केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

GUNDAR AQUIFER SYSTEM, Tamil Nadu

दक्षिण पूर्वी तटीय क्षेत्र, चेन्नई

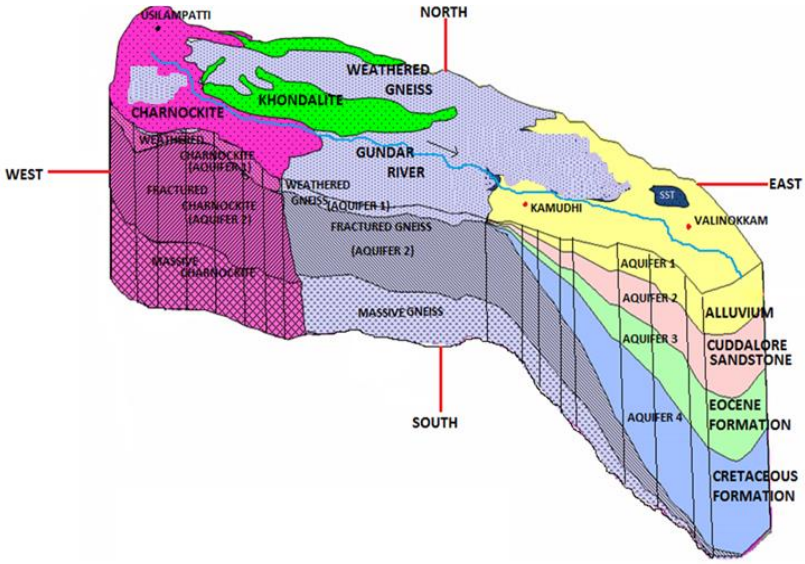
South Eastern Coastal Region, Chennai

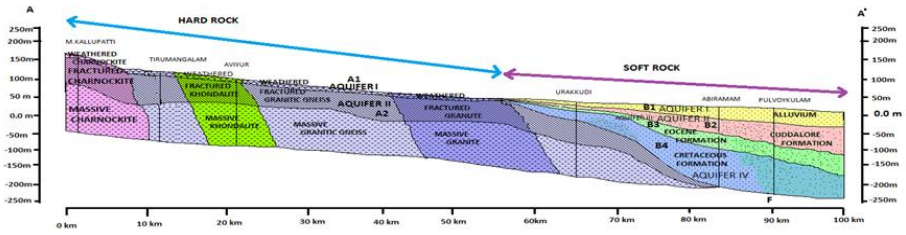
सरकारीउपयोगकेलिए

गुंडार एक्वीफर सिस्टम, तमिल नाडुपर जलभृत मानचित्रण और जलभृत प्रबंधन योजना REPORT

ON

AQUIFER MAPPING AND AQUIFER MANAGEMENTPLAN FOR THE GUNDAR AQUIFER SYSTEM,TAMIL NADU





भारत सरकार
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चेन्नई

GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES
RIVER DEVELOPMENT AND GANGA REJUVENATION
CENTRAL GROUND WATER BOARD
SOUTH EASTERN COASTAL REGION
CHENNAI

Foreword

Groundwater is the major source of freshwater that caters the demand of ever growing domestic, agricultural and industrial sectors of the country. This renewable resource has been indiscriminately exploited in some parts of the country by several users as it is easily available and reliable. Intensive and unregulated groundwater pumping in many areas has caused rapid and widespread groundwater decline. Out of 6607 groundwater assessment units (Blocks/ mandals / taluks/ firkas etc.), 1071 units are over-exploited (groundwater withdrawal is more than recharge) and 914 units are critical (groundwater withdrawal is 90 % of recharge.

Central Ground Water Board (CGWB) has taken up the largest Aquifer mapping endeavor in the world, targeting total mapable area of country ~ 23.25 lakh sq. km with a vertical extent of 300 m in soft rock area and 200 m in hard rock area. The extent of aquifer, their potential, resource availability, chemical quality, its sustainable management options will be addressed by National Aquifer Mapping (NAQUIM). The NAQUIM program will also facilitate participatory management of groundwater to provide longterm sustenance for the benefit of farmers. Currently, focus is on groundwater stressed areas of eight states comprising 5.25 lakh sq.km *viz*., Tamil Nadu, Haryana, Punjab, Rajasthan, Gujarat, Andhra Pradesh, Telangana, Karnataka and

South Eastern Coastal Region, Central Ground Water Board, Chennai, under NAQUIM has been envisaged with the Mapping of an area of 70,102 sq.km during 2012-17 (erstwhile XII five year plan) in Tamil Nadu and UT of Puducherry. This report deals with the Aquifer mapping studies carried out in Gundar aquifer system covering an area of 3008 sq.km with 2094 sq. km as mapable area. The basin comprises of parts of districts of Madurai, Virudhunagar,Ramanathapuram and Sivagangai districts. This aquifer system covers 33firkas of which 4 are Over Exploited and 1 Critical and, 28 are Semi criticaland Safe. The region is mainly dependent on groundwater (90%) for its drinking water needs. The major issues in the basin include declining groundwater levels, sustainability of wells, low yielding aquifers, threat of seawater intrusion. Aquifer units have been deciphered firka wise and regions of high yielding zone and low yielding have been demarcated for both soft and hard rock formations in the Gundar aquifer system. In hard rock regions two aquifer units *viz.*, Aquifer Unit -I (weathered) and Aquifer Unit –II (fractured/jointed zone) are identified. In soft rock formations three aquifer units *viz.*, Aquifer Unit-I (alluvium, sandstone), Aquifer Unit-II (The Tertiaries) and Aquifer Unit III (Cretaceous)are identified. In order to arrest the declining groundwater levels and increase the sustainability of wells, groundwater management plans in supply and demand sides have been formulated firka wise.

I hope this report will be useful for the district administrators, water managers, stakeholders including farmers in knowing the aquifer and managing the resources effectively in the Gundar aquifer system.

(Dr A Asokan)

Regional Director

EXECUTIVE SUMMARY

Detailed hydrogeological studies were conducted in the study of Gundar Aquifer system region wherein huge existing data pertinent to geology, geophysics, hydrology and hydrochemistry were collected, integrated and analysed to bring out this report. This report mainly comprises the lateral and vertical extent of the aquifers with their geometry, aquifer properties of the study area which are considered to be measuring scales for groundwater availability and potentiality. Keeping these parameters in view a sustainable management plan has been suggested through which the groundwater needs can be fulfilled in a reasonable way.

The Gundar aquifer system covering an area of 3008sq. km comprises of 96 sq. km of hilly area,areawith mappable area of2092 sq. km.It falls in parts of Madurai, Virudhunagar, Ramanathapuram and Sivagangai districts**.** Area experiences semi-arid climate with 850 mm average rainfall covering 3008 km^2 area in parts of districts of Madurai, Virudhunagar, Sivagangai and Ramanathapuram districts. Ramanathapuram and Virudhunagar districtsare the water starved districts in the state tagged as aspirational districts of Tamil Nadu. The major tributaries of Gundar river are*Therkkar river, Goundanadhi, Geridhamal river, Kanalodai and Paralaiaru*. Madurai is the largest city lying in the Gundar aquifer system and other major towns lying in the Gundar aquifer system are

Gundar Aquifer system area is divided into A, B and C regions. A-Region represents area underlined by Charnockite, B region represents area underlined by gneiss rocks & C-Region represents area underlined by sedimentary rocks. Aquifer units falling in “A” regions are named as A1 & A2, “B” regions are named as B1 & B2,whereas aquifer units falling in “C” regions are named as C1 & C2.

Two main aquifer systems exist in the basin and they constitute, namely 1. Crystalline rockscharnockites and the gneisses-the weathered zone at the top followed by a discrete anisotropic fractured/fissured zone at the bottom in the northern and central part of the basin. 2. The sedimentaries: Quaternary sediments are found in the southeastern part of Gundar aquifer system all along the coast and river courses. Coastal alluviums are underlain by Cuddalore formation of Mio-Pliocene age. The thickness of the alluvial deposits is about 50 m. The marine deposits extend all along the coast of Ramanthapuram district. Aeolian sands are also found inisolated pockets in coastal areas. Upper Gondwana and Lower Cretaceous formation of Mio-Pliocene age occur in the central and southeastern part. Shale, Sandstone and Conglomerates are the main rocks of Sivaganga formation.

The predominant water levels are in the range of 2 to 26 m bgl during pre-monsoon season and 0 to 10 mbgl during post-monsoon season of 2017. The net annual groundwater availability is 523 MCM and the gross groundwater draft is 195 MCM and the stage of groundwater development is of37% for the basin.

The major issues in the region are overexploitation and declining of groundwater level, massive crystalline formation and in-situ salinity and threat of Sea water intrusion along the coast and Groundwater Pollution– Along the Gundar River in Madurai district

In hard rock regions aquifer systems the thickness of the weathered zone extends down to a depth of 18 m with average thickness of 9 m and fractured zones between 15 and 130 m bgl. The weathered zone is disintegrated from the bed rock and partially/semi weathered in the lower

part (sap rock zone) with transmissivity varying between 3 and 25 m^2/day and specific yield of 1 – 1.5%. The fractured zone is fractured gneiss or Charnockite andthe yield varies from 1 to 3.5lps and the transmissivity of this zone varies between 1 and 53 m^2/day and storativity varies from 0.002 to 0.01. In alluvial regions the first aquifer unit comprising of sand, gravel has thickness ranging from 10 to 55 m with yields ranging from 1 to 5 lps and transmissivity values ranging from 245 to 770 m^2/day. Neogene, Paleogene and upper Cretaceous formations underlie the alluvial formation and have yields ranging from 3 to 10 lps with transmissivity values ranging from 138 to 3162 m^2/day.

Based on the water level monitoring in different seasons across the basin, as well as after having better understanding of the disposition and extent of the aquifer system through exploratory drilling, pumping tests etc. the volume of unsaturated zone available for recharge (upto 3m bgl) is 23 MCM. The annual uncommitted runoff is 38 MCM and 55 % of water from uncommitted runoff is required to fill the available void space of aquifer-I. Artificial recharge and Water conservation plan is prepared firka wise in the basin to harness 8 MCM of water with a total out lay of Rs. 12 Crores. The suggested artificial recharge structures are mainly Nala bunds, Check Dams and Recharge Shafts in addition to removal of silt in the surface tanks.

A total number of 37 check dams, 56Nala bunds and 78 recharge shafts are proposed in the OE and critical firkas of the basin. A total number of 234 Recharge Rejuvenation Ponds are selected for desilting followed by construction of recharge shafts within the tanks. The expected recharge through these artificial recharge structures is 8 MCM which contributes 21% of the 38MCM. The stage of groundwater development would reduce from 104 % to 79% through these techniques.A total number of 1444 recharge ponds covering an area of 722 sq km is proposed which will act as storage tanks in farm as well as augment groundwater recharge and the expected annual groundwater recharge through these ponds are in the order of 0.43MCM. The recharge pond area has been selected based on the wet and dry crop area from the landuse / landcover maps using remote sensing data.

The existing regulatory measures may be modified suitably for optimal utilization of groundwater as well as for sustainable development of rural agricultural based economy. To achieve this goal, opinion pool has to be obtained from more user groups and valid suggestions may be incorporated in the regulatory acts.

REPORT ON

AQUIFER MAPPING AND AQUIFER MANAGEMENT PLAN FOR THE GUNDAR AQUIFER SYSTEM,
TAMIL NADU

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1.0 INTRODUCTION

Comprehensive and integrated multidisciplinary approach calls for precise checks and balances of the groundwater resources translating to focused site specific management interventions. Mapping the geometric attributes of the aquifer, their potential, resource availability, chemical quality, its sustainable management options are the key activities of Aquifer Mapping. A roadmap ensuring the sustainability of the groundwater and strategies for facing future challenges are developed aided through the outcomes of NAQUIM.

This extended exercise of defining the aquifer attributes and potential of the basins of Tamil Nadu under NAQUIM has come up with promising results, sustainable management of the finite groundwater resources being the key derivative among them. Such studies were carried out in Gundar river basin to define the aquifer disposition.

Groundwater is the most dependable source of supply to meet the demands of domestic, irrigation and industrial sectors of the country. The development activities over the years have adversely affected the groundwater regime in many parts of the country. Hence, there is a need for scientific planning in development of ground water under different hydrogeological situations and to evolve effective management practices with involvement of community for better ground water governance.

Aquifer Mapping has been taken up in **GundarAquifer System** which is one of the major seventeen river basins in Tamil Nadu, in a view to formulate strategies for sustainable management plan for the aquifer system in accordance with the nature of the aquifer, the stress on the groundwater resource and prevailing groundwater quality will help in drinking water security and improved irrigation facility. It will also result in better management of the vulnerable areas.

1.1 Objective

The objectives of the aquifer mapping in Gundar aquifer system is

1. To define the aquifer geometry, type of aquifers, aquifer units within, their lateral and vertical extents,
2. To bring out the groundwater regime scenario in comparison with the present.
3. To determine the hydrogeochemical characteristics of the aquifer units
4. Two Dimenstional (2D) and Three Dimesnional (3-D) disposition of the aquifer units.
5. To estimate the availability of groundwater resources in the aquifer system
6. To develop a decisive Aquifer management plan for efficient management of groundwater resources of the Gundar aquifer system.

1.2 Scope of the Study

The important aspect of the aquifer mapping programme is the synthesis of the large volume of data already generated during specific studies carried out by Central Ground Water Board (CGWB) and various Government organizations that broadly describe the aquifer system. The available generated data are assembled, analysed, examined, synthesized and interpreted from

available sources. These sources are predominantly non-computerized data, which is to be converted into computer based GIS data sets.

Data gaps have been identified after proper synthesis and analysis of the available data collected from different state organisations like; Tamil Nadu Water Supply and Drainage Board (TWAD Board), Public Works Department (PWD), Agricultural Engineering Department (AED). In order to bridge the data gap, data generation programme has been formulated in an organised way in the basin. Exploration work has been carried out in different segments of the regions and aquifer parameters have been estimated. Groundwater monitoring regime has been strengthened by establishing additional monitoring wells.

1.3 Issues

The major concerns **(Figure 1)** that have been addressed in the Gunder Aquifer System are

1. Overexploitation and declining groundwater levels,
2. Poorly Yielding crystalline formation
3. Limestone/clays forming poor aquifer (Sedimentary terrain of the basin)
4. High EC in isolated pockets

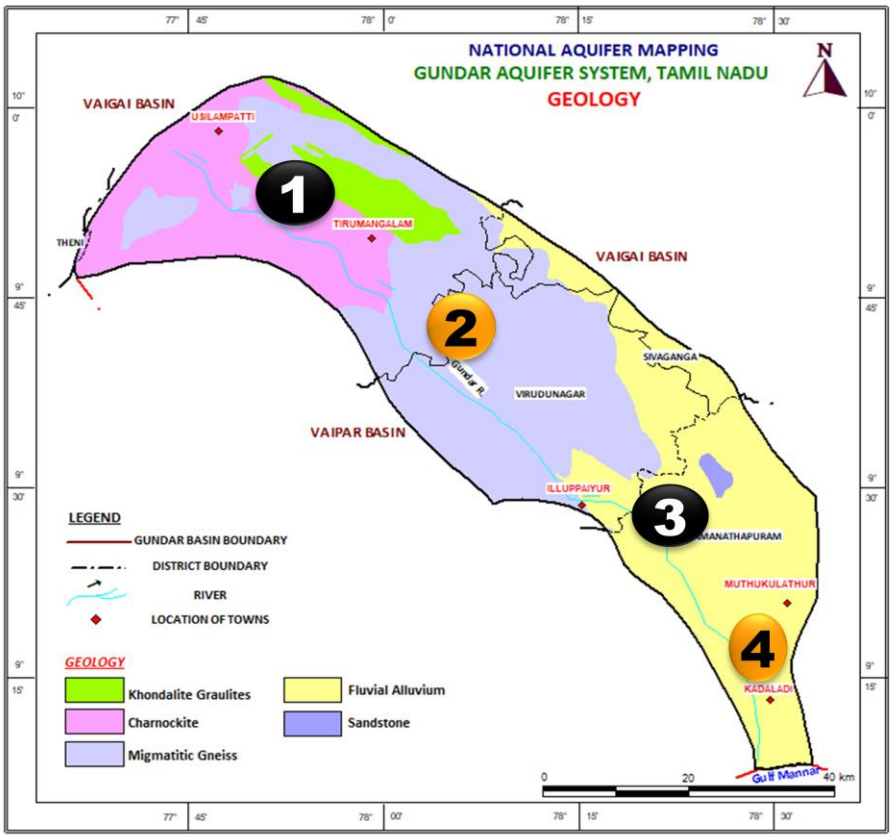


Figure1: Issues pertaining to the Gundar Aquifer system

1.4. Approach & Methodology

Integrated multi-disciplinary approach involving geological, geophysical, hydrological and hydrogeological and hydrogeochemical components were taken up in 1:50000 scale to meet

the objectives of study. Geological map of the basin has been generated based on the GSI maps, geophysical data has been generated through vertical electrical soundings and geoelectrical layers with different resistivities have been interpreted in corroboration with the litho stratigraphy of the observation wells and exploratory wells down to depths of 200 m bgl and 300 m bgl for hard rocks & soft rocks respectively. Hydrological and Hydrometerological data have been collected from state PWD and IMD departments. Drainage, soil and geomorphology of the basin were prepared based on the IRS –IC data, obtained from Institute of Remote Sensing, Anna University, Chennai.

Based on the data gap analysis data generation process has been scheduled through establishing key observation wells, pinpointing exploratory sites for drilling through in-house and outsourcing, collecting water samples in order to study groundwater regime, geometry of the aquifer and aquifer parameters, and quality of the groundwater respectively. Groundwater recharge and draft have been computed through different methods and resources of the basin estimated through groundwater balance method.

Based on the above studies, management strategies both on the supply side through augmentation of groundwater through artificial recharge and water conservation and on demand side through change in irrigation pattern have been formulated for sustainable management of the groundwater resource.

1.5. Study area

The Gundar aquifer system covering an area of 3008sq. km comprises of 96 sq. km of hilly area, with mappable area of2912 sq. km.It falls in parts of Madurai, Virudhunagar,Ramanathapuram and Sivagangaidistricts**.** Ramanathapuram and Virudhunagar districtsare the water starved districts and the aspirational districts in the state. The major tributaries of Gundar river are*Therkkar river, Goundanadhi, Giridhamal river, Kanalodai and Paralaiaru.*

Madurai is the largest city lying in the Gundar aquifer system and other major towns lying in the Gundar aquifer system are Theni, Andippatty, Chozhavandhan, Edaikkaattur, Mana Madurai, Paramakkudi, and Ramanathapuram.

This aquifer system covers 33firkas of which 4 are Over Exploited 1 Critical and, 27 are Safe and Semi critical and 1 saline firka. Over Exploited firkas are Sedapatti, Sindhupatti, Kokulam in Madurai district and Mallankinarin Virudhunagar district. Critical firkais Thirumangalam at Madurai district. The administrative map of the Gundar aquifer system is presented as **Figure 2.**

Table 1: Districts and Firkas of the Gundaraquifer system

Sl No.	District	Area Sq Km	No. of Firkas	No. of OE and Critical firkas
1	MADURAI	965	13	4
2	VIRUDHUNAGAR	893	9	1
3	RAMANATHAPURAM	944	9	0
4	VIRUDHUJAGAR	206	2	0
	Total	3008	33	5

1.6. Data availability

During the aquifer mapping period, existingdata of CGWB i.e. exploration, depth to water level, water quality, geophysical logging and groundwater resource data have been collected and compiled. In addition to this, borewell data, water quality & water level data have been collected from Tamil Nadu Water Supply and Drainage Board. Cropping pattern and soil data have been collected from Agricultural Department. Groundwater level and groundwater exploration data have been collected from Public Works Department. Thematic layers such as geology (GSI), soils, land use&landcover,geomorphology, etc., from various State Government agencies has been collected, compiled and used in this study.

1.7. Data adequacy

Exploratory well data is available for 156 wells drilled by CGWB (40 Nos.) and State Departments (116 Nos.). Water level (99 Nos.) and water quality monitoring data (77 Nos.) data are available for a long period i.e., more than ten years. Seventy two vertical electrical sounding (VES) data are available. Cropping pattern and soil data have been collected from Agricultural and Statistics Department. After plotting the available historical data on 1:50,000 scale maps, data gaps were identified and data generation process was taken up in those gap areas to generate the Aquifer map on the desired resolution of 1:50,000 toposheets.

1.8. Data Gap Analysis & Data Generation

Dug wells 48 Nos. have been established to monitor the first phreatic aquifer and 12 bore wells drilled down to a depth of 200 m bgl to know the aquifer characters of semi-confined aquifer system. It is also proposed to carryout quality monitoring through 48 Nos. of established dug wells for the first phreatic aquifer and through 12 Nos. of irrigation/domestic bore wells for the second semi-confined aquifer in order to assess the groundwater quality for drinking and irrigation purposes.

1.9 Climate and Rainfall

The Gundar aquifer system has a monsoon climate as it lies within the tropical monsoon zone. Based on the hydrometeorological feature of the basin, year is divided into 2 periods, Monsoon period spanning from June to December and Non-monsoon period spanning from January to May. The monsoon period is further sub-divided into 1) South West monsoon period spanning from June to September (4 months) and 2) Northeast monsoon period spanning from October to December (3 months). Similarly, the non-monsoon period is further sub-divided into (1) Winter period spanning January and February (2 months) and (2) Summer period spanning from March to May (3 months). As the monsoon period brings heavy rainfall it improves the recharging of groundwater and storage of surface water. Hence, the monsoon period is hydrologically significant for water resources analysis.Average annual rainfall for the Gundar aquifer system is 928mm.

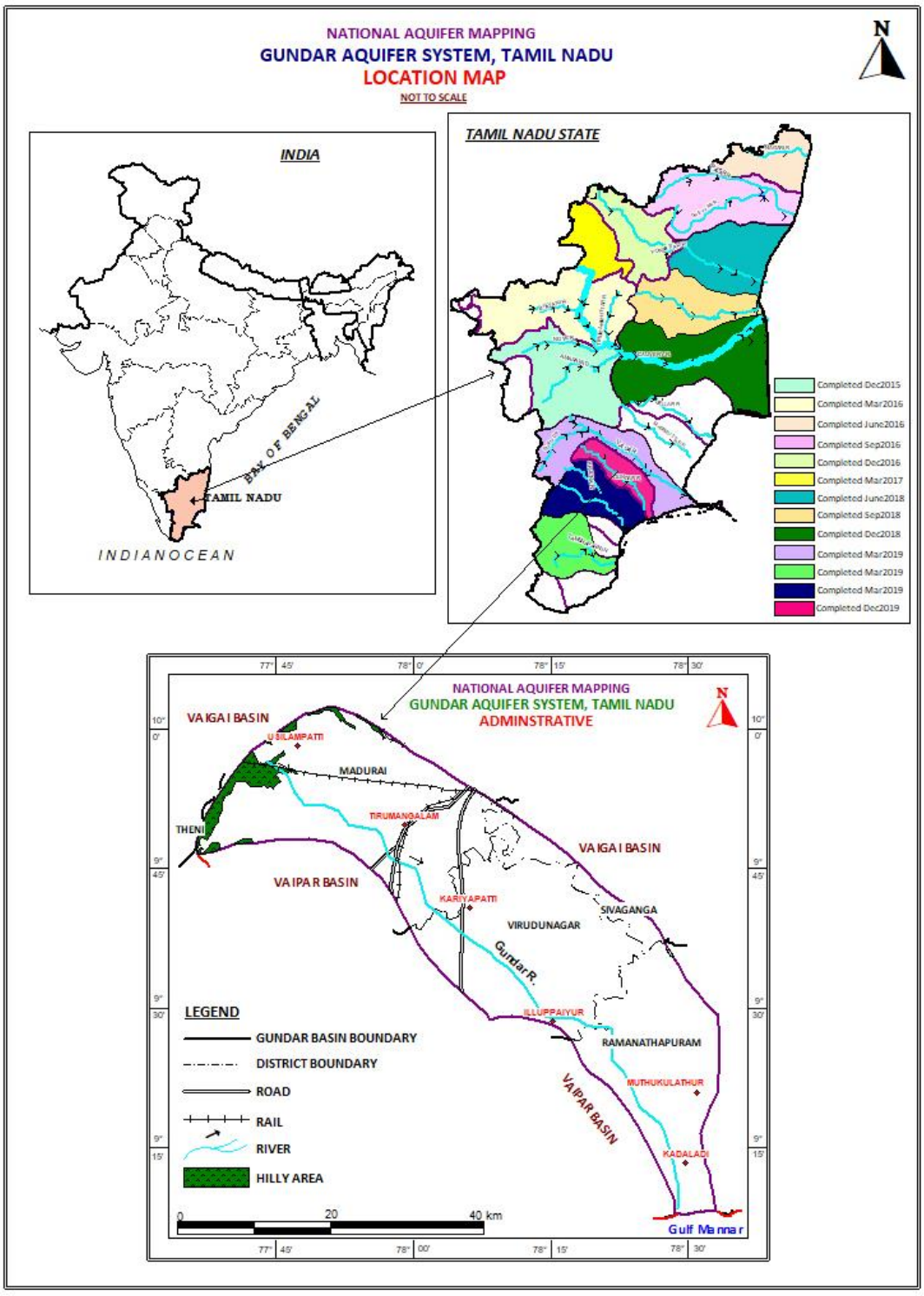


Figure 2:Administrative setup of the Gundar Aquifer system

1.10 Physiography and Drainage

The Gundar aquifer system region comprises of the major river*Gundar* and its tributaries *Therkkar river, Goundanadhi, Geridhamal river, Kanalodai and Paralaiaru.* (**Figure.3**).The

basinis sickle shaped and can be broadly divided into three units, namely (i) Western mountainous terrain with valley complexes, (ii) Central elevated terrain and (iii) Eastern coastal plains. *GundarRiver* is ephemeral and it drains into Bay of Bengal Sea.Gundar the non perennial river originates at an altitude of 1273m near Kottamalai of Satpura reserve forest in the Varushanadu hills. After traversing about 150 km, it falls into the Gulf of Mannar at about 6 km south east of Sayalkudi. The GridhimalRiver draining the plateau south east of Madurai joins Raghunatha Cauvery near Kamudhi. Goundanadhi and Therkkar start in Madurai district and flow in the southeast direction to enter Aruppukkotai taluk of Virudhunagr district and join near Pudupatti village. After confluence of Goundanadhi with Therkkar, the river derives the name Gundar.

Season wise 75 % dependable surface water potential for Gundar River Basin is given in the **Table 2** below

Table 2: Dependable Surface Water Potential for the Gundar Basin

Sl No.	Name of the sub basin	75 % dependable surface water potential in Mcum			
		SW	NE	NM	Annual
1	Upper Gundar	11.84	94.40	38.86	145.10
2	Therkkar	27.40	99.56	47.50	174.46
3	GridhamalNadhi	28.25	48.63	12.36	89.24
	KanalKodai	13.56	24.07	11.00	48.64
4	Palaiaru	30.86	28.45	17.24	76.55
5	Uthirakosamngaiaru	11.47	54.23	33.40	99.10
6	Lower Gundar	16.11	61.47	25.78	103.36
7	Vembar	4.32	52.50	4.51	61.33
8	Palar	2.34	29.35	7.02	38.71
	Total	**146.15**	**492.66**	**197.67**	**836.49**
South West Monsoon Potential		146 MCum			
Nort East Monsoon Potential		493 Mcum			
Non Monsoon Potential		198 Mcum			
Annual Potential		837 Mcum			

The Existing Surface Water Supply Systems

In the Gundar Basin, the surface water is drawn for usage from tanks. The tanks are classified as System tanks and Non System tanks. The non system tanks use surface water of the direct runoff from their own catchment, whereas the system tanks are filled from the canal flow diverted through the anicuts across the river apart from the direct runoff from their own catchment.

Anicuts

Totally there are 42 anicuts constructed across various tributaries of Gundar river which divert the water to irrigate an area of 14388 ha through the tanks in the basin. Five anicuts of Goundanadhi tributary are having direct ayacut only. About 32 anicuts out of 42 are located in the two upper tributaries- Therkkar and Goundanadhi.

Tanks

There are number of system and non-system rain fed tanks lying in the area. There are 2276 tanks with a registered ayacut of 72000 ha serving mostly a single crop of paddy. A large number of tanks are concentrated in the middle and the lower reaches of basin. On an average there exists a tank for every 2.5 sq km. The topography of the basin is almost flat having a gentle slope towards the east. Around 92 percent of the tanks are in chains with hydrologic linkages. These water bodies are very specifically useful in meeting the irrigation need.The nominal topography is generally sloping towards North, Northeast in the western part and Southeast in the central and eastern part. The Hydraulic gradient and the flow lines of ground and surface water are towards Southeast, the sea.

1.11. Geomorphology

The geomorphology of an area is the external appearance of landforms, which gives a reliable picture of the underground strata and its physio-chemical condition. The different formations and the layer confirm and cogent to its geomorphology. Geomorphologically, the area has been delineated into 1. Hills and plateau 2. Pediment zone 3. Flood plains and coastal plains. The Hills and plateau are found in the western and north- western parts of the area comprising the Charnockite group of rocks and Migmatites, The pediments in the central part overlie theMigmaties and Charnockitic domain. The rocks of Upper Gondwanaand recent fluvial sediments form the plains.The coastal areas are flanked by beach ridge complex-sand dunes, swales, swamps and backwater. The sand flat is another feature of the coast comprising of clays and silts, often inundated by seawater and encrusted with salt.

About 42% of the region is covered by pediment and pediment zone, and is represented in **Figure 4.** These are evidenced from the dendritic pattern of drainage. Sedimentary high ground and Alluvial plain are seen in the south eastern part of the area. Flood plains consisting of sand and clay are found along the boundaries of Gundarriver in the South eastern part. **Figure 4** and **Figure 5** illustrates the level I classification of geomorphological features of the Gundar aquifer system.

