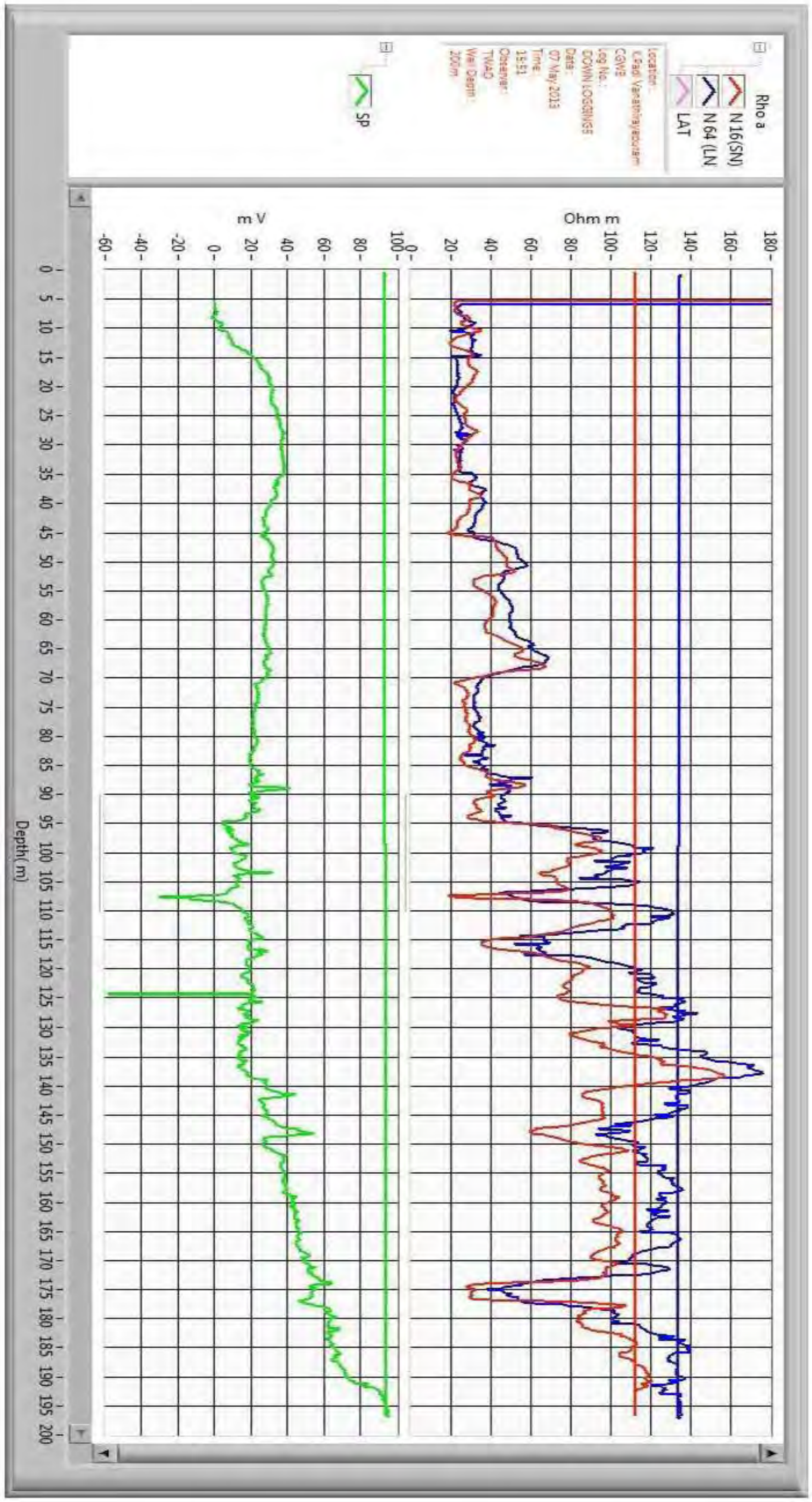
Village: Srinivasapuram
Block: Cuddalore



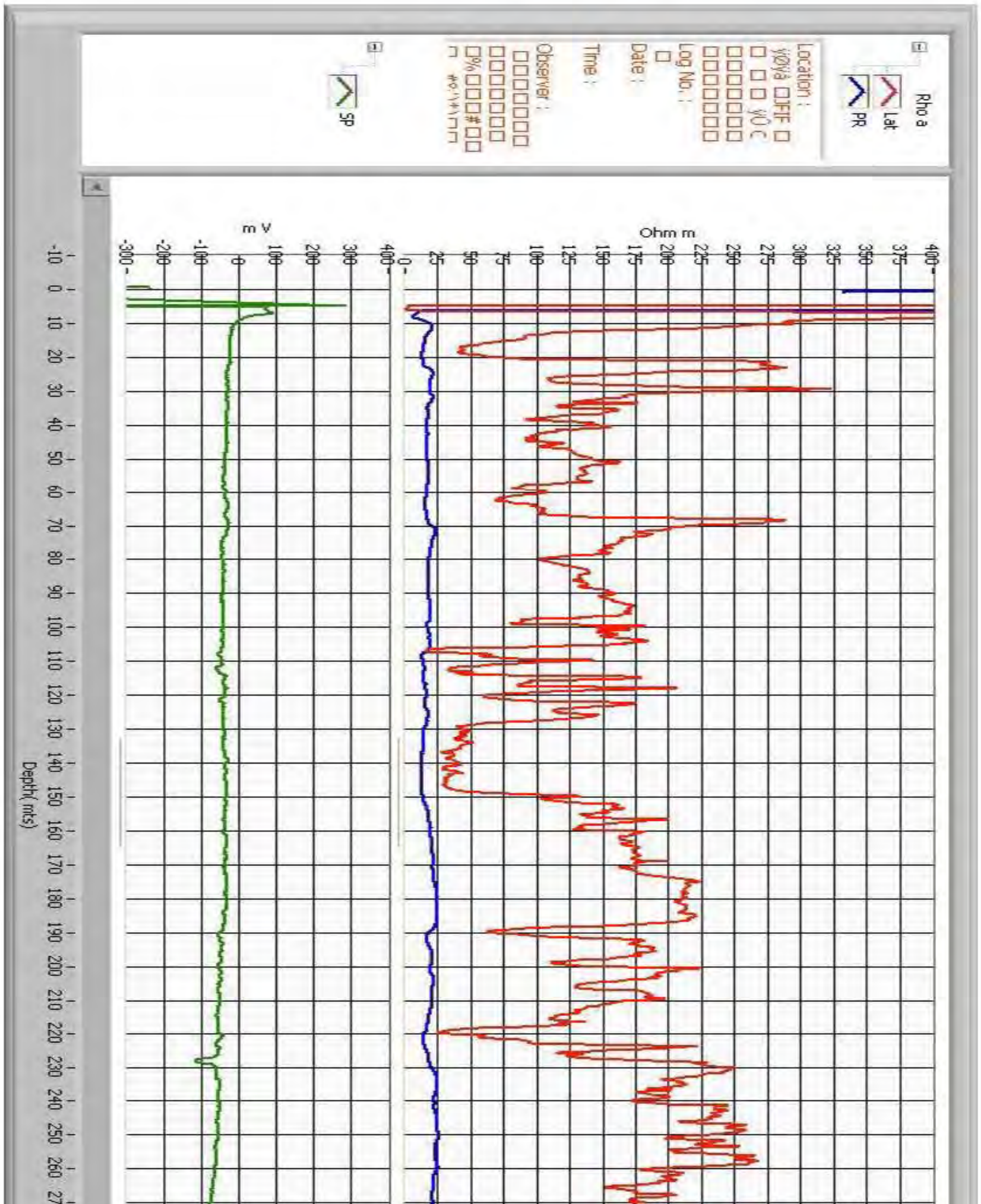
Village: Thaiyalkunapattinam
Block: Kurunjipadi



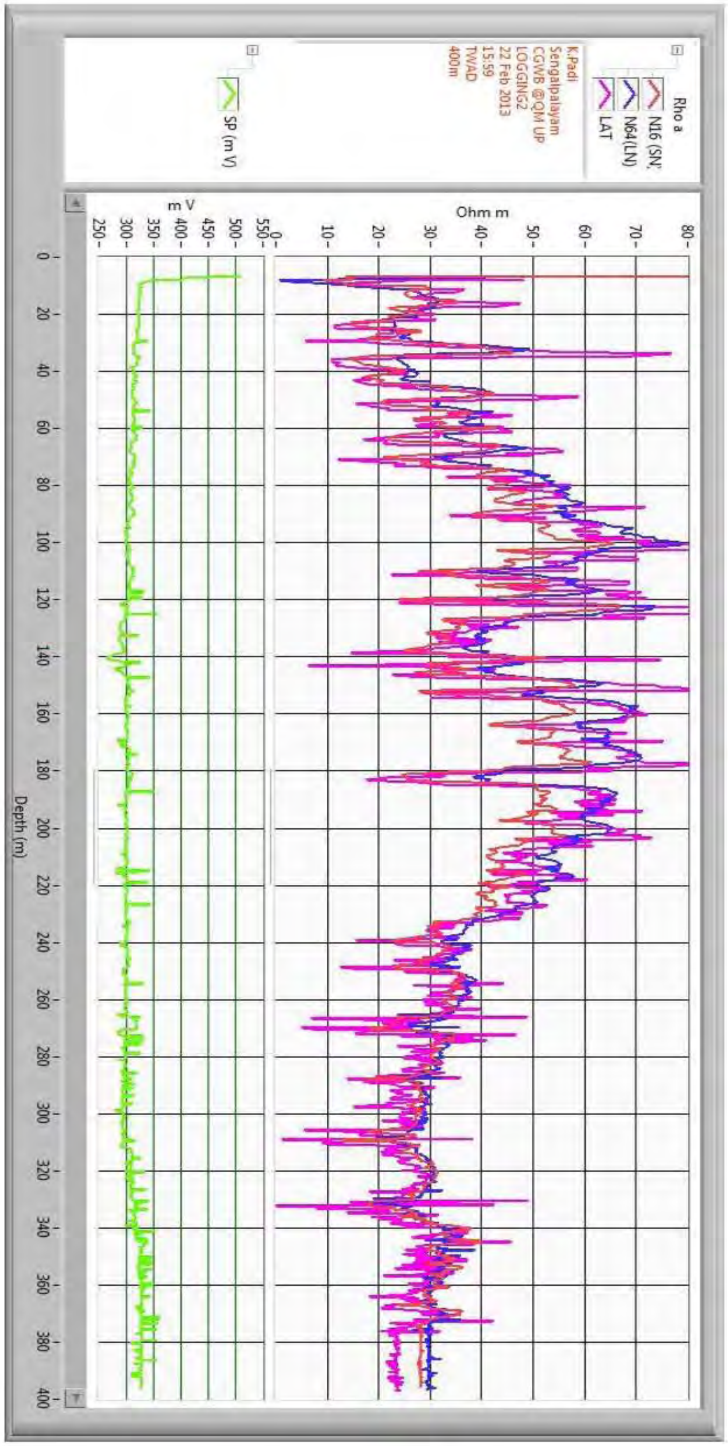
Village: Vanathirayapuram
Block: Kurunjipadi