1.12 Landuse and Landcover

The utilization of land for a particular purpose is governed by a host of factors including topography, type and thickness of soil, rainfall pattern etc. The distribution of area under certain major categories of land use in the basin during 2017-18is given in **Table2**

Agricultural land occupies nearly, 65 % of the Gundar aquifer system area and spread throughout the study area. Forests, water bodies, waste land and built up/urban area occupy 20 %, 8 %, 7% and 4 % of the area respectively. Landuse and land cover is represented in **Figure 6 & 6a.**

Table3LanduseClassification

Sl. No.	LanduseCategory		AreaIn Sq.Km.	% To TheBasinArea
	LevelI	LevelII		
a.	BuiltupLand	Settlement	21.16	0.73

b.	Crop LandDryLand	Paddy, Sugarcane,Groundnut, Cholam,floriculture Groves,Casuarina plantation	51 0.39 10 53	16.96 35.00
c.	ForestLand	Dense ForestDenseForestandPlantation MediumDenseForestShrubs	19 9.18	6.62
d.	WasteLand	Alkalinity/salinityBarrenland/Rockyoutcrop Block cotton soilMining areaStonywaste Beach,salt pan,Sand dunes	1050	34.9
e.	WaterBodies	Back swampsTanks	173.31	5.76
TotalGeographicalArea			**3008**	**100**

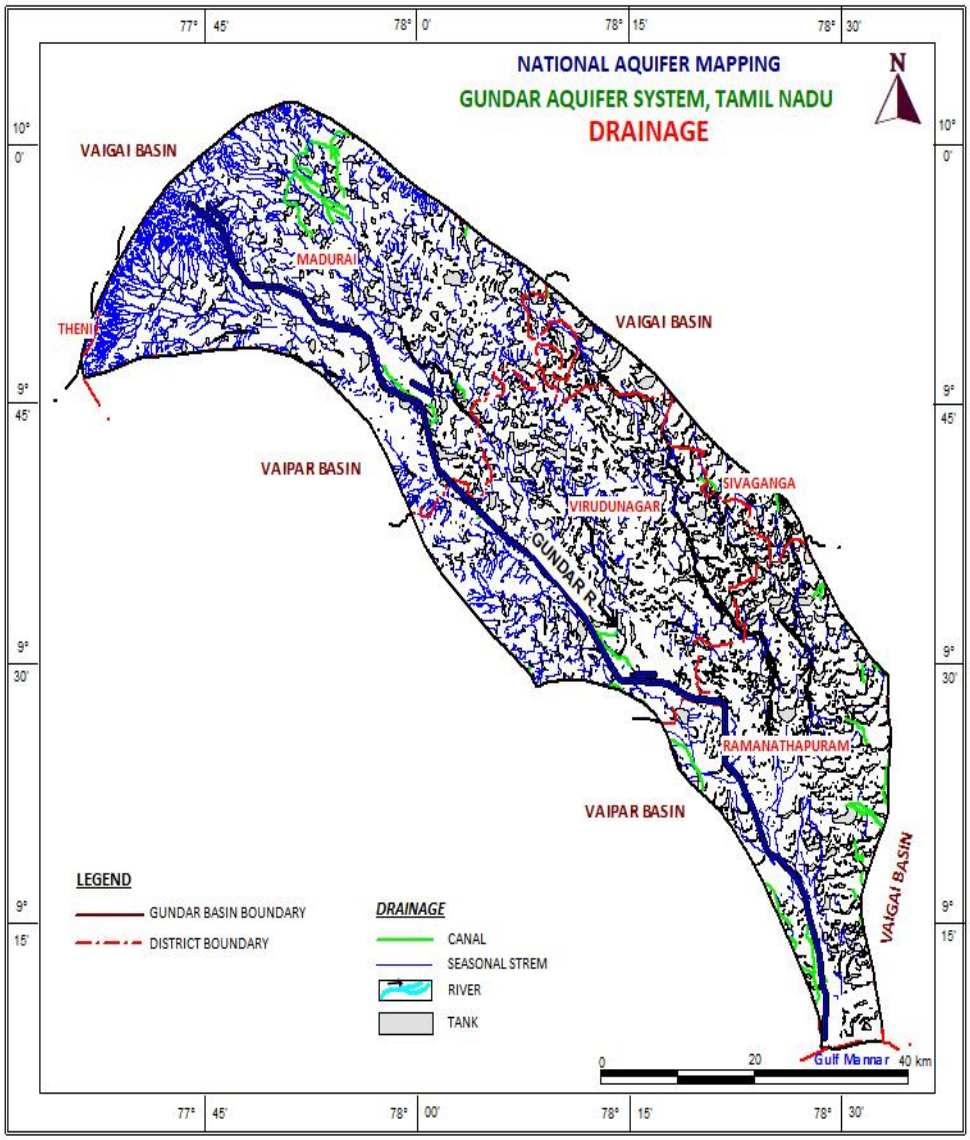


Figure 3: Drainage map of the Gundar aquifer system

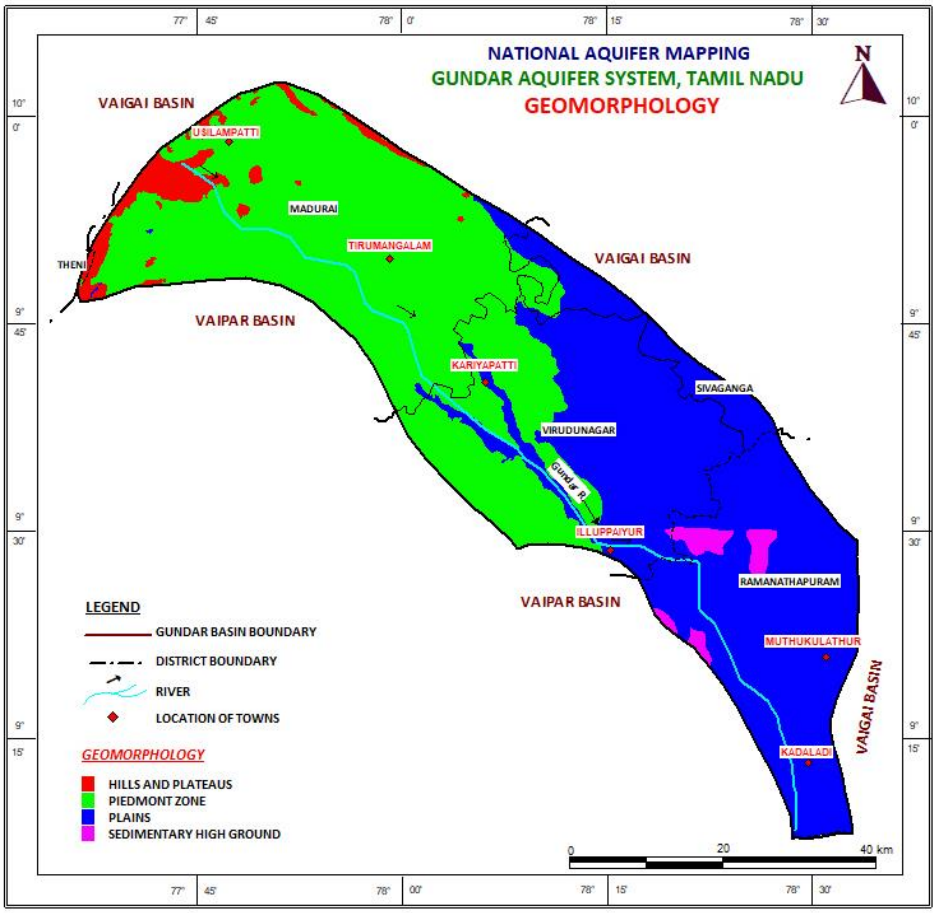


Figure 4: Geomorphology map of the Gundar aquifer system

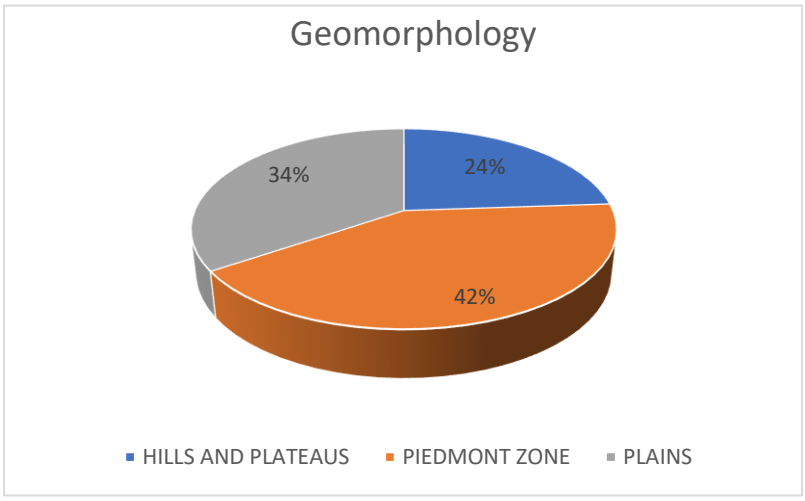


Figure 5: Level I classification of geomorphology of the Gundar aquifer system

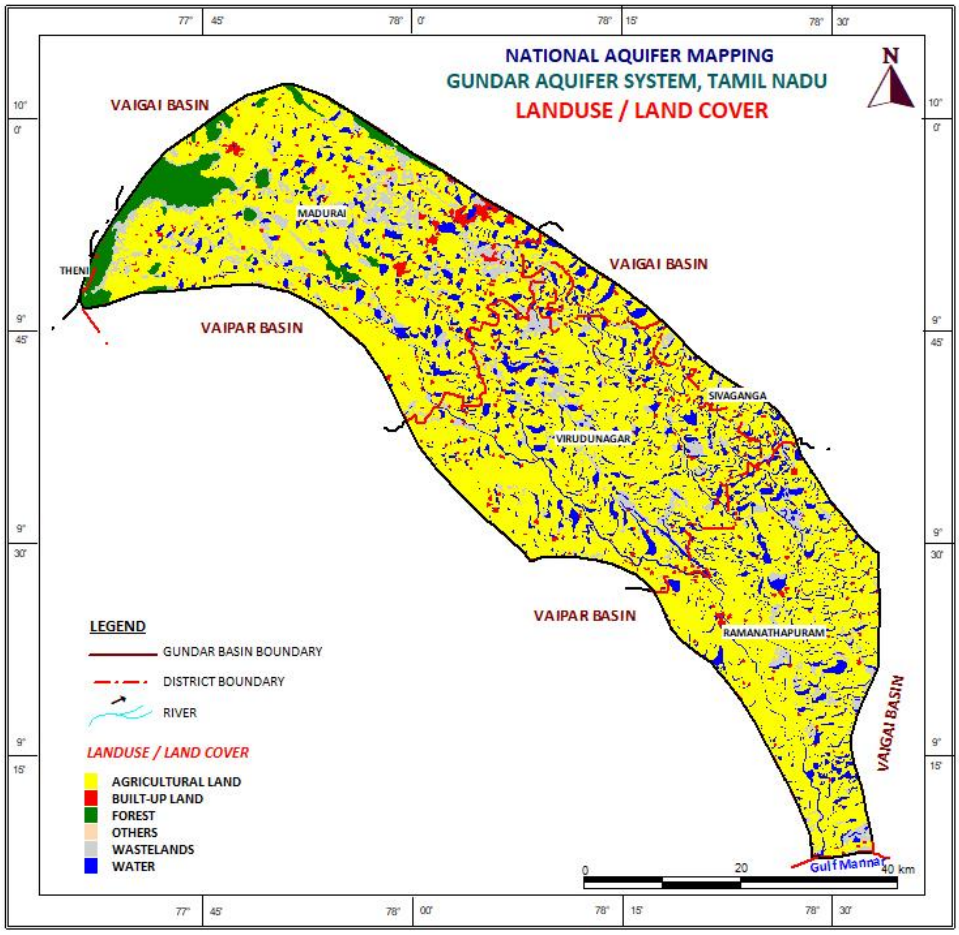


Figure 6: Level 3 Landuse /Land cover map of the Gundar aquifer system

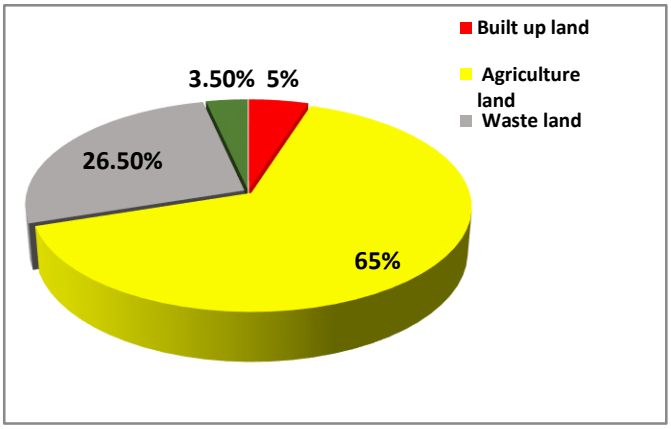


Figure 6a: Level 1 Landuse/Land analysis diagram of the Gundar aquifer system

1.13Soils

Soils play a major role in hydrologic control of the infiltrating water. Soils are generally classified by taking their color, texture, fertilities and chemical combinations

encompassingsalts, minerals and the solution effect over them. The major soil types are Entisols, Hill Soil, Inceptisol, and Vertisols (**Figure 7**)

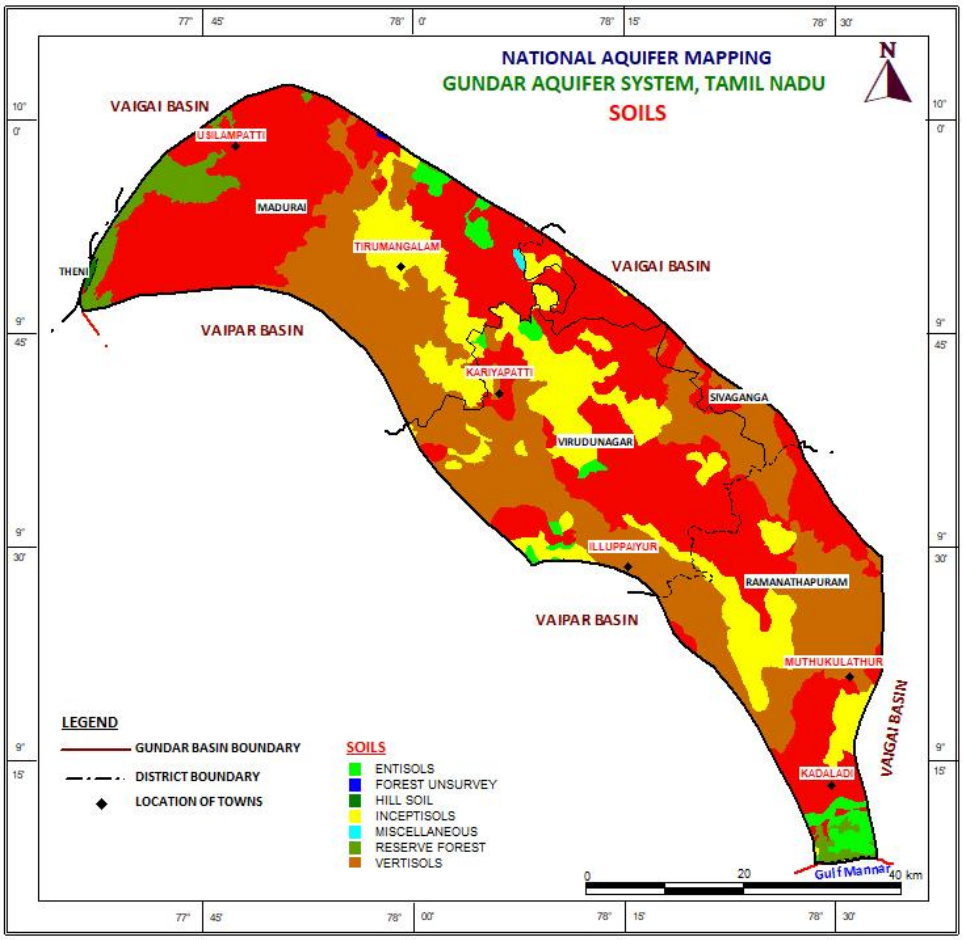


Figure 7: Soil map of Gundar aquifer system

1.14 Cropping Pattern

Agriculture is the main stay of the rural population in the entire study area. Main water intensive crops irrigated are paddy, sugarcane and banana covering about 1488 sq. km **(Figure 8**).The less water intensive crops irrigated are maize, tomato, groundnut and chilly. The other crops include cotton, ragi, etc., and other minor crops are turmeric, flowers and vegetables. The total cultivated area is about 1050 Sq. Km

Climate, type and characteristics of soils and irrigation facilities available are the major factors controlling the cropping pattern in the district. The salient details of area irrigated and cultivated under wet and dry crops are furnished in **Table 4**

Table 4: Details of area irrigated and cultivated under wet and dry crops (Gundar Basin)

District	**Firka**			**Area irrigated as % of**	
		Area irrigated	Area cultivated	Area irrigated	Area cultivated
Madurai	Sedapatti	1210.515	3693.69	3.17	32.77

Madurai	Sindupatti	897.465	1421.885	2.35	63.12
Madurai	Valanthur	1226.035	1468.215	3.21	83.51
Madurai	Kokulam	976.4	1533.475	2.55	63.67
Madurai	Thirumangalam	561.88	1631.8	1.47	34.43
Madurai	Thirupparankundram	702.375	762.835	1.84	92.07
Madurai	Valayankulam	543.67	891.68	1.42	60.97
Madurai	Viranthur	483.19	627.42	1.26	77.01
Madurai	Kuraiyur	956.335	2915.325	2.50	32.80
Madurai	Pannikundu	988.125	5050.52	2.59	19.56
Madurai	Avaniyapuram	586.585	698.875	1.53	83.93
Madurai	Elumalai	2848.305	6053.18	7.45	47.05
Madurai	Sivarakottai	642.515	2656.72	1.68	24.18
Virudhunagar	A Mukkulam	1990.185	3338.055	5.21	59.62
Virudhunagar	Kallukuruchi	128.755	1669.035	0.34	7.71
Virudhunagar	Kariapatti	1581.195	1966.63	4.14	80.40
Virudhunagar	Mallankinar	275.315	3122.455	0.72	8.82
Virudhunagar	Muddukkankulam	1228.005	2157.265	3.21	56.92
Virudhunagar	Narikudi	1810.685	3247.785	4.74	55.75
Virudhunagar	Tiruchuli	1036.68	2787.36	2.71	37.19
Virudhunagar	Veeracholam	1732.97	4449.755	4.53	38.95
Virudhunagar	Palayampatti	394.29	5088.285	1.03	7.75
Ramanathapuram	Appanur	1714.48	4180.77	4.49	41.01
Ramanathapuram	Abiramam	1648.825	4029.835	4.31	40.92
Ramanathapuram	Kadaladi	805.255	2654.36	2.11	30.34
Ramanathapuram	Kamuthi East	703.395	4321.59	1.84	16.28
Ramanathapuram	Kamudhi W	1637.08	6058.415	4.28	27.02
Ramanathapuram	Kovilankulam	404.085	2041.225	1.06	19.80
Ramanathapuram	Melakodumalur	1012.695	2397.33	2.65	42.24
Ramanathapuram	Mudukulathgur	1253.91	3540.195	3.28	35.42
Ramanathapuram	Parthpanur	3428.17	4243.38	8.97	80.79
Sivaganga	Manamadurai	1521.835	1558.735	3.98	97.63
Sivaganga	Konthagai	1291.505	1300.395	3.38	99.32
Basin Total		**38222.71**	**93558.475**	**100.00**	

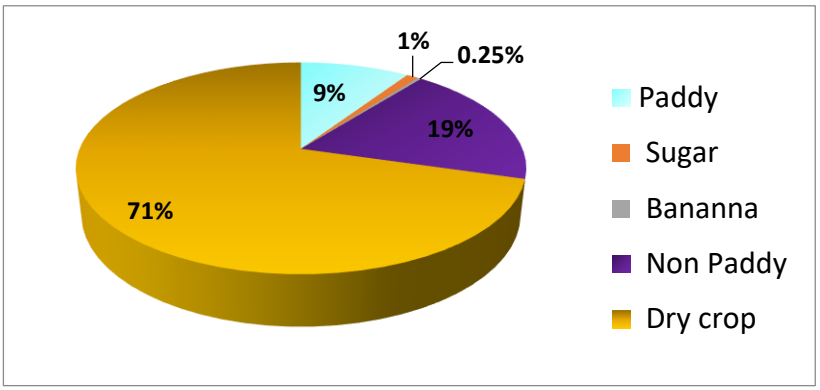


Figure 8: Crop wise distribution in the Gundar aquifer system

1.15. Irrigation

Augmentation of agricultural production is the principal purpose of irrigation in the basin. Wells, canals and tanks are the major sources of irrigation in the basin. Paddy is the main water intensive crop in the study area. About 98% of the groundwater is used for irrigation.

The data available indicate that an area of about 69536 ha of the basin is under irrigated agriculture. The details of area under various sources are furnished in the **Table 5** below

Table 5 : Net area irrigated by different sources in Gundar basin

Sl no.	Source of irrigation	Area irrigated in ha	Area irrigated as % of total area irrigated	Area irrigated as % of total geographical area	Irrigation intensity (%)
1	Canals	763.95	1.098630232	0.23019972	1.03
2	Tanks	20724.73	29.80406431	6.24494673	1.12
3	Tube wells	520.425	0.748418926	0.15681876	1.08
4	Dug wells	18419.84	26.48942089	5.55041824	1.08
5	Others	29107.645	41.85946564	8.77095587	1.03
	Basin total	**69536.59**	**100**	**20.9533393**	**1.034**

Source : Dept. of Economics & Statistics, Govt of Tamil Nadu

The data indicate that wells are the major source of water for irrigation in the basin, accounting for about 67 % of the total area irrigated in the basin. Other sources are of minor importance in comparison. The source wise irrigation intensity computed as the ratio of gross area irrigated to net area irrigated ranges from 1.12 for tanks to 1.08 percent for wells. Tha average intensity of irrigation for the basin for the year 2010-11 works out at 1.03 %.

1.16 Geology

Geologically, the Gundar aquifer system comprises of Recent sediments of marine, estuarine and fluvial alluvium, Lower Cretaceous, underlained by Precambrian rocks of Granitic gneiss, Hornblende BiotiteGniess, Khondalitesand Charnockites. The Charnockitesoccur in the western part, and MigmaticGniess occurs in the central part of the area.Alluvium underlain by sandstone and claystone are found in the southeastern part of area **(Figure 9).** Geologic succession of the Gundar aquifer System is presented in **Table 6.**

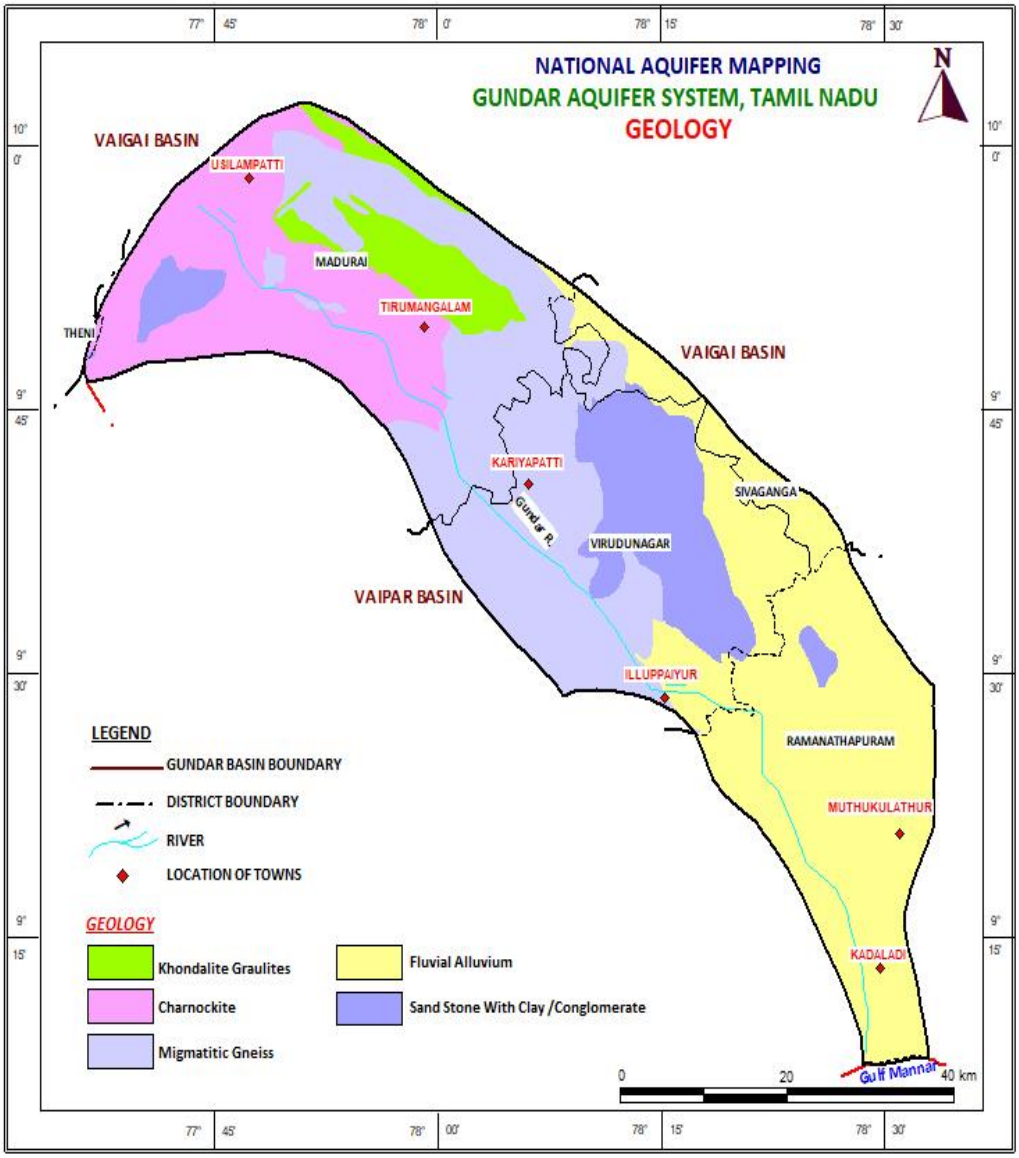


Figure9: Geological map of the GundarAquifer system

Precambrian Rocks

The Precambrian rocks belonging to Archaean age comprising Khondalite group, Charnockite group, the Migmatic complex, Hornblende biotite gneiss, Granitoid gneiss, Granite with acid intrusive are found in western, northwestern and central part of the area. Charnockite forms the basement for the Cretaceousand Quaternary sediments.

Charnockitehas a patchy distribution in the western and central part, and the rocks are scarcely weathered and poorly jointed, generally massive and unfoliated. Granitoid gneiss forms the linear band within Charnockite and the contact between them is highly sheared. The migmatite complex made up of Hornblendebiotite gneiss, pink Augen gneiss and pink Migmatite, occurring in the central part are micaceous with bands of granite, pegmatite and quartz veins. The younger intrusions of granite and basic dykes occur in the magmatic complex.Dolerite

dykes form the youngest basic intrusive traversing both Charnockite as well as the Migmatite complex.

Mesozoic& Tertiary sediments

Upper Gondwana and Lower Cretaceous formation of Mio-Pliocene age occur in the central and southeastern part. Shale, Sandstone and Conglomeratesare the main rocks of Sivagangaformation.

Quaternary

Quaternary sediments are found in the southeastern part of Gundar aquifer system all along the coast and river courses. Coastal alluviums are underlain by Cuddalore formation of Mio-Pliocene age.The Quaternary sediments are of two types, deposited under fluvial environment (river deposits) and marine environment. The fluvial sediments include clays and sands, mud, silt and medium to coarse grained sand (beach deposits). The thickness of the alluvial deposits is about 50 m. The marine deposits extend all along the coast of Ramanthapuram district. Aeolian sands are also found inisolated pockets in coastal areas.

Table 6: Geological succession of the Gundar Aquifer system

S. No	Eon	Era	Series/Epoch Age Group/Formation	Lithology	Groundwater relevance
1.	Phanerozoic	Cenozoic	Quaternary: Holocene-Pleistocene/ Fluvial sediments, Marine sediments	Soils, black clays, coastal /river alluvium (sand & silt), beach sand and laterite	Moderate to very good porous aquifer system
			Unconformity		
2.		Mesozoic	LowerCretaceous/ Gondwana Sivaganga formation	Shale, Sandstone and Conglomerates	Very low Porous aquifer
			Unconformity		
3.	Precambrian	Archaean	Late Archaean to Proterozoic	Dolerite dykes	Weathered and Fractured aquifer units
			Younger granites	Granite	
			Migmatitic complex	Hornblende biotite Gneiss, Pink augen gneiss, Pink migmatite	
			Charnockite group	Charnockites, Pyroxene-granulite, Garnetiferous gabbro	
			Khondalite group	Calc granulite, Limestone, Quartzite, Garnet Sillimanite Graphite Gniess	

2.0 DATA COLLECTION AND GENERATION

Periodical data pertaining to groundwater levels, quality, pumping tests and slug tests were collected during aquifer mapping studies apart from water sample collection to assess the groundwater quality. In addition Geophysical data has been generated through conducting Geo electrical soundings after evaluation of data gap analysis.

2.1. Hydrogeological data:

The periodical monitoring of groundwater level reflects the groundwater recharge and discharge (natural and manmade) occurring in the aquifer systems. It also reveals the interaction between surface and sub-surface water systems. In Gundar Aquifer system area, 99 groundwater monitoring wells (which included 12 CGWB monitoring wells &68 State department wells) and 19 piezometers of CGWB are monitored periodically. The locations of monitoring wells are presented as **Figure 10.**

2.2. Hydrochemical data:

The groundwater quality of the Gundar Aquifer System was studied by analysing available water quality data i.e CGWB monitoring open wells 9 numbers and State government monitoring wells 68 numbers. Long term record was available only for 52 numbers of open wells. The sample locations in the Gundar aquifer system is presented in **Figure 11**.

2.3. Geophysical data:

The geophysical survey was conducted in the study area consisting of Vertical Electrical Soundings (VES) by employing Schlumberger configuration with maximum half current electrode separation of 300m. The objective of the study is to decipher the sub surface conditions such as weathered and fractured layer resistivities, thicknesses and massive formations up to the depth of 200 m bgl. A total number of 48 VES were carried out and geo electric layers inferred through interpretation of the results obtained. The locations of the VES are presented in **Figure 12.**

2.4 Groundwater Exploration data:

Data of 156 Nos. of exploratory wells were drilled in the Gundar aquifer system (40 Nos. CGWB and 116 Nos. State department wells) prior to National Aquifer Mapping project was compiled and analysed (**Figure 13**). These wells were plotted on the 1:50,000 scale topographical map and as per the NAQUIM guidelines for the hard rock& soft rocks, data requirements were identified on the plotted topographical map. Based on the data requirements, 12 Nos. of exploratory wells have been recommended for drilling through outsourcing activity as part of the data generation. The data such as lithology, fracture depth, yield, water level, aquifer properties were generated and utilised to depict the prevailing aquifer systems of the basin (Annexure-1).Similarly wells drilled by state department, 116 Nos. wells drilled upto to the depth of 60 m bgl was used for deciphering the first aquifer.

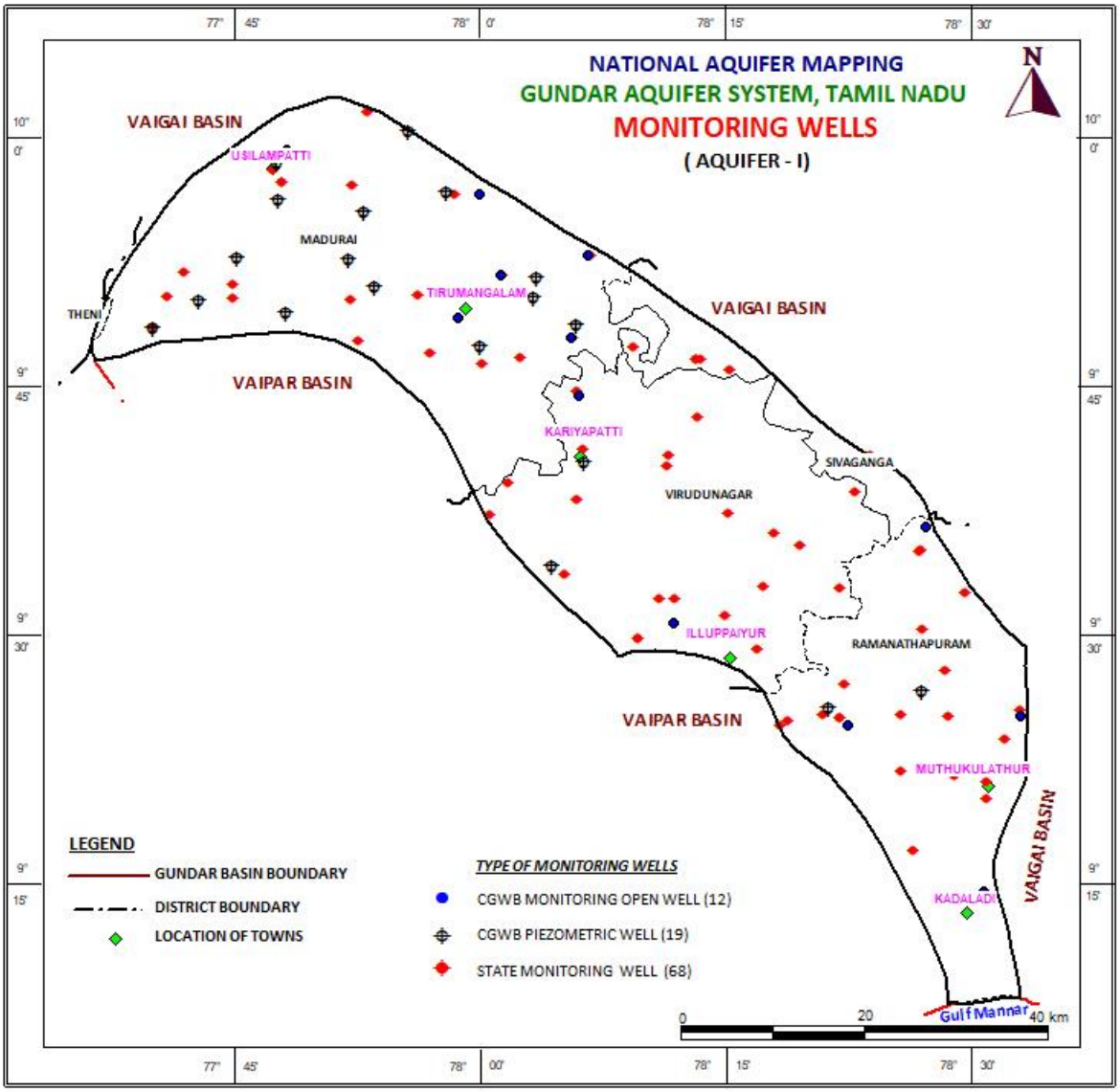


Figure 10. The locations of monitoring wells of the Gundar aquifer system.

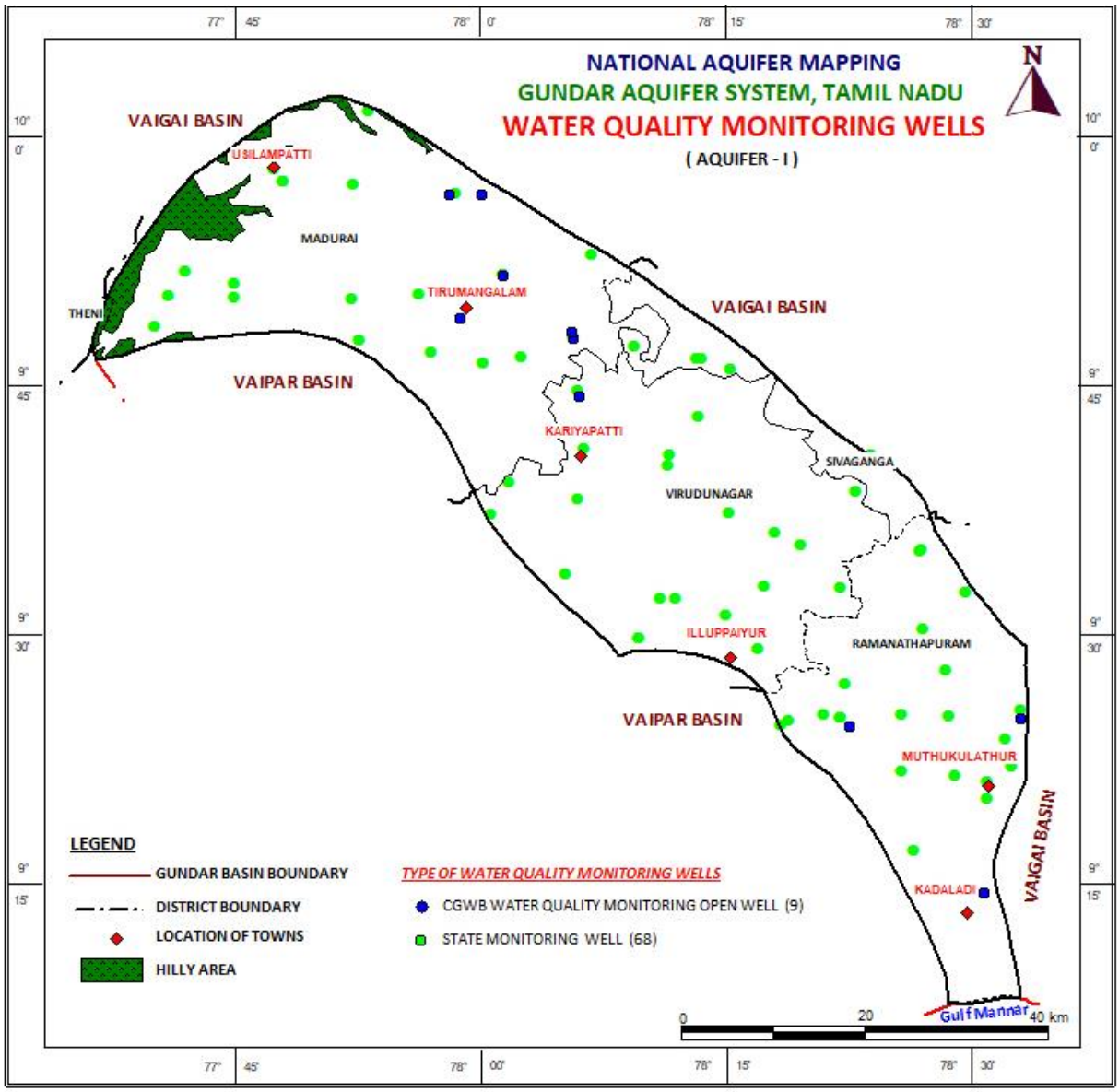


Figure 11. Locations of Groundwater quality Monitoring Wells of Gundar Aquifer System

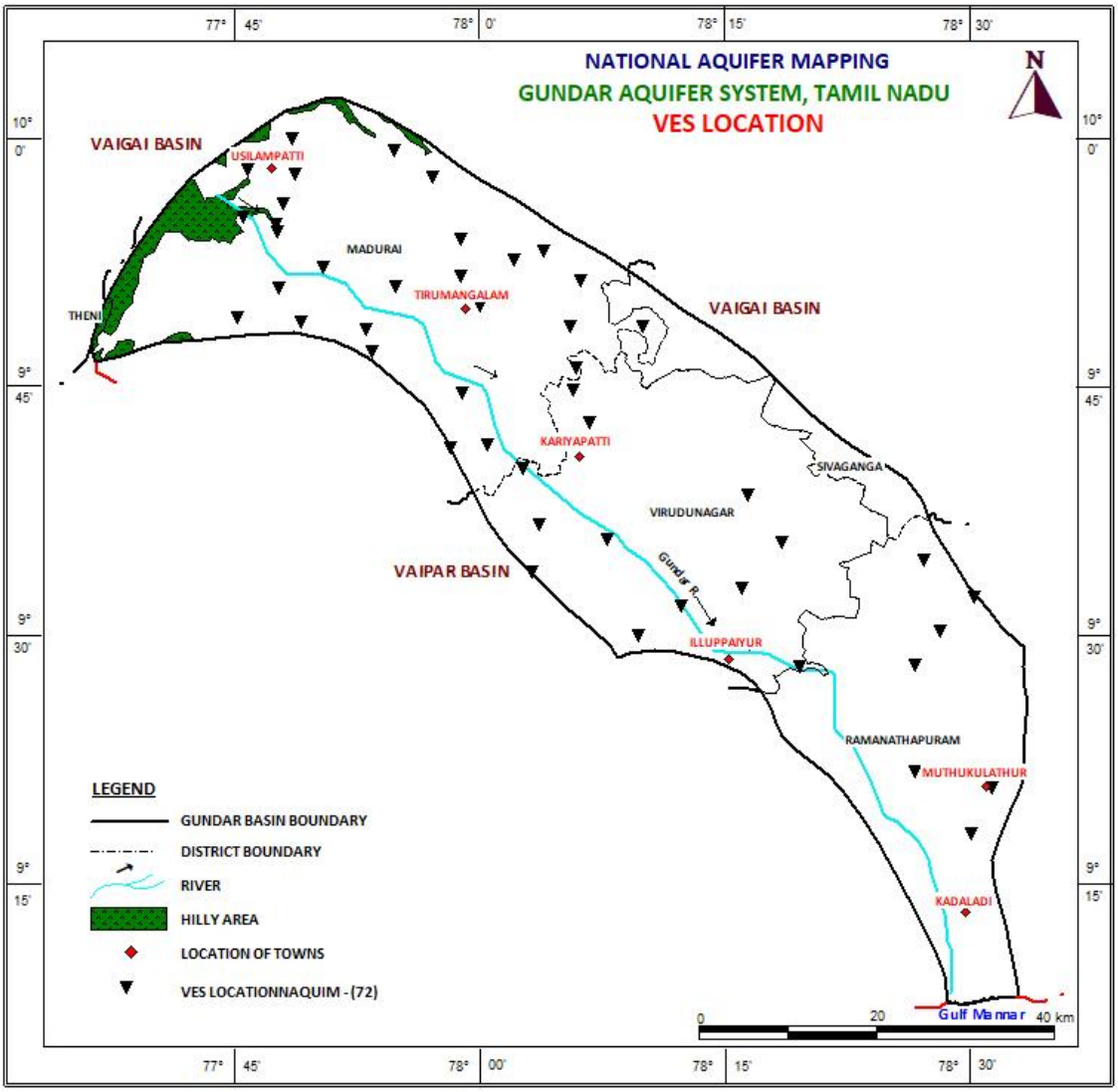


Figure 12. Locations of Vertical Electrical Soundings (VES) of Gundar Aquifer System

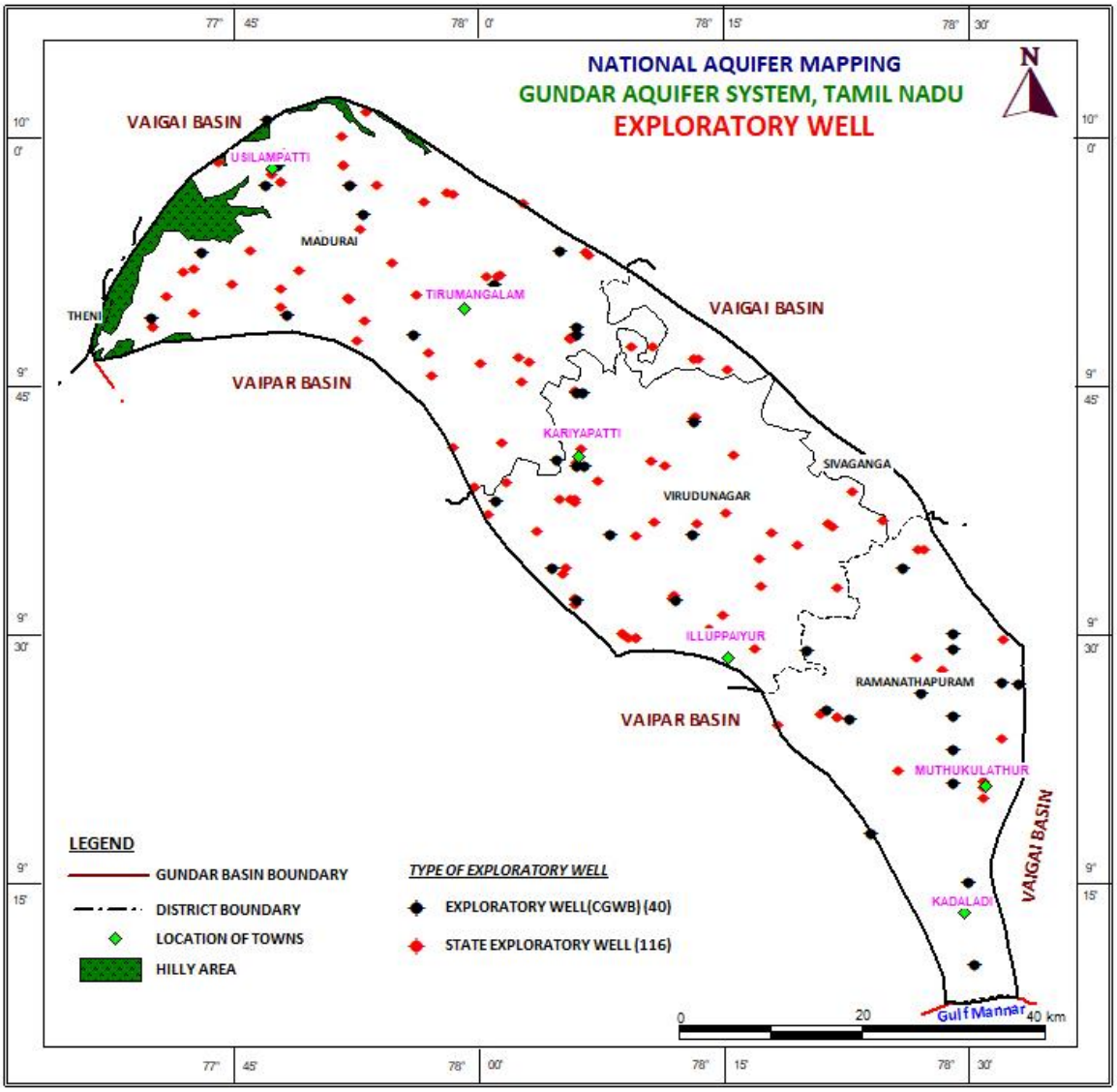


Figure 13. Locations of all Exploratory Wellsof Gundar Aquifer System

3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Hydrogeological Data Interpretation and aquifer disposition

Gundar Aquifer system area is divided into A, B and C regions. A-Region represents area underlined by Charnockite, B region represents area underlined by gneiss rocks & C-Region represents area underlined by sedimentary rocks. Aquifer units falling in “A” regions are named as A1 & A2, “B” regions are named as B1 & B2,whereas aquifer units falling in “C” regions are named as C1 & C2 in accordance to the aquifer characteristics.

3.1.1. Hydrogeology of hard rock region (A& B)

Hard rock region comprising of Charnockite rocks (A)and gneissic rocks(B)is found in the western and central portion of the Gundar aquifer system. Hard rock regions cover an area of 2246sq,km. The gneissic formation covering an area of 1346 sq.km encompasses 18firkas**(Table 7).**The Charnockite formation covers an area of900 sq.km and is found in6 firkas. The gneissic formation and Charnockite formation form two aquifer units namely the weathered and fracture/jointed aquifer unit.

3.1.1.1. Aquifer Unit I – Weathered

Region A: Charnockite rock area.

The weathered aquifer unit occurs from the ground level and has a minimum thickness of 4.1 m and maximum thickness of 31 m with average thickness of 14.6m. 2D disposition along southwest to Northeast clearly shows the vertical and lateral spread of the Charnockite formation. Yield of this weathered aquifer unit ranges from 0.72 to9 m^3/hr with discharge of <3.6 m^3/hr. During monsoon period the wells tapping this aquifer unit sustains for 2 to 4 hrs/dayof pumping, while during non-monsoon period (May to July) wells sustain pumping for less than 1 hour/day of pumping.Groundwater occurs in unconfined condition.Weathered thickness of Aquifer unit-I, Gundar Aquifer System is shown in **Figure 14.**

Table 7: Firkasalong the various geological formations across Gundar aquifer system.

Charnockite (Firkas - 6 Nos)	**Gneiss (Firkas - 18 Nos)**	**Sedimentary (Firkas – 9 Nos)**
Uthappanaickannur	Kokkulam	Kamudhi E
Usilampatti	Pannikudandu	Kamudhi W
Elumalai	Thirumangalam	Mudhukulathur N
sedapatti	Valayankulam	Mudhukulathur S
Sindhupatti	Sivarakottai	Appanur
Karumathur	Karapatti	Kadaladi
	Kuraiyur	Sayalkudi
	Karapatti	Kovilankulam
	A Mukkulam	Melakodumalur
	Mudukakkulam	
	Narikudi	
	Thiruchuli	
	Palayampatti	
	Veeracholan	
	Parthipanoor	
	Malankinar	
	Virathanur	
	Kalukuruchi	

The aquifer parameter such as transmissivity in this aquifer unit ranges from 0.1 to 158 m^2/day. The Specific yield of this aquifer unit ranges from 1 to 1.5% with highly potable groundwater quality. The general EC of this aquifer unit ranges from 386-3250 µS/cm. There are some isolated pockets in Madurai, Thirumangalam and Usilampatti

Region B: Gneissic rock area

In the area covered by gneissic rock the weathered aquifer unit occurs from the ground level and has a minimum thickness of 4.0 m and maximum thickness of 36 m with average thickness of 17.5 m. 2D disposition along Northwest to Southeast clearly shows the vertical and lateral spread of the Gneissic formation. Yield of this weathered aquifer unit ranges from Nil to 15 m^3/hr with an average discharge of 1 to <3.6 m^3/hr. During monsoon period the wells tapping this aquifer unit sustains for 2 to 4 hrs/day of pumping, while during non-monsoon period (May to July) wells sustain for less than 1 to 2 hour/day of pumping. Groundwater occurs in unconfined condition. The aquifer parameter such as transmissivity in this aquifer unit ranges from 0.2 to 253 m^2/day. The Specific yield of this aquifer unit ranges from 1 to 1.5% with highly potable groundwater quality. The general EC of this aquifer unit ranges from 480 to 2350µS/cm.

3.1.1.2. Aquifer Unit II (Fractured/Jointed)

Region A: Charnockite rock area

This aquifer unit comprises of fractured and jointed Charnockite formed due to tectonic activity. Thicknessof this aquifer unit is from 46 to 189m bgl (In general 3 to 4 set of fractures exists and even nil at some places). Based on the analysis of the 156 exploratory well data and 72 VES data it is observed that there is a possibility of occurrence of 3 to 4 Fractures/joints up to 195 m bgl in the charnockitic region**.** The distribution of the fractures with depth is given in **Table 8.**The yield of this aquifer unit II ranges from 0.3 to 9.5 m^3/hr. During monsoon period the wells tapping this aquifer unit sustains for 2 to 6 hrs /day of pumping, while during non-monsoon period (May to July) sustains for 1 to 2 hour/day of pumping.Transmissivity of this aquifer unit ranges from 0.1 to 4.5 m^2/day **(Table 9).** The general EC of this aquifer unit ranges from 440 to 3800µS/cm.

Region B: Gneissic rock area

This aquifer unit comprises of fractured and jointed Gneiss formed due to tectonic activity. Thickness of this aquifer unit is from 13 to 143 m bgl. In general 3 to 4 set of fractures exists and even nil at some places). Based on the analysis of the 156 exploratory well data and 72 VES data it is observed that there is a possibility of occurrence of 3 to 4 Fractures/joints exists up to 197 m bgl in the gneissic region. The distribution of the fractures with depth is given in **Table 10.** The yield of this aquifer unit II ranges from 0.05 to 25 m^3/hr. During monsoon period the wells tapping this aquifer unit sustains for 1 to 6 hrs /day of pumping, while during non-monsoon period (May to July) sustains for 1 to 3 hour/day of pumping. Transmissivity of this aquifer unit ranges from 3 to 296 m^2/day **(Table 11).** The general EC of this aquifer unit ranges from 370 to 2010 µS/cm.

Table 8: Distribution of fractures in the hard rock formation

Gneissic formation		**Charnockite region**	
Depth (m bgl)	**% of fractures**	**Depth (m bgl)**	**% of fractures**
Nil (Fracture/Massive)	5	Nil (Fracture/Massive)	12.5
Upto 50	5	Upto 50	12.5
50 to 100	50	50 to 100	12.5

100 to 150	29	100 to 150	37.5
150 to 195	11	150 to 195	25

Table 9: Salient features of the aquifer units in hardrock (Charnockite) region- A of Gundar aquifer system

Type of Aquifer	Formation	Top of the aquifer(mbgl)	Thickness/ occurrence of fractures (m)	Range of Yield (m^3/h)	Sustainability (hrs)	Aquifer parameter (T – m2/day)	GW quality EC values (µs/cm)	Suitable for Drinking
Aquifer unit – A-I	Weathered Charnockites	GL - 2	4.5 – 31 (Avg. - 14.6 m)	0.72- 9 Majority (< 3.6)	Monsoon : 2-4 hrs& Non monsoon: (May,Jun&July) < 1 to 2	0.1-158	386-3250	Yes -
Aquifer Unit – A-II	Jointed & Fractured Charnockite	21– 182 Nil at some places	46 -189 (3 to 4 fractures exist) Nil at some places	0.3 – 9.5	Monsoon: 1-6 hrs& Non monsoon 1 to 3 hrs	0.1 -4.5	440-3800	Yes - except Saline areas

Table 10: Salient features of the aquifer units in hardrock (Gniess) region- B of Gundar aquifer system

Type of Aquifer	Formation	Top of the aquifer(mbgl)	Thickness / occurrence of fractures (m)	Range of Yield (m^3/h)	Sustainability (hrs)	Aquifer parameter (T – m2/day)	Groundwater quality EC values (µs/cm)	Suitable for Drinking
Aquifer unit –B- I	Weathered gneiss	GL or 2	4 – 36 (Avg. - 17.5 m)	Nil - 15 Majority (< 3.6)	Monsoon : 2-4 hrs& Non monsoon: (May,Jun&July) < 1 to 2	0.2 -253	480-7760	Yes - except Saline areas

Aquifer Unit –B- II	Jointed & Fractured Gneiss	13 – 143 Nil at some places	42- 197 (3 to 4 fractures exist) Nil at some places	0.05 - 25	Monsoon: 1-6 hrs& Non monsoon 1 to 3 hrs	3 -296	370-2010	Yes -

3.1.2. Hydrogeology of Sedimentary area of the aquifer system (C)

Sedimentary rock region comprising of alluvium and Tertiary formations occupy the eastern part of the aquifer system.It covers an area of 762Sq.Km. sedimentary area (Alluvium, Tertiary formation& Cretaceous formation) encompasses 9 firkas**(Table 3)**Alluvium and the unconfined layers of Cuddalore formations form phreatic aquifer- Aquifer unit-I (C1), Tertiary formation is the confined aquifer unit (Cuddalore sandstone and Eocene sandstone formation)defining aquifer unit II and Cretaceous formation is the confined aquifer unit defining aquifer unit III.**(Table 8)**

3.1.2.1 Aquifer Unit – I (C1 - Alluvium and Cuddalore Sandstone)

The top most aquifer is the Aquifer Unit –I and it is a phreatic aquifer or Water table aquifer. This aquifer unit composed of recent river alluvium, Coastal alluvium,Cuddalore sandstone and laterite formations. The thickness of the Aquifer Unit-I varies from 6 to 40 m in the area covered by river alluvium, about 30 to 50 m thick in the area covered by coastal alluvium and it is about 10 to 20m in areas where the Cuddalore sandstone are exposed to the surface. The thickness of the aquifer unit Iis less in the western portion and gradually increases towards east near the coast. The groundwater abstraction from the aquifer is mostly by dugwells and shallow tubewells. The diameter of the dugwells ranges from 1 to 4 m and the depth ranges from 3 to 25 m below ground level (mbgl). The dugwells are energized mostly by electric pumps and the groundwater extracted is mainly used for irrigation and domestic purposes. The depth to the water level of the phreatic aquifer ranges between 1 and 18 mbgl and yield varies in different formation. Yield of the aquifer unit in the river alluvium varies from 2.4 to 65 m^3/hr. whereas in coastal alluvium area the yield varies from 39-132 m^3/hr and the yield varies from 3.5 to 7 m^3/hr in the phreatic unit of Cuddalore sandstone formation **.**

The transmissivity of alluvial formation ranges between 210 and 1500 m^2/day and the specific yield ranges between 12 and 18 %. Where as the transmissivity of Cuddalore sandstone formation ranges between 350 - 2500 m^2/day and its specific yield ranges between 8 to 13%.

The waters are generally alkaline with pH ranging from 7.0 – 8.15. The chemicalquality of ground water in general is good and potable except in the coastal part of the Gundar aquifer system.i.e. in coastal part of Ramanathapuram district (Kadaladifirka) the groundwater is saline. The quality deteriorates in eastern and south-eastern coastal part of the aquifer system. The Electrical conductivity map has been prepared and presented below. Aperusal of the iso-conductivity map reveals that good quality groundwater with EC less than 1500 micro siemens/cm at 25°C occur in the firkas of Kamudhi East, and Mudukulathur North. These firkas are mainly covered under recent river alluvium.

In the area covered by coastal alluvium i.e. firkas like Melakodumalur, Kovilankulaqm, Aapannur the groundwater quality is moderate with EC value of 2000-3000 micro siemens/cm.

The high salinity with Electrical Conductivity (EC) of more than 3000 microsiemens/cm at 25° C in ground water has been observed in parts of Ramanathapuramdistrict covering firkas like Kadaladi and Sayalkudi. The very high salinity with ElectricalConductivity (EC) of more than 5000 micro siemens/cm at 25°C in ground water hasbeen observed in Kadaladiarea.

The chloride in water is also having essentially the same distribution as that ofElectrical Conductance in the area. Chloride concentration exceeding permissiblelimit of 1000 mg/l are seen in around Kadaladi andSayalkudifirkas. This may be due to the washing of salt from the upstream and also due to the insitu salinity of the formation.

3.1.2.2. Aquifer Unit II (C2): Tertiary sandstone

Tertiary sandstone of the Gundar aquifer system consistsof Cuddalore formation and Eocene formation.

Cuddalore Sandstone

Cuddalore Sandstone comprises of argillaceous sandstone, pebble bearing sandstone, ferruginous sandstone, grits and clay beds and are whitish, pinkish, reddish in colour which are friable in nature. The sands and sandstones of Cuddalore formations of Mio-Pliocene age comprise of fine to very coarse grained and are sub-angular to sub-round in shape, occasionally with rounded pebbles of quartz with diameters even upto 3 m. The Cuddalore sandstones occur beneath the alluvium formation and in place where alluvium formations are absent; they are exposed on the surface. The sandstone formation which lies below the unconfined unit ofCuddalore formation forms the aquifer unit II (C2) which is confined in nature.The clay layers separating the unconfined and confined unit of the Cuddalore sandstone are discontinuous at many places. The depth of occurrence of aquifer unit II is between 20 and 60m bgl with thickness varying from 68 to >300 m. The thickness is less in the western portion and gradually increases towards east. Clay occurs as intercalations within the sandstones at some locations. The groundwater abstractions from the aquifer are by shallow tubewells, depth ranges from 40 to 80mbgl and are energized by electric submersible pumps which are mainly used for irrigation and industrial purposes having EC <2500microseimens/cm. The piezometric level of the confined aquifer ranges between 15 and - 10 m with respect to mean sea level (msl) having yield between 10.8 to 66.6 m^3/day. The major source of recharge to the aquifer is rainfall and leakage from unconfined aquifer. The transmissivity ranges between 5and 3615 m^2/day andstorativity between 1.2 x 10^{-3} and 4.1 x 10^{-4} respectively. The chemical quality of groundwater from the Cuddalore sandstone aquifers is of the sodium-chloride type. The degree of mineralization of waters is high in the Ramanathapuram area. Quality data of groundwater exploration of Cuddalore sandstone aquifers reveals that the EC. values range from 3820 to 15540 micro seimens/cm. The mineralization of groundwater in the aquifer unit progressively gets concentrated from west to east in the boreholes. Groundwater in the western part of the Ramanathapuram is of Na-Cl-HCO_3 type.

Eocene Sandstone

The Eocene formations composed of sandstones are made up of fine to coarse grained sand and pale grey in colour with occasional clay intercalations. Similar to the Cuddalore sandstones, Eocene sandstones are also friable in nature. They are shallow in the central part and deeper in the eastern part towards the sea. The occurrence of these formations is restricted to the eastern part of the Gundar aquifer system and found at a depth of 50 to 120 m below mean sea level and is restricted to the firkas like Melakodumalur, Mudhukulathur, Aapanur, Kadaladi and Sayalkudi. In the eastern part the Eocene formations are found in greater depth. The Eocene

sandstone formation forms aquifer which is confined in nature. The thickness is varying from 40 to 85 m. The groundwater in this aquifer unit is abstracted sparely for irrigation activity. Since last decade, tubewells have been constructed by farmers to tap groundwater from this aquifer for irrigation activity.

This aquifer unit is highly potential and its yield varies from 65 to 85 m^3/hr. The groundwater quality of this aquifer is good and fit for drinking, domestic, agriculture and irrigation purpose as the EC values ranges from 600 to 2200 microseimens/cm except in Sayalkudi and Kadaladi. The transmissivity of the aquifer unit range between 300 and 2750 m^2/day and the storativity ranges between 1.6 x 10^{-4} and 2.9 x 10^{-5}.

3.1.2.4. Aquifer Unit III (C3 Cretaceous sandstone)

Cretaceous sandstone which consists of litho units viz the top units of marker fossiliferous sandstone, which is flesh red in colourand compact in nature and the bottom consists of pinkish and greyish sandstoneintercalated with clay and shale. These form the Aquifer unit III in the sedimentary area of the Gundar aquifer system and it occurs only at subsurface. Aquifer Unit III lies below the Aquifer unit-II and separated by confining clay layer which is discontinuous in many places. The Aquifer Unit-IIIoccurs at the depth of 88 to 150 m bmsl. The thickness is less in the western portion i.e 40 m and gradually increases towards east extending more than 200 m. The groundwater abstraction from the aquifer through tubewells constructed to the depth of 220 to 350mbgl. The Aquifer Unit-IV is highly potential and yields 55 to 85 m^3/hr. The transmissivity of aquifer varies from 56.17 to 594.00 m^2/day (Andavurani) with field permeability ranging from 2.810 to 27.00 m/day.Storage co efficient values as computed are indicative of confined condition of the aquifer and ranges from $5.54x10^{-4}$ to $2.72x10^{-5}$. Further the pump test conducted in this area has broughtto light the existence of barrier boundary conditions. For instancethe pumping testconducted in the exploratory wells at Tiruvadanai, Pandakudi, and Mandathukottai in adjoining Sivagangai district. The drawdown is rather highindicative of their proximity to the barrier boundary, thereby of the limit of the extentof the confined aquifer**.**

The depth to weathered thickness of Aquifer I is presented in **Figure 14** and Aquifer II in **Figure 15.**

Table 11: Salient features of the aquifer units in Sedimentary rock region of Gundar Aquifer System

Type of Aquifer	Formation	Top of the aquifers (mbgl)	Thickness _AQ-I)/ Occurrence (Aq-II)up to(m)	Range of Yield (m^3/h)	Sustainability (hrs /day)	Aquifer parameter (Transmissivity – m2/day)	Groundwater quality EC values (µs/cm)	Suitable for Drinking
Aquifer unit -C I	River alluvium	GL	6 to 40	2.4– 65	4-6 hrs	210- 00	740-3750	yes except saline area
	Coastal alluvium	GL	30 to 50	39-132	5-7hrs	350-2500		
	Cuddalore SST	GL-3	10 to 20	3.5-7	3-5 hrs	10.8 to 66.8		
Aquifer Unit –C II	Cuddalore SST	20 - 55	68 to > 300	10.8 - 66.6	5-7hrs	5 to 2615	180-14000	Mostly No,
	Eocene SST	50 – 120	40 to 85	68 - 85	3-5 hrs	300 - 2570	600 - 2200	Yes except saline area

Aquifer Unit –C III	Cretaceous SST	88 - 150	40 - > 200	65 - 85	3 – 4 hrs	56.17 to 594.00	1500 - 2800	yes except saline area

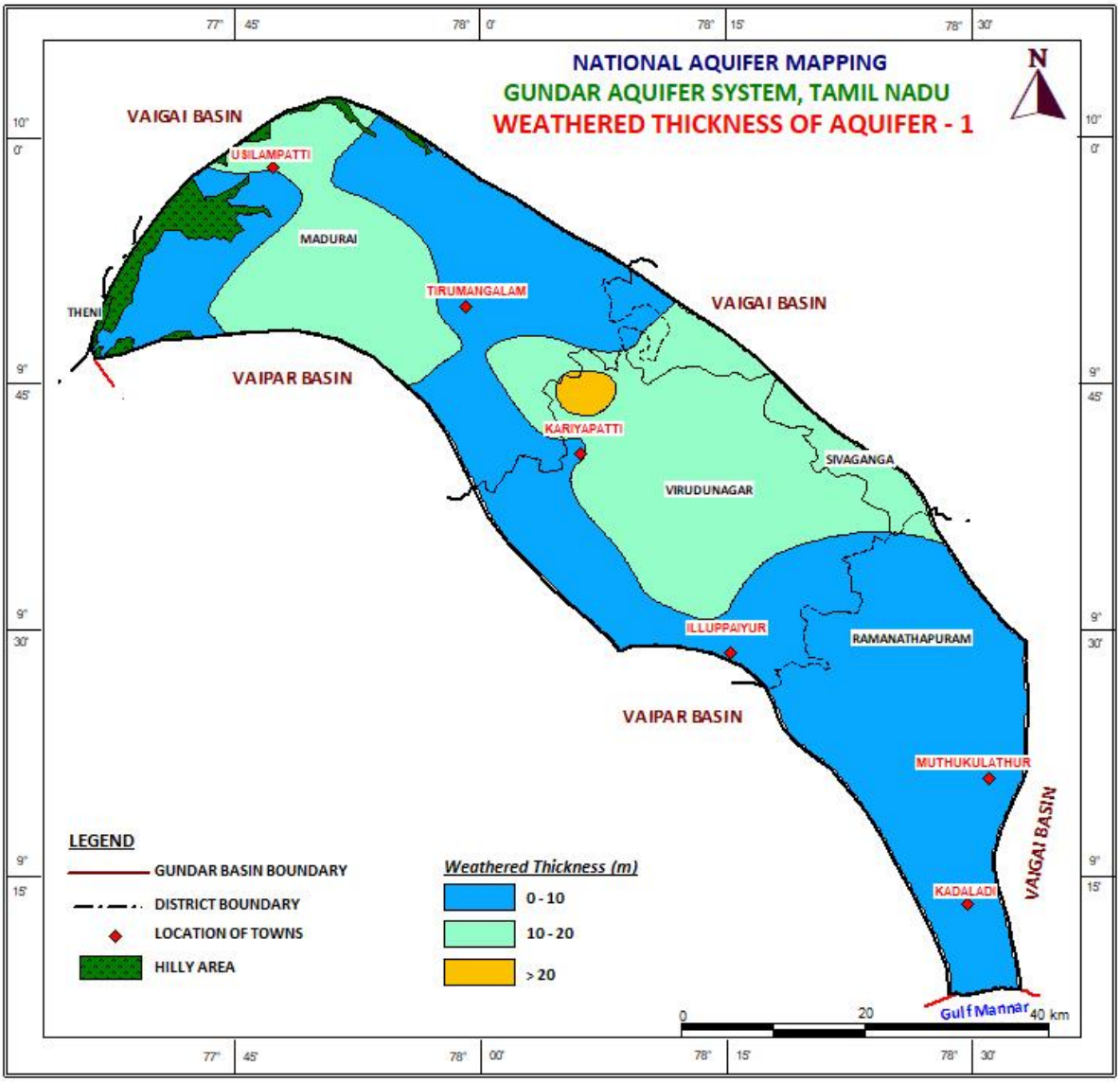


Figure 14: Weathered thickness of Aquifer-I, Gundar Aquifer System

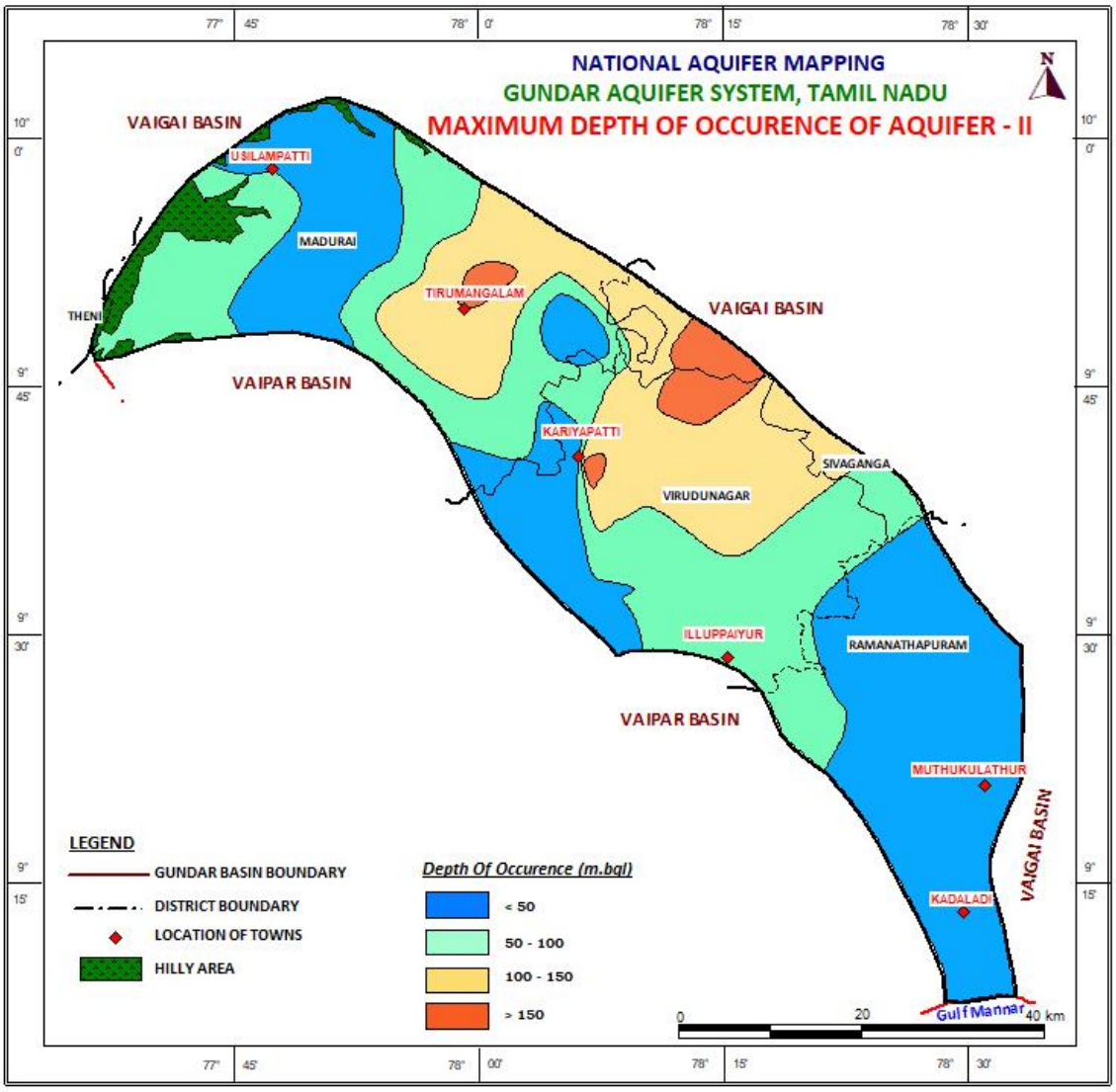


Figure 15: Depth of occurrence of Aquifer-II of Gundar Aquifer System

3.2.Groundwater Level

During Aquifer Mapping studies in Gundar aquifer system 37groundwater monitoring wells have been established and monitored in different formations in order to know the behavior of the groundwater regime**(Table 12).**Apart from this historic water level data monitored by CGWB were analyzed for both Premonsoon and Postmonsoon periods. The water levels monitored from May 2010 to January 2020 (four times in a year) is taken for the analysis. The depth of dug well ranged from 4.00 to 40.00mbgl. The Hydrogeological detail of the basin is reprented in **Figure 16.**

3.2.1. Premonsoon depth to water level for Aquifer I (May2018)

The water level data pertaining to the period of May 2018 (pre monsoon) was used for the preparation of depth to water level map of the basin. The depth to water level during May 2019 varied from 0.85 to 26.83 mbgl. Major part of the basin shows water level in the range of 5 to 10 mbgl. Patches recorded water level in the range of 10 to 20mbgl and found in north eastern portion of the basin. Water levels ranging 5 to 10mbgl are observed in the whole of western part, central part &northern part of the basin.