Village: Vegakollai
Block: Panruti



Village: Sengalpalayam
Block: Kammapuram



Well assembly of Exploratory wells

Village: Ayekuppam
Block: Kurunjipadi

Depth range	Thickness (m)	Description of well assembly
00.00-1.00 m agl	01.00	254 mm Dia (8") MS blank pipe
00.00-120.00 m bgl	120.00	254 mm Dia (8") MS blank pipe
120.00-175.00 m bgl	55.00	152 mm Dia (6") MS blank pipe
175.00-181.00 m bgl	06.00	152 mm Dia (6") MS slotted (1/16") pipe
181.00-186.00 m bgl	05.00	152 mm Dia (6") MS blank pipe
186.00-192.00 m bgl	06.00	152 mm Dia (6") MS slotted (1/16")pipe
192.00-198.00 m bgl	06.00	152mm Dia (6") MS blank pipe with bail plug

Village: Kodandaramapuram
Block: Kurunjipadi

Depth range	Thickness (m)	Description of well assembly
00.00-1.00 m agl	01.00	254 mm Dia (8") MS blank pipe
00.00-100.00 m bgl	100.00	254 mm Dia (8") MS blank pipe
100.00-153.00 m bgl	53.00	152 mm Dia (6") MS blank pipe
153.00-159.00 m bgl	06.00	152 mm Dia (6") MS slotted (1/16")pipe
159.00-177.00 m bgl	18.00	152 mm Dia (6") MS blank pipe
177.00-183.00 m bgl	06.00	152 mm Dia (6") MS slotted (1/16")pipe
183.00-189.00 m bgl	06.00	152mm Dia (6") MS blank pipe
189.00-192.00 m bgl	06.00	152 mm Dia (6") MS slotted (1/16")pipe
192.00-196.00 m bgl	04.00	152mm Dia (6") MS blank pipe with bail plug

Village: Pachcharaparayam Aquifer-IV
Block: Kurunjipadi

Depth range	Thickness (m)	Description of well assembly
00.00-1.00 m agl	01.00	304.8 mm Dia (10”) MS blank pipe
00.00-100.00 m bgl	100.00	304.8 mm Dia (10”) MS blank pipe
100.00-338.00 m bgl	228.00	152 mm Dia (6”) MS blank pipe
338.00-341.00 m bgl	03.00	152 mm Dia (6”) MS slotted (1/16”) pipe
341.00-347.00 m bgl	06.00	152 mm Dia (6”) MS blank pipe
347.00-356.00 m bgl	09.00	152 mm Dia (6”) MS slotted (1/16”)pipe
356.00-362.00 m bgl	06.00	152mm Dia (6”) MS blank pipe with bail plug

Village: Pachcharaparayam Aquifer-III
Block: Kurunjipadi

Depth Range	Diameter(mm)	Description of assembly
00.00 to 01.00 mt agl	203mm	MS Blank pipe
00.00.to 95.00 mt bgl	203mm	MS Blank pipe
95.00 to 152.00mt bgl	150mm	MS Blank pipe
152.00 to 158.00 mt bgl	150mm	MS Slotted pipe
158.00 to 167.00 mt bgl	150mm	MS Blank pipe
167.00 to 170.00 mt bgl	150mm	MS Slotted pipe
170.00 to 198.00 mt bgl	150mm	MS Blank pipe
198.00 to 204.00 mt bgl	150mm	MS Slotted pipe
204.00 to 210.00 mt bgl	150mm	MS Blank pipe with Bail plug

Village: Reddipalayam Aquifer-III
Block: Kurunjipadi

Depth Range	Diameter(mm)	Description of assembly
00.00 to 01.00 mts	254mm	MS Blank Pipe
00.00 to 100.00mts	254mm	MS Blank pipe
100.00 to 165.00mts	150mm	MS Blank pipe
165.00 to 171.00mts	**150mm**	**MS Slotted pipe**
171.00 to 174.00 mts	150mm	MS Blank pipe
174.00 to 180.00mts	**150mm**	**MS slotted pipe**
180.00 to 185.00 mts	150mm	MS Blank pipe with bail plug.

Village: Srinivasanallur
Block: Cuddalore

Depth Range	Diameter(mm)	description of assembly
00.00 to 01.00 mt agl	150mm	MS Blank pipe
00.00 to 123.00mt bgl	150mm	MS Blank pipe
123.00 to 126.00 mt bgl	150mm	MS Slotted pipe
126.00 to 155.00 mt bgl	150mm	MS Blank pipe
155.00 to 158.00 mt bgl	150mm	MS Slotted pipe
158.00 to 165.00 mt bgl	150mm	MS Blank pipe with Bail plug

Village: Vegakollai
Block: Cuddalore

Depth Range	Diameter(mm)	description of assembly
00.00 to 01.00 mt agl	150mm	MS Blank pipe
00.00. to 91.00 mt bgl	150mm	MS Blank pipe
91.00 To 97.00mt bgl	150mm	MS Slotted pipe
97.00 to 100.00 mt bgl	150mm	MS Blank pipe
100.00 to 106.00 mt bgl	150mm	MS Slotted pipe
106.00 to 117.00 mt bgl	150mm	MS Blank pipe
117.00 to 120 mt bgl	150mm	MS Slotted pipe
120.00 To 123.00mt bgl	150mm	MS Blank pipe
123.00 to 126.00 mt bgl	150mm	MS Slotted pipe
126.00 to 131.00 mt bgl	150mm	MS Blank pipe

Village: Sengalpalayam Aquifer-IV
Block: Kurunjipadi

Depth Range	Thickness	Description of assembly
00.00-1.00 m agl	01.00	254 mm Dia (6”) MS blank pipe
00.00-315.00 m bgl	315.00	254 mm Dia (6”) MS blank pipe
315.00-321.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
321.00-327.00 m bgl	06.00	152mm Dia (6”) MS blank pipe
327.00-333.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
333.00-339.00 m bgl	06.00	152mm Dia (6”) MS blank pipe
339.00-345.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
345.00-351.00 m bgl	06.00	152mm Dia (6”) MS blank pipe with bail plug

Village: Sengalpalayam Aquifer-III
Block: Kurunjipadi

Depth Range	Thickness	Description of assembly
00.00-1.00 m agl	01.00	254 mm Dia (8”) MS blank pipe
00.00-100.00 m bgl	100.00	254 mm Dia (8”) MS blank pipe
100.00-159.00 m bgl	59.00	152mm Dia (6”) MS blank pipe
159.00-165.00 m bgl	6.00	152 mm Dia (6”) MS slotted (1/16”)pipe
165.00-171.00 m bgl	6.00	152mm Dia (6”) MS blank pipe
171.00-177.00 m bgl	6.00	152 mm Dia (6”) MS slotted (1/16”)pipe
177.00-183.00 m bgl	6.00	152mm Dia (6”) MS blank pipe
183.00-189.00 m bgl	6.00	152 mm Dia (6”) MS slotted (1/16”)pipe
189.00-195.00 m bgl	6.00	152mm Dia (6”) MS blank pipe with bail plug

Village: Thaiyalkunapattinam
Block: Kurunjipadi

Depth range	Thickness	Description of assembly
00.00-1.00 m agl	01.00	152 mm Dia (6”) MS blank pipe
00.00-150.00 m bgl	150.00	152 mm Dia (6”) MS blank pipe
150.00-156.00 m bgl	06.00	**152 mm Dia (6”) MS slotted (1/16”)pipe**
156.00-162.00 m bgl	06.00	152 mm Dia (6”) MS blank pipe
162.00-168.00 m bgl	06.00	**152 mm Dia (6”) MS slotted (1/16”)pipe**
168.00-174.00 m bgl	06.00	152 mm Dia (6”) MS blank pipe
174.00-180.00 m bgl	06.00	**152 mm Dia (6”) MS slotted (1/16”)pipe**
180.00-186.00 m bgl	06.00	152mm Dia (6”) MS blank pipe with bail plug

Village: Vanathirayapuram (Aquifer-III)
Block: Kurunjipadi

Depth range	Thickness	Description of assembly
00.00-1.00 m agl	01.00	254 mm Dia (6”) MS blank pipe
00.00-100.00 m bgl	100.00	254 mm Dia (6”) MS blank pipe
100.00-132.00 m bgl	32.00	152 mm Dia (6”) MS blank pipe
132.00-138.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
138.00-151.00 m bgl	13.00	152 mm Dia (6”) MS blank pipe
151.00-157.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
157.00-163.00 m bgl	06.00	152mm Dia (6”) MS blank pipe
163.00-169.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
169.00-172.00 m bgl	03.00	152mm Dia (6”) MS blank pipe with bail plug

Village: Silambinathanpettai-IV)
Block: Kurunjipadi

Depth range	Thickness	Description of assembly
00.00-1.00 m agl	01.00	254 mm Dia (8”) MS blank pipe
00.00-120.00 m bgl	120.00	254 mm Dia (8”) MS blank pipe
120.00-322.00 m bgl	202.00	152 mm Dia (6”) MS blank pipe
322.00-325.00 m bgl	03.00	152 mm Dia (6”) MS slotted (1/16”)pipe
325.00-328.00 m bgl	03.00	152 mm Dia (6”) MS blank pipe
328.00-334.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
334.00-337.00 m bgl	03.00	152mm Dia (6”) MS blank pipe
337.00-343.00 m bgl	06.00	152 mm Dia (6”) MS slotted (1/16”)pipe
343.00-348.00 m bgl	05.00	152mm Dia (6”) MS blank pipe with bail plug