3.2.2. Postmonsoon depth to water level for aquifer I (Jan-2019)

To prepare the depth to water level map for the period of January 2019, based on GWMW data collected from the basin area are used. The depth to water level during Jan 2019 varied from 0.92 to 9.4 mbgl.Water levels in the range of 2 to 5 mbgl found in eastern portion of the basin. Water levels ranging 5 to 10mbgl are observed in the rest of the region.

3.2.3. Decadal Water Level Scenario of the aquifer system

Decadal water level scenario maps are prepared for pre-monsoon and post-monsoon period. The analysis shows that during the Pre monsoon period (May 2008- May 2017) majority of the area is having water level in the range of 5 to 10 m bgl. In the north western part of the aquifer system the waterlevel is in the range of 10 to 20 m bgl and in a pocket of around Madurai the water level shows more than 20 m bgl. In the eastern part of the study area where the area is covered with alluvium formations the water level is shallow i.e., 2 to 5 m bgl. Whereas during the post monsoon period (Jan 2009 – Jan 2018) inthe study area the wells show water level ranging between 2 to 5 m bgl in eastern and central part of the study area and in rest of the area shows 5 to 10 m bgl. The deeper water level is restricted only in the eastern part of the study area especially in and around Madurai. The studies show that the basin is responding to the rainfall and recharging the aquifers. Depth to water level (Aquifer-I) – decadal average- Premonsoon of the Gundar Aquifer System presented as **Figure 17**. Depth to water level (Aquifer-I) – decadal average- Postmonsoonpresented as **Figure 18**.

The yield of Aquifer I range from 1 to greter than 4 lps**(Figure 19).** The yield of Aquifer II ranges from <1 to more than 10 lps**(Figure 20).**

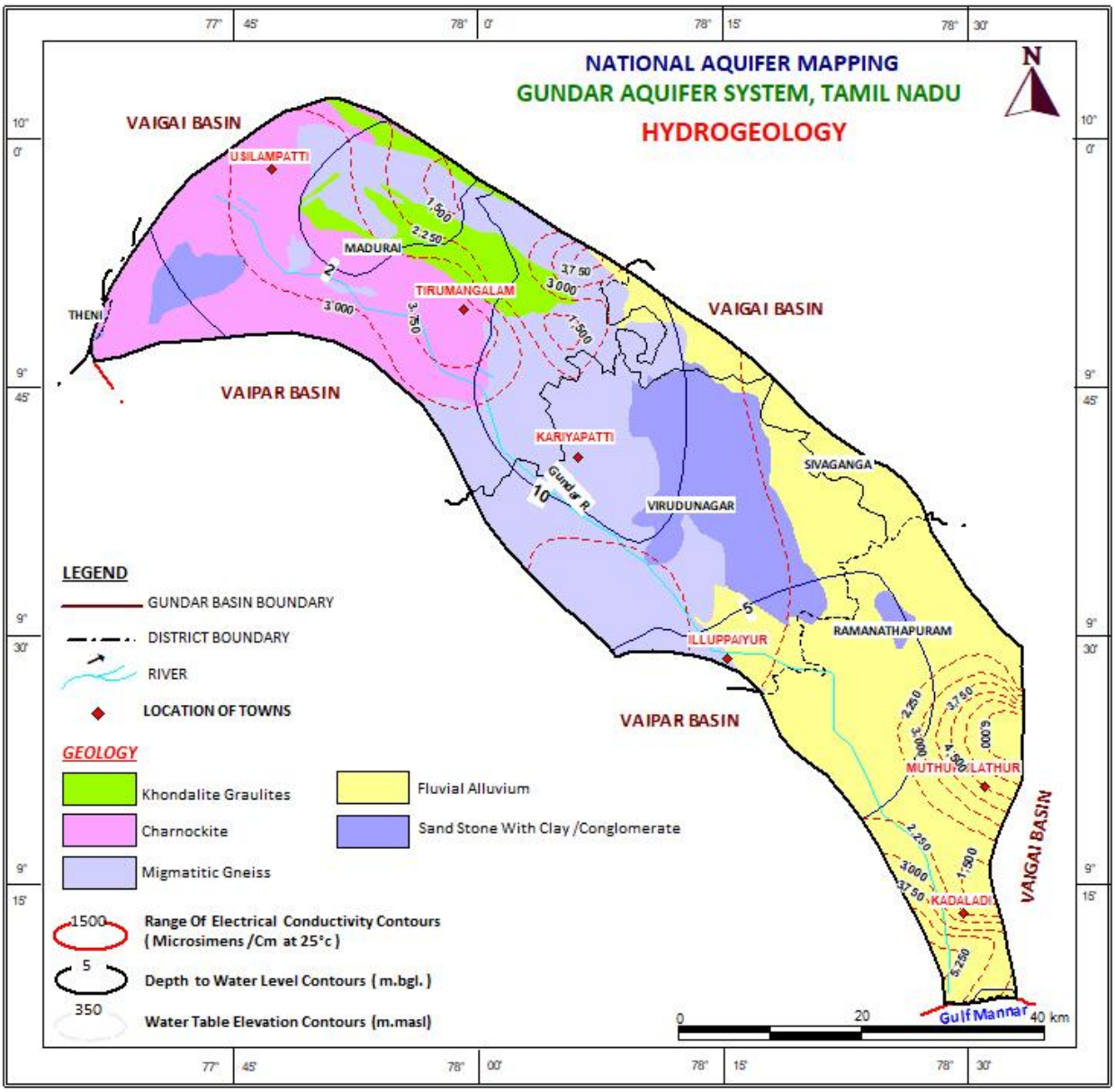


Figure 16. Hydrogeology map of the Gundar aquifer system

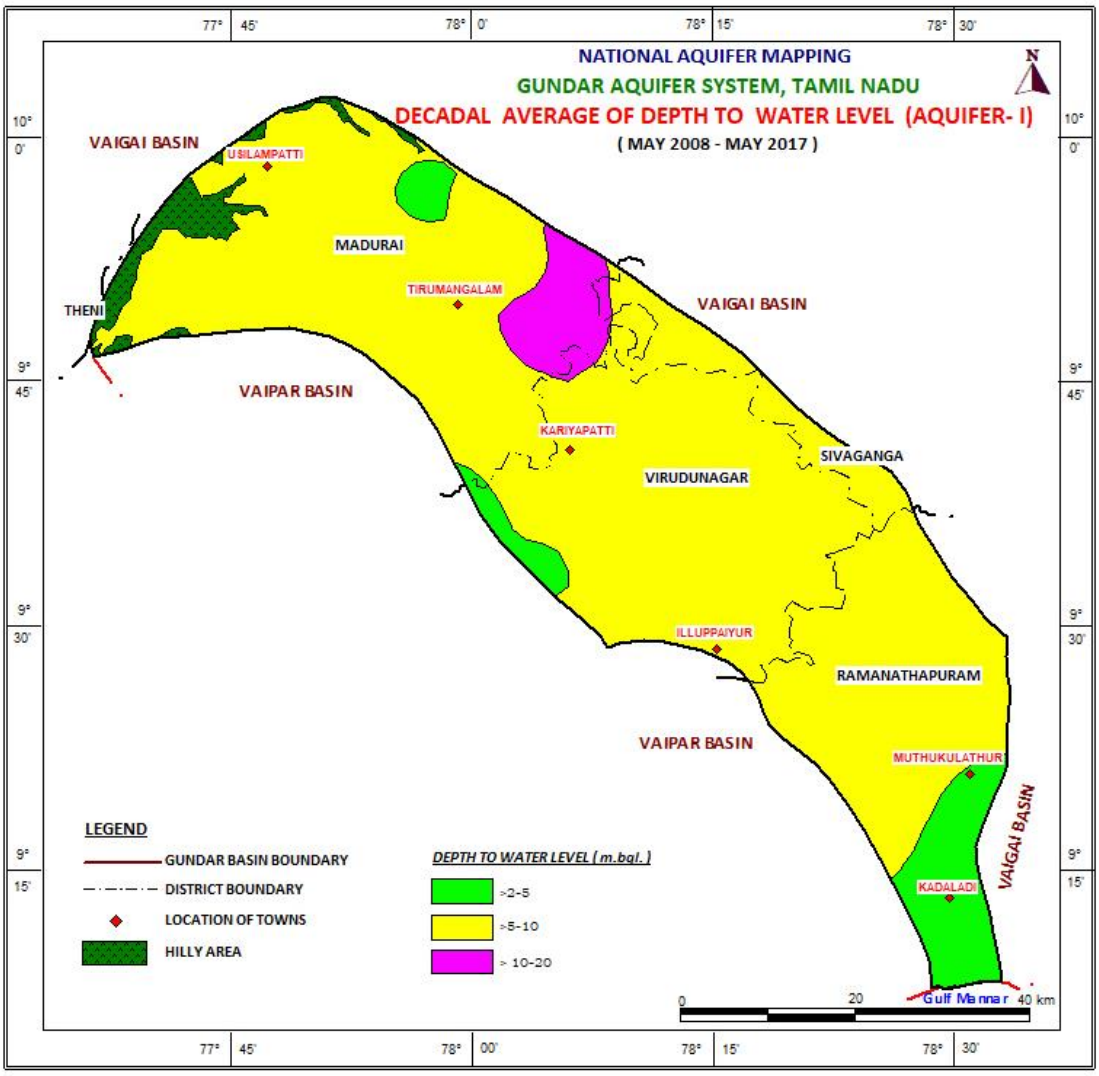


Figure 17: Depth to water level (Aquifer-I) – decadal average- Pre-monsoon of the Gundar aquifer system

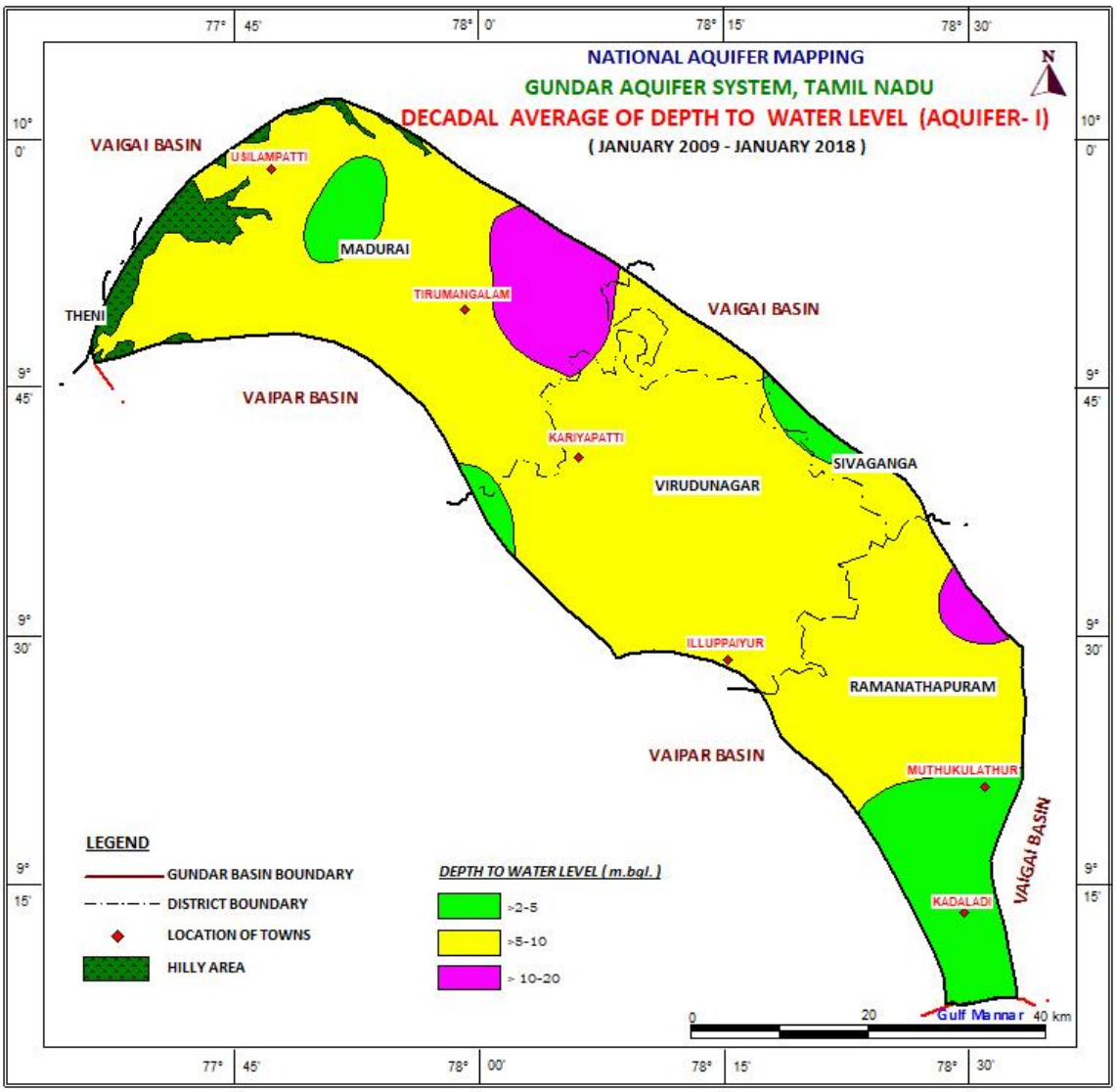


Figure 18. Depth to water level (Aquifer-I) decadal average – Post-monsoon of the Gundar aquifer system

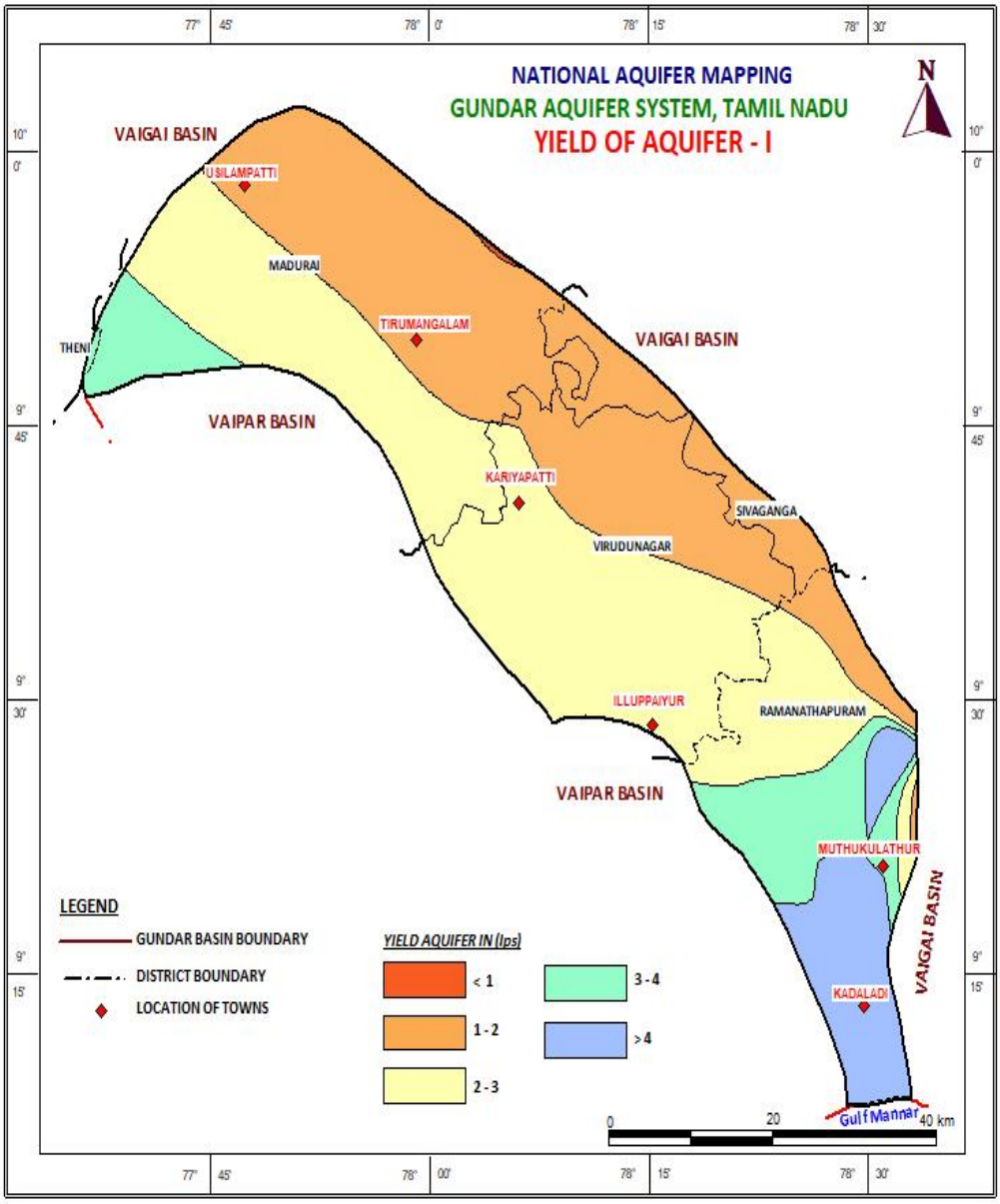


Figure 19: Yield of Aquifer I- Gundar aquifer system

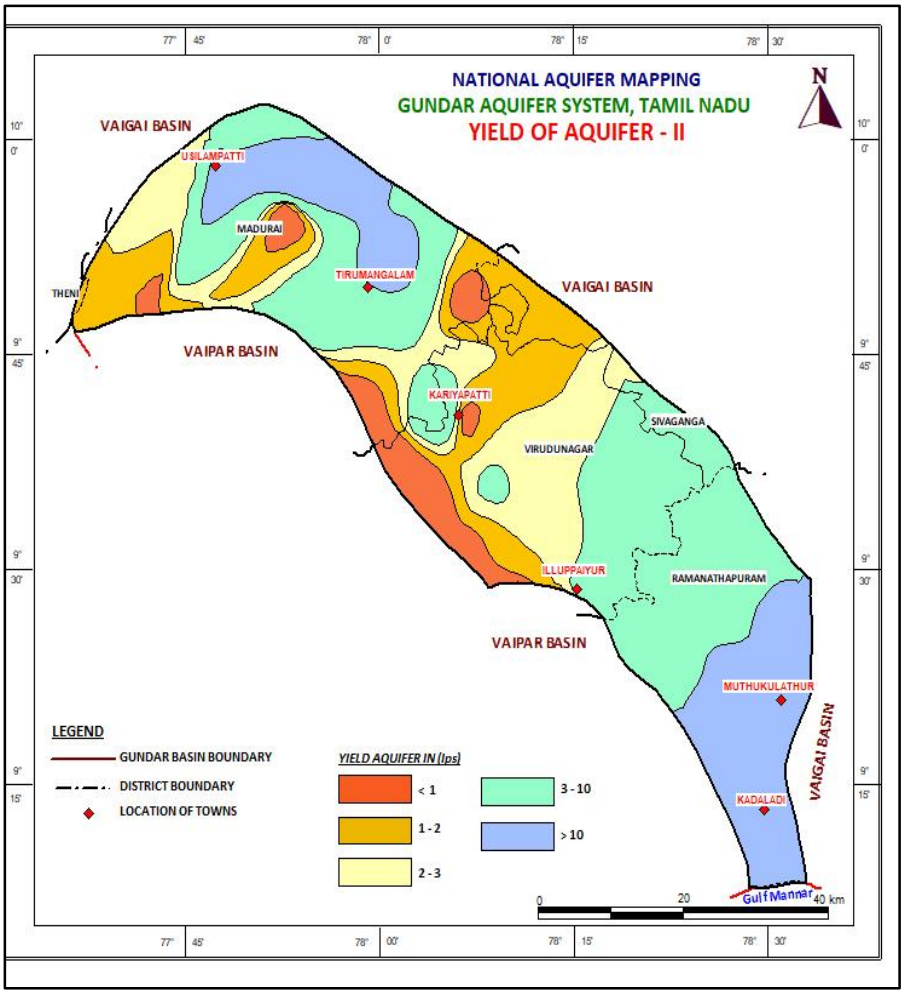


Figure 20. Yield of Aquifer II- Gundar aquifer system

Table 12: Water level of Groundwater monitoring wells (March 2020)

Sl No.	Location	Latitude	Longitude	Water Level
1	Movaraivendram- kelur	9.607	77.643	17.25
2	AyyanKarisakulam	9.6418	77.7593	19.2
3	Maharajapuram	9.6572	77.6546	20
4	W Pudupatti	9.618	77.6132	11.75
5	Krishnakovil	9.5544	77.6765	8.2
6	Thiruvannamalai	9.5353	77.6223	16.1
7	Srivilliputtur- Mahatmanagar	9.4932	77.6172	12.4
8	Rajapalayam-Melapattikarisakkulam	9.4759	77.5787	6.05
9	Krishnapuram O	9.4227	77.5042	5.05
10	Sokkanathapuram			8.35
11	Cholapuram	9.3816	77.5613	4.7
12	S Thiruvenkatapuram	9.4383	77.5353	7.6

13	Keelarajakularaman	9.4382	77.6383	11.8
14	Alankulam	9.3678	77.6744	6.7
15	LakshmipuramVilaku	9.349	77.7316	7.5
16	Vembakottai	9.3341	77.7649	6.7
17	Annapooraniyapuram	9.3158	77.7438	7.1
18	Pitchaivanpatti	9.2051	77.7696	7.7
19	Kovilpatti	9.2064	77.8784	1.7
20	Reddiapatti	9.258	77.8373	7.85
21	MetturElayiarampannai	9.2815	77.8337	3.04
22	O Mettupatti	9.328	77.9039	13.4
23	Mettamalai	9.3918	77.9009	9.1
24	Anuppankulam	9.412	77.8501	14.25
25	Vadamalapuram	9.5031	77.8304	10.1
26	Amathur			12.2
27	Varalotti	9.5992	78.0337	8.42
28	Johilpatti	9.6014	78.1033	8.6
29	Krishnapuram	9.58084	78.152	dry
30	Trichuli-Pallimadam	9.5357	78.2121	dry
31	Nathakulam	9.5575	78.3208	13.28
32	Narikudi	9.59	78.2495	8.87
33	Keel Kuranaikulam	9.4911	78.1738	12.18
34	M Reddipatti	9.4511	78.1781	dry
35	Melaiyur	9.34767	78.2678	14.2
36	Sivanthinathapuram- Valvangi	9.4451	78.1005	dry
37	Palavanatham	9.5552	78.0048	8.76

3.3 Groundwater quality

Evaluation of ground water quality is as important as its quantity for assessment of ground water resources. Ground water is never pure and contains varying amounts of dissolved solids, the type and concentration of which depends on its source, surface and sub-surface environment and rate of ground water movement. The chemical quality of ground water is a function of the quality of the recharge water and the reactions that occur along its flow path, particularly between the moving fluid and the geologic materials. The concentrations of various chemical constituents in ground water depend on the solubility of minerals present, the residence time and the amount of dissolved carbon dioxide. In addition to the natural changes, anthropogenic activities such as sewage disposal, agricultural practices, industrial pollution etc. also contribute significantly to changes in ground water quality.

Water samples have been collected from the study area in different aquifers (Aquifer-I & Aquifers-II) to assess the groundwater quality for drinking and irrigation purpose. The analytical results are given as Annexure I & II for aquifer- I & II respectively. The range of various chemical constituents of ground water and the general water quality of groundwater in different aquifers in Gundar basin, Tamil Nadu are shown Table-1 & 2 respectively. Some of the

important parameters have been illustrated by distribution map of Electrical conductivity, Chloride, Nitrate and fluoride (Fig 1-8). The drinking water suitability has been assessed based on Bureau of Indian Standard (IS 10500:2012

3.3.1. Electrical Conductivity (EC)

Electrical conductivity is the indicator of the total mineral content of water and hence it indicates the total dissolved solids (TDS) present in water. TDS of water determines its usefulness to various purposes. Generally water having TDS <500 mg/L is good for drinking and other domestic uses. However, in the absence of alternative sources TDS up to 2000 mg/L may be used for drinking purposes. The distribution of EC in different aquifers unit I is givenin **Figure 21.**

In the hard rock terrain particularly in the Phreatic aquifer of the Charnockite area the EC ranges from 750-3000 µS/cm. There are some isolated pockets in Usilampatti, Madurai and Thirumangalam areas of Madurai district where the groundwater quality is beyond permissible limit for drinking purposes. In the phreatic aquifer unit of the gneissic formation the EC ranges from 2250 to 3000 µS/cm. There are some isolated pockets in Palyampetti, Mandarasallai areas of Virudhunagar district groundwater quality is beyond permissible limit for drinking purposes.

In the sedimentary rock terrain, the perusal of the iso-conductivity map reveals that the general EC is in the range of 1500 – 3000 micro siemens/cm. However patchy occurrence of high EC > 3000 micro siemens/cm is found all along the southe eastern course of the basin characterized by the presence of Coastal alluvium. These include firkasMudhukulathur N, Mudhukulathur S, Appanur, Kadaladi and Sayalkudi. Highly saline waters with EC > 5000 micro Siemens/cm are found in Kadaladi and Sayalkudifirkas. Those firkas characterized by the occurrence of riverine alluvium have EC in the range 1500-2250 micro siemens/cm at 25°C along Kovilankulam, Kamuthi East and Abiramamfirkas.**Table 13** shows the values range.

Table 13. Distribution of EC in the aquifer unit-I.

Ec (us/cm)	Percentage of sample (%)
0-750	39
>750-2250	47
>2250-3000	06
> 3000	08

3.3.2. Chloride

Chloride is one of the major anion in groundwater. The high mobility of the ion and the high solubility of chloride salts make the chloride ions present in waters. Moreover, chloride ions do not take part in any of the geochemical (or) biochemical reactions, hence it can be used as a good indicator of ground water pollution. Over 500 mg/L it imports saline taste to drinking water. BIS specified 250 mg/L as the desirable and 1000 mg/L as the permissible limit in the absence of alternate sources for drinking water.

About 81% of the groundwater samples of phreatic aquifer has the chloride concentration 0 to 250 mg/l and about 17% of groundwater sample has the chloride concentration 250 to 1000

mg/l. The distribution of chloride concentration in Aquifer-I is presented in **Figure 22** and **Table14.**

Table 14. Distribution of chloride concentration in aquifer

Cl (mg/l)	Percentage of sample
0 -250	81
>250-1000	17
>1000	2

3.3.3. Fluoride

The important fluorine-bearing minerals are fluorite (Calcium fluoride), apatite (Complex fluoride- bearing silicate), certain amphiboles and micas. The concentration of fluoride in groundwater is limited due to the low salinity of most fluoride in groundwater. It is limited due to the low solubility of most fluorides. The solubility of fluoride in pure water at 25^{o}C is only 8.7 ppm of fluoride. The analytical results indicate that the groundwater in the basin falls within the permissible limit of 1.5 mg/l. **(Figure 23**).

3.3.4. Nitrate

Nitrate is one of the major indicators of anthropogenic sources of pollution. The negative charge and high mobility favors its persistence in nature and transport along the ground water flow path. Nitrate is the ultimate oxidized product of all nitrogen containing matter and its occurrence in ground water can be fairly attributed to infiltration of water through soils containing domestic, vegetable and animal waste, fertilizer and industrial pollution. As the lithogenic sources of nitrogen are very rare, its presence in ground water is almost due to anthropogenic activity. The spatial distribution of nitrate concentration in groundwater in the shallow aquiferis shown Fig 5-6 respectively.

The concentration of Nitrate in the shallow groundwater (aquifer- I) ranged between 5 and 293 mg/L. About 62% of the samples showed nitrate below 45 mg/L, the desirable limit for drinking and 27% of the samples showed nitrate between 46-100 mg/L and about 11% of the samples showed nitrate 100 mg/L, which are above permissible limit of BIS.**(Figure 24)**

In most part of the aquifer system the concentration of Nitrate is <45 mg/l which is well within the permissiable limit, whereas few samples falls in firkas like Avaniyapuram, Elumalai, A Mukkulam, Usilampatti and Kariapatti has concentration of Nitrate is > 45 mg/l (Figure 24). This is due to the mixing of sewaragewaterwith the ground water in urban areas and also the increase in concentration of Nitrate is due to the leaching effect of Nitrogen fertilizers applied in the agriculture field in the study area.

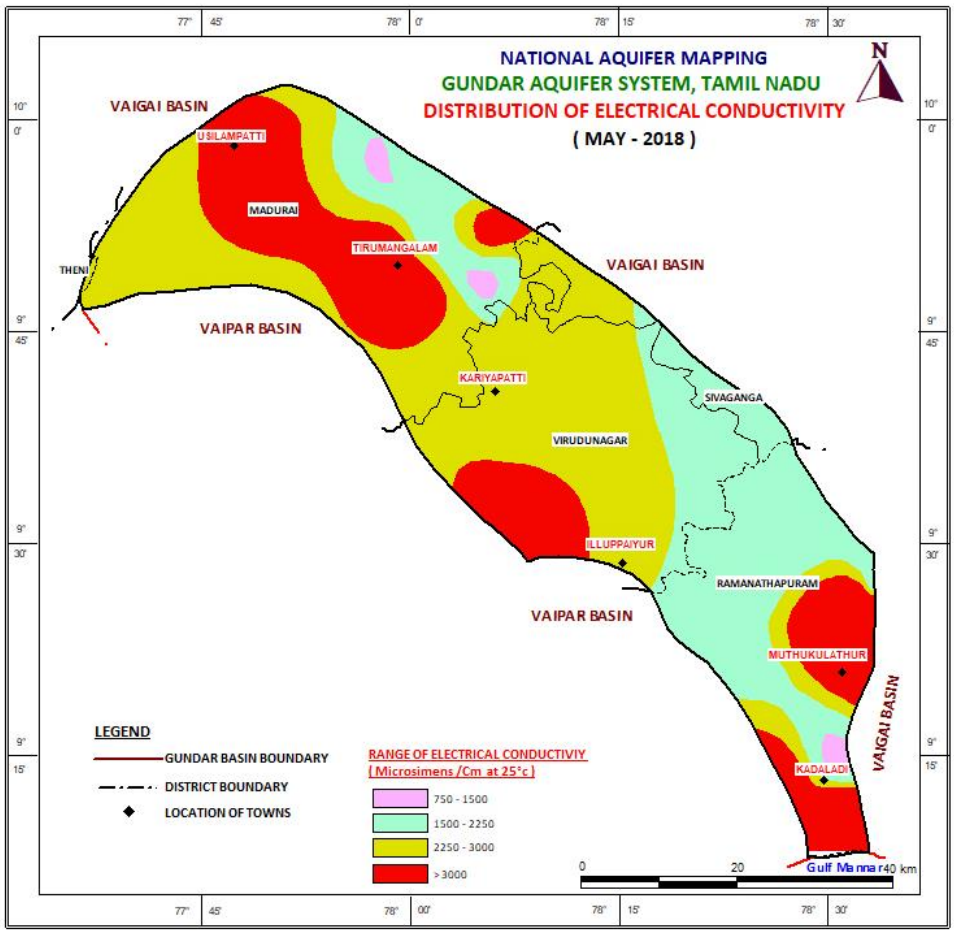


Figure 21: Distribution of EC in Aquifer I of the Gundar Aquifer system.

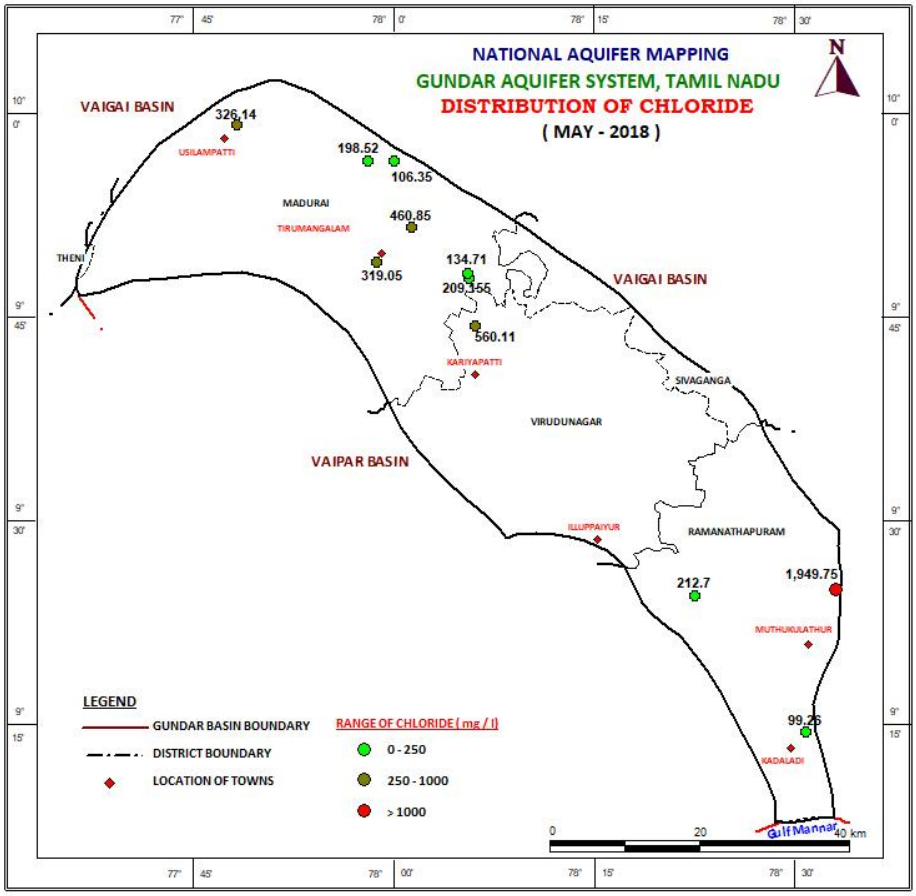


Figure 22: Distribution of chloride in Aquifer I of the Gundar Aquifer system.

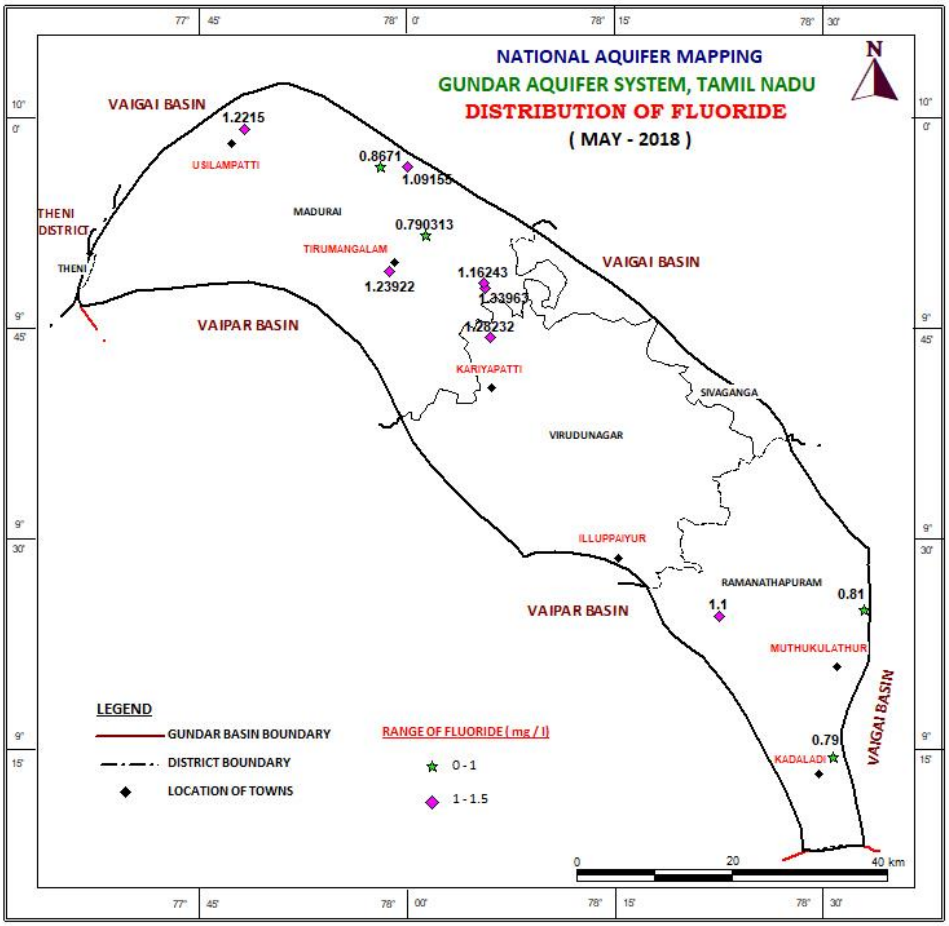


Figure 23: Distribution of Flouride in Aquifer I of the Gundar Aquifer system.

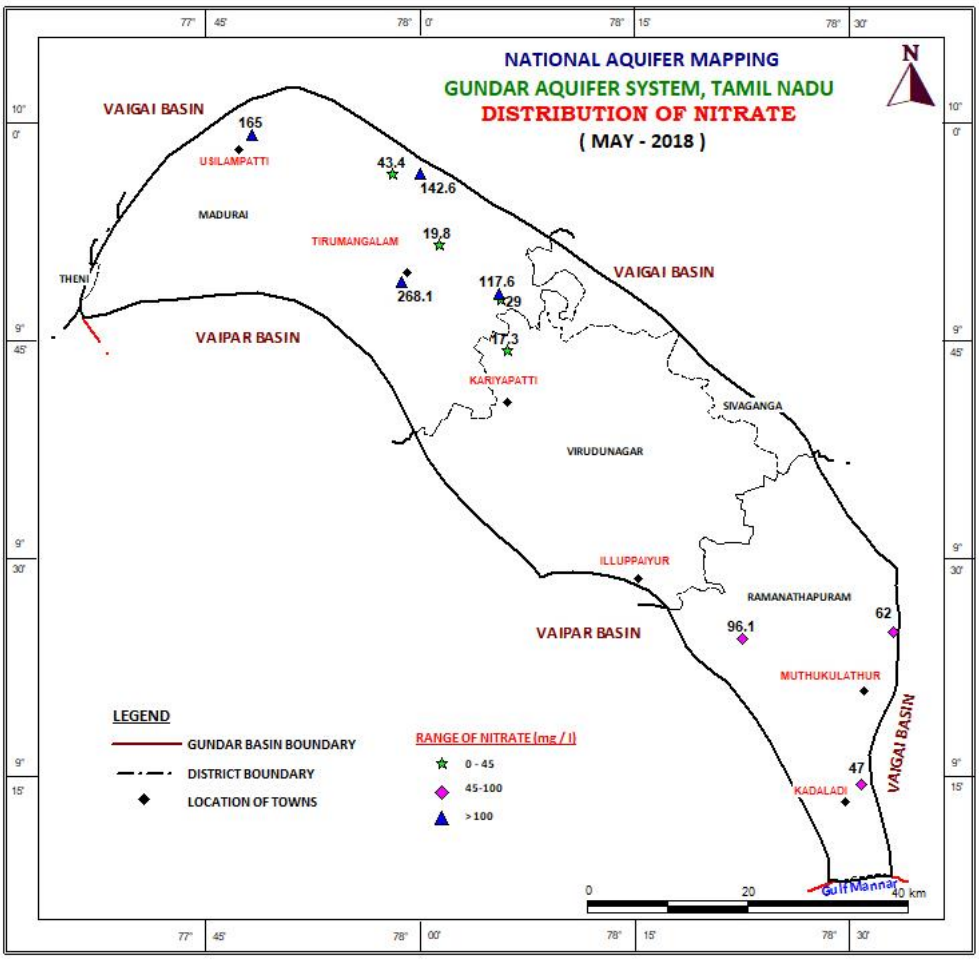


Figure 24: Distribution of Nitrate in Aquifer I of the Gundar Aquifer system.

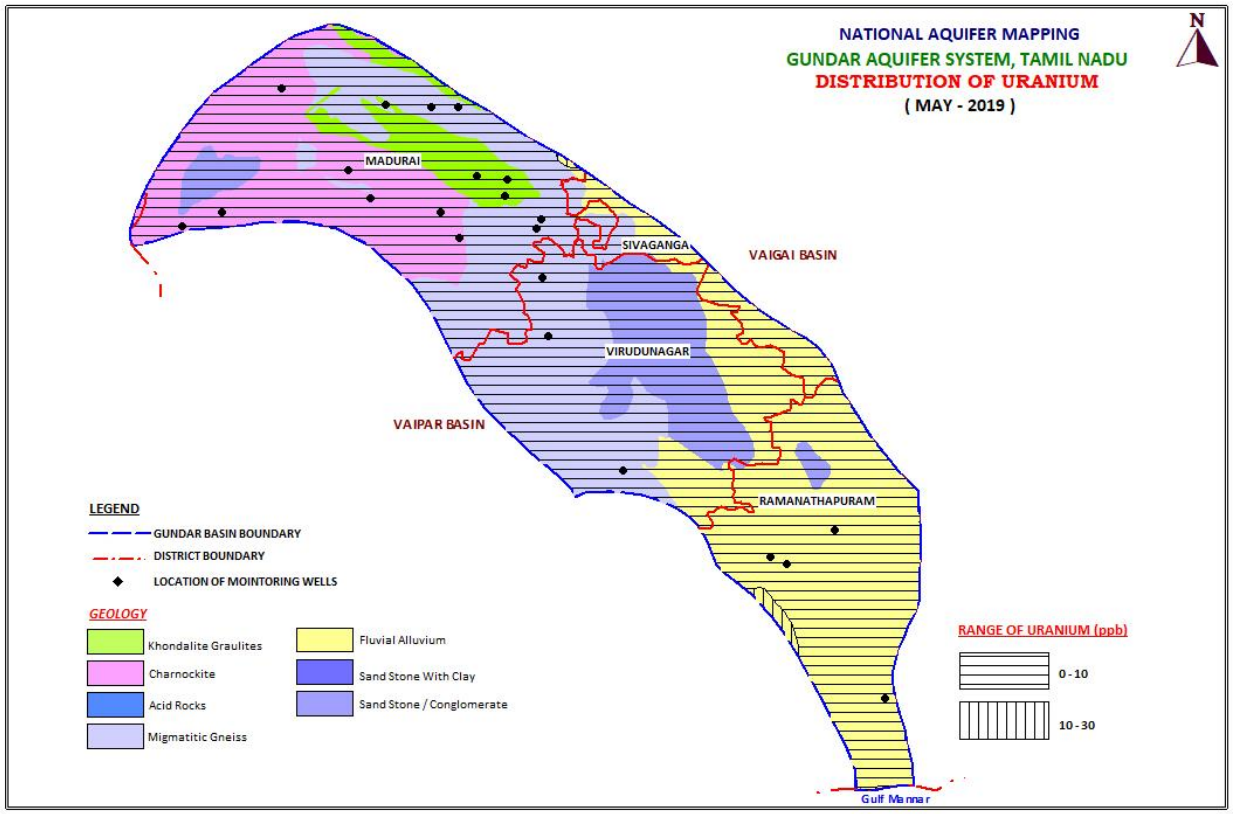


Figure 25: Distribution of Uranium in Aquifer I of the Gundar Aquifer system.

HYDROCHEMICAL FACIES OF GROUNDWATER

The geochemical evolution of groundwater can be understood by plotting the concentration of major cations and anion in the Piper's Trilinear diagram (Piper 1944). The plots of groundwater samples in the shallow aquifers of Gundar basin, TamilNaduis shown**Figure26.** Plotting positions of samples in the two triangles signify the characteristics of cations and anions whereas the overall characteristics of the water are presented in the diamond-shaped field by projecting the position of plots in the triangular field. Generally, in the recharge areas, ground water would be relatively fresh which is indicated by the presence of bicarbonate type of water. As water moves through the aquifer, it is enriched with minerals, and ultimately it attains the seawater composition (NaCl type water). In shallow aquifer, about 32% of the groundwater samples are calcium magnesium bicarbonate type, 23% samples are calcium sodium bicarbonate type, 27% samples are defined as calcium magnesium chloride type and 18 % are sodium chloride type,

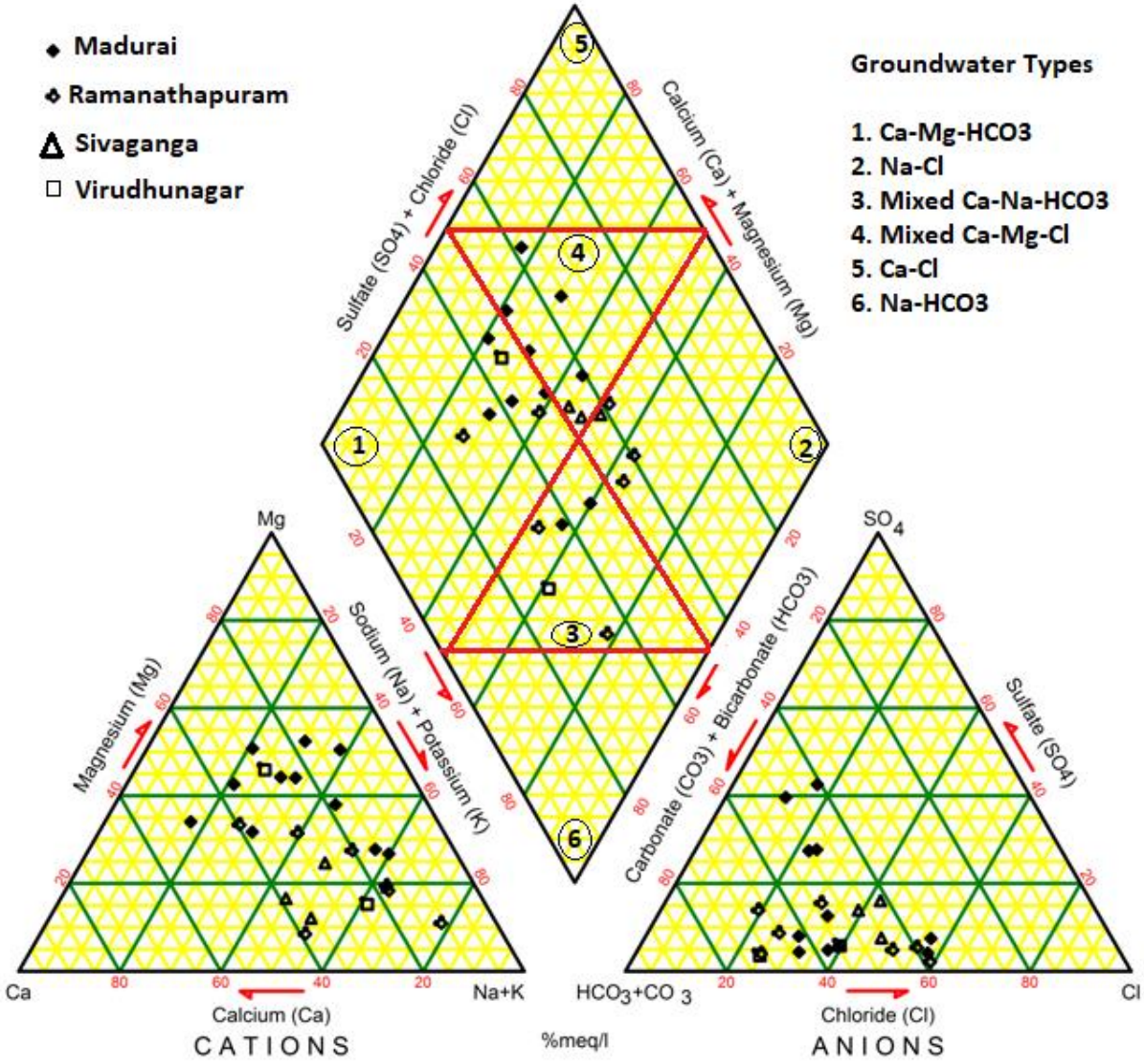


Figure 26: Groundwater facies distribution in the Gundar Aquifer system.

3.4. Aquifer Maps

3.5.1. 2D&3D models showing Aquifer Disposition

Aquifer Disposition (Vertical & Lateral) is generated based on the inputs of data collected through geological, geophysical, hydrogeological, and hydrochemical studies. In particular the aquifer disposition and aquifer characterization has been brought mainly by analyzing the data collected from different groundwater agencies such as 41litholog and 137 Nos. of VES data. 2D & 3D aquifer disposition models of the aquifer system have been deciphered by using ROCKWORKS software and generate numbers of 2D cross section along different directions of the Gundar aquifer system. All such 2D cross sections were verified and the model was calibrated to bring out the 3D aquifer disposition of the aquifer system. The type cross sections generated in different direction of the aquifer system is given in **Figures 27, 28** & the 3D

aquifer disposition is shown in **Figure 29. Figure 30** shows the fence diagram**.** The exploratory wells details are given in **Table15**

Table 15 : Exploratory wells details in Gundar Aquifer System

Sl no	Location	Latitude	Longitude	RL	TOTAL DEPTH
1	2001PZ M.Kallupatti	9.97083333	77.7958333	304.38	38.05
2	Usilampatti(EW)-2010	9.96333333	77.7883333	224.489	116.91
3	Usilampatti(OW)	9.96333333	77.7883333	224.799	80
4	Valandur(EW)	9.95	77.8827778	170.62	102
5	Valandur(OW-I)	9.95	77.8827778	170.525	86.43
6	Valandur(OW-II)	9.95	77.8827778	170.565	95
7	2004PZ Tirumangalam	9.92083333	77.8833333	134	54.25
8	Ekottapatty(EW)-2008	9.88333333	77.725	172.51	175
9	Mallapuram(EW)-2031	9.81944444	77.6708333	205.025	143
10	2003PZ Sellampatti	9.82083333	77.8041667	169.31	41.2
11	Thirali(EW)-2033	9.80416667	77.9458333	130.94	170.25
12	Thirali(OW)	9.80416667	77.9458333	131.34	170.25
13	Nilayur(EW)-2022	9.85833333	78.0166667	131.87	155
14	Nilayur(OW-I)	9.85833333	78.0166667	131.85	150.5
15	Nilayur(OW-II)	9.85833333	78.0166667	132.02	133.15
16	Thirupparankundram(EW)	9.89166667	78.0833333	139.88	202
17	2005PZ Valayankulam	9.80833333	78.0994444	134.65	47.1
18	Rajapalayam(EW)-4406	9.45138889	77.5638889	154.63	184.6
19	Rajapalayam(EW)-4428 (Head works)	9.49166667	77.4833333	176.995	200
20	Seithur(EW)-4405	9.41944444	77.4833333	165.525	200
21	Tiruchuli(EW)-4413	9.5375	78.2041667	60.285	77
22	Tiruchuli(SH)	9.53333333	78.2083333	60.86	100
23	P.Pudupatti(EW)-4414	9.6	78.1416667	70.195	100
24	Mantope(EW)-4412	9.64166667	78.0305556	100.584	100
25	Palayampatti(EW)-4429	9.53333333	78.1	98.229	100
26	Pulavaikarai(EW)	9.76388889	78.2194444	99	200
27	Aviyur(EW)	9.74305556	78.1069444	103	200
28	THalavaipuramRastha(EW)	9.39583333	77.4847222	163.475	180
29	Kariapatti(EW)-4404	9.68055556	78.1	89.605	185
30	Kariapatti(OW)	9.68055556	78.1	89.5	86.43
31	Kariyapatti	9.66944444	78.1083333	85.97	39.5
32	Talakal(EW-I)-2625	9.45833333	78.5416667	28.945	103.75
33	Talakal-II(OW)	9.45833333	78.5416667	28.24	103.75
34	Melperungarai(EW)-2617	9.56666667	78.4333333	47.78	57.73
35	Urakkudi(EHY-II)	9.50833333	78.4916667	46.71	69.5
36	2602PZ Abiramam	9.44027778	78.4513889	41.73	51.2
37	Pulvoykulam(EW)-2627	9.35833333	78.4972222	28.925	106.38

38	A.Poonavisal(EW)-2632	9.25	78.5	32.235	290.66
39	Valinokkam-EW-264	9.16805556	78.5061111	7	101
40	Theertandatanam	9.675	78.0805556	8	190
41	2601PZ Kamudhi	9.42361111	78.3555556	42.33	48.7

Sl no	Location	Depth 1	Depth 2	Formation
1	2001PZ M.Kallupatti	0	0	Alluvium
2	2001PZ M.Kallupatti	0	0	Cuddalore Formation
3	2001PZ M.Kallupatti	0	0	Eocene Formation
4	2001PZ M.Kallupatti	0	0	Cretaceous Formation
5	2001PZ M.Kallupatti	0	17.85	Weathered
6	2001PZ M.Kallupatti	17.85	28.5	Fracture
7	2001PZ M.Kallupatti	28.5	38.05	Massive
8	Usilampatti(EW)-2010	0	0	Alluvium
9	Usilampatti(EW)-2010	0	0	Cuddalore Formation
10	Usilampatti(EW)-2010	0	0	Eocene Formation
11	Usilampatti(EW)-2010	0	0	Cretaceous Formation
12	Usilampatti(EW)-2010	0	6	Weathered
13	Usilampatti(EW)-2010	6	98.05	Fracture
14	Usilampatti(EW)-2010	98.05	180	Massive
15	Usilampatti(OW)	0	0	Alluvium
16	Usilampatti(OW)	0	0	Cuddalore Formation
17	Usilampatti(OW)	0	0	Eocene Formation
18	Usilampatti(OW)	0	0	Cretaceous Formation
19	Usilampatti(OW)	0	6	Weathered
20	Usilampatti(OW)	6	45.71	Fracture
21	Usilampatti(OW)	45.71	116.91	Massive
22	Valandur(EW)	0	0	Alluvium
23	Valandur(EW)	0	0	Cuddalore Formation
24	Valandur(EW)	0	0	Eocene Formation
25	Valandur(EW)	0	0	Cretaceous Formation
26	Valandur(EW)	0	6	Weathered
27	Valandur(EW)	6	44.71	Fracture
28	Valandur(EW)	44.71	102	Massive
29	Valandur(OW-I)	0	0	Alluvium
30	Valandur(OW-I)	0	0	Cuddalore Formation
31	Valandur(OW-I)	0	0	Eocene Formation
32	Valandur(OW-I)	0	0	Cretaceous Formation
33	Valandur(OW-I)	0	6	Weathered
34	Valandur(OW-I)	6	6	Fracture
35	Valandur(OW-I)	6	86.43	Massive
36	Valandur(OW-II)	0	0	Alluvium

37	Valandur(OW-II)	0	0	Cuddalore Formation
38	Valandur(OW-II)	0	0	Eocene Formation
39	Valandur(OW-II)	0	0	Cretaceous Formation
40	Valandur(OW-II)	0	6	Weathered
41	Valandur(OW-II)	6	6	Fracture
42	Valandur(OW-II)	6	95	Massive
43	2004PZ Tirumangalam	0	0	Alluvium
44	2004PZ Tirumangalam	0	0	Cuddalore Formation
45	2004PZ Tirumangalam	0	0	Eocene Formation
46	2004PZ Tirumangalam	0	0	Cretaceous Formation
47	2004PZ Tirumangalam	0	17.7	Weathered
48	2004PZ Tirumangalam	17.7	34.8	Fracture
49	2004PZ Tirumangalam	34.8	47.1	Massive
50	Ekottapatty(EW)-2008	0	0	Alluvium
51	Ekottapatty(EW)-2008	0	0	Cuddalore Formation
52	Ekottapatty(EW)-2008	0	0	Eocene Formation
53	Ekottapatty(EW)-2008	0	0	Cretaceous Formation
54	Ekottapatty(EW)-2008	0	0	Weathered
55	Ekottapatty(EW)-2008	0	0	Fracture
56	Ekottapatty(EW)-2008	0	143	Massive
57	Mallapuram(EW)-2031	0	0	Alluvium
58	Mallapuram(EW)-2031	0	0	Cuddalore Formation
59	Mallapuram(EW)-2031	0	0	Eocene Formation
60	Mallapuram(EW)-2031	0	0	Cretaceous Formation
61	Mallapuram(EW)-2031	0	5.5	Weathered
62	Mallapuram(EW)-2031	5.5	96.05	Fracture
63	Mallapuram(EW)-2031	96.05	102	Massive
64	2003PZ Sellampatti	0	0	Alluvium
65	2003PZ Sellampatti	0	0	Cuddalore Formation
66	2003PZ Sellampatti	0	0	Eocene Formation
67	2003PZ Sellampatti	0	0	Cretaceous Formation
68	2003PZ Sellampatti	0	19.3	Weathered
69	2003PZ Sellampatti	19.3	36.3	Fracture
70	2003PZ Sellampatti	36.3	41.2	Massive
71	Thirali(EW)-2033	0	0	Alluvium
72	Thirali(EW)-2033	0	0	Cuddalore Formation
73	Thirali(EW)-2033	0	0	Eocene Formation
74	Thirali(EW)-2033	0	0	Cretaceous Formation
75	Thirali(EW)-2033	0	0	Weathered
76	Thirali(EW)-2033	0	0	Fracture
77	Thirali(EW)-2033	0	175	Massive
78	Thirali(OW)	0	0	Alluvium

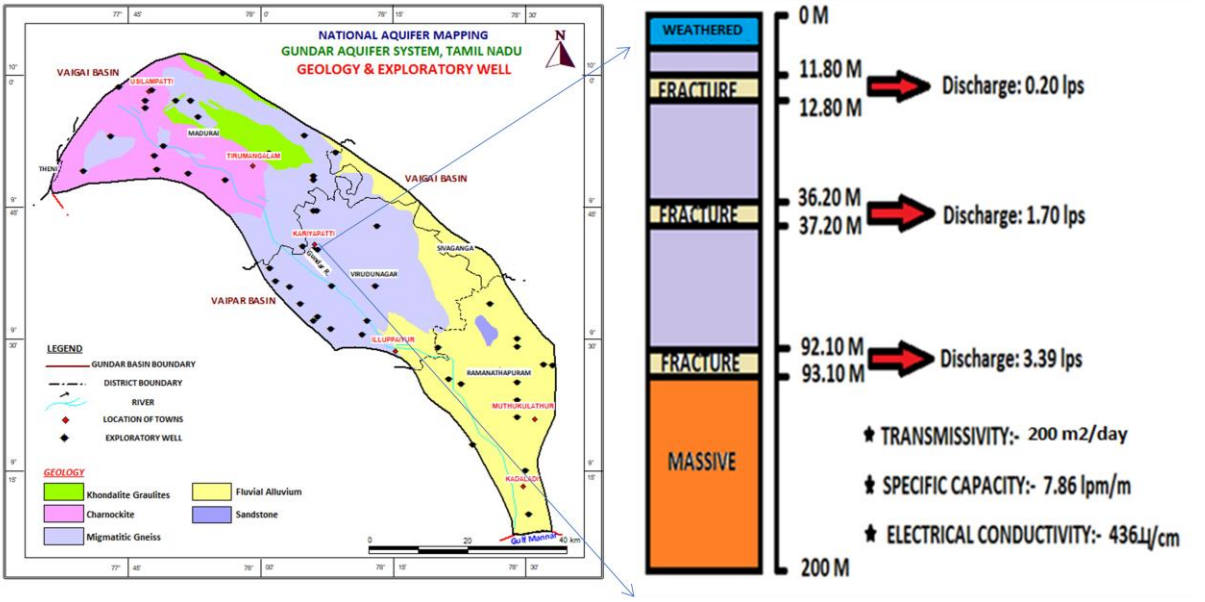
79	Thirali(OW)	0	0	Cuddalore Formation
80	Thirali(OW)	0	0	Eocene Formation
81	Thirali(OW)	0	0	Cretaceous Formation
82	Thirali(OW)	0	11	Weathered
83	Thirali(OW)	11	148.35	Fracture
84	Thirali(OW)	148.35	170.25	Massive
85	Nilayur(EW)-2022	0	0	Alluvium
86	Nilayur(EW)-2022	0	0	Cuddalore Formation
87	Nilayur(EW)-2022	0	0	Eocene Formation
88	Nilayur(EW)-2022	0	0	Cretaceous Formation
89	Nilayur(EW)-2022	0	6	Weathered
90	Nilayur(EW)-2022	6	173.25	Fracture
91	Nilayur(EW)-2022	173.25	202	Massive
92	Nilayur(OW-I)	0	0	Alluvium
93	Nilayur(OW-I)	0	0	Cuddalore Formation
94	Nilayur(OW-I)	0	0	Eocene Formation
95	Nilayur(OW-I)	0	0	Cretaceous Formation
96	Nilayur(OW-I)	0	6	Weathered
97	Nilayur(OW-I)	6	153.39	Fracture
98	Nilayur(OW-I)	153.39	155	Massive
99	Nilayur(OW-II)	0	0	Alluvium
100	Nilayur(OW-II)	0	0	Cuddalore Formation
101	Nilayur(OW-II)	0	0	Eocene Formation
102	Nilayur(OW-II)	0	0	Cretaceous Formation
103	Nilayur(OW-II)	0	6	Weathered
104	Nilayur(OW-II)	6	6	Fracture
105	Nilayur(OW-II)	6	150.5	Massive
106	Thirupparankundram(EW)-2015	0	0	Alluvium
107	Thirupparankundram(EW)-2015	0	0	Cuddalore Formation
108	Thirupparankundram(EW)-2015	0	0	Eocene Formation
109	Thirupparankundram(EW)-2015	0	0	Cretaceous Formation
110	Thirupparankundram(EW)-2015	0	5.5	Weathered
111	Thirupparankundram(EW)-2015	5.5	135	Fracture
112	Thirupparankundram(EW)-2015	135	180	Massive
113	2005PZ Valayankulam	0	0	Alluvium
114	2005PZ Valayankulam	0	0	Cuddalore Formation
115	2005PZ Valayankulam	0	0	Eocene Formation
116	2005PZ Valayankulam	0	0	Cretaceous Formation
117	2005PZ Valayankulam	0	5.5	Weathered
118	2005PZ Valayankulam	5.5	12.2	Fracture
119	2005PZ Valayankulam	12.2	43.2	Massive
120	Rajapalayam(EW)-4406	0	0	Alluvium

121	Rajapalayam(EW)-4406	0	0	Cuddalore Formation
122	Rajapalayam(EW)-4406	0	0	Eocene Formation
123	Rajapalayam(EW)-4406	0	0	Cretaceous Formation
124	Rajapalayam(EW)-4406	0	2.75	Weathered
125	Rajapalayam(EW)-4406	2.75	68	Fracture
126	Rajapalayam(EW)-4406	68	100	Massive
127	Rajapalayam(EW)-4428	0	0	Alluvium
128	Rajapalayam(EW)-4428	0	0	Cuddalore Formation
129	Rajapalayam(EW)-4428	0	0	Eocene Formation
130	Rajapalayam(EW)-4428	0	0	Cretaceous Formation
131	Rajapalayam(EW)-4428	0	12	Weathered
132	Rajapalayam(EW)-4428	12	20.1	Fracture
133	Rajapalayam(EW)-4428	20.1	180	Massive
134	Seithur(EW)-4405	0	0	Alluvium
135	Seithur(EW)-4405	0	0	Cuddalore Formation
136	Seithur(EW)-4405	0	0	Eocene Formation
137	Seithur(EW)-4405	0	0	Cretaceous Formation
138	Seithur(EW)-4405	0	11.3	Weathered
139	Seithur(EW)-4405	11.3	11.3	Fracture
140	Seithur(EW)-4405	11.3	184.6	Massive
141	Tiruchuli(EW)-4413	0	0	Alluvium
142	Tiruchuli(EW)-4413	0	0	Cuddalore Formation
143	Tiruchuli(EW)-4413	0	0	Eocene Formation
144	Tiruchuli(EW)-4413	0	0	Cretaceous Formation
145	Tiruchuli(EW)-4413	0	11.65	Weathered
146	Tiruchuli(EW)-4413	11.65	65	Fracture
147	Tiruchuli(EW)-4413	65	77	Massive
148	Tiruchuli(SH)	0	0	Alluvium
149	Tiruchuli(SH)	0	0	Cuddalore Formation
150	Tiruchuli(SH)	0	0	Eocene Formation
151	Tiruchuli(SH)	0	0	Cretaceous Formation
152	Tiruchuli(SH)	0	0	Weathered
153	Tiruchuli(SH)	0	93	Fracture
154	Tiruchuli(SH)	93	100	Massive
155	P.Pudupatti(EW)-4414	0	0	Alluvium
156	P.Pudupatti(EW)-4414	0	0	Cuddalore Formation
157	P.Pudupatti(EW)-4414	0	0	Eocene Formation
158	P.Pudupatti(EW)-4414	0	0	Cretaceous Formation
159	P.Pudupatti(EW)-4414	0	0	Weathered
160	P.Pudupatti(EW)-4414	0	93	Fracture
161	P.Pudupatti(EW)-4414	93	100	Massive
162	Mantope(EW)-4412	0	0	Alluvium

163	Mantope(EW)-4412	0	0	Cuddalore Formation
164	Mantope(EW)-4412	0	0	Eocene Formation
165	Mantope(EW)-4412	0	0	Cretaceous Formation
166	Mantope(EW)-4412	0	2.22	Weathered
167	Mantope(EW)-4412	2.22	2.22	Fracture
168	Mantope(EW)-4412	2.22	50	Massive
169	Palayampatti(EW)-4429	0	0	Alluvium
170	Palayampatti(EW)-4429	0	0	Cuddalore Formation
171	Palayampatti(EW)-4429	0	0	Eocene Formation
172	Palayampatti(EW)-4429	0	0	Cretaceous Formation
173	Palayampatti(EW)-4429	0	5.53	Weathered
174	Palayampatti(EW)-4429	5.53	41	Fracture
175	Palayampatti(EW)-4429	41	100	Massive
176	Pulavaikarai(EW)	0	0	Alluvium
177	Pulavaikarai(EW)	0	0	Cuddalore Formation
178	Pulavaikarai(EW)	0	0	Eocene Formation
179	Pulavaikarai(EW)	0	0	Cretaceous Formation
180	Pulavaikarai(EW)	0	11.5	Weathered
181	Pulavaikarai(EW)	11.5	165	Fracture
182	Pulavaikarai(EW)	165	174.9	Massive
183	Aviyur(EW)	0	0	Alluvium
184	Aviyur(EW)	0	0	Cuddalore Formation
185	Aviyur(EW)	0	0	Eocene Formation
186	Aviyur(EW)	0	0	Cretaceous Formation
187	Aviyur(EW)	0	23.9	Weathered
188	Aviyur(EW)	23.9	106	Fracture
189	Aviyur(EW)	106	200	Massive
190	THalavaipuramRastha(EW)-4416	0	0	Alluvium
191	THalavaipuramRastha(EW)-4416	0	0	Cuddalore Formation
192	THalavaipuramRastha(EW)-4416	0	0	Eocene Formation
193	THalavaipuramRastha(EW)-4416	0	0	Cretaceous Formation
194	THalavaipuramRastha(EW)-4416	0	6.6	Weathered
195	THalavaipuramRastha(EW)-4416	6.6	6.6	Fracture
196	THalavaipuramRastha(EW)-4416	6.6	200	Massive
197	Kariapatti(EW)-4404	0	0	Alluvium
198	Kariapatti(EW)-4404	0	0	Cuddalore Formation
199	Kariapatti(EW)-4404	0	0	Eocene Formation
200	Kariapatti(EW)-4404	0	0	Cretaceous Formation
201	Kariapatti(EW)-4404	0	6.1	Weathered
202	Kariapatti(EW)-4404	6.1	28.1	Fracture
203	Kariapatti(EW)-4404	28.1	160.3	Massive
204	Kariapatti(OW)	0	0	Alluvium

205	Kariapatti(OW)	0	0	Cuddalore Formation
206	Kariapatti(OW)	0	0	Eocene Formation
207	Kariapatti(OW)	0	0	Cretaceous Formation
208	Kariapatti(OW)	0	0	Weathered
209	Kariapatti(OW)	0	9.4	Fracture
210	Kariapatti(OW)	9.4	185	Massive
211	Kariyapatti	0	0	Alluvium
212	Kariyapatti	0	0	Cuddalore Formation
213	Kariyapatti	0	0	Eocene Formation
214	Kariyapatti	0	0	Cretaceous Formation
215	Kariyapatti	0	11.5	Weathered
216	Kariyapatti	11.5	172.6	Fracture
217	Kariyapatti	172.6	200	Massive
218	Talakal(EW-I)-2625	0	13	Alluvium
219	Talakal(EW-I)-2625	13	72	Cuddalore Formation
220	Talakal(EW-I)-2625	72	156	Eocene Formation
221	Talakal(EW-I)-2625	156	378	Cretaceous Formation
222	Talakal(EW-I)-2625	378	388	Weathered
223	Talakal(EW-I)-2625	388	388	Fracture
224	Talakal(EW-I)-2625	388	388	Massive
225	Talakal-II(OW)	0	12	Alluvium
226	Talakal-II(OW)	12	70	Cuddalore Formation
227	Talakal-II(OW)	70	160	Eocene Formation
228	Talakal-II(OW)	160	378	Cretaceous Formation
229	Talakal-II(OW)	378	386	Weathered
230	Talakal-II(OW)	386	386	Fracture
231	Talakal-II(OW)	386	386	Massive
232	Melperungarai(EW)-2617	0	5	Alluvium
233	Melperungarai(EW)-2617	5	48.71	Cuddalore Formation
234	Melperungarai(EW)-2617	48.71	57.73	Eocene Formation
235	Melperungarai(EW)-2617	57.73	57.73	Cretaceous Formation
236	Melperungarai(EW)-2617	57.73	57.73	Weathered
237	Melperungarai(EW)-2617	57.73	57.73	Fracture
238	Melperungarai(EW)-2617	57.73	57.73	Massive
239	Urakkudi(EHY-II)	0	10	Alluvium
240	Urakkudi(EHY-II)	10	28	Cuddalore Formation
241	Urakkudi(EHY-II)	28	40.12	Eocene Formation
242	Urakkudi(EHY-II)	40.12	69.7	Cretaceous Formation
243	Urakkudi(EHY-II)	69.7	69.7	Weathered
244	Urakkudi(EHY-II)	69.7	69.7	Fracture
245	Urakkudi(EHY-II)	69.7	69.7	Massive
246	2602PZ Abiramam	0	5	Alluvium