Monthly depth to water table elevation- Aquifer I

Annexure -IV

S.No	Village Name	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
1	Aathinarayanapuram	3.5	3.33	2.8	2.2	2.49	3	2.96	3.7	2.97	3.41	3.15	3.19	3.38	3.24	2.79	2.29	2.52	3.05	2.9	3.57	3	3.4	3.32	3.1	3.02
2	Abathanapuram	31.6	30.7	29.43	28	29.6	28.96	29.88	31.38	29.87	30.1	31.6	31.6	31.24	29.97	28.99	28.46	29.57	28.99	30.11	31.11	30.64	31.68	31.33	31.48	31.11
3	Anandampettai	18.4	15.7	16.75	16.7	17.28	17.28	17.55	19.6	18.69	18.64	17.27	17.4	18.2	15.42	16.79	16.7	17.3	17.44	17.11	17.04	16.79	18.57	17.48	17.68	17.58
4	Andikuppam	24.8	24.85	24.5	24.7	24.78	24.62	24.54	25.74	25.47	24.93	24.79	24.8	24.83	24.78	24.3	24.1	24.7	25.18	24.91	24.68	24.48	25.58	24.91	24.79	24.58
5	Ayiekuppam	16.8	16.27	15.77	15.25	15.24	14.11	15.51	18.58	17	16.62	16.56	16.8	16.41	15.72	15.69	14.13	12.9	14.06	15.47	16.03	17.69	16.36	16.49	16.83	16.74
6	Badrakottai-dw	51.13	50.56	48.84	48.8	48.6	48.92	52.02	52.7	53.6	52.81	51.58	51.38	50.71	49.73	48.47	48.45	49.16	49.9	50.69	49.24	49.92	49.72	51.38	52.57	51.63
7	Cherakuppam	26.63	26.69	26.7	27	26.2	26.2	26.04	27.95	27.4	26.88	26.73	26.79	26.74	26.33	26.1	26.09	26.3	26.22	26.15	27.59	27.43	27.02	26.76	26.96	26.48
8	Chinna Andikuli	1.8	1.45	1.15	1.15	1.2	0.8	0.68	2.55	2.35	2.29	1.46	1.62	1.15	0.9	0.83	1.12	1.3	0.79	0.59	2.13	1.97	2.69	1.94	1.93	1.02
9	Gopalapuram, Pilayarkovilst	2.45	2.05	1.72	1.39	1.3	1.66	1.72	2.86	2.79	2.74	2.45	2.39	2.38	1.8	1.8	1.8	1.19	1.7	1.68	2.76	2.51	2.48	2.41	2.19	2.08
10	Kalkunam	7.7	8.85	7.75	7.3	8.1	7.9	8.7	9.2	8.79	8.02	8.54	7.4	8.4	8.18	7.02	6.98	7.66	7.4	8.2	8.88	8.7	8.06	8.13	7.22	7.14
14	Kattukuli	37.15	35.77	36.99	36.9	37.22	36.4	36.38	39.04	37.99	37.34	37.49	37.15	36.98	35.6	35.33	35.47	36.02	36.57	36.22	37.84	38.02	37.41	37.29	36.01	35.3
15	Kattuvegakollai	44.6	45.85	43.65	43.65	42.12	39	40	49.4	48.94	47.73	45.23	44.6	44.55	41.88	38.5	38.11	39.86	40.98	41.13	46.09	45.9	44.38	43.88	43.11	42.36
16	Keelapuvanikuppam	1.9	1.58	1.43	1.39	1.41	1.53	1.15	3	1.11	2.3	2.05	1.92	1.81	1.54	1.02	0.98	1.2	1.9	0.91	0.88	2.64	1.6	1.88	1.32	1.29
18	Kornapattu-DW	36.6	35.77	35.25	35	34.95	34.8	34.57	38.2	37.17	36.99	36.65	36.6	35.77	35.37	35.35	34.91	34.68	34.99	34.77	34.68	34.6	36.97	35.59	35.39	35.12
20	Kothandaramapuram-1	17.3	16.7	16.25	16.77	16.69	16.64	16.58	17.8	17.25	17.4	17.33	17.3	16.9	16.8	17.2	16.88	17.32	16.9	16.44	16.33	17.31	17.42	16.99	17.02	16.97
21	Kottavacheri	6.6	6.23	6.1	6	6.03	5.96	6.2	7.85	7.38	6.85	7.33	6.6	6.15	6.11	5.93	5.74	6.3	6.8	6.4	6.36	7.3	7.05	6.87	6.73	6.49
22	Kulanchavadi	16.5	15.6	15.4	15.3	15.4	15.72	16.18	19.4	17.29	16.92	17.18	16.5	16.12	15.98	16	15.63	15.16	15.64	15.84	15.75	17.32	17.52	17.16	16.31	16.1
23	Kundiamallur	7.1	6.85	6.06	6.06	6.1	5.84	5.35	6.9	6.64	6.79	6.47	7.1	5.86	5.73	4.8	4.71	4.46	4.7	3.91	3.88	6.84	6.75	5.6	5.1	4.84
24	Kurunjipadi	17.55	17.13	15.97	15.4	15.25	15.45	15.05	18.85	17.19	16.54	16.72	17.55	17.23	17.03	14.11	14.53	14.25	14.91	14.84	15	17.64	16.78	16.43	15.67	15.64
25	Meenakshipettai-sivajinagar	26.1	25.75	24.45	25.08	23.51	23.96	23.37	27.4	26.1	26.12	22.7	26.1	25.685	25.63	24.4	23.13	23.57	24.1	23.49	23.12	25.15	24.79	23.18	22.68	22.67
26	Melapudupatti	8.55	8.8	8.24	8.1	8.27	7.87	7.85	9.43	7.93	7.78	9.24	8.55	8.82	8.41	7.95	8.04	8.17	7.9	7.85	7.85	7.87	8.13	7.98	7.83	7.78
27	Mettukuppam	19.05	18.45	18.12	18.1	17.85	19.31	19.46	19.7	19.49	19.4	19.24	19.05	18.5	18.39	18.3	18.16	18.6	19.6	19.54	19.58	19.7	19.57	19.51	19.33	19.17
28	Mettupalayam	1.35	1.09	0.82	0.55	0.72	-0.5	0.38	2	-0.12	1.95	0.9	1.35	1.14	1	0.8	0.01	0.23	0.07	0.48	0.29	1.32	1.01	1	0.28	-0.31
29	Muttukrishnapuram-dw	30.75	29.25	28.3	28.7	30.7	30.5	30.58	31.07	28.56	28.09	27.7	30.75	29.35	29.19	29.19	28.84	29.09	30.18	30.23	29.21	29.02	28.89	28.65	28.59	28.54
30	Nadutitu	3.25	3.1	2.94	2.9	3.55	2.87	2.8	3.92	1.15	3.35	3.15	3.25	3.28	3.05	2.83	2.86	2.75	3.4	2.73	2.65	3.55	3.08	3.03	2.93	2.64
31	Neyveli	56.09	56.25	55.22	55.22	55.59	55.58	54.4	56.75	56.3	55.45	56.69	56.09	56.78	55.6	55.3	55.3	55.19	54.72	54.4	54.4	56.27	55.67	55.56	55.39	55.37
32	Neyveli-Gandhinagar	52.15	51.62	51.25	51.25	51.9	51.4	51.2	60.18	59.94	53	51.5	52.15	51.62	51.68	51.13	50.92	50.83	51.57	50.93	50.94	55.65	58.02	54.59	53.75	52.59
33	Neyveli-MRK salai	51.4	50.7	52.68	52.5	52.71	52.4	52.12	60.07	59.3	54.35	52.79	51.4	51.29	51.02	51.82	51.81	52.56	52.79	51.92	51.59	56.04	57.57	52.91	52.78	51.54
34	Neyveli-Rainbownagar	61.95	61.7	60.95	61.88	61	61	60.76	67.5	66.83	65.6	61.72	61.95	61.75	61.5	61.14	60.74	60.89	61.22	60.96	61.22	66.04	62.59	62.08	61.64	61.33
35	Palanthoopu-Mathanagopal	42.1	40.25	39.85	40.8	39.6	39.49	40	46.9	44.7	42.49	39.8	42.1	40.36	39.47	37.95	37.89	40.93	43.5	42.42	42.37	44.64	43.52	43.06	42.76	41.85
36	Periyakaraikadu	0.9	0.72	-1.3	-3.41	-2.7	-3.27	-1.61	1.2	-2.02	1.7	0.5	0.9	1.32	-0.57	-1.68	-2.21	-2.04	-1.83	-2.11	-2.3	0.53	0.49	0.54	0.12	0.09
37	Pillapalayam	46.15	46.5	44.42	45.18	44.4	44.24	45.4	50.25	48.33	46.2	45.96	46.15	46.6	46.39	45.8	44.22	44.28	44.31	45.08	45.17	48.55	46.88	45.88	45.33	45.29
38	Pulliur Kattusagai-palankolla	29.4	28	26.2	25	25.3	25.14	28.36	33.95	31.77	29.03	26.75	29.4	28.13	26.28	25.79	25.8	#VALUE!	26.88	27.44	26.8	29.87	29.42	29.33	29.13	29.08
39	Pulliyur dw	32.6	33.15	30.74	31.27	30.92	30.89	33.06	36.49	36.43	34.48	32.88	32.6	32.75	31.51	30.2	30.28	30.63	30.59	32.28	33.82	35.03	34.39	34.02	33.4	32.63
41	Reddipalayam	16.6	16.48	15.27	13.25	13.24	11.15	11.75	13.63	12.01	16.1	16.5	16.6	16.08	15.71	14.19	13.64	12.96	15.77	11.95	12.75	17.45	17.01	16.51	14.96	14.84
42	Samiyakuppam	0.7	0.4	0.08	-0.07	0.1	-0.03	-0.05	2.14	1.78	1.45	0.63	0.7	0.56	0.29	0.1	-0.09	0.19	-0.02	-0.17	-0.07	1.5	1.24	0.09	1.04	0.56
43	Samutikuppam	27.05	25.59	27.17	25.99	25.43	25.29	27.21	28.88	26.97	26.02	26.35	27.05	30.31	29.02	28.23	28.11	26.77	25.88	27.55	27.42	28.03	30.79	29.98	28.91	27.33
45	Seerakuppam	23.7	23.45	27.13	27	26.77	26.6	26.34	28.08	27.97	26.65	26.2	23.7	24.71	24.68	25.3	25.79	25.95	27.35	25.89	25.9	27.65	26.66	25.24	24.18	23.71
47	T.Palayam	18.75	17.3	17.24	17.35	17.5	17.4	17.69	19.87	19.15	18	17.7	18.75	17.4	17.3	17.4	17.4	17.3	17.87	18.03	18.25	18.98	18.95	18.69	18.34	18.12
48	Teerthanagiri	2.85	2.18	1.55	1.55	1.37	1.11	0.85	3.85	1.55	1.89	2.55	2.85	1.86	1.74	0.8	0.74	0.51	1.36	0.64	0.62	1.42	2.68	2.63	2.51	2.11
49	Tekkumellur	48.5	48.49	48.34	48.24	48.62	48.28	48.26	49.3	49.28	48.35	48.41	48.5	48.4	48.3	48.2	48.18	48.45	48.7	48.46	48.34	48.73	48.91	48.85	48.7	48.67
50	Tenkuttu	36.2	34.29	39.5	32.75	30.3	33.33	32.61	40.15	36.2	37.8	35.9	36.2	34.82	34.7	34.5	43.4	34.82	36.3	34.37	34.88	39.84	38.26	38.17	36.93	36.01
51	Terkusepalanatam	23.1	23.07	23.1	22.83	22.87	23.38	23.1	23.7	23.78	23.15	23.3	23.1	22.34	22.95	22.89	22.87	22.92	23.17	22.89	22.92	23.54	23.79	23.34	23.3	22.98
52	Thaigavali	2.4	1.5	0.55	1.45	1.32	1.2	1.16	3	2.4	2.55	2.21	2.4	1.62	1.4	1.45	1.34	1.44	2.1	1.66	1.92	2.22	2.49	2.28	2.23	2.2
53	Thalachanchavadi	2.6	2.11	1.72	1.53	1.32	1.19	1.2	3.4	3.53	2.95	2.6	2.4	1.67	1.63	1.47	1.41	1.25	1.03	1.41	1.45	2.55	2.7	2.48	2.33	2.21
54	Thimmavathamkuppam	23.77	22.25	20.9	20.33	21	19.2	20.57	22.88	21.6	21.69	22.05	23.77	22.33	21.46	20.32	20.4	20.9	19.9	20.88	20.44	22.14	23.33	22.69	22.51	22.08
55	tiruchchopuram	1.2	0.43	1.15	0.4	0.22	0	-0.07	1.6	0.6	1.95	1.87	1.2	0.59	0.4	0.34	0.22	0.09	0.3	0.31	-0.81	0.75	1.37	1.13	0.9	0.85
56	Vadakku sepalanatam	36.85	35.56	33.92	34.7	33.82	37.52	37.46	37.94	37.78	37.67	35.56	36.85	35.76	34.91	33.88	33.86	34.45	35.57	37.28	37.15	37.65	37.27	37.21	37.16	36.79
57	Vadakuttu	37.5	32.89	29.35	24.88	25.73	24.4	24.15	37.6	35.11	37.23	29.1	37.5	31.84	30.78	22.9	21.8	25.71	37.5	23.89	24.01	38.4	37.78	37	36	32.04
58	Vadalur	35.78	29.87	25.75	22.8	24.89	26.12	21.8	37.58	33.3	34.9	31.66	35.78	27.74	26.48	22.89	20.58	23.9	31.84	23.7	25.22	36.85	34.7	34.34	33.66	32.89
59	Vadalur-jothinagar	36.5	35.9	33.9	33.73	35.69	36.53	36	38.61	38.04	36.5	35.74	36.5	36.07	36	35.22	35.15	35.08	36.64	36.2	36.18	37.9	38.3	37.69	37.19	36.49
60	Vadamellur	40.05	38.9	37.84	37.5	37	36.58	34.75	41.34	39.74	40.47	39.8	40.05	37.9	37.2	36.7	36.7	36.61	37.56	35.01	34.88	39.3	38.69	37.93	37.89	37.88
61	Vanatirayapuram-dw	37	36.54	36.1	38	35.8	34.7	34.25	39.1	38.53	36.94	35.23	37	35.78	33.01	31.4	32.03	36.13	37.11	35.23	35.3	38.32	37.92	37.88	37.45	36.92
62	Veenakeni	33.3	33.47	31.92	34.8	33.6	36.14	36.03	36.69	36.38	35.9	36.46	33.3	34.83	33.56	32.58	32.47	33.73	34.72	34.71	34.66	36.13	36.05	35.83	35.39	34.36
63	Vegakollai	43.7	43.35	41.28	39.7	41.18	39.71	37.79	49.25	46.84	47.92	44.02	42.7	40.35	38.57	36.9	36.66	35.79	36.79	35.91	42.98	43.3	44.11	43.94	41.02	40.46
64	Vengadampettai	45.05	42.15	41.98	41.3	43.8	44.4	43.32	48.05	46.98	45.92	44.89	45.05	43.9	43.67	43.15	43.09	44.54	45.7	43.82	43.78	45.45	44.93	44.91	44.81	44.34