247	2602PZ Abiramam	5	33.5	Cuddalore Formation
248	2602PZ Abiramam	33.5	33.5	Eocene Formation
249	2602PZ Abiramam	33.5	33.5	Cretaceous Formation
250	2602PZ Abiramam	33.5	33.5	Weathered
251	2602PZ Abiramam	33.5	41.4	Fracture
252	2602PZ Abiramam	41.4	51.2	Massive
253	Pulvoykulam(EW)-2627	0	40	Alluvium
254	Pulvoykulam(EW)-2627	40	95	Cuddalore Formation
255	Pulvoykulam(EW)-2627	95	106	Eocene Formation
256	Pulvoykulam(EW)-2627	106	106	Cretaceous Formation
257	Pulvoykulam(EW)-2627	106	106	Weathered
258	Pulvoykulam(EW)-2627	106	106	Fracture
259	Pulvoykulam(EW)-2627	106	106	Massive
260	A.Poonavisal(EW)-2632	0	46	Alluvium
261	A.Poonavisal(EW)-2632	46	85	Cuddalore Formation
262	A.Poonavisal(EW)-2632	85	152	Eocene Formation
263	A.Poonavisal(EW)-2632	152	290.66	Cretaceous Formation
264	A.Poonavisal(EW)-2632	290.66	290.66	Weathered
265	A.Poonavisal(EW)-2632	290.66	290.66	Fracture
266	A.Poonavisal(EW)-2632	290.66	290.66	Massive
267	Valinokkam-EW-264	0	55	Alluvium
268	Valinokkam-EW-264	55	101	Cuddalore Formation
269	Valinokkam-EW-264	101	101	Eocene Formation
270	Valinokkam-EW-264	101	101	Cretaceous Formation
271	Valinokkam-EW-264	101	101	Weathered
272	Valinokkam-EW-264	101	101	Fracture
273	Valinokkam-EW-264	101	101	Massive
274	Theertandatanam	0	20	Alluvium
275	Theertandatanam	20	80	Cuddalore Formation
276	Theertandatanam	80	125	Eocene Formation
277	Theertandatanam	125	190	Cretaceous Formation
278	Theertandatanam	190	190	Weathered
279	Theertandatanam	190	190	Fracture
280	Theertandatanam	190	190	Massive
281	2601PZ Kamudhi	0	8.5	Alluvium
282	2601PZ Kamudhi	8.5	8.5	Cuddalore Formation
283	2601PZ Kamudhi	8.5	8.5	Eocene Formation
284	2601PZ Kamudhi	8.5	8.5	Cretaceous Formation
285	2601PZ Kamudhi	8.5	11.5	Weathered
286	2601PZ Kamudhi	11.5	58.22	Fracture
287	2601PZ Kamudhi	58.22	125	Massive



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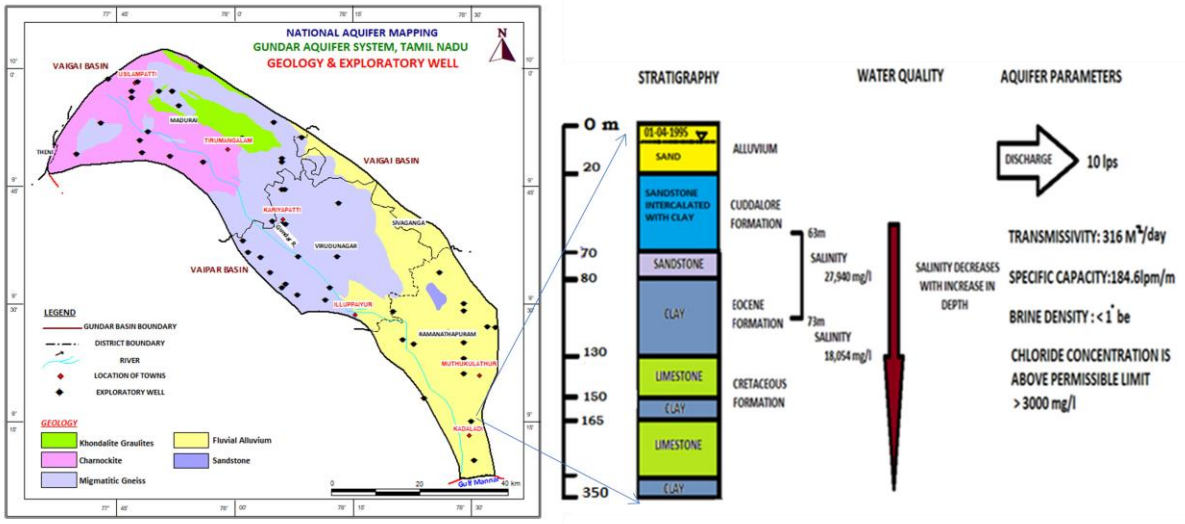


THEERTHANANDHATHANAM, RAMANATHAPURAM

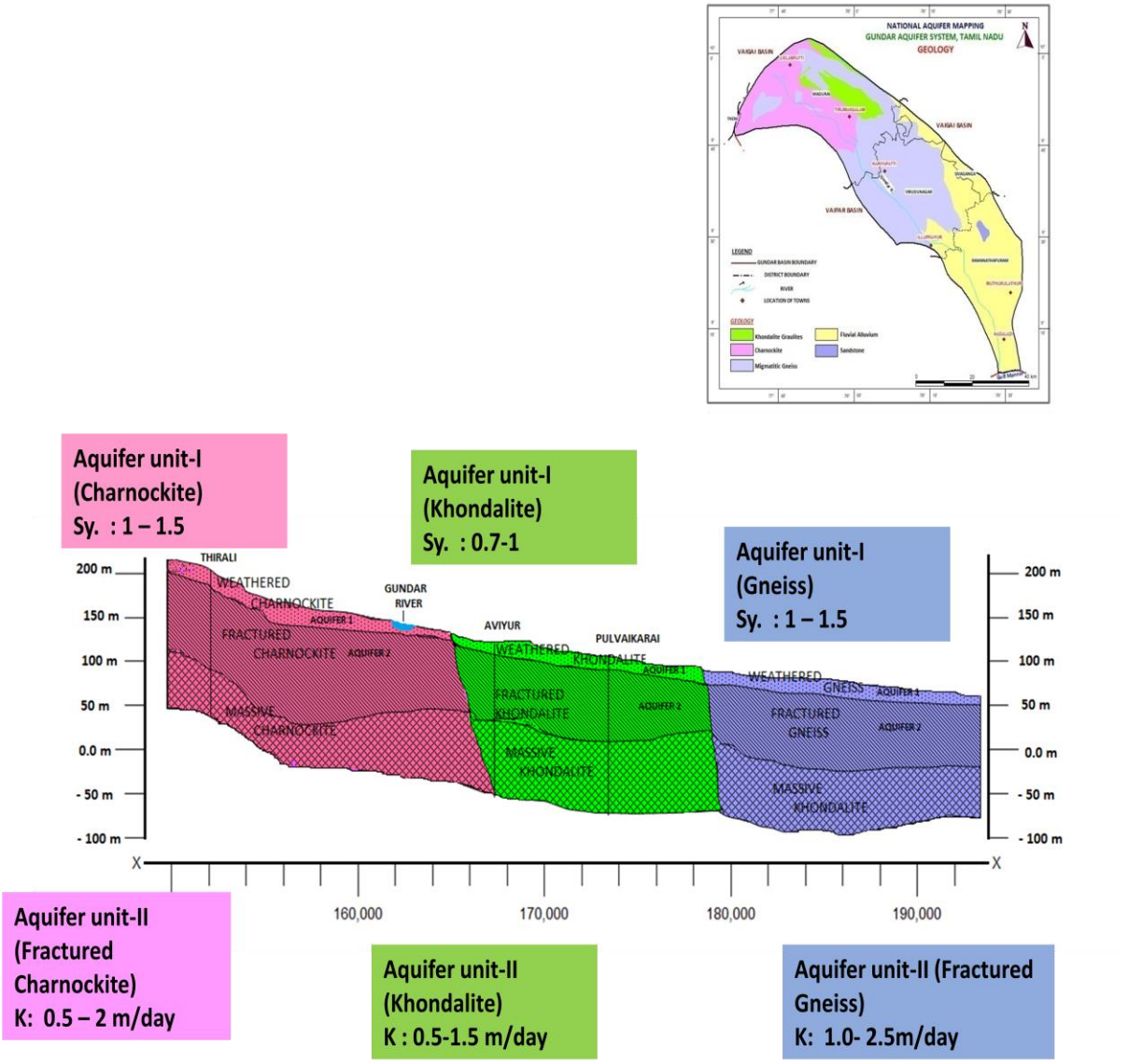


Figure 27: 2D Aquifer Disposition along A-A' (NE-SW direction in Hard rock terrain of the Gundar Aquifer system).

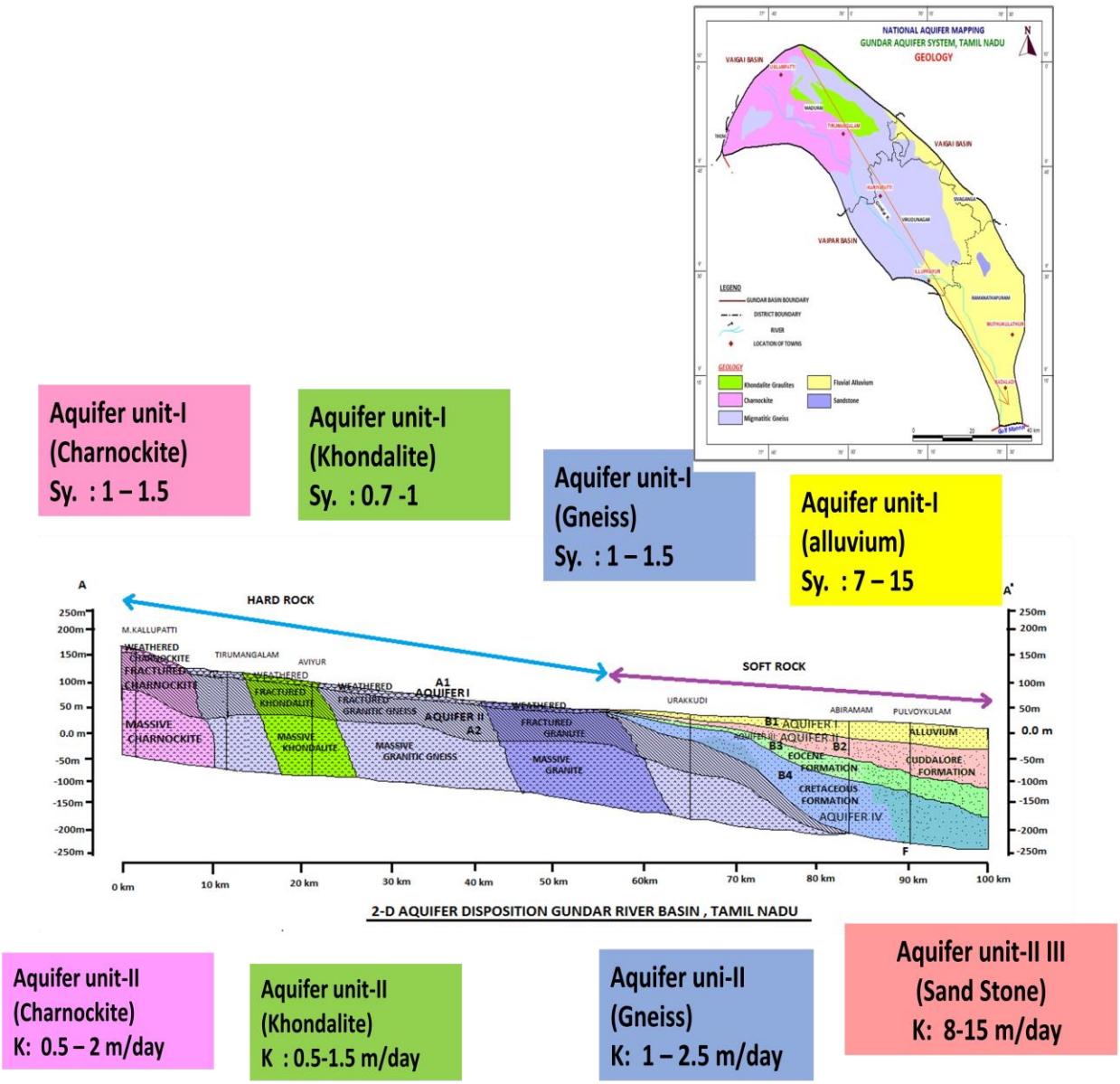


Figure 28: 2D Aquifer Disposition along D-D' (NW-SE direction of the Gundar Aquifer system).

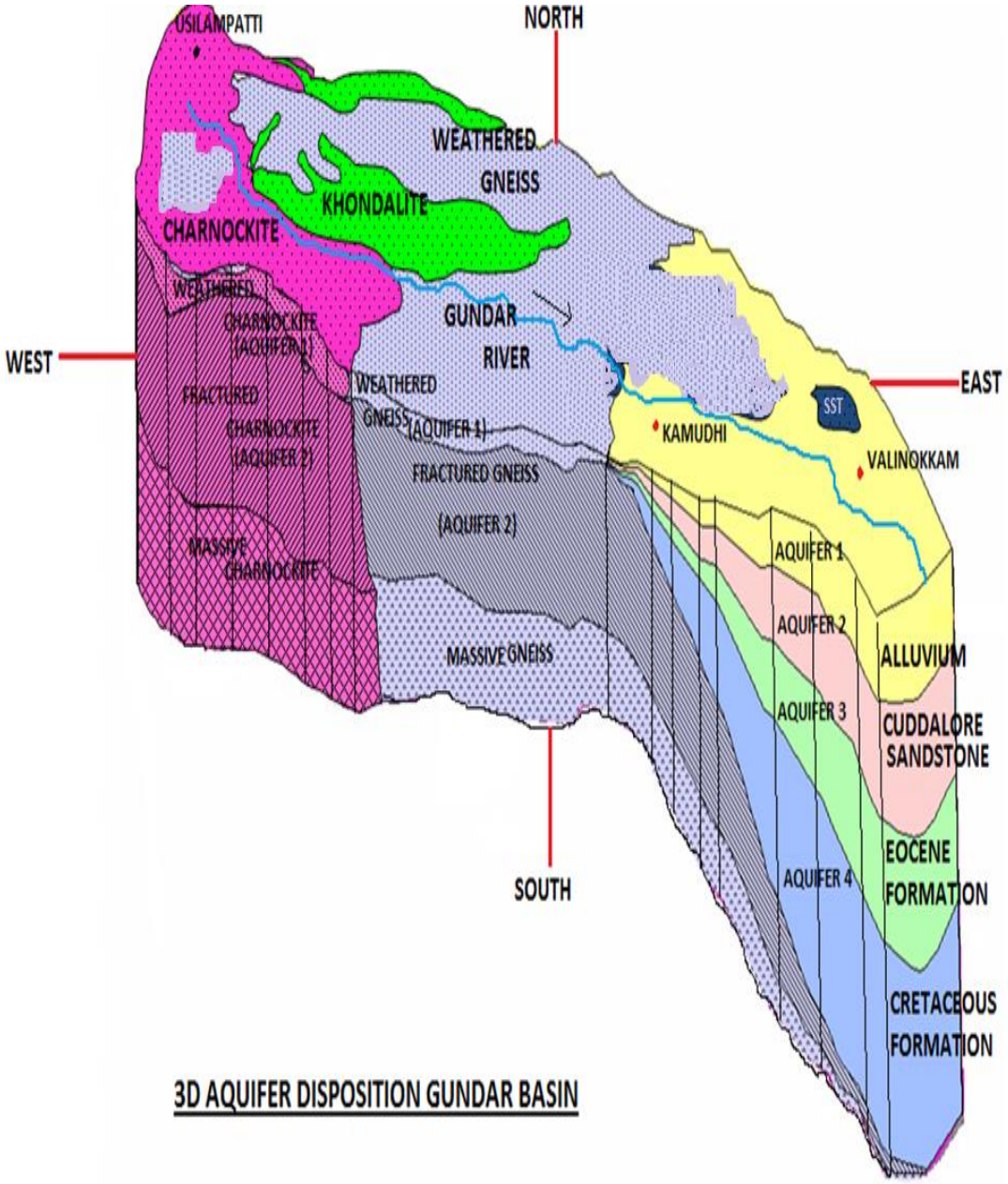


Figure 29: 3D Aquifer Disposition of the Gundar Aquifer system.

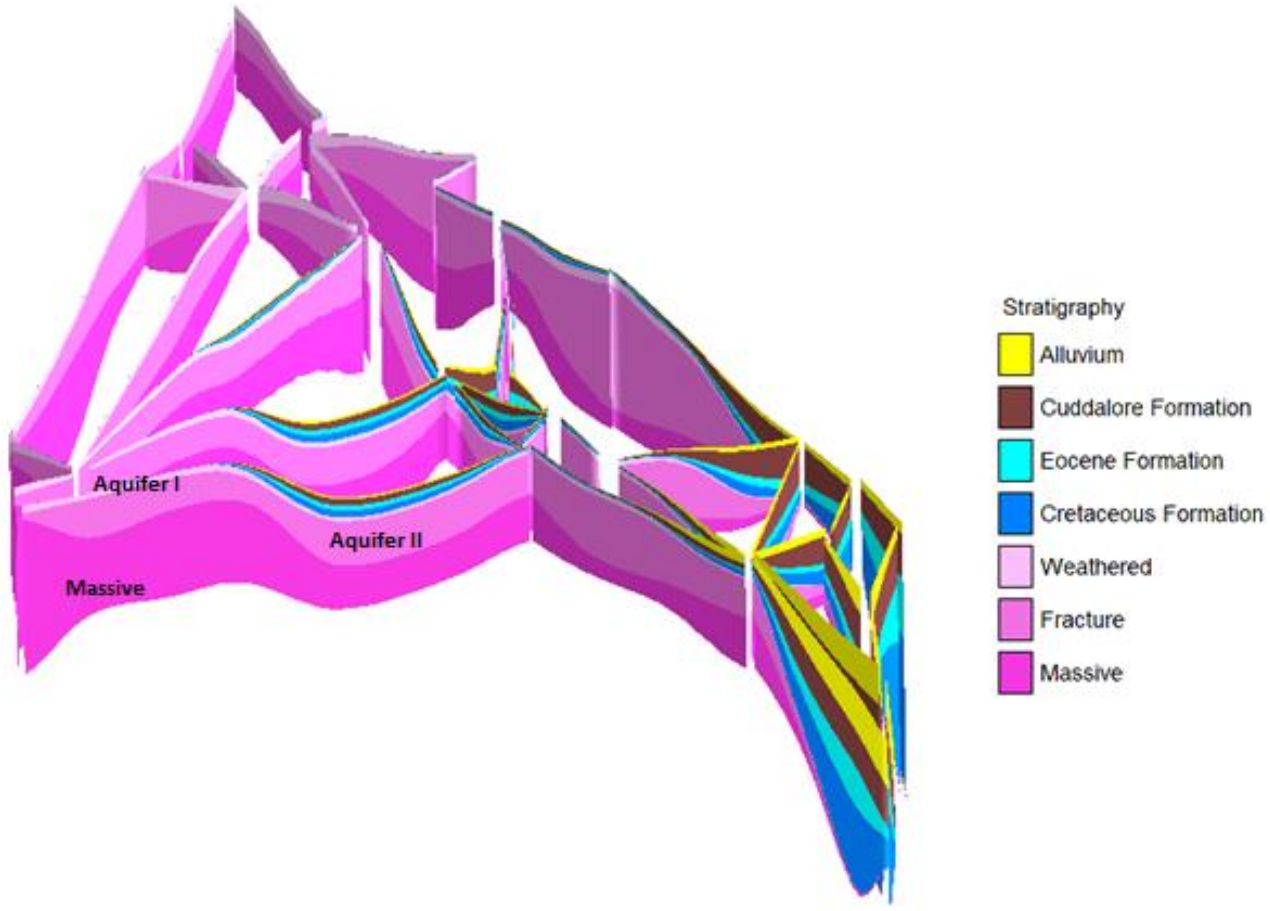


Figure 30: Fence Diagram of the Gundar Aquifer system.

4.0. GROUNDWATER RESOURCES:

The dynamic groundwater resources have been estimated as on 2017 based on the methodology suggested by Ground Water Estimation Committee (GEC) 2015.

The groundwater recharge is calculated both by groundwater fluctuation-specific yield method and by rainfall infiltration method. The annual replenishablegroundwater recharge is the summation of four components viz.

i) Monsoon recharge due to rainfall

ii) Monsoon recharge from other sources

iii) Non-monsoon recharge due to rainfall

iv) Non-monsoon recharge due to other sources

Firka-wise dynamic groundwater resources have been taken from the approved resources estimation done as on March 2017, jointly by State PWD of Tamil Nadu and CGWB, to arrive at the total resources available in the study basin. A total of 33 Firkas are falling in the study area.

4.1. Annual Extractable Groundwater Resources:

The annual extractable groundwater resources availability refers to the available annual recharge after allowing for natural discharge in the monsoon season in terms of base flow and subsurface inflow/outflow. This annual extractable groundwater resources includes the existing groundwater withdrawal, natural discharge due to base flow and subsurface inflow/ outflow in the monsoon season and availability for future development. As the groundwater development progresses the natural discharge gets suitably modified and comes down to negligible quantities due to interception by different groundwater structures. Hence, natural discharges in the monsoon season may not be considered and the total annual groundwater recharge may be taken as annual extractable groundwater resources.The annual extractable groundwater resources of the basin for the year 2017 is arrived at 54389 Ham.

4.2. Annual Groundwater Extraction

The gross annual groundwater extraction has been assessed by using Unit draft method for irrigation draft component and by adopting formula suggested by GEC 2015 for domestic and industrial draft components. The existing annual groundwater extraction of the basin for the year 2017 is arrived at 37385 Ham, and the groundwater draft district is 19507 ham.**(Figure 31).**

4.3. Stage of Groundwater Extraction and Categorization:

The stage of groundwater extraction is defined by

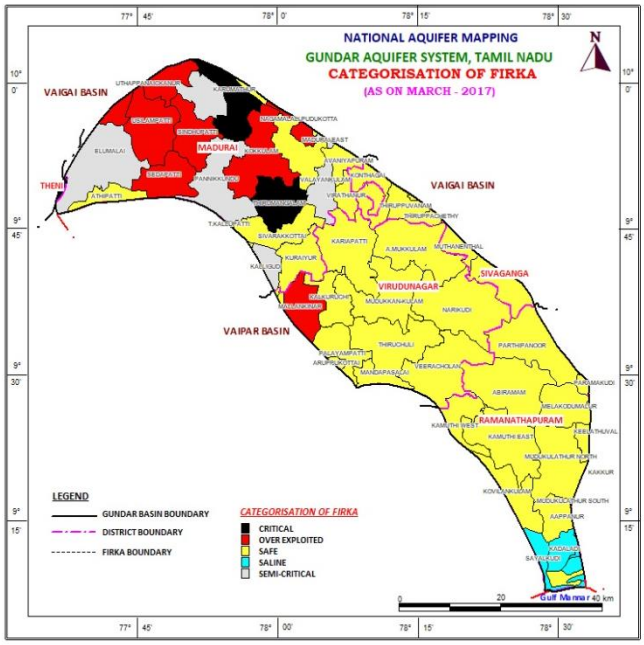
Stage of groundwater extraction (%) = (Existing gross annual groundwater extraction/ Annual extractable groundwater resources) x 100

Based on the stage of groundwater extraction four categories i.e. **a) Safe, b) Semi-critical, c) Critical and d) Over-exploited** have been suggested by GEC-2015.

The stage of groundwater extraction is calculated for all the 33 firkas of the aquifer system.

Based on the above categorization 5 out of the 33 firkas of the Gundar aquifer system falls under over exploited and critical categories. In Madurai district out of 13Firkas3 firkas falls in over exploited and 1 in critical categoriesand 9firkas falls under semi-critical and safe categories. In Virudhunagar district out of 9firkas, 1 fall in OE and the remaining are categorized under semi-critical and safe categories (**Figure 32**). The total stage of extraction of Gundaraquifer system is 52%

Groundwater Resources and stage of Groundwater Extraction – Gundar Aquifer System



Total firkas -33

OE - 4

Critical - 1

Semicritical - 4

Saline -1

Figure 31. Groundwater resources in Gundar aquifer system

District	2013		2017		
	Resources	Draft	Resources	Draft	Stage
Madurai	17352	13233	16146.99	12657.29	78
Virudhunagar	17068	4076.4	16573.8	4080.119	25
Ramanathapuram	15010	1963.54	14951.28	1980.46	13
Sivaganga	4959.48	1017.21	4629.472	789.24	17
Total Basin (ha m)	**54389.48**	**20290.15**	**37385.12**	**19507.11**	52
Total Basin (MCM)	**543.89**	**202.90**	**373.85**	**195.07**	

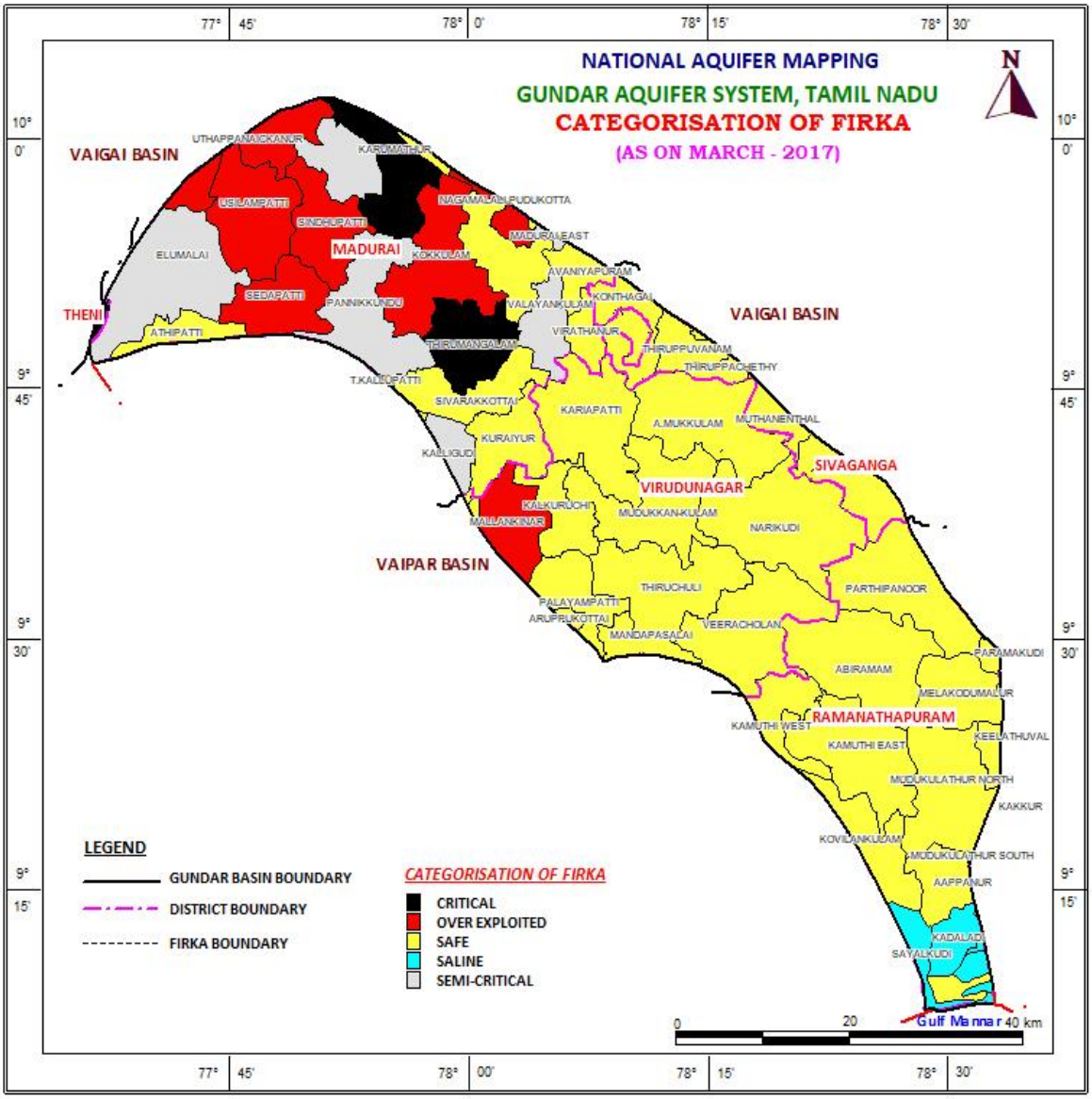


Figure 32. Categorisation of assessment units in Gundar aquifer system

Identification of Recharge Zones aided through Geophysical Studies, Lineaments and fractures

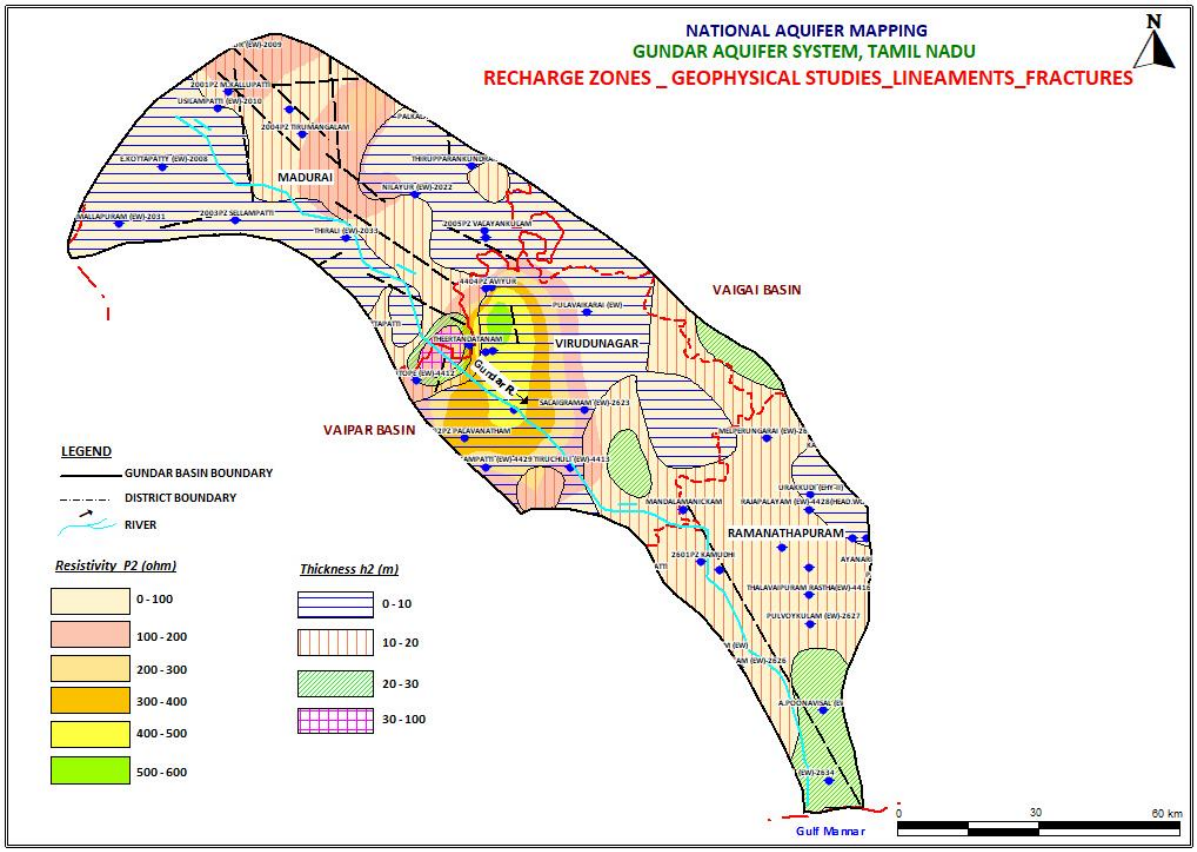


Figure 33. Groundwater potential zones in Gundar aquifer system

Structural features in hard rocks, such as faults, dykes, contacts of zones of deep weathering are often recognized on the surface from remote sensing data as lineaments, ie linear differences in soil tone, vegetation, topographic relief linear components of drainage systems or a combination of these. Lineament studies have their gretest application for locating vertical and near vertical zones of fracturing in consolidated rocks with low primary porosity.

A number of lineaments have been identified from the satellite imagery, which have been digitized. The major linear features identified from the imagery are shown in **Figure 33.**

VES data of 48 locations in the basin have been interpreted to verify the existence of structurally weak zones and to decipher the depth of weathered rocks. The locations of the vertical electrical soundings are shown in Figure 33. The average values of apparent resistivities and the correspondingly high thicknesses of subsurface lithounits shown in most of the cases are indicators of structurally weak zones, which are important from the point of view of ground water development/ recharge.
Salient interpretations made through the analysis of data **(Table 16)** are detailed

- 4 high yielding wells located along the NW-SE trending lineaments
- The high yielding well have more sets of fractures

- Lineament density high in this area indicating structural disturbance
- Low resistivity values ranging from 200 to 300 ohm m at 100 m depth.
- Potential shallow fractures within a depth of 50 mtrs yield above 10 lps
- Over exploited firkas along this zone indicating high groundwater development
- Deep water levels
- Low resistivity values are indicators of structurally weak zones
- NW-SE trending lineaments potential in nature
- Sustainable groundwater yields at depths ranging between 100 – 150 m
  Shallow fractures, dense lineaments, deep water levels, high yields indicative of recharge zone.

The potential groundwater zones identified through this method will aid in focused interventions addressing groundwater sustainability.

Table16 : Exploratory well analysed to interpret groundwater potential zones

Sl no.	**Bore wells**	**Geology, lineament direction**	**Drilled depths**	**Yield (lps)**	**Fractures encountered at**			
					F1	F2	F3	F4
1	Uthapanayakannur	Quartzite and Granite Gneiss/ NW-SE trending	10	2.9	10.23-11	18.85-19	63.75	98.05
2	M Kallupatti	Quartzite and Granite Gneiss/ NW-SE	39	0.441	28.4 -28.5			
3	Usilampatti(EW)-2010	Biotite Gneiss &Charnockite/ Interconnecting NW-SE and N-S	116	21.72	31.47-32	35.09-36	45	
4	Velandhur	Quartzite and Granite Gneiss, NW-SE	102	21.78	8.61	15.23	44.71	
5	Kottepatty	Granite Charnockite	175					
6	Thirumangalam	Charnockite	54.25	0.078	49.6			
7	Thiruparrankundram	Gneiss/ Granite Quartzite &Charnockite	202		79-80	173-174		
8	Sellampatti	Charnockite	41.2	1.79	19.2			
9	Nilayur	Granite Gneiss &Charnockite/NW-SE	155	14.01	64-65	153-154		
10	Thirali	Granite Gneiss and Charnockite	170.25	5	16.5-17	32.47-33	148.35	
11	Valayankulam	Granite Gneiss	201	1.2				

5.0. GROUNDWATER RELATED ISSUES:

Groundwater is extensively utilized for irrigation in the entire basin area for the past two decades, especially in the 4 over-exploited and 1 critical firkas out of the 33 firkas of the study area. Anthropogenic contamination in the basin is restricted to the urbanized centers of Madurai area.

5.1.Geographical distribution & Resource Availability:

In the study area northern and northwestern part is reeling under over development. Over all out of 33 firkas of the study areas 4 firkas are over exploited and 1 critical.In these areas the groundwater has been extensively developed by constructing groundwater abstraction structures like dug wells, dug cum borewells and borewells. Groundwater development in these firkas is to be restricted

Further, there is ample scope for groundwater development in the 27safe and semi-critical firkas. Whereas these area are under developed due to the poor aquifer system developed in the area. Based on the out put of the aquifer mapping studies a management plan is chalked out for the further management of resources available in the aquifer system.

5.2. Massive formation and Poor Aquifer:

Fracture analysis of the borewells drilled in the study area reveals that the almost entire area is covered under hard rock terrain represented by Region A-Charnockite&Khondalite group of rocks and Region B- Gneiss group of rock. In both the region the rocks are massive in nature. In the Region-A most of the fractures occurs within 40-60 m bgl and the frequency of occurrence of fractures are promising in these depth zone. In some area the fracture system exist upto the depth of 197 m bgl, but the frequency of occurrence of fractures in these depth ranges is low. In Region B-Gneiss rock terrain most of the fractures occurs within the depth range of 60-80 m bgl. In Granitic Gneiss region most of the fractures area confined to 100 – 150 m bgl. Comparatively Charnockite are more massive than granitic gneiss and it occupies about 30% of the study basin. In these areas water scarcity problem exist and the people are struggling to meet their domestic demands.

5.3. Future Demand Scenario and Stress on Aquifer system:

Future groundwater demand projected for domestic utilization upto the year 2025 is calculated as 24 MCM. This will have minimal additional stress on the aquifer system compared to the existing groundwater draft. However, draft can be regulated through increasing the water efficiency practices in irrigation sector. Already the dependency on groundwater for domestic and drinking needs is decreasing in groundwater contaminated areas as the alternative surface/ river sources are being harnessed.

6.0 AQUIFER MANAGEMENT PLAN

Management Strategies

Both supply side and demand side interventions are required for efficient management of groundwater resources within the Gundar aquifer system. About 4firkas within the Gundar Aquifer Systemare categorised as over exploited and 1 firkaas critical. The Net availability of the resource is 373.85MCM. The total ground water demand for the basin is 195.05 MCM. Based on the supply of groundwater resources, the stage of groundwater development of the basin is 52%. The stage of groundwater development of the over exploited and critical firkas are 104% (based on 2017). To bring safe groundwater development, 33% of groundwater development should be added to the groundwater system of the basin. Therefore, supply side

intervention is proposed in the basin through groundwater augmentation plan as sufficient uncommitted surplus runoff of 142 MCM is available in the basin. The most acceptable method for augmentation plan is artificial recharge to groundwater.

6.1 Supply side intervention

Based on the water level monitoring in different seasons across the basin, as well as after having better understanding of the disposition and extent of the aquifer system through exploratory drilling, pumping tests etc. the volume of unsaturated zone available for recharge (upto 3m bgl) is 23MCM. The annual uncommitted runoff is 38MCM and 55% of water from uncommitted runoff is required to fill the available void space of aquifer-I. Artificial recharge and Water conservation plan is prepared firka wise in the basin to harness 8 MCM of water with a total out lay of Rs. 12 Crores. The suggested artificial recharge structures are mainly Nala bunds, Check Dams and Recharge Shafts in addition to removal of silt in the surface tanks.

A total number of 37 check dams, 56 Nala bunds and 78 recharge shafts are proposed in the OE and critical firkas of the basin. A total number of 234 Recharge Rejuvenation Ponds are selected for desilting followed by construction of recharge shafts within the tanks. The expected recharge through these artificial recharge structures is 8 MCM which contributes 21% of the 38MCM. The stage of groundwater development would reduce from 104 % to 79% through these techniques.

Water Conservation Plan

A total number of 1444 recharge ponds covering an area of 722 sq km is proposed which will act as storage tanks in farm as well as augment groundwater recharge and the expected annual groundwater recharge through these ponds are in the order of 0.43MCM. The recharge pond area has been selected based on the wet and dry crop area from the landuse / landcover maps using remote sensing data.

6.2 Demand side Management Plan

Demand side management can be accomplished through modification in the irrigation practice. It is recommended to modify the irrigation pattern and practices for paddy, Sugarcane and Banana crops. The general practice for paddy irrigation is by flooding method. It is recommended for ridge and furrow method instead of flooding method in 164.25 sq.km and this would save 4 MCM of water annually (**Figure 33**).

Similarly, for sugarcane and banana crops shift from flooding method to drip irrigation would save 3.5 MCM and 0.58 MCM respectively. The total water saved is 8.5 MCM. The total cost for the change in the irrigation pattern for those water intensive crops would be 11crores.

Aquifer management plan for Gundar Basin

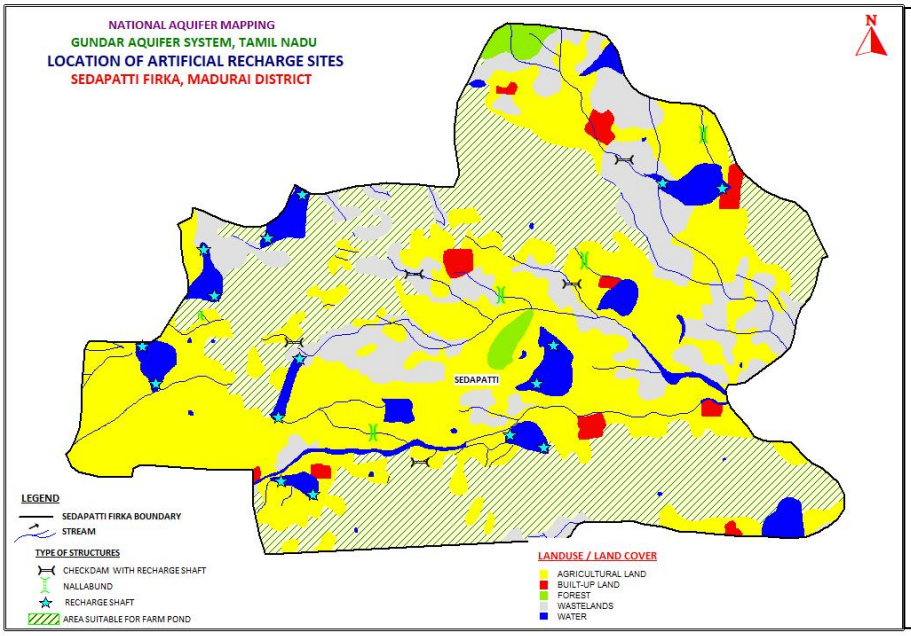
ARTIFICIAL RECHARGE /CONSERVATION MEASURES		
Artificial Recharge Structures Proposed	**Masonry Check dams :** **Nala bunds :** **Recharge shafts :** **RRR ponds with Recharge shafts :**	**37** **56** **78** **234**
Water Conservation Measure ( )	**Recharge Ponds :**	**275**

Tentative total cost of the project (Rs.)	**:**	**12 Cr**
Vol. of unsaturated zone available for Recharge (upto 3m bgl)		**22.539 MCM**
Uncommitted Surplus runoff		**38.223 MCM**
Harnessable runoff		**36 MCM**
Expected recharge		**7.65 MCM**
Additional Potential created for 7.65 MCM of recharge		
Expected outcome	**(OR)** **Arrest Decline in Groundwater levels (or)** **Increase pumping hours (or)** **Increase in sustainability of well yield (or)**	

The stage of groundwater development of the OE and critical firkas would reduce from 124 % to 83% by managing supply and demand side intervention.

FIRKA WISE AQUIFER MANAGEMENT PLAN (OE and Critical firkas)

Management Plan-Sedapattifirka, Madurai District:

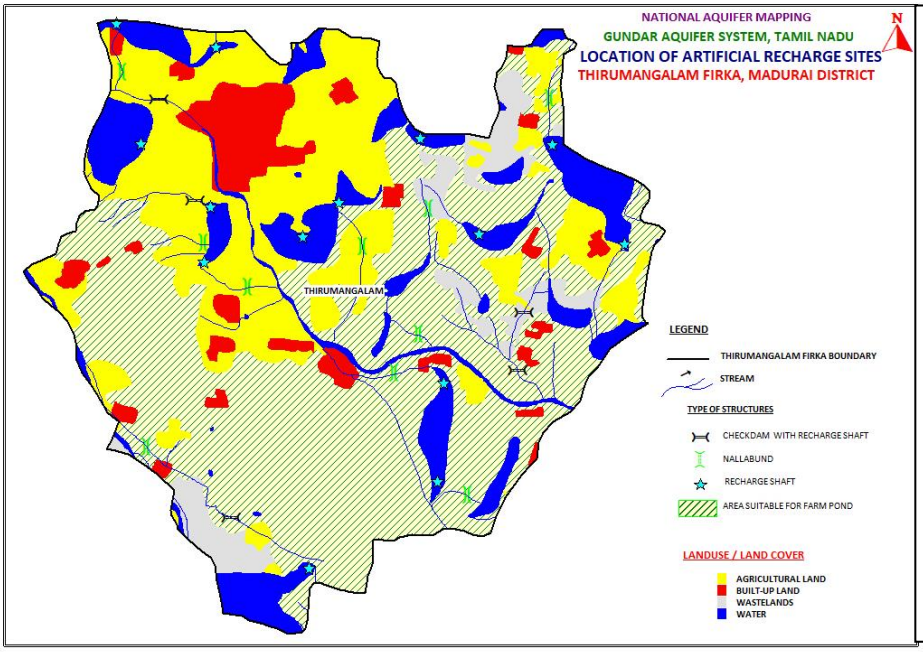


Artificial Rechage/ conservation Structures proposed

- No. of Check Dams- 5
- No. of Nala Bunds – 6
- No. of RR and RS - 13
- No. of Farm ponds - 35

Area	: **73.52 Km**
Monsoon Rainfall	: **610 mm**
Stage of groundwater development	: **101 %**
Uncommitted surface runoff/flow	: **6.72 MCM.**
Total volume of Weathered zone available (Rechargeable)	: **8.82 MCM. (8.00m thickness)**
Total volume of weathered zone available (Rechargeable)	: **5.51 MCM (at 5 m thickness).**
Area are suitable for recharge	: **75 % (As per integration studies)**
Quantity Rechargeable	:**3.23 MCM**
Effect on Water Level	: **3.45 m rise**

Management Plan-Thirumangalamfirka, Madurai District:

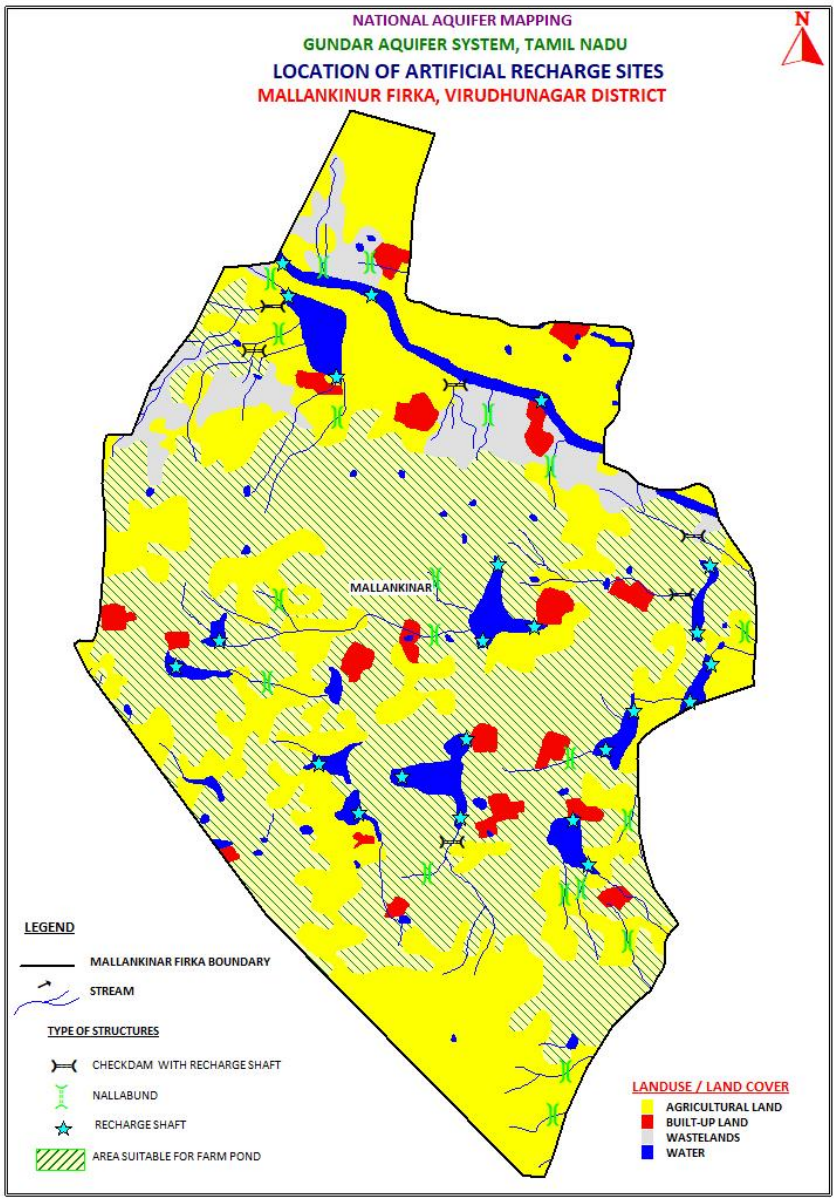


Artificial Rechage/ conservation Structures proposed

- No. of Check Dams- 5
- No. of Nala Bunds – 10
- No. of RR and RS - 13
- No. of Farm ponds - 40

Area	: **71.21sq km**
Monsoon Rainfall	: **539 mm**
Stage of groundwater development	: **95 %**
Uncommitted surface runoff/flow	: **5.75 MCM.**
Total volume of Weathered zone available (Rechargeable)	: **8.54 MCM. (8.00m thickness)**
Total volume of weathered zone available (Rechargeable)	: **5.34 MCM (at 5 m thickness).**
Area are suitable for recharge	: **75 % (As per integration studies)**
Quantity Rechargeable	: **2.62 MCM**
Effect on Water Level	: **2.89 m rise**

Management Plan-Malankinarfirka, Virudhunagar District:

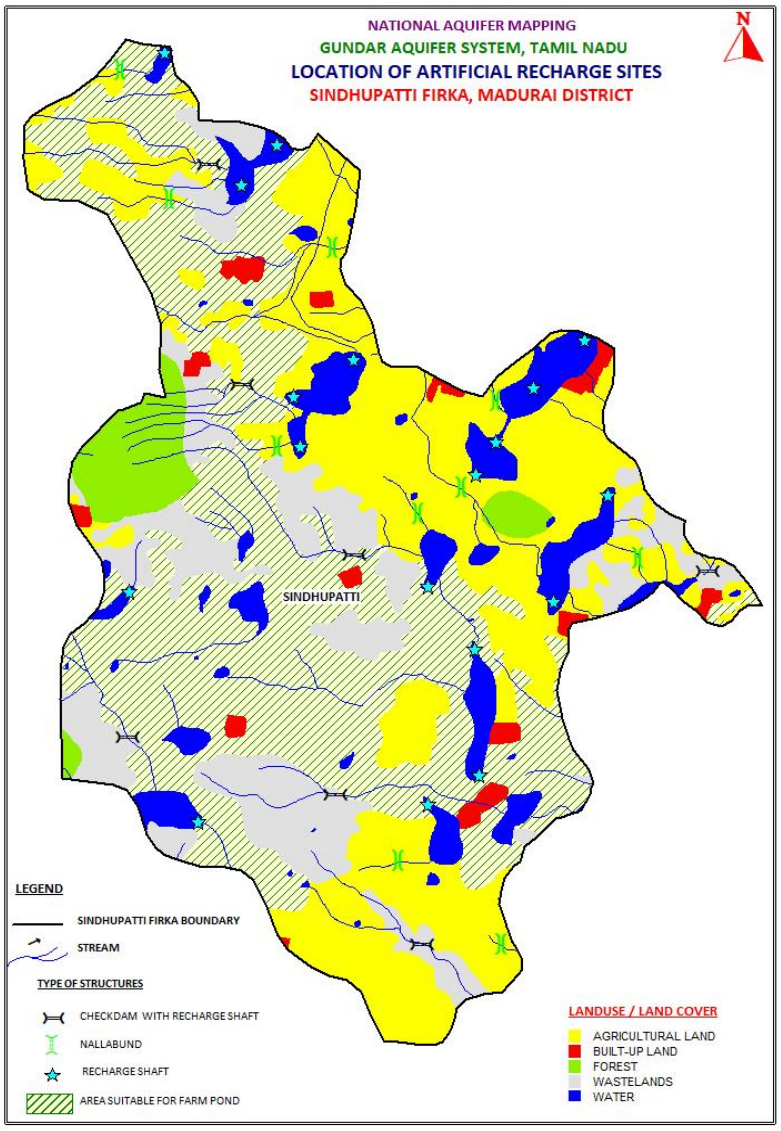


Artificial conservation proposed Rechage/ Structures

- No. of Check Dams- 5
- No. of Nala Bunds – 10
- No. of RR and RS - 13
- No. of Farm ponds - 40

Area	: **89.23 sq km**
Monsoon Rainfall	: **558 mm**
Stage of groundwater development	: **103%**
Uncommitted surface runoff/flow	: **7.46 MCM.**
Total volume of Weathered zone available (Rechargeable)	: **10.70 MCM. (8.00m thickness)**
Total volume of weathered zone available (Rechargeable)	: **6.69 MCM (at 5 m thickness).**
Area suitable for recharge	: **75 % (As per integration studies)**
Quantity Rechargeable	: **2.94 MCM**
Effect on Water Level	: **2.59 m rise**

Management Plan-Sindhupattifirka, Madurai District:

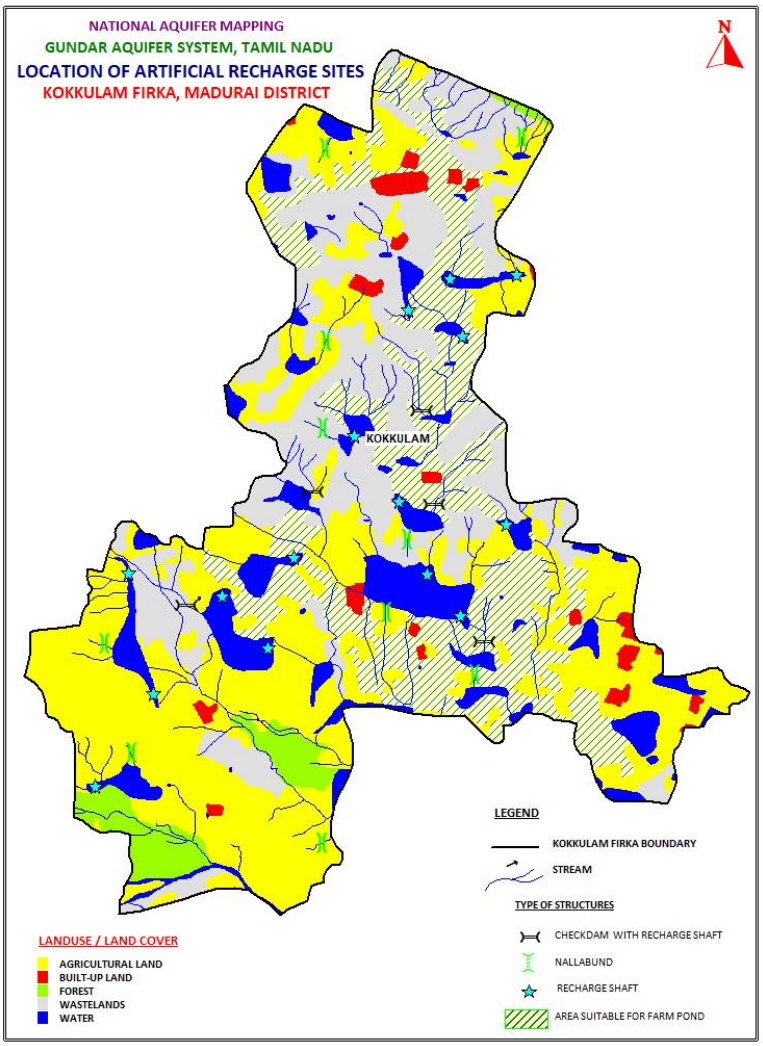


Artificial Rechage/ conservation Structures proposed

- No. of Check Dams- 7
- No. of Nala Bunds – 10
- No. of RR and RS - 15
- No. of Farm ponds - 50

Area	: **71.21sq km**
Monsoon Rainfall	: **539 mm**
Stage of groundwater development	: **95 %**
Uncommitted surface runoff/flow	: **5.75 MCM.**
Total volume of Weathered zone available (Rechargeable)	: **8.54 MCM. (8.00m thickness)**
Total volume of weathered zone available (Rechargeable)	: **5.34 MCM (at 5 m thickness).**
Area are suitable for recharge	: **75 % (As per integration studies)**
Quantity Rechargeable	: **2.62 MCM**
Effect on Water Level	: **2.89 m rise**

Management Plan-Kokulamfirka, Madurai District:



Artificial Rechage/ conservation Structures proposed

- No. of Check Dams- 15
- No. of Nala Bunds – 20
- No. of RR and RS - 20
- No. of Farm ponds - 100

Area	: **108.49 sq km**
Monsoon Rainfall	: **539 mm**
Stage of groundwater development	: **101 %**
Uncommitted surface runoff/flow	: **8.77 MCM.**
Total volume of Weathered zone available (Rechargeable)	: **8.13 MCM. (8.00m thickness)**
Total volume of weathered zone available (Rechargeable)	: **5.34 MCM (at 5 m thickness).**
Area are suitable for recharge	: **75 % (As per integration studies)**
Quantity Rechargeable	: **2.95 MCM**
Effect on Water Level	: **2.14 m rise**

Aquifer management plan along the coastal region of Gundar aquifer system

The eastern part of the Gundar aquifer system borders the Bay of Bengal. Though brackish groundwater exists at different depth as pockets in Ramanathapuram districts, fresh groundwaterexists. More than 2/3rd of paddy cultivation is under rainfed in the Ramanathapuram district. Only 1/3 of paddy irrigation is done mainly through tanks and wells. Groundwater irrigation is done mainly through dugwells and to a limited extent through borewells on right banks of Gundar in parts of Pramakudi, Bogalur and Mudukulathur blocks. In these areas, to enhance the potentiality of the operating dug/borewells farm ponds can be constructed nearer to the wells. This intervention shall improve the quality of water in the wells.

Many system tanks exist along the eastern portion of Gundar aquifer system. These tanks receive supplemental water from major streams or tanks in addition to the yield of their own catchment area. Generally, more than one crop is grown around these tanks. The system tanks over the years had flushed the aquifer beneath. The system tanks can be strengthened by Renovation and repair measures. Strengthening of these system tanks shall induce recharge during monsoon periods and can support irrigation practices. Restoration of system tanks along with other non-system tanks should be taken up periodically to facilitate more recharge and thus should be given utmost priority by the local administration. The system tanks along with shafts shall facilitate more recharge to groundwater in the coastal region of Gundar aquifer system**.**Further, the Kanmois andOoranis are the life line of the people in the coastal region. The Kanmois called as tanks (earthern bunded reservoirs constructed across the slope) were constructed before a period of centuries and is still the main stay of agriculture in the coastal region. Ooranis are called as ponds. These are the earthern reservoirs bounded by earthern bunds along the sides and receive water from the monsoon runoff and stored for the whole year. Hence, along with system tanks, the kanmois and ooranis should be repaired after every monsoon as they are the main sources of drinking water in the saline affected regions of Ramanathapuram district. The local people along with the local administration should ensure for optimum storage of water in the oorani in order to meet the demand during the summer months.

In the entire parts of the Ramanathapuram district, paddy is cultivated through seed boardcasting. This requires more quantity of seed and hampers the productivity. At least in the areas where groundwater is assured, System of Rice Intensification method can be adopted to enhance the crop productivity. By adopting the above interventions, groundwater quality can be improved in the coastal parts of the Gundar aquifer system and additional groundwater potential created shall improve crop production.

Annexure I: Details of Artificial Recharge Structures Proposed in Gundar Aquifer system

District: MADURAI						
Sl no.	**Block Name**	**Firka Name**	**Category**	**Latitude**	**Longitude**	**Proposed AR Structure**
1	Sedapatti	**Sedapatti**	Over exploited	9.8309	77.8136	Recharge Shaft
2	Sedapatti	Sedapatti	Over exploited	9.8284	77.7732	Recharge Shaft
3	Sedapatti	Sedapatti	Over exploited	9.8594	77.8349	Recharge Shaft
4	Sedapatti	Sedapatti	Over exploited	9.8532	77.7735	Recharge Shaft
5	Sedapatti	Sedapatti	Over exploited	9.8631	77.825	Check Dam
6	Sedapatti	Sedapatti	Over exploited	9.844	77.8167	Check Dam
7	Sedapatti	Sedapatti	Over exploited	9.8454	77.7922	Check Dam
8	Sedapatti	Sedapatti	Over exploited	9.8167	77.7934	Check Dam
9	Sedapatti	Sedapatti	Over exploited	9.8349	77.7736	Check Dam
10	Sedapatti	Sedapatti	Over exploited	9.8473	77.8189	Nala Bund
11	Sedapatti	Sedapatti	Over exploited	9.8206	77.7859	Nala Bund
12	Sedapatti	Sedapatti	Over exploited	9.8118	77.7962	Nala Bund
13	Sedapatti	Sedapatti	Over exploited	9.8667	77.8371	Nala Bund
14	Sedapatti	Sedapatti	Over exploited	9.8395	77.7594	Nala Bund
15	Sedapatti	Sedapatti	Over exploited	9.8423	77.8059	Nala Bund
16	Chellampatti	**Sindupatti**	Over exploited	9.96757	77.84188	Recharge Shaft
17	Chellampatti	Sindupatti	Over exploited	9.93922	77.85202	Recharge Shaft
18	Chellampatti	Sindupatti	Over exploited	9.94155	77.88247	Recharge Shaft
19	Chellampatti	Sindupatti	Over exploited	9.92107	77.88575	Recharge Shaft
20	Chellampatti	Sindupatti	Over exploited	9.90872	77.86183	Recharge Shaft
21	Chellampatti	Sindupatti	Over exploited	9.97754	77.82144	Nala Bund
22	Chellampatti	Sindupatti	Over exploited	9.96033	77.82782	Nala Bund
23	Chellampatti	Sindupatti	Over exploited	9.9337	77.87095	Nala Bund

24	Chellampatti	Sindupatti	Over exploited	9.91842	77.86065	Nala Bund
25	Chellampatti	Sindupatti	Over exploited	9.91214	77.8898	Nala Bund
26	Chellampatti	Sindupatti	Over exploited	9.87201	77.85804	Nala Bund
27	Chellampatti	Sindupatti	Over exploited	9.96491	77.83332	Check Dam
28	Chellampatti	Sindupatti	Over exploited	9.93563	77.83782	Check Dam
29	Chellampatti	Sindupatti	Over exploited	9.91271	77.85239	Check Dam
30	Chellampatti	Sindupatti	Over exploited	9.91078	77.89878	Check Dam
31	Chellampatti	Sindupatti	Over exploited	9.88122	77.84985	Check Dam
32	Chellampatti	Sindupatti	Over exploited	9.88864	77.82245	Check Dam
33	Chellampatti	Sindupatti	Over exploited	9.86101	77.86131	Check Dam
34	Chellampatti	**Karumathur**	Critical	10.00851	77.9136	Recharge Shaft
35	Chellampatti	Karumathur	Critical	9.98469	77.91352	Recharge Shaft
36	Chellampatti	Karumathur	Critical	9.95579	77.91775	Recharge Shaft
37	Chellampatti	Karumathur	Critical	9.96053	77.94532	Recharge Shaft
38	Chellampatti	Karumathur	Critical	9.91597	77.93796	Recharge Shaft
39	Chellampatti	Karumathur	Critical	9.90014	77.93729	Recharge Shaft
40	Chellampatti	Karumathur	Critical	10.03235	77.8648	Nala Bund
41	Chellampatti	Karumathur	Critical	10.01352	77.88417	Nala Bund
42	Chellampatti	Karumathur	Critical	10.01211	77.8961	Nala Bund
43	Chellampatti	Karumathur	Critical	9.99136	77.92492	Nala Bund
44	Chellampatti	Karumathur	Critical	9.96779	77.9449	Nala Bund
45	Chellampatti	Karumathur	Critical	10.0376	77.86252	Check Dam
46	Chellampatti	Karumathur	Critical	9.99878	77.90032	Check Dam
47	Chellampatti	Karumathur	Critical	9.98836	77.93957	Check Dam
48	Chellampatti	Karumathur	Critical	9.96437	77.93247	Check Dam
49	Chellampatti	Karumathur	Critical	9.95587	77.96613	Check Dam
50	Chellampatti	Karumathur	Critical	9.95945	77.92232	Check Dam
51	Chellampatti	Karumathur	Critical	9.9295	77.93729	Check Dam
52	Thirumangalam	**Kokulam**	Over exploited	9.9157	77.9765	Recharge Shaft

53	Thirumangalam	Kokulam	Over exploited	9.9226	77.9972	Recharge Shaft
54	Thirumangalam	Kokulam	Over exploited	9.8917	77.9661	Recharge Shaft
55	Thirumangalam	Kokulam	Over exploited	9.8615	77.9406	Recharge Shaft
56	Thirumangalam	Kokulam	Over exploited	9.8657	77.9225	Recharge Shaft
57	Thirumangalam	Kokulam	Over exploited	9.8255	77.957	Recharge Shaft
58	Thirumangalam	Kokulam	Over exploited	9.8931	77.95	Nala Bund
59	Thirumangalam	Kokulam	Over exploited	9.8721	77.976	Nala Bund
60	Thirumangalam	Kokulam	Over exploited	9.8313	77.92	Nala Bund
61	Thirumangalam	Kokulam	Over exploited	9.8577	77.9721	Nala Bund
62	Thirumangalam	Kokulam	Over exploited	9.8459	77.989	Nala Bund
63	Thirumangalam	Kokulam	Over exploited	9.8965	77.9793	Check Dams
64	Thirumangalam	Kokulam	Over exploited	9.8809	77.9577	Check Dams
65	Thirumangalam	Kokulam	Over exploited	9.8596	77.9338	Check Dams
66	Thirumangalam	Kokulam	Over exploited	9.8527	77.9909	Check Dams
67	Thirumangalam	Kokulam	Over exploited	9.8788	77.9816	Check Dams
68	Thirumangalam	Kokulam	Over exploited	9.8572	77.9869	Check Dams
69	Thirumangalam	Kokulam	Over exploited	9.8656	77.9799	Check Dams
70	Thirumangalam	**Thirumangalam**	Critical	9.82093	77.9706	Recharge Shaft
71	Thirumangalam	Thirumangalam	Critical	9.811	77.98	Recharge Shaft
72	Thirumangalam	Thirumangalam	Critical	9.806	77.996	Recharge Shaft
73	Thirumangalam	Thirumangalam	Critical	9.805	78.047	Recharge Shaft
74	Thirumangalam	Thirumangalam	Critical	9.75396	77.997	Recharge Shaft
75	Thirumangalam	Thirumangalam	Critical	9.805	78.006	Nala Bund
76	Thirumangalam	Thirumangalam	Critical	9.805	77.98046	Nala Bund
77	Thirumangalam	Thirumangalam	Critical	9.7905	78.015	Nala Bund
78	Thirumangalam	Thirumangalam	Critical	9.76531	78.02269	Nala Bund
79	Thirumangalam	**Pannikundu**	Semicritical	9.89643	77.8892	Recharge Shaft
80	Thirumangalam	Pannikundu	Semicritical	9.8961	77.9171	Recharge Shaft
81	Thirumangalam	Pannikundu	Semicritical	9.87968	77.899	Recharge Shaft