Monthy Piezometric head data of Project area **Annexure V**

Sl.No	Location	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
1	Kattiyankuppam-EW	62.90	63.10	63.57	63.80	61.90	61.10	60.10	56.74	57.09	62.10	63.21	68.17	68.16	68.17	69.11	71.20	68.36	65.38	58.38	59.21	59.21	63.27	67.39
2	Kattiyankuppam-EW-I	69.68	70.00	71.66	70.01	64.34	64.38	64.67	60.96	60.15	62.82	62.09	69.78	69.31	69.78	68.68	66.95	68.89	66.23	60.72	60.98	61.27	64.39	69.23
3	Kattiyankuppam-EW-II	69.01	69.62	69.95	69.90	62.80	60.80	58.16	60.85	59.94	65.17	66.12	67.13	67.09	67.13	69.56	66.65	66.43	63.48	57.49	58.20	59.29	62.18	66.12
4	Marungur-EW	102.10	102.30	102.68	103.12	106.08	102.35	102.28	100.65	102.82	103.00	103.03	103.10	102.99	102.87	102.80	100.89	100.65	100.70	100.25	102.12	102.90	103.20	103.35
5	Marungur-OW	96.50	96.60	96.34	96.40	96.20	96.60	97.20	94.12	96.60	98.10	98.36	98.67	98.82	99.01	98.67	97.01	96.98	96.90	94.56	95.23	95.93	96.21	96.99
6	Ramapuram-EW	35.67	36.10	35.50	36.60	37.30	35.10	23.17	24.36	33.20	35.30	45.20	47.70	48.86	52.01	47.12	33.21	33.01	25.24	25.20	32.17	34.45	42.73	48.51
7	Ramapuram-EW-I	47.66	49.11	57.12	55.34	56.89	39.10	26.80	29.41	26.70	28.12	31.23	29.40	33.12	35.28	35.09	42.00	39.00	33.00	27.00	28.65	30.76	31.10	32.40
8	MARUDUR PZ-EW	28.25	27.15	27.96	28.23	28.27	28.30	28.75	29.00	28.76	28.60	28.90	29.03	28.90	30.90	31.31	32.10	30.34	30.45	28.16	28.56	28.72	29.10	29.23
9	MARUDUR PZ-I	4.57	5.05	6.05	6.08	6.17	6.42	4.80	5.10	10.17	10.17	9.97	9.65	5.21	7.72	8.91	7.30	7.42	4.92	5.09	9.56	9.78	10.21	10.11
10	MARUDUR PZ-II	23.03	22.88	23.18	23.20	23.50	23.68	23.70	23.62	23.76	23.76	23.75	23.63	23.65	24.72	24.81	25.30	24.12	24.90	25.02	25.13	25.21	25.19	25.20
11	MARUDUR PZ-III	34.65	34.00	34.42	34.70	35.52	36.01	35.70	35.78	35.47	35.49	35.12	36.01	36.63	37.30	38.29	38.91	37.08	36.65	36.87	37.01	37.05	37.09	37.10
12	MARUDUR PZ-IV	35.91	36.03	35.88	35.95	36.30	36.34	36.40	36.80	36.66	36.98	37.08	37.20	37.20	37.40	38.01	38.80	38.21	38.28	38.27	38.35	38.55	38.67	38.70
13	Vadalur	11.03	9.60	10.00	9.99	9.60	10.43	6.80	9.19	7.20	7.31	6.98	8.90	10.69	11.10	12.40	8.12	10.23	7.13	4.65	6.97	7.42	7.21	8.56
14	Vadalur-ow1	72.28	72.27	73.01	73.01	73.02	73.33	72.35	72.16	72.23	73.23	72.89	74.15	75.12	76.23	75.80	75.60	74.12	72.69	74.35	74.80	75.12	75.16	75.21
15	Teerthanagari-EW	16.00	16.66	17.92	18.43	19.14	20.56	19.35	21.12	17.10	17.60	17.56	18.56	20.91	21.50	23.38	24.70	24.72	24.65	20.13	20.94	20.87	21.21	21.30
16	Teerthanagari-OWI	28.23	36.16	33.13	33.14	31.50	31.19	29.50	31.33	26.66	26.66	28.78	34.21	37.18	39.90	40.89	39.43	32.27	31.27	30.18	30.97	31.37	32.25	34.10
17	Teerthanagari-OWII	8.20	12.76	13.32	13.56	12.10	13.18	5.76	9.06	8.20	8.28	9.80	10.02	11.94	18.42	18.80	14.30	13.83	13.98	7.98	8.19	8.79	9.64	10.64
18	Kudikadu-OW	4.85	6.05	6.97	7.12	3.47	7.11	3.23	7.24	3.37	3.50	4.50	5.67	5.98	8.01	7.10	5.01	7.42	4.56	5.21	5.89	4.27	5.10	5.82
19	Kudikadu-EW	11.10	12.20	13.88	13.67	13.88	13.89	13.65	13.89	12.38	12.38	12.89	13.23	13.98	16.38	16.65	16.56	15.67	13.45	13.27	13.43	13.67	14.02	14.59
20	Rajankuppam	21.55	23.00	27.92	28.61	28.79	28.24	19.44	19.89	21.40	19.23	22.17	25.70	27.19	30.70	32.12	29.14	28.65	25.27	21.46	20.32	20.94	21.46	22.93
21	Kattusagaipuliyur-S	56.62	36.10	52.15	55.45	60.12	58.91	56.13	54.12	52.06	50.18	51.56	52.01	53.57	55.05	56.43	53.82	54.32	55.92	53.23	52.68	51.06	52.12	52.86
22	Kattusagaipuliyur-N	48.92	49.83	51.52	51.50	51.75	51.53	51.00	50.57	50.02	52.06	56.72	57.96	62.14	69.89	68.15	64.12	64.21	60.15	56.24	53.21	52.15	52.57	53.79
23	Puduchattram	4.74	5.13	5.00	5.03	5.10	5.30	5.60	5.55	5.30	5.30	5.40	5.33	5.27	5.66	5.70	5.80	5.50	5.40	5.40	5.30	5.64	5.68	5.74
24	Pacharapalayam-I												68.79	68.80	68.79	68.68	68.53	68.60	68.63	68.02	67.93	67.40	67.90	68.20
25	Pacharapalayam-II												68.50	68.60	68.60	68.54	68.61	68.40	68.56	67.90	67.70	67.31	67.82	68.09
26	Sengalpalayam-aq-iii														77.30	77.90	77.01	77.24	77.40	76.38	76.40	74.12	75.06	75.88
27	Sengalpalayam-aq iv														82.50	82.55	82.27	81.93	82.01	79.67	79.62	78.23	78.01	78.92
28	Ayeuppam														59.10	55.63	55.17	54.56	54.13	45.12	45.01	44.53	45.76	47.62
29	Kodandaramapuram												33.06	34.65	36.12	37.83	35.60	35.62	35.68	34.61	33.13	31.23	32.15	34.01
30	Srinivasapuram														18.56	19.21	19.60	20.12	20.67	16.80	16.92	17.00	16.96	18.34
31	Thaiyalkunapattinam												46.80	47.13	48.50	46.64	46.18	46.26	45.98	43.12	42.12	41.11	42.64	44.09
32	Reddipalayam														26.30	24.35	16.97	18.12	19.16	6.88	7.51	7.90	12.78	15.83
33	Vanathirayapuram_I															80.88	80.30	80.32	80.44	79.86	78.16	76.91	77.25	78.67
34	Vanathirayapuram_II															26.63	20.50	20.67	21.67	19.90	20.10	19.20	20.21	23.22
35	Arasadikuppam															82.98	82.48	82.51	82.74	82.31	82.40	82.13	82.66	83.08
36	Vegakollai																74.50	74.33	74.50	72.18	72.21	70.12	71.00	72.18
37	Silambinathanpettai-I																					64.18	65.12	65.38
38	Silambinathanpettai-II																					56.23	58.11	59.87