82	Thirumangalam	Pannikundu	Semicritical	9.88035	77.92953	Recharge Shaft
83	Thirumangalam	Pannikundu	Semicritical	9.88818	77.94627	Recharge Shaft
84	Thirumangalam	Pannikundu	Semicritical	9.85452	77.88058	Recharge Shaft
85	Thirumangalam	Pannikundu	Semicritical	9.85802	77.89157	Recharge Shaft
86	Thirumangalam	Pannikundu	Semicritical	9.8446	77.88734	Recharge Shaft
87	Thirumangalam	Pannikundu	Semicritical	9.79828	77.93452	Recharge Shaft
88	Thirumangalam	Pannikundu	Semicritical	9.77653	77.90467	Recharge Shaft
89	Thirumangalam	Pannikundu	Semicritical	9.892	77.8903	Nala Bund
90	Thirumangalam	Pannikundu	Semicritical	9.86266	78.8779	Nala Bund
91	Thirumangalam	Pannikundu	Semicritical	9.86	77.8906	Nala Bund
92	Thirumangalam	Pannikundu	Semicritical	9.84567	77.87897	Nala Bund
93	Thirumangalam	Pannikundu	Semicritical	9.8231	77.87838	Nala Bund
94	Thirumangalam	Pannikundu	Semicritical	9.78961	77.86198	Nala Bund
95	Thirumangalam	Pannikundu	Semicritical	9.7752	77.84676	Nala Bund
96	Thirumangalam	Pannikundu	Semicritical	9.79753	77.94965	Nala Bund
97	Thirumangalam	Pannikundu	Semicritical	9.77753	77.95363	Nala Bund
98	Thirumangalam	Pannikundu	Semicritical	9.77078	77.92742	Check Dam
99	Thirumangalam	Pannikundu	Semicritical	9.80961	77.86992	Check Dam
100	Thirumangalam	Pannikundu	Semicritical	9.84477	77.88523	Check Dam
101	Thirumangalam	Pannikundu	Semicritical	9.81511	77.89326	Check Dam
102	Thirumangalam	Pannikundu	Semicritical	9.82636	77.86866	Check Dam
103	Thirumangalam	Pannikundu	Semicritical	9.81811	77.88176	Check Dam
104	Thirumangalam	Pannikundu	Semicritical	9.77512	77.8542	Check Dam
105	Thirumangalam	Pannikundu	Semicritical	9.77003	77.86832	Check Dam
106	Thirumangalam	Pannikundu	Semicritical	9.78986	77.88996	Check Dam
District: VIRUDHUNAGAR						
107	Kariapatti	**Mallankinar**	Over exploited	9.6567	78.03282	Recharge Shaft
108	Kariapatti	Mallankinar	Over exploited	9.62564	78.05715	Recharge Shaft
109	Kariapatti	Mallankinar	Over exploited	9.60598	78.05346	Recharge Shaft

110	Kariapatti	Mallankinar	Over exploited	9.65542	78.03101	Check Dam
111	Kariapatti	Mallankinar	Over exploited	9.6463	78.05215	Check Dam
112	Kariapatti	Mallankinar	Over exploited	9.6225	78.07837	Check Dam
113	Kariapatti	Mallankinar	Over exploited	9.59415	78.0515	Check Dam
114	Kariapatti	Mallankinar	Over exploited	9.64257	78.03825	Nala Bund
115	Kariapatti	Mallankinar	Over exploited	9.62372	78.04962	Nala Bund
116	Kariapatti	Mallankinar	Over exploited	9.62172	78.03151	Nala Bund
117	Kariapatti	Mallankinar	Over exploited	9.59051	78.04868	Nala Bund
118	Kariapatti	Mallankinar	Over exploited	9.5879	78.06483	Nala Bund

Annexure 2: FIRKAS AT A GLANCE

MADURAI DISTRICT

	Name of the Firka	**Sedapatti**	**Sindhupatti**	**Karumathur**	**Kokulam**	**Thirumangalam**	**Pannikundu**
	Geographical Area	**73.52**	**75.5**	**89**	**108.49**	**71.21**	**128.69**
	Geological Formation	Charnockite	Granite gneiss	Granite gneiss	Granite gneiss/Charnockite	Granite gneiss	Granite gneiss/Charnockite
	Annual Average Rainfall (mm)	783.51	1066.98	1066.98	1084.49	687.85	687.85
	Potential Aquifer (Fr Zone/Gr Zone)(m bgl	19.2-36.3	18.3-195	35-75.4	64-154	95-148	16.5-33
	Depth to Water level (m bgl) A)Average Premonsoon B) Average Post monsoon	10.4 8.28	14.28 11.24	14.28 11.24	8.57 6.51	8.57 6.51	8.57 6.51
	Water level trend (m/Yr) Rise (+) Fall(-) premonsoonpost monsoon	0.327 0.459	0.935 0.625	0.935 0.625	0.472 0.246	0.304 0.665	
	Depths of Borewell (m bgl) CGWB	200	200	200	200	200	200
	Discharge of Borewells (m3/hr) (CGWB)	6.44	12.06	0.036	17.35	6.444	2.88-11.16
	Specific Yield (%)	1-2	1-2	1-2	1-2	1-2	1-2
	Transmissivity	10	11-30	1	95	50	

	(m2/day)						
	Net Groundwater Availability	11.06	15.24	20.09	16.32	9.99	16
	Gross GW Draft (MCM)	11.17	17.23	19.59	16.45	9.45	12.8
	Net GW availability for future irrigation Development (MCM)	-0.17	-2.07	35.29	-0.266	0.479	3.115
	Irrigation potential created (Ha)						
	Balance irrigation potential (Ha)						
	Stage of GW Development (%)	101	113	98	101	95	80
	Quality of GW	mod	mod	mod	mod	mod	mod
	No. of Expl Bore wells drilled	3	3	1	2	2	2
	No. of Hydrograph stations	16	7	7	14	14	10

	Name of the Firka	**Valanthur**	**Thiruppa rankundr am**	**Valayank ulam**	**Viranthanur**	**Kuraiyur**	**Avaniyapu ram**
	Geographical Area	**54.53**	**69.21**	**46.75**	**43.18**	**81.97**	44.39
	Geological Formation	Granite gneiss	Granite gneiss/Ch arnockite	Granite gneiss	Granite gneiss	Granite gneiss	Granite gneiss
	Annual Average Rainfall (mm)	1067	849.74	849.74	869.87	687.85	849.75
	Potential Aquifer (Fr Zone/Gr Zone)(m bgl	8.61-44	64-154	34.5-34.8	34.5-34.8	8.9-9.4	79.8-174.25
	Depth to Water level (m bgl) A)Average Premonsoon B) Average Post monsoon	14.28 11.24	10.47 8.58	10.47 8.58	10.47 8.58	5.88 5.05	11.78 12.39
	Water level trend (m/Yr) Rise (+) Fall(-) premonsoonpost monsoon	0.935 0.625	-0.179 -0.374	-0.179 -0.374	-0.179 -0.374	-0.172 -0.261	-0.179 +0.374
	Depths of Borewell (m bgl) CGWB	200	200	200	200	200	200
	Discharge of Borewells (m3/hr) (CGWB)	17.28	0.036	0.05		0.25	0.0314
	Specific Yield (%)	1-2	1-2	1-2	1-2	1-2	1-2
	Transmissivity	40	20	5		10	10

	(m2/day)						
	Net Groundwater Availability	19.24	10.81	7.21	4.42	11.52	9.04
	Gross GW Draft (MCM)	14.8	6.76	5.29	3.09	5.64	2.59
	Net GW availability for future irrigation Development (MCM)	4.37	3.9	1.86	4.42	5.85	6.35
	Irrigation potential created (Ha)						
	Balance irrigation potential (Ha)						
	Stage of GW Development (%)	77	63	73	41	49	29
	Quality of GW	mod	mod	mod	mod	mod	
	No. of Expl Bore wells drilled	1	1	2		1	1
	No. of Hydrograph stations	7	10	9	9	13	9

	Name of the Firka	**Elumalai**	**Sivarakotai**
	Geographical Area	177.44	73.49
	Geological Formation	Granite gneiss/Charnockite	Granite gneiss
	Annual Average Rainfall (mm)	783.51	687.85
	Potential Aquifer (Fr Zone/Gr Zone)(m bgl	79.81-174.25	36.6-141.3
	Depth to Water level (m bgl) A)Average Premonsoon B) Average Post monsoon	11.80 9.10	7 8.1
	Water level trend (m/Yr) Rise (+) Fall(-) premonsoonpost monsoon	0.270 0.555	0.172 0.257
	Depths of Borewell (m bgl) CGWB	200	200
	Discharge of Borewells (m3/hr) (CGWB)	0.03	1.008-24.12
	Specific Yield	1-2	1-2

	(%)		
	Transmissivity (m2/day)	10	100
	Net Groundwater Availability	17.09	10.35
	Gross GW Draft (MCM)	15.18	5.4
	Net GW availability for future irrigation Development (MCM)	1.82	4.89
	Irrigation potential created (Ha)		
	Balance irrigation potential (Ha)		
	Stage of GW Development (%)	89	52
	Quality of GW		
	No. of Expl Bore wells drilled	2	2
	No. of Hydrograph stations	15	13

VIRUDHUNAGAR DISTRICT

	Name of the Firka	**Mudukkankulam**	**Narikudi**	**Tiruchuli**	**Veeracholam**	**Palayampatti**	**Mallankinar**	**A Mukkulam**	**Kallukuruchi**	**Kariapatti**
	Geographical Area	**100.63**	**126.19**	**136.6**	**151.03**	**124.71**		142.03	73.66	135.43
	Geological Formation	Granite gneiss	Granite gneiss	Granite biotite gneiss	Granite biotite gneiss	Granite gneiss/Charnockite	Granite gneiss	Granite gneiss	Granite gneiss	Granite biotite gneiss
	Annual Average Rainfall (mm)	1037	1153	680	686	765	686	686.07	686	1044.34
	Potential Aquifer (Fr Zone/Gr Zone)(m bgl	22-37.8	22-37.8	35-75.4	10-90	22-86	18-41	17.90-106.00	8.9-91	9.8-172.6
	Depth to Water level (m bgl) A)Average Premonsoon B) Average Post monsoon	8.40 6.75	8.40 6.75	8.98 6.99	0.59 0.13	8.90 6.79	7.5 6.3	8.40 6.75	7.56 5.82	8.40 6.75
	Water level trend (m/Yr) Rise (+) Fall(-) premonsoonpost monsoon	0.526 0.667	-0.048 -0.097	0.244 0.248	2.813 2.745	0.730 0.779		-0.048 0.015	-0.273 -0.337	-0.048 -0.097
	Depths of Borewell (m bgl) CGWB	200	200	200		200	200	200	200	200

	Discharge of Borewells (m3/hr) (CGWB)	1.8-2.582		0.03		0.12-1.8	18	4.32	6.98-2.7	2.628-5.36
	Specific Yield (%)	1-2	1-2	1-2		1-2	1-2	1-2	1-2	1-2
	Transmissivity (m2/day)	15		10		5	20	80	75	30
	Net Groundwater Availability	22.08	31.74	19.8	22.76	10.4		22.77	6.87	25.92
	Gross GW Draft (MCM)	2.13	167.74	6.53	5.48	4.91		2.17	4.43	7.26
	Net GW availability for future irrigation Development (MCM)	19.76	29.95	12.86	16.24	5.44		20.54	2.31	18.57
	Irrigation potential created (Ha)									
	Balance irrigation potential (Ha)									
	Stage of GW Development (%)	10	5	33	24	47		10	64	28
	Quality of GW									
	No. of Expl Bore wells drilled	2		1		4	2	1	2	2
	No. of Hydrograph stations	14	14	8	14	8		14	5	14

RAMANATAHAPURAM DISTRICT

	Name of the Firka	**Appanur**	**Abiramam**	**Kadaladi**	**Kamudhi East**	**Kamudhi West**	**Kovilankulam**
	Geographical Area	**86.46**	**125.1**	**83.98**	**112.57**	**130.06**	**106.18**
	Geological Formation	SR(Sand with clay fossiliferous sst and shale)	SR(SSt)	SR(sand, clay, gravel)	Granite gneiss	Granite gneiss	SR
	Annual Average Rainfall (mm)	641.04	750.31	639.09	750.31	750.31	750.31
	Potential Aquifer (Fr Zone/Gr Zone)(m bgl	87-99 111-120 126-141 150-156	14-20.07 28-41.4	30-51.00 75.00-90.00	44-46		10-22.04 28.08-37.12
	Depth to Water level (m bgl) A)Average Premonsoon B) Average Post monsoon	 4.89 4.40	 8.10 7.03	 4.37 4.89	 8.16 6.17	 8.16 6.17	 8.16 6.17
	Water level trend (m/Yr) Rise (+) Fall(-) premonsoonpost monsoon	 0.060 0.105	 -0.252 0.371	 0.038 0.060	 0.238 0.013	 -0.238 0.013	 -0.238 0.013
	Depths of Borewell (m bgl)	300	69	101	60		68

	CGWB						
	Discharge of Borewells (m3/hr) (CGWB)	0.03	0.03-2.1	6.3	5.3		12.5
	Specific Yield (%)						
	Transmissivity (m2/day)						
	Net Groundwater Availability	17.71	23.07	13.7	13.7	17.39	12.99
	Gross GW Draft (MCM)	1.12	2.96	1.11	1.11	4.11	4.43
	Net GW availability for future irrigation Development (MCM)	16.46	20	12.51	12.51	13.16	8.29
	Irrigation potential created (Ha)						
	Balance irrigation potential (Ha)						
	Stage of GW Development (%)	6	13	8	8	24	36
	Quality of GW						
	No. of Expl Bore wells drilled	1	3	1	2		1
	No. of Hydrograph stations	7	5	5	5	5	5

	Name of the Firka	**Melakodumalur**	**Mudduk ulathur N**	**Parthipanur**	**Manamadurai**	**Konthagai**	
	Geographical Area	**64.74**	**84.61**	**158.63**	**118.67**		
	Geological Formation	SR	SR	SR	SR/ Alluvium	Granite gneiss	
	Annual Average Rainfall (mm)	712.3	712.3	994.17	1004	874	
	Potential Aquifer (Fr Zone/Gr Zone)(m bgl	58-73	82-88 91-100	37-49	37-49		
	Depth to Water level (m bgl) A)Average Premonsoon B) Average Post monsoon	18.09 18.64	18.09 18.64	14.46 12.42	5.56 4.76	6.37 4.79	
	Water level trend (m/Yr) Rise (+) Fall(-) premonsoonpost monsoon	0.734 1.133	0.734 1.133	-0.385 0.397	0.552 0.517	-0.049 -0.120	
	Depths of Borewell (m bgl) CGWB	104-200	106	60			
	Discharge of Borewells (m3/hr)	0.03	3	4.5			

	(CGWB)						
	Specific Yield (%)						
	Transmissivity (m2/day)						
	Net Groundwater Availability	11.99	17.76	39.33	27.97	18.33	
	Gross GW Draft (MCM)	61.85	98.74	3.61	3.35	5.39	
	Net GW availability for future irrigation Development (MCM)	11.3	16.73	35.58	24.54	12.85	
	Irrigation potential created (Ha)						
	Balance irrigation potential (Ha)						
	Stage of GW Development (%)	5	6	9	12	29	
	Quality of GW						
	No. of Expl Bore wells drilled	3	2	1			
	No. of Hydrograph stations	5	5	6	2	2	

Annexure III: Groundwater Resources of GundarAquifer System

Sl No.	District	Firka	Total Available Resources	Draft for irrigation	Draft for industrial and domestic	Total draft	Provision for domestic and industrial requirement supply to 2027	Future availability for irrigation	Stage of develop mnt	Categorisation
1	Madurai	Sedapatti	1105.68	1086.5	30.47	1116.97	36.29	0	101	OE
2	Madurai	Sindupatti	1524.47	1674.45	48.5	1722.95	57.78	0	113	OE
3	Madurai	Valanthur	1923.91	1445.1	35.08	1480.18	41.78	437.04	77	SC
4	Madurai	Kokulam	1632.08	1574.59	70.65	1645.24	84.16	0	100.8	OE
5	Madurai	Thirumangalam	999.46	908.3	36.27	944.6	43.21	47.92	95	Critical
6	Madurai	Thirupparankundram	1083.9	669.45	76.08	745.53	90.62	323.82	68	Safe
7	Madurai	Valayankulam	721.29	500.7	29.08	529.78	34.64	185.95	73	SC
8	Madurai	Viranthur	753.65	295.6	13.85	309.44	16.48	441.57	41	Safe
9	Madurai	Kuraiyur	1152.42	551.25	13.38	564.63	15.94	585.23	50	Safe
10	Madurai	Pannikundu	1600.55	1233.13	46.89	1280.02	55.86	311.57	80	SC
11	Madurai	Avaniyapuram	904.47	206.83	52.28	259.11	62.28	635.36	29	Safe
12	Madurai	Elumalai	1709.55	1469.85	48.17	1518.02	57.38	182.32	89	SC
13	Madurai	Sivarakottai	1035.56	509.35	31.47	540.82	37.48	488.73	52	Safe

1	Virudhunagar	A Mukkulam	2023.97	190	28.89	218.89	34.42	1799.54	10.81	Safe
2	Virudhunagar	Kallukuruchi	687.388	372.9	70.23	443.131	83.66	230.82	64.46	safe
3	Virudhunagar	Kariapatti	2592.07	681.9	44.522	726.422	53.03	1857.13	28.02	Safe
4	Virudhunagar	Mallankinar	597.995	581.4	36.71	618.11	43.73	0	103.36	OE
5	Virudhunagar	Muddukkankulam	2207.684	119	94.19	213.19	112.21	1976.47	9.657	Safe
6	Virudhunagar	Narikudi	3173.62	109.9	57.84	167.74	68.9	2994.82	5.2	Safe
7	Virudhunagar	Tiruchuli	1980.42	440.85	212.56	653.41	253.21	1286.36	32.99	Safe
8	Virudhunagar	Veeracholam	2275.65	540	7.785	547.78	111.45	1624.195	24.07	Safe
9	Virudhunagar	Palayampatti	1039.57	471.6	19.83	491.43	23.62	544.35	47.27	Safe

1	Ramanathapuram	Appanur	1713.26	64.5	65.76	130.26	78.33	1570.42	7.6	safe
2	Ramanathapuram	Abiramam	2169.833	328	50.09	378.09	59.67	1782.15	17.42	safe
3	Ramanathapuram	Kadaladi	0	0	0	0	0	0	0	Saline
4	Ramanathapuram	Kamuthi East	1262.69	64.8	46.12	110.92	54.94	1142.94	8.78	safe
5	Ramanathapuram	Kamudhi W	1755.71	340.425	65.42	405.85	77.93	1337.34	23.11	safe
6	Ramanathapuram	Kovilankulam	1379.08	446.85	21.58	468.43	25.71	906.52	33.96	safe
7	Ramanathapuram	MELAKODUMALUR	1122.27	25	36.84	61.84	43.89	1053.38	5.5	safe
8	Ramanathapuram	Mudukulathgur	1614.99	38	25.78	63.78	30.72	1546.27	3.9	safe
9	Ramanathapuram	Parthpanur	3933.42	288.15	73.12	361.27	87.11	3558.16	9.18	safe

1	Sivaganga	Manamadurai	1832.65	494.42	44.3449	538.76		1285.4	29.39	safe
2	Sivaganga	Konthagai	2796.81	294.82	40.1004	334.92		2454.22	11.97	safe

Annexure IV: Source wise irrigation data

District	**Firka**	Source of irrigation							
		Area (ha)		Canals	Tanks	Tube wells	Dug wells	Others	Total
Madurai	Sedapatti	73.52	7352	0	0	16.9	1193.62	0	1210.52
Madurai	Sindupatti	75.5	7550	0	0	0	892.465	0	892.465
Madurai	Valanthur	89	8900	763.95	364.6	0	2126.41	0	3254.96
Madurai	Kokulam	108.49	10849	0	414	4	746	1164.26	2328.26
Madurai	Thirumangalam	71.21	7121	0	145.2		533.13	678.33	1356.66
Madurai	Thirupparankundram	69.21	6921	0	66.3	4.15	457.225	527.675	1055.35
Madurai	Valayankulam	46.75	4675	0	6.74	42.34	494.59	543.67	1087.34
Madurai	Viranthur	43.18	4318	0	0	30.795	452.395	483.19	966.38
Madurai	Kuraiyur	81.97	8197	0	484.565	8.61	267.225	760.4	1520.8
Madurai	Pannikundu	128.69	12869	0	0		988.125	988.125	1976.25
Madurai	Avaniyapuram	44.39	4439	0	309.705	0.455	276.425	586.585	1173.17
Madurai	Elumalai	174.44	17444	0	32.28	6.3	3627.325	3665.905	7331.81
Madurai	Sivarakottai	73.49	7349	0	194.885	101.47	346.16	642.515	1285.03
		1079.84	107984	**763.95**	**2018.275**	**215.02**	**12401.1**	**10040.66**	25439

Virudhunagar	A Mukkulam	142.03	14203	0	734.295	65.985	621.195	20.85	1442.325
Virudhunagar	Kallukuruchi	73.66	7366	0	22.425	1.02	105.31	128.755	257.51
Virudhunagar	Kariapatti	135.43	13543	0	694.78	2.235	884.18	28.73	1609.925
Virudhunagar	Mallankinar	89.23	8923	0	21.62		253.695	3.3	278.615
Virudhunagar	Muddukkankulam	100.63	10063	0	978.54	15.33	234.135	1228.005	2456.01
Virudhunagar	Narikudi	126.19	12619	0	1338.91	26.59	445.185	1810.685	3621.37
Virudhunagar	Tiruchuli	136.6	13660	0	546.82	27.19	462.67	23.64	1060.32
Virudhunagar	Veeracholam	151.03	15103	0	749.855	4.195	978.92	7.5	1740.47
Virudhunagar	Palayampatti	124.71	12471	0	4.96	0	389.33	394.29	788.58
		1079.51	107951	**0**	**5092.205**	**142.545**	**4374.62**	**3645.755**	
Ramanathapuram	Appanur	86.46	8646	0	1682.2	0	32.28	1714.48	3428.96
Ramanathapuram	Abiramam	125.1	12510	0	1616.545	0	32.28	1648.825	3297.65
Ramanathapuram	Kadaladi	83.98	8398	0	768.99	0	36.265	805.255	1610.51
Ramanathapuram	Kamuthi East	112.57	11257	0	492.69	0	210.705	703.395	1406.79
Ramanathapuram	Kamudhi W	130.06	13006	0	1166.51	0	470.57	1637.08	3274.16
Ramanathapuram	Kovilankulam	106.18	10618	0	396.73	0	7.355	404.085	808.17
Ramanathapuram	MELAKODUMALUR	64.74	6474	0	945.17	0	67.525	1012.695	2025.39
Ramanathapuram	Mudukulathgur	84.61	8461	0	1136	0	117.91	1253.91	2507.82
Ramanathapuram	Parthpanur	158.63	15863	0	3358	39.01	31.16	3428.17	6856.34
		952.33	95233	**0**	**11562.835**	**39.01**	**1006.05**	**12607.9**	
Sivaganga	Manamadurai	118.67	11867	0	1249.315	51.225	221.295	1521.835	3043.67
Sivaganga	Konthagai	88.29	8829	0	802.1	72.625	416.78	1291.505	2583.01
		206.96	20696	**0**	**2051.415**	**123.85**	**638.075**	**2813.34**	**5626.68**
	Basin area		**331864**	**763.95**	**20724.73**	**520.425**	**18419.84**	**29107.65**	**69536.59**

Annexure V: Exploratory well details in Gundar Basin

Sl.No	District	Firka	EW-Location	Lat	Long	Depth (m)	Fracture depth	Discharge (lps)	EC	RL (m)	Transmissivity (m^2/ day)
1	Madurai	AVANIYAPURAM	THIRUPPARANKUNDRAM (EW)-2015	9.8842	78.0833	202	79.81 - 80.81 173.25 - 174.25	0.01	1717	140	1
2	Madurai	KOKKULAM	Govt college, Thirumangalam	9.8517	78.0156	122	59.9 - 63 109.5 - 112.6	0.08	Nil	136	1.54
3	Madurai	KOKKULAM	NILAYUR (EW)-2022	9.8508	78.0167	155	64 - 65 153.39 - 154	4.82	1003	132	
4	Madurai	USILAMPATTI	Usilampatti	9.9608	77.7958	155	45.7 - 46.7 88.4 - 89.4	0.771	9680	210	2
5	Madurai	USILAMPATTI	2001PZ M.KALLUPATTI	9.9708	77.7958	38.05	28.4 - 28.5	0.441	3250	304	2
6	Madurai	USILAMPATTI	USILAMPATTI (EW)-2010	9.9511	77.7836	116	31.47 - 32 35.09 - 36	4.8	Nil	224	
7	Madurai	USILAMPATTI	Nallathevanpatti EW	9.9366	77.7835	300	18.3 - 19 118.9 - 120 234.8 - 237.9 286.7 - 289.7	3.3534	1022	214	11.97
8	Madurai	ELUMALAI	E.KOTTAPATTY (EW)-2008	9.8833	77.7175	175	137.2 - 139	0.01	1098	173	1

9	Madurai	ELUMALAI	MALLAPURAM (EW)-2031	9.8169	77.6669	143	137.2 - 139	0.01	Nil	205	1
10	Madurai	KARUMATHUR	Karumathur	9.9342	77.9286	300	35.1 - 38.2 72.3 - 75.4	0.01	Nil	155	1
11	Madurai	KURAIYUR	THEERTANDATANAM	9.6750	78.0806	200	8.90 - 9.40	1.93	Nil	100	
12	Madurai	PANNIKKUNDU	Ponnumangalam	9.8892	77.9289	300	106.7 - 109.8 195.2 - 198.2	0.0896	4420	141	1
13	Madurai	PANNIKKUNDU	THIRALI (EW)-2033	9.8003	77.9344	170	16.5 - 17 32.47 - 33	3.1	2840	131	
14	Madurai	UTHAPPANAICKANUR	Kolathupatti	10.0200	77.8072	300	137.2 - 139 209 - 210	0.772	715	225	1
15	Madurai	UTHAPPANAICKANUR	Doddappanaickanur	9.9769	77.7333	200	137.2 - 139	0.772	715	225	1
16	Madurai	VALAYANKULAM	2005PZ VALAYANKULAM	9.8083	78.0994	47	34.5 - 34.8	0.014	620	135	1
17	Madurai	VALAYANKULAM	VALAYANKULAM (EW)-2035	9.8008	78.1000	201	17.85 - 18	0.01	Nil	130	1
18	Madurai	SEDAPATTI	2003PZ SELLAMPATTI	9.8208	77.8042	41.2	19.2 - 19.3 36 - 36.3	1.79	800	169	
19	Madurai	SEDAPATTI	Chinnakattalai	9.8472	77.7999	198	19.2 - 19.3 36 - 36.3	1.79	800	168	
20	Madurai	SEDAPATTI	Perungamanallur	9.8653	77.8168	198	19.2 - 19.3 36 - 36.3	1.79	800	168	
21	Madurai	SIVARAKKOTTAI	Sivarakkottai	9.7439	77.9825	241	36.6 - 37.6 140.3 - 141.3	0.2858	Nil	113	1
22	Madurai	SIVARAKKOTTAI	T Pudur	9.7522	78.0350	214	73.2 - 74.2 137.2 - 138.2 158.6 - 159.6	6.7123	Nil	111	1
23	Madurai	VALANTHUR	VALANDUR (EW)-2011	9.9500	77.8681	102	8.61 15.23 44.71	4.8	Nil	171	

24	Madurai	SINDHUPATTI	Kuppanampatti	9.9503	77.8442	300	18.3 - 19 118.9 - 120 234.8 - 237.9 286.7 - 289.7	3.3534	1022	186	11.97
25	Madurai	SINDHUPATTI	2004PZ TIRUMANGALAM	9.9208	77.8833	54.25	49.6 - 49.8	0.078	2550	134	
26	Madurai	SINDHUPATTI	Kuppanampatti OW	9.9500	77.8400	300	12.2 - 12.7 36.6 - 37 131.1 - 134.2 192.1- 195.2 244 - 244.5 295 - 295.5	3.3534	643	186	30.58
27	Madurai	THENKARAI(M)	Govt school, Vikramangalam	10.0028	77.9292	122	35.1 - 38.2 72.3 - 75.4	0.15	797	191	1.8
28	Madurai	THIRUMANGALAM	Ettunali	9.7872	78.0331	300	54.9 - 55.9	0.0135	1178	109	1
29	Madurai	THIRUMANGALAM	Thirumangalam	9.8244	77.9869	300	95 - 96 147 - 148	1.79	5300	129	1
30	Madurai	T.kallupatti	PulliampattiSalai	9.7119	77.9178	300	67.1 - 68.1	0.0761	898	129	1
31	Madurai	Kalligudi	Vadakkampatti	9.7122	77.9553	190	48.8 - 49.8 79 - 80 97 - 98 110 - 112 129 - 130 183 - 185	9.8637	6890	122	13.36
32	Madurai	Solavandan	Solavandan	10.0228	77.9636	281	175 - 176 209 - 210	0.7823	1138	172	1
33	Madurai	NagamalaiPudukottai	Keelaneri	9.9256	78.0636	305	247 - 249	0.078	4800	144	1
34	Ramanathapuram	Aappanur	A.POONAVISAL (EW)- 2632	9.2500	78.5000	290.66	87 - 99 111 - 120 126 - 141 150 - 156	0.01	36600	32	1
35	Ramanathapuram	Abiramam	2602PZ ABIRAMAM	9.4403	78.4514	51.2	33.5 - 41.4	0.731	1700	42	
36	Ramanathapuram	Abiramam	MANDALAMANICKAM(EW)-2624	9.4833	78.3342	26	14.00 - 20.07	0.36	7920	39	

37	Ramanathapuram	Abiramam	URAKKUDI (EHY-II)	9.5008	78.4842	69.5	28.00 - 40.12	0.01	Nil	47	1
38	Ramanathapuram	Kadaladi	VALINOKKAM-EW -2640, OW	9.1681	78.5061	101	30.00 - 51.00 75.00 - 90.00	2	Nil	10	
39	Ramanathapuram	Kamuthi east	2601PZ KAMUDHI	9.4236	78.3556	48.7	44.0 - 46.0	1.48	490	42	
40	Ramanathapuram	Kamuthi east	KAMUDHI	9.4139	78.3778	49	44.0 - 46.0	1.48	490		
41	Ramanathapuram	Parthipanoor	MELPERUNGARAI (EW)-2617	9.5667	78.4333	57.73	37 - 49	1.5	1000	48	
42	Ramanathapuram	Melakodumalur	TALAKAL (EW-I)-2625	9.4508	78.5342	104.13	58 - 73	0.01	31.6	29	1
43	Ramanathapuram	Melakodumalur	SEITHUR (EW)-4405	9.4169	78.4833	104.13	58 - 73	0.01	31.6	37	1
44	Ramanathapuram	Mudukulathur North	PULVOYKULAM (EW)-2627	9.3508	78.4847	106.38	82.00 - 88.00 91.00 - 100.00	1	2400	29	
45	Ramanathapuram	Mudukulathur North	THALAVAIPURAM RASTHA(EW)-4416	9.3844	78.4833	106.38	82.00 - 88.00 91.00 - 100.00	1	2400	34	
46	Ramanathapuram	Kovilankulam	KARISALKULAM (EW)-2626	9.3000	78.4000	68.85	10.00 - 22.04 28.08 - 37.12	4.5	Nil	33	
47	Sivaganga	Seikalathur	Manamadurai	9.6992	78.4581	43	17.90-18.90 28.50 - 31.80	0.44	1690	76	1
48	Virudhunagar	Kalkuruchi	KARIAPATTI (EW)-4404	9.6681	78.1000	185	13 - 15 32 - 36 60 - 63 88 - 91	1.93	Nil	90	
49	Virudhunagar	Kalkuruchi	P.PUDUPATTI (EW)-4414	9.6000	78.1342	100	13 - 15 32 - 36 60 - 63 88 - 91	0.75	5570	71	

50	Virudhunagar	Mudukkan-kulam	SALAIGRAMAM (EW)-2623	9.6000	78.2175	100	13 - 15 32 - 36 60 - 63 88 - 91	0.75	5570	66	
51	Virudhunagar	Mudukkan-kulam	4401PZ KARIYAPATTI	9.6694	78.1083	39.5	22.0-22.5 37.5-37.8	0.592	2700	86	
52	Virudhunagar	Mallankinar	MANTOPE (EW)-4412	9.6342	78.0181	100	18 - 19 40 - 41	5	1050	111	
53	Virudhunagar	Mallankinar	Mallankinar EW	9.5980	78.0553	100	18 - 19 40 - 41	5	1050	102	
54	Virudhunagar	Palayampatti	Govt ITI Aruppukottai	9.5419	78.1081	122	22 - 23 85 - 86	0.01	1208	100	1
55	Virudhunagar	Palayampatti	4402PZ PALAVANATHAM	9.5667	78.0750	40.9	22.3-22.5 25.5-25.7	0.316	1995	94	
56	Virudhunagar	Palayampatti	PALAYAMPATTI (EW)-4429	9.5333	78.1000	100	22 - 23 85 - 86	0.9	720	98	
57	Virudhunagar	Kariapatti	4404PZ AVIYUR	9.7417	78.1000	37.9	9.8-9.9 22.0-22.4 31.0-31.2	0.731	2180	105	
58	Virudhunagar	Kariapatti	AVIYUR (EW)	9.7431	78.1069	200	81.5 - 82.5 171.6 - 172.6	1.49	1350	106	
59	Virudhunagar	Thiruchuli	TIRUCHULI (SH)	9.5333	78.2008	100	10 - 11 91 - 93	0.01	Nil	61	1
60	Virudhunagar	A.Mukkulam	PULAVAIKARAI (EW)	9.7139	78.2194	200	17.90-18.90 28.50 - 31.80 105.00 - 106.00	1.2	780	101	
61	Virudhunagar	Amathur	Vadamalaikuruchi	9.6297	77.9158	122	47.5 - 50.6	0.08	3510	113	1.14
62	Virudhunagar	Pandalkudi	Govt college, Chettikuruchi	9.4531	78.1039	122	47.5 - 50.6	0.01	3080	95	0.88
63	Virudhunagar	Aruppukottai	STRN Govt school, Aruppukottai	9.5014	78.0967	122	63 - 66.1 94 - 97	0.08	2400	97	1.65
64	Virudhunagar	Palayampatti	Palavanathammoreni	9.5478	78.0181	122	41.3 - 44.4 94 - 97.1	0.04	1184	97	1.45
65	Virudhunagar	Paramakudi	RAJAPALAYAM (EW)-	9.4500	78.5514	184.6	37 - 49	0.01	Nil	155	1

			4406(MADASWAMY KOIL ST)								
66	Virudhunagar	Melakodumalur	RAJAPALAYAM (EW)-4428(HEAD WORKS)	9.4842	78.4833	200	10.10 - 11.50	0.01	Nil	177	1