ANALYTICAL RESULTS OF SAMPLES COLLECTED UNDER AQ MAPPING STUDIES DURING PRE-MONSOON 2012															Annexure VIa
S.No	**Location**	**Source**	**pH**	**EC**	**TH**	**Ca**	**Mg**	**Na**	**K**	**CO3**	**HCO3**	**Cl**	**SO4**	**No3**	**F**
					µS/cm										
1	Athinarayanapuram	Dugwell	7.7	1564	250	16	51	216	51	Nil	397	269	15	82	0.74
2	Abathanapuram	Dugwell	7.45	906	200	40	24	113	8	Nil	79	248	43	1	0.62
3	Anandampettai	Dugwell	7.45	708	150	18	26	67	43	Nil	183	82	72	2	0.43
4	Ayiekuppam	Dugwell	7.5	1240	200	42	23	189	8	Nil	183	252	106	3	0.46
5	Badrakottai	Dugwell	7.01	684	120	16	19	101	4	Nil	61	142	82	12	0.42
6	Cherakuppam	Dugwell	7.12	600	130	18	21	74	4	Nil	122	74	77	8	0.41
7	Gopalapuram	Dugwell	7.45	490	150	18	26	41	4	Nil	183	35	43	2	0.35
8	Kalkunam	Dugwell	7.7	1790	200	18	38	317	5	Nil	427	255	178	0	0.34
9	Kalliyankuppam	Dugwell	7.49	4630	580	120	68	818	13	Nil	610	1276	76	1	0.42
10	Karuppan Chavadi	Dugwell	7.02	280	80	28	2	25	5	Nil	98	43	1	15	0.46
11	Karunguli	Dugwell	7.66	930	100	36	2	155	22	Nil	183	160	86	2	1.5
12	Keelapuvanikuppam	Dugwell	7.94	1670	255	26	46	216	86	Nil	549	223	62	2	0.33
13	Kornapattu	Dugwell	7.37	730	135	30	15	101	9	Nil	122	149	49	2	0.82
14	Kothandaramapuram	Dugwell	7.07	196	65	18	5	10	9	Nil	55	28	5	8	0.35
15	Kottavacherry	Dugwell	8.07	3630	200	20	36	772	10	Nil	1098	255	605	3	0.86
16	Kulanchavadi	Dugwell	7.6	740	100	18	13	112	21	Nil	98	124	101	12	0.36
17	Kundiamallur	Dugwell	7.6	1360	230	60	19	207	5	Nil	427	142	125	7	0.34
18	Meenashipettai	Dugwell	7.6	460	110	18	16	52	5	Nil	79	78	48	7	0.72
19	Melapudupatti	Dugwell	7.5	450	115	18	17	43	13	Nil	73	106	3	3	0.81
20	Mettukuppam	Dugwell	8.05	2740	500	80	73	377	63	Nil	452	574	206	2	2.5
21	Mettupalayam	Dugwell	7.73	1230	240	50	28	170	4	Nil	183	181	192	8	0.37
22	Naduthittu	Dugwell	7.57	720	100	20	12	117	4	Nil	275	92	5	3	0.31
23	Neyveli-Gandhinagar	Dugwell	7.4	230	90	18	11	9	4	Nil	61	39	0	3	0.41
24	Neyveli-rainbownahar	Dugwell	6.8	100	35	12	1	4	5	Nil	24	14	5	3	0.4
25	Palanthoopu	Dugwell	7	190	60	16	5	14	4	Nil	49	32	5	3	0.35
26	Periyakaraikadu	Dugwell	7	360	100	18	13	36	2	Nil	61	43	62	9	0.31
27	Pulliyur	Dugwell	7.1	160	50	16	2	12	4	Nil	55	25	1	1	0.47
28	Reddipalayam	Dugwell	7.1	720	150	60	0	95	2	Nil	134	142	44	4	0.5

29	Samiyakuppam	Dugwell	7.4	340	125	14	22	20	2	Nil	128	32	20	2	0.43
30	Sedapalayam	Dugwell	6.7	380	125	16	21	29	2	Nil	61	92	12	1	0.46
31	Seerakuppam	Dugwell	7.27	920	150	40	12	135	13	Nil	92	160	149	11	0.52
32	Tekkumellur	Dugwell	7.59	500	115	22	15	52	16	Nil	183	71	5	0	0.46
33	Tenkuttu	Dugwell	7.2	470	100	20	12	61	2	Nil	153	74	2	6	0.98
34	Thaigavalli	Dugwell	7.18	380	100	28	7	34	13	Nil	122	32	14	38	2.6
35	Thalachancahvadi	Dugwell	7.34	540	150	32	17	52	5	Nil	183	43	53	4	0.82
36	Thimmavathamkuppam	Dugwell	7.58	360	140	28	17	16	4	Nil	116	53	2	11	0.76
37	Thiruchopuram	Dugwell	7.3	450	125	34	10	36	16	Nil	122	43	43	26	0.75
38	Vadaku sepalanatham	Dugwell	7.59	1960	250	60	24	318	38	Nil	244	401	211	9	0.86
39	Vadalur	Dugwell	7.6	630	115	20	16	86	10	Nil	165	106	24	1	0.74
40	Vadamallur	Dugwell	7.18	790	125	24	16	111	23	Nil	122	177	38	1	0.22
41	Vegakollai	Dugwell	7.4	230	90	20	10	10	2	Nil	61	28	34	3	0.68
42	Vengadampettai	Dugwell	7.3	200	85	18	10	6	2	Nil	43	32	14	3	0.6
43	Viruppachi	Dugwell	7.3	860	190	46	18	104	12	Nil	153	174	48	14	0.66
44	Agathimapuram	Dugwell	7.97	840	190	40	22	105	2	Nil	305	106	5	11	1.36
45	Uppanar	River	7.01	19370	3000	800	243	3266	38	Nil	171	5814	1728	6	1.21
46	Sengal odai	River	8	510	125	24	16	59	2	Nil	183	53	24	1	0.67
47	Peiykanatham	Dugwell	7.74	800	150	46	9	114	2	Nil	244	106	43	3	0.68
48	Silambinatham	Dugwell	7.33	190	60	16	5	9	13	Nil	61	28	1	5	0.2

ANALYTICAL RESULTS OF SAMPLES COLLECTED UNDER AQ MAPPING STUDIES During Post-monsoon (2013)																	Annexure VIb		
Sl.No	LAB.No	Location	DOC	PH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F	TC	TA	%
					µS/cm	..........mg/L..........													
1	449	Aathinarayanapuram	01-07-2013	8.22	2280	350	50	55	241	182	0	549	334	180	78	0.47	22.14	23.40	-2.8
2	450	Abathanapuram	01-08-2013	8.21	1045	320	102	16	99	11	0	173	220	85	26	0.11	10.97	11.21	-1.1
3	451	Anandampettai	01-08-2013	8.47	804	255	66	22	66	37	21	261	78	78	32	0.40	8.93	9.32	-2.1
4	452	Ayiekuppam	01-07-2013	8.17	920	275	92	11	86	5	0	189	165	85	4	0.347	9.36	9.59	-1.2
5	453	cherakuppam	01-07-2013	8.19	780	250	84	10	66	2	0	153	82	148	5	0.45	7.92	7.98	-0.4
6	454	Gopalapuram	01-08-2013	8.21	404	225	44	28	24	0	0	131	36	110	1	0.29	5.55	5.46	0.8
7	455	Kalkunam	01-07-2013	8.03	1930	375	46	63	267	0	0	431	277	248	2	0.66	19.11	20.06	-2.4
8	456	Kalliyankuppam	01-07-2013	8.70	2680	410	90	45	385	115	60	561	454	230	21	0.17	27.91	29.13	-2.1
9	457	Karunguli	01-07-2013	8.63	1118	180	60	7	170	39	36	293	149	82	38	0.35	11.98	12.52	-2.2
10	458	Kattuvegakollai	01-08-2013	7.92	486	175	40	18	40	14	0	189	60	20	28	0.27	5.62	5.67	-0.4
11	459	Keelapuvanikuppam	01-07-2013	8.81	1503	375	80	43	180	68	75	458	170	102	72	0.36	17.06	18.09	-2.9
12	460	Kothandaramapuram	01-07-2013	8.22	398	150	50	6	29	0	0	146	46	12	16	0.23	4.27	4.22	0.7
13	461	Kottuvacheri	01-07-2013	8.37	2200	350	72	41	351	78	39	598	284	280	14	0.46	24.24	25.15	-1.9
14	462	Kulanchavadi	01-07-2013	7.59	565	150	28	19	65	4	0	52	131	16	58	0.11	5.89	5.81	0.7
15	463	Kundimallur	01-07-2013	7.81	1450	420	92	46	147	23	0	427	170	196	23	0.25	15.39	16.25	-2.7
16	464	Meenatchipettai-Sivajinagar	01-07-2013	7.92	1810	350	118	13	208	74	0	300	355	25	128	0.45	17.95	17.52	1.2
17	465	Melapudupatti	01-07-2013	8.12	1015	250	96	2	128	0	0	185	195	102	14	0.24	10.57	10.89	-1.5
18	466	Mettukuppam	01-07-2013	7.98	950	250	70	18	102	18	0	210	99	184	12	0.39	9.89	10.27	-1.9
19	467	Mettupalayam	01-07-2013	8.63	3170	600	144	58	389	94	60	415	540	310	156	0.27	31.32	32.97	-2.6
20	468	Nadutitu	01-07-2013	8.68	748	150	52	5	127	1	45	232	99	16	20	0.40	8.54	8.75	-1.2
21	469	Neyveli-Gandhinagar	01-08-2013	7.45	262	100	26	9	22	0	0	30	39	7	70	0.03	2.98	2.87	1.8
22	470	Neyveli-Rainbow nagar	01-08-2013	8.03	230	135	34	12	12	0	0	86	32	8	40	0.12	3.22	3.12	1.6
23	471	Palanthopu-Mathanagopalapu	01-08-2013	8.05	375	150	36	15	25	0	0	85	64	8	34	0.35	4.09	3.91	2.3
24	472	Paravanur	01-07-2013	7.41	786	265	76	18	53	0	0	29	75	228	15	0.52	7.61	7.57	0.2
25	473	Paravanar	01-07-2013	8.03	940	295	68	30	83	1	0	189	114	159	16	0.67	9.50	9.87	-1.9
26	474	Periyakaraikadu	01-07-2013	7.84	704	215	78	5	87	0	0	189	107	92	15	0.60	8.09	8.26	-1.0
27	475	Reddipalayam	01-07-2013	7.88	685	275	76	21	91	0	0	238	153	59	19	0.22	9.46	9.74	-1.5
28	476	samiyakuppam	01-07-2013	8.53	424	200	46	21	25	0	12	168	39	17	34	0.23	5.09	5.15	-0.6
29	477	Sedapalayam	01-07-2013	8.17	570	200	64	10	37	0	0	111	99	29	7	0.45	5.60	5.34	2.4
30	478	Seerakuppam	01-07-2013	7.57	907	225	66	15	87	18	0	84	107	208	12	0.45	8.74	8.92	-1.0
31	479	Sengal Odai	01-07-2013	8.16	496	125	44	4	64	0	0	171	57	54	2	0.51	5.31	5.56	-2.3
32	480	Theerthanagiri	01-07-2013	8.23	835	200	54	16	95	33	0	336	110	30	11	0.26	8.98	9.40	-2.3
33	481	Tekkumellur	01-08-2013	8.14	620	175	48	13	60	15	0	189	82	54	12	0.31	6.49	6.73	-1.8

Sl.No	LAB.No	Location	DOC	PH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F	TC	TA	%
					µS/cm	..........mg/L..........													
34	482	Tenkuttu	01-08-2013	8.16	683	225	68	13	46	0	0	148	135	22	3	0.17	6.51	6.72	-1.6
35	483	Terkusepalanatham	01-07-2013	7.84	1230	300	72	29	156	23	0	293	167	180	30	0.42	13.38	13.73	-1.3
36	484	Thaigaivali	01-07-2013	8.36	494	160	50	9	39	2	15	170	43	27	4	0.13	4.95	5.11	-1.6
37	485	Thalachanchavadi	01-07-2013	8.43	470	225	52	23	34	2	15	192	28	79	8	0.11	6.01	6.21	-1.6
38	486	Thambipettai	01-08-2013	8.33	620	225	66	15	55	14	21	195	71	36	46	0.15	7.25	7.40	-1.0
39	487	Thimmavathamkuppam	01-08-2013	8.37	557	210	66	11	42	0	15	128	71	60	17	0.34	6.03	6.12	-0.8
40	488	Tiruchopuram	01-07-2013	7.97	265	110	20	15	17	0	0	67	46	22	6	0.97	2.95	2.95	0.0
41	489	Uppanar	01-07-2013	8.11	24600	3600	228	737	5444	98	0	165	10185	1600	9	1.10	311.21	323.08	-1.9
42	490	Uppanar-Perumaleri	01-07-2013	8.13	1354	390	50	64	266	5	0	360	323	240	7	0.78	19.49	20.11	-1.5
43	491	Vadakkusepalanatham	01-08-2013	7.61	2450	380	100	32	357	50	0	293	291	480	32	0.63	24.40	23.52	1.8
44	492	Vadalur-Jothinagar	01-07-2013	8.47	775	250	70	18	61	9	15	194	121	47	9	0.25	7.87	8.21	-2.1
45	493	vadalur-NHS	01-08-2013	8.14	405	160	44	12	33	0	0	111	71	10	30	0.21	4.64	4.51	1.3
46	494	Vadamellur	01-08-2013	8.17	982	260	56	29	92	21	0	198	192	72	5	0.78	9.75	10.23	-2.4
47	495	Vegakollai	01-08-2013	8.43	577	185	48	16	46	24	12	198	67	31	17	0.42	6.32	6.46	-1.1
48	496	Vengadampettai	01-08-2013	7.93	310	150	32	17	27	0	0	93	46	41	30	0.19	4.16	4.17	-0.1
49	497	Virupachi-DW	01-07-2013	8.2	1117	345	86	32	90	0	0	138	245	71	44	0.46	10.82	11.35	-2.4

ANALYTICAL RESULTS OF SAMPLES COLLECTED UNDER AQ MAPPING STUDIES											**Annexure VII**					
	DISTRICT :	**CUDDALORE**														
Sl.No	**Location**	**District**	**DOC**	**PH**	**EC**	**TH**	**Ca**	**Mg**	**Na**	**K**	**CO3**	**HCO3**	**Cl**	**SO4**	**NO3**	**F**
					µS/cm	**..mg/L..**										
1	Sengalpalayam EW-I	CUDDALORE	Feb_13	7.83	600	165	30	22	78	3	0	214	92	35	0	0.31
2	Sengalpalayam EW-I	CUDDALORE	Feb_13	7.75	604	170	40	17	81	5	0	201	85	38	1	0.41
3	Sengalpalayam EW-II	CUDDALORE	Mar_13	7.64	1310	250	30	43	236	7	0	207	249	207	0	0.98
4	Sengalpalayam EW-II	CUDDALORE	Mar_13	7.70	1332	265	34	44	242	7	0	232	249	204	0	0.92
5	Pachcharapalayam EW-I DD	CUDDALORE	Jan_13	7.63	666	150	30	18	107	7	0	244	89	52	1	0.39
6	Pachcharapalayam EW-I ZD	CUDDALORE	Jan_13	8.10	628	140	20	22	102	6	0	153	107	68	0	0.78
7	Pachcharapalayam EW-II DD	CUDDALORE	Jan_13	7.69	282	130	26	16	18	3	0	153	18	28	0	0.34
8	Pachcharapalayam EW-I ZD	CUDDALORE	Jan_13	7.85	276	115	24	13	21	3	0	116	25	23	0	0.08
9	Pachcharapalayam EW-I-SDT-I	CUDDALORE	July_14	7.47	806	200	46	21	118	6	0	299	117	54	0	0.37
10	Pachcharapalayam EW-I -SDT-II	CUDDALORE	July_14	7.69	825	225	30	36	116	4	0	317	89	60	0	0.57
11	Srinivasanallur-EW-I	CUDDALORE	dec_13	8.47	507	155	24	23	135	9	30	110	170	48	12	0.50
12	Taiyalkunnapattinam EW	CUDDALORE	Mar_13	8.50	506	125	26	15	88	9	30	153	60	42	0	0.26
13	Taiyalkunnapattinam EW	CUDDALORE	Mar_13	8.47	494	120	30	11	86	9	30	146	58	45	1	0.31
14	Kothandaramapuram EW	CUDDALORE	feb_13	8.45	440	105	20	13	74	4	30	110	58	36	0	0.45
15	Kothandaramapuram EW	CUDDALORE	feb_13	8.07	486	130	26	16	81	9	0	207	74	26	0	0.11
16	Reddipalayam EW	CUDDALORE	AUG_13	7.76	1391	250	22	47	198	15	0	238	259	172	10	0.38
17	Reddipalayam EW	CUDDALORE	AUG_13	7.47	1498	250	16	51	198	16	0	252	266	166	5	0.73
18	Ayekuppam EW	CUDDALORE	Jan_13	7.92	354	150	16	27	18	1	0	137	43	21	0	0.02
19	Ayekuppam EW	CUDDALORE	Jan_13	7.81	313	135	26	17	24	6	0	183	25	22	0	0.03
20	Vegakollai EW	CUDDALORE	9-12-13	8.04	125	55	16	4	5	2	0	38	21	8	2	0.03
21	Vegakollai EW	CUDDALORE	9-12-13	8.10	121	60	16	5	3	1	0	35	24	7	2	0.44
22	Silambinathanpettai Aq-IV	CUDDALORE	11-6-13	7.62	533	190	52	15	20	6	0	152	67	16	3	0.01
23	Silambinathanpettai Aq-IV	CUDDALORE	11-6-13	7.67	562	215	44	26	18	4	0	148	65	20	2	0.02
24	Silambinathanpettai Aq-II	CUDDALORE	19/12/2013	8.08	126	55	10	7	4	1	0	42	20	4	3	0.02
25	Silambinathanpettai Aq-II	CUDDALORE	19/12/2013	8.09	144	60	16	5	5	2	0	49	22	6	4	0.03

Sl.No	Location	District	DOC	PH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
					µS/cm	....mg/L										
26	Vanathirayapuram	CUDDALORE	AUG_13	8.4	290	100	28	7	23	1	6	122	18	19	13	1.1
27	Vanathirayapuram	CUDDALORE	AUG_13	8.44	270	100	24	10	21	1	6	110	21	9	9	0.73
28	Vanathirayapuram	CUDDALORE	AUG_13	8.36	830	165	40	16	115	6	6	177	124	82	7	0.32
29	Vanathirayapuram	CUDDALORE	AUG_13	8.1	900	140	40	10	145	6	NIL	207	149	53	32	0.32
30	Arasadikuppam	CUDDALORE	AUG_13	8.28	280	95	28	6	23	1	6	85	18	19	13	0.31
31	Arasadikuppam	CUDDALORE	AUG_13	8.31	260	95	28	6	18	1	6	85	18	17	11	0.32

Villages of Pilot Project area

S.No	Village Name	Block Name
1	Abatharanapuram	Kurunjipadi
2	Adinarayanapuram	Kurunjipadi
3	Aduragaram	Kurunjipadi
4	Adurkuppam	Kurunjipadi
5	Agaram	Kurunjipadi
6	Akkatimmapuram	Kurunjipadi
7	Alamelumangapuram	Parangipettai
8	Alappakkam	Kurunjipadi
9	Ambalavanampettai	Kurunjipadi
10	Andarmullippallam A/b	Kurunjipadi
11	Annadanapettai	Kurunjipadi
12	Annavalli	Cuddalore
13	Anukkambattu	Kurunjipadi
14	Arangamangalam	Kurunjipadi
15	Ayikuppam	Kurunjipadi
16	Buddampadi	Kurunjipadi
17	Ellaikudi	Kurunjipadi
18	Gangamanayakkankuppam	Cuddalore
19	Guruvappanpettai	Kurunjipadi
20	Idankondambattu	Kurunjipadi
21	Kalkunam	Kurunjipadi
22	Kambalimedu	Kurunjipadi
23	Kanchamanathapuram	Kurunjipadi
24	Kanjamandanpettai	Kurunjipadi
25	Periya Kannadi	Kurunjipadi
26	Chinna Kannadi	Kurunjipadi
27	Karaikkadu	Cuddalore
28	Karunguli	Kurunjipadi
29	Karuveppambadi	Kurunjipadi
30	Kayalpattu	Kurunjipadi

31	Kayalpattu	Kurunjipadi
32	Kesavanarayanapuram	Kurunjipadi
33	Kilur	Kurunjipadi
34	Kodandaramapuram	Kurunjipadi
35	Koranapattu	Kurunjipadi
36	Krishnankuppam	Kurunjipadi
37	Kudikkadu	Cuddalore
38	Kundiyamallur A/b	Kurunjipadi
39	KURINJIPADI	Kurunjipadi
40	Kurinjipadi A/b	Kurunjipadi
41	Madanagopalapuram	Kurunjipadi
42	North Marungur	Panruti
43	south Maruvay	Kurunjipadi
44	Maruvay	Kurunjipadi
45	Melapuduppettai	Kurunjipadi
46	Nayinakuppam	Kurunjipadi
47	NEYVELI	kammapuram
48	Pachchyankuppam A/b	Cuddalore
49	Parvatipuram	Kurunjipadi
50	Peddunayakkankuppam	Kurunjipadi
51	Ponnaiyankuppam	Cuddalore
52	Poyiganatham	Kurunjipadi
53	Puliyur(west) A/b	Kurunjipadi
54	Puvanikuppam	Kurunjipadi
55	Rajakuppam	Kurunjipadi
56	Ramapuram	Cuddalore
57	Ranganathapuram	Kurunjipadi
58	Sedappalayam	Cuddalore
59	Sembankuppam	Cuddalore
60	Sepalanatham A/b	kammapuram
61	Serakuppam	Kurunjipadi
62	Silambinathanpettai	Panruti
63	Sirupalaiyur	Kurunjipadi

64	Tambipettai	Kurunjipadi
65	Tanur	Kurunjipadi
66	Tayilgunampattinam	Kurunjipadi
67	Tenkuthu	Kurunjipadi
68	Thambipalayam	Kurunjipadi
69	Timmaravuthamkuppam	Kurunjipadi
70	Tirttanagari	Kurunjipadi
71	Tiruchchepuram	Kurunjipadi
72	Tiyagavelli	Kurunjipadi
73	Tondamanatham	Kurunjipadi
74	Toppukollai	Kurunjipadi
75	Vadakkumelur	Kurunjipadi
76	Vadakuthu A/b	Kurunjipadi
77	Valudambattu	Kurunjipadi
78	Vanadirayapuram	Kurunjipadi
79	Vegakollai A/b	Panruti
80	Vellakarai A/b	Cuddalore
81	Vengadampettai	Kurunjipadi
82	Virupakshi	Kurunjipadi

Annexure-IX

Aquifer Wise Ground Water Draft

Groundwater Withdrawal from Aquifer I - (Alluvium & Upper Cuddalore)			
Block name	**Cropping**	**Month**	**Draft (m^3/day)**
Virudhachalam	**crop3**	Jan	3667
		feb	3667
		Mar	3667
		Apr	3667
		May	3667
	Crop1	Jun	12038
		Jul	12038
		Aug	12038
	Crop2	Sep	9078
		Oct	9078
		Nov	9078
		Dec	9078
Panruti	**crop3**	Jan	5159
		feb	5159
		Mar	5159
		Apr	5159
		May	5159
	Crop1	Jun	16935
		Jul	16935
		Aug	16935
	Crop2	Sep	12771
		Oct	12771
		Nov	12771
		Dec	12771
Cuddalore	**crop3**	Jan	5190
		feb	5190
		Mar	5190
		Apr	5190
		May	5190
	Crop1	Jun	17038
		Jul	17038
		Aug	17038
	Crop2	Sep	12849
		Oct	12849
		Nov	12849
		Dec	12849

Melbuvanagiri	**crop3**	Jan	6502
		feb	6502
		Mar	6502
		Apr	6502
		May	6502
	Crop1	Jun	21343
		Jul	21343
		Aug	21343
	Crop2	Sep	16094
		Oct	16094
		Nov	16094
		Dec	16094
Kurunjipadi	**crop3**	Jan	5363
		feb	5363
		Mar	5363
		Apr	5363
		May	5363
	Crop1	Jun	17603
		Jul	17603
		Aug	17603
	Crop2	Sep	13274
		Oct	13274
		Nov	13274
		Dec	13274
Kammapuram	**crop3**	Jan	424
		feb	424
		Mar	424
		Apr	424
		May	424
	Crop1	Jun	1391
		Jul	1391
		Aug	1391
	Crop2	Sep	1049
		Oct	1049
		Nov	1049
		Dec	1049
Tvnallaur	**crop3**	Jan	3216
		feb	3216
		Mar	3216
		Apr	3216
		May	3216
	Crop1	Jun	10558
		Jul	10558
		Aug	10558

	Crop2	Sep	7962
		Oct	7962
		Nov	7962
		Dec	7962
Tirunavalur	**crop3**	Jan	1962
		feb	1962
		Mar	1962
		Apr	1962
		May	1962
	Crop1	Jun	6439
		Jul	6439
		Aug	6439
	Crop2	Sep	4856
		Oct	4856
		Nov	4856
		Dec	4856
Annagaram	**crop3**	Jan	1705
		feb	1705
		Mar	1705
		Apr	1705
		May	1705
	Crop1	Jun	5598
		Jul	5598
		Aug	5598
	Crop2	Sep	4222
		Oct	4222
		Nov	4222
		Dec	4222
Portonova	**crop3**	Jan	3046
		feb	3046
		Mar	3046
		Apr	3046
		May	3046
	Crop1	Jun	10000
		Jul	10000
		Aug	10000
	Crop2	Sep	7541
		Oct	7541
		Nov	7541
		Dec	7541

Groundwater withdrawal from Aquifer-II (Lower Cuddalore)			
Block name	**Crop**	**Month**	**Draft (m^3/day)**
Virudhachalam	crop3	Jan	19931
		feb	19931
		Mar	19931
		Apr	19931
		May	19931
	Crop1	Jun	65426
		Jul	65426
		Aug	65426
	Crop2	Sep	49338
		Oct	49338
		Nov	49338
		Dec	49338
Panruti	crop3	Jan	115842
		feb	115842
		Mar	115842
		Apr	115842
		May	115842
	Crop1	Jun	380263
		Jul	380263
		Aug	380263
	Crop2	Sep	286756
		Oct	286756
		Nov	286756
		Dec	286756
Cuddalore	crop3	Jan	162386
		feb	162386
		Mar	162386
		Apr	162386
		May	162386
	Crop1	Jun	533050
		Jul	533050
		Aug	533050
	Crop2	Sep	401972
		Oct	401972
		Nov	401972
		Dec	401972
Melbuvanagiri	crop3	Jan	83165
		feb	83165
		Mar	83165
		Apr	83165
		May	83165
	Crop1	Jun	272999
		Jul	272999
		Aug	272999
	Crop2	Sep	205868

		Oct	205868
		Nov	205868
		Dec	205868
Kurunjipadi	crop3	Jan	138532
		feb	138532
		Mar	138532
		Apr	138532
		May	138532
	Crop1	Jun	454746
		Jul	454746
		Aug	454746
	Crop2	Sep	342923
		Oct	342923
		Nov	342923
		Dec	342923
Kammapuram	crop3	Jan	111237
		feb	111237
		Mar	111237
		Apr	111237
		May	111237
	Crop1	Jun	365146
		Jul	365146
		Aug	365146
	Crop2	Sep	275356
		Oct	275356
		Nov	275356
		Dec	275356
Tvnallaur	crop3	Jan	65962
		feb	65962
		Mar	65962
		Apr	65962
		May	65962
	Crop1	Jun	216526
		Jul	216526
		Aug	216526
	Crop2	Sep	163282
		Oct	163282
		Nov	163282
		Dec	163282
Tirunavalur	crop3	Jan	36715
		feb	36715
		Mar	36715
		Apr	36715
		May	36715
	Crop1	Jun	120522
		Jul	120522
		Aug	120522
	Crop2	Sep	90885

		Oct	90885
		Nov	90885
		Dec	90885
annagaram	crop3	Jan	154654
		feb	154654
		Mar	154654
		Apr	154654
		May	154654
	Crop1	Jun	507670
		Jul	507670
		Aug	507670
	Crop2	Sep	382833
		Oct	382833
		Nov	382833
		Dec	382833
Portonova	crop3	Jan	21651
		feb	21651
		Mar	21651
		Apr	21651
		May	21651
	Crop1	Jun	71073
		Jul	71073
		Aug	71073
	Crop2	Sep	53596
		Oct	53596
		Nov	53596
		Dec	53596

Village wise aquifer information **Annexure X**

S.No	Village Name	Taluk	Age		Aquifer Units	aquifer top	Aquifer bottom	Thickness (m)	Piezometric Head	Yield range (m3/day)	Quality
1	Adinarayanapuram	Cuddalore	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**90**	**90**	2.85	50 to130	Moderate
					II	**110**	**140**	**30**	-10	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**145**	**190**	**45**	-30	460 to 1150	Good
					IV	**230**	**300**	**70**	-15	700 t0 1730	Good
2	Agaram	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**70**	**70**	16.8	100 to 220	Good
					II	**85**	**140**	**55**	-6	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**170**	**205**	**35**	-30	460 to 1150	Good
					IV	**220**	**300**	**80**	-30	700 to 1730	Good
3	Akkatimmapuram	Cuddalore	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**52**	**52**	18.5	100 to 220	Good
					II	**70**	**125**	**55**	-16	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**161**	**205**	**44**	-30	460 to 1150	Good
					IV	**230**	**300**	**70**	-30	700 t0 1730	Good
4	Alappakkam	Cuddalore	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**38**	**38**	3.5	50 to130	Moderate
					II	**50**	**80**	**30**	-10	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**190**	**210**	**20**	-20	460 to 1150	Good
					IV	**230**	**300**	**70**	-15	700 t0 1730	Good
5	Anukkambattu	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**55**	**55**	17	100 to 220	Good
					II	**70**	**130**	**60**	-8	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**145**	**195**	**50**	-20	460 to 1150	Good
					IV	**225**	**300**	**75**	-15	700 t0 1730	Good
6	Ayikuppam	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**52**	**52**	18	100 to 220	Good
					II	**70**	**125**	**55**	-15	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**161**	**205**	**44**	-32	460 to 1150	Good
					IV	**230**	**300**	**70**	-30	700 t0 1730	Good
7	Idankondambattu	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**52**	**52**	17	100 to 220	Good
					II	**70**	**125**	**55**	-15	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**161**	**205**	**44**	-30	460 to 1150	Good
					IV	**230**	**300**	**70**	-28	700 t0 1730	Good

S.No	Village Name	Taluk	Age		Aquifer Units	aquifer top	Aquifer bottom	Thickness (m)	Piezometric Head	Yield range (m3/day)	Quality
8	Kambalimedu	Cuddalore	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**85**	**85**	2	100 to 220	Moderate
					II	**105**	**130**	**25**	-5	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**140**	**200**	**60**	-20	460 to 1150	Good
					IV	**230**	**300**	**70**	-13	700 t0 1730	Good
9	Kanjamandanpettai	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	0	65	**65**	26	100 to 220	Good
					II	80	120	**40**	10	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	130	170	**40**	-25	460 to 1150	Good
					IV	230	300	**70**	-26	700 t0 1730	Good
10	Kayalpattu	Cuddalore	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**85**	**85**	2.5	100 to 220	Moderate
					II	**105**	**130**	**25**	-5	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**140**	**200**	**60**	-15	460 to 1150	Good
					IV	**230**	**300**	**70**	-10	700 t0 1730	Good
11	Kesavanarayanapuram	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**40**	**40**	19	100 to 220	Moderate
					II	**40**	**90**	**50**	-15	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**140**	**185**	**45**	-25	460 to 1150	Good
					IV	**220**	**300**	**80**	-28	700 t0 1730	Good
12	Peddunayakkankuppam	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**40**	**40**	30	100 to 220	Good
					II	**40**	**90**	**50**	-10	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**140**	**185**	**45**	-25	460 to 1150	Good
					IV	**220**	**300**	**80**	-28	700 t0 1730	Good
13	Puvanikuppam	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**85**	**85**	3	100 to 220	Moderate
					II	**105**	**120**	**15**	-10	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**135**	**190**	**55**	-30	460 to 1150	Good
					IV	**220**	**300**	**80**	-20	700 t0 1730	Good
14	Ranganathapuram	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**65**	**65**	15	100 to 220	Good
					II	**100**	**170**	**70**	-15	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**195**	**220**	**25**	-25	460 to 1150	Good
					IV	**270**	**300**	**30**	-25	700 t0 1730	Good
15	Tambipettai	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**40**	**40**	30	100 to 220	Good
					II	**40**	**90**	**50**	-15	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**140**	**185**	**45**	-25	460 to 1150	Good
					IV	**220**	**300**	**80**	-25	700 t0 1730	Good

S.No	Village Name	Taluk	Age		Aquifer Units	aquifer top	Aquifer bottom	Thickness (m)	Piezometric Head	Yield range (m3/day)	Quality
16	Tanur	Kurunjipadi	Cuddalore	Mio	**I**	**0**	**90**	**90**	3	50 to130	Moderate
			sandstone	Pliocene	**II**	**110**	**140**	**30**	-10	170 to 600	Good
			Neyveli	Eocene	**III**	**145**	**190**	**45**	-20	460 to 1150	Good
			sandstone		**IV**	**230**	**300**	**70**	-15	700 t0 1730	Good
17	Tayilgunampattinam	Kurunjipadi	Cuddalore	Mio	**I**	**0**	**40**	**40**	30	100 to 220	Good
			sandstone	Pliocene	**II**	**40**	**90**	**50**	-12	170 to 600	Good
			Neyveli	Eocene	**III**	**140**	**185**	**45**	-25	460 to 1150	Good
			sandstone		**IV**	**220**	**300**	**80**	-27	700 t0 1730	Good
18	Thambipalayam	Kurunjipadi	Cuddalore	Mio	**I**	**0**	**45**	**45**	30	100 to 220	Good
			sandstone	Pliocene	**II**	**100**	**130**	**30**	-12	170 to 600	Good
			Neyveli	Eocene	**III**	**140**	**230**	**90**	-25	460 to 1150	Good
			sandstone		**IV**	**260**	**300**	**40**	-27	700 t0 1730	Good
19	Tiruchchepuram	Cuddalore	Cuddalore	Mio	**I**	**0**	**60**	**60**	1	100 to 220	Good
			sandstone	Pliocene	**II**	**80**	**130**	**50**	-5	170 to 600	Good
			Neyveli	Eocene	**III**	**150**	**190**	**40**	-15	460 to 1150	Good
			sandstone		**IV**	**205**	**300**	**95**	-10	700 t0 1730	Good
20	Toppukollai	Kurunjipadi	Cuddalore	Mio	**I**	**0**	**52**	**52**	23	100 to 220	Good
			sandstone	Pliocene	**II**	**70**	**125**	**55**	-9	170 to 600	Good
			Neyveli	Eocene	**III**	**161**	**205**	**44**	-30	460 to 1150	Good
			sandstone		**IV**	**230**	**300**	**70**	-30	700 t0 1730	Good
21	Annadanapettai	Kurunjipadi	Cuddalore	Mio	**I**	**0**	**30**	**30**	30	100 to 220	Good
			sandstone	Pliocene	**II**	**55**	**90**	**35**	-12	170 to 600	Good
			Neyveli	Eocene	**III**	**110**	**190**	**80**	-25	460 to 1150	Good
			sandstone		**IV**	**205**	**300**	**95**	-30	700 t0 1730	Good
22	Kilur	Kurunjipadi	Cuddalore	Mio	**I**	**0**	**48**	**48**	37	100 to 220	Good
			sandstone	Pliocene	**II**	**70**	**100**	**30**	-5	170 to 600	Good
			Neyveli	Eocene	**III**	**110**	**245**	**135**	-30	460 to 1150	Good
			sandstone		**IV**	**280**	**300**	**20**	-35	700 t0 1730	Good
23	Poyiganatham	Panruti	Cuddalore	Mio	**I**	**0**	**45**	**45**	34	100 to 220	Good
			sandstone	Pliocene	**II**	**100**	**130**	**30**	-12	170 to 600	Good
			Neyveli	Eocene	**III**	**140**	**240**	**100**	-23	460 to 1150	Good
			sandstone		**IV**	**280**	**300**	**20**	-30	700 t0 1730	Good

S.No	Village Name	Taluk	Age		Aquifer Units	aquifer top	Aquifer bottom	Thickness (m)	Piezometric Head	Yield range (m3/day)	Quality
24	Tenkuthu	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**35**	**35**	37	100 to 220	Good
					II	**40**	**80**	**40**	12	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**90**	**170**	**80**	-35	460 to 1150	Good
					IV	**190**	**300**	**110**	-45	700 t0 1730	Good
25	Vanadirayapuram	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**35**	**35**	48	100 to 220	Good
					II	**40**	**80**	**40**	13	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**90**	**170**	**80**	-35	460 to 1150	Good
					IV	**190**	**300**	**110**	-45	700 t0 1730	Good
26	Vengadampettai	Kurunjipadi	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**45**	**45**	34	100 to 220	Good
					II	**50**	**140**	**90**	-15	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**145**	**200**	**55**	-25	460 to 1150	Good
					IV	**245**	**300**	**55**	-35	700 t0 1730	Good
27	Andarmullippallam A/	Cuddalore	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**95**	**95**	1	100 to 220	Moderate
					II	**105**	**135**	**30**	-6	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**150**	**195**	**45**	-20	460 to 1150	Good
					IV	**210**	**300**	**90**	-10	700 t0 1730	Good
28	Abatharanapuram	Chidambaram	Cuddalore sandstone	Mio Pliocene	**I**	0	65	**65**	31	100 to 220	Good
					II	80	120	**40**	10	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	130	170	**40**	-35	460 to 1150	Good
					IV	230	300	**70**	-40	700 t0 1730	Good
29	Kanchamanathapuram	Chidambaram	Cuddalore sandstone	Mio Pliocene	**I**	0	65	**65**	36	100 to 220	Good
					II	80	120	**40**	5	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	130	170	**40**	-35	460 to 1150	Good
					IV	230	300	**70**	-40	700 t0 1730	Good
30	KURINJIPADI	Chidambaram	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**65**	**65**	9	100 to 220	Moderate
					II	**100**	**170**	**70**	-5	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**195**	**220**	**25**	-25	460 to 1150	Good
					IV	**270**	**300**	**30**	-25	700 t0 1730	Good
31	NEYVELI	Virudhachalam	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**35**	**35**	40	100 to 220	Good
					II	**40**	**80**	**40**	13	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**90**	**170**	**80**	-35	460 to 1150	Good
					IV	**190**	**300**	**110**	-45	700 t0 1730	Good

S.No	Village Name	Taluk	Age		Aquifer Units	aquifer top	Aquifer bottom	Thickness (m)	Piezometric Head	Yield range (m3/day)	Quality
32	Vadakkumelur	Chidambaram	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**30**	**30**	51	100 to 220	Good
					II	**50**	**85**	**35**	13	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**100**	**160**	**60**	-35	460 to 1150	Good
					IV	**185**	**300**	**115**	-45	700 t0 1730	Good
33	Vadakuthu A/b	Chidambaram	Cuddalore sandstone	Mio Pliocene	**I**	**0**	**30**	**30**	52	100 to 220	Good
					II	**50**	**85**	**35**	12	170 to 600	Good
			Neyveli sandstone	Eocene	**III**	**100**	**160**	**60**	-25	460 to 1150	Good
					IV	**185**	**300**	**115**	-40	700 t0 1730	Good

Annexure-XI

Aquifer Parameters determined in the wells located in the Cuddalore aquifer system

Sl.no	Location	Aquifer unit	Specific Capactiy (lpm/m dd)	Transmissivity (m^2/day)	Storage Coefficient
1	Kadampuliyur	Aquifer-II	360	4047.2	2.975×10^{-5}
2	Alapakkam	Aquifer –I	407	143.7	-
3	Chettitteruvu	Aquifer –I	310	837	-
4	Adimankuppam	Aquifer –II	645	-	-
5	Raghavakuppam	Aquifer –II	551	3462	-
6	Vadakuttu	Aquifer –II	548	1800	-
7	Budmur	Aquifer –II	425	1784.3	-
8	Chavdi	Aquifer –IV	388.8	7860	9.58×10^{-5}
9	Valaiyamadevi	Aquifer –III	511	8491	7.72×10^{-5}
10	Shatiatope	Aquifer-III	623	3477.3	-
11	Palayamkottai	Aquifer-II	159	1937.3	-
12	Ayyampettai	Aquifer –III	269	858	-
13	Serikuppam	Aquifer-III	236	-	-
14	Naduveerapattu	Aquifer-III	528	7675	-
15	Mettukuppam	Aquifer-II	202	1193	-
16	Porto novo	Aquifer-I	58	295	-
17	Pudukuraiyapet	Aquifer-II	217	544	1.77×10^{-3}
18	Naduveerapattu	Aquifer-II	122	377	-

Contributors Page

Principal Contributors & Report writing
(Aquifer mapping, Numerical Modelling and Aquifer Management Plan)

Dr.D. Gnanasundar
Scientist -C (Sr.Hydrogeolgist) & Nodal Officer

Sh.N. Rameshkumar
Asst. Hydrogeologist

Dr.M. Senthilkumar
Scientist –C (Jr. Hydrogeologist)

Central Ground Water Board
South Eastern Coastal Region, Chennai
December 2015